Hunting Behavior of a Marine Mammal Beneath the Antarctic Fast Ice

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The hunting behavior of a marine mammal was studied beneath the Antarctic fast ice with an animal-borne video system and data recorder. Weddell seals stalked large Antarctic cod and the smaller subice fish Pagothenia borchgrevinki, often with the under-ice surface for backlighting, which implies that vision is important for hunting. They approached to within centimeters of cod without startling the fish. Seals flushed P. borchgrevinki by blowing air into subice crevices or pursued them into the plateate ice. These observations highlight the broad range of insights that are possible with simultaneous recordings of video, audio, three-dimensional dive paths, and locomotor effort.

The process by which mammalian predators search for, locate, stalk, and subdue their prey has been the subject of considerable research efforts for terrestrial species (1). In contrast, less is known about the foraging behavior of marine mammals, primarily because they are so difficult to observe underwater. Direct observation of marine animal behavior with scuba, fixed-location cameras, remotely operated vehicles, and manned submersibles is limited by depth or duration. Often, these technologies provide only fleeting glimpses of highly mobile species. Animal-borne time-depth recorders and acoustic tracking provide information on diving behavior (2, 4) but do not allow direct observation of animals at depth. As a result, our knowledge of the underwater behavior of marine mammals, especially deep diving species, is based primarily on indirect information provided by dive depth and duration statistics and estimated swim speeds. To provide a better understanding of marine mammal diving and hunting behavior, we developed an animal-borne video system and data recorder that enabled us to observe Weddell seals (Leptonychotes weddellii) foraging at depth and to compute their three-dimensional dive paths.

Weddell seals are large, marine predators that are highly adapted for hunting inshorefast and pack ice habitats (2, 4). To forage beneath the extensive, unbroken fast ice, these seals must locate, pursue, and capture prey in three spatial dimensions under low-light conditions and while holding their breath. Foraging is thought to occur in daily bouts consisting of up to 40 consecutive dives. These dives are usually to depths of 100 to 350 m (the maximum recorded dive depth is 741 m) and less than 25 min long. Analyses of partially digested prey, fish otoliths, and skeletal material obtained from stomach samples and feces indicate that Weddell seals consume a variety of prey, although local diets appear narrow (2, 5). For example, Weddell seals in McMurdo Sound, Antarctica, forage primarily on small nototheniid fish (Platysomus antarcticus, Pagothenia borchgrevinki, and Trematomus spp.). They also capture large Antarctic cod, which grow to 165 cm in length and weigh up to 77 kg (5). However, virtually nothing is known about how Weddell seals find their prey, where they find it, and how they stalk and capture it.

We attached a small video system and data logger (6) to four adult Weddell seals (one male and three females) from October to December 1997 to study their hunting behavior in the fast ice environment of McMurdo Sound, Antarctica. The video system recorded images of the seal’s head and the environment immediately in front of the animal. The data logger recorded time, depth, water speed, and compass bearing once per second, and flipper stroke frequency and ambient sound were recorded continuously on the audio channels. These data enabled us to compute the seals’ three-dimensional dive paths and locomotor effort.

In 57.4 hours of underwater video and data recording, we observed several encounters between seals and their known prey. Three of these encounters were midwater interactions with Antarctic cod. One dive by seal 4, a 462-kg female, provides details on how Weddell seals stalk large prey in three dimensions. This seal departed the breathing hole and descended at an average swim speed of 1.3 m s⁻¹ to a depth of 51 m (Fig. 1A). Without changing horizontal direction (bearing), the seal then ascended to 33 m at 1.2 m s⁻¹ and began a second, gliding descent at 0.7 m s⁻¹. We surmise that the seal visually located a cod and began to stalk it at 4 min 51 s into the dive and a depth of 53 m when the seal suddenly accelerated to speeds of almost 2 m s⁻¹ with large swimming strokes. At this point, the seal was about 23 m from the cod. Before this (minute 4 of the dive), the seal had been gliding at a descent angle of 31° along a straight course, bearing 103°, which almost intersected the point of contact with the cod (Fig. 1, A and B). Instead of continuing directly toward the fish, the seal leveled its descent and veered 28° to the right with the sudden acceleration (Fig. 1, A and B). This bearing took the prey out of the seal’s line of sight and increased the distance between them. At 5 min 39 s into the dive and a distance of 28 m from the cod, the seal accelerated through a looping turn and a 23° descent to 73 m, reaching speeds in excess of 2 m s⁻¹ and bringing it beneath a large (>1 m long) Antarctic cod (Fig. 1C). The seal extended its neck and struck the cod near the anal fin with its muzzle. The fish reacted vigorously with a powerful tail thrust and disappeared from view; it was not seen again. By attacking from below at the posterior part of the fish, the seal silhouetted the cod against the under-ice surface and remained out of sight. The seal did not appear to pursue the cod after the strike but continued descending to 85 m. At the bottom of the dive, the seal turned left and then ascended quickly to the ice hole at an average speed of 1.8 m s⁻¹.

Two other encounters with Antarctic cod were recorded: one by a 475-kg male (seal 2) and another by seal 4. The seals approached to within centimeters of the fish, from slightly below or horizontally, without eliciting a response. The cod encountered by seal 2 was at a depth of less than 20 m and strongly backlighted by the under-ice surface. As the seal approached, it extended its head with erect vibrissae toward the fish. The seal vocalized briefly as it swam over the fish. Seal 4 approached a cod against a dark background at a
depth of 100 m. It moved anteriorly along and extremely close to the fish’s dorsal fins. Neither encounter was aggressive.

In addition to these midwater encounters, we observed Weddell seals hunting for smaller fish in the subice zone. On one brief dive by seal 2, the seal’s eyes scanned the water above as it swam to a depth of 40 m. During the slow ascent, the seal lunged forward and to one side or the other five times apparently in response to something it saw above. The video recording showed small fish darting under the ice. The seal ascended to within a few centimeters of the ice where two fish (identified from the video as P. borchgrevinki) could be seen in a crevice. The seal expelled a blast of air through its nostrils for 1 s (Fig. 2A) and one of the fish immediately swam out of the crevice (Fig. 2B). The seal attempted to catch the fish but failed and returned to the remaining fish. The seal prodded the ice with its muzzle and the second fish fled. During another dive, seal 2 blew air into the subice surface twice and then plunged its head into the soft platelet ice three times for 4 to 6 s at a time. Immediately after withdrawing its head the third time, the seal jerked its head to either side three times in a manner reminiscent of a mammal chewing on something hard or manipulating food. We observed no fish but surmise that the animal had captured a small prey item in the platelet ice. It is not likely that the seal was chewing on ice, as the platelet ice is too fragile to produce such head movement. Seal 4 also penetrated the platelet ice, but deeper (about 1 m) and for a longer period (30 s).

There is circumstantial evidence that vision is important for under-ice prey detection by Weddell seals (7). Our data also indicate that vision may be important for interactions with prey, at least at shallow depths. Both interactions between seal 4 and the cod involved backlighting. When the seal struck the cod from below, the under-ice surface was visible (Fig. 1C). Because the seal eye is more sensitive than our video camera (8), there was sufficient light for the seal to see the cod’s silhouette. Erection of vibrissae when the seal was very close to its prey (cod and P. borchgrevinki; Fig. 2B) suggests that the recently

Fig. 1. (A) Swimming path during a 10 min 20 s dive in the course of which a Weddell seal made contact with an Antarctic cod. The solid circle marks the breathing hole and the star marks the point of contact between the seal and the cod. The numbers indicate elapsed time (in minutes) along the dive path. The total distance traveled was 760 m. The area enclosed by the rectangle in (A) is enlarged in (B). (C) The image is from the video recorded by a camera located on the seal’s back. A second camera on the seal’s head was not in use at the time. The cod is silhouetted against the under-ice surface as the seal approaches from below.

Fig. 2. (A) Seal 2 blowing air out of its nostrils and into crevices in the platelet ice where two P. borchgrevinki are hiding. The image was recorded with a head-mounted camera and shows the seal’s forehead, muzzle, and vibrissae. (B) Moments after seal 2 finishes blowing air into the platelet ice, one of the P. borchgrevinki is flushed out and darts past the right side of the seal’s head.
described hydrodynamic receptor system (9) may help guide seals during the final stages of an attack. Although Weddell seals produce a variety of underwater vocalizations (10), we recorded only nine calls during 139 dives, one of which occurred during a predator-prey interaction (11). Therefore, it seems unlikely that Weddell seals use active sonar to locate prey as some other marine mammals do, though the fact that Weddell seals have excellent directional hearing (2) and may be able to detect and localize soniferous prey. However, we recorded no identifiable sounds from the fish during the interactions.

Although more recordings are needed to understand the importance of observations of Weddell seals interacting with Antarctic cod at depth, some preliminary conclusions can be made. First, not all encounters between this predator and its potential prey result in obvious aggression. In two interactions, the seals displayed curiosity but did not behave aggressive toward the cod. Nevertheless, we know that Weddell seals will capture Antarctic cod after being moved to an isolated ice hole. A few days after seal 1 was transported to the field site and before the camera and data logger were attached, it caught a cod (1.2 m long) and began consuming it in the ice hole by tearing off pieces. Another observation is that seals are able to stay within a few centimeters of cod without startling the fish. Yet even in the absence of antipredator behavior, a seal may contact a cod without capturing it, as is the third interaction. We cannot be certain that the seal intended to catch the cod it struck, but the fish responded vigorously to the contact. This type of interaction may contribute to the scars that are common on the skin of large Antarctic cod (5).

Our records of seals attempting to feed on fish in the subice zone revealed previously unknown tactics for extracting prey from their refuge in the ice. Jansen et al. (12) reported P. borealis taking cover in subice crevices when Weddell seals approached to within 10 to 15 m and, noting previous observations of P. borealis tails in Weddell seal stomachs (13), suggested that the seals bite off the exposed tails of the fish in hiding. Blowing bubbles to flush P. borealis out of the platelet ice has to our knowledge never been observed or suggested. Platelet ice, which is composed of large, loosely packed ice crystals, can be more than a meter thick. In addition to biting exposed fish tails and flushing the fish out, seals may pursue the fish into the ice. This has been reported (7) and was seen during this study. These observations of Weddell seal foraging behavior, although preliminary, highlight the broad range of insights that are possible with simultaneous recordings of video, audio, three-dimensional dive paths, and locomotor effect.

References and Notes
14. This call consisted of a short-duration (242 ms) two-component complex [call type GL (10)] that occurred 6 s after a cod interaction (call 4). The first part of the call lasted 131 ms and had a fundamental frequency that began at 217 Hz and swept down to 159 Hz. The second part of the chug occurred 50 ms later. It was of short duration (61 ms) with a fundamental frequency at 167 Hz that swept down to 139 Hz.