CHAPTER 8. BIOGEOGRAPHIC PATTERNS OF BIRDS AND MAMMALS.


THE BIOGEOGRAPHIC ATLAS OF THE SOUTHERN OCEAN


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PART 8. BIOGEOGRAPHIC PATTERNS OF BIRDS AND MAMMALS
8. Biogeographic Patterns of Birds and Mammals

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1. Introduction

The Atlas would not be complete if the representatives — and sometimes most emblematic species — of the top of the food chains were left aside, and so this section is concerned with sightings of top predators: seabirds, seals and cetaceans. Top predators are classically divided into two broad categories: seabirds and marine mammals. For the purpose of the Atlas, top predators have been split into four main “grand” taxa: flying seabirds (primarily Procellariiformes) are distinguished from penguins (Spheniscidae), while pinnipeds (otarids and phocids) and cetaceans (toothed and baleen whales) are considered separately in the marine mammal category. The distribution maps presented here are based on at-sea sightings data. These observations differ from the other taxa of the Atlas in at least two major aspects:

1. Being air-breathing species, penguins, seals, and cetaceans return frequently to the surface and — with the exception of cetaceans — spend part of their life cycle on land. Although seabird colonies and marine mammal haul-out sites are essential to the understanding of the distribution and ecology of top predators, we have focused here on the at-sea distribution to be comparable with other taxa in the Atlas.

2. Like fish, top predators are highly mobile species. At-sea observations of top predators should thus be taken as snapshots of their real, dynamic distribution in both space and time. Some aspects of the at-sea distributions of top predators are arguably better captured by tracking studies (e.g. Argos or GPS tracking) than by at-sea sightings. However, tracking deployments are labour- and cost-intensive (typically, such a study will track only a few individuals from a small number of colonies). Ship-based observations provide a means for broad sampling of large regions of the Southern Ocean and — although not utilized here — information that is less easily obtained from tracking studies, such as the presence of other animals and observations of behaviour.

A large number of already freely available data were harvested from a variety of data repository centres, including PANGEA, OBIS, or SCAR-MarBIN; the rest of the data were provided by the data contributors identified in the authors list or by institutions which accepted to share them specifically with the Atlas project, like the International Whaling Commission. At-sea sightings data were collected by different observers, either during the regular cruises between southern hemisphere countries (mainly Australia, New Zealand, South Africa, Argentina and Chile) and the research bases located on sub-Antarctic islands or the Antarctic continent, or on transacts conducted by these ships during dedicated marine science surveys. Because of the scheduling of re-supply voyages to research bases, and the logistic difficulties of sampling the Southern Ocean during the winter time, most of the data presented here were collected during the austral summer, i.e. roughly from October to April. Sighting data span from 1955 to 2011, although the majority of the data were collected from the 1980s onward. The IWC historical commercial catch database started in 1900. The observations are irregular in space and time as they depend on the ships’ schedules and the weather. Different protocols of observation were used throughout the years by the research teams involved. Further variability in the data arises from the varying degrees of taxonomic expertise of the observers, the resemblance of certain species (especially some of the petrels), the difficulty in identifying each individual spotted, particularly among seabirds, thus leading to a risk of counting the same individual more than once and the difficulty in counting groups of animals that continuously alternate between diving and surfacing (especially seals and cetaceans). Most datasets were available as presence-only (i.e. absence were not specifically recorded during the surveys). To provide an indication of the breadth of survey effort, and so to assist the reader in distinguishing areas of likely species absence from areas that have not been surveyed, the survey effort is shown in light grey on each map. The survey effort is simply the complete set of locations where any presence data were recorded, indicating that a survey was made at that location. Survey effort was estimated separately for seals and cetaceans (i.e. only seal records were used for estimating seal survey effort). Data for penguins and flying seabirds were combined for the purposes of estimating effort, since surveys of flying seabirds typically also record penguins, and vice-versa. Since the level of survey effort is highly variable across the region, the patterns evident in the maps are necessarily influenced by the patterns in survey effort. While the grey background in the following figures allows surveyed areas to be distinguished from non-surveyed areas, the relative intensity of survey effort is not indicated (and is difficult to estimate from the available data). As such, it is possible that a species may be over-represented in a given region as an artefact of a greater, local survey effort. Although an effort was made to be as exhaustive as possible, there are still a large number of species that are not represented in the Atlas because there were very few, or no sightings (see list below). Similarly, vagrant species are not accounted for in the Atlas.

2. Penguins (Spheniscidae)

Although they are seabirds, penguins are treated separately from the other seabirds. Penguins lost the ability to fly when they evolved to become highly specialized divers. The ancestors of penguins were flying birds but penguins differ morphologically, physiologically and ecologically from flying seabirds in many aspects. Their dense bones and flipper-like wings allow them to dive repeatedly to great depths and exploit a much larger portion of the water column compared to most other seabirds (except for diving petrels and some shearwater species). A substantial proportion of their time at sea is spent underwater and this may affect the ability of observers to detect them compared with flying birds. Among the 18 penguin species, only nine are distributed within the boundaries of the Southern Ocean and were thus considered for the Atlas. These nine species belong to three genera: Aptenodytes (two species; emperor and king), Pygoscelis (three species; Adélie, gentoo, and chinstrap) and Eudyptes (four species; southern and northern rockhopper, macaroni, and royal). Officially the rockhopper penguins are now split into southern (E. chrysocome) and northern rockhoppers (E. moseleyi). These were considered to be two species until genetic analyses proven them to be distinct species (Banks et al. 2006). However, it is extremely difficult — if not impossible — to distinguish these two species at sea and so the rockhopper separation is not reflected in the Atlas. Royal (E. schlegeli) and macaroni penguins (E. chryso- loptus) are pooled for the same reason.

Photo 1 Adélie Penguin, Pygoscelis adeliae. Image © Alain De Broyer, Brussels.
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The Atlas does not detail the distribution of penguin colonies as this information can be found elsewhere (e.g. Borboroglu Garcia & Boersma 2013). Yet it is important to acknowledge that the location of penguin colonies is an important factor in explaining at-sea occurrences: most penguins breed on land and their foraging ranges at sea are limited during the breeding season as they do not return to the sea until they have to feed their chicks. The most important sub-Antarctic breeding sites are, clockwise from the southern tip of South America: the South Sandwich Islands (57°30’S, 27°00’W), the South Georgia group (54°30’S, 37°00’W), Bouvet Island (54°26’S, 03°24’E), the Prince Edward Islands (37°51’E), the Crozet Islands (46°25’S, 51°05’E), the Kerguelen Islands (49°15’S, 69°35’E), Heard Island and McDonald Islands (53°04’S, 73°00’E), and Macquarie Island (54°38’S, 158°52’E). The New Zealand sub-Antarctic islands, including Antipodes Islands (49°40’S, 178°46’E), Auckland Islands (52°32’S, 169°08’E), and Snares Islands (48°01’S, 166°32’E), and their endemic penguin species, such as the yellow-eyed penguin (Megadyptes antipodes) or the erect-crested penguin (E. sclateri), are not included in this synthesis. Although not a sub-Antarctic in the strict sense we include Amsterdam Island and its rockhopper penguin populations.

Two species are genuine Antarctic species: the Adélie (Map 1) and the emperor penguin (Map 2). Emperor penguins are the only species that breed on the land-fast ice along the Antarctic coast during winter. When foraging during winter, emperor penguins have to travel to the edge of the fast ice to feed (Wienecke & Robertson 1997, Zimmer et al. 2008). However, the sighting data are biased towards the summer, which explains the limited extent of the emperor distribution in offshore waters to the north of the continent (Phillips et al. 2012). Adélie penguins breed on the Antarctic continent and nearby islands but their breeding season is in summer, roughly from October to March. The distribution of Adélie penguins therefore resembles that of emperor penguins (Map 1). Adélie penguin activity is heavily dependent on sea-ice conditions — so much so that they have been referred to as “creatures of the pack ice” (Ainley 2002). During incubation, they travel as far as 300 km from the continent (Clarke et al. 2006, Cottin et al. 2012). These distances reduce to less than 100 km once the eggs hatch, because the chicks require food frequently (e.g. Clarke et al. 2000). Both emperor and Adélie penguin species are nearly continuously circumpolar in their distribution (without clear gaps), although survey effort was less extensive in the Weddell Sea and offshore from Marie Byrd Land and Queen Maud Land (Maps 1 and 2). Note the importance of the Weddell and Amundsen sectors of the Scotia Arc for the Pygoscelis spp., where the three species overlap in their distribution (Map 1). Gentoo penguins (P. papua) are probably the most sub-Antarctic of the three pygoscelids, and, like king penguins and Eudyptes spp., their colonies are found on sub-Antarctic islands, scattered around the continent.

Overall, north of 65°S, penguins are distributed across the whole of the Southern Ocean, apart from two regions that seem less populated: the Amundsen Sea (120°–180°W) and the waters off Queen Maud Land (10°–40°E). Exceptional but rarely Antarctic waters. Sightings from some species have been pooled on the maps, including those of diving petrels (Pelecanoides spp.) and large skuas (Stercorarius spp.), as they are difficult to distinguish reliably at sea.

The maps in this Atlas are of species recorded routinely in the open ocean south of the APF. This excludes comorants and gulls that forage close to the coasts of the Antarctic continent or sub-Antarctic islands, and a number of species that breed on sub-Antarctic or sub-tropical islands. Others are trans-equatorial migrants from the Northern Hemisphere that use sub-Antarctic but rarely Antarctic waters. Sightings from some species have been pooled on the maps, including those of diving petrels (Pelecanoides spp.) and large skuas (Stercorarius spp.), as they are difficult to distinguish reliably at sea.

The maps do not show the location of colonies, the distribution of suitable islands for breeding goes some way to explain the at-sea distribution patterns. The bulk of the observations on which these maps are based were made during the austral summer, and survey coverage in many regions was very low, particularly in sub-Antarctic and sub-tropical waters, and across large swaths of the southern Pacific Ocean (30°S, 30°E). Hence, although the maps extend to 35°S, they do not represent the complete at-sea distribution of any species. Nevertheless, inter-specific comparisons provide some interesting insights into large-scale distribution and habitat preferences.

Wandering albatrosses (Di. exulans) have a circumpolar breeding distribution (Map 4) and clearly occur much further south in the Indian Ocean sector, but not in the southern Atlantic, than their congeners, the northern (D. sanfordi) and southern royal albatrosses (D. epomophora), which breed at Campbell, Auckland or the Chatham Islands, or on the South Island of New Zealand (Map 4). None of these species is common in Antarctic waters south of Australia and New Zealand, or in the Pacific. Both black-browed (T. melanophris) and grey-headed (T. chrysostoma) albatrosses have circumpolar breeding distributions on sub-Antarctic islands (Map 5). Their distributions extend from south of the southern boundary of the Antarctic Circumpolar Current (ACC) to sub-tropical waters; the more northerly regions are used in particular during the non-breeding season (Croxall et al. 2005, Phillips et al. 2005b). Indian yellow-nosed albatrosses (T. carteri) breed in sympathy with black-browed and grey-headed albatrosses on some islands in the Indian Ocean, and also further north, without these species, at sub-tropical Amsterdam and St Paul islands. Atlantic yellow-nosed albatrosses breed further north than any other
Flying Birds Maps 4–5

Map 4. Wandering Albatross: *Diomedea exulans* and Southern/Northern Royal Albatross *D. epomophora/sanfordi*.

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Map 6
- Phoebetria palpebrata
- Phoebetria fusca

Map 7
- Macronectes giganteus
- Macronectes halli

Flying Birds Maps 6–7
Flying Birds Maps 8–11


Mollymawk species in the South Atlantic, at the islands of Tristan da Cunha and Gough (Map 5). The at-sea distribution of the yellow-nosed albatrosses therefore reflects their preference for warmer waters (Pinaud & Weimerskirch 2007), although a few individuals were observed in and to the northeast of Prydz Bay, i.e. much further south than expected. The other species shown on map 5 is the Salvin’s albatross (*T. salvini*) which breeds at the Bounty and Snares Islands, and remains largely in sub-tropical waters. Light-mantled albatrosses (*Phoebetria palpebrata*) routinely forage further south than any other albatross (Map 6), even in the marginal ice zone (Phillips et al. 2005a). This species breeds on sub-Antarctic islands in all Southern Ocean basins as far south as Heard and McDonald Islands. There is a tiny colony at 62°S on King George Island in the South Shetland Islands. In general, these birds are more likely to be seen in Antarctic waters than their congener, the sooty albatross (*P. fusca*) (Pinaud & Weimerskirch 2007). The latter also has a circumpolar breeding distribution and is sympatric on a few sub-Antarctic islands in the Indian Ocean, but breeds on sub-tropical islands there and in the Atlantic.

There are some revealing comparisons to be made among the fulmarine petrels (family Procellariidae). Both southern (*Macronectes giganteus*) and northern giant petrels (*M. halli*) have circumpolar breeding ranges (Map 7). The former has a particularly broad latitudinal range; colonies range from the Antarctic continent (~68°S) to Gough Island (40°S). During the early breeding season, males of both species feed extensively on terrestrial resources, including carrion. Later they switch to pelagic waters where the females usually feed. As the maps indicate, both species occur from sub-tropical to Antarctic waters but southern giant petrels are more likely to be seen as far south as coastal Antarctica. This is rare for northern giant petrels except at the Antarctic Peninsula and around Prydz Bay (presumably birds from Kerguelen). Southern fulmars (*Fulmarus glacialoides*) breed on the more southerly sub-Antarctic islands and on mainland Antarctica (Map 8). They are widespread at sea in both regions but less common in more northerly waters. Cape petrels (*Daption capense*) also have a wide latitudinal range in breeding distribution, to as far north as the Crozet Islands (47°S). In winter, they migrate to subtropical waters, giving them an even wider distribution at sea (Map 9). In contrast, both Antarctic (*Thalassoica antarctica*) (Map 10) and snow petrels (*Pagodroma nivea*) breed close to or on the Antarctic continent. Some snow petrels were sighted as far north as South Georgia (Map 11); they are more frequently recorded in Antarctic than sub-Antarctic waters and are more common than cape petrels or southern fulmars in the Ross Sea.

The map for the gadfly petrels *Pterodroma* spp. highlights that although the soft-plumaged petrel (*P. mollis*) and the great-winged petrel (*P. macroptera*) are most common in sub-tropical and sub-Antarctic waters, they also occur routinely in Antarctic regions (Map 12). It is tempting to infer from the rarity of sightings in the southern Pacific that neither species is a circumpolar migrant, but that would need to be confirmed with tracking work or much more extensive at-sea surveys. Although they breed at similar latitudes to soft-plumaged and great-winged petrels, Kerguelen petrels (*Aphrodroma brevirostris*) appear to be less common in sub-tropical and more common in Antarctic waters, particularly in the southwest Indian Ocean (Map 12). White-headed petrels (*P. lessonii*), which breed in the southwest Indian Ocean and at the New Zealand’s sub-Antarctic islands, are widespread throughout sub-tropical
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Flying Birds Maps 19–21

to Antarctic waters in the southeast Indian Ocean and Australasia. Moreover they are the only gaudy pelagic seabirds regularly seen in the Pacific and may be circumpolar migrants (Map 12).

White-chinned petrels (Procellaria aequinoctialis) are very widespread at sea (Map 13); their distribution in most regions ranges from Antarctic to sub-tropical and cool sub-tropical waters. Many species they spend the non-breeding season wintering in the Southern Hemisphere, and a few species (e.g., Wilson’s storm petrels) disperse over great distances from breeding colonies. Although seen routinely in the northern North Atlantic, stable isotope analyses of feathers suggest that many adults of breeding age remain year-round in the Southern Ocean (Phillips et al. 2009). The exception seems to be south of Australia and New Zealand where there are few records in Antarctic waters, suggesting that the subspecies P. a. salvini breeding in the South Pacific has a more southerly distribution than the main population breeding in the subtropical waters of the North Pacific (Map 13). The small number of sooty shearwaters in Antarctic waters in the southwest Atlantic and western Antarctic Peninsula indicates that birds breeding in the Falkland Islands and southern Chile do not routinely use this strategy (Map 14).

Sightings of great shearwaters (Puffinus gravis) at sea were restricted to the sub-Antarctic and southern Atlantic and only rarely to the sub-Antarctic and tropical waters (Map 14). Short-tailed (P. tenuirostris) and sooty (P. griseus) shearwaters from colonies in Australia, and Australia and New Zealand, respectively, frequently travel long distances to Antarctic waters. During chick-rearing, these tips and tricks foraging strategy used by adults to balance the demands of self-maintenance with those of provisioning chicks (Shaffer et al. 2009). The small number of sooty shearwaters in Antarctic waters in the southwest Atlantic and western Antarctic Peninsula indicates that birds breeding in the Falkland Islands and southern Chile do not routinely use this strategy (Map 14).

There are seven species of pinnipeds (seals) commonly found within the area, such as Hooker’s sea lions (Phocarctos hookeri) that breed on the New Zealand’s sub-Antarctic islands (Auckland group and Campbell Island), as well as South American sea lions (Otaria flavescens) which breed along the coast of Patagonia. Neither of these is included in the Atlas because of insufficient sightings.

When at sea, seals are quite cryptic, being relatively small (compared to petrels), and only visible when on the surface to breathe or rest. In the pack ice some species, such as Weddell and crabeater seals, can often be seen hauled out on ice floes, but others, such as elephant seals, spend most of their time in the water and are rarely sighted. Only since the advent of satellite telemetry could the true extent of the use of the sea-ice zone by elephant seals and fur seals be determined.

4.1. Otarids

The current range of the two otarid species is a result of both historical and ecological factors. Both species were hunted to near extinction during the 19th century. Their populations started to recover only after the states in these regions put protective measures into place, and the populations at most sites have grown exponentially (Wynn et al. 2000). However, in some cases, such as Macquarie Island, it is unknown which species originally inhabited the islands. There is also no information on the initial population sizes and it is largely unknown whether the current at-sea distributions represe-nt pre-exploitation distributions is unclear.

Both species give birth to pups on sub-Antarctic islands (or off the Antarctic Peninsula). Mothers alternate periods that can last several days ashore to suckle their young with foraging periods at sea to replenish their energy reserves. Thus, during the breeding season the animals remain relatively close to their breeding sites and only disperse during the non-breeding months (Map 22). For most fur seal species, including A. tropicalis, females suckle their pups for ten months (from December through September) so females commute between areas with predictable food resources (often associated with frontal regions) and the breeding islands where their pups are waiting. In some areas, the females travel several hundred kilometres and take a whole week (Beauquet et al. 2004). Antarctic fur seals (Arctocephalus gazella) that breed on the pack ice lose up to 20% of their body mass at the lactation period of any otarid, lasting for only 4 months (December to April). The brevity of their lactation period is due to the high summer productivity and abundant marine resources at their high latitude breeding sites. This allows the mothers to supply sufficient energy in a short time to allow the pups to grow quickly and reach nutritional independence. This frees the adults to disperse more widely during the winter months.

Sub-Antarctic fur seals breed on sub-Antarctic islands near or north of the APF. The scarcity of at-sea sightings of this species is a reflection of the relatively small sizes of the still-recovering populations, the northerly locations of their breeding sites and the fact that they focus their foraging on the sub-Antarctic and sub-tropical fronts where there is limited survey effort (Map 22). The sightings in the Pacific and Indian oceans are consistent with the major foraging areas for populations at Macquarie, Crozet, and Amsterdam islands. The sightings in the Drake Passage and south Atlantic are likely to be dispersing males (Map 22).

While Antarctic fur seals have a more southerly distribution, breeding on islands associated with the APF or the Antarctic Peninsula, they also breed in sympathy with sub-Antarctic fur seals in lower latitudes at a number of islands (The Prince Edward Islands, Crozet Islands, Macquarie Island) (Map 22). The population at South Georgia is much smaller, but growing populations in the South Shetlands (Map 22). We know from satellite tracking data that males tend to use the northern regions of pack ice, and this can be seen in the sightings south of the ACC in the Indian Ocean. Other tracking studies have indicated that during the winter months, adult females disperse widely from the breeding sites, going to the ice edge along the APF. This is not sent to the sightings data probably due to the lack of sighting effort in these regions in the winter months, as well as the cryptic nature of fur seals at sea.

4.2. Phocids

Southern elephant seals predominantly breed on sub-Antarctic islands near the Subantarctic and South Sandwich islands and also populations in Tierra del Fuego and on the Valdés Peninsula in Patagonia (Map 23). Outside the brief breeding season in October, adults disperse widely. A large number of tracking studies showed that the Antarctic continental shelf and the pack ice are important regions for these seals, as is the APF (Baillieu et al. 2007, Biure et al. 2007). There are clear age- and sex-related differences in distribution. The much larger adult males tend to use the continental shelf and remain there throughout the winter months, despite the excruciating heat of the APF. While many adult females use the APF during the winter and autumn, they leave it as the sea ice advances, remaining in looser pack ice or leaving the sea-ice zone altogether to forage in open water to the north. Juvenile elephant seals tend to remain in open water, moving further south as they get older. Individual elephant seals demonstrate a high degree of foraging site fidelity; animals return to the same areas to feed in subsequent years, indicating that they learn which areas have reliable prey resources (Bradshaw et al. 2004). Southern elephant seals are deep diving specialists that regularly dive to depths of 200 m (often much deeper, with dives in excess of 1000 m common, and more rarely to >2000 m). The seals spend only two to three minutes on the surface between dives which last 20–30 minutes (the maximum recorded is 12 min), and this lack of time on the surface may to some extent
Seals Maps 22–23

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Ross seals are the most poorly studied of the Antarctic seals, largely due to their relatively low densities and preference for breeding in heavy pack ice, which makes ship-based studies difficult. During mid-summer they seem to prefer the denser ice types more prevalent in the inner ice pack, but they are also present in open pack ice within the inner reaches, and occasionally on fast ice. Although absent from the outer pack at this time, it has recently been found that they also make prolonged and repeated foraging trips far to the north into the open water. Such trips ostensibly result in their rare sighting in lower latitudes, such as at Heard Island and southern Australia (Bester & Hofmeyr 2007). Very few individuals have been satellite tracked making the observational studies summarised here our primary source of information regarding their distribution and habitat use. The data presented here suggest that Ross seals are relatively common in the southern Pacific and Indian oceans, particularly in the areas between the Antarctic continental shelf and the SACCF (Map 27). It is remarkable how few sightings there are between 150°E and 30°E despite considerable survey effort (Map 27). However, differences in survey techniques, observation platforms and timing of surveys mean that it is difficult to be sure that this is a true reflection of the distribution and abundance of this species.

5. Whales and dolphins (Cetacea)

Whales or cetaceans are divided into two super families, the Mysticeti (or baleen whales) and Odontoceti (or toothed whales). In the Southern Ocean, there is considerably more information on baleen whales, since they are larger, more conspicuous animals, than the smaller dolphins and generally disperse deep-diving beaked whales. In addition, baleen whales have been exploited to near extinction over the last two centuries and consequently catch data constitute an important source of information regarding the distribution and biology of the target species. Current sources of information on cetaceans include circumpolar surveys with byss designed to evaluate abundances, transect-based methods, such as the IWC International Decade of Cetacean Research/Southern Ocean Whale and Ecosystem Research (IDCR-SOWER), multidisciplinary marine science voyages including a cetacean observation component (e.g. the Australian Baseline Research on Oceanography, Krill and the Environment voyages), and sighting collected from opportunity, such as tourist or supply vessels. Strandings are also a key source of data, especially for Odontoceti. Other techniques for cetacean studies include acoustic, photo-identification, genetic and biochemical analysis from biopsy samples, satellite telemetry, and bio-logging (Boyd et al. 2010).

In the present Atlas, we focus on at-sea sightings using the data available in the SCAR-MarBIN database or available upon request from the International Whaling Commission (IWC), such as the IDCR-SOWER data. Consequently, the Atlas does not intend to be exhaustive (e.g. it does not include the Japanese Antarctic Research Program data). Most observations were made during the austral summer, when at-sea surveys are generally conducted in the Southern Ocean. Therefore, the distribution maps may be summer biased. Baleen and sperm whales are the only species which we discuss current distribution to the International Whaling Commission’s (IWC) historical catch data of commercial whaling, also included in this Atlas (Allison 2013).

Baleen whales of the Southern Ocean feed almost entirely on krill and other euphausiids, which they filter out from the water using their baleen plates. Feeding can be continuous while swimming at the surface (skimming of southern right whales) or can occur by engulfing of large amounts of water and food, which is sieved through the baleen plates by pressure of the tongue (other baleen whales). Baleen whales generally breed in temperate or tropical regions during the austral winter and feed in cold, high latitude waters during summer. However, there is a latitudinal gradient among the different species of baleen whales in terms of their preferential feeding grounds and distance from the ice edge, as detailed below. Baleaenopteridae (rorquals) swim much faster that the slow Balaenidae (right whales), and therefore were not exploited until the onset of industrial whaling when steam boat and harpoon guns first appeared around 1860.

The most pagophilic (“ice-loving”) species is the Antarctic minke whale (Balaenoptera bonaerensis), the smallest whale among the rorquals (Map 28). In addition, an unnamed subspecies of the common minke whale (B. acuto-rostrata), the dwarf minke whale, has also been described in high latitude waters where it represents less than 1% of the Antarctic minke whale numbers. Minke whales are found at 10–20°S in winter but congregate close to and within the pack ice in summer, where they feed on Antarctic krill but also on inshore euphausiids, such as Euphausia cristellarophias or E. frigida. Abundance estimation has been the matter of considerable debate but the IWC recently agreed on a population of ca. 500,000 (International Whaling Commission 2012). Because of their small size, minke whales were not exploited by commercial whaling until the 1970s, after which they replaced the heavily exploited larger species as target for commercial whaling fleets (Map 26). Commercial whaling was almost completely discontinued after the moratorium on commercial whaling came into force in 1986 but they are currently the primary target species of the Japanese scientific whaling in the Southern Ocean, with 200 to 500 animals taken each year. The Antarctic blue whale (Balaenoptera musculus intermedia) has a circumpolar distribution (Map 30). It is a krill specialist that is found at high latitudes in summer, generally close to the ice edge. The smaller subspecies, the...
Seals Maps 24–25

Map 24. Weddell Seal: *Leptonychotes weddellii*

Map 25. Crabeater Seal: *Lobodon carcinophaga*.
Biogeographic Patterns of Birds and Mammals

Seals Maps 26–27


Map 27. Ross Seal: Ommatophoca rossii.

pygmy blue whale (B. m. brevicauda) generally occurs north of 54°S around the Indian Ocean and from southern Australia to New Zealand (Branch et al. 2007). Historical mark-recapture studies showed that Antarctic blue whales are capable of large-scale longitudinal movements (>100°). They generally migrate to lower latitudes in winter, but some overwinter around Antarctica (Branch et al. 2007). A comparison of the relatively recent sightings map and the historical catches map for B. m. intermedius (Map 31) reveals that this species—the largest, most profitable whale on Earth—had been hunted to near extinction, from an estimated pre-exploitation level of 239,000 in 1904 to as low as 360 individuals in 1973 (Branch et al. 2004). The most recent population estimate of Antarctic blue whales is around 2700, with an annual rate of increase of 7.3%. Its current summer distribution is restricted to high latitudes close to the ice-edge while it used to be found at much lower latitudes (up to the APF) when its population was larger during the whaling period (Branch et al. 2007).

Fin whales (B. physalus) are the second largest whales and present a circumpolar distribution in summer. Although they can be encountered at high latitudes along the ice-edge, they are less closely associated with sea ice than minke and blue whales (Map 32). Fin whales occur mostly north of 60°S. The spatial distribution of fin whale catches varies across ocean basins (Map 33); individuals can be encountered further north (up to 45°S) in the south Atlantic and southern Indian Ocean sectors (Leaper et al. 2008) than in other sectors. Migration to lower latitudes in winter has been reported. Fin whales have been heavily exploited, with as many as 700,000 individuals taken in the Southern Hemisphere during the 20th century, and were reduced to a few thousand (Clapham & Baker 2002). Because their feeding grounds extend further north than the areas surveyed by SOWER (which cover latitudes south of 60°S), current population estimates are incomplete. Circumpolar abundance is estimated with a low precision from 4000–8000 individuals, with indications of a higher north than the areas surveyed by SOWER (which cover latitudes south of 60°S), which is probably the reason for the high uncertainty in its abundance estimates. This species is known to prefer the open ocean, and its distribution is therefore difficult to determine (Branch et al. 2007).

Humpback whales (Megaptera novaeangliae) are highly migratory animals that travel seasonally between low latitude breeding grounds and circumpolar feeding grounds (Map 36). They are probably the best-known Mysticeti because they tend to breed in low latitude coastal or inshore waters, where most native communities have detailed knowledge of their presence. Humpback whales feed on small krill and squid, which they capture with their large blowhole and in their mouths using a method called ‘bubble-net feeding’. These whales may occur in large pods, a feature also observed in the North Atlantic (Map 40). In the Southern Ocean, four types have been described based on morphology and feeding behavior. The ‘southern’ type occupies the southernmost waters of the Southern Ocean and is associated with kelp forest. Their propensity to stay inshore made this species a target for fishermen for bait for crab fishery, a practice that is now prohibited (Guinet & Tixier et al. 2011). In the Southern Ocean, four types have been described based on morphology, diet and distribution but their classification as “ecotypes” (Pitman et al. 2011) instead of “morphotypes” is disputed (de Bruyn 2013). In the Southern Ocean, humpback whales feed with various degrees of specialization, preying on fish, squids and cetaceans and have no known predators. They are the primary goal of the whaling industry in the Southern Ocean, and are considered a target species for commercial whaling. Humpback whales are currently protected under the International Whaling Commission’s International Whaling Convention (IWC).

Cetacean species that travel seasonally between low latitude breeding grounds and circumpolar feeding grounds (Map 36) reveal. They are rarely seen south of 60°S, especially in the south polar feeding grounds (Map 36). They are probably the best-known Mysticeti because they tend to breed in low latitude coastal or inshore waters, where most native communities have detailed knowledge of their presence. Humpback whales feed on small krill and squid, which they capture with their large blowhole and in their mouths using a method called ‘bubble-net feeding’. These whales may occur in large pods, a feature also observed in the North Atlantic (Map 40). In the Southern Ocean, four types have been described based on morphology, diet and distribution but their classification as “ecotypes” (Pitman et al. 2011) instead of “morphotypes” is disputed (de Bruyn 2013). In the Southern Ocean, humpback whales feed with various degrees of specialization, preying on fish, squids and cetaceans and have no known predators. They are the primary goal of the whaling industry in the Southern Ocean, and are considered a target species for commercial whaling. Humpback whales are currently protected under the International Whaling Commission’s International Whaling Convention (IWC).

Southern right whales (Eubalaena australis) are the only members of the Balaenidae family in the Southern Ocean. They breed in warm and temperate waters around continental and island coastlines. Breeding populations are reported off South Africa, Australia/New Zealand, and the eastern coast of South America (Leaper et al. 2008); a small population occurs also off Chile. While recent sightings are rare (Map 38), they indicate summer occurrence in sub-Antarctic waters at around 40°–50°S along the sub-Antarctic front in the southern Indian Ocean and south Atlantic (van Waerebeek et al. 2013). In the Southern Hemisphere, the right whale population extends from the southwest Atlantic and southern Indian Ocean. Their diet is entirely zooplankton and includes copepods and krill. Being slow swimmers that float at the surface, southern right whales were the first large whales to be hunted well before the onset of industrial whaling and as such it became nearly extinct in the 1930s. It has been protected since then, although it was illegally hunted by the Soviet whaling fleet in the 1960s. The current population is around 12,000 and increases at a rate of ca. 7% per annum.

Sperm whales (Physeter macrocephalus) are the largest of the Odontoceti and the deepest cetacean divers. Present in all the world’s oceans (Map 39), they feed mostly on squids but also on mesopelagic and large demersal fish, such as toothfish and sharks. Their large size and distinctive blow make them conspicuous at sea, resulting in numerous recent sightings such as seen on the map. They are the most sexually dimorphic cetaceans; mature males attain a much larger size and weight than females (Whitehead 2002). There is a clear sexual segregation in at-sea distribution. Females generally occur north of 40°S, while males inhabit the higher latitudes. Male whales are found as far south as 74°S in the Ross Sea and regularly south of 66°S. Males go back to warmer waters to mate but the timing of their migration is not well understood. Sightings around the Kerguelen and Crozet Plateaus indicate substantial interactions with longline fishery of Patagonian toothfish Dissostichus eleginoides (Chazaeau et al. 2012). Sperm whales were exploited at levels comparable to other great whales. Catches occurred in the frontal zones of the ACC, and around the continent at 55°–65°S during the era of industrial whaling (Branch et al. 2012; Map 40). Sperm whale, the valuable oil from its cerebral oil (colossal head, was the primary goal of the 19th century whalers, along with the blubber, while the female animal was used during the 20th century. Current population estimates of sperm whale south of 60°S is around 10,000, while a couple thousands of individuals still inhabit the north Atlantic. In the Indian Ocean, they are probably not present, and their status is currently unknown. Humpback whales were depredating longline fisheries of Patagonian toothfish (Chazeau et al. 2012; Map 41). In the 1990s the Crozet population suffered from intentional mortality by poaching ships. Sightings around Crozet, obtained from land-based observations or during fishing operations, allowed the scientific community to estimate the population decline at around 60% (Guinet & Tixer et al. 2011). The global population south of the APF is around 80,000. Long finned pilot whales (Globicephala melas edwardi) are squid feeders that occur in the whole Southern Ocean, in sub-Antarctic waters but also around the continent as far south as 66°S (Map 42). Observations are rare, but when they are present in the eastern south Atlantic and the western south Pacific; only a few sightings were reported north of the Ross Sea (van Waerebeek et al. 2004). These whales may occur in large pods, a feature also observed in the North Atlantic subspecies G. melas melas. They have not been exploited and their population is estimated around 200,000 south of the Polar Front (Kasamatsu & Joyce 1995).

Three dolphin species of the genus (Lagenorhynchus) occur in the Southern Ocean (Map 43). Hourglass dolphins (L. cruciger) are the only small dolphins occurring in Antarctic waters. They have a circumpolar distribution and are found in the open waters of the ACC, but also over the circumpolar shelf slope and close to sea ice. Feeding on fish, squid and crustaceans, the population is estimated at 140,000 (Kasamatsu & Joyce 1995). Dusky dolphins (L. maculatus) do not generally venture south of the Antarctic Convergence, but are frequently observed in coastal waters around the southern tip of South America (with occurrences in the Drake Passage and around the Falkland Islands), New Zealand and Tasmania (Map 43). Some rare sightings were made around oceanic islands in the southern Indian Ocean and south Atlantic (van Waerebeek et al. 2004). Peale’s dolphins (L. australis) are confined to coastal waters around southern Chile and southern Argentina, with some incursions in the Drake Passage as far south as 60°S (Map 43). They feed on fish, squid and octopus associated with kelp forest. Their propensity to stay inshore made this species a target for fishermen for bait for crab fishery, a practice that is now prohibited but may still occur illegally (Hammond et al. 2008a).

Other small Odontoceti of the Southern Ocean include Commerson’s dolphin (Cephalorhynchus commersoni), southern right whale dolphins (Lissodelphis peroni), and spectacle porpoises (Phocoena dioptrica). Commerson’s dolphins are an inshore species that occurs in two morphologically and genetically distinct populations (Map 44). The first is located along the east coast of southern South America and around the Falklands Islands, and
Biogeographic Patterns of Birds and Mammals

Whales and Dolphins Maps 28–29


rarely spreads into the Drake Passage (van Waerebeek et al. 2004). The second population occurs around the Kerguelen Islands. As with their northern counterpart, southern right whale dolphins have no dorsal fin. This small species occurs in deep waters between 30°S and 60°S, off the Chilean coastline where it is very common, but also in circumpolar oceanic waters, preying on fish and squid (Map 44). Spectacled porpoises are rarely sighted at sea. They occur both along coastlines of sub-Antarctic islands, and in the open ocean as far south as 64°S. Although this is not visible on map 44, spectacled porpoises can also be seen off the east coast of southern South America. Threats include accidental catches in gillnets or trawls and capture for crab baits (Hammond et al. 2008b).

Beaked whales are probably the most difficult whales to identify at sea at the species level because of poorly understood field marks, and similarities in morphology among some species. This is further complicated by their often elusive behaviour linked to their deep diving habits. Some species are rarely if ever sighted a sea, and so the only information is provided by strandings. As a result, their distribution range is poorly known or uncertain (MacLeod et al. 2006). Because they are rare, sightings for the three Mesoplodon species *M. bowdini*, *M. hectorii*, and *M. densirostris*, as well as for shepherd’s beaked whale (*Tasmacetus sheperdi*) were not included in the Atlas. Arnoux’s beaked whales (*Berardius arnuxii*) and their Northern Hemisphere counterparts Baird’s beaked whale (*B. bairdii*) are the largest among the beaked whales. Arnoux’s beaked whales are found in the whole Southern Ocean from 30°S to the Antarctic continent. Many sightings occur along the sea ice edge or within sea-ice as far south in the Ross Sea (Map 45). With breath holding capacities exceeding an hour, Arnoux’s beaked whales most probably feed on squid at great depths (Hobson & Martin 1996). No abundance estimates are available but they are much rarer than the sympatric southern bottlenose whales (van Waerebeek et al. 2004). Cuvier’s beaked whales (*Ziphius cavirostris*) are the most widespread beaked whales, occurring in all oceans and seas including the Mediterranean Sea. In the Southern Ocean, sightings are few but they have been reported as far south as 65°S (Map 45). They are deep divers, generally exploring waters deeper that 1000 m, presumably feeding on bathy-pelagic prey, such as squid (van Waerebeek et al. 2004). Little is known about their abundance in the Southern Ocean, but they probably stand among the most common beaked whales worldwide (Taylor et al. 2008). Both Gray’s beaked whales (*Mesoplodon grayi*) and strap-toothed beaked whales (*M. layardii*) are distributed in sub-Antarctic and Antarctic waters all around the continent (Map 45). Both species feed on oceanic and bathy-pelagic squid. No abundance data are available, but based on the number of strandings (particularly around New Zealand for *M. grayii*), both species are probably not as uncommon as other species of the *Mesoplodon* genus (MacLeod et al. 2006).
Whales and Dolphins Maps 36–38

Map 36 Observations
- Megaptera novaeangliae

Map 37 Catches
- Megaptera novaeangliae

Map 38 Observations
- Eubalaena australis
Whales and Dolphins Maps 39–40

Map 39 Observations
- Physeter macrocephalus

Map 40 Catches
- Physeter macrocephalus

Whales and Dolphins Maps 41–43

Map 41. Killer Whale: Orcinus orca

Map 42. Southern Longfinned Pilot Whale: Globicephala melas edwardii

Whales and Dolphins Maps 44–45

Map 44

- Cephalorhynchus commersonii
- Lissodelphis peronii
- Phocoena dioptrica

Map 45

- Hyperoodon planifrons
- Berardius arnuxii
- Mesoplodon grayi
- Mesoplodon layardii
- Ziphius cavirostris

THE BIOGEOGRAPHIC ATLAS OF THE SOUTHERN OCEAN

Scope
Biogeographic information is of fundamental importance for discovering marine biodiversity hotspots, detecting and understanding impacts of environmental changes, predicting future distributions, monitoring biodiversity, or supporting conservation and sustainable management strategies.

The recent extensive exploration and assessment of biodiversity by the Census of Antarctic Marine Life (CAML), and the intense compilation and validation efforts of Southern Ocean biogeographic data by the SCAR Marine Biodiversity Information Network (SCAR-MarBIN) (OBIS) provided a unique opportunity to assess and synthesise the current knowledge on Southern Ocean biogeography.

The scope of the Biogeographic Atlas of the Southern Ocean is to present a concise synopsis of the present state of knowledge of the distributional patterns of the major benthic and pelagic taxa and of the key communities, in the light of both biotic and abiotic factors operating within an evolutionary framework. Each chapter has been written by the most pertinent experts in their field, relying on vastly improved occurrence datasets from recent decades, as well as on new insights provided by molecular and phylogeographic approaches, and new methods of analysis, visualisation, modelling and prediction of biogeographic distributions.

A dynamic online version of the Biogeographic Atlas will be hosted on www.biodiversity.aq.

The Census of Antarctic Marine Life (CAML)
CAML (www.caml.aq) was a 5-year project that aimed at assessing the nature, distribution and abundance of all living organisms of the Southern Ocean. In this time of environmental change, CAML provided a comprehensive baseline information on the Antarctic marine biodiversity as a sound benchmark against which future change can reliably be assessed. CAML was initiated in 2005 as the regional Antarctic project of the worldwide programme Census of Marine Life (2000-2010) and was the most important biology project of the international Polar Year 2001-2009.

The SCAR Marine Biodiversity Information Network (SCAR-MarBIN)
In close connection with CAML, SCAR-MarBIN (www.scarmarbin.be, integrated into www.biodiversity.aq) compiled and managed the historic, current and new information (i.a. generated by CAML) on Antarctic marine biodiversity by establishing and supporting a distributed system of interoperable databases, forming the Antarctic regional node of the Ocean Biogeographic Information System (OBIS, www.oirbs.org), under the aegis of SCAR (Scientific Committee on Antarctic Research, www.scar.org). SCAR-MarBIN established a comprehensive register of Antarctic marine species and, with biodiversity.aq provided free access to more than 2.9 million Antarctic georeferenced biodiversity data, which allowed more than 60 million downloads.

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