Journal of Threatened Taxa

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ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

COMMUNICATION

KILLER WHALE *ORCINUS ORCA* (LINNAEUS, 1758) (MAMMALIA: CETARTIODACTYLA: DELPHINIDAE) PREDATION ON SPERM WHALES *PHYSETER MACROCEPHALUS* LINNAEUS, 1758 (MAMMALIA: CETARTIODACTYLA: PHYSETERIDAE) IN THE GULF OF MANNAR, SRI LANKA

Ranil P. Nanayakkara, Andrew Sutton, Philip Hoare & Thomas A. Jefferson

26 September 2020 | Vol. 12 | No. 13 | Pages: 16742–16751
DOI: 10.11609/jott.5006.12.13.16742-16751

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Journal of Threatened Taxa | www.threatenedtaxa.org | 26 September 2020 | 12(13): 16742–16751
ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)
DOI: https://doi.org/10.11609/jott.5006.12.13.16742-16751
#5006 | Received 14 April 2019 | Final received 06 September 2020 | Finally accepted 13 September 2020
PLATINUM OPEN ACCESS

COMMUNICATION

Killer Whale *Orcinus orca* (Linnaeus, 1758) (Mammalia: Cetartiodactyla: Delphinidae) predation on Sperm Whales *Physeter macrocephalus* Linnaeus, 1758 (Mammalia: Cetartiodactyla: Physeteridae) in the Gulf of Mannar, Sri Lanka

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Abstract: To date in Sri Lankan waters, there has been limited research on Killer Whales. These animals have been recorded almost all around the island, except in the northernmost waters and in Palk Bay. The highest observed concentrations are from the northeastern, south/southwestern and northwestern coastal waters of Sri Lanka. These have come from both opportunistic observations and dedicated scientific surveys. Seasonal trends in sightings in some locations suggest fairly consistent occupancy. Transient Killer Whales have been documented attacking/killing Sperm Whales from many geographic locations around the world. To date, there is only one published account of Killer Whales feeding in Sri Lankan waters. Our paper presents, for the first time, field observations of Killer Whales preying upon superpods of Sperm Whales in the waters off the Kalpitiya Peninsula (eastern half of the Gulf of Mannar), northwestern Sri Lanka. The incidents took place on two separate occasions during the months of March and April, 2017.

Keywords: Dolphin, feeding, Kalpitiya Penninsula, marine mammal, observations.

Editor: E. Vivekanandan, Central Marine Fisheries Research Institute, Chennai, India. **Date of publication:** 26 September 2020 (online & print)

Citation: Nanayakkara,R.P., A. Sutton, P. Hoare & T.A. Jefferson (2020). Killer Whale *Orcinus orca* (Linnaeus, 1758) (Mammalia: Cetartiodactyla: Delphinidae) predation on Sperm Whales *Physeter macrocephalus* Linnaeus, 1758 (Mammalia: Cetartiodactyla: Physeteridae) in the Gulf of Mannar, Sri Lanka. *Journal of Threatened Taxa* 12(11): 16742–16751. https://doi.org/10.11609/jott.5006.12.13.16742-16751

Funding: Biodiversity Education And Research (BEAR).

Competing interests: The authors declare no competing interests.

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Author contribution: RN–conceptualisation, research design, data collection, data analysis, drafting manuscript, interpretation; TJ–critical review, edit, research design; AS–data collection & review draft; PH–data collection & review draft.

Acknowledgements: We would like to thank Mr. H.D. Rathnayake (Director), Mr. Dharmathilake, Dr. Lakshman Pieris, Mr. Manjula Morathenne and and the staff of the Department of Wildlife Conservation for all their help both in and out off the field. We thank the Sri Lankan Navy personnel and the coastal villagers for their support and help at all times. We are grateful to Mr. B.A.Y.B. Jayawardana for preparing the map. Lastly, we are indebted to the anonymous reviewers and subject editor for their rigorous reviews and edits.

INTRODUCTION

The Killer Whale *Orcinus orca* is an Odonocete belonging to the family Delphinidae (Oceanic dolphins) and is the largest member of the family. Killer Whales are found in all oceans (Forney & Wade 2006). They range from polar ice edges to the tropics and from the shoreline to the open oceans. Their abundance is highest in temperate and polar waters (Forney & Wade 2006). Killer Whales are the dominant oceanic predator, with a varied diet, including cephalopods, bony fish, sharks, seabirds, marine turtles, and a variety of marine mammals (Jefferson et al. 1991; Dahlheim & Heyning 1999; Ford & Ellis 1999; Ford 2017).

Prey specialization of Killer Whale communities depends on the 'type' they belong to; currently there are three recognized types in the North Pacific: (i) resident, (ii) transient, and (iii) offshore Killer Whales (Ford 2017). Out of the three types, the transients are specialised marine mammal hunters with the occasional bird or cephalopod taken, whereas the other two types appear to feed almost exclusively on fish and invertebrates (Ford 2017), to date only the transient type has been recorded in Sri Lankan waters. Killer Whale predation on marine mammals has been documented from localities around the world (Jefferson et al. 1991). Long-term research in the northeastern Pacific has given us most of our understanding of mammal hunting by Killer Whales. Pinniped and dolphin predation by Killer Whales is reasonably well documented (see Dahlheim & White 2010, for example), but scientific reports of them hunting the great whales are less common (Jefferson et al. 1991; Reeves et al. 2006; Gemmell et al. 2015).

In Sri Lankan waters, there has been limited research on Killer Whales. These animals have been recorded almost all around the island, except in the northernmost waters and in Palk Bay (Illangakoon 2011; Martenstyn 2013). The highest observed concentrations are from the northeastern, south/southwestern, and northwestern coastal waters of Sri Lanka. These have come from both opportunistic observations and dedicated scientific surveys. Seasonal trends in sightings in some locations suggest fairly consistent occupancy (Ranil P. Nanayakkara 2010, 2011, 2015, 2016, 2017, 2018). Most sighting data so far, however, have been collected during whale-watching trips, Sri Lanka Coast Guard records and from fisher folk; none of these can be considered scientifically rigorous.

Transient Killer Whales have been documented attacking/killing Sperm Whales from many geographic locations around the world (Pitman et al. 2001). To date, there is only one published account of Killer Whales feeding in Sri Lankan waters. Gemmell et al. (2015) observed Killer Whales off southwestern Sri Lanka (Mirissa) preying on a mesoplodont beaked whale and Sperm Whales. The latter incident coincided with the egress of the migration (leaving) of Sperm Whales from the Gulf of Mannar. In the same paper, there is a report of a Blue Whale *Balaenoptera musculus* that bore scars from an attack by Killer Whales. Our paper presents, for the first time, field observations of Killer Whales preying upon superpods of Sperm Whales in the waters off the Kalpitiya Peninsula (eastern half of the Gulf of Mannar), northwestern Sri Lanka. The incidents took place on two separate occasions during the months of March and April 2017.

METHODS

Study Site

The Gulf of Mannar is an inlet of the Indian Ocean that lies between southeastern India and western/northwestern Sri Lanka (Image 1). Observations were made from a 19ft fibreglass boat fitted with a 40BHP outboard motor, dedicated to cetacean research during the months of March and April 2017; this period coincides with large mating aggregations of Sperm Whales in the eastern half of the Gulf of Mannar. The vessel departed Kandakuliya fishing harbour (6:45h), northwest, Sri Lanka, and headed offshore, approximately 15nm in a westerly direction in a zig-zag manner. The survey was dedicated to the study of large aggregations of Sperm Whales in the eastern Gulf of Mannar.

For each encounter, we attempted to photograph all the Killer Whales present using DSLR cameras with telephoto zoom lenses following established protocols for photo-identification studies of cetaceans (Ford 2017; Barrett-Lennard 2011). Individual animals were identified by a combination of features including notches of the dorsal fin and fin shape, as well as differences in the eye patch and saddle patch pigmentation and shape. Furthermore, for each encounter we used a GoPro Hero 6 underwater camera to record the underwater activities <https://vimeo.com/227727434>. Additionally, we used a SQ26-08 (Cetacean Research Technology) hydrophone to record the codas, clicks of the Sperm Whales and Killer Whales.

Observation 1: 18 March 2017

The research team followed and observed a pod of 100–200 Sperm Whales distributed in a radius of about

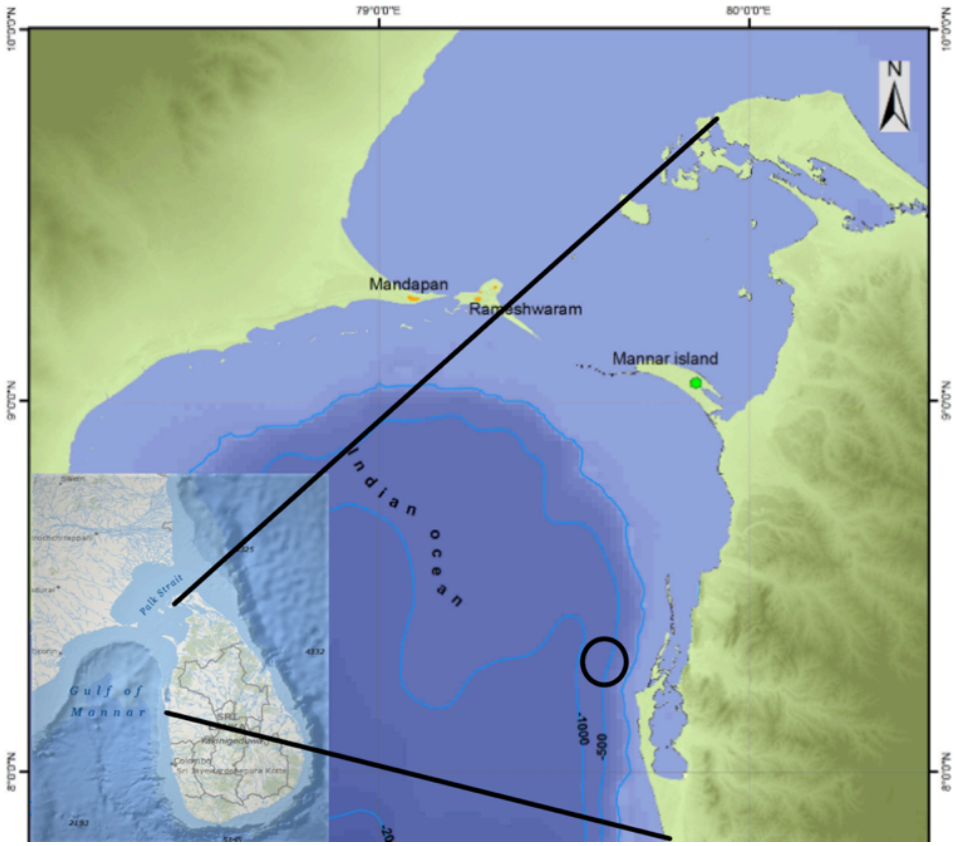

Image 1. The study area in the eastern half of the Gulf of Mannar.

1–3 km. The sea was calm (Beaufort 1) and the team could see to the horizon with blows of Sperm Whales scattered around the research vessel. At around 09.45h, a group of Sperm Whales broke away from the larger aggregation and started travelling in a north-easterly direction at great speed (almost porpoising); the breakaway group consisted of the largest members of the superpod (males), numbering approximately 15–20 individuals. We followed the breakaway group for approximately 1nautical mile. The other whales were far behind and widely spread out. Meanwhile, the breakaway group slowed down and joined up with a smaller group of Sperm Whales, consisting of approximately 10 individuals, which was a maternal pod that consisted of females, sub-adults, and calves. They reoriented in one great mass, packed as close together as possible (the depth of the water was 1,068m). We then noticed a commotion on the water surface just ahead of us; when the vessel approached, we saw the Sperm Whales huddled in a tight group on the surface, with the largest individuals occupying the outer margins of the group; they were arranged laterally, aligned together. They all appeared agitated. Body orientation changed haphazardly, respiration became frequent, there was rolling and tail slapping and the large males kept opening and shutting their jaws below the surface of the water.

Suddenly, a falcate dorsal fin surfaced approximately 5m from the research vessel. Several more falcate dorsal fins soon appeared followed by the unmistakable large triangular dorsal fin of an adult male Killer Whale. It was clear now that the breakaway group had responded to Sperm Whales who were in danger and had sent out sonar signals. They may have been delegated to deal with the situation perhaps even to act as a decoy to allow the Sperm Whales they'd left behind to get away.

The Killer Whales then surfaced again and charged directly into the Sperm Whale pod, with a female Killer Whale leading the attack, while the large male remained 10m away from the focus of attack. The Sperm Whales reacted by thrashing their tails and clustering close together on the surface, with the large mature males guarding the maternal pod by forming a defensive flotilla facing the attacking predators. The Killer Whales attack pod, which comprised approximately 12 individuals including one large male and two calves, was led by a female (Female 1) with a notch on its dorsal fin (Image 2). Female 1 repeatedly charged at the Sperm Whales along with five other Killer Whales (Image 3), whilst the remaining Killer Whales started circling the prey,

not letting them get away (Image 4). The Killer Whales circled around the Sperm Whales, diving in among them, apparently trying to separate the smaller juveniles and the calves. The water at the centre of the Sperm Whales turned white as they started tail slapping. Two Killer Whales then suddenly cut into the midst of the Sperm Whales and moved aggressively between individual Sperm Whales in an apparent attempt to break the pod apart (Image 5 & 6). At times, the attacking Killer Whales seemed to withdraw from the attack and busily jostle along the outer edges before resuming the assault. All the while the large male Killer Whale kept its distance, patrolling the perimeter. The Killer Whales displayed a lot of surface behaviour while attacking the Sperm Whales, e.g., tail slapping, breaching, whilst the members that were not involved in the attack, were seen rolling as well.

The attack lasted from 10.03h to 11.37h. In the turmoil, two Sperm Whales got separated from the pod and were immediately pursued by about six Killer Whales, which swam about 2m from their quarry. The two separated Sperm Whales managed to re-join the maternal pod when three large male Sperm Whales rushed to their rescue and came between them and the attackers. It was evident that the Sperm Whales were agitated; their faeces stained the water orange (Image 7). As the Killer Whales continued their attack, the Sperm Whales changed orientation, bringing their heads into the middle, tails outwards, creating a 'marguerite' formation (Nishiwaki 1962). This did not seem to slow the intensity of the attack, however, so the Sperm Whales reoriented their heads outward, while maintaining the circle formation, now apparently using our nearby boat as another line of defence. The large male Sperm Whales appeared to be trying to shield the females and young from the attacking Killer Whales, opening and closing their mouths to show their teeth. By now, blood was visible in the water. We observed the predators led by the same adult female (Female 1) take bites out of the male defenders, mostly from their bellies and tail stock, beneath the surface. Several Sperm Whales bore scars, from bite marks of the Killer Whales.

After approximately 90 minutes of sustained attack, the Killer Whales gradually started to peel off and we observed them at a distance; they were very active, tail slapping, breaching and, at times, spy hopping. We followed the Killer Whales. Abruptly, the Killer Whales came directly at our research vessel and started to circle it. Closer and closer they came, surrounding us the same way they had surrounded the Sperm Whales. Then one butted our boat; we clearly felt the impact.

Image 2. Female 1: the leader of the attacking pod of Killer Whales.

Image 3. Female 1 leading the attack on the Sperm Whales.

Image 4. Part of the Killer Whale pod circling the Sperm Whale pod.

Image 5. Killer Whales attacking the Sperm Whales.

As we recorded the incident on our GoPro camera, five Killer Whales charged directly at our vessel and dove suddenly just a couple of metres below our boat, passing <1m away from the hull. This behaviour was similar to the technique used by Killer Whales in the Antarctic to dislodge seals from ice floes (Pitman et al. 2001). After this, the Killer Whales broke off and moved away from us all the while displaying a lot of surface activity.

Observation 2: 3 April 2017

At 10.00h, a group of about 20 Killer Whales was observed, comprising all the members of the pod observed on 18 March 2017, as well as eight new members. This pod was made up of adult females, two large adult males, sub-adult males/females and two calves and they were sighted approximately 10nm from shore. The pod was travelling in a northerly direction with consistent surfacing intervals. At around 10.20h, the pod suddenly changed direction and started heading north-east with increasing speed. Our first sighting of Sperm Whales occurred at 10.45h, about 2nm from the 18 March location. It is customary for the superpods of Sperm Whales in the Gulf of Mannar to break up into smaller pods of 20–30 individuals around the end of March (RN unpublished). The Sperm Whales we encountered on 3 April comprised such a smaller grouping and consisted of females, young, and five large males.

Image 6. Remaining Killer Whales joining the attack.

The Killer Whales started to attack the Sperm Whales as soon as they encountered them at 10.52h (the depth of the water was 1,021m). Led by the same lead female (Female 1) (Image 3) we observed during the March 18 encounter, the Killer Whales commenced by nudging and ramming the adult females, in an attempt to get at the calves, while swimming abreast of them. The Sperm Whales responded by swimming rapidly away, with their bodies almost leaving the water, with the predators in close pursuit. Except for the two male Killer Whales

Image 7. Sperm Whales defecating, possibly to distract the Killer Whales.

that stayed about 20m away, all the other Killer Whales repeatedly charged the Sperm Whale pod from left and right. The Sperm Whales were swimming abreast with the calves in the middle. At 11.09h we observed at least five additional Killer Whales appearing to join the attack. The Sperm Whales stopped swimming, and seemed agitated, with considerable surface activity and splashing. They were defecating as was evident from the orange-stained water. The large Sperm Whale males, turned on the Killer Whales, and began to chase them away, the Killer Whale pod started to swim away at great speed. The whole incident lasted two hours.

Curiously, the attack seemed to be confined to harassment because we never observed the Killer Whales lunging to bite chunks from their quarry as we had on 18 March. No signs of physical injury were noted in the Sperm Whales after the attack, nor was blood evident. Perhaps the Killer Whales may have been trying to determine whether there were any particularly vulnerable individual Sperm Whales to take advantage of or perhaps the encounter may have constituted practice or play for the juvenile Killer Whales, which were present in the pod.

DISCUSSION

Sperm Whales are found in Sri Lankan waters year-round in small pods that mostly number 2–15 individuals (Illangakoon 2002). Between January and April, however, they start to occur in larger pods to ultimately form superpods numbering 100–450 individuals (https://uk.whales.org/2015/04/01/an-armada-of-whales-wdc-in-sri-lanka/ & https://www.theguardian.com/environment/gallery/2017/mar/29/sex-death-sperm-whales-orcas-indian-ocean-in-pictures). At that time of the year large males are seen in Sri Lankan waters; these males, denizens of temperate and polar waters, migrate to tropical waters to mate. Superpods congregate in the eastern half of Gulf of Mannar, northwestern Sri Lanka. Our observations confirm Gemmell et al. (2015)'s finding that Killer Whales are predators of Sperm Whales in Sri Lankan waters. For the first time, we show that Killer Whales enter Sri Lankan waters and prey on large aggregations of Sperm Whales.

It was clear that the adult Killer Whales we saw during both incidents were experienced hunters of Sperm Whales. The attacks were well-coordinated and efficient. The copious defecation by the Sperm Whales may well have been occasioned by hyperarousal (Jansen et al. 1995) because we observed that particular

response during both incidents. It was interesting to see the different roles played by adult female and male Killer Whales (see Pitman et al. 2001). Like in a pride of lions (Rudnai 1974) the adult females led the hunt. Was the hunting technique a series of lunges at the much-bigger and potentially dangerous prey, designed to minimize risk for the attacker? No Sperm Whale was observed killed during the two incidents, as far as we could tell. Yet we did see chunks being bitten off the quarry during the 18 March attack and the immediate waters were stained with blood.

The role of the large male in hunting parties of Killer Whales is unclear. The Heinrichs video (2013) of a hunt by Killer Whales on Sperm Whales off southwestern Sri Lanka shows an adult male Killer Whale in the thick of a melee, as attackers appear to try to drown a juvenile Sperm Whale. The male is seen actively participating in the attack, even though a female is leading the pack and inflicting most of the injuries. Interestingly, none of the individuals recorded from the attacks in north-west of the country match to the ones in the video nor from the northern Indian Ocean Killer Whale catalogue (Northern Indian Ocean Killer Whale Alliance (NIOKWA)). None of the adult Killer Whale males we saw actually attacked Sperm Whales; their role appeared to be to intimidate, frighten and corral breakaway quarry. Other accounts of Killer Whale attacks show adult males adopting aggressive, peripheral or passive roles (Whitehead & Glass 1985; Arnbom et al. 1987; Silber et al. 1990). Vidal & Pechter (1989) asserted that predation on large whales by Killer Whales is successful when adult males are involved in the attack, and that attacks on large whales involving only females and subadults are largely unsuccessful. Estes et al. (2006), mentioned that some specialization of roles have been noted in Killer Whales. Adult females appear to be the most active and effective individuals during an actual killing phase of an attack on large whales. An adult male participates in the successful attack on large whales only to finish off a whale that has been critically wounded by the females and immature Killer Whales; however, we did not see a pod of Killer Whales that lacked an adult male, so we are unable to test these hypotheses. Budylenko (1981) observed large male Killer Whales leading attacks; prey weakened by the males were then 'handed over' to females and subadults for final despatch. Our observations do not support this technique being used in Sri Lankan waters. The females and subadults did a very effective job by themselves with no adult male intervention. Cultural differences among different communities of transient Killer Whales may account for the utility of various hunting strategies in different geographical locations (see Whitehead & Glass 1985).

The defensive marguerite formation appeared initially to be dangerous for the Sperm Whales and a hopeless gambit, but is perhaps an attempt by Sperm Whales to present to the predator bodies that they could withstand being injured, yet survive, while shielding the vulnerable young at the centre, with a lot of tail slapping. Perhaps sufficient meat is bitten off during an attack to satiate the Killer Whales, which then leave the young Sperm Whales alone. If this is true, it would be a clear and striking demonstration of altruism among these sentient creatures. The marguerite formation also spreads risk more or less evenly amongst the defenders. During the 18 March attack, evidently the presentation of bodies failed to satisfy the hunger of the large party of Killer Whales, hence the abandonment of the passive technique and the reversion to the full-on threatening forward-facing posture in a line, facing the same direction (flotilla formation). It must be noted that, despite the vulnerability of Sperm Whales as they keep their bodies oriented inward while in marguerite formation, they are not entirely defenceless; the tail stock can deliver a heavy blow. Pitman et al. (2001) asserted that the marguerite formation is used when the Sperm Whale pod is small (10–15 individuals) whereas larger aggregations generally adopt the flotilla strategy to thwart predator attack. We saw both formations being used and the use of one or the other appeared to be determined by the effectiveness of resisting the attackers.

Diving is also used as a defensive strategy by Sperm Whales, and because they can dive at least 2km below the surface, it can be hypothesised that it can be an effective defence against predators that are unable to reach such depths (Rice 1989). Berzin (1972) identified three separate fright reactions of Sperm Whales — diving, aggregating at the surface and flight — but did not identify the circumstances that gave rise to each. Our observations are similar to those of Pitman et al. (2001), and show that a specific reaction is context-dependent. For example, small Sperm Whale pods will dive if a vessel approaches, but large pods will remain at the surface until the perceived threat is imminent. An attack by predators, such as Killer Whales, will on the other hand, elicit a reaction such as a marguerite formation or frontal confrontation (flotilla formation) with jaws being open and shut threateningly (Ranil P. Nanayakkara 2008, 2012, 2013, 2014, 2015). Flight is also possible, but we did not observe diving as a defensive manoeuvre when under predator attack. We

did, however, observe several individual Sperm Whales, approximately 5–10 m below the surface. The inability of the vulnerable young to dive deeper and faster than attacking Killer Whales may discourage defending Sperm Whales from taking that approach.

We observed a pod of about 10–15 adult male Sperm Whales rushing to the aid of a maternal pod during the March 18 incident. The question arises as to how the male group was gathered and how the individuals were coordinated in responding to the danger. Did the maternal pod signal danger or did the males sense peril and respond accordingly? Caldwell et al. (1966) and Arnbom et al. (1987) state that Sperm Whales can sound long-distance alarm/summons calls when threatened. Of course, the gathering of superpods will shorten alarm response times considerably.

Mammal-hunting Killer Whales elsewhere occur mostly in small-sized pods, whereas piscivorous and generalist feeders occur in larger-sized pods of up to 30 individuals (Ford 2017; Dahlheim & White 2010). Baird & Dill (1996) suggested that the optimal group size for northern Pacific transient mammal-hunting Killer Whales is three individuals and suggest that larger groups would suffer the cost of increased probability of detection by prey and therefore reduced hunting success, as the northern Pacific transients feed mainly on seals. Other marine mammal-eating Killer Whales have also been observed around the world in small pods. Hoelzel (1991) reported an average of two individuals for the Patagonian population, while Beck et al. (2012) provided the figure of five for Killer Whales in Scottish waters. Antarctic populations of Killer Whales take the opposite tack. The mammal-feeding Type A and Type B populations gather in large pods —up to 38 individuals for the former and 24 for the latter (Pitman & Ensor 2003). These authors report a pod of 21 individuals of Type A Killer Whales attacking an Antarctic Minke Whale *Balaenoptera bonaerensis*. Visser et al. (2010) reported eight Killer Whales in New Zealand attacking a pod of false Killer Whales *Pseudorca crassidens*. Transient Killer Whales that attack and kill great whales generally operate in large pods, as the large group size would probably be much more effective. As such, the Sperm Whale hunters found in Sri Lankan waters operate in a similar manner, in large pods of 10–20 individuals.

From our limited observations it appears that the hunting packs of Killer Whales off Sri Lanka's coast follow the pattern of their Antarctic counterparts. But again, the high numbers we observed may simply reflect a gathering that comes from the temporary bounty and opportunity offered by the Sperm Whale superpods. Hunting packs of Killer Whales at other times of year may be far smaller. Indeed, Gemmell at al. (2015) did not report a massed attack when they observed the mesoplodont whale being killed. Another interesting observation is that while mammal-hunting Killer Whales are generally silent in other localities, while pursuing Sperm Whale superpods off northwestern Sri Lanka they were very vocal; our hydrophone and recorder picked up loquacious chatter from the predators, even as they attacked their huge prey. This sort of vocalization has been recorded from Monterey Bay, California, where a pod of Killer Whales has been recorded vocalizing frequently while hunting down a female Grey Whale *Eschrichtius robustus* (Goley & Straley 1994). Deecke et al. 2005 stated that being silent may help in being stealthy and in locating prey, and that active sound processing presumably becomes allowable, and might be functionally important, once the Killer Whales have made contact with the prey. As with the encounter of 18 March 2017, Deecke et al. (2005) also mentioned that the sound produced by the hunting pack of Killer Whales might attract other distant foraging Killer Whales to the site, to take advantage of the kill, if a kill should happen. They went on to say that the possibility is unlikely. Conversely, from our April encounter, we did see a smaller pod suddenly appearing on the scene and taking part in the attack. We photographed the dorsal fins of the Killer Whales we observed and are in the process of building up a catalogue, although it is likely that not all the individuals were photographed (Appendix A).

While encounters with Killer Whales typically have been considered rare and unpredictable off Sri Lanka, the area offshore from the northwest to the northeast appears to support abundant Killer Whales throughout the year (Ranil P. Nanayakkara 2009, 2010, 2011–2017.) and provides an opportunity to study the dynamics of this little-known population. Interestingly, before 2008, there was only one record of a Killer Whale and that was an individual that landed ashore as bycatch (Ilangakoon et al. 1992). Since then there have been many sightings of Killer Whales off the south and southeastern waters of the country (RN pers. comm. with whale watching operators). After the end of the 30-year war in Sri Lanka, researchers have had access to the northwestern and northeastern waters off Sri Lanka, resulting in an increase in research activity. Undoubtedly, Killer Whales have always been present, but researchers have been absent, hence the contemporary rise in observations. Along with the considerable increase in Killer Whale sightings there has been a related increase in observations of their predation on large whales, such as the present paper

and Gemmell et al. (2015). Furthermore, anecdotal evidence from the fisher community suggests that Killer Whales have been following Sperm Whales superpods for many years in the waters off northwestern Sri Lanka. Research in Sri Lanka into predator/prey relationships of Killer Whales in the littoral waters off Sri Lanka is still in its infancy and warrants additional study.

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Appendix 1. ID catalogue of Killer Whales encountered in both attacks

NIO-054

NIO-055

NIO-056

NIO-057

NIO-058

NIO-059

NIO-060

NIO-061

Journal of Threatened Taxa

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PLATINUM OPEN ACCESS

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

September 2020 | Vol. 12 | No. 13 | Pages: 16715–16926
Date of Publication: 26 September 2020 (Online & Print)
DOI: 10.11609/jott.2020.12.13.16715-16926

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