



PATTLE DELAMORE PARTNERS LTD

# Canterbury Hapua Fish Survey Pilot Study

Environment Canterbury



---

# Canterbury Hāpua Fish Survey – Pilot Study

✦ Prepared for

Environment Canterbury

✦ May 2021



PATTLE DELAMORE PARTNERS LTD  
Level 2, 134 Oxford Terrace  
Christchurch Central, Christchurch 8011  
PO Box 389, Christchurch 8140, New Zealand

Office +64 3 345 7100  
Website <http://www.pdp.co.nz>  
Auckland Tauranga Wellington Christchurch



**solutions** for your environment

## Quality Control Sheet

TITLE Canterbury Hāpua Fish Survey – Pilot Study

CLIENT Environment Canterbury

VERSION Final

ISSUE DATE 6 May 2021

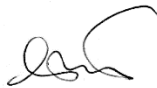
JOB REFERENCE C03818800

SOURCE FILE(S) Canterbury Hapua Fish Survey\_Final .docx

### DOCUMENT CONTRIBUTORS

Prepared by

SIGNATURE



Marty Bonnett

Reviewed by

Approved by

SIGNATURE



Laura Drummond



Steve Pearce

### Limitations:

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Environment Canterbury and others (not directly contracted by PDP for the work), including NIWA. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

This report has been prepared by PDP on the specific instructions of Environment Canterbury for the limited purposes described in the report. PDP accepts no liability if the report is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

© 2021 Pattle Delamore Partners Limited

## Executive Summary

The freshwater areas (hāpua) near the mouths of Canterbury braided rivers have high ecological and cultural value. They support a diversity of freshwater and estuarine fish species, and provide habitat for fish breeding, rearing and feeding.

Comprehensive surveys of the fish communities in the hāpua of some braided Canterbury rivers were last undertaken in the 1980s, these surveys were intensive, based on repeated fortnightly or monthly sampling over one year and generally focused on seasonal patterns of the fish populations, particularly fish migrations and fish recruitment into the rivers.

Surveys of fish communities in the hāpua of the Hakatere, Rangitata, and Rakaia Rivers were undertaken in November 2020. The objective of these surveys was to assess the current state of fish communities relative to historic surveys from the 1980's and to determine broad scale changes in fish populations. The 2020 surveys were designed as a pilot study and should provide a “template” for more regular surveys of these, and other, hāpua in the future to further understand their current state and identify drivers of change. This technical report outlines the methods used in the 2020 surveys, summarises catches by method, and makes high level comparisons between catches in the 1980's and 2020.

The surveys completed in November 2020 suggest that the fish communities in the hapua of the Hakatere, Rangitata and Rakaia Rivers consist predominately of common bullies, inanga, eels, smelt, and yelloweyed mullet. The abundance of black flounder, brown trout, and Chinook salmon in the Rakaia River hapua was greatly reduced compared to results from this area in the 1980's.

The relative abundance of Stokell's and common smelt in the three hāpua surveyed during this study has not yet been determined, and further surveys and laboratory analyses are required.

## Table of Contents

SECTION	PAGE
<b>Executive Summary</b>	<b>ii</b>
<b>1.0 Introduction</b>	<b>1</b>
1.1 Background	1
<b>2.0 Methods</b>	<b>2</b>
2.1 Beach Seine Netting	2
2.2 Fyke Netting	3
2.3 Gee Minnow Trapping	3
2.4 Electric Fishing	4
2.5 Gill Netting	4
<b>3.0 Results</b>	<b>4</b>
3.1 Fish Size	6
<b>4.0 Discussion</b>	<b>6</b>
4.1 Comparison with 1980's Surveys	6
4.2 Overall State of Fish Communities in the Hakatere, Rangitata, and Rakaia Hāpua	9
4.3 Future Surveys	9
4.4 References	9

## Table of Tables

Table 1: Summary of catch (numbers of fish) in the Hakatere, Rangitata, and Rakaia Hāpua 5

Table 2: Summary of catch (numbers of fish) from seine haul sites and fyke net sites combined in all three Hāpua investigated by this study, and comparative historical data from the Rakaia Lagoon study (Eldon & Greager 1983) and Waimakariri Estuary study (Eldon & Kelly 1984) 7

## Appendices

Appendix A: Site Locations and Aerial Photographs

Appendix B: Habitat Data

Appendix C: Fish Size Graphs

## 1.0 Introduction

Pattle Delamore Partners (PDP) was engaged by Environment Canterbury (ECan) to design and assist with undertaking fish surveys of the hāpua and lower reaches of Canterbury braided rivers, following concerns that the fish communities in these areas had become degraded since the 1980's. Surveys of fish communities in the hāpua of three Canterbury rivers (the Hakatere, Rangitata, and Rakaia) were undertaken in November 2020 as a cooperative effort by ECan, the Department of Conservation (DoC), the North Canterbury and Central South Island Fish & Game Councils, Te Rūnanga o Arowhenua, and with the assistance of local residents. The main objective of the 2020 surveys was to conduct a "pilot" study to assess the current state of fish communities relative to historic surveys from the 1980's and to provide a "template" for more regular surveys of these, and other, hāpua in future.

### 1.1 Background

Canterbury's large rivers are predominately braided shingle rivers which discharge directly into the sea through a mouth. Over time the mouth of the river often migrates north due to stable flows coupled with the action of the sea, so that a 'lagoon' of much slower flowing freshwater forms behind - and in parallel to - a shingle bar. Sometimes a flood flow in the river will reform the direct outlet, and what was the lagoon area becomes more of a backwater. Overall, lagoons and backwaters may be transitory/temporary features of the lower river.

Most of the lagoons and backwaters that occur near the mouths of Canterbury rivers are tidally influenced for a considerable distance upstream, however they have little input of salt water, as the strong flow of fresh water out of the mouth (particularly in the large rivers) prevents seawater moving upstream. Some salt water may enter the lagoon/backwater areas if large waves overtop the shingle bars at high tides, and/or by infiltrating through the shingle bars. Overall, the salinity within the lagoon/backwater areas is very low, and these largely transitory areas are mostly not true estuarine environments.

New Zealand's riverine fish communities generally have a high proportion of diadromous species (which spend a portion of their lifecycles in both freshwater and the sea), and estuarine species (which live in the brackish waters between the sea and river). For fish species in braided rivers, the hāpua (loosely defined in this study as the area of lower river and lagoon near the river mouth) not only provide access to and from the sea, but also provide habitat for fish breeding, rearing and feeding. There has always been, and still is, high cultural and recreational use of these fish populations in hāpua habitats. Comprehensive surveys of the fish communities in the hāpua or estuaries of braided Canterbury rivers were last undertaken in the 1980s (Eldon & Greager 1983, Eldon & Kelly

1985). These surveys were based on repeated fortnightly or monthly sampling over one year and generally focused on seasonal patterns of the fish populations, particularly fish migrations and fish recruitment into the rivers.

## 2.0 Methods

The methods used during the 2020 surveys generally replicated the methods used during the surveys completed in the 1980's, so that a fair comparison could be made. The following describes the methods used in the 2020 surveys in some detail, so that future surveys in Canterbury hāpua can be conducted in a consistent manner.

### 2.1 Beach Seine Netting

Daytime beach seine netting was carried out in all three hāpua surveyed in 2020. The nets used were very similar to those used in the surveys of the Rakaia Lagoon in 1980-81 (Eldon and Greager 1983) and Waimakariri Estuary in 1983-84 (Eldon and Kelly 1985), as follows:

- ∴ A 20 m long seine net with 3 m bridles and 30 m haul rope;
- ∴ A 30 m long seine net with 3 m bridles and 30 m haul rope;
- ∴ Nets were 2.5 m deep, with lead weighting on the bottom rope and buoys on the top rope; and
- ∴ Each net was constructed with 12 mm (stretch) knotless mesh, which provided an equivalent aperture of roughly 5- or 6-mm side-of-square so that relatively small fish, including some whitebait, were collected.

Beach seine netting was typically carried out by using a boat to assist setting the net parallel to the shore and up to the extremity of haul ropes and bridle (i.e. up to 30 m offshore). The nets were then hauled gradually to shore while ensuring the weighted bottom rope of the net maintained contact with the riverbed as much as possible. The area of riverbed sampled from each seine haul was estimated, noted, and captured fish were identified, counted, and a sample measured and/or euthanised and preserved.

The beach seining technique worked best where the beach shelved gradually and where there was little or no water flow; some variations of the technique were required where netting took place in embayment's along the shoreline or when snags or aggregations of sediment interfered with the haul. Setting and hauling beach seine nets was difficult and generally unsatisfactory where river flow was substantial, as the water flow caused the bottom rope of the net to "roll" and the set to collapse.

## 2.2 Fyke Netting

Two types of fyke net were used in the hāpua surveys:

- ∴ Single ended “green” fine mesh nets (6 mm stretch), 3 m long with a leader 3 m long by 0.6 m deep; and
- ∴ Single ended “black” coarse mesh nets (18 mm stretch), 2.5 m long with a leader 3 m long by 0.5 m deep.

The two types of fyke nets used in the 2020 hāpua study were somewhat different to the fyke nets used in the studies undertaken during the 1980s, when a mixture of “commercial” eel fyke nets and “mini-fyke” nets were used. The “commercial” eel fyke nets were much larger than the “green” fykes used in 2020 but used much coarser netting, while mini-fykes were roughly half the size of the “green” fykes and used 15mm mesh.

Fyke nets were set, unbaited, overnight in various locations within each hāpua, making sure that nets were not stranded on the outgoing low tide cycle when water levels in the lagoon dropped. Generally, sets were made with the leader of the net staked close to the shoreline and the cod-end (i.e., the trap end) of the net at right angles to the shore; normally the cod-end was weighted with river stones placed inside before the end was tied, and the net then stretched out (or thrown out) into the deeper water. In some areas such as small tributary streams a fyke net was set with the cod-end staked upstream in the flow (or tied to a log etc.) and with the fyke net and leader streaming downstream.

Nets were recovered the following morning, and fish removed, identified, counted and samples measured and/or preserved if required.

While the finer mesh “green” fyke nets were more effective at catching and holding smaller fish, some of these – particularly whitebait - became either trapped in the mesh trying to escape or were eaten by eels also trapped in the net.

## 2.3 Gee Minnow Trapping

Gee Minnow traps are essentially very small versions of the traditional Hinaki fish trap. For the hāpua studies, two-piece metal minnow traps (manufactured by the Gee Company) were clipped together and attached to a short light rope before being set overnight (unbaited) in various locations in each hāpua. Mostly these were set in close proximity to the fyke nets.

Gee-minnow traps were recovered in the morning, fish removed, identified, counted and samples measured and or preserved if required.



## 2.4 Electric Fishing

In each hāpua, areas of braided river habitat upstream of tidal influence were spot electric fished using a Kainga EFM300 portable electric fishing machine (EFM). Electric fishing was limited to shallow (< 1m deep) and moderately flowing areas of the channels; stunned fish were collected in either the operators dip net or in a pole seine placed downstream of the operator and held by an assistant. Fish caught during electric fishing were identified, counted and samples measured and or preserved if required.

## 2.5 Gill Netting

Gill nets of various mesh sizes were used in the Rakaia Lagoon in 1980-81. This survey technique was not considered appropriate for the 2020 hāpua surveys, as gill netting results in high mortality of most fish species.

## 3.0 Results

Surveys of the three Canterbury hāpua were undertaken during November 2020: the Hakatere on the 16th and 17th, the Rangitata from the 18th to the 20th, and the Rakaia on the 24 and 25th.

Appendix A provides maps and aerial photographs of sampling locations for each of the three hāpua surveys. Appendix B details the habitat data recorded for each sampling site at each hāpua.

It was not possible to reliably identify and measure some live specimens to species level in the field without the use of anaesthetic, and in some cases, fish were categorised as “unidentified bully” or “unidentified smelt”. As common smelt and Stokell’s smelt were not able to be differentiated in the field or later from preserved samples, a selection of smelt from various sites within all three hāpua have been set aside for DNA analysis (the results of which were not available at the time of writing this report).

Table 1 summarises catches by method in all three hāpua.

Table 1: Summary of catch (numbers of fish) in the Hakatere, Rangitata, and Rakaia Hāpua																		
	Bully					Smelt	Galaxias		Mullet	Flounder		Eel			Salmonid			Paratya
	Giant	Common	Upland	Bluegill	UID	UID	Inanga	Whitebait	Yellow-eyed	Black	UID	Longfin	Shortfin	UID	Brown trout	Chinook salmon	Torrent fish	
<b>Hakatere (16 - 17 Nov 2020)</b>																		
Total for 14 seine sites 5900 m <sup>2</sup>	0	475	0	0	0	61	3	11	0	0	0	0	0	0	2	0	1	0
Total for 14 fyke nets	4	648	0	0	312	3	125	607	0	0	0	5	30	0	0	0	0	0
Total for 24 GMTs	0	149	2	0	3	0	293	29	0	0	0	0	0	0	0	0	0	0
Total for 5 EFM sites	0	109	7	17	0	3	0	20	0	0	0	0	2	0	0	0	14	0
<b>HAKATERE TOTAL</b>	<b>4</b>	<b>1381</b>	<b>9</b>	<b>17</b>	<b>315</b>	<b>67</b>	<b>421</b>	<b>667</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>5</b>	<b>32</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>15</b>	<b>0</b>
<b>Rangitata (18 - 20 Nov 2020)</b>																		
Total for 15 seine sites 6190 m <sup>2</sup>	0	641	0	0	0	1495	100	3	1505	0	0	0	0	0	5	2	0	0
Total for 13 fyke nets	24	270	0	0	189	27	84	32	1	0	0	21	74	0	0	0	0	12
Total for 29 GMTs	0	320	0	0	53	3	259	8	0	0	0	0	0	0	0	0	0	0
Total for 3 EFM sites	1	38	1	68	200	2	39	26	0	0	1	0	9	4	0	0	7	0
<b>RANGITATA TOTAL</b>	<b>25</b>	<b>1269</b>	<b>1</b>	<b>68</b>	<b>442</b>	<b>1527</b>	<b>482</b>	<b>69</b>	<b>1506</b>	<b>0</b>	<b>1</b>	<b>21</b>	<b>83</b>	<b>4</b>	<b>5</b>	<b>2</b>	<b>7</b>	<b>12</b>
<b>Rakaia (24 - 25 Nov 2020)</b>																		
Total for 15 seine sites 8450 m <sup>2</sup>	0	24	0	0	0	820	14	2	162	0	0	0	0	0	2	3	0	0
Total for 12 fyke nets	13	20	0	0	12	17	176	414	1	2	0	13	29	1	3	0	0	4
Total for 24 GMTs	4	34	1	0	32	0	560	164	0	0	0	0	2	0	0	0	0	6
Total for 10 EFM sites	1	23	3	13	100	0	0	509	0	0	0	0	21	9	5	0	6	20
<b>RAKAIATOTAL</b>	<b>18</b>	<b>101</b>	<b>4</b>	<b>13</b>	<b>144</b>	<b>837</b>	<b>750</b>	<b>1089</b>	<b>163</b>	<b>2</b>	<b>0</b>	<b>13</b>	<b>52</b>	<b>10</b>	<b>10</b>	<b>3</b>	<b>6</b>	<b>30</b>
<b>GRAND TOTAL</b>	<b>47</b>	<b>2751</b>	<b>14</b>	<b>98</b>	<b>901</b>	<b>2431</b>	<b>1653</b>	<b>1825</b>	<b>1669</b>	<b>2</b>	<b>1</b>	<b>39</b>	<b>167</b>	<b>14</b>	<b>17</b>	<b>5</b>	<b>28</b>	<b>42</b>
Notes:																		
UID = unidentified to species																		

### **3.1 Fish Size**

Sufficient numbers of common bully, inanga, and yelloweyed mullet were caught and measured during the 2020 hāpua surveys for a comparison of fish length frequency with fish measured during November 1980 in the Rakaia Lagoon by Eldon and Greager (1983). The length comparisons are presented in Figures 1 to 3 in Appendix C.

## **4.0 Discussion**

### **4.1 Comparison with 1980's Surveys**

Table 2 summarises the 2020 catches from seine hauls and fyke-netting in the three hāpua with catches at the same time of year using these two methods from the Rakaia Lagoon in 1980 and from the Waimakariri Estuary in 1983. Gill nets were also used in the 1980 surveys of the Rakaia Lagoon only, however Gee – minnow traps and electric fishing methods were not used in either the Rakaia or Waimakariri studies.

**Table 2: Summary of catch (numbers of fish) from seine haul sites and fyke net sites combined in all three Hāpua investigated by this study, and comparative historical data from the Rakaia Lagoon study (Eldon & Greager 1983) and Waimakariri Estuary study (Eldon & Kelly 1984)**

	Number		Bully			Smelt	Galaxias		Mullet	Flounder		Eel			Salmonids			Paratya
	seine sites	fyke sites	Giant	Common	UID	*both spp	Inanga	Whitebait	Yelloweyed	black	UID	Longfin	Shortfin	UID	Brown trout	Chinook Salmon	Torrent fish	
<b>Rakaia Lagoon</b>																		
11-13 Nov 1980	12	7	0	43	0	623	88	0	4	34	0	24	26	0	14	39	0	0
25-27 Nov 1980	11	7	0	69	0	3164	225	0	17	43	0	12	24	0	21	42	3	0
<b>Waimakariri Estuary</b>																		
31 Oct-1 Nov 1983	8	5	32	360	0	462	2	0	85	14	0	155	35	0	3	3	0	0
30 Nov - 1 Dec 1983	8	5	29	639	0	296	0	0	328	15	0	94	20	0	11	4	0	0
<b>Hakatere Hāpua</b>																		
16-17 Nov 2020	14	14	4	1123	312	64	128	618	0	0	0	5	30	0	2	0	1	0
<b>Rangitata Hāpua</b>																		
18-20 Nov 2020	15	13	24	911	189	1522	184	35	1506	0	0	21	74	0	5	2	0	12
<b>Rakaia Hāpua</b>																		
24-25 Nov 2020	15	12	13	44	12	837	190	416	163	2	0	13	29	1	5	3	0	4

**Notes:**

1. Data from the 1980's studies include catches in the Rakaia Lagoon from gill nets, which were not used in the 2020 investigation.
2. Other species of fish (e.g., sand flounder, yellow-belly flounder, stargazers, sprats) caught in the Waimakariri Estuary during the periods shown have not been included in this table.

The most meaningful comparison can be made between the Rakaia Lagoon on two occasions in November 1980 (11 and 12 seine hauls, 7 fyke sets) and the Rakaia hāpua in late November 2020 (15 seine hauls and 12 fyke sets). Catches during the 2020 surveys contained:

- ∴ Similar numbers of common bully, inanga, longfinned and shortfinned eels.
- ∴ Similar numbers of smelt (common smelt and Stokell’s smelt combined) in 1980, compared to unidentified smelt in 2020). Preliminary analyses suggest that the relative proportion of each smelt species has changed, however further investigation is required to clarify any changes.
- ∴ Thirteen giant bullies, mostly from two fyke net sites at the north of the Rakaia Lagoon, compared to no giant bullies in November 1980.
- ∴ Greater numbers of whitebait, however most (412 out of 414) were caught in fine mesh fyke nets; the fyke nets used in the 1980 survey utilised larger mesh which would have allowed most whitebait to escape.
- ∴ Greater numbers of yellow-eyed mullet; however, catches of this species varied greatly in the 2020 hāpua surveys; none were caught in the Hakatere Hāpua, whereas over 1500 were caught in the Rangitata, including 1425 in one seine haul.
- ∴ Only two black flounder, compared to 34 and 43 caught in the two November 1980 surveys. There is no suggestion that the much lower catch of flounder in 2020 is a consequence of not using gill nets, as during 1980 and 1981 only 4 out of the total of 577 black flounder caught in the Rakaia Lagoon were caught in gill nets; i.e. comparing flounder catches on the basis of seine hauls and fyke netting catches is appropriate.
- ∴ Fewer brown trout (of all sizes); however, during 1980 and 1981 about 40% of the brown trout caught in the Rakaia Lagoon were in gill nets (not used in 2020) and a comparison of catches for this fish is less meaningful.
- ∴ Fewer Chinook salmon juveniles; however, during 1980 and 1981 large releases (> 600,000) of juvenile salmon were made from hatcheries into the Rakaia River, including directly into the Rakaia Lagoon, and Eldon and Greager (1983) estimated that less than 24% of their catch of juvenile salmon comprised “wild” (i.e. non-hatchery) stocks. Whether any hatchery releases had occurred in the Rakaia prior to the 2020 hāpua Survey is not known, although the capture of only three salmon during the survey indicates that salmon stocks in the river are poor in any case.

## 4.2 Overall State of Fish Communities in the Hakatere, Rangitata, and Rakaia Hāpua

The surveys completed in November 2020 provide a “snapshot” of current fish communities in each of the three hāpua during late spring. The fish communities consist mostly of diadromous species which migrate between freshwater and the sea as part of their normal life cycle, and because of this the species composition of the communities will change with the seasons. Repeated surveys of the hāpua at various times of the year will provide a much clearer picture of current fish communities in each of the hāpua, especially of the large runs of smelt into the hāpua which historically occurred during December and January.

In the spring 2020 surveys, each of the hāpua catches were dominated by common bullies, inanga and eels. The Rakaia and Rangitata hāpua provided substantial catches of smelt and yellow-eyed mullet, whereas the Hakatere hāpua was lacking mullet and flounder, and smelt counts were lower than those in the Rakaia and Rangitata hāpua. The replication of 1980’s sampling methods allows a meaningful comparison with fish communities reported from the Rakaia Lagoon in 1980 and those surveyed in 2020, as shown in Table 2. The Rakaia Lagoon fish community in November 1980 also consisted predominately of common bullies, inanga, eels, smelt, and yelloweyed mullet, although it in 2020 the abundance of black flounder, brown trout, and Chinook salmon was greatly reduced. It must be noted that there are limitations on comparing these surveys, as discussed above.

The relative abundance of Stokell’s and common smelt in the three hāpua surveyed during this study has not yet been determined. Further surveys and laboratory analyses are being led by ECan to investigate the fish communities and potential drivers for their health.

## 4.3 Future Surveys

The main objective of the 2020 surveys was to conduct a “pilot” study to assess the current state of fish communities relative to historic surveys from the 1980’s and to provide a “template” for more regular surveys of these, and other, hāpua in future to account for temporal variation in fish communities. Methods used during the 2020 surveys generally replicated those used during the 1980s surveys and provided a fair comparison; future surveys in Canterbury hāpua can be conducted in a consistent manner.

## 4.4 References

Eldon, G.A. and Greager, A.J. (1983). Fishes of the Rakaia Lagoon: Fisheries Environmental Report no. 30. NZ Ministry of Agriculture and Fisheries, Christchurch. 65p.

Eldon, G.A. and Kelly, G.R. (1985). Fishes of the Waimakairi River estuary. Fisheries Environmental Report no. 56. NZ Ministry of Agriculture and Fisheries, Christchurch. 59p.

## Appendix A

Site Location and Aerial Photographs



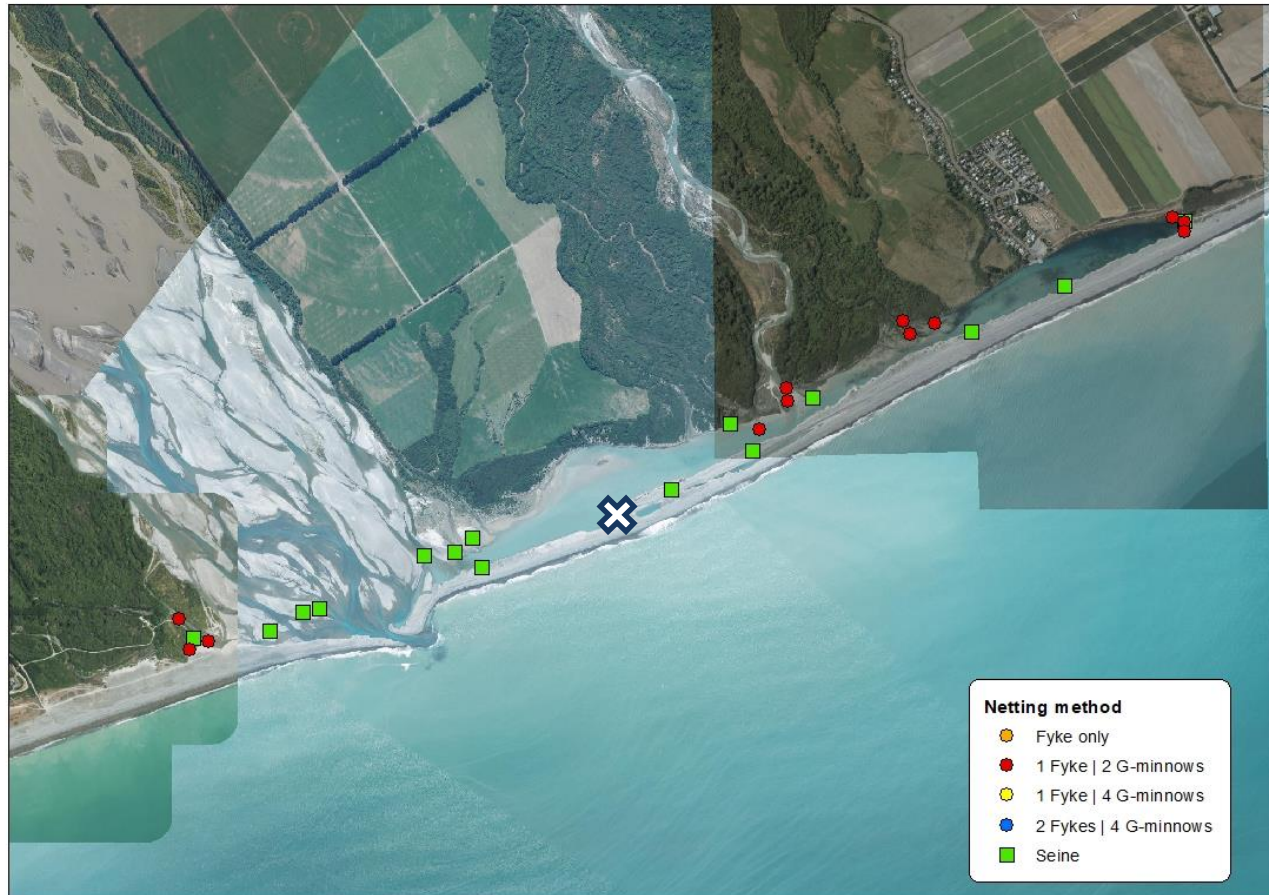


Figure A1: Rakaia Hāpua: 24-25<sup>th</sup> November 2020 ('X' marks the approximate location of mouth opening at the time of sampling)



Photo 1: Rakaia hapua looking South



Photo 2: Rakaia hapua looking North



Photo 3: Rakaia hapua - Seine haul towards beach



Photo 4: Rakaia hapua fish collection from Seine net

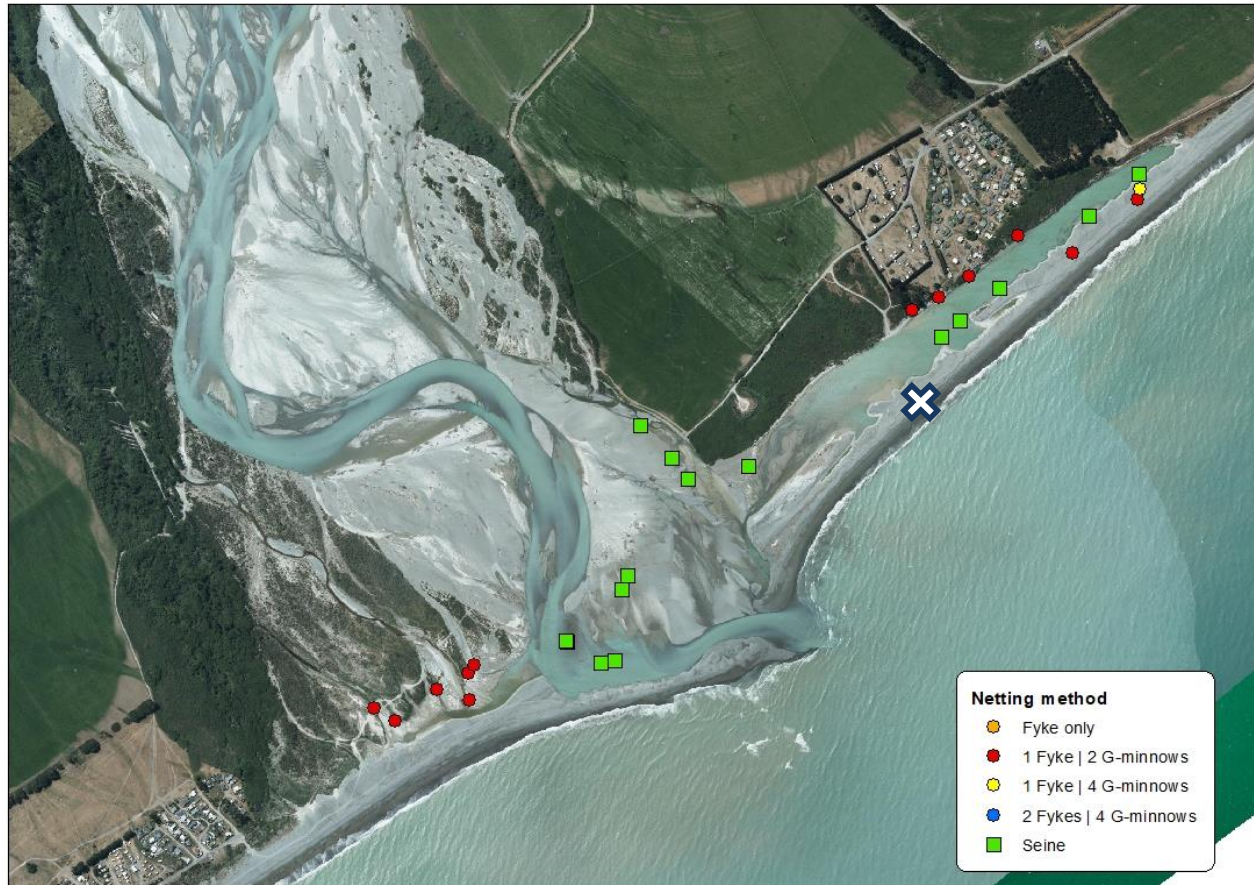


Figure A2: Rangitata Hāpua: 18-20<sup>th</sup> November 2020 ('X' marks the approximate location of mouth opening at the time of sampling)



Photo 5: Rangitata hapua looking South



Photo 6: Rangitata hapua looking North



Photo 7: Seine haul in Rangitata hapua



Photo 8: Seine haul catch in Rangitata hapua

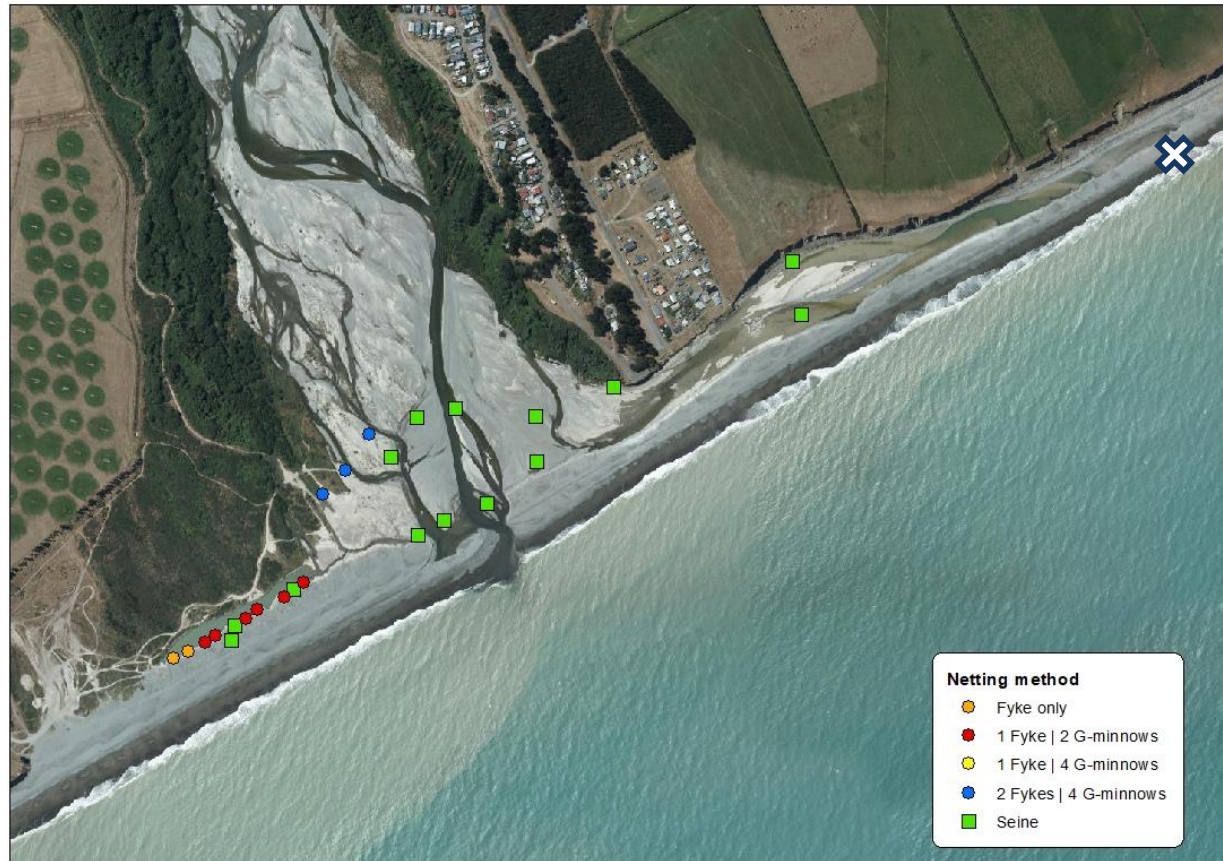


Figure A3: Hakaterere Hāpua: 16-17<sup>th</sup> November 2020 ('X' marks the approximate location of mouth opening at the time of sampling)



Photo 9: Seine haul in Hakatere hapua



Photo 10: Seine haul catch in Hakatere hapua





Photo 11: Giant Bully (*Gobiomorphus gobioides*) caught in Hakatere hapua



Photo 12: Electric fishing in the Hakatere hapua

## Appendix B

Habitat Data

**Table B1: Rakaia River Habitat Data Summary**

Site	Time	NZTM coordinates		Tide cycle	Net width (m)	Distance from shore (m)	Net height (m)	Area fished (m <sup>2</sup> )	Water clarity	Water colour	Max water depth (m)	Habitat type	Velocity	Substrate							Algal cover (%)	Macro phyte cover (%)	Notes		
		Easting	Northing											Silt	Sand	Gravel	Pebble	Cobble	Boulder	Bed rock					
1	9:00 AM	1536921	5139118	Incoming	20	25	2.5	500	Glacially turbid	Blue-green	0.65	Pool/backwater	Static-slow	0	75	10	10	5	0	0	0	0	0	On true left braid on main branch of river. Backwater habitat at the braid-hāpua interface.	
2	9:45 AM	1536921	5139070	Incoming	20	5	2.5	100	Glacially turbid	Blue-green	0.80	Run	Moderate	0	50	50	0	0	0	0	0	0	0	On true left edge of hāpua at margin of swift flowing deep water.	
3	10:05 AM	1536884	5139180	Incoming	20	15	2.5	300	Glacially turbid	Blue-green	0.70	Pool/run	Slow	0	10	20	50	20	0	0	10	0	0	100 m upstream of Site 1. Pool/slow flowing run at the toe of a shallow riffle.	
4	10:30 AM	1536706	5139114	Incoming	20	30	2.5	600	Glacially turbid	Blue-green	0.70	Pool	Static-slow	60	0	10	15	15	0	0	10	0	0	Shallow pool at the toe of main braid riffle. Unlike sites 1 & 2, more silt cover and less sand. Little bird activity. No woody debris.	
5	10:50 AM	1536321	5138921	Incoming	20	15	2.5	300	Glacially turbid	Blue-green	0.75	Pool/backwater	Slow	40	5	30	20	5	0	0	10	0	0	Mouth of braid feeding into hāpua. Quietly flowing area at edge of fast run. Fine substrates prevalent.	
6	11:00 AM	1536264	5138907	Incoming	30	25	2.5	750	Glacially turbid	Blue-green	0.75	Pool/backwater	Static-slow	0	95	0	0	5	0	0	0	0	0	0	Sandy bay habitat and shelf before steep drop into main hapua. Little bird activity.
7	11:30 AM	1536143	5138839	Incoming	30	25	2.5	750	Glacially turbid	Blue-green	2.50	Pool	Static-slow	5	90	0	0	5	0	0	0	0	0	0	Southern arm of the hāpua near the mouths of lower river braids. Deep water dominated by sandy substrates. Fished almost entire width of arm.
8	12:00 PM	1535859	5138812	Incoming	30	25	2.5	750	Glacially turbid	Blue-green	1.00	Pool	Static-slow	100	0	0	0	0	0	0	0	0	0	0	At the southern extreme of the southern arm of the hāpua. Near the mouth of Bully Creek. Shallow pool habitat at the foot of a small riffle/braid at entrance into the hāpua.
9	12:30 PM	1537614	5139356	Outgoing	30	30	2.5	900	Glacially turbid	Blue-green	2.00	Pool/backwater	Slow	0	0	20	60	20	0	0	0	0	0	0	Northern arm of the hāpua. Approx. 100 m north of the hāpua mouth to the ocean, but south of the Rakaia River North Branch. Deep, slow water.
10	1:00 PM	1537916	5139500	Outgoing	30	35	2.5	1050	Glacially turbid	Blue-green	3.00	Pool	Static	0	0	10	80	10	0	0	0	0	0	0	Bay in northern arm of hāpua. Adjacent to a colony of Black Bill Gulls. Approx. 400 m north of hāpua mouth to the ocean. Just south and adjacent to the north branch mouth into the hāpua.
11	1:15 PM	1537833	5139598	Outgoing	30	30	2.5	900	Glacially turbid	Blue-green	1.00	Pool/backwater	Static-slow	50	50	0	0	0	0	0	0	0	0	0	Sandy bay downstream of Rakaia River North Branch mouth entrance into the hāpua. Adjacent to Site 10. Bank vegetation including sedges/rushes, toe toe, grasses, shrubs beyond the high tide mark
12	1:55 PM	1538136	5139692	Outgoing	30	25	2.5	750	Glacially turbid	Blue-green	2.00	Pool/backwater	Static-slow	90	0	0	5	5	0	0	15	0	0	0	Large silty bay leading to a steep drop-off (half shallow water, half deep water). On inland side of hāpua on the northern side of the Rakaia River north Branch mouth feeding into the hāpua. Similar bank vegetation and habitat as Site 11.

**Table B1: Rakaia River Habitat Data Summary**

Site	Time	NZTM coordinates		Tide cycle	Net width (m)	Distance from shore (m)	Net height (m)	Area fished (m <sup>2</sup> )	Water clarity	Water colour	Max water depth (m)	Habitat type	Velocity	Substrate						Algal cover (%)	Macrophyte cover (%)	Notes	
		Easting	Northing											Silt	Sand	Gravel	Pebble	Cobble	Boulder				Bed rock
13	2:30 PM	1538718	5139937	Outgoing	30	30	2.5	900	Glacially turbid	Blue-green	2.50	Pool/backwater	Static	0	0	40	20	40	0	0	0	5	Some limited charophyte growth. Fished from gravel bank located on the spit in the northern arm of the hāpua. Approx. 500 m south of the huts boatramp. Very little bird activity. A small amount of woody debris.
14	2:45 PM	1539062	5140103	Outgoing	20	20	2.5	400	Glacially turbid	Blue-green	2.00	Pool/backwater	Static	0	0	15	80	5	0	0	0	20	Fished from gravel bank located on the spit in the northern arm of the hāpua. Macrophyte growth more prevalent than at other sites. Net dragged in an area to avoid macrophyte bed interference.
15	3:00 PM	1539502	5140342	Outgoing	20	30	2.5	600	Glacially turbid	Blue-green	1.50	Pool/backwater	Static	0	5	45	50	0	0	0	10	30	Cobble/pebble dominated pool habitat at the extreme northern end of the hāpua in the northern arm. Near the outlet of a spring seepage at the top end of hāpua. <i>Potamogeton cheesmanii</i> and <i>Myriophyllum</i> spp macrophytes common. Shoals of whitebait common at the margins. Vegetation such as sedges/rushes common around the inland shoreline.

**Table B2: Rangitata River Hapua Habitat Data Summary**

Site	Time	NZTM coordinates		Tide cycle	Net width (m)	Distance from shore (m)	Net height (m)	Area fished (m <sup>2</sup> )	Water clarity	Water colour	Max water depth (m)	Habitat type	Velocity	Substrate						Algal cover (%)	Macro phyte cover (%)	Notes	
		Easting	Northing											Silt	Sand	Gravel	Pebble	Cobble	Boulder				Bed rock
1	11:00 AM	1569213	5176076	Out going	20	30	2.5	600	Clear-cloudy	Green	1.30	Pool	Static-slow	90	5	5	0	0	0	0	0	0	Fished to the north side of mouth on seaward side of the hāpua. Silty bed. Net snagged half-way out and had to be freed. Flows high and turbid, but flowing directly out to sea and not into the northern arm.
2	11:30 AM	1481518	5106741	Out going	30	30	2.5	900	Clear-cloudy	Green	1.50	Pool	Static	100	0	0	0	0	0	0	0	0	Some bird activity overhead and around water. Fished onto seaward-side, shingle bank. Large numbers of yelloweye mullet caught.
3	11:50 AM	1481595	5106804	Out going	20	30	2.5	600	Clear-cloudy	Green	1.30	Pool	Static	80	20	0	0	0	0	0	0	0	To the north of the mouth in the northern arm of hāpua. Birds circling. Net snagged part way in but freed by boat.
4	12:10 PM	1481769	5106944	Out going	30	20	2.5	600	Clear-cloudy	Green	2.00	Pool	Static	100	0	0	0	0	0	0	0	0	To the north of the mouth. Located near northern extent of hāpua. Fished onto gravel bank, seaward side. Yellow flag iris growing on opposite bank. More woody debris than other sites. Large numbers of adult inanga.
5	12:50 PM	1481867	5107026	In coming	20	20	2.5	400	Clear-cloudy	Green	2.00	Pool	Static	85	0	0	10	5	0	0	0	0	At the very head of lagoon. Fished onto seaward gravel bank.
6	9:20 AM	1480955	5106473	Out going	20	15	2.5	300	Turbid	Brown	0.50	Pool/back water	Static	20	80	0	0	0	0	0	-	-	Pool/backwater on true left bank of river near vehicle track access. Just upstream of the main hāpua area. A few woody debris snag.
7	9:45 AM	1480893	5106536	Out going	20	20	2.5	400	Turbid	Brown	0.35	Run	Slow-moderate	10	10	70	0	10	0	0	-	-	True left of river just upstream of Site 6. Fished on gravel island in river. Run habitat.
8	10:05 AM	1480988	5106431	Out going	20	30	2.5	600	Turbid	Brown	0.50	Pool	Static	20	70	0	0	10	0	0	-	-	Downstream of Site 6 on true left corner at mouth of river into the hāpua. Good net set and pull with very little debris.
9	10:20 AM	1481105	5106456	Out going	20	25	2.5	500	Turbid	Brown	1.40	Pool/run	Slow-moderate	10	85	0	0	5	0	0	-	-	Further around the true left corner from Site 8. Fished in hāpua onto the landward side beach. Opposite a large bird colony.
10	11:25 AM	1480868	5106244	Out going	20	15	2.5	300	Turbid	Brown	0.50	Pool/run	Moderate	80	0	0	0	20	0	0	-	-	Fishing position near the middle of the river opposite seaward gravel bank. Fished onto gravel river bar.
11	11:40 AM	1480857	5106215	Out going	20	15	2.5	300	Turbid	Brown	0.40	Run	Moderate	60	30	0	5	5	0	0	-	-	Very close to Site 10. Partial rolling on the bottom of the net meaning not 100% catch efficacy. Fished onto gravel river bar.
12	12:20 PM	1480752	5106114	Out going	20	20	2.5	400	Turbid	Brown	0.40	Pool/run	Moderate-fast	40	60	0	0	0	0	0	-	-	Soft, sand site further toward the true right of the river where the main braid enters hāpua. Fished onto sandy river bar in middle of river. Smaller set on an angle to the flow.
13	12:30 PM	1480748	5106117	Out going	20	20	2.5	400	Turbid	Brown	0.60	Pool/run	Moderate	50	50	0	0	0	0	0	-	-	Site located on true right of river off a sad bar in the middle of the river. Good set and pull, well fished. Lots of woody debris. Close to Site 12.
14	12:40 PM	1480817	5106074	Out going	20	7	2.5	140	Turbid	Brown	2.00	Pool	Slow	100	0	0	0	0	0	0	-	-	Fished on seaward side of lagoon onto gravel spit. To the true left of Sites 12 & 13 on the opposite side of the hapua. Not much debris. Steep beach at southern end of hāpua.

**Table B2: Rangitata River Hapua Habitat Data Summary**

Site	Time	NZTM coordinates		Tide cycle	Net width (m)	Distance from shore (m)	Net height (m)	Area fished (m <sup>2</sup> )	Water clarity	Water colour	Max water depth (m)	Habitat type	Velocity	Substrate						Algal cover (%)	Macro phyte cover (%)	Notes	
		Easting	Northing											Silt	Sand	Gravel	Pebble	Cobble	Boulder				Bed rock
15	1:00 PM	1480843	5106078	In coming	20	5	2.5	100	Turbid	Brown	2.50	Pool	Slow	90	5	0	0	5	0	0	-	-	Next to Site 14. Fished onto gravel spit. Steep beach and deep water. Not much debris.

**Table B3: Hakatere Hapua Habitat Data Summary**

Site	Time	NZTM coordinates		Tide cycle	Net width (m)	Distance from shore (m)	Net height (m)	Area fished (m <sup>2</sup> )	Water clarity	Water colour	Max water depth(m)	Habitat type	Velocity	Substrate						Algal cover (%)	Macrophyte cover (%)	Notes	
		Easting	Northing											Silt	Sand	Gravel	Pebble	Cobble	Boulder				Bedrock
1	11:30 AM	1504100	5121600	Incoming	30	30	2.5	900	Clear	Green	0.90	Pool /backwater	Slow	90	0	0	5	5	0	0	0	0	Backwater of true right branch of river. Few woody debris. Very silty bed overlying cobbles and pebbles. Very little bird activity. Seine pulled onto silty beach.
2	11:33 AM	1504137	5121656	Incoming	20	7.5	2.5	150	Clear	Green	1.20	Pool	Slow-moderate	70	0	0	5	25	0	0	0	0	Pool adjacent to the mainstem of the river and just downstream of riffle. Smelt present but only in top part of set nearest the riffle. True right of main braid. Silty with a bit of current.
3	12:00 PM	1504192	5121670	Incoming	30	5	2.5	150	Clear	Green	0.90	Pool	Slow-moderate	50	0	40	10	0	0	0	0	0	Pool just below riffle on true left of main river braid. Good set with a few small woody debris. Silt overlying gravels, but not as much as previous sites.
4	12:20 PM	1504306	5121658	Incoming	20	20	2.5	400	Clear	Green	0.40	Run	Moderate	20	0	10	65	5	0	0	0	0	On the true left of the river in a shallow run. Reasonable flow with silt and gravel bars
5	12:30 PM	1504417	5121700	Incoming	20	10	2.5	200	Clear	Green	0.90	Run	Moderate	0	0	0	60	0	0	40	0	0	True left edge of the river near cabbage tree. On the inside corner where river enters the hāpua. Shallow and free flowing.
6	N/A	N/A	N/A	Incoming	N/A	N/A	N/A	N/A	Clear	Green	N/A	N/A	N/A	-	-	-	-	-	-	-	-	-	Site abandoned due to poor set and fishing
7	1:40 PM	1503873	5121340	Incoming	20	20	2.5	400	Clear	Green	1.90	Pool	Static	40	0	0	40	20	0	0	0	10	In southern arm of hāpua beyond the true right of the river. The sampling site located furthest to the south. No debris and some macrophyte beds.
8	2:00 PM	1503878	5121360	Incoming	20	20	2.5	400	Clear	Green	1.70	Pool	Static	40	0	0	40	20	0	0	0	10	In southern arm of hāpua. Just to the north of Site 7. Some charophyte beds.
9	2:10 PM	1503962	5121412	Incoming	20	20	2.5	400	Clear	Green	1.30	Pool	Static	50	0	0	40	10	0	0	0	10	In southern arm of hāpua. Just to the north of Site 8. Some charophyte beds. Hāpua narrower than at Site 8. Good set and drag. Silty bed. As expected, whitebait escapement through net mesh.
10	2:19 PM	1504139	5121489	Incoming	30	30	2.5	900	Clear	Green	1.50	Pool	Static	70	0	10	20	0	0	0	0	0	Just to the true right of the main river braid mouth entering the hāpua. Fished opposite the river onto the gravel beach of the spit (seaward side). Wood debris common with net snagging frequently.
11	2:45 PM	1504176	5121510	Incoming	20	30	2.5	600	Clear	Green	3.00	Pool	Static	80	0	0	20	0	0	0	0	0	Directly opposite the main branch of the Hakatere River. Fished onto seaward gravel bay. Deep silty bottom. Difficult net to set with thick silt and steep bay. Not a good set.
12	3:00 PM	1504236	5121534	Incoming	30	30	2.5	900	Clear	Green	1.70	Pool/run	Slow	80	0	0	20	0	0	0	0	0	Fished onto the gravel bay on the seaward side of the hāpua. Opposite the true left edge of the main stem. A small number of birds (terns, stilts) nearby. A bit of current. Good set.
13	3:15 PM	1504308	5121593	Incoming	20	5	2.5	100	Clear	Green	1.00	Run	Moderate-fast	25	0	30	0	5	0	40	0	0	Set on the seaward side of the hāpua. Terns sitting on the beach. Strong current resulted in a poor set along with too much clay and woody debris.
14	3:30 PM	1504683	5121802	Incoming	30	60	2.5	1800	Clear	Green	1.60	Pool/Run	Moderate	80	0	0	20	0	0	0	0	0	Located in arm of hāpua just north of huts. A long set parallel with the beach and terminating into an isolated bay/backwater. Net pulling with the current into the static bay.

**Table B3: Hakatere Hapua Habitat Data Summary**

Site	Time	NZTM coordinates		Tide cycle	Net width (m)	Distance from shore (m)	Net height (m)	Area fished (m <sup>2</sup> )	Water clarity	Water colour	Max water depth(m)	Habitat type	Velocity	Substrate							Algal cover (%)	Macrophyte cover (%)	Notes	
		Easting	Northing											Silt	Sand	Gravel	Pebble	Cobble	Boulder	Bedrock				
15	3:50 PM	1504670	5121878	Incoming	20	10	2.5	200	Clear	Green	1.40	Run	Moderate	40	0	0	50	10	0	0	0	0	0	True left side of hāpua on the landward side. Just to north/downstream of huts, adjacent to cliffs. More or less opposite to Site 14.



## Appendix C

Fish Size Graphs

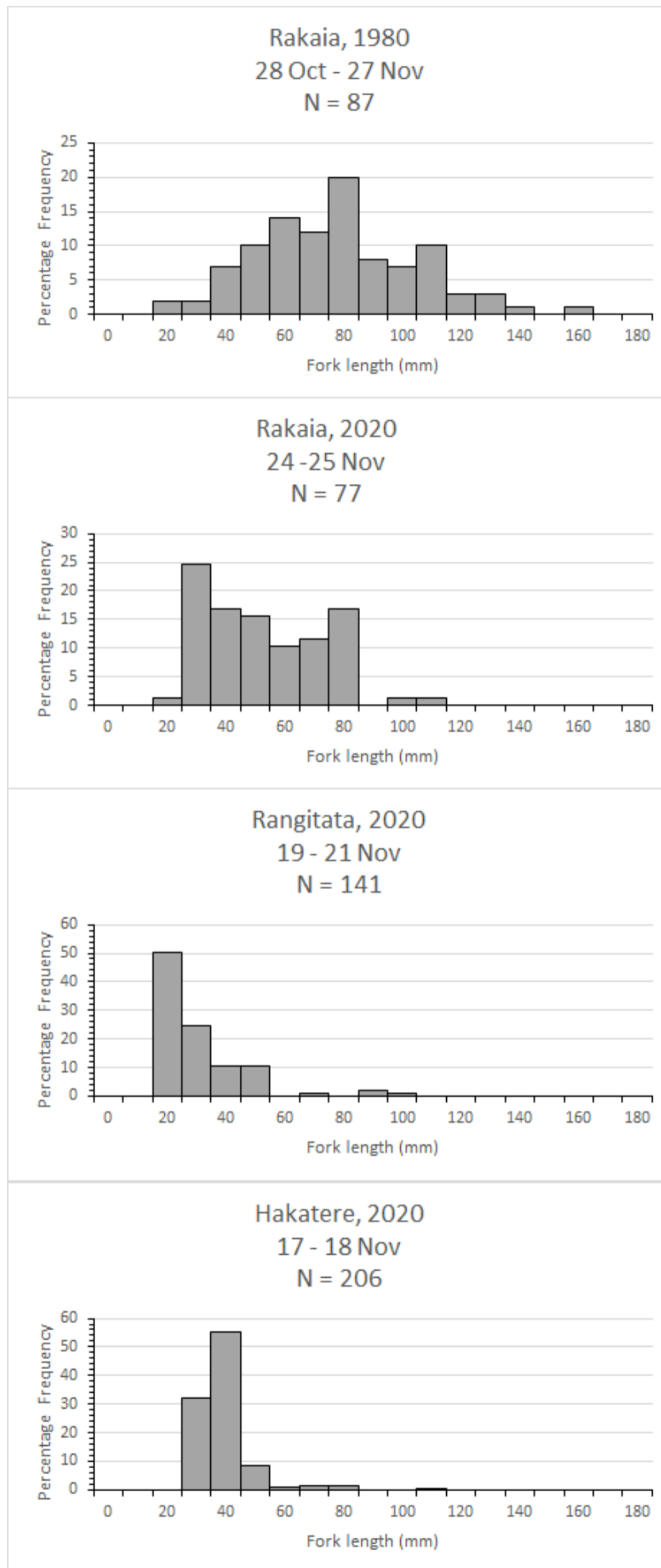


Figure C1. Common bully fork length (10mm size groups).

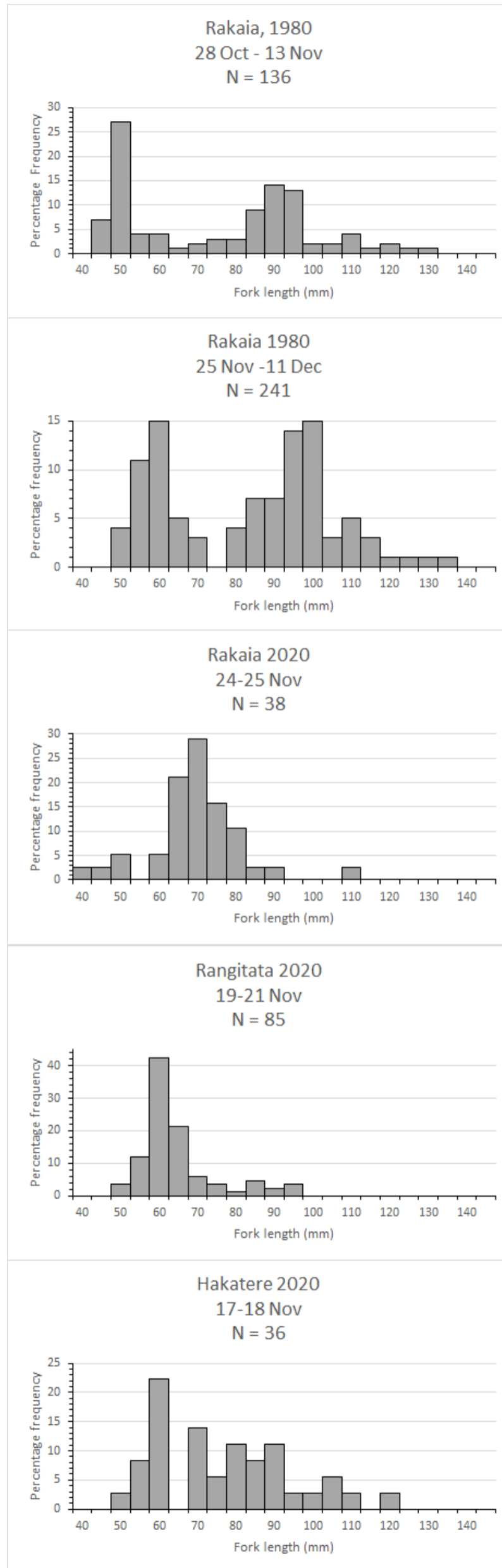


Figure C2 Inanga fork length (10mm size groups)

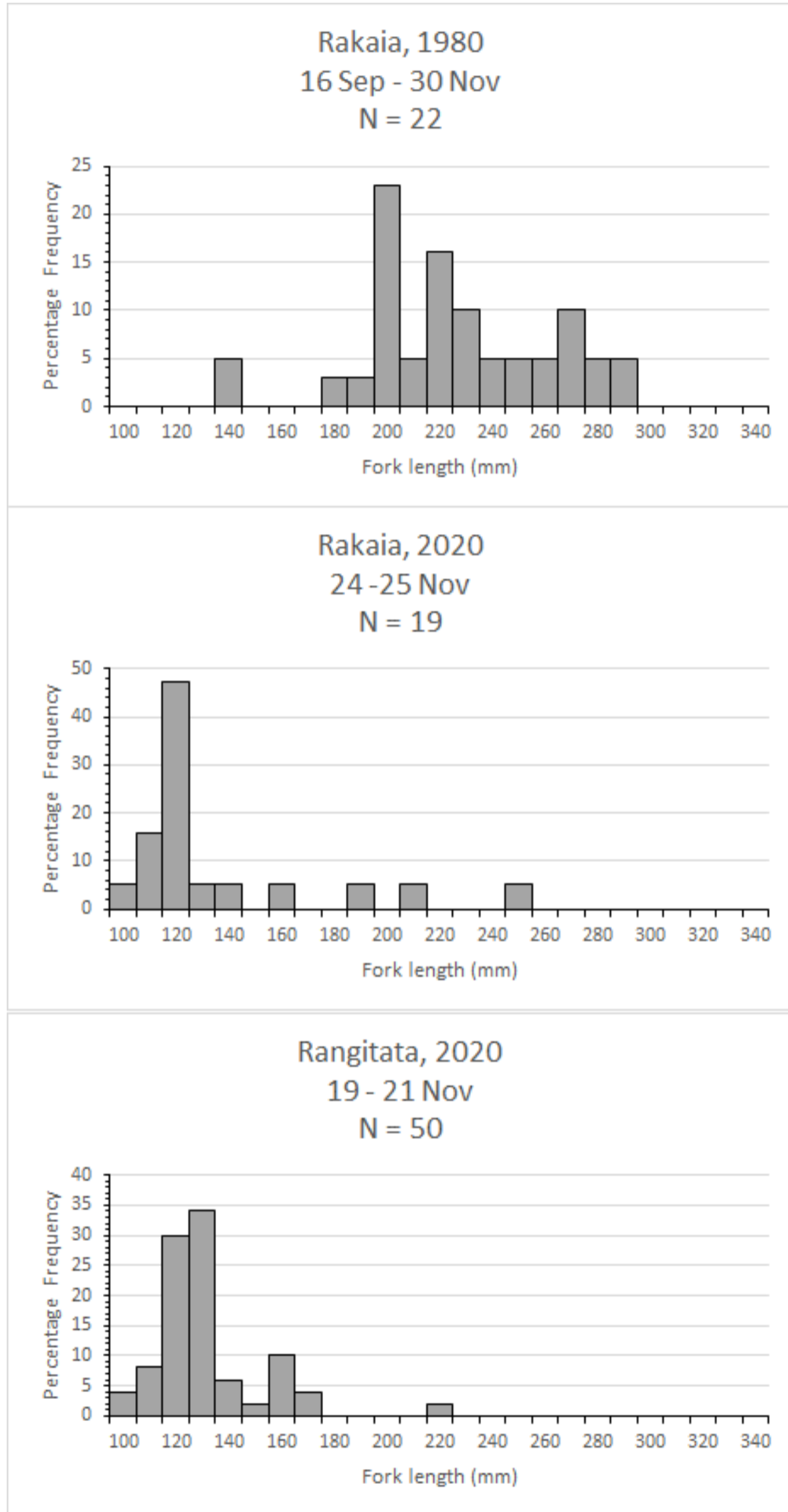


Figure C3 Yelloweyed mullet fork length (10mm size groups).