

Short Note

Observations of Killer Whale (*Orcinus orca*) Attacks on Bryde's Whales (*Balaenoptera edeni*) in the Galápagos Islands

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Killer whales (*Orcinus orca*) are one of the most extensively distributed marine mammals worldwide (Ford, 2002). This species of toothed cetacean is a well-known apex predator and carnivore, affecting food webs under top-down control with predictable effects at the base of the marine trophic chain (Estes et al., 1998). At present, three lineage ecotypes have been described in the northeastern Pacific: (1) the piscivorous “resident” killer whales; (2) mammal-eating “transient” killer whales; and (3) the poorly known “offshore” ecotype, which preys upon fish, including sharks (Bigg et al., 1990; Ford et al., 1998; Saulitis et al., 2000; Ford, 2002).

Killer whale attacks on baleen whales, including minke (*Balaenoptera acutorostrata*) and grey (*Eschrichtius robustus*) whales, have been well documented in the eastern North Pacific Ocean and other regions of the world (Ford et al., 2005; Ford & Reeves, 2008). Pitman et al. (2001) also reported predation on large toothed cetaceans such as sperm whales (*Physeter macrocephalus*). Silber et al. (1990) detailed one of the first accounts of killer whales attacking, killing, and feeding on a Bryde's whale (*B. edeni*) in the northern Gulf of California, Mexico.

Although the Bryde's whale is one of the most common baleen whales observed in Galápagos waters, the species is listed as nationally “Near Threatened” in marine waters off Ecuador by the International Union for Conservation of Nature (IUCN) (Alava et al., 2011a). This cetacean is a mesopredator strongly associated with the major nucleus of upwelling coupled with the Cromwell

current. A total of 316 sightings of Bryde's whales, with an average group size of 1.6 individuals, was recorded from 1973 to 2000 (Palacios & Salazar 2002). The relative abundance of this baleen whale was estimated as 500 individuals within the Galápagos Marine Reserve waters (Alava, 2009), and it might well represent an important source of food and energy for killer whales in this tropical region.

The aim of this note is to describe a successful attack by a group of killer whales on a Bryde's whale in the Galápagos Islands, Ecuador, with a description of their attack behavior. We also present information related to a resighting of one of the killer whales involved in the attack off the coast of Ecuador. To our understanding, there is no photo documentation on killer whale attacks on Bryde's whales in the existing literature for the equatorial Pacific region.

We analyzed a set of eight pictures provided to the first author (JJA) by R. Butler in December 2008. G. Merlen confirmed that R. Wenrick took these photographs on 26 July 2003, who granted permission to the authors for use. The exact location of the predatory event occurred in the Bolívar Channel, a passage located in offshore waters between Fernandina and Isabela Islands (00°12' S–91°25' W and 00°19' S–91°20' W, respectively) in the western region of the Galápagos Archipelago. West of Isabela Island is one of the most productive upwelling areas in the eastern tropical Pacific, and rorquals are frequently sighted there throughout the year (Alarcón, 2012; Denkinge et al., 2013), with Bryde's whales the

most commonly sighted species (Alava, 2009; Alava et al., 2011a; Alarcón, 2012). This area is also one of the most important habitats for killer whales in the Galápagos Marine Reserve (Alarcón et al., 2012; Smith, 2012; Denkinger et al., 2013). Previous observations of killer whale interactions with marine mammals and attacks on baleen whales have frequently occurred in the past, but these observations were not documented in detail (Merlen, 1999; B. Haase, pers. comm., 4 December 2008; Alava, 2009; Alava et al., 2011a). In addition to the Bryde's whale predation event on 26 July 2003, we report other recent killer whale interactions with marine mammals in the Bolivar Channel (Table 1).

Prior to the attack, observations of the behavior of either species were not recorded and, therefore, are unavailable. Initially, a pod of at least six killer whales, including two adult males (Figure 1A), attacked a small-sized baleen whale that had been swimming alone (Figure 1A-C). The rorqual was identified as a Bryde's whale based on its size (≈ 10 to 12 m) and external morphological features along its dorsal surface, including a dark gray color dorsally (Figure 1C & D) and presence of two of the three longitudinal bridges over the straight rostrum, which is a typical trait to this species (Figure 1H). The killer whales approached the Bryde's whale and started assaulting both flanks of the Bryde's whale's body and its rostrum by clashing over it with the mid and anterior parts of the killer whales' bodies in an attempt to force the Bryde's whale down. Then, the killer whales bit into the Bryde's whale from different sides simultaneously in what appeared to be attempts to exhaust it. This episode lasted about 1 h; after 1 h passed, the killer whales bit and ripped off part of the Bryde's whale's mouth and rostrum (Figure 1D-H), presumably targeting the tongue. The Bryde's whale showed a lack of resistance and no signs of defensive actions. Rather, the Bryde's whale showed what might be described as typical "flight" behavior, a strategy consisting of rapid (20 to 40 km/h) directional swimming away from the killer whales (Ford &

Reeves, 2008), but it exhibited no other behaviors to defend itself when it was attacked. As the attack was nearing its end, the Bryde's whale succumbed to the attack (Figure 1H). During the attack, the killer whales exhibited group coordination and effective predation in dispatching the prey; these are foraging behaviour traits similar to those previously documented for killer whales attacking a Bryde's whale in the Gulf of California, Mexico (Silber et al., 1990).

Previously described foraging events in the western region of the Galápagos Archipelago indicate that the event described herein is not an isolated occurrence (Merlen, 1999; Alava, 2009; Alava et al., 2011a).

Similarly, on 25 August 2011, a pair of killer whales was observed harassing an adult female Bryde's whale with her calf in the Bolivar Channel (D. Alarcón, pers. obs., 25 August 2011; Table 1). While the two killer whales ambushed the mother-calf pair and tried to separate the calf from the mother, a group of five humpbacks (*Megaptera novaeangliae*) was heading up and crossing nearby the interactions, practically passing over the Bryde's whales, seemingly as a kind of interference behaviour or aggression against the killer whales. Then, the humpback whales deviated from the attack to follow their previous course without being attacked by the killer whales. The killer whales continued interacting with the Bryde's whales.

Interestingly, a Galápagos sea lion (*Zalophus wollebaeki*) was sighted in close proximity to the killer whales–Bryde's whale interaction. When the killer whales became aware of the new potential prey, they stopped attacking the Bryde's whales and began targeting the sea lion, which initiated rapid swimming to escape. No further effort was invested during the field observation to follow up the persecution due to the late evening hour; therefore, the fate of the sea lion remains unknown.

Another interaction observed in the same passage was recently recorded (see Table 1). An attack of killer whales on an unknown prey species was observed by JO aboard the *R/V BAE Orion* in

Table 1. Interactions between killer whales and marine mammals in the Bolivar Channel, Galápagos

Date	Species	Killer whale group size	Remarks
25 October 1993	Bryde's whale (<i>B. edeni</i>)	10	Observed bites, blood, and whale being eaten
26 July 2003	Bryde's whale	5-6	Harassment and evidence of killing (this study)
6 October, 2008	Galápagos sea lion (<i>Z. wollebaeki</i>)	4	Sea lion was not attacked
25 August 2011	Bryde's whale, humpback whales (<i>M. novaeangliae</i>), and Galápagos sea lion (<i>Z. wollebaeki</i>)	2	Harassment of Bryde's whale and sea lion, but not the humpback whales

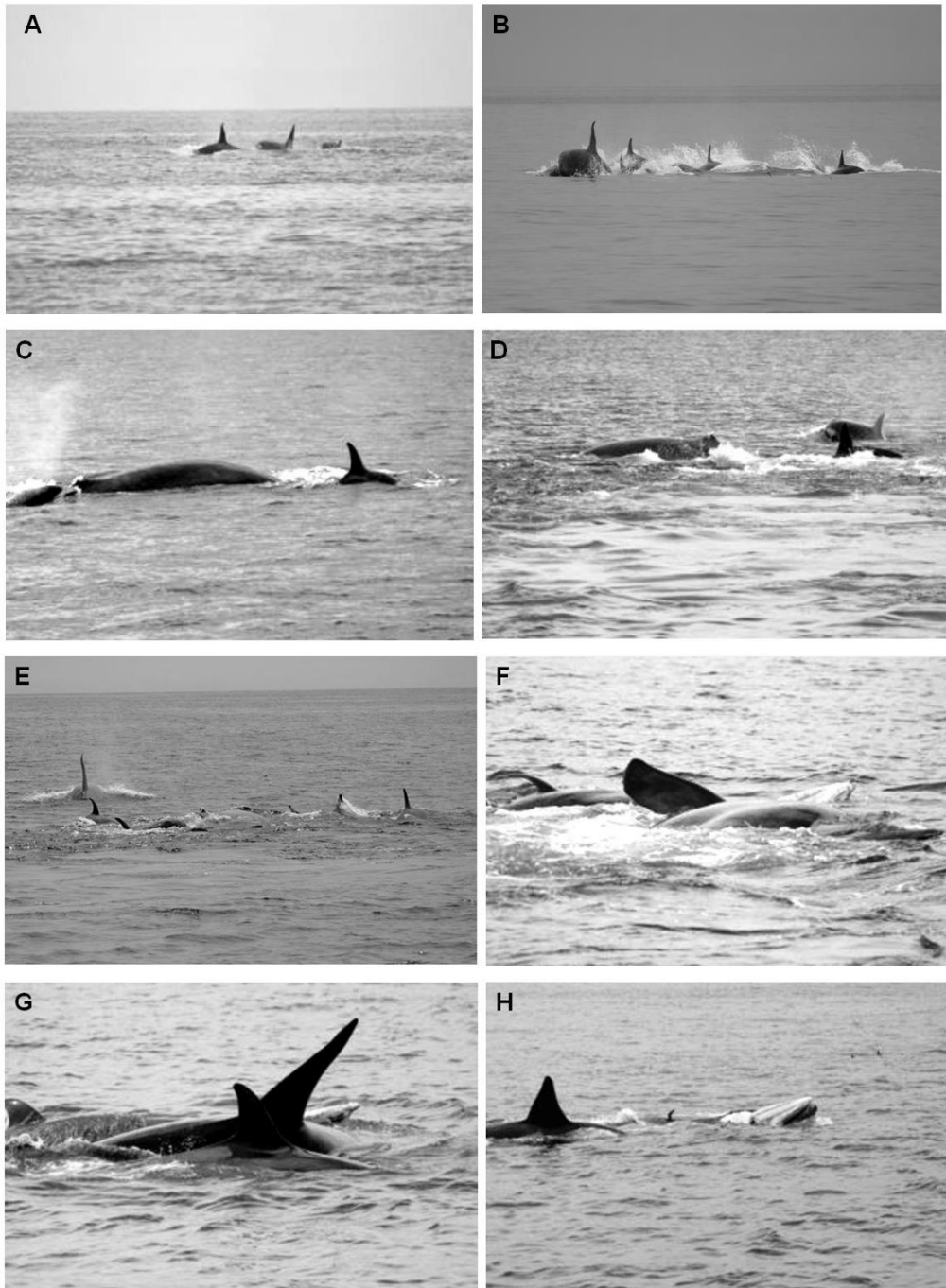


Figure 1. (A-C) A group of five to six killer whales attacking a Bryde's whale in the Galápagos Islands (26 July 2003); (D-G) the killer whales were biting and ripping at the whale's mouth, presumably targeting the tongue and lips; and (H) the dead Bryde's whale showing the mouth and the top of the rostrum with the skin peeled off of it. (Photos by R. Wenrick)

the Bolivar Canal on 6 October 2008. Four killer whales appeared to work cooperatively (often moving in pairs or in groups of 1 and 3) to surround another animal. The killer whales appeared to surround the animal and were observed forcing the forward section of the animal underwater, leaving the fluke of the animal to rest over the head of one of the killer whales. We speculate that the unknown prey was possibly a large shark or a sunfish (*Masturus* sp. or *Mola mola*) because of the shape and size of the body. Throughout this specific observation, the killer whales were often swimming slowly, in very close association, possibly close enough to be touching one another. The *R/V BAE Orion* passed within a few hundred meters of the group, remaining in the area throughout the attack.

Another potential prey animal observed during this interaction between the killer whales and the unidentified prey was a Galápagos sea lion. The sea lion did not appear to be actively swimming away from the killer whales. The killer whales, as far as could be observed, ignored or did not attack the sea lion, which passed within a few meters of the killer whales and could at one point be seen swimming in the same direction as and parallel to the pod. This may have been due to the presence of the other, larger prey animal with which the killer whales were already engaged.

Some individuals involved in the Bryde's whale attack in 2003 could be identified photographically using the recent regional Ecuador and Galápagos killer whale photo-identification catalogue (Alarcón et al., 2012). A closer examination of the dorsal fin of the large adult male in this pod, photographed on 26 July 2003 (Figures 1G & 2A), resembled and showed characteristics similar to an individual previously photo-identified (Figure 2B) off Ecuador's mainland coast at Bajo Atacames, Esmeraldas (0°52' N, 79°50' W), in 2005, approximately 1,000 km away from the Bolivar Channel (Alarcón et al., 2012). This male was recorded as individual Oo0002, possessing an elongated dorsal fin and showing a backward semi-curve on the posterior edge of the fin from the mid-region toward the pointed tip (Figure 2). Interestingly, Oo0002 was observed with another unidentified male in several other attacks on humpback whales, including attacks on mothers, calves, and escorts, during the breeding season (June through September) off Ecuador's northern coast in 2005 (J. Denking, pers. obs., 18 August 2005). However, lack of additional pictures for the male observed off Esmeraldas precluded confirmation as to whether this animal is the same individual matching the male leading the Bryde's whale attack in the Galápagos. Under the assumption of having a positive match

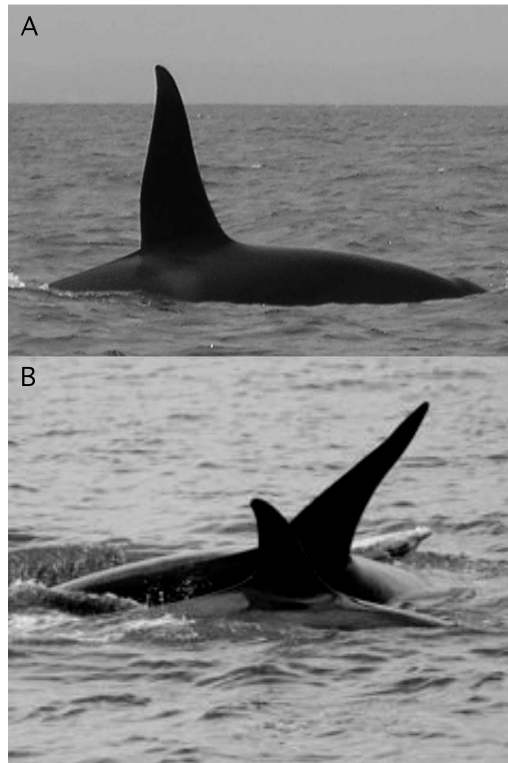


Figure 2. A male killer whale (Oo0002; “Tahuik”) observed (A) off northern Ecuador (0°52' N, 79°50' W) on 18 August 2005 and, presumably, also observed (B) in the pod attacking the Bryde's whale on 26 July 2003 (Photo A by Niki/Instituto Nazca, taken from Alarcón et al., 2012; Photo B by R. Wenrick)

(i.e., same individual observed in both geographical locations), this finding may underscore an inter-regional movement of more than 1,000 km suggesting offshore ecotype or, more likely, transient-like behaviour because of its history of attacks on baleen whales, including humpback and Bryde's whales. It is possible that this animal and its pod conduct seasonal movements synchronized with the reproductive season (i.e., June through September) of humpbacks off Ecuador and the presence of Bryde's whales in the western Galápagos Islands. This might be the first observation of killer whale migratory and feeding behaviour in the southeastern tropical Pacific Ocean.

In Galápagos waters, killer whales feed on and interact with a broad group of marine vertebrates, including teleosts, chondrichthyes, sea turtles, otariids, small cetaceans (e.g., bottlenose dolphins [*Tursiops truncatus*] and common dolphins [*Delphinus delphis*]), and large whales such as sperm whales and baleen whales (i.e., Balaenopteridae), including a sighting of Bryde's

whales being attacked by killer whales in offshore waters near Banks Bay (00°09' S, 91°33' W) on 25 October 1993 (Merlen, 1999). More recently, a predatory interaction between a pod of killer whales and a manta ray was reported (Alava & Merlen, 2009). According to Merlen (1999), Galápagos killer whale group sizes average 3.1 animals (range = 1 to 9; $n = 134$), although some groups found offshore (i.e., oceanic waters with a depth greater than 1,000 m) are larger (mean = 5.1; range = 1 to 48; $n = 49$), which is consistent with the pod sizes reported herein (Table 1). In the northeastern Pacific, the pod sizes for transient, resident, and offshore ecotypes range 2 to 10, 5 to > 50, and > 25 to 60 individuals, respectively (Bigg et al., 1987; Ford et al., 2000). Based on this information, it might be theoretically possible to categorize the Galápagos killer whales as resident or transient mammal-eating killer whales, ecologically similar to those of the northeastern Pacific due to the small groups seen in the Galápagos. In addition, it cannot be ruled out that the individuals visiting and observed in Galápagos waters may reveal multiple resident and transient populations or be part of a population residing in the eastern tropical Pacific (Smith, 2012).

The predatory attacks involving tropical baleen whales are of particular interest given that similar behaviors have been reported for transient killer whales of the eastern North Pacific Ocean. These insights might be used as evidence to further support future studies investigating population and feeding ecology, photo-identification, and the ecotypes occurring in the Galápagos region. Killer whales are considered "Near Threatened" in Ecuadorian waters, including the Galápagos Islands (Alava et al., 2011b), thus highlighting the need for further research to provide the necessary information for effective conservation measures.

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