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How many polar bears walk around Franz Joseph Land?

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How many polar bears walk around Franz Joseph Land?

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Abstract

As a vulnerable species, regular estimates of polar bear numbers are an important requirement for understanding their populations. In the Russian part of Barents Sea, specifically near the Franz Josef Land Archipelago, counts of polar bears have not been conducted since 2004. This article focuses on summarizing the results of recent observations in this territory in order to provide estimates of polar bear numbers. The data collected lead us to believe that their population decline continues. Currently only a few hundred polar bears inhabit Franz Josef Land in the spring season.

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Introduction

The polar bear (*Ursus maritimus*) is one of the best-studied biological species (Amstrup, Steven, 2003). Nevertheless, there are still gaps in our knowledge of this animal. In particular, since the polar bear is a vulnerable species, continuous estimations of population size and the state of habitats are necessary (Wiig et al., 2015). The islands of the Arctic Ocean, which important for the reproduction of polar bears, deserve an especially careful study. One such place is the Franz Josef Land Archipelago. The polar bears inhabiting these islands and the adjacent area are considered as a part of the "subpopulation" or "management unit" of the Barents Sea. The subpopulations are not isolated but their numbers depend on mortality and recovery rather than on migrations from other territories (Paetkau et al., 1999).

The Barents Sea "management unit" is divided into two parts: one is associated with Spitsbergen islands and belongs to Norway, and the other part is associated with Franz Joseph Land and belongs to Russia. The Russian part has always been more poorly studied. The latest estimate of the polar bears living within its boundaries was obtained in 2004 in an aerial survey (Aars et al., 2004). It was believed that 2,650 polar bears (95% confidence interval, 1,900-3,600 individuals) inhabit the Barents Sea, with their numbers in the Russian part being three time greater than in the Norwegian one (Aars et al., 2009; Andersen, Aars, 2016). This means that the Russian part of the subpopulation could comprise 1,988 (1,425-2,700) individuals. However, taking into account recent climate changes and a continuously increasing anthropogenic pressure, a rapid change in the condition of the polar bear subpopulation is quite possible, and an update of the estimate is urgently needed. Recent observations at Franz Josef Land and in surrounding waters can yield some useful information in this respect. This paper presents a summary of these data.

Study area

Franz Josef Land is an archipelago consisting of 192 islands, with a total area of 16,134 km^2. Most of their surface is covered by glacial ice. Remarkably, these islands were discovered only in the end of the 19th century and had never been visited by humans before. Scientific and military stations were established there in the course of time, but human presence has always been very limited and anthropogenic pressure upon the local ecosystems has been relatively weak. At present, there are no permanent residents on the islands. However, there are several military bases and meteorological stations, whose activities has intensified in recent years. Exploration of oil deposits around the islands is planned but almost no development has happened so far. Military and research activity is mainly confined to one island, Alexandra Land, with people working there concentrating in a small area. This means that polar bears are hardly disturbed. They build dens on the islands and walk around them freely. Recently the islands have become part of the "Russian Arctic" national park (www.rus-arc.ru), which should further contribute to the conservation of their wildlife habitats.

Materials and methods

Human activity on Franz Josef Land is supported by voyages of icebreakers and other vessels. Animals including polar bears were observed and registered during some of them. The methodology of these observations reminds that of winter track counts of mammals used in assessments of some game species. The number of mammals is estimated based on the number of intersections of a ski or snowmobile route with mammal footprint tracks. This method was suggested by A. N. Formozov (1932). He proposed a formula for calculating the density of mammals, $P = S/dm$, where density (P) is equal to the encountered number of tracks (S) divided by the area of the registration strip (dm, where m is the length of the route and d is the width of the registration strip, equal to the length of the daily course of the mammal).

This method was developed and Formozov's formula was refined (Malyshev, 1936, Pereleshin, 1950). It was noted that it was applicable only in the case when the tracks of footprints crossed the observer's path at a right angle. In reality, of course, tracks may cross the path at different angles. A correction was required. Eventually, game trackers settled on the formula $P = 1.57 \times S/d \times m$, where 1.57 is the coefficient denoting the average of the arithmetic perpendiculars of the tracks intersecting the observer's path at all possible angles. The improved formula has long been used in studies of game animals in Russia, and similar principles were occasionally used elsewhere (Stephens et al., 2006; Myslenkov, Miquelle, 2015).

During winter track counts of mammals, the route is passed at least twice: first, registered footprint tracks are marked and the next day the observations are conducted again in order to determine how many new tracks appeared. As a result, one obtains the number of times that mammals crossed the route in one day.

The situation is different in the case of icebreakers, if only because repeated passages are impossible. Yet there are several circumstances allowing one to employ Formozov's formula in this case. Polar bears leave fewer tracks than game animals in forests, and usually walk at a distance from each other. This means that recent footprints of polar bears can be identified visually, and confusion of multiple tracks with one another is unlikely. At the same time, visibility across ice fields is much greater than in a forest. Usually, not only recent footprints but the polar bear itself is also visible. Polar bears are not afraid of observers positioned on icebreakers. In fact, they react to icebreakers slightly, if at all, usually resuming their previous activities such as resting, feeding or foraging, within 5 min (Smultea et al., 2016). Taking this into account, we may be fairly sure that next-day observations are unnecessary for recording the crossing of the paths of icebreakers and polar bears.

Initially, the tracking of several individuals was used to determine diurnal travel distance of game mammals, but now average values compiled on the basis of long-term observations are used. A lot of data on the length of daily movements of polar bears have been obtained with the use of telemetry and other methods, and the typical length of the polar bear's daily movement can be considered as known. This means that the modified Formozov's formula can be used for their study.

We observed polar bears from icebreakers in May-June of 2015 and 2017. During this season, polar bears feed actively moving across suitable areas of sea ice in all directions. So, taking into account the chosen methodology, we can expect the results of our observations to be informative. Other seasons would be less suitable: in winter some part of the subpopulation is in dens and cannot be registered, while in summer the ice cover is reduced and polar bears concentrate in relatively small areas.

Our observations took place on a 24-hour basis. The route of the icebreakers was recorded by Garmin GPS. We registered all polar bears and their recent footprints (although the registration of polar bears turned out to be sufficient as they always became visible after the registration of recent footprints). Similar information has been collected on a smaller scale during a survey of Alexandra Island in 2015 from snow mobiles.

To obtain information on the distance of daily movement of polar bears, we searched for relevant articles in the databases “Web of Science Core collection” and “Russian Citation index”. According to them, the distance varies from 0 to 50 km. In our case, the observed bears were unlikely to be stationary or to move rapidly. Therefore, we used the average value. The use of different methods for different polar bears (males or females, females with or without cubs) in different seas resulted in similar numbers. We have chosen the numbers obtained from studies where season and habitat were similar to those in our study, namely: 12.2 km/day (Laidre et al., 2012); 13.9 km/day (Auger-Méthé et al., 2016); 9.9 km/day from October 16 to May 31 and 9.3 km/day from June 1 to July 15 (Belikov et al., 1998) (Table 1). Statistical processing was conducted with the use of Microsoft Office Graph 2007 (analysis of “Standard error”).

To estimate the borders of polar bear habitat, we used the results of our observations of ice condition as well as maps and satellite images provided by the Arctic and Antarctic Research Institute (St Petersburg, Russia). We assumed that the zone of long-standing thick ice was unsuitable for bears (Paetkau et al., 1999). Although they do occur there in small numbers, the main part of the population is located in the zone of relatively thin ice with areas of open water. The land are, that is, the islands, was also considered as part of the habitat because the islands are small in relation to the length of the bears' daily course, and the bears often cross them in different directions during the study season. To calculate the area of suitable ice coverage we used Google Earth Pro program.

Results

According to aerial pictures and our observations, the southern boundary of the ice cover began between the 77th and the 79th parallel in different years. To the north of the 82nd parallel, a zone of long-standing thick ice begins, which is non-optimal for polar bears. The western and eastern boundaries of the territory under consideration are rather arbitrary: the western boundary passes along the border between Norway and Russia, and the eastern boundary, along the border of the Barents and the Kara Sea. This means that the habitat suitable for polar bears in spring lies mainly in the "trapezoid" around the islands of the Franz Josef Land Archipelago, the area of which varies in different years depending on the state of the ice cover (Figure 1). In May-June 2015 this area made up 190,000 km^2, and in May-June 2017, 350,000 km^2.

Observations from the icebreakers showed that one polar bear occurs per several tens kilometers (Table 2). Once a pair of adult bears (male and female) was observed, i.e. two bears occurred at a minimum distance from each other. All the other observed adult bears were alone. Based on the information on the encounters of polar bears and using various assumptions about the daily course, we obtained several estimates of density and, correspondingly, numbers of the polar bears (Table 3.4). These estimates are several hundreds, about a thousand at best (Figure 2). A more accurate assessment is problematic.

These estimates are partly supported by our other observations. In 2015 we surveyed Alexandra Land Island and adjacent ice fields from snowmobiles for 5 days. The total distance of routes was 200 km. Recent traces of bears were observed only once. According to the reports of people working at a military base there, only three polar bears were occasionally seen nearby. This means that the bears were very sparsely distributed. There are places suitable for dens on Alexandra Island, and the polar bears are known to concentrate there during winter, but in May-June they were already absent. This means that in spring the polar bears rapidly disperse in various directions.

Discussion

Observations from icebreakers have been used as a source of data on the numbers of polar bears before our research (Matishov et al., 2014). However, the other authors used a different calculation method, determining the density on the basis of the number of polar bears observed within the visible zone of ice, not within the strip corresponding to daily movement distance. We believe that our method is more accurate, since the width of the strip, within which the bears are visible, is difficult to estimate exactly. It varies depending on weather conditions and, partly, the time of observation. Moreover, the calculation based on a visible ice zone does not take into account the fact that polar bears can walk long distances during a short period of time, and these distances can significantly exceed the width of the visible zone. This calculation would be exact in case of stationary objects. However, the polar bear can leave or re-enter the visible ice zone randomly several times a day, and so the fact of their occurrence cannot serve as a solid basis for density calculation. The same is true of some aerial surveys. They provide exact assessment only if polar bears concentrate in relatively small plots of land or ice, as they do in some seasons. Otherwise, the aerial survey covers only a small portion of habitat. Similarly to observations from icebreakers, the visible zone of ice is smaller than the distance that the polar bear can walk during the period of observation.

Other methods of assessing the numbers of polar bears are also in use but are insufficient for complete assessments. One of them is based on mark-recapture. However, this method tends to underestimate the numbers of bears (Evans et al., 2003), is labor-intensive and cannot be widely used. There were also attempts to calculate the numbers of polar bears based on counts of dens. It is considered that females lying in dens make up 8-10% of the population (Kishchinsky, 1974) but this formula is not very reliable. At the same time, counting dens can also be problematic. They can be counted only in a small portion of potential habitats. In any case, since the polar bears are sparsely distributed over vast expanses, their direct total calculation is impossible. Any method involves extrapolations and assumptions. Therefore, any available data on polar bear occurrence are useful. Reports from icebreakers with the analysis of daily movements are a valuable addition to the general research efforts in this direction.

Our estimates do not contradict the data on polar bear density obtained with other methods. The density in other parts of the Arctic varies from 0.00061 to 0.00681 individuals per 1 km^2 (Evans et al., 2003). Our estimates (0.000565-0.003967) more or less fit this range, the minimal estimate being somewhat lower. This means that the numbers obtained in our study are plausible. Polar bears may be more numerous in the

Barents Sea but significantly larger numbers are unlikely. One may walk for several tens of kilometers across the sea or the islands without encountering any polar bears. An opposite situation, that is, the occurrence of a large number of polar bears close to each other is also unlikely. Such cases are known if a large source of food appears somewhere, for example, a dead whale on the sea shore. However, whales are not numerous in the Barents Sea, and no instances of dead whales in Franz Joseph Land have been recorded.

The obtained numbers for the polar bears around Franz Joseph Land are smaller than the numbers reported in 2004 (1,988) and the recent numbers for the Norwegian part of the Barents Sea (estimated as 973,95% CI = 665 – 1,884) (Aars et al., 2017). These differences are likely to be associated with the use of different methods rather than anything else. The authors of the studies cited above calculated all bears: cubs, juveniles and adults. Taking into account a high mortality of young individuals, estimates based on adults seem to be more informative. Therefore, the above cited numbers can be reduced. Moreover, they were based on the results of aerial surveys in August. During this season, large areas of the Barents Sea around Spitsbergen lose the ice cover. Some polar bears remain inland, while the others move northwards to the edge of the ice cover. During spring the polar bears are distributed more evenly and over larger territory. It is likely that a part of the subpopulation migrates beyond the Barents Sea.

Since the distribution of ice plots and polar bears is continuously changing, it is impossible to obtain exact numbers of a subpopulation or a management unit. In our case we have to accept the estimate of several hundred adult individuals both for the Norwegian and the Russian sections of the Barents Sea. This subpopulation must have been much larger several decades ago, may be even large enough to sustain an average annual loss of about 300 bears during the century leading up to the 1970s (Aars et al., 2017). This means that at least several thousands of polar bears populated Barents Sea, Spitsbergen and Franz Joseph Land in the past. The hunting on polar bears was forbidden in Russia in 1956 and in Norway in 1973 (Prestrud and Stirling, 1994). However, the Barents Sea subpopulation still has not restored. Rather, it is on the decline. Questions arise about its causes. Global warming is often mentioned as the most significant threat for polar bears (Obbard et al., 2010). It results in the decrease in the area of ice cover, this process occurring even more rapidly than expected from climatic models (Stroeve et al., 2007). Evidently the melting of ice decreases the area of polar bears habitats (Stirling, Derocher 2012; Derocher et al., 2013). The Barents Sea is especially sensitive to global warming, being influenced by warm currents from the Atlantic. Therefore, the polar bears there are more susceptible to climate change (Stern, Laidre, 2016). It should be noted, however, that the density of polar bears could be much higher than the current estimate for the Barents Sea. A higher density was noted relatively recently in the Chukchi Sea and in the western part of the Beaufort Sea even though bears are still being hunted there (legally or illegally) (Evans et al., 2003). This means that the density of polar bears in these seas could be even higher. These data indicate that at the moment the area of ice cover does not necessarily limit the number of polar bears, i.e. there is potential for the growth of the polar bear population in the Barents Sea.

Some other factors negatively influencing polar bears have been reported. One of them is water pollution (Andersen et al., 2001; Derocher, 2005; Letcher et al., 2010). However, this is only an assumption based in indirect evidence because the habitats of polar bears are located a long way from the sources of water pollution, and concentrations of pollutants are low. Direct extermination may also be considered as a threat. However, this negative impact was noted recently only in Chukchi Sea, i.e. also far away from the Barents Sea (Wiig et al., 2015). Direct extermination of significant numbers of polar bears in the territory under study is currently unlikely, because there are few humans around. The decline of the polar bear populations is likely to be associated with the state of their nutritive base. Polar bears feed mainly on ringed seals (*Phoca hispida*), which feed on fish, and fish populations are declining continuously due to overfishing (Ellis, 2004). In the Barents Sea, fishing has been going on for centuries, with little regard for regulation or conservation. It is evident that fish abundance is well below the “normal” or “initial” state. The ringed seal has also been hunted for a long time. All these circumstances could not but negatively affect polar bear populations. Unfortunately, a detailed assessment of the number of ringed seals is even more problematic than that of polar bears. However, it is evident that they are not abundant in the Barents Sea. They are sparsely distributed over ice cover. At the time of our studies, the distance between the seals observed on the ice was about several kilometers or even tens of kilometers.

Conclusion

Several hundred adult polar bears walk around Franz Joseph Land in the beginning of summer. This is very little as compared with their “initial” or ”normal” condition, and the decline continues. This is likely to be associated with the decline of their nutritive base, the ringed seals, which, in turn, is due to continuous overfishing.

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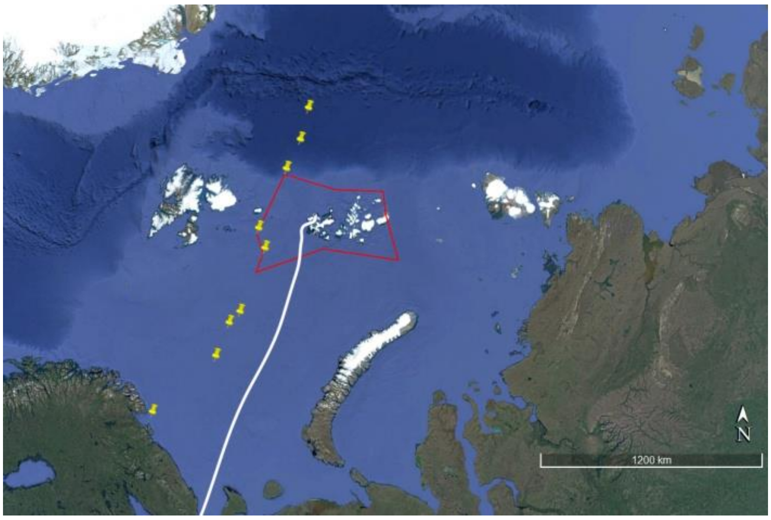
Table 1. Data on daily movement of polar bears

Season	Region of research	Characteristics of individuals	Average distance of daily movement, km/day (with standard error or range)	Method of estimate	Автор
Whole year	Barentzand Kara Seas	Females	20	Satellite telemetry	Belchansky et al., 1998
16 July – 15 September	Waters at the Severnaya Zemlia	Females	12.5 (0.81)	Satellite telemetry	Belikov etal., 1998
16 September – 15 October			7.5 (1.21)		
16 October – 31 May			9.9 (0.62)		
1 June– 15 July			9.3 (0.94)		
1 May– 15 August	Chukchi Sea, Wrangel Island	Females	13.9 (0.6)	Satellite telemetry	Garner et al., 1994
16 August – 15 October			18.5 (1.5)		

16 October– 31 December			18.9 (1.3)		
1 January – 31 March			12.9 (2.2)		
26 March –1 May			8.5 (0.9)		
April - October	Arctic islands of Canada	Females	From 6.9 (5.9) to 8.8 (6.3)	Satellite telemetry	Messier et al., 1992
1 March – 10 May	Alaska	Average for all bears	10.7	Mark recapture	Lentfer, 1983
		Males 3-5 years old	7.3 (from 0.7 to 40.3)		
		Males more than 5 years old	12.3 (from 0.4 to 40.5)		
		Females 3-5 years old	8.2 (from 0.4 to 36.3		
		Female more than 5 years	13.1 (from 0 to 72.0)		
April-May	Bering, Chukchi, East-Siberian and Bofort Seas	Females	14.1 (from 0 to 41)	Satellite telemetry	Garner etal., 1990
June- September	Bofort and Chukchi Seas		12.6 (from 0 to 65)		
October - December	Bering Sea		16.8		
January – March	Chukchi and Bering Seas		10.9		
May - December	Bofort Sea	Females	16.08	Satellite telemetry	Amstrup et al, 2000
April - May	Bofort Sea	Mostly females	13.9	Satellite telemetry	Auger-Méthé et al., 2016
March - May	Baffin Sea, Easterm Greenland	Females and Males	12.2	Simulation	Laidre et al., 2012
Spring	Chukchi	Females	14.1	Satellite telemetry	Amstrup, Steven, 2003
Spring	Hudson Bay	Females	19.2	Satellite telemetry	Sahanatien et al., 2015
	Hudson Bay		31.2 (2.4)		
	Fox Bay		28.8		
Winter	Hudson Bay		21.6 (2.4)		

	Hudson Bay		26.4			
	Fox Bay		26.4			
	Hudson Bay		28.8			
Coldest season	Hudson Bay		21.6	(2.4)		
	Fox Bay		31.2			
	Hudson Bay		26.4	(2.4)		
Season of ice breaking	Hudson Bay		43.2	(7.2)		
	Fox Bay		36.0	(2.4)		
8 October – 21 April	Barents Sea	One female	20.7 20.4		Satellite telemetry	National Snow and Ice Data Center Ocean and Sea Ice, Satellite Application Facility. Citfrom Platonov et al., 2014



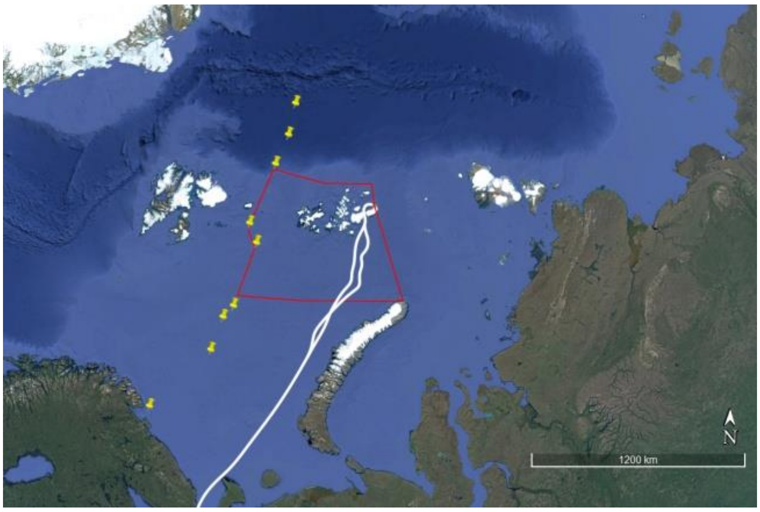


Figure 1. Habitat of Barents Sea subpopulation in the Russian section: a) June 2015, b) May 2017. White lines indicate the routes of icebreakers, red lines and yellow points – the borders of area under study.

Table 2. Results of the observation of polar bears from icebreakers.

Dates	Duration of observation, hours	Distance of route, km	Number of registered polar bears	Calculation of the number of registered polar bears per day
1.06. 2015	17.5	200	3	4.1

7-8.06.2015	15.3	200	3	4.7
18-19.05. 2017	24	400	2	2
21 - 22.05. 2017	24	550	9	9

Table 3. Estimation of polar bear density based on different assumptions on daily movements.

Distance of daily movement, km/day	Dates			
	2015		2017	
	1.06	7-8.06	18.05	22.05
13.9	0.002315	0.002654	0.000565	0.001848
12.2	0.002638	0.003024	0.000643	0.002106
9.9 (before 31 May)	-	-	0.000793	0.002595
9.3 (after 3 May)	0.003461	0.003967	-	-

Table 4. Estimate of the number of polar bears based on different assumptions on daily movements and habitat area (in 2015 - 190 000 km², in 2017 350 000 km²).

Distance of daily movement, km/day	Dates			
	2015		2017	
	1.06	7-8.06	18.05	22.05
13.9	440 (380 – 500)	500 (440 -560)	200(140-260)	650(590-710)
12.2	500 (440 -560)	570 (510-630)	230 (170-290)	740 (680-800)
9.9 (before 31 May)	-	-	280(220-340)	910 (850-970)
9.3 (after 31 May)	660 (600-720)	750 (690-810)	-	-

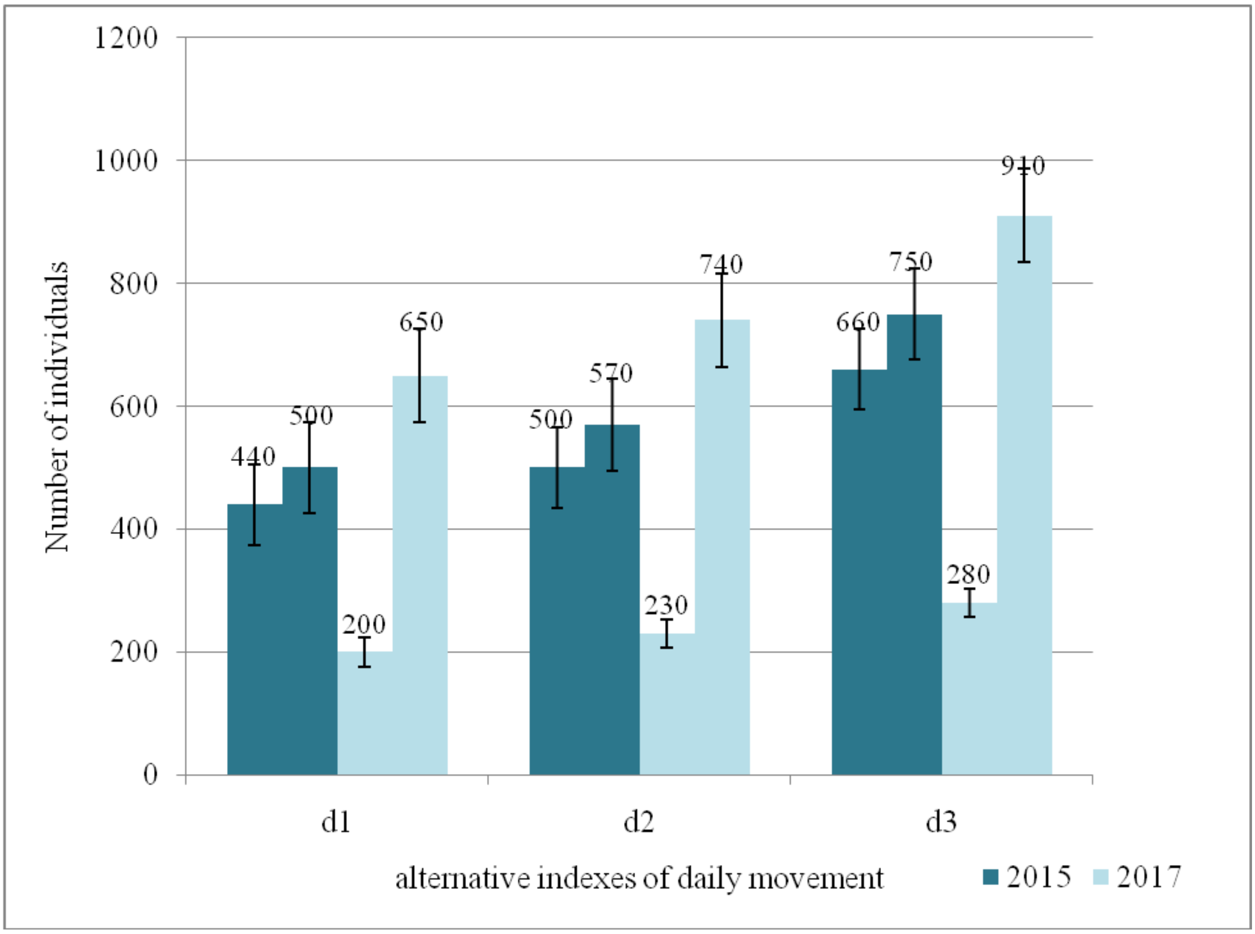


Figure 2. Scheme of different estimates of the numbers of polar bears in the Russian section of the Barents Sea in 2015 and 2017 based on different assumptions on the distance of daily movement: d1 – 13.9 km/day (Auger-Méthé et al., 2016), d2 – 12.2 km/day (Laidre et al., 2012), d3 – 9.9 and 9.3 km/day (Belikov et al., 1998).

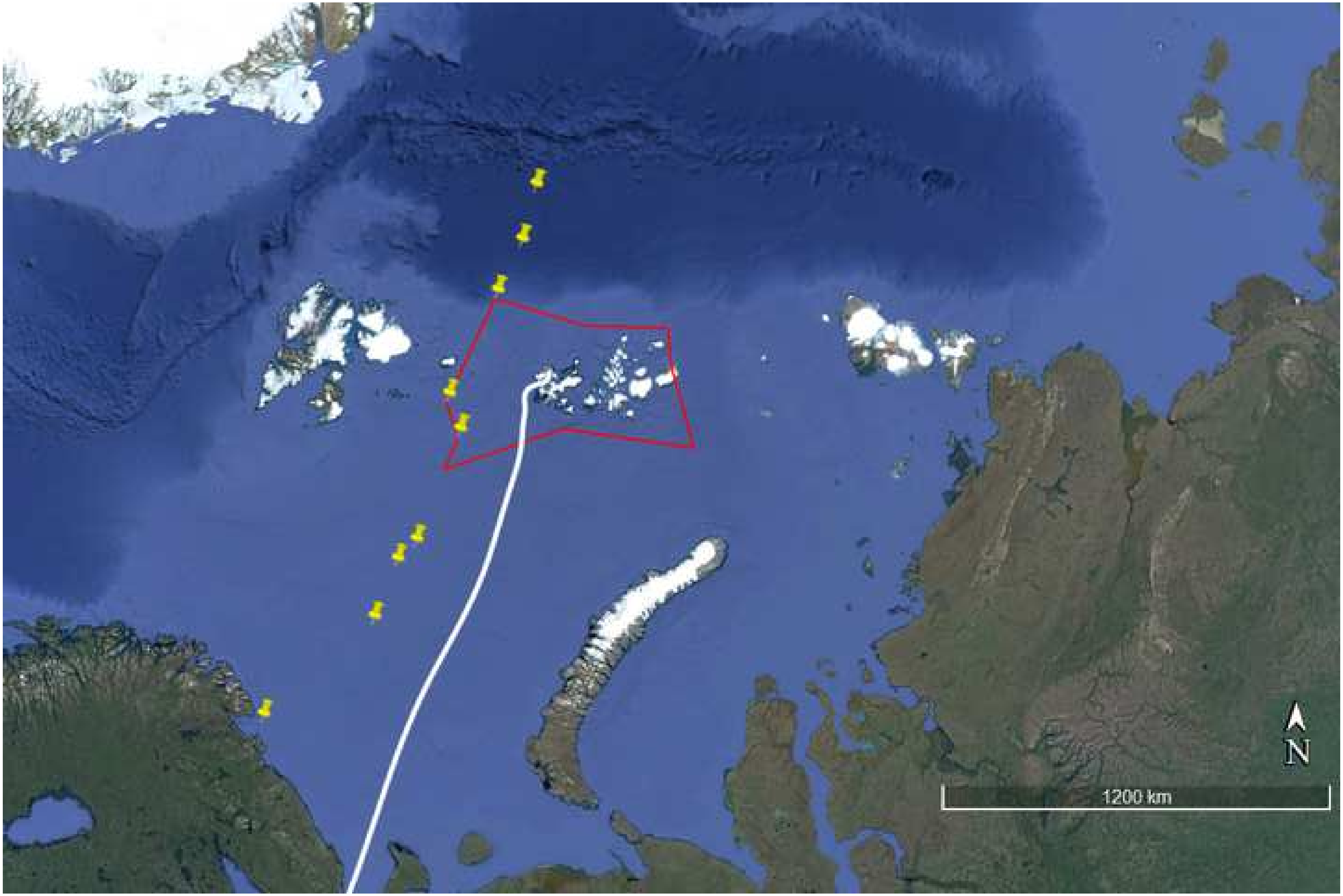

1200 km
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Figure

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