

- An annotated and illustrated catalogue of shark species known to date. Part 1. Hexanchiformes to Lamniformes. *FAO Fishery Synopsis* 125:1–249.
- DUGUY, R. 1988. Les phoques des côtes de France. *Annales de la Société de Sciences Naturelles de la Charente-Maritime*, supplément:1–52.
- GARRIGUE, C., AND G. ROSS. 1996. A record of the subantarctic fur seal, *Arctocephalus tropicalis*, from Madagascar, Indian Ocean. *Marine Mammal Science* 12:624–626.
- HELLE, E. 1992. *Phoca hispida*—Ringelrobbe. Pages 138–161 in R. Duguay and D. Robineau, eds. *Handbuch der Säugetiere Europas*, Band 6: Meeressäuger, Teil II: Robben—Pinnipedia. Aula Verlag, Wiesbaden.
- KINGSLEY, M. C. S. 1990. Status of the ringed seal, *Phoca hispida*, in Canada. *The Canadian Field-Naturalist* 104:138–145.
- MACALPINE, D. F., AND R. H. WALKER. 1990. Extralimital records of the harp seal, *Phoca groenlandica*, from the western North Atlantic: A review. *Marine Mammal Science* 6:248–252.
- MCEACHRAN, J. D., AND S. BRANSTETTER. 1984. Squalidae. Pages 128–147 in P. J. P. Whitehead, M.-L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese, eds. *Fishes of the North-East Atlantic and the Mediterranean*. Vol 1. UNESCO, Paris.
- POPOV, L. A. 1982. Status of the main ice-living seals inhabiting inland waters and coastal marine areas of the USSR. Pages 361–365 in *Mammals in the seas*, 4, *FAO Fisheries Series* 5, FAO, Rome.
- RIEDMAN, M. 1990. *The pinnipeds: Seals, sea lion and walruses*. University of California Press, Berkeley, CA.
- SERGEANT, D. E. 1983. Recent extralimital records of hooded seals in European Seas. *Hooded Seal Workshop*, Bergen, Paper HSW-83. Doc. 3.
- TCHERNIA, P. 1978. *Océanographie régionale: Description physique des océans et des mers*. Ecole Nationale Supérieure des Techniques Avancées, Paris.
- VINCENT RIDOUX, Laboratoire d'Etudes des Mammifères Marins, Océanopolis, BP 411, 29275 Brest Cédex, France; e-mail: vincent.ridoux@oceanopolis.galeode.fr; AILSA J. HALL, Sea Mammal Research Unit, Gatty Marine Laboratory, University of Saint Andrews, Saint Andrews, Fife KY 16 8 LB, United Kingdom; GUNNAR STEINGRIMSSON AND GUDJON OLAFSSON, Stora Holt, 570 Fljot, Iceland. Received 21 August 1997. Accepted 13 November 1997.

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ATTACKS ON SEA OTTERS BY KILLER WHALES

Few references to attacks on sea otters, *Enhydra lutris*, by killer whales, *Orcinus orca*, exist in the literature. In an extensive review of predatory and non-predatory interactions between killer whales and other marine mammals, Jefferson *et al.* (1991) cited only one reference (Nikolaev 1965) in which killer whales aggressively pursued sea otters. In another review of attacks on marine mammals by killer whales in the North Pacific Ocean, Matkin and Saulitis (1994) listed three other interactions between killer whales and sea otters, but with the exception of one personal communication, the references (Barabash-

Table 1. Nine attacks on sea otters by killer whales in Alaska.

No.	Date	Location	Observers
1	18 July 1992	Drier Bay, Knight Is., Prince William Sound (60°12'N, 147°47'W)	D. Marks S. Anderson
2	10 June 1993	Clam Bay, Amchitka Is., Aleutian Islands (51°23'N, 179°08'E)	B. Hatfield
3	10 June 1993	Approximately 300 m from above location	B. Hatfield
4	17 June 1993	Herring Bay, Knight Is., Prince William Sound (60°18'N, 147°47'W)	T. Smallwood P. McManus
5	17 June 1993	Approximately 1 km from above location	Don and Doug Weeks
6	20 December 1994	Constantine Harbor, Amchitka Is., Aleutian Islands (51°23'N, 179°17'E)	T. Tinker
7	20 December 1994	Approximately 200 m from above location	T. Tinker
8	3 November 1995	Pit Rock, Adak Is., Aleutian Islands (51°52'N, 176°35'W)	K. Nolan J. Pierce J. Watt J. Stewart
9	29 May 1996	Finger Bay, Adak Is., Aleutian Isl. (51°50'N, 176°36'W)	T. Tinker J. Stewart R. Boyle

Nikiforov 1938, Tomilin 1957) alluded only to presumed attacks. Kenyon (1969) described only non-aggressive interactions between the two species. No descriptions of killer whale attacks on sea otters have been published. In this note we describe nine observations made between 1992 and 1996 of killer whales attacking sea otters in Prince William Sound and in the Aleutian Islands, Alaska.

In July 1992, an interaction between sea otters and three killer whales was observed in Prince William Sound (Table 1). The observers were on a stationary or slow-moving 17-m vessel between 30 and 50 m from the killer whales at the time of the attack and were using 10× and 7× binoculars and a camera with a 300-mm lens under calm, overcast conditions. Three killer whales of unknown sex were observed feeding on salmon for about 90 min. Two of the whales swam into a small cove in which there were about 40 resting sea otters. Most of the otters were hauled out on intertidal rocks. The whales rushed these rocks several times, causing water to surge onto the rocks where the otters were located. One killer whale headed directly towards a sea otter, originally resting in the water, but now alert and periscoping (head and upper

torso extended out of the water vertically). When the killer whale was <10 m from the otter, the otter dove and was immediately followed by the diving killer whale. Within several seconds the sea otter was observed floating lifeless on the surface. One of the whales, probably the same one that dived after the otter, bit and held on to the otter while flipping it around. This whale then swam out of the small cove, pushing the apparently dead sea otter in front of it for approximately 30 m, then dove with the otter for several seconds before resurfacing without the otter. The sea otter carcass was not seen again. The three killer whales regrouped and departed the area. The entire period during which the whales were in the cove lasted approximately 20 min.

The second and third interactions were observed in June 1993 at Amchitka Island. The observations were made from shore with a 50/80× spotting scope under calm, overcast conditions at distances of 200–300 m. The killer whale group included one adult male and three smaller whales of undetermined sex. At about 1400, the attention of the observer was drawn to a large splash in a clearing between beds of the surface canopy-forming kelp, *Alaria fistulosa*, caused by the movements of the adult male killer whale. A single sea otter was immediately observed swimming at the surface away from the center of the splash area towards a kelp bed. This otter was then observed continuously for approximately 10 min, during which time it acted aberrantly; it swam back and forth at the surface within the kelp canopy and flailed one or both hindflippers in the air, occasionally striking the water with its flippers. There was no pursuit by the killer whale. This otter was seen again approximately 20 min after it was first observed and it continued to behave as previously described. The observer has spent thousands of hours watching sea otters and has not previously observed this behavior. The sea otter's rear appendage(s) was likely injured by the killer whale.

The third killer whale-sea otter interaction observed began at about 1430, occurred approximately 300 m from the location described above, and involved a member from the same group of whales. One of the smaller whales cruised slowly through kelp with its dorsal fin hooking and dragging the surface canopy plants. It raised its eyes above the water line several times before heading directly towards a single resting sea otter, with its dorsal fin still exposed. The otter watched the approaching whale until it was within about 7 m, then dove. The whale continued swimming at the surface to where the otter had been resting and raised its head once again. The sea otter surfaced after a short dive of approximately 10 sec. The whale, after apparently seeing the otter, accelerated rapidly towards it. This sequence was repeated two more times, each time with the otter diving and swimming in a direction away from the killer whale, until the whale at one point was at the surface within 3–4 m of the sea otter. The otter then porpoised and dove back towards the whale and passed it within 1–2 m. This sea otter behavior closely resembled the behavior seen many times in sea otters being chased for capture by motorized skiff (personal observations). The killer whale then made a rapid >160° turn with considerable splashing and surged towards the otter. The otter again

doubled back and the whale once again turned abruptly to chase the sea otter. The chase ended when the otter swam over a shallow rocky area.

Later in June 1993, three killer whales—an adult male, an adult female, and a smaller whale, probably a calf—interacted with sea otters in two separate incidents in Prince William Sound. The female and smaller whale separated from the adult male and approached a resting sea otter. The female whale circled, then attacked, bit, and released the sea otter by tossing it a short distance in the air. It then bit and released the otter at least two more times before briefly submerging with the otter. The otter was not seen again. The adult male killer whale did not participate in the attack. The smaller whale, although it stayed close to the female, did not attack the otter. The observers, who witnessed the attack from kayaks approximately 30 m away, assumed the otter was killed and eaten. The observers then followed the killer whale group for about 1 h in their kayaks to the location where another interaction (the fifth described here) occurred, approximately 1 km from the previous one. This interaction was also observed by two biologists conducting bird surveys. These observers were initially in a small inflatable boat, but then moved to the rocky beach. The attack occurred at a distance of approximately 20 m. The female and smaller killer whale approached a female sea otter with a pup to within 5–10 m before all animals dove. The surface of the water churned for about 30 sec before the female otter surfaced at the edge of the disturbed water and began looking around in all directions. Water depth was approximately 5 m. All whales departed after a total time of about 5 min in the area. The adult female otter was seen in the area after the whales' departure and appeared to be searching for the pup. A dead pup missing a rear limb was found on the beach directly inshore from the attack site two weeks later. Due to the lapse of time, it is uncertain whether this was the same otter pup.

The sixth and seventh interactions occurred at Amchitka Island in December 1994. At about 1000 the observer noticed two adult female killer whales and a calf near the center of the harbor. The whales moved farther into the bay during the next five minutes to where a scattered group of about 15–20 sea otters had been foraging about 300 m from shore. The killer whales began to circle a single otter, approaching to within 10 m with their dorsal fins breaking the surface. One of the adult female whales then partially breached (with its head and 1/3 of its body out of the water) over the sea otter and came down directly on top of it, making contact. During the next three to five minutes, the sea otter was not seen during careful scanning. A few minutes later a second otter was circled and partially breached upon, almost identically as in the first incident, except that this time the otter dove before contact was made. This otter was also not seen again. The calf was observed circling the sea otters with the adults, but was not seen making direct contact with a sea otter. The killer whales then surfaced near several other sea otters, which were visibly agitated and alternately dove and scanned the area while periscoping. The killer whales departed the harbor approximately 15 min after they were first observed. These observations were made with 7×35 binoculars and a 50/80× spotting scope from a bluff under calm, overcast conditions with excellent

visibility. The first breach (with direct otter contact) occurred at a distance of approximately 300 m, and the second breach was about 500 m from the observer.

The eighth attack occurred off Adak Island in November 1995. At approximately 1400 a single male killer whale was observed 4 m from a rock island (Pit Rock) heading in a northerly direction. The observers in a 5-m skiff stopped to watch the whale. Approximately one minute later a sea otter of unknown sex was seen leaving shallow water near another rock outcrop. Apparently unaware of the killer whale's presence, the sea otter swam at the surface in kelp-free water towards Pit Rock. About one min later, from a distance of approximately 40 m under calm overcast conditions, the observers saw the killer whale surface and in one deliberate movement, engulf the sea otter in its mouth. The whale surfaced once more and was not seen again. The killer whale had turned 180° to the south in order to capture the sea otter in what appeared to be a strictly predatory interaction.

The last interaction took place at Adak Island in 1996. At 1400, three researchers were observing a radio-instrumented sea otter. This otter, a territorial male, was resting beside a single female otter about 20 m from shore in a large kelp bed, immediately below a 50-m high bluff on which the observers were positioned. The observers became aware of a single adult male killer whale swimming along the shoreline from the direction of the open sea. The observers noticed the killer whale when it was still approximately 500 m away, however the approach of the orca would not have been visible to the otters due to the shoreline configuration. At a distance of about 300 m from the otters the killer whale dove and disappeared for five minutes. The killer whale surfaced only 1 m from the resting otters. The otters immediately dove to the left of the whale's head. The killer whale pursued by rolling and changing its course towards the sea otters while diving. The killer whale and both otters remained below the surface for 10–20 sec. Both otters surfaced, still within the kelp bed but now closer to shore. The killer whale surfaced a few seconds later at the offshore edge of the kelp bed approximately 30 m from the otters and continued swimming into Finger Bay and away from the otters. The two otters remained visibly agitated and alert for one to two minutes, looking repeatedly in the direction of the killer whale. Within five minutes of the incident both otters began making foraging dives.

Sea otter diving abilities can allow them to seemingly disappear, even at close range in calm seas with good viewing conditions (personal observations during capture attempts using dip nets). It is therefore possible that the pup in attack no. 5 and the adult in attack no. 7, in which no contact was observed between sea otter and killer whale, escaped uninjured and unnoticed by the observers, although we believe this to be unlikely. It is very unlikely that the sea otters involved in attacks nos. 4 and 6 escaped uninjured and unobserved. However, in only one incident was the otter known to be consumed (no. 8). In the other attacks in which the otter was killed (no. 1), or likely killed (nos. 4, 5, and 6), the otters were not seen again following the attack. In a survey of sea otter researchers and one Alaska native hunter, J. Ames (personal com-

munication) found that of over 600 fresh sea otters that had died at or near the surface (mostly drowned in surface set tangle nets or shot), only two sank. He concluded that virtually all sea otters that die at or near the surface will float, at least initially, due to air trapped in their lungs and fur. All observers of the listed attacks believe they would have noticed a carcass at the surface. Unless the otters we observed had the air purged from their lungs and fur during the attack, it is likely at least three or four of the otters observed in these attacks were eaten.

The geographical range of killer whales completely overlaps the current and historic range of sea otters (Heyning and Dahlheim 1988, Kenyon 1969, Reidman and Estes 1990), yet reports of killer whale attacks on sea otters have been rare. It is unclear whether the incidence of attacks are uncommon, or if more attacks have gone unnoticed by chance. Much of the sea otter's range is remote and both killer whales and sea otters have been poorly studied throughout most of this range. Of the attacks described in this note, two were seen by researchers conducting wildlife surveys subsequent to the *Exxon Valdez* oil spill, and six were observed by biologists studying sea otters in the Aleutian Islands. In addition to these observed interactions, there is also circumstantial evidence involving the disappearance of several radio-tagged sea otters that coincided temporally and spatially with observations of killer whales at Adak Island (personal observations). It is possible, therefore, that the observations of killer whale-sea otter interactions described here simply reflect the increase in sea otter research activities in recent years. Yet there have been previous sea otter studies in the Aleutian Islands and in Prince William Sound with no reported killer whale attacks, thus raising the possibility that the rate of killer whale predation on sea otters has increased. Recent declines in Steller sea lion, *Eumetopias jubatus*, and harbor seal, *Phoca vitulina*, abundance (Loughlin *et al.* 1992, Frost *et al.* 1994) may have resulted in a shift in killer whale prey selection to alternate or less preferred food items.

Whether there have recently been more opportunities to observe killer whale attacks on sea otters, or whether there has been an increase in the rate of such attacks, the observations described here indicate aggressive killer whale-sea otter interactions are not as uncommon as previously believed. While the frequency of killer whale attacks or predation on sea otters is likely to vary regionally, the significance of these attacks to either killer whale or sea otter populations is unknown.

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LITERATURE CITED

- BARABASH-NIKIFOROV, J. 1938. Mammals of the Commander Islands and the surrounding sea. *Journal of Mammalogy* 19:423-429.
- FROST, K. J., L. F. LOWRY, E. H. SINCLAIR, J. VER HOEF AND D. C. McALLISTER. 1994. Impacts on distribution, abundance, and productivity of harbor seals. Pages 97-117 in T. R. Loughlin, ed. *The impact of the Exxon Valdez oil spill on marine mammals*. Academic Press, New York, NY.
- HEYNING, J. E., AND M. E. DAHLHEIM. 1988. *Orcinus orca*. *Mammalian Species* 304: 1-9.
- JEFFERSON, T. A., P. J. STACEY AND R. W. BAIRD. 1991. A review of killer whale interactions with other marine mammals: Predation to co-existence. *Mammal Review* 21:151-180.
- KENYON, K. W. 1969. The sea otter in the eastern Pacific Ocean. *North American Fauna* 68:1-352.
- LOUGHLIN, T. R., A. S. PERLOV AND V. A. VLADIMIROV. 1992. Range-wide estimation of total abundance of Steller sea lions in 1989. *Marine Mammal Science* 8:220-239.
- MATKIN, C. O., AND E. L. SAULITIS. 1994. Killer whale (*Orcinus orca*) biology and management in Alaska. United States Marine Mammal Commission Contract No. T75135023. 46 pp. Available from NTIS, 5285 Port Royal Road, Springfield, VA 22161.
- NIKOLAEV, A. M. 1965. On the feeding of the Kuril sea otter and some aspects of their behavior during the period of ice. Pages 231-236 in E. N. Pavlovskii and B. A. Zenkovich, eds. *Marine mammals*. Akademiya Nauk SSR, Moscow (translated from Russian by Nancy McRoy, April 1966).
- REIDMAN, M. L., AND J. A. ESTES. 1990. The sea otter (*Enhydra lutris*): Behavior, ecology, and natural history. U.S. Fish and Wildlife Service, Biological Report 90(14). 126 pp.
- TOMILIN, A. G. 1957. Cetacea. Vol. 9 in V. G. Heptner, ed. *Mammals of the U.S.S.R. and adjacent countries*. Akademiya Nauk SSR, Moscow. (Translated from Russian by Israel Program for Scientific Translations, 1967.)
- BRIAN B. HATFIELD, U.S. Geological Survey, Biological Resources Division, Piedras Blancas Field Station, P. O. Box 70, San Simeon, California 93452, U.S.A.; e-mail: brian_hatfield@usgs.gov; DENNIS MARKS, P. O. Box 243552 Anchorage, Alaska 99524-3552, U.S.A.; M. TIM TINKER,¹ KELLIE NOLAN,² JOSHUA PEIRCE,² National Biological Service, U.S. Fish and Wildlife Service, P. O. Box 5251, FPO AP Adak, Alaska, U.S.A. Received 7 July 1997. Accepted 15 August 1997.

¹ Present address: Glenside Ecological Services, 79 High Street, Victoria, British Columbia V8Z 5C8, Canada.

² Present address: P. O. Box 270, Dillingham, Alaska 99576, U.S.A.