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McMurdo Sound

No latitude for error.
Sir Edmund Hillary

The stage for much of the drama I shall describe is McMurdo Sound, Antarctica. To the west is the continent; the Queen Victoria range towers above the shoreline. To the east, the Sound is bounded by Ross Island, derived from three volcanic cones and dominated by still-active Mount Erebus at 4,000 m. Locked between Ross Island and the continent, this small sea is protected from the major currents of the Antarctic Ocean. As a result, an ice sheet covers the southern portion of the Sound for most of the year (Fig. 1.1 and Fig. 1.2).

Large areas of the Sound begin to freeze as the autumn temperatures decline, usually in late April. By August the mean monthly temperature is −26°C, with daily minimums commonly as low as −40° to −50°C. At this time, the ocean surface is covered for miles with a layer of sea ice several feet thick that is interrupted in only a few places. A break in the ice always occurs along the shoreline, where the daily tidal changes continually raise and lower the level of the sea and prevent the bonding of land and water. Away from the shore, there are only scattered cracks, many of which freeze shut soon after they appear. Others, due to peculiarities in winds and ocean currents, remain open (with only a thin layer of ice) all winter. Along these cracks where the ice is thin, the Weddell seals (*Leptonychotes weddelli*) keep their breathing holes open during the winter. A seal breaks thin new ice with a blow from the top of its head; if too thick for that method, the seal cuts the ice open with its upper canines and incisors.

From a helicopter, these half to one meter diameter black breathing

holes are easily seen scattered over the icy plain. To a Weddell seal, its hole is critical. It is the seal's link to the sea and food, and after a dive its link to the surface and life-sustaining oxygen. How does a seal perceive its hole when on top or below the ice? When on top of the ice, its angle of view is very oblique, and even from a short distance the hole cannot be seen. Such features as ice hummocks around the cracks are probably important aids. Also, the seal seldom wanders more than three meters from its hole.

The seal's problems under the ice are much different. Its ability to see distant objects is enormously reduced, even though these waters are probably the clearest in the world. In the summer, the holes appear as brilliant beacons when the sunlight beams through. In the winter, when the sun does not rise for three and a half months, the beacons are out. Furthermore, a seal can hold its breath for only a finite time. Therefore, during both summer and winter the seal must be able to navigate with pinpoint accuracy, and it must not run out of oxygen before it reaches its destination. The seal's skill in and methods of under-ice orientation together form one of the most fascinating problems in animal behavior. But rather than get ahead of my story, the setting of the stage should be completed.

Although the long winter nights and low temperatures that bring about the freezing of the sea seem severe at McMurdo Sound, they are relatively mild compared to the conditions of other parts of Antarctica. At the South Pole, the sun sets for six months of the year, from March 20 to September 20. Temperatures in the coldest known part of Antarctica are at the 3,488 m high Vostok Station, which is located well inland on the polar plateau. Here, temperatures sink to a monthly mean in August of −68°C. The lowest observation was −88°C, which was recorded August 24, 1960. This is the lowest, naturally occurring ground-level temperature on this planet. In comparison, the coldest month in the Arctic averages only −35°C, with a record low of −68°C.

The temperatures in the Arctic and at McMurdo Sound are not so extreme because of the lower altitude and because of the ameliorating effect of the sea. At McMurdo, the sea temperature is unusually uniform, averaging −2.0°C year round. The annual temperature range is less than 1.0°C, and there is almost no variation with depth. The temperature changes less than .5°C, ranging from the surface to 275 m. In contrast, the temperature range of the sea off San Diego in the summer may be as much as 11.0°C between the surface and 30 m.

Temperature is not the only condition that is less severe in antarctic waters. Ocean currents are rarely more than 3 or 5 km per hour, but the average surface wind at Hut Point, which is in the most southern sector of McMurdo Sound, is 24 km per hour. Possibly the windiest place in the world is Cape Denison, which Douglas Mawson's overwintering party sadly learned. The average annual wind speed was 73 km per hour.

There is very little continental shelf surrounding Antarctica; the water becomes deep near shore. Only five or six km from Hut Point the depth is 600 m. The nearest large land mass is South America, the tip of which is about 900 km from the tip of the Antarctic Peninsula. Looking at these two fingers of land on a globe, they appear to be reaching to touch one another as they once did millions of years ago. Now they are separated by one of the wildest seas in the world. Everywhere else around Antarctica this great southern ocean separates the continent from other significant lands by more than 1,600 km. Such a formidable barrier and such unwelcome weather prevented an invasion by land animals. There are no polar bears or Eskimos; indeed, the most significant residents on this fifth largest continent (33 million square km) are a few insects and mites, the largest being less than 1.6 mm long. In contrast, the sea is rich with life and is as productive as any sea in the world.

If it were not for scuba equipment and deep sea underwater cameras, we would be rather ignorant of the context in which the animals of the sea live. The usual method of collecting data about the bottom, for example, is either to lower a grab or dredge the floor and examine the specimens brought up in this equipment, or to set baited traps for the same purpose. Can you imagine describing a tropical rain forest by similar random-sampling methods? What kind of an impression would we have of a forest if we had never seen it, and all the information about it had been gathered by piecemeal sampling from several hundred to thousands of meters above it without ever being in the forest itself? Fortunately, technological achievements have increased our mobility and observational skills, and our understanding of the sea is broadening.

For the last few years, scientists using scuba equipment have begun to describe in detail the shallow bottom communities of McMurdo Sound. An intensive study of this kind has been carried out by P. K. Dayton and G. Robilliard near Hut Point (Dayton, Robilliard, and Paine, 1970). At the time, these two were graduate stu-

dents at the University of Washington. During an intensive period of study between October 15 and December 11, 1967, they made nearly 200 dives. They followed a similar schedule in 1968. Some of these dives lasted one and a half hours, and in some cases they descended to 60 m. They have described three zones down through these depths.

Zone I extends from the surface to 15 m (Fig. 1.3*a*). It is a rather sterile area, the least inhabited, because ice forms on the bottom. It does so in the form of large, beautiful crystals, which accumulate into mats up to 0.5 m thick (Fig. 1.3*b*). As these crystal clusters grow, they become more buoyant because the specific gravity of ice is lower than that of water. In time, depending upon how well-anchored the ice is, it will break free and rise until it comes against the underside of the sea ice. When "anchor ice" lifts from the bottom, it frequently carries with it animals that have become frozen in it. In some instances, objects as heavy as 25 kg have been carried away. The result is that almost all sessile, or stationary, animals that attempt to settle in

Figure 1.3. (*a*) This remarkable seascape photograph of zone I was a time exposure taken at a depth of 20 m and facing toward the surface. The slit of light in the right-center is a break in the ice 245 m away. The picture was taken in October, a period of maximum water clarity. (Photo by John Oliver.)

this zone are doomed. (Rather interesting is the observation that many of the sea urchins and starfish that become frozen in the anchor ice recover from this state and are able to resume normal activities when the ice melts.)

Zone II ranges from 15 to 30 m below the surface. It consists of a cobble and lava substrate upon which many sessile and motile animals are found (Fig. 1.4). Anchor ice also forms in this zone, but in a much more dispersed manner so that few sessile animals are affected.

Zone III begins 31 m below the surface; its lower limit is unknown. The bottom is covered with a thick mat of siliceous sponges, which is sometimes over 1 m thick (Fig. 1.4). It is rich in animals living on its surface and within the mat. It has been estimated that there are more than 12,500 animals per liter of mat substance. The upper limit of this zone is the lower limit of anchor ice formation. Why the ice stops forming at about 30 m is unknown.

Figure 1.3. (*b*) In this shallow water photograph, the anchor ice growing in large clusters on the bottom can be seen in the foreground. The diver just below the tidal crack is carrying an underwater camera.

Little is known about the pelagic, or open ocean, animals that live in the midwater depths. Aside from the zooplankton (the small, drifting invertebrates), the most abundant animal of all is the squid. Few specimens have been collected, yet it is the most important food item of the emperor penguin and, in some areas, of the Weddell seal. Based on the size of squid beaks found in the stomachs of emperor penguins, some of these squid may have been one-third to two-thirds in meter length.

Of the two or three most common species of fish, the antarctic herring, *Pleuragramma antarcticum*, which is similar in size and appearance to the herring of temperate waters, is the most abundant; it occurs from near the surface to several hundred meters below. The next most abundant fish, similar in size, is the ice-loving *Trematomus borchgrevinki*. (In many cases, only scientific names have been given to animals of the Antarctic, and this fish is an example. It was named for Carsten Borchgrevink, the leader of the first land-based, overwin-

Figure 1.4. Seascape of zones II and III. This was a time exposure taken at 30 m and facing down over a bluff. The bottom of the valley is 60 m deep. The white sponge at the base of the valley (arrow) is 1.3 m tall. (Photo by John Oliver.)

tering expedition to Antarctica.) This fish lives under the sea ice near the surface, and it utilizes the crystal layer formed underneath the sea ice as a place to rest and hide.

The largest fish that occurs in antarctic waters, *Dissostichus mawsoni*, was until recently known from only a few specimens that were stolen from Weddell seals when they brought them to the surface to eat (Fig. 1.5). The largest specimens weigh up to 65 kg and are over one and a half meters long. They look almost like grouper or black sea bass. In the last two years, A. L. DeVries of the University of Illinois has devised methods of catching these fish on hooks set in a vertical array from the sea floor to just under the ice (Raymond, 1975). Most of the fish are caught at midwater depths (150 to 300 m), and they appear to be rather common.

The most unusual fish in the McMurdo Sound area is the ice fish, *Chaenocephalus aceratus*, so named not because it lives in the ice, but because it is so pale, and for good reason (Fig. 1.6). It has no red blood cells, no hemoglobin (the blood respiratory pigment), and no myoglobin (the muscle respiratory pigment) (Ruud, 1965). Its gills are white, its heart is pale yellow, and its blood is gin clear. Again, there has been little success in collecting ice fish at McMurdo Sound, except for those taken from Weddell seals.

The birds and mammals that occur consistently in McMurdo Sound can all be counted on the fingers of one's hands. Such a simple ecosystem of birds and mammals is uncommon.

Of the birds, the south polar skua, *Catharacta maccormicki*, sometimes called the eagle of the Antarctic, is the most commonly seen. It is large, strong flying, and rapacious (Fig. 1.7). It frequents the refuse dumps at most of the antarctic bases. This bird has even been seen at the South Pole. Its stay in the area is seasonal, from October to March.

Only two species of penguin are seen in McMurdo Sound: The first is the Adelie penguin, *Pygoscelis adeliae*, which is an average-size penguin standing 76 cm tall and weighing up to 6.5 kg (Fig. 1.8). Its principal foods are fish and krill. (The latter is a shrimplike invertebrate called "krill" by the Norwegians. The two main species of krill in Antarctica are *Euphausia superba*, the primary food of the large whales, and the more coastal *E. crystallorophias*.) The Adelie penguins do not remain in the area during the harsh winter. They spend March to October in the pack ice, that large region of broken sea ice surrounding the antarctic continent. The second is the emperor pen-

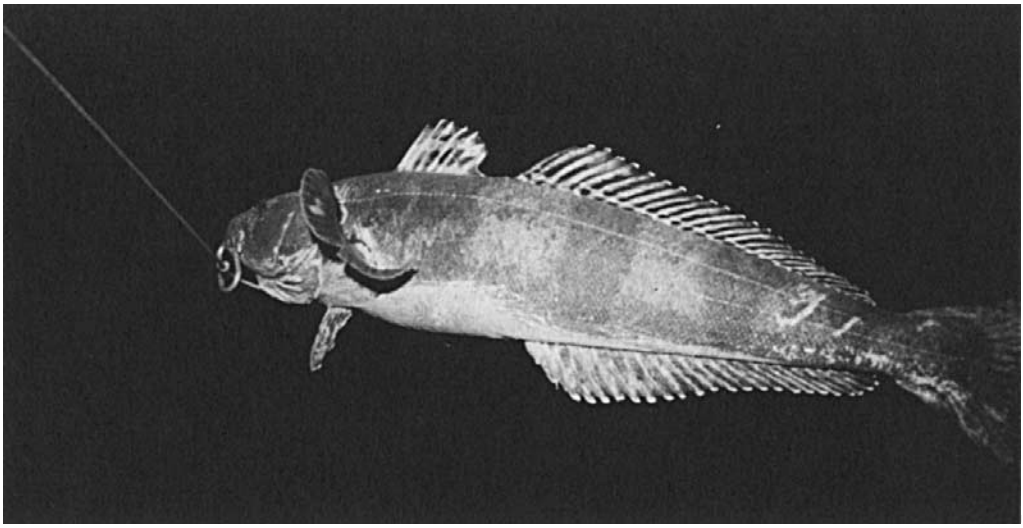

Figure 1.5. Antarctic cod, *Dissostichus mawsoni*, the largest fish known to occur in McMurdo Sound. The fish pictured was captured by a seal and taken from it. The carabiner holding the fish is about 8 cm long. This fish was medium size and probably weighed 25 kg.

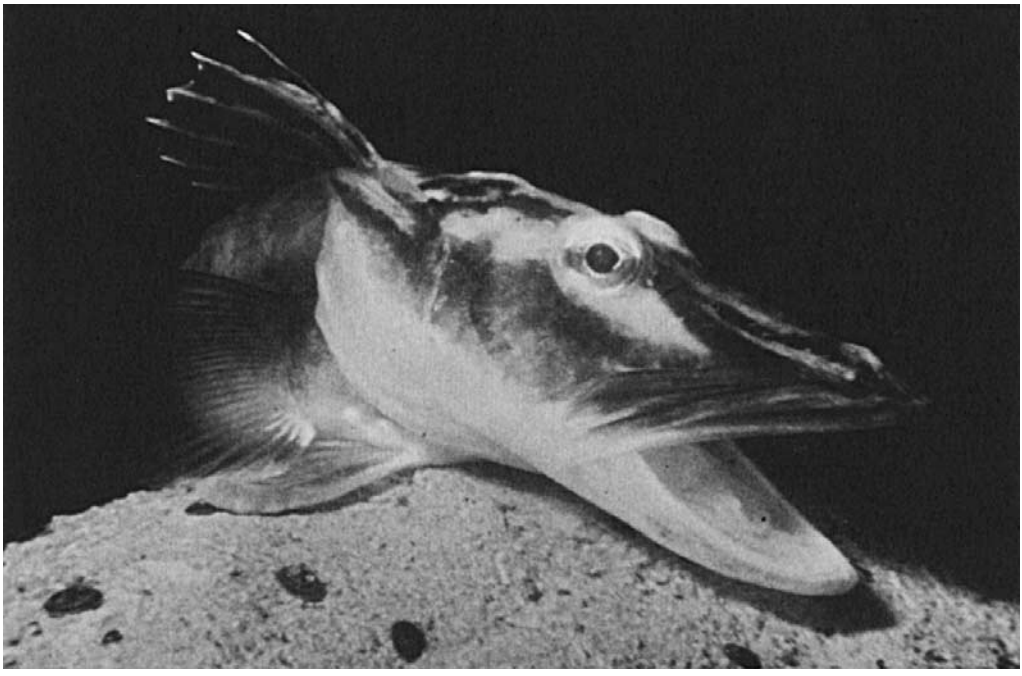

Figure 1.6. Antarctic ice fish, *Chaenocephalus aceratus*. This fish is unusual in its lack of red blood cells, or any oxygen binding hemoglobin in the blood or myoglobin in the muscle.

Figure 1.7. South polar skua, *Catharacta maccormicki*. The wingspan is 1.3 m and it weighs 1.8 kg.

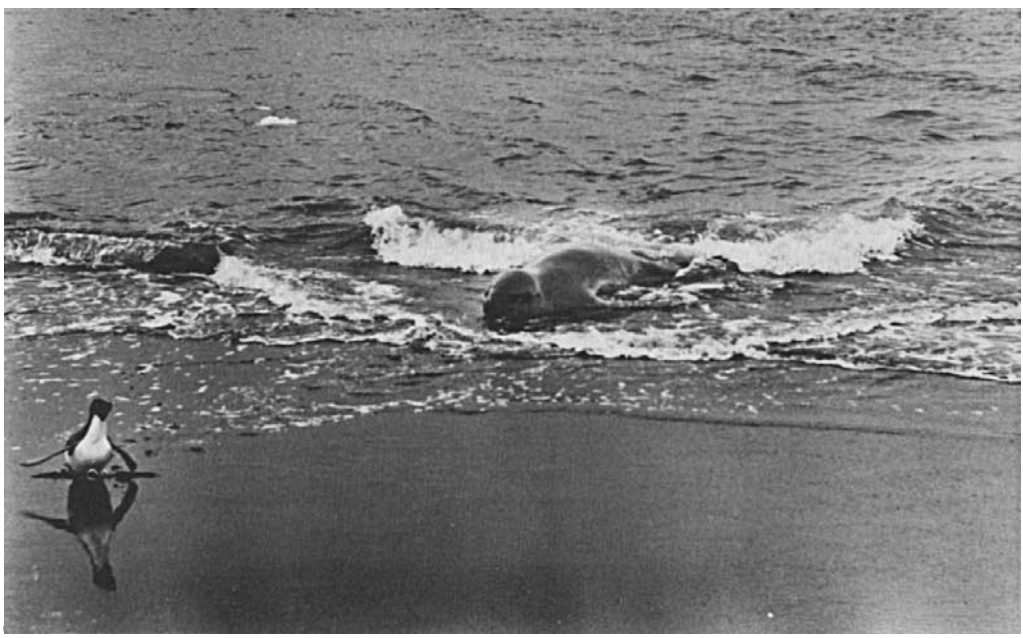

Figure 1.8. An Adelie penguin, *Pygoscelis adeliae*, being chased ashore by a leopard seal, *Hydrurga leptonyx*.

guin, *Aptenodytes forsteri*, which is the largest diving bird in the world (see Figure 1.9). It stands up to 1.2 m tall and weighs as much as 45 kg. If any bird or mammal is more bound to the southern high latitudes than the Weddell seal, it is the emperor penguin. These birds usually nest on sea ice adjacent to the continent or on nearby islands. They begin to arrive at the breeding sites in April and do not depart until February of the next year. This leaves them only two months to wander at sea before returning for another breeding season.

Four species of mammals, other than the Weddell seal, are commonly seen in McMurdo Sound. Like the skua and Adelie penguin, they are only summer visitors. Almost every summer, killer whales, *Orcinus orca*, and minke whales, *Balaenoptera acutorostrata*, come south into the Sound, using the large open leads and the ice breaker channel made by the U.S. Coast Guard. The minke whales, which

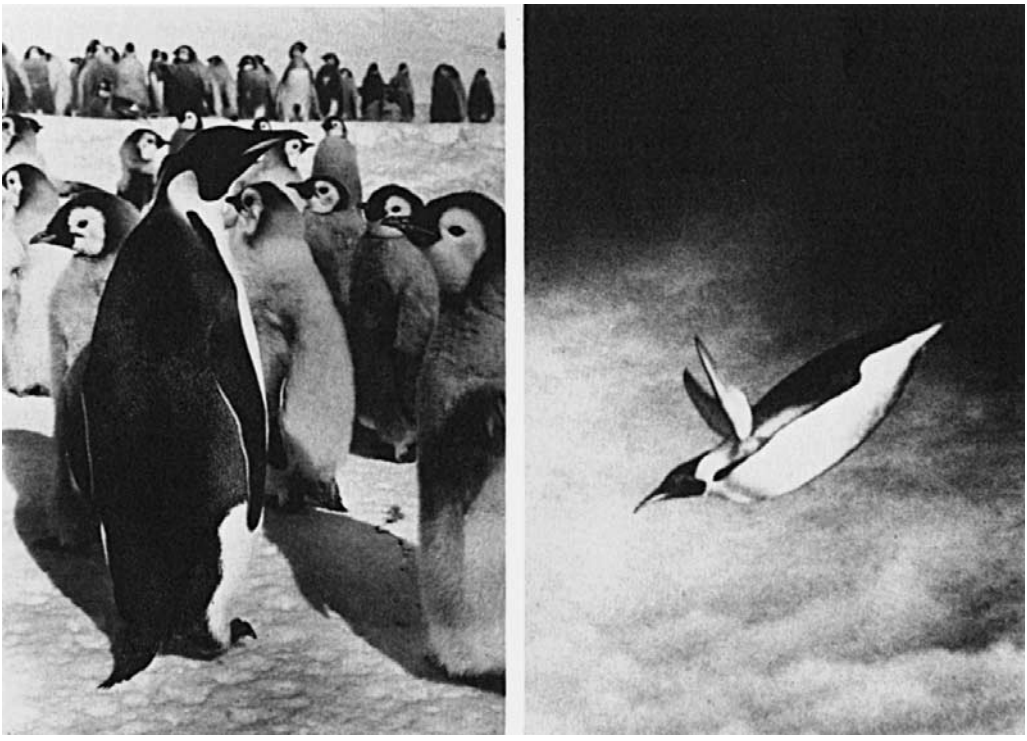

Figure 1.9. (*Left*) An emperor penguin, *Aptenodytes forsteri*, adult in attendance with a group of chicks. (*Right*) Emperor penguin adult diving to depth.