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Barriers to fish passage in the Hunua Ranges and Waharau Regional Parks :

a comprehensive survey

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Barriers to Fish Passage in the Hunua Ranges and Waharau Regional Parks:

a comprehensive survey

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Executive Summary

A high proportion of New Zealand's indigenous fish fauna are diadromous, requiring access between riverine habitat and marine or lake environments. In-stream structures such as culverts, fords, dams or weirs can prevent fish migration.

The Hunua Ecological District is contains areas of outstanding wildlife habitat. The large tract of indigenous forest within the Hunua Ranges and associated high quality freshwater habitats are significant within the district and Auckland Region.

The Brief

A comprehensive survey was undertaken of all in-stream structures located within the Hunua Ranges and Waharau regional parks. All roads and tracks accessible by 4WD vehicle bisecting perennial waterways were inspected for culverts, fords, weirs, dams etc. Structures were assessed for their ability to pass indigenous fish (climbers and eels) according to established assessment protocols.

Key Results

Fifty four structures (mostly culverts) were located and evaluated, of which 63% were barriers to fish passage under most flow conditions. In contrast only 28% allowed unrestricted fish passage.

Approximately 33% of the area below the four water supply reservoirs was affected by fish barriers, with the Mangatangi and Mangatawhiri catchments below the dams the greatest affected (58 and 42%, respectively). This equates to over 32 kilometres of 1st and 2nd order streams with high quality freshwater fish habitat.

Only one structure was consented under the Resource Management Act 1991.

Recommendations

It is recommended that priority be given to restoring fish passage to affected areas of the lower Mangatawhiri, Mangatangi and Waihihi catchments.

1 Introduction and Rationale

1.1 Background

New Zealand contains approximately 35 species of indigenous freshwater fish of which 18 are diadromous (McDowall 1990). Thirteen of these diadromous fish are found in the Auckland Region (Table 1). Diadromy dictates movement of fish between freshwater and marine or lake environments as a critical component of life history. In Auckland, the Galaxiidae family is an important and in some areas dominant, freshwater fish family. The five species of Galaxiidae native to Auckland (inanga, koaro, banded kokopu, shortjaw kokopu and giant kokopu) are diadromous, with a regular (although not compulsory) juvenile marine phase which return to streams as tiny "whitebait" in the spring (McDowall 1990). Shortfinned and longfinned eel and common, giant and redfin bullies are also diadromous.

Table 1: Critical habitat requirements for the life functioning and spawning of freshwater fish species present or possibly present in the study area. (? denotes uncertain life history). (adapted from ARC 2000).

Species	Larvae	Preferred adult habitat	Spawning
Shortfinned eel	at sea	Lowland waterways	at sea
Longfinned eel	at sea	Upper catchments	at sea
Lamprey	silt deposits	at sea	upper catchments
Torrentfish	sea or estuary?	estuary to upper catchments	estuary?
Inanga	at sea	lowland waterways	on spring tide in upper reaches of estuary
Giant kokopu	sea or lake/pond	lake edges and slow flowing waters with good overhead cover	mid to low reaches of flowing waterways
Shortjaw kokopu	sea or lake	small bush clad streams with high water quality	adult habitat
Banded kokopu	sea or lake	small streams with good overhead cover	during freshes in adult habitat
Koaro	sea or lake/pond		during freshes in adult habitat
Common bully	lowland waterways, lake/pond	lowland waterways, lake/pond	adult habitat
Redfinned bully	at sea	streams	streams
Crans bully	streams	streams	streams
Giant bully	at sea	estuaries and lowland waterways	unknown

In-stream structures such as dams, weirs, culverts can potentially isolate optimal habitat, which can ultimately lead to a decline in adult stocks or reduced biodiversity (Baker 2003).

Diadromous fish vary in their ability to negotiate in-stream barriers with locomotory adaptations allowing some species such as koaro, banded kokopu and eels to negotiate the wetted margins of waterfalls, rapids and spillways to bypass obstacles (Boubée et. al.1999). Other species rely on "burst" swimming to get past high velocity areas (Baker 2003). Despite these adaptations many species are unable to negotiate in-stream barriers that are perched, undercut, have sustained high velocity waterflow or lack wetted margins (Boubee et al. 1999).

As with many regions of New Zealand, the majority of low-elevation catchments have been urbanised, developed for intensive agriculture or exotic tree plantations. Associated supporting infrastructure such as roads, dams, ponds and weirs often cross, or are located within, rivers and streams. In the Auckland Region, 21% of streams by length are located within indigenous forest catchments and an additional 13% in scrubland (Terralink International Ltd: New Zealand Landcover Database. http://www.terralink.co.nz/tech/data/lcdb/lcdb.htm), of which the majority are within the Hunua and Waitakere Ranges. The remaining streams are within catchments dominated by prime pastoral (58%), urban (8%), or exotic forestry (6%). The majority of streams in the Auckland Region are small and of short reach, with 1st and 2nd order comprising 89% of total length (O'Brien 1999).

1.2 Study scope

This study aims to comprehensively identify and assess all in-stream structures located within the Hunua Ranges and Waharau regional parks as potential barriers to the passage of indigenous fish. The survey was conducted above and below the four water supply reservoirs (Cosseys, Wairoa, Upper Mangatawhiri and Mangatangi).

This study follows a limited survey of in-stream structures in both parks undertaken by the Auckland Regional Council (ARC) in 2002 (Hunua n = 3; Waharau n = 4) (ARC unpublished data).

2 Study sites

Two locations were chosen, primarily for their abundance of high quality fish habitat and their proximity to each other. The areas were dominated by hard bottom cobble and gravel streams with high water quality and habitat heterogeneity,. Both locations are owned and administered by the ARC as part of the regional park network, although in some circumstances infrastructure is maintained by a third party (i.e. Watercare Services Limited).

The Hunua Ranges study area was extended slightly to include 55 hectares of forested land located within the catchment of the Mangatangi waterflow gauging flume but outside the regional boundary. Thirteen hectares was added to the Waharau study area to include the catchment of the lower most in-stream structure identified on the Waihihi Stream, but outside the southern boundary of that regional park.

2.1 Hunua Ranges Regional Park

The Hunua Ranges Regional Park lies south-east of metropolitan Auckland (Figure 1), within the Hunua Ecological District. The park is approximately 17 500 ha in area.

Greywacke and argillite rocks comprise much of the Hunua Ranges (c. 150 million years ago) forming the High Hunua Horst (Tyrell et al. 1999). Various periods of glaciation, tectonic uplift, sea level oscillation and volcanic activity have shaped the physiography. Elevation extends to over 500 m above sea level in some areas.

The Wairoa, Orere, Mangatawhiri rivers and the Tapapakanga, Mangatangi, Waihihi, Whakatiwai and Aroaro streams are the main waterways draining the ranges, with the Mangatangi and Mangatawhiri discharging to the Waikato River and the others directly to the Hauraki Gulf. The waterways are typically shallow, fast flowing, with cobble and gravel substrate. Within the regional parks the streams have consistently high water quality (ARC 2003), which progressively degrades downstream with increasing agricultural landuse (Larned et al. 2004; NIWA 1993; NIWAR 1992; Vant and Smith 2004).

The Hunua Ranges has the largest tract of indigenous forest on the mainland in the Auckland Region (ARC 2003) and, in parts, contains an almost intact succession from coastal to submontane vegetation. The Hunua Ecological District has been ranked by the Protected Natural Area (PNA) programme as having outstanding wildlife habitat (Tyrell, et al. 1999).

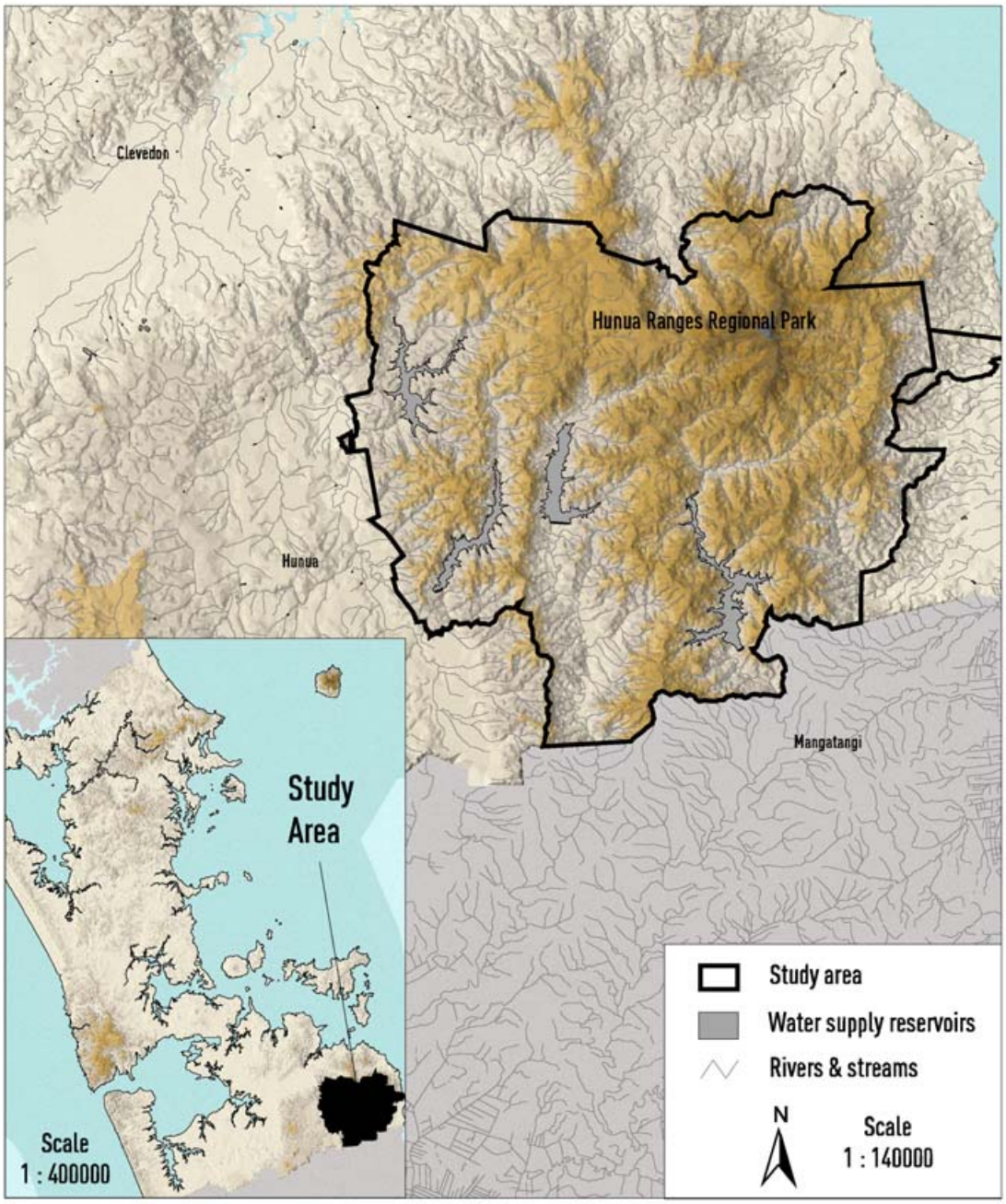

Figure 1: Combined Hunua Forest and Waharau regional parks study area.

A high diversity of fish species have been found within the Mangatawhiri and Wairoa Rivers, despite the Hunua Falls (~30 m) located on the latter (Figure 2) (Bioresearches 1988; NIWA 1993; Joy and Death 2003; Slaven 1990). Galaxiids are well represented in both rivers, though largely absent from the Mangatangi catchment upstream of the waterflow gauging weir (Rowe and Chisnall 1993). The threatened shortjaw kokopu has been found in two tributaries of the Mangatawhiri River, below the Upper Mangatawhiri Dam (G. Barnes pers obs.). Longfinned and shortfinned eels, and Crans

bully are common throughout the park. The distribution of native fish above the four water supply reservoirs is restricted (Slaven 1990; Watercare Service Limited 1996, 1997, 1999), although a number of species, notably banded kokopu and koaro have established landlocked populations in some reservoirs (ARC 2003).

Figure 2: Hunua Falls (~30 m) located downstream of the Cosseys and Wairoa water supply dams on the Wairoa River, Hunua

2.2 Waharau Regional Park

The Waharau Regional Park is located on the eastern flank of the Hunua Ranges and adjoins the Firth of Thames. It is 84 km from the centre of Auckland. The park is approximately 230 ha in area.

Greywacke belonging to the Waiheke Group was variously deposited and uplifted over the past 200 million years to form steeper areas of the park. Flat areas of the park consist of alluvial silts, sands and gravels deposited by the Waihihi Stream (ARC 2003).

Regenerating forest covers the steeper flanks, whilst the foothills and alluvial flats are generally in pasture and grazed.

The Waihihi Stream and its tributaries drain the Hunua Ranges through Waharau to the coast, with the upper headwaters commencing at 300 m above sea level. The stream is generally shallow with a cobble gravel substrate and pool, run, riffle habitat type. A survey of the freshwater fauna in 2001 revealed the presence of banded kokopu, inanga, Crans bully, torrentfish and longfinned eel (Joy and Death 2003).

3 Methods

The survey was conducted over a three day period during May/June 2004. Water levels during the survey period were normal. The study was limited to public and private roads and tracks accessible by 4WD vehicle. Structures on walking or mountain bike tracks, or located outside the park boundaries were not included. Structures on ephemeral streams were not assessed.

Probable structure locations were pre-determined by bisecting streams and roads within the study sites using the NZMS 260 topographic map series on ARCView 3.2a (Environmental Systems Research Institute Inc (ESRI) 2000). In addition, the Auckland Regional Council consents database was searched for activities consented or permitted under section 13 of the Resource Management Act (RMA) 1991. Records of freshwater fish surveyed from the Hunua Ranges and Waharau regional parks were obtained from the NIWA administered New Zealand Freshwater Fish Database (the Fish Database).

3.1 Structure Evaluation

The evaluation of each structure followed a protocol adapted from previous studies of fish passage in New Zealand and overseas (Boubee et al. 1999; Speirs & Kelly, 2001). For each structure an evaluation sheet was completed (Appendix 1).

Field equipment consisted of a measuring tape, gauge board, hand-held Global Positioning System (GPS) unit, digital camera and pocket portable computer (PC). Photographs were taken of the inlet and outlet of all structures. Locations were recorded according to New Zealand Map Grid (Geodetic Datum 1949). The gauge board and measuring tape enabled various attributes of each structure to be recorded.

Structures were assigned to one of four categories following Speirs and Kelly (2001):

- None or minimal, where the structure poses no significant barrier to the upstream or downstream passage of fish likely to be found in the stream under normal flow conditions.
- Low flow, where the structure is a significant barrier to fish passage, but only during periods of low flow.
- High flow, where the structure is a significant barrier to fish passage, but only during periods of high flow.
- Most flow, where the structure is a significant barrier to fish passage during most flow conditions.

3.2 Electronic Data Capture

A Hewlett Packard H2210 was used to capture field data electronically. The field sheet was converted to ARC Pad 6 (ESRI 2002) format using associated ESRI form building software. Data was downloaded to the Auckland Regional Council geographic information system at the completion of each field day.

The pocket PC provided a quick and accurate method of recording field data in a format that allowed immediate access for data analysis, while providing uniformity of descriptors.

3.3 Data Analysis

Initial data analysis was undertaken in ARCView 3.2a (ESRI 2000). Upstream catchment area and stream length were calculated for each structure using the watershed layer developed by NIWA within the River Environment Classification REC system (Snelder et al. 2002), and the New Zealand Map Series 260 streams layer. Distance to sea was calculated for the lower most structure of each subcatchment surveyed (Cosseys, Wairoa, Mangatawhiri, Mangatangi and Waihihi) using 'Tracer Tool' supplied with REC. Additional calculations were made in Microsoft Excel 2000 (Microsoft Corporation, 9.0.6926 SP-3).

4 Results

A total of 54 structures were located and evaluated (Hunua n = 47; Waharau n = 7), of which the majority were culverts (87%; n=47), followed by fords (n=4) and weirs (n=3). Table 2 shows the number of structures assessed within the Hunua Ranges and Waharau regional parks in each category of fish passage restriction. Sixty three percent of structures (n=34) were considered significant barriers to the passage of fish during most flow conditions. In contrast, only 28% (n=15) did not present any barrier.

Table 2: Number of structures located within the Hunua Forest and Waharau regional parks in each category of fish passage restriction.

Severity of passage restriction	Number of structures	Precentage of total structures surveyed
None or minimal	15	28
Low flow only	3	5
High flow only	2	4
Most flows	34	63
Total	54	100

Sixty eight percent of culverts (n=32) were barriers to fish passage during most flow conditions (Table 3), of which 31 were perched at an average height of 0.6 m. In contrast, only 24% (n=11) posed no barrier under similar flow conditions. Most culverts assessed as significant fish passage barriers sat above the stream bed (n=37), were narrower than stream width (n=41) and were flatter than stream gradient (n=36).

Table 3: Number and percentage of structures assessed by severity of fish passage restriction within the Hunua Ranges and Waharau regional parks.

Severity of passage restriction	Structure					
	Culvert		Ford		Weir	
	No	%[a]	No	%[a]	No	%[a]
None or minimal	11	24	2	50	2	67
Low flow only	2	4	1	25	0	0
High flow only	2	4	0	0	0	0
Most flows	32	68	1	25	1	33

a) Percentage values calculated for each structure type

Numerically, two out of three weirs and three out of four fords provided fish passage.

Most culverts were located on 1st order streams (80%; n=37), the rest on 2nd order streams. The gauging weirs on the Mangatangi Stream and Wairoa River were located on 2nd order waterways, whilst the Mangatawhiri weir was 3rd order. The four fords assessed were located on 3rd order waterways.

Of the 54 structures assessed only the water flow gauging flume on the Mangatangi Stream had a valid consent under the RMA 1991, granted in 2001. Two consent applications lodged in 2001 for the water flow gauging structures on the Mangatawhiri and Wairoa rivers are on hold.

4.1 Hunua Ranges Regional Park

Approximately 1400 ha (8%) of the Hunua Ranges Regional Park is above a significant barrier to fish passage[1] (Table 4). The area affected increases substantially to 22% when considering only catchments that include an in-stream structure. Figure 3 shows the location and extent of catchments affected by downstream barriers to fish passage.

Table 4: Comparison of catchment area and stream length lost upstream of in-stream structures assessed as barriers to fish passage under most flow conditions within the Hunua Ranges Regional Park, excluding water supply reservoirs (ha, hectare; km, kilometre).

Catchment	Total catchment area (ha)	Catchment area lost (ha)		Stream length lost (km)
		ha	%	
Mangatangi	455	265	58	8.3
Mangatawhiri below dam	2137	906	42	23.4
Wairoa	332	54	16	1.7
Mangatawhiri above dam	2565	214	8	3.4
Cosseys	698	8	1	0.4
Study area[a,c]	17800	1400	8	35.5
Study area[b,c]	6400	1400	22	35.5
Study area below dams[b,c]	3600	1200	33	32.2

a) Total study area (Hunua Ranges Regional Park plus additional area described in Section 2.1).

b) Reduced area calculated from subcatchments with in-stream structures were located.

c) Rounded to the nearest 100 ha.

Of the areas below the four water supply reservoirs, 1200 ha (33%) are affected by fish passage barriers, with the Mangatangi and Mangatawhiri below dam catchments the greatest affected (58 and 42%, respectively). In contrast, only 1% of the catchment below the Cosseys dam is affected (Table 4).

[1] The effect of the four water supply reservoirs was excluded from the catchment area calculations.

Table 4 also shows the length of stream lost above fish passage barriers[2], with a total of 40 km of waterway within the Hunua Ranges Regional Park affected. The majority of stream length affected (91%, n= 32.2 km) was located below the water supply dams, of which the lower Mangatawhiri area between the flow gauging weir and the Mangatawhiri Dam had the highest number of structures (n =25).

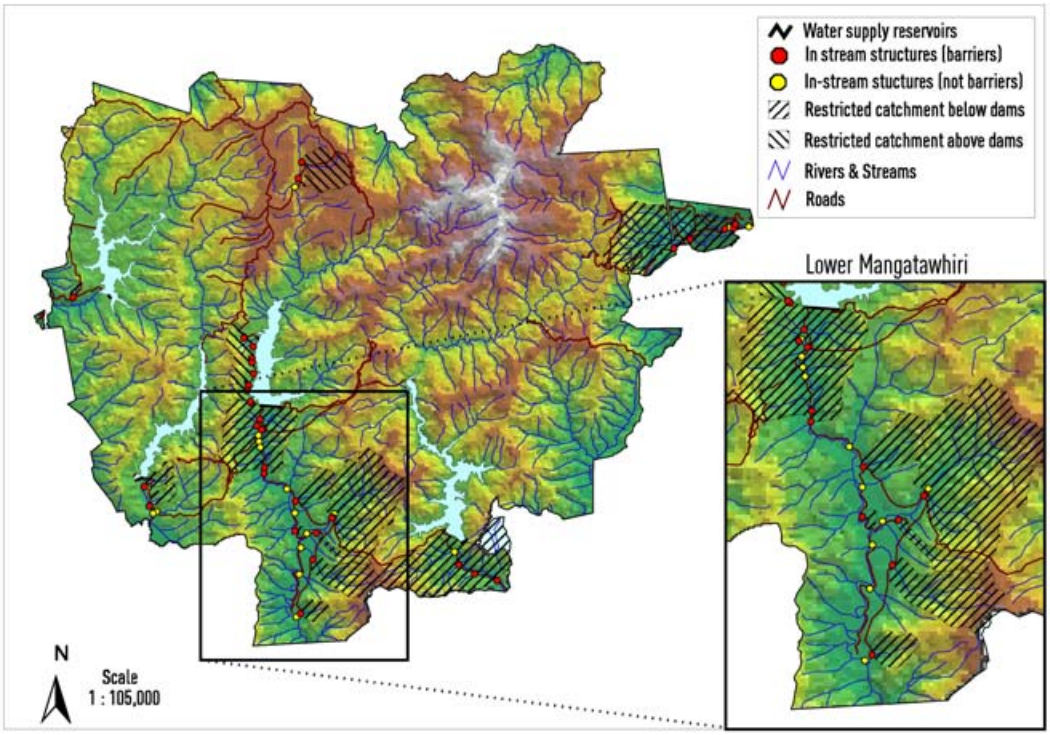

Figure 3: Location of catchments affected by downstream structures assessed as barriers to fish passage during most hydrologic conditions.

Three flow gauging weirs, located on the Wairoa and Mangatawhiri rivers and the Mangatangi Stream, are operated by Watercare Services Limited and provide hydrological information for each respective waterway relating to their operations. Only the structure located on the Mangatangi Stream was considered to be a significant barrier to fish passage (Figure 4)

The Mangatawhiri weir is a barrier to swimming species, however surveys of fish communities by NIWA in 1993 downstream of the structure indicated that natural physical barriers within the Mangatawhiri gorge (rapids and waterfalls), result in a different fish in the upstream and downstream river system (Figure 5) (Tonkin and Taylor 1999).

[2] Calculated as the upstream length from the lower most significant fish passage barrier (23 streams affected (n=20 Hunua; n=3 Waharau)).

Figure 4: Water gauging flume located on the Mangatangi Stream, approximately 2 kilometres downstream of the Mangatangi Dam.

Figure 5: Watercare Services Limited water flow gauging located on the Mangatawhiri River. Photograph taken on the true left bank.

4.2 Waharau Regional Park

Seven structures were evaluated; two fords on the Waihihi Stream and five culverts located variously on the Waihihi Stream and its tributaries. Two were not barriers to fish passage (one ford; one culvert), one was a barrier only during periods of low flow (ford) and four were barriers during most flow conditions (one ford; three culverts) (Table 5).

Table 5: Number of structures located within the Waharau Regional Park in each category of fish passage restriction.

Severity of passage restriction	Number of structures	Percentage of total structures surveyed
None or minimal	2	29
Low flow only	1	14
High flow only	0	0
Most flows	4	57
Total	7	100

Although Waharau is considerably smaller than the Hunua Ranges Regional Park in size, a large percentage of catchment (407 ha, 93%) and length of the Waihihi Stream and its tributaries (16.5 km) were affected by fish passage barriers (Table 6).

Table 6: Comparison of catchment area and stream length lost upstream of in-stream structures assessed as barriers to fish passage under most flow conditions within the Waharau Regional Park (ha, hectare; km, kilometre).

Catchment	Total catchment area (ha)	Catchment area lost (ha)	Percentage catchment area lost	Stream length lost (km)
Waharau	437	407	93	16.5

d) Total study area (Waharau Regional Park plus additional area described in Section 2.2).

e) Reduced area calculated from only catchments where in-stream structures were located.

5 Discussion

The Hunua Ranges contains one of the largest remnant of indigenous forest in the Auckland Region with numerous high quality,rocky substrate waterways with abundant fish habitat. The rivers and streams of the Hunua Ranges have been previously described as having one of the most diverse and significant indigenous fisheries in the Auckland Region (Slaven 1990). Previous studies investigating fish communities within the Hunua Ranges have mostly concentrated on the main rivers below the dams, or tributaries above the dams (Bioresearches 1988; 1992; Joy and Death 2003; NIWA 1993; Rowe and Chisnall 1993).

Most indigenous fish recorded from the Hunua Ranges and Waharau regional parks, with the exception of Crans bully, are diadromous requiring access to the sea to complete their lifecycle. Generally these species are known for their ability to climb obstacles to varying degrees. Koaro are particularly adept and have been observed negotiating near vertical dam faces. Koaro and shortjaw kokopu have specialised habitat requirements generally limited in Auckland to the forested areas of the Hunua and Waitakere Ranges.

The number of catchments affected by in-stream barriers to fish passage, particularly below the water supply dams, is high. These barriers are likely to be adversely affecting the abundance, distribution and diversity of indigenous fish within the study areas, either through severance of upstream habitat or via restricted recruitment. This is supported by reviewing data from the Fish Database, which shows a marked difference in fish communities above, below and between dams. For example, the fish communities of the Mangatangi Stream between the Mangatangi dam and the Watercare Services Ltd flow gauging flume appear depauparate with only eels and Crans bully recorded. Some database returns record no species at all. This is of particular concern given the limited areas of high quality fish habitat remaining in the Auckland Region, and that one important function of the Regional Park network is to protect native flora and fauna and their habitats.

The high diversity of indigenous fish in the Hunua Ranges is evident in the tributaries of the Mangatawhiri River between the Upper Mangatawhiri Dam and the water flow gauging weir. In 2001, shortjaw kokopu were recorded in the Acheson Stream by Massey University (Joy and Death 2003), the first positive identification of this species for the Auckland Region recorded on the the Fish Database. A subsequent survey by the Auckland Regional Council in 2004 confirmed the presence of shortjaw kokopu in the Acheson Stream and recorded a new population in the neighbouring Milne Stream (ARC unpubl. data).

This study confirmed the presence of three potential fish passage barriers on the main stem of the Milne Stream (upstream of the Mangatawhiri gauging weir), of which one was a significant barrier to fish passage (Figure 6). Conversely, no barriers to fish passage were identified on the Acheson Stream. Despite the 2004 fish survey recording the same species diversity (longfinned eel, koaro, banded kokopu, shortjaw

Figure 6: Perched twin culvert the Milne Stream below the Mangatangi Hill Road.

kokopu and Crans bully), there appeared to be a distinct difference in the structure of the two fish communities. In the Milne Stream large galaxiids dominated the catch with a low abundance of small, presumably year 1 and 2^{+} fish encountered. It is possible that the perched twin culverts on the Milne Stream significantly affect upstream recruitment skewing the population towards a few large individuals.

The use of culverts and fords is common in New Zealand, particularly as a cost effective means for roads to cross rivers and streams. Inappropriate design, construction and/or maintenance can quickly result in these structures adversely affecting aquatic life. Traditionally, culverts have been installed with consideration of their hydraulic capacity only, and little thought given to the need for fish passage (Boubee et al. 1993). Recent recognition of the importance of ensuring fish passage and structure design innovations have improved the situation, though this has yet to filter through in a substantive way to the retroffiting of existing structures.

The ARC has developed guidelines on fish passage, which identify parameters important for ensuring fish passage and highly relevant in this study (ARC 2000). The ARC fish passage guidelines identify height (vertical differential between streambed

and structure outlet), water velocity and turbulence, water depth, channel length, light, and climbing medium. Most of the culverts assessed in this study were perched, undersized and badly positioned promoting erosion of bed material at the culvert outfall.

Speirs and Kelly (2001) encountered a similar proportion of in-stream barriers in streams of the Coromandel Peninsula and suggested that this reflected in part the steep nature of the geology and frequent high intensive rainfall events, which move large amounts of bed material and frequently scour stream channels. Similar geologic and meteorologic conditions are likely in the Hunua Ranges where most barriers identified were culverts located in catchments below the water supply dams under roads traversing steep catchments (>25°) with friable soils (comprising mostly northern yellow brown earths from the Te Ranga clay loam), and where downstream erosion protection was consistently absent (Johns 1967). An apparent lack of regular maintenance was a possible exacerbating factor.

5.1 Legislative Obligations

The provision of fish passage for in-stream structures has been a legislative requirement in New Zealand since 1983, following the enactment of the Freshwater Fisheries Regulations by the New Zealand Parliament. Furthermore, the RMA in 1991 added additional requirements ensuring the sustainable management of natural and physical resources.

The ARC administers several statutory documents under the RMA or antecedent legislation, which establish rules pertaining to activities within watercourses. These include the Transititional Regional Plan, the Regiopnal Policy Statement and the Proposed Auckland Regional Plan - Air, Land, Water (ALWP).

The ALWP contains numerous reference to the importance of fish passage in maintaining and enhancing the freshwater environment and maintaining cultural connections of tangata whenua. Specifically, a rule in the proposed plan permits the continued occupation of existing in-stream structures provided that certain conditions, including provision of fish passage, are complied with.

Despite the protection of legislation and regulation it is apparent from this study and others conducted nationwide that protective measures ensuring fish passage may be inconsistently or ineffectively applied (Evans and Glover 1999; Joy and Death 2001; Speirs and Kelly 2001; Taranaki Regional Council 2001; and Taylor 2001).

5.2 Prioritisation of Fish Passage Restoration

There is clearly a lot of work required to restore fish passage to all rivers and streams of the Hunua Ranges and Waharau regional parks. Logically, restorative work requires prioritisation to ensure structures impacting large areas of the highest quality fish habitat are fixed first.

Prioritisation should follow criteria established by the ARC fish passage guidelines (ARC 2000) , which state:

When considering the need to facilitate fish passage, it is essential that the following points are considered;

- *species present and distribution within the catchment,*
- *the size and type of habitat available up stream,*
- *the presence of other migration barriers both upstream and downstream of the culvert,*
- *the timing of fish migrations, duration and their flow requirements, and*
- *elevation and distance from the sea.*

The highest priority for fish passage restoration are the lower Mangatawhiri and Mangatangi catchments between the water flow gauging structures and the water supply reservoirs. The lower Mangatawhiri warrants attention because of its outstanding indigenous fish diversity and the probability that barriers to fish passage are affecting fish community structure in some tributaries of the Mangatawhiri River. The lower Mangatangi is a priority due to the obligation of Watercare Services Ltd to install a fish pass at the flow gauging flume. This has the potential to open over 8 kilometres of stream reach but only if the two other barriers identified are fixed; otherwise the benefits are reduced.

The five barriers identified within the Waharau Regional Park could be fixed relatively easily and for low cost and would restore fish passage to the headwaters of the Waihihi Stream and its tributaries.

Where restoration of fish passage is not practicable, then consent may be required to permit the continued occupation of fish barriers within waterways of the Hunua Ranges and Waharau regional parks.

6 Conclusion

A high proportion of New Zealand's indigenous fish fauna are diadromous requiring connection between high quality adult riverine habitat and marine or lake environments. Incorrectly installed or maintained in-stream structures such as culverts, fords, dams or weirs can prevent or restrict upstream migration of fish.

Substantial areas of the Hunua Ranges and Waharau regional parks are affected by in-stream barriers to fish passage, particularly below the four water supply reservoirs. These structures prevent fish access to significant lengths of high quality 1st and 2nd order streams, potentially affecting fish diversity and abundance.

In many cases restoration of fish passage would be relatively straight forward and of low cost. The ARC provides a technical guideline to assist in this regard.

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Appendix 1: In-Stream Structure Record Sheet

ID:	*Number*	Observer:	*Text*
Date:	*Number*	Co-ordinates:	Easting: *Number* Northing: *Number*
Location:	*Text*	Inland distance (km):	*Text*
Owner:	*Public/Utility/Private*	River system:	*Text*
Altitude (m):	*Number*	Stream name:	*Text*
Catchment area (ha):	*Number*	Catchment No:	*Number*

At Barrier:

Upstream:	Dominant catchment landcover: *Text* Dominant riparian cover: *Text*	
Downstream:	Dominant catchment landcover: *Text* Dominant riparian cover: *Text*	
Dominant substrate type: Upstream:	*Type* *Type* *Type*	*%* *%* *%*
Downstream:	*Type* *Type* *ype*	*%* *%*
Barriers: Upstream: Downstream:	*Yes/No* *Yes/No*	
Tidal:	*Yes/No*	

Structure Description

Type of Structure:	*Culvert/Ford/Weir/Other*		
Weir:	V-notch: *Yes/No*	Height (m): *Number*	
Ford :	No. culverts: *Number*		
Culvert:			
Diameter (m):	*Number*		
Height (m):	*Number*	Width (m):	*Number*
Comment:	*Text*		
Materials:	*Smooth metal/Corrugated/Smooth concrete/Rough concrete*		
Length (m):	*Number*		
Substrate within structure:	*Yes/No*	*Type*	*%*
		Type	*%*
		Type	*%*
Substrate depth (m):	*Number*		
Observed water flow (m/s):	*Number*		
Flow conditions:	*Normal/Low/High*		

Outlet Conditions (downstream)

Water level control at outlet:	*Uniform/Perched/Ponded* If ponded: WL (m): *Number* If perched: WL (m): *Number* BL (m): *Number*
Outlet type:	*Projecting/Flush with Headwall/Bevelled & flush*
Apron present:	*Yes/No*
	Length (m): *Number* Slope (°): *Number* *Number*

Inlet Conditions (upstream)

Water level control at outlet:	*Uniform/Perched/Ponded* If ponded: WL (m): *Number* If perched: WL (m): *Number* BL (m): *Number*
Inlet type:	*Projecting/Flush with Headwall/Bevelled & flush*
Apron present:	*Yes/No*
	Length (m): *Number* Slope (°): *Number* Drop (m): *Number*

Structure attributes

Bed level:	*Above/Same/Below*
Structure width:	*Narrower/Same/Wider*
Structure gradient:	*Flatter/Same/Steeper*
Structure alignment:	*Straight; straight/Straight; curved/Curved; straight/Curve;curve*

Bank Protection

Upstream TR:	*Yes/No*	Type:	*Rip rap/armour/other*
		Erosion:	*Yes/No*
Upstream TL:	*Yes/No*	Type:	*Rip rap/armour/other*
		Erosion:	*Yes/No*
Upstream above:		Erosion:	*Yes/No*
Downstream TR:	*Yes/No*	Type:	*Rip rap/armour/other*
		Erosion:	*Yes/No*
Downstream TR:	*Yes/No*	Type:	*Rip rap/armour/other*
		Erosion:	*Yes/No*
Downstream above:		Erosion:	*Yes/No*

Streambed Protection

Upstream:	*Yes/No*	
	Type:	*Rip rap/armour/other*
Downstream:	*Yes/No*	
	Type:	*Rip rap/armour/other*

Culvert Barrel

Blockages:	*Yes/No*
Blockage type:	*Inlet/outlet/barrel*
Any breaks in culvert:	*Yes/No*

Baffles etc

Baffles:	*Yes/No*
Spoilers:	*Yes/No*

Comments

Text

Severity of Fish Passage Restriction

None/low flow/most flow/high flow