

Estimates of harvest for duck and quail in Victoria

Results from surveys of Victorian Game Licence holders in 2016



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Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian game Licence holders in 2016

Paul D. Moloney and John D. Turnbull

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Front cover photo: Marshes near Kerang - opening morning (GMA Image Library)

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Summary

Between March and July 2016, during the hunting seasons for duck and quail, telephone surveys of Victorian hunters were conducted to estimate the total harvest for each game type. 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 or not during the period for which the survey applied, and (if applicable) the number and species of animals harvested. Additional information was obtained on hunting methods and locations.

Each holder of a Game Licence endorsed for duck hunted on approximately 4.0 days during the 2016 duck hunting season, with an average season harvest of 10.7 ducks per Game Licence holder. Based on the total number of Game Licence holders, this equates to an estimated 271,576 ducks harvested during the 2016 duckhunting season in Victoria (95% confidence interval [CI] = 237,906– 310,010). The three most commonly harvested species were Pacific Black Duck (which comprised 33% of the total harvest), Australian Wood Duck (29%) and Grey Teal (28%). The remaining ducks harvested were Chestnut Teal (7%), Mountain Duck (2%), Pinkeared Duck (<1%) and Hardhead (<1%). Blue-winged Shoveler were prohibited from being hunted in 2016.

Each holder of a Game Licence endorsed for quail hunted on approximately 0.2 days during the 2016 quail hunting season, with an average season harvest of 1.0 quail per Game Licence holder. Based on the total number of Game Licence holders, this equates to an estimated 28,043 stubble quail harvested during the 2016 quail hunting season in Victoria (95% CI = 15,607–50,385). The total number of hunter days during the 2016 hunting season for ducks was estimated to be 100,749 (95% CI = 90,690 - 127,679) and for quail the estimated number of hunter days was 6,559 (95% CI = 4,134 - 10,405).

The total number of hunter days during the 2016 hunting season for ducks and quail was estimated to be 107,308 (95% CI = 91,683 -122,933).

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 was estimated for each survey period and combined with the harvest per 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 previous 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. It needs to be noted that, this year, the quail survey did not follow the methodology, as all surveys happened at the end of the season. This means the results of the 2016 quail telephone survey may have increased memory bias and is not strictly comparable with other years. In future years, surveys will be conducted throughout the season as done for previous surveys.

1. Introduction

To effectively manage game species, it is important to quantify the numbers harvested. Since 2009, the State Government game management agency has commissioned a series of regular telephone surveys of randomly selected Game Licence holders. Three sets of telephone surveys were conducted during the various game harvest seasons for deer, duck and quail. However, this report focuses only on the duck and quail harvests.

The 2016 duck hunting season lasted 12 weeks, from 19 March to 13 June (Game Management Authority 2016). Seven species could legally be hunted in 2016: Pacific Black Duck (*Anas superciliosa*), Australian Wood Duck¹ (*Chenonetta jubata*), Mountain Duck² (*Tadorna tadornoides*), Grey Teal (*Anas gracilis*), Chestnut Teal (*Anas castanea*), Pink-eared Duck (*Malacorhynchus membranaceus*) and Hardhead³ (*Aythya australis*). Blue-winged Shoveller⁴ (a declared game species) was prohibited from hunting for the 2016 season. The daily bag limit for the opening day of the 2016 season was eight game ducks per hunter. However, for the remainder of the season, the daily bag limit was four game ducks per hunter.

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

The 2016 Stubble Quail (*Coturnix pectoralis*) hunting season lasted 12 weeks, from 2 April to 30 June (Game Management Authority 2016). The daily bag limit for the 2016 season was 20 quail per hunter.

The 2016 quail hunting survey used a different method from that used with the telephone surveys performed during the 2009 to 2015 quail-hunting seasons (Gormley 2009; Gormley and Turnbull 2009, 2010, 2011; Moloney and Turnbull 2012, 2013, 2014, 2015). The difference, due to a clerical error, was that instead of surveys being conducted at the end of each month of the season, one larger survey was conducted at the end of the season. Future surveys will be conducted monthly.

^{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.

2. Methods

General methodology

Slightly different methodology was used for estimating duck and 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. 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 respondent⁴ may have hunted during the periods covered by Surveys 2 and 3, if they were contacted as part of Survey 3, then information was only collected that pertained to the period covered by Survey 3.

Previously (2009 to 2015) quail surveys were conducted at the end of each period, similar to the duck surveys. However, for the 2016 quail telephone survey, a single survey was performed at the conclusion of the season. The survey involved telephoning a random sample of Game Licence holders and asking them to report their hunting activities for the opening weekend and each month of the season.

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

For each survey period, the average harvest per hunter⁵ 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 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 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 are provided in Appendix 2.

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

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 2016 season. A random sample of 200 licence holders were interviewed by telephone immediately after opening weekend (Duck Survey 1), followed by surveys of independent random samples of licence holders at two-week intervals for the remainder of the duck season (Duck Surveys 2–7). Respondents were also asked to report the number of each species harvested. To ascertain an estimate of the number of active hunters over the season, two extra questions were asked in the final survey (Duck survey 7). Respondents were asked if they had hunted during the season and if so how many times had they hunted.

Quail

Samples were drawn from hunters who held a Game Licence endorsed to hunt quail during the 2016 season. A random sample of 900 licence holders was interviewed by telephone after the completion of the quail season. Normally the surveys would be conducted during the season, at the end of each of the months April, May and June. In 2015, there were four survey periods: after the opening weekend (Survey 1); 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 number of hunting trips, the number of hunting days, the type of grassland where hunting occurred (native, stubble or introduced) and whether or not dogs were used. To make it as comparable as possible with previous surveys, each respondent was randomly allocated to a month, so that April (including opening weekend), May and June each had 300 independent respondents.

3. Results

Duck

Summary of responses for duck surveys in 2016

The number of Game Licence holders endorsed to hunt ducks remained relatively constant throughout the season, increasing from 25,121 at opening weekend to 25,681 at the end of the season (Table 1). In order to achieve the required sample size of respondents, slightly more than 200 licence holders were contacted each survey, with an average of 97.6% of those contacted being willing to take part.

Table 1							
Duck Survey	Period	Licence holders	Respondents	Respondents who hunted	Days hunted*	Ducks harvested**	
1	19 – 20 Mar	25,121	200	94	137	475	
2	21 Mar – 3 Apr	25,121	200	52	137	294	
3	4 – 17 Apr	25,121	200	27	55	135	
4	18 Apr – 1 May	25,121	200	49	106	257	
5	2 – 15 May	25,381	200	37	105	343	
6	16 – 29 May	25,381	200	23	57	144	
7	30 May – 13 Jun	25,681	200	63	199	498	

* Days hunted indicates the combined number of days that 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 2016

The proportion of Game Licence holders endorsed to hunt duck who hunted in each survey period varied throughout the season: 47% of licence holders hunted during opening weekend, corresponding to approximately 11,807 hunters (Table 2). The proportion who hunted during other survey periods varied from 12% to 32%, corresponding to between 2,919 and 8,090 duck hunters, respectively (Table 2).

Tabl	e 2
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Period	Proportion	SE	959	%CI	Total hunters	SE	95%	6CI
			Lower	Upper			Lower	Upper
19 – 20 Mar	0.47	0.035	0.41	0.54	11,807	887	10,193	13,676
21 Mar – 3 Apr	0.26	0.031	0.21	0.33	6,531	779	5,174	8,245
4 – 17 Apr	0.14	0.024	0.10	0.19	3,391	607	2,394	4,803
18 Apr – 1 May	0.25	0.030	0.19	0.31	6,155	764	4,830	7,843
2 – 15 May	0.19	0.027	0.14	0.25	4,695	697	3,516	6,271
16 – 29 May	0.12	0.023	0.08	0.17	2,919	573	1,994	4,272
30 May – 13 Jun	0.32	0.033	0.26	0.39	8,090	844	6,598	9,918

Average harvest of ducks per hunter (Game Licence holders who hunted) for each survey period in 2016

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 some 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 5.1 ducks on opening weekend, which was only slightly greater than the lowest average harvest per hunter (5.0 ducks in the third survey period), and the largest average harvest per hunter was 9.3 ducks (in the fifth survey period).

Table 5	Та	bl	e	3
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Period	Average harvest per hunter*	SE	95%CI	
			Lower	Upper
19 – 20 Mar	5.05	0.37	4.37	5.84
21 Mar – 3 Apr	5.65	0.83	4.24	7.54
4 – 17 Apr	5.00	0.66	3.86	6.48
18 Apr – 1 May	5.24	0.61	4.18	6.58
2 – 15 May	9.27	1.34	6.99	12.29
16 – 29 May	6.26	1.11	4.43	8.84
30 May – 13 Jun	7.90	0.92	6.30	9.92

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

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 some did not harvest any ducks (Figure 1).



Figure 1: Boxplot of the number of ducks reported harvested by individual hunters for each survey period in 2016. 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 2015 by holders of a Game Licence endorsed for duck

There were an estimated 59,662 ducks harvested during opening weekend (95%CI = 48,576–73,280), which was more than the estimate for any fortnight in April to May and constituted 22% of the total seasonal harvest (Table 4). The harvest throughout the remainder of the season varied considerably between surveys, with fortnightly estimates ranging from 16,957 to 63,946 ducks harvested. The total season harvest estimate was 271,576 (95% CI = 237,906–310,010; Table 4).

Period	Total harvest*	SE	95%CI					
			Lower	Upper				
19 – 20 Mar	59,662	6,275	48,576	73,280				
21 Mar – 3 Apr	36,928	7,007	25,543	53,388				
4 – 17 Apr	16,957	3,776	11,017	26,098				
18 Apr – 1 May	32,280	5,479	23,200	44,915				
2 – 15 May	43,528	9,023	29,119	65,068				
16 – 29 May	18,274	4,834	10,977	30,422				
30 May – 13 Jun	63,946	9,980	47,180	86,669				
Season total	271,576	18,361	237,906	310,010				

* 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 2016

The total average season harvest per licence holder was estimated to be 10.3 birds (95% CI = 9.4-12.2; 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

Table 4

Period	Average harvest*	SE	95%CI	
			Lower	Upper
19 – 20 Mar	2.38	0.25	1.93	2.92
21 Mar – 3 Apr	1.47	0.28	1.02	2.13
4 – 17 Apr	0.68	0.15	0.44	1.04
18 Apr – 1 May	1.29	0.22	0.92	1.79
2 – 15 May	1.72	0.36	1.15	2.56
16 – 29 May	0.72	0.19	0.43	1.20
30 May – 13 Jun	2.49	0.39	1.84	3.37
Season total	10.73	0.72	9.40	12.25

* 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 2016 harvest for each duck species

The total harvest was estimated for each species by multiplying the total estimated duck harvest by the percentage of the total harvest for that species (Table 6). The most frequently harvested species was Pacific Black Duck, comprising 33% of the total reported harvest, followed by Australian Wood Duck (29%) and Grey Teal (28%). The remaining four species comprised 10% of the total harvest.

Table 6

Species	Reported	Proportion	SE	Estimated	SE	95%CI	
	harvest	of harvest		harvest		Lower	Upper
Australian Wood Duck	616	0.29	0.010	77,955	5,900	45,911	132,362
Blue-winged Shoveler*	0	0	NA	0	N/A	N/A	N/A
Chestnut Teal	143	0.07	0.005	18,097	1,906	9,732	33,650
Grey Teal	609	0.28	0.010	77,069	5,843	45,371	130,913
Hardhead	4	0.00	0.001	506	255	145	1,771
Mountain Duck	51	0.02	0.003	6,454	994	3,074	13,551
Pacific Black Duck	710	0.33	0.010	89,850	6,672	53,175	151,821
Pink-eared Duck	13	0.01	0.002	1,645	468	617	4,388

* Game Licence holders were not permitted to harvest Blue-winged Shoveler (Anas rhynchotis), also referred to as Australasian Shoveler, in 2016.

Days on which ducks were hunted per Game Licence holder for 2016

Each Game Licence holder hunted an average of 4.0 days during the 2016 duck hunting season (Table 7). When multiplied by the total number of Game Licence holders in each survey period, this equalled a total of 100,749 hunter days (95%CI = 86,556–117,270).

Period	Days hunted	SE	95%CI	
			Lower	Upper
19 – 20 Mar	0.69	0.06	0.58	0.81
21 Mar – 3 Apr	0.69	0.11	0.50	0.93
4 – 17 Apr	0.28	0.05	0.19	0.40
18 Apr – 1 May	0.53	0.08	0.39	0.71
2 – 15 May	0.53	0.10	0.36	0.77
16 – 29 May	0.29	0.07	0.18	0.45
30 May – 13 Jun	1.00	0.14	0.76	1.31
Total per licence holder	3.98	0.24	3.53	4.48
Total hunting days	100,749	7,817	86,556	117,270

Table 7

Percentage of days hunted and associated duck harvest by land tenure in 2016

Greater duck hunting effort was expended on private land (52.4%) than on public land (42.5%), with an even greater proportion of ducks being harvested solely on private land (56.8% on private land versus 36.5% on private land) (Table 8).

Table 8

Land tenure	Days	Duck harvest
Private land only	52.4%	56.8%
Public land only	42.5%	36.6%
Both	5.2%	6.5%
Total	100%	100%

Estimated total duck harvest in 2016 by CMA region

It was estimated that 63.5% (95%CI = 57.2%–70.5%) of Game Licence holders actually hunted for ducks during the 2016 duck season. Total harvest was estimated to be greatest in the West Gippsland CMA, followed by the Goulburn Broken CMA and the North Central CMA (Figure 2). The top five towns for the total reported number of ducks harvested were (in descending order) Sale, Horsham, Geelong, Shepparton and Echuca. The top five towns for the total number of reported duck hunting days were (in descending order) Sale, Horsham, Geelong, Echuca and Shepparton.



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

Quail

Summary of responses for quail surveys in 2016

The number of Game Licence holders endorsed to hunt quail was rose slightly throughout the season (Table 9). In order to achieve the required sample size of respondents, slightly more than 900 licence holders were contacted for the survey, 300 contacts were then attributed to each survey period, with an average of 98.4% of those contacted being willing to take part.

Table 9

Period	Licence holders	Respondents	Respondents who hunted	Days hunted*	Quail harvested**
April	27,860	300	15	35	191
May	28,233	300	12	20	60
June	28,521	300	7	15	49

* Days hunted indicates the combined number of days that hunting took place by respondents. ** Quail harvested indicates total number of quail harvested by respondents.

Proportion and corresponding total number of Game Licence holders endorsed to hunt quail who hunted in each survey period in 2016

The proportion of Game Licence holders endorsed to hunt quail who actually hunted quail halved after the May survey period, from >4% to 2%. There were an estimated 1,393 Game Licence holders who hunted quail in April—more than in other months (Table 10).

Table 10

Period	Proportion	SE	95	%CI	Total	SE	95	%CI
			Lower	Upper	hunters		Lower	Upper
April	0.05	0.013	0.03	0.08	1,393	351	857	2,264
May	0.04	0.011	0.02	0.07	1,129	319	656	1,945
June	0.02	0.009	0.01	0.05	665	249	328	1,351

* April excludes surveys from opening weekend.

Average harvest of quail per hunter (Game Licence holders who hunted) for each survey period in 2016

Within each survey period, there was large variation in the reported harvest per hunter (i.e. per Game Licence holder who hunted), with some hunters harvesting over 20 quail, and over a quarter harvesting zero quail within a given month-long survey period (Figure 3). The average number of quail harvested per hunter during each survey period varied from 12.7 in April to 5 in May (Table 11).

ľ	a	b	le	1	1	

Period	Average harvest per hunter*	SE	95%0	
			Lower	Upper
April	12.73	4.54	6.47	25.07
May	5.00	1.91	2.42	10.31
June	7.00	2.79	3.30	14.84

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



Figure 3: Boxplot of the number of quail reported harvested by individual hunters for each survey period in 2015. 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 total quail harvest in Victoria in 2016 by holders of a Game Licence endorsed for quail

There were an estimated 28,043 quail harvested by all holders of a Game Licence for quail during the 2016 quail season (95% CI = 15,607–50,385). The April harvest total was substantially greater than the May and June harvest totals (Table 12).

Period	Total harvest*	SE	95%	CI
			Lower	Upper
April	17,738	7,736	7,828	40,190
May	5,647	2,685	2,331	13,679
June	4,658	2,543	1,712	12,674
Season total	28,043	8,575	15,607	50,385

Table 12

* 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 quail per Game Licence holder in each survey period in 2016

The total average season harvest was 1.0 quail per Game Licence holder (95% CI = 0.6–1.8; Table 13). Note that for each survey period, the average quail harvest per Game Licence holder was lower than the average quail harvest per hunter, as the former was averaged across those respondents who did not hunt during the survey period, whereas the latter only included those respondents who hunted.

Table 13

Period	Average harvest*	SE	95%	CI
			Lower	Upper
April	0.64	0.28	0.28	1.44
May	0.20	0.10	0.08	0.48
June	0.16	0.09	0.06	0.44
Season total	1.00	0.31	0.56	1.80

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

Days hunted per Game Licence holder for 2016

The number of hunting days per licence holder in each of May and June was approximately half that of April. On average, each Game Licence holder hunted on only 0.2 days during the 2016 season, corresponding to 6,559 hunter days (95% CI = 4134–10,405; Table 14).

Period	Days hunted	SE	95%(CI
			Lower	Upper
April	0.12	0.04	0.07	0.21
Мау	0.07	0.01	0.04	0.10
June	0.05	0.01	0.03	0.07
Total per licence holder	0.23	0.04	0.17	0.32
Total hunting days	6,559	1,566	4,134	10,405

Table 14

Percentage of days hunted and associated quail harvest by land tenure in 2016

Most quail hunting was conducted on private land (97.9% of the hunting days and of the harvested quail) (Table 15). A very small proportion of hunting was conducted in public land State Game Reserves (2.1%), with no reported hunting on both private land and State Game Reserves during the same hunting trip. The percentage of quail hunting days where dogs were used (68.1%) was larger than the percentage of quail harvested using dogs (43.8%, Table 15).

Table 15

L and tanuna		Days			Quail harvest	
	No dog	Dog used	Total	No dog	Dog used	Total
Private land only	29.8%	68.1%	97.9%	54.1%	43.8%	97.9%
State Game Reserves only	2.1%	0%	2.1%	2.1%	0%	2.1%
Both	0%	0%	0%	0%	0%	0%
Total	31.9%	68.1%	100%	56.2%	43.8%	100%

Percentage of hunting days and associated quail harvest per grassland type in 2016

More quail hunting and quail harvesting took place on stubble (72.3% and 70%, respectively) than on other individual grassland types or combinations of grasslands (Table 16).

Table 16

Grassland	Days hunted	Quail harvest
Introduced grass	2.9%	4%
Native grass	21.4%	26%
Stubble	72.9%	70%
Stubble and native grass	2.9%	0%
Total	100%	100%

Estimated total quail harvest in 2016 by CMA region

It was estimated that 25.3% (95% CI = 20.9%–30.8%) of Game Licence holders endorsed for quail actually hunted for quail during the 2016 quail season. One hunter reported harvesting 80 quail over four days during the 2016 season. The total quail harvest was greatest in the North Central CMA, Goulburn Broken CMA and the West Gippsland CMA (Figure 4). The top five towns for total reported number of quail harvested were (in descending order) St Arnaud, Shepparton, Sale, Lismore and Corinella. The top five towns for total number of reported quail hunting days were (in descending order) Shepparton, Donald, St Arnaud, Pyramid Hill and Horsham.



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

4. Discussion

Duck

A total of 271,576 ducks were estimated to have been harvested in Victoria during the 2016 season (95% CI = 237,906–310,010), which (although similar to the 2015 estimated harvest) was the lowest number since 2009 (Table 17 and Figure 5). The reduced harvest relative to the average was consistent across most species, with the exception of Pink-eared Duck (which reduced significantly), Pacific Black Duck (the only harvest to increase from the 2015 harvest) and Blue-winged Shoveler (which were not permitted to be hunted in 2016). The estimated duck harvest per licence holder was the lowest since 2009. The estimated hunting days per licence holder was slightly below average, and there was a 10% increase from 2015. Some of this may be explained by the change in bag limits, from ten ducks per day in 2014 and five ducks per day in 2015 (except for opening day, when the limit was still ten ducks), to four ducks per day in 2016 (except for opening day, when the limit and reduced hunting opportunities. Hunter efficiency (ducks per hunting day) was the lowest since 2009, and 15% lower than the 2015 season's rate, in line with the 20% reduction in bag limits (Table 17 and Moloney and Turnbull, 2015).



Figure 5: Estimated total duck harvests (in thousands) from 2009 to 2016. The square is the estimate for each season; the solid line indicates the 95% confidence interval; the blue line is the average duck harvest from 2009 to 2016; the shaded area is the 95% confidence interval for the average duck harvest from 2009 to 2016.

Opening Saturday was an important time for duck hunting in Victoria in 2016. Nearly half (46%) of duck Game Licence holders hunted, accounting for 12% of the total duck hunting days and 18% of the total duck harvest. Of Game Licence holders endorsed for duck who hunted on opening Saturday, 20% reported harvesting their bag limit, accounting for 7% of ducks harvested during the 2016 season.

	2009	2010	2011	2012	2013	2014	2015	2016	Average*
Harvest by species									
Australian Wood Duck	131,084	112,390	132,908	150,150	106,553	131,282	80,194	77,955	115,315
Blue-winged Shoveler	NA	216	4,854	1,319	7,104	4,155	1,497	NA	2,735
Chestnut Teal	13,176	14,354	49,812	23,506	39,804	29,866	19,456	18,097	26,009
Grey Teal	20,919	26,011	211,034	110,574	135,947	127,126	79,945	77,069	98,578
Hardhead	NA	324	25,657	30,222	7,349	6,363	998	506	10,203
Mountain Duck	2,173	5,936	8,090	9,234	2,694	8,440	6,860	6,454	6,235
Pacific Black Duck	55,150	96,487	156,484	160,704	92,714	127,646	81,940	89,850	107,622
Pink-eared Duck	N/A	0	12,597	21,587	30,129	14,154	15,839	1,645	13,707
Total harvest	222,302	270,574	600,739	508,256	422,294	449,320	286,729	271,576	378,974
Hunting days**	76,659	85,801	103,450	109,718	91,748	118,800	90,634	100,749	97,195
Ducks per licence holder	11.10	12.54	26.02	21.19	17.24	17.29	11.35	10.73	15.93
Hunting days per licence holder	3.98	3.98	4.48	4.60	3.75	4.57	3.59	3.98	4.12
Ducks per hunting day	2.79	3.15	5.81	4.61	4.60	3.78	3.16	2.70	3.83

Table 17. Comparison of duck harvests of 2009–2016.

Note: The 2009, 2010, 2011, 2012, 2013, 2014 and 2015 estimates are from Gormley and Turnbull (2009), Gormley and Turnbull (2010), Gormley and Turnbull (2011), Moloney and Turnbull (2012), Moloney and Turnbull (2013), Moloney and Turnbull (2014) and Moloney and Turnbull (2015), respectively.

* For individual duck species, averages are calculated using only data from years when they could be legally hunted.

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

Quail

The total of 28,043 quail estimated to have been harvested in Victoria during the 2016 season (95% CI = 15,607–50,385) is a very large decrease from the 2015 harvest of 101,244 (more than three times smaller) (Figure 6 and Table 18). The 2016 season had the second lowest harvest since the survey began in 2009: only 2014 was lower. Over 60% of the quail harvest occurred in April.



Figure 6: Estimated total quail harvests (in thousands) from 2009 to 2016. The square is the estimate for each season; the solid line indicates the 95% confidence interval; the blue line is the average quail harvest from 2009 to 2016; the shaded area is the 95% confidence interval for the average quail harvest from 2009 to 2016.

Due to the structure of Game Licences in Victoria, not every holder of a Game Licence endorsed to hunt quail will hunt 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 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 quail, even though they may not intend to do so. This does not affect the estimates of quail harvest, because the calculations explicitly account for the proportion of quail Game Licence holders who did not actually hunt quail.

	2009	2010	2011	2012	2013	2014	2015	2016*	Average
Total harvest	189,155	86,302	678,431	129,711	184,123	16,243	101,244	28,043	176,656
Hunting days	24,648	24,739	46,719	22,262	21,958	10,852	22,432	6,559	140,114
Quail per licence holder	7.89	3.59	26.17	4.80	6.69	0.56	3.58	1.00	224,900
Hunting days per licence holder	1.03	1.03	1.80	0.82	0.98	0.38	0.79	0.23	22,521
Quail per hunting day	7.97	3.48	14.52	5.81	8.39	1.47	4.51	4.29	6.79

Table 18. Comparison of quail harvests of 2009–2015.

Note: The 2009, 2010, 2011, 2012 and 2013 estimates are from Gormley and Turnbull (2009), Gormley and Turnbull (2010), Gormley and Turnbull (2011), Moloney and Turnbull (2012), Moloney and Turnbull (2013), Moloney and Turnbull (2014) and Moloney and Turnbull (2015), respectively. * The 2016 quail surveys were conducted after the season rather than each month of the season. It is assumed that the change in methodology will produce only minor differences.

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

Locations with the most hunting days

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

The top five towns for the total number of reported quail hunting days were (in descending order) Shepparton, Donald, St Arnaud, Pyramid Hill and Horsham.

Combining duck and quail, Sale had the most hunting days during the 2016 hunting seasons, followed by Horsham, Geelong, Echuca and Shepparton. 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.

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 ducks, would have ensured that both memory bias and non-response bias were kept low (compared with postal surveys and complete end-of-season surveys) (Barker 1991; Barker et al. 1992). Nevertheless, some bias likely remains, and the estimates of total harvest should be interpreted with care.

It needs to be noted that due to a clerical error this year, the quail survey did not follow previous methodology, as all surveys happened at the end of the season. That means the results of the 2016 telephone 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 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 quail. Statistically, these sample sizes were considered adequate for providing reasonable estimates.

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

References

- Barker, R.J. (1991). Nonresponse to New Zealand waterfowl harvest surveys. Journal of Wildlife Management 55, 126–131.
- Barker, R.J. (2006). Survey of waterfowl hunting in Victoria by Victorian licence holders 2006. Report for the Game Management Unit, Department of Sustainability and Environment, Victoria.
- Barker, R.J., Geissler, P.H. and Hoover, B.A. (1992). Sources of nonresponse to the Federal Waterfowl Hunter Questionnaire Survey. Journal of Wildlife Management 56, 337–343.
- Game Management Authority. (2015). Game hunting in Victoria. http://www.gma.vic.gov.au (accessed 8 November 2016).
- Gormley, A.M. (2009). Survey of quail hunting in Victoria by Victorian licence holders 2008. Report for the Game Management Unit. Department of Sustainability and Environment, Victoria. 10 pp.
- Gormley, A.M. and Turnbull, J.D. (2009). *Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2009*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 196. Department of Sustainability and Environment, Heidelberg, Victoria.
- Gormley, A.M. and Turnbull, J.D. (2010). *Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2010*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 210. Department of Sustainability and Environment, Heidelberg, Victoria.
- Gormley, A.M. and Turnbull, J.D. (2011). Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2011. Arthur Rylah Institute for Environmental Research Technical Report Series No. 224. Department of Sustainability and Environment, Heidelberg, Victoria.
- Moloney, P.D. and Turnbull, J.D. (2012). Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2012. Arthur Rylah Institute for Environmental Research Technical Report Series No. 239. Department of Sustainability and Environment, Heidelberg, Victoria.
- Moloney, P.D. and Turnbull, J.D. (2013). Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2013. Arthur Rylah Institute for Environmental Research Technical Report Series No. 251. Department of Environment and Primary Industries, Heidelberg, Victoria.
- Moloney, P.D. and Turnbull, J.D. (2014). Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2014. Arthur Rylah Institute for Environmental Research Unpublished Client Report for the Game Management Authority. Arthur Rylah Institute for Environmental Research, Department of Environment, Land, Water and Planning, Heidelberg, Victoria.
- Moloney, P.D. and Turnbull, J.D. (2015). Estimates of harvest for duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2015. Arthur Rylah Institute for Environmental Research Unpublished Client Report for the Game Management Authority. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.
- Wright, V.L. (1978). Causes and effects of biases on waterfowl harvest estimates. Journal of Wildlife Management 42: 251-262.

Appendix 1

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:

$$p_j = \frac{n_j}{n_i}$$
 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:

 $H_i = p_i L$ 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):

 $W_i = w_i H_i$ 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:

SE
$$(w_j) = \frac{\text{SD}(w_j)}{\sqrt{h_j}}$$
, 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).

$$CV(w_{j}) = \frac{SE(w_{j})}{w_{j}}, \text{ and } CV(p_{j}) = \frac{SE(p_{j})}{p_{j}}$$
$$CV(W_{j}) = \sqrt{(CV(w_{j}))^{2} + (CV(p_{j}))^{2}}$$
$$SE(W_{j}) = CV(W_{j}) \times W_{j}.$$

The standard error of the total harvest was calculated by:

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

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

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

lower limit = $\hat{X} \div r$, where:
 $r = \exp\left(1.96\sqrt{\ln\left(1+CV^2\right)}\right)$

e.g. for the total duck harvest we have

$$CV = \frac{20,286}{286,729} = 0.071$$
$$r = \exp\left(1.96\sqrt{\ln(1+0.071^2)}\right) = 1.15$$

Therefore, Upper and Lower Confidence Intervals are given by:

UL=286,729 × 1.15 = 329,321 *LL*=286,729 ÷ 1.15 = 249,645.

Appendix 2

Explanation of what goes into a boxplot

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 $Q1 - 1.5 \times IQR$ 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: 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 A2.1 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 A2.1: Example boxplot, with labels.

Victorian Duck Hunting Survey

and I am calling about duck season on behalf of the Game Management Authority. Introduction: Hi my name is

I was hoping you had time to answer a few quick questions.

' use if asked to explain why) The survey of licensed Duck Hunters over the open season will provide information on hunting practices and harvest information as part of the continued process to improve game management in Victoria

Survey details:

Date of interview: dd / mm / 2016

Non-responsive: 🔲 (tick box)

Survey questions:

1. Do you use a dog when you hunt ducks? Yes or No

taking part in this survey, if you would like to discuss or view the outcomes of this data, please contact Customer Service Centre on 136 186) Yes 🗌 No 🔲 (tick box, if 'Yes', proceed to question 3, if 'No' "Thank you for 2. Did you go duck hunting over the opening weekend?

3. How many Duck hunting trips did you take over the weekend?

(indicate number in box)

(Each trip needs to be treated separately for question 4 - 8)

Appendix 3

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

Thank you for your time

and I am calling about Stubble Quail season on behalf of the Game Management Authority. Introduction: Hi my name is ______and I am callin I was hoping you had time to answer a few quick questions. (use if asked to explain why) The survey of licensed Quail Hunters over the open season will provide information on hunting practices and harvest information as part of the continued process to improve game management in Victoria.

Survey details:

Date of interview: dd / mm / 2016

Non-responsive: 🔲 (tick box)

Survey questions:

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

2. Did you go hunting on the opening Saturday? Yes
No
(tick box)

3. Did you go hunting on the opening Sunday? Yes

(if 'Yes') (Indicate number of quail taken in box)

(Indicate number of quail taken in box)

(if 'Yes')

□ (tick box) (if yes complete questions for each month hunted) Ŷ Yes 4. Did you go quail hunting in 2016?

April (after opening weekend)

5. How many trips did you go on in April?	Record number of trips						
6. How many days did you go hunting?	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6	Trip 7
 How many Quail did your harvest? 							
8. What type of land did you hunt on? "Can register more than one choice"	State Game Reserve Private land Public land						
 What type of grasslands was the hunt on? "Can register more than one choice" 	Stubble Native Grass Introduced grass	Stubble Native Grass Introduces grass					
10. What was the closest major town to the area you hunted?							

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		Trip 7		State Game Reserve Private land Public land	Stubble Native Grass Introduces grass	
		Trip 6		State Game Reserve Private land Public land	Stubble Native Grass Introduced grass	
		Trip 5		State Game Reserve Private land Public land	Stubble Native Grass Introduced grass	
		Trip 4		State Game Reserve Private land Public land	Stubble Native Grass Introduced grass	
		Trip 3		State Game Reserve Private land Public land	Stubble Native Grass Introduced grass	
		Trip 2		State Game Reserve Private land Public land	Stubble Native Grass Introduced grass	
	Record number of trips	Trip 1		State Game Reserve Private land Public land	Stubble Native Grass Introduced grass	
May	11. How many trips did you go on in May?	12. How many days did you go hunting?	13. How many Quail did your harvest?	 What type of land did you hunt on? "Can register more than one choice" 	15. What type of grasslands was the hunt on? "Can register more than one choice"	16. What was the closest major town to the area you hunted?

		Trip 7		State Game Reserve Private land Public land	Stubble Native Grass Introduces grass	
		Trip 6		State Game Reserve Private land Public land	Stubble Native Grass Introduced grass	
		Trip 5		State Game Reserve Private land Public land	Stubble Native Grass Introduced grass	
		Trip 4		State Game Reserve Private land Public land	Stubble Native Grass Introduced grass	
		Trip 3		State Game Reserve Private land Public land	Stubble Native Grass Introduced grass	
		Trip 2		State Game Reserve Private land Public land	Stubble Native Grass Introduced grass	
	Record number of trips	Trip 1		State Game Reserve Private land Public land	Stubble Native Grass Introduced grass	
aunc	17. How many trips did you go on in June?	18. How many days did you go hunting?	19. How many Quail did your harvest?	20. What type of land did you hunt on? "Can register more than one choice"	21. What type of grasslands was the hunt on? "Can register more than one choice"	22. What was the closest major town to the area you hunted?

Thank you for your time

June

