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NINA Report

The status and trends of seabirds breeding in Norway and Svalbard

Per Fauchald, Tycho Anker-Nilssen, Robert T. Barrett, Jan Ove Bustnes, Bård-Jørgen Bårdsen, Signe Christensen-Dalsgaard, Sébastien Descamps, Sigrid Engen, Kjell Einar Erikstad, Sveinn Are Hanssen, Svein-Håkon Lorentsen, Børge Moe, Tone K. Reiertsen, Hallvard Strøm, Geir Helge Systad

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COVER PICTURE
Glaucous Gull and Common Guillemots on Bjørnøya,
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Abstract

Fauchald P, Anker-Nilssen T, Barrett RT, Bustnes JO, Bårdsen B-J, Christensen-Dalsgaard S, Descamps S, Engen S, Erikstad KE, Hanssen SA, Lorentsen S-H, Moe B, Reiertsen TK, Strøm H, Systad GH (2015) The status and trends of seabirds breeding in Norway and Svalbard – NINA Report 1151. 84pp.

This report presents the updated sizes, trends and spatial distributions of the breeding populations of 17 seabird species breeding in Norway and Svalbard. The analyses are based on available census and monitoring data from SEAPOP; the Norwegian monitoring and mapping program for seabirds. In addition, the report presents results from a species-specific literature review of the most important prey items and drivers of population change.

The report documents large-scale decadal changes in the seabird communities along the coast of Norway and Svalbard. A division of the populations into five geographical regions (North Sea & Skagerrak; Norwegian Sea; Barents Sea; Bjørnøya; and Spitsbergen) was used as a basis for the analyses of population dynamics from 1980 to present. 13 of the 35 regional seabird populations assessed have declined by more than 50% the last 25 years. 5 regional populations increased by more than 100% in the same period, while 8 populations showed large decadal fluctuations. Several populations were not assessed due to the lack of census and/or monitoring data. In order to improve the dataset, it is recommended that a census of breeding seabirds from Vesterålen to the Swedish border is completed.

Declining populations were found in all regions and included all major ecological groups (i.e.; Pelagic surface-feeding (Ps), Pelagic diving (Pd), Coastal surface-feeding (Cs), Coastal benthic-feeding (Cb) and Coastal diving (Cd) seabirds). Populations with more than a 50% decline the last 25 years were: Common Gull (Cs), Lesser Black-backed Gull (Ps) and Atlantic Puffin (Pd) in the North Sea & Skagerrak; Great Cormorant (Cd), Common Eider (Cb), Black-legged Kittiwake (Ps) and Common Guillemot (Pd) in the Norwegian Sea; Herring Gull (Cs), Great Black-backed Gull (Cs), Black-legged Kittiwake (Ps) and Brünnich's Guillemot (Pd) in the Barents Sea; Northern Fulmar (Ps) and Glaucous Gull (Ps) on Bjørnøya; and Brünnich's Guillemot (Pd) on Spitsbergen.

The populations of European Shag and Great Cormorant have shown large fluctuations with a notable increase in the population of *Phalacrocorax carbo sinensis* in North Sea & Skagerrak. Common guillemot has been increasing in the Barents Sea since the collapse in the population in the 1980s, however the population in the Norwegian Sea has been steadily declining since the early 1980s. Atlantic Puffin is declining in the North Sea and Norwegian Sea, but the population in the Barents Sea is stable or is increasing slightly. The datasets were too small to assess several of the large gull species in the Norwegian Sea. However, extensive monitoring in the North Sea & Skagerrak and recent censuses in the Barents Sea suggest declines by more than 50% in several of the gull populations in these areas. Black-legged Kittiwake has declined in all regions except for Bjørnøya. The large colonies of Brünnich's Guillemot on Spitsbergen have declined from 1.15 million pairs in 1988 to 522 000 pairs in 2013. The colony on Bjørnøya (about 100 000 pairs) has in the same period been stable or declined slightly, while the small populations on the Norwegian mainland have almost disappeared. Northern Gannet has been increasing in Norway since the establishment of this species on Runde in the 1940s. The species has expanded northward and has recently established a small colony as far north as Bjørnøya.

The review of diet studies highlighted the importance of the young age-classes of cod fish, the importance of pelagic forage fish species and in particular the importance of sandeel. However, the differences in diet among ecological groups combined with the fact that declining seabird populations were found in all regions and included all major ecological groups suggest that the recent changes in Norwegian seabird communities cannot be explained by changes in the abundance of a single group of resources alone. On the contrary, this might suggest a com-

bined effect of simultaneous changes in several prey items, possibly involving entire trophic levels. Alternatively, it might suggest that bottom-up regulation through food is less important, and that top-down mechanisms such as anthropogenic stressors and predation are more involved in the present changes.

A large number of studies have been conducted to investigate how different anthropogenic and environmental factors affect seabird populations. Factors such as fisheries by-catch, harvest and intentional killing, pollution and disturbance are all anthropogenic stressors with a well-documented negative impact. Although most of these stressors have been reduced in Norwegian waters due to the implementation of regulatory mechanisms and protection measures, they might still have impact on local populations. For example, the decline in the population of Glaucous Gull on Bjørnøya has been related to high levels of persistent organic pollutants. Several case studies suggest that predation from avian and small mammalian predators in the seabird colonies might be important, and we cannot exclude this driver as an important mechanism behind the observed declines. The large spatial and the relatively long temporal scale of the population changes observed in the present report, might suggest that fluctuations in the marine ecosystems, possibly partly due to climate change and past and present fishing pressures, might be important. This is corroborated by numerous studies documenting a direct impact from food deprivation and an indirect impact from climatic factors on seabird population dynamics. Such factors often involve complex indirect trophic links which make it difficult to point out the ultimate cause of the observed change.

We conclude that the two most likely candidates to explain the recent declines in Norwegian seabird populations are 1) increased predation in the seabird colonies from avian and mammalian predators and 2) ecosystem changes affecting the availability of prey. The impact from these drivers might be difficult to document and even more challenging to control. In contrast, more easily managed direct anthropogenic stressors such as fisheries by-catch, pollution, hunting and disturbance have either been constant or have shown a decreasing trend. Although these drivers cannot explain the recent population declines, they still contribute to the cumulative impact on seabird populations and these stressors are therefore especially important to control and minimize in rapidly declining and threatened populations.

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Contents

Foreword

To evaluate the role of food scarcity for the decline in Norwegian seabird populations and to possibly recommend mitigating management actions, a working group of seabird and marine scientists was established in 2013. To aid the evaluation, the Norwegian Environment Agency initiated and funded the task of updating and summarizing the knowledge of population trends, status and environmental drivers of the most important seabird species breeding in Norway and on Svalbard. A draft was presented to the evaluation group in October 2013. It was apparent that more work was needed, especially with respect to estimates of population sizes and dynamics. The work continued throughout 2014 and is finalized here.

Per Fauchald, March, 2015

1 Introduction

Several Norwegian seabird populations have declined in recent years (Ottersen & Auran 2007, von Quillfeldt 2010, Barrett et al. 2014, Descamps et al. 2013). On a national scale, the situation is especially worrying for pelagic, colony breeding seabirds such as Black-legged Kittiwake (*Rissa tridactyla*), Common Guillemot (*Uria aalge*), Brünnich's Guillemot (*Uria lomvia*) and Atlantic Puffin (*Fratercula arctica*) in the Norwegian Sea. As a consequence, these species are currently listed in the Norwegian Red List and/or the Red List for Svalbard as critically endangered, endangered or vulnerable (Kålås et al. 2010). On a global scale, food limitation, and in particular fluctuations in the abundance of small pelagic fish has been suggested to be critical for seabird populations (Cury et al. 2011). This has also been corroborated by Norwegian studies based on monitoring data collected by SEAPOP; the Norwegian monitoring and mapping program for seabirds. For example, the availability of the early life-stages of herring (*Clupea harengus*) is vital for successful reproduction in Atlantic Puffin breeding at Røst, Nordland (Durant et al. 2004, Barrett et al. 2012). In the Barents Sea, capelin (*Mallotus villosus*) is important for adult survival in Kittiwakes (Reiertsen et al. 2014). For Common Guillemots in the Barents Sea, adult survival is positively related to the combined abundance of juvenile fish (0-group cod *Gadus morhua*) and capelin (Erikstad et al. 2013), whereas the chick growth on Hornøya, Finnmark is related to the drift of cod larvae along the Norwegian coast (Myksvoll et al. 2013). In many cases, food limitation has been linked to fluctuations in climatic parameters such as the North Atlantic Oscillation (NAO), sea surface temperature and the sub-polar gyre (Durant et al. 2004, Sandvik et al. 2005, Sandvik et al. 2012, Descamps et al. 2013, Myksvoll et al. 2013, Sandvik et al. 2014), suggesting that climate might play an important indirect role in the observed changes.

The last comprehensive analyses of the sizes and trends of breeding seabird populations was published in 2006 for Norway (Barrett et al. 2006) and in 1994 for Svalbard (Mehlum and Bakken 1994). Monitoring suggests that population sizes have changed considerably since then (Barrett et al. 2014). Moreover, increased monitoring effort combined with censuses of breeding populations in northern Norway and Svalbard warrants an updated analysis. Based on data from SEAPOP, this report summarizes the status, distribution and trends of the breeding populations of 17 seabird species, monitored annually through the Norwegian Monitoring Program for seabirds and the seabird Monitoring program for Svalbard (both currently integrated as a part of SEAPOP), in Norway and Svalbard. In the study by Barrett et al. (2006), most population estimates were assessed from the latest data in the national seabird registry (population census data) after taking into account the most recent population trends. In the present study, we formalize this procedure by combining all data from the population census program (measuring population sizes), with all data from the monitoring program (measuring population trends). The result is time series in population estimates on local, regional and national scales. We are however, at this stage unable to estimate the confidence intervals of the estimates. When data are available, we present the trends and estimates for regional breeding populations from 1980 to present. Otherwise, we present the latest census estimate. For comparisons, the status and trends of international populations are summarized and presented in tables. To identify important prey items and human and environmental drivers affecting population dynamics, we conducted a literature review. The importance of different categories of prey is indicated by summing the number of diet studies from the Northeast Atlantic reporting specific prey items. The results are shown in a table for each species. To address important environmental drivers of population dynamics, we identified studies reporting evidence for a relationship between a specific driver and demographic or population parameters. The sum of reported cases is shown in a table for each species.

2 Materials and Methods

2.1 Norwegian populations; trends and distribution

Breeding population sizes were calculated by combining monitoring data (time series of counts from specific monitoring sites) with population census data (all-covering counts of breeding individuals in specified areas (breeding locations)). The SEAPOP program conducts regional population censuses on a ten year cycle (Anker-Nilssen et al. 2005). Thus, to obtain updated population estimates and trends, it is necessary to combine the census data with data from the monitoring sites. Standardized counts on the monitoring sites provide yearly estimates of site-specific population size and growth. Assuming that the sites are a representative sample of the total population, we combined the population growth from the monitoring sites with the census data to calculate the time-series of the number of breeding pairs on each breeding location. The estimates from the breeding locations were summed up over regions to provide regional and national population estimates and time series. We used the following four regions: North Sea & Skagerrak (Swedish border to Stadt), Norwegian Sea (Stadt to Andenes), Barents Sea (Andenes to Russian border), Bjørnøya and Spitsbergen. Because little monitoring data was available before 1980, the presented time-series span from 1980 (1988 for Spitsbergen) to 2013.

The counts of species with a dispersed breeding or where the nests are difficult to locate will tend to underestimate the true size of the breeding population. This is especially a problem for species such as Northern Fulmar (*Fulmarus glacialis*), Common Eider (*Somateria mollissima*), Common Tern (*Sterna hirundo*), Arctic Tern (*Sterna paradisaea*), Black Guillemot (*Cephus grylle*), Atlantic Puffin (*Fratercula arctica*) and Little Auk (*Alle alle*). There has not been done any attempt to correct for these sources of errors in the present report. However, a note has been made in cases where the counts are considered to grossly underestimate the true value.

Little Auks are difficult to census and estimates for most major colonies were missing. Little Auk is therefore not included in the present report. Moreover, relatively sparsely monitoring and census data combined with low fidelity of the breeding colonies made it unfeasible to make realistic estimates of the population sizes of Common Tern. Common Tern was therefore also excluded from this report. Due to insufficient monitoring and/or census data (see definitions in Chap. *2.1.5 Sample size and uncertainty*), time-series and trend corrected estimates were not presented for the following species (regions): Northern Fulmar (Norwegian Sea, Spitsbergen), Common Eider (Spitsbergen), Common Gull *Larus canus* (Norwegian Sea and Barents Sea), Herring Gull *Larus argentatus* (Norwegian Sea) Glaucous Gull *Larus hyperboreus* (Spitsbergen), Great Black-backed gull *Larus marinus* (Noregian Sea), Arctic Tern (all regions), Common Guillemot *Uria aalge* (Spitsbergen), Razorbill *Alca torda* (Norwegian Sea), Black Guillemot (all regions), Atlantic Puffin (Bjørnøya and Spitsbergen). In these cases, population estimates and maps of breeding populations were based on the most recent census count.

2.1.1 Population census data

The Norwegian seabird registry contains counts of seabirds on defined locations (breeding colonies/areas) along the coast. We retrieved data on complete location counts during the breeding season. Depending on the species specific counting method, the data reflect either the breeding population (e.g. the number of occupied nests) or the number of breeding and non-breeding individuals present at the breeding location. The resulting dataset comprised 52 931 observations from 7 262 locations and 17 species.

The seabird populations breeding in Svalbard were mapped from 2005 to 2012 and a complete census of the breeding populations in northern Norway, from Røst to the Russian boarder, was conducted in the period 2005-2009. The data from further south along the Norwegian coast (i.e. the North Sea and the southern part of the Norwegian Sea) are more fragmentary and many locations have not been counted since the 1980s. Due to different spatial references, old data from Svalbard were difficult to compare with the recent census and we therefore chose to include the recent census only. Accordingly, while the locations in Svalbard were represented

by only one count from the recent census (2005-2012), most locations on the Norwegian mainland are represented by more than one observation from the period 1980 to present. The summary of available census data for each species is presented in the table *Samples and population sizes* under each species.

2.1.2 Population monitoring data

Through the Norwegian Monitoring Program for seabirds, breeding populations of selected species are monitored annually in established monitoring plots using standardized methodology (Lorentsen & Christensen-Dalsgaard 2009). The data from the plots are summed up over specific breeding sites or colonies. Such discrete entities with a median count of individuals or nests larger than 20 are hereby referred to as monitoring *sites.* For species showing large local variation or low colony-specific abundance, data from several sites and plots were summed up over larger areas before entering the analyses (see Lorentsen & Christensen-Dalsgaard 2009).

2.1.3 Combining census and monitoring data

For each species-specific breeding location, we calculated the time-series of the number of breeding birds by combining the count data from the census with estimates of population growth. We used two sources of growth estimates; the intrinsic growth rate from the nearest monitoring sites and the predicted intrinsic growth rate from a Generalized Additive Model (GAM) analysis. The predicted values from the GAM analysis were only used when no monitoring data were available within 300 km from the breeding location.

From the monitoring data, we calculated the annual intrinsic (per capita) growth rate. The intrinsic growth rate r_{t1i} from year *t1* to year *t2* at site *i* is given by:

$$r_{t1i} = \frac{\ln N_{t2i} - \ln N_{t1i}}{t2 - t1}$$

Where N_{t1i} and N_{t2i} are site specific counts in year *t1* and *t2*.

As an estimate of the intrinsic growth rate $\widehat{r_{pt1}}$ at breeding location *p* in year *t1*, we used the inverse distance weighted (IDW) average of r_{t1i} from all monitoring sites; *i* lying within a radius of 300 km from the breeding location:

$$\widehat{r_{pt1}} = \frac{\sum_i w_i r_{t1i}}{\sum_i w_i}$$

Where $w_i = 1/d_i^2$ and d_i is the distance between the breeding location and the monitoring site *i*.

When no monitoring sites were available within a 300 km radius, we used the predicted growth rates from a GAM model. To increase the sample size in the GAM analyses, we also included the intrinsic growth rates calculated from the census database. This increased the total sample size from 2 628 (monitoring data only) to 22 993 observations (census and monitoring data combined). The intrinsic growth rate was smoothed with respect to geographic position and year. We used the ‘‘mgcv’’ library (Wood 2006) in the R software (R Development Core Team 2011). The growth rates were modeled by two covariates: Year (*t*) and *Dcoast*. *Dcoast* is the position of the breeding location along the Norwegian coast, measured as the distance in km from the Swedish border in southeast to the breeding location along the Norwegian sea-boundary. To allow for different development of the growth rate at different positions along the coast, the covariates were modeled by a two-dimensional smooth function:

$$r_{ti} = I + s(t, D_{coast}) + e$$

Where *I* is the intercept and *e* is the residual error (assuming a normally distributed error).

The variation in r_{ti} was inversely related to population size, and was especially large for populations < 20 individuals. To remove the effects of extreme values, we excluded observations where $(N_{t1} + N_{t2})/2 < 20$ and where $|r_{ti}| > 2$.

Based on the fitted models, we used the ''predict'' function in the ''mgcv'' library to predict the average growth rate on each breeding location from 1970 to 2013.

2.1.4 Calculating time-series

When only one census value was present for a given breeding location, the calculation of the time series based on estimated intrinsic growth rates is straight forward; i.e. by calculating the population size backward; $\widehat{N_{t-1}} = N_t/exp(r_{t-1})$ and forward; $\widehat{N_{t+1}} = N_t exp(r_t)$ from the time of the census.

When two or more census values were present, we used the following least-square procedure to fit the time-series to the data. First, we calculated the census-based intrinsic growth rate between consecutive counts. For each time-step between consecutive counts, we calculated the average of the census-based and monitoring-based growth rates. Based on these average values, a time-series of $\widehat{N_t}$ was fitted by minimizing $\sum_t \left(log\widehat{N_t} - logN_t\right)^2$.

2.1.5 Sample size and uncertainty

Two main sources of error are likely to cause uncertainty in the estimates of populations sizes and trends: 1) Measurement errors associated with the sampling procedure and 2) The extrapolation of growth rates to nearby breeding sites with an unknown population growth. The applied methods make use of all available data however the complexity of the analyses, involving step-wise analyses on two more or less independent datasets made it, at present, unfeasible to calculate the associated confidence levels. It is nevertheless important to assess the relative uncertainty of the estimates and trends. Several measures indicating the uncertainty of the analyses is presented in the species-specific tables (see tables *Samples and population sizes*). The number of independent time series (i.e.; *Total no. series* and *No. long series*) is important for the precision of the population trajectories as well as the trend-corrected population estimates. Similarly, the frequency of population censuses (i.e.; *No. counts* relative to *No. locations*) and the time interval covered by the censuses (i.e.; the time interval from the *Year of first count* to the *Year of last count*) is also important regarding the precision of the population trajectory. Finally, in order to achieve a precise estimate of the present population size, it is important that the last census is up-to-date (i.e.; *Year of last count* is close to the present). Regional population trajectories and trend-corrected estimates of population size (*2013-estimate*) are consequently only given when 1) the regional population is represented by at least two long time series (monitoring covers the time span from the 1980s to present with n > 20 years) or equivalent representative sets of shorter time-series, **or** 2) when each census location, on average, has been counted at least twice and the median year of first count is from before 1990 while the median year of last count is more recent than 2000.

2.2 Literature review

A review of the international population status, diet and the most important drivers of change, was based on already published information. The review was mainly based on searches in the Thomson Reuters Web of Science database using each species' scientific name as a search topic (the literature search ended in September 2013). In addition, we also included information from the 'grey literature' found by searches on the internet and communication with seabird scientists. The resulting number of studies with respect to species and subject area (i.e. diet and drivers of change) is shown in table 1. The species-specific reference lists are given in the Appendix.

Status and trends for international populations were retrieved from the literature and were presented in species-specific tables.

To assess the most important prey items, we summed the number of cases from the Northeast Atlantic reporting different categories of prey items. We separated between the following categories: Gadoids, Polar cod, Capelin, Herring, Sprat, Sandeel, Other fish, Squid, Crustaceans, Other invertebrates, Offal and Other. Because the diet might differ considerably among seasons and between chicks and adults (Barrett et al. 2007), we separated studies from non-breeding and summer, and studies of chicks and adults. To avoid double-counting, we summed the diet categories over colonies/areas and seasons/age class. Accordingly, one study might report from several colonies/areas and seasons/age classes, while several studies might report from one single colony/area and season/age class. One case is accordingly a reported prey category from a given colony/area and season/age class.

Drivers of population dynamics was assessed by summing the number of reported populations/colonies where the different drivers have been demonstrated to play a role. The results are shown for each species in the table “Drivers of population dynamics”. Similarly to the diet studies, we summed the drivers over colonies/areas to avoid double-counting, and one case is a reported driver from a given colony/area. Cases from Norwegian populations are shown in parentheses. The set of potential drivers represents different categories that are not mutually exclusive. The categories ‘climate’ and ‘climate and food’, for example, separate between studies that only discuss effects of climate from those who document climatic effects being manifested through climatic induced effects on the birds’ prey species. Direct drivers refer to drivers with a direct impact on survival and/or reproduction. Indirect drivers are drivers operating mainly through food availability. We also separated between direct effects on survival and breeding success reported as incidental observations, and effects measured as quantitative effects on population parameters.

Table 1. *Number of studies and cases included in the literature review of seabird diet and drivers of population change. “Studies” are the number of published studies encompassed by the review. “Diet cases” are the sum of reported prey categories from all colonies/areas and seasons/age groups. “Drivers of change cases” are the sum of reported drivers from all colonies/areas.*

	Diet		Drivers of change	
	Studies	Cases	Studies	Cases
Northern fulmar (*Fulmarus glacialis*)	9	69	21	25
Northern gannet (*Morus bassanus*)	14	28	21	15
Great cormorant (*Phalacrocorax carbo*)	7	35	23	17
European shag (*Phalacrocorax aristotelis*)	13	38	20	20
Common eider (*Somateria mollissima*)	8	11	53	57
Common gull (*Larus canus*)	4	6	11	8
Lesser black-backed gull (*Larus fuscus*)	12	31	19	24
Herring gull (*Larus argentatus*)	15	39	36	34
Glaucous gull (*Larus hyperboreus*)	13	55	20	19
Great black-backed gull (*Larus marinus*)	7	23	17	25
Black-legged kittiwake (*Rissa tridactyla*)	23	90	49	57
Arctic tern (*Sterna paradisaea*)	9	12	14	19
Common guillemot (*Uria aalge*)	23	52	50	50
Brünnich's guillemot (*Uria lomvia*)	14	62	18	29
Razorbill (*Alca torda*)	9	9	20	21
Black guillemot (*Cephus grylle*)	8	16	12	21
Atlantic puffin (*Fratercula arctica*)	25	59	46	32
Total	213	635	450	473

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3 Results

3.1 Figure and table legends

Legends for the species-specific tables and figures are given below.

3.1.1 Samples and population sizes (table)

The table gives a description of the two datasets (monitoring and census data) and the estimates of the regional population sizes. For the monitoring data, the table shows the total number of monitoring series (*Total no. series:* Number of monitoring *sites* with more than 3 years of monitoring) and the number of series covering the period from the 1980s to the 2010s (*No. long series:* Number of monitoring *sites* with more than 25 and 20 years of monitoring on the Norwegian mainland and Svalbard respectively). For the census data, the table shows the number of breeding locations (*No. locations*) where the species has been observed, the total number of counts on these locations (*No. Counts*), the median year of the first count (*Year first count*) and the median year of the last count (*Year last count*). Population estimates are given as the number of breeding pairs summed over all breeding locations within each region. *Last count* is the population sizes calculated from the last count in the census data. *2013-estimate* is the population estimates for 2013; i.e. population sizes are corrected for recent trends. *2005-estimate* is the population sizes given by Barrett et al. (2006). The trend corrected estimates (*2013-estimates*) are only given when monitoring and/or census data are considered to be adequate (see Chap. *2.1.5 Sample size and uncertainty*). Estimates of the global populations were retrieved from the literature.

3.1.2 Norwegian populations; trends and distribution (figure)

Regional population trajectories are given when monitoring and/or census data are considered to be adequate (see Chap. *2.1.5 Sample size and uncertainty*). Maps of breeding sites are given for either the last count or, when available (see Chap. *2.1.5 Sample size and uncertainty*), the trend corrected 2013-estimate.

3.1.3 International populations; status and trends (table)

Population sizes and recent trends were retrieved from the literature.

3.1.4 Diet (table)

Number of cases in the literature documenting different prey items during summer (adult), summer (chick(s)) and winter respectively. A case is a reported prey category from a given colony/area and season/age class.

3.1.5 Drivers of population dynamics (table)

Number of cases in the literature documenting different drivers of population dynamics. The numbers in parentheses represent the number of cases from Norwegian populations. A case is a reported driver from a given colony/area.

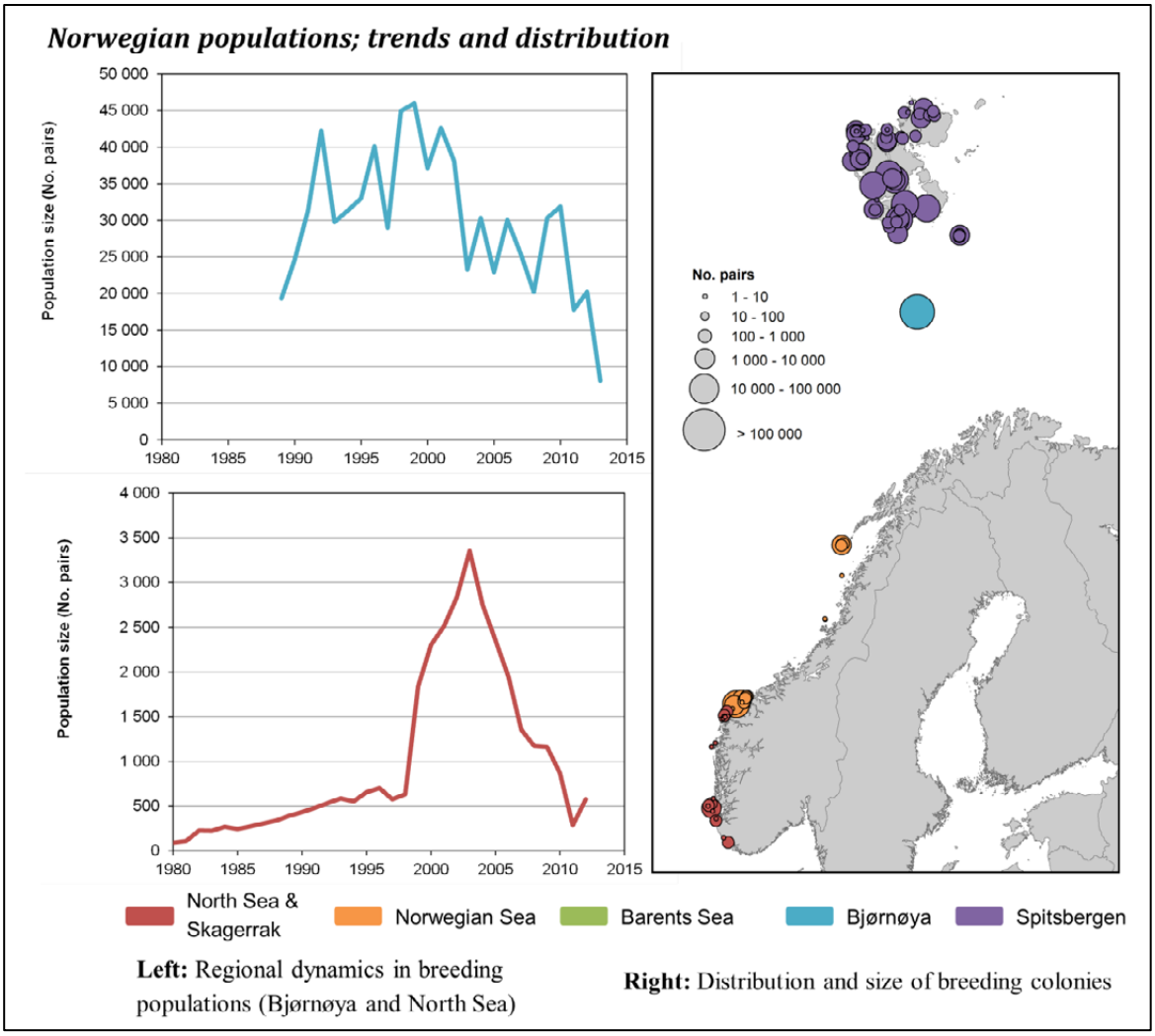
3.2 Northern Fulmar *Fulmarus glacialis*

Ecological niche	Pelagic, surface-feeder
Redlist Norway	Near threatened
Redlist, Svalbard	Not listed

Samples and population sizes (no. of breeding pairs)

	Monitoring data		*Census data*				*Population estimates*		
	Total no. series	*No. long series*	*No. loc-ations*	*No. Counts*	*Year first count*	*Year last count*	*Last count*	*2013-estimate*	*2005-esti-mate*[1]
Norwegian mainland									
North Sea & Skagerrak	4	0	22	129	1984	2006	642	575	1 520
Norwegian Sea	1	0	21	52	1980	1985	5 958		7 500
Barents Sea	1	0	3	26	1981	2005	0		100
Total							**6 600**		**9 120**
Svalbard									
Bjørnøya	1	1	1	1	2006	2006	30 000	8 084	
Spitsbergen[3]	1	0	62	62	2008	2008	34 553		
Total							**64 553**		
Global population[2]									**5 400 000 - 7 100 000**

[1]Barrett et al. (2006), [2]Mitchell et al. (2004), [3]The count grossly underestimates the population on Spitsbergen.



International populations; status and trends

From Mitchell et al. (2004), unless stated otherwise

Region	Population size (number of pairs)	Population trend
Sweden		
Denmark	0-5	
UK & Ireland	539 000	No overall trend[1]
Faeroes	600 000	Declining[1]
Iceland	1 000 000-2 000 000	Declining[1]
Greenland	80 000	No overall trend[1]
Russia	26 000	
Finland		
Europe (rest)	1 208	

[1]Frederiksen (2010)

Diet (no. of cases)

Prey item	Summer		Non-breeding
	Adult	Chicks	
Gadoids	1	2	
Polar cod	8		2
Capelin	3	1	
Herring	1	2	
Sprat			
Sandeel	2	2	
Other fish	2		1
Squid	9	2	1
Crustaceans	1	3	2
Other invertebrates	6		1
Offal	4	3	1
Other			

Drivers of population dynamics

No. of reported cases, Norwegian studies in parentheses

Drivers		Episodic observations		Population level effects		
		Breeding success	Adult survival	Breeding success	Adult survival	Population growth
Direct	*Climate hazards*			2		
	Fisheries bycatch		3 (2)			
	Harvest & intentional killing	5	6 (1)			
	Pollution		2 (1)	1 (1)		
	Predation & parasitism	1				1 (1)
	Disturbance					
	Human infrastructure					
	Disease					
Indirect	*Climate*			1	1	1
	Climate & food					
	Trophic interactions & food					
	Fisheries & food-competition					
	Fisheries & food- discards					1
	Food			1		
	Food (sum)			1		1

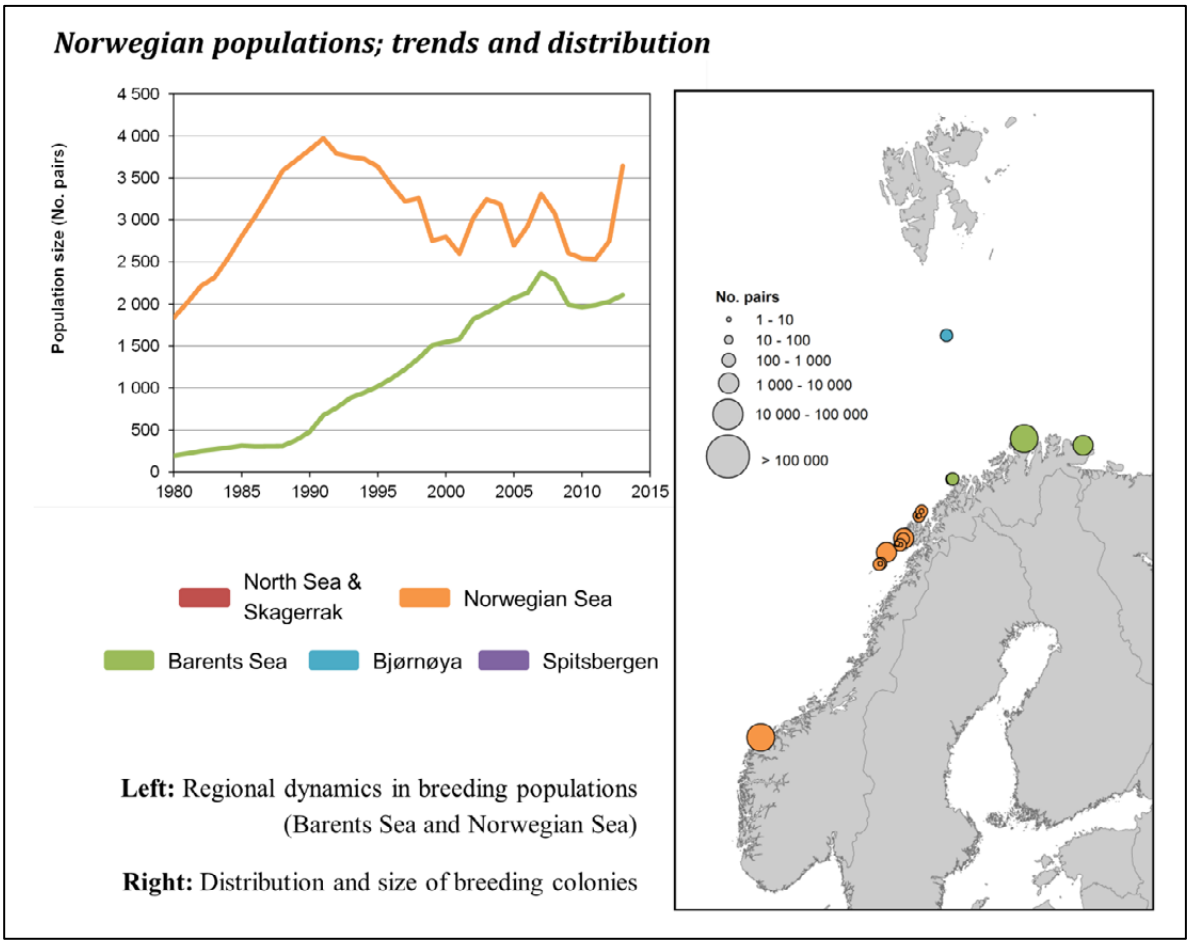
3.3 Northern Gannet *Morus bassanus*

Ecological niche	Pelagic, plunge diving
Redlist Norway	Not listed
Redlist, Svalbard	Not listed

Samples and population sizes (no. of breeding pairs)

	Monitoring data		*Census data*				*Population estimates*		
	Total no. series	*No. long series*	*No. loc-ations*	*No. Counts*	*Year first count*	*Year last count*	*Last count*	*2013-estimate*	*2005-esti-mate*[1]
Norwegian mainland									
North Sea & Skagerrak	0	0					0		0
Norwegian Sea	8	6	22	223	1992	2013	4 644	3 646	2 750
Barents Sea	3	2	5	58	2001	2013	2 098	2 106	1750
Total							**6 742**	**5 752**	**4 500**
Svalbard									
Bjørnøya	0	0	1	1		2014	11		
Spitsbergen									
Total							**11**		
Global population[2]									**390 000**

[1]Barrett et al. (2006), [2]Mitchell et al. (2004)



International populations; status and trends

From Mitchell et al. (2004), unless stated otherwise

Region	*Population size (number of pairs)*	*Population trend*
Russia	35	
Faeroe Islands	2 340	Increasing[1]
Iceland	25 400	Increasing[1]
UK & Ireland	263 000	Increasing (Scotland)[1]
France	14 900	
Germany	69	
Canada	77 700	

[1]Frederiksen (2010)

Diet (no. of cases)

Prey item	Summer		Non-breeding
	Adult	Chicks	
Gadoids		2	
Polar cod			
Capelin	1	1	
Herring	3	5	
Sprat	2		
Sandeel	1	2	
Other fish	4	4	
Squid	1	1	
Crustaceans			
Other invertebrates			
Offal	1		
Other			

Drivers of population dynamics

No. of reported cases, Norwegian studies in parentheses

Drivers		*Episodic observations*		*Population level effects*		
		Breeding success	*Adult survival*	*Breeding success*	*Adult survival*	*Population growth*
Direct	*Climate hazards*					
	Fisheries bycatch		2 (1)			
	Harvest & intentional killing		1 (1)			
	Pollution	2	6 (1)			
	Predation & parasitism			1 (1)		1 (1)
	Disturbance					
	Human infrastructure					
	Disease					
Indirect	*Climate*					
	Climate & food					1
	Trophic interactions & food					
	Fisheries & food-competition					
	Fisheries & food- discards					
	Food			1		
	Food (sum)			1		1

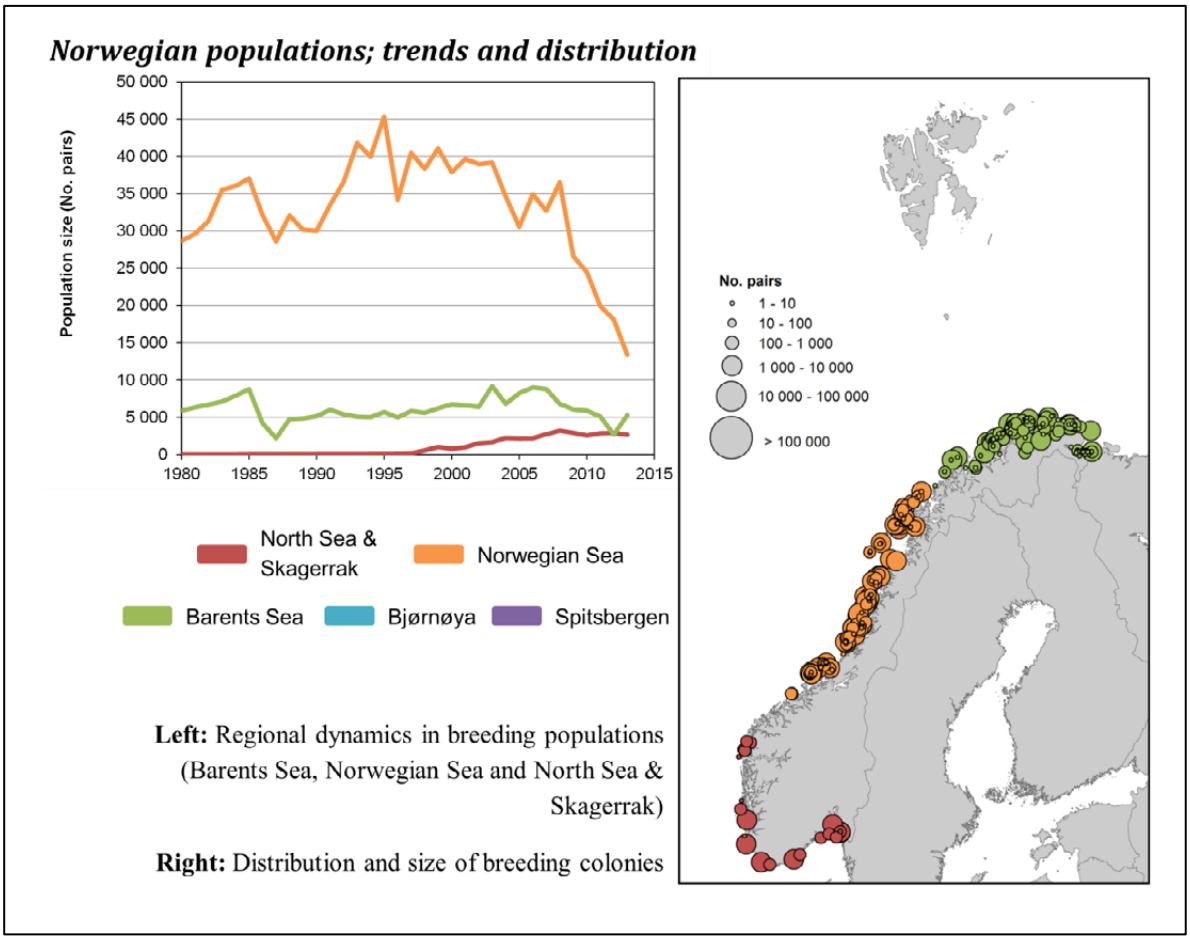
3.4 Great Cormorant *Phalacrocorax carbo*[1]

Ecological niche	Coastal, diving
Redlist, Norway	Not listed
Redlist, Svalbard	-

Samples and population sizes (no. of breeding pairs)

	Monitoring data		*Census data*				*Population estimates*		
	Total no. series	*No. long series*	*No. loc-ations*	*No. Counts*	*Year first count*	*Year last count*	*Last count*	*2013-estimate*	*2005-esti-mate*[1]
Norwegian mainland									
North Sea & Skagerrak	10	4	31	205	2002	2010	2 728	2 653	800
Norwegian Sea	22	12	162	1314	1990	2011	23 577	13 376	20 000
Barents Sea	30	2	155	820	1984	2006	7 185	5 270	10 000
Total							**33 490**	**21 299**	**30 800**
Svalbard									
Bjørnøya							0		
Spitsbergen							0		
Total							**0**		
Global population[2]									**570 000 – 590 000**

[1]Barrett et al. (2006), [2]Mitchell et al. (2004)



[1] *P. carbo carbo* and *P. carbo sinsensis*

International populations; status and trends

From Mitchell et al. (2004), unless stated otherwise

Region	***Population size (number of pairs)***	***Population trend***
UK & Ireland	13 700	Declining (Scotland)[1]
Denmark	40 126	Declining[1]
Sweden	27 300	Increasing[1]
Central and east Europe	100 000 -120 000	
Greenland	2 000-3 000	Increasing[1]
Iceland	2 200	Increasing[1]
Russia	31 681- 46 681	
Eastern Palearctic	100 000	
Southern and western Africa	100 000	
Northwest Africa	10 000	
Canada	6 300	
Pacific	100 000	

[1]Frederiksen (2010)

Diet (no. of cases)

Prey item	**Summer**		**Non-breeding**
	Adult	**Chicks**	
Gadoids	7	2	4
Polar cod			
Capelin	1		
Herring	1		1
Sprat			
Sandeel	2		
Other fish	7	1	6
Squid			
Crustaceans	1		2
Other invertebrates			
Offal			
Other			

Drivers of population dynamics

No. of reported cases, Norwegian studies in parentheses

Drivers		***Episodic observations***		***Population level effects***		
		Breeding success	***Adult survival***	***Breeding success***	***Adult survival***	***Population growth***
Direct	*Climate hazards*					
	Fisheries bycatch		3 (1)			
	Harvest & intentional killing	1	5			1
	Pollution		1 (1)			
	Predation & parasitism					1
	Disturbance					
	Human infrastructure					
	Disease					
Indirect	*Climate*				1	
	Climate & food					
	Trophic interactions & food					
	Fisheries & food-competition					
	Fisheries & food- discards					
	Food			2 (1)	2	
	Food (sum)			2 (1)	2	

3.5 European Shag *Phalacrocorax aristotelis*

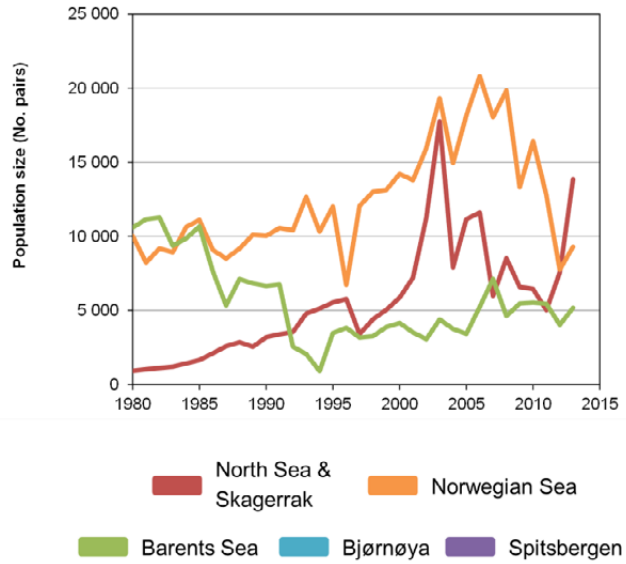
Ecological niche	Coastal, diving
Redlist, Norway	Not listed
Redlist, Svalbard	-

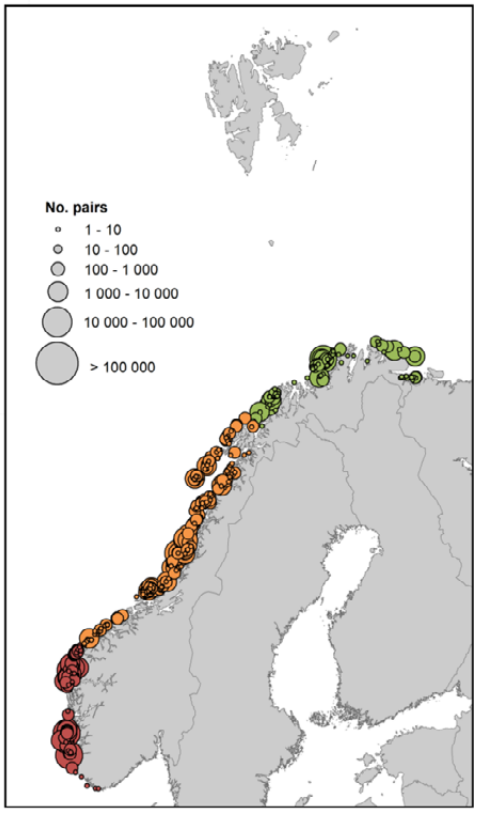
Samples and population sizes (no. of breeding pairs)

	Monitoring data		*Census data*				*Population estimates*		
	Total no. series	*No. long series*	*No. loc-ations*	*No. Counts*	*Year first count*	*Year last count*	*Last count*	*2013-estimate*	*2005-esti-mate*[1]
Norwegian mainland									
North Sea & Skagerrak	11	0	99	361	1992	2008	5 349	13 861	5 000
Norwegian Sea	3	3	315	626	1982	1985	11 043	9303	13 000
Barents Sea	7	1	118	338	1983	1987	6 541	5 177	6 000
Total							**22 933**	**28 341**	**24 000**
Svalbard									
Bjørnøya							0		
Spitsbergen							0		
Total							**0**		
Global population[2]									**73 000 – 83 000**

[1]Barrett et al. (2006), [2]Mitchell et al. (2004)

Norwegian populations; trends and distribution





Left: Regional dynamics in breeding populations (Barents Sea, Norwegian Sea and North Sea & Skagerrak)

Right: Distribution and size of breeding colonies

International populations; status and trends

From Mitchell et al. (2004), unless stated otherwise

Region	***Population size (number of pairs)***	***Population trend***
Albania	20	
Croatia	2 000-4 000	
Faeroes	1000	No overall trend[1]
France (Atlantic)	6 059-6 130	
France (Corsica)	971	
Gibraltar	7-8	
Greece	1 000	
Iceland	8 000-9 000	Declining[1]
Italy (Sardinia)	1 600- 2 000	
Libya	50	
Morocco	20-40	
Portugal	150	
Russia	350	
Spain	3 962	
Tunisia	30	
Turkey	50-350	
UK & Ireland	29 370	Declining (Scotland)[1]
Ukraine	250-400	

[1]Frederiksen (2010)

Diet (no. of cases)

Prey item	**Summer**		**Non-breeding**
	Adult	**Chicks**	
Gadoids	5		3
Polar cod			
Capelin			
Herring			
Sprat			
Sandeel	9	4	5
Other fish	3	1	5
Squid			
Crustaceans	1	1	1
Other invertebrates			
Offal			
Other			

Drivers of population dynamics

No. of reported cases, Norwegian studies in parentheses

Drivers		***Episodic observations***		***Population level effects***		
		Breeding success	***Adult survival***	***Breeding success***	***Adult survival***	***Population growth***
Direct	*Climate hazards*			2	1	1
	Fisheries bycatch		2 (1)			
	Harvest & intentional killing		3 (1)			1
	Pollution		3 (1)	1		1
	Predation & parasitism					
	Disturbance					
	Human infrastructure					
	Disease					
Indirect	*Climate*					
	Climate & food					1 (1)
	Trophic interactions & food					
	Fisheries & food-competition					
	Fisheries & food- discards					
	Food			2 (1)		2 (1)
	Food (sum)			2 (1)		3 (2)

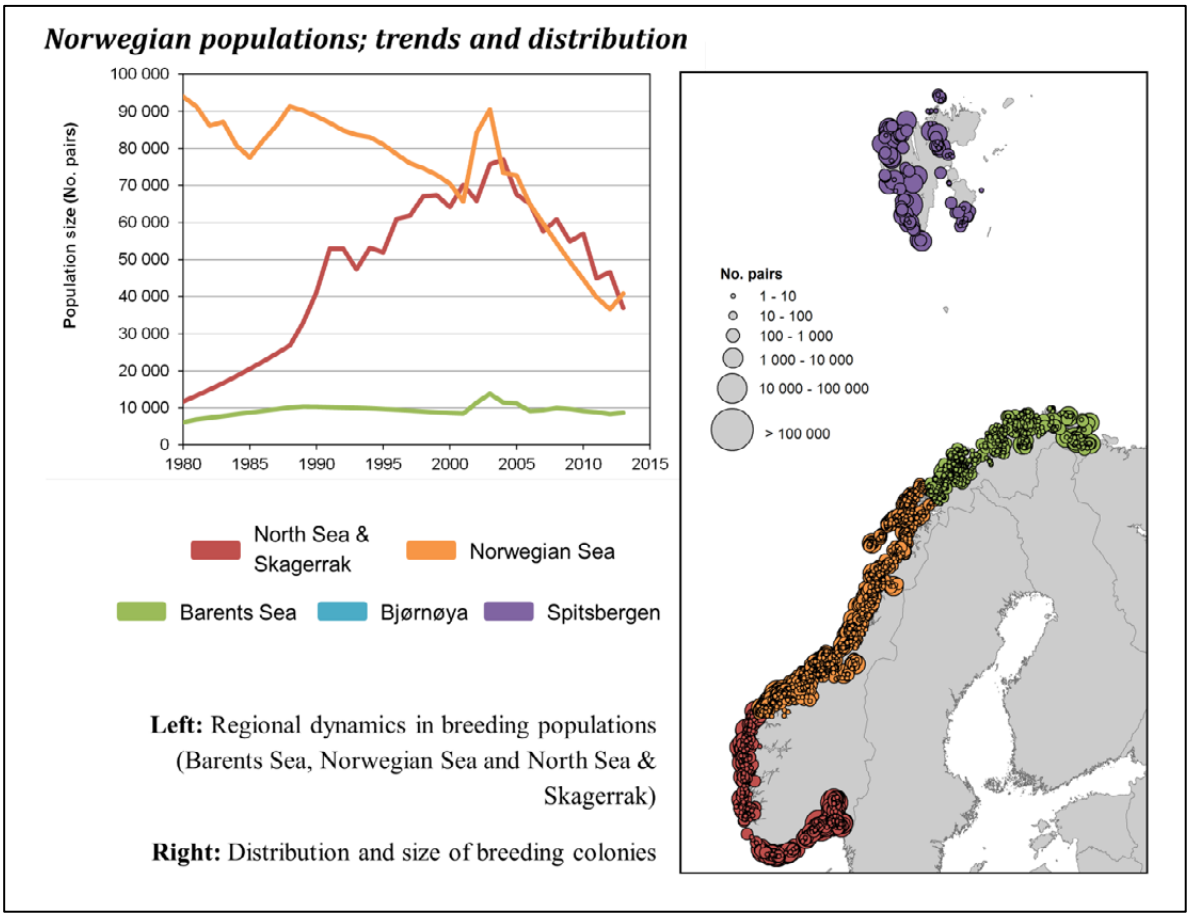
3.6 Common Eider *Somateria mollissima*

Ecological niche	Coastal, benthic-feeding
Redlist Norway	Not listed
Redlist, Svalbard	Not listed

Samples and population sizes (no. of breeding pairs)

	Monitoring data		*Census data*				*Population estimates*		
	Total no. series	*No. long series*	*No. loc-ations*	*No. Counts*	*Year first count*	*Year last count*	*Last count*	*2013-estimate*	*2005-esti-mate*[1]
Norwegian mainland									
North Sea & Skagerrak	16	3	794	3502	1983	1993	36 298	36 917	55 000
Norwegian Sea	27	1	2471	4243	1988	1988	84 502	40 812	100 000
Barents Sea	21	0	840	2505	1988	2005	9 004	8 777	35 000
Total							**129 804**	**86 506**	**190 000**
Svalbard									
Bjørnøya							100		
Spitsbergen	1	1	116	116	2008	2008	17 000		
Total							**17 100**		
Global population[2]									**3 100 000 – 3 800 000**

[1]Barrett et al. (2006), [2]Mitchell et al. (2004)



International populations; status and trends

From Mitchell et al. (2004), unless stated otherwise

Region	***Population size (number of pairs)***	***Population trend***
Finland		
Sweden	30 000[1]	Declining[1]
Denmark	2 200[1]	Increasing[1]
Faeroes	6 000[1]	Increasing[1]
UK		
Iceland	300 000[1]	No overall trend[1]
Greenland	6 000[1]	Increasing[1]
Canada-Atlantic		
Canada-Pacific		Stable[2]
US-Pacific		Stable[2]

[1]Frederiksen (2010), [2]Flint (2013)

Diet (no. of cases)

Prey item	**Summer**		**Non-breeding**
	Adult	**Chicks**	
Gadoids			
Polar cod			
Capelin			
Herring			
Sprat			
Sandeel			
Other fish			1
Squid			
Crustaceans	2		1
Other invertebrates	2		5
Offal			
Other			

Drivers of population dynamics

No. of reported cases, Norwegian studies in parentheses

Drivers		***Episodic observations***		***Population level effects***		
		Breeding success	***Adult survival***	***Breeding success***	***Adult survival***	***Population growth***
Direct	*Climate hazards*					
	Fisheries bycatch		3			
	Harvest & intentional killing	5 (1)	5			1
	Pollution		5 (4)	2	1	1 (1)
	Predation & parasitism		1 (1)	5 (1)	1 (1)	3 (3)
	Disturbance					1
	Human infrastructure		1			2 (1)
	Disease		4	2	2 (1)	2
Indirect	*Climate*					4 (1)
	Climate & food		1			
	Trophic interactions & food					
	Fisheries & food-competition		1			
	Fisheries & food- discards					
	Food		1	1		2
	Food (sum)		3	1		2

3.7 Common Gull *Larus canus*

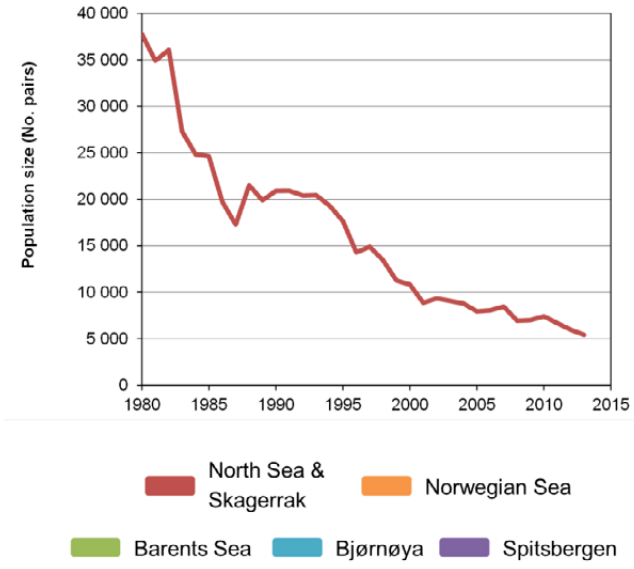
Ecological niche	Coastal, surface-feeding
Redlist, Norway	Near threatened
Redlist, Svalbard	-

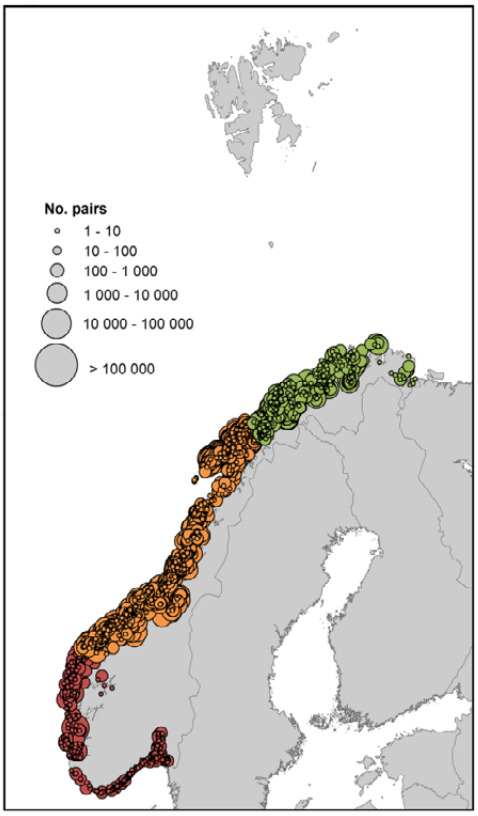
Samples and population sizes (no. of breeding pairs)

	Monitoring data		*Census data*				*Population estimates*		
	Total no. series	*No. long series*	*No. loc-ations*	*No. Counts*	*Year first count*	*Year last count*	*Last count*	*2013-estimate*	*2005-esti-mate*[1]
Norwegian mainland									
North Sea & Skagerrak	12	8	1097	4094	1978	1982	25 407	5 397	50 000
Norwegian Sea	4	0	1765	2629	1982	1983	37 262		75 000
Barents Sea	1	0	555	756	1988	1989	10 500		10 000
Total							73 169		135 000
Svalbard									
Bjørnøya							3		
Spitsbergen							0		
Total							**3**		
Global population[2]									**410 000 – 660 000**

[1]Barrett et al. (2006), [2]Mitchell et al. (2004)

Norwegian populations; trends and distribution





Left: Regional dynamics in breeding populations (North Sea & Skagerrak)

Right: Distribution and size of breeding colonies

International populations; status and trends

From Mitchell et al. (2004), unless stated otherwise

Region	***Population size (number of pairs)***	***Population trend***
Sweden	100 000-200 000	No overall trend[1]
Finland	50 000-70 000	Increasing[2]
Russia	40 000-60 000	
Denmark	25 000	Declining[1]
UK & Ireland	49 600	Increasing (Scotland)[1]
Faeroes	1 000	No overall trend[1]
Iceland	350-450	No overall trend[1]
Europe	37 000-46 000	

[1]Frederiksen (2010), [2]Virkkala (2006)

Diet (no. of cases)

Prey item	**Summer**		**Non-breeding**
	Adult	**Chicks**	
Gadoids			
Polar cod			
Capelin			
Herring			1
Sprat			
Sandeel			
Other fish			1
Squid			
Crustaceans			
Other invertebrates	2		1
Offal			
Other	1		

Drivers of population dynamics

No. of reported cases, Norwegian studies in parentheses

Drivers		***Episodic observations***		***Population level effects***		
		Breeding success	***Adult survival***	***Breeding success***	***Adult survival***	***Population growth***
Direct	*Climate hazards*					
	Fisheries bycatch					
	Harvest & intentional killing	1 (1)	1 (1)			
	Pollution					
	Predation & parasitism	1	1	2	1	1
	Disturbance					
	Human infrastructure					
	Disease					
Indirect	*Climate*					
	Climate & food					
	Trophic interactions & food					
	Fisheries & food-competition					
	Fisheries & food- discards					
	Food					
	Food (sum)					

3.8 Lesser Black-backed Gull *Larus fuscus*[2]

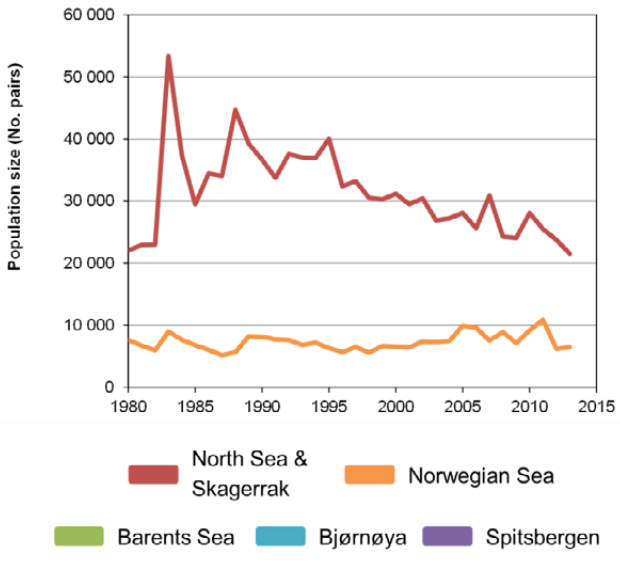
Ecological niche	Pelagic, surface-feeding
Redlist Norway	Not listed
Redlist, Svalbard	-

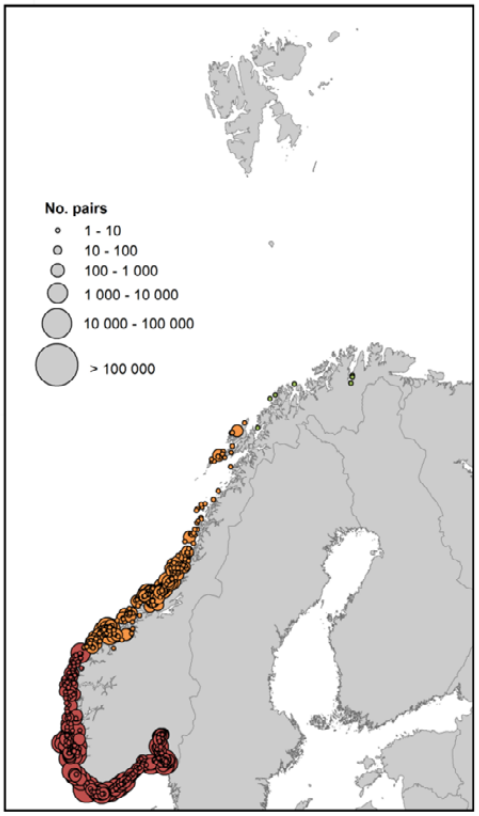
Samples and population sizes (no. of breeding pairs)

	Monitoring data		*Census data*				*Population estimates*		
	Total no. series	*No. long series*	*No. loc-ations*	*No. Counts*	*Year first count*	*Year last count*	*Last count*	*2013-estimate*	*2005-esti-mate*[1]
Norwegian mainland									
North Sea & Skagerrak	18	12	580	3118	1980	1993	22 749	21 545	48 000
Norwegian Sea	26	0	495	1484	1982	1983	5 841	6 481	c. 2000
Barents Sea	0	0	29	58	1985	2005	85	25	< 300
Total							28 675	28 051	50 300
Svalbard									
Bjørnøya							0		
Spitsbergen							0		
Total							**0**		
Global population[2]									**267 000 – 316 000**

[1]Barrett et al. (2006), [2]Mitchell et al. (2004)

Norwegian populations; trends and distribution





Left: Regional dynamics in breeding populations (Norwegian Sea and North Sea & Skagerrak)

Right: Distribution and size of breeding colonies

[2] *L. fuscus fuscus* and *L. fuscus intermedius*

International populations; status and trends

From Mitchell et al. (2004), unless stated otherwise

Region	*Population size (number of pairs)*	*Population trend*
Sweden	15 000-20 000	No overall trend[1]
Finland	6 000-8 000	Declining[2]
Russia	2 120-2 300	
UK & Ireland	121 800	Stable or declining[3]
Denmark	4 400	Declining[1]
Faeroes	9 000	Declining[1]
Iceland	25 000	Declining[1]
Greenland	>700	Increasing[1]
Europe	85 000-110 000	

[1]Frederiksen (2010), [2]Virkkala (2006), [3]JNCC (2013)

Diet (no. of cases)

Prey item	Summer		Non-breeding
	Adult	Chicks	
Gadoids		2	
Polar cod			
Capelin			
Herring	1	3	
Sprat	1	1	
Sandeel		1	
Other fish	4	1	
Squid			
Crustaceans	2		
Other invertebrates	5	1	
Offal	4		
Other	3	2	

Drivers of population dynamics

No. of reported cases, Norwegian studies in parentheses

Drivers		*Episodic observations*		*Population level effects*		
		Breeding success	*Adult survival*	*Breeding success*	*Adult survival*	*Population growth*
Direct	*Climate hazards*					1
	Fisheries bycatch					
	Harvest & intentional killing	2	2	1		1
	Pollution			3 (1)	1 (1)	1
	Predation & parasitism			2		1
	Disturbance					
	Human infrastructure					
	Disease	1	2			
Indirect	*Climate*					1 (1)
	Climate & food					1
	Trophic interactions & food					
	Fisheries & food-competition					
	Fisheries & food- discards					
	Food			1		3
	Food (sum)					3

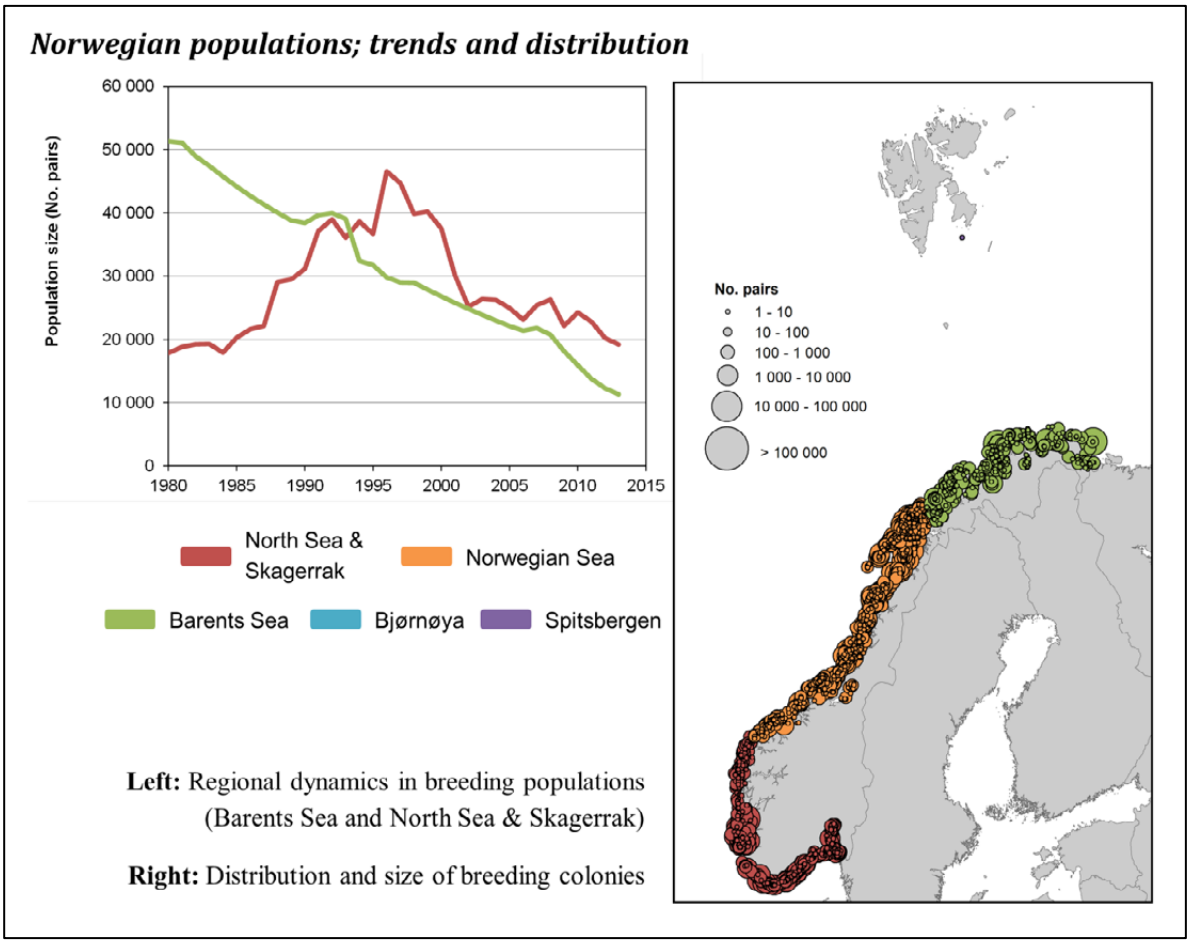
3.9 Herring Gull *Larus argentatus*

Ecological niche	Coastal, surface-feeding
Redlist Norway	Not listed
Redlist, Svalbard	-

Samples and population sizes (no. of breeding pairs)

	Monitoring data		*Census data*				*Population estimates*		
	Total no. series	*No. long series*	*No. loc-ations*	*No. Counts*	*Year first count*	*Year last count*	*Last count*	*2013-estimate*	*2005-esti-mate*[1]
Norwegian mainland									
North Sea & Skagerrak	26	11	835	4039	1978	1986	16 260	19 201	33 000
Norwegian Sea	7	0	1466	2280	1982	1983	41 553		100 000
Barents Sea	1	0	664	1376	1987	2005	33 631	11 429	100 000
Total							**91 444**		**233 000**
Svalbard									
Bjørnøya							0		
Spitsbergen							0		
Total							**0**		
Global population[2]									**1 100 000 – 1 200 000**

[1]Barrett et al. (2006), [2]Mitchell et al. (2004)



International populations; status and trends

From Mitchell et al. (2004), unless stated otherwise

Region	*Population size (number of pairs)*	*Population trend*
Sweden	60 000-100 000	Declining[1]
Finland	28 300	Increasing[2]
UK & Ireland	149 500	Declining[3]
Faeroes	1 500	No overall trend[1]
Iceland	2 500	Increasing?[1]
Greenland	<50[1]	No overall trend[1]
Europe	800 000 – 850 000	

[1]Frederiksen (2010), [2] Virkkala (2006), [3]JNCC (2013)

Diet (no. of cases)

Prey item	Summer		Non-breeding
	Adult	Chicks	
Gadoids			
Polar cod			
Capelin			
Herring	1	1	
Sprat		1	
Sandeel			
Other fish	4	4	2
Squid			
Crustaceans	3	2	
Other invertebrates	5	3	
Offal	1		
Other	6	5	1

Drivers of population dynamics

No. of reported cases, Norwegian studies in parentheses

Drivers		*Episodic observations*		*Population level effects*		
		Breeding success	*Adult survival*	*Breeding success*	*Adult survival*	*Population growth*
Direct	*Climate hazards*	1				
	Fisheries bycatch		1 (1)			
	Harvest & intentional killing	3	1 (1)	3		3
	Pollution		3 (3)			1 (1)
	Predation & parasitism	2		1		2
	Disturbance					
	Human infrastructure					
	Disease	1	2	1		1
Indirect	*Climate*					
	Climate & food					
	Trophic interactions & food				1	
	Fisheries & food-competition					
	Fisheries & food- discards			1		4
	Food	2 (2)				
	Food (sum)	2 (2)		1	1	4

3.10 Glaucous Gull *Larus hyperboreus*

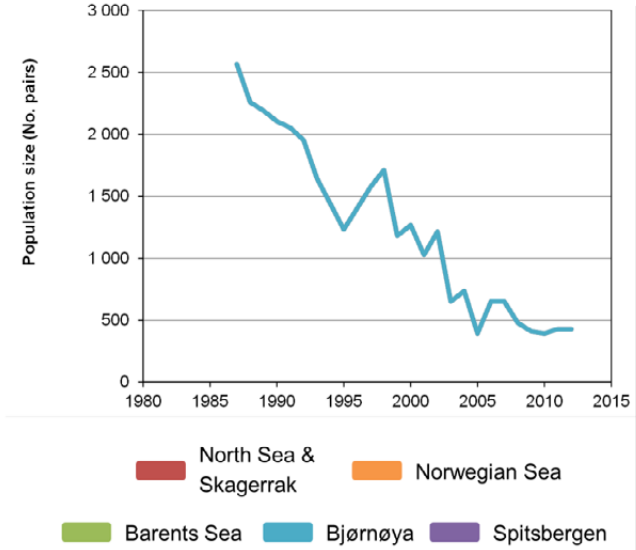
Ecological niche	Pelagic, surface-feeding
Redlist, Norway	-
Redlist, Svalbard	Near threatened

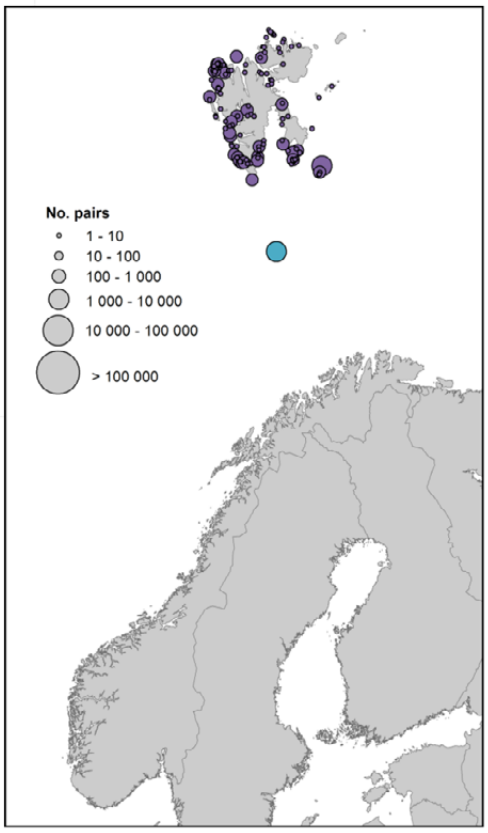
Samples and population sizes (no. of breeding pairs)

	Monitoring data		*Census data*				*Population estimates*		
	Total no. series	*No. long series*	*No. loc-ations*	*No. Counts*	*Year first count*	*Year last count*	*Last count*	*2013-estimate*	*2005-esti-mate*[1]
Norwegian mainland									
North Sea & Skagerrak							0		0
Norwegian Sea							0		0
Barents Sea							0		0
Total							**0**		**0**
Svalbard									
Bjørnøya	1	1	1	1	2006	2006	650	427	
Spitsbergen[3]	1	0	154	155	2008	2008	3600		
Total							**4250**		
Global population[2]									**170 000 – 1 200 000**

[1]Barrett et al. (2006), [2]Mitchell et al. (2004)

Norwegian populations; trends and distribution





Left: Regional dynamics in breeding populations (Bjørnøya)

Right: Distribution and size of breeding colonies

International populations; status and trends

From Mitchell et al. (2004), unless stated otherwise

Region	*Population size (number of pairs)*	*Population trend*
Russia		
Iceland	8 000[2]	Declining[1]
Greenland	150 000[2]	No overall trend[1]
Canada		
North America	85 000[2]	

[1]Frederiksen (2010), [2]Weiser and Gilchrist (2012)

Diet (no. of cases)

Prey item	Summer		Non-breeding
	Adult	Chicks	
Gadoids			
Polar cod	3		1
Capelin			
Herring			
Sprat			
Sandeel			
Other fish	6	5	1
Squid			
Crustaceans	6	2	
Other invertebrates	4	2	2
Offal	3	1	1
Other	1	8	

Drivers of population dynamics

No. of reported cases, Norwegian studies in parentheses

Drivers		*Episodic observations*		*Population level effects*		
		Breeding success	*Adult survival*	*Breeding success*	*Adult survival*	*Population growth*
Direct	*Climate hazards*					
	Fisheries bycatch					
	Harvest & intentional killing	6 (1)	6 (1)			
	Pollution			2 (1)	1 (1)	1 (1)
	Predation & parasitism		1 (1)			
	Disturbance					
	Human infrastructure					
	Disease		1			
Indirect	*Climate*					
	Climate & food					
	Trophic interactions & food					
	Fisheries & food-competition					
	Fisheries & food- discards			1		
	Food					
	Food (sum)			1		

3.11 Great Black-backed Gull *Larus marinus*

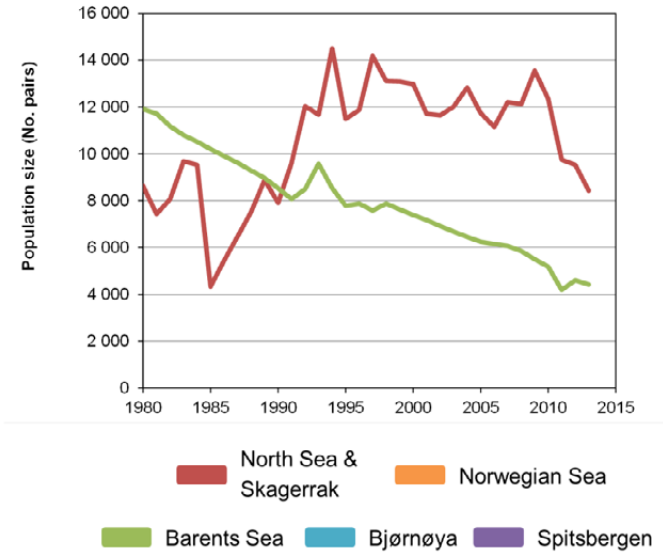
Ecological niche	Coastal, surface-feeding
Redlist, Norway	Not listed
Redlist, Svalbard	Not listed

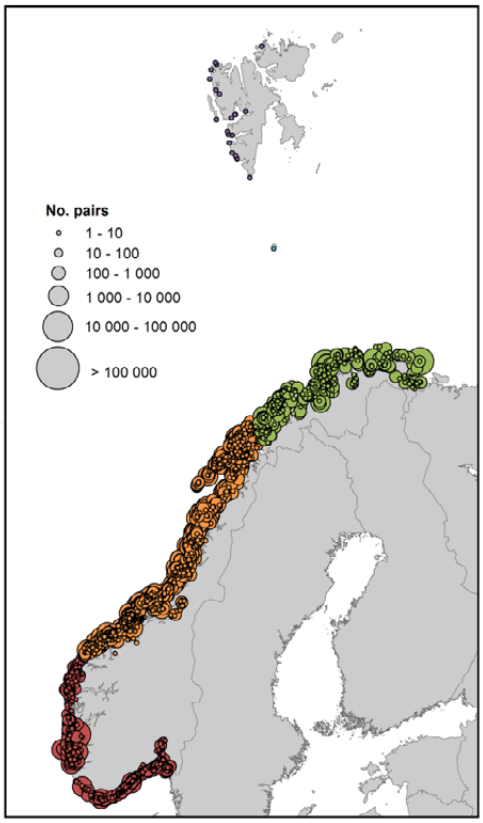
Samples and population sizes (no. of breeding pairs)

	Monitoring data		*Census data*				*Population estimates*		
	Total no. series	*No. long series*	*No. loc-ations*	*No. Counts*	*Year first count*	*Year last count*	*Last count*	*2013-estimate*	*2005-esti-mate*[1]
Norwegian mainland									
North Sea & Skagerrak	5	4	1021	4260	1979	1984	7 412	8 423	8 500
Norwegian Sea	6	0	1989	3045	1982	1982	26 842		30 000
Barents Sea	1	0	749	1577	1988	2005	7 434	4 549	15 000
Total							**41 688**		**53 500**
Svalbard									
Bjørnøya	0	0	1	1	2006	2006	20		
Spitsbergen	0	0	23	23	2008	2008	80		
Total							**100**		
Global population[2]									**170 000 – 180 000**

[1]Barrett et al. (2006), [2]Mitchell et al. (2004)

Norwegian populations; trends and distribution





Left: Regional dynamics in breeding populations (Barents Sea and North Sea & Skagerrak)

Right: Distribution and size of breeding colonies

International populations; status and trends

From Mitchell et al. (2004), unless stated otherwise

Region	***Population size (number of pairs)***	***Population trend***
Sweden	15 000	No overall trend[1]
Finland	2 800	
Russia	3 000-4 000	
Denmark	1 500-1 600	Increasing[1]
UK & Ireland	19 300	Declining [2]
Faeroes	1 200	No overall trend[1]
Iceland	15 000-20 000	Declining[1]
Greenland	3 000-5 000	Increasing[1]
Europe	6 000-9 000	
North America	60 000	

[1]Frederiksen (2010), [2]JNCC (2013)

Diet (no. of cases)

Prey item	**Summer**		**Non-breeding**
	Adult	**Chicks**	
Gadoids			
Polar cod			
Capelin			
Herring	2		
Sprat			
Sandeel			
Other fish	4	3	
Squid			
Crustaceans	2	1	
Other invertebrates	1	1	
Offal	1	1	
Other	4	3	

Drivers of population dynamics

No. of reported cases, Norwegian studies in parentheses

Drivers		***Episodic observations***		***Population level effects***		
		Breeding success	***Adult survival***	***Breeding success***	***Adult survival***	***Population growth***
Direct	*Climate hazards*					
	Fisheries bycatch		1 (1)			
	Harvest & intentional killing	4 (1)	5 (1)	1		1
	Pollution		1 (1)	2 (2)	1 (1)	1 (1)
	Predation & parasitism	1		1		2
	Disturbance					
	Human infrastructure					
	Disease					
Indirect	*Climate*					
	Climate & food					
	Trophic interactions & food					
	Fisheries & food-competition				2	
	Fisheries & food- discards					
	Food			2 (2)		
	Food (sum)			2 (2)	2	

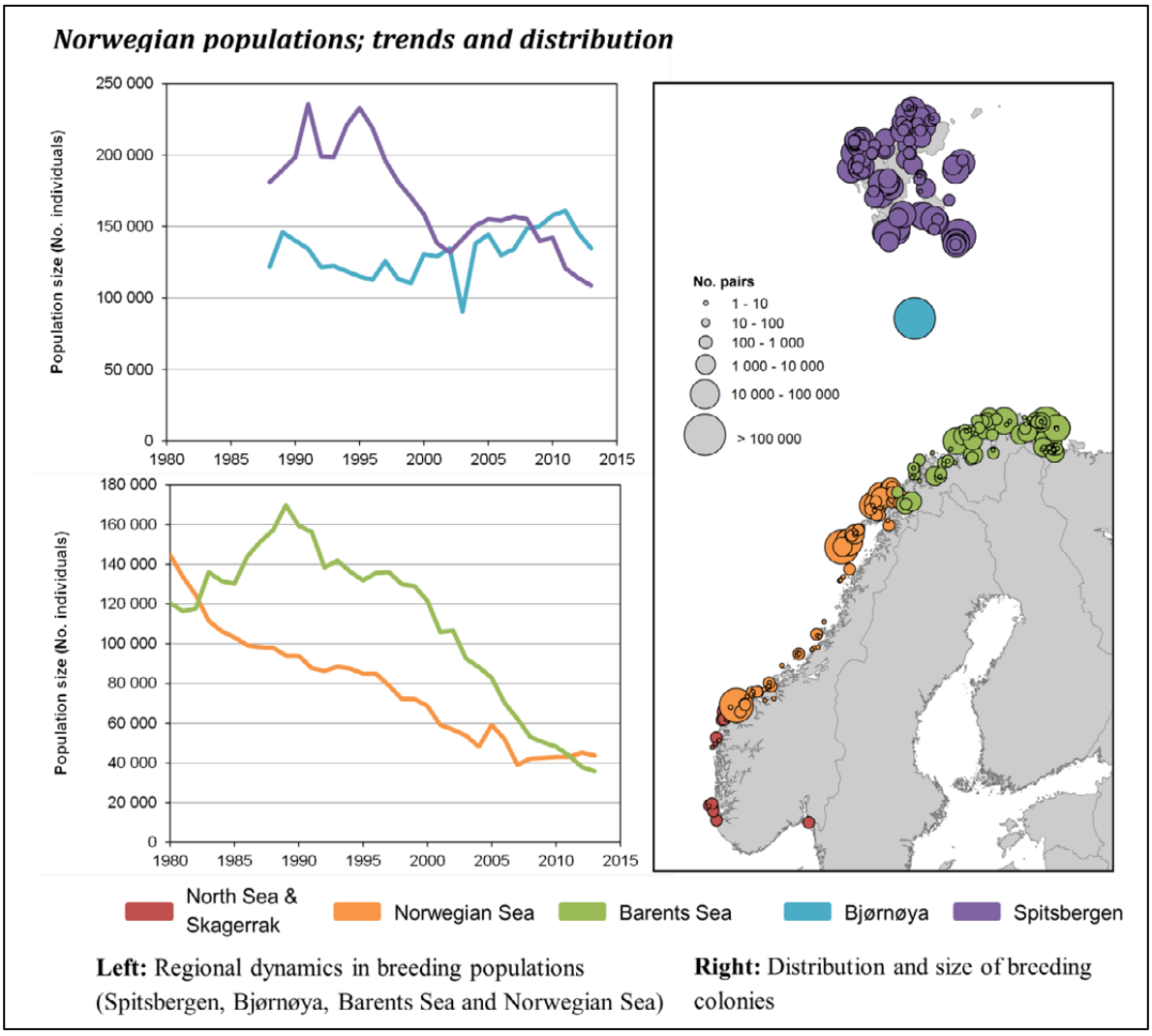
3.12 Black-legged Kittiwake *Rissa tridactyla*

Ecological niche	Pelagic, surface-feeding
Redlist, Norway	Endangered
Redlist, Svalbard	Near threatened

Samples and population sizes (no. of breeding pairs)

	Monitoring data		*Census data*				*Population estimates*		
	Total no. series	*No. long series*	*No. loc-ations*	*No. Counts*	*Year first count*	*Year last count*	*Last count*	*2013-estimate*	*2005-esti-mate*[1]
Norwegian mainland									
North Sea & Skagerrak	0	0	23	62	1978	1984	1 880		6 000
Norwegian Sea	5	3	123	364	1981	1990	76 216	44 424	80 000
Barents Sea	22	2	214	1279	1979	2009	106 482	37 045	250 000
Total							**184 578**		**336 000**
Svalbard									
Bjørnøya	1	1	1	1	2006	2006	130 000	134 755	
Spitsbergen	9	2	110	110	2007	2007	153 689	108 717	
Total							**283 689**	**243 472**	
Global population[2]									**4 300 000 – 5 200 000**

[1]Barrett et al. (2006), [2]Mitchell et al. (2004)



Left: Regional dynamics in breeding populations (Spitsbergen, Bjørnøya, Barents Sea and Norwegian Sea)

Right: Distribution and size of breeding colonies

International populations; status and trends

From Mitchell et al. (2004), unless stated otherwise

Region	*Population size (number of pairs)*	*Population trend*
Russia (Barents Sea)	136 900-146 900	
Sweden	30	No overall trend[1]
Denmark	625	No overall trend[1]
Germany	6 500	Stable or increasing[2]
France	4 690	
Spain	200	
Portugal	3-10	
UK & Ireland	419 000	Declining (Scotland)[1]
Faeroes	230 000	Declining[1]
Iceland	600 000-800 000	Declining[1]
Greenland	100 000-200 000	Declining[1]
Canada	256 500	
Russia (excl. Barents Sea)	1 036 000-1 361 000	
USA(Alaska)	770 000	

[1]Frederiksen (2010), Markones et al. (2009)

Diet (no. of cases)

Prey item	Summer		Non-breeding
	Adult	Chicks	
Gadoids	3	5	1
Polar cod	3	1	1
Capelin	4	5	1
Herring	5	9	
Sprat	2	4	
Sandeel	9	12	1
Other fish	2	5	1
Squid	1	1	
Crustaceans	4	3	
Other invertebrates	1	2	1
Offal	1	1	1
Other			

Drivers of population dynamics

No. of reported cases, Norwegian studies in parentheses

Drivers		*Episodic observations*		*Population level effects*		
		Breeding success	*Adult survival*	*Breeding success*	*Adult survival*	*Population growth*
Direct	*Climate hazards*			1 (1)		
	Fisheries bycatch					
	Harvest & intentional killing	3	4			
	Pollution			2	2	1
	Predation & parasitism	4 (2)	1	1 (1)	2	3
	Disturbance					
	Human infrastructure					
	Disease					
Indirect	*Climate*			1	2 (1)	
	Climate & food			8		3
	Trophic interactions & food			2 (1)	1	
	Fisheries & food-competition			1	1	
	Fisheries & food- discards			1		1
	Food		2 (1)	7 (1)	2 (1)	1
	Food (sum)		2 (1)	19 (2)	4 (1)	5

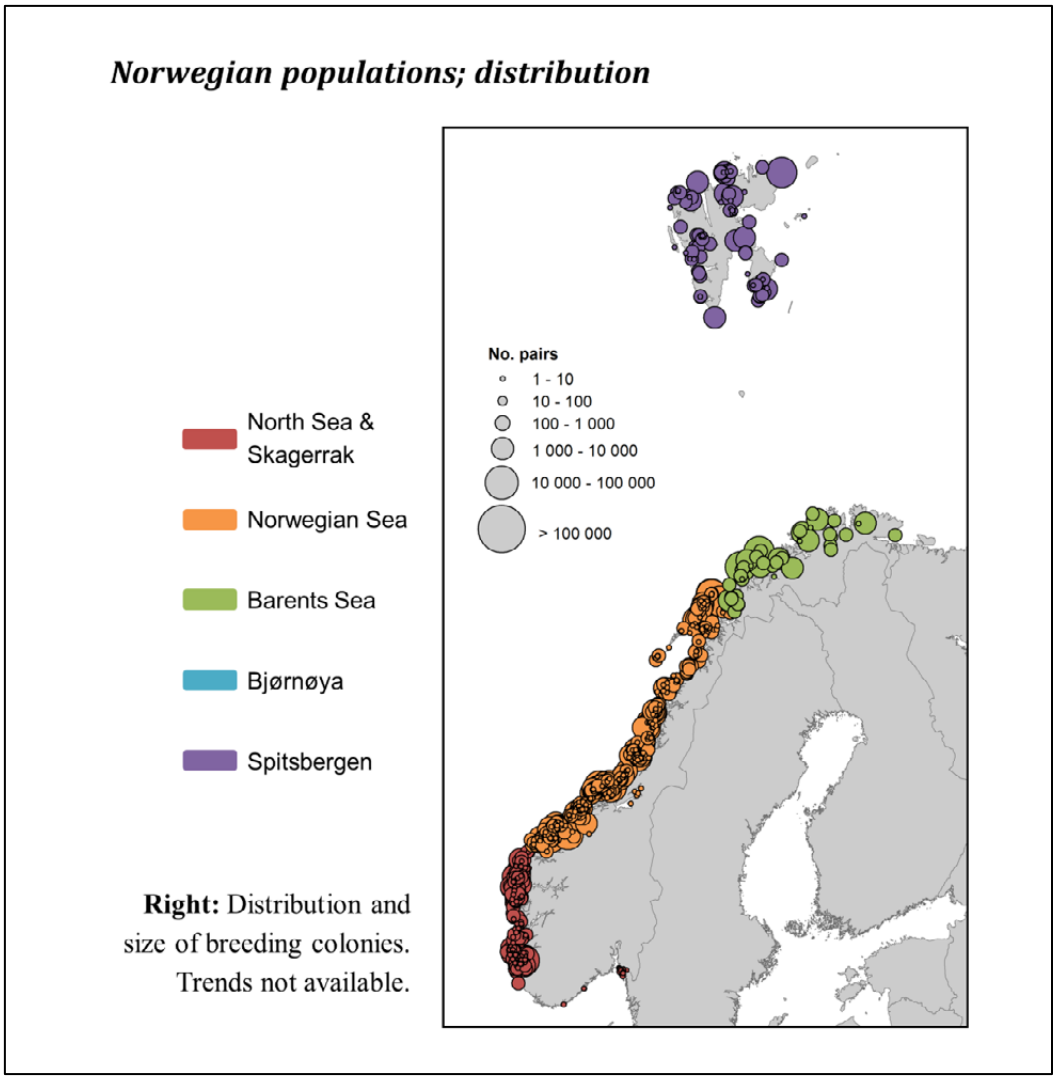
3.13 Arctic Tern *Sterna paradisaea*

Ecological niche	Coastal, surface feeding
Redlist Norway	Not listed
Redlist, Svalbard	Not listed

Samples and population sizes (no. of breeding pairs)

	Monitoring data		*Census data*				*Population estimates*		
	Total no. series	*No. long series*	*No. loc-ations*	*No. Counts*	*Year first count*	*Year last count*	*Last count*	*2013-estimate*	*2005-esti-mate*[1]
Norwegian mainland									
North Sea & Skagerrak	0	0	231	439	1982	1983	6 782		5 100
Norwegian Sea	0	0	610	800	1982	1982	25 668		20 000
Barents Sea	1	0	213	443	1982	2005	3 981		10 000
Total							**36 431**		**35 100**
Svalbard									
Bjørnøya							50		
Spitsbergen	0	0	95	96	2008	2008	5 497		
Total							**5 547**		

[1]Barrett et al. (2006)



International populations; status and trends

From Mitchell et al. (2004), unless stated otherwise

Region	*Population size (number of pairs)*	*Population trend*
Denmark	8 000-9 000	Declining[1]
Iceland	250 000-500 000	Declining[1]
UK & Ireland	56 100	No overall trend (Scotland)[1]
Faeroes	2 000	Declining[1]
Finland	50 000-60 000	
Russia	25 000-30 000	
Sweden	20 000-25 000	No overall trend[1]
Greenland	65 000[2]	Declining[2]
Europe	15 000-16 500	
North America (east)	10 000-1 000 000	
Alaska	300 000-900 000	

[1]Frederiksen (2010), [2]Egevang and Boertmann (2003)

Diet (no. of cases)

Prey item	Summer		Non-breeding
	Adult	Chicks	
Gadoids		2	
Polar cod			
Capelin		1	
Herring		2	
Sprat			
Sandeel		3	
Other fish		2	
Squid			
Crustaceans	1		
Other invertebrates		1	
Offal			
Other			

Drivers of population dynamics

No. of reported cases, Norwegian studies in parentheses

Drivers		*Episodic observations*		*Population level effects*		
		Breeding success	*Adult survival*	*Breeding success*	*Adult survival*	*Population growth*
Direct	*Climate hazards*	1				
	Fisheries bycatch					1
	Harvest & intentional killing	2	2			
	Pollution					
	Predation & parasitism			4		4
	Disturbance					
	Human infrastructure					
	Disease					
Indirect	*Climate*					
	Climate & food					
	Trophic interactions & food					
	Fisheries & food-competition					
	Fisheries & food- discards					
	Food	1		3		1
	Food (sum)	1		2		

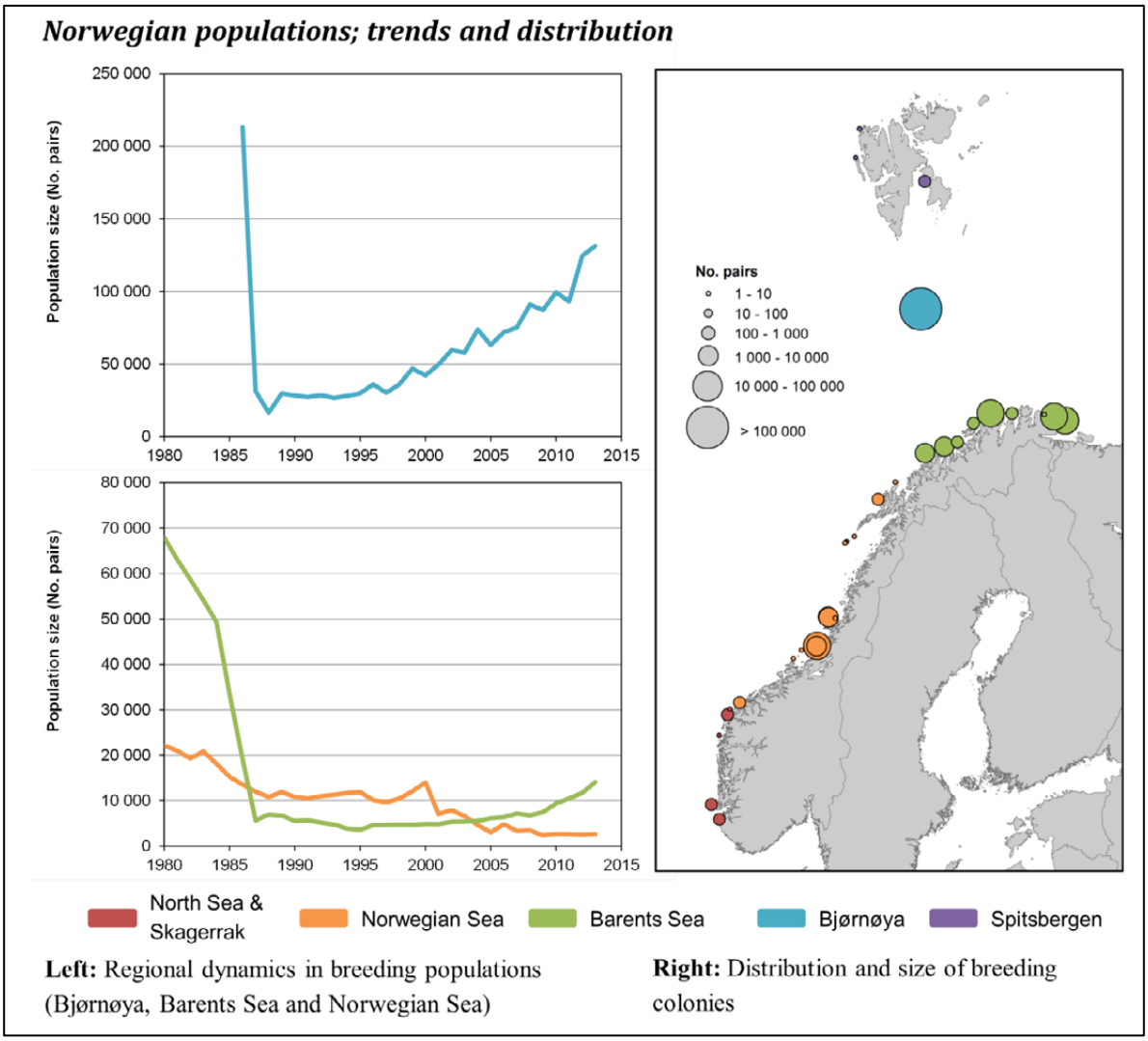
3.14 Common Guillemot *Uria aalge*

Ecological niche	Pelagic, diving
Redlist Norway	Critically endangered
Redlist, Svalbard	Vulnerable

Samples and population sizes (no. of breeding pairs)

	Monitoring data		*Census data*				*Population estimates*		
	Total no. series	*No. long series*	*No. loc-ations*	*No. Counts*	*Year first count*	*Year last count*	*Last count*	*2013-estimate*	*2005-esti-mate*[1]
Norwegian mainland									
North Sea & Skagerrak	0	0	9	32	2000	2008	188	46	150
Norwegian Sea	3	3	26	37	1984	1985	11 326	2 641	< 5 000
Barents Sea	3	2	16	66	1979	2008	17 837	14 094	< 10 000
Total							29 351	16 781	**15 000**
Svalbard									
Bjørnøya	1	1	1	1	2006	2006	72 000	131 394	
Spitsbergen	0	0	3	3	2008	2008	100		
Total							72 100		
Global population[2]									**7 300 000 – 7 400 000**

[1]Barrett et al. (2006), [2]Mitchell et al. (2004)



Left: Regional dynamics in breeding populations (Bjørnøya, Barents Sea and Norwegian Sea)

Right: Distribution and size of breeding colonies

International populations; status and trends

From Mitchell et al. (2004), unless stated otherwise

Region	***Population size (number of pairs)***	***Population trend***
UK & Ireland	1 050 000	Increasing[1]
Faeroes	175 000	Declining[2]
Iceland	990 000	Declining[2]
Russia	20 000-30 000	
Sweden	12 500	Increasing[3]
Denmark	2 500	
Finland	50	
Greenland	2 000	Declining[1]
Europe	3 800	
Canada	500 000	
Pacific	4 500 000	

[1]JNCC (2013), [2]Frederiksen (2010), [1]Peterz and Blomqvist (2010)

Diet (no. of cases)

Prey item	**Summer**		**Non-breeding**
	Adult	**Chicks**	
Gadoids	3	4	2
Polar cod	1		1
Capelin	4	6	3
Herring	1	3	1
Sprat		2	1
Sandeel	4	8	
Other fish		2	1
Squid	1	1	
Crustaceans	1		2
Other invertebrates			
Offal			
Other			

Drivers of population dynamics

No. of reported cases, Norwegian studies in parentheses

Drivers		***Episodic observations***		***Population level effects***		
		Breeding success	***Adult survival***	***Breeding success***	***Adult survival***	***Population growth***
Direct	*Climate hazards*				1	
	Fisheries bycatch		4 (2)			1
	Harvest & intentional killing	2	4			1
	Pollution		5		1	
	Predation & parasitism	1	1	3 (2)		5 (2)
	Disturbance			1		1
	Human infrastructure					
	Disease					
Indirect	*Climate*				2 (1)	1 (1)
	Climate & food	1	1 (1)	1 (1)		1 (1)
	Trophic interactions & food			2		
	Fisheries & food-competition			3 (2)		2 (2)
	Fisheries & food- discards					
	Food		1	2	1	1 (1)
	Food (sum)	1	2 (1)	8 (3)	1	4 (4)

3.15 Brünnich's Guillemot *Uria lomvia*

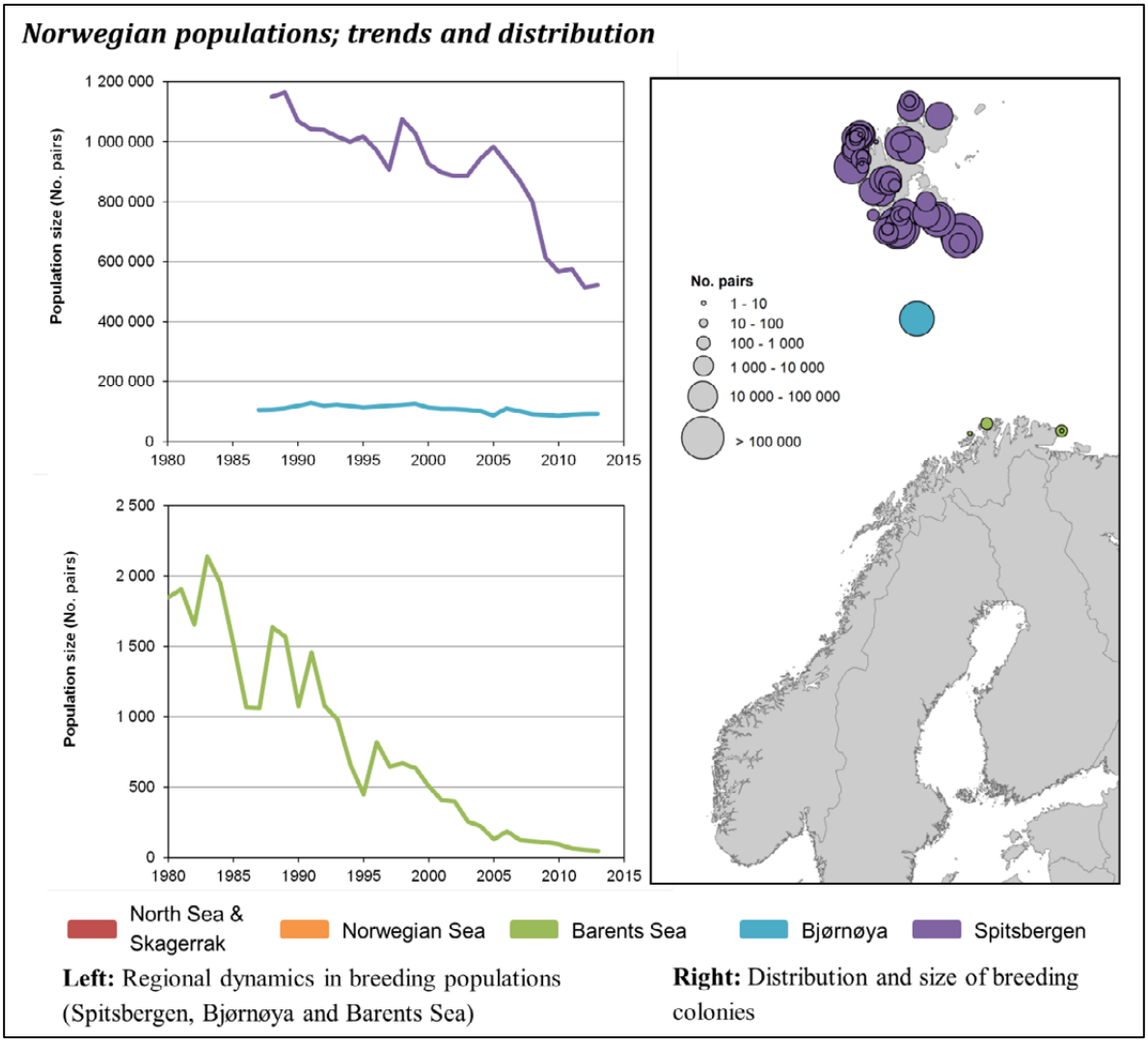
Ecological niche	Pelagic, diving
Redlist Norway	Vulnerable
Redlist, Svalbard	Near threatened

Samples and population sizes (no. of breeding pairs)

	Monitoring data		*Census data*				*Population estimates*		
	Total no. series	*No. long series*	*No. loc-ations*	*No. Counts*	*Year first count*	*Year last count*	*Last count*	*2013-estimate*	*2005-esti-mate*[1]
Norwegian mainland									
North Sea & Skagerrak							0		
Norwegian Sea	0	0	2	3	1974	1983	21		< 10
Barents Sea	2	1	10	17	1984	1992	399	47	< 1 500
Total							**420**		
Svalbard									
Bjørnøya	1	1	1	1	2006	2006	111 000	93 449	
Spitsbergen	8	1	69	69	2008	2008	708 493	521 996	
Total							**819 493**	**615 445**	
Global population[2]									**4 000 000 – 7 500 000**

[1]Barrett et al. (2006), [2]Mitchell et al. (2004)

Norwegian populations; trends and distribution



Left: Regional dynamics in breeding populations (Spitsbergen, Bjørnøya and Barents Sea)

Right: Distribution and size of breeding colonies

International populations; status and trends

From Mitchell et al. (2004), unless stated otherwise

Region	*Population size (number of pairs)*	*Population trend*
Russia	1 051 000	
Iceland	800 000-2 000 000	Declining[1]
Greenland	465 000	Declining[1]
Canada	1 454 000	

[1]Frederiksen (2010)

Diet (no. of cases)

Prey item	Summer		Non-breeding
	Adult	Chicks	
Gadoids	2	2	1
Polar cod	3	4	4
Capelin	3	7	2
Herring	1	1	
Sprat			
Sandeel	3	4	
Other fish	3	5	
Squid		2	
Crustaceans	6		4
Other invertebrates	2		
Offal			
Other			

Drivers of population dynamics

No. of reported cases, Norwegian studies in parentheses

Drivers		*Episodic observations*		*Population level effects*		
		Breeding success	*Adult survival*	*Breeding success*	*Adult survival*	*Population growth*
Direct	*Climate hazards*		1			
	Fisheries bycatch					
	Harvest & intentional killing	2	4		1 (1)	1
	Pollution		1 (1)			1
	Predation & parasitism	2	2	2		2
	Disturbance					
	Human infrastructure		1			
	Disease					
Indirect	*Climate*			3	1	4
	Climate & food					1
	Trophic interactions & food					
	Fisheries & food-competition					
	Fisheries & food- discards					
	Food					
	Food (sum)					1

3.16 Razorbill *Alca torda*

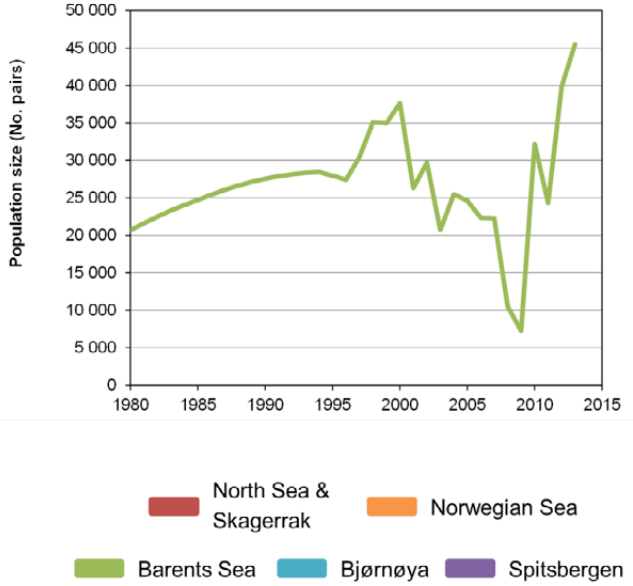
Ecological niche	Pelagic, diving
Redlist Norway	Vulnerable
Redlist, Svalbard	Endangered

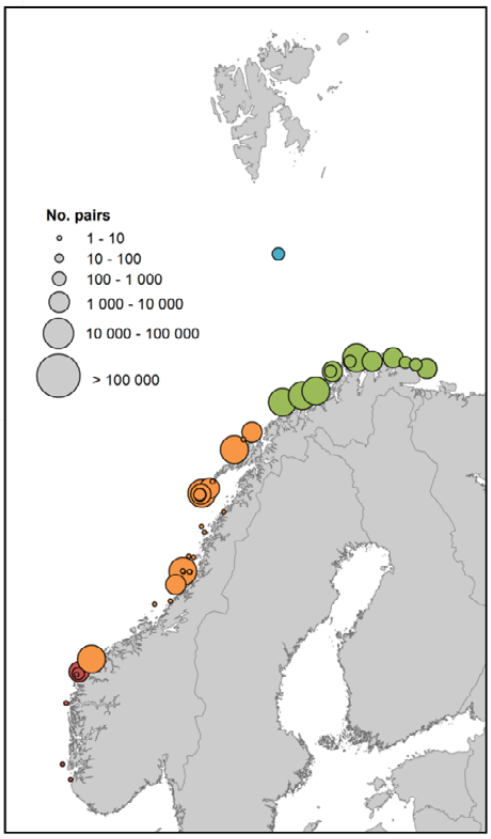
Samples and population sizes (no. of breeding pairs)

	Monitoring data		*Census data*				*Population estimates*		
	Total no. series	*No. long series*	*No. loc-ations*	*No. Counts*	*Year first count*	*Year last count*	*Last count*	*2013-estimate*	*2005-esti-mate*[1]
Norwegian mainland									
North Sea & Skagerrak	0	0	7	33	1977	2008	150		300
Norwegian Sea	2	1	26	63	1984	1985	8 108		< 10 000
Barents Sea	1	0	19	54	1974	2008	24 630	45 498	< 15 000
Total							**32 888**		
Svalbard									
Bjørnøya			1	1	2006	2006	18		
Spitsbergen							20		
Total							**38**		
Global population[2]									**610 000 – 630 000**

[1]Barrett et al. (2006), [2]Mitchell et al. (2004)

Norwegian populations; trends and distribution





Left: Regional dynamics in breeding populations (Barents Sea and North Sea & Skagerrak)

Right: Distribution and size of breeding colonies

International populations; status and trends

From Mitchell et al. (2004), unless stated otherwise

Region	*Population size (number of pairs)*	*Population trend*
UK & Ireland	145 000	Increasing (Scotland)?[1]
Denmark	610	
Faeroes	4 500	Declining?[1]
Finland	6 000 - 6 500	
France	25	
Germany	16	
Greenland	2 000 - 5 000	No overall trend[1]
Iceland	380 000	Declining?[1]
Russia	3 500	
Sweden	9 000 - 11 000	Increasing[1]
Canada (East)	37 800	
USA (Maine)	277	

[1]Frederiksen (2010)

Diet (no. of cases)

Prey item	Summer		Non-breeding
	Adult	Chicks	
Gadoids		2	
Polar cod			
Capelin	1	2	
Herring		3	
Sprat			
Sandeel	1	3	
Other fish			
Squid			
Crustaceans			
Other invertebrates			
Offal			
Other			

Drivers of population dynamics

No. of reported cases, Norwegian studies in parentheses

Drivers		*Episodic observations*		*Population level effects*		
		Breeding success	*Adult survival*	*Breeding success*	*Adult survival*	*Population growth*
Direct	*Climate hazards*					
	Fisheries bycatch		3 (1)			
	Harvest & intentional killing	1	4		1	1
	Pollution					
	Predation & parasitism	1 (1)				2
	Disturbance					
	Human infrastructure					
	Disease					
Indirect	*Climate*				2 (1)	
	Climate & food				1 (1)	1
	Trophic interactions & food					
	Fisheries & food-competition					
	Fisheries & food- discards					
	Food		1 (1)	1		2
	Food (sum)		1 (1)	1	1 (1)	3

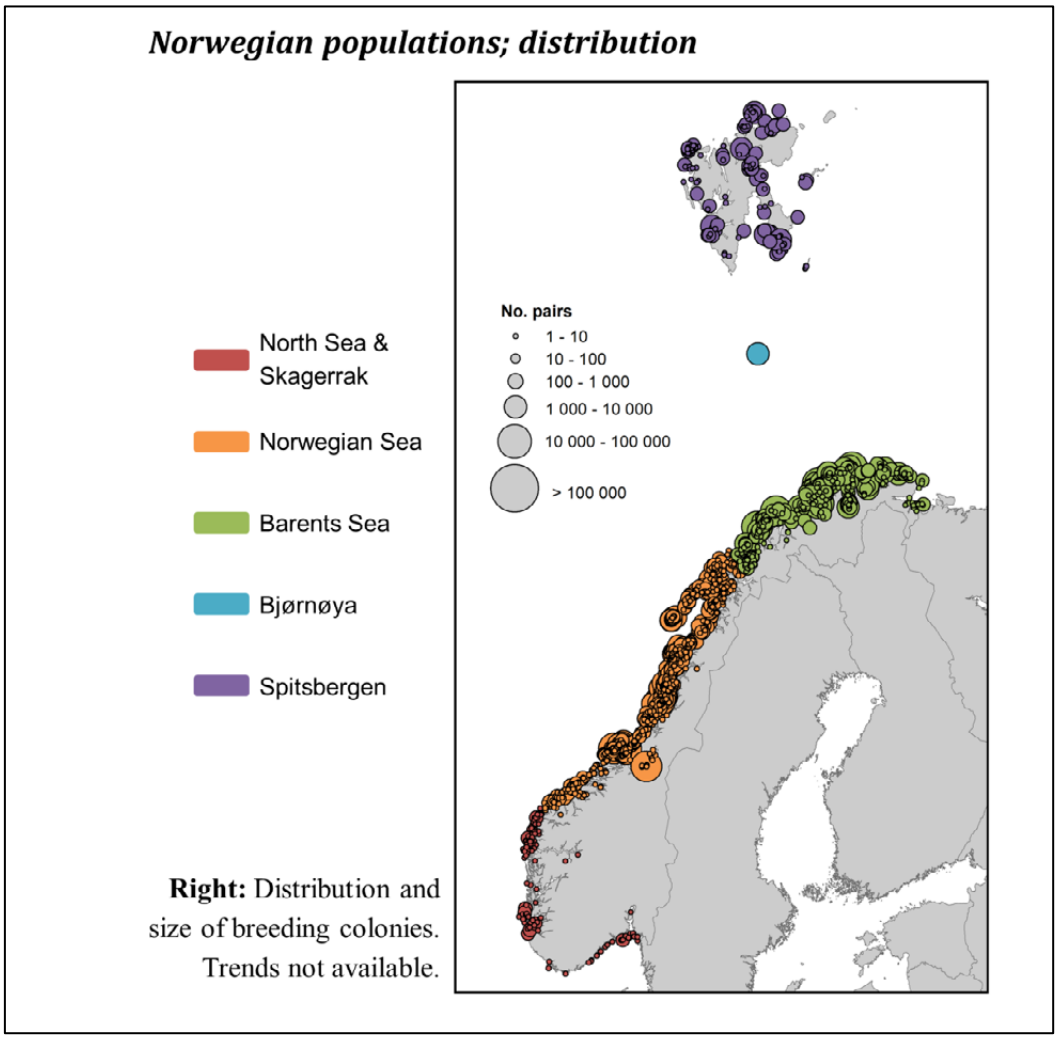
3.17 Black Guillemot *Cepphus grylle*

Ecological niche	Coastal, diving
Redlist Norway	Vulnerable
Redlist, Svalbard	Not listed

Samples and population sizes (no. of breeding pairs)

	Monitoring data		*Census data*				*Population estimates*		
	Total no. series	*No. long series*	*No. loc-ations*	*No. Counts*	*Year first count*	*Year last count*	*Last count*	*2013-estimate*	*2005-esti-mate*[1]
Norwegian mainland									
North Sea & Skagerrak	0	0	179	500	1982	1995	646		380
Norwegian Sea	4	0	1033	1456	1982	1983	21 020		15 000
Barents Sea	0	0	368	603	1984	1987	19 272		20 000
Total							**40 938**		
Svalbard									
Bjørnøya[3]	0	0	1	1	2006	2006	300		
Spitsbergen[3]	0	0	139	139	2008	2008	2 797		
Total							**3 097**		
Global population[2]									**260 000 – 410 000**

[1]Barrett et al. (2006), [2]Mitchell et al. (2004), [3]Grossly underestimated on Bjørnøya and Spitsbergen.



Right: Distribution and size of breeding colonies. Trends not available.

International populations; status and trends

From Mitchell et al. (2004), unless stated otherwise

Region	*Population size (number of pairs)*	*Population trend*
UK & Ireland	21 300-42 500	Increasing (Scotland)[1]
Denmark	1 067-1 111	Increasing[1]
Estonia	6-10	
Faeroes	3 500	Increasing?[1]
Finland	12 000-15 000	
Iceland	30 000-50 000	Declining[1]
Russia (Barents & White Seas)	2 710	
Sweden	7 000-10 000	Declining[1]
Canada	71 500	
Greenland	22 950-64 750	No overall trend[1]
Russia	55 150	
USA (Maine)	5 000	

[1]Frederiksen (2010)

Diet (no. of cases)

Prey item	Summer		Non-breeding
	Adult	Chicks	
Gadoids		1	
Polar cod	3		1
Capelin			
Herring			
Sprat			
Sandeel		1	
Other fish	2	2	1
Squid			
Crustaceans	3		
Other invertebrates	1		1
Offal			
Other			

Drivers of population dynamics

No. of reported cases, Norwegian studies in parentheses

Drivers		*Episodic observations*		*Population level effects*		
		Breeding success	*Adult survival*	*Breeding success*	*Adult survival*	*Population growth*
Direct	*Climate hazards*					
	Fisheries bycatch		4 (2)			2 (2)
	Harvest & intentional killing	3	5			
	Pollution		1 (1)			
	Predation & parasitism			1	1	3 (1)
	Disturbance					
	Human infrastructure					
	Disease					
Indirect	*Climate*				1 (1)	
	Climate & food					
	Trophic interactions & food					
	Fisheries & food-competition					
	Fisheries & food- discards					
	Food					
	Food (sum)					

3.18 Atlantic Puffin *Fratercula arctica*

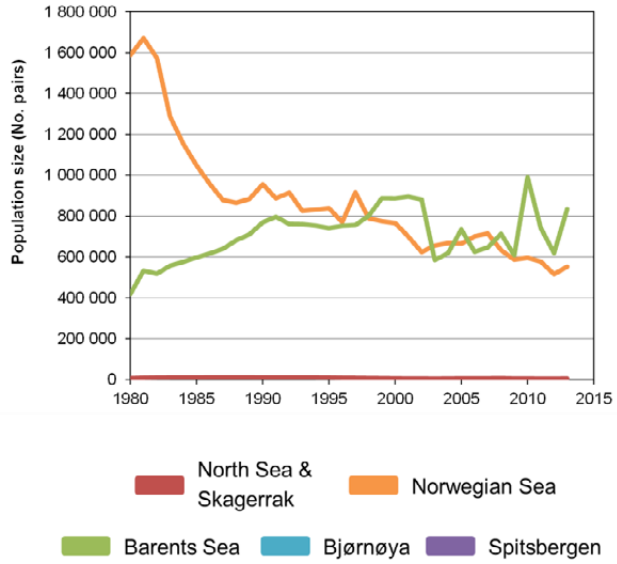
Ecological niche	Pelagic, diving
Redlist, Norway	Vulnerable
Redlist, Svalbard	Not listed

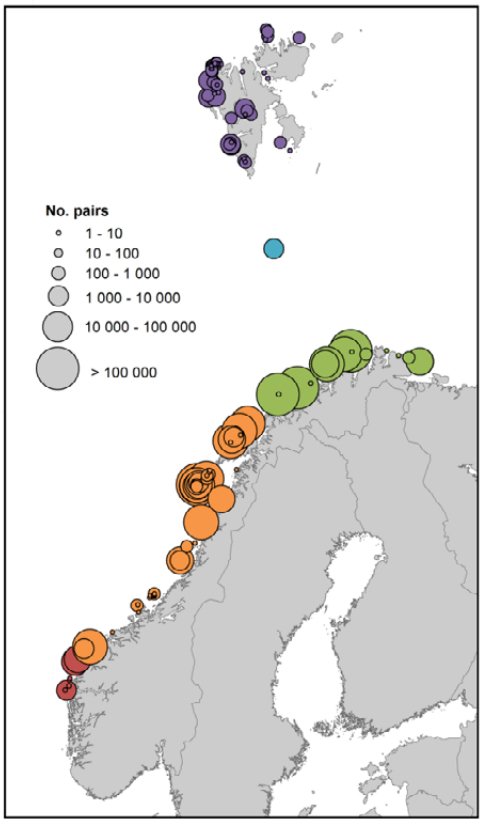
Samples and population sizes (no. of breeding pairs)

	Monitoring data		*Census data*				*Population estimates*		
	Total no. series	*No. long series*	*No. loc-ations*	*No. Counts*	*Year first count*	*Year last count*	*Last count*	*2013-estimate*	*2005-esti-mate*[1]
Norwegian mainland									
North Sea & Skagerrak	1	0	14	49	1979	2005	5 184	4998	14 000
Norwegian Sea	5	3	62	118	1982	1988	939 958	552 718	800 000
Barents Sea	2	1	16	55	1982	2007	939 313	907 259	900 000
Total							**1 884 455**	**1 464 975**	**1714000**
Svalbard									
Bjørnøya[3]	0	0	1	1	2006	2006	360		
Spitsbergen[3]	0	0	58	60	2007	2007	1 686		
Total							2 046		
Global population[2]									**5 500 000 – 6 600 000**

[1]Barrett et al. (2006), [2]Mitchell et al. (2004), [3]Grossly underestimated on Bjørnøya and Spitsbergen.

Norwegian populations; trends and distribution





Left: Regional dynamics in breeding populations (Barents Sea, Norwegian Sea and North Sea & Skagerrak)

Right: Distribution and size of breeding colonies

International populations; status and trends

From Mitchell et al. (2004), unless stated otherwise

Region	*Population size (number of pairs)*	*Population trend*
Russia	5 050	Stable
Iceland	2 500 000- 3 000 000	Declining[1]
Faeroes	550 000	Declining[1]
Britain and Ireland	621 000	Increasing
France	257	Stable, but small
Greenland	5 300 - 8 300	Declining[1]
Canada	350 000 - 400 000	Stable or increasing
US	550	

[1]Frederiksen (2010)

Diet (no. of cases)

Prey item	Summer		Non-breeding
	Adult	Chicks	
Gadoids		11	
Polar cod			
Capelin	3	4	1
Herring	1	12	
Sprat		2	
Sandeel	3	13	1
Other fish	2	1	
Squid			
Crustaceans			3
Other invertebrates	1		1
Offal			
Other			

Drivers of population dynamics

No. of reported cases, Norwegian studies in parentheses

Drivers		*Episodic observations*		*Population level effects*		
		Breeding success	*Adult survival*	*Breeding success*	*Adult survival*	*Population growth*
Direct	*Climate hazards*	1	2 (1)			
	Fisheries bycatch		1 (1)			1
	Harvest		2 (1)			2
	Pollution					
	Predation & parasitism	2 (1)	3 (1)	1	1	1
	Disturbance					
	Human infrastructure					
	Disease					
Indirect	*Climate*					
	Climate & food			3(1)	5 (1)	
	Trophic interactions & food			3 (1)		
	Fisheries & food-competition			1 (1)		
	Fisheries & food- discards					
	Food			3		
	Food (sum)			10 (3)	5 (1)	

4 Discussion

4.1 Populations trends and dynamics

Our analyses document large fluctuations in the seabird communities in Norway and Svalbard. A summary of the time series is given in Table 2. According to our analyses, 13 of the 35 regional populations assessed have shown more than a 50% decrease during the last 25 years. Declining populations were found in all regions and included all the major ecological groups. Declining populations were: Northern Fulmar (Bjørnøya), Great Cormorant (Norwegian Sea), Common Eider (Norwegian Sea), Common Gull (North Sea & Skagerrak), Lesser Black-backed Gull (North Sea & Skagerrak), Herring Gull (Barents Sea), Glaucous Gull (Bjørnøya), Great Black-backed Gull (Barents Sea), Black-legged Kittiwake (Barents Sea and Norwegian Sea), Common Guillemot (Norwegian Sea), Brünnich's Guillemot (Spitsbergen and Barents Sea) and Atlantic Puffin (North Sea & Skagerrak). In the same period 5 regional populations have more than doubled. These were: Northern Gannet (Barents Sea), Great Cormorant (North Sea & Skagerrak), European Shag (North Sea & Skagerrak) and Common Guillemot (Barents Sea and Bjørnøya). In addition, 8 populations have shown large decadal fluctuations with more than a doubling of the population from the minimum to the maximum estimate: These were: Northern Fulmar (North Sea & Skagerrak), Great Cormorant (Barents Sea), European Shag (Norwegian Sea and Barents Sea), Common Eider (North Sea & Skagerrak), Herring Gull (North Sea & Skagerrak), Black-legged Kittiwake (Spitsbergen) and Razorbill (Barents Sea).

The populations of Common Guillemots in Northern Norway and Bjørnøya have been of particular concern due to the decline during the 1960s and 70s and the subsequent collapse in the populations by 70-90% during the winter 1986-87 (Vader et al. 1990). The population on Bjørnøya has increased considerably since then, and is now close to the pre-collapse level. Although the Barents Sea populations have more than doubled, the populations are still low compared to the estimates before the collapse. In contrast to the Barents Sea and Bjørnøya populations, Common Guillemots in the Norwegian Sea show a persistent decline of more than 75% since the early 1980s.

The large populations of Atlantic Puffin in the Norwegian Sea has, according to the analyses, been reduced from 1.6 million pairs in 1980 to 600 000 at present. Although the percentage reduction of the population the last 25 years is less than 50%, the negative trend has been persistent at least since the early 1980s. In the same period, the Barents Sea colonies have been stable or have increased slightly, and the size of total Barents Sea population has according to our analyses at present surpassed the populations further south.

Notably, our estimates indicate that the large colonies of Brünnich's Guillemot on Spitsbergen have declined from 1.15 million pairs in 1988 to 522 000 pairs in 2013. The colony on Bjørnøya (about 100 000 pairs) has in the same period been stable or declined slightly, while the small populations on the Norwegian mainland have almost disappeared.

Unfortunately, the datasets were incomplete in order to assess several of the large gull species in the Norwegian Sea. However, extensive monitoring in the North Sea & Skagerrak and recent censuses in the Barents Sea suggest declines of more than 50% in several populations of the large gulls. This includes the Black-backed and Herring Gulls in the Barents Sea and Common and Lesser Black-backed Gulls in the North Sea and Skagerrak. Notably, the analyses show that the large populations of Black-legged Kittiwake have declined substantially in all regions except on Bjørnøya. On the Norwegian mainland the population has according to our analyses declined from about 280 000 pairs in 1980 to 82 000 pairs in 2013. On Svalbard (Bjørnøya and Spitsbergen), the population has declined from about 300 000 pairs to 240 000 pairs from 1988 to 2013.

The populations of European Shag and Great Cormorant have fluctuated vividly during the last 30 years. It should be noted that the increase in the population of Great Cormorant in the North

Sea & Skagerrak is due to an expansion of the subspecies *Phalacrocorax carbo sinensis*, probably from Danish waters (Lorentsen 2006). In contrast, the population of *P. carbo carbo* in the Norwegian Sea has declined by 58% since 1988. Northern Gannet established a colony on Runde in the mid- 1940s, and has since then expanded to North Norway (Barrett and Folkestad 1996), and has recently also established a small colony on Bjørnøya. The population in the Norwegian Sea has leveled out and has fluctuated around 3000 pairs since the early 1990s. The population in the Barents Sea is however still increasing.

Table 2. *Summary of the regional population dynamics of seabirds breeding in Norway and Svalbard from 1988 to 2013.* **%Change** *is the percentage change in the population from 1988 to 2013.* **%(Max-Min)** *is the percentage difference between the maximum and minimum population sizes recorded during the same period. Missing data are either due to incomplete data (***dd***) (see Chap. 2.1.5 for definitions) or populations close to or equal to zero (open cells). All estimates are based on the analyses presented in the present report.*

		North Sea & Skagerrak		**Norwegian Sea**		**Barents Sea**		**Bjørnøya**		**Spitsbergen**	
	Ecological group	%(Max-Min)	% Change	%(Max-Min)	% Change	%(Max-Min)	% Change	%(Max-Min)	% Change	%(Max-Min)	% Change
Northern Fulmar	Pelagic surface-feeding	1073	70	dd	dd			469	-58	dd	dd
Northern Gannet	Pelagic plunge-diving			57	2	665	577				
Great Cormorant[1]	Coastal diving	10964	9055	239	-58	241	11				
European Shag	Coastal diving	595	384	210	1	679	-27				
Common Eider	Coastal benthic-feeding	187	37	149	-55	67	-14			dd	dd
Common Gull	Coastal surface-feeding	297	-75	dd	dd	dd	dd				
Lesser Black-backed Gull[2]	Pelagic surface-feeding	107	-52	94	14						
Herring Gull	Coastal surface-feeding	142	-34	dd	dd	253	-72				
Glaucous Gull	Pelagic surface-feeding							475	-81	dd	dd
Great Black-backed Gull	Coastal surface-feeding	93	12	dd	dd	128	-52				
Black-legged Kittiwake	Pelagic surface-feeding	dd	dd	147	-55	387	-78	78	11	117	-40
Common Guillemot	Pelagic diving			498	-76	291	102	691	691		
Brünnich's Guillemot	Pelagic diving					3394	-97	51	-13	126	-55
Razorbill	Pelagic diving	dd	dd	dd	dd	528	71				
Atlantic Puffin	Pelagic diving	155	-56	85	-36	68	25			dd	dd

[1] *Phalacrocorax carbo sinensis* and *P. carbo carbo*.
[2] *Larus fuscus fuscus* and *L. fuscus intemedius.*

4.2 Estimation of population size and trends

The presented methodology combines all available monitoring and census data to construct time series and population estimates. Data from the nearest monitoring sites were used to interpolate population dynamics between censuses and extrapolate the dynamics from the first census backwards and from the last census forward. The time series were fitted using a simple least-square algorithm. When no monitoring data was available within 300 km, we used the growth rate estimated from a GAM analysis taking all available data on growth rates into account. These smoothed values gave a relatively conservative estimate of the growth rate.

A variety of species-specific methods are used to census and monitoring seabird populations during breeding, including counting individuals from photographs, counting individuals within stratified plots, or counting apparently occupied nests (Walsh et al. 1995). Clearly, a number of measurement errors are associated with the different methods applied. How well the counts reflect the breeding populations depends on factors such as observer bias, detectability, colony attendance, the presence of juveniles and deferred breeding. These, mostly unknown measurement errors, will in many cases tend to underestimate the true breeding population. It is therefore likely that the presented estimates represent “minimum” estimates.

The analytical method applied is sensitive to infrequent censuses and poor or non-representative monitoring. For example, if more than 20 years have passed since the last census of a colony and the population dynamics at the nearby monitoring sites are mainly governed by local factors, the resulting population estimates might be grossly wrong. Clearly, a higher number of monitoring sites and in particular, increased frequency of censuses will improve the precision of the estimates. At present, the methods used did not include the calculation of confidence intervals. This should be given high priority in a further development of the methods and could be accomplished by including bootstrap methodology and/or Bayesian statistics. Such analyses could potentially answer important questions such as: What is the reliability of the calculated estimates? How sensitive are the estimates to the removal/inclusion of more monitoring sites and how representative are the monitoring sites with respect to predicting the general population trends? How often is it necessary to conduct population censuses and how should the censuses be designed to maximize precision and minimize costs?

For some regional populations the datasets were, according to our definitions (*see Chap. 2.1.5*), considered to be incomplete in order to calculate reliable population trends and estimates. A more recent census of the breeding populations south of Vesterålen on the Norwegian mainland would, to a large degree, solve this problem. In addition, the monitoring of large gulls in the Norwegian and Barents Seas is fragmentary and more series on Common Eider, Glaucous Gull, and Northern Fulmar are needed in order to estimate the population trajectories of these species in Spitsbergen. Finally, some species are difficult to monitor due to high mobility among breeding sites (Common and Arctic Terns) and hidden or inaccessible nests (Black Guillemot, Little Auk and Razorbill). More tailored effort is needed to give reliable estimates for these species.

4.3 Diet

We compiled 213 studies on seabird diet. In total this summed to 635 observations of the different diet categories in specific araea/colonies and seasons/age classes. The distribution of these cases among ecological groups is shown in Figure 1.

Not surprisingly, there was a relatively large difference among the different ecological groups with respect to the reported diet. The diet of pelagic surface-feeding birds was evenly distributed among all the different prey categories. The reported diet of pelagic diving birds was concentrated around *Gadoids* consisting mainly of the young age-classes of cod fishes (e.g. Atlantic Cod, Saithe (*Pollachius virens*) and Haddock (*Melanogrammus aeglefinus*)), the typical pelagic forage fish species (i.e.; Polar Cod (*Boreogadus saida*), Capelin, Herring and Sandeel (*Ammodytes* spp.)), as well as pelagic crustaceans (i.e.; large calanoid copepods, krill and amphipods). The diet of coastal surface-feeding birds consisted to a lesser degree of forage fish

species. This group was more dependent on a diverse assemblage of inshore fish species (*Other fish*), inshore crustaceans and other invertebrates, some discards from the fishing industry (*Offal*) and other resources (i.e.; garbage and other terrestrial resources). Finally, the coastal diving species were highly dependent on the young age-classes of cod fishes, sandeel and a diverse assemblage of inshore fish species (*Other fish*).

The diet studies highlight the importance of the young age-classes of cod fish, the importance of pelagic forage fish species and in particular the importance of sandeel (Figure 2). However, the differences in diet among ecological groups combined with the fact that declining seabird populations were found in all regions and included all major ecological groups suggest that the recent changes in Norwegian seabird communities cannot be explained by changes in the abundance of a single group of resources alone. On the contrary, this might suggest a combined effect of simultaneous changes in several prey items, possibly involving entire trophic levels. Alternatively, it might suggest that bottom-up regulation through food is less important, and that top-down mechanisms such as anthropogenic stressors and predation are more involved in the present changes.

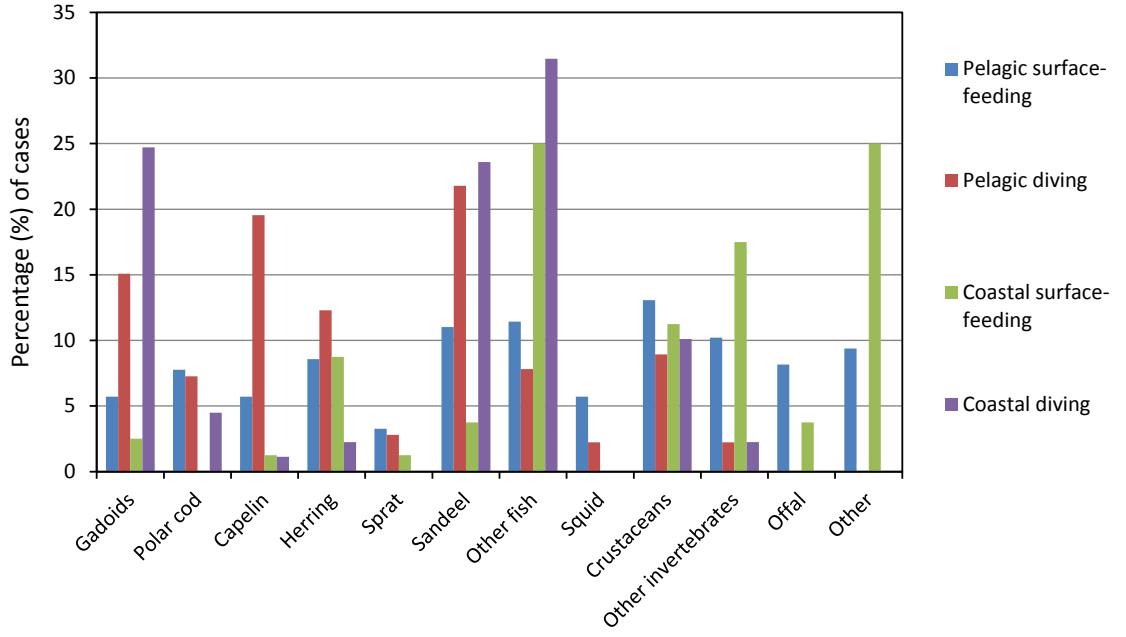


Figure 1. *The percentage of cases documenting different prey categories in the diet of seabirds. Cases were collected from a literature review on seabird diet and were summed over species belonging to the same ecological group. Total sample was 635 cases. Data are given in the species-specific tables; "Diet" and references to the studies are given in the Appendix.*

4.4 Anthropogenic and environmental stressors

Seabirds are exposed to a multitude of anthropogenic stressors and the cumulative impact of pollution, disturbance, harvest, by-catch, competition from fisheries, and climate change are difficult to discern. Many seabird populations in the North East Atlantic increased during the 20th century benefiting from protection measures which reduced the human hunting, harvesting and disturbance (Grandgeorge et al. 2008). Moreover, an increase was also probably enhanced by the fisheries, subsidizing seabirds with discards (Votier et al. 2004) and removing large predatory fishes such as cod from the ecosystems thereby indirectly increasing the abundance of small pelagic fishes that are important as food for seabirds (Grandgeorge et al. 2008). By the end of the century, industrial fisheries of small pelagic fish and climate warming resulting in large-scale ecosystem shifts might have changed the situation, and these drivers are currently suggested to be important challenges facing seabird populations in the North East Atlantic (Frederiksen et al. 2004, Frederiksen et al. 2013, Burthe et al. 2014).

We reviewed 450 relevant studies on environmental drivers affecting seabird population dynamics, many of which were from Norwegian populations. In total, these studies included 473 cases (reported driver from a colony/area) divided on 17 species. This list is probably not exhaustive, and moreover, the review did only record positive or negative results, discarding studies with null-results which tend to be under-represented in the literature. Accordingly, because the number of reported cases documenting effects probably also reflects research effort, the results should be interpreted with care. The distribution of reported cases for each type of driver summed over ecological groups is shown in Figure 2. Interestingly, the ecological groups were relatively similar with respect to the distribution among drivers, suggesting that the most important drivers affecting the population dynamics might be similar across different groups of seabirds.

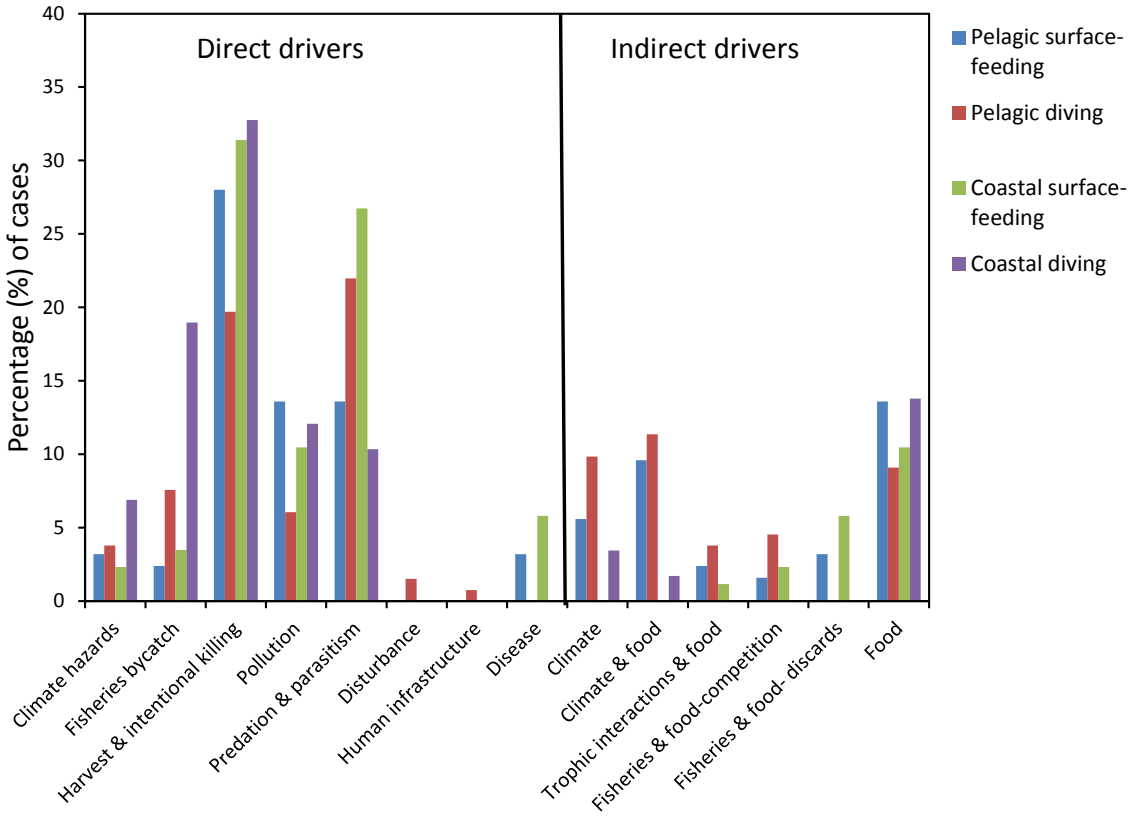


Figure 2.*The percentage of cases documenting effects of different environmental drivers on seabird demography and population dynamics. Cases were collected from a literature review and were summed over species belonging to the same ecological group. Total sample was 473 case studies. Data are given in the species-specific tables; "Driver of population dynamics" and references to the studies are given in the Appendix.*

A majority (71%) of the documented case-studies reported effects of direct drivers. However, the management plans for the marine ecosystems in Norwegian waters[3,4,5] do not report on any acute increase in any direct anthropogenic stressors that might affect seabirds (i.e. pollution, fisheries by-catch, harvesting, disturbance). On the contrary, several of the stressors have been reduced or have been held on a constant level (see below). It is therefore not likely that an increase in the level of direct anthropogenic stressors can explain the recent negative trends in Norwegian seabird populations documented by the present report. Despite this, harvest and intentional killing and predation and parasitism were the two most commonly reported

[3] Meld. St. 37 (2012–2013) Helhetlig forvaltning av det marine miljø i Nordsjøen og Skagerrak
[4] St.meld. nr. 37 (2008-2009) Helhetlig forvaltning av det marine miljø i Norskehavet
[5] St.meld. nr. 8 (2005-2006) Helhetlig forvaltning av det marine miljø i Barentshavet og havområdene utenfor Lofoten

drivers in the review study (Figure 2). It should however be noted that the effect of direct drivers might be more easily studied and documented and that such cases consequently might be over-represented in our review.

While the harvest of seabirds in Norway is negligible and strictly regulated, hunting of seabirds is widespread in other arctic territories and most notably in the Faroe Islands, Iceland, Greenland and Newfoundland (Merkel and Barry 2008, Merkel 2010). Accordingly, Norwegian populations wintering in areas with intensive hunting might be negatively affected. However, a combination of stricter hunting regulations, fewer hunters and declining seabird populations has reduced the harvest of seabirds in the Arctic in recent years (Merkel 2010). Thus, although this driver is frequently reported in the literature and certainly might contribute to a negative cumulative human impact on some Norwegian seabird populations wintering in exposed areas, it is probably not an important factor explaining the recent decline in the Norwegian populations.

In the review study, predation from avian predators such as large gulls (*Larus* spp.), Common Ravens (*Corvus corax*), White-tailed Eagle (*Haliaeetus albicilla*) and small mammalian predators such as foxes (*Vulpes* spp.) and American Mink (*Neovison vison*) was commonly reported as having detrimental impact on seabird colonies. An increase in the meso-predator guild (see e.g. Killengren et al. 2011) with an accompanying increase in the predation pressure could accordingly be a contributing factor to the observed decline in several Norwegian seabird populations. More studies directed towards the abundance and dynamics of relevant predators and how predation might govern the population dynamics of Norwegian seabird colonies, are needed to specifically address this hypothesis.

Pollution, and in particular persistent organic pollutants (POPs), mercury and accidental oil spill, was also often documented as an important factor affecting seabird populations. Stricter national and international regulations have generally reduced the concentrations of POPs in the Arctic (AMAP 2014). On the other hand there is no consistent trend in the concentration of mercury in arctic biota the last 30 years (AMAP 2011). The frequency of accidental oil spills from oil tankers has however generally decreased the last 20 years (Huijer 2005), and similarly, the discharges of oil to the sea from the oil industry have also decreased in the North East Atlantic (OSPAR 2014). Although pollution certainly contributes to the cumulative anthropogenic impact on seabirds, the recent decrease of several of these stressors in Norwegian waters suggest that pollution alone cannot explain the declines documented by the present report. However, some species foraging on the top of the food chain might be particularly vulnerable to long-transported organochlorine pollutants that have been subject to bio-magnification through the food web (Bustnes et al. 2003). For example, on Bjørnøya the decline in the population of Glacous Gull has been attributed to high levels of POPs (Erikstad & Strøm 2012).

Except for effects on coastal diving seabirds (i.e. the Cormorants *Phalacrocorax* spp. and Black Guillemot) relatively few studies reported effects from by-catch in the fisheries. A recent study suggested that about 10 000-12 000 seabirds died in the Norwegian fisheries each year in 2009 and 2010 (Fangel et al. 2011). Northern Fulmars, Cormorants, Black Guillemots, Atlantic Puffins and Razorbills were the species most affected. However, except for the Norwegian populations of Northern Fulmars and possibly some local populations of Black Guillemots, the incident of by-catch was generally low compared to the population size of the affected species. These estimates are much lower than those indicated by a previous study from the Barents Sea which estimated that 20 000 -100 000 Common Guillemots drowned each year in the spring cod and salmon drift-net fisheries in the 1980s (Strann et al. 1991). The salmon driftnet fishery was banned in 1989, and the by-catch in the spring cod fishery is also likely to have declined (cf. Fangel et al. 2011), suggesting that the impact from fisheries by-catch has decreased the last 30 years. Finally, few studies documented impacts from the remaining direct drivers; diseases, human infrastructure and disturbance.

110 (23%) cases documented effects from indirect drivers related to food availability, either via climate and/or trophic interactions. Only 20 of these cases reported a trophic link to fisheries

(i.e. studies where fisheries were suggested to affect food availability). It should however be noted that such indirect links might be difficult to document and that such cases accordingly might be under-represented in the sample. Nevertheless, the review study indicated that most species are susceptible to changes in the marine ecosystem entailing changes in the availability of food. Moreover, an increasing number of studies also indicated that these changes are related to changes in ocean climate. The expected climate warming will presumably accentuate such changes. As a consequence, we would expect an increase of boreal species and a decrease of arctic and sub-arctic species in Norwegian waters. The importance of such relationships is underlined by the fact that the seabird populations showed large decadal fluctuations taking place on a scale corresponding to the large marine ecosystems (i.e. the Barents Sea, Norwegian Sea and North Sea & Skagerrak). It is therefore possible that ecosystem-specific changes, possibly initiated by past and present fisheries in combination with climate change, are the major indirect drivers behind the observed seabird declines. Indeed, major ecosystem changes have recently been documented in the North Sea (Fauchald et al. 2011, Frederiksen et al. 2013), the Norwegian Sea (Huse et al. 2012, Frederiksen et al. 2013) and the Barents Sea (Johannesen et al. 2012, Fauchald et al. 2014).

In conclusion, the two most likely candidates to explain the recent declines in Norwegian seabird populations are 1) increased predation in the seabird colonies from avian and mammalian predators and 2) ecosystem changes affecting the availability of prey. The impact from these drivers might be difficult to document and even more challenging to control. In contrast, more easily managed direct anthropogenic stressors such as fisheries by-catch, pollution, hunting and disturbance have either been constant or have shown a decreasing trend. Although these drivers cannot explain the recent population declines, they certainly contribute to the cumulative impact on seabird populations and these stressors are therefore especially important to control and minimize in rapidly declining and threatened populations.

5 References

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6 Appendix: Literature review; references

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Arctic Tern *Sterna paradisaea*

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Common Guillemot *Uria aalge*

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Brünnich's Guillemot *Uria lomvia*

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Razorbill *Alca torda*

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