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NEW ZEALAND MARINE DEPARTMENT

FISHERIES TECHNICAL REPORT

NO. 63

THE AGE AND RATE OF GROWTH OF QUINNAT SALMON (*ONCORHYNCHUS TSHAWYTSCHA* (*WALBAUM*)) IN NEW ZEALAND

ARTHUR W. PARROTT

WELLINGTON, NEW ZEALAND
1971

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FOREWORD

The following contributions towards a better knowledge of the growth and age of quinnat salmon in New Zealand is a summary of work carried out almost forty years ago, by Arthur W. Parrott.

The information in this report was presented to "The Freshwater Research Committee" of the N.Z. Acclimatisation Societies Association.

When the responsibility for research into freshwater fisheries was transferred to the Marine Department the original report was lodged within Marine Department records.

Mr Parrott consented to edit the information held by the department to permit its formal publication.

The Marine Department acknowledges its gratitude to Mr Parrott by undertaking publication of this valuable information within the Technical Report Series.

R. N. KERR
Secretary for Marine

SUMMARY

Unpublished notes on the introduction, distribution and life-history of quinnat in New Zealand waters are included together with observations on the growth of parr and smolt scales in relation to the procedure of determining the age and rate of growth of the fish from their scales. Finally age and growth analysis of samples taken during the quinnat runs in the Waimakariri, Rangitata and Hakataramea Rivers between 1927 and 1931.

Emphasis is laid on the importance of recognising the relative abundance of stream and ocean type fish and age groups (year-classes) when comparing quinnat from different rivers or from season to season in the same river system.

The data presented should form a basis on which future work on the age and growth of quinnat in New Zealand may be compared, so that changes may be traced in the age and growth patterns of the quinnat stocks in our rivers, thus forming a basis for the conservation and development of the fishery.

INTRODUCTION

The present report on the age and growth of quinnat salmon in New Zealand waters has been compiled at the request of the Fisheries Management Branch of the Marine Department, Wellington from data obtained forty years ago, while the author, as Biologist to the New Zealand Freshwater Research Committee, was investigating the age and rate of growth of introduced salmonoid fishes in New Zealand. The New Zealand Freshwater Research Committee was established in 1930 and financed and controlled by the New Zealand Acclimatisation Societies Association. This Committee operated until 1935 when the work was taken over by the Fisheries Branch of the Marine Department, Wellington.

The data presented in the following pages was originally compiled by the author in 1934 at the request of the Fishery Board of Canada and several independent workers, including Dr Willis Rich, U.S. Bureau of Fisheries, C.H. Gilbert, Stanford University and C. McLean Fraser, Pacific Biological Station, British Columbia. North American workers were at this time extremely anxious to obtain information on the age and growth of quinnat in New Zealand for comparison with data they were collecting in North America.

This interest is exemplified in a letter received by L.F. Ayson who was at that time Chief Inspector of Fisheries, Marine Department, Wellington, from C.H. Gilbert, Stanford University, California, a copy of which was sent to me by Mr Ayson. This letter reads:

8-5-26

Stanford University,
Department of Zoology,
California, U.S.A.

"Dear Mr Ayson,

I was very pleased to have your recent note announcing the forwarding of the salmon scales from Mr Stead. These came to hand at the same time and I have turned to them with the greatest of interest. Unfortunately the time of my departure is so near (May 11) that I have been unable to spare a very limited time to go over the material.

As I wrote to Mr Stead, the results have been unforeseen, and to me astonishing. You will recall that our American quinnats that have spent their first year in freshwater return regularly at the age of 4, 5 and 6. Some of the males return at the age of 2 and 3 but no females. But in your New Zealand fish, those of the stream type return mainly at the age of 3, and these include males and females. Your 3 year fish are of about the same size as our 4 year specimens. They have spent only one summer, a winter and a part of their last summer in the sea. Salmon of this type constituted more than 60% of the material submitted to me.

You can see from this that a whole field of investigation opens out as regards the N.Z. salmon. I have not time to go into the "Sea Type" individuals with you, but they are equally interesting. I hope a renewed effort will be made next season to secure very large samples from the fish of different rivers. I doubt not that soon your local investigators will be prepared to handle your material, but until that time I shall be glad to offer you aid in bringing out important facts in the life history of your fish. Until this is done, you will be unable to judge accurately the course of events in your runs of different size.

Mr Stead's notes on the scarring of the fish he handled are most interesting. Practically all of your running fish have been one or more times in the very jaws of death. It is astonishing under these conditions that you have been successful in starting runs at all. We can only marvel at the results you would have achieved if enemies were no more numerous and effective than they are in our waters.

With best wishes,

Yours sincerely,

(Sgd) C.H. Gilbert"

It was in response to this letter from Gilbert, and requests from other workers in North America, that the work compiled in the following pages was originally undertaken.

I have, however, incorporated additional information from personal correspondence and field notes kept during the period between 1926 and 1934.

Information is given in the main sections of the report on the examination of the scales of 700 quinnat salmon, obtained during their spawning migrations up the Waimakariri, Rangitata and Hakataramea Rivers between 1927 and 1931. In addition the result of a detailed examination of the scales taken from 86 smolts is given, and many of these were pond reared fish of known age, and the opportunity was taken to compare the scales of these fish of known age with the scales taken from wild smolts.

The Waimakariri River enters the sea eight miles north of Christchurch. Like the Rangitata and Waitaki Rivers and other large rivers of Canterbury, the Waimakariri is snow fed. For the last 30 miles the river leaves its gorge in the hills and flows across the Canterbury Plains and enters the sea at Kaiapoi that the 1928 quinnat samples were taken by commercial netting. The anglers' catches that made up the sample from the 1927 run were also taken in the lower reaches of the river.

The Hakataramea River is a tributary of the Waitaki River and enters the Waitaki at Hakataramea, approximately 40 miles from the coast. Although the Waitaki River is only 68 miles in length, with its major tributaries the Tekapo (64 miles), Pukaki (42 miles), Ohau (48 miles), Ahuriri (64 miles) and the Hakataramea (36 miles), the catchment area is 4,565 sq. miles, and is, in size, second only to that of the Clutha River, the largest in New Zealand.

Towards the end of 1900 a Government Hatchery was built on the Hakataramea River in preparation for a concentrated attempt to introduce quinnat salmon into New Zealand. After the quinnat had become successfully established in the Waitaki River, each year during the run the fish were trapped and stripped and the eggs collected and incubated in the hatchery. Ponds were also built where fry and parr were reared before being liberated in other rivers. The material analysed in this report was obtained from trapped fish during the 1931 run up the Hakataramea River.

The Rangitata River is approximately 75 miles in length, and enters the sea just north of Temuka and is formed by two main tributaries, the Clyde and Havelock Rivers. The Rangitata with its numerous tributaries drains the eastern side of the Southern Alps from Lyell Glacier to the Godley Glacier. After leaving its gorge, the river flows across the Canterbury Plains, and it was in this lower portion of the river samples were obtained from anglers' catches during 1930 and 1931.

The only numerically satisfactory sample was that obtained from the Waimakariri River run of 1928, when the measurements and scales were taken from 429 fish. The sample of 197 fish taken from the Hakataramea River during the 1931 run may be considered fairly satisfactory, while the small sample from the Waimakariri River run of 1927 and the nine fish captured during the Rangitata River runs of 1930 and 1931 are of little value for comparative purposes. The figures of the latter are included, however, to place on record such information that is available with the hope that it may indicate what may occur in these rivers.

At the time this investigation was undertaken into the age and growth of quinnat in New Zealand, there was no information available relating to the annual runs of quinnat in any of our rivers and it was emphasised at the time how essential it was to undertake such work and to evolve a scheme by which adequate samples could be collected. Such information should be obtained from each of the major quinnat rivers, annually during the spawning run that would entail collecting scale samples, together with particulars of many hundreds of fish, during the entire run, over a period of years. This unfortunately was not carried out and the present isolated data collected between 1927 and 1931 is all that is now available for future comparisons.

There are four main methods that can be used to obtain adequate samples during the quinnat run. The first method is a comprehensive netting programme at the mouth or lower reaches of the rivers, when the fish are entering freshwater to spawn. The second method is to trap fish migrating upstream to their spawning grounds, the traps being placed in the upper reaches of the rivers. The third, and probably the least satisfactory method, is to obtain scale samples and particulars of rod caught fish, which would require complete cooperation from anglers and is a difficult method to put into practice. The fourth method is by obtaining otoliths from the carcases of dead or dying fish after spawning.

Information and material collected through anglers is difficult to assess, although the angler may have conscientiously carried out his part of the work.

When dealing with material obtained from anglers' catches it is important to know how such material compares with net or trap catches in regard to length, weight and sex ratio of the fish. Snyder (1931) has compared anglers' catches with net catches in North America and found that anglers' catches are very similar in regard to sex and size of fish, to net catches. E.A. McGregor (1921) had previously paid some attention to this question and he also found a remarkable similarity in the relative proportion of males and females and the size of the fish taken by the two methods.

The Waimakariri River net catches of 1928 and the anglers' catches of 1927, numerically are too small to justify a comparison, although it should be noted that the two samples were similar in proportion of males and females and the size of the fish.

It should be emphasised that the results presented in the following pages, analysing, as it does, isolated samples, of which only two can be considered statistically significant, are of limited value, except to form the basis for comparison for future workers on the quinnat in New Zealand. By using such information as presented in this report it would be possible to follow over a period of years, the numerical fluctuations of the different year-classes and growth types of the quinnat in a particular river or between different rivers. Work of this kind carried over a long period would bring to light many important aspects of the life of quinnat in our waters. Such information would enable us to estimate the numerical strength of future runs and to arrive at conclusions as to whether the maintenance of a particular fishery is an economically sound proposition.

THE INTRODUCTION AND DISTRIBUTION OF QUINNAT SALMON IN NEW ZEALAND

The first attempts to introduce quinnat salmon into New Zealand waters were made between 1875 and 1880, when annual consignments of ova were received from California. The ova were distributed to various Acclimatisation Societies, and the fry hatching from these eggs were liberated in local rivers and streams from Wairoa in North Auckland to the Makerewa River in Southland. Apparently this first attempt to acclimatise quinnat into New Zealand was unsuccessful and F.W. Hutton, writing in 1908, writes "the ocean having apparently swallowed them up".

In 1900 the Government decided to make further attempts to establish quinnat in this country, concentrating on one particular river and, for this purpose, the Waitaki River in South Canterbury was selected. A suitable site for building a hatchery was found on a tributary of the Waitaki River, the Hakataramea, and a hatchery was built towards the end of 1900. The first consignment of ova was received at the Hakataramea hatchery in 1901. According to F.W. Hutton these ova were supplied by the United States Bureau of Fisheries from the Baird Hatchery on the McCloud River, a tributary of the Sacramento. During the following years from 1901 to 1907 nearly two million quinnat salmon ova were received and the resulting fry liberated in tributaries of the Waitaki River, with phenomenal results. Hutton mentions that it would be safe to say that from these ova fully 1,500,000 young fish were reared and liberated.

As early as 1905 quinnat were caught by anglers at the mouth of the Waitaki River and one of these fish was sent to Sir James Hector, who identified it as a Pacific salmon. In 1906 salmon were reported for the first time spawning in the Hakataramea River and one of these fish, a spent male, was also identified by Sir James Hector as a Pacific salmon, probably a quinnat. During 1907 quinnat were reported spawning in the Waitaki River and in the smaller streams flowing into Lake Tekapo. During the same year a good many salmon were reported to have been caught by anglers at the mouth of the Waitaki during the three months, January to March. F.W. Hutton reported that salmon were caught by anglers during February and March 1907, at the mouth of the Rangitata River, but specimens were not obtained and were never authentically identified. During the years following 1908, there is little doubt that quinnat were being caught by anglers at the mouths of several Canterbury rivers, including the Rangitata, Rakaia and Waimakariri.

Little is known about the distribution of quinnat in the sea around the New Zealand coast. Odd specimens have been taken off the coast of the South Island, mainly off the East Coast and in the Cook Strait area. These fish are probably stragglers that have strayed from their usual feeding grounds in the sea. Quinnat have been reported running up some West Coast rivers to spawn, and today (1970) it is an established fact that spawning does occur in some rivers of the West Coast of the South Island.

It would appear that rivers, other than the Waitaki, have been stocked by quinnat through the tendency of some to disperse and wander away from their parent streams. There is little doubt that their dispersal in the sea is largely governed by temperature and the dispersal of their food. Young fish wandering about in search of food are attracted to areas of optimum conditions, in respect to temperature and salinity of the water. There is little doubt that the present distribution of quinnat in New Zealand is largely due to ocean currents and temperature.

Finlay (1929) attributes the warm notonectian current to the early maturity of quinnat in New Zealand compared with North America, and it is of interest to note that such favourable conditions have an important bearing on scale development and growth.

Another factor that obviously has considerable influence on the distribution of quinnat in New Zealand waters is river temperatures. Our knowledge of the annual variation and range of fluctuations that occur in freshwater and sea temperatures around our coast and the conditions controlling them is extremely fragmentary.

A relatively small change in temperature may considerably effect the growth and distribution of aquatic animals and plants, and it must be one of the most important factors limiting the distribution of quinnat in New Zealand.

Sea temperatures recorded off the New Zealand coasts prior to 1934 have been spasmodically taken by expeditions and individuals, mostly at the surface, which is subject to diurnal variations. The transference of heat to the lower levels is controlled by the amount of turbulence or eddy motions and by the redistribution of the water brought about by currents, so that it is reasonable to assume that surface temperatures are of little use in ascertaining the temperature distribution of the main mass of water from one year to another. We cannot attach too much importance on these older records of water temperature, for it is impossible to verify anything about the manner in which they were taken.

From what information there is on sea temperatures around our coasts, indicate that the mean maximum temperature for both air and water (surface) occur in January or in some cases February, and the mean minimum temperature occurs in July.

The range in air temperature is almost double that of the surface water temperature, which has a range of between 5 and 7 deg. C. Towards the end of March and during April there appears a distinct fall in surface water temperatures, reaching a minimum towards the end of July or even early August.

The search for food is probably one of the most important agents in the dispersal of the young fish in the sea and they would thus tend to wander away from the influence of their parent stream, and when mature some may return to rivers other than where they were hatched.

NOTES ON THE LIFE HISTORY OF QUINNAT IN NEW ZEALAND

For the purpose of presenting some notes on the life history of the quinnat in New Zealand waters, it is convenient to consider the life of the quinnat under three phases:

(1) Early life spent in freshwater
(2) Ocean life
(3) Final phase when the fish enter freshwater to spawn.

The first phase which is spent in freshwater may extend over a period of one to eighteen months. The results of the present investigation indicates that there is probably no definite time at which the downstream migration of quinnat takes place. On the one hand there are those fish that have reached the sea within one or two months after hatching, while on the other hand there are those fish that have not reached the sea until well into their second summer.

An interesting feature of New Zealand quinnat is their apparently gradual transition from freshwater to salt water and in some extreme cases the fish may have stayed in brackish water estuaries as long as six months after leaving freshwater. To interpret these variations in duration of the first phase of their life history, it is essential to know something of the conditions prevailing in the parent streams. We know that conditions may vary considerably in different tributaries of the same river, and from season to season in the same tributary, and such differences would have a direct effect on the time taken for development and the age at which downstream migration occurs.

On several occasions while netting for silveries during October at the mouth of the Rangitata River, quinnat smolts ranging from 2.5 to 7.5 cm have been taken. During the period November 1929 and November 1933 fly fishermen frequently caught small quinnat, from 10.0 to 15.0 cm in length, in the Ashburton River about five miles up from the mouth.

Smolts have been observed going down the Waitaki River in considerable numbers during April and March, their average length being between 7.5 to 10.0 cms. They have also been seen in much smaller numbers migrating downstream during June. While fishing in November 1929, about a mile up from the mouth of the Waitaki River, the author hooked a 15.00 cms smolt on a dry fly and the scales revealed that this fish was a stream type quinnat approximately 15 months old.

The author is indebted to Mr T.G.A. Harle for the following information in a letter dated 2 November 1931:

"On 5 October 1931 at the mouth of the Ashburton River young salmon up to 3 inches long (7.5 cms) were taken from the stomach of a brown trout. On 24 October 1931, one mile up from the mouth of the Rangitata, I caught in a silvery net a young salmon 1 inch (2.5 cms) long. Each year in October at the mouth of the Ashburton and Rangitata we catch in silvery nets salmon from one to three inches long (2.5 to 7.5 cms). They seem to remain there about a month and then disappear". Mr Harle goes on to say that "During the period from January to April young salmon are frequently taken by fly fishermen from 5 to 8 miles above the mouth in the Ashburton River. These small quinnat are from 3 to 6 inches (7.5 to 15.0 cms) long and are a source of annoyance to anglers."

The second phase in the life of the quinnat, which is spent in the sea, very little is known and only odd specimens have been caught, more especially in harbours and bays along the coast. From information presented in another section of this report there is reason to believe that in New Zealand this phase varies in duration from one year to four years.

The main source of information relating to quinnat during their life in the sea, is from commercial fishermen. Small quinnat are occasionally taken in bays and harbours along the east coast of the South Island. These are immature fish and range in length from 30.0 to 50.0 cms. Net fishermen catch odd specimens in deep water up to 22 miles off the coast of South Canterbury.

On 16 June 1931 five quinnat were taken in the Oamaru Harbour, four of which ranged in length from 20.0 to 22.4 cm and were approximately one year old and of the ocean type. The fifth specimen measured 53.6 cm in length and weighed 1.8 kmg., was a three year old fish of the ocean type.

Another quinnat, approximately one year old, was captured off the Otago coast on 7 June 1931 and measured 25.6 cms and weighed just under 1 kmg. A female quinnat taken at sea off the Kaikoura coast on 16 August 1930 was an ocean type fish measuring 80.5 cm in length and weighed 9.5 kmg and was three years old.

A 35 cm quinnat was captured on 24 September 1930 in Lyttelton Harbour and was approximately one year and two months old. It showed exceptionally rapid growth during the spring in which it was caught, having increased 12.5 cm since the completion of the first winter band, when it had attained a length of 22.4 cm at the end of its first winter. This was an ocean type fish.

The following table (No. 1) summarises what little information I have on the growth of quinnat taken at sea off the east coast of the South Island.

TABLE 1

Length, Weight and Growth Rate of Quinnat taken in the Sea

Date of Capture	Locality	Length (Cm)	Wgt (Kmg)	Growth rate (Yrs) 1st	2nd	3rd
June 1931	Oamaru Harbour	20.0	-	20.0	-	-
June 1931	Oamaru Harbour	20.0	-	20.0	-	-
June 1931	Oamaru Harbour	21.1	-	21.2	-	-
June 1931	Oamaru Harbour	22.5	-	22.5	-	-
June 1931	Oamaru Harbour	53.6	1.8	17.5	40.6	53.7
June 1931	Off Otago Coast	25.6	1.0	25.0	-	-
August 1930	Off Kaikoura	85.0	9.5	17.5	41.2	77.4
Sept. 1930	Lyttelton Harbour	34.9	-	22.5	-	-

The third and final phase in the life of the quinnat occurs when they return to freshwater to spawn.

In New Zealand the quinnat usually begin to congregate in the vicinity of the mouths of our larger snow rivers during December. Towards the end of January or early February they commence to enter freshwater and the run generally continues until the end of May. Although reports have been received of a spring run, there is no definite evidence that such a run occurs in New Zealand similar to the spring runs of North American quinnat.

Mr T.G.A. Harle, at that time Chairman of the Ashburton Acclimatisation Society, has supplied the following information in a letter to the author dated 2 November 1931.

"I have seen odd salmon caught near the mouth of the Rangitata River (about a mile upstream) as early as the following dates:

1 January 1928 (weight 16 lb) (7.3 kgm)
26 December 1929 (weight 22 lb) (10 kgm)
1 January 1930 (weight 30 lb) (13.6 kgm)

"Mr B. Corbett caught his first salmon of the season at the mouth of the Rakaia River, a fish of 25 lb (11.3 kgm) on 31 December 1928 and Mr W. Black, of Rakaia captured a 25 lb quinnat (11.3 kgm) on 15 January also at the mouth of the Rakaia. From 1 January fish are taken, but the main run commences in both the Rangitata and Rakaia Rivers usually between 15 and 19 February and continues spasmodically until the middle of April when it begins to taper off.

"In the Rangitata we have definite evidence that in the second week of June 1930 a large run of salmon went up the river. This run was observed and reported to the Ashburton Acclimatisation Society by the County Council Water Ranger at Montalto (about 30 miles up from the mouth). I am informed at the Rakaia railway bridge, a bridge repair gang observed a run there about the middle of June 1930. Mr Harle continues 'My personal observations lead me to believe that the runs are larger in the Rakaia than in the Rangitata, but that we seem to get bigger fish in the Rangitata.'

"In the Rakaia River quinnat apparently spawn all the way up the river, while in the Rangitata they seem to spawn more beyond the Gorge, where the shingle is smaller. There is a favourite spot through the Rangitata Gorge on Sir W. Nosworthy's property (Mesopotamia Station) called Deep Creek, where they spawn in their thousands. They start to congregate in Deep Creek about 1 May and by the end of May there are thousands spawning throughout the length of the creek. Late run salmon have also been reported spawning a few miles up from the mouth of the Rangitata, and have been reported as low down as Ealing."

Mr J.B. Brown in 1927 recorded the following notes on the spawning of the quinnat:-

> "Although the majority of our quinnat push up to the head waters of our rivers, a large number remain and spawn in pools from the sea upwards. I have seen quinnat actually spawning within a mile or two of the sea during April and May when the river conditions permit. The favourite hour is the middle of the afternoon. The fish come into the shallow water usually about 18 inches (45 cms) to 24 inches (60.0 cms) deep. The female moves slowly forward as she deposits her ova, while the male follows immediately behind covering the eggs with milt. The fact that a few quinnat spawn quite close to the sea has given rise to the belief that some of them may get back to the salt water and survive to spawn a second time - but all evidence that I have been able to obtain is against this possibility."

METHOD OF INTERPRETATION OF AGE AND GROWTH RATES

The calculated length at the end of each winter through which the fish had lived was obtained by Lee's method (Lee 1920). Lee assumed that the fish attains a length of approximately 3.7 cms. before the scale is formed and from then on the yearly increment in the scale is proportional to the increment in the length of the fish taking place during the same interval of time.

The material which forms the basis of this report does not permit an investigation of the validity of Lee's method for New Zealand quinnat salmon, but relative information has previously been published on the formation and growth of the scales in Brown Trout in New Zealand (Parrott 1934). However, data is presented in the following pages under the heading "Observations on the Growth of Parr and Smolt Scales" that deals with the relative growth of, and the formation of winter bands on the scales of quinnat of known ages.

The average length of the fish, which is assumed to be about 3.7 cms when the scales are first formed, was deducted from the length of the fish when captured and the calculated length at the end of each winter was then determined. This constant of 3.7 cms was then added to the computed length of the fish at the end of each year of its life. According to Nall (1930) this method is not strictly correct, but at the time the present work was carried out in 1934, Lee's method was followed so that the data from New Zealand quinnat could be directly compared with figures published by American and Canadian authors on North American quinnat.

Of the scale samples on which this report is based, 26 were discarded owing to either uncertainty of the age of the fish, due to indefinite markings on the scales or because less than three perfect centred scales were available from the fish concerned.

Scale measurements were obtained by means of an Abbe drawing apparatus, the image of the scale being thrown on to a dark brown background at the side of the microscope. A strip of white paper, approximately 1.9 cms wide and 12.7 cms long, was laid parallel to the long axis of the scale. The centre of the scale and the positions of the succeeding winter bands and the total length of the anterior radius of the scale, were marked on the strip of paper. Particulars of the length, weight and sex of the fish when captured were noted on the back of the strip of paper for future reference, together with a serial number accompanying the scale sample. At least three scales from each fish were mounted dry between two glass slides and filed for future reference. The three separate strips of paper recording the measurements from the three scales from each fish were clasped together and filed until the complete sample of fish from a particular river had been completed.

The marks on the strips of paper, representing the centre, and succeeding winter bands and the anterior margin were then interpreted. Before employing the drawing apparatus each scale was carefully examined, in some cases under a high magnification in order to differentiate between false and true winter checks.

A portion of the material used in this report had been previously examined by Finlay (1931) and it was found that the author's interpretations were in general agreement with those of Finlay's, with the exception of three fish. It must be remembered that in the present report a three year old fish is the same as Finlay's 2+ year-old, as in the present report the year of capture is considered a complete year. In the three cases where the author's and Finlay's readings differed, it may be of interest to note these discrepancies in some detail.

No. 1 was a three year old female, the first reading by the author gave an ocean nucleus, a second examination gave the same result. After a closer examination of these scales, which Finlay had noted as a stream type nucleus, the fish was discarded from the present analysis as it was considered a doubtful specimen, possessing what Rich and Holmes (1929) have termed a "composite nucleus" on its scales.

No. 2, a four year old male, showed a discrepancy of 6.3 cms. in the calculated length at the end of its second winter, between Finlay's and the author's interpretations. In the case of No. 3, a three year old female, showed a calculated length of 7.5 cms more than that calculated by Finlay for the second year. In the scales of both these fish the winter bands were poorly defined.

It must be expected that mechanical and personal errors will occur in a few cases, but in numerically large samples such errors would be of little or no significance and should not effect the general pattern of growth for a particular fish population.

Following the terminology of Gilbert (1913) and Rich (1920) and (1925), the entire first year's growth, as depicted on the scale, is termed the nucleus of the scale. As there are two types of quinnat salmon, differentiated by the length of time spent in freshwater before entering the sea, so there are two types of nuclear growth on the scales. One type is designated the "Ocean Type" which is found depicted on the scales of those fish that migrate to the sea during their first year of life, while the other type, designated the "Stream Type" include those fish that remain in freshwater during their first year of life, at the end of which they enter the sea. In most cases there is little difficulty in distinguishing these two types of quinnat growth in New Zealand waters.

It has previously been mentioned that the formation of scales do not begin until the fish has attained a length of about 3.7 cms and for this reason a proportion of very small fish have not developed scales before reaching the sea, and the scales of these fish have a perfect "Ocean Type" nucleus. In many cases there appears in the nuclear portion of the scales intermediate growth indicating that the fish had spent sometime in estuarine waters in the course of its transition from river to sea life.

The recognition of stream and ocean types of growth is important as it separates the fish into two more or less clearly defined categories according to the time spent in freshwater before entering their ocean life.

The time spent in freshwater before migrating to the sea consequently determines the age and size of the quinnat returning to freshwater to spawn. There is every reason to believe that there is a connection between the age at which the young quinnat reaches the sea and its subsequent growth rate. In some cases there is considerable variation in growth rate during sea life, which may become widely dispersed, and consequently subjected to different environmental conditions.

Although local conditions are known to retard development and slow down growth rates, that consequently postpones the age at which maturity takes place, there are other factors that would produce the same results. Such factors would be indicated in the analysis of the runs of quinnat in different rivers over a period of years.

In the section "Growth of Parr and Smolt Scales" the scales from pond reared fish of known ages and wild smolts were examined and compared. The circuli or rings in each scale were counted along the anterior radius and for each individual fish three scales were measured and the number of circuli counted and the mean obtained.

Scale measurements were taken with a micrometer eye-piece with a magnification equivalent to 18 divisions to the millimetre. The measurements are then expressed as fractions with the denominator 18. This method of expressing scale measurements is considered less confusing than if the measurements had been expressed in decimals of a millimetre.

The age in years of the fish is determined by the number of "winter bands" depicted on the scales, and as the fish were captured during their return to freshwater to spawn during the late summer or autumn, the year in which it was caught is considered to have been completed. A three year old fish would therefore show two complete winter bands on its scales, plus the third summer's growth, although no indication of the third "winter band" may necessarily appear on the scales.

OBSERVATIONS ON THE SCALES OF QUINNAT SALMON IN NEW ZEALAND

North American investigators, especially Gilbert and Fraser, have shown that the scales of most Pacific salmon, especially the quinnat, may be divided into two more or less distinct areas. The central area or nucleus in which the circuli are spaced relatively close together and a very much larger peripheral area, where the circuli are spaced much more widely apart and more clearly defined. From the evidence collected there is little doubt that the nucleus of relatively narrow circuli is laid down on the scales during the period spent in freshwater prior to migration, while the wider spaced and more strongly formed circuli are laid down during sea life.

Upon the presence or absence of a nuclear area in the scales is based the classification of the two principle growth types, namely (1) Stream Type and (2) Ocean Type.

The scales of quinnat belonging to the stream type are characterised by the presence of a definite central area of narrow circuli, indicating relatively slow growth during the first year of life, the result of the fish remaining one year or sometimes a little over one year in freshwater before entering the sea.

Scales from ocean type fish are characterised by the absence of a definite central area of narrow circuli, due to relatively fast growth during the first year of life, as a result of the fish having migrated early during their first year of life as fry or fingerlings, to the sea where rapid growth then took place.

In the case of the Yukon and Fraser Rivers in North America, there has apparently been very little difficulty encountered in assigning a particular individual quinnat to either of these two growth types, although Rich (1920) found considerable difficulty in interpreting the nuclear portion of the scales of quinnat taken from the Columbia River. Rich and Holmes (1929) in a later paper stated "The chief difficulty in the interpretation of the scales of chinook salmon are those associated with the growth of the first year .... The nucleus of the scales of these fish consist in a central portion of true stream type of growth, which is usually surrounded by a more or less distinct band of intermediate rings, which in turn is surrounded by the wider rings of ocean growth formed during the second year". It would appear that this intermediate band, immediately outside the true stream growth zone, records the growth that had taken place in the estuary or lower reaches of the river where the individual fish may have spent its second year of life, or a greater part of it.

Rich and Holmes (1929) regarding this intermediate band on the scales of certain quinnat, stated "It frequently, though not always is developed during the time the fish has spent in brackish water of the estuary during the seaward migration". Where the true character of the nuclei cannot be determined, owing to the lack of definition between these three zones, together with the presence of false checks in the scales, these authors have used the term "composite nuclei".

Rich (1920) has shown that although the majority of quinnat apparently migrate to the sea between June and October, migration may take place throughout the year. In the case of yearlings, migration downstream is completed by June. He gives two possible explanations for this prolonged migration period.

(1) The fish from each tributary may migrate gradually, a few at a time, throughout the year.

(2) Fish from each tributary may all migrate at about the same time, but migration from different tributaries takes place at different times of the year.

These authors have been quoted at length, because their work was based on the most extensive and intensive investigations that had been carried out up to 1934, and also because scales of quinnat in New Zealand resemble those from the Columbia River.

Considerable difficulty was experienced in interpreting the nuclear portion of the scales of quinnat salmon taken from the Waimakariri River. The difficulty arose mainly because:

(a) Lack of definition in the scales between stream and ocean growth zones. In many cases there occurs, immediately outside the typical stream type growth, a band of moderately wide circuli although not nearly as wide as those circuli which are laid down during sea life.

(b) By the frequent occurrence of incidental checks of narrow and broken circuli during the first and second year of life.

Although these irregularities in the scales of quinnat from New Zealand appear similar to those irregularities described by Rich and Holmes (1929) in the scales of North American quinnat, they may have been brought about in the scales of New Zealand quinnat by very different factors. In regard to New Zealand quinnat such irregularities could be brought about by any one or more of the following factors:

(1) The time of year when the seaward migration occurs
(2) The duration of the seaward migration
(3) An abrupt change in environmental conditions, such as could occur when a fish is liberated from hatchery ponds into a river.
(4) The duration of the time taken in their transition from freshwater to salt water.

In regard to New Zealand quinnat I do not consider that factors (1) and (2) are of very great importance, but factors (3) and (4) certainly are and warrant careful investigation.

On the scales of Waimakariri River quinnat there are found many secondary checks, similar to those reported by Rich (1920) in the scales from Columbia River quinnat. These checks occur not only in the nucleus area of the scales but also in subsequently formed areas of the scales, and it is the former checks that are the most difficult to interpret.

In order to obtain a better interpretation of the first two years of growth of quinnat in New Zealand, an examination of five separate collections of parr and smolt scales of known ages and four samples of naturally reared parr and smolt scales were taken from a tributary of the Waitaki River, the Hakataramea River, and also the Waimakariri and Rangitata Rivers and the results are given in this report.

OBSERVATIONS ON THE GROWTH OF PARR AND SMOLT SCALES

The data presented under this heading on the growth of parr and smolt scales of quinnat salmon were obtained from eight separate collections of parr and smolt comprising both pond reared and naturally reared fish. Details of the samples are as follows:

Sample No. 1: Pond reared at Hakataramea Hatchery: Collected 2 February 1930.

Sample No. 2: Pond reared at Hakataramea Hatchery: Collected 3 March 1930.

Sample No. 3: Pond reared at Hakataramea Hatchery: Collected 1 April 1930.

Sample No. 4: Pond reared at Hakataramea Hatchery: Collected 21 October 1930.

Sample No. 5: Naturally reared parr and smolts from Hakamaramea Gorge: Collected 14 March 1930.

Sample No. 6: Naturally reared fish collected from the Waimakariri River at Cass on 25 January 1930.

Sample No. 7: Naturally reared smolts from the Waimakariri River below Kaiapoi on 31 July 1930.

Sample No. 8: Naturally reared fish taken one mile up from the mouth of the Rangitata River on 8 November 1931.

Samples Nos. 1 to 4 (inclusive) comprised pond reared fish hatched from ova collected during the winter of 1929. Sample No. 5 comprised parr from the Hakataramea Gorge, and probably included fish that had been liberated as fry some months previously in this area. Samples Nos. 6 to 8 (inclusive) include several specimens of young quinnat taken from the Waimakariri and Rangitata Rivers.

Counts and measurements of three scales from each fish were obtained and averaged. The following measurements and counts were taken:

(1) Longitudinal diameter
(2) Anterior radius
(3) Posterior radius
(4) Total number of circuli
(5) Number and type of circuli in the peripherial band.

The scales were not treated in any way, except that they were cleaned in water and mounted dry between two glass slides for examination. They were examined under a low power objective and the measurements were made with an occular micrometer which gave, under the magnification used, 18 divisions to 1 mm.

DETAILED ANALYSES OF SAMPLES

Sample No. 1

TABLE 2

POND REARED QUINNAT OF KNOWN AGES

2 February 1930

Measurements and Counts				Total	Aver.
Length group (Cms)	8.8-10.0	10.1-11.0	11.1-15.0		
Number Fish:	2	7	3	12	10.3
Length Post, radius:	7.3	8.4	8.5	-	8.1
Length Ant. radius:	4.8	7.3	7.5	-	6.5
Total number circuli:	11.8	11.4	12.1	-	11.8
Peripheral bend:					
Summer circuli:					
Number Fish:	2	7	3	12	100%
Number Circuli:	11.8	11.4	12.1		11.8
Winter circuli:					
Number Fish:	-	-	-	-	-
Number circuli:	-	-	-	-	-

The twelve pond reared parr taken on 2 February 1930 averaged 10.3 cms in length and all exhibited on their scales a summer peripheral band of relatively wide circuli. There was no indication on any of the scales of these fish a winter band of narrow circuli forming on the periphery of the scales. The fish varied in length from 8.8 to 14.8 cms and the average length of the anterior radius of their scales was 6.5/18 mm. The average number of circuli on the scales was 11.8 and the scales generally showed moderately good nuclear growth with minor checks at irregular intervals from the centre.

Sample No. 2

TABLE 3

POND REARED QUINNAT OF KNOWN AGES

3 March 1930

Measurements and Counts				Total	Aver.
Length group (Cms)	10.1-11.0	11.1-12.0	12.1-14.0		
Number Fish:	2	9	1	12	-
Length Post. radius:	9.1	10.0	11.0	-	10.0
Length Ant. radius:	8.1	9.3	10.3	-	9.2
Total number circuli:	13.3	14.7	16.6	-	14.8
Peripheral band:					
Summer circuli:					
Number of fish:	1	6	1	8	66%
Number of circuli:	13.0	14.4	16.6	-	14.6
Winter circuli:					
Number of fish:	1	3	4	-	33.4%
Number of circuli:	2.0	2.3	2.2	-	2.2

The twelve parr taken from the Hakataramea Hatchery Ponds on 3 March 1930 averaged 11.8 cms which represented an increase in length of approximately 1.3 cms compared with the sample taken on 2 February. The corresponding increase in the anterior radius of their scales was 2.7/18 mm. The number of circuli on the scales had increased on an average by three. Two-thirds of the fish showed summer circuli on the periphery of their scales, while the remaining third showed from one to three winter circuli on their anterior periphery. The average number of summer circuli was 11.6, which represented the first summer's growth of these pondreared fish.

Sample No. 3

TABLE 4

POND REARED QUINNAT OF KNOWN AGES

1 April 1930

Measurements and Counts				Total	Aver.
Length group (Cms)	11.6-12.5	12.6-13.5	13.6-14.8		13.0
Number of Fish:	1	7	3	11	
Length Post. radius:	13.0	11.5	12.3	-	12.6
Length Ant. radius:	11.6	9.1	10.3	-	10.3
Total number circuli:	21.3	16.8	19.1	-	19.1
Peripheral band:					
Summer circuli:					
Number of fish:	-	4	-	4	36.4%
Number of circuli:	-	17.3		-	17.3
Winter circuli:					
Number of fish:	1	3	3	7	63.6%
Number of circuli:	4.0	5.0	3.6	-	4.2

The average length of the fish taken from the Hakataramea Hatchery Ponds on 1 April 1930 was 13.0 cms an increase in average length from 1 February of 2.7 cms. The increase in body length from 3 March was approximately 1.3 cms corresponding to an increase in the anterior radius of the scales of 1.1/18 mm and the number of circuli on the scales had increased from 14.8 to 19.1 during the same period. The majority, namely 63.6%, showed narrow winter circuli on the anterior periphery of the scales.

Sample No. 4

POND REARED QUINNAT OF KNOWN AGES - 20 OCTOBER 1930

The 22 fish taken from the Hakataramea Hatchery Ponds during October 1930 were clearly divided into two length groups, the first comprising five fish between 8.8 and 13.5 cms and the second group comprising 17 fish ranging between 18.8 and 23.8 cms. There were no fish of intermediate lengths between 13.5 and 18.8 cms. The significance of such a length frequency distribution of fishes of exactly the same age and reared under almost identical conditions is interesting and probably of considerable significance, but at present is not clearly understood.

Theoretically such differences in size may be accounted for at least in part, by the fact that in the majority of the larger fish considerable scale growth had taken place, which would correspond to a relatively larger body growth shortly before their capture early in their second year of life, but this does not occur in every individual fish of the larger length groups. This cannot therefore be the whole explanation of the peculiar length distribution of these pond reared fish.

We have for instance two of the larger fish showing hardly any spring growth, while three individuals of the smaller length groups show relatively greater growth during their second spring. It may be found that such individual growth rates are connected with the genetical composition of the individual, but only carefully controlled breeding experiments could verify this assumption.

It will be advisable to consider these two length group frequencies separately, as in Tables 5 and 6.

TABLE 5

POND REARED QUINNAT OF KNOWN AGES

SHORTER LENGTH FREQUENCY GROUP

Measurements and Counts			Total	Aver.
Length groups (Cms):	8.5-11.5	11.6-13.5		10.5
Number of Fish:	3	2	5	-
Length Post. radius:	9.5	10.2	-	9.8
Length Ant. radius:	7.5	9.2	-	8.4
Total number circuli:	18.0	21.0	-	20.0
Peripheral band:				
Summer circuli:				
Number of Fish:	1	2	3	60.0%
Number of circuli:	2.0	2.0	-	2.0
Winter circuli:				
Number of Fish:	2	-	2	40.0%
Number of circuli:	6.0	-	-	6.0

TABLE 6

POND REARED QUINNAT OF KNOWN AGES

LONGER LENGTH FREQUENCY GROUP

Measurements and Counts			Total	Aver.
Length groups (Cms)	18.5-20.0	20.1-24.0	-	20.3
Number of Fish:	11	6	17	-
Length Post. radius:	21.0	23.5	-	22.2
Length Ant. radius:	15.1	16.8	-	15.9
Number of circuli:	27.4	30.4	-	28.2
Peripheral band:				
Summer circuli:				
Number of fish:	10	6	16	-
Number of circuli:	6.9	9.3	-	7.3
Winter circuli:				
Number of fish:	1	-	1	-
Number of circuli:	7.0	-	-	7.0

The data presented in Tables 5 and 6 were obtained from a sample of 22 yearling quinnat taken from the Hakataramea Hatchery Ponds on 21 October 1930. The total sample averaged 18.8 cms in length. Compared with the sample taken from the ponds 173 days previously, on 1 April 1930, a period that included the three winter months and approximately six to seven weeks of spring, the increase in average length was 5.8 cms, while the corresponding increase in the length of the anterior radius of the scales was 14.3/18 mm, and the average number of circuli laid down on the scales over the same period was 7.9.

This concludes the analysis of the scales from young quinnat which were pond reared and of known ages. We will now deal with several small samples of wild parr and smolts captured at random from the Hakataramea, Waimakariri and Rangitata Rivers.

Sample No. 5

TABLE 7

YOUNG QUINNAT FROM HAKATARAMEA GORGE

14 March 1931

Measurements and Counts				Total	Aver.
Length groups:	7.5-10.0	10.1-12.5	12.6-13.5	-	12.3
Number of fish:	5	8	1	14	
Length Post. radius:	7.8	8.8	9.5	-	8.6
Length Ant. radius:	6.4	8.5	8.0	-	7.5
Total number circuli:	9.1	14.9	17.0	-	13.0
Peripheral band:					
Summer circuli:					
Number of fish:	2	4	0	6	42.9%
Number of circuli:	9.0	12.8	-	-	10.9
Winter circuli:					
Number of fish:	3	4	1	8	57.1%
Number of circuli:	2.7	2.4	4.0	-	3.2

These 14 wild parr were taken from the Hakataramea River gorge on 14 March 1931. When captured the fish were approximately 9 months old, and it is of interest to compare scale growth and the formation of the winter band in the scales of these fish with those of pond reared fish of the same age.

On an average the wild parr were slightly smaller than the pond reared fish, but the difference is not very great. The number of circuli laid down on the scales of the wild fish is less than those laid down in pond reared fish of approximately the same length. This corresponds with a slightly slower growth rate of both scales and fish. The winter band is formed on the scales of wild parr somewhat earlier than in pond reared parr, as for instance by the first week in March 57.1% of wild parr showed a winter band on the peripheral margin of their scales while in the pond reared fish only 33.4% showed the beginning of the formation of a winter band. The circuli in the scales of pond reared fish are on an average slightly wider apart and more clearly defined than those produced in the scales of wild parr.

Sample No. 6

TABLE 8

WILD PARR FROM THE UPPER WAIMAKARIRI RIVER

25 January 1931

Measurements and Counts			Total	Aver.
Length groups (Cms):	6.5-7.4	7.5-8.4	-	7.0
Number of fish:	3	2	5	-
Length Post. radius:	6.1	6.8	-	6.4
Length Ant. radius:	6.3	6.0	-	6.2
Total number circuli:	6.1	7.8	-	6.9
Peripheral band:				
Summer circuli:				
Number of fish:	3	2	5	100%
Number of circuli:	6.1	7.8	-	6.9
Winter circuli:				
Number of fish:	-	-	-	-
Number of circuli:	-	-	-	-

The five wild parr taken from the Waimakariri River at Cass on 25 January 1931, ranged in length from 6.5 to 7.8 cms. and were approximately 6 months old. Compared with the pond reared fish taken from the Hakataramea Hatchery ponds on 2 February 1930, the Waimakariri fish were considerably smaller, but like the pond reared fish showed no commencement of a winter band forming on their scales. Further comparisons are shown in the tables given above.

Sample No. 7

TABLE 9

WILD YEARLING QUINNAT FROM THE LOWER WAIMAKARIRI RIVER

31 July 1930

Measurements and Counts		Total	Aver.
Length group (Cms):	12.5 - 13.5	-	13.3
Number of fish:	2	2	-
Length Post. radius:	10.3	-	10.3
Length Ant. radius:	11.4	-	11.4
Total number circuli:	20.8	-	20.8
Peripheral band:			
Summer circuli:			
Number of fish:	-	-	-
Number of circuli:	-	-	-
Winter circuli:			
Number of fish:	2	2	100%
Number of circuli:	20.8	-	20.8

The two specimens of quinnat comprising this sample from the Waimakariri River, captured on 31 July 1930, were 12.5 and 13.0 cms in length respectively and were approximately one year old. These lengths should be compared with the calculated length at the end of the first year of mature fish of the stream type taken from the Waimakariri River run of 1927.

Sample No. 8

TABLE 10

WILD PARR TAKEN FROM THE RANGITATA RIVER

8 November 1931

Measurements and Counts		Total	Average
Length group (Cms):	3.5 - 6.5	-	4.5
Number of fish:	3	3	-
Length Post. radius:	4.0	-	4.0
Length Ant. radius:	3.2	-	3.2
Total number of circuli:	2.9	-	2.9
Peripheral band:			
Summer circuli:			
Number of fish:	3	3	100%
Number of circuli:	2.9	-	2.9
Winter circuli:			
Number of fish:	-	-	-
Number of circuli:	-	-	-

The three quinnat parr from the Rangitata River, captured about one mile from the mouth on 8 November 1931, were approximately 5 months old and averaged 4.5 cms in length. These were the smallest quinnat examined and were obviously on their way to the sea and would be of the Ocean Type.

SUMMARY

The data from the eight samples detailed above may be summarised as follows:

TABLE 11

SUMMARY OF SAMPLES 1-8

Month of Capture	River	Average length (cms)	Average number of circuli	% showing broad circuli on scale periphery
November	Rangitata River	4.5	2.9	100%
January	Waimakariri River	7.3	6.9	100%
February	Hakataramea Ponds	10.3	11.8	100%
March	" "	11.3	14.8	66%
April	" "	13.0	20.8	36.4%
July	Waimakariri River	12.8	20.8	0%
October	Hakataramea Ponds	18.8	22.3	86.4%

From Table No. 11 it will be seen that there is a definite correlation between the growth of the fish and the growth of the anterior radius of the scales. Considering the meagre and heterogeneous nature of the material on which these figures are based, the results must be considered satisfactory, and will allow the following tentative conclusions to be drawn:-

(1) That the growth of the fish and the corresponding growth in the scales is considerably retarded during the winter months, although total cessation of growth, either in the fish or its scales, is not apparent.

(2) That the growth rate during the autumn and winter months is between 75% and 80% slower than the growth that takes place during the spring and summer months.

(3) The number of circuli laid down per unit area of scale surface is greater during late summer and autumn than it is in spring or early summer.

(4) It is clearly evident that the bands of relatively wide circuli are laid down in the scales during spring and early summer months and that the bands of relatively narrow circuli are formed during the late summer, autumn and winter months. The terms "summer" and "winter" bands are therefore appropriate when referring

to these more or less clearly defined bands of relatively wide and narrow circuli which alternate on the scales of quinnat salmon in New Zealand (Figure 1.).

(5) Pond reared quinnat increased in length slightly faster than wild parr and there was a corresponding increase in scale growth. This is clearly shown in two samples taken during March 1931, one from the Hakataramea Hatchery Ponds and the other from the Hakataramea River, in which the summer circuli are slightly narrower on the scales of the "wild" parr than in those laid down in the scales of the pond reared fish.

(6) It is also noticeable that the winter band is generally formed on the scales slightly earlier in the case of wild parr, or in other words, relatively rapid growth persists further into late summer and autumn in the case of pond reared fish. This would be expected considering the very different environmental conditions under which the pond reared and wild parr had lived.

AGE AND GROWTH OF QUINNAT SALMON

The data on which the following analysis are based have been obtained from the scales of quinnat salmon returning to freshwater to spawn from three Canterbury rivers, namely the Waimakariri, Hakataramea and Rangitata. The samples were obtained from commercial netting and anglers' catches as described previously in this report.

The following table (No. 12) gives particulars of the samples examined from the abovementioned rivers.

TABLE 12

RIVERS SAMPLED AND METHODS OF CAPTURE

River	Year	No. of Fish	Method of Capture
Waimakariri	1927	56	Anglers' Catches
Waimakariri	1928	429	Commercial Netting
Hakataramea	1931	197	Trapped
Rangitata	1930	9	Anglers' Catches
Rangitata	1931	9	Anglers' Catches

WAIMAKARIRI RIVER RUN 1927

Scale samples were collected from 56 quinnat taken during the 1927 run in the Waimakariri River and the age composition of this sample is summarised in the following table.

TABLE 13

WAIMAKARIRI RIVER RUN - 1927

	STREAM TYPE			OCEAN TYPE		
	3 yrs	4 yrs	5 yrs	3 yrs	4 yrs	5 yrs
Females	31.0% (9)	38.0% (11)	-	31.0% (9)	-	-
Males	3.7% (1)	52.3% (14)	7.4% (2)	26.0% (7)	11.1% (3)	-
Totals	17.8% (10)	44.5% (25)	3.6% (2)	28.5% (16)	5.4% (3)	

NOTE: Actual numbers in brackets beneath percentages.

Of the total sample 51.8% (29 fish) were females of which 69% were of the stream type. The majority of the stream type females returned as three year olds, but the majority of the ocean type returned as two year olds. Stream type males predominantly returned as three year olds and the ocean type males as two year olds. A few four year old stream type males returned but these represented only 7.4% of the total sample.

Year Class Analysis

1924 YEAR CLASS (THREE YEAR OLD FISH)

Stream Type

Of the 1924 year class 62.5% were of the stream type. Their average length at the end of their third year was 77.2 cms, with an average weight of 6.4 kgm. The mean growth rates are given in the following table.

TABLE 14

AVERAGE RATE OF GROWTH - 1924 YEAR CLASS

Stream Type

Sex	Average length at winters				Average weight when captured
	1924	1925	1926	1927	
Males	Hatched	11.4	52.7	81.5	7.7 kgm
Females	"	11.2	44.0	76.0	4.9 "
Average	"	11.3	48.4	78.5	6.3 "

The freshwater growth during the first year of life was very similar in both sexes, but the males apparently grew at a somewhat faster rate during their first year in the sea, that is, their second year of life. The average length of the fish when they reached the sea was 11.5 cms and during their first year in the sea (2nd year of life) they increased on an average of 36.9 cms.

Ocean Type

The ocean type fish of the 1924 year class attained an average length of 82.5 cms which was only 3.8 cms greater than the stream type fish of the same year class, notwithstanding an average of 11.8 cms above the stream type fish at the end of their first year. Table No. 15 gives the average growth rates for the ocean type fish of this year class.

TABLE 15

AVERAGE GROWTH RATE OF THE 1924 YEAR CLASS

Ocean Type

Sex	Average length at winters				Average weight when captured
	1924	1925	1926	1927	
Males	Hatched	23.2	58.2	84.0	7.5 kgm
Females	"	23.4	57.5	82.0	6.0 "
Average	"	23.3	57.7	83.5	6.8 "

1923 YEAR CLASS (FOUR YEAR OLD FISH)

The 1923 year class comprised 50% of the sample, the males and females were represented by 60.7% and 39.3% respectively.

Stream Type

Of the 1923 year class, 89.2% belonged to the stream type, the growth rates are given in Table No. 16.

TABLE 16

AVERAGE GROWTH RATES OF THE 1923 YEAR CLASS

Stream Type

Sex	Average length (cms) at winters					Average weight when captured
	1923	1924	1925	1926	1927	
Males	Hatched	10.9	37.3	64.5	90.1	8.3 kgm
Females	"	10.9	42.2	71.1	84.6	6.2 "
Average	"	10.9	39.7	69.7	87.1	7.3 "

At the end of their fourth year, when returning to spawn in freshwater, the males were larger on an average by 5.1 cms in length and 2.1 kgm in weight, than the females. The growth rate of both sexes was identical during the first year which was spent in freshwater. During the second year (first year of sea life) the females grew slightly faster on the average than the males, but during the third year the growth rates were almost identical.

During their fourth year (the third and last in the sea) the males increased in length almost twice as fast as the females, the average increase was 21.6 cms and 13.5 cms respectively.

Ocean Type

The ocean type was represented in the 1923 year class by only three males with an average length of 91.5 cms and an average weight of 7.8 kgm.

The growth rate of these fish is given in the following Table No. 17.

TABLE 17

AVERAGE GROWTH RATE OF THE 1923 YEAR CLASS

Ocean Type

Sex	Average length at winters					Average weight when captured
	1923	1924	1925	1926	1927	
Males	Hatched	21.6	48.5	72.5	91.5	7.8 kgm

Compared with the males of the 1924 year class the 1923 year class males were slightly smaller at the end of their first year and second year of life.

1922 YEAR CLASS (FIVE YEAR OLD FISH)

Only two males representing the 1922 year class were obtained both of the stream type. The growth rate of these fish is given in the following Table No. 18.

TABLE 18

AVERAGE GROWTH RATES OF THE 1922 YEAR CLASS

Stream Type

Sex	Average length at winters						Average weight when captured
	1922	1923	1924	1925	1926	1927	
Males	Hatched	9.6	46.4	71.1	84.0	100.6	10.8 kgm

Compared with the growth rate of the stream type fishes of the 1923 year class, slower growth was registered during the first year, but during their second and third year considerably faster growth had taken place. Compared with the 1924 year class slower growth had taken place during the first and second years of life.

SUMMARY OF THE 1927 RUN

Of the total number of quinnat in the sample 56.3% belonged to the stream type of growth. The initial advantage in the size of the ocean type fish at the end of their first year was maintained during the second year but this advantage was not apparent in older fish.

Quinnat that returned to freshwater to spawn as two year olds were predominantly of the ocean type, while those returning as three year olds were predominantly stream type.

The following table gives the average rate of growth for each growth type for the three year classes represented in the sample.

TABLE 19

1927 WAIMAKARIRI RIVER RUN - AGE GROUPS

Year class	Growth Types	Length at winters				
		1923	1924	1925	1926	1927
1922	Stream Type	9.6	46.4	71.0	83.5	101.6
	Ocean Type	-	-	-	-	-
1923	Stream Type	-	10.9	39.5	69.5	96.7
	Ocean Type	-	21.6	48.4	72.3	91.4
1924	Stream Type	-	-	11.1	48.6	78.0
	Ocean Type	-	-	23.1	57.0	82.7

In order to compare the growth rates of quinnat of the Waimakariri River run of 1927 with the growth rates of quinnat from other rivers, the following average length and weight of the fish taken during the 1927 run in the Waimakariri River and the average growth rates for the stream and ocean types are given in the following table.

TABLE 20

RATE OF GROWTH 1927 WAIMAKARIRI RIVER RUN

Growth Types	Particulars when captured		Length attained at end of:			
	Av. Length	Av. Weight	1st	2nd	3rd	4th
Stream Type	86.5 cms	7.3 kgm	11.2	40.4	69.8	83.5
Ocean Type	87.5 "	7.8 "	21.8	54.5	71.0	83.5

To summarise we find that the stream type slightly predominated the sample taken from the 1927 quinnat run in the Waimakariri River and that those fish that returned to spawn as two year olds were predominantly of the ocean type, while those returning as three year olds were predominantly stream type fish.

WAIMAKARIRI RIVER RUN 1928

The Waimakariri River run of 1928 was adequately sampled when 429 scale samples were obtained together with the weight, length and sex of the fish from which the scales were obtained.

This particularly large sample (see Table No. 21) from the Waimakariri run of 1928 was available because of the decision of the Government to carry out experimental netting during the run. The following extract from the Annual Report of the Chief Inspector of Fisheries for the year ended 31 March 1928 may be quoted.

In respect to this netting experiment the report states "with the two-fold purpose of obtaining data from the biological analysis of the run of quinnat salmon in the Waimakariri River and in order to obtain a practical understanding of the conditions under which salmon netting operations in this locality are carried on, arrangements were made for a scheme of experimental netting during the past season. Two netmen were employed to carry on netting at Kairaki, near the mouth of the Waimakariri River from 6 February to 28 April. Favoured by fine weather and low river until the last fortnight of the season, a very satisfactory catch was made, totalling 454 fish, having an aggregate weight of 4,885 lb. The first fish was caught on 6 February, the last on 12 April. The most productive month was March."

A monthly analysis of the catch showed that during February 39% were males while those taken during March and April were in almost the same proportion, namely 37% and 39% respectively.

The following table gives the relative abundance of the various age groups for the total catch each month during the netting season.

TABLE 21

RELATIVE ABUNDANCE OF AGE GROUPS

Month	Stream Type				Ocean Type			
	2 Yr	3 Yr	4 Yr	5 Yr	2 Yr	3 Yr	4 Yr	5 Yr
February	14.0	40.6	34.8	33.5	19.0	25.0	-	-
March	72.2	54.1	54.4	33.3	87.0	75.0	100.0	-
April	14.0	5.1	10.8	33.3	-	-	-	-

It is of interest to note that no ocean type fish were obtained during April.

Year Class Analysis

1926 Year Class (Two year olds)

The fish of this year class formed a very small proportion of the total run, represented by 22 individual fish or 6.8% of the total sample. Of these 24.4% were of the stream type while the remainder (75.6%) were of the ocean type. The stream type fish were all males and in the ocean type males predominated, forming 63.7%.

Stream Type

The stream type of the 1926 year class were all males comprising only seven individual fish varying in length on their return to freshwater from 43.0 to 58.5 cms and weighing 1.1 to 2.7 kgm.

TABLE 22

AVERAGE GROWTH RATE OF 1926 YEAR CLASS

Stream Type

Sex	Average length at winters 1926	1927	1928	Average Weight when Captured
Males	Hatched	14.7	51.7	1.2 kgm

At the end of their first year which was spent in freshwater they averaged 14.7 cms in length and the average increase during their second year (first year in the sea) and at the end of which they returned to freshwater to spawn, was 37.0 cms. Their average length and weight when captured was 51.7 cms and 1.9 kgm.

Ocean Type

This year class comprised 26.8% of all those fish that had migrated seawards early in their first summer and 5.1% of the total sample taken during the 1928 run. This group showed a wide range in size when captured, varying from 45.5 to 68.5 cms in length, although the majority ranged from 49.5 to 62.5 cms. The males comprised 63.6% and predominated in the ocean type of the 1926 year class. At the time of capture the fish averaged 57.1 cms which was about 3.8 cms greater than those of the stream type, of the same age, but had migrated to the sea a year later. At the end of their first year the ocean type fish had attained a length of 24.9 cms which was just over 10.2 cms longer than the stream type. It is of interest to note that this type had grown 6.3 cms more than those of the ocean type during their shorter stay in the sea.

TABLE 23

AVERAGE GROWTH RATES OF 1926 YEAR CLASS

Ocean Type

Sex	Average length at winters 1926	1927	1928	Average weight when captured
Males	Hatched	25.1	54.5	1.9 kgm
Females	"	24.9	57.0	4.4 "

1925 Year Class

This was the predominant year class forming 81.1% of the total sample. Females representing 63.2% predominated in the catch. The great majority were of the stream type, being represented by 83.9%. It is of interest to note that the stream type of the 1925 year class formed 68% of the total number of fish taken during the 1928 run.

Stream Type

This was undoubtedly the predominant class of fish forming the run of quinnat in the Waimakariri River during 1928. These fish ranged in length from 52.1 to 85.0 cms with an average of 70.5 cms and the recorded average weight was 4.3 kgm.

Their average rates of growth for both sexes are given in the following table.

TABLE 24

AVERAGE RATE OF GROWTH 1925 YEAR CLASS

Stream Type

Sex	Average length at winters				Average weight when captured
	1925	1926	1927	1928	
Males	Hatched	12.7	38.1	68.5	4.3 kgm
Females	"	13.2	39.6	71.5	4.2 "
Average	"	12.9	38.8	70.1	4.2 "

The stream type fish of the 1925 year class ranged in weight from 1.8 to 8.6 kgm with an average of 4.2 kgm. There was no obvious difference between the growth rate of the males and females.

Ocean Type

The ocean type of the 1925 year class formed 13% of the total sample. The females represented by 68.9% predominated. The fish of this group ranged in length from 66.0 to 86.5 cms, with an average of 79.0 cms. When captured their average weight was 5.3 kgm, ranging from 3.2 to 7.7 kgm.

The average growth rates are given in the following table.

TABLE 25

AVERAGE RATE OF GROWTH 1925 YEAR CLASS

Ocean Type

Sex	Average length at winters				Average weight when captured
	1925	1926	1927	1928	
Males	Hatched	24.6	49.8	74.6	4.9 kgm
Females	"	23.8	53.3	79.0	5.6 "
Average	"	24.1	51.5	77.5	5.3 "

The fish of the 1925 year class that had migrated early during their first summer had gained on an average 11.2 cms in length on those that remained in freshwater until the following spring. When these ocean type fish returned at the end of their third summer to spawn they had an advantage of 6.1 cms in length which would represent approximately 0.8 kgm in weight, over those of the stream type.

It should be noted that the stream type, barely hold their own in growth rate during their second year, actually gaining on an average 5.1 cms of the 11.2 cms start the ocean type had originally during their third year of life.

1924 Year Class (Four year olds)

The 1924 year class comprised 11.6% of the total sample, of which 92% were of the stream type. Of the stream type 68% were females and all the ocean type were males.

Stream Type

The stream type fish of the 1924 year class averaged 82.5 cms in length and 6.8 kgm in weight. They ranged in length from 63.5 to 96.5 cms and from 2.7 to 9.9 kgm in weight. The males showed a greater variation in length and weight than the females.

At the end of their first year, spent in freshwater, the females were only slightly larger than the males. The females, during their first year in the sea, increased on an average by 23.6 cms while the corresponding increase in the males was 21.8 cms. This increase in the length of the females in relation to the males was more pronounced during their second year of life, during which the females increased on an average of 26.0 cms and the males 24.1 cms.

Further particulars are given in the following table.

TABLE 26

AVERAGE RATE OF GROWTH 1924 YEAR CLASS

Stream Type

Sex	Average length at winters 1924	1925	1926	1927	1928	Average weight when captured
Males	Hatched	13.9	35.8	59.8	82.0	6.8 kgm
Females	"	14.4	38.8	64.7	82.5	6.9 "
Average	"	14.2	36.8	62.3	82.3	6.85 "

Ocean Type

The ocean type was poorly represented in the 1925 year class comprising only 0.9%. It is unfortunate that this year type and age group is so poorly represented in the 1928 Waimakariri run, as these fish are the most important from the commercial point of view, because of their generally large size and good condition.

The ocean type fish of the 1924 year class ranged in length from 88.5 to 95.0 cms and in weight from 7.7 to 10.0 kgm. Further particulars are given in the following table.

TABLE 27

AVERAGE RATE OF GROWTH 1924 YEAR CLASS

Ocean Type

Sex	Average length at winters 1924	1925	1926	1927	1928	Average weight when captured
Males	Hatched	26.6	45.9	73.7	92.5	8.9 kgm

1923 Year Class (Five year olds)

This year class was represented by only two stream type females. Their average length, weight and growth rate is given in the following table.

TABLE 28

AVERAGE RATE OF GROWTH 1923 YEAR CLASS

Stream Type

Sex	Average length at winters 1923	1924	1925	1926	1927	1928	Average weight when captured
Females	Hatched	11.7	28.4	53.0	71.8	86.0	7.1 kgm

GENERAL OBSERVATIONS AND SUMMARY OF THE WAIMAKARIRI RIVER RUN OF 1928

From the foregoing analysis it is clear that quinnat of the 1928 run in the Waimakariri River were returning to freshwater to spawn at the end of their third year. Those returning at the end of their fourth year comprised only 11.6% of the total sample of which 92.0% were of the stream type.

In North America quinnat of the stream type apparently return to freshwater to spawn during their 4th, 5th and 6th years and only a few males return at a younger age. It is of interest to compare the growth rates of North American and New Zealand quinnat for each of the growth types. Such a comparison is given in the following table.

TABLE 29

GROWTH RATE NORTH AMERICAN AND NEW ZEALAND QUINNAT SALMON

	Length at the end of each year of life 1st	2nd	3rd	4th	5th	6th
			Stream Type			
North America (Fraser 1921)	9.5	35.8	55.8	72.5	86.0	96.4
New Zealand	13.5	35.6	59.5	71.3	-	-
			Ocean Type			
North America (Fraser 1921)	27.4	48.0	65.5	81.0	93.1	-
New Zealand	24.9	49.8	73.5	-	-	-

To compare the relative abundance of stream and ocean type fish in North American and New Zealand runs of quinnat salmon figures given by Fraser (1921) are compared with the figures for the Waimakariri River run of 1928.

North America	78.2% Sea type	21.8% Stream type
New Zealand	18.3% " "	81.7% " "

The relative abundance of ocean and stream types have previously been discussed in this report.

Fraser (1919) found that males predominated slightly in both the sea and ocean types. In the Waimakariri River run of 1928, although the males do not predominate in the four and five year olds, we do find a higher proportion of males in the younger age groups. It has been inferred from this that males mature at a somewhat earlier age than the females and American authors have suggested that if there is a significant difference between the sexes with regard to age at maturity, the cause may be found in their rate of growth during their life in the ocean. In the Waimakariri River sample the males and females do not differ very much in growth rates in either of the two growth types, as shown in the following table.

TABLE 30

GROWTH RATES MALE AND FEMALE STREAM AND OCEAN TYPES

Growth type	Sex	Length attained at end of each year			
		1st	2nd	3rd	4th
Stream type	Males	13.7	35.8	60.0	-
	Females	13.0	35.2	59.0	-
Ocean type	Males	24.9	50.0	-	-
	Females	25.1	49.5	73.0	-

It would appear that in New Zealand there is little justification for the assumption that the early maturity of the males is due to their faster growth rate during sea life. There are, however, other factors that could bring about earlier maturity in the males and one of these is possibly the age at which they begin their ocean life. There is some evidence to suggest that the ocean type fish mature slightly earlier in life than the stream type fish, and this is especially pronounced in the case of the males. This could, at least partly, explain the earlier maturity of the ocean type males but not of the stream type males.

RELATIVE ABUNDANCE OF STREAM TYPE AND OCEAN TYPE FISHES DURING THE WAIMAKARIRI RIVER RUN OF 1928

In the sample of 429 quinnat taken during the 1928 run in the Waimakariri River, 81.7% were of the stream type while only 18.3% were of the ocean type. This is particularly interesting because it is very different from what occurs in North American Rivers.

Fraser (1921) found in a sample of 1,412 quinnat taken from the Straits of Georgia, not far from Nanaimo on the lower portion of the Fraser River, that 34.6% were of the stream type. Rich (1925) gives the percentage of stream type as 22%, in a large sample of quinnat caught off the mouth of the Columbia River. Mottley (1929), in a sample of 1,116 quinnat taken off Ucuelet, between March and September 1926, found that only 19% were of the stream type, and in a smaller sample of 500 fish from Quatsina and Kigaquot, taken in 1927, yielded 22% stream type fish.

Rich (1925) states "Evidence is presented which shows that the more rigorous climatic conditions associated with higher latitudes and greater altitudes tend to increase the percentage of fish with stream type nuclei - that is to say, more of the young fish remain in their home stream for at least one year after hatching ..."

Finlay (1929) when reporting on the present sample of quinnat from the Waimakariri River run of 1928, does not distinguish between ocean and stream types, but assumed that all the fish had spent one year in freshwater before migrating to the sea. Later in the same report, Finlay made the following statement based upon the conclusions of Rich and Fraser:

> "Considering all these factors, then it does not seem unreasonable, until direct evidence to the contrary is obtained, to suppose that probably an ocean or predominantly ocean nucleus to their scales occurs in New Zealand quinnat".

This is contrary to the conclusions arrived at in the present report, which is based upon the material Finlay examined. (See Table 44).

This difference in the duration of river life in New Zealand quinnat must bear some relation to the conditions prevailing in our rivers and parent streams, in which spawning takes place. Nothing is known at present (1934) of the conditions prevailing in the rivers and streams where spawning takes place, or about any of the factors that could influence the duration of stream life. We must be careful not to draw conclusions from the results of American investigations, because there is little doubt that our rivers differ considerably, both physically and biologically from quinnat salmon rivers of North America.

It would not be surprising, when one considers the variability exhibited by quinnat in North American rivers, that through the conditions they have encountered in New Zealand, their life history and growth may have been altered in many important ways.

HAKATARAMEA RIVER RUN OF 1931

Scale samples and measurements of 197 quinnat were taken during the 1931 run in the Hakataramea River, a tributary of the Waitaki River. It was in the Hakataramea River that quinnat salmon were originally established in New Zealand.

TABLE 31

AGE DISTRIBUTION OF STREAM AND OCEAN TYPES

Age in Years	STREAM TYPE		OCEAN TYPE	
	Males	Females	Males	Females
2	1.3%	-	2.4%	-
3	13.5%	-	45.9%	63.4%
4	24.8%	12.2%	12.1%	21.9%
5	-	2.4%	-	-

In both sexes the ocean type predominated and that the ocean type males spawn a year earlier than the females is most pronounced.

In the total sample more than half (56.8%) of the ocean type fish returned at the end of their third year, and comprised 60.7% of the males and 85.4% of the females of the entire sample. Taking both sexes the total comprised 76.2% ocean type and 23.8% stream type.

Year Class Analysis

1929 Year Class (Two year olds)

This year class was represented by only three fish, all males, of which two were of the ocean type. They comprised 0.5% of the sample and 1.2% of all males.

Stream Type

The only stream type fish of the 1929 year class in the sample was 41.7 cms in length and weighed 1.1 kgm. At the time of entering the sea this fish was just under 12.7 cms in length, but after its first summer in the ocean it had attained a length of 41.7 cms, an increase of 29.0 cms. Particulars of the growth of this fish are given in the following table.

TABLE 32

AVERAGE RATE OF GROWTH 1929 YEAR CLASS

Stream Type

Sex	Length at winters 1929	1930	1931	Weight when captured
Male	Hatched	12.7	41.7	1.1 kgm

Ocean Type

The two ocean type fish, both males, averaged 61.0 cms in length and 3.2 kgm in weight when captured at the end of their second year. Migrating to the sea early in their first year, they averaged 27.4 cms in length at the end of their first year and during their second year in the sea they increased 34.9 cms in length. Their average growth rate and weight when captured are given in the following table.

TABLE 33

AVERAGE RATE OF GROWTH 1929 YEAR CLASS

Ocean Type

Sex	Length at winters 1929	1930	1931	Weight when captured
Males	Hatched	27.4	62.3	3.2 kgm

1928 Year Class (Three year olds)

This is the predominant year class being represented by 62% of the sample. The ocean type of the 1928 year class comprised 56.8% of the fish represented in the sample.

Stream Type

There were no stream type females represented in the 1928 year class, the males when captured averaged 69.5 cms in length and 5.1 kgm in weight.

TABLE 34

AVERAGE GROWTH RATE OF 1928 YEAR CLASS

Stream Type

Sex	Length attained at winters 1928	1929	1930	1931	Average weight when captured
Males	Hatched	11.2	39.5	69.0	5.1 kgm

Ocean Type

The males of the ocean type of the 1928 year class averaged 77.5 cms in length, an increase of approximately 8.5 cms above the stream type males of the same year class. The average growth rates and particulars when captured of the ocean type fish of the 1928 year class are given in the following table.

TABLE 35

AVERAGE GROWTH RATES OF 1928 YEAR CLASS

Ocean Type

Sex	Length attained at winters				Average weight when captured
	1928	1929	1930	1931	
Males	Hatched	22.6	58.0	77.5	6.9 kgm
Females	"	23.9	60.0	81.5	7.1 "
Average	"	23.1	59.0	79.5	7.0 "

Although the females apparently grew at a slightly faster rate than the males, the condition of the latter on entering freshwater was slightly superior to that of the females.

1927 Year Class (Four year olds)

This year class was well represented, comprising 35% of the sample. It is of interest to note that the relative abundance of the stream and ocean type were very similar, although the ocean type slightly predominated, namely 48% and 52% respectively.

Stream Type

The stream type fish of the 1927 year class formed 16.7% of the total sample: the males averaged 83.5 cms in length and 8.0 kgm in weight, while the corresponding figures for the females were 77.7 cms and 6.6 kgm.

TABLE 36

AVERAGE GROWTH RATES OF 1927 YEAR CLASS

Stream Type

Sex	Length attained at winters					Average weight when captured
	1927	1928	1929	1930	1931	
Males	Hatched	11.4	36.0	64.0	83.5	8.0 kgm
Females	"	10.3	32.8	59.0	77.7	6.6 "
Average	"	10.8	34.3	61.0	80.0	7.1 "

Ocean Type

The following table (No. 37) gives particulars for the ocean type fish of the 1927 year class that averaged 85.5 cms in length and 7.9 kgm in weight when captured.

TABLE 37

AVERAGE GROWTH RATES OF 1927 YEAR CLASS

Ocean Type

Sex	Length attained at winters					Average weight when captured
	1927	1928	1929	1930	1931	
Males	Hatched	24.1	46.7	68.0	86.5	8.1 kgm
Females	"	23.1	46.3	66.4	84.0	7.7 kgm
Average	"	23.6	46.4	67.2	85.0	7.9 kgm

1926 Year Class (Five year olds)

This year class was represented by only three fish, all females of the stream type, comprising 1.5% of the total sample. Particulars are given in the following table (No. 38).

TABLE 38

AVERAGE GROWTH RATES 1926 YEAR CLASS

Stream Type

Length attained at winters						Average weight when captured
1926	1927	1928	1929	1930	1931	
Hatched	8.2	25.2	44.7	62.5	78.5	6.9 kgm

The extremely poor growth during the first two years of life of these three females of the 1926 year class is of particular interest. If my interpretation of the nuclear area of their scales is correct, they had not migrated to the sea until well into their second year of life. The nuclear area of these scales showed a similar structure to the nuclear area of the scales of a 17.6 cms smolt taken from the Rangitata River estuary by Mr T.A.G. Harle, in November 1927, which had hatched during the winter of 1926 and had taken approximately 16 months to reach the mouth of the Rangitata River, and at the time of capture had not commenced typical sea growth.

RANGITATA RIVER

The scales with relevant particulars are available from only 9 quinnat salmon from each of the runs of 1930 and 1931. Such a small sample is useless for comparative purposes but are included in the present report to document the growth types and rates of growth of these fish and also to point out certain characteristics exhibited on their scales. Relative information regarding their growth types and growth rates are given below.

1930 Run

Four fish belonged to the 1927 year class and five were of the 1926 year class.

TABLE 39

AGE DISTRIBUTION OF STREAM AND OCEAN TYPES

Age in Years	Stream Type		Ocean Type		Totals
	Males	Females	Males	Females	
3	-	1	-	3	4
4	2	2	1	-	5
Totals	2	3	1	3	9

The average growth rates for males and females of each of the growth types are given in the following table.

TABLE 40

AVERAGE GROWTH RATES 1930 RUN

Growth Type	Sex	Length attained at winters				Average weight when captured
		1st	2nd	3rd	4th	
Stream Type	Males	17.0	44.8	71.0	87.5	10.0 kgm
	Females	10.9	31.0	62.0	84.9	9.1 "
	Average	14.0	37.8	66.5	85.5	9.5 "
Ocean Type	Males	21.6	42.5	75.0	89.0	11.3 "
	Females	20.8	54.7	83.0	-	8.8 "
	Average	21.4	48.5	80.5	89.0	10.2 "

The differences between the growth rates of males and females can be attributed to the small number of fish in the sample, and individual variation appears to be greater in these Rangitata fish than those from other rivers. It should also be mentioned that the scales of Rangitata River quinnat show an unusual number of irregularities and are in many cases extremely difficult to interpret, especially the first year's growth. In the majority of the scales examined and the nucleus was of the composite variety, indicating that the transition from fresh to salt water was prolonged. More satisfactory comparisons could have been made had a larger number of fish been available for study, resulting in more reliable growth determinations.

The irregularities in the scales from quinnat taken from the Rangitata River have previously been referred to in this report.

1931 Run

From the 1931 run of the Rangitata River again only nine quinnat were available for study. These comprised four females and five males. When captured the males averaged 80.7 cms. in length and 7.8 kgm in weight and the corresponding figures for the females were 79.0 cms and 6.7 kgm.

TABLE 41

AGE DISTRIBUTION OF STREAM AND OCEAN TYPES

Age in Years	Stream Type		Ocean Type		Totals
	Males	Females	Males	Females	
3	2	1	3	3	9

The nine fish obtained during the 1931 run all belonged to the 1928 year class and were captured when completing their third year of life. Six were of the ocean type and three of the stream type. The average growth rates for each sex and growth types are given in the following table.

TABLE 42

AVERAGE GROWTH RATES - 1931 RUN

Growth Types	Sex	Length attained at winters 1st	2nd	3rd	Average weight when captured
Stream Type	Males	11.2	41.6	77.5	6.5 kgm
	Females	10.4	47.5	73.5	5.0 "
	Average	10.9	44.4	75.0	5.7 "
Ocean Type	Males	23.1	54.5	87.0	9.1 "
	Females	23.4	55.7	87.2	8.4 "
	Average	23.3	55.4	87.1	8.8 "

As has been mentioned previously the scales from the Rangitata River quinnat are rather characteristic in the form of their circuli and the character of the winter band, and it may be as well to summarise briefly these differences compared with the scales from quinnat from other New Zealand rivers.

(1) Most scales exhibit intermediate growth between typical stream and ocean types of growth and it is not possible to assess accurately growth rates until a much larger number have been examined and compared.

(2) The scales of the ocean type fish show in many cases, an extended or prolonged period of estuarine growth (or intermediate growth) in some cases extending over a period of one and a half years after leaving freshwater.

(3) Because of this prolonged period of presumably estuarine growth the first winter band on the scales of ocean type fish is usually very indistinct, and in most cases the circuli are broken and irregular.

(4) In the scales of some individuals there is evidence of the winter band forming at the time of capture, at the time of entering freshwater during February and March. This is not usually found in fish from other rivers, but in the Rangitata River quinnat this peripheral band is very distinct and well formed.

The above brief analysis of the small sample of Rangitata River fish merely serves to emphasise the necessity for an examination of a large number of specimens taken over a greater period during the run and on several consecutive years.

COMPARISON OF AGE AND GROWTH TYPE COMPOSITION OF QUINNAT FROM DIFFERENT RIVERS

The age distribution of quinnat from the various rivers is given in the following table.

TABLE 43

PERCENTAGE AGE DISTRIBUTION

River	Season	Total Number	2 yr	3 yr	4 yr	5 yr
		Stream Type				
Waimakariri	1927	37	-	27.0	67.5	5.5
Waimakariri	1928	347	2.0	84.2	13.2	0.6
Hakataramea	1931	47	2.1	21.1	70.2	6.4
Rangitata	1930	5	-	20.0	80.0	-
Rangitata	1931	3	-	100.0	-	-
		Ocean Type				
Waimakariri	1927	19	-	84.2	15.8	-
Waimakariri	1928	82	26.8	68.5	4.7	-
Hakataramea	1931	150	1.4	74.6	24.0	-
Rangitata	1930	4	-	75.0	25.0	-
Rangitata	1931	6	-	100.0	-	-

The majority of the quinnat examined from the Waimakariri River run of 1927, returned to spawn at the end of their fourth year of life in the case of the stream type fish, while the ocean type fish returned at the end of their third year. This, however, was not the case during the 1928 run, when the great majority returned to spawn in the case of the stream type at the end of their third year, so that seasonal variations may be expected in the age composition of stream type fish returning to spawn in a particular river.

The Hakataramea River quinnat showed a similar age distribution to the Waimakariri River run of 1927, in the sample taken during the 1931 run.

In the case of the ocean type fish there appears to be a general agreement in that the majority return to spawn towards the end of their third year of life, having spent three years in the sea.

Those returning at the end of their second year were in most cases males, although this occurred in the case of several females. Little significance can be placed on the Rangitata River figures.

RELATIVE ABUNDANCE OF STREAM AND OCEAN TYPES

As I have previously mentioned in this report, quinnat salmon may be divided into two growth types, differentiated by the length of time spent in freshwater during their first year of life. Following the terminology of North American authors, the whole first year's growth on the scale is called the nucleus. Accordingly there are two types of nuclear growth, the "ocean type" in the scales of sea run fry or parr and the "stream type" in the scales of those fish that migrated to the sea at the end of their first year, as yearlings.

Many authors have pointed out that since the freshwater and ocean environments have distinct physiological effects on the growth of quinnat it is possible to distinguish, with little difficulty, the transition from freshwater to marine life, by the effect on the markings in the scales. This being the case it is considered of the greatest importance when comparing growth rates of quinnat salmon to differentiate between these two ocean and stream type fish, as the relative abundance of either type will effect the average growth rate figures and the comparison between the rate of growth of the fish from different rivers becomes less precise, via your tables of growth increments, unless growth types are recognised.

There is strong evidence that the relative abundance of growth types also may have a direct effect on the age and size of quinnat when they return to freshwater to spawn. This would also influence directly the average size and age of quinnat in any particular season and river. Bearing these facts in mind the following comparisons, although based in most cases on inadequate material, are of interest.

The age of the fish is given in years. As the fish were taken in freshwater on their way to the spawning grounds, the year in which they were captured is considered, as far as growth is concerned, completed. For instance a three year old fish shows two completed winter bands plus a third summer's growth on its scales, although no indication of the third winter band may be evident on the peripheral area of the scales. Once the fish has entered freshwater to spawn it is considered that growth has ceased.

The percentage composition of growth types present in the various samples from different rivers is given in the following table.

TABLE 44

RELATIVE ABUNDANCE OF STREAM AND OCEAN GROWTH TYPES

River	Season	No. of Fish	Stream Type	Ocean Type
Waimakariri	1927	56	66.1%	34.9%
Waimakariri	1928	429	81.7%	18.3%
Hakataramea	1931	197	23.8%	76.2%
Rangitata	1930	9	55.5%	44.5%
Rangitata	1931	9	33.3%	66.7%

In each sample the stream type fish predominated except in the case of the Hakataramea River and the inadequate sample of 9 fish taken from the Rangitata River in 1931.

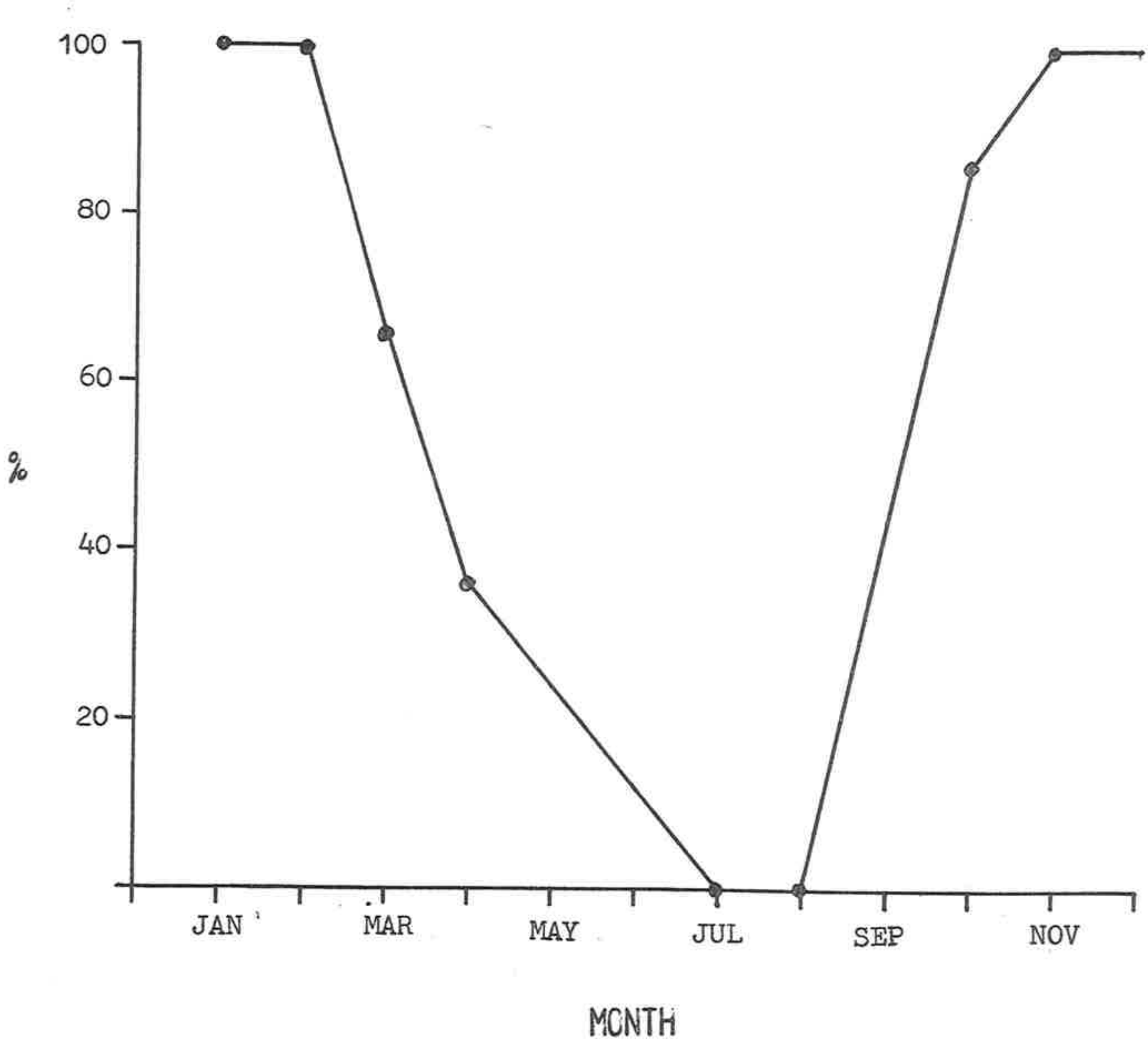
The figures for the two seasons from the Waimakariri River clearly shows that variations from season to season in the same river may be expected. It is also of interest to note that in two rivers where more or less adequate samples were obtained, namely the Waimakariri (1928) and the Hakataramea (1931) the relative abundance of the stream type and ocean type were practically reversed.

ACKNOWLEDGEMENTS

This account of the age and growth of quinnat salmon in New Zealand waters, was prepared at the request of the Fisheries Division, Marine Department, Wellington, and I wish to thank the Secretary for Marine for a "grant in aid" from the department.

I particularly wish to express my sincere thanks to Mr Malcolm Flain, Fisheries Scientist, Christchurch, who is currently engaged on quinnat salmon investigations, for reading the manuscript of this report and for his constructive criticism of the text and for his kindly assistance and cooperation in many ways.

FIGURE 1. Percentage of fish with broad circuli on scale periphery.



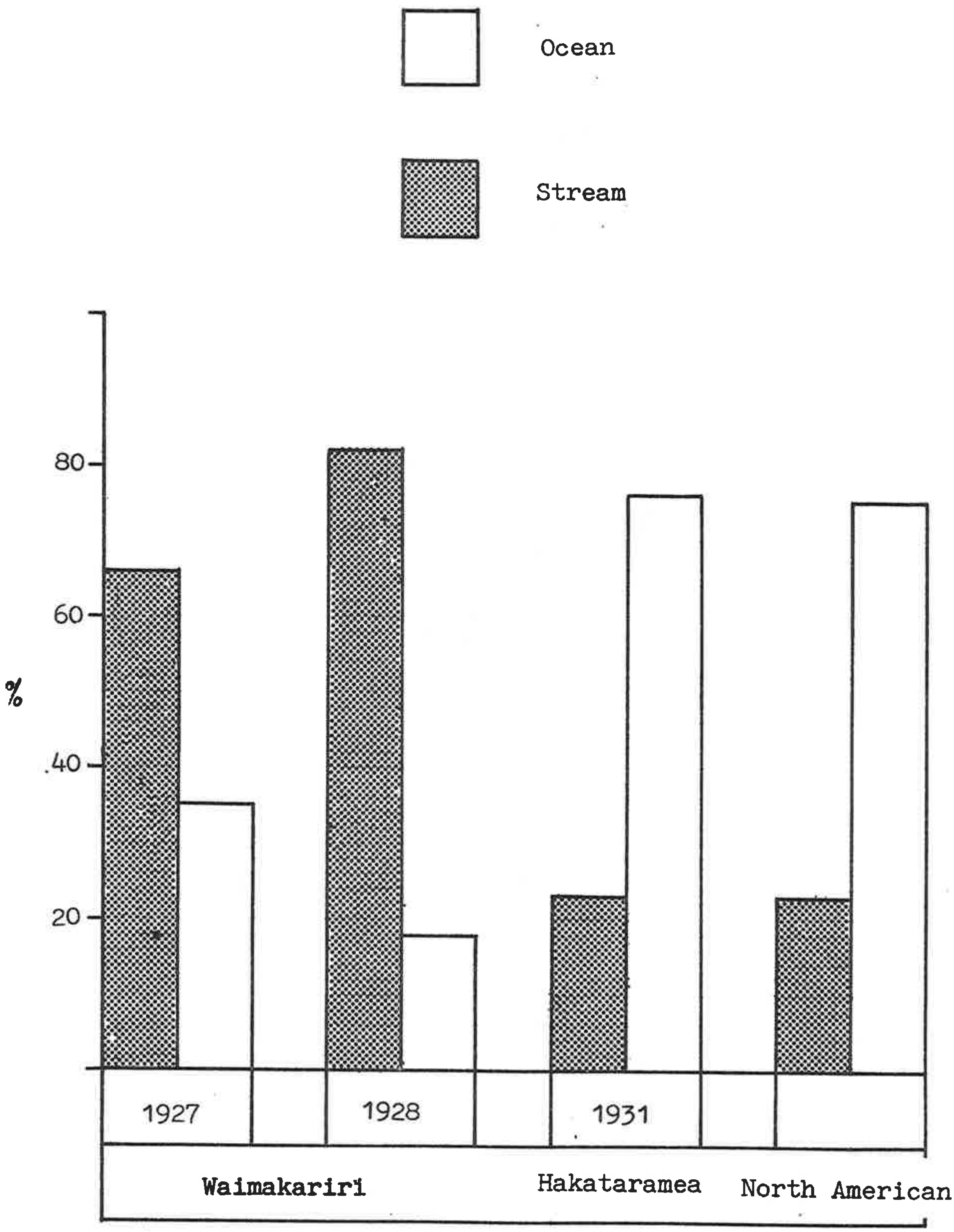


FIGURE 2. Percentage stream and ocean type fish in runs. North American data from Fraser (1921).

FIGURE 3. Comparison of average growth rates of stream and ocean type fish - Waimakariri River (1928) and North America.

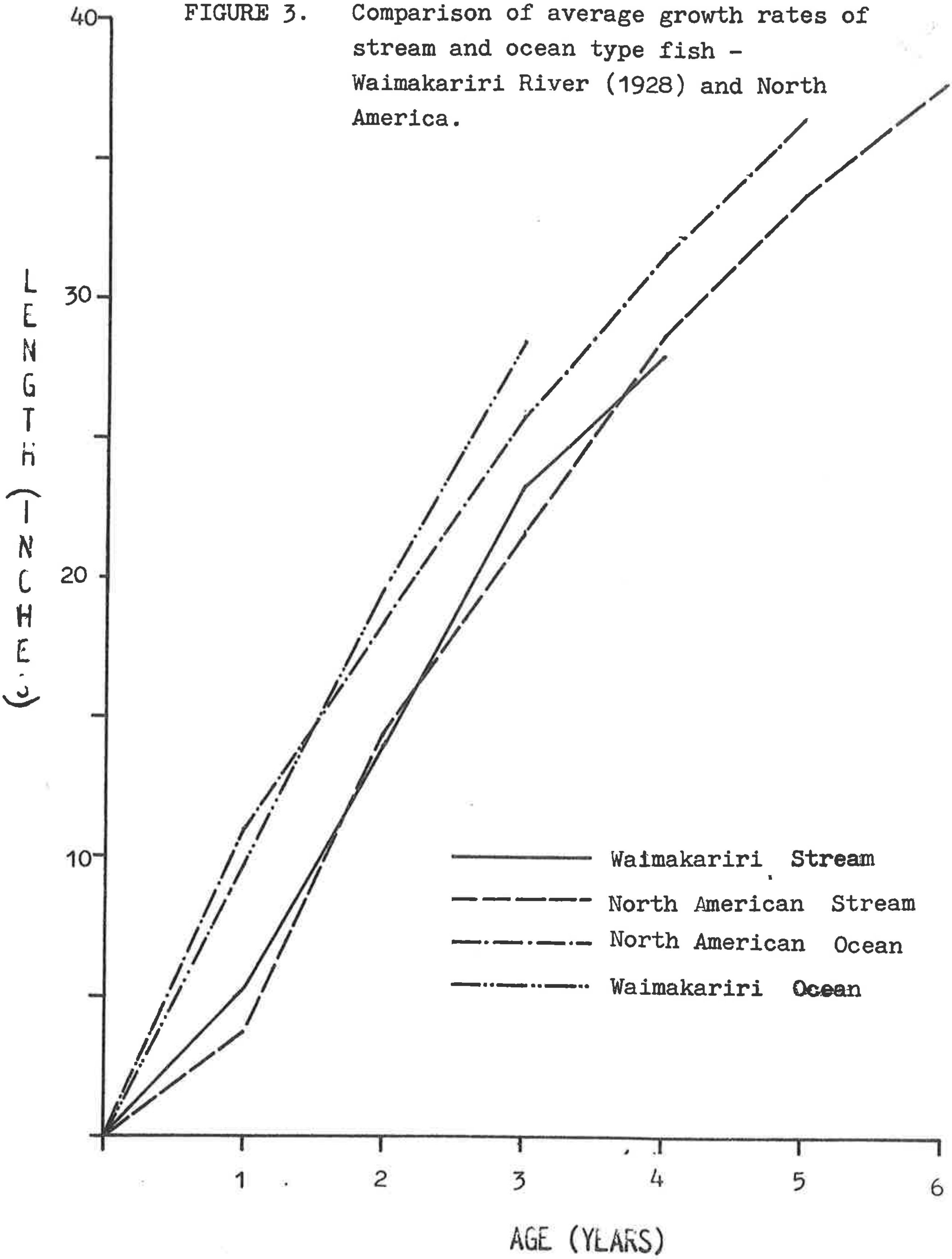
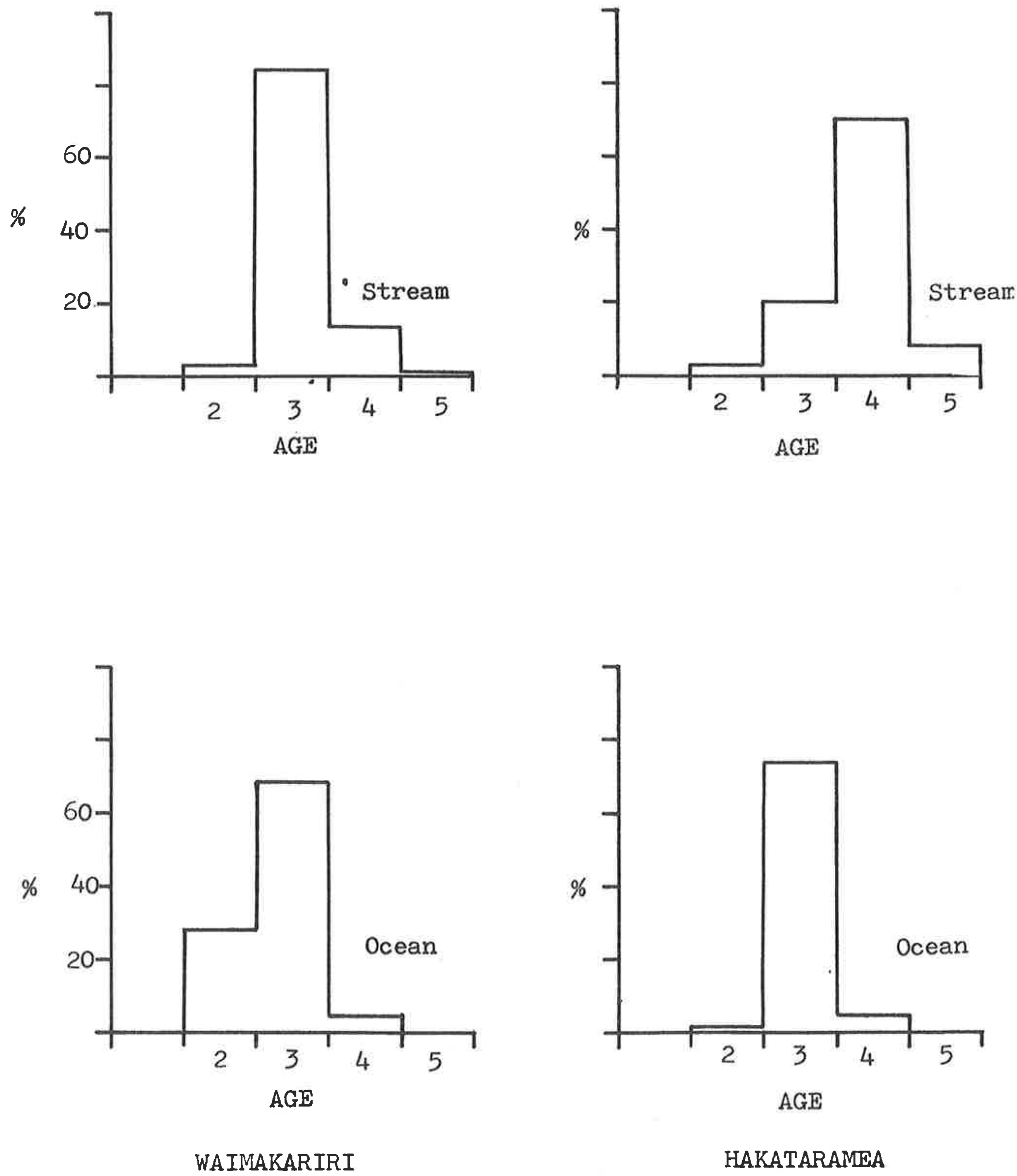


FIGURE 4. Age composition of stream and ocean type fish in 1928 Waimakariri River run and 1931 Hakataramea River run.



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