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Short communication

A preliminary photo-identification study of bottlenose dolphin (*Tursiops truncatus*) in Hauraki Gulf, New Zealand

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Abstract Analysis of photographs of individual bottlenose dolphin (*Tursiops truncatus*) taken in Hauraki Gulf, New Zealand between 2000 and 2003 resulted in 162 uniquely identifiable individuals being included in the Hauraki Gulf bottlenose dolphin photo-identification catalogue. Seventy percent of these catalogued animals were sighted more than once, with sighting frequency ranging from one to eleven encounters. Seasonality was apparent inside the gulf with the majority of observations occurring between April and June, inclusively. Comparison of individual photo-identification catalogues between Bay of Islands and Hauraki Gulf resulted in 59% of the individuals catalogued in Hauraki Gulf being confirmed as occurring in both locations. However, 41% of individuals did not match with animals in the Bay of Islands catalogue, possibly indicating a larger population size than previously suggested for the northeastern region of the North Island, and/or the possibility of individuals overlapping in range between at least two sites along this coastline.

Keywords Bay of Islands; photo-identification; abundance; northeastern; population; range

INTRODUCTION

Bottlenose dolphins (*Tursiops* spp.) are found throughout the world's oceans, from tropical to cold temperate regions near the extremities of their range (Leatherwood & Reeves 1983). Their range is considered a function of water temperature and the associated movement of prey (Hansen 1990; Wells et al. 1990) and may represent individual (home range), group (distribution range), and seasonal variation (Shane et al. 1986). Linear ranges of up to 670 km have been reported for coastal bottlenose dolphin (*T. truncatus*) off the coast of California, United States (Wells et al. 1990). Commuting between separate localities for preferred but discontinuously distributed prey may be typical for at least some individuals (Defran et al. 1999; Stockin et al. 2006).

During the course of inter- and intra-specific interactions and contact with environmental (e.g., foraging around rocks) and anthropogenic (e.g., entanglement in monofilament line) factors, the thin posterior edge (and less often, the leading edge) of the dorsal fin of dolphins may become irregular, resulting in recognisable patterns of notches and scars (Würsig & Würsig 1977). Such patterns are analogous to human fingerprints and are unique to each individual (Würsig & Würsig 1977). Once acquired, notch patterns are usually permanent,

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although masking may occur through continued accumulation of notches (Würsig & Würsig 1977; Wilson et al. 1999). By photographing dorsal fins, researchers are provided with a non-invasive method of identifying and following the progress of individuals over time. This mark-recapture method has become well established for delphinids and other cetaceans (Würsig & Jefferson 1990). The data obtained from photo-identification, in conjunction with other data collected, provide insight into the life history of the individual as well as abundance, range, site fidelity, reproductive biology, group structure, and social organisation (e.g., Haase & Schneider 2001; Lusseau 2005; Merriman 2007).

In New Zealand, dedicated photo-identification studies of bottlenose dolphin (*T. truncatus,* Tezanos-Pinto et al. 2008) have been conducted in Fiordland (Williams et al. 1993; Schneider 1999; Haase & Schneider 2001; Lusseau et al. 2003; Currey et al. 2007), Marlborough Sounds (Merriman 2007) and Bay of Islands (Constantine 1995, 2002; Ryding 2001; Tezanos-Pinto et al. 2005; Mourão 2006). To date, comparison of individual identification photographs between these localities have resulted in no matches (Bräger & Schneider 1998; Constantine 2002), with recent evidence confirming that they are three genetically distinct populations of *T. truncatus* (Tezanos-Pinto et al. 2008).

While undertaking bottlenose dolphin research in Bay of Islands, New Zealand, Constantine (2002) collected photo-identifications of bottlenose dolphin during a small number of opportunistic surveys in the Doubtless Bay area (c. 80 km north of Bay of Islands) and from Tauranga (c. 390 km; Fig. 1). Based on the matching of images of 62 individual bottlenose dolphin from these regions, Constantine (2002) concluded that the bottlenose dolphin along the northeastern coastline of New Zealand form a geographically closed population. Constantine et al. (2003) estimated a population size of 446 adult dolphins (95% CI = 418–487) occur in Bay of Islands and suggested that the majority of the northeastern New Zealand bottlenose dolphin coastal population use the bay as part of their home range.

Here we present results of the first photo-identification study of bottlenose dolphin in Hauraki Gulf, New Zealand, including seasonality, individual resight rate, and a comparison between catalogued animals from Hauraki Gulf and Bay of Islands. Hauraki Gulf (Fig. 1) is situated almost 240 km south of Bay of Islands (based on a linear coastal route from Auckland to Russell; see LINZ Hydrographic Services 2008).

MATERIALS AND METHODS

Hauraki Gulf is a large, relatively shallow embayment, adjacent to Auckland city (36°51′S, 174°46′E). Inside a line from Cape Colville to Cape Rodney (inner Hauraki Gulf, Fig. 1), approximately three-quarters of the 3885 km^2 marine area is ≤40 m in depth (Paul 1968). The greater gulf area includes more than 65 islands (Owen & Owen 1999).

During non-systematic surveys, photographs of bottlenose dolphin (primarily in inner Hauraki Gulf) were collected from November 2000 to December 2003 over 47 discrete days. Data were collected by researchers and experienced marine mammal tour operators who opportunistically photographed bottlenose dolphin during surveys for other species, primarily common dolphin (*Delphinus* sp.) and Bryde's whale, *Balaenoptera brydei*, Wiseman 2008).

Data were collected when visibility was good (≥1 km) and in Beaufort 4 or less. Survey routes were considered non-selective in that they typically were governed by weather conditions (e.g., swell and prevailing winds). However, where feasible, a concerted effort was made to survey equal coverage of the inner gulf. Observations by naked eye and binoculars (Bushnell 8 × 42 magnification) were conducted using a continuous scanning methodology (Mann 1999). Sighting cues used to detect dolphins included splashing and/or silhouettes of porpoising animals, water disturbance owing to surface activity of animals, and/or sighting of dorsal fins.

Once within 400 m of a focal group of dolphins, the boat slowed to an approach speed (c. 9 km/h). Once the boat was within approximately 100 m of the animals, the start time and location for the encounter were recorded using a hand-held Garmin GPS 12. Photo-identification of individuals within a focal group was taken using a Nikon D100 SLR, a Canon EOS5 or a Canon 20D fitted with respective 70–400 mm lenses. Focal groups were only considered independent if they were separated spatially and temporally to a degree that would prevent individuals becoming resampled during a second focal follow (>5 km), and only when subsequent photo-identification analysis revealed no matches between the focal group members.

Photographs selected for inclusion in the Hauraki Gulf bottlenose dolphin photo-identification catalogue (hereinafter referred to as Hauraki Gulf catalogue) were based on the following criteria: (1) they showed a clear, unmasked, lateral view of the dorsal fin (left or right side); (2) the dorsal fin was suitably sized in the frame for all distinguishing features to be

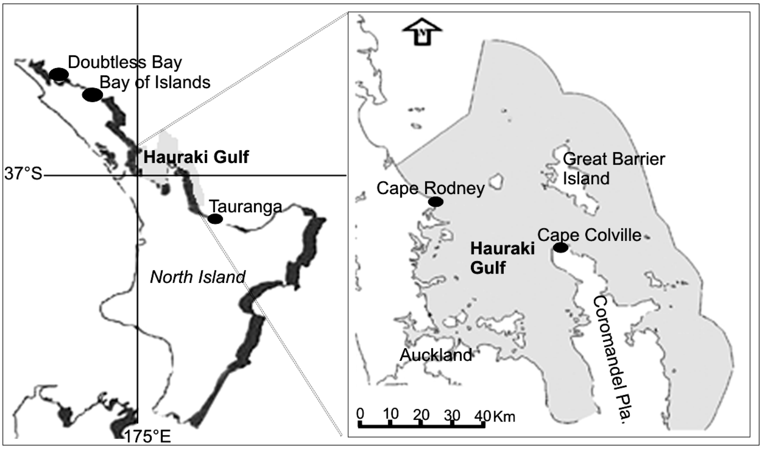

Fig. 1 North Island, New Zealand, indicating the known range of northeastern New Zealand bottlenose dolphin (*Tursiops truncatus*); and the greater Hauraki Gulf area (in grey) of the Hauraki Gulf Maritime Park (insert).

clearly visible; (3) the focus of the image and light intensity (i.e., brightness and contrast) was sufficient to allow all features to be distinguishable; and (4) the dorsal fin had sufficient notches to provide equal probability of recapture (Scott et al. 1990; Heimlich-Boran & Heimlich-Boran 1994; Friday et al. 2000). Features such as body and dorsal fin scars, lesions and tooth-rakings were used as secondary characteristics, thereby reducing the possibility of false positives (Wilson et al. 1999). However, since such characteristics are not necessarily permanent, individuals were not included in the catalogue based on secondary features alone (Würsig & Würsig 1977; Lockyer & Morris 1990). Following Bearzi (1994), the same observer compared each photograph with existing images in the catalogue at least three times before classifying an individual as a new animal and assigning a unique identifying number. Photographs of individuals that matched previously identified animals (i.e., recaptures) were archived. Date, photographer, location, group size and composition (where known), were recorded in a database. Photographs were regularly replaced in the catalogue as better quality or more current images became available. Every photograph was re-examined for false positives (different individuals being assigned the same discrete catalogue number) and false negatives (the same individual being assigned multiple discrete catalogue numbers) and the final data were confirmed by an independent second observer. The ensuing individuals in the Hauraki Gulf catalogue were subsequently matched against the Bay of Islands bottlenose dolphin photo-identification catalogue (hereinafter referred to as Bay of Islands catalogue—Constantine 1995, 2002; Ryding 2001; Tezanos-Pinto et al. 2005; Mourão 2006) by two independent observers, who cross-matched each individual from the Hauraki Gulf to the Bay of Islands catalogue. For individuals that were only sighted twice in Hauraki Gulf during the survey period, any sighting made on a consecutive day to the first ($n = 2$) was discarded.

Statistical analysis was carried out (Minitab 14, Minitab Inc, United States) using Pearson χ^2 tests (Zar 1996) to assess seasonality in bottlenose dolphin occurrence (data per season combined across years). All tests were considered statistically significant at $P \leq 0.05$.

RESULTS

A total of 436 sightings (i.e., one or more usable photograph/s of an individual bottlenose dolphin taken on a discrete day) of 162 individual bottlenose dolphin were recorded in the Hauraki Gulf catalogue database. Individual sighting frequency ranged from one ($n = 48$) to 11 ($n = 1$) times ($\bar{x} = 2.7 \pm 1.8$ SD). The majority of individuals were sighted more than once (70%, $n = 114$; Fig. 2).

The temporal range of sightings (from first to last sighting) of 114 individuals sighted more than once ranged from four days to 36 months ($\bar{x} = 13.2 \pm 9.4$ SD), i.e., the entire temporal range of this study. Fifty-three percent ($n = 60$) of those were sighted over periods 12 months or less.

The majority of bottlenose dolphin sightings were recorded in May (25%, $n = 107$), despite only limited surveys (7.3%, $n = 63$) occurring during this month. No sightings were recorded in February for any year

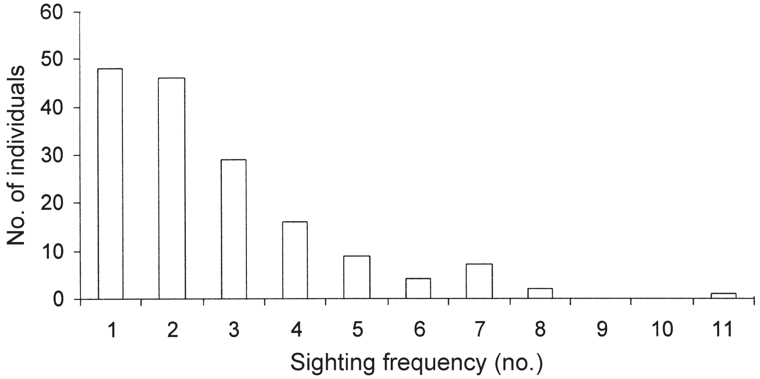

Fig. 2 Sighting frequency of individual catalogued bottlenose dolphin (*Tursiops truncatus*) in Hauraki Gulf, New Zealand.

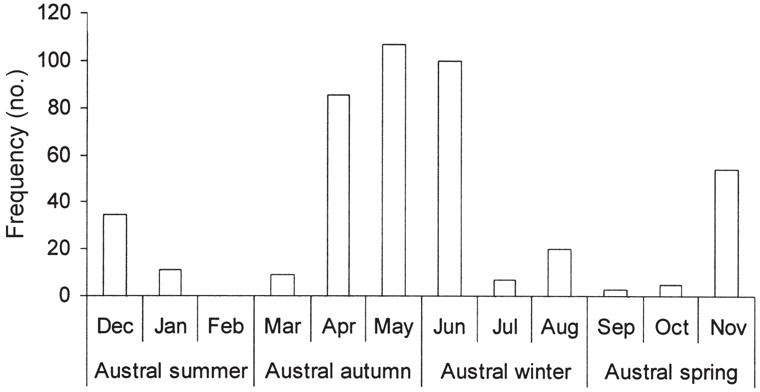

Fig. 3 Number of individual sightings of bottlenose dolphin (*Tursiops truncatus*) by month for all years (2000–03) combined.

(Fig. 3), despite 13.2% of survey effort (n = 114 surveys) occurring during this month. In total, 39 individuals were sighted four or more times. Fifty-four percent (n = 21) of those were sighted in three seasons and a further 13% (n = 5) were sighted in all four seasons. The majority of individuals sighted four or more times (97%, n = 38) were sighted in the austral autumn (March–May) but only 26% (n = 10) were sighted during the austral summer months (December–February). A seasonal occurrence of bottlenose dolphin appeared to be evident in Hauraki Gulf ($\chi^2 = 12.568$, d.f. = 3, $P < 0.01$).

Comparisons with Bay of Islands data

Fifty-nine percent (n = 96) of individuals in the Hauraki Gulf catalogue were positively matched with images in the Bay of Islands catalogue. Of the 48 individuals sighted only once, 58% (n = 28) matched records in the Bay of Islands catalogue. Of the animals that did not match with any images in the Bay of Islands catalogue, 21% (n = 14) were sighted four or more times. Of the animals that did match images in the Bay of Islands catalogue, 26% (n = 25) were sighted four or more times. Excluding individuals sighted only once, 58% of individuals (n = 35) sighted over 12 months or less and 61% of individuals (n = 33) sighted over more than 12 months matched records in the Bay of Islands catalogue.

DISCUSSION

The results presented here provide evidence that a large number of bottlenose dolphin along the northeastern coastline of New Zealand are highly mobile, ranging at least between Bay of Islands and Hauraki Gulf, a distance of approximately 240 km (LINZ Hydrographic Services 2008). However, a substantial portion of individuals in the Hauraki Gulf catalogue did not match images in the Bay of Islands catalogue, suggesting that the occurrence of bottlenose dolphin in Hauraki Gulf is unlikely to be indicative of a shift or extension of the range of the

Bay of Islands population. This suggestion does not preclude that some individuals may have shifted or extended their range from or to Bay of Islands but, rather, the results suggest that the northern coastline of New Zealand supports a larger population than previously thought, thus the range of individuals overlaps between at least two preferred sites along the coastline.

Constantine et al. (2003) suggested that the bottlenose dolphin using Bay of Islands form a geographically closed population of c. 450 animals, and that the majority of northeastern North Island dolphins use this area at some stage and are therefore included in this estimate. However, Constantine et al.'s (2003) study, although including approximately 470 km of the northeastern coastline of New Zealand, was primarily focused in Bay of Islands and no surveys were conducted in Hauraki Gulf. Recent analysis of mtDNA showed that bottlenose dolphin from northeast New Zealand experience genetic interchange with other populations in the Pacific Ocean, mostly from potentially pelagic groups (Tezanos-Pinto et al. 2008). Furthermore, despite an 81% resighting rate, only approximately 21% of identified individuals in the Bay of Islands catalogue were considered core users of Bay of Islands (Constantine 2002) and, in Hauraki Gulf, only 70% of identified bottlenose dolphins were sighted more than once. These data suggest that some individuals are not regular users of these respective areas and further support the suggestion of interchange between these two areas by some individuals.

Seasonality was apparent in Hauraki Gulf, with most and least sightings occurring in the austral autumn and summer, respectively. However, effort in the present study was concentrated predominantly within inner Hauraki Gulf. Bottlenose dolphin are potentially found further offshore in deeper waters during summer months, as has been demonstrated previously in Bay of Islands (Constantine 2002). Great Barrier Island, situated outside the entrance to inner Hauraki Gulf, comprises an area of approximately 285 km^2 (Horrocks et al. 2002) and provides many sheltered bays around its coastline. Opportunistic data from this area confirm bottlenose dolphins use these bays regularly (K.A. Stockin unpubl. data). Dedicated effort, including surveys in outer Hauraki Gulf, may further establish the year-round occurrence of bottlenose dolphin in the Hauraki Gulf area and allow the hypothesis of seasonal movements to be further examined.

Management strategies need to allow for the mobility of the species, potential changes in habitat use and extension or retraction of the distribution range's boundaries (Wilson et al. 2004). Research conducted on bottlenose dolphin (*T. truncatus*) in Moray Firth, Scotland, United Kingdom culminated in the establishment of a marine Special Area of Conservation (SAC) in the 1990s, specifically for the protection of this small, geographically isolated population (Wilson et al. 1997, 2004). However, it was later found that although some animals showed long-term site fidelity, others extended their range (Stockin et al. 2006), using inner Moray Firth less than originally recorded (Wilson et al. 2004). A photo-identification study conducted over 200 km southeast of this site revealed that a proportion of individuals identified in Aberdeenshire waters belonged to the Moray Firth population (Stockin et al. 2006).

The management of New Zealand bottlenose dolphin has previously focused around geographical populations where this species has been extensively studied, i.e., Bay of Islands (Constantine 2001; Constantine et al. 2004) and Fiordland (Lusseau 2003a,b, 2004, 2005; Lusseau & Higham 2004). However, in regions where the occurrence of bottlenose dolphin remains relatively unknown, e.g., Marlborough Sounds (Merriman 2007) and Hauraki Gulf (present study), little baseline data exist concerning the ecology and anthropogenic risks facing this species.

Bottlenose dolphin in Bay of Islands have become sensitised to the impacts associated with dedicated dolphin watching- and swimming-based tourism (Constantine 2001). Although Northland and Auckland (and their respective marine areas) currently represent separate management units, it is important that the bottlenose dolphin along the northern coastline of New Zealand are managed as a single entity, since at least some proportion of the population will be exposed to the cumulative effects of heavy shipping traffic in Hauraki Gulf and dedicated marine mammal tourism in Bay of Islands.

Appropriate management can only be implemented if a thorough understanding of the population's abundance, distribution range and their mediating factors are determined (Wilson et al. 2004; Sini et al. 2005). We recommend that further research on bottlenose dolphin abundance, occurrence, distribution and habitat use in Hauraki Gulf is conducted, including an examination of potential sources of disturbance.

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