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Very low biodiversity of top predators—seabirds and marine mammals—in the high Arctic Ocean

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Abstract During the ARK-XXIII/3 expedition of icebreaking RV *Polarstern* in the high Arctic Ocean (*partim* north of 73°N) from 25 August to 10 October 2008, 550 transect counts lasting 30 min were devoted to seabird and marine mammal counts from the bridge. In the whole area, the three most numerous species, kittiwake *Rissa tridactyla*, fulmar *Fulmarus glacialis* and Brünnich's guillemot *Uria lomvia* represented 90% of the total of 12000 individuals registered, followed by ivory gull *Pagophila eburnea*, black guillemot *Cepphus grylle* and Ross's gull *Rodostethia rosea*. Four geographical zones were recognized on the basis of number of species and density. Both were especially low in the deeper areas (mean depth of 3000 m), both ice-free and heavily ice-covered: 0.3 birds per 30 min count belonging to three and four species respectively. The most numerous species was kittiwake with 0.25 per count (50 individuals) in the ice-covered area. Pinniped numbers were very low as well, the most numerous of the four species tallied being 20 harp seals *Phoca groenlandica* and 10 ringed seal *Pusa hispida*. Seven polar bears *Ursus maritimus* were encountered. These observations were basically confirmed during 12 helicopter flights lasting one hour each with very low numbers: 50 kittiwakes and 13 harp seals, almost none in the ice-covered deep zone. A comparison between data obtained from ship and from helicopter seems however to reflect the importance of seabird followers including for long distances. The only cetaceans were two adult belugas *Delphinapterus leucas* tallied from helicopter.

Keywords **seabirds, marine mammals, at-sea distribution, high Arctic Ocean**

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1 Introduction

At-sea observations of marine "top predators" are essential to understanding the ecological drivers of many species. Although technologies like the Global Positioning System and Geolocator tags are helping to identify environmental parameters that might affect their behaviour, only a limited number of individuals can be targeted. At-sea transects can better identify assemblage areas, and combined with on-board sensors which measure spatially and temporally fine-scale information, we are able to detect the events or features which lead to these accumulations of marine life. This is particularly helpful in remote areas like the high Arctic Ocean, which have generally poor satellite coverage. The area is very poorly studied, being accessible by icebreakers only. The importance of hydrographic features such as water masses and fronts, pack ice and ice edge on seabird distribution was detected decades ago (Joiris, 1978; Pocklington, 1979). The relationship of seabirds and marine mammals to such frontal regions has been previously examined (e.g. Ainley et al., 1998; Hyrenbach et al., 2007; Joiris and Falck, 2011; Ribic et al., 2011; Force et al., 2015; Joiris, 2018; Yurkowski et al., 2018).

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2 Materials and methods

In the frame of our long-term study on the at-sea distribution of "top predators"—seabirds and marine mammals—in polar ecosystems, our main aims are to study the environmental factors explaining their distribution at sea, as well as to detect possible temporal and spatial evolutions, with special attention to global climatic changes. Seabird and marine mammal quantitative at-sea distribution was studied during the high Arctic circumpolar expedition ARK-XXIII/3 of icebreaking RV *Polarstern* from the eastern end of the North-West Passage (130°W) on 25 August, to 10 October 2008 off Northern Norway (29°E). Data selected for this article were all collected north of 73°N. Transect counts were conducted from the bridge (18 m above sea level) without width limitation during 30 min periods, on a continuous basis as ship operations, light and visibility conditions allowed. When detected, followers were included as far as possible only once per count. More details on our counting method have been described and discussed previously (Joiris, 2011, 2018a; Joiris and Falck, 2011; Joiris et al., 2014). Taking into account the importance of followers and the great heterogeneity in the distribution of top predators, basic data are presented in this article, without correction e.g. for the diving pattern of the animals. Nor are calculations such as density presented. Counts were also run during helicopter flights, lasting between 40 and 90 min along return transects (mean: duration 60 min, speed 100 n mile·h^{-1}, height 200 feet).

3 Results

During the northern part of the *Polarstern* expedition in the high Arctic Ocean (north of 73°N), totals of 12135 seabirds, 36 identified pinnipeds and 7 polar bears were encountered during 550 counts. This represented a mean value of 22 birds per count. Most numerous species were 5000 kittiwakes *Rissa tridactyla*, 4000 fulmars *Fulmarus glacialis* and 2000 Brünnich's guillemots *Uria lomvia*. Together, these three species represented thus 90% of the total, followed by 400 ivory gulls *Pagophila eburnea*, 340 black guillemots *Cepphus grylle* and 170 Ross's gulls *Rodostethia rosea*. Among the pinnipeds, 20 harp seals *Phoca groenlandica* and 13 ringed seal *Pusa hispida* were the most numerous of the four species tallied. Seven polar bears *Ursus maritimus* were registered (Table 1).

Moreover, striking very important geographical differences in seabird abundance were registered, allowing to identify four zones (A to D) with mean values of 0.3, 17, 0.3 and 93 birds per count respectively. The majority of counts did not provide any bird contact at all in zones A and C. These zones correspond to differences in hydrological features such as water depth, water temperature and salinity, and ice cover (Table 1, Figure 1). Zones A and C were characterized by their very deep bathymetry, 3000 m mean depth: They both correspond to the deep Arctic basin, zone A being almost ice free, zone C very closely ice-covered.

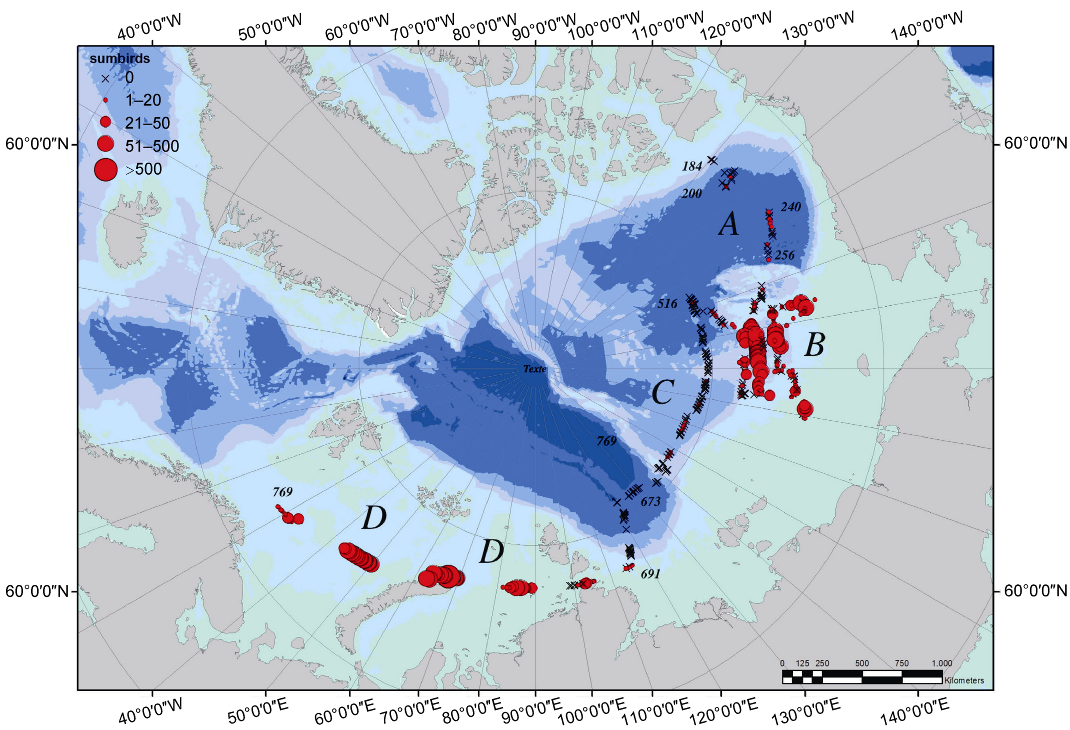

Figure 1 Seabirds recorded during *Polarstern* expedition ARK-XXIII/3 (*partim* north of 73°N) from 25 August to 10 October 2008; *N* = total number, mean per count. Four zones were recognised (A to D, see text); count numbers; positions and hydrological data from Jokat (2009).

Table 1 "Top predators"—seabirds and marine mammals—recorded during *Polarstern* expedition ARK-XXIII/3 (*partim* north of 73°N) from 25 August to 10 October 2008. N = total number of individuals, all seabirds; n = number of 30 min transect counts: mean per count; positions and hydrological data from Jokat (2009)

Zone		A		B*		C**		D***		All	
From		130°W		160°W		160°W		115°E		130°W	
To		160°W		160°E		115°E		29°E		29°E	
n		35		260		171		81		547	
Ice cover/%		5		12		96		16		39	
SST/℃		2.5		1.8		−1.5		−1.5		0.99	
Salinity		23.9		28.4		30.2		31.8		29.2	
Speed****/(n mile·h^{-1})		10.1		6.2		6.0		10.3		7.0	
Depth/m		3300		1262		2825		227		1490	
Species	Species	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
Fulmar	*Fulmarus glacialis*	4		11	0.04	0		3958	49.0	3973	7.26
Great skua	*Stercocaruis skua*	0		1		0		0		1	
Arctic skua	*Stercorarius parasiticus*	0		0		0		1		1	
Long-tailed skua	*Stercorarius longicaudus*	3		3		0		2		8	
Pomarine skua	*Stercorarius pomarinus*	0		49	0.19	0		29	0.36	78	0.14
Glaucous gull	*Larus hyperboreus*	4		46	0.18	6	0.03	88	1.09	144	0.26
Iceland gull	*Larus glaucoides*	0		7	0.03	1		3		11	0.02
Sabine's gull	*Xema sabini*	0		7	0.03	0		0		7	
Kittiwake	*Rissa tridactyla*	1		4009	15.4	0		988	12.2	4998	9.14
Ivory gull	*Pagophila eburnea*	0		222	0.85	42	0.25	132	1.60	396	0.72
Ross's gull	*Rhodostethia rosea*	0		171	0.66	0		1		172	0.31
Little auk	*Alle alle*	0		0		0		5		5	
Brünnich's guillemot	*Uria lomvia*	0		0		0		1992	24.6	1992	3.64
Black guillemot	*Cepphus grylle*	0		0		0		338	4.2	338	0.62
Puffin	*Fratercula arctica*	0		0		0		5		5	
∑ Birds		**12**	**0.34**	**4526**	**17.4**	**49**	**0.29**	**7546**	**93.12**	**12133**	**22.2**
Nber of bird species		4		10		3		13		15	
Ringed seal	*Pusa hispida*	4		6		4		3		13	0.02
Harp seal	*Phoca groenlandica*	0		10	0.04	2		8	0.10	20	0.04
Bearded seal	*Erignathus barbatus*	0		1		1		0		2	
Hooded seal	*Cystophora cristata*	0		0		1		0		1	
Seal sp.	*Pinnipedia*	0		3		5		4		12	0.02
∑ Pinnipeds				**20**	**0.076**	**13**	**0.076**	**15**	**0.185**	**48**	**0.087**
Polar bear	*Ursus maritimus*	0		7		0		0		7	0.01
Polar bear tracks		1		8		21	0.12	0		30	0.05

Notes: "*" S of 80°N; "**" N of 80°N; "***" Laptev, Kara and Barents seas; "****" differences in speed due to both ice-breaking and/or seismic activities.

Seabird numbers were extremely low in zone A: 12 individuals only representing 4 species. Zones B and C correspond to the ice-free and ice-covered parts south and north of 80°N, below and above the continental shelf respectively. In zone B ten species were tallied, mainly 4000 kittiwakes with numbers up to 100 to 150 per count, and a group of 250 out of effort close to count 379, 220 ivory gulls and 170 Ross's gulls. In zone C the very low numbers correspond to one species mainly: 40 ivory gulls. Zone D corresponds to the Laptev, Kara and Barents seas off North Norway: 4000 fulmar, 2000 Brünnich's guillemots and 1000 kittiwakes by far dominated in numbers. Number of species in zone D was 13 out of a total of 15 for the whole expedition (Table 1, Figure 2). Such data resemble the ones obtained in the Greenland Sea and Fram Strait. Some other seabird observations deserve

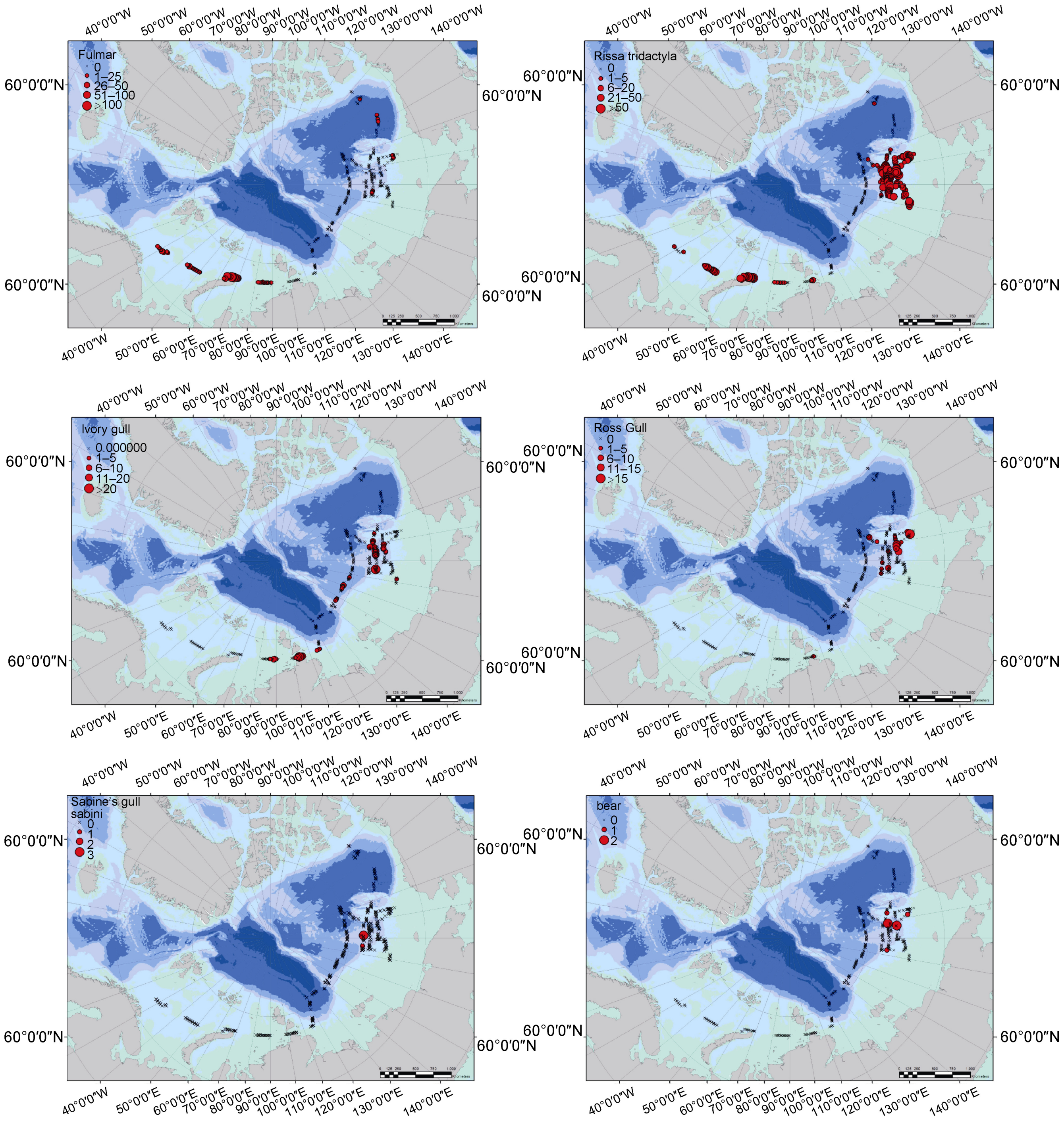

Figure 2 Seabirds and marine mammals recorded during *Polarstern* expedition ARK-XXIII/3 (*partim* North of 73°N) from 25 August to 10 October 2008. Numbers per 30 min count: **a**, fulmar *Fulmarus glacialis*; **b**, kittiwake *Rissa tridctyla*; **c**, ivory gull *Pagophila eburnea*; **d**, Ross's gull *Rhodostethia rosea*; **e**, Sabine's gull *Xema sabini*; **f**, polar bear *Ursus maritimus*.

special mention: three Steller's eiders *Polysticta stelleri* at count 476, two juvenile kittiwakes at counts 722 and 723 on 7 October, and two juvenile Brünnich's guillemots at count 764 on 9 October (see Figure 1).

Numbers of pinnipeds were very low as well, with none in zone A, 17 identified individuals in zone B of which ten harp seals *Phoca groenlandica* and six ringed seals *Pusa hispida*, eight seals in zone C and 11 in zone D, mainly harp seals. One harp seal mother with pup was tallied at count 458. Seven polar bears *Ursus maritimus* were observed in the Outer Marginal Ice Zone of zone B (Table 1, Figure 2) as well as two individuals out of effort close to counts 376 and 447.

No cetaceans at all were tallied from the ship. Two factors can explain this absence of data: or they are basically absent from this area, or they left already to their southern overwintering areas.

Countings were also realised during 12 return helicopter flights from 31 August to 4 October, i.e. six counts covering zone B and six zone C. Numbers were extremely low as well, with the exception of 48 kittiwakes, of which 47 in zone B (33 in one count) (Table 2). The main pinniped concentration consisted in 11 harp seals in zone B. Many ringed seals holes (15) were tallied in zone C during flight number seven. The same two adult belugas *Delphinapterus leucas* only were encountered twice from helicopter during return flight number five (Table 2).

Table 2 "Top predators"—seabirds and marine mammals—recorded during 12 return helicopter flights during *Polarstern* expedition ARK-XXIII/3 (*partim* north of 73°N) between 31 August and 4 October 2008

Flight number		1	2	3	4	5	6	Zone B	7	8	9	10	11	12	Zone C	All
Date (2008)		31-Aug	01-Sept	08-Sept	12-Sept	13-Sept	16-Sept	Mean	23-Sept	27-Sept	30-Sept	02-Oct	02-Oct	04-Oct	Mean	Mean
Duration/min		40	48	75	70	73	55	60	75	60	80	45	70	65	66	64
Speed/(n mile·h^{-1})		110	100	110	110	120	120	112	100	100	100	100	100	110	102	107
Height/(0.3048 m)		150	100	300	100	300	300	208	300	300	150	300	300	300	275	241
Start position N/((°)·min^{-1})		78.17	78.32	75.51	76.14	76.24	77.00		80.37	80.59	81.03	81.10	81.23	79.06		
E/((°)·min^{-1})		−178.40	174.06	−177.37	−172.21	−172.56	−175.30		169.55	141.54	137.00	122.00	124.51	118.07		
Count*		298	307	395	454	457	497		549	643	647	654	667	675		
Species	Species	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*
Sabine's gull	*Xema sabini*	1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kittiwake	*Rissa tridactyla*	0	0	2	4	33	8	47	0	0	0	0	1	0	1	48
Ivory gull	*Pagophila eburnea*	0	0	0	0	3	0	2	0	0	0	0	0	0	0	3
Σ Birds		0	0	2	4	36	8	50	0	0	0	0	1	0	1	51
Nber of bird species		0	0	1	1	2	1	2	0	0	0	0	1	0	1	2
Ringed seal	*Pusa hispida*	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Harp seal	*Phoca groenlandica*	0	0	11	2	0	0	13	0	0	0	0	0	0	0	13
Polar bear	*Ursus maritimus*	0	0	3	0	0	0	3	0	0	0	0	0	0	0	3
Beluga	*Delphinapterus leucas*	0	0	0	0	2	0	2	0	0	0	0	0	0	0	2

Notes: "*" Closest *Polarstern* count (see Table 1 and Figure 1); "**" Out of effort; zones B & C: see Table 1 and Figure 1.

4 Discussion

Densities of seabirds and pinnipeds were extremely low in zones A and C with a mean value of 0.30 birds per count. They were much higher in zone D with 90 birds per count. Numbers were intermediate in zone B with 17 birds per count, representing thus ratios of one and more than two orders of magnitude respectively. The main factor influencing these differences does not seem to be ice coverage since zone A was basically ice-free with a mean ice-coverage of 5%, while zone C was completely ice-covered with a mean coverage of 95%. Ice cover did thus not seem to play a major role. Visually the hydrological main factor seems to be water depth corresponding to the continental shelf, zones A and C showing mean depths of 3000 m, compared to 1300 m in zone B and 225 m in zone D (Table 1, Figures 1 and 3).

The comparison of data collected from the bridge of *Polarstern* and from helicopter flights in zone B are fitting very well for harp seal with mean values of 0.007 and 0.0065 per kilometer from ship and helicopter respectively (calculation based on duration and speed). They were however very different for kittiwake with 2.7 and 0.02 km respectively, i.e. two orders of magnitude (Tables 1 and 2). Such a huge discrepancy between ship and helicopter by one order of magnitude for seabird data does not seem to be due to differences in detection. The basic explanation might thus become that birds are mainly followers including on long distances (one to a few days). Table 3 presents such

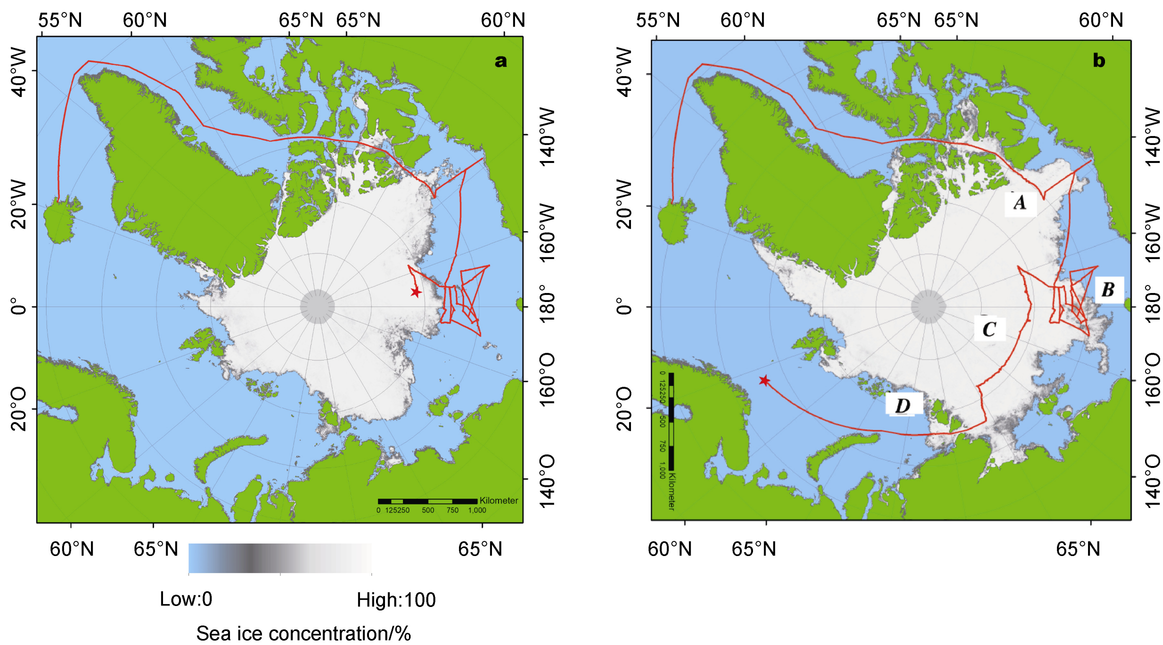

Figure 3 Ice conditions recorded during *Polarstern* expedition ARK-XXIII/3 (*partim* north of 73°N) from 25 August to 10 October 2008: **a**, situation on 22 September 2008; **b**, situation on 10 October 2008; zones: see Table 1 and Figure 1. From: Institute of Environmental Physics, University of Bremen, Germany.

examples, the kittiwake numbers being grouped in successive counts; together these five groups of counts concern 3300 individuals, including 2035 in one group of 33 counts, i.e. by far the majority of the 4000 kittiwakes registered in zone B in 260 counts (Table 3, Table 1). The importance of following seabirds could always be the case in marine ornithology but becomes especially obvious in areas with extremely low ships density—e.g. during this expedition, no ship at all were encountered. This can be extrapolated and generalised to similar zones with very low ships density such as the high Arctic (Joiris et al., 2016; this paper) or the North-East Passage off Siberia (Joiris, in prep).

Table 3 Numbers of kittiwakes *Rissa tridactyla* recorded from the bridge of *Polarstern* during expedition ARK-XXIII/3 (*partim* north of 73°N) during successive counts in zone B; starting count number; N = number of kittiwakes; n = number of counts; mean per count (see Table 1 and Figure 1)

Start	*N*																	Sum	*n*	Mean
276	10	13	30	17	19	40	60	75	22	75	50	22	17	10	4	30		494	16	30.9
333	50	75	100	40	75	75	25	100	40	75	25	25	100	50	100	30	25			
	75	3	20	15	25	175	50	100	100	85	100	55	7	32	145	38		2035	33	61.7
377	10	90	36	30	21													187	5	37.4
398	75	25	28	10	19													157	5	37.4
450	15	17	20	30	30	30	61	38	120	60								421	10	42
Total																		3294	69	47.7

On the other hand, such data also fit the general phenomenon of hotspots, the majority of observations being centralised in a limited surface of the study area (e.g. my synopsis in Joiris, 2018; Yurkowski et al., 2018).

Data were already collected by this team in the same area, in the ice-covered area mainly along the Lomonosov Ridge in July–September 2014 (Joiris et al., 2016). They basically fit the observations presented here, with very low numbers of species and of individuals. Both data sets show a full compatibility with the model predictions of Arctic seabird species distribution (Huettmann et al., 2011; Humphries and Huettmann, 2014), even if our data are lower than predicted. This might be due to temporal limitations or to the fact that many seabirds breeding on the coast actually don't reach the open ocean and thus escape at-sea observations.

5 Conclusion

Data collected on board icebreaking RV *Polarstern* from August till October 2008 reflect the very low numbers of seabird and marine mammal species and densities in the high Arctic Ocean, many 30 min counts from the ship showing no contact at all in some areas corresponding to the deep Arctic basin. In contrast, ice-coverage did not play a major role. A comparison between ship and helicopter observations seems to reflect the presence of many seabird followers, so that the densities registered from ships might provide an over-estimation of actual densities in areas with very low ships presence.

These data confirm previous results collected by this team in the same area (Joiris et al., 2016) and basically fit with the predictive model for number of seabird species by Huettmann et al. (2011).

They reflect an extremely low biodiversity with a few species only, of which one was dominating in numbers in each geographical zone, both for seabirds as for pinnipeds. Moreover, considering that top predators distribution follows their prey abundance, they also reflect very low bio-productivity in the deep Arctic basin.

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References

Ainley D G, Jacobs S S, Ribic C A, et al. 1998. Seabird distribution and oceanic features of the Amundsen and southern Bellingshausen seas. Antar Sci, 10(2): 111-123.

Force M P, Santora J A, Reiss C S, et al. 2015. Seabird species assemblages reflect hydrographic and biogeographic zones within Drake Passage. Polar Biol, 38(3): 381-392.

Huettmann F, Artukhin Y, Gilg O, et al. 2011. Predictions of 27 Arctic pelagic seabird distributions using public environmental variables, assessed with colony data: a first digital IPY and GBIF open access synthesis platform. Marine Biodiversity, 41(1): 141-179.

Humphries G R W, Huettmann F. 2014. Putting models to a good use: a rapid assessment of Arctic seabird biodiversity indicates potential conflicts with shipping lanes and human activity. Diversity Distributions, 20(4): 478-490.

Hyrenbach K D, Veit R R, Weimerskirch H, et al. 2007. Community structure across a large-scale ocean productivity gradient: marine bird assemblages of the southern Indian Ocean. Deep-Sea Res I, 54(7): 1129-1145

Joiris C R. 1978. Seabirds recorded in the northern North Sea in July: the ecological implications of their distribution. Gerfaut, 68: 419-440.

Joiris C R. 2011. Possible impact of decreasing Arctic pack ice on the higher trophic levels—seabirds and marine mammals. Adv Environ Res, 23: 207-221.

Joiris C R. 2018. Seabird and marine mammal "hotspots" in polar seas. Lambert Academic Publishing, Düsseldorf, Germany, 48, ISBN: 978-620-2-19805-9.

Joiris C R, Boos K, D'Hert D, et al. 2016. Low density of top predators (seabirds and marine mammals) in the high Arctic pack ice. Scientifica, 14, doi: 10.11.1155/2016/1982534.

Joiris C R, Falck E. 2011. Summer at-sea distribution of little auks *Alle alle* and harp seals *Pagophilus (Phoca) groenlandica* in the Greenland Sea: impact of small-scale hydrological events. Polar Biol, 34(4): 541-548, doi: 10.1007/s00300-010-0910-0.

Joiris C R, Falck E, D'Hert D, et al. 2014. An important late summer aggregation of fin whales *Balaenoptera physalus*, little auks *Alle alle* and Brünnich's guillemots *Uria lomvia* in the eastern Greenland Sea and Fram Strait: influence of hydrographic structures. Polar Biol, 37(11): 1645-1657, doi: 10.1007/s00300-014-1551-5.

Jokat W. 2009. The expedition of the research vessel "*Polarstern*" to the Arctic in 2008 (ARK-XXIII/3). Rep Polar Marine Res, 597: 221.

Pocklington R. 1979. An oceanographic interpretation of seabird distributions in the Indian Ocean. Mar Biol, 51(1): 9-21.

Ribic C A, Ainley D G, Ford R G, et al. 2011. Water masses, ocean fronts, and the structure of Antarctic seabird communities: putting the eastern Bellingshausen Sea in perspective. Deep-Sea Res II, 58(13-16): 1695-1709.

Yurkowski D J, Auger-Méthé M, Mallory M L, et al. 2018. Abundance and species diversity of tracked marine predators across the North American Arctic. Diversity and Distributions, 1-18, doi: 10.1111/dd i.12860.