Boffa Miskell

Waikanae River -Riffle Fishing

Concluding dataset assessment
Prepared for KCDC

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Appendices

1.0 Introduction

This report relates to Kāpiti Coast District Council's River Recharge with Groundwater Project (RRwGW). The RRwGW Project required comparative fishing to be undertaken above and below the recharge location to ascertain if the recharge project is having an adverse effect to migrating freshwater fishes, in accordance with the Waikanae River Ongoing Mitigation Plan (River OMP).

After consultation between councils, the Adaptive Management Group, and various experts it was concluded fish surveys were to occur via surveying riffles above and below the recharge location (this differs from the consented method (monitoring upstream tributaries) as detailed in the GWRC issued *Alternative 2016-2017 Fish Monitoring Methodology for the Waikanae River* memorandum). Of concern during these discussions was the impact recharge episodes may have on migrating fish; however, recharges are highly unlikely to occur during any peak migration period(s). Therefore, a series of electric fishing (EFM) surveys (ideally between February and March) in riffle-only habitat at each of the monitoring sites (where flows allowed) between 2017 and 2019, inclusive, was settled upon to illustrate the species present. We note, these data will not form any sort of metric to indicate adverse effects and will simply provide information on fish presence at the time of each survey.

In 2017, 2018, and 2019, when flows allowed, data were collected from the two upstream "control" and three (only two in 2017 due to persistent rain and flow issues) downstream "receiving" monitoring sites on the Waikanae River.

This report is the final analysis of the full set of baseline data for fish surveys above and below the water plant. It has been made with the inclusion of technical expert GWRC input into the analysis.

Previous reports

2017 – *Waikanae River Annual Aquatic Baseline Monitoring Report: A report on 2016/2017 aquatic data collection for water permits WGN130103 [34399] & [34400]* (Boffa Miskell Ltd, 2017).

2018 – *Waikanae River Riffle Fishing Report: A River Recharge monitoring component* (Boffa Miskell Ltd, 2018).

2019 – *Waikanae River riffle fishing report: A river recharge monitoring component* (Boffa Miskell Ltd, 2019).

2.0 Methodology

2.1 Site Location

The monitoring locations were determined in the River OMP which include two 'control' sites, (C1 and C2) located upstream of the Waikanae Water Treatment Plant (WTP); and three 'receiving' sites, located at predetermined intervals downstream of the Waikanae WTP (R1, R2,

and R3) (Figure 1). R2 was not required to be surveyed by the OMP, however it has been surveyed when possible.

Figure 1: Waikanae River Monitoring locations (C1, C2, R1 and R3).

2.2 Fish Surveys

Initially a range of techniques and locations were attempted. After discussion and revision, a new "riffle" method was developed and employed. Fish surveys commenced in February each year, proceeding fortnightly, for a total of four survey occasions. Due to untimely high-flow conditions, a fortnight break between surveys was not always achievable, as flows in the Waikanae River had to be below 4 cumecs (m^3/s) to be fishable. An absence of rain was typically required to ensure water clarity did not disrupt EFM surveying. Additionally, high flows and H&S concerns rendered site R2 unfishable in 2017.

A standard EFM single pass was undertaken from bank-to-bank across riffle habitat. At each stop-net placement the EFM operator fished a 3 m run upstream. Once complete, the stop-net was moved the width of the stop-net across and reset. The process was then repeated until the transect was complete. The EFM team then moved 3 m upstream and the transect process was repeated. This was done until the all discernible riffle habitat was fished (i.e. sufficient transects were undertaken to cover all or most of the fishable riffle). The total area fished at each riffle was recorded. Fish caught were measured for size and released at least 3 m downstream of the active fishing zone.

2.3 Analyses

The following aspects were considered and fed into the analyses:

i. Fish data were converted to densities (fish/m^2) to remove effort bias from the results. i.e. no raw/abundance data were compared. Raw fish abundance data can be misleading making it unsuitable for this analysis because the area fished varied

between sites, dates, and years. Additionally, for most of the surveys, all three 'receiving' sites were surveyed compared with only two 'control' sites. Therefore, we have placed more emphasis on density data to allow for a standardised metric to be compared (fish/m^2).

ii. Torrent fish, eels, and redfin bully where the main focus of the analysis as these taxa have juvenile movement potential across the site in or near the time of the recharge, and are also the most abundant fish.

iii. Eels regardless of species have been grouped together as they have similar habitats and passage ability.

iv. Only redfin were used in the comparisons as this taxa was in considerably higher abundances than all or any other bully species.

    a. All juvenile bullies have been clumped as we assumed the vast majority are redfin and many could not be identified in the field due to small size.

v. Species with low abundances/not observed at all sites were excluded from analyses.

vi. Size was the primary factor used to differentiate migrating juveniles from adult residents. The following limits were used:

    b. Juvenile eels - ≤150 mm

    c. Juvenile bullies - ≤40 mm

    d. Juvenile torrentfish - ≤60 mm

Taking into account the above, the following broad comparisons are made:

- Assessing the densities of each site through time.
- Assessing the density of each taxa/group presented across sites,
- Repeating the above analyses after combining the control and receiving site densities. This analysis excludes R3 from receiving sites due to it being clearly different (see section 4.0 for why the difference exists) and skewing the analysis when included.

2.3.1 Statistical analysis

Using excel – statistical analyses were performed. A two-tailed two sample for means t-test was used to determine if there were statistical differences between average fish densities between sites.

3.0 Results

3.1 Raw fish numbers

- In total, 937 fish were caught throughout the survey period, comprising the following ten species (raw numbers):

  - Torrentfish (405)
  - Longfin eel (231)
  - Shortfin eel (9)
  - Redfin bully (138)
  - Inanga (4)
  - Koaro (2)
  - Common bully (2)
  - Brown trout (3)
  - Bluegill bully (2)
  - Banded kokopu (2)
- Plus, the following unidentifiable (due to size) groups:
  - Elver eel (91)
  - Juvenile bully (48; assumed majority to be redfin)

3.1.1 Pooled fish proportions

- Eel have been pooled, comprising 70% longfin, 3% shortfin, 27% elver
- Only redfin bully and juvenile bully are analysed in this report; however, the bully community comprised 73% redfin, 1% common, 1% bluegill, 25% juvenile bully

3.2 Sites through time

Torrentfish densities increased at C2, R2, and R3 in 2019; however, their presence was reasonably stable throughout the surveys at C1 and R1 (Figure 2). Overall, for torrentfish, the greatest densities were observed at R3, and the lowest were typically observed at C1. Torrentfish densities varied but were typically <0.1 fish/m², except at R3 where densities were consistently >0.15 fish/m² since March 2018.

Eels densities were highest during 2017 and the early 2018 surveys at most sites (acknowledging R2 was not surveyed in 2017), before a marked decline in the later 2018 surveys (Figure 2). Eel densities increased in 2019 at C1 and C2, but not at the receiving sites (R). Eel densities varied between sites and dates but were typically <0.1 fish/m².

There were no notable redfin trends through time at each site, with regular fluctuations (Figure 2). However, redfin bully densities were typically >0.4 fish/m².

Figure 2: Observed torrentfish, eel, and redfin bully densities at each monitoring location throughout the survey period. Note eels have been grouped to include longfin, shortfin, and elver eels and redfin bullies include unidentifiable juvenile bullies. R2 was not surveyed in 2017 due to H&S concerns.

3.3 Species per site

Torrentfish median densities were consistently <0.04 fish/m², except for R3 (0.16 fish/m²) and variability limited in the control sites and R1. Variability was greatest at R3, and there were no instances were torrentfish were not observed. Variability in density was also high at R2. The variability at R2 resulted in an average density of 0.06 fish/m² which was notably higher than the median (0.017 fish/m²).

There was a greater variation in median and mean eel densities between sites than torrentfish. Median eel densities were greatest at C1 and R3 (0.064 and 0.065 fish/m², respectively), and between 0.021 and 0.036 fish/m² at the other sites. Average eel densities were above 0.04 fish/m² at all sites other than R2 which was 0.02 fish/m².

There was little variation in redfin bully median and average densities throughout except at R3 which had a notably higher median and average density. Median densities were <0.025 fish/m²

except for R3 which was 0.065 fish/m² and average densities were <0.02 fish/m² except for R3 which was 0.07 fish/m².

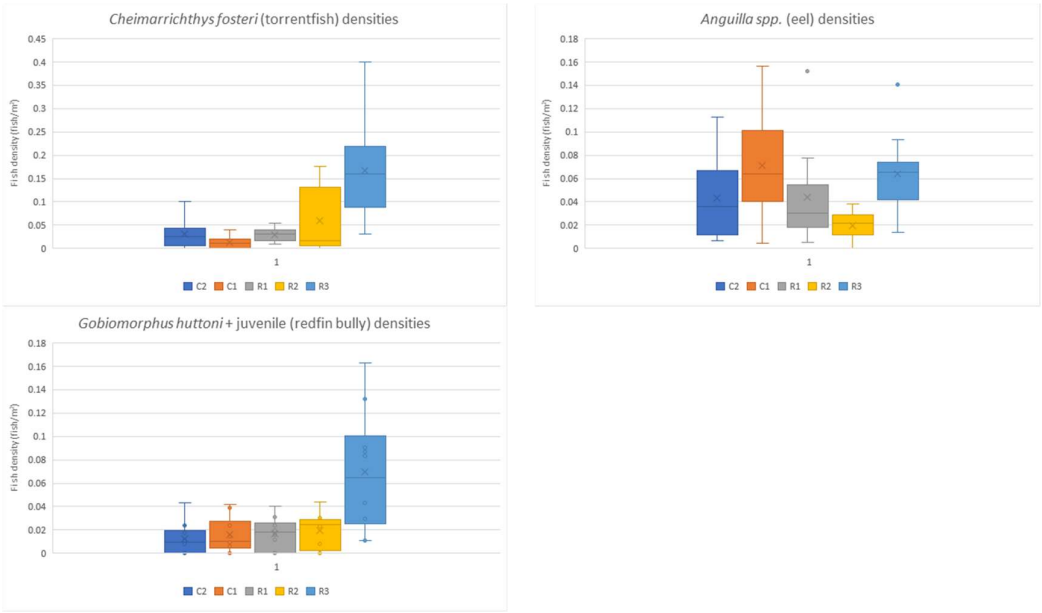

Figure 3: Torrentfish, eel, and redfin bully observed densities between sites combining all monitoring occasions. Note R2 was not surveyed during 2017 due to H&S concerns.

3.4 Above and below through time

Torrentfish densities remained relatively stable above the recharge location throughout the survey period, with a possible slight increase in 2019, whereas densities showed a marked increase below the recharge location (excluding R3) in 2019. Prior to 2019, densities below the recharge location appeared consistent. Broadly, this pattern was the inverse for eels, with a notable decline in densities since 05/02/2018 below the recharge location and since 2017 above the recharge location. There was no discernible difference in redfin bully densities above or below the recharge location through time.

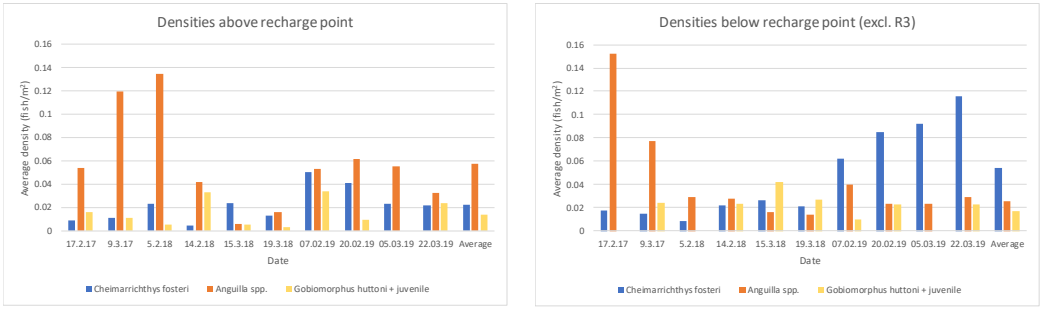

Figure 4: Monitoring sites above and below (excluding R3) combined to show average torrentfish, eel, and redfin bully densities above and below the recharge locations. Note R2 was not surveyed during 2017 due to H&S concerns.

3.5 Above and below by species

The median torrentfish densities between above and below the recharge location are between 0.022 and 0.024 fish/m² (excluding R3 data); however, there is greater variation in densities below the recharge location (Figure 5). Eel density variability is greater upstream of the recharge location, which has a corresponding greater median density (0.053 fish/m²) compared with downstream (0.028 fish/m²; excluding R3 data). The variability in redfin bully densities is comparable between upstream and downstream of the recharge location, averaging between 0.014 and 0.017 fish/m². However, the median redfin bully density is notably higher below the recharge location (0.023 fish/m²) compared with above (0.01 fish/m²).

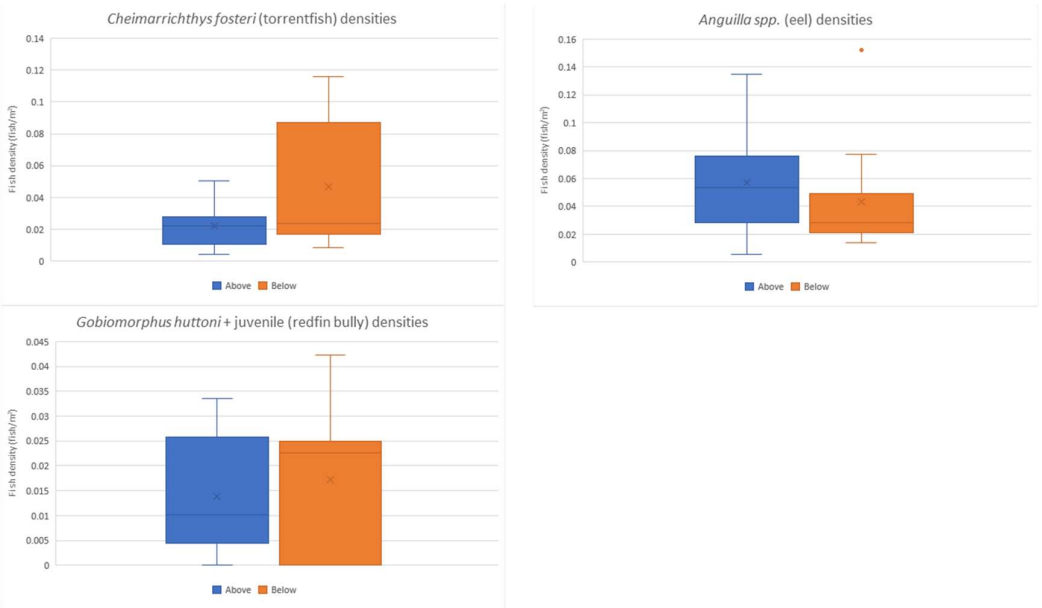

Figure 5: comparing median (-) and mean (x) densities of torrentfish, eels, and redfin bully above and below the recharge location. Note the below densities exclude R3. Eels have been grouped to include shortfin, longfin, and elver eels.

3.6 Juvenile densities

Juvenile torrentfish, redfin bully, and elver eels have been analysed in the 2019 *Waikanae River Riffle Fishing Report* (Boffa Miskell Ltd, 2019) which reports on the findings of the 2017-2019 riffle fishing survey data. That information is reproduced below. Note site R3 is included in the density comparisons and is the main contributor of difference.

3.6.1 Juvenile eel densities (≤150 mm)

Juvenile eel densities varied between sites but was greatest at the C1 and R3 sites (approximately 0.05 fish/m²; Figure 6). R2 had the lowest densities.

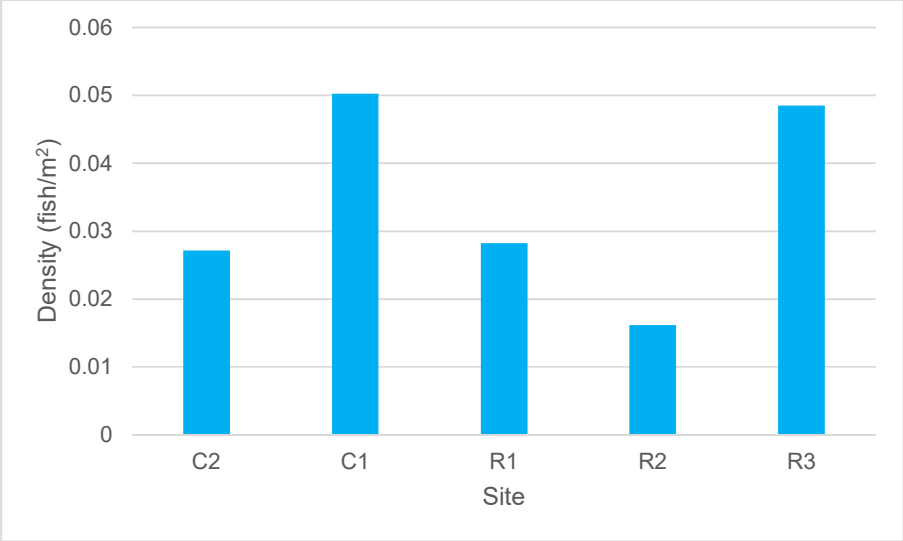

Figure 6: Average densities of juvenile eels (≤150 mm) at each site (2019).

Overall, juvenile eel densities were slightly higher above the recharge location (Figure 7).

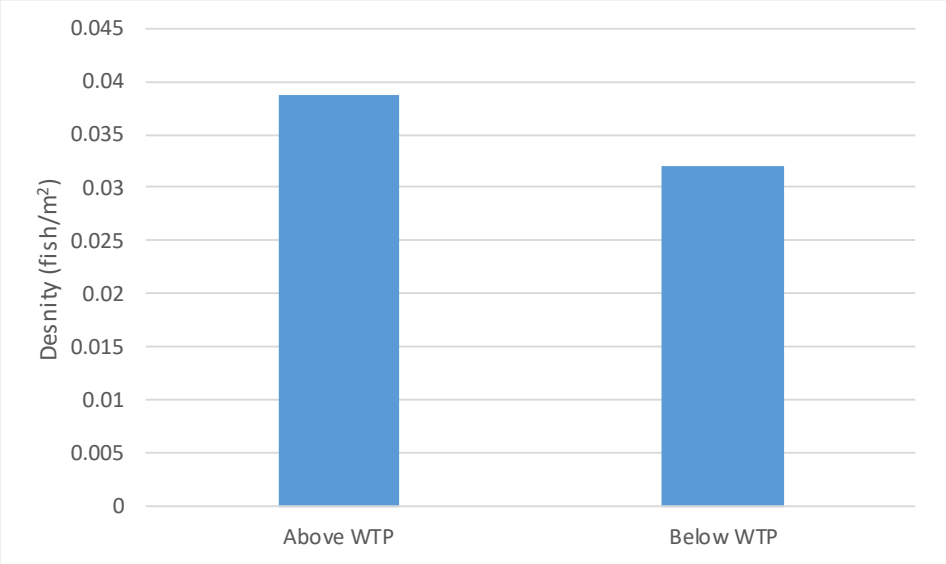

Figure 7: Average densities of juvenile eels (≤150 mm) above and below the water treatment plant.

3.6.1.1 Juvenile torrentfish densities (≤60 mm)

Juvenile torrentfish densities were notably higher at R3 site compared with no observed juveniles at C1 site (Figure 8). Densities were relatively consistent between sites R1 and R2; and were lower at C2. Site R3 is the site furthest from the recharge location (and below the SH1 armour cascade/falls). The comparatively high densities at R3 may be due to a shorter distance-from-sea, or below a swimming barrier, rather than an effect from the recharge discharge.

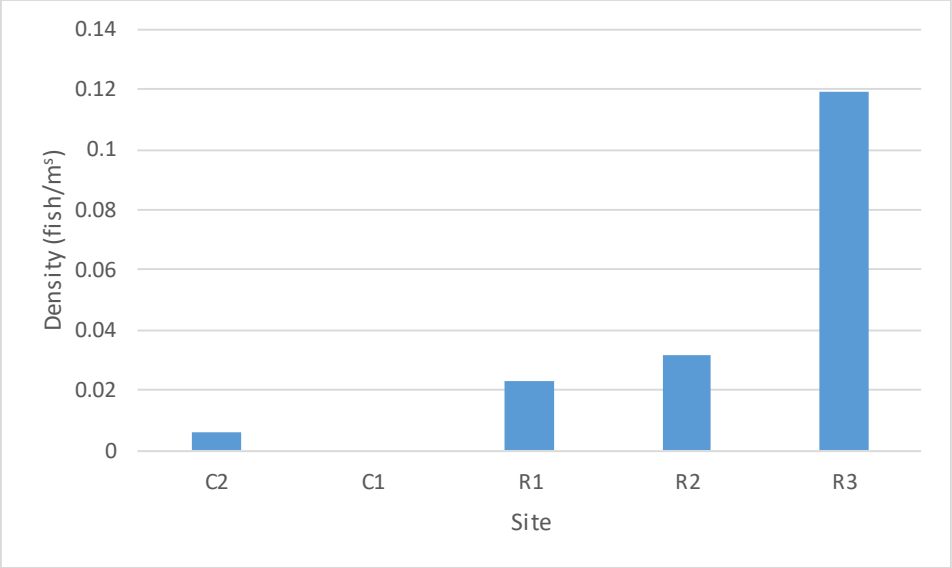

Figure 8: Average densities of juvenile torrentfish (≤60 mm) at each site.

Juvenile torrentfish densities were much higher below the recharge location; however, it is worth noting this is largely due to the comparatively high numbers observed at R3 (i.e. the site furthest from the recharge location; Figure 9).

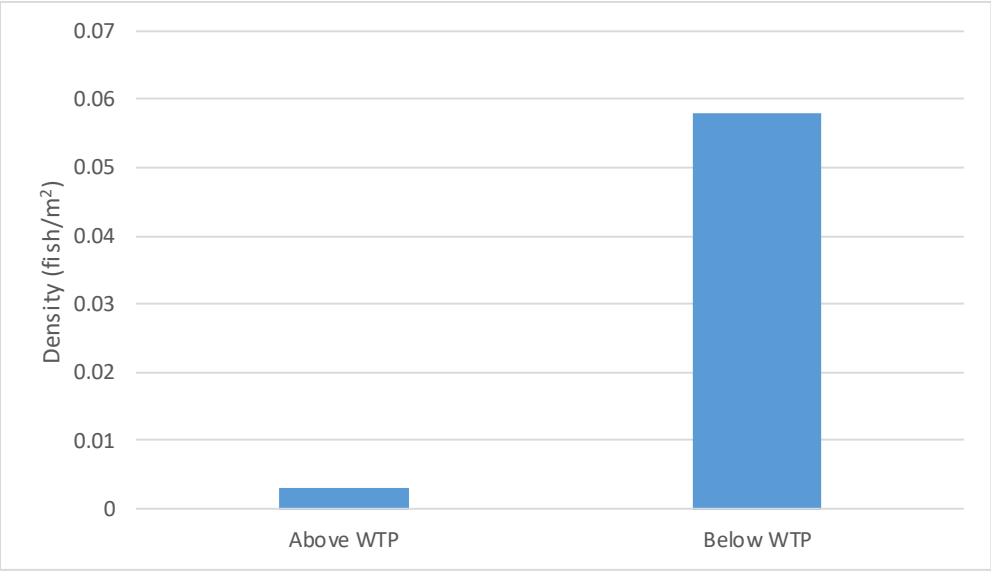

Figure 9: Average densities of juvenile torrentfish (≤60 mm) above and below the water treatment plant.

3.6.1.2 Juvenile bully (≤40 mm) densities

As with juvenile torrentfish, bully densities were notably highest at site R3 compared with all other sites (Figure 10). Densities at the remaining sites were comparable. The consistency in densities between all sites except R3 suggests the recharge is not a barrier to migrating juvenile bullies, but something does appear to be concentrating bully (and torrent fish) at R3, this pattern

was seen in previous years. It is conceivable that the sample reach is the “last” strong riffle habitat before the armouring protection under SH1 and so “accumulates” these fish.

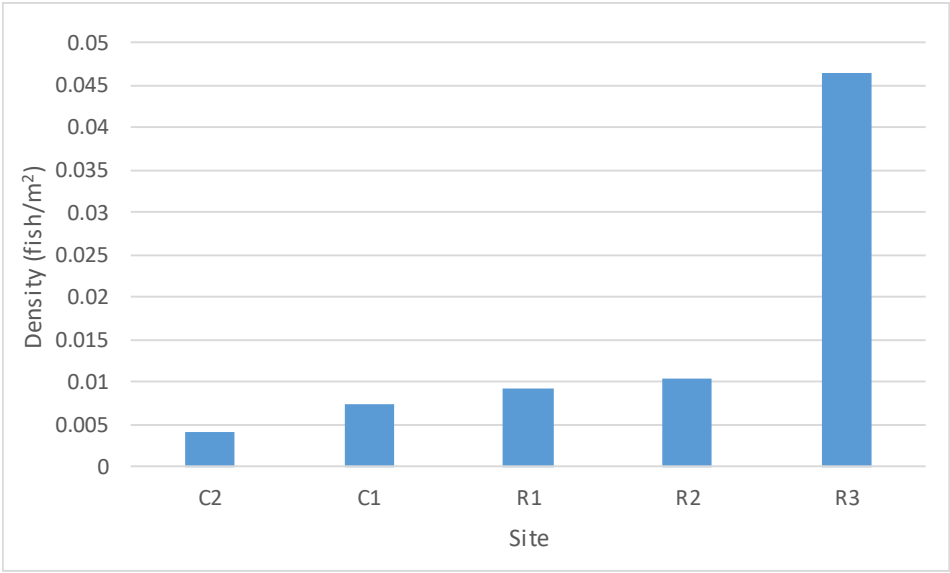

Figure 10: Average densities of juvenile bullies (≤40 mm) at each site.

Juvenile bully densities were considerably higher below the recharge location (Figure 11); however, this is misleading due to the higher densities at R3.

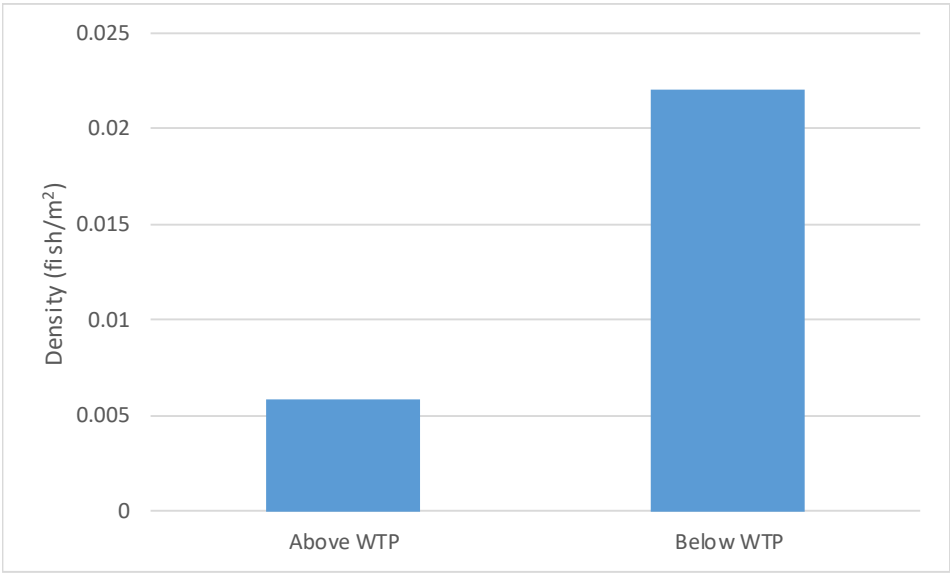

Figure 11: Average densities of juvenile bullies (≤40 mm) above and below the water treatment plant.

4.0 Discussion

4.1.1 Physical habitat comparisons

The considerably higher torrentfish and redfin bully densities observed at R3 compared to the other sites were likely a reflection of the different habitat conditions at this site. The two control sites, and R1 and R2 all resembled low-flow riffles with uniform flows throughout. This was particularly noticeable during low-flow conditions where the 'riffle' habitats were often difficult to discern from run habitats. At these times, substrate differences were used to define the riffle habitat, though we note there is a potential for fish taxa which prefer faster-flow environments to expand into nearby habitats. This was not the case with R3, where a marked gradient increase, coupled with the 'pinching' of flows through substrate build-up along the margins (particularly true right) ensured this area was always a discernible, isolated riffle with relatively (to the size of the river) large pools upstream and downstream. There is a chance density was greatest at this site for torrentfish and redfin bully because it was more stable as a riffle and there was less "venturing" ability into nearby habitats.

The variability in eel densities throughout the monitoring sites may be a symptom of their preference to reside in slower flowing habitats. Furthermore, there was limited habitat for large adult eels in the surveyed riffles, especially during low-flow conditions.

4.1.2 Other potential barriers

The objective of this study was to assess if the recharge programme results in a chemical barrier to migrating fish. Any potential differences in fish densities between monitoring sites may be, in part, due to other physical forms which may hinder or impede fish passage.

i. Rock weir between R2 and R3 – An artificial rock weir has been placed downstream of the old SH1 road bridge which has the potential to provide a velocity barrier to migrating fish.

ii. Concrete and rock weir between R1 and C1 (near the recharge location) – An artificial concrete weir has been installed adjacent to the Waikanae WWTP to assist with operations. The concrete structure results in a vertical concrete face which migrating fish will need to navigate/climb. Large boulders (>1 m) have also been placed throughout this reach which may or may not assist with fish passage (likely dependant on flow conditions at the time of migration.

4.1.3 Timing of surveys

All fish surveys were conducted in February and March each year. This coincides with the tail end of peak upward migration period of longfin and shortfin eels (Smith, 2014) and is at the tail end of the range of upward migration for redfin bully. However, peak upward migration of torrentfish occurs during late autumn and winter with no migration occurring during February and March. Therefore, any potential differences in torrentfish densities between the sites is likely a reflection of habitat differences rather than the presence of a potential chemical barrier during times of recharge.

The temporary nature of any recharge occurrence makes it difficult to measure the potential for a chemical barrier to upward migrating fish. Furthermore, the recharge location is situated on the true right side of the river meaning it is likely sufficient mixing would have occurred as the plume moved downstream before it “crosses” the river.

5.0 Conclusions

- R3 aside, there were no obvious differences in fish densities between communities above and below the recharge location.
- R3 had notably greater fish densities, but this is likely attributable to difference in physical habitat condition.
- Fish densities appeared to dip in 2018 but improved in 2019. It is unclear why this dip may have occurred, but because it was observed throughout the surveys it is highly likely a result of catchment-wide environmental/climatic changes.
- The River OMP states that fish monitoring data will be analysed to determine if an applicable trigger can be implemented. These data (the total data set 2017-2019) do not support an effect of the recharge, and do not, and cannot, be used to set any meaningful measurement trigger of fish species densities or numbers which might relate to a water discharge effect of the recharge programme.
- No further fish surveys are recommended as part of this package of works

6.0 References

Boffa Miskell Ltd. (2017). Waikanae River Annual Aquatic Baseline Monitoring Report: A report on 2016/2017 aquatic data collection for water permits WGN130103 [34399] & [34400]. Prepared for Kāpiti Coast District Council.

Boffa Miskell Ltd. (2018). Waikanae River Riffle Fishing Report: A River Recharge monitoring component. Prepared for Kāpiti Coast District Council.

Boffa Miskell Ltd. (2019). Waikanae River riffle fishing report: A river recharge monitoring component (Report No. W14039). Boffa Miskell Ltd.

Smith, J. (2014). Freshwater fish spawning and migration periods (MPI Technical Paper 2015/17). Prepared by NIWA for Ministry for Primary Industries.

Appendix 1: Raw fish data

17 February 2017

R3			
Transect	1	2	3
Length (m)	7	8	9
Width (m)	3	3	3
Area fished (m²)	21	24	27
Torrentfish	1	4	1
Elver eel	0	1	0
Redfin bully	1	1	4

R1			
Transect	1	2	3
Length (m)	18	20	19
Width (m)	3	3	3
Area fished (m²)	54	60	57
Torrentfish		2	1
Longfin eel	5	7	10
Elver eel	1	3	
Redfin bully	0	0	0

C1				
Transect	1	2	3	4
Length (m)	14	12	10	10
Width (m)	3	3	3	3
Area fished (m²)	42	36	30	30
Longfin eel	5	4	0	0
Elver eel	1	0	0	0
Redfin bully	1	1	0	0
Banded kokopu	1	0	0	0

C2				
Transect	1	2	3	4
Length (m)	8	8	10	12
Width (m)	3	3	3	3
Area fished (m²)	24	24	30	36
Torrentfish	0	2	0	0
Longfin eel	0	4	0	2
Redfin bully	0	2	0	0
Banded kokopu	1	0	0	0

09 March 2017

R3				
Transect	1	2	3	4
Length (m)	11	13	12	7
Width (m)	3	3	3	3
Area fished (m²)	33	39	36	21
Torrentfish	5	6	2	0
Longfin eel	3	3	0	2
Elver eel	1	1	2	0
Redfin bully	6	2	1	8
Brown trout	1	0	0	0

R1				
Transect	1	2	3	4
Length (m)	15	19	18	17
Width (m)	3	3	3	3
Area fished (m²)	45	57	54	51
Torrentfish	2	1	0	0
Longfin eel	5	4	3	0
Elver eel	1	1	2	0
Redfin bully	2	1	0	2

C1			
Transect	1	2	3
Length (m)	9	10	11
Width (m)	3	3	3
Area fished (m²)	27	30	33
Torrentfish	0	0	2
Longfin eel	3	3	3
Elver eel	0	0	4
Redfin bully	0	0	1

C2				
Transect	1	2	3	4
Length (m)	14	15	15	16
Width (m)	3	3	3	3
Area fished (m²)	42	45	45	48
Longfin eel	1	2	3	6
Elver eel	0	1	1	0
Redfin bully	1	0	1	0
Bluegill bully	1	1	0	0
Shortfin eel	2	0	0	1

05 February 2018

R3						
Transect	1	2	3	4	5	6
Length (m)	5.5	6.6	7.7	7.7	8.8	8.8
Width (m)	3	3	3	3	3	3
Area fished (m²)	16.5	19.8	23.1	23.1	26.4	26.4
Torrentfish	9	5	3		2	1
Longfin eel	2	2	1			
Elver eel	8	2	3		1	
Redfin bully	0	1			1	2
Inanga	1					

R2								
Transect	1	2	3	4	5	6	7	8
Length (m)	5.5	6.6	6.6	6.6	5.5	5.5	5.5	7.7
Width (m)	3	3	3	3	3	3	3	3
Area fished (m²)	16.5	19.8	19.8	19.8	16.5	16.5	16.5	23.1
Torrentfish	1							
Longfin eel		1						1
Elver eel		1						1
Common bully		1						

R1						
Transect	1	2	3	4	5	6
Length (m)	17.6	15.4	7.7	7.7	7.7	8.8
Width (m)	3	3	3	3	3	3
Area fished (m²)	52.8	46.2	23.1	23.1	23.1	26.4
Torrentfish		1				1
Longfin eel		1				
Elver eel	1	1		1	2	

C1				
Transect	1	2	3	4
Length (m)	8.8	8.8	11	5.5
Width (m)	3	3	3	3
Area fished (m²)	26.4	26.4	33	16.5
Torrentfish	3	1		
Longfin eel		4	7	1
Elver eel	1		2	1
Redfin bully				1
Brown trout	1			
Koaro	1			

C2						
Transect	1	2	3	4	5	6
Length (m)	5.5	8.8	11	6.6	6.6	8.8
Width (m)	3	3	3	3	3	3
Area fished (m²)	16.5	26.4	33	19.8	19.8	26.4
Torrentfish					1	
Longfin eel		1	6	2		2
Elver eel			4			1

14 February 2018

R3					
Transect	1	2	3	4	5
Length (m)	11	11	11	9.9	11
Width (m)	3	3	3	3	3
Area fished (m²)	33	33	33	29.7	33
Torrentfish	1			1	3
Longfin eel	2	1	1	2	
Elver eel	2	1	1	1	
Redfin bully	1	1		2	2
Common bully			1		
Juvenile bully					1

R2			
Transect	1	2	3
Length (m)	15.4	14.3	14.3
Width (m)	3	3	3
Area fished (m²)	46.2	42.9	42.9
Torrentfish			1
Longfin eel			
Elver eel	1	1	
Juvenile bully			2
Redfin bully			2

R1					
Transect	1	2	3	4	5
Length (m)	15.4	15.4	16.5	17.6	17.6
Width (m)	3	3	3	3	3
Area fished (m²)	46.2	46.2	49.5	52.8	52.8
Torrentfish	4	2	2	1	
Longfin eel	1		2	1	3
Elver eel			1		2
Redfin bully	1		1		2
Inanga			1		

C1						
Transect	1	2	3	4	5	6
Length (m)	7.7	7.7	7.7	7.7	8.8	
Width (m)	3	3	3	3	3	3
Area fished (m²)	23.1	23.1	23.1	23.1	26.4	0
Torrentfish	1					
Longfin eel		4		2	1	
Elver eel	1				1	
Redfin bully			3	1		
Juvenile bully		1				

C2						
Transect	1	2	3	4	5	6
Length (m)	8.8	6.6	6.6	6.6	6.6	6.6
Width (m)	3	3	3	3	3	3
Area fished (m²)	26.4	19.8	19.8	19.8	19.8	19.8
Torrentfish						
Longfin eel	1					
Elver eel						

Redfin bully			2		1	
Koaro	1					

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R3						
Transect	1	2	3	4	5	6
Length (m)	3	3	3	3	3	3
Width (m)	5.5	5.5	4.4	4.4	5.5	4.4
Area fished (m²)	16.5	16.5	13.2	13.2	16.5	13.2
Torrentfish	2		2	1	2	1
Longfin eel			1			
Elver eel	2					
Shortfin eel	1					
Juvenile bully		1				

R2							
Transect	1	2	3	4	5	6	7
Length (m)	3	3	3	3	3	3	3
Width (m)	7.7	8.8	8.8	8.8	8.8	8.8	8.8
Area fished (m²)	23.1	26.4	26.4	26.4	26.4	26.4	26.4
Torrentfish		2	1				
Longfin eel	1						
Shortfin eel		1			1	1	
Juvenile bully				1	1		1
Redfin bully			1	2		1	1

R1				
Transect	1	2	3	4
Length (m)	3	3	3	3
Width (m)	15.4	17.6	16.5	16.5
Area fished (m²)	46.2	52.8	49.5	49.5
Torrentfish	2		1	4
Shortfin eel			1	
Longfin eel			1	
Redfin bully	2	2	1	1
Juvenile bully	1	1		

C1						
Transect	1	2	3	4	5	6
Length (m)	3	3	3	3	3	3
Width (m)	13.2	12.1	11	11	11	11
Area fished (m²)	39.6	36.3	33	33	33	33
Torrentfish	2	1				
Redfin bully			1	1		
Shortfin eel				1		

C2							
Transect	1	2	3	4	5	6	7
Length (m)	3	3	3	3	3	3	3
Width (m)	6.6	7.7	7.7	4.4	5.5	7.7	11
Area fished (m²)	19.8	23.1	23.1	13.2	16.5	23.1	33
Torrentfish				1		4	
Longfin eel					1		

19 March 2018

R3						
Transect	1	2	3	4	5	6
Length (m)	3	3	3	3	3	3
Width (m)	4.4	5.5	4.4	4.4	4.4	7.7
Area fished (m²)	13.2	16.5	13.2	13.2	13.2	23.1
Torrentfish	2	3	2	3	1	5
Longfin eel		1	1			1
Redfin bully						1

R2							
Transect	1	2	3	4	5	6	7
Length (m)	3	3	3	3	3	3	3
Width (m)	7.7	8.8	7.7	7.7	7.7	8.8	8.8
Area fished (m²)	23.1	26.4	23.1	23.1	23.1	26.4	26.4
Torrentfish	1			1		1	
Longfin eel						1	
Elver eel				2		1	
Juvenile bully			2				
Redfin bully	1		1				

R1						
Transect	1	2	3	4	5	6
Length (m)	3	3	3	3	3	3
Width (m)	7.7	11	11	11	11	13.2
Area fished (m²)	23.1	33	33	33	33	39.6
Torrentfish		2	2		1	
Redfin bully		1	2		1	2
Elver eel						1

C1					
Transect	1	2	3	4	5
Length (m)	3	3	3	3	3
Width (m)	13.2	11	11	9.9	9.9
Area fished (m²)	39.6	33	33	29.7	29.7
Longfin eel		1			
Elver eel	1				1
Juvenile bully					1

C2						
Transect	1	2	3	4	5	6
Length (m)	3	3	3	3	3	3
Width (m)	6.6	7.7	8.8	8.8	8.8	9.9
Area fished (m²)	19.8	23.1	26.4	26.4	26.4	29.7
Torrentfish		1			1	2
Longfin eel			1		1	

07 February 2019

R3										
Transect	1	2	3	4	5	6	7	8	9	10
Length (m)	3	3	3	3	3	3	3	3	3	3
Width (m)	4.4	4.4	4.4	5.5	5.5	5.5	5.5	5.5	5.5	5.5

Area fished (m²)	13.2	13.2	13.2	16.5	16.5	16.5	16.5	16.5	16.5	16.5
Torrentfish	5	6	5	1	6	3	1	2		
Redfin bully	3		1	1		3	2	1	1	2
Longfin eel	3			1	1		1			
Elver eel				1		1				

R2								
Transect	1	2	3	4	5	6	7	8
Length (m)	3	3	3	3	3	3	3	3
Width (m)	4.4	4.4	4.4	4.4	5.5	5.5	5.5	5.5
Area fished (m²)	13.2	13.2	13.2	13.2	16.5	16.5	16.5	16.5
Torrentfish		1	3	1		5		2
Elver eel			1					
Longfin eel					2	1		
Redfin bully							1	

R1					
Transect	1	2	3	4	5
Length (m)	3	3	3	3	3
Width (m)	4.4	5.5	5.5	6.6	6.6
Area fished (m²)	13.2	16.5	16.5	19.8	19.8
Elver eel		1		1	
Torrentfish			1		1
Redfin bully			1		
Longfin eel				2	

C1						
Transect	1	2	3	4	5	6
Length (m)	3	3	3	3	3	3
Width (m)	6.6	6.6	7.7	7.7	6.6	6.6
Area fished (m²)	19.8	19.8	23.1	23.1	19.8	19.8
Longfin eel	2				1	2
Elver eel		1				
Redfin bully				1	1	1

C2			
Transect	1	2	3
Length (m)	3	3	3
Width (m)	9.9	8.8	4.4
Area fished (m²)	29.7	26.4	13.2
Longfin eel	2	1	
Torrentfish	4	2	1
Redfin bully	1	2	
Elver eel	1		

20 February 2020

R3										
Transect	1	2	3	4	5	6	7	8	9	10
Length (m)	3	3	3	3	3	3	3	3	3	3
Width (m)	5.5	4.4	5.5	5.5	5.5	6.6	6.6	6.6	6.6	6.6
Area fished (m²)	16.5	13.2	16.5	16.5	16.5	19.8	19.8	19.8	19.8	19.8
Torrentfish		5	11	6	1	5	5	3	1	1
Redfin bully	2	3	1		1	1	3	1	1	3

Longfin eel				1	3	1		3	1	2
Elver eel									1	
Inanga				1						
Juvenile bully		3	4	2		1	1	1	1	

R2					
Transect	1	2	3	4	5
Length (m)	3	3	3	3	3
Width (m)	4.4	5.5	7.7	11	11
Area fished (m²)	13.2	16.5	23.1	33	33
Torrentfish	3	1		8	3
Juvenile bully	1	1			
Longfin eel				1	1
Redfin bully				1	

R1									
Transect	1	2	3	4	5	6	7	8	9
Length (m)	3	3	3	3	3	3	3	3	3
Width (m)	6.6	6.6	8.8	6.6	7.7	7.7	7.7	7.7	8.8
Area fished (m²)	19.8	19.8	26.4	19.8	23.1	23.1	23.1	23.1	26.4
Inanga				1	1				
Torrentfish	1	1	1	1		1	2		1
Redfin bully					1		1	1	
Longfin eel			1				1	1	3
Juvenile bully							1		

C1				
Transect	1	2	3	4
Length (m)	3	3	3	3
Width (m)	11	9.9	9.9	7.7
Area fished (m²)	33	29.7	29.7	23.1
Longfin eel	2	1	4	1
Elver eel			1	
Redfin bully	1			
Torrentfish		2		

C2					
Transect	1	2	3	4	5
Length (m)	3	3	3	3	3
Width (m)	8.8	8.8	7.7	6.6	4.4
Area fished (m²)	26.4	26.4	23.1	19.8	13.2
Longfin eel	3	1			
Torrentfish	4	1	1	1	
Redfin bully			1		
Juvenile bully	1				

05 March 2019

R3									
Transect	1	2	3	4	5	6	7	8	9
Length (m)	3	3	3	3	3	3	3	3	3
Width (m)	6.6	5.5	5.5	5.5	6.6	6.6	6.6	7.7	7.7
Area fished (m²)	19.8	16.5	16.5	16.5	19.8	19.8	19.8	23.1	23.1
Torrentfish	6	14	6	8	13	5	9	6	3

Redfin bully	2			1			1		
Longfin eel	1	3	1				1	1	1
Juvenile bully	1	1	1			1			
Elver eel					1	2			

R2					
Transect	1	2	3	4	5
Length (m)	3	3	3	3	3
Width (m)	5.5	5.5	7.7	7.7	5.5
Area fished (m²)	16.5	16.5	23.1	23.1	16.5
Torrentfish	4	7	1	1	1
Longfin eel				2	

R1				
Transect	1	2	3	4
Length (m)	3	3	3	3
Width (m)	6.6	6.6	6.6	6.6
Area fished (m²)	19.8	19.8	19.8	19.8
Torrentfish	1	2		
Elver eel	1	1		

C1				
Transect	1	2	3	4
Length (m)	3	3	3	3
Width (m)	9.9	8.8	8.8	8.8
Area fished (m²)	29.7	26.4	26.4	26.4
Longfin eel	1	1	2	
Elver eel	1			1
Torrentfish			1	

C2				
Transect	1	2	3	4
Length (m)	3	3	3	3
Width (m)	11	8.8	8.8	7.7
Area fished (m²)	33	26.4	26.4	23.1
Longfin eel	1			2
Torrentfish	2	2		
Elver eel	1	1		1

22 March 2019

R3								
Transect	1	2	3	4	5	6	7	8
Length (m)	3	3	3	3	3	3	3	3
Width (m)	5.5	5.5	5.5	6.6	7.7	7.7	7.7	7.7
Area fished (m²)	16.5	16.5	16.5	19.8	23.1	23.1	23.1	23.1
Torrentfish	5	3	11	3	6	4	3	3
Redfin bully	2	1	1				3	1
Longfin eel		2	1		1	4		
Juvenile bully	2	3					1	
Elver eel	2		1					
Brown trout							1	

R2				
Transect	1	2	3	4

Length (m)	3	3	3	3
Width (m)	5.5	6.6	6.6	7.7
Area fished (m²)	16.5	19.8	19.8	23.1
Torrentfish	6	6	2	
Juvenile bully	2			
Longfin eel	1	2		

R1				
Transect	1	2	3	4
Length (m)	3	3	3	3
Width (m)	12.1	12.1	12.1	12.1
Area fished (m²)	36.3	36.3	36.3	36.3
Longfin eel		2		
Torrentfish	5	2		1
Elver eel	1			
Juvenile bully	1		1	1

C1					
Transect	1	2	3	4	5
Length (m)	3	3	3	3	3
Width (m)	7.7	8.8	8.8	8.8	8.8
Area fished (m²)	23.1	26.4	26.4	26.4	26.4
Longfin eel	2	2	1		
Juvenile bully	2		1		
Redfin bully					1
Torrentfish				1	1

C2				
Transect	1	2	3	4
Length (m)	3	3	3	3
Width (m)	11	11	11	9.9
Area fished (m²)	33	33	33	29.7
Longfin eel	1		1	
Torrentfish	1	1	1	
Redfin bully	1			

About Boffa Miskell

Boffa Miskell is a leading New Zealand professional services consultancy with offices in Auckland, Hamilton, Tauranga, Wellington, Christchurch, Dunedin and Queenstown. We work with a wide range of local and international private and public sector clients in the areas of planning, urban design, landscape architecture, landscape planning, ecology, biosecurity, cultural heritage, graphics and mapping. Over the past four decades we have built a reputation for professionalism, innovation and excellence. During this time we have been associated with a significant number of projects that have shaped New Zealand's environment.

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