Aquatic Mammals 2015, *41*(3), 265-271, DOI 10.1578/AM.41.3.2015.265

Short Note

Killer Whale (*Orcinus orca*) Predation on Whales in Sri Lankan Waters

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Killer whales (*Orcinus orca*) are an apex predator of the marine world. Sophisticated and coordinated hunters, they are known to prey on a wide range of animals from fish to marine mammals, including the great whales (Bigg et al., 1990; Ford et al., 1998; Baird, 2000; Ford, 2002). Killer whale predation on marine mammals has been documented around the globe, with much of our current understanding derived from studies of "transient" mammal-foraging populations in the Pacific Northwest. While accounts of killer whales preying on smaller marine mammals (e.g., pinnipeds and dolphins) are not uncommon, reports of them hunting great whales remain infrequent (Jefferson et al., 1991; Reeves et al., 2006).

Orca Project Sri Lanka (OPSL), a citizen-science study of the local killer whale population off Sri Lanka in the Northern Indian Ocean, collects and compiles images and encounter records to use in a public-access log and photo-identification database. We received photographs and footage documenting two separate attacks on cetaceans in Sri Lankan waters that we will present in this short note: (1) an attack on a pod of sperm whales (*Physeter macrocephalus*) and (2) an attack on a mesoplodont beaked whale (*Mesoplodon* sp.). In addition, we also present circumstantial evidence of an attack on a blue whale (*Balaenoptera musculus*). Please note that the account narratives are derived from the personal accounts of untrained observers and are therefore incomplete. Where exact locations or group sizes were not available, approximations have been given.

Account 1 – Sperm Whales

This event took place on 17 April 2013, roughly 24 km offshore of Mirissa (approximately 05° 45' N, 80° 27' E) on the southern coast of Sri Lanka (Figure 1). A pod of five or six killer whales comprising three or four females/subadult males (F/SMs), a large calf, and an adult male were observed attacking a herd of approximately five F/SM sperm whales and at least one young. The account was documented during a chartered whale-watching excursion via photographs (Figure 2), a 10-min video (Blue Sphere Media, 2013; Heinrichs, 2013), and personal notes recorded by observers Shawn and Brett Heinrichs.

The passengers and crew on board initially noticed a disturbance on the water's surface just ahead of the vessel; when the vessel approached, they saw a herd of approximately six sperm whales huddled in a tight group on the surface. The herd appeared distressed as suggested by behaviours such as erratic changes in body orientation; frequent respiration; inverted surface posturing; rolling; and spy hopping high out of the water, often with their mouths open (see Weller et al., 1996; Pitman et al., 2001; Figure 2A, B & D). A killer whale then surfaced and charged directly into the herd and was immediately followed by another killer whale; the sperm whales reacted by thrashing and clustering close together on the surface. F/SM killer whales repeatedly charged at the sperm whales, surfaced in the midst of the group, and moved between individual sperm whales in an apparent attempt to break the herd apart. At times, the killer whales seemed to recede from the attack and mill along the outer edges of the sperm whale herd before resuming their assault.

Throughout the period of observation, approximately 30 min, the sperm whales made no obvious attempts to dive or fight back but were clustered tightly (often touching) at the surface. At times, they formed a rosette (or "marguerite"; Nishiwaki, 1962)—a ring on the surface with heads pointing inwards and tails radiating out (Figure 2A). As

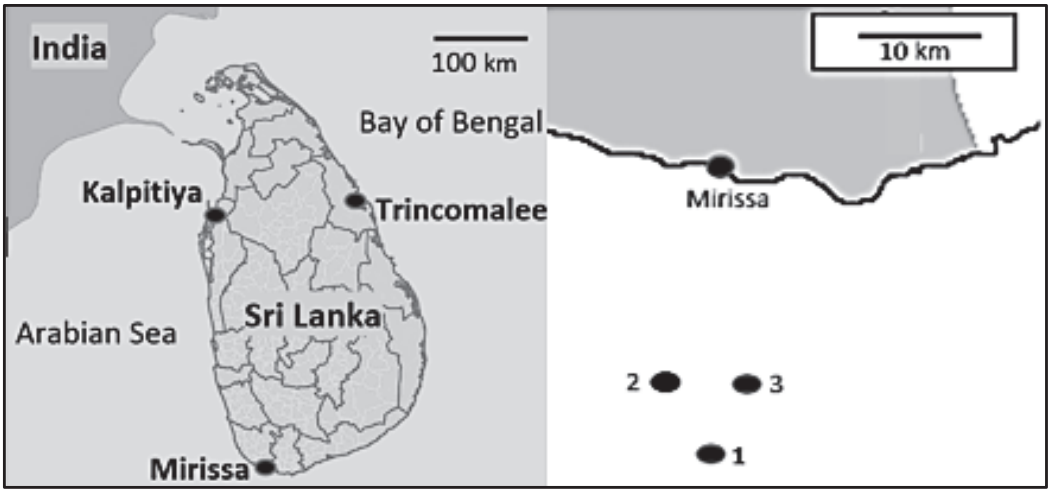

Figure 1. Map of Sri Lanka and surrounding area labelled with the three whale-watching locations (Mirissa, Kalpitiya, and Trincomalee) that make up Sri Lanka's "whale-watching triangle." The attacks described in this short note took place off Mirissa, right inset, and their approximate locations are indicated as 1, 2, and 3. (Map by SEDAC Maps, used and modified under Creative Commons Licence CC BY 2.5, http://creativecommons.org/licenses/by/2.5.)

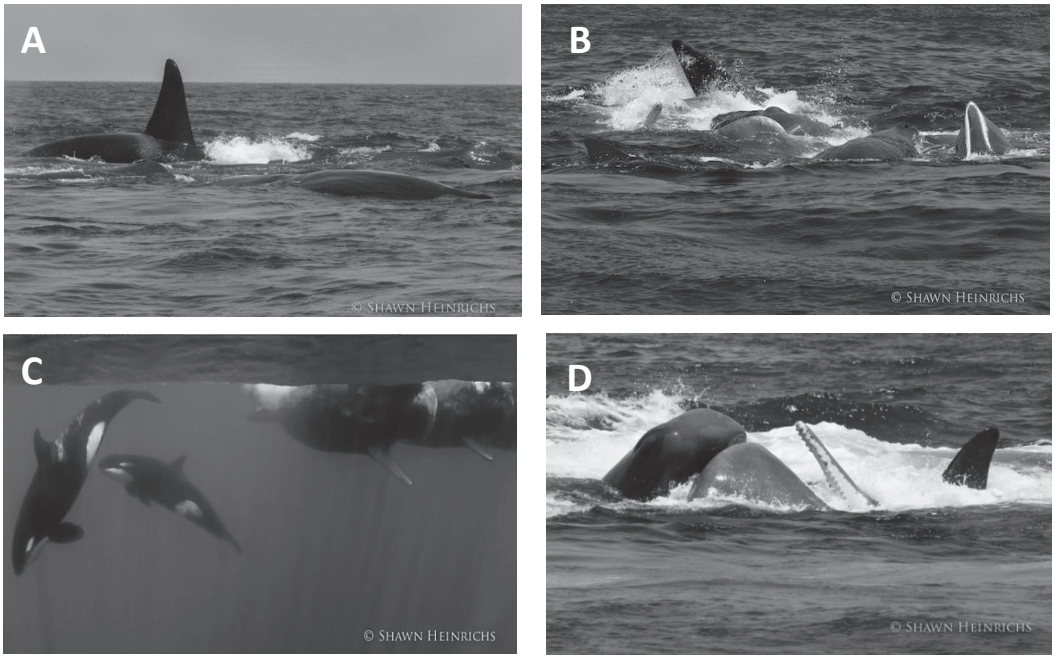

Figure 2. (A) Male killer whale charges into the group of sperm whales in a rosette formation. (B) The sperm whales tightly clustered at the surface and exhibiting rolling and inverted behaviours. (C) A screenshot from the underwater video footage showing an F/SM killer whale and large calf in close proximity to three sperm whales in a tight shoulder-to-shoulder formation with their mouths agape. (D) F/SM killer whale charging into two sperm whales with their heads out of the water; one sperm whale has its mouth open, exposing the teeth and white gums of the lower jaw. (Photos: Shawn Heinrichs)

the attack progressed, the rosette often changed into a phalanx or shoulder-to-shoulder formation (Pitman et al., 2001) wherein the whales flanked each other while facing in the same direction with their jaws agape (screenshot from underwater video in Figure 2C).

While the sperm whales were in the shoulder-to-shoulder formation, F/SM killer whales surfaced on each side of the herd, and the attack suddenly intensified. The large male killer whale charged into the herd, pushed between individuals, and isolated one of the smaller sperm whales. The flukes of the struggling sperm whale were seen briefly breaking the surface on the outer edge of the herd, approximately 7 or 8 m away from the rest of the sperm whales, which were still in a shoulder-to-shoulder formation. The male killer whale surfaced in quick succession and appeared to push down on top of the smaller sperm whale, which was partially submerged, his dorsal fin shaking wildly with the impact. Two F/SM killer whales briefly surfaced in unison at the flukes of the isolated sperm whale, and it appeared to the observers as though the whole killer whale pod was now focused on this individual. The rest of the sperm whales remained in a tight group but began to break formation, and some began tail slapping. These tail slaps did not appear to target or deter the killer whales, and the killer whales did not appear to be in close proximity to the sperm whales during this time; however, it is also possible that they were below the surface and therefore out of view. The splashing and chaos that ensued momentarily reduced visibility of the attack. When the splashing lessened, the sperm whales appeared to have regrouped and were now hastily retreating, surface-swimming in a shoulder-to-shoulder formation towards the east. It was unclear whether the previously isolated sperm whale had rejoined the herd or whether all members of the herd were present at this time. The killer whales briefly pursued the sperm whales before eventually giving up chase. Due to the speed and chaos of the event, it was unclear whether any sperm whales were killed, but the visible surface slick mixed with blood and the strong oily smell emanating from the site suggest that at least one sperm whale was injured.

This account further supports that sperm whale herds employ a defensive rather than offensive strategy when faced with a threat from killer whales (see Dufault & Whitehead, 1995; Pitman et al., 2001). The fact that the herd formed a rosette is noteworthy; and to our knowledge, this is the first record of this behaviour in the Indian Ocean, suggesting that it may be used by sperm whale populations worldwide. The rosette formation has been described by Pitman et al. (2001) as an all-or-none strategy. While it has the benefit of equal protection for all, and especially to those placed in the middle such as calves (Weller et al., 1996), it potentially leaves every member of the herd exposed to attack. In this case, and those previously described (see Pitman et al., 2001), the tight grouping strategy caused the killer whales to attack individuals at random, possibly resulting in several, if not all, of the herd being injured rather than just one sperm whale.

For a majority of the observation, the group was in a huddled mass of no particular shape. Towards the final stages, however, a shoulder-to-shoulder formation of two or more animals was observed increasingly more often (Figure 2C & D). This could have served to provide support for the wounded or helped to usher individuals back into position in the rosette (see Pitman et al., 2001). At no point during the observation were the sperm whales seen to fight back despite their obvious size, large teeth, and powerful tails capable of delivering a lethal blow (Ford & Reeves, 2008). In the underwater footage and Figure 2C, however, three sperm whales are seen flanking each other shoulder-to-shoulder on the surface, facing the killer whales with their mouths open in the water, and exposing the large teeth in the lower jaw. This behaviour has been noted in other aggressive encounters as a possible threat display towards the attackers (see Palacios & Mate, 1996; Weller et al., 1996; Smultea et al., 2014).

The observation of the killer whales withdrawing after a short but intense series of attacks has been described before. Pitman et al. (2001) suggests this wound-withdraw method may be for the purpose of exsanguination; such formidable prey must be weakened before attempting to separate an individual.

All age and sex classes of the killer whales appeared to be involved (see Dufault & Whitehead, 1995; Pitman et al., 2001), with the large adult male playing a pivotal role. The function of the adult male in attacks on large whales is still not fully understood (Jefferson et al., 1991; Pitman et al., 2001) as there are published accounts of them actively participating (Hancock, 1965; Whitehead & Glass 1985), having little to no involvement (Tarpy, 1979; Arnbom et al., 1987; Silber et al., 1990; Jefferson et al., 1991; Pitman et al., 2001) or being absent (Cummings et al., 1972). In this case, the adult male was actively involved; he was seen charging into the sperm whales frequently and, most importantly, he delivered the blow that separated an animal from the herd (Figure 2A).

Account 2 – Mesoplodont Beaked Whale

This event took place on 25 November 2013, 16 km offshore of Mirissa (approximately 05° 48' N, 80° 25' E) on the southern coast of Sri Lanka (Figure 1). Two killer whales, an adult male and a female/subadult male, were observed swimming in close proximity to a piece of blubber

roughly 1 m^2 in size. Based on the photos of the encounter, the male killer whale appears to be holding in its mouth an animal with a greenish coloration (Figure 3). We determined it to be the rostrum of a small beaked whale; the slightly arching gape, distinct beak, and relatively flat melon distinguishes it as a species of *Mesoplodon*. Due to the physical similarity among the mesoplodonts, especially between females and young (Pitman, 2009), we were not able to identify it to species level. To our knowledge, this is the first record to confirm killer whales preying on mesoplodonts. Until now, they were only suggested as prey based on scars consistent with killer whale teeth observed in a beached specimen of *M. densirostris* (Mead, 1989).

It has been suggested that the deep diving and inconspicuous surfacing nature of beaked whales may have evolved as a way to reduce the risk of predation from shallow-diving predators like killer whales (Aguilar de Soto, 2006). An acoustic study of *M. densirostris* revealed that these whales may employ acoustic crypsis and avoid killer whale detection by not vocalizing at depths shallower than 170 m (Aguilar de Soto et al., 2011).

The two killer whales involved in this attack, thought to be an adult male (OM001) and F/SM (OK008), are the most resighted individuals in the killer whale catalogue maintained by OPSL, having been sighted 11 times between years 2008 and 2014. This pair appears to return to the island each year—the only individuals known to visit the northwest, south, and northeast of the island.

Account 3 – Blue Whale

This event took place on 1 February 2014. An injured blue whale was observed and photographed by Joshua Barton roughly 15 km offshore of Mirissa (approximately 05° 48' N, 80° 28' E) on the southern coast of Sri Lanka (Figure 1).

The blue whale appeared to be in poor health (Figure 4); it was thin and apparently unable to dive. Three underwater images of the blue whale (Figure 4A-C) show extensive rake marks of three to five parallel lines outlining large flesh wounds to the flank and dorsal region with the dorsal fin itself almost completely gone (Figure 4B & C). Both pectoral flippers were severely lacerated, with the right missing a large portion of the tip (Figure 4A). The flesh of the abdominal region appeared to be torn, with what appeared to be the penis (or perhaps entrails) extending from the base of the wound (Figure 4B). We infer that the nature and location of the blue whale's injuries are consistent with the attack strategy for killer whales hunting large baleen whales. Although such instances are believed to be rare, we cannot entirely rule out false killer whales (*Pseudorca crassidens*), which have also been known to attack large cetaceans (Jefferson et al., 1991; Palacios & Mate, 1996).

Blue whales resort to flight as their main defence when faced with a threat from killer whales (Ford & Reeves, 2008). They do little to defend themselves and, instead, flee from their aggressors by swimming away at high speed, sustaining speeds of more than 15 to 20 km/h. The killer whales' attack strategy is to exhaust and fatigue the whale, pursuing and wounding it until it is weak. They will often target and bite down on vulnerable appendages such as pectoral flippers, dorsal fin, and flukes to slow the whale down, which would result in the injuries observed in Figure 4A & B. The killer whales bite out large chunks of flesh (Tarpy, 1979; Figure 4A-C) or attempt to prevent surfacing by pushing down on the whale's back (Figure 4C; see also Alava et al., 2013). It is possible, due to the large amounts of flesh missing, that the killer whales fed on this blue whale as it fled before eventually abandoning the hunt (Ford & Reeves, 2008).

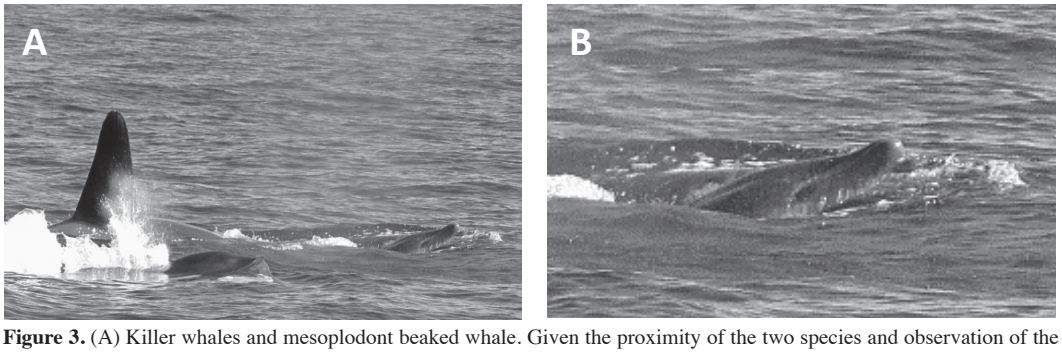

Figure 3. (A) Killer whales and mesoplodont beaked whale. Given the proximity of the two species and observation of the 1 m^2 piece of blubber, it is likely that the beaked whale is already dead, and one of the killer whales is carrying it in its mouth. (B) A close-up view of the mesoplodont's head showing the slightly arching gape, distinct but short beak, and sloping but relatively flat melon. (Photos: Paul Bateson)

During the period of November to April, blue whales occur in Sri Lankan waters during their annual migration between the Arabian Sea and the Bay of Bengal (Figure 1; de Silva Wijeyeratne, 2008; Anderson et al., 2012). At the same time, seasonal commercial whale-watching tours operate daily out of Mirissa Harbour in the south, and regularly from Kalpitiya in the northwest and Trincomalee in the northeast (see Figure 1). This increased effort heightens the possibility for any attack to be witnessed, so the lack of records suggests such events are uncommon. To gauge the level of threat from killer whales, images of blue whales were analysed for the presence of rake marks of three or more parallel lines thought to be consistent with killer whale teeth. A catalogue of 150 individuals maintained by The Sri Lankan Blue Whale Project identified no whales with rake marks that matched the criteria (A. de Vos, pers. comm., 27 October 2014). In addition, a public-science study with 81 unique blue whales, "Wild Blue," also searched their images and found only two potential candidates, which included the individual described above. The overlap between these two catalogues is unknown, and some images were of insufficient quality for assessment so the results are inconclusive. However, the finding of only two blue whales exhibiting rake marks out of 150+ suggests, so far, that predation pressure is low.

The study of this killer whale population is still in its infancy, but these accounts provide the first insight into their dietary habits. We have established that they hunt cetaceans, but we do not yet know if they take other kinds of prey as well (e.g., fish, squid). Populations in the tropics and other areas of low productivity are thought to have a more diverse diet than their temperate counterparts and are, therefore, perhaps less likely to exhibit specialization (Baird, 2000).

At the time of this writing, OPSL has identified 11 individuals consisting of three separate pods, two of which were involved in the whale attacks. It is not yet known whether these groups are resident in Sri Lankan waters or visit seasonally, but photo-identification studies have shown that at least some individuals are resighted each year. The periods of peak sightings for killer whales, November to January and March to April (Gemmell & de Silva Wijeyeratne, 2013a, 2013b), correspond with the peak blue and sperm whale season (November to April) for the southern coast (de Silva Wijeyeratne, 2008; Anderson et al., 2012). During the months of May to September, commercial excursions decrease due to rough seas caused by the southwest monsoon, which may

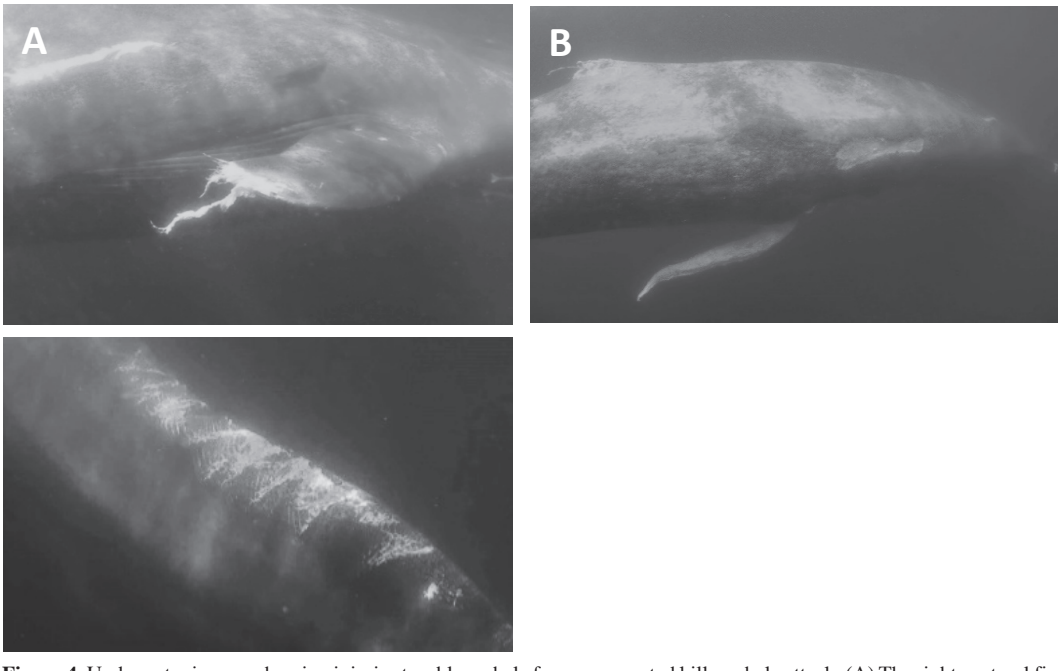

Figure 4. Underwater images showing injuries to a blue whale from a suspected killer whale attack. (A) The right pectoral fin with rake marks and tip missing. (B) The right flank showing a large portion of flesh missing, extensive damage to the dorsal fin, and lacerations on the underside of the abdomen with what appears to be the penis (or possibly entrails) seen protruding from near the wound site. (C) Tooth rake marks on the caudal peduncle. (Photos: Joshua Barton)

explain the reduced number of sightings during this time.

The dearth of information surrounding this population's numbers, movements, and feeding ecology highlight the need for further study. More information is needed for any conservation or management plan to be effective and to ascertain the level of predation threat that they represent to other cetaceans in these waters, particularly those that are endangered.

Acknowledgments

The authors would like to thank the following people and organisations for their assistance in shaping this manuscript and their ongoing support of Orca Project Sri Lanka's work: Shawn Heinrichs, Paul Hilton, Brett Heinrichs, Joshua Barton, Paul Bateson, Andrew Webb, and Dave Williams who kindly allowed us to describe their encounters and shared their images and footage. We are grateful to Robert Pitman for being OPSL's Technical Advisor as well as providing suggestions on how to improve this manuscript. Our gratitude to Robin Baird, Robert Pitman, Colin MacLeod, Asha de Vos, Josh McInnes, Ranil Nanayakkara, and Diane Claridge for assisting us in analysing images and sharing their knowledge. Neville Winchester also reviewed this manuscript and provided suggestions on ways to further improve it. We also thank John Keells Hotels, Chitral Jayatilake, and the Cinnamon Nature Trails team for sponsoring the initiative during the first author's one-year period of work with them. We also thank each and every individual and whale-watching operator who has helped us shape this project by alerting us to orca sightings, sharing images, or sharing information.

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