WWT CONSULTING

Client: West Cumbria Rivers Trust

Project: Water quality in Loweswater, Cumbria

Date: June 2014

Report: An assessment of the contribution of wildfowl to the Phosphorus levels in Loweswater, Cumbria

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1. INTRODUCTION

1.1 The Wildfowl & Wetlands Trust Consulting (WWT Consulting) Ltd. was commissioned by the West Cumbria Rivers Trust to undertake a study on nutrient loading impacts of wildfowl (Anseriformes - ducks, geese and swans) on Loweswater, Cumbria, paying particular attention to phosphorus.

2. METHODS

2.1 A survey of literature was undertaken on the subject of wildfowl contribution to nutrient load in lakes. From our search of scientific papers and reports, relevant publications were found which dealt with nutrient input to lakes from wildfowl.

2.2 The most useful facts obtained from the data search included values for guano production of wildfowl relating to bodyweight and values for the concentrations of phosphorus and other nutrients found in droppings from certain species of wildfowl (Broughton 1998, Sanderson & Anderson 1978 and Manny *et al.*, 1994).

2.3 British Trust for Ornithology (BTO) count data was provided by the West Cumbria Rivers Trust to help calculate nutrient loading by wildfowl. The dataset ranged from 1976 to 2010.

2.4 Peak monthly counts of each species were averaged using data covering the period of 1995 - 2010 (Table 1, Appendix I). This was used to provide an informed estimation of the likely number of birds using the lake daily, by multiplying the average peak monthly count by the number of days in that month. Monthly totals were added to give a number of species days per year (Table 2, Appendix I).

2.5 Standard deviations were calculated to illustrate the variance of the data, which are also shown in Table 1, Appendix I. Variability in this case is described by showing that 68% of the peak monthly count values fall within one standard deviation value of the mean of the peak monthly counts.

2.6 Thirteen species of wildfowl were identified during BTO counts. The list below details common and scientific names of the assemblage.

- Canada Goose *Branta canadensis*;
- Goldeneye *Bucephala clangula*;
- Goosander *Mergus merganser*;
- Greylag Goose (Icelandic) *Anser anser;*
- Greylag Goose (re-established) *Anser anser*;
- Mallard *Anas platyrhynchos*;
- Muteswan *Cygnus olor*;
- Pink-footed Goose *Anser brachyrynchus*;
- Pochard *Aythya ferina*;
- Shoveller *Anas clypeata*;
- Teal *Anas crecca;*
- Tufted Duck *Aythya fuligula*; and
- Wigeon *Anas penelope.*

2.7 A range of body weights for males and females of each species were taken from 'The Birds of the Western Palearctic' (Snow & Perrins, 1998) and an average weight per species calculated. These weights are illustrated in Table 3, Appendix I.

2.8 Sanderson & Anderson (1978) use 2.25% as a ratio of dry weight of guano produced per day to bodyweight of geese. Broughton (1998) suggest that 3.2% of bodyweight of geese is produced in droppings per day. This refers to the dry weight of the guano.

2.9 A mid-point between these values of 2.73% has been used in calculating the weight of guano produced by wildfowl in Loweswater per year.

2.10 Nutrient loading via the 13 bird species per year was calculated by assessing how much guano was produced per species per year, using total monthly counts, then calculating the weights of nutrients within the guano. Calculations are detailed in Table 4, Appendix I.

2.11 Manny *et al.* (1994) calculated that the daily nutrient load into a lake by an average migrant Canada Goose was 24.86g of carbon, 1.57g of nitrogen and 0.49g of phosphorus.

2.12 These values were used to calculate the proportions of nutrients in droppings of all species, by taking into account the bodyweights of the different birds. Droppings were considered to consist of 20.5% carbon, 1.3% nitrogen and 0.4% phosphorus (from an average Canada Goose producing 117.12g of droppings per day).

2.13 Nutrient loading per day, by month, was calculated by assessing the contribution of each species to the total guano production per day (using average peak monthly counts) and then calculating the weights of nutrients within the guano. Table 5, Appendix I, presents these data.

3. RESULTS

3.1 Table 6, Appendix I, shows that an estimated 1,341.9kg of bird droppings are created by wildfowl on Loweswater per year. This guano includes 275.1kg of carbon, 17.4kg of nitrogen and 5.4kg of phosphorus.

3.2 Nutrient loading per day, for each month is presented in Table 5, Appendix I, and as a graph in Figure 1, Appendix II.

3.3 The autumn and winter months are typically the months with the highest nutrient input to Loweswater by wildfowl. November is when birds contribute the most nutrients to the lake and phosphorus input per day in this month is 30.93g. December has the second highest value, with a 26.7g input of phosphorus per day.

3.4 Values fall in January to 13.82g per day, then rise in February to 20.13g per day. During the spring, bird counts are lower and the nutrient loading decreases sharply to 7.9g per day in March. Phosphorus input per day continues to fall through the spring, until a low for the year of 3.41g per day in May.

3.5 In the summer, as bird numbers increase, phosphorus input values start to rise slowly at first, with an input of 4.47g per day in June and 7.39g per day in July. Values rise faster in August and September with values of 14.56g and 22.45g per day respectively.

3.6 Nutrient input decreases slightly to 19.86g per day in October before rising again to the peak of the year in November.

4. DISCUSSION

Assumptions and estimates

4.1 Due to the complex nature of the topic and the coarse bird data which was available, a number of assumptions and estimates have been made in order to proceed:

- Bird numbers on Loweswater have been estimated from BTO peak monthly count data from 1995-2010;
- As requested, only counts of wildfowl (ducks and geese) have been used. Other groups of species such as herons, rails and gulls present on Loweswater have not been considered;
- It has been assumed that the number of individuals in each species' average peak monthly count were present on Loweswater for all days in that month;
- No output of nutrients from wildfowl feeding on Loweswater has been estimated;
- All guano produced by the species is assumed to have been deposited within Loweswater; and
- The guano from all species is assumed to contain the same percentages of nutrients as the Canada Goose droppings tested by Manny *et al.* (1994).

4.2 Problems associated with high phosphorus levels can include algal blooms in the summer months, when factors such as temperature and sunlight can exacerbate high nutrient levels. Related effects such as de-oxygenation of water and subsequent fish kills can also occur.

4.3 The amounts of phosphorus available to plants and algae within the lake may be less than calculated above, as bird droppings can rapidly sink to the bottom of the lake and be incorporated into the sediment (Unckless and Makarewicz, 2007) Nutrients in the sediment may only be released when disturbance occurs which move particles into the water column, for example after strong wind and wave action, or by the foraging behaviour of bottom feeding fish.

5. REFERENCES

Broughton RK. 1988. Eutrophication of a shallow lake in north east England: the impact of feral geese. University of Hull.

Manny BA, Johnson WC & Wetzel RG. 1994. Nutrient additions by wildfowl to lakes and reservoirs: predicting their effects on productivity and water quality. Hydrobiologia 279/280, 121-132

Sanderson GG & Anderson WL. 1978. Waterfowl studies at Lake Sangchris. Illinois Natural History Survey Bulletin 32:4, 656-690

Snow DW & Perrins CM. 1998. The Birds of the Western Palearctic Concise Edition. Oxford University Press.

Unckless RL & Makarewicz JC. 2007. The impact of nutrient loading on Canada Geese Branta canadensis on water quality, a mesocosm approach. Hydrobiologia 586, 393-401

APPENDIX I. Tables

Table 1 - Table of species' average peak means per month (Av.) and their Standard Deviations (SD) using data from 1995 - 2010

Month	Canada Goose		Goldeneye		Goosander		Greylag Goose (Icelandic population)		Greylag Goose (re-established)		Mallard		Mute Swan		Pink-footed Goose		Pochard		Shoveler		Teal		Tufted Duck		Wigeon	
	Av.	SD	Av.	SD	Av.	SD	Av.	SD	Av.	SD	Av.	SD	Av.	SD	Av.	SD	Av.	SD	Av.	SD	Av.	SD	Av.	SD	Av.	SD
Jan	0.00	0.00	3.18	2.89	0.36	0.81	16.27	35.06	0.00	0.00	45.82	50.18	0.00	0.00	0.00	0.00	8.64	6.33	0.18	0.60	0.00	0.00	6.82	3.76	9.82	18.16
Feb	1.42	4.32	7.08	2.64	0.00	0.00	29.33	38.16	1.33	4.62	41.00	39.78	0.00	0.00	0.00	0.00	7.92	7.88	0.00	0.00	0.00	0.00	8.08	5.32	20.17	22.71
Mar	0.15	0.55	6.38	2.53	0.23	0.83	10.69	14.46	0.00	0.00	14.38	16.88	0.00	0.00	0.00	0.00	2.77	5.76	0.00	0.00	0.15	0.55	8.69	5.11	8.31	16.98
Apr	0.50	1.07	4.63	1.41	0.50	0.93	7.75	4.65	0.00	0.00	10.25	6.54	0.00	0.00	0.00	0.00	0.38	0.74	0.00	0.00	0.00	0.00	9.38	4.81	0.00	0.00
May	0.38	1.06	0.00	0.00	0.75	0.89	3.00	2.78	0.75	2.12	11.50	4.28	0.00	0.00	0.00	0.00	0.13	0.35	0.00	0.00	0.00	0.00	5.00	3.96	0.00	0.00
Jun	0.00	0.00	0.00	0.00	0.00	0.00	5.11	6.27	0.00	0.00	18.67	8.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.33	4.27	0.00	0.00
Jul	0.00	0.00	0.17	0.41	0.17	0.41	3.33	8.16	0.00	0.00	34.50	16.06	0.33	0.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.17	9.99	0.00	0.00
Aug	0.00	0.00	0.00	0.00	3.14	7.03	18.86	14.95	0.00	0.00	36.00	50.69	0.57	0.98	0.00	0.00	2.43	3.26	0.00	0.00	0.00	0.00	27.29	13.90	0.00	0.00
Sep	0.00	0.00	0.00	0.00	3.38	6.39	19.13	26.56	31.25	88.39	22.50	18.84	0.00	0.00	0.13	0.35	1.75	2.49	0.00	0.00	0.00	0.00	16.63	14.62	0.25	0.71
Oct	0.00	0.00	0.78	1.99	0.11	0.33	29.67	49.82	0.00	0.00	66.22	44.23	0.22	0.67	0.00	0.00	4.11	4.31	0.00	0.00	0.00	0.00	9.44	8.02	0.00	0.00
Nov	0.00	0.00	2.63	2.50	0.00	0.00	45.50	58.33	0.00	0.00	111.63	71.29	0.00	0.00	0.00	0.00	5.88	4.29	0.00	0.00	0.13	0.35	4.75	3.33	4.50	12.73
Dec	5.33	11.50	3.67	2.12	0.67	1.12	33.33	40.39	0.00	0.00	79.67	28.27	0.00	0.00	0.00	0.00	6.56	2.13	0.00	0.00	1.89	4.96	9.33	3.08	12.33	19.99

Table 2 - Table of species days per month and total days present per year

Month	Days in month	Canada Goose	Goldeneye	Goosander	Greylag Goose (Icelandic population)	Greylag Goose (re-established)	Mallard	Mute Swan	Pink-footed Goose	Pochard	Shoveler	Teal	Tufted Duck	Wigeon	Total days per month across species
Jan	31	0.00	98.64	11.27	504.45	0.00	1420.36	0.00	0.00	267.73	5.64	0.00	211.36	304.36	**2823.82**
Feb	28	39.67	198.33	0.00	821.33	37.33	1148.00	0.00	0.00	221.67	0.00	0.00	226.33	564.67	**3257.33**
Mar	31	4.77	197.92	7.15	331.46	0.00	445.92	0.00	0.00	85.85	0.00	4.77	269.46	257.54	**1604.85**
Apr	30	15.00	138.75	15.00	232.50	0.00	307.50	0.00	0.00	11.25	0.00	0.00	281.25	0.00	**1001.25**
May	31	11.63	0.00	23.25	93.00	23.25	356.50	0.00	0.00	3.88	0.00	0.00	155.00	0.00	**666.50**
Jun	30	0.00	0.00	0.00	153.33	0.00	560.00	0.00	0.00	0.00	0.00	0.00	160.00	0.00	**873.33**
Jul	31	0.00	5.17	5.17	103.33	0.00	1069.50	10.33	0.00	0.00	0.00	0.00	625.17	0.00	**1818.67**
Aug	31	0.00	0.00	97.43	584.57	0.00	1116.00	17.71	0.00	75.29	0.00	0.00	845.86	0.00	**2736.86**
Sep	30	0.00	0.00	101.25	573.75	937.50	675.00	0.00	3.75	52.50	0.00	0.00	498.75	7.50	**2850.00**
Oct	31	0.00	24.11	3.44	919.67	0.00	2052.89	6.89	0.00	127.44	0.00	0.00	292.78	0.00	**3427.22**
Nov	30	0.00	78.75	0.00	1365.00	0.00	3348.75	0.00	0.00	176.25	0.00	3.75	142.50	135.00	**5250.00**
Dec	31	165.33	113.67	20.67	1033.33	0.00	2469.67	0.00	0.00	203.22	0.00	58.56	289.33	382.33	**4736.11**
Total days per year per species		**236.39**	**855.34**	**284.63**	**6715.74**	**998.08**	**14970.09**	**34.94**	**3.75**	**1225.07**	**5.64**	**67.07**	**3997.79**	**1651.40**	**31045.94**

Table 3 - Bodyweights of wildfowl identified by BTO counts on Loweswater in grams (Snow & Perrins 1998)

Species	Min	Max	Average
Canada Goose	3170	5410	4290
Gadwall	550	1000	775
Goldeneye	650	1200	925
Goosander	900	2100	1500
Greylag Goose (Icelandic population)	2100	4300	3200
Greylag Goose (re-established)	2100	4300	3200
Mallard	750	1450	1100
Mute Swan	7000	14000	10500
Pink-footed Goose	1800	3100	2450
Pochard	650	1200	925
Shoveler	470	800	635
Teal	200	450	325
Tufted Duck	500	1000	750
Whooper Swan	8500	10000	9250
Wigeon	500	1000	750

Table 4 - Amount of guano produced per year by species

	Canada Goose	Goldeneye	Goosander	Greylag Goose (Icelandic population)	Greylag Goose (re-established)	Mallard	Mute Swan	Pink-footed Goose	Pochard	Shoveler	Teal	Tufted Duck	Wigeon
Total species days present per year	236.39	855.34	284.63	6715.74	998.08	14970.09	34.94	3.75	1225.07	5.64	67.07	3997.79	1651.40
Average bodyweight in grams	4290	925	1500	3200	3200	1100	10500	2450	925	635	325	750	750
Percent of bodyweight to guano per day	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73
Kilograms of guano per year	27.69	21.60	11.66	586.69	87.19	449.55	10.01	0.25	30.94	0.10	0.60	81.85	33.81

Table 5 - Nutrient load per day by month

Month	Guano per day (g)	Carbon per day (g)	Nitrogen per day (g)	Phosphorus per day (g)
Jan	3454.62	708.20	44.91	13.82
Feb	5033.39	1031.85	65.43	20.13
Mar	1974.12	404.69	25.66	7.90
Apr	1382.10	283.33	17.97	5.53
May	853.11	174.89	11.09	3.41
Jun	1116.27	228.83	14.51	4.47
Jul	1846.73	378.58	24.01	7.39
Aug	3640.94	746.39	47.33	14.56
Sep	5612.71	1150.61	72.97	22.45
Oct	4965.42	1017.91	64.55	19.86
Nov	7732.13	1585.09	100.52	30.93
Dec	6674.83	1368.34	86.77	26.70

Table 6 - Weights of guano and nutrients produced per year by wildfowl species

Nutrient input per year (g)	Canada Goose	Goldeneye	Goosander	Greylag Goose (Icelandic population)	Greylag Goose (re-established)	Mallard	Mute Swan	Pink-footed Goose	Pochard	Shoveler	Teal	Tufted Duck	Wigeon	Total (g)
Guano	27685.78	21599.40	11655.72	586686.83	87192.56	449551.87	10014.55	250.82	30936.02	97.71	595.12	81854.82	33812.46	**1341933.66**
Carbon	5675.59	4427.88	2389.42	120270.80	17874.47	92158.13	2052.98	51.42	6341.88	20.03	122.00	16780.24	6931.55	**275096.40**
Nitrogen	359.92	280.79	151.52	7626.93	1133.50	5844.17	130.19	3.26	402.17	1.27	7.74	1064.11	439.56	**17445.14**
Phosphorus	110.74	86.40	46.62	2346.75	348.77	1798.21	40.06	1.00	123.74	0.39	2.38	327.42	135.25	**5367.73**

APPENDIX II. Figures

Figure 1 - Graph showing the relationship between month and phosphorus values per day in grams