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Rare observations of false killer whales (*Pseudorca crassidens*) cooperatively feeding with common bottlenose dolphins (*Tursiops truncatus*) in the Hauraki Gulf, New Zealand

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Multi-species associations of odontocetes remain poorly understood. While their occurrence is occasionally reported, the driving factors behind these interactions are often difficult to ascertain. False killer whales (*Pseudorca crassidens*) are known to associate with a number of other odontocete species, in particular the common bottlenose dolphin (*Tursiops truncatus*) (*e.g.*, Leatherwood *et al*. 1989). However, little is known about the function or extent of these associations.

False killer whales are poorly documented large delphinids. Gregarious by nature, they typically travel in groups of 20–100 individuals and are known to form strong social bonds (Baird *et al.* 2008). Their diet consists primarily of a range of cephalopod and pelagic fish species (Odell and McClune 1999) and may vary by region (Reeves *et al.* 2002). While little is known about their foraging behavior, they have been observed to forage cooperatively in subgroups (Acevedo-Gutiérrez *et al*. 1997). False killer whales occur worldwide in tropical and warm temperate waters (Odell and McClune 1999), with occasional sightings in cold temperate waters (*e.g.*, Stacey and Baird 1991). Their distribution is predominantly oceanic, but they are known to approach close to shore at oceanic islands (*e.g.*, Baird *et al*. 2008) and to occasionally venture into shallow inshore waters (Palmer *et al.* 2009).

Little is known about false killer whale occurrence or distribution in New Zealand waters, with only a few at-sea documented records (*e.g.*, Visser *et al*. 2010). False killer whales occasionally strand around the New Zealand coastline (Baker 1981), although such events typically involve mass strandings (Te Papa Tongarewa, New Zealand Cetacean Stranding Database). To date, there are few data documenting the occurrence of this species in New Zealand waters.

Here we report on two observations of joint foraging by false killer whales and common bottlenose dolphins (hereafter referred to as bottlenose dolphins) in the Hauraki Gulf, New Zealand, in January 2011. The Hauraki Gulf (approximate position 36′10’–37°10′S, 174°40′–175°30′E) is a shallow (depth <60 m), semi-enclosed body of temperate water situated on the east coast of New Zealand’s North Island.

On 20 January 2011, crew aboard the MV *Dolphin Explorer*, a local whale and dolphin watching vessel, encountered a group of approximately 150 false killer

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Figure 1. A false killer whale (*Pseudorca crassidens*) and a bottlenose dolphin (*Tursiops truncatus*) encircling a shoal of kahawai (*Arripis trutta*) using a carouseling technique and (insert) a false killer whale holding a kahawai in its jaws in the Hauraki Gulf, New Zealand on 20 January 2011. Photo by Sarah Gardner.

whales at 36°34.73′S, 174°58.26′E in 43 m of water. The whales were observed in association with a group of approximately 150 bottlenose dolphins, assumed to be the offshore ecotype (Baker *et al.* 2010) based on the prevalence of oval body scars presumed to be the result of cookie cutter shark (*Isistius* sp.) bites (Dwyer and Visser 2011), as well as morphological differences manifested by a more robust body form. Both species were interspersed into mixed-species subgroups over an area of approximately 4 km^2. Each mixed species group was foraging as indicated by leaps, asynchronous dives and the association of sea birds (Acevedo-Gutiérrez *et al*. 1997).

Nondirectional feeding, as characterized by back and forth movements of individuals heading in different directions and diving asynchronously (Acevedo-Gutiérrez *et al*. 1997) was also recorded, with some false killer whales and bottlenose dolphins observed with unidentified fish in their jaws. Large numbers of flesh-footed shearwaters (*Puffinis carneipes*) were present during the encounter, with many scavenging on floating fish remains. One of these mixed-species subgroups was approached by the observing vessel for closer inspection. This mixed-species subgroup was observed driving a shoal of kahawai (*Arripis trutta*) to the surface (Fig. 1), encircling them using a carouseling technique as described for bottlenose dolphins by Bel'kovich *et al.* (1991). Additionally, bubble bursts were emitted to presumably herd the fish into a condensed "bait ball" (Fig. 2). During this period, the fish were driven closer to the observing vessel with the hull eventually acting as a barrier that restricted the

Figure 2. Bubble bursts used by a mixed-species group of false killer whales (*Pseudorca crassidens*) and bottlenose dolphins (*Tursiops truncatus*) to herd a shoal of kahawai (*Arripis trutta*) into a tight "bait ball". Hauraki Gulf, New Zealand, 20 January 2011. Photo by Cathy Goeldner/Explore Images.

shoal's horizontal movement (Fig. 3) effectively using a wall-formation technique (Bel'kovich *et al*. 1991). Despite efforts to slowly maneuver the vessel away from the bait ball, the mixed-species group continued to restrict the shoal against the hull, while taking turns to feed on individual fish. Several false killer whales were observed with kahawai in their mouths (Fig. 1 insert) and some bottlenose dolphins carried unidentified fish remains presumed to be kahawai also. While both species could be seen to encircle the shoal (Fig. 1) only false killer whales were actually observed ingesting kahawai. Additionally, despite both species being engaged in the herding of the fish, a certain degree of segregation between the two species was observed. Conspecifics were often in clusters of five to eight individuals and less than a body length apart, although generally two to three body lengths away from members of the other species. However, on occasion heterospecific group members were less than one body length apart. The encounter was terminated after 1 h of observation due to time restrictions, with foraging by both species recorded throughout the entire duration. The mixed-species group remained in the area where they were initially encountered and continued to forage.

The second encounter occurred on 25 January 2011 when a mixed-species group of approximately 30 false killer whales and 60 bottlenose dolphins was sighted at 36°31.45′S, 175°06.00′E in 45 m of water by researchers aboard RV *Te Epiwhania*. The group, which included juveniles of both species, was travelling in a southerly direction as indicated by their consistent movement and short constant dive intervals,

Figure 3. A shoal of kahawai (*Arripis trutta*) being herded against the hull of the observation vessel by false killer whales (*Pseudorca crassidens*) and bottlenose dolphins (*Tursiops truncatus*) in the Hauraki Gulf, New Zealand on 20 January 2011. Photo by Sarah Gardner.

and was separated into approximately six single-species subgroups dispersed over approximately 3 km^2. Initially, the entire group was traveling at *ca*. 10 km/h for a distance of 4 km, after which all individuals altered course to a westerly direction and traveled a further 3 km before slowing and changing behavioral state to milling, as indicated by no net movement, short dive intervals and surfacing facing different directions. Approximately 5 min later, both species were observed foraging together in association with flesh-footed shearwaters that were again observed feeding on the fish remains. Subsequently, a single-species subgroup of false killer whales were closely observed foraging, with other single species groups remaining dispersed over approximately 2 km^2. Afterwards, a single species subgroup of bottlenose dolphins was recorded using the carouseling and bubble burst technique described during the first encounter, to herd a shoal of kahawai, with individuals taking turns to swim through the bait ball to feed. Throughout the 45 min period of feeding observations all individuals slowly tracked north, with occasional short periods of milling recorded between foraging bouts. For bottlenose dolphins, the herding of fish was visible from the surface, with the prey species identified as kahawai. However, prey species could not be determined for false killer whales despite observations of fish in their mouths. A certain degree of segregation between species, as outlined previously, was again observed. The encounter was terminated after 2 h when the research vessel departed to rejoin a predetermined survey track. Upon departure, the mixed-species group continued to forage whilst slowly moving in a northerly direction.

Photo-identification of false killer whales was conducted during both encounters, with individuals entered into the New Zealand False Killer Whale Identification Catalogue (JRZ, unpublished data). Twenty five and 13 whales were identified during the first and second encounters, respectively, with at least eight individuals in common between the two encounters.

False killer whales are known to associate with other cetaceans and have been observed in close, nonaggressive association with a number of species including rough-toothed dolphin (*Steno bredanensis*) (Leatherwood *et al*. 1989), Risso's dolphin (*Grampus griseus*) (Best and Reeb 2010), pantropical spotted dolphin (*Stenella attenuata*) (Miyazaki and Wada 1978), short-finned pilot whale (*Globicephala macrorhynchus*) (Flores *et al.* 2003) and in particular, bottlenose dolphin (*e.g.*, Flores *et al*. 2003, Best and Reeb 2010). Despite these records, only very few observations of false killer whales foraging in mixed-species associations with other cetaceans have been documented (Tsutsumi *et al.* 1961). While the extent and nature of these associations remain poorly documented or understood, joint foraging—as observed during these encounters—may play a role in the formation of these interspecific groups. Standard benefits of group formation in cetaceans may also apply in this case (Norris and Schilt 1988). Given that the prey are found in large schools that are likely not to be completely depleted by one species alone, the increase in numbers, achieved by the formation of these mixed species groups is likely to result in greater foraging success due to an increased likelihood of encountering prey. As both species were observed feeding on the same prey species, albeit not during the same encounter, and herding a common prey species in an apparently cooperative manner, the association appears to be mutualistic. Packer and Ruttan (1988) suggest that size and abundance of prey are important determinants of predator cooperation during foraging with small, multiple prey favoring cooperation by its captors further supporting mutualism. However, based on these observations alone, parasitism, in the form of one species taking advantage of the other's superior prey locating abilities, cannot be dismissed. While joint herding by both species was observed during the first encounter, foraging was clearly segregated during the second encounter, despite the apparent pursuit of the same prey species. Further data are required to determine the underlying factors behind these different foraging strategies.

A lower risk of predation via better predator detection and a decreased probability of any one individual to be attacked due to the larger aggregation size may also play a role (Norris and Schilt 1988). Fatal attacks by killer whales (*Orcinus orca*) on both false killer whales and bottlenose dolphins have been observed in New Zealand waters (Visser *et al*. 2010), showing that predation is a bona fide threat for both species.

The use of bubbles during prey capture has been widely described for mysticete species, in particular the humpback whale (*Megaptera novaeangliae*) (*e.g.*, Sharpe and Dill 1997). Although using bubbles to herd prey during foraging is not common among delphinids, it has been observed in Atlantic spotted dolphin (*S. frontalis*) (Fertl and Würsig 1995), short-beaked common dolphin (*Delphinus delphis*) (Neumann and Orams 2003), dusky dolphin (*Lagenorhyncus obscurus*) (Trudelle 2010) and killer whale (Similä and Ugarte 1993). While bottlenose dolphins are known to use bubbles in a

social context (Marten *et al.* 1996), there are very few records of this technique being used during feeding (Fertl and Wilson 1997). To date, bubble herding has not been documented for false killer whales. However, false killer whales have been observed to use bubbles underneath an observation vessel in Hawaiian waters where mahi mahi (*Coryphaena hippurus*) were known to be present. In this case, it was assumed that the bubbles were used to dislodge fish attempting to evade predation.[2]

The proximity of false killer whales to the surfacing bubbles during the first encounter suggests that they were producing at least some of the bubbles and observations during the second encounter confirmed that bottlenose dolphins were emitting bubbles. While coordinated foraging by mixed species groups of false killer whales and bottlenose dolphins has been observed previously in New Zealand waters (JRZ, unpublished data) the use of bubbles has not previously been recorded. Given that these are among the first observations of bubble herding for either species, it is not possible to ascertain if this constitutes broad scale behavior or a specific strategy adopted by this particular group or population.

Kahawai is a schooling coastal species endemic to areas within temperate Australasian waters (Paulin 1993). While kahawai is a known prey species for bottlenose dolphins in New Zealand waters (Constantine and Baker 1997), it has, to date, not been reported as a prey species for false killer whales. While predation on a coastal fish species may simply constitute opportunistic feeding, it may also suggest that foraging in nearshore or inshore waters may occur more frequently than is currently being reported.

Inshore movements of false killer whales are thought to be associated with inward flowing water masses and the pursuit of food sources (Kasuya 1971), which may explain their appearance in the coastal waters of the Hauraki Gulf. The scarcity of previous sighting reports in this region is consistent with the species preferring open oceanic waters (Odell and McClune 1999). The rare occurrence of false killer whales in the Hauraki Gulf, as well as photo-identification matches, suggests the two encounters observed over a five day interval likely represent the same group, or part thereof.

We recommend continued behavioral observations and photo-identification of false killer whales in New Zealand waters in order to gain insight into the nature and extent of these interspecific associations as well as population size. Given their infrequent occurrence and reported offshore distribution, satellite tagging (Baird *et al*. 2010) would be an advantageous method to gain further insight into habitat use, distribution and home range of this poorly described species.

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