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Estimate of duck and Stubble Quail harvest in Victoria for 2023

**Results from surveys of Victorian Game
Licence holders in 2023**

P.D. Moloney and J.S. Flesch

Acknowledgment

We acknowledge and respect Victorian Traditional Owners as the original custodians of Victoria's land and waters, their unique ability to care for Country and their deep spiritual connection to it. We honour Elders past and present, whose knowledge and wisdom has ensured the continuation of culture and traditional practices.

We are committed to genuinely partner, and meaningfully engage, with Victoria's Traditional Owners and Aboriginal communities to support the protection of Country, the maintenance of spiritual and cultural practices and their broader aspirations in the 21st century and beyond.



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Estimate of duck and Stubble Quail harvest in Victoria for 2023

Results from surveys of Victorian Game Licence holders
in 2023

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Summary

Context

To effectively manage game species, it is important to quantify the number of animals harvested. Since 2009, the Victorian State Government game management agency has commissioned a series of regular telephone surveys of randomly selected Game Licence holders. Each year, three sets of telephone surveys are conducted during the various game harvest seasons for deer, duck and Stubble Quail (*Coturnix pectoralis*). This report focuses only on the duck and Stubble Quail harvests for 2023.

In 2023, both the duck and Stubble Quail seasons were reduced to five weeks in length, compared to the prescribed 12 weeks. The start of the seasons were delayed and commenced in late-April. The daily bag limit for ducks was reduced to four down from the prescribed 10 birds. The Stubble Quail daily bag limit remained unchanged at 20 birds per day. Prior to the start of the game bird hunting seasons, a Parliamentary inquiry into Victoria's recreational native bird hunting arrangements commenced.

Aim

The aim of this report is to provide estimates of the total harvests of ducks and Stubble Quail by Victorian Game Licence holders during the 2023 hunting seasons.

Methods

Game Licence holders for each game type were randomly sampled and interviewed by telephone at intervals during their respective game seasons. In all surveys, respondents were asked whether they had hunted during the period for which the survey applied, and (if applicable) the number and species of birds harvested. Additional information was obtained on hunting methods and locations. Data collected during these telephone interviews was analysed to estimate the total harvest and days spent hunting for ducks and Stubble Quail. Additional metrics related to hunting locations, hunting methods and hunter effort and efficiency were also estimated.

Results

The total estimated duck harvest in 2023 was 319,900 (95% confidence interval (CI) = 285,500–358,400) which was very similar to the average annual duck harvests in the previous surveys (320,000 since 2009) and a 22% increase from 2022. The total estimated number of duck hunting days was 99,700 (95% CI = 89,100–111,500) which was 17% above the average annual duck hunting days in previous surveys (85,000). The three most commonly harvested species were Pacific Black Duck (which comprised 45% of the total harvest), Grey Teal (29%) and Australian Wood Duck (18%). The remaining ducks harvested were Chestnut Teal (4%), Mountain Duck (1%) and Pink-eared Duck (2%). Hunting of Blue-winged Shoveler and Hardhead was prohibited for the 2023 season.

Game Licence holders endorsed to hunt ducks who actively hunted ducks during the 2023 duck season harvested an average of 22.7 ducks (95% CI = 19.8–25.9), over an average of 7.1 days (95% CI = 6.2–8.1).

The total estimated Stubble Quail harvest in 2023 was 302,800 (95% CI = 252,500–363,200). This was double the average annual Stubble Quail harvest from previous surveys (149,000). The total estimated number of Stubble Quail hunting days was 27,000 (95% CI = 22,200–32,800), which was 39% more than the annual average from previous surveys (19,000 days).

Game Licence holders endorsed to hunt Stubble Quail who actively hunted Stubble Quail during the 2023 Stubble Quail season harvested an average of 63.6 (95% CI = 49.8–81.2) quail, over an average of 5.7 (95% CI = 4.4–7.3) days.

The total number of hunter days during the 2023 hunting season for ducks and Stubble Quail was estimated to be 126,700 (95% CI = 114,300–139,000).

Conclusions and implications

1. The duck harvest in 2023 was at the long-term average, even though the length of the season (5 weeks) and the daily bag limit (4 ducks) were both reduced. This can be partially explained by:
 - total hunting days being 17% higher than average;
 - the proportion of active duck hunters (65%) was the second highest recorded since 2017, when this statistic was first recorded;
 - hunter efficiency being relatively high at 3.2 ducks per hunting day, which is 80% of what was allowable in 2023. All other years are below 70%.
2. The Stubble Quail harvest in 2023 was double the long-term average, and the second largest estimated harvest, despite the season being reduced to 40% of the prescribed length. This can be partially explained by:
 - total hunting days was the second highest recorded since 2017 when data collection commenced;
 - the proportion of active Stubble Quail hunters was the second highest recorded;
 - hunter efficiency was the second highest recorded.
3. The increase in the total number of Game Licence holders endorsed to hunt Stubble Quail surveyed in 2023 (a total of 2,400 instead of the previous 1,200) had the desired effect of increasing the accuracy of the estimates and therefore should be maintained.
4. Debate over the future of native bird hunting in Victoria may have motivated hunters to increase their hunting effort.
5. Performing telephone surveys throughout the year is likely to minimise memory bias and non-response bias. However, sources of bias will remain (due to over- and under-reporting), and the estimates of total harvest must be interpreted with care.

1 Introduction

To effectively manage game species, it is important to quantify the numbers of animals harvested. Since 2009, the Victorian State Government game management agency (currently the Game Management Authority) has commissioned a series of regular telephone surveys of randomly selected Game Licence holders. Telephone surveys were conducted during the various game harvest seasons for deer, ducks and Stubble Quail (*Coturnix pectoralis*). However, this report focuses only on the duck and Stubble Quail harvests. Deer harvests are addressed in a separate report.

The 2023 duck season was reduced to five weeks (12 weeks is the prescribed duration) running from 26 April to 30 May (Game Management Authority, 2023). Six species could legally be hunted in 2023: Pacific Black Duck (*Anas superciliosa*), Australian Wood Duck¹ (*Chenonetta jubata*), Mountain Duck² (*Tadorna tadornoides*), Grey Teal (*Anas gracilis*), Chestnut Teal (*Anas castanea*) and Pink-eared Duck (*Malacorhynchus membranaceus*). Hunting of Blue-winged Shoveler³ (*Anas rhynchos*) and Hardhead⁴ (*Aythya australis*) (both declared game species) was prohibited for the 2023 season due to continuing low numbers. The bag limit for the 2023 season was four game ducks per hunter per day, reduced from the maximum prescribed daily bag limit of 10 birds.

The 2023 duck hunting survey used a similar method (i.e. telephone surveys) as those followed during the 2005, 2006 and 2009 to 2022 duck hunting seasons (Barker, 2006; Gormley & Turnbull, 2009, 2010, 2011; Moloney & Flesch, 2021; Moloney & Hampton, 2020; Moloney & Powell, 2019; Moloney & Turnbull, 2012, 2013, 2014, 2015, 2016, 2017, 2018). However, in 2023, as in 2022, (Moloney & Flesch, 2021) there was no official opening weekend (the season started on a Wednesday). Additionally, in 2023, surveys were conducted weekly rather than fortnightly due to the reduced season length.

The 2023 Stubble Quail (*Coturnix pectoralis*) hunting season coincided with the duck season, running for five weeks from 26 April to 30 May (Game Management Authority 2023). This is a reduction from the prescribed 12 weeks. The daily bag limit for the 2023 season was unchanged and remained at the prescribed number of 20 Stubble Quail per hunter.

The 2023 Stubble Quail hunting survey used a similar method (i.e. telephone surveys) as those followed during the 2009 to 2015 and 2017 to 2019 and 2021 to 2022 Stubble Quail-hunting seasons (Gormley, 2009; Gormley & Turnbull, 2009, 2010, 2011; Moloney & Flesch, 2021, 2022; Moloney & Powell, 2019; Moloney & Turnbull, 2012, 2013, 2014, 2015, 2017, 2018)^{5,6}. In 2023, surveys were conducted weekly rather than fortnightly due to the reduced season length.

The aim of this report was to provide estimates of the number of ducks and Stubble Quail harvested by licensed recreational hunters in Victoria during the 2023 season. Other metrics on hunter effort, success, methods and locations were also collected.

¹ Australian Wood Duck is also referred to as Wood Duck, Maned Duck and Maned Goose.

² Mountain Duck is also referred to as Australian Shelduck.

³ Blue-winged Shoveler is also referred to as Australasian Shoveler.

⁴ Hardhead is also referred to as White-eyed Duck.

⁵ Due to a clerical error, the 2016 Stubble Quail hunting survey used a slightly different method (Moloney & Turnbull, 2016).

⁶ Due to the COVID-19 restrictions in 2020, the surveys of Game Licence holders endorsed to hunt Stubble Quail started on the first weekend that hunting was allowed on public land (i.e, 16 May) and surveys were then conducted at the end of the month for the remainder of the season (i.e. 3 surveys in total) (Moloney & Hampton, 2020).

2 Method

All surveys were conducted by the independent telephone survey company, Marketing Skill Pty Ltd (Mt Eliza, Victoria) on behalf of the Game Management Authority (see Appendices 1 and 2). Estimates of total harvest by Game Licence holders were based on the hunting activities reported by the survey respondents.

2.1 General methodology

A slightly different methodology was used for estimating duck and Stubble Quail harvests for 2023 compared to other years (e.g. Moloney & Flesch (2021)). For ducks, surveys were performed after the end of the first week of the season (the season opened on a Wednesday) and from then on weekly throughout the 5-week season. The main difference is that prior to 2020, the season started on a Saturday and there was a specific “Opening weekend” survey and historically surveys were conducted fortnightly. For Stubble Quail, surveys were performed on the same schedule as ducks in 2023, instead of the typical schedule of opening weekend and then every month thereafter throughout the season. Each survey involved telephoning a random sample of Game Licence holders and asking them to report their hunting activities for the periods covered by that survey only. Therefore, although a respondent⁷ may have hunted during the periods covered by Surveys 2 and 3, if they were contacted as part of Survey 3, then only information that pertained to the period covered by Survey 3 was collected. An additional random sample of 400 and 600 Game Licence holders were surveyed immediately after the conclusion of the duck and Stubble Quail hunting seasons respectively. The number of active hunters was estimated using the survey question in the final survey on whether they had hunted at any stage of the 2023 duck hunting season and Stubble Quail hunting season, respectively. The number of post-Stubble Quail season surveys was increased from 400 to 600 to increase the accuracy of the activity index.

Survey responses were used to generate an estimate for the whole population of Game Licence holders for each game type. Estimates of harvest were determined for each of the survey periods and were summed to give an estimate of the total season harvest. For each survey period, the proportion of respondents that hunted was used as an estimate of the proportion of Game Licence holders who hunted. The proportion of the Game Licence holders surveyed who had hunted during each survey period was multiplied by the total number of Game Licence holders, yielding the estimated total number of active hunters for that survey period.

For each survey period, the average harvest per hunter⁸ was estimated from the total reported harvest divided by the number of respondents who hunted. The total harvest for each survey period was estimated by multiplying the average harvest per hunter by the previously estimated total number of active hunters for that survey period. Finally, the total season harvest was estimated from the sum of the survey-specific total harvests.

The average season harvest per Game Licence holder was also estimated. For each survey period, the average harvest per survey respondent was estimated by multiplying the average harvest per hunter by the proportion of respondents who hunted. The sum of these estimates across the season provided an estimate of the total season harvest per Game Licence holder.

Respondents who hunted were also asked to provide information on whether hunting was conducted on private land or public land (such as State Game Reserves), the name of the town nearest to where they hunted, and the number of days on which they hunted during the survey period. Regional harvest estimates were calculated by summing the reported harvest for each town, then aggregating these for the corresponding Victorian Catchment Management Authority (CMA) region.

⁷ Respondent refers to a Game Licence holder who was contacted and agreed to take part in the survey.

⁸ Hunter refers to a Game Licence holder who actually went out and hunted (successfully or unsuccessfully) at some point during the period with which the survey was concerned.

There were differences in the number and length of surveys between the duck and Stubble Quail surveys, as outlined in the following sections. Additional details of the methods, as well as examples of the calculations, are provided in Appendix 3. Information relating to describing and interpreting boxplots is provided in Appendix 4.

2.2 Duck

Survey respondents were drawn from hunters who held a Game Licence endorsed to hunt ducks during the 2023 season. An independent random sample of 280 licence holders was interviewed by telephone immediately after the first weekend (Duck Survey 1), and this was followed up by surveys of independent random samples of licence holders at 1-week intervals for the remainder of the duck season (Duck Surveys 2–5). The size of the random sample of licence holders was increased in 2023 from the typical 200 to 280 so that the total sample would still be 1400 licence holders, to account for the shortened season. Respondents were also asked to report the number of each species harvested. An additional independent random sample of 400 Game Licence holders endorsed to hunt ducks were surveyed immediately after the conclusion of the duck hunting season. They were asked if they had hunted ducks at any stage during the season.

2.3 Stubble Quail

Samples were drawn from hunters who held a Game Licence to hunt Stubble Quail during the 2023 season. A random sample of 480 licence holders were interviewed by telephone after the opening week (Quail Survey 1), and this was followed up by surveys of independent random samples of licence holders at 1-week intervals for the remainder of the quail season (Quail Surveys 2–5). The size of the random sample was increased in 2023 from 300 previously to 480 to increase the accuracy of the estimates due to the large proportion of licence holders who never hunt Stubble Quail. Respondents were asked to report the number of Stubble Quail harvested, the type of habitat where hunting occurred (native grass, stubble or introduced pasture) and whether dogs were used. An additional random sample of 600 Game Licence holders endorsed for Stubble Quail were surveyed immediately after the conclusion of the Stubble Quail hunting season. They were asked if they had hunted Stubble Quail at any stage during the season. The number of post-Stubble Quail season surveys was increased from 400 to 600 to increase the accuracy of the activity index.

When a Game Licence holder is endorsed for duck, they are automatically endorsed for Stubble Quail also (hunters can be endorsed for Stubble Quail but not duck). Therefore, the number of Game Licence holders endorsed to hunt Stubble Quail is not representative of the number of self-reported Stubble Quail hunters. In the 2023 Stubble Quail hunter survey, all respondents were asked whether they hunt quail, even if they did not necessarily hunt Stubble Quail during the 2023 Stubble Quail Season. This information was used to increase the precision of the estimates for the total Stubble Quail harvest and number of hunting days.

3 Results

3.1 Duck harvest in 2023

The number of Game Licence holders endorsed to hunt ducks remained relatively constant throughout the shortened season (Table 1). To achieve the required sample size of respondents, slightly more than 280 licence holders were contacted each survey, with typically 98% of those contacted being willing to take part.

Table 1. Summary of responses for duck surveys in 2023

Duck survey	Period	Licence holders	Respondents	Respondents who hunted	Days hunted ⁹	Ducks harvested ¹⁰
1	26-30 April	21,720	280	186	304	806
2	1-7 May	21,959	280	185	252	806
3	8-14 May	21,959	280	157	186	619
4	15-21 May	21,959	280	147	187	666
5	22-30 May	21,959	300	268	370	1,276

The proportion of duck Game Licence holders who hunted in each survey period varied over the season. During the initial 12 days, 66% of licence holders hunted, corresponding to approximately 14,500 hunters (Table 2). In the third and fourth surveys the proportion (and therefore hunters) dropped to under 60%. However, during the final survey, 89% of licence holders hunted.

Table 2. Proportion and corresponding total number of duck licence holders who hunted in each survey period in 2023.

Period	Proportion	SE	95% CI		Total hunters	SE	95% CI	
			Lower	Upper			Lower	Upper
26-30 April	0.66	0.028	0.61	0.72	14,428	613	13,276	15,681
1-7 May	0.66	0.028	0.61	0.72	14,509	621	13,341	15,778
8-14 May	0.56	0.030	0.51	0.62	12,313	651	11,101	13,657
15-21 May	0.52	0.030	0.47	0.59	11,528	655	10,314	12,886
22-30 May	0.89	0.018	0.86	0.93	19,617	391	18,865	20,399

The reported harvest of ducks per hunter (i.e. per Game Licence holder who hunted) was greatest in the final weeks of the season (4.8 ducks per hunter). Some hunters harvested more than 15 ducks in a survey period, whereas some did not harvest any ducks (Figure 1). The average number of ducks per hunter was consistent throughout the season (~4 ducks per hunter) (Table 3).

⁹ Days hunted indicates the combined number of days on which duck hunting took place by respondents.

¹⁰ Ducks harvested indicates total number of ducks harvested by respondents.

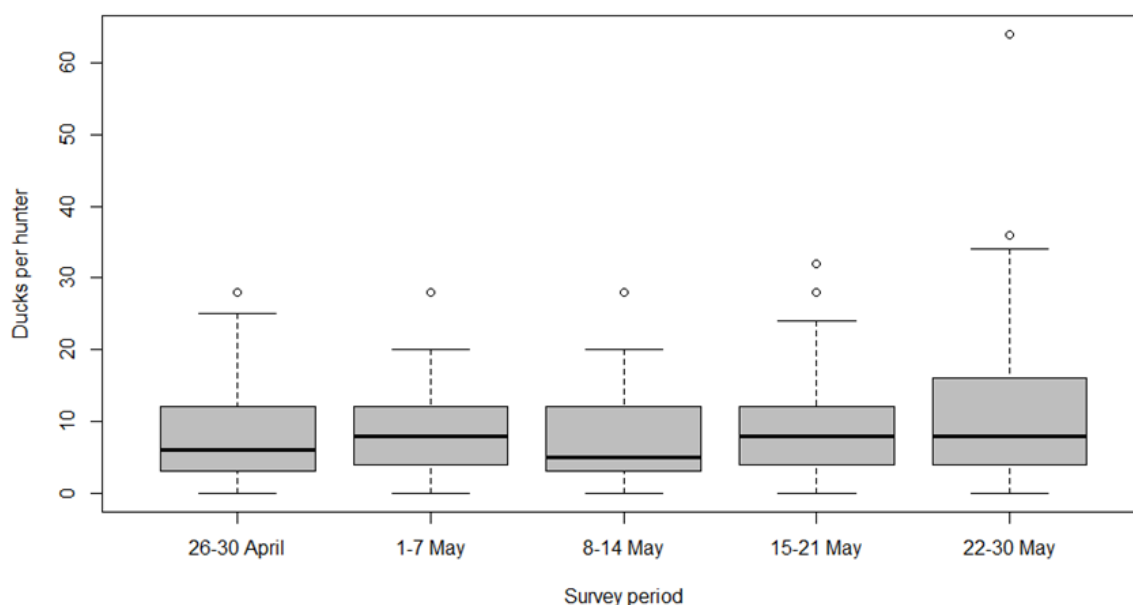


Figure 1. Boxplot of the number of ducks reported harvested by individual hunters for each survey period in 2023.

The bottom and top of each 'box' indicate the 25th and 75th percentiles, respectively, with the black horizontal line indicating the median (50th percentile) reported value.

Table 3. Average harvest of ducks per hunter (Game Licence holders who hunted) for each survey period in 2023.

Period	Average harvest per hunter ¹¹	SE	95% CI	
			Lower	Upper
26-30 April	4.33	0.46	3.53	5.32
1-7 May	4.36	0.41	3.62	5.24
8-14 May	3.94	0.43	3.19	4.87
15-21 May	4.53	0.55	3.57	5.74
22-30 May	4.76	0.65	3.64	6.23

There were an estimated 62,523 ducks harvested during the opening 5 days (95% CI = 50,091–78,039), which constituted 20% of the total seasonal harvest (Table 4). The harvest in the last survey period (9 days) was the largest (93,399), accounting for 29% of the total seasonal harvest. The total season harvest estimate was 319,908 (95% CI = 285,537–358,417; Table 4).

¹¹ Average harvest per hunter = Ducks harvested divided by Respondents who hunted (Table 1).

Table 4. Estimates of the total duck harvest in Victoria in 2023 by holders of a Game Licence endorsed for duck.

Period	Total harvest ¹²	SE	95% CI	
			Lower	Upper
26-30 April	62,523	7,094	50,091	78,039
1-7 May	63,211	6,541	51,635	77,381
8-14 May	48,545	5,843	38,377	61,408
15-21 May	52,231	7,007	40,202	67,860
22-30 May	93,399	12,978	71,225	122,476
Total	319,908	18,568	285,537	358,417

Using a telephone survey immediately after the 2023 duck season ended, it was estimated that 65% (95% CI = 60%–70%) of Game Licence holders endorsed for ducks hunted for ducks during the 2023 duck season (Table 5). That equates to an estimate of 14,118 (95% CI = 13,139–15,170) active duck hunters in the 2023 duck season. The average seasonal duck harvest per active duck hunter was estimated to be 22.7 (95% CI = 19.8–25.9). The average number of duck hunting days per active duck hunter was estimated to be 7.1 (95% CI = 6.2–8.1). In 2023 at least 65% of duck hunting trips reported reaching their daily bag limit (4).

Table 5. Estimates of the overall average active duck hunter¹³ in Victoria in 2023 by holders of a Game Licence endorsed for duck.

Statistic	Annual estimate	SE	95% CI	
			Lower	Upper
Proportion active	0.65	0.02	0.60	0.70
Estimated active hunters	14,118	518	13,139	15,170
Average harvest per active hunter	22.66	1.56	19.81	25.92
Average hunting days per active hunter	7.06	0.48	6.18	8.06

The total harvest was estimated for each species by multiplying the total estimated duck harvest by the percentage of the total harvest for that species (Table 6). The most frequently harvested species was Pacific Black Duck, comprising 45% of the total reported harvest, followed by Grey Teal (29%) and Australian Wood Duck (18%). The remaining three species that could be hunted in 2023 comprised 7% of the total harvest. The duck species was not recorded appropriately for 0.3% of the harvest.

¹² Total harvest = Harvest per hunter (Table 3) × Total hunters (Table 2). Numbers may differ slightly due to rounding of average harvest per hunter.

¹³ Active duck hunter is defined as a Game Licence holder endorsed to hunt ducks who hunted for ducks at least once during the 2023 duck season.

Table 6. Reported numbers of ducks harvested by hunters, proportions of the total harvest, and estimates of total 2023 harvest for each duck species.

Species	Reported harvest	Proportion of harvest	SE	Estimated harvest	SE	95% CI	
						Lower	Upper
Pacific Black Duck	1,895	0.45	0.008	144,995	8,769	90,176	233,141
Grey Teal	1,192	0.29	0.007	91,206	5,746	56,186	148,052
Australian Wood Duck	764	0.18	0.006	58,457	3,895	35,536	96,164
Chestnut Teal	185	0.04	0.003	14,155	1,308	7,905	25,348
Pink-eared Duck	95	0.02	0.002	7,269	849	3,789	13,946
Mountain Duck	37	0.01	0.001	2,831	492	1,292	6,202
Blue-winged Shoveler ¹⁴	NA	NA	NA	NA	NA	NA	NA
Hardhead ¹⁵	NA	NA	NA	NA	NA	NA	NA

Game Licence holders endorsed to hunt ducks hunted an average of 4.6 days during the 2023 duck hunting season (Table A5.2). When multiplied by the total number of Game Licence holders in each survey period, this equalled a total of 99,680 hunter days (95% CI = 89,139–111,467, Table 7).

Table 7. Number of days ducks were hunted by Game Licence holder for 2023.

Period	Days hunted	SE	95% CI	
			Lower	Upper
26-30 April	23,582	2,535	19,114	29,094
1-7 May	19,763	2,306	15,735	24,822
8-14 May	14,587	1,931	11,266	18,887
15-21 May	14,665	2,219	10,921	19,695
22-30 May	27,083	3,460	21,106	34,753
Total hunting days	99,680	5,689	89,139	111,467

During the survey period, greater duck hunting effort was expended on private (47.8%) than on public (41.9%), with similar proportions to those for the ducks being harvested solely on private land (49.5%) and public land (38.4%) (Table 8)

¹⁴ Game Licence holders were not permitted to harvest Blue-winged Shoveler (*Anas rhynchos*), also referred to as Australasian Shoveler, in 2023.

¹⁵ Game Licence holders were not permitted to harvest Hardhead (*Aythya australis*), also referred to as White-eyed Duck, in 2023.

Table 8. Percentage of days hunted and associated duck harvest by land tenure in 2023.

Land tenure	Days (%)	Duck harvest (%)
Private land only	47.8	49.5
Public land only	41.9	38.4
Both	10.2	12.1
Total	99.9	100.0

Total harvest was estimated to be greatest in the North Central CMA, followed by the West Gippsland CMA and the Goulburn Broken CMA (Figure 2). The top five towns for the total reported number of ducks harvested were (in descending order) Kerang, Sale, Horsham, Echuca and Geelong. The top five towns for the total number of reported duck hunting days were (in descending order) Sale, Kerang, Horsham, Geelong and Echuca

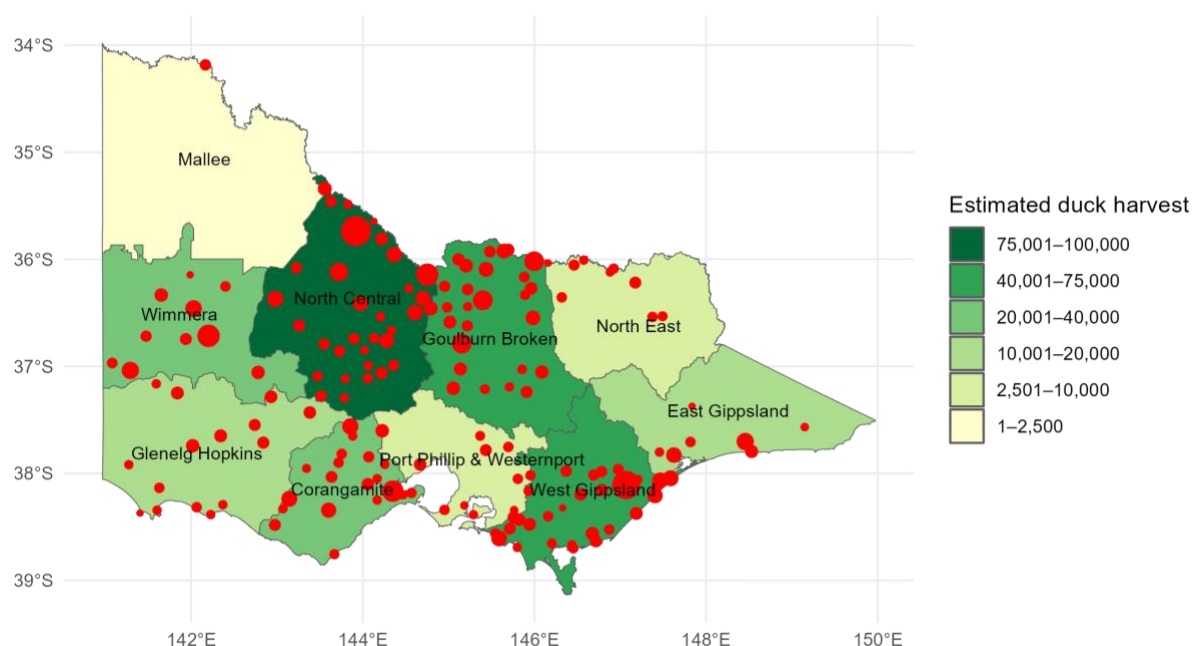


Figure 2. Estimates of total duck harvest in 2023 by CMA region.

Red circles indicate the nearest town to harvest locations, with symbol size proportional to reported harvest.

Ducks were reported shot but lost on 2% of duck hunting trips (19 out of 943) for a total of 29 ducks in the survey. The estimated season total of ducks shot and lost in 2023 was 2,216 (95% CI = 1,333–3,683), which would increase the harvest by 0.7%. Given how small these numbers are as a percentage of the overall duck harvest, their accuracy and use may be limited.

In 2023 at least 65% of duck hunting trips reported reaching their daily bag limit (4 ducks). Eleven respondents (or 1.2% of active hunters) reported average daily harvests exceeding the 2023 daily duck bag limit of 4. They accounted for 1.8% of duck hunting trips. If you assume the number of duck hunting days is correct and reduce their harvest totals to be inline with the daily bag limit, the excess accounts for 1.7% of the total duck harvest.

3.2 Stubble Quail harvest in 2023

The number of Game Licence holders endorsed to hunt Stubble Quail remained relatively constant throughout the season, increasing from 26,249 at opening weekend to 26,627 at the end of the season (Table 9). To achieve the required sample size of respondents, slightly more than 480 licence holders were contacted each survey, with typically 98% of those contacted being willing to take part.

Table 9. Summary of responses for Stubble Quail surveys in 2023.

Stubble Quail survey	Period	Licence holders	Respondents	Stubble Quail hunters ¹⁶	Respondents who hunted	Days hunted ¹⁷
1	26-30 April	26,249	480	229	54	114
2	1-7 May	26,627	480	254	51	101
3	8-14 May	26,627	480	194	31	58
4	15-21 May	26,627	480	227	50	98
5	22-30 May	26,627	480	251	44	117

The percentage of endorsed Game Licence holders who hunted Stubble Quail was consistent in each survey period of the season. About 10% of licence holders hunted in each survey period (except for Period 3 which was 6%), corresponding to approximately 2,800 hunters (Table 10).

Table 10. Proportion and corresponding total number of Stubble Quail licence holders who hunted in each survey period in 2023.

Period	Proportion	SE	95% CI		Total hunters	SE	95% CI	
			Lower	Upper			Lower	Upper
26-30 April	0.11	0.014	0.09	0.14	2,953	379	2,299	3,793
1-7 May	0.11	0.014	0.08	0.14	2,829	375	2,185	3,663
8-14 May	0.06	0.011	0.05	0.09	1,720	299	1,227	2,411
15-21 May	0.10	0.014	0.08	0.14	2,774	371	2,136	3,602
22-30 May	0.09	0.013	0.07	0.12	2,441	351	1,844	3,230

Within each survey period, there was large variation in the reported harvest of Stubble Quail per hunter (i.e. per Game Licence holder who hunted). Some hunters harvested more than 60 Stubble Quail in a survey period, whereas 65% of people who hunted did not harvest any Stubble Quail (Figure 3). The average number of Stubble Quail per hunter varied throughout the season (Table 11). In the opening five days the average harvest per hunter was 28.8 (95% CI = 21.8–38) Stubble Quail, while the first and last surveys in May were about two-thirds of that amount.

¹⁶ Respondents who self-report as Stubble Quail hunters.

¹⁷ Days hunted indicates the combined number of days on which Stubble Quail hunting took place by respondents.

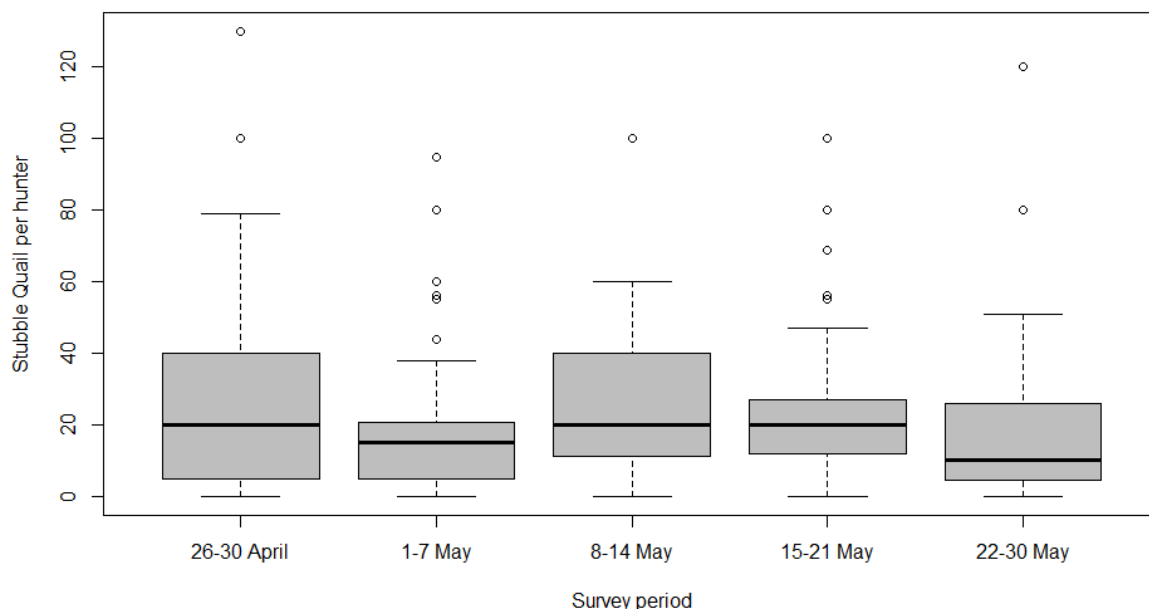


Figure 3. Boxplot of the number of quails reported harvested by individual hunters for each survey period in 2023.

The bottom and top of each 'box' indicate the 25th and 75th percentiles, respectively, with the black horizontal line indicating the median (50th percentile) reported value.

Table 11. Average harvest of Stubble Quail per hunter (Game Licence holders who hunted) for each survey period in 2023.

Period	Average harvest per hunter ¹⁸	SE	95% CI	
			Lower	Upper
26-30 April	28.76	4.09	21.79	37.96
1-7 May	19.57	2.91	14.65	26.14
8-14 May	27.48	4.21	20.39	37.05
15-21 May	24.22	3.11	18.85	31.11
22-30 May	19.70	3.56	13.86	28.01

There were an estimated 302,824 Stubble Quail harvested by all holders of a Game Licence for Stubble Quail during the 2023 Stubble Quail season (95% CI = 252,481–363,205). During the opening five-days the Stubble Quail harvest was 28% of the total season harvest (Table 12).

¹⁸ Average harvest per hunter = Stubble Quail harvested divided by Respondents who hunted (Table 9).

Table 12. Estimates of the total Stubble Quail harvest in Victoria in 2023 by holders of a Game Licence endorsed for Stubble Quail.

Period	Total harvest ¹⁹	SE	95% CI	
			Lower	Upper
26-30 April	84,926	16,339	58,447	123,403
1-7 May	55,362	11,072	37,552	81,618
8-14 May	47,263	11,022	30,105	74,200
15-21 May	67,178	12,510	46,780	96,469
22-30 May	48,095	11,178	30,680	75,396
Total	302,824	28,151	252,481	363,205

A telephone survey immediately after the 2023 Stubble Quail season ended estimated that 18% (95% CI = 15%–21%) of Game Licence holders licensed to hunt game birds hunted during the 2023 Stubble Quail season (Table 13). The estimated number of active Stubble Quail hunters in the 2023 Stubble Quail season was 4,761 (95% CI = 4,040–5,609). Over the whole Stubble Quail hunting season, the average active Stubble Quail hunter was estimated to have harvested 63.6 Stubble Quail (95% CI = 49.8–81.2) over an average of 5.7 hunting days (95% CI = 4.4–7.3).

Table 13. Estimates of the overall statistics for active Stubble Quail hunters²⁰ in Victoria in 2023.

Statistic	Annual estimate	SE	95% CI	
			Lower	Upper
Proportion active quail hunters	0.18	0.01	0.15	0.21
Estimated active quail hunters	4,761	399	4,040	5,609
Average harvest per active hunter	63.61	7.96	49.82	81.22
Average hunting days per active quail hunter	5.67	0.74	4.39	7.31

Stubble Quail hunters had a total of 26,981 hunter days (95% CI = 22,181–32,819) during the 2023 Stubble Quail-hunting season (Table 14).

¹⁹ Total harvest = Harvest per hunter (Table 11) × Total hunters (Table 10). Numbers may differ slightly due to rounding of average harvest per hunter.

²⁰ Active Stubble Quail hunter is defined as a Game Licence holder endorsed to hunt Stubble Quail who hunted for Stubble Quail at least once during the 2023 Stubble Quail season.

Table 14. Estimates of total number of Stubble Quail hunting days for 2023.

Period	Days hunted	SE	95% CI	
			Lower	Upper
26-30 April	6,234.14	1,267	4,203	9,246
1-7 May	5,602.76	1,184	3,719	8,441
8-14 May	3,217.43	857	1,926	5,376
15-21 May	5,436.35	1,157	3,598	8,213
22-30 May	6,490.33	1,492	4,160	10,126
Total hunting days	26,981.01	2,703	22,181	32,819

Most Stubble Quail hunting was conducted on private land (93% of the hunting days) with the remaining hunting occurring on public land (Table 15). A similar percentage (95.6%) of the harvested Stubble Quail reported in the telephone surveys were taken on private land. The percentage of Stubble Quail hunting days where dogs were used (81%) was similar to the percentage of Stubble Quail harvested using dogs (84.2%, Table 15). The majority of Stubble Quail hunting and Stubble Quail harvesting took place on stubble (51.6% and 51.8%, respectively, Table 16).

Table 15. Percentage of days hunted and associated Stubble Quail harvest by land tenure and dog usage in 2023.

Land tenure	Days (%)			Harvest (%)		
	No dogs	Dogs	Total	No dogs	Dogs	Total
Private land only	16.0	77.0	93.0	14.4	81.2	95.6
State Game Reserves only	1.8	3.9	5.7	0.9	3.1	3.9
Total	17.8	81.0	98.8	15.3	84.2	99.5

Table 16. Percentage of hunting days and associated Stubble Quail harvest per grassland type in 2023.

Habitat type	Days (%)	Stubble Quail harvest (%)
Introduced grass	7.8	6.4
Native and introduced grass	1.8	1.4
Native grass	22.5	22.3
Stubble	51.6	51.8
Stubble and introduced grass	1.6	1.1
Stubble and native and introduced grass	3.1	2.4
Stubble and native grass	10.0	14.1
Total	98.6	99.5

Total harvest was estimated to be greatest in the North Central CMA, followed by the Goulburn Broken CMA and the Corangamite CMA (Figure 4). The top five towns for the total reported number of Stubble Quail harvested were (in descending order) Shepparton, Wycheproof, Rochester, Kerang and Geelong. The top five towns for the total number of reported Stubble Quail hunting days were (in descending order) Kerang, Donald, Shepparton, Geelong and Rochester.

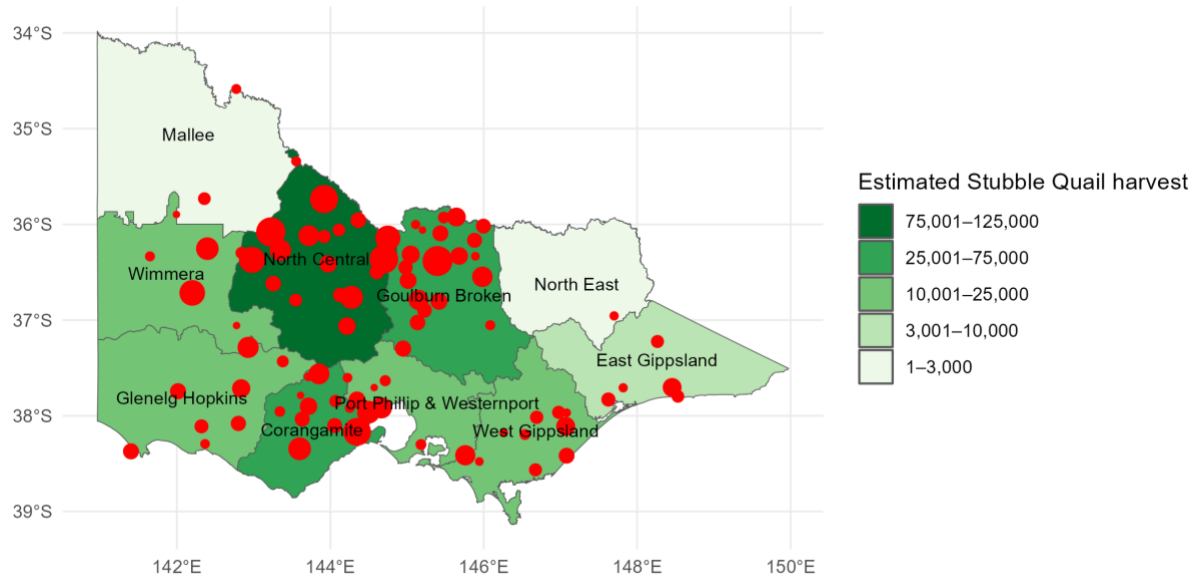


Figure 4. Estimates of total Stubble Quail harvest in 2023 by CMA region.

Red circles indicate the nearest town to harvest locations, with symbol size proportional to reported harvest.

Stubble Quail were reported shot but lost on 7% of Stubble Quail hunting trips (25 out of 381) for a total of 76 Stubble Quail in the survey. The estimated season total of Stubble Quail shot and lost in 2023 is 4,214 (95% CI = 2,195–8,088), which would increase the harvest by 1.4%. Given how small these numbers are as a percentage of the overall Stubble Quail harvest, their accuracy and use may be limited.

4 Discussion

4.1 Duck harvest in 2023

A total of 319,908 ducks were estimated to have been harvested in Victoria during the 2023 season (95% CI = 285,537–358,417), which was approximately the average harvest from 2009 to 2023 (320,000) when the telephone surveys started (Figure 5 and Table 17) and a 22% increase over the 2022 estimate.

The estimated number of total hunting days, duck harvest per licence holder and hunting days per licence holder were all higher than historical levels. This possibly reflects hunters going out more frequently over the shortened season (5 weeks compared to the prescribed 12 weeks) to acquire their desired number of ducks with the reduced daily bag limit (4 ducks per day compared to the prescribed 10). Hunter efficiency (3.21 ducks per hunting day) was 9% below the average from 2009 to 2023 (3.54 ducks per hunting day, Table 17). This is to be expected given the bag limit in 2023 was 4 ducks per day, down from the maximum prescribed daily bag limit of 10 ducks per day. In 2023, the estimated efficiency was 80% of the daily bag limit. The only years where

hunter efficiency was higher than 2023 were when the daily bag limit was at the maximum prescribed daily bag limit of 10 ducks per day. Another factor in the high hunter effort given the daily bag restrictions and shortened season could be that many hunters were motivated to participate in the belief that 2023 could be the final Victorian duck season given the Parliamentary inquiry into native game bird hunting arrangements.

It was estimated that 65% (95% CI = 60%–70%) of Game Licence holders hunted for ducks during the 2023 duck season. That equates to an estimated 14,118 (95% CI = 13,139–15,170) active duck hunters in the 2023 duck season. The average total duck harvest per active duck hunter was estimated to be 22.7 (95% CI = 19.8–25.9) over 7.1 (95% CI = 6.2–8.1) days. These are similar to the estimates outside 2020 and 2021, which had been the lowest at that point, reflecting duck seasons impacted by COVID-19 movement restrictions in 2020 and 2021 and the Black Summer bushfires in 2019–2020.

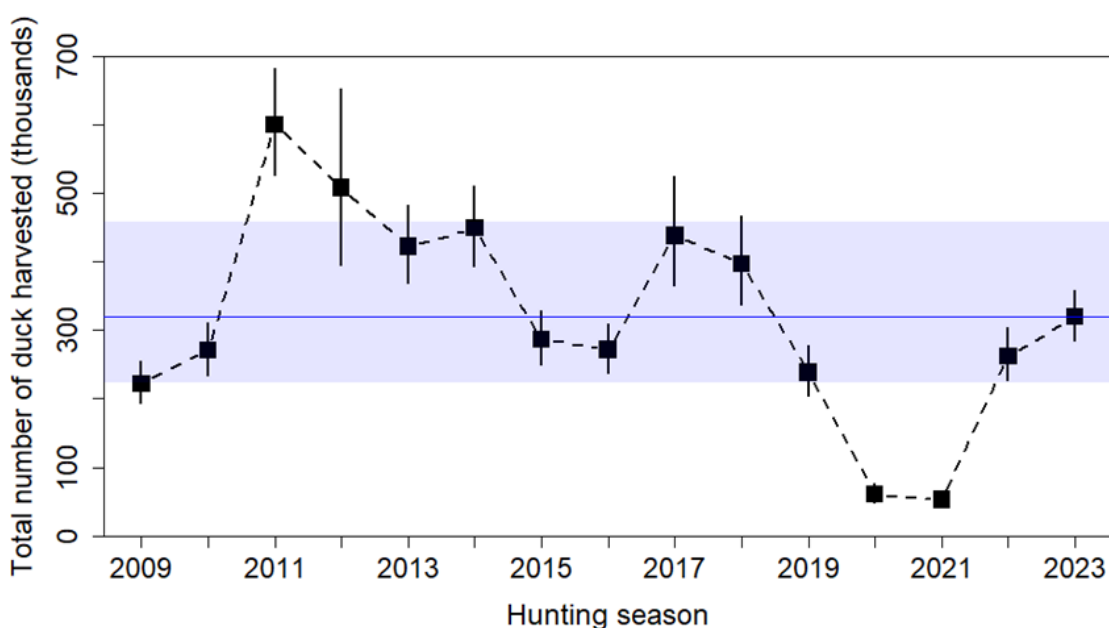


Figure 5. Estimates of total duck harvests (in thousands) from 2009 to 2023.

The square is the estimated total harvest for each season; the solid vertical line indicates the 95% confidence interval; the blue line is the average duck harvest from 2009 to 2023; the shaded area is the 95% confidence interval for the average duck harvest from 2009 to 2023.

Table 17. Comparison of duck harvest statistics of 2009 to 2023²¹.

NA represents years before the end-of-season survey was conducted and where the statistic relied on the end-of-season survey estimate of proportion of active hunters.

Year	Total harvest	Hunting days	Ducks per licence holder	Hunting days per licence holder	Ducks per hunting day	Proportion of active hunters	Ducks per active hunter	Season length	Daily bag limit
2009	222,302	76,659	11.10	3.98	2.78	NA	NA	7	5
2010	270,574	85,801	12.54	3.98	3.16	NA	NA	10	8
2011	600,739	103,450	26.02	4.48	5.81	NA	NA	13	10
2012	508,256	109,718	21.19	4.60	4.63	NA	NA	13	10
2013	422,294	91,748	17.24	3.75	4.60	NA	NA	13	10
2014	449,320	118,800	17.29	4.57	3.78	NA	NA	12	10
2015	286,729	90,634	11.35	3.58	3.17	NA	NA	12	5
2016	271,576	100,749	10.73	3.98	2.70	NA	NA	12	4
2017	438,353	96,508	17.36	3.83	4.53	0.66	25.40	12	10
2018	396,708	91,570	15.65	3.62	4.33	0.55	28.10	12	10
2019	238,666	81,023	9.62	3.27	2.94	0.55	17.60	9	5
2020	60,403	29,501	2.58	1.26	2.05	0.32	8.10	5	3
2021	52,456	19,720	2.16	0.81	2.66	0.32	6.90	3	5
2022	262,567	96,102	11.57	4.24	2.73	0.50	23.30	12	4
2023	319,908	99,680	14.60	4.55	3.21	0.65	22.66	5	4
Average	320,057	86,111	13.40	3.63	3.54	0.51	18.87		

²¹ Duck harvested and hunting days per Game Licence holder in 2023 are reported here for comparison with the results of surveys prior to 2017, when the duck harvested and hunting days per active hunter could be calculated.

The estimated total harvest in 2023 of Pacific Black Duck was 46% higher than the long-term average, while for Grey Teal the harvest was 5% higher (Table 18). All other species of game duck the 2023 had estimated total harvests in 2023 lower than their long-term averages.

Table 18. Comparison of duck harvests by species from 2009 to 2023.

NAs represent years where the hunting of that species was prohibited, while 0 was used if they could be harvested, but there were none reported.

Year	Australian Wood Duck	Blue-winged Shoveler	Chestnut Teal	Grey Teal	Hardhead	Mountain Duck	Pacific Black Duck	Pink-eared Duck
2009	131,084	NA	13,176	20,919	NA	2,173	55,150	NA
2010	112,390	216	14,354	26,011	324	5,936	96,487	0
2011	132,908	4,854	49,812	211,034	25,657	8,090	156,484	12,597
2012	150,150	1,319	23,506	110,574	30,222	9,234	160,704	21,587
2013	106,553	7,104	39,804	135,947	7,349	2,694	92,714	30,129
2014	131,282	4,155	29,866	127,126	6,363	8,440	127,646	14,154
2015	80,194	1,497	19,456	79,945	998	6,860	81,940	15,839
2016	77,955	NA	18,097	77,069	506	6,454	89,850	1,645
2017	90,929	NA	13,639	175,038	8,083	12,124	118,460	20,080
2018	89,354	NA	27,123	122,941	4,816	6,971	132,827	12,674
2019	57,588	NA	13,528	63,421	621	8,688	83,031	3,103
2020	18,204	NA	4,374	6,028	0	3,783	27,778	236
2021	14,301	NA	5,233	11,197	61	1,643	19,534	304
2022	68,632	NA	26,044	47,506	NA	20,567	98,700	1,118
2023	58,457	NA	14,155	91,206	NA	2,831	144,995	7,269
Average	87,999	3,191	20,811	87,064	7,083	7,099	99,087	10,053

4.2 Stubble Quail

The total of 302,824 Stubble Quail estimated to have been harvested in Victoria during the 2023 season (95% CI = 252,481–363,205) is the second largest harvest since the telephone surveys started in 2009 (Figure 6 and Table 19). The seasonal harvest was almost double the long-term average, despite the season length being reduced by almost 60%.

The estimated number of total hunting days (26,981) and Stubble Quail per licence holder (11.42) were higher than historical averages (19,979 and 5.96 respectively). Hunter efficiency (11.23 Stubble Quail per hunting day) was the second highest recorded between 2009 to 2023 and higher than the historical average (7.88).

It was estimated that 18% (95% CI = 15%–21%) of eligible Game Licence holders actually hunted for Stubble Quail during the 2023 Stubble Quail season. That equates to

an estimate of 4,761 (95% CI = 4,040–5,609) active Stubble Quail hunters in the 2023 Stubble Quail season. The average Stubble Quail harvest per active Stubble Quail hunter was estimated to be 63.6 (95% CI = 49.8–81.2). This estimate is the second highest recorded.

As was the case for duck hunting, the high hunter effort despite the shortened quail season length could be due to hunters being motivated to participate in the belief that 2023 could be the final Victorian quail hunting season given the Parliamentary inquiry into native game bird hunting arrangements.

With the extra surveys (2,400 instead of 1,200), the coefficient of variation (a measure of variability relative to the mean) for the total Stubble Quail harvest went from 15% to 40% in previous surveys to 9% in 2023. The result is that the precision of estimates was increased, confidence intervals were reduced, and the effects of outliers has been reduced.

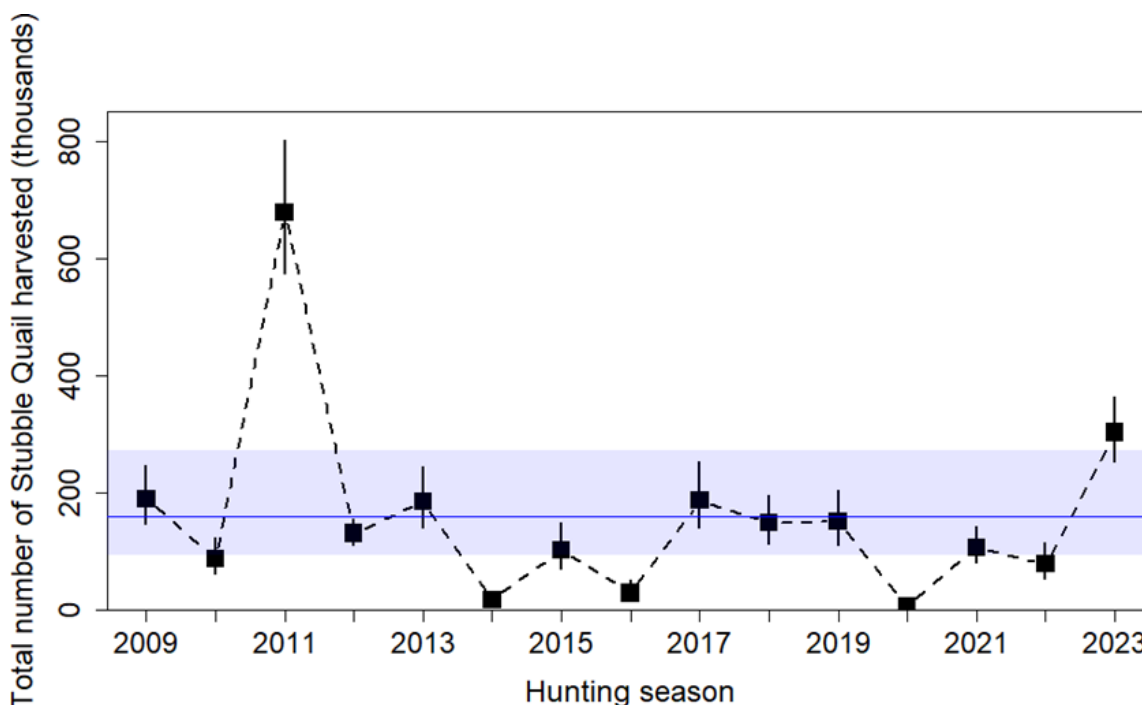


Figure 6. Estimates of total Stubble Quail harvests (in thousands) from 2009 to 2023.

The square is the estimated total harvest for each season; the solid vertical line indicates the 95% confidence interval; the blue line is the average Stubble Quail harvest from 2009 to 2023; the shaded area is the 95% confidence interval for the average Stubble Quail harvest from 2009 to 2023.

Table 19. Comparison of Stubble Quail harvests of 2009 to 2023.

Year	Total harvest	Hunting days	Quail per licence holder	Hunting days per licence holder	Quail per hunting day	Proportion of active hunters	Quail per active hunter
2009	189,155	24,648	7.89	1.03	7.97	NA	NA
2010	86,302	24,739	3.59	1.03	3.48	NA	NA
2011	678,431	46,719	26.17	1.80	14.52	NA	NA
2012	129,711	22,262	4.80	0.82	5.81	NA	NA
2013	184,123	21,958	6.69	0.98	8.39	NA	NA
2014	16,243	10,852	0.56	0.38	1.47	NA	NA
2015	101,244	22,432	3.58	0.79	4.51	NA	NA
2016 ²²	28,043	6,559	1.00	0.23	4.29	NA	NA
2017	186,691	22,052	6.51	0.77	8.45	0.15	43.7
2018	148,500	17,772	5.19	0.62	8.36	0.18	28.5
2019	149,736	22,351	5.30	0.79	6.70	0.08	87.2
2020	4,848	3,771	0.18	0.14	1.29	0.04	5.1
2021	105,968	16,381	3.70	0.57	6.49	0.06	59.4
2022	77,590	10,214	2.84	0.37	7.60	0.09	30.4
2023	302,824	26,981	11.42	1.02	11.23	0.18	63.6
Average	159,294	19,979	5.96	0.76	7.88	0.11	45.4

Due to the structure of Game Licences in Victoria, not every holder of a Game Licence endorsed to hunt Stubble Quail will hunt Stubble Quail. The price of a Game Licence for game birds including duck is the same as a Game Licence for game birds not including duck. Anyone who wants to hunt ducks automatically has Stubble Quail included in their licence. For many game bird hunters, duck hunting will be their primary activity. Hence, a high proportion of Game Licence holders will be permitted to hunt Stubble Quail, even though they may not intend to do so. In 2023, it was estimated that 48% (95% CI = 39–59%) of Game Licence holders endorsed for Stubble Quail self-identified as ‘Stubble Quail hunters’. That includes those

who did not actively hunt Stubble Quail in 2023. This equates to an estimate of 12,778 (95% CI = 10,396–15,705) ‘Stubble Quail hunters’ in the 2023 Stubble Quail season. This does not affect the estimates of Stubble Quail harvest, because the calculations explicitly account for the proportion of Stubble Quail Game Licence holders who did not actually hunt Stubble Quail.

It should be noted that the number of hunting days was only an approximate estimate of total effort: someone who hunted for two hours and someone else who hunted for 12 hours were both recorded as having hunted for one day.

²² The 2016 Stubble Quail surveys were conducted after the season rather than each month of the season. It is assumed that the change in methodology will produce only minor differences.

4.3 Locations with the most hunting days

The top five towns for the total number of reported duck hunting days in 2023 were (in descending order) Sale, Kerang, Horsham, Geelong and Echuca.

The top five towns for the total number of reported Stubble Quail hunting days in 2023 were (in descending order) Kerang, Donald, Shepparton, Geelong and Rochester.

Combining duck and Stubble Quail, Kerang had the most hunting days during the 2023 hunting seasons, followed by Sale, Horsham, Geelong and Echuca. This assumed that all hunting days were equal in length, even though the time spent hunting on any particular day could vary considerably for each respondent, and for game species.

It should be noted that there is potential that the high number of hunting days for both ducks and Stubble Quail (25% and 34% above long-term average per relevant licence holder respectively) may have been motivated by the belief of some in the community that the Parliamentary inquiry (Batchelor *et al.* 2023) could result in 2023 being the last seasons for native bird hunting in Victoria if it was banned. The select committee was announced in February 2023, and called for public submission from March to May 2023, meaning it could have been front of mind for many game licence holders.

4.4 Assumptions

The estimates of harvest for each game type were derived with the assumption that the samples of respondents were representative of the entire population of Victorian Game Licence holders. This assumption may have been violated due to several factors, such as the reasons for non-response (exceeded bag limit, or (conversely) did not harvest anything), memory recall (respondents not remembering their harvest), and deliberate over- or under-reporting (reported numbers knowingly being reported incorrectly). Any bias due to non-response is likely to have been negligible, because the response rate for all surveys was generally above 95% (i.e. very high). Memory bias can inflate estimates of total harvest, in some cases by as much as 40% (Barker, 1991; Wright, 1978). It is likely, however, that the sampling strategy of telephone interviews after each two-week period in the case of ducks, would have ensured that both memory bias and non-response bias were kept low (compared with postal surveys and complete end-of-season surveys (Barker, 1991; Barker, Geissler, & Hoover, 1992). Nevertheless, some bias likely remains, and the estimates of total harvest should be interpreted with caution.

It needs to be noted that due to a clerical error, the 2016 telephone Stubble Quail survey did not follow the standard methodology, as all surveys happened at the end of the season. That means the results of the 2016 telephone Stubble Quail survey may have increased memory bias and may not be strictly comparable with those of other years.

It is also important to note that the methodology explicitly accounts for the possibility that not every Game Licence holder hunts in every survey period (see Gormley & Turnbull, 2010). Therefore, the estimate of total season bag per Game Licence holder is the sum of the 'harvest per Game Licence holder', not the sum of the 'harvest per hunter'.

The uncertainty in the estimates of total harvest (as indicated by the confidence intervals) was due to two factors. First, there was variation in the reported numbers of animals harvested between respondents who had hunted (see Figure 1 and Figure 3). For example, within a given survey period for duck hunting, some respondents indicated that they hunted unsuccessfully, whereas others took multiple trips and indicated a total harvest of more than 50 ducks during the same period. The second source of uncertainty was due to sampling the hunters, rather than taking a complete census. However, the degree of sampling uncertainty was reduced by having sample sizes of 200 respondents per survey for ducks and 300 respondents per survey for Stubble Quail. Statistically, these sample sizes were considered adequate for providing reasonable estimates.

The spatial distributions of the duck and Stubble Quail harvest should also be interpreted with caution. Grouping the harvest for a relatively large region (CMA) provides a broad-scale view of the distribution of the harvest. Grouping by smaller regions would provide a finer-scale representation, but this would come at the cost of increased bias in many regions. Because the data are from a sample of Game Licence holders rather than a complete census, it is likely that some areas that were actually hunted are shown as having a zero harvest if no respondents that hunted those areas were contacted. This would be increasingly likely at finer spatial scales. Furthermore, respondents were only asked to report the nearest town to where they hunted, not the actual location. It is, therefore, possible that the nearest town was in a different CMA than the hunting location.

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Appendices

Appendix 1: Questionnaire for Game Licence holders endorsed to hunt duck

1. Did you go duck hunting over **period X**?

Yes ☐ No ☐

2. Have you been duck hunting ...

... in the last week? since last Sunday? between last Monday and last Sunday?

Yes ☐ No ☐

(Tick box. If 'Yes', proceed to question 4. If 'No', "Thank you for taking part in this survey.")

3. How many duck-hunting trips have you taken over this 1-week period?

(Indicate number in box.)

(Each trip needs to be treated separately for questions 4–8.)

	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6
4. How many days did you go hunting?						
5. How many ducks did your harvest?						
6. What species were the ducks? Include number of each species	Black Duck	Black Duck	Black Duck	Black Duck	Black Duck	Black Duck
	Wood Duck	Wood Duck	Wood Duck	Wood Duck	Wood Duck	Wood Duck
	Mountain Duck	Mountain Duck	Mountain Duck	Mountain Duck	Mountain Duck	Mountain Duck
	Grey Teal	Grey Teal	Grey Teal	Grey Teal	Grey Teal	Grey Teal
	Chestnut Teal	Chestnut Teal	Chestnut Teal	Chestnut Teal	Chestnut Teal	Chestnut Teal
	Pink Ear	Pink Ear	Pink Ear	Pink Ear	Pink Ear	Pink Ear
	Shoveler	Shoveler	Shoveler	Shoveler	Shoveler	Shoveler
	Hardhead	Hardhead	Hardhead	Hardhead	Hardhead	Hardhead
7. What type of land did you hunt on? "Can register more than one choice"	State Game Reserve	State Game Reserve	State Game Reserve	State Game Reserve	State Game Reserve	State Game Reserve
	Private land	Private land	Private land	Private land	Private land	Private land
	Public land	Public land	Public land	Public land	Public land	Public land
8. What was the closest major town to the area you hunted?						

Appendix 2: Questionnaire for Game Licence holders endorsed to hunt Stubble Quail

1. Do you use a dog when you hunt for quail? Yes ☐ No ☐

2. Have you been Quail hunting in the last month? (during April – since the opening weekend?)
Yes ☐ No ☐ (tick box).

If 'Yes', proceed to question 3.

If 'No', "Thank you for taking part in this survey. If you would like to discuss or view the outcomes of this data, please contact the Customer Service Centre on 136 186.

3. How many Quail-hunting trips did you take last month?

(Indicate number in box.)

(Each trip needs to be treated separately for questions 4–8.)

4. How many days did you go hunting?

5. How many Quail did you harvest?

6. What type of land did you hunt on? State Game Reserve / Private land / Public land

"You can register more than one choice."

7. What type of grasslands was the hunt on? Stubble / Native Grass / Introduced grass

"You can register more than one choice."

8. What was the closest major town to the area you hunted?

Appendix 3: Definitions and calculations

Definitions

SD = standard deviation of the data; it represents the variation in the numbers reported.

SE = standard error of the mean; it represents the variation in the estimated mean.

CV = coefficient of variation; it is calculated as: $CV = SE \div \text{mean}$. This provides an indication as to how much uncertainty is in the estimate relative to the mean.

Calculations

For each survey j , we surveyed n_j respondents, of which h_j had hunted. The proportion of respondents who hunted in each period j is given by:

$$p_j = \frac{h_j}{n_j}$$

e.g. for Deer Survey 4 in 2015, we obtained: obtained:

$$\frac{70}{200} = 0.350$$

The total number of hunters for each survey period (H_j) was estimated by multiplying the total number of Licence holders (L) by the proportion of respondents who reported having hunted during that survey period (p_j), as found previously:

$$H_j = p_j L$$

eg. for Deer Survey 4 in 2015, we obtained: $0.35 \times 30,908 = 10,818$.

The estimated average harvest per hunter (w_j) is the total reported harvest for survey j (y_j) divided by the total number of respondents who hunted (h_j):

$$w_j = \frac{y_j}{h_j}$$

e.g. for Deer Survey 4 in 2015, we obtained: $\frac{215}{70} = 3.07$

The total harvest for each survey period (W_j) was estimated by multiplying the average harvest per hunter (w_j) by the total number of hunters (H_j):

$$W_j = w_j H_j$$

e.g. for Deer Survey 4 in 2015, we obtained:

$$3.07 \times 10,808 = 33,226.$$

The estimate of the total harvest was calculated as the sum of the estimated harvest for each survey period:

$$W_{TOT} = W_1 + W_2 + W_3 + W_4 + W_5 + W_6 + W_7.$$

Standard errors (SEs) for the proportion of respondents who hunted are given by:

$$SE(p_j) = \sqrt{\frac{p_j(1-p_j)}{n_j}}.$$

e.g. for Deer Survey 4 in 2015, we obtained:

$$\sqrt{\frac{0.35 \times .65}{200}} = 0.034.$$

Standard errors for the average harvest per hunter are given by:

$$SE(w_j) = \frac{SD(w_j)}{\sqrt{n_j}}.$$

e.g. for Deer Survey 4 in 2015, we obtained:

$$\frac{4.55}{\sqrt{70}} = 0.54$$

The standard error for the total estimated harvest per survey period (W_j) was found by determining the coefficient of variation (CV) for each p_j and w_j and then calculating the square root of the sum of their squares to find the combined CV (assuming independence).

$$CV(w_j) = \frac{SE(w_j)}{w_j}, \text{ and } CV(p_j) = \frac{SE(p_j)}{p_j}$$

$$CV(W_j) = \sqrt{(CV(w_j))^2 \times (CV(p_j))^2 + (CV(w_j))^2 + (CV(p_j))^2}$$

$$SE(W_j) = CV(W_j) \times W_j.$$

The standard error of the total harvest was calculated by:

$$SE(W_{TOT}) = \sqrt{(SE(W_1))^2 + (SE(W_2))^2 + \dots + (SE(W_7))^2}.$$

Confidence intervals were computed on the natural logarithm scale and back-transformed to ensure that lower limits were ≥ 0 . A consequence is that the confidence intervals were asymmetric and could not be reported as the estimate plus or minus a fixed value. For some estimates, denoted as \hat{X} , 95% confidence interval limits were calculated using:

$$\text{upper limit} = \hat{X} \times r$$

$$\text{lower limit} = \hat{X} \div r, \quad \text{where:}$$

$$r = \exp\left(1.96 \times \sqrt{\ln(1 + CV^2)}\right).$$

E.g. for the total duck harvest we have

$$CV = \frac{8,349}{71,142} = 0.117$$

$$r = \exp\left(1.96 \sqrt{\ln 1 + 0.117^2}\right) = 1.26$$

Therefore, upper and lower confidence limits are given by:

$$UL = 71,142 \times 1.26 = 89,471$$

$$LL = 71,142 \div 1.26 = 56,567.$$

Appendix 4 Explanation of what goes into a boxplot

A boxplot is a way of displaying the key points of data and is especially good for comparing groups of data. It is sometimes referred to as a box-and-whisker plot. A boxplot shows the following key points:

- outliers, signified by hollow circles
- minimum, signified by the horizontal line below the box (smallest value, excluding outliers)
- lower quartile (Q1), signified by the horizontal line at the bottom of the box (25% of the data is at this point or below)
- median, signified by the thick horizontal line in the box (50% of the data is at this point or below)
- upper quartile (Q3), signified by the horizontal line at the top of the box (75% of the data is at this point or below)
- maximum, signified by the horizontal line above the box (largest value, excluding outliers)
- interquartile range (IQR; difference between the upper and lower quartiles)
- whiskers—the lines that go from the minimum or maximum to the box.

Outliers are values that are very large (or small) compared with the rest of the data. An outlier is defined as any point that is either below $Q1 - 1.5 \times IQR$ or above $Q3 + 1.5 \times IQR$, which means that any point that lies more than one-and-a-half times the length of the box outside the box is an outlier.

The boxplot indicates the spread of the data. The data is broken into quarters: approximately 25% of the data are in the range between a whisker and the nearest edge of the box, and approximately 25% of the data are in the range between an edge of the box and the median line. Thus, approximately half the data are contained within the box. Any unusual data are highlighted as outliers. As an example, Figure A4.1 shows a boxplot indicating that most hunters harvested between 5 and 13 ducks, and a quarter harvested between 13 and 27 ducks. A number of outliers harvested more than 27 ducks, including one who harvested over 50 ducks. Sometimes there are no whiskers because the minimum (or maximum) is the same as the lower (or upper) quartile (see Figure A4.1, which indicates that at least 25% of Game Licence holders who hunted were unsuccessful).

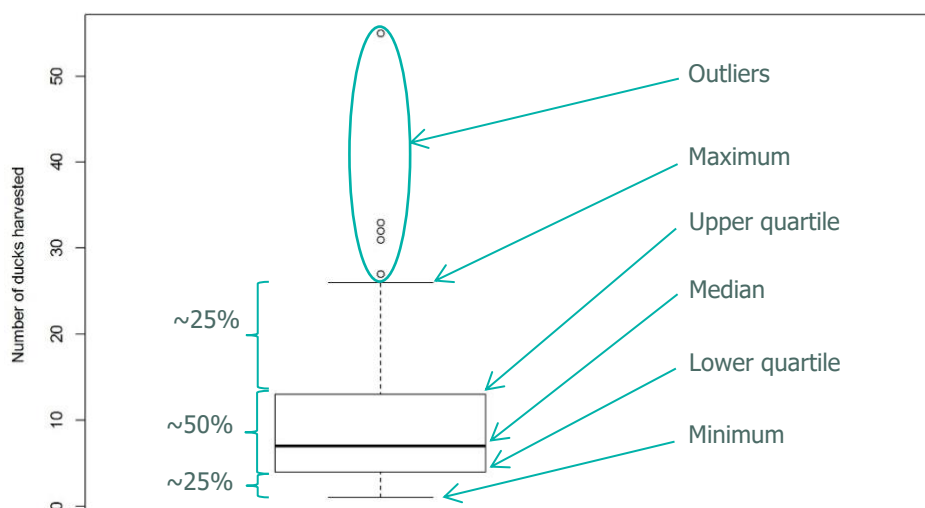


Figure A4.1. Example boxplot, with labels.

Appendix 5 Harvest rates per Game Licence endorsed for hunting duck

Historically (from 2009 to 2016) the data collected only allowed for annual harvest rates to be at the level of Game Licence holder endorsed to hunt duck. Since 2017, when the end of year surveys have been conducted, it has been possible to estimate the annual harvest rate per active hunter. Therefore, the rate per Game Licence holder is not required. It has been included in this appendix to allow comparison between years before 2017.

The total average season harvest per licence holder was estimated to be 14.6 birds (95% CI = 13–16.4; Table A5.1). Note that, for each survey period, the average duck harvest per Game Licence holder was lower than the average duck harvest per hunter (Table 3), as the former includes those respondents who did not hunt during the survey period, whereas the latter includes only those who hunted.

Table A5.1. Estimates of average harvest of ducks per Game Licence holder in each survey period in 2023.

Period	Average harvest ²³	SE	95% CI	
			Lower	Upper
26-30 April	2.88	0.33	2.31	3.59
1-7 May	2.88	0.30	2.35	3.52
8-14 May	2.21	0.27	1.75	2.80
15-21 May	2.38	0.32	1.83	3.09
22-30 May	4.25	0.59	3.24	5.58
Total	14.60	0.85	13.03	16.36

Each Game Licence holder hunted an average of 4.6 days during the 2023 duck-hunting season (Table A5.2). When multiplied by the total number of Game Licence holders in each survey period, this equalled a total of 99,680 hunter days (95% CI = 89,139–111,467).

Table A5.2. Days on which ducks were hunted per Game Licence holder for 2023.

Period	Days hunted	SE	95% CI	
			Lower	Upper
26-30 April	1.09	0.11	0.90	1.32
1-7 May	0.90	0.10	0.73	1.11
8-14 May	0.66	0.08	0.52	0.84
15-21 May	0.67	0.09	0.51	0.88
22-30 May	1.23	0.16	0.96	1.58
Total per licence holder	4.55	0.25	4.09	5.06
Total hunting days	99,680	5,689	89,139	111,467

²³ Average harvest per Game Licence holder = Duck harvest divided by Respondents (Table 1).

Appendix 6 Harvest rates per Game Licence endorsed for hunting Stubble Quail

Historically (from 2009 to 2016) the data collected only allowed for annual harvest rates to be at the level of Game Licence holder endorsed to hunt Stubble Quail. Since 2017, when the end of year surveys have been conducted, it has been possible to estimate the annual harvest rate per active hunter. Therefore, the rate per Game Licence holder is not required. It has been included in this appendix to allow comparison between years before 2017.

The total average season harvest per licence holder was estimated to be 11.4 birds (95% CI = 9.5–13.7; Table A6.1). However, if you limit the respondent to only those who say they hunt Stubble Quail, then the total average season harvest per self-reported Stubble Quail hunter is estimated to be 23.9 birds (95% CI = 20–28.5; Table A6.1). Note that, for each survey period, the average Stubble Quail harvest per Game Licence holder was lower than the average Stubble Quail harvest per hunter (Table 11), as the former includes those respondents who did not hunt during the survey period, whereas the latter includes only those who hunted.

Table A6.1. Estimates of average harvest of Stubble Quail per Game Licence holder in each survey period in 2023.

Period	Average harvest ²⁴	SE	95% CI	
			Lower	Upper
26-30 April	3.24	0.62	2.23	4.70
1-7 May	2.08	0.42	1.41	3.07
8-14 May	1.77	0.41	1.13	2.79
15-21 May	2.52	0.47	1.76	3.62
22-30 May	1.81	0.42	1.15	2.83
Total	11.42	1.06	9.52	13.70

Each Game Licence holder hunted an average of 1 days during the 2023 Stubble Quail-hunting season (Table A6.2). When multiplied by the total number of Game Licence holders in each survey period, this equalled a total of 26,981 hunter days (95% CI = 22,181–32,819).

²⁴ Average harvest per Game Licence holder endorsed for Quail hunting.

Table A6.2. Days on which Stubble Quail were hunted per Game Licence holder for 2023.

Period	Days hunted	SE	95% CI	
			Lower	Upper
26-30 April	0.24	0.04	0.18	0.32
1-7 May	0.21	0.03	0.15	0.29
8-14 May	0.12	0.02	0.08	0.18
15-21 May	0.20	0.03	0.15	0.28
22-30 May	0.24	0.04	0.17	0.34
Total per licence holder	1.02	0.08	0.87	1.18
Total hunting days	26,981	2,703	22,181	32,819

