Coded-wire tagging of juvenile chinook salmon (*Oncorhynchus tshawytscha*) in New Zealand, 1977–86

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M. J. Unwin,
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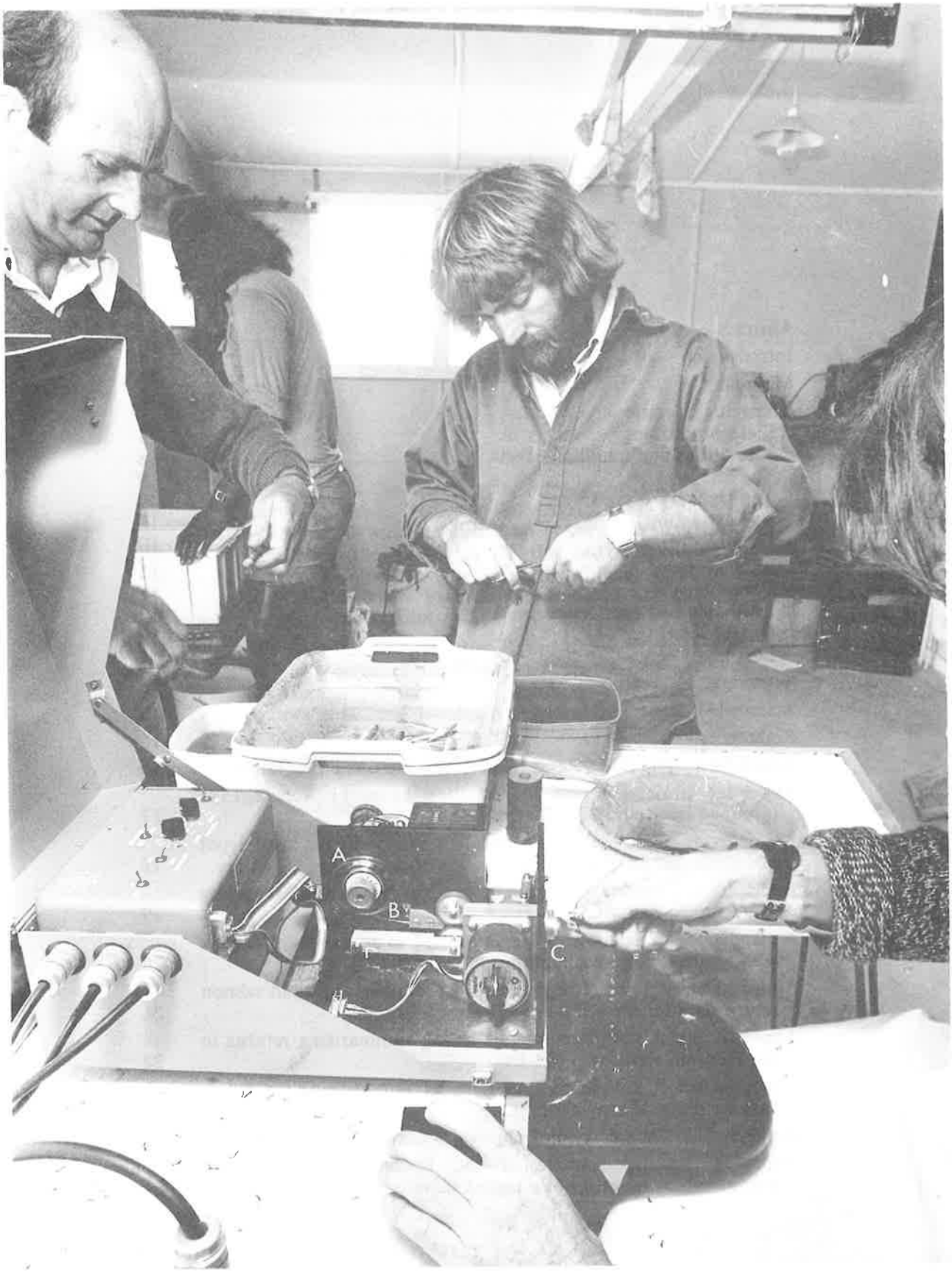

Salmon tagging at FFC's Glenariffe hatchery, January 1979. Clearly visible inside the tagging machine are the spool of pre-coded tagging wire (A) and a length of this wire (B) feeding into the injection unit. A tranquillised salmon is about to be inserted into the head mould (C), while the operator controls the machine with a button under his left hand. Two assistants are removing adipose fins from the fish (before tagging), while the fourth member of the crew (background) is transferring fish to and from the tranquilliser baths as required. (Photograph courtesy *Christchurch Star.*)

Abstract

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Coded-wire nose tagging, a marking method developed in the United States for use with juvenile hatchery reared salmonids, is now widely used in New Zealand for monitoring returns at maturity of ocean-ranched chinook salmon. The tag, consisting of a 1.25 mm length of coded, stainless steel wire, is implanted into the nose cartilage of the young fish, which is also marked externally by clipping the adipose fin. Fish are normally marked in batches of 5000–20 000 and about 1000 fish can be tagged per hour. A network of "head depots" and an extensive publicity programme facilitate the return of tags to the laboratory, where the relevant details are accumulated into a computer data base. Tag return data tend to underestimate survival rates because complete recovery of tagged adult fish can never be guaranteed.

Introduction

Coded-wire nose tagging (CWT) is a marking method, developed in the United States, for evaluating returns at maturity of hatchery reared anadromous salmonids. As the scale of North American hatchery operations increased during the 1950s and early 1960s, fishery managers were faced with the problem of identifying what contribution each of the various North American and Canadian salmonid hatcheries was making to the total stocks. Conventional marking methods were, for a variety of reasons, unable to cope with the size of the problem. Fin removal, for example, offered only a limited range of marks, and external tags were subject to high (and usually unknown) rates of tag loss. A marking method was required which was suitable for use on small (5–10 cm) juvenile salmonids, easy to apply in large numbers, able to leave a tag in place while the fish spent up to 5 years at sea, capable of providing a large number of distinct marks, and harmless to the fish.

The CWT method was proposed in 1963 (Jefferts, Bergman, and Fiscus 1963). It relies on the use of a miniature tag, coded so that it can be read under a microscope, implanted into the nose cartilage of the young salmonid. Each tag consists of a 1.25 mm length of fine stainless steel wire (Fig. 1), with four binary codes (each of 6 bits) engraved at 90° intervals around the circumference. One of these codes serves as a reference mark, and the remaining three codes provide a total of $(2^6-1)^3$, or over one-quarter of a million potential tag codes. Fish are marked in batches (typically of 5 000–20 000), with each batch identified by a single tag code. The tags, and the necessary equipment for injecting and recovering them, are commercially available from Northwest Marine Technology (NMT) in Washington State.

Fig. 1: A coded-wire tag in relation to a New Zealand 1 cent coin. The coin is 17 mm in diameter.

To indicate the presence of a tag within a returning adult salmon (the tag being hidden from view once in place), Jefferts, Bergman, and Fiscus (1963) suggested that tagged fish should also be identified by an external fin clip. By common consent among all the agencies concerned, removal of the adipose fin was taken as the standard. This fin (see Appendix 1) is the easiest and safest to remove, and it does not regenerate.

In New Zealand, the CWT method first attracted interest in the early 1970s, as a possible tool for research on chinook salmon at the Fisheries Research Division (FRD)* Glenariffe field station, in the headwaters of the Rakaia River (Galloway 1976). At about the same time, there was mounting interest in the possibility of controlled rearing of juvenile chinook salmon, both for stock enhancement and commercial

*Freshwater Fisheries Centre (FFC), MAFFish, as from 1 April 1987.

ranching. As a result of this interest, FFC purchased its first tagging machine in 1977, with money supplied by the Council of South Island Acclimatisation Societies, and a second machine was obtained in 1981.

The CWT method is now recognised as a powerful research tool for evaluating ocean ranching techniques, and it is the basis of much of FFC's current chinook salmon research. Freshwater Fisheries Centre has also tagged fish on behalf of the various commercial chinook salmon ocean ranching ventures around the South Island (Fig. 2). The purpose of this publication is to describe the CWT process, as implemented by FFC, and to give details of the tagging, tag recovery, and data recording procedures used.

Many of these procedures are modelled closely on those used in North America, with some modification to suit New Zealand conditions. It is intended that this publication will serve as a reference point for future FFC publications dealing with results from the programme.

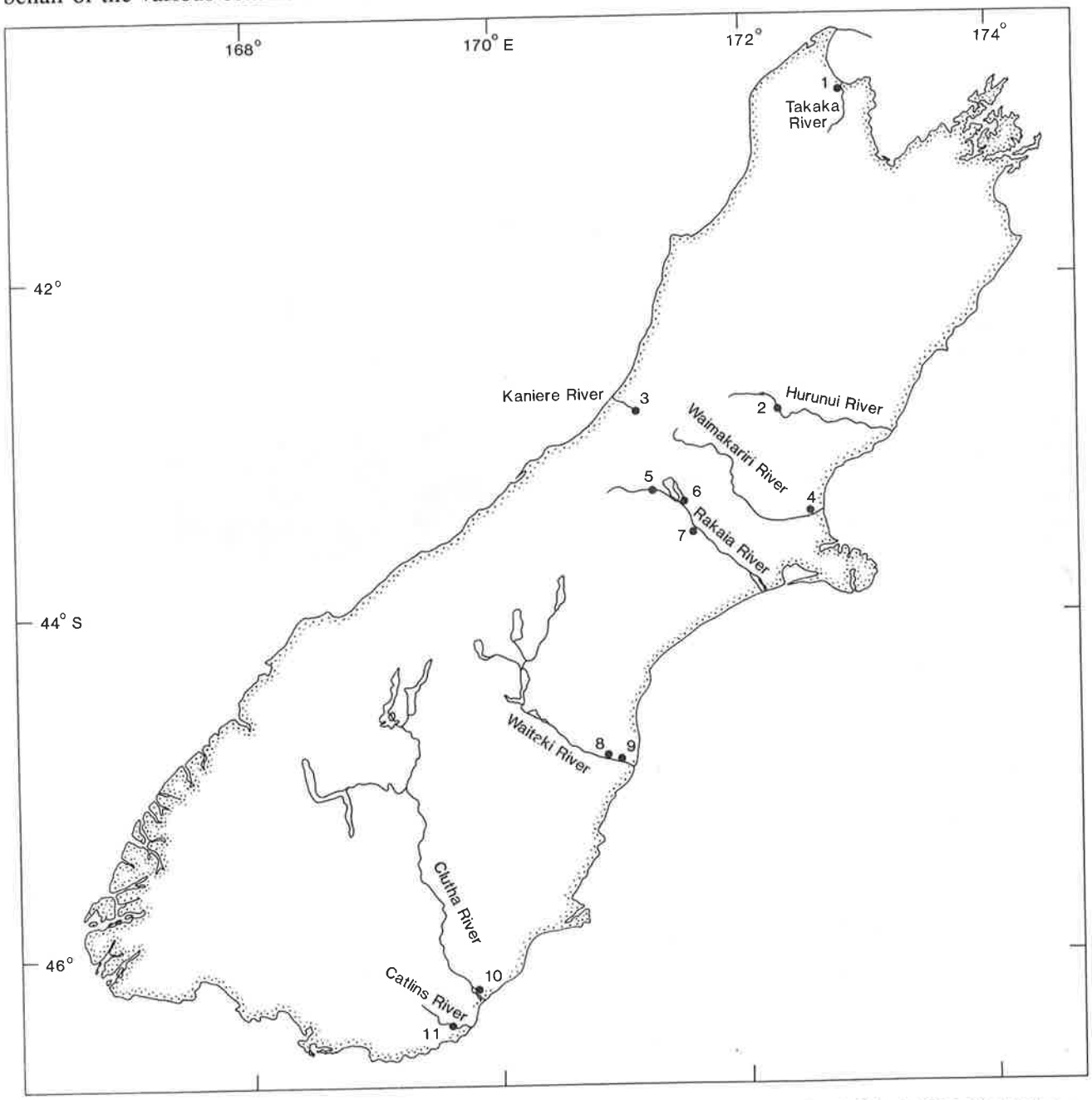

Fig. 2: Location of FFC salmon research sites and commercial ocean ranching ventures in the South Island, 1977–86. 1, Takaka hatchery (Southern Ocean Salmon) (formerly Bubbling Springs Salmon Farm); 2, Hurunui Salmon Farm, Mount Longfellow (now operated by New Zealand Marine Farms Limited); 3, Kaniere hatchery (Tasman Salmon Company) (now operated by New Zealand Marine Farms Limited); 4, Silverstream hatchery (MAF); 5, Glenariffe Salmon Research Station (MAF); 6, Coleridge hatchery (New Zealand Salmon Co Limited) (formerly South Pacific Salmon Company); 7, Blackford Salmon Ranch; 8, Glenavy hatchery (Newhaven Salmon Ranch); 9, "Bells Pond" (ICI/Wattie Joint Salmon Development Project) (closed down in 1980); 10, Kaitangata hatchery (ICI/Wattie Joint Salmon Development Project) (now operated by Southland Salmon Company Limited); 11, Owaka hatchery (Newhaven Salmon Ranch).

Methods

Tagging operations

The CWT procedure makes use of two specialised pieces of equipment. One machine, the tag injector, cuts the tags from a pre-coded length of stainless steel wire and injects them into the nose of the fish. The second machine is a quality control device (QCD), which checks the fish for the presence of a tag, rejects any that have not retained their tag, and keeps a running tally of all tagged fish.

In practice, both machines operate simultaneously. To inject a tag into a juvenile salmon, the head is inserted into a plastic head mould mounted on the front of the tag injector. This guides the tip of the upper jaw to a point directly in front of the injection needle. A manually operated button activates the tagging cycle, whereby a tag is injected through the needle into the nose cartilage of the fish. Head moulds in a range of different sizes are available, suitable for juveniles from 2 to 50 g in weight. Correct choice of the head mould size is important if the tags are to be properly inserted (Jenkinson and Bilton 1981).

As soon as the tagging cycle is completed, which is indicated by a light on the tag injector, the fish is dropped into a chute leading to the QCD. The QCD consists of a rectangular box, about 100 cm long, 30 cm wide, and 20 cm high, mounted directly below the tag injector and sloping gently down from the horizontal. A 6-cm-diameter pipe enters the QCD through its top end (immediately in front of the operator) and extends about two-thirds of the way down the length of the device before branching into two independent outlets. A small flow of water passes through the entry chute into the pipe and carries the fish gently through it.

A magnet and detector coil are located near the top end of the pipe. If a tag is detected, a signal from the coil triggers a jet of water which deflects the fish into the appropriate outlet and thence to a holding or recovery box. Should a fish not contain a tag, it passes unimpeded through the device and into the other outlet, where it can be collected and returned to the injector. If the QCD does not detect a tag, it emits an audible signal during the next tagging cycle, thus alerting the operator who can take corrective action if necessary.

Field procedures

For most applications, the tagging equipment is set up in a specially modified caravan, designed to function as a mobile tagging unit providing for rapid and efficient processing of fish. The caravan contains a holding trough (with the capacity to hold up to 2000 fingerlings depending on their size) and work tables for fin-clipping fish and for supporting the tag injector and QCD. An electric pump supplies running water to the holding trough, work table, and tagging machine. With a four person crew, about 1000 fish can be tagged per hour.

Before being tagged, the fish are immersed in a solution of anaesthetic for a few minutes. To ensure that the tagging operator receives a continuous supply of tranquilised fish, two baths of anaesthetic are used alternately, so that while the fish in one bath are "going under", those in the other bath can be clipped and tagged. By judiciously selecting how many fish are placed into each bowl at a time, and matching this number to the rate at which the machine operator is working, fish can be exposed to the anaesthetic only for as long as is necessary to ensure ease of handling. Before 1981, we used benzocaine at a dilution of 1:15 000 as an anaesthetic, but from 1981 onwards we switched to 2-phenoxyethanol at a 1:2250 dilution. This proved superior to benzocaine because it was more forgiving if fish were over-exposed to it, and also it acted as a mild fungicide.

From 1979 to 1983, virtually all tagging was done from the caravan. In 1977 and 1978, before the caravan was available, the machine arrangement was dictated by the particular location where it was to be used. For tagging operations at FFC's Silverstream and Glenariffe hatcheries, the existing buildings and water supplies provided the neccessary facilities (see photograph on page 4). The only other location where tagging was done in 1977 was the lower Waitaki River, where the project being undertaken required that wild fish be tagged on site. In that instance, a portable electric generator was used to supply power to the pump and tagging machine, and trestle tables provided the necessary working space.

As the tagging programme at FFC's Glenariffe hatchery increased in scope, it became apparent that a more permanent arrangement was necessary. For the 1984 tagging season, a special tagging shed was constructed (Figs. 3 and 4). This shed is arranged along the same lines as the caravan, but with more space available it is considerably easier to work in. The shed contains a large holding trough, a raised working platform where up to five people can sort and fin-clip fish, space for two tagging machines, and a system of pipes which allows tagged fish to be returned immediately to the hatchery raceways. Water is supplied through a pump-fed header tank, and an extensive plumbing network directs running water to the various parts of the shed as required.

In 1977, all tagging was conducted by FFC staff. However, since 1978 it has been necessary to use temporary employees taken on from the Department of Labour's Project Employment Programme (PEP). This situation is less than

Fig. 3: The tagging shed at Glenariffe hatchery. The pipes leading from the shed to the raceways are connected directly to the tagging machines inside the shed, so that tagged fish are immediately returned to the raceways.

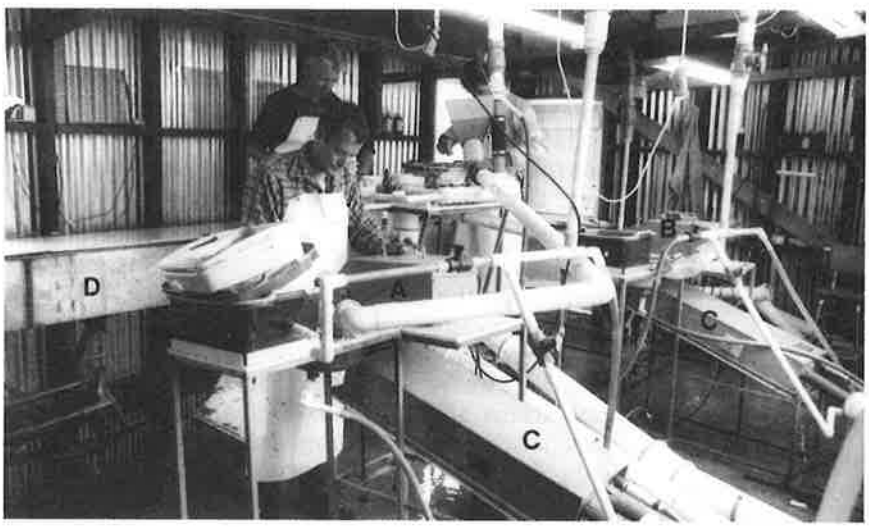

Fig. 4: The interior of the tagging shed. Two members of the crew (on the raised platform at rear) are fin-clipping and sorting fish, while a third member operates one of the tagging machines (A). A second machine (B) is unattended. Note also the QCDs (C) mounted below each tagging machine, part of the holding trough (D) in which fish are kept, and the complex network of plumbing. For maximum throughput, a crew of five is used, with three persons clipping fins and two operating the tagging machines.

ideal, because it requires that a new tagging team be trained from scratch each season. We have also encountered problems finding people who are both sufficiently meticulous with regard to the tagging and fin-clipping operations and who can put up with the rather nomadic lifestyle associated with tagging fish at a variety of locations around the South Island. More recently, the various commercial operators have been able to provide one or two personnel to assist with tagging, and this has eased the workload on FFC staff and reduced the need for temporary workers. If the commercial industry is to continue to develop, it is likely that some farmers will obtain their own tagging machines.

Mortalities and handling effects

Provided due care is exercised, handling mortalities are usually less than 1% and may be less than 0.1% (Table 1). Excessive mortalities are invariably associated with over-exposure to the anaesthetic. This can occur when a temporary machine failure interrupts the flow of fish through the system, or when too many fish are put into the anaesthetic at one time. Under the worst circumstances, the entire contents of an anaesthetic bath (up to 200 fish) may be lost.

TABLE 1: Mortalities* at time of tagging for coded-wire tagged juvenile salmon, 1977–82

Brood year	No. of fish handled	Mortality No.	Mortality %	No. of groups per mortality range <0.1%	0.1–1.0%	1.0–2.0%	>2.0%
1977	144 279	958	0.66	3	7	3	3
1978	339 225	1 346	0.40	8	15	3	1
1979	338 563	1 008	0.30	5	17	1	0
1980	423 020	3 068	0.73	0	22	3	2
1981	479 136	3 386	0.71	10	15	8	2
1982	568 726	945	0.17	18	11	3	2

*Mortalities are given as an average for each brood year and are further broken down by groups—usually 10 000–20 000 fish—representing each of the various tag codes used.

Mortalities also tend to be related to size of fish, with larger fish being more susceptible to handling effects. For this reason, we prefer to tag fish as soon as they are large enough to be handled; 5 g is the ideal weight. However, in recent years the large number of fish to be tagged each season has meant that the tagging machine is in continuous use from November until April or May, by which time fish weights usually exceed 50 g. The only solution in such circumstances is to be aware of the problem and to take extra care.

In a hatchery, tagged fish recover from the handling within about 15 minutes, though it may

take 1 or 2 days for them to resume feeding actively. The most prolonged after-effect of the tagging is the scar left by removal of the adipose fin. To ensure that no regrowth takes place, the fin is cut deeply enough to remove a small section of skin as well. This produces a scar which can take up to 6 weeks to heal and is clearly visible during this time as a white spot on the back of the fish. Wherever possible, tagged fish are held for at least a month before release, to allow for complete healing.

Tag loss

Although the QCD guards against immediate tag loss, further losses inevitably occur after the fish have been returned to the hatchery raceways. Some fish apparently reject the tag, whereas in others it may have been incorrectly inserted (for example, if a head mould of the wrong size was used). In one instance, fish at FFC's Silverstream hatchery were observed crowding against the screen at the upper end of their raceway, thus causing erosion of the nose tissue in some individuals. Subsequently, about 100 tags were recovered by casting a magnet over the raceway floor directly below the screen.

In 1977, 1978, and 1979, "tag retention tests" were done to find out the extent of tag loss. Before the release of a batch of tagged fish, a sample was drawn from the raceway and examined with the QCD for the presence or absence of a tag. Results of these tests (Table 2) showed a distinct decrease in tag loss over the 3 seasons. In 1977, tag losses up to 29% were recorded (22 out of 75 fish examined), and they averaged 6.9% for the 36 samples taken. In 1979 the highest tag loss figure was 8.1%, with 20 out of 22 tests showing less than 5% tag loss. We attributed the improvement over the 3 seasons to our increasing experience with the machine. On the basis of the 1979 results, routine tag retention testing was abandoned from 1980 onwards, though in 1983 and 1984, fish tagged at Glenariffe showed losses averaging 6.03% (ranging from 1.4 to 11.3%) about 3 months after tagging. Where tag loss data were not available, we assumed a figure of 5%.

Tag recovery procedures

The CWT programme depends on the rapid and efficient recovery, by FFC, of all adipose fin-clipped adult salmon captured by anglers, acclimatisation society staff, hatchery operators, or anyone associated with the salmon fishery. The two key elements of this aspect of the programme are publicity, and the "head depot" network.

TABLE 2: Tag loss data* for coded-wire tagged juvenile salmon, 1977–79, over the period between tagging and release

Brood year	No. of fish examined	Tag loss		No. of samples per tag loss range			
		No.	%	<5%	5–10%	10–20%	>20%
1977	5 431	374	6.9	24	7	4	1
1978	4 538	204	4.5	13	5	2	0
1979	7 585	283	3.7	20	2	0	0

*The data are based on samples of 100–400 fish, representing each group of tagged fish from a particular brood—some groups are sampled more than once.

The publicity programme is aimed at alerting anglers to the need to check every salmon they catch for the presence of the adipose fin. As an incentive, FFC runs a lottery offering several cash prizes. Whenever a marked fish caught legally by an angler using a rod and line is found to contain a tag, the angler's name and address are included in the next lottery draw. The list is cumulative; if an angler catches 10 tagged fish in a season, then his or her name is entered 10 times. There are currently two draws per season, with a first prize of $500 and four second prizes of $100. Before 1981, only one draw with a first prize of $100 was held annually.

The recovery programme and lottery are publicised by posters, radio advertisements, newspaper and magazine articles, public displays, and personal contact between FFC staff and anglers. Posters (Appendix 1) are displayed in shops where fishing tackle or licences are sold, garages and shops in the vicinity of the major salmon rivers, motor camps and camping areas frequented by anglers, launching ramps, and access points to the more popular fishing holes. Over the 1983–84 season, extensive use was made of the community services provided by local commercial radio stations, such as Radio Avon in Christchurch and Radio Caroline in Timaru. Many of the main urban and local daily newspapers run feature articles on the salmon fishery at least once a year (for example, at the start of the angling season), and they are willing to include items on the CWT programme. Similarly, local television or radio news items can be arranged from time to time. In recent years, several FFC staff have been active in a public relations role, setting up displays in shopping malls, sports shops, etc., and giving talks to interested groups such as angling clubs. Publicity is also derived from the Ministry of Agriculture and Fisheries publication *Freshwater Catch*, which carries regular updates of the CWT results as they come to hand.

The head depot network is designed to provide anglers with a convenient and efficient channel for sending the heads of marked salmon into FFC's Christchurch laboratory. There are currently 55 depots throughout the South Island, many of which are run by volunteers from the angling community or the acclimatisation societies. Depots are also located at all hatcheries currently in operation (both FFC and commercial). A space is provided on the advertising poster (Appendix 1) whereby anglers can be directed to their nearest depot. A list of depots as at 11 August 1987 is given in Appendix 2. The poster also carries a caution to anglers not to try to find or remove the tag themselves.

Heads handed into a depot are stored either in a deep freezer, or in a 10% formalin solution. Depots which do not have access to a freezer are supplied with a plastic bucket and the required amount of formalin. All depots are supplied with plastic bags, wire twist ties, specially printed labels (on waterproof paper), and a knife for removing fish heads. When an angler brings in a fish which he or she believes to be tagged, the depot operator removes the head and requests that the angler fill in a label (Appendix 3). This label records the angler's name and address and brief details of where the fish was caught. Other details such as the length and sex of the fish may be recorded if known, but are not essential; we deliberately kept the information required to a minimum, to make the label as easy as possible to fill in. Both the completed label and the head are placed inside a plastic bag, which is then sealed and stored until it can be forwarded to FFC.

Tag extraction

Once the heads are received by FFC, they are forwarded to a special laboratory reserved solely for tag extraction. Heads preserved in formalin are usually processed immediately, and all others are kept in a freezer until they can be examined. Priority is given to angler-caught fish, and turn-around time at the laboratory is usually a matter of a few days. However, delays of 2 or 3 weeks have occurred, particularly during the peak of the angling season.

To check for the presence of a tag in a head, the NMT "tag detector" (consisting of a battery powered magnetometer) is used. Any change in the magnetic field in the vicinity of the unit, the sensitivity of which is adjustable, triggers a circuit which generates an audible signal. By passing the head of a salmon rapidly up and down through the detector several times, the presence or absence of a tag is readily established.

If a tag is present, its residual magnetism is usually sufficient to trigger the detector. However, if a tag cannot be detected after a few passes, the head is rapidly scanned between the jaws of a large horseshoe magnet and returned to the detector. If a tag is still not detected, the head is sent to the National Radiation Laboratory in Christchurch for X-ray. (Before 1984, heads were sent to the X-ray Department at the Christchurch Public Hospital.) Only if an X-ray fails to indicate the presence of a tag is the fish finally entered in the records as having no tag.

Once it is established that a head contains a tag, it is thawed (if frozen) and placed on a dissection board. (In 1983, a microwave oven was purchased for thawing frozen heads, and this has considerably streamlined tag extraction.) The upper jaw is detached by cutting vertically through the head, immediately behind the eyes; in all but a few instances the tag is found within this section of the head. The dissection is continued by successively cutting the upper jaw into two pieces; each half is then checked with the detector for the presence of the tag, and the untagged portion is set aside. Eventually this process results in the tag being localised to a sufficiently small piece of tissue that, when placed in a glass dish illuminated from beneath, enables the tag to be seen with the naked eye. The final dissection is accomplished with a scalpel and tweezers, and the tag is then placed in an ultrasonic cleaner for a few minutes to dislodge any residual tissue.

After cleaning, the tag is mounted on a special reading jig and examined under a binocular microscope. The reading jig consists of a small bar magnet which holds the tag horizontally and permits it to be rotated about its long axis and allows all four codes on the tag to be examined. Each of the three data codes translates into a number from 1 to 63. One of these numbers is reserved as an "agency code"; it has the value 63 for all tags used or distributed by FFC. This code has the virtue that in binary form it appears as a continuous series of "1"s and so is easily identified. A typical tag code would be written as 63/36/17, with the agency code appearing first. Once the tag has been read, it is placed inside a small self-sealing plastic envelope, of the type used for holding small numbers of coins, and filed.

Throughout the dissection and reading operations, great care is taken to ensure that tags are not accidentally lost. As the head is cut into progressively smaller pieces, the discarded portions are spread out onto paper towels and are disposed of only when the tag has been located. Occasionally tags become separated from the head at a fairly early stage of the search and are subsequently found stuck to the paper towels, or on the blade of the dissecting knife.

However, despite all precautions, a few tags are inevitably lost at this stage. For the 3 most recent seasons (data on tags lost in this way were not kept before 1981–82), the losses amounted to 3 out of 402 (0.75%) in 1981–82, 10 out of 1419 (0.70%) in 1982–83, and 29 out of 3619 (0.80%) in 1983–84. We have yet to try a strategy suggested to us by one North American operator, who fines any member of his staff unfortunate enough to lose a tag one six-pack of beer (B. Burkle pers. comm.). He reports that in addition to encouraging a high degree of caution on the part of his staff, the scheme also has the effect of mollifying his anger somewhat when a tag is lost.

Data recording

All CWT data are recorded on a standard form (Appendix 4), and filed on the Christchurch laboratory microcomputer. Because length, weight, and sex data are not usually available for each recaptured tagged fish, only a minimum amount of information is recorded against each fish. However, where the fish has previously been handled at a hatchery or other trap site where

details such as length and weight are routinely recorded, the recording form provides a space where a "secondary" tag number can be recorded. At the Glenariffe trap, for example, a numbered plastic sheep's ear tag is attached to the gill cover of all adult salmon which pass through the trap (Flain 1982), and this tag number serves as a cross-reference to the appropriate data file. Similar systems are now used by New Zealand Salmon Co Limited and by the ICI/Wattie Joint Salmon Development Project, for their own records.

Data recording begins as soon as a head is first examined in the laboratory. Each head is assigned a reference number, which is entered on the data sheet and serves as an internal reference for FFC's own records. This reference number is written on the plastic bag which will eventually be used to file the tag, and this bag accompanies the head as it proceeds through the tag extraction process. When the tag has been read, the code is entered on the recording form and also on the plastic bag. It is thus possible to back-check and re-examine any tag at a later date. Only the four digits representing the significant figures of the tag code are recorded on the data form. For example, the code 63/36/17 would be entered as 3617, because the agency code "63" is likely to be the only code used in New Zealand in the forseeable future. When the data are accessed by the computer, the code is restored to its full form. Heads which do not contain a tag are filed as 63/00/00, and the code 63/00/01 is used to identify heads for which the tag was lost during the recovery process.

The only other data recorded with the tag code are the "recovery status" and a "location code". The recovery status identifies how the head was recovered, with seven modes of recovery being recognised at present. These represent fish caught by anglers; fish returning to a hatchery; fish recovered as spent carcasses on spawning grounds (such as the "Hydra waters" in the Rakaia River headwaters); fish caught at traps operated by FFC or acclimatisation society staff on spawning streams (such as Winding Creek in the Waimakariri River catchment); fish recovered by netting (currently practised only by ICI/Wattie on the Clutha River); fish caught at sea (for example, as a commercial by-catch); and those caught by miscellaneous means (such as the fish wheel operated by FFC in the lower Waimakariri River (Docherty 1983)). Recognition of these categories is important for subsequent analysis of the data and is discussed further in the next section. The location code is a two character code, where the first character represents a particular river (or more generally a particular catchment), and the second character represents a particular location within that catchment. Currently, about 150 localities on 22 rivers are recognised, but the system is open ended and can be expanded as necessary.

Also filed on the computer is a list of all the tag codes currently in use. As the recovery data are typed in, the tag code file is checked to ensure that the code entered is legal and to assign an age to each fish (based on the number of years between tagging and recovery). Fish with lost tags are aged whenever possible by use of scales taken from the head, and the age is entered manually. Fish that have lost their tags and cannot be aged are arbitrarily assigned an age of zero.

As part of the publicity associated with the CWT programme, all anglers who send in a salmon head (whether tagged or not) are sent a letter acknowledging their co-operation. When a returned head contains a tag, the letter (Appendix 5) includes details of when and where the fish was released and the latest return figures for that particular tag code. The letter also informs the angler that he or she is eligible for the tag lottery and provides a contact address for those seeking further information. When no tag is detected a different letter is used pointing out that when a head does not contain a tag, the angler is excluded from the lottery. Unfortunately, this is necessary to guard against the possibility of an angler sending in the head of any salmon, whether adipose fin clipped or not, in the hope of winning a lottery prize. When a tag is detected, but subsequently lost during handling, the angler is included in the lottery.

Data analysis

Computer processing

The main aim of most tagging programmes is to evaluate the returns from a given hatchery release, or series of releases. The most commonly used statistic in such instances is simply the number of recovered adults bearing a given tag code, expressed as a percentage of the number of tagged juveniles released. Also of interest, particularly to commercial operators, is the total return expected from a large scale release of which only a proportion have been tagged. For example, a hatchery may have released 100 000 fingerlings, of which only 10 000 were tagged. If the return data indicated a return of 1% (that is, 100 tagged adults were recovered), then on a proportional basis one would expect a total return of 1000 adult salmon, or 1% of the 100 000 originally released.

Sample computer listings reflecting the need for this type of information are presented in Appendices 6a, 6b, and 6c. Appendix 6a is a listing

for all returns specific to a particular brood year—in this instance, 1978. The listing includes a breakdown of returns according to age, the percentage survival, and an estimate of the total returns associated with each tag code. Such a listing might be of interest to someone wishing to compare returns from the various hatcheries and release sites, or to someone who wanted to assess the contribution of a particular hatchery to the salmon fishery. For example, one can readily calculate that releases from Silverstream in 1978 contributed about 440 adult salmon to the fishery in 1980 and 1981, all of which returned as 2 or 3 year old fish.

Appendix 6b illustrates an alternative way of assessing the return data by summarising all returns to a particular river during 1 season. The listing shows that about 190 salmon of hatchery origin were taken in the Hurunui River during the 1983–84 season. These included 7 four year olds, 121 three year olds, and 64 two year olds. Summaries of this type help to assess the degree of straying between catchments, and they can also be used to study the extent and distribution of angling effort on or between rivers. The printout shows, for example, that strays from the Rakaia River outnumbered salmon originating from hatcheries on the Hurunui, and that at least two tagged fish strayed from as far away as the Clutha River.

Appendix 6c shows a third type of listing, representing a summary of all return data for one particular tag code. This includes virtually all the information that can be extracted from the master file of tag returns, and it gives details of how and where tagged fish have been recovered, tabulated by age at return. By comparing similar listings for individual tag codes, one can assess such factors as straying, variations in age at return, and the proportion of the returning fish taken by anglers.

As the above three examples show, the data retrieval system is flexible and can be adapted to meet a wide range of needs. In its present form, the system has been in operation since late 1985, after an upgrading of the Christchurch laboratory computer facilities. This has led to some modification of the data recording procedures used and is described further in Appendix 7a.

Estimates and confidence limits

Apart from errors due to unrecovered or lost tags (discussed in the next section), estimates of percentage returns are subject to sampling variability, and consequently to errors of a statistical nature. Essentially, a release of tagged fish can be regarded as a series of binomial trials, with M fish tagged, m fish recovered, and $M - m$ fish not recovered. The statistic of interest is the probability of recapture, given by $p = mM^{-1}$. Because p is usually less than 0.05 (the highest value recorded so far is 0.082), confidence limits based on the Poisson distribution are appropriate (Cochran 1977). For any estimate of p, the variance is therefore given by $s^2 = p = mM^{-1}$, and the standard error by $m^{0.5}M^{-1}$. The 95% confidence intervals for p are then given by $(m \pm 1.96m^{0.5})M^{-1}$. Where returns of untagged fish have been estimated from CWT return data, confidence limits are obtained directly from the above equations. If N fish were released untagged, the expected return is Np, with a standard error of $(m \pm m^{0.5})NM^{-1}$.

Before 1984, we normally required that a minimum of 10 000 fish were marked with a given tag code. This ensured that for returns of 1% or better (that is, $p > 0.01$) the standard error was at most ± 0.1% (equivalent to a coefficient of variation (c.v.) of 0.1). In practice, returns ranging from 0.01 to 8.2% have been obtained, with m ranging from 1 to over 600. For $m < 10$ the c.v. is large (greater than 0.3), and the accuracy of the estimate of p is correspondingly low. However, in such instances the percentage return is also low (often less than 0.1%), and the low precision of the estimate is of no practical significance.

Similar comments apply to the estimates of returns from untagged fish. The highest estimates are usually associated with returns exceeding 1%, and so they are the most accurately known. Where one wishes to estimate the total returns from a series of releases, addition of the variances for each estimate generally results in quite narrow confidence intervals for the total. For example, over the 1983–84 season, an estimated 7113 untagged hatchery reared adult salmon were recaptured, which represented the combined total for 39 releases. The standard error of this estimate is 189, which gives a c.v. of 0.027 and 95% confidence intervals of 7113 ± 371.

In practice, estimates of untagged returns are subject to further errors, because the total number of untagged juveniles released (N) is seldom known accurately. Unless one were to individually hand count all fish on the day of release, N is available only as an estimate based on the mean weight of the fish at some earlier date. Experience at Glenariffe suggests that errors of 10–15% are typical, though larger errors (for example, about 25%) can arise, particularly where cannibalism occurs in crowded raceways. This type of error is inherently unquantifiable, but should always be borne in mind when dealing with figures extrapolated from known returns of tagged fish.

Unrecovered tags

When interpreting data based on CWT adult salmon recoveries, recovery of all tagged fish returning to freshwater can never be assumed, and so estimates of percentage returns, for example, must necessarily be conservative. The efficiency of recovery depends on the recovery source (for example, anglers, hatcheries, etc.), and it probably also varies between rivers and seasons. In the North American literature, the problem is dealt

with by using an "awareness factor" or "expansion factor" (for example, see Bilton, Alderdice, and Schnute 1982 and references therein; Quinn and Fresh 1984). This factor is a measure of the proportion of tags recovered by a particular source, such as the commercial net and troll fishery (Heizer, Cook, and Argue 1978), or the sport catch (Argue, Cowsley, and Harris 1977).

In New Zealand, the major sources of tagged fish so far have been hatcheries and anglers (Table 3), with smaller contributions from carcass recoveries, netting (in the lower Clutha River), and traps on some spawning waters. Of these recoveries, only returns to hatcheries—where experienced staff are on hand to recognise adipose fin-clipped fish—can be assumed complete. For the remaining sources, many adipose fin-clipped fish are undoubtedly either not recognised as such, or are simply never recovered.

After hatchery recoveries (which account for 49.3% of the tagged fish recovered so far), the next largest recovery source is the sport fishery. Angler-caught fish represented 32.8% of the heads recovered over the last 6 seasons and ranged from 21.5% in 1980–81 to 55.4% in 1978–79. We have no information from which an awareness factor might be calculated, but awareness has undoubtedly improved with increasing publicity in recent years. It is encouraging that tagged salmon have been correctly identified by anglers fishing rivers such as the Wairau, which are well outside the main areas of salmon fishing activity. Nevertheless, FFC staff working on rivers such as the Rakaia and Rangitata regularly find that it is only their chance intervention which leads to adipose fin-clipped salmon being recognised after being landed. Two year old fish in particular are underrepresented in the return figures (Unwin and Davis 1983), though it is not clear whether this is due to selectivity in the anglers' catch, or simply anglers' failure to identify small (450–550 mm) salmon correctly. We know of at least one instance where a tagged salmon of this size was misidentified as a rainbow trout.

Recoveries of tagged carcasses from known salmon spawning grounds are very much a matter of chance, the efficiency of recovery being dependent on stream flows and the frequency of surveys during the spawning season. For spawning systems such as "Double Hill Flats", which are immediately adjacent to FFC's Glenariffe hatchery and are regularly surveyed by FFC staff, recovery efficiency is likely to be high irrespective of flow conditions. By contrast, more remote areas such as the Hydra waters on the north bank of the Rakaia River are surveyed only once or twice per season. If a fresh occurs before a spawning survey, any tagged carcasses present will probably be flushed out of the system and into the main stem of the Rakaia River, where the chance of recovery is virtually nil.

TABLE 3: Mode of recovery for all adipose fin-clipped salmon handed in to FFC, 1978–79 to 1983–84 seasons

	Origin of recovered fish							
Season	Hatchery	Angler*	Carcass	Net	Trap	Other	Sea	Total
1978–79	20	32	0	0	4	0	0	56
1979–80	206	78	12	0	2	1	7	306
1980–81	544	169	54	0	10	0	9	786
1981–82	251	171	18	0	4	0	10	454
1982–83	764	475	51	76	11	6	27	1 410
1983–84	1 617	1 351	443	330	39	2	120	3 920
Total	3 402	2 276	578	406	70	9	173	6 914

*Includes salmon caught by anglers fishing at sea.

Since 1983, ICI/Wattie have augmented their recoveries from the Clutha River by netting immediately down stream of the Roxburgh Dam and also just below their hatchery outlet at Kaitangata. Below the dam, netting was done after the close of the angling season, and so tagged fish recovered in this way would not otherwise have been captured. These netting operations probably compensate for the poor returns directly to the Kaitangata site (Gillard 1985), though we have no means of assessing the efficiency of recovery. For this reason, recovery figures for ICI/Wattie liberations on the Clutha River must be interpreted differently from figures for hatcheries such as Glenariffe, where returns direct to the hatchery make a large contribution to the total.

Other freshwater recoveries—from miscellaneous sources such as the joint FFC and acclimatisation society traps on Winding Creek (Waimakariri River catchment) and Deep Stream (Rangitata River catchment)—represent 1.2% of the tags recovered so far. Data from these traps are something of a bonus, but they are nevertheless of considerable value in providing figures on straying to catchments such as the Rangitata, where no liberations of tagged fish have been made. However, the incidence of tagged salmon in these areas is low (for example, of 1251 salmon recorded at the Winding Creek trap in 1984, 10 were adipose fin-clipped), and we do not consider that tagged fish straying to untrapped areas represent a significant loss of data.

Recoveries of ocean-caught salmon almost certainly represent only a small proportion of the fish actually taken at sea. A few fish in this category were caught with a rod and line, by anglers fishing inshore areas such as Lyttelton Harbour or Moeraki. In 1984, 79 tagged fish (from an ICI/Wattie release at Portobello) were netted in Otago Harbour. However, before 1983, under the existing regulations there was no legal means by which other salmon caught at sea (for example, as a commercial by-catch) could be landed and sold. This legal anomaly did little to encourage the return of tagged fish, and the extent of the commercial by-catch for the seasons listed in Table 3 remains unknown. Under new regulations gazetted in 1983, it is now possible for commercial fishermen to land salmon that have been accidentally caught at sea, provided the salmon are

delivered to an approved fish packing house. It is hoped that this will encourage the return of ocean-caught tagged salmon, and thereby provide information not only on the size of the by-catch, but also on the distribution of hatchery reared salmon at sea.

To summarise, figures for adult salmon returns to fresh water, based on CWT data, are likely to be underestimates. The biggest data losses are probably due to anglers failing to recognise tagged salmon, and spent carcasses which are not recovered from natural spawning grounds represent a further loss. The figures in Table 3 provide a basis for calculating the likely degree of underestimation of returns. For example, if it were known that recoveries from anglers and carcasses represented 50% of the tagged fish actually present, then the return figures as given would be on average 29% too low. The existing figures for ocean-caught salmon are also too low, but data recovery should improve in the future.

Lost tags

The proportion of adult salmon classified as having lost their tags (Table 4) varies substantially both between brood years and recovery sources. However, the proportion has declined consistently over the last 6 years; it fell from 40.6% for the 1977 brood year to 5.9% for the 1982 brood year. Some of the figures are undoubtedly inflated by the inclusion of fish which were not definitely adipose fin-clipped and hence were never tagged. For example, when searching a spawning stream for tagged fish, one frequently finds spent carcasses in an advanced state of decomposition. In such instances, it can be difficult to tell whether an adipose fin is present or not, and the natural tendency is to err on the side of caution and to collect the head from any carcass on which the adipose fin is not definitely present. A similar phenomenon seems to have applied to angler-caught fish, particularly in the early years of the recovery programme, before anglers were aware of exactly what to look for.

The most accurate figures for the proportion of lost tags are those for returns to hatcheries, where fish can be carefully inspected for the presence of the adipose fin. For the 1981 and 1982 broods, these figures (5.0% and 6.1% respectively) are consistent with the assumed tag loss of 5% at the time of tagging. Provided the rate of tag loss remains close to 5%, we do not regard errors arising from this source as a significant problem. A 5% error is usually less than the statistical uncertainties inherent in the return data and would certainly be less than any errors due to unrecovered tags.

TABLE 4: Tag loss data for all recovered salmon (as at 22 August 1985), tabulated by brood year and mode of recovery

Year		Hatchery		Angler		Carcass		Trap		Net		Other		Sea		Total	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1977	Tagged	59	68.6	29	50.9	2	22.2	0		0		0		2	100.0	92	59.4
	Untagged	27	31.4	28	49.1	7	77.8	1	100.0	0		0		0		63	40.6
	Total	86		57		9		1		0		0		2		155	
1978	Tagged	600	87.6	187	82.7	50	89.3	6	66.7	0		0		15	88.2	858	86.4
	Untagged	85	12.4	39	17.3	6	10.7	3	33.3	0		0		2	11.8	135	13.6
	Total	685		226		56		9		0		0		17		993	
1979	Tagged	183	89.3	118	88.7	15	71.4	2	100.0	0		0		7	87.5	325	88.1
	Untagged	22	10.7	15	11.3	6	28.6	0		0		0		1	12.5	44	11.9
	Total	205		133		21		2		0		0		8		369	
1980	Tagged	276	92.0	192	92.8	45	72.6	5	100.0	1	50.0	3	100.0	6	85.7	528	90.1
	Untagged	24	8.0	15	7.2	17	27.4	0		1	50.0	0		1	14.3	58	9.9
	Total	300		207		62		5		2		3		7		586	
1981	Tagged	1 492	95.0	1 212	93.9	206	84.4	15	88.2	136	95.1	3	75.0	22	100.0	3 086	93.7
	Untagged	78	5.0	79	6.1	38	15.6	2	11.8	7	4.9	1	25.0	0		206	6.3
	Total	1 570		1 291		244		17		143		4		22		3 292	
1982	Tagged	2 613	93.9	2 911	94.2	334	92.8	32	97.0	298	94.0	4	100.0	425	95.1	6 617	94.1
	Untagged	169	6.1	180	5.8	26	7.2	1	3.0	19	6.0	0		22	4.9	417	5.9
	Total	2 782		3 091		360		33		317		4		447		7 034	

Summary

This publication describes the methodology used in New Zealand during 1977–86 for coded-wire nose tagging of juvenile chinook salmon. The method is an effective and widely used technique for monitoring returns at maturity of hatchery reared anadromous salmonids. In New Zealand, it is currently used by FFC, and by the developing salmon ranching industry, to evaluate the success of release programmes at salmon hatcheries throughout the South Island. All tagging and tag recovery operations have been done by FFC, though if the industry continues to expand it is likely that some commercial operators will begin tagging on their own behalf.

The method relies on the use of miniature coded-wire tags, injected into the nose cartilage of the young fish. Special equipment is used to inject the tags and to maintain a tally of the marked fish. To indicate the presence of a tag, all tagged fish are externally identified by removal of the adipose fin. Juvenile salmon are tagged in batches (usually of 10 000), with each batch identified by a single tag code. With a four person team, about 1000 fish can be tagged per hour. Mortalities can be kept to a minimum by careful handling and rarely exceed 1%. About 5% of the fish tagged lose (or reject) their tag in the period between tagging and release.

When the mature fish return to fresh water, the heads of any fish lacking an adipose fin are recovered from anglers, hatcheries, and various other sources. A network of head depots, and an extensive publicity programme, provide for rapid and efficient channelling of tagged fish heads to FFC. A lottery system encourages anglers to identify and forward any tagged salmon they catch.

All tagged heads are sent to FFC's Christchurch laboratory, where the tags are extracted and decoded. The data pertaining to each tag are recorded and filed on the laboratory microcomputer. From this data base, listings of return data can be extracted according to the year of recovery, brood year, or other parameters such as geographical location.

The primary source of error in the analysis of return data is lost information due to incomplete recovery of tagged fish returning to fresh water. This applies particularly to returns from the sport fishery; it can never be assumed that all tagged fish are identified as such by anglers. Consequently, estimates of percentage returns based on this return data should always be regarded as conservative.

Acknowledgments

We wish to thank all those individuals, both FFC staff members and casual workers, who have been involved with the CWT programme. Particular thanks are extended to all past and present head depot operators, mostly volunteers, whose enthusiasm and co-operation have been essential to the success of the programme.

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Appendix 1

The poster used to advertise the CWT programme

The actual posters measure 370 × 216 mm and are printed in blue and black. (The prizes shown are as at 13 October 1986.)

SALMON FISHERMEN

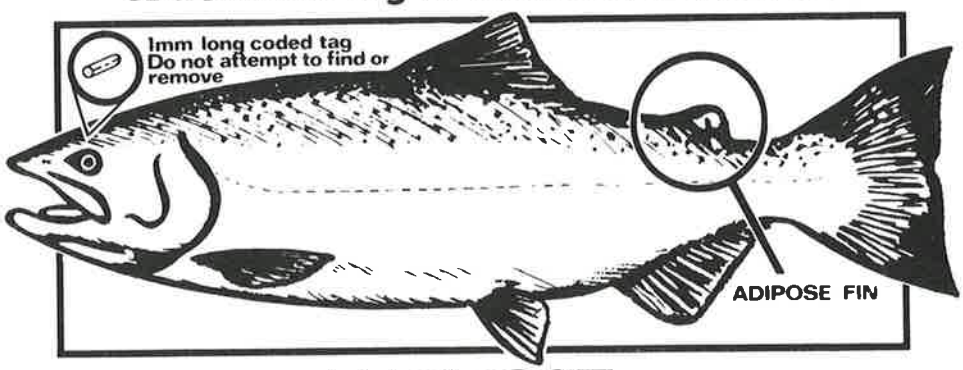
Help improve salmon fishing

WANTED

The head of any salmon that has no adipose fin

REASON:

The missing adipose fin indicates the presence of a minute tag in the head of the fish



PURPOSE:

To evaluate experiments designed to increase the numbers of salmon returning to South Island rivers

REWARD

If the salmon head you turn in contains a tag, your name will be entered in a draw for:

1-$500 prize oo 4-$100 prizes

(Fisheries employees and their immediate families are not eligible.)

IF YOU CATCH A SALMON WITH NO ADIPOSE FIN

1 Remove the fish's head. 2 Hand the head in at a head depot (or freeze it until you can hand it in).

THE NEAREST HEAD DEPOTS ARE:

If in doubt, ring Christchurch 488.902 (collect)

Ministry of Agriculture & Fisheries

Appendix 2

Head depots in operation as at 11 August 1987 (grouped by acclimatisation district)

Nelson and Marlborough

Vlastimil Mrazek
Southern Ocean Salmon
Takaka
Takaka 59 648

Kim Drummond
MAFFish
Vickermann Street
Port Nelson
Nelson 81 069

Rex Frost
21 Dillons Point Road
Blenheim
Blenheim 88 421

Neil Rose
71 Torquay Street
Kaikoura
Kaikoura 679

North Canterbury

Jack Hepburn
145 Jacks Pass Road
Hanmer Springs
Hanmer Springs 7140

Peter Barnes
36 Buckley Street
Cheviot

Brian Sandford
Mitre 10
Hall Street
Cheviot
Cheviot 832

Ian Paton
Domett
R.D. 3
Cheviot
Cheviot 382

Bill Westlake
Horsley Down Road
Hawarden

Peter Geange
Mackett Place
Culverden
Culverden 8184

The Manager
Hurunui Salmon Farm
C/- P.O. Box 13547
Christchurch

Bill Oquist
Fox and Oquist
106 High Street
Rangiora
Rangiora 7983

Alan Adams
37 Otaki Street
Kaiapoi
Kaiapoi 8717

Anthony Bell
Bell-Waimak Services
Main North Road
Kaiapoi
Kaiapoi 7080

Bill McEwan
35 Featherstone Avenue
Kairaki Beach
Kaiapoi
Kaiapoi 7641

Brian Webb
61 Bealey Avenue
Christchurch
Christchurch 69 191

Charlie Wakefield
Rakaia Huts
Rakaia
Christchurch 324 387

Fred Lucas
Freshwater Fisheries Centre
Ministry of Agriculture and Fisheries
Kyle Street
Riccarton
Christchurch 488 939

Peter Hart
Smith's City Market
Riccarton Mall Branch
Riccarton Road
Christchurch

J. C. Hawkins
5 New Brighton Mall
New Brighton
Christchurch
Christchurch 889 825

Brian Ross
184 Horndon Street
Darfield
Darfield 88 640

Bill Elson
Queen Street
Springfield

Peter Hardy
New Zealand Salmon Co Limited
Lake Coleridge
Lake Coleridge 859

Alec Gilbert
Little Rakaia
R.D. 3
Leeston
Southbridge 705

Nick Randall
Mount Hutt Lodge
Rakaia Gorge
Glenroy 898

Ashburton

Lloyd Gledhill
Glenariffe Salmon Research Station
Rakaia Gorge
Lake Coleridge 815

Bruce and Nicky Kelly
Rakaia River Motels
Rakaia
Rakaia 27 257

Gerard Fitzgerald
Methven Butchery
Rakaia Gorge Road
Methven
Methven 28 203

Les Henderson
7 Hakatere Huts
Ashburton

Murray Smith
Ashburton Motors
East Street
Ashburton
Ashburton 83 199

Don Fletcher
Tinwald Service Station
Tinwald
Ashburton 7471

Doug Booth
Mayfield
Mayfield 36 298

Peggy Donn
Rangitata Hut-holders Association
R.D. 3
Ashburton
Ashburton 6470

South Canterbury

Ian Maxwell
Rata Peaks
Rangitata Gorge
Arundel 527

John Moore
Park Headquarters
Peel Forest
Arundel 861

Bob Morrison
Morrison Bros Ltd.
Talbot Street
Geraldine
Geraldine 312

Graham McClintock
30 Richard Pearse Drive
Temuka
Temuka 57 584

Robin Austin
Bago's Sports Equipment
30 Elizabeth Street
Timaru
Timaru 84 952

Waitaki Valley

Jerry Wing
Newhaven Salmon Ranch
Glenavy
Glenavy 884

Murray and Joan McIntosh
Kaik Road
Oamaru
Hilderthorpe 880

Graeme Hughes
Manse Road
Kurow

Gordon Brown
Brownie's Sporting World
229 Thames Street
Oamaru
Oamaru 45 582

Gavin James
MAFFish
56 Trent Street
Oamaru
Oamaru 48 248

Appendix 2—*continued*

Bob and Janice Jones
Moeraki Lighthouse
Moeraki
Hampden 653

Otago

Niall Watson
Otago Acclimatisation Society
35 Hope Street
Dunedin
Dunedin 779 096

Chris Cole
Fishermen's Wharf
Port Chalmers
Dunedin

Jack Jenkins
P.O. Box 29
Portobello
Dunedin
Dunedin 780 799

Ralph Harrison
C/- Electricorp
Private Bag
Roxburgh
Roxburgh 48 014

Evelyn Murray
South Otago Sports
61 Clyde Street
Balclutha
Balclutha 80 370

Neville Findlater
Findlaters Sports
20 Clyde Street
Balclutha
Balclutha 80 466

Peter Buxton
Southland Salmon Company Ltd.
Kaitangata
Kaitangata 566

West Coast and Westland

The Manager
Donaldsons Sports Shop
Mackay Street
Greymouth
Greymouth 4060

Bill Hibbs
9 Doyle Street
Blaketown
Greymouth
Greymouth 5578

Chris Tonkin
Westland Acclimatisation Society
23 Sale Street
Hokitika
Hokitika 1546

Jack Fitzsimmons
C/- Post Office
Jacksons
Westland
Otira 891

Appendix 3

A copy of one of the labels carried by the head depot operators, for recording details of angler-caught tagged salmon

Apart from the angler's name and address, only the river and area where the fish was caught are regarded as essential details. The completed label is enclosed in a plastic bag along with the fish head, which is then forwarded to FFC.

PLEASE PRINT

PLACE FISH CAUGHT	RIVER:		
	AREA:		
SEX:		WEIGHT kg:	LENGTH cm:

NAME .....

ADDRESS .....

PHONE .....

DEPOT NO.:	DATE CAUGHT:

TURNERS LTD

Appendix 4

The data form used by FFC for recording all incoming CWT return data

Since 1985, the small plastic bags used to file the individual tags after they have been recovered have been dispensed with. Instead, we now prefer to use a strip of double-sided adhesive tape down the right hand edge of the form, on which the tags can be securely held in place against the appropriate reference number. This practice eliminates double handling of the tags and greatly speeds up the process of back-checking tags when a reading error is suspected.

ADULT QUINNAT SALMON

CODED WIRE TAG RECOVERY DATA

REF. NUMBER	CWT NUMBER	STAT	LOC. CODE	SECONDARY TAG NUMBER	NOTES

Appendix 5

An example of the letter used to acknowledge anglers who return a tagged salmon head

Variants of this letter are sent to anglers whose fish did not contain a tag and to commercial fishermen catching salmon at sea.

Ministry of Agriculture and Fisheries
Fisheries Research Division
P.O. Box 8324
Riccarton
Christchurch, N.Z.

Location:
Kyle Street
Riccarton
Christchurch
Telephone (03)488-902

3/3/2/3

24 January 1984

159-85

Dear

Thank you for handing in the head of the adipose fin-clipped salmon you caught at the mouth of the Rakaia River on 28.12.84.

The head contained a wire tag with the code 63/36/5. Please see enclosed sheets of tables for details of your tag codes.

As your salmon contained a tag your name will go into the next draw of the salmon lottery with a first prize of $500 and four $100 prizes.

Your co-operation in the search for marked salmon is much appreciated.

Yours sincerely

(D.H. Lucas)
Technical Officer

Appendix 6a

A sample computer listing summarising adult salmon return data for the 1978 brood year

The listing shows, for each tag code: the river and location of the release; the number of fish tagged; the number of adults recovered as 2, 3, or 4 year olds and in total; the percentage return; the number of untagged fish released at the same time; and the expected return from tagged and untagged fish.

1978 Brood Year Returns: All Recovered Fish

Tag code	Where released		Number	Number returned				%	Released	Est.
	River	Location	released	Age 2	Age 3	Age 4	Total	return	untagged	return
63/07/01	Waimakariri River	McIntosh's Rocks	1950	0	1	0	1	0.05	0	1
63/09/01	Rakaia River	Hydro Lakes	3345	1	11	3	15	0.45	0	15
63/10/02	Waimakariri River	Silverstream Hatchery	49766	17	29	0	46	0.09	407962	423
63/11/01	Rakaia River	Hydro Lakes	11206	0	17	10	27	0.24	1000	29
63/11/02	Rakaia River	Glenariffe Hatchery	52041	23	170	10	203	0.39	200	204
63/12/02	Rakaia River	Glenariffe Hatchery	27618	15	153	23	191	0.69	0	191
63/15/01	Waimakariri River	Silverstream Hatchery	2111	2	7	0	9	0.43	0	9
63/20/02	Rakaia River	Glenariffe Hatchery	7333	68	96	27	191	2.60	0	191
63/23/02	Waimakariri River	Silverstream Hatchery	9377	0	1	0	1	0.01	10330	2
63/24/02	Waimakariri River	Silverstream Hatchery	9148	0	2	0	2	0.02	0	2
63/25/02	Waimakariri River	Grasmere Stream	7666	3	1	0	4	0.05	14539	12
63/26/02	Opihi River	Three Springs Creek	10134	2	1	1	4	0.04	15000	10
63/27/02	Rakaia River	Glenariffe Hatchery	10494	3	43	2	48	0.46	0	48
63/29/02	Rakaia River	Glenariffe Hatchery	25657	8	74	9	91	0.35	0	91
63/30/02	Rakaia River	Rakaia Mouth	26201	6	13	3	22	0.08	0	22

Appendix 6b

A sample computer listing summarising returns to the Hurunui River in 1983–84

For each tag code (the data are grouped by brood year or age) the listing shows the release location, the number of fish tagged, the number of recaptures, the number of untagged fish released, and the expected return from tagged and untagged fish.

1983/84 Tagged Salmon Recoveries: Hurunui River

Brood year	Tag code	Where released: River	Where released: Location	Number released	Number recovered	Released untagged	Est. return
1980	63/24/03	Rakaia River	Glenariffe Hatchery	21330	2	48821	7
			Total returns		2		7
1981	63/15/02	Rakaia River	Hydro Lakes	816	1	0	1
1981	63/16/04	Rakaia River	Glenariffe Hatchery	19169	1	31288	3
1981	63/21/04	Rakaia River	Glenariffe Hatchery	19828	2	50394	7
1981	63/22/04	Rakaia River	Glenariffe Hatchery	18714	11	0	11
1981	63/23/04	Hurunui River	Longfellow Hatchery	21340	4	192645	40
1981	63/32/03	Clutha River	Minzion Burn	5292	1	0	1
1981	63/41/03	Rakaia River	Coleridge Hatchery	10520	2	60000	13
1981	63/42/03	Rakaia River	Coleridge Hatchery	10600	3	44100	15
1981	63/46/03	Hurunui River	Longfellow Hatchery	20850	3	53593	11
1981	63/50/03	Rakaia River	Coleridge Hatchery	10523	2	54700	12
1981	63/61/03	Waimakariri River	Silverstream Hatchery	20492	1	133151	7
			Total returns		31		121
1982	63/34/03	Clutha River	Kaitangata Hatchery	5782	1	6863	2
1982	63/36/12	Rakaia River	Glenariffe Hatchery	9888	1	0	1
1982	63/36/31	Rakaia River	Glenariffe Hatchery	9445	3	0	3
1982	63/36/32	Rakaia River	Glenariffe Hatchery	9764	2	0	2
1982	63/36/33	Rakaia River	Glenariffe Hatchery	8606	1	0	1
1982	63/36/40	Rakaia River	Glenariffe Hatchery	10001	2	0	2
1982	63/36/41	Rakaia River	Glenariffe Hatchery	9245	4	0	4
1982	63/36/42	Rakaia River	Glenariffe Hatchery	10153	3	0	3
1982	63/53/02	Rakaia River	Coleridge Hatchery	5700	2	38544	16
1982	63/54/03	Rakaia River	Coleridge Hatchery	10573	2	47557	11
1982	63/56/03	Rakaia River	Coleridge Hatchery	10683	3	55830	19
			Total returns		24		64

Appendix 6c

A sample computer listing summarising tag return data for a specific tag code, in this instance 63/20/02

The listing shows release details (for example, release date, location, weight), the total return, returns by age, returns by recovery status (for all fish), returns by river (for all fish), and returns by location (for all fish recovered in the river of origin—in this instance the Rakaia River).

Coded-Wire Tagging Programme: Age Distribution Summary for Tag Code 63/20/02

Release Data

Brood: 1978
Release date: 14-08-79
Number tagged: 7333
Release location: Glenariffe Hatchery
Weight at release: 35 g
Number recovered: 191

Age Distribution	age2	age3	age4	total
	68 (36%)	96 (50%)	27 (14%)	191 (100%)

Age Distribution v. Recovery Status

Recovery status	age2	age3	age4	total
Angler	8 (12%)	14 (15%)	12 (44%)	34 (18%)
Carcass	2 (3%)	6 (6%)	0 (0%)	8 (4%)
Hatchery	58 (85%)	75 (78%)	15 (56%)	148 (77%)
Trap	0 (0%)	1 (1%)	0 (0%)	1 (1%)

Age Distribution v. River of Recovery

Recovery river	age2	age3	age4	total
Hurunui River	1 (1%)	1 (1%)	0 (0%)	2 (1%)
Opihi River	1 (1%)	0 (0%)	0 (0%)	1 (1%)
Rakaia River	65 (96%)	92 (96%)	25 (93%)	182 (95%)
Rangitata River	0 (0%)	0 (0%)	1 (4%)	1 (1%)
Waiau River	0 (0%)	1 (1%)	1 (4%)	2 (1%)
Waimakariri River	1 (1%)	2 (2%)	0 (0%)	3 (2%)

Age Distribution v. Recovery Location

Recovery location	age2	age3	age4	total
Acheron confluence	1 (2%)	1 (1%)	0 (0%)	2 (1%)
Coleridge Hatchery	0 (0%)	3 (3%)	0 (0%)	3 (2%)
Double Hill	1 (2%)	6 (7%)	0 (0%)	7 (4%)
Glenariffe Hatchery	58 (89%)	72 (78%)	15 (60%)	145 (80%)
Glenariffe confluence	0 (0%)	0 (0%)	2 (8%)	2 (1%)
Highbank	0 (0%)	1 (1%)	0 (0%)	1 (1%)
Kowhai Flats	0 (0%)	0 (0%)	2 (8%)	2 (1%)
Rakaia Gorge	2 (3%)	1 (1%)	1 (4%)	4 (2%)
Rakaia Mouth	0 (0%)	4 (4%)	3 (12%)	7 (4%)
S.H. 1 Bridge	1 (2%)	3 (3%)	2 (8%)	6 (3%)
Steeles Road	2 (3%)	1 (1%)	0 (0%)	3 (2%)

Appendix 7a

Data entry and retrieval procedures since 1985

After the installation of a new laboratory minicomputer in March 1985, with access to relational data base software, the CWT data processing system has been overhauled. Apart from greatly increased flexibility with regard to data analysis and retrieval, the new system has streamlined two of the more time consuming routine data processing tasks. Firstly, it facilitates fully interactive data entry, so that return data can be keyed in directly from the tag recovery laboratory. Secondly, letters of acknowledgment to anglers who hand in salmon heads can be generated automatically.

The data entry routines incorporate all the features of the old system, but perform additional validation checks to ensure, for example, that only valid location codes are accepted. More importantly, as each new tag record is entered, the system performs an immediate update of the appropriate files and displays (on the terminal screen) a summary of the data for that particular tag entry. This includes the release location, the number of fish returned to date and the percentage return, the recapture location, and a brief description of the nature and purpose of the release. The recovery crew are thus kept fully up to date with the latest results and also have a much greater chance of detecting any obvious anomalies in the return data (for example, from a tag being incorrectly read).

The letter writing routines use a standard letter template, into which the appropriate information is inserted. For each record, the operator is prompted for the angler's name and address, which are then stored in a file (along with the relevant data items) and passed as input to a formatting programme. The resulting letter (Appendix 7b) contains a more readable summary of the data than the original version (Appendix 5) and requires far less operator time to produce. Variants of the letter are sent to anglers whose salmon heads do not contain a tag and to fishermen catching salmon at sea.

Appendix 7b

An example of the updated letter used to acknowledge the return of a tagged salmon head

Ministry of Agriculture and Fisheries
P.O. Box 8324
Riccarton
Christchurch, New Zealand

Location: Kyle Street
Riccarton
Christchurch
Telephone (03) 488-939

86-7533

Mr .....
Private Bag
CHRISTCHURCH

Thank you for handing in the head of the adipose fin clipped salmon you caught in the Rakaia River.

This fish was one of 10140 tagged with the code 63/36/31.

Details of your fish are as follows :

Where released : Glenariffe Hatchery
Where caught : Rakaia River
Approximate location : Rakaia Mouth
Age at recovery : 4 years.

This release is part of an extensive FRD experiment designed to evaluate, for hatchery reared salmon, the combination of release weight and release date which gives the best return of adult salmon. Results to date show that good returns (better than 2%) can be obtained by releasing young salmon between April and August, at weights over 30g.

As your salmon contained a tag, your name will be entered into the next salmon lottery, drawn on 1 July 1987, with a first prize of $1000. Your cooperation in the search for marked salmon is much appreciated.

Yours sincerely,
Fred Lucas

Results from the tagging programme and other aspects of fisheries work are covered in the magazine Freshwater Catch, published at three monthly intervals by the Ministry of Agriculture and Fisheries.

If you wish to subscribe to this magazine, please complete this form and send it to me at the above address.

(PLEASE PRINT)

NAME _____

ADDRESS _____

_____

V. R. WARD, GOVERNMENT PRINTER, WELLINGTON, NEW ZEALAND—1987

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