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AEWA European Goose Management Platform

6th MEETING OF THE
AEWA EUROPEAN GOOSE MANAGEMENT
INTERNATIONAL WORKING GROUP

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EGMP POPULATION STATUS AND ASSESSMENT REPORT 2021

The 6th Meeting of the AEWA European Goose Management International Working Group is taking place remotely in an online conference format.

Preface

This report provides the 2021 information for the goose populations managed under the EGMP. The information cover aspects related to population status, survival, productivity, hunting bags and derogation statistics, progress in population models, as well as assessment of cumulative impact of derogation and legal hunting and, for some populations, management recommendations. These may differ for each species, as available data differs from species to species (or populations identified in the framework of the EGMP). Status of indicators related to other aspect of the management plans, such as socioeconomic issues and ecosystem services provided by geese, are presented in the Adaptive Framework Management Programmes (AFMPs) under Indicator factsheets.

The data presented here are the most up-to-date information received from the range states and their monitoring networks. Due to delays in acquiring certain data, some information presented in this report will differ from that in previous reports and may also be subject to updates in future reports. Readers will be able to find a full record of existing data at: [still under development]

Input and output of the assessment runs are available at: https://gitlab.com/aewa-egmp

Previous EGMP reports are available at: https://egmp.aewa.info/resources/publications

Reading guideline

- Executive summary for each population
- Chapter 1: Introduction and data issues
- Chapter 2-6: Population-specific status and assessment

Recommended citation

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Executive Summaries

Svalbard population of the Pink-footed Goose *Anser brachyrhynchus*

Population development and status

The Pink-footed Goose is counted in November and May. The count in November 2020 registered a total of c. 111,000 individuals. The count for some parts of Jutland, Denmark may be biased high due to a mix of Pink-footed Geese and Barnacle Geese in huge flocks and observed at long distances during roost flights. The May count resulted in a total of c. 74,000 geese, and the May population estimate based on resightings is c. 81,000 individuals (95% CL: 70,718-91,453). The survival was 0.81 (se = 0.03) in 2019-2020, which is similar to that of the last decade. The proportion of young in the autumn population was 19.8% (CI: 6.6-37.9), which is high compared to the long-term average for the population. The harvest bags in Denmark and Norway were high in the harvest season 2020/2021, reflecting the high proportion of juvenile birds in the population. In total, the preliminary number of harvested geese was 16,034.

Harvest assessment

The EGM IWG uses a management objective intended to maintain the population size within agreed upon limits by regulating harvest in Norway and Denmark. The objective function used for optimising harvest quotas devalues harvests that are expected to result in a subsequent population size different than the population goal of 60,000, with the degree of devaluation increasing as the difference between population size and the goal increases. Using an integrated population model (IPM), the harvest quota for the 2021/2022 hunting season is 28,000 (which includes an expected 4% crippling loss), based on the IPM estimate of population size in May 2021 of 78,300 and 3 days above freezing in Svalbard. Using an agreed upon allocation of the total quota (30% for Norway, 70% for Denmark), harvest quotas for Norway and Denmark this year (season 2021/2022) are 8,400 and 16,800, respectively. For comparison, the realised harvest has averaged about 15,100 (*se* = 900) during the last five years (54% of this year's quota). For a population at its goal of 60,000, and with a mean number of days above freezing (10), the harvest quota would be 9,000.

Basis of the assessment

ISSMP	International Species Management Plan for the Svalbard Population of the Pink-footed Goose (PFG), Adopted: 2012; to be reviewed: 2024
AFMP	Not developed
Objective	Maintaining abundance of this population near a goal of 60,000 in spring by providing sustainable harvests in Norway and Denmark
Actions	Harvest quota
Input data	Population counts in May and November; May population estimate based on capture-mark-recapture (CMR) data; Proportion of wings submitted by Danish hunters prior to mid-November; Proportion of young in the autumn population; Total harvest in Norway, September – December; Total harvest in Denmark, September – January; The number of days above freezing in May in Svalbard.
Assessment type	Passive adaptive harvest management using an IPM (Johnson et al., 2020) and stochastic dynamic optimization (https://gitlab.com/aewa-egmp/svalbard-population-of-pink-footed-goose/harvest-assessment-2021)

Quality of the assessment

Unlike most goose populations in Europe, an extensive science-focused monitoring program has been in place for this population of Pink-Footed Geese for three decades, with the goal of understanding population dynamics, migratory behaviour, and anthropogenic impacts. The wealth of available information about population size, distribution changes, survival, productivity, and harvests has facilitated the construction of a robust, integrated population model (IPM), which is used to guide harvest-management decisions in Norway and Denmark. Moreover, by using all available demographic information, the IPM can overcome some of the apparent bias in some sources of raw data. Nonetheless, we emphasise that inferences are dependent on the specified structure of the dynamic population model.

Issues relevant for the assessment and advice

The harvest quota for 2021 remains high because the spring population is still far above the target. Since implementation of AHM, harvest quotas have never been realised and, because May population size has largely stabilised, fulfilling more of the quotas (increased and more efficient hunting) may be necessary to reduce population size to the target level. This is especially true with continued warming in the Arctic, as this is expected to increase the annual productivity in the population.

Taiga Bean Goose *Anser fabalis*

Population development and status

Central MU: The population size of the Central MU is estimated based on counts organised three times a year; in October, mid-winter (January) and March. The count in October 2020 was conducted with some complications due to the COVID-19 pandemic but recorded a total of c. 56,000 Taiga Bean Geese, a value that should be used with caution because of limited coverage related to mobility problems related to the pandemic. The mid-winter counts reached a total of 3,994 Taiga Bean Geese and 34,000 Bean Geese (i.e. Bean Geese not assigned specifically to sub-species), however the latter count was far from complete. The March count recorded a total of 67,149 Taiga Bean Geese. Productivity data are usually available from Sweden for the Central MU, however, again due to mobility restrictions due to the pandemic, is was not possible to gather such data for this season. Harvest data are currently not up-to-date for most range states, most recent estimate is from 2019/2020, with a hunting bag of >4,638 Bean Geese (not including potential hunting in Russia).

Western MU: The population size of the Western MU is only estimated based on counts conducted during mid-winter, these reached a total of 1,288 Taiga Bean Geese in January 2021. Despite the potential gaps in survey coverage, the population level remains far below the target of 4,000 individuals. Productivity estimates for the Western MU, showed in 2020 a juvenile percentage of c.12% in Slamannan Plateau, Scotland, which is typical for this population in the past 20 years or so.

Eastern 1 and 2 MUs: The population sizes for the two Eastern MUs remain unknown.

Harvest assessment

An annual harvest assessment is only conducted for the Central Management Unit (CMU) of Taiga Bean Geese. Hunting of the Western and Eastern Management Units is currently considered inadvisable. For the CMU, the EGMP is operating under an interim harvest strategy intended to allow the population size to reach the median target of 70,000 by March 2025 while still providing limited hunting opportunity. During 2020, the integrated population model (IPM) for the CMU was revised to exclude the Tundra Bean Goose (*A. f. rossicus*) from population counts and estimates of offtake. The March 2021 population size of Taiga Bean Geese in the CMU as estimated by the IPM was 66,916 (62,468 – 73,362), which is similar to the comparable estimate from March 2020. The population could be sustained at this level (on the average) with a total harvest of 5,695 (3,994 –7,226). However, a harvest consistent with the goal of reaching the median population target by March 2025 is 2,000 (1,913 – 2,088) and the country-specific allocations of this harvest are: Finland – 1,160 (1,094 – 1,227); Sweden - 600 (553 – 648); and Denmark - 240 (210 – 271). For comparison, the estimated total harvest averaged 2,978 (2,230 – 3,727) during the years of the interim harvest strategy (2017 – 2020). If the population were at its median target of 70,000, the harvestable surplus would be 4,791 (2,684 – 6,578).

Basis of the assessment

ISSMP	International Single Species Action Plan for the Conservation of the Taiga Bean Goose (TBG) Adopted: 2015; to be reviewed: 2025
AFMP	Not yet developed
Objective	Maintain the spring population near a median goal of 70,000
Actions	Offtake levels for meeting the population target by March 2025
Input data	Population counts in March, October and January; Offtake (harvest + derogation) in Denmark, Sweden and Finland
Assessment type	IPM (Johnson et al., 2020)

Quality of the assessment

Both population counts and harvest estimates contain varying numbers of the Tundra subspecies, and attempts to delineate the Taiga and Tundra subspecies in monitoring data have been sporadic and largely confined to recent years. While we have endeavoured to eliminate the influence of Tundra Bean Geese in the IPM, we caution the reader that results and conclusions contained herein must be viewed in light of the limitations of the data and of our methods.

Issues relevant for the assessment and advice

In terms of monitoring, the Task Force has recommended maintaining counts during March, October, and January for the foreseeable future. Efforts are also being continued to better distinguish between the Taiga and Tundra subspecies in count and harvest data. Finally, it should be noted that while the March 2021 population size ($\hat{N}$ = 66,916) is not at the median target of 70,000, it is within the acceptable bounds of that target (i.e., 60,000 – 80,000).

NW/SW European population of Greylag Goose *Anser anser*

Population development and status

The population size in 2020 was estimated at ~800.000 individuals based on EGMP national totals (using the EU Birds Directive Article 12 reported value for the years 2003-2016 for Germany) and ~1 million individuals based on imputed totals from the International Waterbird Census (IWC). However, the high degree of imputing in Germany and Spain results in larger fluctuations and a large uncertainty in the overall population size estimate, which is likely between the values presented by the two different methods to derive a total.

Based on IWC imputed values and adding values from other sites in Denmark, a growth rate for the last 10-years (2011-2020) was estimated at 1.01 (95% confidence limits 1.005-1.011). This indicates that the population's growth rate has decreased but still remains positive. The same tendency is observed using the Common Bird Monitoring Breeding Bird Index, which even indicate a stabilisation in all Fennoscandia countries in the last few years. EGMP totals show a decline of wintering numbers in Spain and a stabilisation in The Netherlands since about 2010.

The numbers killed under derogation in 2019 is at least 155,507 (data is missing from Germany and 2 out of 12 Dutch provinces), which together with the harvested numbers during the hunting season (min. 98,180, data missing from France and Germany) gives a total of at least 253,687 Greylag geese being killed in 2019.

Harvest assessment

Next assessment is up in 2023, with the planned transition to a dynamic and model-based management.

Basis of the assessment

ISSMP	International Single Species Management Plan for the Greylag Goose, Adopted: 2018; to be reviewed: 2028.
AFMP	AFMP, Adopted: 2020; to be reviewed: 2026.
Objective	Maintaining the population at a satisfactory level; 70,000 breeding pairs for MU1 and 80,000 breeding pairs for MU2 (Johnson et al. 2021). However, in the face of deep uncertainty related to estimates of population size and offtake at the flyway level, range states have agreed on a management criterion of 15% reduction in population over 10 years, which means an annual growth rate of 0.96 < lambda < 1.00, until more reliable monitoring information is available (in 2023).
Actions	Offtake levels; Based on an info-gap decision model, countries may increase their nominal offtake by a maximum 40% over those values provided in the ISSMP. (However, this is optional and not an obligation).
Input data	*Up to 2023*: Growth rate is assessed based on 10-year trends calculated from the latest available data using IWC imputed values or additional country-specific data in January; Total offtake by derogation and harvest. *Needed for a transition to a dynamic and model-based management from 2023*: Mid-winter population counts for each range state; Breeding pairs/Summer counts per range state; Offtake per range state (harvest + derogation), distinguished between "breeding" period (1 February-31 July) and "post-breeding" period (1 August-31 January); Crippling rate for the same periods as offtake; Survival rates from Multi-state Capture-Marking-Resighting (CMR) analysis.
Assessment type	*Up to 2023:* Information-gap ("info-gap") decision model (Johnson & Koffijberg, 2021). *Planned from 2023:* Dynamic and model-based management. However, a model has not been developed and neither fiscal and/or personnel resources are in place. Furthermore, increased effort to collect monitoring data as input variables has to be organised.

Quality of the assessment

The info-gap decision model does not provide a sound basis for adaptive, dynamic decision-making, which ultimately will be necessary to reliably manage Greylag Goose abundance in accordance with population targets in the two management units.

Issues relevant for the assessment and advice

At EGM IWG5, it was decided that the info-gap decision model is a one-off option to be applied for a 3-year period (2020-2023), where after it will be ceased, and a dynamic and model-based management should be put in place.

In order to establish the preconditions for the dynamic, model-based management of the population in the long term, the following actions need to be implemented before the 2023/2024 hunting season:

1. Establish the necessary monitoring frameworks outlined in Chapter 6 of the AFMP, particularly:
    a) Reliable and up-to-date offtake data (both derogation and harvest) which can be assigned to Mus.
    b) Summer counts to estimate the population size at MU level.
2. Getting fiscal and/or personnel resources in place to develop population models by 2023.

Currently, neither of these points are in place and a significant effort must be made if management of Greylag Goose shall be continued after 2023.

Russia/Germany and Netherland population of Barnacle Goose *Branta leucopsis*

Population development and status

Census data collected in January 2019 and 2020 suggest a flyway population of about 1.4 million Barnacle Geese, which is 3.7 times the Favourable Reference Population (FRP) at flyway level. There is some uncertainty about the true size of the flyway population, as counts in Germany were not available for January 2017-2020 and interpolated data has been used instead. Data from Belgium, The Netherlands, Denmark and Sweden suggest that the flyway population may have increased by 8% from 2016-2017 to 2018-2019, but numbers in these countries in January 2019 and 2020 were highly similar. Since 1981, the flyway population has increased with on average 9% annually but recently some levelling off has become apparent. Productivity, in the Russian/Baltic population (MU1 and MU2), as assessed in autumn flocks and expressed by the percentage of first-year birds, fitted well in the overall pattern from previous years, but was low compared to the available long-term data. Productivity in 2019 (7.3% first-year birds) was among the lowest recorded so far.

Counts made in summer in the temperate breeding populations give some insight about the numbers in MU2 (Baltic) and MU3 (North Sea), but do not have full coverage yet. For MU2, about similar numbers (average 33,000) were recorded in Finland and in the Oslofjord region in Norway (1800) in summer 2019 and 2020. MU3 is dominated by the large population in The Netherlands (53,500), which in 2019-2020 showed a 12% decrease compared to 2017-2018. As a result, the provisional estimate of 65,000-70,000 individuals for this MU made in the previous status report likely has to be adjusted to a lower level, but also should be confirmed with data from Lower Saxony and Schleswig-Holstein in Germany, to achieve full coverage. Productivity, assessed in parts of Finland, Norway, Germany and in The Netherlands point at higher proportions of first-year birds in the temperate breeding populations, but data may not be representative for all countries yet.

Compared to the previous status report, the number of Barnacle Geese killed under derogation has increased and exceeds 60,000 individuals in recent years (data for 2019-2020 still incomplete). In 2018, 59% of the numbers killed by derogation originated from The Netherlands and 27% from Denmark. In the Netherlands, derogation effort has increased further since then. Only for The Netherlands, detailed data are available when Barnacle Geese are shot or being culled. Data from 2019-2020 show that on average 29% of the offtake in these years was made in July (mainly catches/culling during wing molt), whereas at least 48% of the offtake, from June until September, will involve local breeders and not affect migratory birds from MU1 and MU2. These data make clear, that a higher resolution than just annual totals is important to be able to assign numbers killed under derogation to one of the three defined management units. A first overview of crippling rates, data collected in The Netherlands and Denmark suggest higher incidences in recent years (compared to a first study in 2009-2011), but also show variation among countries. Data from The Netherlands also point at higher incidences among (resident) breeding birds, which are exposed to derogation shooting for a larger part of the year than wintering birds. A more in-depth analysis will be made separately.

Assessment of cumulative impact of derogation and legal hunting

The cumulative impact of derogation and hunting is up for assessment in 2022. However, population sizes for both MU2 and MU3 (14,500 and 19,563 breeding pairs[46]) are below the 200% threshold (23,978 and 23,550 breeding pairs) set in the AFMP, which implies that coordination among countries regarding derogation shooting should be in place.

[46] From the AFMP

Basis of the assessment

ISSMP	AEWA International Single Species Management Plan for the Barnacle Goose, Adopted: 2018; to be reviewed: 2028
AFMP	AFMP, Adopted: 2020; to be reviewed: 2026
Objective	Prevent the population or any of its MUs to decline below the FRP. Thus, the FRPs represent the lower limits of the legally acceptable population sizes but not targets for population reduction.
Actions	Every 3 years (next in 2022): 1) Assessing whether the population size and its MUs are below the 200% threshold and approaching the FRP; 2) Coordination of offtake under derogation and hunting if the population and any of its MUs are below the 200% threshold of the FRP (incl. assessment of the cumulative impact of derogation and legal hunting on the population.).
Input data	*Annual:* Midwinter counts per range states; Offtake (harvest per year, derogation per MU, preferably derived from monthly data of any other assignment to MU-level); Crippling rate for the same periods as offtake. *3-year cycle, next in 2021:* Proportions of young and older birds in each MU; Monitoring of summer counts per range states in MU2 and MU3.
Assessment type	IPM model (Baveco et al 2020)

Quality of the assessment

The cumulative impact of derogation and hunting is up for assessment in 2022. However, in the IPM to undertake this assessment there is still a lack of basic data regarding numbers and productivity for parts of the countries within MU2 and MU3.

Issues relevant for the assessment and advice

The main gaps identified for this population are:

- Lack on information about wintering numbers (January) in Germany, which are missing from 2017 onwards. In previous years, this involved about 25% of the flyway population. Hence, this a major gap which affect proper population size estimates, especially when trends in abundance will deviate from existing data, e.g. when winter weather gets milder and wintering ranges may shift;
- Incomplete coverage of MU3 in summer counts, as a result of missing data from Schleswig-Holstein and Lower Saxony in Germany. Productivity data at present mainly originate from The Netherlands and published data from North Rhine-Westphalia in Germany but do cover relevant parts of these populations;
- Scant information on abundance in summer in MU2, as data is not available for Denmark and Sweden (and Estonia/Russia as well, but likely fewer birds involved). Productivity data is only available for part of the Finnish population and the Oslofjord region in Norway, but preferably should include more regions in Finland in order to achieve representative estimates. In addition, there is a need for productivity estimates in Denmark and Sweden to have representative data in place for MU2;
- Derogation data arrive with some delay and for some countries are not accessible through the data gateway for the EU yet (Eionet central data repository). It should be elaborated how more timely data can be achieved without increasing the reporting burden for the countries. Data preferably should not only include annual totals, but also some sort of segregation over the year in order to be able to assign offtake to the respective management units (either by e.g. data with monthly resolution or making expert judgement which MUs are affected). This is shown by the example for The Netherlands, which makes clear how numbers shot or culled may affect different MUs.

E. Greenland/Scotland & Ireland population of Barnacle Goose *Branta leucopsis*

Population development and status

The total wintering population was estimated at 73,391 birds in March 2020; divided into 58,135 geese in Scotland and 15,256 geese in Ireland. This represents a 1.7% increase on the 2018 census total.
The number counted on Islay in spring 2020 (33,202), the most important site in the winter range, was 4.5% lower than that recorded in spring 2018, whereas the number of geese throughout the remainder of Scotland has increased by 17.7% since 2018.

The results of the 2020 nest counts in Iceland in June gave an increase of 379 nests to a total of 2,474 (+18.5%). The ratio of non-breeding birds at several colonies was 0.589 this year giving an estimate of the Icelandic population of Barnacle Geese 11,688 individuals or 15.8% of the total population.

The total number killed was 4,020 in 2019; divided into 986 killed under derogation in Scotland and 3,034 killed during hunting in Iceland. Data from 2020 is not available yet.

Assessment of cumulative impact of derogation and legal hunting

The cumulative impact of derogation and hunting is up for assessment in 2023. However, the current population size (73,391) is below the 200% population threshold of the FRP (108,000) set in the AFMP, which implies that range states in a coordinated manner should: a) Develop a predictive population model; b) Increase the frequency of full population censuses from 5 years to 3 years; c) Agree on the level of allowable offtake (either under derogation or hunting) in order to avoid that the population size drops below the FRP.

Basis of the assessment

ISSMP	AEWA International Single Species Management Plan for the Barnacle Goose, Adopted: 2018; to be reviewed: 2028.
AFMP	AFMP, Adopted: 2020; to be reviewed: 2026.
Objective	Prevent that the population decline below the FRP. Thus, the FRPs represent the lower limits of the legally acceptable population sizes but not targets for population reduction.
Actions	Every 3 year (next in 2023): 1) Assessing whether the population size is below the 200% threshold and approaching the FRP; 2) Coordination of offtake under derogation and hunting if the population is below the 200% threshold and approaching the FRP (incl. assessment of the cumulative impact of derogation and legal hunting on the population.).
Input data	*Annual:* Population counts at key sites in Scotland; Age counts on Islay and Tiree in Scotland; Offtake data (harvest and derogation); Crippling rate for the same periods as offtake. *3-year cycle, next in 2023:* Total population size; Icelandic breeding population.
Assessment type	IPM model (McIntosh et al. 2021)

Quality of the assessment

The newly developed IPM provides a sound framework from which we can develop projections of how the population will respond to different management scenarios in the future. This can then be used to inform and optimise management strategies. The IPM also provides an ideal framework for adaptation, as model parameters can be updated as additional data become available. Nevertheless, it is important to recognise that the IPM cannot optimise an allocation of offtake across range states. That is a value judgement that must be made independently of the IPM.

Issues relevant for the assessment and advice

In terms of the needed actions towards a coordination of offtake under derogation and hunting, the range states have already succeeded in the development of a predictive population model and the frequency of full population censuses have decreased to every 3 years. Thus in 2023, agreement must be made on the level of allowable offtake (either under derogation or hunting) in order to avoid the population size dropping below the FRP.

1. Introduction

The first management plan to actively manage a migratory population of waterbirds in Europe was implemented in 2013. The plan was for the Svalbard population of Pink-footed Goose and was based on the concept of adaptive management (AM). AM provides a framework for making objective decisions in the face of uncertainty about an ecological system and the impact of management actions. To reduce this uncertainty and improve management over time, AM relies on an iterative cycle of monitoring, assessment, and decision-making.

In 2013, plans for the first iterative cycle were published in the form of a population status report and a harvest assessment report. In May 2016, the European Goose Management Platform (EGMP) was established, following a resolution adopted by the Meeting of the Parties of AEWA. The platform functions under the framework of the African-Eurasian Migratory Waterbird Agreement (AEWA), which provides for the conservation as well as the sustainable use of the migratory waterbird populations it covers. The platform addresses the conservation and management of declining, as well as growing, goose populations in Europe by a coordinated flyway approach amongst all Range States concerned. The setup of EGMP benefited from experiences made with the Svalbard Pink-footed Geese and was extended with the Taiga Bean Goose in 2015. Like for the Pink-footed Goose, individual population status and harvest assessment reports have been published on an annual basis since then.

In 2017, four more populations were added to the EGMP; the NW/SW European population of Greylag Goose, as well as the three populations of Barnacle Goose: the Russia/Germany and Netherlands population, E. Greenland/Scotland & Ireland population and the Svalbard/SW Scotland population.

This report replaces the individual population status and harvest assessment reports published so far and provides a shared platform for the most up-to-date monitoring information and management recommendations on each population managed under the EGMP. As the AFMP for the Svalbard/SW Scotland population of Barnacle Goose is still under development no reporting is provided for this population.

1.1. Data collection, identified issues and further research

Current methods for compiling population status and assessment data

Each year a *Monitoring and reporting plan* is sent from the Data Centre to the National Government Representatives and/or experts/data providers. The *Monitoring and reporting plan* consist of a table with a list of: what data shall be collected, when the data will be collected, by who and where the data will be collected, as well as a submission deadline of the data to the EGMP Data Centre. Unless the National Government Representatives have made agreements with new experts/data providers, the cooperation is continued with those already identified. The *Monitoring and reporting plan* shall be agreed upon within the population specific Task Forces.

Identified data collection issues

For the collection of population data, particularly population size and harvest estimates, a general issue is that data are received with several years time lag or has issues regarding quality or annual coverage. Before up-to-date, coordinated, and reliable monitoring data are available, it is not possible to establish model-based management of those populations. The specific data requirements are discussed under the population specific chapters in this report. Issues with data deliveries are summarised in Table 1.1.

Table 1.1. Identified data collection issues for each population.

Population/MU	Data problem
General issues across populations and species	Delays of EU derogation numbers through Eionet and for some range states data on Eionet are not accessible. Standardised crippling assessment and age ratio assessment in the field across populations. Maintain and increase the network of national volunteers, who contributed with population counts, as well as hunters who delivered data to different schemes.
Svalbard Pink-footed Goose	Pending cuts in the monitoring program from 2022 onwards (primarily the CMR program and the age counts unless funding is made available).
Taiga Bean Goose	Counts from Germany. Up-to-date estimates of offtake data from Sweden, Latvia and Russia. Coordinated counts in WMU. Better distinguish between the Taiga and Tundra subspecies in count and harvest data. Population size and off take information from Eastern 1 and Eastern 2 MU. Improved information on movements (all MUs).
Greylag Goose, MU1 & MU2	Missing recent winter counts from DE and some regions in ES. Missing summer counts for MU1 (DK, NO, SE, FI), as well as some federal states in DE and recent years in NL and BE. Updated info on MU transition probabilities, productivity (MU1) and survival. Crippling info. Common Bird Monitoring information from DE. Missing hunting bag data from FR, DE and some regions in ES. Reporting only every 12 year in FR. Derogation data from DE and FI, DK, DE, NL and SE in 2020. Distinction between "breeding" period and "post-breeding" period in offtake data in FI, DE, SE. Better understanding on methods of deriving harvest estimates from SE and DE. Insight in data quality issues in derogation numbers in NL.
Russia/Germany and Netherland Barnacle Goose, MU1, MU2 & MU3	Missing wintering numbers (2017-2020) and incomplete summer counts in DE. Missing MU2 summer counts from EE, RU, SE, DK and productivity data from DK and SE. Derogation data from 2020 for EE, SE, DK, BE and in 2019 from SE. Distinction between "breeding" period and "post-breeding" period in offtake data in FI, DE, SE and EE.
E. Greenland/Scotland & Ireland population	Localised annual population counts in alternative wintering sites. Productivity data from Iceland and sites outside Islay. Knowledge of environmental conditions that may influence reproduction and/or survival rates. Crippling info. Greenland hunting bag data.

2. Svalbard population of Pink-footed Goose *Anser brachyrhynchus*

This chapter compiles annual monitoring data (methods and results) on the population status of the Svalbard Pink-footed Goose for the season 2020/21 (section 2.1). This data is used to assess the population development and provide input data for the modelling of an optimal harvest strategy for the population for the coming hunting season (2021/2022) (section 2.2).

2.1. Population status

The range states for the Svalbard population of Pink-footed Goose *Anser brachyrhynchus* include Norway, Denmark, Belgium and the Netherlands (Figure 2.1). However, in recent years increasing numbers are observed in Sweden and Finland as well.

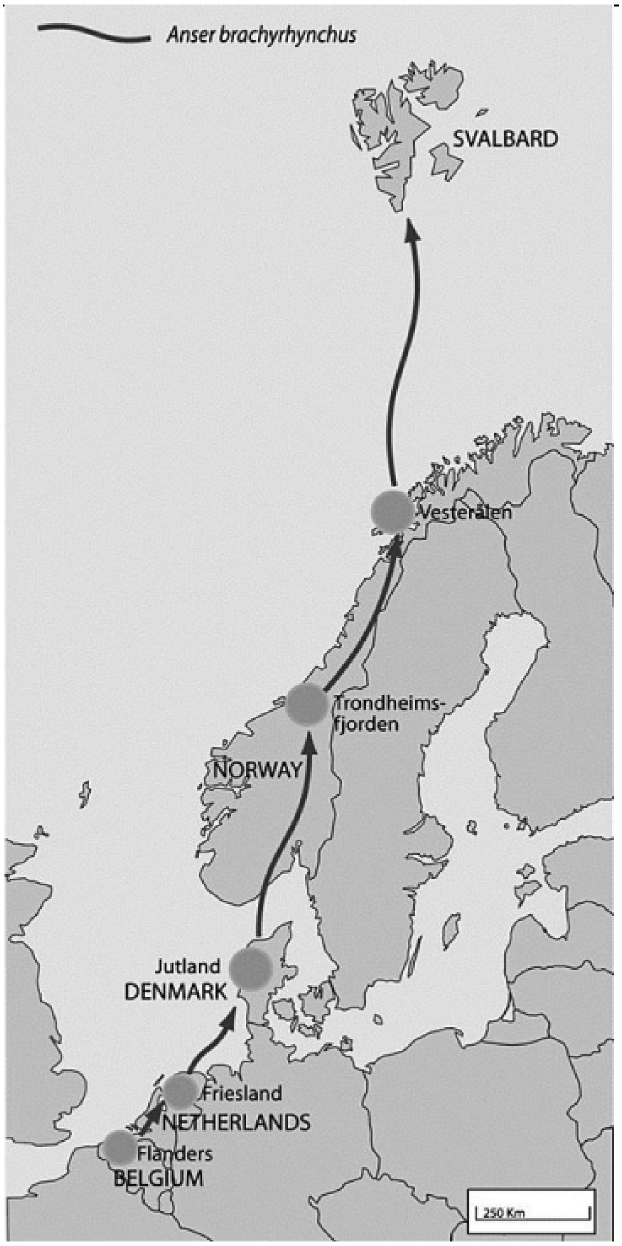

Figure 2.1. Annual distribution and migration route of the Svalbard Pink-footed Goose (copyright NINA, Norway)

Data collection and methods

Counts

Internationally coordinated population counts are performed in autumn in Norway, Sweden, Denmark, the Netherlands and Belgium and in spring in Norway, Sweden, Finland and Denmark. Flocks are either counted when they leave roost sites in the morning, arriving at roost sites in the evening, or alternatively on fields. The main known sites are covered by a network of trained observers who coordinate the coverage and timing of counts. Additional information is retrieved from internet reporting portals, where birdwatchers report flocks in areas outside the main areas (http:/artsobservasjoner.no/fugler; https://www.artportalen.se; http://dofbasen.dk; https://www.tiira.fi/). Numbers are carefully extracted and evaluated in order to exclude potential double counts. In the Netherlands and Belgium, counts are part of nationally coordinated governmental monitoring schemes, mainly run by volunteer networks in the field. Only census data is used to achieve national totals.

Lincoln index

To obtain an alternative estimate of total population size of Pink-footed Geese, we used a capture-mark recapture approach (Lincoln index) on sightings of geese marked with neckbands in Denmark, Norway, Svalbard and Finland. The estimation is based on the ratio of total geese per marked goose and the total number of marked geese in the population (Clausen et al., 2019; Sheaffer and Jarvis, 2013). Recordings of marked versus unmarked individuals in flocks started in 1991 (Ganter and Madsen, 2001). In the first 20 years, recordings were made on relatively few flocks (average number of flocks scanned annually was 28; range 1-153); since 2012, the recordings have been intensified to increase the sample size (range 227-383). For each year we estimated a mean ratio of marked to unmarked geese for all flocks >100 individuals recorded in autumn and spring in Denmark and the Netherlands (Clausen et al., 2019). In 2020/21, only data from Denmark (October-November 2019 and March-April 2020) was available. The number of neck-banded geese alive was estimated based on the number of marked geese seen at least twice in an observation window covering mid-February to mid-May (corresponding to a period with coordinated observation efforts), corrected for the detection rate of marked birds alive. Ringing and re-sighting data was extracted from http://www.geese.org, where observers add their registrations. Detection rate was estimated using the program MARK (White and Burnham, 1999). As the detection rate of the last year in a time series is not estimable, we assumed the detection rate and the variance for the most recent year to be identical to the previous year since the variation between subsequent years has been moderate in recent years. In the springs of 2018 and 2019 as well as in the summer of 2018, a total of 44 Pink-footed Geese have been marked with GPS neckband transmitters by the Netherlands Institute of Ecology and Aarhus University. In the spring of 2021, 22 of these transmitters were still alive. Since we know for sure that these geese were alive, but not part of the CMR analysis on geese wearing traditional collars, this number has been added to the estimate of marked birds alive based on the resighted neckbanded geese. The total population size was estimated as the number of marked geese alive divided by the corrected estimate of the ratio. The confidence limits were estimated based on the variance estimate for the population. A full description of the methods is given in Clausen et al. (2019).

Productivity

The proportion of juvenile birds in flocks during autumn, is tallied in Trøndelag in Norway, NW and W Jutland in Denmark, Friesland in the Netherlands, Flanders in Belgium and since 2019 in Ørebro in Sweden. Only counts performed between 12 October and 4 November have been included in the analysis because it minimises the seasonal changes in the proportion of young.

Since 2012, the proportions of juveniles per country have been weighted by the number of geese present in each of the countries based on the November count. This was done in order to derive a population-wide age ratio. In 2019, the weighted estimates were re-calculated for the years since 2012 in order to estimate the binomial variance around the overall mean age ratio. This approach assumes that areas with the largest populations are most representative of the proportion of young.

To avoid this strong assumption, we have used the daily tallies of young and total birds within a year to calculate a mean annual probability of young ("means model"). This is done using a generalised linear model with a logit-link function. A beta-binomial error distribution is used for the count of juveniles to account for sampling variability in the data that exceeds that expected based on sample size alone (i.e. due to variation among regions, flock sizes, and other uncontrolled factors).

This approach assumes that proportion of juveniles and its 95% confidence interval is an "index" to reproductive success, rather than the "true" post-breeding value that is provided by the IPM. The index assumption rests on the requirement, however, that observations are conducted in a standardised way each year within the same window and areas, with random encounters of flock size, and no multiple observations of the same flock. Furthermore, the comparability among years rests on the assumption that the rates of harvest prior to the observation window are approximately equal each year. Otherwise, changes in the proportion may not accurately reflect changes in reproductive success.

Survival

Annual survival was estimated using the program MARK (White and Burnham, 1999) based on recoveries of dead birds and encounter histories (Joint Live and Dead Encounters) of all Pink-footed Geese ringed with neck collars during 1990-2018 (including observations up until 2021). Ringing and re-sighting data were extracted from https://www.geese.org/ and recoveries of dead birds were supplied by the ringing offices in Denmark and Norway. Encounter histories were based on an observation window from 23 February – 22 May and, because neckbanded individuals are generally seen several times during this period, only birds with at least two sightings within the observation window were included as positive observations. This ensured that the influence of re-sighting errors was kept to an absolute minimum. Using MARK, a number of models were fitted with various constraints on survival, re-sighting probability and recovery probability. These models were evaluated using AIC (Burnham and Anderson, 2002) and estimates of annual survival from the best performing model used. The survival estimates are updated each year and subject to minor changes due to continuous reporting of resightings. Therefore, the most recent estimate is preliminary.

Thaw days

For the modelling of optimal harvest strategy, the weather conditions in May in Svalbard are used as a predictor of the production of young (Jensen et al., 2014). The mean daily temperatures (Mean Air Temperature) are derived from Ny Ålesund and Svalbard Airport meteorological stations (https://seklima.met.no/observations/). This information is used to describe the number of thaw days (days with average temperatures above 0°C) at the two sites each year (being positive related to the number of young produced).

Harvest data

Data on hunting bags from Norway has been supplied by Statistics Norway (www.ssb.no ; the early estimates in the most recent year considered is communicated via the Norwegian Environment Agency). Hunting bags from Denmark have been derived from the National Hunting Bag Statistics (Danish Environmental Protection Agency; Aarhus University) (http://bios.au.dk/videnudveksling/til-jagt-og-vildtinteresserede/vildtudbytte). Both in Norway and Denmark, reporting the harvest is mandatory and hunters report their bags online. However, since not all hunters in Norway and Denmark may yet have reported their hunting bags, the most recent estimate is preliminary.

Derogation

Derogation data presented in this report have been derived from the EU Eionet central data repository (https://ec.europa.eu/environment/nature/knowledge/rep_birds/index_en.htm) for Denmark (available until 2019). In Denmark, there is no compensation or subsidy schemes for geese, but derogation shooting outside the open hunting season (allowed only in February) is used to alleviate agricultural damage.

Derogation killing of Pink-footed Geese is not practiced in Norway. Instead, the agricultural authorities subsidise farmers for allowing Pink-footed Geese to forage on their land and then they are not allowed to shoot geese.

Wings

Danish hunters submit wings from shot geese to the Danish Wing Survey at Aarhus University. We used data from the Danish Wing Survey to estimate the annual juvenile/adult ratio and as a surrogate of the timing of the annual harvest to describe the ratio of the annual bag that is shot before the November counts, an information that is included for the modelling of the optimal harvest strategy.

Crippling ratio

The methods of calculating the "crippling ratio", as well as how the crippling ratio has changed in the population of Svalbard-breeding Pink-footed Geese during the period 1992–2016 is presented in Clausen et al. (2017).

Population data

Counts

Internationally coordinated population counts were performed on 14-15 November 2020 and 1-2 May 2021. Counts were coordinated to take place as closely as possible to these dates. Count data from Germany was not available, but numbers present were likely to be very low (based on previous experiences).

The mid-November population count was performed in Norway, Sweden, Denmark, the Netherlands and Belgium and gave a total of c. 111,000 geese (rounded to nearest 1,000). During this time of the year, a large proportion of the birds was concentrated in Jutland, Denmark (c. 79%), with additional numbers found in Belgium (6.1%; relatively low), in the Netherlands (4.8%, very low), at various places in Sweden (c. 3.6%) and in Norway (c. 6.5%; relatively high) (Table 2.1).

The number for some parts of Jutland, Denmark, may be biased high. Due to a mix of Pink-footed Geese and Barnacle Geese in huge flocks and observed at long distances during roost flights, there is a high uncertainty and probably an overestimate in the numbers from Vadehavet and Vestjylland in Denmark.

The May count was performed in Norway, Sweden, Finland and Denmark, the area expected to host the whole population at that time of the year, and gave a total of c. 74,000 geese. In May the majority of the geese were located in Norway (c. 90%), but with a record high proportion in Finland (7.7%) (Table 2.1). Only a few birds were left in Denmark and Sweden (Table 2.1).

Table 2.1. Results of synchronised counts of Pink-footed Geese in autumn 2020 and spring 2021.

Country	**Region**	**Numbers**	
		Autumn	**Spring**
Norway	Trøndelag, Mid-Norway	6,502	65,735
	Vesterålen, Northern Norway		61
	Southern Norway	704	349
	Mid-Norway (outside Trøndelag)		4
	Northern Norway (outside Vesterålen)	2	15
Denmark	Jutland	87,543	794
	Eastern Denmark	50	1
Finland	Oulu region		5,670
	Elsewhere		NA
Sweden	Various sites	3,985	1,114
Germany			NA
Netherlands	Friesland and elsewhere	5,282	NA
Belgium	Flanders	6,803	NA
TOTAL		**110,871**	**73,743**

Lincoln index

In May 2021, the estimated population size was c. 81,000 individuals (95% CL: 70,718-91,453). As shown in Figure 2.2, there has been a good accordance between the spring population counts and the Lincoln index estimate in recent years. However, in some years, the spring counts are higher than the preceding autumn counts (which makes no sense, biologically), due to the autumn counts being biased low on the average.

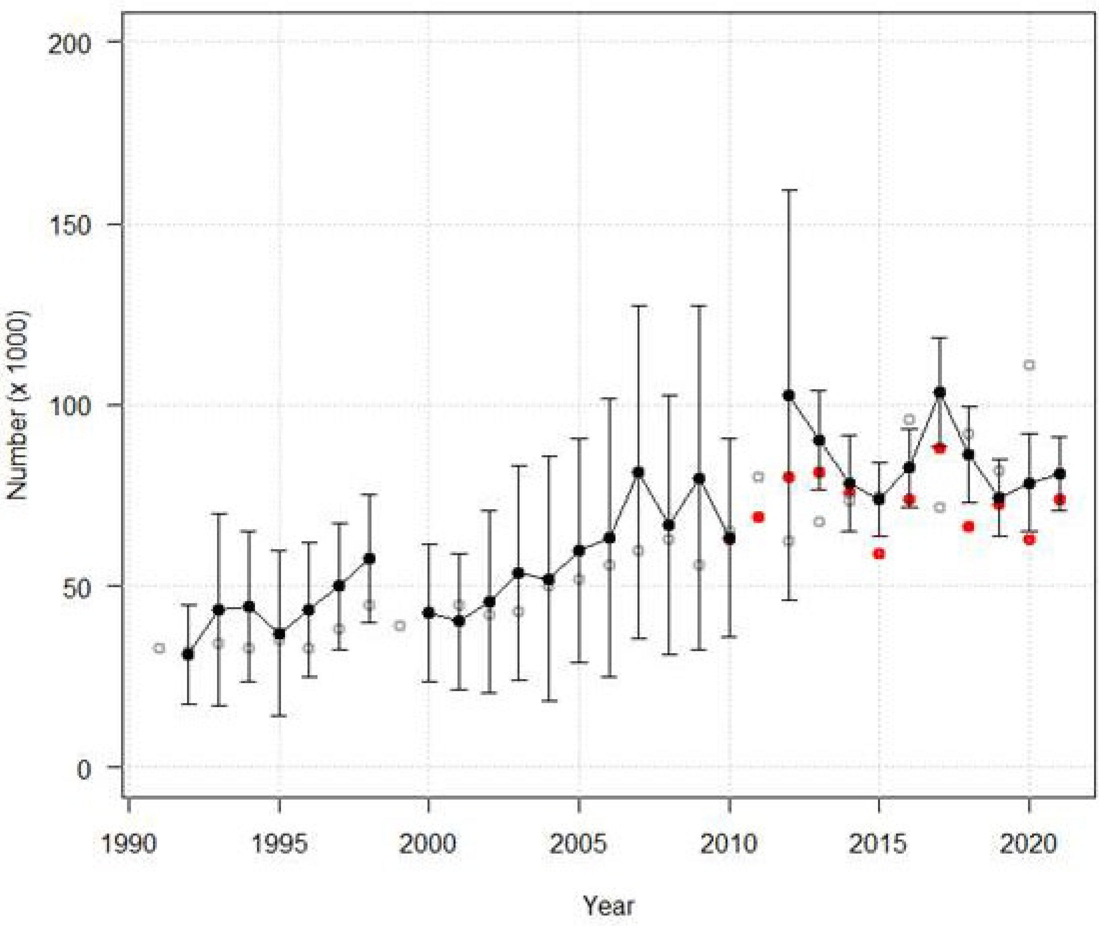

Figure 2.2. Development of the size of the Svalbard autumn population of the Pink-footed Goose, 1991–2021 (open grey) with additional spring population in 2010-2021 (filled red). As well as comparison with spring population estimates based on marked individuals (average ± 95% CL) during 1991/92 – 2020/21 (filled black). During 1991-2011, the number of goose flocks scanned for marked/unmarked birds was relatively low, but since 2012-13 it has increased, which is the reason for the decrease in variance. In years with fewer than 10 flocks scanned (1998/99, 2010/11), estimates have not been shown.

Productivity

The index of the annual proportion of juveniles based on age counts from all five regions and during 12 Oct - 4 Nov 2020 was 19.8% (CI: 6.6-37.9), which is high compared to the long-term average for the population (14.2%, CI: 7.4-23.1) (Figure 2.3). In general, the new index follows the estimates from previous methods, with the main difference being that the new method provides estimates of sample variance. In recent years, particularly since 2010, the sampling variance has increased, corresponding to the period where the sample size decreased in the Netherlands and increased in other regions (Denmark, Norway, Belgium and Sweden). Thus, in 2020 the lowest sample size was in the Netherlands (573 individuals) and highest in Denmark (7,189 individuals) (Table 2.2).

In terms of regional differences, the highest proportion of juveniles was observed in Norway (30.4 % (12.3-52.5)), and the lowest in Denmark (14.7 % (6.6-37.9)) (Table 2.2). There might be several behavioral and/or ecological mechanisms for these regional differences in the proportion of juveniles, mechanisms which are currently being investigated in a scientific analysis.

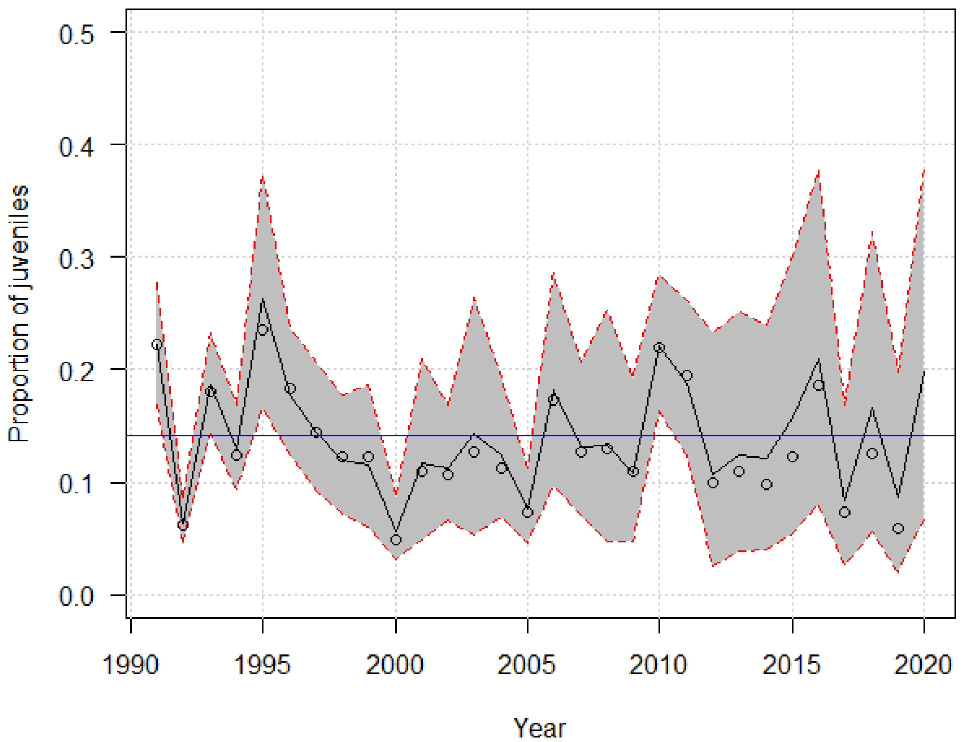

Figure 2.3. Index of the annual proportion of juveniles in the autumn population from 1991-2020 during 12 Oct - 4 Nov (black line) and 95 % confidence interval (grey shaded area). Estimates of the proportion of juveniles based on the previous method is provided in black open dots. Overall mean proportion of juveniles during the period is shown with the blue line.

Table 2.2. Age counts in autumn 2020, and juvenile percentage from a "means model" including 95 % confidence interval.

Year	Range state	No. juveniles	No. adults	Total sample	Mean % juveniles (CI)
2020	Belgium	346	1,323	1,669	20.9 (15.8-26.5)
2020	Denmark	990	6,199	7,189	14.7 (6.6-37.9)
2020	Netherlands	96	477	573	16.8 (12.7-21.1)
2020	Norway	1,560	4,711	6,271	30.4 (12.3-52.5)
2020	Sweden	392	975	1,367	26.6 (9.9-47.9)

Survival

Overall, adult survival has decreased during the last two decades, but seems to have stabilised the last decade (Figure 2.4). Based on the newest update, the adult survival estimate was 0.81 (se = 0.03) in 2019-2020, while the most recent preliminary estimate for 2020-2021 is estimated to 0.74 (se = 0.09), albeit with high uncertainty because the last year in a time series is not fully estimable in the MARK model.

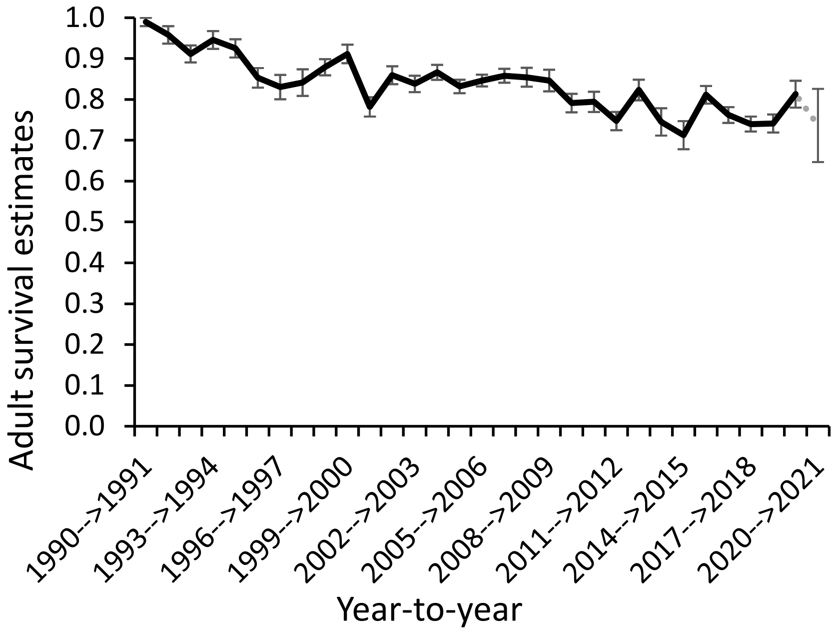

Figure 2.4. Annual adult survival estimates (± se) of the Svalbard Pink-footed Goose (black line), 1990/91-2019/20 with a preliminary estimation for 2020/21 (grey dashed line) (see also text).

Spring weather conditions on Svalbard

In May 2021, Ny Ålesund had 1 thaw day and Svalbard Airport had 5 thaw days (Figure 2.5). For further analysis, an average of 3 thaw days will be used, which is much lower than the long-term average for 1990-2021 (8.7 days). Hence, we predict the 2021 breeding success will be well below average.

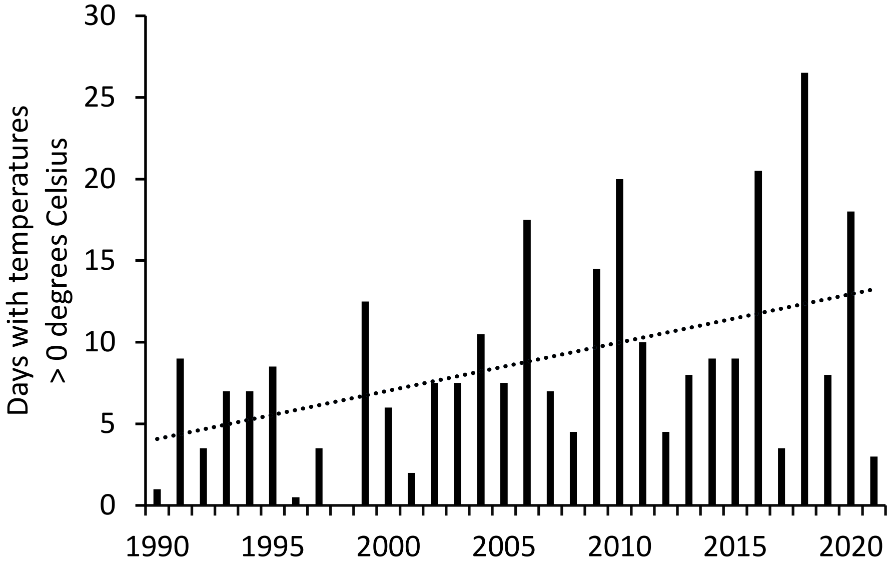

Figure 2.5. Number of thaw-days (days with average temperatures above 0°C in May on Svalbard 1990-2021, expressed as an average for Ny Ålesund and Longyearbyen Airport (data source: Norwegian Meteorological Institute). Dotted lines show the trend based on linear regression. We used the daily 'Mean Air Temperature' from both sites and all years with the exception of Ny-Ålesund in 2021 due to lack of data; instead we used 'Mean Air Temperature, köppens formula'; the difference between these measures is negligible.

Offtake under hunting and derogations

In Norway, a preliminary record high total of 4,318 Pink-footed Geese were reported shot. This is 17% higher than the final number in the previous year. The preliminary number of Pink-footed Geese reported shot in Denmark was 11,716 (Figure 2.6). This estimate is also much higher than the final estimate in the previous season (32%). In total, the preliminary number of harvested geese was 16,034 (Figure 2.6).

We use the preliminary data to obtain as recent data as possible. Data from earlier years have been updated with the final reports. For Norway, the final number of harvested birds was 22% higher than the preliminary number in the 2019/2020 season. In Denmark, the final number in 2019/2020 of harvested birds was 3.2% higher than the reported preliminary numbers.

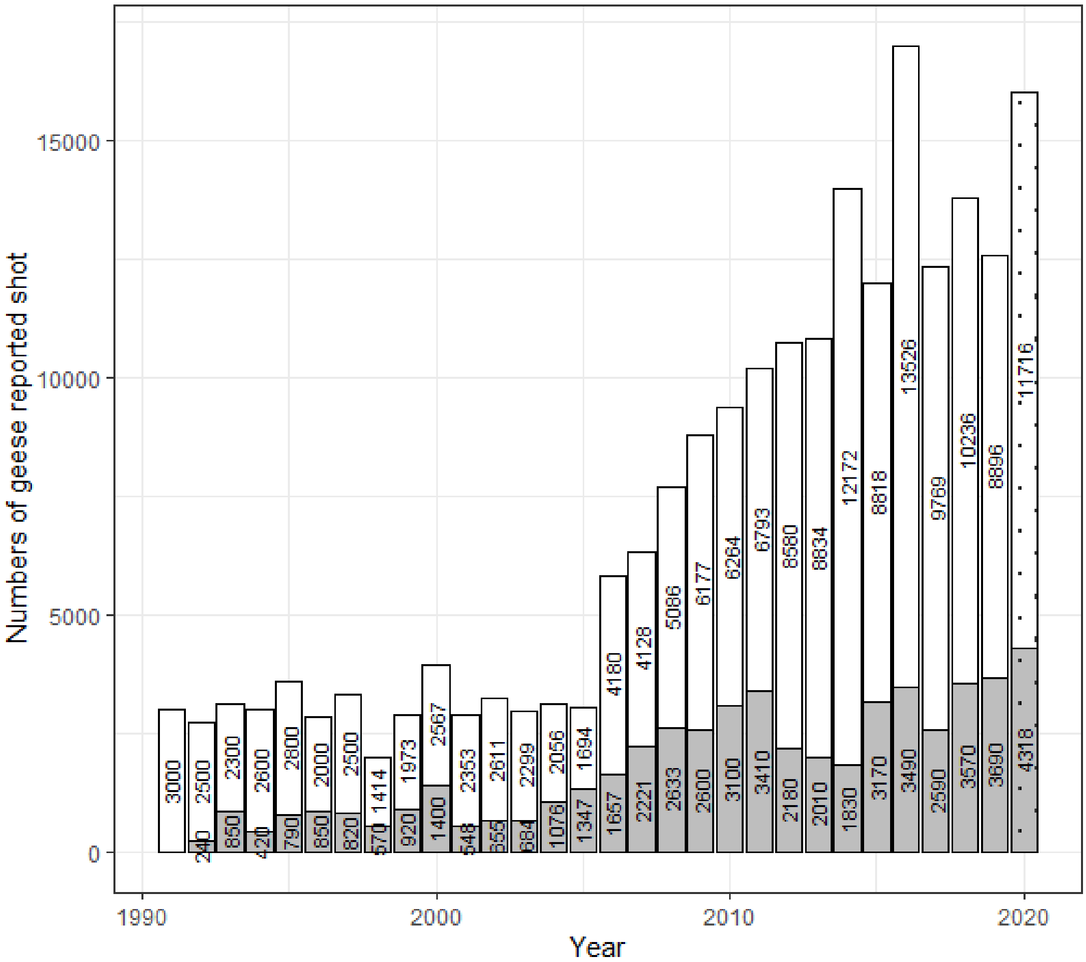

Figure 2.6. Development in the harvest of Pink-footed Geese in Norway (grey) and Denmark (white), 1990/91-2020/21. Harvest data for Norway was available from 1992 onwards. Numbers in the bar are the amount of harvest in each range state. Harvest data from 2020/21 are preliminary (marked with dots).

Based on the reporting of wings to the Danish Wing Survey in 2020/2021, which was at a record high, most geese were shot in October (Figure 2.7). This pattern is vastly different from the previous years with highest wing reporting in January, but there may be a bias in the timing of the reporting this year compared to the previous years due to changes in the ways in which hunters could supply wings. The procedure for delivery of wings was simplified for the hunters, which resulted in a higher number of wings delivered by more hunters.

As a result of reduced ringing activity in recent years, only 13 birds with neckbands were shot in 2020/21, which is too few to describe the seasonal harvest activity, which in previous years supported the information from the reporting of wings. Only two of these were shot in January, confirming the pattern from the wing-survey that the majority of the harvest this year was during autumn.

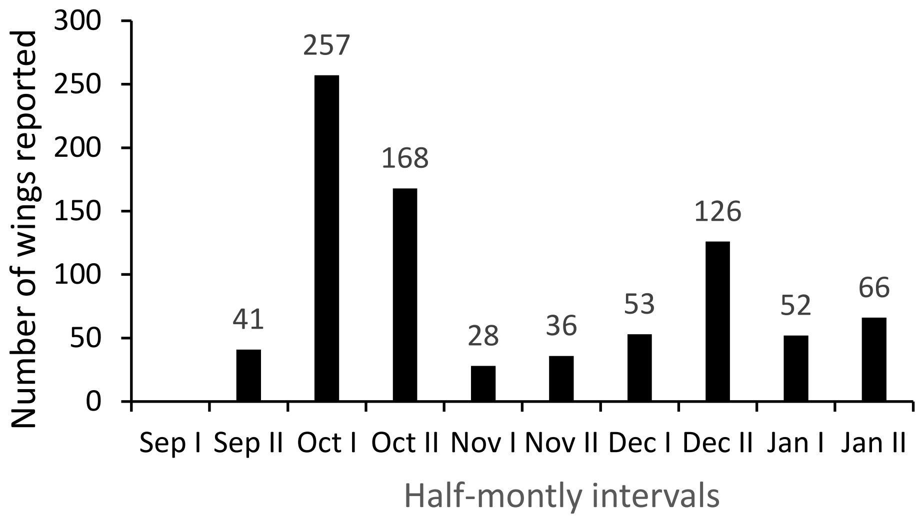

Figure 2.7. Number of wings of Pink-footed Geese (N_{total} =827) collected by hunters in Denmark in the 2020/21 hunting season, divided into half-monthly intervals.

Derogation

Derogation of Pink-footed Goose is only practiced in Denmark, and here the number killed by derogation shooting is typically a few hundred annually, comprising 1-2 % of the annual harvest (Figure 2.8).

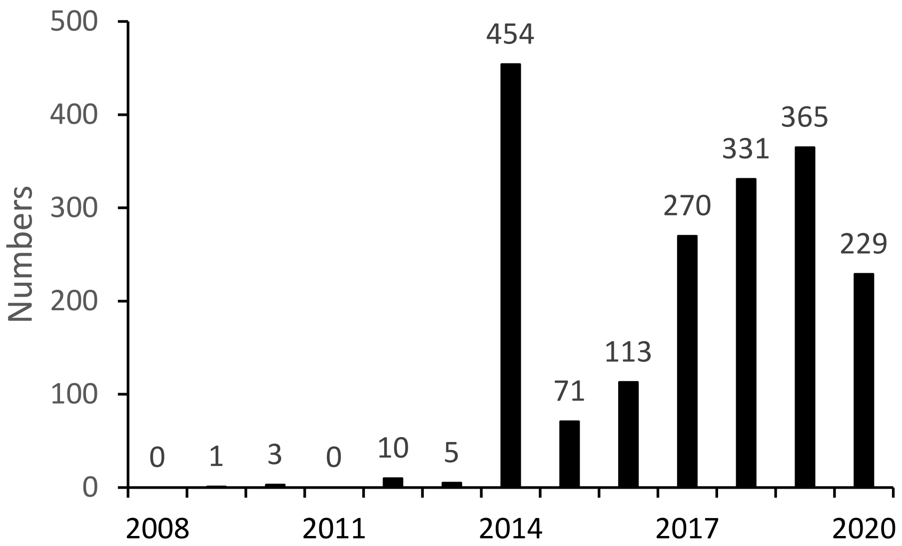

Figure.2.8. Annual derogation in Denmark 2008-2020 of Pink-footed Geese. Data from Eionet; preliminary data from 2020 provided by the Danish Environmental Protection Agency.

Crippling

There was no x-raying of Pink-footed Geese in the 2020/2021 season, and so there is no information concerning the proportion of birds carrying embedded shot.

2.2. Harvest assessment

The AHM program for Svalbard Pink-footed Geese began in 2013 using a set of nine alternative population models described by Johnson et al. (2014). Of growing concern, however, was the observation that the predictive ability of these original models declined over time. Therefore, in 2019 the EGM IWG adopted the use of an IPM (Johnson et al., 2020) to guide the setting of annual harvest quotas. IPMs represent an advanced approach to modelling, in which all available demographic data are incorporated into a single, unified analysis. This approach contrasts with the original modelling work in which survival and reproductive processes were analysed independently.

Annual change in population size in May is described by a difference equation:

$$
\begin{aligned}
N_{t+1}^{M} &= N_t^M \theta_t \left[(1-k_t) + r_t (1 - v k_t) \right] \\
&= N_t^M \theta_t \left[\left(1 - \frac{h_t}{(1-c_t)} \right) + r_t \left(1 - v \frac{h_t}{(1-c_t)} \right) \right] \\
&= N_t^M \theta_t \left[\left(1 - \frac{(h_t^n + h_t^d)}{(1-c_t)} \right) + r_t \left(1 - v \frac{(h_t^n + h_t^d)}{(1-c_t)} \right) \right]
\end{aligned}
$$

where N_t^M is May population size in year *t*, θ_t is the annual rate of survival from natural causes, k_t is an integrated parameter reflecting the total kill rate (i.e., retrieved plus un-retrieved harvest) of birds aged >1 year, h_t is the annual rate of retrieved harvest of birds aged >1 years, c_t is the rate of crippling loss (un-retrieved harvest divided by total un-retrieved and retrieved harvest), *v* is the constant differential vulnerability of young of the year to harvest (i.e., the ratio of the kill rates of young and older birds), and r_t is the ratio of young to older birds at the start of the hunting season (i.e., post-breeding age ratio). In the third expression, the total harvest rate, h_t, is subdivided into a harvest rate for Norway, h_t^n, and one for Denmark, h_t^d. The post-breeding age ratio was estimated as a logistic function of the number of days above freezing in May in Svalbard.

Population size in November is a function of population size in May, six months of natural mortality, harvest in Norway, and the portion of harvest in Denmark occurring prior to mid-November:

$$
\begin{aligned}
N_t^N &= N_t^M \theta_t^{6/12} \left(1 - \frac{(h_t^n + h_t^{d'})}{(1-c_t)} \right) + N_t^M \theta_t^{4/12} r_t \left(1 - v \frac{(h_t^n + h_t^{d'})}{(1-c_t)} \right) \theta_t^{2/12} \\
&= N_t^M \theta_t^{6/12} \left[\left(1 - \frac{(h_t^n + h_t^{d'})}{(1-c_t)} \right) + r_t \left(1 - v \frac{(h_t^n + h_t^{d'})}{(1-c_t)} \right) \right]
\end{aligned},
$$

where N_t^N is November population size and $h_t^{d'}$ is the harvest rate of adults in Denmark prior to mid-November.

The set of difference equations for May and November population size are based on the following assumptions:

- Natural mortality and reproduction are year-dependent;
- Natural mortality is evenly distributed throughout the year, in spite of evidence that there may be some minor seasonal differences (Madsen et al., 2002), and natural mortality is the same for all birds that have survived at least one hunting season (Francis et al., 1992);
- Hunting seasons in September and October in Norway and Denmark expose a common group of birds to harvest (i.e., harvest does not occur sequentially, but simultaneously);
- Young are more vulnerable to harvest than older birds and this rate of differential vulnerability is constant;
- The rate of crippling loss has declined exponentially over time, as reflected in the number of young carrying embedded shot (Clausen et al., 2017);
- Hunters report only retrieved harvest; and
- Harvest mortality is additive to natural mortality.

Data files and R code for running the IPM can be found here: https://gitlab.com/aewa-egmp/svalbard-population-of-pink-footed-goose/harvest-assessment-2021. The reader is reminded that updating of the IPM each year can result in changes to historic estimates of model parameters because all of the available data are included in each update. Because an IPM represents a unified analysis, parameters cannot be estimated independently of each other (i.e., they are all part of a joint likelihood).

The posterior distribution of model parameters from the IPM, along with candidate harvest quotas and an agreed upon management objective, were used to derive a harvest quota for the 2021/22 hunting season.

Candidate harvest quotas. – We considered a set of possible harvest quotas of 0 to 50,000 in increments of 1,000. A quota of zero represents a closure of hunting seasons in both Norway and Denmark. Of the total harvest quota, 70% is allotted to Denmark and 30% to Norway per their agreement.

Objective function. – The EGM IWG uses a management objective intended to maintain the population size within agreed upon limits by regulating harvest in Norway and Denmark. For computational purposes, the optimal value (V^*) of a management strategy (A) at time t is the maximum (max) of the expectation (E) of the temporal sum of population utilities:

$$V^*(A_t|x_t) = \max_{(A_t|x_t)} E\left[\sum_{\tau=t}^{\infty} u(a_\tau|x_\tau)|x_t\right],$$

where population utility $u(a_\tau|x_\tau)$ is action (a_τ) and resource-dependent (x_τ). Population utility is defined as a function of a time-dependent action conditioned on system state:

$$u(a_\tau|x_\tau) = \frac{1}{1 + exp(|N_{t+1} - 60| - 10)},$$

where N_{t+1} is the population size (in thousands) expected due to the realized harvest quota and the population goal is 60,000 (Figure 2.9). The 10 (thousand) in the equation for population utility represents the difference from the population goal when utility is reduced by one half. Thus, the objective function devalues harvest quotas that are expected to result in a subsequent population size different than the population goal, with the degree of devaluation increasing as the difference between population size and the goal increases. We emphasise that the optimisation process only recognises Pink-footed Goose abundance as having value. Harvest is merely used as a tool, without any inherent value recognised.

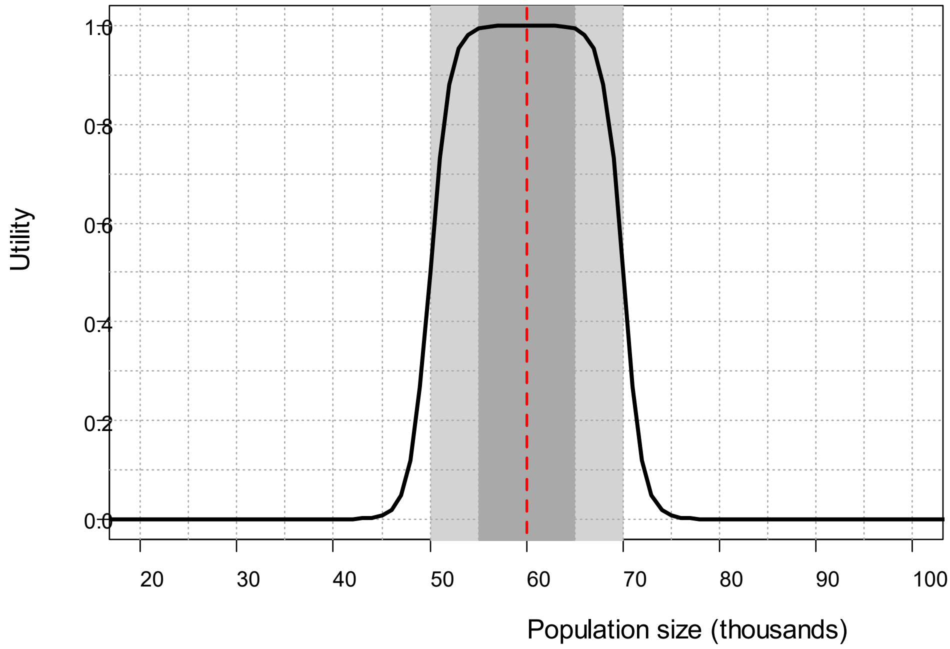

Figure 2.9. Utility (i.e., stakeholder satisfaction) expressed as a function of population size of Svalbard Pink-footed Geese. The population goal is 60,000 (red dashed line), but population sizes between about 55,000 and 65,000 (dark grey band) are acceptable (and thus have maximum utility), while those outside that range are less desirable (and thus have lower utility). The light grey bands represent population sizes that have ≥ ½ of maximum utility.

Calculation of the 2021 harvest strategy. – The harvest management process can be described as a Markov decision process (Marescot et al., 2013). A solution algorithm for a Markov decision process is stochastic dynamic programming, which we used to calculate a management strategy for the Svalbard population of Pink-footed Geese based on results of the IPM, the range of candidate harvest quotas, and the objective function described above. We used the open-source software MDPSolve© (https://github.com/PaulFackler/MDPSolve) with the proprietary software Matlab (https://www.mathworks.com/) to compute an optimal harvest strategy, which evolves over time based on annual updates of the IPM. MDPSolve code to implement the optimization is available here: https://gitlab.com/aewa-egmp/svalbard-population-of-pink-footed-goose/harvest-assessment-2021.

The optimal management strategy based on the IPM explicitly recognises annual variation in the number of days above freezing in May in Svalbard, as well as uncertainty in the relationship between days above freezing in May and subsequent productivity. It also explicitly recognises annual variation in survival from natural causes. Differential vulnerability of young to harvest, v = 1.94 (1.64 – 2.27), is treated as temporally constant, and a contemporary estimate of crippling rate of c = 0.04 (0.01 – 0.08) is implicitly included in harvest quotas. Crippling rate represents the portion of the total kill that is not retrieved. Thus, total kill is equal to the retrieved harvest divided by (1 – the crippling rate).

IPM estimates of abundance in both May and November show a historic pattern of rapid increase, followed by a period of relative stability (Figure 2.10). The period of stabilisation corresponds with a period of substantial increases in total harvest. The May 2020 estimate of abundance was 77,400 (71,400 – 83,800) and the November 2020 estimate was 87,100 (80,000 – 94,700). The raw count in November 2021 was over 110,000; thus, the IPM suggests this count was biased high, supporting the suspicions of those in the field. The May 2021 estimate of population size was 78,300 (71,100 – 85,800), which is similar to the May 2020 estimate.

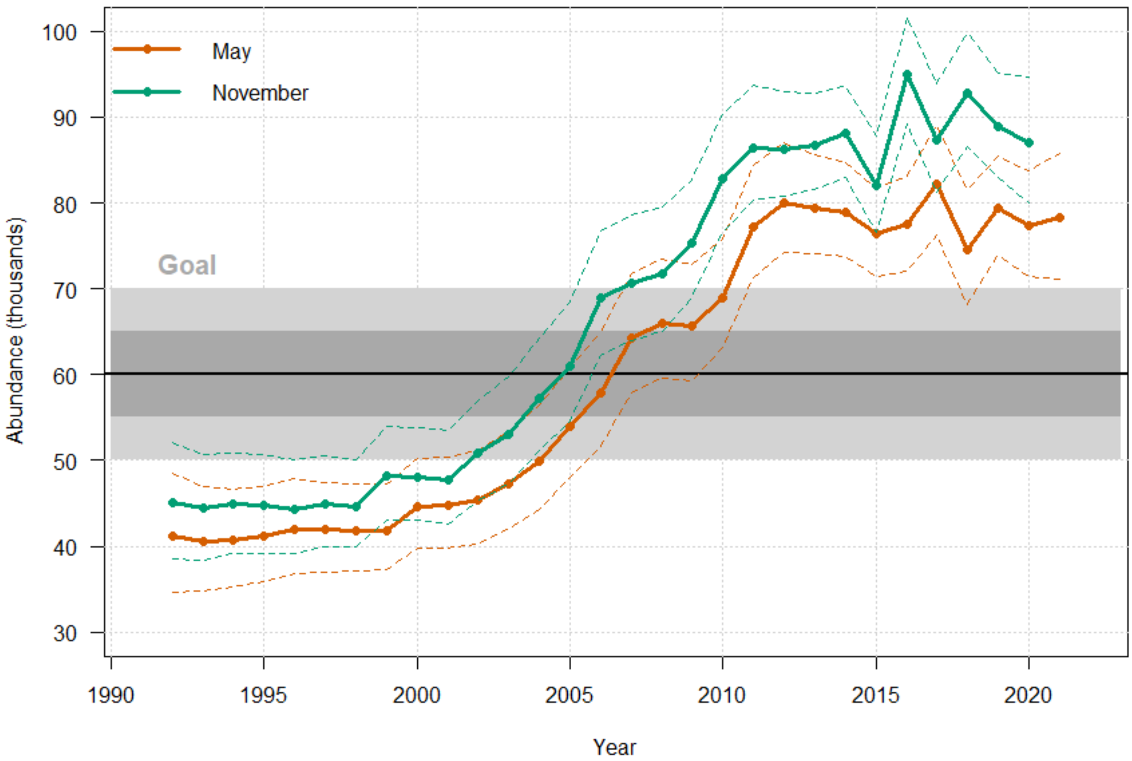

Figure 2.10. IPM-based estimates of abundance of Svalbard Pink-footed Geese in May and November, relative to the goal of 60,000. The dark grey band defines near-complete stakeholder satisfaction with population sizes, while the light grey band exhibits ≥ ½ of maximum satisfaction (see Figure 2.9). 95% credible intervals are indicated by the dashed lines.

Mortality rates are not observed directly, but nonetheless can be estimated by the IPM because of the inclusion of sufficient data on abundance, productivity, and harvests. As with most arctic-nesting geese, the rate of survival from natural causes is relatively high, with little annual variation ($\bar{\theta} = 0.91, se = 0.002$). Estimated harvest rates of adults (i.e., birds that have survived at least one hunting season) have increased over time (Figure 2.11) and median estimates have remained >10% since the implementation of AHM in 2013. Harvest rates of young are higher than adults (i.e., birds that have survived at least one hunting season) by a factor of about two, reflecting the higher vulnerability of young to hunting. Finally, annual survival from all causes reflects a historic pattern of relative stability followed by a period of decline, which coincides with increasing harvest rates (Figure 2.11).

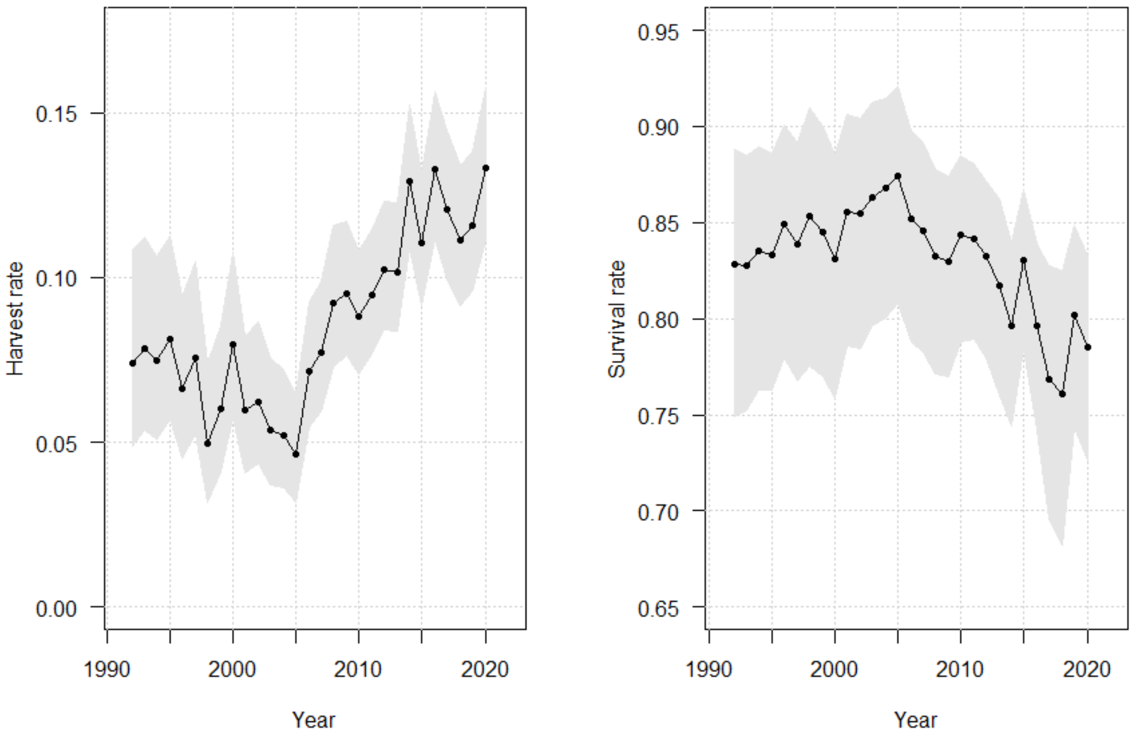

Figure 2.11. IPM-based estimates of harvest and annual survival rates of adult Svalbard Pink-footed Geese. 95% credible intervals are indicated by the shaded polygons.

To reflect the intent to reduce the size of the population towards the target of 60,000, we need a population growth rate $\lambda < 1$. We can approximate the population growth rate using estimates of adult survival and post-breeding age ratio as:

$$\lambda = s(1 + r)$$

Then the desire to reduce the population is expressed as:

$$1 > s(1 + r)$$

Using the average post-breeding age ratio of r = 0.29 (se = 0.025) during the last 10 years:

$$1 > s(1.29)$$

$$s < 0.78$$

suggesting adult survival would need to be less than 0.78 to reduce population size. Based on a linear model of survival as a function of harvest rate (Fig. 2.12), the corresponding adult harvest rate would need to be greater than about 0.13. During the last 10 years the adult harvest rate has averaged h = 0.12 (se = 0.004).

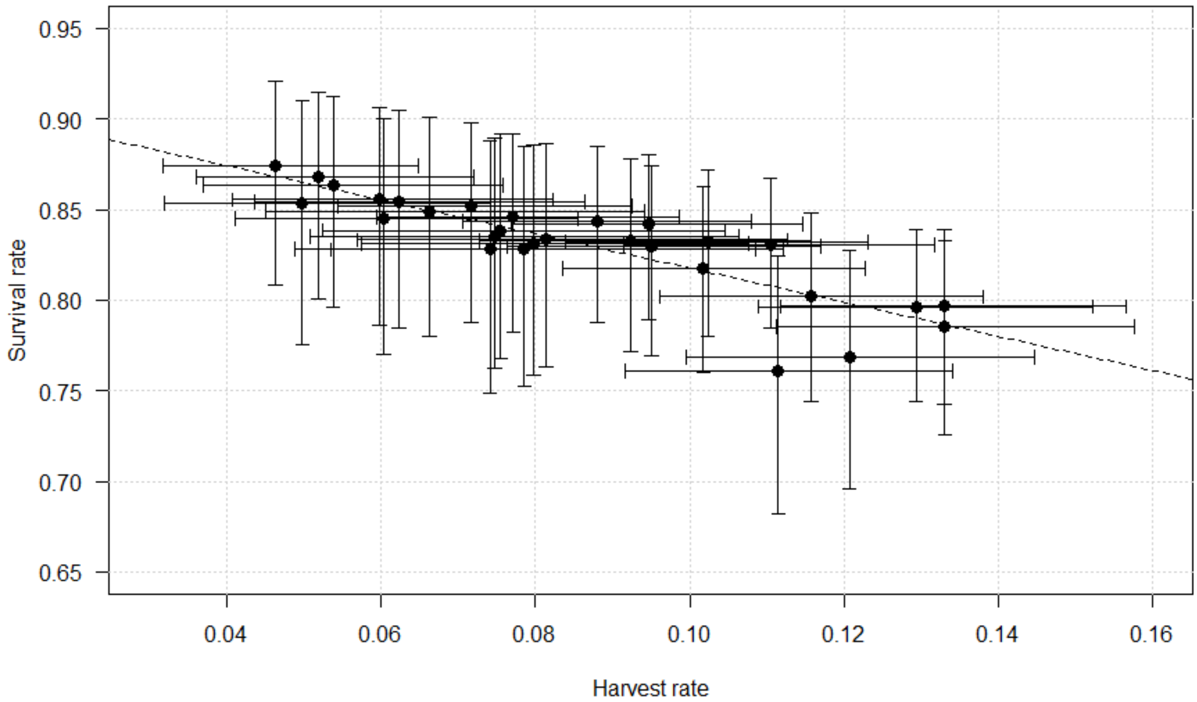

Figure 2.12. Adult harvest and survival rates of Svalbard Pink-footed Geese as based on an IPM. Error bars are 95% credible intervals. The dashed line represents the best fitting linear model.

Increasing harvest rates over the last decade are due mostly to increasing harvest pressure in Denmark, although harvests have increased in Norway as well (Figure 2.13). The total harvest has averaged about 15,100 (*se* = 900) during the last five years, with an average harvest of 3,700 (*se* = 300) in Norway and 11,400 (*se* = 800) in Denmark. The proportion of the harvest occurring before the November count in Denmark has declined over time from roughly 70% in the 1990s to about 45% in recent years, reflecting a change in migratory behavior that keeps the geese in Denmark for a longer time than historically. In the IPM we assume that all of the Norwegian harvest occurs prior to the November count (O. Jerpstad, I. Tombre, and L. Waade, pers. commun.).

Estimates of productivity, as indicated by the post-breeding age ratio, have been variable, with an average of 0.26 (*se* = 0.01) young per adult, or equivalently 20% (*se* = 0.1%) young in the autumn flight (Figure 2.14). Productivity has generally increased over the period of record and is highly correlated with the increasing number of days in which the mean air temperature is above freezing in May in Svalbard. The ratio of young to adults reached a maximum of 0.45 (0.36 – 0.60) in 2018 following 27 days above freezing in May in Svalbard. In contrast, the record low ratio of 0.19 (0.15 – 0.22) occurred in 1998, following 0 days above freezing in May in Svalbard. In 2020, the estimated pre-season age ratio was 0.34 (0.30 – 0.39), following 18 days above freezing in May in Svalbard.

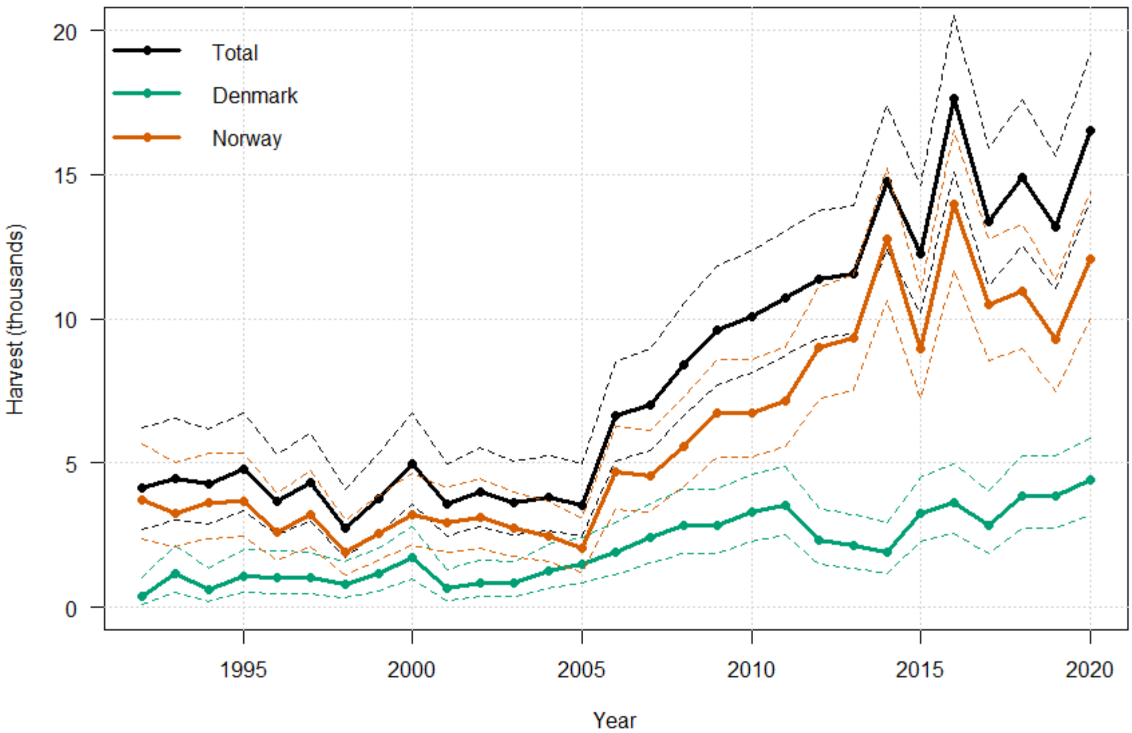

Figure 2.13. IPM-based estimates of harvests of Svalbard Pink-footed Geese. 95% credible intervals are indicated by the dashed lines.

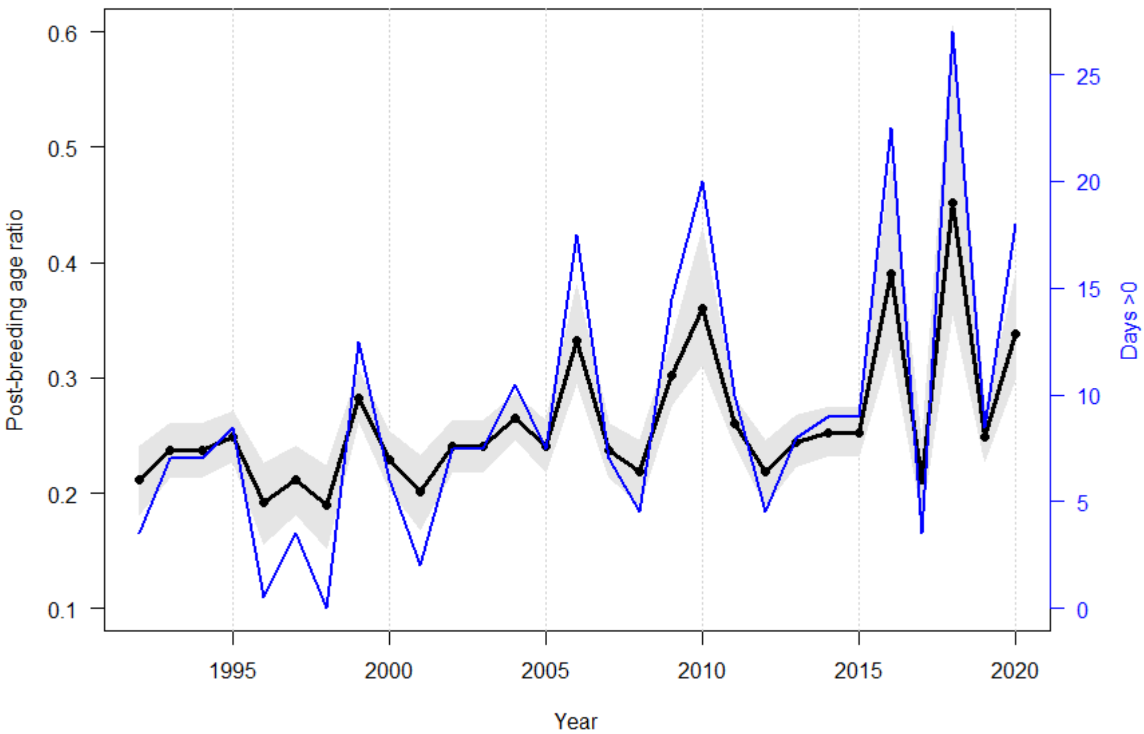

Figure 2.14. IPM-based estimates of the post-breeding ratio of young to adults (i.e., birds that have survived at least one hunting season) for Svalbard Pink-footed Geese. 95% credible intervals are indicated by the shaded polygon. In blue are the number of days above freezing in May in Svalbard.

The optimal harvest management strategy based on results of the IPM, candidate harvest quotas, and the objective function expressing the level of satisfaction with various population sizes recommends harvest quotas ranging from 0 to 30,000 within the most desirable range of population sizes (i.e., 55,000–65,000) (Figure 2.15). Harvest quotas for population sizes <55,000 are very low unless the number of days above freezing in May in Svalbard is very high. Harvest quotas for population sizes >65,000 increase rapidly with small increases in population size, regardless of the number of days above freezing in May. For a population at its goal of 60,000, and with a mean number of days above freezing (10), the harvest quota is 9,000. The management strategy in Figure 2.15 also depicts the evolution of May population size, days above freezing in May, and harvest quotas since implementation of AHM in 2013. Population size in May was increasing rapidly prior to implementation of AHM but has largely stabilized since.

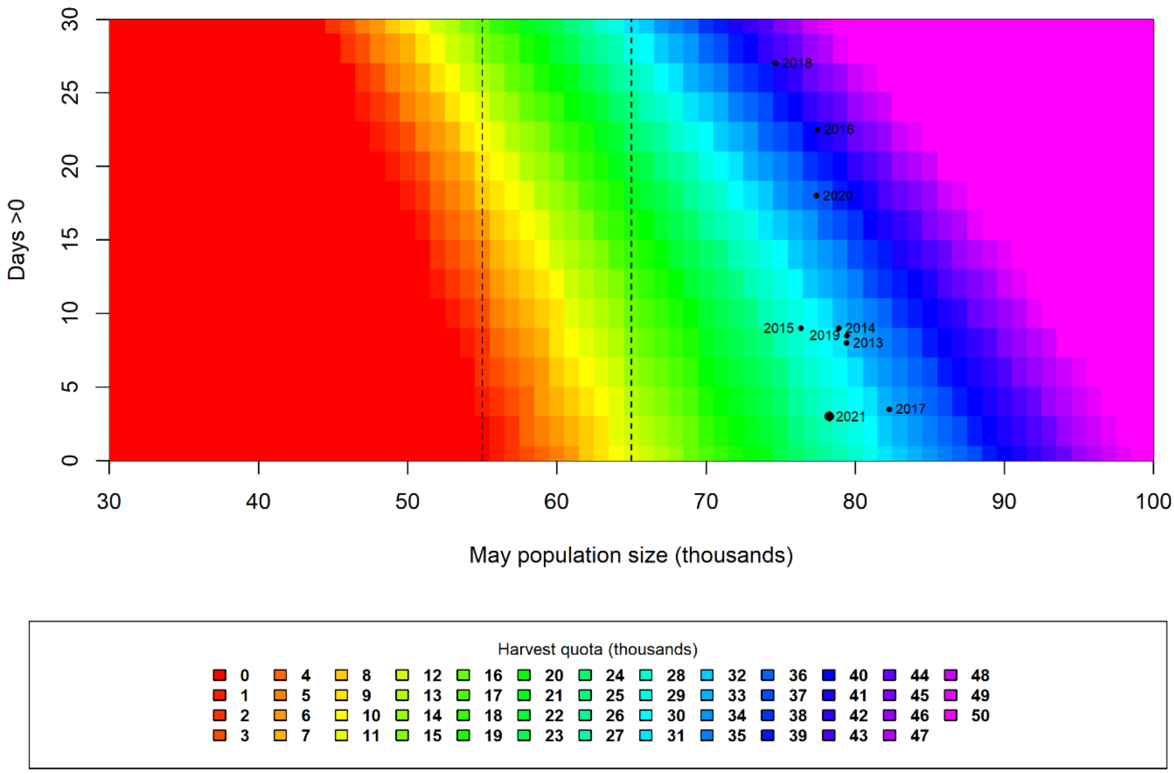

Figure 2.15. Optimal harvest quotas for Svalbard Pink-footed Geese based on an IPM and an objective to maintain population size near 60,000. Days >0 represents the number of days above freezing in May in Svalbard. The vertical dashed lines depict near-complete stakeholder satisfaction with population sizes. Also depicted are population sizes and days above freezing for the years in which AHM has been in place (2013–2021).

The harvest quota for the 2021/2022 hunting season, based on the estimated population size of 78,300 and 3 days above freezing in Svalbard in May 2021, is 28,000, which includes an expected 4% crippling loss. Using an agreed upon allocation of the total quota (30% for Norway, 70% for Denmark), harvest quotas for Norway and Denmark 2021/2022 are 8,400 and 16,800, respectively. For comparison, the realised harvest has averaged about 15,100 (*se* = 900) during the last five years (54% of this year's quota).

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3. Taiga Bean Goose *Anser fabalis*

This chapter compiles monitoring data (methods and results, section 3.1) on the population status of the four Management Units (MUs) (Western, Central, Eastern 1 and Eastern 2) of Taiga Bean Goose for the season 2020/2021. Monitoring data are used to assess the population development and provide input for the modelling of a harvest strategy for the Central MU for the coming hunting season (2021/2022) (Section 3.2).

The four MUs can be recognised based on their different breeding and wintering areas, which also serve as the range states for each MU:

- *Western MU:* Breeding in Northern and Central Sweden and Southern and Central Norway, wintering in Northern Denmark and Northern and Eastern United Kingdom;
- *Central MU*: Breeding in Northernmost Sweden, Northern Norway, Northern and Central Finland and adjacent North-western parts of Russia, wintering mostly in Southern Sweden and South-east Denmark;
- *Eastern 1 MU*: Breeding in upper Pechora region and western parts of west Siberian lowlands of Russia, wintering mostly in North-east Germany and North-west Poland;
- *Eastern 2 MU:* Breeding in eastern parts of west Siberian lowlands of Russia, wintering in North-west China, South-east Kazakhstan and east Kyrgyzstan (Figure 3.1).

In addition to the range states mentioned above, Taiga Bean Geese also occur regularly in Estonia, Latvia, Lithuania, The Netherlands, Ukraine and Belarus during migration or in small numbers in winter.

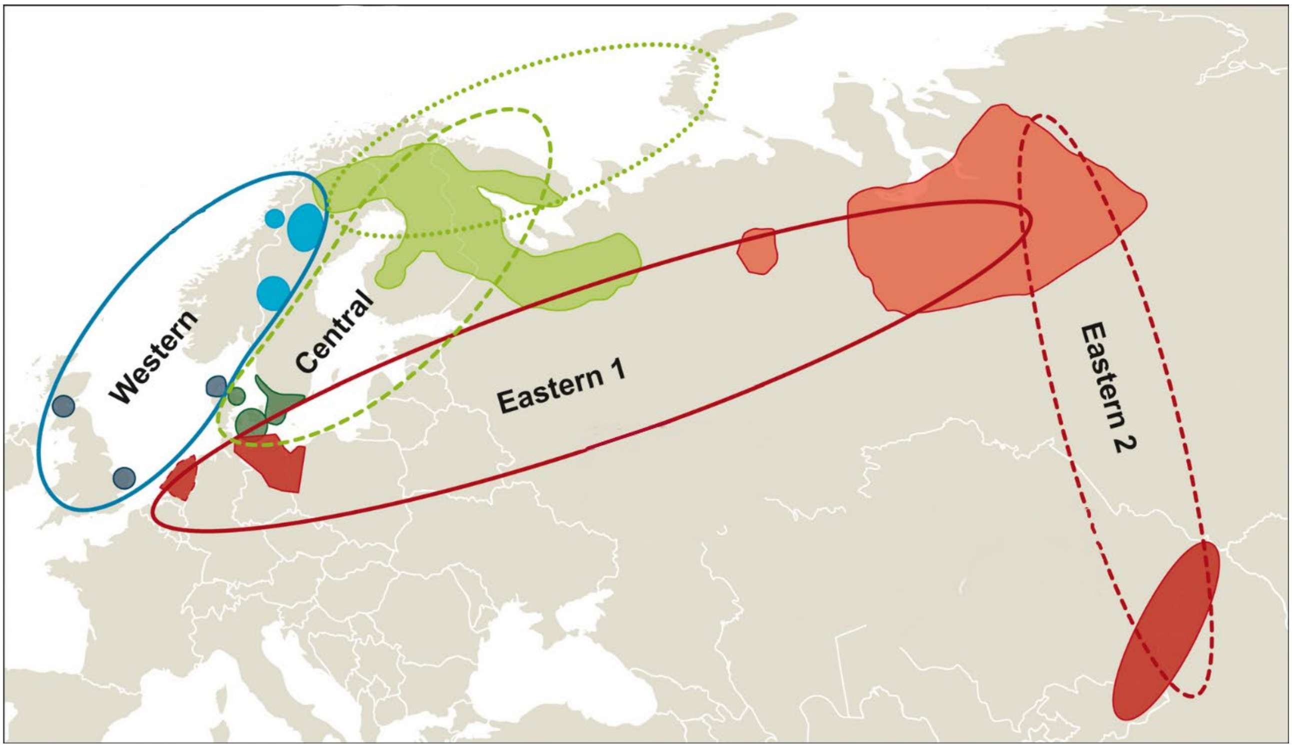


Figure 3.1. The four MUs of Taiga Bean Goose: Western, Central, Eastern 1 and Eastern 2 (dotted line indicates linkages between breeding areas in norther Fennoscandia and known moulting areas in Novaya Zemlya and the Kola Peninsula)
Range States for the Western MU: **Norway*** (b), **Sweden*** (b), **Denmark** (w), **UK** (w)
Range States for the Central MU: Russia (b), **Finland** (b), northern **Norway**** (b), northern **Sweden**** (b), **Denmark** (w), **Germany***** (w), **The Netherlands*****,**** (w), Poland*** (w), southern **Sweden** (w)
Range States for the Eastern 1 MU: Russia (b), **Germany** (w), **The Netherlands****** (w), Poland (w), southern **Sweden*** (w), **Belarus** (m), **Estonia** (m), **Latvia** (m), Lithuania (m), **Ukraine** (m)
Range States for the Eastern 2 MU: Russia (b), China (w), Kazakhstan (w), Kyrgyzstan (w)
Range States marked in bold = EGMP Range States
b = primarily breeding Range State

w = primarily wintering Range State
m = primarily migrating/staging Range State
* Small numbers may be wintering here
** The border between the Western and Central MU breeding birds in northern Norway and northern Sweden is unclear
*** Cold winter refuge
**** It is unclear whether the birds observed in the Netherlands belong to the Central or Eastern 1 MU, the numbers are however very low

3a. Taiga Bean Goose - Central MU

3a.1 Population status

Data collection and methods

October Counts

October population estimates for the Central MU consist of counts in Sweden, where the majority of the Central MU birds are found during this period, with additional information from Finland and Denmark. At present, there is no information from Germany.

Bean Goose count data in Sweden are from the standard mid-monthly waterbird counts in south and central Sweden, organised by Lund University (http://www.zoo.ekol.lu.se/waterfowl/GooseInv/goose.htm). In addition, a dedicated count to separate subspecies of Bean Geese and to estimate the annual age ratio is conducted in most years.

In Denmark, there is no coordinated count in October. Instead, casual records from www.dofbasen.dk are used from a week before and a week after the preferred counting weekend. If there were multiple counts from the same site, the numbers closest to the preferred weekend was used.

In Finland, casual records from www.tiira.fi are used to estimate the numbers of staging Taiga Bean Geese. Data are downloaded from the same period as the geese are counted in Sweden to avoid double counts of migrating flocks.

Winter Counts

January population estimates for the Central MU consist of counts from Sweden, the Netherlands and Denmark. Geese from the Central MU also winter in north-eastern Germany, depending on the severity of winter weather. However, no census data were received from Germany, so it has not been possible to obtain population estimates from Germany.

In Sweden, the Bean Goose counts are part of the contribution to international counts coordinated by Wetlands International, which are performed throughout the winter. In Sweden, the central counting areas are divided into south-west Scania, north-east Scania and north of Scania. In south-west Scania, Bean Geese have always been separated into sub-species, whereas in northeast Scania and north of Scania the observers have only recently (since 2014) been trained and asked to record numbers on the basis of this distinction. All birds in Sweden are regarded as Central MU birds.

In the Netherlands, the national goose counts, including those for Bean Geese, are part of a national governmental surveillance scheme, which includes monthly counts from September to May. They contribute to the international counts coordinated by Wetlands International. Specifically, for Taiga Bean Goose, also casual observations from the portal www.waarneming.nl have been checked. All birds in the Netherlands are regarded as Central MU birds.

In Denmark, Bean Geese are counted in January as part of the mid-winter counts of waterbirds contributing to the international mid-winter counts, organised by Wetlands International. In addition to this, data are extracted from the bird records portal DOFbasen at www.dofbasen.dk. With the exception of the area northwest of Limfjorden in Jutland, which is part of Western MU, birds counted in the rest of Denmark (incl. Vendsyssel, Himmerland and further south and east) are regarded as Central MU birds.

March Counts

The March population estimate is, as the October count, mainly comprised of data from Sweden with additional information from Denmark, Finland and Latvia.

The timing of this monitoring is highly dependent on the advance of the spring. The optimal monitoring occurs when the vast majority of the birds are found in Sweden. The timing of the counts in Sweden is scheduled when almost all Taiga Bean Geese of the Central MU are concentrated to spring staging sites in south-central Sweden and organised annually as a dedicated Bean Goose survey at all relevant sites (Skyllberg 2015).

In addition to this study, data from a network of observers plus extractions from the online portals www.dofbasen.dk in Denmark and www.tiira.fi in Finland are included.

Latvia is at present not an official range state for the Central MU. However, Kampe-Persson & Boiko (2019) describe how Taiga Bean Geese from the Central MU stage in the westernmost part of the country in early spring, while birds from the Eastern 1 MU stage in the eastern part of the country about one month later.

Both October and March counts are valuable, because the great majority of the Taiga Bean Geese from the Western and Central MUs stage simultaneously in Sweden during those periods. The great majority of these birds belong to the Central MU but a smaller number belongs to the smaller Western MU. These are not possible to separate from each other and it is thought that sometimes they occur in mixed flocks. In addition, the estimations are complicated by variation in the timing of the migration, so that Western MU some years are probably in Sweden during the counts but not in other years.

Productivity

In most years, productivity is assessed in southern Sweden. A general issue when assessing productivity of Taiga Bean Goose is to get sample sizes large enough and a geographical coverage that may be regarded as representative for the population.

Offtake (harvest + derogation)

The Taiga Bean Goose of the Central MU is hunted in Sweden, Denmark, Finland, Latvia and Russia, furthermore it is subject to derogation killing in Sweden and the Netherlands.

Hunting

In Sweden, the open hunting season for Bean Geese extends from 1 October until 31 December but is restricted only to the counties of Scania and Blekinge. The Bean Goose harvest is reported on a voluntary basis to the Swedish Association for Hunting and Wildlife Management. Such data originate from defined geographical areas and so are used to extrapolate the levels of reported harvest to unreported areas to generate estimates for entire counties and scaled up nationally (Liljebäck, N. et al., 2021). Data on harvest are made public online (https://www.viltdata.se/).

The open season for Bean Goose in Sweden will be closed from the hunting season 2021/2022.

In Denmark, there is no national hunting season for Bean Geese but in certain areas, they can be hunted legally from 1 September until 30 November. Hunting has, since 2014, only been allowed in south-east Denmark in the municipalities of Vordingborg, Guldborgsund and Lolland. The spatial restrictions on hunting were initially established to protect Taiga Bean Geese of the Western MU in North Jutland, but later expanded to most of the country to protect Taiga Bean Geese in general. Harvest of Bean Geese is reported by hunters through the mandatory Hunting Bag Statistics (administrated by the National Environmental Agency).

In Finland, hunting on Bean Goose was reopened 2017 in a 'Tundra Bean Goose' zone in south-east Finland after a 3-year total moratorium and a 'Taiga Bean Goose' zone was reopened in 2020. Recreational hunting was restricted to October-November (as no derogation shooting was allowed) and there was a mandatory requirement to report the harvest bag. Besides, hunting was open in a restricted area in Lapland, with a hunting season 20-27 August (one week), and with 1 goose/hunter/season quota and a ban on hunting over bait as a limitation. Hunting restrictions were based on national quota, regional historic harvest levels, national considerations in relation to Finnish breeding population and the precautionary principle. Hunting restrictions are evaluated annually and developed based on new data and understanding.

An effective protection of the wintering population of Taiga Bean Goose is in place in Germany. Starting April 2020, all hunting on Taiga Bean Geese has been banned in the Federal State of Mecklenburg-Vorpommern.

In Latvia, the open hunting season for Bean Geese is from 15 September to 30 November.

In Russia, the "official" hunting bag statistics of geese consist of mandatory hunting bag reports. Taiga Bean Geese are protected in some districts and regions covering the Central MU, e.g., Archangelsk District and Karelia Republic (since 2020 in Red book of Karelia). To reduce the accidental shooting of Taiga Bean Geese, as well as protecting other goose species, it has been recommended that the dates of the spring hunting season should be changed to a later period. To greatly improve the conservation of Taiga Bean Goose, it is also necessary to ban hunting at overnight roosting sites and to change the status of the areas important to geese, currently subject to hunting bans, to that of strictly protected area status.

Derogation

In Sweden, derogations ('skyddsjakt') are permitted under two different legal instruments and reporting systems (Jensen et al., 2017). Bean Geese can be shot to prevent damage to crops outside the normal open season and permitted areas. Derogation shooting on Bean Goose is to prevent damage on agricultural crops, however only c. 2% of the total compensation for damage on crops is related to Bean Geese (Frank et al., 2019). Derogation shooting is restricted to the regions Blekinge and Scania during 21 April–20 February and only in flocks of at least five birds on unharvested crops (SFS2021-334.pdf (svenskforfattningssamling.se)).

Bean Geese are protected in the Netherlands but may be subject to scaring and shooting at local level, with permission from the local statutory authority (filed as derogations).

In Latvia, in 2020, shooting of geese to mitigate crop damage was allowed for the first time. Licences for 1,000 geese were issued for the period 15 March–30 May.

Collection of heads and wings

In Sweden, during winter 2017/2018 a targeted sampling of shot Bean Geese in Scania was launched, funded by the Swedish Environmental Agency and Swedish Association for Hunting and Wildlife Management (Jensen et al., 2018). Collection of heads from shot bean geese continued in the following years (Heldbjerg et al., 2020) but have now stopped, at least temporarily, partly due to limited funding. Additionally, preliminary results suggests that the large individual variation found in the measurements taken, making definition of subspecies extremely challenging and for a relatively large fraction of samples impossible. At present, collected data and samples from Sweden are included in a joint effort with Finnish and Danish samples to improve the methods used. Collection of heads in Sweden may restart if adequate methods to define subspecies, given the limitations of the sampling campaign, is found.

In Denmark, hunters may, on a voluntary basis, submit wings from shot geese to the Danish Wing Survey. These wing samples contribute to the knowledge of the temporal hunting bag variations, as well as knowledge of age ratio. Danish hunters are also invited to submit head samples to enable subspecies identification.

In Finland, hunters are invited to send a picture for sub-species identification for estimating the proportion of Taiga Bean Goose.

In Latvia, in 2014, a hunting bag study was initiated, in which hunters were asked to submit photo images of the Bean Geese they had shot. The submitted images have enabled a calculation of the proportion of Taiga Bean Geese among the shot and bagged Bean Geese (Kampe-Persson, 2019; Kampe-Persson & Boiko, 2019). From the autumn of 2020, the hunters were asked to submit two photo images of every bagged goose to the Latvian Hunters' Association, one each of the head and the body (with one wing spread) (Kampe-Persson, 2021). During licenced shooting, it is mandatory to submit one photo image of every bagged goose.

Population data

October counts

October population counts were performed in Sweden, with additional information from Finland, Denmark and the Netherlands, and with missing information from Germany.

In Sweden, goose numbers were assessed during the designated mid-October count period (15-21 October). Pandemic restrictions prevented the usual counts and subspecies identification in Sweden during October 2020. The total counts are considered to be reasonable, albeit with a lesser effort, we will have to include the counts from this autumn with some caution. The total number of Bean geese was 55,782 individuals inclusive of both subspecies, where the majority of unidentified geese are considered to be Taiga Bean geese. Based on reports on www.artportalen.se, the number of Tundra Bean Geese in Sweden in the middle of October were estimated at slightly above 7,000, indicating that the number of Taiga Bean geese, calculated as the difference between the two numbers, are approximately 48,500. The subspecies identification was not conducted in October 2020 (Table 3.1).

The numbers from Finland are based on information from BirdLife Finland / www.tiira.fi. These casual observations rarely identify Bean Geese to subspecies level and the numbers will have to be seen as best-guess estimates. The number of Bean Geese were far higher in 2020 than in 2019. Based on experience of where the Taiga Bean Geese usually are (the Taiga Bean Goose zone), they are estimated at 5,400 during mid-October 2020, compared to 6,300 in 2019, but with a much higher number of unidentified Bean Geese in 2020.

The October 2020 count in Denmark recorded 368 Taiga Bean Geese with the far majority in Lille Vildmose (Table 3.1).

Thus, the October counts totals of the Central MU of Taiga Bean Goose were 55,517 in October 2020 (Table 3.1).

In the Netherlands, the Bean Goose count in October 2020 resulted in a preliminary total of 51,846 Tundra Bean Geese counted, which is much higher than number of c. 35,000 in previous years, but with no Taiga Bean Geese (Table 3.1).

Table 3.1. Results of international counts of Bean Geese in the Central MU in October 2020. Figures which are based on professional judgement (called Estimated) are shown in Italic.

Country	Area	Period	Number of Bean Geese			Reported by
			Taiga	Tundra	Unidentified	
Sweden	Sweden	15-21 October	1,249	523	54,010	Leif Nilsson
		Estimated	*48,500*	*7,000*		
Finland	Finland	15-21 October			16,500	Tiira.fi, Teemu Lehtiniemi
		Estimated	*5,400*	*3,100*	*8,000*	
Denmark	Lille Vildmose	15-21 October	360	2	0	DOFbasen.dk
	Outside Lille Vildmose		8	114	0	
Germany	North-Central Germany	NA				
The Netherlands*		October	0	51,846		www.waarneming.nl (Taiga BG only) Kees Koffijberg
Total	***Estimated***		***55,517***			

*Preliminary figures

Mid-winter counts

January population counts were performed in Sweden, the Netherlands and Denmark, and with missing information from Germany.

In January, the majority of the Taiga Bean Geese is usually found in Scania, the southernmost province of Sweden with additional regular flocks of wintering Bean Geese (mainly Taiga Bean Geese) in the province of Halland. In January 2021, the weather during the monitoring period was extremely mild and larger numbers of Bean Geese stayed in northern parts of Scania and further north. A total of 34,000 Bean Geese were counted but not separated into sub-species. Unfortunately, no exact counts in south-western parts of Scania were conducted, hence there are no reasonable counts from this area in January 2021; a qualified guess based on the experience from many years, is that at least 5,000 would have staged in this area (Table 3.2).

The January 2021 count in Denmark (excluding the region used by the Western MU) recorded 3,638 Taiga Bean Geese, 237 Tundra Bean Geese and 1,228 unidentified Bean Geese. In an attempt to assign the unidentified Bean Geese to sub-species, the following methods have been applied:

- The Bean Geese unidentified to sub-species from north-eastern Jutland are usually assigned to Taiga Bean Geese on the basis of the study of sub-species within this particular region (Brandt et al., 2017). However, in January 2021, all were identified to sub-species.
- The remainder of the unidentified Bean Geese in 2021 elsewhere in Denmark were only found in SE Denmark (former Storstrøms Amt: Municipalities of Vordingborg, Guldborgsund and Lolland), or adjacent areas. These were all assigned to sub-species on the basis of the ratio of identified Taiga to Tundra Bean Geese in the total annual counts in the former Storstrøms Amt; hence 356 were assigned to Taiga Bean Goose and 872 to Tundra Bean Goose.

The total number of Taiga Bean Geese in Denmark in January 2021 was thus judged to be 3,994 (Table 3.2).

In January 2021, only one Taiga Bean Goose was found in a flock of Tundra Bean Geese in the eastern part of the province of Groningen, Netherlands (Table 3.2). In February two single birds and a flock of 2, all well-documented, were reported, also from the north-eastern part of the Netherlands (www.waarneming.nl). No reports were received from the former traditional sites in the southern part of the country. Hence, the species remains a rarity, much sought-after by birdwatchers and often disputed when it comes to the ID characteristics of specific birds. Tundra Bean Goose numbers in January 2021 were about average compared to previous years. A provisional total based on counts submitted online so far includes 158,000 individuals (Table 3.2), but following a comparison of sites checked in previous years, the total number will likely be somewhere around 180,000.

Thus, the January counts totals of the Central MU of Taiga Bean Goose were 3,994 in January 2021, plus 34,000 unidentified Bean Geese (Table 3.2).

Table 3.2. Results of international counts of Bean Geese in the Central MU in winter 2020/2021. Figures, which are based on professional judgement (called Estimated) are shown in Italic, based on the ratio of Bean Geese identified to Taiga Bean Goose and Tundra Bean Goose.

Country	**Area**	**Period**	**Number of Bean Geese**			**Reported by**
			Taiga	**Tundra**	**Unidentified**	
Sweden	N-Scania and N-Sweden	January			34,000	Leif Nilsson
	SW-Scania**		NA	NA	NA	
		Total, SE			34,000	
Denmark*	NE-DK	January	1,072	1		Preben Clausen
	SE-DK		2,566	1,236	1,228	
	DK	*Estimated*	*356*	*872*		
	DK	Total, DK	3,994	2,109		
Germany	North-Central Germany	NA				
Netherlands*		January	0	157,936		www.waarneming.nl (Taiga BG only) Kees Koffijberg
Total estimated			**3,994**	**160,045**	**34,000**	

* Preliminary totals for Tundra Bean Goose
** SW-Scania was not covered. A qualified guess would be that 5,000 Bean geese staged here during this period.

March counts

The March population counts were performed in Sweden with additional information from Denmark, Finland and Latvia. By Mid-March, nearly all Tundra Bean Geese have left The Netherlands.

In 2021, the monitoring was conducted 12-14 March. There was good coverage of the sites in this region and the movements were accounted for in the total numbers. The total number of staging Bean Goose counted in Sweden was 67,465 birds at this time plus additional 270 at the wintering grounds in Scania, 3,200 in Finland and an estimated 500 in Denmark (Table 3.3). The latter might be an overestimate since downloads from www.dofbasen.dk from this period only resulted in a total of maximum 50 Taiga Bean Goose in this period. Whatever is used, the Danish contribution to this total is negligible. The largest congregation was found at Lake Östen with 17,000 Bean Geese of which 6% were identified as Tundra Bean Geese. Assuming this proportion is apparent in the total count, the total numbers are estimated at 67,145 Taiga Bean Geese and 4,286 Tundra Bean Geese in the Fennoscandian countries (Table 3.3).

There were no observations of Taiga Bean Geese from the western part of Latvia, where Taiga Bean Geese from the Central MU usually are found, during the March counts. These birds most likely left Latvia before this monitoring period, as they make early short stop-overs in Latvia (Hakon Kampe-Persson, pers. comm.).

The number of Tundra Bean Geese are close to the approximately 4,000 Tundra Bean Geese being reported to winter in north-east Scania in the last couple of years (see discussion in Skyllberg, 2015). For these reasons, we consider it reasonable to subtract 4,000 Tundra Bean Geese from our total Bean Goose counts to yield an estimate for the numbers of Taiga Bean Geese present at that time.

The estimated total in March of 67,149 Taiga Bean Geese in the Central MU, which confirms the increasing trend from the previous years (Table 3.3). In 2012-2013 the number was as low as c. 44,200 (Skyllberg, 2015).

Table 3.3. Results of international counts of Bean Geese in the Central MU in spring 2021. Figures, which are based on professional judgement (called Estimated) are shown in italics.

Country	**Period** 12-14 March	**Number of Bean Geese**			**Reported by**
		Taiga	**Estimated Tundra**	**Unidentified**	
Finland	Spring staging			3,200	Ulf Skyllberg; tiira.fi
Sweden	Spring staging			67,465	Ulf Skyllberg
	Wintering, Scania			270	
Denmark	Wintering			500	Ulf Skyllberg
Fennoscandia[47]	*Estimated*	*67,149*	*4,286*		
Latvia	'CMU-region' (West-Latvia)	0	NA	NA	Hakon Kampe-Persson
The Netherlands		0	803		Kees Koffijberg
Total	***Estimated***	***67,149***			

Productivity

Productivity data were not available from Sweden in autumn 2020 due to mobility restrictions due to COVID-19 pandemic.

Offtake under hunting and derogations

Hunting

Taiga Bean Geese from the Central MU were hunted in Sweden, Denmark, Finland and Latvia, and probably also in Russia and Germany in 2020/2021 (Figure 3.2; Table 3.4).

In Sweden, during the 2019/2020 hunting season, the total hunting bag of Bean Geese was 2,312 birds (https://rapport.viltdata.se/statistik/; Table 3.4), which is less than the previous year but at the level of most years in the last decade.

[47] Fennoscandia in this case consist of Finland, Sweden and Denmark

In Denmark, during the 2020/2021 hunting season, the total hunting bag of Bean Geese consisted of 608 birds (preliminary data but only small subsequent changes are expected), which is 19% higher than 2019/2020 (509 birds) but at the same level as in the previous years (Figure 3.2; Table 3.4).

The Finnish Wildlife Agency received an increasing number of shot Bean Geese in Finland in 2020/2021. The mandatory reports reported about a harvest of 504 Bean Geese in 2020, compared to 49-176 in 2017-2019. The hunting within the Taiga Bean Goose breeding area in Lapland that opened for the first time since 2013, resulted in 25 shot Taiga Bean Geese. This was much lower than expected, and probably a result of a bad breeding season. Incubation was delayed due to a late spring of 2020 with a long period of snow coverage and most Finnish breeding birds either did not nest or failed breeding and moved to Novaya Zemlya for moult. Low numbers of successful reproductions lead to a low number of birds in hunting areas and therefore harvest was significantly lower than expected.

Furthermore, the harvest in Tundra Bean Goose zone was 479 birds. The main migration of Tundra Bean Geese overlapped more than in previous years, resulting in a higher overall harvest. The delineation to subspecies is based on pictures send by hunters, indicating 86% Tundra Bean Goose in the harvest bag, resulting in estimated hunted bags of 412 Tundra Bean Goose and 67 Taiga Bean Goose in this area. The total harvest of Taiga Bean Goose in Finland in the 2020/2021 hunting season including both zones is 92.

In Latvia, only 15 birds of a total 1,740 Bean Geese were Taiga Bean Geese in 2019 (0.9%). In 2020, Latvia issued for the first time ever licences to shoot geese for mitigation of crop damage (Kampe-Persson, 2021). During the period 15 March–30 May, 140 farmers were allowed to shoot a total of 1,000 geese. Since it was mandatory for the hunters to submit a photo image of each shot goose, it was possible to estimate the number of each subspecies/species. The licences were used to shoot one Taiga Bean Goose, 24 Tundra Bean Geese and 45 Greater White-fronted Geese. In the spring 2021, the farmers got licences for 500 bean geese and 500 Greater White-fronted Geese; numbers on shot birds are not available, yet.

Table 3.4. Bean Goose offtake, 2014/2015-2020/2021.

Country	**2014/15**	**2015/16**	**2016/17**	**2017/18**	**2018/19**	**2019/20**	**2020/21**
Sweden (Bean)	1,675	1,582	2,212	>1,977	3,547	2,312	NA
Sweden (Taiga)	NA	NA	NA	NA	NA	NA	NA
Denmark (Bean)	1,296	1,454	1,220	762	692	509	608**
Netherlands	0	0	0	0	0	0	0
Finland (Taiga)	0	0	0	24	15	12	92
Finland (Bean)	0	0	0	176	49	77	504
Latvia (Taiga)***	17	20	11	0	25	15	NA
Latvia (Tundra)	1,196	1,403	930	1,238	2,008	1,725	NA
Russia*	NA	NA	NA	NA	NA	NA	NA
TOTAL (Bean)	**>4,184**	**>4,445**	**>4,208**	**>4,213**	**>6,321**	**>4,638**	

* The region of Karelia, Murmansk and Arkhangelsk
** Preliminary data
*** Numbers for the whole of the country, i.e., both the Central MU and the Eastern 1 MU (Kampe-Persson & Boiko 2019).

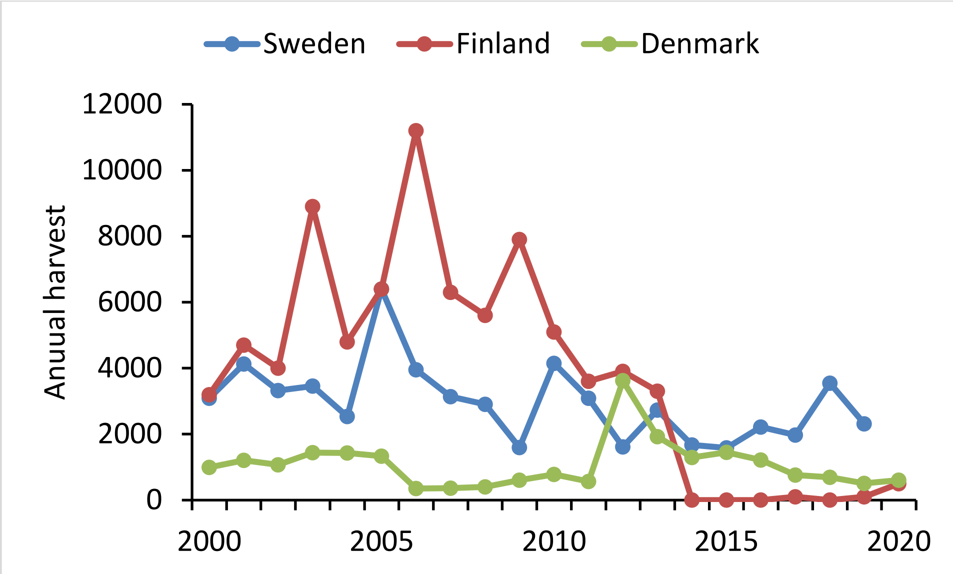


Figure 3.2. Annual harvest of Bean Geese in Sweden, Finland and Denmark during 2000-2020.

Derogation

In Sweden, the number of Bean Geese shot under special licences issued by statutory authorities to reduce agricultural damage are not currently gathered and collated, but the numbers are considered to be small compared to those shot under recreational hunting.

Information from The Netherlands indicates no licenses were issued in the reporting period within the only area where Taiga Bean Geese occur.

Collection of heads and wings

In Denmark, the number of wings submitted in the 2020/2021 hunting season was 26 of which eight were from juvenile birds. This juvenile/adult ratio of 0.44 is much higher than the previous years and for the first time since 2008/2009 higher than the mean 1986/87-2019/2020 juvenile/adult ratio of 0.25, although based on very few birds in some years (Christensen, 2021).

Furthermore, according to the mandatory hunting bag statistics, more than half of the reported Bean Geese were previously shot outside the municipalities and/or the period where hunting is allowed (Sørensen & Madsen, 2017), however in 2020/2021 this ratio has improved (32% shot outside these municipalities). It is unclear to what degree this problem results from incorrect identification of shot geese to species, incorrect reporting (e.g., all reported to home municipality) or limited hunter knowledge of the hunting regulations related to this species. Whatever the explanation, to mitigate any unintentional illegal hunting, the Danish Hunting Association and the Danish Wing Survey have, since 2017/2018, increased the awareness of hunters to the status of "Grey Geese" and encouraged them to submit the head and tail of shot Bean Geese, or photos of these (Sørensen & Heldbjerg, 2019; Sørensen & Madsen, 2017). These body parts enable differentiation of Taiga from Tundra Bean Geese, to obtain better information relating to the size and distribution of the hunting harvest of the two sub-species.

During the hunting seasons 2018/2019-2020/2021, 36 heads were collected. Of the 30 that were hunted legally, preliminary analysis (Thomas Kjær Christensen/Iben Hove Sørensen, pers. comm.) suggests that 26 were Tundra Bean Geese, 3 were Taiga Bean Geese and one was not identified as subspecies. Six more heads came from geese shot outside the three municipalities where hunting is allowed and/or outside the species-specific hunting season: 4 Tundra Bean Geese and 2 Taiga Bean Geese. These results indicate that the current hunting regulations ensure that the majority of hunted Bean Geese are Tundra Bean Geese (90%). However, the small sample size prevents us from drawing any firm conclusions.

An attempt by the Danish Hunters' Association to acquire heads from professional game meat handlers did not result in further data during the season of 2020/21, since no Bean Geese were delivered to the meat handlers (Iben Hove Sørensen, pers. comm.). Efforts to obtain an estimate of the proportion of Taiga Bean Geese in the harvest bag will continue and be further strengthened in the coming season.

In Finland, hunters were asked to collect head samples during 2018 and 2019 for visual identification and DNA-analysis. The results of DNA-analysis are expected to be finalised and published during 2021.

3b. Taiga Bean Goose – Western MU

3b.1 Population status

Data collection and methods

Winter counts

Population estimates for the Western MU of the Taiga Bean Goose, consist of counts from north of Limfjorden in North Jutland in Denmark, as well as from England and Scotland in the United Kingdom.

Goose monitoring in Denmark is coordinated as part of the national nature monitoring programme NOVANA (data recorded online into www.fugledata.dk), supplemented with observations from BirdLife Denmark's citizen science portal www.dofbasen.dk. The programme contributes to the mid-winter International Waterbird Census (IWC) coordinated by Wetlands International. Data in www.dofbasen.dk improve the coverage of the northwestern parts of Denmark, where this population is found.

The Bean Goose counts in the United Kingdom also contribute to the international counts coordinated by Wetlands International. In Scotland and England, the counts are carried out regularly throughout the winter months and, instead of relying on a January count, a maximum winter count (which can be any month, including the January count) is used as the final estimate. The population and distribution of the Taiga Bean Geese, which winter on the Slamannan Plateau has been the subject of a long-term monitoring programme since it was discovered in the late 1980s.

Productivity

Annual age ratios are estimated by ageing of each individual in groups of Taiga Bean Geese during autumn in Slamannan.

Movements

Five Taiga Bean Geese were caught in October 2019 and fitted with GPS tags and a few older tags still provide information. Besides a number of collars also help in understanding the movements of this population.

Offtake (harvest + derogation)

Taiga Bean Geese from the Western MU are protected from hunting in the UK and technically protected from hunting in Denmark by a regional hunting ban.

Population data

Winter counts

The IWC count in 2021 took place in Denmark on and around the weekend of 16-17 January. Data downloaded from www.dofbasen.dk improve the coverage of the northwestern parts of Denmark, where this population is found. Based on the Mid-winter counts from January 2021 there were 1,072 Taiga Bean Geese, 1 Tundra Bean Geese and 0 unidentified Bean Geese in Jutland northwest of Limfjorden (Thy, Hanherred and Morsø; Table 3.5). Estimates for Denmark are currently preliminary, because there might be a few observers who have not yet entered their registrations in www.fugledata.dk and dofbasen.dk. Bean Geese in North Jutland are notoriously very difficult to locate, but this year's number is comparable in size to the numbers in 2019 (1,094) and 2020 (1,170).

In Scotland, the first 75 geese were seen at the traditional place at Slamannan, Falkirk, 5 October and the wintering population gradually increased to a maximum of 210 on 28 November 2020. This total is in line with a gradual decline in wintering numbers from the all-time highs of 300 recorded in winter 2005/2006 and 2007/2008. Birds left the Slamannan Plateau during some of the hardest weather of winter 2020/2021 during early / mid-February.

In England, the first five birds in the winter 2020/2021 were observed in Norfolk, England at around Christmas. The tiny population seems about to disappear. A maximum of only six birds were seen regularly at Cantley and Buckenham, in the Yare Valley until 23 January. Probably the same six birds were then seen on the ground on 24 January at Carlton Marshes in Suffolk on their way east. The total population estimate for the United Kingdom was 216 individuals in 2020/2021 and the total for the Western Management Unit was estimated at 1,288 in January 2021 (Table 3.5).

Counts in UK are made in a collaboration between the Wildfowl & Wetlands Trust (WWT), the Bean Goose Action Group Scotland (BGAG) and the Royal Society for the Protection of Birds (RSPB). The information provided here is based on reports prepared on behalf of the Bean Goose Action Group, Scotland (BGAG) and RSPB, respectively.

Thus, a total of 1,288 individuals were counted in the Western MU in 2020/2021, which is similar to the preceding winters. There are, however, some conditions that might have influenced the count:

1) Data from Denmark are currently preliminary.

2) Bean Geese in North Jutland are very difficult to locate; hence, some flocks might be missing during the counts. Data gathered from telemetry devices fitted to Western MU Taiga Bean Geese in NW Jutland showed them using wetlands and natural habitats well away from roads and human habitation that are not normally extensively searched during count periods and which are unlikely to be found by birdwatchers without a specific interest in locating these birds.

3) We consider mid-winter to be the best period of the year to count the Western MU Taiga geese but they may be more concentrated but also inseparable during other periods. Telemetry tagged Western MU Taiga are known to associate with Central MU birds at staging areas, for instance in the Östen/Ymsen area in Sweden in autumn and spring.

4) The very mild weather conditions that prevailed prior to the mid-winter census might influence temperature-driven movements and an increasing number of birds may winter further up the flyway (for instance in Sweden or Norway).

Despite the potential gaps in survey coverage, the population level remains far below the short-term target (for the next 20 years) of 4,000 individuals, specified in the ISSAP (Marjakangas et al., 2015).

Table 3.5. Results of international count of Bean Geese in the Western MU in winter 2020/2021.

Country	Area	Period	Number of Bean Geese			Reported by
			Taiga	Tundra	Unidentified	
Denmark*	NW Jutland	9-24 Jan 2020 (main 16-17 Jan)	1072	1	0	Preben Clausen & Tony Fox,
UK	Slamannan, Scotland	28 Nov 2020	210	-	-	WWT/ BGAG/RSPB
	Norfolk, E England	January 2021	6	-	-	
		TOTAL	1,288	0	0	

* Preliminary totals

Productivity

Two separate ageing assessment counts were completed on the 17 December 2020; 1) seven juveniles out of 98 aged birds in a flock of 115 and 13 juveniles out of 69 aged birds in a flock of 80, i.e., 20 juveniles out of 167 birds aged, (c. 12%), which is typical for Slamannan Plateau population in the past 20 years or so.

Movements

Tracking data revealed the increasingly early departure of birds from the Plateau at the end of the wintering period which has occurred in recent winters; two tagged birds left as early as the 25 January 2021, whilst others remained until what are nowadays more typical dates of early / mid-February 2021 before they moved to staging areas in Jutland, Denmark and in Southern Norway and Sweden. Tracking data also indicated that the birds used some fields during winter in which they were not recorded by conventional monitoring methods (more information is available at the website Scotland's Bean Geese (Scotland's Bean Geese, 2021).

Offtake under hunting and derogations

There is no hunting on Taiga Bean Geese in the Western Management Unit.

3c. Taiga Bean Goose – Eastern 1 MU

3c.1 Population status

The Taiga Bean Geese of the Eastern 1 MU winters in northeast Germany, north-west Poland, in lower numbers in southern Sweden and only in small numbers in The Netherlands. In this report, all the birds in Sweden and the Netherlands (however, very few) were identified as Central MU birds in the absence of better information (and latest ring sightings from The Netherlands suggest a link with the Central MU). Until we better understand the distribution, abundance and phenology of these Taiga Bean Geese, we are forced to consider that this wintering element has contracted its wintering range eastwards into eastern Germany and Poland. However, as there have been no goose counts from Germany and Poland in January 2021 (nor the previous years) that have been made available, it is not possible to estimate the population size for the Eastern 1 MU. Wintering Taiga Bean Geese were counted in Germany in winter 2020/2021 but these data have not yet been made available to this process.

Ongoing activities in the western part of Yamal-Nenets Autonomous Okrug and in the Yougansky State Reserve still provide information on the migration (see Heldbjerg et al. 2020). One female tagged two years ago continues to provide data, which show her using different migration routes to the same breeding site she has used in both years. However, there is still a need for improved information on the wintering areas, staging areas and migration routes of the two Eastern MU's, and any new investigation will add to improving our knowledge and understanding of the species.

Taiga Bean Geese from the Eastern 1 MU are hunted in Germany, Belarus, Latvia, Russia and Poland, but the bag sizes in these states are in general unknown. In the federal state of Brandenburg, Germany, hunting on all Bean Geese has been banned since autumn 2019, and in the federal state of Mecklenburg-Vorpommern, Germany hunting on all Bean Geese has been banned since April 2020.

In Russia, the Taiga Bean Geese of Eastern 1 and Eastern 2 MUs are now included in the federal Red Data Book. The intention is to protect them from hunting throughout their range in the Russian Federation and that areas of important habitat for the birds should be completely protected under state legislation (Order # 162 from 24 March 2020 of the Ministry of Natural Resources and Ecology of Russia, registered by the Ministry of Justice 02 April 2020). This represents a very important increase in the level of protection for the subspecies/Eastern 1 and 2 MUs in Russia. Taiga Bean Goose is also fully protected in regions, which themselves have included it in their regional Red Data Books, e.g. Krasnoyarsky Kray and Karelia Republic (which are probably mostly relevant for the Central MU).

The number of harvested Bean Geese in the 2018/2019 harvest season (based on Russian bag statistics for 2018/2019 hunting year with correction) was estimated in Russian areas relevant to Central and Eastern 1 Taiga Bean Goose MUs. This estimation was based on the bag statistics for the 2018/2019 hunting year and the proportions of Bean Goose among other geese species from examinations of pictures of shot geese for 2013-2017. The ratio of Taiga Bean Goose is still unknown. The numbers shot were 16,697 in areas within Central Taiga Bean Goose population, 4,699 in areas within Central or/and Eastern 1 Taiga Bean Goose populations and 9,570 in areas within Eastern 1 Taiga Bean Goose population (Solokha & Gorokhovsky, 2017, 2018).

3d. Taiga Bean Goose - Eastern 2 MU

3d.1 Population status

The Eastern 2 MU winters in South-east Kazakhstan, Eastern Kyrgyzstan and North-west China. Altai Province (Altai Kray), Southwestern Siberia on the border with Kazakhstan, is an important staging region for Bean Geese both in spring and in autumn migration seasons for birds from this MU.

Russian scientists have tagged Taiga Bean in the eastern part of the Yamal-Nenets Autonomous Okrug to identify the main staging, moulting, nesting and wintering sites used by birds from this flyway. The results are still providing new and exciting results about the migratory routes and the wintering sites used in NW China (Rozenfeld et al., 2018).

Aerial counts of Taiga Bean Geese during autumn 2020 in Yamalo-Nenetsky autonomous Okrug (YANAO, Western Siberia) registered 1,187 geese in Ob valley and 1,454 in Eastern part of YANAO. This is seen as a slight increase in the population (Sonia Rozenfeld pers. comm.).

The bag statistics and pictures of shot geese from Altai Province were investigated during the years 2017-2020. An estimated number of approximately 3,000 Bean Geese are shot by hunters every year in Altai Province, of which at least 2,500 are considered to be Taiga Bean Geese. These Taiga Bean Geese could belong to Western (*A. f. fabalis*) or Eastern (*A. f. middendorfii*) subspecies. But it is practically impossible to separate one from another because these subspecies look very similar, and there is no geographical isolation between their populations during annual life cycle. Systematic counts and use of GPS tags would be preferable (Alexander Solokha pers. comm.).

Taking into account that Taiga Bean Geese legally or unintentionally are also hunted in other West/Central Siberian regions (e.g. Novosibirsk, Krasnoyarsk, Kemerovo, Tomsk, Yamalo-Nenets, Khanty-Mansy), it raises the question whether the Eastern 2 MU is much bigger than the 2,000-5,000 individuals mentioned in the Taiga Bean Goose ISSAP. Some local experts suggest that between 30,000 and 100,000 Taiga Bean Geese migrate in autumn via Western Siberia towards wintering grounds in NW China (Bondarev, 2019; K. Osadchy & S. Moskvitin pers. comm.). These estimates need further clarification through coordinated counts and need to be verified on the wintering grounds. (Alexander Solokha pers. comm.).

A study on the hunting pressure on Taiga Bean Geese, based on ring recoveries will be published soon, showing that the average Taiga Bean Geese life is shorter than the Tundra Bean Geese, apparently because the former are exposed to a higher hunting pressure (Panov et al., n.d.). In Krasnoyarsky Kray, the spring hunt on the geese within the range of the Taiga subspecies was forbidden regionally since 2021. The Taiga subspecies is now in the list of Red Data Book of Krasnoyarsky Kray (but not signed officially, yet).

3.2 Harvest assessment for the Central MU

An initial assessment of harvest potential for the Central Management Unit was completed in 2016. In 2018, significant advances were made in harvest-assessment methods for species with sparse data, using Taiga Bean Geese as a case study (Johnson et al., 2018). In 2019, Finland (Finnish Wildlife Agency and Natural Resources Institute) funded the development of an integrated population model (IPM) for the purpose of further improving harvest management and that research was completed in 2020.

The anniversary date of the IPM is March, with population size also estimated in the following months of October and January. The IPM predicts changes in abundance using a discrete, theta-logistic model:

$$N_{t+1}^{M} = N_t^M \left\{1 + \left[(\psi(1+\gamma) - 1)\left(1 - \left(\frac{N_t^M}{K}\right)^{\theta}\right)\right]\right\} - H_t$$

where N^M is March population size, ψ is intrinsic survival from natural causes, γ is the intrinsic rate of reproduction, K is carrying capacity in the breeding season, θ is a parameter describing the type of density dependence (i.e., concave, linear, or convex), H is total harvest, and t is year.

Abundance in October, N^O, is predicted as a function of March abundance:

$$N_t^O = N_t^M + N_t^M \left[(\psi^{7/12}(1+\gamma^1) - 1)\left(1 - \left(\frac{N_t^M}{K}\right)^{\theta}\right)\right] - H_t^F$$

in which we assume seven months of natural mortality, all of the reproduction, and a portion of the total harvest occurring prior to October, where H^F represents the harvest in Finland.

Abundance in January is conditional on October abundance:

$$N_t^J = (N_t^O - H_t^D - \alpha H_t^S)\psi^{3/12}$$

where H^D and H^S represent harvests in Denmark and Sweden, respectively, and where α represents the proportion of the Swedish harvest occurring prior to January (i.e., the regular hunting season).

Abundance in the following March is thus:

$$N_{t+1}^M = \left(N_t^J - (1-\alpha)H_t^S\right)\psi^{2/12}$$

where $(1-\alpha)$ represents the proportion of the Swedish harvest that is taken after the regular season to help prevent crop damage (i.e., conditional hunting).

Total harvest rate is a latent (unobserved) parameter, estimated as:

$$h_t = \frac{H_t}{N_t^M \left[1 + (\psi^{7/12}(1+\gamma^1) - 1)\left(1 - \left(\frac{N_t^M}{K}\right)^{\theta}\right)\right]}$$

Annual survival rate is also estimated as a latent parameter by assuming additive hunting mortality:

$$s_t = \psi(1 - h_t)$$

Note that the estimate of survival does not take into account density dependence, so we refer to this parameter as *apparent* survival; actual survival may have been less if density dependence operated on survival in a significant way.

A final report describing development of the IPM was distributed in October 2020 (Johnson et al., 2020). A key difference between previous assessments and the current IPM is that the latter excludes the Tundra subspecies from the population and harvest data. This resulted in minor differences in estimates of demographic parameters, but notable differences in estimates of spring population size (Figure 3.3). We refer the reader to Johnson et al. (2020) for further details concerning the IPM. The IPM was updated for 2021 by including the most recent estimates of population size and offtake from section 3.a.1 of this report. Data files and R code for running the IPM can be found here: https://gitlab.com/aewa-egmp/taiga-bean-goose/harvest-assessment/2021.

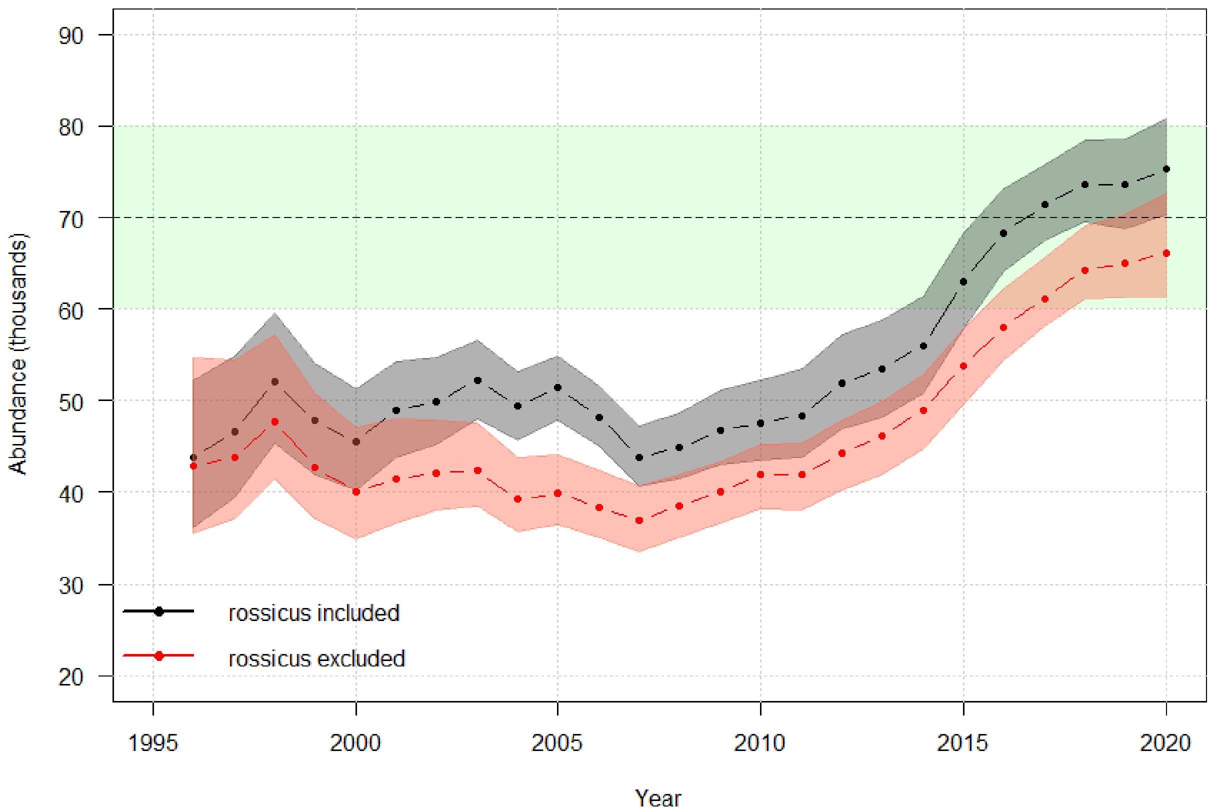


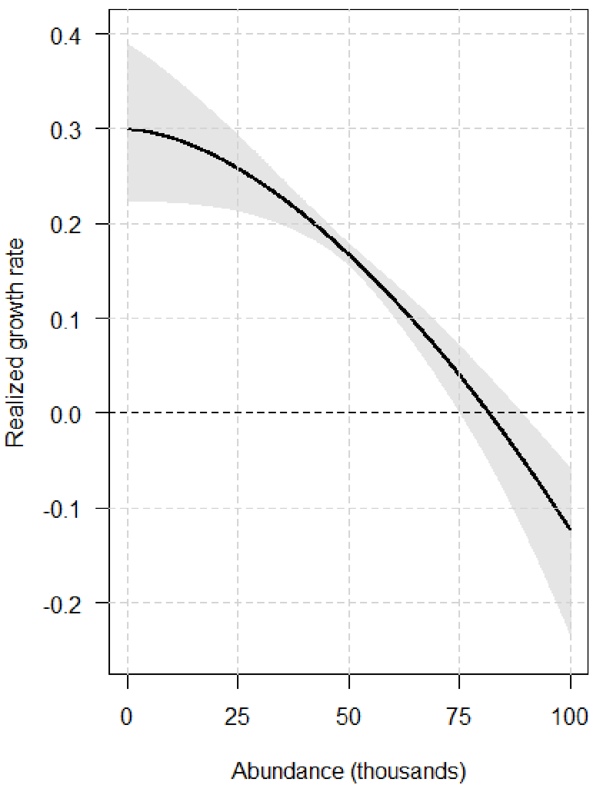
Figure. 3.3. Estimated abundance of Bean Geese in March in the Central Management Unit using an IPM in which the Tundra subspecies (*A. f. rossicus*) is included and one in which it is not. The green band represents the target population size for Taiga Bean Geese. Estimates were based on data through March 2020.

Prior and posterior estimates of the key demographic parameters in the IPM are provided in Table 3.6. Prior estimates are based on allometric information and expert opinion. Posterior estimates are those resulting from implementation of the IPM using the priors in combination with the historic record of population counts and estimates of offtake. Posterior estimates of natural survival and reproduction may appear high, but the reader is reminded that these are biological maxima in the absence of anthropogenic mortality and density dependence.

Table 3.6. Prior and posterior estimates of demographic parameters in a theta-logistic population model for Taiga Bean Geese in the Central Management Unit as based on an IPM. Natural survival and reproductive rates are intrinsic values (i.e., biological maxima in the absence of anthropogenic mortality and density dependence).

Parameter	Prior median	Prior 95% CI	Posterior median	Posterior 95% CI
Natural survival (ψ)	0.884	0.793 – 0.947	0.892	0.814 – 0.948
Reproductive rate (γ)	0.298	0.179 – 0.496	0.465	0.325 – 0.605
Breeding carrying capacity (K)	87553	80951 – 94693	81683	75278 – 88936
Form of density dependence (θ)	2.340	1.300 – 4.212	1.691	1.136 – 2.689

We used posterior samples of carrying capacity and intrinsic survival and reproductive rates to estimate the realized population growth rate in the absence of harvest for varying sizes of the March population. We also estimated surplus production of the population by multiplying the realised growth rate by population size. A plot of surplus production as a function of population size represents harvestable surpluses and is often referred to as a "yield curve." Realised growth rate declines with increasing population size as a result of density dependence, with the decline being convex as indicated by an estimate of $\theta > 1$ (Figure x). Thus, density dependence becomes increasingly stronger as the population approaches carrying capacity. The harvestable surplus is maximized at a population size of 45,374 (41,114 – 51,949), which is substantially lower than the target population size of 70,000. At a population size of 45,374, the harvestable surplus is 8,518 birds (7,961 – 9,044). In contrast, the harvestable surplus at a population size of 70,000 is 4,791 (2,684 – 6,578).



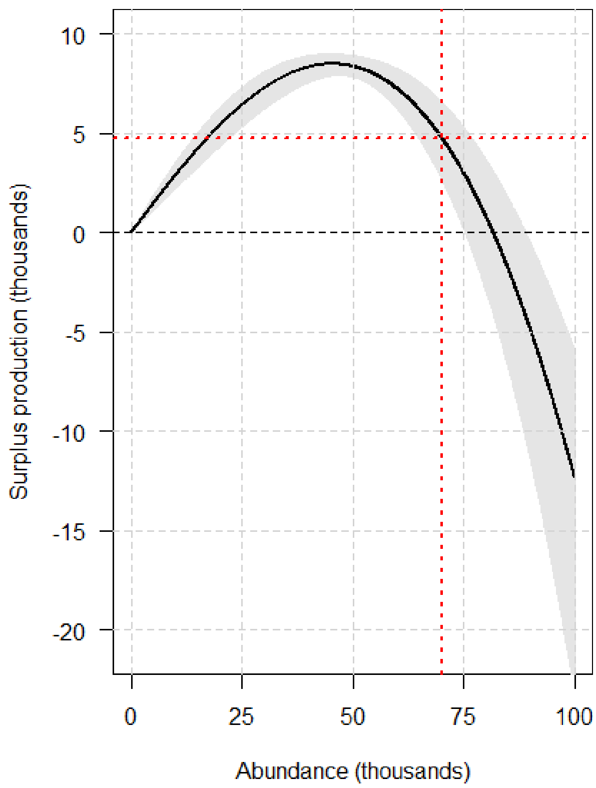


Figure 3.4. Left: realised growth rate of Taiga Bean Geese in the absence of harvest as a function of population size in March. Right: surplus production as a function of population size in March. The vertical, dotted red line indicates the median population target of 70,000. The horizontal, dotted red line indicates the allowable harvest when the population is at its median target.

Posterior estimates of population size at three times of the year are depicted in Figure 3.5. The March 2020 population estimate was 66,306 (62,903 – 72,066). The October 2020 population size, for which there was no reliable corresponding count, was estimated as 73,393 (69,518 – 79,071). The January 2021 population size, also for which there was no reliable corresponding count, was estimated as 68,989 (65,003 – 75,044). And, finally, the March 2021 population estimate was 66,916 (62,468 – 73,362), which is similar to the March 2020 estimate. The population could be sustained at this level (on the average) with a harvest of 5,695 (3,994 – 7,226).

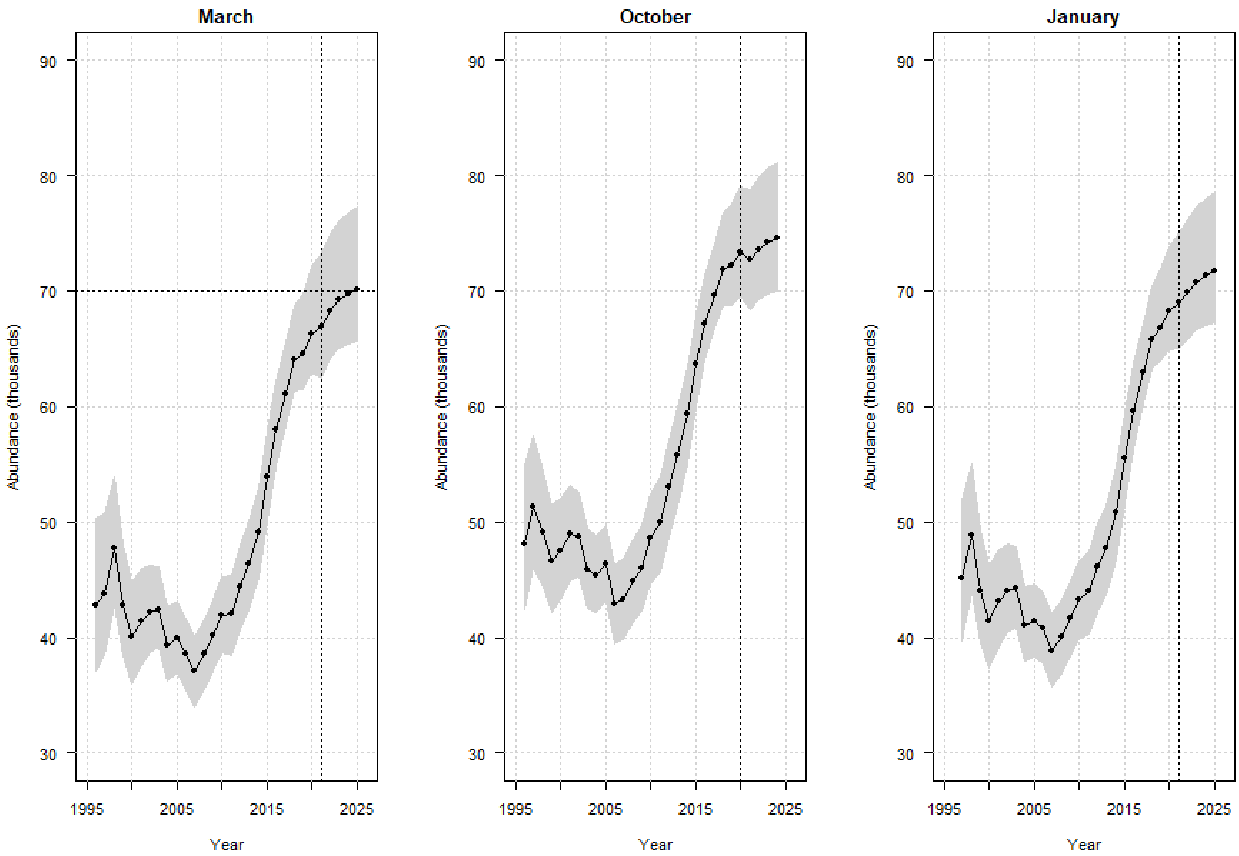


Figure 3.5. Posterior estimates of the abundance of Taiga Bean Geese in the Central Management Unit (in thousands, in black, with 95% credible intervals in grey) as based on an IPM. The vertical, dashed lines represent the last year of data. Future abundances were projected based on the interim harvest strategy intended to reach the median population target of 70,000 by March 2025.

To evaluate the current, interim harvest strategy, we projected population size four years into the future using methods described by Kéry and Schaub (2012). In 2017, the European Goose Management Platform adopted a harvest strategy consisting of a 3% harvest rate to assist with recovery of the population while providing limited opportunities for hunting. In 2020, the interim harvest strategy was revised to prescribe allowable harvests that would permit the population to reach its median population target of 70,000 by March 2025 (on the average). Total harvest is to be allocated among Russia (15%), Finland (49%), Sweden (26%), and Denmark (15%) based on an agreement among Range States. The Russian harvest is unknown, however, and in the IPM it is implicitly included as natural mortality. We thus re-normalised the remaining Range States' harvest allocation as 58%, 30%, and 12% for Finland, Sweden, and Denmark, respectively.

Posterior estimates of country-specific harvests of Taiga Bean Geese are provided in Figure 3.6. The forecasts of harvests for the years 2021 – 2024 are those needed to attain a population size of 70,000 in March 2025 (on the average). Moreover, the country-specific harvests for these future years are in accordance with the agreed-upon allocation of total harvest among the three countries. The total allowable harvest is 2,000 (1,913 – 2,088) and the country-specific allocations of this harvest are: Finland – 1,160 (1,094 – 1,227); Sweden - 600 (553 – 648); and Denmark - 240 (210 – 271). For comparison, the estimated total harvest averaged 2,978 (2,230 –

3,727) during the years of the interim harvest strategy (2017 – 2020). Notice that the projected harvests in Figure 3.6 are quite different in Finland and Sweden than they have been during the years of the interim harvest strategy. The reasons that the projected harvests (H = 2,000) for the interim strategy are so much lower than when the population is at its target (H = 4,791) or when the population is at its current level (H = 5,695) are threefold-fold: (1) additional population growth is desired because current population size is not yet at its median target; (2) the closer population size gets to the carrying capacity, the more difficult it becomes to stimulate population growth; and (3) there are only four years remaining for growth of the population to the median target.

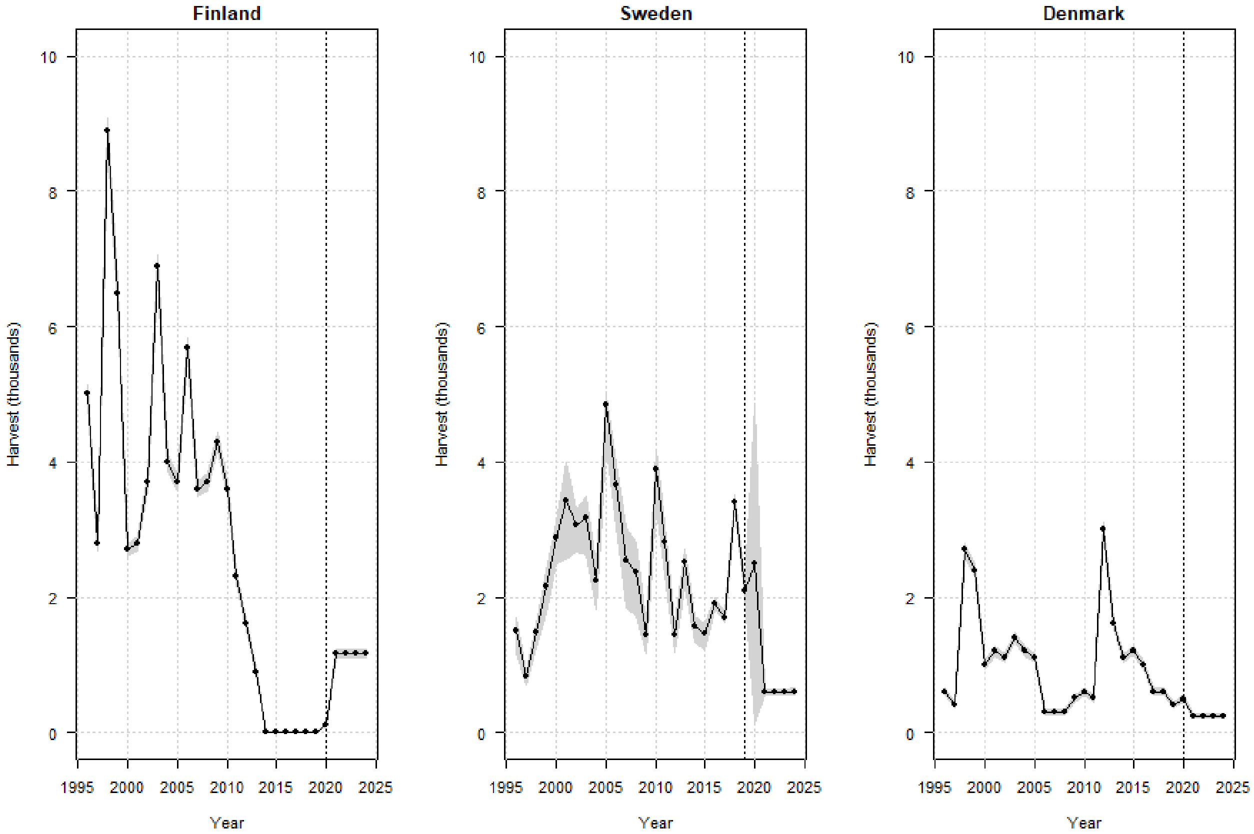


Figure 3.6. Estimated harvests (in thousands, with 95% credible intervals in grey) based on an IPM for Taiga Bean Geese in the Central Management Unit. The vertical, dashed lines indicate the last year of data. Future harvests were projected based on the interim harvest strategy intended to reach the median population target of 70,000 by March 2025, with country-specific allocations as agreed upon. The unusually large credible interval for the 2020 Swedish harvest is due to the fact that there is a one-year lag in obtaining harvest estimates from Sweden (thus no harvest data were available from Sweden for the 2020/21 season).

Posterior estimates of annual harvest rates and apparent survival of the flyway population are provided in Figure 3.7. Harvest rates declined dramatically following the Finnish harvest moratorium in 2014, and this decrease in harvest rate coincides with strong growth in the population. Harvest rates during the four years of the interim harvest strategy (2017 – 2020) averaged 4.4% (3.3 – 5.5%). Estimates of apparent survival increased markedly with implementation of the Finnish harvest moratorium, and have averaged 0.852 (0.843 – 0.882) since implementation of the interim harvest strategy.

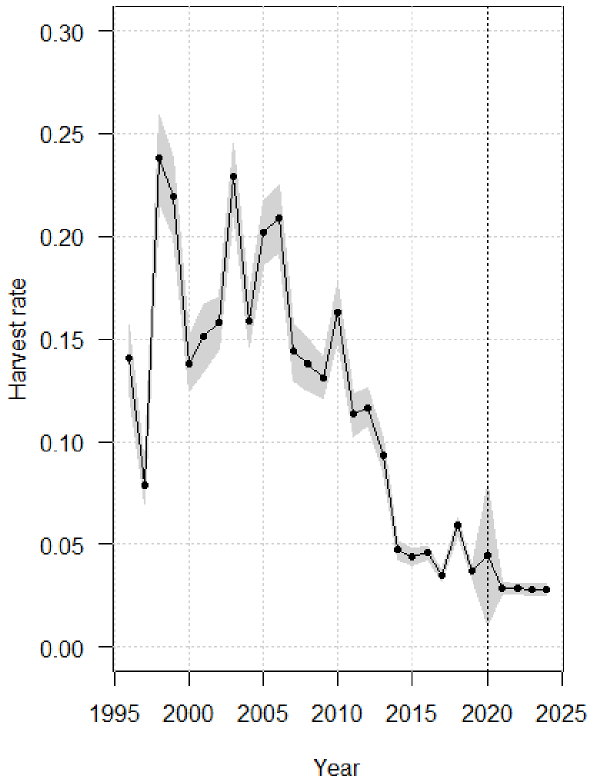


***Figure 3.7**.* Posterior estimates of harvest and apparent survival rate based on an IPM for Taiga Bean Geese in the Central Management Unit, with 95% credible intervals in grey. The vertical, dashed lines represent the last year of data. Future (mean) rates were projected based on the interim harvest strategy intended to reach the median population target of 70,000 by March 2025. The unusually large credible interval for the 2020 harvest-rate estimate is due to the fact that there is a one-year lag in obtaining harvest estimates from Sweden (thus no harvest data were available from Sweden for the 2020/21 season).

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4. NW/SW European Population of Greylag Goose *Anser anser*

This chapter compiles monitoring data (methods and results) on the population status of the NW/SW European population of Greylag Goose up to the season 2020/21 and provides update on the establishment of the necessary monitoring frameworks outlined in Chapter 6 of the AFMP, thus the short-term needs (2020-2022) to set the stage for MU-based models in 2023 (Nagy et al. 2020).

4.1. Population status

The range states for the NW/SW European population of Greylag Goose *Anser anser* include Norway (NO), Sweden (SE), Finland (FI), Denmark (DK), Germany (DE), The Netherlands (NL), Belgium (BE), France (FR), and Spain (ES) (Figure 4.1). Based on the recognition of regional differences in migratory behaviour and the human-wildlife conflicts involved within this population, it has been agreed to define two Management Units (MU) (Nagy et al. 2020).

MU1 includes the breeding populations from Norway, Sweden, Finland and Denmark that is subsequently mainly staging and wintering in areas of The Netherlands, Germany and Belgium and migrating to the southernmost wintering sites in France and Spain but also with some birds staying further north. MU2 is the mainly sedentary populations of The Netherlands, Belgium and Germany, and inclusive a small French population of c. 200 breeding pairs (Bacon et al. 2019, Nagy et al. 2020). Germany is regarded as a unity here, albeit it is known that breeders in the eastern part are showing more migratory behaviour as in the western parts (Bairlein et al. 2014).

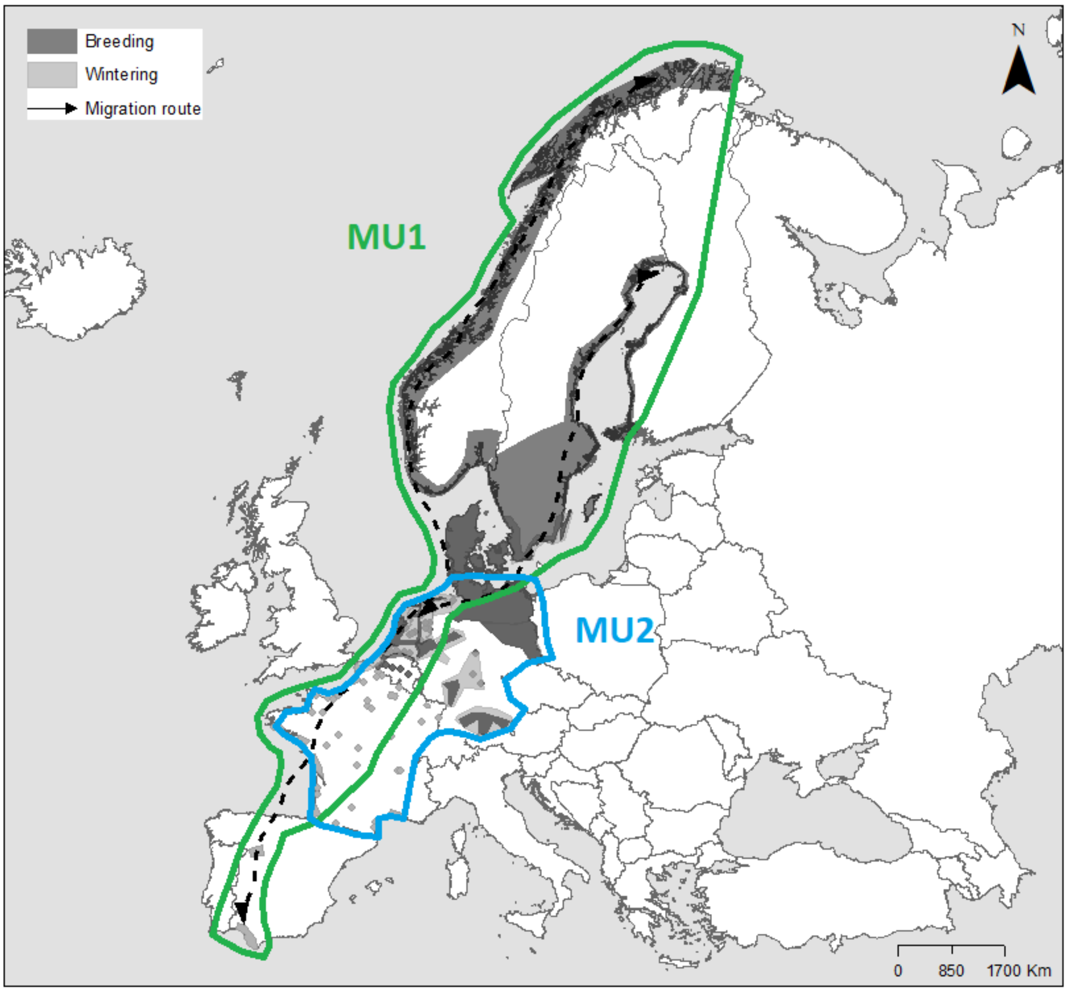

Figure 4.1. Annual distribution and main migration routes for the NW/SW European population of Greylag Goose including breeding (grey) and wintering (light grey) areas, as well as areas, which are both used during the breeding

and wintering period (dark grey) as presented in Powolny et al (2018). The two management units (MUs) are also shown: MU1 for the migratory population (in green) and MU2 for the sedentary population (in blue). Notice that the borders of the MUs are only indicative and may be adapted over time.

Data collection and methods

Winter Counts

Each year in January, the Greylag geese are counted in all range states. The counts refer to counts in wetlands areas, as well as counts from schemes specifically for geese, which mainly focus on farmland areas. The counts are collected by national coordinators and reported to Wetlands International (which coordinates the International Waterbird Census (IWC) survey, van Roomen et al. 2018). However, not all counts from Denmark are reported to the IWC. This result in three different datasets from the January counts:

IWC count totals

These represent the unadjusted number of birds counted in a given year for all IWC sites and reported to Wetlands International. It consists of counts at fixed sites (mainly wetlands) in each range state. Coverage may however vary between years because some data may not have been submitted to national coordinators by observers (Figure 4.1). Thus, the IWC count totals cannot be interpreted as representing the entire population in a range state.

Table 4.1. Availability of IWC count data per range state. In some cases, data from earlier years are omitted due to small observed/imputed ratios.

Range state	**Period**
Belgium	1982–2020
Denmark	1981–2020
France	1987–2020
Germany	1980–2020
The Netherlands	1980–2020
Norway	1980–2018
Portugal	1989–2020
Spain	1990–2017
Sweden	1980–2020

IWC imputed totals

To account for variation in coverage and submission of data, IWC imputed totals are calculated from a subset of IWC sites that have more than five counts and at least one of these is after 2008, thus it excludes sites that are only counted occasionally to avoid overestimations of the population size. Based on these counts, population trends are calculated using a method that first calculates national trends for each country and then combines national trends into a flyway trend. rTRIM 2.0.6 (Boogart et al., 2018) are used for the calculations of imputed values as well as trends. TRIM (Van Strien et al., 2001) takes the observed values whenever they are available and imputes the missing values for sites without counts in the given year using a General Estimation Equation that takes year and site effects into account.

These principles are not applied in Denmark, where no imputing is done because since 2000 the country only reports counts to the IWC from a reduced site list of wetland areas (Pihl 2000, Holm et al. 2018). A large part of the population in Denmark is found in farmland areas not included in the IWC sites. Occurrence varies from year to year, depending on the availability of crops on which the geese forage. Hence, the numbers at the reduced site list sites would not be representative for the status of the species in the country. Instead, Denmark adds the sum of all counted Greylag Geese outside the IWC sites, by inclusion of unsystematic data from the portal www.dofbasen.dk, to the sum within the included sites, providing a good estimate of the total, of which a part is not available for the IWC imputation.

Furthermore, in The Netherlands, the imputed totals are taken from the national Dutch trend analysis, who uses a different method (Hornman et al. 2021). In the Netherlands, imputing is carried out for the network of monitoring sites, which should encompass all relevant areas (including major areas of farmland). The criterion is that sites should have >= 1% of the flyway population, which is reviewed periodically. Thus, opposite to the IWC imputed totals, the imputed values for The Netherlands are considered representative for the total national population.

In general, IWC imputed totals are mainly used to assess trends, but they are not a reliable estimate of population size for a highly congregatory species because imputing can significantly inflate the numbers.

EGMP National totals (collated by the EGMP)

The EGMP totals are usually based on the IWC count and some countries report the observed values without any adjustment for missing counts while others report the imputed values. However, IWC counts in most countries only include a certain fraction of the total wintering population, but it is rarely known how incomplete these counts are.

Nevertheless, the mid-winter counts are an important source of data, as simultaneous counts are performed across the wintering range of the population and movements in this time of the year are limited. However, we should be aware (also when comparing to breeding bird numbers), that the January count is made towards the end of the hunting season and thus affected by the size of the offtake during the hunting season (from late summer to the midwinter period). Moreover, it is at a time of the year when breeding birds from MU1 have migrated to MU2, which makes it impossible to distinguish between the populations in the two MUs. Hence, the midwinter counts only provide information on the overall trend and size of the entire flyway population but not suitable to assess the size and trend in the different management units.

Summer counts

Counts during late summer is the only period in which the size of the population in each MU can be assessed. During this period, the breeding population in Norway, Sweden, Finland and Denmark represent MU1, and the sedentary (and breeding) population in The Netherlands, Belgium, Germany, and a small French population represent MU2 (Table 4.2).

MU2

Summer counts of Greylag Geese have so far only been carried out in range states of MU2: Flanders, Belgium (first 2009 (Adriaens et al. 2010) and 2014-2018), Netherlands (first 2005, annually 2012-2018 (Buij and Koffijberg 2019)), North Rhine Westphalia, Germany (since 2011 (Koffijberg and Kowallik 2018, 2020)) and Lower Saxony in Germany (since 2018 (Nipkow 2019)) (Table 4.2).

The summer counts in general aim to estimate total population size in summer, along with distribution and productivity. They do not only involve active breeding birds, but also failed breeders and immature birds that belong to the non-breeding cohort. So, this type of census covers more birds than those observed with the breeding bird surveys in spring (delivering only active breeding pairs).

The counts have been carried out around mid-July, after the period of primary moult (which may involve long-distance movements but also geese hiding in inaccessible areas, which are difficult to count). Moreover, distribution is rather stable in this period (shortly afterwards, cereal harvest starts, and birds may widely disperse themselves over suitable farmland areas). In Germany, the counts are also taking place before hunting starts whereas in The Netherlands counts are in place after eventually large numbers have been killed during wing moult (in June).

MU1

For MU1, a summer count is currently being explored within the Fennoscandian Greylag Goose Initiative (FGGI). The FGGI was established in 2020, with the aim of:

1. Initiation of counts during late summer (i.e. post-breeding populations), as this is the only period in which total population size (adults + juveniles) and productivity (% young) can be assessed for each MU[48];
2. Monitoring of survival and movements of the MUs using GPS tags and coloured neck bands.[19]

Currently a best strategy is under construction. When transferring the guidance from MU2 to MU1, an optimal count would imply: 1) counts during summer when flocks have not undertaken larger migratory movements, and are still within the management unit where they breed, 2) after the moulting period in early summer, 3) after the breeding season, when geese have started to congregate at specific sites (instead of occurring highly dispersed in the landscape), 4) preferably before the hunting season starts, and 5) at a time when 1st year birds are still easily separated from adults (2nd year or later) in order to be able to assess productivity. Based on these conditions, the first decade of August was chosen for the counts in MU1. Even if the timing of this count is slightly different from counts in MU2, we do not expect larger problems regarding exchange between the two MUs, thus making separate assessments for both MU1 and MU2 possible.

While the intention in Belgium, Netherlands and Germany is to count all birds, the only possible option in Denmark, Norway, Sweden and Finland may be to count at a limited number of sites selected by stratified sampling based on a habitat suitability model, followed by an estimation of the total population. This is a long and complicated process but for 2021, the preparation of the model is in progress (considering grid size, selection of variables etc.) and the model will be tested by using existing data in as many of the included countries as possible. Based on the preliminary model experiences, the fieldwork will be conducted in a few but different (region, habitat) areas of Norway. Hopefully, it will be possible to learn from the Norwegian experiences and include the other countries in 2022.

Table 4.2. Organisation and details of summer counts of Greylag Geese. Summer counts have not been performed for MU1 but is part of the FGGI initiative. Information for France and Spain is not essential due to small breeding populations. Data for Lower Saxony in 2019-2020 have not yet been published while data for The Netherlands have not been compiled at national scale yet.

Range state	**Counts From - to**	**Productivity From - to**	**Counted in 2019-2020**	**Organisation**	**References**
MU1					
Norway	NA	NA	NA		
Sweden	NA	NA	NA		
Finland	NA	NA	NA		
Denmark	NA	NA	NA		
MU2					
Lower Saxony in Germany	2018-2020	2018-2020	Yes, but not available yet	Staatliche Vogelschutzwarte	Nipkow 2019
North Rhine Westphalia, Germany	2011-2020	2011-2020	Yes	Nordrhein-Westfälische Ornithologen Gesellschaft	Koffijberg & Kowallik 2018, 2020

48 A precondition for activity 1) and 2) is that each involved range state covers the needed costs; however, this was only partly achieved. Norway provided an amount considered to cover all costs for the activities in the first year, Sweden covered partly, useful for the initiation of the modelling work, Finland decided to include this work in on-going activities and Denmark did not take any decision, yet.

Netherlands	2005, 2012-2020	1997-2020	Yes, but not available yet	Regional Wildlife Councils and Sovon	Buij & Koffijberg 2019, Hornman et al. 2020
Belgium (Flanders)	2009, 2014-2018	2009, 2014-2018	No	INBO	Adriaens et al. 2010

Common Bird Monitoring Breeding Bird Index

In addition (or alternative) to summer counts, many countries also have Common Breeding Bird Monitoring schemes in place. These provide a method to achieve information on the relative changes in the breeding population. The aim of these schemes is, however, not to count and estimate the total number of breeding pairs (or breeding individuals), but instead to produce comparable national breeding bird indices from year to year, which are useful for the production of trends, and thus provide a second source of information regarding population developments, besides counts in midwinter.

Similar as in winter, these schemes are all based on fieldwork by a large number of volunteers and include all the common species; hence, Greylag Goose is only one of the species counted. The setup of the census scheme varies between the countries but all have standardised methodology, a formal design and all are producing annual breeding bird indices which can be compared between countries and, when combined, deliver aggregated trends (PECBMS 2019). Information about each of the schemes can be found via www.pecbms.info.

In general, the precision of the indices increases with the number of observers and with the abundance of the species. A national index for the Greylag Goose is included when data on the species makes it possible in the given country. These factors explain the length of the time series, the variation in the indices and explains for instance the higher annual variation seen in the data from Finland compared to the data from The Netherlands and the shorter time series for Norway compared to the longer time series for Sweden and Denmark.

The breeding bird indices are obtained from each of the national schemes. For comparison of the different national indices, the indices have been recalculated for this status report, so all indices were set to 100 in year 2010. We used the indices to calculate trends for the longest possible period in each country and for the most recent 10 year's period.

MU transition probabilities

So far, movements of Greylag Geese have been mainly studied by the use of neckbands (e.g. Voslamber et al. 2010, Nilsson and Kampe-Persson 2018, Bacon et al. 2019). However, as part of the neckbands are older and migration strategies have changed in the past decade(s), more/new birds should be neck-banded, and the analyses should be updated. Furthermore, in order to understand how and when the different subpopulations are migrating, especially to study the transition between MUs, the best solution is to include results from GPS tagging. However, the coloured neckbands can add to this information and also provide information on annual survival rates of the adults by a Multi-state Capture-Marking-Resighting (CMR).

The use of GPS tags was large in recent years in large parts of Sweden and Finland but less used recently in Norway and not in use at all in Denmark. The estimated number of new tags in 2021 will be: Norway - 10, Sweden - 0 but 40-50 still working from previous years, Finland - 10-15 and 40-50 still working from previous years, and Denmark - 10. Coloured neckbands will be included at the same catching attempts and the numbers in the different areas depend on how successful the fieldwork will be. The migration pattern for this species has changed quickly during the last decades; hence, it is important to study the movements continuously or alternatively regularly. If we combine the efforts across the countries and if we are able to cover the most important of the so far missing areas, we will have a good coverage and get a good understanding of the present situation. Also in MU2, some tagged birds from a German project are still active (https://www.blessgans.de/index.php?id=843), as are numerous neck-banded birds from Dutch and German projects. More comprehensive analyses are possible when the mentioned tagging projects have been completed.

Survival rates

For this status report, no assessment of survival rates has been carried out, but Powolny et al. (2018) have given a summary of existing data, based on capture-mark-recapture data in several European countries.

Age counts

MU specific age counts, as a measure of productivity, by involvement of volunteers, will be limited in 2021, but are intended in the future in both MUs. So far, only data have been collected in The Netherlands (since 1997) and parts of Germany (since 2011), which will continue in 2021 (Table 4.2).

Offtake (harvest + derogation)

The Greylag Goose is listed on Annex II/A of the EU Birds Directive, which means that Member States across the EU can allow its hunting. Furthermore, it is subject to derogation killing outside the hunting season or in countries that do not have hunting. Hence, the total harvest consists of legal and reported hunting as well as derogation killing.

Hunting

The Greylag Goose is hunted in Norway, Sweden, Finland, Denmark, Germany, Belgium, France and Spain, but not in The Netherlands.

In general, there is an absence of harmonisation among the different hunting bag collecting schemes in Europe. Moreover, there is a lack of information on how calculations are made with the local/regional data to produce the national hunting bag statistics. Thus, making inference about flyway totals is very difficult (Aubry et al. 2020). Furthermore, it is not always clear whether the national derogation data are additional to or included in the reported hunting data in countries where both hunting and derogation occurs. Besides, France has only recorded national harvest totals at approximately 12-year intervals so far but has introduced a new app-declaration system as of 2019 (although not mandatory). Thus, it is not possible to get a total and up to date estimate of the hunting bag.

Derogation

The Greylag Goose is subject to derogation killing in Norway, Sweden, Finland, Denmark, Germany, Belgium and The Netherlands, but not in France and Spain.

EU Member States are obliged to report all derogations to the European Commission in annual derogation reports (according to Article 9 in the Birds Directive; EU 2020), however, for a number of Member States the data are only available after several years. Furthermore, in some countries this reporting involved several administrative levels and with some uncertainty to the true number of killed birds.

Finally, if the Greylag Goose shall be managed at MU level, it is necessary to have offtake (harvest + derogation) per range state and being able to distinguish between "breeding" period (1 February-31 July) and "post-breeding" period (1 August-31 January) seasons.

An evaluation of potential bias in reported offtake in each range state

In 2020, it was concluded that there were most likely biases in the offtake data for Greylag Goose and that the most pressing need was to investigate and strengthen monitoring protocols for Greylag Goose offtake (Johnson and Koffijberg 2021). This led the EGMP Data Centre to undertake an analysis of the offtake data for the population during the winter 2020/2021, based on a questionnaire sent to all range countries.

The questions and short version of the replies are shown in appendices A-B. Replies were received from all countries except Germany and Spain.

Problems related to the reporting of offtake data were reported in one or more countries (harvest and derogation combined): Only voluntary reporting, indirect reporting via mail/paper, parallel systems, no annual reports, invalidated estimates, data cannot be distinguished between breeding and non-breeding periods (derogation), time lag between hunting season and availability of data and not suitable for adaptive harvest management.

This led to the conclusions that:

1. The reporting systems must be improved in most countries to achieve an adaptive harvest management routine.
2. It must be stated for IWG at the 2021 summer meeting that the offtake monitoring should be improved in most countries to be able to achieve adaptive harvest management and that it will take several years before this is realistic (see specific recommendations in section 4.2).

Crippling

The Greylag Goose AFMP also mentions the intention to describe the crippling rate in the population. At present there is only data collected in The Netherlands (Wageningen Environmental Research), which will be extended when catching effort will increase.

Population data

Winter counts

Winter counts of Greylag Geese are presented by three different values; EGMP national totals, IWC count totals and IWC imputed values.

EGMP national totals

EGMP national totals from January 2020 are available from all range states except Germany, one of the most important range states for the species (Table 4.3; Figure 4.2). The latest figures reported from Germany are 106,083 (in January 2012) and a mean of 160,000 for the midwinter period reported in the Article 12 report for the years 2003-2016. Furthermore, figures from Spain only include data from Andalusia (Marismas del Guadalquivir (Donana)), Aragon and Castilla y Leon, which however hold more than 90% of the Spanish wintering population (Rodríguez Alonso and Palacios Alberti 2018).

Based on these limitations, the present best estimate, based on EGMP national totals, is the sum of the totals from all range states except Germany (c. 640,000) plus the abovementioned mean of 160,000 Greylag geese in Germany, totalling c. 800,000 Greylag geese in January 2020.

Looking at individual countries, The Netherlands have reported by far the largest number of wintering Greylag Geese (452,268 individuals). The Dutch wintering population has increased since the start of the 1980s but seems to have stabilised in the last decade (Figure 4.2). The importance of The Netherlands for wintering Greylag Geese is furthermore illustrated by the findings that 92% of neck-banded Dutch breeding Greylag Geese are also found in The Netherlands during winter, and that 47% of Norwegian breeding birds and 26% of the Swedish breeding birds are also found here (Bacon et al. 2019), albeit these percentages also benefit from very high resighting rates in The Netherlands compared to other areas.

The highest numbers of wintering Greylag Geese were reached in Spain in 2000-2009, with an average of c. 100,000 individuals. The situation changed substantially after 2010 with a continuous decline to less than half in 2018-2020, which partly can be explained by less counting activities (see also comments for IWC imputed values below).

The Greylag Goose numbers in Norway are higher than this figure in January but based on available information (including individually marked geese) only Greylag Geese from the counties of Viken, Oslo, Vestfold og Telemark, Trøndelag and Nordland are included, while those registered in the south-western counties (Agder, Rogaland, Vestland & Møre og Romsdag) at this time belong to the Icelandic population (Arne Follestad and Ingunn Tombre pers. comm.).

Table 4.3. Numbers of Greylag Geese in January 2019-2020 based on EGMP national totals.

Country	**2019**	**2020**
Norway	NA	500
Sweden	55,710	49,545
Denmark	86,553	90,500 (provisional)
Germany	NA	NA
The Netherlands	443,771	452,268
Belgium	15,784	12,132
France	13,977	15,434
Spain	48,672	17,856 (Regions of Andalusia, Aragon and Castilla y Leon)

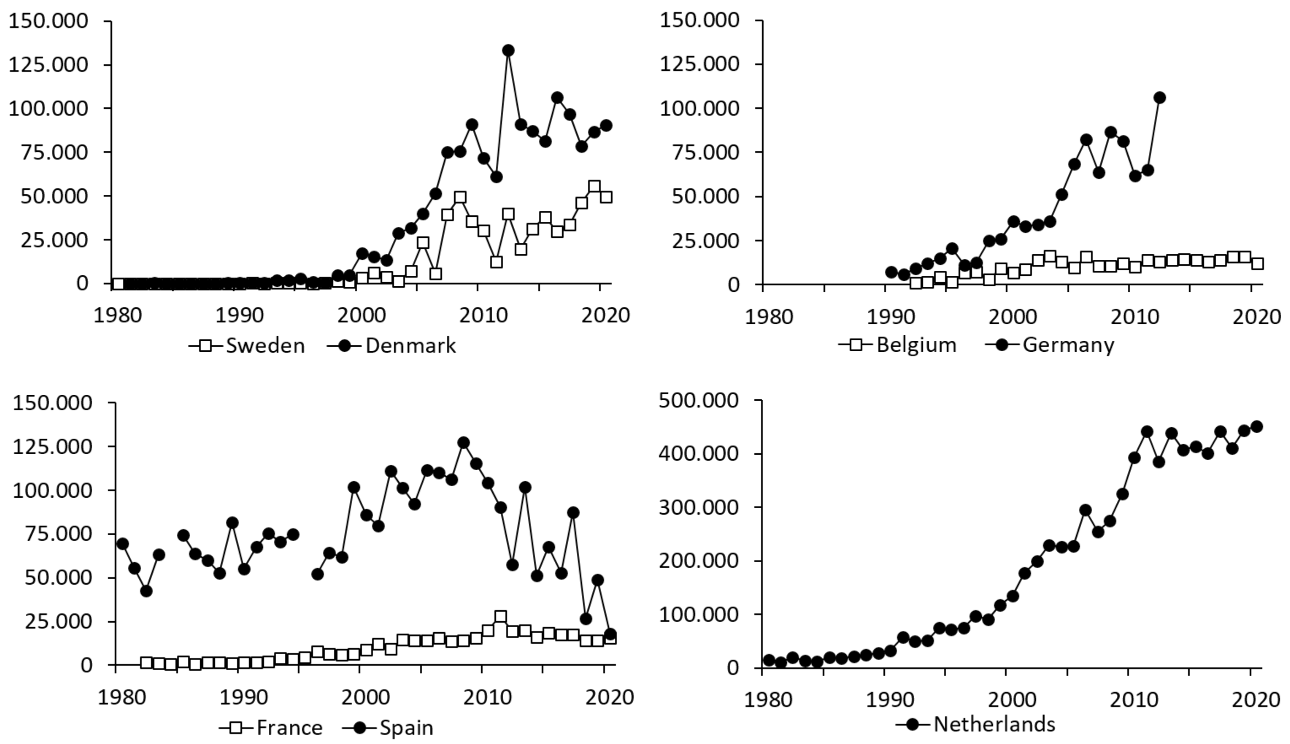

Figure 4.2. Number of Greylag Geese per range state in January 1980-2020 based on EGMP national totals. Note different scale for the y-axis for The Netherlands.

The IWC count totals

The IWC count totals were <u>626,918 individuals in January 2020</u> (Figure 4.3, Table 4.4). However, the IWC count totals cannot be interpreted as fully representing the population size and trends in a country, as coverage vary in different years or some data may not have been submitted to national coordinators in recent years (Figure 4.3).

IWC imputed values

The IWC imputed values produced a total of 999,681 individuals in January 2020 (Figure 4.3; Table 4.4). However, the IWC imputed population size estimates produced by TRIM should be viewed critically for two reasons. First, it uses only a subset of sites. Second, the estimation of missing counts using the year effect can lead to severe overestimations and large fluctuations in case of highly gregarious species such as Greylag Goose. This problem can be especially severe when the number of sites with actual counts is low compared to all sites included in the analysis (ratio observed/imputed; Figure 4.3), which might be the case in Germany and Spain.

In Germany, there is a high proportion of missing counts after 2016 because of data flow issues at national level and the ratio of observed/imputed values has substantially dropped from 69% to 36-42%.

In Spain, there are major data gaps at site level after 2010 because the government stopped supporting the national coordination of IWC at SEO/BirdLife Spain and also several autonomous regions have stopped the counts due to austerity measures. Furthermore, in the last three years (2018-2020) there have been no IWC counts reported to Wetlands International from Spain, and imputed values have been estimated for the country. However, the IWC imputed totals for Spain are about twice as much as those reported as the EGMP national totals (where data is available in recent years; Appendix C).

Thus, the high degree of imputing in range states with missing data results in larger fluctuations and a large uncertainty in the overall population size number using IWC imputed totals, which is particular the case after 2016 (Figure 4.3). As a consequence, the imputed IWC count totals may overestimate the actual population size by some 200,000 birds in recent years.

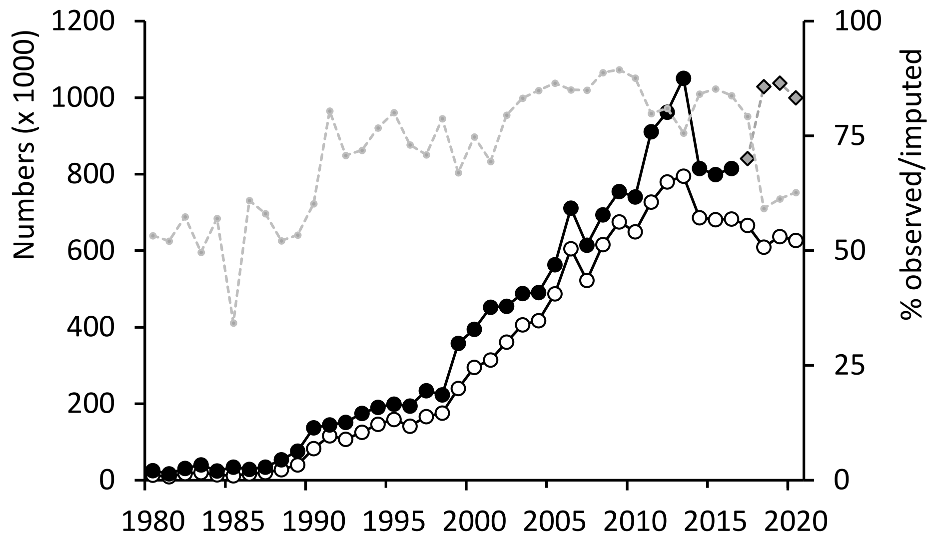

Figure 4.3. Trend in wintering numbers of Greylag Geese in January 1980-2020, based on IWC count totals (open symbols) and imputed IWC totals (filled symbols), however 2017-2020 with a high level of imputing is indicated with a dashed line and grey diamonds. The ratio between observed values and imputed values illustrates the part of the counts based on estimates in the given year (the higher the percentage the better). The % observed/imputed percentage is shown in grey. See also text.

Table 4.4. Number of Greylag Geese in 2019 and 2020 from three different sources; EGMP national totals, IWC counts totals and IWC imputed values (see text for explanations), as well as numbers presented in the ISSMP.

Source	2019	2020	ISSMP population estimate (Powolny et al. 2018)
EGMP national totals	824,467	798,235	900,000-1,200,000 (Wetlands international 2015)
IWC count totals	636,646	626,918	
IWC imputed totals	1,038,023	999,681	

Growth rates based on IWC imputed

At the IWG5 a management criterion of 15% reduction in population size over 10 years was adopted, which means an annual growth rate of 0.98. As it is unlikely to meet this criterion precisely, a growth rate of 0.96 < lambda < 1.00 was accepted (Nagy et al. 2020).

To assess the growth rate, a 10-year trend up to 2020 was calculated, using a combination of IWC imputed values and counts from additional (goose) schemes in The Netherlands and Denmark.

Based on this the 10-year trend[49] between 2011 and 2020 was estimated at 1.01 (95% confidence limits 1.005-1.011) and a long-term trend between 1980 and 2020 was estimated at 1.11 (95% confidence limits 1.104 - 1.115), indicating that the population's growth rate has decreased but remains positive.

Furthermore, to investigate the possible effects from Germany and Spain, with large uncertainties in the numbers, we made a second calculation of long-term and short-term trends where these range states where omitted. This resulted in similar results with an almost stable trend for the last 10 years (1.01) and very narrow confidence intervals (95% confidence limits 1.006-1.009) as well as a much higher observed/imputed ratio (91-95% since 1998). Thus, the large increases and drops and the large uncertainty seems to be caused by the very high level of imputing in Spain and Germany.

Summer counts

There is very little information on the number of Greylag Geese during summer from 2019-2020, as counts have either not been carried out (MU1) or have not yet been compiled (MU2) (Table 4.5). In the previous years, the largest numbers of Greylag Geese were found in The Netherlands with annual totals of 370,000-495,000 during 2012-2018 (Buij & Koffijberg 2019). The average annual number in North Rhine Westphalia is c. 28,000 during 2011-2020 (Koffijberg & Kowallik 2018, 2020) and the summer counts in Lower Saxony in Germany in 2018 revealed c. 40,500 Greylag geese (Nipkow 2019). In Flanders, Belgium, a mean of c. 4,460 were counted during 2010-2018, whereas no counts were carried out in 2019-2020 (Koen Devos, in mail).

Table 4.5. Number of Greylag Geese in July 2019-2020 in MU1 and MU2. *Geese were counted in Lower Saxony and the Netherlands, but data have not been collated nor published yet.

Range state / MU	2019	2020
MU1		
Norway	NA	NA
Sweden	NA	NA
Finland	NA	NA
Denmark	NA	NA
MU2		
Germany (Lower Saxony)	NA*	NA*

[49] Average annual growth rate in each of the 10 years

Germany (North Rhine Westphalia)	29,878	29,776
The Netherlands	NA*	NA*
Belgium (Flanders)	NA	NA
France	NA	NA
Spain	NA	NA

Common Bird Monitoring Breeding Bird Index

The Breeding bird index is presented from Norway, Sweden, Denmark, Finland and The Netherlands. Of the two Swedish breeding bird estimates, we used the Point Counts indices, since it provides data from a much longer period (since 1981) than the Fixed routes (since 1998) (Green et al. 2021). The indices from Finland are provided by Natural Resources Institute Finland (Luke), based on data from the Finnish Archipelago Bird Census Monitoring Scheme, coordinated by Metsähallitus. In Belgium, the species is presently considered too scarce and with an aggregated distribution only in a limited number of wetland areas for the production of a reliable breeding bird index, but the population is however assumed to have at least doubled in the past 20 years (Koen Devos, pers. comm.). For Germany, data have not been made available by the federal administration; however, a graph based on the common bird monitoring information is published and illustrates that Greylag Goose was significantly increasing in Germany since c. 1995 (Kamp et al. 2021).

Breeding Greylag Geese are dispersed over large areas with an aggregated dispersion and are notoriously difficult to count (problems to separate breeders from non-breeders, sometimes only successful pairs counted), resulting in a variation between years related to the sample sizes in the various countries. The indices will therefore fluctuate and should be treated with some caution. However, the trends based on the indices over a number of years are much more robust and are therefore used in this study.

A large increase in the long-term trends is seen in all countries. This increase has slowed down in the short-term trend and even seems to have stabilised in all Fennoscandia countries in the last few years (Figure 4.4, 4.5).

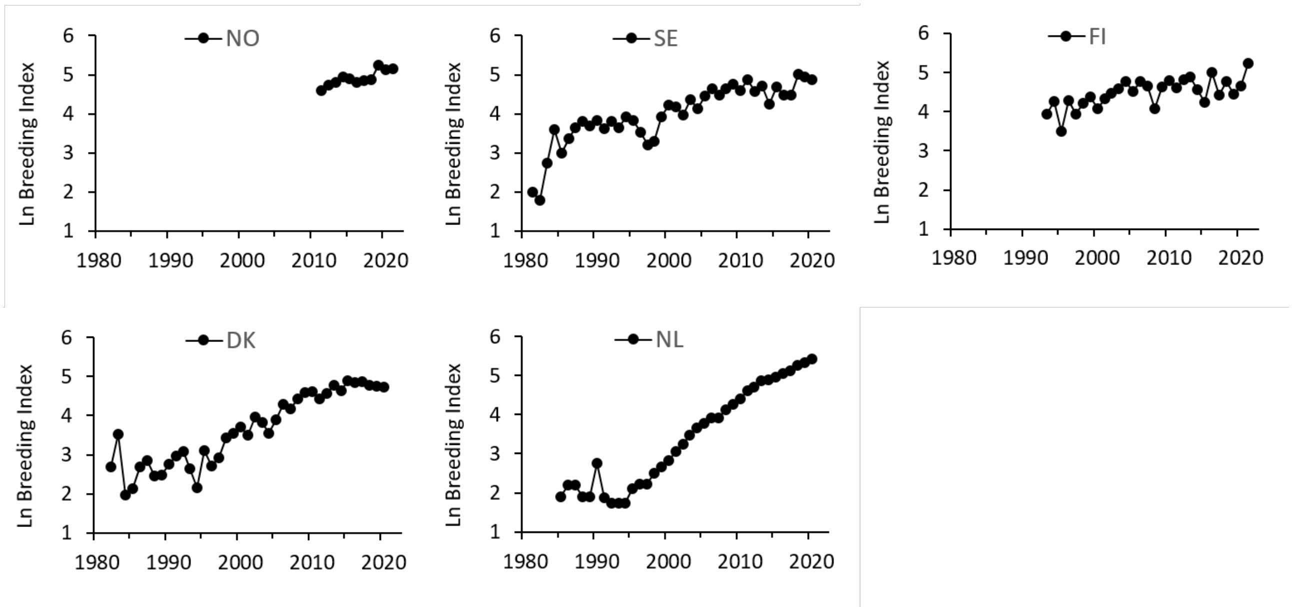

Figure 4.4. National ln-transformed breeding bird indices for the Greylag Goose provided by the different national Common Bird Monitoring programmes: Norway (NO) 2010-2020, Sweden (SE) 1981-2020, Finland (FI) 1992-2020, Denmark (DK) 1982-2020 and The Netherlands (NL) 1984-2019. The index is set to 100 in year 2010.

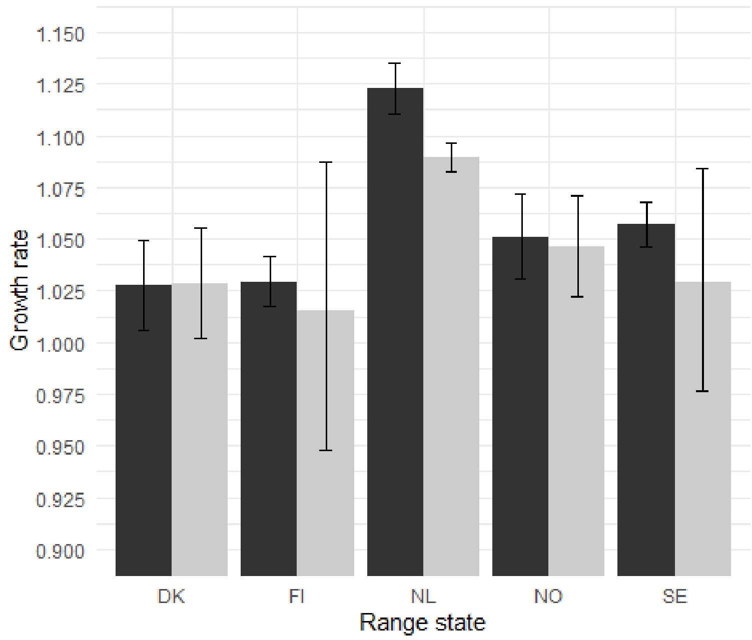

Figure 4.5. Median growth rates + 95% confidence interval for Greylag Goose derived from a log linear regression model and based on the Common Bird Monitoring, obtained from the national schemes: Breeding bird index showing a long-term trend (black) with a starting year as early as possible and a short-term trend (grey), from 2011-(2019)2020, respectively.

Age ratio

MU2

In The Netherlands, counts by Sovon have resulted in annual age ratio data during 1997-2018, showing a decline in juvenile percentages from >35% in the first few years stabilising at c. 15% during the last c. ten years (Hornman et al. 2020). These data refer to the Dutch breeding population only, as fieldwork was always carried out before migratory birds arrive in early autumn. Koffijberg & Kowallik (2018, 2020) found a stable juvenile percentage of c. 15.5% during 2011-2020 in North Rhine Westphalia, Germany and Nipkow (2019) reported a juvenile percentage of 22.7% in Lower Saxony in Germany in 2018.

MU1

No information yet

Offtake under hunting and derogations

Offtake (harvest + derogation)

At present offtake data is only reported as annual numbers. However, to be useful for population management, derogation data must be reported by "breeding” period (1 February-31 July) and "post-breeding" period (1 August-31 January) seasons, something which is not possible for Sweden, Finland and Germany.

Hunting

There is no total hunting bag estimate available from 2020, yet, and in 2019 estimates are only available from part of the range states and regions; Norway, Sweden, Finland, Denmark, Belgium and Andalusia, Spain, giving a total of c. 103,000 from these range states and regions. There is no legal hunting on Greylag Goose in The Netherlands.

The primary limitations in the hunting bag data arise from:

- No reporting from Germany since 2015, however at that time 53,957 was reported shot.

- National hunting bag surveys in France are only carried out approximately every 12 years, with the latest one being in 2013 with 10,614 reported shot. A new app declaration system has been put in place in 2019 but is not mandatory (hence no national total available).

- Hunting bag statistics from Spain are available from the regions expected to hold 90% of the Greylag Geese in Spain during winter: Region of Andalusia (incl. the site Marismas del Guadalquivir) (2,555 shot geese) and Region of Castilla y Leon: Zamora Province (incl. Villafáfila Lagoons Natural Reserve) (15 shot geese) and Palencia Province (incl. the lagoons of La Nava, Boada and Pedraza) (0 shot geese) (Mariano Rodriguez Alonso, pers. comm.).

- Not possible to distinguish between by "breeding" period and "post-breeding" period seasons in Finland, Sweden and Germany.

With these limitations, the total hunting bag in 2019 is as a minimum of 102,895 (Table 4.6).

Table 4.6. Numbers of Greylag Geese killed during hunting in 2019 and 2020. If data are not available, year of latest available data are provided in parenthesis.

Country	**2019**	**2020**	**Source**	**Distinguished between "breeding" and "post-breeding" period seasons**
Norway	15,300	NA	https://www.ssb.no/	Yes
Finland	4,700	NA	https://stat.luke.fi/	No
Belgium	2,081	NA	On request	Yes, mostly
Denmark	54,948[50]	NA	https://fauna.au.dk/	Yes
France	NA (2013)	NA	NA	
Germany	NA (2015[51])	NA	NA	No
The Netherlands[52]	-	-		
Spain	2,570[53]	NA	On request	
Sweden	23,296	NA	https://rapport.viltdata.se/	No

Derogation

Derogation information is available from all range states in 2019, except Germany. A provisional number from 10 of 12 Dutch provinces was provided by the annual reports of the respective Wildlife Councils: 152,293 shot or culled adult Greylag Geese, which makes up 96% of the total reported derogation numbers and is higher as the total hunting bag from countries with an open season. In France and Spain, no Greylag Geese were killed under derogation in 2019 (or any other year) and in the remaining countries, a total of 5,894 was reported. The primary limitations in the derogation data arise from:

- No recent available information from Germany.

[50] Preliminary numbers, but rarely change much
[51] The sum of information from the following Federal states: Lower Saxony, Mecklenburg-Vorpommern, North Rhine Westphalia, Schleswig-Holstein, Bavaria, Rhineland-Pfalz and Brandenburg
[52] There is no legal hunting on Greylag Goose in The Netherlands
[53] Preliminary data from the areas holding 90% of the geese in Spain.

- No final estimation from the Netherlands. However, according to the Article 9 reporting in the Birds Directive (in 2016), the number of birds killed is much higher in The Netherlands than in any other range state (including those with an open season), with most recent reported numbers of c. 163,000 individuals, c. 56,000 eggs and c. 29,000 nests (Table 4.7). In countries with both legal hunting and derogation, the level of the latter is much lower (the numbers are 1-16% of the hunting bag numbers in 2018).

- Up to date derogation data on the EU Eionet website is not available from Germany, Sweden and The Netherlands.

With these limitations the numbers killed under derogation in 2019 is as a minimum 158,262 (Table 4.7), which together with the number shot during hunting (102,895) gives a total of 261,157 Greylag Geese being killed in 2019.

Table 4.7. Numbers of Greylag Geese killed under derogation in 2019 and 2020.

Country	**2019**	**2020**	**Source**
Norway	2,500	1,200	National data
Finland	218	NA	EU Eionet central data repository
Belgium	128	106 (+ 353 eggs)	EU Eionet central data repository in 2019 and national data in 2020
Denmark	2,996 (+10 eggs + 12 nests)	NA	EU Eionet central data repository
France	0	0	National data
Germany	NA	NA	EU Eionet central data repository
The Netherlands	152,293[54]	NA	National data, regional Wildlife Councils
Spain	0	0	National data
Sweden	127	NA	National data

4.2. Harvest assessment

In 2020, it was concluded that the info-gap decision analysis does not provide a sound basis for adaptive, dynamic decision-making, which ultimately will be necessary to reliably manage Greylag Goose abundance in accordance with population targets in the two management units. Only up-to-date, coordinated, and reliable monitoring data on abundance and offtake from throughout the flyway will allow us to realize that goal.

In order to establish the preconditions for the dynamic, model-based management of the population in the long term, the following actions need to be implemented before the 2023/2024 hunting season:

1) Establish the necessary monitoring frameworks outlined in Chapter 6 of the AFMP and specified below;

2) Develop and present new population models by the EGM IWG in 2023.

Recommended Priorities Regarding Monitoring Offtake of Greylag Geese:

General recommendations:

[54] From 10 of 12 Dutch provinces

- Voluntary reporting of harvest by hunters is acceptable only if done using an appropriate sampling frame and with follow up for non-response. Asking all hunters to report their harvest if they are interested is unlikely to provide useful data.

- Time lags between collecting and reporting offtake estimates are tolerable as long as they are no longer than about 1-2 years. It is more important that the data/estimates are correct rather than provided quickly without validation.

- With respect to derogations, data for range states sometimes are held by regional authorities. Range states should endeavour to compile these estimates and quality-check them at a national level each year (as EU reporting is mandatory each year).

- To be useful for population management, derogation data must be reported by "breeding" period (1 February-31 July) and "post-breeding" period (1 August-31 January). The same applies for harvest data. However, in a country like The Netherlands, with sedentary populations, also large numbers of local birds may be shot, and monthly resolution would be preferred for assumptions which birds are affected.

Specific recommendations:

- *All* applicable range states should provide a complete historical record of harvest estimates to the Task Force as soon as possible (i.e. not just those in the ISSMP).

- The Netherlands is currently examining its protocols for assessing the number of birds killed under derogation and their findings would ideally be shared with the Task Force.

- After Denmark, Germany has the highest harvest based on figures in the ISSMP. Germany is strongly encouraged to provide a description of the methods of deriving its harvest estimates to the Task Force.

- Similarly, the Task Force would like to better understand the voluntary reporting protocol used for estimating harvests in Sweden.

Recommended Priorities (in order of importance) Regarding Monitoring population and MU size of Greylag Geese:

- *Size of the total Greylag Goose population by the use of mid-winter counts*

The use of the mid-winter count is complicated by the lack of data from key range states, like Germany and Spain in most recent years. To compensate for the lack of data imputed values have been used where data was missing. However, these values are accompanied by great uncertainty. Thus, complete and up-to-date data from all range states is needed to move to a dynamic, model-based management of the population.

- *Assigning numbers to management units by the use of summer counts*

Surveys of summering populations (July) are carried out for most of the range states in MU2: Belgium, The Netherlands, North Rhine Westphalia and Lower Saxony in Germany; however, this needs to be extended to other German federal states to provide an overview of the size of MU2, and include counts for recent years in NL and BE. Currently summer counts are not taking place in the range states of MU1, however the FGGI have initiated the work, but whether this is practically and economically doable must be considered first. Besides a relationship between breeding population estimates and summering population sizes need to be established because targets and breeding Favourable Reference Populations are expressed in pairs to be consistent with the EU Birds Directive Article 12 reporting. For the Netherlands, such analyses have been done, which may be used to extend with data from other countries.

- *Survival*

Annual adult survival rate, which may be derived from CMR programs coordinated among the breeding range states, as well as data collected in the past.

- *Productivity*

For a better understanding of the annual production of juveniles and the variation in this it would be necessary with a coordinated monitoring after the breeding season and before any harvest of the population, preferably also before the migration starts, so that variation in the production between range states could be studied as well. It is possible to age the full-grown Greylag Goose in summer and early autumn. Collection of such data could be combined with a count of summer populations.

- *MU transition probabilities*

The decision to manage the population divided into a migratory MU1 and a sedentary MU2 implies the need to understand the exchange rates between MUs throughout the year. The analysis based on neck-banding data by Bacon et al. (2019) will have to be updated because of the rapid changes in wintering strategies of the population and because Finland and the eastern parts of Germany were not included in the analysis. This will require a continuous and systematic Capture-Mark-Resighting (CMR) or tracking program in the breeding range states. In 2021 this will start in the Scandinavian countries, by starting new initiatives or extending existing projects (e.g. Sweden, Finland).

- *Crippling information*

The Greylag Goose AFMP also mentions the intention to describe the crippling rate in the population. At present there is only data collected in The Netherlands (Wageningen Environmental Research), which will be extended when catching effort will increase

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Appendix A - Overview of national reporting status in harvest monitoring of Greylag Goose

Each country provided more detailed answers to the requests; here is only presented short versions of the replies for comparison purposes. Replies were received from all countries except Germany and Spain. There is no hunting of the species in The Netherlands. No colour indicates that this reply is in line with what is considered as the optimal solution; Grey shading indicates that there is room for improvement.

COUNTRY	CONDITIONS	OPTIMAL	NO	SE	FI	DK	BE	FR
Conditions	**Required/solicited/volunteer?**	**Required**	Required	Voluntary	Sample survey, voluntary	Required	Required	Voluntary
Data	**Are data routinely compiled?**	**Yes**	Yes	Yes	Yes	Yes	Yes	Yes
Reporting methods	**How is the data flow?**	**Online/app**	Hunters report individually online	Hunters report individually online	Hunters report individually by paper/online	Hunters report online	Hunters report online or on paper	Hunters report via app
Protocols	**Are the existing protocols adequate and consistent?**	**Yes**	Yes	Yes	Yes	Yes	Yes	No - as long as this is only a voluntary reporting
Frequency (years)	**The number of years between sampling?**	**Annually**	Annually	Annually	Annually	Annually	Annually	Previously a survey was conducted very 12-15 years. Current system in place for the last 2 hunting seasons
Data availability	**How soon are the data available after the hunting season?**	**Available < 1 May**	1. May - preliminary data 4 months after season closure .	October	July - Harvest bag estimate by july.	3-6 months	1 April - by the 1st of April.	Immediately
Data source	**Name of responsible organisation**	**One organisation**	Statistics Norway & Norwegian Environment Agency	Swedish Hunters Association	Natural Resource Institute Finland	Danish Environment Protection Agency	Institute of Nature and Forest Research:	Fédération Nationale des Chasseurs
Data suitability for AHM	**Are data suitable for use in adaptive harvest management (AHM) by the EGMP?**	**Yes**	Yes - no timelag	No - time lag one year	No - time lag one year, large confidence intervals.	Yes - no timelag	Yes/No - Should be suitable, but technical problems the last years. Should be remediated.	No - Will only be so when declaration becomes mandatory and enforcement is ensured by appropriate cheking by national wardens

Appendix B - Overview of national reporting status in derogation monitoring of Greylag Goose

Each country provided more detailed answers to the requests; here is only presented short versions of the replies for comparison purposes. Replies were received from all countries except Germany. There is no derogation killing in France and Spain. No colour indicates that this reply is in line with what is considered as the optimal solution; Grey shading indicates that there is room for improvement.

COUNTRY	CONDITIONS	OPTIMAL	NO	SE	FI	DK	NL	BE
Conditions	**Required/solicited/volunteer?**	**Reqired**	Required	Required	Required	Required	Required	Required/Not required (see text) -Two types of derogation exist: 1) Not required, 2) Reqired
Data	**Are data routinely compiled?**	**Yes**	No complete overview for Norway.	Yes	Yes	Yes	Yes	Yes/No - Full reporting by non hunters – unknown for hunters.
Reporting methods	**How is the data flow?**	**Online/app**	Information stays in the municipalities via varying reporting ways	Hunter/Landowner(?) report online	Hunters report individually: Online/paper EU reporting	The permit holder (land owner) report online reporting	Hunters report online Provinces provide data to Ministry for EU reporting	Landowner/landuser report through email or on paper.
Protocols	**Are the existing protocols adequate and consistent?**	**Yes**	No; adding 10% to hunting bag may work.	Yes	Yes	Yes – alt least since 2010	No, these derogation data are not validated yet	Yes
Frequency (years)	**The number of years between sampling?**	**Annually**	Annually	Annually	Annually	Annually	Annually	Annually
Data availability	**How soon are the data available after the hunting season?**	**Available < 1 May**	Data can be provided by approaching the municipalities.	September	January/September (see text)	3-6 months	In July data is available of the previous calendar year	Autumn: After the breeding and moulting season.
Season	**Can you distinguish between "Breeding" and "Non-breeding" periods?**	**Yes**	Yes - Primarily in the breeding period.	No	No	Yes	Yes /(No) - a mix of breeding and non breeding birds in some regions some periods.	Yes /(No) - Mostly breeding but not exclusive.
Data source	**Name of responsible organisation**	**One organisation**	Municipalities where derogation occurs	SEPA	The Finnish Wildlife Agency reporting team: raportointi@riista.fi	Danish Environment Protection Agency	Two systems: FBE (Management Wildlife Agency per province) Dora	Agency of Nature and Forest. Via Floris Verhaeghe
Data suitability for AHM	**Are data suitable for use in adaptive harvest management (AHM) by the EGMP?**	**Yes**	Yes	Yes	Yes - Directly suitable with time lag on compilation	Yes	Yes, but the data process and quality is subject to improvement.	Yes

Appendix C - Annual EGMP national totals in January of Greylag Goose

Annual EGMP national totals in January of the NW/SW European population of Greylag Goose reported to the EGMP by the national coordinators of the respective census schemes.

Year	NO	SE	DK	DE	NL	BE	FR	ES[1]	Andalusia, ES[2]	PT
1980	NA	50	NA	NA	15,502	NA	NA	69,747	NA	NA
1981	NA	18	41	NA	10,794	NA	NA	55,636	NA	NA
1982	NA	0	30	NA	20,270	NA	1,575	42,560	NA	226
1983	NA	30	499	NA	13,902	NA	1,193	63,616	NA	NA
1984	NA	46	NA	NA	12,537	NA	700	NA	NA	NA
1985	NA	31	NA	NA	19,836	NA	2,207	74,311	NA	NA
1986	NA	10	NA	NA	17,526	NA	908	63,686	NA	468
1987	NA	14	5	NA	20,847	NA	1,730	60,220	NA	841
1988	NA	73	136	NA	25,063	NA	1,645	52,704	NA	700
1989	NA	123	334	NA	27,717	NA	1,358	81,942	NA	867
1990	NA	69	252	7,337	32,995	NA	1,749	55,155	NA	950
1991	NA	325	613	5,609	57,403	NA	1,722	67,856	NA	1,731
1992	NA	139	580	9,331	50,243	1,080	2,048	75,528	NA	986
1993	NA	470	1,754	11,983	51,777	1,656	3,826	70,682	NA	1,242
1994	NA	434	1,808	14,790	75,006	4,394	3,483	75,100	NA	1,704
1995	NA	657	2,956	20,797	72,481	1,534	4,648	NA	NA	1,228
1996	NA	96	978	11,103	74,647	6,778	7,951	52,360	NA	3,321
1997	NA	466	561	12,516	96,196	7,215	6,462	64,207	NA	2.652
1998	NA	1,457	4,533	24,896	90,528	2,978	5,850	61,874	NA	3,120
1999	NA	736	4,545	25,897	117,470	9,100	6,493	101,909	NA	4,602
2000	NA	3,455	17,386	36,105	135,198	6,996	8,716	86,074	NA	3,084
2001	NA	6,138	15,374	32,937	177,229	8,763	12,461	79,565	NA	123
2002	NA	3,567	13,295	34,101	199,316	14,173	9,532	110,895	NA	2,261
2003	NA	1,297	28,634	36,069	229,573	16,270	14,610	101,284	NA	3,490
2004	NA	6,989	31,934	51,137	226,195	12,981	13,987	92,426	30,488	1,828
2005	NA	23,380	40,096	68,704	227,407	9,472	14,313	111,757	60,115	2,332
2006	NA	5,847	51,669	82,390	295,642	15,746	15,730	110,078	43,718	2,840
2007	NA	39,300	75,092	63,846	254,039	10,649	13,879	106,517	50,849	2,734
2008	NA	49,592	75,671	86,800	274,701	10,578	14,356	127,306	81,726	2,391
2009	NA	35,631	91,057	81,451	324,915	11,950	15,558	115,650	72,156	2,673
2010	NA	30,260	71,974	61,597	392,559	10,130	20,173	104,549	50,376	2,322
2011	NA	12,510	61,353	65,040	442,545	13,893	28,284	90,412	50,548	3,163
2012	NA	40,033	133,453	106,083	384,680	12,941	19,612	57,694	22,204	2,576
2013	NA	19,849	91,185	NA	439,130	14,031	20,081	101,933	64,101	5,128
2014	NA	31,382	87,095	NA	407,579	14,530	15,898	51,158	30,560	2,959
2015	NA	37,907	81,268	NA	414,401	13,863	18,755	67,935	46,195	2,439
2016	NA	29,749	106,295	NA	400,816	13,100	17,756	52,868	36,449	1,597

1 The Spanish data from 2013-2019 are not verified. 2020 cover Donana, Aragon and Castilla y Leon, which however cover the majority (~90%) of the wintering population in Spain.

2 Donana (data from 2018-2019) is located in Andalusia (data from 2004-2017) and the majority of the birds is from this site.

2017	NA	33,717	96,887	NA	442,278	14,195	17,750	87,372	73,630	2.600
2018	NA	46,151	78,357	NA	411,192	15,935	14,170	26,510	22,190	NA
2019	NA	55,710	86,553	NA	443,771	15,784	13,977	48,672	13,155	NA
2020	500	49,545	90,500	NA	452,268	12,132	15,434	17,856	29,417	NA

5. Russia/Germany & Netherland population of Barnacle Goose *Branta leucopsis*

This chapter presents monitoring data (methods and results) collected in 2018/2019 and 2019/20, along with available long-term data on numbers, productivity and derogations, partly already presented in the first status report in 2020 (Koffijberg et al., 2020). These monitoring data provide input for further development of the IPM (see 6.2) and will serve the AFMP with a cumulative assessment of offtake, carried out under the derogation article of the EU Birds Directive.

5.1. Population status

This Russia/Germany & Netherlands population breeds in the Russian Arctic (assigned as Management Unit 1), in the Baltic (MU2) and in the North Sea areas (MU3) (Figure 5.1). Wintering areas are situated in Belgium (Flanders), The Netherlands, Germany, Denmark and Sweden. Its current range is the result of a major range expansion, starting in the early 1970s and leading to many new breeding sites in both the Arctic and temperate breeding regions (Feige et al., 2008). Wintering range has expanded as well.

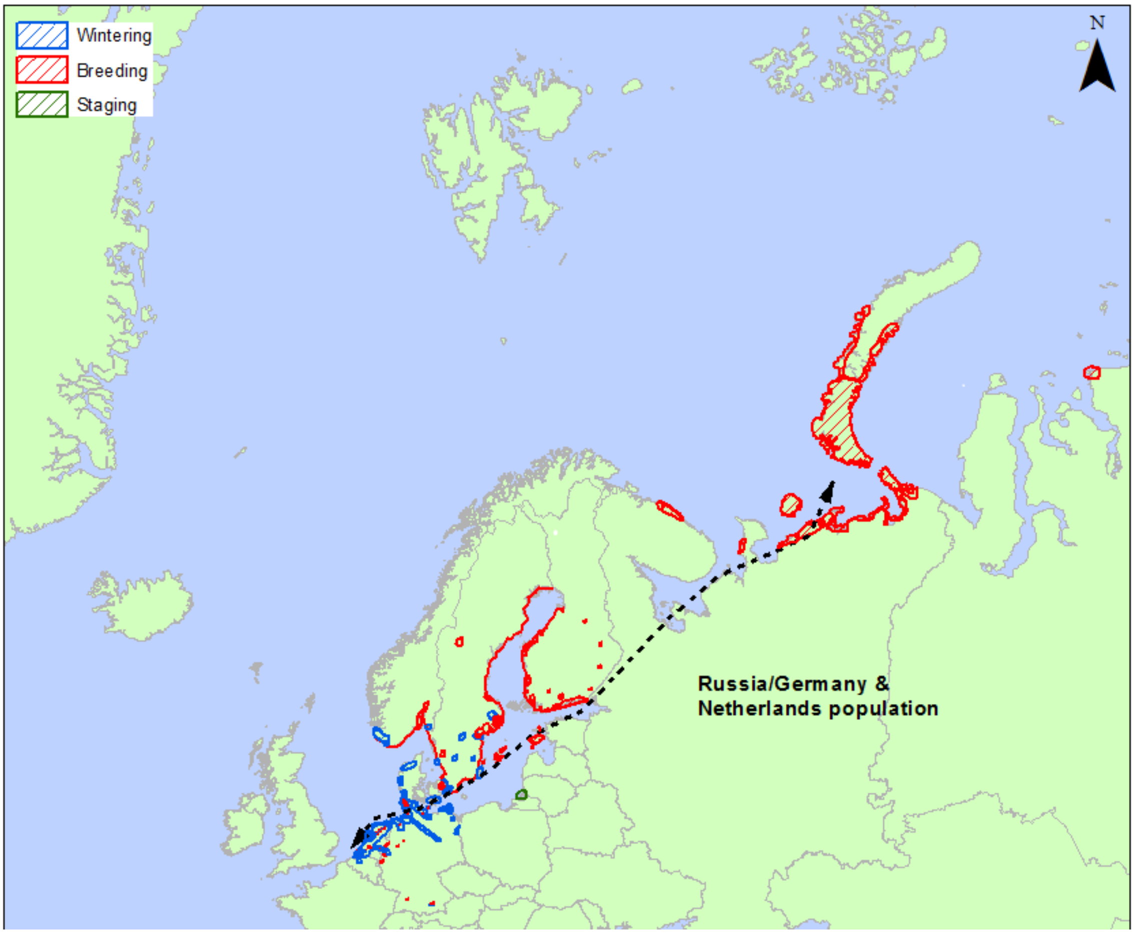


Figure 5.1. Annual distribution and migration routes for the Russia/Germany & Netherlands populations including breeding (red) and wintering and staging (blue and green respectively) areas.

Data collection and methods

Winter counts

Wintering numbers in January are derived from existing census networks in the individual countries and have been delivered by the national coordinators of these schemes. These national counts are part of the framework of the International Waterbird Count (IWC) and international goose counts, coordinated by Wetlands International. The January census, carried out in wetlands and in farmland areas (latter usually by specific schemes for geese), currently provides the best available knowledge on the size of the total flyway population as it has highest coverage in all countries and has been in place for decades to assess population status and monitor numbers internationally (Fox & Leafloor, 2018). The counts are usually carried out during daytime on feeding sites but precise methods, details about gap-filling and especially coverage may vary slightly between countries (see country-specific remarks below). The counts in January represent birds from MU1, MU2 and MU3 and cannot be separated between them in this time of the year. The five countries for which counts are used are likely to cover the entire wintering range of the flyway population, with only very small numbers present in other countries like Poland (see also Table 1 in Jensen et al., 2018). Possible extension of the wintering range is carefully monitored and will be incorporated if relevant numbers start to occur outside the five countries mentioned before. Furthermore, the rate of exchange with wintering populations on the British Isles is negligible in the context of assessing flyway population size, as exchange has been very little so far (Black et al., 2014).

Data in Belgium are collected in an extensive network of counting sites in Flanders, covering all relevant areas for wintering geese in the country during winter, including January (Devos & Kuijken 2012, 2020). Fieldwork is carried out by teams of volunteer observers which cover the entire area in a largely simultaneous survey. Counts for Barnacle Geese have always covered about the entire wintering population present, so reflect national totals. Data for 2019 and 2020 include estimates for small numbers in Wallonia (300-350 individuals), to account for the entire country.

Goose counts in The Netherlands are part of the monthly waterbird census scheme, carried out under the umbrella of a governmental ecological surveillance scheme (Netwerk Ecologische Monitoring, NEM). Given the high number of geese in the country, it involves a major effort to cover all relevant sites, which depends on a network of about 1900 dedicated volunteer counters and some professional staff from various agencies (Hornman et al., 2021). Gaps in the network of counting sites are interpolated ('imputed'), making use of standardised routines developed in collaboration with the national statistics agency (CBS) and based on regional phenology and trend patterns (see Hornman et al., 2021 for details). For this report, estimated totals have been used (so counted + imputed). Given the high coverage (>95%) and gap-filling routines, figures for Barnacle Geese in The Netherlands may be regarded as national totals.

For Germany, data from 1980-2016 have been provided on behalf of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Federal Agency for Nature Conservation (BfN). These data were derived from a network of counting sites in the federal states, covered mainly by volunteer counters (Sudfeldt et al., 2012, Wahl et al., 2017). In the context of Barnacle Goose, it is mainly the federal states of North Rhine-Westphalia, Lower Saxony, Schleswig-Holstein and Mecklenburg-Vorpommern (4 out of 16 federal states) which support relevant numbers. For the period 1981-2000, data used in this report have been taken from January totals used for an earlier population review (see Fox et al., 2010) and are assumed to have high coverage as the winter distribution by that time was still mainly limited to the well-covered coastal areas (which are also part of the TMAP international Wadden Sea monitoring scheme). From 2000-2016 data were derived from a national overview prepared for the latest national EU Birds Directive Art. 12 report. For this purpose, gaps in coverage have been assessed and interpolated, making general assumptions on coverage (and subsequent extrapolation) in each federal state and thus may be regarded to be a good proxy of national totals. For January 2017-2020, however, no data have been made available or published (but counts have been carried out in the field). Since usually about 25% of the flyway population has been recorded in Germany in January, this is a major gap. An interpolation routine with logistic regression (see Baveco et al., 2020) was used to achieve annual estimates, but it should be stressed that this comes with increasing uncertainties about the present numbers and does not replace true counts. This will especially be the case, when numbers in Germany would develop differently as expected from counts in previous years (for instance because of the tendency for mild winter weather).

In Denmark, Barnacle Goose monitoring is part of the National Monitoring and Assessment Programme for the Aquatic and Terrestrial Environment (NOVANA). Numbers presented here represent specific goose counts (both feeding sites and roost counts) carried out by a network of professional and volunteer counters. Results from these counts are supplemented with non-systematic observations available through www.dofbasen.dk for areas not covered in the goose census scheme and with the aim to derive national totals for Barnacle Goose as well as other goose species (Holm et al., 2018). The scheme involves annual counts in January. Data only refer to counted numbers and coverage is regarded high, so figures represent national totals.

Sweden has a long tradition of monthly goose counts, nowadays covering September, October, November and January. Results are reported frequently (e.g. Nilsson & Kampe-Persson, 2020, see also http://www.zoo.ekol.lu.se/waterfowl/index_e.htm). They cover most of the relevant goose staging and wintering sites, mainly located in the southern part of Sweden. Fieldwork is mainly carried out by experienced volunteer counters and in many areas focus on feeding sites during daytime. Locally, also numbers from roost counts are included, often as a result of coordinated effort to cover all flight directions to or from the roost. Records submitted to www.artportalen.se are searched systematically to keep track on newly established staging and wintering areas, leading to some new sites being included in the network of counting sites. Hence, coverage for Barnacle Goose is assumed to be high. Data presented refer to counted numbers (no gap-filling or estimates are made).

Summer counts

At present, summer counts are mostly carried out in June-August in parts of MU2 and MU3 and aim to assess abundance, distribution and productivity. This type of census does not only cover breeding birds and their offspring, but also failed breeders and non-breeders, present during summertime (i.e. all individuals within the respective management unit). So, compared to regular breeding bird surveys in spring (delivering number of breeding pairs), they therefore give a more comprehensive account on abundance (expressed in individuals) during the breeding and post-breeding periods. Analyses in The Netherlands have shown that post-breeding numbers of individuals may exceed the number of breeding pairs by a factor 3.24 (±0.28), depending on local conditions (Schekkerman 2012).

In the framework of the ISSMP, abundance of Barnacle Goose in the breeding areas in summer (but also information of their productivity) is of particular interest, as they provide input for estimates of the respective populations within each management unit. Longest data series, either provided by national coordinators or from published sources, are available for The Netherlands, Finland, Oslofjord/Norway and North Rhine-Westphalia in Germany, see Table 5.1 for details. Summer counts are carried out during daytime and focus on wetlands and waterbodies, which in summer host nearly all birds during daytime. Hence, coverage is regarded high (usually >90%). Data is collected through volunteer networks but locally also with substantial professional input (more so than during winter). Counts in MU3 in Belgium, The Netherlands and the western part of Germany are all carried out around Mid-July (i.e. represent a more or less simultaneous survey), whereas in MU2 this is in June-July (Oslofjord) and late August or early September (Finland). Even if the existing counts in the Baltic are spread over time, we expect no exchange of individuals and double counts as the rate of exchange will be negligible in this time of the year and there still has been no arrival from Arctic breeders. In MU3, summer counts have not been carried out in the Schleswig-Holstein part of Germany (albeit existing counting schemes would already cover a large part of the population) whereas in the Baltic counts are missing for Denmark (only covered once every 6 years) and Sweden. Besides, there are small breeding populations in Estonia and in the Russian part of the Finnish Gulf (see Jensen et al., 2018), which are also not covered by summer counts as well. Thus, there is quite a lot of information on abundance (and productivity) in MU3, but far less so in MU2. Because of missing data in summer, it is also not possible to estimate the size of MU1 (which will be by far the largest one).

Table 5.1. Organisation and details of present summer counts of Barnacle Geese.

MU/Country	**Counts from to**	**2019-2020 available**	**Organisation**	**References**
MU2				
Finland	2008-2020	Yes	BirdLife Finland	
Oslofjord / Norway	2007-2020	Yes	Agency for Urban Environment City of Oslo, NINA	Tombre et al., 2020, Isaksen, 2021
Denmark	2018 (counts only 1x/6 years)	No	Aarhus University / NOVANA scheme	
MU3				
Germany / Lower Saxony	2018-2020	No	Staatliche Vogelschutzwarte	Nipkow, 2018
Germany / North Rhine-Westphalia	2011-2020	Yes	Nordrhein-Westfälische Ornithologen Gesellschaft	Koffijberg & Kowallik, 2018, 2020
The Netherlands	2005, 2009, 2012-2020	Yes	Regional Wildlife Councils & Sovon Vogelonderzoek Nederland	Van der Jeugd et al., 2006; Schekkerman, 2012, Buij & Koffijberg, 2019
Belgium (Flanders)	2015-2018	only estimate	INBO	Adriaens et al., 2010

Productivity

Since goose families tend to stay together during autumn migration and winter, and adult and juvenile Barnacle Geese can be identified by their plumage characteristics at least in autumn, assessments of productivity are usually carried out in the staging and wintering areas, after arrival in autumn. Especially in The Netherlands this has a long tradition, starting for Barnacle Goose in 1974/75 (see Hornman et al., 2021). As the majority of data has always been collected in the Wadden Sea region (including border areas in Germany) and the province of Friesland, the age ratio data in autumn will predominantly represent birds breeding in Russia (MU1) or the Baltic (MU2). Counts are usually done from October to late December. Wintering flocks are scanned by a small team of dedicated and well-trained volunteers and both the individual number of adult and first-year birds and size of individual broods is recorded (the latter in a sub-sample of the flocks). Recently, effort to collect age ratio data has increased in northern Germany (Elbe region and Schleswig-Holstein), coordinated by Sovon from The Netherlands as well. In the 1970s and 1980s, sampled numbers usually involved several 1000s of individuals but nowadays data represent scans involving about 50.000 individuals or more (autumn 2018 and 2019 65.510 and 47.869 respectively).

More recently, age ratios also have been determined in summer, but not on the extensive scale as done in autumn. In MU2, data age ratio data have been collected in 2006-2020 by the Finnish Environment Institute (SYKE) in the Helsinki region (i.e. Helsinki and eastern part of Espoo coastal areas), representing about 30% of the Finnish breeding population of 7,000 pairs (situation 2018, M. Mikkola-Roos, Finnish Environment Institute/SYKE). Counts are done late July or in the beginning of August. Another longer data series originates from North Rhine-Westphalia in Germany, where productivity data have been collected and published by the Nordrhein-Westfälische Ornithologen Gesellschaft during the summer count Mid-July, representing the majority of breeding pairs in this part of Germany (Koffijberg & Kowallik, 2019, 2020). In the Netherlands, counts have been coordinated by Sovon Vogelonderzoek Nederland and Vogeltrekstation since 2018 in some core breeding areas (mainly Delta area SW-Netherlands and river district), representing at least 40% of the national breeding population. Both for winter and summer, figures presented here refer to the sum of all flock scans from all counts carried out.

Derogation data

Barnacle Goose is listed in Annex I of the Birds Directive. Therefore, any lethal control in the EU must be exercised under a derogation fulfilling the requirements of Article 9 of the Directive. Data presented in this report have been derived from the data collected for the ISSMP in 2018 (Table 7 in Jensen et al., 2018) and updated with data either included in the EU Eionet central data repository (https://ec.europa.eu/environment/nature/knowledge/rep_birds/index_en.htm) (available until 2019, but not all countries with open access, last checked 20 April 2021) or retrieved at national level (The Netherlands, data from Regional Wildlife Councils (RWC), coordinated by RWC of Noord-Holland). For Germany, data were retrieved from the annual biodiversity, hunting and species conservation report, published by the administration of Schleswig-Holstein (https://www.schleswig-holstein.de/DE/Fachinhalte/A/artenschutz/as_07_Jahresbericht.html). In earlier years, derogations were only carried out in this part of Germany, so it can be assumed that they represent the total number for Germany as a whole (in Lower Saxony, no derogations took place during the period which is covered by this report, H. Düttmann). It should be noted that in case data have been taken from national sources, numbers should be regarded provisional, as final submission to the EU is still pending. Information on harvest, e.g. from Russia during spring hunting is not available, so data presented here only refer to an overview of derogations. Moreover, we have only included numbers of birds taken out of the population (i.e. shot, or caught and killed during molt, in The Netherlands, FBE Noord-Holland, 2020). In some countries also clutches/nests are controlled (e.g. Oslofjord/Norway, The Netherlands), but as it is not possible to quantify its long-term impact on population size very well (which is presumably small anyway, see e.g. Van der Jeugd et al., 2006) we have not included them in this report.

Crippling

In several goose species, X-ray images have been used to get insight in infliction rates with embedded shotgun pellets (e.g. Noer et al., 2007). The incidence of embedded shotgun pellets is an expression of hunting exposure and also plays an important role in the ISSMP/AFMP process from an ethical viewpoint as they are sub-lethal injuries potentially affecting fitness of the geese. In the ISSMP for Barnacle Goose, two main objectives are associated with crippling rates (4.5 Maintain low crippling rates and 4.6 Improve derogation shooting techniques to further reduce crippling). Holm & Madsen (2012) reported 13% of adult geese and 6% of juveniles inflicted with pellets in cannon-netting catches in Denmark. In the framework of the ISSMP, Wageningen Environmental Research in The Netherlands (Ralph Buij, Sander Moonen & Gerard Müskens, unpublished data) has started an extensive survey of crippling rates among geese caught for ringing, mainly in The Netherlands, but also in other countries. In addition, assessments have been made in Denmark in 2009-2011 (Holm & Madsen 2012) and in 2019 by Aarhus University (unpublished, provided by K. Clausen). Crippling rate is defined here as the number of individuals with at least one embedded shotgun pellet, assessed by processing of X-ray images. All measurements were carried out by using a mobile X-ray device. Results presented in this report aim to give a first baseline overview of the results. An in-depth analysis will be published separately.

Population data

Winter counts

Census data from January 2019 and 2020 point at an overall flyway population of about 1.4 million individuals (Table 5.2, Figure 5.2). It should be noted however, that there is much uncertainty about numbers staying in Germany in January 2017-2020, which have been calculated and are not based on true counts. Data from Belgium, The Netherlands, Denmark and Sweden suggest a rather stable wintering population in 2019-2020 but compared with the same countries in 2017-2018 suggest an 8% increase between these two time periods. The distribution over the countries in 2019-2020 remained about similar as in 2017-2018, when assuming a similar trend in Germany. This means that about 51% of the wintering birds stay in The Netherlands, 25% in Germany, 18% in Denmark, 6% in Sweden and 1% in Belgium. On a longer term, the share of wintering birds in The Netherlands has gone down from a level of more than 90% in the 1980s whilst Danish and Swedish numbers have become important especially after 2010, mainly as a result of the tendency for mild winters and subsequent extension of the wintering range (e.g. Nilsson & Kampe-Persson 2020). Since 1981, January numbers for all five countries together have increased with on average 9% annually, but recently tends to level off (Figure 5.3).

Table 5.2. Numbers of Barnacle Geese in January 2019-2020.

Country	**2019**	**2020**
Belgium	11,898	13,180
The Netherlands	698,777	739,023
Germany	N/A	N/A
Denmark	249,026	259,000
Sweden	96,660	68,521
Total flyway (winter) without Germany	1,056,361	1,079,724
Total including imputed numbers for Germany	1,398,777	1,432,413

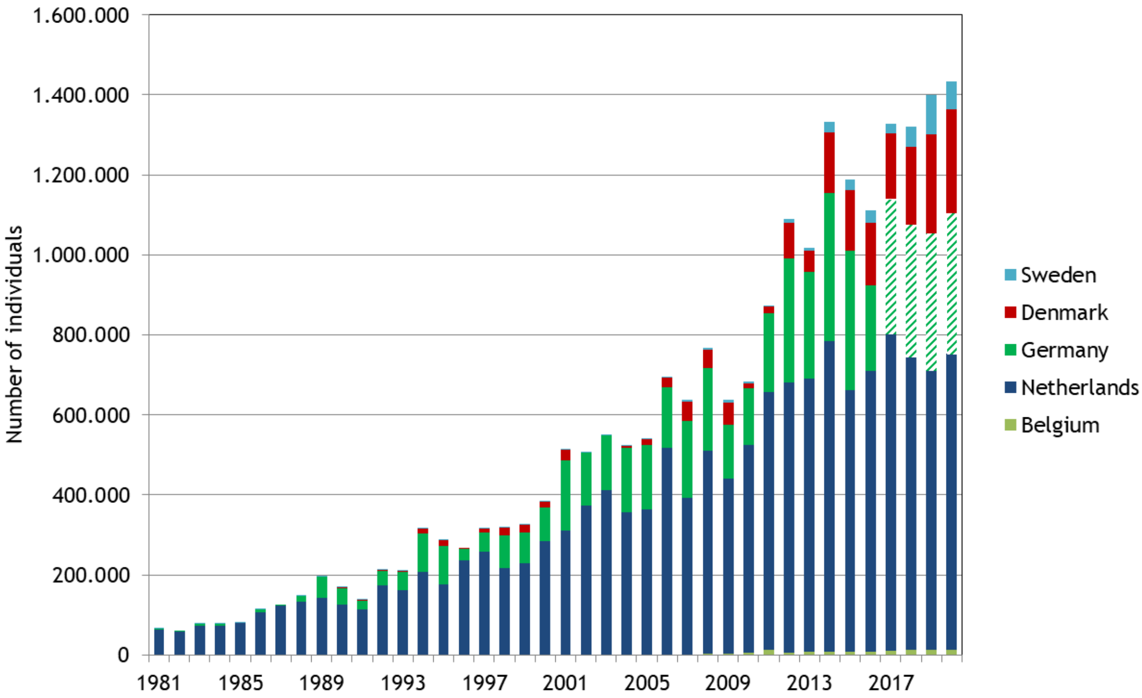


Figure 5.2. Numbers of Barnacle Geese per country in January 1981-2020. Note that for Germany 2017-2020 only imputed numbers have been used, as census data were not available.

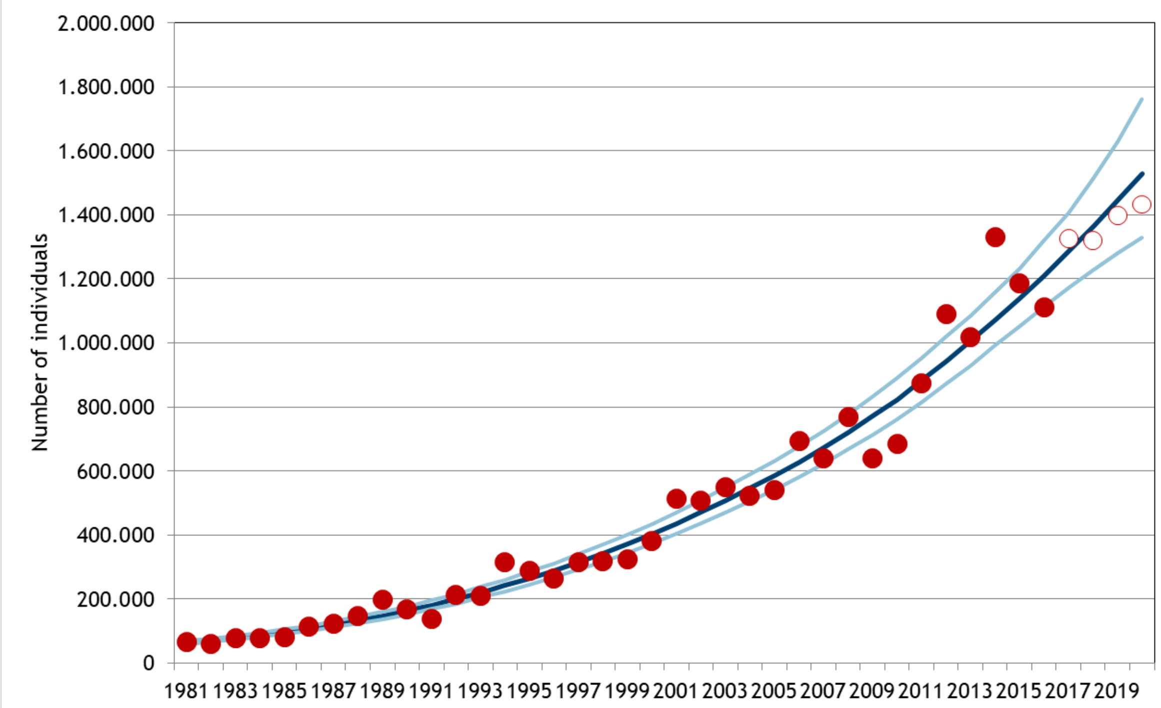


Figure 5.3. Trend in wintering numbers of Barnacle Geese (same data as Figure 5.2). Red dots represent annual totals in January; the bold line the calculated trend (calculated with TrendSpotter, see Hornman et al., 2021) along with lower and upper 95% cl for the trend (thin lines). Annual growth rate since 1981 is on average 9% per year. Note that data in 2017-2020 include only imputed numbers for Germany.

Summer counts

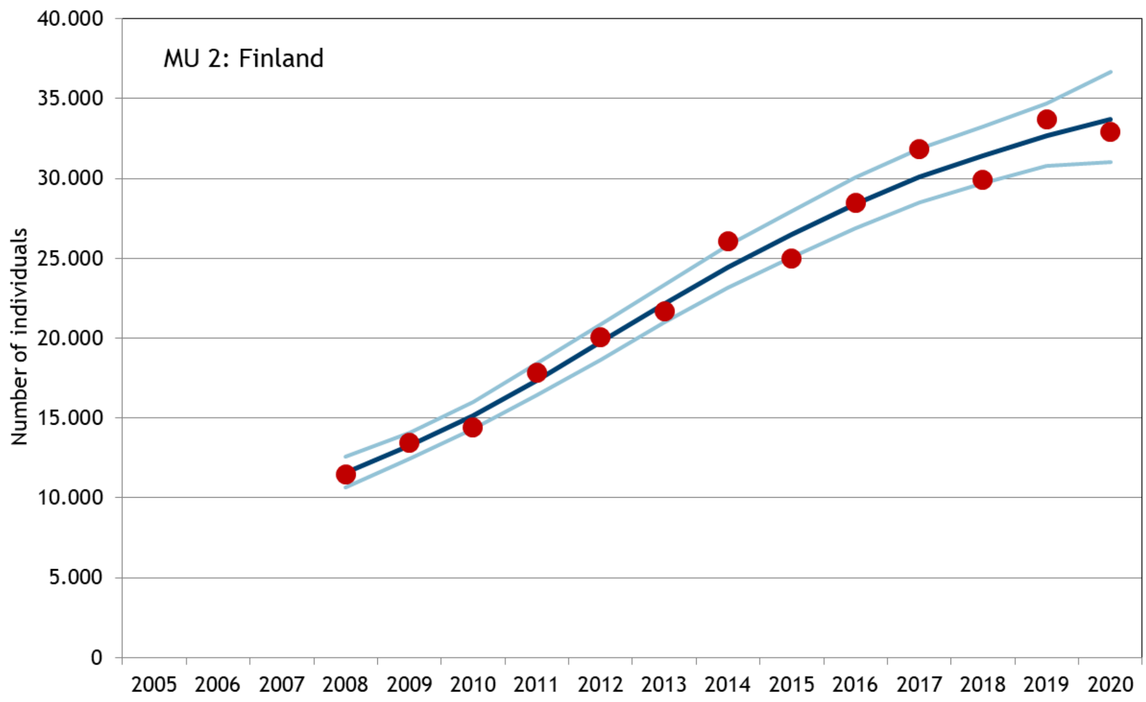
Summer count data is more scattered compared to January counts in winter. In the Baltic (MU2) there is only a good overview of the situation in Finland, where numbers in 2019-2020 were about similar (Table 5.3), but a 10% annual increase has been observed since the start of the counts in 2008 (Figure 5.4). These may eventually also involve smaller numbers occurring in the Russian part of the Finnish Gulf (Kouzov et al., 2019). The population in the Oslofjord region in Norway is very small compared to Finnish numbers but showed some increase between 2019 and 2020. Viewed on a longer term, for only the Oslo/Akershus part of the area (representing the core area, in 2020 62% of all birds counted in entire Oslofjord area), numbers seem to be stable from 2011 onwards (Isaksen, 2021), albeit this may just reflect the core area where some saturation may have occurred and/or the effect of control measures in this area have had an impact. As data is missing for especially Sweden and Denmark (Estonian and Russian population is much smaller), it is not possible to estimate the total Baltic population yet. In Denmark, 15,942 Barnacle Geese were counted only around the island of Saltholm in July 2018 (a moulting site, likely receiving birds from the Swedish population as well; see Koffijberg et al., 2020) whereas the latest estimate for the Swedish population is approximately 21,000 individuals in 2005 (van der Jeugd et al., 2009).

In MU3, numbers in The Netherlands are likely to dominate the overall population size (see also Jensen et al., 2018). Numbers recorded in 2019 and 2020 were fairly similar, with 53,219 and 54,000 respectively (2020 rounded for small gaps in coverage). Since 2005, the Dutch summer population has increased with 6% annually, but this has changed into a slight decline from 2016 onwards (Figure 5.4), likely as a result of population control measures (see section on derogations below). Data from Belgium and North Rhine-Westphalia in Germany represent relatively small numbers, but with a tendency to increase in North Rhine-Westphalia since the start of the data series in 2011, whereas in Belgium numbers have gone down from a level of about 1,000 birds in 2015, due to population control measures (K. Devos). Main gaps in this MU are represented by Lower Saxony and Schleswig-Holstein in Germany. In Lower Saxony, summer counts have been carried out since 2018 (Nipkow, 2018), but data from 2019-2020 have not been published yet. In

Schleswig-Holstein, there is also no overview of numbers in summer, even if some areas (e.g. Wadden Sea area) are covered by counts on a regular basis. In the last status report, a very provisional estimate of 65,000-70,000 individuals was given for MU3, derived from a counted total of 63,375 individuals, including published data for Lower Saxony (see Koffijberg et al., 2020). As numbers in The Netherlands declined by about 12% after 2017-2018, we may assume that also overall population size in MU3 has gone down recently. But this should preferably be confirmed by information on total numbers present in Lower Saxony/Schleswig-Holstein in Germany.

Table 5.3. Numbers of Barnacle Geese in July 2019-2020 in MU2 and MU3. Numbers for Belgium represent an estimate. Birds in Russia may be (partly) included by counts in Finland.

Country / MU	**2019**	**2020**
MU 2:		
Finland	33,707	32,900
Estonia	N/A	N/A
Russia	N/A	N/A
Sweden	N/A	N/A
Norway – Oslofjord	1,777	1,896
Denmark	N/A	N/A
MU 3:		
Belgium	(500)	(500)
The Netherlands	53,219	54,000
Germany - North Rhine-Westphalia	714	705
Germany - Lower Saxony	N/A	N/A
Germany - Schleswig-Holstein	N/A	N/A



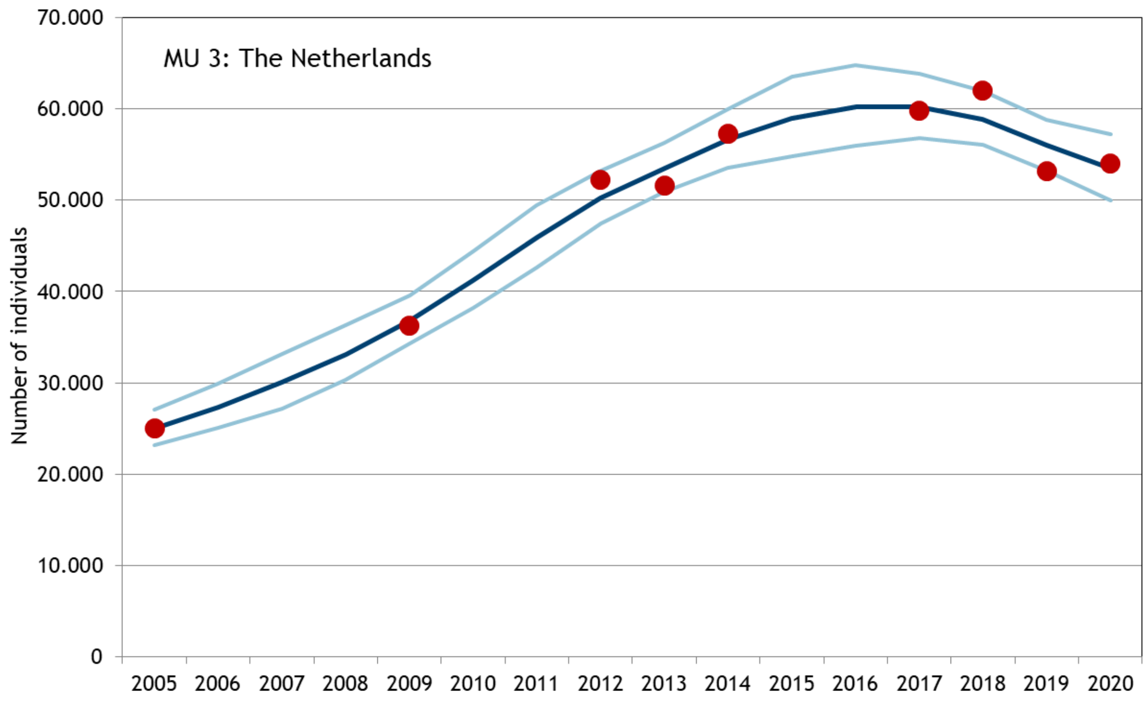


Figure 5.4. Trend in numbers of Barnacle Geese in July in Finland (MU2) and in The Netherlands (MU3). Red dots represent annual totals in July; the bold line the calculated trend (calculated with TrendSpotter, see Hornman et al., 2021) along with lower and upper 95% cl for the trend (thin lines). Note different scale on y-axis. Annual growth rate since 2005 is 10% and 6% respectively, but in the Netherlands, this has turned into a decline recently (see text).

Productivity

Long-term data on productivity in MU1 and MU2, collected mainly in The Netherlands and expressed as the percentage of first-year birds, show a decline from about 15% in the 1970s and early 1980s to a level around 10% in recent years (Figure 5.5). This decline is also associated with a considerably smaller amplitude between "good" and "poor" breeding years, showing very pronounced differences in the 1970s and 1980s but little in recent years. Data collected in autumn 2018 and 2019 fit perfectly well in the overall pattern, with 10.7% and 7.3% first-year birds respectively. Productivity in 2019 was among the lowest since the start of data collection in 1974/75. Long-term declines in productivity have also been observed in other arctic-breeding goose species like Tundra Bean Goose, Greater White-fronted Goose and Dark-bellied Brent Goose (Hornman et al., 2021).

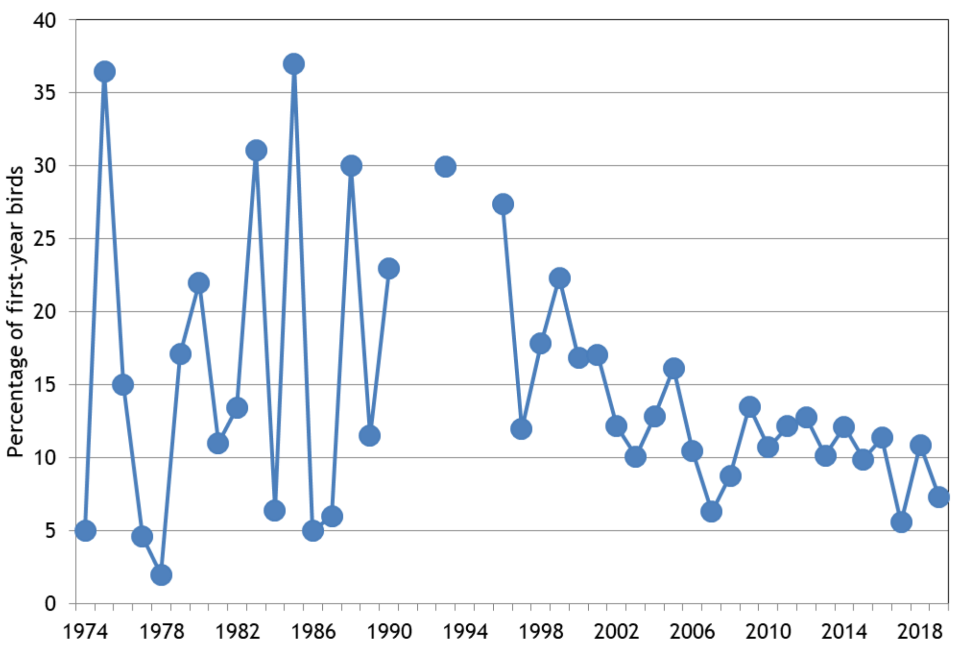


Figure 5.5. Percentage of first-year birds in Barnacle Geese wintering in The Netherlands and Northern Germany since 1974/75 (year on x-axis denotes breeding year). Data represent birds from MU1 and MU2.

Data collected in MU2 (Finland, Norway) and MU3 (The Netherlands and North Rhine-Westphalia /Germany) also give some insight in productivity in temperate breeding areas, derived from counts in July/August (Figure 5.6). Among flocks in The Netherlands and in North Rhine-Westphalia in Germany, about 20% of first-year birds were observed in 2019-2020, indicating higher productivity as recorded for wintering flocks of migratory birds. In Oslofjord area and around Helsinki there was more annual variation, between 10% and 17% on average for 2019 and 2020 respectively. In this context it should also be noted that in the inner part of Oslofjord clutch control measures have been carried out (in 2019, but not in 2020), which may explain part of the difference between the two years, on a longer term, productivity in the Helsinki area seems to have gone down whereas in the small breeding population in North Rhine-Westphalia/Germany an increase is apparent. Note, however, that data from the Helsinki area are not considered fully representative for the entire Finnish population (as the Helsinki area was among the first in Finland to be colonized by Barnacle Geese), nor for the Baltic population as a whole (data for Denmark/Sweden missing). When more data become available in the next years, a more comprehensive evaluation will become possible.

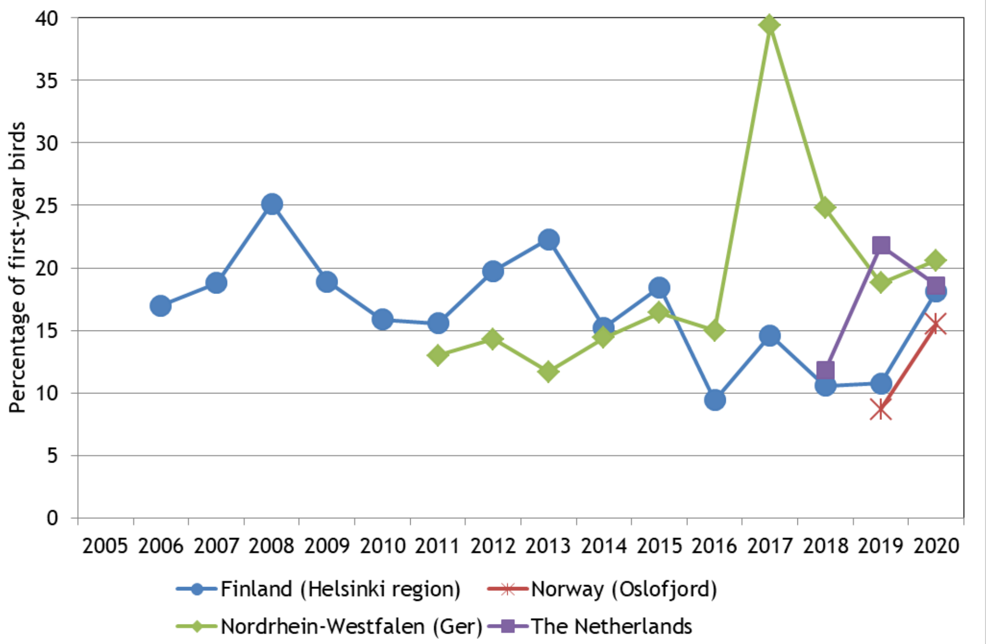


Figure 5.6. Percentage of first-year birds in Barnacle Geese in temperate breeding populations in the Helsinki area in Finland, in inner part of Oslofjord area in Norway (both MU2), in North Rhine-Westphalia in Germany and in The Netherlands (both MU3).

Offtake under hunting and derogations

Derogations

We only report on derogations in EU countries here, as harvest in Russia is unknown (see 'Methods' section) and harvest in Norway is close to zero. In 2018, the last year for which data are available for all countries, 59,753 Barnacle Geese were killed in the EU (Table 5.4, Figure 5.7), mostly in The Netherlands (59%) and in Denmark (27%). Since then, numbers will have increased but are not yet available for all countries. Since 2018, numbers of Barnacle Geese killed under derogation in The Netherlands have increased to 48,926 in 2020, suggesting that the total offtake in the EU is currently at a level well above 60,000 individuals per year. Both The Netherlands and Denmark have reported pronounced increases in numbers of killed Barnacle Geese since 2008 and 2009 respectively, but since 2017 the reported figures have remained rather stable in Denmark (on average 16,193/year) whereas in The Netherlands derogation effort has increased annually (Figure 5.7). Reports for Germany, Belgium and Sweden usually involve (far) less than 2,000 individuals. In Estonia, on average 2,700 Barnacle Geese were killed in 2015-2019.

In most countries, derogations likely especially target migratory birds (notably MU1), but situation may be different from country to country. Only for The Netherlands, there is detailed information in which time of the year birds are killed (with monthly resolution), allowing some division according to the management units. Based on average figures for 2019 and 2020, more than 13,000 Barnacle Geese (29% of annual offtake) were killed in July (Figure 5.8). This refers to catches during wing molt in the provinces of Noord-Holland (main part), Zuid-Holland, Zeeland and Utrecht, including a 10-km range around Amsterdam Airport in which birds are culled for flight safety reasons (FBE Noord-Holland 2020). All these birds can be assumed to refer to MU3. Also, birds killed in June, August and September will involve local breeding populations of MU3, which makes that in 2019-2020 on average at least 48% of all Barnacle Geese killed in The Netherlands referred to birds from MU3. In other months, precise assignment to MUs is not possible without further analysis (ring readings) or a detailed check of the permits issued by the respective provincial authorities (which may specifically target breeding or migratory birds). But as the breeding birds are residents, we may assume that even with only assigning the data from summer to MU3, already more than half of the offtake in The Netherlands will only affect the local breeding population. This also makes clear how important it is to have such detailed (monthly) data, in order to be more precise in the modelling process which birds are affected. Overall, in The Netherlands the majority of Barnacle Geese (in 2019-2020 56% and 69% respectively) is killed in the provinces of Friesland (likely predominantly migratory birds from MUs 1 and 2) and Noord-Holland (predominantly breeding birds from MU3). Apart from July, many Barnacle Geese in The Netherlands are shot in March-April, which is the period when high goose abundance overlaps with the growing season for grass and crops.

Table 5.4. Numbers of Barnacle Geese killed under derogation in EU countries in 2019 and 2020. Only the six countries mentioned that had derogations of Barnacle Geese in 2005-2018. Data for Germany refer to Schleswig-Holstein only, which in former years was the only federal state in which derogations were issued. Note that national data is provisional, pending on final submission to the EU. For Germany published data has been used.

Country	2019	2020	Source
Finland	0	564	National data
Estonia	2,194	N/A	EU Eionet central data repository
Sweden	N/A	N/A	EU Eionet central data repository
Denmark	16,402	N/A	EU Eionet central data repository
Belgium	240	N/A	EU Eionet central data repository
The Netherlands	43,213	48,926	National data, regional Wildlife Councils, see also FBE Noord-Holland, 2020
Germany	1,847	1,988	National report, MELUND, 2019, 2020

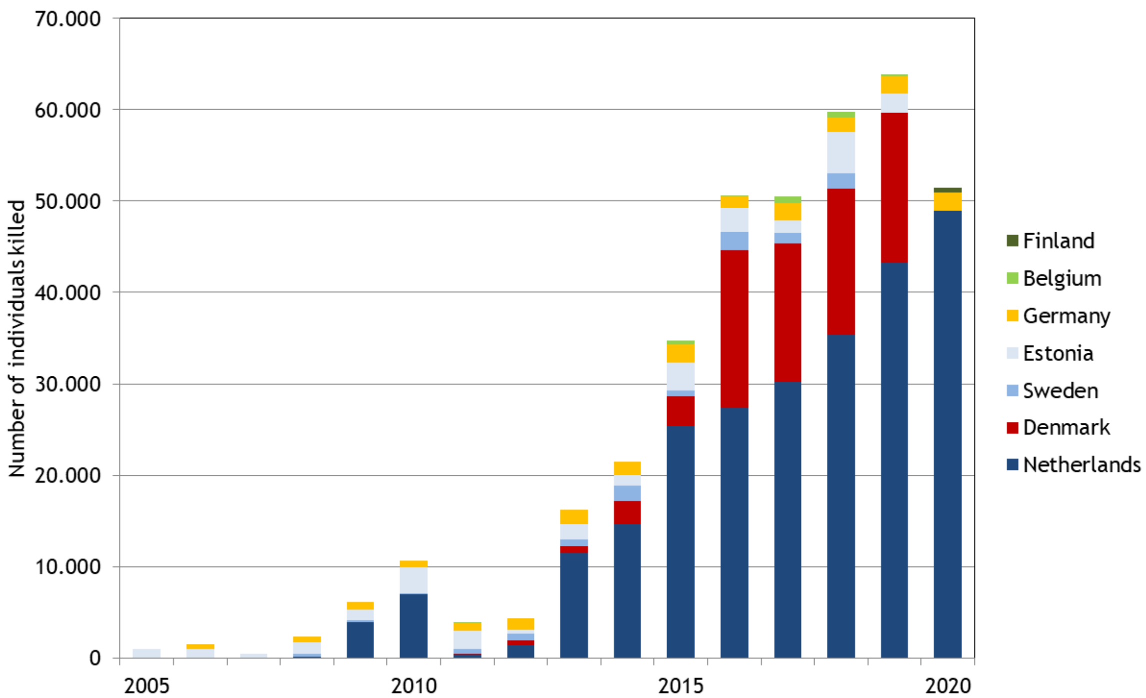


Figure 5.7. Development of numbers of Barnacle Geese killed under derogation in EU-countries 2005-2020. Note incomplete coverage in 2019-2020, see Table 5.4 for details.

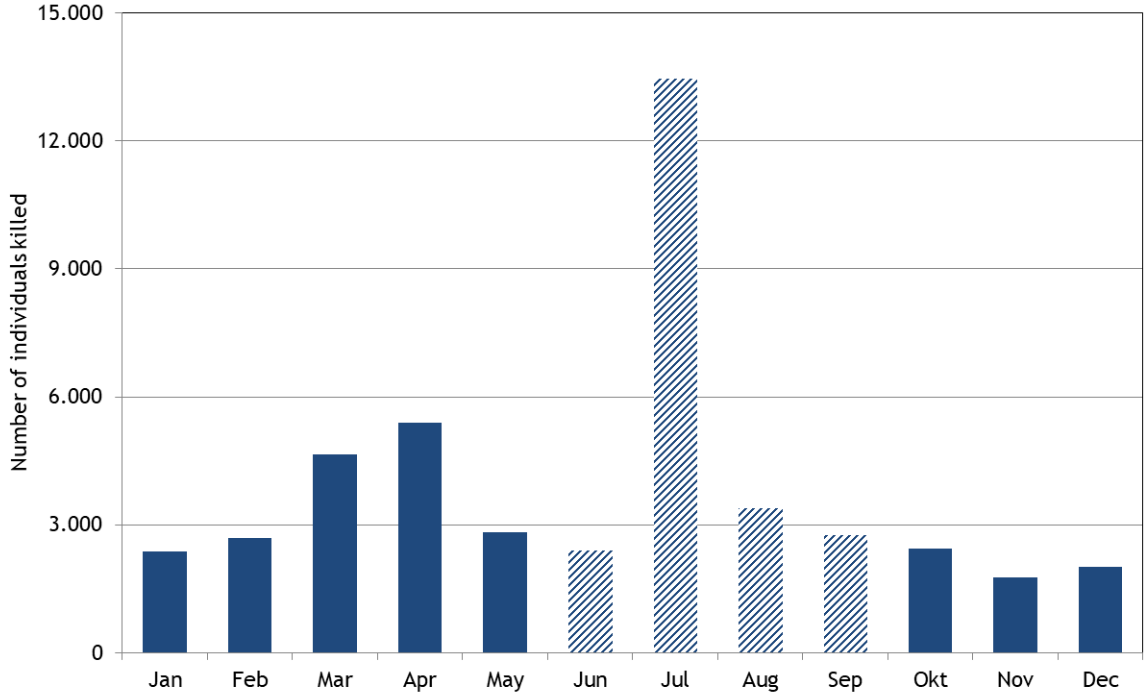


Figure 5.8. Monthly numbers of Barnacle Geese killed in The Netherlands in 2019-2020 (average for both years, data Regional Wildlife Councils). Data from June to September (marked separately) can be safely assumed to belong to MU3. In other months, derogations will refer to a mixture of all three MUs (residents and migratory birds).

Crippling

In a first assessment in Denmark in 2009-2011, Holm & Madsen (2012) reported 12.6% and 11.8% of Barnacle Geese (adults and juveniles combined) to be inflicted with embedded shotgun pellets. More recent data from winter and spring give a mixed picture. In the Netherlands in winter and in Denmark in spring, incidences in 2017-2019 point at an increase compared to the data from Denmark 2009-2011, whereas in Germany and Lithuania the proportion of inflicted birds was lower (Table 5.5). What also stands out, is that in The Netherlands much higher incidences prevail among breeding (i.e. resident) birds compared to wintering birds, which may very well be associated with continuous derogation shooting throughout the year (cf. Figure 5.8). A more detailed analysis, also making comparisons between age-classes and different goose species and providing a more comprehensive assessment will be made separately (Buij et al., in prep.).

Table 5.5. Baseline data on crippling rates recorded for Barnacle Geese.

Country	Year or Season	Time of year	Number sampled	Percentage with embedded pellets	Source
Denmark	2009	Spring	111	12.6	Holm & Madsen, 2012
Denmark	2011	Spring	136	11.8	Holm & Madsen, 2012
The Netherlands	2017	Summer	69	24.6	Wageningen Environmental Research, unpublished
The Netherlands	2018/2019	Winter	284	16.5	Wageningen Environmental Research, unpublished
The Netherlands	2018	Summer	102	26.5	Wageningen Environmental Research, unpublished
Germany	2018/2019	Winter	215	7.4	Wageningen Environmental Research, unpublished
Lithuania	2018/2019	Winter	29	6.9	Wageningen Environmental Research, unpublished

Denmark	2019	Spring	50	18.0	Aarhus University/K. Clausen, unpublished

5.2. Assessment of cumulative impact of derogation and legal hunting

Data collected in 2019-2020 have not yet been included in an update of the IPM, which is due in autumn 2021 in order to be presented during IWG7 in June 2022 (see also Appendix 1). Moreover, so far only the Arctic breeding population (MU1) has been covered in an IPM. An earlier assessment by Baveco et al. (2020) showed that the population size in this unit may remain at a level of about 1 million individuals, as suggested by model output for recent years. Main drivers for this were a rather low reproduction rate and juvenile survival, due to natural causes and unknown Russian offtake. Data from 2018-2019 show that reproduction has not changed a lot (Figure 5.5) while the numbers of birds killed by derogation has further increased in 2019-2020, likely mainly affecting birds from MU1 (in addition to unknown harvest in Russia). The midwinter counts do not suggest major changes in flyway population size in recent years, but this is without proper knowledge about the situation in Germany, where counts have been missing now for the past four years. Hence, the current population status comes with some uncertainties. On the other hand, there is no indication that the strong increase the population has experienced in the past decades is still occurring. In this context it is also striking that major summer populations in Finland (MU2) and in The Netherlands (MU3) do not show large increases at present. The numbers in The Netherlands in 2019-2020 even declined with 12% compared to 2017-2018, likely also affecting total population size in MU3.

Monitoring data for MU2 and MU3 presented in this report will be used as input variables in an updated version of the IPM, which will cover all three management units and treat them with their own population dynamic model and demographic coefficients (survival, reproduction). Population dynamic models are similar for the three populations and basically represent exponential growth. Due to the migratory behaviour of the MU1 and MU2 populations, in part of the year the staging and wintering areas for the different MU populations will overlap. In these periods, populations present in the same area are exposed to the same offtake rate. Populations of MU2 and MU3, however, are also exposed to additional offtake, affecting only the local breeding population, in the months directly before and after the summer counts, when no migratory birds are present (see example for The Netherlands in Figure 5.8). To be able to apply the IPM it is critical that data on derogation offtake are preferably available with a monthly resolution or with any other expert judgement what MUs they affect. Appendix 1 gives a short description of the current stage of IPM and steps to be made in the next months.

Compared to the Favourable Reference Population (FRP) in the AFMP (Nagy et al., 2020), the current flyway population is 3.7 times the FRP of 380,000 individuals. For MU2 and MU3 however, the AFMP also points out that the breeding populations in terms of breeding pairs is within a 200% range set to initiate coordination among range states to coordinate derogations, as pointed out in the AFMP. The decline in total numbers in July in The Netherlands since 2018 is also in line with a stabilisation observed in the national breeding bird survey (Boele et al, 2021).

This status report gives an up-to-date overview of all monitoring data available for the Barnacle Geese Russia/Germany and Netherlands population. Compared to other species, knowledge on Barnacle Geese is rather extensive, but still some gaps exist, of which some are essential to fill in future years.

- The main gap is the lack of data on wintering numbers in Germany in January 2017-2020. In earlier years, Germany hosted about 25% of the flyway population and the longer missing data exist, the more uncertain will be the total population status, as extrapolation from older data will come with an increasing amount of uncertainties (especially when the German wintering population, e.g. under influence of mild winters, would develop differently as expected from data collected in the past);

- At present, only the size of the North Sea management unit (MU3) is very roughly known, but would greatly benefit from an extension of counts in notably Schleswig-Holstein in Germany as well as making the results available, along with data collected already in Lower Saxony;
- The size of MU2 in the Baltic is unknown at present. Apart from Finland and the small population in the Oslofjord region in Norway, there is no data from Sweden and only occasionally (incomplete) data from Denmark (additions from the small populations in Estonia and Russia lack as well). Summer 2021-2022 will probably see some improvement, as a count of Greylag Geese and (in the slipstream) also Barnacle Goose is envisaged in the Scandinavian part of the Baltic. Preferably, this should also include age ratio assessments, in order to get a more comprehensive overview of productivity. In addition, it is recommended to enlarge the geographical scale of age ratio counts in Finland, in order to retrieve a more overall estimate for the country;
- For this report, timely data on derogations partly could be achieved by retrieving published data (e.g. Schleswig-Holstein/Germany) or getting data from national sources (The Netherlands, Finland, Estonia). On a longer term, data were accessible through the EU Eionet central data repository. However, national reports were not available for all countries in recent years and when available only consist of total numbers per calendar-year (and will be re-confirmed when submitted to the EU). As shown by the derogation data from The Netherlands (Figure 5.8), it is essential to have data on at least a monthly basis, or some other division (e.g. by expert judgement) that make quantification possible which MU the offtake refers to. As the number of countries where this applies is rather small, it should be elaborated how to achieve higher-resolution data, without increasing the burden of reporting and the risk of using different data from various sources.

Development of an integrated population model for the Russia/Germany & Netherlands population

The IPM developed and reported at the 2020 EGMP meeting focused on MU1, the Russian breeding population. It has now been extended to include MU2 and MU3 populations. In the single IPM all three populations have their own population dynamic model and demographic coefficients (survival, reproduction). Population dynamic models are similar for the three populations and basically represent exponential growth.

Due to the migratory behaviour of the MU1 and MU2 populations, in part of the year the staging and wintering areas for the different MU populations will overlap. In these periods, populations present in the same area are exposed to the same offtake rate. Populations of MU2 and MU3 are however also exposed to additional offtake, affecting only the local breeding population, in the months directly before and after the summer counts, when no migratory birds are present. To be able to apply the IPM it is critical that data on derogation offtake are available on a monthly base.

At the time of writing no additional monitoring data are available compared to the data underlying the previous IPM for MU1. An extensive analysis of the three population IPM will be prepared for the 2022 EGMP meeting.

In the following, a description of the population dynamic models and the IPM is provided.

Population dynamics model

The IPM for the Barnacle Geese of the Russia/Germany & Netherlands flyway incorporates population dynamic models for each of the populations, breeding in Russia (MU1), the Baltic Sea region (MU2) and in the North Sea region (MU3). These populations are denoted by the superscript R, B and N respectively. Each model assumes two stage classes, juveniles F (fledglings at the start of the timestep) and adults A, and does not distinguish between females and males. Model definition is based on a post-breeding census in July The January counts of the total flyway occur halfway the annual time step. We therefore distinguish between natural survival θ and derogation offtake rates h in the two half-year periods "*summer*" (July 15 to January 15, denoted by subscript s), and "*winter*" (January 15 to July 15, denoted by subscript w). Conceptionally an annual time step can be divided in 10 periods or events, see Table 5.6:

i. Population size in mid-July, separately for juveniles and adults, of the three populations when they are in their breeding areas;
ii. Derogation offtake after the July count in the Baltic Sea and in the North Sea regions, affecting only the local populations, with rates h_s^B and h_s^N respectively. It is assumed that juveniles and adults have the same rate. Derogation offtake in Russia is unknown and is therefore included in the "natural" survival in step iii.;
iii. Natural survival with rates θ_s^R, θ_s^B and θ_s^N respectively;
iv. Derogation offtake in the Baltic Sea region and in the North Sea region with rates denoted by h_s^{BS} and h_s^{NS} respectively. The Russian and Baltic populations are subjected to both harvest rates, while the resident North Sea population is only subjected to h_s^{NS}. It is assumed that the relative sensitivity to derogation offtake of juveniles compared to adults equals ϕ;
v. Population size in mid-January, separately for juveniles and adults, for the three populations;
vi. After the mid-January count there is again offtake like in step iv., but now with rates h_w^{BS} and h_w^{NS} respectively;
vii. Natural survival for all three populations with rates θ_w^R, θ_w^B and θ_w^N respectively. After this period the populations are assumed to be in their breeding areas
viii. Reproduction of the three populations with rates ρ^R, ρ^B and ρ^N respectively;
ix. Derogation offtake like in step ii., before the next July count, with rates h_w^B and h_w^N;
x. Updated population size in mid-July, separately for juveniles and adults, of the three populations when they are in their summer territory.

Table 5.6. Subdivision of an annual time step into 10 periods or events and their associated parameters for the three populations which are denoted by superscripts R (Russian), B (Baltic Sea) and N (North Sea). Population sizes in Mid-July for Juveniles and Adults are denoted by F and A respectively, total population in mid-January by N, harvest rates by h, natural survival rates by θ and reproduction rates by ρ. There are separate values θ for juveniles and adults but this are omitted in this scheme. The subscript s and w denote summer and winter respectively. The subscript t, denoting the annual time step, is mostly omitted.

	i	Event	Russian population	Baltic Sea population	North Sea population	Data	Start Data
Summer	i.	Population size July	F_t^R, A_t^R	F_t^B, A_t^B	F_t^N, A_t^N	C_s^B C_s^N %Juv^B, %Juv^N	2006 2009 2021(1) 2021(1)
	ii.	breeding population offtake	–	h_s^B	h_s^N	H_s^B H_s^N	2008 2013
	iii.	Natural survival	θ_s^R (2)	θ_s^B	θ_s^N		
	iv.	Offtake	$h_s^{BS}+h_s^{NS}$	$h_s^{BS}+h_s^{NS}$	h_s^{NS}	H_s^{BS}, H_s^{NS}	2008
Winter	v.	Population size Flyway January	N^R	N^B	N^N	C_w^{R+B+N} %Juv^{R+B}	1975 1975
	vi.	Offtake	$h_w^{BS}+h_w^{NS}$	$h_w^{BS}+h_w^{NS}$	h_w^{NS}	H_w^{BS}, H_w^{NS}	2008
	vii.	Natural Survival	θ_w^R (*)	θ_w^B	θ_w^N		
	viii.	Reproduction	ρ^R	ρ^B	ρ^N		
	ix.	breeding population offtake	–	h_w^B	h_w^N	H_w^B H_w^N	2008 2013
	x.	Population Size July	F_{t+1}^R, A_{t+1}^R	F_{t+1}^B, A_{t+1}^B	F_{t+1}^N, A_{t+1}^N		

[(1)] Juvenile counts for Baltic and North Sea population from 2021 onwards. [(2)] Including unknown harvest in Russia

The population model employs the following symbols.

t timestep, from July 15 to July 15 the next year
s period s (*"summer"*) (July 15 to January 15)
w period w (*"winter"*) (January 15 to July 15)

The symbols below are used in the population dynamics of the Russian population, with superscript R, with similar symbols for the Baltic Sea population (superscript B) and the North Sea population (superscript N). Note that natural survival in the Russian population includes the unknown Russian harvest.

F_t^R number of juveniles (fledglings) in the Russian population at the beginning of timestep t
A_t^R number of adults in the Russian population at the beginning of timestep t
ρ_t^R reproduction rate in the Russian population at timestep t (fledglings / adult = $0.5\rho_t^R$)
$\theta_{F,s,t}^R$ natural survival of juveniles in the Russian population over period s in timestep t
$\theta_{F,w,t}^R$ natural survival of juveniles in the Russian population over period w in timestep t
$\theta_{A,s,t}^R$ natural survival of adults in the Russian population over period s in timestep t
$\theta_{A,w,t}^R$ natural survival of adults in the Russian population over period w in timestep t

Derogation offtake takes place in the Baltic Sea region and in the North Sea region. We distinguish between offtake occurring when only the local breeding population is present and offtake occurring when also the migrants are present. For the latter, we assume that offtake in the Baltic Sea region concerns Baltic and Russian birds, while offtake in the North Sea region concerns birds from all three MUs.

Derogation offtake rates and numbers in the Baltic Sea region, affecting only the Baltic Sea breeding population (superscript *B*), with similar symbols for offtake in the North Sea region, affecting only the North Sea breeding population (superscript *N*) are given by:

$h_{s,t}^B$ derogation offtake rate at the start of period s, in timestep t
$h_{w,t}^B$ derogation offtake rate at the end of period w, in timestep t
$H_{s,t}^B$ derogation offtake number at the start of period s, in timestep t
$H_{w,t}^B$ derogation offtake number at the end of period w, in timestep t

Derogation offtake rates and numbers in the Baltic Sea region, with superscript BS, with similar symbols for offtake in the North Sea region (superscript NS), are given by:

$h_{s,t}^{BS}$ derogation offtake rate in the Baltic Sea region, in period s, in timestep t
$h_{w,t}^{BS}$ derogation offtake rate in the Baltic Sea region, in period w, in timestep t
$H_{s,t}^{BS}$ derogation offtake number in the Baltic Sea region, in period s, in timestep t
$H_{w,t}^{BS}$ derogation offtake number in the Baltic Sea region, in period w, in timestep t
ϕ relative sensitivity to derogation offtake of juveniles compared to adults

Total survival in summer s and winter w are defined as the product of natural survival and the fraction of birds not killed by derogation, taking into account the relative sensitivity ϕ to derogation offtake of juveniles compared to adults. For the Russian population total survival equals:

$\lambda_{F,s,t}^R = \left(1 - \phi\left(h_{s,t}^{BS} + h_{s,t}^{NS}\right)\right) \theta_{F,s,t}^R$ total survival of juveniles in the Russian population period s

$\lambda_{F,w,t}^R = \left(1 - \phi\left(h_{w,t}^{BS} + h_{w,t}^{NS}\right)\right) \theta_{F,w,t}^R$ total survival of juveniles in the Russian population period w

$\lambda^R_{A,s,t} = \left(1 - \left(h^{BS}_{s,t} + h^{NS}_{s,t}\right)\right) \theta^R_{A,s,t}$ total survival of adults in the Russian population period s

$\lambda^R_{A,w,t} = \left(1 - \left(h^{BS}_{w,t} + h^{NS}_{w,t}\right)\right) \theta^R_{A,w,t}$ total survival of adults in the Russian population period w

Total survival for the Baltic population includes offtake rate h^B_s, at the start of period s, or h^B_w, at the end of period w. These rates only affect the local population:

$\lambda^B_{F,s,t} = (1 - h^B_{s,t}) \left(1 - \phi\left(h^{BS}_{s,t} + h^{NS}_{s,t}\right)\right) \theta^B_{F,s,t}$ total survival of juveniles Baltic population period s

$\lambda^B_{F,w,t} = (1 - h^B_{w,t}) \left(1 - \phi\left(h^{BS}_{w,t} + h^{NS}_{w,t}\right)\right) \theta^B_{F,w,t}$ total survival juveniles Baltic pop. period w

$\lambda^B_{A,s,t} = (1 - h^B_{s,t}) \left(1 - \left(h^{BS}_{s,t} + h^{NS}_{s,t}\right)\right) \theta^B_{A,s,t}$ total survival of adults Baltic population period s

$\lambda^B_{A,w,t} = (1 - h^B_{w,t}) \left(1 - \left(h^{BS}_{w,t} + h^{NS}_{w,t}\right)\right) \theta^B_{A,w,t}$ total survival of adults Baltic population period w

Similarly, total survival of the resident North Sea population is given by

$\lambda^N_{F,s,t} = (1 - h^N_{s,t})(1 - \phi\, h^{NS}_{s,t})\, \theta^N_{F,s,t}$ total survival of juveniles in North Sea population period s

$\lambda^N_{F,w,t} = (1 - h^N_{w,t})(1 - \phi\, h^{NS}_{w,t})\, \theta^N_{F,w,t}$ total survival of juveniles in North Sea pop. period w

$\lambda^N_{A,s,t} = (1 - h^N_{s,t})(1 - h^{NS}_{s,t})\, \theta^N_{A,s,t}$ total survival of adults in North Sea population period s

$\lambda^N_{A,w,t} = (1 - h^N_{w,t})(1 - h^{NS}_{w,t})\, \theta^N_{A,w,t}$ total survival of adults in North Sea population period w

The population dynamics of the Russian population for a single timestep from t to (t +1) is defined by, with similar equations for the Baltic Sea and the North Sea populations

$$\begin{cases} A^R_{t+1} = \lambda^R_{A,s,t}\, \lambda^R_{A,w,t}\, A^R_t + \lambda^R_{F,s,t}\, \lambda^R_{F,w,t}\, F^R_t \\ F^R_{t+1} = 0.5\, \rho^R_t\, \lambda^R_{A,s,t}\, \lambda^R_{A,w,t}\, A^R_t \end{cases}$$

Note that this assumes that one-year old birds do not contribute to reproduction, and that all two-year or older birds have the same reproduction rate.

The total number N_t of the flyway at 15 January in timestep t only involves total summer survival and is given by

$$N_t = \left(\lambda^R_{A,s,t} A^R_t + \lambda^R_{F,s,t} F^R_t\right) + \left(\lambda^B_{A,s,t} A^B_t + \lambda^B_{F,s,t} F^B_t\right) + \left(\lambda^N_{A,s,t} A^N_t + \lambda^N_{F,s,t} F^N_t\right)$$

The fraction π_t of juveniles in groups of birds belonging to the Russian and Baltic population at 15 January in timestep t is given by

$$\pi_t = (\lambda^R_{F,s,t}\, F^R_t + \lambda^B_{F,s,t}\, F^B_t) \,/\, \left(\lambda^R_{A,s,t} A^R_t + \lambda^R_{F,s,t} F^R_t + \lambda^B_{A,s,t} A^B_t + \lambda^B_{F,s,t} F^B_t\right)$$

while in the summer counts, available from 2021 onwards, the fractions for Baltic and North Sea populations are:

$$\begin{cases} \pi^B_t = \frac{F^B_t}{F^B_t + A^B_t} \\ \pi^N_t = \frac{F^N_t}{F^N_t + A^N_t} \end{cases}$$

Harvest on the local breeding populations at the start of the summer, after July 15, is:

$$\begin{cases} H_{s,t}^{B} = h_{s,t}^{B}\ (F_t^B + A_t^B) \\ H_{s,t}^{N} = h_{s,t}^{N}\ (F_t^N + A_t^N) \end{cases}$$

Derogation offtake at the end of the summer in the Baltic Sea Region and in the North Sea region is assumed to occur after summer natural survival. The "size" S of the Russian population which is prone to derogation offtake in summer is then given by

$$S_{s,t}^{R} = \phi\theta_{F,s,t}^{R}F_t^R + \theta_{A,s,t}^{R}A_t^R$$

Similar equations for the Baltic and the North Sea populations account for additional offtake at the start of the summer:

$$S_{s,t}^{B} = (1 - h_{s,t}^{B})(\phi\theta_{F,s,t}^{B}F_t^B + \theta_{A,s,t}^{B}A_t^B)$$

$$S_{s,t}^{N} = (1 - h_{s,t}^{N})(\phi\theta_{F,s,t}^{N}F_t^N + \theta_{A,s,t}^{N}A_t^N)$$

The derogation offtake at the end of period s in the Baltic Sea region $H_{s,t}^{BS}$ and in the North Sea region $H_{s,t}^{NS}$, i.e. occurring at the time migratory birds are also present, are then given by:

$$\begin{cases} H_{s,t}^{BS} = h_{s,t}^{BS}\ \left(S_{s,t}^{R} + S_{s,t}^{B}\right) \\ H_{s,t}^{NS} = h_{s,t}^{NS}\ \left(S_{s,t}^{R} + S_{s,t}^{B} + S_{s,t}^{N}\right) \end{cases}$$

Similarly, derogation offtake in winter after the mid-January count is assumed to occur before natural survival in winter. The "size" S of the Russian population which is exposed to derogation offtake in winter is then given by, with similar equations for the Baltic and the North Sea populations

$$S_{w,t}^{R} = \phi\lambda_{F,s,t}^{R}F_t^R + \lambda_{A,s,t}^{R}A_t^R$$

The derogation offtake in winter after the mid-January count in the Baltic Sea region $H_{w,t}^{BS}$ and in the North Sea region $H_{w,t}^{NS}$ are then given by:

$$\begin{cases} H_{w,t}^{BS} = h_{w,t}^{BS}\ \left(S_{w,t}^{R} + S_{w,t}^{B}\right) \\ H_{w,t}^{NS} = h_{w,t}^{NS}\ \left(S_{w,t}^{R} + S_{w,t}^{B} + S_{w,t}^{N}\right) \end{cases}$$

Note that these equations refer only to the derogation offtake that occurs while migrating birds are present. For the derogation offtake that occurs at the end of the winter w on the local Baltic and North Sea population, during and after breeding but before the mid-July census, additional equations are required:

$$\begin{cases} H_{w,t}^{B} = \left[h_{w,t}^{B}/\left(1 - h_{w,t}^{B}\right)\right]\ \left[\lambda_{A,s,t}^{B}\ \lambda_{A,w,t}^{B}A_t^B(1 + 0.5\ \rho_t^B)\ +\ \lambda_{F,s,t}^{B}\ \lambda_{F,w,t}^{B}\ F_t^B\right] \\ H_{w,t}^{N} = \left[h_{w,t}^{N}/\left(1 - h_{w,t}^{N}\right)\right]\ \left[\lambda_{A,s,t}^{N}\ \lambda_{A,w,t}^{N}A_t^N(1 + 0.5\ \rho_t^N)\ +\ \lambda_{F,s,t}^{N}\ \lambda_{F,w,t}^{N}\ F_t^N\right] \end{cases}$$

Note that division by $\left(1 - h_{w,t}^{B}\right)$ is required because winter total survival, $\lambda_{A,w,t}^{B}$ and $\lambda_{F,w,t}^{B}$ includes this term.

In case ϕ=1, the assumptions that (1) derogation in summer occurs after summer natural survival and (2) derogation in winter occurs before winter natural survival, are not required. In that case offtake and natural survival can be considered to occur simultaneously.

Integrated population model

The following monitoring data are used, with in parenthesis the name of the column in the input file and the corresponding model parameter in the IPM. Lines in italics refer to the monitoring data used in the new 3 population IPM. Some of the data will be available only from 2021 onwards (**Table 5.6**).

- January counts of the total flyway population (Count, N_t);
- Number of observed juveniles in groups of known size, end of period *s*, Netherlands (nFledgling, π_t)
- Group size for which the number of juveniles was observed (nGroup)
- *Number of observed juveniles in groups of known size, summer count, Baltic Sea population (nFledglingBS, π_t^B)*
- *Group size for which the number of juveniles was observed, Baltic Sea population (nGroupBS)*
- *Number of observed juveniles in groups of known size, summer count, North Sea population (nFledglingNS, π_t^N)*
- *Group size for which the number of juveniles was observed, North Sea population (nGroupNS)*
- Period *s* derogation offtake in the Baltic Sea region (hSummerBS, $H_{s,t}^{BS}$)
- Period *w* derogation offtake in the Baltic Sea region (hWinterBS, $H_{w,t}^{BS}$)
- Period *s* derogation offtake in the North Sea region (hSummerNS, $H_{s,t}^{NS}$)
- Period *w* derogation offtake in the North Sea region (hWinterNS, $H_{w,t}^{NS}$)
- *Period s derogation offtake Baltic Sea population (hSummerB, $H_{s,t}^{B}$)*
- *Period w derogation offtake Baltic Sea population (hWinterB, $H_{w,t}^{B}$)*
- *Period s derogation offtake North Sea population (hSummerN, $H_{s,t}^{N}$)*
- *Period w derogation offtake North Sea population (hWinterN, $H_{w,t}^{N}$)*
- Population counts in the Baltic Sea region in the preceding summer (CountB, $A_t^B + F_t^B$)
- Population counts in the North Sea region in the preceding summer in (CountN, $A_t^N + F_t^N$)

The IPM is implemented in JAGS 4.3.0 (Plummer 2003) and runs from within the R computing environment version 4.02 (Team 2019) employing the R package runjags version 2.0.4 (Denwood 2016). **Figure 5.9** indicates that from a technical point of view, the three-populations IPM is operational.

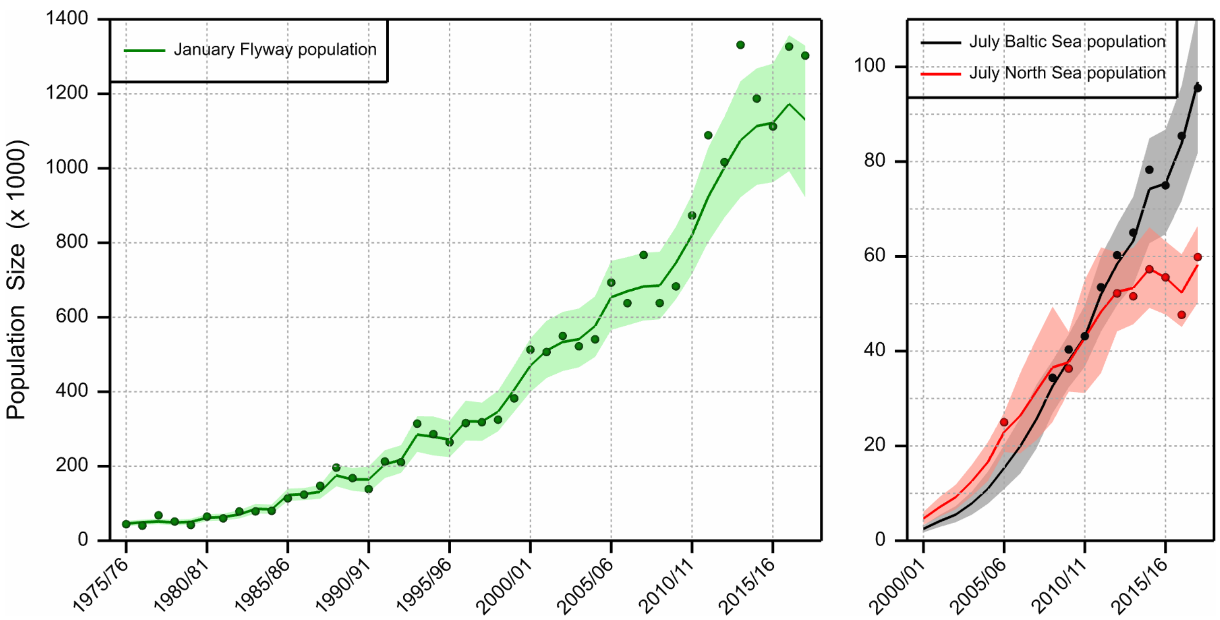


Figure 5.9. Estimated total flyway population size in January (left) and size of the Baltic Sea (MU2) and North Sea (MU3) populations in July (preliminary results based on incomplete monitoring data).

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6. E. Greenland/Scotland & Ireland population of Barnacle Goose *Branta leucopsis*

This chapter compiles monitoring data (methods and results) on the population status of the E. Greenland/Scotland & Ireland population of Barnacle Goose for the season 2020/21. These data have been used to assess the population development and used in the construction of an integrated population model (IPM) for this population. The IPM can furthermore serve the Adaptive Flyway Management Programme (AFMP) with a cumulative assessment of offtake, carried out under the derogation article of the EU Birds Directive, as well as hunting (section 6.2; McIntosh et al. 2021).

6.1. Population status

The Range States for the E. Greenland/Scotland & Ireland population include Greenland, Iceland, Republic of Ireland and United Kingdom (Figure 6.1). The population is managed as one Management Unit (MU) (Jensen et al. 2018, Nagy et al. 2020).

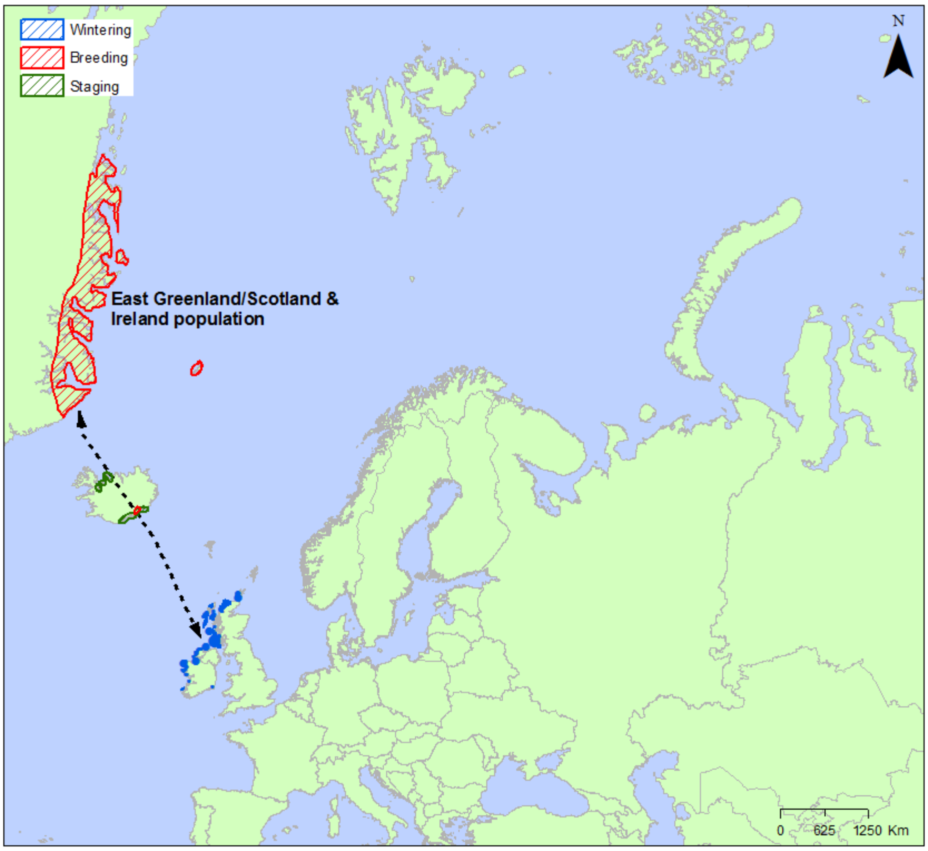

Figure 6.1. Annual distribution and migration routes for the E. Greenland/Scotland & Ireland population of Barnacle Geese, including breeding (red), staging (green) and wintering (blue) areas.

Data collection and methods

Population count

Total population counts in Ireland and Scotland (Triannual counts)

The entire population winters in sites predominantly on the north and west coasts of Scotland and Ireland. Whole flyway population counts have been conducted at approximately five-year intervals since 1959, but this was changed to triennial in 2020. This international census takes place in early to mid-March using a combination of air and ground surveys owing to the remote location of many of the wintering sites.

More information on the count method can be found here: https://monitoring.wwt.org.uk/our-work/goose-swan-monitoring-programme/abundance/icgbg/

Key sites in Scotland (Annual counts)

Islay is a key wintering site, with an estimated 78% of the Scottish population and 63% of the flyway population historically wintering on the island. Whole-island counts have been carried out approximately monthly since 1982.

More information on the count method can be found here: https://monitoring.wwt.org.uk/our-work/goose-swan-monitoring-programme/species-accounts/greenland-barnacle-goose/#:~:text=Branta%20leucopsis,over%2050%25%20of%20the%20population.

Age counts

Age counts based on plumage characteristics conducted on Islay are used to help estimate annual productivity. Age counts are carried out annually on Islay between November and March. Data has focused on Islay previously as a result of the Islay Sustainable Goose Management Strategy and this being the main Scottish site for application of the shooting derogation. However, age counts are also carried out at other locations eg Tiree.

More information on the count method can be found here: https://monitoring.wwt.org.uk/our-work/goose-swan-monitoring-programme/breeding-success/

Icelandic breeding population

The Icelandic breeding population of Barnacle Geese was estimated by total count of nests and total number of birds in each known breeding site just prior to hatching by end of May 2019 by the South East Iceland Nature Research Center and Icelandic Institute of Natural History (Jóhannesdóttir et al. 2020). To have the Icelandic estimate in synchrony with the total count in the non-breeding area in Scotland and Ireland in March the nest count was repeated in 2020 (Jóhannesdóttir et al. in prep.). The plan is to count the Icelandic breeding population every third year onwards.

A simultaneous aerial survey using vertical photography was carried out while geese were counted from ground. It turned out that numbers of nests found were similar from air and ground, but total number of birds was underestimated from air, probably as non-breeding birds did flee the approaching plane while breeding birds stay to guard their nests or goslings. The aerial survey was most valuable in large wet areas difficult to cover from ground, e.g. South-Mýrar (364 nests from ground and 354 from air) compared to Skógey (80 nest counted from ground and 136 from air).

At the turn of this century counts indicated that number of nesting pairs of Barnacle Geese was less than 100. By 2009 the total number of breeding pairs had risen to 120 pairs and 2014 to 600+ pairs (Skarphédinsson et al. 2016). Local nest counts of the Icelandic breeding population have been conducted on Skúmey island since 2014 (https://nattsa.is/wp-content/uploads/2013/09/Skumey-Lokaskyrsla.pdf).

Offtake data (harvest and derogation)

Offtake of the population takes place in Greenland, Iceland and Scotland. The majority of offtake takes place in Iceland, during the autumn migration (hunting), and Scotland, where they are killed under licence (derogation shooting) on Islay as part of the Islay Sustainable Goose Management Strategy (ISGMS) https://www.nature.scot/professional-advice/land-and-sea-management/managing-wildlife/managing-geese/islay-sustainable-goose-management-strategy.

In Iceland, Barnacle Geese are subject to an open hunting season beginning on 1 September and ends with other goose hunting on 15 March. However, in order to protect breeding birds which have established since the late 1990s, hunting is banned in the two counties of East Skaftafellssysla and West Skaftafellssysla until 25 September. These counties are the main stopover areas for the Greenland population in autumn. As such, the effective hunting period for Barnacle Geese in Iceland is limited to four weeks from 25 September until the geese depart for the final stage of their autumn migration in mid-late October (Guðmundur Guðmundsson, pers. comm.).

Crippling rate

The estimate of the crippling rate used on Islay is 10%. This initially came from an estimate following a literature review and was based on the lower end of the scale due to the fact that most geese were being shot by professional marksmen. Work was done in 2016/17 to look at the estimated vs observed crippling loss and the available data confirmed that there was no reason to doubt the 10% rate (Shaw, 2018). Since 2018, regular checks of roost areas for dead and injured birds and examination of sample flocks looking for injured birds are carried out. The data is fed into the thinking around the annual bag limit. There has not been any change to the 10% estimate as a result of that data collection. Further data is expected from a PhD study being undertaken by Aimee McIntosh from Exeter University and this will be included in future status reports. During this study, x-rays are taking of live caught birds from different sites on Islay.

Population data

Population counts

Total population counts and key sites in Scotland

The flyway census undertaken in March 2020 in Ireland and Scotland was carried out by The Wildfowl and Wetlands Trust on behalf of NatureScot and a report is due to be published soon. Publication has been delayed due to Covid restrictions on staff.

In Scotland, 38 sites, out of 188 checked, were found to hold 58,135 Greenland Barnacle Geese. In Ireland, 15,256 geese were counted. The total wintering population was estimated at 73,391 birds. This represents a 1.7% increase on the 2018 census total (Figure 6.2).

The number counted on Islay in spring 2020 (33,202), the most important site in the winter range, was 4.5% lower than that recorded in spring 2018, whereas the number of geese throughout the remainder of Scotland has increased by 17.7% since 2018 (Figure 6.2).

The increase in the number of birds wintering in Scotland has been largely driven by increases at a small number of core areas. Currently, five areas (Islay, North Uist (consolidated), Tiree and Coll, Oronsay/Colonsay and South Walls (Orkney)) hold the majority of geese, accounting for 92.2% of the Scotland total and 73.0% of the international total in March 2020. Islay alone held 57.1% of the Scottish total and 45.2% of the international total. Overall, numbers at these five core areas have increased more than six-fold since 1959, whereas numbers outside these areas have remained relatively stable.

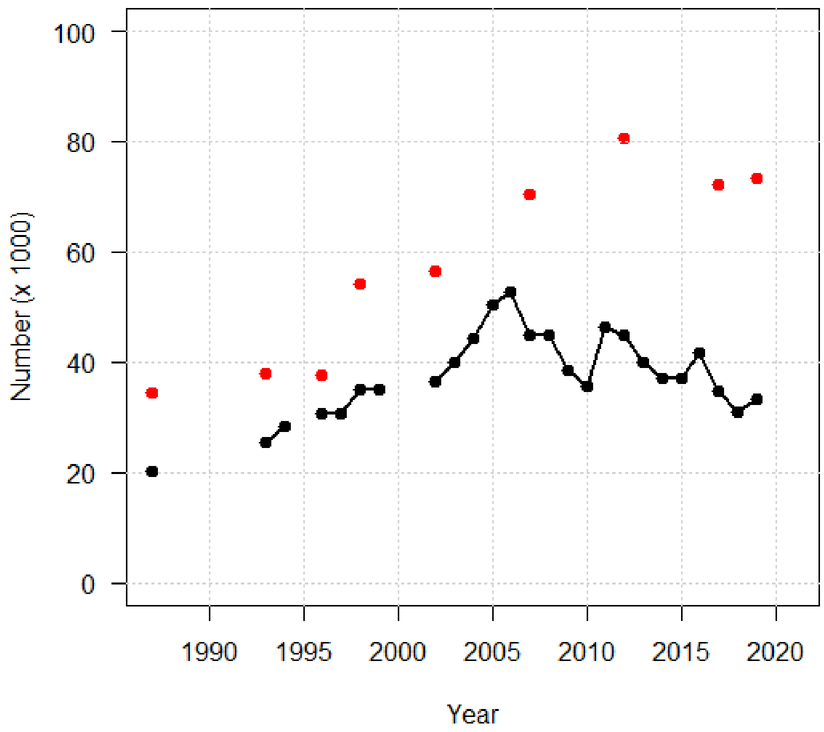

Figure 6.2. Development of the Spring population size of the E. Greenland/Scotland & Ireland Barnacle Goose, Winter 1987/1988-2019/2020 (filled red) with additional annual winter counts from Islay, the most important wintering site in the UK (black line) (WWT).

Icelandic breeding population

Since the late 1990s increasing numbers have been found breeding in Iceland. The longest time series of nest counts is available from the Skúmey island in the Jökusárlón glacial lagoon on Iceland (the main breeding area), where counts are available from 2014-2020. Here nest numbers have increased from 361 in 2014 to 1,495 in 2020 (Figure 6.3) (Jóhannesdóttir et al. in prep.).

The 2019 total count gave 2,052 nests (Jóhannesdóttir et al. 2020) and using an average non-breeding ratio from several sites (0.543) we estimated that the Icelandic fraction of the population could be 8,972 (4,104 breeding birds and 4,868 non-breeders) out of the 72,162 counted in March 2018 or 12.4%

The results of the 2020 count carried out on 1-2 June gave an increase of 379 nests to a total of 2,474 (+18.5%). The ratio of non-breeding birds at several colonies was 0.589 this year giving an estimate of the Icelandic population of Barnacle Geese 11,688 individuals or 15.8% of the total population count in March 2020 (Figure 6.4).

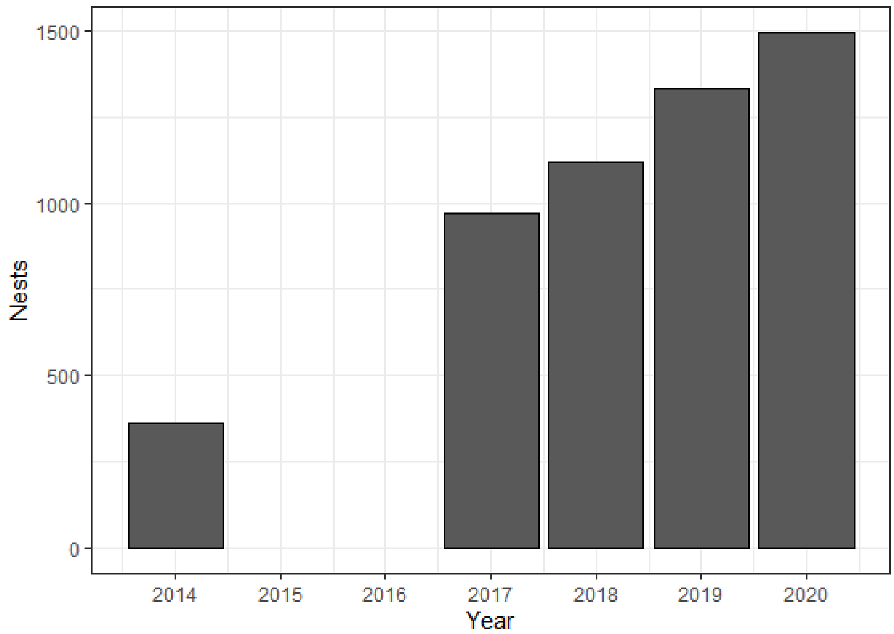

Figure 6.3. Development of number of Barnacle Goose nests on Skúmey island in the Jökusárlón glacial lagoon in Iceland from 2014-2020 (Jóhannesdóttir et al. in prep.).

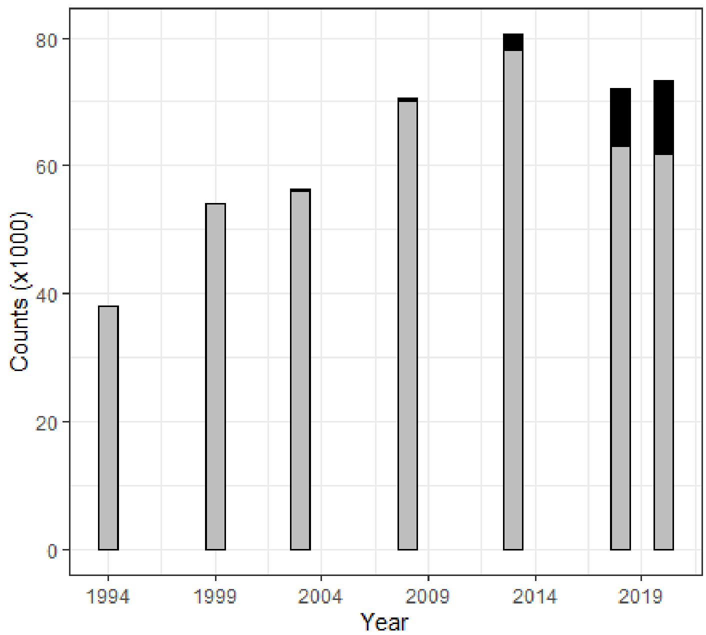

Figure. 6.4. Division of the total number of individuals in the Greenland Barnacle Goose population between breeding quarters in Greenland and Iceland based on nest counts and estimated number of non-breeding individuals in spring in Iceland (Jóhannesdóttir et al. in prep.).

Age counts

The most recent age counts from Islay are set out in table 6.1.

Table 6.1. Breeding success in summer 2019 of Barnacle Geese wintering on Islay

Total aged	Young	%	Broods				
5,184	524	10.11	4	3	2	1	Mean
			32	54	52	31	2.04

Offtake under hunting and derogations

Offtake data (harvest and derogation)

Hunting

Hunting bag in Iceland has increased from 1,876 in 1995 to 3,034 in 2019 (https://statice.is/) (Figure 6.5).

Offtake in Greenland has not been obtained owing to the low numbers of individuals harvested annually (<100 individuals).

Derogation

Derogation in Scotland on Islay have increased from 564 in 2000 to 986 in 2019, with a peak of 3,339 in 2017 (Figure 6.5). In 2020, the maximum bag limit was 1,530 but the total actually shot is expected to be well below that figure.

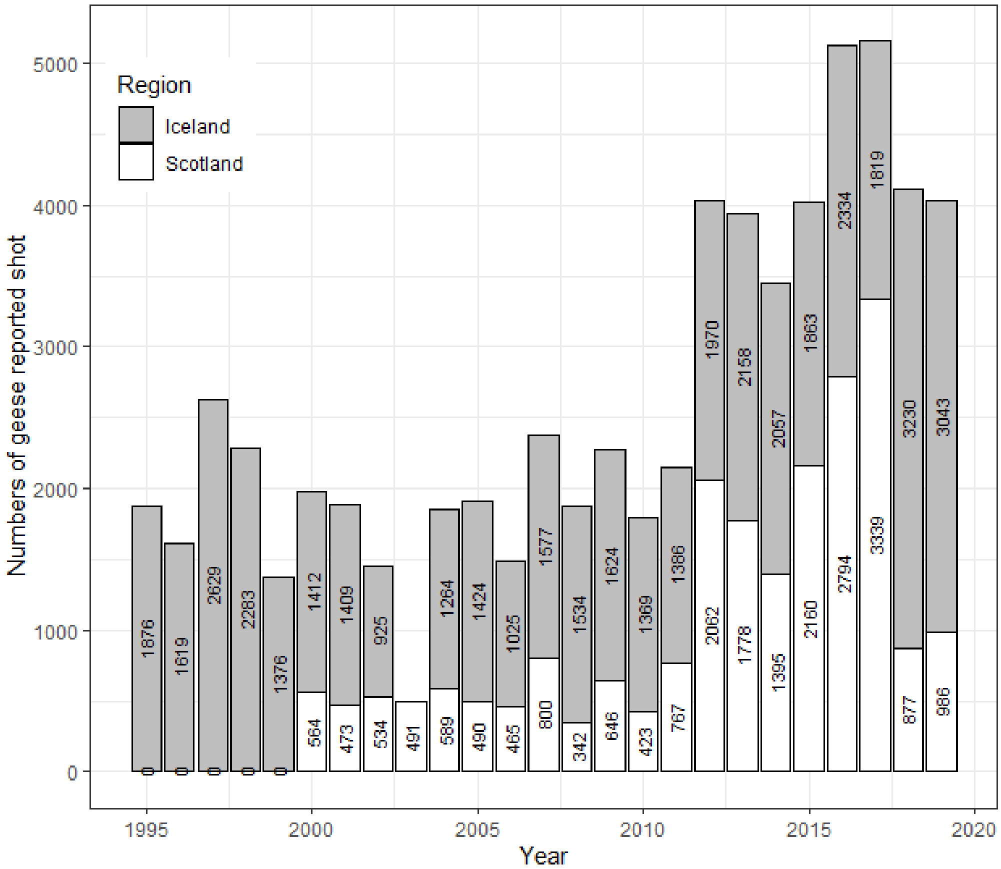

Figure 6.5. Development in the harvest of the E. Greenland/Scotland & Ireland Barnacle Goose population in Iceland (hunting) and Scotland (derogation), Winter 1995/1996-2019/2020. Numbers on the bars show the numbers harvested. In Iceland 2003 data was unusable due to „joke-reports“ delivered by hunters while Ptarmigan hunting was temporarily banned.

Crippling rate

The crippling rate currently used on Islay is 10%. However, further data is expected will be included in future status reports.

6.2. Assessment of cumulative impact of derogation and legal hunting

In 2020, NatureScot and the Department of Housing, Local Government and Heritage Ireland, funded the development of an integrated population model (IPM) for the purpose of better understanding the population dynamics of the flyway population of Greenland barnacle geese and in order to inform the management of offtake for the species. The full report "An Integrated Population Model for the Flyway Population of East Greenland Barnacle Geese" is presented in the Adaptive Framework Management plan for E. Greenland/Scotland & Ireland Barnacle Goose population and a summary is included here.

Observational data included flyway population counts approximately every five years from throughout the winter range (March), annual Islay specific population counts (March), autumn juvenile counts (November) and harvest totals from Iceland and Islay. Prior distributions of natural (or intrinsic) survival were specified using capture-recapture data from the Svalbard population wintering in Scotland, and that for juvenile differential vulnerability in Iceland was specified using data from Pink-footed Geese in Norway. While we have strived to develop a model representative of this flyway population, our results and conclusions should be regarded in light of the limitations of the available data and methods.

Posterior estimates for all parameters fitted data-based counts well, with the majority of observed counts falling within 95% credible intervals. Posterior estimates for the flyway population show a consistent decline from 80,000 (71,000-89,000) in 2012 to 65,000 (55,000-76,000) in 2019. Similarly, population size in Islay has declined since the early 2000 from a peak of 45,000 (42,000-,48,000) in 2005 to 33,000 (29,000-36,000) in 2019.

Harvest rates in Scotland showed the greatest increase from 2011 to 2017 (2%-7% of the flyway population), whilst Iceland harvest rates have shown little variability (consistently <4%). Declines in the flyway and Islay population size coincide with increased harvest rates in Scotland. Similarly, the importance of alternative wintering sites appears to have increased with the increase in derogation shooting on Islay. This suggests that derogation shooting on Islay may not only be causing a decline in the Islay wintering population through direct mortality, but also may be contributing to distributional shifts in the wintering population to alternative sites.

Estimates of juvenile survival rate were consistently lower than those of adults; this is unsurprising given the greater vulnerability of juveniles to harvest and the resulting greater juvenile harvest rate observed here. Age-specific harvest rate and survival show changes in response to increased harvest rates in Scotland, though this is more pronounced in juveniles.

Our results suggest the decline in the population of Greenland Barnacle Geese since 2012 has been driven by poor productivity and increased harvest rates, predominantly in Scotland. The flyway-specific Adaptive Flyway Management Plan does not provide targets for population sizes but does note that the flyway population should not fall below the Favourable Reference Population of 54,000 individuals, which at present is just below the 95% credible interval of our flyway estimate. Our posterior estimates for Islay population size (mean = 33,000, CI = 29,000-36,000) are close to those set as targets to reduce grazing pressure. Scottish derogation shooting appears to have both reduced flyway population size as well as caused distributional changes in use of wintering sites. The IPM provides a sound framework from which projections under different management scenarios can be assessed. Future work to project how harvest management may influence the flyway population should consider whether derogation shooting will be implemented in wintering sites outside of Islay, as well as future adjustments to harvest rates.

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