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DEFINING FAVOURABLE REFERENCE VALUES FOR THE POPULATIONS OF THE BARNACLE GOOSE (*Branta leucopsis*)

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The 5th Meeting of the AEWA European Goose Management International Working Group is taking place remotely in an online conference format.

Contents

List of Abbreviations

AV	=	Agreement Value
CV	=	Current Value (2013-2018 period[1])
DV	=	Directive Value (here Directive means the Birds Directive)
ISSMP	=	International Single Species Management Plan
FCS	=	Favourable Conservation Status
FRH	=	Favourable Reference Habitat
FRP	=	Favourable Reference Population
FRR	=	Favourable Reference Range
FRV	=	Favourable Reference Values
MVP	=	Minimum Viable Population
N_e	=	effective population size
SPA	=	Special Protection Area (under the EU Birds Directive)
PVA	=	Population Viability Analysis

[1] For the EU Member States this corresponds to the latest reporting period on Article 12 of the Birds Directive

Summary

This document presents the technical description of deriving Favourable Reference Values for the three populations that are subject of the Single Species Management Plan for the Barnacle Goose adopted by the AEWA MOP7. The approaches described here apply only to this species in the context of AEWA and its Single Species Management Plan and should not be considered as a precedence in the context of the application of the requirements of the EU Birds Directive.

The Barnacle Goose is a species listed in Annex I of the EU Birds Directive and its three populations are listed in various categories in Table 1 of Annex 3 of AEWA as shown in the table below. The species has declined by the mid-20th century, but has increased again since the 1950s showing the following population trajectories:

Population	**AEWA Table 1**	**1950s**	**Directive Value (1980)**	**Agreement Value (2000)**	**Current Value (2013-2018)**
1. E Greenland/ Scotland & Ireland	B1	8,277	33,815	53,823	72,162
2. Svalbard/SW Scotland	A3a	1,350	9,050	23,000	41,700
3. Russia/Germany & Netherlands	C1	10,000	47,919	380,000	1,200,000

This formerly exclusively Arctic-breeding species has established itself as a breeder in the countries bordering the Baltic and North Seas as well as on the Faroe Islands and Iceland. A significant non-native breeding population exists also in the UK, but that is not subject of the AEWA Single Species Management Plan.

Originally, the Barnacle Goose was a long-distant migrant species with three separate flyway populations. According to the guidelines of DG Environment (2017) the most appropriate approach to define Favourable Reference Values for this type of populations is collaboratively by the Range States. Considering that historic population estimates are not available for most of the populations for the period before numbers were decimated in the late 19th and early 20th centuries, the reference-based approach could not be applied and only the population-based approach could be used to define the Favourable Reference Values. The general approach to define the Favourable Reference Values included the following steps:

(1) It was estimated (see Section 2.4.1.1.1) that a total census population of 1,426 individuals is equivalent to the long-term genetic Minimum Viable Population (MVP) of the effective population of $N_e = 500$ recommended by DG Environment (2017: p. 120).

(2) A population-specific MVP multiplier was calculated from the count data by dividing the estimated population size where the risk that the population declines below the 1,426 individuals quasi-extinction threshold drops below 1% in 100 years (see section 2.4.1.2.4).

(3) The up-scaled MVP (i.e. 1,426 multiplied by the population specific factor) was compared to the legal reference values - i.e. the population size when the Bird Directive and AEWA came into force (Directive and Agreement Values respectively) to check whether these legal reference values are higher than the up-scaled MVP.

(4) It was checked at what legal reference value the population could be considered already being ecologically functional and the Favourable Reference Population was set at that level.
(5) The Favourable Reference Range is suggested to be defined at the level of the Current Value (2013-2018 period) for the naturally occurring population segments and this is to be used as a benchmark in future assessment of the conservation status.
(6) The Favourable Reference Habitat is deduced from the favourable status of the reference population and range (see Section 2.4.3).

Based on the assessment process described above the following reference values are proposed for the three populations of Barnacle Goose. For detailed justification, please read the relevant chapters.

1. E Greenland/Scotland & Ireland population

It is proposed to define the Favourable Reference Population at the Agreement Value level as the population was already ecologically functional but was dependent on artificial habitats to a lesser extent than at Current Value (level of the 2013-2018 period) and it has represented more limited risk to other habitats than at current levels (2013-2018 period). This value is much higher than both the up-scaled MVP and the Directive Value. The Favourable Reference Range is proposed to be set at the Current Value (level of the 2013-2018 period) because that is sufficient to ensure the long-term viability of an ecologically functional population and there is no evidence of past range contraction. The overall growth of the population showed no sign of slowing down before the population regulation started on Islay, which indicates that the available habitat is sufficient to support the population at the current level and possibly beyond.

2. Svalbard/SW Scotland population

This population winters primarily on the Solway Firth, which is an SPA and this population was already subject of international management planning although that process was eventually not concluded. It is proposed to maintain either the Favourable Reference Population of 25,000 individuals proposed in the earlier draft action and management plan for this population (Black 1998), or adjust this value to the conservation objectives set for the Solway Firth if such a value has been set and if it is higher than 25,000 individuals because the Favourable Reference Population cannot be less than the conservation objective at its only key wintering site. Even the 25,000 individuals' value is much higher than both the up-scaled MVP and the Directive Value. The current breeding, staging and wintering range (level of the 2013-2018 period) is sufficient to support the population up to the current level, which is already higher than the proposed FRP. The range shows no deficiency that would jeopardise the long-term viability of the population. Therefore, it is suggested to define the Favourable Reference Range at the current level (2013-2018 period). The overall growth of the population shows no sign of slowing down, which indicates that the available habitat is sufficient to support the population at the current level and possibly beyond.

3. Russia/Germany & Netherlands population

This population consists of three management units: the arctic breeding and long-distance migrant Russian one, the short-distance migrant Baltic breeding one and the resident North Sea one. The temperate breeding populations are partly introduced, partly naturally occurring. All three management units winter in Germany and the Netherlands and increasingly in Belgium, Denmark and Sweden where they mix.

It is proposed to define the Favourable Reference Population for the entire population at the Agreement Value of 380,000 individuals because the population was already ecologically functional at that level. It had already reached the carrying capacity of the Baltic staging areas but was dependent to a lesser extent on artificial habitats than at Current Value. It represented also more limited risk to other habitats than at current levels. This value is much higher than both the up-scaled MVP and the Directive Value.

For the Baltic and North Sea management units, it is suggested to define the FRPs at national level where the population is naturally occurring as a breeding species. The breeding FRP for these management units should be derived by adding up the national FRPs.

The FRP for the Russian management unit should be defined by deducting the FRPs of the other two management units from the FRP of 380,000 individuals for the entire flyway.

It is suggested to define the Favourable Reference Range for the Russian management unit at current level (2013-2018 period) for both the breeding and migration seasons as there is no sign of deficiencies in the range in relation to the Favourable Reference Population.

For the Baltic management unit, the FRR should be defined collectively by the Range States with naturally occurring breeding populations.

For the North Sea management unit, the FRR should be defined nationally by the Range States with naturally occurring breeding populations.

The continued exponential growth of the Russian and North Sea management units shows that there is sufficient habitat even beyond current population levels. Although population levels since the mid-1990s have exceeded the carrying capacity of the staging areas in the Baltic, it is not limiting the growth of the population yet as Barnacle Geese managed to adapt to this situation first by using a larger area in the Baltic on migration and then by staging for a shorter period in the region and staying longer on the wintering grounds. The proposed Favourable Reference Population for the Russian management unit represents a situation when there was a better balance between the population size and the carrying capacity of the habitats and birds used more semi-natural habitats.

The further growth of the Swedish coastal breeding population seems to be limited by the availability of suitable habitats that triggered the expansion of the range within Sweden and to other countries. However, sufficient habitat is available to support at least the current population size.

The Favourable Reference Values for the Baltic and North Sea management units are to be defined at management unit or national level respectively by the range states where it occurs naturally as a breeding species and to be supported by data requested in Annex 1.

All wintering range states are to provide information on the Favourable Reference Range and Favourable Reference Habitat through the data template in Annex 2 for the non-breeding season.

1. Introduction

The goal of the International Single Species Management Plan (ISSMP) for the Barnacle Goose (*Branta leucopsis*) is to "*maintain each of the three populations in Favourable Conservation Status while taking into account ecological, economical and recreational interest*" (Jensen et al., 2018: p. 17). The ISSMP delegates the task of defining Favourable Reference Values for population size, habitat and range to the population-specific Adaptive Flyway Management Programmes (AFMPs), to be adopted by the European Goose Management International Working Group (EGM IWG), in order to support the decision-making process and to secure the long-term viability of the populations.

At the 2nd AEWA International Management Planning Workshop for the Barnacle Goose and the Greylag Goose (NW/SW European population) held in Leeuwarden, the Netherlands on 19 June 2018, it was agreed that the process of setting the FRVs should follow the principles set out in the EU guidance documents (Bijlsma et al., 2019a; 2019b)[2] and that there will be no management targets defined for any of the Barnacle Goose populations because of the species' is not listed on Annex II of the Birds Directive, which makes setting management targets incompatible with the derogation regime under Article 9 of the Birds Directive.

A proposal for Defining the Favourable Reference Values for the Barnacle Goose (*Branta leucopsis*) (Doc. AEWA/EGMIWG/4.17) was presented at the 4th Meeting of the AEWA European Goose Management International Working Group meeting on 18-20 June 2019 following the guidelines and examples presented in Bijlsma et al. (2019a; 2019b). However, it was requested that the document should be revised taking into account the feedback received from the stakeholders. In response to the European Commission's comment concerning the status of the Bijlsma et al. (2019a; 2019b) document, this revised proposal follows the EU guidelines for reporting under Article 17 of the Habitats Directive (DG Environment, 2017).

In line with DG Environment (2017: pp. 115-116), it is proposed that the FRVs for all three populations of Barnacle Goose are set collaboratively by the Range States because these populations perform large, cyclic and directed annual movements.

This document presents the technical description of deriving Favourable Reference Values for the three populations that are subject of the Single Species Management Plan for the Barnacle Goose adopted by the AEWA MOP7. The approaches described here apply only to this species in the context of AEWA and its Single Species Management Plan and should not be considered as a precedence in the context of the application of the requirements of the Birds Directive.

[2] The Netherlands made a disclaimer regarding the use of this approach for other species covered by the Birds Directive in order to avoid setting a precedent in using this approach for bird species in decline. However, it should be noted that the obligation to define Favourable Conservation Status in the context of the ISSMP stems from Article II.1 of the AEWA Agreement Text.

2. Key concepts and considerations

2.1 Favourable Conservation Status (FCS)

As described in Article II.1 of AEWA, a fundamental principle of the treaty is to maintain migratory waterbird species in a Favourable Conservation Status or to restore them to such a status. Consequently, all activities under AEWA, including the ISSMP, shall comply with this requirement. In the context of the Agreement, the Favourable Conservation Status should be interpreted as it is defined in Article I.1.c of the Convention on Migratory Species:

> "Conservation status" will be taken as "favourable" when:
>
> (1) population dynamics data indicate that the migratory species is maintaining itself on a long-term basis as a viable component of its ecosystems;
>
> (2) the range of the migratory species is neither currently being reduced, nor is likely to be reduced, on a long-term basis;
>
> (3) there is, and will be in the foreseeable future, sufficient habitat to maintain the population of the migratory species on a long-term basis; and
>
> (4) the distribution and abundance of the migratory species approach historic coverage and levels to the extent that potentially suitable ecosystems exist and to the extent consistent with wise wildlife management.

The other two legal instruments that are applicable in the case of the Barnacle Goose (i.e. the EU Birds Directive and the Bern Convention) do not use the concept of Favourable Conservation Status, but in the case of the former, the European Commission’s position is that the requirements formulated in Article 2 include the requirement of maintaining the species in a Favourable Conservation Status. This interpretation is further supported in the case of waterbird species listed on AEWA by the fact that the Birds Directive is a domestic legislation of a Contracting Party (the European Union) and its domestic legislation shall comply with AEWA.

Regardless of the formulation of their goals, all these instruments agree that they aim to maintain prospering populations and not simply avoiding extinction in the long-term.

Although all species to which the Convention on Migratory Species applies should be maintained in or restored to a Favourable Conservation Status, the concept has not been elaborated neither by CMS nor by AEWA so far. On the other hand, the concept has been well developed in the context of reporting under Article 17 of the EU Habitats Directive since the mid-2000s. Although that instrument is not directly applicable to the Barnacle Goose, it was proposed and agreed at the 2nd AEWA International Management Planning Workshop for the Barnacle Goose and the Greylag Goose (NW/SW European population) that standards established under that process should be applied also in the AEWA context together with the guidelines of the AEWA Technical Committee (2017).

In the context of reporting under Article 17 of the EU Habitats Directive, the conservation status is assessed through comparing the population’s actual size, range and habitat to defined benchmarks for the same attributes (which are collectively called Favourable Reference Values) and also assessing the trends and future prospects in each of these attributes.

2.2 Favourable Reference Values (FRVs)

If the Favourable Conservation Status is the goal of AEWA (and of the EU Habitats Directive), the Favourable Reference Values can be considered as measurable objectives or indicators that describe hypotheses about the size of the population, its distribution and the availability and quality of habitat needed to achieve this goal (Tear et al., 2005).

The concept of Favourable Reference Values was endorsed by the Habitats Committee (DG Environment, 2005: pp. 8-9)3 and described as follows:

"Favourable Reference Range (FRR): Range within which all significant ecological variations of the habitat/species are included for a given biogeographical region and which is sufficiently large to allow the long-term survival of the habitat/species; favourable reference value must be at least the range (in size and configuration) when the Directive came into force; if the range was insufficient to support a favourable status the reference for favourable range should take account of that and should be larger (in such a case information on historic distribution may be found useful when defining the Favourable Reference Range); 'best expert judgement' may be used to define it in the absence of other data.

Favourable Reference Population (FRP): Population in a given biogeographical region considered the minimum necessary to ensure the long-term viability of the species; favourable reference value must be at least the size of the population when the Directive came into force; information on historic distribution/population may be found useful when defining the Favourable Reference Population; 'best expert judgement' may be used to define it in the absence of other data".

Subsequently, the European Commission has produced guidelines for each reporting under Article 17 of the Habitats Directive developing more detailed interpretation and techniques to set the Favourable Reference Values. This document uses the latest guidelines from the EC (DG Environment, 2017).

Definition of Favourable Reference Values represents the first step in assessing whether a species or population is in Favourable Conservation Status or not. The assessment of conservation status includes periodically (1) comparing the actual population size, range and habitat values to the Favourable Reference Values, (2) considering the direction of change in these values (i.e. is it improving, stable or deteriorating) and (3) assessing the future prospects of the population (i.e. whether it maintains itself in the foreseeable future) and whether there will remain sufficient range and habitat in the foreseeable future4.

The purpose of this document is only to propose Favourable Reference Values, i.e. the parameters of Favourable Conservation Status for the populations and management units of the Barnacle Goose. Assessing their conservation status will be carried out periodically during the implementation of the Adaptive Flyway Management Programmes. Those assessments will use the Favourable Reference Values agreed by the AEWA European Goose Management International Working Group together with information on trends in the Favourable Reference Values and information on future prospects.

DG Environment (2017) proposes a two-step process for setting the Favourable Reference Values:

1. collecting all the information necessary for setting the Favourable Reference Values and then
2. setting Favourable Reference Values.

[3] DG Environment (2005) contains no definition of Favourable Reference Habitat for a species.
[4] DG Environment (2017: p. 145) defines foreseeable future as two future reporting period (i.e. 12 years)

2.3 Collecting information

DG Environment (2017: p. 116) recommends collecting all the relevant information about a species in order to understand their ecological and historical context. Therefore, ideally data and information on the following factors, as per the DG Environment's guidelines, should, when available, be gathered and used for estimating FRVs for species:

- current situation and assessment of deficiencies, i.e. any pressures/problems;
- trends (short-term, long-term, historical, i.e. well before the Directive came into force);
- natural ecological and geographical variation (including genetic variation, inter- and intra-species interactions, variation in conditions in which species occur);
- ecological potential (potential extent of range, taking into account physical and ecological conditions);
- natural range, historical distribution and abundances and causes of change, including trends;
- connectivity and fragmentation;
- requirements for populations to accommodate natural fluctuations, allow a healthy population structure, and ensure long-term genetic viability;
- migration routes, dispersal pathways, gene flow, population structure (e.g. continuous, patchy, metapopulation).

2.4 Setting Favourable Reference Values

DG Environment (2017: p. 111) advocates two broad approaches for setting Favourable Reference Values (Figure 2.4.1.1):

1. one is the reference-based approach (i.e. comparing the current situation to a more favourable historical situation);
2. the other is the model- or population-based approach[5] (defining the Minimum Viable Population and multiplying this by a scaling factor). If there is no sufficient historical information about distribution, population size, trends and pressures, then the reference-based approach is not possible or appropriate and a population-based approach should be used.

The reference-based approach is consistent with Point (4) of the CMS definition of FCS, i.e. "*the distribution and abundance of the migratory species approach historic coverage and levels to the extent that potentially suitable ecosystems exist ...*".

According to DG Environment (2017: p. 118) there are several species for which a reference-based approach is not possible or appropriate to set the FRVs:

- species for which there is not sufficient historical information about distribution, population size, trends, pressures;
- species for which restoration of range and/or population to some historical levels would not be feasible at all;
- species for which the restoration efforts would not be proportional and reasonable in terms of the conservation objectives of the Directive.

[5] DG Environment (2017) uses both terms apparently interchangeably on pages 111 and 118.

DG Environment (2017: p. 111) recognises that reference-based and model-based approaches are not mutually exclusive. For example, the requirement that the Favourable Reference Values shall be at least the Directive Value in the above-mentioned definitions of Favourable Reference Population and range refers to a historic situation of legal importance and reflect the aspiration of "no net loss" of biodiversity. In the context of AEWA similar legal reference values could be the Agreement Values representing "no net loss" since the Agreement came into force. A similar legal reference value in the context of AEWA can be the population size threshold of 25,000 individuals that represents the upper limit for listing a population in Column A (representing endangered migratory species according to Paragraph 2(a) of Article III of the Agreement) based on its small population size alone without taking into account its population trend, the number of sites and the threat status of the habitat on which it depends. On the other hand, the requirement that the Favourable Reference Population should always be bigger than the Minimum Viable Population (MVP; DG Environment 2017: p. 110), represents the population-based approach. Hence, the results of a reference-based approach should be checked against the MVP and the results of a population-based approach shall be checked against the legal reference values even if no other historical information is available.

2.4.1 Considerations concerning the Favourable Reference Population

1. It follows from Point (1) of the Favourable Conservation Status definition that the Favourable Reference Population should be a viable component of its ecosystem in the long-term;
2. It follows from Point (4) of the Favourable Conservation Status definition that abundance should approach historic levels as far as it is feasible and consistent with wise wildlife management;
3. The DG Environment (2005; 2017) emphasises that the Favourable Reference Population should be at least the size when the Directive came into force;
4. Both DG Environment (2017) and the AEWA Technical Committee (2017) recognise that FRVs do not automatically correspond to the 'potential values' such as carrying capacity, but these should be used to understand restoration opportunities and constraints;
5. When applying the reference-based approach and the population has not undergone visible shifts or reductions in the past and the current population size is large enough to ensure the long-term viability of the population, DG Environment (2017: p.117) advise that the Favourable Reference Population should be equal to the current population size except for populations that are secure and have triggered human-wildlife conflict[6]. In that case the FRP should be lower than the Current Value.

[6] The original version of this document used the term "overabundant" following the terminology in AEWA Resolution 6.4. DG Environment (2017, footnote 67) used the term "species with overpopulations". Based on the discussion with the European Commission and EU Member States on 31 January 2020, this term was replaced with the expression "secure and have triggered human-wildlife conflict" throughout this document.

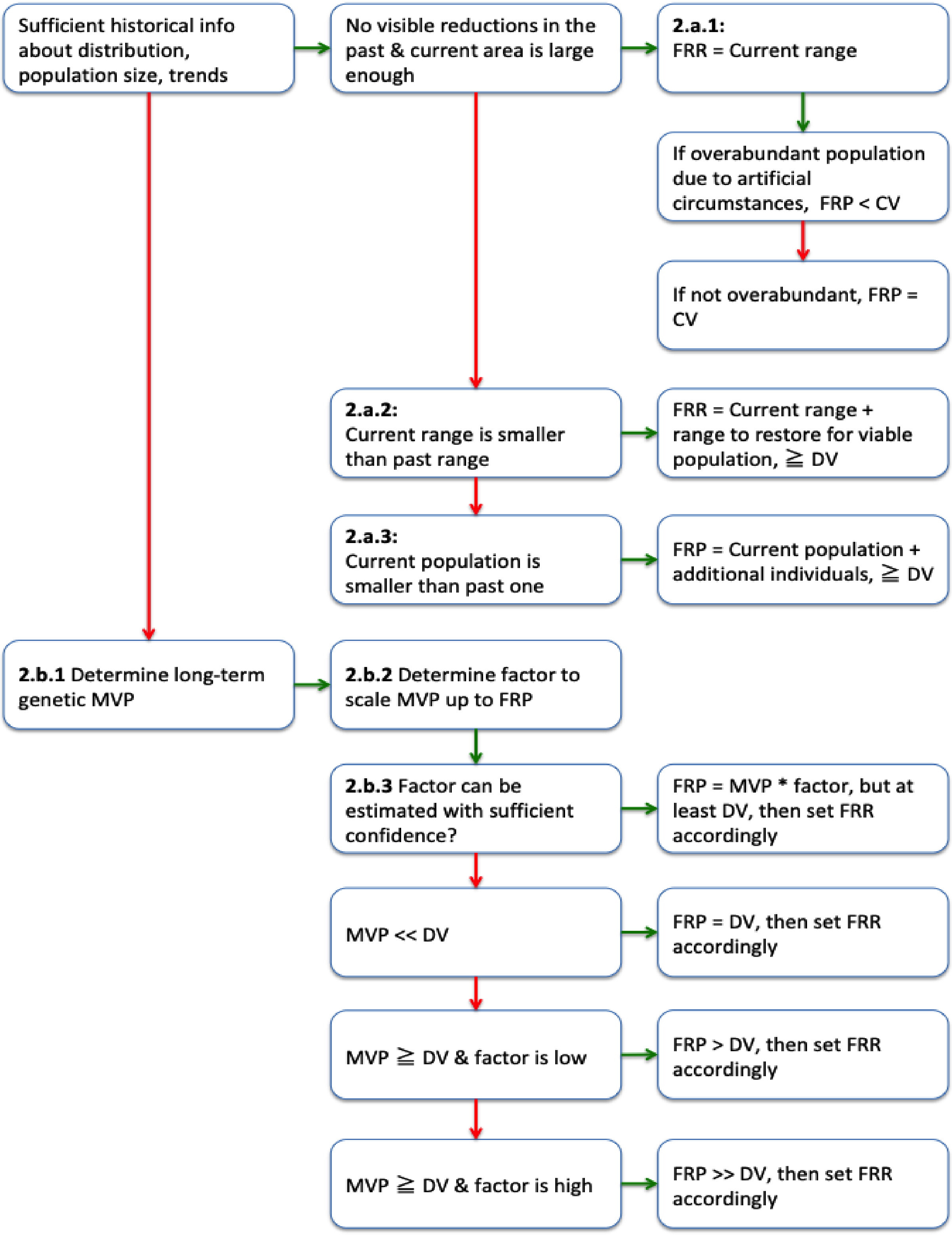

Figure 2.4.1.1. Summary of the approaches to determine Favourable Reference Range (FRR) and Favourable Reference Population (FRP) recommended by DG Environment (2017: pp. 116 - 121); this flowchart has been compiled for the purposes of this paper following DG Environment (2017). Green arrows indicate positive and red ones negative answers. “Viable population” in the context of this graph goes beyond the Minimum Viable Population and represents the requirements of “flourishing” population.

2.4.1.1 Options for a population-based approach

DG Environment (2017: p. 120) recommends performing a Population Viability Analysis (PVA) to determine the Minimum Viable Population if data quality is high. If data quality is moderate/low, they propose to use MVP estimates from species-specific literature or use generalised genetic rules corresponding to an effective population size $N_e \geqq 500$ for long-term 'genetic MVP' or use population-based proxies for MVPs.

Unfortunately, DG Environment (2017) does not provide any explicit standards concerning important attributes that would fundamentally determine the results of any PVA, namely:

- Benchmark persistence probability: there are many levels commonly used. E.g. the IUCN Red List Criterion E defines the extinction probability (i.e. 1 - the probability of persistence) as 10% (i.e. 90% probability of persistence) as the threshold for Vulnerable (IUCN, 2012), while Shaffer (1981), Trail et al. (2007), Brambilla et al. (2011) and the AEWA Technical Committee (2017) define the extinction risk a magnitude smaller, i.e. 1% which means that the probability of persistence of the population is 99% and this reflects the aim of long-term viability as opposed to avoiding extinction. In this assessment is followed the guidelines of the AEWA Technical Committee (2017) because it represents an almost certain persistence;
- Benchmark time period: the IUCN Red List Criterion E uses 100 years for the Vulnerable category, but 20 years for the Endangered and 10 years for the Critically Endangered ones (IUCN, 2012). Shaffer (1981) originally suggested tentatively 1,000 years, but has revised later to 100 years (Shaffer, 1990: p. 39). Trail et al. (2007) recommends 40 generations. In case of the Barnacle Goose with a generation length of 10.5 years (BirdLife International, 2019), 40 generations would result in an assessment period of 420 (!) years. According to Morris & Doak (2002: p. 452) "*it is foolhardy to try to predict the probability that a population will avoid extinction for many centuries into the future*" as the confidence intervals will encompass the entire range between 0 and 1 at that timescale. Unfortunately, most PVAs will not have long enough time series of data to project into the future with the precision required for a 1% extinction probability even within 100-year standard, which leaves applying the 40 generation rule out of question. To be able to predict the extinction probability with an accuracy of ± 0.2 (i.e. if the true risk is 0.3, the estimate should lie between 0.1 and 0.5) would require 5 - 10 times as many years of observations as one wish to predict into the future (Fieberg & Ellner, 2000; Ellner et al., 2002). The AEWA Technical Committee (2017) has recognised the trade-off between the need to assess the long-term viability of a population and the statistical constraints in such assessment and opted for the 100-year timeframe.
- Threshold for quasi-extinction: estimates of extinction risk should be not based on estimates of the probability of absolute extinction (Morris & Doak, 2002: p. 453). Therefore, an appropriate quasi-extinction threshold should be used. Such quasi-extinction thresholds could consider minimising demographic stochasticity (c. 100 breeders), account for avoiding inbreeding depression (approximated through an effective population of $N_e = 50$) or even retaining evolutionary potential (approximated through $N_e = 500$). Although, DG Environment (2017) does not provide any explicit guidance on quasi-extinction risk in the context of PVAs, the 'rule-of-thumb' figure of $N_e = 500$ they advocate as "long-term genetic MVP" (p.120) was used as a quasi-extinction threshold in the further calculations.

2.4.1.1.1 Conversion of effective population size into census population size

As the effective population size is smaller than the census population size, the following equation was used to estimate the effective population size (N_e) following Sinclair et al. (2006):

$$Ne = (NF - 1)/[F+(s^2/F) - 1]$$

Where F is the mean lifetime production of offsprings per individual and s^2 is the variance of production and N is the census population size. First the census population size was calculated for half of the $N_e = 500$ for each sex and then the census population sizes of the sexes were added up.

Based on the estimates of F = 2.4 (SE = 0.2, N = 196) and F = 2.1 (SE = 0.2, N = 175) in Black et al. (2014: p. 168), first an estimate for the census population size of 487 + 528 = 1,015 mature individuals was obtained. Based on the median value of the Total / Adult population ratios from Solway and Islay (Trinder 2014a, 2014b)[7], the total census population corresponding to $N_e = 500$ was estimated to be 1,426 individuals.

2.4.1.2 Determining a factor to scale MVP size up to FRP level

DG Environment (2017: p. 114) emphasises that it is important for Favourable Reference Populations to reflect the 'long-term viable component of the natural habitat' at the level of the species across its natural range and distribution, rather than solely a Minimum Viable Population. Therefore, it suggests scaling up the MVP estimates.

DG Environment (2017: p. 120) states that "*given an MVP estimate, the required favourable population size or the number of required more or less isolated (favourable) populations will at least depend on ecological and genetic variations within the natural range of the species and often on known trends as well*". It recommends that a scaling factor should be determined through one or more of the following approaches:

- modelling the potential range and habitat suitability;
- using available estimates of population density;
- amount of suitable area and maximum dispersal distance to constrain the number of required populations or the spatial extent of one mixing population;
- use population trends to determine an MVP multiplier;
- consider the ecological/genetic variation within the historic range and find the minimum number of populations (connected or isolated) to cover this variation.

2.4.1.2.1 Modelling the potential range and habitat suitability

The Barnacle Goose presents special challenges to model the potential range:

- It is still rapidly expanding its range. Therefore, it violates one of the fundamental assumptions of species distribution models, namely that the species distribution should be in an equilibrium state (Brambilla et al., 2011, Guisan et al., 2017). This is clearly illustrated in the available models by Huntley at al. (2007: p. 72) and Breiner et al. (in prep). Figures 2.2 and 2.3 illustrate this well. Breiner et al. used available observation data from the breeding season of the species (Figure 2.1) up to 1990, i.e. the period BioClim data was parameterised. However, this represents a period before the species started becoming a widespread breeding bird in the Netherlands. This dataset was grossly biased towards the Baltic and Svalbard (with more birdwatchers) and underrepresented Greenland and the Russian Arctic. The predicted breeding distribution based on climatic, elevation, settlement and wetland data reflects this bias in observations by predicting low suitability in the Russian Arctic where the majority of the birds occur and predicting high suitability for areas from where the majority of observations are available. Other attempts to model the species distribution (Huntley et al., 2007, European Bird Census Council, *pers. comm.*) have also lead to biased results for similar reasons.
- Environmental predictors (climate, land cover) typically used in Species Distribution Models usually poorly reflect habitat quality (e.g. crops, sward height, etc.). Hence, they tend to overpredict the potential distribution of the species. Likewise, failure to capture important ecological factors (i.e.

[7] For these calculations here values only of years with survival rate < 1 were used.

distance to water bodies) also result in overpredictions. On Figures 2.2 and 2.3, overpredictions are partly the result of not even using land cover in the modelling.

- Several environmental predictors are not available for the Arctic part of the breeding range or are unreliable. This can also result in truncated models (e.g. the northern part of Svalbard on Figure 2.2 is not predicted because it was not included into the wetland layer used in this modelling).
- Suitability correlates poorly with abundance (Guissan et al., 2017) but reflect more the similarities amongst the training points.

The above illustrates the potential impacts of various pitfalls, that should be addressed when making inferences from species distribution models.

However, even if it is assumed that the potential range is modelled correctly, i.e. it is considered that Ireland, the UK, coastal areas of Norway and the southern Baltic are all part of the potential range of the species, how would this inform scaling up from the MVP estimate? According to DG Environment (2017: p. 159) "*FRVs do not automatically correspond to the 'potential value' (maximum possible extent) which, however, should be used to understand restoration possibilities and constraints*". This was interpreted meaning that using the potential range is only necessary if there are deficiencies in numbers and distribution of the population and the potential range method is to be used to overcome such deficiencies, but it does not represent an obligation to fill up the potential range.

2.4.1.2.2 Using available estimates of population density

Barnacle Goose is a highly congregatory species throughout its annual cycle. Hence, using population densities is of little help in defining an upscaling factor.

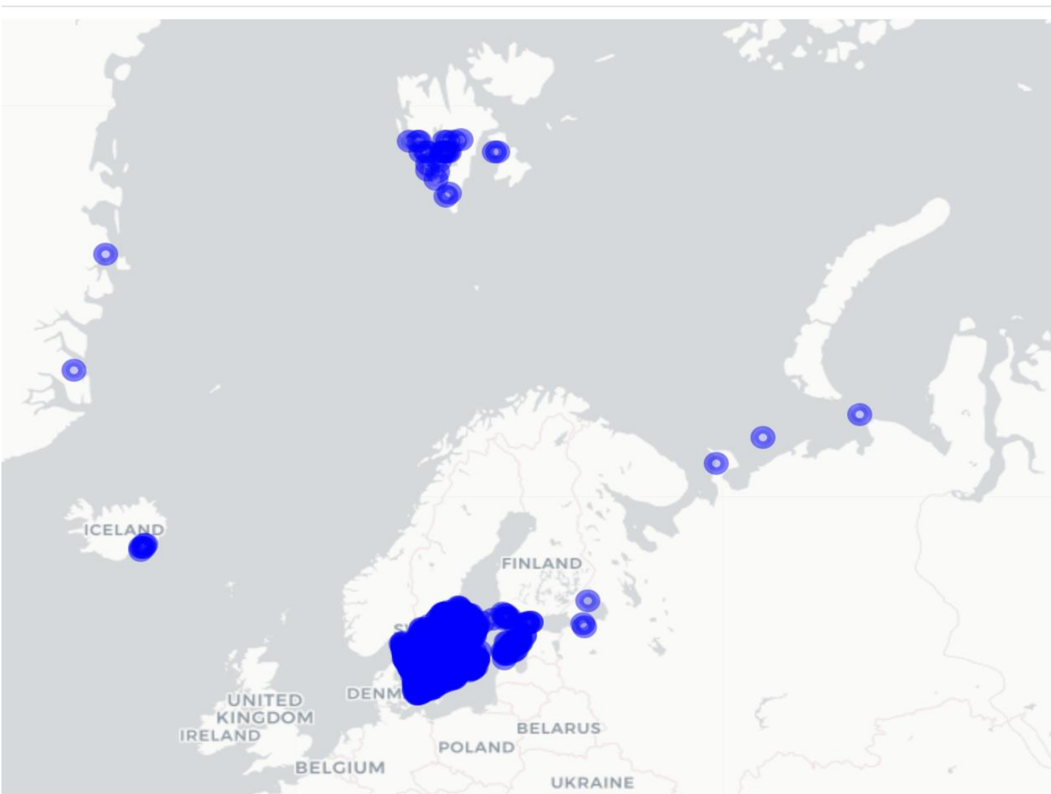

Figure 2.1. Observations from the breeding season of the Barnacle Goose used to train climatic predictors and no habitat ones (Breiner et al., *in prep*).

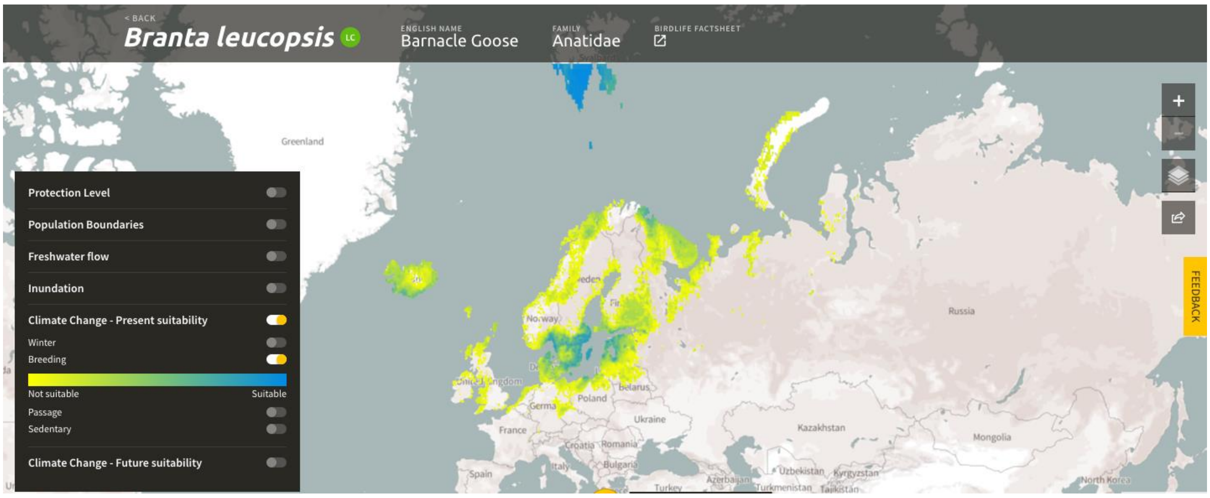

Figure 2.2. Modelled breeding distribution of the Barnacle Goose using climatic predictors and no habitat ones (Breiner et al., *in prep*). Scale ranges from yellow = least suitable to blue = most suitable). Breeding distribution in Russia and Greenland is grossly underpredicted due to sparse data while the distribution in the Baltic is overpredicted.

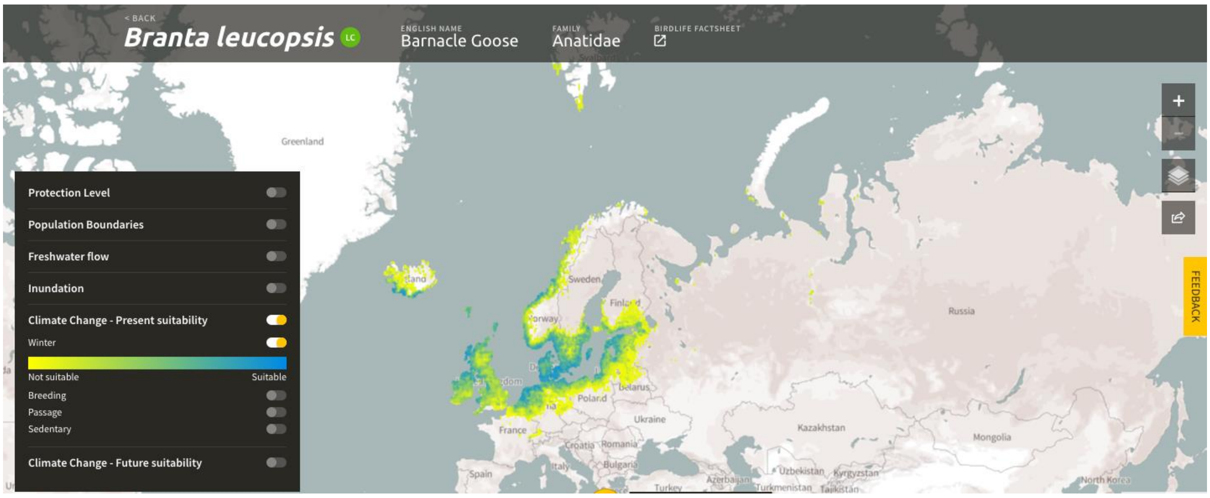

Figure 2.3. Modelled wintering distribution of the Barnacle Goose using climatic predictors and no habitat ones (Breiner et al., *in prep*). Scale ranges from yellow = least suitable to blue = most suitable). Wintering distribution is overpredicted in Ireland, England, Norway, the northern and Eastern Baltic.

2.4.1.2.3 Amount of suitable area and maximum dispersal distance

Barnacle Goose is able to disperse over large distances. On Svalbard, dispersal distances have ranged from 25 - 255 kilometres. On average, young birds moved more than adults, 98.2 kilometres and 69.8 kilometres respectively (Black et al., 2014). However, dispersal between various breeding areas has also been recorded. Van der Jeugd & Litvin (2006) have reported dispersal between the Baltic and Russian as well as North Sea management units and even the Svalbard population. The colonisation of Iceland, the Faroe Islands, the Baltic and possibly also the North Sea region indicates that the species is able to occupy areas at large distances within its flyway, but there are no records of naturally colonising areas outside of its traditional flyway except in the range of the Baltic and North Sea management units that partly originate from introduced birds (Figure 2.4).

The Barnacle Goose is highly adaptive in its selection of breeding sites (Feige et al., 2008). In the Arctic, it has traditionally bred on cliffs and islands, but also colonised the lowland tundra areas since the 1980s. In the Baltic, it started to breed on off-shore islands. As Figure 2.4 indicates, it expands its breeding range further inland along fjords and rivers. In the North Sea area, breeding sites are on islands either in lakes, rivers or embanked areas. Based on the models developed by Breiner et al. (in prep.), there is still a wide band of inland areas in Denmark, Germany, Poland and the Baltic countries where coastal areas, islands in lakes and rivers can be occupied by the species (Figure 2.2). As with the potential range, however, it is a question how this information should inform scaling up of the MVP estimate in this newly established populations. As with the potential range, the interpretation used here is that taking into account available habitat informs defining the Favourable Reference Population when there are deficiencies to be addressed, but it does not represent an obligation to encourage the species to occupy all suitable habitats.

2.4.1.2.4 Population trends to determine an MVP multiplier

The stochastic variation in vital rates leads to stochastic variation in the population growth rate and this increases the risk of extinction. The genetic MVP of Ne = 500 already provides safeguard against demographic and genetic stochasticity, but not against the environmental one. The higher the variability in annual growth rate, the higher the risk of extinction. The recommendation to use an MVP multiplier based on population trends is interpreted as a requirement to provide safeguards against the effects of environmental stochasticity.

Figure 2.4. Breeding distribution of the Barnacle Goose in the European Union (EEA, 2015). The map clearly shows the dispersion of the breeding birds in Finland, Sweden (extending also to the Oslo Fjord in Norway but not shown) and the Netherlands outside of the traditional flyway that would lead through the Bay of Helsinki, Gotland to the Wadden Sea.

To estimate the MVP multiplier is used census data presented in Figures 6 - 8 in the ISSMP (Jensen et al., 2018) to estimate the arithmetic mean of the log population growth rate ($\boldsymbol{\mu}$) and the environmentally driven variance of the log population growth rate ($\boldsymbol{\sigma}^2$) as the mean and variance of log(N_{i+1} / N_i), i.e. the log of the annual population growth rate ($\boldsymbol{\lambda}_i$). Here the cumulative density function (CDF) for the time of quasi-extinction was used as presented in equation 3.5 in Morris & Doak (2002).

The extCDF function in the 'popbio' (Stubben et al., 2018) R package (R Development Core Team, 2013) was used for the calculations. The cumulative density functions of quasi-extinction probabilities for 100 years for different population sizes was calculated starting at the 1,426 individuals (from Section 2.4.1.1.1) quasi-extinction threshold, to the maximum count available for the population. The multiplier factor is determined by dividing the population level where the extinction probability in 100 years falls below 1% by 1,426.

2.4.1.2.5 Ecological/genetic variation within the historic range

Genetic variation is accounted by treating the three flyway populations and their management units separately. Jonker et al. (2013) has shown that there is genetic differentiation amongst these populations and even between the management units.

Ecological variation within the range is also taken into account through aiming for maintaining the current range.

2.4.1.3 Determine the Favourable Reference Population (FRP)

DG Environment (2017: p. 121) provides the following 'decision key' to determine the FRP:

- If the scaling factor can be estimated with sufficient confidence:
    - FRP equal to MVP multiplied by scaling factor (number of required populations or multiplier); in any case, the calculated FRP cannot be lower than the population size at the date of entry into force of the Directive (DV).
- If the scaling factor can only be estimated qualitatively, use operators:
    - if MVP is much smaller than the size of the population at the date of entry into force of the Directive, then the FRP should be equal to the latter value (i.e. FRP = DV);
    - if MVP is approximately equal to or bigger than the size of the population at the date of entry into force of the Directive, and scaling factor is relatively low, then FRP should be bigger than the latter value (i.e. FRP > DV);
    - if MVP is approximately equal to or bigger than the size of the population at the date of entry into force of the Directive, and scaling factor is relatively high, then FRP should be [much][8] bigger than the latter value (i.e. FRP >> DV).

The Directive here refers to the Habitats Directive. However, in the context of birds Bijlsma et al. (2019a) used the Birds Directive. The practical implication of this is that the Directive Value for the Habitats Directive refers to a situation in the mid-1990s, while for the Birds Directive more to a situation in 1980. Both of these periods have been before AEWA came into force. The same considerations can also be applied in the context of the Agreement as in the case of the Habitats Directive, i.e. AEWA aims to maintain the populations at least at the level when it came into force. Therefore, it is proposed to apply the above key also in relation to the 'Agreement Value' (AV) that describes the situation in 2000 and compare the values to the Birds Directive or the AEWA values and select the value whichever is the larger in case of populations subject to both instruments.

[8] Missing word in DG Environment (2017) and assumed based on context.

2.4.2 Considerations concerning Favourable Reference Range

1. It follows from Point (2) of the CMS Favourable Conservation Status definition of that the current range is not to be reduced;
2. It follows from Point (4) of the Favourable Conservation Status definition that it should approach historic coverage;
3. The Habitat Committee emphasises that the range should include all significant ecological variation; and
4. It should be large enough to allow the long-term survival of the species (or in this case: population);
5. It should be at least as large as it was when the Directive came into force;
6. If the range is insufficient to support the Favourable Reference Population, the reference for favourable range should take account of that and should be larger.

Although the Favourable Reference Range has to be increased if it is insufficient to accommodate the Favourable Reference Population, this does not necessarily mean that the Favourable Reference Range has to be reduced if the Favourable Reference Population is smaller than the current one. One reason for this is that the same range can be occupied at very different population levels. As it will be shown, the wintering ranges of the Barnacle Goose populations breeding in Greenland and Svalbard have remained almost unchanged despite of the large increases in the sizes of these populations. The other reason is that the Favourable Reference Population is not a target to which the population has to be reduced if the population has already exceeded it. It simply represents a benchmark to decide whether the population is in a Favourable Conservation Status or not. Based on points (1) and (4) of the Favourable Conservation Status definition, it would indicate that the species or population is not in favourable status if its range has declined compared to the current or to the historic range independently from whether the population size has remained above the Favourable Reference Population and this is a way to ensure that ecological and genetic variability is maintained.

The treatment of the temperate breeding Barnacle Goose management units should take into account the following paragraph from DG Environment (2017: p. 125): “When a species or habitat spreads naturally (on its own) to a new area/territory or when a re-introduction of a species consistent with the procedures foreseen under Article 22 of the Habitats Directive has taken place of a species into its former natural range, this territory has to be considered a part of the natural range. Similarly restoration/recreation or management of habitat areas, as well as certain agricultural and forestry practices can contribute to the expansion of a habitat or a species and therefore its range. However, individuals or feral populations of an animal species introduced on purpose or accidentally by man to places where they have not occurred naturally in historical times or where they would not have spread to naturally in the foreseeable future, should be considered as being outside their natural range and consequently not covered by the Directive”.

In case of migratory waterbirds, Article 11 of the Birds Directive and paragraph 2(g) of Article III of AEWA provide the appropriate legal framework. According to the former “Member States shall see that any introduction of species of bird which do not occur naturally in the wild state in the European territory of the Member States does not prejudice the local flora and fauna. In this connection they shall consult the Commission”. The latter represents a stricter approach: “[Parties shall] prohibit the deliberate introduction of non-native waterbird species into the environment and take all appropriate measures to prevent the unintentional release of such species if this introduction or release would prejudice the conservation status of wild flora and fauna; when non-native waterbird species have already been introduced, the Parties shall take all appropriate measures to prevent these species from becoming a potential threat to indigenous species”.

2.4.3 Considerations concerning Favourable Reference Habitat for the species

It follows from Point (3) of the Favourable Conservation Status definition, that there should be both now and in the foreseeable future sufficient habitat to sustain the species in the long-term.

According to DG Environment (2017: p. 136) habitat for the species refers to the resources necessary at all stages in the life cycle of the species and essentially two questions need to be answered:

a. Are area and quality of the occupied habitat sufficient (for long-term survival)?
b. If ‘No’, is there a sufficiently large area of unoccupied habitat of suitable quality (for long-term survival)?

For species which use a wide range of habitats, often termed ‘generalists’, it is difficult to identify the area used with any precision, and factors such as availability of prey (which represents the qualitative aspects of the habitat for a species) are often more important than the extent of the habitat. For the generalist species it is less likely that the ‘habitat area’ is a limiting factor controlling the population size or reproduction than for a ‘specialist’ species dependent on one or a limited number of habitats (habitat types).

Box 7 in DG Environment (2017: p. 140) presents a flow chart developed by the Joint Nature Conservation Committee (JNCC) of the UK to help assessments of habitat of species, particularly when data are limited. It outlines different approaches used in the assessment of the habitat for the species, for habitat generalists and specialists. For generalist species, it presumes that the habitat for the species is favourable if both population size and range parameters are favourable. This is the approach that was followed in this assessment.

2.4.4 Need for improving the conceptual framework for FRVs

DG Environment (2017) adopts the concept that the Favourable Conservation Status represents a flourishing population, but it also clearly states (p. 110 - 111) that:

- FRVs should be set taking into account the precautionary principle and include a safety margin for uncertainty;
- FRVs do not automatically correspond to a given ‘historical maximum’, or a specific historical date; historical information (e.g. a past stable situation before changes occurred due to reversible pressures) should, however, inform judgements on FRVs;
- FRVs do not automatically correspond to the ‘potential value’ (carrying capacity) which, however, should be used to understand restoration possibilities and constraints.

On the other hand, DG Environment (2017) still quotes the Habitats Committee’s definition of Favourable Reference Population which use the formulation ‘*minimum necessary to ensure the long-term viability of the species*’ (DG Environment 2005).

According to DG Environment (2017: p. 121; described in Section 2.4.1.3 here) the FRP should be equal to the Directive Value if the MVP is much smaller than the Directive Value even if the scaling factor can be estimated only qualitatively. As it has been shown in Section 2.4.1.1, the long-term genetic MVP can be estimated to be around 1,426 individuals in the full census population for Barnacle Goose. This value is much smaller than the Directive Value for any of the populations of the species. However, the Barnacle Goose was listed on Annex I of the Birds Directive, which means that its status was not considered being favourable at that time. This also means that following the decision key above would not lead to a “flourishing” population, it would simply declare an unfavourable status as favourable.

On the other hand, both Point (4) of the Favourable Conservation Status definition and Article 2 of the Birds Directive recognise that populations may reach a secure status where they might trigger human-wildlife conflict. DG Environment (2017: p. 117) addresses such situation only in a footnote:

"*... in exceptional cases (for example of species with overpopulations as result of non-conservation artificially feeding or of species which population is increasing since the Directive came into force and which are harmful to other protected species) the Favourable Reference Population (FRP) should be lower than the current population*".

Obviously, the Article 17 guidance does not deal with birds directly, but the principle is also relevant for birds. In Bijlsma (2019a: p. 63) a special guidance deals with such situation in case of birds:

"*A species' population size can have increased after the BD came into force not as a consequence of restoration/improvement of natural conditions but due to unnatural human influences. In this case, we suggest to set FRP equal to DV (if DV exceeds upscaled MVP), despite a higher current value*".

Both guidances are problematic in case of Barnacle Goose. The first one is unspecific: how much lower the population can be? The second one, in this particular case, suffers from the same problems as applying the 'decision key' of DG Environment (2017).

Applying any other legal reference values (i.e. the Agreement Value or the 25,000 individuals threshold (see Section 2.4) or using the Current Value just on its own would also not answer whether the population is "flourishing" or it is triggering human-wildlife conflict to the degree that its management could be justified.

Therefore, it is proposed to interpret the "flourishing" population level as an ecologically functional population (Sanderson, 2006). Ecologically functional is large enough so that the population interacts strongly with other species and ecosystem processes, i.e. set the Favourable Reference Values at the level where the population becomes ecologically functional (Figure 2.5).

The problem is that calculating an ecologically functional population levels a priori is difficult, because most ecological functions respond to the density (rather than the size) of a population, because most species have many different kinds of ecological functions, and because species share ecological functions ("functional redundancy") within the community. However, reference populations can be used to define such levels especially in the case of populations that have increased a lot and became subject of management problems because of the problems they cause.

In the context of management planning for rapidly increasing populations whose growth depends partly on provision of artificial feeding habitats, it is proposed to define Favourable Reference Values by critically assessing the Directive, the Agreement and Current Values against the following set of criteria and set the favourable reference value at the 'legal reference value' where the answer is 'yes' to question 3 but still predominantly 'no' to questions 4 and 5:

1. Is the population larger than the up-scaled long-term genetic MVP to maintain evolutionary potential?
2. Is the population ecologically self-sustaining at this level?
    a. Does it have redundant populations[9] across a representative[10] range of ecological settings?
    b. Is the population genetically robust?
3. Does the population have strong intra- and inter-specific interactions in its natural ecosystem at this level?
4. Is this population level reliant on artificial habitat and is it above ecologically functional level?
5. Does the population have an unnatural impact on other species and the ecosystem at this level?

[9] Redundancy is necessary to reduce to an acceptable level the risk of losing representative examples of these targets (Tear et al., 2005)

[10] Representation means capturing "some of everything" of the ecological element or target of interest (e.g., a population) (Tear et al., 2005)

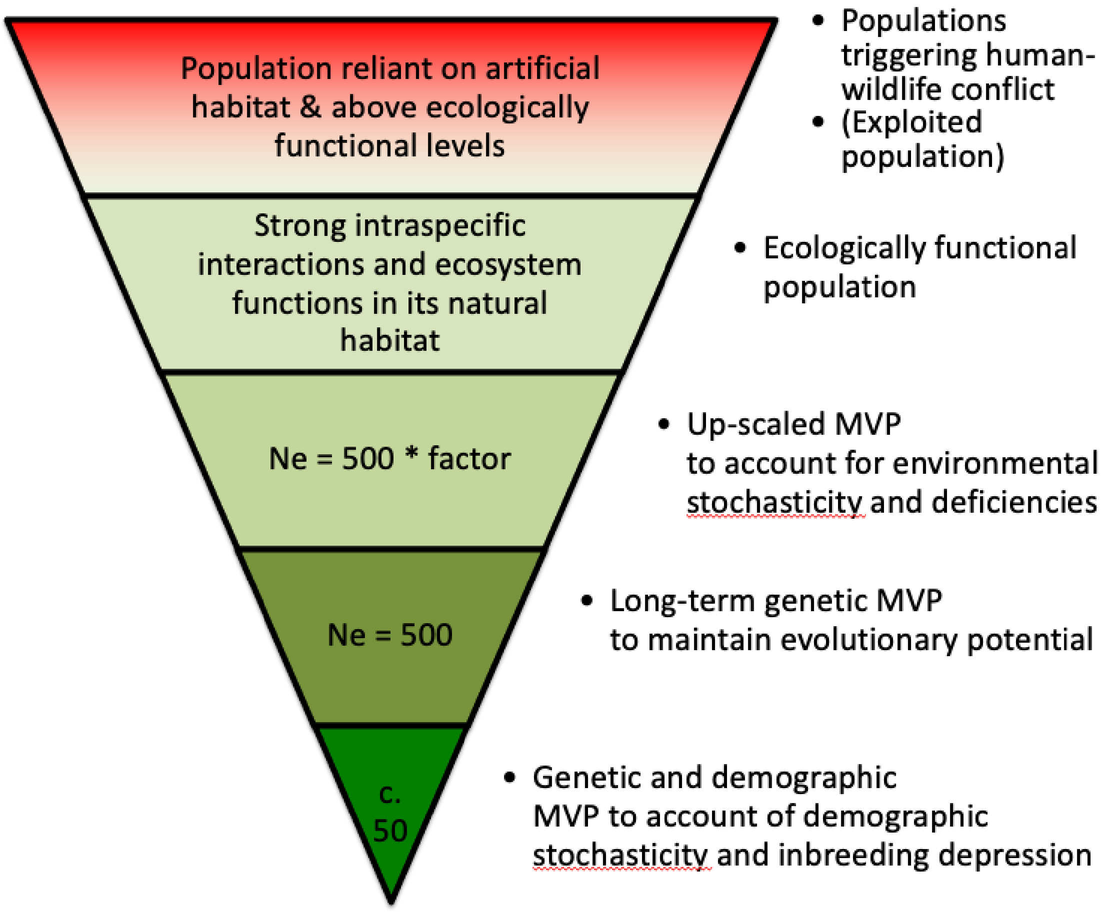

Figure 2.5. Hierarchical population levels to be considered when defining Favourable Reference Values representing increasing population sizes and distribution. The ecologically functional population level represents the level where Favourable Reference Values should be set.

3. Population structure and migratory character

The ISSMP defines three distinct flyway population of the Barnacle Goose in line with Table 1 in Annex 3 of AEWA, which populations are also recognised by Scott & Rose (1996) and Madsen et al. (1999):

- East Greenland/Scotland & Ireland
- Svalbard/South-west Scotland
- Russia/Germany & Netherlands

There is only limited exchange amongst these three populations, which means that immigration and emigration has negligible effect on the demography of these three populations (Black et al., 2014), but there is some gene flow amongst them although these populations are genetically differentiated (Jonker et al., 2013).

Table 18 in DG Environment (2017: p. 115) provides some guidance concerning the level at which the Favourable Reference Values should be defined depending on the migratory characteristics of the populations. It recommends setting Favourable Reference Values through the cooperation of countries where the species occurs if the individuals of the population show large, cyclic, directed movements, but set the FRVs at the level of individual countries if the population is only partially migratory.

All three populations of Barnacle Goose fall into the former category. However, the North Sea management unit can be considered being a large, more or less sedentary ‘population’, and FRVs are to be set at the national level.

To make it easier to follow the logic of the assessment, the rest of this document deals with these populations and management units separately.

4. East Greenland/Scotland & Ireland population

This population breeds only on Greenland and (more recently) on Iceland and winters only in two countries, the UK and Ireland. Therefore, it is most appropriate to define Favourable Reference Values at the flyway level for both the reproductive and non-reproductive period.

4.1 Review of key information

Genetically, this population is the most distinct from all other populations of Barnacle Goose (Jonker et al., 2013).

4.1.1 Current and past distribution

4.1.1.1 Breeding

This population breeds along the coast of East Greenland between c. 70º N and c. 79º N (see Fig. 17.4 in Ogilvie et al., 1999) and the size of the range is estimated to be around 100,000 km^2. Surveys in 2008 and 2009 (Boertmann & Nielsen, 2009; 2010) showed no change in distribution, but moulting flocks have increased (Figure 4.1). Boertmann et al. (2015) has even noted some northward expansion.

The species started breeding also on Iceland in the 1980s with breeding attempts since 1964 (Black, 1997; Ogilvie et al.,1999). Breeding numbers in Iceland have been increasing since the late 1990s, with recent numbers of up to 2,000 pairs in 2017 (K. Skarhedinsson, *pers. comm.* cited by Jensen et al., 2018).

The available limited data from the breeding range indicates no major deficiencies in distribution (Ogilvie et al., 1999; Boertmann et al., 2015). The known colonies of the species are dispersed across the entire breeding range. The species faces little actual threats on its breeding grounds.

Large concentrations of non-breeding Barnacle Geese gather to moult flight feathers in Jameson Land in the southern-most areas of the East Greenland breeding range (Madsen et al., 1984).

4.1.1.2 Passage

During spring-migration the population uses staging areas in the northern valleys of Iceland (Percival and Percival, 1997), while in autumn they are found mainly in south-east Iceland (Ogilvie et al., 1999). According to two counts in 1987 and 1994, c. 70-75% of the estimated total population at that time has concentrated at the main staging areas at Húnavatnssýsla and Skagafjarðarýsla (cited by Ogilive et al., 1999). As Figure 4.2 shows, the distribution has expanded since then although Barnacle Geese still concentrate in the north of Iceland.

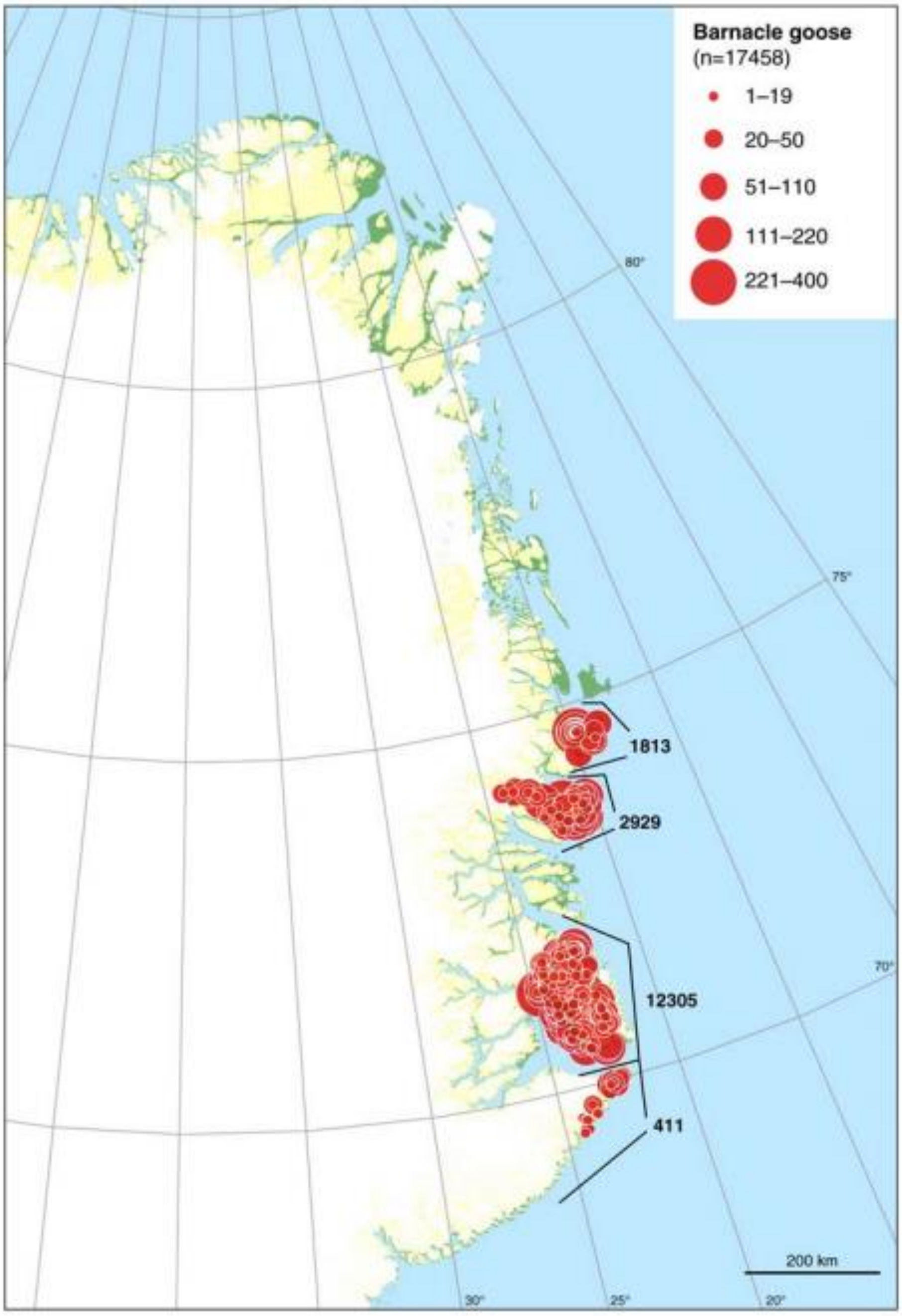

Figure 4.1. Distribution of Barnacle Geese observed during all surveys in July and August 2009. (Source: Boertmann & Nielsen, 2010)

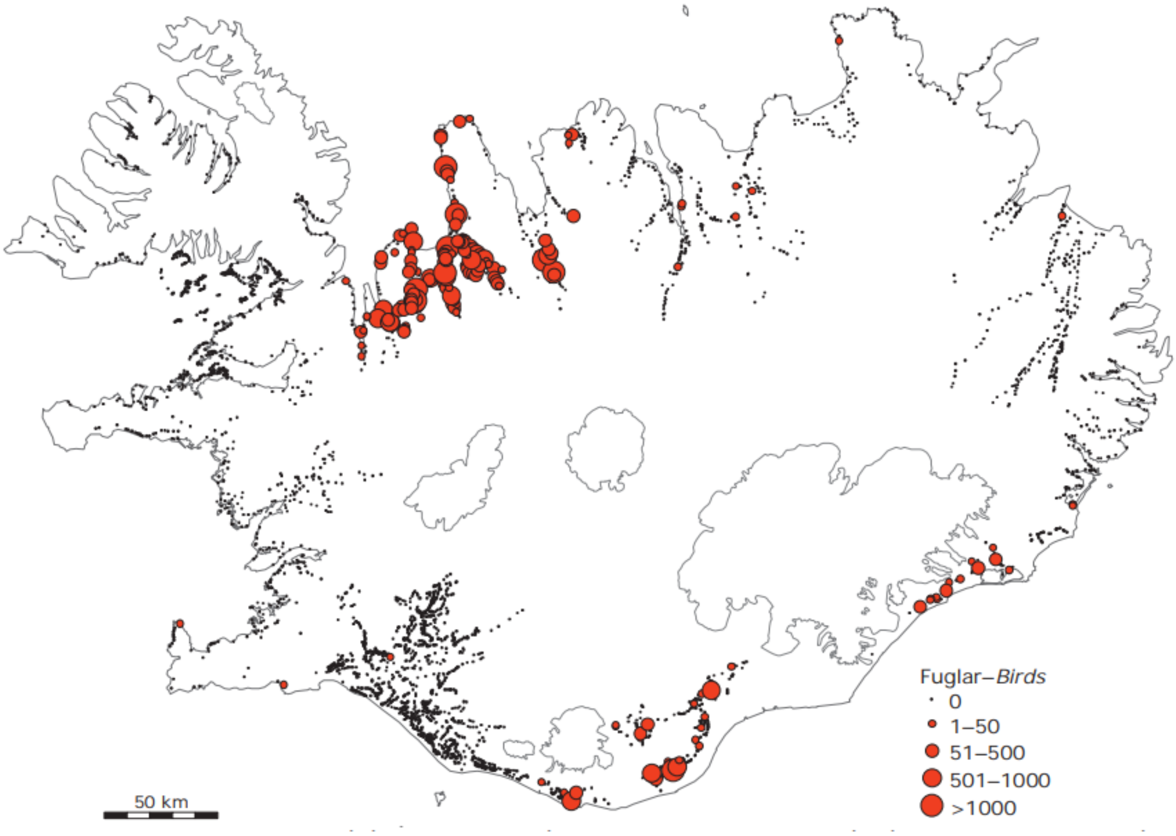

Figure 4.2. Number and distribution of Barnacle Geese in the lowlands of Iceland c. 20 April 2012. The survey did not record this species in a part of Skagafjörður in N-Iceland. A total of 43,948 birds were observed (from Halldór Walter Stefánsson, 2016 in Skarphéðinsson et al., 2016).

4.1.1.3 Wintering

The winter destinations include western Ireland and north and west Scotland, with the island of Islay as the principal winter resort (Ogilvie et al., 1999). The remaining birds scattered in relatively small numbers across many small (traditional) island sites (Jensen et al., 2018).

In Ireland the main part of the range remained largely unchanged along the west coast with only the most southerly haunt of Blasket has been abandoned, while along the east coast two haunts (holding some 600 birds in the 1940s and 1950s) and some others holding small flocks also declining.

In the meantime, there have been only minor changes in Scotland since the aerial surveys have started in 1959. This includes an extension north and east to Orkney and shifted from some of the smaller abandoned islands to larger islands with more intensive agriculture (Ogilvie et al., 1999). In general, the number of occupied sites has increased from c. 50 to around 70 from the start of the surveys to 2012 (Mitchell & Hall, 2013), which indicates some expansion of the wintering range (Figure 4.5).

There is no indication that the species has ever had a larger wintering distribution in the last two-three centuries and no deficiencies can be detected in this respect either. The main reasons for listing the species on Annex I of the EU Birds Directive was its decline in the first half of the 20th century, its small population size at the time when the Directive was negotiated and its high concentration on a small number of sites. According to Mitchell & Hall (2013) only seven sites (Islay, Tiree, Coll, Oronsay/Colonsay, South Walls, Inishkea Islands and Ballintemple/Lissadell) hold the majority of geese (75.5% of the total in 2013) with Islay alone holding 55.7% of the population. Islay has even supported an increasing proportion of the increasing flyway population until 2008. Since then, its share has dropped due to the control measures. Mitchell & Hall (2013) also noted that numbers at the above mentioned seven key sites have increased more than six-fold since 1959 while total numbers are still increasing at a lower rate outside these areas (less than a three-fold increase). However, they also report an increase in the number of occupied sites during the same period and the population does not meet the criterion for concentration on a small number of sites since the 2013 census.

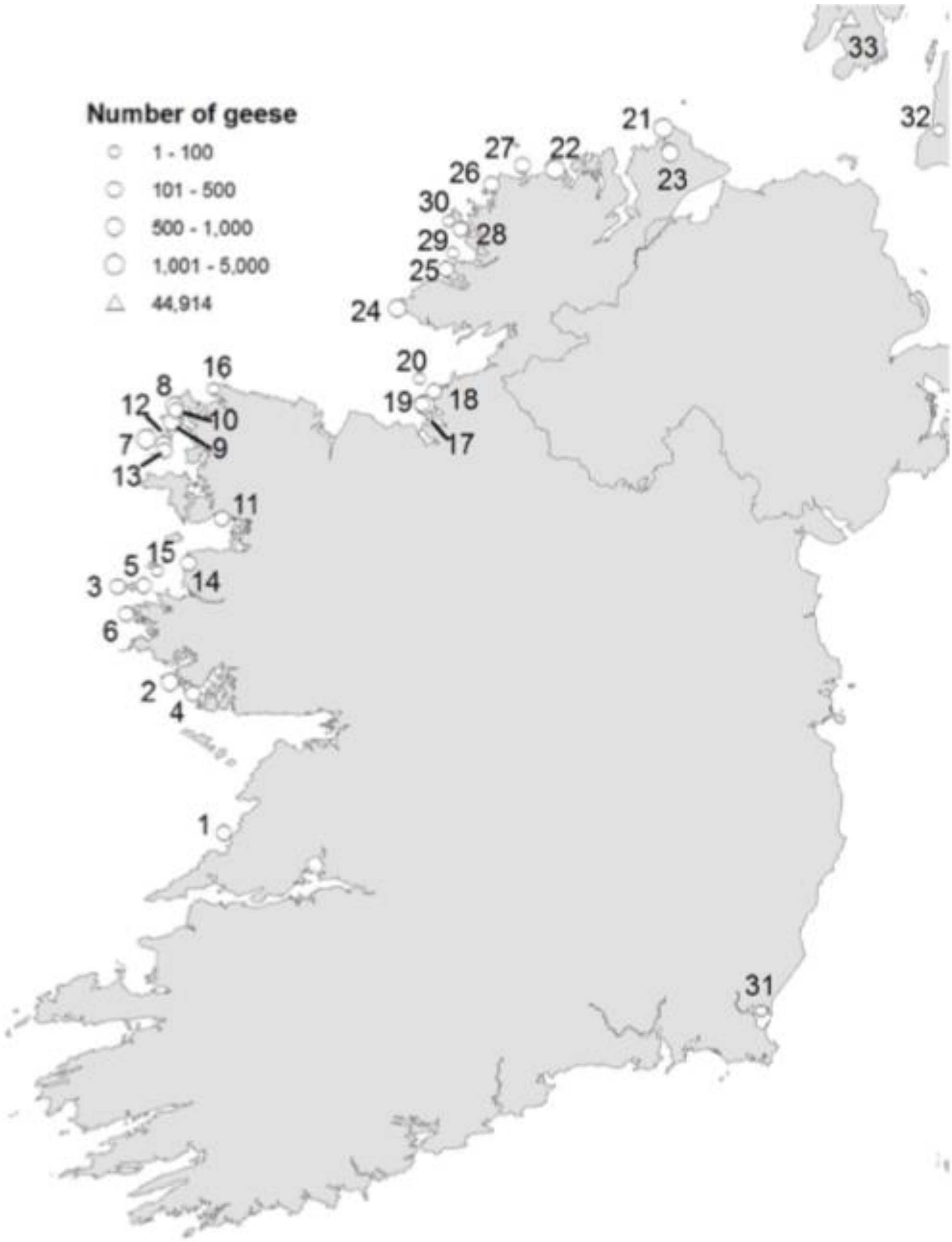

Figure 4.3. Sites in Ireland holding Greenland Barnacle Geese in March 2013 (source: Mitchell & Hall, 2013)

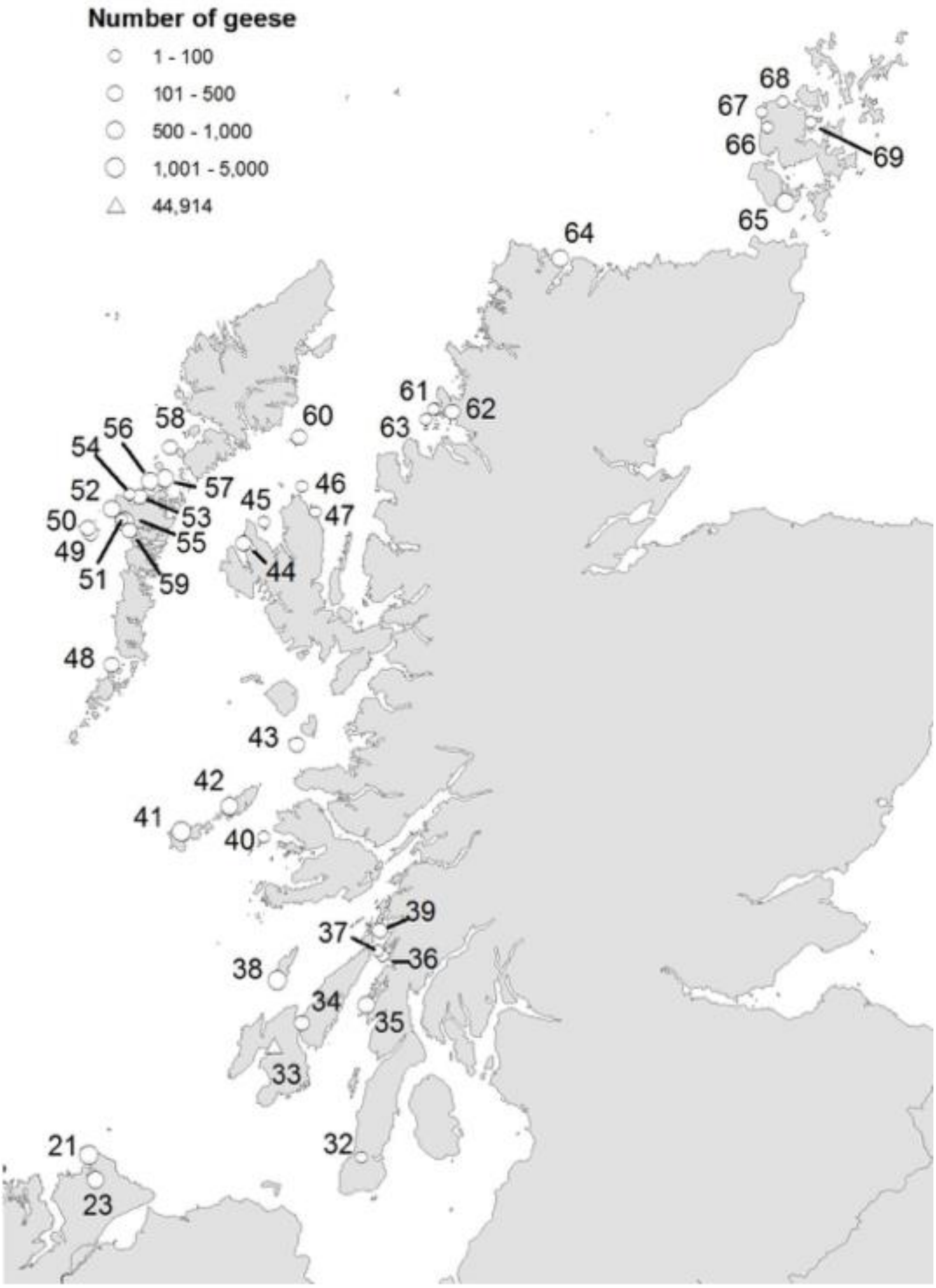

Figure 4.4. Sites in Scotland holding Greenland Barnacle Geese in March 2013 (source: Mitchell & Hall, 2013)

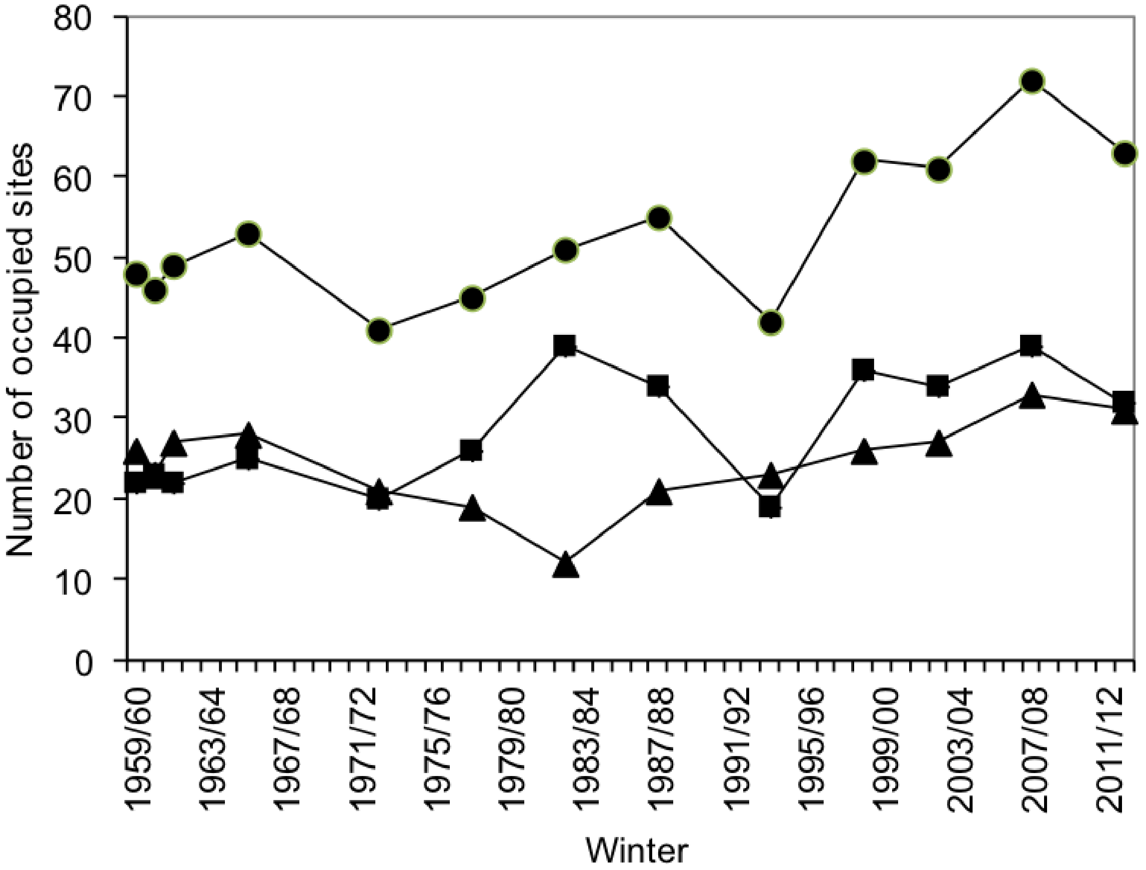

Figure 4.5. Number of sites occupied by Greenland Barnacle Geese (> 10 birds) in spring censuses 1959/60– 2012/13 (● Scotland and Ireland, ■ Scotland, ▲ Ireland). (Source: Mitchell & Hall 2013)

4.1.2 Habitat availability

4.1.2.1 Breeding habitat

This population breeds colonially mainly on cliff ledges above coastal plains or on the side of valleys in Greenland. It selects wetland areas in the high Arctic tundra for feeding and rearing young. These areas are still in natural conditions with little direct human interference. It is expected that the availability of predator free areas will ultimately limit the opportunity of forming new colonies and further population growth within colonies will be limited by local carrying capacity of the feeding areas. However, the observed expansion of breeding birds to Iceland suggests that the population is able to colonise suitable areas even outside of its traditional breeding range and even in the opposite direction to the northward shift that could be expected as a consequence of climate change. The breeding habitat is likely to increase as a consequence of the increase of snow-free areas and earlier spring in Greenland.

4.1.2.2 Staging areas

On spring staging areas, it selects improved agricultural pastures for feeding and it uses wet river meadows to a lesser extent (Ogilvie et al., 1999). Safe roosting sites on wetlands also form part of the habitat requirements of the species. Ultimately, the carrying capacity of spring staging areas may limit population growth through influencing breeding success through carry-over effects, but the continued growth of the population indicates that this is not yet the case at current population levels. However, increasing presence of scaring devices already between 1987 and 1994 indicate the increase of agricultural conflict in Iceland (Ogilvie, 1999), already at the level of the population increasing from around 30,000 individuals to c. 50,000. The carrying capacity might also further increase as a result of intensification of the pastures.

4.1.2.3 Wintering habitats

On the wintering grounds, its traditional feeding areas included unmanaged grasslands on salt-affected coastal and island pastures, but on Islay it selects for newly reseeded Italian Ryegrass pastures and fertilised fields as well as it feeds on barley and oat stubbles (Ogilvie et al., 1999). Barnacle Geese rarely travel more than 5 km from their roost to feed, with roosts occurring on saltmarshes and intertidal sandbanks as well as on small offshore islands. Barnacle Geese are predominantly faithful to specific wintering areas, but there is some movement between sites. Detailed studies of the movement of individually marked birds on Islay have shown that birds are highly site faithful and both UK SPA reviews have concluded that due to these characteristics, together with localised distribution, the site-based conservation is a particularly appropriate conservation strategy, especially if combined with targeted management of grasslands within sites (Stroud et al., 2016).

4.1.3. Past and current population sizes

Historical population sizes are not known with any certainty, but the population was probably never very large. According to Owen (1976), Barnacle Goose was originally restricted to exposed islands and headlands on the west coast of Ireland, the Hebrides and mainland of northern Scotland where short *Plantago*-swards would have been maintained by exposure and sea-spray. Machair has also provided good feeding opportunities. The advance of farming has possibly enhanced the extent of suitable habitats and grazed saltmarshes have increased in importance while the importance of the outer islands has declined.

The population is monitored through five-yearly full aerial censuses at the wintering grounds and through multiple counts annually at key sites such as Islay. No regular and comprehensive monitoring takes place at the breeding or staging grounds. Therefore, the population development can be assessed only based on the data from the wintering surveys.

The latest comprehensive survey in 2018 has produced a population estimate of 72,162 individuals, which represents a 10.5% decrease on the last survey in 2013 (80,670 individuals). In the longer term, the population has increased to the current levels from 8,300 birds in 1959 (see Figure 7 in Jensen et al., 2018). The population size was estimated at 33,815 in 1978 (Ogilvie, 1983), i.e. around the time the Birds Directive entered into force and at 53,823 in 1999, i.e. around the time the AEWA entered into force (Worden et al., 2004). Ogilvie et al. (1999: p. 254) stated that the conservation status of the population "*can now fairly be described as of favourable*" although the concentration of more than half of the birds on a single site, Islay, was still a concern. One may argue that such a concentration might have been reinforced by the sympathetic management both in the reserves and on farms supported by the local goose management scheme.

4.1.4 Trends, major shifts, pressures

Boyd (1960) notes that 6,000 - 10,000 birds were found on Islay nearly every winter since 1954/55 and the numbers have increased to that level over the preceding 30 years. He also noted that the numbers counted in Ireland in 1959 were in the same order as at any time in the previous 10 years. Cabot (1973) has also reported long term stability in Ireland.

Since the first census, the population has grown at an annual rate of 3.6% during the period of 1959-2013 (Jensen et al., 2018). The Islay subpopulation (which represents over half of the entire flyway population according to Mitchell & Hall, 2013) has stabilised around 40,000 individuals as the result of population control on the island, including possible displacement to other areas. Although, the overall population has continued growing according to the 2013 census (showing strong increases in other areas), the 2018 census has produced a lower estimate than in 2013 (see Figure 4.6).

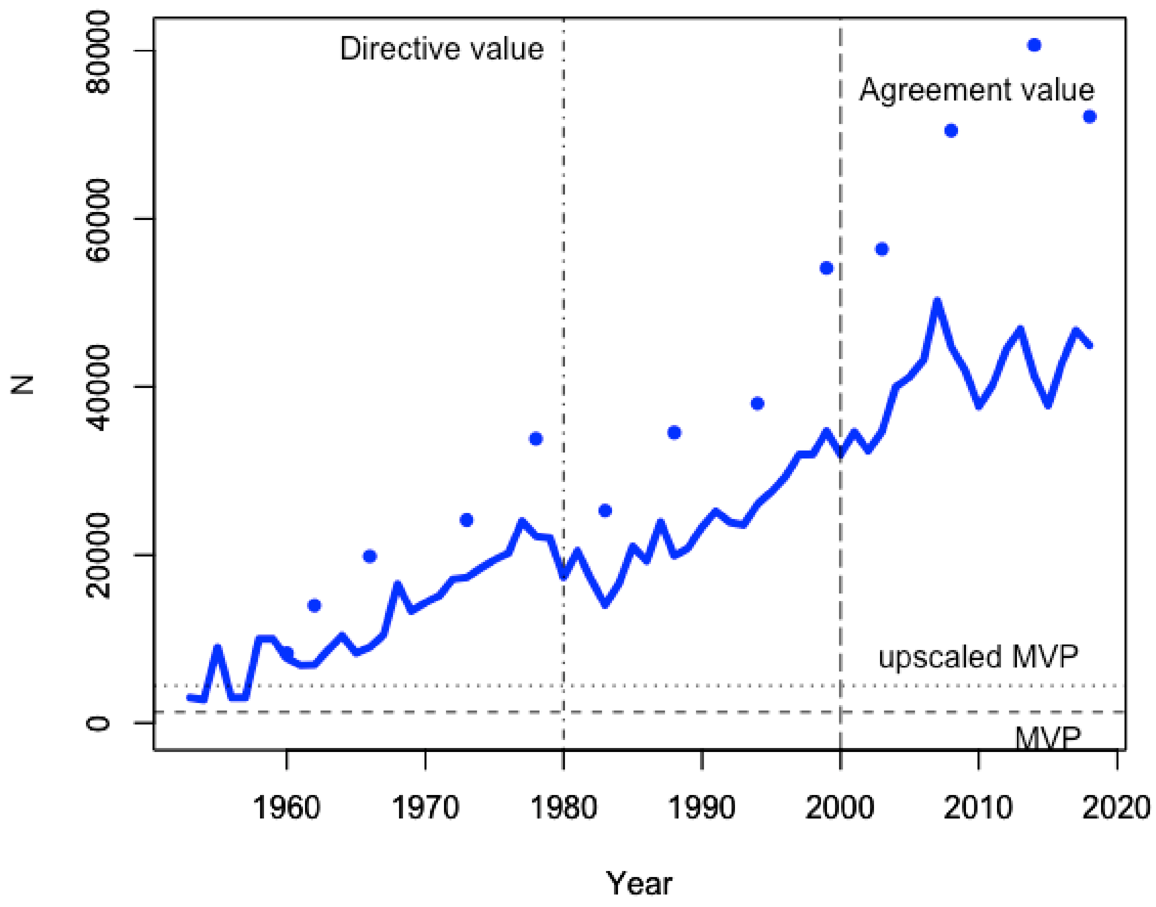

Figure 4.6. The development of the Greenland/Scotland & Ireland population of the Barnacle Goose with various reference values. Blue points represent the total population based on the results of the five-yearly international census, the blue line represents the annual counts of the Islay subpopulation.

This population has been exposed to changes in shooting and this has been reflected also in the population's trajectory. Ogilvie et al. (1999: p. 252) reported a decline in the Islay population in response to increased shooting (1,500 shot out of 13,000-18,000 individuals) around 1980 and recovery of the population growth after the number of birds shot was reduced again. They also speculated that the preference of the geese away from Islay to uninhabited islands was, at least partly, due to shooting and the gradual movement of some of these flocks to managed pastures on inhabited islands was a response to the total protection provided by the Wildlife and Countryside Act introduced in 1981. The population over the most recent census period has declined, probably as a result of increased control on Islay and hunting in Iceland, as well as recent low reproductive success (Mitchell & Hall, 2018).

Mitchell & Hall (2013) reported a strong overall decline in juvenile ratio since the late 1960s from over 15% to around 5% in recent years, but the mean brood size has declined more modestly from 2.5 around 2 young per family. A longer series of years with poor breeding has been observed in the 2010s (WWT, 2019). These all might indicate that the population is approaching the carrying capacity of its habitats. Trinder (2014a) has also found long-term negative trends both in the proportion of juveniles and proportion of breeding adults on

Islay. However, he detected non-significant positive trends for the 1991-2011 period in both parameters. The mean brood size has not shown any trends in relation to year or population size. He concluded that the combination of survival and reproduction rates was still sufficient to maintain the population growth. He also did not find any evidence of density dependent regulation in the Islay population.

A number of threat assessments have been carried out for this population and they often differ in their conclusions. Deinet et al. (2017) assessed the threats to the species using the IUCN Red List threat categories and assessment scheme. The following threats are relevant to the population with their threat assessment:

- Hunting and collecting (Historically High);
- Persecution (High): damage control;
- Agricultural abandonment (High): northwest Scotland and Ireland;
- Human intrusions and disturbance (Medium): Disturbance due to oil exploration in Greenland;
- Problematic native species (Medium): reintroduction of White-tailed Eagle in parts of Scotland may have an impact on population dynamics through disturbance and/or predation events;
- Renewable energy (Unknown): potential impact of wind farms planned or operational onshore in Scotland.

However, this assessment probably exaggerates the importance of the threats mentioned above. For example, scoring persecution as a high impact threat would require that this threat either affects the majority (50 - 90%) of the population and causes very rapid declines (> 30% in 10 years or three generations) or it affects the whole population (> 90%) and causes rapid (20 - 30% declines in three generations) if it concerns a continuing threat. This is clearly not the case when the population is increasing as the East Greenland/Scotland & Ireland population does. If the assessment concerns a threat expected to happen in the short-term, only a threat affecting the whole population and causing very rapid decline would qualify as high impact threat. Considering that c. 20% of the population is in Ireland and that the population model used to assess the impacts of the population management on Islay does not predict such declines (Trinder, 2014a), the high impact threat for population control by Deinet et al. (2017) is not realistic based on the available figures.

The European Red List Assessment for the species (BirdLife International, 2015) identified only the first two threats but it has assessed the persecution only as a low threat and mentions climate change (habitat shifting & alteration) only as an unknown threat.

The Species Fact Sheet for Barnacle Goose on the BirdLife International Data Zone (BirdLife International, 2017) mentions only climate change as a future threat with unknown impact.

Jensen et al. (2018) listed 22 threats in Table 6 based on a questionnaire survey of the Range States but assessed most of them as either negligible current threats (mainly because of the small proportion of the population affected) or as threats with unknown impact using also the IUCN Red List threat assessment methodology. Only hunting (intentional use, the species is taken as the target) and persecution/control were assessed as low impact threats. The UK's assessment of Pressures and Threats for this population in its 2013-2018 Birds Directive Article 12 report found no Pressures and only one Threat (A06 - Abandonment of pastoral systems, lack of grazing) which was assessed as low impact and so was not reported to the EU (Stroud, *in litt.*).

The main shifts that can be observed in the population during its known history can be summarised as follows:

- Expansion of the breeding range to Iceland (and possibly also to the Faroe Islands further south if the breeding population originates from the Greenland population);
- Shifting distribution from some traditional haunts on small abandoned islands to areas with more intensive agriculture stipulated by the combined effect of deteriorating feeding conditions and hunting ban;

- Abandonment of some haunts on the southern edge of the wintering range and expansion of the range on the northeastern one;
- Declining juvenile ratio in the long-term which may indicate increasing density dependent population regulation, but this is not yet statistically significant and continued population growth indicates that recruitment is sufficient for the maintenance of the population.

4.2 Setting Favourable Reference Values

4.2.1 Favourable Reference Population

The Directive Value was 33,815 in 1978 and the Agreement Value was 53,823 in 1999. Both of these figures represent a continued increase since 1959/60 when censuses have started (Figure 4.6). However, it is known that the population has reached a historic low in the 1940s. The reference-based approach alone cannot be used because there is no historical reference concerning the population levels in the last two-three centuries. Therefore, a population-based assessment is necessary to define the Minimum Viable Population with an appropriate scaling factor.

Despite the fact that the East Greenland/Scotland & Ireland population of Barnacle Goose has been monitored since 1959, the data quality is insufficient to produce a Population Viability Analysis for the entire population. Demographic PVAs were produced for the Islay subpopulation (Trinder, 2005; Trinder, 2014a). Trinder (2005) has produced both density-dependent and density-independent models. The latter has predicted that the population will reach 100,000 individuals in 25 years while the former has predicted stabilization of the population around 34,000. In reality, the numbers fluctuated between 38,000 and 49,000 during the period of 2006/07-2017/18 on Islay (Mitchell & Hall, 2018), i.e. the model has failed to predict the effect of density dependence correctly. The probability that the population declines below a quasi-extinction threshold of 10,000 individuals in the next 25 years was less than 0.003 and even less for the quasi-extinction threshold of 1,000 individuals (but this is not specified in the report).

Trinder (2014a) has produced an updated density-independent model which concluded that any population decline after 25 years was less than 0.1% assuming no shooting on Islay.

Although these PVAs have not specified a Minimum Viable Population, they show that there is very little risk of population decline due to demographic or environmental stochasticity with the demographic characteristics of the population at that time (including the contemporary level of shooting throughout the flyway).

As described in Section 2.4.1.2.4, a multiplier factor was estimated based on population trends to upscale the Minimum Viable Population estimate. Figure 4.7 shows the changes in the annual population growth rates for the period of 1959 to 2012.

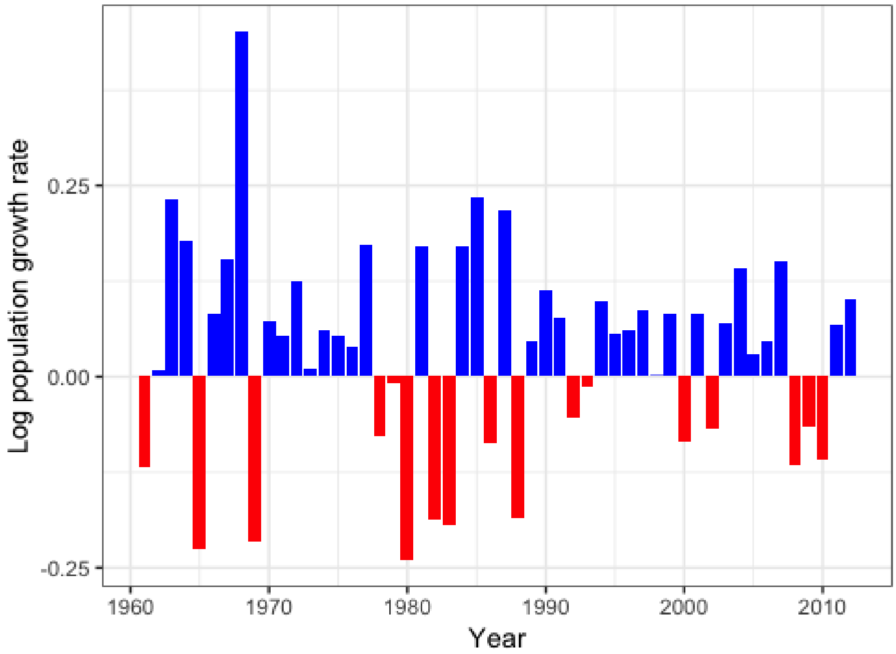

Figure 4.7. Annual population growth rates in the Islay 'subpopulation' from 1959 to 2012.

The arithmetic mean of the log population growth rate (**μ**) is estimated at 3.3%, which is slightly higher than estimated in Jensen et al. (2018). The variance of the log population growth rate (**σ^2**) is estimated as 0.0185.

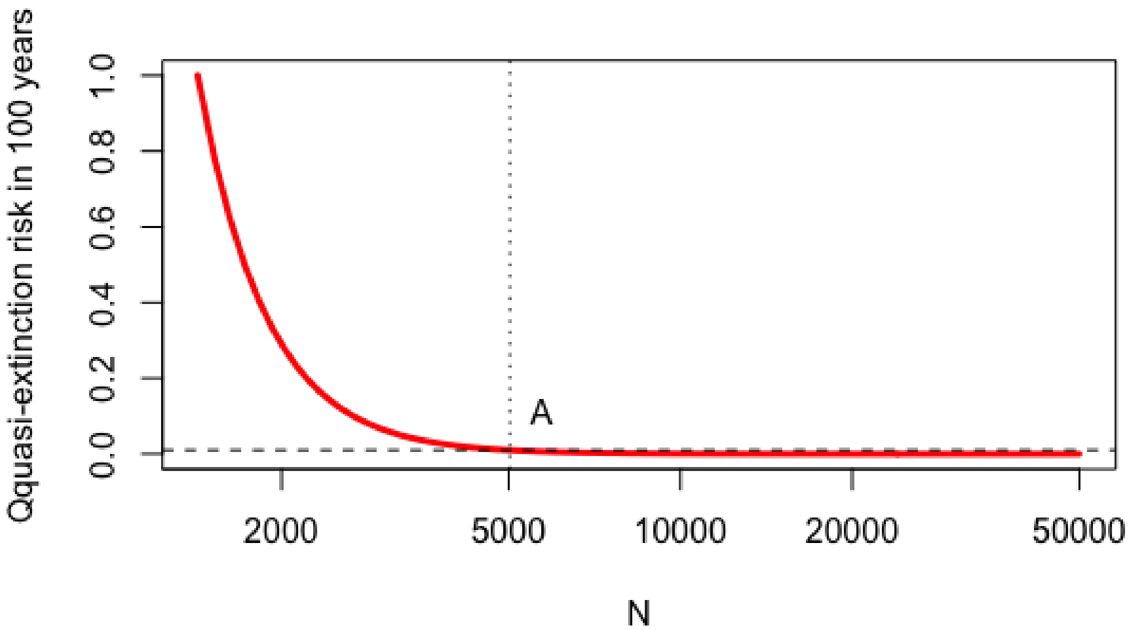

Figure 4.8. The cumulative probability of quasi-extinction risk in 100 years in relation to population size above 1,426 individuals. Point "A" represents the population level where the quasi-extinction risk in 100 years drops below 1%.

Figure 4.8 shows that the extinction risk declines very rapidly and drops below 1% at a population level of 5,026 individuals, which means that a multiplier factor of 3.52 is necessary to upscale the genetic MVP to a level where the extinction risk is minimised. It also shows that further increases in population size would lead to no discernable difference in extinction risk.

The Directive Value is 6.7-times, while the Agreement Value 10.7-times higher than the up-scaled MVP, i.e. both reference values are much larger. In accordance with the decision key in Section 2.4.1.3, it is proposed to define the Favourable Reference Population around the level of the Agreement Value at 54,000 individuals. This population level was already 1.6-times larger than the Directive Value.

The proposed population level meets the requirements of an ecologically self-sustaining population (Redford et al., 2011) because it has several redundant local populations across a range of ecological settings both at the breeding (cliffs, valleys, islands), staging (semi-natural and more intensively managed pastures) and wintering areas (small offshore islands to larger islands with managed grasslands). This population level also meets the requirements of ecologically viable (Tear et al., 2005) or ecologically functional (Sanderson, 2006) population concepts because it maintains critical behavioural, ecological and genetic interactions. At that level the population has already showed normal behaviour (formed large colonies and flocks, had strong competition, but still had a lower pressure for dispersion), it has played an important grazing function both on the tundra and on the saltmarshes, it has served as an important prey to predators in the Arctic. However, that population level was less reliant on intensively managed agricultural habitats than the current population size. It has also represented a lower risk of damaging the Arctic tundra vegetation and increasing nutrient loads of aquatic ecosystems.

4.2.2 Favourable Reference Range

It follows from the definition of the Favourable Conservation Status (i.e. "… the range of the migratory species is neither currently being reduced …") that Favourable Reference Range cannot be smaller than the range at the time of setting FRR.

The current range approaches the historic range of the species (Ogilvie, 1999) as well as the Directive and Agreement Values, which are all the same as no net range loss has been reported. In comparison to a more 'natural' status, the range might have even increased after the deforestation of the British Isles (Owen, 1976) and the natural expansion of the breeding range to Iceland.

The assessment of the Favourable Reference Population has not identified any deficiency in the distribution of the species in the breeding, staging and wintering areas that could be addressed by expanding the species range. Therefore, no need for the expansion of the range can be identified.

4.2.3 Favourable Reference Habitat

No special assessment of the habitat extent and quality of breeding and staging habitats has been conducted yet in Greenland and Iceland. However, it can be deduced from the continued growth of the population that there is sufficient breeding and staging habitat to sustain the population even at current levels. The proportion of successful breeders and juvenile proportion is expected to further decline in the population as it is approaching the carrying capacity of the habitat but this is a normal ecological phenomena and the population already exhibits characteristics of an ecologically functional population.

Madsen et al. (2011) showed that the carrying capacity at Jameson Land, Greenland, has increased substantially as a result of advancement of spring between 1982-1984 and 2008. Increased goose numbers have led to significant increase in dead vegetation, open spots and changes in vegetation composition, but the effect is still more subtle than the effect reported from La Perouse Bay in the Hudson Bay, Canada, where foraging Lesser Snow Geese (*Anser c. caerulescens*) have caused a massive and large-scale degradation of salt marshes.

The 2016 SPA review has concluded that contemporary SPA coverage of numbers and distribution is sufficient in the UK, and there are no other factors suggesting the need to revise the previously identified suite of SPAs for the population. However, consideration of the need for and provision of, additional conservation measures is required (Stroud et al., 2016).

The extent and quality of the wintering habitats have increased in the long-term and it is at least stable in the short-term resulting from the general practices in contemporary dairy and sheep farming that creates favourable conditions for the Barnacle Goose, the past acquisition of reserves by NGOs on Islay and the Goose Management Schemes combined with the protection of key roosting and feeding sites as SPAs.

Table 4.1 Evaluation matrix

	Directive Value	**Agreement Value**	**Current Value (2013-2018 period)**
1. Is the population larger than the up-scaled long-term genetic MVP to maintain evolutionary potential at this level?	Yes, 6.7- times	Yes, 10.7- times	Yes, 14.4- times
2.a. Does it have redundant populations across a representative range of ecological settings at this level?	Yes	Yes	Yes
2.b. Is the population genetically robust?	Yes	Yes	Yes
3. Does the population has strong intra- and inter-specific interactions in its natural ecosystem at this level?	Yes	Yes	Yes
4. Is this population level reliant on artificial habitat and is it above ecologically functional level?	Yes, to some extent on staging and wintering	Yes, increasingly at both staging and wintering	Yes, even more at both staging and wintering
5. Does the population have an unnatural impact on other species and the ecosystem at this level?	Possibly not strong	Some on Arctic tundra	Some more on Arctic tundra

5. Svalbard/South-west Scotland population

5.1 Review of key information

This population is genetically closer to the Russian population than to the one breeding in Greenland, but it is genetically distinct (Jonker et al., 2013).

5.1.1 Current and past distribution

5.1.1.1 Breeding

The Svalbard/South-west Scotland population of Barnacle Goose breeds and moults in Svalbard, mainly on the west coast of Spitsbergen. Traditionally, nests were on cliffs in the large valleys, but offshore islands became more important as the population has grown (Black et al., 1999). The number of colonies has increased from 5 prior to1960s, to 11 in the1960s, 37 in the 1980s, about 50 in the 1990s and the geese have colonised also the eastern shore of the island (Figure 5.1).

The population occurs in 31 50x50 kilometres atlas blocks according to the provisional maps of the second European Breeding Bird Atlas EBBA2 (European Bird Census Council, *in prep.*). Based on this resolution, the extent of the breeding range is estimated at 77,500 km^2. Based on the EBBA2 data further range expansion can be detected in particular on the Edge Island and the population has reached the Kongsoya Island.

5.1.1.2 Passage

The Bjørnøya island is the only staging area on autumn migration. Birds only stop for short time here as the migration between Svalbard and the wintering area at Solway Firth in Scotland is completed in 61 hours on average.

During spring the population gathers in its entirety on Rockcliffe Marsh, Cumbria, before moving to the breeding grounds via the west coast of Norway, mostly staging on small coastal islands in the Helgeland and Vesterålen regions although some birds, more recently, have tended to bypass these areas to travel straight to the breeding grounds from the main wintering area on the Solway Firth, UK (Jensen et al., 2018). In Norway, the geese may utilise vegetation on more than half of the 10,000 islands. Islands furthest from the mainland used to be the strongholds for the geese, but since the 1980s they have colonised larger islands to the north and east closer to the mainland. The northerly Vesterålen attracted Barnacle Geese from the end of the 1990s onwards. In this region the geese feed on the narrow strips of land between the coast and higher grounds that are used by local farmers as pastures and hay fields (Figure 5.2; Black et al., 2014).

5.1.1.3 Wintering

The wintering range is situated along the shores of the Solway Firth estuary and extends 25 km from the northernmost to the southernmost haunts and 50 km from the westernmost to easternmost haunts. The total area of 1,250 km^2 is rather small compared to winter ranges for other goose populations. The geese use a small part of this range since foraging and roosting are concentrated in six areas (Figure 5.3; Black et al., 2014).

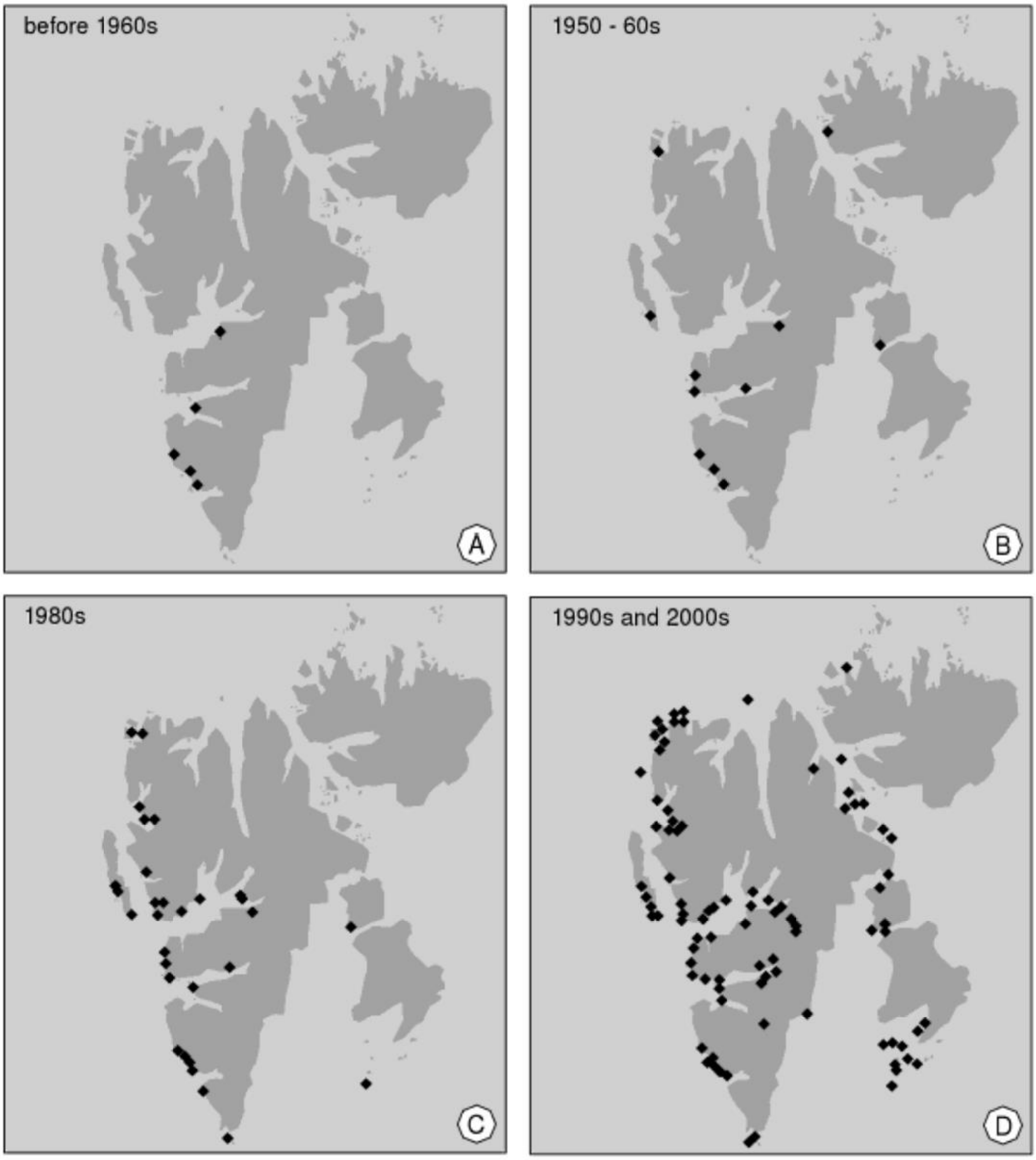

Figure 5.1. Distribution of the Barnacle Goose colonies in Svalbard (A) before 1960, (B) during the 1950s–1960s, (C) 1980s and (D) 1990s and 2000s. (Source: Black et al., 2014).

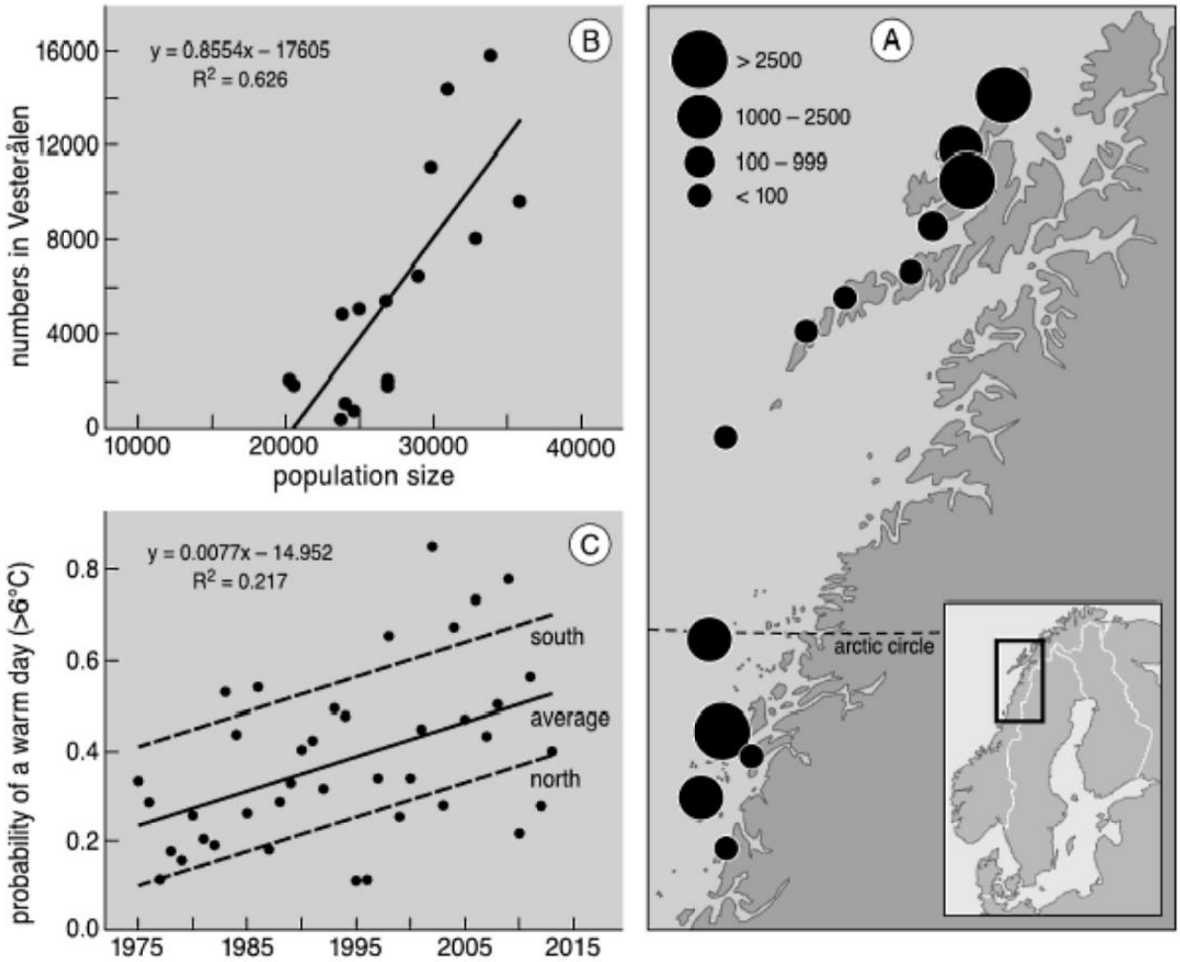

Figure 5.2. Distribution of Barnacle Geese in spring staging areas on the Norwegian coast. Indicated is the distribution of the birds (A). (B) Increasing numbers reaching the northernmost Vesterålen region in relation to the size of the flyway population. (C) The trend in increasing temperatures during the goose staging period from 1975 onwards, portrayed here as the probability of a day warmer than the lower threshold of plant growth (6°C). Dashed lines indicate trends for a northern (69°N) station in Vesterålen and a southern (65°N) station close to Helgeland. Numbers reaching carrying capacity in one area and a warming climate provided an opportunity for the geese to expand their range. (Source: Black et al., 2014).

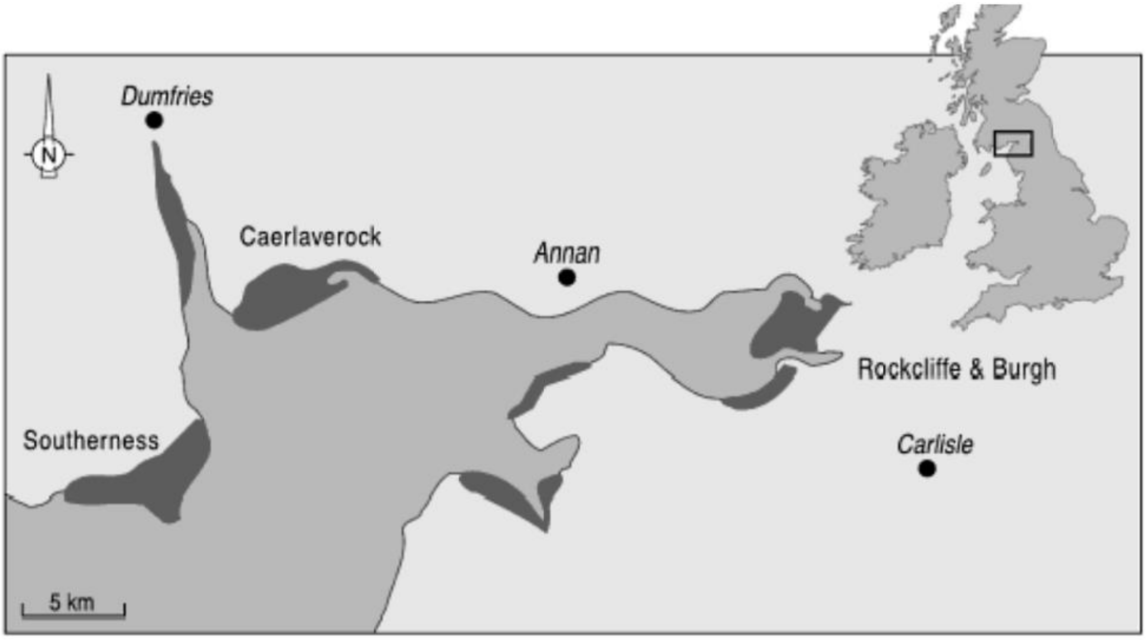

Figure 5.3. Key Barnacle Goose sites on the Solway Firth estuary. (Source: Black et al., 2014).

5.1.2 Habitat availability

5.1.2.1 Breeding habitat

On Svalbard, geese make use of vegetated areas on headlands, around the perimeters of streams and lakes and also exploit habitats near large cliffs with seabird colonies. At the time of arrival, south facing slopes on the coast or sheltered inland valleys offer some feeding opportunities before the onset of breeding (Black et. al., 2014). Traditionally, nests were largely on cliffs, but in recent decades offshore islands became more important and only 6.5% of the nests were on cliffs (Owen & Black, 1999). Moss-meadows around inland lakes and pools are particularly important habitats for geese but these are the last vegetation zones to appear as the snow cover melts (Black et al., 2014). No moult migration is recorded. Immature geese tend to return to their natal sites and concentrations around the various colonies tend to represent the breeding, non-breeding and immature birds produced by those colonies and the moulting lakes are usually depleted by intensive grazing. Following the moult, they use the tundra to feed on a large variety of plants. During brood-rearing and moulting, prime moss meadows are able to support 10 geese per hectare and geese respond to inadequate food availability by shifting to the buffer habitat. Geese number in an area may reflect carrying capacity of the area, but the population increase is accommodated by occupying formerly unused areas (Black et al., 2014).

5.1.2.2 Staging habitat

On the spring staging areas, the feeding habitat and the distribution of birds has changed substantially. Helgeland has accommodated most of the birds for a long time, but its importance has declined in the 21st century. Since 1980, the birds have colonised the larger islands with cultivated grasslands closer to the mainland. This was partly due to the abandonment of the cultivation of these islands, but it was also forced by the growth of the population and enabled by the increase of temperature as shown on Figure 5.2. The more northerly Vesterålen attracted Barnacle Goose from the end of 1990s onwards. In this region, they feed on hay fields and pastures in the narrow strip between the sea and the uplands (Black et al., 2014).

5.1.2.3 Wintering habitat

At the wintering area, birds traditionally used grazed saltmarsh (merse) habitats on Solway moving onto adjacent agricultural land within five kilometres of the coast (Owen & Black, 1999). The use of cropped habitat is determined by crop-type: Ryegrass and White Clover being preferred (Black et al., 2014). Stroud et al. (2016) has concluded that this population "*has now grown much larger than the semi-natural merses can support, however well managed. It is vital for the maintenance of this population in a healthy state that the management of the croplands within the range be maintained so that sufficient suitable habitat remains*". Although the cropping of individual fields may vary between years, overall the proportion of land devoted to grass and arable crops remains very similar from year to year, with more than 90% of the area down to improved grassland.

5.1.3 Current and past population sizes

The size of the Svalbard/SW Scotland population was probably always low suspected based on lack of evidence for its presence in bioarchaeological studies on Svalbard. According to Boyd, 8,000-10,000 individuals have wintered on Solway in 1880-1890 (cited by Black et al., 2014) although Boyd has also suspected that, at that time, Solway was shared with the Greenland population (Black et al., 2014). In the early part of the 20th century, it was not rare to see flocks of 6,000 individuals, but a drastic decline has already happened by the 1930s and it was unusual to see more than 500 birds in that decade. Only 300 geese were found on Solway in 1948 (Black et al., 1999). The population size was 1,350 individuals in 1958/59, 9,050 in 1980/81 (Ogilvie, 1981), i.e. around the time when the Birds Directive came into force, c. 23,000 individuals in 2000, i.e. the Agreement Value, and 41,700 in 2016/2017 (Figure 5.4; WWT, 2018).

5.1.4 Trends, major shifts, pressures

As Figure 5.4 shows that the population has increased following the all time low population levels in 1948. It has gone through a population decline in the first half of the 20th century (Black et al., 1999). However, there is no evidence that the population size was ever much higher than 8,000 - 10,000 individuals. It has been suggested that the population has been established only a few centuries ago by birds from the Russian population (Black et al., 2014) and genetic studies indeed confirm that the Svalbard population is closer to the Russian birds than to the Greenland ones (Jonker et al., 2013).

Since the beginning of the counts in the late 1950s, the population has grown by an annual rate of 6.6%. The recovery of the population has been attributed to reduced mortality rates following protection and creation of reserves (Owen & Black, 1999). The population also illustrates well both the difficulty of estimating carrying capacity in Arctic breeding geese and its variability. Several earlier studies predicted that this population would reach an equilibrium population size based on the observed trends and the limited habitat availability. These predictions were: 8,000–12,000 geese (Owen & Norderhaug, 1977), 12,000 geese (Owen, 1984) and 10,500 geese (Rowcliffe et al., 1995), all of which have considerably under-estimated the population's actual expansion (cited by Trinder, 2005) as the latest count was 41,700 (i.e. c. 3.5-times higher than the highest estimate of carrying capacity).

Trinder (2005) has explained year-to-year variation by temperature and snow conditions on Svalbard and the trend in growth rate with the increasing population size, although could not confirm statistically significant density dependence. Although there is a strong density dependence at colony, staging and wintering site level, the population is able to overcome such limitations by expanding its range (Black et al., 2014).

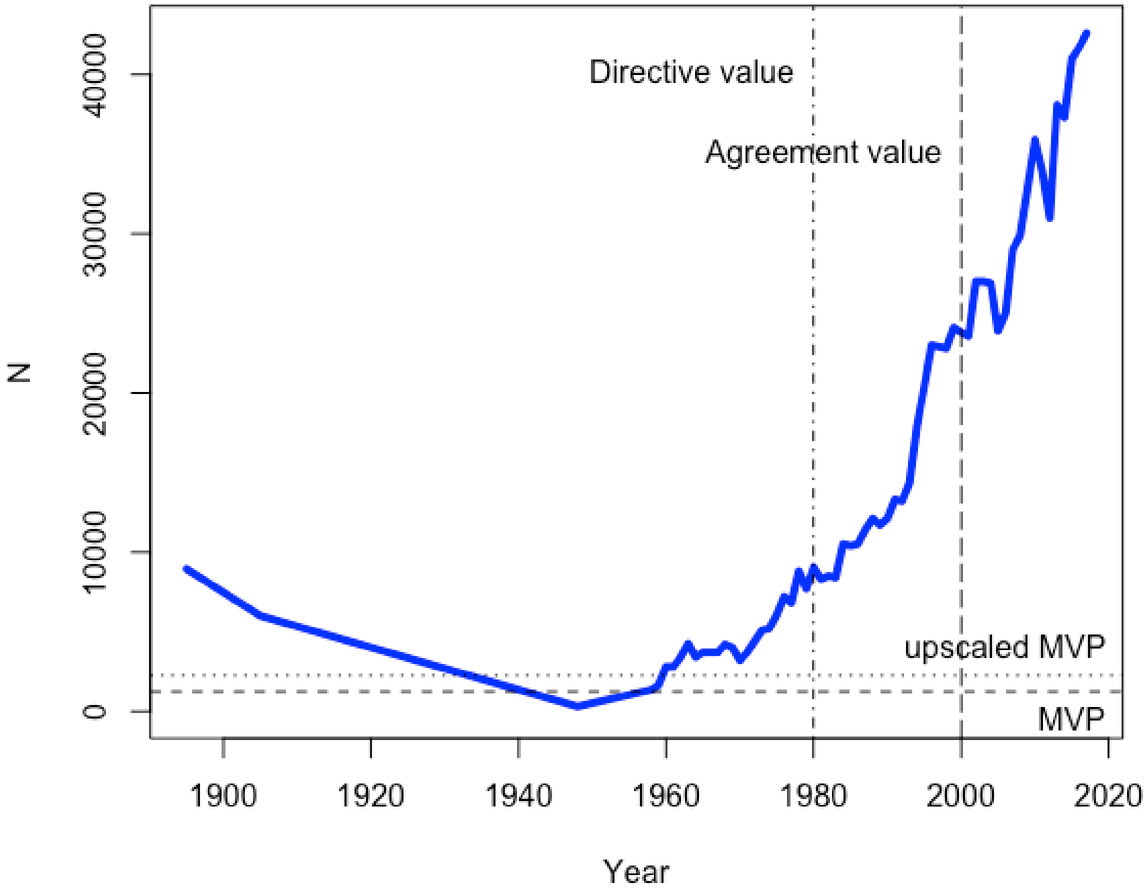

Figure 5.4. The development of the Svalbard/SW Scotland population of Barnacle Goose with various reference values.

In the long-term, the proportion of juveniles has declined from 20-50% in the 1960-1970s to well below 15% in most years after 2000. In the meantime, the brood size has also declined from typically being in the range of 2-3 goslings to 1.5-2.5 goslings (WWT, 2018) and this was associated with the decline of potential breeders as the consequence of density dependence (Black et al., 2014), but the continued growth of the population and the PVA analyses show that this decline is well compensated by increased survival rates and local density dependence does not lead to the levelling off of the population (Trinder 2005, 2014a) Black et al. (2014) shows that the number of juveniles has exceeded the number of deaths in most years even in the 2000s.

A number of threat assessments have been carried out for this population and they often differ in their conclusions. Deinet et al. (2017) has assessed the threats to the species using the IUCN Red List threat categories and assessment scheme. The following threats are mentioned for this population with their threat assessment:

- Hunting and collecting (Historically High);
- Agricultural abandonment (High): not mentioned but happened also on the islands along the Norwegian coast. However, the impact is probably not High because compensated by using other areas (Black et al., 2014), the population continues increasing and its growth has actually accelerated after colonising new staging areas in Norway;
- Renewable energy (Unknown): potential impact of wind farms in England, Scotland and Norway along migratory routes and wintering areas.

The European Red List Assessment for the species (BirdLife International, 2015) also identifies the first two threats but it has assessed the persecution only as a low threat and mentions climate change (habitat shifting & alteration) as an unknown threat.

The Species Fact Sheet for Barnacle Goose on the BirdLife International Data Zone (BirdLife International, 2017) mentions only climate change as a future threat with unknown impact.

UK's assessment of Pressures and Threats for this population in its 2013-2018 Birds Directive Article 12 report found no Pressures and only one Threat (D01 – Conflicts with wind energy) which was assessed as low impact and so was not reported to the EU (Stroud, *in litt.*).

In Table 6, Jensen et al. (2018) listed 22 threats based on a questionnaire survey of the Range States. Most of them were assessed as either negligible current threats (mainly because of the small proportion of the population affected) or whose future impact is unknown. Only problematic native species (Arctic Fox, Polar Bear) were mentioned as having low impact.

The main shifts that can be observed in the population during its known history can be summarised as follows:

- Recovery and exceeding both the known historical maximum population size and the Directive and Agreement Values;
- Expansion of the breeding range on Svalbard;
- Shifting from small extensively managed offshore islands to larger, more intensively managed farmlands at the staging areas in Norway, expansion of the staging range northwards as the result of milder climate (leading to enhanced carrying capacity);
- Increased use of non-reserve areas in the wintering range;
- Declining juvenile ratio in the long-term which may indicate increasing density dependent population regulation, but this is not yet statistically significant and continued population growth indicates that recruitment is sufficient for the maintenance of the population.

5.2 Setting Favourable Reference Values

5.2.1 Favourable Reference Population

The Directive Value was 9,050 in 1980/81 (Ogilvie, 1981) and the Agreement Value was 23,000 in 1999 (WWT, pers. comm.). Both of these figures represent a continued increase since 1958/59 when censuses have started (Figure 5.4). The population was estimated to be around c. 8,000-10,000 in 1880-1890, i.e. around the time when intensive hunting has started (Black et al., 2014). Hence, this value could be considered as the historic reference value.

The Directive Value was already within the same range as the historic reference value. This indicates that the population has probably already recovered to its size before its overexploitation by the time Birds Directive has entered into force.

A demographic Population Viability Analysis (Trinder, 2005) has predicted that the population will exceed 63,000 individuals by 2029 in the absence of density dependence, while the projection of the density dependent model was 29,000 individuals with a 95% confidence interval between 20,000 and 40,000 individuals. (The current population size in 2018 already exceeded the upper limit of this estimate). This model predicted a stochastic average annual growth rate of 5.3% (i.e. underestimated the actual population growth). The probability that the population is declining below a quasi-extinction threshold of 10,000 individuals in 25 years was zero.

An updated PVA (Trinder, 2014b) has predicted a stochastic annual growth rate of 4.9%. The probability of any population decline in 25 years in the absence of shooting is less than 0.01%, but it increases with the increase of the proportion of the population shot as the population growth is the most sensitive to adult survival.

None of these PVAs have calculated specifically a Minimum Viable Population, but have shown minimal risk of any population decline if no shooting is applied.

As described in Section 2.4.1.2.4, a multiplier factor was estimated based on population trends to upscale the genetic Minimum Viable Population estimate of 1,426 individuals. Figure 5.5 shows the changes in the annual population growth rates for the period of 1958-2017.

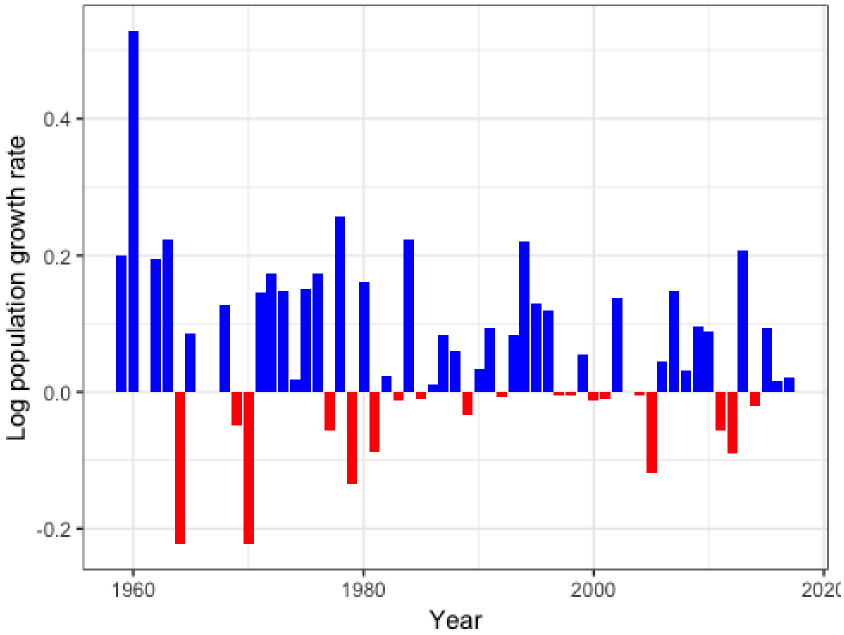

Figure 5.5. Annual population growth rates in the Svalbard/South-west Scotland population from 1958 to 2017.

The arithmetic mean of the log population growth rate (**μ**) is estimated at 5.8%, which is slightly lower than estimated in Jensen et al. (2018). The variance of the log population growth rate ($\boldsymbol{\sigma}^2$) is estimated as 0.0152.

Figure 5.6 shows that the extinction risk declines very rapidly and drops below 1% at a population level 2,626 individuals, which means that a multiplier factor of 1.84 is necessary to upscale the genetic MVP to a level where the extinction risk is minimised. It also shows that further increases in population size would lead to no discernable difference in extinction risk.

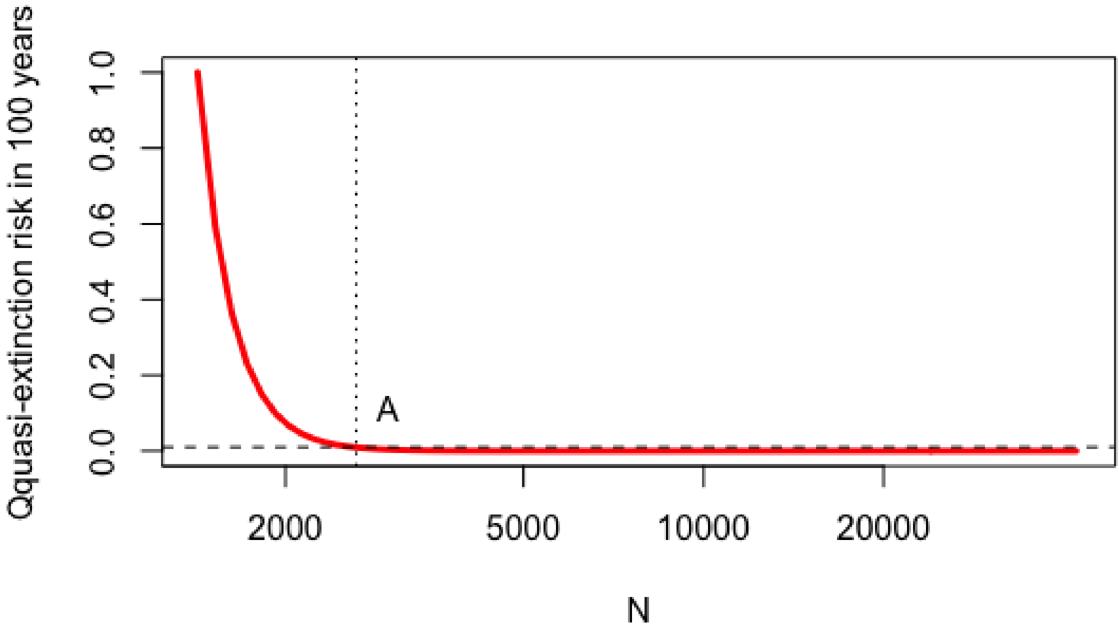

Figure 5.6. The cumulative probability of quasi-extinction risk in 100 years in relation to population size above 1,426 individuals. Point "A" represents the population level where the quasi-extinction risk in 100 years drops below 1%.

The Directive Value is 3.4-times, while the Agreement Value is 8.7-times higher than the up-scaled MVP, i.e. both reference values are much larger. The historic reference value is also similar to the Directive Value. In accordance with the decision key in Section 2.4.1.3, it could be proposed to define the Favourable Reference Population around the level of the Agreement Value at 23,000 individuals. This population level would be 2.5-times larger than the Directive Value.

However, the population could still be considered as being endangered because of its small population size according to the criteria for Category 2 of Column A of AEWA's Annex 3, Table 1. Therefore, the draft Flyway Management Plan for the Svalbard Barnacle Goose (Black, 1998) has defined the Favourable Reference Population at 25,000 individuals. This value exceeds not only the upscaled MVP but also both the Directive and the Agreement Values and it is proposed to set the FRP at this level also under the AEWA management planning process for this population.

The proposed population level meets the requirements of an ecologically self-sustaining population (Redford et al., 2011) because it has several redundant local populations across a range of ecological settings both at the breeding (cliffs, valleys, islands) and at the staging areas (semi-natural and more intensively managed pastures). It has not expanded its wintering range beyond the Solway Firth despite increasing from a few hundred birds to over 40,000. This population level also meets the requirements of ecologically viable (Tear et al., 2005) or ecologically functional (Sanderson, 2006) population concepts because it maintains critical behavioural, ecological and genetic interactions. At the proposed level the population has already showed normal behaviour (formed large colonies and flocks, had strong competition, but still had a lower pressure for dispersion), it has played an important grazing function both on the tundra and on the salt marshes, it has served as an important prey to predators in the Arctic. However, that population level was less reliant on intensively managed agricultural habitats than the current population size. It has also represented a lower risk of damaging the Arctic tundra vegetation and increasing nutrient loads of aquatic ecosystems.

This population is practically restricted to a single wintering SPA (Upper Solway Flats and Marshes). As SPAs should also have site-level conservation objectives, which clarify their contribution to the Favourable Conservation Status of the species, it has to be clarified how the already agreed Favourable Reference Population of 25,000 individuals relates to the conservation objectives of the sites designated for the species. If those conservation objectives are higher than 25,000 individuals, the FRP should be increased to the level of the site level conservation objectives for the Upper Solway Flats and Marshes SPA.

5.2.2 Favourable Reference Range

According to the CMS definition of Favourable Conservation Status, the Favourable Reference Range needs to be defined at least at the level of the current range unless there are deficiencies that would affect the long-term viability of the population or it would not approach historic distribution.

There is no sign of negative change in the distribution of the species. Available data has actually recorded expansion of the range both at the breeding and staging areas (Black et al., 2014).

Currently, the population is considered by AEWA being endangered under Category 3(a) of Column A, i.e. concentration onto a small number of sites in the wintering season. However, the wintering range of the population has remained remarkably stable despite a four-fold increase in population size compared to the population size in the late 1950s. Probably, this is due to the very high site fidelity of the species and it has been enforced by reserve management that makes these areas very attractive for the geese.

Contemporary SPA coverage of numbers and distribution were deemed to be sufficient, and there are no other factors suggesting the need to revise the previously identified suite of SPAs for the species in the wintering areas (Stroud et al., 2016).

So far none of the statutory conservation agencies have identified the need to actively manage for the expansion of the species range at the breeding, staging or wintering areas. The vulnerability of the population to having such a high concentration on one wintering site should be secured through adequate site safeguard measures at the wintering and spring staging areas.

Therefore, it is proposed to set the Favourable Reference Range at the Current Value (level of the 2013-2018 period).

5.2.3 Favourable Reference Habitat

The continued increase in population size and the establishment of new breeding colonies indicate that (1) there is sufficient habitat to support any Favourable Reference Population levels defined at or below the current population levels and (2) the overall carrying capacity is not yet reached on the breeding grounds. However, several studies illustrated that density-dependent effects on population growth do occur in different breeding colonies and has profound effects on vegetation composition and ecosystem processes in the arctic tundra and tundra wetlands might recover only very slowly from intensive grazing by geese (Owen & Black, 1999; Kuiper et al., 2006; 2009; Paquin, 2014; Jensen et al., 2019)

The carrying capacity of the staging area appears to be potentially more limiting for the population than its breeding or wintering area (Pettifor et al., 2000) although density dependent limitations do not affect the growth of the population yet. Hence, it can be concluded that there is sufficient habitat available to support the Favourable Reference Population during passage if it does not exceed the Current Value.

With the population increase, there are concerns amongst land managers about the spread of large numbers of Svalbard Barnacle Geese to areas outside of the current payments zone of the Solway Goose Management

Scheme. The request of expanding the scheme was rejected due to a need to contain both costs and the scheme area (SNH, 2017) and limited value for money in terms of improvement in conservation status as the result in increases in population size (Crabtree et al., 2010). In conclusion, the Barnacle Goose is a generalist species in its wintering habitat requirements. There is sufficient habitat available on the wintering grounds to sustain a Favourable Reference Population at the current or lower population levels.

Table 5.1 Evaluation matrix

	Directive Value*	**Agreement Value****	**Current Value (2013-2018 period)**
1. Is the population larger than the up-scaled long-term genetic MVP to maintain evolutionary potential at this level?	Yes, 3.4-times	Yes, the 25,000 inds. level is 9.5-times	Yes, 15.9-times
2.a. Does it have redundant populations across a representative range of ecological settings at this level?	Restricted distribution during breeding, staging and wintering	Yes at breeding and staging, in winter remained restricted to Solway Marshes	Yes at breeding and staging, in winter remained restricted to Solway Marshes
2.b. Is the population genetically robust?	Yes	Yes	Yes
3. Does the population has strong intra- and inter-specific interactions in its natural ecosystem at this level?	Probably not	Yes	Yes
4. Is this population level reliant on artificial habitat and is it above ecologically functional level?	Yes, to some extent on wintering grounds	Yes, increasingly at both staging and wintering grounds	Yes, even more at both staging and wintering grounds
5. Does the population have an unnatural impact on other species and the ecosystem at this level?	No	Some on Arctic tundra	Some more on Arctic tundra and lakes

* The Directive Value is about the same as the historical reference value (Black et al., 2014).

** The Agreement Value is 2,000 individuals less than the upper threshold for listing a population in Category 2 of Column A of AEWA's Annex 3, Table 1.

6. Russia/Germany & Netherlands population

6.1 Review of key information

Within the Russia/Germany & Netherlands population, three management units were defined at the 4th Meeting of the AEWA European Goose Management International Working Group (Doc. AEWA/EGMIWG/4.15). Jonker et al. (2013) has shown some genetic differentiation amongst the management units within this population, but the estimated exchange rates were higher than with the other flyway populations.

The three management units within this population will be discussed together because (1) they are demographically not entirely separated from each other, but only from the other two populations of the species and (2) because their Favourable Reference Values should add up to the FRVs of the population.

6.1.1 Current and past distribution

6.1.1.1 Breeding

Traditionally, this population has bred in the Russian Arctic. Formerly it was confined to the islands of Novaya Zemlya and Vaygach. Since 1980 it has established breeding colonies in new areas (some of which may have been occupied in the past, before human depopulation). These include mainland Yugorski Peninsula, Kolguyev, Sengeysky, Dolgy, Matveev and Goletz islands, Varandeysksya lapta and whole coastal area along the Pomoprsky channel, Timan coast of Malozemelskaya tundra, and the Kanin Peninsula. Sporadic nesting is known from the Kola Peninsula (Dalnie Zelentsy) and Western Taymir (Lemberova River) (Figure 6.1). Information from the second European Breeding Bird Atlas shows that the range may have expanded in northern Norway and Russia. Based on provisional information the extent of the range can be estimated at 112,500 km^2 (European Bird Census Council, in prep.).

Large moulting aggregations for the Russia/Germany & Netherlands population are confined to the coasts of Novaya Zemlya and Vaygach, Yugorski Peninsula, Kolguyev, Sengeysky, Dolgy, Matveev and Goletz islands, Varandeysksya lapta and coastal strip of the Pomoprsky channel and the Kanin Peninsula (Jensen et al., 2018).

The Baltic breeding ‘population’ has naturally established itself in the early 1970s in Sweden and Estonia. Feige *et al*. (2008) generally assumed that this would be also the case for all newly established breeding colonies outside of Russia. However, the same authors also note that ring recoveries clearly demonstrated that the colony establishment was initiated by birds escaped from breeders or neglected waterfowl collections, such as in Finland (the surroundings of Helsinki, Lathi and Turku). The Finnish population was deliberately established by introduction from zoos (Väänänen et al., 2009).

Now, the range of the Baltic management unit extends to 115,600 km^2 in Estonia, Finland and Sweden (EEA, 2015, see Figure 2.4) but this figure might be even underestimating the distribution based on comparing the EEA maps with the provisional maps from the second European Breeding Bird Atlas (European Bird Census Council, in prep.), which suggests a much more widespread presence in Jämtland, Sweden and in inland Finland. It also occurs in 21 atlas blocks in Norway (52,500 km^2) and 10 atlas blocks in Baltic Russia (25,000 km^2), mostly around the Lake Ladoga and at one location at Lake Onega. Based on this information, the total range can be estimated at 193,100 km^2.

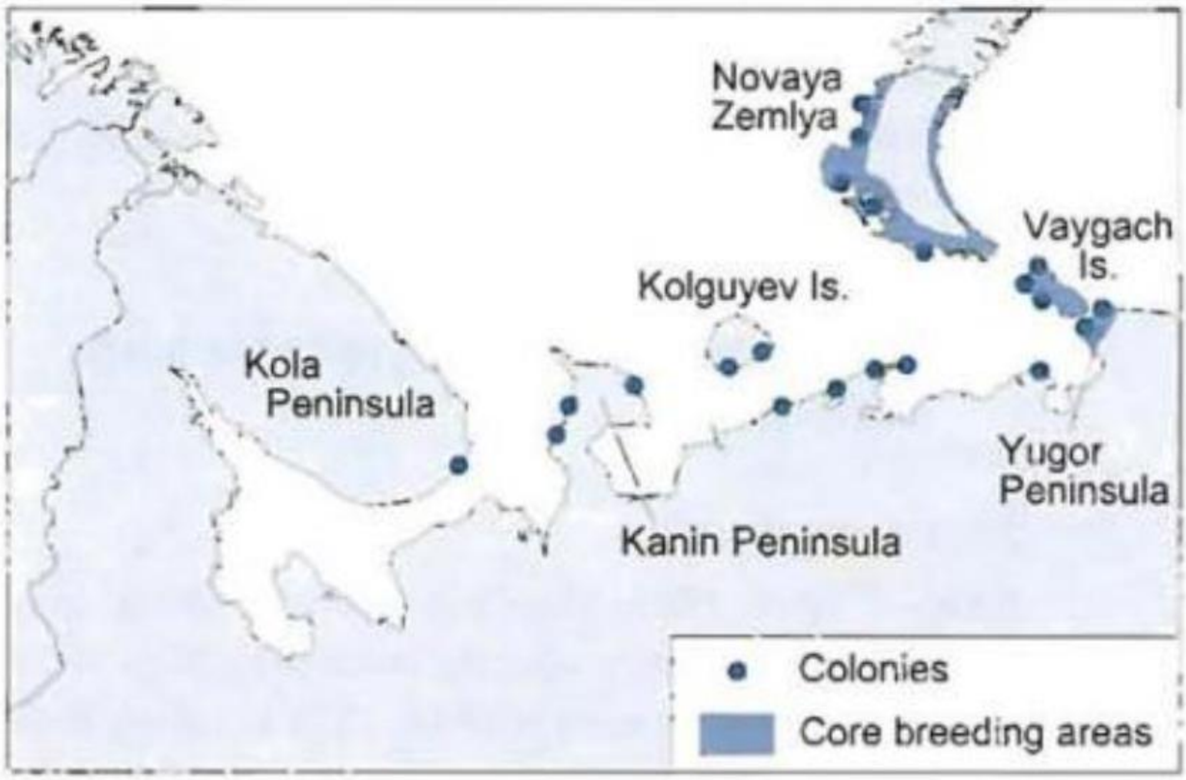

Figure 6.1. Breeding range of the Barnacle Goose in the Russian Arctic in the 1990s. (Source: Ganter et al., 1999).

The North Sea breeding management unit has been established in the late 1980s by birds of captive origin and by injured birds in the Netherlands, Flanders and at Wagerooge in Germany. However, the first breeding colony in Schleswig-Holstein was established by young birds staying in the wintering area (Feige et al., 2008). Inland colonies in Germany are mostly established by ornamental birds (Bauer & Woog, 2008). By 2015, its breeding was recorded (probable and confirmed breeders) in 28% of the 5x5 km atlas squares in the Netherlands (Figure 6.2; van der Jeugd, 2018). Sporadically, it also breeds along the Wadden Sea in Denmark. In the coastal wetlands of Schleswig-Holstein, Germany, 330 breeding pairs were recorded in 2009 and this represents another stronghold of the North Sea management unit besides of the Netherlands (Knopp & Brendt, 2014).

6.1.1.2 Passage

The first main staging areas used after departing from the Arctic breeding areas in autumn are in Khaypudyrskaya, Bolvanskaya, Kolokolkova and Pakhantheskaya bays, Sengeysky Island, the southern island of the Novaya Zemlya archipelago and the Kanin Peninsula. Further south staging areas in the White Sea and the Baltic Sea (especially the Swedish islands Gotland and Öland, western Estonia and eastern Finland) are used before finally reaching the wintering areas (Jensen et al., 2018).

In spring, geese congregate in Sweden (Öland, Gotland), Estonia and, more recently, Lithuania (Jensen et al., 2018).

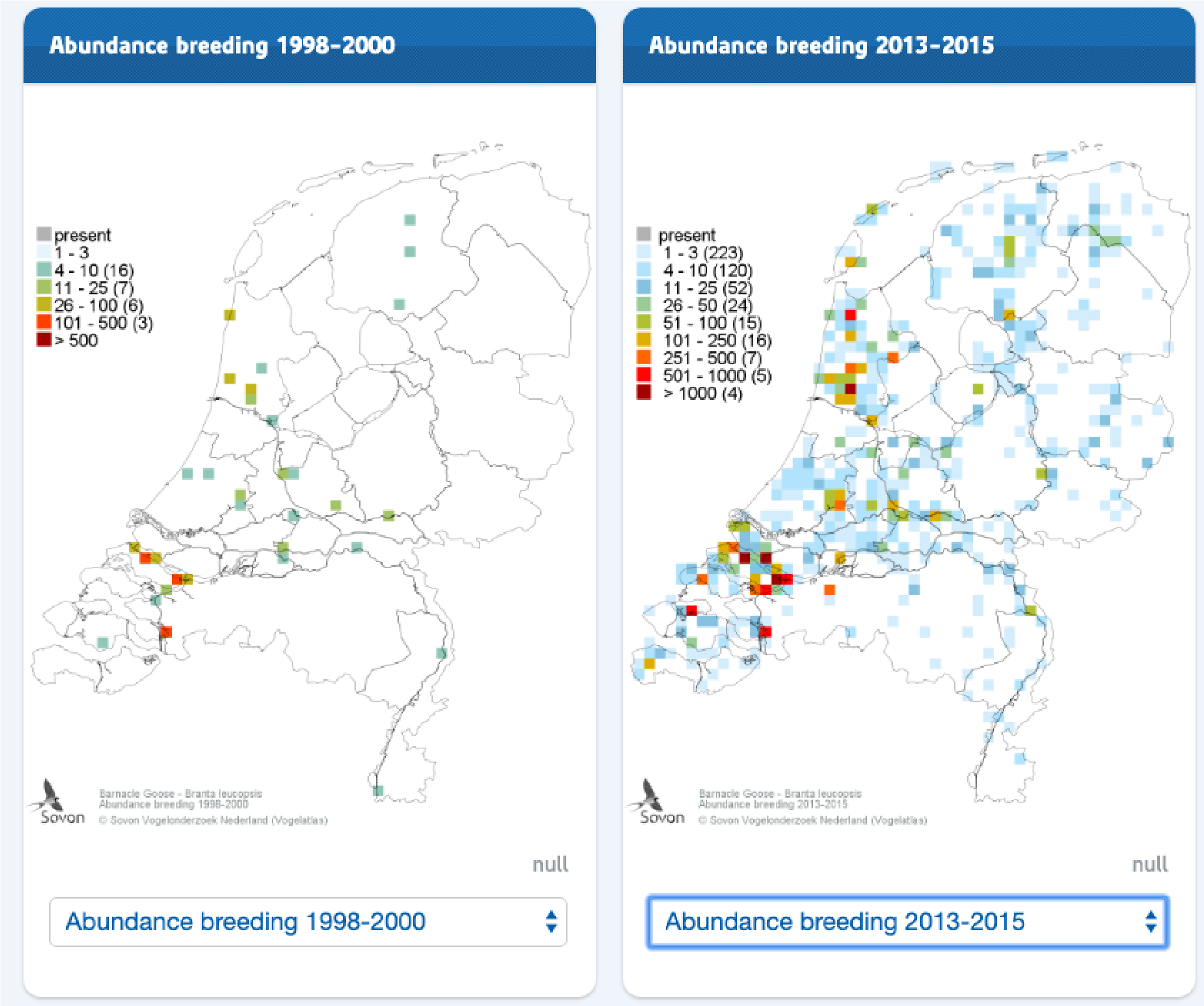

Figure 6.2. Breeding distribution of the Barnacle Goose in the Netherlands in 1998-2000 and 2012-2015. (Source: Sovon, 2018).

6.1.1.3 Wintering

Since the 1950s, the core wintering areas of the Arctic-breeding Russian management unit as well as the temperate-breeding Baltic/North Sea MUs are located in the Netherlands and Germany. Hence, the MUs mix in winter, use some of the same staging areas and, to some extent, exchange individuals between breeding areas, e.g. birds hatched on Gotland in Sweden have been observed breeding in Russia (van der Jeugd and Litvin, 2006; Feige et al., 2008). As the population has grown, the wintering area has gradually extended first to Belgium, then Denmark and followed by southern Sweden. It is likely that this is also facilitated by tendency for mild winters, as other goose species also increase in the Baltic region (Nilsson & Kampe-Persson, 2018).

Prior to the 1950s, however, the Barnacle Goose has wintered in the Netherlands only in small numbers apart from harsh winters. It occurred only occasionally further south in Belgium, France and Spain. The main wintering areas prior to 1950s might have been South-west Jutland and Schleswig-Holstein (Timmerman, 1962). Boyd (1960) quoted Harrison who attributed the increasing number of wintering Barnacle Geese to the more favourable feeding conditions on land reclaimed at that time and to the complete protection from hunting afforded by the Dutch legislation since 1946.

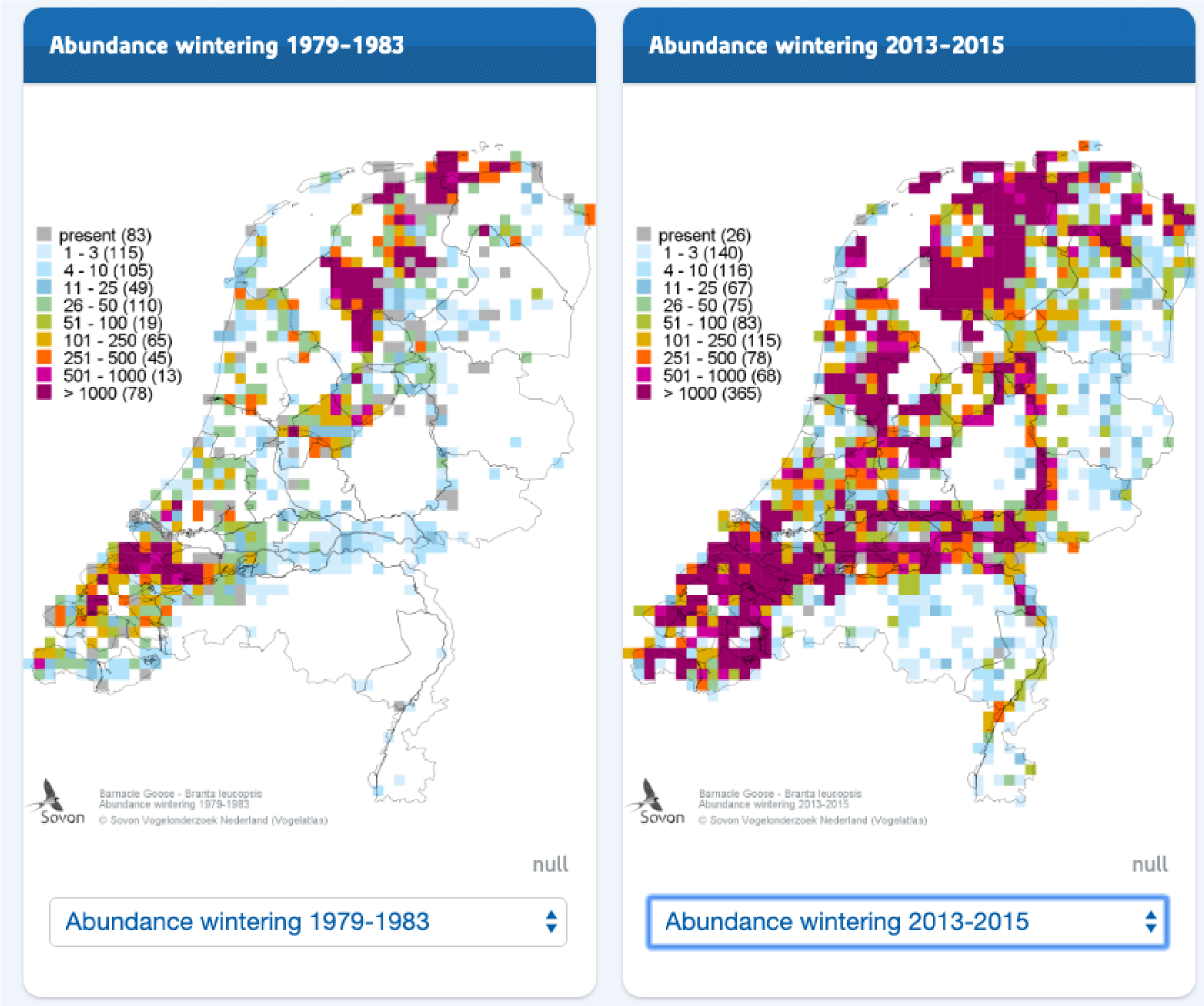

Figure 6.3. Wintering distribution of the Barnacle Goose in the Netherlands in 1979-1983 and 2012-2015. (Source: Sovon, 2018).

6.1.2 Habitat availability

6.1.2.1 Breeding habitat

The nesting habitats of Barnacle Geese in the Russian Arctic include cliff edges, rocky outcrops of small offshore islands on Novaya Zemlya and Vaygach, but recently established colonies along the Barents Sea coast found in very different habitats: sandy islands, dunes, saltmarshes in estuaries and floodplains and terraces in river valleys (Ganter et al., 1999).

6.1.2.2 Staging areas

Formerly, it only occurred on natural and semi-natural coastal meadows and grasslands (Kumari, 1971). With increasing numbers, the original habitats have become saturated and the population has increasingly exploited the cultivated grasslands and cereals (Leito et al., 1991). Eichhorn et al. (2006) showed that the Barnacle Goose population has gradually filled up the carrying capacity of the staging areas in the Baltic by the mid-1990s. Following that, it has reduced its staging time from 5 weeks to a few days on spring migration while it has extended its stay in the wintering areas.

6.1.2.3 Wintering habitats

Until the 1990s, the main feeding areas were large tracks of saltmarshes or recently embanked areas. With the growth of the population, it started using more intensively reseeded and fertilised short grasslands and started feeding on floodplain meadows. In autumn and winter, inland areas, including winter cereal fields, are used more while in late spring there is still a preference for saltmarshes (Ganter et al., 1999), but this preference is not as obvious anymore (Remmelts, *in litt.*).

6.1.3 Current and past population sizes

Large flocks along the Estonian and German coasts suggest that numbers were higher in the 19th century than in the 1950s (Kumari, 1971; Ganter et al., 1999), but possibly those numbers have not approached the Current Values because the species had a more restricted distribution than now and sustaining a large population would have required a larger wintering and staging area as well.

In the early 1950s, the Russian population was probably as low as 10,000 birds. Numbers reached 20,000 already by 1959/60 (Ganter et al., 1999). The Directive Value (i.e. around 1980) was 47,919, the Agreement Value (i.e. around 2000) was 380,000 individuals, while it has reached 1,200,000 individuals by 2014/15 (Figure 6.4; Jensen et al., 2018).

The number of breeding pairs in the Baltic is estimated at around 9,400-12,000 pairs based on the Birds Directive Article 12 reports (EEA, 2015) and 13,300-14,500 pairs based on Jensen et al. (2018).

In 2012, the resident breeding population (including also non-breeding birds) in the Netherlands was estimated at 52,200 individuals (Schekkerman, 2012). In 2013-2015, the number of breeding pairs was estimated to be 16,000-22,000 pairs (van der Jeugd, 2018), while about 60,000 individuals were counted in summer 2017-2018 (Buik & Koffijberg, *in prep.*).

The size of the Russian population is estimated at 130,000-160,000 individuals by BirdLife International (2015), but this must be an underestimate compared to the estimate of a total c. 195,000 pairs in Jensen et al. (2018), which estimate does not include Novaya Zemlya, an important breeding area (Ganter et al., 1999). Deducting c. 75,000 individuals for the two temperate management units from the total wintering number of 1,200,000 (based on population estimates from largely the same period in the first half of the 2010s both for the management units and the flyway population) leaves c. 1,125,000 birds. This suggests 375,000-405,000 potential breeding pairs depending on whether it is calculated simply by dividing the number of individuals by 3 or using the species-specific conversion factor from Section 2.4.1.1.1 (i.e. dividing by 1.39 x 2 = 2.78).

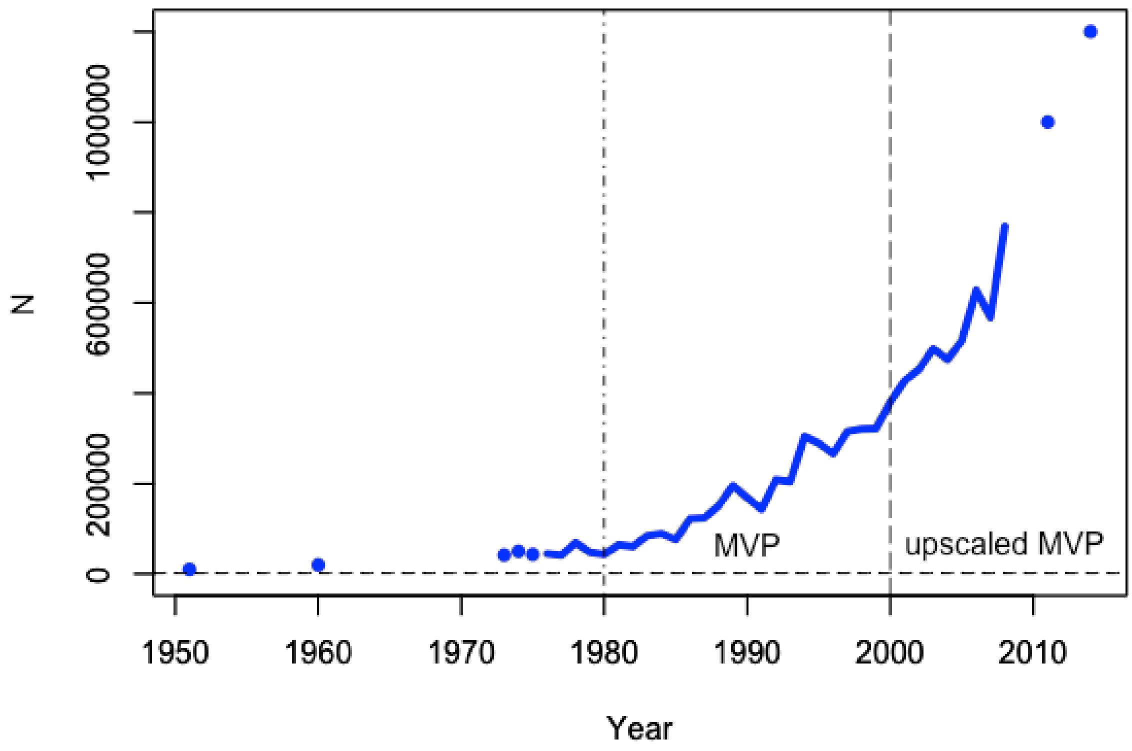

Figure 6.4. The development of the Russia/Germany & Netherlands population of the Barnacle Goose with various reference values.

6.1.4 Trends, major shifts, pressures

By now, the Barnacle Goose became the most numerous goose population in NW Europe. The total numbers of the Russia/Germany & Netherlands population of the Barnacle Goose now exceed even the numbers of Greylag Goose (*Anser anser*) or Greater White-fronted Goose (*Anser albifrons*).

The population has increased spectacularly from the low population level in the 1950s. The annual growth rate of the birds breeding in Russia is estimated at 7.8%. The number of birds breeding in the Baltic increased at the rate of 26% a year until it has stabilized around the current level in the late 1990s. In the North Sea region, the breeding numbers have increased by 25% annually since the establishment of the population (Black et al., 2014).

With the overall increase of the population, the distribution of the species has expanded substantially both at the breeding, staging and wintering grounds as described above. The population is far less restricted to a small number of sites than it was in the 1980s and it is increasingly breeding inland.

Reasons for the initial population increase have been attributed to reduced mortality rates following protection from hunting. The continued increase has been allowed by improved winter foraging conditions, reduced persecution on the Russian breeding and moulting grounds, and the expansion of the breeding range to the temperate zone (Jensen et al., 2018).

Ganter et al. (1999) noted that the Russian and Baltic breeding birds did not yet cause major agricultural conflict on staging and wintering grounds at that time, but conflicts have arisen with the growth of the population. However, at that time, most of the birds used more or less natural coastal areas for a large part of the year and concentrated in protected areas. Certainly, this situation has changed as the wintering flocks became more widespread and stayed longer in spring. In the Netherlands, this once localised population occurs in maximum density of over 1,000 individuals in over 20% of all the 5x5 km atlas squares (including woodland and built up areas) in winter. However, the bulk of the damage can be attributed to the birds in late spring, which are not confined to salt marshes anymore (Remmelts, *in litt.*).

A number of threat assessments have been carried out for this population and they often differ in their conclusions. Deinet et al. (2017) has assessed the threats to the species using the IUCN Red List threat categories and assessment scheme. The following threats are relevant to the population with their threat assessment:

- Hunting and collecting (Historically High): unsustainable and illegal shooting. Historically, egg collecting was an important cause of decline in Russia;
- Persecution (High): damage control;
- Human intrusions and disturbance (Medium): disturbance;
- Problematic native species (Medium): predation by Arctic Fox has an important impact on the Russian population. breeding sites are limited by Red Fox;
- Residential and commercial development (Unknown): breeding grounds in Russia are threatened by the development of oil and gas industry;
- Renewable energy (Unknown): potential impact of wind farms planned or operational onshore in the North Sea and the Baltic.

However, this assessment probably exaggerates the importance of the threats mentioned above. For example, scoring persecution as a high impact threat would require that this threat either affects the majority (50 - 90%) of the population and causes very rapid declines (> 30% in 10 years or three generations) or it affects the whole population (> 90%) and causes rapid declines (20 - 30% declines in three generations) if it concerns a continuing threat. This is clearly not the case when the population is increasing as the Russian one does. If the assessment concerns a threat expected to happen in the short-term, only a threat affecting the whole population and causing very rapid decline would qualify as high impact threat. Neither of these combinations seem to be the case.

The European Red List Assessment for the species (BirdLife International, 2015) also identifies the first two threats but it has assessed the persecution only as a low threat and mentions climate change (habitat shifting & alteration) as an unknown threat.

The Species Fact Sheet for Barnacle Goose on the BirdLife International Data Zone (BirdLife International, 2019) mentions only climate change as a future threat with unknown impact.

Jensen et al. (2018) listed 22 threats in Table 6 based on a questionnaire survey of the Range States but assessed most of them as either negligible current threats (mainly because of the small proportion of the population affected) or whose future impact is unknown. Only, Persecution/Control and Predation by a named species (White-tailed Eagle, Racoon Dog, Red Fox and Arctic Fox) was assessed as having a low impact threat.

The main shifts that can be observed in the population during its known history can be summarised as follows:

- The Netherlands became the main wintering area in the 1950s after the introduction of hunting ban and creating new polders;
- Continuous population growth since the 1950s;
- (Re)colonisation of the lowland arctic tundra in Russia from the 1980s;
- Establishment of a breeding ‘population’ in the Baltic from the 1970s partly naturally, partly through introduction;

- Establishment of a breeding 'population' in the North Sea countries from the late 1980s partly naturally, partly through introduction;
- Reaching the carrying capacity of the Baltic staging areas by the mid-1990s, an increasing proportion of the population stays longer at the wintering areas and skip or shorten its stay in the Baltic;
- Expansion of the wintering range from the coastal salt marshes to a wider range of managed grasslands and other crops in inland areas in the Netherlands and Germany and expansion of the wintering range to Belgium, Denmark and more recently to Sweden;
- Declining juvenile ratio in the long-term which may indicate increasing density dependent population regulation, but this is not yet statistically significant and continued population growth indicates that recruitment is sufficient for the maintenance of the population.

6.2 Setting Favourable Reference Values

Favourable reference values should be defined not only for the flyway population as a whole but also for its management units (see Figure 6.5).

There are various options for the treatment of the Baltic and North Sea management units of the Barnacle Goose. If their establishment is considered as the result of natural range expansion by wild birds without human interference, the population can be considered as a naturally occurring one. According to the review by Feige et al. (2008), this is certainly the case in Sweden and Estonia. If the population is considered as introduced directly or indirectly by man (including establishment through birds escaped from captivity or got injured but excluding attraction by newly available habitat), the breeding population can be considered as non-native and no Favourable Reference Values need to be defined for them.

The Baltic Sea management unit is a predominantly migratory one (Jensen et al., 2018). Therefore, the Favourable Reference Values should be defined at the management unit level in cooperation between the Range States where the population occurs. Only the birds in Sweden and Estonia were considered as naturally established ones by Feige et al. (2008) while the population in Finland is established by birds from zoos and parks.

The North Sea management unit is sedentary (Jensen et al., 2018). Therefore, the Favourable Reference Values should be defined at national level in countries where the breeding population is of natural origin.

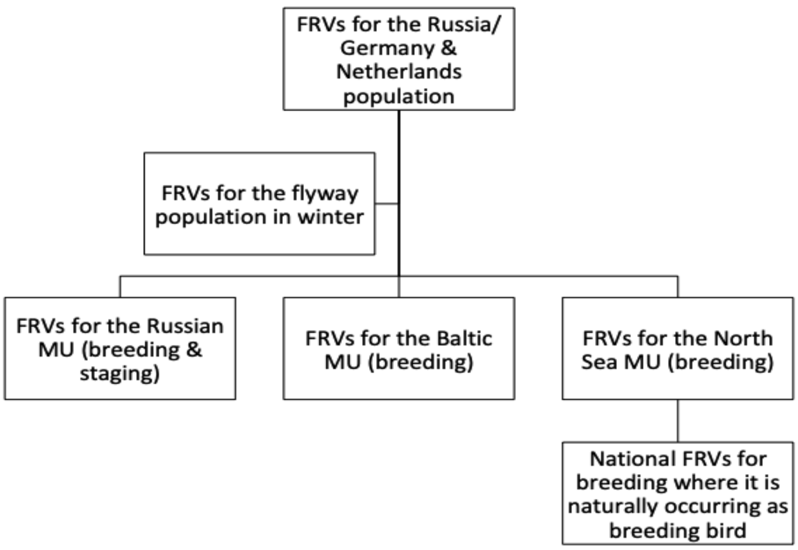

Figure 6.5. A proposed scheme to develop a hierarchical set of FRVs. FRVs for all three populations will be set together for the wintering season because they overlap in this season and their range and habitat cannot be separated. See explanations in the text.

6.2.1 Favourable Reference Population

6.2.1.1 Favourable Reference Population for the entire flyway population in winter

A reference-based approach alone cannot be used because there is no historical reference concerning the population levels in the last two-three centuries (DG Environment, 2017: p. 161). Therefore, a population-based assessment is necessary to define the Minimum Viable Population with an appropriate scaling factor.

As described in Section 2.4.1.2.4, a multiplier factor was estimated based on population trends to upscale the genetic Minimum Viable Population estimate of 1,426 individuals. Figure 6.6 shows the changes in the annual population growth rates for the period of 1976-2008 when annual census data is available across the range.

The arithmetic mean of the log population growth rate (**μ**) is estimated at 8.9%, which is slightly higher than estimated in Jensen et al. (2018) based on data for the entire period since the end of the 1950s. The variance of the log population growth rate (**σ^2**) is estimated as 0.0443, which is much higher than in case of the other two populations of the species.

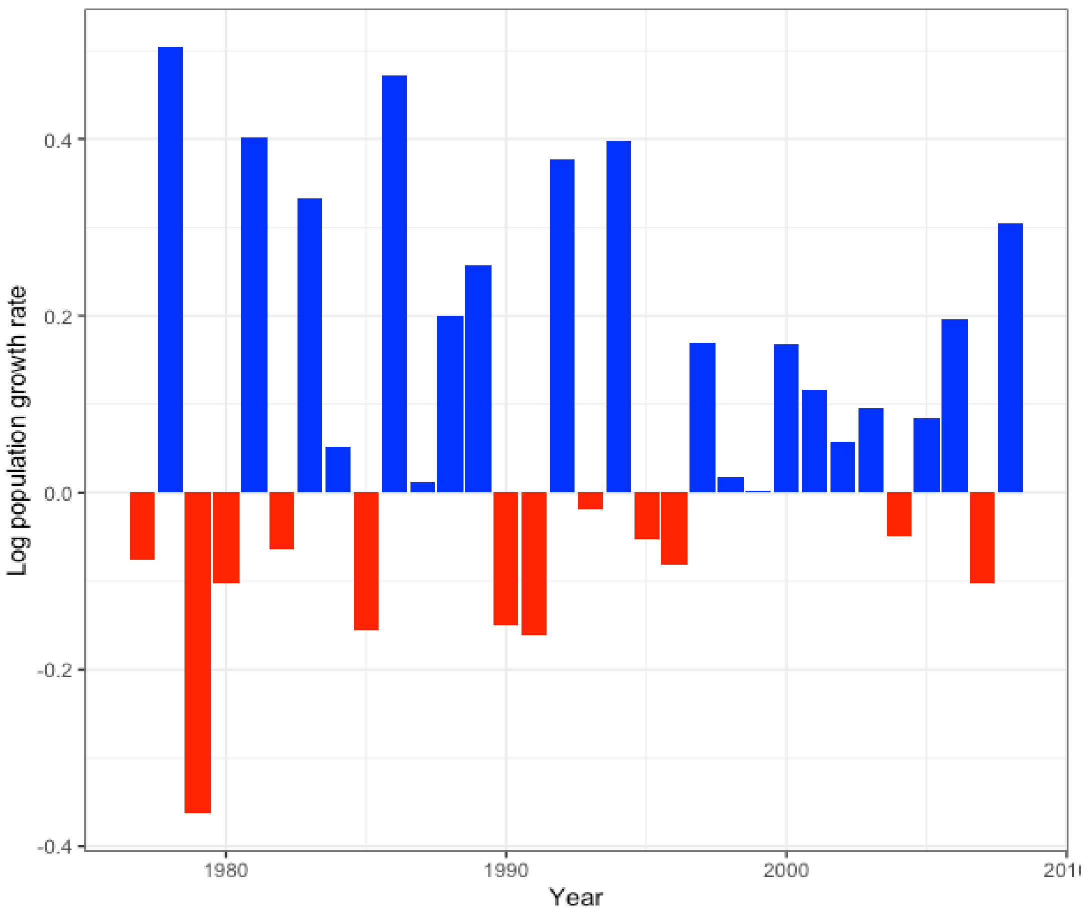

Figure 6.6. Annual growth rate of the population. It shows that the population had positive growth rate in most years.

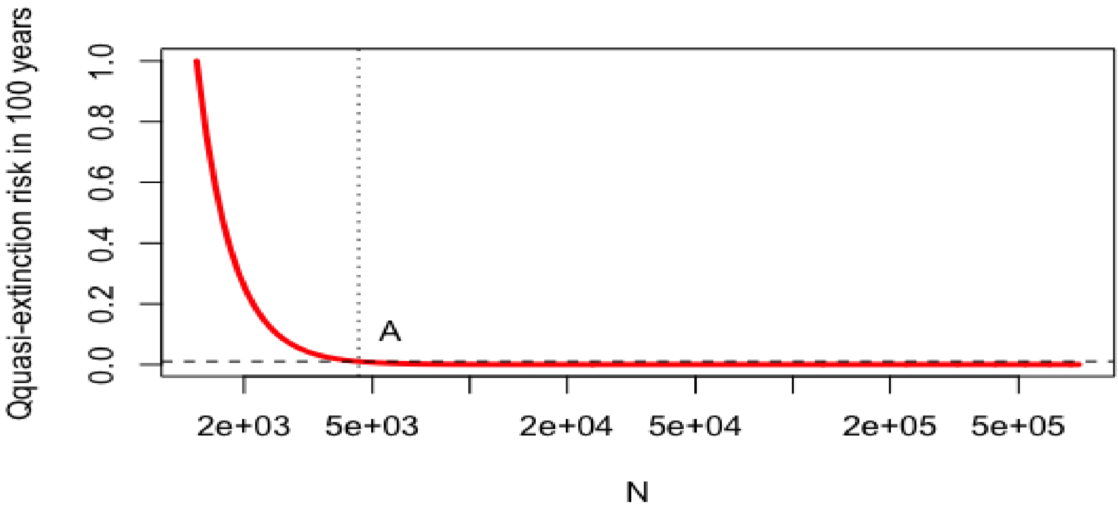

Figure 6.7. The cumulative probability of quasi-extinction risk in 100 years in relation to population sizes above 1,426 individuals. Point "A" represents the population level where the quasi-extinction risk in 100 years drops below 1%.

Figure 6.7 shows that the quasi-extinction risk declines very rapidly and drops below 1% at a population level 4,526 individuals, which means that a multiplier factor of 3.17 is necessary to upscale the genetic MVP to a level where the extinction risk is minimised. It also shows that further increases in population size would lead to no discernible difference in extinction risk.

The Directive Value of c. 48,000 individuals is 10.6-times, while the Agreement Value is 84.0-times higher than the up-scaled MVP, i.e. both reference values are much larger. In accordance with the decision key in Section 2.4.1.3, it is proposed to define the Favourable Reference Population around the level of the Agreement Value at 380,000 individuals at the level of the entire flyway population. This population level was already 7.9-times larger than the Directive Value.

The proposed population level meets the requirements of an ecologically self-sustaining population (Redford et al., 2011) because it has several redundant local populations across a range of ecological settings both at the breeding (cliffs, valleys, islands) and staging (semi-natural and more intensively managed pastures) and it would include a wide range of wintering habitats as well. This population level also meets the requirements of ecologically viable (Tear et al., 2005) or ecologically functional (Sanderson, 2006) population concepts because it maintains critical behavioural, ecological and genetic interactions. At the proposed level the population has already showed normal behaviour (formed large colonies and flocks, had strong competition, but still had a lower pressure for dispersion), it has played an important grazing function both on the tundra and on the salt marshes, it has served as an important prey to predators in the Arctic. However, that population level was less reliant on intensively managed agricultural habitats than the current population size. It has also represented a lower risk of damaging the Arctic tundra vegetation and increasing nutrient loads of aquatic ecosystems.

6.2.1.2 Favourable Reference Population for the Baltic management unit in the breeding season

The size of the Baltic management unit was less than 1,000 pairs when the Birds Directive came into force and the Agreement Value could be 5,000-6,300 pairs (BirdLife International, 2004). Of this only the birds in Sweden and Estonia are considered of natural origin (see Feige et al., 2008) and the total of these two national populations was 4,600-5,600 pairs in 2000. It is proposed to define the FRPs for the breeding populations at national level in the countries where the species is considered as a naturally occurring breeding species (see

Section 2.4.2 for guidance). The FRP for the management unit will be derived by adding up the national FRPs. The national FRPs in countries with naturally occurring breeding populations shall be set at least at the Agreement Value.

6.2.1.3 Favourable Reference Population for the North Sea management unit in the breeding season

The North Sea population was not yet established when the Birds Directive came into force, but the Agreement Value of this population could be 780-1,130 pairs (BirdLife International, 2004). However, the national breeding 'populations' in Belgium, the Netherlands, Germany and Denmark were founded by released, escaped or injured birds at least in part (Feige et al, 2008). As these national populations are sedentary, the assessment should be carried out at the national level according to DG Environment (2017) in the countries where the breeding population is naturally occurring. It is proposed to define the FRPs for the breeding populations at national level in the countries where the species is considered as a naturally occurring breeding species (see Section 2.4.2 for guidance). The FRP for the management unit will be derived by adding up the national FRPs. The national FRPs in countries with naturally occurring breeding populations shall be set at least at the Agreement Value.

6.2.1.4 Favourable Reference Population for the Russian management unit in the breeding season

It is proposed to define the Favourable Reference Population for the Russian management unit by extracting the FRP values for the Baltic and North Sea management units from the Agreement Value of the entire flyway population because the combined share of those two management units is less than 6-8% depending on which period it is calculated for. These calculations should be carried out by the EGM Monitoring Centre after receiving the proposed FRP values from the Baltic and North Sea management units Range States and applying appropriate conversion factors between breeding pairs and wintering numbers.

6.2.2 Favourable Reference Range

The breeding and passage ranges of the three management units recognised in Jensen et al. (2018) differ, but their wintering area overlap and cannot be separated. Therefore, the wintering range is discussed together for the entire population and not separately for each of its management units.

It is also noted that there is no linear relationship between the Favourable Reference Population and Favourable Reference Range, i.e. it is possible to maintain the current range even if the Favourable Reference Population is defined at a lower level than the Current Value.

6.2.2.1 Favourable Reference Range for the Russian management unit in the breeding and passage seasons

It follows from the definition of the Favourable Conservation Status that the Favourable Reference Range cannot be smaller than the current range. The current breeding range in the Russian Arctic (level of the 2013-2018 period) is much larger than what was ever known, but it has been argued that Novaya Zemlya and Vaygach have merely acted as refugia from human persecution at the time when the Barents Sea coast became populated by humans and birds only recolonised their former breeding range on the lowland tundra (Ganter et al., 1999).

The current range appears to be sufficient to ensure the long-term viability of the population at least at the current population levels. The proportion of juveniles in the wintering flocks has declined since the mid-1990s (Jensen et al., 2018). This may indicate density dependence, but there is no sign that the exponential population growth of the population would be levelling off based on the mid-winter counts (Sovon, 2019). This is explained by the growth of the colonies within the range and then followed by expansion of the range as illustrated by Kondratyev et al. (2013) on the example of the Kolguev island. Therefore, it is proposed to define the Favourable Reference Range for the breeding season at current level.

The passage range of the species has also expanded. Formerly, Estonia and Sweden acted as staging areas during spring and autumn migration (Ganter et al., 1999), but from the mid-1990s the staging range has expanded to the whole eastern Baltic. The current staging range is more-or-less sufficient to accommodate the Russian management unit at the level of the proposed Favourable Reference Population level. At higher population levels an increasing proportion of the population is forced to stay longer at the wintering areas and skip the Baltic (Eichhorn et al., 2006). Staying until May at the wintering sites instead of March represents a new phenomenon that has probably been triggered by the unprecedented increase in the size of the population (Eichhorn et al., 2009).

Therefore, it is proposed to define the Favourable Reference Range for both the breeding and the passage season at the Current Value (level of the 2013-2018 period).

6.2.2.2 Favourable Reference Range for the Baltic management unit in the breeding season

Birds from the Baltic management unit winter together with birds from the other two management units and its passage range cannot be separated from the one of the Russian management unit where they overlap. The Favourable Reference Range for the breeding season of this population should be defined for the naturally occurring populations at the level of Current Value (level of the 2013-2018 period). In line with DG Environment (2017: p. 125), ranges associated only with feral or introduced local populations can be excluded from the current range.

6.2.2.3 Favourable Reference Range for the North Sea management unit in the breeding season

The Favourable Reference Range for this management unit should be defined at national level by the competent national authorities at the current level (2013-2018 period) in countries where it is considered as naturally occurring one in the breeding season.

6.2.2.4 Favourable Reference Range for the flyway population in the breeding season and on passage

The Favourable Reference Range for the flyway population in the breeding season should be defined by adding up the Favourable Reference Ranges of the three management units.

The Favourable Reference Range for the flyway population on passage equals to the Favourable Reference Range of the Russian management unit in this season.

6.2.2.5 Favourable Reference Range for all three management units and the flyway population in the wintering season

The traditional core wintering areas for the Arctic-breeding Russian MU as well as the temperate-breeding Baltic and North Sea MUs are located in the Netherlands and Germany. As the population has grown, the wintering area has been extended to Denmark, southern Sweden and Belgium (Jensen et al., 2018). Although, the population was once vulnerable because it was restricted to a small number of sites (Tucker & Heath, 1994). Now, it can be considered being rather widespread. In the Netherlands, the number of 5x5 km atlas blocks where the species is observed in winter has increased from 35% to 61% and the number of atlas blocks with over 1,000 individuals has increased from 5% of the country to 22% of the country (van der Jeugd, 2018).

In line with Point (2) of the CMS definition of Favourable Conservation Status, it is proposed to set the Favourable Reference Range for the wintering season at the current level (2013-2018 period).

6.2.3 Favourable Reference Habitat

As in the case of the Favourable Reference Range, the breeding and passage habitats of the three management units recognised in Jensen et al. (2018) differ, but they overlap in the wintering area and cannot be separated. Therefore, the Favourable Reference Habitat for the wintering season is discussed together for the entire population and not for its management units.

6.2.3.1 Favourable Reference Habitat for the Russian management unit in the breeding and staging seasons

The extent and suitability of the breeding habitat is difficult to assess, but its sufficiency can be deduced from the fact that the population continues to increase. However, this is not the case even at the level of the current population and it is certainly not the case at the proposed level for the Favourable Reference Population.

As mentioned earlier, the availability of suitable habitats might be more of a question at the staging areas in the Baltic but possibly also at the White Sea. Eichhorn et al. (2006) attributed the fact that an increasing number of birds stay longer on the wintering sites and stay only for a few days at the staging areas in the Baltic (or even completely skip them) to the limited capacity of the staging areas compared to the population sizes after the mid-1990s even if the Barnacle Geese are exploiting also the available intensive agricultural areas. The population has been able to adapt to this situation by modifying their migration strategy (Eichhorn et al., 2006; 2009). Apparently, reaching the carrying capacity of the staging areas does not seem to limit the growth of the population yet.

6.2.3.2 Favourable Reference Habitat for the Baltic management unit in the breeding season

As the rapid population growth and subsequent stabilisation at the various colonies in the Baltic has demonstrated there is sufficient habitat to maintain the population at the level of about 13,000-15,000 birds (Black et al., 2014), including introduced individuals, but suitable habitat is even larger outside of the current range and the species has already started colonising both inland areas and spreading along the coasts of the Baltic Sea and the North Sea coast of Norway. The suitable habitat is certainly sufficient to maintain the Favourable Reference Population proposed earlier.

6.2.3.3 Favourable Reference Habitat for the North Sea management unit in the breeding season

The Favourable Reference Habitat should be defined at national level, but it can be concluded from the rapid growth of the numbers in this management unit that there is sufficient habitat to sustain even the current population levels if that was the objective.

6.2.3.4 Favourable Reference Habitat for all three management units and the flyway population in the wintering season

It is not possible to quantify the extent of the Favourable Reference Habitat for this highly mobile and generalist species. As Figure 6.1.1.3.1. illustrates, the population finds suitable habitat both within its range and gradually expands its range into habitats where it has not been abundant or even not occurred traditionally. Based on the International Waterbird Census data, it can be deduced that it expands its wintering range primarily along the rivers Rhine (and its tributaries), Emse, Elbe and along the Baltic Sea coast where it can find roost sites and pastures. Based on the still exponential growth of the wintering population (without any sign of stabilisation) and on the observed expansion further inland, it can be concluded that there is sufficient habitat available in the wintering range for the population and it is able to find and utilise suitable pasture dominated landscapes even beyond its current range. The available habitat exceeds the needs of an ecologically functional population as the growth of the population is supported by intensively cultivated grasslands and other agricultural areas and not by natural or semi-natural habitats.

6.3 Documenting Favourable Reference Values

Range states with naturally occurring breeding populations in the Baltic and North Sea management units are requested to document their national Favourable Reference Values by filling in Annex 1 in this document by 31 December 2019.

All wintering and staging range states are requested to document the current range and habitat of the species by answering the questions in Annex 2 in this document by 31 December 2019.

Table 6.1 Evaluation matrix

	Directive Value	**Agreement Value**	**Current Value (2013-2018 period)**
1. Is the population larger than the up-scaled long-term genetic MVP to maintain evolutionary potential at this level?	Yes, 10.6-times	Yes, 84.0-times	Yes, 265.1-times
2.a. Does it have redundant populations across a representative range of ecological settings at this level?	Yes, but range expansion has just started	Yes, recolonised Arctic tundra, colonised the Swedish archipelago, reached carrying capacity of Baltic staging areas, but still mostly wintering on salt marshes	Yes, but colonising areas well beyond historical range both in the breeding and wintering season, altered migration strategy (skipping the Baltic)
2.b. Is the population genetically robust?	Yes	Yes	Yes
3. Does the population have strong intra- and inter-specific interactions in its natural ecosystem at this level?	Possibly not	Yes	Yes
4. Is this population level reliant on artificial habitat and is it above ecologically functional level?	No, mainly still dependent on salt marshes	Yes, increasingly at both staging and wintering grounds	Yes, even more at both staging and wintering grounds, skipping the Baltic is only possible because of feeding

			longer on pastures in the North Sea region
5. Does the population have an unnatural impact on other species and the ecosystem at this level?	No	Some on Arctic tundra	Prominent impact on some Arctic areas (e.g. Kolguev island)

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Annex 1: Data form for assessing the conservation status of the national breeding populations of the Barnacle Goose in the Baltic and North Sea management units[11]

0. Range State:

0.1 Report completed by: *name, email and phone number*

5. Range

For the sake of consistency with the reporting under Article 12 of the Birds Directive, we suggest reporting simply the number of occupied 10x10km ETRS89 grid squares multiplied by 100 for both the breeding[12] and the non-breeding seasons[13].

5. Range within the country (breeding season)[14]

5.0.a Is Barnacle Goose naturally occurring[15] as a breeding species in your country?

YES / NO

5.0.b If NO, what is the evidence that the species has been intentionally or accidentally introduced as a breeding species?

5.10 Favourable Reference Range: *in km^2, please describe the method used to set the reference value. This process should be informed by the results of mapping of the breeding range already carried out for the Birds Directive Article 12 for the periods of 2003-2012 and 2013-2018. The range concept described in DG Environment (2017, pp: 124-128) should be applied when setting the FRR. Based on Box 3.2 in Bijlsma (2019, p. 40) the recommended gap distance for Barnacle Goose is 140 km using a body mass value of 1.765 kg.*

5. 12 Additional information: *Optional. Other relevant information not provided under 5.a.10*

6. Population

Please provide information only on the breeding population in your country.

[11] For the sake of consistency, this data form is based on the Report format for reporting under Article 17 of the Habitats Directive for the period of 2013-2018 developed by DG Environment (2017), but has been shortened to avoid gathering information that has been already gathered through the reporting under Article 12 of the Birds Directive and adapted to ensure consistency of assessment periods with the Birds Directive (i.e. the long-term covers the period of 1980-2018 and not 1994-2018). The numbering follows the Article 17 report format to make it easier to follow the guidance provided by DG Environment (2017).

[12] This is what is already requested under the Article 12 reporting.

[13] This can be obtained from the non-breeding distribution maps requested above.

[14] Refer to the guidance in DG Environment (2017) as 5.10, or 5.12.

[15] See Section 2.4.2 of this document

6.15 Favourable Reference Population: *in breeding pairs. Please describe the method used to set the reference value. This process should be informed by the results of mapping of the breeding range already carried out for the Birds Directive Article 12 for the periods of 2003-2012 and 2013-2018.*

6.17 Additional information: *Optional. Other relevant information not provided under 6.15*

7. Habitat for the species in the breeding season[16]

7.1 Sufficiency of area and quality of occupied habitat

Please answer the questions below:

a) Are area and quality of occupied habitat sufficient (for long-term survival)?

YES / NO / Unknown

b) If NO, is there a sufficiently large area of unoccupied habitat of suitable quality (for long-term survival)?

YES / NO / Unknown

7.2 Sufficiency of area and quality of occupied habitat: Method used

Select one of the following methods:

a) Complete survey or a statistically robust estimate

b) Based mainly on extrapolation from a limited amount of data

c) Based mainly on expert opinion with very limited data

d) Insufficient or no data available

7.9 Additional information. *Optional. Other relevant information, complementary to the data requested under fields 7.a.1–7.a.8. Free text*

[16] Refer to the guidance in DG Environment (2017) as 7.1, etc.

Annex 2: Data form for assessing the conservation status of the national non-breeding (wintering and staging) populations of the Barnacle Goose[17]

0. Range State:

0.1 Report completed by: *name, email and phone number*

2. Distribution map for the non-breeding season*

Mapping the non-breeding distribution of the population requires obtaining standardised distribution maps for this period. Unfortunately, this information is not collected in as part of the reporting under Article 12 of the Birds Directive and therefore we have to ask for this here. Please refer to Section 4 of the Birds Directive Article 12 reporting guidelines (page 31) or for more detailed guidelines to pages 24-26 in DG Environment 2017.

Complementary note to the European Commission's guidance:

1. *Barnacle Goose typically gather at roosts and feed at areas that might be at a certain distance from the roost but since these areas collectively form the habitat of the species, we suggest mapping the occurrences of all moulting, roosting and feeding birds but not to include observations of birds only passing over an area.*
2. *The non-breeding season includes moulting, staging and wintering areas. Some locations support the species only in one of these annual cycle stages, while others in multiple ones. However, all these areas should be included in mapping the non-breeding distribution.*
3. *National monitoring schemes (including the national schemes of the International Waterbird Census) and on-line reporting portals can provide information to determine the non-breeding distribution of the species.*

2.2 Year or period: *Please, indicate the period data presented in the map is valid for. The map should represent the situation as close to the current one as possible and not a period older than 10 years.*

2.3 Non-breeding distribution map: *Submit a map together with relevant metadata following the technical specifications in the Explanatory Notes and Guidelines. The standard for species distribution is 10x10km ETRS grid cells, projection ETRS LAEA 5210.*

2.4 Distribution map, method used: *Select one of the following methods:*

a) Complete survey or a statistically robust estimate

b) Based mainly on extrapolation from a limited amount of data

c) Based mainly on expert opinion with very limited data

d) Insufficient or no data available

[17] For the sake of consistency, this data form is based on the Report format for reporting under Article 17 of the Habitats Directive for the period of 2013-2018 developed by DG Environment (2017), but has been shortened to avoid gathering information that has been already gathered through the reporting under Article 12 of the Birds Directive and adapted to ensure consistency of assessment periods with the Birds Directive (i.e. the long-term covers the period of 1980-2018 and not 1994-2018). The numbering follows the Article 17 report format to make it easier to follow the guidance provided by DG Environment (2017).

2.5 Additional maps: *Optional. Range States can submit additional maps (e.g. for different annual cycle stages such as moulting, staging and wintering, deviating from standard submission map under 2.3).*

5. Range

For the sake of consistency with the reporting under Article 12 of the Birds Directive, we suggest mapping the occupied 10x10km ETRS89 grid squares and applying the range concept the same way as described in DG Environment (2017, pp: 124-128). Based on Box 3.2 in Bijlsma (2019, p. 40) the recommended gap distance for Barnacle Goose is 140 km using a body mass value of 1.765 kg.

5.10 Favourable Reference Range: *in km^2. Please describe the method used to set the reference value. This process should be informed by the results of mapping of the non-breeding range under Point 2 above.*

5.12 Additional information: *Optional. Other relevant information not provided under 5.b.10*

7. Habitat for the species in the non-breeding season

7.1 Sufficiency of area and quality of occupied habitat

Please answer the questions below:

a) Are area and quality of occupied habitat sufficient (for long-term survival)?

YES /NO / Unknown

b) If NO, is there a sufficiently large area of unoccupied habitat of suitable quality (for long-term survival)?

YES / NO / Unknown

7.2 Sufficiency of area and quality of occupied habitat: Method used

Select one of the following methods:

a) Complete survey or a statistically robust estimate

b) Based mainly on extrapolation from a limited amount of data

c) Based mainly on expert opinion with very limited data

d) Insufficient or no data available

7.9 Additional information. *Optional. Other relevant information, complementary to the data requested under fields 7.b.1–7.b.8. Free text*