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BENTHIC FORAGING ON STINGRAYS BY KILLER WHALES (*ORCINUS ORCA*) IN NEW ZEALAND WATERS

One method of foraging not previously reported for the killer whale is benthic foraging. This paper describes frequent feeding by killer whales on rays in shallow water off the North Island of New Zealand. Few accounts of killer whale predation on elasmobranchs (sharks, skates, and rays) have been reported worldwide (Fertl *et al.* 1996). However, rays may be important prey for killer whales in New Zealand.

Studies of the New Zealand population of killer whales have been on-going since December 1992. To date (December 1997) 117 individuals have been photoidentified, using methods developed by Bigg *et al* (1987). Data were collected in an opportunistic manner. Killer whales were encountered after sightings were reported by the public (including whale and dolphin watching boats, fishermen, and Coast Guard). The whales were followed until such constraints as fuel, weather conditions, or the animals' behavior would cause the encounter to be terminated. Where possible, photographs of individual whales were taken, using a Nikon F90x camera with a 80–200 lens and Kodak 100 Select transparency film. Observations of behavior were recorded *ad libitum* onto a microcassette (Altmann 1974). Underwater observations were made with both SCUBA and snorkel. A 4.3-m rigid-hull inflatable with a 60-hp outboard engine was used as the observation platform. Depths were recorded using the onboard depth sounder or taken from nautical charts of the area, and locations were recorded from nautical charts and/or a hand-held Global Positioning System (GPS).

Photoidentified killer whales were grouped based on sex and/or age: "adult male", categorized by having a distinctively large dorsal fin; "SAM" (sub-adult male), fin had begun to grow but was not yet as big as an adult male's fin; "female", seen to be constantly accompanied by a calf, seen to suckle a calf, or genital area had been viewed and sex determined; "juvenile", between ½ to ¾ the size of an adult female, but still larger than calves; "calf", less than ½ the size of an adult female and often 'yellow' in colour; and "unidentified", whales which were yet to be assigned to an age/sex class. Whales photoidentified in this population have not been assigned to pods, due to insufficient data.

Benthic foraging by killer whales was observed in five areas (Fig. 1): Bay of Islands, Whangarei Harbour, Kawau Channel, Gulf Harbour, and Auckland Harbour, all located on the east coast of the North Island. Each of the areas covered approximately 5 × 5 nmi. Within each of the five areas the substrate varied considerably but was similar between areas, with a tidal range of 0.53–3.17 m. Each area had substantial mud or sand flats and some form of estuarine component lined with mangroves (*Avicennia resinifera*) bordered by rocky headlands.

Prey identification was by visual observation (the killer whale surfaced with prey in its mouth, tossed prey into the air, or prey was seen escaping) or by examination of prey remains.

Benthic foraging occurred during all observations made in Whangarei Harbour (n = 5), Kawau Channel (n = 1), Gulf Harbour (n = 3), and Auckland Harbour (n = 4). Nine out of 12 times that killer whales were observed in the Bay of Islands they were observed to forage benthically. In all areas where killer whales were seen to forage thus the water was no deeper than 30 m and averaged less than 12 m.

The cues used to determine benthic foraging included 'milling' (Shane 1990*b*, Hoelzel 1993) where individuals repeatedly dove in varying directions onto one location (where a location is approximately 5 × 5 m). If the killer whales were vertically inverted, *i.e.,* in a 'head stand,' subsurface tail thrashing was often seen. On all occasions when the water was not deep enough for the whales to completely submerge (n = 20), they were seen to 'thrash' their tails in the air, and when pursuing and capturing prey they could often be seen to turn on their sides to navigate the shallow areas. Killer whales foraging on the bottom commonly stirred up sediment. An unmistakable cue used to identify benthic foraging was the observation of a killer whale surfacing with mud on its rostrum extending almost to the blowhole (n = 2).

Between September 1994 and September 1996, on 22 d (98 h) benthic foraging was observed (during 82 h). Group size ranged from 3 to 20 ($\bar{x}$ =

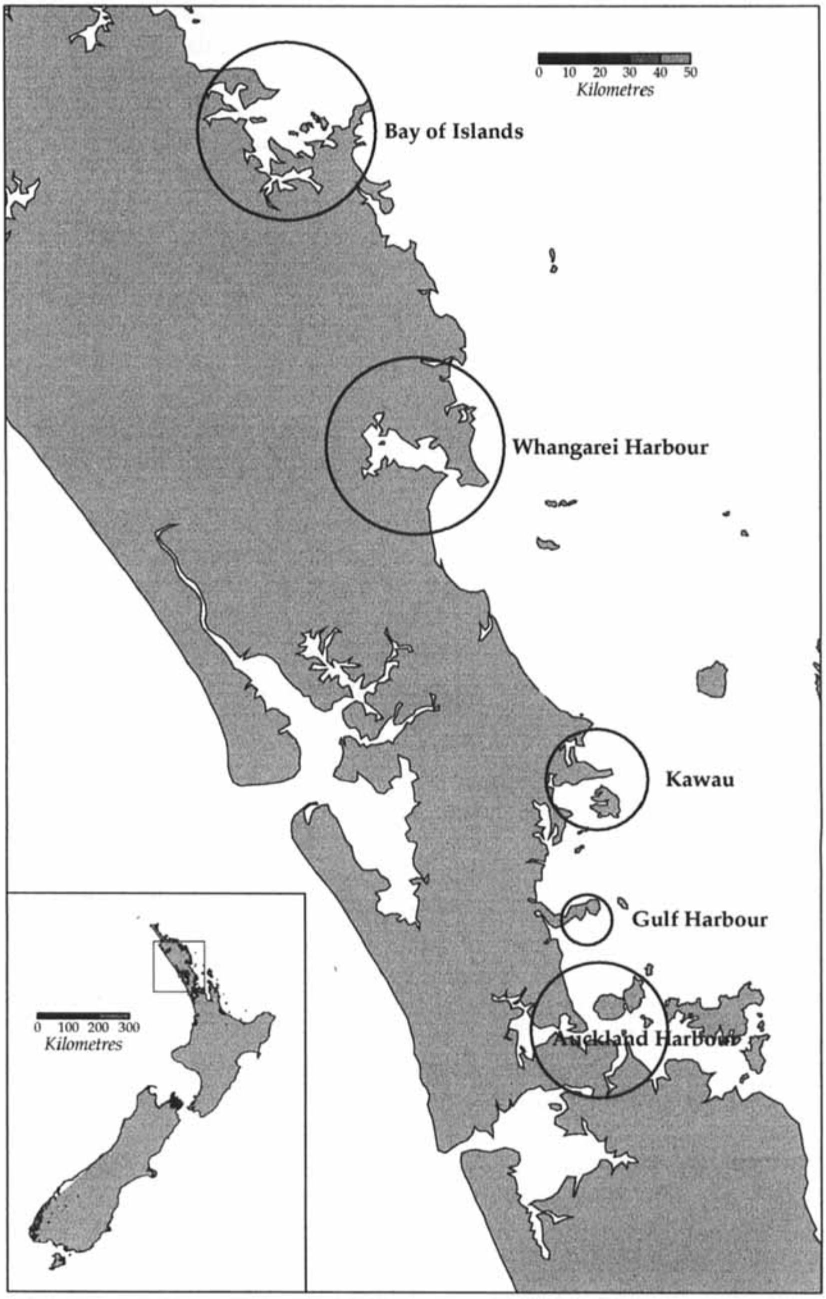

Figure 1. Map of New Zealand, showing areas where benthic foraging occurred.

11), of which 2–5 ($\bar{x}$ = 6) animals engaged in benthic foraging. Nineteen killer whales were seen to catch rays. Twelve were photoidentified: four adult males, two SAMs and six females. Of the 12 identified killer whales, six were observed catching rays at more than one location. Calves accompanied benthically foraging adult killer whales but were not observed to forage or catch rays. Although other identified killer whales were seen to apparently forage for rays, they were not observed to catch them. During two encounters in Whangarei Harbour, one or more killer whales stranded while in the shallow water. They refloated themselves by violent thrashing of their tails.

The prey were identified as rays of one of the following three species: eagle ray (*Myliobatis tenuicaudatus*), short-tailed stingray (*Dasyatis brevicaudatus*), or long-tailed stingray (*Dasyatis thetidis*). All three of these are commonly found in a variety of habitats in New Zealand waters (Ayling and Cox 1987). The two *Dastyatis* species reach a size of over 2 m across, and the eagle ray has been recorded with a wingspan of 1.5 m (Ayling and Cox 1987). Killer whales were observed holding rays in their mouths during 20 of the 22 encounters, with a total of 55 rays seen captured. Thirty-one rays were identified visually to species: eagle ray (n = 23), short-tailed stingray (n = 6), long-tailed stingray (n = 2). On 60% (n = 33) of the times that a ray was caught it was shared with another killer whale. During 20 encounters, prey remains were recovered and identified as ray livers (n = 19) or ray body parts (n = 1). The liver was often retrieved complete, with puncture marks from killer whale teeth. On some occasions, only small parts of the liver were observed floating to the surface (n = 9). Gulls (adult and juveile, *Larus* and *Dominican* sp.) were commonly observed following the killer whales and scavenging remains.

Large bubble releases occurred 15 of the 55 times when sting rays were captured and on 20 occasions when no rays were observed in a killer whale's mouth. On nine occasions (60%) the time between the bubble release and the capture of a ray was less than three minutes. The longest duration between bubble release and the capture of a ray was less than eight minutes. Underwater observations by the author show the killer whales were, on three occasions, rolling on their sides and releasing the bubble in a downward direction, towards the ray buried in the substrate. On two occasions a ray was seen to be picked up by the tail, while another killer whale took the ray by the head. On one occasion a ray was seen to be 'pinned down' by a whale pressing its rostrum against the body area of the ray, whilst another whale took the rays' tail.

Although benthic foraging has been recorded for several cetacean species, it has not been previously reported for killer whales. On two occasions killer whales surfaced with mud on their rostrums, suggesting they may have been digging in the mud. It is possible that this behavior is also occurring in sandy bottoms, but due to the consistency of the sediment it is not adhering to the whale. Würsig and Clark (1993) reported that bowhead whales (*Balaena mysticetus*) have been seen surfacing with mud on their sides and bellies during bouts of bottom feeding, and reports of gray whales (*Eschrichtius robustus*) with mud on them are common, *e.g.,* Scammon (1874), Wilke and Fiscus (1961), Pike (1962), Ljungblad and Moore (1983). Plumes of sediment and stirring up of the bottom have been reported during benthic feeding by other cetaceans: bottlenose dolphin, *Tursiops truncatus* (Shane 1990*a*); humpback whale, *Megaptera novaeangliae* (Swingle *et al.* 1993); *Balaena mysticetus* (Würstig *et al.* 1985); *Eschrichtius robustus* (Hatler and Darling 1974, Würsig *et al.* 1986). Milling has been reported for *Tursiops truncatus* (Shane and Wells 1986) and for killer whales when feeding in the water column (Hoelzel 1993).

The killer whales were observed underwater using the bottom as a physical barrier to trap the stingrays against, as dolphins (Shane 1990*b*, Herzing 1996) and killer whales (Heimlich-Boran 1988, Hoelzel 1993) have been reported to do while chasing fish. The killer whale may 'pin' the ray to the bottom and prevent it from escaping. Rays chased by killer whales attempted escape by going under wharves (under which the killer whale cannot pass), going under rocks, or by leaving the water—either jumping out of it, racing along the surface at speed, or by proceeding some distance up the beach. The rays also attempted to avoid capture by maneuvering in shallow water (less than 2 m) at high speed and with erratic movements.

Killer whales have been reported tossing pinnipeds and penguins out of the water (Guinet 1992). Constantine *et al.* (1998) reported a dusky dolphin (*Lagaenorhynchus obscurus*) being tossed by a killer whale, and Frost *et al* (1992) reported a killer whale tossing a beluga (*Delphinapterus leucas*). This is the first report of killer whales tossing rays.

Bubble use by killer whales during feeding events has been reported on two previous occasions (Sigurjónsson *et al.* 1988, Similä and Ugarte 1993). The specific function of the large bubble releases reported here is not certain, but they may to be used to dislodge rays. On the three occasions where large bubble releases were observed underwater, the rays were seen to move from their location in the substrate and were seen to be captured. Although bubble releases may also be a form of social signalling whilst foraging, the fact that they are used when only one whale was present suggests this is not the only function (Fertl and Wilson 1997).

Although some New Zealand killer whales appear to have specialized in catching rays, there is no doubt a cost involved in this. Rays have venemous spines, and although to date no deaths of killer whales can be directly attributed to ray stings, this is not the case for *Tursiops truncatus.* Walsh *et al.* (1988) and Main (1995) reported tail spines of rays embedded in various tissues of *T. truncatus,* causing death. Hunting for rays cooperatively may decrease the risk of injury (Jefferson *et al.* 1991), but there is also the associated risk of stranding for killer whales when foraging in shallow water (Guinet 1991*b*). Although the New Zealand killer whales do strand themselves occasionally while hunting for rays, it does not appear to be intentional, as has been observed in Argentina (Lopez and Lopez 1985) and Crozet Island (Guinet 1991*a*).

The literature suggests that elasmobranchs are not a major food source of cetaceans in general, although some species of rays have been reported in stomach contents of sperm whales, *Physeter macrocephalus* (Rameirez 1992), *Tursiops truncatus* Gunter 1942), and killer whales (Norris and Prescott 1961, Castello 1977, Fertl *et al.* 1996). When discussing killer whales preying on elasmobranches Fertl *et al* (1996) suggested that they may be taken on more occasions than originally considered. The evidence here supports this, as more rays were taken on one day of observations of New Zealand killer whale (n = 15) than were reported in the literature over a 40-yr period (n = 11) (Fertl *et al.* 1996). The New Zealand killer whales have developed benthic foraging as a specialized technique for capturing rays and this, along with the high number of ray captures, suggests that rays may be a significant component of the diet of New Zealand killer whales.

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FIRST RECORD OF AN ALBINO BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*) IN THE GULF OF MEXICO, WITH A REVIEW OF ANOMALOUSLY WHITE CETACEANS

In June or July 1994, an all-white individual bottlenose dolphin (*Tursiops truncatus*) was sighted in a group of 4–5 dolphins in Little Lake (28°28′8″N, 90°9′3″W) near New Orleans, Louisiana. The water depth was 1.5–1.8 m. The animal was the same size as the normally-pigmented individuals accompanying it and was completely white with no darker pigmentation visible. The group with the white individual was first sighted approximately 50 m from where one of us (JJL) was fishing, then moved as close as 27 m. While slowly swimming, each dolphin raised its head out of the water far enough to expose the eyes (Shane 1990 termed this behavior as "peek"). The white dolphin was observed to have reddish eyes, in sharp contrast to the normally-pigmented eyes of its darker companions. This group of dolphins was observed for a total of 20–30 min and then not seen again. This incident represents the first report of an albino bottlenose dolphin in the Gulf of Mexico.

Reports of anomalously white cetaceans are infrequent. Hain and Leatherwood (1982) reviewed the occurrence of such individuals for 13 cetacean species. We have compiled a list that includes overlooked or recent reports of