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Freshwater Fisheries Centre Annual Report January 1991–June 1992

New Zealand Ministry
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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. MAFFish combined the functions of the old Fisheries Research Division and Fisheries Management Division and the fisheries functions of the old Economics Division.

The research functions of MAF Fisheries Freshwater Fisheries Centre were transferred on 1 July 1992 to the National Institute for Water & Atmospheric Research Limited, and the location of this office is

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Cover: A densely willowed section of the Shag River (see page 17). (Photo: Gordon Glova)

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(at June 1992)

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Christchurch

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C. L. Hopkins MA *salmon aquaculture*
D. J. Jellyman PhD *eels and Maori fisheries*
I. G. Jowett BE *trout in rivers*
R. M. McDowall PhD *native fish*
M. J. Unwin MSc (Distinction) *chinook salmon biology*

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M. Flain BSc
G. J. Glova PhD
J. W. Hayes PhD
G. D. James MSc (Distinction)
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Rotorua

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C. P. Mitchell MSc (Distinction)
J. Richardson BSc
D. K. Rowe PhD
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R. J. van Boven NZCS

Hamilton

Leader: J. A. T. Boubee DPhil *effects of thermal power stations and hydro reservoirs*

Introduction

This Freshwater Fisheries Centre Report for 1991–92 is the last annual report for the Freshwater Fisheries Centre. As from 1 July 1992, the MAF Fisheries Freshwater Fisheries Centre ceased to exist, and the research functions carried out at the three laboratories, in Christchurch, Rotorua, and Hamilton, were transferred to the new Crown Research Institute, the National Institute for Water & Atmospheric Research Limited (NIWAR). Therefore, it was decided to extend the annual report to cover activities undertaken by the Freshwater Fisheries Centre in 1991 and the first half of 1992.

The past year has seen a major restructuring of science in New Zealand, with the dissolution of the major Government research organisations (Department of Scientific and Industrial Research (DSIR), Ministry of Agriculture and Fisheries (MAF), Forestry Research Institute) and the formation of 10 Crown Research Institutes.

The Freshwater Fisheries Centre has been part of this restructuring, which has not been without cost. Because of a projected reduction in funding for 1992–93, not all Freshwater Fisheries Centre science staff could be transferred, and six staff were classified as unfunded. At the Rotorua Laboratory, Charles Mitchell and Rowan Strickland did not transfer to NIWAR. Charles's expertise in fish passes and contribution to whitebait research, and Rowan's contribution to Maori fisheries, will be sadly missed. In Christchurch, Malcolm Flain, Trevor Washbourne, Ron Dougherty, and Michael Field-Dodgson were not transferred to NIWAR. Their contribution to salmonid research and aquaculture will also be missed, and best wishes are extended to all these staff for the future. As part of the change, Peter Todd elected to remain with MAF Fisheries and transfer to marine fisheries management and research, and Brian Swale remained with MAF Fisheries to carry out freshwater fish farm licensing responsibilities. Sally Davis, formerly science administration and deputy manager, was appointed as General Manager of the Freshwater Division of NIWAR in Christchurch. This Division incorporates all of the Christchurch Freshwater Fisheries Centre staff, the Hydrology Centre of DSIR, and part of the Taupo Research Laboratory of DSIR. It is located at the old Freshwater Fisheries Centre Laboratory in Kyle Street, Riccarton.

Although a good deal of time was taken up with the restructuring, ongoing research activities were given the highest priority. In November, a major staff meeting was held to consider the structure of the Freshwater Fisheries group. It was decided to reorganise research activity into five teams: eels and Maori fisheries, native fish, trout in rivers, lake ecology, salmon biology and aquaculture. Strategic research plans have been developed for each area of research, and these will be used to bid for research funds from the Foundation for Research, Science and Technology (FRST).

For the 1991–92 financial year, the centre achieved a revenue target of 37% of gross budget from external clients, which include Electricorp, Fish and Game Councils, Department of Conservation, and aquaculture clients. About half of the 1991–92 budget was obtained from MAF Fisheries, appropriated through Vote: Fisheries. For the 1992–93 financial year, this money has been transferred to the Public Good Science Fund, the pool of money available to competing bids for research funding administered by FRST. This fund will be the major ongoing source of revenue for the new Crown Research Institutes.

With changes to statutory responsibilities that have occurred over the past few years, MAF Fisheries has retained little responsibility for freshwater fisheries. The responsibilities for native fish conservation and habitat protection, and the role of administering the Fish and Game Councils in relation to recreational freshwater fisheries, were transferred to the Department of Conservation in 1987.

MAF Fisheries only retains responsibility for commercial freshwater fisheries (eels) and Maori fisheries. As a result of these changes over the past few years, the location of the Freshwater Fisheries Centre as part of MAF Fisheries has been increasingly questioned. The establishment of the Crown Research Institutes, and particularly NIWAR, has now provided a suitable location for freshwater fisheries research in New Zealand. It has also provided an opportunity where freshwater fisheries studies can be integrated with other disciplines, to provide research that can be used for the overall management and utilisation of water resources. This should ensure that freshwater fisheries research continues in New Zealand as part of a multidisciplinary approach to freshwater research.

Peter Todd

Manager, Freshwater Fisheries Centre

Sampling galaxiid and salmonid populations in Deep Creek, a tributary of the upper Rangitata River. (Photo: Gordon Glova)

Native fish

Fish studies

During the year staff from Christchurch and Rotorua formed a native fish research group. The existing working environment was not conducive to the development of vigorous research themes and cohesive objectives. Diverse research objectives were being undertaken, partly because the work was being funded by varied clients, and partly because of the disparate origins of the group. These objectives needed to be completed. Furthermore, because of the pending transfer from MAF to the National Research Institute of Water & Atmospheric Research on 1 July and because future structures and funding sources were uncertain, emphasis was placed on completion of all work presently underway.

Staff in the native fish group resolved to pursue more integrated goals in studies of native fish communities, and the processes that determine the structure and interrelationships of the species in the communities, and in research that supports the community studies, in particular that which develops understanding of fish life histories and focuses on species in streams where the community studies are being undertaken.

Maori fisheries. Under the Treaty of Waitangi, the Government has the responsibility to ensure that Maori have access to traditional food resources. Therefore, it is important that there be some understanding of the historic value of freshwater fisheries as food for the Maori people. Literature on this topic is extensive and proves to be much more substantial than is evident from the usually cited publications, like those of Elsdon Best and Te Rangi Hiroa.

An annotated bibliography is being compiled. This will provide access to the considerable body of literature, some of it in the fisheries field, but much of it is derived from early historical records, ethnological and archaeological writings, as well as from submissions to the Waitangi Tribunal in recent years.

Cucumber odour in fish. Fish from quite widespread fish families have been reported to emit the odour of freshly sliced cucumbers when first lifted from the water — for example, Osmeridae (northern smelts), Retropinnidae (southern smelts), Prototroctidae (southern graylings), and Chlorophthalmidae (ocean fishes). A project in collaboration with Graham Wright and Bruce Clark of the Department of Chemistry at the University of Canterbury has shown that for Osmeridae, Retropinnidae, and Prototroctidae the same chemical causes the odour, and that it is essentially the same as that which causes the odour in cucumbers, though no common causal relationship can be ascribed to the odour in cucumbers.

Otago *Galaxias*. Work by fish biologists at the University of Otago has suggested that the present understanding of the taxonomy of inland-living, freshwater-limited species of the *Galaxias vulgaris* type does not adequately cover the populations present, at least in the upper Taieri River, and probably more widely than just the Taieri. Studies of populations from a wide range of this "species" group (in collaboration with Colin Townsend, Graham Wallis, and Todd Crowl of the University of Otago) suggest that there is a very complex genetic and evolutionary situation. This defies the application of standard taxonomic procedures, though it is clear that there are several taxa, referred to generally as *G. vulgaris*, present in the Taieri and nearby catchments.

Stokell's smelt

M. L. Bonnett

Studies of the distribution and freshwater residence of Stokell's smelt have been completed. This species is found along the east coast of the South Island from North Canterbury to North Otago, though it is particularly abundant in the large, braided, shingle rivers south of Banks Peninsula, such as the Rakaia and Rangitata. The limited distribution of Stokell's smelt distinguishes it from the rest of the indigenous freshwater fish fauna because all the other diadromous species are widespread throughout New Zealand. The pattern of their distribution resembles that of the introduced chinook salmon; possibly the distribution of both species is limited by some oceanographic features.

Analysis of samples from the Rakaia River established that some Stokell's smelt entered fresh water well before reaching sexual maturity. Although the length of freshwater residence could not be determined, this species may be more vulnerable to exploitation than was previously thought.

Effect of smelt introductions on koaro in Lake Rotopounamu

D. K. Rowe

A comprehensive fisheries survey established that koaro have disappeared from Lake Rotopounamu. The extinction of this species in this lake is attributed to the illegal introduction of smelt sometime before 1981.

Freshwater eel studies

D. J. Jellyman

Information on the distribution and movements of both species of eel in Lake Pounui has been analysed. Both species occurred in all habitats in the lake, though there was a tendency for longfins to avoid swamps. Although the eel population was dominated by shortfins (91%), this species constituted only 66% of all eels caught in fyke nets. Thus, longfins were much more prone to fyke net capture than were shortfins, and 62% of marked (cold-branded) longfins were recaptured, compared with 9% of marked shortfins. Shortfins showed more restricted movements and greater site fidelity than did longfins; although there was a definable home range for shortfins, there was no evidence of a home range for longfins. Revision of some of the extensive information on age and growth of eels in Lake Pounui is also underway.

The national distribution of both species of eel is being investigated from records of the Freshwater Fish Database. Of the 9500 records, longfins were present at 33% of the sites and shortfins at 13%. A subset of the data was generated for those records that included some qualitative measure of abundance, and this is being used to investigate habitat associations for each species. In addition, species composition per return area has been extracted from the catch data for the commercial eel fishery. The commercial catch data will also be used to study the influence of water temperature on catches.

Management of freshwater eels

D. J. Jellyman

The Freshwater Fisheries Centres in Christchurch and Rotorua continued to provide advice on management of the eel fishery to MAF Policy, Wellington. The commercial eel fishery has been undergoing an extensive review, and, as a major component of this review, a report which documents trends in the national and regional catch statistics has been compiled. In addition, age and size distribution data from three locations have been supplied to biometrics staff of MAF Fisheries for use in modelling the impacts of possible changes in the minimum commercial size.

Freshwater fish database

J. Richardson, M. J. Taylor

MAF Fisheries maintains a computer-based store of information on the distribution of freshwater fish species. Over 1000 new entries were added in 1991–92, bringing the total to 9700.

About 20 requests for information were received and processed for agencies other than MAF Fisheries. The Department of Conservation now receives selected fields of information from the database and has these on-line throughout their internal computer network.

Conservation of dwarf inanga

D. K. Rowe

Surveys of previously unexplored Northland dune lakes were carried out in 1991 and 1992 with joint funding from the Department of Conservation and MAF Fisheries. Another new population of the rare dwarf inanga was found, this time in Lake Rotopouua. However, the surveys have now exhausted the possibilities of finding new populations and a definitive map of this species distribution has been produced. Dwarf inanga occurred in twelve lakes before 1970. However, this species is no longer abundant in any of these lakes, being common in only three, and rare or extinct in the other nine. Trout predation is probably responsible for its demise in at least four of the lakes, but other factors may be affecting this species because it is rare or extinct in lakes where trout have never been stocked.

Adult inanga abundance and habitat requirements

P. M. Sagar

Inanga are a major proportion of the whitebait runs in New Zealand. Therefore, it is important that we have an adequate understanding of factors affecting their distribution and abundance in fresh water, so that stocks can be effectively managed and enhanced where appropriate.

It is widely held that the whitebait runs are largely limited by the widespread lack of suitable spawning habitat for inanga. However, it is possible that the runs are limited by a lack of suitable rearing habitat for maturing inanga, about which very little is known. The aim of this Department of Conservation funded project is to quantitatively describe the habitats occupied by maturing inanga.

Field work on a number of Canterbury and West Coast coastal streams during 1991–92 showed that maturing inanga occupied a wide range of habitats. The prime limitations to their distribution appear to be access from the sea, distance from the sea, altitude, and the occurrence of large trout. However, although maturing inanga may occupy a wide range of habitats, their foods may limit growth and reproduction potential.

Establishment of an inanga spawning database

M. J. Taylor

Following the recommendation of *N.Z. Freshwater Fisheries Report No. 133*, a waterproof form was developed for field observations of inanga spawning grounds. Each Department of Conservation conservancy, except Taupo, was provided with 15 plastic field forms for use in wet weather. In dry weather, paper photocopies of the form can be used in order to save printing costs.

All known records of spawning grounds found since surveys began in 1987 have been added to the database. To date, the database has 174 records of inanga surveys. Of these, 57 surveys located spawning activity, 28 found inanga egg aggregations, and 5 recorded both eggs and spawning activity. Good contributions during the 1992 season were from the Tauranga and Stratford areas of the North Island, where new spawning areas were found on the Wairoa, Waiau, Waingongoro, and Rangitikei Rivers.

Distribution and density of native freshwater fish

J. Richardson

In an investigation known as the "100 rivers survey", 144 river sites around New Zealand with reliable longterm hydrological records were chosen for study. For many of these sites, the abundance of trout, periphyton, and benthic invertebrates was related to hydrological factors, water quality, and catchment characteristics. Now native freshwater fish data are being added to the existing and extensive database to provide an opportunity to analyse factors which influence native fish distribution and density.

This year, efforts were concentrated on establishing which method was the most effective for the capture of native fish in medium to large rivers. Six rivers were investigated and Gee minnow traps, hinakis, fine-meshed fyke nets, and electric fishing were all trialled. Electric fishing was the best and quickest method and will be used in conjunction with seine nets to sample the rivers.

A total of ten species was recorded from the six rivers. Eels were the most common and abundant species, but torrentfish, common bullies, inanga, and bluegilled bullies were sometimes present in high numbers. Native fish data will be collected at approximately 60 river sites over the next 2–3 years.

Spawning requirements of *Galaxias maculatus* (whitebait)

C. P. Mitchell, G. A. Eldon

Two publications on inanga spawning grounds were produced during the year. A pocket manual on waterproof paper with colour plates, entitled "How to Locate and Protect Whitebait Spawning Grounds", was circulated before the 1992 spawning season. More recently, *N.Z. Freshwater Fisheries Report No. 133* entitled "South Island Inanga Spawning Surveys 1988–1990" was produced.

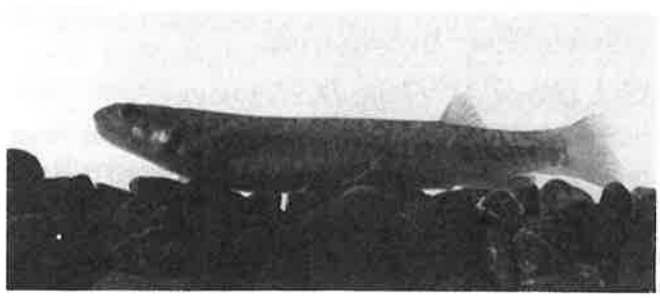
Galaxiid-salmonid interactions winding up

G. J. Glova, P. M. Sagar

Our studies on food and space interrelations between galaxiid and salmonid fishes are coming to an end. Over the years we have progressed with research on this phenomenon from a simple situation consisting of a galaxiid population living in isolation from salmonids to a more complex community of these fishes, which comprises two galaxiid species and two salmonid species in small streams. All but the last of these works have been documented in primary publications, and the main findings were:

1. galaxiids were more abundant living in isolation from salmonids;
2. dietary and spatial overlap between these two families of fishes was considerable;
3. direct competition was minimal as galaxiids fed primarily at night and salmonids fed mostly during the day; and
4. predation rather than competition may be a significant mechanism of impact on galaxiids by salmonids.

The final paper from these studies is nearing completion and will bring together information on the interactive ecology of these fishes from simple to relatively complex communities.



Juvenile common river galaxias.

Salmonid biology and fisheries

Headwater trout studies

D. J. Jellyman

This is the third and final year of this programme, and a report is being written. Part of the report covers the characteristics and identification of headwater trout rivers throughout the country and reviews changes in their management over the 3 years. A major section discusses species composition, size and age structure, and condition of the fish stocks; much of the information for which was obtained from 2700 scale samples supplied by anglers.

Age determination from scales has proved to be extremely difficult. Firstly, up to 33% of scales supplied have been found to be "replacement scales" and of no use for ageing because there is no record of growth before scale loss. Secondly, the annual checks in scales are often very difficult to detect, especially as growth slows and checks become crowded at the scale margin. Thirdly, there is often marked erosion at the scale margin during spawning, especially in males; this can result in the complete loss of several years record of growth, with a consequent underestimate of the age of trout, but an overestimate of backcalculated length at previous age. Eric Graynoth has developed a model to compensate for scale erosion.

Headwater trout are large (male brown trout averaged 57.7 cm and females 52.9 cm) because they are old, not because they grow particularly rapidly. From the available data, the average age of brown trout was just over 5.5 years; 5 and 6 year old fish constituted 50% of the samples. Growth rates of both sexes were similar, and the larger average size of males is because males averaged about a year older than females. It is apparent, from recaptures of tagged fish from the upper Oreti River in Southland, that many such large trout remain in the same location during the year, and even from year to year.

Selwyn River brown trout

G. J. Glova, M. Flain, D. H. Lucas

The age, size, growth (backcalculated from scales), and life history type of the Selwyn River brown trout spawning runs have been analysed for selected years during 1932–87 from samples collected by the North Canterbury Fish and Game Council (formerly North Canterbury Acclimatisation Society). The objective was to investigate possible trends in these population characteristics over time, which might help explain the decline of this once renowned fishery. The data have been analysed and a manuscript for primary publication is near completion.

Drift diving ratification

J. Richardson

During 1990–91 reaches of the Mohaka, Rai, and Riwaka Rivers were netted off and the numbers of fish assessed by drift diving, seining, and hand netting to determine the accuracy of drift diving.

Results for the Mohaka and Riwaka Rivers showed that for rivers with only, or predominantly, brown trout, drift diving is very accurate; between 80% and 90% of large and medium trout were counted. In rivers with both species and high numbers of trout, the results were less accurate. The classification into size class and identification of species were especially hard to duplicate.

Drift diving remains the fastest, easiest, and most cost-effective method for counting trout in clearwater rivers. However, it is important to adhere to established protocols. Replicate counts to establish means and standard error may be warranted in some situations.

Source to the sea — Kakanui River

I. G. Jowett, J. Hayes

This project began in the summer of 1991–92. Its aim is to study the distribution and abundance of trout in the Kakanui River from the source to the sea and to investigate the reasons for that distribution and any changes that may occur during the year. The study has received a high degree of cooperation from the Otago Regional Council, which has carried out four instream habitat surveys along the river, and from Central Fish and Game Council, which has assisted in site selection and communication with the local landowners and has been involved in the trout surveys. DSIR Marine and Freshwater were also running concurrent studies on the distribution of periphyton in the river and the primary productivity of the river, and it is hoped to begin benthic invertebrate studies in the next year.

The first adult trout survey in January this year showed a very pronounced decline in abundance of adult trout with distance from the estuarine reaches of the river, and this distribution was confirmed by another survey in March. Flooding in the river has so far prevented a survey in May or June, when it is expected to observe some change in the distribution of trout because of spawning movements.

Juvenile trout surveys began in December last year with an initial objective of establishing methods by which large areas of the river could be surveyed efficiently. The three surveys carried out this year showed that the distribution of juvenile trout was different to that of adults — the highest number of juveniles was in the middle reaches of the river. A comparison of crawl diving and electric fishing showed that, although crawl diving counts gave a reasonable idea of the distribution of juveniles in the summer, the method was not suitable in winter because the juvenile trout were hidden in the substrate.

Feeding habitat for brown trout

J. W. Hayes

The study of the habitat preferences of drift-feeding brown trout was completed this year, after data collection in the Mohaka, Travers, and Mataura Rivers in previous years. Water velocity, depth, and substrate are the primary variables that determine the suitability of a point in a river as a trout drift-feeding station. There was no interdependence between these variables, and habitat preference curves developed from this work were used to establish significant relationships between brown trout abundance and habitat quality for 59 rivers of the "100 rivers" dataset (habitat data were not available for the remainder). Other variables were examined using logistic regression and shown to be significant, though not as important as depth and velocity. These included measures of how water velocity varied in the area surrounding the fish. Fish were more likely to select locations where adjacent velocities were higher, or where the bottom velocity was markedly lower than the mean velocity in the water column above the fish. A valuable part of the study has been the numerical methods developed for comparison of the habitat used by the fish with the habitat available in the river and derivation of habitat preference curves.

Enhancement of the Lake Ellesmere brown trout fishery

G. J. Glova, T. J. Washbourne

Releases of hatchery-reared 50 g brown trout have been made into the lower Selwyn River over the past 2 years. It is hoped that these releases will subsequently provide us with information that will enable us to assess the feasibility of using hatchery-reared trout as a means to revive the once renowned Lake Ellesmere fishery. Reasons for the decline of this fishery are not specifically known, but are believed to be the cumulative effects of the 1968 *Wahine* storm, swamp land drainage, increased pollution, and the bycatch in eel and flounder nets. In the light of the bycatch problem and relatively high angler exploitation, recruitment to the lake is seen as the possible bottleneck in the recovery of this fishery, particularly as foods suitable for trout are abundant in the lake. Major future releases of hatchery-reared trout may be a way of expediting the recovery of this fishery. Our hatchery releases will, we hope, provide us with information on trout growth and survival in the lake, and their contribution to the fishery. The fish are coded-wire nose-tagged and adipose-clipped for identification in subsequent recaptures.

Releases totalled 4700 trout in November 1990 and 2600 in December 1991. About 10 000 trout are being reared at the Glenariffe Salmon Research Station (imported as eyed ova from a North Island hatchery) for release in late 1992, the final of our experimental releases.

Echosounding in lakes

D. K. Rowe

The fish species responsible for the five layers of echoes recorded by high frequency (200 kHz) echosounding, and segregated by depth in Lake Rotoiti (North Island), were identified previously. Recent work has examined the effect of lake water quality on fish distribution. Seasonal variations in the depth distributions of the five layers were determined over 2 years in Lake Rotoiti and compared with those for the same fish species in Lake Rotoma and Lake Okataina. The depth distribution of 1+ year old smelt showed little seasonal variation between lakes. However, the scattering layer of larval bullies did not descend over winter months in Lake Rotoiti. This was attributed to the disruptive effect of the autumnal deoxygenation of the hypolimnion in this lake. Further work established that larval bullies congregated at depths in the metalimnion where oxygen levels were highest, whereas 2+ year old smelt preferred deeper, cooler, hypolimnetic waters. As a consequence, low oxygen levels limited the depth to which the 2+ year old smelt could descend in Lake Rotoiti, and they were forced to congregate at the bottom of the metalimnion. These changes in fish distribution are due to a deterioration in water quality and will have major implications for lake ecology, as well as for fisheries.

Scale marking using different feeding regimes

D. H. Lucas

A characteristic feature of scales collected from adult chinook salmon of hatchery origin is the presence of distinct "check" marks in the nucleus. These represent interruptions to growth during juvenile hatchery residence and possibly result from handling and/or changes in feeding regime. To examine how such checks develop, two experimental groups of juvenile salmon held at Glenariffe were subjected to an initial full demand-feeding regime, then 3 months of reduced feeding (which involved hand feeding for one group and limited demand feeding for the other group), and a subsequent return to full demand feeding. Scale samples were collected monthly throughout the trial. Up to three distinct checks were formed on the scales, and these reflect times of faster or slower growth associated with the different feeding regimes. In general, the checks were more pronounced among the handfed group.

Relationship between wild and hatchery stocks

M. J. Unwin

With the use of linear discriminant analysis, a method for classifying scale nucleus types (and hence determining whether a fish is of wild or hatchery origin) has been developed and has shown better than 90% accuracy when applied to scales from fish of known origin. Application of these results to scale samples collected during the 1991 spawning season shows that about 50% of the salmon returning to the Waimakariri, Rakaia, and Rangitata Rivers and 20–30% of those returning to the Waitaki River were of hatchery origin. These figures are considerably lower than results published in previous reports, which were based largely on subjective interpretation of the scale patterns and have proved to be significantly biased towards hatchery fish.

During a 6 month (January-June 1992) visit to the laboratory, Professor Tom Quinn (University of Washington) took the opportunity to explore some of the large datasets on wild salmon populations in the various rivers, to determine whether there were significant interpopulation differences. To our surprise, we found substantial differences in virtually all life history traits examined. The proportion of adults that had reared for a full year in the river before their seaward migration varied from 29% in the Hydra Waters to 76% in Winding Creek, and mean age at maturity varied from 2.93 on the Rangitata to 3.32 on the Waitaki. There were also differences in mean length at age; for example, 4 year old males ranged from 847 mm in Glenariffe Stream to 913 mm in the Waitaki River. Waitaki River salmon were also heavier for their length than those from the Rakaia River. Run timing varied between rivers, both in entry date into fresh water (median entry date was 7 February on the Rakaia compared with 9 March for the Waitaki) and date of arrival on the spawning grounds, which varied by 16 days between Glenariffe Stream and Winding Creek. These life history traits are influenced by genetic and environmental factors; hence the differences may reflect variation in rearing regimes or genetic adaptation to local conditions.

Homing and straying in chinook salmon

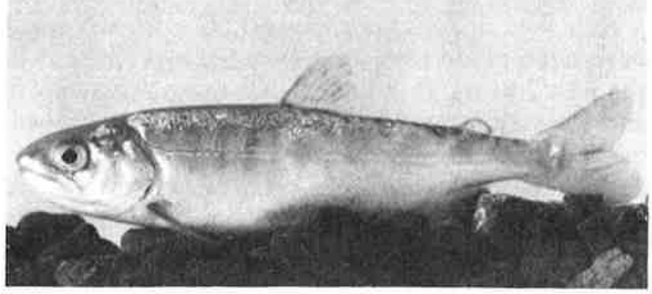
M. J. Unwin

Professor Tom Quinn's visit also provided an opportunity to prepare a joint paper on homing and straying in chinook salmon, based on the unusually large dataset (17 671 recovery records) provided by coded-wire tag returns from this study. Salmon homing to the Rakaia River represented 88% of the recoveries, and the rest were recovered from 12 other catchments up to 500 km away. The number of strays which entered a given river increased with discharge and with proximity to the Rakaia, but most strays were recorded in catchments north of the Rakaia. A higher proportion of salmon released in winter, when the down-river migration of naturally produced chinook is at a minimum, strayed to other catchments (14.9–20.6%), than did those released at other times of the year (3.6–7.6%). However, straying within the Rakaia catchment was largely unaffected by release date, which suggests that imprinting by fry to the natal tributary is separate from imprinting by smolts to the mainstem river. There was also a complex interaction between age at maturity, release date, and straying rates; straying of 4 year old fish was more strongly influenced by release date than was straying of younger fish. Notwithstanding this interaction, straying was more prevalent among older fish.

Control releases of chinook salmon

M. J. Unwin

In tandem with the salmon database programme, annual releases of tagged salmon at a consistent size and time of year will generate a longterm dataset on variations in brood year survival, which can be compared with similar data on natural stocks. A total of 100 000 tagged fish at Glenariffe were set aside for this programme, in 10 groups of 10 000.



Juvenile chinook salmon.

One of these groups was used for the North Canterbury Fish and Game Council Hydra Waters release, but the remaining nine groups were released in March, July, and August, and two of these groups were released at Silverstream.

Migration of juvenile salmon from Glenariffe Stream

G. D. James, M. J. Unwin

Trapping of the downstream migration of juvenile salmon from Glenariffe Stream was undertaken in 1991 to assess whether egg to migrant survival had changed with low adult runs of fish into the stream. Earlier studies in 1973–76, when adult runs were considerably higher, had shown that survival was around 50%. Data from 1990–91 showed similar survival rates, which suggests that survival is independent of spawning density over a wide range (70–1500) in the number of female spawners. Therefore, it seems that any decline in the number of wild salmon returning to Glenariffe Stream cannot be attributed to a decline in spawning success.

Chinook salmon fecundity and ova mortality in the Waitaki River

S. Bloomberg, K. R. Deverall, G. J. Glova, G. D. James, J. R. M. Kelso, T. P. Quinn (visiting scientist for 6 months from the University of Washington)

Salmon fecundity in the Waitaki and Rakaia rivers has been documented and compared for the first time by Quinn and Bloomberg. Fecundity was positively correlated with length; estimated fecundities at 750 mm fork length were 5024 eggs for Waitaki and 4829 eggs for Glenariffe salmon. The slopes of the regressions of fecundity on length differed between populations, though the Glenariffe data did not differ from Rakaia River samples for 1967, 1973, and 1976. Significant between-year variation in the length-fecundity relationship was detected in Waitaki River samples. Egg weights, taken from the Glenariffe samples, were positively correlated with length and averaged 0.17 g. However, salmon with high fecundity for their length tended to have small eggs, and those with low fecundity for their length had large eggs.

Investigation of the effects of glacial silt on salmon egg mortality in the Waitaki River showed that substrate permeability, apparent velocity, and oxygen in redds were all well above minimum thresholds likely to cause significant egg mortalities. If anything, there was an indication that, because of the large substrate size and interstitial spaces, velocities were high enough to perhaps cause some damage. However, there is a possibility that in a residual river created as part of a possible lower Waitaki hydroelectric scheme, interstitial spaces could become more occluded, which may result in increased egg mortalities.

Stream simulator: chinook salmon and brown trout interaction

G. J. Glova

Research on the interaction between fry and fingerling stages of chinook salmon and brown trout has been completed. This study showed that both salmonid species were highly territorial and actively defended preferred drift-feeding sites and resting areas in the pool. Species dominance differed with life stage, but was influenced by prior residence and size of fish. Although chinook salmon were larger in the fry stage, they were not socially dominant when brown trout had prior residence. In the fingerling stage, brown trout were dominant in all tests, though dominance took longer to establish when chinook salmon were given prior residence. Most aggressive attacks of both species were initiated and won by the dominant fish of both fry and fingerlings. Tactics in maintaining territory differed between species; brown trout used a more energy-conserving strategy (frequent resting in preferred cover areas) than did chinook salmon (infrequent resting in water column). It is concluded that brown trout dominance has the potential to affect juvenile chinook salmon residency, particularly as fingerlings, and thus brown trout, are not considered the ideal cohabitant with chinook salmon in small streams.

Salmon at sea

G. D. James, M. J. Unwin

Introduction of the bycatch verifier scheme last season proved highly successful, both from the viewpoint of bycatch management and also collection of scientific data. Fishing effort off Banks Peninsula was somewhat less than in previous seasons, partly because several vessels which normally fished for red cod remained in southern waters (to fish for orange roughy) throughout the entire season, and partly because of a poor red cod season several vessels preferred to fish for barracouta off Oamaru. Total salmon landings for the season (as of 30 April) were 1.27 t, the lowest figure since landing records were first collected in 1984–85, and represented less than 0.07% of the total landed weight of fish from the Canterbury region. Catch rates for salmon and red cod were 3–8 times higher within the seasonally closed area off Banks Peninsula. There was a high proportion of immature 2 year old fish (49%) compared with only 10%

among salmon returning to the Rakaia River; this suggests that many of these fish would not have returned to fresh water this season.

Based on 143 stomachs containing identifiable food items, sprats were the most important part of the diet (62% of the weight of food eaten). Juvenile hoki made up about 16% of the diet and *Munida* (red krill) about 8%. Whereas sprats and hoki were eaten regularly during December and January, *Munida* were eaten on only a few occasions, but in large numbers. This is consistent with the intermittent presence of *Munida* and suggests that salmon prefer *Munida* when they are available. Records of salmon injuries showed that 87% of fish were unmarked, 6% had healed scars, and 7% fresh scars.

Salmon databases

M. J. Unwin

Management of the salmon fishery and development of a salmon population model requires reliable population estimates for key spawning stocks and accurate information on the sports harvest. This programme, funded by the N.Z. Fish and Game Council, involves setting up longterm monitoring programmes based on regular helicopter surveys of key spawning areas and telephone surveys to estimate angling effort and catch. For the 1992 spawning season, a successful pilot series of helicopter flights has shown that five flights a year should be possible within the available budget, and these should enable spawning populations to be estimated to within ±20–25%. Information from these flights will be used to set up a detailed schedule so that the monitoring programme can be fully implemented in 1993.

Migration rates and behaviour of Rakaia River chinook salmon

G. J. Glova

Completion of this project depended on our success in capturing, radio tagging, and tracking a sample of at least 20 salmon of the early-running fish in November-December 1991. Unfortunately, as in the previous two years, the numbers of returning salmon were down, and once again we were unsuccessful in completing this important segment of the study. In an all-out effort for the season, we managed to tag and release six salmon before the early summer floods arrived; too few to justify the costs of tracking these fish by jet boat to headwater areas to determine their upriver movements over time. As a compromise, a short manuscript will be prepared for primary publication on the migration rates of summer- and autumn-running chinook salmon, work that was completed in previous years.

Chinook salmon spawning in Hurunui River

G. J. Glova

The spawning runs of the North and South Branches of the upper Hurunui River were studied for 3 years to gather information on the numbers, age and size, and timing of the runs. The data have been analysed, and a manuscript which summarises the results is in progress.

Salmon fecundity in lower Waitaki River

G. J. Glova

A manuscript was submitted for consideration for publication as a note in a primary journal. In the process of revising the manuscript to comply with the editor's and referee's comments, Professor Tom Quinn, a visiting scientist from the University of Washington, became involved and was able to contribute significantly in synthesising a much-improved revised version by gathering additional information on egg size, gonad weight, and fecundity of the 1992 salmon run at Glenariffe. The additional new information, and Professor Quinn's knowledge of the life history of North American chinook salmon stocks, helped to produce a much-improved comparison of chinook salmon fecundity in the Waitaki, Rakaia, and relevant North American stocks.

Effects of water and land management practices

Rakaia invertebrate drift study

P. M. Sagar

This study has been completed and a paper accepted for publication in *Freshwater Biology*. Drift densities in the Rakaia were greatest in autumn and at night, in all seasons except winter. A greater proportion of larger animals drifted at night than during the day in all seasons. Mean annual drift densities were 96 animals per 100 m^3 and 47 mg dry weight per 100 m^3. There were relatively few taxa in the drift, and *Deleatidium* spp. constituted more than 85% of the drifting aquatic invertebrates in all seasons, except autumn. Chironomidae and terrestrial forms were the only other groups to occur at densities of more than one animal per cubic metre in all seasons. Drift density was positively correlated with benthic density, which in turn was adversely affected by floods, particularly during spring and summer.

Use of suitability curves for benthos

I. G. Jowett

This study used existing data on the invertebrate species, abundance, and instream habitat in the Clutha, Mangles, Mohaka, and Waingawa Rivers to derive habitat suitability curves for *Coloburiscus humeralis*, *Nesameletus* spp., *Zelandoperla* spp., *Pycnocentrodes* spp., *Olinga feredayi*, *Aoteapsyche* spp., Hydrobiosidae, Chironomidae, *Potamopyrgus antipodarum*, Naididae, *Deleatidium* spp., and *Aphrophila neozelandica*. Good relationships were found between the abundance of *Coloburiscus humeralis*, *Zelandoperla* spp., *Aoteapsyche* spp., Hydrobiosidae, Naididae, and *Aphrophila neozelandica*. The distribution and abundance of *Nesameletus* spp. and *Olinga feredayi* showed little relationship to the instream habitat variables of water velocity, depth, and substrate. The habitat suitability curves were also tested against the invertebrate abundances recorded for about 40 rivers of the "100 rivers survey". There were no significant correlations between instream habitat and the abundance of any species, though there was a significant correlation between food producing habitat suitability and total invertebrate biomass.

The conclusion of the study was that species-specific habitat suitability curves could "predict" the distribution within a river of most common invertebrate species, but could not predict which species would be in a particular river or the relative abundance between rivers.

Instream habitat management system

I. G. Jowett

The purpose of this work was to transfer the results of the recent research into habitat preferences of brown trout and benthic invertebrates, the development of a brown trout model, and the results of the "100 rivers survey" into useful management strategies. A conference paper and chapter for a forthcoming book were prepared to describe the work and how it could be utilised in water management. Briefly, the principle that there is a relationship between aquatic fauna and instream habitat is explained, with particular reference to the studies which have established relationships between benthic invertebrate and brown trout abundance and the amount and quality of the instream habitat. For any flow in a river the amount and quality of the instream habitat can be predicted by modelling the river hydraulically and applying habitat suitability curves. Data from the "100 rivers survey" were presented to show how the habitat quality varied between rivers and were used to suggest a system whereby a river could be "graded" as poor, good, or excellent in terms of the amount of useful habitat it contained. This information gives water managers an objective measure of the existing habitat quality and, in conjunction with hydraulic modelling, can be used to assess the relative impact of flow and habitat modifications.

Avon River survey

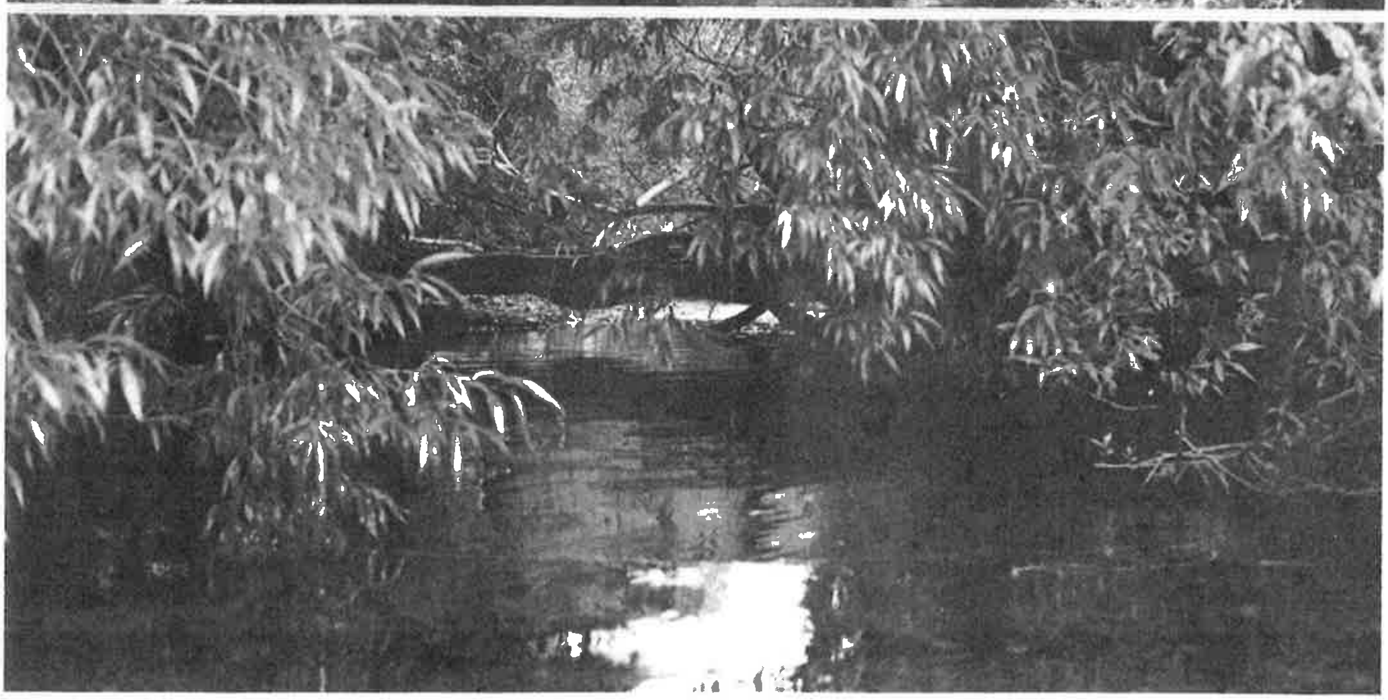
G. A. Eldon

Fisheries values of the Avon River were surveyed for the Christchurch City and Canterbury Regional Councils. The survey completed the trilogy of urban river surveys originally initiated by the former Christchurch Drainage Board.

First work on the Avon was carried out during winter, with a series of trout spawning surveys. The Department of Conservation assisted with the first survey, during which the entire catchment above tidal reaches was examined for potential spawning grounds. Subsequent surveys of gravelled reaches were the responsibility of MAF Fisheries.

During summer a selection of habitats throughout the catchment was electric fished or netted to determine species composition and distribution. In autumn a survey was made of the whitebait spawning reach. A preliminary report was issued to the councils in May. Species composition was similar to that of the Heathcote and Styx Rivers, but with different relative abundances.





Fish and benthic invertebrates in relation to riparian willows

G. J. Glova, P. M. Sagar

As an extension to investigations of the distribution of fish and benthic invertebrates in relation to riparian willow (*Salix* spp.) concentrations in the Shag (Palmerston south) and Wakapuaka (Nelson) Rivers in summer 1990, comparable work was carried out in the Tiritea Stream (Palmerston North) in late summer 1991. As in the previous studies, five representative sites were sampled in each of the subjectively chosen nonwillowed and moderately willowed sections of stream (*see* photographs). Both the abundance and biomass of brown trout were significantly greater in the willowed than in the nonwillowed section, which supported the findings in the other two rivers in the previous year. In each of the rivers, mean size of trout was greater in the willowed sections than in the nonwillowed sections, though the differences were not significant. Eels showed no such consistent pattern in population characteristics between streams, though their abundance in the Shag and biomass in the Wakapuaka were both significantly greater in the moderately willowed sections than in the nonwillowed sections. Other native fish species (e.g., bullies, inanga) showed no apparent relationship in their distribution to riparian willows.

However, several benthic invertebrate taxa showed highly significant differences in their abundance and biomass in relation to riparian willows, especially Ephemeroptera and Trichoptera. In each of the three streams, Ephemeroptera were scarce in the nonwillowed sections; the same pattern prevailed for Trichoptera in the Wakapuaka, but in the Shag and Tiritea they were more abundant in the nonwillowed than in the willowed sections. In all three streams, species richness and diversity of the benthic invertebrate communities were greater in the willowed than the nonwillowed sections of stream.

Opposite. Sampling fish populations in non-willowed and moderately willowed sections of the Tiritea Stream (above and centre), and a densely willowed section of the Shag River (below). Note the unstable banks in the non-willowed section. (Photos: Gordon Glova)

Northwest Nelson survey

G. A. Eldon

In February the Freshwater Fisheries Centre and the Department of Conservation Nelson Conservancy carried out a joint survey of fisheries of northwest Nelson. The Nelson-Marlborough Fish and Game Council also participated, and data were collected from isolated waters never before sampled.

The MAF helicopter, piloted by Compliance Officer Marshall Freer, was used to transport two two-man electric fishing teams to over 100 sampling sites over a 2 week period; sites ranged from just above the tideline to alpine regions. Seven people took part, though only five, including the pilot, were in the field at any one time. Three bases were used, at Karamea, Heaphy River, and Kahurangi Point.

The information collected provided data on fish distribution and habitats in the South Island.

Swan Burn, 300 m a.s.l.

Research on lake ecology and fisheries 1991–92

Rotorua and Christchurch staff formed a small research team in 1991 to study fish populations and fisheries in lakes. After a strategic planning exercise, four main research areas were focused on. These were: factors which influence trout abundance and distribution, factors which influence trout growth rates, research on hydroelectric reservoirs, and studies on sockeye salmon.

Although the emphasis at the present time is on trout fisheries, we expect to expand our research into native fish in lakes and lake ecosystems in 1992–93 when the National Institute of Water & Atmospheric Research is formed.

Distribution and abundance of trout, salmon, and other fish in lakes

Echosounding

D. K. Rowe

Conventional techniques for estimating fish populations in lakes involve extensive sampling programmes and logistical support not available in New Zealand. Echosounding techniques offer the potential to accurately measure fish populations and their distributions in lakes and deep rivers. Such measurements are needed if the responses to changing water quality (and climate) are to be determined.

Echograms have been analysed to show the seasonal distribution and diurnal migrations of fish in Lakes Rotoiti, Okataina, and Rotoma and the effects of environmental variables (temperature, oxygen, wind). The depth distribution of fish differed between lakes. In summer the hypolimnion deoxygenates in Lake Rotoiti and all fish are forced to remain above 20 m for several months. Light levels also influence smelt distribution and wind-generated, subsurface currents can have major impacts on the horizontal distribution of fish. A scientific paper has been submitted to the *N.Z. Journal of Marine and Freshwater Research* and another is in preparation.

Trout distribution and habitat in eutrophic lakes

D. K. Rowe

Variation in growth and age at first maturation was significantly greater for wild, lakeshore spawned rainbow trout than for hatchery trout in Lake Rotoma, and some wild trout ultimately grew larger than the hatchery trout. Differences also occurred between the distribution, the predominant foods of hatchery and wild rainbow trout, and between male and female trout. A manuscript describing these results has been prepared and internally reviewed.

Estimation of trout abundance by trapping spawning runs

E. Graynoth

The numbers of trout and salmon in lakes can be roughly estimated by trapping their spawning runs and densities expressed as numbers per hectare of lake surface. Examination of trapping data suggests densities range from about 21 per ha in Lake Hayes (1949) down to less than 1 per ha in large alpine lakes such as Lake Coleridge. The annual variations are also very significant, as shown by trapping records from the Ngongotaha Stream and other trout spawning streams.

Size, growth, and age of fish in lakes

Juvenile life history studies

J. W. Hayes

Issues pertaining to the survival of juveniles constitute an important facet in the understanding of the dynamics of salmonid populations in lakes. One issue that commonly arises is the importance of stream rearing to the survival of juveniles. Survival of fry may be dependent upon them attaining a certain size threshold before entry to a lake. This threshold may be related to feeding or to predator avoidance in the lake environment. Understanding life history requirements of juvenile salmonids has important implications for the management of lake fisheries, and lake and spawning/nursery stream habitat.

Early life history patterns in salmonids can be determined indirectly from studies of scales and otoliths. Changes in growth pattern on these structures may reflect the movement of the fish from one habitat to another, for example from a spawning/nursery stream to a lake. These growth patterns may be driven by temperature differences between habitats.

In Lake Taupo, recent research on the scale patterns of spawning rainbow trout has suggested that fry need to grow to 10 cm in the spawning/nursery tributaries to survive when they enter the lake. This equates to stream residence duration of between 6 and 12 months. It is thought that 10 cm is the minimum size at which trout can handle postlarval smelt, the main food available in the lake. This is not an unreasonable hypothesis for this lake, which has a food chain dominated by smelt and apparently poor, unproductive littoral habitat for juvenile trout. This research and other studies have made the Lake Taupo fishery managers aware that the production of trout in the lake was limited by the capacity of the tributaries to rear juveniles. Nothing is known of the life history requirements of juvenile salmonids in other lake systems in New Zealand. It would be particularly useful to undertake research on the life history requirements of juvenile trout in lakes that do not have food chains dominated by smelt, in contrast to Lake Taupo and other central North Island lakes — that is, most lakes in the country.

Studies on Lake Alexandrina, and on lakes in North America, have demonstrated that rainbow fry may emigrate downstream *en masse* after emergence from spawning gravels into the parent lake. The fry that rear in the spawning/nursery stream, for periods of a few weeks to a year or more, may represent only a small proportion of the total out migration into the lake. It is known from North American studies that once in a lake fry rear close to cover around the shoreline. Presumably in lakes that have stable water levels with plenty of cover around the shoreline, early lake migrant fry could contribute significantly to the recruitment of trout populations.

The Lake Alexandrina studies showed that the period of stream residence was variable and ranged from a few weeks to 6 or 12 months. Scales cannot provide information on life history pattern during the first month or two of life because too few circuli are formed for patterns to be determined. Instead, patterns of daily otolith ring formation may be used. Techniques for examining daily otolith rings in salmonids are well advanced overseas and have proved successful in studies of early life history patterns. These techniques are in their infancy for the study of freshwater fish in New Zealand, though the ageing group at MAF Fisheries Greta Point has considerable expertise in this area for marine fish.

I have begun a study attempting to determine whether daily otolith ring patterns can be used to distinguish between lake-reared and stream-reared rainbow trout fry. I am using Lake Alexandrina as a study system because much is already known about its rainbow trout population. I have been experimenting with techniques and am now reasonably confident that I can grind and polish otoliths and read the daily rings. I have obtained samples (30–70 fish) of recently emerged migrant fry and stream-reared fry from Scotts Creek, the main spawning/nursery stream, and lake-reared fry and adults from the lake and now plan to examine the daily otolith patterns of these fish.

Fin rays

M. Flain

Previous research has shown that fin rays are often better than scales for ageing trout. A comparison was made of the estimated age of 48 trout and chinook salmon from their fin rays and scales. It was found that more annuli were counted on the fin rays than the scales and that only 48% of the fish had the same age when both methods were used.

Scales

E. Graynoth

The rate at which fish grow is the primary factor which controls the formation of checks and annuli (annual checks) on scales. When growth is slow, narrow circuli are formed on the scales; when growth rates increase, the spacing between circuli increases and a check is formed. An annual check (annulus) usually forms in spring, when growth rates increase. However, checks form in fish in summer in some New Zealand streams, presumably because temperatures become too high and growth slows down. Conversely in lakes which are relatively cool in summer and warm in winter, such as Lake Taupo, growth continues unabated and no checks are formed on the scales.

Attempts were made in 1992–93 to determine age and growth rates directly from measurements of the width of circuli on chinook salmon scales. Although various equations were developed, more work is needed before the technique can be applied more generally. A method was also developed to estimate the age and growth rates of mature trout with eroded scales, as part of the headwater trout project.

If conventional scale reading techniques are to be used to age trout and determine growth rates, then research is needed to determine precisely when annuli and summer checks are formed and the factors responsible.

Fish stocks and fisheries in hydroelectric reservoirs

Hinemaiaia angling and trout study

B. J. Hicks, I. G. Jowett

Over the past 2 years adult and juvenile rainbow trout in the Hinemaiaia River, a tributary of Lake Taupo, have been monitored. The purpose was to determine whether the hydroelectric flow fluctuations were affecting the trout or angling and to advise the Department of Conservation whether any measures could be taken to improve the angling and productivity of the river.

The study of trout population changes showed that there was an early run of rainbow trout that entered the lower river in autumn and, after a period, moved to the furthest upstream reaches, where they spawned. The fry and juveniles from these early spawners were considered especially valuable to the Lake Taupo fishery because they had the opportunity to grow to a large size, enhancing their chances of survival on migration to the lake.

The instream habitat studies showed that there was less habitat for juvenile trout and food production at peak hydroelectric flow than at the low flow. However, close examination of the data showed that, though the area of suitable juvenile habitat was reducing, its location was the same. This was interpreted to mean that juvenile trout could occupy the same location in the fluctuating flow without being forced to move with the consequent risk of downstream displacement.

A survey of angler opinion showed general dissatisfaction with fluctuating flows, with the majority of anglers preferring to fish in lower flows when fish were more visible.

Lake Benmore and the Tekapo River

E. Graynoth, M. J. Taylor

Current fisheries research projects on Lake Benmore and the Tekapo River have now been completed with the issue of a report on the brown and rainbow trout spawning runs into the Tekapo River. Trout spawning surveys were carried out from 1977 to 1983, and the spawning runs were trapped in the Tekapo River, Mary Burn, and Grays River from 1980 to 1983. Other projects included research on the trout stocks of Lake Benmore and studies in the Tekapo River on trout food supplies, rearing habitat, and juvenile trout abundance and production.

The spawning runs in the Tekapo River ranged from 400 to 2000 trout per annum. Most trout spawned in the Tekapo River above its junction with the Pukaki River, and relatively few spawned in the tributaries. Brown trout were more abundant, older, and larger than rainbow trout. It was shown that the Tekapo River system is the major trout spawning and rearing area for the Haldon Arm of Lake Benmore. These spawning runs require protection to maintain the important trout fisheries in the Tekapo River and Lake Benmore.

Discussions have been held with the Department of Conservation about the programme to clear willows and spray herbicides along 3 km of the lower Tekapo River. This will recreate a natural habitat for rare riverbed birds such as the black stilt. The effects of this programme on fish stocks and fisheries is unknown and will be difficult to monitor as large, irregular floods from Lakes Tekapo and Pukaki will also influence the fish stocks.

Lake Pukaki

G. D. James

A report which describes the results of an Electricorp-funded programme undertaken in 1982–84 to investigate the trout stocks of Lake Pukaki has been completed.

Based on gillnet surveys, trout abundance was found to be extremely low around the lake shore (1.7 fish per 100 m of net per hour), though around river mouths catch rates were broadly similar to those recorded for most other lakes in the catchment. Rainbow trout were found to be less abundant and smaller than brown trout, in contrast to most other lakes in the area. Brown trout netted at stream mouth sites were significantly larger than those caught around the lake shore, whereas both browns and rainbows were generally in poor condition and grew slowly compared with trout in other waters.

Most of these characteristics of Lake Pukaki trout populations are likely to be related to the high concentrations of suspended sediments, though other factors such as low nutrient levels and limited spawning habitat may also limit the number and quality of the trout.

Lake Ruataniwha and upper Ohau River augmentation studies

G. D. James, E. Graynoth

Part of the recent agreement which renewed Electricorp's water rights throughout the Waitaki River system was that flows would be augmented in the upper Ohau River. This is scheduled to occur during 1992 and is expected to significantly increase trout stocks in the upper Ohau River and perhaps also have some impact on stocks in Lake Ruataniwha. Changes will be monitored and compared with information collected over the past 10 years during a series of Electricorp-funded studies on Lake Ruataniwha and the upper Ohau River.

A report which describes the results of various surveys carried out from October 1982 to December 1984 has been completed. Lake Ruataniwha and the adjoining Wairepo Arm were filled early in 1982, when the Ruataniwha Dam across the Ohau River was finished. Studies were undertaken to monitor trout stocks and fisheries in the lake and to recommend means by which they could be improved.

During their spawning run up the Ohau River, 400 brown trout and 89 rainbow trout were trapped. Juvenile brown and rainbow trout densities in the Ohau River varied and averaged 0.40 per m^2 and 0.05 per m^2 respectively. Trout grew faster in Lake Ruataniwha immediately after formation of the lake in the summer of 1982–83 than in 1983–84. Growth rates of brown trout were rapid and were similar to those measured for trout in Lake Benmore when it was filled. In comparison with other lakes, Ruataniwha contained average to moderately high stocks of small, well-conditioned, fast-growing trout.

Trout fry and fingerling densities, biomass, and production in the residual Ohau River were either equivalent to or higher than those found in the Tekapo River and its tributaries. This showed the residual river was a good habitat for rearing juvenile trout. Although it is difficult to assess whether enough fish were produced to adequately stock Lake Ruataniwha, there is no evidence stocking is necessary.

More recent studies undertaken in 1989–90 (James 1991, James *et al.* 1992) determined densities of juvenile and adult trout and native fish in the residual upper Ohau River and the Ohau Canal before flow augmentation. The latter report also suggested that, if augmentation occurred, then flows between 8 and 12 cumecs would provide good trout habitat, and flows between 10 and 12 cumecs should support high numbers of brown trout.

To complete the pre-augmentation studies, a further gillnet survey of Lake Ruataniwha was undertaken in March 1992 (James and Kelso 1992). This showed that although total salmonid abundance had changed little from the early 1980s, rainbow trout had become much less abundant, and brown trout and, to a small extent, sockeye salmon had increased in abundance. The reasons for these shifts in species composition are unclear, but warrant further study. Post-augmentation studies are being planned to monitor changes and ascertain how successful the increased flows have been.

Juvenile brown trout.

Lake Dunstan and the Lindis River

D. J. Jellyman, M. L. Bonnett

After numerous delays, the filling of Lake Dunstan commenced shortly after Easter 1992. Filling will be in stages, and, depending on the results of stabilisation studies, could be complete by the end of 1993. The water-right requirement that a hatchery be built has now been changed to allow for investigations to see whether a hatchery is needed. MAF Fisheries has carried out several pre-lakefill surveys of the area to be affected by the formation of the lake to obtain baseline information on fish stocks so that future changes can be measured.

Surveys have concentrated on the Lindis River because this will be the major spawning tributary for Lake Dunstan trout. A major concern about this river is the extensive abstraction of water for irrigation, and the impact this has on fish stocks. Drawoff of water is such that the river stops flowing in the lower reaches, often for several months; also, downstream moving trout fry and fingerlings become entrained in unscreened races from where there is no return back to the river.

A trust has been formed to oversee and fund appropriate studies on the development of the recreational fishery in the lake. Acclimatised fish already present are brown and rainbow trout, and some chinook salmon migrate downstream each year. Perch are thought to occur in the flooded dredge ponds that will be inundated as the lake forms; although this species is not a welcome addition to the fish fauna, it is also present at further locations upstream and, therefore, will eventually colonise the lake.

Lake Coleridge and the Wilberforce and Harper diversions

E. Graynoth, P. M. Sagar

Lake Coleridge is a large oligotrophic lake situated in the Southern Alps, about 130 km northwest of Christchurch. The lake supports an important fishery for landlocked chinook salmon, and hundreds of anglers fish the lake during the opening weekend of the fishing season.

In 1914 the Lake Coleridge power station began operating, and in 1921 the Harper River was diverted into the northwest corner of the lake to increase power generation. In 1977 the Wilberforce River was also diverted into the lake via the Oakden Canal. Both rivers carry substantial amounts of glacial silt and the visual clarity of the lake has declined significantly since 1977.

There has been concern for many years about the potential impacts of the Wilberforce Diversion on the fish stocks and fisheries of Lake Coleridge. However, there was little information available on the biology of fish in the lake or on their sensitivity to increases in water turbidity. The numbers and size of salmon in the spawning runs and in anglers' catches had fluctuated irregularly over the years and there was no clear evidence of any longterm trends.

Therefore, when Electricorp applied for a 10 year renewal of water rights to divert the Wilberforce River into Lake Coleridge in 1985, it was granted on the condition that the effects of the diversion on the fish stocks and fisheries should be monitored. Past studies on the lake were reviewed, and a research programme was undertaken using funds provided by MAF and Electricorp.

We found that the benthic fauna in the sublittoral zone of Lake Coleridge was dominated by the snail *Potamoprygus antipodarum*, chironomid larvae, and worms. In deeper water, below 18 m, worms were more abundant, whereas the numbers of snails and all other invertebrates decreased. The effects of siltation were determined by comparing the abundance of benthic invertebrates within 1 km of the Harper Diversion with samples collected 1–5 km away. Contrary to expectations, samples collected close to the diversion in 1967–68 had lower than average numbers of worms, average numbers of chironomids, and much higher numbers of snails and trichoptera. Therefore, siltation appeared to have little or no adverse effects on the invertebrate fauna at this time. Initial examination of more recent data suggests that the diversions still have had no gross effects on the benthic fauna, though final analysis has not yet been completed.

Bullies (*Gobiomorphus cotidianus*) were abundant near the Wilberforce and Harper Diversions and high numbers of large brown trout and rainbow trout were caught in gillnets near here. These fish were in good condition and had grown relatively rapidly. Salmon were difficult to capture in nets, and the few caught were large and in good condition.

Since the diversion was created in 1977 there has been no obvious decline in the numbers of anglers fishing the lake during the opening weekend and no statistically significant decline in either catch rates or the size and condition of fish caught.

Therefore, it appears that the Wilberforce Diversion has little effect on the aquatic fauna, fish stocks, or fishery of Lake Coleridge. Nevertheless, future impacts are difficult to predict and continued low level monitoring of the fish stocks and fisheries is required.

Sockeye salmon in lakes

Distribution and abundance of sockeye salmon

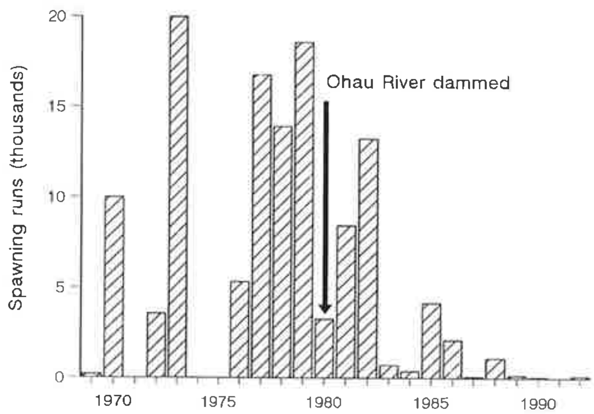
E. Graynoth, M. J. Taylor, T. P. Quinn (visiting scientist for 6 months from the University of Washington)

Larch Stream was trapped for the first time for 6 years, from 6 to 20 March 1992. Although 45 male and 40 female fish were caught in the trap and released upstream, none were seen in spawning surveys. It is suspected small runs of up to 100–200 fish could occur in this stream and escape detection. The fish averaged 276 mm in length and were large in size for 3 year olds from Lake Ohau. If the females survived they could have deposited a maximum of about 13 600 eggs in the stream.

Only three sockeye were seen in the boat harbour at Ohau C and none in the nearby stream. At least 11 spawned in the Aviemore Spawning Race and 17 were netted in Lake Ruataniwha. None were seen in the other locations surveyed, such as Stockyard Stream and Second Stream.

The spawning runs of sockeye salmon have declined dramatically over the past decade and, though small numbers are still present, their future is not secure. The fish may survive for the next decade with spawning runs of less than a few hundred fish. From 1 July 1992, Department of Conservation and the Fish and Game Councils will be responsible for the conservation and management of sockeye salmon. Discussions need to be held to discuss the current status and future of sockeye and other rare exotic fish species in New Zealand. Future possibilities include the improvement of spawning gravels at the Ohau C Stream, the stocking of Lake Benmore with hatchery reared fish, and the release of sockeye into new lake systems. Annual surveys will still be needed to monitor the status of the spawning runs.

We have collected additional information on fecundity and egg size and have sent tissue samples to Canada for electrophoretic analysis to provide a comparison of New Zealand and ancestral populations.



Decline of sockeye salmon spawning runs.

Salmon aquaculture

Genetic manipulation and sex control

C. L. Hopkins

In December 1990, a batch of 600 triploid juvenile female chinook salmon were transferred from Silverstream hatchery to Glenariffe for on-rearing with 600 diploid females of the same age (1990 year class) and size (2–3 g). Both groups were sired by sex-reversed females. The fish are being sampled for length and weight at bimonthly intervals to compare growth between the two ploidy types. During their first year, there was no significant difference in growth between triploid and diploid salmon, but triploids showed greater weight for length (higher condition factor) than diploids. From the start of their second year, growth of triploids has been significantly less than that of diploids. No differences in survival have been noted. It is planned to continue the trial until the end of summer 1993, when diploid females should be maturing.

Attempts to induce triploidy in salmon, by heat or pressure shock on newly fertilised eggs, are accompanied by high mortality during embryonic development. Therefore, we are investigating an alternative method which involves the use of tetraploid sires and normal diploid females to produce triploids. It has been found that in rainbow trout such matings provide higher numbers of viable triploids than do shock techniques on eggs of normal diploid parents. However, the initial problem is to produce an F1 tetraploid generation. In May 1992, females returning to Silverstream were stripped and their eggs fertilised by XX males from Glenariffe broodstock. Batches of these eggs were heat-shocked at half-hour intervals from the estimated time of start of karyokinesis (4 hours after fertilisation) to the estimated time of first cell division of the embryo (8 hours after fertilisation). Eyed embryos have been obtained from eggs shocked at karyokinesis, but samples have not been analysed for ploidy.

Sex-reversed female sockeye salmon stock

C. L. Hopkins

A random sample of 10 sockeye salmon from a broodstock of mixed XX and XY males (1989 year class) was selected to fertilise 10 batches of eggs, one male per batch. The protocol was similar to that used to produce XX male (sex-reversed female) chinook broodstock in 1989. At hatching the major part of each batch was treated with testosterone, the remainder being untreated controls. All sub-batches were reared to about 15 g, then the controls were sexed to assess which families were monosex female, i.e., had been sired by XX males. Out of the 10 control families, 3 were identified as monosex female. Their masculinised siblings were transferred to Glenariffe to form an XX male broodstock which can be used to sire monosex female progeny.

Salmon produce sales

C. L. Hopkins, G. D. James

Although the adult run returning to Glenariffe in 1992 was small, all egg orders were able to be satisfied. The demand for monosex female ova was high, and 1.6 million were sold to clients. Additionally, a small number of chinook and sockeye fry were reared for commercial requirements.

A release of 77 500 smolts was made to the Hydra Waters in April 1992. Organisers of the Rakaia Salmon Fishing Competition combined with North Canterbury Fish and Game Council and the Salmon Anglers' Association to fund and help with this release of fish initially raised at Glenariffe.

Salmon farmers reported to us this year that males have been found in captive stocks originating from MAF Fisheries as monosex female ova or XX milt. The proportion of males identified varied widely amongst farms. The cause is still under investigation. Tissue samples from about one third of the stock of maturing males (1990 year class) held at Glenariffe were genotyped and all were reported as of female (XX) genotype. Only these males were used to sire female stock in 1992. Samples of progeny are being on-reared at Glenariffe for eventual sex analysis to follow up a possibility that male modifiers could accumulate in the XX genome — an occurrence reported from some fish species, though not yet identified in salmonids.

Policy advice on salmonid fish health

N. C. Boustead

Technical knowledge in the area of our expertise on salmonid fish health is provided to MAF Policy at their request and provides input into policy formulation. Matters addressed this year have included information on the distribution of whirling disease in New Zealand, in connection with the efforts to gain access for salmon sales to Australia; the status of salmonid diseases in New Zealand, prepared for visiting officials from the Japanese Ministry of Fisheries; and information on proposed changes to the marine farming act and new aquaculture legislation.

Aquaculture Information Leaflet

N. C. Boustead, J. Potter, C. M. Whaitiri

This newsletter to salmon farmers was issued twice yearly to about 130 salmon farmers, MAF Fisheries staff, and others with an interest in salmon culture. The ninth and last issue (July 1991) contained information on the salmon bycatch, the Glenariffe Salmon Research Station open days, and the salmon disease course. The newsletter has now been incorporated into *Aquaculture Update*, a new quarterly publication produced by MAF Fisheries Greta Point, which is distributed to marine and freshwater fish farmers. Contributions of items about salmon culture and the Freshwater Fisheries Centre were provided for the new leaflet.

Bacterial gill disease on a galaxiid.

Salmon disease courses

N. C. Boustead

Another salmon disease course was organised for August 1991 by the Freshwater Fisheries Centre as part of extension services and to assist in the promotion of the production of healthy salmon and sound aquaculture practices. Most course attendants were from salmon farms, but others were from feed companies, universities, pharmaceutical companies, and MAF. The course offered a mixture of practical work in laboratories as well as lectures and included subjects such as basic salmon anatomy and physiology, diseases of chinook salmon in marine and fresh water, the law, environmental variables, and procedures for submitting fish for examination.

Fish health services

N. C. Boustead

Most submissions of salmon in 1991 were wild fish from anglers. These fish were affected by a great variety of wounds, lesions, or damage. Investigations into these abnormalities found that they did not appear to be caused by any form of infectious disease. The deformed fish were tested for whirling disease and all results were negative. Some of the damage was characterised by extensive haemorrhaging in the muscle and attributed to trauma. For some fish, wounds were consistent with predator bites.

The most common infectious disease was bacterial gill disease recorded from four fish. However, the disease is easily diagnosed and treated and did not cause significant losses. It was interesting to note the first report of bacterial gill disease in some captive alpine galaxiids. Other illnesses investigated included bloat in sea farmed chinook, enteric redmouth disease in freshwater farmed chinook, and nephrocalcinosis and sockeye syndrome, both in sockeye salmon. For all these, losses were not significant. Off flavours in fish were investigated and information on a wide variety of topics was provided to clients.

Larger contract jobs for clients were the licensing of the anaesthetic benzocaine for use on fish, reports on fish disease risks associated with a new salmon farming venture, and investigations into the role of diets on the incidence of bloat in sea farmed salmon. Health checks were carried out on salmon stocks for some clients.

Other species of wild salmonids and native fish were submitted for examination. These revealed the parasite *Eustrongylides* and other cysts in rainbow trout and fungal infections on koaro.

Disease status of New Zealand salmon stocks

N. C. Boustead

Whirling disease work has been written up for two publications: a paper has been submitted to the *N.Z. Journal of Marine and Freshwater Research*, and the data and other aspects of the work have been published in *Freshwater Fisheries Report No. 135*.

Other disease studies were the successful sampling of hatchery stocks for specific diseases for the fourth year of the programme. Results have been negative, which shows the importance of maintaining our policies on fish health. The results have been written up and submitted for publication.

Hatcheries

Glenariffe Salmon Research Station

S. P. Hawke, M. W. Tawa, J. R. E. Sykes, C. L. Hopkins, G. D. James

In 1991, a total of 1861 adult chinook salmon returned to Glenariffe. Almost all of these entered the hatchery trap; only 98 moved up into the old trap, which spans the Glenariffe Stream. Based on scale analysis, only 71 salmon out of the whole run were of wild origin. Of the returned fish, 15% were 2 year olds, 62% were 3 year olds, and 23% were 4 year olds. Because of the very low run into the stream trap, 46 males and 18 females were released upstream of the trap to join the natural spawners. A further 20 females, transported from MAF Silverstream hatchery, were also released into the Glenariffe Stream. About 400 000 eyed ova were planted in the headwaters of the main stream, though subsequent examination of the artificial redds indicated a low survival.

Ova stripped at Glenariffe were transferred to Silverstream for incubation. Later, 628 200 standard eyed ova and 356 000 all-female ova were returned to Glenariffe for on-rearing and eventual release.

Over 1 million smolts were reared in 1991–92 at Glenariffe, including 340 000 all-female stock reared for the Regal Salmon Company for release from Glenariffe to boost female returns. Almost all reared fish were, or are yet to be, released direct from Glenariffe. One batch of 77 500 was transported by helicopter across the Rakaia River to the upper catchment of the Hydra Waters, and an experimental batch of 5000 tagged smolts will be released to Otago Harbour during the winter.

The 1992 run of adult salmon into Glenariffe was even smaller than in the previous year, totalling 1571, of which 207 entered the old trap. Tagged fish numbered 154. Analysis of age structure and tag data for adult returns are not yet complete.

Ova retained in 1992 for on-rearing in 1992–93 at Glenariffe numbered 504 000 standard and 687 000 all-female stock.

Silverstream salmon hatchery

L. J. Hawke, C. L. Hopkins

Salmon returning to Silverstream in 1991 (321 fish, 80 of them tagged) and 1992 (228 fish, 57 tagged) contributed significant numbers of eggs to the total pool taken at the two MAF hatcheries. In both years, some salmon were released to spawn naturally at the end of the season. In 1991, some were also transported for release into the Glenariffe Stream.

The fall in numbers of adult returns to Silverstream since 1990 is considered to be due to the reduction in smolt release numbers made from the hatchery. From 1988, 10 000–30 000 smolts (of Glenariffe origin) have been released annually as against some 70 000 in 1987.

Over the last three years, with an apparently increasing annual incidence, many of the salmon returning to Silverstream had predator scars. Noticeable scars occurred on 26% of the fish in 1990, 37% in 1991, and 45% in 1992. The proportion of scarred fish has not been specifically recorded for Glenariffe returns, but staff there regard the percentages reported from Silverstream as being probably much higher than they would expect to observe at Glenariffe. This may indicate a difference in sea areas occupied or traversed by salmon from the Waimakariri and Rakaia catchments.

The total number of ova incubated at Silverstream in 1991 was 3.1 million, of which 1.3 million were supplied to commercial clients. In 1992, of the 4.1 million ova incubated, commercial farmers took 2.1 million, all of them female stock.

Eggs and mixed XX and XY milt obtained from Glenariffe were used for progeny testing of sockeye at Silverstream during the spring of 1991 to provide a sex-reversed all-female stock. The juveniles are currently rearing at Glenariffe. Contract research was carried out for an overseas company, which involved trialling a food additive on chinook salmon. Experiments on the induction of tetraploidy in salmon embryos were done at Silverstream during the autumn of 1992.

Opposite: Glenariffe Salmon Research Station. (Photo: Nelson Boustead)

Aquaculture of marron and carps

Marron

D. K. Rowe

In December 1990 Cabinet directed MAF Fisheries to carry out studies into the environmental consequences of marron. The major issues to be addressed by such studies were subsequently identified, and the design, cost, and timeframe of the work needed to resolve them were determined. However, events overtook these plans and in the end an agreement to remove all marron from New Zealand made any further study unnecessary. A report was subsequently published, and this detailed the ecological dangers of crayfish introductions and the main issues to be addressed in any impact assessment of marron, or any other crayfish, introduction to New Zealand.

Grass and silver carp

N. H. McCarter, R. van Boven

Funding for the grass and silver carp programme was transferred to the Foundation for Research, Science and Technology in 1991. The programme received a low priority rating for the 1992–93 funding round, and funding was withdrawn after July 1992.

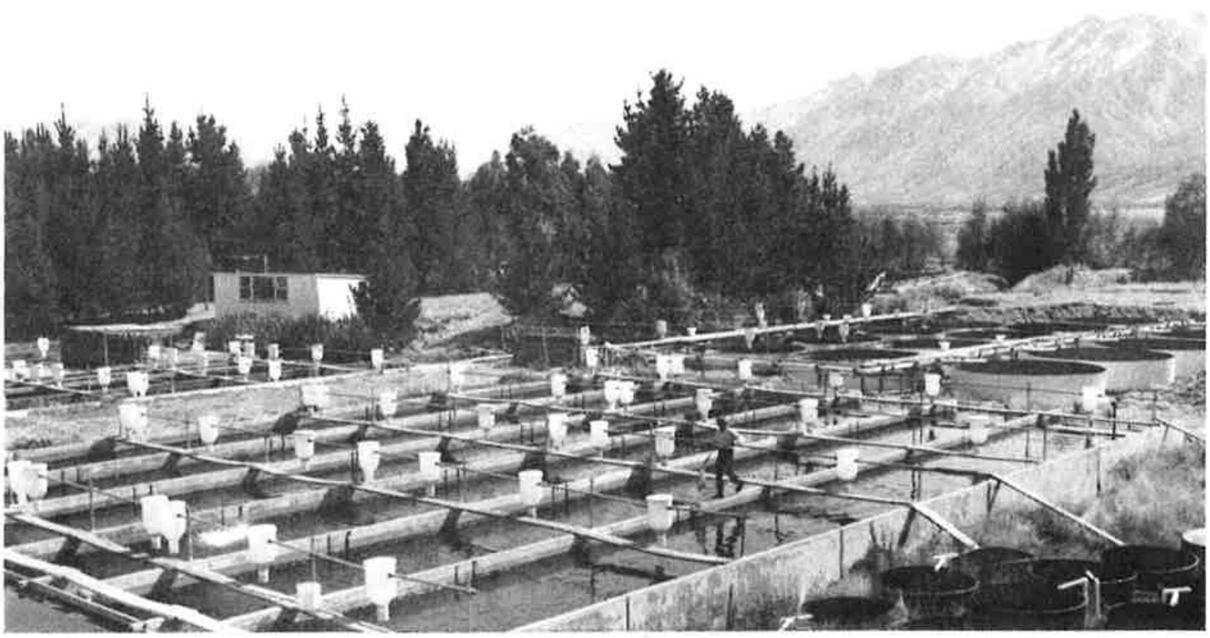
Grass and silver carp have been funded by the state for almost 20 years. The transfer of both species from government to private aquaculture has been suggested on frequent occasions over the last 5 years. However, the transfer process has proved difficult. Firstly, the political opposition to the use of grass carp for aquatic plant management has hindered the development of a market for carp. Secondly, the aquaculture of freshwater species other than salmon has not developed in New Zealand for economic and political reasons.

Under these circumstances, the withdrawal of funding is no surprise. If the species cannot be taken over by private sector aquaculture, there is little point in government continuing to fund the maintenance of stocks and research into induced spawning.

However, individual staff regret the curtailing of sound, exciting research ideas. The most promising avenue for research was the development of oral delivery systems for synthetic hormones. The programme was a collaborative venture with the School of Pharmacy, University of Otago. Oral delivery systems for short chain peptides, such as synthetic sex hormones, could have applications outside aquaculture, and the School of Pharmacy may continue this research independently.

The carp stocks will be transferred to NIWAR which intends to sell or lease the diploid carp stocks to private ownership as soon as possible.

During the year we developed new egg-hatching funnels and increased survival of eggs to hatch out by artificially hardening hatch water. We also developed a new method of observing particulate ingestion by fish larvae.



Administration

Fish farm licensing

B. J. Swale

Interest in freshwater aquaculture declined from that of the previous year. There was a steady trickle of enquirers about farming koura and eels, and to a lesser degree salmon, and many about freshwater aquaculture in general, but few of these have taken their interest beyond the enquiry stage. Five licences were granted to farm freshwater species during the year, including the first eel farm since the 1970s, and four for marine species farmed in on-land facilities. Two licences to process the produce of freshwater fish farms were granted.

Fish transfers

B. J. Swale

Transfers of fish from farms and from nonfarm sites have continued at usual levels of activity. Outbreaks of *Yersinia ruckeri* and detection of whirling disease at some sites have heightened awareness of the need for careful consideration of disease matters when live transfers are proposed. There were 61 transfers of farm fish and 138 transfers of nonfarm fish and other organisms approved during the year.

Electric fishing services

M. S. Weeks

In April, another electric fishing operators course was held at the Kyle Street laboratory. Subjects covered included electrical theory, safety, physiology of fish, and practical demonstrations of the effects of electricity on fish, and there were three electric fishing field trips. The final field trip consisted of a full population estimation study of a section of the Cust drain, about 10 km inland from Christchurch. Three electric fishing teams used different electric fishing methods to collect their data so that comparisons could be made. Fourteen people attended and successfully completed the course. Further courses will be held in 1992.

An electric fishing course for operators with overseas experience or previous experience in electric fishing, who wish to become certificated as operators in this country, is now available. Special conditions apply. Three people successfully completed this course this year. Details of all electric fishing courses are available from the Freshwater Division, National Institute of Water & Atmospheric Research Ltd, PO Box 8602, Christchurch.

In response to comments from clients, and feedback from the review of electric fishing services, all certification of equipment is now done at the Kyle Street laboratory, rather than part being contracted out. This has helped to streamline the process and to keep costs to users as low as possible.

Electric fishing equipment specifications were produced in 1991 and distributed to users. These will be superseded in the near future by specifications being prepared by the International Electrotechnical Commission (IEC). However, these should closely resemble the specifications that were distributed recently. As from 1 July 1992, the Ministry of Commerce will be responsible for all electric fishing regulations in force in New Zealand. We will be their approved agent to certificate equipment and operators. The Ministry will use the existing regulations and the IEC specifications as their standard.

Library

J. Potter

The library has gone from strength to strength over the last year. New shelving has been added to cope with continued growth.

Over 250 books have been added to the catalogue and five new serial titles are available for loan. We now receive over 180 journal titles either by subscription or free. Interlibrary loan statistics show that we have received 507 requests for articles or books and have applied to other libraries to borrow 336; both totals show a 50% increase on last year's totals.

The librarian has been responsible for printing, binding, and supplying the *N.Z. Freshwater Fisheries Miscellaneous Report* series, which has now reached issue No. 122.

A database of references pertaining to freshwater fisheries in New Zealand has been established and used to produce an index to *Freshwater Catch* magazine.

Juvenile alpine galaxias.

Freshwater Catch

P. M. Sagar

This magazine continued to provide current news and articles about all aspects of freshwater fish and fisheries in New Zealand. Recent issues have included articles about the Resource Management Act and fisheries, reviews of the 1991 salmon season, the salmon bycatch issue, the biology of native fish, climate change and its potential effects on fish, the management of koi carp, and the transfer of MAF's Freshwater Fisheries to NIWAR.

Although *Freshwater Catch* is published by MAF Fisheries, articles may be contributed by anyone with an interest in freshwater fish and fisheries. Recent contributors, other than MAF Fisheries staff, include Fish and Game Council, Department of Conservation, and university staff.

As from 1 July 1992, *Freshwater Catch* will be superseded by the NIWAR publication *Water & Atmosphere* and anyone wanting to receive the magazine should address their enquiries to:

The Subscription Clerk
Water & Atmosphere
Freshwater Division
National Institute of Water and Atmospheric Research Ltd
PO Box 8602
Christchurch.

N.Z. Freshwater Fisheries Report

S. F. Davis

During the past 18 months, a further 16 reports were published in this series, including the proceedings of two conferences — Salmon towards 2000 (No. 129) and the Fisheries-Forestry conference (in press). With the establishment of NIWAR, the future of the series is uncertain, but it is likely that a similar in-house publication for client reports will be established.

A complete list of reports in the series is available from:

The Library
Freshwater Division
National Institute of Water & Atmospheric Research Ltd
PO Box 8602
Christchurch.

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