NINA Report 363

SEAPOP studies in the Barents and Norwegian Seas in 2007

Tycho Anker-Nilssen
Robert T. Barrett
Jan Ove Bustnes
Signe Christensen-Dalsgaard
Kjell Einar Erikstad
Per Fauchald
Svein-Håkon Lorentsen
Harald Steen
Hallvard Strøm
Geir Helge Systad
Torkild Tveraa

NINA
Norwegian Institute for Nature Research

Teamwork Enthusiasm Integrity Quality

Cooperation and expertise for a sustainable future

NINA Publications

NINA Report (NINA Rapport)
This is a new, electronic series beginning in 2005, which replaces the earlier series NINA commissioned reports and NINA project reports. This will be NINA's usual form of reporting completed research, monitoring or review work to clients. In addition, the series will include much of the institute's other reporting, for example from seminars and conferences, results of internal research and review work and literature studies, etc. NINA report may also be issued in a second language where appropriate.

NINA Special Report (NINA Temahefte)
As the name suggests, special reports deal with special subjects. Special reports are produced as required and the series ranges widely: from systematic identification keys to information on important problem areas in society. NINA special reports are usually given a popular scientific form with more weight on illustrations than a NINA report.

NINA Factsheet (NINA Fakta)
Factsheets have as their goal to make NINA's research results quickly and easily accessible to the general public. The are sent to the press, civil society organisations, nature management at all levels, politicians, and other special interests. Fact sheets give a short presentation of some of our most important research themes.

Other publishing
In addition to reporting in NINA's own series, the institute's employees publish a large proportion of their scientific results in international journals, popular science books and magazines.

Norwegian Institute for Nature Research

SEAPOP studies in the Barents and Norwegian Seas in 2007

Tycho Anker-Nilssen
Robert T. Barrett
Jan Ove Bustnes
Signe Christensen-Dalsgaard
Kjell Einar Erikstad
Per Fauchald
Svein-Håkon Lorentsen
Harald Steen
Hallvard Strøm
Geir Helge Systad
Torkild Tveraa

Anker-Nilssen, T. (ed.), Barrett, R.T., Bustnes, J.O., Christensen-Dalsgaard, S., Erikstad, K.E., Fauchald, P., Lorentsen, S.-H., Steen, H., Strøm, H., Systad, G.H. & Tveraa, T. 2008. SEAPOP studies in the Barents and Norwegian Seas in 2007. - NINA Report 363. 92 pp.

Trondheim, April 2008

ISSN: 1504-3312
ISBN: 978-82-426-1927-3

COPYRIGHT

AVAILABILITY
Open

PUBLICATION TYPE
Digital document (pdf)

EDITED BY
Tycho Anker-Nilssen

QUALITY CONTROLLED BY
The authors

SIGNATURE OF RESPONSIBLE PERSON
Research director Inga E. Bruteig (sign.)

CLIENT(S)
Ministry of Environment, Oslo
Directorate for Nature Management, Trondheim
Norwegian Maritime Directorate, Haugesund
Ministry of Petroleum and Energy, Oslo
Norwegian Petroleum Directorate, Stavanger
Directorate of Fisheries, Bergen
Norwegian Oil Industry Association, Stavanger

CLIENTS' CONTACT PERSON(S)
Brit Veie-Rosvoll (DN)
Espen Andreas Hauge (OED)
Egil Dragsund (OLF)

COVER PICTURE
Adult herring gull *Larus argentatus*, a focal species at several SEAPOP key-sites (© Tycho Anker-Nilssen, Røst 2007)

KEY WORDS
Barents Sea, Norwegian Sea, seabirds, mapping, monitoring

NØKKELORD
Barentshavet, Norskehavet, sjøfugl, kartlegging, overvåking

CONTACT DETAILS

NINA head office
NO-7485 Trondheim
Norway
Phone: +47 73 80 14 00
Fax: +47 73 80 14 01

NINA Oslo
Gaustadalléen 21
NO-0349 Oslo
Norway
Phone: +47 73 80 14 00
Fax: +47 22 60 04 24

NINA Tromsø
Polarmiljøsenteret
NO-9296 Tromsø
Norway
Phone: +47 77 75 04 00
Fax: +47 77 75 04 01

NINA Lillehammer
Fakkelgården
NO-2624 Lillehammer
Norway
Phone: +47 73 80 14 00
Fax: +47 61 22 22 15

www.nina.no

Abstract

Anker-Nilssen, T. (ed.), Barrett, R.T., Bustnes, J.O., Christensen-Dalsgaard, S., Erikstad, K.E., Fauchald, P., Lorentsen, S.-H., Steen, H., Strøm, H., Systad, G.H. & Tveraa, T. 2008. SEAPOP studies in the Barents and Norwegian Seas in 2007. - NINA Report 363. 92 pp.

This is the third annual report of the SEAPOP programme, which was initiated in 2005. In 2007, the work continued at full scale in the Lofoten-Barents Sea area, and similar studies were initiated in the southern part of the Norwegian Sea. The report is divided into three sections. The first is an executive summary, the second presents five selected highlights from the studies in 2007, whereas the third presents results from other projects within the programme. The programme is wide-ranging and with at least 17 project activities running in parallel, there is no room for 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. This is made at a series of key-sites, no numbering nine locations after the inclusion of two new sites in central Norway (Sklinna and Runde) in 2007. Comparative analyses of these data series, across species and sites and against various environmental factors, are essential for explaining any documented changes and to predict future population trends. SEAPOP also aims to take advantage of advances in technology and develop more efficient methods of data collection, and uses high-tech data sampling techniques to document migration patterns and habitat use in species of special conservation concern.

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). The distribution and abundance of seabirds at sea in the various seasons are modelled from documented associations between oceanographic factors and the distribution of different seabird species and their prey. These associations are derived from data collected in a multi-disciplinary cooperation on ecosystem surveys run by the Institute of Marine Research, Bergen.

The programme's web site (www.seapop.no) was launched at the first programme seminar, held in October 2007. The pages are under constant revision, and advanced computer technology is put to use to communicate the results to various users.

Norwegian Institute for Nature Research *NO-7485 Trondheim* *Norway*	**Norwegian Institute for Nature Research** *Polar Environmental Centre* *NO-9296 Tromsø, Norway*	**Norwegian Polar Institute** *Polar Environmental Centre* *NO-9296 Tromsø* *Norway*	**Tromsø University Museum** *NO-9037 Tromsø* *Norway*
Tycho Anker-Nilssen *tycho@nina.no*	Jan Ove Bustnes *jan.o.bustnes@nina.no*	Harald Steen *harald.steen@npolar.no*	Robert T. Barrett *robb@tmu.uit.no*
Signe Christensen-Dalsgaard *signe.dalsgaard@nina.no*	Kjell Einar Erikstad *kjell.e.erikstad@nina.no*	Hallvard Strøm *hallvard.strom@npolar.no*	
Svein-Håkon Lorentsen *shl@nina.no*	Per Fauchald *per.fauchald@nina.no*		
	Geir Helge Systad *geir.systad@nina.no*		
	Torkild Tveraa *torkildtveraa@nina.no*		

Sammendrag

Anker-Nilssen, T. (red.), Barrett, R.T., Bustnes, J.O., Christensen-Dalsgaard, S., Erikstad, K.E., Fauchald, P., Lorentsen, S.-H., Steen, H., Strøm, H., Systad, G.H. & Tveraa, T. 2008. SEAPOP-studier i Barentshavet og Norskehavet i 2007. – NINA Rapport 363. 92 s.

Dette er den tredje årsrapporten fra SEAPOP-programmet, som startet i 2005. I 2007 fortsatte undersøkelsene på full skala i området Lofoten-Barentshavet, og tilsvarende arbeid i de sørlige deler av Norskehavet ble startet opp. Rapporten er inndelt i tre hovedseksjoner. Den første gir et mer detaljert sammendrag (Executive summary), den neste presenterer noen utvalgte høydepunkter fra undersøkelsene i 2007, mens den siste omfatter rapporter fra hvert av de øvrige prosjektene i programmet dette året. Programmet spenner svært vidt, og med minst 17 parallelle prosjektaktiviteter 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. Dette foregår på en serie nøkkellokaliteter, foreløpig begrenset til ni, etter at slikt arbeid ble startet opp på Sklinna i Leka kommune og Runde i Herøy kommune i 2007. Komparative analyser av disse dataseriene på tvers av arter og områder i forhold til ulike miljøfaktorer, er avgjørende for å belyse årsakene til endringene som dokumenteres og lage pålitelige prognoser for bestandenes videre utvikling. SEAPOP legger også vekt på å utnytte teknologiske fremskritt og rasjonalisere innsamlingen av data, og avansert datateknologi benyttes bl.a. i programmets arbeid med å avdekke vandringsmønstre og habitatbruk for spesielt sårbare arter.

Kartleggingen av de ulike artenes utbredelse foregår både på kysten og i åpent hav. Av hensyn til ressursbruk og minstekrav til dataenes gyldighet, dekkes kystområdene etter et rullerende prinsipp hvor alle områder skal kartlegges én gang i hver sesong (hekking, fjærfelling/høst, vinter og vår) i løpet av en tiårsperiode. I åpent hav modelleres utbredelsen til ulike årstider på grunnlag av påviste sammenhenger mellom oseanografiske faktorer og fordeling av ulike sjøfugler og deres viktigste byttedyr. Disse dataene blir innsamlet i et tverrfaglig samarbeid med Havforskningsinstituttets økosystemtokt.

Programmets nettsted (www.seapop.no) ble lansert i forbindelse med det første fagseminaret som ble arrangert i oktober 2007. Sidene utvikles løpende og benytter avanserte, datatekniske løsninger for effektiv kommunikasjon av resultater til ulike målgrupper.

NINA Trondheim *NO-7485 Trondheim*	**NINA Tromsø** *Polarmiljøsenteret* *NO-9296 Tromsø*	**Norsk Polarinstitutt** *Polarmiljøsenteret* *NO-9296 Tromsø*	**Tromsø Museum** *Universitetsmuseet* *NO-9037 Tromsø*
Tycho Anker-Nilssen *tycho@nina.no*	Jan Ove Bustnes *jan.o.bustnes@nina.no*	Harald Steen *harald.steen@npolar.no*	Robert T. Barrett *robb@tmu.uit.no*
Signe Christensen-Dalsgaard *signe.dalsgaard@nina.no*	Kjell Einar Erikstad *kjell.e.erikstad@nina.no*	Hallvard Strøm *hallvard.strom@npolar.no*	
Svein-Håkon Lorentsen *shl@nina.no*	Per Fauchald *per.fauchald@nina.no*		
	Geir Helge Systad *geir.systad@nina.no*		
	Torkild Tveraa *torkild.tveraa@nina.no*		

Contents

Foreword

This is the third annual report of SEAPOP, a programme aiming to coordinate the monitoring, mapping and research activities required to cover the main information needs for the future management of Norwegian seabird populations. SEAPOP is 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 programme took another important step forward in 2007 when long-term studies of seabird demography were initiated on key-sites in the southern part of the Norwegian Sea. The full-scale level of activities in the Lofoten and Barents Sea area was continued, and generated a variety of important results for increasing the understanding of seabird distribution and dynamics in this globally important seabird area.

Hopefully, this report indicates some of the ways seabirds can provide useful information for the functioning of the marine ecosystems they belong to. We, who are working at the 'front end' of the programme, are certainly convinced that combining all good forces to fill the most urgent gaps in knowledge needed for a sustainable management of seabirds and their environment is the most cost-efficient way to a successful outcome. So, although it is a labour-intensive and long-running task to accomplish the many goals of the programme, our simple ″slogan“ still sums up what it all comes down to:

A special thank goes to the main sponsors of the programme in its third year, the Ministry of Environment (MD), the Ministry of Petroleum and Energy (OED) and the Norwegian Oil Industry Association (OLF), and to the dedicated members of the programme's steering committee for their contribution. The committee is chaired by the Directorate for Nature Management (DN) and has representatives from OLF, the Norwegian Petroleum Directorate (OD), the Norwegian Coastal Administration (Kystverket) and the Norwegian Maritime Directorate (SDIR). The Institute of Marine Research (IMR), 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 Hornøya, Anda and Sklinna 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 by the Norwegian Nature Inspectorate (SNO). As always, IMR was an excellent partner and their vessels again served as ideal platforms for the ecosystem surveys. Last, but not least, sincere thanks are certainly due to the numerous field workers and many of our colleagues that helped us carry out the great variety of studies included in the programme in 2007, as well as to all of those involved in the extensive long-term monitoring activities formerly established and run by the executive scientific institutions. It is an important premise for implementing SEAPOP that this very relevant work continues with its traditional funding.

On behalf of the project leaders
Trondheim, 8 April 2008

Tycho Anker-Nilssen
SEAPOP coordinator

1 Executive summary

Yet another milestone in SEAPOP was reached in 2007 when the programme started up work in the southern part of the Norwegian Sea where two new key-sites for monitoring breeding seabirds were established; at Sklinna in Nord-Trøndelag county, central Norway and at Runde in Møre and Romsdal county, SW Norway. The work in the Lofoten – Barents Sea area was continued at the same scale as in the preceding year. Eight key-sites, one of which (Spitsbergen) is divided on three different localities and one (Hjelmsøya/Gjesvær) on two, are now fully operational between Spitsbergen in the north and Runde in the south, and more and more breeding data are being collected annually. In addition, eiders are being intensively studied on Grindøya, Tromsø, and ongoing studies of the northern subspecies of the lesser black-backed gull at Horsvær, Helgeland were incorporated in SEAPOP in 2007.

The SEAPOP programme 2007 consisted of a wide variety of projects, most of which are presented in this report along with some of their results. There is not room here to dive deep into it all, but a selection of highlights is included to illustrate some of the many aspects and challenges that are currently dealt with. The remainder of this executive summary gives a brief description of each topic or project, in the order they appear in the report.

1.1 Selected highlights (Section 2)

The 2007 breeding season was characterized by population declines and breeding success ranging from poor to total failure among the pelagic-feeding species that breed west and south of the North Cape, while further north and east breeding conditions were better and most species fared well. One exception that is of considerable concern was the continued decline in the kittiwake population throughout most of the SEAPOP area of interest (the exceptions being Anda in Vesterålen and one of the two colonies monitored at Spitsbergen) and a generally poor breeding success. In contrast, most species that feed closer to the coast experienced a better breeding season along the whole coast, possibly the result of a more stable food supply.

One goal of SEAPOP is to shed light on how the environment affects demographic parameters such as adult survival, the proportion of mature adults that actually breed, breeding success, etc. Some of these are very difficult and time-consuming to document, and SEAPOP is investigating the use of novel DNA-techniques as alternative methods. Such techniques will hopefully give us clues concerning the long-term effects of population change through knowledge of population structure and gene flow, and thus strengthen analyses concerning future population viability. Similarly, a recent development of a molecular technique has greatly improved our ability to study sex-specific processes driving population fluctuations in general, and is used to study e.g. differential offspring mortality at one of the SEAPOP key-sites.

Another important aspect of SEAPOP is to document and predict the numbers and distribution of seabirds in the open ocean. Such a task is extremely difficult based on counts alone due a number of factors, not in the least the mobility of seabirds and their rapid movements over large areas, but a new approach relating the abundance of seabirds to a combination of biotic and abiotic properties of the ecosystem such as the stock size of important forage species or ocean temperature is looking very promising. Such modelling will hopefully help us predict better the distribution of given species at a given time. In this project, continuous seabird habitat maps for the 13 most common seabird species in Norwegian and adjacent waters have been produced based on more than 0.5 million kilometres of transects in a period from 1980 to present. Predictive maps of seabird density have been derived using observed seabird density as response variable and geographic position, distance from coast, surface temperature, surface salinity and depth as predictive variables. These are now available on the SEAPOP website.

In addition to the annual monitoring and mapping studies, SEAPOP also takes part in other seabird studies being carried out in Norwegian waters. One such study based at CNRS, France started in 2007 in collaboration with SEAPOP and addresses the foraging ecology of gannets breeding in different colonies along the Norwegian coast to gain a better understanding of factors influencing their current and contrasting population trends. Apart from traditional colony-based observations, this study also incorporates new techniques in the form of GPS data-loggers which record the foraging activity of gannets that are out gathering food for their young. Initial results suggest that food was readily available at all the colonies studied and that other factors are probably more important to explain the differential population changes along the coast. This study will continue in 2008 and 2009.

1.2 Monitoring at key-sites (Section 3.1)

Detailed reports are given for each of the key-sites in Section 3.1, and the main results are already summarized briefly above and discussed across sites in more detail in Section 2.1.

On Spitsbergen, the new time-lapse cameras which were introduced in 2006 were again deployed, and analyses are being carried out to determine the precision of using photographs to determine the breeding success of kittiwakes and guillemots.

At Hornøya, the demographic studies of the herring and great black-backed gulls initiated in 2006 continued in 2007 and are showing great promise. Interesting patterns are also arising from the long-term estimates of adult survival. Whereas the common guillemot has long had a high and constant survival, the survival rates for both for the kittiwake and puffin appear to be much more variable. There also seems to be some synchrony in their variation, with a decreasing survival rate between 2001 and 2004 and then an increase until 2006. Any causes of this variation and the effect on the population sizes remain to be analyzed.

The herring gull was added to the suite of species studied on Hjelmsøya in 2007 with the monitoring of its breeding success. There the differential breeding success between open- and sheltered-breeding common guillemots continued, and new sites for the study of adult mortality of puffins and common guillemots were established after heavy mink predation in 2006.

On Grindøya, an increase in mortality among female eiders, most likely from feral mink, has been registered in recent years resulting in a bias towards males in the population, the implications of which need to be addressed further.

While kittiwake numbers dropped at all key-sites along the mainland coast, those at Anda were the only exception and actually increased by >10% since 2006. Furthermore, three of the four key species had a moderate to good season. It seems that there is a local food source near this colony that results in better breeding conditions than elsewhere in the region.

Røst was again the site of the most comprehensive studies within SEAPOP and, in terms of population trends, 2007 was probably the worst year on record. Population collapses were recorded for the fulmar and open-nesting common guillemot (to near extinction) and razorbill, and another large decrease in the main kittiwake colony (Vedøy). Total breeding failures were also recorded for the fulmar, common guillemot, puffin and kittiwakes. Near-shore feeding species (shag, cormorant and black guillemot) did better although the overall breeding success of the shag and black guillemot was somewhat lower than normal.

The northern subspecies of lesser black-backed gull is among the rarest and certainly the most threatened seabird breeding on the Norwegian mainland. It was therefore considered highly relevant to study and monitor its population ecology within SEAPOP, and ongoing studies on Horsvær, Helgeland were incorporated in the programme. These studies focus on factors important for population growth and address reproduction, recruitment, adult survival, diet and migration.

About 30 km further southwest is Sklinna which has been an important seabird monitoring site since the early 1980s, and these studies were also incorporated in SEAPOP in 2007. Here key population parameters of herring gulls, cormorants, shags, kittiwakes, common guillemots, razorbills and puffins are now being or will be studied.

The third new colony to be included in SEAPOP in 2007 is on Runde, near Ålesund and immediately north of the North Sea border at 62°N. This classic seabird locality is known world-wide for its impressive bird cliffs, and the large populations of several species have been monitored for many decades. Studies of new parameters such as adult survival were initiated in 2007, and it is hoped to extend these in 2008. The major challenge here is logistical with the need to hire and train local field workers that are willing to spend the whole season in the colony.

1.3 Other project reports (Sections 3.2-3.8)

The extensive monitoring of kittiwakes initiated in 2006 with counts made in 96 extant and 77 extinct colonies also continued in 2007. The project aims at exploring how the variation in important population parameters such as colony size and breeding success vary across different spatial and temporal scales. Some interesting patterns are already staring to emerge and better insight into such meta-population dynamics will help interpreting the inter-annual variation in similar parameters across key-sites and species less intensively monitored.

The monitoring of numbers of seabirds that spend the winter along the Norwegian and Spitsbergen coasts continued in 2007 with counts along selected stretches of the coast in Troms, western Finnmark and eastern Finnmark in early March. The winter distribution of seabirds along the outermost part of the mainland coast, where new monitoring areas were established in 2006, appears to be highly dynamic and changes between years. On Spitsbergen, counts were made along the outer part of the coast from Prins Karls Forland to Sørkapp, with most areas covered by helicopter. The traditional, land-based survey from outer Isfjorden to outer Bellsund became a part of the SEAPOP-programme in 2007, with the intention to expand the extent to include the coastline from the outer part of Bellsund south to Torellbreen.

One major goal of SEAPOP is to produce and update comprehensive maps of the distribution of seabirds both along the coast and at sea during and outside the breeding season. In 2007, priority was given to mapping of the breeding distribution and occurrence of coastal seabirds in the area from Lofoten to the Russian border, with a focus on breeding birds in Lofoten-Vesterålen, and some of the larger seabird colonies not covered during earlier years.

More than 600,000 birds were counted with the dominating species being kittiwakes (>177,000 pairs), common eiders (17,888 breeding males) and herring gull (>38,000 pairs). Also the north coast of Spitsbergen was covered in 2008, from Magdalenefjorden, about 58 km north of Ny-Ålesund to Kapp Platen on Nordaustlandet. There the dominant species were Brünnich's guillemots (>50,000 individuals) and kittiwakes (>20,000 nests).

Mapping of seabirds at sea continued in 2007 based on the Institute of Marine Research (IMR) ecosystem surveys in the Barents and Norwegian Seas in spring/summer and autumn 2007, covering a total transect length of almost 11,000 km. The density of pelagic surface-feeders such as gulls and fulmars was much higher during the cruise in the Norwegian Sea in spring 2007 than in the previous two years. Why is unclear. The increased density could either reflect an increased abundance in the area, or it could reflect an increased tendency for these species to forage on discards from fishing vessels, maybe as a consequence of shortage of other food items. It should be noted that this pattern was not present during the autumn survey.

In 2006, SEAPOP funded a project to track king eiders wintering on the Norwegian coast using satellite technology. An attempt to deploy 10 transmitters in April 2007 failed, but in February 2008, all transmitters were implanted in 10 birds (5 males and 5 females). So far signals have been received from all 10 transmitters. The project is in cooperation with scientists from the Danish National Environmental Research Institute (Danmarks Miljøundersøkelser).

In 2007, the SEAPOP website (www.seapop.no) was officially launched. Apart from presenting the aims of the programme, the methods used and many of the results, a series of map services were also made available. These are:

1. SEAPOP WMS Service, a free and public web map service (WMS) that publishes online maps of seabird distribution (according to season and species or ecological species group) from the SEAPOP database. The user can look at the maps directly in the web application or implement the maps into GIS software.

2. SEAPOP Grid Service, a free and public web application for downloading GIS files (on shapefile format) with maps of seabird distribution in a 10x10 km^2 grid.

3. SEAPOP Advanced Management Application, a username and password protected application that requires a signed agreement. When logged in to the application, the user can search for and display detailed information of all the data in the SEAPOP Database and get them presented in tables and a flexible map system.

4. The "Species Maps" service of Artsdatabanken (The Norwegian Biodiversity Information Centre) where, in November 2007, the entire SEAPOP database was made available. This is displayed in a web map application, located at http://artskart.artsdatabanken.no/.

2 Selected highlights

This section presents a selection of highlights from some of the studies in 2007. Note also that many of the specific project reports (Section 3) include some shorter highlights, especially those that present results from long-term monitoring of seabird demography and diet on the selected key-sites (Section 3.1).

2.1 Regional differences in breeding performance and population trends across the Barents and Norwegian Seas

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

Differences in breeding success and population trends of seabirds within and across regions and species are likely to reflect important changes in environmental conditions, such as changes in energy transport within marine food webs resulting from natural or man-induced impacts on key ecosystem functions. In this perspective, we present here a summary of the breeding season for seabirds in the Barents and Norwegian Seas in 2007 (cf. Table 2.1.1), compare the results with data from previous years, and point to a few challenges for future, ecosystem-scale analyses of these data sets.

2.1.1 Breeding success

While breeding failures caused by food shortages continued in 2007 among pelagic seabirds breeding in Mid- and most of North-Norway, many of the coastal species that feed inshore and in the fjords succeeded to raise normal numbers of chicks (**Table 2.1.1**). One interesting break in this pattern among the pelagic species was the high breeding success of kittiwakes *Rissa tridactyla* on Anda, the only colony monitored on the mainland where kittiwakes produced 1.0 chicks/nest (Section 3.1.6). On Hjelmsøya, Røst and Runde no chicks survived to fledging. Among the other pelagic species, virtually no chicks of the common guillemot *Uria aalge* (and the few Brünnich's guillemots *Uria lomvia* on Hjelmsøya) left the breeding ledges in any of the colonies west of the North Cape, and the puffin *Fratercula arctica* had a very low breeding success on Hjelmsøya and Sklinna, a complete breeding failure in Røst and only moderate success on Anda and (possibly) Runde.

Among the coastal species monitored on the mainland, all had moderate to good seasons with the exception of the great skua *Stercorarius skua*, great black-backed gull *Larus marinus* and herring gull *Larus argentatus* that produced very few to no fledglings on Røst.

In the most arctic areas, 2007 was in general a successful season for seabirds (**Table 2.1.1**). All but two species monitored in eastern Finnmark and on Svalbard had moderate to good breeding success, although one should note that relatively few inshore species are monitored in these regions. The exceptions were kittiwakes on Hornøya that experienced a near complete breeding failure (0.14 chicks/nest), and the glaucous gulls *Larus hyperboreus* on Bjørnøya (Bear Island). In the more boreal areas, and especially from the Lofotens and southwards, conditions were so bad that many pairs, especially of pelagic species, skipped breeding (i.e. laid no eggs) or gave up in the incubation or early chick-rearing period. This year's data show that snake pipefish was, for the first time, offered to chicks along most of the mainland coastline, but with the same lack of success as recorded elsewhere in Europe.

***Table 2.1.1** Schematic summary of the breeding success in 2007 and short- and longer-term population trends of seabirds on or near by the main SEAPOP key-sites in the Barents and Norwegian Seas (cf. map in Figure 3.1.1). Most trends for 1998-2007 are from Lorentsen (2007). Note that the trends indicated for guillemots and razorbill on Hjelmsøya and Røst only apply for study plots on open ledges. In general, birds breeding in shelter have produced far better in most years over the last decade.*

Breeding success 2007

Locality	Pelagic species								Coastal species							
	Fulmar	Gannet	Kittiwake	Razorbill	C. Guillemot	Br. Guillemot	Little Auk	Puffin	Cormorant	Shag	C. eider	Great skua	Glaucous gull	Gr. bl-b. gull	Herring gull	Blcak guillemot
Spitsbergen	▨		G			G	G	▨			?	▨	▨	▨		▨
Bjørnøya	▨		M	▨	G	G	G	▨			▨	M	B	▨	▨	▨
Hornøya			B	M	G	▨		G		G	▨	▨		M	M	▨
Hjelmsøya	▨	▨	B	B	B	B		B	G	G	▨	G		G	G	▨
Anda			G	▨	B			M		G	▨			▨	▨	▨
Røst	B		B	M?	B			B	G	M	G	B		B	B	G
Sklinna	▨		?	▨	▨			B	▨	M	▨			▨	▨	▨
Runde	▨	▨	B	▨	B			M?		M	▨	▨		▨	▨	▨

Symbols	
G	Good
M	Moderate
B	Bad
▨	Unknown
	Do not breed

Change (%) in breeding population 2006-2007

Locality	Fulmar	Gannet	Kittiwake	Razorbill	C. Guillemot	Br. Guillemot	Little Auk	Puffin	Cormorant	Shag	C. eider	Great skua	Glaucous gull	Gr. bl-b. gull	Herring gull	Blcak guillemot
Spitsbergen	▨		+19			-1	▨	▨			?	▨	▨	▨		▨
Bjørnøya	0		0	▨	+5	0	▨	▨			▨	±	±	▨	▨	▨
Hornøya			-6	▨	-3	▨		+1		+?	▨	▨		▨	▨	▨
Hjelmsøya	▨	▨	-20	-1	+40	-32		+5	▨	▨	▨	+33		▨	▨	▨
Anda			+10	▨	▨			-10		▨	▨			▨	▨	▨
Røst	-81		-18	-93	-97			+2	-1	-11	▨	+50		▨	▨	+3
Sklinna	▨		-34	-14	+2			+20	+4	-14	▨			▨	▨	▨
Runde	▨	+9	-40	▨	-72			+5		+4	-10	▨		▨	▨	▨

Symbols	
+	≥ 5% increase
±	Stable (< ± 5%)
-	≥ 5% decline
▨	Unknown
	Do not breed

Annual rate (%) of population change 1998-2007

Locality	Fulmar	Gannet	Kittiwake	Razorbill	C. Guillemot	Br. Guillemot	Little Auk	Puffin	Cormorant	Shag	C. eider	Great skua	Glaucous gull	Gr. bl-b. gull	Herring gull	Blcak guillemot
Spitsbergen	+2		-1			-6	▨	▨			±	▨	▨	▨		▨
Bjørnøya	-7		+2	▨	+7	±	▨	▨			▨	+	-	▨	▨	▨
Hornøya			-10	▨	+10	▨		+3		+	▨	▨		▨	▨	▨
Hjelmsøya	▨	+3	-12	-13	-12	-29		-5	+?	▨	▨	+		▨	▨	▨
Anda			±	▨	▨			±		▨	▨			▨	▨	▨
Røst	-20		-4	-11	-33			-1	+24	+6	±	+		▨	▨	±
Sklinna	▨		-5	+11	+35			-14	+6	+6	▨			▨	▨	▨
Runde	▨	+1	-13	▨	-30			-3	▨	+1	±	+?		▨	▨	▨

Symbols	
+	≥ 2% p.a. increase
±	Stable (< ± 2% p.a.)
-	≥ 2% p.a. decline
▨	Unknown
	Do not breed

2.1.2 Population changes 2006-2007

Data collected in 2007 revealed large changes (20% or more) in breeding numbers of several species since the previous year (**Table 2.1.1**). The deferred breeding mentioned above probably contributed to some of the apparent declines registered since 2006, although many of the species have been declining over many years.

Again, the situation in Svalbard and East Finnmark was more favourable with most of the species showing little change since 2006. One of the two kittiwake colonies counted on

Spitsbergen increased significantly, while the other and that monitored on Bjørnøya were practically stable. The kittiwakes on Hornøya, however, declined by another 6%. Although the shags *Phalacrocorax aristotelis* were not counted on Hornøya in 2007, their numbers were considered to be higher than in 2006. All the other populations remained stable (within ±5%).

Along the mainland coast west of the North Cape, pelagic species were hit hardest with large declines in kittiwakes, razorbills *Alca torda* and guillemots since 2006 in nearly all colonies. At Røst, for example, the open-nesting population of the nationally red-listed common guillemot declined by 97% between 2006 and 2007, while numbers of razorbills and fulmars *Fulmarus glacialis* each declined by >80%. With the exception of Anda, kittiwakes at the key-site colonies declined by 6 to 40% since 2006. Gannets *Morus bassanus* continued their long-term increase on Runde while the few common guillemots left on the ledges on Hjelmsøya increased their numbers by 40% since 2006. However, much of the Hjelmsøya and Røst populations of common guillemot and razorbill now breeds well hidden among boulders such that the true, short-term development of both species is difficult to document.

2.1.3 Long-term trends 1998-2007

For several species that have been declining over many years, the breeding failure in 2007 was very serious (**Table 2.1.1**). The common guillemot, whose population has declined drastically over the last 40-50 years, is approaching extinction in some colonies. According to models developed after the 2006 breeding season, there is a 93% chance that the colony at Vedøy, Røst will be abandoned within 50 years, and a 41% and 27% chance that the same will happen on Runde and Hjelmsøya, respectively (cf. Section 2.1 of last year's report). This year's results certainly did not improve these predictions. Fulmars are also declining fast at Røst at a rate of -20% p.a. between 1997 and 2007.

The situation at Hjelmsøya, West Finnmark is of great concern with steep declines (-5 to -29% p.a.) in nearly all species monitored since 1997. Only the great skua and the gannet (the latter strictly speaking breeding on the neighbouring island Gjesvær, but included here under Hjelmsøya) have increased in the same period. There are, however, also here signs of a culmination in the gannet population growth.

The kittiwake is a second species that is declining throughout its range, with the possible exceptions of Svalbard, where numbers seem to be more stable, and the small colony on Anda (cf. also Section 3.2). The puffin has also declined over the last decade throughout its main distribution area (west of North Cape), but again with the possible exception of Anda where it was likely more stable. The increases of 1-8% annually at Røst over the last five years explain the change to a more stable situation here, but numbers are still only a third of those in 1979.

The situation east of the North Cape and in Svalbard, is currently better. Nearly all species had a good breeding season in 2007 and most of the monitored populations seem to be stable. The exceptions are declines among fulmars on Bjørnøya (-7% p.a. since 1998) and kittiwakes in East Finnmark (-10% p.a. since 1998). The small puffin population on Hornøya continued to increase at a rate of close to 3% p.a.

2.1.4 Discussion

In terms of breeding success, 2007 was a successful season for all seabirds breeding in the Barents Sea east of the North Cape and for the coastal species along the Norwegian coast.

Species feeding out at sea (the pelagic species) had, however, a poor season southwest of the North Cape. This included both the surface-feeding kittiwake and the diving common guillemot and puffin. A closer look at the food collected for chicks, and the availability of suitable food items (from e.g. independent surveys by the Norwegian Institute of Marine Research) is a central part of SEAPOP, and will hopefully help us explain the poor breeding success among pelagic species in 2007.

An interesting anomaly in this analysis is the apparent success of seabirds on Anda, where both breeding success was good and numbers seem to be stable. The failure of the common guillemots on Anda was probably due to disturbance or predation early in the season when all or most of the eggs were wiped out, and not to lack of food. These results suggest there is a local food base around Anda which seabirds can utilize and that is not available elsewhere, a possibility that merits closer attention.

That the coastal species were more successful may be explained by the availability of a more stable food supply. Some (common eider *Somateria mollissima*, cormorant *Phalacrocorax carbo carbo* and the large gulls) feed only or partly on benthic species that are known to have more stable populations than e.g. pelagic fish, while others (shag and black guillemot *Cepphus grylle*) feed close inshore where, likewise, the food base is more stable.

A closer synthesis of the population data within SEAPOP, including data collected in other colonies as part of the National Seabird Monitoring programme (Lorentsen 2007), will hopefully enable us to explain the regional and species specific differences in the short- and long-term population changes. Again, is food availability the (only) key factor? Is the food base changing with respect to e.g. water temperature? Can we expect further changes, and in which direction during the forecasted period of climate change?

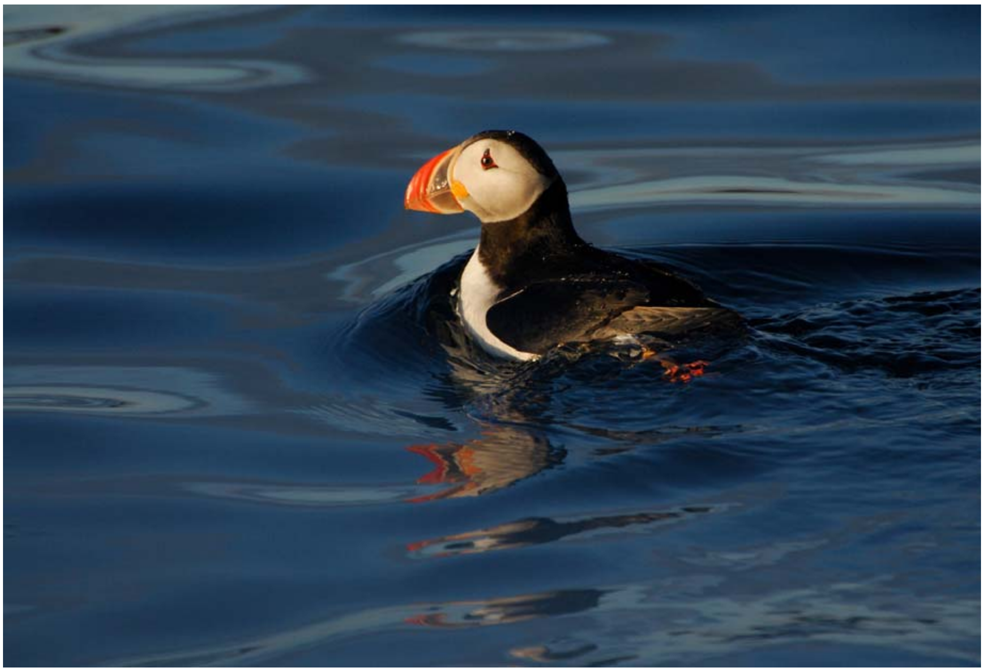


Figure 2.1.1
An adult puffin at sea. Despite its large decrease in the 1980s and 1990s, the puffin still constitutes almost 60% of the 2,9 million pairs of seabirds currently estimated to breed in mainland Norway (Barrett et al. 2006). (© Tycho Anker-Nilssen, Røst 2007)

2.2 The use of molecular genetics to study demographic processes in seabirds

Kjell Einar Erikstad, Truls Moum, Trond R. Skog Jenssen & Tone Kristin Reiertsen

Understanding how environmental variability affects demographic parameters is fundamental in our interpretation of changes in population size. For seabirds, as for other iteroparous species, key demographic parameters are adult survival, breeding propensity (i.e. the proportion of a population attempting to reproduce in a given year given that they have reproduced in an earlier year), breeding success, recruitment of young birds, emigration and immigration. At the selected SEAPOP key-sites, high priority is given to obtaining sound estimates of these parameters.

Most of these parameters are straightforward but time consuming to measure. There are, however, two demographic processes, often previously neglected, which have recently received much attention. One is the rate of emigration and immigration of birds among seabird colonies, which may vary over different spatial scales and greatly affect the viability of populations. The other is the sex specific differences in survival of both adults and young. Realistic estimates of both these traits have been hampered by methodological issues. However, novel DNA techniques have recently been developed to overcome this problem. A standard procedure at each key-site is therefore a non-invasive blood sampling of birds. DNA extracted from the blood of both adults and chicks is used for sex determination, and for mapping of population genetic structures and realized migration rates of species at different spatial scales.

2.2.1 Population genetic variation and structure

Seabirds are vulnerable to environmental change, whether it is man-made or naturally occurring. Human exploitation of the marine environment may affect seabird populations in a direct and drastic way. In particular, diving seabirds like guillemots and puffins that spend most of their time at, or beneath the ocean surface, may suffer heavily from oil spills and entrapment in fishing gear.

While the immediate impact of mass mortality events to seabirds is evident, the longer-term population effects are harder to estimate. This is because the rate of recovery depends on several population parameters that may vary temporally, both between species and between geographic regions. Thus, studying population structures and understanding the mechanisms of population differentiation is important for conservation.

Population viability analysis (PVA) has proved to be a valuable tool for predicting the future status of populations, but PVA estimates are critically dependent on precise knowledge of population structures and gene flow. Bird ringing is a useful, but costly and time consuming way of collecting information on dispersal. However, molecular genetic analysis represents an alternative way of investigating population structures.

Recent advances in population genetic theory and empirical research provide new possibilities in this respect. Researchers have tested and evaluated several genetic markers for use in population genetic studies. There are principally two types of DNA in animal cells; a small piece of so-called mitochondrial DNA (mtDNA) in the cytoplasm, and then the bulk of DNA which is found in nuclei (nDNA). MtDNA is a small, circular DNA molecule that is inherited

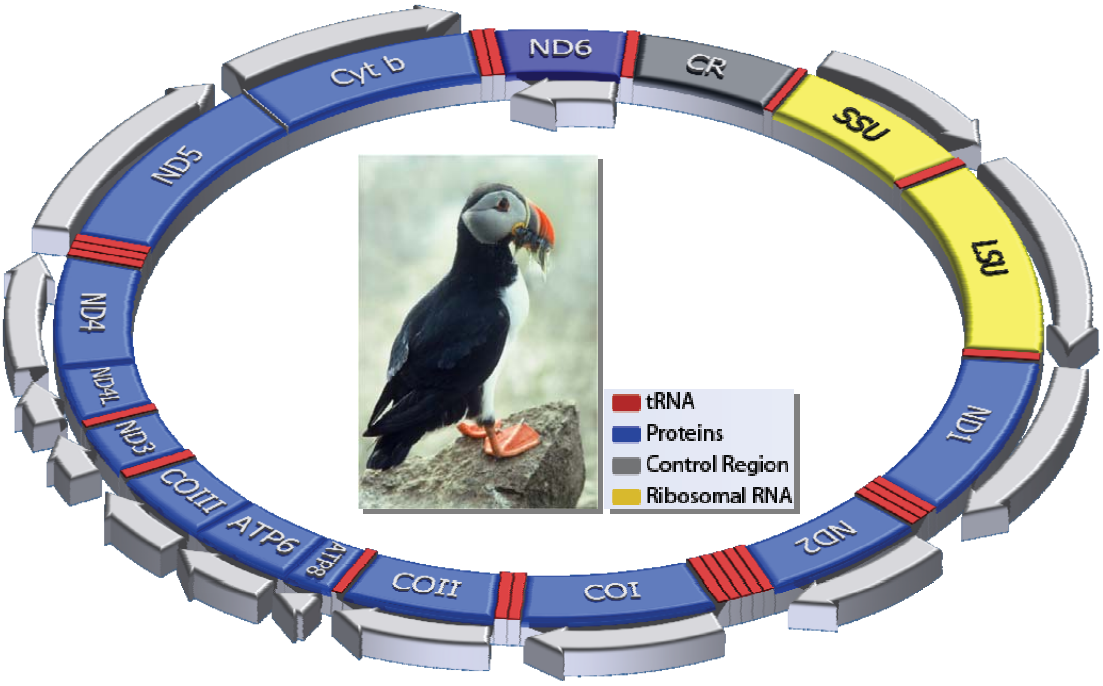


Figure 2.2.1
Schematic representation of the 16.7 kb mitochondrial genome in the puffin. Thirteen protein coding genes are shown in blue, two ribosomal RNA genes in yellow, twenty-two tRNA genes in red, and the control region (CR) in grey. Arrows indicate the direction of transcription of each gene. (Photo © Truls Moum)

through the maternal line. It is more abundant (in copy numbers) than nDNA and has a conserved gene arrangement, and is therefore easy to analyse (**Figure 2.2.1**). It is, however, variable in its primary sequence, which means that it is a well suited marker for population studies. MtDNA is sensitive to population bottlenecks and restrictions to gene flow.

Moum & Árnason (2001) studied the genetic population variation in razorbills and common guillemots in the Atlantic Ocean using mtDNA sequence analyses. An effectively small population size and lack of differentiation was found in guillemots throughout the Atlantic, suggesting repeated population bottlenecks, population expansion and gene flow. In contrast, Razorbills were geographically structured, suggesting restrictions to gene flow and with a population signature of former subdivisions (**Figure 2.2.2**). We are currently investigating population structure in puffins along the Norwegian coast. The resolution of the analysis is improved by identifying SNPs (single nucleotide polymorphisms) for the complete puffin mitochondrial genome (**Table 2.2.1**).

Table 2.2.1 *Summary survey of observed nucleotides (nObs) at variable nucleotide positions (nPos) in the mitochondrial genome of puffins. Positional numbers refer to the southern black-backed gull (*Larus dominicanus*) mitochondrial DNA sequence.*

nPos	978	1251	2123	2971	3890	3891	3894	4483	4771	6093	6195	6266	7478	7894
nObs	C/T	C/T	G/A	C/T	G/A	G/A	G/A	C/A	C/T	C/T	C/T	G/A	G/A	T/A
nPos	8117	8353	8576	8612	9327	9652	10534	10743	10851	10998	12473	14747	15765	15845
nObs	G/A	G/A	G/A	C/T	C/T	G/A	G/A	G/A	G/A	G/A	G/A	G/C	C/T	C/T

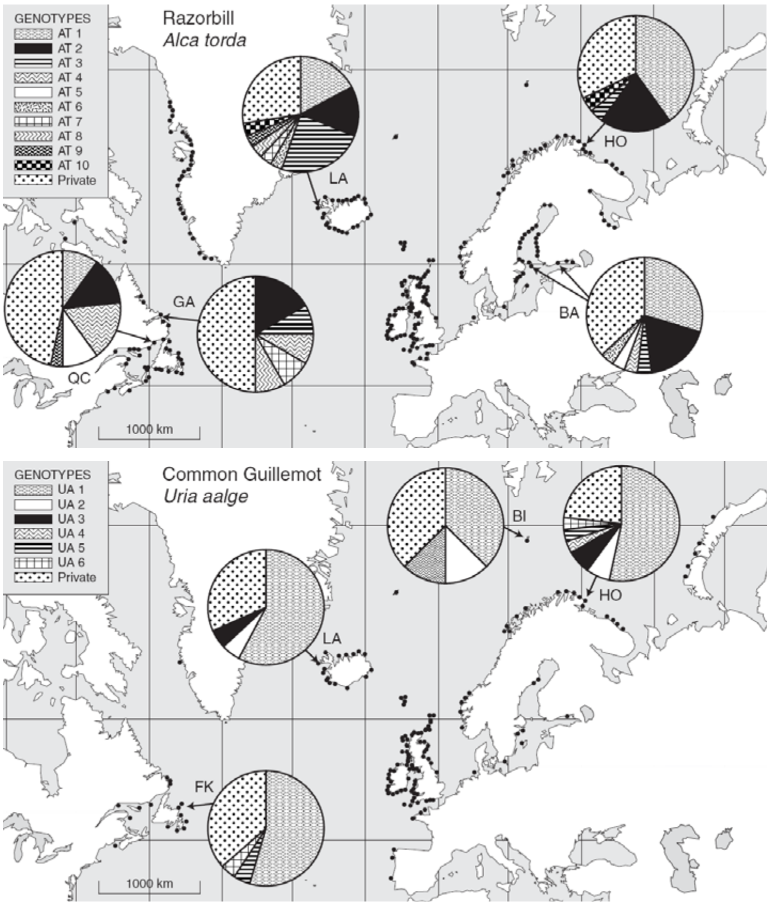


Figure 2.2.2
Mitochondrial genotype frequency distributions (pie charts) of razorbill and common guillemot in breeding colonies (dots) across the Atlantic Ocean, illustrating the divergent population structures of the two species. The localities sampled were: Gannet Islands, Labrador (GA); Latrabjarg, Iceland (LA); Funk Island, New Foundland (FK); Bear Island (i.e. Bjørnøya, BI); Hornøya (HO); two sites in the Baltic (BA). (From Moum & Árnason 2001)

So far, mtDNA has been the molecular marker of choice in population studies, but it also has its short-comings. In principle, it only reflects female-mediated gene flow and female effective population sizes. The complete variation has to be assessed using both mtDNA and nuclear markers, a combination which also offers increased resolution. Among the variety of nuclear markers available, microsatellites are most often employed for investigations at the population level. These are highly variable tandem repeat sequences that are randomly distributed throughout the genome of most species. Microsatellites have to be developed for the species in question, but are relatively easy to score once the analytical conditions have been established.

The extent of population structure in seabirds varies widely among species, but is positively correlated to land and ice barriers within the distribution area. However, many species also show population structure in the absence of geographic barriers, suggesting that other barriers to gene flow exist. In spite of their obvious dispersal capabilities, many seabird species show remarkable nest-site fidelity, which suggests restricted gene flow. For instance, the Galapagos petrel (*Pterodroma phaeopygia*) and Xantus's murrelet (*Synthliboramphus hypoleucus*) show distinct population genetic structures, despite the absence of obvious physical or other barriers to dispersal (Friesen et al. 2007).

In summary, studies of geographic variation using molecular genetic analyses are useful in order to identify management units, population connectedness and structure, as well as the various factors generating these patterns.

2.2.2 Sex specific differences in demographic processes

Among most seabirds, adult males and females are of similar size and colour. The problem of sex determination has hampered our knowledge of any sex specific differences in demographic traits. Similarly, it has been impossible to sex newly hatched chicks using external characteristics. The development of a molecular technique in the late 1990's (Griffiths et al. 1998) solved this problem and has greatly improved our opportunity to study sex specific processes that drive population fluctuations.

In birds, the female is the heterogametic sex, having one W and one Z chromosome; whereas males have two Z chromosomes. DNA extracted from small blood samples (25-50 µL) is subjected to PCR using primers (for seabirds P2 and P8) which anneal to conserved exonic regions and amplify across an intron in both the CHD1-W and CHD1-Z genes. The length of the non-coding introns differs between the CHD-W and CHD1-Z genes and PCR products from males (one band) and females (two bands) are easily distinguished on a 3% agarose gel (Griffiths et al. 1998) (**Figure 2.2.3**).

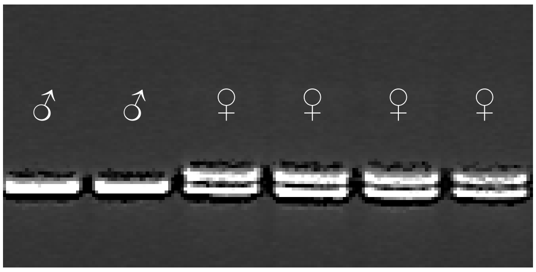


Figure 2.2.3
DNA sex identification of puffins sampled at key-site Røst, using PCR with a single set of primers P2 and P8. The PCR products are shown on a 3% agrose gel under UV-light. The birds with two bands are female and those with one band are males.

More than 30 years ago, Trivers and Willard (1973) hypothesised that parents should practice facultative sex allocation, depending on their physical body condition at the time of reproduction. Since then, this influential hypothesis has received much interest and has been the subject of a huge number of studies (reviewed in Pike & Petrie 2003, Alonso-Alvarez 2006).

In size-dimorphic species, differential sex allocation is most noticeable. In gulls, males are typically larger than the females and have greater energy requirements and food consumption than females. Such size dimorphism may lead to male offspring being more vulnerable to poor breeding conditions (Nager et al. 1999, 2000). There are, in general, two ways parents can manipulate the sex of their offspring. One is to overcome the random segregation of chromosomes such that the actual production of the two sexes may be skewed through female controlled chromosomal segregation (Pike & Petrie 2003). The other is through a possible sex bias in early chick mortality. The latter could occur through selective provisioning of one sex by the parents, or through the differential vulnerability of one sex to poor parental investment or unfavourable rearing conditions (Clutton-Brock 1986).

Sex specific mortality of gull chicks can be illustrated using results from a study on Hornøya (**Figure 2.2.4**). Around hatching, the ratio between male and female offspring is about even (50:50) in both herring gulls and great black-backed gulls. However, in one of the years (2006) the mortality of female chicks during the first two weeks post-hatch was twice as high as among male chicks, resulting in a strong skew in sex ratio towards males (more than 70%). This was evident for both species.

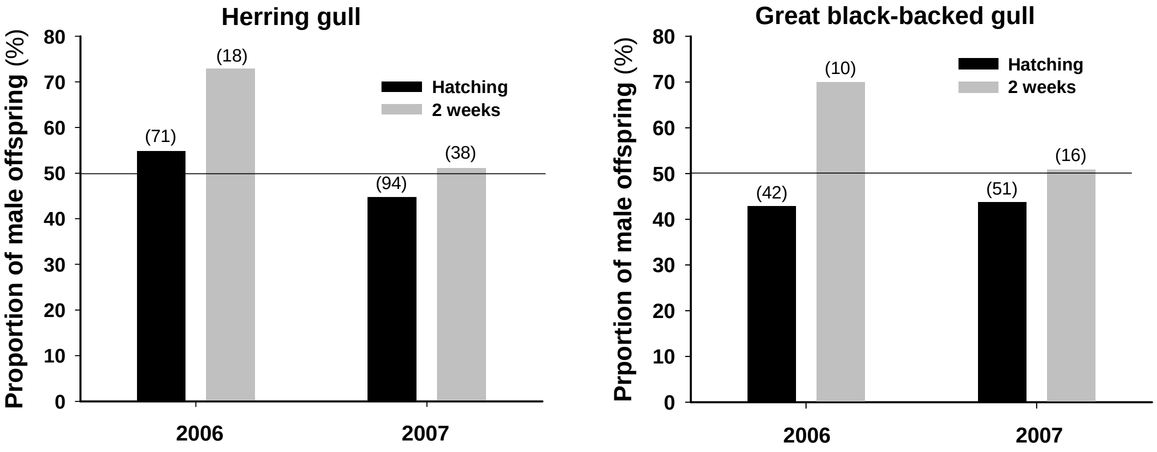


Figure 2.2.4
Sex ratio (proportion of male offspring) around hatching and when the chicks were two weeks old, among chicks of herring and great black-backed gulls at Hornøya in eastern Finnmark in 2006 and 2007. Sample sizes are shown in parentheses. The horizontal line indicates an even sex ratio (50:50). (After Jenssen 2008)

We do not yet know what caused this differential offspring mortality. The year (2006) when mortality of female offspring was highest was a bad breeding season. Other gull studies have shown that during unfavourable conditions, parents direct their feeding effort towards the "cheapest sex", which, in this case is the female; males being larger than females and therefore more costly to raise. Thus, the present observation is the opposite of what we would expect. There are at least two likely mechanisms which may contribute to this result. One is sibling competition where the male offspring are more aggressive and beg more intensively for food and therefore are fed more frequently than their sisters when the breeding conditions get worse. Another, more serious explanation is the high contamination of organochlorines often found in gulls and which may have severe effects on their health. It is known that organochlorines can mimic hormones and also that they have estrogenic effects. One possible explanation is that these compounds affect female offspring more severely than male offspring. Importantly, the strongly skewed sex ratio may, irrespective of the mechanisms causing it, severely affect population viability (see Section 2.2.1).

2.3 Population level effects of sex-biased mortality in gull offspring

Kjell Einar Erikstad & Tone Kristin Reiertsen

A central issue in population ecology is how parents optimise their effort when raising young contra their own chances of survival. In a variable and stochastic environment, where the available food resources vary greatly from year to year, a strategy to balance the costs to raise young and at the same time maximise the number of recruits, is especially important. Traditionally, the number of potential recruits has been assumed to equal the number of young survived. However, there is now growing evidence that parents are able to invest their effort in male and female offspring differently, depending on breeding conditions. There are also strong indications that pollution may influence mortality of male and female offspring differently.

There is ample evidence to conclude that parents have control over the sex of their offspring (see also Section 2.2). This is especially well documented in gulls, among which size dimorphism is clearly evident; males being about 15% larger than females. When parents are in poor body condition and/or the food situation is bad, they may put more effort into raising females, which need less food to reach independence (Trivers & Willard 1973, Nager et al. 1999, 2000). However, when we studied the variation in sex ratio among chicks of the herring gull and great black-backed gull on one of the key-sites, Hornøya, the results showed a remarkable male-biased skew in sex ratio (70%) during a bad breeding season. This was caused by higher mortality of female than male chicks during the first two weeks post-hatch. A similar skew in sex ratio has also been found for lesser back-backed gulls breeding on Horsvær, Helgeland (Erikstad et al. unpubl. data, cf. Section 3.1.8).

We have, as yet, no simple explanation for this result, which is contrary to that expected according to sex allocation theory. One possibility may be the effect of pollution. A number of gull species in the north have accumulated high levels of organochlorines such as PCB and DDT (Bustnes et al. 2003, 2008). Such compounds are known to have oestrogenic effects (Brunstrøm et al. 2003) and are also known to affect the sex determination processes in reptiles (Bergeron et al. 1994). Oestrogenic effects may be more detrimental to female than male offspring and are especially serious in the way that they interact with evolutionary processes.

On this background, we here quantify the population level effect of a skewed sex ratio in gulls (see also Erikstad & Reiertsen 2007 for a different approach). We have developed a stochastic, environmental and demographic, age-structured population projection matrix model. The data used to parameterize the model were taken from previous studies on gulls. In our exploration of possible population effect of skewed sex ratio of offspring, we assumed a high and constant adult survival of breeding adults (0.85), that they start to breed at an age of 4 years, and that the annual survival of immatures from fledging to first breeding is 0.75. We also included environmental variance in the model and assumed that productivity varies from 0.8 chicks in good years to 0.6 and 0.4 chicks in intermediate and bad years, respectively. This model gives a stable population (stochastic growth rate λ=1). We then modelled the stable age distribution for use as a population vector and simulated the future population density depending on the degree of skew in sex ratio of offspring.

We assumed no skew in sex ratio during good breeding seasons, but only during bad and intermediate conditions. We simulated the development of a breeding population of 1000 pairs into the future, depending on the proportion of female offspring produced (**Figure 2.3.1**). The model is kept as simple as possible and only the sex ratio of young is varied.

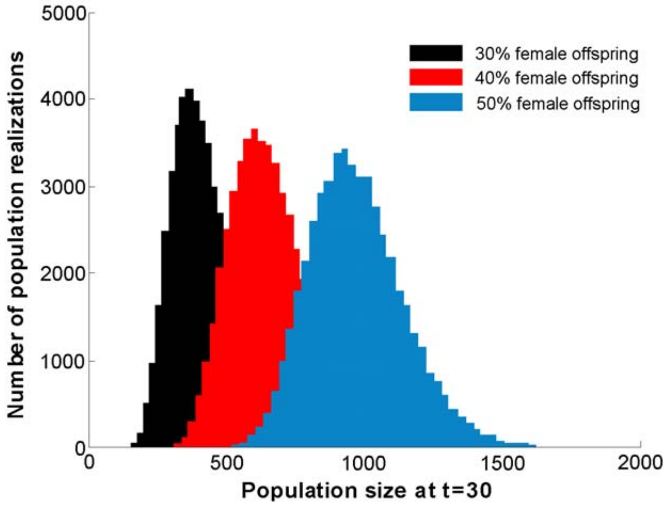


Figure 2.3.1
Results from stochastic simulation (with 50,000 replicate trajectories in each of the three runs) of a gull population of 1000 pairs 30 years ahead in relation to the proportion of female offspring produced (30%, 40% and 50%). We assumed normally distributed environmental conditions and a skewed sex ratio only during bad and intermediate breeding conditions.

To quantify the effect of skew in sex ratio we also simulated the probability that a population will be halved during given time periods (20 to 50 years) (**Figure 2.3.2**). For this simulation we used the "Cumulative distribution function" (CDF), which summarizes the proportion of the resulting trajectories that cross the predefined lower limit of population size of 500 pairs.

The results from the simulations show that a skew in sex ratio of offspring could severely affect the population growth rate in gulls. The highest proportion of female offspring that we have observed in a bad breeding seasons is ca 30% (Jenssen 2008, Erikstad et al. unpubl.). Such a skew in sex ratio may reduce the population size from 1000 to a median value of 401 pairs in 30 years (**Figure 2.3.1**). The risk that a population will be halved with a sex ratio of 30% is about 40% within 20 years and as much as 80% within 30 years (**Figure 2.3.2**). With a smaller skew in sex ratio (40% females) the risk of being halved within 20 years is small (<5%), but within 40 years it is as high as 75%.

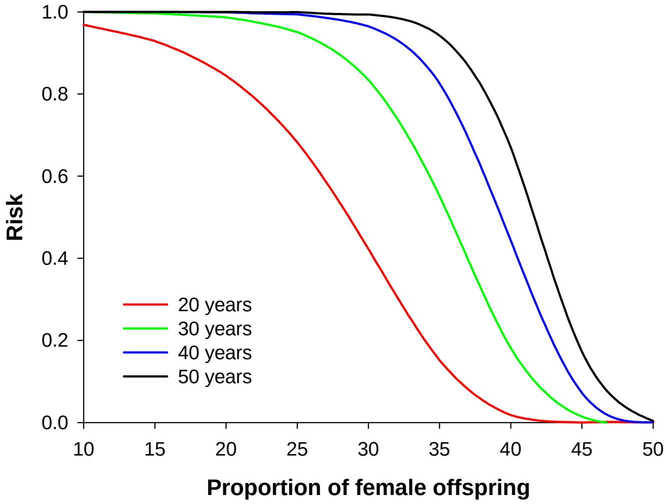


Figure 2.3.2
The probability (risk in %) that a gull population will be halved within 20 to 50 years, depending on the skew in sex ratio (proportion of females) of young that survive and recruit to the population. The risk was calculated as the cumulative proportion of population realizations crossing a pre-defined halving of the population. Fifty thousand simulations were carried out in each run, and each line in the graph is the mean of 10 repeats.

The effect of offspring sex ratio on the population level is poorly understood, but, as shown here, it may have severe consequences on population dynamics. The observation that a skew in sex ratio may be linked to pollution levels is especially alarming and may indicate that it is not merely an optimal adjustment in favour of any normal environmental conditions.

The prediction from the simple model presented here is indicative; however the results may stress the need to consider some important aspects of demographic processes. One is the link between pollution and sex-specific survival of offspring. Especially in arctic and sub-arctic ecosystems, top predators such as gulls (**Figure 2.5.3**) have accumulated high levels of organochlorine pollutants that negatively affect a number of traits such as egg size, clutch size, survival of chicks and adult survival (Bustnes et al. 2003, 2008). We do not yet know if any skew in sex ratio also applies to other seabirds at the SEAPOP key-sites, but relevant samples have been collected from several species and should be tested. We also lack knowledge of any sex-specific recruitment and dispersal of young between colonies for most species. The tradition of demographic modelling has been to assume an even sex ratio and only consider the female gender. But, as pointed out by Becker et al. (2008): *"… female focused demography is only one side of the coin: more attention should be devoted to the frequently ignored male gender …"*.

Figure 2.5.3
A less than a week old great black-backed gull chick. (© Tycho Anker-Nilssen, 2006)

2.4 Estimating the abundance of seabirds at sea

Per Fauchald & Torkild Tveraa

The number of seabirds at sea depends on how many birds recruit into the population, how many birds survive and how many birds move in and out of the specific ocean area. Seabirds roam over large areas and it can therefore be expected that the number of birds that for example spend the winter within a certain sea area depends more on the movement of birds than it depends on survival or birth rates. Moreover, such movements of birds are most likely related to the suitability of the area as a wintering habitat and should therefore depend on environmental factors such as the availability of favourable food items. Using the North Sea and Barents Sea as model areas, we present here a new approach to how to estimate the abundance of seabirds at sea.

Patchy and variable distributions of seabirds make it difficult to estimate precisely of their numbers at sea. Furthermore, the survey tracks that are used to map seabirds are often designed for other purposes (e.g. acoustic measurements of fish) and might therefore be concentrated in particular areas or have a variable coverage from year to year. To control for bias with respect to coverage, the geographic distribution of the seabirds should be controlled for in the analyses. To do this, it is convenient to estimate the abundance of seabirds as a factor in a statistical model that controls for geographic position and habitat variables (Clarke et al. 2003, Wood 2006, **Figure 2.4.1**). One important assumption related to this approach is that the birds should respond to the habitat in similar ways in each year. Furthermore, it is also necessary that there is a “reasonable” coverage of the total ocean area in each year.

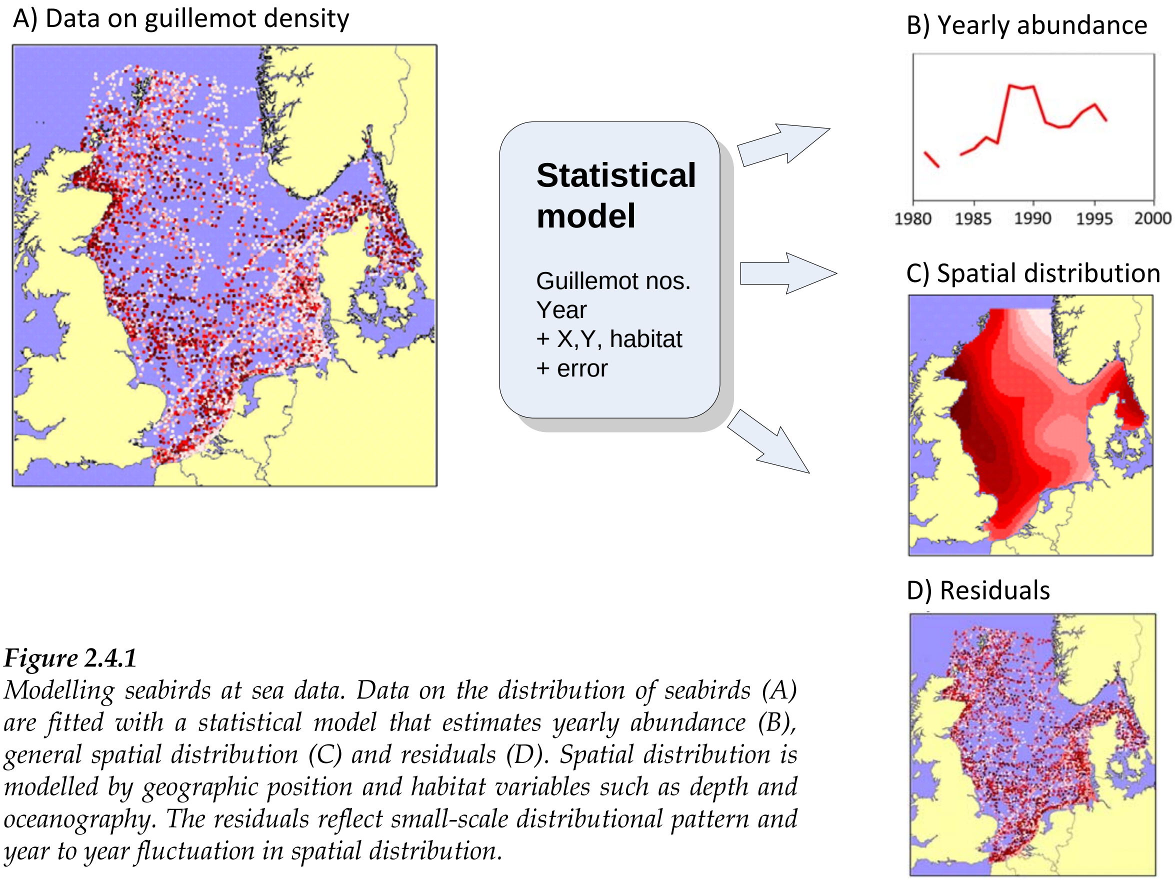
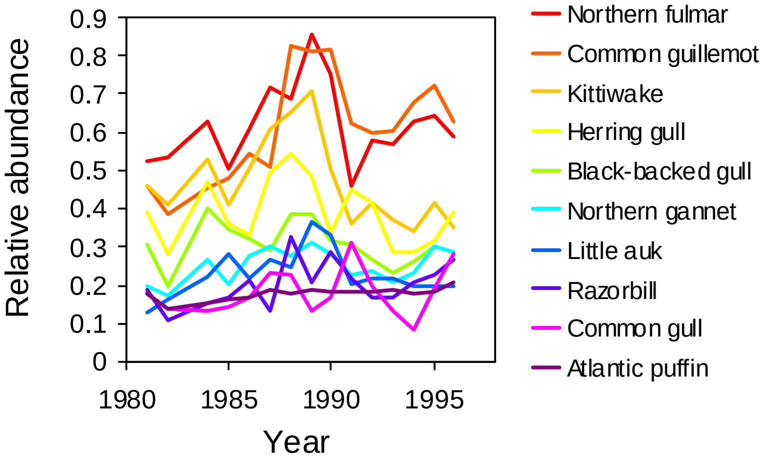


Figure 2.4.1
Modelling seabirds at sea data. Data on the distribution of seabirds (A) are fitted with a statistical model that estimates yearly abundance (B), general spatial distribution (C) and residuals (D). Spatial distribution is modelled by geographic position and habitat variables such as depth and oceanography. The residuals reflect small-scale distributional pattern and year to year fluctuation in spatial distribution.

Figure 2.4.2
Estimates of abundance of different seabird species in the North Sea during winter. Abundance estimates are log-transformed values from models relating density of seabirds to year, geographic position and various habitat variables (modified from Fauchald et al. 2006). Data are from the European Seabird at Sea database.



When the abundance of seabirds in an ocean area has been estimated, it is possible to relate these estimates to population parameters measured in adjacent seabird colonies (e.g. diet, population size and breeding success). Furthermore, it is possible to relate the abundance of seabirds to the properties of the ecosystem such as ocean temperature or the stock size of important forage species. We have analysed the yearly abundance of different seabird species wintering in the North Sea and in the Barents Sea respectively. The analyses show clear synchrony in the abundance of the different seabird species, with some years having much higher numbers of seabirds than other years (**Figure 2.4.2**). For example, in years with a high number of fulmars in the North Sea, there was also a high number of kittiwakes.

Such synchronous changes in seabird numbers is probably not related to mortality or breeding success, but rather to whether birds tend to use the North Sea as a wintering area and thus the suitability of the North Sea as a wintering habitat. Accordingly, we found a close positive relationship between the stock of herring and the number of overwintering seabirds in the North Sea (**Figure 2.4.3**). It should be noted that the strongest response in the number of seabirds was delayed one year with respect to the herring stock. Thus, it is possible that seabirds did not respond to herring as a prey item per se, but responded positively to a herring-dominated ecosystem.

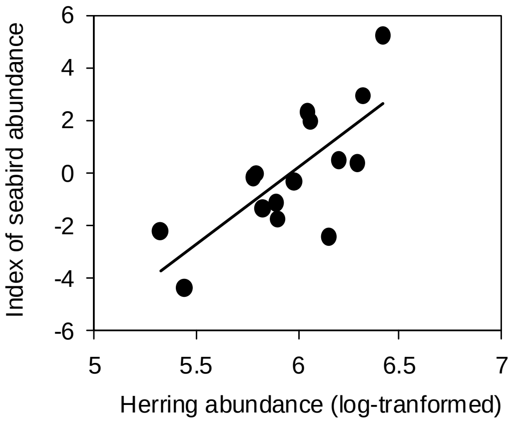


Figure 2.4.3
The relationship between yearly abundance of herring and seabirds in the North Sea. Each point represent one of the years 1981-1996 (except 1984). Abundance of seabirds is the first principal component from a PCA analysis of the abundance estimates of the 10 most common seabird species. Herring is estimated abundance of herring less than 20 cm (IBTS data from ICES) in year -1 (see text). Data on seabirds are from the European Seabird at Sea database modified from Fauchald et al. (2006).

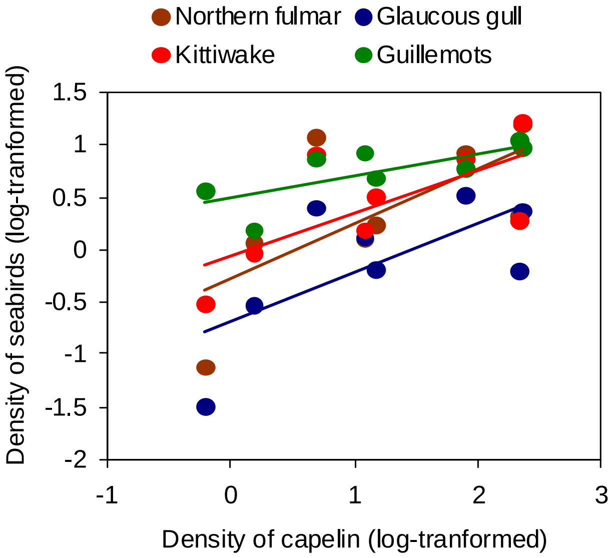


Figure 2.4.4
Average yearly density of spawning capelin related to average yearly density of different seabird species in the Barents Sea during late winter (February-March). Each point represents one year in the period from 1987-1994. Data on capelin are average echo integral values (from Fauchald 2008).

Similarly, we found a positive relationship between the number of seabirds in late winter in the Barents Sea and the spawning stock of capelin (**Figure 2.4.4**). However, in contrast to the North Sea, this response was not delayed. Spawning capelin as well as their spawning products, are important food items for seabirds along the coast of the Kola Peninsula and Finnmark in late winter (e.g. Fauchald & Erikstad 2002). It is likely that seabirds respond to this massive pulse of highly energy-rich and easily available food and migrate into the area according to the size of the spawning stock of capelin.

2.5 The foraging ecology of Norwegian gannets

Emeline Pettex, Svein-Håkon Lorentsen, Rob Barrett & David Grémillet

In 2007, SEAPOP took part in an international cooperative study of the foraging ecology of gannets breeding in four Norwegian colonies. One of the aims is to uncover possible reasons for the species' negative population trend in parts of northern Norway over the last decade. Besides measuring the duration of foraging trips by observation, the project also put advanced technology into use by deploying GPS data-loggers on breeding birds at one colony, Gjesvær.

Figure 2.5.1 *Adult gannet near the colony on Ulvøyholmen in Vesterålen. (© Luis De Sousa)*

2.5.1 General background and aim of the project

Many seabird populations are increasingly impacted or threatened by human activities such as fisheries, oil exploration, ship traffic and accumulation of deleterious pollutants. From a management point of view, as well as from the perspective of the general public, it is essential to understand how seabirds will react to these activities, and to environmental changes in the marine environment.

Recent studies have documented that some Norwegian seabird species are currently under threat (e.g. Barrett et al. 2006, Lorentsen 2007). Among them is the gannet which, after a remarkable increase in numbers after their establishment as a nesting species in Norway in the 1940s, has experienced a considerable decrease in numbers in the Lofoten/Vesterålen area (Barrett et al. 2006, Lorentsen 2007).

In this project we studied the foraging ecology of gannets along the Norwegian coast to gain a better understanding of factors influencing their current population trends. There are three reasons why Norwegian gannets are ideal models to study the impact of environmental change on seabirds of the Barents Sea.

(1) Gannets are widespread in western Europe, particularly around the British Isles (225,000 breeding pairs), but the Norwegian gannet population is considerably smaller, with approximately 4200 breeding pairs (Barrett et al. 2006, Lorentsen 2007). This is probably because Norwegian gannets live on the northern edge of the species' distribution range and experience more marginal conditions than birds living within the core area (i.e. in the UK). We predict, therefore, that Norwegian gannet populations will be more sensitive to environmental change than other gannet populations.

(2) In contrast to all other gannet populations, breeding numbers are currently declining in parts of the Barents Sea (Lorentsen 2007). For instance, there have been dramatic declines in colonies in the Lofoten/Vesterålen area, whereas colonies further north in Finnmark are still increasing, albeit slowly. This is a clear sign that some of the Norwegian gannet populations face considerable environmental stress. It has been suggested that the decreases in Lofoten and Vesterålen may be partly due to predation by an increasing population of white-tailed eagles (Barrett et al. 2006), but it is also possible that it is related to changes in food availability which, in turn, is influenced both by fisheries and oceanographic conditions (e.g. Anker-Nilssen et al. 2000, Barrett et al. 2006).

(3) Gannets are the largest of all seabirds in the North Atlantic. Their size makes them particularly suitable as model species for studying the interactions between food availability, seabird behaviour and population dynamics; simply because various types of data loggers that records feeding behaviour and at-sea movements can be attached to them without impairing their body condition or breeding success (e.g. Grémillet et al. 2004, 2006).

Whereas the population trend and the breeding biology of Norwegian gannets have been monitored, nothing is known about their behaviour at sea, e.g. where and how they gather food. As a result, the ultimate causes of their population change remains obscure. To fill this gap and thereby contribute to a better management of gannet populations, we tested the hypothesis that current population trends in Norway are conditioned by food availability. We specifically compared the foraging behaviour of birds from rapidly declining colonies (in Lofoten/Vesterålen) and those that are slowly growing (in Finnmark and Møre og Romsdal), with literature and field data available for more dynamic colonies in France (Grémillet et al. 2006) and the British Isles (Lewis et al. 2001, Hamer et al. 2001, Wanless et al. 2005).

2.5.2 Methods

Foraging ecology

From mid-June to the end of July 2007, we studied gannet foraging behaviour at four Norwegian colonies: Runde (Møre og Romsdal), Ulvøyholmen (Vesterålen), Gjesvær (Finnmark) and Syltefjordstauran (Finnmark), using two complementary approaches.

For all colonies, we conducted an attendance survey, recording foraging trip durations for 18 to 24 breeding pairs. Continuous observations performed from 40 to 200 m distance with a spotting scope (Kowa TSN1 20-60x) lasted between 36 to 52 hours. For each nest, we recorded the time of arrival and departure for both parents. These data were used to calculate foraging trip duration and time spent by the parents together on the nest. There is a significant relationship between foraging trip duration and foraging range in gannets (Hamer et al. 2001, Lewis et al. 2001, Grémillet et al. 2006). We therefore used foraging trip durations as a proxy for foraging effort and compared Norwegian gannetries with similar published data for UK and French colonies of different size (Lewis et al. 2001, Grémillet et al. 2006).

In order to study in detail foraging trip duration, foraging range and foraging areas of Norwegian gannets in the Barents Sea, we also equipped 21 breeding adults with miniaturised GPS recorders for an average period of 24 hours each at the Gjesvær colony. The birds were all rearing 3-6 week old chicks. The deployments were conducted between 9 and 18 July 2007. One of the pair members at a nest was caught when both partners were sitting together. One partner always stayed at the nest to guard the chick. We used one-channel GPS data-loggers from Newbehavior (Technosmart, Rom, Italy) housed in waterproof and pressure tight, streamlined containers (95x48x24 mm; mass 65 g, i.e. 2.2 % of adult body mass, see Grémillet et al. 2004 for details). Latitude and longitude (both with an accuracy of 10 m), and speed were recorded at 10 second intervals.

Population trends

The breeding population of gannets in North Norway has been monitored since 1961 through counts of apparently occupied nests on aerial photographs or from land (Lorentsen 2007). We used these data to compare colony growth rates at the four Norwegian colonies with UK and French colonies (using data from Wanless et al. 2005 and Grémillet et al. 2006).

Figure 2.5.2 *The gannet colony on Gjesvær as seen from above. (© Céline Le Bohec)*

2.5.3 Results

Foraging ecology

We recorded 463 trips from 82 nests by direct observation at the four colonies. Mean foraging trip duration did not exceed 8 hours. The foraging trips at Ulvøyholmen, the smallest colony, were significantly ($p<0.001$) longer than at Syltefjord and Gjesvær (**Figure 2.4.1**), which contradicts the expected density dependence effect on the foraging trip duration since the Ulvøyholmen colony is markedly smaller than the Syltefjord and Gjesvær colonies. Birds from Runde performed the longest foraging trips ($p<0.001$ for Syltefjord and Gjesvær, $p=0.052$ for Ulvøyholmen).

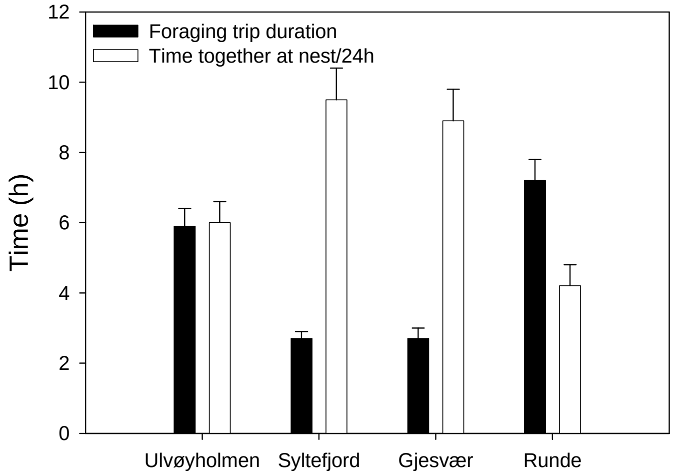


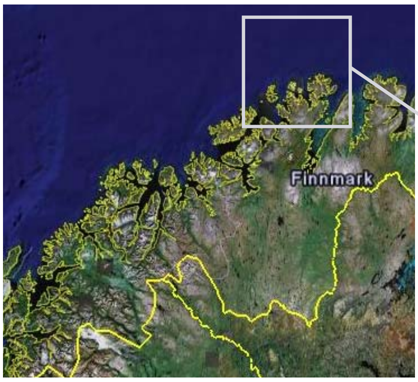
Figure 2.5.3
Foraging trip durations (black bars) and joint attendance duration (white bars) of chick-rearing gannets from four Norwegian breeding colonies in 2007.

As foraging trips were relatively short, both parents spent a substantial time together at the nest in all colonies, and chicks were never left alone. In comparison, gannets from Bass Rock (UK), who perform very long foraging trips, often leave their chicks unattended (Lewis et al. 2006). The joint attendance duration fits with the foraging trip duration from the four colonies: birds from Runde spent less time together per day than birds from Ulvøyholmen, while parents from Gjesvær and Syltefjord jointly attended their chick for the longest periods (**Figure 2.5.3**).

We recovered all the 21 GPS recorders deployed on gannets from the Gjesvær. Complete data sets were recorded for a total of 48 foraging trips. To minimize pseudo-replication problems, one trip per bird, randomly selected, was used for the analysis.

The gannets from Gjesvær foraged in three different areas: southwards to the Kobbefjorden area, northwest of the North Cape and to the west (towards the islands of Hjelmsøya and Rolvsøya) (**Figure 2.5.4**). The birds generally foraged within 20 km of the coast, except for two that foraged between 40 and 63 km offshore. The longest foraging trip lasted for 15.5 h while the shortest was about 20 min.

The mean path length travelled during foraging trips was 103.4 km (*SE*=17.6, range 3.6-295.3 km), with a mean maximum distance to the colony of 22.5 km (*SE*=3.9, range 1.7-63.8 km). This result comforts the idea of relatively good prey availability in the North Cape area, as the birds performed relatively short foraging trips.



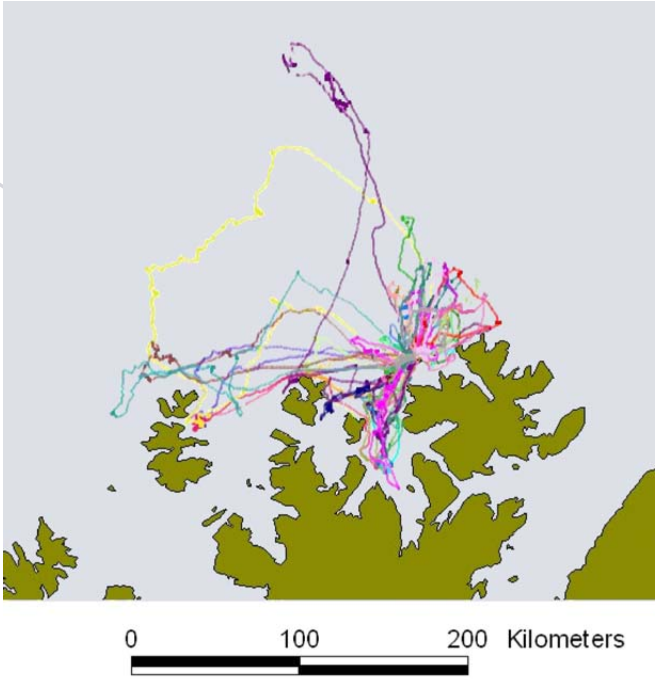


***Figure* 2.5.4**
GPS tracks recorded during 48 foraging trips by 21 breeding gannets from Gjesvær (Storstappen), Norway.

A positive significant relationship has been shown between the foraging trip duration and the foraging range of gannets from the UK and France (Hamer et al. 2001, Lewis et al. 2001, Grémillet et al. 2006). This relationship is also significant for the Gjesvær colony (*p*=0.001). There was also a positive relationship between foraging trip duration and foraging path length (*p*=0.000; **Figure 2.5.5**) and foraging trip duration and the flying time (*p*=0.000).

We can therefore use foraging trip duration as a proxy for foraging effort, and compare this variable for Norwegian gannetries of different size with similar data from UK and French colonies (Lewis et al. 2001, Grémillet et al. 2006). Such comparison (**Figure 2.5.6**) shows that birds from Runde and Ulvøyholmen exerted the expected effort, while birds from Syltefjord and Gjesvær colonies made shorter foraging trips than expected for birds attending colonies of the actual size. This comparison strongly suggests than food availability is not a limiting factor for gannet colonies in Norway, especially along the Finnmark coast.

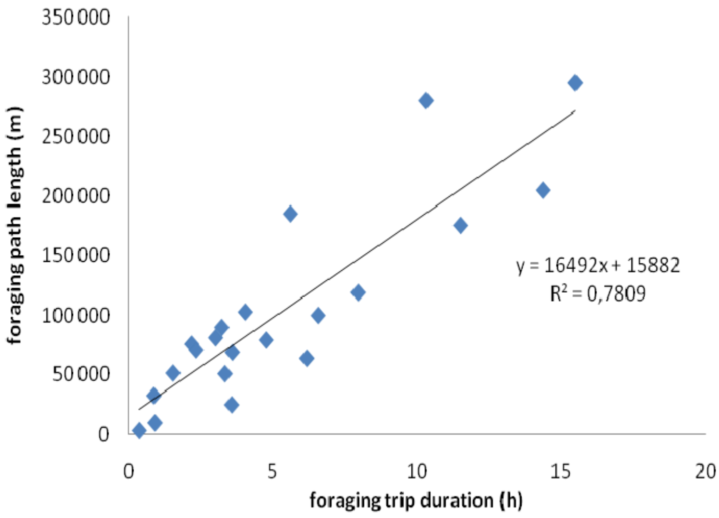


***Figure* 2.5.5**
Relationship between foraging trip duration and foraging path length in breeding gannets from Gjesvær, Norway (n=21)

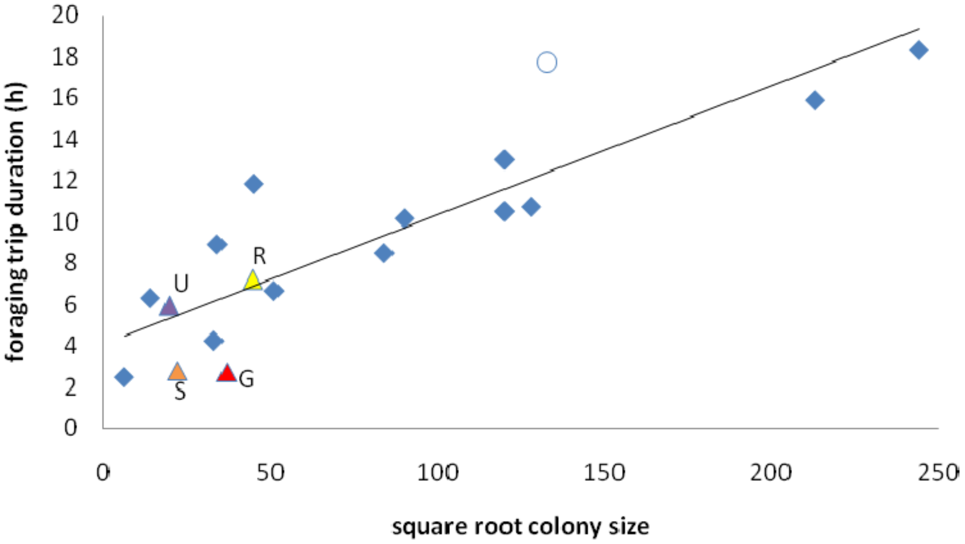


Figure 2.5.6
Relationship between foraging effort of breeding adult gannets and the size of their colony. Norwegian birds (triangles) produce an equivalent (U=Ulvøyholmen, R=Runde) or smaller (S=Syltefjord, G=Gjesvær) foraging effort than gannets from British Isles (blue diamond) or France (white circle) (British and French results are from Lewis et al. 2001).

2.5.4 Conclusions

This study strongly suggests that food is readily accessible for Norwegian gannets. Indeed, the foraging effort of breeding adults measured in the colonies is similar to (Runde, Ulvøyholmen) or lower (Gjesvær, Syltefjord) than the foraging effort in British and Irish colonies. The latter more or less all show positive population trends, with an average of 4% growth per year (Wanless et al. 2005). Diet samples gathered at Gjesvær mainly constituted herring, a high quality prey for the growing chick.

However, the Syltefjord population stopped increasing in 1995 and the colonies in Vesterålen and Lofoten archipelagos have experienced huge declines during recent years (Lorentsen 2007). If prey availability cannot explain this phenomenon, two other mechanisms could be involved. First, predation by sea eagles is suspected to have an impact on both chicks and adults in the Lofoten/Vesterålen area (Barrett et al. 2006) and during our stay in Syltefjord, we observed numerous sea eagles and signs of predation (on kittiwakes mainly) around the colony. The second hypothesis involves limited recruitment of adults to the breeding sites, and therefore lack of renewal of the breeding population.

3 Other project reports

3.1 Monitoring at key-sites

A great variety of species and parameters are currently being monitored at the eight key-sites established for SEAPOP in the Barents and Norwegian Seas (**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 2004-07. 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 sections below. Survival estimation was made in Program MARK (ver. 5.0, Cooch & White 2007), following a standard procedure detailed by Anker-Nilssen (2008). No covariates were included in the modelling. The estimates reported here are those calculated by the model that in each case fitted the data set best, usually the model with the lowest Akaike information criterion (*AICc*) after having adjusted for overdispersion by the *Median c-hat* method (*QAICc*). In cases where this model was not clearly different from all the three other models, the model averaging procedure was applied including all models with *Delta QAICc* ≤ 2. In all cases, sample size was defined as the number of marked individuals contributing to the survival estimation for the year interval(s) in question (i.e. not including those ringed in the last year).

Figure 3.1.1
The geographical positions of the SEAPOP key-sites (red circles) in the Norwegian and Barents Sea, at which data series on seabird demography were collected in 2007. Note that the key-site on Spitsbergen is divided among several localities in Isfjorden and the Kongsfjorden area. The positions of Grindøya and Horsvær, where there are studies of common eider and lesser black-backed gull, respectively, are also shown (cf. Sections 3.1.6 and 3.1.8).

Table 3.1.1 *Population parameters monitored annually at SEAPOP key-sites in the Barents and Norwegian Seas, 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	Fulmar	1988	—	—	—	—	—
	Eider	1981	—	—	—	1981[1]	Yes
	Kittiwake	1988	1998	2000	—	2004	Yes
	Brünnich's guillemot	1988	2005	2006	—	2005	Yes
	Little auk	—	2005	2005	—	2005	Yes
Bjørnøya	Fulmar	1989	—	—	—	—	—
	Great skua	^{03}2005	2005	2005	2005	2005	Yes
	Glaucous gull	1997	(1997)	(1997)	—	^{86}1997	Yes
	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	Shag	(1981)	2004	^{89}	$^{80-81}$	$^{80-81}$2005	Yes
	Herring gull	—	2006	—	2006	2006	Yes
	Great black-backed gull	—	$^{02-03}$2005	—	$^{02-03}$2006	$^{02-03}$2006	Yes
	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
	Puffin	1980	1990	$^{80-83}$1987[3]	$^{80-81}$1988	$^{80-81}$1988	Yes
Hjelmsøya	Great skua	(1997)	—	—	—	—	—
	Kittiwake	1991	2004	2005	2005	2004	Yes
	Common guillemot	1984	2004[4]	—	—	2004	Yes
	Brünnich's guillemot	1984	—	—	—	—	—
	Razorbill	(1996)	—	—	—	—	—
	Puffin	1997[5]	2004[4]	—	—	2006	Yes
Grindøya	Eider	(1985)	1985	—	—	1986	Yes
Anda	Shag	2005	2006	—	—	—	Yes
	Herring gull	2005	—	—	—	2007	Yes
	Kittiwake	2005	2005	2006	—	2005	Yes
	Common guillemot	2005	—	—	—	—	—
	Puffin	$^{81-83}$2005	2005	2005	2005	2005	Yes
Røst	Fulmar	1997	—	—	—	—	—
	Cormorant	1997	—	—	—	2002	Yes
	Shag	1985	2002	(2006)	—	1985	Yes
	Eider	^{88}2000	—	—	—	2001	—
	Great skua	(1988)	—	—	—	(2005)	(Yes)
	Common gull	—	—	—	—	2006	—
	Herring gull	—	—	—	—	2006	—
	Great black-backed gull	—	—	—	—	2006	Yes
	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
	Puffin	1979	1990	1979	1964	1974	Yes

1) *Except for 1988-90, 1992 & 1994 (no data);* ***2)*** *Data from most years in 1996-2007 have been collected by Thierry Boulinier and co-workers (CNRS, France);* ***3)*** *Except for 1988 (no data);* ***4)*** *Due to heavy predation from feral mink in the original study plots in 2006, new plots were established in 2007;* ***5)*** *Population size is monitored at Gjesværstappan, about 20 km east of Hjelmsøya.*

***Table 3.1.1** continued*

Key-site	Species	Population size	Adult survival	Chick food	Chick growth	Reprod. success	Other data
Horsvær	Lesser black-backed gull	(1980)	2005	2005	2005	2005	Yes
Sklinna	Fulmar	(2007)	—	—	—	—	—
	Shag	1984	2004	2007	2007	2007	—
	Herring gull	(2007)	—	—	—	2007	—
	Kittiwake	1980	—	—	—	—	—
	Common guillemot	1983	—	—	—	—	—
	Razorbill	1983	—	—	—	—	—
	Puffin	1981	2007	2007	2007	2007	—
Runde	Shag	(1975)	—	2007	—	2007	—
	Eider	(1986)	—	—	—	—	—
	Great Skua	1998	—	—	—	—	—
	Kittiwake	1980	—	—	—	—	—
	Common guillemot	1980	—	—	—	—	—
	Puffin	1980	2007	$^{80-82}$2007	—	$^{80-82}$2007	—

Figure 3.1.2
A young puffin returning to the colony for the first time. The dark-faced appearance and lack of grooves on the slender and pale orange bill of this individual proves it is only one year old (cf. Figure 2.1.1). The survival of young birds from fledging to first breeding is a key factor in the population dynamics of seabirds, but is unfortunately too time-consuming to monitor for a large selection of key species and sites. (© Tycho Anker-Nilssen, Røst, June 2007)

3.1.1 Spitsbergen

Harald Steen

In 2007, we collected data from the Brünnich's guillemot colonies at Diabasodden (78°22′N 16°08′E) in Isfjorden and at Jock Scott (79°10′N 11°52′E) in Krossfjorden, and from the little auk colony in Bjørndalen (78°14′N 15°19′N) for the third year in a row (**Table 3.1.2**). Data on kittiwake were collected from one plot at Ossian Sars (78°56′N 12°29′E) in Kongsfjorden, and at Grumantbyen (78°10′N 15°09′E) in Isfjorden. The work at the two key-sites for Brünnich's guillemot continued with ringing of new individuals, re-sighting of previously ringed birds and counts of chicks and adults (**Figure 3.1.3**).

The monitored population of kittiwake increased quite substantially from 2006 to 2007, while those of the Brünnich's guillemot changed less and in opposite directions. Chick production of the kittiwake was also higher in 2007 than in 2006, as was that of little auks. The latter is measured as the probability for an egg to result in a large chick (≥ 20 days old). It seemed that 2007 was a relatively "warm" year and the diet of little auk consisted mainly of *Calanus glacialis* and some *Themisto* species. Data on adult survival rates were analysed for little auks only, with results being almost identical to those from the previous winter.

Estimating breeding success of cliff-nesting birds has always been difficult since it is not always certain that a nest is inhabited or whether or not it contains egg(s) or chick(s). As a consequence, it is often very time-consuming to collect reproduction data of sufficient quality by observation only. In remote areas, such as in the Arctic, where the expenses in terms of manpower and logistics per unit effort spent in the colony are much higher than elsewhere, this can severely limit the success of seabird monitoring. The key-site work for SEAPOP in Spitsbergen has therefore focussed on developing easier and more robust methods for such studies. We therefore started a project in 2006 in which time-lapse cameras were used to automatically collect data that enables estimating the production and survival of chicks to fledging, as well as the true number of breeders. Purpose-built time-lapse cameras were installed so they faced the cliff, preferably from above, and pictures were taken every four

Table 3.1.2 Key population parameters *(SE, n) of seabirds in Spitsbergen in 2007. Population change is the numeric change in size of the breeding population registered between 2006 and 2007 on the basis of plot counts (p) or total censuses (t). The Fuglehuken colony is situated on the north end of Prins Karls Forland, close to Kongsfjorden. See introduction to Section 3.1 for details of survival estimation.*

Species	**Population**	**Annual adult survival**		**Reproductive performance**	
	change	Period (yrs)	Estimate %	Sampling unit	Estimate
Fulmar	No data				
Eider	[1]			Clutch size	[1]
Kittiwake					
Ossian Sars, Kongsfjorden	+ 36.3% p	Ongoing analysis [1]		Large chicks/nest [2]	1.58 (*n*=167)
Fuglehuken, near Kongsfj.	+ 0.9% p				
Brünnich's guillemot					
Ossian Sars, Kongsfjorden	– 8.7% p			Large chicks/nest [2]	0.45 (*n*=47)
Jock Scott, Krossfjorden	+ 6.0% p	Data not yet analysed		Large chicks/nest [2]	0.68 (*n*=62)
Diabasodden, Isfjorden	No data	Data not yet analysed		No estimate yet available	
Little auk	No data	2005-07 (2)	0.84 (0.03, 48)	Chicks ≥ 20d/egg	0.64 (*n*=50)

1) Data collected by MOSJ not yet available; 2) Number of chicks observed in the last week before fledging divided by number of nests as judged from series of photographs.

hours throughout the breeding season. Kittiwakes have large chicks that are easily counted from the pictures. To estimate the overall chick production, however, we also need to know the number of occupied nests. This was done by counting the number of nests that had an incubating or brooding bird in almost every picture during one week prior to when the chicks were sufficiently large to be left unattended for longer periods of time.

To monitor reproductive performance of the Brünnich's guillemot is much more difficult because the birds conceal their egg or chick, often making it impossible to determine if a bird is incubating, brooding or simply sitting on an empty nest site. The work at the two key-sites for Brünnich's guillemot was therefore paralleled by similar time-lapse camera series taking pictures of the same part of the colonies where manual observations were made. From the photographs we made nest-specific records of whether a chick was visible (1) or not (0) on each nesting site occupied by a pair. These data were then used to estimate chick survival using standard capture-mark-recapture (CMR) models implemented in Program MARK (Cooch & White 2007). In 2007, we also surveyed the colonies carefully for chicks at approximately 15 days post-hatch, which is also the established standard for estimating guillemot chick production on Bjørnøya (cf. Section 3.1.2). The two methods produced similar survival rates for chicks, making future use of time-lapse cameras for monitoring of production looking very promising.

Our study also showed, however, that the usefulness of the method is very dependent on the camera angle and whether the ledges have crevices or not. The camera is best positioned above and perpendicular to the cliff wall. The CMR method clearly underestimated survival rate on ledges where the chicks can hide in crevices, which is logical since the chicks can hide and hence be recorded as dead when they, in reality, simply remain undetected. We are currently developing the methods further to improve their precision and account for the problems (such as that of detectability) outlined above.

Figure 3.1.3
One of the crew noosing an adult Brünnich's guillemot at the cliff edge of the Jock Scott colony in Krossfjorden. (© Erlend Lorentzen)

3.1.2 Bjørnøya

Hallvard Strøm

The monitoring of seabirds on Bjørnøya was initiated in 1986. Since then the number of species and parameters monitored has increased gradually. The programme now includes six species whose population development is monitored, plus the little auk (**Table 3.1.3**). Demographic parameters and chick diet are monitored for five of the seven species, the exceptions being the fulmar and glaucous gull.

The field work period in 2007 was 18 June to 12 August. The 2007 season was characterized by periods of strong wind and heavy rain. Although Bjørnøya is known for its high number of foggy days in June and July, heavy rain such as in 2007 is uncommon in summer. If the heavy rain we experienced reflects more permanent changes in the climate on Bjørnøya, it is likely to influence breeding success of several species. During long periods of rain, chicks of open-nesting species easily get wet, and observations in 2007 indicated that this, in combination with low temperatures, led to increased chick mortality for at least the glaucous gull and both species of guillemots.

The breeding population of the fulmar continued to fall in 2007, whereas the kittiwake and the glaucous gull populations were stable from 2006 to 2007. It has been a general trend on Bjørnøya over the last few years that the breeding population of the surface-feeding species (fulmar, glaucous gull and kittiwake) have been declining. For kittiwakes, this has been part of a wide-spread decline for the species throughout the North-Atlantic. The number of apparently occupied nests of glaucous gulls was on the same level as in 2006, 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 by 65 % since 1986.

The recovery of the common guillemot population after the collapse in 1987 continued in 2007, as in previous years. The species' breeding success was higher than in 2006, and the mean body mass of chicks at the age of 15 days (248 g, *n*=77) indicated a good breeding season. Capelin was, as in previous years, the most important prey species for both guillemot species,

Table 3.1.3 Key population parameters *(SE, n) of seabirds on Bjørnøya in 2007. Population change is the numeric change in size of the breeding population registered between 2006 and 2007 on the basis of plot counts (p) or total censuses (t). See introduction to Section 3.1 for details of survival estimation.*

Species	**Population change**	**Annual adult survival**		**Reproductive performance**	
		Period (yrs)	Estimate %	Sampling unit	Estimate
Fulmar	– 0.4% p				
Great skua	[1]	2005-07 (2)	87.2 (12.0, 98)	Large chicks/nest	0.62 (0.07, 63)
Glaucous gull	[3]	1998-00 (2)	83.6 (*n*=92) [4]	Large chicks/nest	0.30 (0.05, 152)
Kittiwake	0.0% p	2004-07 (3)	81.6 (5.0, 201)	Large chicks/nest	0.77 (0.05, 538)
Common guillemot	+ 4.5% p	1988-2003 (15)	97.5 (0.01, 149) [5]	Fledging success	0.86 (*n*=69)
Brünnich's guillemot	+ 0.4% p	1988-2003 (15)	93.0 (0.01, 78) [5]	Fledging success	0.80 (*n*=54)
Little auk		Data not yet analysed [6]		Chicks ≥ 15d/nest	0.78 (*n*=90)

1) *Monitoring of the breeding population was initiated in 2005, but the results are not yet fully analysed.;* ***2)*** *Colour-ringing was initiated in 2005 with 49, 44 and 20 adults ringed in the first 3 years;* ***3)*** *Data not yet analysed;* ***4)*** *Bustnes et al. (2003);* ***5)*** *Bakken & Strøm (submitted);* ***6)*** *Colour-ringing was initiated in 2005 with 88, 152 and 82 adults ringed in the first 3 years.*

Figure 3.1.4
A total of 322 adult little auks have been colour-ringed on Bjørnøya since 2005, using a combination of three colour rings in addition to the metal ring. (© Tonje Jerstad)

but both squid *Gonatus fabricii* and 0-group saithe *Pollachius virens* constituted an important part of the diet for both species. Squid was also recorded as an important part of the chick diet in 2007, but not in previous years.

The monitoring of the little auk that was initiated in 2004 continued in 2007, and now includes adult survival, breeding success, diet and several other parameters. Eighty-two adults and 44 chicks were ringed, and the adults were also equipped with colour rings (**Figure 3.1.4**). One hundred and sixteen little auk nests were inspected regularly until the chicks reached the age of 15 days or older (**Figure 3.1.5**). The median hatching date was 16 July, and 76% of the eggs hatched in the five day period 14–18 July. A breeding success of 0.78 (*n*=90) to age ≥ 15 days is the highest recorded for the species on Bjørnøya so far (three seasons). The monitoring of the great skua population on the northern part of the island continued, and 20 adults and 32 chicks were ringed with both metal and coded colour-rings. A total of 113 adults have so far been ringed with coded rings. Sixty-two nests were followed until the chicks reached the age of 15 days or older. The breeding success in 2007 (0.62 chicks/nest) was very similar to that in 2006 (0.60).

Figure 3.1.5
The local interest in the study of breeding performance in burrows of little auks on Bjørnøya is certainly irreproachable. (© Tonje Jerstad)

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 seven key species were studied during the 2007 season (**Table 3.1.4**). Except for kittiwakes and the other gulls, the 2007 season was moderate to good for all species on Hornøya. Although the start of the breeding season for the kittiwake was reasonably early with the first eggs being laid at the end of April (normally a good sign), their overall breeding success was very poor with only 0.1 chicks fledging per nest. Only once (in 2001) has the breeding success been lower in the 24 seasons for which such data exist since 1980. Furthermore, the breeding population of kittiwakes continued to drop (by 7 % since 2006). As in 2006, 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.

In 2006, a slight decline in numbers of Atlantic Puffin burrows was apparent from the monitoring counts, and it was suggested that this may have been because an early, lush growth of vegetation concealed some of the burrow entrances at the time of counting. However, numbers were about the same in 2007 (**Table 3.1.4**) such that this decline may indeed be real. Since its collapse in 1987, the common guillemot population on Hornøya has been increasing every year, but in 2007 there were signs of a culmination with numbers actually dropping (by 3 % since 2006) for the first time. However, although no direct measure of their breeding success was made, the mass of chicks leaving the nest sites on several nights in early July (means of 250-270 g) suggested yet another good breeding season.

The fledging success of puffin chicks was good (74%), but their mean growth rate (4.1 g/d) was much lower than normal (10-12 g/d), suggesting that food conditions were poor. Mean wing growth rates (2.9 mm/d, normal 3.5-4.0 mm/d) were also the lowest ever recorded on Hornøya. Razorbill chicks had higher growth rates (ca. 10 g/d) during the main growth period, but an overall fledging success of ≤ 53 % was lower than expected. The mean hatching dates of 43 razorbill eggs was 3 July (range 25 June-12 July) and of 45 puffin eggs was 28 June (range 10 June-15 July), which were both similar to the timing of breeding in 2005 and 2006.

Table 3.1.4 Key population parameters *(SE, n) of seabirds on Hornøya in 2007. Population change is the numeric change in size of the breeding population registered between 2006 and 2007 on the basis of plot counts (p) or total censuses (t). See introduction to Section 3.1 for details of survival estimation.*

Species	**Population change**	**Annual adult survival**		**Reproductive performance**	
		Period (yrs)	Estimate %	Sampling unit	Estimate
Shag	No data	2004-07 (3)	77.1 (3.6, 117)	Clutch size	2.68 (0.14, 47)
Herring gull	No data	No estimate yet possible [1]		Clutch size	2.41 (0.11, 108)
				Large chicks/nest	0.32 (0.08, 53)
Great black-b. gull	No data	Data not yet analysed		Clutch size	2.82 (0.12, 38)
				Large chicks/nest	0.52 (0.21, 38)
Kittiwake	– 6.2% p	2005-06 (1)	80.7 (10.0, 1103)	Clutch size	1.47 (0.04, 775)
				Large chicks/nest	0.14 (0.01, 1899)
Common guillemot	– 3.3% p	1989-07 (18)	96.0 (0.5, 174)	No data	No data
Razorbill		1994-07 (13)	91.1 (1.1, 164)	Fledging success [2]	53.2% (*n*=62)
Puffin	+ 0.9% p	1990-07 (17)	86.8 (1.7, 685)	Fledging success [2]	74.1% (*n*=54)

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

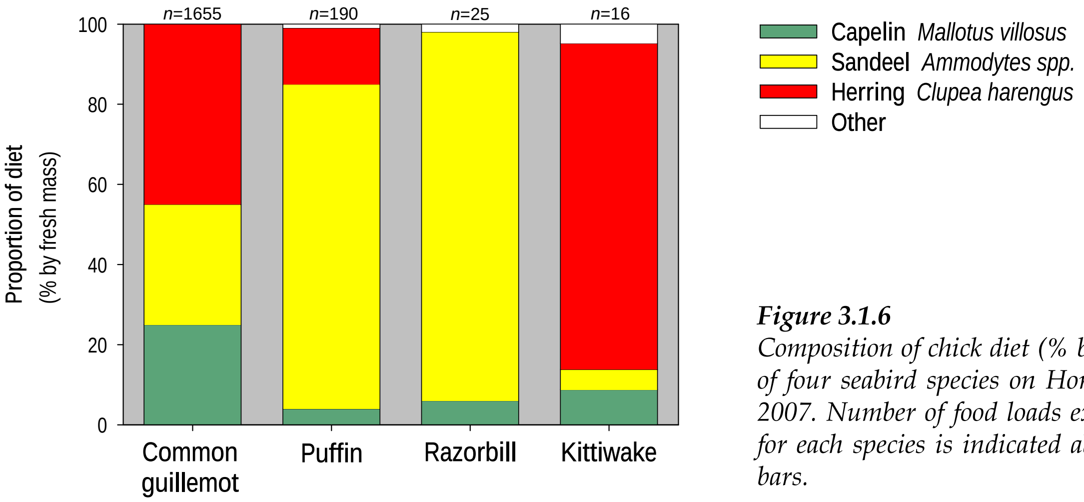
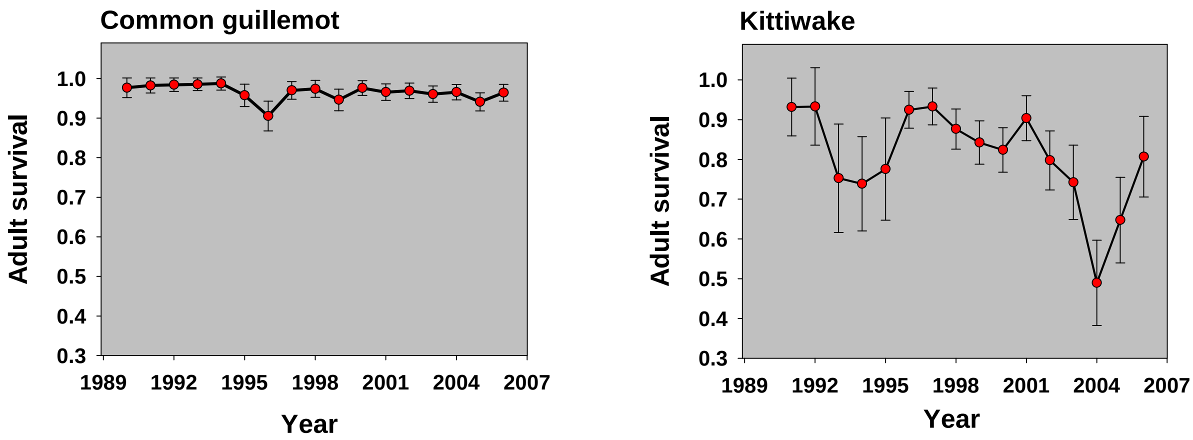


Figure 3.1.6
Composition of chick diet (% by mass) of four seabird species on Hornøya in 2007. Number of food loads examined for each species is indicated above the bars.

Demographic studies on herring gulls and great black-backed gulls were initiated at Hornøya in 2006. Both adults and full-grown chicks are ringed annually to follow both adult survival and recruitment rates of young to the colony. We also monitor the clutch size and success of a sample of nests. The 2006 breeding season was a complete failure for both species. In 2007 the success was somewhat higher, but still low for both species (herring gulls 0.32 chicks per pair and great black-backed gull 0.52 chicks per pair).

At present we have adult survival estimates for five species at Hornøya. The shag has had a constant yearly survival rate of 77.1 % since 2004, which is somewhat above the estimate based on data for the period 2004-2006 (71.7%). However, this estimate is still low compared to the estimate from Røst and colonies abroad (Harris et al. 2000) suggesting that the Hornøya population is still suffering from relatively poor survival of adults.

Figure 3.1.7
An adult kittiwake on the nest about to feed (one of) its small chick(s). (© Rob Barrett)



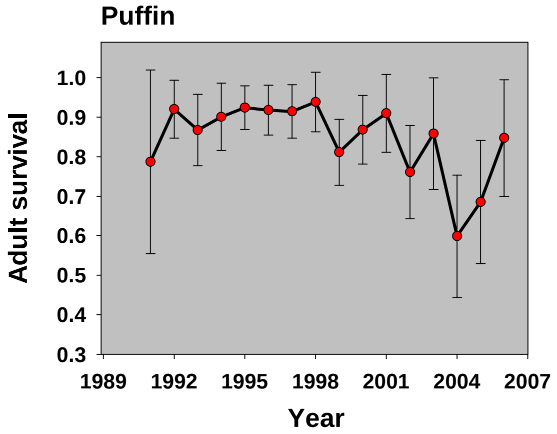


Figure 3.1.8
The yearly variation in survival rate (mean ± 1 SE) from the preceding year of common guillemot, puffin and kittiwake at Hornøya in the period 1990-2007. Note that the modelled variation in survival is only significant for kittiwake.

For the common guillemot and razorbill, the survival rate has remained high and stable (about 96% and 91% p.a., respectively). The survival rate of the kittiwake is highly variable between years, and the variability of puffin survival seems to have increased over the last decade, although the overall variation is not significant. With 18 years of data on adult survival for the kittiwake, puffin and common guillemot, some general patterns seem to emerge (**Figure 3.1.8**). Whereas the common guillemot has had a high and constant survival for the whole period, the survival rates for both for the kittiwake and puffin appear to be much more variable. There also seems to be some synchrony in their variation, with a decreasing survival rate between 2001 and 2004 and then an increase until 2006. Any causes of this variation and the effect on the population sizes remain to be analyzed.

Figure 3.1.9
An adult herring gull about to eat the egg of a common guillemot. Predation on eggs from large gulls may have significant negative impact on the breeding success of guillemots, especially in colonies where frequent disturbance from white-tailed eagles pave the way for gulls and corvids. (© Rob Barrett)

3.1.4 Hjelmsøya

Kjell Einar Erikstad & Geir Helge Systad

Hjelmsøya in western Finnmark was established as a SEAPOP key-site in 2004 and three species, the puffin, common guillemot and kittiwake were selected as the primary target species (**Table 3.1.5**). In 2007, we also included the monitoring of breeding performance of herring gull.

Monitoring of the puffin population on nearby Gjesværstappan started in 1997, since when the population has dropped by 4.8% p.a. (Lorentsen 2007). From 2005 to 2006, there was a strong decline in the population estimate (-22.9%) which is in contrast to the slight increase in the population from 2006 to 2007 (+5.4 %). The fledging success of puffins was low (20.3%) and much lower the estimate from Hornøya in Eastern Finnmark (74%). To avoid the severe problem of mink predation in the original monitoring plots for survival rates (see last year's report), we had no option other than to established new plots for colour-ringing of puffins (80 adults and 20 chicks were ringed) and common guillemots (60 adults were ringed). Consequently, there is no updated estimate of survival of adults for these species and the interval 2006-07 will remain as a permanent gap for this important parameter.

The breeding success of razorbill was low (6.9%) and the success of common guillemot was a complete failure on open ledges. Only the birds which nest in sheltered areas managed to produce some chicks (success 27.7%, **Table 3.1.5**).

The kittiwake also suffered a complete breeding failure in 2007, as it did in 2006, and again this phenomenon seemed to be caused by a combination of a food shortage and the predation of eggs and small chicks by ravens. The population trend for kittiwake is still alarming with a reduction number of birds in study plots of 20% since 2006. The steep decline in the kittiwake population is occurring over large areas in the Barents Sea (see also Section 3.2). It seems

***Table 3.1.5 Key population parameters** (SE, n) of seabirds on Hjelmsøya in 2007. Population change is the numeric change in size of the breeding population registered between 2006 and 2007 on the basis of plot counts (p) or total censuses (t). Numbers of 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. See introduction to Section 3.1 for details of survival estimation.*

Species	**Population change**	**Annual adult survival**		**Reproductive performance**	
		Period (yrs)	Estimate %	Sampling unit	Estimate
Great skua[1]	+ 33.3% $^{\mathrm{t}\,1}$				
Herring gull				Clutch size	2.78 (0.12,46)
Kittiwake	– 19.9% $^{\mathrm{p}}$	2005-06 (1)	64.6 (8.9, 206)	Clutch size	1.73 (0.11, 179)
				Large chicks/pair	0.00 (0.00, 247)
Common guillemot	+ 40.0% $^{\mathrm{ip}}$	No update possible[2]		Fledging success[3]	0.00 (*n*=378) $^{\mathrm{ip}}$
	+ 58.8% $^{\mathrm{ep}}$			Fledging success[3]	0.28 (*n*=173) $^{\mathrm{ep}}$
Razorbill	– 1.4% $^{\mathrm{ip}}$			Fledging success[3]	0.07 (*n*=58) $^{\mathrm{ip}}$
	– 2.3% $^{\mathrm{ep}}$				
Puffin	+ 5.4% $^{\mathrm{p}}$	No update possible[2]		Fledging success[3]	0.20 (*n*= 102)

__1)__ From 6 to 8 pairs; __2)__ Previous data series (established in 2004) was destroyed in 2006 due to predation from feral mink in the study plot. New series was established in 2007, i.e. data on survival between 2006 and 2007 will be lost; __3)__ Medium sized chicks per egg laid.

that this downward trend is related to low breeding success and lack of recruitment of young birds rather than increased mortality of adults.

Although the best model now indicates that kittiwake survival rates on Hjelmsøya vary between years dropping to a very low level (64%) between 2005 and 2006, the latter was only paralleled by a 10% decrease in breeding numbers between the same two years (cf. last year's report). It should therefore be pointed out that the time series is still very short, and the drop in survival could partly be an artefact of many adults abandoning the breeding site early in both 2006 and 2007 due to the total breeding failure of the colony in both years. This can only be documented when data from a successful year is added to the series.

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 2007). The population breeding on opens ledges declined steeply after the collapse of the Barents Sea capelin in the 1980s (**Figure 3.1.10**) and is now at a very low level with high risk of extinction if the there is no improvement of the breeding conditions (Erikstad et al. 2007). Annual counts of eggs in other and more sheltered parts of the colony since 1992 are much more variable as they also reflects variations in reproductive performance, but clearly 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 (Lorentsen 2007).

From 2006 to 2007, there was a strong increase in the population estimates for both open and sheltered areas (40% and 59%, respectively). It is unlikely that this large increase reflects any true population increase, but may rather be a result of yearly variation in non-breeding birds which do not settle in the colony each year or in the proportion of established breeders that stay put until the counts are made. A similar difference in the long term trends for sheltered and exposed breeders is probably also valid for razorbills even though the estimates for open and sheltered habitats were about the same in 2006 and 2007 (**Table 3.1.5**).

There is, however, no question that the breeding population of common guillemots has increased since 1992 in sheltered parts of the colony and decreased on open ledges (Lorentsen 2007). One problem is that monitoring guillemots in sheltered areas are not possible using standard monitoring methods. We thus do not yet know the ratio of the population nesting in open contra sheltered areas. However, if one assumes as "an educated guess", that the ratio of birds nesting at open vs. sheltered habitats was 70:30 in 1992, the monitoring data on population trends in the two habitats indicate that the total population of common guillemots breeding on Hjelmsøya has been relatively stable over the last 15 years, and that the fraction of birds nesting at open vs. sheltered habitats has changed gradually to about 30:70 in 2007.

Such habitat shifts in the common guillemots challenge the traditional monitoring which is designed for open habitat. There are some obvious questions which need to be considered. For instance, we do not know if birds on open ledges, which for years have suffered complete breeding failure, move to the sheltered areas. The situation is also relevant for other breeding areas such as in Røst, where the common guillemot population on open ledges at Vedøy is now virtually extinct, while the population on other islands in the archipelago breeds in sheltered areas and is increasing (see Section 3.1.7). At key-site Sklinna, all guillemots are nesting in shelter and the population is increasing strongly (see Section 3.1.9).

Figure 3.1.10
The density of common and Brünnich's guillemot on three monitoring plots at Hjelmsøya in 1994 and 2007, illustrating the drastic decline in density of birds at open ledges. The few birds now left are not able to produce young due to heavy predation from gulls, ravens, crows and white-tailed eagles. Common guillemots breeding in more sheltered habitats on the island have increased in numbers, whereas Brünnich's guillemot still only breeds on open ledges and are close to extinction.

3.1.5 Grindøya

Kjell Einar Erikstad, Jan Ove Bustnes & Sveinn Are Hanssen

Grindøya (69°38′N 18°49′E) near Tromsø 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. Many other aspects of the Grindøya common 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. From 2006 to 2007 there was again a drop (5.2%) from 528 to 491 males (**Table 3.1.6**). For the whole Balsfjorden area, however, there was a slight increase (6.9%) in number of males seen (from 1734 in 2006 to 1850 in 2007).

The mean clutch size of 4.3 eggs in 2007 is considered "normal" and within the upper part of the range of annual means (3.1-4.5) registered between 1986 and 2007.

The survival of breeding females increased from 53% in 2004-05 to 68% in 2005-06 (**Figure 3.1.11**). The survival during the period 1986-2002 (mean level above 80% p.a.) was, however, much higher than that observed during the period 2003-06 (mean level less than 70% p.a.). The drop in female survival around 2002 coincides with an increase in predation by feral mink on incubating females.

We have, since 2002, also observed a skew towards males in the sex ratio of birds wintering in the area with more than 60% males (**Figure 3.1.12**), corroborating the observed increased mortality of breeding females. Such a skew in sex ratio of common eiders towards males on the wintering ground has also been registered recently in Finland. A skewed sex ratio may have implications for the design of eider monitoring. As the standard method used in the National monitoring programme is to count males, the observed change in sex ratio suggests that the overall population decline in the outer parts of the Balsfjorden area is even worse than that indicated by the monitoring data.

Table 3.1.6 *Key population parameters (SE, n) of common eider on Grindøya in 2007. Population change is the change in number of adult males registered in breeding areas farther out in Balsfjorden between 2006 and 2007 on the basis of total counts (t). See introduction to Section 3.1 for details of survival estimation.*

Species	**Population change**	**Annual adult survival**		**Reproductive performance**	
		Period (yrs)	Estimate %	Sampling unit	Estimate
Eider	– 5.2% t	2005-06 (1)	68.0 (0.14, 1258)	Clutch size	4.31 (0.14, 35)

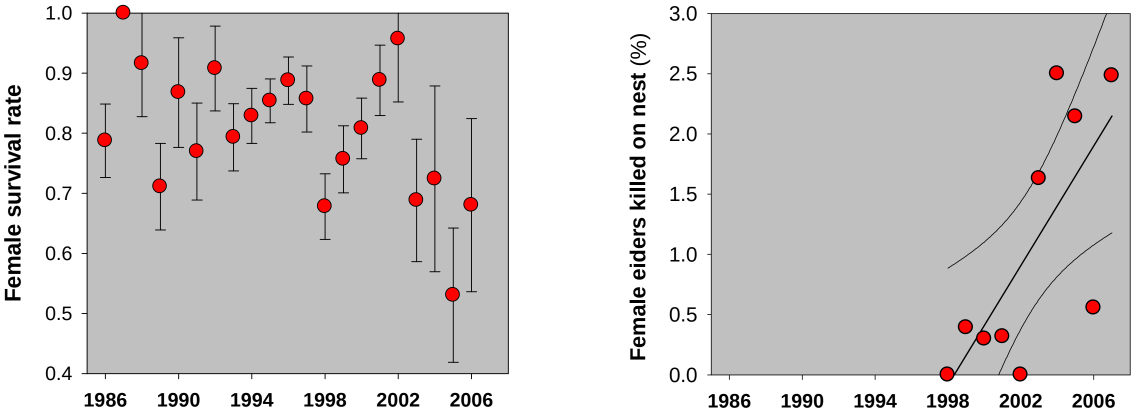


Figure 3.1.11
The survival from preceding year of female common eiders on Grindøya in 1986-2006 (left panel) and the proportion (mean and 95% confidence limit) of incubating females killed on their nest by mink during the period 1998 to 2007. Before 1998, mink predation was negligible.

Predation by mink may not be the only explanation to the increased mortality of females. Other suggested mortality factors includes an increasing numbers of white-tailed eagles, which may target incubating females because they are likely to be an easier prey than males. Female common eiders also experience severe stress associated with their fasting strategy during breeding. This makes them especially vulnerable to food stress in the pre-breeding season, when they need to accumulate large amounts of body reserves to spend on eggs and incubation. The fasting strategy may also make females more sensitive than males to contamination by various chemical compounds, and it is possible this can interact with food stress in a synergistic manner such that the overall effects are more pronounced than additive effect of the two factors acting independently. Obviously, more research is needed to explain the mechanisms behind the downward population trend and the observed male bias in common eiders.

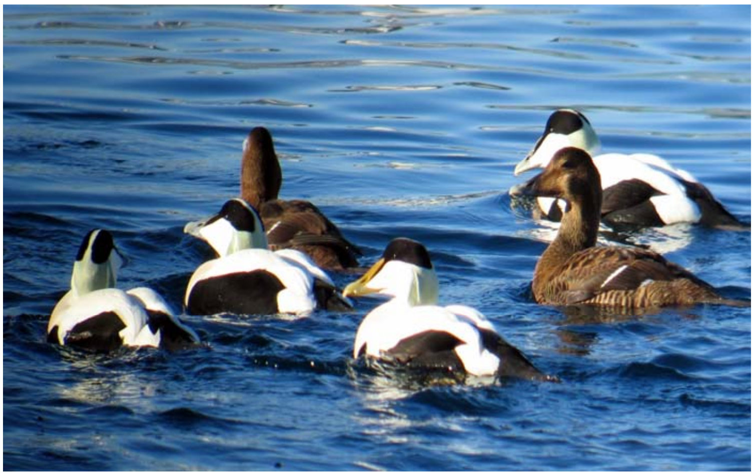


Figure 3.1.12
The common eider population at Grindøya has decreased during the last years, most likely due to heavy predation by mink on incubating females at the nest. An observed skew in the sex ratio (excess of males) of common eiders on the wintering grounds in the Balsfjorden area is worrying and suggests that the problem is not limited to Grindøya. (© Sveinn Are Hanssen)

3.1.6 Anda

Svein-Håkon Lorentsen & Signe Christensen-Dalsgaard

The island Anda (64°04′N 15°10′E) in Vesterålen was established as a SEAPOP key-site in 2005.

Puffins were first monitored at Anda in 1981-83 but until 2005, no regular studies were carried out on the island. Fortunately, the monitoring plots counted in the early 1980s were well documented and comparisons could be made with results from the monitoring in 2005-2007. In 2005, new plots for puffin monitoring using the Star system (Anker-Nilssen & Røstad 1993) and monitoring plots for kittiwakes were established. The first counts were made in 2006, and were followed up in 2007. Total censuses of the shag, herring gull and common guillemot populations were also made. In 2007, data on breeding success of puffin and kittiwake were collected. For monitoring of adult survival, 26 and 27 individuals of puffin and kittiwake respectively, were fitted with individually coded colour rings (as a supplement to the 185 and 182 individuals, respectively, ringed in 2005 and 2006). Forty-eight food loads containing 401 fish were collected from puffins, and 62 food loads from kittiwakes.

Results from the national monitoring programme for seabirds (Lorentsen 2007) suggest that the breeding population of puffins at Anda was relatively stable between 1981 and 2007. Although the total population appears to have declined by only 0.3% annually from an estimated 22,200 pairs in 1981 to 20,040 pairs in 2007, a total decrease of 9.6% (**Table 3.1.7**, **Figure 3.1.13**), the trend in the monitoring plots was not statistically significant (Lorentsen 2007). Annual survival rates for adults equalled 84.3% between 2005 and 2006, which is remarkably low for puffin populations (e.g. Harris et al. 2005).

The mean hatching date for puffins in 2007 was 29 June, four days later than in 2006, and six days later than in 2005. Chicks hatched in 56% of the study nests (*n*=54), compared to 86% (*n*=50) and 67% (*n*=58) in 2006 and 2005, respectively. 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 2007, 73% of the puffin chicks reached the age of at least 10 days (compared to 80% in 2006 and 62% in 2005), and 67% reached the age of 20 days (compared to 74% in 2006).

Sandeel comprised 69% of the diet by mass of puffins at Anda in 2007 (compared to 43% in 2006 and 60% in 2005), followed by 22% first-year herring (49% in 2006 and 38% 2005) and 9%

***Table 3.1.7** Key population parameters (SE, n) of seabirds on Anda in 2007. Population change is the numeric change in size of the breeding population registered between 2006 and 2007 on the basis of plot counts (p) or total censuses (t). See introduction to Section 3.1 for details of survival estimation.*

Species	**Population change**	**Annual adult survival**		**Reproductive performance**	
		Period (yrs)	Estimate %	Sampling unit	Estimate
Shag				Clutch size	2.90 (0.30, 11) [1]
Herring gull				Clutch size	2.18 (0.73, 49) [1]
Kittiwake	+ 10.1% p	2005-07 (2)	88.3 (0.03, 150)	Clutch size	1.75 (0.44, 40) [1]
				Large chicks/nest	1.00 (*n*=581)
Puffin	– 9.6% p	2005-07 (2)	84.3 (0.05, 153)	Chick ≥ 10d/egg	0.41 (*n*=54)
				Chicks ≥ 20d/egg	0.37 (*n*=54)

1) *Number of eggs or small chicks per nest (with content) 20-21 June.*

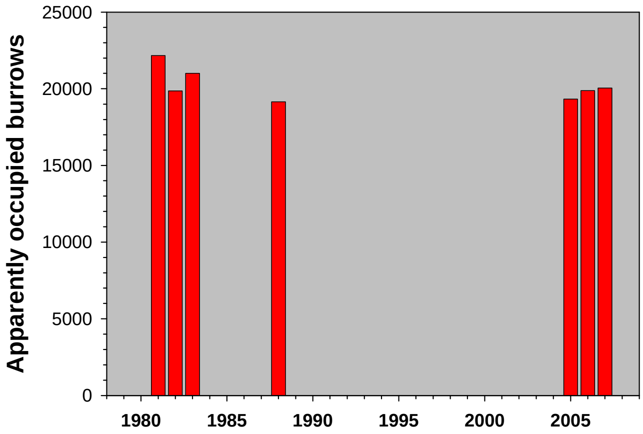


Figure 3.1.13
Development of the population of puffins breeding at Anda, as monitored in seven years between 1981 and 2007.

gadoids (8% in 2006 and 2% in 2005). Most of the herring were relatively small larvae, on average 43.9 mm long (*SD*=17.0, range 10-142, *n*=135), compared to 54.7mm in 2006 and 45.2 mm in 2005. For sandeel the mean length was 70.3 mm (*SD*=19.4, range 13-177, *n*=234). The proportion of herring in the puffin diet at Anda in 2007 varied between 30 and 56% during the chick period, whereas the proportion of sandeel varied between 37 and 61% (**Figure 3.1.14**).

About 1000 pairs of kittiwakes bred on Anda in 2005-2007. Compared to a census made in the early 1980's (Røv et al. 1984), it appears that the population has remained relatively stable over the last two decades. From 2005 to 2007, the population increased by 10.1% (**Table 3.1.7**). The annual survival rate of adults between 2005 and 2007 was estimated at 88.3%, which is within the normal range for kittiwakes.

Gadoids dominated the diet of kittiwakes (42.8% by mass), followed by sandeel (32.4%) and herring (24.3%) (**Figure 3.1.14**). Herring and sandeel caught by kittiwakes were smaller than those caught by puffins, mean lengths 30.9 (*SD*=18.2, *n*=218 otoliths) and 56.6 mm (*SD*=7.9, *n*=569 otoliths), respectively.

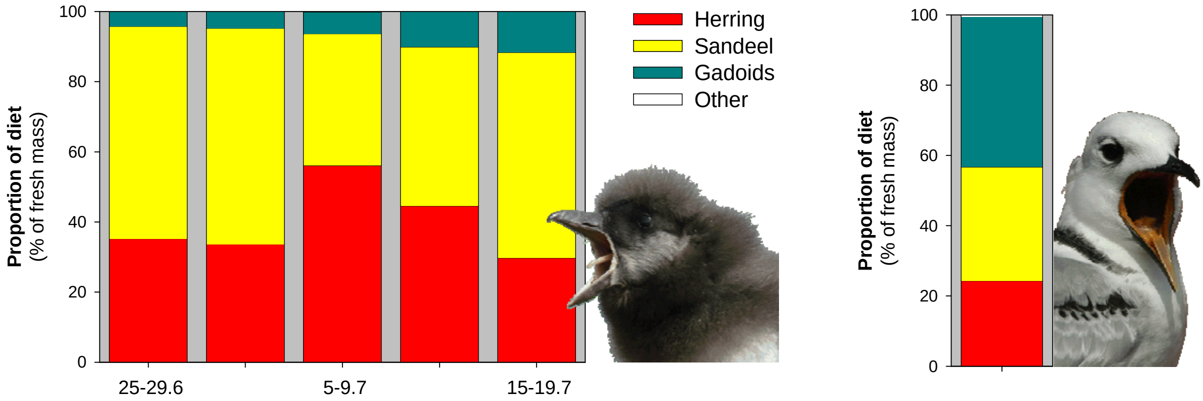


Figure 3.1.14
The diet composition (% by mass) of puffin chicks (left panel, 5-day periods) and kittiwake chicks and adults (right panel) on Anda in 2007. (Photos © Tycho Anker-Nilssen)

3.1.7 Røst

Tycho Anker-Nilssen & Tomas Aarvak

All existing long-term data series on seabird population trends, survival rates, reproductive performance and diet in the Røst archipelago were updated in 2007 following well-established, standardised procedures (**Table 3.1.8**), but sample sizes were limited by very poor breeding conditions for many species. For the puffin, various other aspects of their breeding performance (not listed in the table) were also monitored in the traditional way. As usual, the field work was divided on two field periods: 4.5-14.5 and 8.6-10.8. The main tasks during the first period are standardised monitoring of puffin breeding numbers (cf. Anker-Nilssen & Røstad 1993) and body condition, and setup of the automatic time-lapse camera for registering attendance patterns of puffins every hour throughout the rest of the season. 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 briefer reports for later years are included in the present series of SEAPOP annual reports, the more extensive reports for Røst will be updated less frequently.

Table 3.1.8 Key population parameters *(SE, n) of seabirds in Røst in 2007. Population change is the numeric change in size of the breeding population registered between 2006 and 2007 on the basis of plot counts (p) or total censuses (t). The main kittiwake colony is on Vedøy (ca 10.200 pairs in 2007), whereas that on Kårøy is a relatively small (462 pairs) population nesting on buildings. See introduction to Section 3.1 for details of survival estimation.*

Species	**Population change**	**Annual adult survival**		**Reproductive performance**	
		Period (yrs)	Estimate %	Sampling unit	Estimate
Fulmar	– 81.4% ^{p}				
Cormorant	– 1.1% ^{t}			Clutch size [1]	2.52 (0.13, 92)
Shag	– 10.6% ^{p}	2002-07 (5)	85.3% (1.6, 291)	Clutch size [2]	2.31 (0.10, 641)
Eider	*No data*			Clutch size	3.67 (0.18, 49)
Great skua [3]	50.0% ^{t}			Breeding success	0.00 (0.00, 3)
Common gull				Clutch size	2.38 (0.18, 21)
Herring gull				Clutch size	2.03 (0.13, 34)
Great black-b. gull				Clutch size	2.03 (0.09, 66)
Kittiwake					
Vedøy	– 18.0% ^{p} [5]			Large chicks/nest [5]	0.00 (*n*=379)
Kårøy	+ 4.3% ^{t}	2003-07 (4)	88.7% (2.5, 162)	Clutch size/pair	1.56 (0.07, 82)
				Large chicks/pair	0.53 (0.08, 53)
				Large chicks/nest [4]	0.27 (*n*=462)
Arctic tern	*No breeding*			*No breeding*	
Common guillemot	– 96.6% ^{p}	No estimate yet possible [6]		*No breeding*	
Razorbill	– 93.4% ^{p}				
Puffin	+ 1.5% ^{p}	2005-06 (1)	88.6% (2.8, 452)	Fledging success	0.00 (*n*=33) [7]
Black guillemot	+ 3.3% ^{p} [8]	1997-07 (10)	88.2% (2.5, 73)	Clutch size	1.67 (0.09, 27)
				Large chicks/clutch	1.30 (0.26, 10)

1) *Minimum estimate from counts made on 9 June (n=62) and 13 June (n=30), when some clutches were still incomplete while others had relatively large chicks;* ***2)*** *On 1 July; estimated by linear regression of mean values for nine different counts between 22 June and 29 July, excluding empty nests. Similar values for 2005 and 2006 should be 2.55 (0.05, 722) and 2.34 (0.06, 774), respectively, not those reported by Anker-Nilssen et al. (2006, 2007);* ***3)*** *Three pairs, one more than in 2006;* ***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, but the birds abandoned the study plot early in 2007 due to extremely poor conditions for breeding;* ***7)*** *Most eggs were abandoned before hatching;* ***8)*** *Maximum number of individuals on a resting site close to the colony, as monitored by time-lapse photography.*

An extremely poor season for pelagic species

In terms of population trends, 2007 was one of the worst years on record, with what would seem like population collapses for the fulmar, common guillemot and razorbill, and another large decrease in the main colony of kittiwake (**Table 3.1.8**). As these species forage almost exclusively offshore, this most likely reflected a massive non-breeding event caused by extremely poor food supply in pelagic areas within reach of the colony in June-July, i.e. at the time when most species are being monitored.

A variety of qualitative observations strongly indicated that the populations of fulmar and common guillemot both experienced total breeding failures, although their reproduction is not monitored. Furthermore, a total breeding failure was documented for the population of kittiwake in the main colony at Vedøy (**Table 3.1.8**), where the colony was totally abandoned by 9 July. However, every 2-3 pairs of kittiwakes breeding on buildings at Kårøy were able to raise one young, which indicated the Vedøy colony suffered not only from food shortage but also from heavy predation from white-tailed sea eagles (see also last year's report; Anker-Nilssen *et al.* 2007). There were also many signs of poor food conditions for the chicks at Kårøy, and the colony was gradually swamped by dried, undigested tail-ends of snake pipefish *Entelurus aequoreus* regurgitated from both chicks and adults (**Figure 3.1.15**). This is clearly not a well-suited prey for seabirds (Harris et al. 2007).

Figure 3.1.15

Snake pipefish is bad food for kittiwakes. The pictures show an adult and chick struggling to swallow and digest at least the foremost part of this low-quality food item. (© Tomas Aarvak (left) and Tycho Anker-Nilssen (right), Røst 2007).

The puffin completed the picture

The problems for pelagic species were strongly supported by the colony attendance of adult puffins, which was at a normal level throughout May but dropped to an extremely low level already in early June and stayed low throughout the rest of the season (**Figure 3.1.16**). The contrast to the attendance level in the preceding year, which was the highest ever recorded, is striking. Whereas the mean number of birds per picture in 2006 was 17.78 (*SE*=0.68, *n*=2115), the corresponding number in 2007 was only 1.65 (*SE*=0.18, *n*=2178), a decrease of 91%. Compared to the other good year (2004; mean 3.70, *SE*=0.16, *n*=2157), the decrease was 55%.

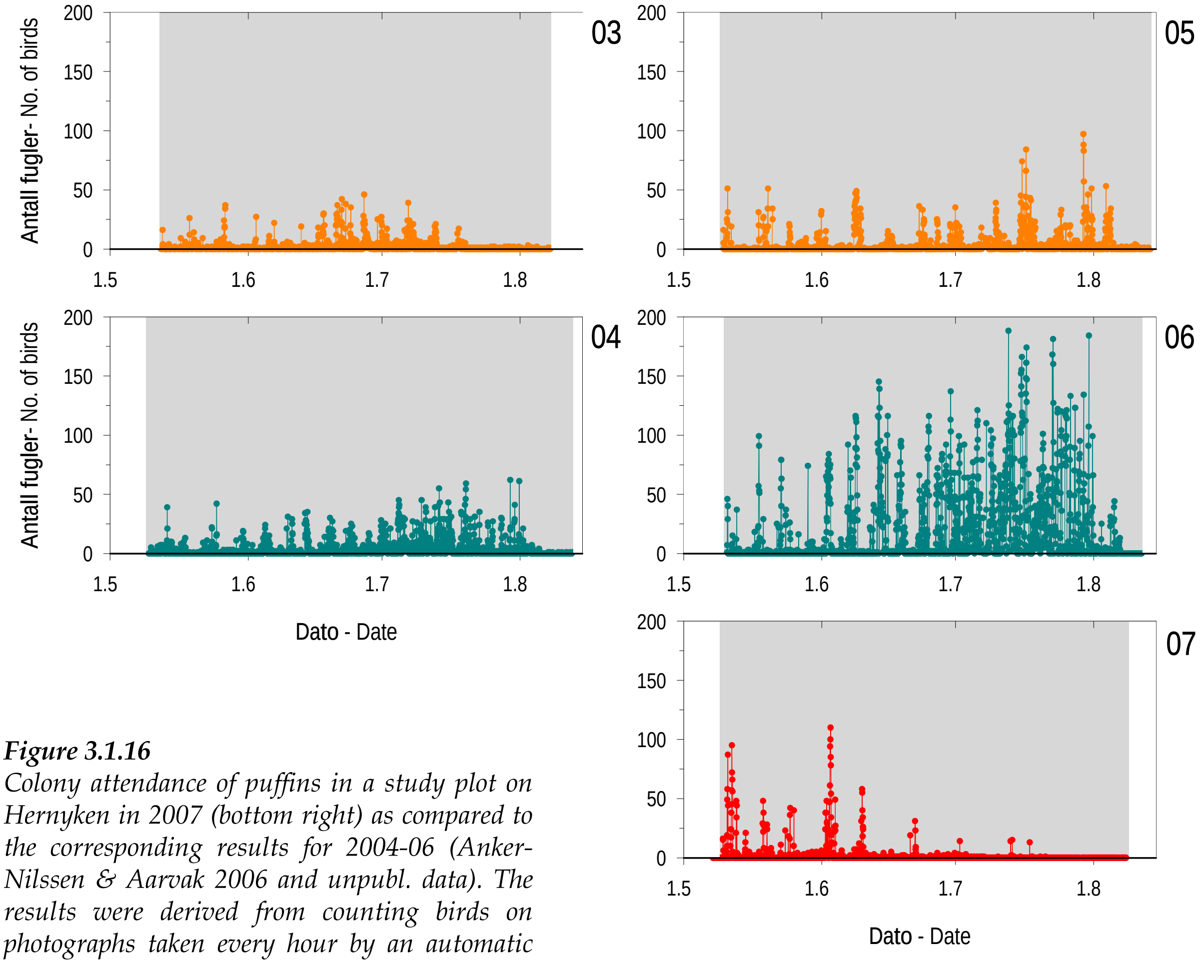


Figure 3.1.16
Colony attendance of puffins in a study plot on Hernyken in 2007 (bottom right) as compared to the corresponding results for 2004-06 (Anker-Nilssen & Aarvak 2006 and unpubl. data). The results were derived from counting birds on photographs taken every hour by an automatic time-lapse camera. Plot colour indicates the fledging success of puffin chicks in the colony in the same years; red = total failure (0%), orange = poor (8% in 2003, 35% in 2005), and green = good (88% in both years).

Consequently, the 12th total breeding failure for this species since 1964 (not counting another five seasons with fledging success of only 1-10%; Lid 1981, Anker-Nilssen & Aarvak 2006) came as no surprise. Only one third (33 of 101) of the puffin eggs in the study burrows hatched, and most chicks received no food and died as soon as their yolk-sac reserves were expended (age at death: mean 3.8 days, *SE*=0.29, range 0-8, *n*=32). The mean hatching date was 24.4 June (*SE*=0.37, *n*=33), i.e. exactly the same as the annual average recorded for 26 years in the period 1978-2005 (*SD*=7.6, Anker-Nilssen & Aarvak 2006).

The puffin is the only species that is monitored in early May, and its small, but continued population increase indicated food conditions for pelagic species were much better at the start of the breeding season. Also the mean body mass of adults captured in the colony on 11 May (477.8 g, *SE*=5.65) was slightly above its average level for that time of year (474.9 g, *SE*=5.33, *n*=15 years). The total population of puffins was estimated at 473,900 occupied burrows, which equals 33.0% of the population size when the monitoring started in 1979.

Although we only managed to collect one complete food load (**Figure 3.1.16**), which weighed 2.96 g and consisted of 34 herring 30-39 mm long (mean 34.4, SD=1.94), another 85 loads were

Figure 3.1.16
The only food load collected from puffins on Røst in 2007, which consisted of 34 transparent herring larvae weighing less than 3 g altogether. (© Tycho Anker-Nilssen)

identified mainly by observing adult puffins temporarily resting at sea just outside of the colony through an 80 mm spotting scope with a 20-60X zoom ocular. The results are being analysed by two MSc students comparing the very contrasting breeding performances of puffins at Røst and Anda in 2007 (G. Sæterhaug & C. Iversen *in prep.*). In terms of frequency of occurrence, the very few puffins that tried feeding their chicks were apparently bringing back mainly larval rockling (51%) and other gadoids (18%), as well as small, transparent post-larvae of herring (20%). Five loads (6%) consisted of 1-3 snake pipefish each.

Common guillemots on Vedøy seemingly extinct
The drastic decrease of common guillemots highlights the relevance of the viability analyses reported by Erikstad et al. (2007). The mean number of birds present within the monitoring plots at Vedøy, which used to hold half the cliff-breeding population on the island (and in the Røst archipelago as a whole), was only four (4!) and well below the level of 'quasi extinction'. Breeding success on open ledges has not been quantified for decades, but has been neglectable for many years (pers. obs.).

However, an increasing, but not monitored number of common guillemots breed in shelter under boulders and in other natural hides on several of the other islands. This population component has been roughly estimated to be about 500 pairs (cf. Anker-Nilssen 2006) and seems to reproduce reasonably well (pers. obs.). Nevertheless, even these birds failed in 2007 and left the colonies in second half of June, far earlier than normal and before we were able to read any colour rings on those breeding at Hernyken. In contrast, many of the razorbill pairs that breed in the same habitat probably succeeded in fostering their chick. The fact that 21 of 23 observed food loads for this species consisted of 1-3 saithe *Pollachius virens* (mean 1.4, *SE*=0.16), could suggest they are more able to switch to near-shore prey than are common guillemots.

Fulmars in long-term trouble
The study colony on Hernyken supports only a minor part of the population of fulmar in Røst, but is subjectively assessed as being reasonably representative of the situation for the species within the whole archipelago. As Røst has the largest aggregation of breeding fulmars in mainland Norway, the average decrease of 20% p.a. recorded on Hernyken since 1997 (Lorentsen 2007) is worrying and deserves closer attention. One hypothesis is that it is due to increased predation of adult fulmars from non-breeding white-tailed sea eagles, numbers of which have been about five times higher in the Røst area after 1996, as compared to the preceding 19 years (Anker-Nilssen & Aarvak 2006).

Near-shore species did better

Both cormorant species feed in near-shore waters and bred in reasonably high numbers, but clutch sizes were clearly lower than in the previous year, but note that the similar estimates for shags in 2005 and 2006 were 2.55 (*SE*=0.05, *n*=722) and 2.34 (*SE*=0.06, *n*=774), respectively, and not those reported by Anker-Nilssen et al. (2006, 2007). The importance of standardising sampling date in this species (and obviously in several others) is illustrated by a very variable temporal decrease in clutch size when monitoring successively the different monitoring plots (**Figure 3.1.17**). Cormorants seemed to fledge their young at a normal rate, and 103 chicks were ringed. When including one bird we observed breeding as a 2-year-old in 2007, 5.1% (28 of 553) of the chicks ringed since 2002 have so far been recovered: Nordland (4), Central Norway (10), SW Norway (6), SE Norway (3), SW Sweden (1), SE Sweden (1), E Denmark (1), NW Germany (1) and the Netherlands (1). The shags experienced a higher than normal chick mortality in July, but breeding success was not fully quantified in these species. The black guillemots laid their smallest clutches since 2000, but succeeded in fledging a normal proportion of the chicks (78%, cf. Anker-Nilssen & Aarvak 2006). Chick diet was monitored by the observation of 1632 food items delivered by adults on 23 different nests between 26 June and 9 August, and consisted mainly of butterfish *Pholis gunnellus* (31.5%), sculpins (Cottidae, 26.2%), Yarrel's blenny *Chirolophis ascanii* (21.6%) and saithe (15.9%).

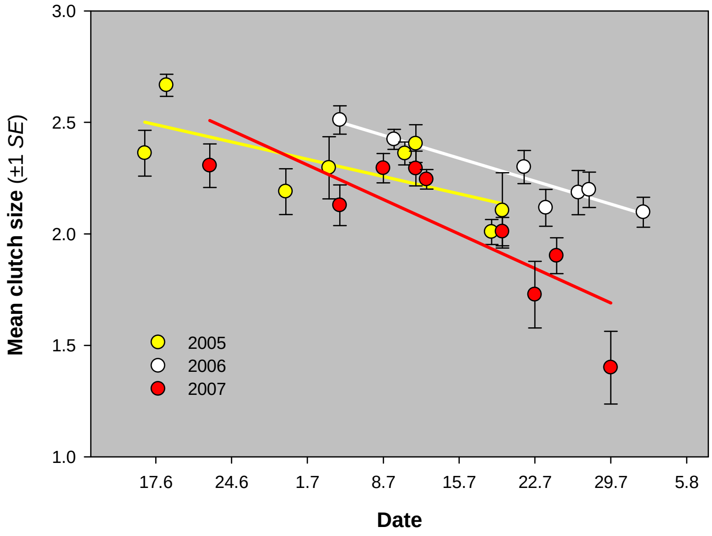


Figure 3.1.17
Seasonal variation in the mean clutch size of shag in the colony on Ellefsnyken, Røst in 2005-2007 as indicated by differences between study plots monitored on different days in the seasons. Linear regression lines for each year are included (p=0.008, 0.059 and 0.001, respectively).

The estimations of adult survival for the four species monitored 4-17 years were updated with data from 2007 and adjusted for over-dispersion with *median c-hat* (Cooch & White 2007). With no covariates included in the analyses, survival rate varied significantly between years only for the puffin, in which an estimated 88.6% survived from (the poor breeding year) 2005 to (the good breeding year) 2006. This is relatively low compared to many of the previous years (range for all 17 years 81.2-97.1%). For both the shag and the kittiwake, the constant estimates for the whole monitoring period increased to 85.3% (2002-07) and 88.7% (2003-07), respectively, the latter being very similar to that of 88.2% (1997-2007) for the black guillemot.

A visitor from the north

The importance of using different ring codes and colours in different colonies was clearly demonstrated when a kittiwake wearing a pale green ring engraved 'MB' in white letters turned up at our study colony at Kårøy on 11 June 2007 (**Figure 3.1.18**). A few days and e-mails later we learned that it was ringed as a chick by the SEAPOP crew on Hjelmsøya in 2005. This was also confirmed by reading the number on the metal ring through a spotting scope. Not only do we know its age and colony of origin, we also know it was born in nest 2 in field 2 on the western study cliff for kittiwakes on the island, and that it weighed 290 g and had a head+bill length of 65.9 mm when she was ringed on 16 July. Moreover, blood sampling had proved it was a female, as was her younger sister 'MA', and numerous data have been collected about the breeding performance of her father 'GX' and mother 'HJ' on Hjelmsøya. The long-range movements of prospering young kittiwakes are certainly intriguing, and emphasize the importance of the extensive monitoring of the species (Section 3.2).

Figure 3.1.18
Annual survival rate of kittiwake is monitored by colour-ringing birds breeding on buildings at the fisherman's shack camping facilities on Kårøy. On 11 June 2007, this bird visited the colony, resting on a rack for drying stock fish. It turned out it had been ringed as a chick in 2005 by our colleagues on Hjelmsøya, 670 km of coastal waters NW from Røst. (© Tycho Anker-Nilssen, 2007)

3.1.8 Horsvær

Population ecology of the northern lesser black-backed gull

Jan Ove Bustnes

Project background
Since the 1970s, the population of the northern subspecies of the lesser black-backed gull, *Larus fuscus fuscus*, which breeds from Trøndelag and northwards, has declined dramatically and in the mid 1990s the population was only 10-20% of the size in 1980 (Lorentsen 2007). This subspecies is presently considered endangered over its whole distribution range in the Baltic and northern Norway (Hario et al. 1998). Interestingly, parallel to the decline of the *L. f. fuscus* population, the population of the more southern subspecies of lesser black-backed gulls, *L. f. intermedius,* has increased (Lorentsen 2007). The causes of the population decline in *L. f. fuscus* are not known, but in Norway it has been hypothesised that it is related to poor feeding conditions following the collapse of the Norwegian spring-spawning herring stock (Myrberget 1985, Røv 1986, Loen 1987, Bevanger & Thingstad 1990, Strann & Vader 1992). However, in Finland, where *L. f. fuscus* has also declined dramatically, there have been no reports of food shortage (Hario et al. 2004), but high frequencies of chick mortality due to disease have been documented (Hario & Rudbäck 1996, 1999, Hario et al. 2004). The levels of organochlorines (OCs), especially p,p'-dichlorodiphenyldichloroethylene (DDE, a metabolite of DDT), have been high in dead chicks, compared to levels assumed to cause reproductive effects in birds (Hario et al. 2004). It is therefore possible that the population decline results from a combination of nutrient stress and pollutants.

The northern subspecies of lesser black-backed gull is among the rarest and certainly the most threatened seabird breeding on the Norwegian mainland. It was therefore considered highly relevant to study and monitor its population ecology within the SEAPOP program. At present, the coast of Helgeland in the southern part of Nordland county, is an important area for *L. f. fuscus*, and Horsvær, a small archipelago in the municipality of Sømna, only 32 km NE of Sklinna (see next section) was therefore selected as a suitable study area. Horsvær has the largest known colony of *L. f. fuscus* on the Norwegian coast, and its breeding numbers have been monitored in 19 different years since 1980, as part of the National monitoring programme for seabirds (Lorentsen 2007). The study of their population ecology was started in 2005 with funds from DN, and included in the SEAPOP programme from 2007. The project focuses specifically on factors important for population growth, including the collection of data on the following parameters:

- Reproduction, as monitored annually by the number of nests, egg size, clutch size and breeding success. Data on sex ratio among chicks in different years have also been collected.
- Recruitment, as measured by monitoring the return and establishment of young, native birds previously banded with colour rings as chicks (ringed annually since 2005).
- Adult survival, as monitored annually by using standard capture-mark-recapture procedures based on the re-sighting of adult birds. This study is the first ever to band adult *L. f. fuscus* with colour rings in Norway.
- Feeding ecology, as measured by monitoring the diet composition of chicks and adults. A number of food samples have been collected from both age groups in all three years.
- Migration, as hopefully to be reflected by re-sightings of colour-ringed birds outside of the breeding area. The migration routes of the Norwegian *L. f. fuscus* population are very poorly known (Bakken et al. 2003).

Table 3.1.9a *Results of the population study of northern lesser black-backed gull* Larus fuscus fuscus *in the Horsvær archipelago in 2005-2007.*

Parameter	**2005**	**2006**	**2007**	**Total**
Number of nests	378	385	135	898
Number of adults colour-ringed	83	42	13	138
Number of young ringed	371	226	52	649
Number of young colour-ringed	246	218	46	510
Approximate number of young in late July	400-500	350-400	150	900-1000
Number of young ringed 2005 returned		0	9	9
Number of young ringed 2006 returned			0	0
Number of adults ringed 2005 returned		62 (74.7%)	50 (60.2%)	71 (85.5%)
Number of adults ringed 2006 returned			32 (76.2%)	32 (76.2%)
Number of young observed on migration				13
Number of adults observed on migration				2

Table 3.1.9b *Key population parameters (SE, n) of lesser black-backed gull* Larus fuscus fuscus *breeding in Horsvær in 2007. Population change is the numeric change in size of the breeding population registered between 2006 and 2007 on the basis of total nest counts (t). See introduction to Section 3.1 for details of survival estimation.*

Species	**Population change**	**Annual adult survival**		**Reproductive performance**	
		Period (yrs)	Estimate %	Sampling unit	Estimate
Lesser black-backed gull	– 64.9% t	2005-06 (1)	90.1 (4.4, 125)	Large chicks/nest	1.11 (*n=135*)

Demography

As counted by the number of nests, the breeding population in 2005 and 2006 was close to 400 pairs, while it was only 135 pairs in 2007 (**Table 3.1.9a**). However, the breeding success among the pairs that bred did not seem to vary much between the three years (range 0.9-1.1 large chicks per nest in late July). It was still too early to expect young banded in 2005 and 2006 to establish themselves as breeding birds, but it was encouraging to find that 9 birds banded as chicks in 2005 were observed on the islands in 2007. Of the 83 adults marked with colour rings in 2005, we re-sighted 71 (85.5%) birds in 2006 and 2007, of which 9 were only seen in 2007. This indicates winter survival was high in both years and that the population decline from 2006 to 2007 is unlikely to be attributed to poor survival. However, the data so far only allow the calculation of survival rate between 2005 and 2006, which was estimated to be as high as 90.1% (**Table 3.1.9b**).

Feeding ecology

So far 72 food samples from Horsvær have been analysed. The dominating prey was saithe *Pollachius virens*, especially for the young from which more that 80% of the samples contained saithe, while less than 15% contained herring. This was the case both in good and bad breeding seasons. The dominant size of the fish was about 10 cm. For adults, a surprisingly high proportion of the food samples contained snake pipefish *Entelurus aequoreus*, a species that have recently appeared in Norwegian waters but is a poor food item in terms of energetic value (Harris et al. 2007). The occurrence of pipefish in the diet of seabirds in 2007 was also documented at Røst (see Section 3.1.7) and indicated poor conditions.

Migration

To date, 15 colour-ringed birds have been re-sighted outside Horsvær (13 ringed as young and 2 as adults). One of the birds was found in Kenya, suggesting that the birds from Horsvær have a migration pattern similar to that of Finnish birds. However, birds from Horsvær seem to have a more dispersed migration pattern than we expected. Two birds were found in the Baltic, 2 in England, 4 in continental Europe (France, Germany and Belgium), 3 at the Iberian Peninsula (Spain and Portugal), 2 in Morocco (one of which were actually spotted by one of the field workers from Horsvær, **Figure 3.1.19**) and one that has been seen both in England and Morocco (**Figure 3.1.20**).

Figure 3.1.19
Young lesser black-backed gull from Horsvær on a beach in Morocco. (© Morten Helberg)

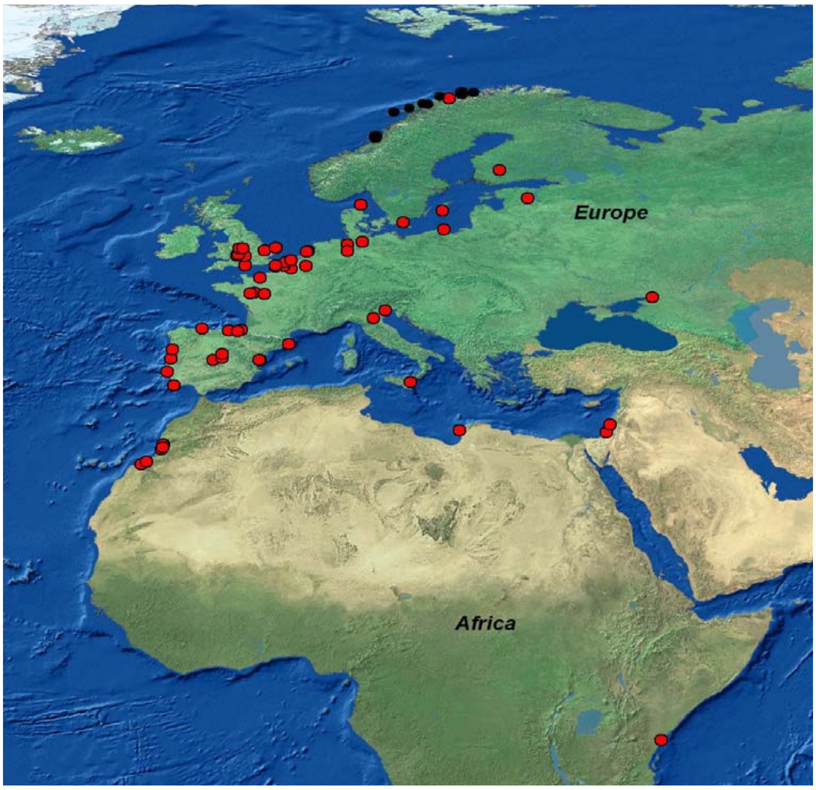


Figure 3.1.20
Recoveries of lesser black-backed gulls from northern Norway (red dots). The black dots indicate locations where birds wee ringed.

Climate and the number of breeding birds

In a recent analysis (Bustnes et al. in manuscript), we used the data on variation in breeding numbers since 1980 to test whether this was related to the availability of young herring and climate variables such as the winter temperature in the breeding area and the North Atlantic Oscillation (NAO). The results were surprisingly clear and showed that breeding numbers were strongly and positively related to both mean winter air temperature in the surroundings of Horsvær and NAO. After mild winters, which are associated with high NAO, the breeding population was high (**Figure 3.1.21**). Herring did not seem to contribute to explaining the variation in breeding numbers of lesser black backed gulls. This may be because other fish, such as saithe, is presently the most important prey (Bustnes et al. in prep). However, it cannot be excluded that a lack of young herring in the gulls' foraging areas in the breeding season have had an indirect and lagged effect on population size by reducing reproductive success and, consequently, recruitment rates.

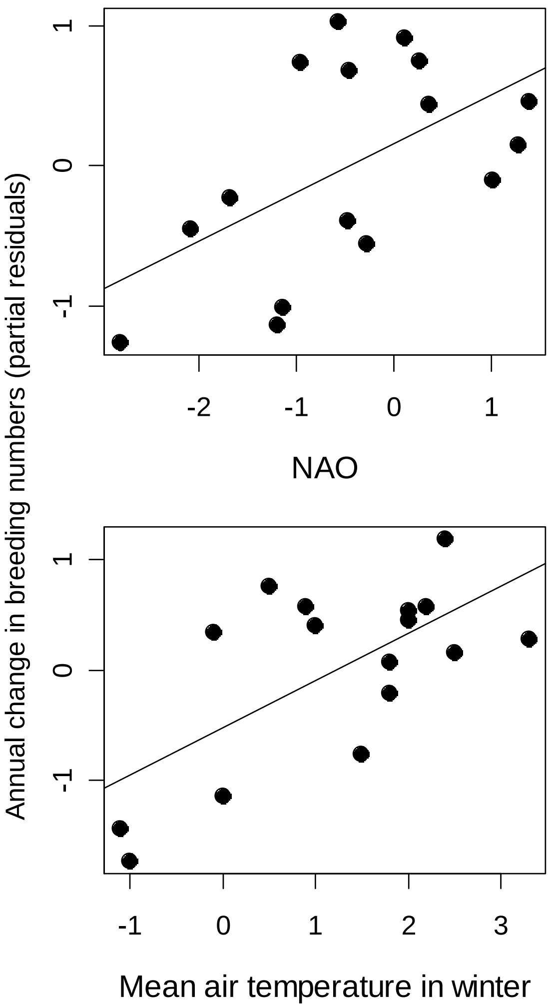


Figure 3.1.21
The relationship between annual changes (Log) in numbers of breeding lesser black-backed gulls at Horsvær and the North Atlantic Oscillation (NAO) index in the preceding winter (upper panel), and the mean winter air temperature at Sklinna in January-March of the same years. The combined effects of NAO and air temperature were controlled for (partial residuals). Data from 1980-2005.

3.1.9 Sklinna

Svein-Håkon Lorentsen, Eirin Bjørkvoll, Jorunn Mittet Eriksen & Terje Kolaas

Sklinna (65°13′N 10°58′E), off Vikna in Nord-Trøndelag, was established as a SEAPOP key-site in 2007. Thanks to the Norwegian Coastal Administration and the County Governor in Nord-Trøndelag, the lighthouse buildings (**Figure 3.1.22**) were offered to use as a field station, and have proved to be excellent!

The island has been an important site for seabird monitoring since the early 1980s and the populations of many of the monitored species have increased (Lorentsen 2007, **Table 3.1.10**). This is especially true for the common guillemot and the razorbill that probably started breeding on the island in the early 1980s. The breeding population of common guillemot in 2007 was nearly 600 pairs. This corresponds to an annual growth rate of 21%, which suggests there has been extensive immigration. The breeding population of razorbills is much lower, about 30 pairs, representing an annual growth rate of 6%. The breeding population of shag has also increased considerably at Sklinna, at an annual rate of 7% since 1984. The shags have greatly profited from the establishment of a new breakwater in 1990, in which they breed, but the numbers of birds breeding on the main islands have also increased considerably. The breeding population of cormorant has also increased, although more slowly than that of the shag; at an annual rate of 2% since 1979. Two of the monitored seabird populations at Sklinna have decreased; the kittiwake and the puffin with annual rates of –8% (since 1980) and –4% (since 1981), respectively. Currently, only about 20 pairs of kittiwakes breed at Sklinna, whereas the breeding population of puffins is estimated to be ca. 3000 pairs.

Monitoring of adult survival rate for shag was initiated in 2004 when 150 individuals were ringed with coded rings. This was continued in 2005 and 2007 with an additionally 24 and 50 individuals ringed, respectively. There was no ringing in 2006. More unfortunately, the searches for ringed birds in 2005 and 2006 were inadequate, and this might explain why the survival estimate obtained so far (70.1%, **Table 3.1.10**) is low compared to those from Røst and Hornøya (85.3% and 77.1%, respectively, Sections 3.1.7 and 3.1.3). Monitoring of puffin adult survival was initiated in 2007 when 101 individuals were marked with coded rings.

Table 3.1.10 *Key population parameters (SE, n) of seabirds on Sklinna in 2007. Population change is the numeric change in size of the breeding population registered between 2006 and 2007 on the basis of plot counts (p) or total censuses (t). See introduction to Section 3.1 for details of survival estimation.*

Species	**Population change**	**Annual adult survival**		**Reproductive performance**	
		Period (yrs)	Estimate %	Sampling unit	Estimate
Herring gull				Clutch size[1]	0.85 (1.02, 115)
				Clutch size[2]	1.81 (0.68, 54)
Cormorant	+ 4.2% t				
Shag	– 13.8% p	2004-07 (3)	70.1 (0.08, 174)	Chicks ≥ 10d/nest	0.84 (*n*=57)
				Chicks ≥ 20d/nest	0.44 (*n*=57)
Kittiwake	– 34.5% t				
Common guillemot	+ 2.1% p				
Razorbill	– 13.9% p				
Puffin	+ 20.3% p	No estimate yet possible[3]		Chicks ≥ 10d/nest	0.13 (*n*=55)
				Chicks ≥ 20d/nest	0.05 (*n*=55)

***1)** Including empty nests; **2)** not including empty nests; **3)** Colour-ringing for monitoring of survival rates was initiated in 2007*

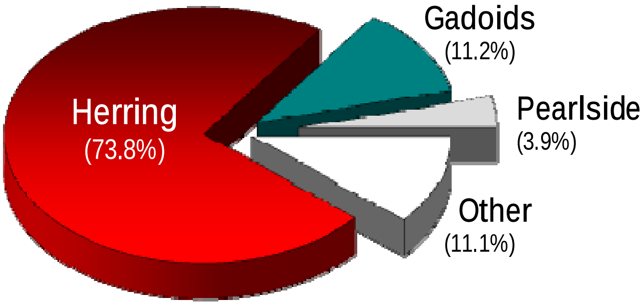
Figure 3.1.22
The lighthouse buildings at Sklinna have proved to be an excellent field station. (© Svein-Håkon Lorentsen)

Sixty-two food loads containing 645 fish were collected from puffins (see below). In addition a number of pellets from shags were collected, but these are not yet analysed.

Results from the national monitoring programme for seabirds (Lorentsen 2007) show that the breeding population of puffins at Sklinna declined by 29% between 1981 and 2007. To estimate their reproductive performance, 55 puffin nests were monitored throughout the field season. Chicks were observed in only 21 (38.2%) of these burrows. We used growth curves for the head+bill length of chicks measured at Røst in poor years (Anker-Nilssen & Aarvak 2004) to estimate chicks' ages and thus compute an index of reproductive performance at Sklinna (**Table 3.1.10**). The first chick was observed on 17 June and the mean hatching date was 21 June. After 9 days, 12 (22%) of the nests contained a chick but on 10 July, the last inspection, only 4 (7%) of the nests contained a chick. On average, these chicks were then 20 days old but had a mean body mass of only 93.8 g (*SE*=9.9). This is very similar to that of (still surviving) chicks at Røst in years when most chicks died in the nest (Anker-Nilssen & Aarvak 2006), and strongly indicated that food supply was critically poor.

This was also reflected in that the mean weight of food loads brought to the chicks by their parents was only 5.2 g (*SE*=0.4, range 0.2-13.4, *n*=62). Although some of the food loads may have been incomplete due to difficulties in finding all the small fish when the samples drop in the vegetation, this is still low compared to data from other colonies. The puffin chicks were mainly fed first-year herring (73.8% by mass, **Figure 3.1.23**) with a mean length of 45.1 mm

Figure 3.1.23
Composition of the chick diet (% by mass) of puffins at Sklinna in 2007.



(*SE*=0.55, range 24.0-69.0, *n*=252). Haddock, pearlside, Norway pout and Atlantic cod comprised 5.7%, 3.9%, 3.0% and 2.5% respectively, while other prey (representing eight species) contributed only 5.5% of the diet. In addition, 5.6% of the diet was registered as a mixture of small food items of different, unidentified species.

About 2600 pairs of shags (**Figure 3.1.24**) bred on Sklinna in 2007. In order to estimate their reproductive success, 57 nests were monitored throughout the field season. The mean hatching date was 22 June, but as is normal for shags, hatching was spread over an extended time period (from 7 June to 11 July). Thus, at the end of the field period (11 July), the number of chicks of age at least 10 and 20 days per nest averaged 0.84 and 0.44, respectively (**Table 3.1.10**).

When continuing the key-site work at Sklinna in the coming years, the plan is to initiate monitoring of key population parameters (adult survival, reproduction and diet) of the common guillemot and black guillemot, as well as adult survival and diet of the herring gull.

Figure 3.1.24
With about 2600 breeding pairs, the shag colony at Sklinna is one of Europe's largest, and many of the adults are approachable to very short distances. (© Svein-Håkon Lorentsen)

3.1.10 Runde

Tycho Anker-Nilssen, Svein-Håkon Lorentsen, Alv Ottar Folkestad, Oddvar Olsen & Ketil Valde

Runde (62°24′N 5°36′E), in Herøy municipality, Møre and Romsdal, just north of Stad and the border between the Norwegian and North Sea (at 62°N), was established as a SEAPOP key-site in 2007. Its steep cliffs (**Figure 3.1.25**) make field work a great challenge, but the hiring of local field workers that have decades of experience from this site, will hopefully solve this problem.

Runde has been an important site for seabird monitoring since the early 1980s, but seabird studies started here long before that. The island has long been known for its huge seabird populations, and has attracted both researchers and tourists. Since the early 1980s, both large population increases and decreases have been observed (Lorentsen 2007). This is especially true for the gannet that started to breed with four pairs at Runde in 1946, since when the population has increased to more than 2000 pairs in 2007. The other species that has increased is the puffin, but only by 29% since 1980. The breeding numbers of shag, kittiwake and common guillemot have dropped by 73%, 88% and 98% respectively since the early 1980s. It should however be noted that parallel to most severe decreases in the past 5-6 years, very poor breeding conditions have been observed for several species. An increased tendency for non-breeding is therefore likely to be part of the explanation, and it is too early to conclude that the steepest negative trends translate into massive die-offs of adult birds.

Figure 3.1.25
The seabird cliffs on Runde rise to about 200 m a.s.l., creating ideal breeding conditions for seabirds and challenging working conditions for the field crew. The steepest cliffs (left) are utilized by gannets that breed from the central part to the top and by kittiwakes and common guillemots that breed in the lower parts, whereas puffins find their nesting places in the somewhat less steep grassy slopes (right). (© Svein-Håkon Lorentsen)

Table 3.1.11 *Key population parameters (SE, n) of seabirds on Runde in 2007. Population change is the numeric change in size of the breeding population registered between 2006 and 2007 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
Gannet	+ 9.4% ^{t}				
Shag	+ 4.4% p			Clutch size [1]	1.58 (0.12, 126)
				Clutch size [2]	2.40 (0.08, 83)
				Large chicks/nest [3]	0.58 (*n*=126)
Great skua	No data [4]				
Kittiwake	– 39.8% ^{t}			Large chicks/nest [5]	0.00 (*n*=133)
Common guillemot	– 72.2% p			Breeding success [6]	0.00 [6]
Puffin	+ 5.4% p	No estimate yet possible [7]		Fledglings/egg	0.67 (*n*=58) [8]

1) *On 9 June, including empty nests (cf. Figure 3.1.27);* ***2)*** *On 9 June, excluding empty nests (cf. Figure 3.1.27);* ***3)*** *Maximum estimate, see text for details;* ***4)*** *Counted in 5 years between 1998 and 2005, but no counts were made in 2006-07;* ***5)*** *On 20 July. Many nests in the monitoring plots were still incomplete and no chicks were seen anywhere in the colony in 2007;* ***6)*** *No eggs or chicks were seen on open ledges;* ***7)*** *Colour-ringing for monitoring of survival rates was initiated in 2007;* ***8)*** *Maximum estimate, see text for details.*

Population changes from 2006 to 2007 were positive for the gannet, the shag and the puffin (**Table 3.1.11**). For the kittiwake and the common guillemot, however, large decreases were observed, and for both species the breeding season seemed to be very late. By the end of May, it seemed that egg-laying had not yet been initiated for either species, and the overall reproductive performance was evidently very poor, with no chicks observed in any of the kittiwake nests or on the open guillemot ledges. Actually, the field crew did not observe kittiwake chicks anywhere on the island in 2007, and even on 20 July many nests still remained uncompleted. Seen in combination with the large drop in breeding numbers, this clearly indicates the vast majority of the kittiwake population skipped breeding in the pre-laying or incubation period.

As regards the common guillemots, large numbers of birds at sea in April indicated many adults did not breed, and not even a single egg was seen on any of the open ledges within or outside the monitoring plots. A few birds seen accompanying their young at sea towards the end of the season showed however that some pairs did succeed, but this was most likely birds breeding in sheltered habitats (which are not monitored).

The puffins seemed to have at least a moderately good season. The quality of the chick diet appeared to be adequate (see below) and the maximum breeding success in 58 study nests containing an egg in early June was estimated to be 67% (**Table 3.1.11**). This is best regarded as a qualified assessment, and was based the following three assumptions: 1) no chicks had fledged before the nests were inspected again on 10 July, when 13 nests were empty, 2) all 39 chicks that disappeared later in the season, i.e. before the third and last inspection on 6 August, fledged successfully, and 3) the two chicks still present on 6 August were in too poor condition to fledge (body mass 184 and 185 g, respectively).

The breeding success of shags also seemed to be relatively poor, although much better than for the kittiwakes and common guillemots. When excluding empty nests, clutch size on 9 June (**Table 3.1.11**) was close to that in Røst two weeks later (cf. **Figure 3.1.17**), but the parallel proportion of empty nests was much higher at Runde (34% compared to only 5% (*n*=58) in Røst). The proportion of empty nests remained high throughout the season, indicating many pairs failed to lay eggs, and the overall production of chicks was low (**Figure 3.1.26**). All

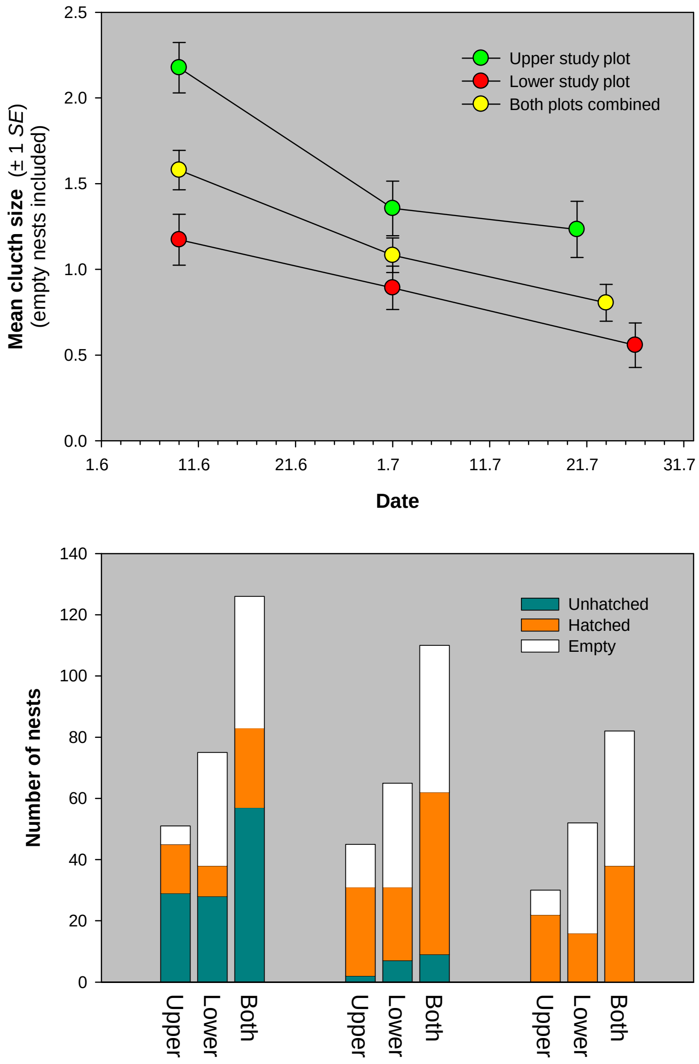
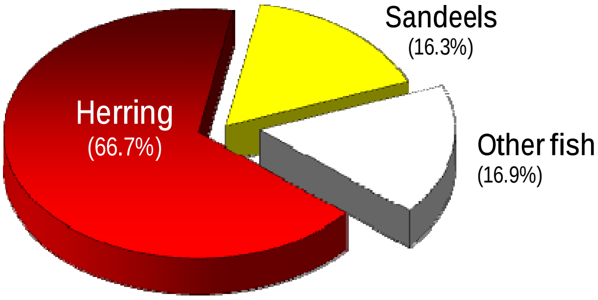


Figure 3.1.26
Seasonal variation in observed clutch size (top) and the parallel distribution of nests contents (bottom) of shags in the two study plots at Runde in 2007. Unhatched = egg(s) only; Hatched = at least one chick (some nests also contained 1-2 eggs); Empty = no eggs or chicks.

53 chicks found on the first visit to the study plots (9 June) were characterised as 'small' and therefore unable to fledge before the second visit (1 July) when 110 nests contained 74 live chicks (0.67/nest) and only 19 chicks (26%) were characterised as 'large'. Assuming these all fledged before the last visit (20-26 July) when 54 live chicks (43 large and 11 medium-sized) and 5 dead chicks remained, the maximum overall breeding success in the study plots was coarsely estimated at 0.58 large chicks/nest (**Table 3.1.11**). A number of pellets from shags were collected but have not yet been analysed.

Thirty-three food loads containing 244 fish were collected from puffins. Load quality suggested that food availability was relatively normal. The mean load mass of 11.1 g (*SE*=0.2, range 3.6-22.6, *n*=33) was much higher than in the years 1980-82 (4.0-7.8 g) when irregular inspections suggested chicks growth was relatively normal (Barrett et al. 1987). In 2007, the puffins fed their chicks mainly first-year herring, which constituted 66.7% of the total diet by mass (**Figure 3.1.27**). Sandeels comprised 16.3%, while the remainder 16.9% of the diet was 'other prey' (unidentified fish). The mean length of the herring was 59.8 mm (*SE*=0.07, range 43.0-90.0, *n*=118). This is large compared to the size of herring in the puffin diet in Røst, where mean herring length on 1 July has been higher in only two out of 28 different years (Anker-Nilssen & Aarvak 2006, unpubl. data). Both were excellent seasons (2002 and 2004). However, the northward drift of young herring in spring and summer suggests herring size is not an

Figure 3.1.27
Composition of the chick diet (% by mass) of puffins at Runde in 2007.



equally good indicator of food supply on Runde, where large first-year herring are only likely to be found where they can escape the coastal current, i.e. in the fjord areas. The importance of local fjords as a feeding area for seabirds on Runde deserves special attention in future years.

Monitoring adult survival of puffin was initiated in 2007 when 158 individuals were ringed with coded rings. The poor breeding success of kittiwakes and guillemots made it difficult to establish similar time series for more species in the starting year, but it is a clear aim to include shag and kittiwake from 2008, possibly also common guillemot. Since Runde holds the largest colony of great skua in mainland Norway, it is likely that this species also will be included as a key species with annual monitoring of adult survival rates and breeding success.

The late and very poor breeding season on Runde in 2007, combined with problems of getting experienced field workers to cover the whole breeding season, made the data collection sparse. From logistical reasons, problems are always difficult to avoid when establishing new key-sites, and effort is made to minimize similar problems in the coming field seasons.

For several reasons, the gannet is not suited as a key species in the SEAPOP programme. However, the feeding ecology of gannets (**Figure 3.1.28**) breeding on Runde was studied in 2007 as part of the international project described in Section 2.5.

Figure 3.1.28
Aspects of the feeding ecology of gannets breeding on Runde were studied in an international project in 2007 (see Section 2.5). This ringed adult was sitting in the colony on Ulvøyholmen in Vesterålen, where similar studies were made for comparison. (© Luis De Sousa)

3.2 Extensive monitoring of kittiwakes in the Barents Sea

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 criterion for the selection of key-sites in the SEAPOP program is the ability to separate natural population trends from those caused by humans through e.g. oil spills and fisheries. To achieve this, we monitor the diet, breeding success, adult survival rate and population trends (in a few cases also dispersal and 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 now established in the Barents and Norwegian Seas.

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 kittiwake. This is the only seabird which breeds in large numbers throughout the Barents Sea area, where it is distributed in both small and large colonies with highly variable population trends in different areas (Lorentsen 2007). As both its population development and reproductive rates can be monitored more efficiently than for most other seabirds (**Figure 3.2.1**), this species is ideal for studying how environmental variability affects vital demographic parameters in a top predator. Such knowledge is of crucial importance for interpreting the 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.

Figure 3.2.1
The kittiwake is the only seabird species that 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. Their breeding success can easily be monitored at a distance by counting numbers of large chicks in the nest. (© Morten Helberg)

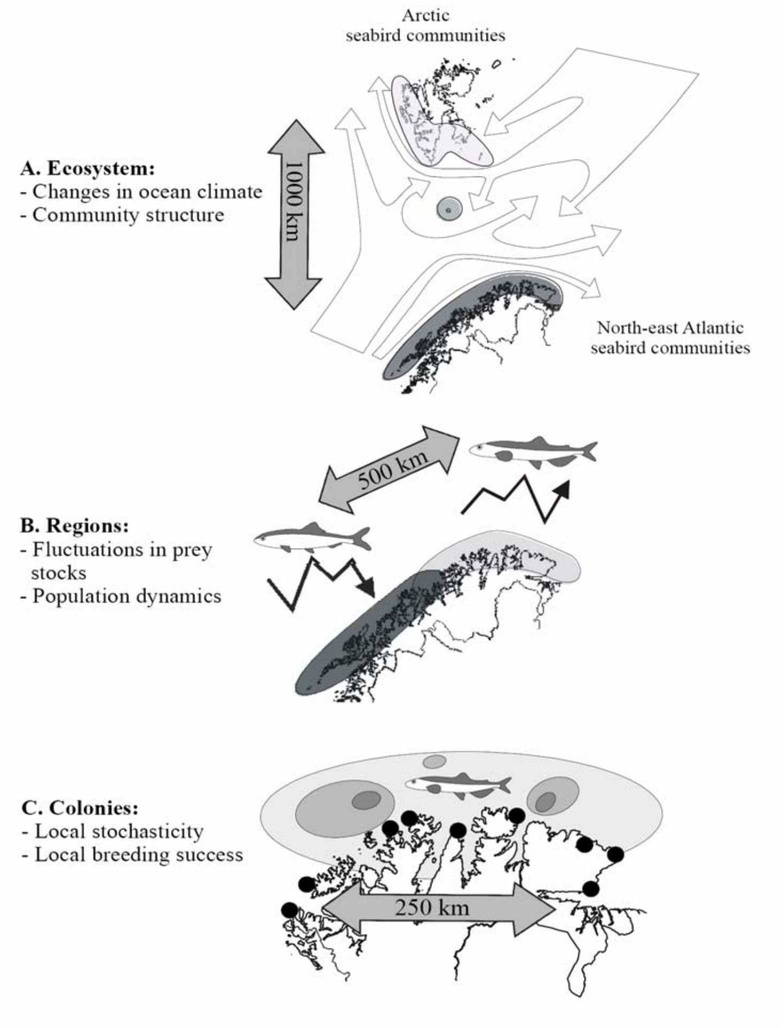


***Figure** 3.2.2*
Scale-dependent ecological processes in the marine ecosystem illustrated by (A) the distribution of different seabird communities and ocean currents, (B) regional populations and hypothetical variation in important prey stocks, and (C) the distribution of colonies (filled circles) and hypothetical spatial distribution of prey (darker areas illustrates increasing densities).

Although the environmental variability affects seabirds mainly through effects on foraging success and consequently reproduction and survival, the ecological processes behind the environmental variability are scale-dependent (Hunt & Schneider 1987; Fauchald et al. 2000, Fauchald & Erikstad 2002). The observed effects on seabird populations will reflect this scale dependency, and can be monitored from the colony level through to the ecosystem level (**Figure 3.2.2**).

On a large scale, physical properties of the oceans generate more or less distinct ecosystems that differ in productivity, biomass and the presence of particular prey species.

On a smaller scale, stochastic changes in the distribution of prey may impact local breeding performance in colonies. For example local winds and currents may affect the timing and distribution of fish spawning grounds and the drift of juvenile fish. Such small-scale events may cause differences in breeding success between single colonies (Barrett & Krasnov 1996). The variability in productivity and prey availability may affect the foraging performance in different regions in different ways, and consequently create incentives for short- or long-distance migration of birds (see below).

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. At the key-sites, both adults and full grown chicks are colour-ringed to enable us to study such dispersal of birds at different spatial scales.

To study the dynamics of kittiwake populations we have selected 96 extant colonies and 77 extinct colonies in seven different regions from Lofoten to eastern Finnmark (**Figure 3.2.3**). The selection of extinct colonies enables us to study any future re-colonization by breeding birds. The sizes of the extant colonies vary form a few pairs (<10) to very large colonies (>100,000 pairs). Each colony was visited twice during each of the 2006 and 2007 breeding seasons. 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.

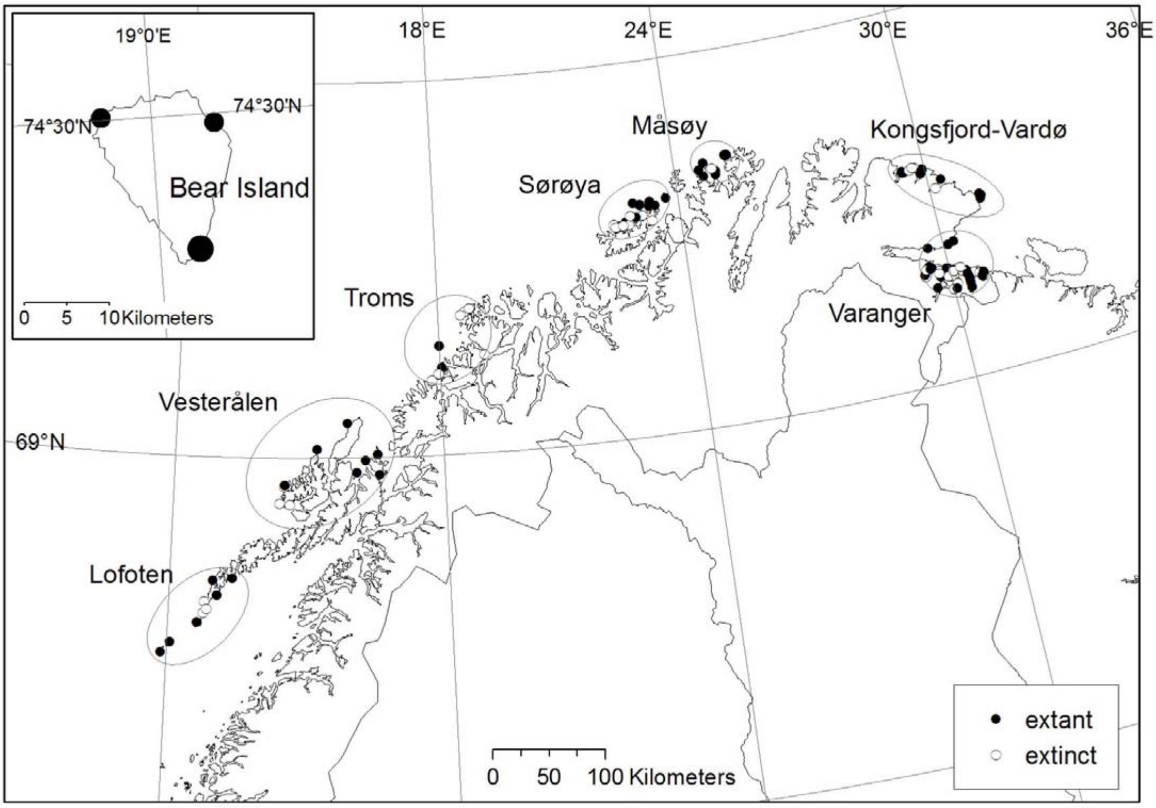


Figure 3.2.3
The distribution of extant and extinct breeding colonies of kittiwakes selected for extensive monitoring in the Lofoten-Barents Sea area.

Based on the data from the first two breeding seasons, some trends are already apparent. First, the breeding success was much lower in 2007 than in 2006. This was evident in all seven regions (**Figure 3.2.4**). Secondly, in both years breeding success was higher in the Lofoten and Vesterålen area as compared to the other regions. Thirdly, the breeding success was in general very low and on average less than 50% of the colonies produced any recruits at all (**Figure 3.2.5**). The kittiwakes seemed to have suffered from severe food shortage during the breeding season over a large area. For all colonies and all regions in both years, the average number of large chicks per nest was only 0.12 (*SE*=0.02, *n*=185). This is a very low estimate which hardly can maintain a stable population.

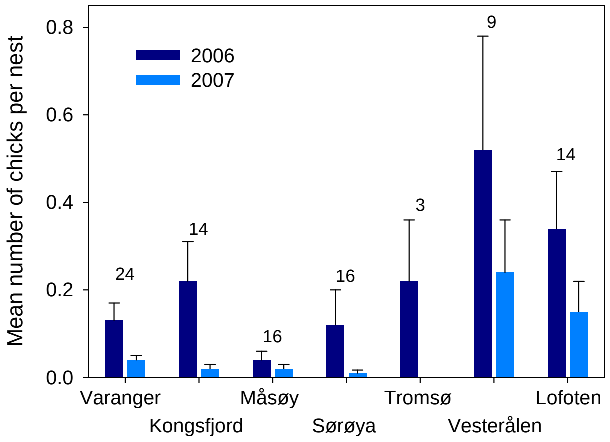


Figure 3.2.4
Kittiwake breeding performance along the mainland coast of the Lofoten and Barents Sea area as measured by the mean number (+1 SE) of chicks fledged per nest in different regions (cf. Figure 3.2.3). Sample size (number of colonies) is indicated above each bar. The breeding success differed both between years and between regions (p<0.001 in both cases). The colonies in the Tromsø region were not monitored in 2007.

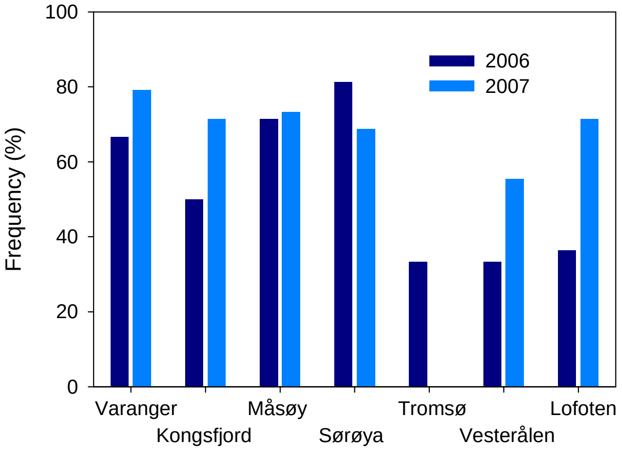


Figure 3.2.5
The proportions of kittiwake colonies that suffered complete breeding failure in different regions in 2006 and 2007. Sample sizes are as in Figure 3.2.4.

The adult survival rates of kittiwakes at the key-sites are relatively high. Mean annual survival rate at Hornøya (1990-2006), Hjelmsøya (2004-07), Anda (2005-07) and Røst (2003-07) was estimated to be 82.3, 85.0, 88.3 and 88.7% respectively. Applying a simple, age-structured Leslie matrix model assuming 1) an adult survival rate of 0.85, 2) that the kittiwake starts to breed at three years of age, 3) that the survival rate of young birds from fledging to first breeding is 0.75, and 4) that there is an even sex ratio of fledglings, indicates that a fledging success of 0.72 chicks per nest is needed to maintain a stable population over time. Obviously, the observed fledging success in 2006-07 was far below this level throughout the area monitored, and at only a few of the colonies was the fledging success of that magnitude. Low recruitment rates may therefore contribute to explain the dramatic decline in kittiwake populations documented in Norway. Based on data from the National monitoring program for seabirds, the Norwegian kittiwake population has declined severely since 1980, and there are indications that this trend has accelerated since the mid 1990s (Barrett et al. 2006). 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. The mean fledging success on Røst in the same period was 0.64 chicks per nest (T. Anker-Nilssen pers. comm.). We do not know the direct causes, but in East Finnmark the instability (including several collapses) and general decline in the Barents Sea capelin stock may have contributed to this negative trend (Barrett 2007). Another important factor seems to be the increasing harassment and predation of chicks caused by the increasing population of white-tailed eagles, which appears to have severely reduced the breeding success of kittiwakes on Røst (Anker-Nilssen & Aarvak 2006).

3.3 Expanded monitoring of wintering seabirds in mainland Norway

Geir Helge Systad & Jan Ove Bustnes

A central aim of SEAPOP is to provide better monitoring data for coastal seabirds, especially on the outer coast. Before 2006, the Norwegian winter surveys within the SEAPOP area covered only three areas between Vesterålen and Varangerfjorden (**Figure 3.3.1**). To improve the coverage, we extended the winter surveys of seabirds in three regions; Troms, western Finnmark and eastern Finnmark, starting in 2006. The areas were selected based on their accessibility by road. All counts were carried out in early March 2006 and 2007. The surveys show that the distribution of seabirds at winter time is highly dynamic, and changing between years.

In Troms, two areas were surveyed; the outer parts of Kvaløya and at Vannøya (**Figure 3.3.1**). In 2007, there were 693 seabirds of eight species in the Kvaløya zone, and 2415 seabirds of 11 species at Vannøya, with a dominance of gulls and common eiders. In the Kvaløya zone, the reduction in numbers in 2007 compared to 2006 corresponds to a reduction in the two most prevalent species; herring gull and common eider. There were also fewer common eiders in the Vannøya zone in 2007 than in 2006; from 865 to 255 individuals (**Table 3.1.1**).

In western Finnmark, the area between Hasvik and Sørvær at Sørøya was counted (**Figure 3.3.1**). In 2007, there were 7572 seabirds of 15 species in this area, with dominance of kittiwakes and large gulls (**Table 3.1.1**). The increase in numbers from 2006 was and mainly caused by the high numbers of kittiwake.

In eastern Finnmark, the area between Berlevåg and Kongsfjorden was counted (**Figure 3.3.1**) and we observed 1353 seabirds of 7 species, with a dominance of king eiders and common eiders (**Table 3.1.1**). The numbers were considerably lower in 2007 than in 2006. In Varangerfjorden, there were 7426 seabirds of 19 species, dominated by sea ducks such as common eider, Steller's eider, king eider and long-tailed duck. Except for the long-tailed duck, there were fewer individuals in 2006 than in 2007. The counts in Varangerfjorden and Berlevåg-Kongsfjord focused on diving species.

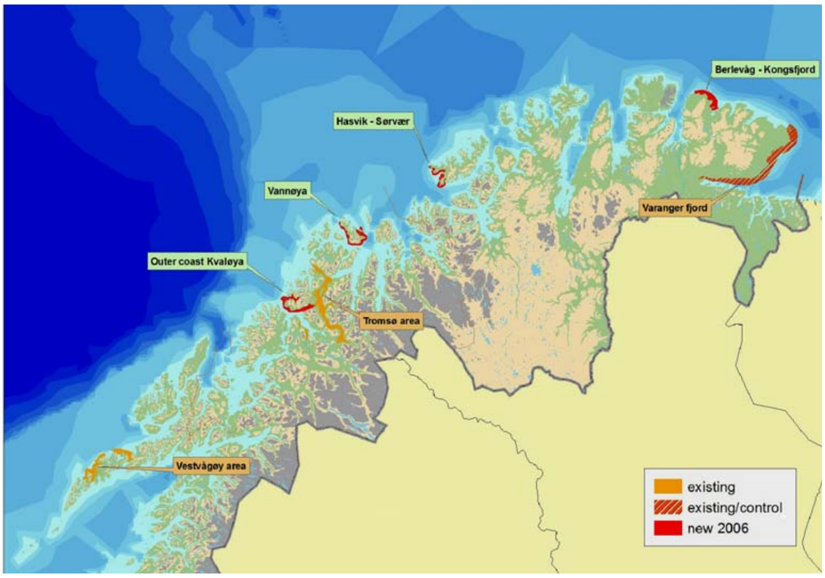


Figure 3.3.1
Areas for monitoring of wintering seabirds along the Norwegian mainland in the Lofoten-Barents Sea. New areas are marked in red.

Table 3.3.1 *Summary of results (in descending order of total abundance in 2007) of seabird counts in the new monitoring areas for wintering seabirds in northern Norway. The counts were conducted during March 2006 and 2007. Note that gulls are omitted in the totals for the Berlevåg-Kongsfjord and Varangerfjorden zones where the counts are focussed on diving species.*

English name	**Kvaløya**		**Vannøya**		**Sørvær-Hasvik**		**Berlevåg-Kongsfjord**		**Varanger-fjorden**	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Kittiwake	0	0	21	8	483	4342	(537)	–	(146)	–
Herring gull	654	222	1224	1443	2600	1894	(68)	–	(495)	(10)
Common eider	1144	252	865	255	301	154	1989	327	4580	2400
Steller's eider	0	0	0	0	0	0	219	233	3430	2065
King eider	3	0	47	0	720	59	1843	503	1149	1122
Great black-backed gull	69	83	382	505	448	766	(17)	–	(175)	(5)
Long-tailed duck	14	4	0	0	2	41	87	197	588	1001
Purple sandpiper	50	0	0	0	0	25	0	0	363	362
Cormorant	63	89	72	134	61	93	33	0	29	29
Red-breasted merganser	55	4	64	22	9	9	38	43	80	186
Shag	0	0	5	0	43	123	92	16	110	60
Oystercatcher	0	31	0	10	0	15	0	0	0	0
Common scoter	33	0	0	0	0	0	32	0	237	52
Black guillemot	0	0	4	5	72	0	111	34	31	7
Velvet scoter	13	0	0	0	1	0	2	0	51	45
Glaucous gull	0	0	1	1	3	0	(3)	–	(2)	(41)
Mallard	74	8	7	0	21	13	0	0	46	12
Black-headed gull	0	0	0	30	0	0	0	0	0	0
White-billed diver	1	0	0	0	0	0	1	0	0	21
Common gull	0	0	0	2	0	18	0	0	0	0
Puffin	0	0	0	0	0	16	0	0	5	0
Iceland gull	0	0	0	0	1	0	(1)	–	–	(7)
White-tailed eagle	0	0	0	0	10	4	0	0	0	0
Common guillemot	0	0	0	0	0	0	16	0	0	1
Unidentified large gull	0	0	0	0	615	0	(1000)	0	0	0
Cormorant/shag	0	0	0	0	32	0	0	0	8	0
Grey heron	10	0	0	0	0	0	0	0	0	0
Red-throated diver	0	0	0	0	0	0	1	0	6	0
Gannet	0	0	0	0	0	0	7	0	0	0
Unidentified auk	0	0	0	0	0	0	5	0	0	0
Razorbill	0	0	0	0	0	0	2	0	0	0
Fulmar	0	0	0	0	0	0	1	0	0	0
Black-throated diver	0	0	0	0	0	0	1	0	0	0
Total	**2183**	**693**	**2692**	**2415**	**5422**	**7572**	**4480**	**1353**	**10713**	**7362**

Figure 3.3.2
The red-listed Steller's eider is one of the most common coastal seabirds in Varangerfjorden in winter. (© Geir Helge Systad)

3.4 Monitoring of wintering seabirds in Svalbard

Hallvard Strøm, Georg Bangjord & Erik Torp

Most of the bird species in Svalbard are migratory and take advantage of the high productivity in the Greenland and Barents Seas during summer. However, some seabird species winter in the restricted ice-free waters off the archipelago. Species of which many individuals may winter in Svalbard are common eider, long-tailed duck and black guillemot (Bustnes & Bianki 2000, Bustnes & Tertitski 2000, Strøm 2006). Single individuals or small groups of other species, e.g. glaucous gull and Brünnich's guillemot may also be recorded in winter, but it is uncertain if these birds are residents from Svalbard or migrants originating from other breeding areas. The only fully resident terrestrial bird species is the Svalbard rock ptarmigan *Lagopus mutus hyperboreus* that remains on the island throughout the year.

The overall knowledge of distribution and abundance of wintering seabirds in Svalbard is, in general, poor. The winter darkness, combined with the inaccessibility of many areas, hinder investigations at this time of the year. The waters surrounding Svalbard are covered with sea ice to a varying extent, depending on the time of year and shifting meteorological and oceanographic conditions. Normally, the ice has its greatest extent in March-April, with areas of open water restricted to the west and northwest coast of Spitsbergen (Hisdal 1998).

Surveys of wintering seabirds in Svalbard have been conducted since the mid 1990s with logistic and financial support from the Governor of Svalbard and the Norwegian Polar Institute (G. Bangjord, unpubl. data). The area covered has been Nordenskiöldkysten (the coast of Nordenskiöld), from Festningen in outer Isfjorden to Camp Millar on the north coast of Bellsund (**Figure 3.4.2, right**). This area is readily accessible from Longyearbyen and is probably representative for the west coast of Spitsbergen in winter with one of the main wintering areas for long-tailed duck and common eider. From 2007, this monitoring survey was integrated as part of the SEAPOP programme and extended to include the coastline from outer part of Bellsund south to Torellbreen. However, weather and sea ice conditions in late February prevented a survey of the new parts in 2007. The field work was thus restricted to the original area and conducted in the period 21-24 February by a two-person field team moving along the coast on snowmobiles and counting from the shore using binoculars and telescopes (**Figure 3.4.1**). The study area was, in general, free of sea ice, but slush and pancake ice occurred in some parts (**Figure 3.4.3**). In addition to the land-based counts, a helicopter survey was conducted in late February covering the area from Sørkapp to Bellsund and the southern part of Forlandssundet and Prins Karls Forland (**Figure 3.4.2, left**).

Figure 3.4.1
Counting wintering seabirds at Diabaspynten on Nordenskiöldkysten, west coast of Spitsbergen, Svalbard in February 2007. (© Georg Bangjord)

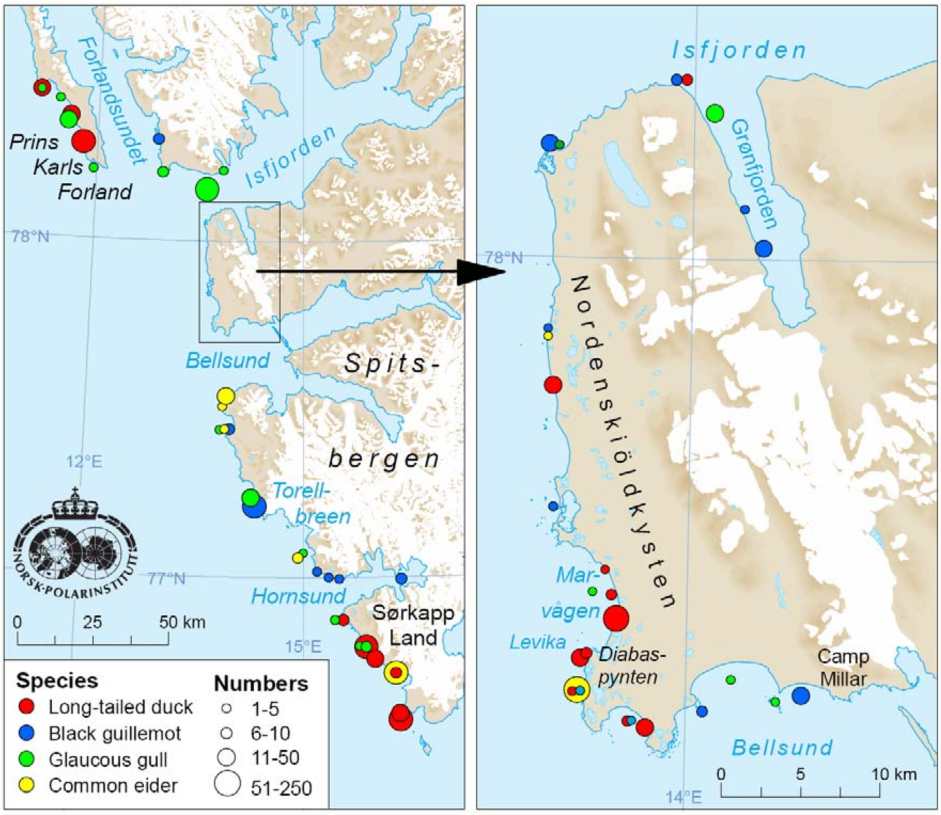


Figure 3.4.2
The distribution of long-tailed duck, glaucous gull, common eider and black guillemot along most of the west and southwest coast of Spitsbergen in late February 2007, as surveyed by helicopter (left map) and along Nordenskiöldkysten, which was surveyed from land (extracted section, right).

A minimum of about 800 birds of six species was observed in the area from Sørkapp to Prins Karls Forland (**Figure 3.4.2**), with a dominance of long-tailed duck (650 individuals) and common eider (157 individuals), in addition to a few glaucous gulls and black guillemots and single individuals of kittiwake and Steller's eider. Of the species wintering along the west coast of Spitsbergen, only the long-tailed duck occurs in such numbers that it can be assumed that a large part of the local breeding population winters in Svalbard.

Figure 3.4.1
View from Levika towards Marvågen on Nordenskiöldkysten, west coast of Spitsbergen, Svalbard in February 2007.
(© Georg Bangjord)

3.5 Mapping of seabird distribution on the coast

3.5.1 Distribution of seabirds in Spitsbergen and Nordaustlandet

Harald Steen

In Svalbard, mapping priority in 2007 was given to the northern coast of Spitsbergen and Nordaustlandet. We censused all major seabird colonies in the area, from Magdalenefjorden (79º34′N 11º00′E) about 58 km north of Ny-Ålesund on the west coast of Spitsbergen to Kapp Platen (80º30′N 22º45′E) on Nordaustlandet (**Figure 3.5.1**). The cruise started from Longyearbyen on 15 June and ended in Kinnvika, Nordaustlandet on 18 July. For accommodation and transport of the six-man crew between the colonies, we used the S/Y *Arctica*, a 48 ft and 33 t sailboat built for sailing in ice-filled waters (**Figure 3.5.2**). The cruise covered more than 1900 km over 34 days. Two zodiacs were used to reach land and to speed up movement between colonies in the vicinity of the sailboat. At the end of the cruise, the fieldworkers were transported to Longyearbyen by helicopter.

All birds in 115 colonies were counted during the cruise. To facilitate comparison with earlier counts the results were grouped into well defined regions (**Table 3.4.1**). It is difficult to make comparisons on a more detailed scale since some colony limits were rather diffuse. No clear trends since the earlier counts were evident, thus populations were considered to have remained fairly stable. This conclusion must, however, be treated with caution because the intensity and quality of earlier counts are unknown.

Figure 3.5.1. *Counting seabirds in Hamiltonbukta, Raudfjorden, on 27 June 2007. The glacier in the background is Hamiltonbreen. (© Harald Steen)*

***Table* 3.5.1** *Total numbers of Brünnich's guillemots (individuals) and kittiwake (apparently occupied nests) counted in colonies in different regions along the coasts of northern Spitsbergen and Nordaustlandet in 2007.*

Region	No. of colonies	Brünnich's guillemot	Kittiwake
NW Spitsbergen (Magdelenefjorden to Biskayarhuken)	45	23114	4426
The coastline Raudfjorden – Widjefjorden – Woodfjorden – Liefdefjorden – Moffen	24	23681	11049
Sjuøyane	13	4724	2621
North coast of Nordaustlandet	33	0	3808
Total	**115**	**51519**	**21904**

***Figure* 3.5.2.** *S/Y Arctica on the seabird cruise to northern Spitsbergen in summer 2007. (© Harald Steen)*

3.5.2 Distribution of seabirds on the mainland coast

G. H. Systad & J. O. Bustnes

The aim of the 2007 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, with focus on breeding birds in Lofoten-Vesterålen, and some of the larger seabird colonies not covered in the previous years.

Data were collected between 23 May and 16 June, using three complimentary methods: 1) aerial surveys of the coastal strip, 2) visits to colonies by boat and 3) counts from land. 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 by counting teams based on coastguard vessels or using zodiacs from the shore. For the aerial surveys, we used small, single-engine aircraft flying at 150 m a.s.l. and 150 km/h, and all birds observed were recorded on tape. Their GPS positions were also registered, and whenever large flocks or breeding aggregations of birds were encountered, photographs were taken and counted later. Apart from some of the larger seabird colonies, the counting from photographs has been completed.

The surveys of large seabird aggregations outside the key-sites; i.e. large colonies of puffins, guillemots, and kittiwakes, will be completed in 2008. Another focus in 2008 will be mapping of seabirds in the non-breeding season, with a focus on autumn and winter distribution from Lofoten to the Russian border, starting in the Lofoten-Vesterålen area.

Except for the larger seabird colonies, Troms and Finnmark counties were covered almost completely in the breeding seasons of 2005-2006. The remaining areas in Troms were covered in 2007 together with the Lofoten-Vesterålen area. Larger colonies such as Syltefjordstauran, Kongsøyene, Sværholt, Gjesværstappan and Hjelmsøya were also surveyed. Overall 612,000 birds were observed, distributed among more than 9000 observations (**Table 3.5.2**). The dominating species were kittiwake (more than 177,000 pairs), common eider (17,888 males classified as breeding) and herring gull (more than 38,000 pairs) (**Figures 3.5.3 & 3.5.4**).

***Table** 3.5.2 Species, counting units, numbers of localities (i.e. colonies for colonial species) and total counts of selected seabirds breeding in Troms and Finnmark in 2005-2007. Note that some of the larger colonies have still not been censused and are not included in the counts.*

Species	**Counting unit**	**No. of localities or colonies**	**Total count**
Cormorant	Apparently occupied nest	122	13,091
Common eider	Adult male in breeding area	1164	17,888
Goosander	Nonbreeding individual	184	4,302
Arctic tern	Adult individual in breeding area	128	30,000
Herring gull	Apparently occupied nest	970	38,136
Great black-backed gull	Apparently occupied nest	1402	16,692
Common gull	Apparently occupied nest	533	2,859
Kittiwake	Apparently occupied nest	430	177,606

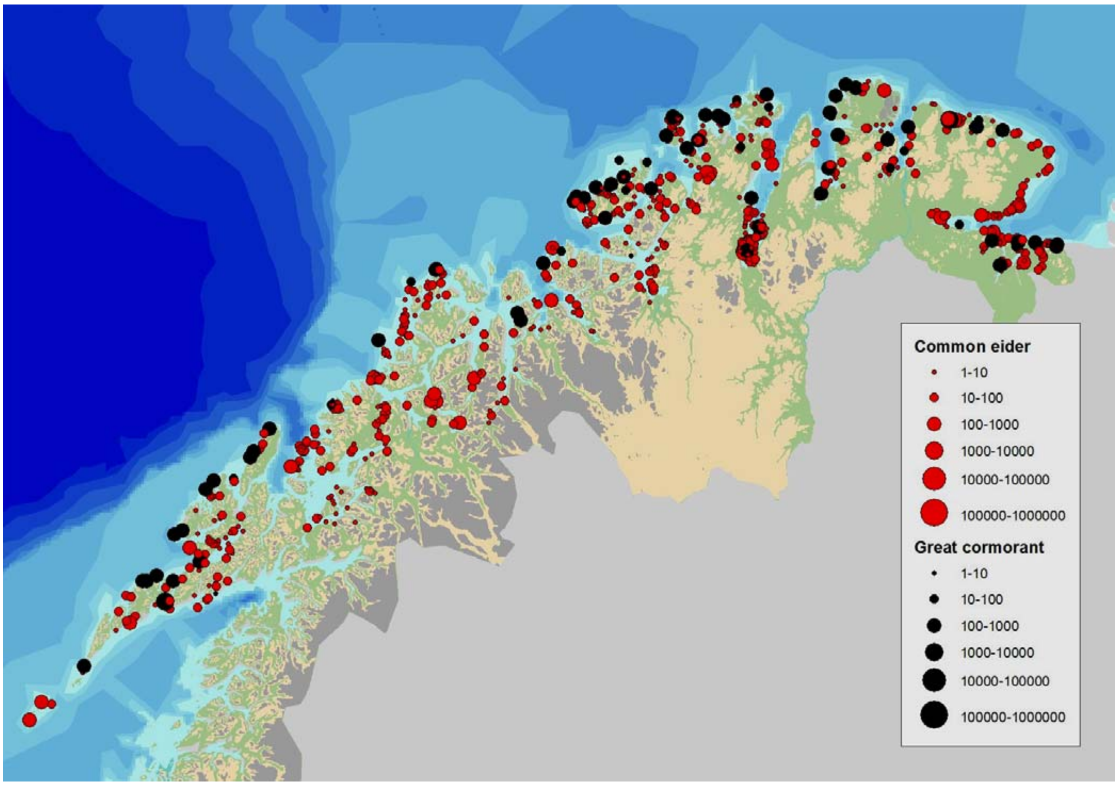


***Figure* 3.5.3** *The distribution of breeding common eiders and great cormorant in northern Nordland (Lofoten and Vesterålen), Troms and Finnmark in 2005-2007.*

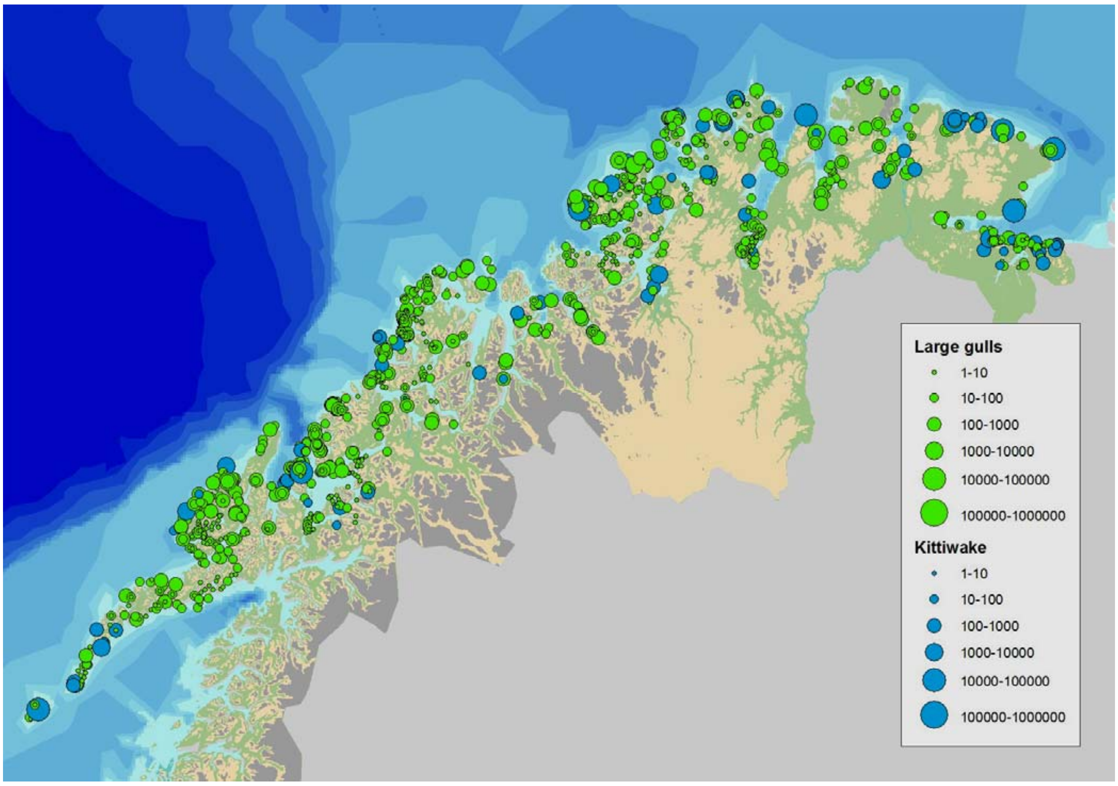


***Figure* 3.5.4** *The distribution of breeding kittiwake and large gulls (herring gull and great black-backed gull) in northern Nordland (Lofoten and Vesterålen), Troms and Finnmark in 2005-2007.*

3.6 Seabirds at sea

Per Fauchald & Torkild Tveraa

3.6.1 Surveys in 2007

Seabirds at sea are surveyed using internationally standardised counts of birds in transects from aboard ocean-going vessels. The winter period in the Barents Sea was extensively covered in the period 1986-1994. In the first years of SEAPOP, we have therefore concentrated on the spring, summer and autumn seasons. As in 2005 and 2006, we attended the regular ecosystem surveys of the Institute of Marine Research (IMR) in the Barents and Norwegian Seas in spring/summer and autumn 2007 (**Figure 3.6.1, Table 3.6.1**). These surveys covered a total transect length of 10,982 km. Despite standardised methodology and similar coverage, the observed density of some of the species changed markedly between years (**Table 3.6.2**). Notably, the density of pelagic surface-feeders such as gulls and fulmars was much higher during the cruise in the Norwegian Sea in spring 2007 than in the two preceding years. The reason for this is unclear. These species do, however, tend to follow the ship to forage on discards from trawl samples taken during the cruises. The higher density could thus either reflect a real increase in abundance in the area, or an increased in foraging on discards from fishing vessels as a consequence of a shortage of other food items. It should be noted that this pattern was not present during the autumn survey.

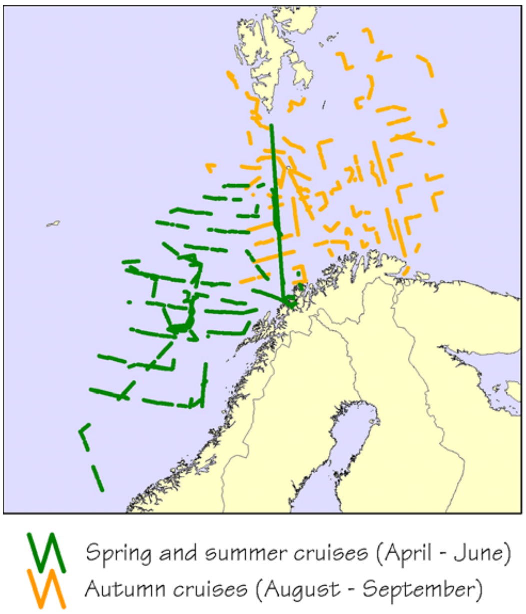


Figure 3.6.1
Coverage of seabirds-at-sea surveys in 2007.

Table 3.6.1 *Seabird surveys as a part of the marine ecosystem surveys conducted by the Institute of Marine Research (IMR), Bergen, in the Norwegian and Barents Seas in 2007.*

Period	**Vessel**	**Time period**	**Survey**	**Total transect length** (*km*)
Spring	G.O. Sars	25 Apr – 20 Jun	Norwegian Sea Ecosystem, IMR	6,013
Autumn	Johan Hjort	3 Aug – 30 Aug	Barents Sea Ecosystem, IMR	1,340
Autumn	G.O. Sars	15 Aug – 28 Sep	Barents Sea Ecosystem, IMR	2,833
Sum				19,982

Table 3.6.2 *Mean densities of seabirds (individuals/km²) during surveys in 2005-2007.*

English name	Scientific name	Spring and summer			Autumn		
		2005	2006	2007	2005	2006	2007
Fulmar	*Fulmarus glacialis*	3.304	10.788	402.433	17.385	31.986	25.019
Sooty shearwater	*Puffinus griseus*	0	0	0	0.080	0.008	0.011
Manx shearwater	*Puffinus puffinus*	0	0	0	0	> 0	0
Storm petrel	*Hydrobates pelagicus*	> 0	> 0	0	0	0	0
Gannet	*Morus bassanus*	0	0	0	0	0.014	0
Cormorant	*Phalacrocorax carbo*	0	0.004	0	> 0	0.007	0
Shag	*Phalacrocorax aristotelis*	0	> 0	0.003	0.001	0.002	0.001
Common eider	*Somateria mollissima*	0	0.003	0.026	0	0.004	0.001
Long-tailed duck	*Clangula hyemalis*	0.013	0.014	0.007	0	0.002	0
Common scoter	*Melanitta nigra*	0	0	0	>0	0	0
Pomarine skua	*Stercorarius pomarinus*	0.122	0.214	0.061	0.085	0.426	0.358
Arctic skua	*Stercorarius parasiticus*	0.029	0.029	0.008	0.124	0.053	0.044
Long-tailed skua	*Stercorarius longicaudus*	0.069	0.043	0.013	0.007	0.007	0.005
Great skua	*Stercorarius skua*	0.042	0.024	0.030	0.029	0.005	0.007
Common gull	*Larus canus*	0	0.009	0	0	0.015	0
Lesser black-backed gull	*Larus fuscus*	0.068	0.130	10.392	0	0.008	0
Herring gull	*Larus argentatus*	0.368	2.738	9.687	1.968	1.933	1.781
Iceland gull	*Larus glaucoides*	0.011	0	0.185	0	0	0
Glaucous gull	*Larus hyperboreus*	0.363	0.143	19.470	0.129	1.315	1.016
Great black-backed gull	*Larus marinus*	0.323	1.427	11.311	1.618	0.204	0.474
Kittiwake	*Rissa tridactyla*	2.802	9.101	60.392	8.709	14.408	14.644
Arctic tern	*Sterna paradisaea*	0.095	0.037	0.001	0.025	0.017	0.027
Common guillemot	*Uria aalge*	0.108	0.049	0.017	0.090	0.051	0.095
Brünnich's guillemot	*Uria lomvia*	0.330	0.068	0.039	1.527	1.351	1.768
Unidentified guillemot	*Uria aalge / U. lomvia*	0.094	0.201	0.099	0.154	0.166	0-040
Little auk	*Alle alle*	0.045	0.013	0.068	0.044	0.207	0.243
Black guillemot	*Cepphus grylle*	0.004	0.006	0.004	0.005	0.016	>0
Razorbill	*Alca torda*	0.044	0.024	0.002	0.020	0.014	0.003
Puffin	*Fratercula arctica*	0.418	0.321	0.364	0.882	0.348	0.665

3.6.2 Seabirds at sea habitats

In a project financed by Norsk Hydro in 2006, we analysed the European Seabird at Sea (ESAS) database to produce maps of seabird habitats in the North Sea. In 2007, we combined this effort with the SEAPOP dataset covering the Barents and Norwegian Seas to produce continuous seabird habitat maps for the 13 most common seabird species in Norwegian and adjacent waters. These two datasets comprise seabird counts from more than 0.5 million kilometres of transects in a period from 1980 to 2007. Predictive maps of seabird density were derived from non-linear regression models (Generalised Additive Models, Wood 2006) using observed seabird density as response variable and geographic position, distance from coast, surface temperature, surface salinity and depth as predictive variables. For each seabird species the predicted number of individuals to be observed in a 10x10 km² grid cell was modelled separately for each of the following three seasons: winter (1 November – 31 March), summer (1 April – 31 July), and autumn (1 August – 31 October). The maps and datasets are available on the SEAPOP website (www.seapop.no).

It is important to note that in terms of absolute values, the predicted numbers of seabirds might be biased in several ways. For example, small diving birds such as puffins and little auks are difficult to observe and might therefore be under-estimated, while large conspicuous species that tend to follow the ship, such as fulmars, might be over-estimated. However, we assume these problems to be equally valid in different areas and that the predicted spatial pattern therefore represents an unbiased picture of the most important seabird habitats at sea.

Below we present the results for six important species (**Figures 3.6.2-3.6.4**). To quantify for use in environmental risk assessments the variability in the number of individuals affected by an oil spill incident (Fauchald & Brude 2005), new simulated scenarios for each species will be modelled and published on the SEAPOP web in 2008.

The distributions of the two large auk species (**Figure 3.6.2**) are very different. Brünnich's guillemots are found at high density in the Barents Sea in all seasons while common guillemots are mainly found in the western part of the North Sea, with only small numbers in the Barents Sea area. The major part of the data from the Barents Sea area is from the period after the sharp decline in the population of common guillemots in the mid 1980s. There are therefore good reasons to believe that the historic density of common guillemots was much higher in this area. The densities of the two species remain relatively constant in the two ocean systems throughout the year with only small local movements. This might indicate that they are relatively stationary with little degree of seasonal migration between ocean systems.

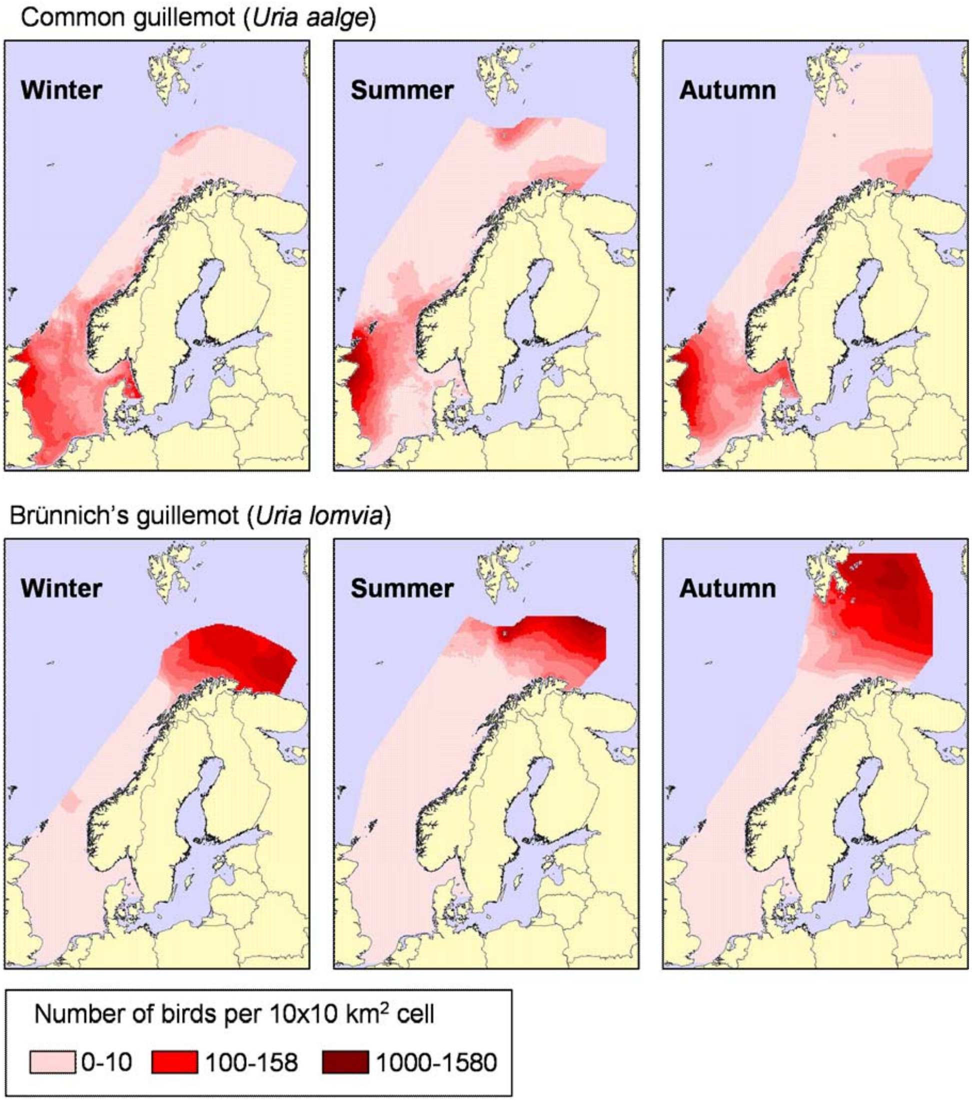


Figure 3.6.2 *Predicted distribution of common and Brünnich's guillemots in Norwegian and adjacent waters during winter (1.11-31.3), summer (1.4-31.7) and autumn (1.8-31.10).*

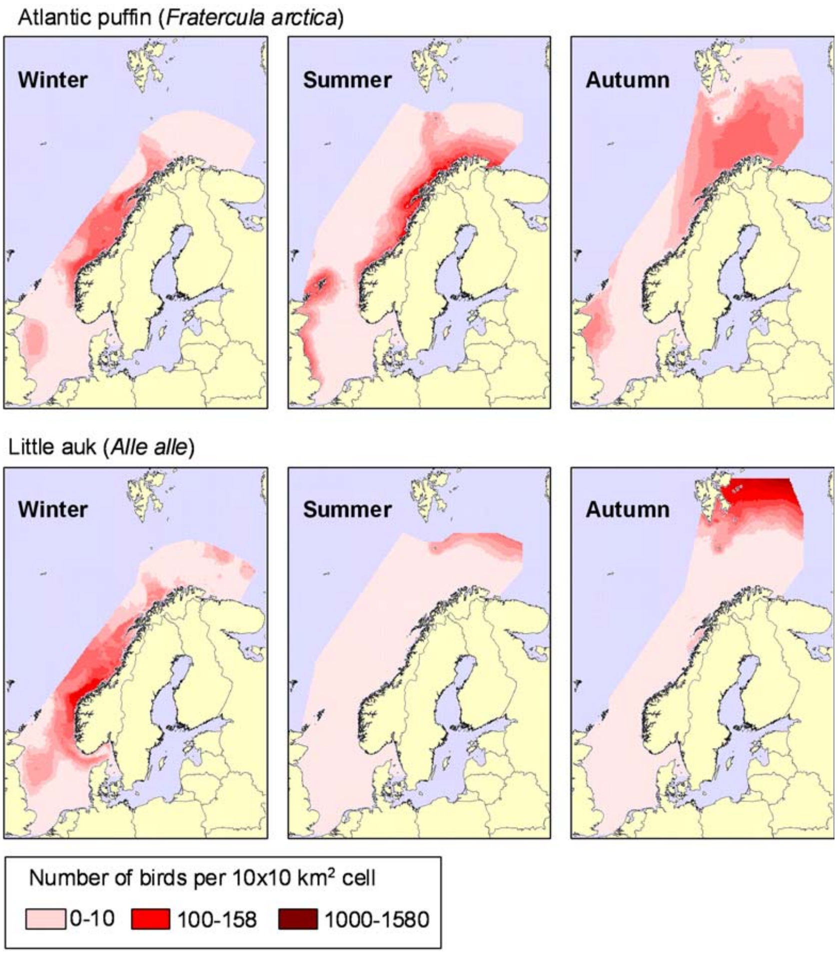


Figure 3.6.3 *Predicted distribution of puffin and little auk in Norwegian and adjacent waters during winter (1.11-31.3), summer (1.4-31.7) and autumn (1.8-31.10).*

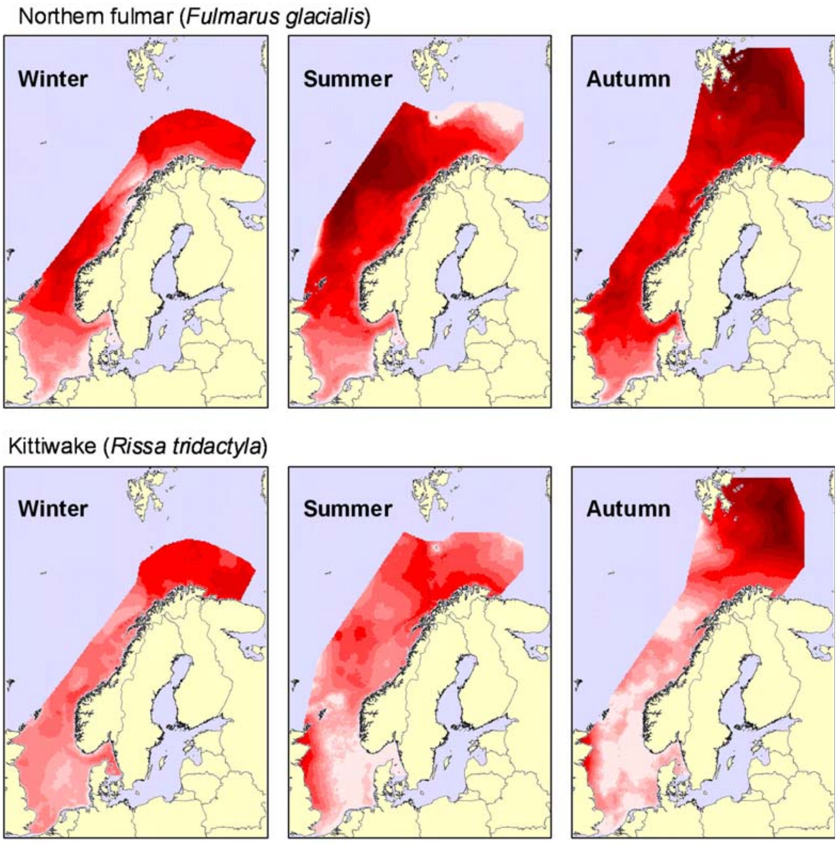


Figure 3.6.4 *Predicted distribution of fulmar and kittiwake in Norwegian and adjacent waters during winter (1.11-31.3), summer (1.4-31.7) and autumn (1.8-31.10).*

In winter, the two small auk species (puffin and little auk) are found in high concentrations in the Norwegian Sea close to the Norwegian coast (**Figure 3.6.3**). From this central wintering area they migrate to their respective breeding areas. When breeding, puffins are found in high concentrations close to the large colonies in northern Norway and Great Britain while little auks are found in the high Arctic. In autumn puffins migrate into the central Barents Sea, possibly to forage on 0-group fish, while little auks are found in high numbers in the northern part of the Barents Sea, close to the marginal ice zone.

The two most numerous pelagic surface feeders (kittiwake and fulmar) are found widespread in all oceans systems throughout the year (**Figure 3.6.4**). There are, however, some regional and seasonal differences. The densities of both species are generally lower in the North Sea compared to the Norwegian and Barents Sea. During winter, high densities of both species are found in the Norwegian and Barents Seas. In summer, high densities of kittiwakes are found around the breeding colonies in northern Norway and Great Britain. In the same period large numbers of fulmars are found offshore in the Norwegian Sea. In autumn, high concentrations of both species are found in the Barents Sea.

Figure 3.6.4 *The fulmar is the most common seabird at sea in Norwegian waters and adjacent sea areas at all times of year. (© Tycho Anker-Nilssen)*

3.7 Satellite tracking of king eiders wintering in Norway

Jan Ove Bustnes & Geir Helge Systad

In 2006, SEAPOP funded a project aiming to track the migration of king eiders wintering on the Norwegian Coast back to their breeding ground using satellite transmitters. This was based on the lack of knowledge about the origin and migration routes of this wintering population. Ten transmitters were purchased, and Båtsfjord in eastern Finnmark, where relatively high numbers of king eiders are known to winter in the harbour area, was selected as the location at which to deploy the transmitters. However, an attempt to catch birds there in early April 2007 failed because the birds had already left the area somewhat earlier than normal. In February 2008, however, we successfully implanted all 10 transmitters in 5 males and 5 females. When this report was written a few weeks after the deployment, adequate signals were received from all ten. The project is undertaken in cooperation with the two scientists Anders Mosbech and Christian Sonne from the National Environmental Research Institute (NERI) in Denmark, University of Aarhus (Danmarks Miljøundersøkelser), who have experience from similar studies of king eiders in Greenland and Arctic Canada.

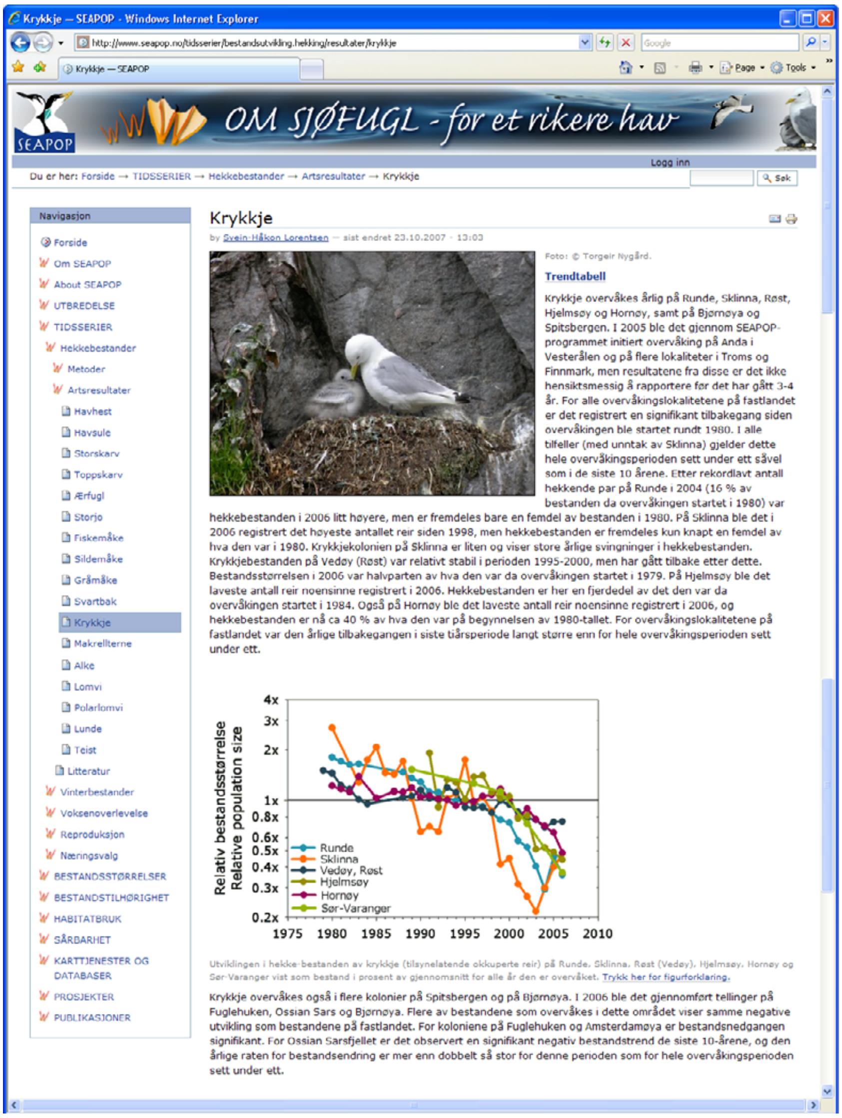
Figure 3.6.4 *A male king eider (left) together with male and female common eiders. (© Geir Helge Systad)*

3.8 Operationalisation of results

3.8.1 The SEAPOP Web

Hallvard Strøm, Signe Christensen-Dalsgaard, Svein-Håkon Lorentsen & Tycho Anker-Nilssen

The Norwegian version of the SEAPOP webpage (www.seapop.no) was launched at the first SEAPOP seminar that was held at Holmen Fjordhotell near Oslo in October 2007. The webpage is the primary line of communication from SEAPOP to the partners involved in the programme, as well as the general public. Most of the data and information collected through the various SEAPOP projects are presented on the Web. The major share of this information is freely available as maps, tables, figures and text. Three different web-map services have been developed (see Section 3.8.2). The site also contains an up-to-date list of scientific papers and other publications associated with the programme, and all technical reports can be downloaded as PDF files. This structure ensures that everyone has an immediate access to the same quality-controlled results, new or updated, and that the information can be standardised in such a way as to be most useful for all involved. So far the web site is in Norwegian, but an English version is under way.



Krykkje

by Svein-Håkon Lorentsen — sist endret 23.10.2007 · 13:03

Foto: © Torgeir Nygård.

Trendtabell

Krykkje overvåkes årlig på Runde, Sklinna, Røst, Hjelmsøy og Hornøy, samt på Bjørnøya og Spitsbergen. I 2005 ble det gjennom SEAPOP-programmet initiert overvåking på Anda i Vesterålen og på flere lokaliteter i Troms og Finnmark, men resultatene fra disse er det ikke hensiktsmessig å rapportere før det har gått 3-4 år. For alle overvåkingslokalitetene på fastlandet er det registrert en signifikant tilbakegang siden overvåkingen ble startet rundt 1980. I alle tilfeller (med unntak av Sklinna) gjelder dette hele overvåkingsperioden sett under ett såvel som i de siste 10 årene. Etter rekordlavt antall hekkende par på Runde i 2004 (16 % av bestanden da overvåkingen startet i 1980) var hekkebestanden i 2006 litt høyere, men er fremdeles bare en femdel av bestanden i 1980. På Sklinna ble det i 2006 registrert det høyeste antallet reir siden 1998, men hekkebestanden er fremdeles kun knapt en femdel av hva den var i 1980. Krykkjekolonien på Sklinna er liten og viser store årlige svingninger i hekkebestanden. Krykkjebestanden på Vedøy (Røst) var relativt stabil i perioden 1995-2000, men har gått tilbake etter dette. Bestandsstørrelsen i 2006 var halvparten av hva den var da overvåkingen startet i 1979. På Hjelmsøy ble det laveste antall reir noensinne registrert i 2006. Hekkebestanden er her en fjerdedel av det den var da overvåkingen startet i 1984. Også på Hornøy ble det laveste antall reir noensinne registrert i 2006, og hekkebestanden er nå ca 40 % av hva den var på begynnelsen av 1980-tallet. For overvåkingslokalitetene på fastlandet var den årlige tilbakegangen i siste tiårsperiode langt større enn for hele overvåkingsperioden sett under ett.

Utviklingen i hekke-bestanden av krykkje (tilsynelatende okkuperte reir) på Runde, Sklinna, Røst (Vedøy), Hjelmsøy, Hornøy og Sør-Varanger vist som bestand i prosent av gjennomsnitt for alle år den er overvåket. Trykk her for figurforklaring.

Krykkje overvåkes også i flere kolonier på Spitsbergen og på Bjørnøya. I 2006 ble det gjennomført tellinger på Fuglehuken, Ossian Sars og Bjørnøya. Flere av bestandene som overvåkes i dette området viser samme negative utvikling som bestandene på fastlandet. For koloniene på Fuglehuken og Amsterdamøya er bestandsnedgangen signifikant. For Ossian Sarsfjellet er det observert en signifikant negativ bestandstrend de siste 10-årene, og den årlige raten for bestandsendring er mer enn dobbelt så stor for denne perioden som for hele overvåkingsperioden sett under ett.

Figure 3.8.1
Screenshot of the SEAPOP web page with results from the monitoring of kittiwake population trends.

In 2007, the work related to the web pages focused on the production of texts, tables and figures prior to the launch at the SEAPOP seminar in October. All the major parts of the web pages are now in place, including the front page news bulletin board, and near-future focus will be the development of an English version. The SEAPOP web site seems to be widely used with a number of unique visitors steadily increasing from 273 in December 2007 to 635 in April 2008. The web statistics show that the average visitor visits about five different pages and stays on the site for ca. 3 minutes. The visitors are mainly from Norway, but also people in 15 other European countries and in USA, Canada, Egypt and Japan have frequented the site so far.

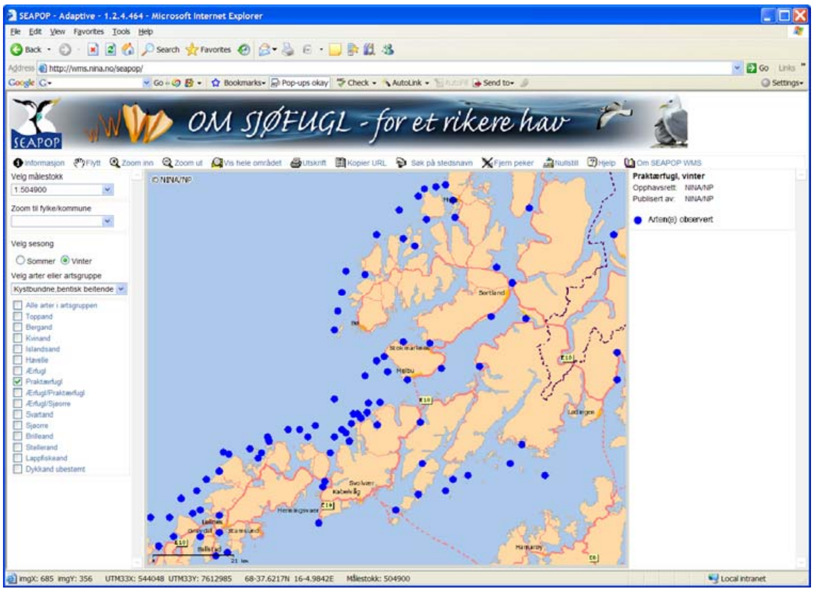
3.8.2 The SEAPOP Database and web map services

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

Data from the Norwegian Seabird Database and from the Colony Database (Svalbard) have been merged together into one central SEAPOP database located at NINA, Trondheim. From this database, data are made available through four different channels presented below. The applications were developed over the last two years, and released on the web in October 2007.

1. The SEAPOP WMS Service

This is a free and public Web Map Service (WMS) application that publishes online maps of seabird distribution from the SEAPOP database (**Figure 3.8.2**). The user can select different seasons, species and ecological groups of species and look at the maps directly in the web application or implement them into a GIS software by using the *getCapabilities* request (link found at the SEAPOP web page).



Velg målestokk: 1:504900

Zoom til fylke/kommune:

Velg sesong: ○ Sommer ● Vinter

Velg arter eller artsgruppe: Kystbundne,bentisk beitende

☐ Alle arter i artsgruppen
☐ Toppand
☐ Bergand
☐ Kvinand
☐ Islandsand
☐ Havelle
☐ Ærfugl
☑ Praktærfugl
☐ Ærfugl/Praktærfugl
☐ Ærfugl/Sjøorre
☐ Svartand
☐ Sjøorre
☐ Brilleand
☐ Stellerand
☐ Lappfiskand
☐ Dykkand ubestemt

Praktærfugl, vinter
Opphavsrett: NINA/NP
Publisert av: NINA/NP

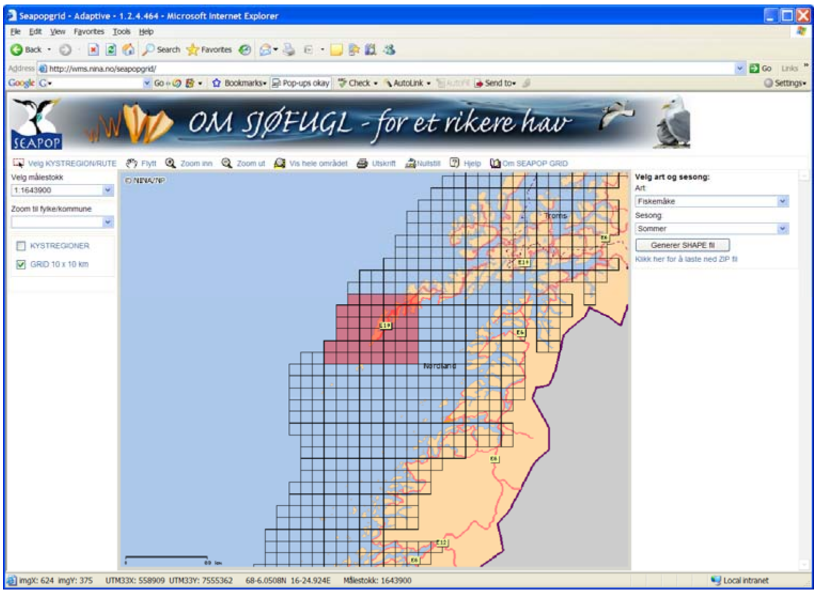
● Arten(e) observert

imgX: 685 imgY: 356 UTM33X: 544048 UTM33Y: 7612985 68-37.6217N 16-4.9842E Målestokk: 504900

Figure 3.8.2
Screenshot from use of the SEAPOP WMS Service, here indicating the winter distribution of king eiders in parts of the Lofoten and Vesterålen area.

2. The SEAPOP Grid Service

This is a free and public web application for downloading GIS files (on *ESRI* shapefile format) with maps of relative seabird densities at sea in pre-defined 10x10 km^2 grid (**Figure 3.8.3**). The user only has to select the seabird species, season and grid-cells or coastal region of interest



Velg målestokk: 1:1643900

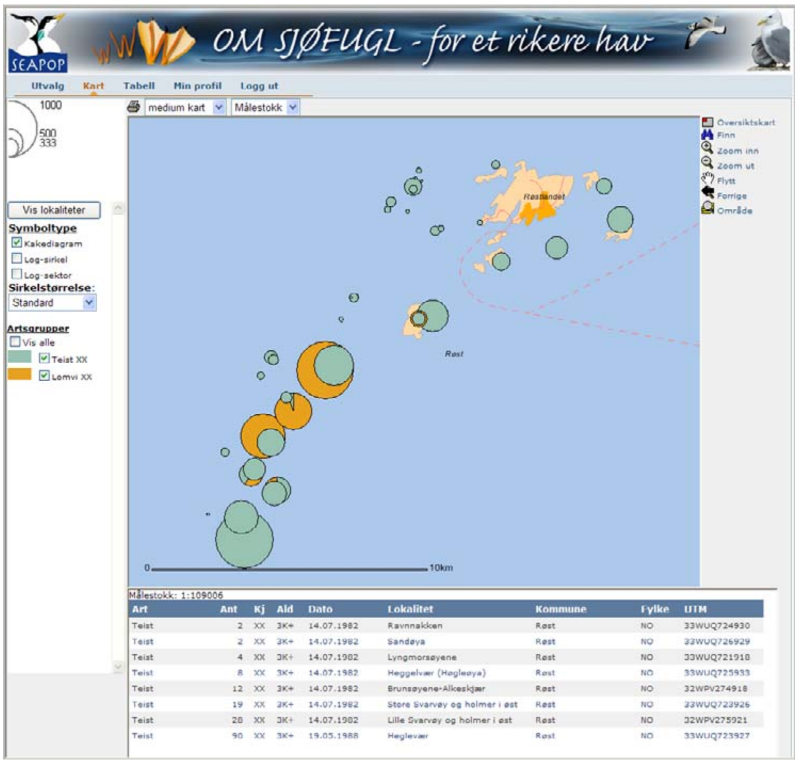
Velg art og sesong:
Art: Fiskemåke
Sesong: Sommer

Figure 3.8.3
Screenshot from use of the SEAPOP Grid Service illustrating the selection procedure for acquiring shapefile data on seabird distribution, in this case the summer distribution of common gull in the outer part of the Lofoten Islands.

and press the button (**Figure 3.8.3**) to generate and download the resulting package of shapefiles (as a *WinZip* file archive). The embedded shapefiles are ready to be used directly in a GIS.

3. The SEAPOP Advanced Management Application

This web application requires a signed agreement before a username/password is provided for the user. When logged on to the application, the user can search for and display detailed information of all the data in the SEAPOP Database in tables and maps. In December 2007 the advanced module was extended with a pilot version of an option that allows the user to display time series data for single localities (**Figure 3.8.5**).



Målestokk: 1:109006

Art	Ant	Kj	Ald	Dato	Lokalitet	Kommune	Fylke	UTM
Teist	2	XX	3K+	14.07.1982	Ravnnakken	Røst	NO	33WUQ724930
Teist	2	XX	3K+	14.07.1982	Sandøya	Røst	NO	33WUQ726929
Teist	4	XX	3K+	14.07.1982	Lyngmorsøyene	Røst	NO	33WUQ721910
Teist	8	XX	3K+	14.07.1982	Heggelvær (Hegleøya)	Røst	NO	33WUQ725933
Teist	12	XX	3K+	14.07.1982	Brunsøyene-Alkeskjær	Røst	NO	32WPV274918
Teist	19	XX	3K+	14.07.1982	Store Svarvøy og holmer i øst	Røst	NO	33WUQ723926
Teist	28	XX	3K+	14.07.1982	Lille Svarvøy og holmer i øst	Røst	NO	32WPV275921
Teist	90	XX	3K+	19.05.1988	Heglevær	Røst	NO	33WUQ723927

Figure 3.8.4
Screenshot from use of the SEAPOP Advanced Management Application indicating the presentation of specific observation data on seabird distribution and abundance in tables and on highly flexible maps, in this case the summer distribution of black guillemots within the municipality of Røst, Nordland.

Art	Lokalitet	Kommune	Fylke	UTM	Antall tellinger	
Fiskemåke	Nygardsneset-Gavlen	Andøy	NO	33WWS206416	2	Vis bestandsutvikling
Alke	Bleiksøya	Andøy	NO	33WWS345854	4	Vis bestandsutvikling
Lomvi	Bleiksøya	Andøy	NO	33WWS345854	3	Vis bestandsutvikling
Storskarv	Skarvklakken	Andøy	NO	33WWS268724	8	Vis bestandsutvikling
Havsule	**Skarvklakken**	**Andøy**	**NO**	**33WWS268724**	**25**	**Vis bestandsutvikling**
Krykkje	Bleiksøya	Andøy	NO	33WWS345854	3	Vis bestandsutvikling
Lunde	Bleiksøya	Andøy	NO	33WWS345854	5	Vis bestandsutvikling

År	Antall individer
1969	14
1970	72
1971	130
1972	206
1973	254
1974	290
1975	274
1976	340
1978	618
1979	688
1982	1054
1983	600
1985	1408
1988	1710
1991	1886
1995	1490
1997	1200
1998	820
1999	480
2001	706
2002	410
2003	0
2004	0
2005	0
2006	14

Figure 3.8.5
Screenshot from the use of a new feature in the advanced SEAPOP database module, presenting time series data from different localities, in this case breeding numbers of gannets at Skarvklakken, Vesterålen in 1969-2006.

4. Artsdatabankens "Species Maps" service

In November 2007, the entire SEAPOP database was made available through the "Species Maps" service created by The Norwegian Biodiversity Information Centre (Artsdatabanken) in Trondheim. We have implemented several web services, which extract data from the database and display them in a web map application located at http://artskart.artsdatabanken.no/.

Some detailed information about localities and observations can be viewed, but the data cannot be downloaded locally. Note also that the system does not yet distinguish between confirmed breeding sites and occasional observations of adults. The same applies to the SEAPOP WMS Service for data from the summer season.

Figure 3.8.6
The logo of Artsdatabanken has got a seabird touch to it…

4 References

Alonso-Alvarez, C. 2006. Manipulation of the primary sex-ratio: an updated review. **Avian and Poultry Biology Reviews 17**: 1-20.

Anker-Nilssen, T. 2008. En enkel guide til estimering av overlevelse og fangbarhet i MARK Ver. 5.0 for løpende rapportering av resultater i regi av SEAPOP. **Unpublished guide**, Norwegian Institute for Nature Research, Trondheim. 10 pp. (*In Norwegian*)

Anker-Nilssen, T. & Røstad, O.W. 1993. Census and monitoring of Puffins *Fratercula arctica* on Røst, N Norway, 1979-1988. **Ornis Scandinavica 24**: 1-9.

Anker-Nilssen, T. & Aarvak, T. 2004. The population ecology of Puffins at Røst. Status after the breeding season 2003. **NINA Oppdragsmelding 809**, Norwegian Institute for Nature Research, Trondheim. 44 pp. (*In Norwegian with English summary*)

Anker-Nilssen, T. & Aarvak, T. 2006. Long-term studies of seabirds in the municipality of Røst, Nordland. Results with focus on 2004 and 2005. **NINA Rapport 133**, Norwegian Institute for Nature Research, Trondheim. 85 pp. (*In Norwegian with English summary*)

Anker-Nilssen, T., Bakken, V., Strøm, H., Golovkin, A.N., Bianki, V.V. & Tatarinkova, I.P. (eds.) 2000. *The status of marine birds breeding in the Barents Sea Region.* **Norsk Polarinstitutt Rapportserie No. 113**, Norwegian Polar Institute, Tromsø, 213 pp.

Anker-Nilssen, T., Bustnes, J.O., Erikstad, K.E., Fauchald, P., Lorentsen, S.-H., Tveraa, T., Strøm, H. & Barrett, R.T. 2005. SEAPOP. A national seabird programme for improved decision support in marine areas. **NINA Rapport 1**, Norwegian Institute for Nature Research, Trondheim. 66 pp. (*In Norwegian with English summary*)

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**, Norwegian Institute for Nature Research, Trondheim. 63 pp. (*In Norwegian with English summary*)

Bakken, V., Runde, O. & Tjørve, E. 2003. *Norsk ringmerkingsatlas. Vol. 1.* Stavanger Museum, Stavanger.

Bakken, V. & Strøm, H. *submitted manuscript*. Adult survival of guillemots *Uria* sp. breeding on Bjørnøya, 1988-2003.

Barrett, R.T. 2007. Food web interactions in the southwestern Barents Sea: black-legged kittiwakes *Rissa tridactyla* respond negatively to an increase in herring *Clupea harengus*. **Marine Ecology Progress Series 349**: 269-276.

Barrett, R.T. & Krasnov, Y.V. 1996. Recent responses to changes in stocks of prey species by seabirds breeding in the southern Barents Sea. **ICES Journal of Marine Science 53**: 713-722.

Barrett, R.T., Anker-Nilssen, T., Rikardsen, F., Valde, K., Røv, N. & Vader, W. 1987. The food, growth and fledging success of Norwegian Puffin chicks *Fratercula arctica* in 1980-1983. **Ornis Scandinavica 18**: 73-83.

Barrett, R.T., Lorentsen, S-H. & Anker-Nilssen, T. 2006. The status of seabirds breeding in mainland Norway. **Atlantic Seabirds 8**: 97-126.

Becker, P.H., Thomas, H.G.E, Ludwigs, J.D., Sauer-Gürth, H. & Wink, M. 2008. Population sex ratio shift from fledging to recruitment: consequences for demography in a philopatric seabird. **Oikos 117**: 60-68.

Bergeron, J.M., Willingham, E., Osborn, C.T., Rhen, T. & Crews, D. 1994. Developmental synergism of steroidal estrogens in sex determination. **Environmental Health Perspectives 107**: 199-205.

Bevanger, K. & Thingstad, P.-G. 1990. Decrease in some Central Norwegian populations of the northern subspecies of the Lesser black-backed gull (*Larus fuscus fuscus*) and its possible causes. **Fauna Norvegia Series C, Cinclus 13**: 19-32.

Brunström, B., Axelsson, J. & Halldin, K. 2003. Effects of endocrine modulators on sex differentiation in birds. **Ecotoxicology 12**: 287-295.

Bustnes, J.O. & Bianki, V.V. 2000. Long-tailed duck *Clangula hyemalis*. In: Anker-Nilssen, T., Bakken, V., Strøm, H., Golovkin. A., Bianki, V. & Tarinkova, I. (eds.) 2000. The status of marine birds breeding in the Barents Sea Region. **Norsk Polarinstitutt Rapportserie No. 113**, Norwegian Polar Institute, Tromsø, pp. 56-58.

Bustnes, J.O. & Tertitski, G.M. 2000. Common eider *Somateria mollissima*. In: Anker-Nilssen, T., Bakken, V., Strøm, H., Golovkin. A., Bianki, V. & Tarinkova, I. (eds.) 2000. The status of marine birds breeding in the Barents Sea Region. **Norsk Polarinstitutt Rapportserie No. 113**, Norwegian Polar Institute, Tromsø, pp. 46-50.

Bustnes, J.O., Erikstad, K.E., Skaare, J.U., Bakken, V. & Mehlum, F. 2003. Ecological effects of organochlorine pollutants in the Arctic: A study of the Glaucous Gull. **Ecological Applications 13**: 504-515.

Bustnes, J.O., Tveraa, T., Fauchald, P. & Skaare, J.U. 2008. The potential impact of environmental variation on the concentrations and ecological effects of pollutants in a marine top predator. **Environment International** (*in press*).

Bustnes, J. O., Lorentsen, S.-H. & Anker-Nilssen, T. *in manuscript*. Local and large-scale climatic variables as predictors of the breeding numbers of endangered lesser black-backed gulls on the Norwegian Coast.

Clarke, E.D., Spear, L.B., McCracken, M.L., Marques, F.F.C., Borchers, D.L., Buckland, S.T. & Ainley, D.G. 2003. Validating the use of generalized additive models and at-sea surveys to estimate size and temporal trends of seabird populations. **Journal of Applied Ecology 40**: 278-292.

Clutton-Brock, T.H. 1986. Sex ratio variation in birds. **Ibis 128**: 317-329.

Cooch, E. & White, G. (eds.) 2007. *Program MARK. "A Gentle Introduction". 6th Edition*. Available at http://www.phidot.org/software/mark/docs/book/pdf/mark_book.zip, 744 pp.

Erikstad, K.E. & Reiertsen, T.K. 2007. Effekter av forurensning på bestandsutviklingen til måker. **NINA Rapport 274**, Norwegian Institute for Nature Research, Trondheim. 24 pp.

Erikstad, K.E, Reiertsen, T.K., Anker-Nilssen, T., Barrett, R.T., Lorentsen, S.-H., Strøm, H. & Systad, G.H. 2007. Population viability analyses of Norwegian Common Guillemots (*Uria aalge*). **NINA Rapport 240**, Norwegian Institute for Nature Research, Trondheim. 25 pp. (In Norwegian)

Fauchald, P. & Brude, O.W. 2005. Simulering av fordelingsmønsteret til sjøfugl som en komponent i MIRA. **NINA Rapport 15**, Norwegian Institute for Nature Research, Trondheim. 36 pp. (In Norwegian)

Fauchald, P. & Erikstad, K.E. 2002. Scale-dependent predator-prey interactions: the aggregative response of seabirds to prey under variable prey abundance and patchiness. **Marine Ecology Progress Series 231**: 279-291.

Fauchald, P. Erikstad, K.E. & Skarsfjord, H. 2000. Murres and capelin in the Barents Sea; hierarchical predator prey interactions in the marine ecosystem. **Ecology 81**: 773-783.

Fauchald, P., Lorentsen, S.-H., Systad, G.H. & Tveraa, T. 2006. Utbredelsen av sjøfugl i Skagerrak, Kattegat og Nordsjøen. [*The distribution of seabirds in the Skagerrak, Kattegat and North Sea*]. **NINA Rapport 171**. Norwegian Institute for Nature Research, Trondheim. 54 pp. *(In Norwegian)*

Fauchald, P. 2008. Seabird monitoring and the Barents Sea ecosystem. In Haug, T., Misund, O.A., Gjøsæter, H. & Røttingen, I. (eds.) Long term bilateral Russian-Norwegian scientific co-operation as a basis for sustainable management of living marine resources in the Barents Sea. **Proceeding of the 12th Norwegian-Russian Symposium**, Tromsø, 21-22 August 2007. Institute of Marine Research, Bergen, Norway.

Friesen, V.L., Burg, T.M. & McCoy, K.D. 2007. Mechanisms of population differentiation in seabirds. **Molecular Ecology 16**: 1765-1785

Gill, F. & Wright, M. 2006. *Birds of the World: Recommended English Names*. Princeton University Press, Princeton NJ, USA.

Grémillet, D., Dell'Omo, G., Ryan, P.G., Peters, G., Ropert-Coudert, Y. & Weeks, S. 2004. Offshore diplomacy, or how seabirds mitigate intra-specific competition: a case study based on GPS tracking of cape gannets from neighbouring breeding sites. **Marine Ecology Progress Series 268**: 265-279

Grémillet, D., Pichegru, L., Siorat, F. & Georges, J.Y. 2006. Conservation implications of the mismatch between population dynamics and foraging effort in Northern gannets from the English Channel. **Marine Ecology Progress Series 319**: 15-25

Griffiths, R., Double, M.C., Orr, K. & Dawson, R.J.G. 1998. A DNA test to sex most birds. **Molecular Ecology 7**: 1071-1075

Hamer, K.C., Phillips, R.A., Hill J.K., Wanless, S. & Wood, A.G. 2001. Contrasting foraging strategies of gannets *Morus bassanus* at two North Atlantic colonies: foraging trip duration and foraging area fidelity. **Marine Ecology Progress Series 224**: 283-290

Hario, M. & Rudbäck, E. 1996. High frequency of chick diseases in nominate Lesser Black-backed Gulls *Larus f. fuscus* from the Gulf of Finland. **Ornis Fennica 73**: 69-77.

Hario, M. & Rudbäck, E. 1999. Dying in the midst of plenty - the third-chick fate in nominate Lesser Black-backed Gulls *Larus f. fuscus*. **Ornis Fennica 76**: 71-77.

Hario, M., Bianki, V. & Zimin, V. 1998. *Larus fuscus fuscus*. In: Kotiranta, H., Uotila, P., Sulkava, S. & Peltonen, S.–L. (eds.). *Red Data Book of East Fennoscandia*. Ministry of Environment, Finnish Environment Institute & Botanical Museum, Finnish Museum of Natural History, Helsinki, pp. 247-249.

Hario, M., Hirvi, J.P., Hollmen, T. & Rudbäck, E. 2004. Organochlorine concentrations in diseased vs. healthy gull chicks from the northern Baltic. **Environmental Pollution 127**: 411-423.

Harris. M.P., Wanless, S. & Rothery, P. 2000. Adult survival rates of Shag *Phalacrocorax aristotelis*, Common Guillemot *Uria aalge*, Razorbill, *Alca torda*, Puffin *Fratercula arctica* and Kittiwake *Rissa tridactyla* on the Isle of May 1986-96. **Atlantic Seabirds 2**: 133-150.

Harris, M.P., Anker-Nilssen, T., McCleery, R.H., Erikstad, K.E., Shaw, D.N. & Grosbois, V. 2005. Effect of wintering area and climate on the survival of adult Atlantic puffins *Fratercula arctica* in the eastern Atlantic. **Marine Ecology Progress Series 297**: 283-296.

Harris, M.P., Newell, M., Daunt, F., Speakman, J.R. & Wanless, S. 2007. Snake Pipefish *Entelurus aequoreus* are poor food for seabirds. Ibis (doi: 10.1111/j.1474-919x.2007.00780.x)

Hisdal, V. 1998. *Svalbard Nature and History*. Polarhåndbok No. 12, Norwegian Polar Institute, Tromsø.

Hunt, G.L. Jr. & Schneider, D.C. 1987. Scale-dependent processes in the physical and biological environment of marine birds. In: Croxall, J.P. (ed.). *Seabirds: feeding biology and role in marine ecosystems.* **Cambridge University Press**, Cambridge, pp. 7-41.

Jenssen, T.R.S. 2008. Kjønnsspesifikk overlevelse av unger hos gråmåke *Larus argentatus* og svartbak *Larus marinus*. **MSc thesis**, University of Tromsø.

Lewis, S., Sherrat, T.N., Hamer, K.C. & Wanless, S. 2001. Evidence of intra-specific competition for food in a pelagic seabird. **Nature 412**: 816-819.

Lewis, S., Hamer, K.C., Money, L., Redman, K.K., Griffiths, R., Wanless, S. & Sherratt, T.N. 2004. Brood neglect and contingent foraging behaviour in a pelagic seabird. **Behavioural Ecology and Sociolbiology 56**: 81-88.

Lewis, S., Grémillet, D., Daunt, F., Ryan, P.G., Crawford, R.J.M. & Wanless, S. 2006. Using behavioural variables to identify proximate causes of population change in a seabird. **Oecologia 147**: 606-614.

Loen, J. 1987. Vekst og mortalitet hos sildemåkeunger *Larus fuscus* relatert til kolonistruktur og bestandsutvikling: en sammenligning mellom to norske kolonier. M.Sc. thesis, University of Trondheim. (*In Norwegian*)

Lorentsen, S.-H. 2007. The national monitoring programme for seabirds. Results up to and including the 2007 breeding season. **NINA Rapport 313**, Norwegian Institute for Nature Research, Trondheim. 54 pp. (*In Norwegian with English summary*)

Moum, T. & Árnason, E. 2001. Genetic diversity and population history of two related seabird species based on mitochondrial DNA control region sequences. **Molecular Ecology 10**: 2463-2478.

Myrberget, S. 1985. Hekking av sildemåke på Tranøya i Senja. **Fauna 38**: 140-145. (*In Norwegian with English summary*)

Nager, R.G., Monaghan, P., Griffiths, R., Houston, D.C. & Dawson, R. 1999. Experimental demonstration that offspring sex ratio varies with maternal condition. **Proceedings of the National Academy of Sciences 96**: 570-573.

Nager, R.G., Monaghan, P., Houston, D.C. & Genovart, M. 2000. Parental condition, brood sex ratio and differential young survival: an experimental study in gulls (*Larus fuscus*). **Behavioral Ecology and Sociobiology 48**: 452-457.

Pike, T.W. & Petrie, M. 2003. Potential mechanisms of avian sex manipulation. **Biological Reviews 78**: 553-574.

Røv, N. 1986. Bestandsforhold hos sildemåke *Larus fuscus* i Norge med hovedvekt på *L. f. fuscus.* **Vår Fuglefauna 9**: 79-84. (*In Norwegian with English summary*)

Røv, N. (ed.), Thomassen, Anker-Nilssen, T., Barrett, R., Folkestad, A.O. & Runde, O. 1984. Sjøfuglprosjektet 1979-1984. **Viltrapport 35**, Directorate for Wildlife and Freshwater Fish, Trondheim. 109 pp. (*In Norwegian with English summary*)

Strann, K.–B. & Vader, W. 1992. The nominate lesser black-backed gull *Larus fuscus fuscus*, a gull with a tern-like feeding biology, and its recent decrease in northern Norway. **Ardea 80**: 133-142.

Strøm, H. 2006. Birds of Svalbard. In: Kovacs, K.M. & Lydersen, C. (eds.). *Birds and Mammals of Svalbard*. **Polarhåndbok No. 13**, Norwegian Polar Institute, Tromsø, pp. 86-191.

Trivers, R. & Willard, D.E. 1973. Natural selection of parental ability to vary the sex ratio of offspring. **Science 179**: 90-92.

Wanless, S., Murray, S. & Harris, M.P. 2005. The status of northern gannet in Britain and Ireland in 2003-2004. **British Birds 98**: 280-294.

Wood, S.N. 2006. *Generalized Additive Models. An Introduction with R*. Texts in Statistical Science, **Chapman & Hall/CRC**.

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. Although not being capitalised, all English names in this report are otherwise according to the English vernacular names listed on *The British List* by the British Ornithologists' Union (http://www.bou.org.uk/recbrlst1.html). The only two exceptions are for the eider and the guillemot, where we have used the names common eider and common guillemot throughout to better distinguish between the two pairs of *Somateria* and *Uria* species.

English vernacular name	**Agreed international English name** (where different; Gill & Wright 2006)	**Scientific name**	**Norwegian name**
Red-throated diver	Red-throated loon	*Gavia stellata*	Smålom
Black-throated diver	Black-throated loon	*Gavia arctica*	Storlom
Great northern diver	Great northern loon	*Gavia immer*	Islom
White-billed diver	White-billed loon	*Gavia adamsii*	Gulnebblom
Fulmar	Northern fulmar	*Fulmarus glacialis*	Havhest
Sooty shearwater		*Puffinus griseus*	Grålire
Manx shearwater		*Puffinus puffinus*	Havlire
Storm petrel	European storm petrel	*Hydrobates pelagicus*	Havsvale
Gannet	Northern gannet	*Morus bassanus*	Havsule
Cormorant	Great cormorant	*Phalacrocorax carbo*	Storskarv
Shag	European shag	*Phalacrocorax aristotelis*	Toppskarv
Grey heron		*Ardea cinerea*	Gråhegre
Mallard		*Anas platyrhynchos*	Stokkand
Eider	Common eider	*Somateria mollissima*	Ærfugl
King eider		*Somateria spectabilis*	Praktærfugl
Steller's eider		*Polysticta stelleri*	Stellerand
Long-tailed duck		*Clangula hyemalis*	Havelle
Common scoter	Black scoter	*Melanitta nigra*	Svartand
Velvet scoter		*Melanitta fusca*	Sjøorre
Red-breasted merganser		*Mergus serrator*	Siland
Goosander	Common merganser	*Mergus merganser*	Laksand
White-tailed eagle		*Haliaeetus albicilla*	Havørn
Purple sandpiper		*Calidris maritima*	Fjæreplytt
Oystercatcher	Eurasian oystercatcher	*Haematopus ostralegus*	Tjeld
Pomarine skua	Pomarine Jaeger	*Stercorarius pomarinus*	Polarjo
Arctic skua	Parasitic Jaeger	*Stercorarius parasiticus*	Tyvjo
Long-tailed skua	Long-tailed Jaeger	*Stercorarius longicaudus*	Fjelljo
Great skua		*Stercorarius skua*	Storjo
Black-headed gull	Common black-headed gull	*Chroicocephalus ridibundus*	Hettemåke
Common gull	Mew 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
Kittiwake	Black-legged kittiwake	*Rissa tridactyla*	Krykkje
Arctic tern		*Sterna paradisaea*	Rødnebbterne
Guillemot	Common murre	*Uria aalge*	Lomvi
Brünnich's guillemot	Thick-billed murre	*Uria lomvia*	Polarlomvi
Razorbill		*Alca torda*	Alke
Black guillemot		*Cepphus grylle*	Teist
Little auk		*Alle alle*	Alkekonge
Puffin	Atlantic puffin	*Fratercula arctica*	Lunde

NINA Report 363

ISSN: 1504-3312
ISBN: 978-82-426-1927-3

Norwegian Institute for Nature Research
NINA head office
Postal address: NO-7485 Trondheim, NORWAY
Visiting address: Tungasletta 2, NO-7047 Trondheim, NORWAY
Phone: + 47 73 80 14 00
Fax: + 47 73 80 14 01
Organisation number: NO 950 037 687 MVA

www.nina.no

Graphic design: NINA
Cover photos: Per Jordhøy, Børre Dervo,
Knut Kringstad, Tycho Anker-Nilssen