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Distribution and Population Densities of Marine Mammals South of 60 °S

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INTRODUCTION

The aim of this contribution is to supply summarized information on the distribution and numbers of marine mammals in the Antarctic. In relation to the topic of the workshop the question to be answered is: "Is there spatial or temporal variation in mammalian presence in the Antarctic area that has relevance to the operation of acoustic devices". If acoustic devices have impact on marine mammals, this does not stop at political borders. Nevertheless, since legal implementation of the Antarctic Environmental Protocol was the major stimulus behind the workshop, this contribution was asked to limit itself to the Antarctic Treaty area, that is south of 60 °S.

HABITAT TYPES

The area south of 60 °S (Fig. 1) incorporates only part of the major habitat types. The Antarctic Polar Front (APF) is a zone where cold Antarctic water and warmer water from the north bounce and submerge together. This biologically enriched front completely encircles the Antarctic and is a consistent feature acting as a natural border for Antarctic ecosystems, as recognized in the Convention of Antarctic Marine Living Resources (CCAMLR). To the south of the APF lies an area of cold, but never frozen ocean, the Antarctic Circumpolar Current (ACC) before one enters the Seasonal Sea-ice Zone (SSZ). Around the Antarctic Continent sea-ice grows in winter to an area of about 20 million km^2. In midsummer this sea-ice is reduced to about 4 million km^2 of residual sea-ice in a variable band around the continent and major concentrations in for example Weddell and Ross Seas.

The marine area south of 60 °S almost exclusively represents the Seasonal Sea-ice Zone, hardly has permanent open water, and only marginally touches the Polar Front area to the west of the Antarctic Peninsula (Fig. 1). The SSZ is very rich in marine top-predators, both mammals and birds.

MARINE MAMMALS OF THE ANTARCTIC SEASONAL SEA-ICE ZONE

A range of species of seals (Phocidae and Otariidae) and whales (Mysticeti and Odonticeti) occur in the seasonal sea-ice zone, some of them sedentary, others migratory. For each species a short summary is given of what is known of estimated population size, distribution over habitat type(s) and migratory behaviour.

Seals

Crabeater Seal *(Lobodon carcinophagus)*
This is the most abundant Antarctic mammal with a population of probably 12 million animals all around the Antarctic. It is a true "ice-seal" in that it spends most its life in the sea-ice area, summer and winter, and gives birth to pups on the ice-floes in spring. During summer, groups may be seen away from ice, but the majority of animals tends to stay in or near sea-ice leading to concentrations of animals in residual ice areas in summer.

Leopard Seal *(Hydrurga leptonyx)*
The Leopard Seal is a large agile predator and also an ice seal giving birth to pups mainly on sea-ice during spring. However, it disperses more into open ocean and ice-free coastal waters than the Crabeater. Nevertheless, virtually its whole population of an estimated 300,000 individuals resides south of 60 °S throughout the year.

Ross Seal *(Ommatophoca rossii)*
This ice-seal was long considered to be a rare species, but intensified research effort in heavy ice early in the season indicates that the population is at least 130,000. Animals reside deep in the sea-ice for a relatively short period during the spring pupping season, but probably most reside in open waters in other parts of the year. However, it may be expected that the bulk of the population spends the full annual cycle in or very near our area of interest, that is south of 60 °S.

Weddell Seal *(Leptonychotes weddellii)*
This abundant species, with an estimated 750,000 animals in its population, is mostly an ice-seal, resident throughout the annual cycle in a zone close to the Antarctic continental shore or ice-shelves. A small proportion may reproduce on land and few animals wander away from coasts.

Southern Elephant Seal *(Mirounga leonina)*
This land breeding seal has its main reproduction areas on subantarctic islands (about 80,000 animals) outside our area of interest, only marginally touching the Peninsula area. Only occasionally Elephant Seals are observed hauled out on ice, and they are hardly ever seen in open ocean. However, on many continental shores groups are known to occur, mainly of males. Possibly the continental shelf zone is a favourite feeding area of this deep diving species, but we have no idea of the number of animals. For the purpose of this paper an esti-

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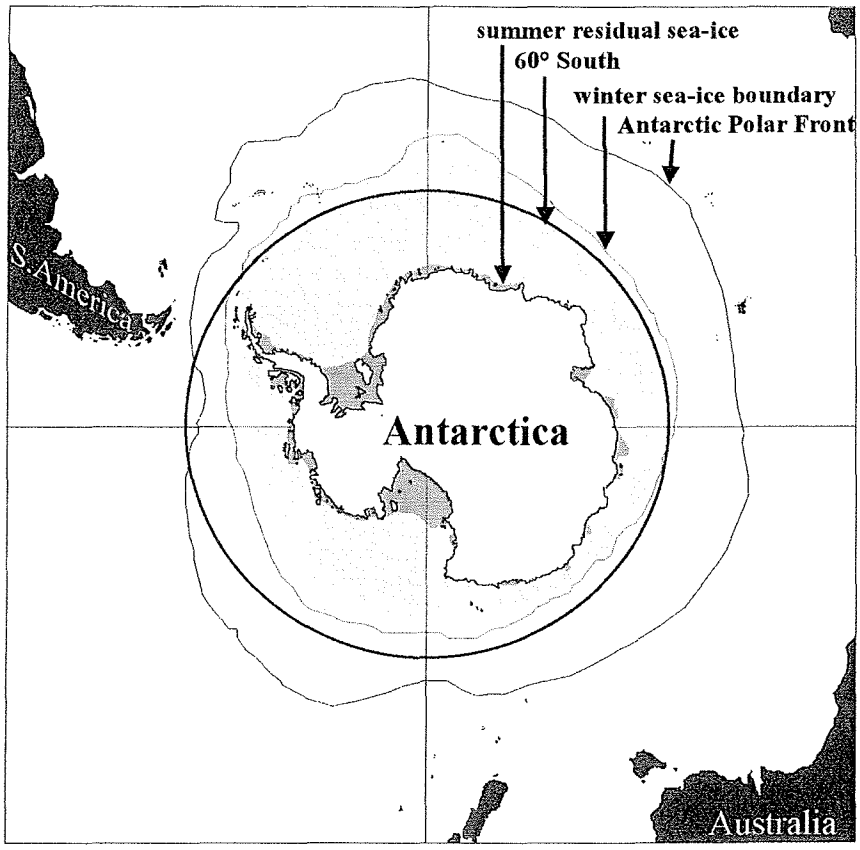

Fig. 1: The Antarctic Treaty and its Environmental Protocol are limited to the area of south of 60 °S. In terms of marine habitats, this largely means a limitation to the habitats of the seasonal sea-ice zone (light grey) and residual summer pack-ice area (dark grey).

mate of 50,000 animals has been made for summer, with virtually all of these forced north of 60 °S in winter because of sea-ice.

Antarctic Fur Seal *(Arctocephalus gazella)*
The once heavily hunted and reduced populations of Fur Seals show a spectacular come-back, and probably number over 2.75 million animals in recent years. These breed on the shores of mainly subantarctic islands, but seem to be "invading" the Peninsula area in particular. Considerable numbers of animals are currently seen on coasts and in open water south to the Bellingshausen Sea. Numbers south of 60 °S are guessed at 50,000 animals in summer, most of which are probably pushed out of the area at the peak of winter sea-ice.

Baleen Whales

Minke Whale *(Balaenoptera acutorostrata)*
The population of Minke Whales in the Southern Ocean has been estimated at 760,000, although this figure has recently been challenged by estimates that could indicate numbers to be less than half this figure. The bulk of the Southern Ocean Minke Whales probably occurs in the seasonal ice zone in summer all around the continent, being abundant both in open water and deep in sea-ice areas. Many of the animals, tentatively two-thirds, remain in the area over winter, unlike the larger migratory baleen whales.

Larger Balaenoptera species (Sei Whale: *Balaenoptera borealis;* Fin Whale: *Balaenoptera physalus;* and Blue Whale: *Balaenoptera musculus)* are mostly migratory summer visitors that remain in open water, often associating with fronts like the APF and espe-cially so off the Antarctic Peninsula area. Probably relatively minor parts of the reduced populations of these species really use the open waters south of 60 °S, and all are expected to have disappeared in winter.

Southern Right Whale *(Eubalaena australis)*
Also the summer visitors of this species probably largely remain north of 60 °S, and all disappear in winter.

Humpback Whale *(Megaptera novaeangliae)*
The Southern Ocean population has been estimated at 12,000 animals, but this seems conservative and the population is growing. Many animals go much further south and closer inshore than the other large baleens, and may enter areas with considerable presence of sea-ice. So, a considerable part of the population is expected to utilize the area south of 60 °S. Evidence is growing that also a substantial number of these may remain in Antarctic waters during winter.

Toothed Whales

Sperm Whale *(Physeter macrocephalus)*
The species prefers open and deeper water. Of an estimated Southern Ocean population of 28,000, about 12,000 are thought to occur south of 60 °S in summer, and few in winter.

Beaked whale spp. (mainly Southern Bottlenose Whale *Hyperoodon planifrons* and Arnoux Beaked Whale *Berardius arnouxii)*
are rather obscure and shy species, occurring both in open

water and deep into the sea-ice area. Their combined populations have been estimated at 600,000 animals, largely south of 60 °S. For the purpose of this paper about half of the animals is expected to be present during winter, but this figure may be an underestimate.

Killer Whale *(Orcinus orca)*
As for Beaked whales, the bulk of the estimated Southern Ocean population of 80,000 animals is considered to live south of 60 °S, often in sea-ice areas. Killer Whales usually live in groups that exploit fixed areas. Although some seasonal migration is expected, it is estimated here that at least half of the population is resident.

Long-finned Pilot Whale *Globicephala melas* and Hourglass Dolphin *Lagenorhynchus cruciger*
are both considered to be species usually not venturing deep into Antarctic waters, most animals not going far south of the APF. However, especially near the Antarctic Peninsula, animals may be observed further south into the Bellingshausen Sea, but probably only in summer.

DISCUSSION

Estimates for Southern Ocean marine mammal populations have been listed in Table 1. Most published estimates refer to the area south of the APF, some were also directly available for our target area south of 60 °S. However, several of the estimates given for summer populations south of 60 °S, and even more so the winter populations in that area are personal opinions of the author, based on available literature (only few major ones are cited below), IWC documentation and personal observations. Table 1 can be viewed in the light of the initial question of spatial and temporal variation of relevance to acoustic activities.

Roughly, 15 million (0.75 per km²) marine mammals are thought to occur south of 60 °S, with only a minor reduction in the winter season. This is not only because the numerically most abundant Crabeater Seal is a resident. Populations of many other species also stay behind, at least partly.

For seals, the overall density over the whole marine area south of 60 °S shows hardly any difference between summer and winter, because all major species are residents. Average density is about 0.7 seal per km². However, the dominance of Crabeater Seals means that during summer, the densities tend to concentrate in and near residual sea-ice. Lower densities of seals are at risk in open water (Ross, Elephant and Fur Seals). Increasing numbers of Fur Seals may gradually change this picture, with elevated densities also in open water. Evidently, regional differences in seal densities exist, with for example much higher numbers near the Peninsula than in e.g. the eastern Weddell Sea. All seals, but especially so Crabeaters, tend to show highly patchy distributions, often linked to ice-conditions which cannot be allocated to particular geographical spots. So, even if particular regions could be labeled as "low density", local hotspots with elevated densities may occur anywhere.

	±CCAMLR area population individuals	south of 60 °S max. summer population	south of 60 °S min. summer population
SEALS			
Crabeater Seal	12,000,000	12,000,000	12,000,000
Leopard Seal	300,000	300,000	300,000
Weddell Seal	750,000	750,000	750,000
Ross Seal	130,000	130,000	130,000
Elephant Seal	800,000	50,000	1,000
Antarctic Fur Seal	2,750,000	50,000	1,000
	16,730,000	*13,280,000*	*13,182,000*
BALEEN WHALES			
Minke Whale	760,000	750,000	500,000
Sei Whale	38,000	5,000	0
Fin Whale	2,500	5,000	0
Blue Whale	1,700	100	0
Southern Right Whale	4,000	1,000	0
Humpback Whale	12,000	10,000	2,000
	840,700	*771,100*	*502,000*
TOOTHED WHALES			
Sperm Whale	28,000	12,000	1,000
Beaked Whales (mainly S. Bottlenose Whale)	600,000	500,000	250,000
Killer Whale	80,000	70,000	35,000
Long-finned Pilot Whale	200,000	10,000	0
Hourglass Dolphin	144,000	10,000	0
	1,052,000	*602,000*	*286,000*
Marine mammals total (millions)	**19**	**15**	**14**

Tab. 1: Estimates for marine mammals populations south of the Antarctic Polar Front (CCAMLR area), and for summer maxima and winter minima south of 60 °S.

Densities and distributions of the baleen whales are dominated by Minke Whales, which concentrate south of 60 °S in both open water and sea-ice areas. The relative low seal risks in open water in summer are counteracted by the summer arrivals of the vulnerable populations of the large baleen whales, although in terms of densities these have low significance. Overall, baleen whale densities south of 60 °S are in the order of 0.02 to 0.04 per km² (one in every 25 to 50 km²) with no major differentiation between open water or ice or between seasons. Like for seals, baleen whales have regions of higher densities, but patchy distributions can create hot spots even in low density areas.

The toothed whales (Odontoceti) are more common than often thought (average densities from 0.01 in winter to maybe 0.03 per km² in summer) and widespread over open water, sea-ice and near-shore habitats.

The conclusions of the above in relation to the potential availability of "mammal free" situations is therefore:
- The area south of 60 °S is rich in marine mammals, both seals and whales.
- There are no "mammal free" temporal or spatial windows.
- On a regional level "richer" versus "poorer" areas may be identified,
- but even in "poor" regions extreme patchiness can lead to local hotspots.
- In many cases, locations of "hotspots" are unpredictable and do not have a fixed position.

This means that if one fears unacceptable interference of acoustic signals with marine mammals, to some extent preliminary risk assessments are possible on a regional basis, but observations at the time and spot of intended activities remain needed. For non-biological acoustic studies it would thus be feasible to adapt time and or location of the research to reduce risk of interference. This could include consideration of species-specific annual cycles (for example avoidance of reproductive period Oct-Nov for the ice-seals), or behavioural patterns (for example the synchronised haul-out times of Crabeater Seals).

In the case of bio-acoustic studies, it is not an option to stop the acoustic application in the vicinity of concentrations of marine mammals. This would conflict with the aims of the research. It is exactly (also) the concentrations of predators which one wants to study interdisciplinarily (also by echo-sounders) in order to understand and quantify trophic relations in Antarctic ecosystems. Without such understanding it is impossible to protect or manage the ecosystem. So, the option to "avoid" mammalian predators is irrelevant to such studies. If the acoustics used in biological research pose a problem, solutions need to be looked for in terms of changes or improvements to equipment so that they can be applied in the presence of marine mammals.

An important solution here may be to apply methods that allow animals to use their innate avoidance behaviour to phenomena that are considered disturbing or of potential danger. To allow avoidance, relatively slow speed of movement of the sound source (the ship) and the gradual build-up of sound levels from acoustic equipment are required. Also other, specific pre-warning sounds can be used. As for ship speed, known collisions of whales with commercial ships are virtually limited to ships speeding at over 15 knots. Research vessels tend to operate at much slower speed but further reductions for particular types of acoustics could be considered. Gradual build-up of sound levels is already practice in some air-gun research and could be applied to other sound sources. So-called "pingers" are increasingly used commercially on fishing nets to keep porpoises, dolphins etc. away from dangereous situations and if necessary, similar applications could be applied on research vessels. Observations of Antarctic marine mammals suggest that avoidance (unintentionally) already occurs under normal ship operations. This is illustrated by the Beaked Whales, which are rarely observed from normal research vessels. Evidence for the considerable size of their Antarctic populations has been obtained by specific studies using high speed vessels with dedicated long-distance whale-searching and closing-in modes. This means that the Beaked Whales, known to be sensitive to sounds including physical damage, tend to avoid ships at greater distances even in areas like the Antarctic where virtually none of the animals will have prior experience with ships. Ships are most likely detected from normal engine sounds. Apparently the speed of the average research vessel is moderate enough to allow early avoidance by the animals. It is reasonable to assume that for many research acoustics a gradual build-up of required sound levels would trigger species-specific avoidance behaviour in marine mammals which would prevent risk for physical damage and which would limit negative impacts to acceptable levels of spatially and temporarily limited disturbance.

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