AEWA EUROPEAN GOOSE MANAGEMENT PLATFORM

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REPORT AND RECOMMENDATIONS OF THE PINK-FOOTED GOOSE TASK FORCE AND DRAFT WORKPLAN FOR 2021/2022

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with contributions from the members of the Pink-footed Goose Task Force

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

Introduction

This document provides an overview of the work that has taken place since the EGM IWG5 and the recommendations and draft work plan for 2021/2022.

1. Status of the Task Force Membership

The full list of members is presented in Annex 1.

Currently, the Task Force consist of 18 members from six Range States (Norway, Sweden, Finland, Denmark, the Netherlands and Belgium).

Prof. Jesper Madsen (DK) has been identified as Coordinator of the PFG TF.

2. Meetings

Since no funding has specifically been allocated for the work of the PFG TF, communication and information exchange has been conducted through online meetings.

The 7th meeting (virtual) was held on 17 February 2021.

The 8th meeting (virtual) was held on 9 April 2021.

3. Report of key activities and outcomes

In June 2020, the EGM IWG approved the PFG TF workplan for 2020/2021, which encompassed the following tasks:

1 Continue as internal reviewers of annual PFG Monitoring and Harvest Assessment Reports;
2 Continue initiative to improve international exchange regarding hunting organisation and hunters‘ contribution to data collection via wing collection of shot geese;
3 Continue technical discussions regarding potential biases in demographic variables and monitoring; programs, and analysis of critical components in the monitoring program (in collaboration with the Data Centre); and
4 Propose a plan for the assessment to be used for the revision of the ISSMP in 2022/2024[1].

Outcomes and progress have been accomplished on all tasks, which will be reported here.

4. Recommendations

4.1. Internal review of Population Status and Assessment Reports

The timeline for review has been agreed and will be implemented in advance of EGM IWG6.

[1] Waiting a final approval from the Standing Committee and AEWA Meeting of the MOP Parties

4.2. Continue initiative to improve international exchange regarding hunting organisation and hunters' contribution to data collection via wing collection of shot geese

Both Denmark and Norway had a wing survey this season. This information is used in the IPM to get the proportion of wings submitted by Danish hunters prior to mid-November, which is used to calculate the harvest rate of adults in Denmark prior to mid-November. Furthermore, from a wing it is possible to determine the age of the geese (juvenile vs adult bird), and this information is then used to calculate the proportion of juveniles in the hunting bag in both Denmark and Norway.

In Norway, through the Norwegian Goose Project (NGP) wings of PFGs have been collected, and in total 1238 wings were collected in 2020. Furthermore, some of the hunters have been trained to determine age of the geese. In Denmark the number of wings submitted during the latest season (2020/2021) was a record high, with a total of 834. This high number can be attributed to the placement of several freezers around the country to make it easier for hunters to contribute to the survey, as well as a high degree of communication between The Danish Hunters' Association, EGMP and hunters that have shot large numbers of PFGs each year.

Moreover, the NGP has developed a national goose hunting course for the *Norwegian Hunters and Anglers Association*, as well as an introduction video "Goose hunting in farmland" for television (duration 23 min) and for the *Norwegian hunting and anglers association* to use with hunting course. The main goal of the video is to give a short introduction to goose hunting by including the following: how to hunt with decoys, reduce crippling and training program on clay pigeons for hunters, learning how to call geese as well as general management of geese.

Furthermore, work is being done on the development of an English version of about 5-7 min, which can be used for international cooperation. Moreover, funding has been applied for the development of a similar movie showing how to hunt geese along the coast (as conditions here are somewhat different than hunting in the stubble field system as presented in the original video).

Finally, due to Covid-19 there has not been any exchange/workshop/conference between countries this hunting season. This is however still the intention as soon as it is possible.

4.3. Continue technical discussions regarding potential biases in demographic variables and monitoring programs, and analysis of critical components in the monitoring program (in collaboration with the Data Centre)

This task has been continued using the Integrated Population Model for the Svalbard population of the Pink-footed Goose, described in the scientific publication:

Johnson FA, Zimmerman GS, Jensen GH, Clausen KK, Frederiksen M, Madsen J. 2020. Using integrated population models for insights into monitoring programs: an application using pink-footed geese. Ecological Modelling. 415. https://doi.org/10.1016/j.ecolmodel.2019.108869

Currently, the IPM has been improved and investigated in a number of aspects:

Reproduction

Originally, counts of young and adults were restricted to Denmark and Friesland, with an observation window of 12 October – 4 November. However, the number of observations has declined over time in Friesland due to birds remaining farther north later in the autumn. Thus, the combined sample sizes from

Friesland and Denmark have declined. In addition to observations in Friesland and Denmark, however, counts are available in more recent years from Flanders, Norway, and Sweden. Unfortunately, there is considerable intra-annual variability in all of the data, and it is impossible to know which areas might be most representative of the proportion of young in the flyway population. Hence, to sustain sample sizes, total counts of young and adults from all five regions are now used in the IPM (in the same 3-week window as before) as a measure of the annual reproduction outcome of the population.

November count bias

Originally, the bias in November counts was assumed to be temporally constant. However, it seems unlikely that any bias in the November count is truly constant over time. Therefore, the bias is now modeled as a random-year effect. It should be noted, however, that even when the degree of bias was allowed to vary temporally, IPM results suggest minimal annual variation. The bias suggests the November population is about 15% higher on average than the count.

Survival and CMR

Most problematic in revising the IPM involved decisions about whether to include informative priors for annual survival rates, whether to treat natural survival as a fixed-year or random-year effect, and whether to specify a state-space model for the May Lincoln-Peterson population estimates. After many investigations, it was decided not to include the CMR survival estimates of priors in the IPM. Furthermore, the ability to fit CMR estimates of survival was much better with a fixed-year effect than with a random-year effect. Finally, a state-space model for Lincoln-Peterson estimates of population size was chosen so that the sampling variances of the estimates are considered explicitly.

Finally, progress have been made on a Value of Information (VOI) analysis. This exercise will help us understand how the various sources of monitoring data are being used, and ultimately to quantify the tradeoff between the value of monitoring information to successful population management and the cost of acquiring such information. This research is technically complicated and time consuming and will be continued in the coming year.

4.4. Propose a plan for the assessment to be used for the revision of the ISSMP in 2022/2024[2]

The PFG ISSMP is due for revision. Based on the workflow however, it has been proposed to the Technical Committee to extend the PFG management plan so that it can align with the next cycle of the AEWA Meeting of the Parties (MOP). The Technical Committee has discussed and submitted the document to extend the validity of the PFG ISSMP from 2022 to 2024 and have a revised plan developed during that period and submitted for adoption to MOP9. The document was agreed by the recent 16th Meeting of the AEWA Standing Committee and will be submitted to the MOP for approval. Once approved it will come to EGMP and PFG TF to develop a revised plan.

Another document proposed at the Technical Committee was the revision of the ISSMP structure to adapt it to a new format with the possibility of using Adaptive Flyway Management Plan, which has been introduced to the GG & BG ISSMPs.

[2] Waiting a final approval from the Standing Committee and AEWA Meeting of the MOP Parties

Planning ahead for the revision of the ISSMP in 2022/2024[3]. Possible aspects to be included in evaluation report:

- Tundra degradation assessment
- Agricultural damage assessment
- Assessment of other ISSMP indicators (recreational values, crippling)
- Population target assessment, including a Multi-criterion Decision Analysis
- Assessment of the range of the PFG population: how to deal with the new Swedish/Finnish/Russian group?
- Assessment of habitat restoration activities outside the breeding grounds
- Evaluation of existing monitoring program and proposal for future monitoring and assessment protocols
- Stakeholder satisfaction with the ISSMP process

Proposal for process:

- The PFG TF, Data Centre and EGMP Secretariat prepare a proposal for the organization, outline and a time plan for an assessment process.
- The IWG endorses the outline and time plan.
- The PFG TF and Data Centre start compiling the agreed data for assessment.
- The PFG TF reports on progress of compilation at IWG.
- The PFG TF and Data Centre finalize the assessment.
- The PFG ISSMP achievements are presented, and revision is discussed and decided at IWG.

5. Draft Workplan 2021/2022

The work plan for the PFG TF for the coming year was discussed at the virtual meeting in the TF in April 2021 and will be presented at the EGM IWG6.

A background document for the discussion is presented in Annex 2 *"Evaluating Monitoring Programs for the Svalbard Population of Pink-Footed Goose*". Based on this document the implications of the foreseen cuts in the monitoring program from 2022 onwards (primarily the CMR program and the age counts unless funding is made available) shall be considered and discussed at the IWG6.

During the TF review process of the progress report *"Evaluating Monitoring Programs for the Svalbard Population of Pink-Footed Goose"*, a number of comments were received, mainly related to "other non-quantitative effects" of monitoring. However, as no of these comments are questioning the analysis itself, they are not incorporate into the report at this stage but included here to provide a more complete picture of the monitoring activities and the effect of remove one or more of these.

Comments to the progress report "Evaluating Monitoring Programs for the Svalbard Population of Pink-Footed Goose"

Kees Koffijberg, SOVON

Contrary to the Nordic countries, in NL and BE there is quite a number of folk, volunteers, who are going after ringed Pinkfeet and there is a number of even more dedicated people, who are doing age-counts. As such, all feel so to say very committed to the project as a whole. In the Nordic countries, it seems that all these data (or

[3] Waiting a final approval from the Standing Committee and AEWA Meeting of the MOP Parties

the most of it) is collected by paid staff, since motivation to report rings etc. (nearly an ornithological sport in NL, BE and also DE) seems to decline steeply as soon as you have crossed the border from Germany to Denmark or Sweden. I think this should be made clearer at some place in the paper, as the gross cost calculations of course do not include these volunteer contributions but of course have assisted in building up the system as it is now. The current balances are mainly depicting staff time and costs and do not make clear that part of the contributions have been "for free" (which does not change the conclusions but adds some important context).

Without age-ratio counts and a neckband program, only the November count would remain as a joint-effort of all four participating countries. Despite this, I can foresee that the commitment from NL and BE participants would go down, especially when it encourages people to re-think their activities. The November count will be done anyway, as it is just part of the monthly census scheme (this is both true for NL and BE).

Stopping ringing would also imply that neckband density would drop quickly and people also stop searching (there is some trade-off: if you hardly find them anymore, one stops looking for it), while in other species (Greylag Goose) we like to expand neckband (and tagging) projects, as we are not in the "luxury" position as with Pinkfeet. But this of course only affects activities in NL and BE, as there would be no need any more to send out staff out in the field to search for neckbands in DK and NO.

Moreover, as we have seen dynamic dispersal in staging and wintering sites in only a short period of time, some baseline ringing activity may get less information on changes in future years (alternatively, a certain number of tags may help to overcome this, as it "only" involves the catching operations, and it would also keep track on crippling rates (when caught birds are x-rayed) - but hence, I guess that many costs in the CMR are associated exactly with these catching operations...).

Finally, perhaps less important in the paper as such (which entirely focusses on Pinkfeet), but more in context of other EGMP-covered species: this analysis specifically targets Pinkfeet monitoring, but certainly will also be used in discussions on monitoring activities in other species, by folk who are not aware that the amount of data collected so far in Pinkfeet is from a totally different dimension as compared to e.g. Greylag Goose, and clear predictions for e.g. productivity are not so easy to establish for other species.

Iben Hove Sørensen, Danish Hunters' Association

First of all, it would be nice to highlight even more that the cannon-netting/catching also allows us to monitor the crippling rate and make sure it remains low, which is an important objective of the management plan (and all the other goose plans, too). The cost of the "C-part" of the CMR is estimated at 16,721 EURO + overhead, so it is a relatively small part of the CMR-costs. Related to that, would it be possible to evaluate management performance with a reduced CMR-program only including catching, marking and a less intensive (or strictly voluntary) search for marked individuals? So, in this case perhaps excluding data obtained from professional (paid) observers and only including "random" information from hunters and birdwatchers? Finally, a question on the overhead value: Is it necessary to add the overhead to activities carried out by staff not directly employed by the university?

Ingunn Tombre, NINA

Cost assessments from the Norwegian side

Some revised cost assessments for spring and autumn monitoring of pinkfeets are needed from Norway, as much of the monitoring is sponsored by the Norwegian Environment Agency. Specific figures can be delivered when a final version is under development.

Last paragraph in Abstract

The Norwegian Environment Agency (NEA) sponsor NINA by around 400 000 NOK annually for the autumn monitoring of pinkfeets and similar amounts in spring which also covers barnacle geese and the Vesterålen region. This is however not only monitoring as such, as it also covers local meetings with farmers, hunters, managers, information, communication, outreach, data analyses for various reports and scientific papers etc. Hence, for this purpose we may probably only extract what specifically is used for the spring count and the juvenile assessments in October, as it is done in your paper. But figures should be slightly higher… In Trøndelag four persons are in action – having a daily fee and costs for driving covered. For the count weekend this is 15 000 NOK (11 130 DK or 1 497 Euro). In addition, we have one person in Vesterålen with a daily cost of 2 500 NOK (1 855 DK or 250 Euro). I also spend time on contracts, organising the people, compiling and summarising the data etc. If we say approximately one day (but I usually spend more…), that will cost 11 800 NOK – or 8 750 DK or 1 180 euro. Hence, Norwegian costs for total spring count is 11 130 + 1 855 + 8 75 = 21 735 DK (or 2 927 euro). For the juvenile assessment we pay Paul Shimmings in Birdlife Norway to do the assessment (including salary and driving costs etc.): 15 000 NOK. Juvenile assessment: 11 130 DK / 1 497 euro.

Last paragraph in Abstract

Maybe specify already in the Abstract what these "monitoring data beyond those managing harvest and population size" is. Not obvious for the reader at this stage.

Other reasons than cost assessments for monitoring

Somehow, I think, in a document like this, it will also be worth mentioning that other aspects than the cost considerations of monitoring activities briefly can be mentioned. It is already commented the qualitatively judgements of pop size and agriculture damage (before Methods at page 3), but also the fact that activities in the field by counting the geese is a conflict reduction activity in itself? At least that is the case for Trøndelag, where farmers (and local managers) know that "something is actually happening", and things are not at a distance as an "academic exercise". Not sure how wording should be, but this kind of evaluations should also be considered in the overall assessment? That is, we lose more than only the money perspectives if we reduce some of the activities in the field? So, "corresponding" arguments for November counts (keep up the network of volunteers etc.) can also be used for the May count (reduce conflict), at least from the Norwegian perspectives?

Timing of harvest in Norway (bottom page 3)

There is always some late harvest in Norway, so change "assume all" to "the majority"?

Number of birds assessed when quantifying productivity

Will it cost so much more if more birds are assessed as long as someone is out there anyway to do the productivity assessments? Some hours longer in the car, OK, but can't really see how much there is to save there and the arguments behind it?

Christine Verscheure, Natuurpunt Belgium and Eckhart Kuijken, Research Institute for Nature and Forest, Flemish Government of Belgium, Univ. Ghent Belgium

Thanks for the opportunity to read this paper. Evaluation is very important when using public money indeed.

We feel obliged to give some personal comments on the actual situation of the AEWA PfG project. What follows is not directly related to the text as such but reflects some feelings of colleagues in the field.

The conclusions of the report are quite clear: cutting in the budget seems to be inevitable. The paper mostly comments on the way in which modelling can be continued, the model itself, whereas the predetermined 60.000 population level is not that much discussed/the fact that the 60.000 population level was maintained for the coming years, without comments that this needed a review this year. You could try to run the model also changing this figure (e.g. 75000?) to predict consequences for harvest (the main concern?).

Therefore, we suggest changing the title of this report as follows:

“Evaluating Monitoring Program ***Costs*** *for the Svalbard Population of Pink-Footed Goose”*

The table of costs was for us rather eye opening, and it looks like there are two different worlds in the Flyway concerning monitoring fieldwork & neckband reading: Scandinavia in the north and the Low Countries in the south.

It looks like the highest expenditures go to neckband reading as a job in the north. We understand that this was needed in the past to achieve the goal of the CRM analysis (optimally to be based on 1% of the population marked, which is now declining) because the number of volunteers to collect resightings seems to be too low indeed. At different occasions (PfG TF, commenting Status Reports etc.) we have always stressed the importance that ornithological NGOs (existing in all countries) should be stimulated by AEWA to cooperate in this field work. However, when volunteers see that paid staff does the job, we understand that this can reduce their willingness.

In Belgium, we are used to do the monitoring for free and we hope this 'model' can be more explicitly promoted (just a reference of 'unpaid contributions' in papers such as in AMBIO 2017, 46(Suppl. 2): S275–S289 is not sufficient). As far as we know this is also more or less the fact in The Netherlands.

The cooperation with volunteers and NGO’s as a low-profile monitoring has a lot of opportunities, not only for the Pinkfoot population understanding and management. The future AEWA work on other species also will largely need or even depend on the input of volunteers (waterbird counts started by IWRB in 1966!). Without this historic background, probably AEWA had never been established...

A short assessment for last winter (only for ourselves and our counting teams) makes some costs clear (Table 1). However, it should be noted that these costs have never been claimed or reimbursed (e.g. by the institutions where I was working before my retirement in 2007). Furthermore, we only prepared this estimate of volunteer contribution as an example to compare with those in the other flyway states (please note that the time spend by the officials from Agency and INBO is not included).

Table 1. Estimate of volunteer contribution

	# km	# hours	€
6 simultaneous midmonthly counts + 1 additional count end December.	1100		396.00
Adult/juv counts end Oct. early Nov.	450		162.00
Neckband reading EKCV Id. other volunteers: no data, but estimate	8055 1200		2900.00 430.00
Total	10805		3888.00

It would be nice to mention in the paper the level of basic cost by volunteers without details. Thus, currently the table of expenditures included in the report should be looked at carefully.

This basic fieldwork of counting geese and reading neckbands will possibly remain the motor of the monitoring. Professionals are needed for supervising, making models and reports, communicating, etc. For the Low Countries, this model gives opportunities for both volunteers and professionals.

Although this is here not the right place to discuss this, but on behalf of the Belgian goose counters and neckband readers we would like to stress again the value of volunteer work. It is a way of living and it brings happiness in your life. Neckband reading, especially with using the BirdRingApp gives you direct information on the individual bird you read. Many younger volunteers still wondering what a strong birds they are meeting in the field, some of them 10x travelling Belgium -Svalbard with their family. This neckband reading has something challenging since Jesper started in 1990; increasing number of ring readers come up annually (indeed Gitte comparing with Pokémon). This neckband reading did become an excellent example of citizen science. Volunteers all realize how important the scientists behind these projects are to get information back as a reward.

Therefore, we hope – again on behalf of the Belgian readers – that some neck banding can still be part of the project. When the density of neckbands to be detected in the field becomes too low, we are afraid that the input of volunteers also for counting will rapidly decrease (except the fanatic ones ☺). Furthermore, we stress the importance of ring resightings by volunteers; when ring density becomes too low, the efforts will decline; this would have serious consequence for collecting essential data of GG and BG as well!

Finally, we stress the importance of continuing November counts; we wonder that only for November counts a bias analysis is given (to be sure that the model fits well); does this suggests that May counts have no bias?

Annex 1. Members of the Pink-footed Task Force as of 18 May 2021

Representative	**Affiliation**
Floris Verhaeghe	Nature and Forest Agency, Belgium
Frank Huysentruyt	Institute for Nature and Forest Research
Eckhart Kuijken	Research Institute for Nature and Forest, Flemish Government of Belgium Expert, Univ. Ghent Belgium
Christine Verscheure	Natuurpunt Belgium
Jesper Madsen (Coordinator)	Aarhus University
Iben Hove Sørensen	Danish Hunter's Association
Niels-Erik Jørgensen	Danish Hunters' Association
Knud Flensted	BirdLife Denmark
Jorma Pessa	Centre for Economic Development
Kees Koffijberg	Sovon Vogelonderzoek Nederland
Ingunn Tombre	Norwegian Institute for Nature Research, Department of Arctic Ecology
Ove Martin Gundersen	Norwegian Farmer's Union
Per Risberg	Swedish Environmental Protection Agency
Leif Nilsson (tbc)	Department of Animal Ecology
Fred A. Johnson	EGMP Data Centre/Aarhus University
Henning Heldbjerg	EGMP Data Centre/Aarhus University
Eva Meyers	UNEP/AEWA
Gitte Høj Jensen	EGMP Data Centre/Aarhus University

Annex 2. Evaluating Monitoring Programs for the Svalbard Population of Pink-Footed Goose

Evaluating Monitoring Programs
for the Svalbard Population of Pink-Footed Goose

Progress Report
10 May 2021

Fred A. Johnson, Jesper Madsen, and Gitte H. Jensen
EGMP Data Centre
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Abstract: Unlike most goose populations in Europe, an extensive, science-focused monitoring program has been in place for the Svalbard-breeding population of pink-footed geese for three decades. The wealth of available information about population size, survival, productivity, and harvests has facilitated the construction of an integrated population model (IPM), which is now used to guide harvest-management decisions in Norway and Denmark. The monitoring program has been maintained by a network of managers, researchers, volunteers, and contract employees at a current annual cost of €117,461. After 30 years, however, one could ask whether there is a need to continue the monitoring in its current form or whether some monitoring efforts could be reduced without a significant sacrifice of management performance. We are conducting retrospective value-of-information analyses by asking what loss of management performance can be expected if we had stopped using a particular monitoring instrument in the past. Preliminary results suggest that the IPM appears quite robust, in that the posterior estimates of natural survival, differential vulnerability of young, and coefficients describing the relationship between spring thaw days on the breeding grounds and productivity changed little with some loss of monitoring data. Optimal harvest policies also are expected to perform well for the most part under the reduced-data scenarios we examined. It appears that substantial cost savings could be realized with reducing or eliminating the capture-mark-recapture program and productivity surveys, without much loss of the ability to maintain the population around its goal of 60,000 individuals. This is fortuitous, because funding for both of these programs ends in 2021, and will be discontinued unless more funding is forthcoming. Ultimately, any decisions to reduce monitoring efforts for pink-footed geese should consider the limitations of our analyses, which we describe herein. Moreover, we note that there are uses of monitoring data beyond those for managing harvests and population size. While these other uses cannot currently be valued quantitatively, they should nonetheless be considered in any decisions about the future of monitoring efforts for pink-footed geese.

Disclaimer: All results reported in this document are preliminary and therefore subject to change. Also, the Task Force provided comments on an earlier draft of this report, mainly related to the qualitative value of monitoring not directly related to the AHM program. However, as none of these comments questioned the analysis itself, they are not incorporated at this time but are included as an appendix in the Task Force report to help provide a more complete picture of monitoring activities and the potential impacts of reducing them. Finally, we note that total costs of monitoring in this report need to be revised because at the time of report production we were unaware of some contributions by Norway.

Introduction

Monitoring the demography and relevant environmental conditions of a wildlife population costs time and money. Because resources available for monitoring are always limited, wildlife managers must strive to make monitoring as cost effective as possible. The challenge thus facing managers is to assess the tradeoff between the cost of monitoring and the benefits derived from it in terms of understanding population dynamics and effectively directing conservation activities.

Generally, we can think of three basic types of monitoring (Nichols and Williams 2006). The first we refer to as surveillance or omnibus monitoring, in which resources are broadly (but perhaps not intensively) monitored in the hope that the information will eventually be useful to science or to conservation decision-making. Because this type of monitoring lacks unambiguous objectives, it is impossible to assess its cost effectiveness. The second type we refer to as science-focused monitoring, in which the primary goal is to discriminate among competing hypotheses concerning population dynamics (e.g., whether survival rates differ between males and females). In this case, the researcher must balance the cost of the monitoring data against the statistical power to discriminate among hypotheses. Finally, there is decision-focused monitoring, in which the goal is to inform conservation actions and track their performance. Here the manager must balance monitoring costs with the efficacy of meeting conservation objectives. To these three basic types of monitoring, we can also add monitoring within the context of adaptive management, in which the goals are both informing conservation actions and reducing uncertainty about population dynamics so that future conservation efforts can be improved.

Our principal focus here is on the management of the Svalbard population of pink-footed geese and, in particular, on the adaptive harvest management process that has been in place since 2013 (Madsen et al. 2017). Unlike most goose populations in Europe, an extensive science-focused monitoring program has been in place for this population of pink-footed geese for three decades, with the aim to understand population dynamics, migratory behavior, and anthropogenic impacts. The wealth of available information about population size, survival, productivity, and harvests has facilitated the construction of a robust, integrated population model (IPM), which is used to guide harvest-management decisions in Norway and Denmark (Johnson et al. 2020). The monitoring program has been maintained by a network of managers, researchers, volunteers, and contract employees. After 30 years, however, one could ask whether there is a need to continue the monitoring in its current form or whether some monitoring efforts and associated costs can be reduced without a significant sacrifice of management performance. Moreover, our research ultimately can lead to investigations for other goose populations that are monitored poorly, where managers often want to understand how additional investments in monitoring could improve management performance.

These questions can be addressed using so-called value-of-information (VoI) analyses (Williams and Johnson 2015). In simple terms, VoI is the expected management performance with complete information minus the expected performance with incomplete information. We stress that VoI analyses can only be conducted within the context of a formalized decision problem, in which there are unambiguous objectives, alternative choices of actions, and the predicted consequences of those choices in terms that are relevant to the objectives. In this sense, VoI analyses can be used to evaluate both science-focused and decision-focused monitoring and, therefore, for monitoring conducted within the context of adaptive management. In the research described here, we are conducting retrospective analyses of various monitoring instruments for pink-footed geese. In particular, we are focusing on those monitoring efforts that are *not* associated with some larger monitoring effort (e.g., monitoring goose harvests in Norway and Denmark), which would be conducted regardless of its utility for managing pink-footed geese. Rather, we are focusing on monitoring efforts that involve additional expense, in terms of money, time, or both. We refer to our analyses as retrospective in the sense that we look back in time and ask: what loss of management performance can be expected if we had stopped using a particular monitoring instrument in the past? Retrospective diagnosis is a common fisheries diagnostic, examining how models perform when fewer years of data are included (e.g., Deroba 2014, Miller and Legault 2017). By examining various monitoring instruments, and by varying the time in the past they were theoretically discontinued, we can begin to understand the relative importance of various monitoring instruments and whether the improvement in management performance they produce can be justified by their cost.

We stress that our analyses are conducted within the context of a specified decision problem: what level of pink-footed goose harvest in Norway and Denmark will best maintain the population near the goal of 60,000 in spring? The decision problem is dynamic, in the sense that harvest levels must be adjusted each year depending on population status. We recognize, however, that pink-footed goose monitoring data may have uses beyond managing harvest and population size. Such uses include, for example, understanding the relationship between population size and agricultural damages and meeting inventory and assessment obligations under international treaties (e.g., Ramsar, EU Birds Directive). We therefore describe some other uses of pink-footed goose monitoring instruments, but stress that their value can only be judged qualitatively.

Methods

Monitoring instruments

We here briefly describe the extant monitoring program for pink-footed geese and provide estimates of the annual cost of the various monitoring instruments. The costs given below for each monitoring activity have been calculated on the basis of annual budgets and expenditures (average 2012-2020). Costs include an overhead rate of 44%, which is a Danish standard for Danish externally funded research projects. We note that the cost estimates provided do not include time spent by volunteers in the field (although they do include reimbursed travel costs). Moreover, cost estimates are only provided for those monitoring instruments that are *not* part of a larger, routine monitoring effort for waterbirds. Currently the additional costs for pink-footed geese monitoring are shared by Aarhus University (95%) and the Norwegian Environment Agency (5%). The Aarhus University funding, which has been a strategic investment in developing tools to support adaptive management, ends at the end of 2021.

<u>Population counts conducted in spring and autumn</u> – Internationally coordinated population counts of pink-footed geese have been performed annually since 1990 in Denmark, Belgium and the Netherlands in late October or early November (hereafter referred to as the November count) (Madsen et al. 1999). Over time, the population has expanded its distribution and the spatial coverage of the count has repeatedly been extended to capture new sites occupied by geese (Madsen et al. 2015). Since 2005, the population has also been counted in Norway, and since 2016 in Sweden. Because of increasing challenges in monitoring the autumn population, an additional count was introduced in May in 2010, which includes Norway, Denmark, Sweden and, since 2016, Finland. The known sites are covered by a network of trained observers who coordinate the coverage. The May census costs €2338 per year for academic staff salary and travel costs of volunteers. The cost of the November census is similar, costing €2145 per year.

<u>Harvest estimates</u> – Pink-footed geese are subject to an open hunting season in Norway, including Svalbard, and in Denmark. The species is protected in The Netherlands, Belgium, Sweden, and Finland. In both Norway and Denmark, reporting the harvest is mandatory and hunters report their harvests online. Harvest monitoring imposes no additional costs on the pink-footed goose management community.

<u>Temporal distribution of harvest in Denmark</u> – The November count occurs after the start of hunting seasons in Norway and Denmark and so it is important to be able to partition harvest into that occurring before and

after the count. We assume all of the harvest in Norway occurs prior to the November count. The temporal distribution of the pink-footed goose harvest in Denmark is derived from wings submitted to the Danish wing survey. Danish hunters voluntarily submit wings from harvested individuals, providing information on date, location, and age of harvested geese. Monitoring the temporal distribution of the harvest in Denmark imposes no additional costs on the pink-footed goose management community.

Proportion of young in the autumn – Based on age-specific plumage characteristics, random counts of the number of young of the year and of older geese in flocks have been conducted by trained observers in the Netherlands and Denmark since 1980 (Madsen 1982, Madsen et al. 1999), and in more recent years in Belgium, Norway, and Sweden as migratory behavior has changed. We use only counts occurring between October 12 and November 4, inclusive, to minimize the effect of seasonal changes in age ratios. Fall counts of young and adults are relatively expensive, and at the current level of effort cost €21,177 per year for academic staff salary, contract observers, and travel costs for observers.

Annual survival rates – Estimates of annual survival rate are available from a capture-mark-recapture (CMR) program (Madsen et al. 2002). During the period 1990-2018, 4938 pink-footed geese were captured and fitted with neck-bands and tarsus metal rings during spring staging in Denmark and Norway and, in four years, on the Svalbard breeding grounds. Resightings are made by a network of professional and volunteer observers outside the breeding grounds (September-May). Dead recoveries are reported by members of the public to the ringing centers involved (in Denmark and Norway). They include both geese reported shot by hunters, and those found dead by other members of the public.

Capture-mark-resight estimates of population size – The CMR data used to estimate survival are also used to derive an estimate of pink-footed goose population size (*N*) by dividing the number of marked geese in the population (*M*) by the ratio of the number of marked geese to the number of geese screened (*R*) (Sheaffer and Jarvis 1995): $N = {}^{M}/_{R}$. This approach has been used in the monitoring program since 1991 and effort has been increased since 2011. As described by Clausen et al. (2019), the CMR data are used to derive estimates of pink-footed goose population size in spring, which are independent of the May counts. *M* is estimated from the number of marked birds seen alive in any given year corrected for annual variation in detection probability, and *R* is estimated as the average of the ratios from observations of marked individuals in screened flocks.

The CMR program is the most expensive of all monitoring instruments, costing €91,801 per year for materials, salary, and travel.

Spring temperature in Svalbard – Warm May temperatures on the breeding grounds, used as a proxy for snow melt in relation to the timing of egg-laying by geese, tend to improve reproductive success of pink-footed geese (Jensen et al. 2014). Therefore, daily average temperatures during May at two locations in Svalbard (Ny Ålesund and Svalbard Airport) are retrieved each year from the Norwegian Climate Service Center's online database (https://klimaservicesenter.no/observations/). The number of days in which the average temperature is above freezing are tabulated and the number of "thaw days" are calculated by averaging values from the two stations. There is no additional cost incurred in acquiring these data.

VoI analyses

We start from the assumption that posterior estimates of population size and demographic parameters from the IPM using the full set of available monitoring data represent the benchmark against which reduced monitoring will be judged. Thus, the process for evaluating management performance with reduced data involves the following steps:

1. The IPM is first fit using the entire record of three decades of monitoring data, following the methods described by Johnson et al. (2020).

2. Posterior estimates of population size, natural mortality, the differential vulnerability of young to harvest, and the regression coefficients expressing the relationship between thaw days and reproductive success are used to derive an optimal harvest policy using stochastic dynamic programming (Johnson et al. 2014). We explicitly consider uncertainty related to current population size, temporal variation in natural survival, and uncertainty about the regression coefficients in the relationship between thaw days and productivity. These sources of uncertainty are described by discrete statistical distributions in the optimization process. We call the resulting harvest policy the full-data policy. The performance of this policy is assessed by examining the long-term expectation of population-size utility (Fig. 1) under this policy, assuming the full-data IPM best represents pink-footed goose demography.

3. Next, we eliminate some of the data used to fit the IPM. For example, we might eliminate the last several years of May population estimates based on the CMR program and then re-fit the IPM. From a technical perspective, we simply eliminate some data from the joint likelihood in the IPM. As before, we now derive a new optimal harvest policy using the posterior estimates from this reduced-data IPM. When data are removed from the IPM, both the variance and bias of May population estimates tend to increase. Therefore, we express the uncertainty in population size as a mean squared error (MSE), which considers both the variance and bias of population estimates ($MSE = bias^2 + variance$). We use the MSE to calculate a coefficient of variation as $CV_{MSE} = \sqrt{MSE} / \bar{N}$, where $\bar{N}$ is the mean population size.

4. The expected performance of the harvest policy derived from the reduced-data IPM can be evaluated, assuming that the harvest policy from the full-data IPM is the benchmark against which it is judged. In other words, we evaluate the expected performance of the reduced-data policy, assuming that the "true" population dynamics are those expressed by the full-data IPM. We solve for the expected performance of the reduced-data policy analytically, recognizing that every policy has a stationary Markov transition matrix and corresponding vector of stationary utilities (Williams et al. 2002:208). We again describe performance as the long-term expectation of population-size utility under this policy and the assumption that the full-data IPM best represents pink-footed goose demography.

5. Finally, we plot expected management performance of each reduced-data scenario against its amortized, annual cost over the last 10 years (i.e., the total 10-year cost of all monitoring instruments less the cost associated with the reduced-data scenario, divided by 10 years). We seek the Pareto-efficient frontier (Kennedy et al. 2007), in which no data-reduction scenario can improve management performance without a concomitant increase in monitoring costs. A Pareto frontier describes the tradeoffs inherent in both maximizing performance and minimizing costs, and also identifies those data-reduction scenarios not worthy of further consideration.

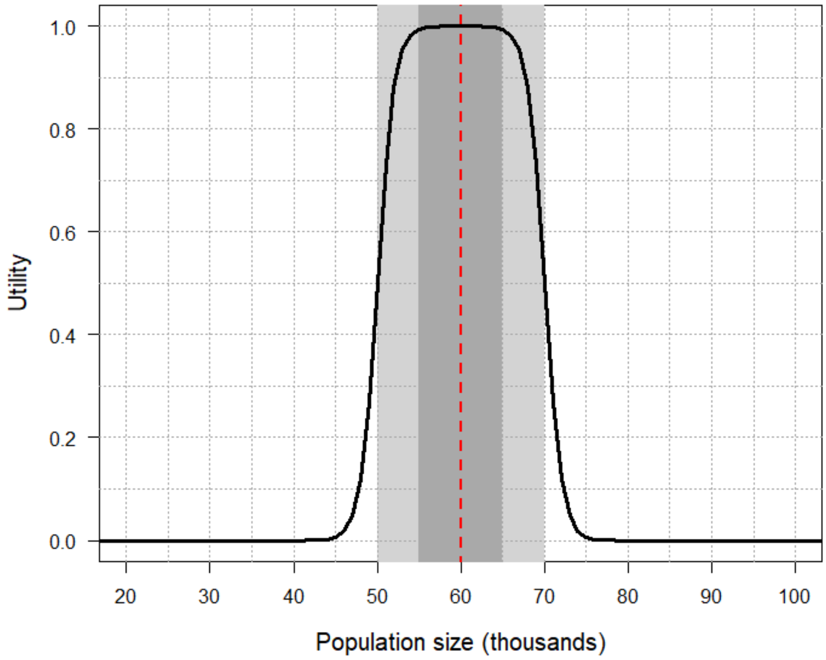

Fig. 1. Utility (i.e., stakeholder satisfaction) expressed as a function of population size of Svalbard Pink-footed Geese. The population goal is 60000 individuals (red dashed line), but population sizes between about 55,000 and 65,000 (dark grey band) are acceptable (and thus have utility ≅ 1), while those outside that range are less desirable (and thus have lower utility). The light grey bands represent population sizes that have utility ≥ 0.5.

Data-reduction scenarios

We currently are investigating scenarios in which three key monitoring instruments "were discontinued" in the recent past. In particular, we are focusing on the CMR-based estimates of population size, the November count, and the productivity survey. In most cases, we retain the May count because it is probable that managers would want to maintain at least one estimate of population size for May because it plays a central role in prescribing appropriate harvest levels. The data-reduction scenarios we evaluate here are not an exhaustive list and many other possibilities are possible. The time required to fit a reduced-data IPM, and then derive and evaluate its associated harvest policy, is about one hour. Therefore, evaluation of many more scenarios is eminently practical.

Results

Of key importance in managing harvest and populations size, are the IPM variables describing natural survival, differential vulnerability of young, and the relationship between thaw days and productivity. In this regard, the IPM appears quite robust, in that the posterior estimates of these demographic variables changed little with some loss of monitoring data. The most notable change occurred in the measure of bias and precision (CV_{MSE}) of the posterior estimate of May population size in 2020. The CV_{MSE} ranged from 0.05 (i.e., 5%) for the full-data IPM to 0.36 for case # 10 (M = 2011, N = P = 2010) (Fig. 2) (refer to Table 1 for an explanation of case #'s). In case # 8, the CV_{MSE} was 0.66, which led to convergence failure in attempting to derive the associated harvest policy. In essence, one is so uncertain about population size in this case that any one harvest level looks about as good as any other.

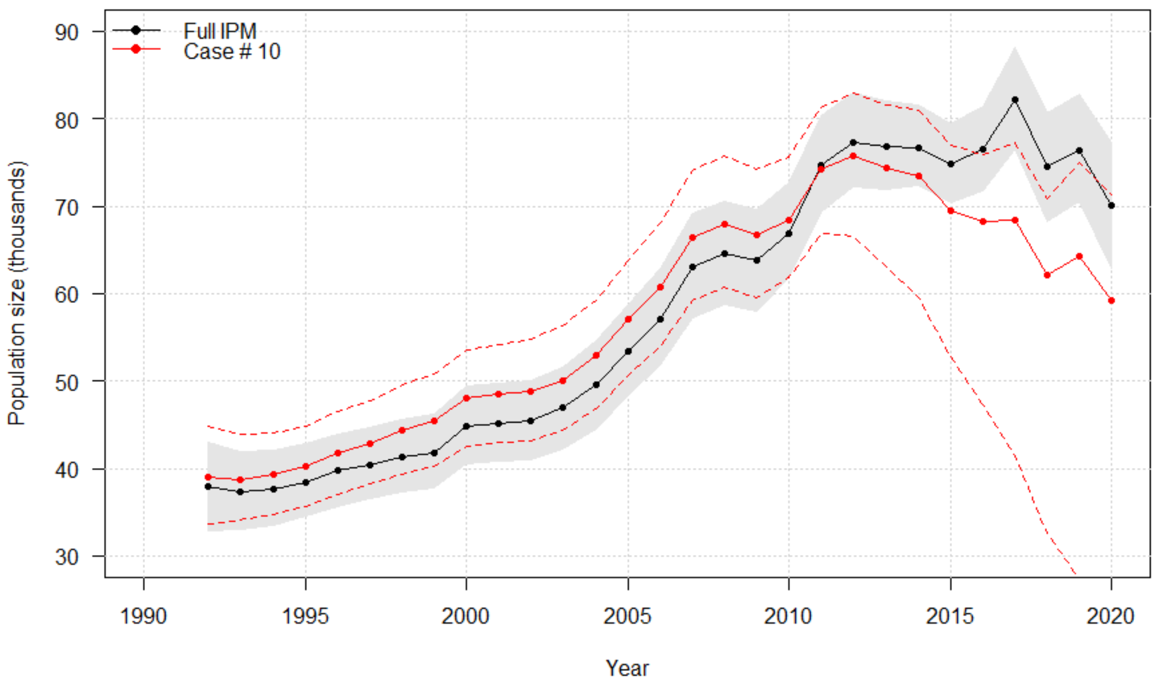

Fig. 2. Posterior estimates of May population size from the full-data IPM (with 95% CIs), compared with those from Case # 10 in Table 1, in which CMR estimates of population size were discontinued in 2011 and November counts and the productivity survey were discontinued in 2010. While the past decade of population estimates from Case # 10 show a decline (albeit with a lot of uncertainty), the optimal strategy derived from the reduced-data IPM suggests that future populations would range far above the target of 60,000 (Table 1).

We direct the reader to Table 1 for comparisons of the data-reduction scenarios evaluated so far. The complete monitoring program as it is now conducted costs €117,460 per year (Appendix). Significant cost savings are associated with reductions in the CMR program and productivity surveys, which are the most expensive monitoring instruments. In most cases, the expected population utility remained close to one, which would be that attained if the population could be maintained at exactly 60,000 each year.

Table 1. Various scenarios for reducing monitoring efforts for pink-footed geese, ranked from the highest to lowest population utility. M represents the final of year CMR-based estimates of population size. Similarly, N represents the final year of the November count, and P represents the final year of productivity data. Case # 0 represents the full-data IPM. Expected utility is the long-term population utility as expressed in Fig. 1. Mean population size is that expected when managing the population based on reduced data when the "true" population dynamics are described by the full-data IPM. Annual cost represents the 10-year amortized annual cost (€) of all monitoring. Annual savings represents the cost-savings from the complete monitoring program as it currently exists. Note that for case #'s 15 and 16, the May count was discarded in addition to the reductions expressed by M and P. Case # 8 could not be evaluated because the optimal harvest policy failed to converge.

Case #	M	N	P	Expected utility	Mean population (k)	Annual cost (€)	Annual savings (€)
0	2020	2019	2019	0.9900	59.76	117460	
12	2020	2019	2010	0.9899	60.72	98402	19059
3	2020	2019	2015	0.9898	61.03	108990	8471
13	2011	2019	2019	0.9892	62.17	34840	82621

11	2011	2019	2015	0.9890	62.19	26369	91092
1	2016	2019	2019	0.9889	62.60	80741	36720
6	2016	2019	2015	0.9889	62.51	72270	45191
5	2020	2015	2015	0.9883	62.31	108132	9329
2	2020	2015	2019	0.9882	62.88	116603	858
15	2011	2019	2010	0.9861	63.77	11105	106356
16	2011	2019	2019	0.9822	64.52	30164	87297
7	2016	2015	2015	0.9785	64.42	71412	46049
14	2011	2015	2015	0.9741	64.58	25511	91950
4	2016	2015	2019	0.9494	65.26	79883	37578
9	2011	2019	2010	0.0094	98.12	15781	101680
10	2011	2010	2010	0.0003	98.61	13850	103611
8	2011	2010	2019	NA	NA	32910	84551

Case #'s are plotted in Figs. 3 and 4. While annual costs are distributed somewhat evenly over a wide range, management performance in terms of expected population utility falls into two discrete groups: those that perform well and those that perform very poorly. As we might expect, the poorly performing policies also have the lowest associated monitoring costs. Ignoring the poorly performing cases (Fig. 4), we can discern that case #'s 13 and 11 perform almost as well as the full-data policy, but demonstrate substantial cost savings. Notably, both of these cases eliminated CMR-based estimates of population size during the last nine years, but still are able to maintain a mean population size of 62,000, well within the range of tolerance for the goal of 60,000. Case # 15, which also eliminated the productivity survey from the last nine years, also performed reasonably well at a still lower annual cost. Cases in which the November count was eliminated performed relatively poorly and were not associated with large cost savings.

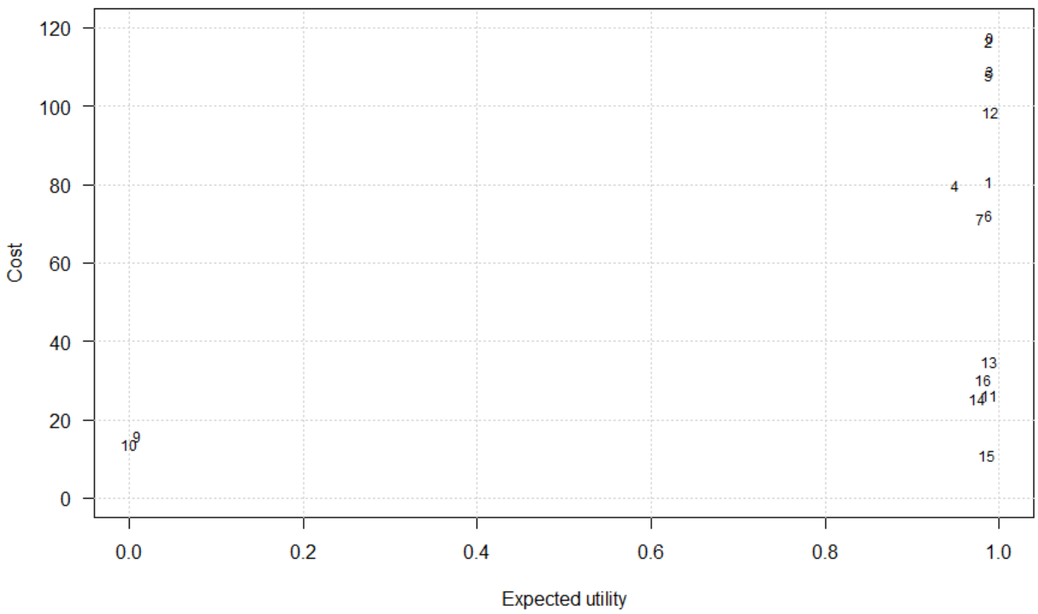

Fig. 3. Case numbers from Table 1 plotted as functions of the expected population utility and the 10-year amortized annual cost (€ in thousands).

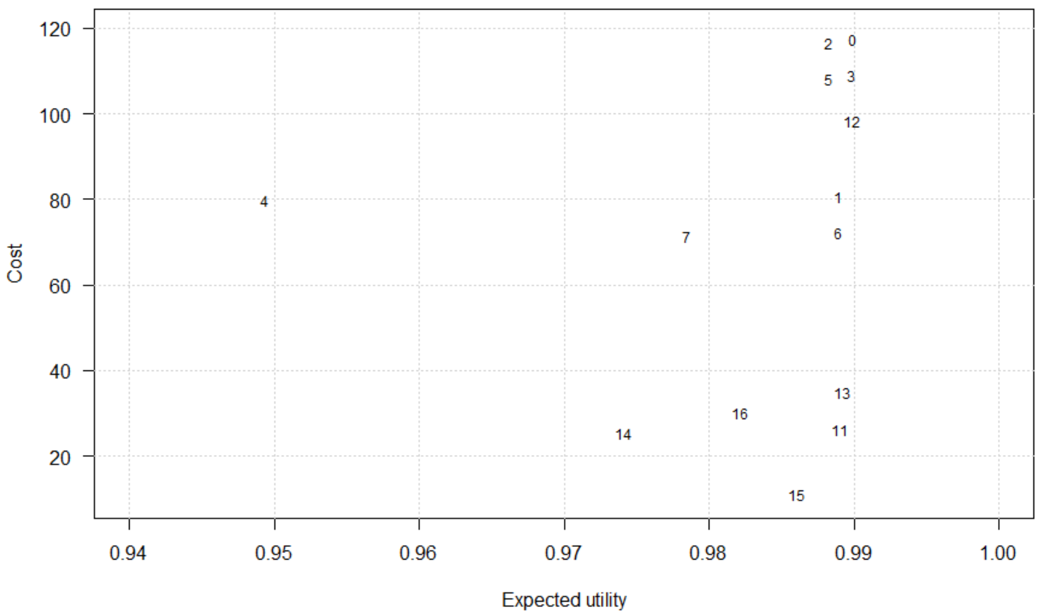

Fig. 4. Same as Fig. 3 but zoomed-in to include only the right-most portion of the graph.

Other uses of monitoring data

The CMR program is used to estimate annual survival in addition to May population size. While the CMR-based survival estimates are not used in the IPM due to conflicts with other sources of data that could not be resolved (Johnson et al. 2020), annual survival can nonetheless be estimated as a latent (unobserved) variable. The CMR-based survival estimates thus provide an independent check of the estimates provided by the IPM (Fig. 5). The IPM estimates of survival correspond relatively well with the CMR estimates, except at the beginning and ending of the timeframe. Possible reasons for lack of correspondence are discussed by Johnson et al. (2020). Interestingly, even when we omit the last nine years of CMR-based May population sizes, the IPM still does a reasonable job of estimating annual survival (Fig. 5).

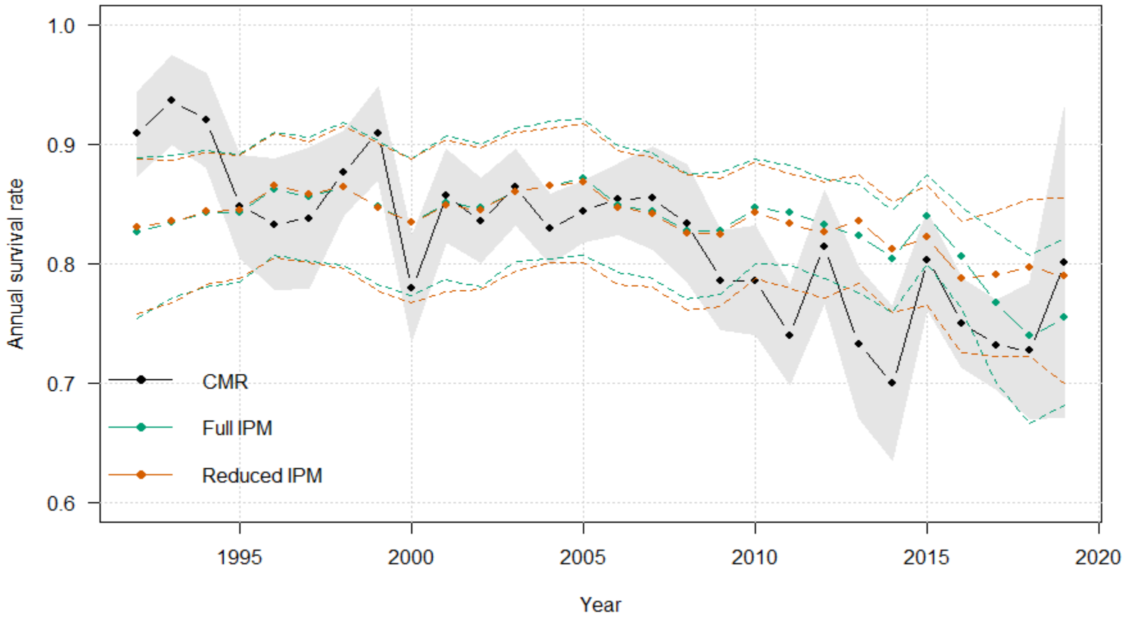

Fig. 5. Estimates of annual survival of adult pink-footed geese (and 95% CIs) as based on the CMR program, on the full-data IPM that does not use the CMR-based survival estimates, and from a reduced-data IPM that eliminates the last nine years of CMR-based estimates of May population size.

The CMR program also provides other useful information. When geese are caught and tagged, they are also screened by x-ray for the presence of shotgun pellets to help evaluate crippling rates (Noer et al. 2007). Moreover, some geese may be fitted with GPS tags, resulting in new information on movements, which is highly dynamic within the existing range of the population of the pink-footed goose (Clausen et al. 2018), as well as in terms of new migratory routes and breeding grounds being established outside the current range (Madsen et al. in prep.).

November population counts are used as reference values by international organizations such as Wetlands International and the Ramsar Convention. The November count is also the most important contribution to the ISSMP from The Netherlands and Belgium. If the November counts were discontinued, these Range States would 'loose' some of their connection to the ISSMP and the contrast in management approaches between Norway/Denmark and The Netherlands/Belgium would be more obvious. Moreover, in The Netherlands the November count would be carried out for national reasons regardless of whether it was conducted range-wide, as fieldwork is mainly carried out by volunteers. The same is true for Belgium, and being a partner in the ISSMP is an important incentive to organize the count. Finally, the November count serves as a source of ecosystem services in terms of bird-watching and goose damage assessments.

Discussion

Optimal harvest policies performed well for the most part in the reduced-data scenarios. The optimization process relies of estimates of natural survival, differential vulnerability of young, the coefficients for the relationship between thaw days and productivity, and May population size. If their uncertainty is considered explicitly, the optimal policy can do good job of prescribing harvests even if the underlying population model is “wrong.”

In terms of future monitoring efforts, it appears that cut-backs or elimination of some monitoring efforts could be considered without a large decrease in expected management performance, but with substantial savings in annual cost. In particular, it appears that the loss of the CMR program would cause no immediate loss in performance, but would result in a cost savings of €91,801 annually. The productivity survey is also relatively expensive, and its elimination might be considered because the relationship between thaw-days and productivity is firmly established. An alternative to total elimination of the productivity survey would be to scale back the effort. In a typical recent year, over 20,000 birds are examined in the field for age. We suspect that many fewer samples would provide a reasonable estimate of productivity. Finally, our analyses suggest that the November count is relatively important, and it is also inexpensive. Therefore, there seems to be no compelling reason to discontinue this count.

Any decisions to reduce monitoring efforts for pink-footed geese should consider the limitations of these analyses. First and foremost, we must assume that the demography of this population will not change in any substantive way in the future. A reduced monitoring effort could lead to a failure to recognize any such changes. Also, we would expect management performance to degrade the further out in time we get from the end of data collection. In particular, we here treat CV_{MSE} as temporally fixed because we have no basis for doing otherwise; yet it is expected to increase over time especially with elimination of the CMR program (Fig. 2), and this could eventually have a substantive effect on management performance.

We emphasize that the monitoring program and the IPM have been designed to ensure robust decisions regarding harvest. In the past, annual harvest decisions were based on the May population count. In 2015, there was a problem with the count and population size was biased low, which led to inappropriate restrictions on the harvest in Denmark and Norway (Madsen et al. 2017). To avoid similar 'mistakes,' the IPM was developed, which includes the November and May counts as well as the CMR population estimates as input, and this has 'smoothed' the population trajectory and ensured more predictable and reliable hunting regulations. If we reduce monitoring, we are at risk that the remaining program will again be more prone to uncertainty and bias, which could ultimately result in less effective harvest decisions.

Finally, we note that there are uses of monitoring data beyond those for managing harvests and population size. While these other uses cannot currently be valued quantitatively, they should nonetheless be considered in any decisions about the future of monitoring efforts for pink-footed geese.

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Appendix: Estimated annual costs of maintaining monitoring activities related to adaptive harvest management of the Svalbard population of the pink-footed goose, not including time spent by volunteers in the field.

Maintaining CMR program	DKK	EURO
Canon-netting with professional team of 5 professionals and 3 volunteers DK		
Salary 5 academic staff x 5 days	71,750	9,618
Travel + accommodation + allowances	30,000	4,021
Accommodation and food for volunteers	9,000	1,206
Neckbands (200 pieces; 30 DKK each)	6,000	804
Baiting (grain) prior to canon-netting	8,000	1,072
Re-sightings of neckbands and marked versus unmarked recordings		
DK: salary for 2 professional observers 757 hours + driving costs	279,670	37,489
N: salary 3 weeks for 1 professional observer + driving costs + accommodation + per diem	56,810	7,615
Analysis of data: salary for academic staff 5 days	14,350	1,924
Subtotal	475,580	63,751
Subtotal including 44% overhead (DK university standard for scientific projects)	684,835	91,801
Organization of November survey (N, DK, NL, B, S)		
Organization and reporting: salary 3 days for academic staff	8,610	1,154
Driving costs volunteers	2,500	335
Subtotal	11,110	1,489
Subtotal including 44% overhead (DK university standard for scientific projects)	15,998	2,145
Organization of May survey (N, DK, S, F)		
Organization and reporting: salary 3 days for academic staff	8,610	1,154
Driving costs volunteers	3,500	469
Subtotal	12,110	1,623
Subtotal including 44% overhead (DK university standard for scientific projects)	17,438	2,338
Age counts (breeding success): N, DK, NL, B, S)		
N: fee for professional observer 4 days + driving costs	10,000	1,340
DK: salary 3 weeks by 1 professional technician + driving costs	49,410	6,623
NL: accommodation and driving costs for volunteer observer	15,000	2,011
S: salary 7 days by 1 professional observer + accommodation + driving costs + per diem	26,690	3,578
Organization, analysis and reporting: salary academic staff 3 days	8,610	1,154
Subtotal	109,710	14,706
Subtotal including 44% overhead (DK university standard for scientific projects)	157,982	21,177
TOTAL	608,510	81,570
TOTAL including 44% overhead (DK university standard for scientific projects)	876,254	117,460