Ross seal distribution in the Weddell Sea: Fact and Fallacy

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Abstract

The presence of Ross seals (*Ommatophoca rossii*) throughout the Weddell Sea is at best equivocal although overview articles usually depict this as fact on distribution maps. This study reviewed the appropriate literature on the distribution of Ross seals in the Weddell Sea *sensu lato* and investigated their presence/absence during two expeditions (summer/autumn of 2014 and 2018) into its most southern reaches off the Filchner-Ronne Ice Shelf. Both ship-board and helicopter surveys were done primarily along the eastern aspect and the south-western limit of the Weddell Sea. Evidence suggests that Ross seals are absent from the Weddell Sea during winter, utilizing the northernmost fringes of the pack-ice during the spring breeding (pupping and mating) season. Ross seals are absent from the inner reaches of the Weddell Sea past about 73°S in summer and early autumn when they occur in number in the eastern Weddell Sea eastwards from about 30°W longitude.

Keywords: Pack-ice, Ross seals, Weddell Sea, ship-board and aerial censuses, seasonal distribution

Introduction

Southwell et al. (2012) comprehensively reviewed data on abundance, trends in abundance, habitat use and diet of ice-breeding seals in the Southern Ocean and showed that the Ross seal (*Ommatophoca rossii*) are the least numerous and least studied of the Antarctic ice-breeding seals.

Ross seals are described as “commuters” (Kooyman and Kooyman 2009) because of their long foraging trips north of the pack-ice into pelagic areas of the Southern Ocean for most of the year and return to the pack-ice only for short periods to breed and moult (Blix and Nordøy 2007; Arcalís-Planas et al. 2015). The Perennial Acoustic Observatory in the Antarctic Ocean (PALAOA) located on the Ekström Ice Shelf (70°31’S, 8°13’W) hydro-acoustically recorded Ross seal presence between December 2006 and February 2007 (van Opzeeland et al. 2010) which matches the migratory behaviour of the Ross seals in the eastern Weddell Sea derived from satellite tags (Blix and Nordøy 2007). Therefore, the presence of Ross seals in the Weddell Sea and Ross Sea is seasonal (Blix & Nordøy 2007; van Opzeeland et al. 2010; Arcalís-Planas et al. 2015) and the timing of surveys for Ross seals is crucial to locate them in the pack-ice region.

The peak summer haul out in the pack-ice by Ross seals coincides with the presence of most research vessels in the Antarctic, which makes summer the optimal time for locating Ross seals. However, the generalised continuous distribution maps of Ross seals throughout the Weddell Sea (e.g., Reeves et al. 2002; Shirihai 2002; Hückstädt 2018) are at odds with results from earlier work (Erickson et al. 1969; Siniff et al. 1970; Erickson and Hofman 1974; Erickson 1984; Erickson and Hanson 1990). Then no Ross seals were sighted in the Weddell Sea area bound by 32ºW-65ºW and 71ºS-78ºS in summer when the seasonal pack-ice was accessible (*cf*. Seals, Sheet 4 in Brown et al. 1974).

Here we investigate the presence of Ross seals in the Weddell Sea, in particular the area bounded by 32ºW-65ºW and 71ºS-78ºS, outside of the eastern Weddell Sea where Ross seals are relatively abundant as compared to other regions of the Antarctic pack-ice except for the Ross Sea (Bester et al. 2017). This was done for both the breeding (pupping) season [probably from mid-October through November, variable according to region] and moulting season [from late December, but especially

through January to early February] when the Ross seals are tied to pack-ice (Blix and Nordøy 2007; Bester et al. 2017). To this end, we researched (a) the published literature for Weddell Sea seal distribution records, (b) searched for Ross seals during the research cruises 'Seal Research at the Filchner Outflow System' (SEAFOS; Grant No AWI_PS82_03; Knust and Schröder 2014) and the 'Filchner Ronne Outflow System Tomorrow' (FROST; Grant-No. AWI_PS111_00; Schröder 2018) research cruises of the RV *Polarstern* (Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung 2017) into the Weddell Sea (this study), and (c) synthesise this information to provide an up-to-date assessment of Ross seal distribution in the Weddell Sea.

Materials and methods

Literature survey

Antarctic seal literature within the Mammal Research Institute (MRI) collection, as well as those provided by the Alfred Wegener Institute for Polar and Marine Research (AWI), and that sourced from the University of Pretoria's Merensky library, were scrutinised.

Spatial framework for Weddell Sea

The Weddell Sea in the Southern Ocean has land boundaries defined by the bay formed from the coasts of Coats Land and the Antarctic Peninsula, and the Filchner-Ronne Ice Shelf forms the southern border. To facilitate the presentation of results and comparison with published information about the distribution of Ross seals in the Weddell Sea, we created the following sub-sections of the study area:

Outer Weddell Sea: Cape Norvegia at the Princess Martha Coast, Queen Maud Land, delineates the Outer Weddell Sea (OWS) from the neighbouring King Haakon VII Sea, but we include the latter area into what is loosely called the 'Eastern Weddell Sea' (e.g. Bester et al. 2019). We consider the Eastern OWS (EOWS) as extending eastwards of 30ºW to 00ºW (see Bester et al. 1995), and the Western OWS (WOWS)

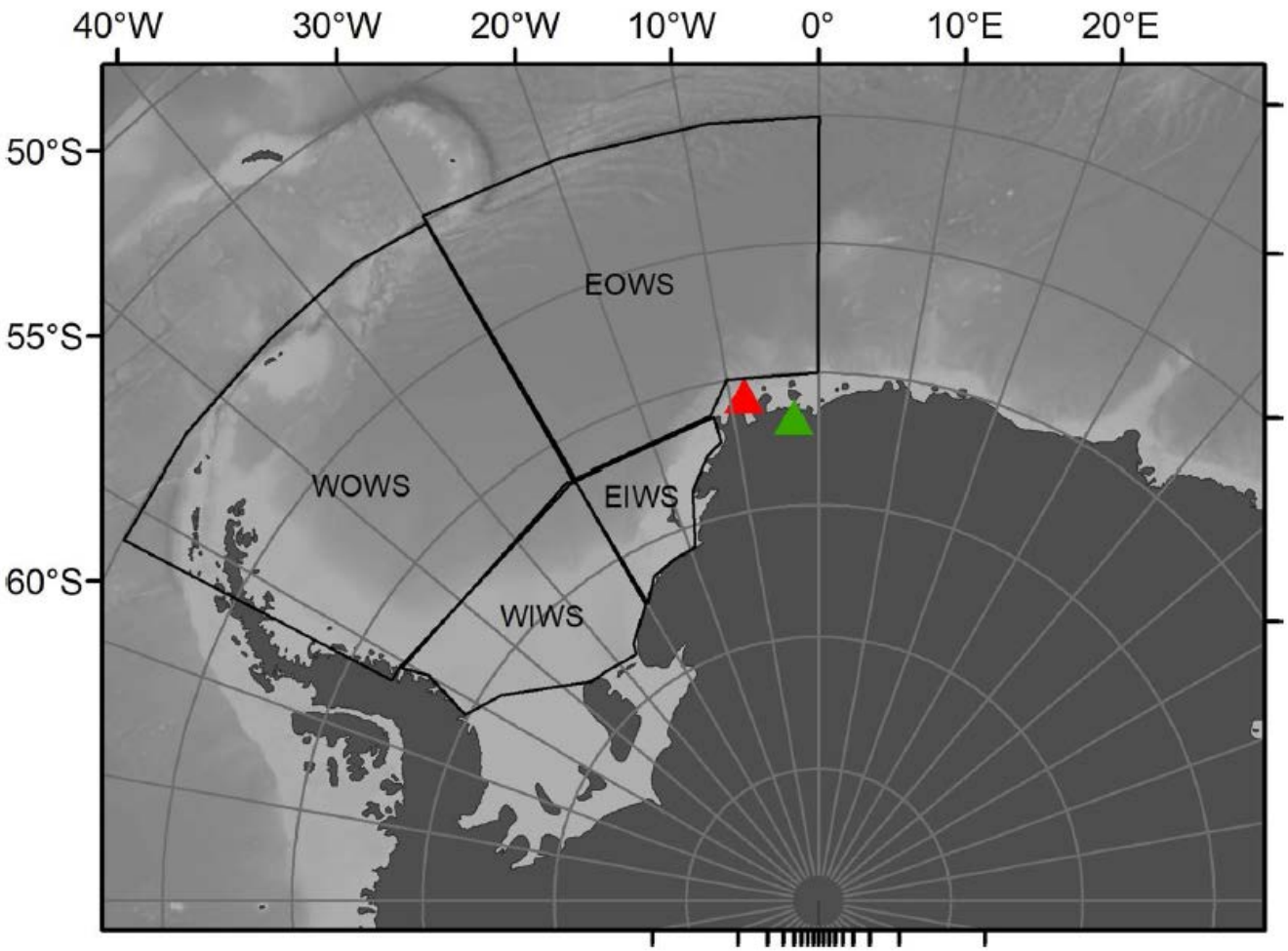

Figure 1: Spatial framework for the Weddell Sea delineating the Outer Weddell Sea (OWS), divided into East (EOWS) and West (WOWS), and Inner Weddell Sea (IWS), divided into East (EIWS) and West (WIWS). The geographical positions of Neumayer Station III (red triangle) and SANAE IV station (green triangle) are indicated.

westward of 30ºW to 60ºW, including the tip of the Antarctic Peninsula and associated island groups. The latitudinal extent of the OWS is from 60ºS to 73ºS (Fig. 1).

Inner Weddell Sea: The IWS extends from 73ºS to roughly 78ºS off the Filchner Ice Shelf, and to 75ºS off the Ronne Ice Shelf at the intersection with southernmost extent of the Antarctic Peninsula (Fig. 1). The IWS is delineated by 30ºW longitudinal line into Western (WIWS) and Eastern (EIWS) sections.

Pack-ice seal surveys

During SEAFOS, aerial sighting surveys of pack-ice seals using helicopters were done from 4 January to 9 February 2014 from aboard RV *Polarstern* (Fig. 2). Aerial surveys were flown with a Bölkow Blohm twin engined helicopter at a height of approximately 60 m (200 ft) and at a velocity of ~110 km/h (60 knots). Three observers (two on portside, one on starboard) independently searched for seals hauled out on ice, and identified seals sighted to species level following Laws (1993). Full details of the survey design can be sourced from Bornemann et al. (2014).

During FROST, ship-board sighting surveys for Ross seals were done from the bridge of the RV *Polarstern* at an elevation of 18 m, by one observer, rotating with 2 others in three- to four-hour shifts during all daylight hours while the ship was steaming through pack-ice. Using binoculars, observers searched within an approximate distance of 400-500 m either side of the ship in the period 28 January – 27 February 2018, which resulted in 230 h 23 min of observations. Over the same period, aerial sighting surveys during 16 helicopter flights ahead of the RV *Polarstern* steaming direction (Fig. 3), were done to search for Ross seals using at least two experienced observers (one on portside and another on starboard), except for reconnaissance flights 4 and 6-8 with only one of us aboard. Flights were at varying heights and speeds, primarily in the time slot 10:00 – 15:00 local apparent time, the most likely period during which the Ross seals are hauled out on the ice floes (Blix and Nordøy 2007). During the 16 flights, a total of 1,379 nm (2,553.9 km) were flown over 16 h 30 min. Seals that could not be positively identified from altitude were usually closely approached by helicopter to ascertain the species. Full details of the methods used during FROST appear in Bester et al. (2018).

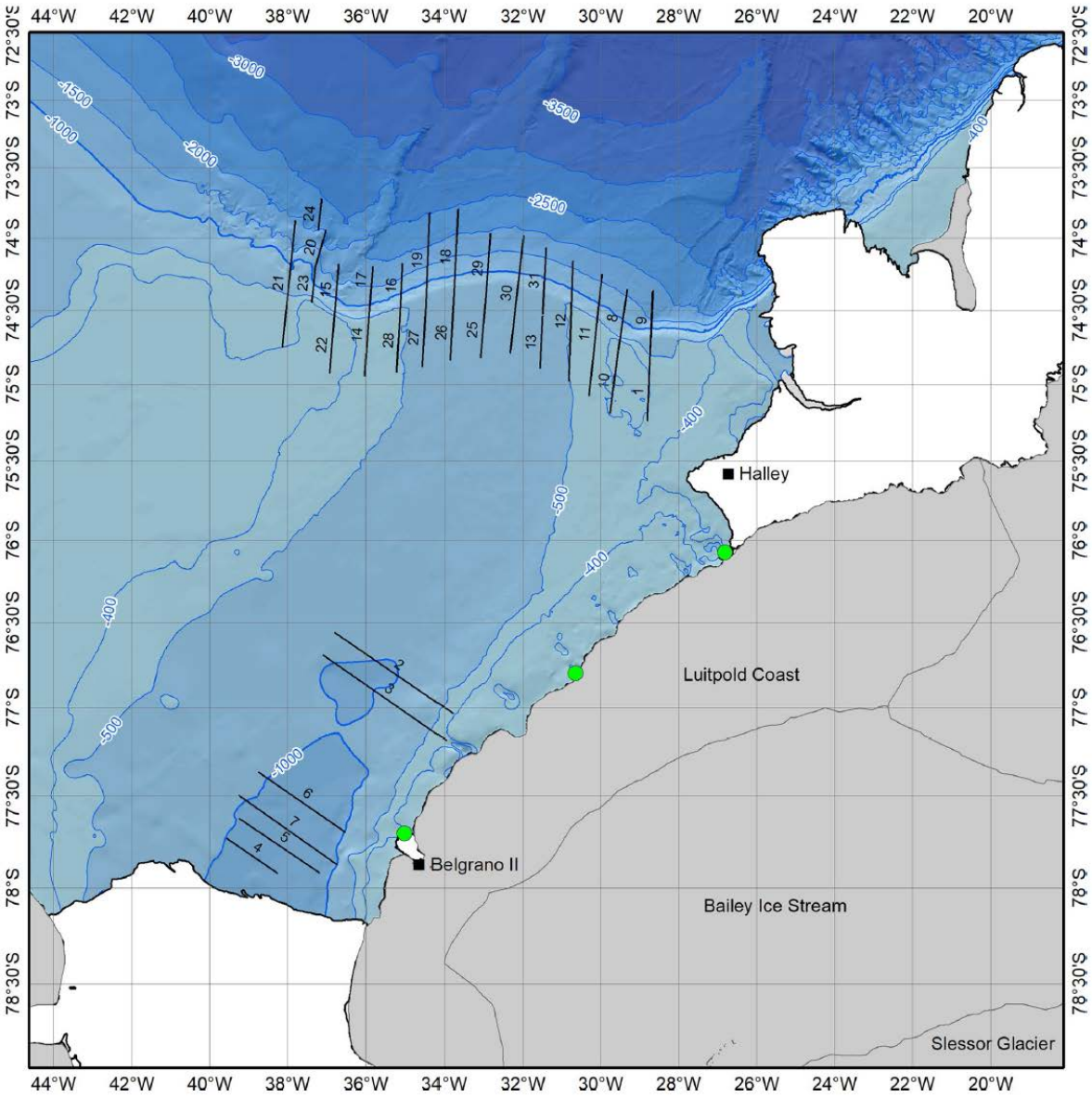

Figure 2: Placement of (a) the six numbered (2-7) census lines totalling 425.54 km (229.77 nm), perpendicular to the coast across the bathymetric gradient, starting at the 400 m contour, in the Filchner Trough region, and (b) the 14 census lines comprising twenty-five numbered (1, 8-31) transects, totalling 1,367.61 km (738.45 nm), perpendicular to the 1,000 m bathymetric contour, extending up to the 400 and 2,000 m bathymetric contours, in the Filchner Outflow region, flown during SEAFOS in the Weddell Sea from 4 January to 9 February 2014. Range limitations of the helicopter relative to the ship's position required some census lines to be completed in sections (transects 1, 8-31). Green dots denote locations of aggregations of other pack-ice seals encountered during reconnaissance flights. Map provided by Boris Dorschel, AWI. Data sources: IBCSO v1 (Arndt et al. 2013), SCAR Antarctic Digital Database (ADD).

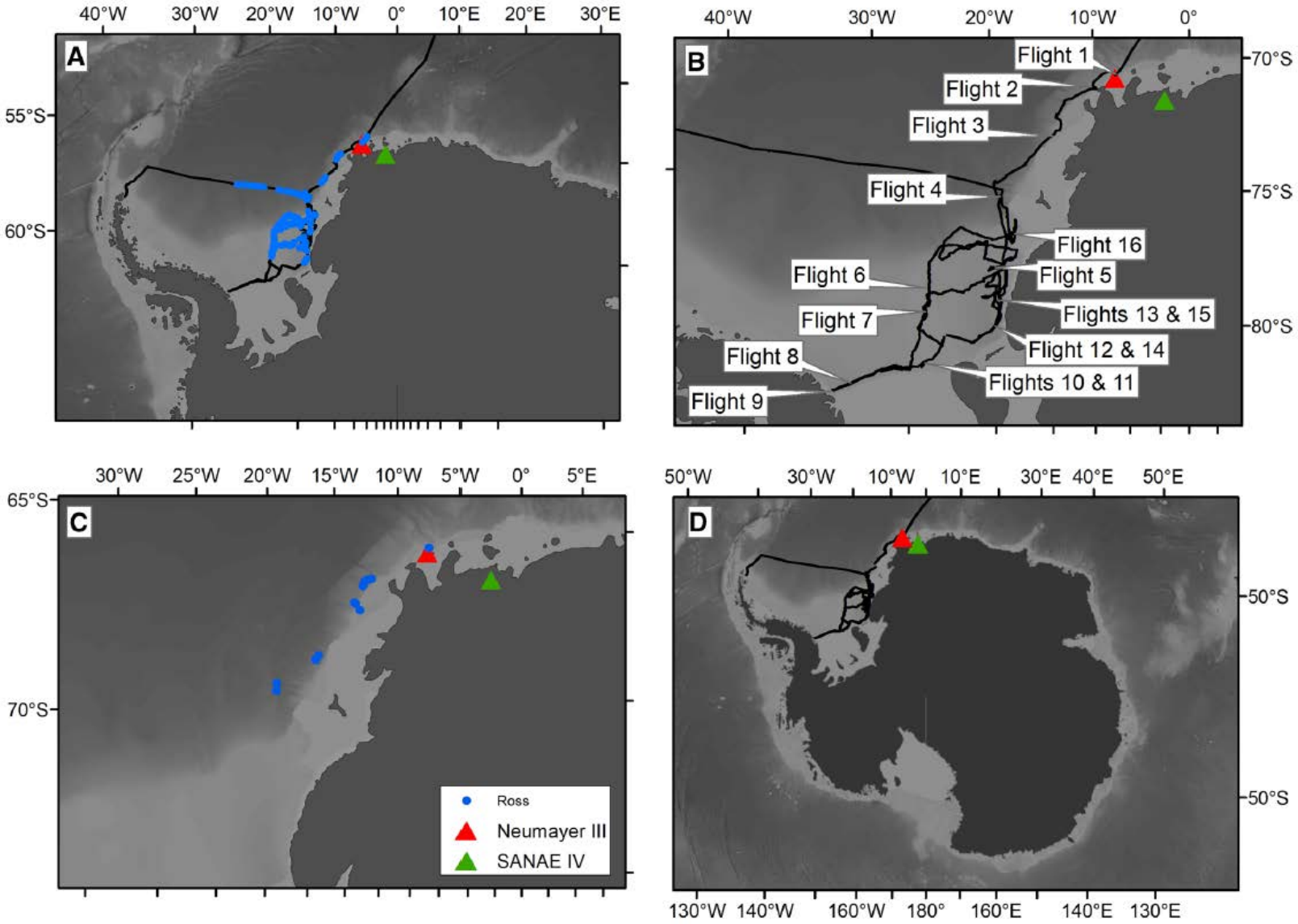

Figure 3: A) RV *Polarstern* track during FROST (28 January - 8 March 2018) within the Weddell Sea shown with black and observation locations along the track are shown in blue. B) The locations of flights 1-16 along the RV *Polarstern* track during FROST. C) Sightings of Ross seals along the cruise track. D) The location of the RV *Polarstern* track during FROST within the Weddell Seal in relation to Antarctica. Background is Gebco 0.5 minute bathymetry.

Results and Discussion

LITERATURE REVIEW

Distributional maps of Ross seals (e.g., Reeves et al. 2002) depict the presence of the species throughout the Weddell Sea. However, pupping areas of Ross seals are generally inaccessible during austral spring (October to November), and thus records of females with pups are scarce, and in the Weddell Sea limited to the fringes of the pack-ice.

Western Outer Weddell Sea (WOWS): Thomas et al. (1980) found a newborn pup at 64°21.5'S, 62°47.4'W near the Antarctic Peninsula on 14 November 1978, and in late November 1983 four individual Ross seals (unknown status) were seen west of the South Orkney Islands in the area bound by 61°30'-62°48'S, 39°28'-38°51'W (Erickson 1984). Øritsland (1970) collected pregnant Ross seals within the outer edge of pack-ice between the South Shetland and South Orkney islands. These were taken north of 62°S and between 55°W–44°W longitude near the tip of the Antarctic Peninsula, in the period 22 September to 31 October 1964. No records of pregnant females and/or unweaned pups exist for the more inner reaches of the Weddell Sea at comparable times presumably due to the inaccessibility of this consolidated pack-ice area for surveys. Additionally, both Blix and Nordøy (2007) and Arcalís-Planas et al. (2015) showed that Ross seals are at sea in open water north of the pack-ice region in winter, and breeders briefly return to penetrate the outer reaches of the pack-ice for pupping. Thereafter they depart for the open sea again upon weaning their pups after a median nursing period of about 2 weeks, mating occurs at the end, or shortly after, the nursing period, evidently in the last week of November (Blix and Nordøy 2007). It is therefore unlikely that Ross seals utilise the inner reaches of the Weddell Sea during spring and early summer.

Eastern Outer Weddell Sea (EOWS): During late summer (January/February) Ross seals were encountered in very low densities (0.006 km^{-2}) in the outer reaches of the Weddell Sea (Erickson et al. 1969). Just 4 of 4,742 seals encountered in 1,895 km^2 were Ross seals (Erickson and Hofman 1974), two of which were seen marginally

(less that 02º longitude) to the west of 30ºW and south (less than 01º of latitude) of 70ºS (their exact localities are not known - Seals; Sheet 4 in Brown et al. 1974). Excluding the remaining two Ross seals that were located eastwards of 30ºW and marginally southwards of 70ºS in the EOWS (Seals; Sheet 4 in Brown et al. 1974) all other Ross seal locations were depicted to be north of 70ºS (Brown et al. 1974). In concert with the aforementioned observations, Ross seals were also found in the EOWS in relatively high numbers during the summers of 1974-1977 (Condy 1977), 1991-1993 (Bester et al. 1995, 2002) and in the summer of 2015/16 (Bester et al. 2019), all north of 72º30'S. Blix and Nordøy (2007) encountered Ross seals in the EOWS as far south as 72ºS and eastwards from 17ºW while Bester et al. (2018) encountered Ross seals between 09º-24ºW, but mostly in the area centred on 02ºW. Ross seal abundance also increased progressively from west to east in the pack-ice of the EOWS (Condy 1977; Bester and Odendaal 2000; Bester et al. 2002, 2018). The total estimated abundance of Ross seals through aerial census, between 1995 and 2001, in the OWS area between 20ºW and 5ºE, were 830 (119–2,894) individual Ross seals (Gurarie et al. 2017).

Ross seals were only identified on one occasion (unspecified) in the period 22-29 January 1999 during aerial surveys in the WWS area bounded by 90º-30ºW at 60º-80ºS (Forcada et al. 2012) which straddles the OWS and IWS. Although the Forcada et al. (2012) survey included the IWS, most effort was directed at the West Antarctic Peninsula region. The Ross seal(s) mentioned (Forcada et al. 2012) were most likely sighted in the latter region, as the species has previously been recorded in the area around the tip of the Antarctic Peninsula (Øritsland 1970; Brown et al. 1974; Thomas et al. 1980; Bengtson and Stewart 1997). Perhaps parts of the WOWS are areas of higher Ross seal density (Stewart 2007), similar to the King Haakon VII Sea (EOWS) and the Ross Sea (Stewart 2007; Bester et al. 2017). However, no Ross seals were positively identified in the approximate area 66º-69ºS, 58º-39ºW in the north-western Weddell Sea (WOWS) in the period 20 November 2004 to 04 January 2005 (Flores et al. 2008). Siniff and Cline (1968) only saw one Ross seal off the northern tip of the Antarctic Peninsula in the period January-March 1968, after 42 days at sea. Unbeknown to Siniff and Cline (1968), the latter part of the cruise coincided with the time that Ross seals would have departed the pack-ice region (Blix and Nordøy 2007).

SEAFOS

A total of 20 helicopter flights lasting 30 h 08 min were flown (range 7 min to 3 h 08 min). First, pack-ice along the east coast of the EIWS (Coats Land), from the Brunt Ice Shelf (76°S section) along the Luitpold Coast (77°S section) southwards to the Filchner Ice Shelf (78°S section), were surveyed (Fig. 2). Second, pack-ice to the west of the Brunt Ice Shelf along the outflow of the Filchner Trough between the section 'eastern' and the section 'western' shelf (Fig. 2) were surveyed. The survey design, detailed in Bornemann et al. (2014), is not pursued further as this study only reports on basic presence/absence scoring for Ross seals during the aerial surveys. No Ross seals were detected. The absence of Ross seals is unlikely to be a survey timing issue (4 January – 9 February) as adult Ross seals were still present within the pack-ice of the EOWS off Dronning Maud Land in the overall period 03-11 February, in 1992 (Bester et al. 1995) and 2001 (Blix and Nordøy 2007).

FROST

Ross seals (n = 20) were seen from the ship in an area of high relative abundance off Atka Bay, and along the cruise track of the RV *Polarstern* past Cape Norvegia, in the area (EOWS) bound by 26°W-08°W and 70°31,5'S-73°19.6'S, from 28 January to 02 February 2018 (see ship's cruise track, Fig. 3). A further two Ross seal sightings were recorded on 3 February during reconnaissance flight 4 further along the Riiser-Larsen Ice Shelf at 73.7°S, 25.2°W (on fragmented fast ice) and 73.8°S, 24.1°W (in pack-ice) respectively although these sightings were not confirmed by descending to lower altitude for a closer look (see Methods). No Ross seals were seen in the IWS (see the ship's cruise track and helicopter flights in Fig. 3). Perhaps the absence of Ross seals in the deeper reaches of the Weddell Sea is partly a survey timing issue. The area was traversed from 03–27 February, and therefore largely after the period (late January) when PALAOA in Atka Bay (EOWS) recorded a drop in the calling rate of Ross seals which likely corresponded with the migration of most Ross seals northward (van Opzeeland et al. 2010). However, at a comparable time (14-16 February) in 1983, Ross seals were still numerous in the EOWS and King Haakon VII seas from 08ºW-18ºE (Erickson and Hanson 1990). Therefore, it is curious that all reported sightings of Ross seals were within 74ºS latitude in the present study, a consequence unrelated to the timing of the survey. The sighting at 73ºS, 26ºW is the southernmost confirmed

sighting of a Ross seal in the Weddell Sea, within the westernmost limit of Ross seal sightings (~32^{o}W) in this part (EIWS) of the Weddell Sea (Brown et al. 1974).

We suggest that Ross seals do not exploit the vast majority of the Weddell Sea during the moult haul out (this study). This notion is supported by the absence of Ross seals during the SEAFOS campaign, the outcomes of the 1968 and 1969 surveys (Siniff and Cline 1968; Erickson et al. 1969; Siniff et al. 1970), the FROST campaign, and the January 1999 aerial foray into the western Weddell Sea (Forcada et al. 2012).

Conclusions

We hypothesize, based on circumstantial evidence, that during the breeding (pupping) season the inner reaches of the Weddell Sea are devoid of Ross seals. We provide proof that this is true for the summer/autumn moulting period of Ross seals when they are absent right across the inner part of the Weddell Sea. Furthermore, the eastern Weddell Sea off Dronning Maud Land is a local area of abundance for Ross seals during the summer/autumn, seals generally occurring to the east of 30^{o}W longitude, and rarely venturing further south than ~73^{o}S latitude. The reason(s) for this situation is unknown, but this is an important conclusion in terms of (a) delineating a possible CCAMLR Marine Protected Area in the Weddell Sea (Teschke et al. 2016), given the paucity of Ross seal sightings in other regions of the Weddell Sea (Erickson et al. 1969; Siniff et al. 1970; Erickson 1984; Erickson and Hanson 1990; Bornemann et al. 2014; Bester et al. 2018; this study), and (b) extrapolating seal densities recorded in some part(s) of the Weddell Sea (e.g. Gurarie et al. 2017) to the entire Weddell Sea.

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Compliance with Ethical and Environmental Standards

The authors declare that they have no conflict of interests.

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, extended by IEE 14/12/16/5/1/18 for expedition PS111 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)). Research carried out during expedition PS82 was approved by the German Federal Environmental Agency ("Umweltbundesamt"), Reference No. I 3.5 – 94003-2/142 as of 14 August 2013 under the German acts implementing the Protocol of Environmental Protection to the Antarctic Treaty.

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