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# Estimate of duck and Stubble Quail harvest in Victoria for 2021

**Results from surveys of Victorian Game  
Licence holders in 2021**

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 2021

Results from surveys of Victorian Game Licence holders in 2021

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# Contents

<b>Acknowledgements</b>	<b>ii</b>
<b>Contents</b>	<b>iii</b>
<b>Summary</b>	<b>1</b>
<b>1 Introduction</b>	<b>3</b>
<b>2 Method</b>	<b>4</b>
2.1 General methodology	4
2.2 Duck	5
2.3 Stubble Quail	5
<b>3 Results</b>	<b>6</b>
3.1 Duck	6
3.2 Stubble Quail	11
<b>4 Discussion</b>	<b>17</b>
4.1 Duck	17
4.2 Stubble Quail	19
4.3 Locations with the most hunting days	21
4.4 Assumptions	21
4.5 Conclusions and implications	22
<b>References</b>	<b>23</b>
<b>Appendix 1</b>	<b>25</b>
<b>Appendix 2</b>	<b>27</b>
<b>Appendix 3</b>	<b>28</b>
<b>Appendix 4</b>	<b>30</b>
<b>Appendix 5</b>	<b>31</b>
<b>Appendix 6</b>	<b>32</b>

## Tables

Table 3.1: Summary of responses for duck surveys in 2021.....	6
Table 3.2: Proportion and corresponding total number of duck licence holders who hunted in each survey period in 2021.....	6
Table 3.3: Average harvest of ducks per hunter (Game Licence holders who hunted) for each survey period in 2021.....	7
Table 3.4: Estimates of the total duck harvest in Victoria in 2021 by holders of a Game Licence endorsed for duck.....	8
Table 3.5: Total days on which ducks were hunted in 2021.....	8
Table 3.6: Estimates of the overall average harvest per active duck hunter in Victoria in 2021 by holders of a Game Licence endorsed for duck, and the average hunting days per active hunter.....	9
Table 3.7: Reported numbers of ducks harvested by hunters, proportions of the total harvest, and estimates of total 2021 harvest for each duck species. ....	9
Table 3.8: Percentage of days hunted and associated duck harvest by land tenure in 2021. ....	10
Table 3.9: Summary of responses for Stubble Quail surveys in 2021.....	11
Table 3.10: Proportion and corresponding total number of Stubble Quail licence holders who hunted in each survey period in 2021. ....	11
Table 3.11: Average harvest of Stubble Quail per hunter (Game Licence holder who hunted) for each survey period in 2021.....	12
Table 3.12: Estimates of the total Stubble Quail harvest in Victoria in 2021 by holders of a Game Licence endorsed for Stubble Quail.....	<b>Error! Bookmark not defined.</b>
Table 3.12: Estimates of the total Stubble Quail harvest in Victoria in 2021 by holders of a Game Licence endorsed for Stubble Quail.....	13
Table 3.13: Days on which Stubble Quail were hunted per self-reported Stubble Quail hunter for 2021. ....	14
Table 3.14: Estimates of the overall average active Stubble Quail hunter in Victoria in 2021 by holders of a Game Licence endorsed for Stubble Quail. ....	14
Table 3.15: Percentage of days of Stubble Quail hunting and associated Stubble Quail harvest by land tenure and dog usage in 2021.....	15
Table 3.16: Percentage of days of Stubble Quail hunting and associated Stubble Quail harvest per grassland type in 2021. ....	15

Table 4.1: Comparison of duck harvests of 2009 to 2021.....	18
Table 4.2: Comparison of Stubble Quail harvests of 2009 to 2021.....	20
Table A5.1: Estimates of average harvest of ducks per Game Licence holder in each survey period in 2021.....	31
Table A5.2: Days on which ducks were hunted per Game Licence holder for 2021.....	31
Table A6.1: Estimates of average harvest of Stubble Quail per Game Licence holder in each survey period in 2021.....	32
Table A6.2: Days on which Stubble Quail were hunted per Game Licence holder for 2021. ....	33

## Figures

Figure 3.1: Boxplot of the number of ducks reported harvested by individual hunters for each survey period in 2021.....	7
Figure 3.2: Estimates of total duck harvest in 2021 by CMA region. Red circles indicate the nearest town to harvest locations, with symbol size proportional to reported harvest. ....	10
Figure 3.3: Boxplot of the number of Stubble Quails reported harvested by individual hunters for each survey period in 2021.....	12
Figure 3.4: Estimates of total Stubble Quail harvest in 2021 by CMA region. ....	16
Figure 4.1: Estimates of total duck harvests (in thousands) from 2009 to 2021.....	17
Figure 4.2: Estimates of total Stubble Quail harvests (in thousands) from 2009 to 2021.....	19
Figure A4.1. Example boxplot, with labels. ....	30



## Summary

### Context

To effectively manage game species, it is important to quantify the numbers 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 2021.

### 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 2021 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 number of days spent hunting for ducks and Stubble Quail. Additional metrics related to hunter effort and efficiency were also estimated.

### Results

The total estimated duck harvest in 2021 was approximately 52,500 ducks [95% confidence interval (CI) = 41,600–66,100]. This was the lowest recorded duck harvest since the telephone surveys were introduced in 2009—less than one-sixth of the average annual duck harvests determined in the previous surveys (347,000 ducks). The total estimated number of duck-hunting days was 19,700 days (95% CI = 15,700–24,800), which was similarly the lowest recorded estimate—less than one-quarter of the annual duck-hunting days determined from previous surveys (90,000 days). The three most commonly harvested species were Pacific Black Duck (*Anas superciliosa*) (37% of the total harvest), Australian Wood Duck (*Chenonetta jubata*)

(27%) and Grey Teal (*Anas gracilis*) (21%). The remaining ducks harvested were Chestnut Teal (*Anas castanea*) (10%), Mountain Duck (*Tadorna tadornoides*) (3%), Pink-eared Duck (*Malacorhynchus membranaceus*) (1%) and Hardhead (*Aythya australis*) (<1%). Hunting of Blue-winged Shoveler (*Anas rhynchotis*) was prohibited for the 2021 season.

Game Licence holders endorsed to hunt ducks and who actively hunted during the 2021 duck-hunting season harvested an average of 6.8 ducks (95% CI = 5.2–9.0), over an average of 2.6 days (95% CI = 2.0–3.4).

The total estimated Stubble Quail harvest in 2021 was 106,000 quail (95% CI = 79,300–141,600), which was 69% less than the average annual Stubble Quail harvest from previous surveys (155,000 quail). The total estimated number of Stubble Quail-hunting days was 16,400 (95% CI = 12,000–22,400), which was 19% less than the annual average from previous surveys (20,000 days).

Game Licence holders endorsed to hunt Stubble Quail who actively hunted during the 2021 Stubble Quail season harvested an average of 59.4 quail (95% CI = 38.9–90.6), over an average of 9.2 days (95% CI = 5.9–14.2). The large estimate for the average Stubble Quail harvest per active hunter is likely to be a statistical anomaly due to the very low number of Game Licence holders surveyed at the end of the season who hunted.

The total number of hunter days during the 2021 hunting season for ducks and Stubble Quail was estimated to be 36,100 (95% CI = 29,200–43,000).

### Conclusions and implications

At various times during 2021, government-imposed COVID-19 restrictions impeded the movement of hunters within Victoria, limited the size of social gatherings, and prevented overnight camping. Combined, these restrictions limited the ability of hunters to actively participate in hunting. The duck season was reduced in duration (only 3 weeks instead of the prescribed 12) and bag limit (only 5 ducks per day, down from the prescribed 10 ducks per day). It should be noted, however, that the limit was only 5 and 3 ducks per day in 2019 and 2020,

respectively, due to ongoing drought conditions that reduced game duck abundance and habitat availability. The Stubble Quail seasonal arrangements remained unchanged from the regulations (i.e. 3 months in length and a 20-birds-per-day bag limit).

The COVID-19 restrictions reduced the ability of hunters to travel for hunting and likely played a central role in the following findings:

The proportion of active duck hunters was only 32%, down from 55% in 2018 and 2019, and the same as 2020, which was also affected by COVID-19 restrictions.

The proportion of active Stubble Quail hunters was 6%, down from 17% in 2018 and similar to the 8% in 2019 and 4% in 2020.

The number of ducks harvested, and the number of hunting days were the lowest recorded.

The number of Stubble Quail harvested, and the hunting days were below average.

The number of Game Licence holders endorsed to hunt Stubble Quail who do not hunt Stubble Quail is affecting the accuracy of the activity indices. Either the end-of-season survey needs to investigate whether the respondent is a Stubble Quail hunter or survey a greater number of Game Licence holders.

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), so the estimates of total harvest must be interpreted with care.

# 1 Introduction

To effectively manage game species, it is important to quantify the numbers 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 to determine the levels of hunting activity and the number of each species harvested. 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.

Due to Victorian Government policies regarding COVID-19, duck hunting was not allowed until the 26 May. It closed on 14 June, reducing the duck-hunting season to just under 3 weeks (Game Management Authority 2021). Seven species could legally be hunted in 2021: Pacific Black Duck (*Anas superciliosa*), Australian Wood Duck<sup>1</sup> (*Chenonetta jubata*), Mountain Duck<sup>2</sup> (*Tadorna tadornoides*), Grey Teal (*Anas gracilis*), Chestnut Teal (*Anas castanea*), Pink-eared Duck (*Malacorhynchus membranaceus*) and Hardhead<sup>3</sup> (*Aythya australis*). Hunting of Blue-winged Shoveler<sup>4</sup> (*Anas rhynchotis*, a declared game species) was prohibited for the 2021 season due to continuing low numbers. The bag limit for the 2021 season was five game ducks per hunter per day reduced from the prescribed 10 birds.

The 2021 duck-hunting survey used a similar method (i.e. telephone surveys) to that followed during the 2005, 2006 and 2009 to 2020 duck-hunting seasons (Barker 2006; Gormley and Turnbull 2009, 2010, 2011; Moloney and Turnbull 2012, 2013, 2014, 2015, 2016, 2017, 2018; Moloney and Powell 2019; Moloney and Hampton 2020). However, due to the unusual circumstances in 2021, there was no opening weekend (the season started on a Wednesday), and surveys were conducted weekly, rather than fortnightly, for the 3 weeks of the season.

The 2021 Stubble Quail-hunting season lasted 12 weeks, from 3 April to 30 June (Game Management Authority 2021). The daily bag limit for the 2021 season was 20 Stubble Quail per hunter.

The 2021 Stubble Quail-hunting survey used a similar method (i.e. telephone surveys) to those followed during the 2009 to 2015 and 2017 to 2019 Stubble Quail-hunting seasons (Gormley 2009; Gormley and Turnbull 2009, 2010, 2011; Moloney and Powell 2019; Moloney and Turnbull 2012, 2013, 2014, 2015, 2017, 2018). Due to a clerical error, the 2016 Stubble Quail-hunting survey used a slightly different method (Moloney and Turnbull 2016). 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 each month for the remaining months of the season (i.e. 3 surveys in total) (Moloney and Hampton 2020).

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<sup>1</sup> Australian Wood Duck is also referred to as Wood Duck, Maned Duck and Maned Goose.

<sup>2</sup> Mountain Duck is also referred to as Australian Shelduck.

<sup>3</sup> Hardhead is also referred to as White-eyed Duck.

<sup>4</sup> Blue-winged Shoveler is also referred to as Australasian Shoveler.

## 2 Method

### 2.1 General methodology

Slightly different methodology was used for estimating duck and Stubble Quail harvests. All surveys were conducted by the telephone survey company Marketing Skill Pty Ltd (Mt Eliza, Victoria) on behalf of the Game Management Authority (see Appendices 1 and 2 for Harvest Questionnaires). Estimates of total harvest by Game Licence holders were based on the hunting activities reported by the survey respondents.

For ducks, surveys were performed every week (rather than fortnightly) throughout the 3-week season. For Stubble Quail, surveys were performed for the 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 respondent<sup>5</sup> may have hunted during the periods covered by Surveys 2 and 3, if they were contacted as part of Survey 3, then only information pertaining to the period covered by Survey 3 was collected. An additional random sample of 400 Game Licence holders were surveyed immediately after the conclusion of the duck- and Stubble Quail-hunting seasons respectively. Respondents were asked whether they had hunted at any stage during that season. The responses to these questions were subsequently used to estimate the number of active hunters during the 2021 duck-hunting and Stubble Quail-hunting seasons, respectively.

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 who hunted was used as an estimate of the proportion of Game Licence holders who hunted. The proportion of 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 hunter<sup>6</sup> 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 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.

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

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<sup>5</sup> Respondent refers to a Game Licence holder who was contacted and agreed to take part in the survey.

<sup>6</sup> 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.

## 2.2 Duck

Samples were drawn from hunters who held a Game Licence endorsed to hunt ducks during the 2021 season. An independent random sample of 400 licence holders were interviewed by telephone at weekly intervals for the remainder of the duck season (Duck Surveys 1–3). This is twice the number of respondents (200) that is usually surveyed, in an attempt to reduce uncertainty in the estimates due to the unusual conditions for the 2021 duck season. Respondents were also asked to report the number of each species harvested. An additional random sample of 400 Game Licence holders was surveyed immediately after the conclusion of the duck-hunting season. They were asked whether they had hunted 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 2021 season. A random sample of 300 licence holders were interviewed by telephone after the opening weekend (Survey 1), and in April (excluding opening weekend; Survey 2), May (Survey 3) and June (Survey 4). Respondents were asked to report the number of Stubble Quail harvested, the type of habitat where hunting occurred (native, stubble or introduced pasture) and whether dogs were used. An additional random sample of 400 Game Licence holders was surveyed immediately after the conclusion of the Stubble Quail–hunting season. They were asked if they had hunted at any stage during the season.

When a Game Licence holder is endorsed for hunting duck, they are automatically endorsed for hunting Stubble Quail (you can be endorsed for hunting 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<sup>7</sup>. In the 2021 Stubble Quail hunter survey, all respondents were asked whether they hunt quail, even if they did not necessarily hunt Stubble Quail during the 2021 Stubble Quail season. This information was used to increase the precision of the estimates for the Stubble Quail harvest and number of hunting days.

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<sup>7</sup> Self-reported Stubble Quail hunters are Game Licence holders endorsed to hunt Stubble Quail who say that they may actually hunt Stubble Quail, regardless of whether they hunted Stubble Quail this season.

## 3 Results

### 3.1 Duck

The number of Game Licence holders endorsed to hunt ducks remained relatively constant throughout the shortened season (Table 3.1). In order to achieve the required sample size of respondents, slightly more than 400 licence holders were contacted each survey, with typically 98% of those contacted being willing to take part.

**Table 3.1: Summary of responses for duck surveys in 2021.**

Duck survey	Period	Licence holders	Respondents	Respondents who hunted	Days hunted <sup>8</sup>	Ducks harvested <sup>9</sup>
1	26–30 May	24,276	400	77	127	370
2	31 May – 6 June	24,330	399	39	71	160
3	7–14 June	24,330	399	52	126	332

The proportion of duck Game Licence holders who hunted during each survey period was consistent after the opening 5 days (Table 3.2). During the first survey period, 19% of surveyed licence holders hunted, corresponding to approximately 4673 hunters altogether (Table 3.2). In comparison, the number of estimated hunters during the following two survey periods was significantly less (Survey 2 = 10% of licence holders who hunted, Survey 3 = 13%, Table 3.2).

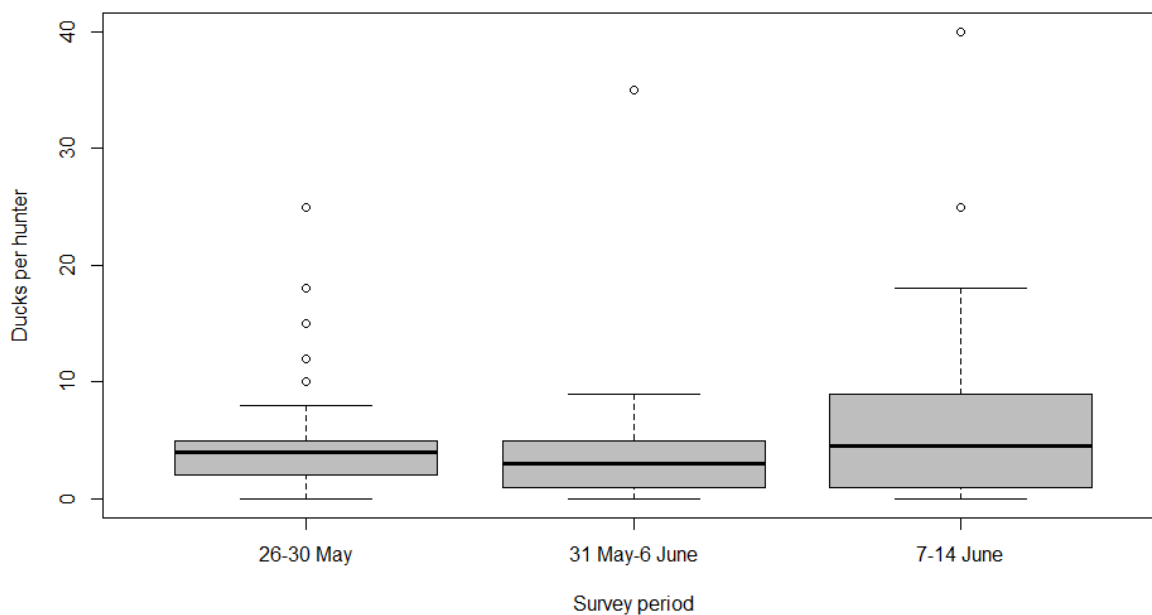
**Table 3.2: Proportion and corresponding total number of duck licence holders who hunted in each survey period in 2021.**

Period	Proportion	SE	95% CI		Total hunters	SE	95% CI	
			Lower	Upper			Lower	Upper
26–30 May	0.19	0.020	0.16	0.24	4,673	479	3,825	5,709
31 May – 6 June	0.10	0.015	0.07	0.13	2,378	362	1,768	3,199
7–14 June	0.13	0.017	0.10	0.17	3,171	410	2,463	4,081

The reported harvest of ducks per hunter (i.e. per Game Licence holder who hunted) was greatest in the final week of the season (6.4 ducks per hunter, Table 3.3). Some hunters harvested more than 15 ducks in a survey period, and some did not harvest any ducks (Figure 3.1). The average number of ducks per hunter was consistent throughout the first 2 weeks of the season (Table 3.3).

<sup>8</sup> Days hunted indicates the combined number of days on which duck hunting took place by respondents.

<sup>9</sup> Ducks harvested indicates total number of ducks harvested by respondents.



**Figure 3.1: Boxplot of the number of ducks reported harvested by individual hunters for each survey period in 2021.**

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

**Table 3.3: Average harvest of ducks per hunter (Game Licence holders who hunted) for each survey period in 2021.**

Period	Average harvest per hunter <sup>10</sup>	SE	95% CI	
			Lower	Upper
26–30 May	4.81	0.57	3.82	6.05
31 May – 6 June	4.10	0.91	2.67	6.31
7–14 June	6.38	1.10	4.57	8.93

CI = confidence limit.

There were an estimated 22,455 ducks harvested during the opening 5 days (95% CI = 16,550–30,467), which constituted 43% of the total seasonal harvest (Table 3.4). The harvest in the last 8 days of the season was similar (20,245 ducks) to that of the first 5 days. However, the harvest during the middle week was substantially lower (9756 ducks) than that of the other survey periods. The total season harvest estimate was 52,456 ducks (95% CI = 41,622–66,110; Table 3.4).

<sup>10</sup> Average harvest per hunter = Ducks harvested divided by Respondents who hunted (Table 3.1).

**Table 3.4: Estimates of the total duck harvest in Victoria in 2021 by holders of a Game Licence endorsed for duck.**

Period	Total harvest <sup>11</sup>	SE	95% CI	
			Lower	Upper
26–30 May	22,455	3,517	16,550	30,467
31 May – 6 June	9,756	2,646	5,788	16,447
7–14 June	20,245	4,385	13,306	30,802
<b>Total</b>	<b>52,456</b>	<b>6,213</b>	<b>41,622</b>	<b>66,110</b>

CI = confidence limit.

Each Game Licence holder endorsed for ducks hunted an average of 0.8 days during the 2021 duck-hunting season (Appendix 5, Table 5.2). When multiplied by the total number of Game Licence holders in each survey period, this equates to a total of 19,720 hunter days (95% CI = 15,702–24,767; Table 3.5).

**Table 3.5: Total days on which ducks were hunted in 2021.**

Period	Days hunted	SE	95% CI	
			Lower	Upper
26–30 May	7,708	1,224	5,657	10,502
31 May – 6 June	4,329	1,070	2,687	6,977
7–14 June	7,683	1,627	5,096	11,584
<b>Total hunting days</b>	<b>19,720</b>	<b>2,300</b>	<b>15,702</b>	<b>24,767</b>

CI = confidence limit.

Using a telephone survey immediately after the 2021 duck-hunting season ended, it was estimated that 32% (95% CI = 28%–37%) of Game Licence holders endorsed for ducks hunted for ducks during the 2021 duck-hunting season. That equates to an estimate of 7663 (95% CI = 6644–8839) active duck hunters in the 2021 duck season. The average total duck harvest per active duck hunter was estimated to be 6.8 ducks (95% CI = 5.2–9). The average number of duck-hunting days per active duck hunter was estimated to be 2.6 days (95% CI = 2–3.4).

<sup>11</sup> Total harvest = Harvest per hunter (Table 3.3) × Total hunters (Table 3.2). Numbers may differ slightly due to rounding of average harvest per hunter.



**Table 3.6: Estimates of the overall average harvest per active duck hunter<sup>12</sup> in Victoria in 2021 by holders of a Game Licence endorsed for duck, and the average hunting days per active hunter.**

Statistic	Annual estimate	SE	95% CI	
			Lower	Upper
Proportion active	0.32	0.02	0.28	0.37
Estimated active hunters	7663	559	6644	8839
Average harvest per active hunter	6.85	0.95	5.22	8.98
Average hunting days per active hunter	2.57	0.35	1.97	3.37

CI = confidence limit.

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 3.7). The most frequently harvested species was Pacific Black Duck, comprising 37% of the total reported harvest, followed by Australian Wood Duck (27%) and Grey Teal (21%). The remaining four species comprised 14% of the total harvest.

**Table 3.7: Reported numbers of ducks harvested by hunters, proportions of the total harvest, and estimates of total 2021 harvest for each duck species.**

Species	Reported harvest	Proportion of harvest	SE	Estimated harvest	SE	95% CI	
						Lower	Upper
Australian Wood Duck	235	0.27	0.015	14,301	1,871	7,192	28,436
Blue-winged Shoveler <sup>13</sup>	0	NA	NA	NA	NA	NA	NA
Chestnut Teal	86	0.10	0.010	5,233	819	2,479	11,050
Grey Teal	184	0.21	0.014	11,197	1,515	5,570	22,507
Hardhead	1	0.00	0.001	61	61	12	312
Mountain Duck	27	0.03	0.006	1,643	367	681	3,962
Pacific Black Duck	321	0.37	0.016	19,534	2,470	9,933	38,415
Pink-eared Duck	5	0.01	0.003	304	140	91	1,018

CI = confidence limit.

<sup>12</sup> Active duck hunter is defined as a Game Licence holder endorsed to hunt ducks who hunted for ducks at least once during the 2021 duck season.

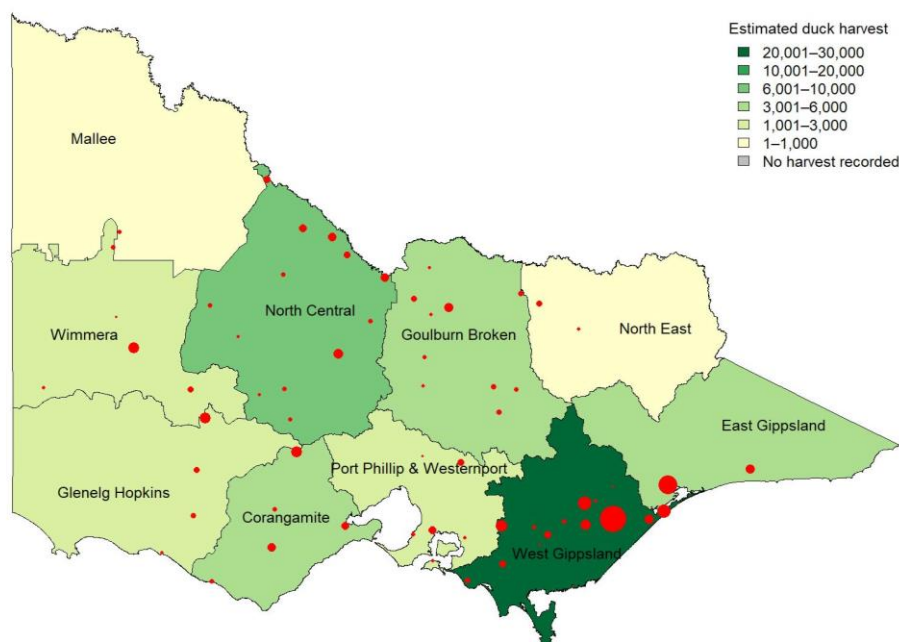
<sup>13</sup> Game Licence holders were not permitted to harvest Blue-winged Shoveler (*Anas rhynchos*), also referred to as Australasian Shoveler, since 2015.

During the survey period, greater duck hunting effort was expended on private land (48.5%) than on public land (39.8%), with similar proportions to those for the ducks being harvested solely on private land (50.7%) and solely on public land (35.3%) (Table 3.8).

**Table 3.8: Percentage of days hunted and associated duck harvest by land tenure in 2021.**

Land tenure	Days (%)	Duck harvest (%)
Private land only	48.5	50.7
Public land only	39.8	35.3
Both	11.4	14.0
<b>Total</b>	<b>99.7</b>	<b>100.0</b>

Total harvest was estimated to be greatest in the West Gippsland CMA, followed by the North Central CMA and the East Gippsland CMA (Figure 3.2). The top five towns for the total reported number of ducks harvested were (in descending order) Sale, Bairnsdale, Heyfield, Loch Sport and Warragul. The top five towns for the total number of reported duck-hunting days were (in descending order) Sale, Bairnsdale, Ballarat, Horsham and Loch Sport.



**Figure 3.2: Estimates of total duck harvest in 2021 by CMA region. Red circles indicate the nearest town to harvest locations, with symbol size proportional to reported harvest.**

## 3.2 Stubble Quail

The number of Game Licence holders endorsed to hunt Stubble Quail remained relatively constant throughout the season, increasing from 28,366 licence holders at opening weekend to 28,938 at the end of the season (Table 3.9). In order to achieve the required sample size of respondents, slightly more than 300 licence holders were contacted each survey, with an average of 98% of those contacted being willing to take part

**Table 3.9: Summary of responses for Stubble Quail surveys in 2021.**

Stubble Quail survey	Period	Licence holders	Respondents	Stubble Quail hunters <sup>14</sup>	Respondents who hunted	Days hunted <sup>15</sup>	Quail harvested <sup>16</sup>
1	Opening weekend	28,366	300	189	19	31	223
2	April <sup>17</sup>	28,366	300	99	19	33	384
3	May	28,819	300	96	18	37	150
4	June	28,938	299	71	29	70	353

The percentage of endorsed Game Licence holders who hunted Stubble Quail was consistent in each survey period throughout the first 2 months of the season, then increased in the last month. During opening weekend, 6% of licence holders hunted, corresponding to approximately 1797 hunters (Table 3.10). That percentage remained the same until the June survey, when participation increased to 10%, corresponding to approximately 2807 hunters (Table 3.10).

**Table 3.10: Proportion and corresponding total number of Stubble Quail licence holders who hunted in each survey period in 2021.**

Period	Proportion	SE	95% CI		Total hunters	SE	95% CI	
			Lower	Upper			Lower	Upper
Opening weekend	0.06	0.014	0.04	0.10	1,797	399	1,169	2,762
April	0.06	0.014	0.04	0.10	1,797	399	1,169	2,762
May	0.06	0.014	0.04	0.09	1,729	395	1,111	2,691
June	0.10	0.017	0.07	0.14	2,807	495	1,991	3,956

CI = confidence limit.

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) (Figure 3.3 and Table 3.11). Some hunters harvested more than 20 Stubble Quail in a survey period, whereas 19% of people who hunted did not

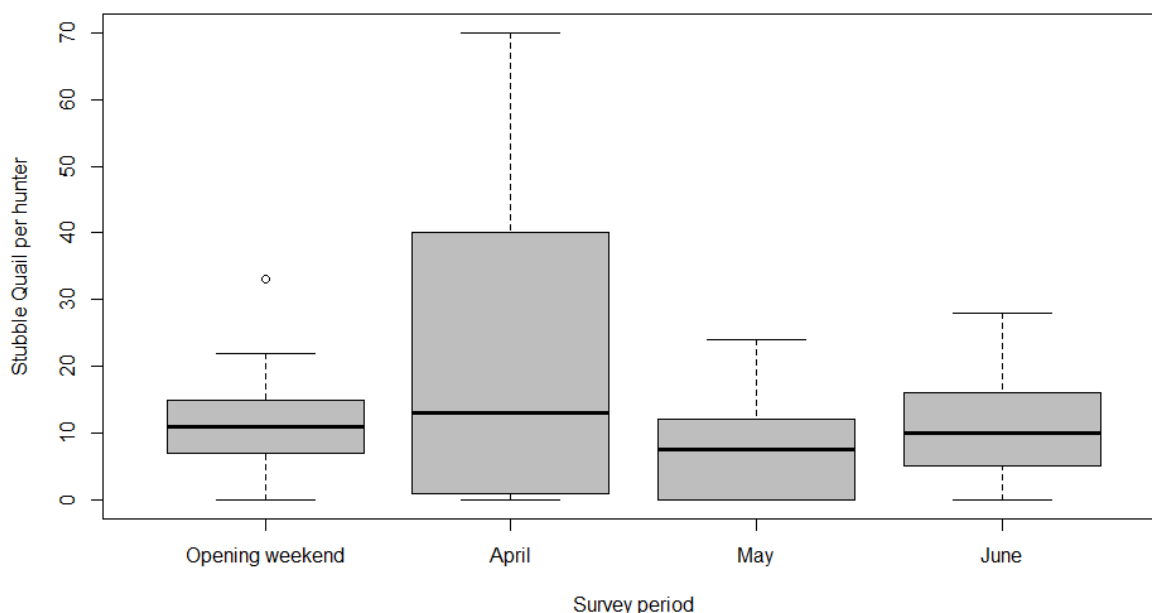
<sup>14</sup> Respondents who self-report as Stubble Quail hunters.

<sup>15</sup> Days hunted indicates the combined number of days on which Stubble Quail hunting took place by respondents.

<sup>16</sup> Stubble Quail harvested indicates total number of Stubble Quail harvested by respondents.

<sup>17</sup> April after the opening weekend.

harvest any Stubble Quail. The average harvest per hunter was 11.7 quail on opening weekend. The largest average harvest per hunter was 20.2 Stubble Quail in April<sup>18</sup>.



**Figure 3.3: Boxplot of the number of Stubble Quails reported harvested by individual hunters for each survey period in 2021.**

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

**Table 3.11: Average harvest of Stubble Quail per hunter (Game Licence holder who hunted) for each survey period in 2021.**

Period	Average harvest per hunter <sup>19</sup>	SE	95% CI	
			Lower	Upper
Opening weekend	11.74	1.81	8.69	15.85
April	20.21	4.66	12.93	31.58
May	8.33	1.94	5.32	13.06
June	12.17	1.48	9.60	15.43

CI = confidence limit.

<sup>18</sup> April after the opening weekend.

<sup>19</sup> Average harvest per hunter = Stubble Quail harvested divided by Respondents who hunted (Table 3.9).

There were an estimated 105,968 Stubble Quail harvested by all holders of a Game Licence for Stubble Quail during the 2021 season (95% CI = 78,788–135,909). The opening weekend Stubble Quail harvest per hunter was approximately a fifth of the total harvest. Including the opening weekend, the April harvest total was greater than the May and June harvest totals combined (Table 3.12).

**Table 3.12: Estimates of the total Stubble Quail harvest in Victoria in 2021 by holders of a Game Licence endorsed for Stubble Quail.**

Period	Total harvest	SE	95% CI	
			Lower	Upper
Opening weekend	21,085	5,743	12,481	35,621
April <sup>20</sup>	36,308	11,775	19,535	67,483
May	14,410	4,759	7,670	27,072
June	34,164	7,358	22,507	51,859
<b>Total</b>	<b>105,968</b>	<b>15,762</b>	<b>79,297</b>	<b>141,609</b>

CI = confidence limit.

Stubble Quail hunters had a total of 16,381 hunter days (95% CI = 11,963–22,429) during the 2021 Stubble Quail–hunting season (Table 3.13).

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<sup>20</sup> April after the opening weekend.

**Table 3.13: Days on which Stubble Quail were hunted per self-reported Stubble Quail hunter for 2021.**

Period	Days hunted	SE	95% CI	
			Lower	Upper
Opening weekend	2,931	955	1,573	5,461
April	3,120	1,056	1,637	5,948
May	3,554	1,339	1,740	7,260
June	6,775	1,780	4,083	11,241
<b>Total hunting days</b>	<b>16,381</b>	<b>2,643</b>	<b>11,963</b>	<b>22,429</b>

CI = confidence limit.

A telephone survey conducted immediately after the 2021 Stubble Quail season ended estimated that 6% (95% CI = 5–8%) of Game Licence holders hunted during the 2021 Stubble Quail season (Table 3.14). The estimated number of active Stubble Quail hunters in the 2021 Stubble Quail season was 1785 (95% CI = 1309–2433). The average active Stubble Quail hunter was estimated to have harvested 59.4 quail (95% CI = 38.9–90.6) over an average of 9.2 hunting days (95% CI = 5.9–14.2). These results reflect either an unusually low estimate of active Stubble Quail hunters from the end-of-season survey, or most active Stubble Quail hunters hunted during each survey period, or a combination of both.

**Table 3.14: Estimates of the overall average active Stubble Quail hunter<sup>21</sup> in Victoria in 2021 by holders of a Game Licence endorsed for Stubble Quail.**

Statistic	Annual estimate	SE	95% CI	
			Lower	Upper
Proportion active quail hunters	0.06	0.01	0.05	0.08
Estimated active quail hunters	1785	284	1309	2433
Average harvest per active hunter	59.4	12.9	38.9	90.6
Average hunting days per active quail hunter	9.2	2.1	5.9	14.2

CI = confidence limit.

Most Stubble Quail hunting was conducted on private land (67.8% of the hunting days), with the remainder occurring on public land (32.2%, Table 3.15). A similar percentage of the harvested Stubble Quail reported in the telephone surveys was on private land (73.2% of harvested quail). The percentage of Stubble Quail hunting days where dogs were used (37.4% of hunting days) was similar to the percentage of Stubble Quail harvested using dogs (36% of the harvested quail; Table 3.15). The majority of Stubble Quail hunting and harvesting took place on stubble habitat (58.5% and 66.2%, respectively, Table 3.16).

<sup>21</sup> 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 2021 Stubble Quail season.

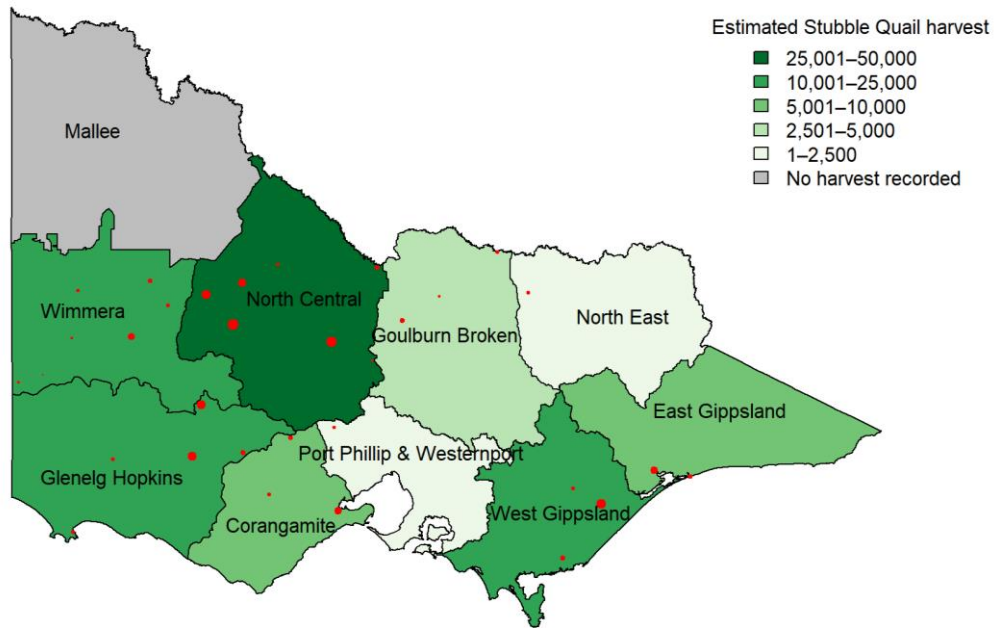
**Table 3.15: Percentage of days of Stubble Quail hunting and associated Stubble Quail harvest by land tenure and dog usage in 2021.**

Land tenure	Days (%)			Harvest (%)		
	No dogs	Dogs	Total	No dogs	Dogs	Total
Private land only	24.6	18.1	67.8	29.5	17.7	73.2
State Game Reserves only	3.5	19.3	32.2	2.1	18.4	26.8
Both	0.0	0.0	0.0	0.0	0.0	0.0
<b>Total</b>	<b>28.1</b>	<b>37.4</b>	<b>100.0</b>	<b>31.6</b>	<b>36.0</b>	<b>100.0</b>

**Table 3.16: Percentage of days of Stubble Quail hunting and associated Stubble Quail harvest per habitat type in 2021.**

Habitat type	Days (%)	Stubble Quail harvest (%)
Introduced grass	11.1	4.8
Native grass	15.8	8.8
Stubble	58.5	66.2
Stubble and introduced grass	0.6	1.2
Stubble and native grass	9.4	15.8
NA	4.7	3.2
<b>Total</b>	<b>100.0</b>	<b>100.0</b>

Total harvest was estimated to be greatest in the North Central CMA, followed by the Glenelg Hopkins CMA and the West Gippsland CMA (Figure 3.4). The top five towns for the total reported number of Stubble Quail harvested were (in descending order) St Arnaud, Bendigo, Sale, Donald and Ararat. The top five towns for the total number of reported Stubble Quail hunting days were (in descending order) Sale, Bairnsdale, Ararat, Bendigo and St Arnaud.



**Figure 3.4: Estimates of total Stubble Quail harvest in 2021 by CMA region.**

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



## 4 Discussion

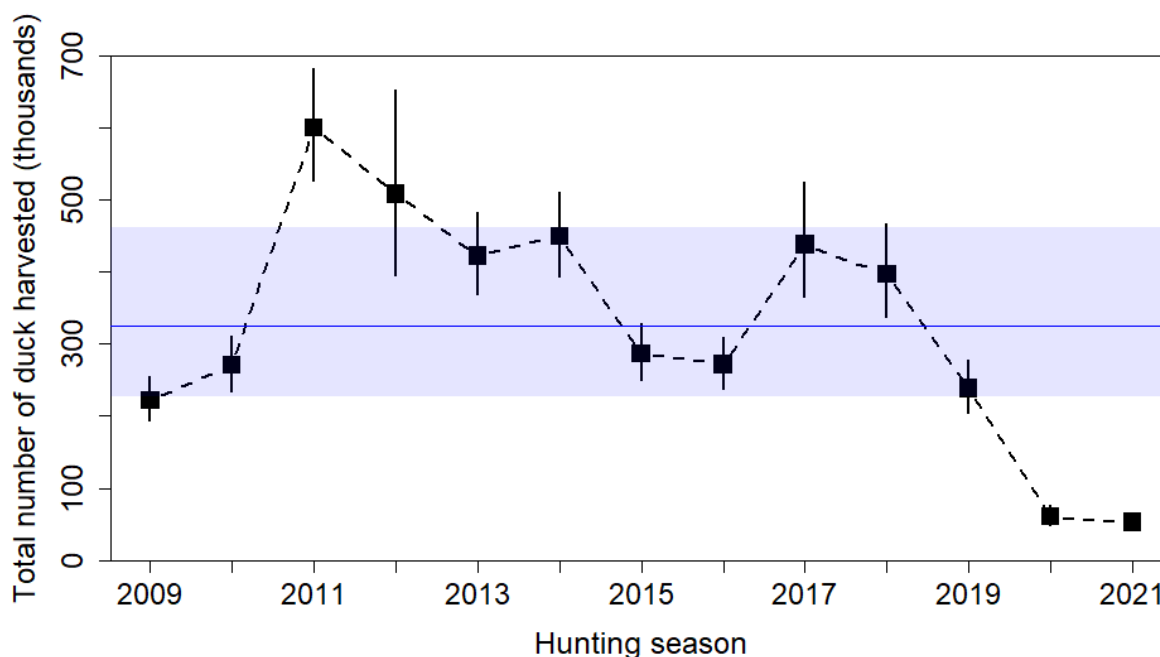
### 4.1 Duck

A total of 52,456 ducks were estimated to have been harvested in Victoria during the 2021 season (95% CI = 41,622–66,110), which was the lowest estimated harvest since 2009, when the telephone surveys started (Figure 4.1 and Table 4.1). The estimated harvest of each duck species available to harvest in 2021 was less than 30% of their average estimated harvest since 2009. Given the lower bag limit and a shortened duck season, a reduction in harvest is to be expected. COVID-19 restrictions limiting movement, camping and gatherings is also likely to have negatively affected the 2021 duck harvest in Victoria.

The estimated number of total hunting days and ducks harvested per licence holder were much lower than historical levels (Table 4.1). The lowest number of hunting days recorded (less than a quarter of the average) is to be

expected due to the restrictions in 2021 (3-week duck season compared to the typical 12 weeks). Hunter efficiency (ducks harvested per hunting day) was 30% below the average from 2009 to 2021 (Table 4.1). This is to be expected given the bag limit in 2021 was 5 ducks per day, down from a more typical bag limit of 10 ducks per day.

It was estimated that 32% (95% CI = 28%–37%) of Game Licence holders hunted for ducks during the 2021 duck season. That equates to an estimate of 7663 active duck hunters (95% CI = 6644–8839) in the 2021 duck season. The average duck harvest per active duck hunter for 2021 was estimated to be 6.8 ducks (95% CI = 5.2–9) over 2.6 days (95% CI = 2–3.4). These estimates are similar to or lower than the figures for 2020, which had been the lowest at that point, reflecting the unusual duck seasons in 2020 and 2021.



**Figure 4.1: Estimates of total duck harvests (in thousands) from 2009 to 2021.**

The squares are the estimated total harvests for each season; the solid vertical lines indicate the 95% confidence intervals; the blue line is the average duck harvest from 2009 to 2021; the shaded area is the 95% confidence interval for the average duck harvest from 2009 to 2021.

**Table 4.1 : Comparison of duck harvests of 2009 to 2021.**

Year	Australian Wood Duck	Blue-winged Shoveler	Chestnut Teal	Grey Teal	Hardhead	Mountain Duck	Pacific Black Duck	Pink-eared Duck	Total harvest	Hunting days	Ducks per licence holder	Hunting days per licence holder	Ducks per hunting day
2009	131,084	NA	13,176	20,919	NA	2,173	55,150	NA	222,302	76,659	11.10	3.98	2.79
2010	112,390	216	14,354	26,011	324	5,936	96,487	0	270,574	85,801	12.54	3.98	3.15
2011	132,908	4,854	49,812	211,034	25,657	8,090	156,484	12,597	600,739	103,450	26.02	4.48	5.81
2012	150,150	1,319	23,506	110,574	30,222	9,234	160,704	21,587	508,256	109,718	21.19	4.60	4.61
2013	106,553	7,104	39,804	135,947	7,349	2,694	92,714	30,129	422,294	91,748	17.24	3.75	4.60
2014	131,282	4,155	29,866	127,126	6,363	8,440	127,646	14,154	449,320	118,800	17.29	4.57	3.78
2015	80,194	1,497	19,456	79,945	998	6,860	81,940	15,839	286,729	90,634	11.35	3.59	3.16
2016	77,955	NA	18,097	77,069	506	6,454	89,850	1,645	271,576	100,749	10.73	3.98	2.70
2017	90,929	NA	13,639	175,038	8,083	12,124	118,460	20,080	438,353	96,508	17.36	3.83	4.53
2018	89,354	NA	27,123	122,941	4,816	6,971	132,827	12,674	396,708	91,570	15.65	3.62	4.32
2019	57,588	NA	13,528	63,421	621	8,688	83,031	3,103	238,666	81,023	9.62	3.27	2.94
2020	18,204	NA	4,374	6,028	0	3,783	27,778	236	60,403	29,501	2.58	1.26	2.05
2021	14,301	NA	5,233	11,197	61	1,643	19,534	304	52,456	19,720	2.16	0.81	2.67
<b>Average</b>	<b>91,761</b>	<b>3,191</b>	<b>20,921</b>	<b>89,788</b>	<b>7,083</b>	<b>6,392</b>	<b>95,585</b>	<b>11,029</b>	<b>324,490</b>	<b>84,299</b>	<b>13.45</b>	<b>3.52</b>	<b>3.82</b>

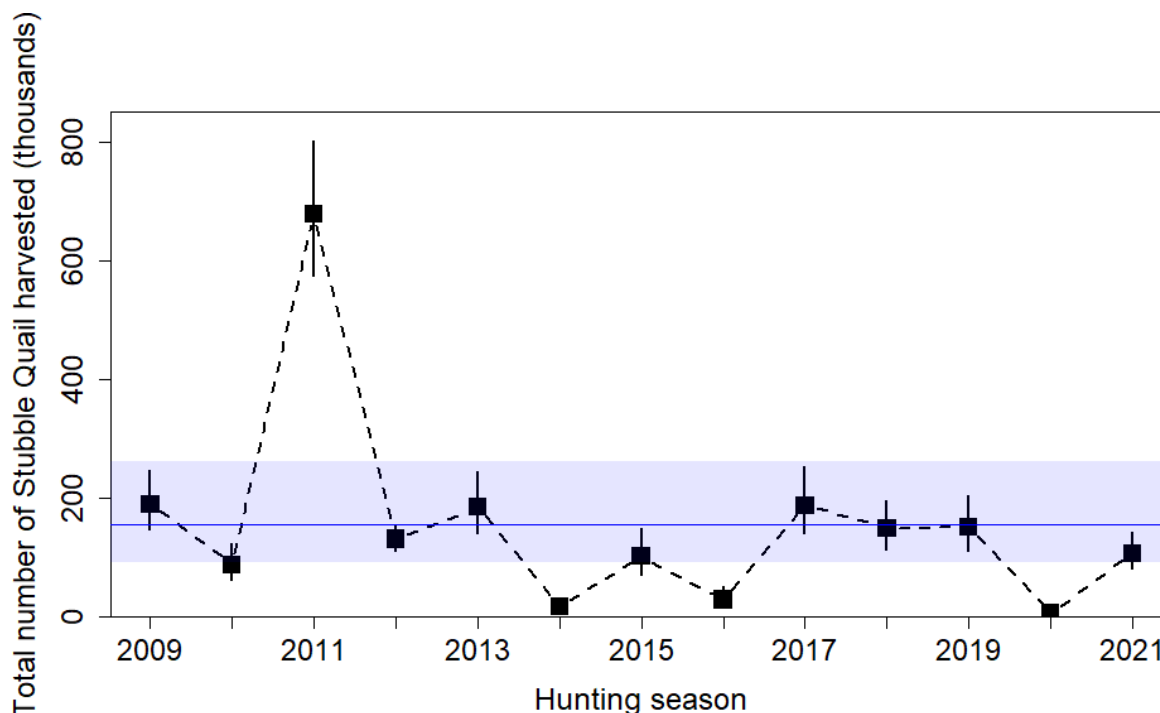
## 4.2 Stubble Quail

The total of 105,968 Stubble Quail estimated to have been harvested in Victoria during the 2021 season (95% CI = 79,297–141,609) was lower than the average harvest since the telephone surveys began in 2009 (Figure 4.2 and Table 4.2).

The estimated numbers of total hunting days (16,381 days) and Stubble Quail harvested per licence holder (3.7 quail, Table A6.1) were marginally lower than historical levels (20,192 and 5.8, respectively, Table 4.2). Hunter efficiency (6.5 Stubble Quail per hunting day, Table 4.2) was slightly below the average from 2009 to 2021 (7.55 quail per hunting day, Table 4.2).

It was estimated that 6% (95% CI = 5%–8%) of Game Licence holders hunted for Stubble

Quail during the 2021 season. That equates to an estimate of 1785 (95% CI = 1309–2433) active Stubble Quail hunters in the 2021 season. This estimate is lower than the June estimate, which could be due to sampling error or may be related to a difference in the number of self-identified Stubble Quail hunters in each survey. If it is the latter, then it could be addressed by asking the respondents in the end-of-season survey whether they identify as Stubble Quail hunters. The average Stubble Quail harvest per active Stubble Quail hunter in 2021 was estimated to be 59.4 quail (95% CI = 38.9–90.6) over 9.2 days (95% CI = 5.9–14.2). This estimate is greater than 2018 (13.7) and 2020 (5.1) estimates, while similar to 2017 (34.7) and 2019 (69.4) estimates, reflecting the volatility of the active hunter estimate.



**Figure 4.2: Estimates of total Stubble Quail harvests (in thousands) from 2009 to 2021.**

The squares are the estimated total harvests for each season; the solid vertical lines indicate the 95% confidence intervals; the blue line is the average Stubble Quail harvest from 2009 to 2021; the shaded area is the 95% confidence interval for the average Stubble Quail harvest from 2009 to 2021.

**Table 4.2: Comparison of Stubble Quail harvests of 2009 to 2021.**

Year	Total harvest	Hunting days	Quail per licence holder	Hunting days per licence holder	Quail per hunting day
2009	189,155	24,648	7.89	1.03	7.97
2010	86,302	24,739	3.59	1.03	3.48
2011	678,431	46,719	26.17	1.80	14.52
2012	129,711	22,262	4.80	0.82	5.81
2013	184,123	21,958	6.69	0.98	8.39
2014	16,243	10,852	0.56	0.38	1.47
2015	101,244	22,432	3.58	0.79	4.51
2016 <sup>22</sup>	28,043	6,559	1.00	0.23	4.29
2017	186,691	22,052	6.51	0.77	8.45
2018	148,500	17,772	5.19	0.62	8.36
2019	188,015	25,358	6.68	0.90	7.43
2020	4,848	3,771	0.18	0.14	1.29
2021	105,968	16,381	3.70	0.57	6.49
<b>Average</b>	<b>154,538</b>	<b>20,192</b>	<b>5.78</b>	<b>0.77</b>	<b>7.55</b>

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 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 2021, it was estimated that 38% (95% CI = 29–50%) 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 2021. This equates to an estimate of 10,565 (95% CI = 8,027–13,905) ‘Stubble Quail hunters’ in the 2021 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 2 hours and someone else who hunted for 12 hours were both recorded as having hunted for 1 day.

<sup>22</sup> 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 that year would only have produced minor differences.

### 4.3 Locations with the most hunting days

The top five towns for the total number of reported duck hunting days in 2021 were (in descending order) Sale, Bairnsdale, Ballarat, Horsham and Loch Sport.

The top five towns for the total number of reported Stubble Quail hunting days in 2021 were (in descending order) Sale, Bairnsdale, Ararat, Bendigo and St Arnaud.

Combining duck and Stubble Quail, Sale had the most hunting days during the 2021 hunting seasons, followed by Bairnsdale, Ararat, Bendigo and Horsham. 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.

### 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 [exceeding bag limit, or (conversely) not harvesting anything], memory recall (respondents not remembering their harvest), and deliberate over- or under-reporting (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% (Wright 1978; Barker 1991). It is likely, however, that the sampling strategy of the telephone interviews (after each 1-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 end-of-season surveys (Barker 1991; Barker et al. 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 important to note that the methodology explicitly accounts for the possibility that not every Game Licence holder hunts in every survey period (see Gormley and 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 limits) was due to two factors. First, there was variation in the reported numbers of animals harvested between respondents who had hunted (see Figure 3.1 and Figure 3.3). For example, within a given survey period for duck hunting, some respondents indicated that they hunted unsuccessfully, whereas others had undertaken multiple trips and reported 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 harvests 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 who 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.

## 4.5 Conclusions and implications

1. At various times during 2021, COVID-19 restrictions impeded the movement of hunters within Victoria. Some restrictions limited the ability of hunters to actively participate in hunting. The duck season was reduced in duration (only 3 weeks instead of the prescribed 12) and bag limit (only 5 ducks per day, down from the prescribed 10 ducks per day). It should be noted, however, that the limit was only 5 and 3 ducks per day in 2019 and 2020, respectively, due to ongoing drought conditions that reduced game duck abundance and habitat availability. The Stubble Quail seasonal arrangements remained unchanged from the regulations (i.e. 3 months in length and a 20-birds-per-day bag limit).
2. The COVID-19 restrictions reduced the ability of hunters to travel for hunting and likely played a central role in the following findings:
  - The proportion of active duck hunters was only 32%, down from 55% in 2018 and 2019, and the same as 2020, which was also affected by COVID-19 restrictions.
  - The proportion of active Stubble Quail hunters was 6%, down from 17% in 2018 and similar to the 8% in 2019 and 4% in 2020.
  - The number of ducks harvested, and the number of hunting days were the lowest recorded.
  - The number of Stubble Quail harvested, and the hunting days were below average.
3. The number of Game Licence holders endorsed to hunt Stubble Quail who do not hunt Stubble Quail is affecting the accuracy of the activity indices. Either the end-of-season survey needs to investigate whether the respondent is a Stubble Quail hunter or survey a greater number of Game Licence holders.
4. 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), so the estimates of total harvest must be interpreted with care.

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# Appendix 1

## Questionnaire for Game Licence holders endorsed to hunt ducks

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?	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 Private land Public land	State Game Reserve Private land Public land	State Game Reserve Private land Public land	State Game Reserve Private land Public land	State Game Reserve Private land Public land	State Game Reserve Private 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

### Additional method details

Common definitions used

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

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:

$$H_j = p_j L$$

e.g. 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:

$$SE(w_j) = \frac{SD(w_j)}{\sqrt{n_j}}. \text{ e.g. for Deer Survey 4 in 2015, we obtained: } \frac{4.55}{\sqrt{70}} = 0.54$$

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  $\geq 0$ . 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

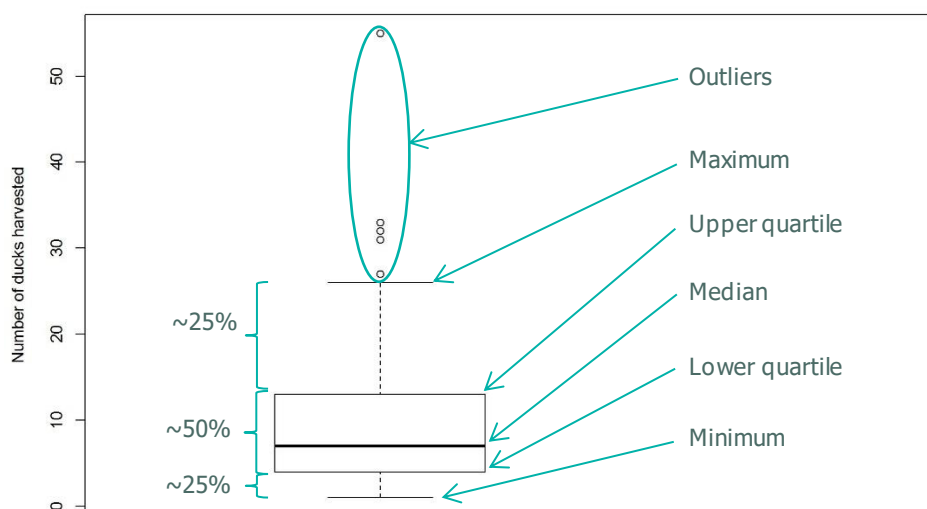
### Explanation of what goes into a boxplot

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, end-of-year surveys have been conducted and it has been possible to estimate the annual harvest rate per active hunter. This has meant that the rate per Game Licence holder is no longer required. It has been included in this appendix, however, to allow comparison with data for the years prior to 2017.

The total average season harvest per licence holder was estimated to be 2.2 birds (95% CI = 1.7–2.7; Table 5.1). Note that, for each survey period, the average duck harvest per Game Licence holder was lower than the average duck harvest per hunter (Table 3.3), 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 2021.**

Period	Average harvest <sup>23</sup>	SE	95% CI	
			Lower	Upper
26–30 May	0.92	0.14	0.68	1.26
31 May – 6 June	0.40	0.11	0.24	0.68
7–14 June	0.83	0.18	0.55	1.27
<b>Total</b>	<b>2.16</b>	<b>0.26</b>	<b>1.71</b>	<b>2.72</b>

Each Game Licence holder hunted an average of 0.8 days during the 2021 duck-hunting season (Table 5.2). When multiplied by the total number of Game Licence holders in each survey period, this equalled a total of 19,720 hunter days (95% CI = 15,702–24,767).

**Table A5.2: Days on which ducks were hunted per Game Licence holder for 2021.**

Period	Days hunted	SE	95% CI	
			Lower	Upper
26–30 May	0.32	0.04	0.25	0.40
31 May – 6 June	0.18	0.03	0.12	0.26
7–14 June	0.32	0.05	0.23	0.44
Total per licence holder	0.81	0.07	0.68	0.97
<b>Total hunting days</b>	<b>19,720</b>	<b>2,300</b>	<b>15,702</b>	<b>24,767</b>

<sup>23</sup> Average harvest per Game Licence holder = Ducks harvested divided by Respondents (Table 3.1).

## 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, end-of-year surveys have been conducted and it has been possible to estimate the annual harvest rate per active hunter. This has meant that the rate per Game Licence holder is no longer required. It has been included in this appendix, however, to allow comparison with data for the years prior to 2017.

The total average season harvest per licence holder was estimated to be 3.7 birds (95% CI = 2.8–5; Table 6.1). 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 11.6 birds (95% CI = 8.8–15.2; Table 6.1). 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 3.11), 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 2021.**

Period	Average harvest <sup>24</sup>	SE	95% CI	
			Lower	Upper
Opening weekend	0.74	0.20	0.44	1.26
April	1.28	0.42	0.69	2.38
May	0.50	0.17	0.27	0.94
June	1.18	0.25	0.78	1.79
<b>Total</b>	<b>3.70</b>	<b>0.55</b>	<b>2.77</b>	<b>4.95</b>

Each Game Licence holder hunted an average of 0.6 days during the 2021 Stubble Quail–hunting season (Table 6.2). When multiplied by the total number of Game Licence holders in each survey period, this equalled a total of 16,381 hunter days (95% CI = 11,963–22,429).

<sup>24</sup> Average harvest per hunter = Ducks harvested divided by Respondents who hunted (Table 1).



**Table A6.2: Days on which Stubble Quail were hunted per Game Licence holder for 2021.**

Period	Days hunted	SE	95% CI	
			Lower	Upper
Opening weekend	0.10	0.02	0.07	0.16
April	0.11	0.03	0.07	0.18
May	0.12	0.04	0.07	0.22
June	0.23	0.04	0.16	0.34
<b>Total per licence holder</b>	<b>0.57</b>	<b>0.07</b>	<b>0.45</b>	<b>0.72</b>
<b>Total hunting days</b>	<b>16,381</b>	<b>2,643</b>	<b>11,963</b>	<b>22,429</b>

