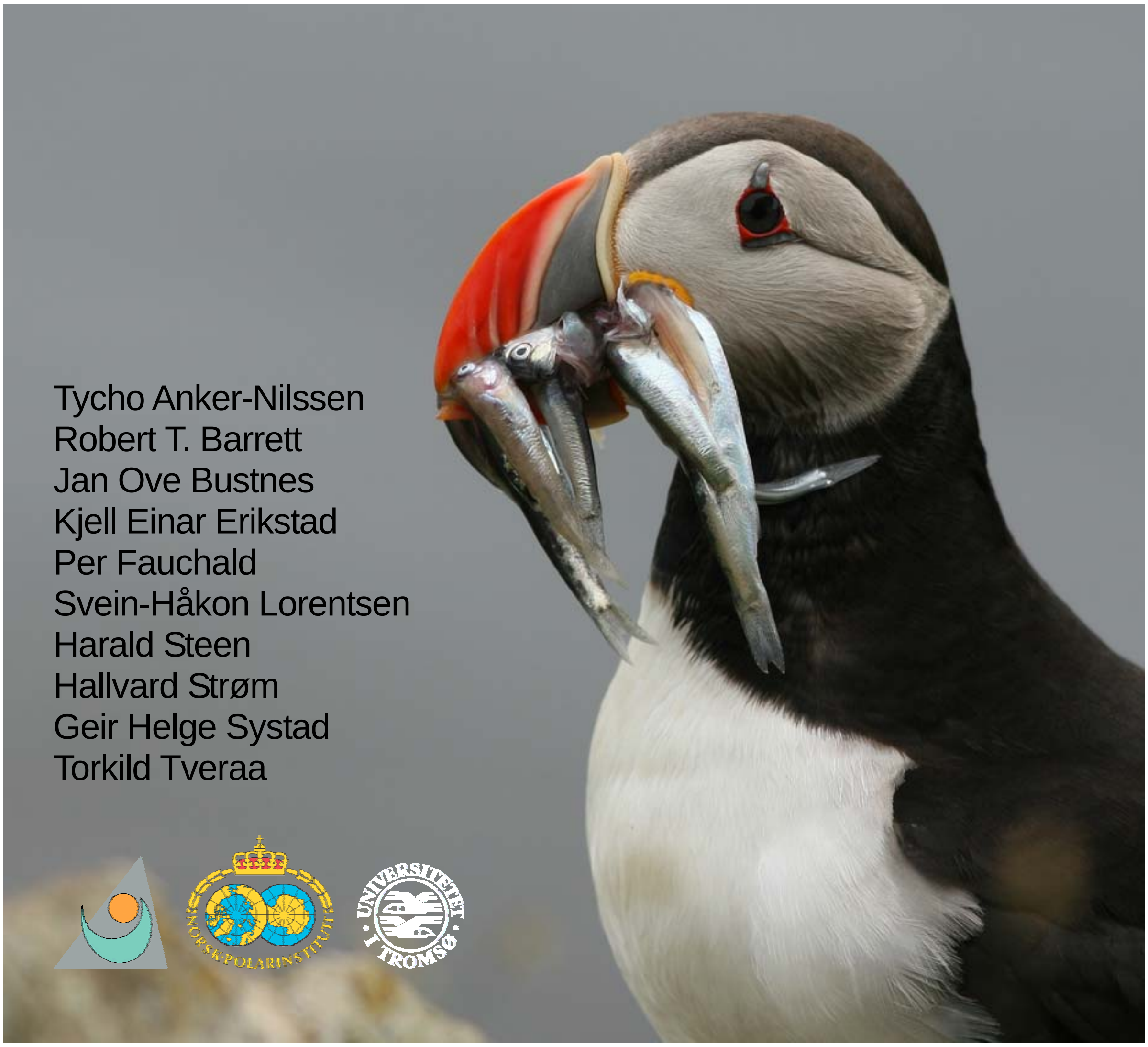
NINA Report 249

SEAPOP studies in the Lofoten and Barents Sea area in 2006



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Norwegian Institute for Nature Research

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COVER PICTURE
Atlantic puffin *Fratercula arctica* arriving at the colony with a load of young herring for its chick (© Tomas Aarvak, Røst 2006)

KEY WORDS
Lofoten Islands, Barents Sea, seabirds, mapping, monitoring

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Abstract

Anker-Nilssen, T., Barrett, R.T., Bustnes, J.O., Erikstad, K.E., Fauchald, P., Lorentsen, S.-H., Steen, H., Strøm, H., Systad, G.H. & Tveraa, T. 2007. SEAPOP studies in the Lofoten and Barents Sea area in 2006. – NINA Report 249. 63 pp.

This is the second annual report of the SEAPOP programme, which was initiated in 2005. In 2006, the programme was extended to the near full scale in the Lofoten-Barents Sea area, but it is aimed for implementation at the national level within few years. The report is divided into three sections. The first is an executive summary, the second presents five selected highlights from the studies in 2006, whereas the third presents results from other projects within the programme. The programme is wide-ranging, and with about 20 activities running in parallel, there is no room for emphasising details of the results in this short abstract. The main effort is however being put into mapping and monitoring.

The most demanding activity is to build-up the long-term data series for the numerical development, reproduction, survival and diet of an ecological and geographical selection of breeding populations. These data series are compared and analysed in relation to various environmental factors in an attempt to find the cause of the documented changes and to predict future population trends. This work is made at a series of key-sites spread from north to south: Spitsbergen, Bjørnøya, Hornøya, Hjelmsøya, Grindøya, Anda and Røst. More key-sites will be established further south when the programme is extended to the national scale. Seabirds are mapped both along the coast and at sea. To balance resource use against minimum requirements for validity of data, coastal areas are covered such that each area is mapped once every ten years in each season (breeding, moulting/autumn, winter and spring periods). A habitat model predicting the distribution of coastal seabirds has also been developed. For seabirds at sea, the focus is put on modelling distributions in different seasons from documented associations between seabird occurrences, oceanographic factors and distributions of prey. These associations are derived from data collected in a multi-disciplinary cooperation within the ecosystem surveys of the Institute of Marine Research.

SEAPOP aims to use recent advances in technology to develop more efficient methods of data collection. The programme is also developing its own web site (www.seapop.no) where advanced computer technology is put to use to communicate the results to various users.

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Sammendrag

Anker-Nilssen, T., Barrett, R.T., Bustnes, J.O., Erikstad, K.E., Fauchald, P., Lorentsen, S.-H., Steen, H., Strøm, H., Systad, G.H. & Tveraa, T. 2007. SEAPOP-studier i området Lofoten-Barentshavet i 2006. – NINA Report 249. 63 s.

Dette er den andre årsrapporten fra SEAPOP-programmet som startet i 2005. I 2006 kom programmets arbeid opp på nær full skala i området Lofoten-Barentshavet, men det er tilrettelagt for implementering på nasjonalt nivå i løpet av få år. Rapporten er inndelt i tre hovedseksjoner. Den første gir et mer detaljert sammendrag (Executive summary), den neste presenterer fem utvalgte høydepunkter fra undersøkelsene i 2006, mens den siste omfatter rapporter fra hvert av de øvrige prosjektene i programmet dette året. Programmet spenner svært vidt, og med omkring 20 ulike aktiviteter gående parallelt er det ikke rom for å trekke fram enkeltresultater i denne korte oppsummeringen. Hovedinnsatsen er imidlertid rettet mot kartlegging og overvåking.

Den tyngste aktiviteten er å opparbeide lange tidsserier for antallsutvikling, reproduksjon, overlevelse og diett til et økologisk og geografisk utvalg av hekkebestander. Dataseriene blir sammenholdt og analysert i forhold til ulike miljøfaktorer for å belyse årsakene til de bestandsendringene som dokumenteres og muliggjøre pålitelige prognoser for bestandenes videre utvikling. Dette arbeidet foregår på en serie av nøkkellokaliteter fra nord til sør: Spitsbergen, Bjørnøya, Hornøya, Hjelmsøya, Grindøya, Anda og Røst. Flere tilsvarende lokaliteter vil bli opprettet lenger sør når programmet utvides til nasjonal skala. Kartleggingen av de ulike artenes utbredelse foregår både på kysten og i åpent hav. For å balansere bruken av ressurser mot minstekrav til dataenes gyldighet, dekkes områdene langs kysten etter et rullerende prinsipp hvor alle områder i løpet av ti år kartlegges én gang i hver sesong (hekke-, myte-/høst-, vinter- og vårperiode). En habitatmodell som predikerer utbredelse for kystnære sjøfugler er også utviklet. I åpent hav er hovedvekt lagt på å modellere utbredelsen til ulike årstider basert på analyser av data som avdekker viktige sammenhenger mellom ulike sjøfuglforekomster, oseanografiske faktorer og fordeling av ulike byttedyr. Disse dataene er innsamlet i et tverrfaglig samarbeid med Havforskningsinstituttets økosystemtokt.

SEAPOP søker hele veien å utnytte teknologiske fremskritt til å utvikle mer rasjonelle metoder for innsamling av data. Programmet utvikler også et eget nettsted (www.seapop.no) hvor avanserte, datatekniske løsninger blir tatt i bruk for å kommunisere resultatene til ulike brukergrupper.

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Contents

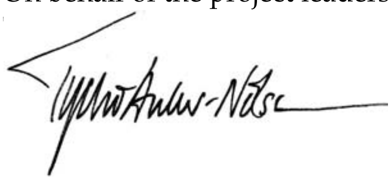
Foreword

This is the second annual report of the SEAPOP programme, which aims to coordinate the monitoring, mapping and research activities required to cover the main information needs for the future management of Norwegian seabird populations. The programme took an important step forward in 2006 with an increase in activity to the near full scale level in the Lofoten and Barents Sea area. Again this was a result of the combined forces of management authorities, the oil industry and the main scientific institutions involved in the long-term seabird research in Norway. The results emerging from these studies already contribute significantly to our understanding of seabird distribution and dynamics in this globally important seabird area, and to how these seabirds can provide useful information for the functioning of the marine ecosystems they belong to. We sincerely hope this report shows that the programme is on the right track towards the national programme it is designed to be in the near future. The concept of joining forces to fill the most urgent gaps in knowledge needed for a sustainable management of seabirds and their environment is cost-efficient, and even though it is a labour intensive and long-running task to accomplish the main goals of the programme, our simple ”slogan“ sums up what it all comes down to:

A special thank goes to the three main sponsors of the programme in its second year, the Ministry of Environment (MD), the Ministry of Petroleum and Energy (OED) and the Norwegian Oil Industry Association (OLF). The programme's steering committee was recently reappointed by MD for a four-year period and we thank its members for their contribution. The committee is chaired by the Directorate for Nature Management (DN) and had in 2006 representatives from OLF, the Norwegian Petroleum Directorate (OD), the Norwegian Coastal Administration (Kystverket) and the Norwegian Maritime Directorate (SDIR). In addition, NINA and NP were represented as observers and advisers for the group. We also thank Kystverket for kindly allowing us to use the lighthouse facilities on Anda and Hornøya as field stations, and the Norwegian Coast Guard for transporting the field crew safely and comfortably to Bjørnøya, and for letting us use their ships as observation platforms. Valuable cruise assistance was also generously provided in Finnmark by the Norwegian Nature Inspectorate (SNO). As always, the Institute of Marine Research (IMR) was an excellent partner and their vessels again served as ideal platforms for the ecosystem surveys. Thanks are, of course, also due to many of our colleagues and all the field workers that helped us carry out the great variety of studies included in the programme in 2006.

An important premise for implementing the SEAPOP concept is that all relevant long-term monitoring activities formerly established and run by the executive scientific institutions continue with their traditional funding. Thus, our sincere thanks also go to all of those too numerous to mention by name who have been involved in this extensive long-term work.

On behalf of the project leaders



Tycho Anker-Nilssen
SEAPOP coordinator

1 Executive summary

An important milestone in the short history of SEAPOP was reached in 2006 when the programme was run at a near full-scale level in the Lofoten-Barents Sea area. Six key-sites, one of which is divided among three localities, are now fully operational between Spitsbergen in the north and Røst in the south, and huge amounts of breeding data are being collected annually. Important in SEAPOP is the use of standardized methods which will allow direct comparisons to be made between sites as well as across national borders. As a follow-up to these key-sites, an extensive monitoring of black-legged kittiwakes was initiated in 2006 with counts made in more than 100 colonies in order to get a better understanding of how variability in the Barents Sea ecosystem affects the populations at various spatial scales. Numbers of seabirds which spend the winter in Norway are also monitored by SEAPOP, and the number of sites at which counts are made along the coast between Lofoten and Varanger was increased from three to seven. As a result, this monitoring now is up to a scientifically acceptable level.

High on the list of priorities is the continuation of the mapping of breeding seabirds. In 2006, the first detailed survey since the 1980s of the huge numbers of seabirds breeding on Bjørnøya (Bear Island) was completed, and the comprehensive survey of seabirds breeding along the mainland coast of the Barents Sea was continued by covering East Finnmark. The largest colonies in North Norway were excluded in the latter survey, but will be visited in 2007 when counts will be made using standardized methods described in a census handbook to be completed before the field season.

Further offshore, data concerning the distribution of seabirds at sea were collected during a series of ecosystem ship surveys covering large areas of the western Barents Sea and northeastern Norwegian Sea during which nearly 30 species were observed and counted. Based on a synoptic collection of other biological and oceanographic parameters, the results of these surveys help explain and, more importantly, enable the prediction of how the distribution of seabirds may be affected by natural and man-induced changes in the marine environment.

1.1 Selected highlights (Section 2)

Huge amounts of data have been collected both prior to and during the SEAPOP programme, and much of 2006 was spent analysing various aspects of the results. For example, numbers of common guillemots breeding in Norway have declined severely in some colonies and a theoretical model was developed to predict the chances of one or more of the colonies becoming extinct in the near future (**Chapter 2.1**). At the same time, the same model highlighted important caveats in our present knowledge, and will help guide us in our future efforts in the field. It shows, for example, that it is essential to know the rates of immigration and emigration of birds to and from a colony before one can establish how long that colony is viable. Similarly, the results of an analysis of Atlantic puffin population data from a number of colonies over the years stress the importance of collecting synoptic data concerning a variety of breeding parameters, including food choice, breeding success and adult survival, to be able to explain the population changes that are observed (**Chapter 2.2**).

Addressing seabird distribution data collected at sea, another type of modelling carried out in SEAPOP has provided us with powerful tools with which we can predict the spatial distribution of different groups of seabirds at a given time, both far offshore and along the coast, on the basis of environmental parameters. For example, many auks which dive for their food are found relatively close to the shore throughout most of the year, while two other auks, the Brünnich's guillemot and Atlantic puffin, and pelagic surface-feeding species like the black-legged kittiwake and northern fulmar roam further offshore but in areas that become more restricted as winter approaches (**Chapter 2.3**). However, the distribution of the latter group within these areas is much dependent on the unpredictable aggregations of prey resulting in small clusters of many birds distributed more or less randomly within their habitat. Closer ashore, along the coast, analyses relating seabird distribution with factors such as water depth, length of coastline and fisheries activity are still in progress, but already show some promise in being able to predict seabird distribution (**Chapter 2.4**). When linked to e.g. models of oil drift, these models will provide valuable input in environmental risk assessments.

In these days of advancing technology, SEAPOP is also experimenting with an automation of monitoring seabird numbers and breeding success in a colony, and results from time-lapse photography of Brünnich's and common guillemot breeding sites on Spitsbergen and Bjørnøya and of a black guillemot roosting site at Røst are encouraging (**Chapter 2.5**). Future use of such cameras will possibly enable us to carry out an effective and efficient monitoring of colonies interspersed between the key-sites, as well as of specific parameters within the same key-sites.

1.2 Monitoring at key-sites (Chapter 3.1)

At the six major key-sites (Spitsbergen, Bjørnøya, Hornøya, Hjelmsøya, Anda and Røst), annual counts were made of numbers of many different species breeding at each site, and a long series of breeding parameters such as adult survival, chick food, chick growth and breeding success (**Table 3.1.1**) were documented. On Spitsbergen, where SEAPOP has only been operative since 2005, there was little change in numbers of black-legged kittiwakes and Brünnich's guillemots (**Chapter 3.1.1**), while at Bjørnøya the guillemot populations continued to increase and that of black-legged kittiwakes to decrease (**Chapter 3.1.2**). There is still a lot of concern about the high levels of organic contaminants found in the glaucous gulls breeding on Bjørnøya.

At Hornøya, a large decline in black-legged kittiwakes since 2005 was recorded and their breeding success was low (**Chapter 3.1.3**). The common guillemot population continued its recovery since 1987, but the numbers of Atlantic puffins apparently declined, but this may have been a result of the counting conditions. The breeding success of all auks was considered to be good, with capelin, sandeels and herring constituting the main chick diets. New demographic studies of herring and great black-backed gulls were initiated in 2006.

At Hjelmsøya (**Chapter 3.1.4**), there was a near complete breeding failure among the Atlantic puffins due to predation by mink, but that of black-legged kittiwakes was also very poor with most chicks dying soon after hatching. Numbers of kittiwakes breeding in the colony continued to drop, while those of common guillemots showed a very slight recovery since 2005. Their numbers are, however, still critically low.

Anda (**Chapter 3.1.6**) is the newest of the key-sites on the mainland, and 2006 was only the second year of SEAPOP fieldwork. Counts suggest that both the black-legged kittiwake and the Atlantic puffin populations have been relatively stable, and their breeding successes were both high. Sandeels, herring and gadoids made up most of the chick diet of both species.

The most extensive monitoring work was carried out at Røst where 14 species were targeted in one way or another (**Chapter 3.1.7**). 2006 was a positive year for most populations with only the northern fulmar showing signs of a decline since 2005. The Atlantic puffins increased in numbers for the fourth year in a row and their breeding season was successful with herring and sandeels making up the bulk of the chick diet resulting in a high fledging success. The kittiwake population increased slightly, but their breeding success in the main cliff was greatly impaired (about halved) by the disturbance and predation of young by white-tailed eagles.

At Grindøya, an additional key-site restricted to the studies of common eiders only (**Chapter 3.1.5**), numbers and survival of females eiders breeding on the island have dropped in recent years, possibly due to predation by mink, a factor which may cause the abandonment of the island in the next few years.

1.3 Other project reports (Chapters 3.2-3.7)

One important assumption made in the selection of the SEAPOP key-sites is that they are representative of the region in which they are sited. This is now being tested using an extensive monitoring scheme for one of the key species, the black-legged kittiwake (**Chapter 3.2**). More than 100 colonies have been selected between Lofoten and East Finnmark, and their size, timing of breeding and breeding success will be followed in the years to come. This data will be an important supplement to the key-site data, and will greatly add to our knowledge concerning the population dynamics of this species in the region.

The expansion of the monitoring programme for seabirds wintering in North Norway from four to seven sites was successful and will give a much better basis for future trend analyses (**Chapter 3.3**). In 2006, nearly 28,000 individuals of 30 species were observed with the three eider species and large gulls dominating the counts.

The complete survey of seabirds breeding on Bjørnøya in 2006 (**Chapter 3.4.1**) showed that the populations of northern fulmar, black-legged kittiwake and Brünnich's guillemot had increased since 1986/87, while that of the glaucous gull had declined by 65%. The common guillemot population was still less than 50% of that counted prior to the collapse in 1986/87. On the mainland coast, detailed mapping was carried out in East Finnmark between Laksefjord and the Russian border (**Chapter 3.4.2**). Nearly half a million birds were recorded spread among 7500 sites with black-legged kittiwakes (> 100,000 pairs), common eiders (17,765 males) and herring gulls (30,517 pairs) being the most common species.

Equally impressive figures were reached during the three marine ecosystem surveys at sea during which seabirds were counted over more than 13,000 km of transects equivalent to nearly 4000 km^2 of open ocean (**Chapter 3.6**). Twenty-five species were observed with northern fulmars being by far the most common reaching densities of 32 birds per km^2 in the autumn. As yet, the data series are too short to make clear inferences, but the design and continuity of the surveys will enable us in future to generate predictive models of the distribution of seabirds at sea at any given time of year.

In 2006, the SEAPOP web-page (www.seapop.no) was launched (**Chapter 3.7.1**) and all data and information generated by the programme (and associated projects), including this report, will be presented to the partners involved in the programme and to the general public. Specific needs for downloadable maps and tables were identified in 2006, and three levels of application were developed for data access (**Chapter 3.7.2**). This was another important milestone for SEAPOP and it is hoped that the web will be frequently accessed.

2 Selected highlights

This section presents a selection of highlights from some of the studies in 2006. This includes reports from projects that were finalised, as well as from monitoring activities that are planned to run for many years.

2.1 Extinction risks in common guillemots: *the influence of dispersal and environmental covariance*

Kjell Einar Erikstad, Tone Kristin Reiertsen, Tycho Anker-Nilssen, Rob Barrett, Svein-Håkon Lorentsen, Hallvard Strøm & Geir Helge Systad

The breeding population of common guillemots in Norway has declined dramatically over the last 5-6 decades and some colonies are now close to extinction. In this study we used a multi-site population viability analyses (PVA) to examine the effect of dispersal (exchange of birds between colonies) on the fate of populations. Even when populations are strongly declining, such dispersal may greatly enhance the population viability. However such an effect depends to a large extent on the rate of covariance in the growth rates among colonies.

Figure 2.1.1
Common guillemots are very dependent on schooling fish like capelin, sandeel and herring. (©Tone Kristin Reiertsen)

All animal populations vary in size as a result of variation in reproduction, survival, immigration and emigration. In seabirds, immigration and emigration (hereafter called dispersal) are not well quantified, but may contribute to spatial-temporal variation in population sizes. Such dispersal is therefore fundamentally important to consider in studies which have conservation and management implications (e.g. Nichols et al. 2000). Temporal variation in dispersal among breeding sites may also be a major destabilizing event in monogamous long-lived species (Clobert et al. 2001).

In this study, we have used a "multi-site count based population viability analyses" (PVA) to explore how dispersal and environmental covariance among colonies may affect viability and extinction risk of common guillemots (*Uria aalge*) in Norway (**Figure 2.1.1**). A PVA analysis is the use of "quantitative methods to predict the likely future status of a population or a collection of populations of conservation concerns" (Morris & Doak 2002). Such analyses can be used on monitoring data to quantify the risk of extinction of one or several populations and thus help management authorities to determine which populations need protection.

The breeding population of common guillemots in Norway has declined dramatically over the last 5-6 decades (Lorentsen 2006). The causes of this decline are unclear, but factors such as hunting, egging, climate change, over-fishing of important prey species, oil pollution and drowning in fishing gear have all been implicated (Barrett et al. *in press*).

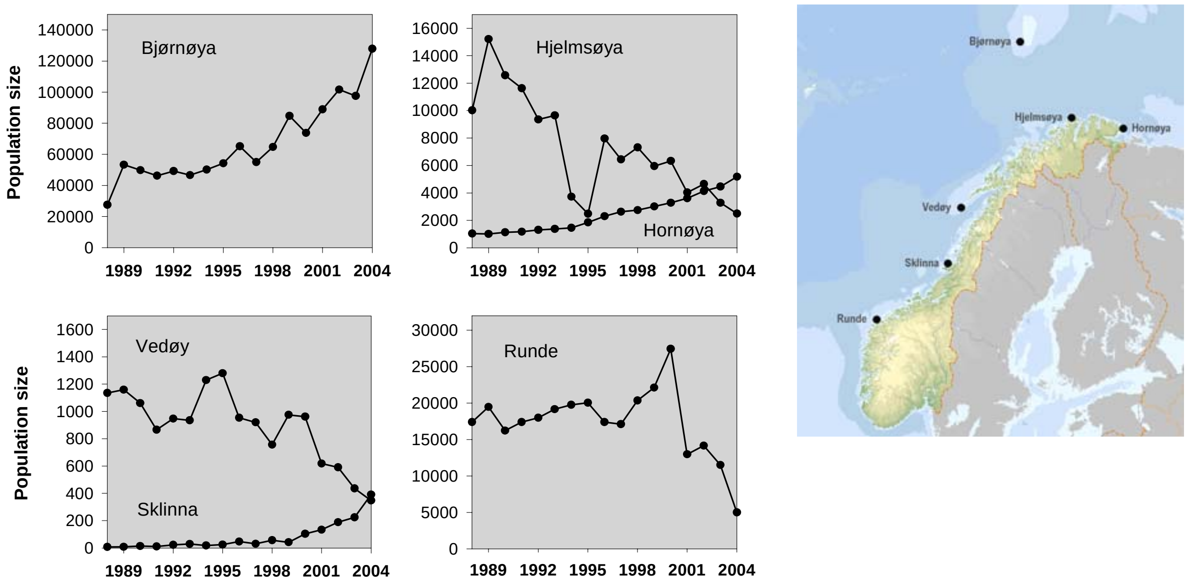


Figure 2.1.2
The geographical location and population development (number of individuals at the breeding site) in 1988-2004 of the six Norwegian common guillemot colonies where populations are monitored.

Six colonies along the Norwegian coast and on Bjørnøya (**Figure 2.1.2**) have been monitored since 1988, such that parallel population data are available. At three colonies (Hjelmsøya, Vedøya and Runde) numbers have declined rapidly whereas at the other three (Bjørnøya, Hornøya and Sklinna) they have increased (**Figure 2.1.2**). The aim of this study was not to quantify the viability of the total common guillemot population, but instead to focus on how dispersal and environmental covariance among colonies may influence the probability of extinction. As an example, we have here simulated the three declining colonies Hjelmsøy, Vedøy and Runde. Using a "patch based" PVA analyse (which ignores emigration or immigration) we find that the viability of the three declining colonies is low and especially Vedøy is threatened, with a risk of 93% of going extinct within 50 years. For Hjelmsøya and Runde the corresponding figures are 27% and 41% (**Table 2.1.2**).

Table 2.1.2 *Mean log population growth rates (μ), the variance in growth rate (σ^2) and the risk of quasi-extinction after 50 years (p) for three populations of common guillemots. Probability of extinction is estimated for each colony assuming no dispersal and no environmental covariance. (Data from Erikstad et al. 2007).*

Colony	Number of pairs in 2004	μ	σ^2	p
Hjelmsøya	3100	– 0.064	0.062	0.27
Vedøy	140	– 0.071	0.065	0.93
Runde	3000	– 0.073	0.085	0.41

2.1.1 Environmental covariance

The mathematical models used are too tedious to go into here, but to examine the covariance in environmental conditions at different colonies we estimated the correlation between the annual growth rates (**Figure 2.1.3**) between each pair of populations. There is a strong positive correlation between the growth rates at Runde and Vedøy (r=0.60, p=0.01), while the growth rate at Vedøy was negatively correlated to that at Hjelmsøya (r=–0.31) although not significantly so. The growth rate at Runde was only weakly correlated to that at Hjelmsøya (r=0.19). Why the growth rates at Hjelmsøya deviated so much from the other colonies in 1993 and 1995 (**Figure 2.1.3**) is difficult to explain. For none of the colonies was there any trend in the growth rates over the years (p>0.3). To simulate the effect of covariance in growth rates among colonies on the probability of extinction we used both negative and positive values (see below).

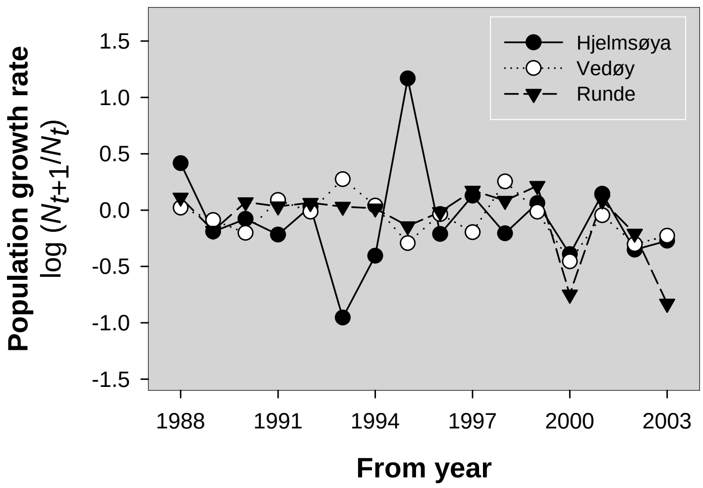


Figure 2.1.3
The yearly variation in population growth rates for three colonies of common guillemots in 1988-2004.

2.1.2 Effect of dispersal and environmental covariance on population growth rate and extinction probability

The variation in probability of extinction of a colony when simulating the effect of dispersal and covariance in growth rates among colonies is shown in **Figure 2.1.4**. When there is a positive covariance in growth rates (**Figure 2.1.4a**), dispersal among colonies has little effect and the populations rapidly go extinct. However when there is no covariance among colonies in the growth rates (**Figure 2.1.4b**), dispersal reduces the risk of extinction and when there is negative covariance in growth rate among colonies (**Figure 2.1.4c**), dispersal reduces the extinction risk even more. This is because any move by a bird to a colony with a higher growth rate will always enhance the overall viability. For instance, the probability of the three colonies reaching extinction is 72% after 100 years with no dispersal and a positive covariance in growth rates whereas the corresponding figure is only 22% when there is a negative covariance and a 5% dispersal (**Figure 2.1.4**).

Knowing the rate of dispersal of individuals and the scale of environmental covariance is critical for quantifying the viability of guillemot populations. Whereas measuring covariance in growth rates is straight forward, measuring the rate of dispersal is difficult. There are a few observations of marked, immature guillemots that have moved to a non-natal colony, but an overall quantification of such movements of individuals among colonies is extremely difficult. The simplest method is to mark a large number of birds and later look for them in other colonies but, for seabirds, this is very time-consuming.

Another, but indirect method to estimate dispersal is by using genetic data. Studies on common guillemots have shown weak genetic structure among colonies even at large scales (Moum et al. 1991, Riffaut et al. 2005). This suggests that gene flow is high and that dispersal is a common phenomenon. However, mechanisms of population differentiation among seabird species are poorly understood, and are likely to involve a complex interplay of isolation by

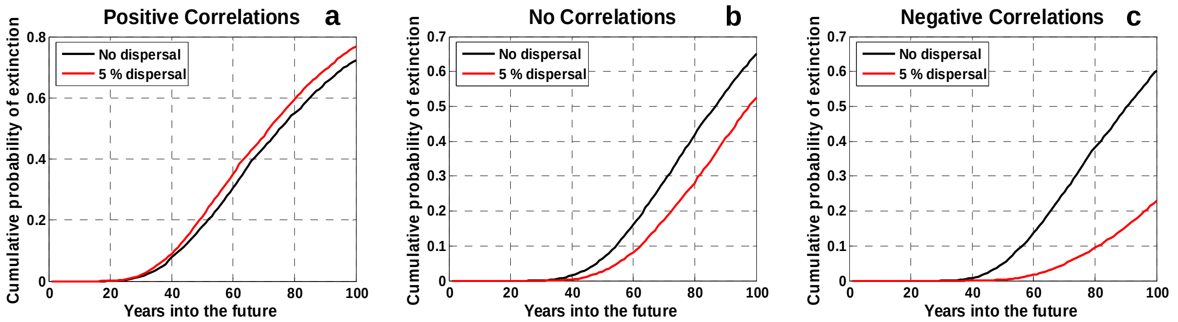


Figure 2.1.4
*Cumulative distribution functions for count-based simulations (5000 trajectories in each run) of extinction time for three colonies of common guillemot. We simulated the time to quasi-extinction (lower threshold of 30 pairs) with no dispersal and 5% dispersal among colonies when **a**) the growth rates are strongly positive (r=0.8), **b**) there is no correlation in growth rates among different colonies, and **c**) the growth rates are strongly negative (r=–0.8).*

distance and geographic barriers, selection of habitat, and genetic drift. The population genetic structure of species can, however, be an important conservation tool indicating the potential for genetic loss when single populations go extinct and also the capacity for re-colonisation.

2.2 Contrasting trends across colonies: the puffin as an example

Svein-Håkon Lorentsen, Tycho Anker-Nilssen, Robert T. Barrett & Kjell Einar Erikstad

A key question in all monitoring is whether the parameters selected are representative for the parts of the environment they are intended to describe the status of. In the mainland part of Lofoten-Barents Sea area, the Atlantic puffin is a dominant species in the seabird community representing nearly 65% of all breeding seabirds, 97% of all seabirds belonging to the ecological group of pelagic diving birds (Barrett et al. *in press*), and 54% of the seabird biomass. Thus, puffins represent a key-element in the ecosystem and may qualify as a valuable indicator species.

Monitoring programmes suffer typically from limited funds, so all activities should be carefully evaluated. A question that is often asked is how many colonies need to be monitored in order to gain a representative picture for the situation for the species in a given geographical area? Furthermore, what additional parameters should one monitor to be able to describe the causes of any population trends found?

In the national monitoring programme for seabirds (Lorentsen 2006) and SEAPOP (Anker-Nilssen et al. 2005), numbers of Atlantic puffin (*Fratercula arctica*) breeding in four colonies are monitored in the Lofoten-Barents Sea area; Røst, Anda, Gjesvær and Hornøya (see **Figure 3.1.1**). Long-term population trends have differed greatly in these four colonies (**Figure 2.2.1**). At Røst the breeding population has declined by an annual rate of -3.8% in the period 1979-2006, and the current population is only 32% of that in 1979. This is in strong contrast to Anda and Gjesvær where the populations have been stable, and Hornøya where the population has increased by an annual rate of 2.6% and hence doubled since 1980 (Lorentsen 2006).

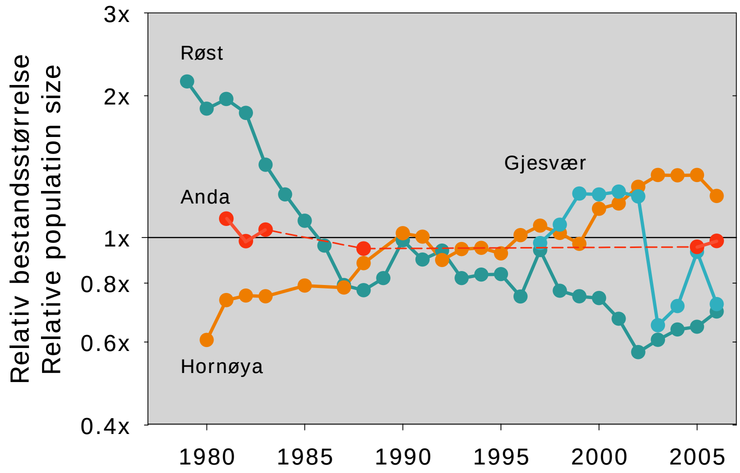


Figure 2.2.1
Development of the puffin breeding population at Røst, Anda, Gjesvær and Hornøya since 1979-81.

Hornøya and Røst, for which the long-term population trends are totally opposite, are 850 km apart and located in two quite different ecological regimes regarding fish availability, and hence, puffin chick diet. At Hornøya in the southwestern Barents Sea, adult capelin (*Mallotus villosus*) and sandeels (*Ammodytes* sp.) were long the main prey species. These two species constituted on average 72% (*SE*=5.6) of the diet in the period 1980-2000 (Barrett 2002), and their total share of the diet never fell below 46% of the diet for 16 of 17 years. In recent years, much smaller fish (0- and I-group gadoids, herring and sandeels) have made up increasing proportions of the diet, but there is not yet evidence of any changes in breeding success. At Røst in the northeastern Norwegian Sea, first-year (0-group) herring (*Clupea harengus*) is the most important prey item, constituting on average 42% by mass of the diet (*SE*=4.7) in the period 1979-2005 (Anker-Nilssen & Aarvak 2006). Sandeels also constituted an important part of the diet at Røst, with an average of 14% (*SE*=3.1) in the same period and, thus, the total share of these two species in the diet was on average 56%. At Røst there is a significant and positive correlation between the amount of herring in the diet and chick fledging success (Anker-Nilssen & Aarvak 2006).

The newly-established key-site at Anda is situated only 220 km NW of Røst so the stable population trend here, compared to the negative one at Røst, is striking. Food samples collected in 1981-1983 and 2005-2006 suggest that herring and sandeels are equally important in the chick diet, and constituted, on average 82% (SE 4.3) of the diet. This might indicate that, for the puffins at Anda, sandeels represent a more stable source of food than for those at Røst, with herring as an easy prey when it is available (**Figure 2.2.2**).

For puffin chicks to fledge successfully, a stable source of food is necessary throughout the nest period. Long-term studies at Røst have demonstrated the chicks' unique dependence on herring larvae for successful fledging and strongly suggest the collapse of the Norwegian spring-spawning herring population in the late 1960s was the most important cause of the decline in breeding numbers here (e.g. Anker-Nilssen 1992, Durant et al. 2003, Anker-Nilssen & Aarvak 2006). The turning point came with the remarkably strong herring year-class of 1983, which started the recovery of the herring stock (e.g. Holst 2005) and the improvement of breeding conditions for puffins at Røst. Although many more seasons with failing reproduction for both species have inflicted puffin numbers at Røst to drop further, there are now signs of a recovery for this impoverished seabird population (**Figure 2.2.1**).

The stable puffin population at Anda suggests that sandeels may be a staple source of food and any dependence on herring will be monitored carefully in the coming years in SEAPOP. At

Hornøya large capelin and sandeels were a staple diet, probably contributing significantly to the doubling of the breeding population in two decades, but there are now signs of deterioration in food supply and breeding conditions.

The results from these key-site studies raise at least two important considerations. First, global warming and increasing sea temperatures will affect the most important fish species taken by seabirds differently. As recruitment in sandeels and capelin will decline with increasing sea temperatures and that in herring increase (Toresen & Østvedt 2000, Arnott & Ruxton 2002, Sætre et al. 2002, Hjermann et al. 2004), increasing sea temperatures may influence the Røst population positively, and the Hornøya population negatively. However, even though adult survival in these colonies do indeed respond correspondingly and differently to sea temperature variations, no important difference in survival rates was found that could explain their very opposite population trends (Harris et al. 2005). The projected trajectory for the Anda population will probably depend on how much the herring population will profit from increased sea temperatures, compared with the expected decrease in the sandeel population.

The other important consideration regards the minimum number of colonies needed to give a representative picture for the species monitored within a given geographical area. In the present study it is easy to see that if only one puffin colony had been monitored in the Barents Sea, the picture of what was going on in the marine ecosystem would have been unbalanced. Even with two colonies (e.g. Røst and Hornøya) the picture would have been far from complete. Currently, four puffin colonies are being monitored in the area and this is considered a minimum, as demonstrated by the different trends found at Røst and Anda which are only 220 km apart.

This study demonstrates clearly that monitoring population trends only is like monitoring a patient's temperature, without knowing anything about the cause, and thus potential treatment of any rise or fall. If the puffin populations breeding in Barents Sea are the patients, knowledge of e.g. their food choice, reproductive performance and adult survival is necessary to be able to diagnose the causes of any changes, and, hence, propose a cure for those changes.

Figure 2.2.2
For the puffins at Anda herring and sandeel are a staple source of food. This bird has caught both species as food for its chicks. (© Svein-Håkon Lorentsen)

2.3 The distribution of seabirds at sea

Per Fauchald & Torkild Tveraa

In the marine pelagic ecosystem, environmental variables such as sea temperature, salinity and water depth, distinguish areas with different productivity and species composition. Such environmental variables might therefore be used to describe the habitats of seabirds. By analysing the relationship between the distribution of seabirds and environmental variables in sampled areas, we were able to characterise seasonal and species-specific habitats and thereby predict the spatial distribution of different seabird species throughout the Barents and Norwegian Seas.

2.3.1 Habitats of seabirds at sea

In this project, we have analysed data and developed models by which to predict the distribution of pelagic seabirds at sea. Different seabird species are adapted to utilise different parts of the marine ecosystem. Some species travel over large areas in search of highly dispersed and patchy prey while other species are found in more limited areas with distinct environmental characteristics. Some species depend on seasonal resources and are therefore found in different areas in different seasons while other species stay in the same area year-round.

Data on seabirds at sea were gathered from ship-based transect surveys, mostly during multi-discipline research cruises conducted by the Institute of Marine Research, Bergen. Usually, an extensive set of ecosystem components are monitored on these surveys including seabirds and sea mammals, pelagic and benthic fish, zooplankton and oceanography. The SEAPOP database from the Barents and Norwegian Seas (north of 61°N) includes data from 1983 to present and covers a total cruise length of 101,122 km. In SEAPOP, these data are updated continuously and 13,134 km of transects were added to the database in 2006.

Analyses were done for the nine most common seabird species in the Barents and Norwegian Seas. These species accounted for 93% of all observations and were northern fulmar (*Fulmarus glacialis*), herring gull (*Larus argentatus*), glaucous gull (*L. hyperboreus*), black-backed gull (*L. marinus*), black-legged kittiwake (*Rissa tridactyla*), common guillemot, Brünnich’s guillemot (*Uria lomvia*), little auk (*Alle alle*) and Atlantic puffin. Depending on data coverage and known seasonal cycles, we performed separate analyses on data from winter (1 Nov – 31 March), summer (1 April – 31 July) and autumn (1 Aug – 31 Oct).

Environmental variables used in the analyses included salinity, temperature, stratification of the water column and depth. We used salinity and temperature from the surface and at 100 m depth. Stratification was measured as the difference in temperature and salinity between the surface and 100 m. Data on salinity and temperature was obtained from the ICES CTD database (www.ices.dk). Depth was taken from a global terrain model developed by the National Geophysical Data Center (www.ngdc.noaa.gov/mgg/global).

For each observation in the seabird data, we found the corresponding set of environmental data. The relationship between the presence/absence of the different seabird species and the marine environment was analysed in generalised additive models. Since the marine environment was known, we used the results from the analyses to predict the distribution of the different species in the entire study area.

Pelagic diving species
(**Figure 2.3.1**)

Common and Brünnich's guillemots, little auks and Atlantic puffins are pelagic diving auks. These species are excellent divers and actively hunt for prey underwater among shoals of small fish and crustaceans. They have a compact body and relatively short wings and flying is consequently energetically expensive. In summer, these species are accordingly found close to the major breeding colonies. Puffins are mainly found in large numbers along the coast of mainland Norway, common guillemots along the mainland coast and around Bear Island and Brünnich's guillemots and little auks in the high arctic.

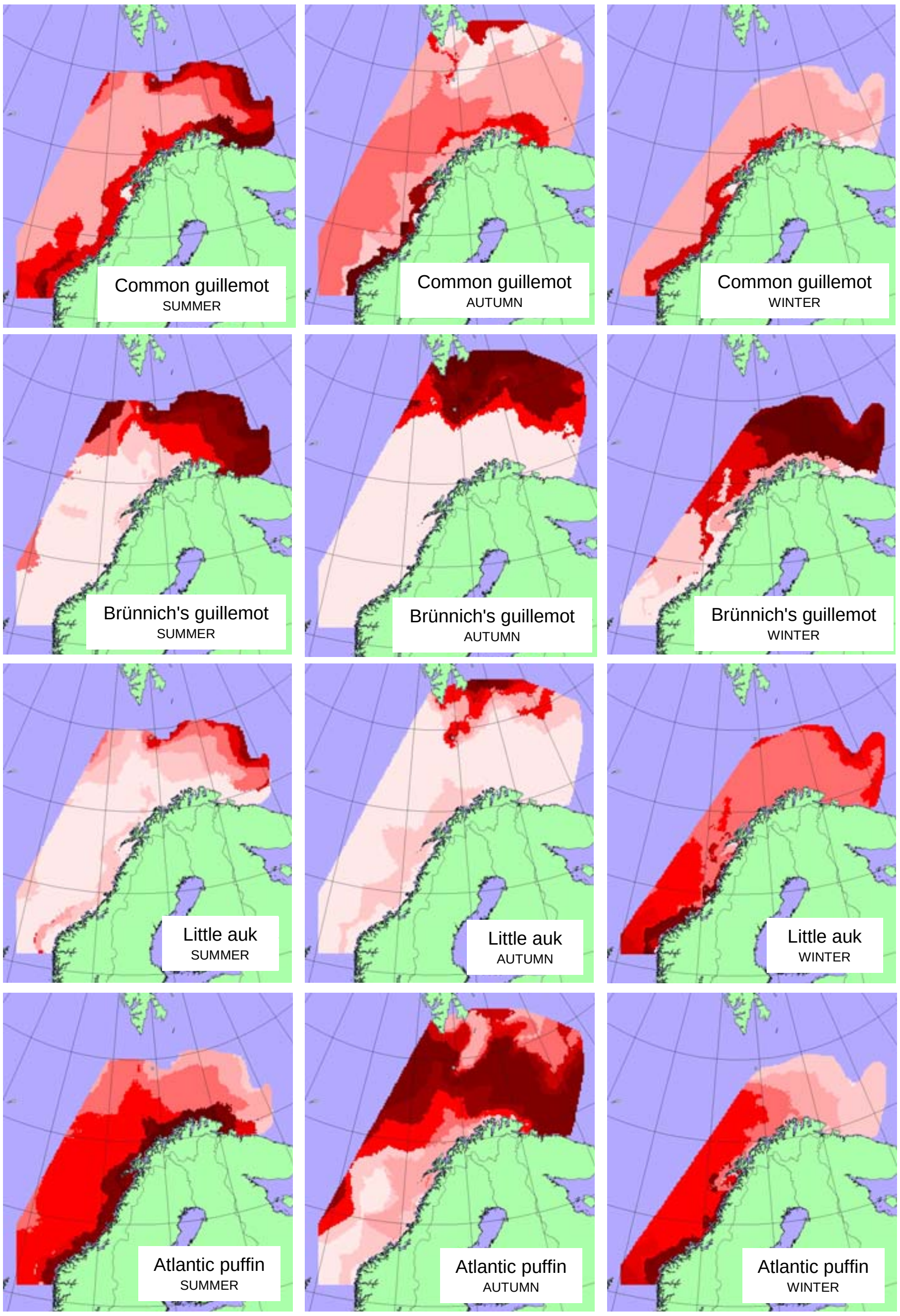


Figure 2.3.1
Habitats of pelagic diving seabirds in the Barents and Norwegian Seas.

Juvenile fish that drift with the Norwegian coastal current into the Barents Sea in summer are important prey for Atlantic puffins at the large breeding colonies along the coast. After breeding, puffins seem to follow the juvenile fish into the Barents Sea and, in autumn, they are mainly found in the southern and central Barents Sea. In the same period, little auks are found in the northern part of the Barents Sea, close to the ice where they forage on the bloom of krill and amphipods. Brünnich's guillemots are found in the northern part of the Barents Sea where they possibly track the feeding migration of capelin (*Mallotus villosus*). Common guillemots are found along the Norwegian coast but some concentrations are also found far north in the Barents Sea.

By winter, puffins and little auks have migrated southward, out of the Barents Sea, and the highest concentrations of these species that still remain in the study area are found along the Norwegian coast south of the Lofoten Islands. Common guillemots are also mainly found along the Norwegian coast, while Brünnich's guillemots that do not migrate out of the study area largely stay in the ice free part of the Barents Sea during winter, where they forage on capelin and possibly also herring.

Pelagic surface-feeding species
(**Figure 2.3.2**)

Kittiwakes and northern fulmars are pelagic surface-feeding species found in relatively high numbers throughout the study area with only small geographical and seasonal differences in distribution. These species can only utilize the upper couple of meters of the water column but they are excellent flyers and roam over large areas in the search for sparsely distributed patches of food. They often follow ships and forage on discards from the fishing fleet. For that reason the abundance of these species is probably over-estimated.

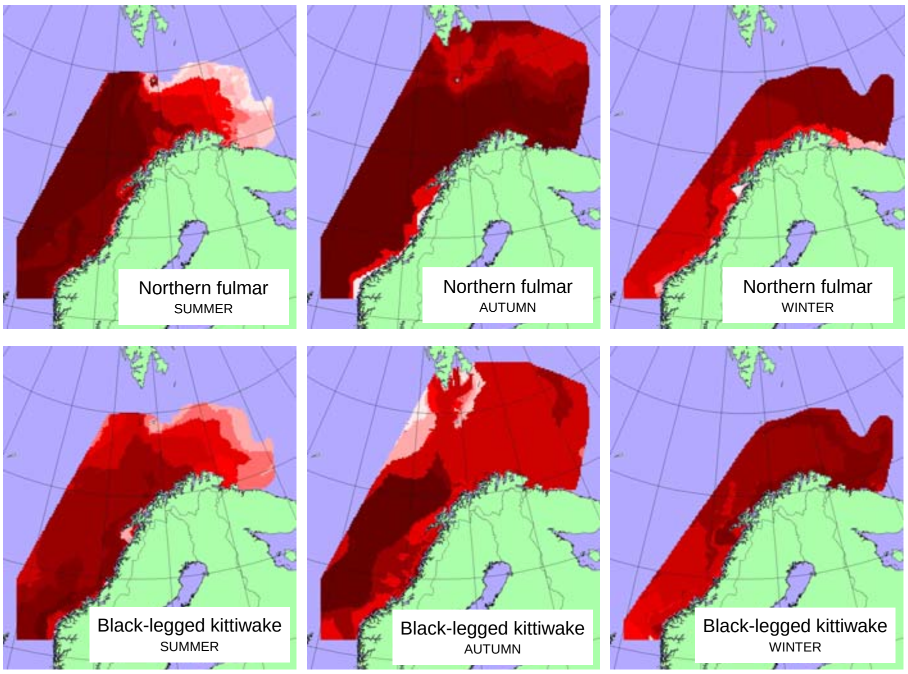


Figure 2.3.2
Habitats of pelagic surface-feeding seabirds in the Barents and Norwegian Seas.

Coastal surface-feeding species
(**Figure 2.3.3**)

The large gulls, herring gull and great black-backed gull (*Larus marinus*), are coastal surface-feeding species. They are opportunistic with a varied diet and are mainly found along the Norwegian coast all year round. The glaucous gull is a large arctic gull. This species is more pelagic, with the highest concentrations in the Barents Sea.

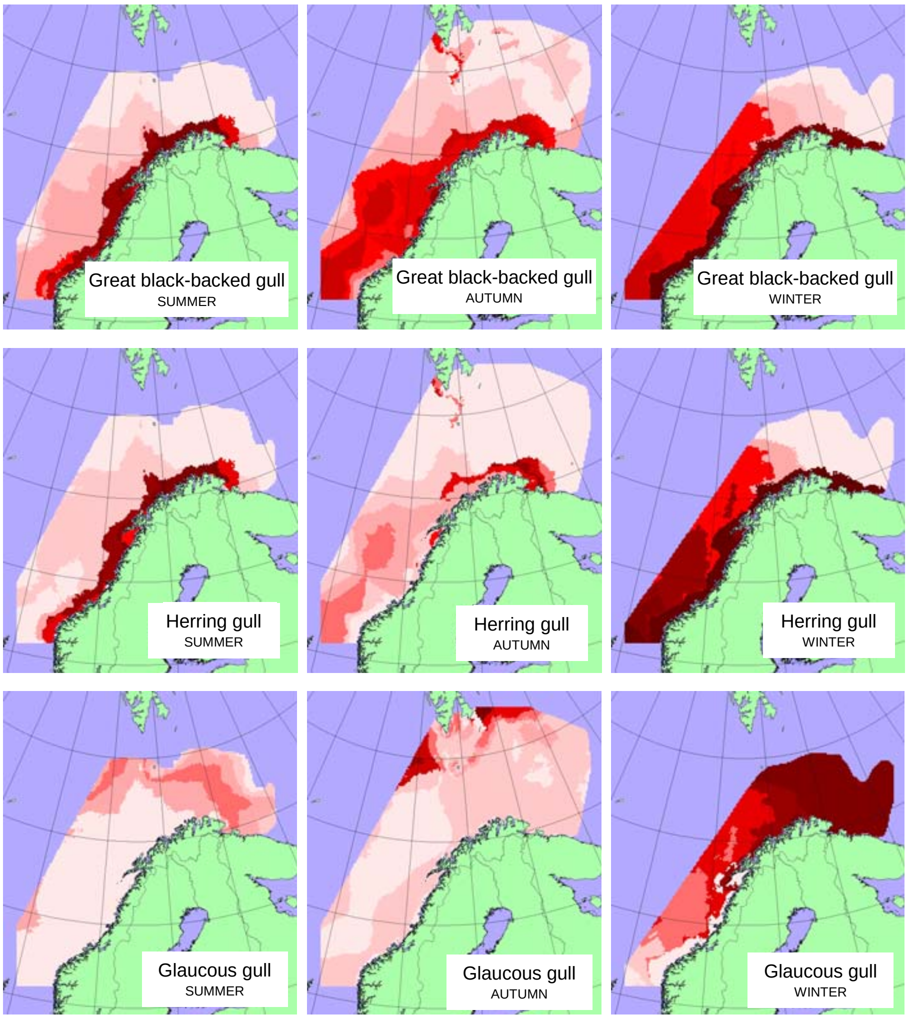


***Figure** 2.3.3*
Habitats of coastal, surface-feeding seabird species in the Barents and Norwegian Seas.

2.3.2 Modelling scenarios of seabird distribution

Pelagic schooling fish and euphausiids (krill) are the major prey for seabirds at sea. This type of prey has typically a highly patchy and short-lived spatial distribution. Moreover, the abundance of krill and schooling fish may fluctuate markedly from year to year. The biomass of capelin in the Barents Sea has, for example, fluctuated between millions of tonnes to only a few hundred thousand tonnes within a few years. From time to time, seabirds that depend on capelin as the primary food source will have to search for food in other places and, consequently, the number of seabirds inhabiting the Barents Sea fluctuates markedly between years. On a large scale, the spatial distribution of food is more or less predictable through their known feeding and spawning migrations, vertical migrations and drift along the major currents. Such large-scale patterns are among the mechanisms explaining the habitat analyses above. On a smaller scale, krill and pelagic fish aggregate in short-lived and unpredictable swarms and schools. Seabirds aggregate on these patches and, as a consequence, one might find thousands of birds within only a few square kilometres. Such clusters of birds might be found more or less randomly within their habitat. As a result, the outcome of an area-restricted disturbance such as an oil spill will have a highly variable outcome. In most cases only a few birds will be affected while occasionally the disturbance will involve thousands of birds.

To be able to calculate the risk from area-restricted disturbances, we have developed a model that generates scenarios of the distribution of seabirds. Based on the results from the habitat analyses and analyses of spatial patch structure, the model distributes measured densities of seabird on to the study area. Three simulated scenarios of Atlantic puffin in autumn are shown in **Figure 2.3.4**. One hundred scenarios were generated for each species and season. Linked to models of oil drift, these scenarios are valuable input in environmental risk assessments because they allow for calculating the stochastic variation in the number of birds affected by a single oil spill incident.

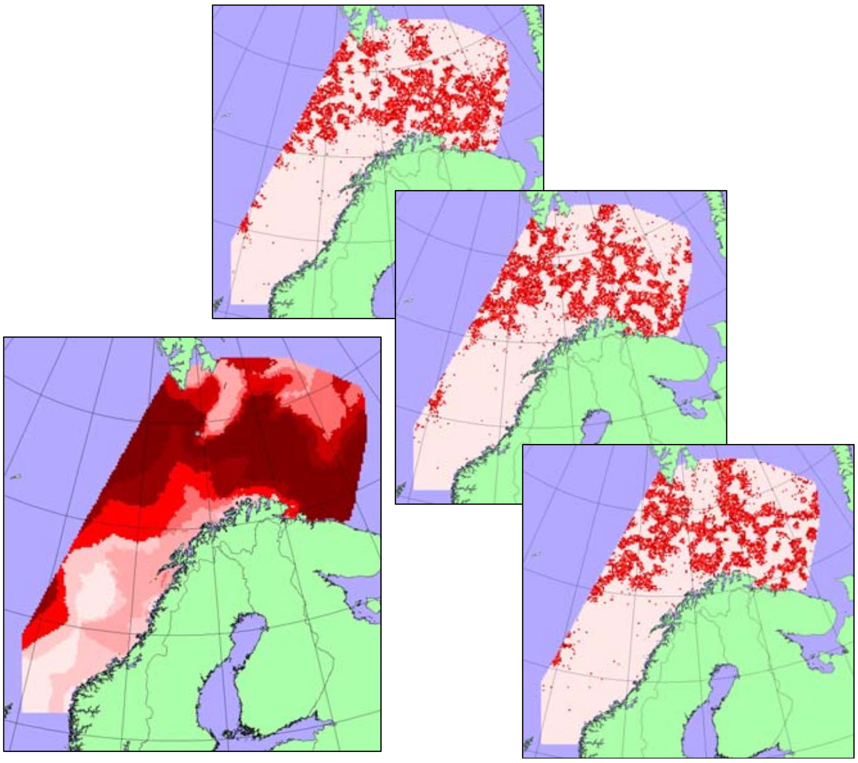


Figure 2.3.4
Results from habitat analysis (bottom left) and three simulated scenarios of the spatial distribution of Atlantic puffin in autumn (1 August – 31 October).

During the ecosystem cruises conducted by IMR, data on all major components of the marine ecosystem are collected. These include acoustic measures of major prey items for seabirds such as capelin, herring and polar cod and net tows of zooplankton. In collaboration with IMR, we are therefore in a position where we can analyse the relationship between seabirds and important prey items. Such analyses will give insight into the trophic position of seabirds in the marine ecosystem, they will improve the models of the distribution of seabirds at sea and they will improve our understanding of the interactions between fisheries and seabirds.

2.4 Methods for predicting the distribution of coastal seabirds

Geir Helge Systad & Jan Ove Bustnes

Seabirds including cormorants, black guillemot, various gulls and sea ducks such as eiders, are important components of coastal ecosystems. Several of these species are often associated with areas exploited by humans; e.g. for fish farming, fisheries and leisure, and are thus vulnerable to human induced threats throughout the year. The distributions of different species are dynamic in space and time, but birds are likely to choose feeding areas based on certain characteristics. The aim of this project was to establish what factors characterize important seabird areas, and thereby develop methods by which to predict the distribution and occurrence of non-breeding coastal seabirds on the basis of environmental parameters.

2.4.1 Data collection

The distribution and approximate numbers of coastal seabirds were mapped using aerial surveys (totalling 120 hours). The whole coast of Finnmark, apart from Varangerfjord, was counted four times from the end of September until mid May: in September-October, November-December, February to early March and from mid April to mid May. The only other exception was the area east of Nordkynn Peninsula in December, which was not surveyed due to poor weather and light conditions. During the surveys, the airplane flew at 150 m a.s.l. and 110-150 km/h. At all times, there were two observers on the plane.

2.4.2 Associations between occurrence of seabirds and environmental variables

To test the associations between environmental variables and the occurrence of coastal seabirds, the following method was used: The whole coast was divided into 10x10 km squares and each square was classified based on the following environmental variables: the amount of shallow water (**Figure 2.4.1**), the length of coastline, the complexity of the coastline, and the occurrence of human activity such as fish farming and fisheries (fish processing plants etc.). Analyses including freshwater outlets and substrate are in preparation.

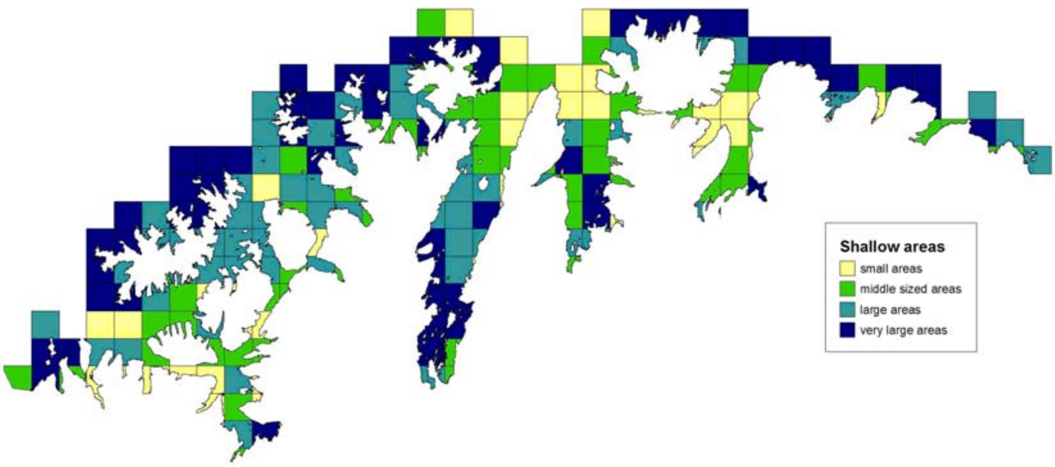


Figure 2.4.1
Shallow sea areas along the coast of Finnmark.

These variables will reflect the amount of food available to the birds in different ways. For example, the amount of shallow waters in an area (**Figure 2.4.1**) is an indication of the food availability for benthic feeding sea ducks that cannot dive very deep. Through a statistical analysis of these environmental variables and the occurrence of coastal seabirds in each square, in the different counting periods, we attempted to establish which variables were important for different coastal seabird species. If such analysis revealed strong associations between environmental variables and bird density, it would be possible to use the environmental variables to predict the probability of finding birds in a specific area.

Our analyses showed that the associations between environmental variables and seabird occurrence varied between the different periods. For example, human activity was important as a food source in mid winter, but not necessarily in spring when the birds leave for their breeding grounds.

Here we summarize a few examples of how environmental variables might predict the distribution of important species.

2.4.3 Cormorants

The environmental variables significantly related to the distribution of cormorants, i.e. great cormorant (*Phalacrocorax carbo*) and European shag (*P. aristotelis*), were coastline complexity and coastline length. The amount of shallow water was also important, especially in spring: i.e. large areas of shallow water were associated with many cormorants. If there were fish farms in an area, more cormorants were observed. This may be because fish farms attract wild fish hunted by cormorants, or because cormorants directly try to catch fish in the farms. A third explanation is that the cormorants are attracted to locations with characteristics which are also favourable for fish farming. The most important areas for cormorants in Finnmark were shallow waters in the outer coast, but our analyses also suggest that there were good habitats for cormorants in Porsangerfjord and in Laksefjord (**Figure 2.4.2**).

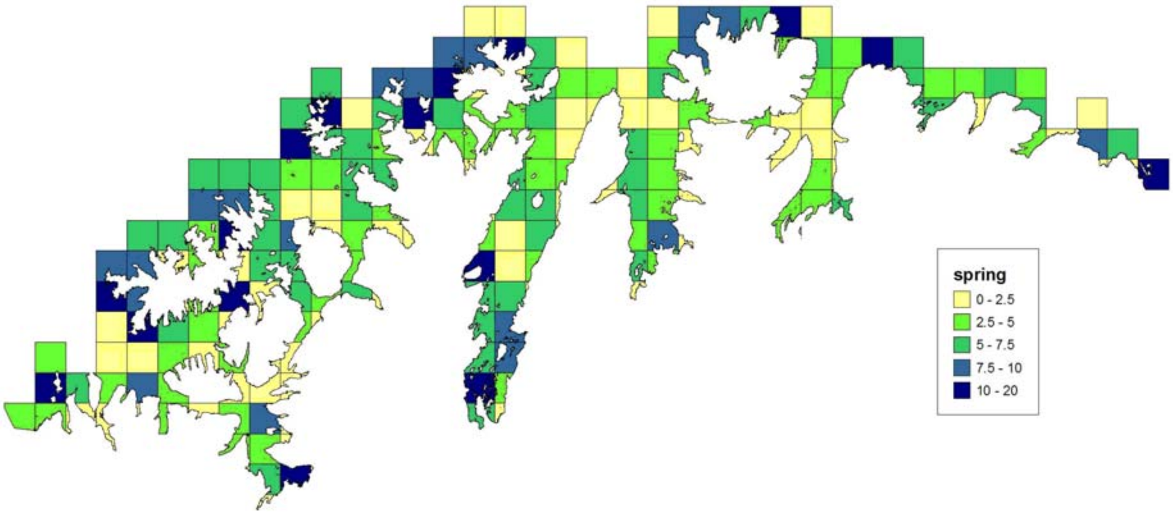
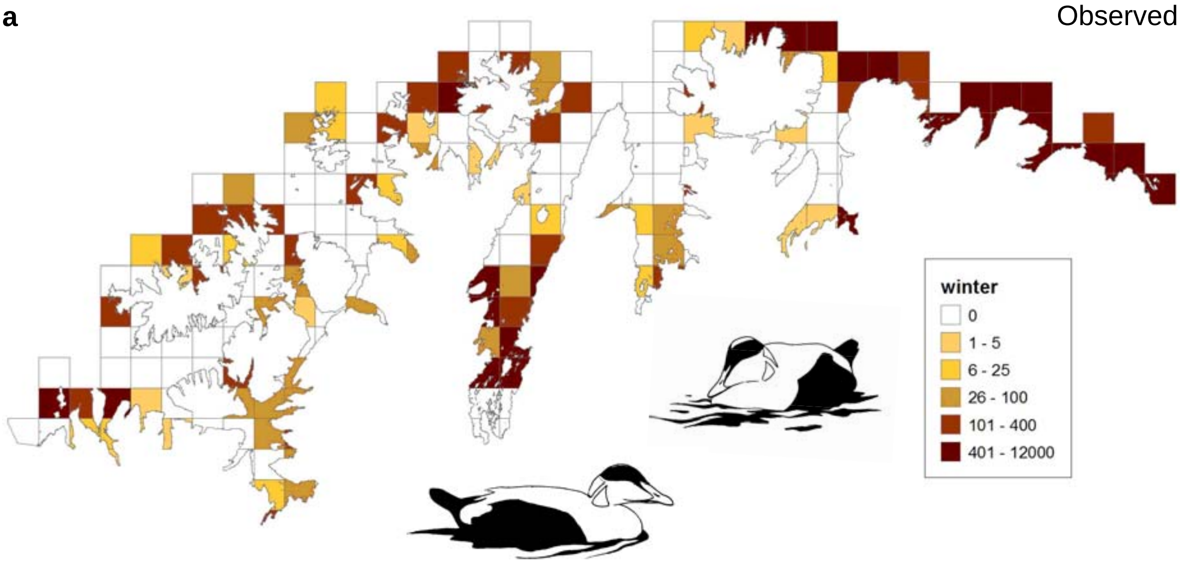


Figure 2.4.2
Suitable habitats for great cormorants in spring in Finnmark, northern Norway.

2.4.4 Common eider

The analyses showed that the number of common eiders (*Somateria mollissima*) in an area was strongly dependent of the amount of shallow water. The species was also found in fishery ports throughout the winter. The highest numbers of common eiders were found in eastern Finnmark (**Figure 2.4.3a**). Although the numbers were lower in western Finnmark, our analyses indicated that there are many potentially good areas for common eiders in that region (**Figure 2.4.3b**). This suggests that these areas can be important for common eiders, even if there were no birds present at the time of surveying.

a



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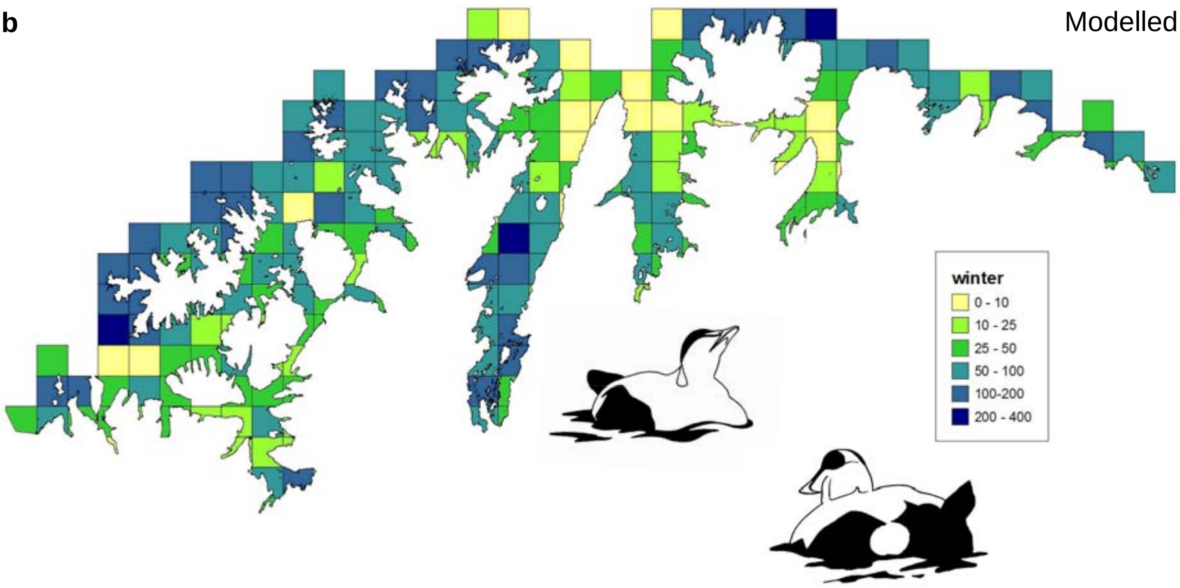


Figure 2.4.3
***a**) The observed distribution of and **b**) suitable habitats for common eider in midwinter in Finnmark, northern Norway. (Drawings © Tycho Anker-Nilssen)*

2.4.5 Herring gull

Human activity, both fish farming and other fisheries activity increased the probability of finding herring gulls in a given area. This is important in winter, but less so when the birds have left for their breeding colonies. The length of the coastline and the area of shallow waters were also important (**Figure 2.4.4**).

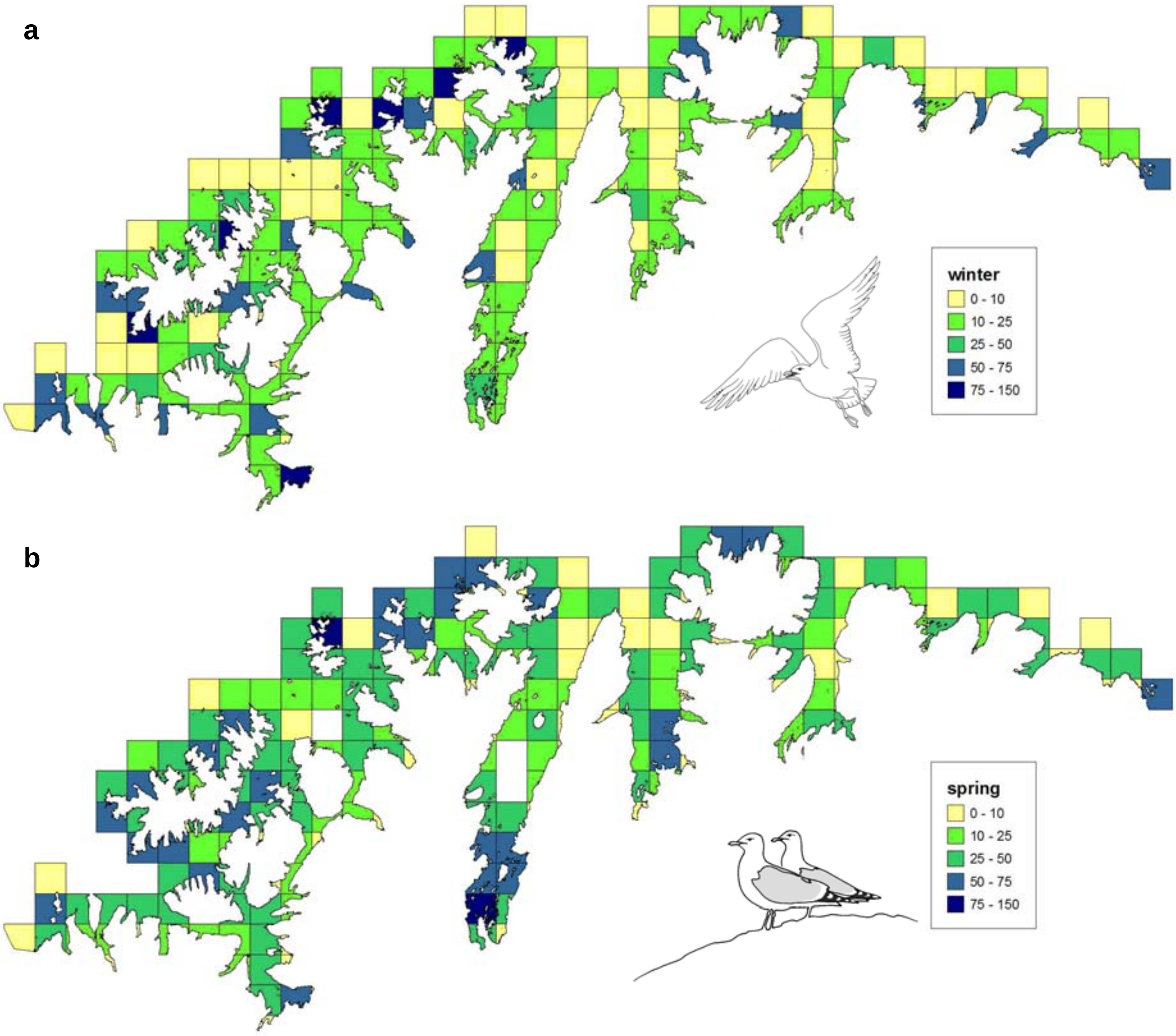


Figure 2.4.4
Suitable habitats for herring gulls in ***a****) winter, related to fisheries activities, and* ***b****) spring, when the birds concentrate in the breeding colonies. (Drawings © Tycho Anker-Nilssen)*

This study is one of the first to show how environmental variables may be used to predict the distribution of coastal seabirds. We found that it is possible to explain some of the occurrence of coastal seabirds by a set of predetermined environmental variables. The strength of such statistical analyses is that it helps us to find potentially important seabird areas. We might use such models in areas where no seabird counts have been made, to evaluate whether such areas are suitable for different seabirds. Such information may be useful in relation to planning of petroleum activity. There is, however, still much unexplained variation in the analyses, and future seabird counts are necessary to update the databases.

The results of this study will be presented in a scientific paper (Systad & Bustnes *in prep. Predicting the winter distributions of coastal seabirds from habitat features in a sub-arctic area*).

2.5 Automatic monitoring techniques

2.5.1 Test studies in Svalbard

Harald Steen & Hallvard Strøm

To estimate the numbers of breeding birds and/or chick production of cliff-breeding birds is a tedious task requiring a large input of expensive hours. In an attempt to make the sampling more efficient we wanted to develop a system using a durable and easy to use camera and modern statistical estimation methods.

The studies were initiated in 2006 when we used six automatic camera units on four sites on Spitsbergen (**Figure 2.5.1**) and another four units on Bjørnøya. The 7.2 Megapixel cameras (*Sony Cyber-shot DSC-W7*) took one frame every 4th hour throughout the breeding season of selected parts of Brünnich's and common guillemot colonies. We also counted visible chicks during the latter period of the chick rearing. By calibrating the number of chicks counted on the photos with those from traditional counts we can get a statistical model predicting number of chicks from photos.

Using cameras will make the field sampling more efficient and more data can be collected from many colonies distributed along an ecological gradient. Experience shows that camera position and the angle to the colony is of crucial importance for obtaining good quality pictures. This applies if the aim is to count adults as well as chicks. Throughout the day the weather conditions change from hot to freezing cold. During cold weather spells and early in the breeding season, the parents protect their young making it impossible to see the chick whereas when the weather is warm the chick is visible. With pictures every 4th hour we were able to get a series of good photos from all periods of the breeding cycle. Future work will decide to what extent and under what circumstances cameras can be used.

Figure 2.5.1
Automatic time-lapse camera rigged at the Ossian Sars colony in Kongsfjorden, Spitsbergen. (© Harald Steen)

2.5.2 Test studies in Røst

Tycho Anker-Nilssen

Monitoring black guillemots by nest counts is difficult as it is usually very time consuming to find every nest in a colony. In a study initiated in Røst in 2006, we aimed to find a more convenient measure of population size from an automatic and frequent recording of bird numbers present at the colony site, even if this number is known to be highly variable.

An automatic camera unit identical to those used in Svalbard (see previous chapter) was used in Røst to monitor the population size of a small colony of black guillemots (*Cepphus grylle*) breeding close to the field station at Hernyken. This population is also targeted for monitoring of adult survival rates, chick diet and reproductive success (**Chapter 3.1.7**, Anker-Nilssen & Aarvak 2006).

The unit was rigged on a neighbouring island to photograph a small islet (**Figure 2.5.2**) about 300 m off the colony and frequently used by the black guillemots for resting and preening. The system was active throughout most of the chick period, resulting in a total of 281 pictures taken between 25 June and 11 August. Numbers of birds in the pictures were counted manually on a computer. When tens of birds were present, this was greatly facilitated using the cell counter function of programme *ImageJ* (rsb.info.nih.gov/ij/). It was however impossible to identify black guillemots on 38 (14%) of the pictures, which were either blurred by fog, dew or rain, or too dark (last week only). The midnight sun disappears from Røst on 12 July.

Figure 2.5.2
The picture taken at 22:54 hrs on 27 June, when 61 black guillemots were resting on the islet. The bird in the foreground is a great black-backed gull that bred close to the camera. (© Tycho Anker-Nilssen)

The highest number of black guillemots resting on the islet, 61 individuals, was recoded in the evening of 27 June (**Figure 2.5.2**). The results suggest more birds rested on the islet early and late in the period (**Figure 2.5.3a**) than in mid July when more birds were probably occupied in feeding their chicks (**Figure 2.5.4**). There was a significant diurnal variation throughout the period with very few birds resting during the day and numbers peaking in late evening (**Figure 2.5.3b**). True midnight at this site (11°52'E) is at 01:12 hrs local time (the crossing point of the y axis in the figure).

This monitoring will continue in future years, and the results will be compared with parallel nest counts in the main colony. Based on this we aim to derive a suitable indicator of population size for future use in this colony as well as in colonies where monitoring is less intensive.

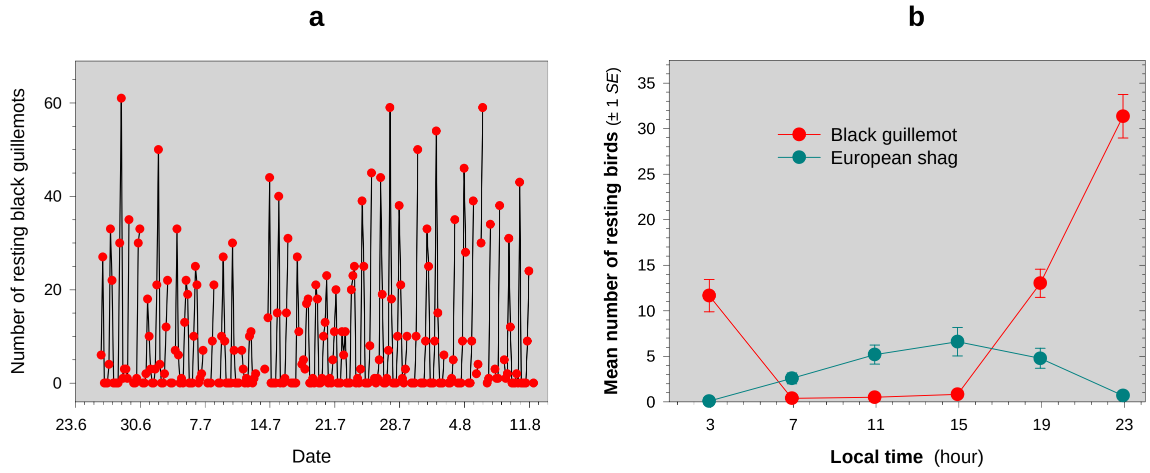


Figure 2.5.3
*The seasonal (**a**) and diurnal (**b**) variation in numbers of black guillemots resting on a small islet close to the colony on Hernyken, Røst in 2006. The corresponding diurnal variation in numbers of European shags sitting (either drying up, preening or resting) on the islet is also shown for comparison.*

Figure 2.5.4
An adult black guillemot on its way to the nest carrying a long-spined bullhead (Taurulus bubalis), which is a small sculpin species. (© Tomas Aarvak)

3 Other project reports

3.1 Monitoring at key-sites

A great variety of species and parameters are currently being monitored at the six key-sites established for SEAPOP in the Lofoten and Barents Sea area (**Figure 3.1.1**, **Table 3.1.1**). Studies of seabird demography (i.e. reproduction and survival rates) on Røst, Hornøya and Bjørnøya date back to 1964, 1980 and 1986, respectively, whereas the collection of corresponding data series on the other sites was first started in 2004 (Hjelmsøya) and 2005 (Anda and Spitsbergen). The monitoring of population trends has, however, longer traditions on most sites.

Key population parameters for each key-site are listed in separate tables in the various chapters below. In all cases, the survival estimates reported here are those calculated by the model that in each case fitted the data set best, i.e. the model with the lowest corrected Akaike information criterion (*AICc*). Sample size for such results was defined as the number of marked individuals contributing to the survival estimation for the year interval(s) in question.

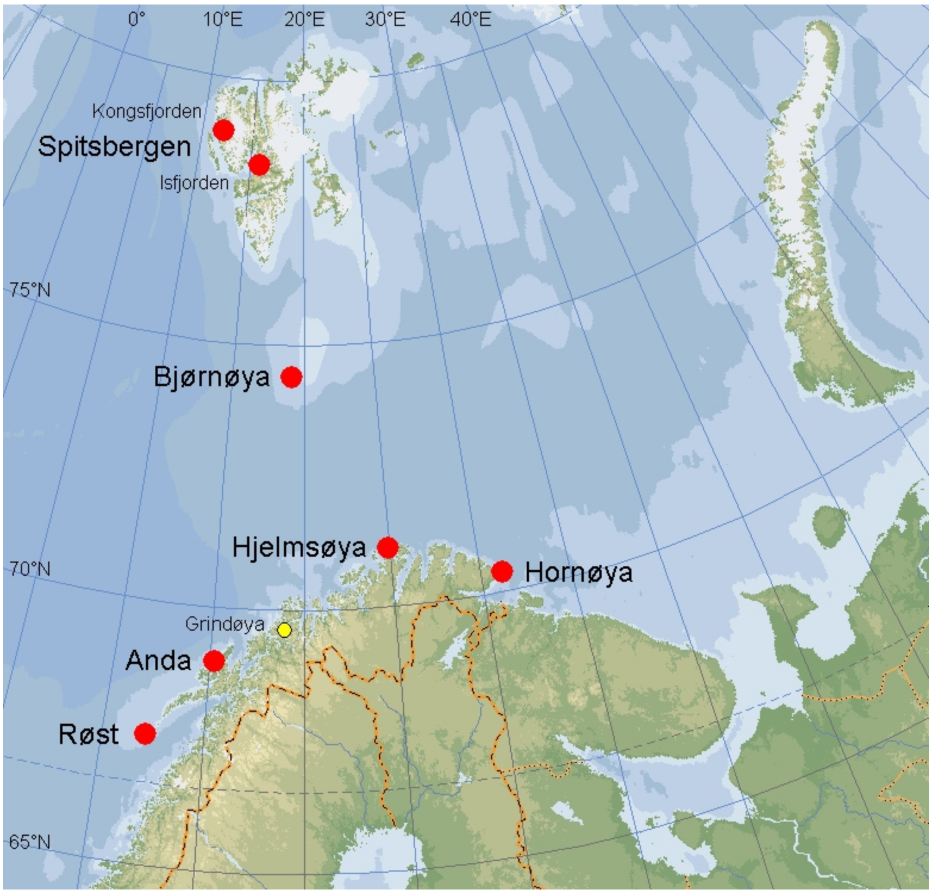


Figure 3.1.1
The geographical positions of the six SEAPOP key-sites (red circles) in the Lofoten and Barents Sea area where data series on seabird demography were collected in 2007. Note that the key-site on Spitsbergen is divided among several localities in Isfjorden and Kongsfjorden (and the neighbouring Crossfjorden). The position of Grindøya close to Tromsø, where detailed studies of the common eider have been performed annually since 1985, is also shown (cf. Chapter 3.1.6).

Table 3.1.1 *Population parameters monitored annually at SEAPOP key-sites in the Lofoten and Barents Sea area, indicated by the first year of continuous data series. Superscripts indicate similar data existing from earlier year(s), whereas parentheses indicate low sample size or missing data for some years. Note that variables used to measure elements of reproductive success (e.g. clutch size, fledging success, overall breeding success) vary from species to species, sometimes also between different sites for the same species.*

Key-site	Species	Population size	Adult survival	Chick food	Chick growth	Reprod. success	Other data
Spitsbergen	Northern fulmar	1988	—	—	—	—	—
	Common eider	1981	—	—	—	1981[1]	Yes
	Black-legged kittiwake	1988	1998	2000	—	2004	Yes
	Brünnich's guillemot	1988	2005	2006	—	2005	Yes
	Little auk	—	2005	2005	—	2005	Yes
Bjørnøya	Northern fulmar	1989	—	—	—	—	—
	Great skua	^{03}2005	2005	2005	2005	2005	Yes
	Glaucous gull	1997	1997	(1997)	—	^{86}1997	Yes
	Black-legged kittiwake	1988	2004	2004	—	2004	Yes
	Common guillemot	1986	1988	(1988)	2004	(1988)	Yes
	Brünnich's guillemot	1986	1988	(1988)	2004	(1988)	Yes
	Little auk	—	2005	2004	—	(2005)	Yes
Hornøya	European shag	(1981)	2004	^{89}	$^{80-81}$	$^{80-81}$2005	Yes
	Herring gull	—	2006	2006	2006	2006	Yes
	Great black-backed gull	—	$^{02-03}$2006	2006	$^{02-03}$2006	$^{02-03}$2006	Yes
	Black-legged kittiwake	1980	1990	$^{80-83}$1987	$^{80-81}$1990[2]	$^{80-83}$1988	Yes
	Common guillemot	1980	1988	$^{80-83}$1988	$^{80-83}$1988	—	—
	Brünnich's guillemot	—	$^{89-01}$	$^{90-91}$	$^{90-91}$	$^{90-91}$	Yes
	Razorbill	—	1995	1989	1988	1988	Yes
	Atlantic puffin	1980	1990	$^{80-83}$1987[3]	$^{80-81}$1988	$^{80-81}$1988	Yes
Hjelmsøya	Great skua	(1997)	—	—	—	—	—
	Black-legged kittiwake	1991	2004	2005	2005	2004	Yes
	Common guillemot	1984	2004	—	—	2004	Yes
	Brünnich's guillemot	1984	—	—	—	—	—
	Razorbill	(1996)	—	—	—	—	—
	Atlantic puffin	1997[4]	2004	—	—	2006	Yes
Anda	European shag	2005	2006	—	—	—	Yes
	Herring gull	2005	—	—	—	—	Yes
	Black-legged kittiwake	2005	2005	2006	—	2005	Yes
	Common guillemot	2005	—	—	—	—	—
	Atlantic puffin	$^{81-83}$2005	2005	2005	2005	2005	Yes
Røst	Northern fulmar	1997	—	—	—	—	—
	Great cormorant	1997	—	—	—	2002	Yes
	European shag	1985	2002	—	—	1985	Yes
	Common eider	^{88}2000	—	—	—	2001	—
	Great skua	(1988)	—	—	—	(2005)	(Yes)
	Common gull	—	—	—	—	2006	—
	Herring gull	—	—	—	—	2006	—
	Great black-backed gull	—	—	—	—	2006	Yes
	Black-legged kittiwake	1979	2003	(2006)	—	1980	Yes
	Common tern	—	—	—	—	2006	—
	Arctic tern	—	—	—	—	2003	—
	Common guillemot	$^{61+66}$1971	2005	2006	$^{71-85}$	$^{71-85}$	Yes
	Razorbill	(1997)	—	—	—	—	—
	Black guillemot	1996	1997	1990	1996	1996	Yes
	Atlantic puffin	1979	1990	1979	1964	1974	Yes

1) *Except for 1988-90, 1992 & 1994 (no data);* ***2)*** *Data from most years in 1996-2006 have been collected by Thierry Boulinier and co-workers (CNRS, France);* ***3)*** *Except for 1988 (no data);* ***4)*** *Population size is monitored at Gjesvær-stappan, about 20 km east of Hjelmsøya.*

3.1.1 Spitsbergen

Harald Steen

In 2006, we collected data on Spitsbergen for the second year from two Brünnich's guillemot (*Uria lomvia*) colonies, one at Diabasodden (78°22′N 16°08′E) in Isfjorden the other at Jock Scott (79°10′N 11°52′E) in Crossfjorden, and from the little auk colony at Bjørndalen (78°14′N 15°19′E) in Isfjorden. The fieldwork lasted from 1 June – 5 August. Only for little auks are the data series now suitable for survival estimation (**Table 3.1.2**), although only for a single estimate. This is, however, the first estimate of adult survival ever produced for this species in the NE Atlantic. As regards breeding success, which we measured as the proportion of the eggs that resulted in a fledged chick, 2006 was apparently a year with low chick production. This was considered to be a "warm" year and the diet of little auk consisted mainly of copepods (*Calanus glacialis*). The causal relationships will be established in the coming years through cooperative work with zooplankton researchers at NPI and UNIS.

The sampling protocol for Brünnich's guillemots does not allow survival estimation before the end of the 2007 season, but the work at the two study colonies continued with colour-ringing of new individuals and resighting of previously marked birds. In addition, we counted chicks on one study plot in each colony. This was paralleled by a time lapse camera that took pictures of the plots at 4-hour intervals (see **Chapter 2.5.1**). In early July, the plot on Diabasodden contained on average 92 (*SE*=19.2) individuals, while that on Jock Scott had 134 (*SE*=1.3) individuals. We are in the process of developing methods to extract chick production from these digital picture series, but no estimates for 2006 are yet available. We also studied Brünnich's guillemot diet by direct observation using binoculars. Twenty-five of the deliveries were polar cod (*Boreogadus saida*) and nine were capelin, but 81 other prey was not identified. Data for black-legged kittiwake was collected on one site at Upper Blomstrand (78°59′N 12°07′E) in Kongsfjorden. A total of 51 nests were followed and by day 12, 76% of the active nests had a live chick. By day 30, this figure had fallen to 55%. Median hatching date was 9 July and the clutch size was 1.96.

Table 3.1.2 *Key population parameters (SE, n) of seabirds in Spitsbergen in 2006. Population change is the numeric change in size of the breeding population registered between 2005 and 2006 on the basis of plot counts (p) or total censuses (t). The listed survival estimate was derived from the model that fitted the data set best (i.e. the one with the lowest AICc value).*

Species	**Population change**	**Annual adult survival**		**Reproductive performance**	
		Period (yrs)	Estimate	Sampling unit	Estimate
Northern fulmar	No data				
Common eider	1			Clutch size	1
Black-legged kittiwake	– 2.8% p	Ongoing analysis 1		Clutch size	1.96 (*n*=*51*)
Brünnich's guillemot	+ 1.5% p				
Diabasodden, Isfjorden	No data	No estimate yet possible 2		No estimate yet available 2	
Jock Scott, Crossfjorden	No data	No estimate yet possible 2		No estimate yet available 2	
Little auk		2005-06 (1)	0.84 (0.12, 30)	Chicks ≥ 20d/egg	0.38 (*n*=29)

1) *Data collected by MOSJ not yet available;* ***2)*** *Colour-ringing for monitoring of survival rates was initiated in two colonies in 2005.*

3.1.2 Bjørnøya

Hallvard Strøm

Figure 3.1.2 *Kapp Kolthoff, the southernmost point on Bjørnøya, with islets Alkeholmen and Stappen. This area has the highest breeding densities of common and Brünnich's guillemot on the island. (© Hallvard Strøm)*

The monitoring program on Bjørnøya (**Figure 3.1.2**) continued in 2006 as in previous years (**Table 3.1.3**), although the activity was higher than normal due to the census of breeding seabirds (**Chapter 3.4.1**) that were undertaken parallel to the monitoring activity. The programme on Bjørnøya includes six species whose population development is monitored, plus the little auk. Demographic parameters and chick diet are monitored for five of the seven species, the exceptions being the northern fulmar and glaucous gull. The monitoring programme on Bjørnøya was initiated in 1986, since when the number of species and parameters monitored has increased gradually.

The fieldwork period in 2006 was 10 June – 1 August. The breeding population of black-legged kittiwakes continued to fall in 2006, and was lower than in the two previous years. The recovery of the common guillemot population after the collapse in 1987 continued in 2006, as

Table 3.1.3 *Key population parameters (SE, n) of seabirds on Bjørnøya in 2006. Population change is the numeric change in size of the breeding population registered between 2005 and 2006 on the basis of plot counts (p) or total censuses (t). For each species the listed survival estimate was derived from the model that fitted the data set best (i.e. the one with the lowest AICc value).*

Species	**Population change**	**Annual adult survival**		**Reproductive performance**	
		Period (yrs)	Estimate	Sampling unit	Estimate
Northern fulmar	+ 0.4% p				
Great skua	1	No estimate yet possible 2		Large chicks/nest	0.57 (0.04, 61)
Glaucous gull	3	1998-00 (2)	83.6% 4	Large chicks/nest	0.21 (0.07, 134)
Black-legged kittiwake	– 2.6% p	Ongoing analysis 5		Large chicks/nest	0.72 (0.04, 503)
Common guillemot	+ 4.4% p	1988-2003 (15)	97.5% 6	Fledging success	0.84 (*n*=67)
Brünnich's guillemot	+ 0.3% p	1988-2003 (15)	93.0% 6	Fledging success	0.72 (*n*=61)
Little auk		No estimate yet possible 7		Chicks ≥ 15d/nest	0.67 (*n*=43)

1) *Ongoing analysis. Monitoring of the breeding population was initiated in 2005;* ***2)*** *Colour-ringing initiated in 2005 and an additional 44 adults ringed in 2006;* ***3)*** *Ongoing analysis;* ***4)*** *Bustnes et al. (2003) based on 92 individuals;* ***5)*** *Colour-ringing initiated in 2004;* ***6)*** *Bakken & Strøm (submitted) based on 149 common and 78 Brünnich's guillemots;* ***7)*** *Colour-ringing initiated in 2005 and an additional 152 adults ringed in 2006.*

in preceding years. The breeding success of the species was higher than in 2005, and the mean mass of chicks at the age of 15 days (232 g, *n*=67) indicated a moderate breeding season. As in previous years capelin was an important prey species for both guillemot species, but both also the small (*Gonatus fabricii*) and 0-group saithe (*Pollachius virens*) constituted important parts of their diets. Squid has not previously been recorded as an important part of the chick diet for any seabird on Bjørnøya.

The monitoring of the little auks (diet) and the great skuas (*Stercorarius skua*) (number of breeding pairs and breeding success) that was initiated in 2004, continued in 2006 and now includes adult survival, breeding success and other parameters. A total of 152 adult little auks and 44 adult great skuas were ringed with coded rings, and 41 little auk nests and 62 great skua nests were followed until the chicks reached the age of at least 15 days. The great skua was first recorded breeding on Bjørnøya in 1970. The census carried out in 2006 indicated that Bjørnøya holds a breeding population of about 300-350 pairs of great skuas.

The number of apparently occupied nests of glaucous gull was higher than in previous years, but the breeding success was again extremely low, with only a few chicks fledging. The breeding population of the glaucous gull on Bjørnøya has declined since the programme started in 1986. The total census of apparently occupied nests conducted in 2006 confirmed this trend, with a 65% reduction in the breeding population, from ca. 2000 pairs in 1986 to only 650 pairs in 2006. Glaucous gulls on Bjørnøya accumulate high levels of organic contaminants, especially in birds that specialize in preying on eggs and chicks of other seabirds. Effects on hormone production and the immune system as well as lower levels of reproduction and adult survival have been documented (Bustnes et al. 2003, Verreault et al. 2004).

In a new study, liver and brain samples of 21 glaucous gulls and two great black-backed gulls (*Larus marinus*) found dead or dying on Bjørnøya in the years 2003-05 (**Figure 3.1.3**) were analyzed for halogenated organic contaminants (HOCs) and mercury (Knudsen et al. 2007). The very high levels of most HOCs that were found in the glaucous gull sample, were among the highest HOCs concentrations ever reported in arctic seabirds. Forty-three percent of the birds in the study were found to be completely or severely emaciated. When body lipids are mobilized contaminants accumulated in fat tissue are released and enter the blood circulation of the organism. Observations of dying glaucous gulls on Bjørnøya with apparently abnormal behaviour suggest that high levels of contaminants, directly or indirectly, contribute to the birds' death and the population decline.

Figure 3.1.3
A dead glaucous gull found close to its nest at Fuglefjellet, July 2006. (© Hallvard Strøm).

3.1.3 Hornøya

Rob Barrett & Kjell Einar Erikstad

As in earlier seasons, population trends, the timing of breeding, breeding success, food choice and adult survival of five key species were studied during the 2006 season. Except for the black-legged kittiwakes, the 2006 season was moderate to good for all species on Hornøya. The breeding population of kittiwakes showed a sharp drop (24%) since 2005, the start of the breeding season was again delayed until the end of May and, compared to earlier years, their breeding success was poor with only 0.6 chicks fledging per nest. There was very little feeding activity among any of the gull species in the waters around Hornøya and a near complete absence of "feeding frenzies" which, in previous years, have been common in inshore waters. A total count of the kittiwake population was made in 2006 resulting in 11,500-12,000 apparently occupied nests. This is a considerable decline since a similar count of ca. 19,000 nests was made in 1983.

Although a slight decline in numbers of Atlantic puffin burrows was apparent from the monitoring counts (**Table 3.1.4**), it is possible that an early, lush growth of vegetation concealed some of the burrow entrances at the time of counting. The recovery of the common guillemot population after the collapse in 1987 continued in 2006 and, although no direct measure of their breeding success was made, the mass of chicks leaving the nest sites in the first half of July (mean ca. 250 g) suggested a good breeding season. As a result of the increase in guillemot numbers and their spread up the cliff and onto one counting position, one monitoring plot (Fuglefjell F) had to be abandoned. To compensate for this, two new plots (Fuglefjell H & I, **Figure 3.1.4**) were defined and counted in 2006.

Similarly Atlantic puffin and razorbill (*Alca torda*) chick growth rates of 10-14 g per day during the main growth period and an overall fledging success of ca. 68-75% indicated that both species had a moderately successful season. The mean hatching dates of 49 razorbill eggs was 3 July (range 23.6-11.7) and of 45 Atlantic puffin eggs was 2 July (range 21.6-17.7), which were both similar to the timing of breeding in 2005.

Table 3.1.4 *Key population parameters (SE, n) of seabirds on Hornøya in 2006. Population change is the numeric change in size of the breeding population registered between 2005 and 2006 on the basis of plot counts (p) or total censuses (t). For each species the listed survival estimate was derived from the model that fitted the data set best (i.e. the one with the lowest AICc value).*

Species	**Population change**	**Annual adult survival**		**Reproductive performance**	
		Period (yrs)	Estimate	Sampling unit	Estimate
European shag	No data	2004-06 (3)	71.5 (6.7, 87)	Clutch size	2.47 (0.11, 74)
Herring gull		No estimate yet possible [1]		Clutch size	2.08 (0.07, 107)
Great black-b. gull		No estimate yet possible [1]		Clutch size	2.39 (0.11, 40)
Black-legged kittiwake	– 24.4% p	2005-06 (1)	83.2 (12.9, 1071)	Clutch size Large chicks/nest	1.48 (0.03, 729) 0.58 (0.02, 1595)
Common guillemot	+ 3.0% p	1989-06 (17)	96.2 (0.6, 176)		
Razorbill		1994-06 (12)	90.0 (1.1, 156)	Fledging success [1]	68.8% (*n*=64)
Atlantic puffin	– 9.8% p	1990-06 (16)	86.9 (1.7, 672)	Fledging success [1]	75.0% (*n*=48)

1) *Colour-ringing for estimating survival rates was initiated in 2006;* ***2)*** *Medium-sized chicks/egg laid.*

Fuglefjell **H** Fuglefjell **I**

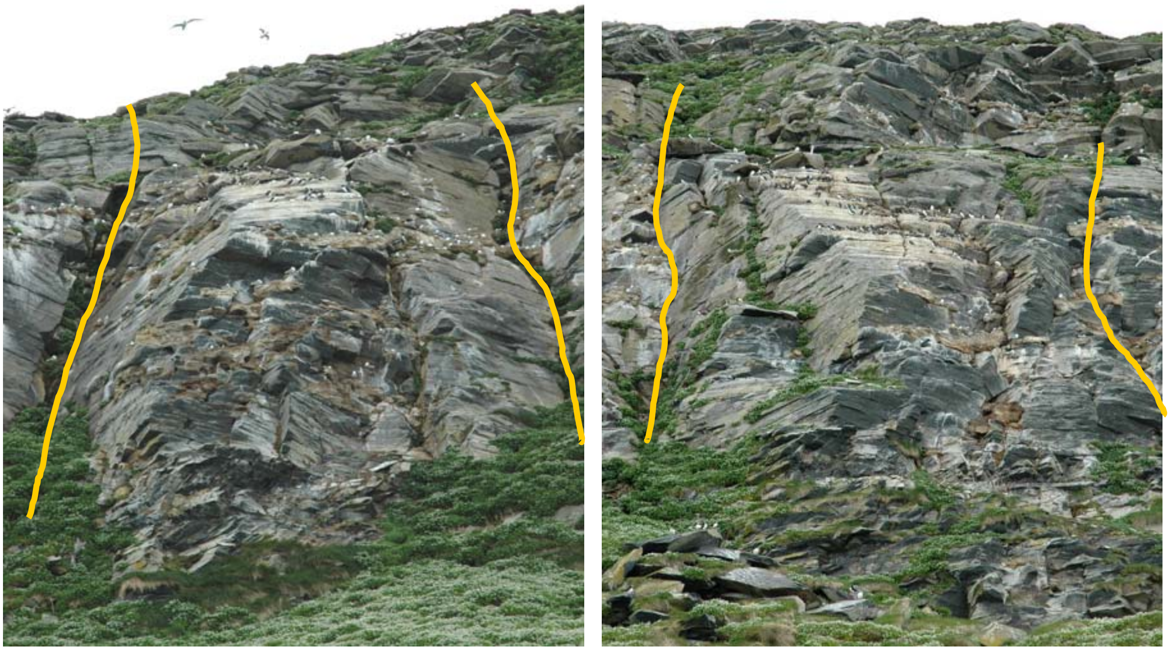


Figure 3.1.4
The new monitoring plots (demarcated by yellow lines) for common guillemots established in 2006, Fuglefjell H and I, on which means of 84 and 121 individuals respectively bred.

Herring and sandeels were important constituents of the diet of chicks while capelin and small gadoids played a minor role (**Figure 3.1.5**). Kittiwakes fed their chicks mostly on herring while razorbills and Atlantic puffins took mainly sandeels. Compared to 2005, there was a marked increase in the harvest of sandeels and a decrease in that of capelin by kittiwakes, razorbills and Atlantic puffins. A preliminary survey of the diet of European shags showed that they also took almost exclusively sandeels. A more systematic sampling of shag food is planned for future years.

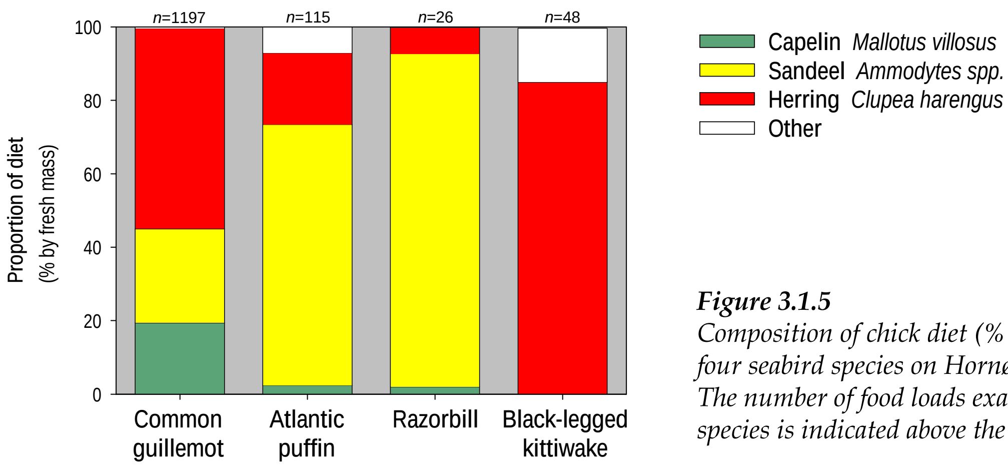


Figure 3.1.5
Composition of chick diet (% by mass) of four seabird species on Hornøya in 2006. The number of food loads examined for each species is indicated above the bar.

In collaboration with NERC Centre of Ecology and Hydrology, Scotland, 32 adult shags were fitted with global location sensing (GLS) loggers (**Figure 3.1.6**) as part of an international study of the species' winter foraging strategies and their impact on survival and breeding at high latitudes. Similar loggers were also deployed on 20 shags at Røst, and on conspecifics on Flatey (Iceland) and Isle of May (Scotland). The work on Hornøya was partly funded by the Norwegian Research Council, whereas that on Røst was financed by Norsk Hydro ASA. As many of the loggers as possible will be retrieved during the 2007 breeding season for downloading and data processing in collaboration with the British Antarctic Survey who produces the loggers.

***Figure** 3.1.6*
Adult European shag carrying a Global Location Sensing logger attached to the green colour ring. (© Rob Barrett)

Adult survival rates for common guillemot, Atlantic puffin, razorbill, and European shags showed no significant variation between years (**Table 3.1.4**). While that of common guillemots has remained at a very high level throughout the 17-year monitoring period, the survival of the kittiwakes, which is the only species on Hornøya that shows a variable survival between years, has fluctuated greatly. The estimate from 2005 to 2006 was reasonably high for this species (83.2%) and higher than any of the estimates for the four preceding years (range 59.9-79.7%). Adult survival rate of shags was estimated at only 71.5%, which is the first survival estimate for this population. Comparison with results from Røst (**Chapter 3.1.7**) and colonies abroad (e.g. Harris et al. 2000) this suggests that the Hornøya population has suffered from relatively poor survival of adults in the two most recent years.

***Figure** 3.1.7*
The breeding season for gulls at Hornøya in 2006 was extremely bad and virtually no chicks fledged. Most chicks died in their nest at or soon after hatching when the parents tried to feed them blue mussels. (© Kjell Einar Erikstad)

In 2006, new demographic studies on herring gulls and great black-backed gulls were initiated at Hornøya. Both adults and chicks were ringed in order to follow both adult survival and future recruitment rates of young to the colony. Egg laying dates, clutch sizes and chick survival to fledging were also monitored. The breeding season in 2006 was extremely poor, resulting in the adults becoming very shy and difficult to catch at the nest (only 11 herring and 19 great black-backed gulls were ringed). Egg predation was very high and almost all chicks died in the nest within two weeks of hatching. It was obvious that both adults and chicks suffered from food shortage, and during the first days after hatching we found no fish remains at any nest. Instead, the parents tried to feed their young blue mussels (*Mytilus edulis*) which the chicks were unable to swallow (**Figure 3.1.7**).

3.1.4 Hjelmsøya

Kjell Einar Erikstad

Hjelmsøya in western Finnmark was established as a SEAPOP key site in 2004 and three species, the Atlantic puffin, common guillemot and black-legged kittiwake were selected as the primary target species (**Table 3.1.5**). Monitoring of common guillemots in selected study plots on open ledges was initiated in 1984, and has since been part of the national monitoring program for seabirds (Lorentsen 2006). The population breeding on opens ledges declined steeply after the collapse of the Barents Sea capelin in the 1980s and is now very small. A recent population viability analysis (PVA) of this colony shows that it is highly vulnerable (**Chapter 2.1**). Based on the population trends from the period 1988 to 2004, there is a 27% probability that this population will go extinct within 50 years (or approximately 3 generations) (Erikstad et al. 2007). From 2005 to 2006 there was, however, a slight increase (12.6%) in the population at open ledges for the first time since 2002. The estimated survival of adults was however extremely low (65.0%) compared the long-term average at Hornøya (96.6%). The estimate from Hjelmsøya is from the open ledges where the population has been declining steeply. We do not know at present whether birds from open ledges die or simply move to the sheltered areas where numbers have increased since 1992.

Figure 3.1.8
A new field station was built at Hjemsøya in August 2006. The standards of the station are in strong contrast to the old one (at left) and greatly improve the working facilities. (© Lars Asbjørnsen)

Table 3.1.5 Key population parameters (SE, n) of seabirds on Hjelmsøya in 2006. Population change is the numeric change in size of the breeding population registered between 2005 and 2006 on the basis of plot counts (p) or total censuses (t). Numbers of Atlantic puffins are monitored at nearby Gjesværstappan, about 20 km east of Hjelmsøya. For common guillemot and razorbill counts of individuals in plots (ip) on exposed cliffs and of eggs in plots (ep) in more sheltered habitats are treated separately.

Species	Population change	Annual adult survival		Reproductive performance	
		Period (yrs)	Estimate	Sampling unit	Estimate
Great skua [1]	+ 100.0% ^{t} [1]				
Black-legged kittiwake	– 9.6% ^{p}	2004-05 (2)	90.6 (4.3, 206)	Clutch size	1.49 (0.04, 247)
				Large chicks/pair	0.00 (0.00, 247)
Common guillemot	+ 12.6% ^{ip}	2004-06 (2)	65.0 (1.1, 92)		
	– 14.7% ^{ep}				
Brünnich's guillemot	+ 100.0% ^{p} [2]				
Razorbill	– 32.1% ^{ip}				
	+ 12.0% ^{ep}				
Atlantic puffin	– 22.9% ^{p}	2004-06	Not possible [3]	Fledging success	0.00 (0.00, 102)

***1)** From 3 to 6 pairs; **2)** From 1 to 2 pairs; **3)** Around hatching a feral mink preyed upon virtually all 102 puffin chicks in the burrows studied causing adult birds to abandon the colony and thus precluding resighting of the 152 marked adults from earlier years.*

Annual counts of eggs in other and more sheltered parts of the colony since 1992 are much more variable as they also reflect variations in reproductive performance, but indicate that the numbers of birds breeding in the least exposed habitats are increasing, possibly because they escape the increasing disturbance from white-tailed eagles (*Haliaeetus albicilla*) (e.g. Barrett et al. *in press*). However, the number of eggs counted in sheltered areas in 2006 was lower than in 2005. This may not necessarily reflect any population decline but rather indicate a lower breeding success in 2006 than in 2005. A similar difference in the long-term trends for sheltered and exposed breeders is probably also valid for razorbills, as was evident between 2005 and 2006 (**Table 3.1.5**).

Monitoring of the Atlantic puffin population on nearby Gjesværstappan started in 1997, since when the population has dropped by 4.9% p.a. (Lorentsen 2006). From 2005 to 2006 there was an apparent decline in the population (–22.9%) which is in contrast to the increase from 2004 to 2005 (+31.5%). The monitoring of breeding success and adult survival rates were severely set

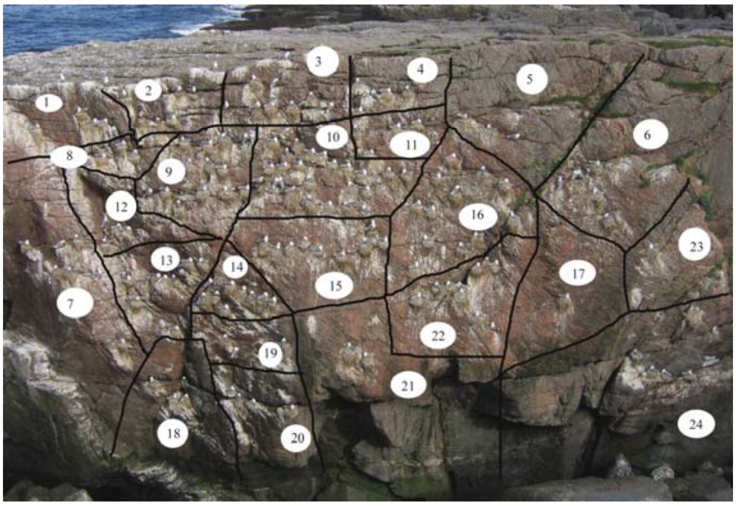


Figure 3.1.9
One of two cliffs at Hjelmsøya selected for studying the spatial variation in population trends over years in relation to fate and success of individual birds. (© Lars Asbjørnsen)

back by the ravaging of a feral mink (*Mustela vison*), which preyed upon virtually all the eggs and chicks in the 102 study burrows and was even seen killing an adult puffin on the monitoring plot.

The survival estimate of adult kittiwakes in 2004-05 was high and estimated at 90.6%, which is higher than the parallel estimate from Hornøya (83.3%) and the average estimate for Røst (85.0%) for the period 2003-2006. The breeding success of kittiwakes in 2006 was, however, extremely low and virtually no chicks fledged from the 247 study nests. Most chicks died soon after hatching which also made it impossible to collect food samples. At Hjelmsøya, monitoring of the kittiwake is designed to study the spatial variation in population trends over years in relation to fate and success of individual birds (**Figure 3.1.9**). This will give us new information on how to better design monitoring and also improve our understanding of the habitat selection of birds.

3.1.5 Grindøya

Kjell Einar Erikstad, Jan Ove Bustnes & Sveinn Are Hanssen

Grindøya (69°38′N 18°49′E) in Balsfjorden is not a full SEAPOP key-site, but is included in the programme because the most extensive time series for the common eider breeding in mainland Norway have been collected here since 1985. These time series include laying date, clutch size and the longest data series on adult survival (of females) of any marine bird species in Norwegian areas (**Table 3.1.6**). Many other aspects of the Grindøya eider population have also been extensively studied, with special focus on parental care and parental investment. Two PhD students and nine master students have collected data for their theses at this colony. Today, the Grindøya population is also a part of a large international project on bird health led by Sveinn Are Hanssen and funded by the Norwegian Research Council as an International Polar Year (IPY) project.

In 2000, the outer parts of Balsfjorden near Grindøya were included as part of one of the national monitoring areas for common eider with annual counts of adult males made early in the breeding season each year. The numbers dropped by 25.9% from 713 in 2005 to 528 in 2006. A similar trend was also documented for the whole Balsfjorden area where the number of males dropped by 57.4% from 2101 to 1206 between 2002 and 2006. Since the monitoring of common eiders on Grindøya started, there have been large inter-annual variations in egg-laying date (range 10 days, **Figure 3.1.10a**) and clutch size (range 3.1-4.5 eggs, **Figure 3.1.10b**). There is also a clear-cut trend in that egg-laying was gradually delayed in the period 1986 to 1998, only then to advance again until 2006. As birds typically lay fewer eggs when breeding is delayed, the similar, but opposite trend in clutch size (**Figure 3.1.10b**) is not surprising.

Table 3.1.6 *Key population parameters (SE, n) of common eider on Grindøya in 2006. Population change is the change in number of adult males registered in breeding areas farther out in Balsfjorden between 2005 and 2006 on the basis of total counts (t). The listed survival estimate was derived from the model that fitted the data set best (i.e. the one with the lowest AICc value).*

Species	**Population change**	**Annual adult survival** Period (yrs)	Estimate	**Reproductive performance** Sampling unit	Estimate
Common eider	– 25.9 % t	2004-05 (1)	51.0 (0.11, 1166)	Clutch size	4.21 (0.08, 51)

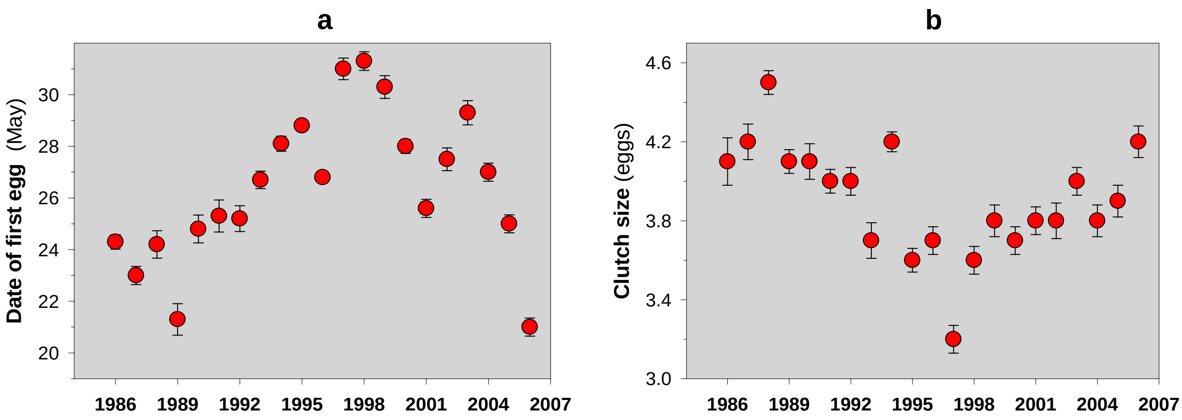


Figure 3.1.10
*The mean (±1 SE) egg-laying date (**a**) and clutch size (**b**) of common eiders on Grindøya, in 1986-2006.*

Although we have yet no verified explanation for the pattern of these changes, several possibilities including both climatic factors and food supply are now being explored. The survival of breeding females also varied between years (**Figure 3.1.11**). In 1986 to 2002, their mean survival rate was estimated at above 80% and showed no significant trend. Since then, it has dropped considerably and was estimated at only 51% from 2004 to 2005. This may explain the recent steep decline in population size in the area. One serous threat to the eider population at Grindøya, which may explain this trend, is the recent appearance and establishment of feral mink on the island. These mustelids prey heavily on incubating females. We have since observed a skew towards males in the sex ratio of birds wintering in the area (unpublished data), corroborating the observed increased mortality of breeding females. There is now a clear risk that mink may ultimately cause the eiders to abandon the island, leading to an extinction of the colony within few years.

The estimation of annual survival rates is based on resighting of female eiders captured at their nest and marked with nasal discs for individual recognition (**Figure 3.1.11**). This also enables us to follow their movements at sea in the wintering area in Balsfjord.

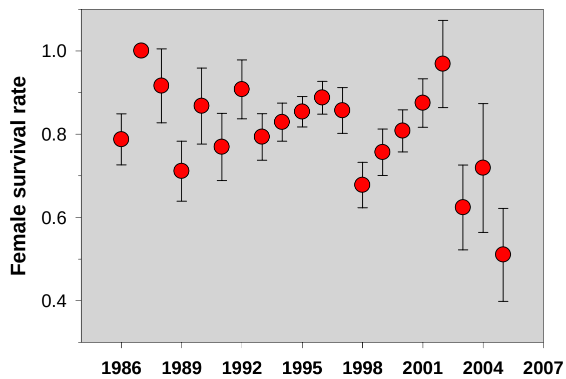


Figure 3.1.11
The variation in survival estimates of females common eiders at Grindøya in 1986-2005, based on resightings of birds marked with nasal discs for individual recognition. (Photo © Sveinn Are Hanssen)

Figure 3.1.12
The lighthouse at Anda serves as an excellent field station. It is very close to the colony of Atlantic puffins, which breed in the grassy slope seen in the foreground. (© Svein-Håkon Lorentsen)

3.1.6 Anda

Svein-Håkon Lorentsen

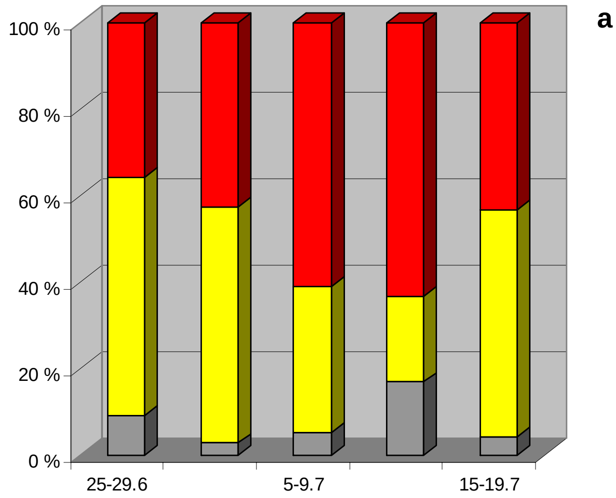
Anda (64°04'N 15°10'E) in Vesterålen was established as a SEAPOP key-site in 2005. The lighthouse on Anda (**Figure 3.1.12**) was automated in 1987 and, thanks to the Norwegian Coastal Administration, we are able to use the lighthouse buildings as our base. During two field seasons it has proved to be an excellent station for this purpose.

The population size of Atlantic puffins at Anda was monitored in 1981-83, but since then no regular studies have been carried out on the island before it was selected as a SEAPOP key-site. Fortunately, the monitoring plots counted in the early 1980s were well documented and comparisons could be made with results from the monitoring in 2005 and 2006. New plots for puffin monitoring using the Star system developed by Anker-Nilssen & Røstad (1993) and monitoring plots for black-legged kittiwakes were established in 2005, and counts were made in 2006 (**Table 3.1.7**). Total censuses of the European shag, herring gull and common guillemot populations on Anda were also made. In 2006, data on breeding success of Atlantic puffin and black-legged kittiwake were collected and 35 and 32 individuals, respectively, were fitted with individually coded colour rings (as a supplement to the 150 individuals ringed in 2005) for monitoring of adult survival rates. Sixty-nine food loads containing 805 fish were collected from Atlantic puffins, and 18 food loads from black-legged kittiwakes.

Table 3.1.7 *Key population parameters (SE, n) of seabirds on Anda in 2006. Population change is the numeric change in size of the breeding population registered between 2005 and 2006 on the basis of plot counts (p) or total censuses (t).*

Species	**Population change**	**Annual adult survival** Period (yrs)	Estimate	**Reproductive performance** Sampling unit	Estimate
European shag	[1]			Clutch size	1.94 (0.73, 18) [2]
Black-legged kittiwake	+ 1.7% p	No estimate yet possible [3]		Clutch size	1.49 (0.52, 95) [2]
				Large chicks/clutch	0.96 (*n*=78)
				Large chicks/clutch	0.26 (*n*=131) [4]
Atlantic puffin	+ 2.9% p	No estimate yet possible [3]		Chicks ≥ 20d/nest	0.74 (*n*=50) [5]

1) *Ongoing analysis;* ***2)*** *Number of chicks (medium to large) per nest (with content) on 19 July;* ***3)*** *Colour-ringing for monitoring of survival rates was initiated in 2005;* ***4)*** *Including two study plots that had been predated by white-tailed eagles;* ***5)*** *Including a survival rate of 0.80 (n=50) for chicks from hatching to age ≥ 10 days.*



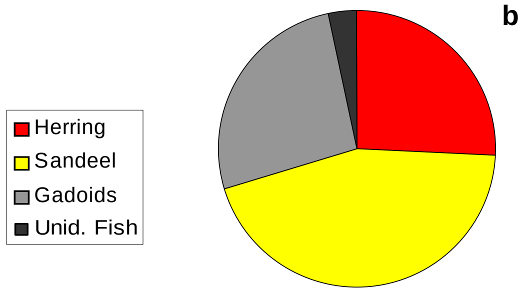


Figure 3.1.13
***a**) Seasonal variation (5-day periods) in composition of the chick diet (% by mass) of Atlantic puffins and **b**) composition of the diet (% by mass, adults and chicks) of black-legged kittiwakes on Anda in 2006.*

First-year herring comprised 49% of the diet by mass of Atlantic puffin chicks at Anda in 2006 (38% in 2005), followed by sandeel which constituted 43% (60% in 2005) and gadoids 8% (2% in 2005). Although most herring were relatively small (mean length 54.7 mm, *SE*=0.4, range 33-81mm, *n*=403) when compared to the sandeels (mean 75.7 mm, *SE*=0.6, range 54-118 mm, *n*=228), they were considerably larger than the herring brought to the colony by puffins in the preceding year (mean 45.2 mm). There was a gradual shift in the diet from a dominance of sandeels in late June to a dominance of herring in first half of July, but this trend was reversed in the last sampling period (**Figure 3.1.13a**).

Sandeels dominated the diet of black-legged kittiwakes (44.5% by mass), followed by gadoids (26.4%) and herring (25.9%) (**Figure 3.1.13b**). The herring and sandeels caught by kittiwakes were smaller than those caught by puffins, and had mean lengths of 29.2 mm (*SE*=0.7, *n*=64 otoliths) and 59.8 mm (*SE*=1.2, *n*=130 otoliths), respectively. About 1000 pairs of black-legged kittiwakes bred on Anda in 2005 and 2006, and many nests are easily accessible (**Figure 3.1.14**). Compared to the census made in the early 1980's (Røv et al. 1984), it seems that the population has remained relatively stable over the last two decades. From 2005 to 2006, the population increased by 1.7% (**Table 3.1.7**). A study plot for the monitoring of adult survival was first established in 2005 so the first estimates will not be obtainable until after the 2007 field season.

Figure 3.1.14
The author reaches out for a black-legged kittiwake chick on Anda. Obtaining growth curves requires repeated measurements of the chicks. (© Arild Espelien)

Results from the national monitoring programme for seabirds (Lorentsen 2006) suggest that breeding population of Atlantic puffins at Anda was relatively stable between 1981 and 2006. Although the total population appears to have declined by 0.3% annually from an estimated 22,200 pairs in 1981 to 19,880 pairs in 2006, a total decrease of 10.5% (**Chapter 2.2**, **Figure 2.2.1**), the trend in the monitoring plots was not statistically significant (Lorentsen 2006). The mean hatching date for puffins in 2006 was 25 June, two days later than in 2005. Chicks hatched in 86% of the study nests (*n*=50), compared to 67% (*n*=58) in 2005. We used growth curves for the head+bill length of chicks measured at Røst in good years (Anker-Nilssen & Aarvak 2004) to estimate chicks' ages and thus compute an index of reproductive performance at Anda (**Table 3.1.7**). In 2006, 80% of the puffin chicks reach the age of at least 10 days (compared to 62% in 2005), and 74% reached the age of 20 days.

3.1.7 Røst

Tycho Anker-Nilssen

All the existing long-term data series on seabird survival, reproduction and chick diet in the Røst archipelago were updated in 2006 following well-established, standardised procedures (**Table 3.1.8**). The field work was divided on two field periods: 2.5-11.5 and 7.6-14.8. For the Atlantic puffin (**Figure 3.1.15**), the traditional monitoring of various other aspects of their breeding performance was also continued. A more extensive report with results for all species covered by the monitoring in Røst up to and including 2005 is given by Anker-Nilssen & Aarvak (2006). As brief reports are now included in the present series of SEAPOP annual reports, the more extensive reports for Røst will hereafter be updated less frequently.

In terms of population trends, 2006 was a positive year for most species monitored with only the northern fulmar decreasing in numbers from the previous year (**Table 3.1.8**). Although the study colony on Hernyken only supports a minor part of the fulmar population breeding in Røst, the steep decline observed here over the last decade is subjectively assessed as being reasonably representative of the situation for the species within the whole archipelago.

Figure 3.1.15
Adult Atlantic puffins attending the key-site colony at Hernyken in Røst (© Tycho Anker-Nilssen)

Table 3.1.8 *Key population parameters (SE, n) of seabirds in Røst in 2006. Population change is the numeric change in size of the breeding population registered between 2005 and 2006 on the basis of plot counts (p) or total censuses (t). For each species the listed survival estimate was derived from the model that fitted the data set best (i.e. the one with the lowest AICc value). The main kittiwake colony is on Vedøy (ca 12.400 pairs in 2006), whereas that on Kårøy is a relatively small (443 pairs), building-nesting population.*

Species	**Population change**	**Annual adult survival** Period (yrs)	Estimate	**Reproductive performance** Sampling unit	Estimate
Northern fulmar	– 13.9% p				
Great cormorant	+ 32.9% t			Clutch size [1]	2.41 (0.14, 93)
European shag	+ 1.5% p	2002-06 (4)	83.2% (1.5, 256)	Clutch size [2]	2.17 (0.03, 812)
Common eider	+ 3.35% p			Clutch size	3.84 (0.18, 50)
Great skua [3]	0.0% t			Breeding success	0.00 (0.00, 2)
Common gull				Clutch size	2.59 (0.13, 22)
Herring gull				Clutch size	1.85 (0.16, 26)
Great black-b. gull				Clutch size	2.27 (0.11, 45)
Black-legged kittiwake *Vedøy*	+ 0.7% p [5]			Large chicks/nest [5]	0.55 (*n*=462)
Black-legged kittiwake *Kårøy*	+ 51.6% t	2003-06 (3)	85.0% (2.3, 139)	Clutch size/pair Large chicks/pair Large chicks/nest [4]	1.78 (0.05, 135) 1.20 (0.09, 88) 1.07 (*n*=443)
Arctic tern				Clutch size	1.95 (0.11, 55)
Common guillemot	+ 143.7% p	No estimate yet possible [6]			
Razorbill	+ 225.0% p				
Atlantic puffin	+ 7.8% p	2004-05 (1)	91.8% (1.8, 436)	Fledging success	0.88 (*n*=57)
Black guillemot	*Data not analysed*	2005-06 (1)	70.4% (9.7, 74)	Clutch size Large chicks/clutch	1.85 (0.08, 20) 1.09 (0.25, 11)

1) On 19 June; minimum estimate (some clutches were still incomplete, while others had relatively large chicks); 2) On 1 July; estimated by linear regression of mean values for eight different counts between 4 July and 1 August; 3) Two pairs as in 2005; 4) Based on total counts; 5) Based on total counts in the study plots; 6) Monitoring of survival rates was initiated in 2005 by the colour-ringing of 69 adults, 22 of which were re-sighted in 2006.

After huge decreases to an all-time low for both species in 2005, common guillemots at Vedøy bounced back to their 2003-04 level while razorbill numbers rose to their highest level in ten years. The latter was mainly due to a large increase on one of the three cliff-faces monitored where disturbance from white-tailed eagles is judged to be least intensive. However, the total number of birds within the plots is nevertheless very low. Both cormorant species bred in record-high numbers, with the 93 pairs of great cormorants marking the 10-year anniversary of the establishment of the present Røst population. The Atlantic puffins increased in numbers for the fourth year in a row, and its total population was estimated at 466,700 occupied burrows, equalling 32.5% of the population size when the monitoring started in 1979.

The effort to monitor survival rate of common guillemots breeding in shelter under boulders on Hernyken, was continued by numerous visits distributed on 14 different days between 30 June and 9 August to observe birds that were colour-ringed in 2005. This proved more difficult than one could hope for, especially on the upper of the two main ringing sites. Only three of the 24 birds ringed there were seen in 2006, in sharp contrast to 19 of the 45 ringed on the lower site (χ^2_{corr}=5.07, df=1, p=0.024). A high-speed, high-resolution digital SLR camera (*Canon EOS 30D*: 5 fps, 8 Mpix) with a fast autofocus telephoto lens (*Canon EF 300 mm f/4 IS USM*) was an excellent aid in identifying birds that entered the colony too fast for identification by binoculars or spotting scope. The procedure is simply to take one or more snapshots of the

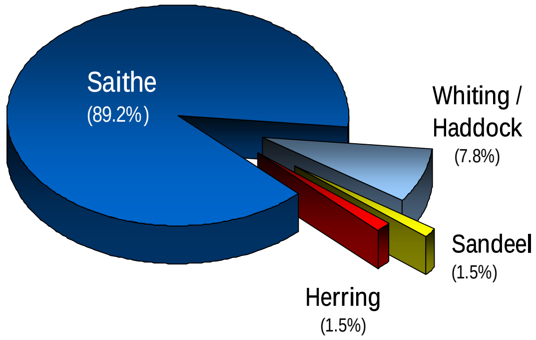


Figure 3.1.16
Diet (% by frequency) of common guillemot chicks at Hernyken in late July and early August 2006 (n=204). (Photo: Adult bringing a saithe. © Tomas Aarvak)

bird, view the picture(s) on the camera's LCD monitor, zoom in on the ring and read the code. This technique also proved very efficient for identifying colour-ringed European shags when scanning the colony from a small boat, which is a not a very good platform for using binoculars. It was also a good aid for identifying fish brought to the colony by the common guillemots (**Figure 3.1.16**). One of the three sandeels was collected and was identified as a great sandeel (*Hyperoplus lanceolatus*).

The puffins hatched their eggs at almost the same time as in 2005, i.e. about one week earlier than normal (Anker-Nilssen & Aarvak 2006). They fed their chicks mainly on first-year (0-group) herring (73.6% of the diet), but a significant proportion of the diet in late June consisted of lesser sandeels (**Figure 3.1.17**). Other prey (*n*=47) constituted nine species, but only 5.2% of the diet by mass. For comparison this is only half the number of prey species identified in the preceding poor season of 2005. The standard length index of the herring (*n*=908, length on 1 July calculated by regression on mean values for 5-day periods) was estimated at 54.4 mm and has only been higher in four of the 26 preceding years: in 1992 and in 2002-04. The mean sandeel size of 96.6 mm (*SE*=0.66, range 57-114, *n*=175) has only been higher in one year (1992). Food supply remained good to very good throughout most of the nestling period with a mean of 12.4 g (*SE*=0.39, range 1.6-22.6, n=114) and 9.8 fish per load (*SE*=0.39, range 1-25, *n*=114). The high fledging success of the puffin chicks (estimated at 88%, *n*=57) made 2006 the fifth good season in the last eight years, and the 11th good season in the last 32 years.

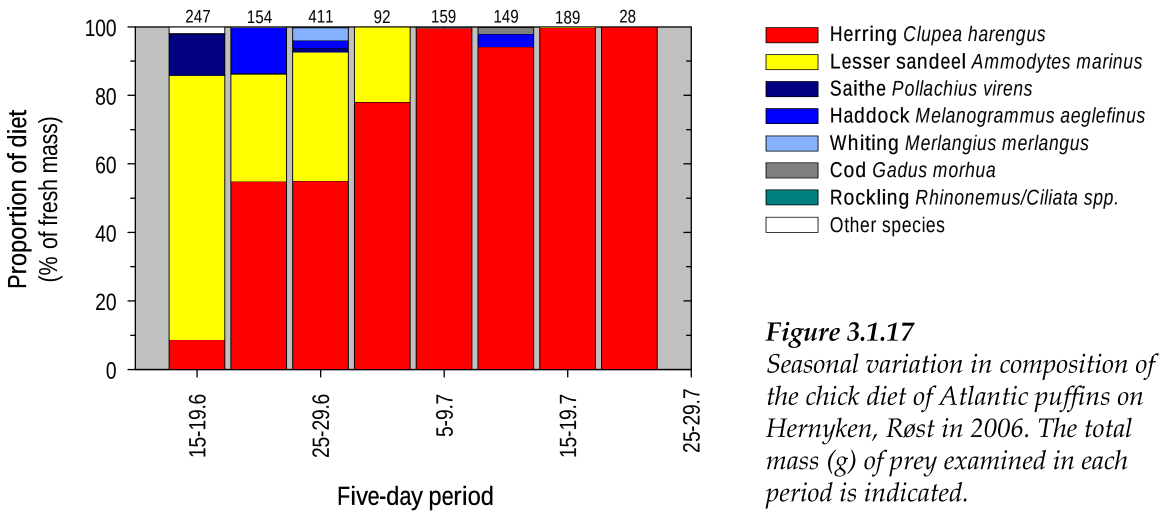


Figure 3.1.17
Seasonal variation in composition of the chick diet of Atlantic puffins on Hernyken, Røst in 2006. The total mass (g) of prey examined in each period is indicated.

Figure 3.1.18
The monitoring of survival rate in the black-legged kittiwake in Røst takes places in the colony nesting on buildings at the Kårøy Rorbucamp. The total population here in 2006 counted 343 pairs, with an additional 48 pairs on a small cliff just below the garden fence (seen to the left on the picture) outside the building with the most birds. (© Tycho Anker-Nilssen, 2006)

The breeding success of kittiwakes breeding on buildings on Kårøy (**Figure 3.1.18**) in the Røst harbour area was twice that of those breeding in the main cliff on Vedøy (**Table 3.1.8**). This illustrates the extreme effect of disturbance and predation from white-tailed eagles at Vedøy since the late 1990s (TAN et al. pers. obs.). A preliminary analysis shows that in 1981-97, when the mean daily number of eagles observed by the station crew during the field season varied between 2.4 and 5.2 birds (n=13 years), the mean success of kittiwakes on Kårøy was only 9% higher and insignificantly different from that on Vedøy (Mann-Whitney U=78, n_1=n_2=13, p=0.739). In sharp contrast, it has been exactly 100% higher and clearly significant in the last nine years (U=13, n_1=n_2=9, p=0.015), when the corresponding numbers of eagles observed ranged between 11.2 and 32.9 birds.

The annual survival estimate of 85.0% for kittiwakes at Kårøy over the study period 2003-2006 (**Table 3.1.8**), was close to an overall mean of 84.1% (range 80.1-89.6) for seven other colonies in the NE Atlantic (Frederiksen *et al.* 2005, updating results for Hornøya after Sandvik *et al.* 2005). When introducing sex as a grouping factor (which reduces sample size to 105 individuals), the model with no group effect but a year effect in survival is significantly better than that without any group or year effects (χ^2=5.62, df=1, p=0.018) and estimates survival rates of 96.7% (SE=3.4), 80.3% (SE=4.9) and 83.5% (SE=4.1) in the three time steps. Even the model with a sex effect and no year effect, which indicates male survival (86.3%, SE=3.3, n=57) is higher than that of females (82.4, SE=4.2, n=48), fits the data set better, but not significantly better, than the simplest model with constant survival and recapture rates (χ^2=0.542, df=1, p=0.462).

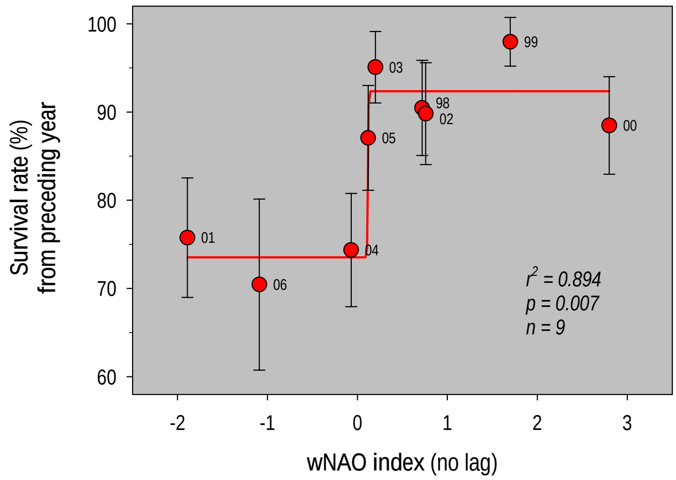


Figure 3.1.19
The relationship between annual survival rates of adult black guillemots on Hernyken and the NAO index in the concurrent winter. The last year of each time step is indicated for each plot (1998-2006).

Survival rates of European shags have remained relatively stable on Røst over the four-year study period, and the updated estimate is close to that documented in many other parts of the species' breeding range (e.g. Harris *et al.* 2000). The estimated survival rate of 91.8% for the Atlantic puffins between 2004 and 2005 is not corrected for "trap happiness" (and therefore slightly underestimated), but again very close to the overall mean for this population and four other European colonies in 1990-2002 (range 91.5-93.5%, Harris *et al.* 2005). In contrast to the puffins and shags, the survival rate of black guillemots dropped to its lowest level ever. Although this 9-year data set only comprises 74 individual birds, their survival shows a remarkable threshold relationship with the North Atlantic Oscillation (NAO) (**Figure 3.1.19**). The sigmoid model estimates that the mortality of adults is 3-4 times higher in the winters with a negative NAO index than in the positive years (above the threshold).

3.2 Extensive monitoring of black-legged kittiwakes

Kjell Einar Erikstad & Geir Helge Systad

Seabirds at high latitudes experience a highly variable environment. This variability will affect them in many ways, probably most significantly by altering their foraging success, and will have important consequences for vital demographic parameters such as reproduction and survival. One important assumption for the selection of key-sites in the SEAPOP program is to distinguish natural population trends from human impact like oil spills and fisheries. To achieve this we monitor the diet, breeding success, adult survival rate and population trends (in a few cases also recruitment rates) of a selection of species on a few key-sites. The aim is to have 3-4 such sites in each sea region (Anker-Nilssen et al. 2005), such as those already established in the Lofoten-Barents Sea area (cf. **Chapter 3.1**)

In order to test to what degree the key-site populations are representative for the species over a larger area, we have established a more extensive monitoring of one species, the black-legged kittiwake (**Figure 3.2.1**). The kittiwake is the only seabird which breeds in large numbers over the whole Barents Sea area, where it is distributed in both small and large colonies with highly variable population trends documented in different areas (Lorentsen 2006). As both its population development and reproductive rates can be monitored more cost-efficiently than for most other seabirds, this species is ideal for studying how environmental variability at

Figure 3.2.1
The black-legged kittiwake is the only seabird species which breeds in large numbers in the whole Barents Sea area. It is therefore a good model species for studying how the variability in the marine ecosystem affects the populations at various spatial scales. The ring combination (a light blue above two grey rings) identifying this adult is visible, as is just barely the white letter-coded colour ring of one of its chicks. (© Kjell Einar Erikstad)

different spatial scales in the marine ecosystem affects vital demographic parameters of a top predator. Such knowledge is of crucial importance for interpreting the temporal population dynamics observed at the key-sites and will also increase our understanding of how variability in the Barents Sea ecosystem might affect other populations at various scales.

Another important aspect of seabird population dynamics, which is not possible to study at the key-sites, is the dynamics of neighbouring populations. The exchange or, more precisely, dispersal of birds among colonies in a variable environment may greatly enhance the viability of a species within a given area, even when populations are strongly declining. However such an effect depends to a large extent on the rate of covariance in the growth rates among colonies (cf. **Chapter 2.1**).

To study the dynamics of kittiwake populations we selected 95 extant colonies and 32 extinct colonies in seven different regions from Lofoten to eastern Finnmark (**Figure 3.2.2**). The selection of extinct colonies will enable us in the future to study the possible re-colonization of these sites. The sizes of the extant colonies vary form a few pairs (< 10) to very large colonies (> 100,000 pairs). Each of the colonies was visited twice during the 2006 breeding season. We recorded the following parameters: 1) colony size, 2) timing of breeding, 3) clutch size, and 4) number of large chicks (assumed to fledge) per nest.

Although we have only one year of data so far, preliminary results may suggest there were some trends in breeding success. The mean number of potential fledglings appeared to be higher in large than in small colonies, and higher in Nordland and Troms than in Finnmark (**Figure 3.2.3**). Based on data from the National monitoring program for seabirds, the Norwegian population of black-legged kittiwake has declined severely since 1980 and there are indications that this trend has accelerated since the mid 1990s (Barrett et al. *in press*). For instance the number of breeding pairs in monitoring plots on the key-sites Runde, Vedøy (Røst), Hjelmsøya and Hornøya dropped by 75%, 50%, 75% and 50% respectively between the early 1980s and 2005. Little is known about the direct causes of these declines, but in the eastern part of Finnmark the instability (including several collapses) and general decline in the

Barents Sea capelin stock may have contributed to this negative trend. Another possible factor is the increasing harassment and predation of chicks caused by the increasing population of white-tailed eagles.

Most studies of seabird demography have been confined to single colonies. However, the multi-scale approach in this project is the only possible way to uncover the spatial dynamics of reproductive success and population trends in relation to oceanographic changes and variation in abundance of important prey species. Being one of the very first empirical studies to address such interactions, we are confident that the results of this extensive monitoring project will greatly improve our future opportunities to predict how kittiwake as well as other seabirds in this area is affected by a changing marine environment.

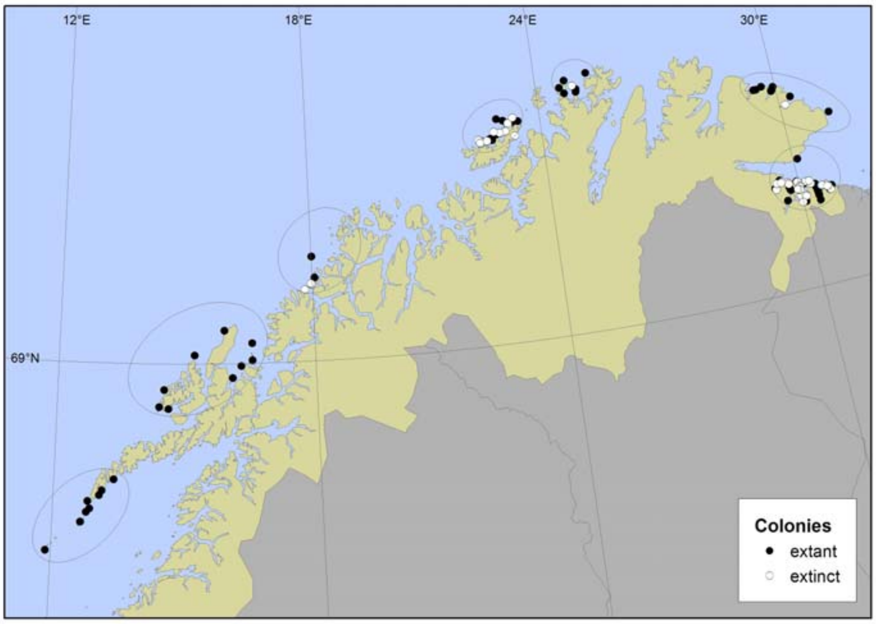


Figure 3.2.2
The distribution of extant and extinct breeding colonies of black-legged kittiwakes selected for extensive monitoring in the Lofoten-Barents Sea area.

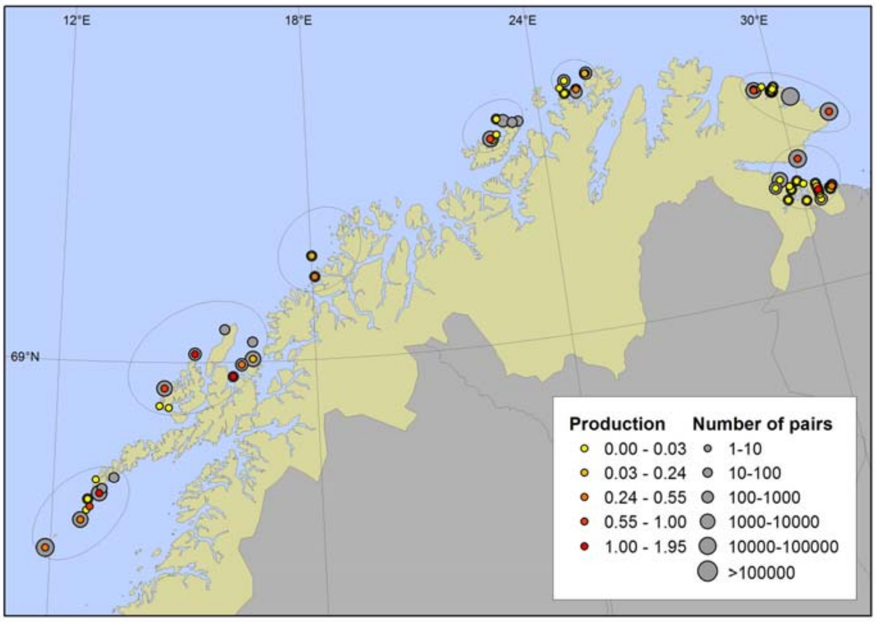


Figure 3.2.3
The colony sizes of the extant study colonies of black-legged kittiwakes in the Lofoten-Barents Sea area and the mean number of chicks per nest surviving to near fledging in 2006.

3.3 Expanded monitoring of wintering seabirds in mainland Norway

Geir Helge Systad & Jan Ove Bustnes

One aim of SEAPOP is to provide better monitoring data for coastal seabirds, especially on the outer coast. The regular Norwegian winter surveys within the SEAPOP area comprised only three areas from Vesterålen to Varangerfjord (**Figure 3.3.1**). To improve the coverage, we selected three regions for the expanded winter surveys; Troms, western Finnmark and eastern Finnmark. The areas were selected based on their accessibility by roads since we depend on efficient time use. This project was started in 2005, and in 2006 all counts were carried out in late February and early March.

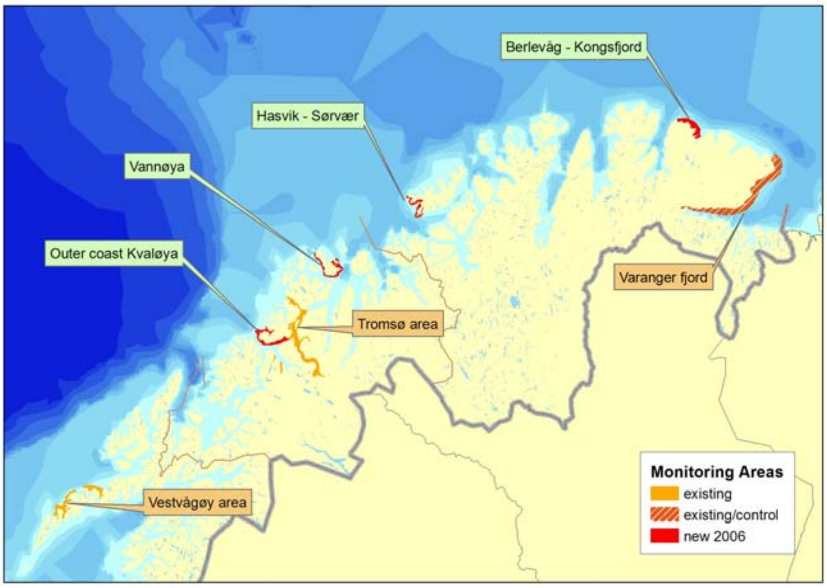


Figure 3.3.1
Monitoring areas of wintering seabirds in the Lofoten-Barents Sea area. The new areas established in 2006 are indicated in red.

In Troms, two areas were surveyed; the outer part of Kvaløya and the south coast of Vannøya (**Figure 3.3.1**). Altogether 2183 seabirds of 13 species were observed in the Kvaløya zone and 2691 seabirds of 11 species at Vannøya, with a dominance of gulls and eiders (**Table 3.3.1**).

In western Finnmark, the area between Hasvik and Sørvær on Sørøya was surveyed (**Figure 3.3.1**). The number of seabirds in this area was 5422 individuals of 17 species with a dominance of kittiwakes and king eiders (*Somateria spectabilis*), in addition to many common eiders and large gulls (**Table 3.3.1**).

In eastern Finnmark, we surveyed the area between Berlevåg and Kongsfjord (**Figure 3.3.1**). On this coastline, we observed 6106 seabirds of 24 species, with a dominance of king eiders and common eiders (**Table 3.3.1**). In addition, a survey was carried out in Varangerfjord. The count results totalled 11531 individuals of 19 species, and the dominating species were common eider, Steller's eider (*Polysticta stelleri*) and king eider. The number of Steller's eiders, which is listed as vulnerable on the Norwegian red-list (Gjershaug et al. 2006), was lower than in previous years.

***Table 3.3.1** Summary of results (in descending order of abundance) of seabird counts in the new monitoring areas for wintering seabirds in northern Norway. The counts were conducted in March 2006. Note that the Varangerfjord area was surveyed as a comparison to the ongoing monitoring in that area. This area is much larger than, and thus not directly comparable with, the other areas.*

Common name	Scientific name	Kvaløya	Vannøya	Sørvær – Hasvik	Berlevåg – Kongsfjord	Varanger-fjord	Total
Common eider	*Somateria mollissima*	1144	864	301	1989	4580	8878
Herring gull	*Larus argentatus*	654	1224	2600	68	495	5041
King eider	*Somateria spectabilis*	3	47	720	1843	1149	3762
Steller's eider	*Polysticta stelleri*				219	3430	3649
Unidentified large gull	*L. argentatus/L. marinus*			615	1000		1615
Black-legged kittiwake	*Rissa tridactyla*		21	483	537	146	1187
Great black-backed gull	*Larus marinus*	69	382	448	17	175	1091
Long-tailed duck	*Clangula hyemalis*	14		2	87	588	691
Purple sandpiper	*Calidris maritima*	50				363	413
Common scoter	*Melanitta nigra*	33			32	237	302
Great cormorant	*Phalacrocorax carbo*	63	72	61	33	29	258
European shag	*Phalacrocorax aristotelis*		5	43	92	110	250
Red-breasted merganser	*Mergus serrator*	55	64	9	38	80	246
Black guillemot	*Cepphus grylle*		4	72	111	31	218
Mallard	*Anas platyrhynchos*	74	7	21		46	148
Velvet scoter	*Melanitta fusca*	13		1	2	51	67
Unidentified cormorant	*Phalacrocorax* sp.			32		8	40
Common guillemot	*Uria aalge*				16		16
Grey heron	*Ardea cinerea*	10					10
White-tailed eagle	*Haliaeetus albicilla*			10			10
Glaucous gull	*Larus hyperboreus*		1	3	3	2	9
Northern gannet	*Morus bassanus*				7		7
Red-throated diver	*Gavia stellata*				1	6	7
Unidentified auk	Alcidae				5		5
Atlantic puffin	*Fratercula arctica*					5	5
Razorbill	*Alca torda*				2		2
Iceland gull	*Larus glaucoides*			1	1		2
White-billed diver	*Gavia adamsii*	1			1		2
Norhern fulmar	*Fulmarus glacialis*				1		1
Black-throated diver	*Gavia arctica*				1		1
Total		2183	2691	5422	6106	11,531	27,933

3.4 Mapping of seabird distribution on the coast

3.4.1 Distribution of seabirds on Bjørnøya

Hallvard Strøm

In Svalbard, mapping priority in 2006 was given to Bjørnøya (Bear Island). Bjørnøya is situated midway between mainland Norway and the southern tip of Spitsbergen (**Figure 3.4.1**).

The last total census of breeding seabirds on the island was conducted in 1986-87 (Bakken & Mehlum 1988). Bjørnøya is known to support some of the largest seabird colonies in the Barents Sea region, and is a very important breeding site for guillemots. The island represents the northern limit of the European distribution of razorbill and common guillemot and the southern limit of the distribution of glaucous gull and little auk. The island is probably the only place in the world where large numbers of all six Atlantic alcids breed together.

Figur 3.4.1
Bjørnøya (Bear Island).
(© Norwegian Polar Institute)

The fieldwork for the 2006 census was carried out from 10 June to 1 August. Six teams, each of two persons operating from land or from Zodiac rubber boats (**Figure 3.4.2**), took part in the census. The coastline was covered systematically and general methods followed Walsh et al. (1995). Priority was given to cliff-breeding seabirds and gulls, but coastal, ground-nesting species were also included in the survey. As part of a project financed by the Governor of Svalbard, two additional field teams surveyed the inner part of the island for breeding great northern diver (*Gavia immer*) and other wetland/freshwater bird species. Preliminary population estimates of the more typical seabird species covered are presented in **Table 3.4.1**.

Table 3.4.1 *Species, counting units and estimated numbers (preliminary results) of seabirds breeding on Bjørnøya (Bear Island) in 2006.*

Common name	Scientific name	Counting unit	Total
Northern fulmar	*Fulmarus glacialis*	Apparently occupied nest site	30,000
Great skua	*Stercorarius skua*	Apparently occupied territories	350
Glaucous gull	*Larus hyperboreus*	Apparently occupied nest	650
Great black-backed gull	*Larus marinus*	Apparently occupied nest	6
Black-legged kittiwake	*Rissa tridactyla*	Apparently occupied nest	130,000
Arctic tern	*Sterna paradisaea*	Apparently occupied nest	50
Common guillemot	*Uria aalge*	Individual on breeding site	125,000
Brünnich's guillemot	*Uria lomvia*	Individual on breeding site	185,000
Razorbill	*Alca torda*	Adult on breeding site	30
Black guillemot	*Cepphus grylle*	Individual on breeding site	500
Atlantic puffin	*Fratercula arctica*	Individual on breeding site	600
Little auk	*Alle alle*	Not censused	Several colonies

Preliminary analysis indicates that compared to the survey conducted in 1986-87, the northern fulmar, black-legged kittiwake and Brünnich's guillemot have increased their population size by 20-50%. The breeding population of the glaucous gull has, in the same period, declined by 65%, from ca. 2000 breeding pairs in 1986 to ca. 650 pairs in 2006. The common guillemot population is still less than 50% of that counted prior to the collapse in winter 1986/87. A more thorough analysis of the results will be made available on the SEAPOP web site in late 2007.

Figure 3.4.2
One of the field-teams when approaching Bjørnøya (Bear Island) on 10 June 2006. The 30 m high steep cliffs which are typical of the island's northern coastline, are seen in the background. (© Hallvard Strøm)

3.4.2 Distribution of seabirds on the mainland coast

Geir Helge Systad & Jan Ove Bustnes

The aim of the 2006 data collection was to continue the mapping of the breeding distribution and occurrence of coastal seabirds in the area from Lofoten to the Russian border. In 2006, we restricted our counts to east Finnmark, between Laksefjord and the Russian border, due to financial restraints.

We used three complimentary methods of gathering data: 1) aerial surveys of the coast, 2) visits to colonies by boat and 3) ground counts. The whole coastal strip was covered from the air, including the fjords and islands, and afterwards the smaller seabird colonies in most of the area were surveyed from boats (counting teams based on coast guard vessels or zodiacs). The aerial surveys were based on flights at 150 m a.s.l. and at 150 km/h. All birds observed were recorded on tape and their GPS positions were noted. Only breeding birds were counted, except from moulting goosanders (*Mergus merganser*). Counting units were adult males for common eiders, number of individuals in breeding area for terns and black guillemot, and apparently occupied nests for the other species. Whenever large flocks or breeding aggregations of birds were encountered, photographs were taken and later counted. The counts from photographs have been completed, apart from larger seabird colonies. The data collection was undertaken from 23 May to 16 June.

The Lofoten and Vesterålen area will be surveyed in 2007. Moreover, surveys of large seabird aggregations, i.e. large colonies of Atlantic puffins, common guillemots, and black-legged kittiwakes, outside the key sites, will start in 2007.

***Table 3.4.2** Species, counting units, numbers of colonies/localities and total counts of seabirds breeding in Troms and Finnmark in 2005 and 2006. Non-breeding goosanders are also presented in the table. Some of the larger colonies are not included in the counts, and will be surveyed in 2007-2008.*

Common name	Scientific name	Counting unit	No. of localities	No. of birds
Great cormorant	*Phalacrocorax carbo*	Apparently occupied nest	108	8,560
Common eider	*Somateria mollissima*	Male in breeding area	581	17,765
Goosander	*Mergus merganser*	Non-breeding individual	137	4,034
Arctic tern	*Sterna paradisaea*	Adult in breeding area	103	15,059
Common gull	*Larus canus*	Apparently occupied nest	199	2,489
Herring gull	*Larus argentatus*	Apparently occupied nest	514	30,517
Great black-backed gull	*Larus marinus*	Apparently occupied nest	723	15,229
Black-legged kittiwake	*Rissa tridactyla*	Apparently occupied nest	175	118,606

Results

Selected results from the mapping are presented in **Table 3.4.2** and **Figures 3.4.3-3.4.4**. Troms and Finnmark were almost completely covered in 2005 and 2006, except for the larger seabird colonies. Overall 438,313 birds were observed, distributed among more than 7500 sites. The dominant species recorded are presented in Table 5.1. The most numerous species were black-legged kittiwake (more than 100,000 pairs), common eider (17,765 males) and herring gull (30,517 pairs). The distributions of kittiwake and large gull concentrations are shown in **Figure 3.4.3** and those of common eiders and great cormorants in **Figure 3.4.4**.

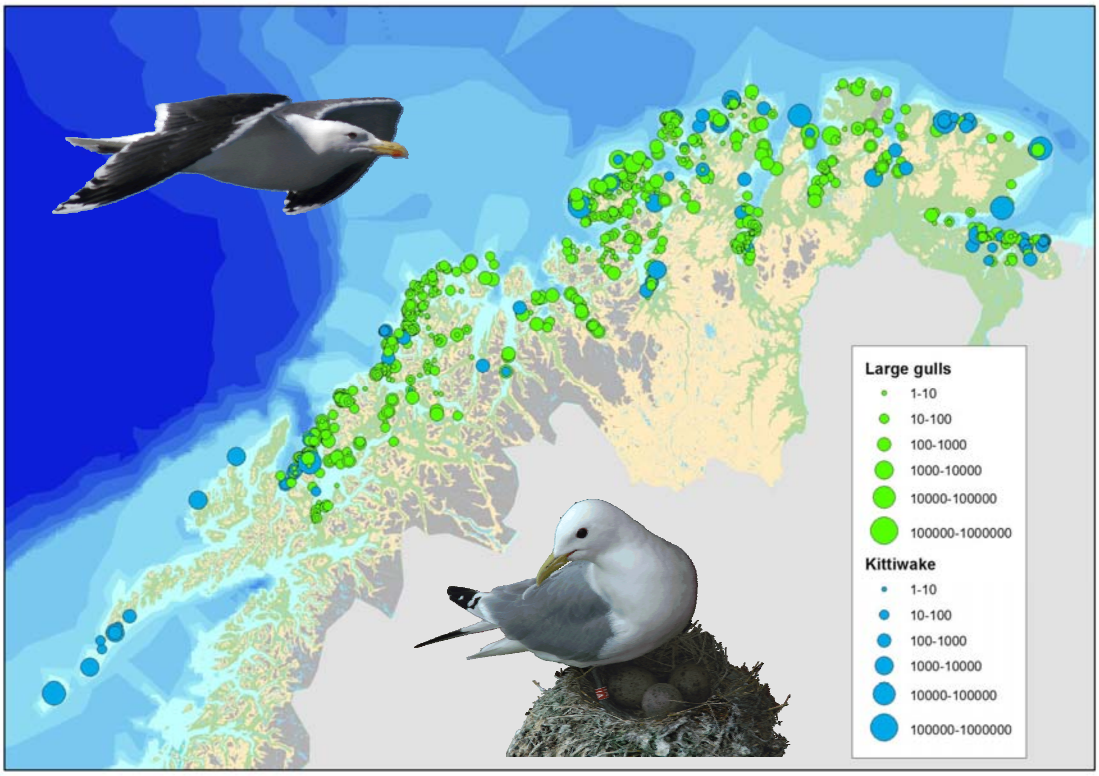


Figure 3.4.3
The distribution of breeding kittiwake and large gulls (herring and great black-backed gull) in Troms and Finnmark in 2005 and 2006. The largest colonies will be counted in 2007-2008 and are not included. (Inserted photos © Tycho Anker-Nilssen)

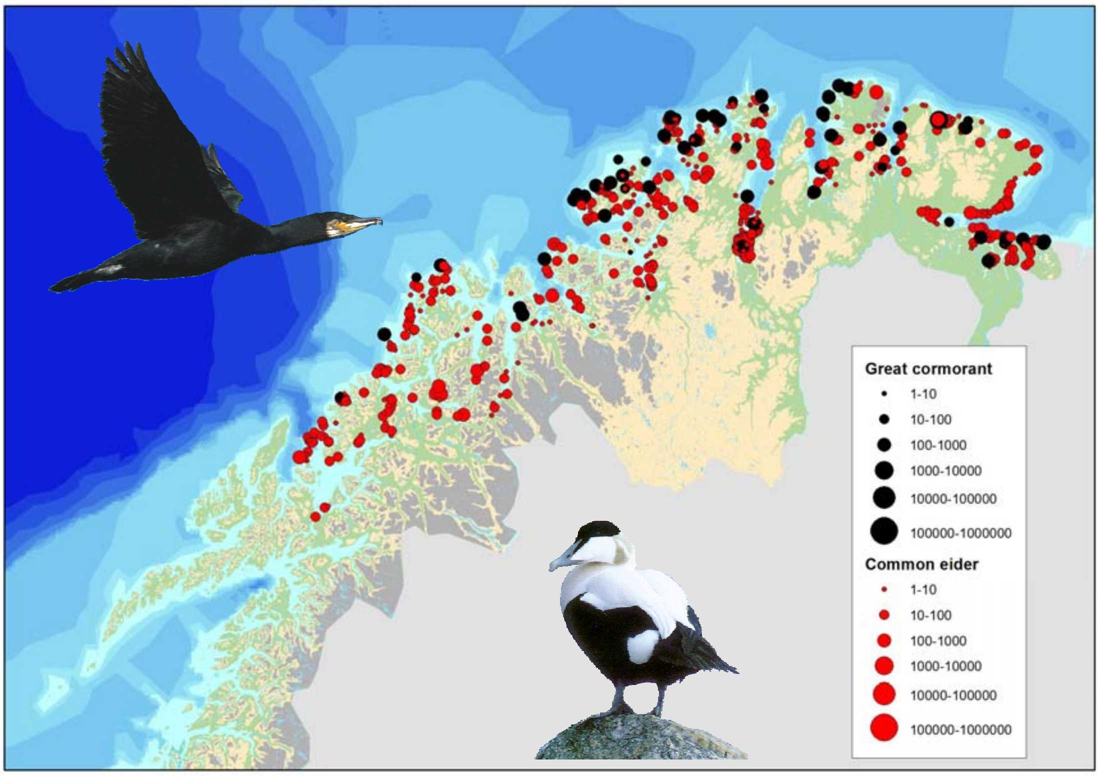


Figure 3.4.4
The distribution of breeding common eiders and great cormorants in Troms and Finnmark in 2005 and 2006. (Inserted photos © Tycho Anker-Nilssen)

3.5 Census techniques for large bird cliffs

Duncan Halley & Svein-Håkon Lorentsen

Seabirds are important environmental indicators of the health of the ocean environment. Their habit of breeding in often huge colonies makes their populations (often) relatively easy and inexpensive to monitor, compared to most other elements in the oceanic ecosystem. For these reasons, much work has been done over the years in developing methods to systematically monitor seabird populations (e.g. Walsh et al. 1995). However, these methods are not always directly applicable for making estimates (censuses) of entire seabird populations, or are published in widely scattered scientific papers which are not readily accessible to most fieldworkers. Furthermore, seabirds breed in colonies which may not be directly accessible for fieldworkers (**Figure 3.5.1**) such that estimates of total populations have to be made based on different methods, often using estimates of breeding density and colony area.

For this reason, SEAPOP is developing a seabird censusing (and monitoring) manual intended primarily for use within the SEAPOP programme, but it may also be useful more widely. The manual is intended to provide fieldworkers with a practical, step-by-step guide to how to carry out a scientifically rigorous censusing of the main seabird species in the programme. This will result in fewer difficulties in comparing results reported to SEAPOP from the different fieldworkers. The manual will outline methods for population censusing (and monitoring) of storm petrels, fulmars, gannets, great cormorants, shags, skuas, gulls, terns and auks.

Figure 3.5.1
Seabirds often breed in steep cliffs that are not accessible for fieldworkers and where population sizes have to be estimated from a distance using different methods. This cliff at Hjelmsøya in Finnmark is about 200 m high and contains breeding Atlantic puffins and common guillemots (© Svein-Håkon Lorentsen)

3.6 Ecosystem surveys at sea

Per Fauchald

In 2006, data on seabirds at sea was collected during three major ecosystem surveys in the Barents and Norwegian Seas. In Norway, these surveys involve several research vessels operated and coordinated by the Institute of Marine Research (IMR). Ecosystem surveys are multi-discipline surveys where several physical and biological parameters are monitored simultaneously, including oceanography, plankton, bottom and pelagic fish, sea mammals and seabirds. Seabird observers were coordinated and financed by the SEAPOP program and the Norwegian Research Council (NFR). Synoptic measures of several parameters during the surveys make it possible to investigate how the different components of the ecosystem are temporally and spatially interrelated. Of specific interest to SEAPOP is the spatial distribution of seabirds and how the abundance and distribution of seabirds are related to important prey species and oceanography. Data on seabirds and oceanography are used to generate predictive models of the distribution of seabirds, which are described in more detail in **Chapter 2.3**. These maps are used by the oil industry in environmental risk assessments.

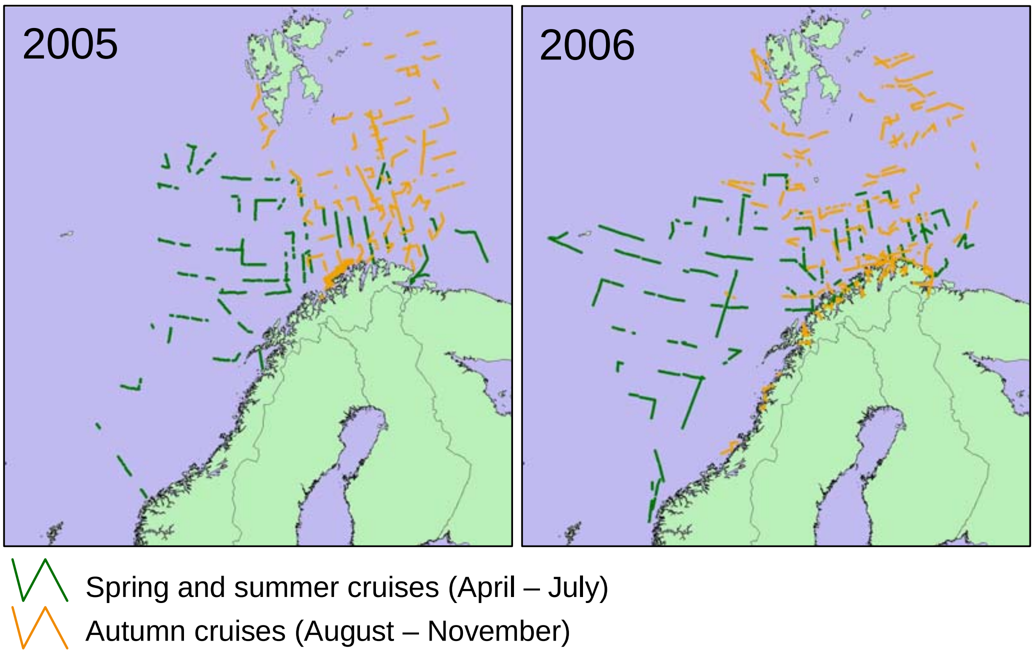


Figure 3.6.1
Coverage of surveys of seabirds in 2005 and 2006.

From 1986-1994, the Barents Sea was extensively covered in winter. In the first two years of SEAPOP, we have therefore concentrated on the spring, summer and autumn seasons. In 2006, we participated in IMR's regular ecosystem surveys in the Barents Sea and the Norwegian Sea covering a total transect length of 13,134 km equivalent to an area of 3940 km^2 (**Table 3.6.1** and **Figure 3.6.1**). The average densities of different seabird species observed in 2005 and 2006 are summarised in **Table 3.6.2**. Despite standardised methodology and similar coverage, the observed density of some of the species differed markedly between the two years. These changes are probably due to changes in stocks of prey species and/or changes in physical oceanography. At present the data series are too short to make any clear inferences, but the design and continuity of the ecosystem surveys will make it possible to scrutinise such relationships in the future.

Table 3.6.1 *Seabird surveys as a part of the marine ecosystem surveys conducted by the Institute of Marine Research in the Norwegian and Barents Seas in 2006.*

Period	Vessel	Time period	Survey	Seabird survey	Total transect length (*km*)
Spring & summer	G.O. Sars	27 Apr – 31 May	Norwegian Sea Ecosystem, IMR	SEAPOP	4,626
	Johan Hjort	24 May – 10 Jun	Barents Sea, IMR	SEAPOP	1,385
Autumn	Jan Mayen	8 Aug – 15 Aug	Barents Sea Ecosystem, IMR	SEAPOP	701
	G.O. Sars	19 Aug – 19 Sep	Barents Sea Ecosystem, IMR	SEAPOP	2,748
	Johan Hjort	16 Aug – 18 Sep	Barents Sea Ecosystem, IMR	NFR	2,334
	G.O. Sars	24 Oct – 13 Nov	Norwegian Sea Ecosystem, IMR	SEAPOP	1,340
Sum					13,134

Table 2.6.2 *Mean densities of seabirds (individuals/km²) during surveys in 2005 and 2006.*

Common name	Scientific name	Spring and summer		Autumn	
		2005	2006	2005	2006
Northern fulmar	*Fulmarus glacialis*	3.304	10.788	17.385	31.986
Sooty shearwater	*Puffinus griseus*	0	0	0.080	0.008
Manx shearwater	*Puffinus puffinus*	0	0	0	> 0
European storm-petrel	*Hydrobates pelagicus*	> 0	> 0	0	0
Northern gannet	*Morus bassanus*	0	0	0	0.014
Great cormorant	*Phalacrocorax carbo*	0	0.004	> 0	0.007
European shag	*Phalacrocorax aristotelis*	0	> 0	0.001	0.002
Common eider	*Somateria mollissima*	0	0.003	0	0.004
Long-tailed duck	*Clangula hyemalis*	0.013	0.014	0	0.002
Common scoter	*Melanitta nigra*	0	0	>0	0
Pomarine skua	*Stercorarius pomarinus*	0.122	0.214	0.085	0.426
Arctic skua	*Stercorarius parasiticus*	0.029	0.029	0.124	0.053
Long-tailed skua	*Stercorarius longicaudus*	0.069	0.043	0.007	0.007
Great skua	*Stercorarius skua*	0.042	0.024	0.029	0.005
Common gull	*Larus canus*	0	0.009	0	0.015
Lesser black-backed gull	*Larus fuscus*	0.068	0.130	0	0.008
Herring gull	*Larus argentatus*	0.368	2.738	1.968	1.933
Iceland gull	*Larus glaucoides*	0.011	0	0	0
Glaucous gull	*Larus hyperboreus*	0.363	0.143	0.129	1.315
Great black-backed gull	*Larus marinus*	0.323	1.427	1.618	0.204
Black-legged kittiwake	*Rissa tridactyla*	2.802	9.101	8.709	14.408
Arctic tern	*Sterna paradisaea*	0.095	0.037	0.025	0.017
Common guillemot	*Uria aalge*	0.108	0.049	0.090	0.051
Brünnich's guillemot	*Uria lomvia*	0.330	0.068	1.527	1.351
Unidentified Guillemot	*Uria aalge/Uria lomvia*	0.094	0.201	0.154	0.166
Little auk	*Alle alle*	0.045	0.013	0.044	0.207
Black guillemot	*Cepphus grylle*	0.004	0.006	0.005	0.016
Razorbill	*Alca torda*	0.044	0.024	0.020	0.014
Atlantic puffin	*Fratercula arctica*	0.418	0.321	0.882	0.348

3.7 Operationalisation of results

3.7.1 The SEAPOP Web

Hallvard Strøm, Svein-Håkon Lorentsen & Tycho Anker-Nilssen

The SEAPOP Web (www.seapop.no) is the primary line of communication from the research institutions to the partners involved in the programme. All data and information which is collected through the various SEAPOP projects will be presented on the web in the most relevant formats for the different users groups targeted by the programme, and technical reports will be downloadable as PDF documents. This structure will not only ensure that everyone gets the same information, but the access to new, updated and quality-controlled results will be immediate and the information can be standardised in such a way as to be most useful for all involved. As the major share of this information will be freely available as maps, tables, figures and text, we also hope it will be of interest for educational purposes and to the general public.

The work in 2006 focused on the establishment of the web site, producing text and to develop the map services (**Chapter 3.7.2**). The web page is now published, and although it is still far from complete, it already presents some of the data and results generated by the programme and associated projects. This includes, among other things, data on the coastal and at sea distribution of seabirds, time series data on the development of breeding and wintering populations, time series data on the demography and diet of breeding populations, and data on habitat use and vulnerability of seabirds. The web site will also contain up-to-date lists of all projects and publications associated with the programme and information on the partners and sponsors. As the tool for managing the web content we have chosen the software *Plone* (http://plone.org/foundation) and the maintenance of the site is shared between a web master and the project leaders of the various SEAPOP projects.

Figure 3.7.1
Screenshot of the SEAPOP Web frontpage (www.seapop.no). Most of the text is presently in Norwegian, but an English version will be developed in near future.

3.7.2 The SEAPOP Database and web-map services

Frank Hanssen, Svein-Håkon Lorentsen & Tycho Anker-Nilssen

All data collected by the various SEAPOP projects will be made available on the SEAPOP Web (www.seapop.no), which is the primary line of communication from the research institutions to the partners involved in the programme (**Chapter 3.7.1**). A fundamental basis for managing the data on seabird distribution is a common central database, the SEAPOP Database, which is updated regularly with quality-controlled data from the Norwegian Seabird Database (administered by NINA) and the Colony Database (administered by NP). Through a close co-operation with the SEAPOP steering committee and with feedback from other institutions experienced in the use of such data, specific needs for downloadable maps and tables of data have been identified. The main access to these products is organised through the development of three different applications (**Figure 3.7.2**) specified in more detail below. Note that all dialogues between the user and the database and map modules are currently only provided in Norwegian.

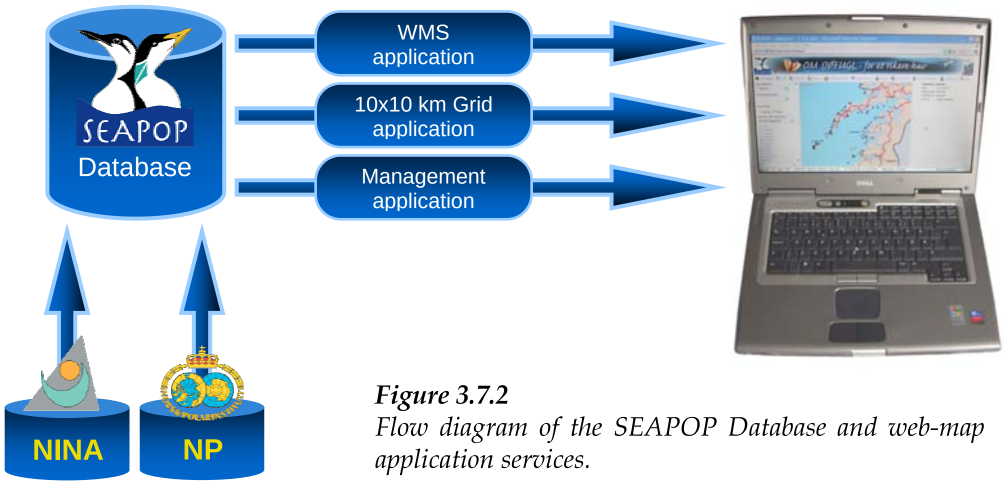


Figure 3.7.2
Flow diagram of the SEAPOP Database and web-map application services.

1. The WMS application

This application offers a large number of predefined maps of seabird distribution along the coasts of Norway and Svalbard in the summer (breeding) and winter periods. The maps are created using Web Map Services (WMS, based on OGC version 1.1.1), which enables distribution patterns of various species (organised as WMS layers) and accompanying information to be accessed from the user's own applications. The maps and metadata can therefore be combined interactively with a high degree of subjectivity in terms of species and spatial resolution (**Figure 3.7.3**). In addition to single-species maps, maps of predefined ecological groups can also be selected. The WMS application is a public service freely open for all users.

Note that the WMS-service is also available for use in external GIS by using the getCapabilities at http://wms.nina.no/SEAPOP/wms.aspx?SERVICE=wms&VERSION=1.1.1&REQUEST=getCapabilities.

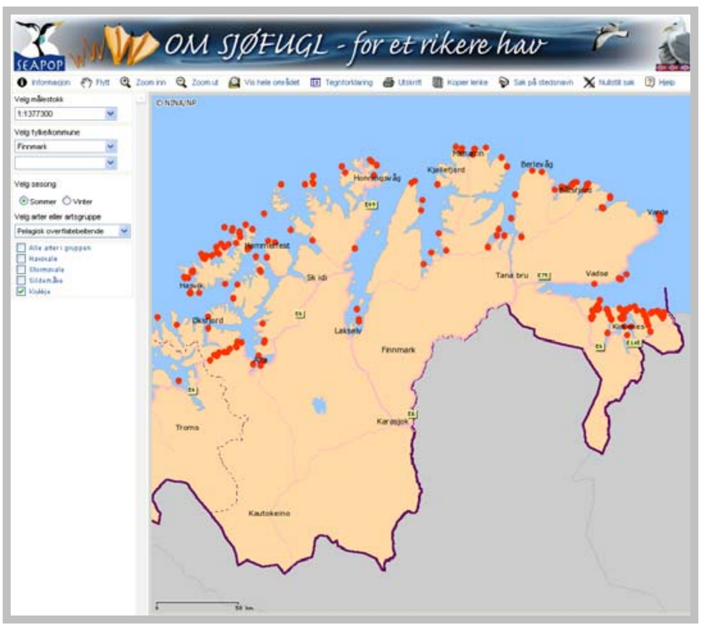


Figure 3.7.3
Example of a distribution map using the WMS application. The map indicates all localities in Finnmark county where black-legged kittiwakes are found in the breeding season.

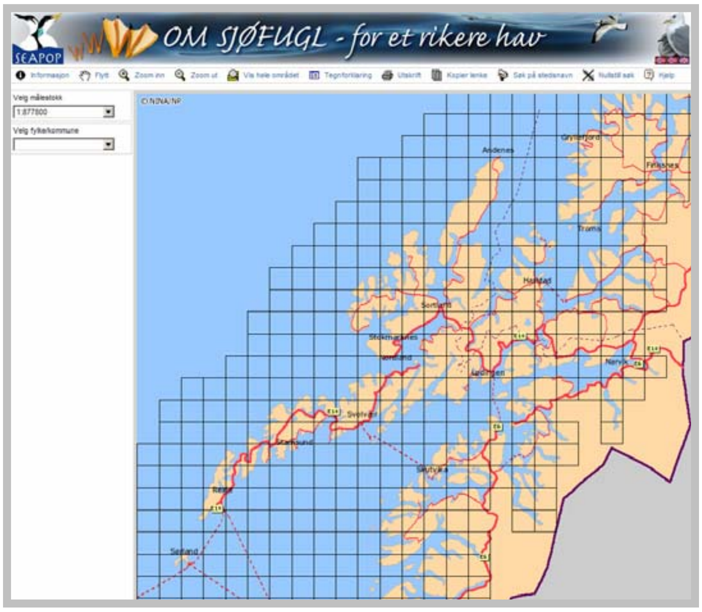


Figure 3.7.4
Example of a (empty) 10x10 km grid map covering the northern part of Nordland county.

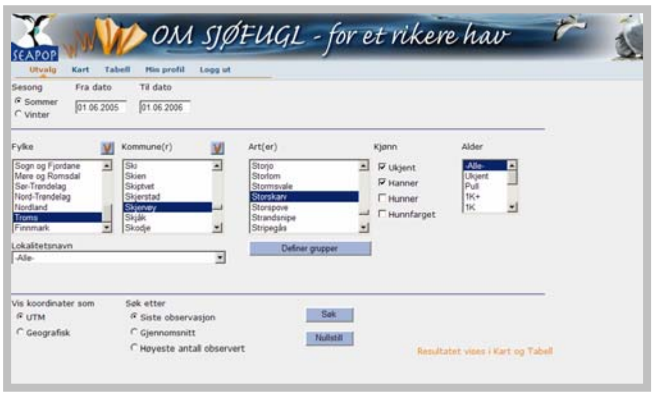
2. The 10x10 km Grid application

From this application, the user get access to maps and tables of relative seabird densities during the breeding and wintering periods, distributed in a predefined 10x10 km grid (**Figure 3.7.4**). Through a map-based interface, the user can select the set of grid-cells that covers the geographical area of interest, and download the relative distribution data of selected seabird species or ecological seabird groups as ESRI Shapefiles for use in own GIS systems. This application is also freely open for all users.

3. The Management application

From this application, maps and data tables infinitely scalable to cover everything from the national, county or municipality level down to any single locality (the smallest spatial scale of the database) can be created and exported. Through predefined search forms (**Figure 3.7.5**) it enables user-specific generation of maps and tables with full access to all quality-controlled "raw data" stored in the SEAPOP database. The application is designed specifically for use by the environmental management authorities and requires a signed agreement for data use.

Figure 3.7.5
The on-line search form in the management application (in Norwegian) where the user selects according to 1) season (summer or winter) or time interval, 2) preferred county and one, several or all municipalities, 3) species or ecological species groups, and (optional) 4) the sex and/or age of the birds. Positions can be tabulated as UTM or geographical coordinates, and counts can be displayed as either the latest observation (default), the mean of all observations, or the maximum number observed on each locality.



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Appendix 1 English, scientific and Norwegian names of species

The English, scientific and Norwegian names of all bird species mentioned in this report are listed in the following table.

Common name	Scientific name	Norwegian name
Red-throated diver	*Gavia stellata*	Smålom
Black-throated diver	*Gavia arctica*	Storlom
Great northern diver	*Gavia immer*	Islom
White-billed diver	*Gavia adamsii*	Gulnebblom
Northern fulmar	*Fulmarus glacialis*	Havhest
Sooty shearwater	*Puffinus griseus*	Grålire
Manx shearwater	*Puffinus puffinus*	Havlire
European storm-petrel	*Hydrobates pelagicus*	Havsvale
Northern gannet	*Morus bassanus*	Havsule
Great cormorant	*Phalacrocorax carbo*	Storskarv
European shag	*Phalacrocorax aristotelis*	Toppskarv
Grey heron	*Ardea cinerea*	Gråhegre
Mallard	*Anas platyrhynchos*	Stokkand
Common eider	*Somateria mollissima*	Ærfugl
King eider	*Somateria spectabilis*	Praktærfugl
Steller's eider	*Polysticta stelleri*	Stellerand
Long-tailed duck	*Clangula hyemalis*	Havelle
Common scoter	*Melanitta nigra*	Svartand
Velvet scoter	*Melanitta fusca*	Sjøorre
Red-breasted merganser	*Mergus serrator*	Siland
Goosander	*Mergus merganser*	Laksand
White-tailed eagle	*Haliaeetus albicilla*	Havørn
Purple sandpiper	*Calidris maritima*	Fjæreplytt
Pomarine skua	*Stercorarius pomarinus*	Polarjo
Arctic skua	*Stercorarius parasiticus*	Tyvjo
Long-tailed skua	*Stercorarius longicaudus*	Fjelljo
Great skua	*Stercorarius skua*	Storjo
Common gull	*Larus canus*	Fiskemåke
Lesser black-backed gull	*Larus fuscus*	Sildemåke
Herring gull	*Larus argentatus*	Gråmåke
Iceland gull	*Larus glaucoides*	Grønlandsmåke
Glaucous gull	*Larus hyperboreus*	Polarmåke
Great black-backed gull	*Larus marinus*	Svartbak
Black-legged kittiwake	*Rissa tridactyla*	Krykkje
Arctic tern	*Sterna paradisaea*	Rødnebbterne
Common guillemot	*Uria aalge*	Lomvi
Brünnich's guillemot	*Uria lomvia*	Polarlomvi
Razorbill	*Alca torda*	Alke
Black guillemot	*Cepphus grylle*	Teist
Little auk	*Alle alle*	Alkekonge
Atlantic puffin	*Fratercula arctica*	Lunde

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