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Status of the black-legged kittiwake (*Rissa tridactyla*) breeding population in Greenland, 2008

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Abstract

Based on the intensified survey efforts (since 2003) of Greenlandic breeding colonies of black-legged kittiwake (*Rissa tridactyla*), the total Greenland breeding population was estimated at roughly 110 000 breeding pairs, constituting about 4% of the total North Atlantic breeding population. This population estimate of black-legged kittiwake is the most reliable and updated estimate hitherto reported for Greenland. The results confirm considerable population declines in many areas of West Greenland. The breeding population of black-legged kittiwakes in the Qaanaaq area appears healthy, whereas the rest of the west coast has experienced declines, especially the north-western region (in the area from Upernavik to Kangaatsiaq). Exactly when these reductions have occurred is uncertain because of the limited survey effort in the past, but some colonies declined as far back as the mid-1900s, whereas declines of other colonies have occurred since the 1970–80s. East Greenland data from the past are few, but recent aerial surveys confirm that the abundance of breeding kittiwakes on this inaccessible coast is low. The reasons for the West Greenland declines are not documented. Poor feeding conditions and a high hunting pressure, particularly prior to 2002 when the open season was shortened considerably, are possible explanations.

The black-legged kittiwake *Rissa tridactyla* (hereafter kittiwake) is a widely distributed seabird in the circumpolar Arctic (Cramp & Simmons 1983; Hatch et al. 1993), numbering more than 5 million pairs when all national population estimates are summed (Cramp & Simmons 1983; Hatch et al. 1993; Anker-Nilssen et al. 2000; Mitchell et al. 2004; Bakken et al. 2006; Hatch et al. 2008; Barrett et al. 2006). Reports on declines in breeding populations, poor breeding performance and so on, from many regions of the breeding range of kittiwakes, have led to an increased international focus on this species (Regehr & Montevecchi 1997; Carscadden et al. 2002; Frederiksen et al. 2004; Mitchell et al. 2004; Barrett et al. 2006; Bornaechea & Gardarsson 2006; Gardarsson 2006; Mavor et al. 2006; Sunnanå & Fossheim 2008). Hence, the kittiwake is now considered to be a species of conservation concern by the Arctic Council working group Conservation of Arctic Flora and Fauna (CAFF), and the need for a circumpolar conservation strategy and action plan is being considered by CAFF's Seabird Expert Group. The kittiwake is categorized as vulnerable (VU) on the Greenland Red List (Boertmann 2007).

The kittiwake is a widespread breeder in Greenland, particularly along the west coast. Former estimates of the West Greenland breeding population have been somewhere between 80 000 and 200 000 pairs (Boertmann et al. 1996; Bakken et al. 2006), based largely on outdated surveys (as old as 80 years) of varying quality, and the East Greenland population has been virtually unknown.

As the kittiwake is subject to hunting in Greenland, in contrast to elsewhere in the North Atlantic (Merkel & Barry 2008), an updated and more reliable estimate of the breeding population is required for management purposes. This was underlined by Nyeland (2004), who documented a general decreasing trend in the breeding population in West Greenland during the past century. Therefore, the survey effort of the Greenland kittiwake breeding population was intensified after 2003 with the aim of surveying all significant breeding areas within a

reasonably short time frame. The results from these surveys have been published in regional reports (Boertmann 2004, 2006; Nyeland & Mathæussen 2004; Burnham et al. 2005; Merkel et al. 2007; Nyeland 2007), and in combination with unpublished results from other surveys, allow us to make an updated estimate of the breeding population in Greenland. The objective of this study is to present an updated population estimate of breeding kittiwakes in Greenland. Key breeding areas are identified and apparent population trends are discussed.

Methods

Data on kittiwake breeding numbers are stored in a database containing information about Greenland's seabird colonies, which is maintained by the National Environmental Research Institute and is available on the institute's website (Boertmann et al. 1996; Bakken et al. 2006). This database includes historical kittiwake data (breeding location data back to 1898) as well as all survey results from recent years (e.g., Boertmann et al. 1996; Boertmann 2006; Merkel et al. 2007). The database contains information on colony location and survey results for all colonial seabird species breeding in Greenland (Boertmann et al. 1996; Bakken et al. 2006).

From this database the most recent survey results (2007 was the most recent survey year in West Greenland; 2008 in East Greenland) from all known kittiwake colonies in Greenland were extracted. These data are expressed either as the number of individuals or nests/pairs. Nest/pairs are here presented as "apparently occupied nests" (AONs), and numbers of individuals were converted to number of AONs by using a K-factor of 0.65. This was derived from a study in Qaanaaq (Merkel et al. 2007), which, as a result of the lack of data from other regions, was applied to the entire area. Survey data in the database are categorized as being of high, medium or low quality. Colonies are spatially grouped according to administrative municipalities, which are named after the largest town. For the purpose of this presentation the West Greenland data were further grouped into four larger regions (north, north-west, south-west and south), and the East Greenland data were grouped into two regions (north-east and south-east), as shown in Fig. 1.

All survey results in the West Greenland data set were obtained by direct counts on site (primarily from a boat using binoculars), except for two colonies in Ilulissat, two in Upernavik and the four colonies in the Qaanaaq area, which were all photographed systematically, and AONs were counted from these photographs (Boertmann 2006; Merkel et al. 2007; Nyeland 2007). Colony surveys were mainly carried out in July (96% of the West Greenland surveys), which is the time when at least one of the adults or large chicks are present on their nests. A few colonies were surveyed in late June ($n = 7$), in August ($n = 3$) and in very early September ($n = 1$) (see the Appendix).

East Greenland data were treated separately. In June–July 2008, an aerial seabird survey was conducted along the entire coast from Kap Farvel (60°N) to Kap Morris Jesup (83.5°N), and this contributed significantly to the otherwise limited data for this part of Greenland (Boertmann et al. 2009; Merkel et al. 2010).

Results

West Greenland

Sixteen West Greenland kittiwake colonies in the database may never have existed, and were excluded from the data set. The remaining 246 colonies, accepted to have been occupied at some time in West Greenland since 1920, were included in the present summary (see the Appendix; Fig. 1). The median year of the most recent count of these colonies was 2003 (standard deviation = 6.7 years); of the 246 colonies, 64.6% had been visited since 2003 and 92.3% within the past 10 years (1998–2007) (Table 1). The remaining 19 colonies (with most recent survey data of more than 10 years old) were all small (≤65 AONs) or empty. The oldest count included in the present summary is from 1954 (see the Appendix; Table 1).

Among the 246 colonies, 139 were occupied by breeding pairs during the most recent visit, and their numbers add up to a total West Greenland breeding population of 103 348 AONs (Fig. 1; Table 2). As much as 95.8% of the total number of AONs were counted in 2003 or later, and 99.7% in 1998 or later (Table 1). The mean colony size was 744 AONs, with a range from 1 to 18 707. The median colony size was 57 AONs, and only three colonies had more than 10 000 AONs (Fig. 1).

Data from 12 colonies were converted from number of individuals to AONs, and added up to 3588 AONs (3.5% of the total number of AONs). The quality of the count data were categorized as high, medium and low for 94, 20 and nine colonies, respectively. For 16 colonies the quality of the count data was not reported (see the Appendix). Low-quality count data accounted for 0.3% of the total number of AONs. Count data of medium and high quality accounted for 98.4% of the total number of AONs.

Figure 1 and Table 2 give an overview of the regional distribution and abundance in West Greenland. The northern region is characterized by very few but large colonies, holding 34.5% of the West Greenland breeding population in only four colonies. Colonies are far more abundant in the north-west region, from Upernavik in the north to Kangaatsiaq in the south, being home to 71.1% of all registered colonies, although they house

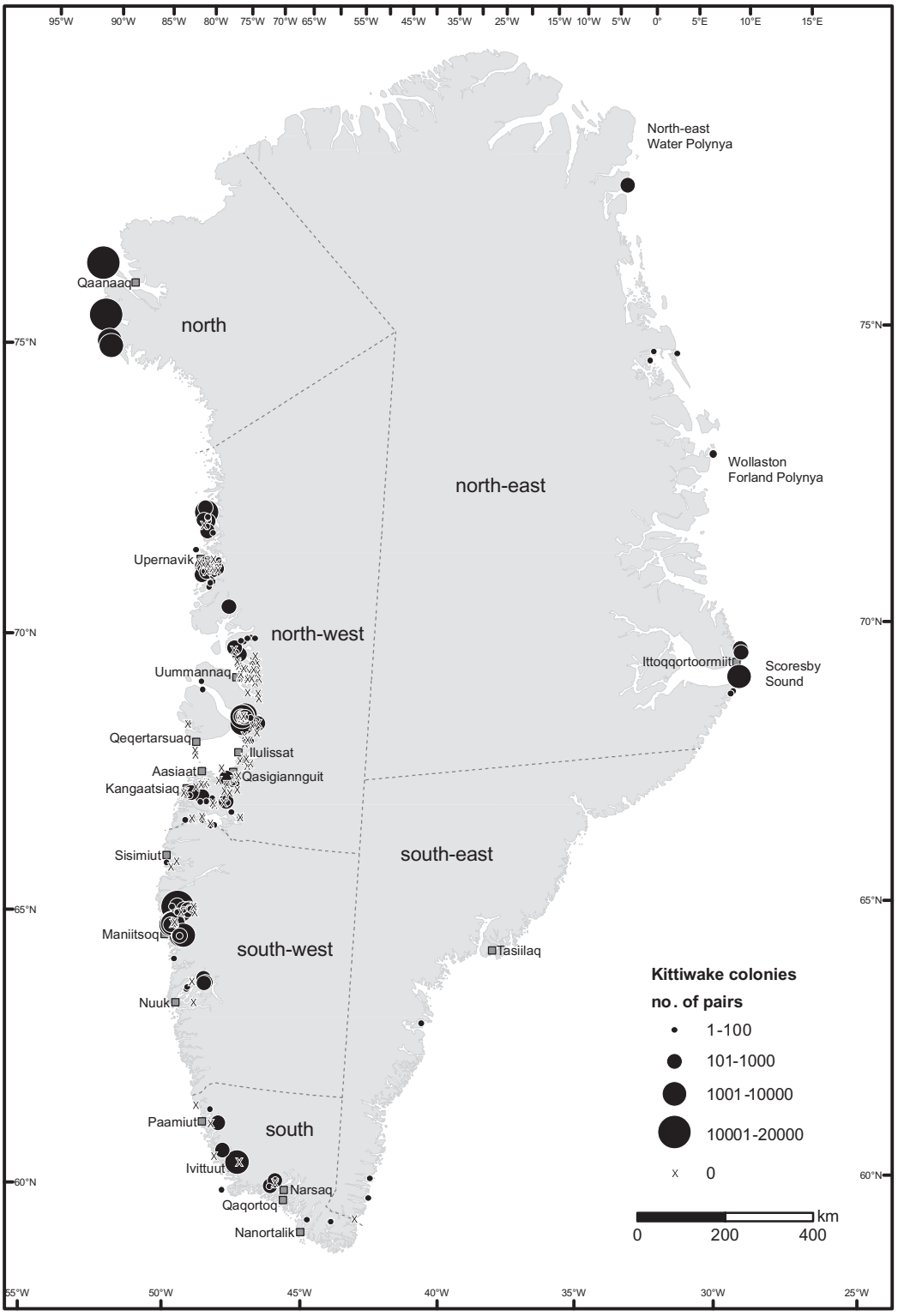

Fig. 1 Map of Greenland with locations of the largest town from each municipality (marked as squares), and locations of all 246 registered breeding colonies in West Greenland and 16 registered breeding colonies in East Greenland. The size of the colonies at the most recent visit (with 2007 being the most recent survey year in West Greenland and 2008 in East Greenland) is indicated by the size of the circle. Empty colonies are marked with an X. The borders between the four regions in West Greenland (north, north-west, south-west and south) and the two regions in East Greenland (north-east and south-east) are indicated with dotted lines.

Table 1 Distribution of the number (*N*) of kittiwake colonies and number of apparently occupied nests (AONs) by the most recent survey year in West Greenland.

					Cumulative	
Year	$N_{colonies}$	N_{AONs}	$N_{colonies}$ (%)	N_{AONs} (%)	$N_{colonies}$ (%)	N_{AONs} (%)
2007	28	4884	11.4	4.7	11.4	4.7
2006	10	35 746	4.1	34.6	15.4	39.3
2005	74	23 301	30.1	22.5	45.5	61.9
2004	1	0	0.4	0.0	45.9	61.9
2003	46	35 025	18.7	33.9	64.6	95.8
2002	2	2623	0.8	2.5	65.4	98.3
2001	3	10	1.2	0.0	66.7	98.3
2000	40	732	16.3	0.7	82.9	99.0
1999	6	301	2.4	0.3	85.4	99.3
1998	17	514	6.9	0.5	92.3	99.8
1988–97	8	121	3.3	0.1	95.5	99.9
1978–87	2	50	0.8	0.0	96.3	100.0
1968–77	8	0	3.3	0.0	99.6	100.0
1958–67						
1948–57	1	41	0.4	0.0	100.0	100.0
Total	246	103 348				

Table 2 Number of kittiwake colonies, number of colonies occupied by breeders and number of apparently occupied nests (AONs) at the most recent survey (with 2007 being the most recent survey year in West Greenland and 2008 in East Greenland) within each region in Greenland. The regions in West Greenland are divided further into municipalities.

		Number of colonies		Number
Region	Municipality	Total	Occupied	of AONs
North	Qaanaaq	4	4	35 666
North-west	Upernavik	42	32	6230
	Uummannaq	39	12	732
	Qeqertarsuaq	6	2	75
	Ilulissat	40	17	22 034
	Qasigiannguit	12	5	323
	Aasiaat	1	0	0
	Kangaatsiaq	35	17	1065
Subtotal north-west		**175**	**85**	**28 376**
South-west	Sisimiut	5	1	50
	Maniitsoq	35	29	32 421
	Nuuk	7	5	905
Subtotal south-west		**47**	**35**	**33 376**
South	Paamiut	8	4	3295
	Qaqortoq	3	3	188
	Narsaq	5	4	299
	Nanortalik	4	4	65
Subtotal south		**20**	**15**	**3847**
West Greenland total		246	139	103 348
North-east		12	12	3537
South-east		4	3	ca. 200
TOTAL		**262**	**155**	**107 085**

only 29.5% of the breeding population. The south-west region (from Sisimiut to Nuuk) holds 19.1% of all the colonies, and 32.3% of the total breeding population. The smallest numbers of kittiwakes were found in the southern region (from Paamiut to Nanortalik), with 8.1% of the colonies and 3.7% of the breeding population (Table 2).

Of the 246 West Greenland colonies included in the data set, 107 (43%) were abandoned at the latest survey. Only in Qaanaaq were no colonies abandoned, whereas 51% were abandoned in the north-west, 26% in the south-west and 25% in the southern Greenland region (Table 2).

Looking at the smaller regions, the municipalities, the largest numbers of breeding kittiwakes occur in Qaanaaq, Maniitsoq and Ilulissat, with 34.5, 31.4 and 21.3%, respectively, of the total West Greenland population. The remaining municipalities hold between 0 and 6% of the breeding population (Fig. 1; Table 2). The municipalities with the largest numbers of empty kittiwake colonies during the most recent survey were Uummannaq (27 of 39), Kangaatsiaq (25 of 35) and Ilulissat (17 of 40) (Table 2).

East Greenland

Only 16 breeding colonies or possible breeding colonies are recorded from East Greenland (see the Appendix; Fig. 1). Four are in the region between 60° and 69°N (in the south-east region), and 12 are found north of 69°N (in the north-east region). Nine colonies were surveyed in 2008, of which three were new and one abandoned. One new colony was recorded in north-east and two new colonies were recorded in south-east Greenland, although the name of one of the latter colonies indicates that the site has previously been occupied by kittiwakes

(see the Appendix). Five colonies north of 69°N were surveyed in 2003–04 by Gilg (2005) (in two of these kittiwakes were present, but breeding was not confirmed), and the remaining two colonies have not been surveyed since 1993 and 1933, respectively. The colonies in East Greenland are relatively small (maximum 1300 AONs), and the sum of the latest counts adds up to less than 4000 AONs (Table 2).

Discussion

Numbers

The results of recent kittiwake surveys have improved our knowledge on the status and distribution of the breeding population of kittiwakes in Greenland considerably. Given the large distribution range and the often remote locations of the breeding colonies, the presented population estimate of nearly 110 000 pairs must be considered as a good estimate. The total estimate is within the range of former estimates, but has now been updated and much better documented (Boertmann et al. 1996; Bakken et al. 2006).

Population estimates based on surveys distributed over time suffer from some sources of error. One is interannual variation in attendance at breeding colonies (Hatch & Hatch 1988; Baird 1990). However, considering the large number of colonies counted within a relatively short time frame, a balance between unusually high or low colony attendances in the survey year is expected. Another factor is the possibility that some of the colonies found with few or no breeding pairs more than 10 years ago may have changed status. Yet, large increases in colony size are unlikely to stay unnoticed in West Greenland, where local people frequently travel along the coasts and are very aware of the presence of seabird colonies. As the majority of the kittiwake data were collected as AONs in July, before the fledging period (when prospecting immature birds may occupy empty nests), the population estimates are not highly sensitive to variation in daily or seasonal attendance (Boulinier et al. 1996; Cadiou & Monnat 1996). Count data of kittiwakes are most commonly given in AONs (e.g., Mitchell et al. 2004; Barrett et al. 2006), and the K-factor used to convert from the number of individuals to AONs may not be representative for all of Greenland. However, as most count data were collected as AONs (96.5%), this error is small. The small contribution of data categorized as being of low quality is similarly considered a minor source of error (0.4% of the total number of AONs). The fact that all the largest colonies and the areas with high densities of registered colonies were covered in the more recent surveys should secure a good estimate for the population status in West Greenland.

The present estimate of the Greenland breeding population constitutes about 3.8% of the North Atlantic kittiwake population (Cramp & Simmons 1983; Anker-Nilssen et al. 2000; Mitchell et al. 2004; Bakken et al. 2006; Barrett et al. 2006; Hatch et al. 2008), which is less than the 8–15% previously indicated (Boertmann et al. 1996; Bakken et al. 2006). This disparity must be ascribed to the higher quality of the current data, and does not document a shift in the size of the populations.

Distribution

By far the majority of the population is distributed along the West Greenland coast, with two key areas: Maniitsoq and Qaanaaq. The West Greenland population estimate of breeding kittiwakes falls within the range of former estimates, although the regional distribution is somewhat different from previous perceptions (Boertmann et al. 1996; Nyeland & Mathæussen 2004), in that the Qaanaaq area is now identified as equally or more important than the Maniitsoq area (Table 2).

In contrast to West Greenland, the East Greenland coast is much more influenced by sea ice in spring and summer (Hansen et al. 2008; Hvidegaard et al. 2008), and the 2008 aerial survey confirmed that this coast holds only a sparse and scattered breeding population of kittiwakes. All the important colonies are located at the major coastal polynyas: the Scoresby Sund Polynya (five colonies, including the largest East Greenland colony, with 1300 AONs), the Wollaston Forland Polynya (three small colonies, with a maximum of 75 AONs) and the Northeast Water Polynya (one colony, with 873 AONs). The remaining three colonies (<50 AONs) are in the northern Dove Bay, which becomes free of ice relatively early. New information (available after the 2008 survey) indicates that more colonies of minor sizes may be found along this remote and inaccessible coast of south-east Greenland: in 2006 about five small colonies with 20–120 AONs (in total ca. 340 AONs) were located between Tasiilaq and Umiivik (A. Rosing-Asvid, pers. comm.). However, even if more colonies remain unknown along this remote and harsh coastline of East Greenland, they are likely to be small and unstable.

Trends

West Greenland. The size of the Qaanaaq population, in the north, is much larger than the former estimates of 14 000 from 1987 (Kampp 1990). However, the original 1987 estimates were crude because these colonies were visited primarily for monitoring thick-billed murres (*Uria lomvia*). Moreover, nests at the two largest colonies are located high above sea level (up to ca. 400 m a.s.l.), and

are often dispersed over large cliff areas, which may have caused an underestimation in 1987 (Merkel et al. 2007). Archived photos from 1987 of selected areas indicate that the kittiwakes were at least as plentiful then as today. In one colony (76014) fewer birds were counted in the 2006 photographs (2793 birds in 1987 versus 2484 birds in 2006; 17 colony sections), whereas the opposite was the case in another colony (77002; 659 birds in 1987 versus 733 birds in 2006; six colony sections). In total, the comparison of 23 colony sections indicates a small population decline of ca. 7% (Greenland Institute of Natural Resources, unpubl. data). Nearby High-Arctic colonies of kittiwakes in Barrow Strait, Canada, are doing well, and the area has experienced significant increases in the breeding population since the 1970s (Mallory et al. 2009).

The breeding population of the north-west region, on the other hand, appears to have experienced a substantial decline, indicated by the large number of abandoned colonies (Fig. 1), as well as large reductions in colony sizes (Burnham et al. 2005; Boertmann 2006). The updated figures show a decrease of 39, 79 and 36% in number of AONs in Upernavik, Uummannaq and the Disko Bay area (from Ilulissat to Aasiaat), respectively, compared with previous information (Boertmann et al. 1996). However, it is uncertain when these reductions have occurred because of the limited survey effort in the past (Burnham et al. 2005; Boertmann 2006). The Uummannaq area shows the most drastic declines (from 268 000 AONs in 1920 to 1100 AONs in 2000), with large reductions in the number of colonies as well as birds, a decline that may have happened at any time during the past 90 years, given that many colonies had not been surveyed since 1920 (Burnham et al. 2005). However, data from a few larger colonies indicate some reduction by 1949, and a survey in 1984 showed that several large colonies were abandoned by then (Burnham et al. 2005). In the Disko Bay region, and the fjords immediately to the south of the bay, substantial decreases were recorded in 2003. For example, by 2003 the populations in the fjords Arfersiorfik ($n = 15$ colonies and 3099 AONs in 1954) and Nordre Strømfjord ($n = 9$ colonies with 715 AONs in 1954) were reduced by 75 and 88%, respectively. Even larger reductions may have taken place in the Disko Bay, but presumed exaggerated survey results in the 1950s preclude sound comparisons (Boertmann 2006).

The latest survey (2003) of the Maniitsoq area concluded that the breeding population of this key breeding area had been halved since 1977 (Nyeland & Mathæussen 2004), and for some of the larger colonies, this decrease had occurred by the early 1990s (Nyeland 2004). Similarly, the breeding population of the surveyed colonies in south Greenland has decreased by 60% since the previous (1970–80s) counts (Boertmann 2004). The south-west and south Greenland regions show a common characteristic. Even though the total number of AONs has decreased, the population is now more dispersed, as several new and small colonies have been established (Boertmann 2004; Nyeland & Mathæussen 2004). Such small colonies are often unstable over time, but this phenomenon may give a false impression of a healthy and increasing population (Nyeland & Mathæussen 2004).

East Greenland. In 2004 the population in north-east Greenland seemed to have increased considerably (Gilg 2005). This was, however, moderated in 2008, when six of these colonies had decreased from 700 to 302 AONs (see the Appendix). Despite this decrease, the conditions for kittiwakes have probably improved in recent years, because less drift ice has occurred along the coasts in the summer months (Johannessen et al. 2004; Hansen et al. 2008; Hvidegaard et al. 2008). This is underlined by the fact that the boreal lesser black-backed gull (*Larus fuscus*) has extended its breeding range to these coasts of Greenland in recent years (Boertmann 2008).

Reasons for decline. The exploitation of seabirds in Greenland (hunting and egg collecting) has been a key factor for the decrease in several breeding seabird populations, such as the thick-billed murre and common eider (*Somateria mollisima*) (Kampp et al. 1994; Merkel 2004), and may also be a contributing factor for the declines in the kittiwake population. Hunters in Greenland are annually obliged to report the number of birds taken each month, and these bag records date back to 1993. During the first year as many as 63 000 birds were reported to have been killed, but this decreased gradually to about 32 000 in 2001 (Government of Greenland, unpubl. hunting statistics 2008). From 2002 the open season was shortened from 16 August–31 May to 1 September–15 February (Government of Greenland 2002), after which the annual harvest declined further, and has stabilized at roughly 8000 birds (Government of Greenland, unpubl. hunting statistics 2008). These figures must be considered as index values because an uncertain number of birds are not reported, however, the pre-2002 records indicate that more than half of the annual catches were from the spring period. Ring recoveries indicate that there was a higher fraction of Greenlandic breeders in the spring catches than in the autumn catches, whereas the autumn catches had a higher fraction of younger birds and of adult breeders from abroad (Lyngs 2003). Thus, the spring harvest may have been more harmful to the Greenlandic breeding population than the autumn harvest, both in terms of direct mortality and from disturbances as a result of hunting close to breeding

colonies. However, a population effect of the reduced hunting season has yet to be observed. So far, the linkage between the population decline and the harvest has not been as clear for kittiwakes as for other seabirds harvested in Greenland (Nyeland 2004).

Kittiwakes are pelagic surface feeders, which, particularly in the breeding season, makes them more vulnerable to reduced food availability (Furness & Tasker 2000). In some areas of the North Atlantic, the observed reductions in breeding populations as well as reduced reproductive success of kittiwakes has been connected to limited access to suitable food resources as a result of large-scale shifts in marine ecosystems (Ekker 2008). In Canada, a clear demarcation in population trends and biology between kittiwake colonies in the high Arctic and along the Atlantic coast give a similar picture as in Greenland, of healthy colonies in the High Arctic and colonies with reduced breeding populations further south (Gaston et al. 2009). The colonies in Atlantic Canada have decreased because of changes in feeding regimes (Regehr & Montevecchi 1997; Gaston et al. 2009). Little is known about the diet of kittiwakes in Greenland; however, to our knowledge, severe breeding failure has not been reported from Greenlandic colonies.

Future surveys may show if the reduced hunting season will have an effect on the size of the breeding population. Other questions that are vital to address in Greenland include reproduction success, diet, impacts of climate change, etc., data which are also relevant for the management of the population. We therefore strongly recommend that a kittiwake monitoring programme is initiated in Greenland.

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Appendix

Latest count of all registrated breeding colonies of black-legged kittiwakes in Greenland. Based on data from the seabird breeding colony database maintained by the National Environmental Research Institute. In West Greenland, the area name is listed by municipality. In East Greenland the area name is listed by name of site.

Area	Colony number	Date	Quality[a]	Unit[b]	Min pairs[c]
North					
Qaanaaq	77002	25 July 2006	H	P	12 860
Qaanaaq	76014	27 July 2006	H	P	18 707
Qaanaaq	76013	28 July 2006	H	P	2457
Qaanaaq	76012	29 July 2006	H	P	1642
North-west					
Upernavik	73069	16 July 1998	L	I	10
Upernavik	73056	8 July 2007	H	N	43
Upernavik	73043	8 July 2007	H	N	152
Upernavik	73026	6 July 2007	H	N	13
Upernavik	73025	6 July 2007	H	N	13
Upernavik	73011	6 July 2007	H	N	608
Upernavik	73010	31 July 2002	H	I	437
Upernavik	73009	1 August 2002	H	I	2186
Upernavik	73008	6 July 2007	H	N	219
Upernavik	73007	5 July 2007	H	N	0
Upernavik	72151	13 July 1999	H	N	2
Upernavik	72140	13 July 1999	H	N	2
Upernavik	72137	15 July 1998	H	N	16
Upernavik	72096	7 July 1998	H	N	26
Upernavik	72092	13 July 1998	L	I	20
Upernavik	72083	16 July 1998	L	I	65
Upernavik	72078	15 July 1998	H	N	57
Upernavik	72047	12 July 1998	M	P	0
Upernavik	72038	13 July 1998	L	I	65
Upernavik	72037	11 July 2007	H	N	0
Upernavik	72036	4 July 1998	H	N	8
Upernavik	72035	1 July 2007	H	N	130
Upernavik	72034	1 July 2007	H	N	12
Upernavik	72033	14 July 1998	L	I	7
Upernavik	72032	13 July 1998	H	N	9
Upernavik	72031	13 July 1998	L	I	39
Upernavik	72027	1 July 2007	H	N	48
Upernavik	72026	18 July 1994	M	P	0
Upernavik	72025	11 July 2007	M	N	104
Upernavik	72024	13 July 1998	M	P	0
Upernavik	72023	4 July 1998	M	P	0
Upernavik	72022	14 July 2000	M	P	0
Upernavik	72020	13 July 1998	H	N	0
Upernavik	72018	13 July 1998	H	N	192
Upernavik	72017	1 July 2007	H	N	3
Upernavik	72016	8 July 1998	M	P	0
Upernavik	72014	9 July 2007	H	N	994
Upernavik	72013	26 July 1999	H	N	83
Upernavik	72011	26 July 1999	H	N	145
Upernavik	72009	28 June 2007	H	I	465
Upernavik	72008	8 July 2008	H	N	0
Upernavik	72005	9 July 1999	H	N	57
Uummannaq	72002	10 July 2000	H	I	228
Uummannaq	71090	18 July 2000	H	N	6
Uummannaq	71087	18 July 2000	H	N	80
Uummannaq	71086	18 July 2000	H	N	4

Appendix *Continued*

Area	Colony number	Date	Quality[a]	Unit[b]	Min pairs[c]
Uummannaq	71084	18 July 2000	H	N	21
Uummannaq	71050	18 July 2000	H	N	60
Uummannaq	71026	16 July 2000	H	P	0
Uummannaq	71025	16 July 2000	H	N	125
Uummannaq	71023	18 July 2000	H	N	4
Uummannaq	71015	2 July 2000	M	N	180
Uummannaq	71011	13 July 2000	H	P	0
Uummannaq	71010	13 July 2000	H	P	0
Uummannaq	71009	13 July 2000	H	N	2
Uummannaq	71008	13 July 2000	H	P	0
Uummannaq	71007	13 July 2000	H	P	0
Uummannaq	70114	13 July 2000	H	P	0
Uummannaq	70113	13 July 2000	H	P	0
Uummannaq	70112	13 July 2000	H	N	2
Uummannaq	70111	12 July 2000	H	P	0
Uummannaq	70109	12 July 2000	H	P	0
Uummannaq	70106	15 July 2000	H	P	0
Uummannaq	70101	13 July 2000	H	P	0
Uummannaq	70099	13 July 2000	H	P	0
Uummannaq	70098	13 July 2000	H	P	0
Uummannaq	70097	12 July 2000	M	P	0
Uummannaq	70095	12 July 2000	H	P	0
Uummannaq	70090	12 July 2000	H	P	0
Uummannaq	70088	12 July 2000	H	P	0
Uummannaq	70086	8 July 2000	H	P	0
Uummannaq	70079	8 July 2000	H	P	0
Uummannaq	70072	8 July 2000	H	P	0
Uummannaq	70069	8 July 2000	H	P	0
Uummannaq	70068	8 July 2000	H	P	0
Uummannaq	70065	8 July 2000	H	P	0
Uummannaq	70064	12 July 2000	H	P	0
Uummannaq	70053	15 July 2000	H	P	0
Uummannaq	70049	15 July 2000	H	P	0
Uummannaq	70042	7 July 2000	H	P	0
Uummannaq	70026	4 July 2000	H	N	20
Qeqertarsuaq	70005	3 September 1995	L	I	65
Qeqertarsuaq	69116	15 July 2001	H		0
Qeqertarsuaq	69064	22 July 2001	L	N	10
Qeqertarsuaq	69063	15 July 2001	H		0
Qeqertarsuaq	69001	11 July 2005	M	P	0
Qeqertarsuaq	68012	11 July 2005	L	P	0
Ilulissat	69129	7 July 2005	H	P	15
Ilulissat	69118	6 July 2005	H	P	0
Ilulissat	69103	5 July 2004	M	P	0
Ilulissat	69081	6 June 2007	H	N	0
Ilulissat	69077	5 July 2005	H	N	1
Ilulissat	69049	5 July 2005	M	P	2783
Ilulissat	69048	6 July 2005	H	N	90
Ilulissat	69046	6 July 2005	H		0
Ilulissat	69045	6 July 2005	H	N	42
Ilulissat	69043	6 July 2005	H	N	44
Ilulissat	69042	6 July 2005	H		0
Ilulissat	69041	6 July 2005	H	N	210
Ilulissat	69040	7 July 2005	H	N	18
Ilulissat	69039	7 July 2005	H	N	136
Ilulissat	69038	6 July 2005	H	P	7072

Appendix *Continued*

Area	Colony number	Date	Quality[a]	Unit[b]	Min pairs[c]
Ilulissat	69037	6 July 2005	M	N	1077
Ilulissat	69036	6 July 2005	H		0
Ilulissat	69035	6 July 2005	M	P	800
Ilulissat	69034	6 July 2005	H	P	0
Ilulissat	69033	6 July 2005	H	P	9514
Ilulissat	69032	7 July 2005	H	N	45
Ilulissat	69030	7 July 2005	H	N	27
Ilulissat	69028	7 July 2005	H		0
Ilulissat	69027	7 July 2005	H	N	111
Ilulissat	69026	7 July 2005	H	P	0
Ilulissat	69025	7 July 2005	H		0
Ilulissat	69022	8 July 2005	H	I	0
Ilulissat	69020	5 July 2005	H		0
Ilulissat	69019	5 July 2005	H		0
Ilulissat	69018	5 July 2005	H		0
Ilulissat	69017	4 July 2005	H		0
Ilulissat	69016	4 July 2005	H		0
Ilulissat	69015	4 July 2005	H	N	49
Ilulissat	69014	4 July 2005	H		0
Ilulissat	69011	5 July 1976		I	0
Ilulissat	69010	5 July 1976		P	0
Ilulissat	69007	6 July 1976	M	P	0
Ilulissat	69003	5 July 1976		I	0
Ilulissat	68036	6 July 1976		P	0
Ilulissat	68035	6 July 1976	M	P	0
Qasigiannguit	68209	8 July 2005	H	I	1
Qasigiannguit	68203	9 July 2005	H	N	314
Qasigiannguit	68138	9 July 2005	H	N	1
Qasigiannguit	68112	9 July 2005	H	N	2
Qasigiannguit	68106	26 June 1976		I	0
Qasigiannguit	68081	23 July 1997	M	P	0
Qasigiannguit	68054	21 July 2005	H	P	0
Qasigiannguit	68026	8 July 2005	H		0
Qasigiannguit	68025	8 July 2005	H		0
Qasigiannguit	68020	8 July 2005	H	P	5
Qasigiannguit	68017	8 July 2005	H	P	0
Qasigiannguit	68014	8 July 2005	H		0
Aasiaat	68029	July 2006	M	P	0
Kangaatsiaq	68219	12 July 2005	H	N	3
Kangaatsiaq	68202	19 July 2005	H	N	9
Kangaatsiaq	68159	14 July 2005	H	P	85
Kangaatsiaq	68158	14 July 2005	H	N	195
Kangaatsiaq	68129	20 July 2005	H	P	0
Kangaatsiaq	68123	14 July 2005	H	N	84
Kangaatsiaq	68121	19 July 2005	H	N	12
Kangaatsiaq	68095	14 July 2005	H	P	0
Kangaatsiaq	68094	14 July 2005	H	P	0
Kangaatsiaq	68093	14 July 2005	H	P	0
Kangaatsiaq	68086	13 July 2005	H	P	0
Kangaatsiaq	68085	13 July 2005	H	N	59
Kangaatsiaq	68084	13 July 2005	H	N	243
Kangaatsiaq	68083	13 July 2005	H	N	14
Kangaatsiaq	68082	24 July 1997	M	P	0
Kangaatsiaq	68079	21 July 1997	M	P	0
Kangaatsiaq	68077	13 July 2005	H	N	90
Kangaatsiaq	68072	11 July 1954	M	UP	41

Appendix *Continued*

Area	Colony number	Date	Quality[a]	Unit[b]	Min pairs[c]
Kangaatsiaq	68067	20 July 2005	H	N	147
Kangaatsiaq	68066	20 July 2005	H		0
Kangaatsiaq	68065	20 July 2005	H	P	0
Kangaatsiaq	68061	21 July 2005	H	P	0
Kangaatsiaq	68059	21 July 2005	H	P	0
Kangaatsiaq	68058	21 July 2005	H	P	0
Kangaatsiaq	68055	21 July 2005	H	P	0
Kangaatsiaq	67062	19 July 2005	H		0
Kangaatsiaq	67061	12 July 2005	H	P	1
Kangaatsiaq	67060	12 July 2005	H		0
Kangaatsiaq	67059	12 July 2005	H		0
Kangaatsiaq	67030	16 July 2006	H	N	38
Kangaatsiaq	67027	16 July 2006	H	N	5
Kangaatsiaq	67026	16 July 2006	H		0
Kangaatsiaq	67025	16 July 2006	H	N	37
Kangaatsiaq	67024	16 July 2006	M	P	0
Kangaatsiaq	67011	16 July 2005	H	N	2
South-west					
Sisimiut	67017	16 July 2005	H		0
Sisimiut	67015	16 July 2005	H		0
Sisimiut	67014	16 July 2005	H		0
Sisimiut	66201	28 August 1993	L	P	50
Sisimiut	66028	20 July 1975	M		0
Maniitsoq	66044	22 July 2003		N	118
Maniitsoq	66043	22 July 2003		N	23
Maniitsoq	66021	28 June 1992	M	P	0
Maniitsoq	66008	22 July 2003		N	10
Maniitsoq	66007	22 July 2003		N	67
Maniitsoq	66005	22 July 2003		N	39
Maniitsoq	66003	22 July 2003	M	P	0
Maniitsoq	66002	22 July 2003		N	14
Maniitsoq	66001	21 July 2003		N	502
Maniitsoq	65064	26 July 2003	H	N	1205
Maniitsoq	65043	1980	M	P	50
Maniitsoq	65036	22 July 2003		N	103
Maniitsoq	65030	22 July 2003		N	43
Maniitsoq	65029	22 July 2003		N	41
Maniitsoq	65028	22 July 2003		N	164
Maniitsoq	65027	22 July 2003	M	P	0
Maniitsoq	65026	22 July 2003		N	12
Maniitsoq	65024	22 July 2003	M	P	0
Maniitsoq	65023	22 July 2003		N	48
Maniitsoq	65022	22 July 2003		N	20
Maniitsoq	65021	22 July 2003		N	27
Maniitsoq	65019	21 July 2003	H	N	11 337
Maniitsoq	65018	21 July 2003		N	34
Maniitsoq	65015	25 July 2003	H	N	3930
Maniitsoq	65013	25 July 2003	H	N	1730
Maniitsoq	65012	25 July 2003	M	P	0
Maniitsoq	65011	25 July 2003	H	N	1390
Maniitsoq	65010	25 July 2003	M	P	0
Maniitsoq	65009	25 July 2003	H	N	3393
Maniitsoq	65008	25 July 2003	H	N	715
Maniitsoq	65004	26 July 2003	H	N	2400
Maniitsoq	65003	26 July 2003	H	N	4770
Maniitsoq	65002	26 July 2003	H	N	130

Appendix *Continued*

Area	Colony number	Date	Quality[a]	Unit[b]	Min pairs[c]
Maniitsoq	65001	26 July 2003	H	N	100
Maniitsoq	64200	4 July 1992	H	P	6
Nuuk	64035	28 June 2007	H	P	48
Nuuk	64023	6 July 1986	M	P	0
Nuuk	64022	27 June 2007	M	P	276
Nuuk	64019	13 July 2007	M	P	302
Nuuk	64018	27 June 2007	M	P	217
Nuuk	64016	2 July 2007			0
Nuuk	64015	13 July 2007	M	P	62
South					
Paamiut	62018	26 July 2007	H	P	437
Paamiut	62010	22 July 2007	H	N	0
Paamiut	62003	22 July 2007	H	N	41
Paamiut	62001	26 July 2007	H	P	0
Paamiut	61028	26 July 2003	H	N	0
Paamiut	61009	26 July 2007	H	P	697
Paamiut	61007	July 2003	M	P	0
Paamiut	61002	26 July 2003	M	N	2120
Qaqortoq	60087	28 July 2003	M	N	81
Qaqortoq	60016	28 July 2003	M	N	95
Qaqortoq	60012	1 August 1999	M	N	12
Narsaq	61040	28 July 2003	M	N	33
Narsaq	61039	28 July 2003	M	N	22
Narsaq	61038	28 July 2003	M	N	110
Narsaq	61010	28 July 2003	L		0
Narsaq	60015	28 July 2003	M	N	134
Nanortalik	60044	16 July 2003	H	N	32
Nanortalik	60028	16 July 2003	H	N	3
Nanortalik	60027	16 July 2003	H	N	25
Nanortalik	60001	18 July 2003	H	N	5
North-east					
Mallemukfjeld	80501	July 1993	H	N	873
Fugleø	76528	16 August 2003	L	I	7
Rødeø	76524	16 August 2003	L	I	5
Maroussia	76508	29 July 2008	L	N	50
Hvalros Ø	74512	24 July 2008	H	N	75
Hvalros Ø	74511	24 July 2008	H	N	30
Hvalros Ø	74502	24 July 2008	M	N	40
Kangikajik	70508	9 July 2004	H	N	1300
Immikkeertikajik	70507	23 July 2004	H	N	600
Appalik	70505	23 July 2004	H	N	450
Sulussuutikajik	69503	26 July 2008	L	N	50
Dunholm	69502	26 July 2008	H	N	57
Southeast					
Umiivik	64501	18 July 1933			Small colony
Taateraat	61501	18 June 2008	M	I	97
West of Kap Discard	60502	16 June 2008	M	I	39
Kangerlussuatsiaq	60501	1 June 2008	L		0

[a] L, low; M, medium; H, high.

[b] The original unit for which the count number was given. I, individual; N, nest; P, pair.

[c] Number of individuals were converted to number of breeding pairs using a factor of 0.65.