# Antarctic pack ice seal observations during spring across the Lazarev Sea


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## Abstract

The distribution, density and percentage contribution of pack ice seals during ship-board censuses in the marginal sea ice zone beyond the Lazarev Sea in spring 2019 are presented. Adult/juvenile crabeater seals (*n* = 19), leopard seals (*n* = 3) and Ross seals (*n* = 10) were sighted during 582.2 nm of censuses along the ship's track line in the area bounded by 00°00' – 22°E and 56° – 60°S. Antarctic fur seals (*n* = 21) were only encountered on the outer fringes of the pack ice, and Weddell seals were absent due to their primary use of fast ice and inner pack ice habitats close to the coast. Crabeater seal sightings included juveniles (*n* = 2) and another four groups of 2-3 unclassified crabeater seals, singletons (*n* = 5), single mothers with pups (*n* = 3) and a family group (*n* = 1 triad). Only one leopard seal attended a pup, while no Ross seal pups were located. The survey was likely of insufficient effort, in both extent (north of 60°S) and duration (18 days), to locate seals in considerable numbers this early (late October/early November) in their austral spring breeding season.


Key words: Antarctic fur seals, crabeater seals, leopard seals, Ross seals, ship-board censuses

## Introduction

Most Antarctic apex predators breed during the austral spring in the Southern Ocean, the start of which in September is also the month of maximum ice extent around Antarctica (Gloersen et al. 1993). The ice-covered ocean is difficult to access for ship- and helicopter-based surveys. Therefore, very little is known about the breeding season haul-out patterns, distributions and densities of the three pack ice breeding seal species: crabeater (*Lobodon carcinophaga*), Ross (*Ommatophoca rossii*) and leopard (*Hydrurga leptonyx*) seals.

In the Weddell, King Haakon VII and Lazarev seas, it is particularly difficult to access the pack ice due to the workings of the Weddell Gyre and the build-up of multi-year sea ice and increasing ice extent (Vernet et al. 2019). With the exception of the surveys of the north-western parts of the Weddell Sea by Øritsland (1970) in 1964, Erickson (1984) in 1983, and Joiris (1991) in 1988, no other comparable data exists on abundance and densities for pack ice seals in spring in the larger Weddell Sea region. Recently, satellite census data was used to build potential habitat model distributions exclusively for crabeater seals in the entire Weddell Sea (Wege et al. 2020).

This note deals with the distribution and percentage contribution of pack ice seals encountered on the cruise track of the MV SA Agulhas II, in the marginal sea ice zone (north of 60°S latitude) off the Lazarev Sea during late October/early November 2019.

## Materials and Methods

The seal survey discussed here was ancillary to Ross seal research within this interdisciplinary SCALE (Southern oCean seAsonaL Experiment) research cruise in the south-eastern Atlantic sector of the Southern Ocean (Fig. 1) (SCALE Project, http://scale.org.za).

Seals present in the pack ice were recorded continuously during daylight hours from an elevation of 23 m with observers standing on the bridge of the MV SA Agulhas II as the vessel transited the pack ice north of 60˚S across the Lazarev Sea (located at 65° 0' 0" to 70° 19' 42.6" S, 0° 0' 0 to 14° 0' 0.2" E; https://www.marineregions.org/) in austral spring 2019 (Fig. 1). Strip censuses (*n* = 11), shown in Fig. 2, were done while the ship was underway, variously between 03:45 and 20:00 local apparent time (LAT). The censuses were partly (censuses 1 – 3, 10) or fully (censuses 4 – 5, 8 – 9, 11) done between 10:00 and 15:00 LAT, which generally covers the peak haulout period of both crabeater seals (Erickson, Bledsoe, & Hanson, 1989; Southwell, 2005) and Ross seals (Blix & Nordøy, 2007; Southwell et al., 2008) during summer. We observed seals 200 m to either side of the ship track (400 m total width). The census strip widths were determined through triangulation using sighting boards (Siniff, Cline, & Erickson, 1970); we assumed no noteworthy undercounting given the narrow strip censused from the ship. We calculated density estimates for the seals encountered within the boundaries of the census strips. All seals sighted outside of the census strip widths and census periods were also recorded as to time of day and geographical position.

The ship's track was mostly determined by other SCALE scientific endeavours, but on one occasion (census 8; Fig. 2) we were able to manipulate the cruise track. We successfully included 10 nm long north-south survey lines, spaced at 2.5 nm, within census 8 (Fig. 2). This we did firstly to cover the area in between longitudinally spaced, successive oceanographic stations as comprehensively as travel distance and speed allowed. Secondly, we aspired to an ideal survey design which would have multiple regularly spaced transects extending in a north–south direction across the ice gradient (Erickson, Siniff, & Harwood, 1993; Southwell et al., 2012). This, despite leaving the entire inner and the outermost regions of the pack ice not sampled during north-south strip censuses (this study) due to the vast extent of the ice.

Four observers searched for seals from the wings of the ship's bridge. The ship's position was recorded every 15 min from the ship's GPS navigational system. Seal identification to species followed Laws (1993). Ice type (brash, cake, ≥ small floes) and ice coverage (in tenths) was broadly classified following Erickson et al. (1993), and predominant ice coverage (reported as percentages) estimated over 15 min intervals of travel. A constant vigil by one to two observers, rotating with the others in one to three-hour shifts, allowed identification of seals outside of the census periods to ascertain their presence within sighting distance of the ship.

## Results and Discussion

Several sources of bias and uncertainty underlie pack ice seal abundance estimates derived from ship-board surveys (Erickson et al., 1993; Southwell et al., 2012). Despite the drawbacks, we opted for a simple methodological approach, following previous ship-board surveys (Bester & Odendaal, 2000; Bester et al., 2002, 2019) in the same general area (eastern Weddell Sea and inner Lazarev Sea). This ensured methodical congruence and thus comparability of data sampled in the present study with contiguous data sets from the earlier surveys (e.g. Bester et al., 2002, 2019).

The ship entered fields of brash and pancake ice from about 10:00 LAT on 21 October 2019, and at 14:00 LAT, (56°05'S, 00°00'E) we commenced strip censusing. Shortly before, an adult male Antarctic fur seal *Arctocephalus gazella* was sighted on cake ice. A further twenty Antarctic fur seals, including 15 adult males, were recorded on the return leg (east-west) on cake ice and small floes in the outer reaches of the pack ice before exiting the pack ice (Fig. 1). The species are often seen during their foraging trips to the outer reaches of the pack ice in the proximity of the tip of the Antarctic Peninsula and associated islands such as the South Shetlands and South Orkneys (Bester & Odendaal, 2000; Joiris, 1991), and Bouvetøya well north of the Lazarev Sea (Bester, 1979).

*Ship-board (within strip) censuses*

A total 582.2 nm of strip transects was surveyed during eleven ship-board censuses (Fig. 2). Crabeater seal juveniles ($n$ = 2), adults ($n$ = 5) and pups of the season ($n$ = 2) were sighted, together with Ross seals ($n$ = 4) and Antarctic fur seals ($n$ = 4) in the marginal sea-ice zone (Fig. 3) at low densities (Table 1). Crabeater seal densities along the track were exceptionally low (0.04 $nm^{-2}$), a fraction of that recorded for ship-board surveys in the eastern Weddell Sea in mid-summer which varied between 2.46 $nm^{-2}$ and 5.24 $nm^{-2}$ (summarised in Bester et al., 2019), with 2.47 $nm^{-2}$ recorded by aerial census in the inner Lazarev Sea in mid-summer (Bester et al., 2002). Similarly, Ross seals density (0.03 $nm^{-2}$) was much less than the 0.45 $nm^{-2}$ to 2.91 $nm^{-2}$ reported for mid-summer ship-board censuses (Bester et al., 2019) in the eastern

Weddell Sea, yet exactly the same as that recorded by aerial census in the inner Lazarev Sea (Bester et al., 2002) within similar longitudinal boundaries (12°W – 18°E).

*Ship-board (within and outside of strip) sightings*

The surveyed marginal sea ice zone produced only fifty-eight seals; crabeater seals (*n* = 19, four with pups), leopard seals (*n* = 3, one with pup), Ross seals (*n* = 10) and Antarctic fur seals (*n* = 21) (Fig. 3). Proportional representation of the phocid species (excluding pups) translates to 59.3% crabeaters, 31.3% Ross and 9.4% leopard seals, compared with, for example, a phocid species composition of 97.8% crabeater, 1.7% Ross, 0.3% leopard and 0.2% Weddell seals in the inner Lazarev Sea during mid-summer (Bester et al., 2002). The disparity clearly is a function of season and the likely effect of latitude (marginal sea-ice zone versus inner reaches of the pack ice). Including the Antarctic fur seals, the proportional representation is 35.8% crabeater, 18.9% Ross, 5.7% leopard and 39.6% Antarctic fur seals. Overall, during censuses pack ice cover varied little (mean ± standard deviation) at 81.0 ± 18 % (range: 20 – 100%).

<u>Weddell seals</u>

The absence of Weddell seals during the ship-board survey attests to their primary use of fast ice and nearby pack ice habitats close to the coast during the breeding season (LaRue et al., 2019; Nachtsheim et al., 2019; Southwell et al., 2012).

<u>Leopard seals</u>

Only three widely separated leopard seals (Fig. 3), one suckling a pup, were sighted near the outer edge of the pack ice. During the austral spring leopard seals breed on the outer fringes of the circumpolar pack ice (Gilbert & Erickson, 1977; Siniff, 1991) which they seem to follow both during its seasonal expansion and contraction (Bester, Erickson, & Ferguson, 1995; Nordøy & Blix, 2009), even hauling out on sub-Antarctic islands primarily in winter (e.g. Bester & Roux, 1986; Gwynn, 1953). Located on a small ice floe, in an area of primarily cake ice, the sighting of the leopard seal pup (3 November) was marginally before the pupping period (between 8 November and 25 December) of the species in East Antarctica (Southwell et al., 2003). However, it approximated the 2 November 1988 sighting of the first newborn leopard seal in the northern Weddell Sea (Joiris, 1991). The leopard seals' impending pupping and breeding season probably explained their paucity in the outer pack as a portion of the adult population may spend the winter mainly in open water, off the edge of the pack ice, from mid-May to at least late September (Nordøy & Blix, 2009). However, by 18 October to 16 November in spring 1988, most (97%) of all leopard seals sighted ($n$ = 72, including pups of the season) were primarily found south of 60°S in the inner marginal sea ice zone and consolidated pack ice region of the northern Weddell Sea (Joiris, 1991).

Crabeater seals

Crabeater seals breed in the pack ice zone surrounding Antarctica in the austral spring (Siniff, Stirling, Bengtson, & Reichle, 1979; Southwell, Kerry, Ensor, Woehler, & Rogers, 2003) when pack ice is extensive, and ship access is difficult (Shaughnessy, Jones, & Viggers, 2019). Consequently, there have been few studies of crabeater seals during their breeding season (Joiris, 1991; Shaughnessy et al., 2019; Wege et al., 2020). Crabeater seals, including triads (*n* = 1) as defined by Siniff et al. (1979), comprising an adult female (presumably the mother) and its pup with an adult male nearby (Shaughnessy et al., 2019), female-pup pairs (*n* = 3), singletons (*n* = 5) and unsexed groups (*n* = 4) of 2-3 seals were widely dispersed in the marginal sea ice zone (this study). This agrees with the single largest crabeater seal survey and habitat modelling for the Weddell Sea during breeding season, which showed crabeater seals are rarely found in the deep Weddell Sea, but around the outer fringes of the pack ice and in the northern Lazarev Sea (Wege et al., 2020). This breeding season distribution is associated with typical Antarctic krill (*Euphausia superba*) habitat (Wege et al., 2020), as it is during the austral summer (Nachtsheim, Jerosch, Hagen, Plötz, & Bornemann, 2017), krill being the key prey species of crabeater seals (Hückstädt et al., 2012). Previous sightings in any year of a crabeater seal pup accompanied by an adult were between 2 October and 15 December in Eastern Antarctica (Southwell et al., 2003), which brackets the timing of sightings of pups in the present study (25 – 31 October). In the present study, almost all of those with pups, and the majority of the remaining crabeater seals (78.9%) were hauled out in consolidated pack of 80 – 100% coverage. Similarly, crabeater seals were present principally as pairs and triads in spring 1988, their distribution reflecting a preference for extensive ice cover (Joiris, 1991), and perhaps with Antarctic krill habitat in the area as well (see Hückstädt et al., 2020), during the crabeater seal breeding season.

The relatively poor percentage contribution of the crabeater seals (59.4%) to phocid species composition compared to the inner region of the Lazarev Sea (see above) during summer off the coast of Dronning Maud Land (Bester et al., 2002), is largely due to the considerably higher Ross seal contribution (31.3%). In addition, the paucity of crabeater seals probably also results from the earlier census dates in spring (late October/early November) in this study compared to summer (December/early January), the optimal time for visual surveys of crabeater seals (Southwell, 2005), of previous studies when the extent of seasonal pack ice cover would have diminished. Furthermore, there is an inverse relationship between pack ice cover and seal densities (Bester et al., 1995; Eklund & Atwood, 1962). Perhaps crabeater seals prefer to haul out deeper in the pack ice for breeding, in the area south of 60°S latitude (not surveyed in the present study) where they preferred extensive ice cover in the northern Weddell Sea in 1988 (Joiris, 1991). Similarly, elsewhere in the southern Indian Ocean sector of the Southern Ocean in October and November 1987, between 64°S – 69°S and again in September 1995 between 62°S – 63°S, crabeater seal triads were in abundance in the inner regions of the pack ice (Shaughnessy et al., 2019).

<u>Ross seals</u>

Ross seals use the pack ice surrounding Antarctica for breeding and moulting, and make long foraging trips north of the pack ice (Blix & Nordøy, 2007). They breed in the austral spring (Shaughnessy & Jones, 2019; Southwell et al., 2003), when pack ice is extensive. Yet only few Ross seals ($n$ = 10) were encountered in the present study. Curiously, only three Ross seals (15.8%) were sighted within the midday maximal haulout window established for mid-summer. Most others were sighted during late afternoon and early evening in October/November, from 15:21 to 19:50 LAT (this study). We suspect this a result of a semi-diurnal (lunar or tidal) activity pattern as known from other ice seals (Bornemann, Mohr, Plötz, & Krause, 1998), though we cannot provide any comprehensive analyses as yet. No Ross seal pups were seen, and all Ross seals were sighted between 56°S and 59°S (Fig. 3). More than half ($n$ =

6) of the Ross seals were seen in discontinuous ice fields composed largely of brash, cake ice and the occasional small floe, of 80% coverage on the outer fringe of the pack ice in the region (Fig. 2, censuses 6 & 8). This was unlike the remaining Ross seals (*n* = 4) which were found in the more consolidated pack (80 - 90% coverage) similar to those during the breeding season (Bester, Wege, Oosthuizen, & Bornemann, 2020) and moulting season (Bester et al., 1995, 2002, 2019). This suggests that most, if not all, of the Ross seals present were most likely resting within the outer marginal zone of the pack ice in early November during their commute to higher latitudes where they pup and breed (see below).

Blix and Nordøy (2007) satellite-tracked three female Ross seals to continuous (14 – 17 days) haul outs in the pack ice from 6 – 10 November. The extended haul out was considered indicative of pupping and nursing. These animals hauled out between 60°S - 63°S, 5°W – 20°E and therefore south of the innermost area (58°S – 59°S) searched in the present study (21 October – 08 November 2019). Similarly, the breeding area for Ross seals in the Amundsen Sea is located between 65°S and 68°S (Arcalís-Planas et al., 2015), and Ross seal pups (n = 13) each with an accompanying adult or adults were observed in pack ice of East Antarctica, in the region of 63ºS – 65°S (Shaughnessy & Jones, 2019). Southwell et al. (2003) summarized that the sightings of pups with an accompanying adult occur between 24 October and 22 November.

## Conclusions

We hypothesise that presumed breeding Ross seals in the present study were (a) either still on their way to the deeper reaches of the pack ice to pup and breed or were non-breeders resting before returning to the open ocean to forage, and (b) that our survey was perhaps too early to locate mother-pup pairs during the peak in pupping which lies between 6 and 15 November (Southwell et al., 2003). In the austral summer, Ross seals may occur in open pack (Condy, 1977), but seem to prefer dense concentrations of interior pack ice (Bester et al., 2019; Condy, 1976; Gilbert & Erickson, 1977; Wilson, 1975). It is therefore hardly surprising that they do not pup in the outer, unstable regions of the pack ice in the spring breeding season (this study).

The decline in the proportional representation of crabeater seals (to 35.8%), from a high of about 97% of seal species present in mid-summer (Bester et al., 2002) in the Lazarev Sea, results from the dominance of Antarctic fur seals (39.6%). This situation is confined to the marginal sea ice zone in spring (this study), as it was in the northern Weddell Sea (~80% Antarctic fur seals) during spring (Joiris, 1991), and apparently during winter as well (Bester, 1979). This dominance of Antarctic fur seals likely results from the presence of the large fur seal breeding population at the proximate (~165 nm/306 km distant) Bouvetøya (Bester, 1979; this study). Located at 54°24'S, 03°21'E, the island supports about 66,000 Antarctic fur seals (Hofmeyr, de Bruyn, Bester, & Wege, 2016; Hofmeyr, Krafft, Kirkman, Bester, Lydersen, & Kovacs, 2005) most of which are foraging at sea in late October and early November (when this study was undertaken) before adults return to the island for the short austral summer breeding season of the species in late November/December (McCann & Doidge, 1987).

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**Compliance with Ethical Standards**

The University of Pretoria Animal Ethics Committee cleared the procedures of this project (Number EC082-15) under South African Department of Environmental Affairs Permit 04/2015-16, pursuant to the provisions of Article 3 of the Protocol on Environmental Protection to the Antarctic Treaty, and Annex II and Annex V (Article 10(2)).

**Conflict of Interest**

None

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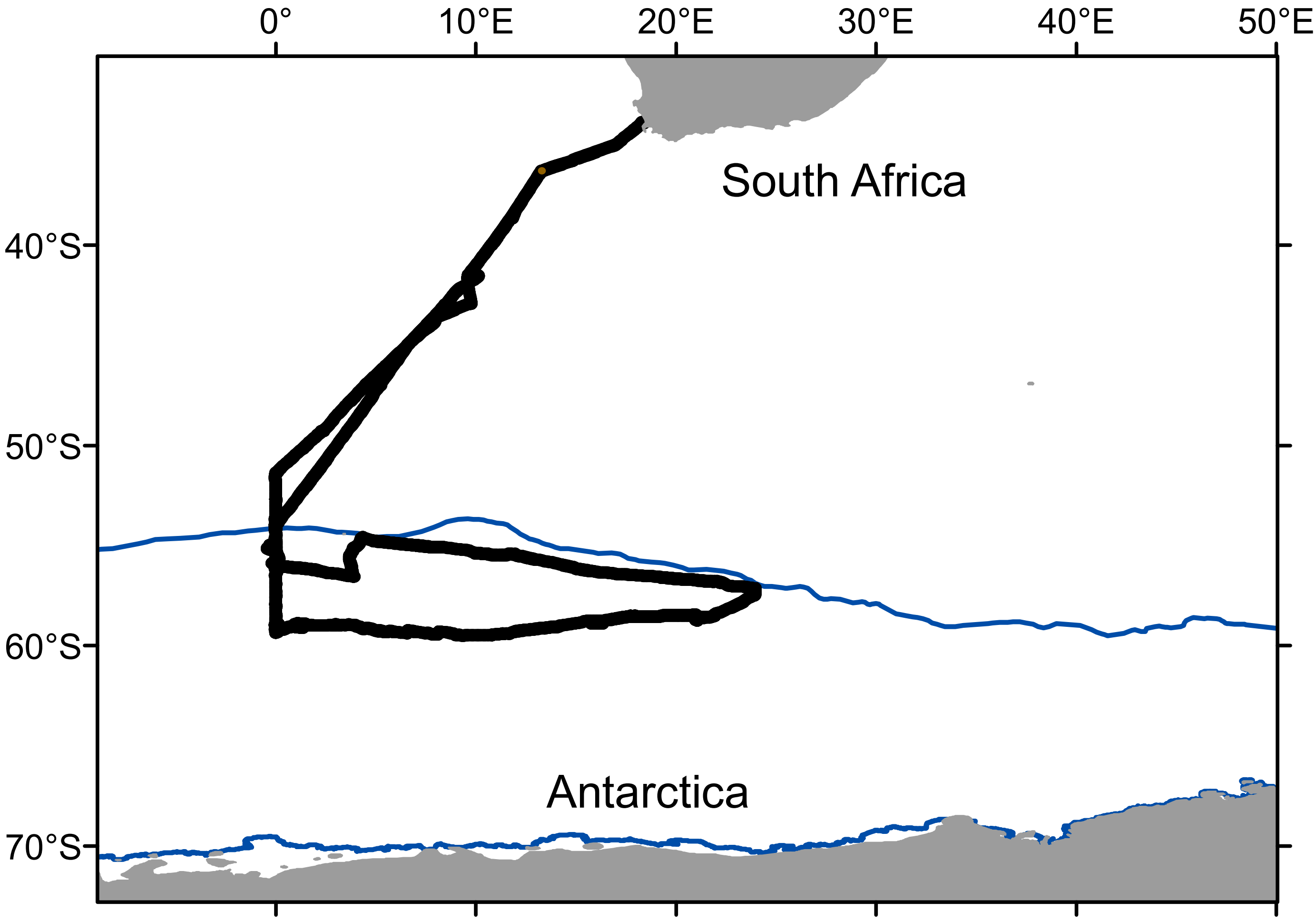
| **Date** | **Census Number** | **Distance sailed (nm)** | **Total area surveyed ($nm^2$)** | **Seal density ($nm^{-2}$)** | | | |
|---|---|---|---|---|---|---|---|
| | | | | **Crabeater** | **Ross** | **Leopard** | **Fur** |
| 22.10.2019 | 1 | 7.818 | 1.69 | 0.0 | 0.0 | 0.0 | 0.0 |
| 23.10.2019 | 2 | 11.692 | 2.53 | 0.0 | 0.0 | 0.0 | 0.0 |
| 25.10.2019 | 3 | 11.755 | 2.54 | 0.0 | 0.39 (1) | 0.0 | 0.0 |
| 26.10.2019 | 4 | 73.066 | 15.78 | 0.06 (1) | 0.0 | 0.0 | 0.0 |
| 27.10.2019 | 5 | 71.307 | 15.40 | 0.26 (4) | 0.06 (1) | 0.0 | 0.0 |
| 29.10.2019 | 6 | 23.718 | 5.12 | 0.0 | 0.0 | 0.0 | 0.0 |
| 30.10.2019 | 7 | 17.119 | 3.70 | 0.0 | 0.27 (1) | 0.0 | 0.0 |
| 31.10.2019 | 8 | 167.762 | 36.23 | 0.0 | 0.0 | 0.0 | 0.0 |
| 02.11.2019 | 9 | 76.589 | 16.54 | 0.0 | 0.06 (1) | 0.0 | 0.0 |
| 03.11.2019 | 10 | 22.076 | 4.77 | 0.0 | 0.0 | 0.0 | 0.0 |
| 08.11.2019 | 11 | 99.299 | 21.45 | 0.0 | 0.0 | 0.0 | 5.36 (4) |
| Total | | 582.201 | 125.75 | 0.0397 | 0.0318 | 0.0 | 0.0318 |

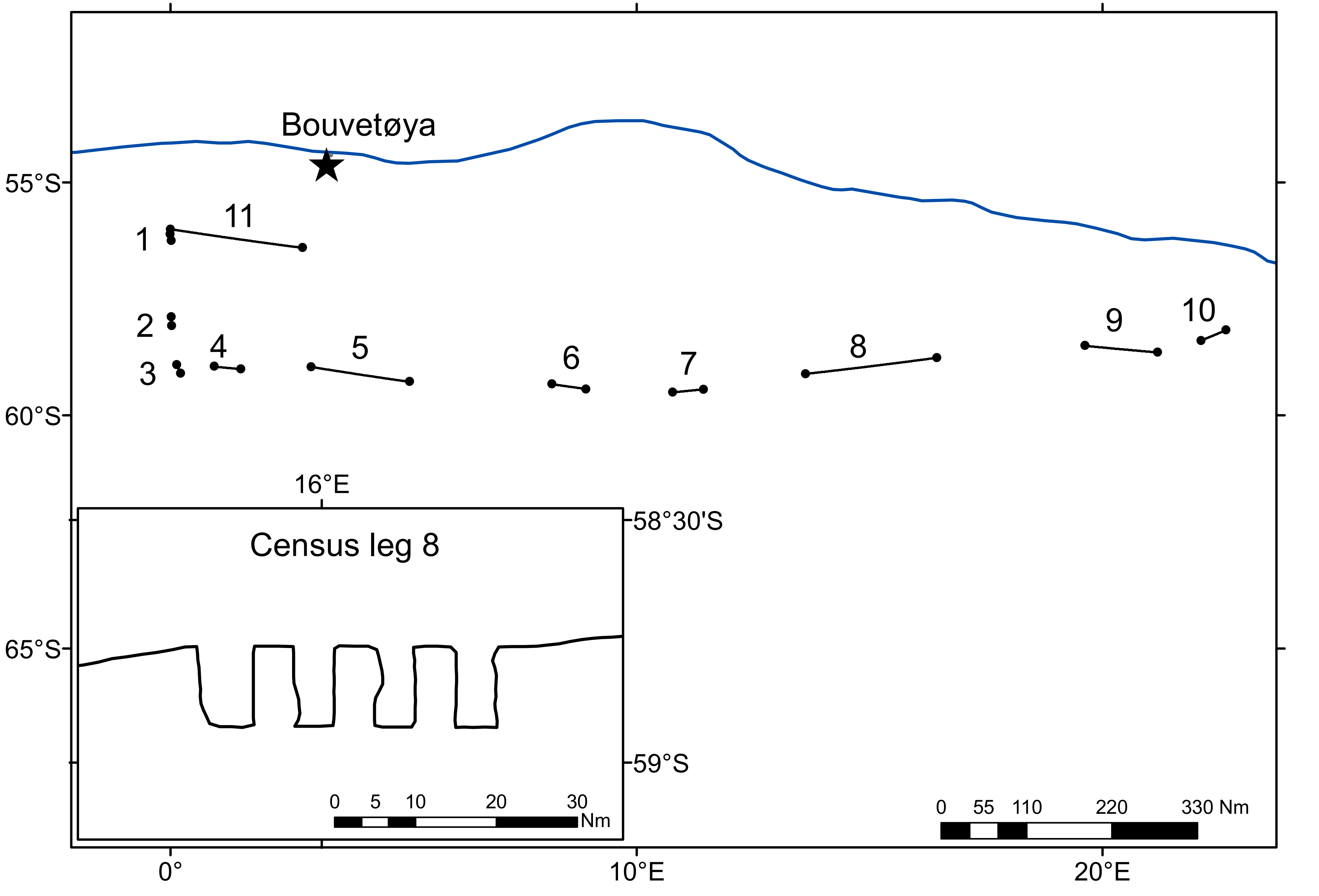
**Table 1:** Summary of ship-board censuses (*n* = 11) of Antarctic pack ice seals older than pups of the season. Seals located within the 200 m/0.108 nm strip on either side of the ship's track (400 m/0.216 nm total width) during local daylight hours of the SCALE oceanographic cruise of the MV SA Agulhas II from 22 October to 08 November 2019 across the Lazarev Sea are considered here. Seal numbers observed within the strips appear in brackets and are summed to calculate overall seal densities (total seal number/overall area surveyed).

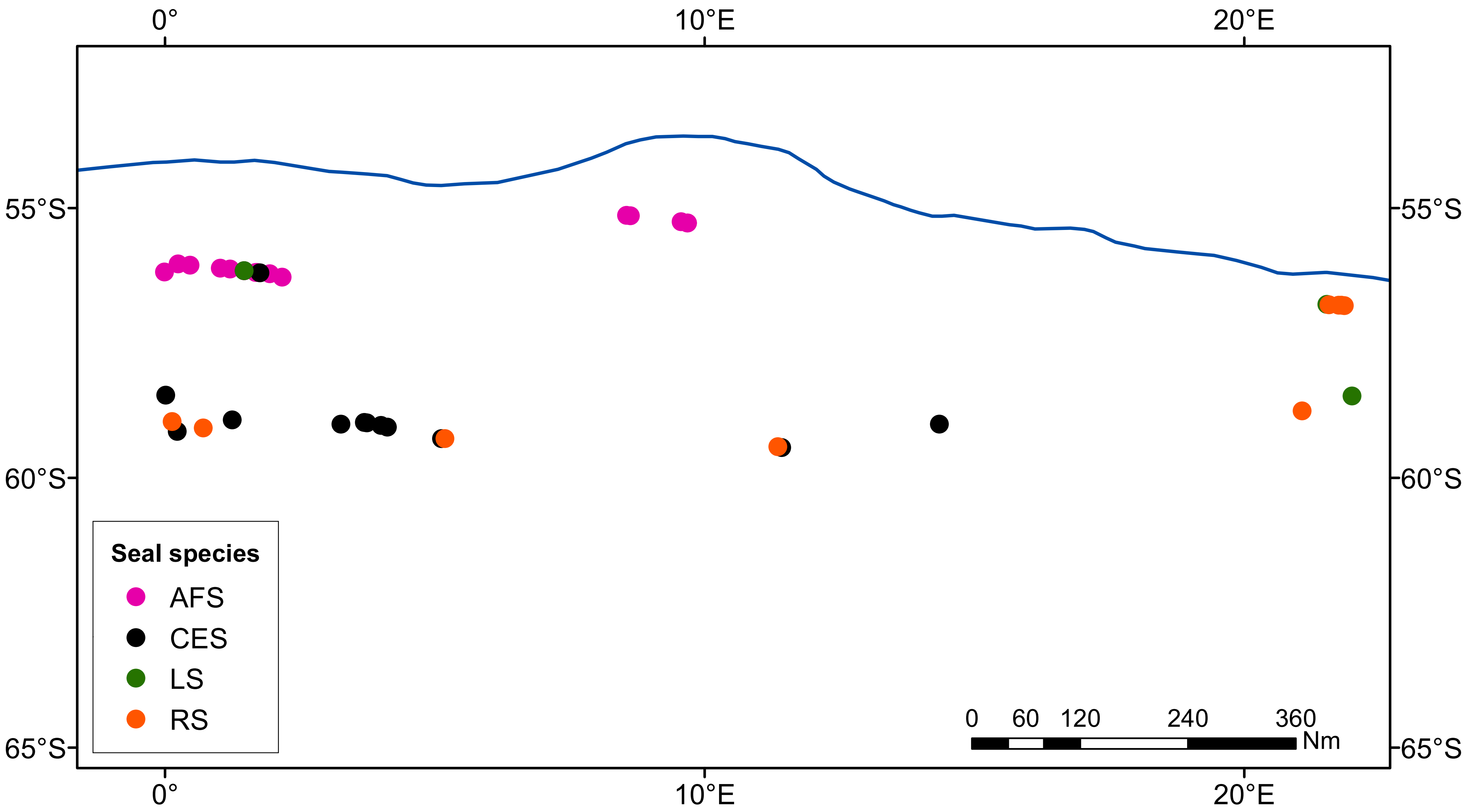
**Figure 1:** Cruise track (black) of the SA Agulhas II during the 2019 SCALE investigation of the marginal sea-ice zone (ice edge indicated by blue line) along the Lazarev Sea.

**Figure 2:** Location of sequentially numbered ship-board censuses (n = 11), variously conducted on 22 October to 08 November 2019 between 03:45 and 20:00 LAT south of the ice edge (blue line). **Inset:** The survey pattern of census 8 within the Lazarev Sea.

**Figure 3:** The locations of seals sighted during census both within and outside of the census strip south of the ice edge (blue line). AFS: Antarctic fur seal, CES: crabeater seal, LS: leopard seal, RS: Ross seal. Ice data (sea ice edge defined as 15% ice concentration indicated as blue line) derived from the National Snow & Ice Data Center's Sea Ice Index, Version 3 (https://nsidc.org/data/G02135/versions/3; Fetterer, Knowles, Meier, Savoie, & Windnagel (2017).


0°
10°E
20°E
30°E
40°E
50°E
40°S
50°S
60°S
70°S
South Africa
Antarctica


Bouvetøya
55°S
60°S
65°S
0°
10°E
20°E
1
2
3
4
5
6
7
8
9
10
11
16°E
58°30'S
59°S
Census leg 8
0
5
10
20
30
Nm
0
55
110
220
330 Nm


0°
10°E
20°E
55°S
60°S
65°S
Seal species
AFS
CES
LS
RS
0
60
120
240
360
Nm