

Victorian Summer Waterbird Count, 2019

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Front cover photo: The critically endangered Curlew Sandpiper, a species recorded during the 2019 Summer waterbird Count (Photo: Peter Menkhorst)

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Summary

Context

The Victorian Summer Waterbird Count is a statewide survey of waterbirds using selected wetlands and is conducted in late February each year, prior to the beginning of the Victorian duck hunting season.

Aims

The Summer Waterbird Count gathers numerical, locational and breeding data about game ducks and non-game waterbirds to inform management decisions regarding the forthcoming duck hunting season.

Specifically, the aims are:

- to identify wetlands that are open to hunting and are holding large numbers of significant, non-game waterbirds (to inform consideration of further regulation of hunting, including closure of individual wetlands to hunting)
- to identify cases of local breeding by waterbirds, particularly colony-breeding species (for consideration of further regulation, including closure to hunting)
- to provide details on the distribution and numbers of game and non-game species of waterfowl on wetlands open to hunting.

Methods

During the 2019 Summer Waterbird Count, held between 11 and 22 February, 135 wetlands across Victoria were surveyed; however, 58% of these were dry at the time. Counts were made of all waterbirds on a wetland (or a defined part of a large wetland), using binoculars or a spotting scope. Observations of breeding of any waterbird species were also recorded, including numbers of broods or nests, and nest contents where appropriate.

Count data were collated during the last week of February, and a preliminary report detailing significant findings was conveyed to the regulatory authorities (Department of Environment, Land, Water and Planning, and Game Management Authority) on 27 February 2019 in time for management decisions to be implemented prior to opening day of the hunting season (16 March 2019).

Key results

Threatened waterbird species were detected in numbers above agreed thresholds at seven wetlands, and these wetlands received extra monitoring in the lead-up to opening weekend. The most numerous game species in the count results were Australian Shelduck (29.4%), Grey Teal (23.9%) and Pink-eared Duck (23.4%), together accounting for a little over three-quarters of all game ducks counted. The eight non-game species were dominated by three species: Eurasian Coot (43.7%), Hoary-headed Grebe (24.0%) and Black Swan (15.3%), and together they comprised 83% of non-game birds counted. During the 2019 Summer Waterbird Count, Freckled Duck (a threatened species considered to be particularly susceptible to being unintentionally shot) were scattered across numerous wetlands in Victoria, mostly in relatively small groups.

Conclusions and implications

1. Overall, counts in 2019 were lower than those of the previous year, probably due to the continuing very dry conditions (the first three months of 2019 in Victoria were the driest on record; 55% of wetlands visited were completely dry). Consequently, waterbirds were concentrated on a smaller number of large, more permanent wetlands. This situation risks increasing the proportion of birds harvested because hunters are concentrated on fewer wetlands.
2. Based on the survey results, five wetlands were closed to hunting for the duration of the season, and one wetland was closed for opening weekend. Partial closures or other management actions were applied at a further four wetlands.
3. The number of wetlands counted has varied over the 32 years of Summer Waterbird Counts. This variation in survey effort between years has resulted in biases in the database that affect its value as a basis for making management decisions.

Introduction

Project context

Annual counts of waterbirds have been conducted at wetlands across Victoria since 1987, when the then Department of Conservation, Forests and Lands implemented a recommendation from a review of the management of duck hunting within the state (Loyn 1989, 1991). Throughout this period, the purpose of the Summer Waterbird Count (SWC) has been to collect selected information regarding waterbird numbers and distribution. This information is used to inform management decisions about further regulation of hunting on specific wetlands during the forthcoming duck hunting season. Dates for the SWC are set so that enough time is available to recommend further regulation of duck hunting and for recommended management action to be legally enacted prior to opening day.

All count data obtained during these surveys are stored in departmental databases held at the Arthur Rylah Institute for Environmental Research (ARI) and are submitted to the Victorian Biodiversity Atlas. The results of SWCs have been published in various reports (Martindale 1988; Hewish 1988; Peter 1989–1992; Purdey and Loyn 2011, 2013; Purdey and Menkhorst 2014, 2015) or are available as unpublished summaries (Price 1993; O'Brien 1994; Pert 1995; Norman 1996–2006; Norman and Purdey 2007; Purdey and Loyn 2008–2010; Menkhorst and Purdey 2016; Menkhorst et al. 2017, 2018).

The coverage achieved during SWCs steadily declined through the 2000s because of declining departmental capacity to cover a large sample of wetlands. Therefore, in 2015 a new approach was introduced that limited survey coverage to wetlands that have been historically important duck hunting sites on public land, or have a history of supporting threatened waterbird species, rather than including any wetland, regardless of hunting status. The one exception to this strategy is the inclusion of the Western Treatment Plant, an extensive series of artificial wetlands not open to hunting, where comprehensive waterbird counts have been conducted 4 to 6 times per year since 2000 (Loyn et al. 2014, ARI unpublished data). Data from the Western Treatment Plant provide detailed baseline data against which the results of the SWC from elsewhere in the state can be compared.

Thus, the objectives of the 2019 SWC were:

1. to identify wetlands that are open to hunting and currently support large numbers of significant, non-game waterbirds (to inform consideration of further regulation, including closure of individual wetlands to hunting)
2. to identify cases of local breeding by waterbirds, particularly colony-breeding species (for consideration of further regulation, including closure to hunting)
3. to provide details on the distribution and numbers of game and non-game species of waterfowl on wetlands open to hunting.

Methods

Survey methods

Most wetlands were surveyed by staff from either the Department of Environment, Land, Water and Planning (DELWP) or the GMA, and a small number were independently surveyed (or partially surveyed) by volunteers from Birdlife Australia and the Hamilton Field Naturalists Club. Counts were made of all waterbirds on a wetland (or a defined part of a large wetland), using binoculars or a spotting scope. Observers were asked to record the wetland name, location (using Australian Map Grid reference or nearest town as a guide), date, time, species and number of birds of each species present. At each wetland, an estimate of water level was taken (as a percentage of its full supply level) and, if the entire wetland could not be surveyed, an estimate of the proportion of the wetland that was surveyed was sought. Observations of breeding by any waterbird species were also recorded, including numbers of broods or nests (and contents where appropriate). Wetlands that were found to be dry or almost so were generally not formally surveyed but were simply noted to be not supporting waterbirds.

Survey organisation

The SWC was coordinated centrally through the ARI (DELWP) in collaboration with the GMA. Five DELWP regional coordinators were assigned the task of arranging the on-ground logistics. Because Port Phillip Region had only one priority wetland (the Western Treatment Plant), no coordinator was required from that region.

Each regional coordinator was responsible for liaising locally with other DELWP and GMA officers in their region, distributing instructions and count forms, and ensuring adequate coverage of regional wetlands without duplication. The coordinators acted as a conduit for problems encountered during surveys and were expected to review completed forms before forwarding them to the central coordinator at ARI by a specified date.

Regional coordinators were also required to inform the central coordinator immediately if Freckled Ducks, Blue-billed Ducks, large aggregations of other uncommon or threatened waterbirds, or significant breeding events (e.g. colony-breeding waterbirds) were detected during counts. In cases where a wetland was counted by persons other than government agency staff and significant waterbird values were reported, a government agency staff member was sent to the site to verify the report.

Completed forms, once processed locally, were scanned and emailed to the central coordinator as soon as possible. This allowed preliminary data to be examined for records of rare or threatened non-game species, or any evidence of breeding birds that might require special protection. At ARI, staff checked all data sheets for accuracy and completeness, queried coordinators or individual observers on unusual or deficient records, and entered data into a Microsoft Access® database.

Count dates

The period over which the SWC is conducted has been reduced to 12 days in the second half of February (11–22 February in 2019). This timing and duration allows the counts to be as close as possible to opening day while allowing sufficient time for a preliminary review of the data to enable decisions to be made regarding the management of the forthcoming duck hunting season. This timing also helps to minimise error due to waterbird movements between the count and opening day. Even so, the period between the count and opening day, which is necessitated by requirements to implement legal mechanisms under the *Victorian Wildlife Act 1975*, was 22 days in 2019, an ample period for flocks of waterbirds to change location. This time lag remains a shortcoming in the decision-making process as it is currently structured. To minimise the chance of errors due to waterbird movements, wetlands at which significant values (above-threshold numbers of threatened species or breeding activity) were identified during the SWC were monitored by GMA or DELWP staff prior to management decisions being finalised (i.e. until publication in the *Victorian Government Gazette* of Friday 8 March 2019) to ensure that the issue still existed at the site. Further targeted monitoring by GMA or DELWP staff took place throughout the duck hunting season to assess the need for further management intervention, such as further closures or re-openings.

Wetlands surveyed

In recent years (2015 onwards), the strategy for selecting wetlands to be counted changed from one of encouraging surveys of any wetland to requesting surveys only of important duck-hunting wetlands. One result of this approach is that wetland selection is not biased by factors such as proximity and ease of access; rather, it focuses on wetlands that are likely to be visited by hunters, thereby reducing the risk of missing important waterbird populations that may be at risk from hunting. Before the 2016 SWC, the list of priority wetlands was further refined to remove very large wetlands at which waterbirds cannot be comprehensively counted, such as water supply dams (e.g. Lake Hume and Lake Eildon) and Western Port. The list of priority wetlands for 2019 is provided in Appendix 1. A list of other wetlands surveyed in 2019 is provided in Appendix 2.

Species counted and analysed

Sixteen species of waterbirds (eight game and eight non-game) are considered for routine analysis in the SWC. These species include all eight species of game ducks (family Anatidae) as well as non-game waterbirds that commonly associate with these ducks. The prescribed game species are Australasian Shoveler *Spatula rhynchotis*, Australian Shelduck *Tadorna tadornoides*, Australian Wood Duck *Chenonetta jubata*, Chestnut Teal *Anas castanea*, Grey Teal *Anas gracilis*, Hardhead *Aythya australis*, Pacific Black Duck *Anas superciliosa* and Pink-eared Duck *Malacorhynchus membranaceus*. Note that the Australasian Shoveler was a prohibited species during the 2019 duck hunting season.

The eight non-game species included in the SWC are four other species of Anatidae—Freckled Duck *Stictonetta naevosa*, Blue-billed Duck *Oxyura australis*, Musk Duck *Biziura lobata* and Black Swan *Cygnus atratus*—and four other waterbirds that commonly associate with species of Anatidae in Victoria—Australasian Grebe *Tachybaptus novaehollandiae*, Hoary-headed Grebe *Poliiocephalus poliocephalus*, Great Crested Grebe *Podiceps cristatus* and Eurasian Coot *Fulica atra*. Other notable (rare or threatened) species are also counted if present.

Results

Number of wetlands counted

The 2019 SWC contributes to a dataset now spanning the 33 years from 1987. Table 1 provides the total counts of eight game and eight non-game waterbird species from each of the SWCs, along with the number of wetlands counted. These data show that the number of surveyed wetlands peaked in the 1989–1993 period and declined thereafter but has now stabilised at between 126 and 144 wetlands (Table 1).

During the 2019 SWC, 135 wetlands across Victoria were surveyed (or visited in the case of dry wetlands) (Table 1), the same total as in the previous year; however, 74 (55%) of these were dry at the time. This total included 123 of the 154 recommended wetlands (Table 2) (those not surveyed are indicated in Appendix 1) and 58% of this subset were dry. A further 12 non-priority wetlands were also surveyed. The numbers of priority wetlands in each DELWP region and the number that were surveyed in 2019 are shown in Table 2.

Game species

In 2019, the total count of ducks belonging to the eight game species was 225,733 (Tables 1 and 3). This total represents a 13.2% decrease on the 2018 total (Table 3). The most numerous species were Australian Shelduck (29.4%), Grey Teal (23.9%) and Pink-eared Duck (23.4%), together accounting for a little over three-quarters of all game ducks counted. The grazing ducks (Australian Shelduck and Australian Wood Duck) represented a substantially increased proportion of the total compared with 2018, and the Pacific Black Duck, both teal species and the Hardhead all made smaller contributions to the total count of game species (Table 3).

Non-game species

In 2019, the total count of birds belonging to the eight non-game species was 85,889 (Tables 1 and 4), a 25% decrease on the 2018 total (Table 4). In numerical abundance, the eight non-game species were dominated by three species: Eurasian Coot (43.7%), Hoary-headed Grebe (24.0%) and Black Swan (15.3%), and together they comprised 83% of non-game birds counted. These species may occur at very high densities in prime habitat, and did so at the Western Treatment Plant during the 2019 count, when they made up 24%, 93% and 70%, respectively, of their statewide totals (Table 5). The Western Treatment Plant also supported large proportions of the total counts of three threatened duck species – the Freckled Duck (34.1%), Blue-billed Duck (60.4%) and Musk Duck (73%) (Table 5).

Numbers of Eurasian Coot, Hoary-headed Grebe, Freckled Duck and Black Swan were lower in the 2019 count than in the previous count, while Great Crested Grebe and Musk Duck showed increases over their 2018 totals (Table 4).

The contribution of the Western Treatment Plant

The high counts of both game and non-game species in the Port Phillip Region are mainly due to the disproportionate impact of the Western Treatment Plant near Werribee (Table 5). This 11, 000 ha site is comprehensively and meticulously counted as part of a monitoring program undertaken for Melbourne Water (Loyn et al. 2014). Part of this extensive complex of natural and artificial wetlands is used for the treatment of sewage, and much of the site is managed to maintain its value as wildlife habitat, as recognised under the Ramsar Convention. It is not open to hunting. In years of relatively low rainfall, the site has regularly contributed more than half the birds counted during SWCs.

Victoria has experienced below average rainfall over the past 2 years (<http://www.bom.gov.au/jsp/awap/rain/index.jsp?colour=colour&time=latest&step=0&map=anomaly&period=24month&area=vc>) and this probably partly explains the higher proportion of birds counted at the permanent wetlands within the treatment plant than in the past few years— in 2019, 62% of all game ducks counted and 51% of the non-game species were at the WTP (Table 5). The treatment plant held more than 50% of birds counted for six species of game duck: Australasian Shoveler and Hardhead (thus providing important refuge for the two least common game ducks), and Australian Shelduck, Chestnut Teal, Pacific Black Duck and Pink-eared Duck. Amongst the non-game species, the treatment plant counts of Hoary-headed Grebe, Musk Duck, Black Swan and Blue-billed Duck were also high (Table 5).

Because it is counted frequently (now four times per year, pre-2018 six times) and meticulously, the Western Treatment Plant provides an excellent baseline against which trends determined from the SWCs can be assessed. For this reason, we recommend that the Western Treatment Plant should continue to be counted during the SWC, noting that this is done at no cost to DELWP or the GMA.

Freckled Duck

The Freckled Duck *Stictonetta naevosa* is a non-game species that is of particular concern because it is listed as a threatened species under the *Flora and Fauna Guarantee Act 1988* and meets the criteria for Endangered status (DSE 2013). Freckled Ducks are at risk of being shot during duck hunting season because they can be difficult to distinguish from Pacific Black Duck and Hardhead when flying. The Victorian Government is concerned to minimise the risk to this species during the duck hunting season (DSE 2000; available here

https://www.environment.vic.gov.au/_data/assets/pdf_file/0022/32863/Freckled_Duck_Stictonetta_naevosa_.pdf.

During the 2019 SWC, Freckled Duck were scattered across numerous wetlands in Victoria, mostly in relatively small groups. The total count was 58% of the very high 2018 count (Table 6). The highest counts were at the Western Treatment Plant (327), Lake Lonsdale (320), Lake Bolac (175) and Lake Murphy (87). Smaller numbers were scattered across another 8 of the 135 wetlands counted.

Breeding and moulting

The SWC is timed to fall immediately prior to the annual duck hunting season and after the main waterbird breeding period (July–January in Victoria). No colony-breeding events, or incidences of large-scale moulting were reported during the 2019 SWC. Most species have typically finished moulting and breeding by the time of the SWC, and no need has been recognised to close waters to protect moulting birds for many years. Moulting was considered a significant management issue in the 1970s, when duck hunting seasons sometimes opened as early as January (Loyn 1989), coinciding with the peak moulting period for species such as Australian Shelduck, which often gather to moult in large aggregations (Frith 1982). However, with the season prescribed to open on the third Saturday in March of each year, it seems that this is no longer a significant management issue.

Wetlands with high numbers of waterbirds

The wetlands that produced the highest numbers of all waterbirds during the 2019 SWC are listed in Table 7. In general, large waterbodies in the west of the state provided the best waterbird habitat, most smaller wetlands being dry. Leaving aside the WTP, Barwon South West and Loddon Mallee regions had the most waterbirds.

Further regulation of hunting activity

In 2019, information collected during the SWC contributed to decisions to further regulate hunting activity, including the complete closure of five wetlands to duck hunting and partial closure of another, due to the presence of significant numbers of threatened species. On two large wetlands hunting from boats was prohibited to provide refuge for large numbers of Blue-billed Duck.

Table 1. Summary of Summer Waterbird Counts conducted in Victoria from 1987 to 2018

Year	Count period	Number of wetlands surveyed	Total count of game species	Total count of non-game species
1987	17–25 January	332	205,000	177,000
1988	6–14 February	472	294,108	185,821
1989	4–12 February	626	292,598	170,375
1990	18–26 February	668	385,148	225,230
1991	16–24 February	786	414,417	264,610
1992	22 February – 1 March	659	408,004	219,411
1993	20–28 February	534	218,562	107,650
1994	26 February – 6 March	284	292,899	173,887
1995	25 February – 5 March	367	196,955	141,609
1996	24 February – 3 March	234	200,861	197,916
1997	22 February – 2 March	223	124,914	92,003
1998	21 February – 1 March	309	216,476	152,348
1999	27 February – 7 March	312	206,839	128,969
2000	26 February – 5 March	298	128,021	78,675
2001	24 February – 4 March	336	240,671	102,926
2002	23 February – 3 March	225	231,235	106,191
2003	22 February – 2 March	175	155,623	93,972
2004	21–29 February	249	187,139	85,468
2005	19–27 February	272	155,069	81,950
2006	25 February – 5 March	268	182,487	85,887
2007	24 February – 4 March	176	91,210	46,770
2008	23 February – 2 March	191	58,628	41,454
2009	21 February – 1 March	161	78,723	38,283

Year	Count period	Number of wetlands surveyed	Total count of game species	Total count of non-game species
2010	20–28 February	153	77,649	35,485
2011	19 February – 6 March	201	104,903	16,768
2012	11 February – 4 March	136	212,865	81,848
2013	9 February – 2 March	133	185,507	103,467
2014	10–23 February	166	267,055	113,717
2015	16–28 February	126	159,666	74,290
2016	15–26 February	131	92,168	74,452
2017	13–24 February	127	283,430	114,463
2018	12–23 February	144	262,397	130,762
2019	11-22 February	135	225,733	85,889
Mean		291	207,181	116,047

Table 2. Coverage of priority wetlands in the 2019 Summer Waterfowl Count by DELWP region.

Note that the reason for not surveying many of the priority wetlands that were missed is that they were known to be dry.

DELWP region	Number of priority wetlands	Number of priority wetlands surveyed (%)	Number of non-priority wetlands surveyed
Barwon South West	42	33 (79)	5
Gippsland	14	11 (79)	2
Grampians	37	29 (78)	1
Hume	17	15 (88)	1
Loddon Mallee	43	34 (79)	3
Port Phillip	1	1 (100)	0
All	154	123 (80)	12

Table 3. Numbers of each game species counted in each DELWP region during the 2019 Victorian Summer Waterbird Count

Note that hunting the Australasian Shoveler was prohibited during the 2018 duck hunting season.

DELWP region	Species								Total
	Australian Wood Duck	Australian Shelduck	Pacific Black Duck	Chestnut Teal	Grey Teal	Australasian Shoveler	Pink-eared Duck	Hardhead	
Barwon South West	16	11,558	360	5,030	18,171	2,383	13,823	4,665	56,006
Gippsland	480	124	225	315	204	9	31	8	1,396
Grampians	38	2,369	129	226	6796	834	1,400	603	12,395
Hume	55	0	65	0	0	0	0	0	120
Loddon Mallee	1,502	561	710	4	10,186	329	1,580	83	14,955
Port Phillip	6	51,672	2,765	9,786	18,595	10,437	36,089	11,511	140,861
2019 total (% of total game birds)	2,097 (0.9%)	66,284 (29.4%)	4,254 (1.9%)	15,361 (6.8%)	53,952 (23.9%)	13,992 (6.2%)	52,923 (23.4%)	16,870 (7.5%)	225,733 (100%)
2018 total (% difference, 2019–2018)	1,594 (32%)	52,120 (27%)	6,408 (–34%)	22,697 (–32%)	90,779 (–41%)	11,555 (21%)	52,771 (0%)	24,473 (–31%)	260,180 (–13%)

Table 4. Numbers of the selected species of non-game waterbirds counted in each DELWP region during the 2019 Victorian Summer Waterbird Count

DELWP region	Species								Total
	Eurasian Coot	Great Crested Grebe	Australasian Grebe	Hoary-headed Grebe	Freckled Duck	Black Swan	Blue-billed Duck	Musk Duck	
Barwon South West	16,232	424	752	549	210	1,272	3,531	66	23,036
Gippsland	16	0	12	11	0	409	0	0	448
Grampians	6,752	2	2,065	526	320	248	0	210	10,123
Hume	31	0	0	0	0	90	0	0	121
Loddon Mallee	5,600	50	70	270	103	1916	45	15	8,069
Port Phillip	8,934	200	8	19,229	327	9174	5,447	773	44,092
2019 total (% of total non-game birds)	37,565 (43.7%)	676 (0.8%)	2,907 (3.4%)	20,585 (24.0%)	960 (1.1%)	13,109 (15.3%)	9,023 (10.5%)	1,064 (1.2%)	85,889 (100%)
2018 total (% difference, 2019–2018)	63,239 (–41%)	284 (138%)	2,765 (5%)	33,556 (–39%)	1,658 (–43%)	20,673 (–37%)	7,748 (16%)	839 (27%)	114,463 (–25%)

Table 5. Comparison of the numbers of game and selected non-game species counted statewide and at the Western Treatment Plant (WTP) in 2019

Species	Total count	WTP count	WTP %
Game species			
Australian Shelduck	66,284	51,672	78
Australian Wood Duck	2,097	6	0.3
Australasian Shoveler	13,992	10,437	75
Chestnut Teal	15,361	9,786	64
Grey Teal	53,952	18,595	34
Hardhead	16,870	11,511	68
Pacific Black Duck	4,254	2,765	65
Pink-eared Duck	52,923	36,089	68
Game species total	225,733	140,861	62
Non-game species			
Australasian Grebe	2,907	8	0.3
Black Swan	13,109	9,174	70
Blue-billed Duck	9,023	5,447	60
Eurasian Coot	37,565	8,934	24
Freckled Duck	960	327	34
Great Crested Grebe	676	200	30
Hoary-headed Grebe	20,585	19,229	93
Musk Duck	1,064	773	73
Non-game species total	85,889	44,092	51

Table 6. Numbers of Freckled Duck recorded during Summer Waterbird Counts, 1987–2019

Year	Number of wetlands counted	Number of wetlands with Freckled Duck	Total count of Freckled Duck
1987	445	23	219
1988	484	7	69
1989	642	11	76
1990	665	13	95
1991	786	12	167
1992	664	14	106
1993	504	13	149
1994	343	6	44
1995	367	4	63
1996	234	1	2
1997	223	2	55
1998	309	1	4
1999	298	8	82
2000	328	2	16
2001	336	7	32
2002	225	9	550
2003	175	10	798
2004	249	11	929
2005	272	9	186
2006	268	13	661
2007	176	5	82
2008	191	3	46
2009	161	2	69
2010	153	2	9
2011	201	2	8
2012	136	7	133
2013	133	23	1056
2014	166	18	2803
2015	126	9	258
2016	130	4	174
2017	126	20	447
2018	144	13	1658
2019	135	10	960
Mean	297	8.9	364

Table 7. Five most populous wetlands (sum of counts of the eight game and eight non-game species) in each DELWP Region in 2019.

DELWP Region	Wetland	Count
Barwon South West	Lake Linlithgow	27,502
	Lake Bolac	27,106
	Tower Hill lake	8,822
	Lake Murdeduke	6,335
	Lake Rosine	5,316
Gippsland	Dowd Morass	908
	Heart Morass	692
	Victoria Lagoon	615
	Morleys Swamp	295
	Lake Kakydra	248
Grampians	Lake Lonsdale	16,795
	Pine Lake	1,767
	Lake Fyans	1,674
	Lake Burrumbeet	1,270
	Lake Buninjon	804
Hume	Lake Buffalo	364
	Lake Nagambie	195
Loddon Mallee	Lake Cullen	8,650
	Heywoods Lake	5,189
	Lake Murphy	4,521
	Lake Elizabeth	3,696
	Round Lake	2,813
Port Phillip	Werribee Treatment Plant	186,588

Discussion

Overall, counts in 2019 were lower than those of the previous year, probably due to the continuing very dry conditions (the first three months of 2019 in Victoria were the driest on record and 55% of wetlands visited were completely dry). Consequently, waterbirds were concentrated on a smaller number of large, more permanent wetlands. This situation risks increasing the proportion of available birds harvested because hunters are concentrated on fewer wetlands.

Total counts of Pacific Black Duck, Grey Teal, Chestnut Teal and Hardhead had decreased from the 2018 totals while Australian Wood Duck, Australian Shelduck and Australasian Shoveler increased. The total count of Pink-eared Ducks did not change between years. Amongst the non-game species, decreases were found for Eurasian Coot, Hoary-headed Grebe, Freckled Duck and Black Swan while Great Crested Grebe and Musk Duck increased in number between years.

Limitations and constraints

The limitations and constraints of the SWC need to be appreciated when considering the results. While it is the only long-term, land-based survey of the State's waterbirds, with annual counts since 1987, the number of wetlands surveyed has declined from a peak of 786 wetlands in 1991, to 125–140 in recent years. The current level of survey effort renders meaningful statewide, year-by-year comparisons increasingly difficult. Regional organisers are encouraged to focus survey effort on those wetlands that are on public land, are open to hunting and which consistently hold large numbers of game species. This biases the data towards waterbird species that prefer large and more permanent wetlands (such as Hardhead, Blue-billed Duck, Eurasian Coot and Hoary-headed Grebe), and against those species that prefer shallower, ephemeral and more highly vegetated wetlands (such as teal, Pink-eared Duck and bitterns). Furthermore, as survey coverage decreases, the chances of the survey failing to record aggregations of significant species increases, which compromises the value of the SWC as a tool for informing the management of duck hunting.

The future

The original SWC was designed to achieve two main objectives (Loyn 1989, 1991):

1. to locate flocks of threatened waterfowl or breeding aggregations of waterbirds that may warrant additional management during the coming duck hunting season
2. to obtain data on numbers of waterbirds in Victoria for long-term monitoring.

Management of game species requires long-term tracking of changes in species abundance across the state and the continent. The inherent variability of the Australian climate has profound effects on the availability of habitat for waterbirds, and breeding opportunities are typically provided by flood events in disparate parts of the continent (e.g. Frith 1982; Kingsford and Norman 2002).

Long-term datasets are essential to tease out the relative importance of these climatic influences, compared to immediate human impacts, such as hunting and the provision of environmental water. Such datasets are rare in Australia, and many have been discontinued. In Victoria, only Western Port has been monitored long term, since 1973 (Loyn et al. 1994; Hansen et al. 2015), and the WTP has been intensively monitored since 2000 (Loyn et al. 2014). On a much broader scale, the Eastern Australian Aerial Waterbird Survey (EAAWS), which began in 1983, has provided annual abundance indices of waterbirds and wetland habitats across a standard series of aerial census lines from Queensland to Victoria and into South Australia (see <https://www.ecosystem.unsw.edu.au/content/rivers-and-wetlands/waterbirds/eastern-australian-waterbird-survey>). However, the aerial census lines used in the EAAWS are widely spaced (2 degrees of latitude or approximately 168 km in Victoria) and thus many important Victorian wetlands are not covered.

The SWC adds a broad perspective to our understanding of waterfowl numbers and distribution within Victoria, with data having been collected from a large number of wetlands (126+ annually, and approximately 1,500 altogether) between 1987 and 2019. The data summarised here add to the series that is used to assist decision making about duck hunting and wetland management in the state, as envisaged by Loyn (1991). Only a sample of the State's wetlands is surveyed each year, and it should be stressed that most of these counts do not provide data on absolute numbers of waterbirds or total species diversity. While the primary aim of the Summer Waterbird Count is to identify wetlands that warrant consideration for further regulation of

hunting (objective 1), it also has value as an index of abundance for comparisons between years (objective 2), for example, Murray et al. (2012).

As well as informing the further regulation of hunting, SWC data have proved helpful in other waterfowl monitoring programs (e.g. Pacioni et al. 2017, and BirdLife Australia's Australian Waterbird Index project (Clemens et al. in prep)). However, for game species, abundance data tell only part of the story and more detailed information such as sex and age structuring within populations is required to allow meaningful population modelling that would provide greater confidence that game species are being managed sustainably. To better assess the impact of the Victorian duck hunting season on populations of game species, we recommend adoption of an adaptive harvest model approach, as foreshadowed in the Sustainable Hunting Action Plan 2016-2020 (DEDJTR 2016).

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Appendix 1: List of priority wetlands

DELWP region	Wetland name	Counted	Dry during count
Barwon South West	Bradys Swamp	Y	Y
Barwon South West	Brown Swamp	Y	Y
Barwon South West	Bryans Swamp	N	
Barwon South West	Bullrush Swamp	Y	
Barwon South West	Carter Swamp	Y	Y
Barwon South West	Deep Lake	Y	
Barwon South West	Eurack Swamp	Y	
Barwon South West	Holdsworth Swamp	N	
Barwon South West	Horse Poles Dam	Y	Y
Barwon South West	Hospital Swamp	N	
Barwon South West	Lake Balkil Narra	Y	Y
Barwon South West	Lake Bolac	Y	
Barwon South West	Lake Bookar	Y	Y
Barwon South West	Lake Buninjon	Y	
Barwon South West	Lake Colac	Y	
Barwon South West	Lake Colongulac	Y	
Barwon South West	Lake Connewarre	N	
Barwon South West	Lake Coradgill	Y	Y
Barwon South West	Lake Elingamite	Y	
Barwon South West	Lake Forest	N	
Barwon South West	Lake Gherang	Y	Y
Barwon South West	Lake Kariah	Y	Y
Barwon South West	Lake Kennedy	Y	
Barwon South West	Lake Koreetnuug	Y	Y
Barwon South West	Lake Linlithgow	Y	
Barwon South West	Lake Martin	Y	Y
Barwon South West	Lake Muirhead	N	
Barwon South West	Lake Murdeduke	Y	
Barwon South West	Lake Oundell	N	
Barwon South West	Lake Pumpunal	Y	Y
Barwon South West	Lake Rosine	Y	
Barwon South West	Lake Round	Y	Y
Barwon South West	Lake Struan	Y	

DELWP region	Wetland name	Counted	Dry during count
Barwon South West	Lake Terang Goodwich	Y	Y
Barwon South West	Lake Terangpom	Y	
Barwon South West	Lake Tooliorook	Y	
Barwon South West	Lake Turangmoroke	Y	
Barwon South West	Lake Weering	Y	
Barwon South West	Lough Calvert	N	
Barwon South West	Reedy Lake	N	
Barwon South West	Tower Hill	Y	
Barwon South West	Walkers Swamp	Y	Y
Gippsland	Blond Bay SGR	Y	
Gippsland	Clydebank Morass	Y	
Gippsland	Dowds Morass SGR	Y	
Gippsland	Freshwater Swamp SGR	Y	Y
Gippsland	Heart Morass	Y	
Gippsland	Hollands Landing (Lagoon)	N	
Gippsland	Jack Smith SGR	Y	
Gippsland	Lake Coleman	Y	
Gippsland	Lake Corringale	N	
Gippsland	Lake Curlip	N	
Gippsland	Lake Kakydra	Y	
Gippsland	Macleods Morass	Y	
Gippsland	Morleys Swamp	Y	
Gippsland	Victoria Lagoon	Y	
Grampians	Black Swamp	N	
Grampians	Booroopki Swamp	Y	Y
Grampians	Coghills Creek Dam	Y	Y
Grampians	Connan Swamp	Y	Y
Grampians	Dock Lake	Y	Y
Grampians	Harnath Swamp	N	
Grampians	Jacka Lake	Y	Y
Grampians	Krause Swamp	Y	Y
Grampians	Lake Albacutya	Y	Y
Grampians	Lake Buninjon	Y	
Grampians	Lake Burrumbeet	Y	
Grampians	Lake Carpolac	Y	
Grampians	Lake Clarke	Y	Y
Grampians	Lake Fyans	Y	
Grampians	Lake Goldsmith	N	

DELWP region	Wetland name	Counted	Dry during count
Grampians	Lake Hindmarsh	Y	Y
Grampians	Lake Karnac	Y	Y
Grampians	Lake Kennedy	N	
Grampians	Lake Koynock	Y	Y
Grampians	Lake Lonsdale	Y	
Grampians	Lake Muirhead	Y	Y
Grampians	Lake Natimuk	Y	Y
Grampians	Lake Oundell	Y	Y
Grampians	Lake Wongan	Y	Y
Grampians	McGlashins Swamp	Y	Y
Grampians	Merin Merin Swamp	Y	Y
Grampians	Pine Lake	Y	
Grampians	Shooters Swamp	N	
Grampians	Taylors	Y	
Grampians	Toolondo Reservoir	Y	
Grampians	Wally Allans Swamp	Y	Y
Grampians	Waurin Swamp	Y	Y
Grampians	Winter Lake	Y	Y
Grampians	Yarrackigarra Swamp	Y	Y
Hume	Big Reedy Lagoon	Y	Y
Hume	Black Swamp (Black Dog Creek)	Y	
Hume	Black Swamp (Nine Mile Creek)	Y	Y
Hume	Buffalo Dam	Y	
Hume	Dowdle Swamp	Y	Y
Hume	Jubilee Swamp	Y	Y
Hume	Lake Moodemere	Y	
Hume	Lake Nagambie	Y	
Hume	Lehmann Swamp	Y	Y
Hume	Loch Garry	Y	Y
Hume	McBurney Swamp	Y	Y
Hume	Moodie Swamp	Y	Y
Hume	Morphett Swamp	Y	Y
Hume	Murchison Swamp	N	
Hume	Reedy Lake Nagambie	N	
Hume	Rowan Swamp	Y	Y
Hume	Tungamah Swamp	Y	Y
Loddon Mallee	Lake Wandella	N	

DELWP region	Wetland name	Counted	Dry during count
Loddon Mallee	Browns Lake	N	
Loddon Mallee	First Marsh	N	
Loddon Mallee	Gaynors Swamp	Y	Y
Loddon Mallee	Gil Gil	N	
Loddon Mallee	Green Lake	Y	
Loddon Mallee	Heywoods Lake	Y	
Loddon Mallee	Hird Swamp	N	
Loddon Mallee	Horseshoe Bend Billabong	Y	
Loddon Mallee	Johnson's Swamp	N	
Loddon Mallee	Lake Bael Bael	N	
Loddon Mallee	Lake Batyo Catyo	N	
Loddon Mallee	Lake Boort	N	
Loddon Mallee	Lake Buloke	Y	Y
Loddon Mallee	Lake Carpul	Y	Y
Loddon Mallee	Lake Cooper	Y	Y
Loddon Mallee	Lake Coorong	Y	Y
Loddon Mallee	Lake Cullen	Y	
Loddon Mallee	Lake Elizabeth	Y	
Loddon Mallee	Lake Grassy	Y	Y
Loddon Mallee	Lake Hancock	Y	Y
Loddon Mallee	Lake Leaghur	Y	Y
Loddon Mallee	Lake Meran	Y	
Loddon Mallee	Lake Murphy	Y	
Loddon Mallee	Lake Nurrumbeet	Y	Y
Loddon Mallee	Lake Powell	Y	Y
Loddon Mallee	Lake Tutchewop	Y	Y
Loddon Mallee	Lake Yando	Y	Y
Loddon Mallee	Little Lake Buloke	Y	Y
Loddon Mallee	Mansfield Swamp	Y	Y
Loddon Mallee	McDonalds Swamp	Y	Y
Loddon Mallee	Meridian Basin	Y	Y
Loddon Mallee	Racecourse Lake	Y	
Loddon Mallee	Richardsons Lagoon	Y	
Loddon Mallee	Round Lake	Y	
Loddon Mallee	Second Marsh	Y	Y
Loddon Mallee	Third Marsh	Y	Y
Loddon Mallee	Tobacco Lake	Y	Y
Loddon Mallee	Walkers Lake	YY	
Loddon Mallee	Wallenjoe	Y	Y

DELWP region	Wetland name	Counted	Dry during count
Loddon Mallee	Woolshed Swamp	Y	Y
Loddon Mallee	Wooroonook Lake (Church)	Y	Y
Loddon Mallee	Wooroonook Lake (Main)	Y	
Port Phillip	Western Treatment Plant	Y	

Appendix 2: Other wetlands surveyed

DELWP region	Wetland name
Barwon South West	Killarney East Swamp
Barwon South West	Killarney Middle Swamp
Barwon South West	Killarney West Swamp
Barwon South West	Krause Swamp
Barwon South West	Cundare Pool
Gippsland	McLennan Strait, Hollands Landing
Gippsland	Lake Wat Wat
Grampians	Green Swamp
Hume	Reedy Swamp Shepparton
Loddon Mallee	Little lake Meran
Loddon Mallee	Vinnifera Billabong
Loddon Mallee	Wirra -Lo wetland