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In McMurdo Sound, Antarctica, Weddell seals ~~(*Leptonychotes weddellii*)~~ return to traditional breeding colonies on shorefast ice each austral spring. This fast ice provides a stable platform, over a 2-month period, for raising pups and a fixed location for establishing underwater mating territories. However, it also may provide protection from predators, such as leopard seals (*Hydrurga leptonyx*) or killer whales (*Orcinus orca*). Weddell seals are the only marine mammal in the shorefast ice of McMurdo Sound from October through early December. When killer whales and leopard seals arrive in mid-December, they work the ice edge for available prey, ~~especially penguins~~. As the fast ice breaks up, leads provide access to nearby Weddell seal colonies ~~(Thomas et al. 1981)~~. In late December, ~~U.S. Coast Guard~~ icebreakers open a lead for entry to McMurdo Station ~~(figure 1)~~. Killer whales and leopard seals use this large lead and its tributaries to move closer to Weddell seal colonies. The objective of this study was to document the rate of underwater calls from Weddell seals throughout the breeding season and to monitor changes in this rate associated with the arrival of leopard seals and killer whales. (to p 234)

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19. ABSTRACT (Continued)

Silence as an anti-predation strategy by Weddell seals

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In McMurdo Sound, Antarctica, Weddell seals (*Leptonychotes weddelli*) return to traditional breeding colonies on shorefast ice each austral spring. This fast ice provides a stable platform, over a 2-month period, for raising pups and a fixed location for establishing underwater mating territories. However, it also may provide protection from predators, such as leopard seals (*Hydrurga leptonyx*) or killer whales (*Orcinus orca*). Weddell seals are the only marine mammal in the shorefast ice of McMurdo Sound from October through early December. When killer whales and leopard seals arrive in mid-December, they work the ice edge for available prey, especially penguins. As the fast ice breaks up, leads provide access to nearby Weddell seal colonies (Thomas et al. 1981). In late December, U.S. Coast Guard icebreakers open a lead for entry to McMurdo Station (figure 1). Killer whales and leopard seals use this large lead and its tributaries to move closer to Weddell seal colonies.

Leopard seals and killer whales are the top mammalian predators in the antarctic ecosystem and feed opportunistically on seasonally available species. Leopard seals hunt krill, squid, fish, penguins, seabirds, and crabeater seal (*Lobodon carcinophagus*) pups (Siniff and Bengtson 1977). Scars on 78 percent of adult crabeaters confirm the importance of this species in the leopard seal's diet and the occasional ability of the prey to escape (Siniff and Bengtson 1977). When crabeater pups wean, leopard seals also are present in the pack ice. Weddell seal pups are in shorefast ice areas when they are weaned (Thomas and DeMaster 1984). Whether newly weaned Weddell seals also are at risk of predation is unknown. The absence of scars in Weddell seals suggests that, if such predation by leopard seals occurs, it is highly successful.

Killer whales take antarctic cod, penguins, and all age classes of all antarctic seals (Siniff and Bengtson 1977; Thomas et al., 1981). Seals do not have scars from killer whale predation, which testifies to a high success rate for this predator.

Our objectives were to document the rate of underwater calls from Weddell seals throughout the breeding season and monitor changes in this rate associated with the arrival of predators, such as leopard seals and killer whales.

Recordings of underwater calls at the Hutton Cliffs breeding colony were made from 19 October 1977 through 14 January 1978. Recordings were made automatically every hour for a duration of 2.5 minutes. With this time interval, we stored data from a 24-hour period on one side of a 90-minute cassette. A battery-operated Superscope C101A cassette recorder (frequency response 0.20–10.00 kilohertz) and a digital timer were housed in an insulated box and warmed with chemical heat-packs. We used an Interoceans R130 hydrophone (frequency response 0.03–10.00 kilohertz ± 1.0 decibels) dropped through a seal breathing hole to a depth of 6 meters. A tone generated by the digital timer separated each hourly recording on the cassette.

We counted the number of Weddell seals hauled-out at Hutton Cliffs each day from October 1977 through mid-January 1978. We also compiled sightings of killer whales and leopard seals from occasional helicopter flights, other investigators in the area, and icebreaker logbooks. Systematic visual surveys for leopard seals and killer whales were not conducted. Rather, we monitored the presence of these predators from the hourly recordings of their underwater sounds.

In the laboratory, one of two researchers listened to the cassettes and classified sounds as from Weddell seals, leopard seals, or killer whales. Weddell seal calls were divided into one of ten adult call categories (MT, MC, MP, MR, MK, MM, ME, MG, MH, MA) and a single pup call category (MQ) as described by Thomas and Kuechle (1982). Although leopard seals (Stirling and Siniff 1979) and killer whales (Jehl et al. 1980; Thomas et al. 1981) produce a variety of sounds, our samples were too small to score their calls into categories. For each hourly sample, the number of calls in 11 Weddell seal categories, one leopard seal

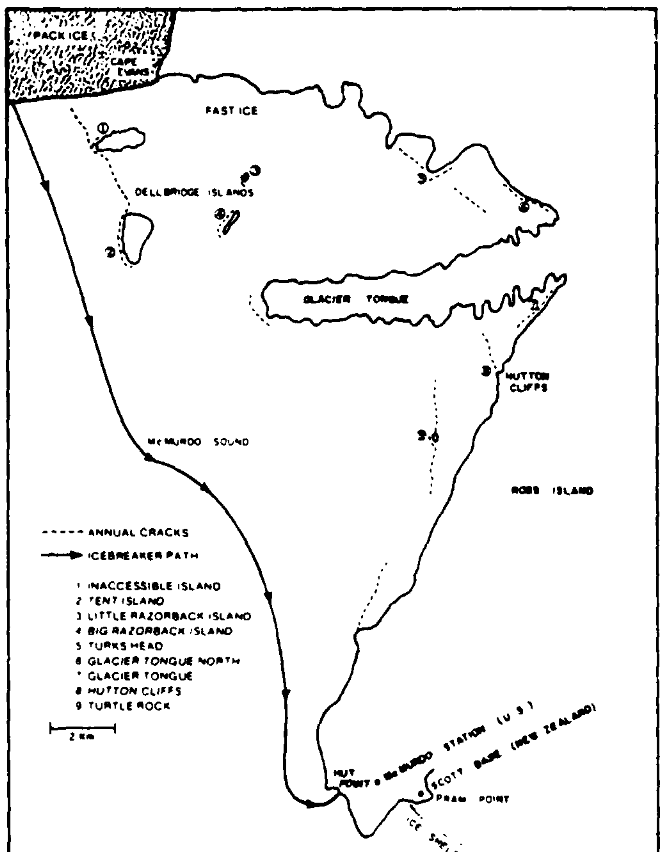

Figure 1. Map of McMurdo Sound, Antarctica, showing Hutton Cliffs, the fast ice edge, and the ice breaker path in December of 1977.

category, and one killer whale category, were divided by 2.5 to calculate the rate per minute. Data from each hourly sample were sorted into weekly intervals (starting on 1 October and ending with 8 January). Rates of calls in each category were plotted against weeks of the study and the period of sympatry of all three species was identified.

Weddell seals are highly vocal; during the peak breeding period we sometimes recorded nearly 20 underwater calls per minute at the Hutton Cliffs colony. Around mid-December, when mating is nearly complete and pups are being weaned, a sudden decrease to about two calls per minute occurred. Except for the MA call, all adult and pup (MQ) calls showed this decline (figure 2). This decline in call rate may not be solely the result of the end of breeding and subsequent dispersal of adults from the colony. This decrease in the number of calls by Weddell seals is concurrent with the arrival of leopard seals and killer whales into the fast ice.

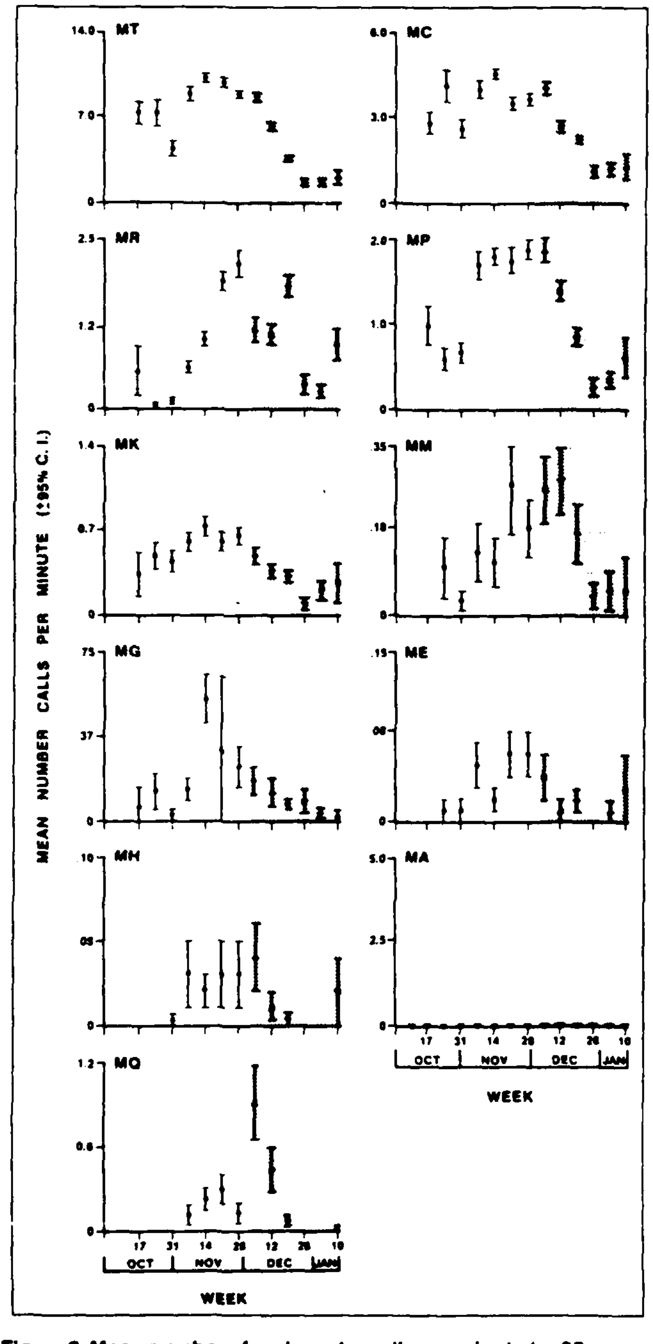

Figure 2. Mean number of underwater calls per minute (± 95 percent confidence interval) for types of adult Weddell seal sounds (MT, MC, MR, MP, MK, MM, MG, ME, MH, MA) and pup sounds (MQ). Stippled area shows period of sympatry with leopard seals and killer whales.

Data on hearing abilities in Weddell and leopard seals are not available. Hall and Johnson (1971) found the most sensitive hearing in killer whales to be between 2 and 32 kilohertz, a range which brackets the sounds produced by Weddell seals. Because they all produce sounds in the same frequency range (2–20 kilohertz, it is likely that killer whales, leopard seals, and Weddell seals hear each other. We believe that the decrease in number of underwater calls is an anti-predation strategy by all age classes of Weddell seals to avoid detection by killer whales and also may limit detection of newly weaned Weddell seal pups by leopard seals.

The channel cut by the icebreaker (figure 1) allows predators to move closer to Weddell seal colonies. Although we did not make systematic counts of killer whales and leopard seals in 1977, Thomas et al. (1981) surveyed this area during the austral spring of 1981 and reported many sightings of killer whales in McMurdo Sound in December and January. During a single flight, they saw 152 killer whales, with an estimated 50 animals in a single herd, including calves of the season. In January 1981, Thomas et al. (1981) made tape recordings of killer whales swimming in fast ice leads. Killer whales produced many sounds, but no calls were heard from nearby Weddell seals.

We first detected sounds from killer whales about 10 December 1977, with the majority produced during the next 2-week period. On the average, we detected about one call per minute (figure 3). Many killer whales were sighted in December 1977 near the ice edge or leads off the edge. In January 1978, the icebreaker channel allowed them to disperse throughout the Sound, and we were less likely to detect them with our recording system at Hutton Cliffs. This may explain the sudden decrease in killer whale sounds in late December (figure 3).

Leopard seals were detected by their underwater sounds from late November 1977 to mid-January 1978, with a peak of about 3.6 calls per minute around mid-December (figure 3). Leopard seals in McMurdo Sound produced the same sounds they produce near Palmer Peninsula (Stirling and Siniff 1979). In general, sightings of leopard seals were in pack ice, rather than fast ice. However, because underwater sounds travel long distances, Weddell seals at Hutton Cliffs probably heard sounds from leopard seals near the fast ice edge (about 20 kilometers away). Unlike killer whales which use leads to approach a Weddell seal colony, leopard seals can swim long distances under fast ice and haul out through breathing holes in the Weddell seal colony. As a result, the detection of distant leopard seal calls may be enough of a threat for Weddell seals to stop vocalizing.

During the austral spring, all antarctic marine mammals are vociferous. Predators, which do not have to avoid detection unless they are pursuing prey, have relatively large sound repertoires. For example, leopard seals produce five types of sonic sounds; these include buzzes, pulses, and frequency-modulated sweeps (Stirling and Siniff 1979) and perhaps three types of ultrasonic sounds (Thomas et al. 1982). Killer whales generate a variety of sounds over a broad frequency range, including pulses, buzzes, screams, and whistles (Jehl et al. 1980; Awbrey et al. 1982).

For a prey species, the number of sounds and their use is a compromise between the need to communicate with conspecifics for breeding and the need to avoid detection by a predator. The most vulnerable prey species, the crabeater seal, produces only a single call (Stirling and Siniff 1979). Its simple

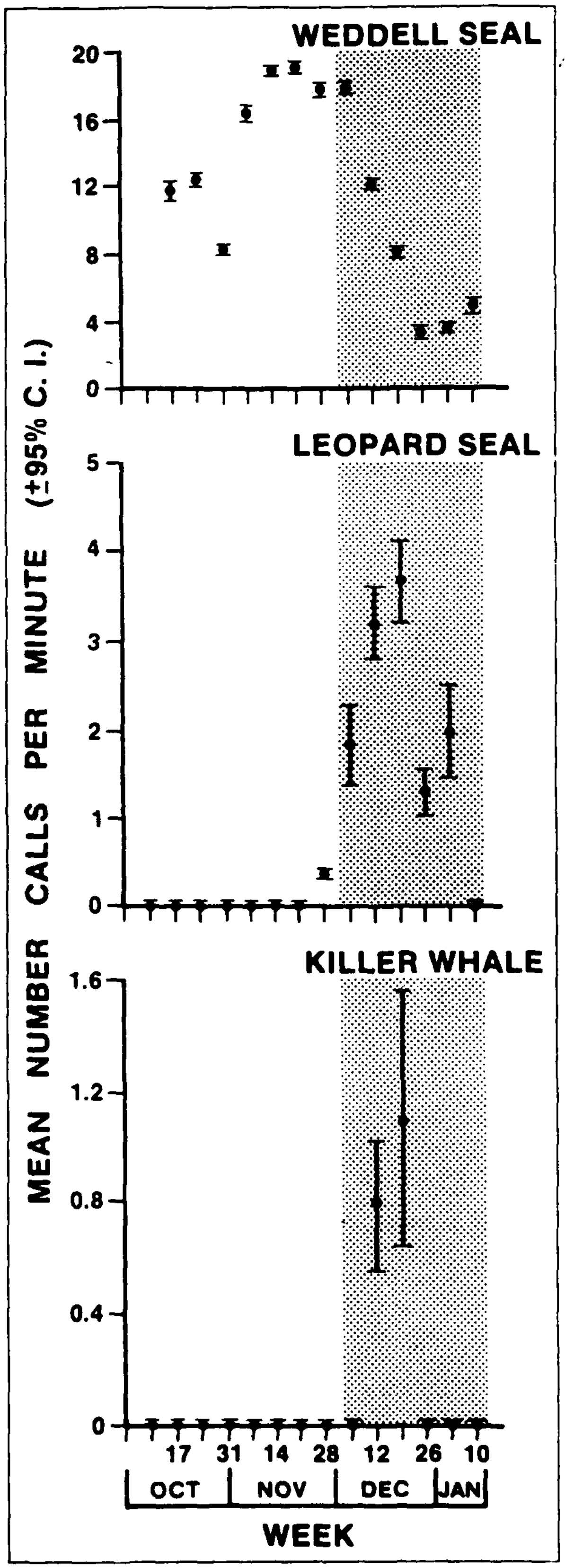

Figure 3. Mean number of calls per minute (± 95 percent confidence interval) for Weddell seals, leopard seals, and killer whales. Stippled area shows period of sympatry for these species.

sound repertoire also is associated with seasonal monogamy (Siniff and Bengtson 1977). In contrast, polygynous Weddell seals have 34 underwater sounds (Thomas and Kuechle 1982). We hypothesized that if fast ice provides Weddell seals a refuge from predators during breeding, then Weddell seals can risk advertising and defending underwater mating territories with loud sounds. Weddell seals also can afford a variety of airborne calls in surface pupping colonies and probably developed a large call repertoire due to their polygynous social system. However, when the fast ice habitat no longer provides isolation from predators, Weddell seals become silent to prevent detection. We suggest that Weddell seals have adapted the timing of reproductive events and abundant calls to precede the breakup of fast ice and subsequent intrusion of predators.

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