NINA Report 127

SEAPOP studies in the Lofoten and Barents Sea area in 2005

SEAPOP

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

NORSK POLARINSTITUTT
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CLIENTS
Ministry of Petroleum and Energy (OED), Oslo
Norwegian Oil Industry Association (OLF), Stavanger
Directorate for Nature Management (DN), Trondheim
Norwegian Petroleum Directorate (OD), Stavanger
Directorate of Fisheries (FDIR), Bergen

CLIENTS' CONTACT PERSONS
Christer af Geierstam (OED)
Bente Jarandsen (OLF)
Brit Veie-Rosvoll (DN)

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Kittiwake (© Tycho Anker-Nilssen)

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CONTACT DETAILS

NINA Trondheim
NO-7485 Trondheim
NORWAY
Phone: +47 73 80 14 00
Fax: +47 73 80 14 01

NINA Oslo
Box 736 Sentrum
NO-0105 Oslo
NORWAY
Phone: +47 73 80 14 00
Fax: +47 22 33 11 01

NINA Tromsø
Polar Environmental Centre
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

http://www.nina.no

Abstract

Anker-Nilssen, T., Barrett, R.T., Bustnes, J.O., Erikstad, K.E., Fauchald, P., Lorentsen, S.-H., Steen, H., Strøm, H., Systad, G.H. & Tveraa, T. 2006. SEAPOP studies in the Lofoten and Barents Sea area in 2005. - NINA Report 127, 38 pp.

This is the first annual report from SEAPOP, a long-term seabird programme aiming to provide and maintain base-line knowledge needed for an improved management of marine areas. For several reasons, the activities in the initial year were restricted to the Lofoten and Barents Sea area, but the programme is designed for implementation on the full national scale within a few years. The report presents briefly some important results from the investigations made in 2005 and some leading principles for how data and knowledge will be organised and served to different users online via a SEAPOP web site.

The monitoring of population trends, reproduction, adult survival rates and diet of selected seabirds species on the previously established key-sites Røst, Hjelmsøya, Hornøya and Bjørnøya was extended and further adjusted to meet the general design of the programme. In addition, two new key-sites were established, one on Anda in Vesterålen and the other on western Spitsbergen. The latter was divided among several localities because there is no suitable single site in the area that holds a sufficient variety of breeding species. For each key-site, the report presents a table listing the main results from the monitoring in 2005. On the basis of time series that date back many years, a number of interesting trends for different species and parameters were uncovered, both within and between the colonies. Some selected topics are treated in more detail in separate text boxes, which also present a few technological advances and statistical challenges for monitoring design.

The work in 2005 represented a new initiative for the mapping of seabirds in Norway's northernmost areas, and included an updating survey of breeding seabirds in the Isfjorden area on Spitsbergen and along the entire coastline of Troms and Finnmark counties east to Laksefjorden. Studies of seabirds at sea were continued through participation on several ecosystem surveys led by the Institute of Marine Research. The data analyses were aimed at developing further the modelling of seabird distribution at sea from oceanographic features and to explore the degree of co-variation in distribution for different species.

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* Svein-Håkon Lorentsen *shl@nina.no*	Jan Ove Bustnes *jan.o.bustnes@nina.no* Kjell Einar Erikstad *kjell.e.erikstad@nina.no* Per Fauchald *per.fauchald@nina.no* Geir Helge Systad *geir.systad@nina.no* Torkild Tveraa *torkildtveraa@nina.no*	Harald Steen *harald.steen@npolar.no* Hallvard Strøm *hallvard.strom@npolar.no*	Robert T. Barrett *robb@tmu.uit.no*

Sammendrag

Anker-Nilssen, T., Barrett, R.T., Bustnes, J.O., Erikstad, K.E., Fauchald, P., Lorentsen, S.-H., Steen, H., Strøm, H., Systad, G.H. & Tveraa, T. 2006. SEAPOP-studier i området Lofoten-Barentshavet i 2005. - NINA Rapport 127, 38 s.

Dette er den første årsrapporten for SEAPOP, et langsiktig kunnskapsprogram om sjøfugl innrettet for å styrke beslutningsstøtten til ulike aktører i norske marine områder. Innsatsen i oppstartsåret ble av flere årsaker begrenset til områdene i Lofoten og Barentshavet, men programmet er designet for å implementeres på full nasjonal skala i løpet av få år. Rapporten beskriver kortfattet noen viktige resultater fra undersøkelsene i 2005 og enkelte grunnleggende prinsipper for hvordan data og kunnskap vil bli tilrettelagt og servet online til ulike brukere via en egen SEAPOP web som er under konstruksjon.

Overvåkingen av bestandsendringer, reproduksjon, voksenoverlevelse og næringsvalg for utvalgte sjøfuglarter på de tidligere etablerte nøkkellokalitetene Røst, Hjelmsøya, Hornøya og Bjørnøya ble videreført og ytterligere tilrettelagt i henhold til programmets føringer. Dessuten ble to nye nøkkellokaliteter etablert, hhv på Anda i Vesterålen og på Spitsbergen. I mangel av egnede kolonier med stort artsutvalg ble sistnevnte fordelt på et utvalg av lokaliteter. En tabell med hovedresultater fra overvåkingen på de enkelte nøkkellokalitetene i 2005 er gitt under omtalen av hver lokalitet. Med god støtte i tidligere opparbeidede tidsseriedata avdekket arbeidet en rekke interessante utviklingstrekk for ulike arter og parametere, både innen og mellom lokalitetene. Noen utvalgte tema er behandlet mer utførlig i egne tekstbokser som også tar for seg enkelte teknologiske fremskritt og statistiske utfordringer for gjennomføringen av overvåkingen.

Kartleggingen av sjøfugl i nord fikk en ny giv, og innsatsen i 2005 omfattet blant annet en oppdaterende kartlegging av hekkende sjøfugler i Isfjordområdet på Spitsbergen og kyst-strekningene i Troms og Vest-Finnmark øst til Laksefjorden. Arbeidet med kartlegging av sjøfugl i åpent hav ble videreført med deltakelse på flere tokt i Barentshavet. Analysene ble innrettet mot å videreutvikle modeller for å estimere sjøfuglenes utbredelse til havs ut fra oseanografiske forhold og belyse i graden av samvariasjon i utbredelsen for ulike arter.

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*
Svein-Håkon Lorentsen *shl@nina.no*	Kjell Einar Erikstad *kjell.e.erikstad@nina.no*	Hallvard Strøm *hallvard.strom@npolar.no*	
	Per Fauchald *per.fauchald@nina.no*		
	Geir Helge Systad *geir.systad@nina.no*		
	Torkild Tveraa *torkild.tveraa@nina.no*		

Contents

Foreword

The original idea for designing a scientific programme like the one SEAPOP is shaped to become, is only a few years younger than the average age of the latest data on seabird distribution along the Norwegian coast and still older than many of the long-term data series the programme intends to maintain. It took five years before Statoil AS presented us with the first but excellent opportunity to construct the basic details of its framework, and another five years of further refinements and lobbying before the most important participants agreed on a common concept. Through a combination of good will, common effort and joint financial forces, management authorities and the oil industry have, together with the main scientific institutions involved in the long-term seabird research in Norway, proven able to implement the programme in the Lofoten and Barents Sea area. I am convinced that the participants and many of their associates, as well as other interested parties, will have good use of improved knowledge on a number of seabird issues. We should all keep an open eye on how seabirds can be of better use as the early, sensitive and cost-efficient indicators of changes in the marine environment that they certainly are. On this background it is an extra pleasure to introduce the first annual report from SEAPOP, albeit still not fully fledged as the national programme we trust it will be in the near future.

A special thank goes to the two main sponsors of the programme in the first year, the Ministry of Petroleum and Energy (OED) and the Norwegian Oil Industry Association (OLF). We also thank the members of the steering committee for the initial work, which was appointed by the Ministry of Environment. The committee is chaired by the Directorate for Nature Management (DN) and had in 2005 representatives from OLF, the Norwegian Petroleum Directorate (OD) and the Directorate of Fisheries (FDIR). We thank the Norwegian Coastal Administration for kindly allowing us to use the lighthouse facilities on Anda and Hornøya as field stations, and the Norwegian Coast Guard for transporting the field crew on Bjørnøya safely and comfortably to and from the island and for letting us use their ship as a platform for observations. The Institute of Marine Research (IMR) was also an excellent partner and their vessels served again as ideal platforms for the ecosystem surveys. Thanks are of course also due to many of our colleagues and all the field workers that helped us carry out the studies in 2005. The SEAPOP concept requires that all long-term monitoring activities formerly established and run by the executive scientific institutions, are continued with their traditional funding, if they are considered relevant for the programme. Thus, our sincere thanks also go to all of those who have been or still are involved in this extensive long-term work. None mentioned, none forgotten.

On behalf of the project leaders

Trondheim, 24 February 2006

Tycho Anker-Nilssen
SEAPOP coordinator

1 Introduction

In their final description of the SEAPOP concept, Anker-Nilssen et al. (2005) conclude as follows (*quote*):

(**1**) *SEAPOP (Seabird population management and petroleum operations) is a national seabird mapping and monitoring programme organized to improve decision-making for marine areas. The concept was initially developed for the oil industry in collaboration between the Norwegian Institute for Nature Research (NINA) and the Norwegian state oil company (Statoil), but has since been further developed in collaboration with the Norwegian Polar Institute (NP), Tromsø University Museum (TMU) and the Directorate for Nature Management (DN) so as to incorporate moments needed in management issues. The vision of SEAPOP is to give the oil industry, environmental managers and other actors the knowledge necessary to make decisions concerning environmental questions related to seabirds and petroleum operations or other activities in coastal and offshore areas. If the programme is fully implemented, detailed and up-to-date knowledge will be generated concerning the distribution, status and dynamics of Norwegian seabird populations through a coordination of the activities of the participating institutions. Special focus is put on process-oriented studies and monitoring so as to address both natural and man-made factors.*

(**2**) *The principal basis for the programme is that the oil industry, other maritime activities and nature management have overlapping needs with regards to their knowledge of seabirds. To elucidate the effects of oil and other factors on seabirds, justifiable predictions of the extent of impact and restitution capabilities are required. An improved accuracy of such analyses will, amongst others, ease the identification of the least controversial areas and time periods for any operation. Whatever the influence, sufficiently precise estimates of the potential impact will be dependent on up-to-date data concerning the distribution of seabirds in time and space, and on the status and origin of the populations involved. Managerial appraisements of the restitution capabilities of any population also require data concerning natural mortality and fecundity rates, and data concerning other factors which affect these parameters. This type of data is also necessary to distinguish between natural influences and those caused by man.*

(**3**) *To fulfil this, SEAPOP aims to collect all the necessary data within a comprehensive programme, to organise all the seabird data relevant for the participants in a database which would be accessible on the internet, and to ensure that these data are always standardised, updated and of sufficient quality. Through this, important gaps in knowledge will be filled cost efficiently, and development of more expedient tool for analyses related to the effects of different encroachments made possible. SEAPOP will thus simplify the preparation of comprehensive environmental assessments concerning petroleum activities and other environmental encroachments, as well as pave the way for a better coordination, standardisation and quality control of such reports.*

With support from the Norwegian Oil Industry Association (OLF), the monitoring of seabird demography on key-sites was expanded in 2004 (Barrett *et al.* 2004). In 2005, additional funds were granted by the Ministry of Petroleum and Energy (OED), which, with increased support from OLF, enabled us to implement new SEAPOP activities at about half the annual level scheduled for the northern parts of the areas the programme intends to cover. With continued support from OLF and substantial funding from OED and the Ministry of Environment (MD), the programme will reach the level of full implementation in the Lofoten and Barents Sea area in 2006.

The rest of this report presents briefly some important results from the investigations made in 2005 and some leading principles for how data and knowledge will be organised and served to different users online via a SEAPOP web site.

2 Monitoring on key-sites

A great variety of species and parameters are currently being monitored at the six key-sites established for SEAPOP in the Lofoten and Barents Sea area (**Figure 2.1**, **Table 2.1**). Studies of seabird demography (i.e. reproduction and survival rates) on Røst, Hornøya and Bjørnøya date back to 1964, 1980 and 1986, respectively, whereas the collection of corresponding data series on the other sites was first started in 2004 (Hjelmsøya) and 2005 (Anda and Spitsbergen). The monitoring of population trends however has longer traditions on most sites.

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

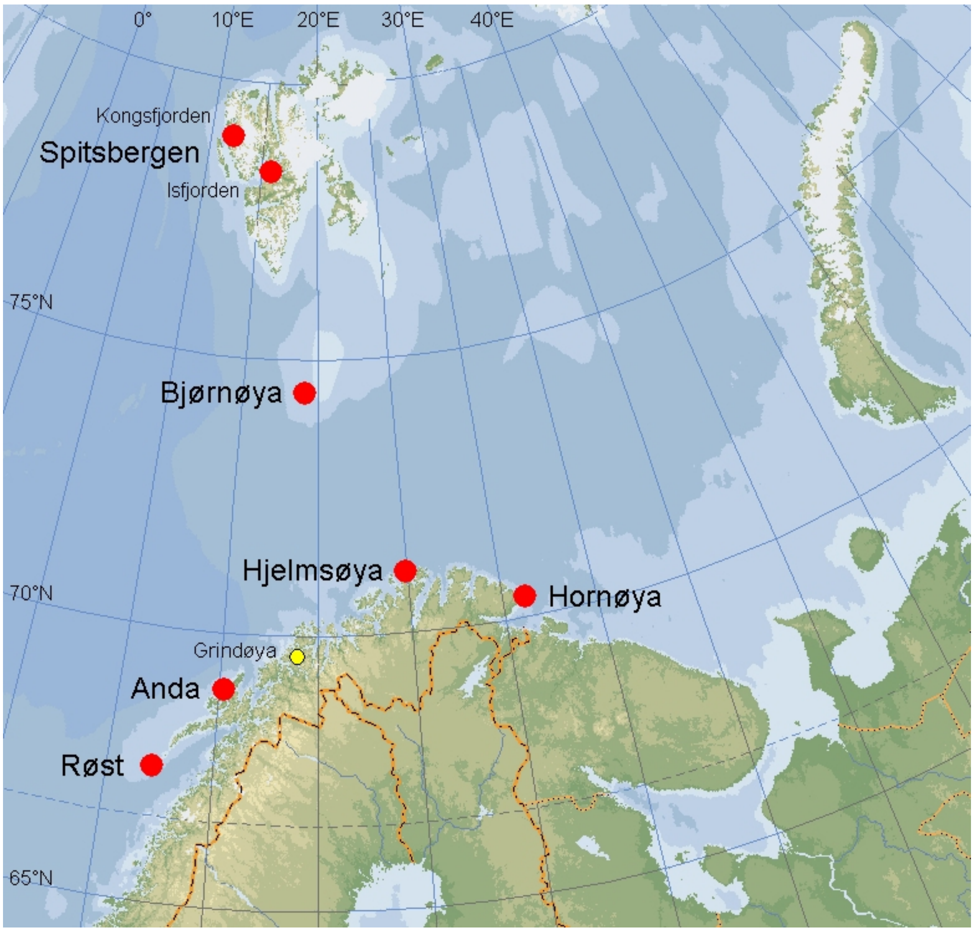


Figure 2.1
The six key-sites (red circles) established for SEAPOP in the Lofoten and Barents Sea area. Note that the key-site on Spitsbergen is divided among several localities in Isfjorden and Kongsfjorden (and the neighbouring Crossfjorden). The position of Grindøya close to Tromsø, where detailed studies of common eider have been performed annually since 1985, is also shown (cf. chapter 2.5).

Table 2.1 *Population parameters monitored annually at SEAPOP key-sites in the Lofoten and Barents Sea area, indicated by the first year of continuous data series. Superscripts indicate similar data existing from earlier year(s), whereas parentheses indicate low sample size or missing data for some years. Note that variables used to measure elements of reproductive success (e.g. clutch size, fledging success, overall breeding success) vary from species to species, sometimes also between different sites for the same species.*

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

1) *Except for 1988-90, 1992 & 1994 (no data);* ***2)*** *Data from most years in 1996-2004 were collected by Thierry Boulinier and co-workers (CNRS, France); 3****)*** *Except for 1988 (no data); 4****)*** *Population size is monitored at Gjesværstappan, about 20 km east of Hjelmsøya.*

2.1 Spitsbergen

Harald Steen

In Spitsbergen, the 2005 season was devoted to establish key-sites for Brünnich's guillemot (*Uria lomvia*) and little auk (*Alle alle*). For Brünnich's guillemot we decided to select two key-sites; one at Diabasodden (78°22'N 16°08'E) in Isfjorden and the other on the east side of Crossfjorden (79°10'N 11°52'E), 27 km north of Ny-Ålesund in Kongsfjorden. Totals of 57 and 40 adults were marked with colour rings on these sites, respectively. The two key-sites will be fully operational from the 2006 season and will then also include collection of data on reproductive performance.

One key-site for little auks was established in Bjørndalen (78°14'N 15°19'E) close to Longyear-byen. Altogether 62 adults were tagged with individual PIT-tags (**Box 2.1**) and the chicks in 24 nests with known hatching dates were followed until fledging or 4 August (**Table 2.2**).

The demographic studies of black-legged kittiwake were made at Krykkjefjellet, Kongsfjorden and also included collection of diet samples.

***Table 2.2** Key population parameters (SE, n) of seabirds in Spitsbergen in 2005. Population change is the numeric change in size of the breeding population registered between 2004 and 2005 on the basis of plot counts (p) or total censuses (t). For each species the listed survival estimate was derived from the model that fitted the data set best (i.e. the one with the lowest AICc value).*

Species	**Population change**	**Annual adult survival** Period (yrs)	Estimate	**Reproductive performance** Sampling unit	Estimate
Northern fulmar	+ 2.3% p				
Common eider	1			Clutch size	1
Black-legged kittiwake	– 0.2% p	Ongoing analysis 1		Large chicks/nest	1.06 (*n*=135)
Brünnich's guillemot	+ 1.8% p	No estimate yet possible 1			
Little auk		No estimate yet possible 2		Chicks ≥ 20d/nest	0.58 (*n*=24)

__1)__ Data collected by MOSJ not yet available; __2)__ Colour-ringing for monitoring of survival rates was initiated in two colonies in 2005 (57 and 40 adults ringed); __2)__ PIT-tagging for monitoring of survival rates was initiated in one colony in 2005 (62 adults tagged).

2.2 Bjørnøya

Hallvard Strøm

The monitoring programme on Bjørnøya continued in 2005 as in previous years, but new data series were initiated on the little auk and great skua (*Catharacta skua*) (**Tables 2.1, 2.3**). The programme now includes seven species of which population development is monitored for all except the little auk. Demographic parameters and chick diet are monitored for all seven species except northern fulmar (*Fulmarus glacialis*) and glaucous gull (*Larus hyperboreus*). The monitoring programme on Bjørnøya was initiated in 1986 and the number of species and parameters monitored has since been increased gradually.

Box 2.1 Estimating survival and time budgets using PIT-tags

Harald Steen

*When using standard capture-recapture techniques, the estimation of adult survival rates and reproductive performance of seabirds are costly in terms of logistics and man-power required in the field, especially when operating in remote places. Since survival and reproduction are the two main proximate factors determining changes in population size over the longer term, reliable estimates for these parameters and their temporal variation is a prerequisite for any successful monitoring programme. It is therefore a challenge to develop and employ technology that can reduce monitoring cost without loss of precision. By injecting small PIT-tags (passive induced transponders) under the skin of breeding birds it is later possible to register the presence of these individuals without having to observe the birds in the field. This is done by deploying special antennas close to the nest or on selected landing rocks. The antennas are connected to an automatic data recorder and scan repeatedly for PIT-tagged birds. Using this technology, the time spent re-sighting birds in the colony can be saved and difficulties with identifying birds because of ring wear (which is a problem with several species) are eliminated. We started testing this system in 2005 for monitoring survival rates and nest attendance of little auks in Bjørndalen, and of little auks and Brünnich's guillemots on Bjørnøya (**Figure 2.2**).*

Figure 2.2
A PIT-tagged Brünnich's guillemot on its nest site on Bjørnøya in 2005. The circular antenna is placed underneath the egg. (© Hallvard Strøm)

Ultimately, variations in food availability cause variations in the birds' reproduction and survival rates, either directly, or through delayed responses. Their reproductive performance and survival should therefore correlate with the time the birds spend foraging, i.e. either searching for or processing food. The PIT-tag technology enables us to test this assumption by monitoring the birds' time budgets and following their reproductive performance more closely. If the assumption holds, we may in the future be able to monitor the key dynamics of a seabird colony reasonably accurately with a minimum of resources and thereby allocate more effort into exploring the spatial variation in such parameters.

Table 2.3 *Key population parameters (SE, n) of seabirds on Bjørnøya in 2005. Population change is the numeric change in size of the breeding population registered between 2004 and 2005 on the basis of plot counts (p) or total censuses (t). For each species the listed survival estimate was derived from the model that fitted the data set best (i.e. the one with the lowest AICc value).*

Species	**Population change**	**Annual adult survival** Period (yrs)	Estimate	**Reproductive performance** Sampling unit	Estimate
Northern fulmar	+ 0.6% p				
Great skua		No estimate yet possible [1]		Large chicks/nest	0.62 (0.04, 61)
Glaucous gull	[2]	1998-00 (2)	83.6% [3]	Large chicks/nest	0.10 (0.09, 109)
Black-legged kittiwake	– 3.5% p	No estimate yet possible [4]		Large chicks/nest	0.67 (0.03, 411)
Common guillemot	+ 6.6% p	1988-2003 (15)	97.5% [5]	Fledging success	0.64 (n=82)
Brünnich's guillemot	+ 1.3% p	1988-2003 (15)	93.0% [5]	Fledging success	0.61 (n=65)
Little auk		No estimate yet possible [6]		Chicks ≥ 15d/nest	0.81 (n=16)

1) Colour-ringing for monitoring of survival rates was initiated in 2005 (50 adults ringed); 2) Ongoing analysis; 3) Bustnes et al. (2003) based on 92 individuals; 4) Colour-ringing for monitoring of survival rates was initiated in 2004 (200 adults ringed); 5) Bakken & Strøm (submitted) based on 149 common and 78 Brünnich's guillemots; 6) Colour-ringing for monitoring of survival rates was initiated in 2005 (88 adults ringed).

The fieldwork in 2005 was conducted between 10 June and 4 August. The breeding numbers of glaucous gull and black-legged kittiwake continued to drop in 2005, whereas those of northern fulmar and Brünnich's guillemot increased slightly. The recovery of the common guillemot (*Uria aalge*) population after the collapse in 1987 continued in 2005. Its breeding success was higher than in 2004, and the mean chick mass at 15 days of age (215 g, n=46) indicated a moderate breeding season. The breeding successes of black-legged kittiwake and Brünnich's guillemot were somewhat lower than in 2004. Capelin (*Mallotus villosus*) was the main prey species for the kittiwake and both guillemot species, and constituted more than 90% of the chick diet for all three species.

The breeding population of glaucous gull on Bjørnøya has declined since monitoring started in 1986. Its breeding success in 2005 was extremely low, and only a few chicks survived to fledging. Glaucous gulls on Bjørnøya accumulate high levels of organic contaminants, especially birds that specialize in preying on eggs and chicks of other seabirds (**Figure 2.3**). Adverse effects on hormone production and the immune system as well as depressed reproduction and survival rates of adults have been documented. Furthermore, changes in food availability and predation from a growing population of arctic foxes may be important factors behind the observed decline. In 2006, a special study will be set up addressing the possible factors reducing breeding success of glaucous gulls.

The monitoring of little auk (diet) and great skua (number of breeding pairs and breeding success) that was initiated in 2004 continued in 2005, and was expanded to include adult survival and breeding success (as well as other parameters) for both species. A total of 88 adult little auks and 50 adult great skuas were ringed with individually coded colour rings. Twenty-four little auk nests and 61 great skua nests were checked regularly until the chicks were 15 days or older. The little auk colonies on Bjørnøya are the southernmost for this species in the Barents Sea region. The great skua was first found breeding on Bjørnøya in 1970 and on Spitsbergen in 1976. Since then the population has been growing rapidly. The census carried out in 2005 indicated that Bjørnøya holds a breeding population of about 150-200 pairs of great skuas.

***Figure* 2.3**
A female glaucous gull lying dead, probably from contamination, on its nest on Bjørnøya. The mate and the three small chicks (insert) were still alive. A bridled common guillemot turns its back to the predators. (© Hallvard Strøm)

2.3 Hornøya

Rob Barrett & Kjell Einar Erikstad

As in earlier seasons, population trends, the timing of breeding, breeding success, food choice and adult survival of five key species were studied during the 2005 season. The 2005 season was overall good for all species on Hornøya. Although the breeding population of kittiwakes continued to fall and the start of the breeding season was again delayed until the end of May, their breeding success was relatively high with nearly one chick fledging per nest. The recovery of the common guillemot population after the collapse in 1987 continued in 2005 and, although no direct measure of their breeding success was made, the mass of chicks leaving the nest sites in early July (mean > 260 g) indicated a good breeding season. Similarly chick growth rates of 10-12 g per day during the main growth period and an overall fledging success of ca. 80-85 % indicated that Atlantic puffins and razorbills had a successful season. Herring and sandeels were important constituents of the diet of chicks while capelin and small gadoids played a minor role (**Figure 2.4**).

There was no annual variation in survival rates for any of the four species monitored (**Table 2.4**). When compared to earlier estimates from Hornøya (Sandvik *et al.* 2005), the updated long-term estimates for common guillemot and razorbill were close to the previous ones, whereas those for black-legged kittiwake and Atlantic puffin were considerably lower. However, in their estimations Sandvik *et al.* (2005), who based the models on data from 1990 to 2002, controlled for the effects of heterogeneity in re-sighting frequency (so-called “trap happiness”), which was particularly high for puffins and kittiwakes. This was not corrected for in the survival rates reported here, and probably explains the discrepancy between the results. In general, the estimates of adult survival rates for seabirds at Hornøya are high and suggest these populations are not heavily affected by e.g. food shortage or other severe conditions outside the breeding season.

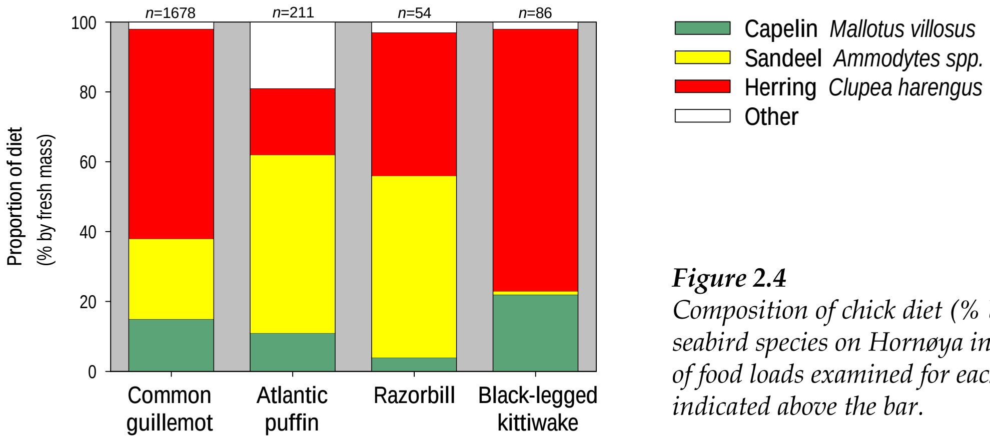


Figure 2.4
Composition of chick diet (% by mass) of four seabird species on Hornøya in 2005. Numbers of food loads examined for each species is indicated above the bar.

***Table 2.4** Key population parameters (SE, n) of seabirds on Hornøya in 2005. Population change is the numeric change in size of the breeding population registered between 2004 and 2005 on the basis of plot counts (p) or total censuses (t). For each species the listed survival estimate was derived from the model that fitted the data set best (i.e. the one with the lowest AICc value).*

Species	**Population change**	**Annual adult survival** Period (yrs)	Estimate	**Reproductive performance** Sampling unit	Estimate
European shag	+ 3.1% t	No estimate yet possible 1		Clutch size	2.57 (0.09, 98)
Black-legged kittiwake	– 8.7% p	1990-04 (15)	82.8 (1.7, 1050)	Clutch size	1.65 (0.06, 824)
				Large chicks/nest	0.97 (0.02, 1195)
Common guillemot	+ 8.1% p	1989-04 (15)	96.0 (0.6, 163)		
Atlantic puffin	+ 0.2% p	1990-05 (15)	87.4 (1.7, 641)	Fledging success 2	82.9% (*n*=41)
Razorbill		1994-05 (11)	90.7 (1.1, 143)	Fledging success 3	84.8% (*n*=66)

***1)** Colour-ringing for monitoring of survival rates was initiated in 2004 and continued in 2005 (50 and 37 adults ringed, respectively); **2)** Medium-aged chicks/egg laid; **3)** Large chicks/egg laid.*

Figure 2.5
Puffins on Hornøya (© Rob Barrett)

Box 2.2 Population statistics and food base – a case study on Hornøya

Rob Barrett

*Since studies on Hornøya began in 1980, there have been considerable changes in the stocks of the major forage fish species in the southern Barents Sea. The amount of capelin has fluctuated considerably, while the numbers of small herring have gradually increased over the years as a result of the recovery of the spawning stock (**Figure 2.6**). These changes have had marked effects on the numbers of seabirds, especially common guillemots breeding on Hornøya.*

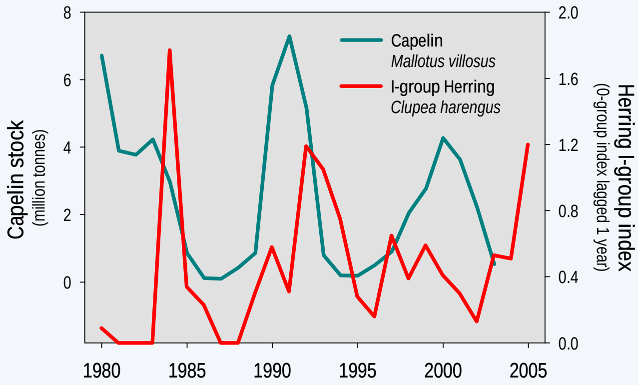


Figure 2.6
Estimated size of the capelin stock and an index of I-group herring in the Barents Sea (data from Institute of Marine Research, Bergen)

*During the first five years of the study, the numbers of common guillemots were relatively stable but between 1985 and 1987, they suddenly declined by 85% (**Figure 2.7**). This sudden collapse was also documented in many other colonies in the southern Barents Sea and was attributed to the lack of capelin and other suitable forage fish causing a mass starvation of adult common guillemots wintering in the region (Vader et al. 1990). During the same period, there was little change in the Atlantic puffin and black-legged kittiwake populations as both species spend the winter outside the Barents Sea and thereby had access to alternative food. Since 1987, the common guillemot population has recovered very rapidly despite subsequent collapses in the capelin stocks, probably because of the presence of e.g. young herring acting as an alternative food base.*

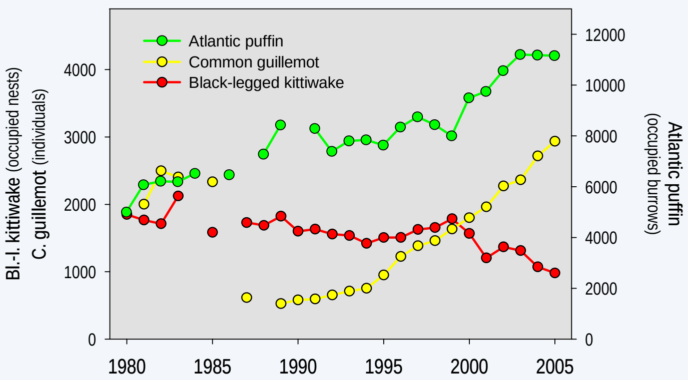


Figure 2.7
Population trends of black-legged kittiwake (apparently occupied nests) and common guillemots (individuals on breeding ledges) in monitoring plots and estimates of the total breeding population of Atlantic puffins (apparently occupied burrows) on Hornøya in 1980-2005.

*In contrast to the common guillemots, the numbers of Atlantic puffins breeding on Hornøya have increased at a steady rate of ca. 2.5 % per annum, while the kittiwake population has declined, also steadily, by about 1.5% per annum since 1980 (**Figure 2.7**). Similar declines have been documented in other kittiwake colonies in Norway (Barrett 2003).*

Box 2.2 continued

*The decline on Hornøya is paralleled by a steady decline in the breeding success during the same period (**Figure 2.8**). Although an earlier analysis showed a close correlation between the amount of capelin in chick diet and breeding success (Barrett & Krasnov 1996), the addition of ten more years of data has weakened this relationship considerably such that Barrett & Krasnov's (1996) hypothesis that the return of the herring into the southern Barents Sea and the accompanying decline in the capelin availability is causing difficulties for kittiwakes has been weakened. Until further analyses are carried out using the various data collected on Hornøya, the cause of this decline thus remains unknown. There is, however, evidence of a near global decline in black-legged kittiwake numbers (CAFF unpubl. data), and a current investigation of its cause will certainly benefit from the long-term data collected on Hornøya and other Norwegian colonies. It might also shed light on why the Norwegian population is also declining.*

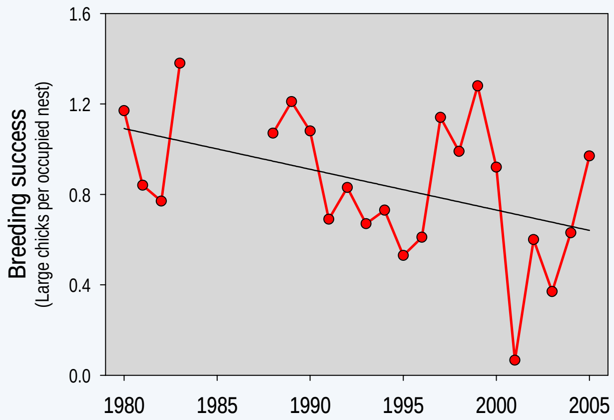


Figure 2.8
The breeding success (no. of large chicks per occupied nest) of black-legged kittiwakes on Hornøya in 1980-2005. The negative trend is statistically significant (linear regression, r^2=0.188, p=0.044).

*The steady increase in the puffin population is interesting as it is despite an apparent deterioration in feeding conditions on Hornøya since 1980. This is seen through a gradual shift from a few energy-rich food items (large capelin and sandeels) per load in the early 1980s to larger numbers of poorer quality food items (e.g. Gadidae and fish larvae) in recent years (**Figure 2.9**). At the same time as the number of prey items in each load brought to the chicks has increased, the mass of each load has decreased (Barrett 2002). It seems, however, that the adults are able to compensate for the decrease in food quality by increasing frequency at which they feed their chicks without any negative effect on body condition or subsequent survival (Ericson 2004, Sandvik et al. 2005, Eilertsen et al. in prep.). Further data collection will determine if and when feeding conditions improve or, if they continue to deteriorate, when they will negatively affect the breeding population.*

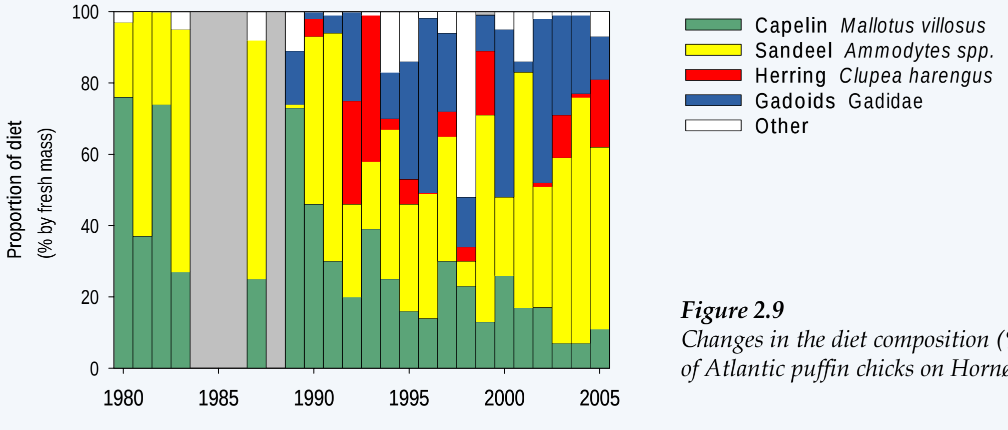


Figure 2.9
Changes in the diet composition (% by fresh mass) of Atlantic puffin chicks on Hornøya in 1980-2005.

Box 2.3 Recruitment rates of Atlantic puffins

Kjell Einar Erikstad

Adult survival is often assumed to be the single most important life-history trait in long-lived species such as many seabirds. While adult survival is probably much more important than annual fecundity, other traits, such as survival to maturity, have been largely neglected. Because of high ages at first reproduction, small cohort sizes and absence from the breeding colonies, this parameter is not easily studied, and very few studies have attempted to do so.

To address this question, we carried out a study of the Atlantic puffin on Hornøya. Prior to fledging in 1994 and 1995, a total of 80 and 173 chicks respectively were weighed, measured, and individually colour-ringed in the same manner as for adults. Subsequently, the colony was monitored for both the return of established breeders and the recruitment of new breeders. Based on more than ten years of observation (1994 to 2005) after the chicks were first colour-ringed, and using capture-mark-recapture modelling, we have now been able to model the natal recruitment rates for these two cohorts of Atlantic puffins on Hornøya.

*Most surprising, the analysis indicates that about 70% of the fledglings survived to the age of two years, i.e. their annual survival rate in their first two years of life was almost similar to that of established breeders (**Table 2.10**). As expected, very few one- and two-year old birds were re-sighted in the colony, but from age three years they returned as often as did established breeders. As the Atlantic puffin rarely start breeding before they reach 4-5 years of age, this indicated that the immature birds spend at least 2-3 summers prospecting in the colony.*

***Table 2.10** Estimated annual survival rate and re-sighting probability (an estimate of return rate) of Atlantic puffins colour-ringed as fledglings in 1994 and 1995 during their first two years of life, compared to parallel estimates for adult established breeders. There was no difference in survival between the two cohorts of young. (After Erikstad et al. in prep.)*

Age group	**Individuals**	**Survival rate** (*SE*)	**Return rate** (*SE*)
Young birds (0-2 years)	153	83.4% (7.2)	3.0% (2.5)
Established breeders	638	87.5% (1.6)	66.3% (2.5)

*An annual survival of 83% or more until maturity is exceptionally high and much higher than any estimate from other areas. This certainly suggests that breeding conditions for puffins on Hornøya in 1994 and 1995 were very good. In such years parents are able to raise high quality young at a very low cost (Erikstad et al. 1998). Clearly, conditions for the young at sea after leaving the colony must also have been very benign. Interestingly, the adult survival rate of Atlantic puffins on Hornøya has been rather stable during the last 15 years (**Table 2.10**). The steady parallel increase in population size (**Figure 2.7**) was therefore most likely to be the result of high recruitment of young birds. This finding is consistent with results of a recent analysis of adult survival rates of puffins from five different colonies in the eastern Atlantic. Despite contrasting trends in population size, the annual survival of adults was very similar over the whole area (Harris et al. 2005).*

These findings challenge the traditional view that adult survival in long-lived species is the demographic parameter that contributes most to the population growth rate. The immature stage, despite having a potentially relative low impact could prove to be the critical component. Similar suggestions have been made for long-lived herbivores (Gaillard et al. 2000). To detect and take into account such relationships it is therefore important to estimate the temporal variation in both adult survival and natal recruitment in seabirds.

2.4 Hjelmsøya

Kjell Einar Erikstad

Hjelmsøya in western Finnmark was established as a SEAPOP key site in 2004 and three species, the Atlantic puffin, common guillemot and black-legged kittiwake were selected as the primary target species (**Table 2.11**). Monitoring of common guillemots in selected study plots on open ledges was initiated in 1984, and has since been part of the national monitoring programme for seabirds (Lorentsen 2005). The population breeding on open ledges declined steeply after the collapse of the Barents Sea capelin in the 1980s and is now at a very low level with high risk of extinction. Annual counts of eggs in other and more sheltered parts of the colony since 1992 are much more variable (as they also reflect variations in reproductive performance), but indicate that the numbers of birds breeding in the least exposed habitats are increasing, possibly because they escape the increasing disturbance from white-tailed eagles (Lorentsen 2005). A similar difference in trends for sheltered and exposed breeders is probably also valid for razorbills. Monitoring of the puffin population on nearby Gjesværstappan started in 1997, since when the population has dropped by 4.3% p.a. (Lorentsen 2005). However, the large increase in numbers of apparently occupied burrows in the sample plots in 2004 and 2005 (**Table 2.11**) is probably explained by improved breeding conditions for the population after breeding numbers suddenly halved between 2002 and 2003.

Table 2.11 *Key population parameters (SE, n) of seabirds on Hjelmsøya in 2005. Population change is the numeric change in size of the breeding population registered between 2004 and 2005 on the basis of plot counts (p) or total censuses (t). Numbers of Atlantic puffins are monitored at nearby Gjesværstappan, about 20 km east of Hjelmsøya. For common guillemot and razorbill counts of individuals in plots on exposed cliffs (ip) and of eggs in plots in more sheltered habitats (ep) are treated separately.*

Species	**Population change**	**Annual adult survival** Period (yrs)	Estimate	**Reproductive performance** Sampling unit	Estimate
Great skua [1]	– 25.0% [t]				
Black-legged kittiwake	– 6.1% [p]	No estimate yet possible [2]		Clutch size [5] Large chicks/nest [6]	1.70 (0.05, 72) 1.18 (0.10, 73)
Common guillemot	+ 0.4% [ip] + 93.8% [ep]	No estimate yet possible [3]		Data not yet analysed	
Brünnich's guillemot	– 68.4% [p]				
Razorbill	–29.3% [ip] + 27.3% [ep]				
Atlantic puffin	+ 31.5% [p]	No estimate yet possible [4]			

1) *Change from 4 to 3 pairs;* ***2)*** *Colour-ringing for monitoring of survival rates was initiated in 2004 and continued in 2005 (132 and 74 adults ringed, respectively);* ***3)*** *Colour-ringing for monitoring of survival rates was initiated in 2004 and continued in 2005 (40 and 51 adults ringed, respectively);* ***4)*** *Colour-ringing for monitoring of survival rates was initiated in 2004 and continued in 2005 (150 and 1 adults ringed, respectively).*

In 2004 and 2005, a total of 206 adult kittiwakes, 91 adult common guillemots and 151 adult puffins were individually marked with coded colour rings for later monitoring of their survival. As the maximum likelihood modelling used to produce such estimates requires data from at least three capture/recapture occasions, the first estimates will not be produced before the end of the 2006 season.

Black-legged kittiwakes had high breeding success in 2005 (**Table 2.11**). The collection of food samples (regurgitations from 9 chicks and 23 adults) showed that both adults and juveniles fed nearly exclusively on herring (**Figure 2.10**). Herring has probably become more important for seabirds in this area since the recovery of the Norwegian spring-spawning herring stock, which has its main nursery grounds (0-3 years of age) in the Barents Sea (cf. **Figures 2.6** & **2.9**)

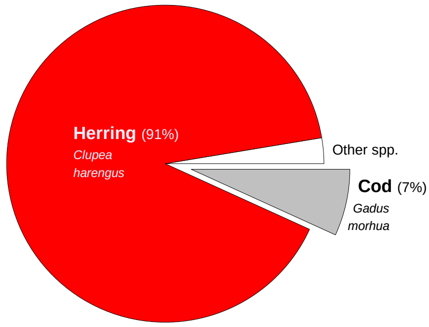


Figure 2.10
Composition of chick diet (% by mass) of black-legged kittiwakes on Hjelmsøya in 2005 (based on 32 food samples).

The field-work at Hjelmsøya in 2005 was hampered by bad weather for long periods, which gave the present field station little credit as a suitable working facility (**Figure 2.11**). In addition, there was an exceptional predation on puffin eggs and young from nests that were being used in detailed studies of chick growth and survival. As a result, we did not succeed in collecting any food samples from or measurements of breeding success of the puffins in 2005. The general impression was, however, that the breeding success was high for the puffins, and for common guillemots.

Figure 2.11
The field station on Hjelmsøya in 2005.
(© Lars Asbjørnsen)

2.5 Grindøya

Kjell Einar Erikstad

Grindøya (69°38′N 18°49′E) in Balsfjorden is not a full SEAPOP key-site, but is included in the programme because the most extensive data time series for the common eider (*Somateria mollissima*) breeding in mainland Norway have been collected here. Breeding parameters studied annually include laying date, reproduction (clutch size and chick survival) and survival rates of females (e.g. **Table 2.12**). 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 population trend indicated in the table results from counts in these sub-areas (specifically zones 15 and 17) where the number of males in the breeding area dropped from 681 to 469 between 2004 and 2005.

***Table 2.12** Key population parameters (SE, n) of common eider on Grindøya in 2005. Population change is the change in number of adult males registered in breeding areas farther out in Balsfjorden between 2004 and 2005 on the basis of total counts (t). The listed survival estimate was derived from the model that fitted the data set best (i.e. the one with the lowest AICc value).*

Species	**Population change**	**Annual adult survival**		**Reproductive performance**	
		Period (yrs)	Estimate	Sampling unit	Estimate
Common eider	+ 45.2 % ^{t}	1985-2005 (20)	82.5 (0.6, 1136)	Clutch size	4.18 (0.06, 235)

2.6 Anda

Svein-Håkon Lorentsen

The island of Anda (64°04'N 15°10'E) in Vesterålen was established as a new SEAPOP key-site in 2005 (**Figure 2.1**). Thanks to the Norwegian Coastal Administration we were allowed to use the lighthouse buildings at Anda which has been abandoned since 1987 as our base (**Figure 2.12**). It proved to be an excellent field station.

Figure 2.12
Aerial view of Anda with the lighthouse situated on the top of the island. What might look like one island extending to the right from the lighthouse is in fact a group of three islands and a boat is needed to access them all. (© Rob Barrett)

Atlantic puffins were monitored at Anda in 1981-83 but since then no regular studies have been carried out on the island. Fortunately, the monitoring plots counted in the early 1980s were well documented and enabled a comparison with results from counts in 2005. In addition to putting out new plots for puffins using the Star system described by Anker-Nilssen & Røstad (1993), monitoring plots for black-legged kittiwakes were also established and counted and total censuses of the European shag, herring gull, common guillemot and black guillemot populations were made. Data on the breeding success of Atlantic puffin and black-legged kittiwake were collected and 150 individuals of each of the two species were individually colour ringed for future monitoring of adult survival rates. Additionally, 16 food loads containing 263 fish were collected from Atlantic puffins.

Table 2.13 *Key population parameters (SE, n) of seabirds on Anda in 2005. Population change is the numeric change in size of the breeding population registered between 1981 and 2005 on the basis of plot counts (p).*

Species	**Population change**	**Annual adult survival** Period (yrs)	Estimate	**Reproductive performance** Sampling unit	Estimate
Black-legged kittiwake		No estimate yet possible [1]		Chicks/nest	1.16 (0.07, 146) [2]
Atlantic puffin	– 12.8% p	No estimate yet possible [3]		Chicks ≥ 10d/nest	0.62 (*n*=58) [3]

1) Colour-ringing for monitoring of survival rates was initiated in 2005 (150 adults ringed); 2) Number of chicks (small- to medium-sized) per nest in the period 1-5 July; 3) Including a survival rate of 0.92 (n=39) for chicks from hatching to age ≥ 10 days on 5 July (last control) or documented to grow so well that they no doubt would reach that age.

Results reported by the national monitoring programme for seabirds (Lorentsen 2005) suggest that the breeding population of Atlantic puffins at Anda was relatively stable from 1981 to 2005. The total population appears to have declined by only 0.4% annually from an estimated 22,200 pairs in 1981 to ca. 19,300 pairs in 2005, a total decrease of 12.8% (**Table 2.13**), but the trend in the monitoring plots was not significant. The mean hatching date for puffins at Anda in 2005 was 23 June, i.e. about a week later than at Røst (cf. chapter 2.7). A chick was hatched in 67% of the study nests (*n*=58). 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 2.13**).

First-year herring was the most common species in the puffin diet and comprised 64% of all individual fish brought to the chicks, followed by sandeel which constituted 34%. However, most herring were relatively small larvae and the mean length of the herring was only 45.2 mm (*SD*=5.0, range 32-65mm, *n*=113) compared to a mean of 72.3 mm (*SD*=15.9, range 26-128 mm, *n*=79) for sandeel, which was the most important prey and constituted 60% of the diet by mass (**Figure 2.13**). Future studies will show whether the seabirds breeding on Anda rely more on sandeels than on herring, which, if proved to be the case, might explain why its population of Atlantic puffins has been relatively stable compared to that in Røst, which declined by 67% in the same time period (1981-2005).

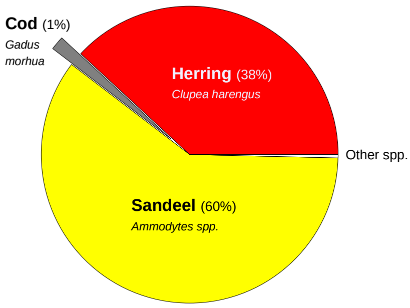


Figure 2.13
Composition of chick diet (% by mass) of Atlantic puffins on Anda in 2005.

About 1000 pairs of black-legged kittiwakes bred on Anda in 2005. When compared with a census made in the early 1980's (Røv *et al.* 1984) it seems that the population has remained quite stable over the last two decades. A study plot for monitoring of reproductive success and future adult survival was established (**Figure 2.14**). For several reasons including poor weather, logistic problems and very restricted funds in this first year, no food samples from kittiwakes were collected in 2005.

Figure 2.14
The study plot established for monitoring of reproductive success and adult survival of black-legged kittiwake on Anda. (© Svein-Håkon Lorentsen)

2.7 Røst

Tycho Anker-Nilssen

The long-term monitoring on Røst continued in 2005 following well-established, standardised procedures. The field work was divided on two field periods: 3.5-12.5 and 13.6-15.8. As always, the main focus was the Atlantic puffin for which all long-term data series (see e.g. Anker-Nilssen & Aarvak 2004) were updated, but all data series established for other species in earlier years were also continued (**Table 2.14**). A more detailed report of these studies with focus on results from 2004 and 2005 will be published in April 2006 (Anker-Nilssen & Aarvak *in prep.*).

Except for yet another huge drop in numbers of common guillemots on cliff ledges and a slight drop in fulmar numbers, the breeding populations of the other monitoring species showed signs of increase from 2004 to 2005. The increase was largest for the two cormorant species, with the population of European shag on Ellefsnyken reaching an all-time high with 943 breeding pairs. For the first time on record, puffin numbers (i.e. burrow occupancy) increased in the third consecutive year. Nevertheless, the increase has only restored 5% (or 3.5 percentage points) of the 73% drop in numbers between 1979 and the all-time low in 2002.

There was a clear tendency that coastal diving species feeding in near-shore waters (such as the cormorants) reproduced reasonably well in 2005, whereas pelagic species (such as black-legged kittiwake and Atlantic puffin) had a bad year. For the latter, this was most likely a direct consequence of a very poor year-class of young herring and almost no sandeels available in offshore areas within reach of the colony, a phenomenon that was also partly documented by trawl surveys in the Norwegian Sea in second half of July (IMR 2005). The arrival of a very strong year-class of first-year saithe into shallow waters in summer secured a high reproductive success for many near-shore species (including cormorants and Arctic terns), but an unusually cold spring seemed to cause breeding failure for most gulls (own observations).

Table 2.14 Key population parameters (SE, n) of seabirds in Røst in 2005. Population change is the numeric change in size of the breeding population registered between 2004 and 2005 on the basis of plot counts (p) or total censuses (t). For each species the listed survival estimate was derived from the model that fitted the data set best (i.e. the one with the lowest AICc value).

Species	Population change	Annual adult survival		Reproductive performance	
		Period (yrs)	Estimate	Sampling unit	Estimate
Northern fulmar	– 1.5% p				Probably 0.00 [1]
Great cormorant	+ 37.3% t			Clutch size [2]	2.37 (0.16, 70)
European shag	+ 34.3% p	2002-05 (3)	80.8% (1.8, 237)	Clutch size [3]	2.10 (0.04, 814)
Common eider	+ 2.5% t			Clutch size	3.07 (0.31, 14)
Great skua [4]	+ 100.0% t			Breeding success	1.50 (0.50, 2)
Black-legged kittiwake	+ 8.0% p	2003-05 (2)	82.6% (3.2, 101)	Clutch size [5]	1.26 (0.07, 128)
				Large chicks/nest [6]	0.39 (*n*=459)
Arctic tern				Clutch size	2.08 (0.09, 60)
Common guillemot	– 59.0% p	No estimate yet possible [7]			
Razorbill	– 34.4% p				
Atlantic puffin	+ 1.3% p	2003-04 (1)	90.9% (1.1, 195)	Fledging success	0.08 (*n*=51)
Black guillemot		2004-05 (1)	80.8% (5.9, 36)	Clutch size	1.73 (0.10, 22)
				Large chicks/clutch	1.22 (0.19, 18)

***1)** No detailed data, but most fulmars left the colonies unusually early (in July, own observations); **2)** On 17 June; minimum estimate (some clutches were still incomplete, while others had relatively large chicks); **3)** On 1 July; estimated by linear regression of mean values for eight different counts between 16 June and 19 July; **4)** The population increased from 1 to 2 pairs, which produced 3 chicks that were colour-ringed; **5)** Measured in a sub-population nesting on buildings at Kårøy Rorbucamping; **6)** In the study plots on the main colony at Vedøy; **7)** Colour-ringing for monitoring of survival rates was initiated in 2005 (69 adults ringed).*

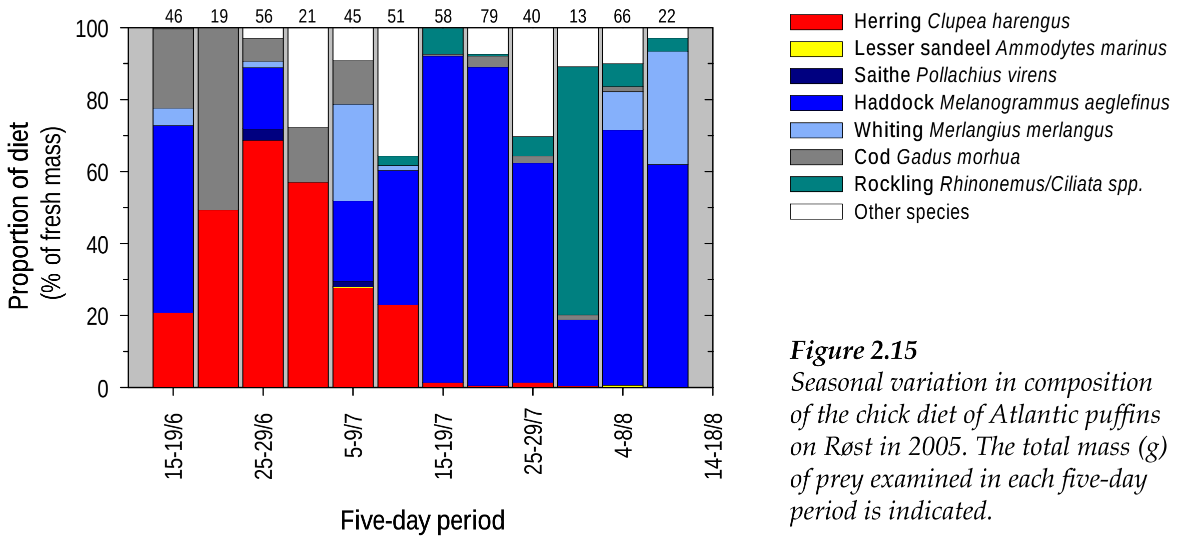


Figure 2.15
Seasonal variation in composition of the chick diet of Atlantic puffins on Røst in 2005. The total mass (g) of prey examined in each five-day period is indicated.

The mean hatching date of puffins was 17 June, which is one week earlier than the long-term average (Anker-Nilssen & Aarvak 2004). The diet of the puffin chicks was poor and very variable (**Figure 2.15**). The first-year herring brought back to the colony by the puffins was the smallest on record since 1982 with a mean length of only 35.3 mm on 1 July (standard index calculated by regression on mean values for 5-day periods), and herring comprised only 20.9%

of the chick diet by weight, its lowest proportion in 20 years. Haddock (43.4%) was the most important prey and except for the herring most of the other prey was cod (9.6%), rockling (7.9%) or whiting (6.4%). Gadoid species constituted altogether 73.2% of the diet mass. For the first time ever snake pipefish (*Entelurus aequoreus*) was found in the puffins' diet, a phenomenon registered for several species over large areas of the NE Atlantic in 2005. The mean length and mass of those examined in Røst was 288 mm (range 227-373, *n*=14) and 3.9 g (range 1.5-7.0, *n*=6), respectively. Also the Arctic terns (*Sterna paradisaea*) brought some pipefish back to their chicks.

The studies of other species were further extended by the colour ringing of 69 adult common guillemots breeding within a boulder scree on the west side of Hernyken in order to monitor survival rate. This is extra important because the breeding habitat for the species in Røst is now clearly shifting, possibly because of the disturbance caused by an increasing population of non-breeding white-tailed eagles *Haliaeetus albicilla* (own unpubl. data). When the first census was made on Vedøy in 1960-63, the vast majority of the 11,900 pairs that bred on the island in that year was found on open ledges on steep cliffs (Tschanz & Barth 1978). These numbers have since been dropping almost continuously and are now close to zero (e.g. Lorentsen 2005, see also chapter 3), while the numbers breeding in shelter have been increasing over the last decade. Breeding success is also markedly different in these two habitats, but no detailed data have been collected.

According to the best model, there was no annual variation in the survival rates of European shags on Røst over the three-year study period. No other estimates exist from Norwegian areas, but the estimated survival rate of 80.8% was only slightly lower than that documented in many other parts of the species' breeding range (e.g. Harris *et al.* 2000). The latest survival estimate for the puffins was relatively close to the mean for this population (93.5%) and four other European colonies in 1990-2002 (range 91.5-93.5%, Harris *et al.* 2005). The survival estimate for kittiwakes over the first two years was also close to an overall mean of 84.1% (range 80.1-89.6) for seven other colonies in the NE Atlantic (as listed by Frederiksen *et al.* 2005, when updating results for Hornøya after Sandvik *et al.* 2005).

Figure 2.16
Annual monitoring of survival rates for European shags was established on Røst in 2002.
(© Tycho Anker-Nilssen)

3 Sampling design for monitoring population trends

Kjell Einar Erikstad & Tycho Anker-Nilssen

The main objective of seabird monitoring is to document the status and trends of a sample of populations, which has been selected to reflect important differences between species and areas. With few exceptions, the most cost-efficient way to monitor changes in population size of a species on a specific site is by counting its numbers on selected study plots that only cover parts of the local breeding area or colony. This is also the way most seabirds are monitored in Norway (e.g. Lorentsen 2005), and the counting of the plots usually follow internationally standardised procedures (e.g. Walsh *et al.* 1985). The way the monitoring plots were selected, however, seems to have been much less consistent, probably both for logistic reasons and in order to make the best of limited funds. As a consequence, the size and location of the study plots relative to the true distribution of the local population they were intended to reflect vary greatly within (as well as between) sites. In most cases, only a small fraction of the whole colony is counted. Despite this, there are few analyses which have considered in any detail whether the trends on the study plots actually reflect with a reasonable degree of accuracy the trends for the breeding population as a whole.

There are only two seabird populations in Norway for which a large number of small monitoring plots have been distributed more or less evenly throughout the colony and the plots since monitored annually for decades. One is the population of Atlantic puffin on Hernyken in Røst (cf. Anker-Nilssen & Røstad 1993 for methods) and the other is the population of common guillemot at Vedøy, another island in the Røst archipelago. The unique resolution of these data series presents us the opportunity to analyse the spatial and temporal trends in bird numbers on the different plots in relation to a number of different factors related to e.g. nesting habitat quality and variation in environmental conditions (e.g. climate, food availability and predators), as well as the density of the birds themselves. Such exercises provide us with important information on how to improve the design of seabird monitoring.

Here we report a few highlights from a preliminary analysis of the population trends of common guillemots on individual ledges on Vedøy. The counting unit for monitoring common guillemots is an adult individual sitting on a ledge suitable for breeding, i.e. any ledge that can support an egg or chick as well as the adult(s), and the counts are repeated on at least seven different days during the incubation period. Except for the years 1984-87, the population on Vedøy has been monitored annually in great detail since 1981. The population shows a steep decline over the monitoring period and is now close to extinction (**Figure 3.1**).

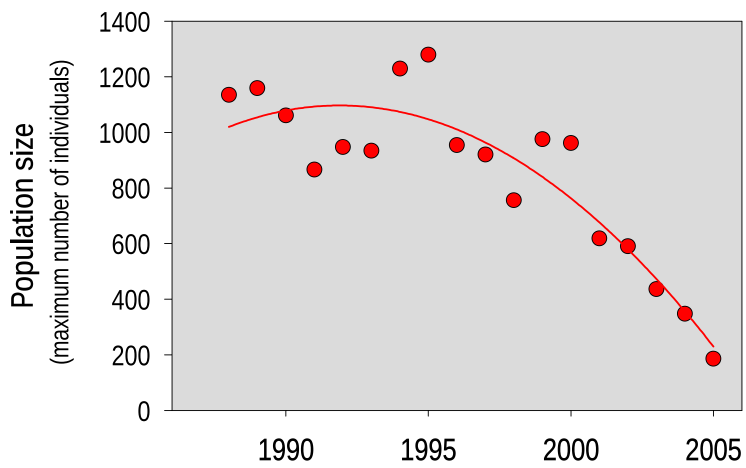


Figure 3.1
The population trend of common guillemot on Vedøy, Røst in 1988-2005.

The scheme covers a total of 308 study plots, all of which are individual breeding ledges of varying size. The plots cover more than 60% of the total number of birds breeding on the island (Bakken 1989). As many as 182 (59%) of the plots became extinct between 1981 and 1988, and another 91 plots had become extinct by 2005 when only 25 (8%) plots still contained birds.

We were not able to document any spatial variation in trends of birds breeding in different parts of the colony. However, the density of birds was in general highest on the smaller ledges and bird density clearly influenced the number of years it took for ledges to reach extinction (**Figure 3.2**A). For instance, this longevity of a ledge was more than doubled when the density of birds increased from two to eight per running meter of ledge face (**Figure 3.2**B). This suggests that a certain density of birds is important for successful breeding of the common guillemot, which is a highly social species. It may also partly explain the accelerated negative trend for the colony (**Figure 3.1**).

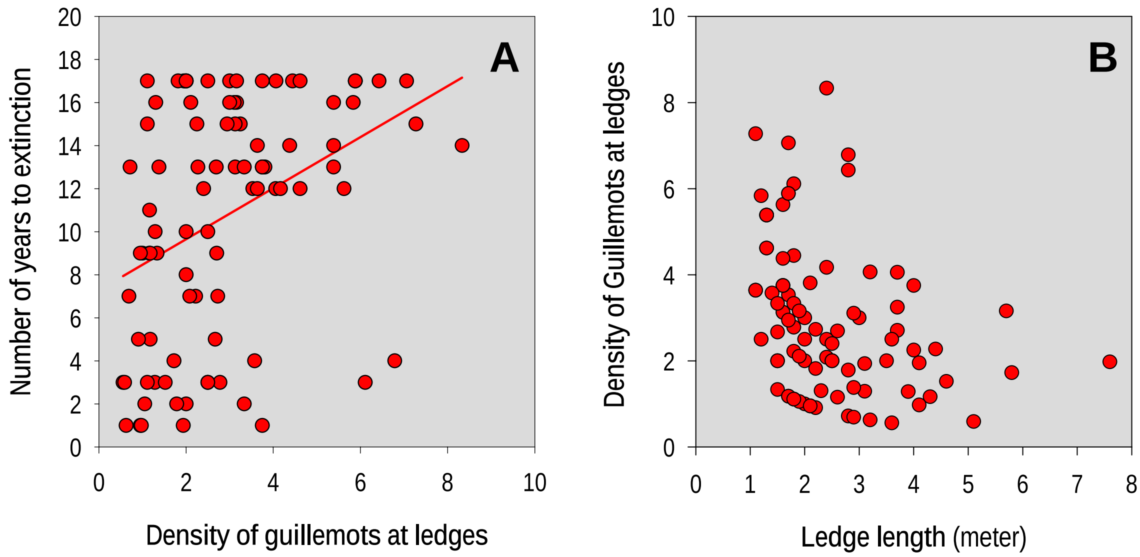


Figure 3.2
*The relationships between the density of guillemots at individual ledges and (**A**) the number of years it took (from 1988) until the ledges went extinct, and (**B**) the length of the ledge face in meter.*

The population trend of common guillemots on Vedøy is extraordinary. However, it may prove to have several important implications for monitoring design:

- Since we do not find any spatial variation in population trends in different parts of the colony, there seems to be little need to randomise the selection of sample plots or to distribute the plots evenly over the whole colony.
- Effort should be made to sample ledges of different sizes and with different densities of birds. Thus, the number of ledges needed to detect significant population trends should be quantified after prospecting the colony for the variance in density of birds and sizes of the breeding ledges.

4 Suitability of potential monitoring sites

4.1 Suitability of potential key-sites

Svein-Håkon Lorentsen

In order to cover the geographical variation in seabird population dynamics, it was considered important to establish a SEAPOP key-site in the Vesterålen area, i.e. on the border between the Barents and Norwegian Seas (Anker-Nilssen *et al.* 2005). Based on the then existing knowledge, only two localities (both relatively small and exposed islands) were judged as having the potential to meet the qualities required of a key-site; Bleiksøy in the municipality of Andenes and Anda in the municipality of Øksnes. We assessed historical data on local breeding populations of seabirds and evaluated the logistics for working at the sites. Large populations of Atlantic puffin and black-legged kittiwake had been documented on both Anda and Bleiksøy, but smaller populations of European shag, common guillemot and razorbill. This was confirmed by the game wardens of the two islands, who also told us that disturbance by white-tailed eagles had probably caused a steep decline in the population of kittiwakes on Bleiksøy.

We visited Anda in May 2005 and found it very well suited as a key-site, despite its quite small populations of European shag and common guillemot. The puffins and kittiwakes breed in easily accessible sites, and there is also a relatively large population of herring gulls (*Larus argentatus*) on the island. We intended to visit Bleiksøy on the same field trip, but the weather conditions prevented this. Bleiksøy was however visited by Rob Barrett in late June. He confirmed the collapse of the kittiwake population (only 10% of its size in 1993), and concluded that very few kittiwake nests were accessible for studies of adult survival, chick growth and diet. Furthermore, very few pairs of common guillemot and razorbill were available for similar studies and the puffin colony at Bleiksøy was also less accessible. Finally, the small cabin (originally a workmen's hut) that was put up on Bleiksøy in the late 1980s was in a condemnable state, as opposed to the very suitable lighthouse buildings on Anda that the Norwegian Coastal Administration kindly allows us to use as a base for long-term work. Anda was thus judged as being best suited as the last SEAPOP key-site in the Lofoten and Barents Sea area (cf. chapter 2.6).

4.2 Suitability of sites for extensive monitoring of kittiwakes

Jan Ove Bustnes & Geir Helge Systad

Seabirds experience a highly variable environment. This variability will affect seabirds in many ways, probably most significantly by altering their foraging success, and will easily have important consequences for vital demographic parameters such as reproduction and survival. At present we monitor the diet, breeding success, adult survival rate and population trends (in a few cases also recruitment rates) of a selection of species on a few key-sites. In order to test to what degree the key-site populations are representative for the species over a larger area, the idea is to establish a more extensive monitoring of one species, the black-legged kittiwake, by including several colonies within the surrounding areas of some of the key-sites. In the long run, this will enable us to get a better understanding of how climatic variability in the marine ecosystem affects the kittiwake populations at various scales in the Barents Sea area.

During the mapping of coastal seabirds in summer 2005, most colonies of black-legged kittiwake in Troms, and western and central Finnmark as far east as Laksefjorden (27°E) were visited. The numbers of apparently occupied nests were counted in all colonies except for the largest seabird cliffs, which are planned to be censused in 2007. The counts were made directly from boats or photographed and later counted from the pictures.

In Troms, there were 17 kittiwake colonies with numbers of breeding pairs ranging from a few up to 6,200 (**Figure 4.1**). Most colonies (15 of 17) were smaller than 100 pairs, hence the likelihood that some of them may disappear must be considered as high. Thus most kittiwake colonies in Troms are probably too small to be included as suitable components of an efficient and reliable scheme for extensive monitoring of the species. The one exception is the colony in Sundvoldsundet, which holds about 6,200 pairs (counted from photographs). However, if it is necessary to include more colonies in Troms for monitoring of kittiwakes, those on Auvær and Hekkingen are potentially the best locations, albeit still small.

In western and central Finnmark, more than 50 kittiwake colonies were visited. The colonies ranged in size from 31 to more than 100,000 breeding pairs (**Figure 4.1**). Judging from their accessibility and other experiences made when doing these counts, we suggest that the colonies on Gjesværstappan, Kongsfjorden, Altafjorden and the northern part of Sørøya, are the most suitable sites for an extensive monitoring scheme. Additionally, one or to of the larger colonies, such as those on Sværholt and Omgang, should be included.

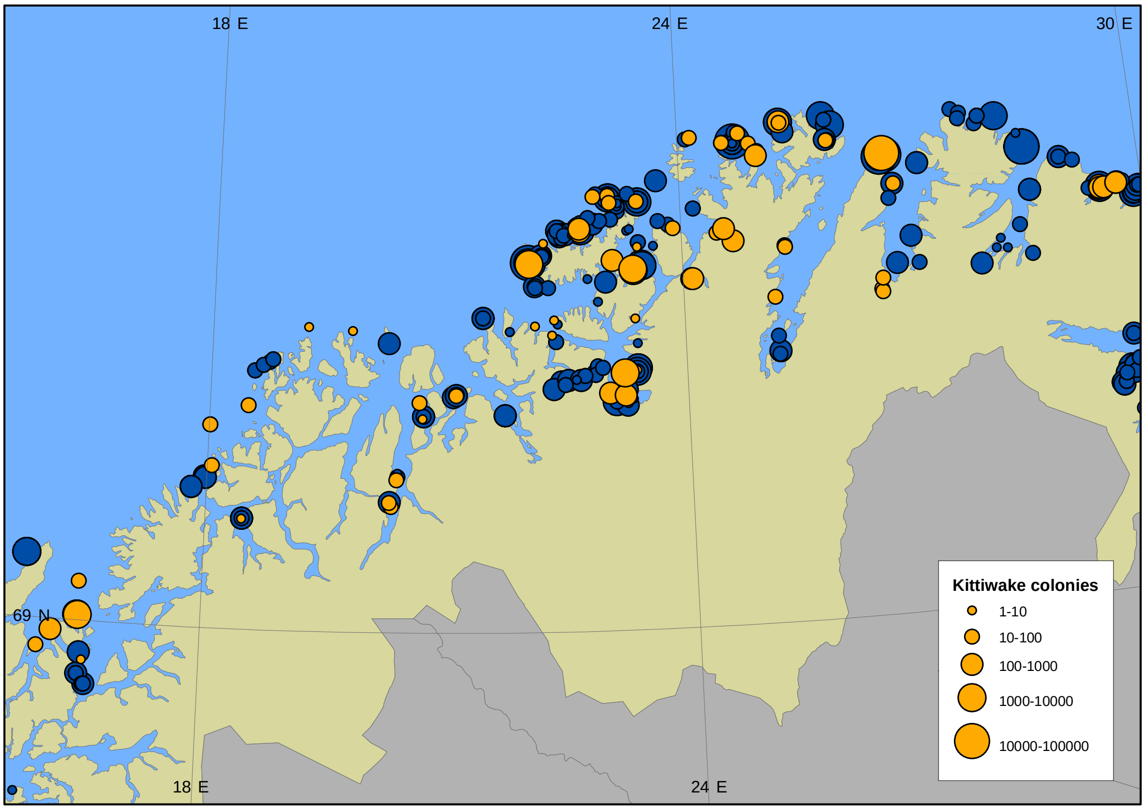


Figure 4.1
The distribution and sizes of breeding colonies of black-legged kittiwake on the Norwegian mainland coast of the Lofoten and Barents Sea area. Colonies indicated by blue circles were censused in 2005, whereas the sizes of those shown in pink are based on older data.

5 Mapping of coastal seabirds

5.1 Mapping of coastal seabirds in Svalbard

Hallvard Strøm

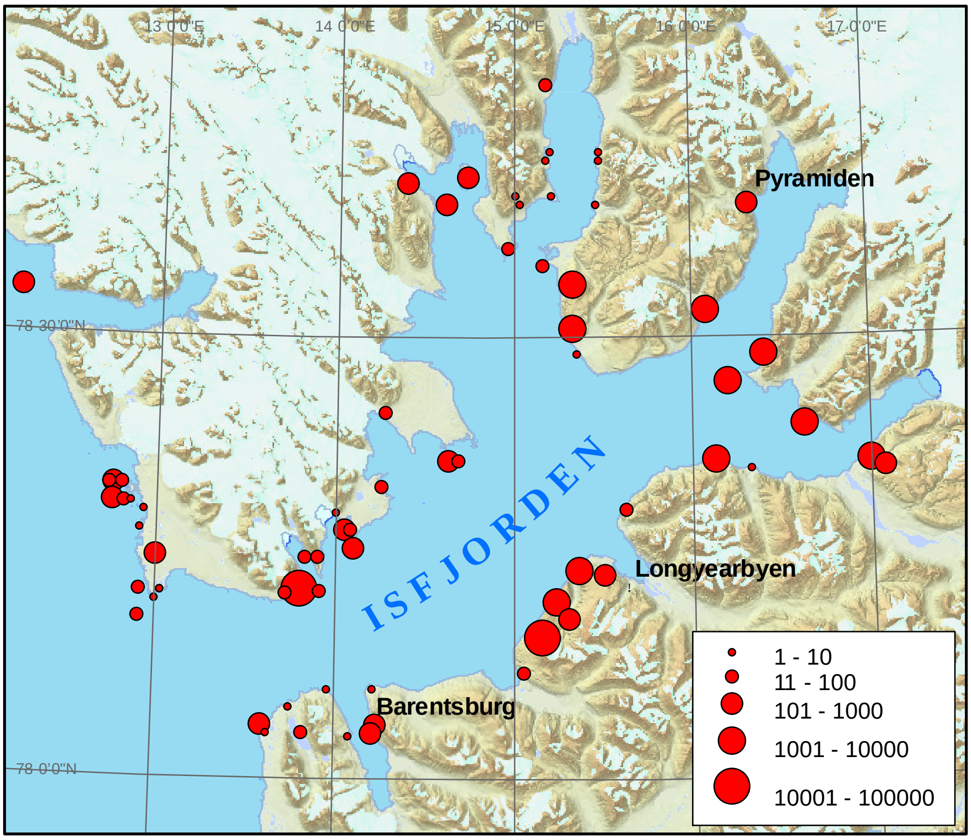
In Svalbard, priority was given to the Isfjorden area in 2005. Isfjorden is the largest fjord system on Spitsbergen, and the most frequently used area for cruise ships, local tour operators and the local inhabitants of the Longyearbyen and Barentsburg settlements. Some of the seabird colonies in Isfjorden had previously been censused in the 1980s and in the early 1990s, but no complete survey had ever been conducted. The field-work was carried out from 16 June to 26 July. Three teams, each consisting of two persons operating from Zodiac rubber boats, took part in the census. The coastline was covered systematically and the general census methods followed Walsh *et al.* (1995). Priority was given to cliff-breeding seabirds and gulls, but coastal, ground nesting species were also included in the survey. The inland colonies of northern fulmar and little auk were not censused, but their geographic positions and approximate spatial extents were noted. A list of the species covered, counting units and total population estimates is given below (**Table 5.1**).

Table 5.1 *Species, counting units, numbers of colonies and total population estimates of seabirds breeding in the Isfjorden area, Spitsbergen in 2005.*

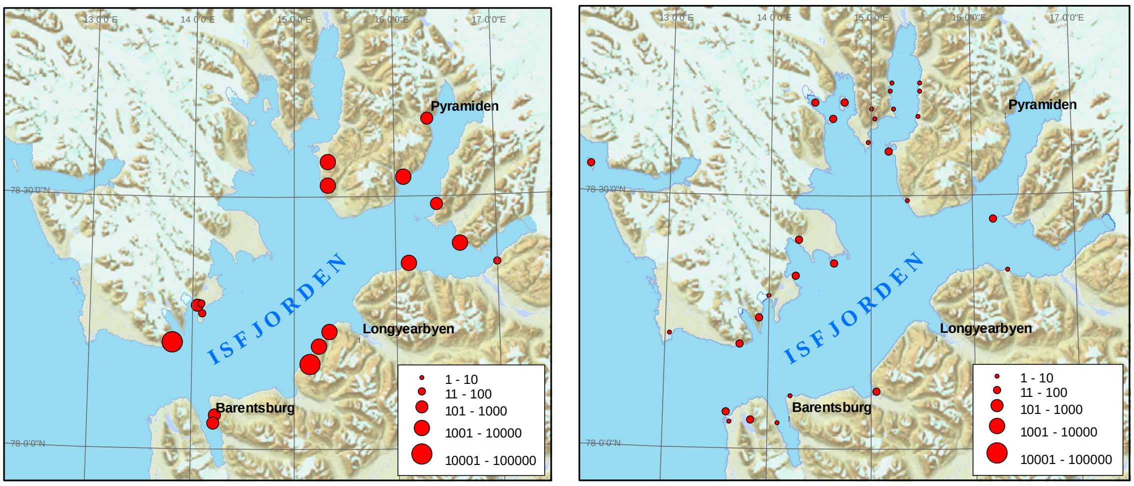
Species	Counting unit	No. of colonies	Total population
Northern fulmar	Apparently occupied nest site	14	21280
Common eider	Male in breeding area	11	2700
King eider	Male in breeding area	Dispersed breeding	60
Glaucous gull	Apparently occupied nest	18	196
Great black-backed gull	Apparently occupied nest	Dispersed breeding	30
Black-legged kittiwake	Apparently occupied nest	20	72786
Arctic tern	Apparently occupied nest	30	1000
Little auk		10	Not assessed
Brünnich's guillemot	Individual adult	17	91485
Black guillemot	Individual adult	12	318
Atlantic puffin	Individual adult	9	1213

A total of 86 colonies of 15 species were surveyed in Isfjorden in 2005 (**Table 5.1, Figure 5.1**). The seabird community in this fjord system is dominated by Brünnich's guillemot, black-legged kittiwake, northern fulmar and common eider. A few examples of the distribution of colonies of different species are shown in **Figure 5.2**. The area also supports a growing population of barnacle and pink-footed geese, and 700 and 180 pairs (or nests) respectively were registered during the survey.

Compared to previous censuses in 1988 and 1992, there were apparent increases in the numbers of breeding black-legged kittiwakes and Brünnich's guillemots in the four largest colonies, from ca. 21,000 apparently occupied nests (AONs) in 1988/92 to ca. 32,000 AONs in 2006, and from ca. 54,000 birds in 1988/92 to ca. 64,000 birds in 2006, respectively. These differences may, however, be partly due to a more comprehensive and thorough census in 2005 than in 1988/92 as monitoring data from four colonies (Alkhornet, Tchermakfjellet, Diabasodden and Fuglefjella) for the same period indicate more or less stable populations for both species.



Figur 5.1
Distribution and sizes (total numbers of breeding pairs) of seabird colonies in Isfjorden, Spitsbergen in 2005. A total of 86 colonies are known in the area.



Figur 5.2
Distribution and sizes (total numbers of breeding pairs) of in most cases mixed colonies of Brünnich's guillemots and black-legged kittiwakes ***(left panel)*** *and colonies of Arctic terns* ***(right panel)*** *in Isfjorden, Spitsbergen in 2005.*

5.2 Mapping of coastal seabirds in mainland Norway

Geir Helge Systad & Jan Ove Bustnes

The aim of the data collection in 2005 was to map the breeding distribution and occurrence of coastal seabirds in the area from Lofoten to the Russian border. This is a vast area and the approach had to be a compromise between accuracy and the possibility of covering the area efficiently; hence we chose three complimentary methods of gathering data: 1) aerial surveys of the coastline, 2) visits to the colonies by boat, and 3) counts from larger vessels and smaller boats. The field-work was undertaken from 20 May to 5 July.

The area covered comprised the counties of Troms and Finnmark east to Laksefjorden. The whole coastline was covered from the air, including all fjords and islands, and afterwards the smaller seabird colonies in most of the area were surveyed from boats (counting teams based on coast guard vessels or using Zodiacs from shore). For safety reasons, similar aerial surveys will unfortunately not be allowed in later seasons.

The Lofoten and Vesterålen area was not covered and may not be surveyed before 2007. In 2006, the remaining areas in eastern Finnmark will be surveyed from boats. Moreover, large seabird aggregations, i.e. the main colonies, were not censused. This means that no data has so far been collected on major concentrations of Atlantic puffins, common guillemots and black-legged kittiwakes outside the key-sites. This work is, however, planned to start in 2007. The methods used from the aircraft were as follows: We used a small single-engine aircraft flying at low altitude (150 m) and slow speed (150 km/h). All birds observed were recorded on tape and the GPS positions of the birds were also recorded. Whenever large flocks or aggregations breeding of birds were encountered, photographs were taken and later counted. Apart from the largest seabird colonies, the counting of photographs has been completed. One of the remaining tasks is to compare the results obtained from aerial and boat based surveys.

More than 5,000 km of coastline were surveyed in 2005. A total of 106,144 pairs (or corresponding breeding units) were registered, distributed on 2,659 separate observations. The dominating species were the black-legged kittiwake, common eider and herring gull (**Table 5.2**). The outer coast of Sørøya was the most important area for the large gulls, whereas the highest numbers of common eiders were found in Porsangerfjorden (**Figures 5.3-5.4**).

Table 5.2 *The most common species, counting units, numbers of colonies and total population estimates of seabirds breeding in Troms and western Finnmark in 2005.*

Species	**Counting unit**	**No. of colonies**	**Total population** (pairs)
Common gannet	Apparently occupied nest site	2	1 830
Great cormorant	Apparently occupied nest site	47	4 444
Goosander	Individuals	111	1 887
Common eider	Male in breeding area	176	11 605
Herring gull	Apparently occupied nest	366	17 270
Great black-backed gull	Apparently occupied nest	644	6 921
Common gull	Apparently occupied nest	33	85
Black-legged kittiwake	Apparently occupied nest	77	75 406
Arctic tern	Apparently occupied nest	51	4 601

The aerial surveys provide good documentation of the distribution of coastal seabirds with high visibility such as common eider males near the breeding sites. Thus, for the first time the distribution of breeding common eiders on the Barents Sea coast of mainland Norway is well covered. One very interesting aspect of our mapping of common eiders is the importance of the inner parts of Porsangerfjorden as a year-round "hotspot" for the species. Based on this survey and on winter counts from the same area (Systad & Bustnes 1999), we conclude that this area may have a stationary population of common eiders of about 4,000 pairs (**Figure 5.4**).

The aerial surveys also provided good data on pre-breeding aggregations of other seaduck species such as scoters and mergansers, which breed inland, and on the breeding distribution and numbers of great cormorants and large gulls.

The boat- and land-based counts gave reasonably good information on the distribution and numbers of European shags, large gulls, terns and small colonies (up to a few thousand pairs) of black-legged kittiwakes (results not shown here). All in all, from the strategic use of different counting platforms including on-land, boats, larger vessels and aircraft, we were able to get good quality data of the distribution of breeding seabirds along the surveyed coast. One notable exception is the black guillemot *Cepphus grylle* which, for several reasons, is notoriously difficult to census accurately.

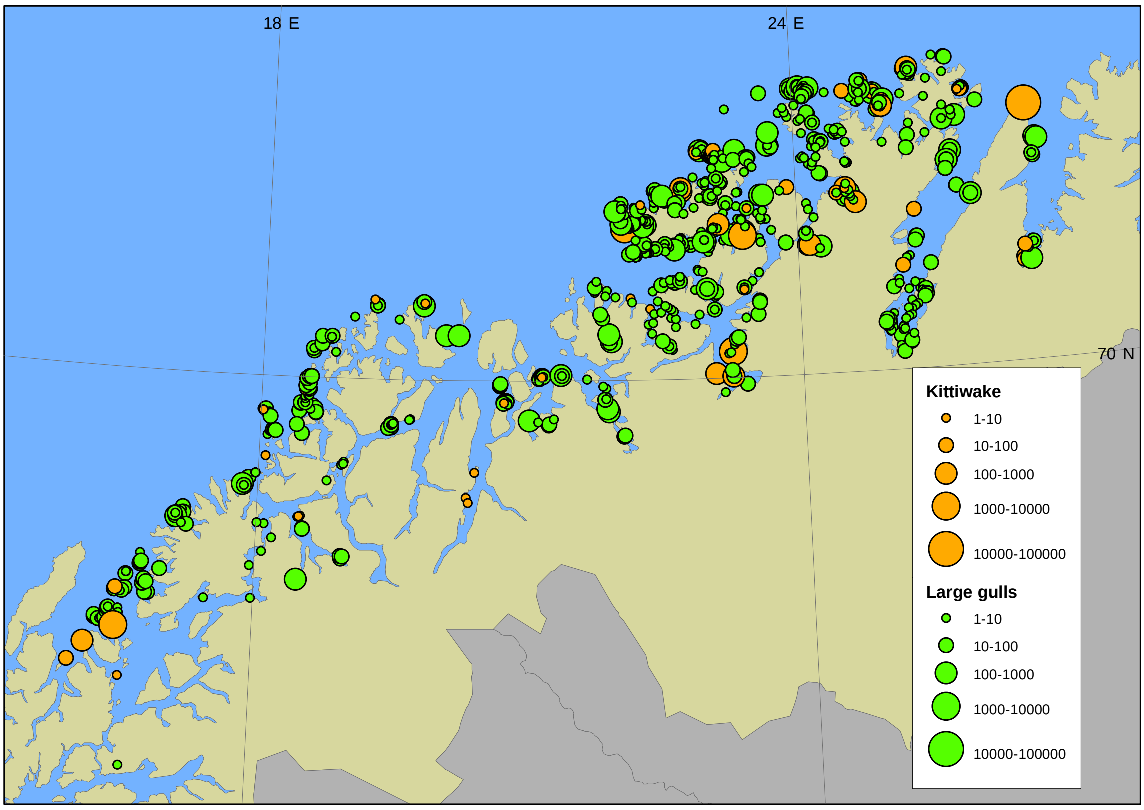


Figure 5.3
The breeding distribution (number of breeding pairs) of black-legged kittiwake and the two large gull species (herring and great black-backed gull) in Troms and western Finnmark in 2005.

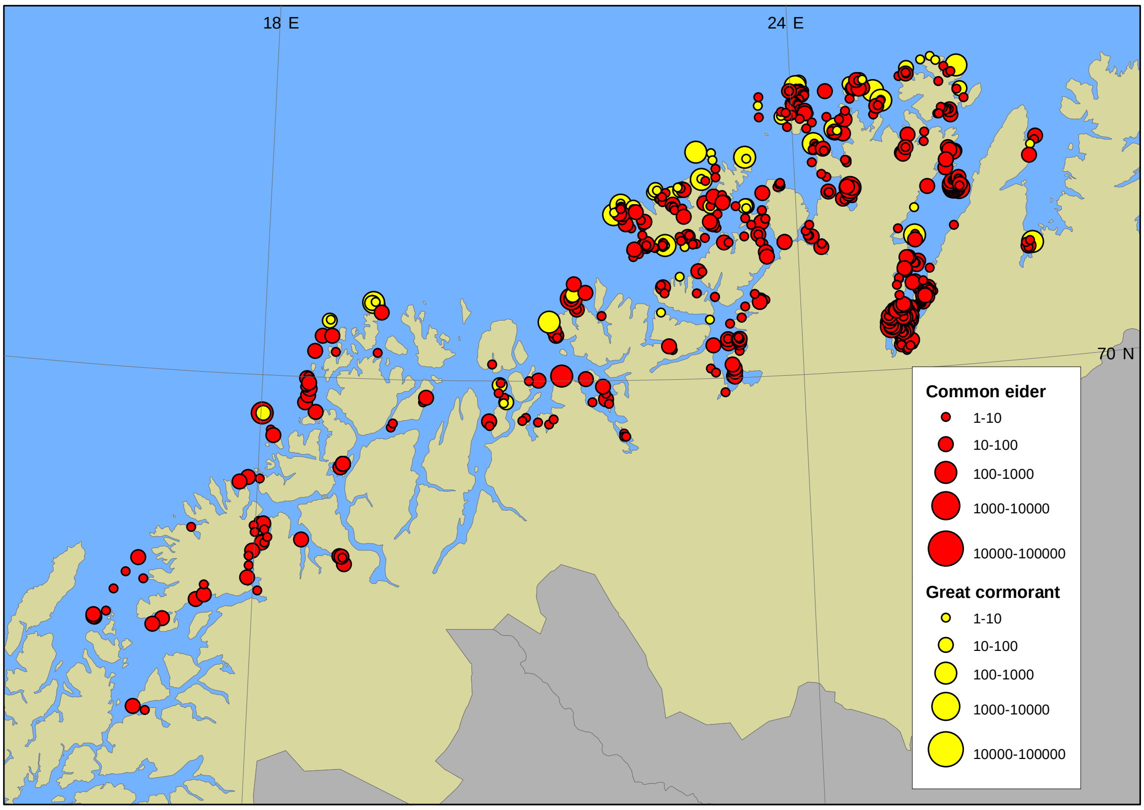


Figure 5.4
The breeding distribution of common eider (males in breeding area) and great cormorant (apparently occupied nests) in Troms and western Finnmark in 2005. Note that data from some fjord areas in Troms are not shown because they were covered by parallel surveys using different platforms and therefore need to be analysed in more detail.

Figure 5.5
Field studies of great cormorant reproduction. (© Tycho Anker-Nilssen)

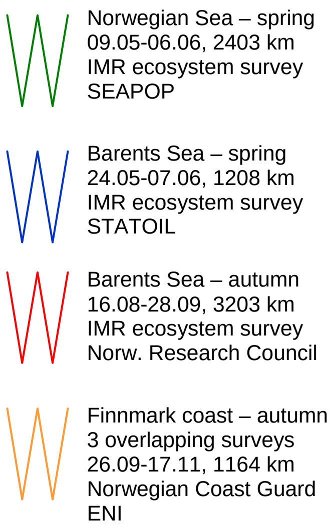
6 Predictive models for seabird distribution at sea

Per Fauchald, Kjell Einar Erikstad & Torkild Tveraa

To understand what determines the distribution of seabirds at sea is of vital importance when assessing the effects of human induced stressors such as oil pollution and fishing activity. Generally, the spatial distribution of seabirds is highly patchy and dynamic. This is because the spatial distribution depends on a range of species-specific factors such as prey preference, the distribution and abundance of prey, seasonal migration pattern and life-cycle stage. This complicated picture makes high demands to both the datasets and the methodology that are used in such assessments.

Distributional data on seabirds are gathered from ship-based transect surveys. NINA and NP have databases on seabirds collected since 1983 covering a total cruise length of 100,969 km in Norwegian waters. An amalgamated database will be updated and extended in SEAPOP. Internationally, GIS methodology, spatial statistics and spatial modelling are under rapid development. In SEAPOP, new methodology will be developed and implemented to give the best possible predictions on the distribution of different seabird species in Norwegian waters.

Data from four new cruises in 2005 with a total transect length of 7,978 km were included in the database (**Figure 6.1**). This was a much higher activity than initially planned, but was made possible by the support from Statoil, ENI Norge and the Research Council of Norway. On three of the cruises, we followed the ecosystem surveys of the Institute of Marine Research (IMR). The fourth survey was supported by ENI, and the Norwegian Coastal Guard kindly let us use their ship as a platform for observations. On the ecosystem surveys, data on marine environmental parameters and prey abundance were gathered synoptically with the seabird registrations. An agreement between NINA and IMR is under development to ensure that seabird observers are normally present on IMR's ecosystem surveys.



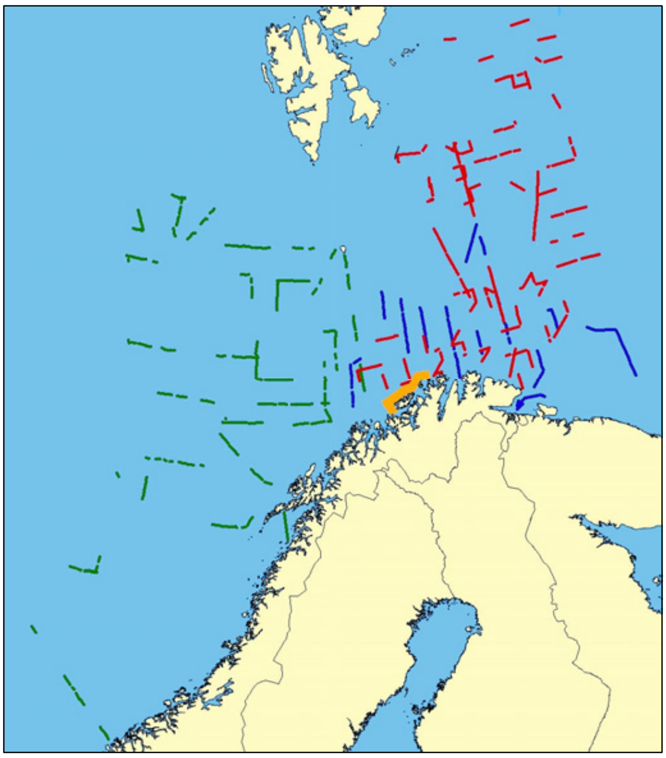


***Figure 6.1** Seabirds at sea surveys conducted in 2005. Time period, total transect length, platform of observations and source of funding for observers are indicated in the legend.*

New methodology has recently been developed and implemented in projects funded by a consortium of Norwegian oil companies (NoBaLes) in 2004 and by Norsk Hydro in 2005 (e.g. Fauchald *et al.* 2005). This methodology includes non-linear modelling of the spatial distribution of different seabird species using environmental features such as sea surface temperature, salinity, ocean colour and bathymetry. In the SEAPOP project, data from four autumn surveys in the Barents Sea were analysed by principal component analyses to identify seabird communities. We were, however, not able to detect any clear tendency of species to co-occur or to be spatially segregated. Thus, the analyses did not reveal any clear community pattern at this scale (see e.g. **Figure 6.2**). The tendency of species to co-occur would probably be linked to the abundance and availability of food. In a variable environment, an assemblage of different seabird species might accordingly be limited in space and time. The analyses suggest that the spatial distribution of seabird species should be mapped and modelled separately. More data will give higher precision and the models will therefore be continuously updated and developed in the course of SEAPOP.

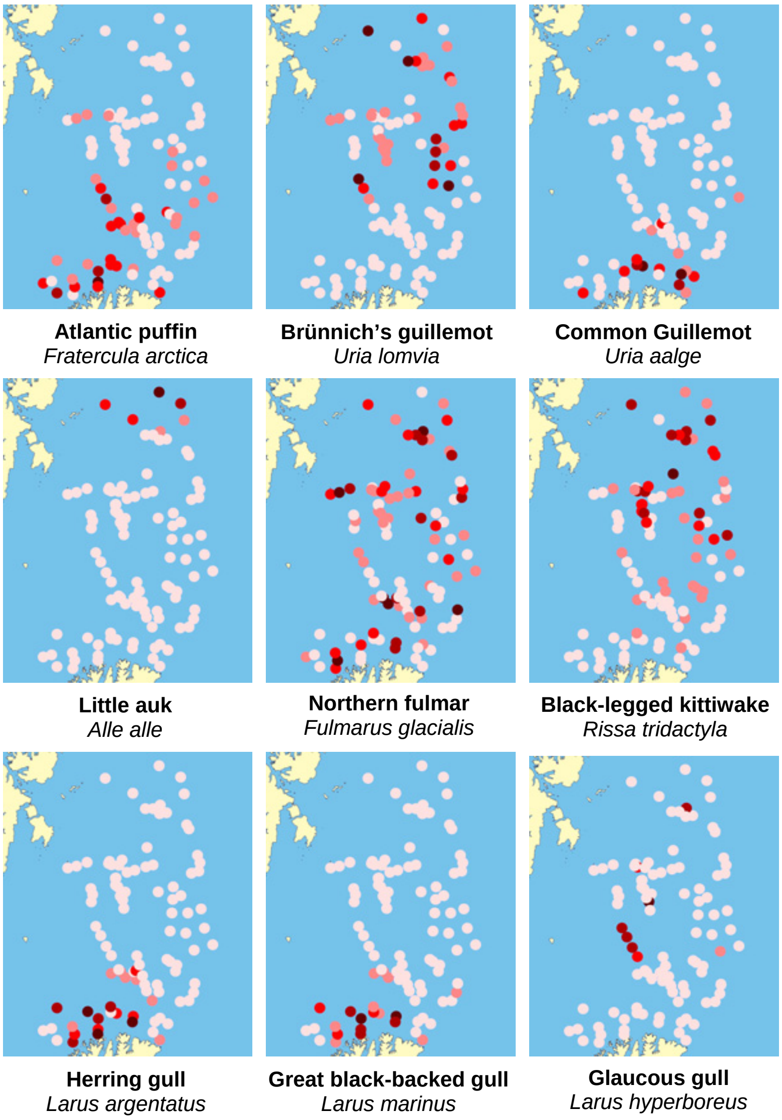


***Figure 6.2** The spatial distribution of the nine most numerous seabird species in the Barents Sea during the 2005 autumn survey. Note that the different species were found in different parts of the study area. The tendency of species to co-occur was weak and no clear community pattern could be identified.*

7 Operationalization of data

Hallvard Strøm & Svein-Håkon Lorentsen

All information which is collected through SEAPOP will be presented on the Web, and the programme's web pages will function as the primary line of communication between the various partners and the research institutions. This will ensure that everyone will have an immediate access to 1) new, updated and quality-controlled results and 2) the same information, and that the information can be standardised in such a way as to be most useful for all involved. The work in 2005 focused on the operationalization of existing data at NP and NINA, and the establishment of a web site for the SEAPOP programme.

A joint working group of seabird scientists and information technology experts from the two institutions has been established to produce the SEAPOP web as expediently as possible. The web site will be in two parts. One will have open access for anyone who wishes to know more about SEAPOP and will present a variety of information, including links to all partners in the programme. The other part will be restricted to those with user verification, and will give access to pre-prepared data from NINA's and NP's seabird databases as well as data and results from the ongoing studies.

The primary data are and will continue to be stored in local databases maintained individually by each of the two data providers. The specific database solutions may differ between the locations, but for the web portal data will be harvested from the individual databases through an XML-based connection.

The restricted part will contain a WEB client application with aggregated data from NINA's and NP's seabird databases (SQL-server etc.). Data from NINA and NP will be distributed as Web Map Services (WMS) based on the WMS standard from Open Geospatial Consortium and collected in one user-friendly interface in the WEB client application. This will give a high degree of interoperability, and serve the users with maps, dynamic fact-sheets and metadata.

Within NP, priority was given to provide access to a historical photograph archive of the seabird colonies on Svalbard. This material includes pictures and documentation of counts made in previous years and is an important reference point for the mapping and monitoring of coastal seabirds. All pictures have been digitalized and entered into a database. Other work in 2005 focused on enabling access to older data on the demography and diets of seabirds breeding on Bjørnøya and Spitsbergen.

Similarly, NINA is in the process of reviewing all the data in the National Seabird Mapping project (Sjøfuglkartverket) to ensure that all data are made operational and available at an optimal resolution. One important task has been to develop modules for automatic updates of the estimates of population sizes of cliff-breeding seabirds in relation to the annual counts made for the National Seabird Monitoring Programme.

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Norwegian Institute for Nature Research
NINA Head Office
Postal address: NO-7485 Trondheim, NORWAY
Visiting address: Tungasletta 2, Trondheim, NORWAY
Phone: + 47 73 80 14 00
Fax: + 47 73 80 14 01
Organisation number: 9500 37 687

http://www.nina.no

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