BEFORE THE CANTERBURY REGIONAL COUNCIL

UNDER	the Environment Canterbury (Temporary Commissioners and Improved Water Management) Act 2010
IN THE MATTER	of the proposed Hurunui and Waiau River Regional Plan

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STATEMENT OF EVIDENCE OF ROSS MILLICHAMP ON BEHALF OF THE NORTH CANTERBURY FISH AND GAME COUNCIL

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1. **INTRODUCTION**

1.1 My name is Ross Roger Heslop MILLICHAMP. I have a Bachelor of Science and a Post Graduate Diploma in Science from the University of Canterbury. I am a member of the American Fisheries Society.

1.2 I have been employed by Fish & Game New Zealand since 1991, initially as a Field Officer specialising in salmon management, then between 2000 and 2011 as Regional Manager, and in 2012 as a part time Fish and Game Officer. I have a long association with management of the New Zealand salmon fishery, through long term field investigations and more recently in a strategic planning role. I acted as the observer on the very first aerial count of salmon in the Hurunui River in 1992, a precursor to the modern monitoring program. In recent years I have led the development of a statutory management plan for anadromous salmon, which sets out to manage the fishery in a consistent manner throughout most of the South Island (The Sea Run Salmon Management Plan is at a final draft stage and about to be sent to the Minister of Conservation for gazettal). I have also been involved in liaising with North American salmon fishery managers and have visited the United States, Canada and Alaska on three occasions, where I have observed fishery management practices and examples of human induced salmon population degradation and extinction.

1.3 I am an experienced and successful salmon angler. Although my river of choice these days is the Rakaia, I have fished the Hurunui on many occasions and the Waiau a number of times. My enjoyment of salmon fishing has spilled over into freelance writing and photography. My work has appeared in mainstream publications such as "New Zealand Geographic" and the Air New Zealand in-flight magazine, the Christchurch Press where I was a regular columnist, as well as in many New Zealand and international fishing magazines. I am the author of the book "Salmon Fever, a Guide to Salmon Fishing in New Zealand".

1.4 I confirm I have read and agree to comply with the Code of Conduct of Expert Witnesses (November 2011). This evidence is within my area of expertise, except where I state where I am relying on what I have been told by another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

2. SCOPE OF EVIDENCE

2.1 My evidence will cover the following:

a. The life cycle of salmon in New Zealand;
b. The New Zealand salmon fishery;
c. The Hurunui River salmon population;
d. Salmon angling on the Hurunui River;
e. The Waiau River salmon population;
f. Salmon angling on the Waiau River ;
g. Requirements for the protection of the salmon fisheries and angling; -the likely impacts of development of the Hurunui and Waiau River catchments on the salmon fisheries.

2.2 In preparing my evidence I have relied on the hydrology evidence of Mr Dave Stewart.

3. EXECUTIVE SUMMARY

3.1 The Hurunui and Waiau salmon fisheries are of regional significance, with both among the top ten salmon fisheries in New Zealand. Salmon fisheries attract very strong interest from anglers, with salmon fisheries of local and regional significance often generating higher levels of angling activity than trout fisheries of national significance.

3.2 Fish and Game surveys have found that most Hurunui salmon spawn in the South Branch. The rest spawn in the North Branch and Landslip Creek (a small spring fed tributary of the North Branch). Most Waiau salmon spawn on the Waiau mainstem upstream of the confluence of the Ada River and in the Ada River itself. The construction of high dams downstream of existing spawning grounds will block salmon access. Salmon are unlikely to find alternative spawning sites and run degradation or extinction is likely to follow within three to four years.

3.3 Minimum flow rules should not increase the frequency at which rivers are below the minimum levels for salmon migration during summer months. In my view the current minimum flows of both rivers are inadequate to permit continuous fish passage. I support moves to lift summer minimum flows and believe the proposed increases are barely adequate and should be raised further.

3.4 Flow regimes should also preserve the frequency and duration of flood and fresh events during summer months to allow regular periods when salmon are able to move upstream and anglers are able to fish for them. Flow regimes which focus on allowing adequate passage of salmon across shallow riffles, tend not to be sufficient for successful salmon migration.

3.5 A regime of moderate to high flows is also necessary for salmon angling which has been shown in other South Island salmon rivers to require even higher flows than salmon passage.

3.6 In my view, the allocation of water to the new "C blocks" appears to result in a dramatic loss of days when these rivers are suitable for salmon migration and salmon angling, and threatens the future survival of these fisheries.

4. SALMON IN NEW ZEALAND

The Life Cycle of Salmon in New Zealand

4.1 Pacific salmon are native to the North Pacific where they are one of the most dominant species in the ocean. Their success relates to their ability to migrate long distances through fresh and salt water environments, taking advantage of the many opportunities these habitats provide.

4.2 The New Zealand Chinook salmon (Oncorhynchus tshawytscha) population is the most successful example of the establishment of a salmon population outside of its native range. It is likely that the combination of suitable ocean temperatures and the presence of high quality freshwater spawning habitat are the key reasons why the run took hold in New Zealand while attempts elsewhere failed.

4.3 The New Zealand Chinook salmon population is concentrated in the Canterbury region with smaller, often marginal populations existing in the Marlborough, West Coast, Otago and Southland regions. The East Coast of the South Island has the coldest seawater temperatures in New Zealand, which come close to replicating the conditions present in the North Pacific. However in order to be successful, salmon populations also require suitable freshwater habitat, and it appears in this requirement that they are particularly selective. The best combination of freshwater habitat appears to be a large braided river with a permanent connection to the ocean, and stable, flood-limited or flood-free tributaries in the foothills or mountains. Salmon use the large braided river to penetrate well inland, before laying their eggs in the cool, stable tributaries.

4.4 Salmon start their lives as a fertilised ova buried beneath a pile of river cobbles, which is called a "redd". The choice of spawning location appears to be of extreme importance, and salmon tend to spawn in dense congregations in confined areas. In Double Hill Stream, a tributary of the Rakaia River, salmon spawn in just one of the three available braids, and completely ignore others which appear very similar to the human eye.

Figure 1: Aerial photograph of Double Hill Stream. The braid used for spawning is highlighted. The other two braids immediately below are seldom used. Note also the difference in water colour (and silt loading) between the mainstem of the Rakaia River (bottom right) and the spawning stream.

4.5 Various researchers have attempted to define the characteristics of Chinook salmon spawning habitat. In North America they have been found to spawn in a range of water depths, current velocities and substrate sizes, but appear to be strongly selective of sites with high rates of sub-gravel flow. This suggests that fertilised ova, which in salmon are very large with a correspondingly low surface area to volume ratio, will quickly suffocate unless exposed to a steady flow of cool, well oxygenated water. Vronskiy (1972) said "*The apparent preference of chinook for spawning areas with high sub-gravel flow may explain their tendency to aggregate in particular locations for spawning and to ignore other, superficially similar areas*".

4.6 Salmon fry emerge from the redd at between eight and ten weeks of age and are initially very vulnerable to predation. They fiercely compete for territories within the spawning stream, particularly places which offer ready access to an invertebrate food supply and shelter from predators. Typically this means they occupy shallow riffles where predators cannot penetrate. In a healthy spawning stream there are far more salmon fry than there is rearing space available and many are forced to migrate out before they are able to handle the volatility of the braided river. As the salmon grow, they require more space and so more individuals are pushed out by intra-specific competition. The mortality rate amongst young salmon that are forced to leave the spawning streams before they are ready is very high, although some do find refuge in the main stem and successfully survive to the age at which they are able to handle the transition to salt water. Most young salmon "choose" to leave the spawning streams and migrate down the braided river at around three months of age. However they do not appear to reach the ocean for a further three months which suggests that the braided river does provide quality rearing habitat for salmon fingerlings, although there must be some lower size limit to main stem survival. A number of salmon remain in freshwater until they are a year old ("stream-type"), and although few in number, are thought to have higher rates of survival than the more numerous "ocean-type" smolt.

4.7 Prior to entering the ocean, salmon go through a process called smoltification, in which their osmotic system changes to prepare them for life in a saline environment. Salmon appear to be unable to undergo smoltification, and hence survival in the ocean, if they are less than five grams in weight.

4.8 What happens to salmon smolt after they enter the ocean is unknown. It is thought that they do not migrate long distances offshore, because they are rarely if ever, picked up in the catch of the offshore fishing fleet. Most salmon return to freshwater in the third year of their life, although some also return at two, four and even five years of age.

4.9 The vast majority of salmon return to not only the catchment of their birth but to the same spawning tributary. Typically they arrive at the river mouth between the months of November and March, and move slowly up the river. Early run fish appear to have a slow, stop/start upstream migration that can last up to 5 months. Late run fish move more quickly and can reach the headwaters in a matter of weeks.

Salmon do not eat during their upstream migration, and appear to stop feeding some time in advance of returning to freshwater. Their entire migration is focused on using as little of their supply of stored fats and oils as possible so that they arrive on the spawning grounds with enough reserves to secure and defend a prime spawning site.

4.10 Salmon tend to time their movement through the river mouth and upstream to coincide with flood or fresh events. This is particularly apparent in salmon rivers with smaller flows, where salmon may struggle to get over the river mouth bar or over shallow riffles during low flow events. Water temperatures also tend to be lower during fresh and flood events, conditions in which salmon are more metabolically efficient and use less of their precious energy reserves for a given upstream movement.

4.11 Salmon appear to be reluctant to backtrack during their upstream migration. If they encounter obstacles, they tend to wait at the obstacle for conditions to improve rather than seeking out an alternate route. One such obstacle to salmon migration in the Rakaia River is the tailrace of the Highbank hydroelectric power station. In the past when the tailrace was un-screened, salmon would swim up the tailrace and come up against the power station. Rather than backtrack down the tailrace and into the main stem of the Rakaia, salmon would simply sit and wait for conditions to improve. In particularly bad years up to 20% of the Rakaia's salmon run would have to be salvaged from the Highbank Tailrace and transported back to the river. When hooked on an angler's line, salmon are also reluctant to run downstream and give up hard-won ground, even though it would actually be the best strategy for escape. This behaviour could be viewed as a weakness but in reality it demonstrates just how critical it is to preserve energy during the upstream migration. It is likely that the key energy-sapping aspect of upstream migration is not the passage of time, nor the distance covered, but the gain in altitude. It is better to wait at an obstacle at which time the fish will be burning little energy, than to backtrack and have to re-climb through the same stretch in a different braid.

4.12 Most salmon do not enter the spawning tributaries until they are ripe and spawning is imminent. Results from fish traps operated by Fish and Game New Zealand indicate that salmon spend between 15 and 25 day on the spawning grounds. They appear to spawn within the first few days of entering the spawning stream, and to spend the rest of the time defending their redd(s) from other fish who wish to spawn in the same place. However the long journey and cessation of feeding takes its toll and all Chinook salmon die within a week or two of spawning.

The New Zealand Salmon Fishery

4.13 New Zealand salmon fisheries are characterised by small and highly variable runs compared with those in their native homeland in the North Pacific. Whereas the biggest run measured in a New Zealand salmon fishery since the current monitoring program began in 1993 is 22000 fish in the Rakaia, many North American fisheries have runs into the millions.

Figure 2: Mid-season salmon count results as displayed outside a tackle shop in Soldotna, Alaska.

4.14 Despite the relatively small run size of New Zealand salmon fisheries, they attract significant interest from anglers. The 2007-08 National Angler Survey estimates that seven of the top ten river fisheries in New Zealand, in terms of angler visits, contain salmon runs. Analysis of angler catch data in the Central South Island region indicates that 50% of anglers surveyed stated that they fished for salmon. When the annual catches of those anglers were assessed, the most common season bag was zero, the next most common was one salmon, then two and so on (see Figure 3).

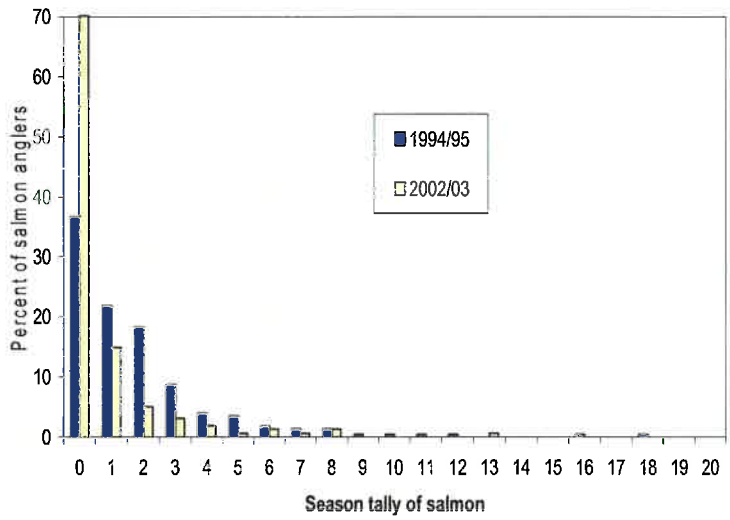

Figure 3: Season tally of salmon anglers in the Central South Island Fish & Game Region, in the 1994-1995 and 2002-03 seasons.

4.15 Salmon anglers are very passionate and every fish that is landed is treasured. The catching of a single salmon can turn an angler's season from failure to success. Perhaps only in the North Island marlin fishery, is each single fish as highly valued by the angler. Such is the importance of each fish to an angler, that most can recall how many they caught for the season, and often for many seasons that have passed.

5. HURUNUI RIVER SALMON

The Hurunui River Salmon Population

5.1 The Hurunui River salmon fishery is described in the Draft Sea Run Salmon Management Plan as being of "regional significance", with an annual run of between 100 and 5000 salmon (see Figure 4). This places it 5th in terms of run size of the known 24 salmon fisheries in New Zealand. To put the fishery into wider context, the fact that almost all of the Southern Hemisphere's salmon fisheries are found in New Zealand, probably places the Hurunui in the top ten south of the equator.

River	Estimated Population Range 2001-2005	Estimated Maximum Historical Run	Fishery Significance	Reference
Wairau	200-600	600	Regionally Significant	F&G Spawning Count
Clarence	200-1000	1000	Regionally Significant	F&G Spawning Count
Waiau (Nth Canty)	200-500	3000	Regionally Significant	F&G Spawning Count
Hurunui	100-1000	5000	Regionally Significant	F&G Staff
Ashley	20-100	250	Locally Significant Degraded by low flows.	F&G Staff
Waimakariri	2000-5000	15000	Nationally Significant	NIWA Population Model
Rakaia	1500-5000	23000	Nationally Significant	NIWA Population Model
Ashburton	20-100	5000	Locally Significant Degraded by low flows & mouth closures.	F&G Spawning Count
Rangitata	900-2000	13000	Nationally Significant Degraded by unscreened abstractions.	NIWA Population Model
Orari	50-200	1000	Locally Significant	F&G Spawning Count
Opihi	350-2000	4500	Regionally Significant	F&G Spawning Count
Waitaki	1500-2200	36000	Nationally Significant Degraded by instream dams and unscreened abstractions. Fishery upstream of Waitaki Dam extinct.	NIWA Population Model
Moeraki	50-200	200	Locally Significant	F&G Staff
Mapourika	125-400	400	Locally Significant	F&G Spawning Count
Paringa	150-350	700	Locally Significant	F&G Spawning Count
Taramakau	50-300	300	Locally Significant	F&G Staff
Hokitika	50-300	300	Locally Significant	F&G Staff
Haast	50-300	300	Locally Significant	F&G Staff
Taieri	50-500	500	Locally Significant	F&G Staff
Clutha	50-1000	5000	Regionally Significant Degraded by instream dams. Fishery upstream of Roxborough Dam extinct. Current spawning is in the Clutha mainstem and Pomahaka River.	F&G Spawning Count
Mataura	20-100	100	Locally Significant	F&G Staff

Oreti	50-250	250	Locally Significant	F&G Staff
Waiau (Southland)	100-400	400	Locally Significant	F&G Staff
Hollyford/Pyke	50-400	400	Locally Significant	F&G Staff

Figure 4: Table from the Draft Sea Run Salmon Management Plan summarizing what is known about salmon abundance in New Zealand salmon fisheries.

5.2 The Hurunui is considered by anglers to be a "small river salmon fishery", in that river flows cause salmon to behave differently than in larger volume rivers such as the Waitaki and Rakaia. Small river fisheries are characterised by the fact that salmon congregate at the rivermouth during normal flows, waiting for fresh or flood flows before running the river. Much of their upstream movement takes place during the short periods when the river is running at higher than average flow, presumably because water temperatures are cooler and water depth over critical riffles is more favourable. The Hurunui River suffers from extreme low flow events during the period when most salmon are running through the river mouth (mid January to mid March), which constrains both their ability to enter the river mouth and to cross the shallow riffles which frequent the river between the upstream limit of the tidal reaches and the start of the gorge upstream of the Mandamus River confluence.

5.3 Although the Hurunui is one of the smaller salmon rivers in terms of flow, it is also relatively un-braided which facilitates the upstream migration of adult fish. However when the river becomes low in mid-summer, there are a number of reaches where migration is difficult. Duncan (2004) did a critical reach analysis on the Hurunui and found that the area where the pylons crossed the river at map reference M33:840183 had the shallowest riffles. The survey was conducted when the river was flowing at 13 cumecs and found that in one place, water depth was at the level which is thought to prevent salmon passage (250mm).

5.4 The Hurunui River has relatively little of the spring fed tributary spawning habitat which is present in other salmon fisheries. When Fish & Game New Zealand undertook the trial aerial survey which pre-dated the current salmon monitoring program, the NIWA scientists who designed the survey were unsure about where to look. A survey of the section downstream of the Lake Sumner outlet which at the time was thought to be the prime spawning reach, found only 22 salmon, most of which appeared to be on their way to the spawning grounds rather than actually spawning (Unwin (1993). Subsequent foot surveys conducted by Fish and Game found that salmon spawned in Landslip Creek, a small spring-fed tributary of the North Branch of the Hurunui above Lake Sumner, and in the main braid of the South Branch of the Hurunui, in the section upstream of the Gorge (see Figures 5 to 8).

Figure 5: Landslip Creek (top) entering the North Branch of the Hurunui River above Lake Sumner.

Figure 6: Pair of salmon redds in Landslip Stream, immediately above the confluence with the Hurunui River.

Figure 7: Typical spawning reach in the South Branch of the Hurunui River above the Gorge.

Figure 8: Salmon redd in the South Branch of the Hurunui River, just below the Mason Stream confluence. Note the presence of grasses growing on the banks indicating a relatively stable bed in this section.

5.5 The finding that most Hurunui salmon spawn in the main braid of the South Branch was surprising because this reach is subject to occasional flooding which could wash out salmon redds before the eggs have hatched. I have observed this section of river in flood during the salmon spawning and incubation season and although flows lift and the water discolours, the floods do not appear to be of the same magnitude as those which affect the river further down or affect more braided rivers such as the Rakaia and Waimakariri.

5.6 Since 2001, the Hurunui salmon population has been surveyed annually and a long term data set has been developed (see Figure 9). Counts are conducted during early May, to coincide with peak spawning activity. As such the counts are one-off trend counts rather than estimates of total spawning activity. Salmon residency time research conducted by Fish and Game New Zealand on the Rakaia and Waimakariri Rivers, suggests that spawning takes place over an eight to ten week period, with each individual salmon spending between 15 and 25 days on the spawning grounds. This means that there are a number of "turn-overs" of spawning fish each season. If the findings from the Rakaia and Waimakariri Rivers apply in the Hurunui, the total spawning population should be 2-3 times greater than the peak spawning count.

Year	Date	Landslip/ North Branch	South Branch	Trend count Total	Estimated Spawning Escapement*
2001	3/05/2001	0	20	20	50
2002	8/05/2002			132	330
2003	7/05/2003	32	119	151	377
2004	10/05/2004	62	44	106	265
2005	24/05/2005	75	18	93	233
2006	16/05/2006	9	28	37	93
2007	8/05/2007	14	66	80	200
2008	15/05/2008	32	106	138	345
2009	12/05/2009	34	75	109	273
2010	11/05/2010	n/a	n/a	58	145
2011	Not Done				
2012	20/05/12	20	189	209	522

Figure 9: Salmon trend count and spawning escapement estimates for the Hurunui River, Fish and Game New Zealand Aerial Survey Program 2001-2012. Please note that in 2002, the split between North and South Branch spawning was not recorded. *Estimated spawning escapement was calculated by multiplying trend count figure by 2.5.

5.7 The one-off trend count methodology has been used in the Hurunui in place of the more robust "area under the curve" methodology which is used on rivers with larger salmon runs. This is because a high proportion of Hurunui salmon spawn in the mainstem where it is difficult to distinguish salmon that are waiting to spawn from those that are actually spawning. The inability to separate spawning salmon from pre-spawning salmon makes the estimation of residency time difficult and introduces unacceptable error into area under the curve modelling.

5.8 When the surveys conducted between 2001 and 2009 are averaged, they indicate that 72% of Hurunui River salmon spawn in the South Branch and 28% in the North Branch and Landslip Creek. All of the South Branch fish spawn above a dam site that has been proposed by Hurunui Water Project at the top end of the gorge.

5.9 Estimates of angler catch are presented later, and although they contain high margins of error, they suggest that the spawning population is low compared to the size of the fishery. This indicates that the Hurunui fishery is fragile, and relies on a comparatively small spawning population for continued existence. This could be a factor of a higher than normal rate of angler catch, the effect of occasional flooding on the South Branch spawning population, or the lack of quality spawning habitat in the catchment. I am of the view that the lack of quality spawning habitat is the principle driver of the fragility of the fishery. One mitigating factor for the low spawning numbers could be a potentially high survival rate amongst the fish that do hatch. By comparison with other Canterbury braided salmon rivers, the Hurunui is less flood prone and should offer a better environment for the survival and growth of young salmon.

Salmon Fishing in the Hurunui River

5.10 Although located some distance from major population centres, the combination of high scenic values and consistent fishing attracts anglers to the Hurunui River from Christchurch and beyond. Being one of the most northern salmon fisheries, the Hurunui is also a popular choice of anglers from Nelson and Marlborough.

5.11 The majority of salmon fishing activity in the Hurunui takes place at the rivermouth, both in the "gut" where the river narrows prior to running into the sea, and in the surf adjacent to the rivermouth (see Figure 10). This is due in part to the way that salmon congregate at the mouth prior to fresh events, and in part due to the highly scenic landscapes which are present. Unlike most Canterbury rivers which flow out to sea from a flat plain, the Hurunui mouth is located amongst bush- clad hills. The Hurunui rivermouth also tends to be a less crowded and less competitive environment than is present at other rivermouths. It appeals to anglers who want a relaxed and scenic experience rather than one focussed principally on harvest.

Figure 10: Hurunui River Mouth.

5.12 There is also significant salmon fishing in the lower and middle reaches of the Hurunui River, in particular downstream of the Mandamus River confluence. The gorgy nature of the river means that access is more difficult than at the mouth which may limit participation. Many of the successful upriver anglers on the Hurunui access the river through private land. The Hurunui River is closed to salmon fishing upstream of the South Branch confluence in an attempt to preserve the fragile spawning population. No analysis of angling amenity in relation to river flow has been conducted in the Hurunui River, however anglers report that optimal upriver fishing occurs when the flow is between 25 and 40 cumecs (M Bell pers com), at a time when the river first becomes "fishable" as it recedes from a flood or fresh.

5.13 Teirney (1982) found that up to 75% of Hurunui anglers fished either solely for salmon or for salmon and trout. Greenaway (2001) estimated that 57% of angling activity was focussed on salmon. The difference between the two results probably reflects the fact that the 2000-01 salmon season was poor, causing more anglers to focus on trout. Fish & Game National Angler Surveys conducted between 1995 and 2007 did not differentiate between salmon and trout anglers, but it is likely that salmon anglers dominate the fishery, because that is what is observed in most other Canterbury fisheries where salmon are present. The most recent Fish and Game National Angler Survey (Unwin (2009)) estimated that 12,600 angler days were spent in the Hurunui River in the 2007/08 season, at least 5,660 of which were spent below the Mandamus confluence. In my opinion most of the "below-Mandamus" effort would have been from anglers fishing for salmon.

5.14 Fish and Game New Zealand conduct an annual salmon harvest survey throughout the Canterbury region. Between 10 and 20% of anglers are contacted by telephone at the end of the season and asked how many salmon they caught from each river. The data is more accurate for rivers such as the Rakaia and Waimakariri which are very heavily fished, with higher error applying to smaller fisheries such as the Hurunui (see Figure 11).

Season	Estimated Salmon Harvest
1995-1996	714
1996-1997	826
1997-1998	665
1998-1999	559
1999-2000	195
2000-2001	15
2001-2002	113
2002-2003	307
2003-2004	439
2004-2005	268
2005-2006	128
2006-2007	109
2007-2008	441
2008-2009	219
2009-2010	415
2010-2011	220
2011-2012	360

Figure 11: Estimated season angler catch from the Hurunui River, Fish and Game New Zealand Phone Surveys, 1995-1996 to 2010-2011.

6. WAIAU RIVER SALMON

The Waiau River Salmon Population

6.1 The Waiau River salmon fishery is described in the Draft Salmon Management Plan as being of regional significance with an annual run of between 200 and 3000 salmon (Figure 4). This places it in the top ten of New Zealand's salmon fisheries in terms of abundance.

6.2 The Waiau River is another "small river salmon fishery", where upstream migration is closely linked to times of higher flow for the riffle clearance and temperature advantages described earlier. However the Waiau River enjoys a higher flow than the Hurunui which means that salmon passage through the river mouth should remain possible at most times except in periods of very low flow. Passage up the river itself remains reliant on flood and fresh events however with even small lifts in flow aiding migration. So while Hurunui River salmon require fresh events to both enter the river and to move upstream, Waiau River salmon appear to require fresh events principally for the purpose of upstream migration.

6.3 The Waiau River features a large number of significant tributaries compared to other Canterbury salmon rivers with inflows from the Ada, Hope, Boyle, Doubtful and Lewis Rivers. Although trout spawning is spread throughout these tributaries, most salmon spawning occurs in a relatively confined area on a main stem reach of the Waiau River immediately upstream of the confluence of the Ada River on St James Station, and in the Ada River itself. Although these reaches are not completely flood-free which is normally considered to be ideal for salmon spawning, they are nowhere near as flood-prone as the main stem reaches of rivers such as the Rakaia and Waimakariri. The presence of riparian plants on low banks adjacent to the spawning reaches is an indicator of a stable flow regime (see Figure 12). Having continued unimpeded access to these waters is pivotal to the continued existence of the Waiau River salmon fishery.

Figure 12: Upper Waiau River salmon spawning reaches. Note the presence of riparian growth indicating a relatively flood-free flow regime.

6.4 Fish and Game monitor Waiau River salmon returns by a single aerial count of live fish during peak spawning, from which total spawning escapement can be roughly estimated (see Figure 13 and earlier explanation in 5.6).

Year	Date	Trend count Total	Estimated Spawning Escapement*
2001	3/05/2001	87	218
2002	8/05/2002	162	405
2003	7/05/2003	203	508
2004	10/05/2004	121	302
2005	24/05/2005	197	493
2006	16/05/2006	66	165
2007	8/05/2007	168	420
2008	15/05/2008	614	1535
2009	12/05/2009	316	790
2010	11/05/2010	192	480
2011	Not Done	n/a	n/a
2012	20/05/12	663	1657

Figure 13: Salmon trend count and spawning escapement estimates for the Waiau River, Fish and Game New Zealand Aerial Survey Program 2001-2012. *Estimated spawning escapement was calculated by multiplying trend count figure by 2.5.

Salmon Fishing in the Waiau River

6.5 The Waiau is unique amongst salmon rivers in that angler access to its river mouth is difficult due to lack of public roads in the area. Most anglers access the river mouth by launching a jet boat below Spotswood, and boating downstream for approximately six kilometres to the mouth. As a consequence the vast majority of salmon angling takes place away from the river mouth, generally in the reaches between State Highway 1 near Cheviot and State Highway 7 near Hanmer. The most recent Fish and Game National Angler Survey (Unwin (2009)) estimated that 4340 angler days were spent on the Waiau River in the 2006-07 season, the majority of which are likely to be from salmon anglers.

6.6 Once again the Fish and Game salmon angler harvest survey captures data for the Waiau River with the same limitations as occur on the Hurunui River and described in 5.14 (see Figure 14).

Season	Estimated Salmon Harvest
1995-1996	63
1996-1997	305
1997-1998	70
1998-1999	496
1999-2000	253
2000-2001	30
2001-2002	40
2002-2003	40
2003-2004	40
2004-2005	110
2005-2006	18
2006-2007	16
2007-2008	111
2008-2009	24
2009-2010	n/a
2010-2011	11
2011-2012	185

Figure 14: Estimated season angler catch from the Waiau River. Fish and Game New Zealand Phone Surveys, 1995-1996 to 2010-2011.

6.7 The lack of access to the river mouth and relative distance from population centres means that the Waiau River is most popular amongst local salmon anglers although it does attract some use by visiting anglers. The reach between Spotswood and the mouth is particularly popular amongst visiting jet boat anglers, being one of the most scenic and remote boating/fishing locations in the Canterbury region.

6.8 At most rivers, salmon anglers tend to concentrate on the river mouth during times of low flow when salmon are congregating there, and on upriver fishing when the river is clearing after a fresh and salmon are actively moving upstream. The relative lack of access to the river mouth and strong focus on upriver angling means that Waiau River salmon anglers are particularly reliant on flood and fresh events in order to be successful. No analysis of angling amenity in relation to river flow has been conducted in the Waiau River, however anglers report that optimal upriver fishing occurs when the flow is between 50 and 75 cumecs in the Waiau (A Matravers pers com), at a time when the river first becomes "fishable" as it recedes from a flood or fresh.

7. REQUIREMENTS FOR PROTECTION OF SALMON FISHERIES AND ANGLING - THE LIKELY IMPACTS OF DEVELOPMENT OF THE HURUNUI AND WAIAU RIVER CATCHMENTS ON THE SALMON FISHERIES.

Dams and Weirs

7.1 Instream dams which create a vertical barrier between the reaches above and below, almost inevitably stop salmon migration at that point. Dams are likely to have the greatest impact on salmon fisheries if built downstream of known spawning habitat by preventing the upstream migration of spawning adults to the spawning grounds, by delaying or blocking the downstream migration of fingerlings, and by flooding potential spawning and juvenile rearing habitats.

7.2 Adult salmon passage past dams can be achieved through the construction of fish passes. Successful examples can be found in Great Britain and North America but generally only when the dam is low in height and a large amount of water is available to run through a by-pass channel or fish ladder. Two formerly productive New Zealand salmon fisheries have had dams built in their main stems, downstream of historical spawning grounds. A fish pass was built adjacent to the Waitaki Dam but failed to allow any salmon passage. No fish pass was constructed in the Roxburgh Dam on the Clutha River. In both rivers the salmon fisheries plummeted from being of national significance to of local and regional significance only (Figure 4).

7.3 In North America the impact of hydro-electric dam construction has been even more profound. Lichatowich (1999) states that salmon are extinct in almost 40% of the waters in which they historically spawned in Oregon, Washington, Idaho and California. The construction of dams which prevent access to traditional spawning ground is one of the principle (but not only) causes.

7.4 One of the best examples of salmon run degradation due to the impact of dams is in the McCloud River, a tributary of the Sacramento River where the New Zealand salmon population was first sourced from. Williams and Williams (1990) wrote: *The Sacramento River winter Chinook salmon are nearing extinction. The unacceptable loss of this distinct and valuable race of salmon would be the result of conscious management decisions that demonstrated a lack of concern for the needs of the species. The winter Chinook salmon are adapted to entering the main Sacramento River in late winter and spawning far upstream during the early months of the Central Valley's long, hot summer. Their ancestral spawning grounds were in the McCloud River, a tumbling, spring-fed tributary of the upper Sacramento. Eggs hatched and fry matured in the cold, consistent flows of the McCloud, seemingly oblivious to the hot summer weather. .All this changed when Shasta and Keswick dams were built on the Sacramento. Migrating adults, blocked by the dams, no longer could reach historic spawning areas. Pollution, water diversions, and stream channelization also exacted their toll. As recently as 1969, more than 100,000 spawners were tallied. Annual counts from 1982* *to 1988 average only 2,334 adult fish—more than a 97 percent decline. At the reduced population levels of recent years, extinction is likely from continued habitat losses or a chance event such as drought or flood.*

7.5 Dams can also pose problems for downstream migrating fry which appear to travel with the current rather than actively migrating on a magnetic heading towards the coast. In North America Chinook salmon smolt appear to become disorientated by the lack of current when migrating through man-made lakes and are reluctant to enter the by-pass channels. In some cases authorities have resorted to barging salmon smolts through lakes and releasing them downstream of dams.

7.6 The flooding of spawning and rearing habitat is also a problem associated with instream dams. While Sockeye salmon appear to be able to successfully spawn and rear in lakes in North America, Chinook salmon prefer flowing water. Their large eggs require steady flows of well-oxygenated water in order to remain viable, and the young appear to specialise in rearing in stream margins.

7.7 New Zealand salmon fisheries are in my view even more vulnerable to extinction through habitat loss than those in North America. New Zealand salmon populations tend to be small, and rely on spawning in a very limited range of sites in each catchment. New Zealand salmon also tend to spawn almost exclusively in high country areas, with lower elevation tributaries tending to be unsuitable due to high sediment loads and unfavourable temperature regimes. The sites chosen by dam developers almost are invariably downstream of most or all of the salmon spawning habitat in the catchment.

7.8 In the case of the Hurunui River, dam sites which have been proposed in the South Branch are all downstream of known salmon spawning and rearing habitat. A dam on the Hurunui River downstream of the South Branch confluence would prevent almost all salmon from reaching the spawning grounds. A dam on the South

Branch at the top of the gorge, would prevent an estimated 72% of Hurunui salmon from reaching their chosen spawning grounds. This dam would also submerge much of the spawning and rearing habitat available.

7.9 It has been suggested that salmon would find alternative spawning grounds in the event of dam construction. This has occurred on the Waitaki and Clutha Rivers but only to a very limited extent and the run has undergone a dramatic reduction in size. Salmon are great opportunists and most existing salmon fisheries were colonised within a decade of the first releases into the Waitaki River. In the 100 years that have passed since, no significant new fisheries have emerged. This suggests that by the end of that first decade, salmon were occupying all of the suitable habitats available. The same mechanism appears to be in action within catchments where salmon spread to a range of spawning habitats within a short time of colonisation, but their range has remained stable ever since. In the period since 1993 when salmon spawning has been rigorously assessed by aerial survey methodology, no new spawning habitats have been discovered.

7.10 It is probable that salmon currently occupy all of the suitable spawning and rearing habitats available in the Hurunui and Waiau catchments. The areas that salmon do not currently use for spawning are likely to be unsuitable to their needs. It is likely that dam construction in the Hurunui River downstream of existing spawning habitat would have a similar impact on the Hurunui as has been observed in the Waitaki, Clutha and a host of North American rivers. Furthermore the fact that the run already appears to be fragile and spawning-limited, means that dam construction might lead to fishery extinction. Painter (2010) in his report "Canterbury Water Management Strategy, Preliminary Strategic Assessment Project 1, Integrated Hurunui Waiau" said "*A dam located on the South Branch would significantly impact the trout and salmon fishery in this reach of the river, Lake Mason and Little Lake Mason and potentially the Hurunui River at large. Fish passage would be prevented and habitat* *inundated and significant variances from the recreation and ecological targets would result."* In verbal advice to the North Canterbury Working Group of the Canterbury Strategic Water Study, Dr John Hayes of the Cawthron Institute opinioned that run extinction was a real possibility in the event that mainstream dams were constructed on the Hurunui. I agree with this opinion and believe that a similar risk exists were a dam to be built in the Waiau River which blocked salmon access to spawning grounds on St James Station.

7.11 Submerged weirs, such as has been proposed for the Lake Sumner outlet, are likely to have little effect on salmon populations, depending on their location. Salmon are a strong, active fish and should be able to get past a weir as long as it is designed in a sympathetic manner. Further, in the case of a weir on Lake Sumner, given that the North Branch only contains a minority of the spawning habitat in the catchment, the effect is likely to be insignificant.

7.12 A number of techniques have used with mixed success in North American salmon fisheries to mitigate the effects of instream dams. However these are likely to be unsuitable or unaffordable in New Zealand. As mentioned earlier fish passes can been constructed to allow fish to migrate past instream dams. In New Zealand the "cost" of the pass itself and the cost of sacrificing sufficient water to run the pass (in terms of lost irrigation storage and/or hydro-electric generation) is likely to be unaffordable. The cost of capturing, barging and releasing downstream migrating smolts below the dam site also needs to be taken into account and will further threaten the affordability of this type of mitigation in New Zealand.

7.13 In some North American salmon fisheries, attempts to get migrating salmon past instream dams have been abandoned and hatcheries have been built to sustain runs. The use of hatcheries to mitigate the loss of access to spawning and rearing grounds is controversial and does not have the full support of fisheries managers, due to the negative genetic impacts on the population. However even if hatchery mitigation was accepted by fishery managers, it is again likely to be unaffordable in New Zealand, given the high costs of a hatchery program (estimated at $500 000 to $1 000 000 per river per year) and the relatively low profitability of small scale irrigation storage and hydro-electric schemes.

Flow Regime

7.14 In order to protect salmon fisheries, flow regimes need to:

a. Prevent abstraction reducing river flows to below levels at which salmon migration occurs;

b. Preserve the flows at which salmon angling is successful;

c. Preserve the frequency and duration of flood and fresh events.

7.15 The Officer's Report by Duncan argues that 15 cumecs in December and January and 12 cumecs in February, March and April is "sufficient" to facilitate unimpeded passage in the Hurunui River (paragraph 16).

7.16 There appears to be some disagreement between the hydrological experts regarding the flow required to facilitate salmon migration in the Waiau River. Duncan and Bind (2009) undertook a 2D IFIM study and predicted that salmon passage was possible (but not ideal) at 15 cumecs, but generally acceptable at 20 cumecs. In his 2012 Officer's Report Duncan qualified this earlier finding by saying *"it is quite possible that there will be locations where there is insufficient water depth at a flow of 15 m3/s for salmon passage"* (paragraph 19). In his Officer's Report, Jellyman refers to the above comment by Duncan saying *"to allow salmon passage in these locations, I agree that a greater minimum flow in February and March is required"* (paragraph 27). In another survey Olsen et at (2011) argued that the 2D IFIM analysis was not appropriate and predicted that flows as high as 60 cumecs were required for salmon passage. Despite the disagreement amongst the experts, both studies do suggest that the proposed summer minimum flows are inadequate for salmon migration.

7.17 This criticism of the use of 2D IFIM modelling to predict salmon passage brings into question the findings of Duncan on both the Hurunui and Waiau Rivers. An example of the potential risk of using data developed by modelling the hydrology of short reaches as a predictor of the impact of abstraction on whole catchments can clearly be seen in the difference between Duncan's predicted "jet boat passage flows" in the Waiau River and the practical observation of experienced Waiau River jet boaters. Duncan's model predicted that the river could be boated at 15 cumecs while experienced boaters thought that 25-30 cumecs were required. The angler I spoke to while developing this evidence (A Matravers pers com) thought that 45 cumecs were needed to safely boat from Spotswood to the rivermouth.

7.18 Although I have some concerns about the validity of modelling short river reaches and using the results to predict passage throughout entire catchments, I have much wider concerns about using predictions of the ability of salmon to cross shallow riffles as an indicator of successful salmon migration. In my view the practice of focussing on a single low flow value as a predictor of river suitability for salmon migration is overly simplistic. Salmon migration is an event which takes place over both geographical and temporal scales. In order to reach headwater spawning grounds salmon need to travel through a river reach in excess of 100 kilometres in length over a period lasting three to four months. It is not fatal to salmon for the river to drop below the minimum level for passage over a particular riffle. Salmon have plenty of time on their hands and can merely wait out short periods of low flow. However if the river gets low enough for long enough, the energetic cost of waiting out the delays and travelling through the river when it is at levels less than optimal for upstream movement, may mean that the salmon is unable to reach its spawning ground. If the salmon is unable to reach the spawning grounds it will be forced to spawn in sub-optimal habitat and will make no contribution to the fishery. Protecting salmon migration requires a flow regime which minimises the time the river spends below the level at which passage is possible and preserves the frequency and duration of flood and fresh events.

7.19 The information contained in the Officer's Reports of Duncan and Jellyman deals principally with "passage"; -that is the ability of an average salmon to move through a typical shallow riffle. In order for salmon fisheries to survive and flourish, the flow regime needs to allow salmon "migration", which is the movement of all of the fish through the entire river system within pre-determined time and energy constraints. As such the minimum flow value is of comparatively minor importance compared to the flow regime. Any flow regime which reduces the number of days that the Waiau and Hurunui Rivers run at moderate to high flow is likely to cause harm to the respective salmon fisheries.

7.20 Although serving a vital river function, high flows are relatively rare in terms of the number of days they are present and tend not to be affected by abstraction regimes unless instream dams are constructed. Moderate flows are more important to salmon fisheries because they last longer and offer the best conditions for meaningful upstream movement. Moderate flows are also the flows most targeted for abstraction. The hydrographs produced by Mr Stewart show some loss of moderate flows compared to natural flows as a result of the existing A block abstraction and the proposed B block abstraction in both the Hurunui and Waiau Rivers. In my view this is having/will have a small negative effect on the salmon fisheries of both rivers but would be difficult to measure. The hydrographs which show the effect of A plus B plus C blocks show a dramatic loss of moderate flow days, and considerable "flat-lining" of the rivers where they sit at minimum flow levels for extended periods.

7.21 As mentioned earlier, having a river drop below the flow at which passage is possible is not on its own a disaster for migrating salmon. My observation of salmon behaviour is that they tend to wait out days where flows are "below-adequate" or even "adequate" and time their upstream movement for days when flows are "optimal". This gives them the best return in terms of distance covered for energy spent. The hydrographs showing the effect A plus B plus C blocks show an almost complete loss of optimal migration days. In my view this is likely to cause more harm to salmon fisheries than can be offset by small increases to the minimum flows.

7.22 In summary I have concerns that the existing and proposed minimum flows for the Hurunui and Waiau Rivers are likely to be having/will have a negative impact on salmon migrations and will cause a portion of the run to be unable to reach the headwater spawning grounds. However I have much greater concerns about the loss of moderate flows and flow variability to both rivers in the event that the proposed C block abstraction regimes are introduced.

? But that wasn't what was just argued??

Vulnerability of the Hurunui and Waiau Salmon Fisheries to Run Collapse and Extinction

7.23 Although highly valued by local and visiting anglers, the Hurunui and Waiau River salmon fisheries are in my view vulnerable to run collapse and extinction. Both are small rivers which are prone to extended periods of low flow. Both exist towards the northern end of the geographical range of salmon in New Zealand where presumably ocean temperatures are warmer than ideal. Both rely on mainstem spawning instead of the more productive spring-fed tributary spawning that is the mainstay of the nationally significant salmon fisheries. Setting minimum flows that are "sufficient" (Duncan 2012) instead of "optimal", places the fishery at risk. Establishing allocation regimes which are likely to cause a reduction in the frequency of moderate flows and flow variability also poses risks to the fishery.

8. OFFICER REPORTS

8.1 I have read the Officer's Reports produced by Duncan and Jellyman and while I generally agree with their modelling and opinions, as referred to above I believe that the focus on "passage" rather than "migration" tends to understate the impact of the proposed HWRRP on the salmon fisheries of the Hurunui and Waiau Rivers.

8.2 I also disagree with a comment by Jellyman (paragraph 16) in which he suggests that upstream migration by salmon "may be relatively quick (days to a few weeks)". My observations are that peak movement of salmon through the rivermouths (as indicated by angler catches) takes place in mid January while peak spawning (as indicated by Fish and Game spawning surveys) takes place in early May, suggesting a typical migration duration of 3.5 months.

8.3 I have read the Officer's Report by White and disagree with her comments that if salmon passage is catered for, so by default is salmon angling (paragraph 260). Once again my concern is the focus on short-term/short duration "passage" rather than whole of catchment "migration". The creation of passage will not necessarily cause salmon to migrate, which is what is required in order for angling to be successful. A regime of moderate to high flows over extended periods of time is necessary for both migration and angling. Studies in the Rangitata and Waimakariri that I have been involved in have shown that salmon angling tends to require even higher flows than salmon migration, because the amount of "fishable area" declines with river flow. The large density of anglers on rivers with salmon fisheries means that a reduction in fishable area results in a reduction in angling activity.

Does policy framework capture this though?

8.4 I have further concerns about White's recommendation (paragraph 188) to change policy 2.7 and (paragraph 189) to modify the 'Environmental Flows' section in part 1 of the HWRRP where it is proposed that reference to flows of particular importance to salmon anglers (35 to 75 cumecs in the Waiau River and 30 to 50 cumecs in the Hurunui River) are removed and replaced with a more general comment about preserving flow variability. It appears it is being suggested that the loss of optimal salmon anglings days will be mitigated by the creation of more optimal trout fishing days. I have two concerns. Firstly optimal salmon angling days occur far less frequently than optimal trout fishing days and need to be protected. Secondly optimal trout fishing is based largely on river clarity.

How can this be addressed then => are flows in 2.7 correct?

Lowering the river by abstraction will not change the clarity of the river and so it will remain unfishable for trout. Optimal salmon fishing conditions are partly a function of river clarity where some sediment in the water is of benefit, but also a function of flow where the higher the flow, the more fishing locations that are available.

R Millichamp

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References Cited

Draft Sea Run Salmon Management Plan, Fish and Game New Zealand March 2011.

Duncan, M. and Shankar, U. (2004). Hurunui River Habitat 2-D Modelling. NIWA Client Report: CHC2004-011.

Duncan , M (2012). Salmon and Jet Boat Passage and River Habitat. Section 42a Plan Report.

Duncan, M. and Bind, J. (2009); -Waiau River Instream Habitat Based on 2-D Hydrodynamic Modelling. NIWA Client Report CHC 2008-176. May 2009

Greenaway, Rob. 2001. *Hurunui River Recreation Study 2000/01*. Fish and Game Council and Environment Canterbury

Jellyman, Donald 2012. Effects of Mid Range Flow Changes on Fish Migration. Section 42a Plan Report.

Lichatowich, Jim. Salmon Without Rivers, A History of the Pacific Salmon Crisis. Island Press, Washington DC. 1999.

Olsen, D. et at (2011). Assessment of the Amuri Hydro Project on the Waiau River, North Canterbury. Cawthron Report No. 2011, September 2011.

Painter B. Canterbury Water Management Strategy, Preliminary Strategic Assessment, Project 1, Integrated Hurunui Waiau. Report prepared for the Canterbury Water Executive, Canterbury Regional Council, 6 December 2010.

Review of Daily and Season Bag Limits for Salmon, Fish and Game New Zealand, Central South Island Region, 2008.

Taylor, Joseph. Making Salmon, An Environmental History of the Northwest Fisheries Crisis. University of Washington Press, Seattle. 1999.

Teirney, L.D.; Unwin, M.J.; Rowe, D.K.; McDowall, R.M.; Graynoth, E. (1982). Submission on the draft inventory of wild and scenic rivers of national importance. *Fisheries Environmental Report 28.* 122 p.

Unwin, M.J.; Image, K. (2003). Angler usage of lake and river fisheries managed by Fish & Game New Zealand: results from the 2001/02 National Angling Survey. *NIWA Client Report CHC2003-114.* 48 p.

Unwin, M.J. (2009). Angler usage of lake and river fisheries managed by Fish & Game New Zealand: results from the 2007/08 National Angling Survey. *NIWA Client Report CHC2009-046.* 48 p.

Unwin, M.J. (1993). Estimating salmon spawning populations using repeated aerial counts: progress during 1992/93. NIWA Freshwater Miscellaneous Report, No. 68.

Vronskiy, B.B 1972. Reproductive biology of the Kamchatka River Chinook salmon (Oncorhynchus tshawytscha (Walbaum)). J Ichthyol. 12:259-273.

White, Liz 2012. Proposed Hurunui and Waiau River Regional Plan; And Proposed Plan Change 3 to the Canterbury Natural Resources Regional Plan Section 42A Report September 2012.
Planning

Williams, J. E and Williams, C.D. Chapter 9, California's Salmon and Steelhead; The Struggle to Restore an Imperilled Resource. University of California Press 1991.