Phosphorus to St. Mary Lake from wintering waterbirds.

For Technical Advisory Committee of Salt Spring Island Water Protection Authority

John B. Sprague
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Summary

(1) Wintering waterbirds probably contribute about 13 kg of phosphorus to St. Mary Lake in their excrement. This is a relatively small amount, somewhat more than the 10 kg which is thought to come from groundwater entering at the bottom of the lake.

(2) The 13 kg of phosphorus was the amount estimated to be in the total food intake by the waterbirds during their stay in the lake. The birds apparently show little growth during the winter, and so the output of phosphorus in excrement should approximately equal the input in the birds' food.

(3) Fifteen species of waterbirds are commonly found on the lake during winter, for long or short periods. The most numerous were Ring-necked Duck and Canada Goose. The most important in terms of numbers and length of stay were usually Ring-necked Duck (26,000 bird-days), Canada Goose (14,000 bird-days), and Common Merganser and Double-crested Cormorant, each with about 3,000 bird-days. The biggest contributors of excrement phosphorus to the lake are probably Canada Geese, Double-crested Cormorants, Common Mergansers, and Ring-necked Ducks.

(4) Readers can decide the significance of this input. Almost all of the food intake by the birds is vegetation, invertebrates and fish that were available in the lake. Accordingly, the phosphorus in the birds' food was already in the lake, and the excreted phosphorus was simply cycling through the birds and returning to the lake. From one point of view, there has been no new phosphorus added to the lake. From another point of view, the phosphorus was previously locked up in vegetation, fish, or invertebrates, but after passing through the waterbirds, it was released into the water, presumably in a soluble form. Thus it would be available to stimulate algal growth.

(5) One small importation of phosphorus would be land-based vegetation, eaten by Canada geese with later excretion into the lake. This would possibly be only 1 or 2 kg during the year. This land-based importation was not separated out in the analysis.

(6) The numerical values in this study are derived from considerably incomplete or scanty sets of data, together with a number of assumptions, best estimates, and simplifications.

Numbers of birds

Records for 12 years of the Christmas bird count were used (1998 -2014). The data for "zone 11" of the count included St. Mary Lake, and those data are shown in Table 1. That zone also includes observations near the shore of Walker Hook. Numbers for St. Mary Lake were estimated by subtractions of some birds that would have been likely at Walker Hook, in the author's judgement. The adjustments may be seen in Table 1.

Birds were classified according to the predominant nature of their feeding, as herbivorous, carnivorous, or omnivorous.

	1998	1999	2000	####	2003	2005	2006	2007	2008	2010	2013	2014		AVERAGE	WALKER HOOK
Herbivorous (mostly)															
Coot	12	0	0	0	6	9	18	27	0	0	9	28		9	**9**
American Wigeon	95	85	0	0	88	128	26	76	11	218	230	60		85	**17**
Canada Goose	79	0	112	28	67	179	65	340	6	145	52	84		96	**96**
Trumpeter Swan	0	0	0	0	11	7	0	4	17	0	0	5		4	**4**
Carnivorous (mostly)															
Northern Shoveller	0	0	0	0	0	0	0	0	0	0	140	0		12	**12**
Common Goldeneye	31	22	16	0	6	18	27	32	10	30	27	10		19	**4**
Ruddy Duck	0	0	0	2	55	0	11	0		2	13	0		7	**7**
Dbl-crstd Cormorant	10	8	2	1	43	20	6	52	74	33	45	35		27	**21**
Common Merganser	28	14	5	3	68	30	88	202	36	19	75	74		54	**54**
Lesser Scaup	3	12	1	0	7	3	11	5	2	20	0	12		6	**6**
Pied-billed Grebe	12	0	12	5	20	24	8	4	2	2	9	2		8	**8**
Bufflehead	89	46	97	20	75	94	129	90	31	123	145	36		81	**41**
Omnivorouss															
Glaucous-winged Gul	48	0	13	6	30	12	55	58	5	11	15	22		23	**5**
Ring-necked duck	76	25	295	8	505	398	21	410	102	89	230	417		215	**215**
Mallard	83	13	75	0	9	9	64	13	4	47	6	22		29	**29**

Combining numbers of birds and lengths of stay

The Christmas counts of Table 1 are single-day observations. The various species have different schedules for coming to the lake and leaving it. To get an estimate of times spent by the birds, I consulted Dr. R. Weeden, an ornithologist who passes by the lake most days, and has noted the species present. From his observations, and in some cases from his written notes, general descriptions were obtained for movements of the various species. I used personal judgement in applying these observations, to estimate the numbers of days that the species would be present in the lake, *at the density observed in the Christmas bird count.* In other words, allowance was made for the number of days present, but also for some gradual increase and gradual tapering off, as a species came to the lake and later moved out of the lake. Considerable judgement was involved in those estimates.

The result was stated as the number of *bird-days* for each species, shown in Table 2.

TABLE 2. AVERAGE NO. OF BIRDS FROM C'MAS COUNT MULTIPLIED BY ESTIMATED TIME PRESENT

(I.E. ALLOWING FOR BUILD-UP OF NUMBERS IN AUTUMN AND TAPERING OFF IN SPRING.)

SPECIES	NUMBER AT CMAS	MONTH-EQUIVALENTS	BIRD-DAYS	NOTES
Herbivorous				
Coot	9	1	**273**	Short-timers. Perhaps a month at most
American Wigeon	17	3	**1526**	Mainly salt-water species but a few in winter. About 3 months.
Canada Goose	96	5	**14463**	A dozen stay for summer, others leave early spring. About 5 mo.
Trumpeter Swan	4	1.5	**165**	Spend weeks on lake. Equivalent 1.5 months.
Carnivorous				
Northern Shoveller	12	0.7	**245**	Short-timers ... 2 or 3 weeks.
Common Goldeneye	4	3	**344**	Erratic. Arrive late in Nov., leave March. About 3 months.
Ruddy Duck	7	0.25	**52**	Relatively short time. For a week.
Dbl-crstd Cormorant	21	5	**3084**	Most of winter, 3-4 weeks at a time. Equivalent perhaps 5 mo..
Common Merganser	54	2	**3210**	Come C'mas & go end Feb. as flock, sometimes absent. So 2 mo.
Lesser Scaup	6	3	**570**	Similar to Ring-necked, so about 3 months full-time equivalent.
Pied-billed Grebe	8	1.5	**375**	Not always present in winter. Equivalent maybe 1.5 months.
Bufflehead	41	4	**4875**	Come Nov., most gone April. Occasional absence. Equiv. 4 mo.
Omnivorous				
Glaucous-winged Gul	5	2	**275**	Erratic. All winter but on and off. Equivalent maybe 2 months.
Ring-necked duck	215	4	**25760**	Start appear Oct., leave starting late Feb. About 4 full-time mo.
Mallard	29	4	**3450**	Most to ponds in spring, a few stay. =4 mo. at Cmas strength.

Allowing for size of individuals and food intake

Clearly, size of bird will influence food intake and egestion/excretion. Wet weights of the various species were obtained from a definitive source, *Birds of North America online* (Cornell Lab. of Ornithology and American Ornithologists Union). Those weights are shown in Table 3.

Food intake for many of the species could be obtained from the same source. Sometimes the intake was given as actual weight of food, and sometimes as a proportion of body weight. Those values could be translated to each other, and both are given in Table 3. Some species did not have information on amount of food intake, so values were estimated (last column of Table 3) from the average percentage of body weight for the category of bird.

TABLE 3. ESTIMATED FOOD INTAKE BY WINTER WATERBIRDS

				FOOD INTAKE. g/day•bird			
SPECIES	**WEIGHT OF BIRDS, grams**			**% OF**		**THEOR-**	
	FEMALE	**MALE**	**AVERAGE**	**BODY**	**AMOUNT,**	**ETICAL**	**NOTES.**
				WEIGHT	**GRAMS**	**AMOUNT**	
Herbivorous						**GRAMS***	
Coot	451	629	540	10%	54		Vascular plants, algae, invert 11%. 10% body wt/day
American Wigeon	716	792	754			202	Aquatic plants, grass clover, some inverts
Canada Goose	3251	3882	3567			954	Grass sedge berries seeds, aquatic plants
Trumpeter Swan	9950	11900	10925	43%	4750		Herbivore, occas. fish, invert. 4.5-5.5 kg wet wt/day
		Herbivore average =		27%			
Carnivorous							
Northern Shoveller	543	620	582	33%	194		700 gm bird needs 204 kcal/day (see below**
Common Goldeneye	804	1042	923	6%	59		Needs 70 kcal/d = 59 g insects
Ruddy Duck	530	590	560			132	
Dbl-crstd Cormorant	1831	2089	1960	26%	500		
Common Merganser	1334	1712	1523	23%	379		23% of body weight in winter
Lesser Scaup	693	708	701			165	
Pied-billed Grebe	358	474	416	27%	113		75-150 gm fish/day
Bufflehead	337	465	401	26%	103		
		Carnivore average =		23%			
Omnivorous							
Glaucous-winged Gu	946	1180	1063			170	
Ring-necked duck	644	692	668			107	62% aquatic plants, seed, 38% aquatic invert.
Mallard	1081	1203	1142	16%	185		
		Omnivore average =		16%			

* Theoretical amount is based on average for the group, of intake as % of body weight.

Total consumption of food by waterbirds

For each species, the number of bird-days during the winter was multiplied by the daily food intake per bird. That estimated the total food consumption for each species during its winter stay in St. Mary Lake. By addition, the total food consumption by all species was obtained although that total was not useful in further calculations. Results of these operations are shown in Table 4.

TABLE 4. ESTIMATED TOTAL FOOD INTAKE BY WINTER WATERBIRDS

SPECIES	WEIGHT OF AVERAGE INDIVIDUAL BIRD	FOOD INTAKE PER BIRD, GRAMS	BIRD-DAYS FOR THE YEAR	Kg FOOD PER YEAR
Herbivorous				
Coot	540	54	**273**	15
American Wigeon	754	202	1526	308
Canada Goose	3567	954	14463	13,792
Trumpeter Swan	10925	4750	165	784
Carnivorous				
Northern Shoveller	582	194	245	47
Common Goldeneye	923	59	344	20
Ruddy Duck	560	132	52	7
Double-crested Cormorant	1960	500	3084	1,542
Common Merganser	1523	379	3210	1,217
Lesser Scaup	701	165	570	94
Pied-billed Grebe	416	113	375	42
Bufflehead	401	103	4875	500
Omnivorous				
Glaucous-winged Gull	1063	170	275	47
Ring-necked duck	668	107	25760	2,753
Mallard	1142	185	3450	638
			Total	21,806

Estimating the total amount of phosphorus from waterbirds

The final step was to search the literature for amount of phosphorus in the various foods used by waterbirds. This was not entirely satisfactory. There was little information for freshwater invertebrates, especially for insects. Apparently such information for invertebrates has not been of great interest to investigators. The information for fish was often for flesh, i.e. fillets, not for whole fish. Searching was impeded by charges, usually about $U.S. 35, to read scientific papers online.

There was reasonable information for aquatic plants, with phosphorus (P) values for a representative selection of 28 species. The weighted average content of P, corrected to wet weight of the plants, was 0.0076%.

The P content obtained for invertebrates was 0.174% of wet weight, based on five aquatic insects and two freshwater crustaceans. For freshwater fish, two whole-fish measurements were found, and a value was added for meal produced from whole fish. Six estimates for fish flesh were included and did not appear to be out of line with the whole fish values. The weighted average was 0.190% wet weight.

Most of the analyses for P were stated in terms of dry weight. A search was made for water content of organisms. Average values adopted for water content were 88% for aquatic plants, 45% for invertebrates, and 75% for fish.

Each species of bird now had (a) an estimate for kg of food consumed during its stay at the lake, (b) reasonable indication of the dietary composition, and (c) approximations of the P content of food. Those values were combined to estimate the amount of P in the food of each species. The estimate for each species was tailored to the approximate proportion of plants, invertebrates, and fish in the diet. Totalling the species provided a value of 13 kg of P in all food consumed by waterbirds during their stay at St. Mary Lake. Calculations are shown in Table 5.

An assumption was that the birds did not grow during the winter. That appears to be more or less correct according to the literature (Birds of North America online). Therefore the egestion/excretion of P would be approximately equal to the intake with the food. Accordingly, the birds would put 13 kg of P into the lake during the year. This would presumably be in a soluble form.

TABLE 5. ESTIMATED AMOUNT OF PHOSPHORUS IN FOOD OF WINTER WATERBIRDS

SPECIES	KG OF FOOD PER YEAR	P CONTENT OF FOOD (see footnote*)	KG OF P PER YEAR	NOTES
Herbivorous (mostly)				
Coot	15	4.37%	0.006	89% plants, 11% invertebrates
American Wigeon	308	2.76%	0.085	Almost entirely vegetation
Canada Goose	13792	2.76%	3.807	Vegetation
Trumpeter Swan	784	2.76%	0.216	Vegetation
Carnivorous (mostly)				
Northern Shoveller	47	17.4%	0.083	Mostly very small invertebrates, Cladocera etc.
Common Goldeneye	20	17.4%	0.035	Largely fish, perhaps 10% vegetation.
Ruddy Duck	7	15.9%	0.011	Mostly invertebrates, perhaps 10% vegetation.
Dbl-crstd Cormorant	1542	19.0%	2.930	Almost entirely fish
Common Merganser	1217	19.0%	2.312	Almost entirely fish
Lesser Scaup	94	13.7%	0.129	75% invertebrates, remainder vegetation
Pied-billed Grebe	42	19.0%	0.081	Fish
Bufflehead	500	15.2%	0.760	15% vegetation, 85% invertrbrates and fish.
Omnivorous				
Glaucous-winged Gull	47	14.3%	0.067	Largely animal matter.
Ring-necked duck	2753	8.32%	2.292	38% invertebrates, 62% vegetable
Mallard	638	4.96%	0.316	Mostly vegetable in winter, inverts as available.
		Total:	**13**	

* Phosphorus content of food taken as averages of 0.0276% from 28 measurements for plants, 0.174% from 7 invertebrates, and 0.190% from 11 fish samples.

Discussion

No conclusion is offered here on the effect of this phosphorus release to the lake. No doubt the Technical Advisory Committee can come to agreement on this. As indicated in the summary, there are two ways of looking at the situation. (1) The P is already in the lake, contained in aquatic plants, invertebrates, plankton, and small fish. From that point of view there is no net input to the lake. (Some importation from the land by Canada Geese is an exception.). (2) The P contained in the food plants and animals is locked up in their tissues, and unavailable in the water column, as a source for encouraging algal blooms. The waterbirds convert the P to a form that is presumably available in the water column, and that represents a net increase for the water of the lake.

There is no apparent way of banishing the waterbirds from the lake. They are protected under the Migratory Birds Protection Act Canada. Cormorants are not included in that protection, but under the B.C. Wildlife Act, they are; it is a criminal offense if a person “injures, molests or destroys .... a bird”.

Assumptions, simplifications, and approximations

This was supposed to be a “back-of-the-envelope” estimation of the potential effect of the waterbirds. However, without some concrete data, any estimate would have been purely guesswork, and probably rather wild guesswork. That would have been of little use to the committee. Accordingly, some information was gathered to allow the approximations given here. Because of all the approximations, the result should be considered order-of-magnitude.

One assumption was that none of the species showed growth of individuals during their stay on the lake. That is apparently correct for many of the waterbirds during winter, but information was not available for all species.

Approximations included the author’s judgement on how many of the birds in the count for “zone 11” were at Walker Hook rather than St. Mary Lake.

One simplification was using averages, for example averaging the number of birds in each species, from the 12 years of information. There are major differences in behaviour of the species from year to year. Another simplification was using the same average water content for all species in a category, water contents based on information from a few species. Similarly, many of the food intakes were stated in terms of kilocalories; they were translated to a wet-weight basis from information available for a few species.