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SPERM WHALES REACT TO AN ATTACK BY KILLER WHALES

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Killer whales or orcas, *Orcinus orca*, are known to prey occasionally upon members of larger whale species, including sperm whales, *Physeter macrocephalus* (Hoyt, 1981; Martinez and Klinghamer, 1970). Despite several references in the Russian literature, Berzin (1972) considered the reports to be too rare for killer whales to be "branded serious enemies of the sperm whale." Schevchenko (1975) stated that, in the Antarctic, 65.3% of sperm whale carcasses examined showed signs of killer whale tooth marks, although he did not say if or how he differentiated between marks of killer whale teeth and those made by other sperm whales. Yukhov et al. (1975) found remains of sperm whales in killer whale stomachs in the subtropical and temperate waters of the southern hemisphere, and mention a movie-film showing an attack by a group of killer whales on a school of female sperm whales and their calves. However no description was given. We report here observations made during an encounter between a group of sperm whales and a group of killer whales off the Galapagos Islands, and the subsequent flight of the sperm whales from the area of the attack.

During the early part of 1985, we used the 10-m sloop *Elendil* to follow groups of sperm whales west of the island of Isabela (1°00'S, 91°00'W) in the Galapagos Islands, Ecuador. The methodology employed was based on that described by Whitehead and Gordon (in press). The groups of whales were tracked acoustically using a directional hydrophone at night, and acoustically and visually during the daytime. Sperm whales could be heard at about 8 km using our acoustic equipment. Whenever possible, photographs of dorsal fins and flukes were taken to identify individuals from distinctive marks and scars. At 5-min intervals we recorded the compositions, relative positions, speeds (estimated by comparison with nautical speedometer on boat), headings, and behavior of each visible subgroup. A subgroup constituted a set of whales swimming in a coordinated manner, each less than 100 m from its nearest neighbor within the subgroup. Except in exceptional circumstances, once each hour on the hour an acoustic recording was made through an omnidirectional hydrophone lasting 5 min. The steady click (at about 1 click per second) of the sperm whale is an indicator that the sperm whale is feeding at depth (Whitehead and Gordon, in press). In the following, "many clicks" indicates that we were hearing the output of roughly 10 or more sperm whales. Depth sounder traces of diving whales were obtained when possible. Positions were from a satellite navigator.

The encounter between the sperm whales and the killer whales occurred between 0945 and 1230 h local time (GMT - 6 h) on 18 April 1985. The observations were divided into five periods: 1. The day before the encounter; 2. The night before the encounter; 3. The morning just before the encounter; 4. The encounter; 5. After the encounter. Analysis of photographs showing individually identifying marks indicated the same group of animals to be present throughout these periods. The position of the sperm whales, maximum number of whales visible at any time, the average subgroup size, the maximum subgroup size, acoustic output, and the whales' speed and heading are summarized for each period in Table 1. The behavior of the sperm whales during each period is described below.

Period 1. The day before the encounter: 0510–1834 h, 17 April.—A group of about 40 sperm whales, including one large adult male and at least one small calf, was being tracked. The whales were sighted in small subgroups (Table 1). The subgroups, each a few hundred metres from one another, formed a line more than 2,000 m long. This line was oriented approximately perpendicular to the direction of travel, about 225° (all bearings in degrees from True North). They regularly fluked-up (lifted their flukes into the air) as a prelude to diving. Ten depth sounder traces of diving sperm whales showed that the whales were diving to about 400 m, where they were presumably feeding.

Period 2. The night before the encounter: 1834 h, 17 April–0632 h, 18 April.—The whales travelled on a heading of approximately 200°, clicking steadily.

Period 3. The morning just before the encounter: 0632–0945 h, 18 April.—The behavior of the whales was similar to that on 17 April. The whales were regularly fluking-up, and three depth sounder traces showed

TABLE 1.—Summary of movements, minimum group size (maximum number of whales visible at any time), subgroup sizes (from records of all whales visible made every 5 min), and acoustic output of sperm whale group before, during, and after the encounter with the orcas.

Period	1 Day before	2 Night before	3 Just before	4 Encounter	5 After
Date	17 April	17–18 April	18 April	18 April	18 April
Time	0510–1834 h	1834–0632 h	0632–0945 h	0945–1230 h	1230–1808 h
Latitude	0°02.6'N	0°23.5'S	0°49.1'S	0°56.7'S	0°51.7'S
Longitude	92°47.4'W	92°53.6'W	93°02.9'W	93°07.0'W	92°43.8'W
Time of fix	0510 h	1834 h	0632 h	1025 h	1810 h
Group size	≥40	—	≥15	≥31	≥34
Subgroup size:					
Mean	1.9	—	1.5	16.2	18.2
Maximum	7	—	8	31	34
Sperm clicks	many	many	many*	very many	none**
Speed km/h	3.0–4.0	4.0***	2.7–4.0	1.8	9.0–11.0
Heading	225°	200°***	200°	various	055°

* = Sperm whales silent at 0940 h.

** = Distinctive clicks of large male sperm whale heard at 1700 h.

*** = Speed and heading of boat tracking whales at night.

them to be diving to about 420 m. Between 0920–0935 h the subgroups, each of 1–3 whales, were arranged in a roughly east-west rank at least 3,500 m long with a few hundred metres between subgroups. The whales were heading south. At 0935 h the sperm whales suddenly coalesced into two subgroups, one about 2,000 m from the boat bearing 315° containing at least three animals, and one about 3,000 m from the boat bearing 060° containing at least six animals. Because of their ranges from the boat, subgroup sizes were probably underestimated. Killer whales were seen within a few hundred metres of the latter subgroup, and approaching it at greater than 9 km/h. The subgroup bearing 315° was not sighted after 0950 h. The hydrophones were monitored at 0940 h but no sounds of either sperm whales or killer whales were heard.

Period 4. The encounter: 0945–1230 h, 18 April.—Between 0945 and 1020 h, as we approached the subgroup with the killer whales surrounding it, we determined that there were at least 20 sperm whales present and at least 10 killer whales. At 1005 h, when 1,800 m from the whales, we monitored the hydrophones and heard sperm whale clicks. We came within 200 m of the whales at 1020 h. Continuous tape recordings of vocalizations of both whale species through a hydrophone, together with a verbal commentary on the visually observable action, were made from 1024–1102 h, 1105–1151 h, and 1213–1235 h.

The subgroup of sperm whales was tightly packed, with animals less than 3 m from their nearest neighbors, and probably often touching. They generally all headed the same direction, facing towards the nearest subgroup of killer whales. The sperm whale subgroup usually formed a compact circular or oval mass in the horizontal plane about 120 m in diameter, although on two occasions, when the nearest killer whales were more than 200 m away, the sperm whales spread out into two ranks, one a few metres behind the other. One sperm whale calf, probably less than 1 year old, was seen, always in the middle of the subgroup. One large mature male sperm whale was present, usually occupying a position on the flank or at the rear of the subgroup. The subgroup moved slowly, generally at less than 2 km/h, and there was no constant dominant heading. At 1110 h, a subgroup of at least six sperm whales separated from the principal subgroup. The “breakaway” subgroup was last seen at 1115 h, 700 m away heading east. The small calf was not sighted after this time.

Approximately 15–25 killer whales were present, including at least two large males, one smaller male, and two juveniles, which were identifiable from their smaller size. They were spread out in subgroups of two to seven individuals, usually moving at between 2 and 15 km/h, but occasionally reaching 20 km/h. When greater than 60 m from the sperm whales, killer whales would sometimes lobe (thrash their flukes onto the water surface), fluke-up, or breach (leap from the water).

The killer whales seemed to make fairly discrete “attacks” on the main subgroup of sperm whales. During these “attacks” the killer whales were observed to approach the sperm whales actively at close quarters. Approximately six “attacks,” at 1031, 1037, 1049, 1112, 1121, and 1125 h, were noted in the 106 min of our acoustic recordings, made during the 165-min encounter. In each “attack,” between two and seven killer whales, often including juveniles but rarely adult males, turned and, skirting the sperm whale subgroup, approached them from the flank or rear at 9–15 km/h. The killer whales dived when 20–40 m from the

sperm whales, and generally remained under the surface for the remainder of the "attack," approximately 3 min. At 1210 h (probably during an "attack," but the acoustic recording was not operating at this time) a depth sounder trace showed whales (sperm whales and/or killer whales) at depths of 60–100 m. No other depth sounder traces of whales were obtained during the encounter. After an "attack" the killer whales appeared at the surface 60–150 m away. Although sounds such as "squeals," "whines," and "screams" were heard from the killer whales throughout the encounter, these were not significantly more numerous during "attacks."

As killer whales "attacked," the sperm whales turned, attempting to keep the killer whales directly ahead. Some of the sperm whales arched their tail-stocks to hang vertically with their flukes at the surface; others fluked-up. The sperm whales appeared to be attempting to face the killer whales beneath the surface. Sperm whales were seen to spyhop (raise their heads slowly out of the water), sidefluke (move their flukes through the water at the surface horizontally, while oriented vertically), or roll about a longitudinal axis. Several lobtails were seen from sperm whales when killer whales were "attacking." At 1114 h the large male sperm whale, when on the edge of the subgroup, was seen to roll, presenting his dorsal surface to the killer whales, which were approximately 40 m away. During the "attacks" abnormally intense clicking with high repetition rates was heard from the sperm whales.

At 1140 h, bloody cuts were first observed on at least three sperm whales. These cuts were approximately 0.1–0.75 m in length. Some consisted of single lines, others of three to five parallel lines, situated on the cases (foreheads) of the sperm whales at least 1 m behind the blowhole. No cuts were seen on the killer whales.

At 1223 h the sperm whale subgroup started turning anticlockwise, so that they were making a complete 360° change in heading every 2–3 min. Six spyhops and six sideflukes were seen from the sperm whales between 1223 h and 1230 h.

Period 5. After the encounter: 1230–1808 h, 18 April.—At 1231 h, with the killer whales 500 m away to the west, the sperm whales stopped circling and moved northeastwards at 9–11 km/h. The killer whales were last seen at 1245 h, 1,500 m to the west. The sperm whales swam as a tight subgroup maintaining constant speed and direction for the rest of the afternoon. Periods at the surface of 7–12 min were followed by fluke-ups by up to 30 whales within 1–2 min. Between surfacings, the whales were out of sight for intervals of 10–21 min. The whales generally showed close coordination in their surfacings and dives. The only exception to this was the large male who at 1620 h was lagging 500 m behind the principal subgroup, and fluked-up 8 min before them. Between 1715 and 1740 h he was together with the other animals, but fluked-up 2 min earlier and then 2 min later, than they did. During this flight we dispensed with the 5-min recordings each hour, but monitored the hydrophones at 1405, 1630, 1700, 1750, and 1800 h. No sperm whale clicks were heard, except at 1700 h, when the distinctively slow clicks of the large male (Whitehead and Gordon, in press) were audible. The sperm whales were last seen at 1808 h.

We were unable to follow the sperm whales after 1808 h, acoustically or visually, due to a lack of clicks and light respectively. However we maintained the course and speed of the sperm whales (9 km/h at 055°) during the night, and, in the morning, at 0900 h on 19 April, encountered a group of sperm whales, including at least one large male, in position 0°44.7'S, 91°52.6'W. Analysis of photographs taken of this group during the morning of 19 April showed the large male to be the same animal that was present during the encounter with the killer whales, and on the day preceding it, but that he was now associated with a different group of females.

The methods of attack employed by the killer whales during the encounter were largely hidden from us, but the sperm whales' defensive measures were more apparent. Both the sperm whales and the killer whales seemed to consider the front of the sperm whales to be their least vulnerable regions: the sperm whales headed towards the killer whales, which in turn attempted to attack from the flank or rear. This is in contrast to the defensive measures of humpback whales, *Megaptera novaeangliae*, which rolled belly towards attacking killer whales (Whitehead and Glass, 1985). For humpback whales, which do not have teeth, the flukes are probably the major defensive instrument. However like the sperm whales described here, the humpbacks huddled together when attacked, although not in such great numbers or as closely as the highly social sperm whales. The sudden coalescing of the sperm whale subgroups just before the attack was unparalleled in our experience of tracking sperm whales. Sperm whales sometimes gather into large subgroups at the surface, but the process usually happens slowly, with mean subgroup size increasing gradually over a period of several hours. As with the humpbacks described by Whitehead and Glass (1985), the sperm whales made no attempt to flee from the faster killer whales until the killer whales had left them. During about 8 months spent tracking sperm whales off Sri Lanka, the West Indies, and the Galapagos, we never observed behavior equivalent to the long, silent, fast, and well-coordinated flight of the sperm whales after the encounter.

The silence of the sperm whales immediately before the encounter and during the flight can be interpreted as an adaptation to not revealing their position acoustically to the killer whales. The intense bursts of clicks heard when the killer whales were circling the sperms, and especially when the killer whales "attacked," possibly represent the sperm whales attempting to assess the positions, orientations, and behavior of the killer whales by echolocation.

The behavior of the large male during and after the encounter indicated that he was not a fully integrated member of the group. He took an external position during the encounter, lost coordination and broke silence during the flight, and had left the group by the following morning.

We saw no indication that any of the sperm whales was injured seriously by the killer whales, and the majority of the killer whales never "attacked" together. Their actions may have been directed towards determining whether there were any particularly vulnerable individual sperm whales, which might then be assaulted more vigorously. Alternatively, or perhaps additionally, the encounter may have constituted practice or play for the juvenile killer whales, which took a disproportionately large part in the action. The protection afforded to the sperm whale calf may have been especially important. Best et al. (1984) presented evidence that sperm whale calves may be harmed by killer whales. The presence of the calf may be one reason why the sperm whales did not flee by diving to depths at which the killer whales could not follow. Sperm whale calves probably cannot dive to the depths that the adults attain (Best, 1979).

Caldwell et al. (1966) suggested that sperm whales often defecate in situations of stress. During our research off the Galapagos we usually observed sperm whale defecations several times every day. Although we were well placed to observe feces during the encounter with the killer whales, none was seen. However, some facets of the sperm whales' behavior that we observed are echoed in Caldwell et al.'s (1966) summary of observations made by the whalers during whaling. Among other reactions, they describe sperm whales crowding together when approached by whalers, as well as "rapid swimming from the danger area."

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