Mallard and Grey Duck Population Status

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1 SUMMARY

This report's primary objective is to estimate the mallard and grey duck population by banding and other appropriate techniques. Grallard population size is an important metric for gamebird managers, and understanding the factors that influence it is key to moving towards an adaptive gamebird management framework. The Auckland Waikato Fish & Game Council estimates grallard population size from data generated by the gamebird harvest survey (GBHS) and from a banding programme which have run from 1993 and 2002, respectively. Population size is calculated based on the assumption that we know two things:

1. How many birds in total were harvested each year.
2. What proportion of the population was harvested.

In this report, population estimates were generated from 2002 to 2024. Estimates suggest that while the grallard population has decreased from historical levels, it remains relatively stable in recent years. Harvest rates fluctuate considerably from year to year while total harvest remains relatively stable, indicating that outside (i.e., environmental factors) are likely to have a significant effect on changes in the population. However, no links between population dynamics and environmental data were identified. Efforts to identify potential effects and ways to improve how we estimate population size will continue to be investigated.

2 METHODS

Grallard population size ($\widehat{N}$[1]) is calculated for each year using the Lincoln[2] estimate, which states that if we know the proportion of the population harvested (harvest rate $\hat{h}$) and the total harvest $\widehat{H}$ then, we can estimate the total population by dividing $\widehat{H}$ by $\hat{h}$ however, it is more commonly written as:

$$\widehat{N} = \frac{b\widehat{H}\hat{\rho}}{r}$$

Where b is the number of newly banded birds, r is the number of newly banded birds shot in the proceeding season (also called first-year returns), $\widehat{H}$ is the estimate of total grallard harvest, and $\hat{\rho}$ is the probability of band reporting.

Estimates of total harvest are estimated from the Game Bird Harvest Survey (GBHS), which runs over several periods that span the gamebird season. In each period, a minimum of 120 adult and junior full-season licence holders are phoned and asked about how many ducks they harvested We estimate the average grallard harvest per person for each period. The sum of all periods represents the average harvest per person throughout the season. This can be multiplied by the number of licence holders to get an estimated total harvest for the year.

Values for b and r are known; however, because not all bands get reported, we must correct for non-reporting each year by estimating the non-reporting rate $\hat{\rho}$. Previously, data to estimate $\hat{\rho}$ was collected as part of the GBHS, and a three-year average was used because estimates had high uncertainty and fluctuated considerably from year to year. This year, we ran an SMS survey that aimed

[1] The "hat" notation signifies an estimated quantity.

[2] Lincoln FC. 1930. Calculating waterfowl abundance on the basis of banding returns U.S. Department of Agriculture Circular No. 118

to improve estimates (the report is attached separately). We found that the verified reporting rate in 2024 was around 52%. Given that this may be the least biased estimate of $\hat{\rho}$ I chose to extrapolate these estimates back to all previous years. There are naturally limitations to this. However, it is worth noting that:

1. No significant trend was observed over time based on the GBHS data.
2. Eastern's verified reporting rates[3] are also consistent over time, albeit a bit higher at around 58%.

It is also worth noting that $\widehat{H}$, $\hat{h}$ and $\hat{\rho}$ have their associated uncertainty, which needs to be included in our estimate of $\widehat{N}$. More details on this are found in the paper by Alisauska[4]. Additionally, hand-reared birds were excluded from the analysis due to concerns that they were not representative (i.e., they were more likely to be harvested and more or less likely to be reported – depending on the site).

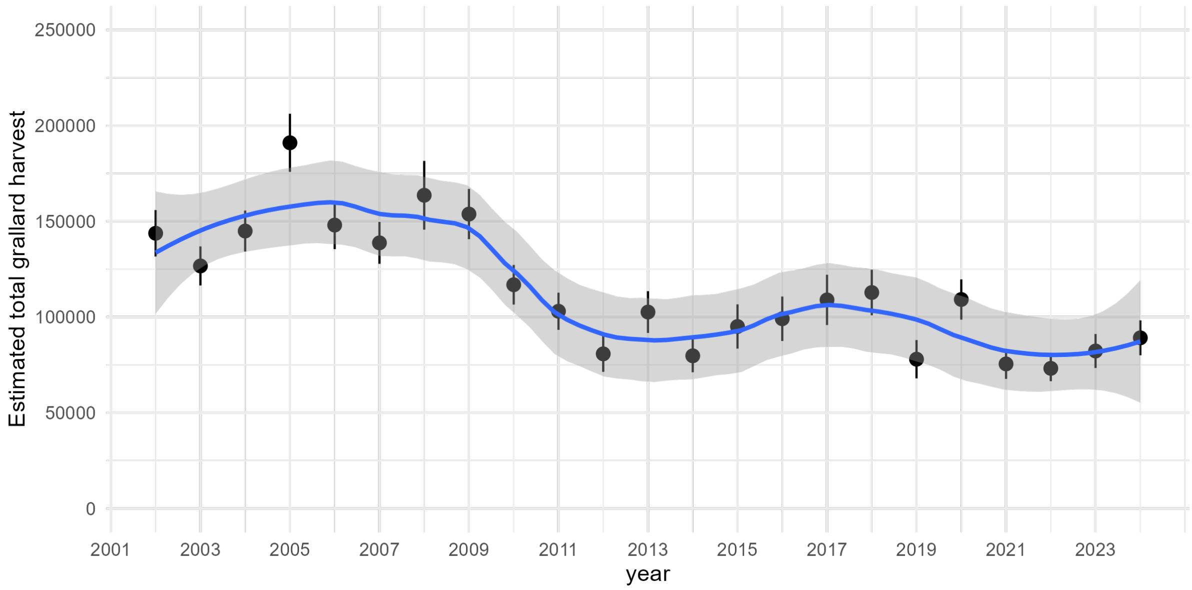

Figure 1: Auckland Waikato total grallard total estimated harvest $\widehat{H}$ from 2002 to 2024 (the years we have a banding programme) with 95% confidence intervals. The blue line is a floating average to help illustrate the trend over time.

[3] Which are also calculated in a way which means previous years data are used towards the current years estimate. Specifically a Bayesian approach with previous years estimates as priors.

[4] Alisauskas RT, Arnold TW, Leafloor JO, Otis DL, Sedinger JS. Lincoln estimates of mallard (Anas platyrhynchos) abundance in North America. Ecol Evol. 2014 Jan;4(2):132-43. doi: 10.1002/ece3.906. Epub 2013 Dec 18. PMID: 24558569; PMCID: PMC3925377.

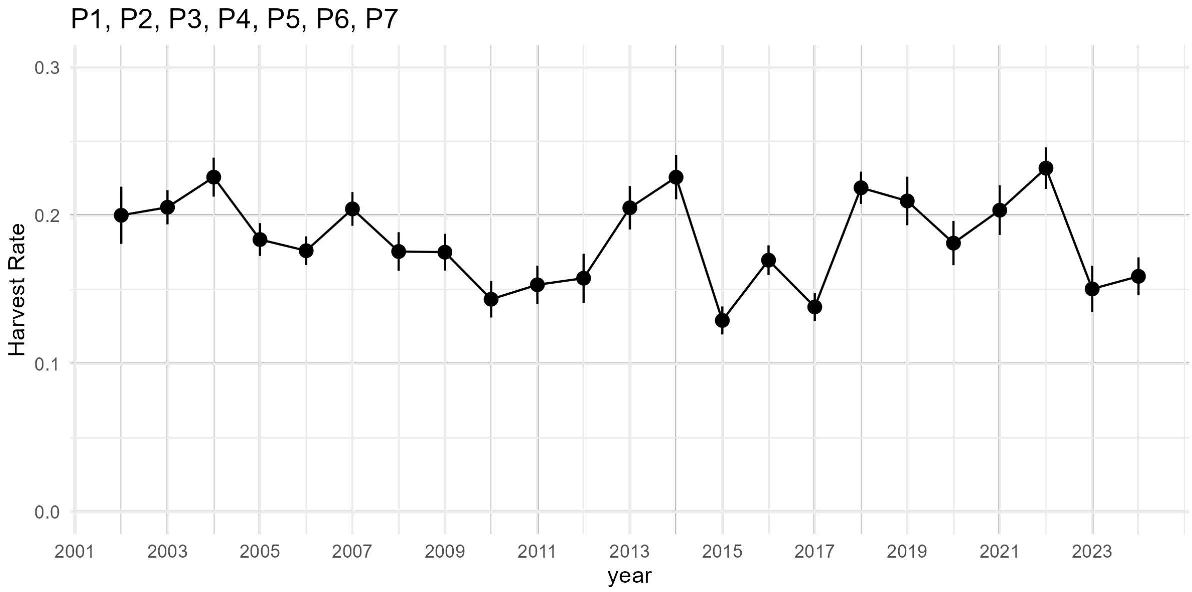

Figure 2: Estimates of grallard harvest rate $\hat{h}$ from 2002 to 2024 for all periods (P1-P7)). Harvest rates reflect the proportion of banded birds harvested within the first year and, assuming they are representative of the population, the proportion of the population that is harvested each year. Harvest Rates are corrected for verified non-response, which is estimated at 52% for years 2002-2023 and 56% for 2024 based on the 2024 SMS survey.

3 GRALLARD POPULATION ESTIMATES 2002-2024

Based on our estimates of $\widehat{N}$, it appears that the grallard population size has changed significantly over the last 22 years. There are two things to consider:

1. A hypothesised large-scale population collapse.
2. Year-to-year variation.

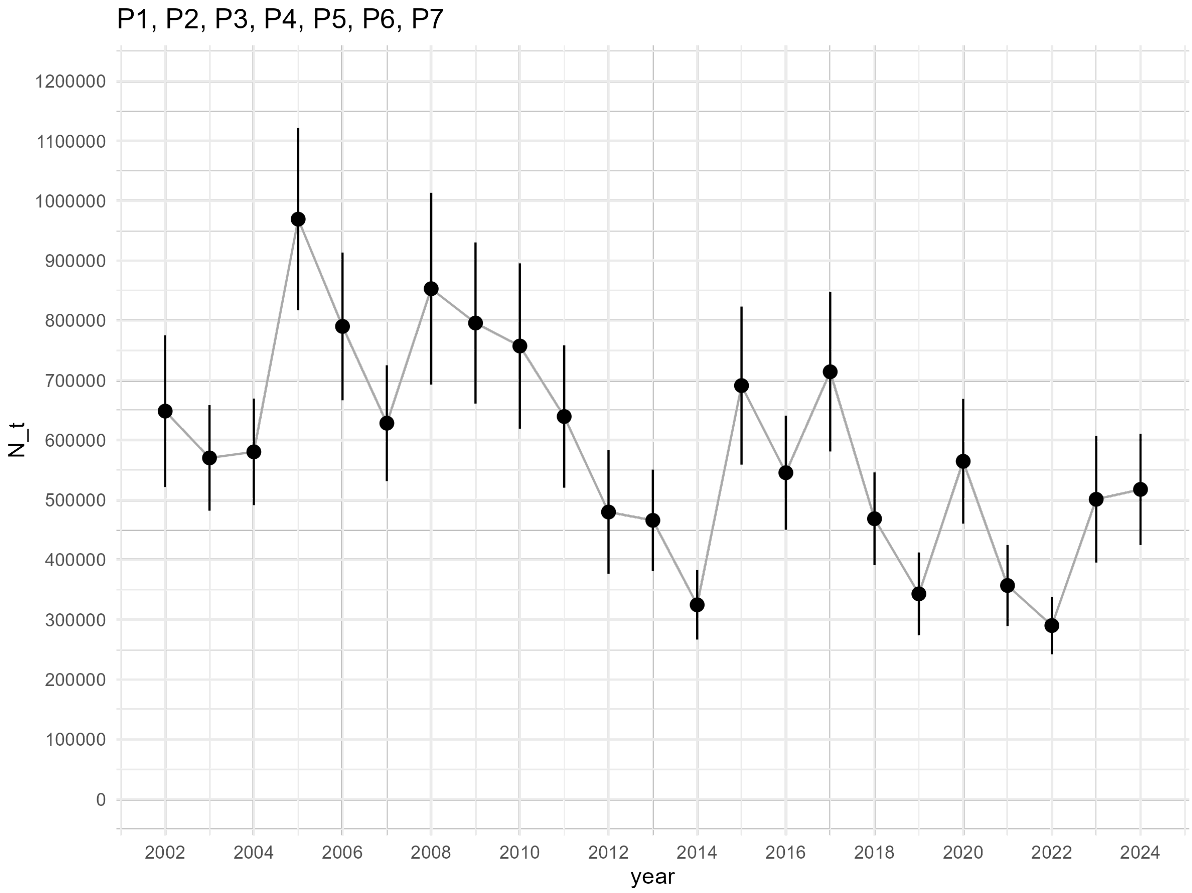

Figure 3: Auckland Waikato grallard population estimates $\widehat{N}$ from 2002 to 2024. $\widehat{N}$ is calculated using harvest estimates from periods 1-7 and bands retrieved during periods 1-7.

3.1 Population collapses (circa 2009)

Evidence for a large-scale population collapse comes from the fact that the harvest rate is relatively stable over time (albeit with significant year-to-year variation) (Figure 2) despite a significant reduction in harvest post-2009 (Figure 1). This indicates that the population underwent a considerable change in order for harvest rates to remain stable. In other words, after 2009, harvest dropped by around 50,000 birds, yet the proportion of the population harvested remained, on average, just below 20%[5]. This drop in harvest post-2009 may come as a result of more restrictive season regulations, which were put in place in response to the anticipated or due to environmental factors, e.g. drought, impacting grallard population size[6]. (discussed further in the harvest report). In addition, it is worth noting that without experimental controls (which are infeasible), we cannot say with certain that our estimates of

[5] Prior to 2009, the lowest estimate size was ~575k, and the highest was close to 1 million, whereas post-2009, the highest estimate was around 700k, and the lowest was around 300k.

[6] "A drought event lasted from November 2007 to April 2008, during which the Waikato experienced its driest January in a century. A shortage of feed caused by the drought increased the price of silage to four times its normal rate. The cost of the drought was believed to be $1.5 billion to the Dairy sector alone. The economic effect of the drought was one of the factors that threw New Zealand's economy into recession by mid-2008. Waikato had dry springs in 2009 and 2010, which resulted in a double drought. The drought led to the owners of the Waikato River hydro scheme, Might River Power, announcing a 10 per cent drop in hydro production for the December quarter. Dairy farmers were estimated to have lost an average $100,000- $150,00 in income over the previous three years due to consecutive drought events." https://www.waikatoregion.govt.nz/services/regional-hazards-and-emergency-management/drought/

population size are not also influenced by unknown or unmeasured factors that change over time (e.g., data collection, reporting rates, hunter behaviour).

3.2 Understanding year-to-year variation.

It is interesting to note that, unlike harvest, harvest rate fluctuates significantly from year to year. Using an extreme example, estimates show that in 2014, we harvested between 21% and 24% of the population. The following year, despite the increase in total harvest, our estimates show we harvested between 12% and 14% of the population. The current hypothesis is that climatic conditions primarily drive annual changes in the grallard population. International literature has found strong links between droughts and mallard populations, and from an ecological perspective, the logic is sound. However, I have yet to find evidence in the data that lends itself to the idea of drought (i.e., rainfall, soil moisture deficit, etc.) as a predictor of grallard population size despite there being some significant events in recent years[7]. This may, in part, be due to variables such as rainfall being indirect and, therefore, blunt substitutes for the environmental factors that affect waterfowl. One can appreciate the lack of a relationship between population size and environmental conditions by comparing the population estimates with the drought index for Hamilton (Figure 4) while remembering that we are looking for a link between the population size in one year and the environmental conditions in the preceding year. Also, given the scale of the Auckland Waikato region, environmental conditions should likely be considered at more local scales—of which data are not always available.

Without a link between population size and environmental conditions, one may be inclined to question the quality of our population estimates. While there may be some bias in our estimates concerning the overrepresentation of juveniles (as discussed in the Appendix), the effect of this on temporal trends is minimal, especially in recent years (Figure 9). What is reassuring is the similarity observed when comparing our trends in estimated population size with the Eastern region estimates — which collect and analyse data independently from us. Like our estimates, Eastern Fish & Game observed a peak in numbers around 2005, a decline between 2010 and 2014, a large jump in 2015, and a relatively stable plateau at a reduced population from 2018 onwards (Figure 5). Similarities in population trends between neighbouring regions (with different harvest regulations) lend weight to the hypothesis that large-scale climatic patterns are the primary driver of changes to the grallard population. A combined analysis of banding data for North Island regions may improve our understanding of how environmental conditions impact the grallard population, bringing us closer to an adaptive management system.

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[7] Efforts to date have looked at correlations between grallard population size, growth rate and harvest rate with seasonal rainfall, seasonal SPEI (drought index), and seasonal soil moisture deficit. Relevant seasons include the preceding winter, spring and summer (e.g., using a 3-month average) as well as looking at 3, 6 and 12-month averages for SPEI. Relationships post-2010 were also tested to examine more recent trends (i.e., post-collapse).

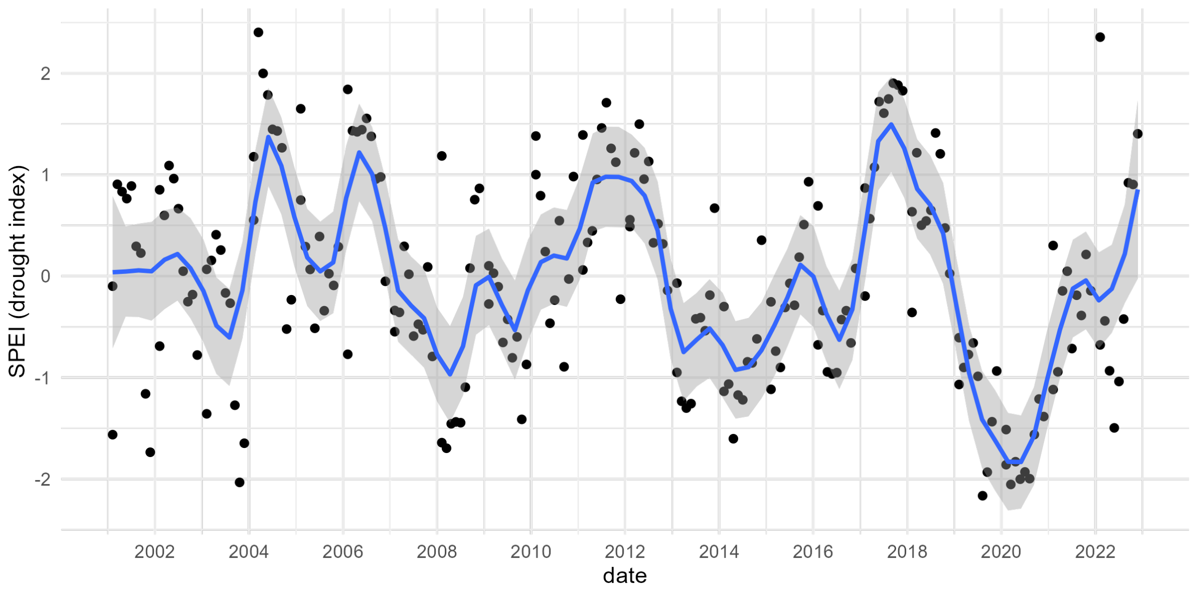

Figure 4: Standardised Precipitation Evapotranspiration Index (SPEI) for Hamilton 2002-2023. Here, values between -1 and 1 represent normal conditions, while values above 1 represent wet conditions and values below -1 represent dry conditions. Each point represents how wet or dry the previous 6 months were compared to the average. While 6-month averages may not best represent the temporal scale of environmental conditions that impact waterfowl, it is helpful to understand large-scale patterns over time.

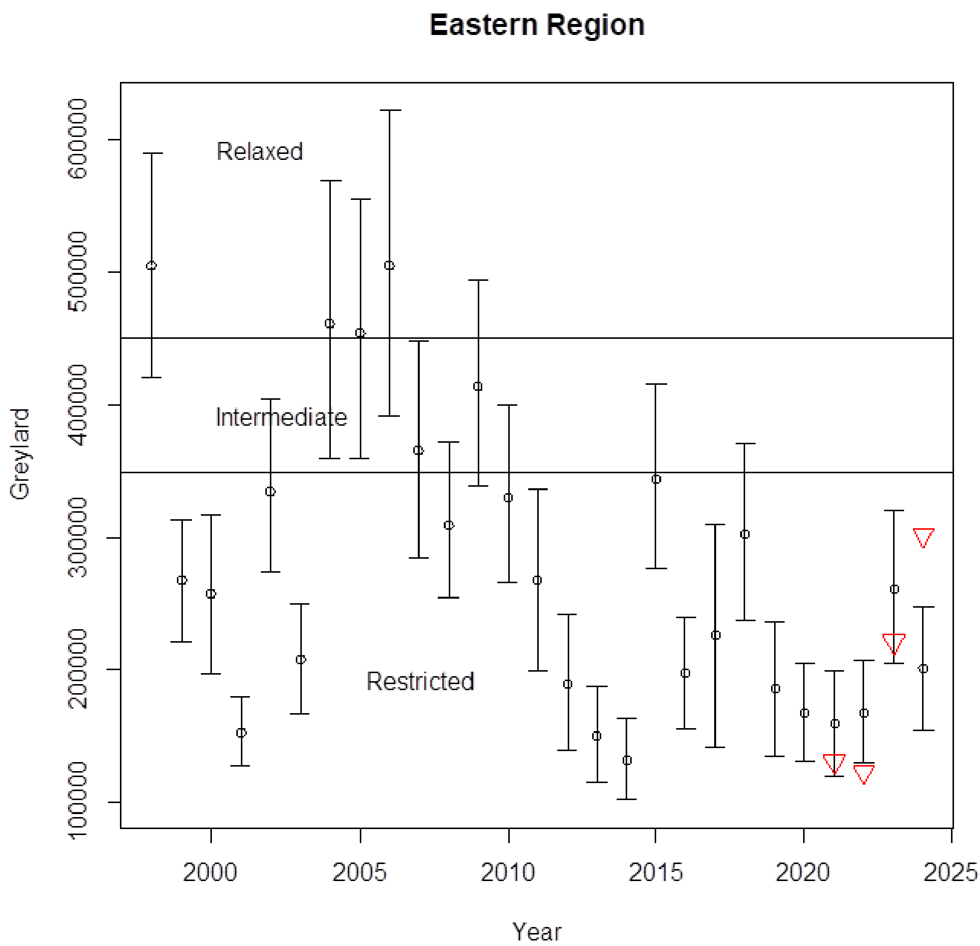

Figure 5: Grallard population estimates $\widehat{N}$ from 1998 to 2024 for the Eastern Fish & Game region.

4 APPENDIX

Having struggled to identify any links between grallard population dynamics and environmental conditions, I decided to take a more detailed look at the data – specifically harvest rate estimates, as these fluctuate considerably without apparent reason.

Firstly, we observe that adult harvest rates do not vary significantly by sex. For juveniles, harvest rates for males are often higher than for females, but this is not consistent for all years. The most significant difference is between adults and juveniles – shown separately in Figure 6.

It is not particularly surprising that juvenile harvest rates are often higher than adults –as they are naïve and therefore easier to target, particularly on opening weekend. Interestingly, harvest rates for adults and juveniles do not seem to follow the same pattern (unlike sex). For example, in 2014, when juvenile harvest rates peaked, adult harvest rates were near their lowest.

Most birds that get banded in the Auckland Waikato region are juveniles (Figure 7). While it is difficult to know the true adult–juvenile ratio in the population, the current sentiment is that the traps (and trap locations/time of year) do not result in a random sample, meaning that juveniles may be overrepresented in our banding data. If this were true, our harvest rate would likely be overestimated, and our population size would be underestimated.

4.1 POTENTIAL UNDERREPRESENTATION OF ADULTS

We can use a weighted average to correct for the underrepresentation of adults in our banding sample[8,9]. For the sake of argument, assuming the true ratio of adults-juveniles is 1:1, our estimate of the juvenile harvest rate would represent half of our estimate of the overall harvest rate (as opposed to the proportion of juveniles, which is around 90%). Figure 8 demonstrates the effect of a weighted average on population estimates. For 11 of the 23 years, using a weighted average increased the estimated population by greater than 100,000 birds (Figure 8). It is worth noting, however, that the weighted approach has little influence on estimates in the last 4 years – where adult and juvenile harvest rates are similar. It is also worth noting that our estimates are not meaningfully different trend-wise. While more accurate estimates are worthwhile, if trends in the population do not change, it is unlikely we will find a link with environmental factors that have previously been tested.

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8 In other studies, $\widehat{H}$ and $\widehat{h}$ are calculated separately by age and sex, allowing for group-based population estimates (Alloche, 2016). However, such an approach is not possible as the GBHS does not differentiate by sex or age (nor could it), and the use of feather samples was deemed futile (D. Klee , personal communication).

9 The details of which are described on page 473 of D.L. Thomson et al. (eds.), Modeling Demographic Processes in Marked Populations, Environmental and Ecological Statistics 3, DOI 10.1007/978-0-387-78151-8 20,

Figure 6: Estimates of grallard harvest rate $\hat{h}$ from 2002 to 2024 for all periods (P1-P7)) by sex (M = male, F= female) and age (A= adult, J= juvenile). Harvest rates reflect the proportion of banded birds harvested within the first year and, assuming they are representative of the population, the proportion harvested each year. Harvest Rates are corrected for verified non-response, which is estimated at 52% for years 2002-2023 and 56% for 2024 based on the 2024 SMS survey.

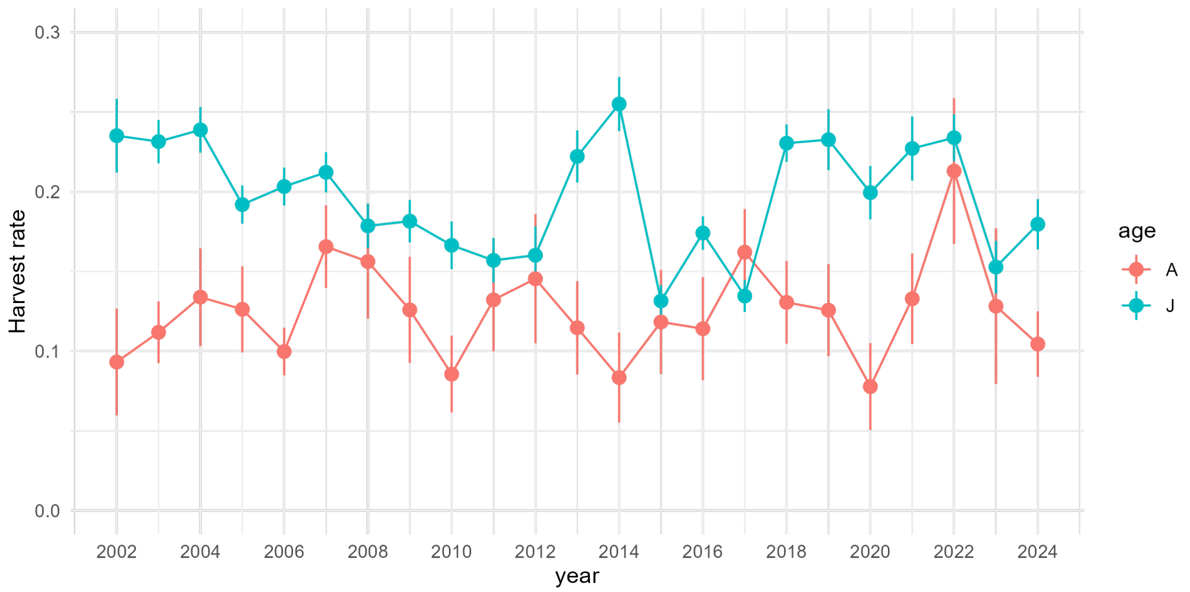

Figure 7: Estimates of grallard harvest rate $\hat{h}$ from 2002 to 2024 for all periods (P1-P7)) by age (A= adult, J= juvenile). Harvest rates reflect the proportion of banded birds harvested within the first year and, assuming they are representative of the population, the proportion harvested each year. Harvest Rates are corrected for verified non-response, which is estimated at 52% for years 2002-2023 and 56% for 2024 based on the 2024 SMS survey.

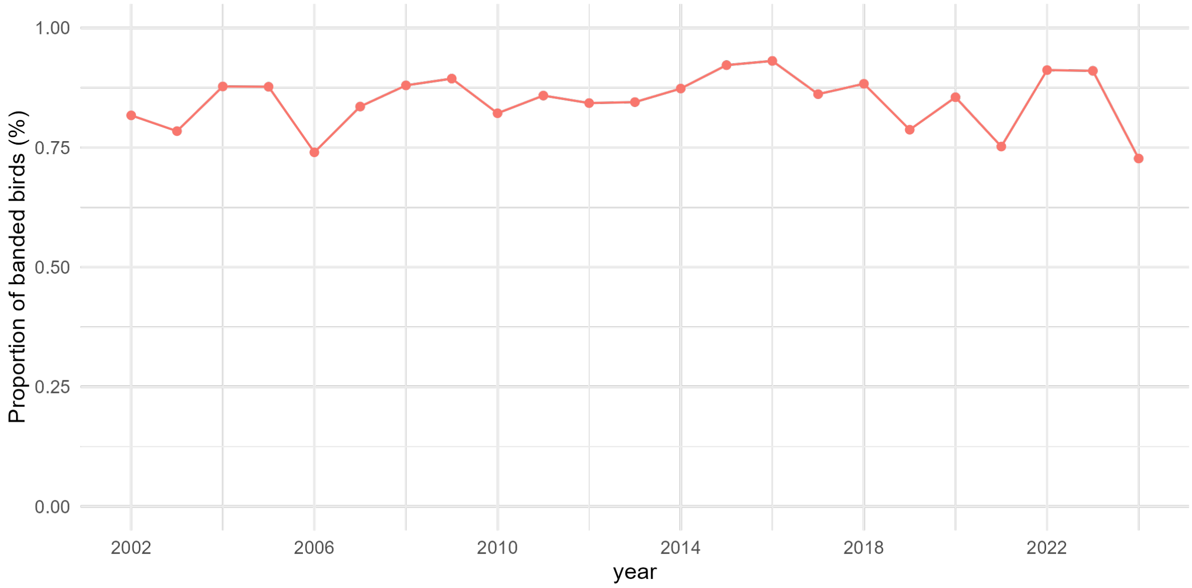

Figure 8: Proportion of banded birds that are juveniles from 2002 to 2024.

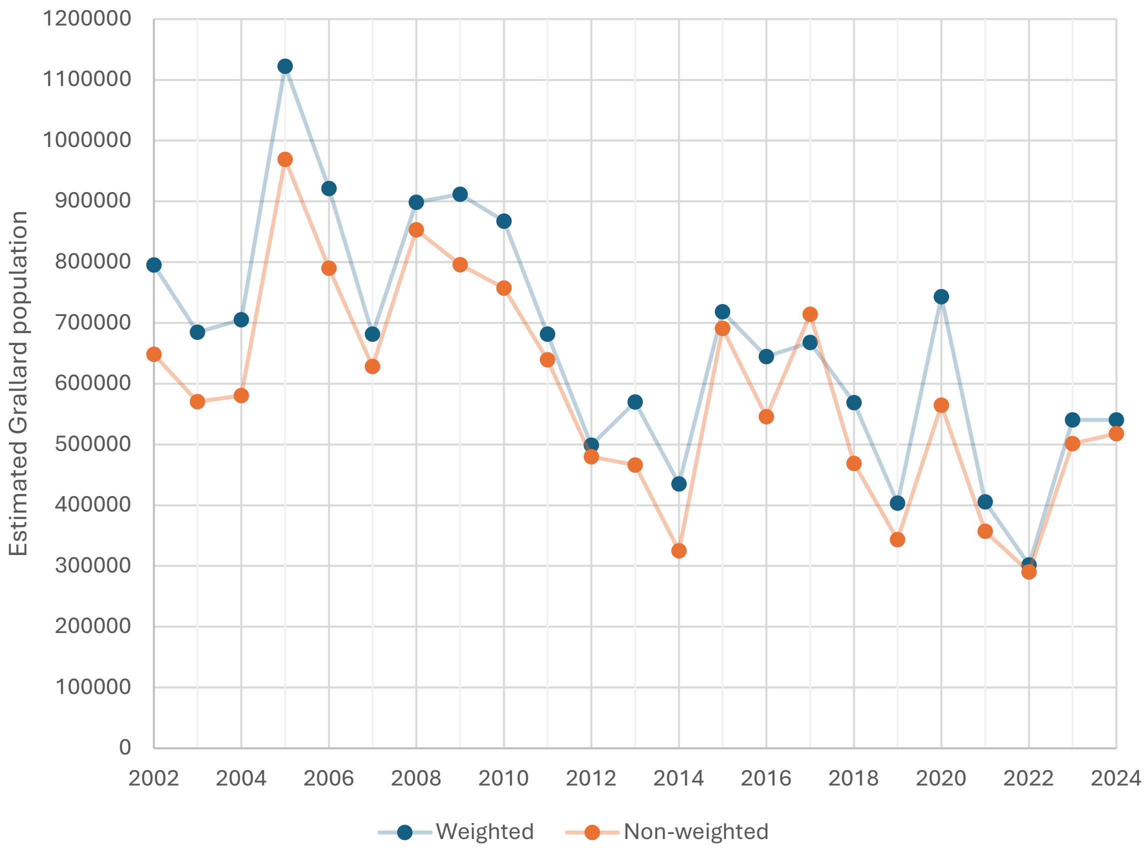

Figure 9: Grallard population estimates $\widehat{N}$ from 2002 to 2024 calculated assuming (1) a 1:1 adult-juvenile ratio (weighted) and (2) assuming that banding samples are representative of the population (non-weighted).