LIFE IN THE ANTARCTIC

With illustrations from a visit to Bransfield Strait, January 2006.

For parents and teachers:
Background information for the children's book
"Feed Me! The Story of Penny the Penguin Chick"
by Wolf Berger
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The coldest place on Earth

The Antarctic continent has the coldest temperatures on Earth, and is surrounded by great expanses of very cold water – some with temperatures below the normal freezing point (zero deg. Celsius, 32 deg. Fahrenheit). The continent is almost entirely covered by a thick ice sheet. Even the Antarctic Peninsula, farthest north, is largely covered by ice (Figs. 1-3).

Figure 1. Glacier at the edge of the sea, Bransfield Strait, Antarctica.

Figure 2. Ice-carved rocks, glacier and icebergs, Gerlache Strait (southern extension of Bransfield Strait).

Figure 3. Glaciers at the edge of the sea, icebergs, Bransfield Strait.

Life among the icebergs

Despite being inhospitable for much of the year, in summer the seas around Antarctica are visibly teeming with life. Penguins and other seabirds are abundant, as are seals. Also, whales can be seen (they used to be much more abundant, but were decimated by overhunting in the last century).
All these creatures do not seem to mind the cold water; on the contrary, they are living right within it, and at its edge (Figs. 4-9).

Figure. 4. Chinstrap Penguins “porpoising” off Deception Island.

Figure 5. Gentoo Penguins emerging from icy water. Gerlache Strait.

Figure 6. Albatross near entrance to Bransfield Strait.

Figure 7.   Giant Petrel, Bransfield Strait, Jan. 2006.

Figure 8. Humpback whale sounding in Gerlache Strait (southern extension of Bransfield Strait). Jan. 2006. The markings on the tail are specific for each individual whale, allowing the mapping of migrations.

Figure 9. Orca (killer whales): one male, two females, Gerlache Strait.

We know that the waters are freezing cold, as long as ice is in the water. Icebergs split off from glaciers reaching the water's edge. Tabular icebergs stem from glaciers sitting on a shelf. In the area where the photos were taken (Bransfield Strait, January 2006), no sea ice remained – it had melted.

Figure 10. Small icebergs in Gerlache Strait, from local glaciers.

Figure 11. Tabular icebergs, Bransfield Strait, drifting in from the eastern side of the Antarctic Peninsula.

Food, the big attractor

What makes the Antarctic region such an attractive place for so many birds and mammals is the great concentration of food that is available in Antarctic waters in the southern summer (December to February).

During this period in the year, the days are very long and there is plenty of sunlight for photosynthesis. The fearsome winds that usually travel around the Antarctic continent are the strongest on the planet (Fig. 12). They keep the water moving in strong currents from west to east around the continent (Fig. 13). The currents help bring nutrients to the surface, by deep vertical mixing. When summer sets in and the sea ice melts the water becomes more stratified, providing a surface layer for diatoms to grow, that is, minute algae that use these nutrients together with sunlight to produce enormous green masses of food for small zooplankton organisms (Fig. 14). Among these is the "krill," a two-inch long planktonic shrimp (Fig. 15).

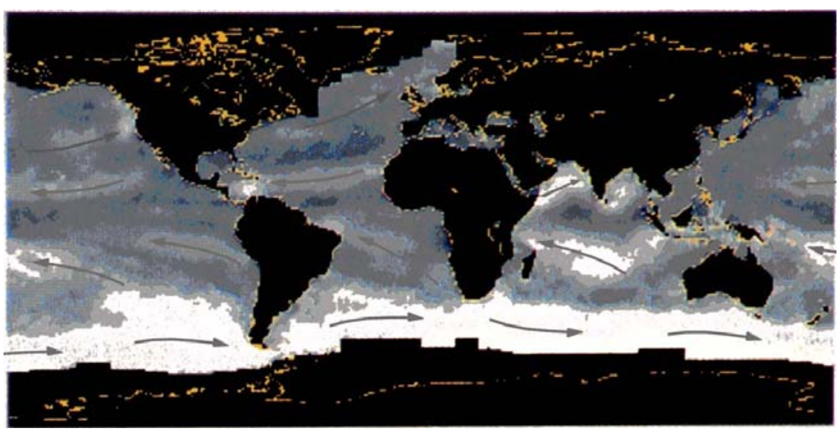

Figure 12. The strongest winds on Earth are found around the Antarctic continent (white fields denote strong winds). Winds are driven by temperature gradients, and these are especially strong in the Southern Ocean (see Fig. 13). The reason is the locking in of very cold temperatures on the continent (by the ice) and the unobstructed path around the polar region, where winds (and currents) can build up to high speed. (Source: NASA JPL, as given by K. Kuenzi in Hempel and Hinrichsen, 2002, modified.)

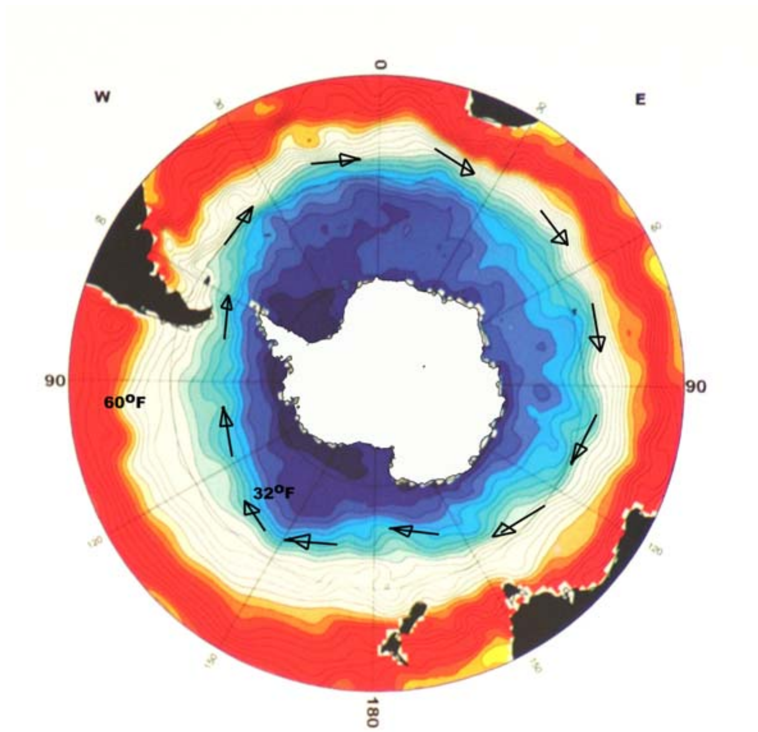

Figure 13. Temperatures in the Ring Current around Antarctica vary from below zero (Celsius; dark blue - light blue boundary) to about 15 degrees Celsius (60 degree Fahrenheit, yellow). Most of the fast-moving water occurs where the temperature gradient is at maximum (polar front), around 5 degrees Celsius (41 deg. Fahrenheit). It is here that diatom productivity is especially high (and seabirds are especially abundant). (Source: D. Olbers in Hempel and Hinrichsen, 2002, modified.)

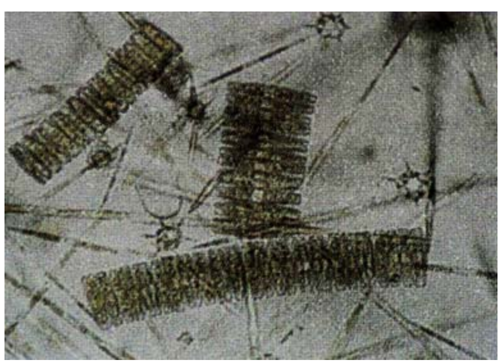

Figure 14. Typical Antarctic diatoms: thin and needle-like (*Pseudonitzschia*) and stacked disks (*Fragilariopsis*). These provide food for krill. (Source: V. Smetacek et al. in Hempel and Hinrichsen, 2002. Copyright Wittheit Bremen.)

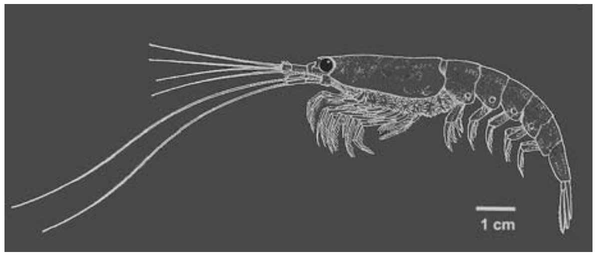

Figure 15. Krill (euphausid shrimp), about 2 inches body length. Krill are the staple food of penguins, crabeater seals, and baleen whales. (Source: After a drawing of R. Dietz, 1962, modified.)

Penguins, denizens of the shores of the Southern Ocean

All around the shores of the Southern Ocean – the great cold deep body of water moving eastward – we find various species of penguins large and small. Among the most common are the three species of *Pygoscelis* known as Gentoo, Chinstrap and Adelie Penguins (Fig. 16). Of these, the Gentoo is the most northerly, the Adelie the most cold-adapted. The Chinstrap is unusually abundant near the northern portion of Bransfield Strait (Fig. 17) where it has an enormous breeding colony on Deception Island (Fig. 18).

Figure 16. The three species of *Pygoscelis* (*P. papua; P. antarctica; P. adeliae*). They are abundant in Bransfield Strait (Figure 17).

Figure 17. The northernmost tip of Antarctica – the Antarctic Peninsula – is separated from South America by the Drake Passage, named after the British pirate and sea captain Francis Drake (1540-1596), who served Queen Elisabeth I and was licensed (by her) to do damage to Spanish ships and ports engaged in establishing colonies in South America. Bransfield led the British Expedition that explored the strait named in his honor, in 1820.

Figure 18. Deception Island, Bransfield Strait, is famous for its huge Chinstrap colony.

Deception Island has ongoing volcanic activity. Eruptions and storms bring volcanic ash to snow and ice fields. The ash-rich layers in glaciers make for interesting patterns in the moving ice (Fig. 19).

Figure 19. Sea cliff made by a glacier on Deception Island, next to the Chinstrap Penguin colony. The ice is gray from volcanic ash contained in it. As the ice melts, the ash collects at the foot of the ice cliff. Waves then redistribute it, nourishing the beach.

Figure 20. The Chinstrap Penguins (like other species) are not afraid of human spectators, and go about their business without paying much attention to photographers (Penguin Island, Bransfield Strait).

Figure 21. Feeding the young (here: Adelie Penguins) is a strenuous never-ending task all summer long, for the adult birds. These juveniles are ready to begin the moulting or already engaged in getting their adult feathers.

Figure 22. Subadult Adelie Penguins in the process of moulting, Jan 2006, Bransfield Strait. The moulting seems early, given the clement conditions. Adelies are pre-adapted to a short summer.

The general warming seen on the Peninsula (in the retreat of snow and ice) favors expansion of the Gentoo Penguins, whose breeding habits fit with a longer season. When the season is longer, the birds feed their young longer so they get heavier and have a better chance to survive (Figure 23). (Soper and Scott, 2004: in low latitudes Gentoo are heavier than in high).

Figure 23. In Gentoo, sub-adult birds still being fed take on the appearance of adult birds, even before the moult.

Figure 24. In Adelies, arguments may arise when juveniles beg food from adults other than their parents. Or perhaps when parents believe the feeding season has ended, and the offspring does not agree.

There are a number of ways to cope with warm summer days (Fig. 25). A standard stance, spreading wings while resting, allows heat to dissipate from the underside of the flippers. Close contact with the cool rocks (which retain the average temperature below a thin layer heated during the day) may conduct away heat from the belly. As mentioned, the water always is near freezing, so entering it will bring instant relief, for the adults. Eating snow may be a way to cool off for sub-adults not ready to enter the water.

Figure 25. Ways to cool off (clockwise): flippers exposed to wind, close contact with the ground, taking a dip in ice water, eating snow.

The number of breeding pairs in the *Pygoscelis* penguins number in the millions, with Adelies being the most abundant (but apparently declining relative to the two other species). Emperor Penguins are roughly a hundred times less abundant. However, the Emperor has achieved iconic status, because of its size (almost twice the height of the Chinstrap, and six times the weight of the Gentoo, at just short of 4 feet and with a weight of 36 kg). Its peculiar habit of breeding on ice far away from the water’s edge means that much of the feeding of the young depends on stored fat. Thus, its weight varies greatly over the seasons.

No Emperor Penguins were seen during the trip here reported on, to Bransfield Strait. The image (Fig. 26) was created using Adobe Photoshop, and working from a photo taken at the Zoological Museum in Hamburg, of a mounted specimen.

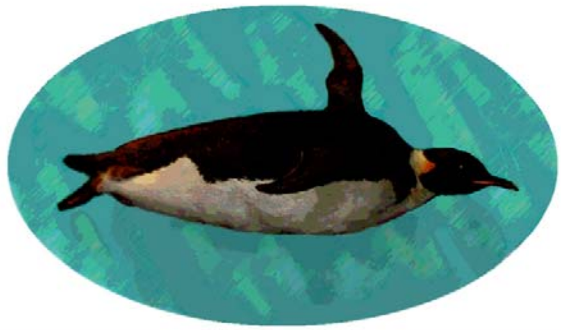

Figure 26. Emperor Penguin (*Aptenodytes fosteri*), swimming under water. Based on a photograph of a mounted specimen in the Zoological Museum, Hamburg. The species occurs all around the shores of the Antarctic.

The image shows nicely the typical spindle shape that allows penguins to move at considerable speed through the water, with little effort. Short, interlocking feathers and a subcutaneous layer of fat keep out the cold.

Many penguin species lay two eggs but end up raising only one chick. In some species, two eggs hatch, but one chick is left to starve, the bigger one getting all the food. In some species (erect-crested penguins, royal penguins, macaroni penguins) one egg is much larger than the other, and the smaller one is abandoned as soon as the larger one is laid. The Emperor penguin male broods one egg sitting on its feet, and the parents raise one chick.

The patterns suggest the following: The simplest case is that of the Emperor: there is room for one egg on the feet and in the pouch, and there is just enough food for one chick if everything works out. The species with one very small and one very large egg are adapting to shrinking resources or changes in predation patterns on a scale of thousands of years (which is the scale relevant to evolution). The small egg is a memory of the good times in the past, when it was possible to raise two chicks, in a good year. Laying two eggs has become a waste of resources. The species that have two eggs but restrict themselves to raising one chick only (when times are bad) are betting on good times (two chicks), but have a fallback position (if not two, then at least one fat one). The tem "insurance" in this context (used by some writers who contemplated the subject) is not appropriate, the term "gambling" is. Producing viable offspring is a gamble; the stake is eggs and effort.

Regarding geologic history, bones of true penguins are found in Eocene deposits in New Zealand. These birds, using their wings to fly in the water but not in air, have been around for at least 40 million years (Davis, 2001). The oldest fossils, then, are from regions bordering the Southern Ocean. In the Eocene, the nature of the circumpolar sea was quite different from today. There was then no large ice cap on the adjacent continent, and the Tasmanian Straits and Drake Passage were much narrower than now. Penguins evolved and diversified since then, on a cooling planet. The largest specimens were nearly as tall and as heavy as sumo wrestlers.

The modern genera (with 16 or 18 species, depending on how one counts species) originated within the modern ice ages (last 3 million years). This geologic period (the one that also produced humans) is characterized by very large long-term fluctuations in climate and ocean productivity, thus rewarding an ability to adapt to changing conditions. The most important requirement for a successful penguin existence is high productivity of the nearby ocean. High productivity regions are present off Peru and around the Galapagos, and these are the northernmost habitats for penguins. The question of why penguins are restricted to the southern hemisphere is not solved. A common explanation is that they are unable to cross the warm waters of the tropics because of high temperatures there. More likely, areas of low or unreliable productivity levels provide the barrier.

One cannot discuss the question why there are no penguins north of the equator without taking account of the ice age history of upwelling regions. In principle, high-yield upwelling areas suitable for penguins are dependent on diatom production. Diatoms need silicate in the water. The upwelling areas that fulfill this criterion are close to the Antarctic (whose waters are always rich in silicate), all other upwelling areas run out of silicate from time to time (for reasons not entirely clear; e.g. see Berger and Lange, 1998; Berger and Wefer, 2002). Thus, on the time scale of tens of thousands of years any pioneer penguin populations just north of the equator would have found no place to feed from time to time and thus left no offspring.

In short, penguins evolved in the Antarctic regions because reliable silicate-rich upwelling first arose there, providing a diatom-based food chain since the Eocene, 40 million years ago. They never left the Antarctic, except to go to the outlying upwelling regions fed by Antarctic waters (at depths below the warm surface layers).

The feeding of the southern upwelling zones with silicate-rich cold water from the Southern Ocean is greatly enhanced whenever North Atlantic Deep Water (NADW) is sent at depth from the Atlantic to the Antarctic mixing ring. The pattern of this process is nicely seen in a drawing published in the classic textbook by Sverdrup, Johnson and Fleming, in the 1940s (see Fig. 27). NADW production started up in earnest around 10 million years ago. As a result, we should see an expansion of habitats suitable for penguins around that time. Similar expectations hold for all birds and mammals that depend on diatom-rich upwelling.

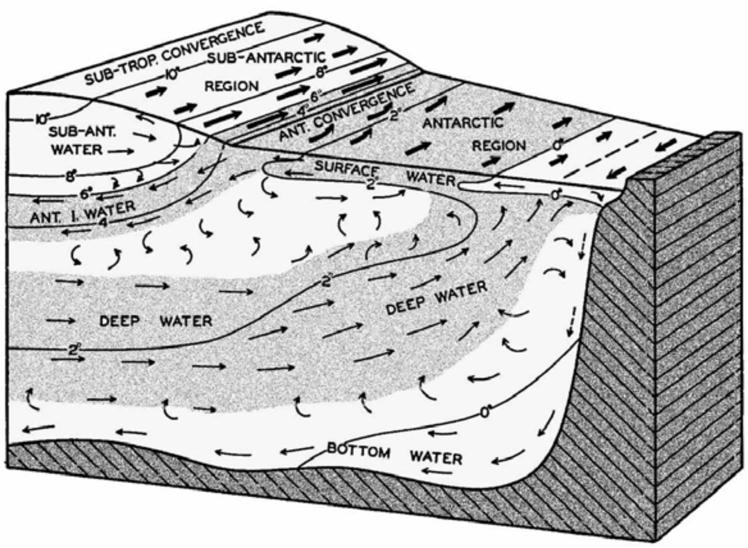

Figure 27. Influx of deep water from the Atlantic into the Antarctic Ring, and redistribution of (silicate-rich) waters to adjacent ocean regions in the southern hemisphere, as "Antarctic Intermediate Water." When silicate from this water layer becomes available to upwelling areas off South Africa and South America, it stimulates diatom growth, resulting in high food production for fishes, birds and mammals. Vertical scale distorted, expanding upper layers. (Source: Sverdrup et al., 1942, Fig. 164, shading added.)

The seabird season

The one- to two-month long pulse of high diatom production in the Southern Ocean during the ice-free summer season is centered on December (Wefer, 1989) (see Fig. 28). It supports the breeding efforts of a rich variety of seabirds besides penguins: many different types of petrels, the Antarctic Shag (a kind of cormorant; Fig. 31), the Snowy Sheathbill (a scavenger in penguin colonies; Fig. 32), the Skua (a hunter of other birds; Fig. 33), the Kelp Gull, and the Antarctic Tern (Fig. 34). The timing of egg-laying (in November) is such that hatching of chicks occurs when zooplankton becomes abundant. Zooplankton populations lag somewhat behind the phytoplankton bloom on which they feed.

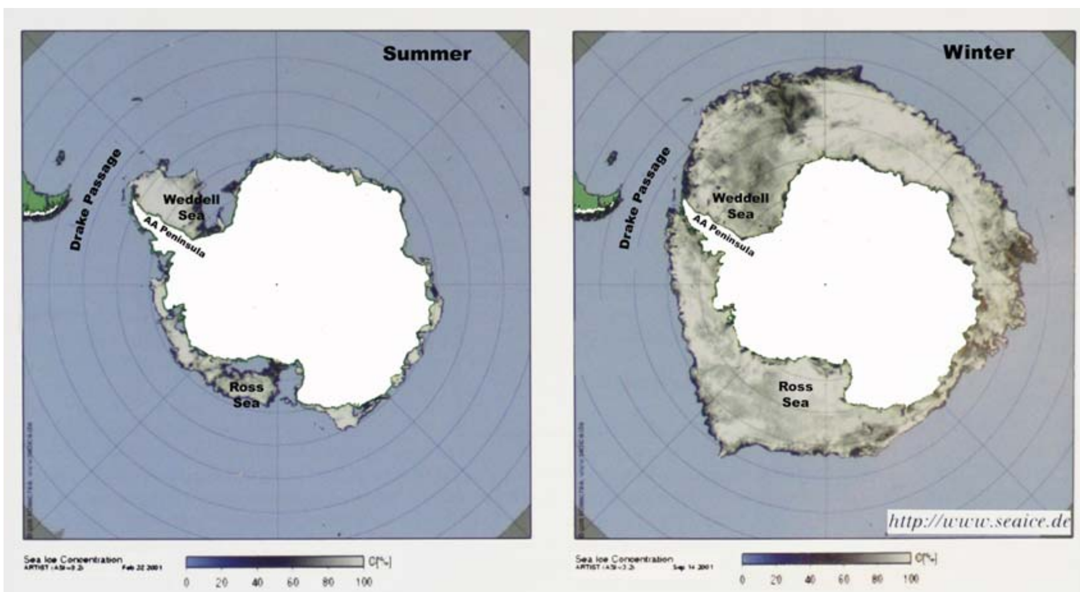

Figure 28. Extent of sea ice around Antarctica in southern summer (left) and winter (right). Darker shades indicate less complete coverage with ice. (Source: Klaus Kűnzi in Hempel and Hinrichsen, 2002, modified.)

Among the most conspicuous petrels in the vicinity of the entrance to Bransfield Strait are the Cape Petrel (*Daption capense*) and the Southern Giant Petrel (*Macronectes giganteus*); the first for its distinct wing patterns, the second for its impressive size (2 m wingspan). The Cape Petrel's garb is mainly black and white; its wings (with a span of up to 3 feet) have a striking symmetrical pattern reminiscent of some butterfly markings. It is commonly seen gliding just above the waves, wing tip almost touching the

Surface of the water, flapping rapidly in intervals to gain speed or height (Fig. 29).

Figure 29. Cape Petrel hunting for fish, squid and krill. Drake Passage.

In the Southern Giant Petrel, adults and juveniles have distinctly different plumage (Fig. 30). The ecologic niche of this species is that of a vulture; adults were seen closely overhead, patrolling the beach zone (Fig. 30) and also tearing at carrion, on the beach.

Figure 30. Southern Giant Petrel, northern entrance to Bransfield Strait, January 2006. Left: patrolling the beach at about 30 feet overhead. Middle: Adult on the nest. Close approach discouraged by likelihood of being spat at, with an ill-smelling stomach oil. Right: Juvenile taking off from the water.

Figure 31. Antarctic Shag, a blue-eyed cormorant (*Phalacrocorax atriceps bransfieldensis*). Adult feeding immature bird, in the cliffs of Paradise Bay, Bransfield Strait. A second juvenile (not shown) was present in the nest.

Figure 32. Snowy Sheathbill (*Chionis alba*) on Joinville Island, associated with a colony of Adelie Penguins. The bird scavenges spilled food and is reported to steal food during transmission from adult to chick penguins. It flies north across the Drake Passage during winter, but prefers walking when in summer camp.

Figure 33. Antarctic Skua (Brown Skua, *Catharacta antarctica*). The top predator among the seabirds, a bold and aggressive raptor. Takes eggs and juveniles of penguins, terns and shags, and forces adult shags to disgorge their food by pursuing them and tugging on wings and tail feathers. They stake out a territory during breeding time, such as a penguin colony, which supports them. The bird shown is taking a bath in a small pond of meltwater.

Figure 34.The Antarctic Tern (*Sterna vittata*) is a common sight along the shores and in the bays of Gerlache Strait, at the southern extension of Bransfield Strait. They plunge-dive for krill and small fish. They are preyed upon by skuas; small groups of terns will dive on passing skuas to make them leave the area.

Of seals and whales

At the northern end of Bransfield Strait we find “Elephant Island,” named after the Southern Elephant Seal (*Mirounga leonina*), the largest living seal in the world. In high summer, on nearby Penguin Island (a small volcanic island off King George Island to the southwest of Elephant Island) one can see rows of enormous Elephant Seals hauled out on a gravelly beach, resting, fasting and moulting (Figs. 35, 36).

Figure 35. Southern Elephant Seals hauled out along the shore, in the process of renewing their skin (moulting). Contact with the ice-cold water brings relief from heating up on long summer days.

Figure 36. Juvenile Elephant Seal, Penguin Island. Passing Chinstrap Penguin (2.3 feet high) for scale.

The most abundant seal species in the world is the “Crabeater Seal” which feeds on krill (a euphausid shrimp only remotely related to crabs). The total population of this seal (*Lobodon carcinophagus*), which is entirely restricted to the icy waters south of the polar front, is estimated at around 15 million. It is preyed upon by the Killer Whale (*Orcinus orca*) and the Leopard Seal (*Hydrurga leptonyx*). While resting, Crabeater Seals haul out on floating ice, presumably to avoid these predators. (Fig. 37).

Figure 37. Crabeater Seal resting on an ice floe. Note bite marks.

The Crabeater Seal has peculiar modifications of its teeth (alluded to in the genus name *Lobodon,* lobed teeth), which allow the filtering of swallowed water for the krill contained in it. When feeding, they take a big gulp of krill-rich water and then force out the water between the teeth. The Leopard Seal, a related species, has lobed teeth as well, but it also has impressive canines useful in preying on penguins and juveniles of Crabeaters (Fig. 38).

Fig. 38. Skulls of Crabeater and Leopard Seals, showing lobed teeth.
Source: After specimens at Bremerhaven “Zoo am Meer” (retouched).
Note difference in size.

Elephant-, Crabeater- and Leopard Seals are “true seals,” belonging to the superfamily Phocidae. These seals have no visibly protruding ear and they do not run across the beach, or raise themselves on fore flippers. When they move, it looks much like a huge caterpillar crawling across the ground. They stay close to the water. Seals of another superfamily, the Otariidae, can swivel their hind flippers forward and hold themselves erect on their fore flippers. Also, they have protruding ears. In Antarctic waters, the Fur Seal represents the otarid seals (sea lions do not live here). Odobenid seals (walruses) are not represented. Fur seals can run and even climb up a hill and can be found resting quite a bit away from the water on occasion (Fig. 39). Visitors are warned to keep a safe distance from these mobile and somewhat unpredictable animals. They feed on fish, squid, krill and the occasional penguin (Soper and Scott, 2004).

Figure 39. Antarctic Fur Seals (*Arctocephalus gazella*) on Penguin Island, as small volcanic island off King George Island near the northern end of Bransfield Strait. Left: At the water, perched on a block of basalt. Right: Resting on a terrace above the beach, about 300 feet from the water.

The largest animals in Antarctic waters – and indeed on the planet – are the whales, of which there are two fundamentally different kinds: whales that have teeth (Odontoceti) and those that have no teeth but filter their food using baleen (Mysticeti). The most commonly representative of the odontocetes is the Killer Whale (*Orcinus orca*), also now commonly referred to as “Orca.” The Orca is a very large dolphin, in all respects, including a predatory habit, high intelligence, and an ability to echolocate targets while hunting.

What is usually seen at sea is the triangular fins of the Orcas (Fig.9). The animals weigh between three and seven tons (the females being smaller). Depending on pod-related custom, they hunt fish, penguin and seals, including the large and well-armed leopard seal. They have been observed hunting in packs, like wolves, driving prey. They have been seen to pursue seals right up to the beach (and occasionally beaching themselves in the process). And they were seen (by various naturalists) to lean on one side of an ice floe, to dislodge the seal hauled out on it. Their jaws have rows of peg-like teeth adapted for grabbing, but not for chewing (Fig. 40). Prey is commonly swallowed whole (except when attacking baleen whales, of course). Orcas are the largest predators on Earth that hunt mammals. Sperm whales (*Physeter macrocephalus*) are much larger, but they specialize on prey living at great depth, in particular deep-sea squid.

Figure 40. Skull of an Orca, top predator of the sea. Length of the skull is about 4 feet. The shape of the skull is that of a dolphin. (Source: After a specimen exhibited at the “Zoo am Meer,” Bremerhaven.)

Several species of mysticetes are present in Antarctic waters, including the Southern Right Whale (*Eubalaena australis*), the Blue Whale (*Balaenoptera musculus*), the Fin Whale (*Balaenoptera physalus*), the Antarctic Minke Whale (*Balaenoptera bonaerensis*, abundant), and the Humpback Whale (*Megaptera novaeangliae*, several populations). It is estimated that the mass of whales around Antarctica has been reduced to about one-sixth of former presence by whaling. Now that Antarctic whaling has been suspended by international agreement, stocks are apparently increasing in all impacted species, including the Blue Whale, which had been brought to the brink of extinction, and Southern Hemisphere Humpbacks (Bannister, 2001).

Humpback Whales are readily recognized from the shape of their tail, which shows clearly when the animals get ready to dive deeply (Fig. 8). As mentioned, the markings on the tail are diagnostic for individuals. Humpbacks are best known for their eerie and melodious singing during courtship, and the habit of breaching. These whales generally feed in high latitudes and breed in warmer waters, with long seasonal migrations connecting the different areas.

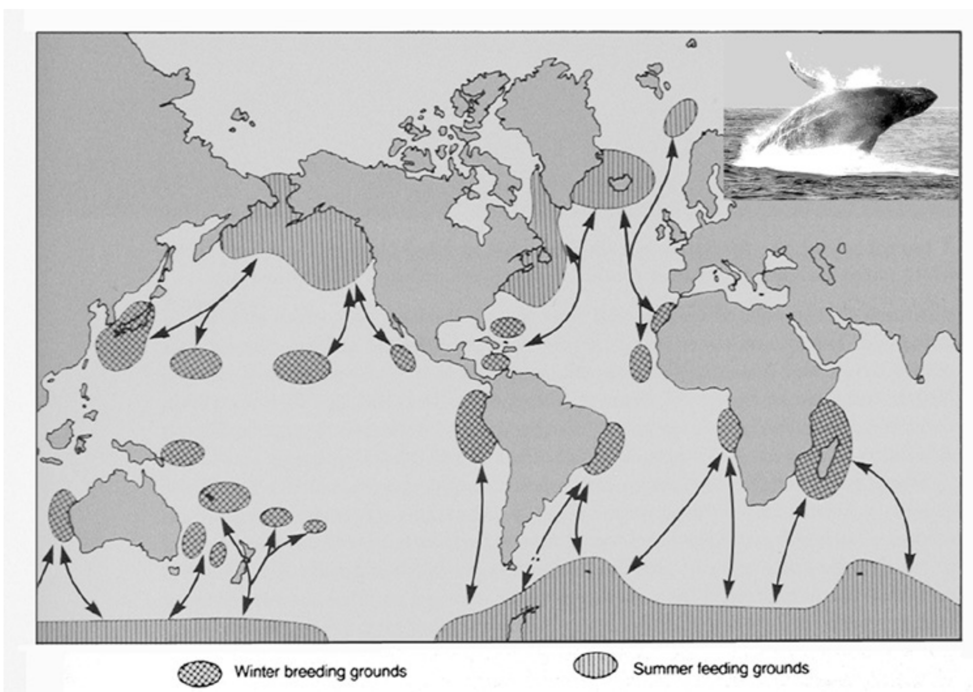

Figure 41. Migration routes of different populations of Humpback Whales. Feeding areas in high latitudes, breeding areas in low latitudes. (Source: Bonner, 1989. Photo of breaching whale: Karl Berger.)

Toothed whales and baleen whales differ in their ecologic functions roughly like cats and dogs from cattle and horses. The toothed whales are hunters. The baleen whales scoop up whatever is in the water – they have evolved into large plankton-gathering nets with a big opening and a strong tail to push through the water. Because of this great difference in the style of feeding, odontocetes and mysticetes have taken completely different paths of evolution, which is reflected in their body structures (and not just in presence and absence of teeth). The common ancestral form was a toothed whale, with a relatively small head and an enormously long body, reminiscent of certain ancient marine reptiles (the mosasaurs) (Fig. 42). Thus an ancestral whale was even originally misidentified as a marine reptile and given a corresponding name ("Basilosaurus" meaning king of reptiles), before its true nature was recognized.

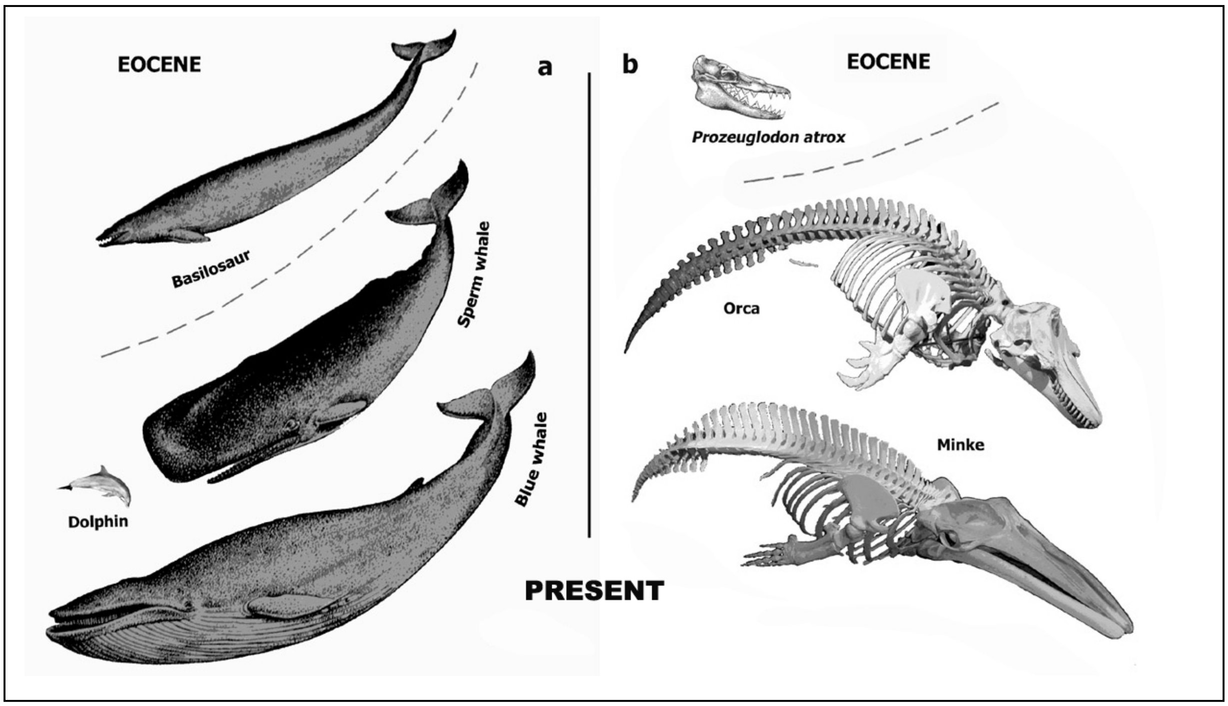

Figure 42. Ancestral whales (Eocene) and evolution of contrasting body forms according to feeding strategy. The toothed whales have modified skulls to accommodate echolocation organs for hunting. The baleen whales have skulls modified for plankton filtering. (Sources: E.H. Colbert, 1955; A.S. Romer, 1966; and exhibits at the Zoological Museum in Hamburg; all images modified.)

While the abundance of whales is no longer as striking in the region of the Bransfield Strait as it was before factory ships started mining the ocean, the general presence of whales is richly documented in the skeletons of the great mammals, which are strewn about on the beaches. With the good news of recovery of stocks the hope must be that the great whales, which have been with us for some 15 million years, will yet be with us for the distant future, as long as diatoms grow in abundance around Antarctica (Fig. 43).

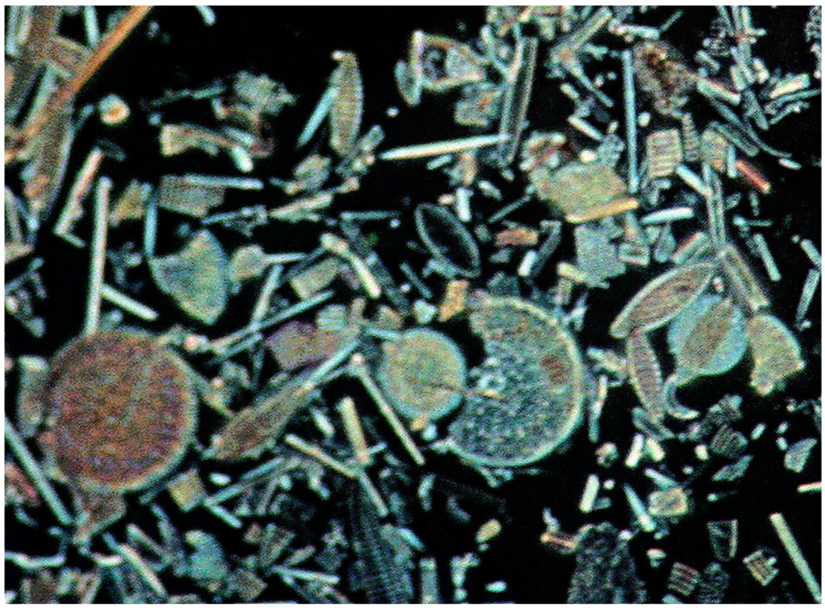

Figure 43. The accumulation of diatoms below the highly productive Antarctic Ring current testifies to the abundance of these microbes in glass houses, sometimes called "grass of the sea." Whale evolution took a sharp turn to greater diversity when these meadows first appeared in abundance, some 20 million years ago. Climate change in the future will affect the abundance patterns of diatoms, but it is not known exactly how. (Source of the illustration: Smetacek et al., 1997.

Acknowledgements

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