

# Wintering Areas and Recovery Rates of Brünnich's Guillemots *Uria lomvia* Ringed in the Svalbard Archipelago

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**ABSTRACT.** We mapped wintering areas and estimated the recovery rates of Brünnich's guillemots (thick-billed murre) ringed in Svalbard during 1954–98. Recoveries were reported from Iceland, Greenland, and Newfoundland. An intensive hunt occurs annually off Greenland and Newfoundland, and more than 95% of the recovered birds were reported as shot. Birds recovered as immatures differed from birds recovered as adults in their temporal and spatial distribution. Immatures were more exposed to hunting because they arrived at the hunting areas earlier in the autumn and formed a higher proportion of the population in hunting areas farthest away from Svalbard. The recovery rate of birds ringed in Svalbard as chicks was comparable to the recovery rate reported from Canada. Interestingly, no Svalbard birds have ever been recovered in the southern part of the Barents Sea or along the Norwegian coast, suggesting that these areas are not important to the Svalbard population. The distribution of winter recoveries of birds ringed in Svalbard was compared to the winter recovery areas of Brünnich's guillemots ringed elsewhere in the North Atlantic. Only birds ringed in Svalbard have been recovered in Iceland in winter.

**Key words:** wintering areas, recovery rate, migration, common guillemot (common murre), *Uria aalge*, Brünnich's guillemot (thick-billed murre), *Uria lomvia*

**RÉSUMÉ.** On a cartographié les aires d'hivernage des guillemots de Brünnich (marmettes de Brünnich) bagués au Svalbard de 1954 à 1998, et estimé leurs taux de recapture. Des recaptures ont été signalées en Islande, au Groenland et à Terre-Neuve. Durant la chasse intensive qui a lieu chaque année au large du Groenland et de Terre-Neuve, 95 % des oiseaux recapturés auraient été abattus au fusil. Les oiseaux recapturés en tant qu'immatures différaient dans leur distribution temporelle et spatiale de ceux recapturés en tant qu'adultes. Les immatures étaient plus exposés à la chasse parce qu'ils arrivaient dans les zones de chasse plus tôt à l'automne et qu'ils formaient une plus grande proportion de la population dans les zones de chasse les plus éloignées du Svalbard. Le taux de recapture des oiseaux bagués au Svalbard en tant qu'oisillons se comparait à celui rapporté pour le Canada. Fait intéressant, aucun oiseau du Svalbard n'a jamais été recapturé dans la partie méridionale de la mer de Barents ou le long de la côte norvégienne, ce qui laisse à penser que ces régions ne sont pas importantes pour la population du Svalbard. On a comparé la distribution des oiseaux recapturés en hiver et qui avaient été bagués au Svalbard aux aires de recapture hivernale des guillemots de Brünnich bagués ailleurs dans l'Atlantique Nord. Seuls des oiseaux bagués au Svalbard ont été recapturés en Islande en hiver.

**Mots clés:** aires d'hivernage, taux de recapture, migration, guillemot marmette (marmette commune), *Uria aalge*, guillemot de Brünnich (marmette de Brünnich), *Uria lomvia*

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## INTRODUCTION

An unknown portion of the breeding populations of Brünnich's guillemot (thick-billed murre, *Uria lomvia*) breeding in the Northeast Atlantic migrates southwest after the breeding season and spends the winter in the Northwest Atlantic (Norderhaug et al., 1977). Ringing of Brünnich's guillemots in Svalbard, on Novaya Zemlya, and along the Murman and Norwegian coasts has resulted in recoveries in Iceland, Greenland, Canada, and along the southern coasts of the Barents Sea (Salomonsen, 1967, 1971; Norderhaug et al., 1977; Kampp, 1988; Mehlum and

Bakken, 1994; Isaksen and Bakken, 1995; Nikolaeva et al., 1996; Lyngs, 2003).

Many gaps exist in current knowledge of the migration routes and the wintering areas of Brünnich's guillemots breeding in the Northeast Atlantic. Relevant data may be obtained from ringing recoveries, but this material is biased since it depends on human presence for finding and reporting ringed birds. However, to date, these data are the best available source of information for linking Brünnich's guillemots found outside the breeding season to the breeding colonies.

An intensive hunt of seabirds occurs in Greenland and Newfoundland in winter, and about 900 000–1 200 000

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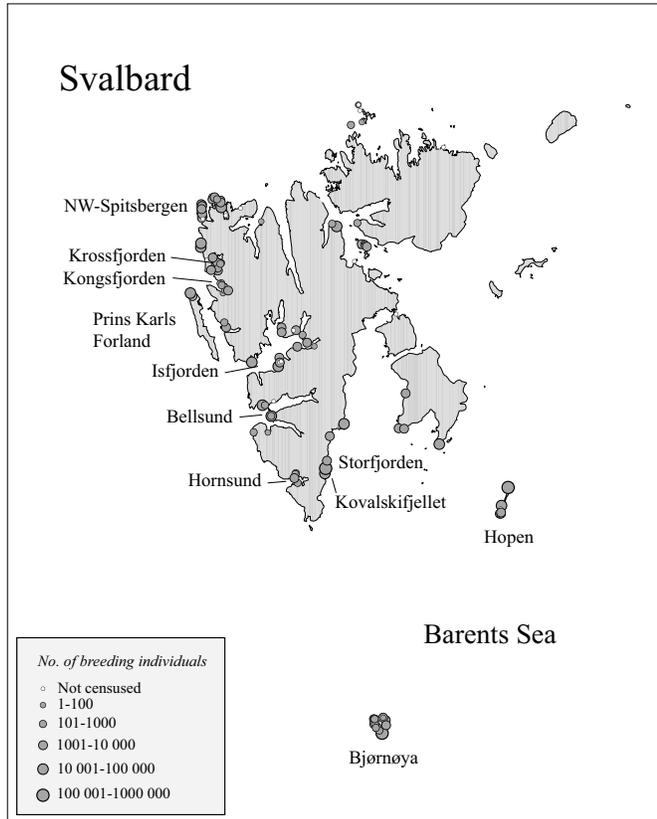


FIG 1. Map of the Svalbard archipelago, showing the Brünnich's guillemot colonies (dots). Names indicate the ringing sites referred to in the text.

Brünnich's guillemots are shot in these areas annually (Elliot, 1991; Falk and Durinck, 1992). A large proportion of these birds originates from colonies in Greenland and Canada (Gaston, 1980; Kampp, 1988; Donaldson et al., 1997; Lyngs, 2003), but birds from Iceland (A. Petersen, pers. comm. 2003) and the Barents Sea (Mehlum and Bakken, 1994; Isaksen and Bakken, 1995; Nikolaeva et al., 1996) are also affected. Brünnich's guillemots are also hunted in Iceland, and in 1995–97 between 15 000 and 20 000 birds were shot annually (Petersen, 2001). In Svalbard, hunting of Brünnich's guillemot is allowed from 1 September to 31 October (Bakken and Anker-Nilssen, 2001), but only a few birds are shot along the western coast of Svalbard (Fig. 1). In 1999–2002 between 0 and 30 were reported shot annually (R. Bergstrøm, Environmental Department, Governor of Svalbard, pers. comm. 2004). Brünnich's guillemots are protected all year along the Norwegian and Russian coasts (Bakken and Anker-Nilssen, 2001; Golovkin, 2001).

The high proportion of recovered ringed birds reported as shot may indicate the significance of hunting to the bird populations. The severity of the effect on the population will also depend on whether mainly immatures or adult birds are shot. In long-lived seabirds such as guillemots (Croxall and Rothery, 1991), hunting of adult birds will have a greater negative effect on the population than hunting of immatures.

For a number of colonies in Canada, Gaston (1980) and Donaldson et al. (1997) found both a temporal and a spatial segregation of first-year birds from older birds in winter. These results appear to be in accordance with Baker's (1980) exploratory model of bird migration, which suggests that young vertebrates acquire knowledge of an area far larger than the area they will need as adults. We wanted to investigate whether the Svalbard birds showed segregation similar to that of the Canadian birds and had migration patterns in accordance with Baker's migration model.

We present current knowledge, based on ringing recoveries, of the wintering areas and recovery rates of Brünnich's guillemots ringed in Svalbard. The recovery rates, causes of mortality, and spatial and temporal distribution of immatures and adults are compared with those of Brünnich's guillemot populations ringed elsewhere in the North Atlantic. Our null hypotheses are that immatures and adults of birds ringed in Svalbard have similar migration patterns, both temporal and spatial, and that immatures and adults are equally exposed to hunting.

## MATERIAL AND METHODS

### *Ringling*

The material includes data on birds ringed in Svalbard (Fig. 1) from 1954 until the end of 1998 and recovered before the summer of 1999. In 1954–98, a total of 11 145 Brünnich's guillemots were ringed in colonies in Svalbard (Table 1).

More than 75% of the birds were ringed in the 1990s, mainly in two colonies: Bjørnøya (74°30'N, 19°01'E) and Kovalskifjellet (77°03'N, 17°17'E) (Fig. 1, Table 1). The birds ringed in these colonies constitute more than 80% of the total number of Brünnich's guillemot ringed in Svalbard. Bjørnøya and Kovalskifjellet are the only colonies where more than 1000 birds have been ringed in Svalbard. Except for one colony, Ingeborgfjellet (Bellsund), the total number of birds ringed in the other colonies is less than 500 (Table 1). Since 1982, all birds have been ringed using stainless steel rings. The rings used earlier were made of Monel Metal.

Birds have been ringed in the breeding colonies only. Most adults and some chicks were ringed on the breeding ledges. Most of the chicks, and some accompanying adults, were ringed on the beach below the colonies just after fledging. In total, 6850 birds were ringed as adults and 4295 as chicks.

### *Recoveries and Analyses*

The spatial distribution of the recoveries was divided into three separate geographic areas: Newfoundland, Greenland, and Iceland. One recovery at sea east of Iceland was defined as an Icelandic recovery in the analysis. The distance between the ringing site and the recovery site was

TABLE 1. Brünnich's guillemots ringed in different areas of Svalbard from 1954 to 1998 and recovered outside the Svalbard archipelago. See also the ringing location map (FIG. 1).

Area	Total	Ringed as chicks	Recovered (%)	Ringed as adults	Recovered (%)	Ringing period
Bellsund	510	503	29 (5.8)	7	0	1976–97
Bjørnøya	5142	207	9 (4.4)	4935	10 (0.2)	1965–98
Hopen	46	0	0	46	0	1984
Hornsund	298	169	0	129	1 (0.8)	1962–65
Isfjorden	408	147	6 (4.1)	261	1 (0.4)	1954–97
Kongsfjorden/Krossfjorden	571	34	3 (8.8)	537	12 (2.2)	1960–98
NW Spitsbergen	65	40	0	25	0	1963–90
Prins Karls Forland	59	6	0	53	0	1993–97
Storfjorden (Kovalskifjellet)	4046	3189	121 (3.8)	857	11 (1.3)	1989–97
Total	11 145	4295	168 (3.9)	6850	35 (0.5)	1954–98

calculated as the Euclidean distance between the two points (in kilometres). For recoveries in Newfoundland and southwest Greenland, the distance was calculated through a point just south of Greenland, as the guillemots probably do not migrate over land.

We analyzed the spatial distribution of recovered birds ringed in Svalbard and compared these birds to recovered Brünnich's guillemots ringed elsewhere in the North Atlantic. A recovery is defined as any record of a ringed bird that is reported to the national ringing scheme. In addition to birds ringed in Svalbard, this data set (4973 recoveries) included birds ringed in Russia, Norway (mainland), Iceland, Greenland, Canada, and the United States and recovered between 1929 and 1999. The analyses were carried out using the GIS program ArcView (ESRI, Inc). The general analysis and sorting of data were carried out using a specially designed database program called "RECOVERY" that was made in CLIPPER (Computer Associates) by the first author. All chi-squares are based on actual numbers of recoveries, not percentages. Yates' correction was used when there was one degree of freedom.

Age classes of immature birds were defined as 1st winter, 2nd winter, 3rd winter, and 4th winter. Older birds were classified as adults. An additional age category used was calendar year (cy). In the hatching year, a chick is in its first calendar year (1 cy) until 31 December. During the subsequent year (1 January–31 December), the chick is in its second calendar year (2 cy) and so on. The winter period was defined as 1 October to 31 March.

## RESULTS

By May 1999, 203 recoveries from the 11 145 Brünnich's guillemots ringed in Svalbard had been reported to the Norwegian Ringing Centre. No birds have ever been recovered in the Svalbard archipelago during the winter period. About 95% of the birds were shot, 1.5% were trapped, and 3.5% had no obvious cause of death. The longest migration distance was to Newfoundland (4506 km). The oldest bird ringed as a chick was 17.4 years old when recovered, and the oldest bird ringed as an adult was recovered 19.5 years after ringing.

TABLE 2. Brünnich's guillemots ringed in Svalbard in different time periods and recovered outside the Svalbard archipelago.

Period	Chicks		Adults	
	Ringed	Recovered (%)	Ringed	Recovered (%)
1954–59	32	4 (12.5)	0	0
1960–69	248	3 (1.2)	333	8 (2.4)
1970–79	375	26 (6.9)	17	2 (11.8)
1980–89	605	29 (4.8)	1162	9 (0.8)
1990–99	3035	106 (3.5)	5338	16 (0.3)
Total	4295	168	6850	35

### Recovery Rates

Adding a period of at least six years for recoveries to be reported, we based the recovery rate calculations on birds ringed before 1993. The total recovery rate was 1.8% (183 recoveries of 9990 ringed), and birds ringed as chicks had a higher recovery rate (3.5%) than those ringed as adults (0.5%) ( $\chi^2 = 145.6$ ,  $df = 1$ ,  $p < 0.001$ ).

The recovery rates of birds ringed as chicks and adults, aggregated in 10-year intervals, have been variable (Table 2). Comparing the recoveries for only seven years after ringing made a difference in the recovery rates for chicks ( $\chi^2 = 12.9$ ,  $df = 4$ ,  $p < 0.05$ ), but not for adults ( $\chi^2 = 3.6$ ,  $df = 2$ ,  $p > 0.1$ ) (combining the data from the 1960s and 1970s).

The recovery rates of adults and chicks ringed at Kovalskifjellet and Bjørnøya were compared in selected time intervals (birds ringed before 1993 and 1996, respectively) dependent on the main ringing effort and the time available for recoveries until 1999. The maximum available time span for recoveries was seven years for Kovalskifjellet and four years for Bjørnøya. Birds ringed as chicks had a significantly higher recovery rate than birds ringed as adults, both at Kovalskifjellet ( $\chi^2 = 12.2$ ,  $df = 1$ ,  $p < 0.001$ ) and on Bjørnøya ( $\chi^2 = 88.7$ ,  $df = 1$ ,  $p < 0.001$ ). The recovery rates for chicks ringed on Bjørnøya and at Kovalskifjellet were not different for birds ringed before 1996 ( $\chi^2 = 0.03$ ,  $df = 1$ ,  $p > 0.1$ ), but the recovery rate for adults was significantly higher for birds ringed at Kovalskifjellet ( $\chi^2 = 20.4$ ,  $df = 1$ ,  $p < 0.001$ ).

TABLE 3. Brünnich's guillemots ringed in all Svalbard (1954–98), on Bjørnøya (1965–98), and at Kovalskifjellet (1989–97), recovered as immatures (1–4 cy) and as adults in different countries.

	Country	Recovered as immatures (%)		Recovered as adults (%)		Total
<b>Svalbard:</b>	Greenland	130	(92.2)	54	(87.1)	184
	Canada	8	(4.8)	1	(1.6)	9
	Iceland	3	(1.8)	7	(11.3)	10
	Total	141		62		203
<b>Bjørnøya:</b>	Greenland	9	(100)	4	(40)	13
	Canada	0	(0)	1	(10)	1
	Iceland	0	(0)	5	(50)	5
	Total	9		10		19
<b>Kovalskifjellet:</b>	Greenland	111	(91.7)	9	(81.8)	120
	Canada	7	(5.7)	0	(0)	7
	Iceland	3	(2.5)	2	(18.2)	5
	Total	121		11		132

### *Spatial Distribution of Recoveries*

Of a total of 203 recoveries, 184 (90.6%) are reported from Greenland, 10 (5.0%) from Iceland, and 9 (4.4%) from Canada (Newfoundland) (Table 3). Seven of the Newfoundland recoveries were ringed as chicks at Kovalskifjellet.

The distribution of recoveries of birds ringed as chicks and recovered during the first year after ringing, compared to birds recovered as adults, was different in Iceland, Greenland, and Newfoundland, with a higher proportion of immatures recovered in Greenland and Canada and a higher proportion of adults in Iceland ( $\chi^2 = 11.5$ ,  $df = 2$ ,  $p < 0.005$ ). For the combined immature period (0–4 years after ringing), compared to birds recovered as adults, the difference was also significant ( $\chi^2 = 12.8$ ,  $df = 2$ ,  $p < 0.005$ ). Nine birds ringed as chicks and recovered more than four years after ringing, i.e., as adult birds, were all recovered in the southwestern part of Greenland. We could not compare the distributions of recoveries for immature birds vs. adult birds ringed at Kovalskifjellet and on Bjørnøya because the samples are too small (Table 3).

The distribution of winter (October–March) recoveries (immatures and adults) of Brünnich's guillemots ringed in Svalbard and in other northern Atlantic colonies (Fig. 2) shows large areas in the southwestern part of Greenland and Newfoundland where Svalbard birds, especially the immature birds, mixed with other populations. Svalbard birds have not been recovered in the northern part of the recovery area in Greenland or in some areas in Newfoundland. In Iceland, only Svalbard birds have been recovered in winter, and all the recoveries are from the 1990s. No Svalbard birds have ever been recovered along the southern coasts of the Barents Sea or along the Norwegian coast.

### *Temporal Distribution of Recoveries*

Ten recoveries were reported in April–September and 157 in October–March (Table 4), excluding those of

uncertain date. Six of the recoveries in April–September were immatures recovered one to three years after ringing. When the recoveries are merged into three periods (October–November, December–January, and February–March), the difference in recovery time of birds recovered as immatures and as adults is significant ( $\chi^2 = 9.5$ ,  $df = 2$ ,  $p < 0.01$ ). The time elapsed between ringing and recovery for birds ringed as chicks and as adults before 1993 is shown in Table 5. When the data are combined into three groups (1–3 years, 4–6 years, and more than 6 years after ringing), the difference is highly significant ( $\chi^2 = 60.4$ ,  $df = 2$ ,  $p < 0.001$ ).

The first immature birds were recovered on the southwestern coast of Greenland in October. In November, more immatures were recovered there and also in areas farther north. In December–January, the most northerly recoveries occurred, but immatures were also found in the southern areas. There were few recoveries in February–March, but those in February included some from both the southern and northern parts of the Greenland coast. In Canada, the earliest recovery was in November, but four of the total five recoveries were in February and March. In Iceland, only two immature birds were recovered, both in January. On the western coast of Greenland, two immature birds in their second calendar year (2 cy) were recovered, one in May and one in June, as well as one 3 cy bird in June and one 4 cy bird in September.

Adults appeared on the southwestern coast of Greenland in October, and during November–December they were also recovered in the northern areas. Although adult recoveries are few and they appear later in the season, the recovery pattern seems quite similar to that of the immatures; however, two adults were also recovered on the east coast of Greenland in January and February. In Iceland, two adults were recovered in January and two in April. Only one adult was recovered in Canada, in March. Two adults were recovered on the southwestern coast of Greenland, one in June and one in July.

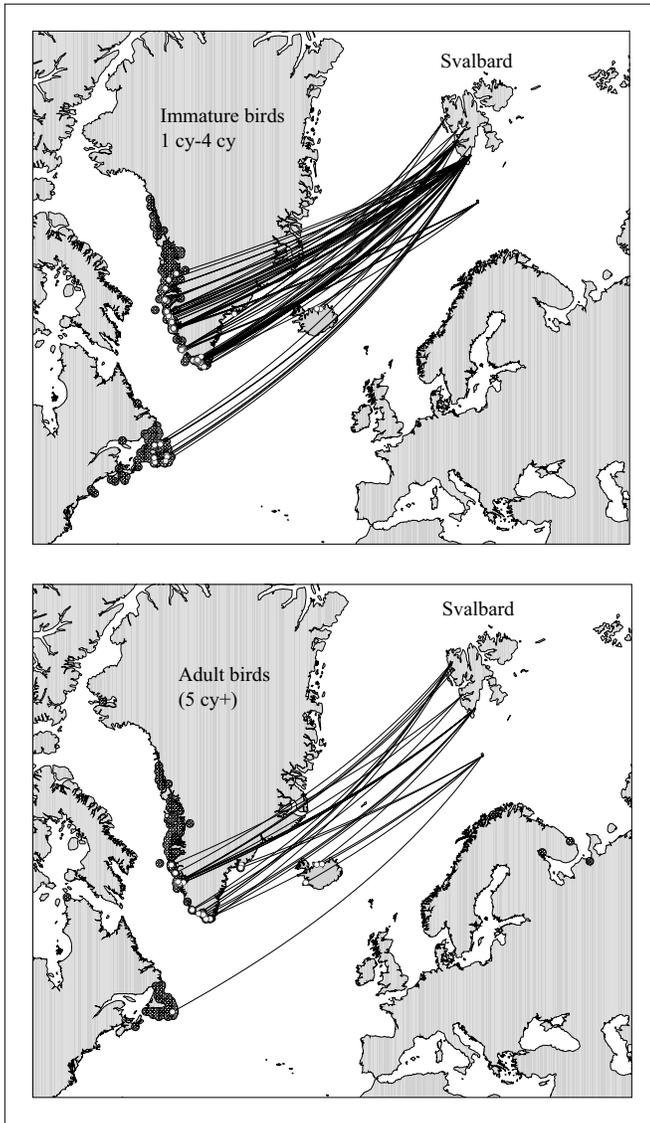


FIG 2. Map of North Atlantic, showing where immature (top) and adult (bottom) Brünnich's guillemots ringed in Svalbard were recovered from October to March (white rings). Dotted polygons indicate winter recovery areas for Brünnich's guillemots ringed elsewhere in the North Atlantic (buffered from single recovery points with a 50 km radius in order to be seen on the map).

## DISCUSSION

### Recovery Rates

The recovery rate (3.7%) for birds ringed in Svalbard as chicks and recovered before their fifth year was not different from the mean recovery rate of 3.6% reported by Donaldson et al. (1997) for birds ringed on Coats Island, Canada, in 1984–87 ( $\chi^2 = 0.3$ ,  $df = 1$ ,  $p > 0.1$ ). Comparable recovery rates for chicks ringed in Svalbard and Coats Island may indicate, if the hunters' report rates are comparable, that a similar proportion of the immature birds is hunted in both populations. However, the recovery areas are different, as the majority of the chicks from Coats

TABLE 4. Monthly distribution of recoveries with respect to age.

Month	Immatures	Adults	Total
October	4	1	5
November	54	4	58
December	28	8	36
January	24	11	35
February	11	3	14
March	6	3	9
Total	127	30	157

TABLE 5. Elapsed time from ringing to recovery of Brünnich's guillemots ringed as chicks and adults before 1993.

Recovery period	Ringed as chicks (%)		Ringed as adults (%)	
1st year	89	(69.0)	1	(3.8)
2nd year	18	(14.0)	4	(15.4)
3rd year	7	(5.4)	2	(7.7)
4th year	7	(5.4)	2	(7.7)
5th year	0		2	(7.7)
6th year	3	(2.3)	0	
Over 6 years after ringing	5	(3.9)	15	(57.7)
Total	129		26	

Island were recovered in Newfoundland (Donaldson et al., 1997), while most of the chicks ringed in Svalbard were recovered in Greenland (Table 3). Of 798 adults and 38 576 chicks ringed in West Greenland during 1946–80, a total of 2748 were recovered (Kampp, 1988), indicating an overall recovery rate of 7.0%. Although the recovery number is not split into immatures and adults, it is significantly higher than for birds ringed in Svalbard, even though recovery areas for the populations overlap. The recovery rates of birds ringed in colonies in North Norway and recovered in the hunting areas in the northwestern Atlantic are lower than those for the Svalbard population. Of a total of 555 birds ringed as adults and 91 as chicks on Hornøya (Norway), one bird from each group was recovered (recovery rates: 0.2% and 1.8%), the adult in Greenland and the chick in Newfoundland (Nikolaeva et al., 1996).

The relatively low recovery rate of adults ringed in Svalbard (0.5%), compared to birds ringed as chicks, suggests that only a small proportion of the adult birds spend the winter in the hunting areas. This rate also suggests that only a small proportion of the Svalbard adults is hunted, in comparison to adults breeding in Canada and Greenland (Gaston, 1980; Kampp, 1988; Donaldson et al., 1997; Lyngs, 2003). Increased immature mortality has smaller population consequences than increased adult mortality in long-lived seabirds such as guillemots (Croxall and Rothery, 1991). Hence, hunting is likely to have a less significant effect on the Svalbard population than on populations in Greenland and Canada.

### Spatial Distribution

Since the reporting of ringed birds is dependent on human presence, Brünnich's guillemots staying offshore

or in coastal areas outside the hunting zones have a minimal possibility of being found and reported. This means that the recovery information must be treated with great caution if the purpose is to map the wintering areas.

An unknown proportion of the Brünnich's guillemots ringed in Svalbard migrates southwest in the autumn and spends the winter close to Iceland, Greenland, and Newfoundland. However, the pattern of recoveries certainly does not show the actual distribution of the Svalbard birds in winter. The recoveries are almost exclusively connected to coastal areas close to human settlements where hunting is important. Brünnich's guillemots are also known to remain offshore in the winter period (Brown, 1984, 1986; Anker-Nilssen, 1988; Erikstad, 1990; Isaksen, 1995; Mosbech and Johnson, 1999), and they may also stay along the marginal ice edge and in the ice-covered waters (Irving et al., 1970; Divoky, 1979; Brown and Nettleship, 1981; Bakken, 1990; Mehlum and Isaksen, 1995; Durinck and Falk, 1996; Hunt et al., 1996; Mehlum, 1997).

Brünnich's guillemots occur offshore and in coastal waters in the Barents Sea outside the breeding season (Barrett, 1979; Anker-Nilssen, 1988; Bakken, 1990; Erikstad, 1990; Isaksen, 1995; Mehlum and Isaksen, 1995; Hunt et al., 1996). The distribution analyses (Fig. 2) show that birds breeding in Svalbard frequently mix with birds from other colonies in the winter period. However, no recoveries of birds ringed in Svalbard have ever been reported in the southern part of the Barents Sea, though Brünnich's guillemots ringed in the southern Barents have also been recovered there (Nikolaeva et al., 1996) (Fig. 2), which suggests that the Svalbard birds probably do not frequently visit the southern Barents coast.

The distribution of birds ringed as chicks and recovered during the first year as compared to adults differed geographically, with the adult proportion higher in Iceland and lower in Greenland and Newfoundland. Also, two of the three birds recovered in southeast Greenland were adult birds. These facts may indicate that the immature birds migrate farther than adults in winter and that adults stay closer to the breeding areas (See Brown, 1985 for discussion). Similar recovery patterns are found in other seabird species such as black-legged kittiwake *Rissa tridactyla*, northern fulmar *Fulmarus glacialis*, and alcids (Coulson, 1966; Mead, 1974; MacDonald, 1977; Harris, 1984; Brown, 1985; Stolt et al., 1991; Lyngs and Kampp, 1996; Barrett and Bakken, 1997).

Baker's (1980) exploratory migration model suggests that young vertebrates acquire knowledge of an area far larger than the area they will need as adults, but it is difficult from our data to confirm that the Svalbard birds fit into the model. We have shown that the proportions of immatures and adults are different in the different recovery areas and that immatures prevail in the hunting areas farthest away from the ringing sites, but we do not know the total distribution of the different age groups. For example, a possibility is that adults stay farther offshore than the immatures, thus remaining outside the reach of the

hunters. Several surveys have mapped Brünnich's guillemot distribution at sea (e.g., Irving et al., 1970; Brown, 1984, 1986; Anker-Nilssen, 1988; Bakken, 1990; Isaksen, 1995; Durinck and Falk, 1996; Hunt et al., 1996; Mosbech and Johnson, 1999), but as long as the birds' origin and age are unknown, it is not possible to confirm from our data that the immatures exploit an area far larger than the adults' area. Inexperienced immatures may also be more vulnerable to hunting even when they occur together with adults. Such effects are unknown, but emphasize the difficulties in interpreting recovery data.

#### *Temporal Distribution of Recoveries*

The results showed a difference in recovery period between immature birds and adults in the hunting areas in Iceland, Greenland, and Newfoundland, with more immatures than adults recovered early in the season. Immatures may reach the hunting areas earlier in the autumn than adults, as indicated by Gaston (1980) and confirmed for a larger number of colonies by Donaldson et al. (1997). The latter study showed that the majority of recoveries of first-year birds occurred before the end of December, whereas recoveries of older birds occurred mainly later in the winter for Greenland and Canadian colonies. As the immatures probably arrive earlier in the autumn, they are exposed to hunting for a longer period than adults, which may partly explain their preponderance in the hunted sample. Recoveries of immature birds from Svalbard along the Greenland coast in May–June show that immature birds may stay in this area all year.

## CONCLUSIONS

In conclusion, the tendency for immature Brünnich's guillemots ringed in Svalbard to disperse earlier and farther in winter than the older birds is similar to that observed for birds ringed in Canada (Gaston, 1980; Donaldson et al., 1997). However, the main wintering areas are different. Lack of recoveries of Svalbard birds in North Norway in winter suggests that the majority winter in the northern part of the Barents Sea and farther southwest off Iceland, Greenland, and to some extent, Newfoundland. Hunting is likely to have a much smaller effect on the Svalbard population than on the Greenlandic and Canadian populations.

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