Estimates of harvest for duck and Stubble Quail in Victoria

Results from surveys of Victorian Game Licence holders in 2018

Game Management Authority

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Estimates of harvest for deer, duck and Stubble Quail in Victoria: results from surveys of Victorian game Licence holders in 2017

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Front cover photo: Male and Female Wood Ducks with many ducklings (Photograph: John Turnbull).

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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. This report focuses only on the duck and Stubble Quail harvests for 2018.

Aim

The aim of this report is to provide estimates of the total harvest of duck and Stubble Quail by Victorian hunters during the 2018 hunting seasons for each game type.

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.

Results

Each holder of a Victorian Game Licence endorsed for duck hunted on approximately 3.6 days during the 2018 duck hunting season, and there was an average season harvest of 15.7 ducks per Game Licence holder. Based on the total number of Game Licence holders, this equates to an estimated 396,708 ducks harvested during the 2018 duck hunting season in Victoria [95% confidence interval (CI) = 337,186 – 466,738]. The three most commonly harvested species were Pacific Black Duck (*Anas superciliosa*) (which comprised 33% of the total harvest), Grey Teal (*Anas gracilis*) (31%) and Australian Wood Duck (*Chenonetta jubata*) (23%). The remaining ducks harvested were Chestnut Teal (*Anas castanea*) (7%), Pink-eared Duck (M*alacorhynchus membranaceus*) (3%), Mountain Duck (*Tadorna tadornoides*) (2%) and Hardhead (*Aythya australis*) (1%). Blue-winged Shoveler (*Anas rhynchotis*) were prohibited from being hunted in 2018. However, in the survey, one hunter reported harvesting two Blue-winged Shovelers.

Every Game Licence holder endorsed for duck automatically receives an endorsement for Stubble Quail as an artefact. Therefore, the majority of Game Licence holders which have an endorsement to hunt Stubble Quail, have it as an artefact without ever intending on hunting Stubble Quail. Only 37% of holders of a Game Licence endorsed for Stubble Quail (*Coturnix pectoralis*) stated that they hunt Stubble Quail. Each of those self-identified Stubble Quail hunters hunted on an average of approximately 1.6 days during the 2018 Stubble Quail hunting season and had an average season harvest of 13.6 Stubble Quail. Using the total number of Game Licence holders endorsed to hunt Stubble Quail, this yields an estimate of 148,500 Stubble Quail being harvested during the 2018 Stubble Quail hunting season in Victoria (95% CI = 113,252–194,719).

Conclusions and implications

The total number of hunter days during the 2018 duck hunting season was estimated to be 91,570 (95% CI = 77,727–107,878); for Stubble Quail, the total number of hunter days was estimated to be 17,772 (95% CI = 12,922–24,443).

The approach used here explicitly accounts for the possibility that not every holder of a Game Licence will hunt during every survey period. The total number of Game Licence holders who hunted (‘active hunters’) was estimated for each survey period and combined with the harvest per active hunter to derive the total harvest for each survey period.

The methodology of performing telephone surveys throughout the season is likely to minimise memory bias and non-response bias compared with the earlier end-of-year postal surveys. However, sources of bias will remain (due to over- and under-reporting), and the estimates of total harvest must be interpreted with care.

Note: Numbers within the text have been rounded.

1. Introduction

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. This report focuses only on the duck and Stubble Quail harvests for 2018.

The 2018 duck hunting season lasted 12 weeks, from 17 March to 11 June (Game Management Authority 2018). Seven species could legally be hunted in 2018: Pacific Black Duck (*Anas superciliosa*), Australian Wood Duck (*Chenonetta jubata*), Mountain Duck (*Tadorna tadornoides*), Grey Teal (*Anas gracilis*), Chestnut Teal (*Anas castanea*), Pink-eared Duck (*Malacorhynchus membranaceus*) and Hardhead (*Aythya australis*). Blue-winged Shoveller, a declared game species (*Anas rhynchotis)*, was prohibited from hunting for the 2018 season. The bag limit for the 2018 season was 10 game ducks per hunter per day.

The 2018 duck hunting survey used the same methods (i.e. telephone surveys) as those followed during the 2005, 2006 and 2009–2017 duck hunting seasons (Barker 2006; Gormley and Turnbull 2009, 2010, 2011; Moloney and Turnbull 2012, 2013, 2014, 2015, 2016, 2017).

The 2018 Stubble Quail (*Coturnix pectoralis*) hunting season lasted 12 weeks, from 7 April to 30 June (Game Management Authority 2018). The daily bag limit for the 2018 season was 20 Stubble Quail per hunter.

The 2018 Stubble Quail hunting survey used the same methods (i.e. telephone surveys) as those followed during the 2009–2015, and 2017 Stubble Quail hunting seasons (Gormley 2009; Gormley and Turnbull 2009; 2010; 2011; Moloney and Turnbull 2012; 2013; 2014; 2015; 2017). Due to a clerical error, the 2016 Stubble Quail hunting survey used a slightly different method (Moloney and Turnbull 2016).

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. Hardhead is also referred to as White-eyed Duck.
4. 4. Blue-winged Shoveler is also referred to as Australasian Shoveler.

2. Methods

General methodology

Slightly different methodology was used for estimating the 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. Estimates of total harvest by Game Licence holders were based on the hunting activities reported by the survey respondents.

For duck, surveys were performed for the opening weekend and then every fortnight thereafter throughout the 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 [4] 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 Game Licence holders was surveyed immediately after the conclusion of the duck hunting season. The numbers of active duck hunters was estimated using the responses to the survey question in the final survey asking whether they had hunted at any stage of the 2018 duck season.

The survey responses were used to generate estimates of the harvest for the whole population of Game Licence holders for each game type. Estimates of harvests 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 the respondents who actively hunted was used as an estimate of the proportion of Game Licence holders who actively 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 licensed hunters for that survey period.

For each survey period, the average harvest per hunter [5] 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 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 sums for the corresponding Victorian Catchment Management Authority (CMA) region.

There were differences in the number and length of 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 1. Information describing and interpreting boxplots is provided in Appendix 2.

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

5. 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.

Duck

Samples were drawn from hunters who held a Game Licence endorsed to hunt ducks during the 2018 season. A random sample of 200 licence holders was interviewed by telephone immediately after opening weekend (Duck Survey 1). This was followed by surveys of independent random samples of licence holders, conducted at two-week intervals for the remainder of the duck season (Duck Surveys 2–7). Respondents were 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 if they had hunted at any stage during the season.

Stubble Quail

Samples were drawn from hunters who held a Game Licence endorsed to hunt Stubble Quail during the 2018 season. A random sample of 300 licence holders was interviewed by telephone immediately after the opening weekend (Survey 1), in April excluding opening weekend (Survey 2), in May (Survey 3) and in June (Survey 4). Respondents were asked to report the number of Stubble Quail harvested, the type of grassland where hunting occurred (native, stubble or introduced) and whether dogs were used.

When Game Licence holders are endorsed for duck, they are automatically endorsed for Stubble Quail. However, you 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-identified Stubble Quail hunters . In the 2018 Stubble Quail hunter survey, all respondents were asked whether they hunt quail, even if they did not necessarily hunt Stubble Quail during the 2018 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

Duck

Summary of responses for duck surveys in 2018

The number of Game Licence holders endorsed to hunt ducks remained relatively constant throughout the season, increasing from 24,883 at opening weekend to 25,799 at the end of the season (Table 1). To achieve the required sample size of respondents, slightly more than 200 licence holders were contacted each survey; an average of 98% of those contacted were willing to take part.

Table 1

Duck Survey	Period	Licence holders	Respondents	Respondents who hunted	Days hunted*	Ducks harvested**
1	17–18 Mar	24,883	200	72	95	455
2	19 Mar – 1 Apr	24,883	200	41	134	468
3	2–15 Apr	25,313	200	39	100	446
4	16–29 Apr	25,313	200	48	111	467
5	30 Apr – 13 May	25,673	200	48	108	480
6	14–27 May	25,673	200	39	101	473
7	28 May – 11 Jun	25,799	200	35	74	341

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

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

Proportion and corresponding total number of duck licence holders who hunted in each survey period in 2018

The proportion of duck Game Licence holders who hunted in each survey period varied throughout the season. During opening weekend, 36% of licence holders hunted, corresponding to approximately 8,958 hunters (Table 2). The proportion who hunted during other survey periods was a maximum of 24%, corresponding to approximately 6,162 duck hunters (Table 2).

Table 2

Period	Proportion	SE	95%CI		Total hunters	SE	95%CI	
			Lower	Upper			Lower	Upper
17–18 Mar	0.36	0.034	0.30	0.43	8,958	845	7,450	10,772
19 Mar – 1 Apr	0.20	0.029	0.16	0.27	5,101	710	3,888	6,693
2–15 Apr	0.20	0.028	0.15	0.26	4,936	709	3,730	6,532
16–29 Apr	0.24	0.030	0.19	0.31	6,075	764	4,752	7,767
30 Apr – 13 May	0.24	0.030	0.19	0.31	6,162	775	4,819	7,877
14–27 May	0.20	0.028	0.15	0.26	5,006	719	3,783	6,625
28 May – 11 Jun	0.18	0.027	0.13	0.24	4,515	693	3,347	6,089

Average harvest of ducks per hunter (Game Licence holders who hunted) for each survey period in 2018

Within each survey period, there was large variation in the reported harvest of ducks per hunter (i.e. per Game Licence holder who hunted). Some hunters harvested more than 30 ducks in a survey period, whereas others did not harvest any ducks (Figure 1). The average number of ducks per hunter varied throughout the season (Table 3). The average harvest per hunter was 6.3 ducks on opening weekend, and this was smaller than the average harvest per hunter in any other survey period. The greatest average harvest per hunter was 12.2 ducks (in the sixth survey period).

Table 3

Period	Average harvest per hunter*	SE	95%CI	
			Lower	Upper
17–18 Mar	6.32	0.62	5.21	7.66
19 Mar – 1 Apr	11.41	2.11	7.97	16.35
2–15 Apr	11.44	1.78	8.44	15.50
16–29 Apr	9.73	1.23	7.61	12.44
30 Apr – 13 May	10.00	1.37	7.66	13.06
14–27 May	12.13	2.11	8.64	17.03
28 May – 11 Jun	9.74	3.23	5.17	18.35

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

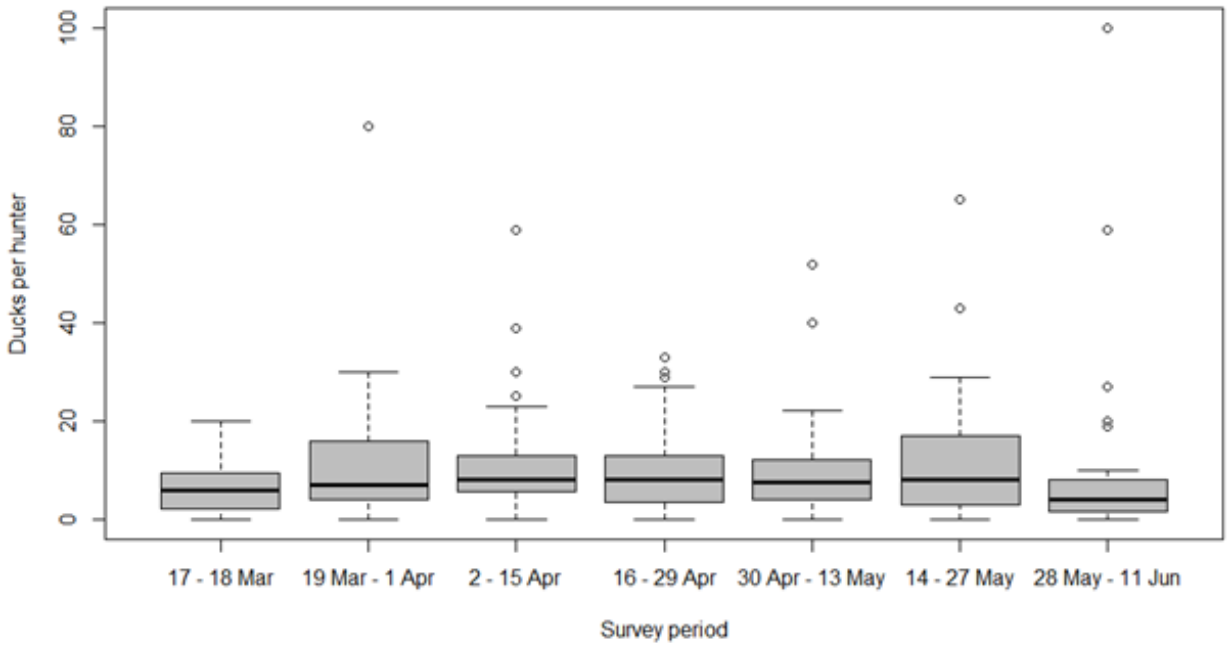

Figure 1: Boxplot of the number of ducks reported harvested by individual hunters for each survey period in 2018. The bottom and top of each 'box' indicate the 25th and 75th percentiles, respectively, with the black horizontal line indicating the median (50th percentile) reported value.

Estimates of the duck harvest in Victoria in 2018 by holders of a Game Licence endorsed for duck

There were an estimated 56,609 duck harvested during opening weekend (95% CI = 43,365–73,898), which constituted 14% of the total seasonal harvest (Table 4). The harvest throughout the remainder of the season varied between surveys, with fortnightly estimates ranging from 43,987 to 61,615 ducks harvested. The total season harvest estimate was 396,708 (95% CI = 337,186–466,738; Table 4).

Table 4

Period	Total harvest*	SE	95%CI	
			Lower	Upper
17–18 Mar	56,609	7,733	43,365	73,898
19 Mar – 1 Apr	58,226	13,563	37,106	91,367
2–15 Apr	56,448	12,036	37,339	85,336
16–29 Apr	59,106	10,571	41,744	83,689
30 Apr – 13 May	61,615	11,497	42,876	88,545
14–27 May	60,717	13,801	39,107	94,267
28 May – 11 Jun	43,987	16,229	21,839	88,596
Total	**396,708**	**32,961**	**337,186**	**466,738**

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

Estimated average harvest of ducks per Game Licence holder in each survey period in 2018

The total average season harvest per licence holder was estimated to be 15.7 birds (95% CI = 13.3–18.4; Table 5). 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 5

Period	Average harvest*	SE	95%CI	
			Lower	Upper
17–18 Mar	2.27	0.31	1.74	2.97
19 Mar – 1 Apr	2.34	0.55	1.49	3.67
2–15 Apr	2.23	0.48	1.48	3.37
16–29 Apr	2.34	0.42	1.65	3.31
30 Apr – 13 May	2.40	0.45	1.67	3.45
14–27 May	2.37	0.54	1.52	3.67
28 May – 11 Jun	1.70	0.63	0.85	3.43
Total	**15.65**	**1.30**	**13.31**	**18.40**

* Average harvest per Game Licence holder = Ducks harvested divided by Respondents (Table 1).

Reported numbers of ducks harvested by hunters, proportions of the total harvest, and estimates of total 2018 harvest for each duck species

Using a telephone survey immediately after the 2018 duck season ended, it was estimated that 55% (95% CI = 50–60%) of Game Licence holders actually hunted for ducks during the 2018 duck season. That equates to an estimate of 14,125 (95% CI = 12,922–15,440) active duck hunters in the 2018 duck season. The average duck harvest per active duck hunter was estimated to be 28.1 (95% CI = 23.3–33.8).

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 were Pacific Black Duck, comprising 33% of the total reported harvest, followed by Grey Teal (31%) and Australian Wood Duck (23%). The remaining four species comprised 13% of the total harvest. It should be noted that one respondent reported harvesting two Blue-winged Shoveler, which is a game species that was not permitted to be harvested in 2018. These two birds were excluded from the analysis.

Table 6

Species	Reported harvest	Proportion of harvest	SE	Estimated harvest	SE	95%CI	
						Lower	Upper
Australian Wood Duck	705	0.23	0.007	89,355	7,947	50,426	158,338
Chestnut Teal	214	0.07	0.005	27,123	2,866	14,574	50,480
Grey Teal	970	0.31	0.008	122,942	10,663	69,857	216,368
Hardhead	38	0.01	0.002	4,816	872	2,165	10,716
Mountain Duck	55	0.02	0.002	6,971	1,095	3,297	14,738
Pacific Black Duck	1,048	0.33	0.008	132,829	11,462	75,579	233,442
Pink-eared Duck	100	0.03	0.003	12,674	1,628	6,413	25,050
Pink-eared Duck	159	0.05	0.004	20,080	2,428	10,355	38,938

Days on which ducks were hunted per Game Licence holder for 2018

Each Game Licence holder hunted an average of 3.6 days during the 2018 duck hunting season (Table 7). When multiplied by the total number of Game Licence holders during each survey period, this yielded a total of 91,570 hunter days (95% CI = 77,651–107,984).

Table 7

Period	Days hunted	SE	95%CI	
			Lower	Upper
17–18 Mar	0.48	0.05	0.39	0.58
19 Mar – 1 Apr	0.67	0.13	0.46	0.97
2–15 Apr	0.50	0.09	0.35	0.71
16–29 Apr	0.56	0.08	0.42	0.74
30 Apr – 13 May	0.54	0.09	0.39	0.74
14–27 May	0.50	0.09	0.36	0.72
28 May – 11 Jun	0.37	0.09	0.23	0.60
Total per licence holder	**3.62**	**0.24**	**3.17**	**4.12**
Total hunting days	**91,570**	**7,617**	**77,651**	**107,984**

Percentage of days hunted and associated duck harvest by land tenure in 2018

Greater duck hunting effort was expended on private land (50.1%) than on Public land (46.5%), and similar proportions of ducks were harvested solely on private land (52.5%) and on Public land (43.6%) (Table 8).

Table 8

Land tenure	Days (%)	Duck harvest (%)
Private land only	50.1	52.4
Public land only	46.5	43.6
Both	3.5	4.0
Total	**100.0**	**100.0**

Estimates of total duck harvest in 2018 by CMA region

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

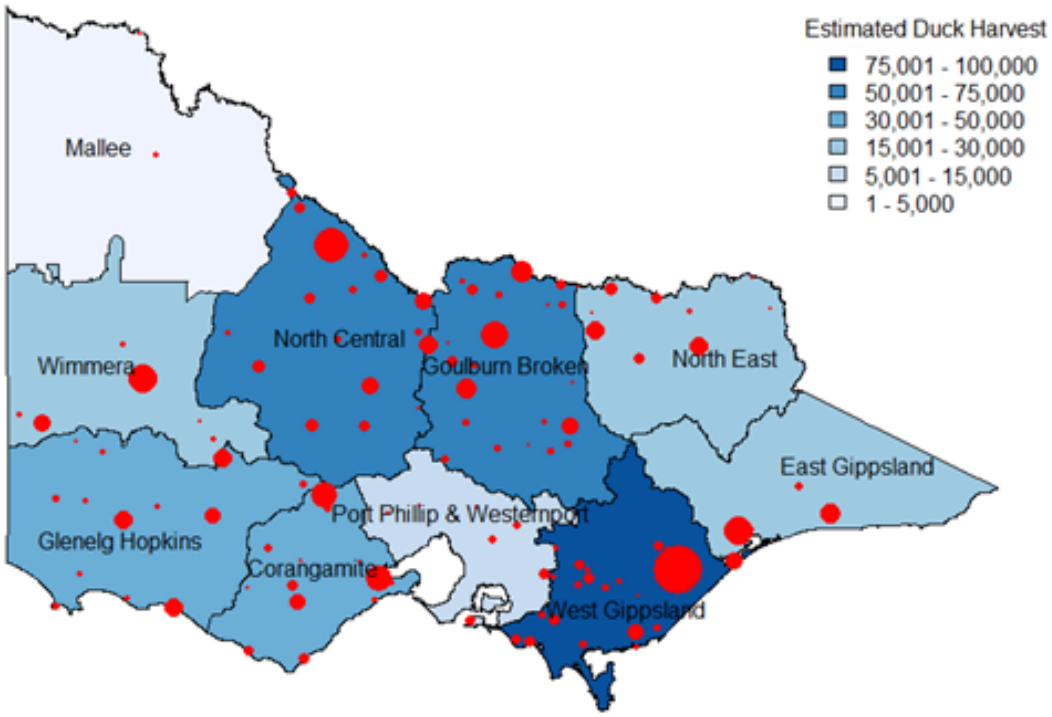

Figure 2: Red circles indicate the nearest town to harvest locations, with symbol size proportional to reported harvest.

Stubble Quail

Summary of responses for Stubble Quail surveys in 2018

The number of Game Licence holders endorsed to hunt Stubble Quail remained relatively constant throughout the season, increasing from 28,290 at opening weekend to 28,932 at the end of the season (Table 9). To achieve the required sample size of respondents, slightly more than 300 licence holders were contacted each survey; an average of 99.4% of those contacted were willing to take part.

Table 9

Stubble Quail survey	Period	Licence holders	Respondents	Quail hunters*	Respondents who hunted	Days hunted**	Stubble Quail harvested***
1	Opening weekend	28,290	298	103	11	13	117
2	April (after opening weekend)	28,290	300	110	22	47	452
3	May	28,720	300	113	31	64	453
4	June	28,932	300	122	24	62	533

* Respondents who self-report as Stubble Quail hunters.

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

*** Stubble Quail harvested indicates total number of Stubble Quail harvested by respondents.

Proportion and corresponding total number of Stubble Quail licence holders who hunted in each survey period in 2018

The proportion of Game Licence holders endorsed to hunt Stubble Quail who hunted in each survey period varied throughout the season. During opening weekend, 5% of licence holders hunted, corresponding to approximately 1,396 hunters (Table 10). The proportion who hunted during other survey periods was up to 10% (Table 10).

Table 10

Period	Proportion	SE	95%CI		Total hunters	SE	95%CI	
			Lower	Upper			Lower	Upper
Opening weekend	0.11	0.030	0.06	0.18	1,044	298	604	1,806
April (after opening weekend)	0.20	0.038	0.14	0.29	2,075	396	1,432	3,005
May	0.27	0.042	0.20	0.37	2,968	454	2,203	3,999
June	0.20	0.036	0.14	0.28	2,315	423	1,622	3,303

Average harvest of Stubble Quail per hunter (Game Licence holders who hunted) for each survey period in 2018

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 40 Stubble Quail in a survey period, whereas others did not harvest any Stubble Quail (Figure 3). The average number of Stubble Quail per hunter varied throughout the season (Table 11). The average harvest per hunter was 10.6 Stubble Quail on opening weekend, which was less than the average harvest per hunter for any other survey period. The largest average harvest per hunter was 22.2 Stubble Quail (in June).

Table 11

Period	Average harvest per hunter*	SE	95%CI	
			Lower	Upper
Opening weekend	10.64	4.05	5.17	21.88
April	20.55	3.32	14.99	28.16
May	14.61	1.98	11.22	19.04
June	22.21	4.67	14.77	33.39

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

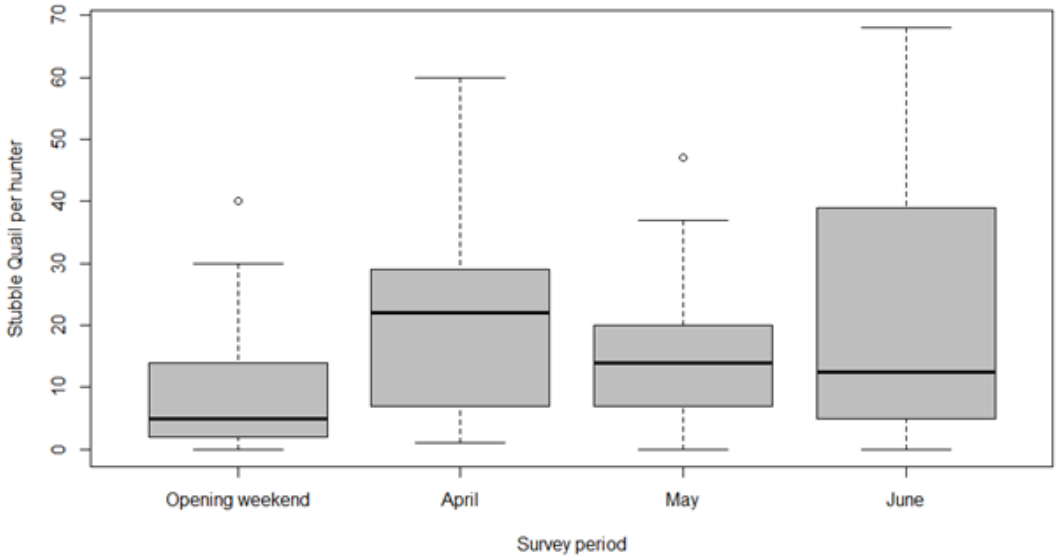

Figure 3: Boxplot of the number of Stubble Quail reported harvested by individual hunters for each survey period in 2018. The bottom and top of each 'box' indicates the 25th and 75th percentiles, respectively, with the black horizontal line indicating the median reported value.

Estimates of the total Stubble Quail harvest in Victoria in 2017 by holders of a Game Licence endorsed for Stubble Quail

There were an estimated 148,500 Stubble Quail harvested by all holders of a Game Licence for Stubble Quail during the 2018 Stubble Quail season (95% CI = 113,252–194,719). The opening weekend Stubble Quail harvest per hunter was approximately a quarter of that of the other periods. Including the opening weekend, the April harvest total was greater than the May and June harvest totals (Table 12).

Table 12

Period	Total harvest*	SE	95%CI	
			Lower	Upper
Opening weekend	11,107	5,283	4,584	26,915
April (after opening weekend)	42,624	10,660	26,301	69,076
May	43,367	8,865	29,170	64,474
June	51,403	14,332	30,066	87,880
Total	**148,500**	**20,629**	**113,252**	**194,719**

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

Estimates of average harvest of Stubble Quail per Game Licence holder and per self-identified Stubble Quail hunter in each survey period in 2018

The total average season harvest per licence holder was estimated to be 6.5 Stubble Quail (95% CI = 4.8–8.8; Table 13). 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 13

Period	Average harvest*	SE	95%CI		Harvest per Stubble Quail hunter **	SE	95%CI	
			Lower	Upper			Lower	Upper
Opening weekend	0.39	0.19	0.16	0.95	1.14	0.54	0.47	2.75
April (after opening weekend)	1.51	0.38	0.93	2.44	4.11	1.03	2.54	6.66
May	1.51	0.31	1.02	2.24	4.01	0.82	2.70	5.96
June	1.78	0.50	1.04	3.04	4.37	1.22	2.56	7.47
Total	**5.19**	**0.72**	**3.96**	**6.80**	**13.62**	**1.87**	**10.42**	**17.81**

* Average harvest per Game Licence holder = Stubble Quail harvested divided by Respondents (Table 9).

** Average harvest per self-reported Stubble Quail hunter = Stubble Quail harvested divided by respondents who were self-identified Stubble Quail hunters (Table 9).

Days on which Stubble Quail were hunted per Game Licence holder for 2018

Each self-identified Stubble Quail hunter averaged 1.6 days of hunting during the 2018 Stubble Quail hunting season, whereas Game Licence holders hunted an average of 0.6 days (Table 14). When multiplied by the total number of Game Licence holders in each survey period, this yielded a total of 17,772 hunter days (95% CI = 12,922–24,443).

Table 14

Period	Days hunted	SE	95%CI	
			Lower	Upper
Opening weekend	0.13	0.04	0.07	0.23
April (after opening weekend	0.43	0.09	0.29	0.64
May	0.57	0.11	0.39	0.83
June	0.51	0.15	0.29	0.89
Total per self-identified Stubble Quail hunter	1.63	0.21	1.27	2.10
Total per licence holder	0.62	0.13	0.41	0.93
Total hunting days	**17,772**	**2,909**	**12,922**	**24,443**

Percentage of days hunted and associated Stubble Quail harvest by land tenure and gundog usage in 2018

Most Stubble Quail hunting was conducted on private land (91.9% of the hunting days and 92.7% of the harvested Stubble Quail) (Table 15). A very small proportion of hunting was conducted in State Game Reserves (5.9% of days and 7.2% of the harvested Stubble Quail), and less than 1% of active hunters reported hunting on both private land and State Game Reserves during the same hunting trip. The percentage of Stubble Quail hunting days on which dogs were used (80.1%) was similar to the percentage of Stubble Quail harvested using dogs (86.3%, Table 15).

Table 15

Land tenure	Days (%)			Stubble Quail harvest (%)		
	No gundogs	Gundogs used	Total	No gundogs	Gundogs used	Total
Private land only	17.7	74.2	91.9	11.6	81.2	92.7
State Game Reserves only	2.2	3.8	5.9	2.1	5.1	7.2
Both	0.0	2.2	2.2	0.0	0.1	0.1
Total	**19.9**	**80.1**	**100.0**	**13.7**	**86.3**	**100.0**

Percentage of hunting days and associated Stubble Quail harvest per grassland type in 2018

More Stubble Quail hunting and Stubble Quail harvesting took place on stubble (55.9% and 57.5%, respectively) than on other individual grassland types or combinations of grasslands (Table 16).

Table 16

Grassland	Days hunted (%)	Stubble Quail harvest (%)
Introduced grass	8	9
Native and introduced grass	1	1
Native grass	23	20
Stubble	60	58
Stubble and introduced grass	5	6
Stubble and native grass	7.0	7.0
Total	**100**	**100**

Estimates of total Stubble Quail harvest in 2018 by CMA region

Total harvest was estimated to be greatest in the Corangamite CMA region, followed by the North Central CMA region and the Goulburn Broken CMA region (Figure 4). The five towns with the highest total reported number of Stubble Quail harvested were (in descending order) Bendigo, Shepparton, Ballarat, Colac and Geelong. The five towns with the highest total number of reported Stubble Quail hunting days were (in descending order) Shepparton, Bendigo, Horsham, Ballarat and Geelong.

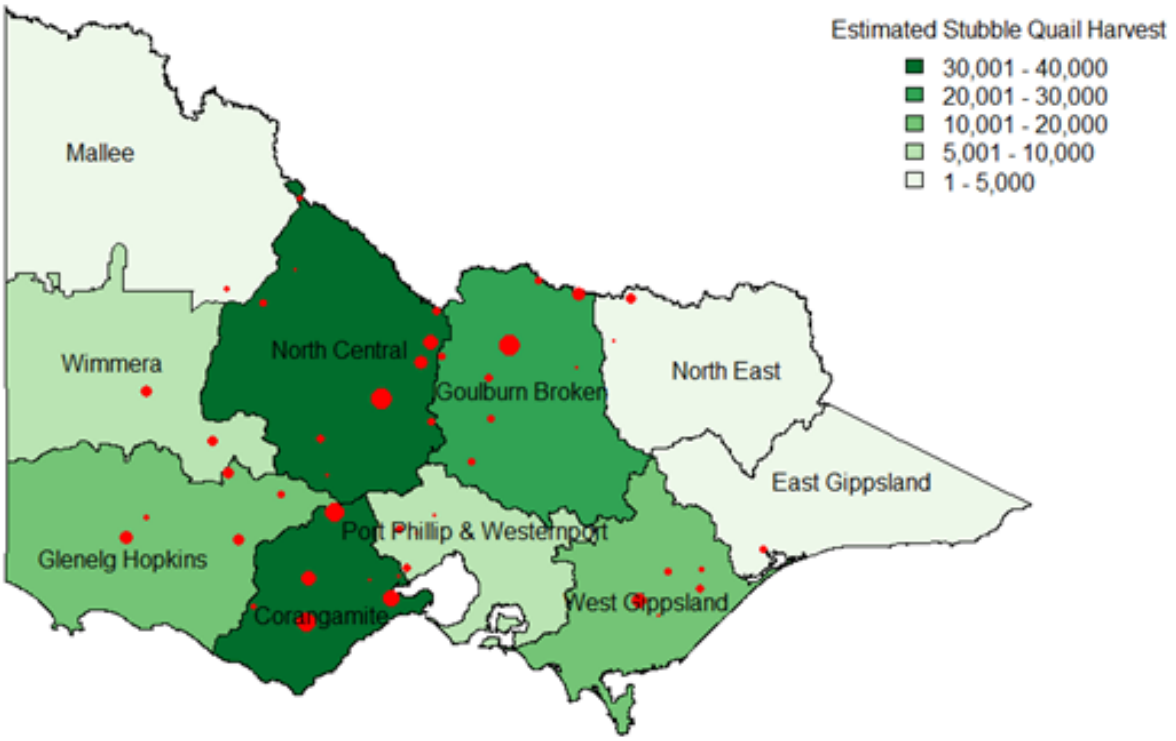

Figure 4: Red circles indicate the nearest town to harvest locations, with symbol size proportional to reported harvest.

4. Discussion

Duck

A total of 396,708 ducks were estimated to have been harvested in Victoria during the 2018 season (95% CI = 337,186–466,738), which was on par with average estimated harvests from 2009 to 2018 of 387,000 (Table 17 and Figure 5). The estimated harvest of most duck species available for harvest in 2018 were within 20% of their average estimated harvest since 2009. Only Hardhead (49% lower than average) was more than 20% off the average harvest since 2009.

The estimated numbers of total hunting days and ducks per licence holder were similar to historical figures. Hunter efficiency (ducks per hunting day) was slightly (9%) higher in 2018 than the average from 2009 to 2018 (Table 17).

It was estimated that 55% (95% CI = 50–60%) of Game Licence holders hunted for ducks during the 2018 duck season. That equates to an estimate of 14,125 (95% CI = 12,922–15,440) active duck hunters in the 2018 duck season. The average duck harvest per active duck hunter was estimated to be 28.1 (95% CI = 23.4–33.8).

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

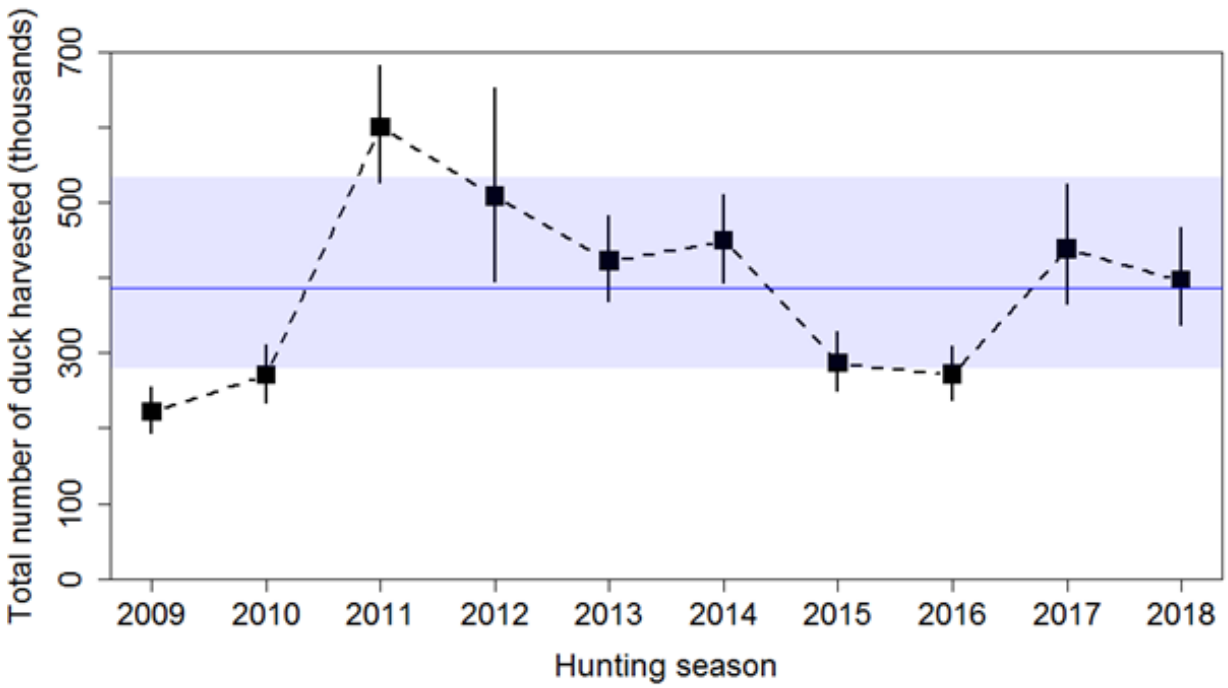

Figure 5: Estimated total duck harvests (in thousands) from 2009 to 2018. The square is the estimated total harvest for each season; the solid vertical line indicates the 95% confidence interval for each year's harvest; the blue line is the average duck harvest from 2009 to 2017; the shaded area is the 95% confidence interval for the average duck harvest from 2009 to 2017.

Table 17. Comparison of duck harvests of 2009 to 2018.

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
Average	**110,280**	**3,191**	**24,883**	**108,660**	**9,369**	**6,898**	**111,226**	**14,301**	**386,685**	**96,564**	**16.05**	**4.04**	**3.97**

NA: Years where a species was not available to hunt, and no ducks of that species were reported.

Stubble Quail

The total of 148,500 Stubble Quail estimated to have been harvested in Victoria during the 2018 season (95% CI = 113,252–194,719) is consistent with the average estimated harvest from 2009 to 2018 (Figure 6 and Table 18).

It is estimated that 37% (95% CI = 35–40%) of Game Licence holders endorsed for Stubble Quail self-identified as 'Stubble Quail hunters' during the 2018 Stubble Quail season. That includes those who did not actively hunt Stubble Quail in 2018. This equates to an estimate of 10,819 (95% CI = 10,055–11,641) 'Stubble Quail hunters' in the 2018 Stubble Quail season The proportion of the 'Stubble Quail hunters' who were active in the 2018 Stubble Quail season was 47% (95% CI = 34–65%).

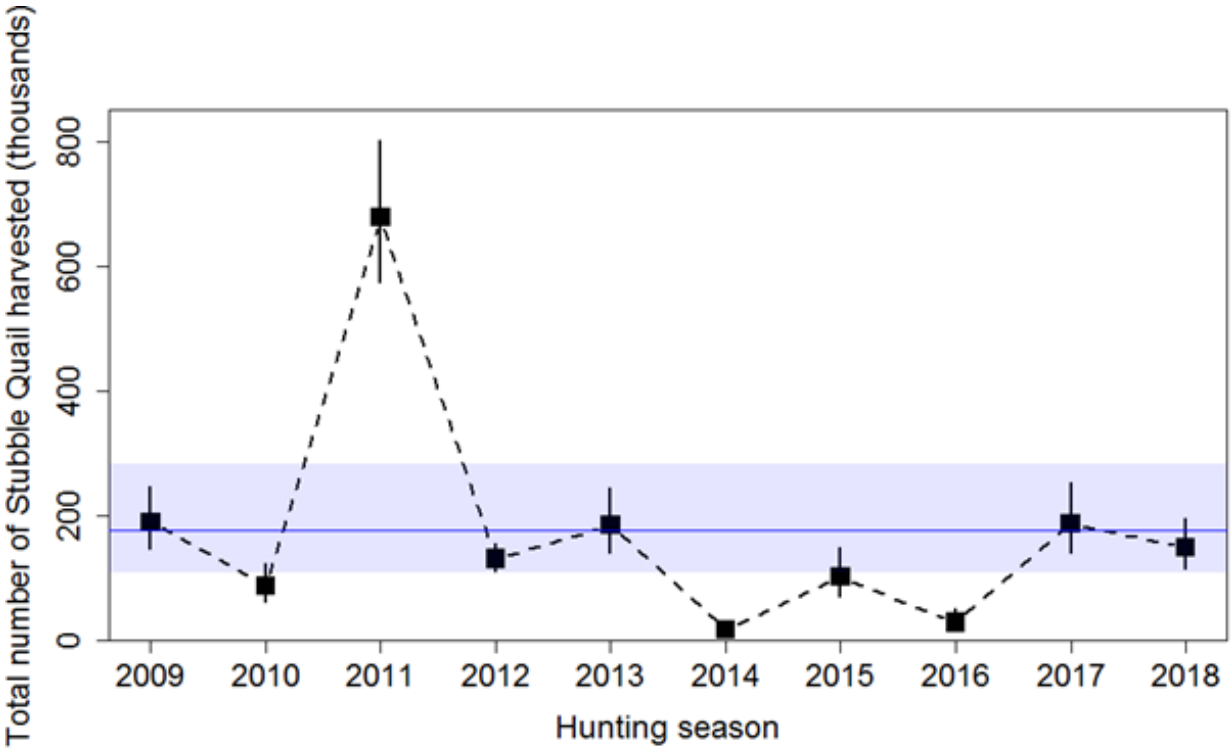

Figure 6: Estimated total Stubble Quail harvests (in thousands) from 2009 to 2018. The square is the estimate for each season; the solid line indicates the 95% confidence interval; the blue line is the average Stubble Quail harvest from 2009 to 2017; the shaded area is the 95% confidence interval for the average Stubble Quail harvest from 2009 to 2017.

Table 18. Comparison of Stubble Quail harvests of 2009 to 2017.

Year	Total harvest	Hunting days	Stubble Quail per licence holder	Hunting days per licence holder	Stubble 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	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
Average	**174,844**	**21,999**	**6.60**	**0.85**	**7.80**

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. This does not affect the estimates of the 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 the total effort: a hunter who hunted for two hours and another hunter who hunted for 12 hours were both recorded as having hunted for one day.

Locations with the most hunting days

The five towns with the highest total numbers of reported duck hunting days in 2018 were (in descending order) Sale, Kerang, Horsham, Shepparton and Geelong.

The five towns with the highest total numbers of reported Stubble Quail hunting days in 2018 were (in descending order) Shepparton, Bendigo, Horsham, Ballarat and Geelong.

Combining duck and Stubble Quail, Sale had the most hunting days during the 2018 hunting seasons, followed by Shepparton, Horsham, Kerang and Geelong. The assumption was made 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 the different game species.

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% (Wright 1978; Barker 1991). It is likely, however, that the sampling strategy of telephone interviews after each two-week period in the case of duck hunting, 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 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. This means that the results of the 2016 telephone Stubble Quail survey may have increased memory bias and may not be strictly comparable with the results 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 the total season bag per Game Licence holder was obtained from the sum of the ‘harvest per Game Licence holder’, not the sum of the ‘harvest per hunter’.

The uncertainty in the estimates of the total harvests (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 harvests should also be interpreted with caution. Grouping the harvest for a relatively large region (i.e. a 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 in 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 from the hunting location.

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Appendix A: Additional method details

Common definitions used

SD = standard deviation of the data. Represents the variation in the numbers reported.

SE = standard error of the mean. Represents the variation in the estimated mean.

CV = coefficient of variation. Calculated as: CV = SE ÷ 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 Duck Survey 3, we obtained: $\frac{34}{200} = 0.170$.

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 Duck Survey 3, we obtained: $0.17 \times 25418 = 4{,}321$.

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 Duck Survey 3, we obtained: $\frac{290}{34} = 8.53$.

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 Duck Survey 3, we obtained: $8.53 \times 4{,}321 = 36{,}856$.

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 Duck Survey 3, we obtained: $\sqrt{\frac{0.17 \times 0.83}{200}} = 0.027$.

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

$\mathrm{SE}(w_j) = \frac{\mathrm{SD}(w_j)}{\sqrt{h_j}}$, e.g. for Duck Survey 3, we obtained: $\frac{9.196}{\sqrt{34}} = 1.58$.

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

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

$$\mathrm{CV}(W_j) = \sqrt{\left(\mathrm{CV}(w_j)\right)^2 + \left(\mathrm{CV}(p_j)\right)^2}$$

$$\mathrm{SE}(W_j) = \mathrm{CV}\left(W_j\right) \times W_j .$$

The standard error of the total harvest was calculated by:

$$\mathrm{SE}(W_{TOT}) = \sqrt{\left(\mathrm{SE}(W_1)\right)^2 + \left(\mathrm{SE}(W_2)\right)^2 + \cdots + \left(\mathrm{SE}(W_7)\right)^2} .$$

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 cannot be reported as the estimate plus or minus a fixed value. In general, for some estimates denoted as $\hat{\mathrm{X}}$, 95% confidence interval limits were calculated using:

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

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

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

e.g. for the total duck harvest we have

$$CV = \frac{20{,}286}{286{,}729} = 0.071$$

$$r = \exp\left(1.96\sqrt{\ln\left(1 + 0.071^2\right)}\right) = 1.15 .$$

Therefore, Upper and Lower Confidence Intervals are given by:

$$UL = 286{,}729 \times 1.15 = 329{,}321$$

$$LL = 286{,}729 \div 1.15 = 249{,}645.$$

Appendix B: Boxplot explanation

A boxplot is a way of displaying key points of the data and is especially good for comparing groups of data. They are sometimes referred to as box-and-whisker plots. 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 or 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. Formally, an outlier is any point that is either below Q1 – 1.5 × IQR or above Q3 + 1.5 × 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: 25% of the data are in each whisker and between the edge of the box and the median line. Approximately half the data are contained within the box. Any unusual data are highlighted as outliers. As an example, Figure B1 shows a boxplot indicating that most hunters harvested between 5 and 13 ducks, and a quarter harvested more than about 27 ducks, including one who harvested more than 50 ducks. Sometimes there are no whiskers because the minimum (or maximum) is the same as the lower (or upper) quartile (see Figure 3, where at least 25% of Licence Holders who hunted were unsuccessful).

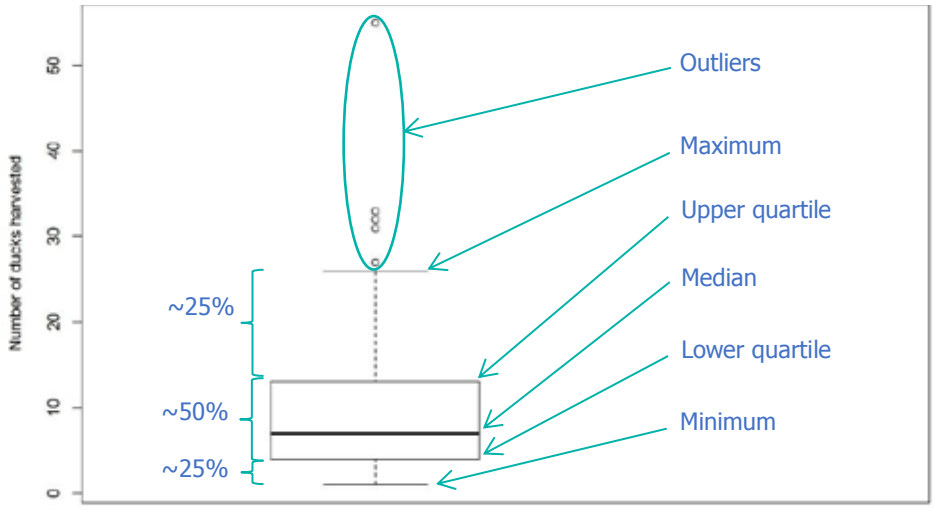

Figure B1: Example boxplot, with labels.


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