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Master thesis

Body mass dynamics in autumn staging geese, their response to hunting and optimal hunting arrangement

Master in Applied Ecology

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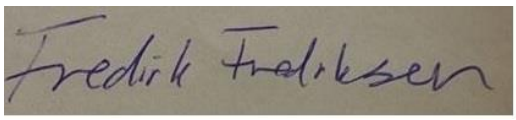

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Abstract

The Svalbard breeding population of Pink-footed Goose *Anser brachyrhynchus* and the Norwegian breeding population of Greylag Goose *Anser anser* have increased considerably over the last 30 years while at the same time embracing Nord-Trøndelag in central Norway as a stopover site. Due to increasing agricultural conflicts, population control has been attempted, but so far with limited effect. This study investigates the possibilities to increase the hunting bag when planning the hunt temporally and spatially, and explores the body mass dynamics in the harvest for the two goose species during autumn staging in 2014-2016. The study showed a record number of geese shot each year in the study period compared to the yearly bags in six previous years at the same study area. Most of the geese were shot after one and two hunting free days, whereas two consecutive hunting days gave the lowest average harvest. The average hunting bag went from two geese per hunting event (field being hunted), to almost 20. The spatial hunting response showed that the geese moved to a different field in 77.1% of the occasions on the day after a hunt, with an average distance of 1371 meters from the hunting field. When not exposed to hunting, the geese changed fields in 14% of the following days with an average of 856 meter from the field used the previous day. A total of 1041 geese were shot over the three-year period, and the harvest was dominated by juveniles for both Greylag Goose (58%) and Pink-footed Goose (70%). Average body mass differed significantly for all age and sex-classes within each species except for juvenile males and adult females of Greylag Geese that were not significantly different. Body mass was not related to the date shot in neither of the classes for Greylag Geese. For Pink-footed Geese, both juvenile males and females had a significantly higher body mass when shot later in the season. This indicates that the area is especially important for family groups of Pink-footed Goose, and also suggests that the Greylag Goose use the area to maintain their weight. This study also demonstrates that temporal and spatial organisation of hunting can be used as a tool to increase the harvest, and hence data from the present study can provide useful information for the management of these goose populations.

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1. Introduction

Birds use different strategies for migration between breeding and non-breeding areas (Davis *et al.* 2014). While many avian species minimize the time spent on migration (Dänhardt & Lindström 2001; O'Neal, Stafford & Larkin 2010), waterfowl have a number of different migratory strategies. Their time of departure from breeding areas vary largely (O'Neal, Stafford & Larkin 2010; Krementz, Asante & Naylor 2012), and while some species spend limited time on stopover sites (Luigujõe *et al.* 1996; Beekman, Nolet & Klaassen 2002), others stay for weeks before migration continues (Krementz, Asante & Naylor 2012; Jensen 2014). This variety of strategies is probably a result of different impacting factors like resource availability, competition, weather conditions, human impacts or other cost-benefit trade-offs. Geese are generally known to use regular migration routes when leaving and returning to breeding sites (Madsen, Cracknell & Fox 1999; Tombre *et al.* 2008; Clausen & Clausen 2013) but sudden changes in these patterns are also known (Larsson *et al.* 1988; Black 1998; Prop *et al.* 1998; Madsen *et al.* 2016).

Populations of geese staging in Europe has with few exceptions increased significantly in numbers since the 90's (Fox *et al.* 2010). The Svalbard breeding population of Pink-footed Goose *Anser brachyrhynchus* and the Norwegian breeding population of Greylag Goose *Anser anser* have increased considerably over the last 30 years (Pistorius *et al.* 2007; Pedersen *et al.* 2016; Madsen *et al.* 2017). Simultaneously, a change in migration pattern have been observed where especially Nord-Trøndelag County in central Norway have been embraced as a stopover site both during autumn and spring migration (Madsen *et al.* 1999b; Tombre *et al.* 2008; Jensen, Tombre & Madsen 2016b). During autumn migration, the Pink-footed Geese migrate directly from Svalbard and arrives Nord-Trøndelag in mid to late September. Based on observations of ringed individuals, some stay for three or four days, while others remain for up to five weeks before they continue their migrating to wintering areas in Denmark, Belgium and the Netherlands (Jensen 2014). There may be pink-footed geese in the region until November. The Greylag Goose also migrates southwards after breeding, but unlike the Pink-footed Goose, their breeding sites are scattered along the coast of Norway (Registration from Birdlife Norway:
http://www.birdlife.no/fuglekunnskap/fugleatlas/index.php?taxon_id=3435&vis=kart).
Hence, before they are seen in Trøndelag they have migrated at least 1000 km less (roughly the distance between northern Norway and Svalbard) than the Pink-footed Geese. Flocks of

several thousand Greylag Geese stage in Nord-Trøndelag from mid-August (own observations; (Tombre, Gundersen & Reinsborg 2016)). The highest local concentrations are observed in Skogn and Nesset in Levanger municipality, as well as several thousand at Egge in Steinkjer (Tombre, Gundersen & Reinsborg 2016). There has been an increase in numbers over the last years (A. Follestad, unpublished), and hunting statistics support these registrations demonstrating more than a tripling in the number of harvested Greylag Geese in Levanger from 2009 to 2014 (Statistics Norway: https://www.ssb.no/en/). As with the Pink-footed Goose, a change in the migration pattern have been observed, with earlier autumn migration possibly being the result of intensified hunting and climate change (Pedersen *et al.* 2016).

The two goose species partially overlap both temporally and spatially during their autumn staging period in Nord-Trøndelag. The Greylag Geese arrive earlier and tend to leave the area gradually when the Pink-footed Geese arrive. The primary diet for both species is spilt grain from the harvest, and some grass and roots. Depending on the weather, the fields are harvested from early August to mid-September, and there is plenty of spilt grain in harvested stubble fields when the Pink-footed Geese arrive (Jensen, Madsen & Tombre 2016). Moreover, in recent years, Greylag Geese are registered to forage on unharvested cereal fields when the harvest is late (own observations).

Increasing numbers of geese have led to substantial conflicts with agricultural interests in Nord-Trøndelag during the spring migration (Bjerke *et al.* 2014; Fox *et al.* 2016). It is assumed that more or less the whole population stops for varying lengths in Trøndelag each spring (Madsen *et al.* 2014) grazing on the newly sown fields and thus causing harvest losses with corresponding economical losses to farmers (Bjerke *et al.* 2014). In addition, damages on the vulnerable Svalbard tundra have been registered (Speed *et al.* 2009; Pedersen *et al.* 2013). Collectively, these factors led to the development of an international management plan for Pink-footed Goose in 2012 (Madsen & Williams 2012). While maintaining a sustainable population and its' habitats, important goals were to limit the tundra degradation and reduce the conflicts with agricultural interests. The population goal was set to 60 000 individuals with hunting as the management action. The recent population estimate from May 2016 is 74 000 geese (Madsen *et al.* 2016). Accordingly, at present more geese must be harvested in order to reach the management goal. Hunting is only conducted in the autumn in Denmark and Norway, with a 70:30 % distribution respectively (Madsen *et al.* 2017). Around 80% of the

Pink-footed Geese shot in Norway are harvested in Nord-Trøndelag (Statistics Norway: https://www.ssb.no/en/).

In order to achieve the population goal for Pink-footed Goose, it is essential to find a way to increase the harvest during the weeks they stay in Nord-Trøndelag in the autumn. If the hunting is organized and planned temporally and spatially, more geese may be shot (Tombre *et al.* 2011; Jensen 2014; Jensen, Madsen & Tombre 2016), but the generality of these findings in terms of different areas and species has yet to be demonstrated. The hypothesis is that a reduced hunting pressure will enhance the hunting possibilities as geese are less disturbed and hence more geese may be hunted. To test this hypothesis, a semi-experimental study was conducted in a well-established goose hunting area in Steinkjer municipality in Nord-Trøndelag from 2014 to 2016 during the autumn staging period. It is hypothesized that there will be an increase in the yearly harvest for both Pink-footed Geese and Greylag Geese when reducing the hunting pressure in terms of fewer hunting days. Having the complete control over the goose hunting activity in the area, it is further tested whether there is an optimal number of hunting free days between the hunts that maximizes the harvest.

Since the Pink-footed Geese travel a significant longer distance than the Greylag Geese before they arrive the stopover site in Nord-Trøndelag, it is predicted that the Pink-footed Geese are more dependent of this stop as they need good foraging conditions to refuel their body reserves before the next migration leg. Especially the young are predicted to increase in body mass over the staging period, which is supported by previous registrations showing that Nord-Trøndelag is the region in the autumn with the highest fraction of staging family groups of Pink-footed Geese along their flyway (Gundersen, Clausen & Madsen 2017). The Greylag Geese have a shorter pre-staging migration distance, as they have their breeding sites along the coast of mainland Norway. The increase in numbers using this area in recent years, however, demonstrates that Trøndelag apparently has become an important stopover site for the Greylag Geese as well. However, a corresponding trend in weight dynamics is not expected as they have spent less body reserves on the migration, they breed earlier in the season and have most likely had more food resources available prior to their arrival than the Pink-footed Geese.

The weight dynamics of geese staging in Trøndelag can be quantified by measuring harvested individuals during the hunting period in the area. Measures were taken separately for each goose species, sex and age (adults and juveniles). This study is hence divided in two sub-

themes, as the open hunting season also gives the opportunity to test optimal hunting arrangements on the number of harvested geese. The semi-experimental study design, with the hunting team hunting at different intervals in the area, will demonstrate how varying day-intervals result in a corresponding number of geese shot. This study will therefore provide knowledge on the weight dynamics of two autumn-staging goose species in relation to their migration strategies, as well as providing guidelines for an optimal harvest arrangement in the area.

2. Material and methods

2.1 Study area and study population

The study was carried out in the agricultural areas of Egge in Steinkjer municipality in Central-Norway. The study area ranges approximately 2 km inland from the shoreline and consists of 1 km^2 of cereal grain fields (Figure 1). The cluster of cereal fields, only divided by a 3-500 meter wide ridge and a small road, is surrounded by dense settlements and roads to the east, forests to the north and west, and Beitstadfjorden to the south, making the preferred areas for geese relatively isolated. Accordingly, it is possible to keep track of the geese and register their spatial distribution and numbers staying in the area.

The increase in agricultural conflicts, as well as increased hunting interests, motivated the landowners in Egge to organize the hunting permit sale following the County Governor's advice in 2008. This resulted in a yearly harvest ranging from 24 to 216 geese over the period 2008-2013, with the majority being Pink-footed Geese. The variation in harvest success indicated an unexploited hunting potential in Egge, and in 2014, an agreement for the present study was made with the landowners in Egge giving all the hunting rights over the study period 2014-2016.

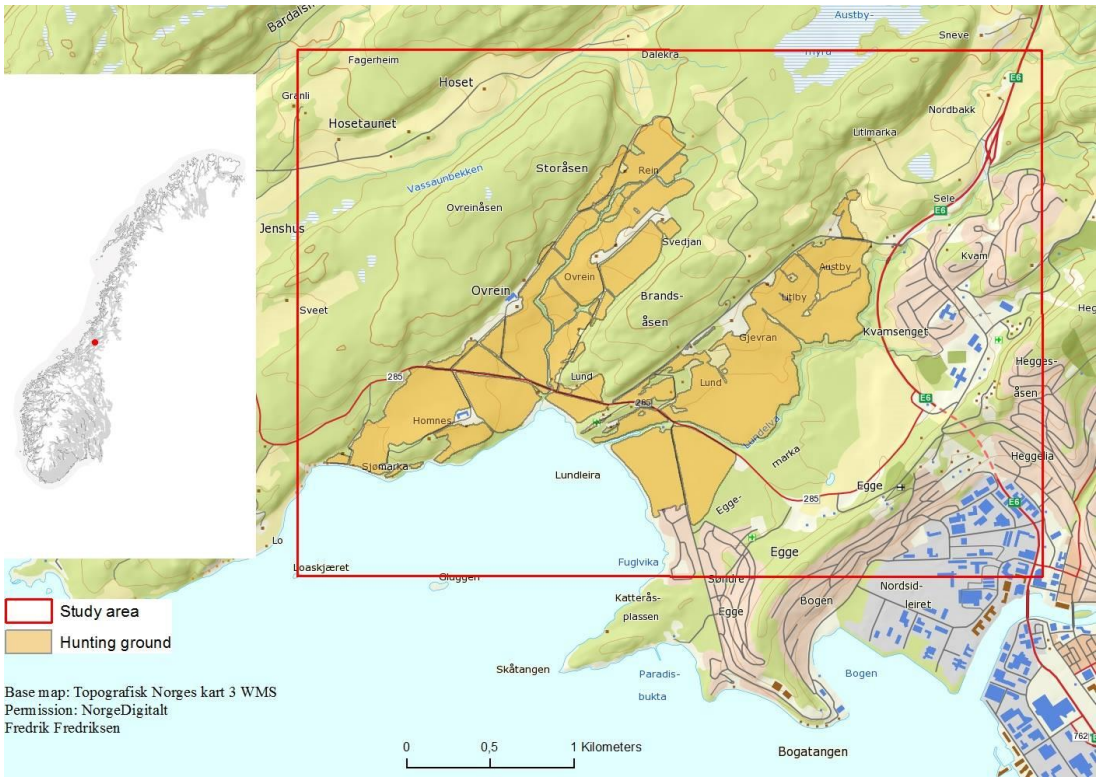

Figure 1. Study area with location in Norway to the left. Orange parts are farmland fields where the geese forage

2.2 Experimental design

The hunting agreement with the landowners consisted of exclusive hunting rights on geese with only few restrictions for developing an experimental design. The agreement followed the terms set by the landowners in 2008, meaning that the hunt could be conducted between 06.00-12.00 a.m. on weekdays, and from 07.00 to 12.00 a.m. in the weekends. This made the results comparable to the previous year's hunting. The fields were originally divided into different plots with names linked to the landowners. They were based on where it was feasible to hunt, regarding both safety and success. These plots were kept, and some nearby fields were also included matching the area use by the geese. The hunting should not be conducted more than two days in a row. It was possible to hunt on several plots on the same hunt if the hunting parties kept a distance to ensure that enough area without disturbance was left for the geese. As for previous years' statistics from Egge, each time it was hunted on a field it was registered as "a hunting event". This provided possibilities to relate harvest success to number of hunting events.

The experimental design was based on previous studies in nearby areas (Tombre *et al.* 2011) with some adjustments needed for this specific study. Due to the increased presence of Greylag Geese, which in 2013 counted 53 of the total harvest (N=126, 42%) in Egge, this species was also included in the study. To quantify the hunting response with regards to making the harvest more efficient for both species, the variables number of geese in the area and the number of days between hunting and the distribution of geese (in relation to the hunting location) was quantified.

2.3 Data collection

The study area was scouted for geese every day from the first observations in August (the area were regularly searched from early August), and until the geese left the area in October. Once a day the geese were counted using binoculars, telescope and a hand clicker. Geese were primarily counted resting along the seashore at high tides. As far as possible, their preferred feeding field was registered, which on days with hunting would be where they either landed, or tried to land but possibly were scared away by hunting. Before hunting days, geese were observed several times a day to identify the optimal field to perform the coming hunt. Accordingly, the hunting took place after estimating the number of geese in the area, as well as their field use as geese tend to come back to the same field the following day. Some fields are easier to hunt due to a wider shooting angle and also the weather conditions were assesses as fog, rain and wind often make geese fly lower which reduces their sight making them easier to get into range. Finally, the number of days since the last hunt was an important determining factor of when to hunt. Usually, the number of geese exceeded 500 before a hunt, but if the hunt was conducted on a smaller number, it was because it was unlikely that more geese would arrive.

A hunting party of three to five hunters began establishing the equipment two hours before daylight on each hunting day (between 03.00 and 05.00 A.M. depending on the date, as this determine the light period). As far as possible, the party consisted of the same people, but with some replacements during the study period. The equipment consisted of ground blinds, covered with stubble for camouflage, and goose decoys (50-200) placed around the blinds to attract the geese into shooting range (Figure 2). Based on previous experience and communication with other goose hunters, this arrangement is known to be the most efficient method for goose hunting and was used throughout the whole study. Almost without

exceptions, the geese came from the roosting area on the seashore to feed on surrounding fields in the morning, most often leading to several shooting opportunities they approached the field. Following the Norwegian hunting law, a maximum of two shots per person was used before reloading. The hunt ended when it seemed unlikely that new shooting opportunities would appear, or at the latest at 12.00 PM.

Figure 2. An established goose hunting field; decoys spread around the ground blinds covered with stubble. The decoys faces towards the wind and the blinds faces the opposite way to get clear shots on the front of the geese.

After they were shot, the geese were weighed to the nearest 5 g using a digital weight, and species and age (juveniles or adults) were determined by plumage characteristics. In 2015 and 2016, the sex was also registered by cloacal examination by the same person to avoid biased results.

Since Egge is a well-organised hunting area, hunting statistics from 2008-2013 exists and were available for comparisons of the data gathered in the present study.

2.4 Statistical analyses

Data was sorted and analysed in Excel v 1702 and R software v. 1.0.136 (R Core Team 2015). Body mass did not differ between 2015 and 2016 for any of the species, age classes or sexes (all p-values >0.09). Hence, body mass measures were pooled when further analysed. ANOVAs were conducted for testing differences in body mass within each species for the different age and sex classes, with a Tukey test identifying significant differences between groups. Linear regression analyses were carried out to evaluate any trends between goose body mass when shot and the date of hunting. For further testing other determining factor for the body mass when shot, General Linear Models (GLM) were run with body mass as response variable and date of hunting, the sex and age (adult versus juvenile) as predictor variables. Sex and age were treated as class variables and date as a continuous variable. Interaction terms were included in the GLMs, and non-significant results were stepwise deleted until only significant results remained. A two-way sample t-test, assuming unequal variance, was carried out to test for differences in the distance the goose flock moved the following day after being exposed to hunting or not.

3. Results

3.1 Goose numbers

The earliest seasonal observation of Greylag Goose at Egge was on 17th of August in 2016, and the latest was the 24th of August in 2015 (Figure 3). The earliest observed departure from Egge was on 13th of September in 2016, a month earlier than the last observation in 2014. The highest daily number of Greylag Geese registered was 1900 on two consecutive days in 2015 (Table 1). For Pink-footed Goose, the earliest seasonal observation was 3rd of September 2016, and the latest was 18th of September (Figure 3). Their departure was on the 13th of October in both 2014 and 2016, and two days earlier in 2015. The highest daily number registered was 5450 on October 1st in 2015 (Table 1). The highest mean observed was in 2015 for both species (Table 1).

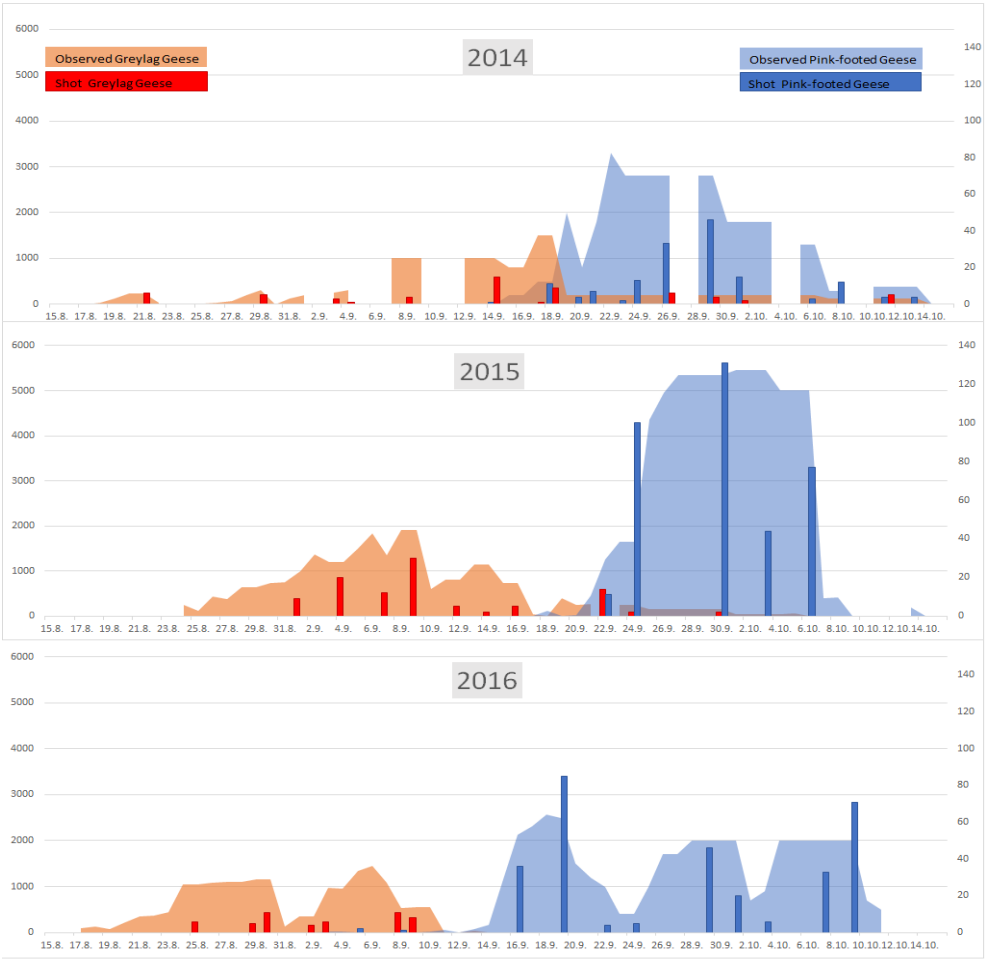

Figure 3. Number of observed (primary Y-axis) and shot (secondary Y-axis) Greylag Geese and Pink-footed Geese each day between 15th of August and 15th of October 2014-2016 at Egge, Steinkjer.

Table 1. Number of geese within the core period 20th of August and 20th of September for Greylag Geese, and 15th of September to 15th of October for Pink-footed Geese. Mean calculated from first observation of >100 individuals to when numbers stabilized below 100 for both species within the core period.

	Greylag Geese		Pink-footed Geese	
YEAR	max (date)	mean±stderr	max (date)	mean±stderr
2014	1500 (17. Sept)	501 ± 93	3300 (22. Sept)	1461 ± 207
2015	1900 (8. Sept)	851 ± 101	5450 (1. Oct)	3228 ± 498
2016	1450 (6. Sept)	788 ± 84	2000 (25. Sept)	1569 ± 125

3.2 Harvested Geese

The hunting resulted in a total of 827 Pink-footed Geese and 212 Greylag Geese summarised for all three years (Figure 4). The harvest was highest in 2015 for both species with 363 Pink-footed Geese and 101 Greylag Geese. Juveniles dominated the harvest with 70% (n=582) of the Pink-footed Geese and 58% (n=122) of Greylag Geese. For Pink-footed Geese, 56.2 % out of 667 geese with determined sex were males (excluding the 160 individuals registered with an unknown sex). For Greylag Goose the males represented 51.4% out of 140 registrations (72 individuals were registered with unknown sex).

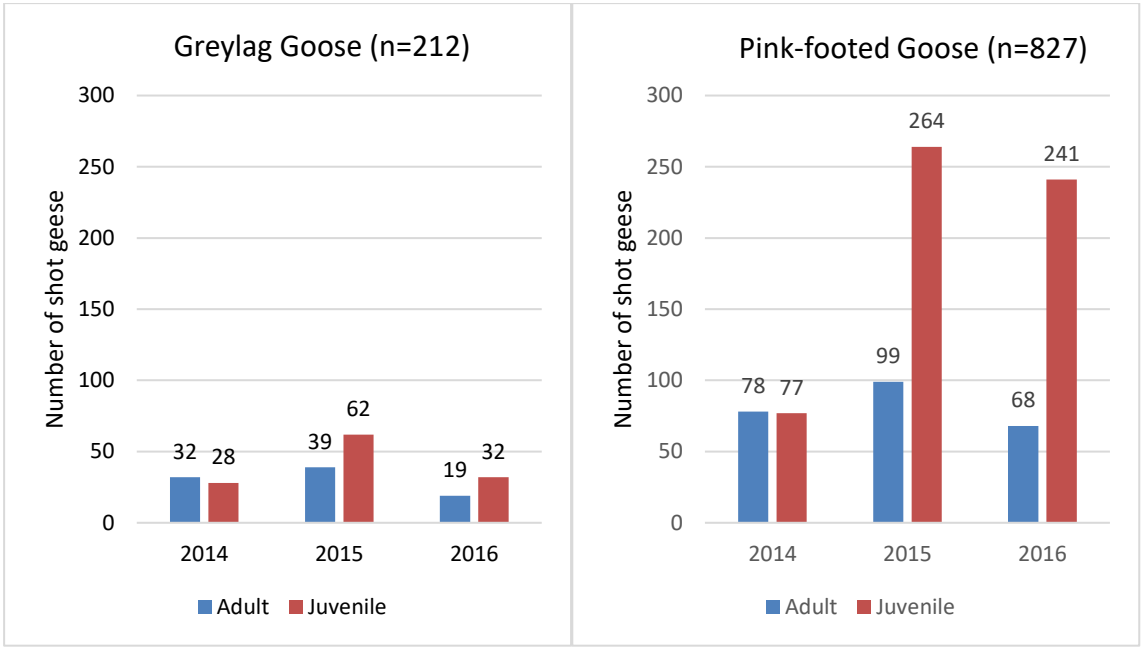

Figure 4. Number of Pink-footed Geese and Greylag Geese harvested at Egge, Steinkjer, in 2014-2016.

Most of the Greylag Geese were harvested before September the 20th, whereas for Pink-footed Goose the majority were harvested between September 15th and October 15th (Figure 3). The first seasonal harvest varied between 21st of August and 1st of September for Greylag Geese and 5th and 22nd of September for Pink-footed Geese (Figure 3). The highest number of Greylag Geese shot on a single hunting event was 30 individuals in 2015, which was on the same date as the highest number of Greylag Geese counted in the area. For Pink-footed Goose, the highest number harvested on a single hunting event was 133 on 30th of September in 2015.

3.3 Body mass

The Greylag Goose has a higher average body mass than the Pink-footed Goose for all demographic classes (Table 2, Figure 5). Overall, the weight-differences were significant between demographic groups for both species (ANOVA, Pink-footed Goose: $F= 157.55$, $p<0.001$, Greylag Geese: $F=66.42$, $p<0.001$), but for Greylag Geese the difference between female adults and male juveniles were not significantly different ($p>0.1$) (Figure 5). For both species, adult males were heavier than adult females.

Table 2. Average body mass of Pink-footed Goose (N=659) and Greylag Goose (N=138) summarised for the years 2015 and 2016.

Species	Age	Sex	Average body mass (g± std. err.)	Sample size
Pink-footed Goose	Adult	Female	2313 ± 26.6	69
		Male	2577 ± 26.7	95
	Juvenile	Female	1921 ± 16.4	219
		Male	2115 ± 16.4	276
Greylag Goose	Adult	Female	2834 ± 68.5	21
		Male	3316 ± 43.5	35
	Juvenile	Female	2422 ± 39.8	46
		Male	2826 ± 50.3	36

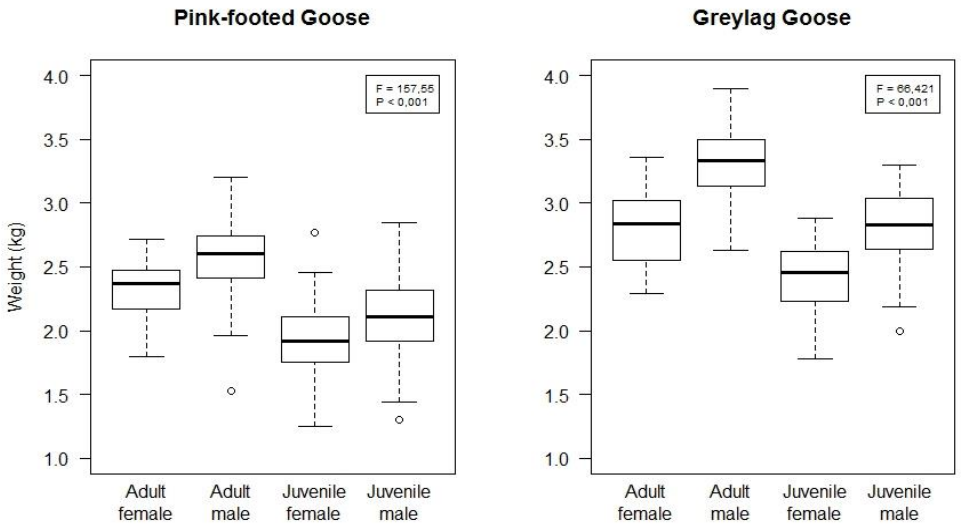

Figure 5. Boxplots of body mass of the different demographic classes of Pink-footed Geese and Greylag Geese for 2015 and 2016 combined. The boxes are

interquartile ranges with black lines inside representing the median. Vertical lines outside boxes show minimum and maximum values, and hollow dots are outliers.

Results from a GLM supported the body mass pattern found in Table 2, where the body mass of Pink-footed Geese was significantly affected by sex and age, but also by the date they were harvested (Table 3). Hence, males were heavier than females, adults heavier than juveniles, and the body mass also depended on when the bird was shot. However, the date effect was only significant for the juveniles, demonstrated by a significant interaction term between date and age (Table 3, Figure 6). Therefore, juvenile geese shot late in the season weighted significantly more than those shot early for both female and male juvenile Pink-footed Geese (Figure 6). The body mass for adult females and males did not depend on the hunting date (Figure 6). For Greylag Geese, regardless of demographic class, the body mass differed between sex and age (Table 2 and 3) but were not affected by date (Figure 7).

Table 3. The results from General Linear Models with body mass as the response variable, and the sex, age (adult or juvenile) and date of hunting as predictor variables. Only significant results, after stepwise deleting non-significant relationships, are listed.

Variable	F	p
Pink-footed Goose		
Sex	114.22	<0.001
Age	30.92	<0.001
Date shot	9.62	0.002
Date shot * Age	5.89	0.015
Greylag Goose		
Sex	33.51	<0.001
Age	49.63	<0.001

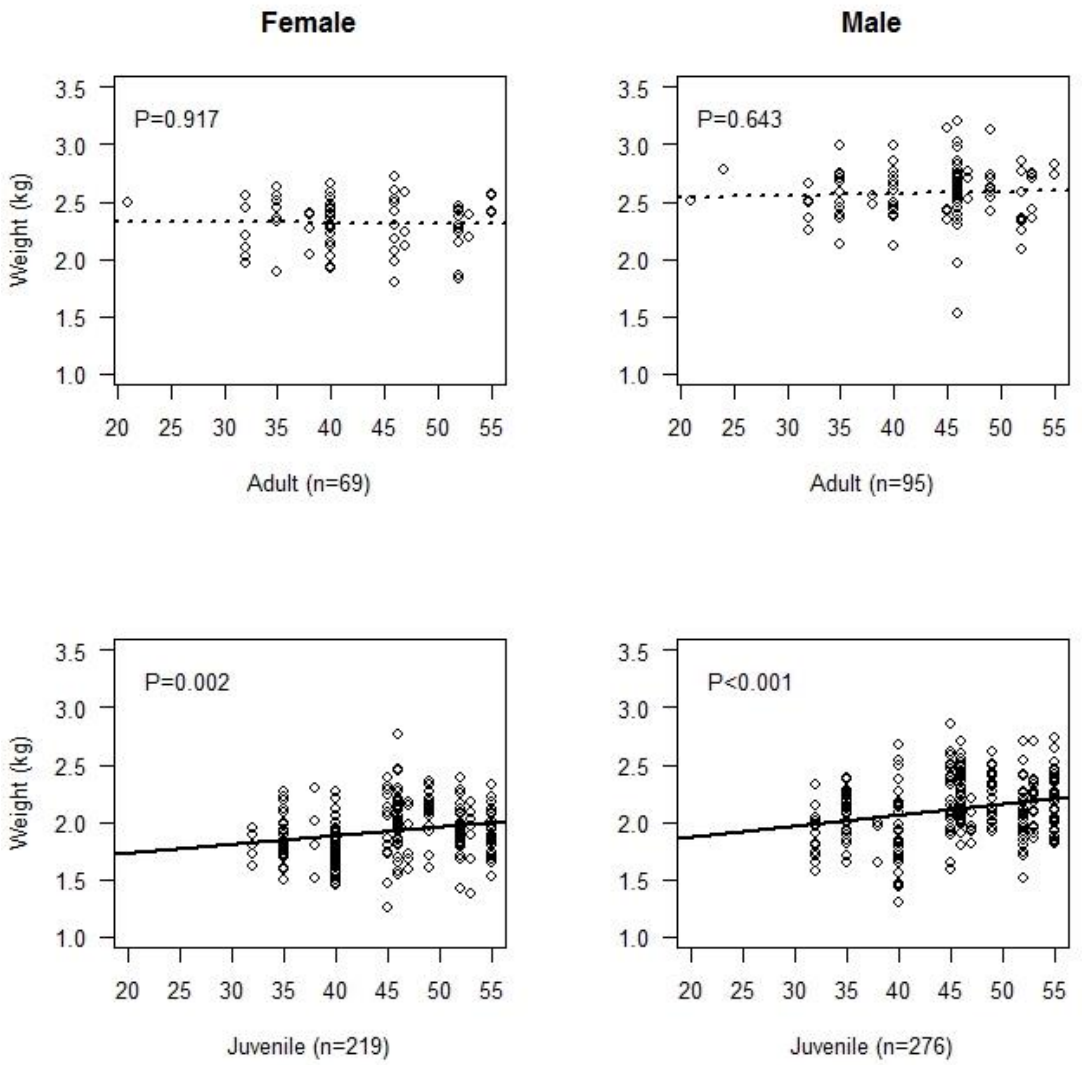

Figure 6: The body mass of Pink-footed Goose harvested in 2015 and 2016 (data pooled for both years) in relation to the date when shot (0=15th August). The black lines are regression lines where dotted lines demonstrate a non-significant relationship and solid lines significant results.

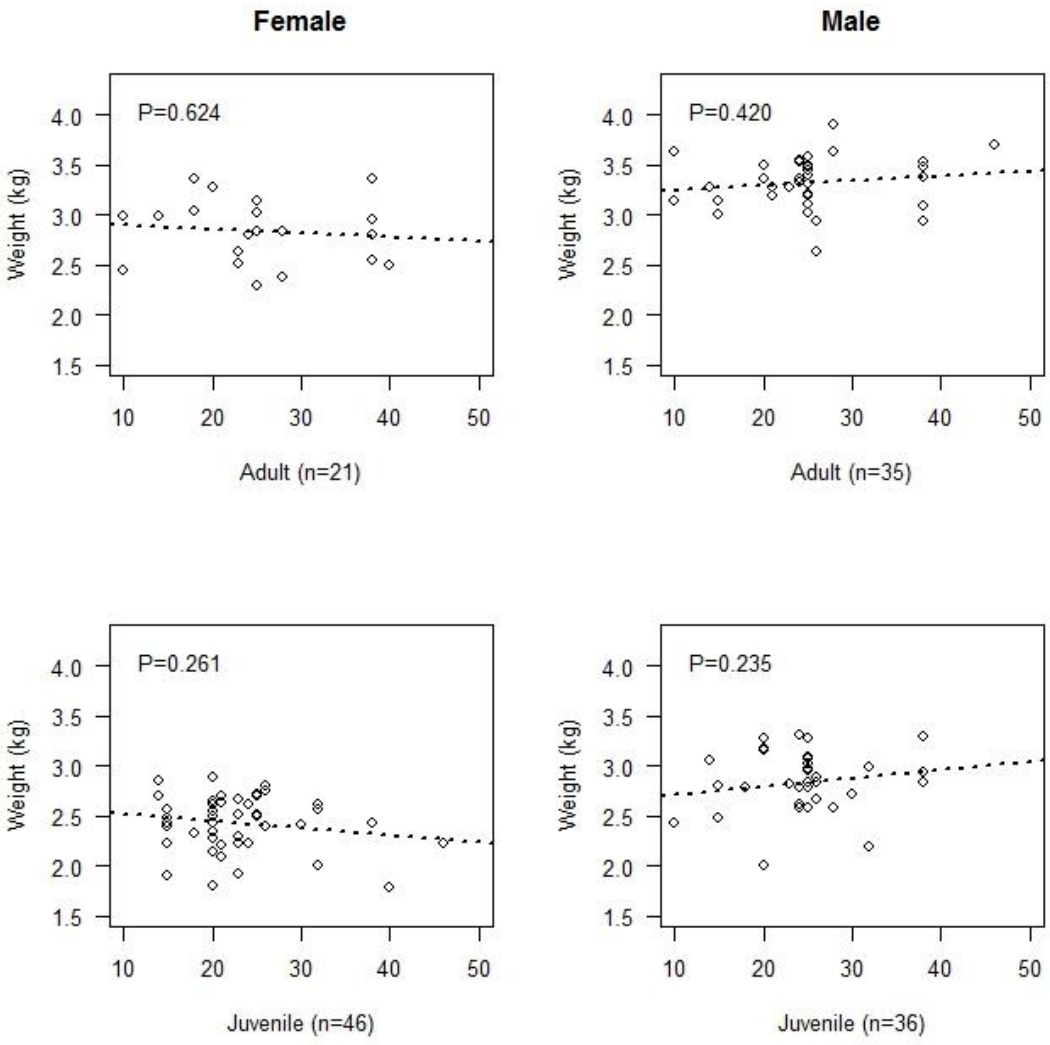

Figure 7: The body mass of Greylag Goose harvested in 2015 and 2016 (data pooled for both years) in relation to the date when shot (0=15th August). The black lines are regression lines where dotted lines demonstrate a non-significant relationship and solid lines significant results.

3.4 Goose response to harvest

Out of 65 observations (all three years combined), the geese came back to the same field as they used the previous day to forage at 56 times when no hunting had been conducted (86%) (Figure 8). In the remaining nine observations, the geese travelled on average 856 meters away to another field (left panel on Figure 8). Only at one occasion, they travelled more than 1000 meters to a new field after a hunting free day (2700 meters in 2015). A similar evaluation at the fields where hunting was conducted showed that the geese moved to different fields the

day after hunting in 27 of 35 observations (77.1%), with an average distance of 1371 meters away from the field with hunting the previous day. 21 of the observations (77.8%) exceeded 1000 meters. At only six occasions did the geese come back to the same field the following day after a hunt (17%, Figure 8). On average, the geese moved 515 meters longer the day after hunting compared to the day after no hunting (t-test, t=6.8, n=100, p<0.0001).

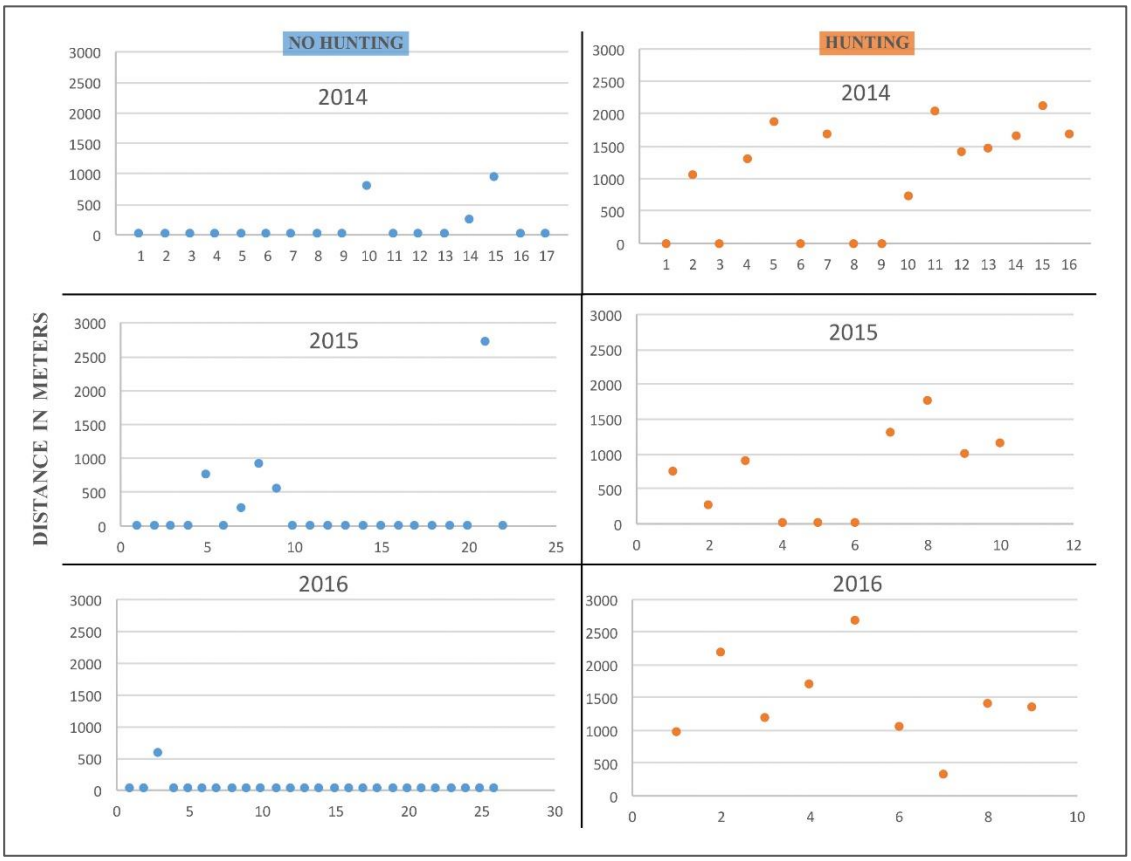

Figure 8. Distance between a registered goose flock and the preferred grazing field from one day to another after hunting and hunting free days. Distance is measured from the centre of each field. Numbers on the x-axis represent the different occasions of goose flock observations between two consecutive days. The left panel shows the flock observations on fields without hunting, the right panel observations after hunting events.

3.5 Harvest in relation to hunting

A total of 52 hunting events (number of fields being hunted) was registered during the study, with an average of 20 geese harvested per event. Excluding the first hunting event each year, most of the 49 events (63%) took place after one or two hunting free days, resulting in an average harvest of 22.5 and 21.5 geese respectively (Figure 9). In total, most geese were shot after one hunting free day (425). Hunting on two consecutive days was conducted eight times with an average of 6.5 geese as a result. The highest average geese shot was with five hunting free days with 84.5 geese per event (Figure 9) based on two events (133 + 36).

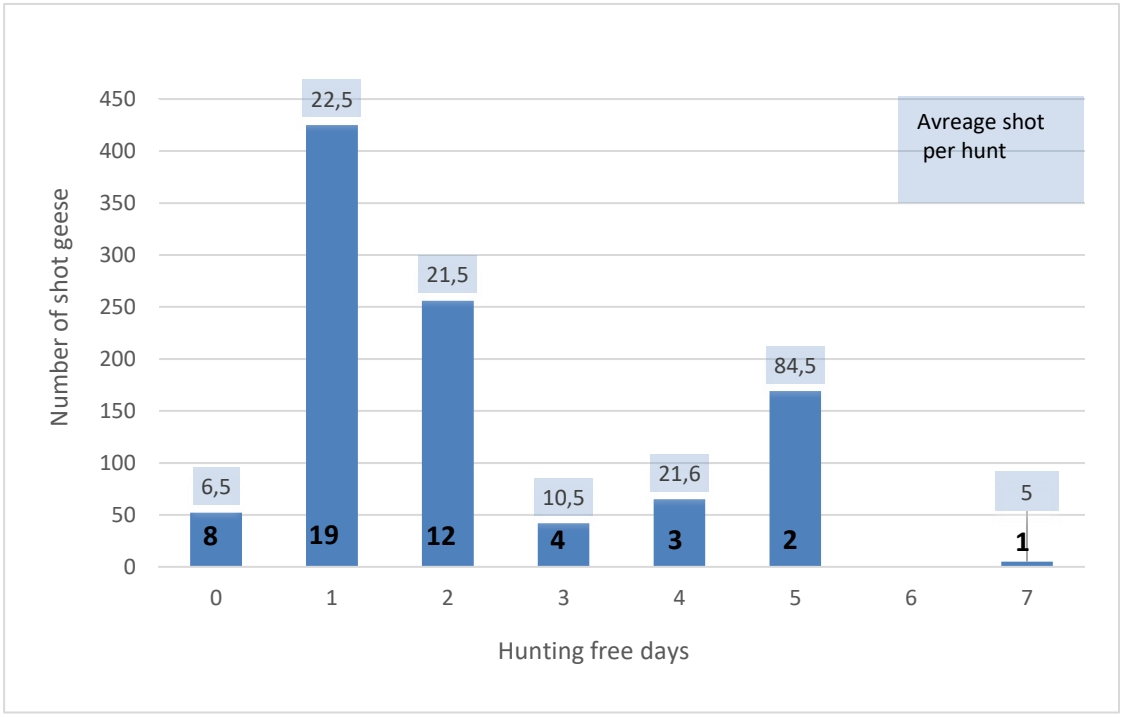

Figure 9. Number of harvested geese in relation to number of hunting free days between hunting events. Black numbers inside columns represent the number of hunting events and boxes on top the average number of geese shot per event.

In total, the harvest was higher in each of the years of the present study compared to any other year in the period 2008-2013 (Table 4).

Table 4. Number of Greylag Geese and Pink-footed Geese shot in Egge, Steinkjer, from 2008 to 2016. Study period marked in bold.

	2008	2009	2010	2011	2012	2013	**2014**	**2015**	**2016**
Greylag Geese	0	3	10	6	12	53	**60**	**101**	**51**
Pink-footed Geese	58	56	142	209	11	71	**155**	**363**	**309**
Total	58	59	152	216	23	124	**217**	**464**	**360**

Since data on hunting pressure (number of hunting events) also exists from 2008 to 2013, it is possible to compare the hunting efficiency/harvest rate as well (Figure 10). The figure demonstrates that the hunting efficiency has increased considerably in the present study compared to previous years. Reducing the number of hunting events clearly has an effect on the number of geese shot. E.g., in 2011, 216 geese were shot during 82 hunting events. In 2015, 464 geese were shot during 15 hunting events, thus giving an average of 2.6 geese per hunting event in 2011 and 30.9 geese per hunting event in 2015.

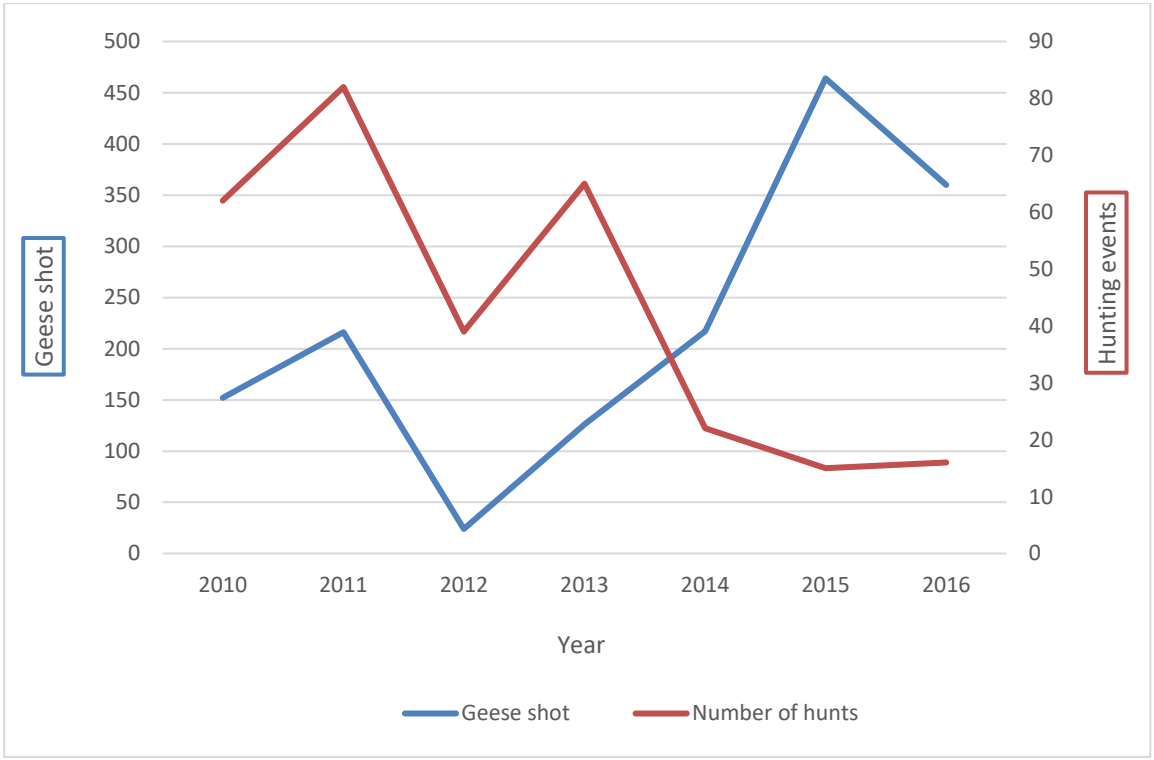

Figure 10. Number of geese shot (summarised for Greylag Geese and Pink-footed Geese) in Egge, Steinkjer in Nord-Trøndelag, in 2010 to 2016.

4. Discussion

The main findings in this study show, as hypothesized, that an increase in the harvest for both Greylag Geese and Pink-footed Geese is possible when planning and organizing the hunt temporally and spatially. The total harvest was higher than the previous maximum in all three years of the study and at the most, the harvest more than doubled compared to the harvest in the area before this study. Correspondingly, the hunting efficiency increased considerably, with almost nine times as many geese shot per event, on average, compared to the four years prior to the study. Most of the geese were shot after one or two hunting free days, but the highest average per event was after five days without hunting. The lowest average per event was, as expected, on the second day of two consecutive hunting days. Spatially, the geese returned to their preferred field (the field used the previous day) more frequently after a hunting free day (86% of the occasions) than after a day with hunting (22.9%), and after exposed to hunting, they moved on average more than 500 meter further away than when not exposed to hunting. The Greylag Geese dominated in the area, as well as in the harvest, the first month from 15th of August, whereas the Pink-footed Geese dominated from 15th of September with cumulative numbers much higher than the Greylag Geese. The age compositions in the harvest showed a dominance of juveniles for both Greylag Geese (58%) and Pink-footed Geese (70%) all three years combined, supporting the hypothesis that the area is an important stopover site in autumn for migrating family groups.

The body mass measures showed that the Greylag Geese weighed more than the Pink-footed Geese for all demographic groups. Within both species, the body mass was significantly different for all demographic groups except for adult females and juvenile males of Greylag Geese. A linear regression analysis demonstrated a significant positive relationship between body mass and the date being shot for both sexes of juvenile Pink-footed Geese, suggesting that autumn staging juveniles presumably gain weight throughout their stay. This further supports the hypothesis that the area is important for family groups since the juveniles can gain weight and build body reserves before the final migration during their stay in Nord-Trøndelag. The body mass measures for Greylag Geese did not change over the season, suggesting that they do not gain weight during their stay.

A study from 2011 suggested that Pink-footed Geese would stay in Nord-Trøndelag for a longer time period if the number of hunting events is reduced (Tombre *et al.* 2011). It was also suggested that, for this region, this would be essential for increasing the harvest. This was later

supported in experimental studies from the same study area (Jensen 2014; Jensen, Madsen & Tombre 2016). Temporal restrictions in hunting apparently increased the harvest, and hunting on several consecutive hunting days, as in the present study, gives the smallest harvest. Whereas in this study one hunting free day was apparently sufficient for increasing the bag, Jensen (2014 & 2016) showed that waiting three days is optimal. With an average of 84,5 geese shot after five hunting free days in Egge, it can be argued that waiting even longer before a new hunt is optimal, but one of these hunting events was "extreme", where 133 geese was shot and hence affecting the average. Nevertheless, to distribute the hunting events at the same location with at least one day, or more, appears to be a good strategy, regardless of location, if the goal is to increase the number of harvested geese. The spatial response to hunting/no hunting demonstrated that the geese moved longer, and more often, after being exposed to hunting, a finding which is supported by another study elsewhere in the region in 2011-2013 (Jensen, Madsen & Tombre 2016). This emphasizes the importance of coordinating the hunt in an area that is large enough. This contradicts to another study in Denmark, that showed that Greylag Geese did not move away after a hunting event (Bregnballe, Madsen & Rasmussen 2004). It cannot be ruled out that in some hot spots the geese have a higher threshold for leaving, and that the different topography in Denmark affects the spatial distribution compared to Norway. Still, harvest statistics from Steinkjer municipality, and the relative percentage contribution from Egge, suggest that less intensive hunting in the form of fewer hunting events, keep the geese in the study area and possibly attracting more geese from surrounding area thereby increasing the harvest rate (Table 5). E.g. on average, 12% of the Greylag Geese harvested in Steinkjer municipality were harvested in Egge in 2009-2013, and 43% in 2014-2015. Similar figures for Pink-Footed Geese were 22% and 63%.

*Table 5. Geese shot in Steinkjer municipality (*Statistics Norway: https://www.ssb.no/en/) *with percentage shot in Egge in parenthesis. 2016 data is not yet released from statistics Norway.*

	2009	2010	2011	2012	2013	2014	2015
Greylag Geese	120 (2.5)	120 (8.3)	100 (6)	120 (10)	160 (33.1)	170 (35.3)	200 (50.5)
Pink-footed Geese	550 (10.2)	530 (26.8)	700 (29.9)	130 (8.5)	220 (32.3)	240 (64.6)	590 (61.5)

The age composition in the harvest is similar to the what has been shown earlier (Gundersen 2013). Field observations of Pink-footed Goose from the autumn 2014 and 2015 showed a proportion of juveniles staging in Norway of 20.5% and 21.8% respectively (Madsen *et al.* 2015; Madsen *et al.* 2016), whereas the harvest in the study area was 50% and 73% respectively. This demonstrate that family groups are more exposed to hunting, which is previously hypothesized (Madsen 2010), but further also suggests that the area is especially important for family groups feeding on spilt grain on the stubble fields where the hunting is conducted. Moreover, as shown in Gundersen (2013), compared to the harvest in Denmark, there is a higher proportion of juveniles in the bag in Nord-Trøndelag than in Denmark. Behavioural responses like juveniles being more sceptical when arriving Denmark after the hunt in Norway, or differences in topography, resource availability and hunting experience might also influence these differences. However, the juvenile-adult ratios among the countries are also reflected in the field observations in autumn (Gundersen 2013; Madsen *et al.* 2016) supporting the country-based differences in the autumn with more family groups staging in Nord-Trøndelag, Norway.

For Greylag Goose, the body mass did not vary in relation to date shot. The food resources are abundant when the Greylag Geese leave the region (Tombre *et al.* 2011), suggesting that during their staging period food resources are sufficient and that they hence stay in the area to maintain weight. The Greylag Geese stayed just as long as the Pink-footed Goose, although their staging period was earlier than for Pink-footed Geese. This temperate-breeding bird also have completed their nesting period earlier than the Arctic-breeding Pink-footed Goose, giving a longer post-nesting period to regain body reserves and growth for the goslings/juveniles before they are seen in Nord-Trøndelag. Accordingly, this has presumably been achieved somewhere else than in the study areas, as they arrive Nord-Trøndelag in August (while nesting in early spring). Their shorter migration leg is also less energy demanding than the migration from Svalbard, and along with the earlier timing of nesting this is probably the reason why the Greylag Geese apparently not put on extra weight during the autumn-staging period in Nord-Trøndelag. For Pink-footed Geese, on the other hand, male and female juveniles weighed more later in the season than early, findings also supported by studies elsewhere in the region (Gundersen 2013; Gundersen, Clausen & Madsen 2017). In the present study, however, neither adult females nor adult males had a higher same body mass when shot later in the season, which contradicts to the findings in the other studies in the region, where male adults weighted significantly more later in the season. This was explained

by the sex-specific differences in the cost of raising young in Svalbard prior to arrival, where females presumably already have regained some of the body reserves lost during incubation in the brood rearing period, a period where the males spend a significant proportion of their time guarding the family giving less time to feed. Hence, when arriving the autumn stopover site, the males need to rebuild body reserves and the females must contribute in guarding the young. These behavioural patterns were also found in an observational study in Nord-Trøndelag, where the vigilance behaviour was similar for females and males (Kristoffersen 2016). The last body mass measures in the present study were in mid-October. In the studies by Gundersen (2013) and Gundersen et al. (2017), the last body mass measures were in November. Therefore, it cannot be excluded that adult males could have increased in body mass if stayed longer in Egge and could well have gained more reserves elsewhere further south in the region before departing Nord-Trøndelag.

As the hunting party didn't always consist of the same persons, some differences in shooting skills and experience might have impacted the harvest. Still, the accuracy did not vary a lot between years (39.4%, 50.5%, and 44% of the shots killed a goose the three years respectively). The skills of the hunters can be argued as the main reason for the increased harvest in the study period compared to previous years in Egge, and not the fewer hunting events as such. According to local information (pers. comm. Odd Jerpstad) there were also "professional teams" with a high hunting efficiency hunting in Egge before the present study. After their presence, however, there were hardly any hunting opportunities as most of the geese departed the area after being exposed to intensive shooting. The combination of skilled hunters and a reduced hunting pressure, organised temporally and spatially, are accordingly suggested as the way forward if the aim is to increase the harvest rate in an area.

The increased harvest, due to more geese being exposed to hunting for a longer time period, might also be affected by abiotic factors (e.g. weather) or resource availability. In previous studies from the region, Jensen et al. (2016b) suggested that the geese may depart due to snow cover or reduced food availability (depletion or ploughing by farmers). However, most of the geese left the study area before the snow permanently covered the fields, and there was still food (spilt grain) remaining on their foraging fields. Jensen et al. therefore proposed the hunting intensity to be a driver for goose departure and thus fewer hunting opportunities. It cannot be ruled out that an even higher harvest rate could have been achieved in the present

study area. There was a drop in goose numbers after the last hunt in 2015 and 2016, a hunt that could have triggered their departure in those years.

The geese were not tracked individually in this study, making it difficult to assess individual responses to hunting. At the most, almost 5500 Pink-footed Geese were staging in the area. There is little doubt that the harvest number is related to the number of geese staying in an area, which appears to be reflected by the 2015-season in the study (more geese were shot in the season with the highest number of geese). Goose registrations from the years before the present study shows that there were fewer geese staging in the area than at present (between 200 and 800 geese, unpublished data, I. Tombre, *pers. comm.*). However, registrations from 2009 show that around 1200 geese were staging in the area (unpublished data, P.I. Nicolaisen) and hence constituting a significant number being exposed to hunting. More intensive hunting in the years after 2009 may well have affected the number of geese staging in Egge.

The behavioural response to hunting was not directly compared between the two species in the study. But the Greylag Geese seemed more shy and sceptical when being hunted on, which might be due to less pressure on the need for food to build reserves (the need is to maintain the body mass), or that they have been exposed to hunting before arriving the study area and hence more alert.

This study show how an increased harvest on migrating waterfowls is possible when planning and organizing the hunt spatially and temporally. Results demonstrate the harvest potential and suggests a specific number of hunting free days within at least a 1.4 km radius in order to increase the harvest. It is demonstrated how two waterfowl species with different migration strategies both stop and utilise an autumn stopover site, but their stay is presumably for different reasons although the site apparently fulfils their needs when staging there. It may be argued that Nord-Trøndelag provides resources necessary and crucial for the Pink-footed Goose, and preferable and useful for the Greylag Goose. Seeing how both species have increased in population numbers after embracing the Nord-Trøndelag county (Madsen *et al.* 2016; Pedersen *et al.* 2016), the benefits of staging seem to outweigh the costs such as the autumn hunting. As the population goal for Pink-footed Goose is not yet reached, and the Greylag Goose continues to increase in numbers (Pedersen *et al.* 2016), the current hunting practices is not efficient enough. But findings from the present study demonstrate a way forward to reach the management goals. The total harvest of Pink-footed Goose did not increase much from 2012 to 2015 (Madsen *et al.* 2016), and the recent decrease in population

size appears to be due to an extended hunting season in Denmark in 2014. Adopting the organization practice from Egge in other areas in Norway as well, may assist in achieving the desired population reduction. Knowledge about the age-composition in the harvest is important for the management and setting a harvest quota when the Pink-footed Goose population has reached an agreed population target (Madsen & Williams 2012).

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