Trapping the adult eel migration at Aniwhenua Power Station

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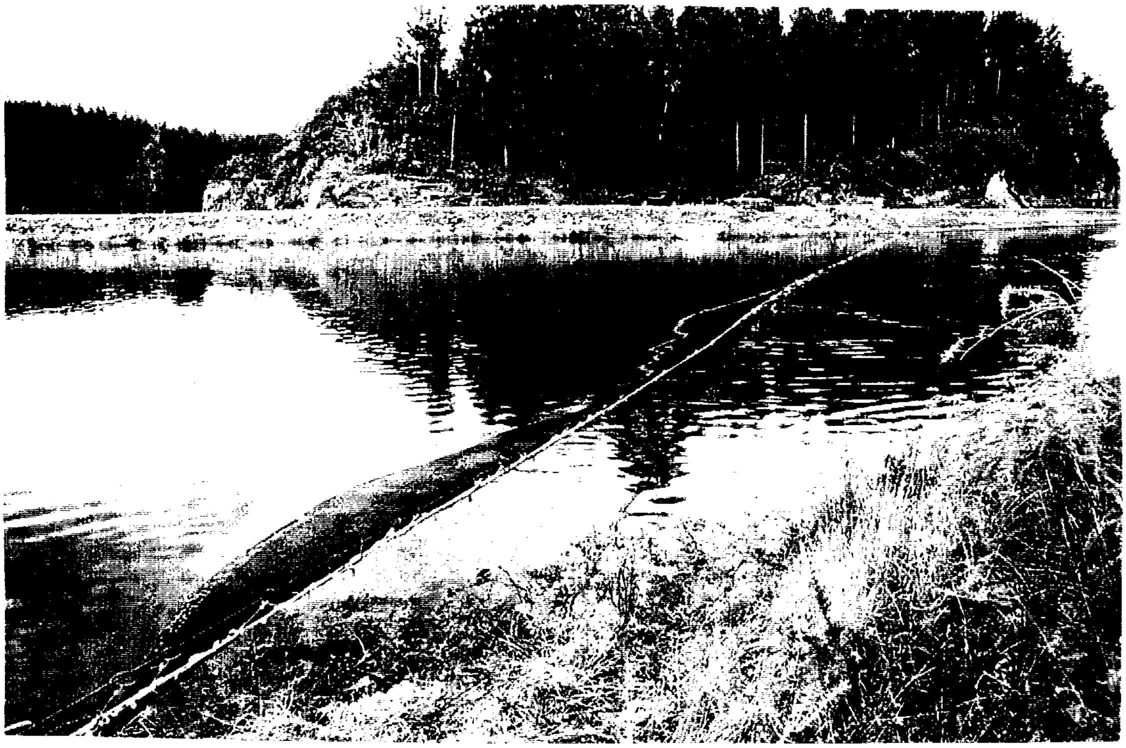


FRONTISPIECE: SETTING THE NET ACROSS THE CANAL AT ANIWHENUA

Abstract

This report covers ongoing work to develop methods to trap the eel migration at Aniwhenua Dam and transfer the migrating eels without harm to points downstream of the dam. As a result of experience in 1994, and the loss of the net used that year, a new and better net was made up. The net was delivered on time in 1995, but could not be set before the eels migrated.

When the net was tested it was found that a number of minor modifications to the setting procedure and the equipment were required, owing to the greater weight and size compared with the previous net. However, the net is now available and the cables are permanently secured in place.

A major problem is predicting sufficiently in advance when the eels are going to migrate. At least 12 to 24 hours' warning is desirable. An analysis of rainfall and river flow patterns from 1992 until 1995 showed that rainfall is probably the best predictor of an eel migration. It appears that when rainfall exceeds a cumulative total for 5 days of 40 mm in the Ruatahuna area from February until April, there will probably be an eel migration.

It is recommended that a network of interested persons who already record rainfall be set up to form an early warning system.

1. Introduction

At present, sexually mature eels above the dam at Aniwhenua Power Station migrate downstream during flood peaks in autumn and are blocked for further downstream migration by two hydro-electric dams, Aniwhenua and Matahina. This is becoming unacceptable for biological and cultural reasons. Options for re-establishing the continuity of the migration are limited. A workable technique of continuing to catch these eels unharmed and then releasing them below the two hydro-electric dams on the river needs to be developed and demonstrated.

This is a report on the results of a study jointly funded by DoC and Bay of Plenty Electricity Ltd, in which the objectives were to develop techniques for trapping the migration of adult eels above Aniwhenua Power Station. Methods were required that could separate relatively few eels from the main flow of the Rangitaiki River. In addition, techniques for predicting in advance the few nights each autumn when the migration occurs were required.

1.1 BACKGROUND TO WORK AT ANIWHENUA

I have been involved from the very beginning with the restoration of eel stocks in the upper Rangitaiki River. In 1983 I made the recommendation that juvenile eels be collected from below Matahina and stocked into Aniwhenua (Mitchell C. P.,1983, unpublished report to Electricorp Ltd). In addition, at that time I produced the basic design concept for the present elver pass (ECNZ 1993) at Matahina Dam. By 1992 it had become obvious that shortfinned eels stocked above the dam were reaching sexual maturity and appearing in the catch of migrating eels (Mitchell & Chisnall 1992). Another study (Mitchell & Boubee 1992) showed that few eels were likely to survive going through turbines in New Zealand and suggested that a study be undertaken at Aniwhenua.

Stocking of eels has become increasingly practised in many parts of New Zealand. The motives for stocking are varied, but the issue of sustainability must be addressed in all cases. In my opinion, the stocking of eels above hydro-electricity dams does not constitute sustainable management unless it is possible to move downstream migrants back unharmed past the turbines; otherwise, all that is gained is an enhanced harvest of eel flesh - provided that sufficient recruitment of elvers continues from other, as yet undeveloped, rivers.

1.2 THE 1994 EEL NETTING TRIAL AT ANIWHENUA

In 1994 Bay of Plenty Electricity Ltd funded an experimental net to be set across the power station canal when a migration was anticipated.

The major reason for selecting Aniwhenua Dam for this work is the 30 mm bar spacing on the penstock screens. This is much smaller than the screens used at most power stations around New Zealand. Larger screens allow the migrant eels past, to be killed as they pass through the turbines (Mitchell & Boubee 1992). The bodies are mutilated and dispersed with the dam discharge and are impossible to count or measure.

Owing to the fine screens, which collect the eels and so provide a measure of success, Aniwhenua is an excellent experimental site for testing some methods for trapping migrating eels (Mitchell, C. P. 1989, 1993, unpublished reports to Bay of Plenty Electric Power Board).

At the conclusion of the work in 1994, the results were critically examined. In the event, two nights were trapped in late February and a total of 12 very large migrant eels were released unharmed into the river below Matahina, to continue their migration. This is the first time that this action has been taken in New Zealand, and as far as I am aware, in the world.

We had succeeded with the primary aim: to demonstrate that it was possible to catch migrant eels, transport them below the dams, and release them into the river.

However, a number of problems were obvious:

1. It was difficult to predict the 2–3 nights each year when the eels were going to migrate. The major migration was missed, as I was away working elsewhere at the crucial time.

2. The trial net was only 50 metres long, which was too small to fully cover the canal. In addition, this experimental net was of old material and it began to tear under the load of being set across the canal. In fact the tearing was initiated by an experiment to set trap nets in the body of the net, with the aim of seeing whether eels migrated at any particular area of the net. Sewing these nets on to the main net caused loadings which tore it. In an attempt to remedy the problem of the relatively small size of the net, an experiment was run to discourage eels from bypassing the net where it fell short of the far bank. A 500 watt spotlight shone on the water surface on that side of the dam canal gave encouraging results. On the one night it was tested, the net took 80% of the migrating eels, in comparison with the previous night, when only 30 % of the migrating eels were caught.

3. All the equipment was left, ready to be set quickly, on the river bank. However, it disappeared in May 1994.

4. Apart from the issues of sustainable management of the biological resources above the dam, the eel trapping trials developed other implications. The dam and power station became part of a Treaty of Waitangi claim (Claim no. 212), by Te Runanganui O Te Ika Whenua. One of the issues of the claimants was the depletion of eel stocks and other native fishes in the upper Rangitaiki River. In no way could this trapping programme be considered to compensate for the losses suffered. It was stated at this hearing that the trapping of migrant eels was not an Ika Whenua tradition and thus should not be allowed to continue. A further criticism was that, as the net was too small and eels had died on the screens despite the trapping, the whole concept was deemed to be a failure. However, other individuals from Ika Whenua remained supportive of the idea.

Despite these criticisms, it was decided (in consultation with staff from Bay of Plenty Electricity Ltd and from the Department of Conservation) to press ahead. Practical methods for sustainable eel management were required by both organisations.

2. Objectives for 1995

1. To develop a netting system that would catch all the eels.

2. To develop a technique for predicting when the eel migration will occur so that preparations for trapping the eels can be made in time.

3. To develop techniques for transporting and releasing the eels so that they could continue their migration without obvious harm.

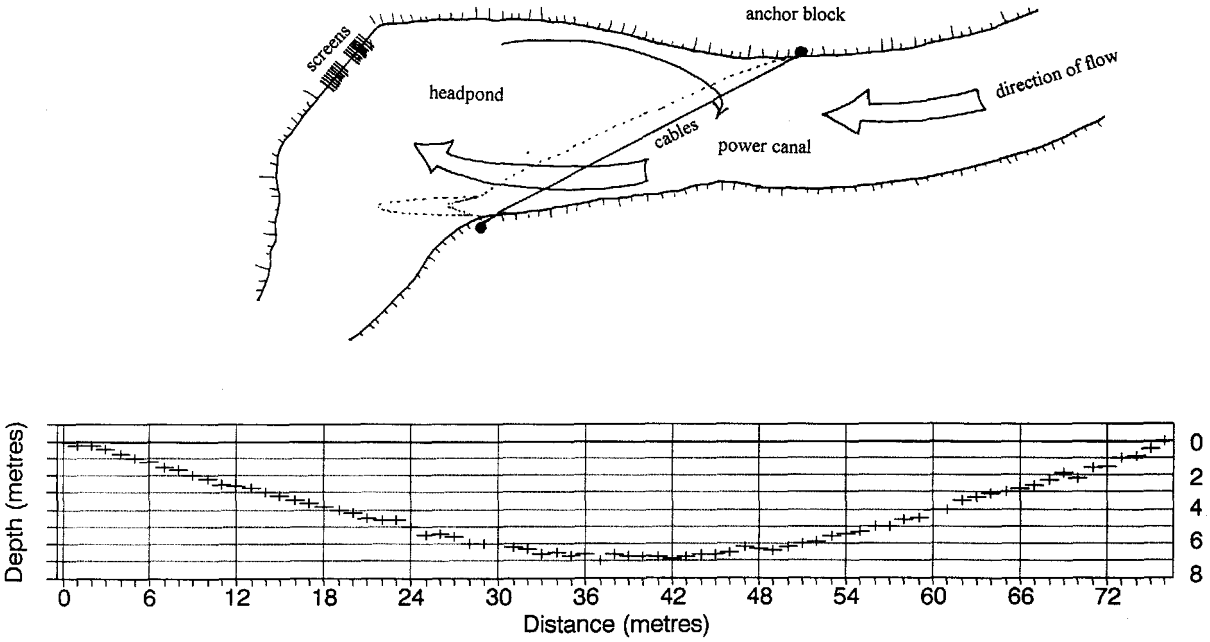


FIGURE 1. PLAN OF ANIWHENUA POWER STATION CANAL AND NET SITE, AND DIAGONAL DIMENSIONS OF THE CANAL AT THE ENTRY TO THE HEAD POND.

3. Methods and Results

3.1 A BETTER NETTING SYSTEM

As the first net had shown that the method could work, it was decided to construct a bigger and better net. The Department of Conservation issued a study contract of $10,000 to assist in funding the work. In association with DoC staff, the canal was accurately measured in December 1994 (Fig. 1). The new net, 76 metres long and 10 metres deep at the deepest point, was designed to fit the shape of the canal when set on the diagonal at an angle of 45° to the flow. This new net was intended to cover the whole canal, thereby negating one of the criticisms that had been levelled at it. The belly of the net, towards the downstream end, was also far greater than in the first net. This was so that the trapping part of the net formed an even more acute angle across the canal than the supporting ropes, providing a better lead to guide the eels into the holding trap. In addition, this belly, which was nearly 5 metres at the downstream end of the net, was so deep that it was unlikely that the eels would be able to swim back upstream to get under the net.

Construction of the net was contracted to the netmaker, Networks, of Balclutha, which had made up the first one. The material used came from a large fine-mesh experimental purse seine made by Fletcher Fishing. The net was only used twice and then placed in store. Material costs were more than halved by re-using this netting.

Although this net used some second-hand materials, it was of far better quality than the first trial one. The new net was cut to fit the canal precisely and was made sturdily, with heavy reinforcing panels at all load points.

Provided that it is stored carefully, this new net should last for years. It has been in store since it was tested briefly in an experimental purse seine and so has had little exposure to ultra-violet light. To all intents and purposes this specialised piece of equipment is now wholly the property of Bay of Plenty Electricity Ltd and is stored in the tractor shed at Aniwhenua on a pallet made up by Bay of Plenty Electricity Ltd.

I had requested that the net be finished and freighted to Rotorua before the end of February. This target was achieved and it was ready to be tested from that time. Field work, design, construction and shipping costs came to $15,000, of which Bay of Plenty Electricity Ltd contributed $10,000 and DoC $5,000 from the study contract.

Delays

It was planned to follow the same method for setting the new net as was developed in 1994. The net slides in and out on permanently set cables. Two steel cables are stretched diagonally across the canal, at the point where the canal enters the headpond. One cable (15 mm diam.) is stretched over the surface of the canal and the other (25 mm diam.), lies on the bottom of the canal. Weights are fixed to the bottom cable approximately one third of the distance from the upstream anchor block. The force of water on the net tends to lift the bottom cable up and to pull the surface cable down under the water surface, so these weights are intended to hold the bottom cable down. At each setting, the net is tied to steel rings threaded on to these cables and is hauled across the canal using a vehicle.

In the first trials, the surface steel cable tended to sag into the water, where it collected drifting weed. The loading from the weed eventually became so great that the anchor block on the downstream end of the diagonal tore loose. Accordingly, both cables were removed from the canal by Bay of Plenty Electricity staff in the winter of 1994. The first task in 1995 was to reinstate the downstream anchor block. Materials were provided by Bay of Plenty Electricity and, with the assistance of two helpers from Waihao Marae, the new anchor was set into place in early March. The anchor was placed at a higher position so that weed fouling would not occur, and was embedded in a cubic metre of concrete. The concrete then had to cure for two weeks.

Because staff were not available at the time, the net was not set on 29 March 1995, when it had rained heavily and an eel migration could have occurred.

On 5 April, the cables were relaid across the canal, using the power station tractor. It rained again heavily in the upper catchment on 8 and 9 April. Ralph Ingoe got through to me at 11 a.m. on 10 April and at 3:30 p.m., Frank Mitai and I began to rig the net so that we could set it.

A bigger and heavier net

At the time we set the net, the water flow at the station was about 65 cumecs. Our experience the previous year had been at flows around 40 cumecs. Drag increases with the square of the flow velocity, so the loadings on the equipment were much greater than had been experienced before.

The new net proved to be a bigger job to set than the first one. The front section is heavily weighted on the bottom line and has to be dragged into place across the canal. After this section, the bottom of the net is tied off to the rings attached to the steel cable. A pulley anchored to the bottom is needed to keep the pull on this section horizontal. In 1994 we had a pulley shackled to the steel weights with a permanent rope threaded through it; this rope had been stolen with the net.

Another problem was that the light-weight and inexpensive polypropylene ropes used in 1994 had deteriorated after lying in the sun and began to break as we tried to pull out the net. The surface and bottom lines from the net were passed through two pulley blocks tied off to a pine tree and were then hitched to a tractor. The station was being run at full load, both to cope with the "fresh" and to supply the evening power demand at the time. As a result the load on the net was enormous. The design is fail-safe, in that if the ropes break the net simply folds back downstream and rests against the bank, but it was frustrating work as our repair knots would not run through the pulleys. At half past eleven we gave up and set two trap nets, one on either side of the canal. As it happened, we caught no eels that night, as the major run for the year had already occurred on 30 and 31 March.

We untied the bottom line of the net and streamed it out across the canal to clean it of weed. We then untied all the net from the rings and flaked it out into the pallet on the landing barge. Using the power station tractor, we restrained the upper cable to lift it out of the water and then stored the net away in the shed.

Further materials and actions

About 200 metres of significantly stronger rope, and a pulley and associated shackles to be slid out on the bottom cable to help with hauling the net out were required. This was purchased by Bay of Plenty Electricity Ltd for the 1996 migration season. A small migration was successfully trapped in March 1996, and the catch of 5 eels was released below Matahina. All of the equipment worked well, including a new trap net.

This new net is valuable. If stored carefully it will last for years. The main destructive agents are rats and chemical solvents such as oil. The steel ring to which the bottom line is attached should also be painted, as if it is stored against a wet net, the rust will eventually cut through the net. Rats are a major problem for fishing nets, and rat baits have been regularly placed in the storage shed.

I consider that there is now an excellent resource available for trapping the eel run. This facility now offers the potential for experiments on tagging and trapping migrating eels. Studies funded by the Foundation for Research Science and Technology are planned for autumn 1997 to provide data important for protecting eels at other sites in New Zealand.

3.2 PREDICTING WHEN EEL MIGRATION WILL OCCUR

A major problem with trapping is to know when an eel migration is likely to occur.

From these studies, discussions with station staff, and previous work (Mitchell & Chisnall 1992), we know that the migrations occur from mid February until late April each year. Studies of flow records at Aniwhenua obtained from the National Institute of Water and Atmospheric Research (NIWA), indicated that migrations occurred during or shortly before an increase in flow above the previous level (Fig. 2). Flow at Aniwhenua in the autumn months is usually around 25–40 cumecs (m^3/s) with "freshes" peaking at 55–70 cumecs. As setting the net takes time, a method for predicting in advance when river flows are going to increase is required.

When enough rain falls, the streams and rivers which flow into Lake Aniwhenua flood, but it takes some time for the water (and therefore the eels) to reach the lake. It seemed possible that flow or rainfall recordings in the upper catchment could be used as an early warning system.

There are a number of rainfall and river level monitoring sites in the upper Rangitaiki Catchment. Wheao Power Station operators monitor levels in the Rangitaiki River at their intake. The river level is recorded again at Murupara and below Aniwhenua. The Whirinaki and Horomanga tributaries are also gauged. Rainfall is measured at Murupara and at Tarapounamu (by Ruatahuna). Much of this information is recorded every 15 minutes and telemetered to NIWA.

Rainfall is likely to give an earlier warning than river flow, because it takes time for runoff to enter the river and swell the flow. This lag will be greater for the pumice catchments of the upper Rangitaiki than the less absorptive greywacke catchments such as the Horomanga. Murupara tends to be in a rainshadow compared with higher sites in the Urewera. Discussions with NIWA staff suggested that the best site to predict flows would be to measure rainfall at Tarapounamu, which is in the ranges, in the upper Whirinaki Catchment near the middle of the upper Rangitaiki Catchment.

Daily rainfall totals from Tarapounamu were plotted against river flows and eel migrations (Fig. 2). There was a very good correlation of rainfall with flow over the autumn. A finer scale analysis was made of 5 known migration events which occurred from 1992 to 1995 (Fig. 3). There are a number of striking similarities in these graphs. The first is that migration tended to occur on the night of the day that the rainfall event was recorded. However, these records are cumulative, i.e. they measure the rainfall collected from the day before. In addition, records of migrating eels are gathered when the screens are cleaned, which means that they are taken the day after the night that migration has occurred, or even some days after, if there has been no requirement to clean the power station screens in the interim. To allow for this, the eel capture days have been shifted forwards by 24 hours on the figures. The eel capture days can then be viewed as days when that night following should have been trapped. In practical terms, we need to know before 10 a.m. that the trap should be set that night. Scales on the figures vary depending on whether NIWA data or Bay of Plenty Electricity data are used.

From these graphs it appears that rainfall data could be used to predict an eel migration.

Another important point is that the migration tends to be in advance of the flood wave. Evidently the eels are responding in anticipation of the flood, or they move as the water first begins to rise. This raises the issue of how the eels know it is going to be a large flood. From this perspective it is interesting to note that there was one small migration of 4 eels in 1992 (Fig. 2) that was not accompanied by a flood event. An examination of the weather records for the time shows that the weather was overcast, with a thunderstorm and a hail shower. From the known behaviour of other fishes, eels would be likely to respond to changes in air pressure. It is possible that eels interpret low pressure to indicate the magnitude of a coming storm event and synchronise their migration accordingly.

The fact that the run is likely to occur in advance of the peak flow is important for trapping the run. The first night is usually the heaviest run, with only stragglers the following night. Trapping can therefore be conducted in a river that is still running at relatively low flows and before the main wave of flood debris arrives to foul the net. Migrations appear to occur at flows of around 35-50 cumecs, whereas the peak flow will reach over 70 cumecs.

It must be recognised that these flow values are from 24 hour averages. This can be seen in the figure produced by NIWA of Whirinaki River and Aniwhenua flows recorded at 15 minute intervals (Fig. 4).

The generation pattern can be seen as morning and evening flow peaks with much lower levels between. The rainfall event recorded at 0330 (30 March) was not reflected in power station flows until the following morning. Trapping for

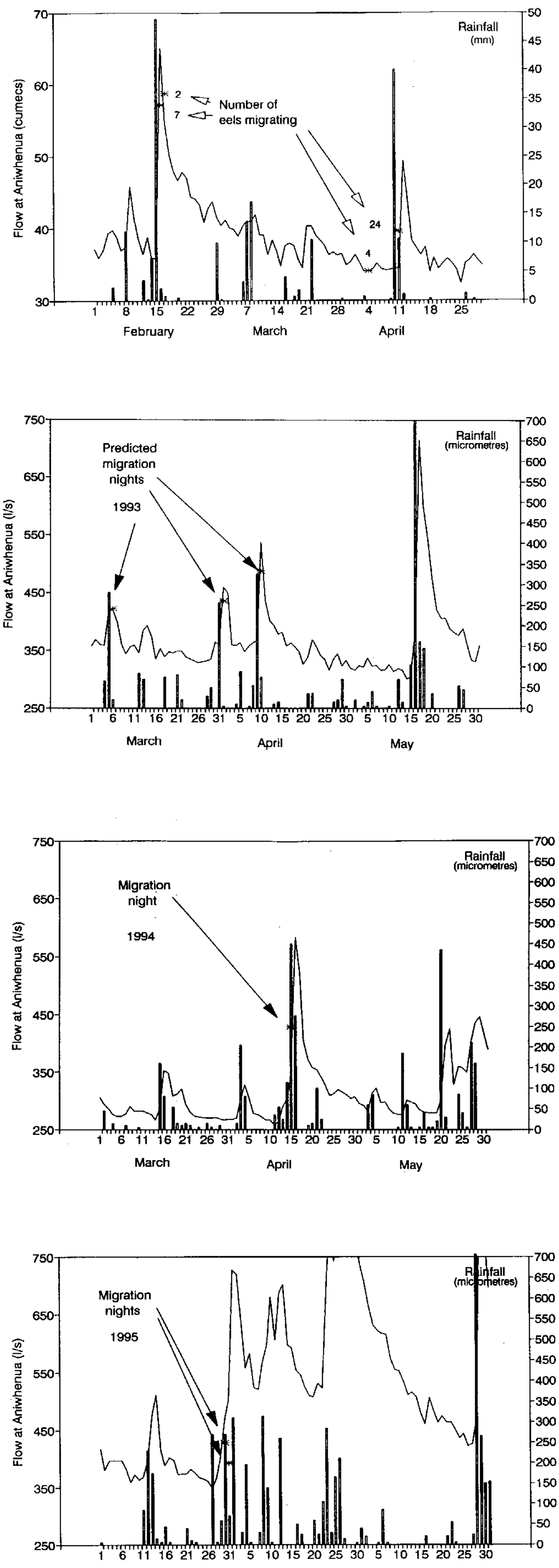
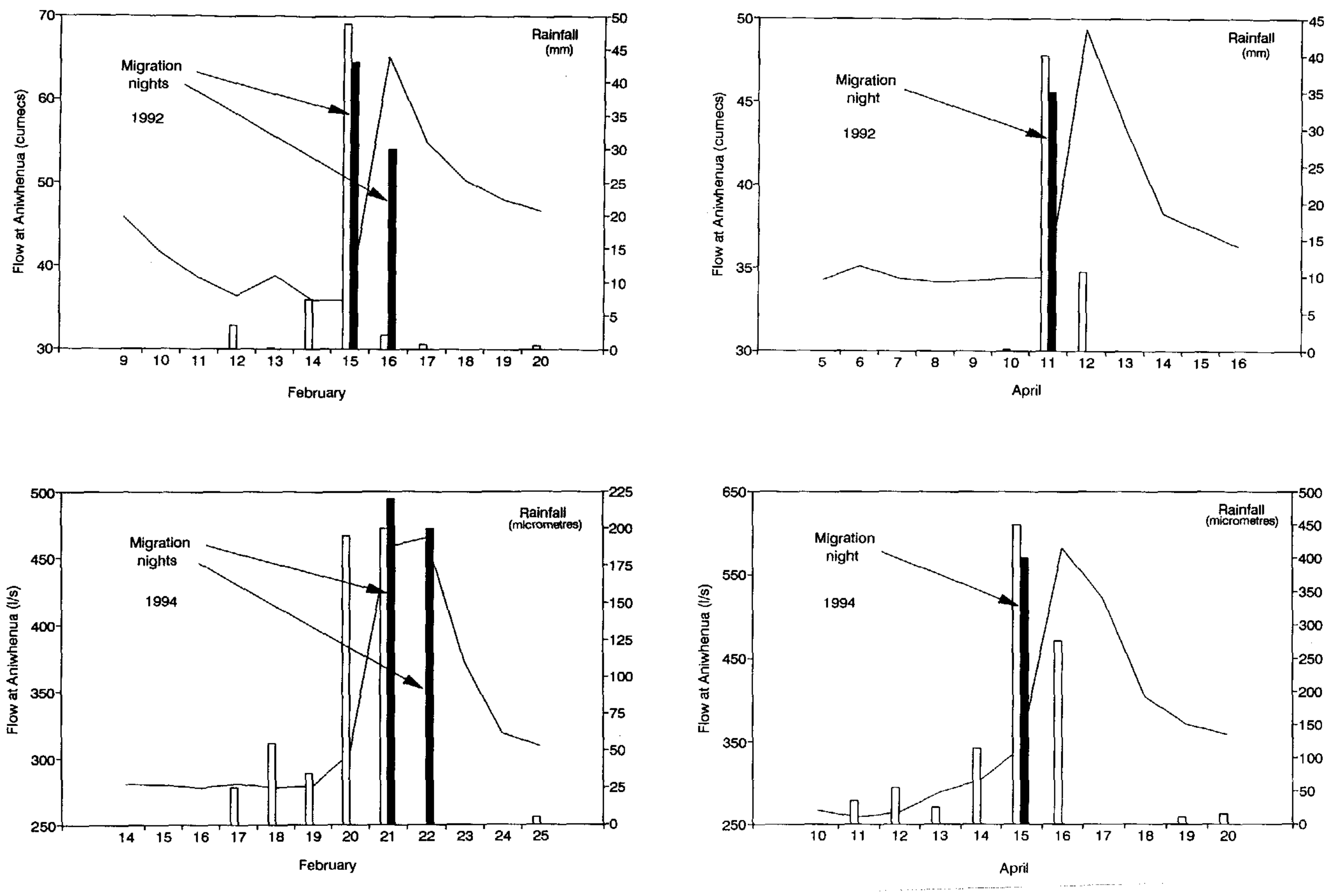


FIGURE 2. EFFECTS OF FLOW AND RAINFALL ON EEL MIGRATION AT ANIWHENUA, 1992 (UPPERMOST), 1993 (SECOND FROM TOP), 1994 (THIRD FROM TOP), AND 1995 (LOWERMOST).



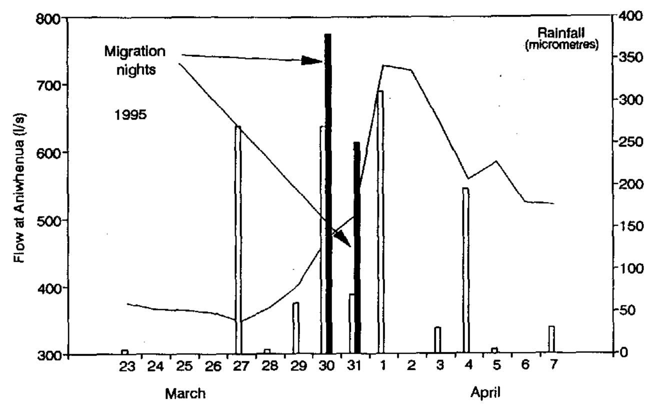


FIGURE 3. EEL MIGRATION EVENTS IN 1992 (TOP), 1994 (CENTRE), AND 1995 (BOTTOM).

the nights of 30 and 31 March would have been at a flow of around 40 cumecs. Even flows on the following night dropped to this level.

Although migrations were often the result of a single day's storm event, some appeared to be the result of a number of days of relatively light rain. To increase the accuracy of prediction, all significant rainfall events over 1992, 1994, and 1995 from mid-February until the final migration each year were summed for 5 days. They were then divided into rainfall events when there was eel migration and events when there was no migration. Fig. 5 shows that, if a total rainfall of

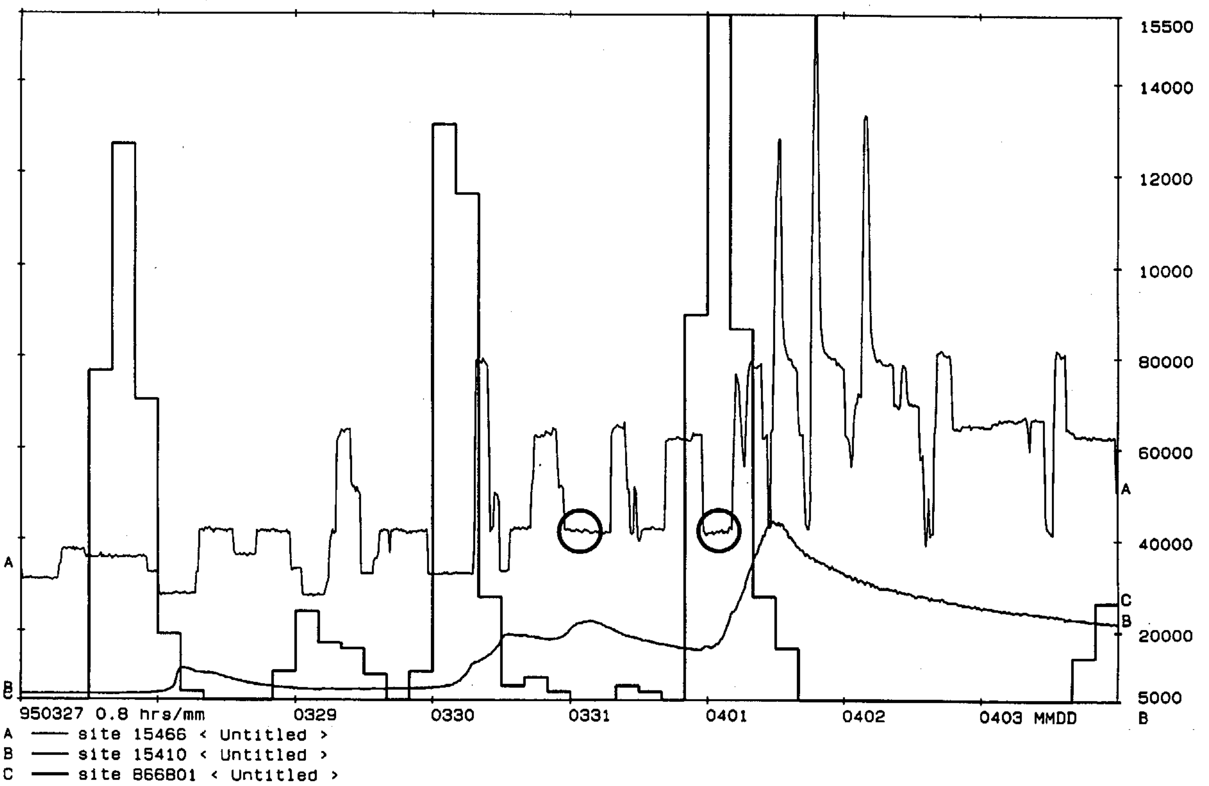


FIGURE 4. NIWA FLOW RECORDINGS SHOWING RAINFALL (BARS), WHIRINAKI RIVER FLOW (LOWER LINE) AND ANIWHENUA FLOWS (UPPER LINE) IN MARCH/APRIL 1995. THE MIGRATIONS (CIRCLES) OCCURRED ON THE NIGHTS OF 30 MARCH (0331) AND 1 APRIL (0401).

over 50 mm occurs within 5 days, there is likely to be a migration. To allow for error, a trigger rainfall of 40 mm is suggested.

NIWA is not the only source of information on weather conditions in the upper Whirinaki, and it should be possible to establish one or more early warning systems involving several people with monitoring the weather. This approach is the next step required to make eel trapping reliable and effective.

3.3 DEVELOPING TECHNIQUES FOR TRANSPORTING AND RELEASING EELS

Migrating eels are very different from the familiar resident feeding and immature eels. To begin with they do not appear to be aggressive: there are many reports of migrating eels balling together, and therefore there are no great concerns about packing them into a trapping net. However, there are concerns about the number that will be caught when a large migration is eventually trapped. The present trap net has an inadequate capacity. In anticipation of this problem two holding nets were made up for the 1995 season. Although they remained unused, the concept was to pull the holding net over the cod end of the Tyke net before opening the cod end and emptying the fyke. The catch was then to be periodically emptied into one of the holding bags. A working spotlight was

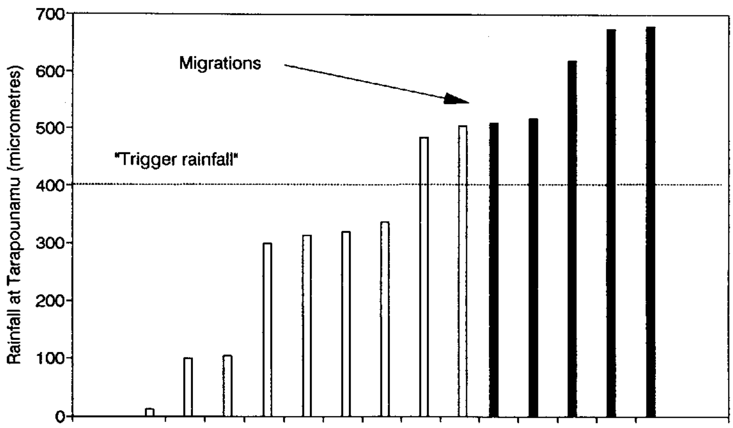


FIGURE 5. EFFECTS OF THE PREVIOUS 5 DAYS' CUMULATIVE RAINFALL TOTAL ON EEL MIGRATION. 400 MM IS SUGGESTED AS AN ACTION LEVEL.

made up with a red filter so that the eels would not be alarmed by the lights needed for this moving of the catch.

Another problem with migrating eels is that they appear to be very sensitive to light. The well known tradition of the migrations occurring during Hinepouri, the new moon, suggests that migrations are timed to occur when the night is at its darkest. Analysis of visual pigments of migrant eels has shown that they have a peak sensitivity to the very low light levels deep in the ocean, where they head to spawn. In contrast, the light levels in shallow clear water would be extremely high, and migrant eels would probably hide under vegetation and in mud while they metamorphosed. The migrants released in 1994 were transported down to Matahina and released around midday, into a clear, unflooded river, which might have been difficult for them.

4. Conclusions

1. Netting: The methods for setting the net should be practised and made to work. Rigging, handling, cleaning and storing the net are all part of this process.

2. Predicting when to set: A warning system for flood flows, using one of the variety of rainfall recording stations in the upper catchment should be set up. A network of interested people needs to be established who can report when 5-day rainfall exceeds 40 mm, or when a forecast of heavy rain is issued for the eastern Bay of Plenty.

3. A communication structure is needed: It has been difficult to make decisions about netting from Rotorua. Perhaps contact could be centred within Ika Whenua.

4. Management of the netting should be delegated: The trapping system needs to be improved so that it can be operated by local DoC staff or the iwi. Judging by the controversy the trapping has aroused, there will be people interested in

making it work. An idea is only successful if people take it, make it their own and improve upon it.

5. Transport and stocking: Holding and release techniques need to be adjusted to maximise the survival chances of the released eels. For future releases I would recommend that the migrants be held in sacks or shaded holding nets in the Aniwhenua head pond until the following night. Once it is dark they should be transported down to Matahina for release. A further advantage of this arrangement would be that the timing of flood peaks through the system would be within their natural timing of the eels for passing this point.

5. Acknowledgments

I would like to thank the DoC staff at Rotorua and Murupara for their support for these trials. Success can never be guaranteed when a totally new approach to anything is attempted, but without testing new techniques, there can be no improvement. In addition, Ralph Ingoe of Bay of Plenty Electricity Ltd was always patient and good humoured about the demands I placed on him at all hours of the day and night, including a stream of phone calls to his home.

The combined assistance of DoC and Bay of Plenty Electricity Ltd is gratefully acknowledged.

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7. Appendix

7.1 SUSTAINABLE MANAGEMENT OF THE EEL FISHERY OF THE UPPER RANGITAIKI

Eel life cycles

Even as far as it is known, the life-cycles of the two species of eels found in New Zealand (*Anguilla australis* - the shortfinned eel and *Anguilla dieffenbachii* - the longfinned eel) are complex. In spring each year, small transparent eels swarm into New Zealand rivers from the sea. These glass eels metamorphose into darkly pigmented elvers which migrate upstream. The migrations upstream are remarkable, not only for the numbers of elvers involved, but also for the tenacity with which they approach obstacles such as waterfalls and rapids.

Elvers will climb up the wetted sides of waterfalls such as Aniwhenua Falls on their migration inland. This migration may take several years before the elvers settle into suitable habitats and take up a territorial existence. Longfinned eels are the top predator in New Zealand freshwaters. They grow slowly and reside in rivers, lakes and streams for very long periods.

Adult eels migrate back to the sea to breed when they have attained a suitable size and perhaps fat level. There is a metamorphosis involving degeneration of the gut, the gonads begin to develop, the eyes enlarge and new colour patterns develop. When the river floods in autumn, groups of migrating eels drift downstream. Where they go to breed is unknown, but it is thought to be in the tropical Pacific Ocean, perhaps somewhere off Tonga. Longfinned eels are closer to spawning when they migrate than shortfinned eels. Possibly this species spawns closer to New Zealand. Analysis of the visual pigments of migrant eels shows a peak sensitivity for light levels 200 metres beneath the ocean surface. Migrant adult eels never return.

Minute transparent eel larvae have been caught in the sea. They look like a glass willow leaf and are called leptocephalus larvae. This stage may take two years to drift back to New Zealand on the ocean currents. When the leptocephalus encounter coastal waters over the continental shelf they undertake their first metamorphosis, into glass eels.

Fish that must migrate to and from the sea to complete their life cycles are called diadromous fish. New Zealand has a remarkably high proportion of diadromous species in the freshwater fish fauna. Diadromous fish pose particular problems for conservation, as the migration pathways to and from the sea must be kept open.

Impact of dams

The diadromous life cycle of eels is why dams and power stations pose such obstacles for sustainable management of the fishery upstream. First, elvers must attempt to scale a concrete wall 70 metres or so high (no easy task for a 60–70 mm animal). Secondly, the adults returning to the sea have to survive passage through the turbines. Overseas studies (Larinier & Dartiguelongue 1989) indicate that mortality in turbines is directly related to the size of the turbine and the size of the fish. A study on the problem in New Zealand (Mitchell and Boubee 1992) concluded that survival of the particularly large migrant eels found in New Zealand was likely to be poor.

In 1982 I designed and built an experimental pass for elvers at the radial arm gates controlling the outlet to Lake Waikare. The success of this pass led to a design for Patea Dam. Patea Dam won the design engineers an award for environmental excellence. The fishpass has been maintained and updated and continues in use today.

In 1983 I became involved with the problem of maintaining eel stocks in the upper Rangitaiki River. Acting on a request from constituents, the then MP for Eastern Maori, Dr Peter Tapsell, requested MAF to look into the problem. The report I prepared gave designs for elver passes for both Matahina and Aniwhenua Dams. As an interim measure it was also recommended that elvers be stocked from below Matahina into both Matahina and Aniwhenua reservoirs.

Recruitment of elvers to the eel population of the upper Rangitaiki would have been greatly reduced by construction of Matahina Dam. Fisheries surveys in Matahina Lake found the catch rate of eels above the dam to be low and individual eels had very high growth rates. Both features suggest a low-density population, with individuals facing little competition from other eels. Nonetheless some eels seem to have got over the dam in the years since construction. In a sample of 35 shortfinned eels and 22 longfinned eels caught in Lake Matahina in 1988, 75% of the shortfins and 28% of the longfins were younger than the time of construction. Elvers may have been able to climb the concrete of the spillway and around the radial arm gates on rainy nights (although this has never been observed by station staff). The finding of a few 7–10 cm elvers below Aniwhenua barrage in 1981 supports this hypothesis. Night-time inspections of the barrage, falls, and base of the powerhouse in 1992 and 1993 found elvers present in ones to tens, not teeming multitudes as described by Best (1929). There are also other ways whereby eels could have got into Matahina Lake, for example local eel fishermen have always released their smaller eels, caught in the river below the dam, into the lake.

Migrant longfinned eels killed by Aniwhenua Power Station were between 25 and 65 years of age (Mitchell & Chisnall 1992). These eels predate both Matahina and Aniwhenua power schemes.

Rotorua Electricity operates the Wheao Power Scheme on the upper Rangitaiki River. They have never recorded eels upon their intake screens and elvers have never been seen upstream as far as their power station. It is local knowledge that eels cannot be caught above Te Arawhata and this may represent a natural upstream limit to distribution. However, local fishermen reported eels used to live in the Wheao River at the power station site.

The lost kokopu

Another diadromous fish, kokopu (*Galaxias fasciatus*), was formerly found in the upper Rangitaiki River in numbers sufficient to support a traditional fishery, but now appears to have disappeared. The young of kokopu grow in the sea and return to freshwater as whitebait. Suprisingly, kokopu whitebait are excellent climbers; they breathe atmospheric oxygen through their skins and will scale obstacles in a similar manner to elvers.

Kokopu are still found above Matahina Dam. Two year classes were found in the Mangapapa Stream and adult fish were caught in Lake Matahina. Kokopu whitebait were common below Matahina Dam and have been recorded climbing the fish pass, but it is probable that a landlocked population now exists in the lake. Instead of going to sea, the larvae of these fish are retained in the lake and grow through the whitebait stage in freshwater. Landlocked kokopu are known from a number of other lakes in New Zealand. The population of adult kokopu that could be expected from a lake-resident stock would be smaller than for a seagoing population. Adult fish are very sensitive to changes to catchment vegetation, increased erosion and pollution. For example, farming in the Waikokopu Stream catchment is a reason why few, if any, of this fish could be expected there nowadays.

The barrage at Aniwhenua would present an impassable barrier for movement further upstream. It is also unlikely that a landlocked population of this species could develop in Lake Aniwhenua, as the residence time of the water is too brief for a 4 month long planktonic whitebait stage. Unlike eels, kokopu have a 3–5 year life-cycle. They disappeared quickly after completion of the dams, and it is unlikely that any kokopu now remain above Aniwhenua Barrage.

Matahina Dam elver pass

As a consequence of the water rights process, ECNZ requested a design brief for an elver pass at Matahina in 1990. Subsequently the elver pass was built and followed the route initially suggested in 1983. In 1993 I prepared a publicity brochure for ECNZ on the construction and operation of the elver pass at Matahina (ECNZ 1993). ECNZ subsequently received an environmental award for this structure.

Aniwhenua

In 1992 I was given a brief by Bay of Plenty Electricity Ltd to examine Aniwhenua Power Station and barrage, again with a view to installing an elver pass. I concluded (Mitchell & Chisnall 1992) that the very low numbers of elvers present below the dam did not justify the expense of constructing an elver pass. A repeat survey in summer 1992–93 confirmed that few elvers were present. It was considered far more cost effective to continue capturing elvers from below Matahina and releasing them into Aniwhenua reservoir.

With support from Bay of Plenty Electricity Ltd, the stocking of elvers has continued. Over the summer of 1993–94, a hitherto unprecedented number of elvers were transported and released by both DoC and local residents. Although none of the parties involved have kept accurate figures it can be roughly estimated that approximately 200 000 elvers have been stocked over that period. It can be concluded that the measures introduced by both ECNZ and Bay of Plenty Electricity Ltd to restore and enhance the eel populations of the Rangitaiki River above their respective power stations have been sincere and positive, and are likely to be effective.

Releases of elvers into Matahina and Aniwhenua have been made over the past 10 years. Records of the numbers actually stocked were irregularly kept, but a search of Wildlife Service files uncovered some references to the numbers stocked in the early years (15 000–40 000). These early releases were certainly successful, as eels displayed remarkable growth rates in the productive waters of this area.

New eels

"New" eels were introduced as part of the stocking process. Apart from the differences in fin length, longfinned eels have a wide rounded head with thick lips and looser, thicker skin, whereas shortfinned eels have a more slender head (a "sharp nosed eel"). Of course Maori eel fishermen, with the depth of observation that comes from study of the quarry, recognised a far greater variety of types than just two species. Strickland (1990) records 183 names used to describe types of freshwater eels. These names refer to the different physiological stages and to changes in proportion and coloration resulting from the different habitats where eels can be found.

In New Zealand rivers there is a fall in the ratio of shortfinned eels: longfinned eels with distance inland (Jellyman 1977). Shortfinned eels are primarily lowland fish. They are most common in estuaries, swamps, ponds and slow-flowing rivers. In contrast, longfinned eels live in the same areas but also range far into the interior, where they can be found in stoney bottomed fast-flowing streams such as the upper Rangitaiki system. Studies have shown that of all our native freshwater fishes, longfinned eels are found the furthest upstream (Hanchet 1990, Swales & West 1991). This gradient was obvious in recent studies in the Waiau River and the Clutha River: in contrast to longfinned eels, which were abundant, few shortfinned eels were encountered in the upper river.

In the upper Rangitaiki, shortfinned eels appeared to have ranged as far upstream as the Kioreweku Stream, as I have caught them there in the main river. Aniwhenua Falls was likely to be the point where the relative abundance of this species fell. Thus both habitat type and distance inland would have almost certainly resulted in longfinned eels being the dominant eel in the upper Rangitaiki in former times.

The present reality is that elvers are collected for stocking from the base of Matahina Dam, which is still in the lowlands. Shortfinned elvers dominate the catch and it is not feasible to even attempt to separate them out. Therefore shortfinned eels are now being stocked above Aniwhenua when few would have migrated past this point naturally.

The next reality is that there is now a new shallow and fertile lake, formed by building the dam and fertilised by farming the catchment. The lake provides excellent habitat for both species of eel. Shortfinned eels grow faster and become sexually mature at a far earlier age than longfinned eels, and downstream migrants have already begun to appear. Age and growth estimates from migrant shortfinned eels collected at Aniwhenua screens (Mitchell & Chisnall 1992) showed that the growth rates of these eels over the 8–11 years from stocking exceeded any eel growth rates previously measured in New Zealand (Chisnall & Hayes 1991).

In my opinion, incidental stocking of shortfinned eels into the upper catchment has had a benign effect. Longfinned eels are the top predators in New Zealand freshwaters and will eat smaller shortfinned eels when they encounter them. In contrast shortfinned eels are much less piscivorous and feed to a large extent on invertebrates (insects, molluscs and crustaceans). Releases of longfinned elvers will tend to gradually spread throughout the catchment. Shortfinned eels should remain more confined to the new lake, where their rapid growth results in a productive eel fishery and aids in the fuller exploitation of the food resources of this new habitat.

Unfortunately I failed to consider the status of longfinned eels as a traditional food in my original recommendations for restocking. However, shortfinned eels are excellent eating, and this species is exported in bulk from New Zealand to other eel-eating countries. Perhaps the appearance of shortfinned eels in the fisherman's catch can be considered a reflection of the success of the eel restocking programme. Longfinned eels should remain proportionally much more abundant than shortfinned eels in the upper river and tributary streams of the upper Rangitaiki.

The issue of sustainability

Sustainability of an eel population implies more than simply releasing elvers to support a fishery. To simply view them as a resource for humans to take is ultimately counterproductive. A sustainable eel fishery will allow all aspects of the lifecycle to be completed by at least part of the population.

Eels must migrate to the sea to breed. Every autumn large and fat eels depart from the upper Rangitaiki River. It is probable that most perish before reaching the sea. Eels live for long periods in freshwater (there are still longfinned eels above Aniwhenua which are older than Matahina Dam). Both stocked eels and eels which pre-date the dams gather in autumn to migrate downstream. Sustainable management should allow at least a proportion of the migrants to pass downstream unharmed, to continue on to spawning grounds somewhere in the tropical Pacific Ocean. If not, then even stocking elvers becomes unsustainable, a net drain on the continuity of other eel populations in New Zealand.

It was suggested that Aniwhenua was an ideal site for an experiment to see whether migrant eels could be trapped for release downstream unharmed (Mitchell & Boubee 1992). In 1993 a project proposal was put to Bay of Plenty Electricity Ltd which they have since supported. It was proposed to trap the eel migration within Aniwhenua Power Canal. Methods for trapping eels without disruption to power station operation were to be tested.

Ika Whenua requested that a two-way channel for eels be provided, but I could not see how such a channel would be workable. Downstream migrating eels follow the main water flow. If the entire flow was spilled at the time of migration this would then constitute the return part of a "two-way channel". However, the financial losses in terms of spilt water would be considerable. Logically, any power station in New Zealand would be required to shut down and spill water at this time.

I consider trapping eels is better for the following reasons:

1. The eels are few in number. Therefore eels should be separated from the water flow and concentrated by a net. When it is considered that a maximum of perhaps 100 eels are presently involved with the migration over 2–3 nights per year, the need for a concentration system is apparent.
2. Matahina exists downstream. Any two-way channel at Aniwhenua would simply divert eels to their death at Matahina.
3. If the eels are caught, then some can be taken. People will be involved together with trapping the eels and there is a reward for their efforts. A take of migrating eels is fully compatible with traditional Maori fishing practice. Manually transporting mature eels safely past the dams is really a revival of the traditional fishery in a modern context. Release of large poutuna for breeding was the custom along with a take of the smaller eels.

The initial proposal suggested that electricity, strobe lights and netting could be suitable methods. Discussions with NIWA staff and results of overseas studies indicated that electricity may not be successful for downstream migrating fish. Increased turbidity during the freshes, when eel migration occurs, may render lights ineffectual. In contrast, nets are a definite way to collect fish. It was seen as critical for the future that this first trial produced some results.

Iwi participation and control

Although the impetus for this work on eels originally came from local Maori, I was not initially involved in any consultation with them; my role was as an employee of a government agency. However, I recommended that local Maori be supported to trap elvers below Matahina for release into Aniwhenua. Plans for trap designs and trapping site were presented. This recommendation was favourably viewed by local hapu, but it is only recently that local people have become involved with the stocking of eels.

It is important that this work is supported by iwi and that local people are trained in the net operation. People on site are the best judges of when hinepouri, the eel migration, is in progress.

Trapping migrant eels was a traditional Maori fishery. Migrants were fat and prime eating; they could also be stored for winter use. It was energetically efficient to collect eels as they moved downstream past a catching point, rather than taking the traps all over the countryside to the fish. Large and permanent traps, patuna, were built for the purpose on rivers and maintained by families for generations. Maori fishermen knew the precise times to fish and took massive harvests by trapping the heke (or migration). A point of great interest is the deliberate release of the largest eels. The reproductive contribution of these fish (poutuna) was much greater than the smaller eels, which were kept. For example a 1500 mm long female longfinned eel will produce approximately 40 million eggs. An eel half as long, 750 mm, will produce only 3 million eggs. What experience caused this tradition of releasing the largest eels is unknown, but it is fully compatible with sustainable management of eels.

I would like to see the tradition of trapping the heke restored. There are a considerable number of benefits. A significant increase in the local eel harvest should result. Prime eels, otherwise wasted, will be harvested. Members of the local iwi would participate in the work and the catch would be taken by them. The largest eels caught would be transported below Matahina Dam to continue their migration.

The work to date on downstream migrating eels has been supported by some Maori. Young men from Murupara and Waihou have assisted. Tuna Tawhara, Rua Te Pairiri and "Dorso" Horne, led by Frank Mitai, helped to set the net up. Peter White led the group from Waihou who helped lift the net and shift the catch; Morris Kahukiwa, Ron Tikawa, Wallace Tikawa, Billy Weko, Matiu Weko and Maurice Toetoe all gave their time and assisted willingly when needed. Dick Hieke Tupe blessed the eels before their release.

My discussions with these people and local residents such as Bill Kerrison lead me to believe that a migrant eel catch and release programme may be possible.

Bay of Plenty Electricity Ltd has clearly demonstrated their support for the sustainability of a natural resource. The results of studies planned at this small-scale/low-cost site will be important for management of eel stocks (under the present day requirements of the Resource Management Act) behind dams around New Zealand. If the concept can become widely accepted, a traditional fishery and traditional fishing customs will have been demonstrated to have relevance in modern times.

The logical extension of this work as I see it is that local iwi should manage the work, take the catch and allocate the eels for release and those for eating. However, the people will need encouragement and support before they can be expected to become involved fully in the project.

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