

NEW ZEALAND FRESHWATER FISHERIES MISCELLANEOUS REPORT NO. 12

POSSIBILITIES FOR ENHANCEMENT OF THE
QUINNAT SALMON RUN IN THE CLUTHA RIVER
BELOW ROXBURGH DAM

by

D.J. Jellyman

Report to: Electricorp (Dunedin) Ltd

Confidential to client

Freshwater Fisheries Centre

MAF Fisheries

PO Box 8324

CHRISTCHURCH

Servicing freshwater fisheries and aquaculture

JULY
1989

NEW ZEALAND FRESHWATER FISHERIES MISCELLANEOUS REPORTS

This report is one of a series initiated in January 1989, and issued by the Freshwater Fisheries Centre, MAF Fisheries. The series was established to ensure that reports prepared for clients, tribunal hearings, internal use, etc., are collected together and available to future users. They are for limited circulation, and some may be confidential.

ISBN 0-477-08198-3



MAF Fisheries is the fisheries business group of the New Zealand Ministry of Agriculture and Fisheries. The name MAF Fisheries was formalised on 1 November 1989 and replaces MAFFish, which was established on 1 April 1987. It combines the functions of the former Fisheries Research and Fisheries Management Divisions, and the fisheries functions of the former Economics Division of MAF.

Enquiries to: The Librarian
Freshwater Fisheries Centre
PO Box 8324
Riccarton, Christchurch
New Zealand

CONTENTS

	Page
Summary	1
1 Historical Review of Salmon in the Clutha River	2
2 Review of the Present Situation	4
3 Rationale for Enhancement	7
3.1 Roxburgh Dam, Design and Operation	7
3.2 Importance of Salmon Angling	8
4 Enhancement Possibilities	9
4.1 Smolt Releases	9
4.1.1 Releases at Roxburgh	11
4.2.2 Releases in Tributaries Below Roxburgh	11
4.2 Habitat Improvement	13
4.2.1 Fish Access	13
4.2.2 Instream Improvements	13
4.3 Artificial Spawning Channels	14
4.4 Commercial Operations	14
4.5 Enhancement Opportunities Elsewhere	14
5 Recommendations	14
6 References	15

SUMMARY

- 1 Installation of Roxburgh Dam stopped the run of anadromous salmon upstream to Lakes Wakatipu, Hawea and Wanaka. The size of this run is guessed to have been 20-30 000 fish annually.
- 2 When Roxburgh was built the advice of fisheries managers was that fish passes would not work and were not needed. It is inappropriate to hold Electricorp responsible for cessation of the anadromous salmon run above Roxburgh.
- 3 The operating regime of Roxburgh Dam down-grades downstream fish habitats and angling opportunities. Some compensation in lieu of this is reasonable.
- 4 Kaitangata hatchery (formerly ICI/Watties) releases contributed about three-quarters of all fish caught at Roxburgh Dam. The Roxburgh fishery is of considerable regional significance attracting salmon anglers from Otago and Southland.
- 5 Smolt releases at Roxburgh would provide many returning fish for anglers, but would not enhance the river's natural production significantly. Basically the fishery would be a 'put and take' one.
- 6 Tributary releases could lead to increased natural production and so not need to be carried out annually. The Tuapeka River is proposed as the best option for enhancement but this would require removal of an old weir (5 m? high) in the lower reaches.
- 7 An artificial spawning race at Roxburgh Dam is not recommended due mainly to the likelihood of it not being successful. Other factors are lack of suitable sites, size and cost, and the possibilities of further hydro development downstream.
- 8 The commercial/recreational enhancement potential of the most downstream dam in any future hydro development needs recognition. If engineeringly feasible smolt production and adult recapture facilities could be incorporated into dam design.
- 9 Substitutionary enhancement of salmon fisheries elsewhere (eg. Otago Harbour) is likely to be unacceptable to fisheries managers.

- 10 Recommended enhancement opportunities are, firstly, an investigation of the Tuapeka River - this would necessitate removal of the present weir and, secondly, instituting a continuing smolt release programme at Roxburgh. A release strategy at Roxburgh, sufficient to make up the previous contribution from the Kaitangata hatchery (approximately three-quarters of the present catch) is suggested.

1. HISTORICAL REVIEW OF SALMON IN THE CLUTHA RIVER

Prior to the installation of Roxburgh, quinnat salmon had access from the sea to the tributary rivers of Lakes Hawea and Wanaka. Thus a sea-going (anadromous) population was established although there is no records that sea run fish entered Lake Wakitipu. It is probable that the high current velocities associated with the 'Natural Bridge' upstream of Roaring Meg on the Kawarua River, prevented passage beyond this point. However, voluntarily "landlocked" populations of salmon also developed in all three source lakes. These stocks now constitute an important angling resource.

Roxburgh Dam stopped the run of anadromous salmon to the headwater lakes. No estimates of size of this run are available but suggestions in the literature of 100 000 fish per annum are bound to be substantial over-estimates. Based on estimates of runs in other east coast rivers, a figure of 20-30 000 would be a more reasonable guess. During the years immediately after the dam was built, large schools of salmon accumulated below it. Virtually no quantitative data are available, except a count of redds (buried 'nests') in 1959, three years after the dam was built - counts in the Bengier Burn and Teviot River, the tributaries closest to Roxburgh, were 306 and 150 respectively, compared with 3 and 0 in 1983 (see Jellyman 1987).

When the Roxburgh Dam was constructed, the fisheries managers (Wildlife Service of the Department of Internal Affairs, and Fisheries Division of the Marine Department) agreed that the inclusion of a fish pass was not justified. They considered that the absence of a pass would "protect upper lake fisheries from contamination by eels or salmon" (Little 1975). A newspaper report of the period indicates that Central Otago anglers were divided in their opinions about a fish pass:

"Some regard the salmon as a major attraction, while others consider that these fish do inestimable damage to the spawning beds of brown and rainbow trout. Most sportsmen agree that the fishing would be very considerably improved if there were no salmon ..." (Otago Daily Times, 4 April 1950).

The same article quotes the then Minister of Internal Affairs, Mr W.A. Bodkin:

"It is definitely desirable to eliminate quinnat salmon from the headways [headwaters] of the Molyneaux [Clutha], for they destroy the trout. I am absolutely opposed to any suggestion that a fish ladder should be built at Coal Creek [Roxburgh]. It is hoped to make the lake behind the new dam and the southern lakes together with all the streams that feed them into safe places for trout to live and spawn".

It seems that the Otago Acclimatisation Society did not pursue any objections to the lack of fish passage facilities. To quote from the president's report in the 1952 Annual Report of the society.

"A problem of which Otago has as yet had little experience is arising from the building of the big hydro-electric dams. When Roxburgh is completed this will become a local problem. It is, of course, that these dams bar the passage of fish in the rivers, and stop trout and salmon, in particular, from getting up to spawn. The Waitaki and Highbank schemes are acute cases. I am afraid that, from what we learn from the Departments, and what they in turn have learnt from abroad, there just isn't any solution, and fishermen may as well become resigned to the position. There has been much talk of fish ladders (which apparently don't work) and electric gadgets to make the fish go various ways, but as usual costs are the vital factor. We were told at the South Island Council among other things, that some dams are so high that no scheme is possible, and the rest would cost about fifty thousand pounds per dam for a possible solution: and, pretty bluntly, that no Government would spend such an amount of money - a decision that, as we are all taxpayers, I imagine none of us will quarrel with. So if our Upper Clutha

friends feel inclined to enlist our help when Roxburgh nears completion, I'm afraid they know the answer in advance."

The position was summarised in recent correspondence to me "The society was advised by Marine Department that the dam was too high for a fish pass and that a hydraulic lift would be too expensive (Dr D Scott, president OAS, pers. comm.).

Ten years after Roxburgh was commissioned, Little (1975) commented that the decision not to include a fish pass "is not considered to have been a wise decision by us at this time". However, a suggestion that the migration of anadromous salmon to Lakes Hawea and Wanaka should be restored by a combination of fish passes and irrigation link races (Woods 1982) has been criticised as biologically unfeasible (Jellyman 1983). The cost of installing fish passes at Roxburgh, Clyde, Queensberry, and Luggate was conservatively estimated in 1984 at \$40m (based on costings supplied by Dr R. Hamilton, Fisheries Consultant, USA). With the development of these stations, Jellyman (1984) concluded that the re-establishment of the salmon migration beyond Roxburgh would be impractical.

2. REVIEW OF THE PRESENT SITUATION

The lower Clutha River supports a regionally important recreational fishery (Richardson et al. 1984). After the Taieri River, the lower Clutha is the most heavily fished river in the Otago Acclimatisation Society district, receiving an estimated 30 000-35 000 visits per year (Richardson et al. 1984, Whiting 1986). About 80% of these are made by trout anglers, and the other 20% by salmon anglers (Richardson et al. 1984).

The main species caught is brown trout, at an estimated annual catch of 21 000 (Whiting 1986) to 25 000 (Graynoth 1974). The salmon catch is much smaller, being estimated at about 2000 fish for the 1982/83 angling season (Whiting 1986). Large sea-run (anadromous) brown trout enter the river from December to March, and are caught mostly in the Pomahaka River and below Balclutha, although some are caught as far up the river as Roxburgh. A few rainbow trout (Salmo gairdnerii) and perch (Perca fluviatilis) are also caught.

Results from the postal questionnaire of the 1982/83 angling season (Whiting 1986) indicated that the reach below Balclutha was the most popular with both adults and juniors. This was followed by the reach from Roxburgh to Beaumont Bridge for adults, and Lake Roxburgh and the Tuapeka Mouth-Balclutha reach for juniors. The least popular reach was that from Beaumont Bridge to Tuapeka Mouth. The fishery below Balclutha is so popular that, since 1973, it has been open to anglers throughout the year (Otago Acclimatisation Society 1975), whereas, further upstream, the river can be fished only from 1 October to 30 April. Lake Roxburgh is also open for fishing all year.

Although angler surveys have not been carried out each year, the available information shows that there have been some 'good' salmon fishing seasons since the Roxburgh dam was installed. For instance, during the 1972/73 season, 695 salmon were caught, and the number caught in the following season "far exceeded the 1973 figure" (Otago Acclimatisation Society 1973, 1974). However, these years were exceptional, and the average catch per season would appear to have been about 100 salmon. Since 1983, the salmon fishery has been enhanced by releases of fry and smolts from the ICI/Watties salmon farm at Kaitangata. The annual catches for 1979-82 were estimated to be 50-200 fish, but more recent estimates are higher: 800 (1982/83), 1400 (1983/84), 1600 (1984/85) and 500 (1985/86) (Gillard 1984, 1985). The 1986/87 and 1987/88 seasons were both 'poor' although no catch estimates are available. In contrast, the 1988/89 season has been extremely good, with up to 120 anglers fishing per day at "The Wall" at Roxburgh during December and January. Salmon fishing at Beaumont and Millers Flat has also been popular (M. Wright, OAS, pers. comm.).

While the ICI/Watties hatchery at Kaitangata liberated salmon smolts into the Clutha (1977-1985), the run of salmon in the Clutha River was significantly enhanced. The proportion of ex-hatchery salmon in the catch varies with location in the river and with season. During 1983/84, all of the fish caught below Balclutha ($n = 257$) were considered to be ex-hatchery fish, compared with 42% of those caught at Roxburgh ($n = 386$) (Gillard 1984). This was probably because ex-hatchery fish tended to remain near their place of origin, although few actually returned to the hatchery, while wild fish continued further upstream. For the 1982/83 to 1986/87 seasons, the proportion of

ex-hatchery fish in the total catch has been estimated at 31% (1982/83), 78% (1983/84), 64% (1984/85), 87% (1985/86), 95% (1986/87). Therefore, with cessation of hatchery releases in the past few seasons a reduction of the annual run by about three-quarters could be expected. (This reduction does not take into account any contribution from OAS and NZ Salmon Anglers Association activities.) Although catch data are unavailable, it has been previously stated that the 1988/89 salmon fishery has been a very good one. Although the Kaitangata hatchery released fish as recently as 1986, these releases were small (6800 smolts) meaning that hatchery releases effectively finished in 1985 (234 000 smolts). These last releases could have contributed to the 1988/89 fishery as 5-year-old fish but, at the time of writing there have been virtually no returns of tagged (= ex-hatchery) fish. It seems likely then that the good fishery of the past season was predominantly sustained by wild fish - a contradiction to the previous pattern.

Associated with the increasing number of salmon caught in the Clutha River over recent years has been the development and promotion of the fishery. An Otago branch of the New Zealand Salmon Anglers Association was formed on 7 April 1984, and has more than 350 members (Ellis 1986). In submissions to the Lower Clutha Hydro-electric Investigations Interim Report (Ministry of Works and Development 1984), the Clutha Central Otago United Council, the Otago branch of the New Zealand Salmon Anglers Association, the Otago Regional Development Council, the Roxburgh Borough Council, and the Lower Clutha Residents and Ratepayers Association all stressed the importance of safeguarding the existing fishery below Roxburgh. In their submissions, they suggested that the passage of salmon to Roxburgh be maintained by installing fish passes on any dams that are constructed. While this might seem a worthwhile objective from the point of view of the local community, it is not in the national interest. Given North American estimates that fish passes cost 5-10%, of total scheme cost (I. Jowett pers. comm.), and a 1983 estimate of \$1,083m for the complete lower Clutha development (Ministry of Energy 1983), it could cost as much as \$60m to provide fish passes. A cost of this order is not warranted for the benefit of a small group of anglers.

One reason for the large annual fluctuations in the run of 'wild' salmon in the lower Clutha, is that it is thought that most of the wild

fish originated in Lakes Wakatipu, Hawea or Wanaka; each year a proportion of these fish (mainly three-year-olds) migrate to sea and return 1-3 years later as adults. Evidence for this assumed life history pattern is largely circumstantial, but, in brief is as follows:

- 1 Salmon are present only seasonally in Lake Roxburgh.
- 2 No spawning salmon have been recorded in any tributary rivers/streams above Roxburgh, except the tributaries of the source lakes.
- 3 A tagged salmon released in Lake Wanaka was caught in Lake Roxburgh.
- 4 Adult salmon from the Clutha River are mostly four- and five-year-olds and have typically spent 3-4 years in freshwater. It seems probable that most of this extended freshwater rearing has taken place in the upper lakes rather than the river. Such a life history is atypical of normal salmon runs, eg. the Rakaia.
- 5 The age structure of spawning landlocked salmon in the lakes suggests a lower proportion of three- and four-year-old fish than would be expected - this is consistent with fish of these ages migrating downstream.

It follows then, that a large out-migration of salmon from the lakes, as occurred this past summer, could be expected to make a significant contribution to the run of wild fish in two and three years' time.

3. RATIONALE FOR ENHANCEMENT

3.1 Roxburgh Dam, Design and Operation

When Roxburgh Dam was being planned, the Ministry of Works sought the opinion of the fisheries managers about whether a fish pass was required or not. The advice given was that a fish pass was neither feasible nor necessary (although the local acclimatisation society did not necessarily concur with this view). Question: "Can Electricorp be held responsible for the cessation of runs of anadromous salmon beyond the Roxburgh Dam 35 years ago, given that the fisheries advisers of the time recommended that no fish pass was required?" Logic would determine that Electricorp cannot be held responsible, and thus any

compensation is not obligatory. It may be that for reasons of goodwill, and public relations Electricorp will consider some form of compensation based on lack of salmon access beyond Roxburgh Dam. If so this should be promoted as an exercise of "good faith" and not as acknowledgement of non-compliance with past advice.

There remains the question of whether compensation is reasonable as a means of redress for problems associated with the operation of Roxburgh Dam. Present daily fluctuations in flow can be pronounced, eg. 500 m³/s change over six hours (Harvey and Jellyman 1986) and result in daily dewatering of shallow fish habitats, exposure of salmon and trout redds, plus some bank instability and erosion problems. (River level differences immediately below Roxburgh Dam from minimum to maximum load have been calculated at 3.8 m; this reduces to about 1.3 m by Millers Flat 21 km downstream (Harvey and Jellyman 1986).) It can be reasonably argued that operation of Roxburgh has degraded downstream fish habitats, and angling opportunities and that some compensation is justified.

3.2 Importance of Salmon Angling

Results from the National Angling survey (Teirney et al. 1982), conducted over the 1978/79 angling season, indicated that many Otago and Southland anglers were prepared to travel to the Waitaki River for salmon fishing. The improvement in the Clutha salmon fishery over recent years has provided an alternative closer to home for these anglers. For instance, interviews of 243 anglers fishing between Roxburgh dam and the township showed that only 6 were not from Otago or Southland (Whiting 1986). Therefore it is likely that anglers from these areas would strongly advocate that salmon fishing continue to be available in the Clutha River.

The importance of the present salmon fishery to the local community has already been mentioned. Some comment on the impact to anglers of further hydro development below Roxburgh Dam is also appropriate.

Results from angler interviews (Whiting 1986) indicated that only 20% of anglers fishing between the Roxburgh dam and Roxburgh Bridge were "locals" (of 240 anglers, 35% lived within a 50-km radius of the dam,

36% lived within 50-100 km, and 29% lived more than 100 km away). Thus, the Roxburgh salmon fishery mainly attracts people from outside the district, and because these anglers are 'mobile', they would probably relocate their fishing to below the lowest dam. In fact, such a shift would bring salmon fishing nearer to most anglers. Whiting's data show that if the salmon fishery was at the Tuapeka Mouth dam rather than the Roxburgh dam, 59% of the anglers interviewed would have less distance to travel. Although it is acknowledged that such a shift in angling would have a detrimental effect on the Roxburgh community, it would benefit that of Tuapeka Mouth and its environs.

4. ENHANCEMENT POSSIBILITIES

A number of possibilities exist for enhancing the lower Clutha salmon fishery. these are reviewed below.

4.1 Smolt Releases

Some consideration of enhancement opportunities including smolt releases is contained in Jellyman (1987). To quote:

"Maintenance, or preferably enhancement, of the present run is suggested as worthwhile as partial compensation for the cumulative effect of hydro development on the wild stock of salmon. While the existing commercial hatchery continues to release juvenile salmon, this objective is being met. Should this facility be closed, we suggest that Electricorp take responsibility for continued enhancement by preserving the wild stocks through protection and enhancement of spawning areas, and by releasing hatchery-reared juveniles."

As previously stated, it is suggested that such enhancement is in lieu of the fisheries' problems associated with operation of Roxburgh and not due to the loss of the anadromous salmon run beyond there. Jellyman (loc. cit.) also estimated costs of smolt enhancement.

"Should the commercial hatchery close, and the responsibility for enhancement pass to Electricorp, it would be appropriate to have some idea of the size and cost of this operation.

It is possible to calculate the approximate number of juvenile salmon required to sustain the desired level of catch. Given an estimated annual run of 5000 salmon (Gillard 1984), an angler catch of 2000 (equivalent to the estimate of Whiting (1986) for the 1982/83 angling season) represents an angler cropping rate of 40% of the annual run, compared to 45-50% for the Rakaia River (Unwin and Davis 1983) and 75% for the Rangitata River (Davis et al. 1987). Increased angling pressure and a shorter stretch of river for fish to be distributed in would make the lower Clutha angler crop likely to exceed 40% of the run.

Because present and future hydro development will further reduce wild stocks (Pack and Jellyman 1988), we have assumed that the total angler catch will be sustained by hatchery releases. A conservative juvenile-to-adult return rate of 2% would mean that release of 250 000 juveniles would be needed to sustain a run of 5000 adult fish. Juvenile salmon currently cost about 1c/g (P.R. Todd pers. comm.). Results from present research indicate that a release size of about 50 g is optimal (M.J. Unwin pers. comm.). Therefore, the cost of buying 250 000 fish of 50 g each is \$125,000."

It is suggested that it is reasonable for Electricorp to consider a commitment to stocking equivalent to that provided by the former ICI/Watties hatchery. This would amount to three-quarters of the proposed target of 5000 adult salmon, ie. 3750 adults. Using the previous conversions, this equates to a released 187 500 smolts at a cost of, say \$94,000 per year.

The same report then reviewed the commercial potential of harvesting surplus fish, ie. adult salmon surviving beyond the closure of the angling season. The potential of these fish at Roxburgh is small, due mainly to the cost and danger of netting at the dam to recover them. However, if hydro development of the river below Roxburgh went ahead, then it may be possible to incorporate some recapture facility into the design of the dam. The operating rights for such a facility (eg. ladder or lock) could remain with Electricorp, be leased, or be sold. Installation of a viewing chamber would have widespread public appeal.

Should downstream hydro be developed, then the lowermost dam would also have potential as a commercial release site. As Tuapeka Mouth is less than 70 km from the river mouth, most adults arriving here would be in marketable condition. The failure of the Kaitangata release site was largely due to an inability to attract fish to the recapture area - consequently most ex-hatchery fish continued to migrate upstream until encountering Roxburgh Dam. It should be possible to incorporate both a rearing facility and a specially designed recapture site into the lowermost dam. Thus smolts could be reared on-site and released - as the returning adults would home on mainstem water, a very high proportion would return to the dam itself. Should such development occur then this option should be seriously explored. It is considered very unlikely that such a facility could be added to Roxburgh Dam though.

4.1.1 Releases at Roxburgh

Smolt releases at Roxburgh would certainly prove an effective means of enhancing the salmon fishery. Returning adults have to traverse 130 km of river and this gives anglers good access to them and maintains the important fishery at the 'wall' at Roxburgh Dam itself. Estimated numbers and costs are as above (Section 4.1). The disadvantage of this venture is that it remains a 'put and take' fishery where anglers' catches are sustained from hatchery production - the natural production of the river is not enhanced significantly, and once releases stop, the fishery declines 2-3 years later. There is some mainstem spawning below Roxburgh Dam (see Pack and Jellyman 1988) but the success of this will be adversely affected by fluctuating flows from Roxburgh. Assuming that most fish remaining at Roxburgh after closure of the angling season spawn in unfavourable conditions and few fry eventually hatch, consideration could be given to extending the angling season at the dam to allow anglers to harvest as many fish as possible.

4.1.2 Releases in tributaries below Roxburgh

Tributary releases have the advantage of establishing or enhancing a homing run of salmon and hence theoretically, do not need to be carried out perpetually. Historically, ICI/Watties made a smolt release into

the Minzion Burn but there was no apparent increase in returning adults in subsequent years. OAS and the Otago branch of the New Zealand Salmon Anglers Association have released a total of 25 000 smolts into the Waitahuna over a three year period. The last release was 5 May this year but, to date, returns have been poor (11 fish). Some habitat improvement work (willow removal) has been carried out in the Waitahuna, and although the gravels of the upper river appear suitable for spawning, the project needs to be re-evaluated before a further commitment for releases is made.

Salmon already spawn in several tributaries between Roxburgh and Tuapeka River. Of these, the most important are the Bengier Burn and Carsons Stream. Neither has much potential as a release site - the Bengier Burn is a 'flashy' stream prone to short-term floods especially during late summer and autumn; during summer flows recede rapidly and surface flows often stop for 2-3 months. Carsons Stream is small (6.3 km) and extensively used for brown trout spawning. Both the Blackleugh Burn and Beaumont River (approximate mean flows at 0.8 and 1.3 m³/s respectively) have gorges in their lower reaches which are thought to be impassable to salmon.

The Tuapeka River (mean flow 1.9 m³/s) is the longest of this group of tributaries (40.2 km). It has been estimated that there is sufficient suitable spawning area to accommodate almost 300 redds (Jellyman 1987). However, the presence of a disused concrete weir 2 km above the mouth means that salmon access to spawning areas is denied - below the dam gravels are too fine, but there are considerable areas of suitable gravels above the dam and beyond Lawrence (M Wright, OAS, pers. comm.). Removal of the weir and some bankside fencing to prevent stock trampling have previously been identified as possible mitigation measures (Jellyman 1987). The Tuapeka weir is not listed in the "New Zealand Dam Inventory" (December 1988), so its original purpose and current status are unknown but would warrant further investigation. Likewise the Otago Catchment Board have no information on the weir (L Smith, OCB, pers. comm.). As it retains a head of water several metres high, and is constructed of river-gravel concrete, dismantling would need to be approved by the Otago Catchment Board and probably require the use of explosives.

The Pomahaka River (mean flow 26 m³/s) is the largest of the downstream tributaries. Salmon spawn naturally within the river and there are indications that the number of salmon using this river is increasing. The river has considerable potential for smolt releases, although this may be unacceptable to OAS. The river constitutes a very important regional brown trout fishery and is now protected by a local water conservation notice. The increased number of juvenile salmon over recent years has been the subject of mounting controversy, prompting letters to the Otago Daily Times. Biologically, salmon smolts should have little negative interaction with juvenile brown trout as the species have different hatching times, rearing and feeding preferences, and rates of downstream migration. However, salmon smolts do become something of a problem for fly fishermen as they are largely surface feeders and will readily take anglers' flies - much to the ire of the anglers. It is thus unlikely that releases of salmon smolts into the Pomahaka would be permitted.

4.2 Habitat Improvement

4.2.1 Fish Access

The possibility of re-establishing salmon access above Roxburgh has already been discussed and rejected (Section 1).

It is unlikely that access beyond the gorges in the Blackleugh Burn and Beaumont Rivers can be achieved, and the cost-benefit of such an exercise would be very questionable. Removal of the Tuapeka River weir though would seem a distinct possibility and give access to a reasonable area of good quality spawning water. There may be opportunities for improved fish access in some tributaries by further removal of willows. The Otago Acclimatisation society would need to be contacted about this.

4.2.2 Instream Improvements

There will be situations where willow removal will increase angling opportunities; both OAS and OCB would need to be involved in advice. Likewise bankside fencing of potentially important spawning areas would reduce trampling of redds by livestock while encouraging bank stabilisation by riparian vegetation.

4.3 Artificial Spawning Channels

Although artificial spawning channels have been used quite extensively in North America for trout and salmon, they have not proved to be effective for quinnat (= chinook/king) salmon which have proved extremely loathe to enter the channels. Other factors which also mitigate against spawning channels are the size and cost (eg. 1000 female salmon would require approximately 10 000 m² of area - say a raceway 5 m x 2 km) and the possibility of further hydro development below Roxburgh. The only site where a channel would be of benefit at present is at Roxburgh Dam. Ignoring the mechanics of location, etc, should one be built here it would become superfluous should hydro development proceed downstream.

4.4 Commercial Operations

Given the inability of the ICI/Watties project to succeed, it is unlikely that further commercial operations would be attracted to the Clutha. However, as mentioned (Section 4.1) the lowermost dam of any new hydro development below Roxburgh would have substantial potential as a commercial release site, provided some effective recapture facility could be constructed.

4.5 Enhancement Opportunities Elsewhere

Releases of salmon into Otago Harbour by New Zealand Salmon Anglers Association (NZSAA) have been extremely successful. An alternative to stocking the Clutha could be stocking of the harbour. This would need discussion with both the NZSAA and OAS as the former already reap excellent publicity from this venture, and the latter do not benefit from increased licence sales. Also harbour fishing is very different from river fishing and is unlikely to be seen as acceptable compensation for Clutha fishing by local residents. Thus this possibility is biologically feasible but probably politically unacceptable.

5. RECOMMENDATIONS

Opportunities for enhancement within the Clutha catchment are limited. It is recommended that Electricorp:

- Investigate opportunities for dismantling of the weir in the lower Tuapeka River.
- Consider a continuing commitment to stocking of salmon smolts at Roxburgh Dam, at a rate which will sustain the fishery at the level previously achieved from hatchery releases at Kaitangata.

Enhancement of the Tuapeka River is seen as the only mitigation option with potential to enhance the wild fishery. Some commitment to stocking of, say, 5000 smolts for three years could also be made. However, on its own it does not provide much benefit to the bulk of the anglers who fish at Roxburgh - assuming that fish reared in the Tuapeka River will ultimately home on that river. Hence a programme of continuing releases at Roxburgh is advocated. The extent of these obviously negotiable but a release of, say, 188 000 smolts at a cost of \$94,000 is suggested.

6. REFERENCES

- Davis, S.F., Unwin, M.J., Zeldis, J.R., and Hayes, J.W. 1987. Angler use of the Rangitata River salmon and trout fisheries. N.Z. Freshwater Fisheries Report No. 85. 109 p.
- Ellis, G. 1986. February general meeting, Otago Branch NZSAA. The Salmon Angler 12: 14-16.
- Gillard, M. 1984. The ICI/Wattie salmon development project. Otago Acclimatisation Society Annual Report 1984: 33-35.
- Gillard, M. 1985. The ICI/Wattie salmon development project. Otago Acclimatisation Society Annual Report 1985: 52-55.
- Harvey, M.J., and Jellyman, D.J. 1986. Background to fisheries studies of the lower Clutha River. N.Z. Ministry of Agriculture and Fisheries, Fisheries Environmental Report No. 76. 101 p.
- Jellyman, D.J. 1983. Fish passage in the Clutha River. Fisheries Research Division, Ministry of Agriculture and Fisheries, Christchurch. Unpublished report. 6 p.

- Jellyman, D.J. 1987. Possible impacts of hydro development on fish and fisheries of the lower Clutha River. N.Z. Freshwater Fisheries Report No. 92. 72 p.
- Little, R.W. 1975. Clutha Valley Development: Fisheries Interests. Appendix 4. 2 p. In: Upper Clutha Valley Development. Environmental Impact Report. Ministry of Works and Development. 119 p. and appendices.
- Ministry of Works and Development. 1984. Lower Clutha. Hydro electric investigations. Interim Report 84/2, May 1984. Office of the Chief Power Engineer, Ministry of Works and Development, Wellington. 50 p.
- Otago Acclimatisation Society 1973. Annual Report. 40 p.
- Otago Acclimatisation Society 1974. Annual Report. 64 p.
- Otago Acclimatisation Society 1975. Annual Report. 73 p.
- Pack, Y.M., and Jellyman, D.J. 1988. Fish stocks and fishery of the lower Clutha River. N.Z. Freshwater Fisheries Report No. 98. 117 p.
- Richardson, J., Unwin, M.J., and Teirney, L.D. 1984. The relative value of Otago rivers to New Zealand anglers. N.Z. Ministry of Agriculture and Fisheries, Fisheries Environmental Report No. 48. 79 p.
- Teirney, L.D., Unwin, M.J., Rowe, D.K., McDowall, R.M., and Graynoth, E. 1982. Submission on the draft inventory of wild and scenic rivers of national importance. N.Z. Ministry of Agriculture and Fisheries, Fisheries, Fisheries Environmental Report No. 28. 122 p.
- Unwin, M.J., and Davis, S.F. 1983. Recreational fisheries of the Rakaia River. N.Z. Ministry of Agriculture and Fisheries, Fisheries Environmental Report No. 35. 110 p.
- Woods, C.S. 1982. Clutha fishway options. Planning and Technical Services, Water and Soil Division, Ministry of Works and Development, Wellington. Internal Report. 14 p.