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Date:	23/05/2017	environment SOUTHLAND			
File Refere	nce:	Te Taiao Tonga			
Subject: No	ew River Estuary Water quality trend analysis	Environment Southland is the brand name of Southland Regional Council			
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Background

Water quality data for New River Estuary has been collected by Invercargill City Council (ICC) and monitored at their laboratory since at least 1991. The 1991-2015 data was collected from 8 shallow sites within the estuary and 1 site on Oreti Beach (Figure 1). Samples were collected at monthly intervals, at both high and low water.

Sites were located in the upper estuary (Stead St, Tip Outlet, Dunns Rd and Ski Club), mid estuary (McCoys), lower estuary (Sandy Pt, Awarua, and Omaui) and Oreti Beach. Sites were sampled approx 0.5m below the water surface, either from a bridge where available or by wading from the shore. Parameters measured included; temperature, dissolved oxygen, conductivity, nitrate-N, ammoniacal-N, total coliforms, faecal coliforms, enterococci, total phosphorus, dissolved reactive phosphorus and chlorophyll *a*.

Trend analysis was undertaken on the following variables; NH3/NH4-N (mg/L), faecal coliforms/ 100ml, NO3-N (mg/L), total P (mg/L), soluble reactive P (mg/L), chlorophyll *a* (mg/L), dissolved inorganic N (mg/L) and DIN:DRP (*Robertson et al. In Press*).

The trend analysis component was undertaken by NIWA scientist (Dr Bruce Dudley) and followed the two-step procedure outlined in McBride et al. (2014, 2015) in which we ask:

- (a) can we confidently infer the direction of the trend? and
- (b) if we can, is it environmentally important?

The output of the work includes a tabulated set of summary trend analysis statistics with accompanying graphs. The statistical results have been tabulated and are provided here.

A simplified overview of how these statistics are to be interpreted was also provided as follows:

- Does the range between the 5% and 95% confidence intervals in the Time Trends output for the slope intersect zero?
- If not (i.e. for a positive trend both are above zero or for a negative trend they are both below zero) one can confidently assert that the trend is significantly different from zero.
- Some indication of the strength of the trend in the data may be gleaned from the p value (column d), although p values above 0.05 are NOT sufficient evidence to suggest that no trend exists in the data, but only that we can say that the null hypothesis (there is no trend) is 'not rejected' (at p=0.05).
- If a trend exists, the next step is to ask whether or not it is ecologically important. This should be based on expert opinion (e.g., if N was a limiting nutrient to algal growth in the New River estuary in 1991, a small annual nitrate change after that time may be considered ecologically important. This is informed by the 'Percent annual change'. In other studies of river water quality it has been observed that Kendall Trend Tests have been used (e.g., Vant and Wilson 1998; Vant 2013), trends >=1% p.a. have been considered 'important', whereas trends with slopes less than that were considered 'slight'.



Figure 1. New River Estuary, showing location of ICC water quality monitoring sites (Photo LINZ)

Results

Table 1. All Year, Seasonal Kendall test with multiple values/season (both high and low water, summer and winter). Note that a positive trend indicates deterioration and a negative trend indicates an improvement.

used otherwise a normal approximation is used to determine P value.									
Variable/Site	Trend direction	Confidence in trend direction	Per cent ann ual cha nge	Ecologically important		Trend direction	Confidence in trend direction	Percent annual change	Eco logically importa nt
	Awarua					Sandy Pt			
NH3/NH4-N (mg/L)			0		- ·			0	
Faecal coliforms/100ml	Negative	High	-1.7704	Yes		Negative	High	-2.9854	Yes
NO3N (mg/L)	Positive	High	1.0959	Yes		Positive	High	1.5291	Yes
Total P (mg/L)	Positive	High	2.1114	Yes		Positive	High	1.7828	Yes
Soluble reactive P (mg/L)			0.6789					0	
Chlorophyll a (mg/L)			-0.1815					-0.5617	
Dissolved inorganic N (mg/L)	Positive	High	0.8692	No		Positive	High	1.307	Yes
DIN:SRP			0.4947			Positive	High	1.5173	Yes
		Du	nns				Ski	Club	
NH3/NH4-N (mg/L)			0					-0.5364	
Faecal coliforms/100ml			-0.4511			Negative	High	-1.9872	Yes
NO3N (mg/L)	Positive	High	2.1196	Yes		Positive	High	2.0219	Yes
Total P (mg/L)	Positive	High	3.2897	Yes		Positive	High	2.478	Yes
Soluble reactive P (mg/L)	Positive	High	0.7154	No				0.1763	
Chlorophyll a (mg/L)			-0.6544			Negative	High	-0.6446	No
Dissolved inorganic N (mg/L)	Positive	High	1.7042	Yes		Positive	High	1.6546	Yes
DIN:SRP	Positive	High	0.806	No		Positive	High	1.1818	Yes
		McC	Coys			Stead St Bridge			
NH3/NH4-N (mg/L)			0					-0.4163	
Faecal coliforms/100ml	Negative	High	-2.2126	Yes		Negative	High	-5.116	Yes
NO3N (mg/L)	Positive	High	1.0398	Yes		Positive	High	1.3554	Yes
Total P (mg/L)	Positive	High	2.4495	Yes		Positive	High	2.4842	Yes
Soluble reactive P (mg/L)			0					-0.4335	
Chlorophyll a (mg/L)	Negative	Low	-0.2103	No				-0.0734	
Dissolved inorganic N (mg/L)	Positive	High	0.8786	No		Positive	High	1.1296	Yes
DIN:SRP	Positive	High	0.9407	No		Positive	High	1.2445	Yes
		Om	aui				Tip C	Outlet	
NH3/NH4-N (mg/L)			0			Negative	High	-2.5874	Yes
Faecal coliforms/ 100ml	Negative	High	-1.7544	Yes		Negative	High	-11.7929	Yes
NO3N (mg/L)	Positive	High	0.2668	No				0.1809	
Total P (mg/L)	Positive	High	1.6386	Yes		Positive	High	2.0825	Yes
Soluble reactive P (mg/L)			0					0.1873	
Chlorophyll a (mg/L)	Negative	High	-0.9515	No				0.5575	
Dissolved inorganic N (mg/L)	Positive	Low	0.6664	No		Negative	Low	-0.2922	No
DIN:SRP	Positive	High	0.8912	No		Negative	Low	-0.3305	No
		Or	eti						
NH3/NH4-N (mg/L)			0						
Faecal coliforms/100ml	Negative	Low	0	No					
NO3N (mg/L)	Positive	High	4.2903	Yes					
Total P (mg/L)	Positive	High	2./417	Yes	-				
Chlorophyllo (mp.4.)	Nogetive	Ujek	0.673	Ma					
Dissolved inorganic N (mg/L)	Positive	High	-0.6/3	NO Voc					
DIN:SRP	Positive	High	4.358	Yes					
UNIX.SRF	Fositive	nigh	4.330	162					

Table 2. Summer Only, Seasonal Kendall test with multiple values/season (both high and low water, summer). Note that a positive trend indicates deterioration and a negative trend indicates an improvement.

Seasons used in analysis are: Dec - Feb, Mar - May, Jun - Aug, Sep - Nov. If the sample size is less than 10 small sample size probabilities are used otherwise a normal approximation is used to determine P value.									
Variable/Site	Trend direction	Confidence in trend direction	Per cent ann ual cha nge	Ecologically important		Tre nd direction	Confidence in trend direction	Percent annual change	Ecologically important
	Awarua					Sandy Pt			
NH3/NH4-N (mg/L)			0	No				0	
Faecal coliforms/100ml			0.165	No		Negative	High	-2.7829	Yes
NO3N (mg/L)	Positive	Low	0.935	No		Positive	High	1.1974	Yes
Total P (mg/L)	Positive	High	2.319	Yes		Positive	High	1.4072	Yes
Soluble reactive P (mg/L)	Positive	High	1.431	Yes				0	
Chlorophyll a (mg/L)			0.31	No				0.157	
Dissolved inorganic N (mg/L)	Positive	Low	0.639	No		Positive	High	1.029	Yes
DIN:SRP			-0.21	No		Positive	Low	1.0884	Yes
		Du	nns				Ski	Club	
NH3/NH4-N (mg/L)			0		1			0	
Faecal coliforms/100ml			-0.49			Negative	High	-1.7736	Yes
NO3N (mg/L)	Positive	High	2.0074	Yes		Positive	High	1.8223	Yes
Total P (mg/L)	Positive	High	3.5789	Yes		Positive	High	2.6672	Yes
Soluble reactive P (mg/L)	Positive	High	0.9781	No				0.7012	
Chlorophyll a (mg/L)			-0.0252					0.1832	
Dissolved inorganic N (mg/L)	Positive	High	1.6792	Yes		Positive	High	1.5079	Yes
DIN:SRP	Positive	High	0.5543	No		Positive	Low	0.7223	No
		McC	loys			Stead St Bridge			
NH3/NH4-N (mg/L)			0		1 1			-0.6371	
Faecal coliforms/100ml	Negative	High	-2.2075	Yes		Negative	High	-5.116	Yes
NO3N (mg/L)	Positive	Low	0.8313	No		Positive	Low	1.1065	Yes
Total P (mg/L)	Positive	High	2.5094	Yes		Positive	High	2.6393	Yes
Soluble reactive P (mg/L)			0					0	
Chlorophyll a (mg/L)	Negative	Low	0.4461	No				0	
Dissolved inorganic N (mg/L)	Positive	High	0.6763	No		Positive	High	0.8305	No
DIN:SRP			0.6126					0.6222	
		Om	aui				Tip C	utlet	
NH3/NH4-N (mg/L)			0			Negative	High	-2.8762	Yes
Faecal coliforms/100ml			-1.1743	Yes		Negative	High	-12.1235	Yes
NO3N (mg/L)			0					-0.4269	
Total P (mg/L)	Positive	High	1.672	Yes		Positive	High	2.5074	Yes
Soluble reactive P (mg/L)	Positive	High	0.3949	No		Positive	High	0.7835	No
Chlorophyll a (mg/L)			-0.4005			Positive	High	1.1188	Yes
Dissolved inorganic N (mg/L)	Positive	Low	0.7697	No		Negative	High	-0.8524	No
DIN:SRP			0.6395			Negative	High	-1.4199	Yes
		Or	eti						
NH3/NH4-N (mg/L)			0						
Faecal coliforms/100ml			0						
NO3N (mg/L)	Positive	High	5.5366	Yes					
Total P (mg/L)	Positive	High	2.6857	Yes					
Soluble reactive P (mg/L)			0						
Chlorophyll a (mg/L)			-0.3806						
Dissolved inorganic N (mg/L)	Positive	High	4.4843	Yes					
DIN:SRP	Positive	High	4.2514	Yes					

References

McBride, G., Snelder, T., Unwin, M., Booker, D., Verburg, P. and Larned, S. 2015. "A new approach to water quality trend assessment" Appendix A in Larned, S. et al. Analysis of Water Quality in New Zealand Lakes and Rivers. Prepared for Ministry for the Environment, NIWA Client Report CHC2015-033, Project MFE15503, 74 p. plus Appendices.5 Barr, N.G. et al., 2013. Broad-scale patterns of tissue- d 15 N and tissue-N indices in frondose Ulva spp.; Developing a national baseline indicator of nitrogen-loading for coastal New Zealand. Marine Pollution Bulletin, 67(1-2), pp.203–216. Available at: http://dx.doi.org/10.1016/j.marpolbul.2012.11.033.

McBride, G.B., Cole, R., Westbrooke, I. and Jowett, I.G. 2014. Assessing environmentally significant effects: A better strength-of-evidence than a single P value? Environmental Monitoring and Assessment 186(5): 2729–2740. doi: 10.1007/s10661-013-3574-8.

Vant, B., Wilson, B. (1998) Trends In River Water Quality In The Waikato Region, 1980–97. Environment Waikato technical report, 1998/13.

Vant, B. (2013) Trends in river water quality in the Waikato region, 1993-2012. *Waikato Regional Council Technical Report*, 2013/20: 50. ISSN 2230-4355

Robertson, B.M., Steven & L.M., Dudley, B. (In Press). New River Estuary - review of water quality data in relation to eutrophication 1991-2015. Report prepared by NIWA and Wriggle Coastal Management for Environment Southland. 32p.