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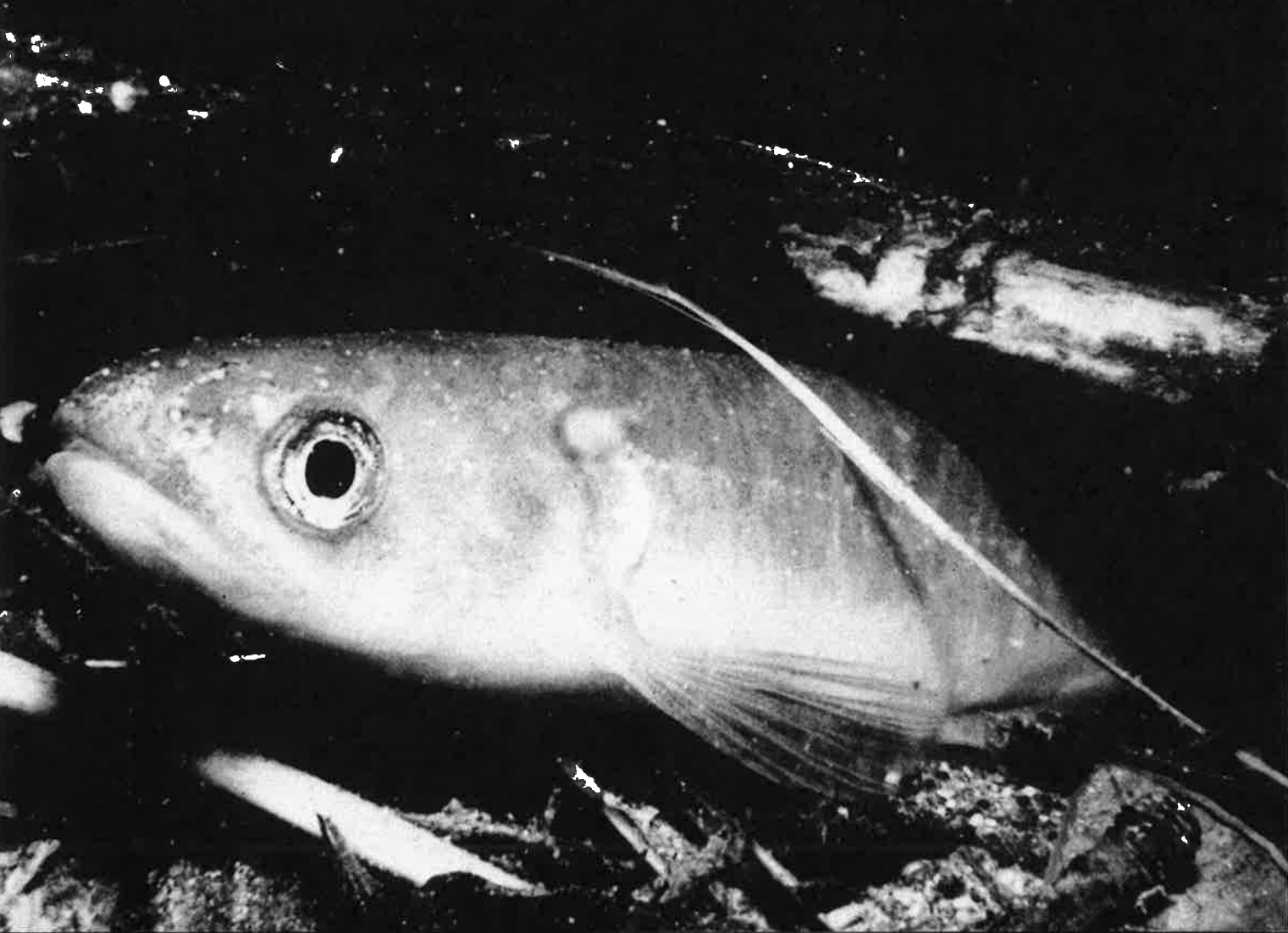
Freshwater Fisheries Centre Annual Report for 1989

New Zealand Ministry of Agriculture and Fisheries 1990



Freshwater Fisheries Centre Annual Report for 1989

New Zealand Ministry of Agriculture and Fisheries
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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.

Location directory

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Cover: Banded kokopu, sometimes known as native trout, occurs in small bush streams. Its juvenile forms part of the whitebait catch. (Photo: R. R. Strickland)

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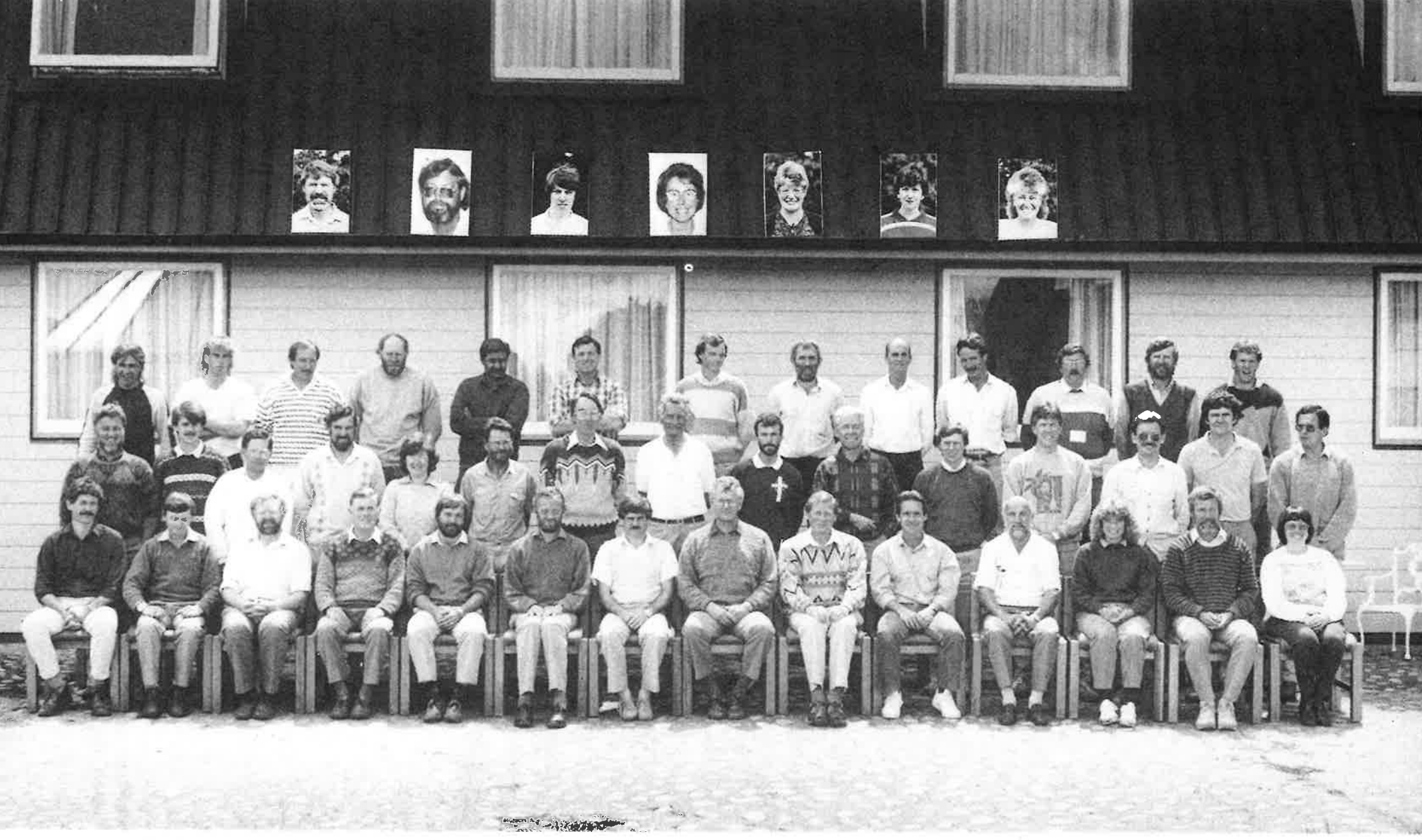


Freshwater Fisheries Centre staff. ***Back row*****: Tom Gough, Julian Sykes, Lindsay Hawke, Selwyn Hawke, Martin Tawa, Michael Weeks, Mark Taylor, Martin Unwin, Fred Lucas, Greg Kelly, Marty Bonnett, Kent Palmer, Simon Bloomberg.** ***Middle row*****: Ron Dougherty, Ben Chisnall, Kevin Roche, Gavin James, Jean Potter, Ian Jowett, Brian Swale, Tony Eldon, John Hayes, Malcolm Flain, David Rowe, J Graybill, Jacques Boubee, Charlie Mitchell, Mike Field-Dodgson.** ***Front row*****: Rowan Strickland, Trevor Washbourne, Nelson Boustead, Ceri Hopkins, Paul Sagar, Nigel McCarter, Peter Todd, Bob McDowall, Eric Graynoth, Brendan Hicks, Gordon Glova, Jody Richardson, Don Jellyman, Sally Davis.** ***Insets*****: Gerald Smith, Bob van Boven, Judith Hay, Madeline Lauder, Carol Whaitiri, Cynthia Murray, Shane Rogers.**

Introduction

The past year has seen the Freshwater Fisheries Centres in Christchurch and Rotorua, with their subsidiary units in Oamaru and Hamilton, settle into the cost-recovery/revenue-generating mode that is overtaking all Government research units. We have made a successful transition, even though the change in emphasis subjects staff to new stresses and new ways of doing things. It will no doubt be some years before we feel comfortable in the changed operating environment. Nevertheless, we are achieving our goal for the 1989/90 financial year of earning 37% of our gross expenditure. This revenue comes from four main sources.

1. Acclimatisation societies — funding is derived through the research levy on fishing licence sales;
2. Department of Conservation — contract research is funded under the transfer-funding programme instigated at the formation of the new department in 1987;
3. Electricorp — research relating to environmental impact and mitigation studies associated with the lower Waikato (thermal) and Waitaki (hydro) power scheme proposals, and studies relating to the issuing of Waitaki and Lake Coleridge water rights are funded by contract;
4. Salmon products — revenue is derived from sales of salmon ova, salmon smolts, and advisory and disease services to a diverse range of clients in salmon aquaculture.

Numerous smaller research contracts and revenue-earning services have also made a significant contribution to revenue, and their success to date in achieving these demanding revenue-earning goals. Like all other scientific institutions, we also face the challenge of applying for research funding from the new Ministry of Research, Science and Technology to sustain our research effort.

Modifications to Government administrative structures, though not directly affecting the Freshwater Fisheries Centre, have had their impact, and will continue to do so as changes to the structure of the acclimatisation societies are introduced, probably early next year. In addition, the demise of catchment boards and the incorporation of their functions into the new regional councils provides challenges and opportunities for work in freshwater fisheries.

During 1989, research planning took two significant steps forward. Firstly, a comprehensive strategic operating plan for research work was prepared. This has been circulated for comment to a diverse range of agencies with interests in freshwater fisheries research and management. Secondly, a Research Advisory Group is being established to provide advice to MAF on research directions. The group comprises representatives from acclimatisation societies, the Department of Conservation, and Electricorp, all of which are major clients with interests either in the management of fish stocks and fisheries, or in the use of the water that provides habitats for these. In addition, a major research planning meeting was held during early November to enable in-depth consideration of research directions and priorities, research and staff management, and sundry matters of general interest to staff. Particular attention was paid to our role in revenue generation: the need to develop our commercial skills, to obtain contract work and accurately cost it, and to ensure that clients obtain the services and information that they are seeking and paying for. There is, of course, a sense in which this always should have applied to our services, since Government, as our major paying "client", is entitled to have the same criteria applied to the work that we do for it.

Salmon research and management continued to consume substantial effort and resources. The establishment of an exclusion zone for large trawlers off Banks Peninsula during the period of the 1988/89 salmon run was greeted with acclaim by anglers, and in the view of salmon research staff came just in time. The run into the rivers was very low during the 1989 season, and that to Glenariffe was the lowest in nearly 25 years of records. However, the appearance of many small 2-year-old fish in the runs has encouraged belief in the likelihood of a recovery as a result of the exclusion, though it is too early to be certain about this. A judicial review of the decision by the Minister of Fisheries to establish the exclusion zone was sought in the High Court in November 1989, but it failed, thereby affirming the Minister's right to institute such restrictions. The sale of the first stocks of all-female salmon ova to salmon farmers was initiated during the year. This provided farmers with stock that would not be affected detrimentally by early maturation of small males. High demands for these ova could not be met because of the reduction in hatchery returns of fish from which ova could be derived.

We took several steps towards increasing publicity about, and awareness of, freshwater fish and their fisheries, and also of the skills and services available at the Freshwater Fisheries Centres. With the closure of MAF functions in publishing in Head Office, production of *Freshwater Catch* was transferred to the Christchurch Freshwater Fisheries Centre where desktop publishing software was used to produce camera-ready copy. Efforts to increase circulation of the magazine are being made with the co-operation of acclimatisation societies. A publicity brochure was inserted into all the annual reports sent to society members, and this resulted in a significant increase in subscriptions (about 25%). Two productions from the Rotorua Centre were a video that displays and discusses native fish and their habitats and the way that land and forest management affect fish stocks, and a dictionary of Maori fish names, to be published in the *New Zealand Fisheries Occasional Publication* series.

The most significant structural change during the year was the decision to close the Oamaru laboratory. As the work on the lower Waitaki, which has been mostly funded by Electricorp, has reduced, the need for a laboratory in Oamaru is declining, necessitating redeployment to Christchurch of the staff based there.

Staff changes during the year have been minimal, but Christchurch welcomed the arrival of Kevin Roche as Administration Officer. His accounting and financial skills are making a significant contribution to management. Two scientists have returned from overseas; they both have completed PhDs, David Rowe after 3 years at Pitlochry in Scotland (studying factors affecting maturation in Atlantic salmon), and Brendan Hicks after 4 years at Corvallis, Oregon, U.S. (investigating the impact of geology on the responses of catchments and their fish populations to deforestation). We look forward to them applying their new skills and attitudes to research in Rotorua.

The Freshwater Fisheries Centres continue to attract overseas visitors. Scientists from Canada and Sweden are currently in Christchurch for 6 month periods, and one from Canada is due for 3 months in late January 1990. These people bring the stimulus of fresh ideas and different perspectives to us, and their presence is greatly appreciated.

R. M. McDowall
Manager, Freshwater Fisheries

Staff list

(at December 1989)

Manager: R. M. McDowall PhD

Christchurch

Salmon research

Leader: P. R. Todd PhD *aquaculture, salmon, eels*
- **M. S. Field-Dodgson MSc** *salmon culture, salmon ecology*
- **C. L. Hopkins MA** *salmon production, aquaculture, sex control technology*
- **M. J. Unwin MSc (Distinction)** *salmon populations, computing*
- **N. C. Boustead NZCS** *salmonid diseases*
- **R. A. Dougherty** *salmon at sea, liaison*
- **T. Gough** *tagging*
- **L. J. Hawke** *Silverstream, sockeye*
- **S. P. Hawke** *hatchery manager, Glenariffe*
- **D. H. Lucas** *tagging, scale reading*
- **J. R. E. Sykes** *Glenariffe*
- **M. W. Tawa** *Glenariffe*
- **T. J. Washbourne** *fish transport*

Freshwater resource assessment and research

Leader: E. Graynoth BSc *recreational fisheries, effects of power development schemes*
- **M. Flain BSc** *scale reading*
- **G. J. Glova PhD** *fish populations*
- **J. W. Hayes PhD** *eels, trout fisheries*
- **D. J. Jellyman PhD** *eels, trout fisheries*
- **I. G. Jowett BE** *environmental simulation modelling, hydrology*
- **P. M. Sagar MSc** *benthic fauna, native fish*
- **M. L. Bonnett BSc, DipSc** *upland galaxiids*
- **G. A. Eldon** *native fish*
- **G. R. Kelly** *native fish, draughting*
- **M. J. Taylor BSc** *native fish, data bases*

Administration
- **K. F. Roche** *administration officer*
- **J. M. Hay** *senior clerk*
- **M. Lauder** *clerk (Rotorua)*
- **C. T. Murray** *clerk*
- **C. M. Whaitiri** *wordprocesser operator*

Science management
- **S. F. Davis BSc (Hons)**

Library
- **J. Potter BA (Hons)**

Statutory functions
- **B. J. Swale BSc, MA**

Electric fishing
- **G. B. Smith**
- **M. S. Weeks**

Oamaru

Freshwater resource assessment and research

Leader: G. D. James MSc (Distinction) *fisheries resources*
- **S. Bloomberg BSc (Hons)** *hydro development and fisheries*
- **J P. Graybill MSc** *salmonid ecology, regulated streams*
- **K. L. Palmer MSc (Hons)** *salmonid ecology*

Rotorua

Leader: N. H. McCarter BSc (Hons) *recreational fisheries, aquaculture*
- **B. J. Hicks PhD** *recreational fisheries, effects of land use*
- **C. P. Mitchell MSc (Distinction)** *native fish*
- **J. Richardson BSc** *freshwater fisheries database*
- **D. K. Rowe PhD** *salmonid biology, lake fisheries*
- **B. L. Chisnall MSc** *eels, native fish, koi carp*
- **R. R. Strickland** *native fish*
- **R. J. van Boven NZCS** *aquaculture*

Hamilton

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

Native fish

Maori names for fish

R. R. Strickland

A list of Maori names for fish, which has been compiled over the last 3 years, is to be published. It is titled "Nga tini a Tangaroa", and it will be available as a *New Zealand Fisheries Occasional Publication* in 1990. The list contains more than 1300 Maori names and includes marine and freshwater fish, molluscs, and cetaceans. Names are given in Maori to English and English to Maori, and the English list contains common and scientific references. The publication is aimed at identifying many of the Maori names which have never had English equivalents recorded, and it will serve as a basis for additions and alterations. A foreword has been provided by his Excellency the Governor General, the Most Reverend Sir Paul Reeves.

Freshwater eel studies

D. J. Jellyman

Dietary studies of both species of freshwater eel in Lake Pounui, Wairarapa, have been completed and published. Both species were found to feed intermittently on a wide range of organisms, though feeding by individual eels was often selective. Diets of both species changed with the size of the eels, and there were also differences in diet between the species. During a flood, the diets of both species changed markedly, because eels foraged on flooded lake margins and fed almost exclusively on earthworms and grassgrub larvae.

The infection of both species by the parasitic intestinal nematode *Hedruris spinigera* was noted during the diet study. Results showed that the incidence of infection declined with increasing size of the eels, though there was no evidence that this infection was detrimental to the wellbeing of the eels.

Work on the ultrastructure of glass eel otoliths is continuing. At present, juvenile eels are being reared in fresh water to determine whether the number of "fine" rings in the otolith are daily rings.

Age verification in eels by tetracycline labelling

B. L. Chisnall

A study of tagged eels in a Waikato pastoral stream is being used to calibrate a technique for determining eel age by examination of otoliths. The first sample, taken from the study stream in September 1989, returned 15 of the 47 tagged eels released in August 1988. The new type of internal tag used is incorporated into the mesentery and is easily identifiable. Nine of the tagged eels also retained their external, pan-jet inoculated, alcian blue markings. Otoliths from all 15 recaptured eels, as well as from 5 others, exhibited the fluorescence caused by the injections of tetracycline in 1988.

Tagged eels had grown very well, with length increments of between 36 and 108 mm for the year. Most of these eels had remained within 10 m of the site where they were first caught.

Age and growth of longfinned eels

B. L. Chisnall

A study on the growth rates of longfinned eels in the Waikato basin is underway to complement data gathered for shortfinned eels. Preliminary results suggest that growth is much faster in pastoral than in bush sections of four Waikato streams, and that longfinned eels from Lake Karapiro (a hydro impoundment) have some of the fastest growth rates in the country.

Sampling techniques for adult inanga

P. M. Sagar

Effective management of whitebait stocks relies on knowledge of the relative importance of various rivers as rearing and spawning areas for inanga. Studies of spawning habitats have been undertaken, but there is little information on factors which affect the growth and survival of adult inanga. Therefore, it is proposed to develop techniques for capturing adult inanga, as a prelude to identifying the habitats that they use and to predicting the density of standing stocks of the fish from the physical and biological features of their habitat.

Whitebait spawning grounds and requirements

C. P. Mitchell, G. A. Eldon

After spawning sites for inanga *(Galaxias maculatus)* in the major Bay of Plenty rivers were identified, a programme of management was begun. A major site on the Kaituna River has been fenced off and subdivided so that the effects of various levels of grazing pressure on whitebait egg survival can be determined. Over the 1989/90 summer, the Department of Conservation (DOC) and the regional water board will combine to begin effective management of other known spawning areas in the Bay of Plenty.

Identification of inanga spawning grounds in the South Island has continued. A spawning site at Lake Ellesmere was one of the successful discoveries; this

was one of the more difficult habitats to investigate, as the lake has an outlet only intermittently and does not conform to the normal estuarine pattern. On the debit side, no spawning locations could be discovered for the Mataura River, or its tributary, the Titiroa.

Included with the surveys on the west coast was the continued training of DOC staff in locating spawning areas. This resulted in DOC's discovery of spawning grounds in the Karamea system.

We intend to produce an illustrated field guide of spawning ground characteristics this year for use by DOC officers.

Canterbury mudfish

G. A. Eldon

No breakthroughs have occurred in the past year. A population of mudfish, established several years ago in an artificial pond near Tai Tapu, has died out because of the effects of the prolonged drought. There is no intention to restock this pond, as there is no point in establishing populations which cannot survive in the long term.

The idea of promoting the Canterbury mudfish as an aquarium and garden pond fish is being investigated. MAF Fisheries could supply fish from its self-perpetuating stock at prices calculated to discourage trivial purchasers, but low enough to discourage exploitation of wild stocks.

Otolith ageing in galaxiids

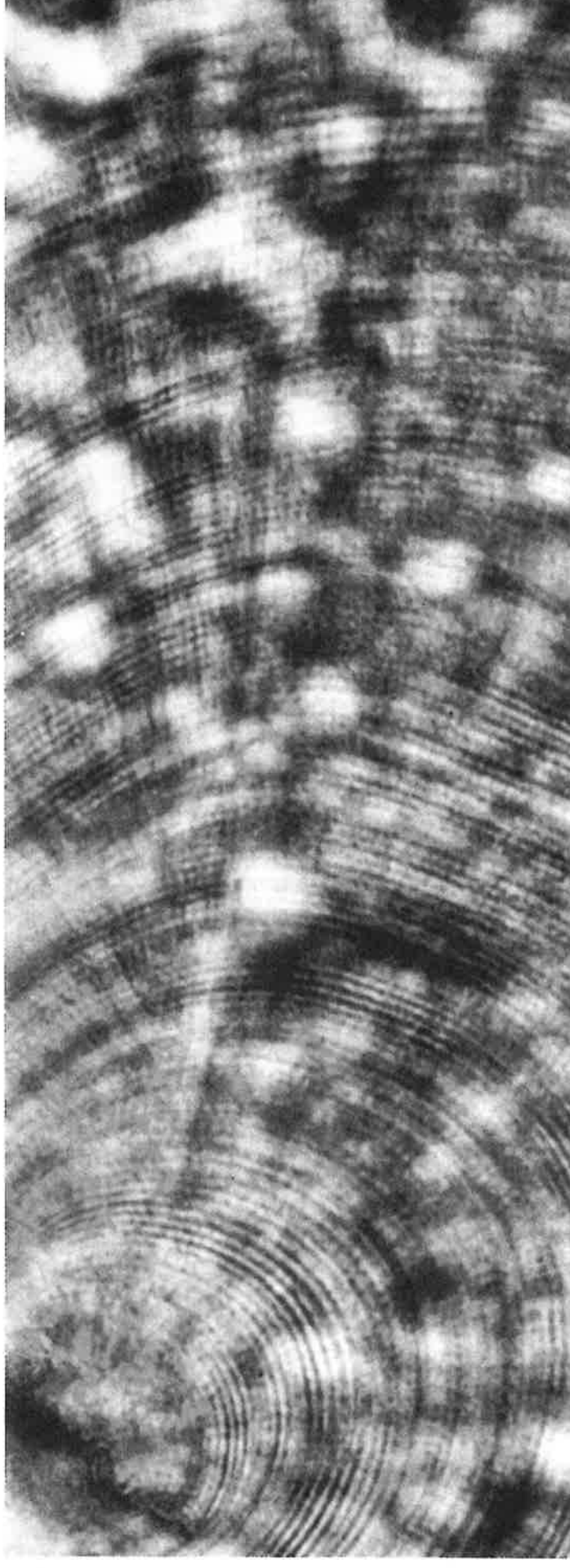
C. P. Mitchell

As with many other species of fish, whitebait lay down daily growth rings in their otoliths. Estimates of the age of samples of whitebait from three Bay of Plenty streams have been made, and the accuracy of the method has been checked by sampling otoliths from a laboratory-reared population of whitebait. Differences in the size of whitebait over the season were found to be linked to age. Later migrating whitebait are both smaller and younger than those caught at the beginning of the season. The spacing of daily growth rings may allow growth to be related to climatic and biological events in the ocean.

Fish passes for native species

C. P. Mitchell

The Department of Conservation and Electricorp have expressed interest in the concept of native fish passes over structures on New Zealand rivers. A summary of the present state of the art has been prepared and plans have been drawn up for a number of designs. Based on their swimming ability and adaptations, native fish can be ranked into four categories. The expense and difficulty of constructing



Daily growth rings in the otolith of inanga whitebait. (Photo: C. P. Mitchell)

fish passes for these categories increases with the ranking.

1. Insinuator-type passes. These passes use a trickle of water to wet brushes inside a pipe. They are very economical, but suitable only for elvers.
2. Climbing-type passes. These use the wetted margin of a trickle of flowing water. They are suitable for eels, climbing galaxiids, some bullies, and possibly lampreys.
3. Fish ladders. These use the pool and weir principle; if the design and scale can be optimised, these should pass all the fish listed in (1) and (2) above, plus smelt and inanga.
4. Fish elevators. These need testing, but may be suitable for all native fish, including grey mullet.

Our policy is to recommend the type of fish pass that is consistent with the management requirements of upstream fisheries. Downstream migration requirements, particularly for eels, have been identified as a key area requiring research.

Dietary overlap between common river galaxias and upland bully in a foothills stream

G. J. Glova, P. M. Sagar

Samples of common river galaxias (*Galaxias vulgaris*), upland bully (*Gobiomorphus breviceps*), invertebrate drift, and benthos were collected from the Hawkins River over a 24-h period in summer to determine dietary overlap of these two species. The common river galaxias fed primarily from dusk to dawn, whereas the upland bully fed throughout the 24-h period, though least at dusk and most at dawn (the times when the common river galaxias began and ceased feeding, respectively). Dietary overlap between these two species of fish was extensive, the main prey being larval *Deleatidium*, *Austrosimulium*, Chironomidae, and various Trichoptera. The terrestrial coleopteran *Costelytra zealandica* was common in the diet of the common river galaxias, but was not found in the diet of upland bully.

Upland galaxiids

M. L. Bonnett

Studies of the diet, spawning, age, and growth of two species of galaxiid (*Galaxias paucispondylus* and *G. prognathus*) are mostly complete. Both species spend their entire life cycle in fresh water, and they are sometimes found together in high-country streams of the South Island.

Their diets are quite similar and consist exclusively of soft-shelled aquatic invertebrates. *G. paucispondylus* spawns in mid winter, whereas *G. prognathus* spawns in autumn and late winter. Ripe females of both species contain few eggs (< 300), but they are large (up to 2.2 mm in diameter). This is typical of galaxiids which have a wholly freshwater life cycle. Although fish of age 4+ were found, most were either age 0+ or 1+, and, for both species, most growth occurred during the first year of life.

Now that we have a better understanding of their life histories, research on these two species may be directed at their distribution and habitat requirements.

Stokell's smelt

M. L. Bonnett

Smelt are best known for their spawning migrations, in which large numbers of fish migrate from the sea into estuarine areas in spring and early summer. Migrations of common smelt (*Retropinna retropinna*) occur in rivers throughout New Zealand, whereas migrations of Stokell's smelt (*Stokellia anisodon*) occur only in rivers along the east coast of the South Island from the Waiau River in North Canterbury to the Waitaki River in North Otago. Large concentrations of these fish are found only in large, silty, flood-prone rivers south of Banks Peninsula — notably the Rakaia and Rangitata Rivers.

The next objective of this study is to determine the length of freshwater residence and timing of sexual maturity of this species, which may in turn allow us to assess its vulnerability to commercial exploitation.

Native fish in the Whanganui River

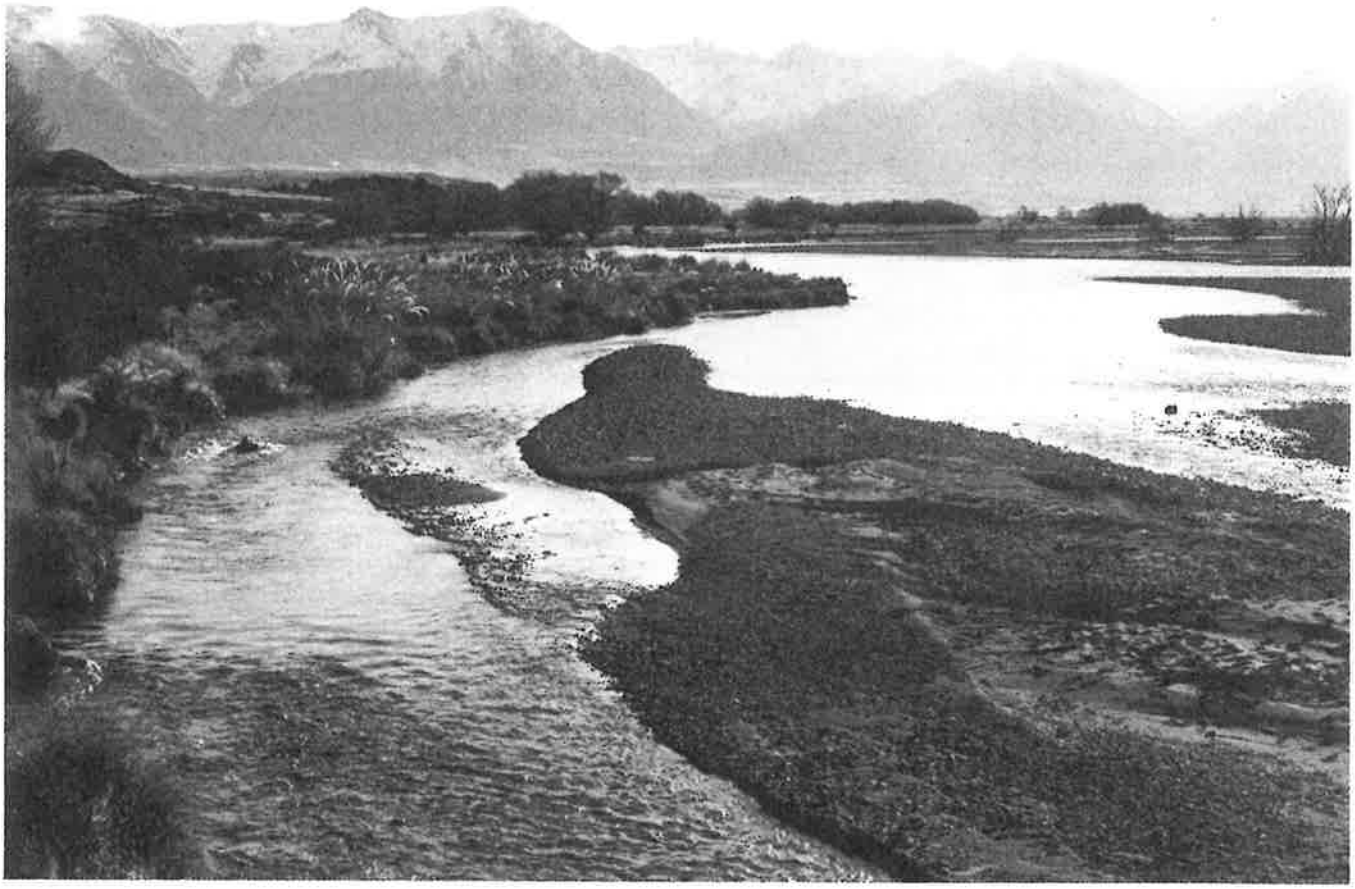
D. K. Rowe, B. L. Chisnall, J. A. T. Boubee

The native fish in catchments of the Whanganui River were surveyed for Electricorp. The composition of the fish fauna was similar to that in other large North Island rivers, but species diversity was low. Stations in the Whanganui River catchment contained fewer species and comparatively lower densities of fish despite the presence of suitable habitat. Differences in the time of sampling (i.e., winter versus summer) may explain some of the reduction in species diversity, but not all of it.

Freshwater fish database

J. Richardson, M. J. Taylor

MAF Fisheries maintains a computer database on the distribution of freshwater fish species. Over 400 new entries were added in 1989, bringing the total to 8320. Fourteen requests for information were received and processed for agencies other than MAF Fisheries. A system for allowing direct access to the database by outside agencies is being considered.



Typical upland galaxiid habitat, upper Rangitata catchment. (Photo: M. L. Bonnett)

Native fish video

R. R. Strickland, C. P. Mitchell

A 30-minute video, "New Zealand's Freshwater Native Fish", was produced this year for the Department of Conservation (DOC). Twenty fish species and the habitats they occupy are shown. The video highlights the many impacts affecting native fish, and explains why many of these fish are no longer, or rarely, encountered.

Filming took place in the Bay of Plenty and the Waikato between March and July 1989, and post-production was completed by August. Copies of the video are available from MAF Fisheries, Rotorua, or DOC, Wellington, at a cost of $39.95 (including GST).

Salmonid biology and fisheries

Analysis of salmon scale nuclei

D. H. Lucas, M. J. Unwin, M. Flain

Work on reading and classifying scales from a number of scale collections is now largely complete, and the information is being assembled into a database. This should
provide enough data to yield a semi-quantitative definition of the scale nucleus patterns associated with hatchery-reared fish and with the various life history types (e.g., "intermediate" and "stream") which occur amongst wild salmon populations.

Application of these techniques over the 1988/89 season has yielded some valuable results. For example, samples taken from the Tentburn hatchery and from anglers fishing below the hatchery outfall show that few of the fish entering the hatchery were of wild origin. This information negates anglers' claims that the hatchery was attracting wild fish (from the Rakaia and other rivers) to the detriment of anglers elsewhere. Scale analysis shows that over 90% of the fish which entered the Glenariffe trap this season were of hatchery origin. This result (which has been confirmed by coded-wire tag data for Glenariffe) means that the number of wild fish entering Glenariffe in 1989 (235 fish) was the lowest in 25 years of recording.

Biology of sockeye salmon

E. Graynoth, S. Bloomberg

For the third consecutive year no sockeye salmon were seen spawning in Larch Stream at the head of Lake Ohau. To reduce costs, the stream has not been trapped since 1985 and the size of the spawning runs has been estimated by spawning surveys (visual counts of the number of fish present). This method is less accurate than trapping and small spawning runs may have occurred and not been detected.

As in 1987 and 1988, fish from Lake Benmore spawned in streams and ponds near the Ohau C tailrace. About 130 fish were counted, which is well down on the run of 1100 fish in 1988. No evidence of disease was found in a sample of 35 spent fish.

Malcolm Flain reading and classifying salmon scale nuclei. (Photo: N. C. Boustead)

The fish averaged 326 mm and 363 g, and were mainly 3 years old. Examination of their otoliths suggested that they were the progeny of the 1986 spawning run to Larch Stream. In addition, small numbers of mature sockeye salmon were observed in the Tekapo and lower Ohau Rivers, and it is possible that some of these spawned successfully. More spawning surveys are planned in 1990 and 1991 to determine the status of the spawning runs to Larch Stream and Ohau C and to assess how to maintain the runs.

In February 1989 a few mature sockeye were seen by anglers in tributaries of Lake Brunner. These were probably fish from the 1985 release into Lake Poerua, which lies upstream of Lake Brunner. The West Coast Acclimatisation Society plans to survey these tributaries in 1990 and to assess whether attempts should be made to establish sockeye in Lake Brunner.

Coded-wire tagging programme

D. H. Lucas, T. Gough, M. J. Unwin

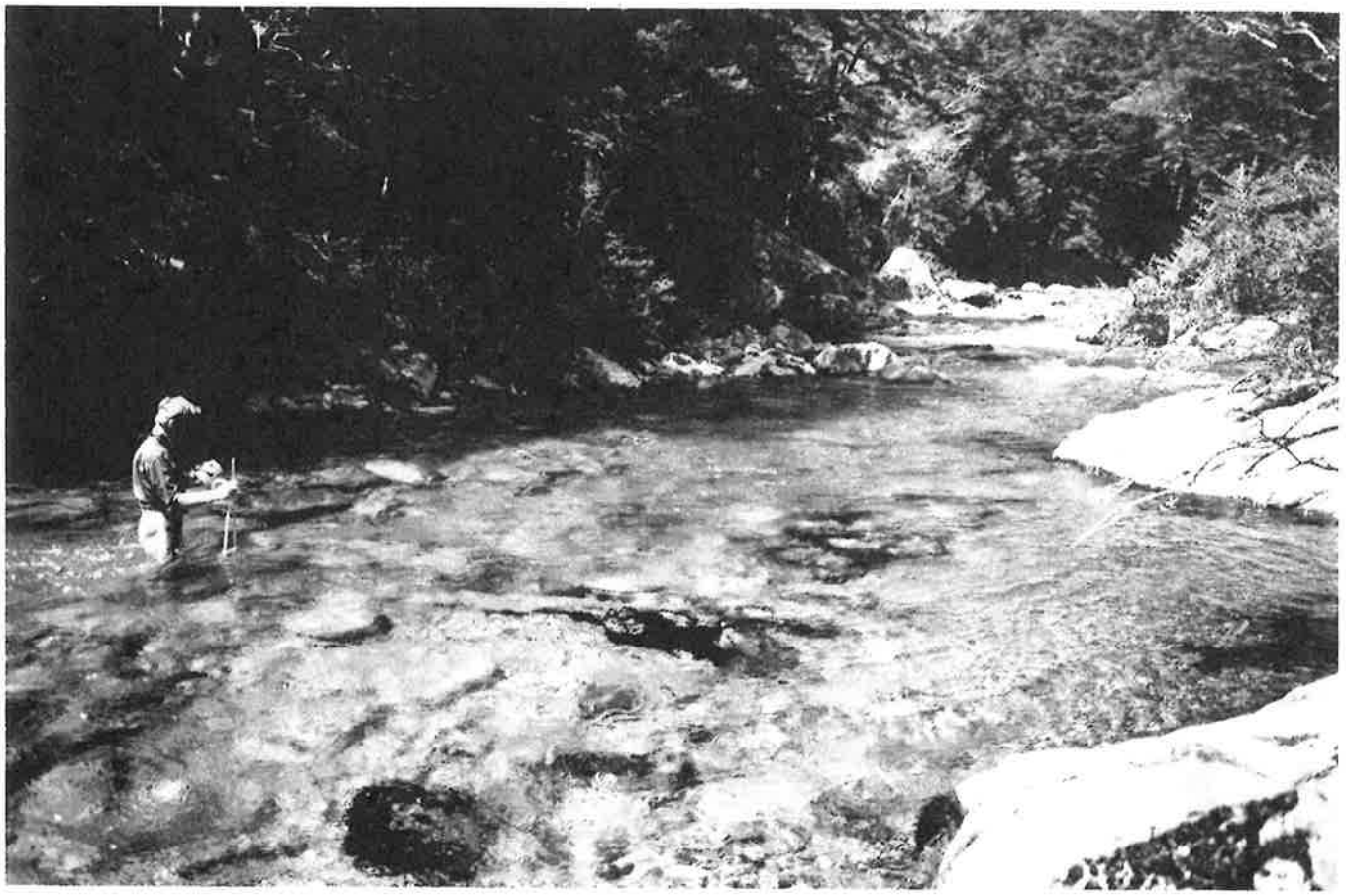
For the 1988/89 salmon season, 1000 tagged salmon heads have been processed at the laboratory, and 335 more have been intercepted and decoded by commercial salmon farms such as Tentburn. Most of the tags were recovered from fish caught in 1989, although 64 heads from the previous season (1987/88) were also handed in. As expected, few tags were recovered from 4-year-old fish, which reflects the poor survival of the 1985 brood. However, returns for the 1987 brood are more promising and this, together with the release of nearly 230 000 tagged fish in 1989, should increase the returns during the 1989/90 season.

Tagging programmes for the 1988 brood year included the release of over 60 000 tagged fish (in eight groups) from Glenariffe, and the release of 57 000 more (in 12 groups) for a variety of research/enhancement projects. These projects included three releases into Otago Harbour (after another good season for Dunedin anglers) and an experimental release into Lyttelton Harbour to see if the same release strategy can be used there. Fish reared at Glenariffe have been transported to and released into the Rangitata and Waimakariri Rivers.

Lyttelton Harbour salmon fishery enhancement

R. A. Dougherty

In July 1989, 5479 tagged and 6046 untagged hatchery salmon were released into Lyttelton Harbour in the hope of emulating the success of the Otago Branch of the N.Z. Salmon Anglers'



Greg Kelly recording water depths and velocities occupied by large brown trout in the Travers River. (Photo: J. W. Hayes)

Association's releases into Otago Harbour and the resulting sports fishery. This release was funded by the Lyttelton Promotion Council's "Lyttelton Harbour Salmon Fishing Club" (for which family tickets are available) and by sports goods retailers in Christchurch. The first returns of salmon are expected to be in the summer of 1990. A second release is planned for July 1990.

Radio-tracking of Rakaia River salmon

G. J. Glova

As the number of salmon returning during the 1988/89 season was low, no progress has been made in the radio-tracking programme. Twice in March 1989, test drift-netting was carried out over several kilometres of river and only two salmon were caught. The programme has been postponed to the 1989/90 season when, perhaps, the salmon runs will be greater. Sixty radio transmitters are available for the tracking programme, and we plan to tag 20 salmon during the early part of the run (December), 20 during the middle of the run (February), and 20 at the end of the run (April). The tagged salmon will be tracked to the headwaters of the Rakaia River.

Physical conditions of brown trout feeding habitat

J. W. Hayes

The depths, velocities, and substrate composition of brown trout feeding locations have been examined in the upper Mohaka and Travers Rivers. These rivers have been studied because they are clear and allow trout to be spotted easily from the bank. One of the aims of the study is to see if habitat use varies between rivers, taking into consideration differences in habitat availability. The feeding habitat data will be used with the instream flow incremental methodology (IFIM) in the modelling of habitat changes with flow in New Zealand rivers. The feeding habitat information previously used in IFIM studies appears to have underestimated velocities of large brown trout by at least 0.1 $m.s^{-1}$.

Drift diving ratification

J. Richardson

Drift diving is a quick and practical way to obtain trout counts from rivers where other techniques, such as electro-fishing, cannot be applied. However, controversy has arisen over whether a comparable measure of fish abundance is obtained among rivers within a certain range of underwater visibility and river form.

Field work will be carried out in the Mohaka and Rai Rivers early in 1990. A netted-off reach of river will be dived and about one-third of the fish removed. A second dive will be made the next day and the counts compared. Expansion of the project to rivers which are more difficult to dive will depend on results from these rivers.

Factors influencing the abundance of trout in rivers

I. G. Jowett

The drift diving method of assessing trout abundance in larger, clear water rivers has been described in a *New Zealand Freshwater Fisheries Report*. This report discusses the methods used to assess trout stocks at 158 drift diving locations in 93 rivers throughout New Zealand. It considers the accuracy of the method by reviewing ratification studies and comparing the precision of repeat dives with the variability of trout counts in different rivers. The geographical distributions of brown and rainbow trout are described and some of the factors influencing abundance are discussed. Stable flows were a feature of rivers with high abundance of both brown and rainbow trout, whereas fine substrate and little instream cover were characteristic of rivers with few brown trout. No further field work was carried out this year.

These data were analysed in more detail using classification techniques and discriminant analysis. This generally confirmed the impressions of the drift diving team, and showed that the distributions of brown and rainbow trout were determined largely by climatic (water temperature), geographical, and hydrological factors, whereas trout abundance was determined by instream habitat, flow variability, and river gradients. Low gradients and stable flows were common features of rivers with high abundance of brown and rainbow trout.

Headwater trout fisheries

D. J. Jellyman

Angling for large trout in remote and scenic headwater reaches of rivers is a highly valued pastime for increasing numbers of New Zealand and overseas anglers. However, little is known about the biology of the trout stocks in these sensitive areas and so a study programme has begun to identify these areas and to obtain information on the age structure and growth rates of the fish stocks. A list of recognised headwater/trophy trout areas throughout the country is being prepared with the assistance of regional fishery managers. This list will be compared with that obtained from responses to the national river angling survey (conducted by MAF Fisheries in the early 1980s). Experienced anglers and professional fishing guides have been asked to help to obtain scale samples from headwater trout and to comment on the behaviour of these fish when subjected to

increased angling pressure. Estimates of abundance in selected areas will be carried out by a limited drift diving programme.

Trout fisheries in water-supply reservoirs

D. K. Rowe

A feasibility study for the establishment of trout fisheries in one or more of the water-supply reservoirs in the Waitakere and Hunua Ranges has been completed for the Auckland Regional Council. The report examined trout habitat, food supply, and spawning areas, and identified those reservoirs best able to support trout populations.

Echosounding and fish distribution in lakes

D. K. Rowe

Echoes from various fish species have been identified in the Rotorua lakes. Aggregations of larval bullies and shoals of juvenile and adult smelt can be distinguished by the shape of their echoes; they occur at different depths. However, echoes from trout are sometimes indistinguishable from small schools of smelt, and fish in the top 2–3 m and bottom 1–2 m of water cannot be detected. (Rainbow trout are frequently found in these depths, so echosounding has limited application for population estimates of this species.) Nevertheless, the method is useful for examining distributions of fish and has produced valuable insights into the biology of the main forage fish for trout.

Drift divers tally their counts of large, medium, and small trout in the Tarawera River. (Photo: R. R. Strickland)

Trout distribution and habitat in eutrophic lakes

D. K. Rowe

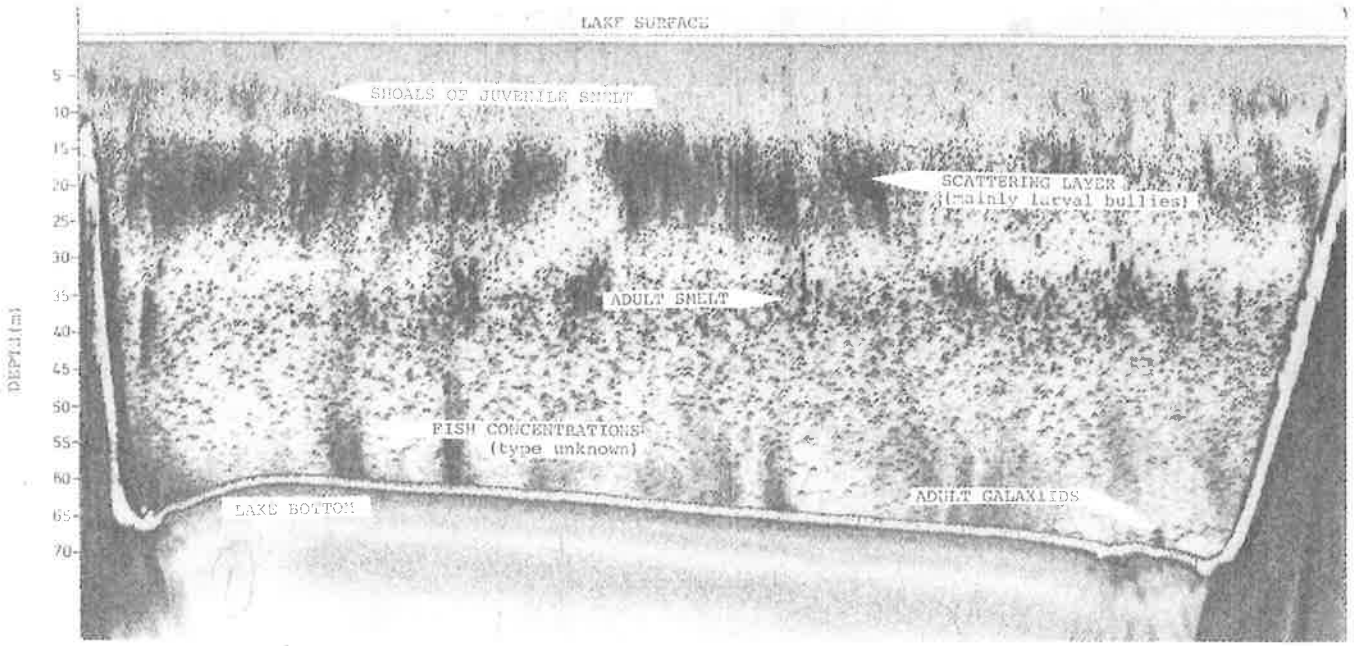
Many New Zealand lakes are becoming enriched as a consequence of agricultural development and urban growth. This eutrophication results in deterioration in water quality and the degradation and loss of trout fisheries in lakes. An understanding of how this occurs is needed if the loss of trout fisheries is to be checked.

Trout are visual feeders, and increased turbidity because of high planktonic biomass in eutrophic lakes causes summer feeding to change from smelt (which are the preferred food) to bullies (which are less preferred). This change in diet is accompanied by a change in distribution from surface waters to bottom waters. Echosounding studies have shown that trout are limited by the 20–21 °C isotherm and to oxygen levels below 3 ppm. In eutrophic lakes, high surface water temperatures force trout towards the bottom, low oxygen levels force them towards the surface, and the middle zone of habitable water becomes reduced. This restriction in habitat, together with the change in feeding, results in reduced growth of trout and a decline in the lake's carrying capacity for trout. The trend for trout fisheries in lakes to decline with increasing eutrophication could be exacerbated by increased warming due to the greenhouse effect.

Lake Ellesmere brown trout enhancement pilot scheme

G. J. Glova

A pilot programme to test the feasibility of enhancing the Lake Ellesmere brown trout fishery by stocking it with hatchery-reared yearling fish began in April 1989. Spawning brown trout were stripped at Glenariffe, the eggs were incubated at Silverstream hatchery, and the resulting fry were transferred to Glenariffe for rearing over the next 10 months to about a 50 g body weight. It was planned that about 20 000 fish would be available for release into the lake, but there will be a lot less, owing to culturing difficulties in the early fry stage. Before release into the lake the fish will be nose-tagged and adipose-clipped to allow their growth, survival, and contribution to the fishery to be determined. Fish will be recovered from anglers' catches, Selwyn trapping operations, bycatch from the eel and flounder fisheries, and experimental netting in Lake Ellesmere. The culturing and release of yearling brown trout into the lake will be continued for 3 years to assess the feasibility of the enhancement scheme.



Distribution with depth of small native fish in winter in Lake Rotoiti (North Island) revealed by high frequency (400 kHz) echosounding.

Climate change: impact on freshwater fisheries

G. J. Glova

As a participant in the Primary Impacts Working Group for the N.Z. Climate Change Programme for the past year, I was responsible for preparing a chapter on the impact of climatic warming on freshwater fisheries. The report emphasised that New Zealand data on fish responses to temperature variations are limited, which makes impact predictions difficult. Most native fish species are found almost throughout New Zealand, and so they may be little affected by temperature change, except perhaps by summer maxima. Impacts are likely to be greatest on salmonid and whitebait species. With the climate change, salmonids may become restricted to more southerly and higher altitude water courses. Rivers in and north of the Waikato area and in the eastern North Island, and some of the smaller and lower elevation lakes in the Rotorua area, would become marginal for salmonids. Whitebait stocks would decline as a result of the loss of spawning habitat in estuaries and wetland areas from rising sea levels and already reclaimed land.

Rakaia River invertebrate drift

P. M. Sagar, G. J. Glova

All work on this project during the past year has involved data analyses and writing of a manuscript about the drift dynamics of invertebrates in the Rakaia River. These analyses examined species composition and abundance of drift with respect to diel periodicity, vertical distribution, and seasonal patterns of occurrence.

As expected, the results showed defined peaks of abundance — during the night for aquatic invertebrate drift and during the day for drift of terrestrial origin. The density and biomass of drifting invertebrates was greatest in autumn, declined sharply between autumn and winter, and was lowest in spring before showing a marginal increase by summer. This pattern of abundance reflects the flow regime of the river, with floods during spring and summer decimating aquatic invertebrate populations. The distribution of drifting invertebrates in the water column was not uniform and varied with time of day and season. Perhaps the most significant result was that greatest densities and biomass of aquatic drift were recorded near the water surface at night, especially in autumn.

These data will be integrated with the results of recolonisation and fish diet studies completed earlier to obtain a better understanding of biological systems in our large unstable rivers.

Invertebrate habitat models

J. Richardson, I. G. Jowett

Habitat (water velocity, depth, and substrate) preference curves for *Deleatidium* spp., the most abundant invertebrate species in the Waingawa River and one of the most common species in New Zealand rivers, were developed.

A model developed using these curves showed that although there was a significant relationship between habitat suitability and abundance, there was a large random, or unexplained, component. A paper describing this work has been accepted for publication in the *New Zealand Journal of Marine and Freshwater Research*. Analysis of data from the Clutha, Hawea, Mangles, and Mohaka Rivers showed that relationships between *Deleatidium* abundance and habitat suitability are better defined in stable flow rivers. Work is continuing on this topic.

The upper Mohaka River, a nationally important trout fishery. (Photo: R. R. Strickland)

Effects of water and land management practices

Rehabilitation of streams after gold mining

G. A. Eldon, P. M. Sagar, M. J. Taylor, M. L. Bonnett, G. R. Kelly

The Big Hohonu River study has been discontinued, as no more useful data could be obtained. The results of the work are being published as a *New Zealand Freshwater Fisheries Report*.

The intention to continue this type of work on other waters has been frustrated by the difficulty of finding a study site with a suitable control area, despite continued monitoring of water right applications and some field visits. A proposal is now being considered to study a stream which was channelised when mining ended some years ago.

Toxicity tests

J. Richardson, R. J. van Boven

The Pulp and Paper Research Organisation (PAPRO) of the Ministry of Forestry has contracted MAF Fisheries to conduct seven 96-hour acute lethal toxicity tests of New Zealand pulp and paper mill effluents. The test protocol follows a Canadian standard which uses juvenile rainbow trout as the test organism. At present, test results are confidential to PAPRO and to the mills concerned, but approval for wider publication is being negotiated.

Whanganui Inlet freshwater fisheries survey

G. A. Eldon, M. J. Taylor, J. W. Hayes

Whanganui Inlet, on the northwest coast of Nelson, receives the waters of many small streams from steep, bush-clad catchments which are virtually unmodified. As the Department of Conservation (DOC) is contemplating establishing a marine reserve for the inlet and no freshwater or diadromous fisheries data existed for this region, a faunal survey was undertaken in October 1989. DOC, Nelson Acclimatisation Society, and MAF Fisheries staff combined to electric fish a number of streams, and MAF Fisheries will produce a report on the results.

Motueka River survey

G. A. Eldon

MAF Fisheries assisted Nelson Acclimatisation Society to survey the fishes of the Motueka system. Many rivers and streams were electric fished in this large catchment, and the detailed environmental data collected at each site have made a valuable contribution to the freshwater fisheries database.

Heathcote and Styx Rivers surveys

G. A. Eldon, G. R. Kelly

Results of a summer survey of the Heathcote River for the Christchurch Drainage Board have been published (*New Zealand Freshwater Fisheries Report No. 111*). The fish found were predominantly shortfinned eels, inanga, and various bullies; no trout were recorded.

This summer, we have been contracted to survey the Styx River fisheries. This popular trout stream should provide some interesting data to contrast with the Heathcote River data. The habitat data collected from the Heathcote and Styx Rivers will be used to extend our understanding of the interactions of trout and native fish, a subject of increasing interest.

Monitoring of fish communities in Lake Whangape

J. W. Hayes, B. L. Chisnall

This study follows on from a comparative study of the fish communities of Lakes Waahi and Whangape which was undertaken to assess the impacts of coal mining in the lower Waikato basin. Since the mid 1980s, the water clarity and aquatic macrophyte beds of Lake Whangape have declined. We hope to monitor this lake for 5 years to see how the fish communities respond to environmental changes. The results of the comparative study between the two lakes suggest that most members of the fish community in Lake Whangape will be able to cope with a further deterioration in water clarity and macrophytes.

Effects of timber harvest on salmonids

B. J. Hicks

This study was made during the past 4 years at Oregon State University, Corvallis, for a doctorate in fisheries science. Salmonid populations were assessed in Oregon Coast Range streams using a combination of diving and electric fishing. The distributions of juvenile steelhead, resident rainbow trout, cutthroat trout, and coho salmon were found to be related to rock type and channel morphology of the streams. Coho salmon dominated streams in sandstone, whereas steelhead and trout preferred the higher-gradient streams found in basalt. Flow gauging data suggested that summer low flows were reduced as a long-term result of logging, but there was little effect of timber harvest on channel morphology.

Long-term effects of timber harvest on summer stream flows

B. J. Hicks

Removal of mature forest cover has been shown to increase summer water yield. However, most studies have concentrated on the period between logging and about 10 years after. Examination of longer term records of summer stream flow in paired watersheds in the H. J. Andrews Experimental Forest, Cascade Mountains, western Oregon, U.S., showed that increases in water yield were short lived (up to 8 years after logging). Subsequently, summer low flows were substantially below pre-logging values. This condition persisted up to 1988, 27 years after logging started.

Salmonid survival has been linked to the levels of summer low flows, and it is thus possible that forest management practices affect fish production.

Mohaka National Water Conservation Order

J. Richardson

MAF Fisheries presented evidence to a Planning Tribunal hearing in Napier in July 1989 in support of an application by the Hawke's Bay Acclimatisation Society for a National Water Conservation Order for the Mohaka River catchment. MAF's evidence relied heavily on results from our national river angling survey, which identified the Mohaka mainstem as one of only nine nationally important angling rivers in the North Island. At December 1989 the tribunal's decision had not been made public.

Environmental consulting

J. W. Hayes, G. A. Eldon, N. C. Boustead, M. L. Bonnett

The latter part of 1989 was a busy period for commercial environmental consulting. Fisheries surveys were undertaken for mining interests on the west coast, and for salmon farming interests in Marlborough. Fisheries information was reviewed for the objectors to the Mataura River National Water Conservation Order, which was applied for by the Southland and Otago Acclimatisation Societies. A contract was negotiated with N.Z. Coal Corporation, Huntly, to review the fisheries status of Lake Waahi. This is related to water right renewal applications by the Corporation for the Huntly west mine.

Releasing elvers into Lake Matahina during studies on designing a fish pass for the 80 m high dam. (Photo: J. A. T. Boubee)

Effects of power development

Fisheries studies for Electricorp Northern Hydro Group

J. A. T. Boubee

This work has involved monitoring fish stocks in habitats affected by hydro-electric generation in the North Island. A fish survey of Lake Matahina was undertaken and advice given on the design of a fish pass to allow elvers to migrate over the 80 m high dam. In Lake Aratiatia macrophytes are causing serious generation loss and lake lowering is being considered to cause frost kill of the aquatic plants. Fish surveys were carried out to help determine the effects of this.

Land use in the Wanganui catchment appears to be seriously affecting fish stocks. An electric fishing survey of the catchment was undertaken to extend our fish distribution database.

During headrace and tailrace dewatering at the Arapuni dam (to carry out major structural repairs), help was given to rescue fish, and fisheries information was collected. In the tailrace (which forms the head of Lake Karapiro) a good population of large longfinned eels was found, a rarity in the Waikato catchment these days.

Lower Waikato River fisheries studies

J. A. T. Boubee, C. P. Mitchell, with assistance from temporary staff

The Waikato fisheries group is still largely dedicated to monitoring the effects of thermal discharges on fish and fish communities in the lower Waikato River for Electricorp Northern Thermal group.

A large volume of Waikato River water is required for cooling purposes at Huntly thermal power station. During downstream migration, many fish (mainly eels) impinge on the screens. A study of the screens has provided valuable information on the timing of fish migrations. At our suggestion, the intake screens have been modified and there has been substantial improvement in the survival rate of trapped fish.

Many glass eels (young eels which are not fully pigmented) and elvers migrate past Huntly power station, which is about 80 km from the sea. This migration is not confined to the river margins, as previously thought, but occurs over the entire river bottom. These studies have shown that an elver pass at the power station is unnecessary.

During spring and autumn, thermal discharges from the Huntly and Meremere power stations attract many fish, especially small mullets. These unusual concentrations of fish may sometimes attract large numbers of predators (including recreational fishers). Field studies are being undertaken to determine the consequences of these aggregations on the fish populations.

To minimise the effect of thermal discharges on the Waikato River, Electricorp is researching means of improving mixing at the outfall. Several modifications to the discharge structure are being considered and assessed in terms of their impact on upstream migrating fish, particularly inanga.

Last year's study of inanga migration into the Waipa catchment showed that fish tended to avoid waters from the Waipa River, especially at times of high water level. This may result from the high silt load carried by the river, and laboratory studies are being made to test this theory.

Data analysis and reporting on ichthyoplankton in the lower Waikato River is continuing, in co-operation with A. Meredith and P. Empson (who are now with the Waikato Regional Council). Smelt dominate the drift, and the catch of larvae increases markedly below Huntly. Highest densities were found in mid river at night, although there was a significant annual variation in abundance.

Grey mullet biology in the Waikato River

J. A. T. Boubee

The Waikato River supports a sizable traditional, recreational, and commercial mullet fishery, yet little information is available on the biology of the species. Studies are continuing on the migration, feeding, and reproductive biology of this warm water fish.

Smelt biology in the lower Waikato River

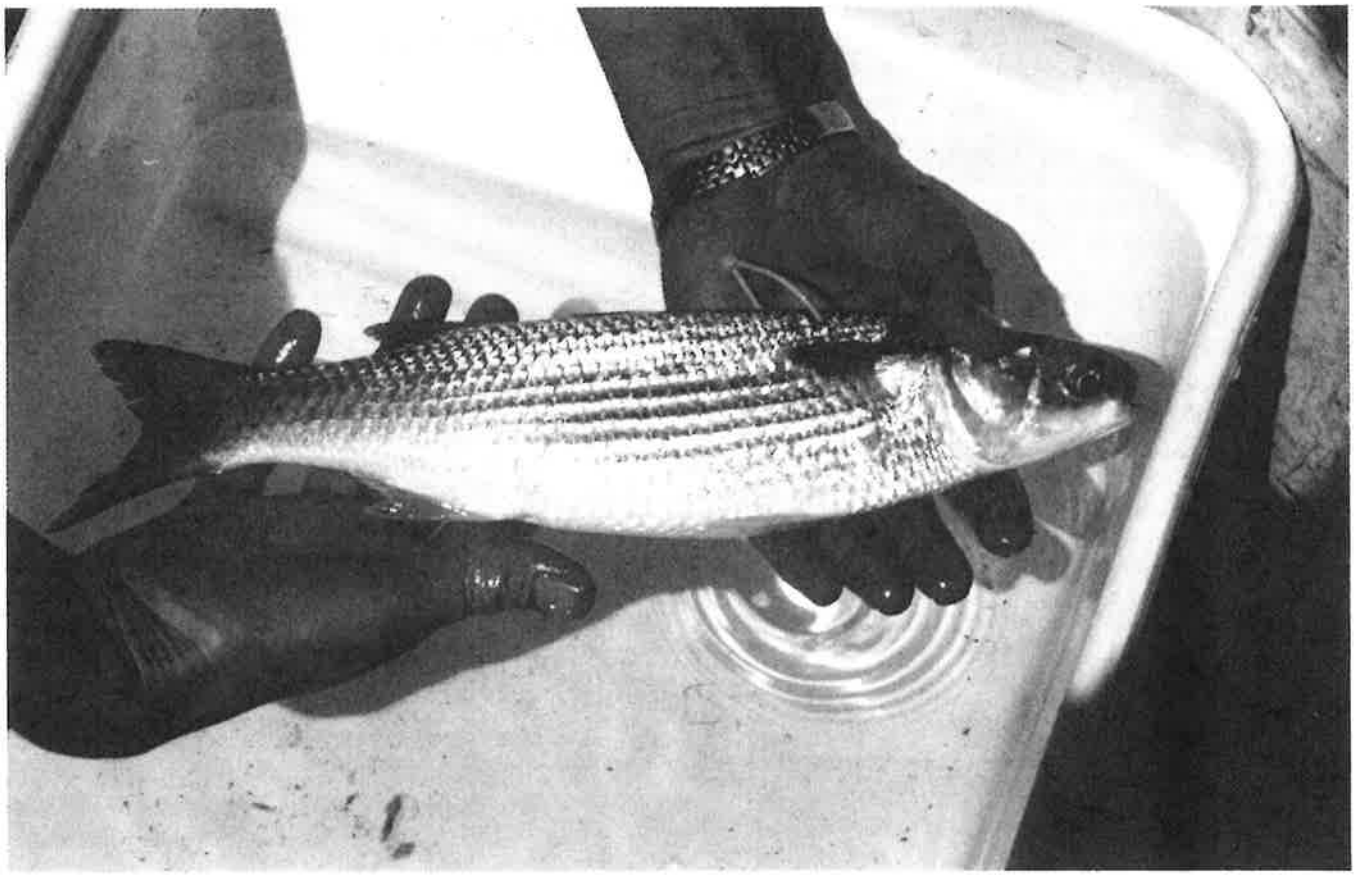
J. A. T. Boubee

Lacustrine and riverine smelt differ not only in their morphology but also in the timing of their reproduction and in the size of their eggs and larvae. These differences may be adaptations to habitat. Studies on the feeding and general biology of the fish are continuing.

Exploitation of Waikato River fisheries

J. A. T. Boubee

To determine the status of Waikato River fisheries, up-to-date records of commercial, recreational, and traditional fisheries are being sought. Information gathered so far suggests that fish stocks are declining alarmingly. For example, the 1988 commercial whitebait catch was the lowest on record, and catches



Tagging mullet in the Waikato River. (Photo: J. A. T. Boubee)

in 1989 appear to be even lower. Similarly, complaints have been received about poor eel returns. However, because catch records for eels are returned on a voluntary basis, no accurate data are available. Contact with fishers, processors, and groups involved in the fisheries will be maintained to improve our records.

Lake Coleridge water right monitoring

E. Graynoth, P. M. Sagar, M. J. Taylor

Over the past year, five species of fish (quinnat salmon, rainbow and brown trout, and upland and common bullies) have been taken from Lake Coleridge to clarify the food webs in the lake. Juvenile fish were obtained by beach seining the littoral margins of the lake, and gill nets (set overnight) and anglers' catches provided samples of adult fish. In total, 447 salmonids (109 salmon, 254 rainbow trout, 84 brown trout) were obtained from the lake, although it was difficult to obtain large salmon during winter.

The diet analyses for all species have been completed; the results are being analysed and a final report is being prepared. There appear to be strong differences in diet with fish species, season, locality, and fish size. Although benthic invertebrates provide an important staple diet for salmonids throughout the year, bully juveniles and fry are consumed by trout and salmon of all sizes in winter and autumn when the number of terrestrial and aquatic insects on the water surface declines. Galaxiids (koaro) and, rarely, quinnat salmon fingerlings are eaten by the larger salmonids.

Juvenile bullies of both species consume chironomids and zooplankton, which are replaced by snails, oligochaetes, and benthic invertebrates when the fish become larger. The presence of a particular snail species in the largest adult specimens suggests that older bullies forage in deeper water than the younger fish.

During the year, divers collected 85 quantitative benthic samples from near the Wilberforce diversion at depths of 9 m and 18 m along four transects of the lake. These samples have been sorted and identifications of the major species are being checked.

The benthic invertebrate fauna of Lake Coleridge is typical of South Island high country lakes; the few species that occur are dominated by gastropods and chironomids, which may reach densities of several thousand per square metre.

Once final identifications are completed, the data will be examined to determine any association between species composition and abundance of the benthic fauna and the composition of the aquatic macrophytes in the lake.

Lower Waitaki River salmon studies

G. D. James, S. Bloomberg

Information collected from postal surveys of anglers during the 1985, 1986, and 1987 seasons and from a creel census in 1988 have been written up for publication. Estimates of angler effort and catch show that the lower Waitaki River has a salmon fishery which is at least as good as any other in New Zealand. Exploitation rates (the proportion of the total run taken by anglers) during the seasons surveyed were about 50%.

The annual helicopter survey of salmon spawning was completed in late May, and although only the Hakataramea River could be surveyed (because of poor water clarity in the Waitaki River) the numbers of spawners were about equal to the long-term average, and about twice those of the previous year.

Length, weight, age, and condition data were collected in the annual angling competition, as well as samples of eggs for the estimation of fecundity.

Lower Waitaki River adult rainbow trout

G. D. James, S. Bloomberg, J P. Graybill, K. L. Palmer

Drift-netting studies in the lower Waitaki River to assess the distribution and relative abundance of medium to large rainbow trout (and any brown trout caught incidentally) have been completed. Conclusions to date can be summarised as follows.

1. Brown trout were caught, on average, twice as often as rainbows;
2. catch rates were higher in the Kurow area than further downstream; and
3. average size of both trout species decreased in a downstream direction.

Age data and tag returns from the drift-netting studies are yet to be analysed.

The Awakino River rainbow trout spawning run has again been trapped, with major logistical support from the Waitaki Valley Acclimatisation Society. The 1989 run was the largest of the 3 years trapped — 328 males and 494 females. These numbers indicate that this small river is of major importance for rainbow trout spawning in the lower Waitaki system. The biological data collected are currently being analysed.

Lower Waitaki River rainbow trout recruitment

J P. Graybill, K. L. Palmer, S. Bloomberg, G. D. James

Studies have continued to assess recruitment of rainbow trout into the lower Waitaki River and to assess the effectiveness of the Aviemore spawning race as a means of supplementing rainbow trout stocks in the proposed residual river. We tested two trap types, an inclined plane and a modified fyke net, in the lower Waitaki tributaries (Awakino, Hakataramea, and Maerewhenua) to capture juvenile trout migrating down stream. Though both were effective at capturing juveniles, the fyke net was better because it was easier to set and retrieve, less sensitive to debris and flow change, and therefore required less maintenance.

Downstream-migrating fry were captured in peak numbers from late November to mid December, although we missed sampling the early part of the migration. The fry migration pattern did not appear to be related to flow. Some fry remained in the tributaries to rear as fingerlings. These fish moved down stream in low numbers throughout the year, but their movement was usually associated with a fresh.

In the Aviemore spawning race, peak numbers of downstream-migrating fry were captured from late November to mid December, but again we missed sampling the early part of the run. Few fingerlings remained to rear in the race, presumably because of poor rearing conditions.

The total numbers of fry migrating down stream over the sampling period were estimated for each of the tributaries and for the spawning race. Two progress reports (one for the tributaries and one for the spawning race) prepared for Electricorp included recommendations for completing the second year of studies, which we have now begun. Studies are scheduled to be completed by late 1990.

Lower Waitaki River flow regime studies

J P. Graybill, G. D. James

Studies were undertaken for Electricorp to assess the effects of regulated flow on fish stocks and fisheries of the lower Waitaki River. The results will provide information for their water right applications for the Waitaki power scheme. The study objectives are to assess the effects of past and current flow regimes on fish stocks and fisheries, and to determine flow regime guidelines to counter the adverse effects of the current flow regime. This will be done mainly by comparing historical fisheries and flow records.

Upper Ohau River fisheries studies

G. D. James, S. Bloomberg, S. F. Davis, I. G. Jowett, P. M. Sagar

Electricorp has commissioned MAF Fisheries to assess the likely fisheries value of increasing the residual flow down the upper Ohau River.

This section of river was virtually dewatered when the upper Waitaki power scheme was built in the

The Clutha River above Cromwell. All willows have been removed and the new Lake Dunstan will submerge all river bank areas in the foreground and centre of the photograph. (Photo: B. J. Swale)

early 1980s. Electricorp will be applying to renew its water rights for these schemes in 1990, and is interested in knowing if a limited increase in the flow down this river would enable a fishery to re-establish. There is good circumstantial evidence to suggest that this is very likely, but studies are required to quantify the benefits that could result from various discharges.

To assess the state of the fishery under the present residual flow of about 0.5 $m^3.s^{-1}$, information is being collected on the number of adult fish in the river (which is very low, at about 2 fish per km), the extent of trout spawning, the survival and rearing of juveniles, and the suitability of the bottom-dwelling invertebrate fauna as a food supply for fish.

Modelling work is being done to assess the numbers of trout that could be expected in the river if flows were augmented. In addition, the Ohau canal (which carries the water that used to flow down the Ohau River) will be dived so that trout numbers there can be compared with those predicted for, and now occurring in, the upper Ohau River.

Fisheries studies of Lake Dunstan

D. J. Jellyman, M. L. Bonnett

Under the present terms of the Clyde dam water rights, a fish hatchery is required for "re-establishing and maintaining the fish stocks" in the new Lake Dunstan and surrounding areas affected by the dam. As there is now some concern that a hatchery may not be necessary, it has been decided to clarify the fisheries requirements. Interest from the money set aside by Electricorp to build a hatchery is being used to fund the studies. If a hatchery is not required, alternative forms of enhancing the fishery will be recommended.

The study aims to determine the distribution and abundance of fish stocks in the area that will become Lake Dunstan, and to assess the significance of the recreational trout fishery. Studies to date have been on the trout spawning and rearing potential of the Lindis River (where brown trout predominate), and on the feeding, age, and growth rates of adult trout in the main Clutha River where many rainbow trout are caught. Although growth rates of both species have been found to be similar to those in other areas of New Zealand, there will probably be a sharp increase in growth rates for the first few years after lake-fill.

Salmon aquaculture

Genetic manipulation and sex control

C. L. Hopkins

A broodstock of XX males (masculinised females) is now established at Glenariffe. Some of these were stripped as 2-year-olds in 1989 to fertilise eggs of sea-run females returning to the hatchery. The resulting fish will be all-female. Most of these eggs were sold to salmon farmers, but a few were retained, hatched, and masculinised to sustain our own broodstock.

All-female stocks have the potential to produce non-maturing triploid fish. Triploidy (in which each cell carries three sets of chromosomes instead of two) can be induced by heat, cold, or pressure shock on newly fertilised eggs, and theoretically leads to sterility at adulthood (*see* MAF's Fisheries Research Division Annual Report 1984). In male salmon, triploidy does not prevent growth of the testes or colouring up, nor does it result in a deterioration in flesh quality as the spawning season approaches. However, triploid females remain completely immature and can be harvested up to and through the breeding season. Such fish may live longer, which is of benefit in lake fisheries.

In 1989, two batches of triploid salmon were produced by the pressure shock technique. One batch was sold as eyed ova to a salmon company, the other was reared-on and released as tagged juveniles into Lake Coleridge. The fate of the latter group will be followed by tag returns from anglers over the next few years.

Control over maturation in salmonids

D. K. Rowe

Early maturation is a major problem with salmonids, as further growth is curtailed once the fish mature. Commercial and recreational fisheries are both affected.

Age of maturation is directly related to growth rate. Studies to determine the mechanism by which growth influences age of maturation were made at the Freshwater Fisheries Laboratory of the Department of Agriculture and Fisheries, Scotland as part of a PhD programme. An early start to the growing season, and, specifically, an increase in the size of certain fat stores (past a genetically determined threshold) during spring months, are required for maturation to proceed. Maturation is suppressed in fish unable to increase fat stores beyond their threshold by late spring.

This discovery permits a degree of control over the age of maturation in salmonids. For example, the incidence of grilse (early-maturing male salmon returning from the sea within 1–2 years) in a salmon farm in Scotland was greatly reduced by restricting the food supply during spring months. In North America, overfishing of wild salmon stocks is believed to be responsible for the increase in numbers of male fish maturing in fresh water as parr (juvenile salmon which have never been to sea); this reduces the returns of adults to rivers. Enhanced spring growth, due to low densities of fish or warmer spring temperatures, is probably responsible for the increased incidence of mature parr. Supplementary stocking to increase parr densities and suppress growth may overcome this. Grilse are already a problem for salmon farmers in New Zealand, and overexploitation of wild salmon stocks, or increased spring temperatures (greenhouse effect), are likely to increase the already high incidence of mature male parr in New Zealand rivers. The principles of maturation control by growth manipulation also apply to rainbow and brown trout.

Salmon industry services and product sales

M. S. Field-Dodgson, C. L. Hopkins

In 1989, strong industry demand for salmon eggs coincided with one of the poorest salmon runs on record. Some rationalisation was required as it became clear that we could not fully supply all our clients. It was decided to concentrate our resources on the new, all-female stocks, and transfer our standard, eyed-egg order clients to New Zealand Salmon – who also sold us about 500 000 green eggs to fertilise for all-female production.

The period from March until June was one of uncertainty — not knowing how many fish would return, and trying to service our clients — but support from the industry was firm and although lost orders totalled over 800 000 standard eyed-eggs, revenue was bolstered by the added value of all-female stock.

Advice continues to be given to people interested in farming salmon, and to clients who need help through the establishment and development stages. Other services include fish disease advice, fish transport, and the micro-tagging of salmon smolts (these are discussed elsewhere in this report).

Salmon diet trials

M. S. Field-Dodgson

Negotiations with a large livestock food manufacturer for a 3-month trial to assess the effectiveness of a commercially produced diet formulation are nearing completion. The trial will be

at Glenariffe, where facilities for replication are available and variables can be controlled to ensure that only the diet-fish relationship is tested.

A study of the feeding regimes used on a sea cage salmon farm has been underway in Akaroa Harbour for several months, in association with Akaroa Salmon and the Canterbury Regional Council. It has pinpointed several areas where fish feeding can be fine-tuned to increase on-farm efficiency, optimise fish growth, and cut food costs significantly. The study should finish in February 1990.

Salmon sea cage farming

P. R. Todd

The two main areas used for salmon sea cage culture are the Marlborough Sounds and Stewart Island. Production of salmon at Stewart Island was severely reduced in January 1988 by a bloom of the alga *Heterosigma*, which caused substantial losses of salmon. From a projected production of 1200–1300 t, about 650–750 t were lost. Full farming licences were to be allocated after the DSIR's study of carrying capacity and environmental impact of salmon farming. Issuing of licences was delayed, but is now proceeding. Salmon group staff have been involved with developing policies for the licensing, and for the movement of salmon farms in the event of further algal blooms.

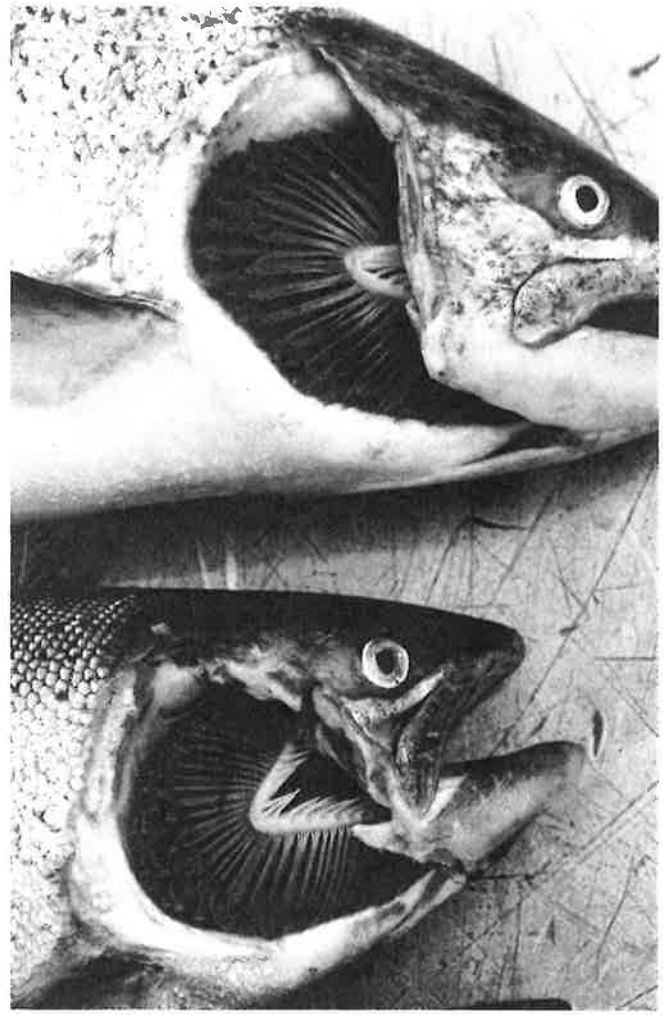
Fish health services

N. C. Boustead

Diseased fish are investigated for MAF Fisheries and on a user-pays basis. Enquiries about fish health are also subject to user-pays. The most significant work in 1989 was the study (carried out with DSIR) that identified the alga *Heterosigma* as the cause of significant losses of sea cage chinook salmon in Big Glory Bay, Stewart Island. Other diseases identified in 1989 (at different locations) included bacterial gill disease, whitespot, *Chilodonella* (an environmental gill disease), and the failure of salmon to adapt to seawater transfer. Fish samples were received from anglers and acclimatisation societies as well as from salmon farms, and included the identification of shagworm and a suspected eel bite.

Contract work was undertaken to investigate the disease status of fish in waters above a commercial salmon farm. Occasional requests to examine other species, including marine and native fish, were received, and cysts of a myxosporean (*Myxobolus* sp.) were found on *Galaxias vulgaris*.

A report on the parasites and diseases of New Zealand salmon has been prepared and published (*N.Z. Freshwater Fisheries Report No. 112*).



Moribund quinnat salmon (affected by *Heterosigma*) from sea cages in Big Glory Bay, Stewart Island. (Photo: N. C. Boustead)

Disease status of New Zealand salmon stocks

N. C. Boustead

These studies are being undertaken in association with the United States Fish and Wildlife Service to establish a sound database on the status of some serious diseases in New Zealand chinook and sockeye salmon. Extensive sampling revealed no further evidence of *Renibacterium salmonarium* and no evidence of fish viruses. MAF Quality Management have advised further findings of the IPN virus in apparently healthy chinook salmon.

Other studies on the effectiveness of methods for the detection of *Myxobolus cerebralis*, the parasite that causes whirling disease, have been completed. These studies showed no appreciable loss of spores through the method used.

Policy advice on salmonid fish health

N. C. Boustead

A significant part of our fish health work is to provide soundly based advice for policy formation. Input has been provided for the development of policies on the management of fisheries with respect to IPN and whirling disease. Contributions have been made to the disease control provisions in new aquaculture briefing papers and draft legislation. In association with Tony Avery (MAF Fisheries South) policy has been developed for the movement of sea cages to avoid toxic algae.

Aquaculture Information Leaflet

N. C. Boustead, J. Potter

This newsletter to salmon farmers is issued twice yearly. It is distributed to 132 salmon farmers, MAF Fisheries staff, and others with an interest in salmon culture. This year's issues have contained information on fish transfers, VHS in America, salmon imports into Japan, and Tentburn salmon farm's problems with anglers. They also contain lists of publications on salmon culture that have been received at the Freshwater Fisheries Centre library. Copies of these publications can be ordered through the newsletter.

Fish transport

T. J. Washbourne

MAF Fisheries fish transport was again active during the year, transporting fish for salmon fishery enhancement projects, the commercial salmon industry, and experimental research projects. Work for commercial fish farmers doubled during 1989, while transport for ourselves and acclimatisation societies increased by 20%. MAF Fisheries hires out some of the fish transport equipment and several salmon farmers have used this service.

Quinnat salmon was the main species transported: other species included rainbow trout, mackinaw, sockeye salmon, and perch. Fish were delivered to many destinations throughout the South Island, including: 71 000 to mid Canterbury; 52 000 to Kaikoura; 10 000 for the Kaiapoi River experimental release; 11 000 for the Lyttelton Harbour experimental release; 40 000 to Otago Harbour; and 9000 to Lake Coleridge (these were triploid salmon for enhancement of the recreational fishery).

Replacement, truck-mounted transporter units of larger capacity, built from marine-grade stainless steel, were purchased during 1989 to replace two older units and have enhanced transporting abilities.

Transporting fish from Glenariffe salmon research station for release into Otago Harbour. (Photo: N. C. Boustead)

Aquaculture of carps and other species

Production of triploid grass carp

N. H. McCarter

Broodstock grass carp were transferred to warm water tanks in the hothouse at the Rotorua laboratory in August. In previous years, ovulation and spermiation have been induced by injections of human chorionic gonadotrophin and carp pituitary extract (CPE). MAF Quality Management have prohibited the importation of CPE, so we attempted to induce spawning with synthetic hormones and dopamine antagonist drugs. This method should be cheaper and more reliable than CPE. However, no viable eggs were obtained from the first attempt in October.

Stocks of triploid grass carp were sent to South Auckland, New Plymouth, Feilding, and Bulls during the past year. Procedures for vetting and approving proposals to stock waterways with grass carp were agreed between MAF Fisheries and the Department of Conservation at a meeting last year.

Production of silver carp

N. H. McCarter

Silver carp were successfully spawned using analogue synthetic hormones. However, egg viability was low and only 5000 fry were produced. Over the past 12 months, silver carp have been delivered to Auckland, Lake Omapere, and the marron farm at Warkworth.

Culture of European perch

C. L. Hopkins, L. J. Hawke

It is intended to study perch culture techniques at Silverstream hatchery. Perch are recognised as good table fish in Europe and North America but, until recently, have not been considered for commercial exploitation in this country. Information on culture techniques is sparse. Preliminary work began in spring 1989. Adult maturing perch were obtained from wild populations and held for spawning. Eggs are now being incubated at the hatchery and tanks have been prepared to hold fry.

Importation of channel catfish: possible consequences

G. J. Glova

Northland Support, Kerikeri is seeking the importation of channel catfish into New Zealand for aquaculture. Several fisheries researchers in the United States were contacted in August 1989 to further our assessment of environmental issues concerning the importation of this species. The information gathered has been summarised in a report to Northland Support. The main findings in the report were as follows.

1. Channel catfish are unlikely to have any significant effect on wild rainbow trout stocks in either riverine or lake systems.
2. Native fish, such as bullies and other bottom-dwelling species, are not likely to be seriously affected by channel catfish, although possibly more so than trout because of the greater likelihood of competition for bottom foods and some predation.
3. Koura stocks may be reduced significantly in some watersheds, as this is a prey type commonly eaten by channel catfish in the United States.
4. The bottom-foraging activity of channel catfish is not likely to seriously alter invertebrate drift rates or decrease water clarity for fly fishing in trout streams.

Hatcheries

Glenariffe Salmon Research Station

S. P. Hawke, M. W. Tawa, J. R. E. Sykes

Despite another disappointing return of adult quinnat salmon to the trap this year, the results from other activities such as egg sales, the all-female quinnat salmon project, the salmon enhancement scheme, and general hatchery operations were encouraging.

The total run of salmon into Glenariffe this year totalled 2492 fish, comprising 2257 hatchery fish and only 235 wild fish. From the returning fish, 2.75 million eggs were taken, of which 1.01 million were fertilised with standard milt and incubated at Silverstream for our own rearing programme and for the salmon enhancement programme. The remaining 1.74 million eggs were fertilised with sex-reversed milt (from masculinised females) and sold to the industry as all-female stock. Those companies wanting to use their own eggs for all-female stock were accommodated by shipments of "magic milt" in small polystyrene containers. This appeared to be very successful.

MAF Fisheries released 550 000 juvenile salmon this year. These fish ranged from 40 to 80 g and from 145 to 180 mm in length at the time of release; 422 000 were released into the Rakaia in March, July, and August, and the remaining 128 000 were transported as part of the salmon enhancement programme to the following locations: Rangitata River, 40 000; Lyttelton Harbour, 11 000; Lake Coleridge, 9000 (triploid); Otago Harbour, 40 000; and Upper Waimakariri River, 20 000.

The river and lake releases were funded by the acclimatisation society movement, and the Otago Harbour release was part of the Otago Branch of the New Zealand Salmon Anglers' Association's continuing (and very successful) enhancement programme.

At the start of the 1989 season we introduced a different diet, and we have seen extremely good survival and growth responses from the young fry. Fertilisation to ponding losses were only 8%, and the small fish are almost 5 weeks ahead of normal growth at this time of the year. Favourable weather patterns, with no flooding, have assisted the successful transfer of fish from the hatchery to the raceways.

Recent arrivals at Glenariffe include lake trout (mackinaw), Atlantic salmon, and rainbow trout. The mackinaw are being investigated for their potential to enhance angling, and the Atlantic salmon for their aquaculture potential. The rainbow trout are sex-reversed fish that have been developed at our Silverstream hatchery. The potential of sockeye salmon for full-scale aquaculture in both sea water and fresh water will be investigated. This species of salmon is not farmed in the rest of the world because of its susceptibility to infective haemorrhagic septicemia (IHN), a viral disease unknown in New Zealand.

The public open day in April was dampened by wet weather, but still attracted about 800 people who, as usual, were all very supportive of Glenariffe Research Station and its role in the salmon fishery and industry. Staff were impressed by the good nature of the people that attended.

Sampling sockeye salmon from the circular ponds at Glenariffe salmon research station. (Photo: N. C. Boustead)

Silverstream Salmon Hatchery

L. J. Hawke, C. L. Hopkins

Returns of adult quinnat salmon to Silverstream in 1989 were 279, an appreciably higher number than last year. Most returning fish were males (207) and most of these were 2-year-olds. Only six salmon carried tags, two of which had been released as smolts from Silverstream, one in 1985 and the other in 1987. Of the remaining four, one came from a release to Winding Creek (Waimakariri basin) in 1987, and the other three from Tentburn hatchery (N.Z. Salmon Company). Other Silverstream-origin salmon were recovered from elsewhere; one was caught at sea, six were caught by anglers in the lower Waimakariri River, and one was found as a carcase in Winding Creek.

In June, 5000 tagged smolts were transferred from Glenariffe hatchery to Silverstream and held for 15 days before being released into the hatchery stream. On the day of their release, a further 5000 tagged smolts were brought down from Glenariffe and released with them. Both lots were of about 50 g mean weight.

Egg yield from the 72 female salmon that returned to the hatchery was 260 000. An additional 2.75 million ova from Glenariffe were incubated at Silverstream. At eyeing, 1 million were returned to Glenariffe to provide for the rearing and release programme. Most of the remainder were sold off to farming companies or supplied to acclimatisation societies. Of the eggs raised for commercial sales, 83% were all-female eyed ova fertilised with milt stripped from XX males that had been reared at Glenariffe (*see* salmon aquaculture section). One batch of these ova was retained at Silverstream, masculinised after hatching with testosterone, and transferred back to Glenariffe to be grown-on to maturity.

Administration

Electric fishing services

G. B. Smith, M. S. Weeks

In April, the first electric fishing operators' course to be conducted entirely by MAF Fisheries staff was held. Subjects covered included basic electrical theory, safety, physiology of fish, and practical field work. The course has been shortened by including a correspondence section. Eleven people attended, and 10 have been issued with operator's certificates. The next course is scheduled for April 1990. It is now possible for people with overseas experience in electric fishing to gain an operator's certificate without attending the standard course. Special conditions apply, and details are available from the Freshwater Fisheries Centre, Christchurch.

Certification and repairs, together with the manufacture of new equipment, continue to demand most of our time; 60 sets of equipment are checked annually. Four new sets of equipment were manufactured during 1989. Records of all electric fishing equipment and licensed operators have now been computerised, which has assisted us to keep better track of the ever-increasing volume of information.

Work is continuing on the development of a higher powered, pack-set electric fishing machine, more suitable for general use than the small model which is now out of production.

Written specifications for the design and construction of electric fishing machines are almost completed. These specifications have taken into account overseas trends and advances in equipment safety standards.

Review of electric fishing services

J P. Graybill, M. L. Bonnett

MAF Fisheries electric fishing services are being reviewed. The terms of reference include the structure of electric fishing services, user training, machine certification, safety requirements, and the suitability of electric fishing equipment. The review will include a survey of users to assess their needs and their satisfaction with the service provided.

Fish farm licensing

B. J. Swale

Stimulated by several Government initiatives, there has been an upsurge of interest in all forms of aquaculture over the past 12 months. Following the controversy in Parliament over responsibility for the administration of coastal waters, MAF Fisheries now has the lead role for aquaculture in New Zealand. However, this interest has not yet led to a significant increase in applications for freshwater fish farming licences.

All arrears in processing freshwater fish farm licences have now been dealt with, except for those with some statutory impediment. In addition to the salmon farms (of which there are 25 in production), there are now fish farms licensed for grass carp (1), silver carp (1), marron (1), prawn (*Macrobrachium*) (1), paua (3), and koura (1).

Following the publication of notices in the *New Zealand Gazette*, it is now legal to farm four new species of fish: deepwater scampi (*Metanephrops*), paddle crab, grey mullet, and marron. In response to requests, similar gazetting of perch and cockle is being investigated.

Fish transfers (freshwater)

B. J. Swale

Authorisation to move fish between catchments and between fish farms is required (under two regulations) before transfer. All authorisations are the responsibility of the Freshwater Fisheries Centre, Christchurch. There are practical reasons for this requirement. Firstly, should disease eventuate, there is a need to be able to trace fish movements back to their source rapidly and accurately. Secondly, the introduction of species to catchments where they do not currently occur must be controlled. Thirdly, New Zealand's fish stocks and fisheries must be managed in an orderly fashion to prevent the actions of individuals confounding the management of the resource as a whole.

In 1989, 96 fish farm, and 92 non fish farm, transfers were authorised.

Salmon landings by commercial fishing vessels

M. J. Unwin, R. A. Dougherty, P. R. Todd

Although the Freshwater Fisheries Centre is involved mainly with freshwater research, staff also have been involved with research into the catching of salmon at sea. The main development in the salmon bycatch issue over the last 12 months has been the introduction by the Minister of Fisheries of a limited closed area off Banks Peninsula. The closure applies to commercial trawlers over 23 m registered length, and extends from mid December to the end of February. It has been imposed for an initial trial period of 2 years to allow for an assessment of the effects on salmon returns to fresh water and on the commercial trawling industry.

Reported salmon landings for the 1988/89 season were 14.4 t, compared with 45 t in 1987/88. Only 34 tags were recovered from trawl-caught fish this season; these probably represent only a small proportion of those actually landed. The tag data are equivalent to an estimated 550 ± 260 fish, almost all of which were taken in the Banks Peninsula and Pegasus Bay areas.

The imposition of the closed area has been strongly opposed by the commercial fishing sector, which lodged an appeal against the legality of the closure with the High Court. Preparation of evidence on behalf of the Ministry was one of the main tasks undertaken in 1989. At the hearing (held in November 1989), the legality of the closure was upheld, but the court recommended that MAF Fisheries undertake further work into the effect of the closure on commercial landings of red cod and barracouta.

Library

J. Potter

The year began with the recording of all the books held at the Rotorua office to make their library more manageable and useful. With the addition of freshwater material transferred from the central MAF library and the Fisheries Research Centre library at Greta Point, over 400 items have been added to our library catalogue this year. The computer-held listing of books has been converted into a database format, which should make it much easier for staff to access. Work has started on planning a system for recording and storing the laboratory's photographic collections.

The library has responded to 260 incoming inter-library loan requests and sent out 230. This reflects the growing interest in aquaculture in the universities and in the community at large. Budget constraints led us to cancel our subscriptions to four journals — *Journal of Ichthyology, Fish Physiology and Biochemistry, Journal du Conseil,* and *Behaviour* — but we have new subscriptions to *Seafood Leader* and the *New Zealand Gazette*.

The library responds to a continual demand for publications in the *New Zealand Freshwater Fisheries Report* series, and for other freshwater publications.

Computing facilities

I. G. Jowett, M. J. Unwin

Computer facilities for the Freshwater Fisheries Centre in Christchurch were expanded over the past year. A local area network has been installed, primarily for file transfer and the sharing of printers between IBM-compatible computers and a 386 IBM-compatible running a multi-user DOS system, with eight terminals. Offices in Rotorua and Oamaru also have IBM-compatible computers, but are not yet directly linked to Christchurch.

The Tower computer, using the UNIX operating system, has been retained, and communication is possible between it and the IBM-compatibles.

The CPT word-processing computers have largely been replaced by an IBM-compatible, and this has facilitated the preparation and editing of reports. It has allowed us to take over the entire preparation and publication of *Freshwater Catch* using desktop publishing programmes.

The freshwater fish database continues to be maintained on the Pyramid computer in Wellington, and terminals in both Christchurch and Rotorua allow staff to access this information.

Financial management

K. F. Roche

Full accrual accounting for MAF Fisheries was introduced in 1989, together with changes in the balance date to a June year. In addition, cash management procedures were introduced to match receipts from Government funding and cash payments.

Freshwater Fisheries Report series

S. F. Davis

Most of the research that is carried out by staff at the Freshwater Fisheries Centre is eventually published in the scientific literature. However, there is a considerable amount of work that is either not substantial enough for a scientific paper, or is subject to a deadline for a client. In these cases, the work is generally written up and published in our internally produced *N.Z. Freshwater Fisheries Report* series.

Over 100 reports have now been issued in this series. Topics have included general fisheries surveys, submissions, recreational surveys, the regional results of the national river angling survey, invertebrate studies, impact assessments, and salmon diseases. During the past year, a further 14 reports have been published, bringing the total to 115.

A list of the reports is available from:

The Librarian
Freshwater Fisheries Centre
MAF Fisheries
PO Box 8324
Riccarton, Christchurch

All reports are available for purchase; prices vary according to length.

Freshwater Catch

P. M. Sagar

This quarterly magazine provides current news and informative articles about all aspects of freshwater fish and fisheries in New Zealand. Recent issues have included discussion of the potential effects of climate warming on trout populations, channel catfish, results of angling surveys and fishing competitions, identification of the various species of salmon and trout, reviews of environmental threats to fisheries, and reviews of the 1989 salmon season.

Although *Freshwater Catch* is published by MAF Fisheries, articles are solicited from acclimatisation societies, regional councils, Department of Conservation, and university staff.

The Freshwater Fisheries Centre, Christchurch, assumed full editorial, layout design, and production control of the magazine in late 1989. Previously these were the responsibilities of MAF Primedia, Wellington. The first issue produced under this system appeared in December 1989 and, with increased numbers of subscribers, we look forward to the efficient production of many more issues.

Public relations

R. A. Dougherty

Throughout the year, the Freshwater Fisheries Centre has been represented at a variety of events and functions, as well as at meetings of various sports and business groups. Numerous staff members have been invited as guest speakers to give presentations on our activities.

In Canterbury, we have had several displays at A and P shows, in shopping malls, and in sports shops, particularly to promote awareness amongst salmon anglers of the need to return the heads of tagged salmon for analysis.

Ron Dougherty (white apron) cleaning and checking an angler's salmon during the 1989 Rakaia fishing competition. (Photo: P. Bush)

Publications list

Bonnett, M. L., Sagar, P. M., and Docherty, C. R.: Diets of alpine galaxias (*Galaxias paucispondylus* Stokell) and longjawed galaxias (*G. prognathus* Stokell) in a South Island, New Zealand, high-country stream. *N.Z. Journal of Marine and Freshwater Research 23*: 453–458.

Bonnett, M. L.: Alpine and longjawed galaxiids. *Freshwater Catch No. 40*: 11.

Bonnett, M. L.: New format for electric fishing course. *Freshwater Catch No. 40: 21–22.*

Boustead, N. C.: A guide to diseases of salmon in New Zealand. *N.Z. Freshwater Fisheries Report No. 112.* 87 p.

Boustead, N. C., Chang, H., Pridmore, R., and Todd, P.: Big Glory Bay algal bloom identified. *Freshwater Catch No. 39*: 3–4.

Boustead, N. C. [1988]: The occurrence of whirling disease (*Myxobolus cerebralis*) in New Zealand salmonids. *In*: Conference handbook, International Fish Health Conference, Vancouver, B.C., Canada, 19–21 July 1988. Fish Health Section, American Fisheries Society. [Abstract.]

Boustead, N. C.: VHS in America. *Aquaculture Information Leaflet No. 5.*

Boustead, N. C.: Whirling disease. *Freshwater Catch No. 41*: 22–23.

Boustead, N. C. and Washbourne, T. J.: Shifting salmon. *Freshwater Catch No. 41*: 9–10.

Chang, F. H. and Boustead, N. C.: First record of a lethal phytoplankton bloom of *Heterosigma* in New Zealand waters. Poster paper at the 4th International Conference on Toxic Marine Phytoplankton, Sweden.

Chisnall, B. L.: Koi carp thrive in Waikato waterway. *Freshwater Catch No. 39*: 18.

Chisnall, B. L.: Age, growth, and condition of freshwater eels (*Anguilla* sp.) in backwaters of the lower Waikato River, New Zealand. *N.Z. Journal of Marine and Freshwater Research 23*: 459–465.

Davis, S. F. and Unwin, M. J.: Freshwater life history of chinook salmon (*Oncorhynchus tshawytscha*) in the Rangitata River catchment, New Zealand. *N.Z. Journal of Marine and Freshwater Research 23*: 311–319.

Dougherty, R. A.: Salmon for Lyttelton Harbour? *Freshwater Catch No. 41*: 8.

Eldon, G. A.: Whither the Banks Peninsula redfin? *Freshwater Catch No. 39*: 12–13.

Eldon, G. A.: Questions about inanga remained unanswered. *Freshwater Catch No. 39*: 14.

Eldon, G. A.: Whitespots and red faces. *Freshwater Catch No. 40*: 10.

Eldon, G. A.: One of life's ironies. *Freshwater Catch No. 40*: 13.

Eldon, G. A., Kelly, G. R., Bonnett, M. L., and Taylor, M.: Fisheries survey of the Heathcote River, January 1989. *N.Z. Freshwater Fisheries Report No. 111.* 50 p.

Field-Dodgson, M. S.: Water flow and facility design for salmon farming. *Freshwater Catch No. 39*: 8.

Field-Dodgson, M. S.: Disappointing salmon season. *Freshwater Catch No. 40*: 17.

Field-Dodgson, M. S.: Feeding farmed salmon. *Freshwater Catch No. 41*: 23–24.

Flain, M. [1988]: Arthur Wilson Parrott 1908–1988. *Freshwater Catch No. 36*: 24.

Flain, M. [1988]. Migratory brown trout. *Freshwater Catch No. 37*: 20–21.

Flain, M.: Manta board surveys of Lake Coleridge. *Freshwater Catch No. 41*: 19.

Flain, M. and Lucas, F.: Glenariffe 1989 — the lowest wild run ever. *Freshwater Catch No. 41*: 11– 12.

Gifford, J. and Richardson, J.: Toxicity evaluation of New Zealand pulp and paper mill effluents. Fish bioassays: September 1989. Experimental protocols. *Forest Research Institute Report No. C222.* (Confidential.) 18 p., plus appendices.

Glova, G. J.: Preferred holding areas of pre-spawning salmon. *Freshwater Catch No. 39*: 7.

Glova, G. J.: Native and salmonid fishes: are they compatible? *Freshwater Catch No. 40*: 2–13.

Glova, G. J.: Salmon early outmigrants: are they ecological losers? *Freshwater Catch No. 41*: 7–8.

Glova, G. J.: Importation of channel catfish to New Zealand: possible consequences. *Freshwater Catch No. 41*: 5–6.

Glova, G. J.: Salmon, trout and char. How to tell them apart. *N.Z. Rod and Rifle 10(6)*: 8–11.

Glova, G. J.: New Zealand climate change — potential impact to freshwater fisheries. Report to Ministry for Environment. 15 p.

Glova, G. J. and Sagar, P. M.: Prey selection by *Galaxias vulgaris* in the Hawkins River, New Zealand. *N.Z. Journal of Marine and Freshwater Research 23*: 153–161.

Glova, G. J. and Sagar, P. M.: Feeding in a nocturnally active fish, *Galaxias brevipinnis*, in a New Zealand stream. *Australian Journal of Marine and Freshwater Research 40*: 231–240.

Hanchet, S. M. and Hayes, J. W.: Fish and fisheries values of the Mokau River and tributaries draining the Mokau coalfield. *N.Z. Freshwater Fisheries Report No. 110*. 79 p.

Hardy, C. J. [1988]: Establishment and operation of Silverstream fish hatchery, 1964 to 1982. *N.Z. Freshwater Fisheries Report No. 102*. 132 p.

Hardy, C. J. [1988]: Importation of channel catfish (*Ictalarus punctatus*) into New Zealand. Report to Northland Support, Kerikeri. 105 p.

Hardy, C. J.: Fish habitats, fish, and fisheries of the Lake Ellesmere catchment. N.Z. *Freshwater Fisheries Report No. 104*. 152 p.

Hardy, C. J.: Quinnat salmon spawning in the Waimakariri catchment. *N.Z. Freshwater Fisheries Report No. 114*. 65 p.

Hayes, J. W.: Social interactions between 0+ brown and rainbow trout in experimental stream troughs. *N.Z. Journal of Marine and Freshwater Research 23*: 163–170.

Hayes, J. W.: Comparison between a fine mesh trap net and five other fishing gears for sampling shallow lake fish communities in New Zealand. *N.Z. Journal of Marine and Freshwater Research 23*: 321–324.

Hayes, J. W., Leathwick, J. R., and Hanchet, S. M.: Fish distribution patterns and their associations with environmental factors in the Mokau River catchment. *N.Z. Journal of Marine and Freshwater Research 23*: 171–180.

Hicks, B. J.: The influence of geology and timber harvest on channel morphology and salmonid populations in Oregon Coast Range streams. PhD thesis, Oregon State University, Corvallis.

James, G. D., Inada, T., and Nakamura, I. [1988]: Revision of the oreosomatid fishes (Family Oreosomatidae) from the southern oceans, with a description of a new species. *N. Z. Journal of Zoology 15*: 291– 326.

Jellyman, D. J. [1987]: Review of the marine life history of Australasian temperate species of *Anguilla*. *American Fisheries Society Symposium 1*: 276– 285.

Jellyman, D. J. [1988]: Angling methods and fish mortality. *Freshwater Catch No. 35*: 11.

Jellyman, D. J. [1988]: "No brain, no pain" — the fishes' viewpoint. *Freshwater Catch No. 35*: 12.

Jellyman, D. J. [1988]: Summaries of Limnological Society Workshops — May 1987. *Freshwater Catch No. 35*: 17.

Jellyman, D. J. [1988]: Eel life history still a mystery. *Freshwater Catch No. 37*: 11–12.

Jellyman, D. J. [1988]: Illegal immigrants. *Freshwater Catch No. 38*: 17.

Jellyman, D. J. [1988]: Giant kokopu — the reclusive swamp dweller. *Freshwater Catch No. 38*: 24.

Jellyman, D. J.: Diet of two species of freshwater eel (*Anguilla* spp.) in Lake Pounui, New Zealand. *N.Z. Journal of Marine and Freshwater Research 23*: 1–10.

Jellyman, D. J.: Occurrence of the nematode *Hedruris spinigera* in the stomachs of freshwater eels. *N.Z. Journal of Zoology 16*: 185–189.

Jellyman, D. J.: The Canterbury drought and effects on fish. *Freshwater Catch No. 39*: 22–24.

Jellyman, D. J.: Grey River national conservation order covers limited catchment area. *Freshwater Catch No. 40*: 3–4.

Jellyman, D. J.: Clyde Dam nears completion. *Freshwater Catch No. 40*: 5–6.

Jellyman, D. J.: Dollars and directions — recreational fishery in Canada. *Freshwater Catch No. 40*: 23.

Jellyman, D. J.: New Zealand angler — you think you've got it tough! *Freshwater Catch No. 40*: 24.

Jellyman, D. J.: Fishing facts and figures. Angling in the United States. *Freshwater Catch No. 41*: 18.

Jones, B. and Swale, B.: Aquaculture checklist. *Freshwater Catch No. 36*: 22–23.

Jones, B. and Swale, B.: Letter — Aquaculture checklist. *Freshwater Catch No. 39*: 23.

Jowett, I. G. and Richardson, J.: Effects of a severe flood on instream habitat and trout populations in seven New Zealand rivers. *N.Z. Journal of Marine and Freshwater Research 23*: 11–17.

Kelly, G. R. [1988]: An inventory of whitebaiting rivers in the South Island. *N.Z. Freshwater Fisheries Report No. 101*. 65 p.

Kokich, D. and Swale, B.: Silver carp to filter Lake Omapere. *Freshwater Catch No. 40*: 6–9.

McCarter, N. H. [1988]: Verification of the production of triploid grass carp (*Ctenopharyngodon idella*) with hydrostatic pressure. *N.Z. Journal of Marine and Freshwater Research 22*: 501–505.

McCarter, N. H. [1988]: Risk assessment report on the proposed stocking of a water supply pond with triploid grass carp. Report to Waitaki International, Feilding. 6 p.

McCarter, N. H. [1988]: Risk assessment report on the proposed stocking of ponds with triploid grass carp. Report to New Plymouth Golf Club. 5 p.

McCarter, N. H.: Overseas travel report: Carp spawning techniques and triploid production in USA: Recirculating aquaculture systems in the UK. Fisheries Research Centre Internal Report No. 124. 10 p. (Unpublished report held in MAF Fisheries Greta Point library, Wellington.)

McCarter, N. H.: Grass carp may solve *Hydrilla* problem. *Freshwater Catch No. 39*: 21.

McCarter, N. H.: Risk assessment report on proposed restocking of parts of the Aka Aka drainage system. *N.Z. Freshwater Fisheries Miscellaneous Report No. 8*. 7 p.

McCarter, N. H.: Risk assessment report on proposed stocking of grass carp into New Zealand Steel water intake lagoon at Waikato North Heads mine. *N.Z. Freshwater Fisheries Miscellaneous Report No. 7*. 6 p.

McDowall, R. M.: Living with whirling disease. *New Zealand Trout and Salmon 1*: 38–39.

McDowall, R. M.: Another look at a rainbow's eyes. *Freshwater Catch No. 39*: 19–20.

McDowall, R. M.: Freshwater Fisheries Advisory Council disbanded. *Freshwater Catch No. 39*: 19–20.

McDowall, R. M.: Freshwater aquaculture in New Zealand: developing a perspective. *In* Beardsell, M. F. (Comp. and ed.), Proceedings of AQUANZ '88 — a national conference on aquaculture, pp. 9–16. *N.Z. Fisheries Occasional Publication No. 4*.

McDowall, R. M.: Chinese whitebait — cheap but you get what you pay for. *Freshwater Catch No. 40*: 13–14.

McDowall, R. M.: William Arthur and anadromy. *Freshwater Catch No. 40*: 20.

McDowall, R. M.: A net income. *Pacific Way 23*: 92–95.

McDowall, R. M.: Did the grayling go to sea? *Freshwater Catch No. 41*: 17–18.

Meredith, A. S., Empson, P. W., Boubee, J. A. T., and Mitchell, C. P.: Ichthyoplankton studies on the lower Waikato River. II. Larval distributions at Huntly. *N.Z. Freshwater Fisheries Report No. 109*. 58 p.

Mitchell, C. P.: Laboratory culture of *Galaxias maculatus* and potential applications. *N.Z. Journal of Marine and Freshwater Research 23*: 325–336.

Pack, Y. M. and Jellyman, D. J. [1988]: Fish stocks and fisheries of the lower Clutha River. *N.Z. Freshwater Fisheries Report No. 98*. 117 p.

Palmer, K. L., Rutledge, M. J., and Pierce, L. A.: Macro-invertebrate community composition in the lower Waitaki River. *N.Z. Freshwater Fisheries Report No. 105*. 30 p.

Penlington, B. P. [1988]: The kahawai fishery at the Motu River mouth. *N.Z. Freshwater Fisheries Report No. 103*. 27 p.

Pierce, L. A. and Smith, J. J. L.: Angling postal questionnaires schemes on the lower Waitaki River, 1980/81 and 1981/82. *N.Z. Freshwater Fisheries Report No. 106*. 35 p.

Pierce, L. A.: Aerial surveys of angling on the lower Waitaki River, 1974-1983. *N.Z. Freshwater Fisheries Report No. 113*. 37 p.

Richardson, J.: The all-new freshwater fish database. *Freshwater Catch No. 41*: 20–21.

Rowe, D. K.: The role of growth and seasonal fat dynamics in the maturation of Atlantic salmon parr. PhD thesis, University of Stirling. 230 p.

Rowe, D. K. and Hill, R. L.: Aquatic macrophytes. *In*: A review of biological control of invertebrate pests and weeds in New Zealand, 1874–1987, pp. 331–337. *DSIR Entomology Division Technical Communication No. 10*.

Rowe, D. K.: Algal blooms. In: A review of biological control of invertebrate pests and weeds in New Zealand, 1874–1987, pp. 321–324. *DSIR Entomology Division Technical Communication No. 10*.

Rowe, D. K., Chisnall, B. L., and Boubee, J. A. T.: A synoptic survey of native fish in selected catchments of the Wanganui River, August 1989. *N.Z. Freshwater Fisheries Miscellaneous Report No. 16*. 54 p.

Rowe, D. K. and Scott, D.: Effects of climate warming on trout fisheries in northern New Zealand. *Freshwater Catch No. 41*: 3–4.

Sagar, P. M. and Sagar, J. L.: The effects of wind and sea on the feeding of Antarctic terns at the Snares Island, New Zealand. *Notornis 36*: 171–182.

Schicker, K. P., Boubee, J. A. T., Palmer, D., Stancliff, A. G., and Mitchell, C. P.: Elver movement in the Waikato River at Huntly. *N.Z. Freshwater Fisheries Report No. 108*. 28 p.

Scrimgeour, G. J. and Eldon, G. A.: Aspects of the reproductive biology of torrentfish, *Cheimarrichthys fosteri*, in two braided rivers of Canterbury, New Zealand. *N.Z. Journal of Marine and Freshwater Research 23*: 19–25.

Stancliff, A. G., Boubee, J. A. T., and Mitchell, C. P.: Cross-channel movement of small migratory fish and shrimps in the Waikato River near Huntly thermal power station. *N.Z. Freshwater Fisheries Report No. 107*. 30 p.

Swale, B. [1988]: Scientific name of silver carp. *Freshwater Catch No. 37*: 14.

Swale, B.: Correction: Scientific name of silver carp. *Freshwater Catch No. 40*: 16.

Taylor, M. J. [1988]: Features of freshwater fish habitat in South Westland and the effect of forestry practices. *N.Z. Freshwater Fisheries Report No. 97*. 89 p.

Taylor, M. J.: Appendix I. Analysis of fish habitats in tributaries of Lake Ellesmere. *In* Hardy, C. J. Fish habitats, fish, and fisheries of the Ellesmere catchment, pp. 122–152. *N.Z. Freshwater Fisheries Report No. 97*. 152 p.

Todd, P. R. and Coates, G.: Development of salmon farming in New Zealand: prospects for the future. *In* Beardsell, M. F. (Comp. and ed.), Proceedings of AQUANZ '88 — a national conference on aquaculture, pp. 21–25. *N.Z. Fisheries Occasional Publication No. 4*.

Todd, P. R. [1988]: Salmon farming in New Zealand — prospects for the future. *Freshwater Catch No. 38*: 3–6.

Todd, P. R.: The Tentburn salmon controversy. *Freshwater Catch No. 40*: 14–16.

Todd, P. R. and Unwin, M. J. [1988]: A user-funded salmon enhancement programme. *Freshwater Catch No. 38*: 15.

Todd, P. R., Unwin, M. J., and Dougherty, R. A.: Salmon by-catch update. *Freshwater Catch No. 39*: 6.

Unwin, M. J. and Dougherty, R. A.: Salmon tag lottery results. *Freshwater Catch No. 40*: 15.

Unwin, M. J. and Lucas, D. H. [1988]: 1987–88 coded-wire tag lottery results. *Freshwater Catch No. 38*: 15.

Unwin, M. J. and Lucas, D. H.: Wild salmon, hatchery salmon, and the Glenariffe trap. *Freshwater Catch No. 40*: 13–14.

Unwin, M. J., Lucas, D. H., and Gough, T. [1988]: Coded-wire tagging of chinook salmon (*Oncorhynchus tshawytscha*) in New Zealand, 1977–81: release programmes and returns at maturity. *N.Z. Fisheries Data Report No. 33*. 50 p.

Unwin, M. J., Field-Dodgson, M. S., Lucas, D. H., and Hawke, S. P.: Experimental releases of coded-wire tagged juvenile chinook salmon (*Oncorhynchus tshawytscha*) from the Glenariffe Salmon Research Station, 1982–83 to 1984–85. *N.Z. Fisheries Technical Report No. 10*. 22 p.

Ward, F. J., Boubee, J. A. T., Meredith, A. S., and Northcote, T. G.: Characteristics of common smelt, *Retropinna retropinna* (Richardson), of the Waikato River system. *N.Z. Journal of Marine and Freshwater Research 23*: 345–355.