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Antarctic peninsula killer whales (*Orcinus orca*) hunt seals and a penguin on floating ice

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In 1979, Smith *et al*. (1981) observed a group of seven killer whales (*Orcinus orca*) conduct a coordinated attack on a crabeater seal (*Lobodon carcinophaga*) by creating a wave to wash the hauled-out seal off floating ice. Since then a number of similar events have been witnessed along the Antarctic Peninsula. The increased tourist ship traffic in this area has provided an opportunity for many observers equipped with cameras and video recorders to document a number of these.

Given that it is often difficult to gain an accurate description of events involving a number of killer whales moving quickly and typically under water, in an ice-filled environment, the availability of good quality video recordings is often the best way of documenting such a fast-moving incident. The vantage point is of importance and those observations from the bow of a large ship, which can maneuver to within a short distance of the animals, are of significantly better quality than those at water level. Still photography, in addition to video, is of particular importance in any attempt to identify individual whales or groups.

Here we present six "events" (some involving multiple attacks) by killer whales on prey that were hauled out on ice floes, one of which we describe in detail. Prey kills were confirmed by the presence of body parts, blood or fat, either in the mouth of a killer whale or in the water. Across all incidents we estimated the total size of the ice floes by comparing them to the average known size of the seal; 2.5 m for crabeater and Weddell (*Leptonychotes weddellii*) and 3 m for leopard (*Hydrurga leptonyx*) seals (Nowak 1999). When an accurate estimate of the total floe size was difficult or impossible, an approximate estimate of diameter is provided.

The sex/age class of the individual killer whales was determined based on relative size (*e.g.,* calves were defined as less than a third the size of adult females, juveniles were approximately half the size of adult females). Adult males had dorsal fins that were at least twice the size of adult female dorsal fins; however, given that it can be difficult to determine non-sprouted sub-adult males (*i.e.*, the dorsal fin had not yet begun rapid pubescent growth in height) from females, all animals of this size were classified together as adult female/sub-adult male (AF/SAM).

Of the six events described, five involved seals and one involved a penguin (Table 1). All seals were adults and during each attack they moved to the approximate center of the ice floes. One event involved two different species of seals (leopard and Weddell) on two separate ice floes but within 10 m of each other. Of the three events involving crabeater seals, there was one probable and two definite kills. Leopard seals were involved twice; one was washed into the water and killed, the other remained on the ice floe. One Weddell seal was attacked five times and dislodged from the ice floe by waves induced by the killer whales each time, but no definite kill was confirmed (Table 1). One lone adult Adélie penguin was attacked twice; however, it remained on the ice floe (Table 1) and was not killed.

The killer whale group size ranged from five to seven individuals, with the exception of the event involving the Adélie penguin, where a single killer whale mounted the attacks. The age/sex structure for the groups is given in Table 1.

Quantity of sea ice covering the surface is typically described as a fraction, where 10/10ths would be complete coverage. All of the events occurred in areas where there was at least 2/10th ice cover. In all cases the prey was on a piece of first-year sea ice. These ice floes varied in initial size from 4.5 to 18 m wide. In two cases (12 November 1979 and 14 January 2000) the ice was thicker than 1 m. In all the other cases the ice had melted to less than <0.5 m thick, and the ice floes were very low to the water surface, making them easily fractured by waves generated by the killer whales.

In four of the five events involving attacks on seals, the prey, after being dislodged from the ice floe, either regained the original ice floe or, in three cases, moved to emerge on another nearby ice floe. During two attacks the dislodged seals were carried in the mouth of a killer whale but were either released, escaped, or were deposited, still alive, on another ice floe.

On 15 January 2006, a coordinated event involving a crabeater seal in the Grand Didier Channel at 65°47′S, 065°02′W, on the west side of the Antarctic Peninsula, was observed. We summarize the most significant incidents in Table 2 and provide further details here. We had a high and close vantage point on the bow of a tourist ship, the Lindblad Expeditions′ MS *National Geographic Endeavour*. The seas were

Table 1. Comparison of six attacks by killer whales made on three seal and one penguin species, on ice floes during the period 1979 to 2006.

Date	Approximate duration (min)	Location	Killer whale group[a] composition	Prey species	Ice cover within 1 km^2	Ice type and thickness (m)	Initial floe size (m)	Number of waves observed	Number of times prey dislodged	Kill	Observer, platform, recording method
12 November 1979	17	64°53′S, 062°53′W Paradise Bay	1 AM, 4 AF/SAM, 1 j, 1 c	Crabeater seal	4/10	1st year (>1.5 m)	8 (diam)	1	1	Probable	Smith *et al*. (1981) ship, photo
18 January 1998	23	65°15′S, 064°16′W Argentine Islands	3 AF/SAM, 2 j	Leopard seal	2–3/10	1st year (<0.5 m)	25 (diam)	6	5	Yes	J. Drennan zodiac, video
14 January 2000	36	65°14′S, 064°10′W Yalour Islands	2 AM, 2 AF/SAM 1 j, 2 c	Leopard seal	3–4/10	1st year (>1.5 m)	12 (diam)	0	0	No	GDG, OGC, SI zodiac, photo, video
				Weddell seal			16 × 5	6	5	No	
25 November 2004	6	65°10′S, 064°30′W Penola Strait	1 sprouting M	Adélie penguin	5/10	1st year (>1.0 m)	5 × 2	3	0	No	IDB land, visual
25 December 2004	45	64°57′S, 063°22′W S end Gerlache Strait	1 AM, 3–4 AF/SAM, 2 c	Crabeater seal	2/10	1st year (<1.0 m)	5 × 6	6	3	Yes	GDG, SI ship, photo
15 January 2006	32	65°47′S, 065°02′W Grand Didier Chanel	5 AF/SAM, 1 j, 1 c	Crabeater seal	2/10	1st year (<0.5 m)	15 × 10	11	3	Yes	TGS, INV ship, photo, video

[a]AM = adult male, AF/SAM = adult female/subadult male, j = juvenile, and c = calf.

Table 2. Summary of hunting tactics used by a group of seven killer whales, *Orcinus orca*, during a 28-min observation of an attack on an adult crabeater seal, *Lobodon carcinophaga*, lying on a piece of first year sea ice (see Table 1, 15 January 2006, for location and group composition details).

Elapsed time (min)	Floe size (meters)	Behavior	Result
+3.12	15 × 10	Killer whales submerge to create Wave 1	Broke into five pieces
3.56		Wave no. 2	
4.10	5 wide	Seal leaves broken floe and swims right, to new floe	Seal on new floe
4.12	25 × 15	Wave no. 3	Floe reduced by 30%
5.37	18 wide	Wave no. 4	Floe reduced by 20%
6.36	16 wide	Wave no. 5	Floe reduced by 20%
8.34	13 wide	Wave no. 6	No floe reduction
9.24	12 × 13	Wave no. 7, washes only west floe	No floe reduction
10.30	12 × 13	Wave no. 8	Floe reduced by 10%
10.30–11.30		Group actively steering floe into open water and clearing obstructing brash	
11.40	11 × 12	Wave no. 9, washes across floe	Floe reduced by 30%
12.00	7 × 8	Group steering floe into open water	
13.00		Killer whale clears adjacent floes by surfacing and diving between floes	Floe in open water
14.56		Seal rolls onto back (submissive)	
15.16	7 × 8	Wave no. 10, washes across floe	Seal washed off far side of floe
15.36		Killer whale seen with seal in mouth	
18.43	6 wide	Seal reappears on new floe	
19.36		Wave no. 11	Floe reduced by 50%
19.42		Seal back in the water	
20.48	4 wide	Seal hauling out onto floe, but dragged back in by hind flippers	Killer whale takes seal
25.32		One killer whale with seal body part in mouth	Kill confirmed
28.04		Group moving out of area	

calm with 2/10th ice cover consisting mostly of first-year ice floes of varying size, all <0.5 m thick and in an advanced state of melt. At approximately 2330 we sighted killer whales spyhopping beside an ice floe, on which an adult male crabeater seal was lying. The floe was approximately 15 × 10 m and in an advanced state of melt. We watched and filmed for approximately 30 min as the group of killer whales, consisting of five AF/SAM, one juvenile, and one calf, mounted a number of coordinated attacks, dislodged the seal from four different ice floes, and ultimately killed it. The ship was approximately 1 km distant when the killer whales were first sighted but gradually closed to less than 100 m without any noticeable reaction to the ship by either the

whales or the seal. The event was recorded onto high definition video (HDV) and we refer to timings as elapsed time, *e.g.*, +12.30 min.

At +3.12 min, after a period of spyhopping, bubble blowing, and moving around the ice floe on which the seal was hauled out, two AF/SAM killer whales submerged suddenly. They were approximately 15 m away from the ice floe and simultaneously swam directly at and under it, creating a significant wave (hereinafter referred to as wave-washing), which tipped the ice floe and washed over it. This did not dislodge the seal but broke the ice floe into five pieces (as illustrated in Fig. 1A), leaving the seal on a smaller fragment less than 5 × 5 m. Shortly afterwards (+4.10 min) the seal went into the water of its own accord and swam quickly to emerge on a larger floe (25 × 15 m), which was approximately 100 m away from the seal's original platform.

From +5.37 to +14.56 min the killer whales created a further six wave-washes, none of which dislodged the seal but sequentially reduced the ice floe to approximately 7 × 8 m. During this period the killer whales were also seen to actively move the ice floe into an area of open water free of adjacent ice floes or ice debris. It is apparent from the video footage that the whales were sometimes actively pushing the ice floe with their bodies, particularly their rostrums, although it appears that ice floe movement was also created by individual whales submerging and creating vortices at the very edge of the ice floe (as illustrated in Fig. 1B, C). The whales also blew bubbles underwater near the edge of the ice creating turbulence, which was seen to clear ice debris away from the edge. On one occasion a killer whale was clearly seen to separate the target ice floe from an adjacent pan. It swam fast, submerged between the ice floes, thereby making a wave that moved them apart. At the end of this maneuver, it surfaced and then submerged on the far side of the obstructing ice floe, which created a vortex and then pulled it away further (Fig. 1C).

Near the end of this period it was evident that the crabeater seal was severely agitated. Its chest was heaving, its jaws were opening and closing, and it eventually turned completely on its back.

At +14.58 min, one AF/SAM killer whale remained in position with its rostrum against the ice floe while four AF/SAM killer whales moved away from the ice floe with the seal on it. These four killer whales reappeared simultaneously, approximately 20 s later in line-abreast with all submerged just under the surface. All four were coordinated-swimming, with their left sides orientated towards the surface. A trail of bubbles emanated from each of the animals blowholes as they accelerated and passed directly under the ice floe, two on each side of the stationary killer whale (Fig. 2). This generated a large wave, which tipped the ice floe initially towards the wave, then as the wave poured over and crested under the ice, it pivoted and tilted the ice in the other direction where the attacking whales were now waiting (as illustrated in Fig. 1D). The breaking wave washed the seal into the water at +15.19 min. A short segment of HDV can be viewed at http://www.orcaresearch.org/dvd. The seal was then seen to be jerked down vertically, presumably grabbed by one of the killer whales, submerged in position on the far side of the ice floe. At +15.37 min the seal was lifted out of the water in the mouth of an AF/SAM killer whale. Given the short time frame (*i.e.*, 18 s) between when the seal entered the water and when it

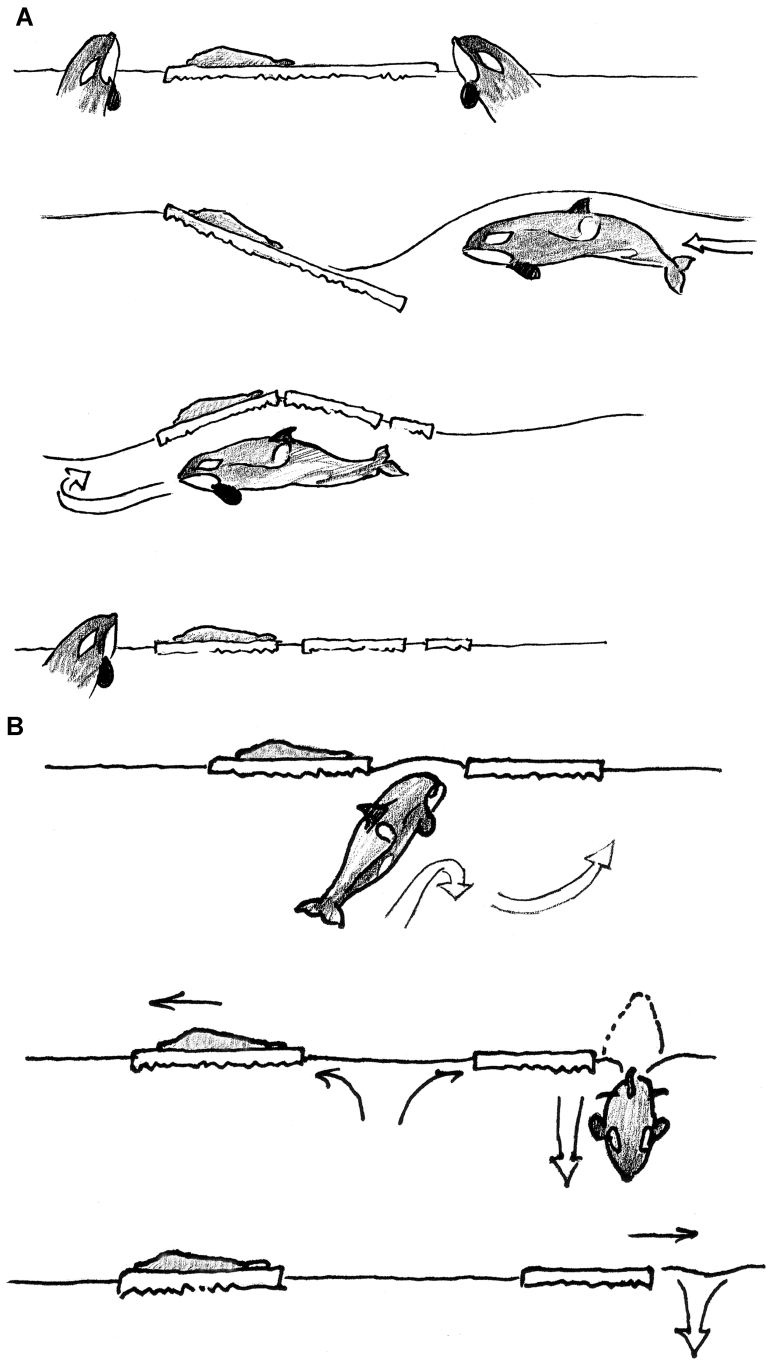

Figure 1. The use of waves by killer whales for (A) reducing ice floe size, (B) clearing the ice around the floe, (C) moving the target floe into open water, and (D) wave washing the prey into the ocean. (Illustrations by IDB).

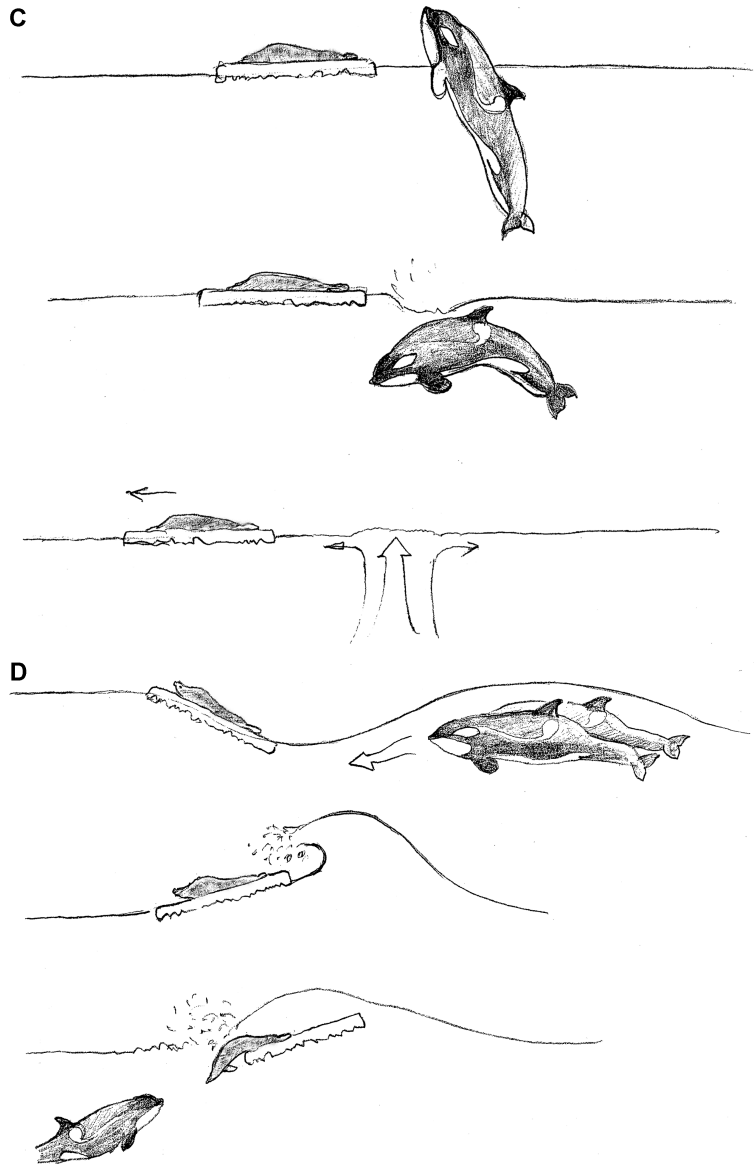

Figure 1. Continued.

was observed in the mouth of the killer whale, we assume this was the same seal. At +15.39 min the seal, which was still in the mouth of the killer whale, was taken underwater.

At +18.4 min, the seal egressed onto an ice floe approximately 6 m wide, and less than a body length from the whales yet several hundred meters from the original ice floe. At +19.42 min the whales created a wave that again washed the seal into the ocean (this now being the 11th and last wave observed during the event). At

Figure 2. Four submerged killer whales swim two on either side of a stationary killer whale (blowing a bubble burst). They created a wave, which washed the adult crabeater seal off the ice floe, in Grand Didier Channel, W. Antarctic Peninsula on 15 January 2006. (Photo from video, by INV).

+20.48 min, the seal attempted to climb onto a third ice floe but was pulled back into the water by an AF/SAM killer whale, which had grabbed it by the hind flippers. At +25.32 min, parts of the body of the seal were seen in the mouth of an AF/SAM killer whale, and we could confirm that the seal had been killed. Observations ended at +28.04 min as the group of killer whales moved slowly away from the ship.

We were afforded a unique opportunity to observe the details of coordinated killer whale hunting. After the initial period of spyhopping and looking at the seal, the killer whales engaged in two types of wave-creating behavior as well as bubble-blowing, which appeared to have three separate ends: ice movement, ice fragmentation and ice tipping. The frequent submergence of individual whales at the very edge of the ice floe began to actively move it in a concerted direction. These waves did not break over the ice floe but instead created sufficient turbulence to drive it in a consistent direction, sometimes straight, sometimes rotating it. This behavior as well as bubble-blowing was also used to move ice debris or adjacent ice floes clear of the ice floe carrying the seal. Larger breaking waves created by killer whales swimming towards and then under the ice floe resulted in breaking up the fragile melting ice and reducing it significantly in size.

Once the floe was a smaller size and had been steered into open water, a coordinated attack by five AF/SAM killer whales (four swimming while one remained in position) created a breaking wave that tipped the ice floe (resulting in the seal being displaced). As the four killer whales approached the ice, streams of bubbles were seen emanating from their blowholes. It is possible, but we have no direct evidence, that they were emitting whistles while making these bubble-streams. Similar bubble-streams have been associated with whistles for bottlenose dolphins, *Tursiops truncatus* (Caldwell and Caldwell 1972). It cannot be ruled out that whistles may help coordinate the animals during such an attack, yet we could not determine the role of the stationary killer whale.

As the four killer whales approached the ice floe they all swam on their sides (Fig. 2), possibly to protect their dorsal fins and enable them to pass very close to the underside of the ice floe. By swimming on their sides they augmented the plane of their bodies, which deflected the water, and possibly increased the size of the wave they were creating. It appears that the group had not only learned to place the ice floe in open water where the chances of the seal escaping were minimized, but they could enhance their success by reducing ice floe size, using the waves to dislodge their prey, and also increase the size of the waves to maximize their effect. In the December 2004 event at least two (probably three) killer whales were also involved in coordinated wave making, and they too swam on their sides.

In several of our documented attacks the killer whales did not kill the prey immediately. For at least three of the five events involving seals, the seal was washed into the water, captured, and carried in the mouth of an adult whale, after which it was either released, escaped, or was deposited alive onto another ice floe. Such manipulation of the prey (intentional or not) might serve in part as training, social learning, or coaching for the young animals—see full definitions of each in Caro and Hauser (1992). The immediate cost to the teacher (*i.e.*, potential loss of the prey *cf.* to immediately killing and consuming prey) may have long-term benefits if the naïve pupil(s) can learn and therefore later participate in the coordinated hunt (Caro and Hauser 1992). Complex hunting strategies, such as those described here, necessarily involve a lengthy apprenticeship for the young group members. Such training could manifest itself through imitation or assisted practice as has been observed for killer whales (*e.g.,* see Guinet 1991, and references therein). However, Baird and Dill (1995) found that, for "transient" killer whales off the west coast of North America, prolonged prey handling time (*i.e.*, from catch until consume) did not necessarily represent training opportunities for younger whales, but it was characterized by behaviors typical of social-play behavior.

The attack on a penguin by a single juvenile killer whale is the only penguin attack using wave-washing methods reported in the many years during which we have recorded attacks on seals in this area.

Where possible, photo-identification quality images were obtained of the killer whales. These were compared to the Antarctic Killer Whale Identification Catalogue (www.akwic.org). This catalogue contains over 100 photographically identified Antarctic killer whales. Perhaps due to the limited number of images obtained from each event listed here, only one adult male has been resighted (from the 14 January 2000 encounter to a subsequent record on 23 December 2001, where no hunting was observed), approximately 64 km to the south of the observation recorded here (Visser, unpublished data). However, despite only one match to the catalogue, we can still determine that all of the killer whales that have been involved in the seal attacks that we have documented here are Type B killer whales, as described by Pitman and Ensor (2003), in that they are gray and white and have large eye patches, oriented parallel to the body axis. The Type B killer whales are thought to specialize in hunting for pinnipeds and the data presented here reflect that. We could not ascertain the type of killer whale involved in the penguin attack.

Observations of killer whale predation and prey handling are rarely documented in the Antarctic habitat. With such a small sample size it is difficult to draw strong conclusions. Nonetheless, we speculate that such complex coordinated hunting behaviors are culturally transmitted (*i.e.*, passed down [or carried forward] over generations). Although this wave-washing hunting method may be novel to this area (all observations were within 61 km, if distances are measured in a straight-line), we cannot exclude the possibility of its existence elsewhere because of the paucity of observations in the greater Antarctic area. We anticipate that this noticeable behavior will be seen more frequently as Antarctic ship traffic increases in the future, and this will hopefully lead to a more accurate assessment of the extent of this behavior among killer whales.

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