Notornis, 2015, Vol. 62: 184-191
0029-4470 © The Ornithological Society of New Zealand Inc.

Analysis of the impacts of a water channel diversion wall on waterbirds inhabiting the western end of Lake Rotoiti, Bay of Plenty, New Zealand

DES SMITH
Wildland Consultants Ltd, PO Box 33499, Christchurch, New Zealand

CHRIS BYCROFT
Wildland Consultants Ltd, PO Box 7137, Te Ngae, Rotorua 3042, New Zealand

RACHEL McCLELLAN*
Wildland Consultants Ltd, PO Box 50539, Wellington, New Zealand

RICHARD GILLIES
WILLIAM SHAW
Wildland Consultants Ltd, PO Box 7137, Te Ngae, Rotorua 3042, New Zealand

Abstract Cyanobacterial blooms in Lake Rotoiti have been linked to nutrient flows from Lake Rotorua via the Ohau Channel. To mitigate this, a diversion wall was constructed in 2008 that was designed to redirect water entering Lake Rotoiti from Lake Rotorua into the Kaituna River. One concern was whether the presence of the diversion wall might have adverse impacts on the abundance of birds using the lake. Monthly bird counts were undertaken at 8 sites in Lake Rotoiti, over 8 years, and which spanned the period before, during and after construction of the wall. Generalised linear mixed effect models and AIC were used to investigate any effects of the wall on 6 bird species. There was no apparent impact of the wall on 5 of the species. The sixth species, little black shag (*Phalacrocorax melanoleucos*), was more abundant in sites surrounding the wall post-construction, and appeared to be using the wall for roosting and to hunt for smelt.

Smith, D.; Bycroft, C.; McClellan, R.; Gillies, R.; Shaw, W. 2015. Analysis of the impacts of a water channel diversion wall on waterbirds inhabiting the western end of Lake Rotoiti, Bay of Plenty, New Zealand. *Notornis 62 (4):* 184-191.

Keywords water diversion; waterfowl; Lake Rotoiti; bird counts; little black shags; *Phalacrocorax melanoleucos*

INTRODUCTION

Water diversions such as dams and drainage systems can have serious negative effects on waterbird breeding and abundance (Kingsford & Johnson 1998; Kingsford 2001; Kingsford & Auld 2005). However, with careful research and management, this can be alleviated in some circumstances (Walters 1992). Consequently, there is a need to carefully monitor waterbirds whenever water diversion structures are constructed.

Received 27 January 2015; accepted 27 November 2015
*Correspondence: *Rachel.McClellan@wildlands.co.nz*

Lakes Rotorua and Rotoiti (Bay of Plenty, New Zealand) have had increasing prevalence of cyanobacterial blooms due to lake eutrophication (Scholes & McIntosh 2010). Most of the variation in nutrient input into Lake Rotorua is correlated with surrounding land use, and over 70% of nutrients reaching Lake Rotoiti come from Lake Rotorua via the Ohau Channel (Scholes & McIntosh 2010). The Bay of Plenty Regional Council was granted resource consents to build a diversion wall in Lake Rotoiti, which was completed in September 2008. The wall is constructed of sheet pile and is 1275 m long. It is attached to the lake bed with king piles

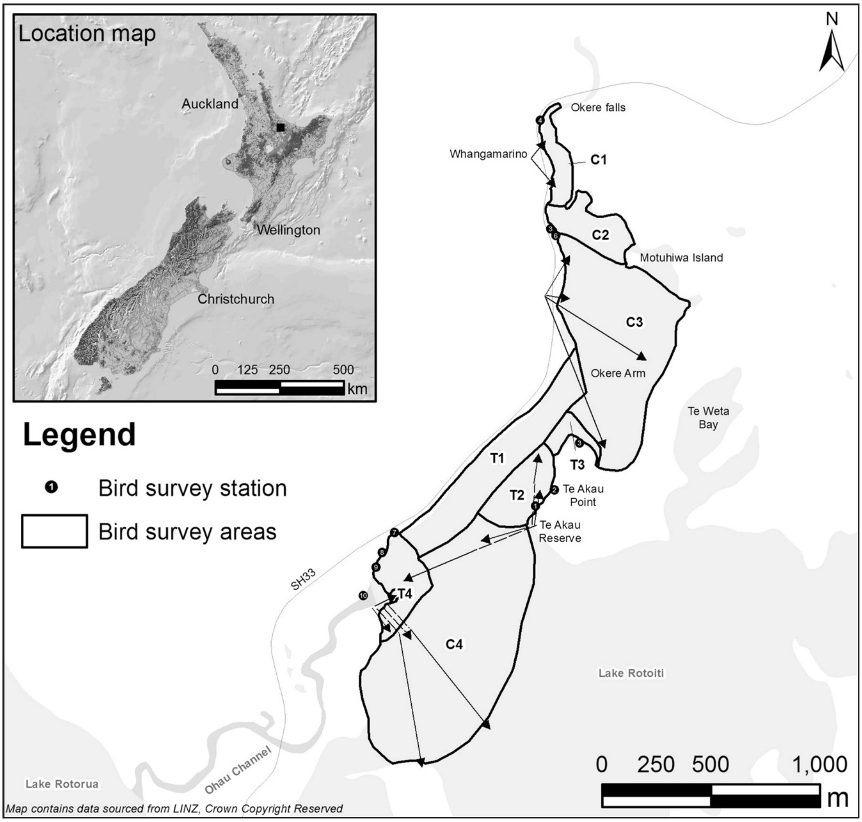

Fig. 1. Locations of the areas where birds were surveyed on Lake Rotoiti, Bay of Plenty, New Zealand, before, during and following construction of a water diversion wall. T = treatment area, C = control (non-treatment) area.

which are up to 70 m deep in places (Bay of Plenty Regional Council, *unpubl. data*). The wall was designed to be visually non-intrusive by having a low profile, which only extends 500 mm above the water surface. The objective of the structure is to divert nutrient-rich water flowing from Lake Rotorua into Lake Rotoiti, via the Ōhau Channel, by redirecting the bulk of the Ōhau Channel outflow towards the Kaituna River, the main outlet from Lake Rotoiti. The wall was predicted to reduce harmful algal blooms within Lake Rotoiti by 40% within 5 years, and has already resulted in significant water quality gains for the lake (Scholes & McIntosh 2010).

Despite the apparent increase in water quality in the lake, one remaining question is whether the diversion wall and consequent change in flow regime has affected the numbers of waterbirds using the area. To address this we analysed 8 years of waterbird counts collected on Lake Rotoiti before, during and after construction of the wall (Wildland Consultants 2005; 2006; 2007; 2008; 2009; 2010; 2011; 2012; 2013; 2014). Our aim was to establish whether the presence of the diversion wall has had any negative or positive impacts on water bird abundance.

METHODS

Data collection

Bird counts were carried out on Lake Rotoiti (38° 03′ 76′′S 176° 33′ 75′′E), Bay of Plenty, New Zealand, once per month between July 2005 and September 2013. Areas of the lake were broken up into 4 treatment and 4 control sites (Fig. 1) depending on their proximity to the diversion wall. Although control sites are not strictly independent because they are on the same lake, we assumed that if the diversion wall had a negative impact on waterbirds then their counts would be lower in the more proximate ‘treatment’ sites, compared with the more distant ‘control’ sites. Monitoring began at some treatment sites during May 2005, but we excluded these first 2 months to balance the data. The counts were divided into 3 phases associated with construction of the wall: (1) pre-construction (July 2005–May 2007), (2) during construction (June 2007–September 2008), and (3) post-construction (November 2008–September 2013).

All waterbirds seen or heard during the monitoring period at each survey area were identified and recorded. All counts were undertaken using a tripod-mounted spotting scope (telescope), with binoculars used for birds located close to

Table 1. Models of waterbird counts for 6 species inhabiting Lake Rotoiti, Bay of Plenty, New Zealand, before, during and after construction of a diversion wall. The models were ranked using Akaike's Information Criterion. The model names reflect the predictor variables (the dependent variable is always monthly counts); for example, a model named 'Year' considers only annual variation on counts. Phase = before, during, and after construction. Treatment = treatment site, non-treatment site. Null = intercept only (no other predictors), Year = 2005–2013.

Species	Model	AIC	Δ AIC	Akaike W	Species	Model	AIC	Δ AIC	Akaike W
Dabchick	Year	3532.43	0	0.728447	Little shag	Year	1762.79	0	0.98289563
	Year+Month	3535.477	3.047	0.158763		Month+year	1770.98	8.19	0.01637086
	Null	3538.078	5.648	0.043246		Phase	1777.49	14.7	0.000631601
	Phase	3539.5	7.07	0.021241		Treat*Phase	1781.14	18.35	0.000101825
	Treatment	3540.021	7.591	0.016369		Null	1796.44	33.65	4.84733E-08
	Treat*Phase	3540.342	7.912	0.013942		Treat	1797.25	34.46	3.23306E-08
	Month	3541.014	8.584	0.009963		Month	1802.64	39.85	2.18368E-09
	Treat+Phase	3541.446	9.016	0.008028	Black swan	Month+Year	3977.89	0	0.999960335
Scaup	Month+Year	5907.91	0	0.991796844		Month	3998.16	20.27	3.96651E-05
	Month	5917.5	9.59	0.008203151		Year	4082.04	104.15	2.42157E-23
	Phase	5947.19	39.28	2.93008E-09		Treat*Phase	4094.99	117.1	3.73285E-26
	Treat+Phase	5949.01	41.1	1.17943E-09		Phase	4097.98	120.09	8.37087E-27
	Year	5950.78	42.87	4.86766E-10		Treat+Phase	4099.77	121.88	3.4204E-27
	Null	5952.33	44.42	2.24255E-10		Null	4107.71	129.82	6.45547E-29
	Treat*Phase	5952.58	44.67	1.97904E-10		Treat	4109.53	131.64	2.59848E-29
	Treat	5954.16	46.25	8.98179E-11	Little black shag	Treat*Phase	1993.31	0	0.99614973
Coots	Month	6400.401	0	0.528718357		Phase	2005.75	12.44	0.001981586
	Month+Year	6400.631	0.23	0.471281643		Year	2007.59	14.28	0.0007897
	Year	6461.51	61.109	2.84167E-14		Treat+Phase	2007.75	14.44	0.000728985
	Null	6464.811	64.41	5.4547E-15		Month+Year	2009.42	16.11	0.000316288
	Treatment	6466.001	65.6	3.00861E-15		Null	2014.71	21.4	2.24581E-05
	Phase	6468.45	68.049	8.84243E-16		Treat	2016.7	23.39	8.3033E-06
	Treat+Phase	6469.66	69.259	4.82863E-16		Month	2018.77	25.46	2.94955E-06
	Treat*Phase	6471.62	71.219	1.81224E-16					

observer stations. Counts were undertaken between 10 am and 4 pm during each survey. All surveys were undertaken within a single day. At each site counts were always undertaken from the same point or station. Most of the birds were counted in the water during a 5–10 min sweep of the site. Although some double counting is inevitable, it was avoided where possible by not re-counting birds that were seen to fly from on part of a site to another. It is possible that birds may from time to time have moved between sites during the survey period, but the likelihood of this is believed to be consistent between sites, and therefore unlikely to bias counts. Counts were generally undertaken during settled weather (little or no wind or rain), as waves can make accurate counting of waterbirds difficult. However, in some months, this was not possible due to extended periods of inclement weather. Bias between observers was reduced by using only 2 observers for the counts.

Data analysis

A total of 18 species of water birds was counted across the sites over the period of monitoring. However, we undertook statistical analyses on only 6 of these species. The main reason for exclusion of the other species was lack of data, as some species were rarely seen at certain sites or were scarce during certain years, making analysis difficult. The species that were analysed are: New Zealand dabchick (*Poliocephalus rufopectus*, Threatened-Nationally Vulnerable), New Zealand scaup (*Aythya novaeseelandiae*, Not Threatened), little black shag (*Phalacrocorax sulcirostris*, At-Risk Naturally

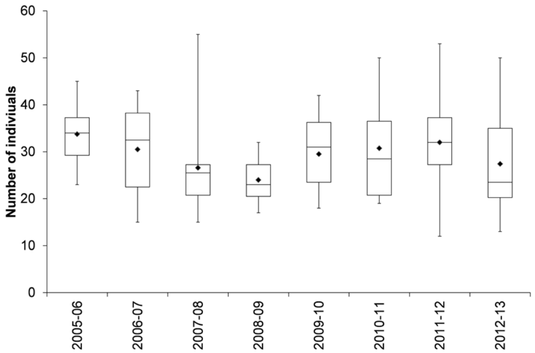

Fig. 2. Non-calendar annual differences (June to May) in the number of individual New Zealand dabchicks recorded in monthly surveys at Lake Rotoiti near the Ohau Channel between June 2005 and May 2013 (12 months). The boxplot shows minimum, 25th percentile, mean (♦), median, 75% percentile, and maximum.

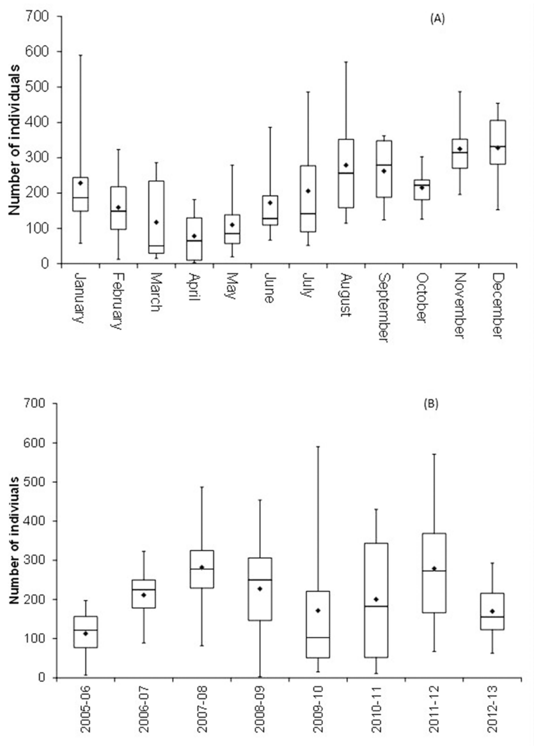

Fig. 3. (A) Differences in the number of individual New Zealand scaup recorded in monthly surveys at Lake Rotoiti near the Ohau Channel between June 2005 and May. The boxplot shows minimum, 25th percentile, mean (♦), median count per month over the eight years of the study, 75% percentile, and maximum. (B) Non-calendar annual differences (June to May) in the number of individual New Zealand scaup recorded in monthly surveys at Lake Rotoiti near the Ohau Channel between June 2005 and May 2013 (12 months). The boxplot shows minimum, 25th percentile, mean (♦), median, 75% percentile, and maximum.

Uncommon), little shag (*Phalacrocorax melanoleucos*, At-Risk Naturally Uncommon), Australian coot (*Fulica atra*, Not Threatened), and black swans (*Cygnus atratus*, Not Threatened). See Appendix 1 for relative counts of the other 12 species.

The data were analysed using generalised linear mixed-effect models in R (Ihaka & Gentleman 1996). Initially a Poisson distribution was used, but the models were over-dispersed. Therefore a negative-binomial distribution (log-link) was used, as negative-binomial models have their own over-dispersion parameter (Bolker 2008; Sileshi 2008). The models were ranked using AIC, and Akaike weights (Burnham & Anderson 2002).

For each analysis of each species an intercept model was included (*i.e.,* a model that had an intercept term but no other covariates). We used this model as a null model to reference our other models against. Models that AIC ranks below the null model are not considered informative. In addition to the null model, the following models were run for each species: count~year, count~month, count~month+year, count~treatment, count~phase, count~treat+phase, count~treatment*phase. For all models 'site' was included as a random effect to account for the repeated measures. The latter model with the interaction effect between treatment group and phase of wall development is the model we hypothesised would have the smallest AIC value if there was an impact of the construction and presence of the diversion wall on that species.

RESULTS

New Zealand dabchick

For New Zealand dabchick all models containing treatment and phase fell below the null model (Table 1). The model that most strongly predicted dabchick counts contained the single variable 'year' which had 0.73 of the Akaike weight (Table 1). Coefficients from this model suggested that dabchick counts were considerably lower in 2008 and 2009 and this was supported by plots of the data (Fig. 2).

New Zealand scaup

For scaup the models with phase and treatment + phase were ranked above the null model, but their Akaike weights were very small suggesting little support for these models (Table 1). The model with the additive effects of month and year (seasonal and annual variation) had overwhelming support with an Akaike weight of 0.99. This model predicted lower counts of scaup between March and June and higher counts of scaup in 2007 and 2008. These trends were also evident in plots of the data (Fig. 3, Fig. 4).

Table 2. Mean counts, standard errors and confidence intervals for little black shags in Lake Rotoiti, Bay of Plenty, New Zealand, during 3 phases of the construction of a diversion wall. Phase 1 = prior to construction, Phase 2 = during construction, Phase 3 = post construction. C = control site, T = treatment site. SE = standard error, Lower CI = lower 95% confidence interval, Upper CI = upper 95% confidence interval. Predict = the predicted values from the top model: counts~treatment*phase.

Site	Mean	SE	Lower CI	Upper CI	Predict
Phase 1					
C1	0.35	0.41	0	0.79	0.24
C2	0.35	0.35	0.04	0.66	0.24
C3	0.43	0.42	0	0.9	0.31
C4	1.91	0.86	0	3.8	3.77
T1	0.52	0.38	0.16	0.89	0.42
T2	0.17	0.31	0	0.42	0.06
T3	0.14	0.24	0	0.29	0.02
T4	0.30	0.36	0	0.64	1.16
Phase 2					
C1	0.38	0.32	0.05	0.7	0.43
C2	0.44	0.32	0.1	0.77	0.42
C3	0.38	0.35	0	0.76	0.55
C4	8.1	1.17	3.68	12.44	6.62
T1	1.69	0.59	0.56	2.82	1.35
T2	0.56	0.39	0.09	1.04	1.9
T3	0	0	0	0	0.07
T4	1.19	0.73	0	2.91	3.7
Phase 3					
C1	0.23	0.31	0.09	0.38	0.27
C2	0.22	0.31	0.07	0.37	0.27
C3	0.33	0.35	0.15	0.52	0.35
C4	4.95	0.97	3.49	6.41	4.25
T1	2.25	0.79	1.28	3.22	2.46
T2	0.13	0.27	0.02	0.24	0.33
T3	0.08	0.24	0	0.17	0.13
T4	9.55	1.43	6.36	12.74	6.72

Australian coot
For Australian coots all models containing treatment had less support than the null model (Table 1). The models year and month+year had near equal support (Akaike weights of 0.53 and 0.47, respectively). Coefficients from these models indicated that coots tended to be more abundant on the lake between

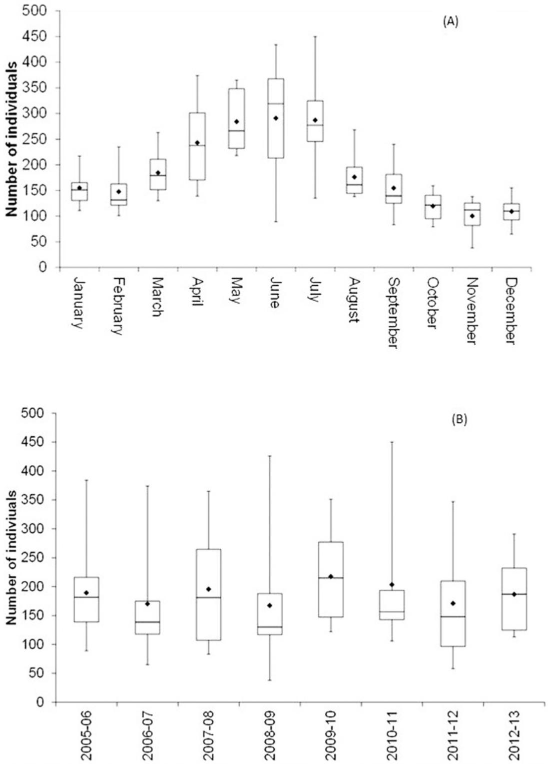

Fig. 4. (A) Differences in the number of individual Australian coots recorded in monthly surveys at Lake Rotoiti near the Ohau Channel between June 2005 and May. The boxplot shows minimum, 25th percentile, mean (♦), medianover the eight years of the study, 75% percentile, and maximum. (B) Non-calendar annual differences (June to May) in the number of individual Australian coot recorded in monthly surveys at Lake Rotoiti near the Ohau Channel between June 2005 and May 2013 (12 months). The boxplot shows minimum, 25th percentile, mean (♦), median, 75% percentile, and maximum.

April and July, and that there were less coots on the lake in 2006, 2011 and 2012 compared with the other years of the study (Fig. 5, Fig. 6).

Little shag
For little shags the models with phase and treatment*phase had more support than the null model, but their Akaike weights were very small suggesting these models were not well supported (Table 1). The model with overwhelming support was year, which had an Akaike weight of 0.98. Coefficients from this model suggest there was an increase in little shags on the lake (at all sites) during 2011–2013 (Fig. 7).

Black swan
For black swans the model with overwhelming support was month+year with an Akaike weight of 0.999 (Table 1). Coefficients from this model

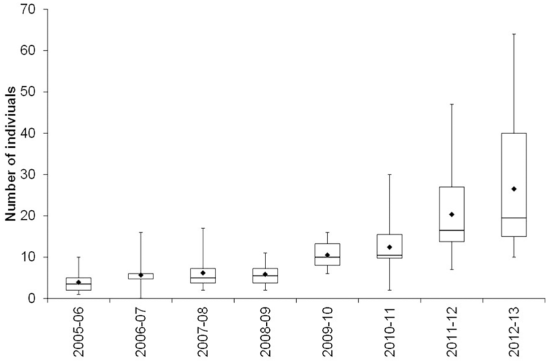

Fig. 5. Non-calendar annual differences (June to May) in the number of individual little shags recorded in monthly surveys at Lake Rotoiti near the Ohau Channel between June 2005 and May 2013 (12 months). The boxplot shows minimum, 25th percentile, mean (♦), median, 75% percentile, and maximum.

indicated that black swans were less abundant on the lake during winter, and that there were less swans on the lake during 2006 (Fig. 8, Fig. 9). While models with phase, treatment*phase and treatment+phase were ranked above the null model, their very small Akaike weights suggested they had little support compared with the top model.

Little black shag

For little black shags the top model was treatment*phase with overwhelming support (Akaike weight = 0.996, Table 1). Coefficients from this model indicated that little black shag counts were higher in the treatment area during phase 3 (after construction). Table 2 shows the average count for each site during each phase (± 95% confidence intervals) compared with model predictions of the average count size. The observed and predicted counts are higher for the treatment sites (T1–T4) in phase 3 compared with phase 1 and 2.

DISCUSSION

We were unable to detect any negative impacts of the diversion wall on any of the 6 species whose data we analysed. The temporal effects of season and year were the strongest predictors of the variance in the data for dabchicks, scaup, Australian coots, little shags and black swans. One notable exception was little black shags for which there was evidence of an impact of the diversion wall, but this appeared to be positive rather than negative. Increases in little black shags in treatment sites may be because they are using the wall for nesting, roosting and as a sentinel position for fishing for smelt (*Retropinna retropinna*) (CB & WS, *pers. obs*). There was no

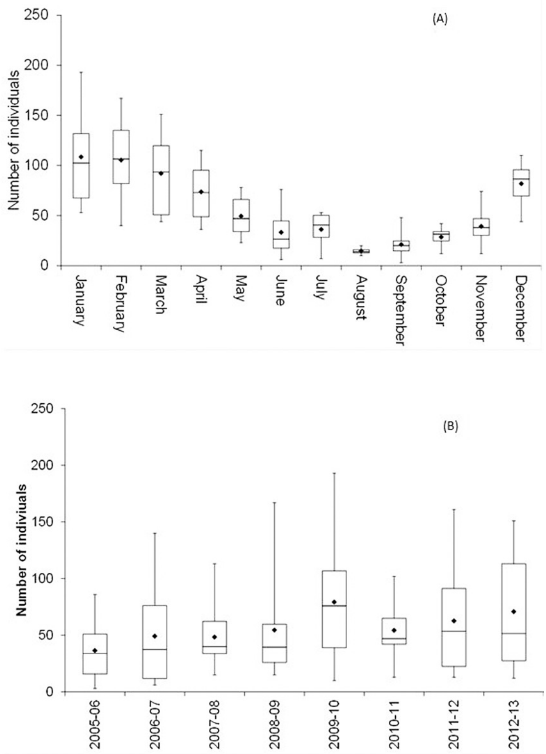

Fig. 6.(A) Differences in the number of individual black swans recorded in monthly surveys at Lake Rotoiti near the Ohau Channel between June 2005 and May 2013. The boxplot shows minimum, 25th percentile, mean (♦), medianover the eight years of the study, 75% percentile, and maximum. (B) Non-calendar annual differences (June to May) in the number of individual black swans recorded in monthly surveys at Lake Rotoiti near the Ohau Channel between June 2005 and May 2013 (12 months). The boxplot shows minimum, 25th percentile, mean (♦), median, 75% percentile, and maximum.

overall increase in little black shags on Lake Rotoiti during the timeframe of our counts, suggesting our observations may have resulted from a shift in distribution of little black shags into the treatment sites.

The data were raw counts meaning some caution is needed in interpreting patterns as change in abundance, because we were unable to account for temporal and spatial variation in detection probabilities or account for movement between sites. However, the counts used consistent methodology and were undertaken over several years. We are not able to comment on the impacts of the water diversion on bird life in the Kaituna River, nor have we measured the breeding success of waterbirds inhabiting the lake. Research overseas has suggested that waterbird breeding success and flow regimes can be correlated in complicated ways (Kingsford & Johnson 1998; Kingsford 2001; Kingsford & Auld 2005). Nevertheless, negative impacts on breeding success have generally been driven by a loss of breeding habitat, because of reduced water flow in breeding areas (Kingsford & Johnson 1998; Kingsford 2001; Kingsford & Auld 2005). The Ōhau Channel diversion has had little influence on the water level of Lake Rotoiti, the level of which is controlled by the raising and lowering of the Okere radial gates within set parameters (Britton & Wickramanayake 2010), so may not have affected bird breeding in this way.

Monthly patterns of scaup, Australian coots, and black swans likely reflect migration to and from the lake. Innes *et al.* (1999) analysed waterbird counts that encompassed the entire shoreline of all 17 Rotorua Lakes during the summers of 1985, 1991, and 1996. They observed a decline in counts of little shag, and little black shag on all of the lakes except Okareka between 1991 and 1996. They noted this coincided with a period of improved water quality on Lake Rotorua and Lake Rotoiti following the cessation of direct sewage input. Our counts suggest there has been an increase in little shags on Lake Rotoiti over the past few years, particularly from 2009–2013. There also may have been an increase in Canadian geese (*Branta canadensis*) (see Appendix 1), which is likely to be a continuation of the increase and spread also noted by Innes *et al.* (1999), which they associated with the rapid expansion of this species observed in many other parts of New Zealand. The results we have presented provide further baseline information on these species in Lake Rotoiti.

Our results suggest that low profile diversion walls that cause little variation in water levels may not negatively impact populations of waterbirds inhabiting the area. In fact, they may be utilised in a positive fashion by some species, as observed for little black shags. For Lake Rotoiti, this is an important result, given the role the Ōhau Channel diversion wall is playing in preventing nutrient enrichment, which otherwise would have profound long-term consequences for the lake ecosystem (Smith *et al*. 1999; Davis *et al.* 2010). However, the consequence, for waterbirds living downstream, of diverting nutrients into the Kaituna River remains unknown and should be the subject of further research.

ACKNOWLEDGEMENTS

Monthly bird counts were funded by Bay of Plenty Regional Council and we wish to thank them for allowing us to use the results for this analysis. Jo McQueen (Wildland Consultants) provided useful comments on a draft of this paper.

LITERATURE CITED

Britton, R.; Wickramanayake, M. 2010. Technical report to support rivers and drainage Okere Gates and Ohau weir consent application. *Rivers and Drainage Publication 2010/01.* Bay of Plenty Regional Council. 166pp.

Bolker, B.M. 2008. *Ecological models and data in R*. Princeton, New Jersey: Princeton University Press.

Burnham, K.P.; Anderson, D.R. 2002. *Model selection and multimodel inference: a practical information-theoretic approach* (2nd ed.). New York: Springer Science + Business Media, LLC.

Davis, J.M.; Rosemond, A.D.; Eggert, S.L.; Cross, W.F.; Wallace, B.J. 2010. Long-term nutrient enrichment decouples predator and prey production. *Proceedings of the National Academy of Sciences 107*: 121–126.

Ihaka, R.; Gentleman, R. 1996. R: a language for data analysis and graphics. *Journal of Computational and Graphical Statistics 5*: 299–314.

Innes, J.; Whaley, K.; Owen, K. 1999. Abundance and distribution of waterbirds of the Rotorua lakes, 1985-1996. *Conservation Advisory Science Notes No. 236*. Wellington, New Zealand: Department of Conservation.

Kingsford, R.T.; Johnson, W. 1998. Impact of water diversions on colonially nesting waterbirds in the Macquarie Marshes of arid Australia. *Colonial Waterbirds 21*: 159–170.

Kingsford, R.T. 2001. Ecological impacts of dams, water diversions and river management on floodplain wetlands in Australia. *Austral Ecology 25*: 109–127.

Kingsford, R.T.; Auld, K.M. 2005. Waterbird breeding and environmental flow management in the Macquarie Marshes, arid Australia. *River Research and Applications 21*: 187–200.

Scholes, P.; McIntosh, J. 2010. The tale of two lakes: managing lake degradation, Rotorua lakes, New Zealand. *In*: Marinov, A.M.; Brebbia, C.A. (eds) *Water Pollution X*. Southampton, UK: WIT Press.

Sileshi, G. 2008. The excess-zero problem in soil animal count data and choice of appropriate models for statistical inference. *Pedobiologia 52*: 1–17.

Smith, V.H.; Tilman, G.D.; Nekola, J.C. 1999. Eutrophication: impacts of excess nutrient input on freshwater, marine and terrestrial ecosystems. *Environmental Pollution 100*: 179–196.

Walters, C.J. 1992. Experimental policies for water management in the Everglades. *Ecological Applications 2*: 189–202.

Wildland Consultants. 2005. Ecological effects of a proposed diversion structure on the Ōhau Channel, Lake Rotoiti. *Wildland Consultants Contract Report No. 1048*. Prepared for Beca Consulting, Tauranga.

Wildland Consultants. 2006. Supplementary information on ecological effects of a proposed diversion structure on the Ōhau Channel, Lake Rotoiti. *Wildland Consultants Contract Report No. 1449*. Prepared for Environment Bay of Plenty and Rotorua District Council.

Wildland Consultants. 2007. Bird monitoring in the vicinity of the proposed Ōhau Channel diversion structure at Lake Rotoiti progress report. *Wildland Consultants Contract Report No. 1709*. Prepared for Environment Bay of Plenty. 41 pp.

Wildland Consultants. 2008. Bird monitoring in the vicinity of the proposed Ōhau Channel diversion structure at Lake Rotoiti 2008 progress report. *Wildland Consultants Contract Report No. 2004*. Prepared for Environment Bay of Plenty. 21 pp.

Wildland Consultants. 2009. Bird monitoring in the vicinity of the proposed Ōhau Channel diversion structure at Lake Rotoiti 2009 progress report. *Wildland Consultants Contract Report No. 2225*. Prepared for Environment Bay of Plenty. 25 pp.
Wildland Consultants. 2010. Bird monitoring in the vicinity of the proposed Ōhau Channel diversion structure at Lake Rotoiti 2010 progress report. *Wildland Consultants Contract Report No. 2480*. Prepared for Bay of Plenty Regional Council. 27 pp.
Wildland Consultants. 2011. Bird monitoring in the vicinity of the proposed Ōhau Channel diversion structure at Lake Rotoiti 2011 progress report. *Wildland Consultants Contract Report No. 2711.* Prepared for Bay of Plenty Regional Council. 27 pp.
Wildland Consultants. 2012. Bird monitoring in the vicinity of the proposed Ōhau Channel diversion structure at Lake Rotoiti 2012 progress report. *Wildland Consultants Contract Report No. 2711a.* Prepared for Bay of Plenty Regional Council.
Wildland Consultants. 2013. Bird monitoring in the vicinity of the proposed Ōhau Channel diversion structure at Lake Rotoiti 2013 progress report. *Wildland Consultants Contract Report No. 2711b.* Prepared for Bay of Plenty Regional Council.
Wildland Consultants. 2014. Bird monitoring in the vicinity of the proposed Ōhau Channel diversion structure at Lake Rotoiti 2014 progress report. *Wildland Consultants Contract Report No. 2711d.* Prepared for Bay of Plenty Regional Council.

Appendix 1. Relative counts of bird species not included in the statistical analyses. Figures are given for the periods before, during and after construction of the Ohau Channel diversion wall. As the length of each phase was different, counts for each species in each phase have been divided by the number of years in that phase (1.92 years before construction, 1.33 years during construction, and 5 years after construction).

Species	Before construction		During construction		After construction	
	Treatment	Control	Treatment	Control	Treatment	Control
Egretta novaehollandiae	2.1	2.1	0.8	1.5	4.4	2.2
Botaurus poiciloptilus	0	0	0	0	0	0
Platalea regia	0	0	0	0	0	0
Branta canadensis	0	8.3	0	6.8	2.2	127.8
Anser anser	0	0	0	1.5	0	1.8
Tadorna variegata	0	0	0	0	4	0.2
Anas platyrhynchos	10	16.7	16.5	16.5	11.6	7.6
Anas gracilis	1.6	0	0	0	0.8	0
Anas rhynchotis	1.04	0	1.5	0	1.2	0
Larus dominicanus	2.6	7.8	3.8	0	2.8	4.4
Larus novaehollandiae	20.8	6.8	23.3	0.8	3.8	9.4
Larus bulleri	27.1	8.3	72.9	2.26	86.6	12.6