Fisheries Research Bulletin No. 20

# The Ecology of Whitebait Migrations (Galaxiidae: *Galaxias* spp.)

by
R. M. McDowall and
G. A. Eldon

Fisheries Research Division
New Zealand Ministry of Agriculture and Fisheries

# The Ecology of Whitebait Migrations (Galaxiidae: *Galaxias* spp.)

R.N.Z.A.F. photograph.

Frontispiece: The mouth of the Waiatoto River, which was studied intensively throughout the period of the investigation of whitebait migration on the west coast of the South Island.

Fisheries Research Bulletin No. 20

# The Ecology of Whitebait Migrations (Galaxiidae: *Galaxias* spp.)

by

R. M. McDowall and

G. A. Eldon

Fisheries Research Division,
Ministry of Agriculture and Fisheries,
Christchurch, New Zealand

Fisheries Research Division
New Zealand Ministry of Agriculture and Fisheries
1980

Published by the New Zealand Ministry of
Agriculture and Fisheries
Wellington
1980

ISSN 0110-1749

# FOREWORD

MAINTENANCE of the unique whitebait fishery poses a series of unusual problems, but it is quite apparent that appropriate resource management cannot be achieved unless the fish themselves are better understood. This exhaustive study by Dr McDowall and Mr Eldon contributes substantially to our knowledge of the biology and behaviour of the five galaxiids which compose the resource.

Major modifications to river catchments can seriously deplete the stocks, and in this respect the ability of the different species to select water of a particular character so soon after their entry to fresh water is of especial interest. It is also apparent that the present level of fishing in South Westland is such as to permit adequate recruitment to the up-stream adult environment. Thus, provided the catchments remain unchanged, the fishery can continue with the present level of effort.

Some questions remain unanswered: notably, what oceanic mechanisms bring or retain the young fish within reach of suitable rivers at the appropriate stage of development and what factors trigger their up-stream migration?

It is for these reasons that the wealth of data collected on the various aspects of the fish and their environment has been published in this bulletin. The information is readily accessible for others who may wish to pursue studies on the fish or the fishery.

G. DUNCAN WAUGH,
Director, Fisheries Research Division

# CONTENTS

## CONTENTS (continued)



## FIGURES

## FIGURES (continued)

## TABLES

## TABLES (continued)

# INTRODUCTION

"Whitebait" is the popular and commercial name in New Zealand for juveniles of five species of *Galaxias*. They are 40–60 mm in total length, slender, and transparent, and are netted in tidal river estuaries as they migrate up stream from the sea in huge shoals during late winter to early summer. They are the basis for a recreational fishery throughout New Zealand and a commercial fishery, principally on the west coast of the South Island.

For a long time it was believed that *Galaxias maculatus* (Jenyns) was the only species in the migrations, but several persons conjectured that other species may also be present (Hector 1903, Stokell 1955, Woods 1963). In a regular whitebait sampling programme on the Waikanae River during 1963–64 pigmented juveniles (which follow the transparent migratory whitebait stage) of several species of *Galaxias* appeared in the river; they must have come either from up-stream tributaries or from the sea. Whitebait samples fresh run from the sea and collected during the 1963 season in the Awarua River, South Westland, contained several species of *Galaxias* (McDowall 1964). In subsequent reports (McDowall 1965, 1966, Woods 1966) it has been shown that New Zealand whitebait comprises juveniles of *G. maculatus* (Jenyns), *G. argenteus* (Gmelin), *G. fasciatus* Gray, *G. postvectis* Clarke, and *G. brevipinnis* Günther.

A review of the New Zealand whitebait and its fishery (McDowall 1968) noted that there were "few objective data on factors affecting the whitebait migration". Since this was a subject in which knowledge was deficient, and since further information would contribute directly both to proper conservation of the fishery and its most effective exploitation, it was considered to be important and fruitful for study. Knowledge of the natural history of the galaxiid species in the fishery is reviewed by McDowall (1968, 1970a, 1978).

An investigation of factors affecting migration of galaxiid juveniles in the whitebait fishery was therefore begun in 1969 and continued in varying detail until 1973.

A series of rivers with regular substantial runs of whitebait was chosen. Whitebait samples and catch data were obtained, and a record was kept of a variety of environmental parameters.

In the present study we have attempted to follow the whitebait migrations and relate variations in fish abundance and species composition on a variety of time bases in an effort to understand factors in the environment that affect migration. This bulletin presents the results of this study. It also discusses fluctuations in seasonal catch for the past few years and tries to relate them to meteorological conditions existing between migration and spawning.

# FIELD STUDY AREAS AND SAMPLING LOCALITIES

If the various whitebait species migrate from the sea in response to different types of environmental stimuli, or if they respond to the same types of stimuli but at different thresholds, it seems most profitable to examine factors affecting whitebait migrations into a series of rivers that are diverse in character. For successful monitoring of river conditions and whitebait catch the rivers should be close together and yet as isolated and fished by as small and stable a number of fishermen as possible. The area best meeting these requirements was South Westland, where the Waita, Haast, Okuru, Turnbull, Waiatoto, and Arawata Rivers enter the sea along about 50 km of coastline (Figs. 1 and 2). This is one of the most productive areas for whitebait, and the resident human population is very small (a few hundred), though considerably augmented by spring influx of whitebaiters. There is access to most rivers by only one road, and the nearest towns (Wanaka and Hokitika) are several hours' drive away, so that itinerant fishermen tend to be few. The small and stable number of fishermen facilitates assessment of catch.

This study, during five whitebait fishing seasons (1969–73), varied from year to year as each season's results resolved questions for which we were seeking answers and indicated fruitful directions of inquiry for subsequent years. Work was concentrated largely in South Westland.

In 1969 sampling was broadly based and we studied catch quantity and composition, and river conditions, in the Waita, Haast, Okuru, Turnbull, Waiatoto, and Arawata Rivers and in two small streams — Ship Creek and one we designated Jackson Bay Stream (Fig. 1, Table 1).

In 1970 we concentrated on the Waiatoto River with a more intensive catch sampling programme both in the river and its tributaries. Environmental changes were monitored at all sampling localities. Catch composition and river conditions were again studied in the Okuru River, and catch sampling was established in the Buller, Hokitika, and Cascade Rivers (Fig. 1). The Okuru sampling provided results from a type of river different from the nearby Waiatoto, and the Buller, Hokitika, and Cascade sampling provided data for a broad-based analysis of variation in catch composition.

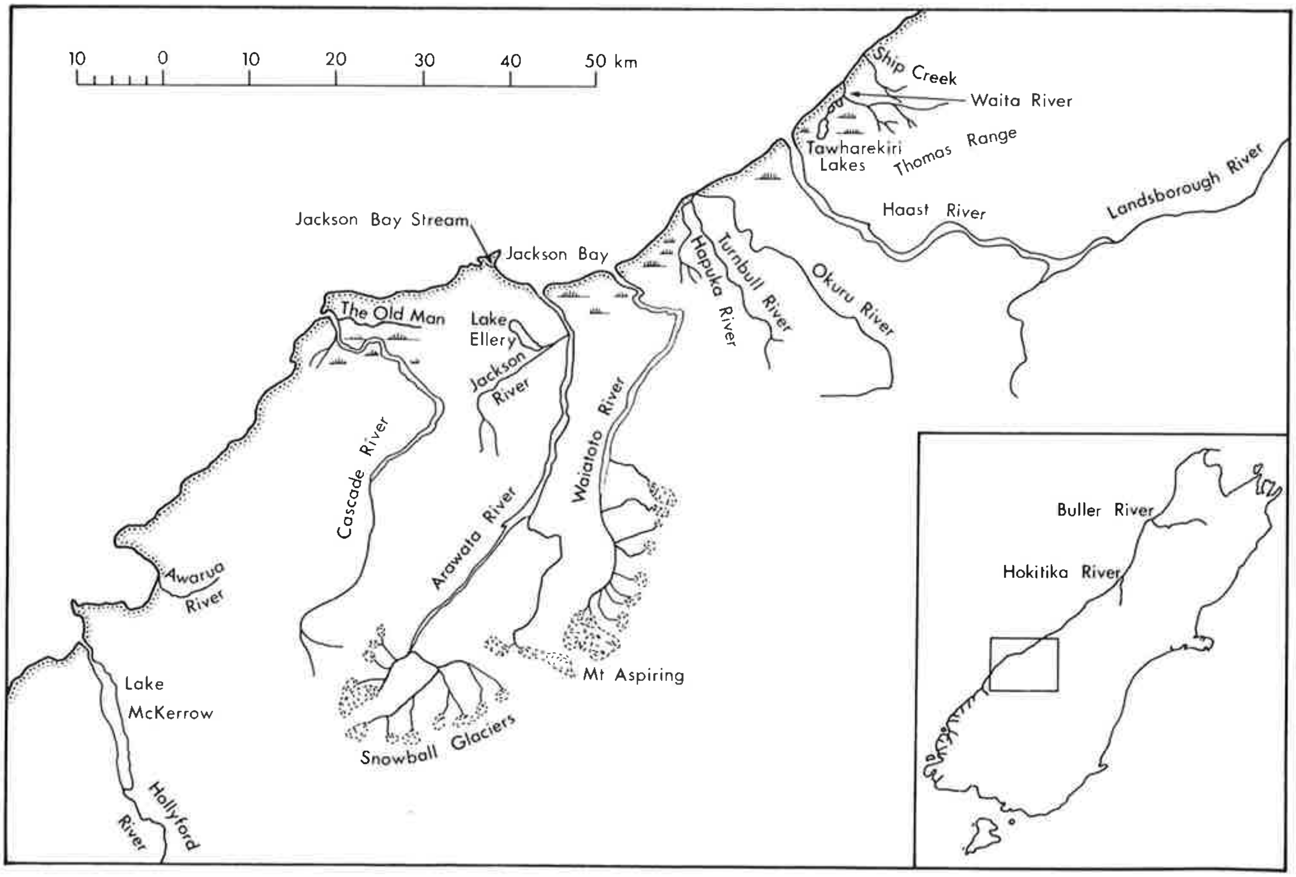



Fig. 1: Haast area, west coast of the South Island, showing sampling rivers and localities mentioned in the text.

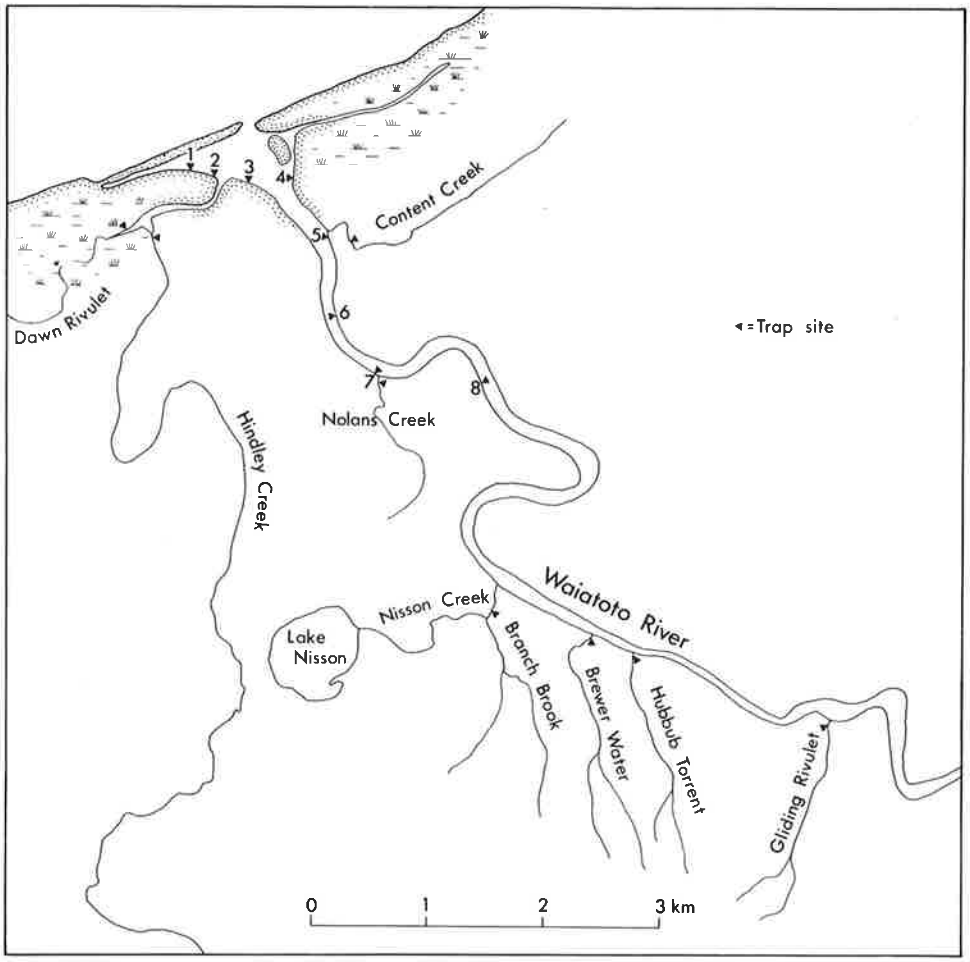



Fig. 2: Sampling localities in the Waiatoto River and its tributaries. Sites 1- to 8 are as shown in Table 2, below. Sites 1, 5, and 8 were experimental fishing sites; all others in the Waiatoto River were worked by commercial fishermen.

The 1971 and 1972 programmes had similar emphases to the 1970 one and differed only in details. In 1973 we obtained samples from only the Okuru, Waiatoto, and Cascade Rivers. The main rivers and streams sampled are indicated in Fig. 1, and the years in which sampling was undertaken are shown (Table 1).

The Waiatoto River was studied intensively throughout the research period. It is a consistently productive river, its catchment is virtually unmodified except for the effects of deer in headwater forests, and

**TABLE 1: Years in which west coast, South Island, rivers were sampled for whitebait catch**

| River | Year 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|
| Buller | | × | × | × | |
| Hokitika | | × | × | | |
| Ship Creek | × | | | | |
| Waita | × | | | | |
| Haast | × | | | | |
| Okuru | × | × | × | × | × |
| Turnbull | × | | | | |
| Waiatoto | × | × | × | × | × |
| Arawata | × | | | | |
| Jackson Bay Stream | × | | | | |
| Cascade | | × | × | × | × |

**TABLE 2: Years in which sampling localities in the Waiatoto River system were sampled**

| Sampling locality | Year 1969 | 1970 | 1971 | 1972 | 1973 | Distance of trap from river mouth (km)* |
|---|---|---|---|---|---|---|
| Waiatoto River | | | | | | |
| Site 1† | | | | × | | 0.6 |
| 2 | × | × | × | | × | 0.8 |
| 3 | × | × | × | × | | 1.0 |
| 4 | | | × | × | | 1.1 |
| 5† | | × | × | | | 1.8 |
| 6 | × | × | × | × | × | 2.4 |
| 7 | × | × | × | × | | 3.2 |
| 8† | | | | × | | 4.4 |
| Tributaries‡ | | | | | | |
| Dawn | | | × | × | | 2.4 |
| Hindley | | | × | × | | 2.7 |
| Content | | × | × | × | | 1.9 |
| Nolans | | | × | × | | 3.4 |
| Nisson | | × | × | | | 7.9 |
| Brewer | | × | × | | | 9.2 |
| Hubbub | | × | × | | | 9.7 |
| Gliding | | × | × | | | 12.1 |

*This distance is approximate, as the river mouth may shift up to 1 km or more.

†Sites 1, 5, and 8 were experimental fishing sites; all others in the Waiatoto River were operated by commercial fishermen.

‡Tributaries are closed to all fishing, and sampling was carried out by research staff with experimental traps.

access to the river is very restricted, which results in lower and more stable numbers of fishermen. A further factor affecting its choice was navigability of the lower 15 km by jet boat.

Finally, early studies of catch composition (1969) indicated that the Waiatoto whitebait catch had the three principal whitebait species in relatively large numbers.

Sampling in the Waiatoto was designed to determine: (1) composition of whitebait entering the river, (2) seasonal variation in composition, and (3) variation in composition with locality in the river and differences between tributaries.

To accomplish this fishermen in diverse localities in the river kept samples, and we established experimental traps in both the river and its tributaries. Localities sampled regularly in the Waiatoto River are indicated in Fig. 2, and the years in which samples were obtained are listed (Table 2). Most catch sampling was confined to sites listed in Table 2, but occasionally we obtained fish from additional localities. Some samples were obtained with a scoop net at the river mouth, and others were collected at various distances up stream in set nets. During severe floods, when there was little fishing, we obtained samples from any fishermen available. Characteristics of the rivers in which migrations of whitebait were examined are discussed in Appendix 2, "West Coast Rivers Sampled", page 98.

# SAMPLING

## COLLECTION OF WHITEBAIT SAMPLES

Whitebait samples were collected from diverse localities in the Waiatoto River system. Traps easily reached were serviced two or more times a day. Less accessible traps were serviced each day or every 2 days. Servicing schedules were repeatedly delayed by floods.

Daily whitebait samples were desired from rivers so widely separated that the co-operation of whitebait fishermen had to be sought in sample collection. This co-operation was received in full measure.

There is a serious pitfall in having fishermen collect samples. The species migrate together in mixed-species shoals. When fish are removed from the whitebait net, they are placed in "4-gallon tins" with perforated walls to allow excess water to drain away. Woods (1966) found that "samples taken from the top, middle and bottom of each of three tins of live whitebait did not differ significantly in species composition", but this is contrary to our experience. Although there may be no stratification of species when the fish are first tipped from the nets into draining tins, differences develop as time passes. The more active, virile, and muciferous *G. brevipinnis* whitebait force their way to the surface of the tin and ultimately they form a layer at the surface. (In such a tin, if the top few centimetres of whitebait are carefully pushed aside, a greater proportion of *G. maculatus* is revealed beneath. In rivers like the Haast, *G. brevipinnis* often linger in the shallows, feeding and becoming strongly pigmented before moving on up stream. They mix with fresh-run whitebait and are caught with them; their intense pigmentation lowers the value of the whitebait catch at the market. But if the fish are left in the draining tins overnight, fishermen have found that a high proportion of the strongly pigmented *G. brevipinnis* force their way to the surface and can be removed, many still alive, and discarded with little loss of marketable fish.)

Woods's (1966) procedure of taking samples from tins of whitebait was duplicated for two tins of whitebait from the Waiatoto River in 1969. The results (Table 3, Fig. 3) amply demonstrate stratification of fish in the tins. Comparisons of samples from the three levels showed that the superficial layer differed significantly from both levels that were sampled beneath.

In a series taken on 19 October 1969 the middle and bottom samples were homogeneous and of the same origin (chi-squared = 0.69, $0.50 > P > 0.25$), but the series of 23 October strongly suggested stratification of the middle and bottom samples (chi-squared = 5.89). Comparisons of the surface layer with the middle and bottom layers gave immense chi-squared values (768.40 and 1408.95 respectively), compared with the much lower value for comparison of the middle and bottom layers. The critical fact is that, contrary to Woods's findings, whitebait may not be homogeneously distributed in draining tins, but that, owing to behavioural differences between the species, stratification may develop. Because of this, bias in the species composition of samples could easily occur through samples being taken from the surface layers of tins of whitebait which have stood draining for a while. Great care must therefore be exercised in sampling. Fishermen keeping samples for us were requested to preserve them as the catch was removed from the net, and where this was not possible, to mix the catch thoroughly before samples were removed.

Whitebait fishermen obtained their catches (and our samples) generally by fishing methods prevailing among fishermen (see Appendix 3, "Fishing Methods", page 101).

**TABLE 3: Analysis of whitebait samples from Waiatoto River to determine movement in draining tins**

| Date | Position in tin* | *G. maculatus* No. | % | *G. brevipinnis* No. | % | Chi-squared tests | Chi-squared | Significance |
|---|---|---|---|---|---|---|---|---|
| 19 October | 1 | 163 | 78.0 | 46 | 22.0 | 1 v. 2 | 8.88 | $P < 0.005$ |
| | 2 | 229 | 98.7 | 3 | 1.3 | 1 v. 3 | 50.75 | $P \ll 0.005$ |
| | 3 | 194 | 99.5 | 1 | 0.5 | 2 v. 3 | 0.69 | $0.25 < P < 0.50$ |
| 23 October | 1 | 3 | 2.0 | 144 | 98.0 | 1 v. 2 | 769.4 | $P \ll 0.005$ |
| | 2 | 234 | 92.5 | 19 | 7.5 | 1 v. 3 | 1 408.95 | $P \ll 0.005$ |
| | 3 | 264 | 86.0 | 43 | 14.0 | 2 v. 3 | 5.89 | $0.010 < P < 0.025$ |

*1. Top of tin.
2. Middle of tin.
3. Bottom of tin.

Scoop nets (Buller River), open-mouthed, wooden-framed box nets (Hokitika River), open-mouthed, wire-framed nets (Waita River), and single- or double-trap wooden-framed box nets (most rivers in the Haast area) are used by whitebaiters. Research staff used scoop nets or a one-man push-seine net in small tributaries, but mostly used wooden-framed box-trap nets of construction similar to that used by whitebaiters, but designed to meet various experimental demands, for example, the need to fish deep into the water or to remain fishing at all stages of the tide without needing attention. We have little knowledge of the effect of different types of net on the species composition of the catch (though these certainly affect catch quantities). The only known bias from methods of capture is that fish caught with the push-seine may be those resident in an area rather than those migrating up stream, so that we cannot distinguish between resident and migratory fish in push-seine catches. However, sorting out "fresh-run" and "gutty" fish is likely to place most resident fish in the "gutty" category (see Appendix 4, "Sorting and Identification of Samples", page 103).

## INFLUENCE OF SAMPLING SITES ON CATCH COMPOSITION

The sites at which samples are collected in any river are important, as on any one day catch composition varies with locality, particularly distance up stream. This variation has a fairly clear pattern, which will be discussed later with reference to the Waiatoto River (see "Effect of Distance up Stream", page 62). It is difficult to estimate the effect on catch composition of the tributary waters the fish must migrate through before reaching the respective fishing sites, but results from the Waiatoto River probably apply generally to the other rivers. We have assumed that this is true.

Buller River samples came from fishermen scoop netting on the left bank below any tributaries entering the river. Samples were obtained from 1970 to 1972.

Hokitika River samples were caught with open-mouthed, wooden-framed box nets. The 1970 series was obtained from a fisherman on one of the islands in the river about 1½ km up stream from the mouth and above the point where the brown waters of Mahinapua Creek enter the south side of the river. In 1971 our sampling fisherman fished from an island closer to the river mouth and down stream from the mouth of Mahinapua Creek. We do not know how typical our two series from the Hokitika are likely to be.

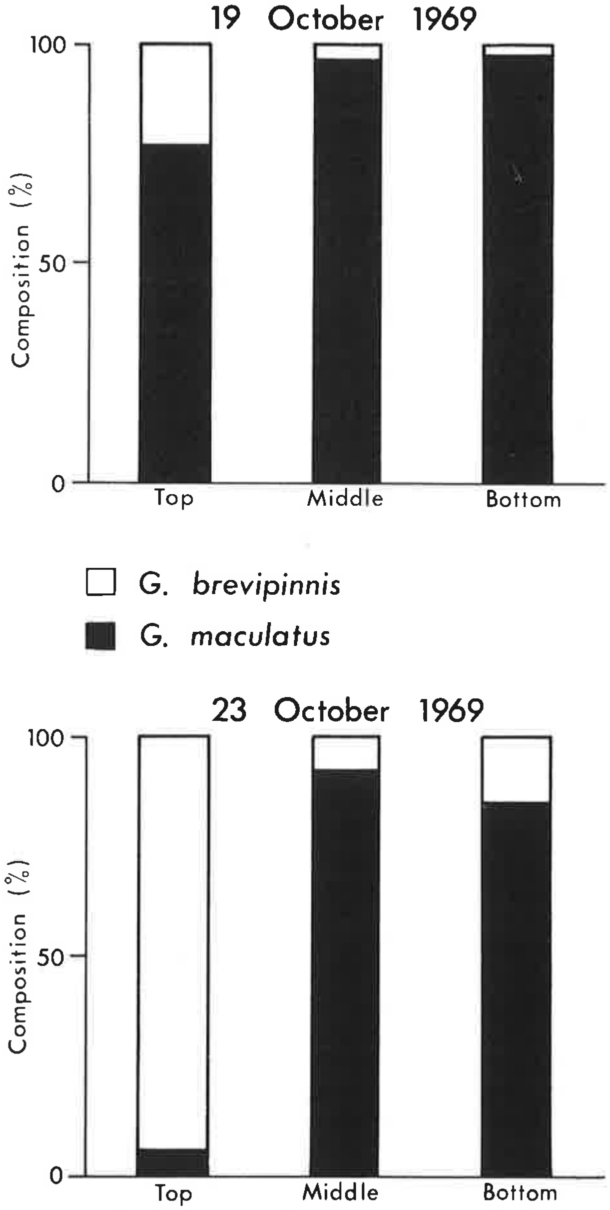



Fig. 3: Variation in composition of whitebait sampled at various levels in a whitebait draining tin.

Ship Creek samples were collected from the estuary with a small push-seine net wherever they could be found. A few samples were obtained from a fisherman who used a trap net in the lower estuary. For part of the 1969 sampling programme a trap net was installed in the small forest tributary (right bank).

Waita River samples were obtained from fishermen using a wire-framed, open-mouthed net, who generally fished in the surf at the river mouth, but who occasionally fished in the lower several hundred metres of the estuary. Clearly those fish caught in the surf are a proper representation of fish entering the river and the same probably applies to those caught in the estuary.

Haast River samples were obtained from a site on the right of the river about 300 to 400 m from the sea, just below the outlet of a small swampy area (Haast River, site 1). Flow from this swamp is very slight, and the river forms a deep channel running along the north bank, with moderately swift water flowing almost straight down to the river mouth. Our samples from the Haast River seem likely to be a good representation of fish entering the river. A few samples were obtained at a site 3 km up stream (site 2).

Some difficulty was experienced in obtaining samples from the Okuru River in 1969, and samples were received from three different fishermen on a regular basis and from several others on occasions. One fisherman (site 1) was fishing about 200 m above the confluence of the Okuru River with the Turnbull, on the left bank; another fished about 400 m further up stream, also on the left bank (site 2), and the third 300-400 m further up, again on the left bank (site 3). Between these fishermen there was little entry of tributary water into the Okuru River. Samples in 1970-73 came entirely from the third of these sites.

Samples from the Turnbull River were received from one site about 75 m above the confluence of the Turnbull River and Hapuka River, on the left bank of the Turnbull. This was the first fishing site on that bank of the river. In the Okuru-Turnbull system the movement and mixing of waters are complex and it is impossible to do more than guess at how representative our samples are of the whitebait entering the common mouth of the two rivers. The species composition of the run entering the mouth would be a response to the characteristics of the water flowing out of the combined mouths. This water comprises the very clear and pure water from the Okuru and Turnbull Rivers and the brown water from the Hapuka River. Our samples from the Okuru River could also have been affected by distance up stream. An up-stream decline in the proportion of *G. maculatus* is evident from comparison of the catches of the three Okuru fishermen from whom we obtained samples in 1969 (Table 71 in Appendix 5). Thus the Okuru samples for 1970-73, which came from the sampling site furthest up stream of the three used in 1969, may contain lower proportions of *G. maculatus* than those entering the lower reaches of the river from the sea.

Our samples from the Turnbull River, coming from the lowermost fisherman on the left bank of the river, should reflect the composition of the whitebait run entering the river, though the composition of shoals reaching the river may be affected by mixing of clear Turnbull River and brown Hapuka River water.

Waiatoto River samples were obtained from diverse and widespread localities on both banks of the river (Fig. 2 and Table 2). Sampling was designed to determine variations in composition with locality, which are discussed elsewhere in relation to characteristics of the water at each sampling site (see "Species Composition of Whitebait Run in Waiatoto River and its Tributaries", page 58).

Arawata River samples were initially obtained from a fisherman on the left bank, about 300 m from the river mouth, the first fisherman on this side (site 1). During late November Arawata samples came from the right bank about a kilometre from the sea (site 2). These later samples may have tended to emphasise the importance of *G. brevipinnis* if Waiatoto River data are applicable to the Arawata. Several small samples were obtained at the main road bridge, about 7 km from the sea (site 3).

The Jackson Bay Stream is not fished by whitebaiters, and our samples were obtained from a small trap placed in the stream about 400 m from the mouth.

Cascade River whitebait samples were collected by the lowermost fishermen on the right bank. The site is about a kilometre up stream from the river mouth and immediately up stream from the confluence with The Old Man, a stream that drains extensive areas of lowland and coastal swamps. As fishing below this confluence is prohibited, the migrating fish have free access to The Old Man. (Because this creek drains open swamps, it is likely to be warmer than the main river and is likely to attract *G. maculatus*, but not other species.)

Having noted that there are likely to be biases in the sampling methods in these rivers, but having no absolute figures which allow adjustment for this bias, we have taken the various series of samples as being representative of each river or stream, though we know that this may not be wholly appropriate.

## PRESERVATION AND STORAGE OF SAMPLES

Whitebait fishermen were supplied with ½-litre jars with about 30 ml of full-strength formalin and with sequentially numbered water-resistant labels. The numbered labels allowed us to identify occasional unnamed or undated samples. Samples collected by research staff were preserved in 10% formalin. After fixation all samples were washed in tap water for several days and stored for study in 40% isopropyl alcohol.

### PRESERVED AND FRESH WEIGHT OF SAMPLES

Our information on whitebait catch comprised its total weight and the relative proportions of each species. From these data we needed to derive the number of fish of each species migrating each day. This is not simply accomplished by applying the percentage composition of the sample for a day to the weight of fish caught on that day, because the three principal component species differ widely in size and weight at migration (see "Size at Migration", page 21). Moreover, each species varies both within and between years in size at migration and in length to weight ratio. To determine empirically the numbers of fish of each species migrating each day, daily data on average length and weight of each species would be required. Working conditions in the field, personnel limitations, and, often, sampling limitations prohibited such a programme. In 1969 no direct observations on weight were made, in 1970 a limited number were made, and in 1971 and 1972 samples were weighed whenever possible. Samples were allowed to drain before being weighed, generally with tubular spring balances weighing to 250 g and 1 kg (to the nearest 5 g), 5 kg (nearest 20 g), and 20 kg (nearest 0.5 kg). (Occasionally samples were weighed on a Mettler P.1200 balance to the nearest gram.)

The data derived were not sufficient to permit their direct use for estimation of seasonal changes in fish weight or for determining interspecific differences. Accordingly, to obtain this information we examined the relationship between fresh and preserved weight. A series of 206 preserved samples in which fresh weight was known was selected, drained until surface dry, and weighed to the nearest gram (fresh weight of samples 10-360 g, mean 174 g). We calculated the linear regression of fresh weight on preserved weight and found that fresh weight equalled preserved weight, with 95% confidence interval for this slope of 1.00 ± 0.01. Thus with high reliability preserved weights of subsamples can be taken as equivalent to their fresh weights, and the error is likely to be no greater than that involved in weighing the fresh sample in the field.

## STUDY OF ENVIRONMENTAL FACTORS

A wide variety of environmental factors was examined in relation to variation in whitebait migrations. These factors included weather, river levels, river temperatures, water colour and turbidity, pH, oxygen saturation, and water chemistry. Methods used and results obtained are discussed in Appendix 1, "Study of Environmental Factors — Methods and Results", page 90.

## ESTIMATION OF WHITEBAIT MIGRATIONS

To determine factors which affect whitebait migrations it is necessary to estimate the quantity of fish running into each river under study at any time. In large rivers fished by commercial whitebait fishermen estimations of whitebait migrations can be made from catch figures. Such estimations are subject to many serious pitfalls, not the least of which is changing fishing effort and ignorance of how catch changes with effort (see "Catch and Effort in the Whitebait Fishery", page 74). Because of the behaviour of the fish and the distribution of fishermen in the rivers the quantity of fish caught is likely to be closely related to the quantity of fish entering the rivers, and catch fluctuations are likely to reflect fluctuations in the absolute number of fish migrating. From discussion of the relationship between catch and effort (page 74) it appears that on typical heavily fished rivers of Westland catch is not particularly closely related to effort. Once a certain fishing effort is reached further increase in effort seems likely to result in a given quantity of fish being shared among an increasing number of fishermen. If this is so, changing fishing effort from day to day should have little effect on catch unless the change in effort is substantial. We have assumed that whitebait catch fluctuations represent real fluctuations in quantities migrating.

Although it is assumed that catch figures fairly represent quantities migrating, the problem remains of obtaining accurate catch figures. We assessed total catch from rivers under study by examining purchasing records of the two principal whitebait buyers at Haast. Their figures were augmented by catch diaries kept by some fishermen, including several diaries covering many consecutive years, some pre-dating the start of this study. Most diaries were obtained from fishermen working in the Haast area, but some were received from other areas. Generally fishermen are reluctant to fill in diaries.

Since two whitebait buyers at Haast bought a high proportion of the local catch, it was considered that their figures should adequately represent catch. During the 1969 whitebait season a fire destroyed records of one whitebait buyer for September. As most of the catch for 1969 was taken in September, data for the 1969 season are less complete than for other years. In subsequent years full sets of buyers' figures were obtained.

Whitebait not bought by the two principal buyers has a variety of destinations:

**Itinerant buyers.** Itinerant buyers do not have freezing and packing facilities in the fishing area. Several operated in the Haast area from time to time and bought large quantities of whitebait, such as 270, 200, and 115 kg, respectively, in three 2-day periods in 1969 from one river. We found it hard to obtain figures from these buyers; they seem to operate during periods of high catch and their activities may significantly lower known catch figures on days with peak runs. Their purchasing steadily increased from 1969 to 1973.

**Direct sales to shops.** A few fishermen send their catches to towns like Alexandra for sale from shops. The impact of such direct sales is probably fairly small.

**Sales to individuals.** Fishermen sometimes sell large quantities of whitebait to travellers and thus lower quantities of whitebait sold to buyers. Unlike sales to itinerant buyers, these sales occur haphazardly and randomly throughout the season. They depress catch estimates a little when catch has been high, but relatively far more when catch has been low.

**"Scoopers".** A further source of error in catch estimates is the intermittent presence of "scooper" fishermen (see Appendix 3, "Fishing Methods", page 101), who may sell to local whitebait buyers, but who may fish for a few days and take their catch home. Occasionally, catches retained by scoopers are substantial.

**Local consumption.** Yet a further source of error is fish consumed by fishermen and their families (several hundred persons in the Haast area). Although we can only guess, it is likely that more whitebait is eaten early in the season (when it is still a novelty) than later, and it is certainly true that when catches are poor, the fishermen may not sell the kilogram or two of fish caught. Local consumption probably makes up a few percent of catch. (Figures in the annual *Report on Fisheries* allow 5% for local consumption in the Haast region — Ministry of Agriculture and Fisheries head office file No. 42/10/7.) The quantity of whitebait kept for local consumption has risen with increasing use of domestic freezers.

Some fishermen kept daily catch diaries, and comparison of these diaries with buyers' records shows the accuracy of buyers' records as an indicator of total catch. With few exceptions fishermen reported daily catch the same as or greater than that recorded by buyers. The few instances of buyers apparently buying more fish on a day than fishermen reported catching are almost certainly due to bulking of catch for 2 or more days by one fisherman or the bulking of catch for 1 day by several fishermen. Sometimes figures for fishermen and buyer were out of phase by 1 day, and these were instances where catch for 1 day was not sold until the following day.

There is no reason to believe that fishermen who kept diaries disposed of their fish any differently from "average fishermen", so that a comparison of their figures with buyers' figures can be interpreted as representative of differences between fishermen and buyers.

In Table 49 (Appendix 5) figures from fishermen are compared with those for fish sold to buyers. In 1969 figures for September are excluded for fishermen who sold to the buyer whose records were destroyed by fire. Buyers' figures vary tremendously as a percentage of fishermen's catch figures (0 to 100.06% for 1969–71).

On the basis of Table 49 (Appendix 5) it seems that buyers' figures represent about 65% of fishermen's catches. The difference between the figures may partly reflect overestimation of catch by fishermen or weighing before the catch has drained properly. Such errors cannot be quantified. In some instances it is clear that fishermen were filling out diaries from sale dockets supplied by buyers. Generally differences between buyers' and fishermen's catch figures can be accounted for by the various avenues outlined above.

If buyers' figures alone were used to estimate whitebait runs, there would be substantial loss in estimates of absolute quantities of fish caught, though not necessarily in the relative fluctuations from day to day. Whether or not fluctuations in buyers' figures accurately reflect catch fluctuations can be ascertained by calculating correlations between the two sets of figures. High correlations will indicate that a more or less constant percentage of catch is reaching buyers, even though fluctuations may be damped by loss of fish to unrecorded destinations. Correlation coefficients were calculated for fishermen's and buyers' figures summed for each year (1969–71), and very high correlations were found ($r = 0.710$, for $n = 74$ in 1969; $r = 0.95$, for $n = 86$ in 1970; and $r = 0.95$, for $n = 74$ in 1971; in all $P < 0.001$). This shows that fluctuations in figures from fishermen's diaries and buyers' purchase records are in very close agreement and that buyers therefore tend to obtain a fairly constant proportion of the catch. Fluctuations are well represented by buyers' figures, which, augmented wherever possible by fishermen's diaries, can therefore be used with confidence to examine catch fluctuations. These figures are used throughout this study as indicative of and representing absolute numbers of fishes.

## SORTING AND IDENTIFICATION OF WHITEBAIT SAMPLES

Whitebait samples were sorted according to stage of development and species. The two chief problems were: (1) separation of fresh-run whitebait from those which had spent some time in the rivers before capture, and (2) separation and identification of five species from mixed-species samples, which may contain *Galaxias maculatus*, *G. fasciatus*, *G. postvectis*, *G. argenteus*, and *G. brevipinnis*. Methods used for sorting and identification of samples are discussed in Appendix 4, "Sorting and Identification of Samples", page 103.

## WHITEBAIT IN THE SEA

The nature and origin of whitebait are subject to much conjecture and discussion by fishermen. Despite numerous reports of "whitebait" caught in the sea, few are authentic. Most of these reported catches have proved to be anchovies (*Engraulis australis* (Shaw)), other clupeoids (*Sardinops neopilchardus* (Steindachner) or *Clupea antipodum* Hector), a small, benthic, marine eleotrid (*Grahamichthys radiatus* (Valenciennes)), or the whitebait-like juveniles of the smelt *Retropinna retropinna* (Richardson) (McDowall 1972). *Galaxias maculatus* whitebait were caught under lights both in the Marlborough Sounds in 1965 (McDowall 1968) and off the Jackson Bay wharf in October 1970. Recently small numbers of *Galaxias* whitebait have been taken at sea during sampling for larval fishes (McDowall, Robertson, and Saito 1975). They were taken up to 700 km off shore (between the Bounty and Antipodes Islands) and are widespread in seas around New Zealand. All those which could definitely be identified were *G. maculatus*.

Although *G. maculatus* has generally been considered to occur in the sea, Benzie (1968a) appears to have doubted that whitebait of *G. brevipinnis*, *G. argenteus*, *G. fasciatus*, and *G. postvectis* also migrate from the sea: "From observations so far it seems that the young of the coastal region *Galaxias* species other than *G. m. attenuatus* [now *G. maculatus*] have a marine tolerance and also move in and out of the mouth of freshwater streams. . . . At present it seems that they are caught by chance when they join the schools of about six-month-old *G. m. attenuatus* entering fresh water." Benzie thus seems to imply that the four species other than *G. maculatus* may live in and around the river mouths. She further states: "The observation that *G. brevipinnis* may lead *G. m. attenuatus* schools (Woods 1966) is not surprising if they are in fact familiar with the area they are entering, as is suggested in this paper" (Benzie 1968a). In another paper she observes: ". . . the marine tolerance seen in the other coastal species has been extended so that in *G. m. attenuatus* the first 6 months are spent at sea as specialised marine larvae" (Benzie 1968b).

Benzie's suggestions that certain species move in and out of the estuaries, that they are "familiar with the area they are entering", and that they have lower marine tolerances than *G. maculatus* are unsupported by any published data and at present we know of no information that suggests that the behavioural pattern of whitebait of the five diadromous species of *Galaxias* differ from one another in any fundamental way in their life in the sea and entry into fresh water.

Analyses of whitebait catch (McDowall 1965, Woods 1966, present study) show that numbers of *G. brevipinnis* in the catch may be of the same order of magnitude as those of *G. maculatus*. It is inconceivable to us that millions of *G. brevipinnis* are living in the river mouths, moving in and out, and getting caught "by chance" as they join shoals of *G. maculatus*, as Benzie suggested. The five species are all similar in appearance, have a similar and most unusual metamorphosis, are consistent in cessation of feeding before migration, have a similar migratory period and responses, and migrate in mixed-species shoals. These similarities, with the information discussed earlier in this section, indicate to us that until we have some evidence to the contrary we must conclude that the whitebait of all five species are similarly truly marine in habit. They must form a vast pool of fishes in the ocean, though at present it is not known precisely where. Their transparency and small size at hatching (less than 10 mm) suggest that they are initially planktonic, perhaps becoming surface pelagic as they grow and their swimming powers increase. Benzie (1968a) concluded from the "nature" of a small diverticulum of the foregut, from "the presence of large gill rakers on the first gill arch, and from the fragments of gut contents of the migrating whitebait that *G. m. attenuatus* is a filter-feeder during the marine phase of its life". Although we can conjecture that the whitebait are probably planktonic and pelagic, at present little is known of their habits in the sea.

## AGE OF WHITEBAIT AT MIGRATION

It is generally agreed (McDowall 1968, Benzie 1968a) that the age of *G. maculatus* at migration is about 6 months. Recent studies of whitebait taken at sea (McDowall, Robertson, and Saito 1975) strongly support this. Benzie (1968a), recording spawning of *G. fasciatus* as early summer (December?), postulated age at migration as 8 to 10 months. Studies of egg size and gonad development (McDowall 1970a) suggested that in all five whitebait species spawning was primarily in autumn and early winter. Recent observations by Ots and Eldon (1975) showed that the young of *G. fasciatus* were hatching in late June. Thus, like those of *G. maculatus*, the whitebait of *G. brevipinnis*, *G. fasciatus*, *G. argenteus*, and *G. postvectis* are probably about 6 months old at migration from the sea.

## FEEDING OF WHITEBAIT BEFORE AND DURING MIGRATION

Migratory whitebait **appear** to have empty stomachs. This suggests that they cease feeding before migration. We examined stomach contents of whitebait of *G. maculatus*, *G. fasciatus*, *G. brevipinnis*, and *G. argenteus* from three habitat types:

1. Lower or mid-tidal reaches (Waiatoto, Okuru, Arawata, Cascade, and Buller Rivers). These fish were caught by commercial fishermen who emptied their traps at least once every tide. A total of 275 fresh-run whitebait was examined and none contained any marine organism. Ninety *G. maculatus* were examined, and 80 contained no food of any type. The remaining 10 contained either small adult Diptera or chironomid larvae and only 4 contained more than one food organism (3 fish had two, and 1 had six). Of 80 *G. brevipinnis*, 79 were empty, and 1 contained chironomid larvae; 75 *G. fasciatus* and 30 *G. argenteus* contained no food.

2. Fish were taken from tributaries entering the Waiatoto River estuary and from a trap at the upper limit of tidal influence in the river, 4.4 km from the sea. Of 60 *G. maculatus* 7 contained food, and in all there were Diptera larvae, pupae, or imagos; 29 of 30 *G. brevipinnis* were empty and 1 contained a chironomid larva. All 26 *G. fasciatus* examined were empty, with the exception of an insect antenna in one fish.

3. Samples of migrating fish caught 8-12 km up stream in the Waiatoto River and its tributaries and from about 8 km up stream in the Arawata River were examined. Twenty *G. maculatus* taken from Nisson Creek (7.9 km up stream from the sea) were empty, though 10 showed discoloration of the intestine at the vent, which perhaps indicated that food may have passed through. Ten fish from Brewer Water (9.2 km from the sea) had been feeding mainly on chironomid larvae, but also on simuliid larvae, adult Diptera, Oligochaeta, and caddis larvae. Eight of 10 *G. maculatus* from Gliding Rivulet (12.1 km from the sea) contained adult and larval Diptera, as did 5 of 10 from the Arawata River. In many of those fish which had been feeding the gut was full or nearly full of food.

One *G. brevipinnis* of 10 from Nisson Creek contained a chironomid larva, but 27 of 30 fish from the upper tributaries — Brewer Water, Gliding Rivulet, and Hubbub Torrent — contained food, primarily various stages of simuliids and chironomids, but also mayfly, stonefly, and caddis larvae, oligochaetes, and ants. Fish from the Arawata River were similar — 3 empty, 5 with small numbers of chironomids, simuliids, and similar insects, and 2 in which larger numbers were present.

One sample of 10 *G. fasciatus* came from these up-stream localities (Nisson Creek); 7 fish were empty and 3 contained minute and unidentifiable insect remains.

Evidence from fresh-run fish taken in the lower estuary shows that the fish cease feeding at sea for a period before migrating into fresh water. No marine organisms were found in any species. This is in accord with previous findings (Benzie 1968a, McDowall 1968). Our observations suggest that whitebait of *G. maculatus* usually do not begin to feed until they have migrated beyond tidal reaches. Most of what little food is taken before this seems to be taken from the surface (adult Diptera). Whitebait have, on several occasions, been observed to begin feeding at the surface at dusk when trapped in marginal river shallows by the falling tide. Nine of 20 *G. maculatus* examined from the Okuru River contained food, and these were also 9 of the 10 fish of this species found to feed in lower estuarine waters. There is a large lagoon in the lower Okuru River estuary and these feeding fish had possibly settled in the lagoon overnight. The *G. brevipinnis* examined from the Okuru River came from the same samples and had not fed; either *G. brevipinnis* moves up stream more rapidly or, if it stops migrating during the night, it does not feed.

There is no doubt, however, that both species may feed intensively before their migration is over. The samples for the Arawata River were caught in a net placed between rocks in swift current where the fish could be observed moving up stream. Most of the fish caught there were well pigmented and had been in fresh water for some days. Only two of the *G. brevipinnis* whitebait had empty guts and both were fresh run.

The *G. brevipinnis* caught at Hubbub Torrent and at Gliding Rivulet likewise were probably still migrating, though fish caught at Brewer Water may not have been, as the trap was situated in a flat between two short rapids, and *G. maculatus* were resident there by about mid September each year.

Earlier observations on the food of *G. maculatus* (McDowall 1968) showed that the fish is an opportunist carnivore feeding on a wide range of benthic aquatic and surface terrestrial animals. Our few observations on whitebait of *G. brevipinnis* suggest that this is also true for this species. Aquarium observations (Eldon 1969) have shown that *G. brevipinnis* will take surface food, and the presence of adult Diptera in *G. brevipinnis* whitebait indicates that this happens in the wild.

There were insufficient *G. fasciatus* in our samples to determine when they begin to feed, but it appears that they do not do so until they have migrated through the river estuaries.

# SIZE AT MIGRATION

Whitebait at migration from the sea vary considerably in size. This variation has interspecific and intraspecific, interseasonal and intraseasonal, and geographical components.

## METHODS

Variation in size was studied by measuring subsamples of at least 50 whitebait of each of the three principal component species where the samples were sufficiently large to permit this; otherwise the entire sample was measured. Measurements of length to caudal fork were taken to the nearest millimetre, and a subsample was measured at least once every 2 or 3 days, depending on the availability of material. When samples were very small, material from 2 or more consecutive days was bulked to produce a minimum sample size of about 25 fish. In addition to variation in length, it was found that length-weight relationship varied. To examine this variation we grouped fish of each species at 1-mm intervals throughout the size range for each species and for each year. The average weight of each species at each size was obtained from weighing the sized subsamples and dividing this weight by the number of fish in each subsample.

## INTERSPECIFIC VARIATION

Although there is considerable overlap, and though each species varies in size, both geographically and temporarily, there are differences between species in size at migration.

Large numbers of fish were measured each year, and a consistent relationship between species, in size at migration, is evident. Data for fish from the Waiatoto River, measured for study of seasonal variation in size at migration (1971, 1972), were combined for each species each year (Table 51 in Appendix 5; Fig.4). In both years whitebait of *G. maculatus* were longer than those of *G. brevipinnis*, and both species were significantly larger than *G. fasciatus* (Table 4). Lack of material prohibited presentation of comparable figures for *G. argenteus*, but general observations indicate that it is intermediate in size between *G. brevipinnis* or *G. maculatus* and *G. fasciatus* (see Appendix 4, "Sorting and Identification of Samples", page 103). The species also differ in stoutness. From figures in Tables 52-54 (Appendix 5) it is evident that *G. fasciatus*, though the smallest whitebait, is also the stoutest, *G. brevipinnis* is intermediate in stoutness, and *G. maculatus* is generally the largest and most slender (Fig. 5).

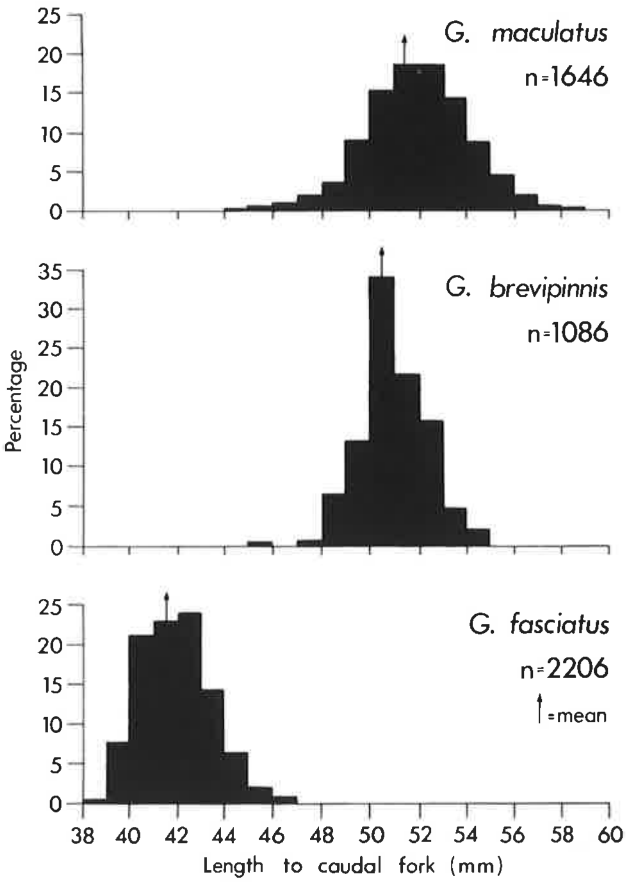



Fig. 4: Relative sizes of whitebait of the three principal species taken from the Waiatoto River in 1971.

The relative stoutness of the whitebait is similar to that of the respective adults, though the relative lengths of the whitebait are the reverse of adult sizes, adult *G. fasciatus* being longest and stoutest, *G. brevipinnis* intermediate in both length and stoutness, and *G. maculatus* shortest and most slender.

## INTRASPECIFIC VARIATION

Intraspecific variation in size at migration was found to have intraseasonal, interseasonal, and geographical components.

### Intraseasonal Variation

*G. maculatus*

A study of juveniles that had recently entered the Waikanae River (1963-64) showed clearly that size at migration in this species varies seasonally (McDowall 1968). A series of samples from the Awarua River, South Westland (1963), showed a rise to peak size in late September followed by a decline, which agreed with results from the Waikanae River. Data from fish caught in the Moeraki River showed a similar decline beginning in early October, but data from the Taramakau River showed no clear pattern (McDowall 1968). Benzie (1968a) found no seasonal variation in the size of whitebait running into the Ashley River in 1959.

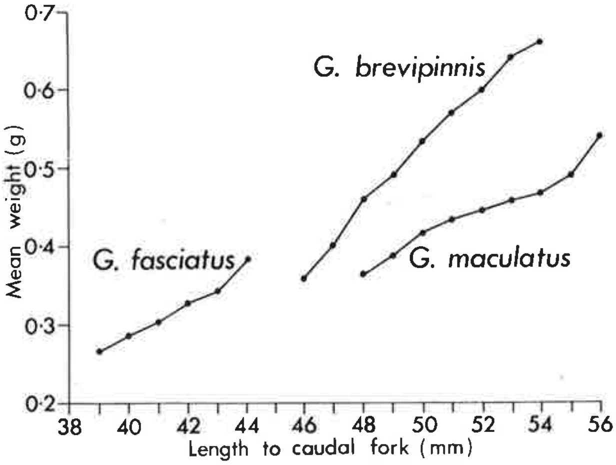



Fig. 5: Length-weight relationship for the three principal species of whitebait taken from the Waiatoto River in 1971.

**TABLE 4: Tests of significance for interspecific differences in size of whitebait at migration in Waiatoto River in 1971 and 1972**

| Species | | 1971 | 1972 |
|---|---|---|---|
| *G. maculatus/G. brevipinnis* | *t* | 13.72 | 11.40 |
| | n | 2 732 | 4 972 |
| *G. maculatus/G. fasciatus* | *t* | 173.99 | 130.69 |
| | n | 3 852 | 3 514 |
| *G. brevipinnis/G. fasciatus* | *t* | 170.72 | 125.85 |
| | n | 3 292 | 3 234 |

For n $> 1\ 000$, $t > 1.96$ for 5% level of significance.

Intraseasonal variation was studied further in this investigation. In 1969 variation in size was examined in five of the six rivers under study in that year (Fig. 6) (Waita, Haast, Okuru, Waiatoto, and Arawata). The sixth river — the Turnbull — has a common mouth with the Okuru, and material from the Turnbull was not measured.

In the Waiatoto River average size of fish varied between 54 and 55 mm in early September. It remained so until about 18 October, but then declined steadily to about 50 mm in mid to late November. A similar change at about the same time occurred in Okuru River samples, though size fell to about 51 mm. Day-to-day fluctuations in size were much greater in fish from the Haast and Arawata Rivers. Nevertheless, in both there is a clear decline in size, beginning about 18-20 October. A fairly compact and uniform envelope contains plots of mean length of *G. maculatus* from these four rivers.

The fish from the Waita River, however, began to fluctuate broadly in length after about 20 October. Previously there were occasional fluctuations, but after 20 October these increased in magnitude and frequency.

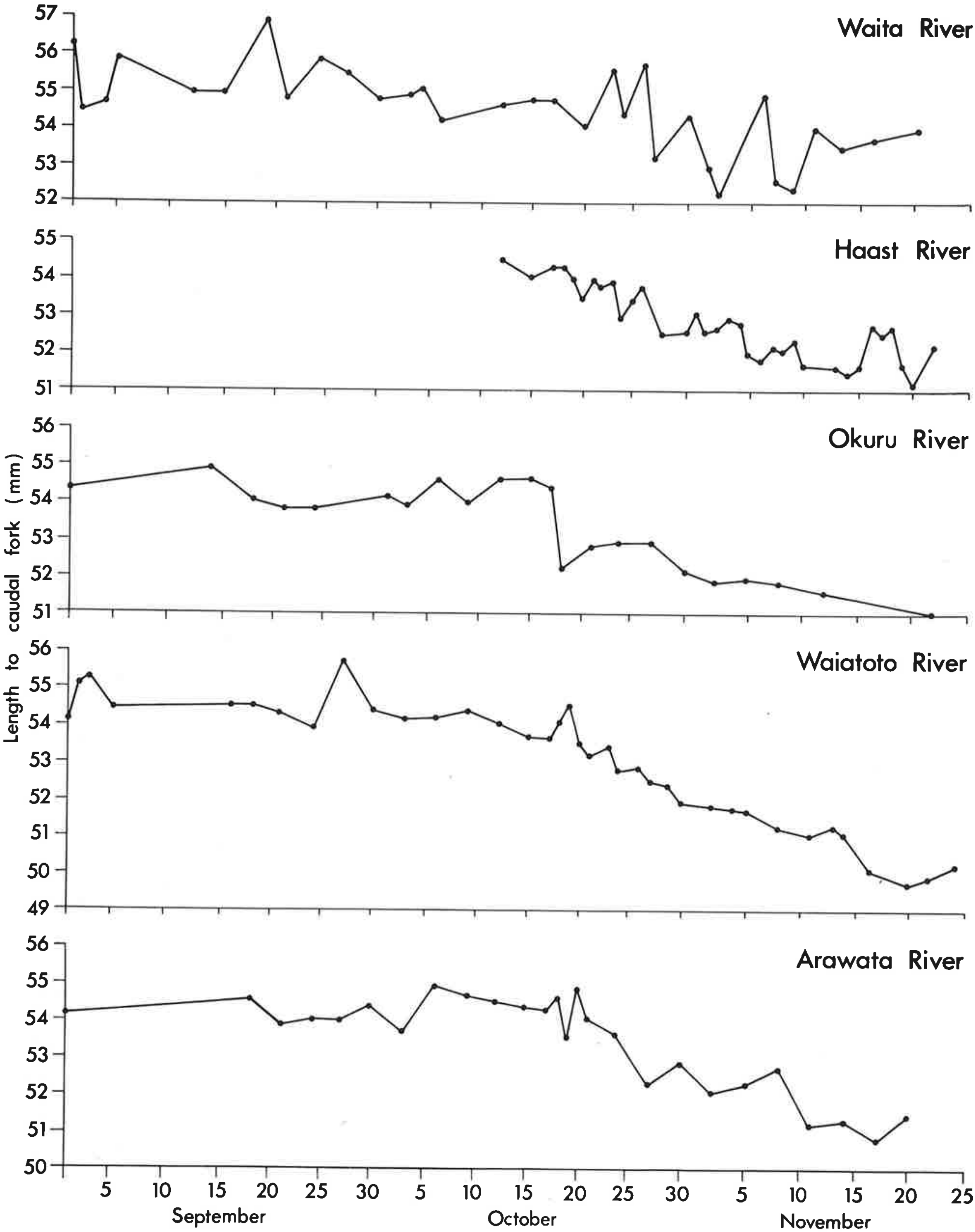



Fig. 6: Seasonal variation in mean size of *G. maculatus* at migration in Haast area rivers in 1969.

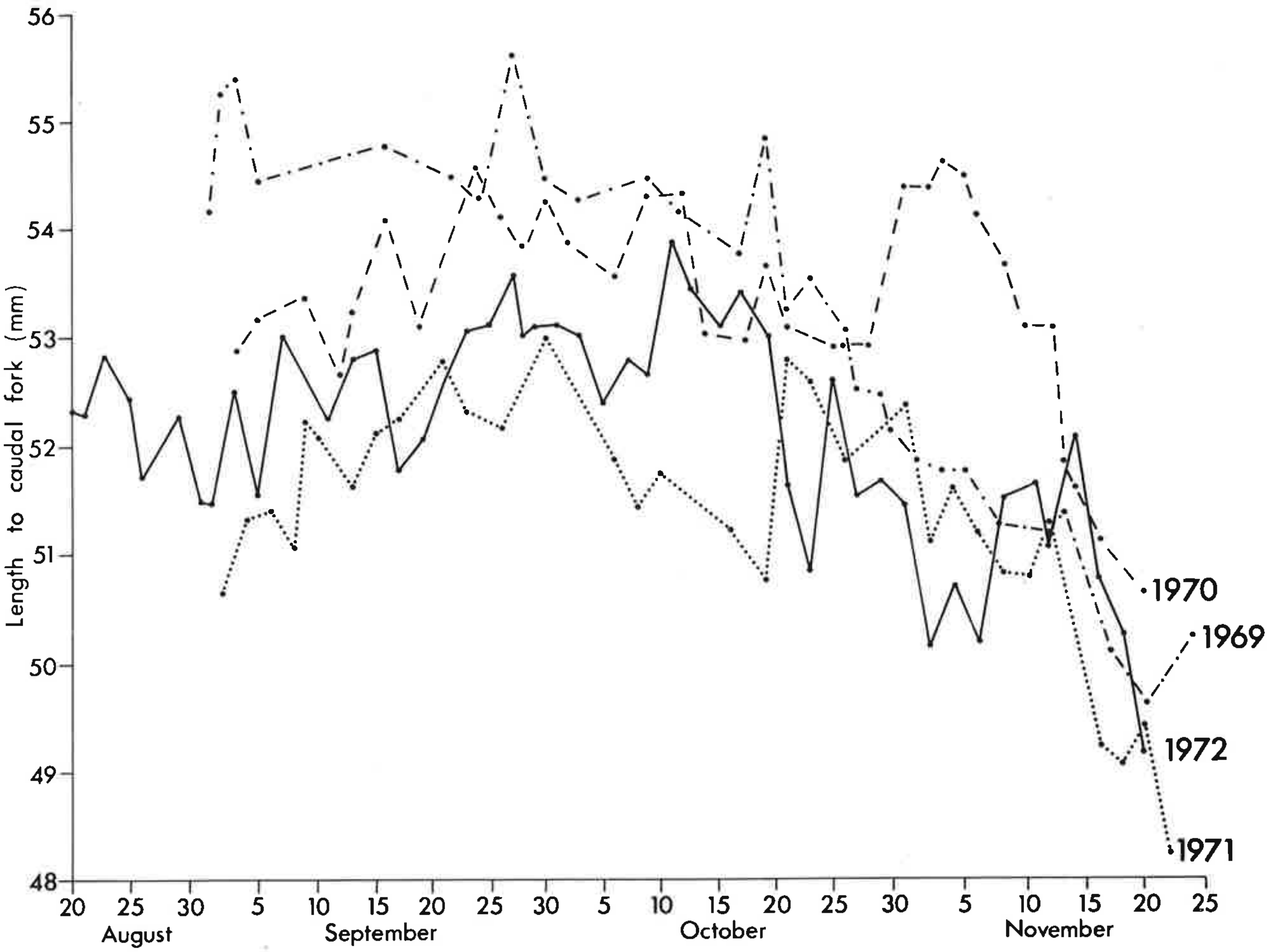



Fig. 7: Seasonal variation in mean size of *G. maculatus* at migration in the Waiatoto River from 1969 to 1972.

From 1970 to 1972 measurement of fish was restricted largely to Waiatoto River samples (Fig. 7), and similar patterns are evident as in 1969. In 1970 fish size showed a decline about 6 November, from mean values of about 54 mm down to 51-52 mm. Day-to-day fluctuations in size were rather broader in 1971, which made trends in size less easy to discern. Early-season fish (September) increased in size from about 51 mm to about 53 mm, fell during mid October to about 51 mm, rose again to about 53 mm, and declined steadily through November to less than 50 mm late in the month. Occasional broad fluctuations are also evident in 1972 data, but there is an overall rise from late August through September to a peak in late September, at about 53 mm, a stable period through to mid October, and an abrupt, though not consistent, decline during November.

Generally a decline in size of late-season whitebait is evident from all data.

It was previously observed that there appears to be a period of maximal whitebait size during the time of peak migrations (McDowall 1968). In 1969 decline in size began about 18-20 October, when 87% of fish caught on the Waiatoto River and 88% of that on the Okuru River had been taken. The decline in size for 1970 began about 6 November, when 90% of Waiatoto catch for that year had been recorded; in 1971 it began about 30 October, when 85% of the catch had been taken, and in 1972 about 21 October, when 80% of the season's catch was taken.

An unusual feature of the 1972 season was that floods continued to occur during mid November. By early November catches had dropped — only 7% of the 1972 catch was taken between 21 October and 8 November — and it appeared that the run was over for the year. However, floods from 1 to 7 November induced a substantial run of fish, and this coincided with a recovery in fish size which persisted for the few days of the run, but which was followed by a rapid decline in size.

*G. brevipinnis*

Our data on size fluctuations in *G. brevipinnis* are less complete than those for *G. maculatus*, but are sufficiently extensive to indicate seasonal patterns of

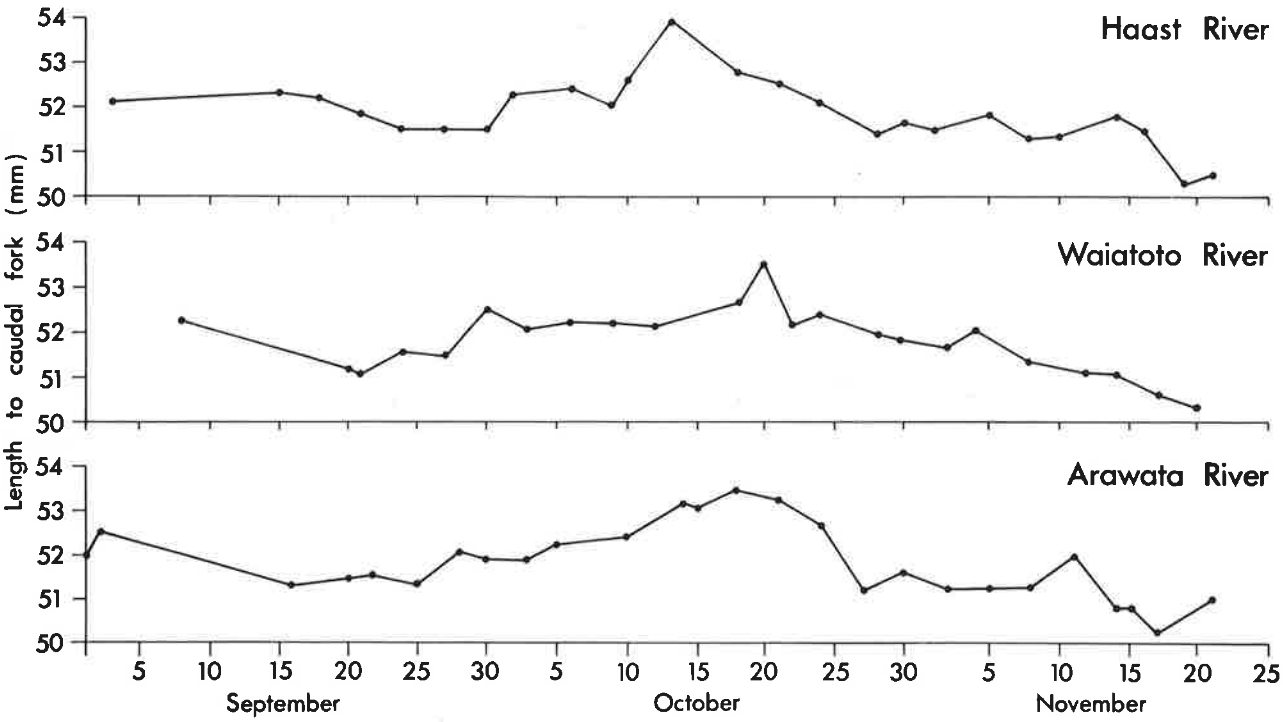


Fig. 8: Seasonal variation in mean size of *G. brevipinnis* at migration in Haast area rivers in 1969.

change in fish size. The pattern varied from year to year. In 1969 we examined *G. brevipinnis* from the Haast, Waiatoto, and Arawata Rivers in sufficiently large numbers to permit analysis of measurements (Fig. 8). Whereas in 1969 *G. maculatus* was found to decline from a relatively constant size during the first 6 weeks to lower sizes after mid October, *G. brevipinnis* showed a slight increase in size from mid September to reach a peak about 20 October and then declined again. There is a clear decline in size from a peak length of about 53-54 mm about 18-20 October to 50-51 mm in late November. The pattern is similar in all three rivers. The decline in size coincides closely in time with that occurring in *G. maculatus* in that year (Fig. 6).

The pattern in 1970, however, is quite different. In spite of irregularities, the size of *G. brevipinnis* caught that year increased fairly consistently until early November (Fig. 9).

The 1971 figures over all show a slight decline in size (Fig. 9), though this is clear only from about 18 October. Although by this date only about 55% of the catch of all species in the Waiatoto had been taken, from percentage composition data it appears that most *G. brevipinnis* that entered the Waiatoto River in the 1971 season had already done so by 18 October. A decline in the catch of *G. brevipinnis* before a similar decline in *G. maculatus* is evident, and so it seems that the drop in size of *G. brevipinnis* in 1971, as in 1969 and 1970, is close in time to a decline in abundance of the species.

The 1972 data show a clear-cut rise in average length from 51-52 mm in mid September to about 53 mm in early to mid October and then a very significant decline to about 49 mm by mid November. The decline in 1972 is more abrupt and substantial than in any other year or species.

*G. fasciatus*

Size at migration was studied only in the Waiatoto River in 1971 and 1972 (Fig. 10), there being insufficient of this species to permit this work in earlier years. The 1971 data show a clear and fairly regular rise to a peak size in late September and early October at 42-43 mm, followed by a distinct and steady decline continuing until records ceased in late November, when the fish averaged about 39 mm or less.

The 1972 data are much more limited, but indicate a decline in size during October from about 44 mm to 41.5 mm followed by a rise in November to about 42-42.5 mm. The reason for these 1972 figures being different from the other data is not clear. However, relatively few fish were measured in 1972 and the problem may be one of sampling limitation.

## Discussion

It seems clear that towards the end of the major whitebait run each season there is generally a decline in the size of the fish. Although changes in size

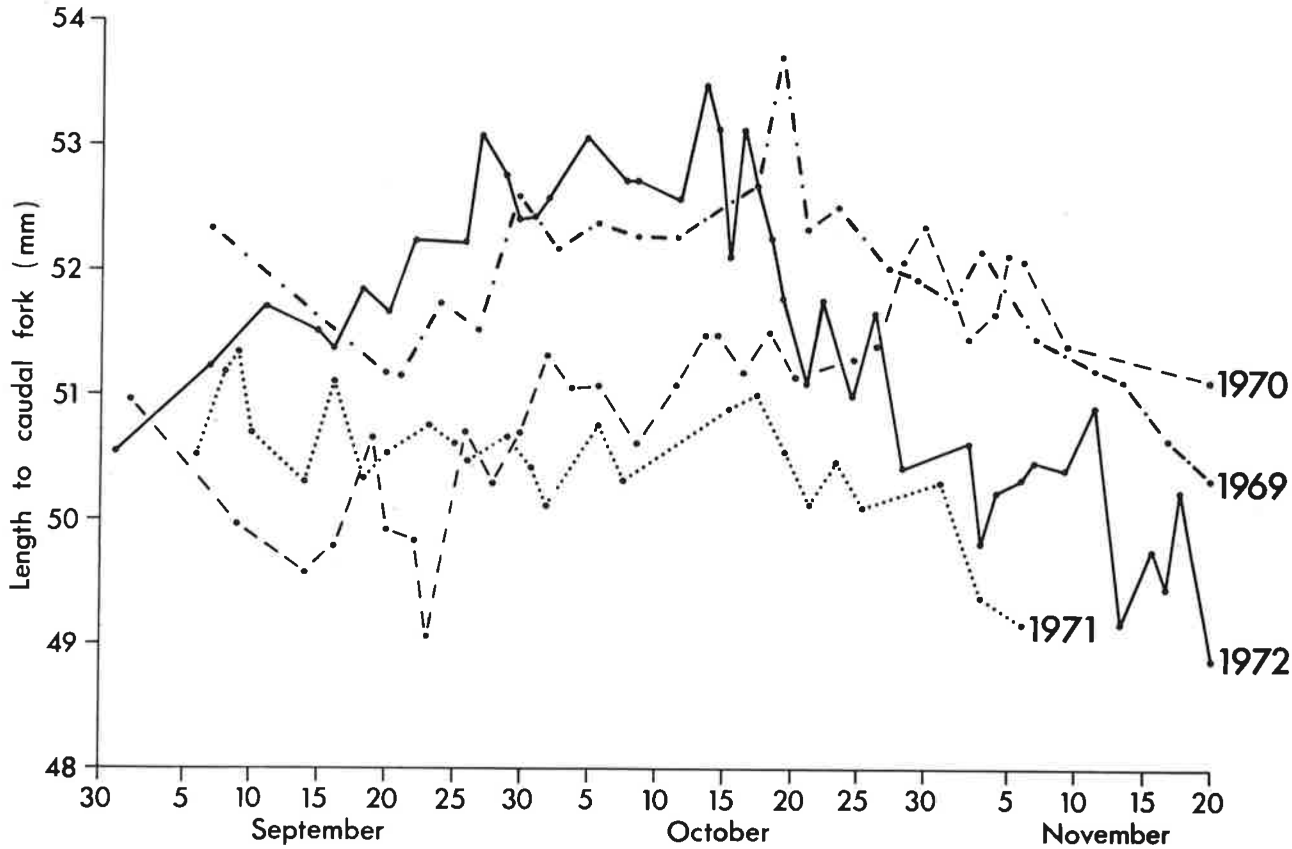



Fig. 9: Seasonal variation in mean size of *G. brevipinnis* at migration in the Waiatoto River from 1969 to 1972.

demonstrated for the three whitebait species appear to be slight — about 2.5 mm — they are sufficient for small late-season whitebait to be visually obvious and are known to the more observant whitebait fishermen. Although we have no data, the distinctive appearance of the smaller late-season fish is possibly accentuated by their being relatively more slender than fish of similar length taken in mid season. Thus, since it is associated with a decline in size of fish, the end of the run each season can be predicted by this decline, though circumstances at the end of the 1972 season show that prediction is not wholly reliable.

Benzie (1968a) studied size of *G. maculatus* at migration; she found no increase in length during the whitebait season and concluded that this excludes the "idea of a restricted population of fish all of a similar age lying off shore, with occasional incursions of schools into nearby fresh water". Instead she emphasised that the fish migrate when they reach "a physiological stage facilitating migration". Benzie's argument assumes that the "physiological stage" is reached at a certain size, though both her data and ours show that the fish of each species will migrate at widely differing sizes. Previously published data (McDowall 1968) showed, too, that there are substantial geographical differences in size at migration. Size, in itself, seems to have little to do with response of the fish to fresh waters or the migration from the sea that this response produces, though it may be true that the fish migrate when they reach a certain "physiological stage". However, such a statement has no biological significance unless we have accompanying information about physiological changes occurring before and during migration and associated with physiological adjustments necessary during transition from salt to fresh water. Benzie (1968a) described some morphological changes in the alimentary canal and kidney of *G. maculatus* whitebait, but at present we know nothing about the more critical physiological changes and adaptations associated with migration from salt to fresh water.

Reasons for the change in size are not known and have not been investigated. We suspect that the timing and intensity of the seasonal whitebait run may be related to the timing, duration, and intensity of spawning activities of adult fish the previous autumn; small whitebait that migrate later in the season could be the progeny of late spawners.

A reduction in size during the season has been observed for elvers of the European eel (*Anguilla anguilla* L.) by Strubberg (1923) and Menzies (1936). Menzies reported "a decrease of almost four

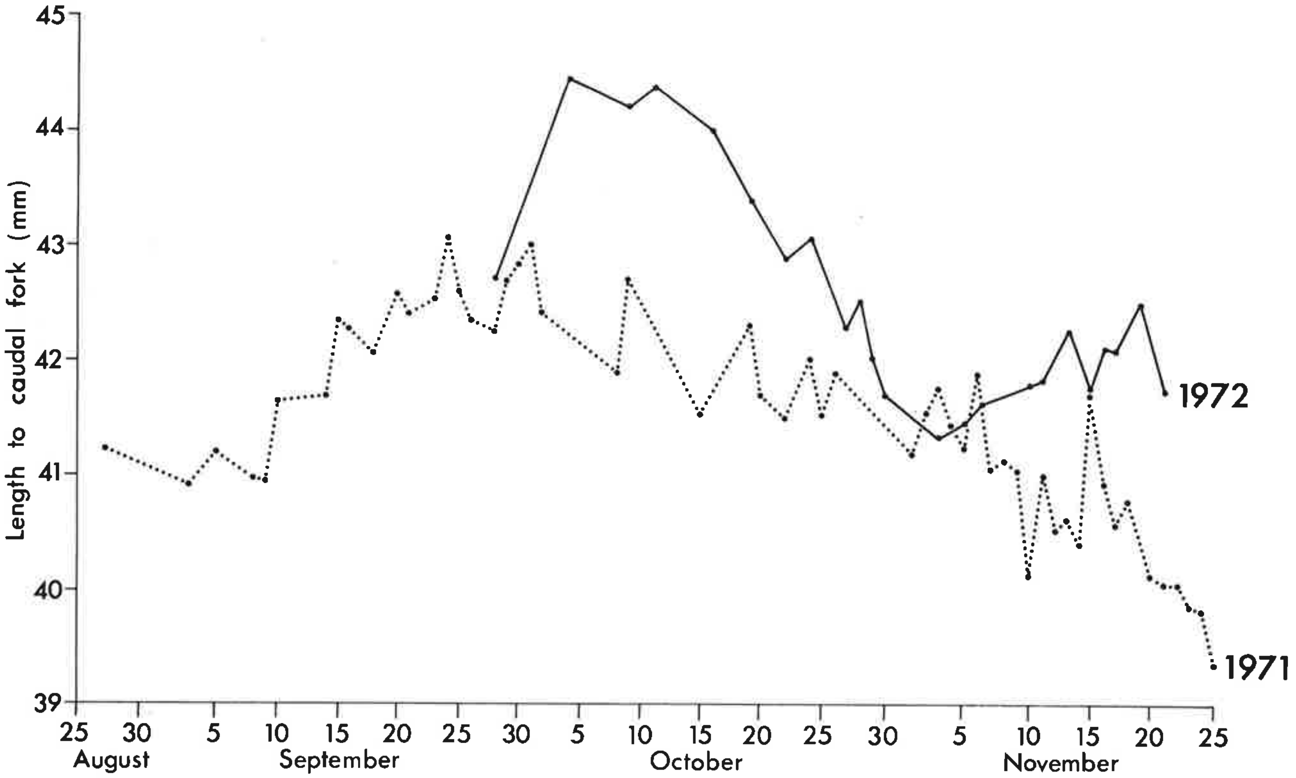



Fig. 10: Seasonal variation in mean size of *G. fasciatus* at migration in the Waiatoto River in 1971 and 1972.

millimetres during the season. The later fish are also obviously thinner and these facts would suggest that the process of deterioration indicated at the metamorphic stage is, at least to some extent, progressive until the little fish reach fresh water." More recently Jellyman (1974) has reported the occurrence of a similar decline in size in New Zealand eels, *A. dieffenbachii* Gray and *A. australis* Richardson.

Strubberg (1923) hypothesised that decline in size of eels during the season was due to the ability of larger elvers to swim in shore and up river sooner than smaller ones. Larvae of *G. maculatus* have been found many kilometres off shore (McDowall, Robertson, and Saito 1975). If the up-stream migration of *Galaxias* juveniles is preceded by a substantial, active, in-shore migration in the sea, it is possible that the explanation offered by Strubberg for the European eel applies to *Galaxias* whitebait: smaller, late-season fish are, because of their smaller size, taking longer to make the in-shore migration to reach the river mouths. This could perhaps be construed from the unexpected rise in fish size during the late-season run in mid November 1972; a late run was stimulated by large floods, and the first arrivals were the larger, perhaps more mobile, fish.

**Interseasonal Variation in Length**

Comparison of length-frequency distributions for the summed data for all fish measured from Waiatoto River samples for each species each year (Table 51 in Appendix 5) showed slight but significant differences (5% level of significance) for each species between years (Table 5). Determination of any interseasonal differences is complicated by intraseasonal changes in size and by differences between seasons in the shapes of curves through the daily means. Examination of lines through the data for each year also indicates interseasonal differences (Figs. 7, 9, and 10). We have further examined this by comparing means for each day between all possible pairs of years for each species. The comparison was made on the basis that 95% of observed sample means fall within twice the standard

**TABLE 5: Tests of significance for comparisons between years of mean lengths of whitebait for entire season in Waiatoto River***

| Species | | | Years compared 1970 | 1971 | 1972 |
|---|---|---|---|---|---|
| *G. maculatus* | 1969 | *t* | 3.345 9 | 23.989 8 | 16.926 5 |
| | | n | 3 915 | 3 899 | 4 879 |
| | 1970 | *t* | | 28.621 9 | 20.856 7 |
| | | n | | 3 306 | 4 286 |
| | 1971 | *t* | | | 10.382 2 |
| | | n | | | 4 270 |
| *G. brevipinnis* | 1969 | *t* | 13.482 0 | 22.337 6 | 5.088 3 |
| | | n | 2 432 | 2 223 | 3 483 |
| | 1970 | *t* | | 7.704 0 | 8.449 4 |
| | | n | | 2 379 | 3 639 |
| | 1971 | *t* | | | 15.717 2 |
| | | n | | | 3 430 |
| *G. fasciatus* | 1971 | *t* | | | 15.506 8 |
| | | n | | | 3 092 |

*Data contained in Table 51 (Appendix 5).

error of the mean (Mayr, Linsley, and Usinger 1953). The results of comparing means between pairs of years for similar dates each year or for adjacent dates when similar dates were not available are shown in Table 6.

*G. maculatus*

The data in Table 6 and in Fig. 7 show that 1971 fish were consistently and generally significantly shorter than those in other years. Although 1969 and 1970 fish were generally larger, several of the curves intersect, so that 1969 fish were larger than 1970 fish early in the season, but smaller from about late October.

*G. brevipinnis*

From Table 6 and Fig. 9 it is evident that 1969 was also a good year for *G. brevipinnis*, as 1969 fish were consistently and significantly larger than those of 1970 and 1971 and generally also than those of 1972. As with *G. maculatus*, too, 1971 was a poor year, the fish in that year being relatively small. The basic pattern appears to be a decline from 1969 to 1971 followed by a recovery in 1972.

*G. fasciatus*

Our data did not permit comparisons of size between years.

## Interseasonal Variation in Length-Weight Relationship

*G. maculatus*

Associated with changes in length there are interseasonal changes in the length-weight relationship (Table 52 in Appendix 5; Fig. 11). The 1971 fish, as well as being shorter, are also more slender at any given length.

**TABLE 6: Comparison of length of *G. maculatus* and *G. brevipinnis* at migration on a day-to-day basis from 1969 to 1972**

| Years compared | | No. of days for which length compared *G. maculatus* | *G. brevipinnis* |
|---|---|---|---|
| 1969 and 1970 | 1969 fish larger | 8 | 13 |
| | 1970 fish larger | 3 | 0 |
| | No significant difference | 14 | 5 |
| 1969 and 1971 | 1969 fish larger | 17 | 14 |
| | 1971 fish larger | 0 | 0 |
| | No significant difference | 9 | 1 |
| 1969 and 1972 | 1969 fish larger | 12 | 9 |
| | 1972 fish larger | 9 | 2 |
| | No significant difference | 12 | 12 |
| 1970 and 1971 | 1970 fish larger | 19 | 7 |
| | 1971 fish larger | 0 | 2 |
| | No significant difference | 2 | 10 |
| 1970 and 1972 | 1970 fish larger | 19 | 8 |
| | 1972 fish larger | 0 | 18 |
| | No significant difference | 12 | 3 |
| 1971 and 1972 | 1971 fish larger | 6 | 0 |
| | 1972 fish larger | 9 | 22 |
| | No significant difference | 15 | 3 |

*G. brevipinnis*

The decline in length evident from 1969 to 1971 is accompanied by a general loss in condition, with a recovery to about 1970 levels in 1972 (Table 53 in Appendix 5; Fig. 11).

*G. fasciatus*

Although we had insufficient material to examine interseasonal variations in length, there was enough to examine variations in length-weight relationship. Data for 1969 to 1972 form a much more compact envelope than those for other species (Table 54 in Appendix 5; Fig. 11).

The biological significance of these variations in length and weight is not known. Variations in length could be due either to a later breeding season in the preceding autumn or to slower growth during winter in the sea.

The substantial decline in size and loss in condition of 1971 fish are marked in both *G. maculatus* and *G. brevipinnis*, but a loss in condition is not evident in *G. fasciatus*. The common occurrence of this decline in *G. maculatus* and *G. brevipinnis* may point to poor growth in the sea. The drop in weight-length ratio which coincided with decline in length in 1971 also points to poor living conditions or inferior food supplies. Catch during 1971 was very low; as is discussed elsewhere, this could have been due to low reproductive success and/or high mortalities during winter life in the sea. High mortalities would be in accord with slow growth under inferior conditions in the sea. We can only speculate, but the small size, poor condition, and low numbers of fish in 1970 seem to indicate that environmental factors affecting life in the sea were important for growth and survival in 1970.

Whatever the biological implications of these variations in size, the implications to the fishery are that changes in length and condition can contribute to

**TABLE 7: Mean length and calculated weight at mean length for whitebait from Waiatoto and Buller Rivers (calculated from log/log regressions of length-weight relationship)**

| River | Year | Mean length (mm) | Weight at mean length (g) |
|---|---|---|---|
| | | *G. maculatus* | |
| Waiatoto | 1969 | 53.21 | 0.546 |
| | 1970 | 53.44 | 0.582 |
| | 1971 | 51.46 | 0.433 |
| | 1972 | 52.14 | 0.541 |
| Buller | 1972 | 53.91 | 0.607 |
| | | *G. brevipinnis* | |
| Waiatoto | 1969 | 51.84 | 0.678 |
| | 1970 | 50.96 | 0.588 |
| | 1971 | 50.47 | 0.548 |
| | 1972 | 51.51 | 0.622 |
| Buller | 1972 | 54.33 | 0.830 |
| | | *G. fasciatus* | |
| Waiatoto | 1971 | 41.46 | 0.293 |
| | 1972 | 42.46 | 0.336 |
| Buller | 1972 | 44.61 | 0.398 |

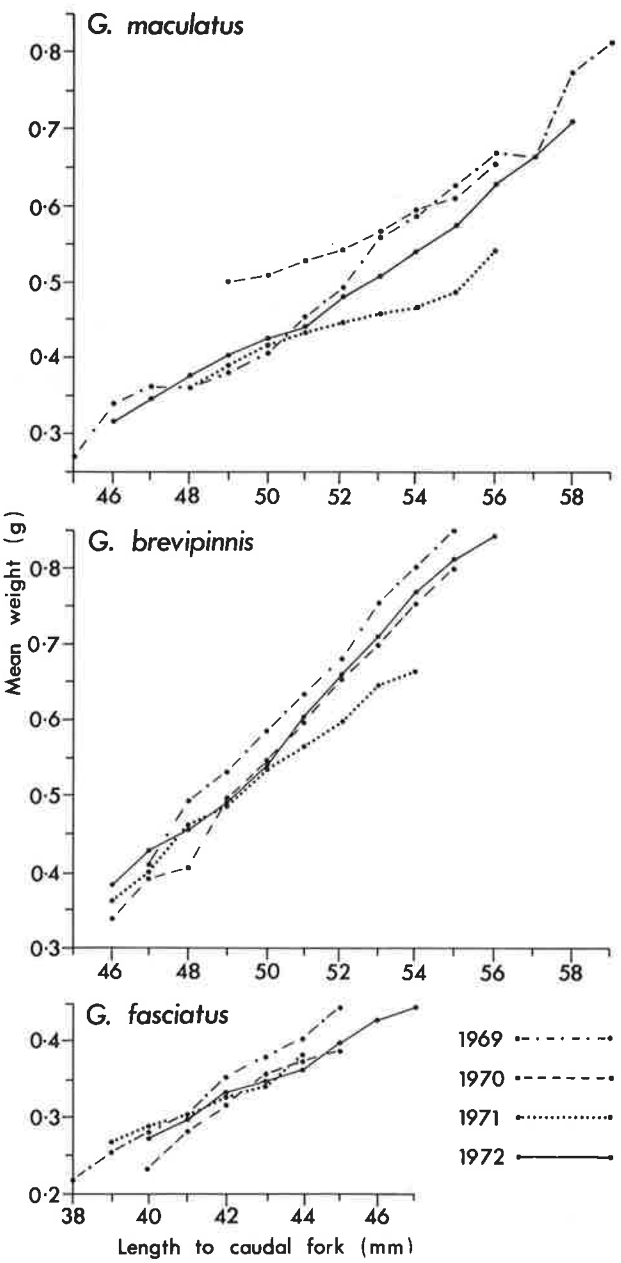



Fig. 11: Interseasonal variation in the length-weight relationship of whitebait of the three principal species in the Waiatoto River from 1969 to 1972.

changes in catch. If we take the average size of fish each year and the average weight of a fish of that size, some indication is obtained on the contribution to variations in catch due to change in fish size (Table 7).

Decline in size accompanied by a decline in condition in *G. maculatus* in 1971 would account for a drop in catch of 25.6% from 1970 to 1971 if the same number of fish of this species were caught. Put another way, there were on average about 1720 fish per kilogram in 1970 and 2310 per kilogram in 1971. Clearly then the condition of fish and their size at migration have important implications for total weight of fish caught. Because of variation in length-weight relationship the total weight of fish caught does not always indicate the number of fish caught.

## Geographical Variation in Size

Earlier work has suggested substantial geographical variation in the size of whitebait at migration (McDowall 1968). From limited data, collected in 1964, it was shown that whitebait (*G. maculatus* only) from the east coast of the North Island (48.9 mm mean length to caudal fork) were smaller than those from either the west coast of the North Island (51.1 mm) or the east coast of the South Island (51.3 mm). Those from the west coast of the South Island were substantially larger than any others (53.4 mm). These observations did not take into account seasonal size variations and were based on limited numbers of fish. However, Benzie (1968a) found that *G. maculatus* collected from rivers near Christchurch in 1959 averaged 45.41 mm standard length; standard length averages 90.9% of length to caudal fork (McDowall 1970a), so that the average length to caudal fork of Benzie's specimens was about 49.96 mm, compared with 51.3 mm for fish from the east coast of the South Island in 1964. Clearly east coast whitebait tend to be smaller than west coast whitebait in the South Island.

Geographical variation in size was not studied intensively. However, whitebait from the Buller River collected for other purposes appeared so distinct that a series of measurements was made for 1972 Buller River whitebait. These confirmed that Buller River whitebait — *G. maculatus*, *G. brevipinnis*, and *G. fasciatus* — tended to be longer and stouter than those from the Waiatoto. Comparison of means for the summed data for each species showed that the figures are significantly different (5% level of significance) (Table 8). Comparison of daily means showed that Buller River *G. maculatus* were significantly longer than those from the Waiatoto River on 17 of 21 possible days and on 4 of 5 remaining days were longer, though not significantly (Fig. 12). In addition, whitebait of average size from the two rivers differ in weight; for the Waiatoto mean length was 52.14 mm, with calculated weight of 0.54 g, and the respective values for the Buller River were 53.91 mm and 0.61 g. The difference in weight at any given length can be seen in Fig. 13. Similarly *G. brevipinnis* whitebait from the Buller River were significantly longer than those from

**TABLE 8: Tests of significance for comparison of size of fish in Waiatoto and Buller Rivers in 1972**

| Species | *t* | n |
|---|---|---|
| *G. maculatus* | 24.740 0 | 3 669 |
| *G. brevipinnis* | 43.157 7 | 4 179 |
| *G. fasciatus* | 22.394 8 | 1 169 |

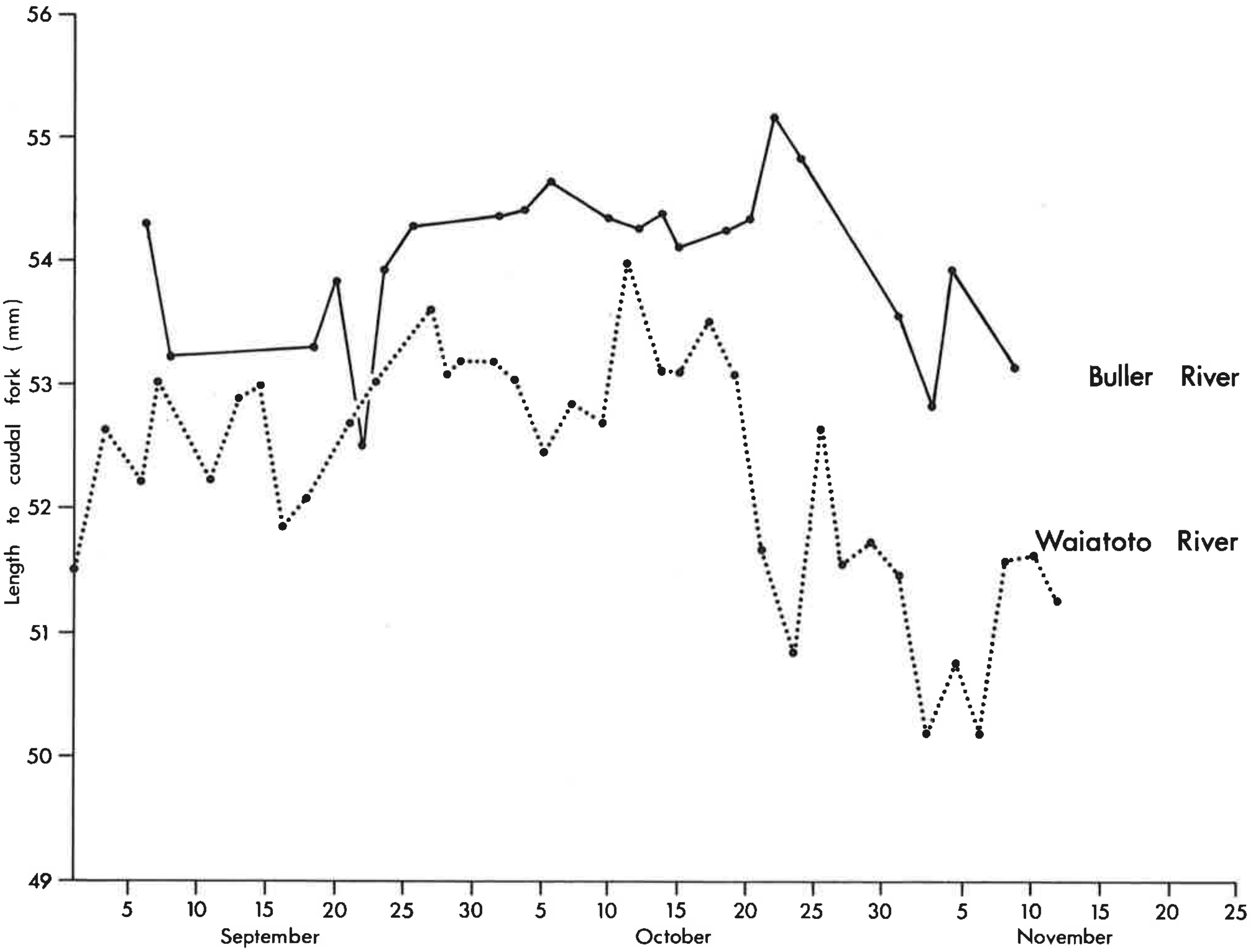



Fig. 12: Geographical variation in size of *G. maculatus* at migration in the Buller and Waiatoto Rivers in 1972.

the Waiatoto on all 22 days for which comparison is possible and weighed substantially more (51.51 mm and 0.62 g from the Waiatoto River, 54.33 mm and 0.83 g from the Buller River; see also Fig. 13).

The data for *G. fasciatus* are much less complete, but for all 8 days on which comparisons were possible, the Buller River fish were significantly larger than the Waiatoto ones (Fig. 13).

These geographical differences suggest that fish entering the Buller and Waiatoto Rivers may be derived from different stocks, and if this is true, it has important implications for management of the fishery and for understanding its fluctuations. Clearly further investigation of regional variation in the size of whitebait may be fruitful in identifying the nature and extent of whitebait stocks.

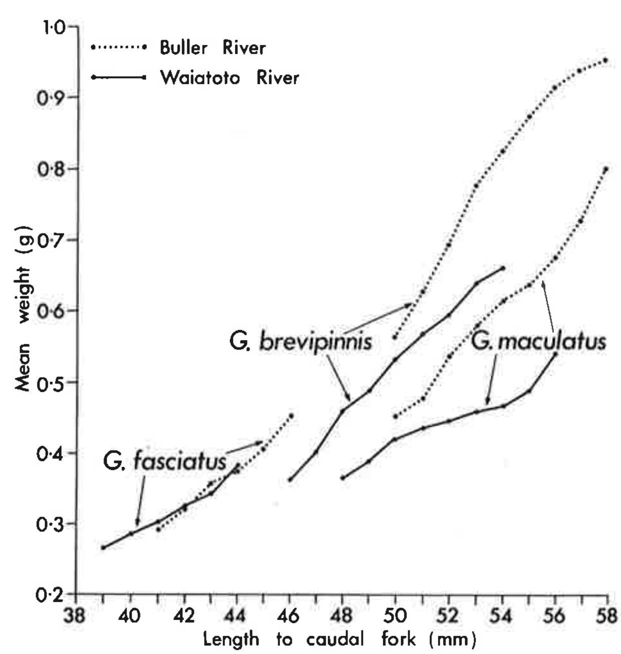



Fig. 13: Geographical variation in the length-weight relationship in the three principal whitebait species in the Buller and Waiatoto Rivers in 1972.

# EARLY GROWTH OF WHITEBAIT IN FRESH WATER

In previous studies (McDowall 1968) it was shown that the length to caudal fork/head length ratio of *G. maculatus* declines during early life in fresh water. This was interpreted as shrinkage of the fish shortly after it entered fresh water. Benzie (1968a) found a "considerable change" in relative head length between whitebait and adult stages and she assumed that this was due to shortening of the body length while head length remained constant. She concluded that as standard length/head length ratios of *G. brevipinnis*, *G. fasciatus*, and *G. postvectis* whitebait differ strikingly from the ratios for adults, these species must also "undergo a similar shortening in length as they grow". Woods (1968) agreed (from study of moderate numbers of *G. maculatus* (261), *G. brevipinnis* (169), and *G. fasciatus* (193), but very small numbers of *G. postvectis* (35) and *G. argenteus* (7)) that shrinkage was a phenomenon common to all five whitebait species. Woods's data on *G. postvectis* and *G. argenteus* certainly do not suffice to prove that shrinkage occurs in these two species, but because of the similarity and relationship between these species (McDowall 1970a) it is fair to assume that what is demonstrated for *G. maculatus*, *G. brevipinnis*, and *G. fasciatus* applies also to *G. postvectis* and *G. argenteus*.

None of the evidence so far published proves that shrinkage occurs. Rather, shrinkage is inferred from changes in relative head length, though evidence presented seems to permit the conclusion that shrinkage takes place.

In this study we have examined shrinkage by two further approaches.

A live box was established in a small tributary of the Waiatoto River and a sample of fresh-run whitebait (*G. maculatus*) placed in the box. Subsamples of fish were removed at intervals of several days and the fish measured (Table 55 in Appendix 5; Fig. 14). The

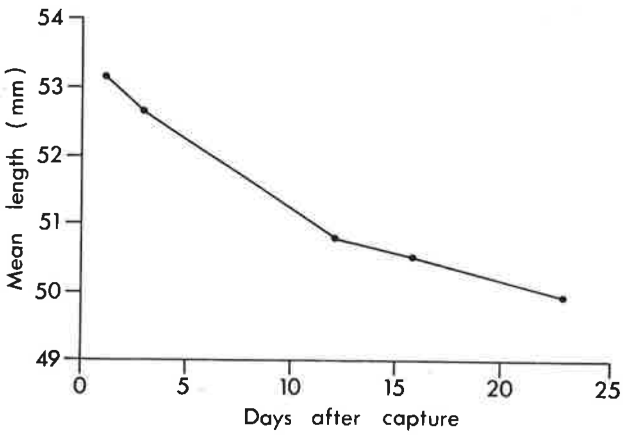



Fig. 14: Shrinkage of whitebait of *G. maculatus* held in a live box.

results demonstrate a steady decline in average length during the 23-day observation period. The fish averaged 53.08 mm at migration and after 23 days were 49.97 mm long. The curve through the data appears to be approaching an asymptote at about 49.5 mm; thus shrinkage is about 3.5 mm or 6.6% of length at migration. This amount of shrinkage may exceed that which naturally occurs. The experimental fish were largely deprived of food during the time they were held in the live box, whereas normally these fish would have been feeding actively and probably growing as a result. How much shrinkage was due to starvation is unknown, but it seems unlikely to have caused all the shrinkage observed. This shrinkage is consistent with what has been inferred from studies of body proportions (McDowall 1968).

We have also compared the average length of *G. maculatus* whitebait caught in the Waiatoto River estuary with that of those caught in Nisson Creek, about 8 km up stream from the sea. The average length of Nisson Creek fish was consistently lower in both 1970 and 1971 than the length of fish caught in the estuary (Tables 56 and 57 in Appendix 5; Fig. 15). With only occasional exceptions in both years (2 of 11 samples in 1970 and 3 of 18 in 1971), the average size of fish in samples measured from Nisson Creek is lower than that of fish from the lower estuary on or about the same date. The difference in size between the Nisson and estuary samples varies widely.

Although this is not direct proof of shrinkage in *G. maculatus* after entry into fresh water, it is more direct evidence for shrinkage than observations on change in relative head length; and it seems reasonable to conclude that the difference in size between the fresh-run fish in the estuary and those caught 8 km up stream in Nisson Creek is due to shrinkage during the time it takes the fish to swim this distance up stream. (At present we have no data on how long it takes the fish to migrate up stream as far as Nisson Creek.)

Several explanations can be advanced for the irregularity in size differences between estuary and Nisson Creek fish. The two most obvious are sampling irregularities and variation in size of fish between shoals. Sampling irregularities could easily explain the differences. Samples of 50 measured (sometimes fewer when samples contained fewer specimens) may not be sufficiently large to represent adequately the fish migrating into the river. Variation in size of fish between shoals may result in random sampling not producing a properly representative sample. In addition, though it certainly takes time for the fish to migrate up stream, the time taken may vary. Fish were removed from the Nisson Creek trap usually every 1 or 2 days. It is therefore possible that there is variation in

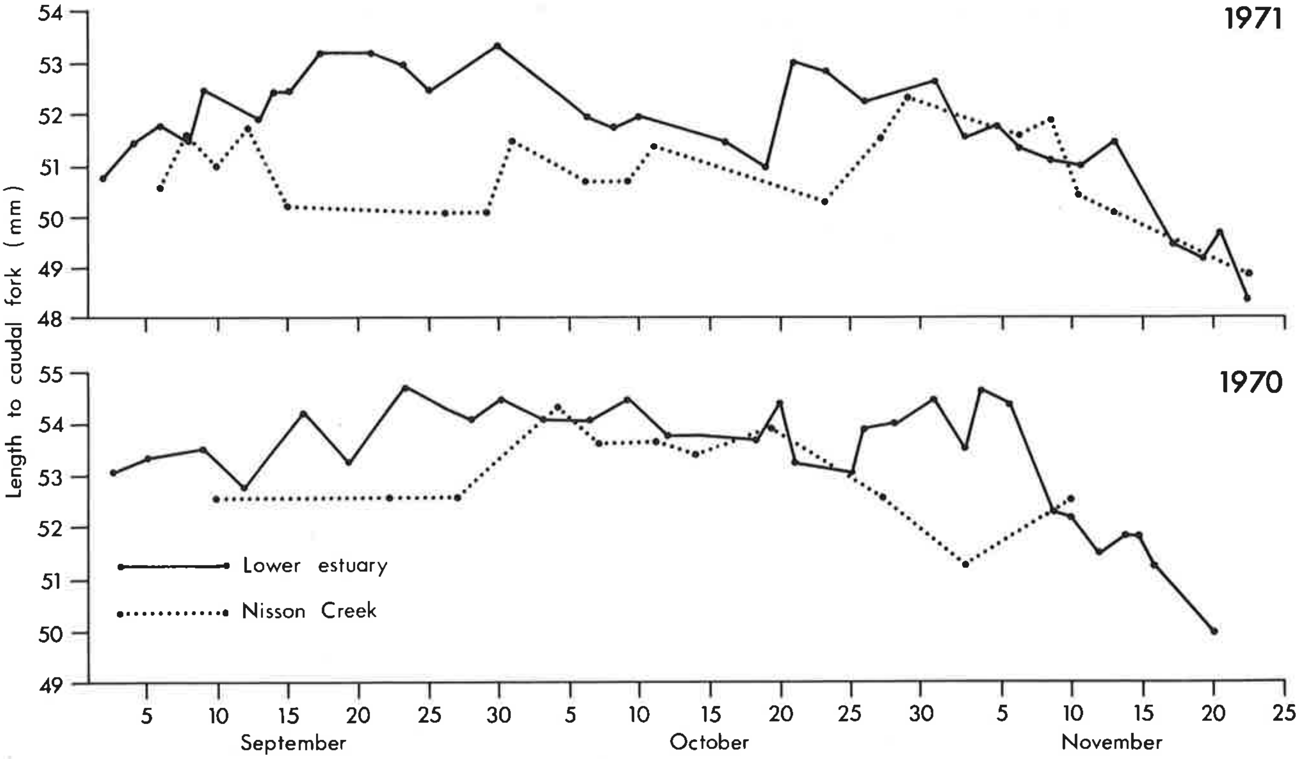



Fig. 15: Shrinkage of *G. maculatus* whitebait during up-stream migration. Comparison of size at migration of fish caught in the lower Waiatoto River estuary with those caught at Nisson Creek, 7.9 km up stream.

the time which elapsed between entry into fresh water and final capture and fixation in formalin. Thus for various reasons it seems that shrinkage at capture at Nisson Creek may or may not be complete.

# ANNUAL PERIOD OF WHITEBAIT MIGRATION

The whitebait migration has always been regarded as a spring phenomenon, and placement of the regulated fishing season from August (North Island) or September (South Island) until the end of November recognises this (New Zealand Statutory Regulations 1964). It is common knowledge in New Zealand that whitebait migrate in spring, though there has been no discussion of why this is so.

Analysis of records of the beginning of the whitebait run each season (New Zealand Marine Department 1932–47) showed that major runs began mostly in July to September, but later in the south than in the north (McDowall 1968). In earlier studies (McDowall 1968) fresh-run or recently run whitebait of *G. maculatus* made up more than 50% of samples from the Waikanae River estuary during July to February. In the Waikanae River the period of peak migration was clearly early spring to summer. Despite concentration of migratory activity during spring, research in the

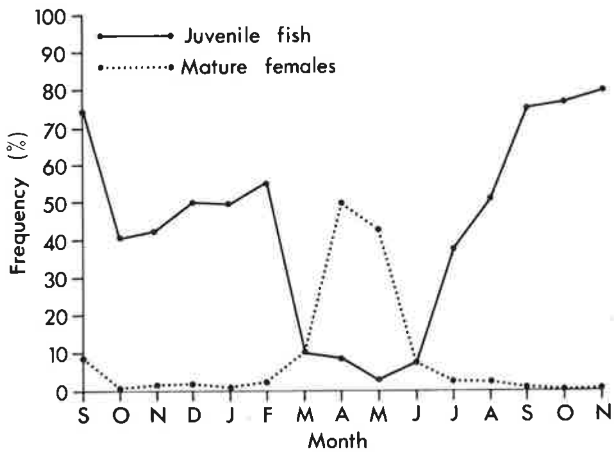



Fig. 16: Relationship between autumn maturation of gonads and spring migration of young in *G. maculatus* (adapted from McDowall 1968).

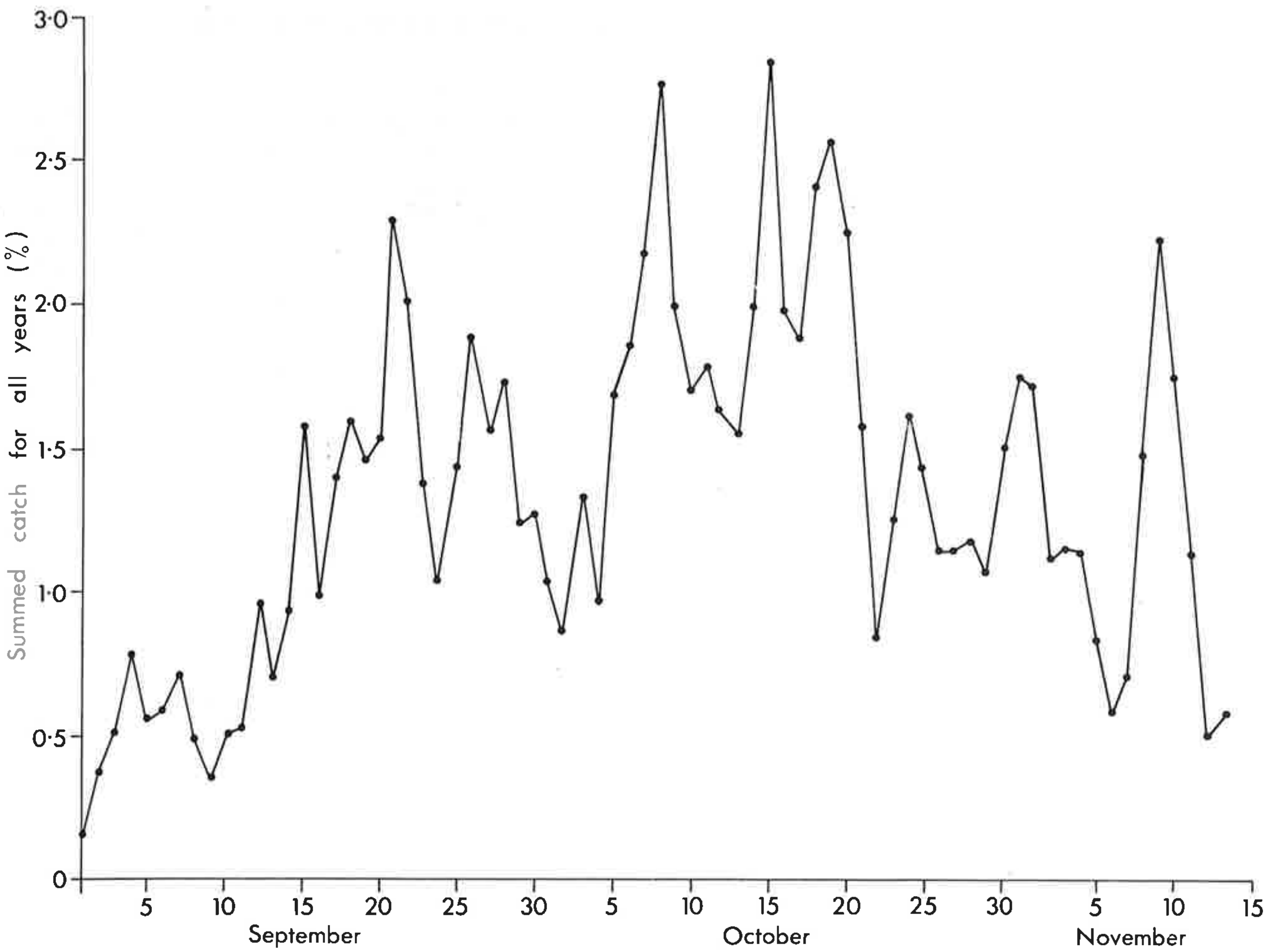



Fig. 17: Seasonal distribution of catch in the Cascade River from 1959 to 1973.

Waikanae River also showed that fresh-run or recently run whitebait were present in that river in all months of the year. Occasionally, "big whitebait runs" are reported in Westland rivers during summer and autumn. How "big" these runs are is undetermined, but people familiar with whitebait and whitebait fishing are observing shoals running up stream outside the recognised migratory period and in sufficient quantities to excite interest and comment.

The very prolonged migratory period is probably related to the equally long spawning season (at least September to June, though mostly February to May (McDowall 1968)). The abundance curves for gonad maturity and juvenile migrations are of similar shape, with about a 6-month displacement (Fig. 16). It looks as though the period of peak migration is partly governed by peak spawning and the time taken to develop to "migratory size and maturity".

We took catch data for the Cascade River (1959-73) and summed catch for each day of the season for these years. The data are shown in Fig. 17 reduced to the percentage that each day's total contributes to the grand total catch. The graph shows wide variation from day to day, but overall a distinct peak in catch from about mid September onwards and highest catches in mid October. Our data, derived from fishermen's catches, are necessarily restricted to the regulated fishing season (September-November). How our understanding of the patterns of migration would have changed if complete data had been available is unknown, but normal cessation of fishing on most rivers by mid November suggests that our data reflect the true end of migration in most years.

## MIGRATION — A RESPONSE TO FRESH WATER

Movement of fishes from the sea into fresh water is a widespread phenomenon and there is nothing distinctive about the migrations of *Galaxias* whitebait. It is usually considered that fish migrating into freshwater rivers from the sea are responding to the influence of reduced salinities in the sea around the river mouths and that they navigate towards the river mouths in response to decreasing salinities. Tully (1952) has shown that lighter, less saline river waters form a surface layer flowing over and only slowly mixing with heavier sea water beneath, so that migration of whitebait in shore is likely to be a response to reduced salinities around river mouths and probably occurs close to the sea surface. We envisage an accumulation of fish around river mouths, probably during the falling to low tide, when the outflow of fresh water is greatest, with migration into the rivers following.

## FACTORS AFFECTING BEGINNING OF WHITEBAIT RUNS

Although whitebait may run in any month of the year, there is a distinct spring peak. Environmental variables that are changing in late August-early September include temperatures, photoperiod, tidal amplitudes, and rainfall patterns. The fact that the run seems to have begun in the north earlier than in the south (McDowall 1968) suggests that the ultimate factor controlling onset of migration may be sea temperature. However, the presence of fresh-run fish throughout the year indicates that if temperature is an ultimate factor, it does not exercise strong control. At the onset of whitebait migration in spring, sea and river temperatures are starting to rise after winter. However, at this time in all major rivers under study, and in all years from 1969 to 1972, the sea was consistently several degrees warmer than rivers throughout the period of migration. Thus an approach of river temperatures to equal sea temperatures cannot be a significant factor in initiating migration. When the whitebait are migrating from the sea to fresh water they are consistently moving into colder water.

The considerable diversity in the temperatures of the rivers into which the whitebait are migrating (Tables 39 and 40 in Appendix 5) also suggests that it is unlikely that a relationship between sea and river temperatures is important. Furthermore, whitebait runs are stimulated by floods (see "Factors Contributing to Day-to-day Fluctuations in Migrations", page 47) and as river temperatures usually fall during floods, stimulation of whitebait runs by rising temperatures seems unlikely. If the beginning of the whitebait run is related to water temperatures, it seems likely that sea temperatures reach a level stimulating migration or that at temperatures below a certain threshold migration is not stimulated as strongly.

Some slight circumstantial evidence for the importance of temperature in migration comes from movement patterns of whitebait early in spring. Occasionally, and always at the beginning of the season (early September), whitebait fishermen report fish moving down stream. Possibly this is due to the cold water experienced by the whitebait after they migrate from the mixing sea and river waters of the estuary into the colder unmixed river waters; they may cease moving up stream if the water is too cold.

One of the environmental factors affecting the beginning of the whitebait run could be ocean currents. The period spent in the sea by the whitebait is believed to be about 6 months (see page 20). As the freshly hatched larvae go to sea at less than 10 mm long, they are likely to be at the mercy of ocean currents for much of the period at sea. The fish are therefore likely to be carried far off shore (see McDowall, Robertson, and Saito 1975), and whitebait runs may depend partly on either timing of the ocean currents bringing the fish in shore again or the time that the fish take to migrate in shore before moving into fresh water. Very little is known about life of whitebait at sea and any discussion about the role of ocean currents in timing of the whitebait season is speculative.

We do not have the data to determine whether temperature is the ultimate factor in timing the onset of migration. The existence of some factor, like temperature, as the ultimate factor controlling migration is obscured by the presence of a proximate factor that actually stimulates the migrations on a day-to-day basis. The period of intense whitebait migration begins, at least in Westland, as the spring rains begin after a dry winter.

Our records of the development of spring whitebait runs rely wholly on whitebait fishermen's catch records. These necessarily apply only to the months of the regulated whitebait season (1 September to 30 November since the 1947 Whitebait Regulations were gazetted), so that they give no indication of the extent of migrations during August. Such migrations do occur; for example, in 1969 substantial runs were reported by fishermen during the last 2 weeks of August, but we have no information on the frequency and extent of August migrations.

We have extensive data on the whitebait catch in the Awarua River (1948-61) and Cascade River (1959-73) (Tables 60 and 61 in Appendix 5). With the exception of Cascade figures for 1970-73, these data include the entire catch from these rivers in each season; for the Cascade in the period 1970-73 a high proportion of the catch is included. These data enable us to examine the manner in which whitebait runs, as expressed by fish caught, developed from the beginning of September. Sometimes the data are affected by floods early in the season preventing fishing, but this applies principally to the Cascade. (Only 28 days' fishing were lost during September in the Awarua River in 14 years, whereas 82 days were lost during September in 15 years at Cascade. Sometimes this is due to a late start to either fishing or the keeping of records at Cascade, and the loss of these data from Cascade somewhat limits the value of the data for the present purpose.)

Data for cumulative percentage of the season's catch at each date for the Awarua River from 1948 to 1961 are shown in Fig. 18. In some years there is a rapid rise in cumulative catch from the beginning of fishing. This is especially evident in 1955, when during the first 6 days' fishing (8.2% of days fished) 873 kg or 11.6% of the season's catch was taken. (The average for 14 years' data is 2.75% of the season's catch during the first 6 days' fishing.) In 1960, 6.9% of the season's catch was taken in the first 4 days (5.1% of days fished). More often catch builds up slowly during early September. This is especially evident in 1948, 1951, 1952, 1953, 1956, 1958, and 1959. In 1952, for instance, only 133 kg or 3% of the season's catch was taken in the first 23 days' fishing; in 1956 it took 17 days to reach this level, in 1958, 25 days, and in 1959, 19 days.

Photoperiod changes on a regular seasonal basis and thus cannot account for variability in the onset of migration of the nature and extent exhibited by the Awarua catch data. Nor is it likely that photoperiod has much importance as the ultimate factor in controlling or stimulating migration, because the earlier Waikanae River study (McDowall 1968), and the observations of fishermen of "big runs" at diverse times of the year, show that whitebait may migrate during widely varying photoperiod conditions. However, photoperiod may, through hormonal activity, establish "physiological readiness" to migrate,

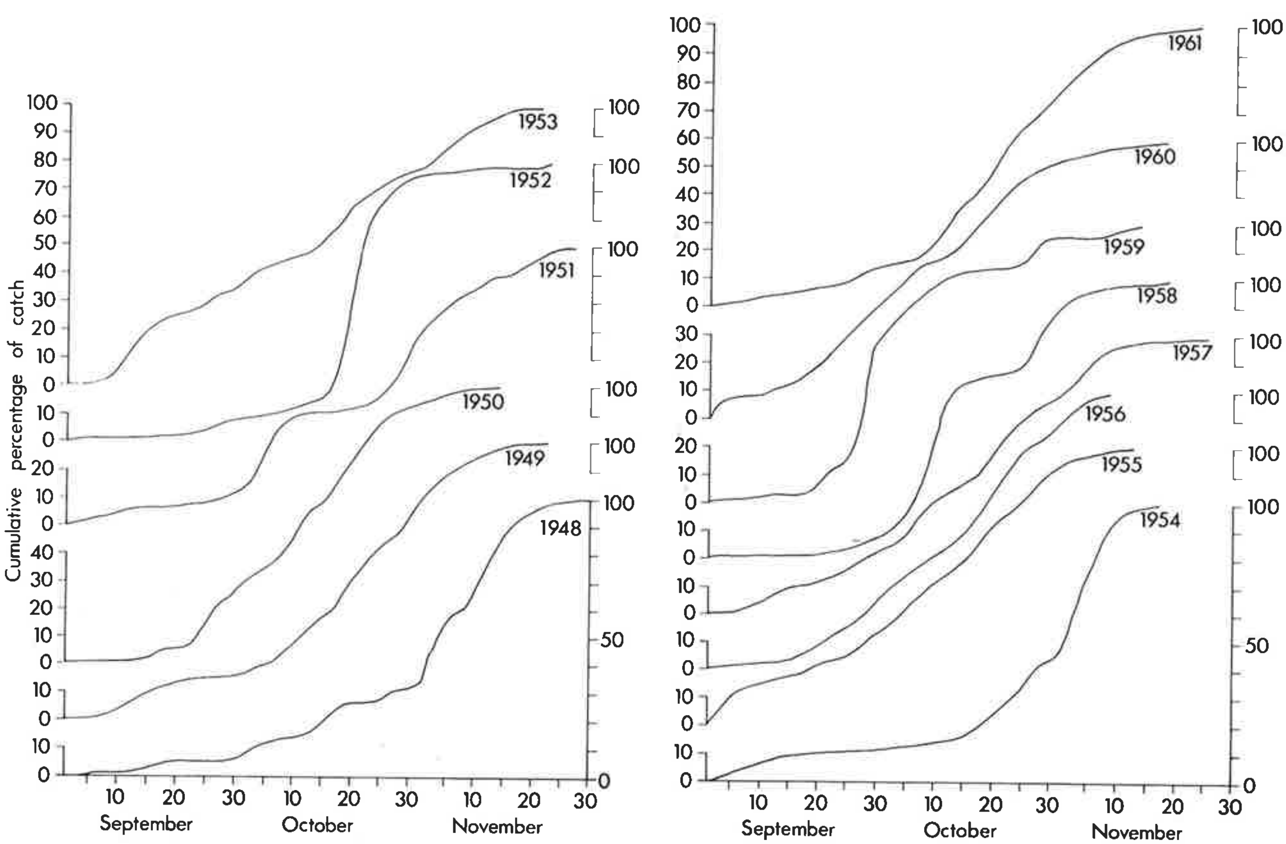



Fig. 18: Cumulative percentage of catch in the Awarua River from 1948 to 1961.

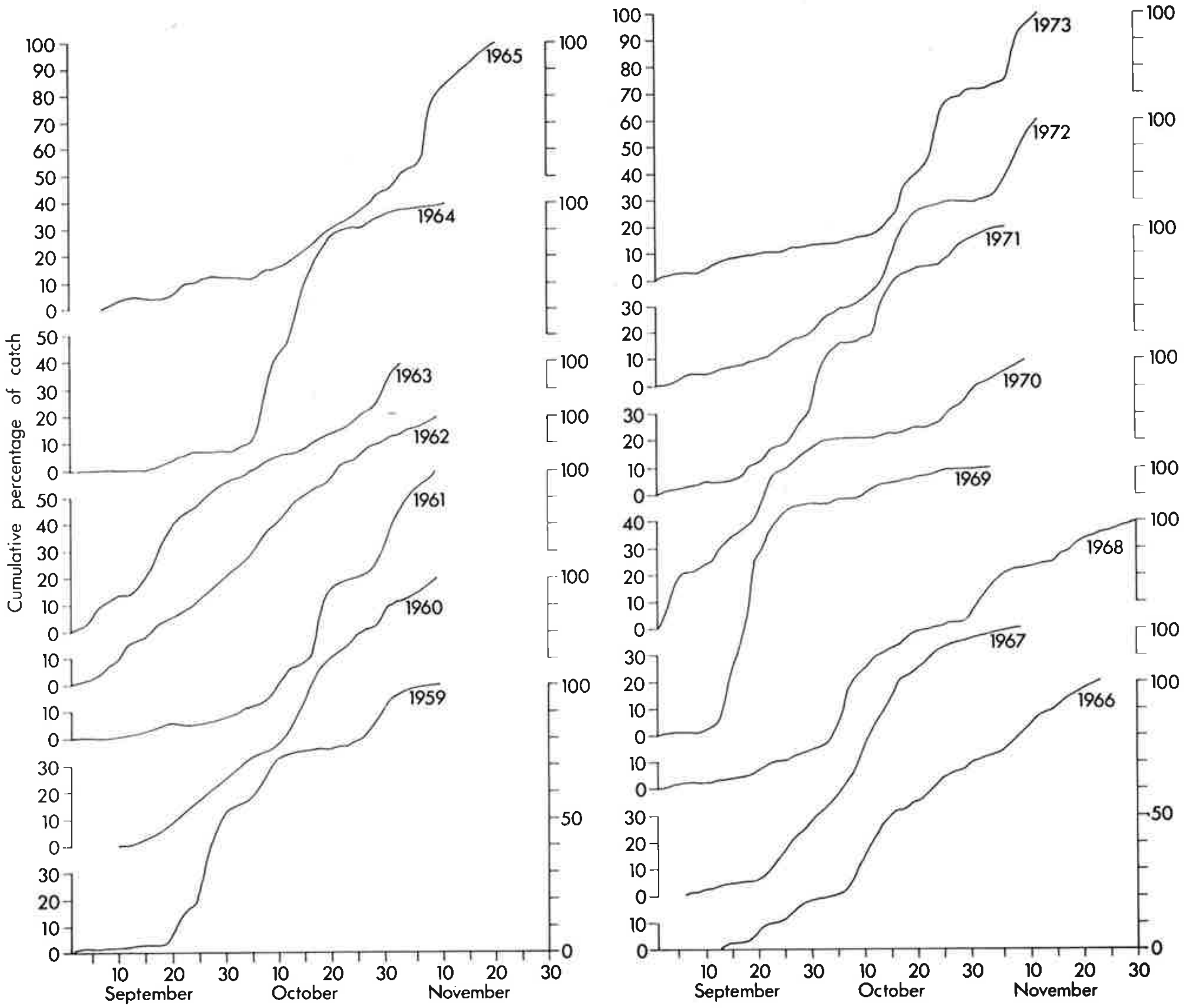



Fig. 19: Cumulative percentage of catch in the Cascade River from 1959 to 1973.

and other proximate environmental factors may then stimulate migration.

The spring equinox is in September and spring tides then have greatest amplitude. Thus spring tides peak at about the time whitebait migrations begin. Analysis showed that day-to-day fluctuations in whitebait runs are not affected by tides (see "Factors Contributing to Day-to-day Fluctuations in Migrations", page 47) and it seems unlikely that changes in tidal amplitude are important in stimulating the beginning of migration each season.

Winter in South Westland tends to be drier than spring, and our data suggest that whitebait migrations follow the first or second major flood of spring. In the 2 years when whitebait catch in the Awarua River rose rapidly from the beginning of fishing there was rainfall in the last week of August. In 1955, 175 mm of rain fell from 21 to 28 August, and the large run that followed occurred in a falling river during the first week of September. The rather smaller early season run in 1960, essentially limited to 1-3 September, when 220 kg were caught, followed 79 mm of rain from 22 to 26 August and can probably be interpreted as the end of a run occurring in late August.

The more common situation is a slow rise in catch during early September. The relation between development of the whitebait run and rainfall and river level changes is not consistent. The 3 years in which the slowest rise in catch is evident were 1952, 1958, and 1959. In 1952 only 15% of the season's catch had been taken by 16 October (more than half way through the fishing period) and up until that time river levels had been low, except for a small brief freshet on 3-4 October, when the river rose to 46 cm above lowest recorded level and 25-30 cm above the base level preceding the freshet. A further freshet to 66

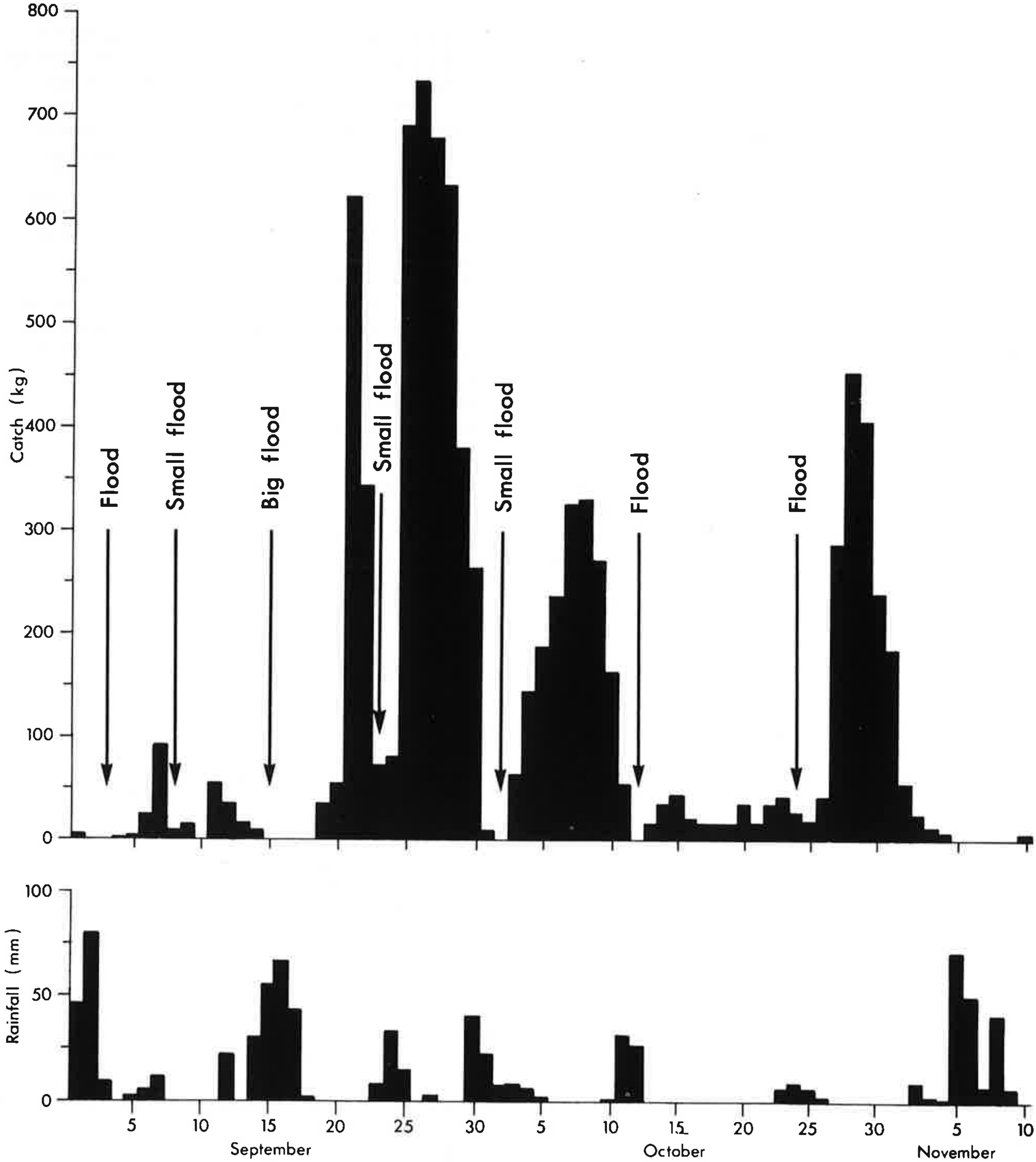



Fig. 20: Relationship of catch to floods and rainfall in the Cascade River in 1959.

cm on 16 October preceded the striking increase in catch evident from 17 October to the end of the month, and in these 15 days 78% of the season's catch was taken.

The 1958 figures show a consistently low river throughout September and poor catches (5.8% of the total by 30 September). A flood with the river rising to 94 cm above known minimum occurred on 30 September, and the whitebait run began with 55% of the 1958 catch being taken in the next 14 days. In 1959 there was a small freshet on 2-4 September (56 cm peak), but no run followed. The river level declined again to about 20 cm, and poor catches persisted until 16 September (cumulative total 2.8% of 1959 total). A flood with a rise in excess of 130 cm occurred on 17-20 September and catches increased, with 50% of the 1959 catch being taken in the next 10 days.

The pattern of development of catch is not always this clear cut, however. Catch total rose steadily through September 1957, though river levels were low during the first 3 weeks. In 1961, on the other hand, a freshet on 6–8 September to 58 cm resulted in little change in catch levels, and another to 58 cm on 23–24 September also had little effect. It was not until after a much smaller freshet (37 cm) but lasting 4–5 days (3–7 October) that catch responded, and 70% of the 1961 total was taken in the next month.

The data for the Cascade River (Fig. 19) are less easily interpreted, as fishing is more seriously hampered by flooding, and in many years did not begin until 6–10 days after the season opened. However, 1959 data from Cascade exhibit the same sort of pattern as the Awarua data (Fig. 20). August was relatively dry (749 mm rain for month), and after 129 mm of rain (recorded at Haast) on 1–2 September there was a flood on 3–4 September. A minor run followed (125 kg). A further small flood on 8 September was followed by a further small run (154 kg). From 15 to 18 September a large flood occurred (compare with the Awarua data; rainfall at Haast was 229 mm in 6 days) and fishing began on the 18th as the river level dropped. In the next 24 days 6400 kg of whitebait were caught, the run being punctuated by two further small floods.

In 1964 (Fig. 19), though there was some rain in the first half of August (320 mm by 13 August), there was little from then until 31 August, when 60 mm fell. Fishing records for the Cascade River did not begin until 6 September, when the river was normal. A freshet on the 8th resulted from rain on 7–8 September (30 mm at Haast), but catch in the subsequent 4 days totalled only 7 kg among 8 fishermen. Rain totalling 130 mm fell on 12–14 September, and the ensuing flood on 13–14 September was followed by a catch of 745 kg in 10 days. Late September was punctuated by a freshet on the 24th, and then major flooding was reported from 30 September to about 4–5 October. In the next 16 days 10 552 kg of whitebait were caught.

The 1973 data are interesting, as mid August, September, and early October were particularly dry (275 mm of rain from 15 August to 9 October), and fishermen reported only one flood, on 6 September. Catch was very poor in September and early October, and by 14 October (57% of days fished) only 18% of the season's catch was recorded. A big flood was recorded on 13–14 October, and during the next 12 days (15–26 October) 50% of catch for the season was taken (9835 kg).

The data are limited and far from conclusive, but from instances discussed in the foregoing it does seem that until there is a substantial flood the whitebait runs do not begin; that is, until there are major increases in the flow of fresh water out to sea, whitebait do not move in shore and run into fresh water. This conclusion is tentative in view of limitations of the data, but we cannot envisage other stimuli that may trigger migration. The conclusion that migration is started by the first major flood of the spring is in accord with the much clearer evidence that fluctuations in the run throughout the season are also related to floods (see "Factors Contributing to Day-to-day Fluctuations in Migrations", page 47).

## DO WHITEBAIT RETURN TO THEIR NATAL STREAM?

The question posed here of whether whitebait return to their natal stream or not is one which recurs frequently, especially among whitebait fishermen, and therefore needs some consideration. The question arises primarily because of known "homing" habits of some Northern Hemisphere salmonids, particularly Atlantic salmon, *Salmo salar* (L.), and Pacific salmons, for example, *Oncorhynchus nerka* (Walbaum) (Hasler 1966). It has been fairly clearly demonstrated that olfaction plays an important role in homing in these salmon, which recognise the odour of the waters in which they lived for several weeks to more than a year, depending on species, before their seaward migration. The natal waters are recognised after as many as 5 years' absence in the sea. There are no data with which to discuss the problem of homing in *Galaxias* whitebait, but some inferences seem possible.

The larvae of *G. maculatus* hatch after about 2 weeks' development in the humid atmosphere of grassy, supratidal river banks (Benzie 1968c, McDowall 1968). On hatching, the larvae are believed to be swept out to sea as the ebbing tide flushes the estuary, and they do not again enter fresh water until the following spring, 6 months or so later. Benzie (1968b) showed developed olfactory organs in the hatchling, but it would seem unreasonable to hypothesise that larvae of *G. maculatus*, washed briefly by partly saline waters during hatching and being swept out to sea, would be able, after 6 months' absence, to recognise characteristics of their natal stream accurately enough to distinguish it from other waters. For this reason, it seems to us unlikely that whitebait of *G. maculatus* return to their natal stream in a manner comparable with Atlantic and Pacific salmons and other salmonids.

The situation is not as well defined for other whitebait galaxiids, since their spawning is undescribed. These species seem likely to spawn in or near normal adult habitats (McDowall 1970a); the eggs may be exposed to waters of their natal stream for a few weeks during development, though during much of this period olfactory organs of the larvae will be undeveloped or rudimentary, and the larvae are protected from direct contact with stream water by the chorion of the egg. Ots and Eldon (1975) have shown that larvae of *G. fasciatus* are swept down stream from the hatching site soon after hatching. This is possibly true also of *G. argenteus*, *G. postvectis*, and *G. brevipinnis*. If our inferences about breeding and development of these species are correct, or nearly so, their larvae will be exposed to the waters of their natal streams for longer than those of *G. maculatus*, yet their small size, rudimentary development, and brief exposure to their natal waters may preclude return to natal waters by use of olfaction to recognise the water.

Some evidence to the contrary may be inferred from consistent and significant differences in the composition of whitebait runs in closely adjacent rivers. These differences (see page 58) show that the fish recognise and respond to certain water characteristics; however, it is an altogether different matter to conclude that they recognise and respond to certain water attributes characteristic of their natal stream.

At present little is known about dispersal of whitebait at sea, but there is some very limited evidence for the existence of local stocks of whitebait in the sea (see "Stocks in the Whitebait Fishery", page 82). The implication of this in the present context is that though homing in the strict sense may not occur, some fish may return to their natal water because they do not move far from it during life in the sea.

Although the question must remain open and will, no doubt, receive further discussion, proof of homing in *Galaxias* whitebait would be a task of considerable magnitude.

## PATTERNS IN THE ENTRY OF WHITEBAIT INTO FRESH WATER

Data show that whitebait migrate **into** rivers mainly during the rising tide (see "Factors Contributing to Diurnal Fluctuations in Migrations", page 41). Observations on whitebait movements **in** the rivers show that the fish migrate in response to water currents, with a positive rheotaxis. Flow conditions at river mouths at the time of entry of fish vary from a normal river outflow to inflow or tidal bore. The positive rheotaxis implies that the fish enter the river by swimming up current into the estuary. But at times in some rivers there is no river outflow for them to swim against. From the time when outflow in the river is in equilibrium with the inwards push of the rising tide until high tide there may be a fluctuating but persistent inwards up-river current. If the fish enter the rivers in response to the outflowing current, migration would be expected to cease when the rising tide and river current reached equilibrium. Migration does not cease at this time and probably continues until, on the falling tide, a strong outflow develops. Thus for much of the period when the tide is rising the fish may be entering the river, moving **with** rather than **against** the current. In such circumstances the fish are probably swept helplessly into the river in the up-stream tidal bore, and their response to fresh water overrides their response to current. Possibly there is a behavioural change, initially a response to fresh water and, once the fish are in fresh water, then a rheotaxis resulting in movement against the current.

Fishermen who erect fishing stands in the lower estuaries work partly on the basis that surge carries shoals of fish on to the screens and into the nets. Surf fishermen work entirely on this basis; they throw their nets into the water as a wave rolls in and lift them as the wave passes through. The fish are swept into the net on the waves. (In a heavy surf whitebait that have accumulated in the sea around river mouths are sometimes swept on to the beach nearby and are left stranded on the beach as the water recedes.)

All the observations described point to the following conclusions: The fish accumulate in reduced salinities in the sea around river mouths, and as outflow through the mouth is counteracted by the rising tide they swim up current into the estuary. As the tide continues to rise the river outflow may be replaced by a tidal inflow and the voluntary up-current migration is replaced by an involuntary down-current, but up-river, movement. This ceases at high tide, as the inwards tidal flow is replaced by an increasingly powerful seawards flow.

# MIGRATORY PATTERNS WITHIN RIVERS

Our attempts to obtain detailed information on patterns of movement of whitebait in rivers were frustrated by irregularity of the fishing activities of fishermen and reluctance by many of them to keep catch records. Ideally we would require catch figures from regular lifts of nets throughout the tide, and we were unable to obtain such data. However, from 5 years of observation by research staff on patterns of movement, and many hours of discussion with fishermen, we obtained some ideas on the movement patterns. Catch patterns vary broadly, in a complex but systematic way, in various parts of the river in response to changes in river flow patterns with the rising tide.

Catch patterns at any site do not necessarily accurately reflect quantities of whitebait reaching that site. Often, for instance, a fisherman's catch may decline well before high tide, at a time when peak catches are expected. The explanations of such irregularities are related to responses of the fish to water currents. We have no quantified data, but there seems to be an optimal water flow rate for whitebait migration. When current rates are swift the fish are hindered in their movement, and shoals of fish can be observed lying in quieter marginal waters and not venturing out into swift flows until the rising tide reduces flow rates. This was frequently observed when fish were forced to move towards mid river by the blocking screens of a whitebait stand. The shoals work their way outwards into swift current just down stream from the screens, but as they are unable to progress against the current, they ultimately drift down stream and then towards the river bank again. In one instance in the Arawata River shoals were seen moving up stream along the edge of an indented rocky bank, where the water was swift, by dashing from one indentation to the next.

When flow rates are very low the shoals disperse, fish movements become haphazard and uncoordinated, and migration ceases. Fishermen commonly reported large, loose shoals of fish in backwaters and embayments, where they were not affected by river currents, and these shoals remained stationary throughout much of the tidal cycle until a change in river current affected them. Between these extremes the fish were found to swim persistently against river flow. The effects on movement patterns of fish are as follows: On any given day, at the beginning of migration, the fish tend to swim close to the bank, where currents are less swift than in mid stream. As the tide rises, the estuary fills, flow rate declines, and the whitebait find optimal flow rate for migration progressively further from the river banks. When a river is low and the tides are big (spring tides), decline in river flow rate as the tide rises is considerable and the tendency for the shoals to move towards the centre of the river is marked. Conversely when the river is high and the tides are small (neap tides), decline in river flow rates is less and the tendency for the fish to move away from the river banks is much less marked. A complete range of intermediate situations occurs.

Within any river system flow rates tend to be greatest in the upper reaches of the estuary, declining through the estuary towards the river mouth. The effects of tide on river flow rates are greatest at the river mouth and least in the upper estuary. Thus the fish have much greater tendency to occur in mid river in the lower estuary and towards the banks in the upper estuary. The fish are caught as they migrate close to the banks, because that is where the nets are placed. Thus when the tide is low, or when the river is high and swiftly flowing, the fish tend to move along the banks and are caught in the lower estuary. Alternatively, when the tide is high, or when the river is low and slower flowing, the fish tend to swim up mid river in the lower estuary and elude capture there, but move progressively closer to the banks as flow rates rise in the mid to upper estuary and are caught there.

The results of these patterns, for fishermen, are as follows: Those fishing near the river mouth tend to catch most fish early in the rising tide and catch more fish in a high river with small tides; those fishing well up stream can catch only those fish that elude capture in the lower estuary — either those entering the river late on the rising tide or in a low river with very high tides. Intermediate situations occur and exceptions to these general patterns are common. Nevertheless, we think that the patterns described here are real and that the exceptions are a result of peculiar or local effects.

# DEPTH AT WHICH FISH MIGRATE

Visual observations made during experimental fishing showed that the depth at which fish migrate varies. At times shoals of whitebait are at or near the surface and at other times they may be so deep in the water that they are scarcely visible. Two extremes may be identified. When the water is clear, the surface is smooth and undisturbed by wind, and sunshine is bright, whitebait shoals tend to migrate deeper in the water. When the water is turbid, the relatively few whitebait migrating are close to the surface.

During our experimental fishing we used a trap with three compartments, each 60 cm high, placed in a vertical series, so that theoretically we were fishing at three depths, 0–60 cm, 60–120 cm, and 120–180 cm (Fig. 51). In practice fishing depths were more variable, as manpower limitations made it impossible to attend to the net at all times and prevented the continuous adjustment of net level as the tide rose and fell. Furthermore, at low tides we did not have sufficient depth of water to submerge the entire net. At varying times we were therefore fishing one to three traps, with the uppermost functional trap often not completely submerged. We had sufficient data to examine the effects of turbidity on all species for our turbidity levels 1 to 3 only (see the visual turbidity scale in "Water Turbidity", Appendix 1, page 93).

**TABLE 9: Percentages of migrating fish caught at different depths**

| Turbidity category* | Percentage of catch at each level: Trap 1 (0–60 cm) | Trap 2 (60–120 cm) | Trap 3 (120–180 cm) | No. of samples |
|---|---|---|---|---|
| 1 | 58.6 | 33.4 | 8.3 | 29 |
| 2 | 46.5 | 47.3 | 6.6 | 84 |
| 3 | 63.2 | 33.3 | 3.7 | 31 |
| Mean percentage at each level | 56.1 | 38.0 | 6.2 | Total 144 |

*See visual turbidity scale in "Water Turbidity", Appendix 1, page 93.

The data (Table 9) are rather sparse and no detailed statistical analysis was possible. The only fact clearly emerging is that the fish are more abundant in the upper 120 cm of the water column than below this (only 6.2% were caught below 120 cm). The percentage caught in the bottom trap (120–180 cm) declined slightly with increasing turbidity, but the change is probably not significant. There seems to be no difference in the numbers in traps 1 and 2 at the varying turbidity categories.

# FACTORS CONTRIBUTING TO DIURNAL FLUCTUATIONS IN MIGRATIONS

Whitebait migrations fluctuate diurnally. Environmental factors that fluctuate diurnally include light and tides. There is also diurnal variation in water temperatures, but this has been ignored in the present analysis, as diurnal changes were generally small compared with longer-term temperature variations. Tidal fluctuations cause related changes in river flow patterns and water levels in the river estuaries. Light and tidal patterns are out of phase by about 50 minutes, so that the lunar-tidal day is theoretically 20.84 hours long, and high and low tides on any day are about 50 minutes later than the day before. Our tidal data were taken from the *New Zealand Nautical Almanac and Tide Tables* for the years of the study (New Zealand Marine Department 1968–71, New Zealand Ministry of Transport 1972). As both tides and light affect whitebait movements, the diurnal pattern of whitebait movement varies from day to day.

Our data on diurnal variations in whitebait movements are derived primarily from fishing at experimental sites in the Waiatoto River and its tributaries in 1970–72. Observations of commercial fishermen are also included where appropriate. Our data from experimental fishing sites have limitations and biases that must be understood to interpret catch patterns. Data limitations result from high fishing pressure on the river which dictated where we were able to construct fishing sites in the river. Sites available for experimental use were always relatively unproductive or unsuitable for experimental fishing; productive sites were all occupied by fishermen. Our wish to quantify migrations at all times of the tide required that our fishing site had fishable water at low river and low tide, and this requirement further limited possible fishing sites.

Biases in our data come from a variety of sources. Where there is a series of fishing sites along the bank of the river, it is clear that what is caught by the fishermen up stream is limited to that which is not caught by those below, and as fishing pressure and fishing efficiency both vary during the day, it is impossible to fish experimentally in the river under stable fishing pressure conditions; and further, it is impossible to quantify and make adjustments for such variations as do occur. In addition, the efficiency of our experimental fishing sites varied diurnally and from day to day. (The degree of efficiency is denoted by the proportion of those fish migrating up the side of the river where the experimental trap is placed that reaches the trap and is caught.) The manner in which fishing efficiency varies is discussed elsewhere (see "Migratory Patterns within Rivers", page 40). The result of variations and factors influencing whitebait migrations discussed in the foregoing is that our data relating catch to light and tidal fluctuations could be used to show that whitebait migrate at any time under almost any conditions. Our observations here are therefore principally our general and unquantified observations of whitebait movements, supported where possible by catch figures.

## EFFECT OF TIDES

Patterns in the occurrence of whitebait fishermen working on the river can reasonably be taken to reflect patterns in fish movement. Fishing usually starts during the 1 to 2 hours after low tide and continues until after high tide. This **seems** to reflect patterns in the movement of fish, though all fishermen would not be catching fish for all of this time, and some fishermen would do so outside these limits either regularly or under special conditions. The tidal influences on the fish seem, essentially, to be related to the effect of the tide on river flow patterns. At low tide the rivers are flowing out to sea at about the river flow volume. As the tide rises flow rate and flow volume both decline. How far this decline goes depends on the rate of fall in the lower estuary, flow volumes, the size of the estuary, and the height of the tide. Interaction of all these variables produces a highly complex and variable set of situations. In large rivers with small estuaries and with rapid fall in the estuaries and thus rapid flow the rising tide produces a rise in water level in the estuary, a drop in both flow rate and flow volume, but no reversal in flow direction. In smaller rivers in which fall in the estuary is slight, flow rates and volumes are low, and the estuarine basin is large the rising tide produces a rise in water level in the estuary followed by a reversal in flow direction. After high tide there is an outflow in all types of rivers, the rate and volume depending in part on the size of the estuary and the

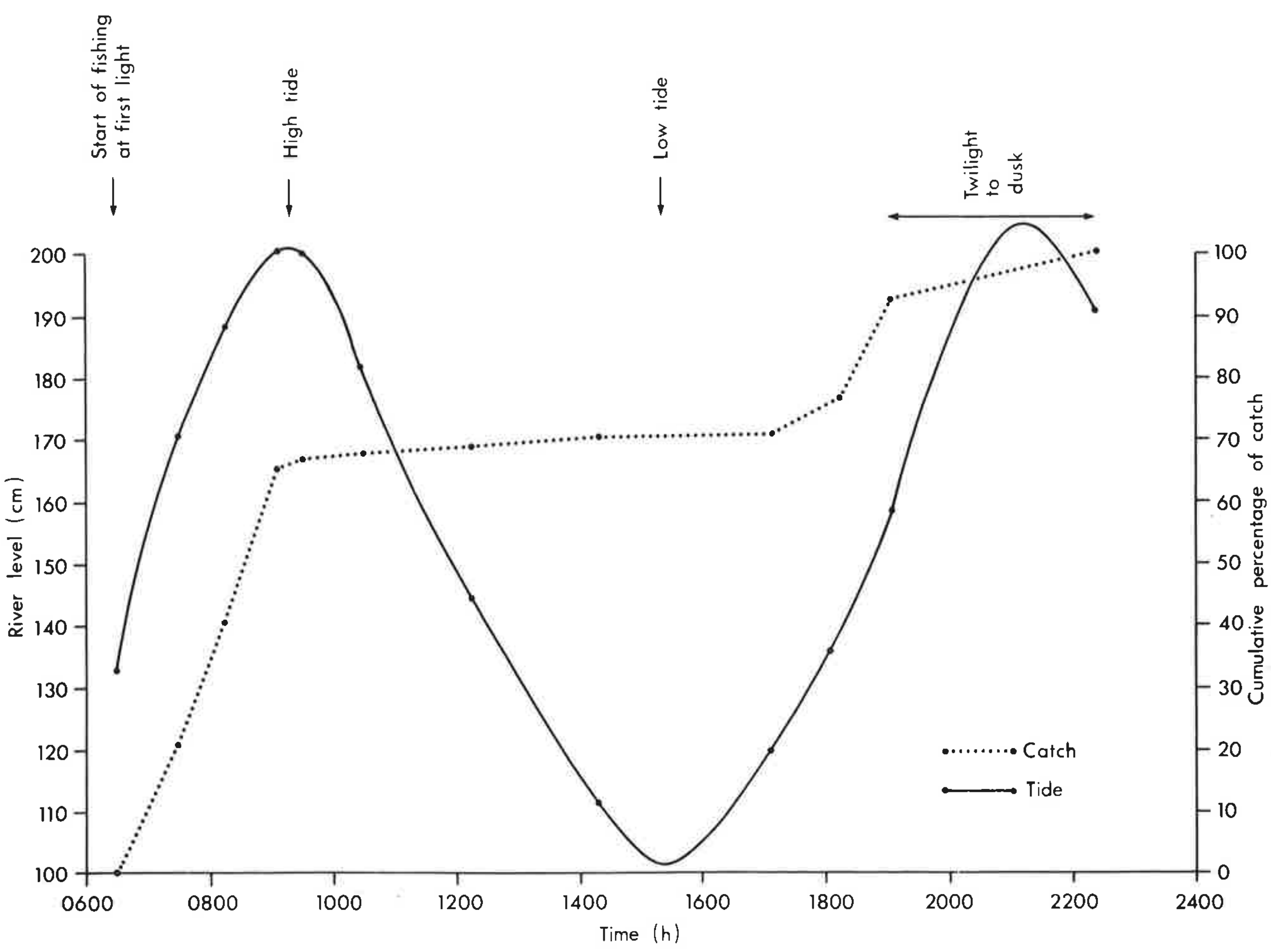



Fig. 21: Relationship of catch pattern to tidal fluctuations in the Waiatoto River on 27 September 1970.

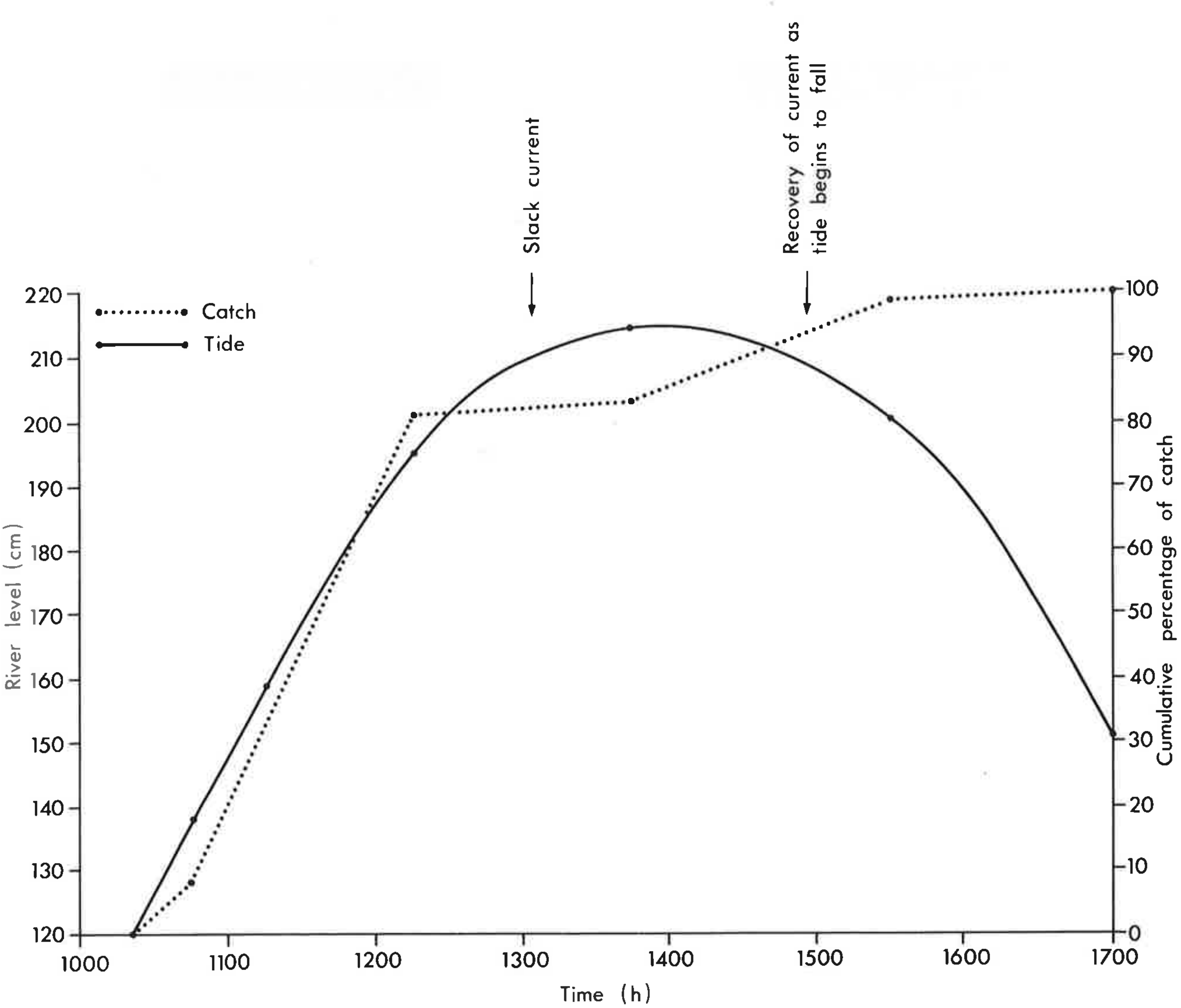



Fig. 22: The effect of reduced current rate at high tide on the relationship of catch pattern to tidal fluctuations in the Waiatoto River on 24 September 1970.

amount of water ponded in it during the rising tide. The two types of situation described here represent extremes between which intermediate situations of any type may be found. About the only factor that is general for all rivers is that there is a decline in flow rates with the rising tide and this may be the important factor for whitebait migrations.

We have no quantified observations on when the fish start to move through the river mouth or on the way in which the intensity of movement builds up at the mouth during the rising tide. But it appears that the fish start to move as soon as water begins to back up in the estuary. Our observations, and comments from fishermen, suggest that movement of fish intensifies during the rising tide to reach a peak before high tide, declines somewhat towards high tide, and stops abruptly as the tide starts to fall (Fig. 21). This pattern is not experienced by all fishermen or by any fishermen all the time. The most obvious consistent variant is that fishermen in the upper estuary must wait until the fish have moved right through the estuary before they begin to catch them. Thus it may be 1 hour or more between the entry of fish into the river and their capture by fishermen in the upper estuary. Sometimes, for no obvious reason at present, fish will continue to run after high tide. However, there is also a special circumstance when fish are caught on a falling tide: when the preceding high tide was just before dawn. The explanation of this occurrence and its implications are discussed on page 47.

Figures 21 and 22 show some catch patterns produced by experimental fishing at a site 1.8 km from a river mouth. In these figures it is evident that catch at this site did not begin to rise rapidly until some hours after the turn of the tide. This is due to the distance up stream from the river mouth of our fishing site and the swiftness of the current there. In Fig. 21 (27

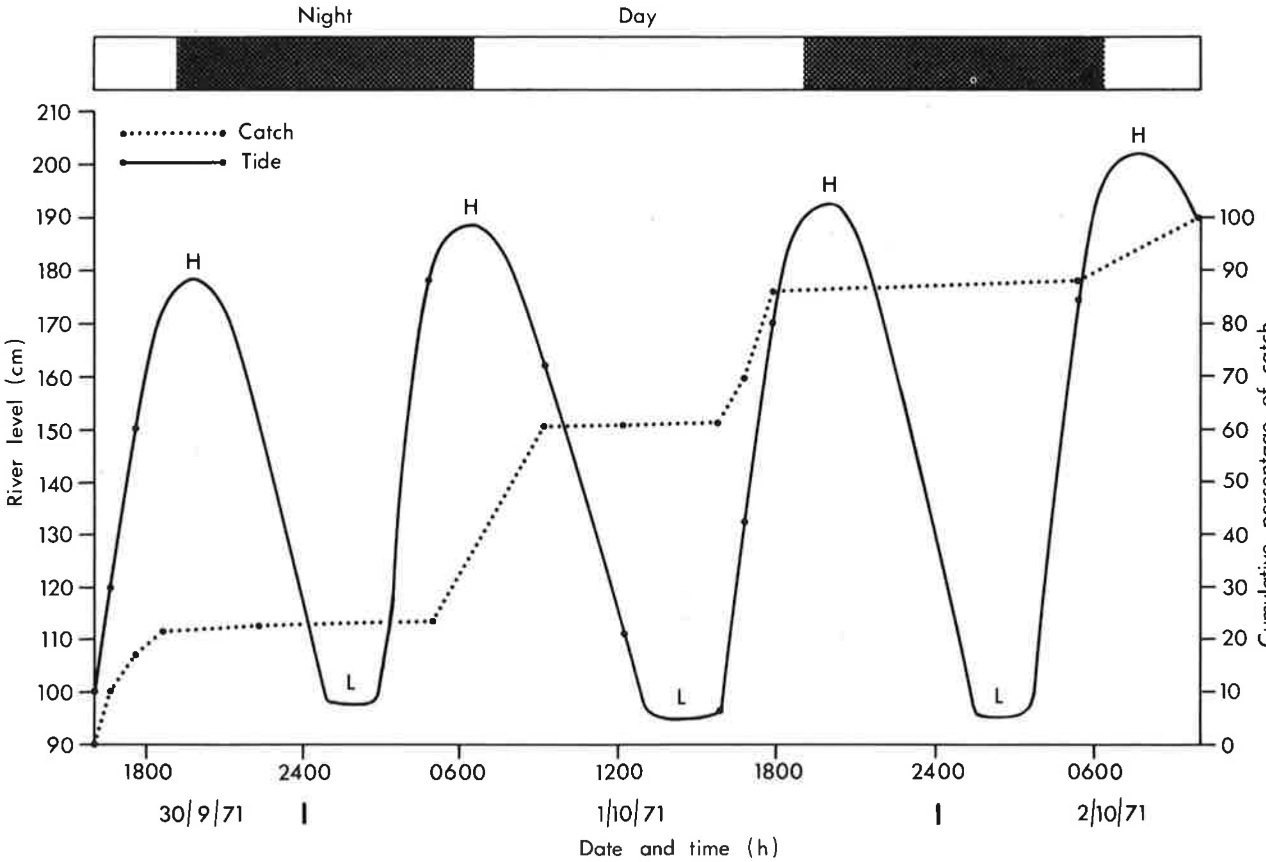



Fig. 23: Relationship between catch patterns, tidal fluctuations, and light changes in the Waiatoto River from 30 September to 2 October 1971. (H shows high tide, and L shows low tide.)

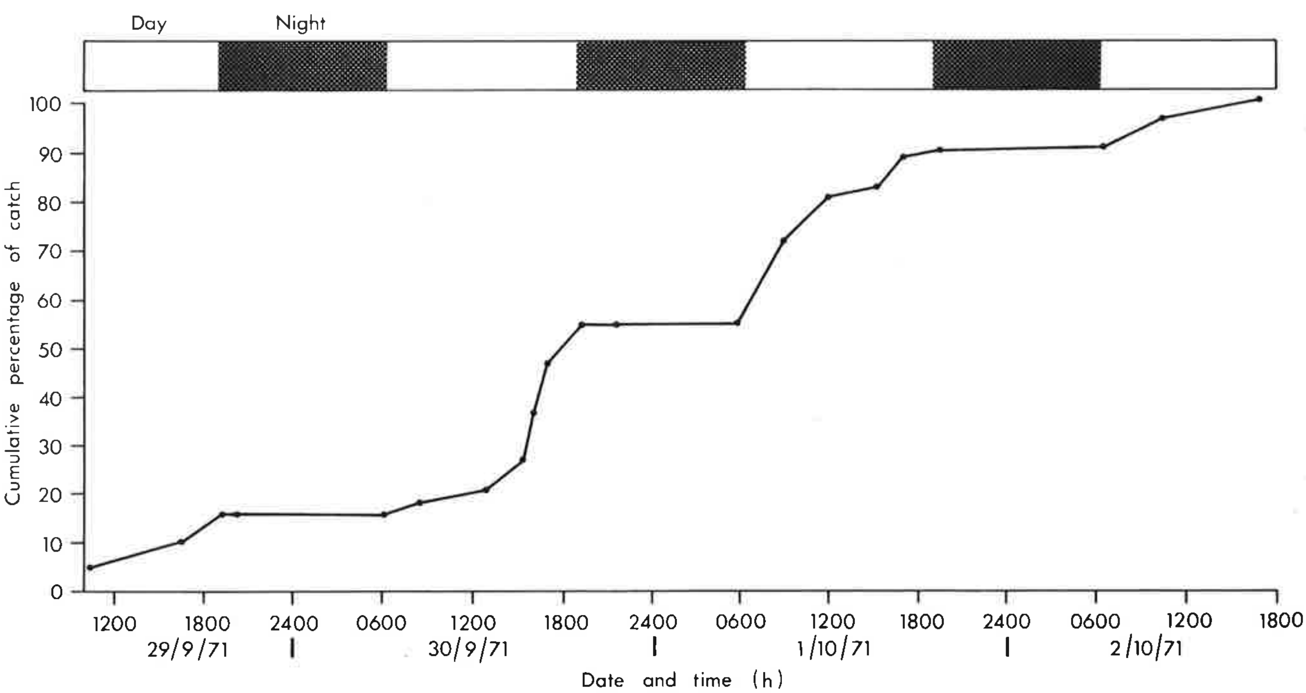



Fig. 24: Relationship between catch patterns and light changes in Hindley Creek from 29 September to 2 October 1971.

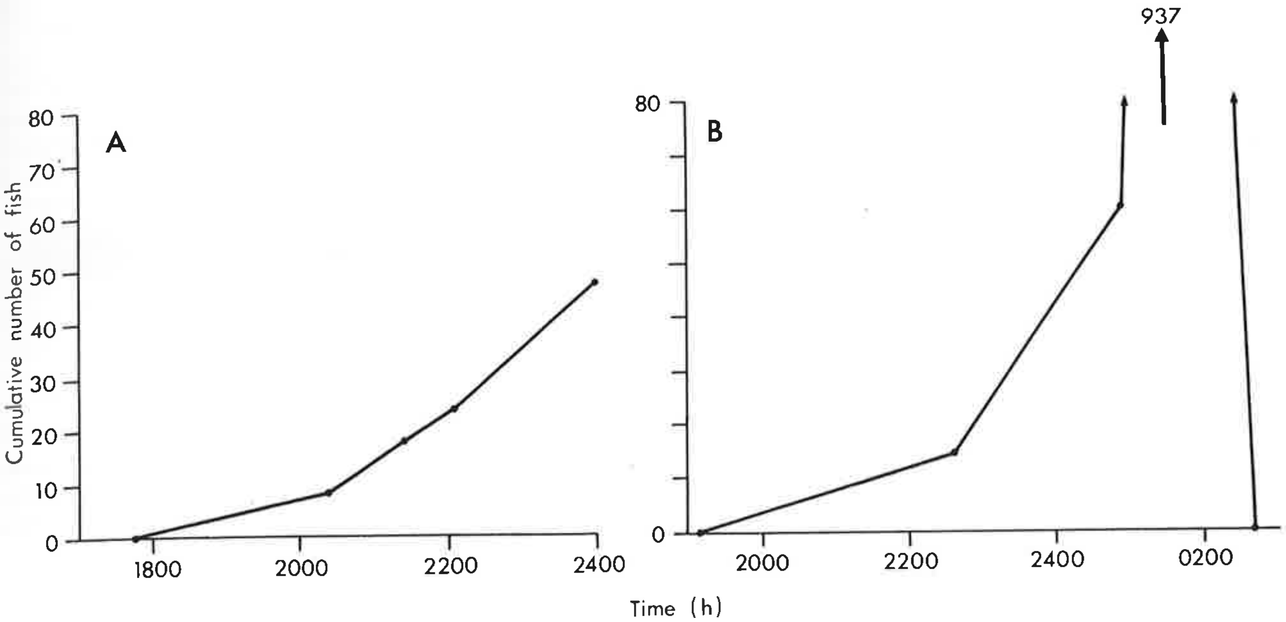



Fig. 25: Whitebait migrations at night in the Waiatoto River. A: A dark, overcast night on 30 October 1970. B: A calm, starlight night on 31 October 1970.

September 1970) it is noticeable how sharply catch rate declined at high tide.

It is common for catch to decline well before high tide (Fig. 22). Observations recorded during fishing indicate that in such instances the fish are reaching the fishing site, but are not being caught. As the tide rises, the optimal current for migration is apparently found further and further towards mid stream. Early in the rising tide the fish migrate up stream close to the banks, along the screens of the fishing stands, and into the net. As river current slackens the fish migrate further and further from the bank and ultimately so far from the bank that they no longer encounter the screens and net at all and elude capture. (At such times the location of whitebait shoals, if they are too far from the observation point to be seen, can be identified by brown trout (*Salmo trutta* L.) rising to feed on them. The trout move progressively further out into the river, following the whitebait shoals.) An instance of decline in catch well before high tide is shown in Fig. 22, with some recovery in catch after high tide, as the estuary began to drain and flow rates quickened.

## EFFECT OF LIGHT

Diurnal rhythms in whitebait migrations relate closely to diurnal light rhythms. Unfortunately, we did not have equipment suitable for measuring light changes of the magnitude experienced from full sunlight to dark night with heavy cloud cover. Thus we are able to relate diurnal changes only to gross light changes. Times for sunrise and sunset are derived from the *New Zealand Nautical Almanac and Tide Tables* for the years of the study (New Zealand Marine Department 1968–71, New Zealand Ministry of Transport 1972).

Our data show that whitebait generally do not migrate in the river at night. Repeated fishing between dusk and dawn produced negligible catches. Rising catches on a rising tide were truncated by the onset of dusk, with catch after sunset negligible. This is true of both the Waiatoto River (Figs. 21 and 23) and its tributary Hindley Creek (Fig. 24).

Attempts to obtain data on migrations during clear moonlight and starlight nights were frustrated largely by the unstable weather of South Westland in spring, with long periods of heavy, continuous, or intermittent overcast sky. Very small numbers of fish were caught on dark overcast nights (Fig. 25A) and few more on calm, clear nights without moon (Fig. 25B). On one night (31 October 1971), when there was a clear sky and full moon for a period on a rising tide, some fish were caught, but catch was meagre after development of cloud cover (Fig. 26) (400 fish in moonlight in 2¼ hours, 40 fish in overcast conditions in the subsequent 9¼ hours). In a second instance (13 September 1970, Fig. 27) it is evident that sunset about 3 hours before high tide (moon near full, sky clear to partial overcast) did not lead to cessation of migration. Ninety percent of fish caught between 1000 hours and 2330 hours were taken after sunset, under moonlight.

To examine the effect of light on migrations three 40-watt incandescent lamps were mounted on a fishing stand about 3 m above water level, one light over each of two nets and one at the bank. It was a clear, starlight night without moon.

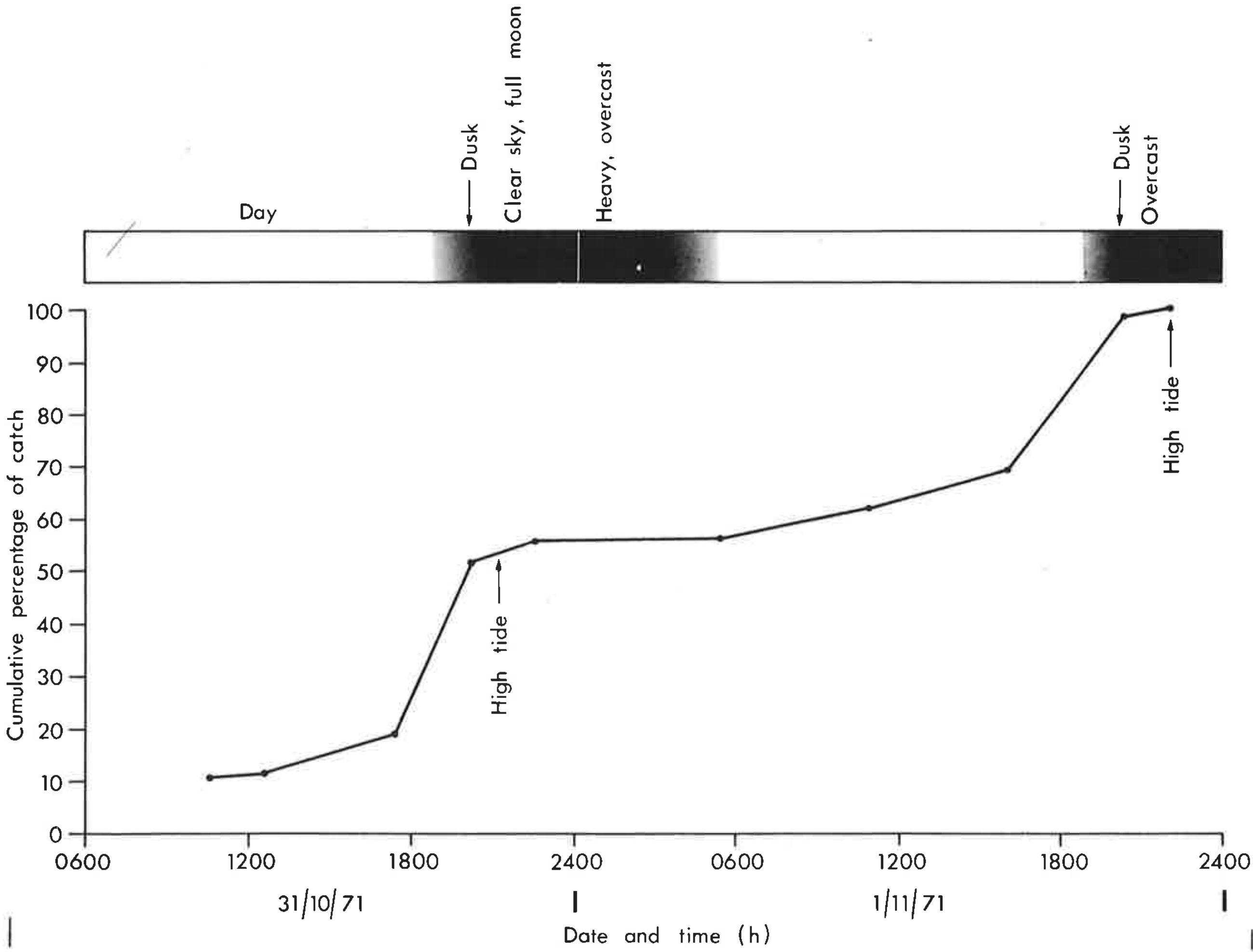



Fig. 26: Whitebait migrations at night in the Waiatoto River from 31 October to 1 November 1971 (total catch 13 783 fish).

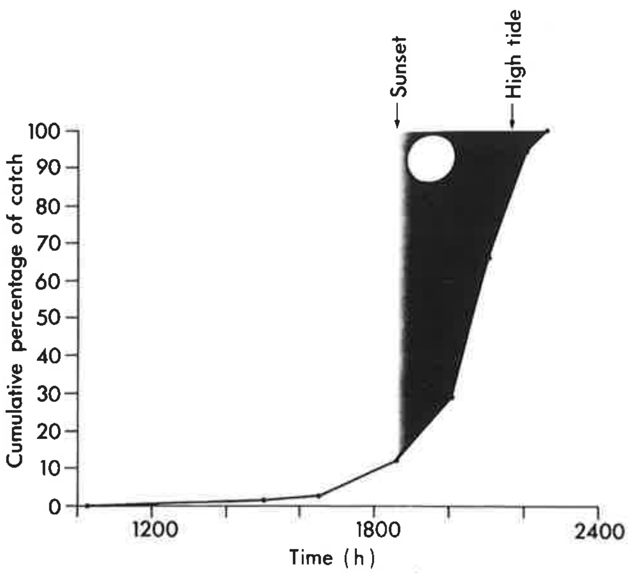



Fig. 27: Catch during moonlight in the Waiatoto River on 13 September 1970. The moon was 2 days before full and the sky was clear to 2000 hours, partly overcast to 2100 hours and clear to 2230 hours.

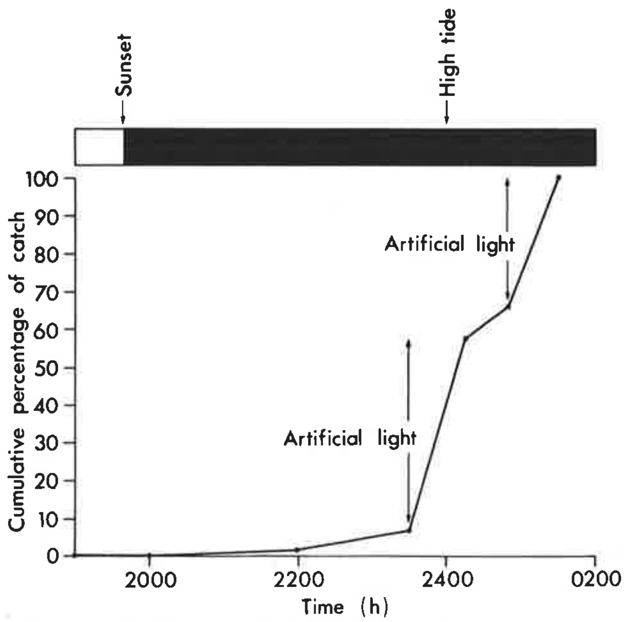



Fig. 28: The effect of artificial lights on catch at night in the Waiatoto River. The night, 31 October–1 November 1970, was clear, with starlight and a new moon.

During the day before the evening of the experiment (31 October 1970) the fisherman at the site had caught 163 kg of whitebait — about 100 000 fish. From about sunset to 2330 hours under natural light 155 fish were caught (Fig. 28). Lights were switched on at 2345 hours for 30 minutes, during which 1115 fish were caught. The lights were then off for 30 minutes, when 153 fish were caught, and on again for 30 minutes, with 758 fish caught. These results show a clear response of the fish to light. However, comparison of the numbers caught under light with those caught during the day suggests that the effect of the lights is very local.

These limited results indicate that generally whitebait do not migrate at night, that there is some movement on clear, starlight nights, and that under moonlight there is somewhat increased fish activity, compared with dark, overcast, or starlight nights.

### DISCUSSION

There seem to be two phases in the whitebait migration — first movement of fish from sea water to fresh water, and, second, migration in fresh water. All our data on the effect of light on migration concern movements in fresh water. Reports from fishermen suggest that the pattern of movement of the fish from sea water into fresh water may differ from that in fresh water. Although it is illegal to fish at night, fishermen have reported catching whitebait, sometimes in large quantities, when fishing at night in the surf zone at river mouths, and they believe that fish do enter river mouths at night.

Support for this comes from a commonly occurring pattern of movement of whitebait in the early morning. Substantial catches of whitebait are often reported by fishermen on a falling tide during the first hour or more after dawn. Generally large catches, on a falling tide just after sunrise, were taken when high tide was an hour or two before dawn. We believe that these fish were carried into the estuary during the rising tide of the previous night. It is probable that when the previous high tide occurs in the evening, fish carried in on the tide are carried out again when the estuary flushes with the falling tide, but when high tide is towards dawn, so that the tide is only beginning to fall at sunrise, the fish are still in the river and begin to migrate up stream as soon as light levels are high enough, presumably for visual orientation to permit rheotaxis.

## FACTORS CONTRIBUTING TO DAY-TO-DAY FLUCTUATIONS IN MIGRATIONS

In the past factors contributing to day-to-day fluctuations in whitebait catches have received little attention. The quantity of whitebait entering a river fluctuates broadly from day to day (for example, on 7 consecutive days, 16–22 October 1961, catch from the Cascade River was 0, 276, 726, 1017, 581, 276, and 36 kg). Fluctuations of this type, though perhaps not of this magnitude, are typical of most whitebaiting rivers.

There are two types of factors whose effects on the quantity of fish **entering** a given river are quite different from one another, but whose effects on the quantity of fish **caught** in a river are not easily distinguished. Thus factors that affect whitebait migrations may control fish behaviour through the receipt by the fish of sensory stimuli **or** they may influence fish behaviour by physically impeding their movement up stream. This section is concerned primarily with environmental stimuli controlling migration rather than with physical barriers to migration, though the latter need brief discussion.

The structure and position of the river mouth are important in their effect on whitebait migrations into any river, especially small ones, since in an extreme situation the flow may soak away to sea through beach gravel. Under these and less extreme conditions entry of the fish into the river is hindered by purely physical factors.

The structure and position of the river mouths are related largely to two factors: (1) water volume and flow rates in the river, that is, the ability of the river to scour gravel and sand from the opening in the beach, and (2) wind direction and strength and surf conditions, that is, the ability of wave action and coastal drift of sand to close the river mouth by driving sand into the beach opening. In the Haast area the prevailing winds are north to west. Northerly winds drive river mouths south and heavy seas tend to close them. Westerly winds drive river mouths northwards and also close them. In both events large floods counteract the effect of wind and surf. It is not common for large rivers of the Haast area to be closed, but if they are low for long periods and there is persistent on-shore wind, closure may follow (Waiatoto River, late November 1971). In addition to restricting entry of fish physically, modification and partial closure of river mouths, in limiting outflow of water, probably also affects the influence of the river's fresh water in the sea nearby. Rivers that flow obliquely across the beach tend to flow along the seashore, rather than out to sea, as occurs when a river flows straight across the beach. This affects the distance that fresh water extends out to sea.

These effects are difficult to quantify and no attempt has been made to do this or to relate these factors to quantities of whitebait migrating.

Analysis of variation in whitebait migrations is based on catch figures. It is difficult to identify changes in catch that are due to changes in fishing effort, especially during floods. Our observations showed that **some** whitebait **may** migrate in very turbid flood waters, and very occasionally large catches have been recorded during floods. But fishing generally ceases. Unless the runs appear likely to be very good, fishermen remove all nets and screens from the water to avoid damage to fishing gear. Fishing stands are often partly or wholly destroyed by floods, and many are not repaired in time to permit fishing immediately after floods. These factors all lead to a broadly changing fishing effort. For example, in the Waiatoto River on 15 October 1969, before a flood, 15 fishermen reported catches (189 kg); on the 16th, at the flood peak, there were only 3 fishermen (5 kg), but on the 17th, after the flood had fallen, 18 fishermen reported catches (123 kg). Clearly part of the change in total catch is due to change in fishing effort.

Natural environmental parameters that vary periodically or cyclically include tides, river levels, and water turbidity. These may affect quantities of whitebait migrating at any time by influencing the behavioural patterns of the fish through their sensory perception (as distinct from impeding their movement). These are the principal variables exhibiting short-term fluctuations. To analyse the effects of these variables we first carried out multiple linear regression analyses, relating catch to river level, tidal level, water turbidity, day, and rainfall. Day was included to enable the effect of seasonal change in abundance of fish to be taken into account. Rainfall was included to determine its effect, because for large blocks of catch data we have no river level information.

The results of these multiple regression analyses are discussed under each environmental variable. Analysis was made for all Haast area rivers in 1969, for the Waiatoto and Okuru River data (1969–72), and for the Awarua River for 1951–61. The Awarua data do not include turbidity (Tables 10 and 11). We also calculated correlation coefficients for catch and tidal levels for the Cascade River data (1959–72).

## CATCH AND RIVER LEVELS

Data relevant to analysis of the effect of river levels on catch include river levels measured daily (1969–72) with associated catch data as follows: **1969** — catch and river levels for the Waita, Haast, Okuru, Turnbull, Waiatoto, and Arawata Rivers; **1970–71** — catch for all these rivers and river levels in the Okuru and Waiatoto Rivers; **1972** — catch for all rivers and river levels in the Waiatoto River.

From 1947 to 1961 E. R. Midgley and J. Jenkins fished the Awarua River and kept a record of daily catch. From 1951 onwards rainfall and river levels were also recorded.

Since 1959 a party of from 6 to 10 fishermen has fished the Cascade River, and detailed catch records have been kept by R. B. Buchanan. These records also listed river levels as "low", "normal", "rising", "high",

**TABLE 10: Multiple regression analysis coefficients showing relationship of catch to environmental variables in Haast area rivers from 1969 to 1972**

| | | | Variable | | | | |
|---|---|---|---|---|---|---|---|
| Year | River | | Day | Level | Tide | Turbidity | Rainfall |
| 1969 | Waita | R.C.* | −0.041 2 | 0.000 3 | 27.815 2 | −7.959 2 | −0.242 5 |
| | | *F*† | 0.015 3 | 0 | 2.844 9 | 1.988 9 | 0.409 1 |
| | Haast | R.C. | −0.092 1 | −0.240 7 | 18.556 0 | 4.352 4 | 0.129 6 |
| | | *F* | 0.188 0 | 2.614 6 | 2.805 9 | 1.156 8 | 0.273 6 |
| | Okuru | R.C. | −1.383 0 | −0.771 5 | 20.640 9 | 39.447 0 | −0.866 9 |
| | | *F* | 6.630 1 | 20.102 0 | 0.624 3 | 24.250 5 | 2.396 0 |
| | Turnbull | R.C | −0.075 5 | 0.293 6 | −4.291 2 | −22.831 6 | −0.034 1 |
| | | *F* | 0.012 6 | 3.350 4 | 0.046 6 | 5.954 8 | 0.003 9 |
| | Waiatoto | R.C. | −0.566 3 | −0.318 5 | 34.390 8 | −0.678 8 | −0.004 1 |
| | | *F* | 1.465 9 | 2.300 1 | 1.465 1 | 0.194 1 | 0.139 0 |
| | Arawata | R.C. | 0.059 6 | 0.043 7 | 25.226 0 | −3.092 0 | −0.528 4 |
| | | *F* | 0.043 5 | 0.076 2 | 3.165 4 | 0.405 8 | 2.461 1 |
| 1970 | Okuru | R.C. | 0.445 8 | −0.063 8 | 14.957 5 | −6.902 1 | −5.867 7 |
| | | *F* | 3.019 1 | 0.103 6 | 0.909 9 | 1.408 5 | 0.667 3 |
| | Waiatoto | R.C. | 3.680 6 | −0.285 2 | 6.946 4 | −28.561 1 | −13.096 4 |
| | | *F* | 15.834 1 | 0.532 7 | 0.017 2 | 1.520 5 | 0.309 9 |
| 1971 | Okuru | R.C. | −0.551 7 | −0.367 6 | 26.851 5 | 1.230 6 | −0.624 0 |
| | | *F* | 2.069 3 | 0.011 5 | 2.858 0 | 0.007 8 | 1.962 0 |
| | Waiatoto | R.C. | −1.486 6 | 0.466 5 | 151.606 1 | −49.358 5 | −1.969 9 |
| | | *F* | 2.962 0 | 1.446 1 | 10.835 7 | 3.925 5 | 4.379 1 |
| 1972 | Waiatoto | R.C. | −1.273 4 | −0.559 6 | −225.615 3 | 13.098 2 | −1.846 1 |
| | | *F* | 0.936 1 | 1.740 7 | 9.639 3 | 0.311 1 | 1.960 6 |

*R.C.: Regression coefficient for multiple regression.
† *F*: *F* values for reduced model.
For 1 and 5 degrees of freedom $F = 6.61$ at 5% level of significance.

**TABLE 11: Multiple regression analysis coefficients showing relationship of catch to environmental variables in Awarua River from 1951 to 1961**

| Year | | Day | Level | Tide |
|---|---|---|---|---|
| 1951 | R.C.* | 0.32 | −0.50 | 5.00 |
| | *F*† | 5.69 | 2.57 | 1.54 |
| 1952 | R.C. | 1.18 | 1.50 | 7.20 |
| | *F* | 3.54 | 2.12 | 0.37 |
| 1953 | R.C. | 0.01 | −0.07 | 1.42 |
| | *F* | 0.01 | 0.04 | 0.15 |
| 1954 | R.C. | 2.09 | −0.39 | −7.63 |
| | *F* | 34.50 | 0.85 | 1.20 |
| 1955 | R.C. | 0.06 | −0.68 | 7.77 |
| | *F* | 0.02 | 1.73 | 0.54 |
| 1956 | R.C. | 0.80 | −0.68 | 14.58 |
| | *F* | 4.01 | 2.27 | 4.45 |
| 1957 | R.C. | 1.01 | −0.30 | 11.11 |
| | *F* | 5.66 | 0.52 | 1.61 |
| 1958 | R.C. | −1.96 | −0.36 | 3.61 |
| | *F* | 1.50 | 0.11 | 0.03 |
| 1959 | R.C. | −2.58 | −1.31 | −24.86 |
| | *F* | 11.14 | 5.50 | 4.87 |
| 1960 | R.C. | −0.12 | −0.79 | 4.35 |
| | *F* | 0.56 | 10.49 | 2.01 |
| 1961 | R.C. | 0.55 | −0.37 | 9.55 |
| | *F* | 5.05 | 2.10 | 0.71 |

*R.C.: Regression coefficient for multiple regression.
†*F*: *F* values for reduced model.
For 1 and 3 degrees of freedom $F = 10.1$ at 5% level of significance.

or "flood". Although this scale is imprecise and subjective, the data indicate when floods occurred and thus make it possible to determine any relationship between catch and river levels.

From 1970 to 1972 some additional registered whitebait fishermen kept catch diaries, and useful information was obtained, especially from some southern rivers.

In analysing these data we have looked first at the broad-ranging data for the Haast area in 1969. Changes in river levels in the rivers in the Haast area synchronise closely. It is likely that floods in the Cascade River, 25 km south of the Arawata, and in the Awarua River, 56 km south of the Arawata, are also in synchrony with floods in rivers of the Haast area, as analysis of rainfall patterns showed that there is close correlation between rainfall recorded at Awarua and at Haast (see "Weather", Appendix 1, page 90).

### Haast Region, 1969–73

During the 1969 fishing season catch patterns (Tables 58 and 59 in Appendix 5) closely followed flood patterns in the rivers. In all rivers peak whitebait runs came very soon after long-lasting floods during the first 2 weeks of September, followed by a warm, dry period extending into early October. In the Waita the run began about 23 September, in the Haast about the 19th, in the Okuru and Turnbull about the 18th, in the Waiatoto on the 17th, and in the Arawata about the 22nd. Differences in the date of the start of the runs relate to flooding patterns in the rivers. The Waita is unstable, floods badly, and clears slowly, and the Arawata and Haast are big, open-valleyed, snow-fed rivers that tend to be slow to clear. But the response of catch to this September flood is obvious in all rivers. As river levels declined during late September and early October catches also fell and remained low until about 12 October. Heavy rain about 5–8 October produced substantial flooding which lasted only 2 or 3 days, and after this, catch was again high for 4 days, dropped sharply during a spate on 16 October, recovered, and then declined. Further rain produced almost continuous flooding until about 18–19 October, which prompted a recovery in catch in the Waiatoto River, but not in the others. A flood in all rivers on 10 November had no effect on catch.

By 18 October 1969, 87% of the season's catch in the Waiatoto River and 88% of that in the Okuru had been recorded. Figures are comparable for the other rivers, and runs recorded from 10 to 18 October represented the virtual end of the 1969 whitebait run.

Although the relationship between floods and (a few days later) large whitebait runs appears fairly clear from the 1969 Haast region data, we have been unable to establish a quantified relationship between floods and whitebait runs. Big runs do not show a constant, day-to-day relationship to river levels, but rather follow floods by one to several days.

After a large flood of long duration the rivers tend to clear more slowly, and the run will sometimes begin while the rivers are still in moderate flood, though clearing, for example, September floods in 1969. If the flood has been brief, especially after a prolonged dry spell, there may not be prolonged, excessive, silty run-off from the land. The flood may thus be over in a day or so and the rivers may have returned to almost normal levels and clarity before the run occurs. Runs after such floods may occur in rivers at nearly normal levels, as during or after the flood of 7–9 October 1969.

Turbidity levels do not relate closely to water levels. For instance, the Okuru River was classed as **grey turbid**, **moderately turbid**, **slightly turbid**, and **clear** on days when its water level was measured at about 45 cm. **Grey turbid** conditions were reported with river level varying from 120 cm to 16 cm, and **clear** water from 55 cm to 5 cm. River conditions at any given level vary over a broad spectrum. There is synchrony in catch fluctuations in the Haast area rivers (Fig. 29), and this synchrony seems to support the view that big catches follow floods.

A similar sequence of events — floods followed by runs — is evident in subsequent years. In 1970 high catches and floods alternated. There is little evidence of catch declining during low river levels, as floods followed each other too regularly. Relatively high catches occurred at any time the river was not in flood.

There is nothing distinctive about 1971 and 1972 catch patterns. The 1973 season was very poor in the Haast area (though very good at Cascade; see page 51).

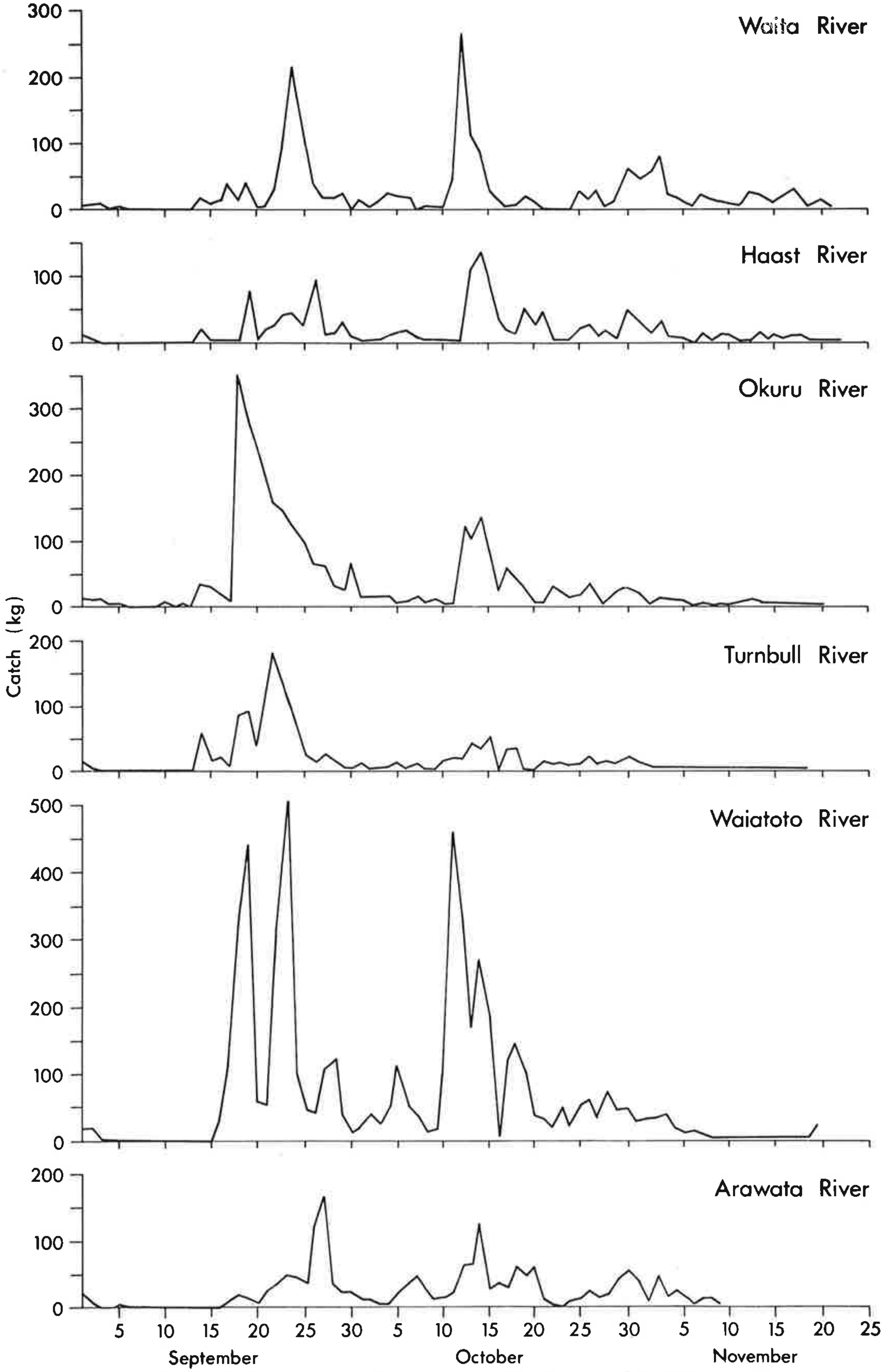



Fig. 29: Synchrony in catch patterns in the Haast area rivers in 1969.

Spring rain was late in 1973 (only 275 mm of rain from 15 August to 9 October on 26 rain days, compared with an average of 450 mm on 35 rain days). When floods eventually occurred (208 mm of rain from 10 to 15 October and 312 mm from 30 October to 7 November) runs followed.

Multiple regression analyses did not support a relationship between river levels and catch in the Haast area rivers (Table 10).

The reasons for absence of correlation between catch and levels are complex. Big runs do not occur during floods (thus there is no positive correlation); nor do they occur in very low rivers (no negative correlation). Best runs often occur on a falling river, that is, at intermediate river levels. Sometimes, however, if the river level is high, but the water is clearing, the run may occur at almost flood levels. Alternatively, a flash flood may be over in a day or two, and big runs may occur with rivers down to nearly normal conditions. Thus correlation between river levels and catch is not to be expected. The time lapse between floods and runs varies, so that sequential correlation is not to be expected either.

### Cascade River, 1959–73

Catches of whitebait from the Cascade River are high. The lack of precision in river level data from the Cascade prevents detailed quantitative comparisons between floods and catch. But there are clear instances in the Cascade data of poor catches during periods of low river levels followed by a flood and a significant increase in catch (Fig. 30). Cascade River data do not conflict with the pattern evident in the 1969-73 Haast region data — that whitebait migrations are stimulated by floods and that peak runs follow floods by a few days, for example, the Cascade River in 1959 (Fig. 30). The initial September run in 1959 followed 4 days of flooding (15-18 September). Catch declined on 23 and 24 September (river "rising" and "falling") and then another peak run occurred. Catch then declined about 11-12 October and remained low in a low river until 27 October, when a peak in catch occurred. River conditions for the preceding days were: 25 October — "low, rain needed"; 26th — "slight rise, light rain"; 27th — "normal, conditions good". River level fell again on 30-31 October, and catch fell sharply on 1-2 November.

The pattern for 1959 seems applicable to all Cascade data. Large runs follow floods, though floods do not necessarily stimulate large runs; for example, a minor peak followed floods on 13-14 September 1964, but in this year catch was concentrated on about 19 days in October (84% of the season's catch was taken between 3 and 21 October after floods from 1 to 5 October).

Catch in 1968 was the best recorded. This season was punctuated by numerous floods, fishermen recording 11 different flood peaks, with river "high" or "flood" on 36 of 90 days. Floods followed one another so closely that a relationship between catch and river levels is not clear.

The 1969 pattern is comparable in many respects with that seen in rivers in the Haast region, especially for big runs that followed major floods at the beginning of September. Only a minor increase in catch occurred after early October floods; the season was virtually over after the September runs (85% of the Cascade River catch for 1969 was reported between 10 and 26 September).

The 1973 season at Cascade was very good, and the pattern of runs is particularly interesting. There was little flooding in the early season; fishermen reported "flood" on 6 September, and occasionally the river was "high". Catches were poor until mid October. Frequently the water was described as "black", which indicated large proportions of swamp and forest water. However, rain from 10 to 15 October (275 mm) brought a big flood, with the river high and dirty until 17 October. On 15 October a very big run began and continued until 26 October. In these 12 days 9835 kg of whitebait were caught. River level declined through late October until a flood after 312 mm of rain between 30 October and 7 November; a second big run of whitebait followed from 8 to 13 November — 4740 kg. Thus in 1973 there were two major runs, each following one of the only two major floods of the season.

### Awarua River, 1948–61

We have detailed records of whitebait caught in the Awarua River, South Westland, from 1948 to 1961 (Table 61 in Appendix 5) and also records of rainfall and river levels for most years. These data enable comparisons of river levels and catch for a further river system. Benzie (1968a) examined records for 1948-53 and concluded that a "sudden rise in the river level was followed by a peak in the whitebait catch in 20 cases out of 25". Our examination of the data for 14 years produced the same conclusion, that big whitebait runs follow floods. However, as with Haast area rivers, there is no statistical relationship between river levels and catch (Table 11).

## CATCH AND TIDES

Whitebait fishermen place much reliance on tides in their expectancy of big whitebait catches, predicting them on high spring tides. Our observations gave no support for this. Multiple regression analysis of catch against day, river level, tides, turbidity, and rainfall for 4 years' catch data from rivers in the Haast area in 1969-72 (Table 10) gave no evidence of any significant contribution by tidal fluctuations to catch fluctuations. In only two instances (Waiatoto in 1971

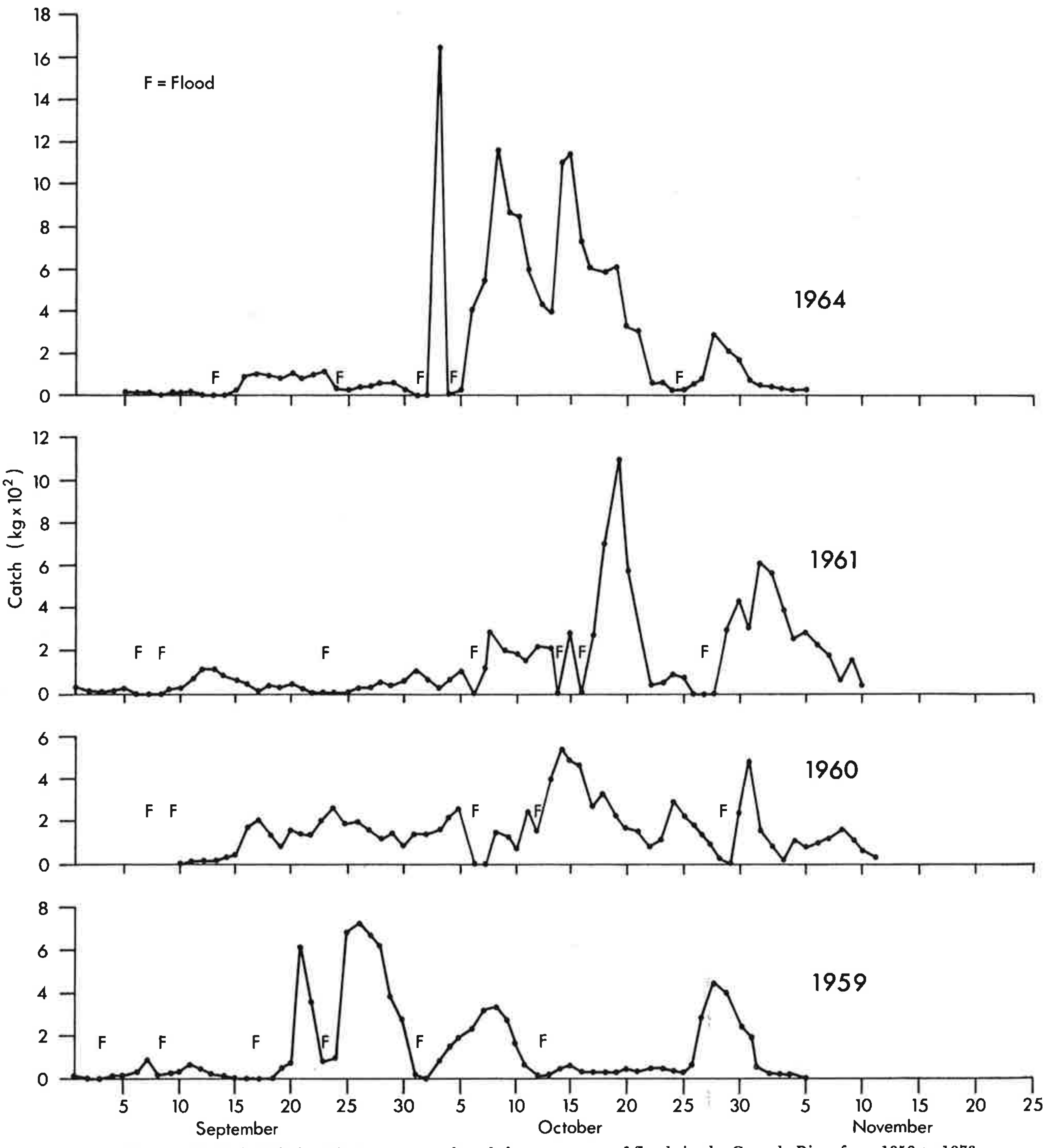
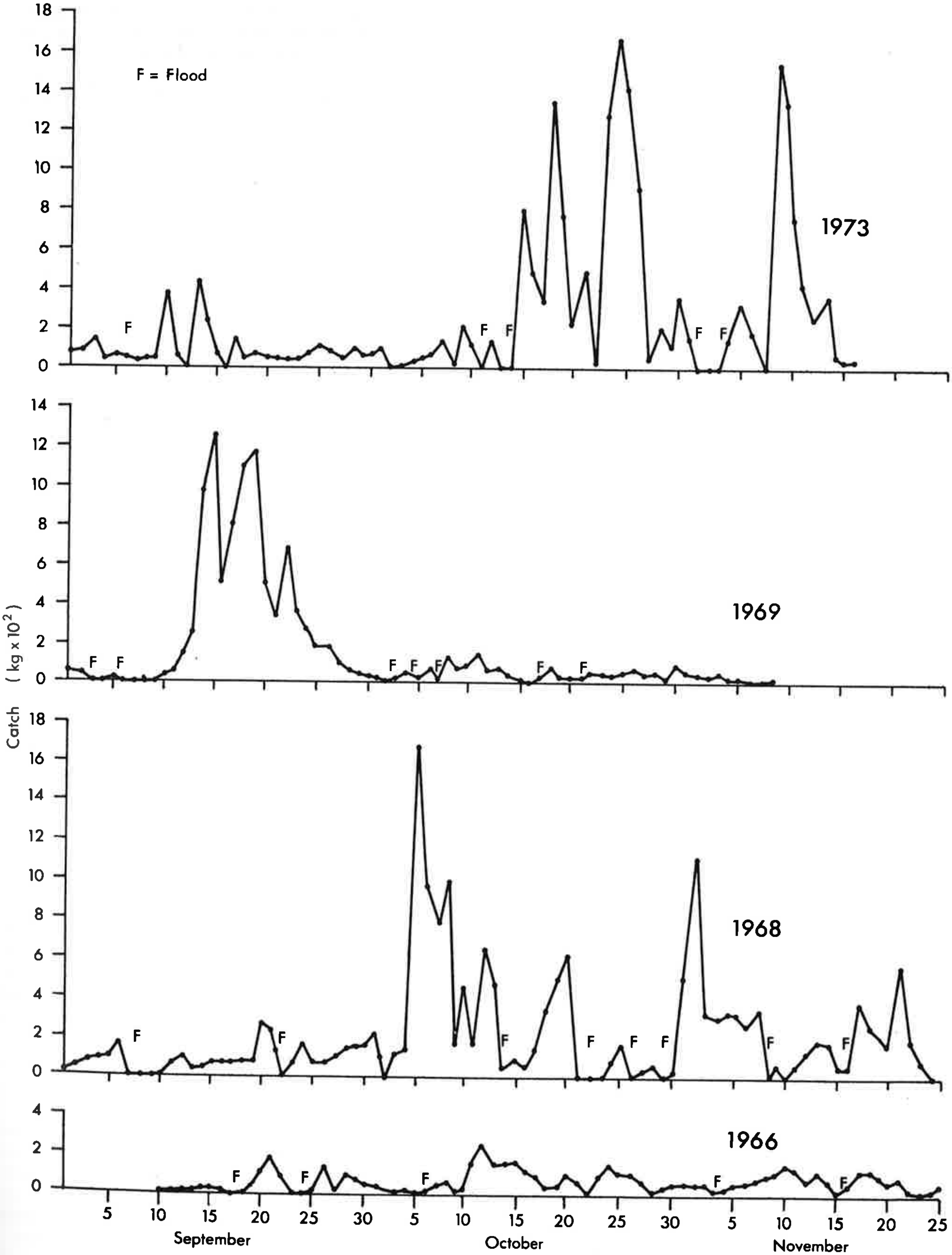



Fig. 30 (above and right): Relationship between catch and the occurrence of floods in the Cascade River from 1959 to 1973.

and 1972) was the contribution of tides to the regression significant, and in one instance the correlation was negative and in the other positive. In no instance was the contribution of tide to the regression significant in the Awarua River (Table 11; Table 61 in Appendix 5).

In the Cascade River from 1959 to 1972 (Table 12) correlations significant at the 5% level or better occurred in 1959, 1960, 1961, 1962, and 1972 (all negative) and 1971 (positive). Negative correlations evident in 5 years indicate biggest catches at neap tides, contrary to expectations of fishermen. When high tide is between 0530 and 0730 hours there is a second fishable tide in the evening, and negative correlations may relate to the opportunity to fish two high tides a day during neap tides. Unfortunately the data do not allow us to determine whether this is so.



F = Flood
1973
1969
1968
1966
Catch ( kg x 10²)
September
October
November

**TABLE 12: Relationship between daily catch and height of tide in Cascade River from 1959 to 1972**

| Year | No. of days | $r$ | $P$ |
|---|---|---|---|
| 1959 | 70 | −0.33 | 0.01 |
| 1960 | 66 | −0.23 | 0.05 |
| 1961 | 71 | −0.30 | 0.02 |
| 1962 | 71 | −0.08 | 0.10 |
| 1963 | 68 | 0.21 | 0.05 |
| 1964 | 69 | 0.20 | 0.05 |
| 1965 | 77 | 0.12 | 0.10 |
| 1966 | 77 | 0.20 | 0.05 |
| 1967 | 71 | −0.10 | 0.10 |
| 1968 | 89 | 0.16 | 0.10 |
| 1969 | 69 | 0.10 | 0.10 |
| 1970 | 75 | 0.02 | 0.10 |
| 1971 | 76 | 0.31 | 0.01 |
| 1972 | 82 | −0.17 | 0.05 |

## CATCH AND RIVER TURBIDITY

Multiple regression analysis relating catch to various environmental variables revealed that only for the Okuru 1969 catch did turbidity make a significant contribution ($P<0.05$) to the regression ($F$ = 24.2505, 1 and 5 degrees of freedom) (Table 10). The rather subjective data that we have make the relating of catch to turbidity difficult, especially as fishing virtually ceases in very turbid flood waters. Turbidity patterns closely follow flood patterns, and discussion of catch in relation to river levels has similarities to a discussion of catch and turbidity. At all turbidity levels between **grey turbid** (4) and **clear** (1) whitebait runs **do** occur (see the visual turbidity scale in "Water Turbidity", Appendix 1, page 93). In 1969 the big September run did not reach its peak in the Waita River until the water was **clear** (1); in the Haast the run was high when the river was **grey turbid** (4) to **moderately turbid** (3); peak runs occurred in the Okuru with the river clearing from **brown turbid** (5) through the turbidity scale to **clear** (1); the Turnbull River was **clear** (1) for the entire run; the Waiatoto River was **grey turbid** (4) to **moderately turbid** (3); and the Arawata River was **moderately** (3) to **slightly turbid** (2). Thus the presence or absence of sediment in the water is apparently not critical. However, it is rare for runs to occur with rivers **brown turbid** (5) and unusual in **grey turbid** water (4).

Data from Dawn Rivulet (also known as Weedy Creek) gave some indication of migrations when the river is turbid. From 0530 hours on 1 October to 1740 hours on 2 October 1971, when the Waiatoto River was **clear**, we caught 6570 whitebait in the Dawn Rivulet trap; at the same time 393 kg were caught by fishermen in the Waiatoto River (about 70 000 fish). From 1740 hours on 2 October to 1830 hours on 6 October, when the Waiatoto River was in flood and **brown** to **moderately turbid** and Dawn Rivulet **clear**, the Dawn Rivulet trap caught only 44 fish, though the trap was fishing throughout the flood; 4.5 kg were caught in the Waiatoto River. Change in catch in the Waiatoto River could be attributed to changed effort, but this does not apply to Dawn Rivulet, and it appears that flooding (turbidity) in the Waiatoto River was preventing fish reaching Dawn Rivulet.

Our observations indicate that usually increases in catch after floods begin when river water is about **moderately turbid** (3) or clearer and continue as the water continues to clear. The absence of a significant contribution by turbidity to the multiple regression (Table 10) has two causes. First, runs are often highest at intermediate turbidity levels and lower at the extremes, and, second, though big runs may occur in clear water, very poor catches are also often made when the water is clear (after a prolonged dry period). Thus catch in clear water varies between very high (after a flood) and very low (after a dry spell). Under such circumstances a significant contribution by turbidity to the regression is not to be expected.

## CATCH AND RIVER TEMPERATURES

Data on temperatures of the study rivers are given in Table 39 (Appendix 5). River temperatures fluctuated, but generally rose gradually through spring. Temperature patterns are complex, water temperatures depending partly on whether rain comes with northerly, westerly, or southerly winds. Floods usually resulted in a decline in river temperatures, but during long, dry, warm spells water temperatures rose. Snow-fed rivers may remain very cold during spells of warm weather owing to an increased water contribution from glaciers and snowfields. Above all, differences between rivers at any one time are as great as fluctuations within a river from day to day. Temperature changes seem unlikely to contribute much to gross day-to-day changes in quantities of whitebait caught.

However, as is noted elsewhere (see "Factors Affecting Beginning of Whitebait Runs", page 34) there is some very slight circumstantial evidence to suggest that whitebait may move out of the rivers under very cold river conditions. When sharp reductions in water temperature occur, migration may therefore be impeded. Existing data do not permit exploration of such a hypothesis.

## CATCH AND RIVER SALINITY

River salinities were very low (Table 45 in Appendix 5). The waters of these rivers are so pure that in relation to sea water (salinity about 35 ‰) their salinity is almost nil, and changes in salinity, or differences between rivers, can have little to do with changes in abundance of whitebait from day to day.

## CATCH AND FLOW RATES — EFFECT OF FLOW RATES AND FLOODS ON MIGRATIONS INTO TRIBUTARIES

Catch quantities were recorded at traps in Content Creek (1970-72) and Hindley Creek and Dawn Rivulet (1971-72). These data reveal aspects of the response of the fish to changes in flow rates and volume from these tributaries.

Catch at the Content Creek trap was small, usually less than 1000 fish per day, often only 100-200. Occasionally, however, much larger catches were made, for example, about 11 400 fish on 14 September 1970, 16 300 fish on 4 October 1970, and more than 20 000 on 6 October 1971. These large catches often occurred during or immediately after flood conditions in the Waiatoto River, but when Content Creek was high, but clear. Peak catches in Content Creek did not always coincide with those in the Waiatoto River (Fig. 31); for example, peaks in Content Creek on 7 September and 14 September are not related in any way to peaks in the Waiatoto River, though high catch in Content Creek on 4 October coincides with high catches in the Waiatoto River. Of equal interest is the failure of peaks in catch in the Waiatoto River to be reflected in catches in Content Creek, for example, on 21-22 September, 30 September, 13, 20, 27, and 30 October, and 5 November 1970 (Fig. 31). The whitebait appear to be responding to high flow rates and volumes and greater water clarity in Content Creek when the river is in flood. The absence of large catches in Content Creek when they are occurring in the Waiatoto River is related to low water flows from Content Creek. The volume of outflow from Content Creek into the Waiatoto River and the relative clarity of the water in the two are important in determining the quantities of whitebait migrating into Content Creek.

The effect of flow volume and current rates was particularly noticeable in Dawn Rivulet. At normal

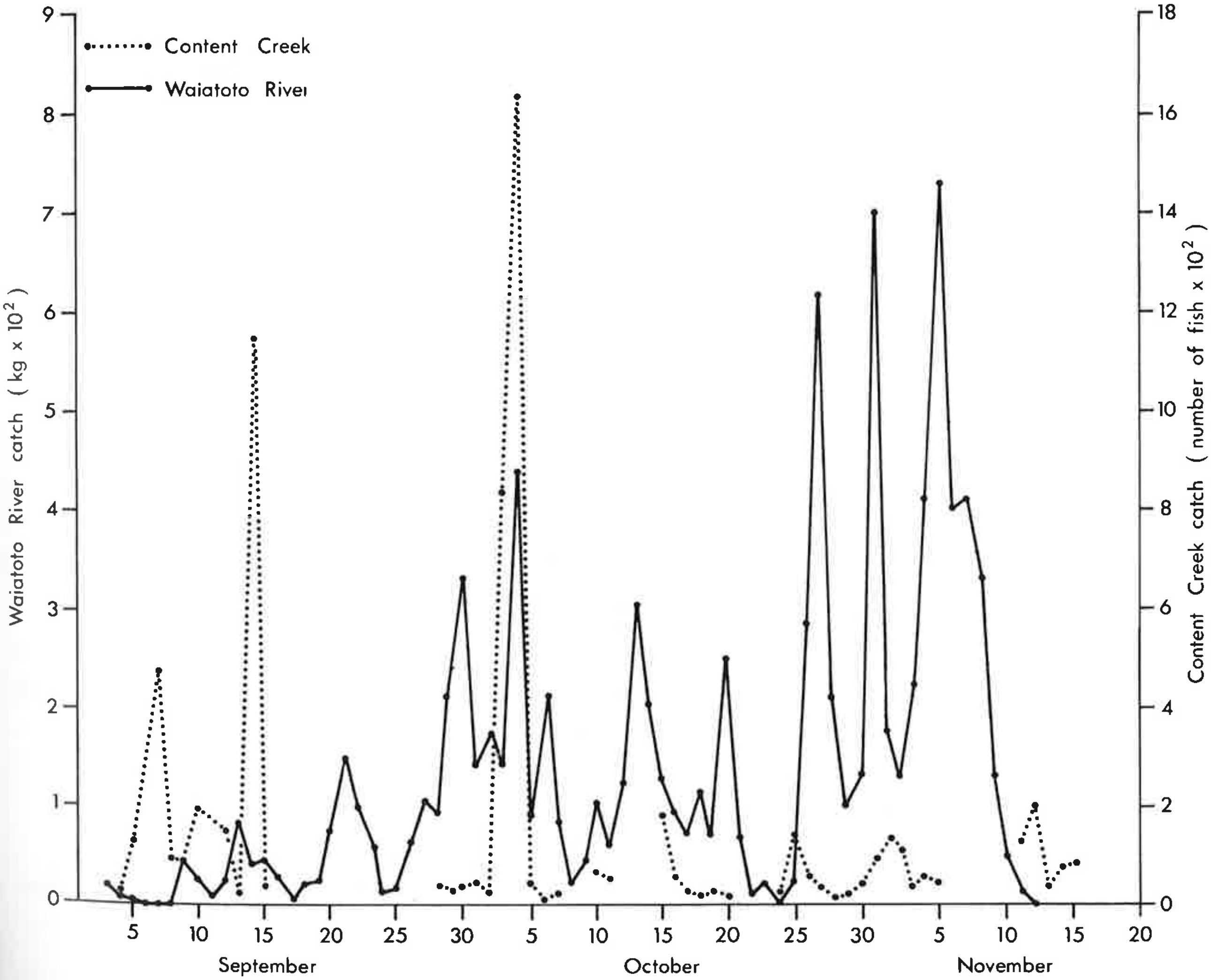



Fig. 31: Comparison of catches in the Waiatoto River (weight in kilograms) and Content Creek (number of fish) in 1970.

and low water levels there is little flow from Dawn Rivulet, and at high tides water backs up, the normally moderate to swift flow of Hindley Creek is reduced, and outflow from Dawn Rivulet into Hindley Creek is greatly reduced or ceases.

Catch in Dawn Rivulet was normally low. The total number of fish caught in Hindley Creek and Dawn Rivulet for 1971 and 1972, with the same fishing gear is shown in Table 13. About 2½ times as many fish were caught in Hindley Creek as in Dawn Rivulet. However, there is not a consistent day-to-day difference in catches. In 1972 the ratio of Hindley Creek to Dawn Rivulet catches varied between 104.00 and 0.09. The mean daily ratio of catches in the two streams was 5.25. It is clear from these figures that much greater numbers of fish entered Hindley Creek than Dawn Rivulet, especially when stream levels were low; for example, on 2 October 1972 our field notes recorded "water backing up" from Hindley Creek into Dawn Rivulet at high tide, and 596 fish were taken from the Hindley trap and 25 from the Dawn trap. The traps were revisited about 2 hours later, when the tide was falling and the water which had backed up into Dawn Rivulet had flowed out, and there were 170 fish in the Hindley trap and 106 in the Dawn trap. On 30 September 1971 we recorded "no current in Dawn Rivulet" and on that day 9600 fish were caught in Hindley Creek, but only 371 in Dawn Rivulet (Fig. 32). On 10 October 1972 our notes recorded "Hindley water" at the Dawn Rivulet trap, at 1040 hours, when we took 114 fish from Hindley and 73 at Dawn. At 1230 hours, about high tide, there were 281 fish at Hindley and none at Dawn. When the tide fell, water that had backed up in Dawn Rivulet flowed out and we recorded (1600 hours) 694 fish at Hindley and 1818 at Dawn.

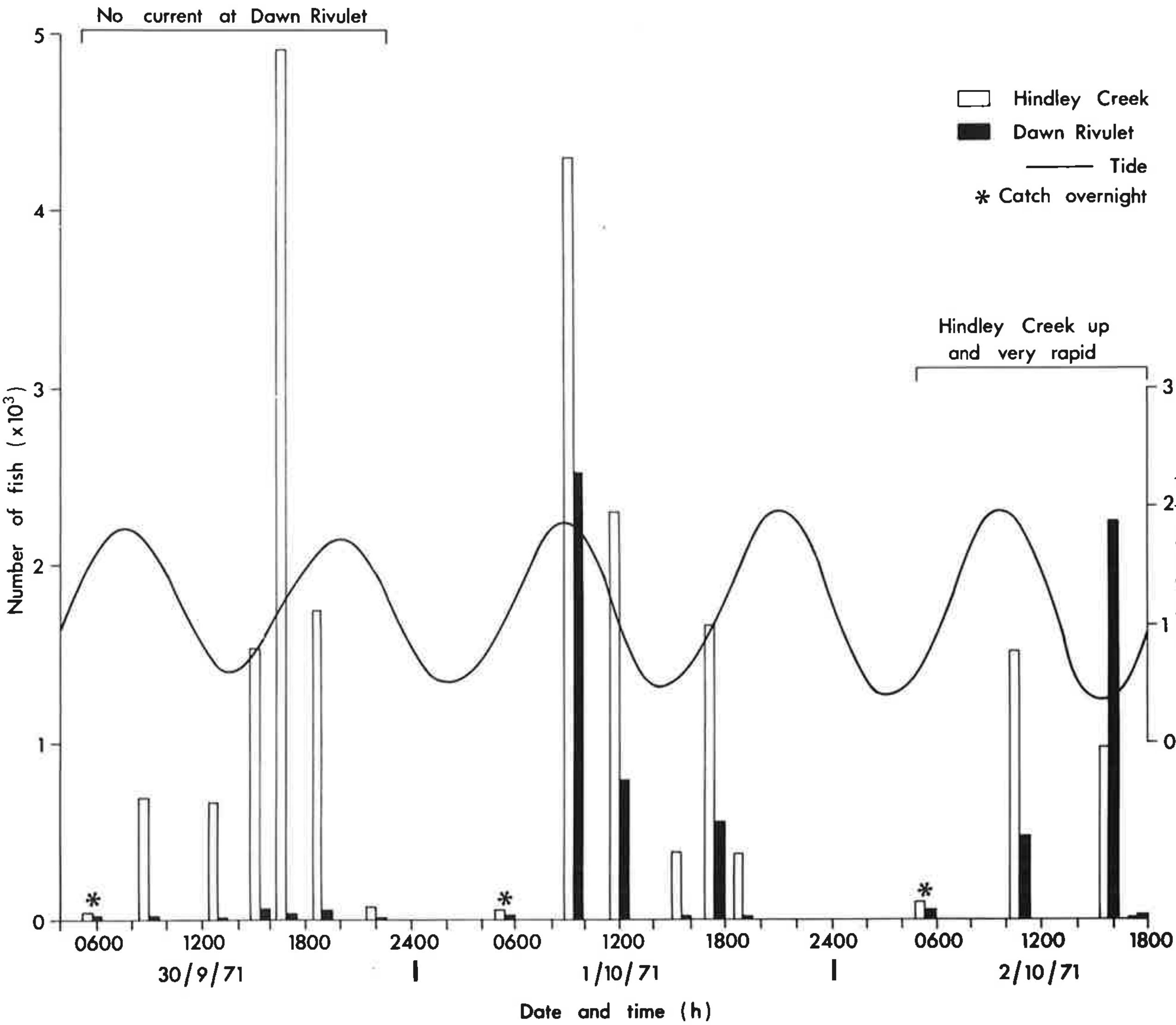



Fig. 32: Relationship between catches at Hindley Creek and Dawn Rivulet from 30 September to 2 October 1971.

After periods of heavy rainfall, flow volume and velocity of Dawn Rivulet increase and catches there are greater than at other times. There was heavy rain on the night of 2 October 1971 (41 mm), causing floods and very swift flows in Hindley Creek. Catch on 2 October was 2544 fish in Hindley Creek and 2722 in Dawn Rivulet. On this day the biggest catch was caught in Hindley Creek in the period up to and a little after high tide (1501 fish), but in Dawn Rivulet the biggest catch was taken between high tide and low tide (2220 fish) (Fig. 32).

Between 14 and 19 October 1971 the two streams were high or in flood, and in this period only 75 fish were caught in Hindley Creek, but 869 were taken in Dawn Rivulet. On 20 October water levels declined and 1830 fish were caught in Hindley and 1138 in Dawn. "Normal flows" were occurring in both streams by 21 October and catches were 4162 (Hindley) and 1916 (Dawn) fish.

Our data are not complete enough to permit continuous and detailed analyses of these interactions, but the pattern seems generally to be as follows: At normal flow rates and volumes many more fish enter Hindley Creek than enter Dawn Rivulet and they do so on the rising to full tide. Those fish that enter Dawn Rivulet tend to do so on the falling tide, when flow rates from Dawn Rivulet are greatest. When flood conditions apply, more fish may enter Dawn Rivulet than enter Hindley Creek because relatively higher flow rates from Dawn Rivulet stimulate movement into it.

This is a simplification of a complex set of interacting factors, but our data do not permit statistical analysis or clearer resolution of the patterns of change.

**TABLE 13: Number of fish caught in Hindley Creek and Dawn Rivulet in 1971 and 1972**

| Year | Number of fish Hindley | Dawn | Ratio Hindley/Dawn |
|---|---|---|---|
| 1971 | 84 744 | 36 072 | 2.35 |
| 1972 | 207 603 | 74 684 | 2.78 |

## DISCUSSION

Although a statistical relationship between catch patterns and changes in river levels has not been established, we believe that peak whitebait catches are closely related to floods and that tides do not stimulate peak whitebait migrations.

In essence we can conclude that when the whitebait are "ready" to run, floods in the river stimulate migration. Floods before the whitebait are "ready" to run or after the flush of the season will, of course, not induce large whitebait runs. Not all floods stimulate runs.

Little is known about which aspects of flooding stimulate whitebait migrations. Benzie (1968a) speculated that flooding clears the shingle bar of the river, which allows water to penetrate further out to sea, and presumed that "the extent to which fresh water penetrates out to sea influences the influx of whitebait". The effect of the floods in clearing the river bar is twofold. As Benzie suggested, it allows water easier egress from the estuary. But probably of primary importance is the greatly increased volume of water leaving the river mouth during a flood. We do not know, but can only presume that the fish locate the rivers by the reduced salinities around the mouths. This is easily comprehended with large rivers, but whitebait also enter tiny creeks with a normal flow of only a fraction of a cumec, creeks which sometimes trickle across or filter through steep, gravelly beaches (though the whitebait may make their entry when these creeks flood and form torrents across the beach). The areas of reduced salinities at such stream mouths would be very limited, but it seems most probable that the whitebait migrate after encountering reduced salinities in the sea around river mouths, this reduction in salinity being accentuated at floods.

During the whitebait season temperatures of rivers in the Haast region are consistently lower than sea temperatures at Jackson Bay (Table 39 in Appendix 5). The difference between river and sea temperatures is greater during floods, since rivers tend to be cooler during floods. Thus an increased influx of relatively cooler, fresh water into the sea during floods may amplify the effect of reduced salinities, though, as noted above, we doubt that fluctuations in temperature themselves contribute to fluctuations in catch.

# MIXED-SPECIES ASPECTS OF THE MIGRATIONS

Preceding sections have dealt with the whitebait migrations primarily as if only one species of fish is involved, though the whitebait fishery is a multi-species one. In the following section aspects of the mixed-species character of the fishery are explored. In the section on identification (Appendix 4, "Sorting and Identification of Samples", page 103) we point out that five species — *Galaxias maculatus*, *G. brevipinnis*, *G. fasciatus*, *G. argenteus*, and *G. postvectis* — are present in whitebait catches, but that *G. argenteus* is in the commercial catch in such low numbers that it is insignificant. Identification problems prevented the separation of *G. brevipinnis* and *G. postvectis* whitebait (see page 105), but numbers of adults of *G. postvectis* found in exploratory fishing have always been very low; this species is probably insignificant in the whitebait catch, and we regard the possibility that some fish of this species were misidentified as *G. brevipinnis* as unimportant in the analysis. There are thus three species of commercial importance which we can distinguish, and the following discussion is limited mainly to them — *G. maculatus*, *G. brevipinnis*, and *G. fasciatus*. The three species vary broadly in their occurrence, geographically, seasonally, both within and between seasons, and in relation to a wide range of environmental variables. Sampling programmes were designed to investigate these differences by examining catch samples from a series of widely diverse rivers over the period of the migrations and during several years.

In a preliminary study of species composition of the whitebait catch (McDowall 1965) gross differences were revealed between closely adjacent rivers in the composition of catch. It was noted then: "The distinct differences between the catches in closely adjacent rivers indicate that entry to a particular river is not haphazard but is closely controlled." Reference was made to a series of samples from rivers in the Haast region, taken over a 2-day period, which contained between 0% and 78% *G. brevipinnis*. It was suggested that these differences were likely to be temperature related, and a distinction was drawn between waters thought to be "colder, rocky stream habitat" and "warmer lowland stream" habitat. Our temperature studies have shown this distinction to be erroneous. Nevertheless, our continuing studies have clearly shown that species composition differences between the rivers are valid and we have explored the reasons for these differences.

## SPECIES COMPOSITION OF MIGRATORY SHOALS

We made no special study of species composition of individual shoals of migrating whitebait. However, the three important component species can be distinguished visually in shoals in the river before capture, and our observations indicate that whitebait consistently migrate in mixed-species shoals. We know of no reason to suspect that the fish behave any differently either in the sea or when first moving into rivers from the sea, and subsequent discussion assumes that the fish move in mixed-species shoals.

## SPECIES COMPOSITION OF WHITEBAIT RUN IN WAIATOTO RIVER AND ITS TRIBUTARIES

Differences in migratory patterns of the species were examined in the Waiatoto River and its tributaries by collecting samples from various parts of the system and comparing species composition.

The Waiatoto River derives much of its water from the glaciers of Mount Aspiring and is a cold river, but in its lower and tidal reaches it is fed by several brown-water streams draining coastal and lowland forests and coastal swamps. This brown water is much diluted after entry into the river, but that which flows from Hindley and Content Creeks can be seen along the margins of the river below the creek mouths for several hundred metres, especially at low tide. Therefore the water in these tributaries is likely to influence movements in the river below their confluence as well as influencing the migrations out of the river into the tributaries.

One way of examining the effects of environmental variables on movement of the species is to examine what happens to catch composition near confluences.

The sampling programme is outlined in "Field Study Areas and Sampling Localities" (pages 12–14), and results of the sampling are given in Tables 14 to 18 and in Tables 62 to 72 (Appendix 5).

Hindley Creek is moderately brown and acid and enters the lower reaches of the Waiatoto River estuary (Fig. 2). We had fishermen sampling below and above the mouth of this stream (sites 2 and 3 in Table 2) and had traps in Hindley Creek and in Dawn Rivulet, a tributary of Hindley Creek. Comparison of catch composition at sites 2 and 3 in the river shows that the site below the confluence consistently had a lower proportion of *G. brevipinnis* than the site above the confluence (Tables 15 to 17). Site 2, below the confluence, is strongly affected by the brown water flowing from Hindley Creek, especially at low tide, when swift flow of the Waiatoto River forces Hindley Creek water to flow along the river margins. At such times little-diluted Hindley Creek water flows through site 2. The difference in catch composition above and below the Hindley Creek confluence can be regarded as a reflection of the influence of the brown Hindley

Creek water at site 2 in the Waiatoto River. The inference to be drawn from these data is that *G. brevipinnis* tends to avoid the low-pH, brown-stained waters of Hindley Creek. This inference is confirmed from examination of catch composition in Hindley Creek and Dawn Rivulet. In 2 years we sampled a total of 108 474 whitebait in these two streams, of which only 169 (0.16%) were *G. brevipinnis* (Tables 16 and 17). That fewer *G. brevipinnis* were caught in the Hindley Creek system than at site 2 in the Waiatoto River (Fig. 33), which was strongly influenced by Hindley Creek water, is a reflection of the mixing of river water and Hindley Creek water at that site.

The proportion of *G. fasciatus* caught at these sites contrasts with that of *G. brevipinnis*. The data (Tables 16 and 17) show that higher proportions of *G. fasciatus* were caught below the confluence (site 2) than above it (site 3) and that in 1971 more were caught at the Hindley Creek trap than in traps in the river. The figures are not as clear in 1972 owing to sampling irregularities. The 1972 samples from the Waiatoto River below the Hindley confluence (site 2) covered a restricted period including only those days when river levels were low, and sampling there extended further into November than sampling in Hindley Creek. The figures in Table 17 (a summary of catch composition — 6.7% *G. fasciatus* at site 2 and 0.79% in Hindley Creek) indicate many more *G. fasciatus* in the Waiatoto River than in Hindley Creek. However, examination of the sampling periods shows that site 2 in the Waiatoto River was fished only in late October and early November, when numbers of *G. fasciatus* are much higher. Direct comparison of the data showed that, during the period when both site 2 and Hindley Creek traps were operating, the percentage of *G. fasciatus* at the Hindley Creek trap was consistently higher than that in the river (Tables 68 and 69 in Appendix 5; Fig. 33). The 1971 and 1972 data indicate that *G. fasciatus* whitebait are choosing the slightly acid, brown waters of Hindley Creek in preference to the river water. This is consistent with differences in catch composition in the Waiatoto River above and below the confluence.

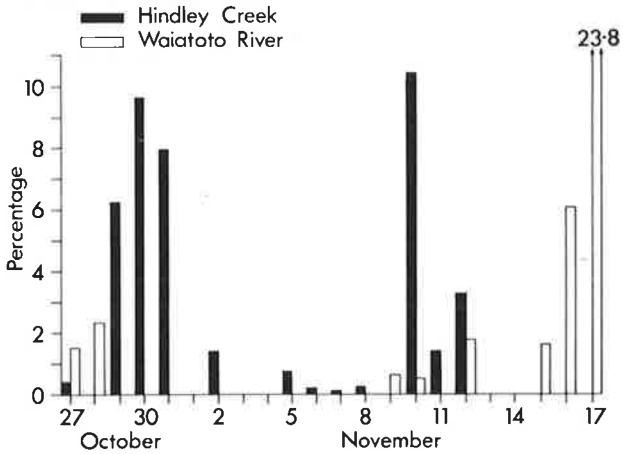



Fig. 33: Percentages of *G. fasciatus* caught at site 2, Waiatoto River, and Hindley Creek trap in late October and early November 1972.

We also examined the partition of whitebait shoals migrating into Hindley Creek by comparing catch in a tributary — Dawn Rivulet — with catch in Hindley Creek above its confluence with Dawn Rivulet. Dawn Rivulet is browner, more acid, slower flowing, much smaller, and less oxygenated and tends to be warmer than Hindley Creek. Comparison showed that *G. fasciatus* made up a greater proportion of the catch in Hindley Creek than in Dawn Rivulet; for example, *G. fasciatus* contributed 4.15% in 1971 and 0.79% in

**TABLE 14: Catch composition summary for west coast, South Island, rivers sampled in 1969**

| Locality | Sampling period | No. of samples | Percentage composition *G. maculatus* | *G. brevipinnis* | *G. fasciatus* | *G. argenteus* | No. of fish |
|---|---|---|---|---|---|---|---|
| Ship Creek | 31/8-7/11 | 39 | 77.0 | 17.7 | 5.3 | 0 | 1 873 |
| Ship Creek tributary | 6/10-3/11 | 18 | 7.8 | 13.0 | 79.1 | 0 | 115 |
| Waita River | 1/9-20/11 | 44 | 97.6 | 2.1 | 0.3 | 0 | 11 113 |
| Haast River | | | | | | | |
| Site 1* | 1/9-22/11 | 68 | 73.5 | 25.9 | 0.6 | 0.1 | 18 548 |
| Site 2 | 14/10-18/11 | 8 | 45.8 | 53.7 | 0.5 | 0 | 1 339 |
| Okuru River | | | | | | | |
| Site 1 | 14/9-3/11 | 21 | 92.2 | 7.6 | 0.2 | 0 | 6 282 |
| Site 2 | 25/10-12/11 | 23 | 86.5 | 13.2 | 0.4 | 0 | 9 585 |
| Site 3 | 1/10-15/10 | 15 | 89.0 | 9.0 | 1.9 | 0 | 3 428 |
| Others | 5/9-22/11 | 8 | 87.8 | 9.7 | 2.1 | 0.4 | 3 339 |
| Turnbull River | 1/9-12/11 | 58 | 92.8 | 6.7 | 0.5 | 0 | 16 016 |
| Waiatoto River | | | | | | | |
| Site 2 | 1/9-24/11 | 70 | 90.2 | 7.0 | 2.7 | 0.1 | 17 778 |
| Site 6 | 8/9-20/11 | 56 | 66.8 | 32.2 | 1.0 | 0 | 18 897 |
| Site 7 | 1/9-15/11 | 32 | 49.1 | 50.7 | 0.3 | 0 | 6 053 |
| Others | 18/9-27/10 | 16 | 78.3 | 21.6 | 0.1 | 0 | 3 596 |
| Arawata River | | | | | | | |
| Site 1 | 1/9-9/11 | 57 | 67.4 | 32.0 | 0.6 | 0.1 | 14 378 |
| Site 2 | 11/11-20/11 | 10 | 35.4 | 60.4 | 4.3 | 0 | 2 780 |
| Site 3 | 22/9-18/11 | 7 | 11.3 | 88.7 | 0.1 | 0 | 1 864 |
| Jackson Bay Stream | 11/9-23/11 | 30 | 26.3 | 1.8 | 71.9 | 0 | 874 |
| | | | | | | | Total 137 858 |

*For explanation of site numbers see page 13.

**TABLE 15: Catch composition summary for west coast, South Island, rivers sampled in 1970**

| Locality | Sampling period | No. of samples | Percentage composition *G. maculatus* | *G. brevipinnis* | *G. fasciatus* | *G. argenteus* | No. of fish |
|---|---|---|---|---|---|---|---|
| Buller River | 2/9-26/11 | 38 | 72.3 | 12.1 | 15.0 | 0.6 | 9 309 |
| Hokitika River | 10/9-15/11 | 25 | 77.2 | 8.3 | 14.1 | 0.4 | 8 866 |
| Okuru River | | | | | | | |
| Site 3* | 4/9-23/11 | 56 | 96.5 | 1.9 | 1.4 | 0.1 | 17 747 |
| Waiatoto River | | | | | | | |
| Site 2 | 9/9-13/11 | 56 | 96.5 | 1.0 | 2.5 | 0.1 | 14 197 |
| Site 3 | 9/9-13/11 | 44 | 95.7 | 2.1 | 2.2 | 0.1 | 13 980 |
| Site 5 | 4/9-20/11 | 153 | 95.3 | 3.5 | 1.2 | 0.1 | 34 228 |
| Site 6 | 1/9-11/11 | 44 | 89.5 | 9.9 | 0.6 | 0 | 15 582 |
| Site 7 | 3/9-7/11 | 44 | 88.5 | 11.1 | 0.4 | 0 | 10 769 |
| Content Creek | 4/9-23/11 | 76 | 96.4 | 0.1 | 3.5 | 0.1 | 30 365 |
| Nisson Creek | 10/9-11/11 | 25 | 96.3 | 3.7 | 0.1 | 0 | 4 929 |
| Brewer Water | 3/9-11/11 | 27 | 13.8 | 86.2 | 0 | 0 | 174 |
| Hubbub Torrent | 8/9-11/11 | 13 | 4.1 | 95.9 | 0 | 0 | 49 |
| Gliding Rivulet | 30/9-16/11 | 17 | 9.3 | 90.0 | 0.7 | 0 | 126 |
| Cascade River | 2/9-15/11 | 61 | 95.9 | 1.2 | 2.9 | 0 | 24 764 |
| | | | | | | | Total 185 085 |

*For explanation of site numbers see page 13.

**TABLE 16: Catch composition summary for west coast, South Island, rivers sampled in 1971**

| Locality | Sampling period | No. of samples | Percentage composition *G. maculatus* | *G. brevipinnis* | *G. fasciatus* | *G. argenteus* | No. of fish |
|---|---|---|---|---|---|---|---|
| Buller River | 2/9-22/11 | 40 | 84.5 | 8.7 | 6.5 | 0.2 | 7 283 |
| Hokitika River | 29/9-7/11 | 14 | 85.1 | 3.4 | 11.5 | 0 | 9 756 |
| Okuru River | | | | | | | |
| Site 3* | 7/9-19/11 | 56 | 95.6 | 1.8 | 2.6 | 0.1 | 18 205 |
| Waiatoto River | | | | | | | |
| Site 2 | 8/9-13/11 | 35 | 94.7 | 0.5 | 4.8 | 0 | 6 884 |
| Site 3 | 8/9-12/11 | 32 | 95.4 | 2.3 | 2.3 | 0 | 8 123 |
| Site 4 | 7/9-4/11 | 44 | 97.4 | 1.3 | 1.2 | 0 | 26 987 |
| Site 5 | 29/8-23/11 | 240 | 95.7 | 2.6 | 1.7 | 0.1 | 55 009 |
| Site 6 | 6/9-13/11 | 47 | 91.1 | 8.1 | 0.8 | 0 | 18 323 |
| Site 7 | 9/9-8/11 | 21 | 91.9 | 7.7 | 0.3 | 0 | 6 533 |
| Hindley Creek | 26/8-25/11 | 97 | 95.8 | 0.1 | 4.2 | 0 | 26 407 |
| Dawn Rivulet | 25/8-25/11 | 93 | 98.9 | 0.1 | 1.1 | 0 | 21 985 |
| Content Creek | 10/8-25/11 | 88 | 96.2 | 0.1 | 3.8 | 0.1 | 11 105 |
| Nolans Creek | 19/8-20/11 | 76 | 99.0 | 0.4 | 0.6 | 0 | 6 151 |
| Nisson Creek | 3/9-22/11 | 44 | 93.8 | 5.6 | 0.6 | 0 | 2 625 |
| Brewer Water | 26/9-18/11 | 16 | 36.8 | 63.2 | 0 | 0 | 76 |
| Hubbub Torrent | 8/10-22/11 | 18 | 1.4 | 98.6 | 0 | 0 | 146 |
| Gliding Rivulet | 1/10-6/11 | 14 | 2.7 | 97.3 | 0 | 0 | 146 |
| Cascade River | 2/9-1/11 | 60 | 97.7 | 1.1 | 1.2 | 0 | 30 004 |
| | | | | | | | Total 255 748 |

*For explanation of site numbers see page 13.

**TABLE 17: Catch composition summary for west coast, South Island, rivers sampled in 1972**

| Locality | Sampling period | No. of samples | Percentage composition *G. maculatus* | *G. brevipinnis* | *G. fasciatus* | *G. argenteus* | No. of fish |
|---|---|---|---|---|---|---|---|
| Buller River | 6/9-10/11 | 41 | 66.1 | 30.2 | 3.7 | 0.1 | 8 957 |
| Okuru River | | | | | | | |
| Site 3* | 3/9-14/11 | 54 | 95.8 | 3.5 | 0.7 | 0.1 | 10 967 |
| Waiatoto River | | | | | | | |
| Site 1 | 26/8-14/11 | 108 | 98.0 | 1.5 | 0.5 | 0.1 | 32 579 |
| Site 2 | 29/10-17/11 | 11 | 91.8 | 1.5 | 6.7 | 0.1 | 5 977 |
| Site 3 | 6/10-12/11 | 22 | 97.0 | 2.5 | 0.6 | 0 | 8 275 |
| Site 4 | 4/9-18/11 | 58 | 97.1 | 2.3 | 0.6 | 0.1 | 25 805 |
| Site 6 | 5/9-21/11 | 54 | 79.5 | 19.9 | 0.6 | 0.1 | 20 766 |
| Site 7 | 27/9-30/10 | 23 | 84.1 | 15.8 | 0.1 | 0 | 6 946 |
| Site 8 | 19/8-30/10 | 43 | 94.8 | 5.2 | 0.1 | 0 | 12 918 |
| Hindley Creek | 28/9-14/11 | 94 | 98.8 | 0.4 | 0.8 | 0.1 | 29 435 |
| Dawn Rivulet | 17/8-14/11 | 102 | 99.6 | 0.1 | 0.2 | 0 | 30 647 |
| Content Creek | 30/8-12/11 | 76 | 99.3 | 0.1 | 0.6 | 0.1 | 20 257 |
| Nolans Creek | 16/8-7/11 | 64 | 99.7 | 0.2 | 0.1 | 0 | 7 089 |
| Cascade River | 1/9-22/11 | 76 | 97.2 | 2.0 | 0.8 | 0 | 44 037 |
| | | | | | | | Total 264 655 |

*For explanation of site numbers see page 13.

**TABLE 18: Catch composition summary for west coast, South Island, rivers sampled in 1973**

| Locality | Sampling period | No. of samples | Percentage composition *G. maculatus* | *G. brevipinnis* | *G. fasciatus* | *G. argenteus* | No. of fish |
|---|---|---|---|---|---|---|---|
| Okuru River | | | | | | | |
| Site 3* | 1/9–15/11 | 44 | 85.1 | 13.4 | 1.4 | 0.1 | 11 179 |
| Waiatoto River | | | | | | | |
| Site 2 | 1/9–16/11 | 36 | 93.6 | 3.1 | 3.3 | 0 | 14 514 |
| Site 4 | 3/9–15/11 | 55 | 91.9 | 6.4 | 1.7 | 0.1 | 18 942 |
| Site 6 | 1/9–16/11 | 34 | 68.9 | 30.6 | 0.5 | 0.1 | 10 626 |
| Cascade River | 1/9–16/11 | 70 | 95.0 | 3.9 | 1.1 | 0.1 | 40 746 |
| | | | | | | | Total 96 007 |

*For explanation of site numbers see page 13.

1972 in Hindley Creek and 1.07% and 0.23% in these years in Dawn Rivulet (Tables 16 and 17). Which environmental factor is important in influencing these differences — colour, pH, flow rate and volume, oxygen levels, or temperature — is not clear to us, but data from Content Creek suggest that colour and pH are probably not important. Content Creek is heavily brown stained and has very low pH, yet *G. fasciatus* enters it in large numbers.

Content Creek is brown, acid, well oxygenated, and cool; it is a moderately large stream with steady flow rate and enters the mid Waiatoto River estuary. We sampled migrations in the stream (1970–72) and, in 1970 and 1971, also in the Waiatoto River (site 5 in Table 2) just up stream from its confluence with Content Creek. There was a striking difference in catch composition (Tables 15 and 16), with *G. fasciatus* being relatively much more abundant in Content Creek and *G. brevipinnis* more abundant in the Waiatoto River. The difference for *G. brevipinnis* was especially marked. These data support our inferences from the Hindley Creek data that *G. brevipinnis* tends not to enter brown-water streams and that *G. fasciatus* enters these streams freely and shows preference for them. The data again indicate a fairly clear sorting of the mixed-species shoals according to water type.

Further confirmation that *G. brevipinnis* avoids acid, brown water comes from data from Nolans Creek, a very small, brown, acid, and poorly oxygenated creek. As discussed below, there is a tendency for increased proportions of *G. brevipinnis* in the upper Waiatoto estuary, so that the whitebait shoals passing the mouth of Nolans Creek have large numbers of *G. brevipinnis*. This is evident from catches taken just below the mouth of the creek (7.7% in 1971, 15.8% in 1972; site 7 in Tables 16 and 17). Despite these high percentages, very few *G. brevipinnis* were caught in Nolans Creek (35 of 13 240 fish caught there in 1971 and 1972, 0.26%). At high tides, especially when the Waiatoto River was high, the trap in Nolans Creek was inundated by river water, and it is likely that this influenced catch at the trap. If so, eliminating the influence of river water would probably reduce the already low numbers of *G. brevipinnis*. Numbers of *G. fasciatus* penetrating this far up stream are low (0.32% and 0.06% of catch taken at site 7, Waiatoto River, in 1971 and 1972; Tables 16 and 17). Proportions in Nolans Creek (0.57% and 0.11%) are a little higher, but probably not significantly so.

Nisson Creek enters the Waiatoto River about 8 km up stream from the river mouth and has water of composite origin. That which comes from Lake Nisson is acid and brown stained; that from a spring has neutral pH and is clear. The two tributaries meet about 300 m above the confluence of Nisson Creek with the Waiatoto. The relative contributions of the two tributaries vary with rainfall (see page 100). Catch of *G. brevipinnis* in Nisson Creek was surprisingly high (3.7% in 1970, 5.6% in 1971; Tables 15 and 16) in view of the results from brown-water streams lower in the river (Hindley and Content Creeks). It may be related to the presence of spring water in the creek. Possibly high numbers of *G. brevipinnis* occurred when the relative contribution of spring water to the combined flows was high. Possibly, too, the increasing proportion of *G. brevipinnis* in the catch with distance up stream (see page 62) contributes to the relatively high proportion of *G. brevipinnis* in Nisson Creek.

The spring stream (Branch Brook) enters Nisson Creek from the right bank. In 1970 our sampling trap was on the left bank below the confluence of Branch Brook and Nisson Creek, but in 1971 it was on the right bank immediately below this confluence. Although the overall percentage of *G. brevipinnis* in the catch in the Waiatoto River was 2.2 in 1970 and 3.3 in 1971 (Tables 15 and 16), the Nisson Creek figures were 3.7% in 1970 and 5.6% in 1971, and the increase in 1971 may be related to the greater influence of clear Branch Brook water at the 1971 fishing site.

Several kilometres further up stream we sampled migrations into three very small tributaries. These are relatively cool, clear, and slightly to moderately acid. Catches were small (only 717 fish from all three, in 2 years), but they were predominantly *G. brevipinnis* (90.01% over all; Tables 15 and 16). It may be argued that the high proportion of *G. brevipinnis* is a consequence of the failure of other species to migrate so far up stream, and this may be correct. The absence of clear tributaries entering the Waiatoto River estuary made it impossible to elucidate this question. But data do show that *G. brevipinnis* whitebait will enter these small, relatively clear tributary streams, in contrast to the brown-water streams.

### Effect of Distance up Stream

Comparison of the composition of samples taken at various localities in the Waiatoto River showed that the proportion of *G. brevipinnis* in the catch rose with distance up stream, *G. brevipinnis* replacing both *G. maculatus* and *G. fasciatus* in the catch. The most marked difference was between sites in the lower-mid estuary (fishing sites 1-5) and those in the upper estuary (sites 6 and 7). (Complete day-by-day catch composition data are given for all fishing localities in all years in Tables 62 to 72 (Appendix 5) and are summarised in Tables 14 to 18.)

Catch taken at various sites in the river is influenced by such environmental variables as entry of brown-water tributaries nearby, and thus the pattern of changing composition with distance up stream is not always simple.

The 1969 sampling programme included samples from site 2 in the lower estuary below Hindley Creek, site 6 in the mid-upper estuary, and site 7 in the upper estuary. *Galaxias brevipinnis* increased in importance from 7.0% at site 2 to 32.2% at site 6 and 50.7% at site 7 (Table 14). In 1970 samples were obtained from additional sites, and though *G. brevipinnis* was relatively much less abundant in this year (Table 15), a rise in proportion with distance up stream is evident. The pattern is similar in all subsequent years, except in certain instances. Thus in 1971 the percentage of *G. brevipinnis* at site 4, 1.1 km up stream, was a little lower than that at site 3, 1.0 km up stream (Table 16). This difference, if significant, may be related to the fact that the two sites are on opposite banks of the river and that fish from site 4 were derived in part from a small channel connected with a large area of coastal swamp, where *G. brevipinnis* would not be expected even in small numbers. A more substantial decline in the proportion of *G. brevipinnis* is apparent in 1972 between sites 6 (2.4 km up stream) and 7 (3.2 km up stream) (Table 17). The explanation for this is not evident to us, but it may be related to differing fishing habits. (The fisherman at site 6 in 1972 fished long hours, whenever conditions permitted, but the fisherman at site 7 in this year fished relatively few days, for few hours, and only when fishing was "easy". The result of this is that the fisherman at site 6 spent much more time fishing in turbid flood waters.) *Galaxias brevipinnis* is more abundant in the catch under turbid, marginal-fishing conditions, and this may be the explanation (see page 63).

Aware of the tendency for *G. brevipinnis* to become more important in the catch with distance up stream, we established in 1972 a sampling site above tidal influence about 4.4 km up stream from the mouth (site 8 in Table 2); we expected that the proportion of *G. brevipinnis* there would be high. This expectation was not realised, and, as Fig. 34 and Table 17 show, the proportion of *G. brevipinnis* was relatively low. Detailed day-by-day figures on catch composition (Table 68 in Appendix 5) show that on some days the proportion was high, but this was not consistently true. Reasons for this are unclear.

The pattern of up-stream increase in the proportion of *G. brevipinnis* in the Waiatoto River seems to recur in other rivers, as indicated by the few data we have from 1969 sampling. In the Haast River we obtained regular samples near the mouth and a few at a site about 4.2 km up stream. The proportion of *G. brevipinnis* at the up-stream site was about twice that near the mouth (Table 14). Similarly, regular sampling in the Arawata River near the mouth and a small series 7.4 km from the mouth showed a striking increase in the proportion of *G. brevipinnis* at the up-stream site (Table 14).

In contrast, the percentages of both *G. maculatus* and *G. fasciatus* decline up stream. This is especially clear for *G. maculatus* in 1969 and 1970, less so in 1971 and 1972, but strongly evident in 1973 (Fig. 34). Because *G. fasciatus* contributes so small a proportion of the catch, figures for the other two species are

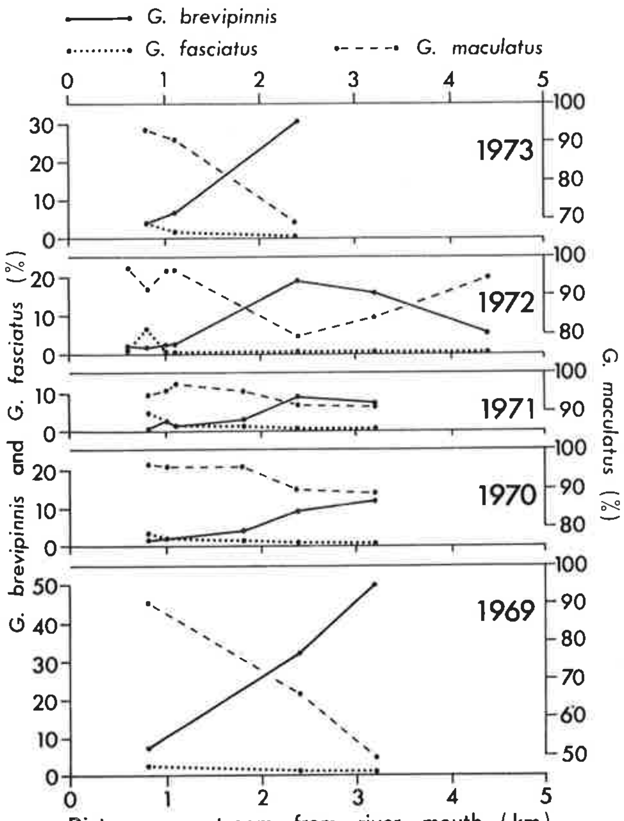


Fig. 34: Change, with distance up stream, in the proportion of *G. maculatus*, *G. brevipinnis*, and *G. fasciatus* in the Waiatoto River from 1969 to 1973.

closely and inversely related to one another. However, the percentage of *G. fasciatus* shows a decline up stream in all years (Fig. 34). This is especially clear in 1971, except that the influence of brown-water tributaries entering the Waiatoto River must be taken into account, as for *G. brevipinnis*. (However, the effect is the opposite, with an increase in the proportion of *G. fasciatus* at fishing sites influenced by brown water.)

Few *G. fasciatus* were found to reach upper sites in the Waiatoto River in all years studied; the figure for sites 7 and 8 in 1972 was 0.1% (Table 17).

The data for *G. argenteus* are very limited, but all except two of the few *G. argenteus* caught in the Waiatoto River were taken in the lower 2 km of the river. Two *G. argenteus* (one each in 1972 and 1973) were taken at site 6, 2.4 km up stream.

### Effect of Turbidity on Species Composition

Field observations suggested that the proportion of *G. brevipinnis* in the catches was often higher immediately after floods, when the water was still turbid, than at other times. Our data (Table 14) also show that *G. brevipinnis* is relatively more abundant in snow-fed rivers (Haast, Waiatoto, and Arawata), which tend to become turbid during the spring snow thaw, than in rivers draining coastal hills (Waita, Okuru, Turnbull, and Cascade). These observations suggest that turbidity is affecting species composition.

We calculated correlations between water turbidity (Table 42 in Appendix 5) and daily percentage composition of *G. brevipinnis* for a variety of rivers and years (Table 19). The results showed that in 4 of 19 instances there is a significant correlation — one negative and the others positive. These calculations do not give much support for a hypothesis that turbidity affects species composition.

We then plotted percentage composition of *G. brevipinnis* against river levels, water turbidity, and total catch and this showed that the proportion of *G. brevipinnis* tended to be high at the beginning of a run in turbid water after a flood. As the flood subsided, catch began to rise and the percentage of *G. brevipinnis* was high. With continued decline in river level and lowering turbidity the percentage of *G. brevipinnis* dropped, though the total catch continued to rise.

We have presented data in Fig. 35 for site 6 in the Waiatoto River in 1970, a site at which the correlation between turbidity and *G. brevipinnis* was not significant (Table 19). There is a flood peak (19 September) with low catches. As the river dropped, catch rose (20 September), with 37% *G. brevipinnis* caught at site 6. The river continued to drop; on 21 September *G. brevipinnis* declined to 16%, but catch continued to rise. This sequence of events was repeated from 24 September (flood); the percentage of *G. brevipinnis* was high when fishing began at site 6 on 27 September (22%), but declined as catch rose to a peak on 30 September. There was a large flood on 8 October, after which river level declined rapidly; the proportion of *G. brevipinnis* was 31% on 9 October, but declined to only 4% on 11 October, rose to 10% on 12 October, and dropped to 3% as catch rose to a peak on 13 October. Two small and brief peaks in percentage of *G. brevipinnis* occurred in the following few days; for one of these we have no level or turbidity data (15 October), but there was heavy rain (Table 32 in Appendix 5) and so probably a flood. The second peak on 19 October coincided with another minor freshet and increase in turbidity. A high peak in *G. brevipinnis* (49%) on 30 October does not appear to be related to any flood or high turbidity, though our data are incomplete from 30 October to 1 November. Unfortunately we have no sampling data for the period after the large flood from 22 to 24 October. A final small flood occurred in early November and the ensuing pattern was as described for previous floods. Similar patterns were evident in data for other years.

These observations indicate that *G. brevipinnis* is more tolerant of high water turbidities than *G. maculatus*. The observations do **not** show that *G. brevipinnis* prefers turbid waters, as catch of *G. brevipinnis* normally rises as total catch rises, but more slowly than catch of *G. maculatus*. As floods subside and rivers clear, *G. brevipinnis* becomes relatively less important in the catch, even though actual numbers migrating may be rising rapidly.

**TABLE 19: Relationship between water turbidity and percentage of *G. brevipinnis* in catch**

| Locality | n | *r* |
|---|---|---|
| 1969 | | |
| Waita River | 30 | 0.003 3 |
| Haast River | 68 | 0.115 5 |
| Okuru River | 39 | 0.152 5 |
| Turnbull River | 56 | −0.191 0 |
| Waiatoto River | | |
| Site 2* | 67 | 0.110 8 |
| Site 6 | 56 | 0.626 8† |
| Arawata River | 66 | 0.209 4 |
| 1970 | | |
| Waiatoto River | | |
| Site 2 | 38 | −0.126 4 |
| Site 5 | 42 | 0.046 2 |
| Site 6 | 41 | 0.239 9 |
| Site 7 | 39 | −0.333 1† |
| Okuru River | 39 | 0.369 9† |
| 1971 | | |
| Okuru River | 36 | 0.145 8 |
| Waiatoto River | | |
| Site 4 | 30 | 0.152 4 |
| Site 5 | 41 | 0.241 3 |
| Site 6 | 38 | 0.447 6† |
| 1972 | | |
| Waiatoto River | | |
| Site 1 | 38 | −0.185 1 |
| Site 4 | 40 | −0.098 4 |
| Site 6 | 41 | −0.183 0 |

*For explanation of site numbers see page 13.
†Correlation significant at 5% level of significance.

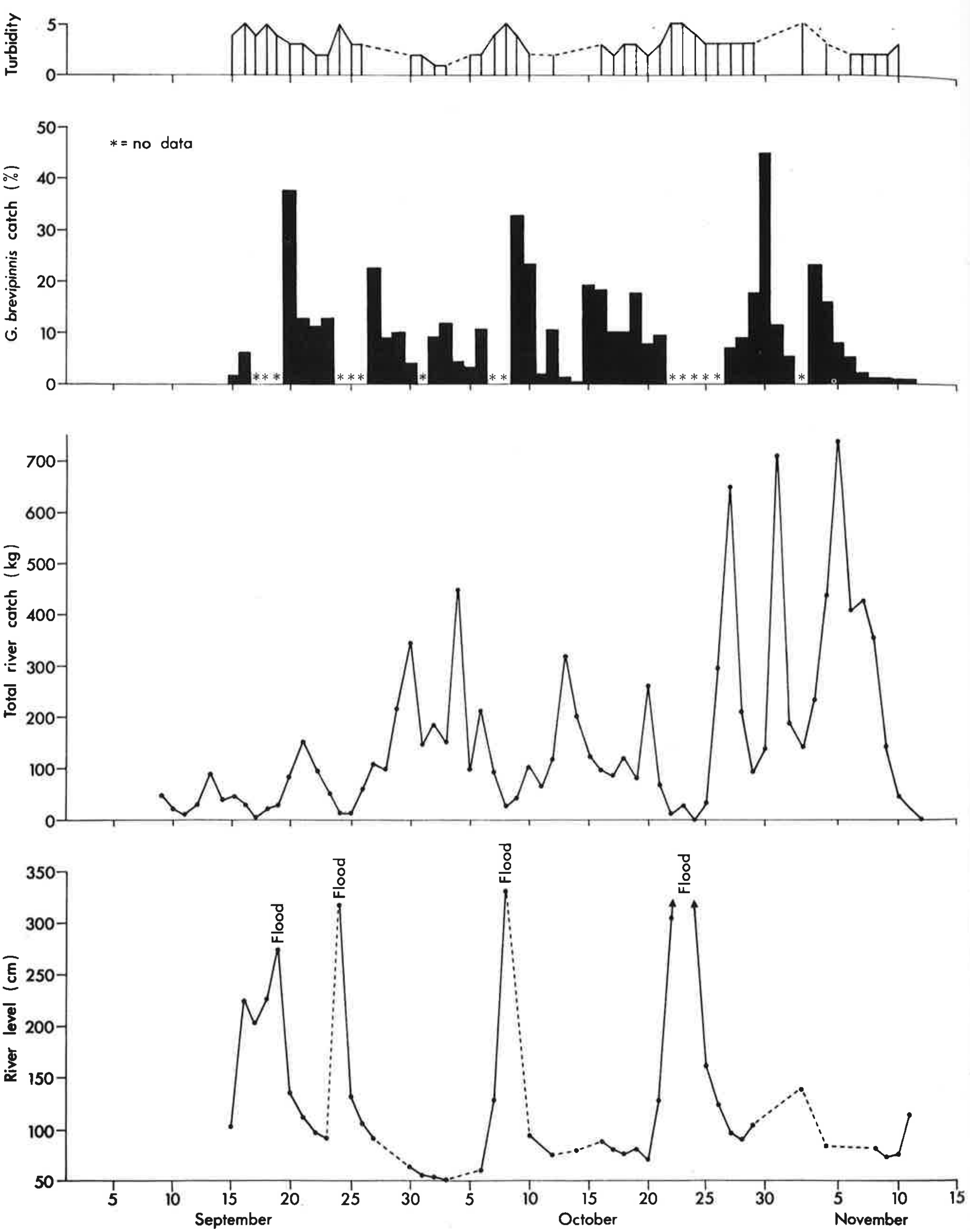



Fig. 35: Relationship between floods, turbidity, and percentage of *G. brevipinnis* in catch at site 6, Waiatoto River, in 1970.

Although there are sometimes rises in the percentage of *G. brevipinnis* apparently unrelated to changes in water turbidity (for example, 28 September-5 October 1969, Waiatoto River; Table 62 in Appendix 5), high proportions of *G. brevipinnis* are most evident when water turbidity has increased during and after floods.

## LOCAL VARIATION IN CATCH COMPOSITION IN HAAST AREA RIVERS

In addition to examining variation in catch composition **within** the Waiatoto River system, we studied variation **between** closely adjacent rivers in the Haast area, namely, Ship Creek, Waita River, Haast River, Okuru River, Turnbull River, Waiatoto River, Arawata River, Jackson Bay Stream, and Cascade River. Years when samples were obtained are shown in Table 1. Summed data for each river in each year are given in Tables 14 to 18 and daily sample composition is set out in Tables 62 and 63 (Appendix 5).

Substantial differences in catch composition between the various rivers observed in 1964 (McDowall 1965) recur in the present study. The percentage of *G. maculatus* is perhaps the best indicator of differences between rivers; in 1969 it varied from 97.6 for the season in the Waita to 26.3 in the Jackson Bay Stream (Table 14). The percentage of *G. maculatus* reached 97.7 in 1971 in the Cascade River (Table 16).

In any year certain rivers have very high proportions of *G. maculatus*, with only a small percentage of the other species. Thus the Waita and Turnbull (1969), the Okuru (1969-72), the Waiatoto (sites near river mouth) (1969-73), and the Cascade River (1970-73) had *G. maculatus* in excess of 90%, usually greater than 95% (Tables 14 to 18). The Haast and Arawata Rivers in 1969 had relatively low proportions of *G. maculatus* (60%-70%), but many more *G. brevipinnis*. The Jackson Bay Stream in 1969 carried a very large proportion of *G. fasciatus* (Table 14). Relative proportions of each species vary from year to year. This is due partly to sampling irregularities; for example, Cascade River samples were taken only to the beginning of November in 1971 (Table 72 in Appendix 5) and low numbers of *G. fasciatus* in the total samples may be due to the increasing abundance of *G. fasciatus* that is usual in the catch in November (see "Catch Composition and Seasonality", page 68).

Just as catch composition could be related to water characteristics in the Waiatoto River and its tributaries, so it can be related to water characteristics in these other rivers. Ship Creek is a deeply brown-stained, acid stream with oxygen levels at about saturation. The proportion of *G. brevipinnis* caught in Ship Creek in 1969 is very high in comparison with those from other brown-water streams (17.7%) (Table 14), but this is easily explained. Data from the Waiatoto River showed that the proportion of *G. brevipinnis* in the catch rose sharply immediately after floods while the water was still turbid; 196 of the *G. brevipinnis* caught in Ship Creek were taken in three samples collected immediately after severe and prolonged flooding in September 1969 and a further 89 after a flood in early October. These fish can be regarded as responding to flood conditions in Ship Creek and if we set these samples aside, *G. brevipinnis* constitutes only 59 of 1608 fish caught in the stream, or 3.7%. This is still a higher proportion than we would have expected from this brown-water stream. Possibly when mixed-species shoals are migrating from the sea, choosing between sea water and fresh water, the brown staining of the fresh water becomes less important.

Very high proportions of *G. fasciatus* were caught in a small tributary of Ship Creek. This is an acid and brown-stained stream and as it is a moderately swiftly flowing, tumbling forest stream, it is likely to be cool (we have no temperature measurements). A substantial proportion of the fish that entered this stream was *G. brevipinnis* (13.0%) (Table 14), a much higher proportion was *G. fasciatus* (79.1%), and there were very few *G. maculatus*.

The Waita River has moderately acid, brown water. It is a relatively warm river with substantial daily amplitude in temperatures. The run of whitebait into the river contained a high proportion of *G. maculatus* (97.6%), with a few *G. brevipinnis* (2.1%) and very few *G. fasciatus* (0.3%) (Table 14). Uniformity of the Waita catch is emphasised by the fact that of 233 *G. brevipinnis* caught 138 were taken on 2 days after the long September floods in 1969.

The Haast River has a high contribution of glacial and snow water and is cold, but its temperature fluctuates broadly. Samples taken in the lower estuary had relatively high proportions of *G. brevipinnis* (25.9%) and very few *G. fasciatus* (0.6%) (Table 14).

The Okuru River is clear and has moderate temperatures with average fluctuations. In 3 years *G. maculatus* was by far the most important species, but *G. brevipinnis* became important in 1969 (10.5%) and 1973 (13.4%) (Tables 14 to 18).

The Turnbull River resembles the Okuru, but its temperature fluctuates a little more. The water is extremely clear. Catch in this river in 1969 comprised a high percentage of *G. maculatus* (92.8%), some *G. brevipinnis* (6.7%), and very few *G. fasciatus* (0.5%) (Table 14).

The Waiatoto River, like the Haast, is snow and glacier fed; it is cold and its temperature fluctuates relatively little. Catch in the lower estuary (site 3) consisted mostly of *G. maculatus* (more than 95%), with a few of both *G. brevipinnis* and *G. fasciatus* (Tables 14 to 18).

The Arawata River resembles the Haast in most characteristics, but its temperature fluctuates more.

Samples from the lower estuary in 1969 contained moderate proportions of *G. maculatus* (62.1%), high numbers of *G. brevipinnis* (36.6%), and few *G. fasciatus* (1.2%) (Table 14, all sites combined).

The Jackson Bay Stream is a small, relatively clear, cool, and thermally stable stream, completely shaded by forest canopy. Samples from the stream in 1969 contained few *G. maculatus* (26.3%), occasional *G. brevipinnis* (1.8%), and large proportions of *G. fasciatus* (71.9%) (Table 14).

The Cascade River is of moderate size. We have few data on its physical characteristics, but it is surrounded in its lower reaches by extensive areas of swamp, and its water is brown stained. Temperatures are cool, with low amplitudes. Whitebait catches show consistently high proportions of *G. maculatus* (95.0%-97.7%), with few *G. brevipinnis* and *G. fasciatus* (Tables 14 to 18).

This series of rivers does not allow us to examine partition of mixed-species shoals at confluences, but only to make direct comparisons. The Haast and Arawata Rivers are distinctive in the high proportion of *G. brevipinnis*. These two rivers are the most affected by snow thaw and glacial flour, especially during floods and snow thaw. The high proportion of *G. brevipinnis* is likely to reflect greater tolerance of water turbidity (see "Effect of Turbidity on Species Composition", page 63). Remaining rivers, with the exception of the Okuru River in 1969 and 1973, had relatively low numbers of *G. brevipinnis*. Why *G. brevipinnis* was abundant in the Okuru in these years is not clear. It was particularly abundant in most rivers in 1969. In spite of the abundance of *G. brevipinnis* in 1969, few were caught in the Waita River (2.1%). This reflects warmer temperatures and brown water in this river.

Very high numbers of *G. fasciatus* and low numbers of *G. brevipinnis* in the Jackson Bay Stream are a contrast with the numbers in all other waters except those in the Ship Creek tributary mentioned above. The Jackson Bay Stream is a typical small, tumbling, bouldery, forest-enclosed stream where adult *G. fasciatus* are most often found, so that it is no surprise that whitebait of this species are abundant there. But the almost complete exclusion of *G. brevipinnis* is surprising, as this stream is not unlike streams where *G. brevipinnis* is found. Exploratory electric fishing for adult galaxiids in the Jackson Bay Stream, for several kilometres, revealed very large numbers of *G. fasciatus* adults, but few *G. brevipinnis*.

## CATCH COMPOSITION IN HOKITIKA AND BULLER RIVERS

Catch sampling was done in the Buller (1970-72) and Hokitika (1970-71) Rivers. The Hokitika River is notable for the relatively high proportion of *G. fasciatus* and the Buller for abundance of both *G. brevipinnis* and *G. fasciatus* (Tables 15 to 17). We have some evidence from size of fish at migration that the Buller River stock is a fairly local one, and it is possible that high proportions of *G. fasciatus* and *G. brevipinnis* in this river, compared with those in the Haast area, may be related to land development in the Buller catchment; that is, extensive land development for agriculture in the lower and coastal Buller catchment may have led to a decline in the abundance of *G. maculatus* in the Buller River stock. Inland forest streams in the catchment are less affected by land development, as large areas of forest remain. Hence the effects of *G. brevipinnis* and *G. fasciatus* may be less severe. The topography of the immediate coastline in the Buller area is rugged and steep. Areas suitable for growth in fresh water and for estuarine spawning of *G. maculatus* are probably much more restricted than in rivers to the south. Relatively low numbers of *G. maculatus* in the Buller River possibly reflect this.

## DISCUSSION

Our data on differences in species composition in relation to water characteristics enable some generalisations to be made about the factors that affect the pattern of fish movements.

*Galaxias maculatus* occurs in large numbers, in almost all water types and conditions. It seems little affected by water temperatures, as it is abundant in both warm and cool waters, by pH, as it occurs in both neutral and acid waters, or by water colour, as it is found in both clear and brown-stained waters. Its reduced abundance after floods in turbid water, and in snow-fed rivers, suggests that migration may be affected by high turbidity. Very low numbers taken in the Jackson Bay Stream, where the trap was placed in heavy bush, may indicate that *G. maculatus* does not enter streams where there is a heavy forest covering and low light levels.

*Galaxias brevipinnis* occurs in cool waters, but less commonly in warm waters, and in clear, neutral waters much more than in brown, acid waters. Turbidity seems to affect migration of *G. brevipinnis* less than that of other species.

*Galaxias fasciatus* is found only in cold waters and may occur in clear, neutral pH or brown, acid waters, but seems to avoid high turbidity.

Both *G. maculatus* and *G. fasciatus* seem to penetrate up stream less than *G. brevipinnis* in the Waiatoto, though general observations show that in some river systems *G. fasciatus* may penetrate long distances (McDowall 1970a).

# INTERSPECIFIC VARIATION AND SEASONALITY IN WHITEBAIT MIGRATIONS

The annual period of whitebait migration was discussed on page 32. Migration occurs primarily in spring, and analysis of 15 years' catch data from the Cascade River showed that the main period of catch is from mid September to late October (Fig. 17). Within the cycle of changing catch quantities there is seasonal variation in occurrence of the species in the catch. Therefore we examined seasonality in the three principal species by looking at both seasonal changes in relative composition of the catch and changes in the absolute numbers of each.

## CATCH COMPOSITION AND SEASONALITY

Seasonal changes in catch composition were examined primarily in Cascade River samples (1970–73), partly because this river is not affected by snow-thaw turbidity in late spring (which itself affects composition) and partly because of consistency of sampling in the river. Data from other rivers were used in support.

Initially we plotted percentage composition of samples against day. We also took the percentages of *G. brevipinnis* and *G. fasciatus* in each day's sample, summed percentages for each species, and calculated each day's percentage as a weighted percentage of the summed daily figures. This procedure gives equal weight to each day's sample as a percentage of total sampling for each species for the season. These weighted percentages were then accumulated by day, and the cumulative figures were plotted against day. The graphs (Figs. 37 and 40) indicate when the two species occurred in consistently large proportions in the catch; the gradient of the line is proportional to the cumulative increase in catch for the species. Where seasonal variation in percentage composition of samples is pronounced, the plots of percentage composition against day reveal this (for example, Cascade River in 1970; Fig. 36). Less abrupt or profound changes become more evident in a plot of cumulative percentage (Fig. 37).

***G. maculatus***. Because the percentage of *G. maculatus* in the catch is so consistently high and fluctuates little, seasonal patterns of occurrence are more

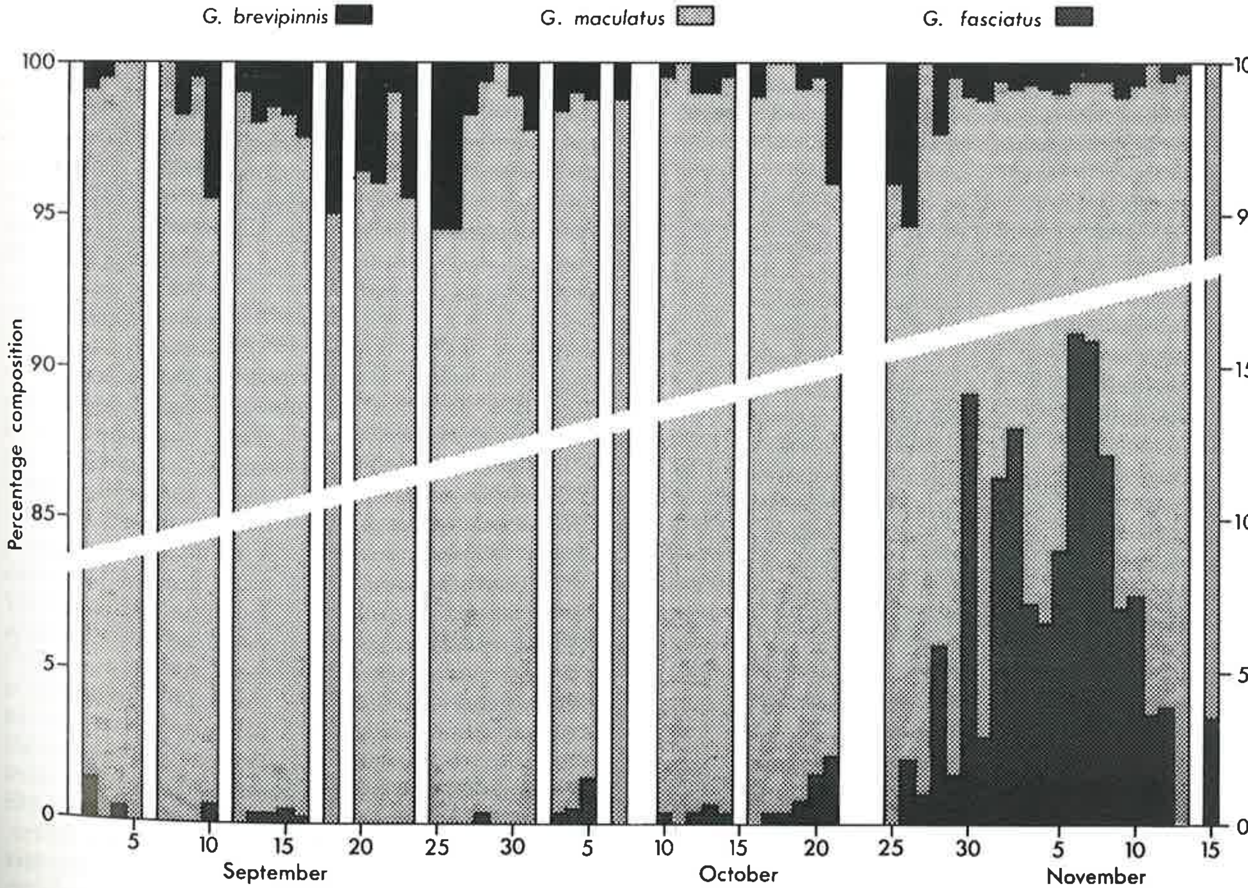



Fig. 36: Seasonal variation in percentage composition of catch in the Cascade River in 1970.

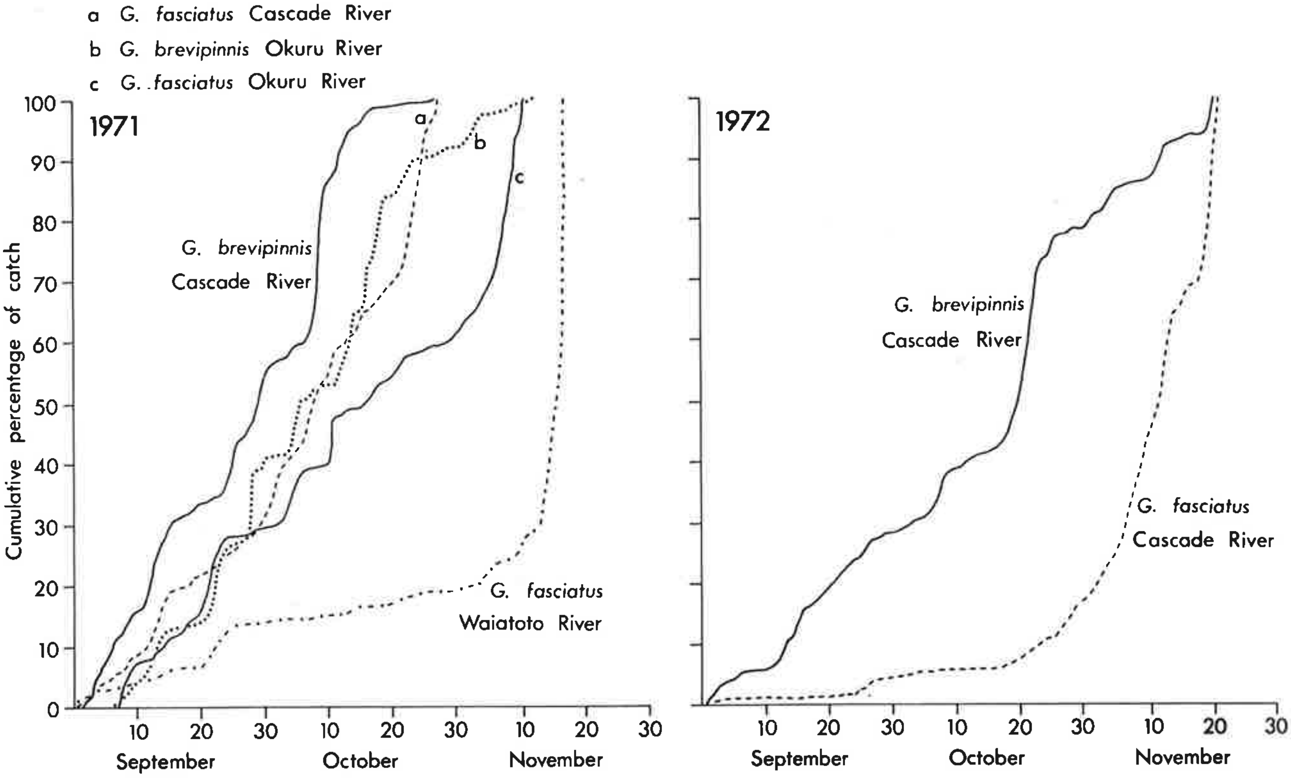



Fig. 37: Seasonal variation in cumulative percentage composition of catch in various rivers in 1971 and 1972.

or less equivalent to seasonal patterns of change in total catch. Peak catches of whitebait, and consequently of *G. maculatus*, occur from mid September to October.

***G. brevipinnis***. In September and October *G. brevipinnis* contributes most to the catch, with a decline in proportion usual in November. The plot of catch composition against day for the Cascade River in 1970 (Fig. 36) indicates that *G. brevipinnis* is more abundant in September and declines thereafter. The cumulative percentage plot reveals the same pattern. In 1971 sampling in the Cascade River ceased at the end of October, but data for September and October show a decline in abundance of *G. brevipinnis* during late October after steady occurrence before this time. The Okuru River data in 1971 showed a similar decline in late October, this decline persisting until sampling ceased in mid November. Figures for the Cascade River in 1972 and 1973 show similar patterns.

*Galaxias brevipinnis* fluctuates broadly and irregularly from day to day, partly because of the effects of water turbidity (see page 63). Periods when the proportions of *G. brevipinnis* are very high thus tend to follow floods. Consequently the proportion of *G. brevipinnis* tends to be high during September and October, but to decline in November.

***G. fasciatus***. Data on *G. fasciatus* for 1970 and 1972 show a pronounced concentration in relative abundance during late October and November. Thus only about 10% of the cumulative percentage figure was taken by 29 October in 1970 and by 28 October in 1972. The 1971 Cascade figures contain no November material, so that the graph indicates a steady rise in the proportion of *G. fasciatus* through September and October. Examination of the catch figures (Table 72 in Appendix 5) shows that the proportion of *G. fasciatus* in the catch was low for the entire period. By comparison, data on *G. fasciatus* for 1971 in the Waiatoto and Okuru Rivers (Tables 66 and 71 in Appendix 5) reveal a moderate increase in the proportion in the Okuru River, but there is a conspicuous rise between 10 and 23 November in the Waiatoto River. The 1973 Cascade River data differ from those in other years (Table 72 in Appendix 5); *G. fasciatus* shows a steady rise in cumulative proportion during the whole of October. In general when our catch composition data continue well into November they show that the greatest proportions of *G. fasciatus* occur late in the season, mostly in mid November.

***G. argenteus***. Very few *G. argenteus* were found in samples. They occurred almost exclusively in November and most often from 6 to 8 November onwards (Table 73 in Appendix 5). In Fig. 38 we show the bulked catches of *G. argenteus* for all years in the Haast area and in the Hokitika and Buller Rivers. Concentrated occurrence of *G. argenteus* in the late season is clearly evident.

## CATCH NUMBERS AND SEASONALITY

The preceding discussion has examined variation in proportions of the species in the catch, but has given no consideration to variation in catch quantities with time. Thus *G. fasciatus* is increasing in proportion at the end of the fishing season, at a time when the catches are declining rapidly. It is therefore important to examine seasonal variation in the numbers of fish migrating. Fish numbers were calculated for the Waiatoto (1969-73), Okuru (1969-73), and Cascade (1970-73) Rivers.

### Calculation of Fish Numbers

To determine seasonality in migration of each species each year the number of fish of each species migrating each day had to be found. These figures were derived from the following data: (1) weight of fish caught each day, (2) species composition of catch each day, and (3) length and length-weight relationship of each species each day.

1. We obtained catch data for each day from fishermen's diaries, from figures from principal commercial whitebait buyers in the Haast area, and by questioning fishermen (see page 17).

2. The species composition is known for between two and six fishing sites on the Waiatoto River (1969-73; see Table 2), for from one to three sites on the Okuru River (1969-73), and for one site on each of the Waita (1969), Haast (1969), Turnbull (1969), Arawata (1969), and Cascade (1970-73) Rivers (Table 1).

3. Length and length-weight relationship data were obtained during study of variation in size at migration (see page 21).

We calculated quadratic regression equations, length against day, for each species, each season, which give a predicted length for each species on each day of each season (Table 74 in Appendix 5). We calculated the log/log regression for length-weight relationship for each species in each season (Table 75 in Appendix 5), and application of predicted daily length for each species to these length-weight regressions gave a predicted daily weight for fish of each species in each season. Knowing species composition of the catch for each day and using the predicted weight for the species on that day, we were able to convert weight of fish caught into numbers of fish of each species caught per day.

On some days whitebait catch was recorded, but no samples were obtained to determine species composition. When this occurred species composition values assigned to that day's catch were the means of the values for the days before and after.

This procedure resulted in some errors and assumptions. It assumed that the condition of the fish (length-weight relationship) did not alter during the season; that is, that a fish of, say, 49 mm weighs the same at any time during the season. In most rivers we obtained catch samples from only one site in the river. Thus when converting these catch composition figures to fish numbers, by use of the catch weights from the entire river, we are assuming that the catch composition figures we have are representative of all catches on the river. Our catch composition data for the Waiatoto River are much more extensive than those for other rivers, and they show that there is a tendency for the percentage of *G. maculatus* and *G. fasciatus* to decline up stream and for that of *G. brevipinnis* to increase (see page 62).

Most whitebait were caught near lower sampling sites; for example, in 1972, 66.3% of catch in the Waiatoto River was taken below sampling site 4 in the lower 1.1 km of the river; 87.1% of the season's catch was taken either below site 4 or in the next kilometre up stream. Our catch quantity data are not sufficiently complete to allow us to partition catch among various sampling sites. Accordingly we have bulked all catch data in the lower 2.5 km of the river and have taken this figure as being equivalent to the mean percentage composition for all sampling stations in the lower reaches. In effect all whitebait caught below the main road bridge has been regarded as having the average species composition of all sampling stations in that area of the river. There were a few fishing sites

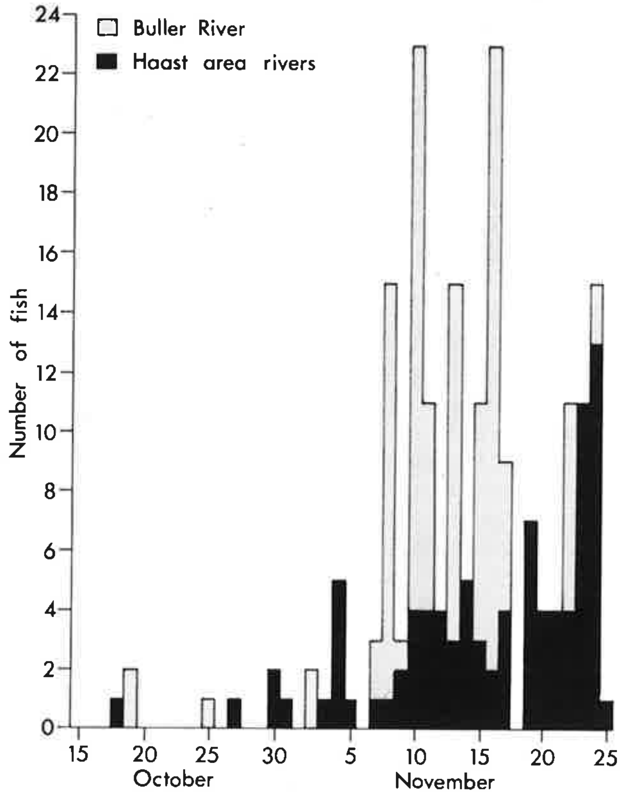



Fig. 38: Seasonal occurrence of *G. argenteus* in whitebait catch for all years combined.

further up stream, two of which were sampled from 1969 to 1972 and one also in 1973. Whitebait caught above the bridge has been assigned species composition values of those of the nearest sampling station. The quantity of whitebait caught above the bridge is very small, for example, 5.5% of the 1972 season's catch. Most fish caught there were taken by a fisherman sampling for us (4.9% of the 1972 season's catch or 88.4% of catch above the bridge).

*G. maculatus*

Seasonal distribution of this species is essentially a reflection of seasonal distribution of whitebait catch as a whole because of its preponderance in the catch. Thus in 1969 both the Okuru and Waiatoto data showed *G. maculatus* abundant from mid September to mid October and decreasing thereafter (Fig. 39). The 1970 data varied from river to river. The Cascade River showed major catches of *G. maculatus* in September, low numbers through October, and a substantial peak (evident as a steep gradient) in early November (Fig. 40). The Okuru data show a succession of high catches throughout the season, some of these coinciding with those observed in the Cascade. The Waiatoto catch pattern is different again, with little catch in September, small runs in October, and a major run in late October and early November.

The 1971 pattern is similar in the three rivers, with poor catches of *G. maculatus* in early to mid September and runs developing in late September and persisting through the first week of November before declining. The 1972 season is similarly more consistent between rivers and shows poor September catches and periods of high catch in mid October and early November. In 1973 catches of *G. maculatus* were very poor in the Cascade River until mid October (less than 20% of the season's catch), but rose and remained high almost until fishing ceased in mid November. In the Okuru and Waiatoto Rivers cumulative catch rose more consistently throughout the season.

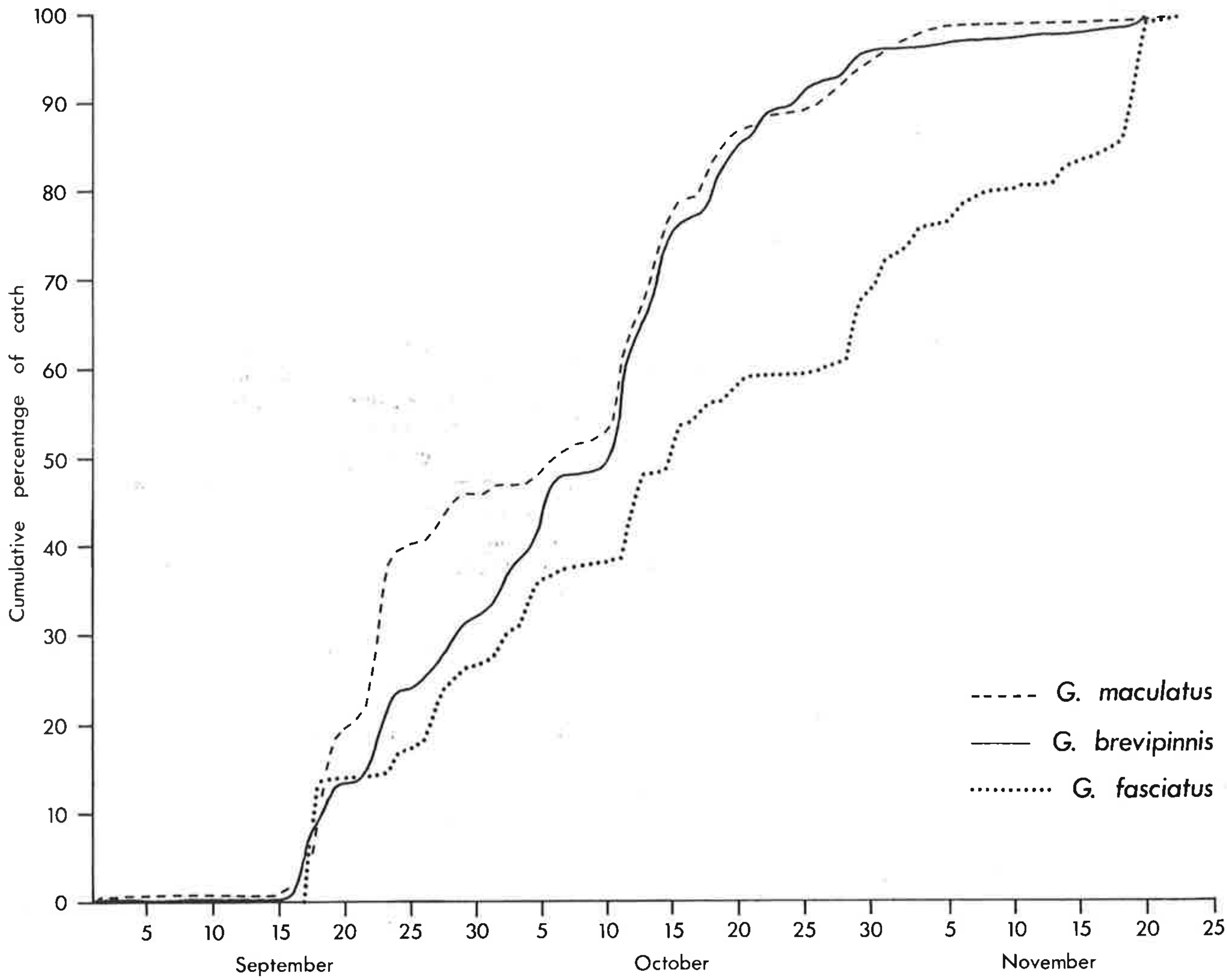



Fig. 39: Seasonal distribution of *G. maculatus*, *G. brevipinnis*, and *G. fasciatus* in catch in the Waiatoto River in 1969 (absolute numbers).

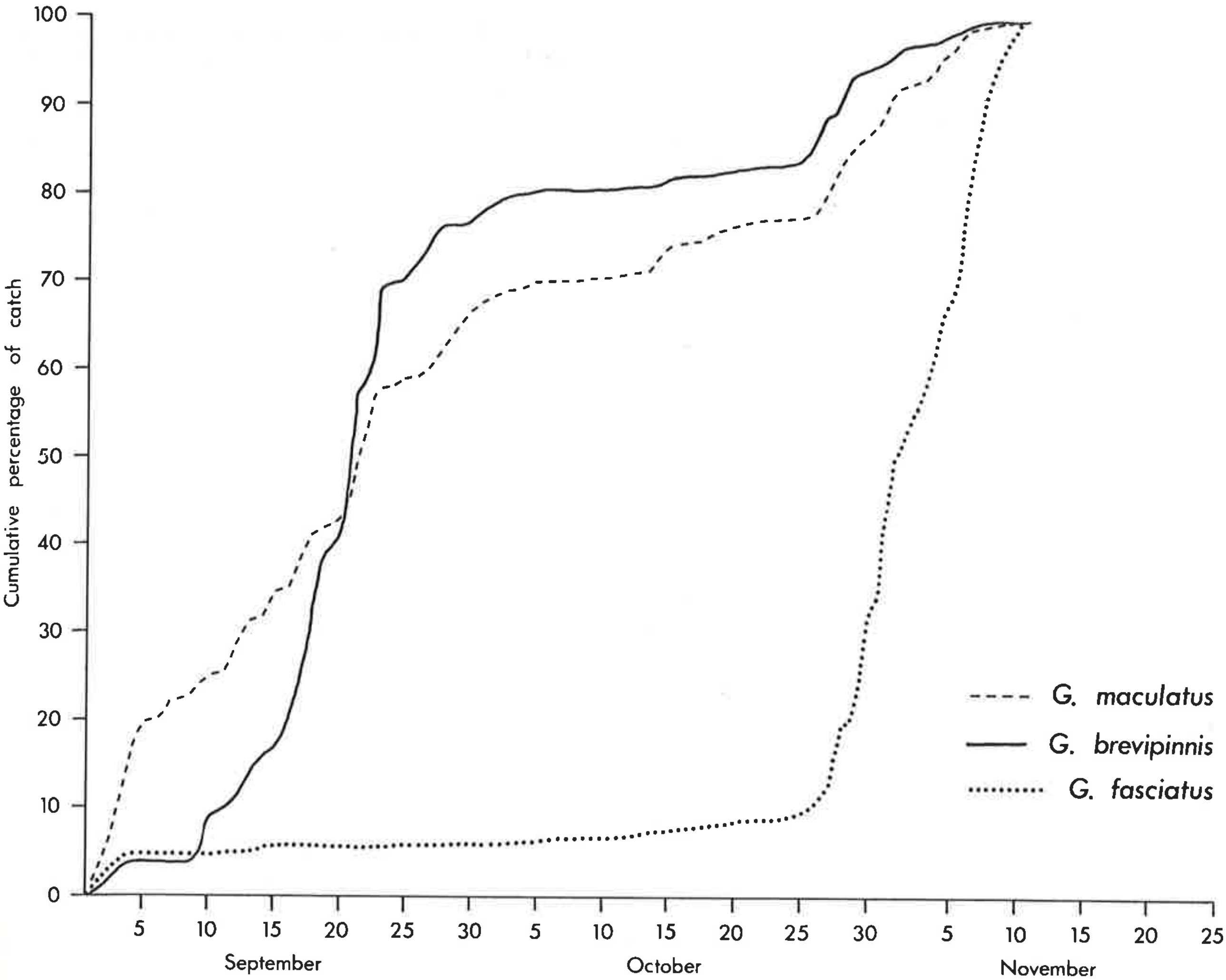



Fig. 40: Seasonal distribution of *G. maculatus*, *G. brevipinnis*, and *G. fasciatus* in catch in the Cascade River in 1970 (absolute numbers).

These data suggest that biggest catches of *G. maculatus* may be taken at any time between mid September and early November and that the time of occurrence of *G. maculatus* is fairly flexible. Unfortunately fishing activity substantially reflects abundance of *G. maculatus* in the rivers, so that the data do not extend far into periods of low abundance in the late season.

Usually fishing has ceased by mid November and only rarely are large catches made in late November. We know of only one such instance in recent years. A big flood in the Haast River about 20 November 1968 was followed by a run of fish, and one fisherman caught 380 kg of whitebait in the following 10 days. This was 45% of his catch for the whole season (837 kg). Although these figures are for total catch, because *G. maculatus* makes up such a high proportion, they are likely also to relate closely to catch of *G. maculatus* and can be regarded as an unusual instance of a run of *G. maculatus* in late November.

Examination of fishing records for the Awarua River (1948–61) and Cascade River (1959–73) indicates that large catches were rare after about 15 November; in many years fishing ceased before this date, though it is notable that in 1968, the year when a good, late run occurred in the Haast River, the Cascade fishermen also fished to the end of November and caught substantial quantities of whitebait, presumably mostly *G. maculatus*, late in the month.

*G. brevipinnis*

The seasonal pattern of occurrence of *G. brevipinnis* tends to resemble closely the pattern for *G. maculatus*, and normally most *G. brevipinnis* are caught before the end of October. The cumulative percentage graphs (Fig. 37) show this to be so. High catches of *G. brevipinnis* are sometimes evident in September, for example, Cascade in 1970 (Fig. 40), but more often they occur in October and occasionally in late October or early November, for example, Cascade and Waiatoto in 1973. It seems clear that large catches of *G. brevipinnis* tend to coincide with large total catches, as do catches of *G. maculatus*.

*G. fasciatus*

The seasonal pattern of occurrence of *G. fasciatus* differs from that of *G. maculatus* and *G. brevipinnis*; *G. fasciatus* tends to run much later. There is variation from river to river and year to year, but late runs of *G. fasciatus* were especially evident in the Waiatoto River in 1969 (Fig. 39), 1970, and 1972, the Okuru in 1970 and 1972, and the Cascade in 1970 (Fig. 40) and 1972.

The major run of *G. fasciatus* was equally late in the year in all rivers in 1973, but because of the late advent of major flooding to stimulate runs in 1973, the major runs of *G. maculatus* and *G. brevipinnis* occurred at about the same time as those of *G. fasciatus*. Late runs of *G. fasciatus* would probably be even more evident if more fishing was carried out in late November and perhaps later.

# INTERSEASONAL VARIATION IN NUMBERS

Data for estimated numbers of whitebait of *G. maculatus*, *G. brevipinnis*, and *G. fasciatus* caught were summed for each species each year for the Okuru and Waiatoto Rivers (1969–73) and the Cascade River (1970–73) (Table 20, Fig. 41). Similarities within species and between rivers are greater than similarities within rivers and between species; that is, patterns of change within species correlate more closely than patterns within rivers. In particular, changes in abundance of each species in the Okuru and Waiatoto Rivers bear a close resemblance.

Because *G. maculatus* usually makes up more than 90% of total catch, numbers of *G. maculatus* relate closely to total catch. In contrast, numbers of *G. brevipinnis* may change in a quite different pattern. When total catch rose from 1969 to 1970, the number of *G. brevipinnis* caught in the Okuru and Waiatoto Rivers declined. Catch declined in these rivers, and also in the Cascade in 1971, but numbers of *G. brevipinnis* caught in the Okuru River rose slightly. Total catch and numbers of *G. brevipinnis* rose in all rivers in 1972, but though catch in the Okuru and Waiatoto declined sharply in 1973, catch in the Cascade rose, and numbers of *G. brevipinnis* caught in all three rivers rose, slightly in the Okuru, sharply in the Waiatoto, and very sharply in the Cascade River (from 315 551 fish in 1972 to 2 446 809 in 1973). The rise in numbers of *G. brevipinnis* in the Okuru and Waiatoto Rivers in 1973, which coincided with a sharp decline in total catch, resulted in a sharp rise in the percentage contribution of *G. brevipinnis* to the catch in these two rivers. Although total catch in the Cascade rose from 1972 to 1973, the rise in numbers of *G. brevipinnis* was relatively much greater than that of *G. maculatus*. As a result the percentage contribution of *G. brevipinnis* to total catch in the Cascade River is also higher in 1973 than in other years. In fact, comparison shows that many more *G. brevipinnis* were caught in the Cascade River in 1973 than *G. maculatus* in the Okuru River in that year. This is not normally true.

Variations between seasons in numbers of *G. fasciatus* tend to follow those of *G. maculatus* more closely. A rise from 1969 to 1970 and a fall in 1971 in total catch and numbers of *G. maculatus* are repeated in those of *G. fasciatus* for all three rivers. Catch rose

**TABLE 20: Estimates of total catch of the three principal whitebait species in Okuru, Waiatoto, and Cascade Rivers from 1969 to 1973**

| Year | *G. maculatus* No. of fish | % | *G. brevipinnis* No. of fish | % | *G. fasciatus* No. of fish | % | Total No. of fish |
|---|---|---|---|---|---|---|---|
| Okuru River | | | | | | | |
| 1969 | 4 939 876 | 94.4 | 270 722 | 5.1 | 24 106 | 0.5 | 5 234 704 |
| 1970 | 5 102 974 | 96.5 | 92 934 | 1.8 | 89 005 | 1.7 | 5 284 913 |
| 1971 | 3 300 451 | 95.0 | 115 918 | 3.3 | 57 329 | 1.7 | 3 473 698 |
| 1972 | 9 567 526 | 96.9 | 250 243 | 2.5 | 59 023 | 0.6 | 9 876 792 |
| 1973 | 1 315 909 | 80.6 | 289 775 | 17.7 | 29 282 | 1.7 | 1 634 966 |
| Waiatoto River | | | | | | | |
| 1969 | 7 996 666 | 90.0 | 836 502 | 9.4 | 54 475 | 0.8 | 8 887 643 |
| 1970 | 15 746 950 | 95.2 | 465 598 | 2.8 | 338 639 | 2.0 | 16 551 187 |
| 1971 | 11 217 168 | 96.6 | 260 733 | 2.2 | 128 975 | 1.1 | 11 606 876 |
| 1972 | 15 306 910 | 97.0 | 349 077 | 2.2 | 128 656 | 0.8 | 15 784 643 |
| 1973 | 6 286 785 | 89.1 | 728 973 | 10.1 | 131 596 | 1.8 | 7 147 354 |
| Cascade River | | | | | | | |
| 1970 | 14 044 870 | 96.6 | 203 803 | 1.4 | 287 453 | 2.0 | 14 536 126 |
| 1971 | 12 965 670 | 98.1 | 130 046 | 1.1 | 116 474 | 0.9 | 13 212 190 |
| 1972 | 24 332 200 | 97.4 | 315 551 | 1.3 | 309 599 | 1.3 | 24 957 350 |
| 1973 | 36 177 480 | 92.0 | 2 446 809 | 6.2 | 683 172 | 1.8 | 39 307 461 |

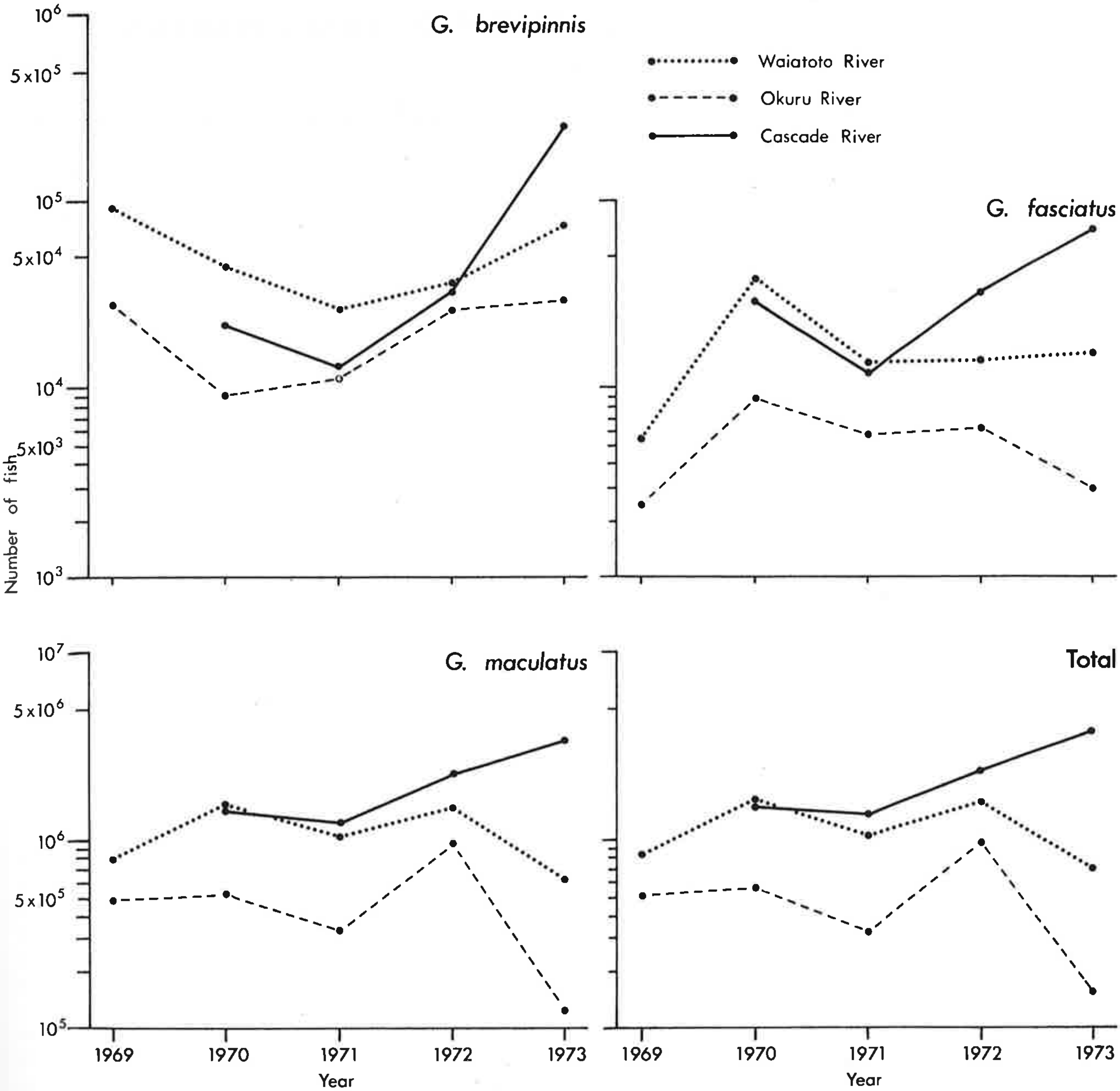



Fig. 41: Variation in the total numbers of *G. maculatus*, *G. brevipinnis*, and *G. fasciatus* caught in the Waiatoto, Okuru, and Cascade Rivers from 1969 to 1973.

again in 1972, but numbers of *G. fasciatus* remained relatively stable in the Okuru and Waiatoto Rivers, but rose in the Cascade. In 1973 total catch and numbers of *G. fasciatus* in that total fell in the Okuru. Total numbers fell, but numbers of *G. fasciatus* remained stable in the Waiatoto, and both total numbers and numbers of *G. fasciatus* rose in the Cascade.

Over all, the numbers of *G. fasciatus* caught are so small that variation has little effect on total catch. This is not true for *G. brevipinnis*; the very large numbers caught in the Cascade River in 1973 constituted a significant part of the fishery.

Reasons for these variations and differences between species in the patterns of variation are not understood, and they will not be until the biology of the adults of the respective species is better known. However, differences between the species in the pattern of abundance may indicate that life in diverse adult freshwater habitats is of major importance in controlling survival and production. Possibly interspecific differences in behaviour and habitats in fresh water are critical to reproductive success and of more importance to survival than differences in habits in the marine plankton.

# CATCH AND EFFORT IN THE WHITEBAIT FISHERY

An important question for both understanding and managing the whitebait fishery is that of catch and effort and the relation of these to escapement of fish. Fishing pressure and efficiency determine the proportion of the run on a given river that is caught and the proportion that eludes capture and thus provides for recruitment into the adult population.

Fishing methods have not changed much for many years, so that fishing efficiency (if it is defined as the proportion of those fish reaching the mouth of a net that enter it and are retained) is unlikely to have changed much in recent times. However, fishing pressure (the number of man-hours spent on the rivers) has undoubtedly increased as both population and the relative value of whitebait on the markets have risen (McDowall 1968). Road access has improved in South Westland, the use of light aircraft has increased, and more and more fishermen are working on the rivers, which are becoming increasingly crowded. There is a limit to this crowding. Whitebait fishing regulations provide that whitebait stands shall be no closer than 2 chains (about 40 m). To limit the number fishing and prevent crowding the fishermen commonly space stands at about 3½ chains (70 m) apart. (Fishermen believe that if stands were 2 chains apart, the fish would be so spread among them that no one would make a living. In other words, they believe that increased effort leads to spread of limited catch among more fishermen.)

At present we have no data on how catch increases with total effort, that is, number of fishermen. Fishing effort has been rising for many years, but total and regional catches have fluctuated so widely that comparisons of catch with effort, and attempts to correlate the two, are meaningless. For example, in the last 19 years the greatest total catch for the West Coast was more than eight times the least catch. Nor is it possible now to trace a build-up in the fishery with increase in effort during development of the fishery since its beginning about 100 years ago, as there are no records. There is no doubt, though, that increased effort, where it includes spread of effort to new river systems, has increased production. However, much, if not most, increased effort has meant increased numbers of fishermen on rivers sometimes already fished heavily; this is likely to continue, and the problem of rising fishing pressure is in need of continuing attention.

With better knowledge of the fish's behaviour, fishing methods, and interaction of the two, it becomes possible to draw some inferences on the likely relationship between catch and effort.

The fish are exposed to the threat of capture as soon as they enter fresh water; in some small rivers they are caught while still in the surf. The threat of capture persists until the fish enter tributaries which are unfished or in which fishing is prohibited (there are few of the latter) or until they leave tidal waters, beyond which fishing by registered fishermen is prohibited. (Fishermen not at registered sites are free to fish as far up stream as they choose.)

At river mouths the fish are netted by scoop fishermen, who may catch substantial quantities; on most southern rivers there are relatively few scoopers, they fish less intensively, and they are able to fish only along the river margins. In rivers near population centres — Westport, Greymouth, and Hokitika — scoopers are more numerous and catch large quantities of whitebait.

Once they enter the estuaries the fish move up stream and are caught by being blocked by vertical screens, which regulations permit to project out into the river up to one-third of river width. The manner in which the fish move up river depends on current patterns; the fish probably seek an optimal water current rate, which seems to be the swiftest water in which they can make easy progress up stream (this is subjective, but we have no data). In brief, the fish seeking optimal water current may be found anywhere from close to the banks to mid stream.

When the tide is rising-to-full they may move straight up mid stream, especially when the rivers are low and down-stream current is reduced. Current tends to be greatest in centre river and decreases towards the banks, and flow rate increases with distance up stream from the river mouth. Thus as they progress up stream the fish tend to swim closer and closer to the river banks. Because fishing stands are normally lined along the river banks, it is when the fish are forced by river flow to swim close to the banks that they are most subject to capture. They swim up stream against the screens of the stand, along the screens towards mid stream, and into or around the terminal net (depending on current flow through or around the outside of the net). Those fish that escape capture swim on up stream. Because they follow the river current, and because the current swings in towards the river bank between stands, the fish soon encounter the next stand up stream. Since there may be 20 to 30 or more stands up each side of the river it may seem surprising that any fish escape at all! Nevertheless, fishermen near the upper tidal limits of estuaries may catch substantial quantities of fish. The reason is partly that in the low flow conditions of high tide some fish can and do easily swim up the middle of the river, never encountering any stands. Thus, although it would seem that the first stand on a river would get the largest catches of fish, this does not necessarily follow and is often untrue. Catch at any site depends on river and tide conditions and current patterns and on the way which these modify fish movements. Two processes affect catch at any fishing stand. As the fish swim closer to the river banks their catchability, or accessibility to the fishermen, increases. At the same time more and more fish are being caught and removed from the river as the shoals move up stream past the fishing stands.

It seems clear that in many situations if one stand was removed from in front of another, the one behind would obtain increased catch directly related to the potential catch of the stand removed. Theoretically each fisherman catches fish that elude capture at the stands down stream. What the stands down stream "miss" depends on the size of such stands, their position in relation to river currents, the condition of the river at the time, and where in the river the fish are travelling. But ultimately, since the fish are forced by increasing river currents towards the margins of the river, if fishermen used large and efficient stands in the upper tidal reaches of the rivers, the total catch would not depend on the number and efficiency of stands further down stream at all, but on the efficiency of the up-stream stands.

In the early days of the South Westland whitebait fishery the few fishermen on the rivers — often only one on each bank — used to fish well up stream near the limits of tidal influence. High up in the estuary it is possible to fish efficiently and effectively with simple gear — small stands and few screens and nets. Current conditions are highly favourable; there is little tidal fluctuation and no tidal surge. It is only as the number of fishermen has risen that fishing pressure has increased in the lower estuaries.

Further down stream fishing conditions are more difficult. Bigger stands are built with many screens and more nets; such stands are much more prone to damage by flooding. Current conditions are less favourable, as at high tide the slack current in the lower estuary allows many fish to elude capture there. Tidal fluctuations necessitate higher stands and very long screens. Tidal surge may make fishing difficult or impossible. As fishing in the lower estuary requires more equipment, which is more vulnerable to floods, it is more expensive. Increased numbers of fishermen also result in fishermen building very big stands in difficult and unsuitable locations in the river, some of them in mid river with no connection to the bank.

Thus increased numbers of fishermen on the rivers have resulted in a change in the pattern of fishing, with a broader spread of fishermen throughout areas where fishing is legal. If there are many stands, the highly effective stands at the top of the estuary will catch relatively little, though they will catch most of the fish that reach them. If there are few or inefficient stands at the front, or if the whitebait are migrating up the mid river, the back stands fishing at the margins of rapid water will catch relatively more fish and continue to catch nearly all the fish that reach them. In the final analysis total catch, fishing efficiency, and escapement depend on the number of fish that the fishermen highest up in the estuary allow to escape.

In rivers which have important tributaries entering estuaries among the fishing stands the amount of whitebait that is allowed to escape capture also depends on the efficiency of stands immediately below the mouths of such tributaries.

We can perhaps reduce this to the following generalisation: In theory escapement of whitebait depends primarily **not** on fishing pressure as related to number of fishermen and man-hours fished, but **rather** on the efficiency of the last stands that the fish must swim past before they are no longer threatened with capture. Stands just below the point of entry of tributaries into estuaries and those at the top of estuaries are thus those which determine the number of fish which escape; the number of registered fishermen in the rivers does not.

How, then, has increased fishing pressure affected productivity and stability of the fishery?

It has increased catch on many southern rivers as these have become more accessible. Many of them may have been underexploited in the past, though knowledgeable fishermen were probably making good use of whitebait runs in these rivers when there were few fishermen. Increase in fishing pressure may continue until overexploitation occurs, and fluctuations in the catch on individual rivers and in subregions of the West Coast may need to be watched carefully to ascertain the effects of increased pressure on stocks.

Between 1959 and 1967 the Cascade River was fished by a pioneering group of 6 to 8 fishermen. Catch fluctuated widely. Further parties of fishermen first reached the Cascade River in 1968 and boosted the number of fishermen to 12; in 1969 there were 19 fishing there, 22 in 1970 and in 1971, and 18 in 1972 and 1973. Despite the increase in the number of fishermen, there has not been a decline in the catch of the pioneering group; rather total catch on the river has risen. This suggests underexploitation in earlier years.

In other rivers the number of fishermen has increased and as a result there has been a spread of a limited and intensively exploited resource among a greater number of fishermen. This has almost certainly brought an increase in average man-hours fished per fisherman. In addition, fishermen have been forced to increase their effectiveness, which has resulted in longer stands, more nets, and greater effort. It is here that danger of overexploitation lies. But, ultimately, we come back to the efficiency and fishing hours of critical fishermen immediately below routes of escape. If they are forced to build bigger stands and fish longer hours, the point may be reached when they allow no escape at all. This is quite practicable and within the law governing whitebait fishing.

Increased competition among fishermen has helped to ensure that they abide by the regulation that stands must be fished for at least 4 days a week. Formerly fishermen ceased fishing when catches were low or when the run terminated in mid, or even early, November. In recent years they have had to fish their stands until the end of the season for fear of losing their legal right to reregister the next year. This has increased fishing pressure and has reduced escapement resulting from failure of fishermen to persist in fishing to the end of the season. Late-season runs which formerly escaped are now being caught. (In 1970 the regulations were amended to allow fishermen to leave the rivers after 14 November.)

In principle escapement is controlled by the efficiency of the last net the fish must elude before they escape. In practice low efficiency of the critical upstream stands and low density of those further down stream may have meant that in the past the resource has not been fished as intensively as the regulations permit; escapement may have been good in earlier years, and certainly a few fishermen advised us that they made efforts to permit it. Increased stand density may have forced up-stream stands to increase fishing efficiency, and so, indirectly, increased numbers of fishermen have undoubtedly reduced escapement. Change in escapement seems likely to be due more to changed patterns of fishing induced by increased fishing effort rather than directly to changes in the number of fishermen fishing.

# FLUCTUATIONS IN THE WHITEBAIT FISHERY

The only "consistent", long-term, and broad-ranging record of whitebait catch in the past is the Marine Department annual *Report on Fisheries.* This began to record whitebait catch in 1927 and assumed a fairly standard form about 1930. From 1951 onwards, when it became clear that the commercial fishery was confined largely to the west coast of the South Island, published catch figures have been restricted to this region. The figures are obtained by fisheries officers through co-operation with commercial whitebait buyers and are derived primarily from buyers' records. A percentage is added by the fisheries officers to the figures for each area to allow for local consumption. How this percentage was originally determined is not known.

**TABLE 21: Whitebait catch on West Coast from 1931 to 1973**

| Year | Catch (kg) | Year | Catch (kg) |
|---|---|---|---|
| 1931 | 53 441 | 1953 | 220 369 |
| 1932 | 177 541 | 1954 | 218 695 |
| 1933 | 42 266 | 1955 | 322 224 |
| 1934 | 90 881 | 1956 | 181 763 |
| 1935 | 10 143 | 1957 | 168 250 |
| 1936 | 26 010 | 1958 | 115 113 |
| 1937 | 76 885 | 1959 | 140 548 |
| 1938 | 49 632 | 1960 | 51 359 |
| 1939 | 32 207 | 1961 | 86 105 |
| 1940 | 86 868 | 1962 | 38 253 |
| 1941 | 118 618 | 1963 | 102 158 |
| 1942 | 12 446 | 1964 | 143 359 |
| 1943 | 190 855 | 1965 | 121 923 |
| 1944 | 200 405 | 1966 | 47 803 |
| 1945 | 284 428 | 1967 | 96 926 |
| 1946 | 195 325 | 1968 | 153 517 |
| 1947 | 261 060 | 1969 | 144 943 |
| 1948 | 143 561 | 1970 | 85 025 |
| 1949 | 269 747 | 1971 | 42 245 |
| 1950 | 41 365 | 1972 | 99 993 |
| 1951 | 66 092 | 1973 | 44 662 |
| 1952 | 101 497 | | |

Buyers' records may be inaccurate (see page 18). Further data reflect on this accuracy. We have fishermen's diaries from the Awarua River for 1948–61. The Awarua subregion (New Zealand Marine Department 1951) includes the Awarua, Hollyford, and Kaipo Rivers, but the Kaipo has never been fished seriously. Thus catch figures for the Awarua River (Table 61 in Appendix 5) should enable us to determine catch figures for the Hollyford by subtracting Awarua River figures from those for the subregion. In one year (1954) the figure for the Hollyford was apparently negative; that is, catch recorded for the Awarua subregion was 25 kg less than that reported for the Awarua River by fishermen. And in 1960 Hollyford catch was only 17 kg. Furthermore, 5% has already been added to catch figures to allow for "local consumption" and so it is clear that reported catch figures are scarcely an accurate record of catch. However, they are the only figures available; as they seem likely to report a fairly constant proportion of the catch each year, the relative abundance of fish from year to year and region to region is probably represented adequately by the figures.

Since the 1930s fluctuations in reported catch on the west coast of the South Island have been very broad — 10 143 kg in 1935 to 322 224 kg in 1955 (Table 21, Fig. 42), almost a thirty-twofold fluctuation. Since 1951, when reports were subdivided into subregions on a consistent basis, a fluctuation of more than eightfold is evident.

The early whitebait fishery and its decline were discussed briefly by McDowall (1968). It was con-

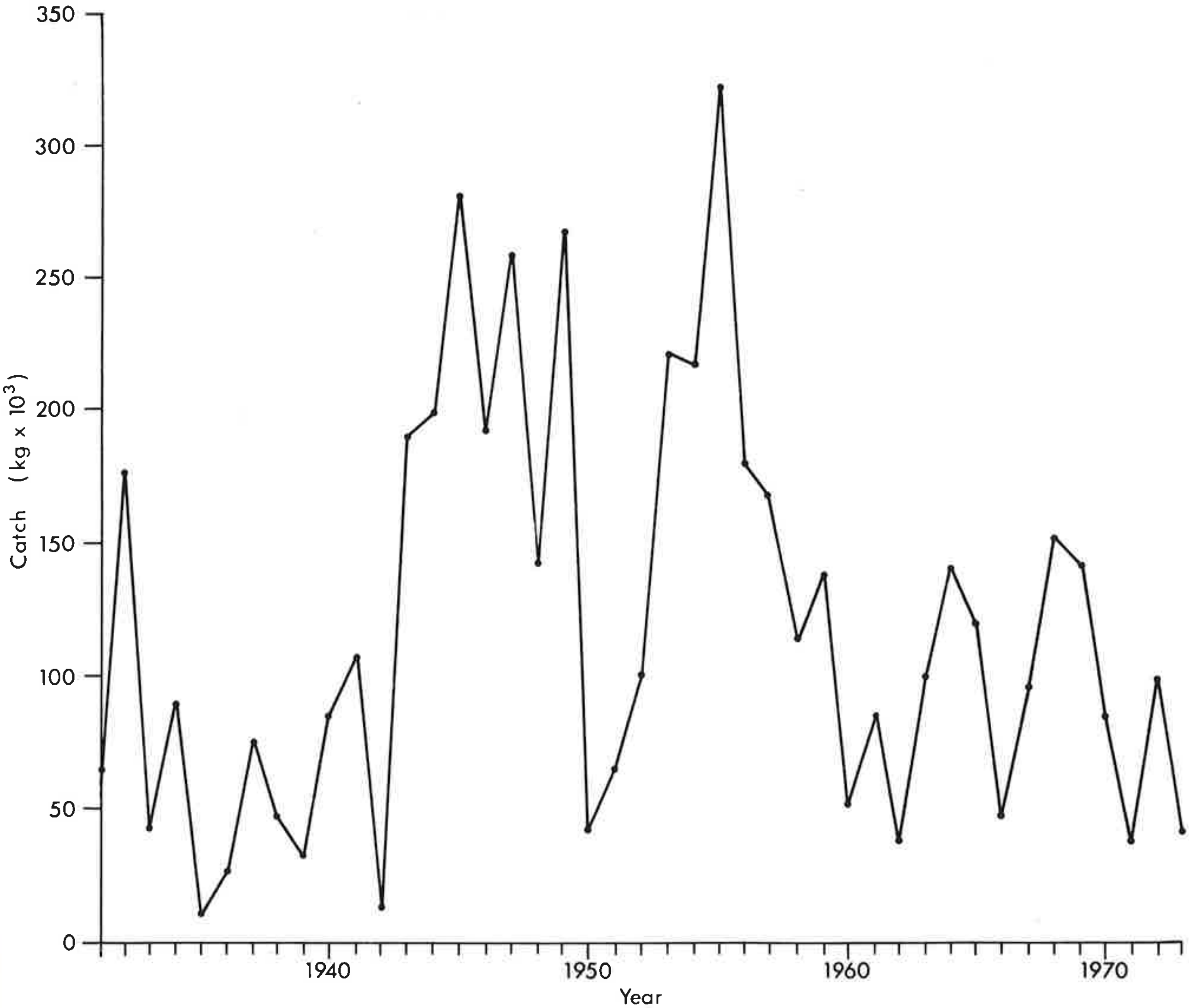



Fig. 42: Annual whitebait catch on the West Coast from 1931 to 1973.

cluded then: "There is no evidence from the published figures to indicate that there has been a permanent decline in the catch of the West Coast whitebait fishery since these records were begun. . . . There seems little reason to conclude that the recent poor years are anything more than a normal irregular fluctuation of the fishery which cannot at present be explained." At the time this was written (1966) catch levels were recovering from a low in 1962 (38 253 kg). The 1966 catch was poor (47 803 kg), but rose and fell from year to year until 1973 (Table 21). If we take the catch figures at face value (and this may **not** be justifiable), there has been no significant long-term decline in the fishery that can be separated from gross fluctuations since the inception of records.

In examining fluctuations in the fishery it is necessary to consider fishing pressure, and since the 1930s fishing pressure has changed. It has both increased and shifted, though details are not available. The New Zealand Marine Department (1932–51) published figures purporting to be numbers of fishermen, but these figures vary in their presentation to such an extent that they are of little comparative value. And there are gross and inexplicable changes that cast serious doubt on their reliability; for example, for the Hokitika subregion the 1931 figure is 216 fishermen, none are reported for 1932, 1933, or 1934, but 98 is the number in 1935. The figures are listed sufficiently consistently from 1940 to 1950 to allow tabulation (Table 22). However, there is broad variation in numbers of fishermen. Numbers tend to rise steadily, though there are also erratic declines; for example, Whataroa, 1948 to 1949. The abrupt rise in 1945 to 1947 may be attributable to the return of troops after the Second World War.

In 1950 the figures were presented in a manner that

**TABLE 22: Number of fishermen in Greymouth, Hokitika, and Whataroa subregions, as reported by Marine Department between 1940 and 1950**

| | Number of fishermen | | | | | |
|---|---|---|---|---|---|---|
| | Greymouth | | Hokitika | | Whataroa | |
| Year | Full-time | Part-time | Full-time | Part-time | Full-time | Part-time |
| 1940 | 4 | 150 | 81 | 52 | 20 | 30 |
| 1941 | 6 | 150 | 76 | 200 | 30 | 25 |
| 1942 | 2 | 200 | —* | — | 20 | 30 |
| 1943 | 0 | 130 | 0 | 127 | 60 | 36 |
| 1944 | 0 | 150 | 22 | 85 | 98 | 10 |
| 1945 | 2 | 200 | 49 | 231 | 100 | 25 |
| 1946 | 3 | 221 | 171 | 473 | 270 | 20 |
| 1947 | 53 | 80 | 229 | 26 | 226 | 7 |
| 1948 | 38 | 320 | 183 | 350 | 307 | 50 |
| 1949 | 47 | 450 | 126 | 247 | 165 | 20 |
| 1950 | 23 | 390 | 146 | 245 | 186 | 25 |

*No figures given.

allows comparison with present-day figures derived from whitebait registration forms, which full-time whitebaiters must submit to obtain permits to fish (Table 23). What is most noticeable from these figures is an increase in fishing pressure in the far south — Cascade-Waita and Hollyford-Hope. This follows opening up of the area in 1956 by a road from Central Otago over the Haast Pass and in 1965 by another down the West Coast from Paringa. In the 1940s some of these rivers were not fished at all (for example, Awarua and Cascade) or were fished by only two or three fishermen (for example, Waita, Turnbull, and Waiatoto). The number of fishermen had risen to 10-12 by the 1950s and is now 40-50. Present numbers fluctuate; they rise after a good season and drop after a poor one, but in all years the rivers remain fairly crowded (Table 24).

Whereas in the period 1930-50 there was sometimes, in good seasons, an oversupply of the fresh-whitebait market and of canneries, today there is rarely oversupply, because demand has increased and freezing of whitebait has become commonplace, food-marketing firms and hotel-restaurant chains being major buyers. This, with high prices on the river to fishermen (they received $4.40 per kilogram throughout the 1973 season in the Okuru and Awarua subregions), ensures persistent and heavy fishing pressure for as long as there are fish to be caught.

Furthermore, although we doubt the reliability of catch figures recorded by the Marine Department, it is likely that increases in the number and activity of fisheries officers on the West Coast have resulted in

**TABLE 23: Number of registered fishermen on West Coast rivers in 1950 and 1971**

| | No. of fishermen in | |
|---|---|---|
| Rivers | 1950 | 1971 |
| Taramakau | 23 | 33 |
| Arahura to Hokitika | 136 | 93 |
| Totara to Waitaha | 10 | 58 |
| Wanganui to Moeraki | 108 | 110 |
| Waita to Cascade | 72 | 174 |
| Hollyford to Hope | 6 | 16 |

**TABLE 24: Number of registrations for Haast area rivers from 1970 to 1973**

| | Registrations in | | | |
|---|---|---|---|---|
| River | 1970 | 1971 | 1972 | 1973 |
| Haast | 8 | 9 | 10 | 23 |
| Okuru | 34 | 43 | 42 | 45 |
| Turnbull | 7 | 16 | 10 | 16 |
| Waiatoto | 35 | 45 | 46 | 44 |
| Arawata | 9 | 25 | 19 | 34 |
| Cascade | 22 | 22 | 18 | 18 |
| Awarua | 16 | 19 | 12 | 8 |
| Hollyford | 3 | 11 | 6 | 5 |

recent figures being more accurate than formerly. It could therefore be argued, especially in the far south, that catches in recent years have remained as high as they have only through increased fishing effort and more accurate recording of catch. It is difficult to determine whether this is so. If sustained yield has been due to increased fishing pressure, it could be expected that there would be increase in catch in southern areas. Because the quantity of fish caught fluctuates so broadly, even in the most southern subregions (Okuru and Awarua), increase in catch in these areas cannot be related to increased effort. It is true that from 1970 to 1973 the Okuru subregion provided 47% or more of the West Coast catch and reached 59.61% in 1973 (Table 76 in Appendix 5). However, although overall catch declined from 1972 to 1973 (99 993 to 44 662 kg) and catch in the Okuru subregion also declined (47 101 kg in 1972 to 26 624 kg in 1973), the percentage contribution of the Okuru subregion to the year's total rose (59.61%). In addition, (1) the contribution of the Cascade River to the Okuru subregion's total rose (12 419.9 kg in 1972 and 19 619.5 kg in 1973, Table 25), (2) its percentage contribution to the subregion rose (34.0% to 67.7%, Table 25), but (3) the number of fishermen remained stable (Table 24). Fishing effort in the most important and productive rivers in the Haast area fishery — Waiatoto and Okuru Rivers — also remained relatively stable (Table 24), though it rose in some other rivers. The rise in number of fishermen was particularly marked in the Haast River in 1973, probably as a result of very good catches there in 1972 (Table 58 in Appendix 5).

That there are broad, naturally occurring fluctuations in the whitebait fishery can be demonstrated from study of diary records of catches on the Awarua and Cascade Rivers in South Westland.

Fishing effort was stable on the Awarua River from 1947 to 1961, so that catch figures reveal fluctuations in whitebait runs during these years. Catch ranged from 2043 kg to 7828 kg (mean 4457 kg, S.D. 1721 kg, Table 26). The maximum was nearly four times the minimum. Thus variation in catch over 15 years, with effort constant, is very broad, which shows that the fishery is subject to extensive natural fluctuations. Catch in the Awarua rose rapidly from early low yield

**TABLE 25: Variation in catch in Haast area rivers***

| River | Catch in 1969 (kg) | % | 1970 (kg) | % | 1971 (kg) | % | 1972 (kg) | % | 1973 (kg) | % |
|---|---|---|---|---|---|---|---|---|---|---|
| Waita | 1 867.6 | 7.93 | 3 584.1 | 11.37 | 2 269.2 | 12.41 | 2 374.6 | 6.49 | 1 202.0 | 4.15 |
| Haast | 1 360.9 | 5.78 | 2 245.0 | 7.12 | 411.7 | 2.25 | 3 996.5 | 10.93 | 1 321.8 | 4.56 |
| Okuru | 2 914.3 | 12.38 | 3 235.3 | 10.27 | 1 310.0 | 7.17 | 5 170.0 | 14.13 | 814.2 | 2.81 |
| Turnbull | 1 412.6 | 6.00 | 1 751.5 | 5.56 | 490.9 | 2.69 | 1 483.9 | 4.06 | 312.8 | 1.08 |
| Waiatoto | 5 430.2 | 23.06 | 9 653.7 | 30.64 | 5 085.2 | 27.81 | 7 744.2 | 21.17 | 3 954.8 | 13.65 |
| Arawata | 1 675.9 | 7.12 | 2 662.6 | 8.45 | 2 163.9 | 11.84 | 3 390.9 | 9.27 | 1 752.7 | 6.05 |
| Cascade | 10 752.5 | 45.66 | 8 376.9 | 26.59 | 6 559.0 | 35.88 | 12 419.9 | 33.95 | 19 619.5 | 67.71 |
| Total | 23 546.5 | | 31 509.1 | | 18 289.9 | | 36 580.0 | | 28 977.8 | |

*The totals in this table may not agree with catch totals in Table 76 (in Appendix 5), as the figures here were independently derived from fishermen and buyers.

in 1947 (2043 kg) to a peak in 1949 (7828 kg) and then dropped sharply. This might appear to be due to overfishing, but under continued and constant fishing pressure yield remained low for 5 years and fluctuated a little; it then rose to about the 1949 peak in 1955 (7796 kg) before declining again.

For 9 years (1959-67) fishing effort on the Cascade River was fairly constant, but increased substantially from 1968 onwards (Table 27). The effect of changing number of fishermen is not clear, but, like the Awarua data, the Cascade figures provide information on natural fluctuations in the fishery. (Unfortunately the time periods for the two sets of data scarcely overlap, so that comparison of fluctuations is not possible.)

The Cascade fishermen caught between 5094 and 19 620 kg per year (mean 10 573 kg, S.D. 4041 kg). But there is no correlation between number of fishermen and catch ($r = 0.1688$, $n = 15$, $P > 0.10$). As with the Awarua, it appears that in the Cascade under fairly stable fishing conditions for 9 years, followed by an increase in fishing pressure for 6 years, the yield has been subject to broad, apparently natural fluctuations.

Fluctuations in catch in rivers along the West Coast are similarly broad (Table 76 in Appendix 5; Fig. 43). The extent of these fluctuations varies. We calculated the coefficient of variation (standard deviation/mean) for each of the eight West Coast subregions, and an interesting pattern is evident (Table 28, Fig. 44): the coefficient tends to be higher in more intensively settled and farmed areas, particularly the Greymouth to Ross area. It drops markedly between Ross and Whataroa. (The Whataroa area covers a mixture of moderately developed river catchments where pastoral development is extensive but not intensive and an area to the south — Mahitahi, Paringa, and Moeraki catchments — where there is little or no pastoral development.) The Okuru subregion covers an area where there is little farming (most of the land remains as forest) and, further south again, the Awarua subregion includes completely undeveloped catchments. With decreasing agricultural development south from Ross, through Whataroa, Okuru, and Awarua, there is a decline in the coefficient of variation (Fig. 44). This pattern has two implications. First, of primary importance to the present discussion, it suggests that interseasonal variation in catch is lower in catchments that are little modified than in those which are highly modified. It seems that forested catchments, and the existence of larger areas of undeveloped swamp land and of unmodified tidal-estuarine marshy vegetation in southern catchments, has resulted in lower fluctuations in whitebait catches. The second implication is the existence of separate or

**TABLE 26: Whitebait catch in Awarua River from 1947 to 1961**

| Year | Catch (kg) | Year | Catch (kg) |
|---|---|---|---|
| 1947 | 2 043 | 1955 | 7 796 |
| 1948 | 5 884 | 1956 | 4 178 |
| 1949 | 7 828 | 1957 | 4 814 |
| 1950 | 3 179 | 1958 | 5 707 |
| 1951 | 2 820 | 1959 | 3 872 |
| 1952 | 4 523 | 1960 | 3 488 |
| 1953 | 2 830 | 1961 | 4 461 |
| 1954 | 3 429 | | |

**TABLE 27: Whitebait catch in Cascade River from 1959 to 1973**

| Year | Catch (kg) | No. of fishermen |
|---|---|---|
| 1959 | 8 788 | 7 |
| 1960 | 10 043 | 8 |
| 1961 | 9 848 | 8 |
| 1962 | 10 529 | 8 |
| 1963 | 5 094 | 8 |
| 1964 | 13 009 | 8 |
| 1965 | 7 940 | 8 |
| 1966 | 6 685 | 6 |
| 1967 | 10 584 | 6 |
| 1968 | 18 347 | 12 |
| 1969 | 10 753 | 19 |
| 1970 | 8 377 | 22 |
| 1971 | 6 559 | 22 |
| 1972 | 12 420 | 18 |
| 1973 | 19 620 | 18 |

**TABLE 28: Coefficient of variation for whitebait catch in West Coast subregions from 1951 to 1973**

| Subregion | Mean (kg) | Standard deviation | Coefficient of variation |
|---|---|---|---|
| Karamea | 7 396 | 6 290 | 0.850 4 |
| Westport | 21 017 | 13 362 | 0.635 8 |
| Greymouth | 8 509 | 8 836 | 1.038 5 |
| Hokitika | 15 418 | 15 328 | 0.994 1 |
| Ross | 3 217 | 3 589 | 1.115 7 |
| Whataroa | 25 110 | 14 732 | 0.586 7 |
| Okuru | 33 362 | 17 512 | 0.495 2 |
| Awarua | 5 381 | 1 989 | 0.369 7 |
| Total | 121 426 | 69 002 | 0.568 3 |

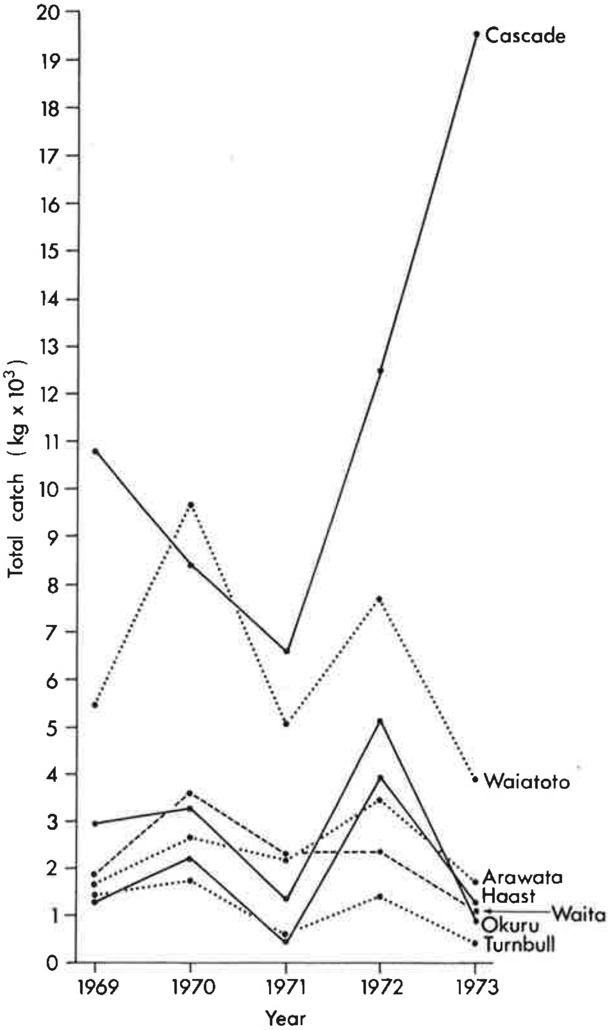



Fig. 43: Variation in catch from Haast area rivers from 1969 to 1973.

fairly local stocks of whitebait along the west coast of the South Island. This will be discussed elsewhere (see page 82).

Examination of the pattern of variation in catch in West Coast subregions in 1951-73 shows that there is strong tendency for fluctuations to correlate. We calculated correlation coefficients for all pairs of subregions (Table 29). The Awarua subregion data are distinct in that correlations are in no instance significant. Otherwise the paired correlations are in all instances, except for that between the Greymouth and

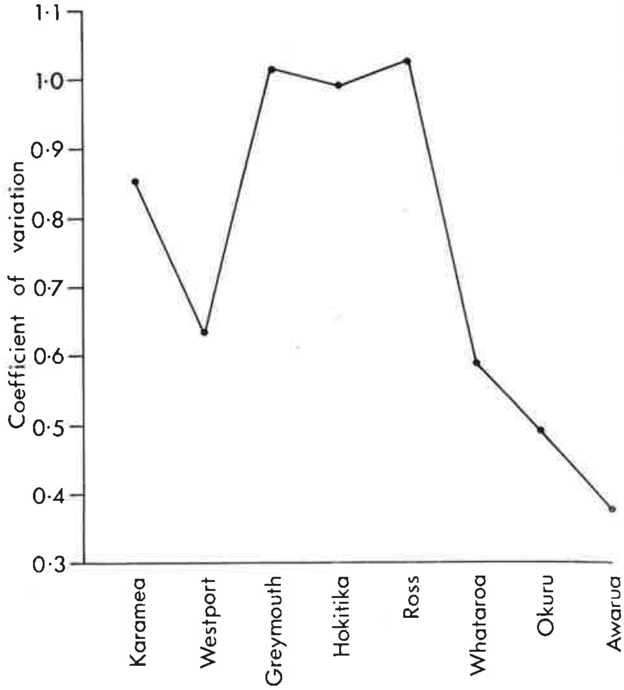



Fig. 44: Coefficient of variation for whitebait catch in the West Coast subregions from 1951 to 1973.

Okuru subregions, positive and significant at the 5% level of significance. With the exception of Awarua, it is generally true that fluctuations in the subregions follow each other closely. It is notable that the correlation coefficients between closely adjacent regions are no higher than those between distant regions. Catch fluctuations are closely related along the coast from Karamea to Okuru. This suggests that there is some common environmental factor that is contributing to catch fluctuations or that the fish are derived from a single stock. Within the Okuru subregion we have figures for the whole subregion and for the Cascade River from 1959 onwards. We calculated the correlation between the Cascade River catch (Table 27) and the Okuru subregion catch (Table 76 in Appendix 5) less that contributed to this total by the Cascade River ($r$ = 0.2505, n = 15, $P > 0.10$). Thus fluctuations at Cascade are not closely similar to those in other rivers of the Okuru subregion. Nor are they similar to those in the Awarua subregion, which is immediately south of the Cascade River ($r$ = −0.0239, n = 15, $P > 0.10$). This is confusing, as the

**TABLE 29: Correlation between West Coast subregions in fluctuations in catch from 1951 to 1973**

| Subregion | Westport | Greymouth | Hokitika | Ross | Whataroa | Okuru | Awarua |
|---|---|---|---|---|---|---|---|
| Karamea | 0.865 7 | 0.639 5 | 0.755 4 | 0.568 4 | 0.714 6 | 0.819 3 | 0.254 3 |
| Westport | | 0.719 7 | 0.837 2 | 0.655 2 | 0.707 0 | 0.701 4 | 0.179 7 |
| Greymouth | | | 0.786 7 | 0.682 4 | 0.687 7 | 0.349 1 | −0.002 1 |
| Hokitika | | | | 0.650 1 | 0.831 3 | 0.632 9 | 0.139 6 |
| Ross | | | | | 0.510 7 | 0.489 6 | 0.121 4 |
| Whataroa | | | | | | 0.610 2 | 0.128 2 |
| Okuru | | | | | | | 0.254 0 |

For n = 23, $r$ = 0.351 5, $P < 0.05$.

Okuru subregion fluctuated with the other subregions to the north, yet the Cascade River, which contributes a very high proportion of the Okuru subregion figures, differs from other regions in the way catch fluctuations occur. It seems that we do not have sufficient data to make the detailed comparisons that are desirable for a full analysis of variation and that we can say no more than that the subregions, with the exception of Awarua, tend to fluctuate together.

Reasons for fluctuations are poorly understood. There is a widespread belief among fishermen that poor years are a result of "overfishing" in the previous year(s). After a poor season there are alway calls for closure of the fishery for one or several seasons or for more restrictive controls on fishing practices or areas. However, we believe that the data do not indicate overfishing and that we must look for natural causes for these fluctuations (see "Management of the Whitebait Fishery", page 83). There is little doubt that they have no simple explanation.

Factors likely to affect whitebait catch include:

1. Size of the adult spawning stock the previous autumn; number and size of adult fish and their fecundity.

2. Favourability of environmental conditions during spawning, development, and down-stream movement to sea of newly hatched fry.

3. Growth conditions in the sea during winter; that is, growth rate and survival of the fry.

4. Nature of ocean currents and their impact on dispersal of fry at sea.

5. Condition of rivers during the period when fish are migrating up stream.

6. Period of intense migrations in relation to the fishing season.

We have few data on the importance of any of these factors, but some discussion is worth while.

**Size of the adult stock.** We have no data on this. Obtaining data on one river system, let alone the whole West Coast region, seems to us an impossible task with existing research resources.

**Favourability of environmental conditions during spawning, development, and down-stream movement of fry.** Many experienced fishermen believe that the amount of rain and flooding during the autumn-early winter spawning period is important. It is easy to imagine that high rainfall, when the eggs of *G. maculatus* are stranded out of the water on the banks of tidal estuaries, would be beneficial in maintaining high ground humidity and so preventing dehydration of the eggs. It seems possible that the reason the West Coast is, and apparently has always been, a very productive whitebait area is that there is very high rainfall there.

We looked for a relationship between rainfall during the freshwater life of each generation and the whitebait run the following spring. We calculated the correlation coefficient ($r$) between rainfall for each month (November to May) and for every combination of 2, 3, 4, 5, 6, and 7 successive months, and in no instance did we find a significant correlation. Monthly rainfall totals give no support for the view that the whitebait run is affected by rainfall during freshwater life of the parental generation. However, this does not show that such a relationship is absent and it is likely that any relationship is much more complex and that its identification requires additional data and more detailed, probably multiple regression, analysis.

However, it seems likely that whitebait, especially *G. maculatus*, are sensitive to environmental variables, particularly climate and during spawning. Spawning in *G. maculatus* occurs on supratidal, grassy, estuarine flats, and the eggs are left exposed to the air for 2 weeks or more while they develop. At present we know nothing of egg mortalities in *G. maculatus* in periods of drought or of the effects of smothering by silt during floods.

After *G. maculatus* move into fresh water they penetrate every available and accessible waterway, including drainage channels that contain water only during receding floods. As a result, depending on climatic factors, large numbers of fish are known to enter temporary waterholes and perish when access to permanent water is cut off and the waterholes dry up. Many accessible temporary ponds created by heavy rainfall are invaded by *G. maculatus* and if a dry period follows, huge numbers may perish. This was observed after large September floods in 1969.

**Growth conditions in the sea during winter.** As is pointed out in "Size at Migration" (see page 27), there is interseasonal variation in size of whitebait at migration. Both length and condition vary from season to season. In particular we found that both *G. maculatus* and *G. brevipinnis* were shorter and in poorer condition in 1971 than in other years. The common occurrence of lower size and condition in 1971 appears to point to poor growth in the sea. Catch during 1971 was also poor (see page 76). Loss in condition was sufficient to account for a 25.6% drop in catch from 1970 to 1971. Actual decline in catch was about 50% for the whole West Coast (Table 21) and also for the Okuru subregion (Table 76 in Appendix 5). Thus decline in condition accounts for about half the fluctuation in catch from 1970 to 1971; fish size and condition are clearly of major importance in fluctuations in the whitebait fishery. It probably follows that because growth was poor in the winter of 1971, mortalities were high, and we seem to have evidence here that conditions for growth in the sea are important for productivity of the whitebait fishery. This is, of course, not surprising.

**Nature of ocean currents and dispersal at sea.** Little is known about the life of whitebait in the sea.

However, a recent paper (McDowall, Robertson, and Saito 1975) reports on their occurrence as determined from intermittent larval fish sampling around New Zealand during 1970–73. The study showed that whitebait may disperse great distances off shore; one was caught between the Bounty and Antipodes Islands, about 700 km from New Zealand. Most fish were caught within 50 km of the New Zealand coast, but most sampling was done within this distance. A substantial proportion of the larger fish were caught about 100 km off shore and this certainly shows that the fish may disperse far off shore. Implications of this dispersal for the fishery are not yet understood, as we have insufficient data. Occurrence of larvae well off shore could represent either normal patterns of movement in ocean current systems around New Zealand, or they could represent expatriation of fish from the populations and loss to the fishery. In either case the populations are subject to vagaries of near-shore and off-shore current systems of New Zealand and in some seasons a substantial loss of fish is likely to occur.

**Condition of rivers during migration.** The condition of river mouths during whitebait migrations has local effects on catch. Some smaller rivers, especially, may become closed at the mouth in certain weather, so that the whitebait are unable to enter. It is not known what happens to whitebait shoals nearby, but some fishermen believe that the fish move up adjacent rivers. Certainly, in 1972 the Waita River mouth was obstructed for long periods and catch in that river was poor. Catch in the nearby Haast River was very high compared with those of other years (Table 25).

**Timing of migrations.** The size of the season's catch is related partly to when the peak migrations take place during spring. The regulated fishing season in the West Coast fishery lasts from 1 September to 30 November. There is no reason why the peak runs should be restricted to this period, and in 1969, for instance, there were substantial runs of whitebait in late August. It is not known how often this happens. At other times there are big runs either in late November or December after most fishermen (thinking the run is over) have left the rivers. There was a big run in the last few days of November in 1968. Fishermen who fished the Awarua River from 1947 to 1961 noted several times that they may have stopped fishing too soon. Variation in timing of the whitebait run in relation to the regulated season possibly has an important bearing on the quantity of whitebait caught in any season.

What emerges from this discussion is, primarily, that at present we know something about what variables may affect the runs, but have little information on how they interact to produce the broad fluctuations that are occurring.

# STOCKS IN THE WHITEBAIT FISHERY

An important problem related to management of the whitebait fishery is the question of whitebait stocks. We have no evidence about whether there is one large stock in New Zealand, a discrete West Coast stock, or smaller local stocks. However, several facts emerging from various aspects of this study have pointed to the likelihood that there are local stocks.

The distinct difference between the size and condition of Buller River fish and those of fish from Haast area rivers suggests that Buller River fish may come from a distinct stock. The Waita River fish in 1969, though not differing as distinctly from other Haast area fish as do the Buller River fish, nevertheless exhibited peculiar variations in size that prompt the view that the Waita River might lie at or near the boundary of two stocks (see page 22).

The failure of seasonal catch fluctuations in the Awarua subregion to correlate with the fluctuations elsewhere suggests that the Awarua subregion rivers may be deriving their fish from a stock distinct from that of the rest of the West Coast. The failure of Cascade River data to correlate with those of other rivers in the Okuru subregion may suggest that the Cascade River does not derive its fish from the same stock as rivers to the north. The existence of local stocks is also supported by the fact that southern rivers have maintained highly productive fisheries and those of the north have fluctuated much more (high coefficients of variation) and have declined in production since the early beginnings of the fishery. High catches at Cascade in 1973, when catches elsewhere were poor, may also indicate distinct stocks. The good correlations in the fluctuations between those subregions to the north of Awarua may indicate that all these regions receive their whitebait runs from a single stock. However, it could as easily be due to some common environmental or climatic variable affecting all the subregions in the same way.

The evidence is meagre, but isolated pieces of it from diverse aspects of this study seem to point to the existence of fairly local stocks in the fishery. This conclusion is in accord with earlier, even more meagre, data showing that there are substantial differences in the sizes of whitebait caught on the east and west coasts of the North and South Islands of New Zealand (McDowall 1968).

# MANAGEMENT OF THE WHITEBAIT FISHERY

The New Zealand whitebait fishery has a series of characteristics that, together, make it unique and pose a series of unusual management problems:

1. It is a multi-species fishery in which there is no known selectivity for any species.

2. The stock is exploited during an up-stream migration from the sea into fresh water, it is subject to exploitation at only one point in the life cycle, and the part that escapes capture is not again threatened by fishing.

3. The stock being exploited consists of pre-spawning fish; they are juveniles which do not reach maturity for 6–18 months.

4. The principal component of the fishery is an essentially annual species.

The multi-species aspect of the fishery is not unusual and requires little comment here. What is unusual is that most fishes which migrate from the sea do so in single-species shoals, for example, the "herring" runs (*Alosa* spp.) on the eastern coasts of North America and the more widespread smelt (family Osmeridae) and Pacific salmon (genus *Oncorhynchus*) runs in cool and cold areas of the Northern Hemisphere. The Tasmanian whitebait fishery is a similarly mixed-species, up-stream, migratory fishery (Blackburn 1950), though there are some important differences that are discussed below.

As in all the fisheries mentioned above, primary exploitation occurs during the period of intensive migration, so that the stock is exploited only during a restricted phase of the life cycle. This is true of the herring and smelt runs in North America and used to be true of the Pacific salmon fishery. However, with increasingly sophisticated methods being developed for finding and catching fish at sea, there is increasing exploitation of Pacific salmon stocks in the sea. This seems unlikely to become a problem in the New Zealand whitebait fishery unless very intense concentrations of the fish are found at sea, and efficient and economic means of harvesting them are developed.

The exploitation of pre-spawning stock is not unusual, but is common to the capture of most anadromous fishes, like the salmons, smelts, and herrings mentioned, and also like the Tasmanian *Lovettia sealii* (Johnston). However, the exploitation of juveniles is distinctive.

These characteristics of the fishery lead to peculiar management problems.

*Galaxias maculatus*, the annual species in the fishery, makes a major contribution and in all but a few localities contributes more than 95% of the catch. Accordingly management of the fishery is concerned primarily with management problems of this species.

Although a very small percentage of any population of *G. maculatus* may delay maturing until the second or third year (Burnet 1965, McDowall 1968) and although a small percentage may survive spawning (McDowall 1968), most of the fish mature in their first summer in fresh water, breed the following autumn when about a year old, and die. This has important, hitherto undiscussed implications for management of the fishery. Because there is generally only a single year class, the population is very easily exposed to sudden and serious decline, and it can be expected to fluctuate widely. Loss of a major proportion of the progeny of any year class results in a correspondingly high decline of the entire population. Catastrophic events of any type such as drought and floods or overfishing will have pronounced effects on the population and therefore on the fishery. Thus serious overfishing (or other major cause of population reduction) in any year in a fishery for an annual species like *G. maculatus* will inevitably result in a reduced stock the next year. Overexploitation of the juvenile migrant stock has immediate effects on the reproductive stock the following autumn and, as a direct consequence, effects on the juvenile migrant stock produced. Some overfishing may be offset if survival through escapement and growth rates, fecundity, and spawning success of the stock are especially good. However, if overfishing is serious and continuous, the fishery must decline rapidly. This is what happened to the somewhat comparable *Lovettia* fishery in Tasmania. Blackburn (1950) showed how this fishery began in the 1940s, built rapidly until 1947, and then plummeted in 1948. It continued to decline until the early 1950s. Since then the catch has fluctuated widely, but has not approached the peak catch of 483 000 kg or Blackburn's "suggested optimum" of about 305 000 kg. The highest peak after the decline was only 61 000 kg (1953), and catch fell to 1570 kg only 2 years later (1955). The fluctuations continued, reaching a low of 1010 kg in 1972 and the fishery has since been closed. What happened in the establishment phases of the fishery, as described by Blackburn (1950), is a classic example of the decline of a fishery as a result of overfishing, and it shows how rapidly a fishery for an annual species will decline when it is overexploited.

Because the migrating fish are juveniles in the New Zealand whitebait fishery, assessment of the extent of escapement needed to maintain the adult spawning stock is difficult. In fisheries such as the Pacific salmon fishery and the Tasmanian *Lovettia* fishery the migrants are spawning adults; their fecundity and mortalities before imminent breeding can be assessed, and some estimation of the escapement needed can be made. In the *G. maculatus* fishery the intervention of 6 months until the migrants grow to maturity means that growth rates and mortalities during this period must also be known and that fecundities of the potential spawning population are less easily estimated. Further, the fact that there is essentially only one year class in the population makes the estimation of mortality rates by use of relative abundance of various age classes impossible. Juvenile freshwater eels (*Anguilla* spp.) are being increasingly harvested in New Zealand rivers during a migration that is similar to the galaxiid whitebait migration, but the eel situation is different in that the adult populations can be examined on a long-term basis for changes in the age structure of the population and determination of mortality rates. These enable some stock assessments to be made.

Because the fishery exploits pre-breeding stocks primarily of an annual species, escapement of the exploited year class is of prime importance. Estimating the reproductive effort that will accrue from the escapement of *G. maculatus* is difficult, because it is an annual species, which migrates as a pre-breeding juvenile that must spend at least 6 months in fresh water before spawning. Regulations governing the fishery must therefore ensure that sufficient fish escape to allow for mortalities during this period, and at present there are no data. As we have discussed elsewhere (page 75), it seems highly likely that escapement is not related primarily to fishing effort (if that is defined as man-hours or net-hours fished), but rather to the efficiency and hours fished by fishermen operating at those positions in the rivers beyond which the migrating shoals are no longer subject to exploitation.

All these variables, and the limited data available, make it hard to manage the fishery on principles derived from the dynamics of the populations. Unless a much more profound study of the population dynamics of the species and of factors affecting abundance and population densities is undertaken, the fishery will continue to be managed on the basis of the response of the fishery to existing management techniques and current fishing pressures.

The only alternative approach to management of the fishery seems to be to estimate the abundance of the stocks in the sea before they enter the fishery. However, Boerema and Gulland (1973) noted that for the huge Peruvian anchovy fishery (annual production up to 12.3 million tonnes) estimation "of the abundance of young fish before or soon after they enter the fishery is a difficult technical problem, not completely solved in Peru or anywhere else". This being true for a fishery of the size of the Peruvian one, it is unlikely that it would be either practicable or economic to estimate the abundance of stocks entering the very small New Zealand whitebait fishery.

It seems to us that either the New Zealand whitebait fishery was heavily overexploited during the establishment phases (before records were kept) and subsequently declined, so that our fishery is in a seriously depleted condition comparable with the Tasmanian fishery, or there has not been serious overexploitation and the fishery fluctuates naturally in response to environmental variables and escapement. The absence of early records on catch and fishing effort makes it difficult to choose between these alternatives. The yield from rivers in the far south has fluctuated broadly, but there seems no evidence of a catastrophic decline after the establishment of a fishery in the Awarua River in 1947 and the Cascade River in 1959. Catch figures from these rivers suggest that the populations are able to withstand present fishing pressure. If serious and continued overfishing was and is occurring under stable or rising fishing pressure, the fishery would show a rapid and continuing decline. The fact that catch on numerous occasions rose from one year to the next, with fishing pressure stable or rising, shows that there was adequate escapement.

It does not necessarily follow that escapement rose; possibly environmental conditions allowed survival of a bigger population than in the previous year. It seems that the whole whitebait fishery, like that at Awarua and Cascade, though subjected to heavy exploitation, is not being exploited in a way that warrants its description as overfished. Rather, under stable or rising fishing pressure in the past 10–20 years there has been a widely fluctuating fishery which has shown a capacity to recover in spite of fishing pressure.

Although *G. maculatus* is the principal component of the fishery, in some places and at some times two other species — *G. brevipinnis* and *G. fasciatus* — make significant contributions to the catch (Two further species make insignificant contributions to the fishery; see "Mixed-species Aspects of the Migrations", page 58). The presence of at least three species that make a significant, if small, contribution to the commercial fishery complicates the understanding and management of the fishery, as many more variables must be considered. On the other hand, the inclusion of several species in the fishery makes it more resilient and more able to withstand overfishing or natural events causing decline in the populations.

As the life histories of *G. brevipinnis* and *G. fasciatus* are similar as far as is known, especially in those respects in which they differ from *G. maculatus*, they (and also *G. argenteus* and *G. postvectis*, whose numbers are insignificant) can be discussed together.

The fundamental and here important difference between *G. maculatus* and the other species is that *G. maculatus* is an essentially annual species, whereas the others are not. They live for several years, certainly 3 to 5 and perhaps many more (Eldon 1969). Hopkins (1979) has reported *G. fasciatus* reaching at least 9 years (245 mm length to caudal fork), and a very large *G. argenteus* of 400 mm length to caudal fork has been tentatively aged at more than 20 years. *Galaxias vulgaris* Stokell, a non-diadromous galaxiid studied by Cadwallader (1978), was found to live for up to 6 years, and it is known to reach 150 mm long (McDowall 1970a). *Galaxias argenteus* has been recorded up to 584 mm, *G. fasciatus* to 260 mm, *G. postvectis* 261 mm, and *G. brevipinnis* 250 mm. All four species commonly exceed 200 mm in length. It seems certain that these diadromous galaxiids live for several years. In discussing the fishery we are considering a relatively small annual species whose contribution to the fishery is very large and several larger, perennial species whose contribution to the fishery varies from moderate to totally insignificant. These species do not seem to mature until 18 months after entering fresh water (that is, at an age of about 2 years), they survive spawning, and they probably spawn several times. Our conclusion that these species spawn several times means that the populations do not respond as directly to overfishing or to other factors affecting larval and juvenile survival. Destruction of one year class in a perennial species reduces the population size and distorts the age-size-frequency distribution in the populations for the duration of that year class in the population. However, since any year class is only a fraction of the total population, the effect of loss of an entire year class from the population is less serious. Thus the perennial species are more resilient in their response to natural or man-induced population declines and thereby add some resilience to the fishery for the annual species, *G. maculatus*. In the event of a permanent decline in the contribution of *G. maculatus* to the fishery, the proportional contribution of the other species will rise, though the total yield of the fishery declines.

At present we do not have sufficient data to analyse changes in the proportional composition of the fishery in relation to changes in total yield. Although it is likely that each of the species is affected by similar variables while in the sea, it is also likely that different factors affect abundance of freshwater stocks of each species. Thus we should not expect fluctuations in abundance to correlate between species in any year. The ability of *G. brevipinnis* to support a fishery on its own is not known, though in 1969, for example, 36.6% of the whitebait sampled from the Arawata River were *G. brevipinnis*, and figures for the Haast and Waiatoto Rivers are similar. It seems unlikely that an economically viable fishery could be supported, though a recreational fishery might be possible in some snow-fed rivers of the West Coast.

Little is known of the biology of the perennial species. It seems most likely that the adults spawn in or near adult habitats and that the newly hatched young are swept down stream to the sea (see Ots and Eldon 1975, McDowall 1970a). The adults tend to live well inland, either in small tributary streams (*G. brevipinnis*, *G. postvectis*, and *G. fasciatus*), in forest swamp lands (*G. fasciatus*), or in more open flax-raupo swamps and along shallow, vegetated lake margins (*G. argenteus*). *Galaxias brevipinnis*, *G. postvectis*, and *G. fasciatus* occur abundantly only in streams that have good and stable forest cover. Because of stability of the environment in which they live, these species seem likely to be less exposed to the vagaries of climate. For this reason, in areas where catchments are stable, remain forested, and are not interfered with by man, production of the fishery for the perennial species is likely to persist as long as overfishing is avoided. The presence of perennial species, in particular *G. brevipinnis*, in the catch should have a stabilising effect on the fishery.

However, observations on the distribution of the perennial species suggest that they are subject to serious population declines in areas where catchment modification — such as logging, pasture development, and swamp drainage — has occurred. These activities are likely to have serious detrimental effects on populations of these species and consequently on their ability to continue to support the fishery.

The galaxiid whitebait seem to show greater ability to support a fishery of this type than the Tasmanian whitebait *Lovettia sealii*. When Blackburn (1950) described the establishment and subsequent collapse of the Tasmanian fishery he reported that samples of the catch comprised 78 383 *L. sealii* (98.03%), 1311 *G. truttaceus* (Valenciennes *in* Cuvier and Valenciennes) (1.64%), 204 *G. maculatus* (0.26%), and 60 "others" (0.08%).

Lynch (1965) re-examined the composition of the Tasmanian whitebait catch and found, from rather limited numbers of samples, a very different composition, namely, 559 *L. sealii* (24.69%), 1002 *G. maculatus* (44.26%), 358 *G. truttaceus* (15.81%), 340 *G. brevipinnis* (15.02%), and 5 "others" (0.22%). Lynch noted that 1964 "was the first time for six years" that *L. sealii* appeared in the catches of the rivers of north-western Tasmania and said: "This evidence makes it tempting to suggest that in some rivers of the north-west, there has been a change in the species composition of the catch. In the 1964 fishing season in the Forth River no whitebait (*Lovettia sealii*) was taken in the catch up to the end of October." By contrast Blackburn (1950) reported 99.17% of *L. sealii* in whitebait caught in the Forth River between 16 September and 2 October 1945.

Lynch (1965), for the first time, reported *G. brevipinnis* in the whitebait catch. (Lynch listed this species as *G. weedoni* Johnston, this name being a junior synonym of *G. brevipinnis* (McDowall 1970b).) It seems unlikely that *G. brevipinnis* appeared in the catch only in recent years and most probable that there was misidentification of the *Galaxias* species by Blackburn (1950). (*Galaxias brevipinnis* was clearly recognised as a constituent of the New Zealand whitebait catch only as recently as 1963 (McDowall 1964).) Lynch's limited data seem to indicate a substantial decline in the abundance of *L. sealii* and a proportionate increase in the numbers of the three *Galaxias* species.

As Scott (1971) noted, a comparison between the results of Blackburn (1950) and Lynch (1965) "would seem clearly to indicate that the period of decline was one, not only of absolute, but also of relative decrease in the abundance of *Lovettia*".

The susceptibility of *Lovettia* to overexploitation is not surprising. The species is an annual one and grows to only 40-60 mm; its fecundity is very low (mean 128.0 eggs in females 40 mm long, mean 205.9 eggs in females 51 mm long), compared with fecundity of up to 13 500 in large *G. maculatus* (McDowall 1968). There are very few data for other New Zealand whitebait galaxiids, but several thousand eggs have been reported for all species (McDowall 1970a, Hopkins 1979).

Campos (1973) reported a fishery for *G. maculatus* in the Rio Valdivia in southern Chile where catch "from 1968 to 1970 was from 1.5 to 2 tons" (presumably per year), caught by about 80 fishermen. (Campos reported the New Zealand West Coast catch in 1955 as 3.171 tons. If these are metric tons, the quantity is 3171 kg, and if they are British tons (2240 lb), it is 3222 kg. The actual figure is 322 224 kg (Table 24).) Unfortunately there are few figures for the yield of the Chilean fishery or for fishing pressure, but if Campos's figures for the Valdivia fishery (1.5-2 tons) are British tons, this is a catch for the river of only 1520-2030 kg, a very low catch for a large river system, caught by a substantial number of fishermen (80), over a long fishing season (April to November). Campos (1973) did not discuss fishing methods, but if the Valdivia River fishery is exploited by the intensive and effective means used in New Zealand rivers, it seems that either the natural population is small or the fishery is in much worse condition than the New Zealand fishery.

## PROSPECTS FOR FUTURE OF FISHERY

Despite widespread pessimism about the condition of the West Coast whitebait fishery and frequent forecasts of imminent collapse, we think that existing evidence gives little cause for concern that the populations are being overexploited. Our view is that fluctuations in the fishery are largely natural ones and that sustained productivity in southern areas of the West Coast under heavy exploitation indicates that the fish populations are able to stand the level of harvesting at present occurring. It seems likely, however, that the maintenance of a productive fishery in West Coast rivers during the past 30 years, when there has been a major decline in other parts of New Zealand, is due to relatively slight agricultural development in the West Coast. Increased agricultural and forestry activity in the area seems likely to have detrimental effects on the fish populations. The felling of forest, conversion of forest and swamp lands to pasture, and modification of stream channels to facilitate drainage of flood waters are bound to have adverse effects leading to a decline in the West Coast fishery similar to that which has occurred elsewhere in New Zealand.

# SUMMARY

The New Zealand whitebait fishery is based on capture of the up-stream-migrating juveniles of five species of *Galaxias*. These are *G. maculatus* (Jenyns), an essentially annual species, and *G. brevipinnis* Günther, *G. fasciatus* Gray, *G. postvectis* Clarke, and *G. argenteus* (Gmelin), all of which live for several years and probably spawn several times. *Galaxias maculatus* is the principal component of the catch, and *G. brevipinnis* and *G. fasciatus* make variable, usually minor, contributions to the fishery; *G. postvectis* and *G. argenteus* are insignificant in the catches.

Factors affecting the spring up-stream migration of juveniles of these species were studied in rivers in South Westland during 1969–73. Age of the fish at migration is about 6 months. The migrants cease feeding at sea before migration and resume feeding as they approach adult habitats in fresh water, where they grow to maturity. Size at migration varies between species, within seasons, and between seasons, and condition also varies between seasons. There is generally a decline in fish size at the end of the period of most intense migration. A minor metamorphosis, primarily slight trunk shrinkage, occurs as the fish settle in fresh water.

Migration may occur at any time of the year, but the peak occurs during spring, between early September and mid to late October. Stimulation of the first major migration each season is thought to be related to the spring equinoctial rains and floods in the rivers caused by these rains. Migration is thought to be a response to fish meeting the mixing fresh and salt water near river mouths — initially a response to fresh water and, once the fish are in the river estuaries, a response to river currents. Movement through the river mouths begins as the tide starts to rise and ceases at about full tide, though once the fish are in fresh water they continue to migrate up stream regardless of the state of the tide. Their response to currents results in flow patterns in the river estuaries modifying the migratory patterns of the fish as they seek "optimal" currents. The migratory shoals are found mostly in the upper 120 cm of the water column.

Migration occurs primarily in daylight hours and ceases at dusk, but some fish may move when there is bright moonlight.

Day-to-day fluctuations in whitebait catches are very broad and are related to occurrence of floods in the rivers, big catches following a few days after big floods. Height of the tides is not regarded as being important.

The species migrate in mixed-species shoals, but they differ in their response to a variety of environmental parameters; water turbidity, pH and water colour, and water temperatures together affect species composition of the shoals entering rivers and their tributaries. With increasing distance up stream, the species composition of the shoals also alters, the proportion of *G. brevipinnis* rising noticeably.

There is interspecific variation in seasonality in the migrations; in particular, *G. fasciatus* was found to migrate late in the season, from about mid October onwards, and *G. argenteus* usually appeared in the catches during the second week of November each season.

Consideration of catch and effort in relation to fishing patterns suggested that catch and effort are not closely related and that escapement is controlled by the effectiveness of nets being fished in key positions in the rivers, particularly nets fishing at up-stream limits of the estuaries.

Catch figures for the past 40 years show extensive fluctuations in catch. Figures for the Awarua River (1947–61) and Cascade River (1959–73), under relatively stable fishing pressures, suggest that there are broad, naturally occurring fluctuations in fish abundance from year to year. Fluctuations in annual catch were found to correlate between most West Coast areas, though this correlation does not apply to the most southern areas. Reasons for the fluctuations are not understood, but in the southern, less-developed areas of the West Coast coefficients of variation for catch are much lower than in more northern, developed areas. Thus environmental factors which affect fish abundance during their life in fresh water may have less impact on the populations in areas that remain forested and unmodified by man.

Management of the whitebait fishery poses special problems because the fishery exploits primarily an annual species at the juvenile stages. Overexploitation would result in rapid decline in production, and problems in estimating the necessary escapement require production from the fishery to be monitored carefully. Natural fluctuations in catch are so broad that any decline resulting from overfishing will be difficult to identify.

# ACKNOWLEDGMENTS

Completion of this research programme was possible only with the support and assistance of numerous technicians of Fisheries Research Division. Their willingness and enthusiasm in working long hours, often in wet and difficult conditions, are acknowledged with gratitude.

Considerable assistance was also rendered by many whitebaiters on the various rivers, who collected samples, kept diaries of catch, assisted with transport on the river, provided numerous cups of tea, and took a general interest in the work. They are too numerous to mention all individually, but special thanks are due to the following:

The late Mr N. Brazil; Mr and Mrs H. J. Buchanan; Mr and Mrs R. B. Buchanan; Mr L. C. Clelland; Mr and Mrs C. P. Eggeling; Mr and Mrs J. R. Evers; Mr and Mrs V. Hawker; Mr H. J. Hawker; the late Mr C. E. McGlashan; Mr and Mrs T. Marr; Mrs and the late Mr H. Morris; Mr and Mrs D. J. Nolan; Mr and Mrs R. P. Nolan; Mr and Mrs E. J. Ohara; Mr B. Prendergast; Mrs R. E. Rasmussen; Mr and Mrs N. C. Russ; Mr and Mrs M. F. Russ; Mr and Mrs J. C. Russ; Mr I. Thompson. Thanks are also due to Mr D. J. Hogan, Chemistry Division, Department of Scientific and Industrial Research, for carrying out water analyses. To all of these and to other unnamed fishermen and local residents go our thanks.

# REFERENCES


BENZIE, V. 1968a: A consideration of the whitebait stage of *Galaxias maculatus attenuatus* (Jenyns). *N.Z. Journal of Marine and Freshwater Research 2*: 559-73.

——— 1968b: The life history of *Galaxias vulgaris* Stokell, with a comparison with *G. maculatus attenuatus. N.Z. Journal of Marine and Freshwater Research 2*: 628-53.

——— 1968c: Some ecological aspects of the spawning behaviour and early development of the common whitebait, *Galaxias maculatus attenuatus* (Jenyns). *Proceedings of the N.Z. Ecological Society 15*: 31-9.

BLACKBURN, M. 1950: The Tasmanian whitebait, *Lovettia seali* (Johnston), and the whitebait fishery. *Australian Journal of Marine and Freshwater Research 1*: 155-98.

BOEREMA, L. K., and GULLAND, J. A. 1973: Stock assessment of the Peruvian anchovy (*Engraulis ringens*) and management of the fishery. *Journal of the Fisheries Research Board of Canada 30*: 2226-35.

BURNET, A. M. R. 1965: Observations on the spawning migrations of *Galaxias attenuatus* (Jenyns). *N.Z. Journal of Science 8*: 79-87.

CADWALLADER, P. L. 1978: Age, growth, and condition of the common river galaxias, *Galaxias vulgaris* Stokell, in the Glentui River, Canterbury, New Zealand. *Fisheries Research Bulletin, N.Z. Ministry of Agriculture and Fisheries, No. 17*. 34 pp.

CAMPOS, H, 1973: Migration of *Galaxias maculatus* (Jenyns) (Galaxiidae, Pisces) in Valdivia Estuary, Chile. *Hydrobiologia 43*: 301-12.

ELDON G. A. 1969: Observations on growth and behaviour of Galaxiidae in aquariums. *Tuatara 17*: 34-46.

HASLER, A. D. 1966: "Underwater Guideposts — Homing of Salmon." University of Wisconsin, Madison. 155 pp.

HECTOR, J. 1903: Notes on the New Zealand whitebait. *Transactions and Proceedings of the N.Z. Institute 35*: 312-9.

HOPKINS, C. L. 1979: Age-related growth characteristics of *Galaxias fasciatus* (Salmoniformes: Galaxiidae). *N.Z. Journal of Marine and Freshwater Research 13*: 39-46.

JELLYMAN, D. J. 1974: Aspects of the biology of juvenile freshwater eels (Anguillidae) in New Zealand. Ph.D. thesis lodged in Victoria University of Wellington library.

LYNCH, D. D. 1965: Changes in Tasmanian fishery. *Australian Fisheries Newsletter 24 (4)*: 13, 15.

MCDOWALL, R. M. 1964: A consideration of the question "What are whitebait?" *Tuatara 12*: 134-46.

———1965: The composition of the New Zealand whitebait catch, 1964. *N.Z. Journal of Science 8*: 285-300.

———1966: Further observations on *Galaxias* whitebait and their relation to the distribution of the Galaxiidae. *Tuatara 14*: 12-8.

———1968: *Galaxias maculatus* (Jenyns), the New Zealand whitebait. *Fisheries Research Bulletin, N.Z. Marine Department, No. 2*. 84 pp.

———1970a: The galaxiid fishes of New Zealand. *Bulletin of the Museum of Comparative Zoology 139*: 341-431.

———1970b: A second species of *Galaxias* common to Tasmania and New Zealand (Pisces: Galaxiidae). *Records of the Dominion Museum, Wellington, 7*: 13-9.

———1972: Clearing up confusion among fishermen: Are you positive those were whitebait you saw out at sea? *Commercial Fishing 11* (7): 6-7.

———1978: "New Zealand Freshwater Fishes — a Guide and Natural History". Heinemann Educational Books, Auckland. 230 pp.

MCDOWALL, R. M., ROBERTSON, D. A., and SAITO, R. 1975: Occurrence of galaxiid larvae and juveniles in the sea. *N.Z. Journal of Marine and Freshwater Research 9*: 1-9.

MAYR, E., LINSLEY, E. G., and USINGER, R. L. 1953: "Methods and Principles of Systematic Zoology". McGraw-Hill, New York. 328 pp.

MENZIES, W. J. M. 1936: The run of elvers in the River Bann, Northern Ireland. *Journal du Conseil Permanent International pour l'Exploration de la Mer 11*: 249-59.

NEW ZEALAND MARINE DEPARTMENT. 1932-51: *Report on Fisheries* for the years 1931-32 to 1950.

———1968-71: *N.Z. Nautical Almanac and Tide Tables* for the years 1969 to 1972.

NEW ZEALAND MINISTRY OF TRANSPORT. 1972: *N.Z. Nautical Almanac and Tide Tables for the Year 1973*.

NEW ZEALAND STATUTORY REGULATIONS. 1964: Whitebait Fishing Regulations 1964/120.

OTS, J.-P., and ELDON, G. A. 1975. Downstream movement of fry of *Galaxias fasciatus* Gray (note). *N.Z. Journal of Marine and Freshwater Research 9*: 97-9.

PASCOE, J. D. (Ed.) 1957: "Mr Explorer Douglas." Reed, Wellington. 331 pp.

SCOTT, E. O. G. 1971: Observations on some Tasmanian fishes. Part XVIII. *Papers and Proceedings of the Royal Society of Tasmania 105*: 119-43.

STOKELL, G. 1955: "Fresh Water Fishes of New Zealand". Simpson and Williams, Christchurch. 145 pp.

STRUBBERG, A. C. 1923: Elvers from North and South Europe. *Report on the Danish Oceanographical Expeditions 1908-10 to the Mediterranean and Adjacent Seas 3 (4)*: 1-29.

TARAS, M. J., GREENBERG, A. E., HOAK, R. D., and RAND, M. C. (Editorial Board) 1971: "Standard Methods for the Examination of Water and Wastewater." 13th ed. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, New York. 838 pp.

TULLY, J. P. 1952: Notes on the behaviour of fresh water entering the sea. *Proceedings of the Seventh Pacific Science Congress 3*: 267-88.

WARDLE, J., HAYWARD, J., and HERBERT, J. 1972: Influence of ungulates on the forests and scrublands of South Westland. *N.Z. Journal of Forestry Science 3*: 3-36.

WOODS, C. S. 1963: "Native and Introduced Freshwater Fishes". Reed, Wellington. 64 pp.

——— 1966: Species composition of whitebait (*Galaxias* spp.). *Records of the Canterbury Museum 8*: 177-9.

——— 1968: Growth characteristics, pigmentation, and the identification of whitebait (*Galaxias* spp., Salmonoidea). *N.Z. Journal of Marine and Freshwater Research 2*: 162-82.

# APPENDIX 1

## STUDY OF ENVIRONMENTAL FACTORS — METHODS AND RESULTS

### WEATHER

The only consistent weather observation made during the research programme was the measurement of rainfall. A rain gauge was mounted near the field station and rainfall measured for each 24 hours at about 0900 hours each day (Table 32 in Appendix 5).

South Westland is an area of very high rainfall. Average annual rainfall at Haast for the period 1949–71 (New Zealand Meteorological Service data) was 3555 mm, with about 200 rain-days per year; rainfall at Jackson Bay (1935–49) averaged 4483 mm, with 205 rain-days per year. Higher rainfall at Jackson Bay (33 km south of Haast) is part of a consistent pattern of increasing rainfall southwards as the distance between the Southern Alps and the coast lessens.

Rainfall is not evenly distributed through the seasons, though there may be heavy rainfall in any month. Peak monthly rainfall at Haast (1949–72) is over 375 mm in every month of the year. However, winter **tends** to be dry, especially in June and July. Spring rains usually begin in late August and persist through September into October.

We have rainfall figures for the Awarua River mouth (about 85 km south of Haast) for 3 years (1959–61). The correlation between rainfall patterns at the Awarua and those for the same period at Haast, for 199 days' data, is $r = 0.6174$, $P < 0.001$, so that there is a very close relationship for these years in rainfall in the two localities. It therefore seems safe to apply rainfall patterns at Haast to the Awarua River. The Cascade River, about 50 km south of Haast, probably has a similar rainfall pattern as well.

### WATER LEVEL

River levels were measured by use of stakes marked at 5-cm intervals and sited above tidal influence. Water levels were read daily to the nearest centimetre unless access was prohibited by flooding (Tables 34 to 36 in Appendix 5).

The objective of studying river levels was to relate changes in whitebait runs to floods and, for this purpose, only information on gross fluctuations was necessary. Diurnal variations in level, related to daytime thawing of snow in the sources of the rivers as observed by Douglas (Pascoe 1957), were not regarded as important.

Water levels are related to rainfall and in some rivers also to snow thaw. Generally in early August the rivers of the area are low and clear. In late August or early September the spring rains begin (see "Weather", on this page) and there are big floods in the rivers.

Although these early spring floods are caused mainly by rainfall, occasionally, when a warm northerly storm blows in from the sea, there is a sudden and massive snow thaw which results in a flood out of all proportion to the rainfall. This occurred, for instance, on 11 September 1971, when the Waiatoto River rose about 4 m, with only 10 mm of rain recorded on the 10th and 38 mm on the 11th.

The rivers rise and fall frequently during September and most of October. Often by early November the weather is more stable (though this was not true in 1970 or 1972) and the rivers stabilise at normal levels. However, as the weather settles and air temperatures rise rivers that originate in glaciers and alpine snow fields become discoloured and remain higher than they were before the spring rains.

The onset of snow thaw, and the resulting raised river levels and increased turbidity, varies in timing from year to year; the onset of the thaw is of considerable importance to the fishery (see "Effect of Turbidity on Species Composition", page 63).

In the 1969 river level data the snow thaw can be identified in the Haast, Waiatoto, and Arawata figures. From 26 October 1969 until 20 November there was only 90 mm of rain, and rain fell on only 6 days. Rivers with little or no snow in the headwaters (Waita, Okuru, and Turnbull) dropped to low levels and rose only briefly in response to rain. While these rivers dropped, the Haast, Waiatoto, and Arawata Rivers remained high and turbid in spite of the absence of rain. In 1970 and 1972 rain and flooding continued into November, so that raised river levels cannot be attributed entirely to snow thaw. In 1971, as in 1969, there was little rain during November. The Waiatoto River remained 50–60 cm above low winter levels because of snow thaw, the high levels occurring with slightly to moderately turbid snow water (see "Effect of Turbidity on Species Composition", page 63).

### TEMPERATURE

Water temperatures were measured daily in study streams and rivers and also in the sea at Jackson Bay. As there may be substantial diurnal fluctuations in temperatures, maximum-minimum mercury thermometers were used. We were unable to obtain thermometers designed for use immersed in water, and the instruments used, intended for meteorological purposes, needed careful and sometimes repeated calibration against a standard thermometer.

The thermometers were of the type in which a metal index is moved up the column by the mercury. They were either weighted in the water or placed in cases made of sections of galvanised water pipe; they were lowered on to the river bed.

Some temperatures recorded were obviously nonsensical from comparison with adjacent days' figures. This may have been due to careless handling, to buffeting in a flooded river, or to air exposure when there was a sudden drop in river level or when insufficient allowance was made for tidal flux. To eliminate these recordings we calculated the temperature amplitude for each day for each maximum-minimum pair. The mean daily amplitude for each recording site for each year was calculated and any pair of readings giving an amplitude that deviated from the mean amplitude for that station by more than three times the standard deviation of the mean was discarded.

Sea temperatures were recorded at Jackson Bay (from the wharf) in 1970 and 1971 with a Negretti and Zambra clockwork strip-chart recorder and in 1972 with a Grant Model D miniature battery-operated, clockwork-drive strip-chart recorder. A Grant recorder was also used for the up-stream Waiatoto River temperatures in 1972.

Temperature records were kept for the Cascade River by Mr R. B. Buchanan for the years 1959–72. A maximum-minimum thermometer was placed in the water above the point at which sea water penetrated the river, and it was read daily.

Water temperatures for the various rivers and seasons are given in Table 39 (Appendix 5), where the minimum, mean daily minimum, maximum, and mean daily maximum temperatures and the minimum, mean, and maximum amplitudes for each water in each year are listed. Figures for the Cascade River are given in Table 40 (Appendix 5). In all years observations began in late August and continued until mid November.

Water temperatures vary within and between rivers. Temperatures, and fluctuations in temperature, depend on such factors as the origin of the water; that is, whether it is from glaciers and snow fields of high mountains, from subalpine scrub lands and forest of lower hills, or from run-off from lowland forest and coastal swamps.

Rain from the north to west is warmer than that from the south or south-west. Winds blowing off the mountains are very cold; those blowing off the sea are less so. Whether rain is "warm" or "cold", river temperatures always drop during floods. Warm northerly rain falling in the mountains may produce rapid snow thaw accompanied by a severe drop in water temperatures. Periods of warm and dry weather are accompanied by rises in river temperatures, except in snow-fed rivers, which because of snow thaw may remain cold despite warm weather.

Factors contributing to daily fluctuations are complex and numerous, but include flow velocity, water colour, water depth, ambient air temperatures, and valley configurations.

Daily amplitude in temperature varied from 0.0° to 7.5°C. With the exception of Ship Creek swamp, the only body of standing water studied, all the waters reached low temperatures (5–8°C), most as low as 6°C.

Low temperatures usually followed cold, southerly rain. Maximum temperatures and daily fluctuations varied with the nature of the river and the origin of the water. Glacial rivers — Haast, Waiatoto, and Arawata — have cold water at their sources. In the Waiatoto, which is a deep, narrow river, the water remained cold, with low maxima and low amplitudes (Table 39 in Appendix 5). The Haast and Arawata are open-bedded, shallower, braided rivers; overall and mean daily maxima, and maximum and mean amplitudes, are high. The Okuru and Turnbull Rivers drain coastal hills; minima show that the water is cool at its origin, but the water warms up so that maxima and amplitudes are moderately high. The Waita is a short river that reaches low minima, though the average daily minimum is higher than in other rivers studied, and maxima and amplitudes are high. These high figures for the Waita probably reflect the origin of much of its water in the Tawharekiri Lakes, a group of small, swampy lagoons, and the shallow, somewhat braided, and extremely exposed nature of the river bed. The Waita is much the warmest of the six principal rivers in the study area.

Temperature patterns in the minor streams and in tributary streams showed some interesting features. Most of them have a fairly complete forest canopy, so that they are cool, and temperature amplitudes tend to be low, especially Content Creek, Jackson Bay Stream, and the upper Waiatoto River tributaries (Brewer Water, Hubbub Torrent, and Gliding Rivulet). Open standing water, as in Ship Creek swamp and Dawn Rivulet, is rather warmer and amplitudes are much higher.

Temperatures in the lower Waiatoto River estuary differ from those above tidal influence; average temperatures and amplitudes are higher in the estuary.

The sea at Jackson Bay was consistently warmer than most of the fresh waters studied.

## SEASONAL CHANGE IN TEMPERATURES

During the whitebait season river and sea temperatures rise as ambient temperatures rise, though short-term fluctuations are induced by floods, which make temperatures drop sharply. In the absence of floods temperatures rise steadily during spring in waters derived from coastal hills and foothills and coastal forests and swamps. However, with the

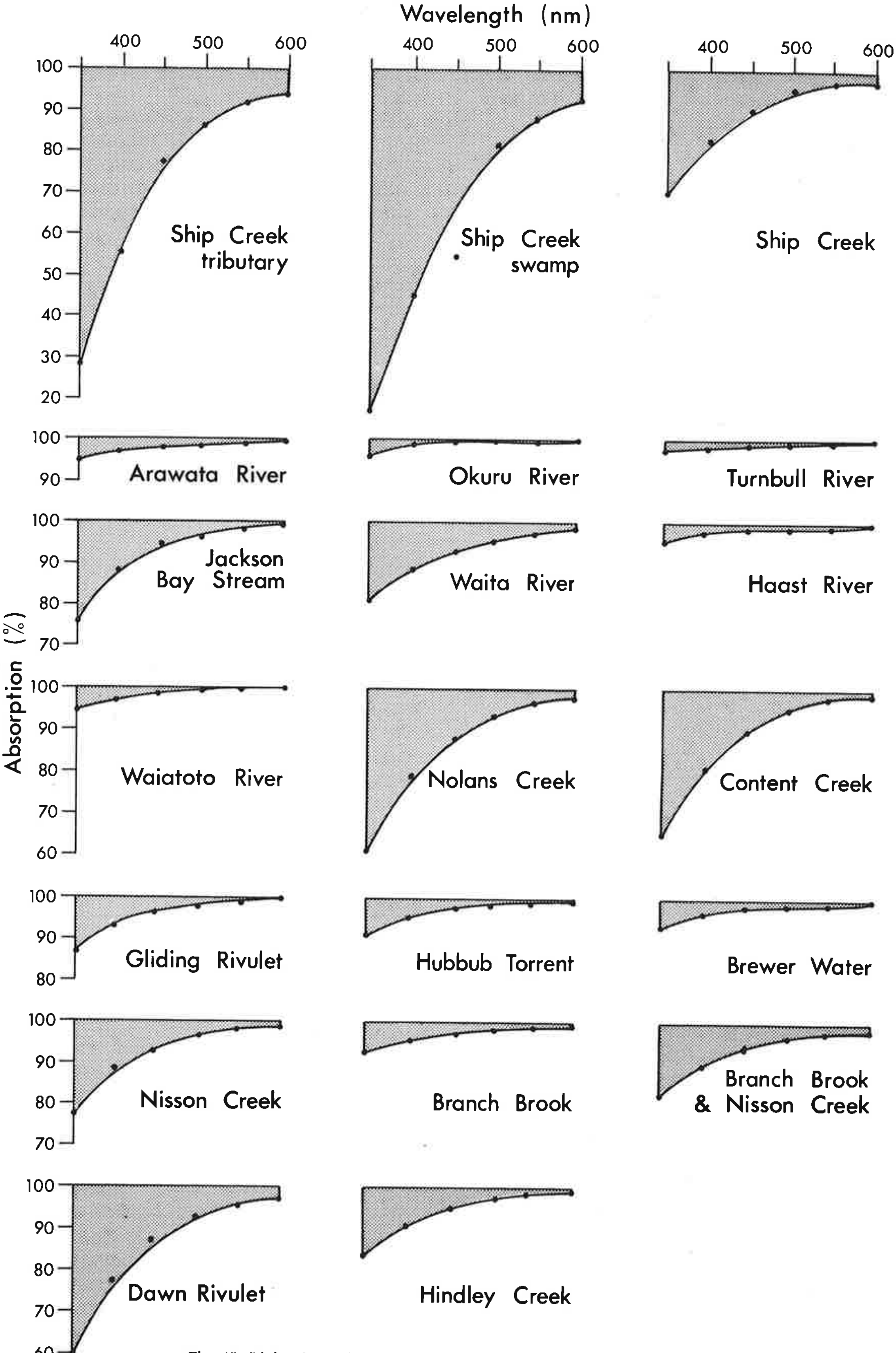



Fig. 45: Light absorption curves for water samples from the study rivers.

onset of snow thaw snow-fed rivers become colder and may stay cold until at least mid November, when measurements ceased. Thus in 1969 the Waiatoto River was as cold in late October during snow thaw as it was in early September, and it was little warmer by mid November.

## WATER COLOUR

Water colour was measured in two ways. Water samples were collected for chemical analysis, and American Public Health Association (Taras, Greenberg, Hoak, and Rand 1971) colour estimations were made by analysts of the Chemistry Division of the Department of Scientific and Industrial Research in Christchurch. Samples were also run through a "Spectronic 20" spectrophotometer with 2.5-cm-diameter tubes. Water samples were taken as much as possible when the rivers and streams were unaffected by flood sediments, as the spectrophotometer does not distinguish, except for spectral differences, between light interference caused by colour and that caused by turbidity. The spectrophotometer was calibrated against distilled water and percentage transmission measured at 350, 400, 450, 500, 550, and 600 nm.

The colour of the water in the study rivers varied widely from clear and colourless to deep brown. Colour analysis was not intended to demonstrate differences in the spectral qualities of the water, but rather to determine the intensity of the coloration. Accordingly, to classify the waters in degree of staining, average percentage transmissions at the six spectral levels for each water were calculated (Table 41 in Appendix 5) and converted to give a total average light loss for each water. These figures allow direct comparisons of the various waters.

The light absorption curves for the waters studied are shown in Fig. 45.

Staining of the water is most intense in streams draining standing water, whether open swamps (Ship Creek swamp and Dawn Rivulet), lowland lakes (Nisson Creek lake water), or water lying within lowland forest (Content Creek). Streams that drain forest, but in which run-off is rapid because of steep topography, show some brown staining. The Jackson Bay Stream shows moderate brown coloration, and the smaller and swifter upper Waiatoto tributaries — Gliding Rivulet, Hubbub Torrent, and Brewer Water — show much less. With the exception of the Waita River, the larger rivers are much clearer, the Waita being an exception because of the drainage into this small river of water from the Tawharekiri Lakes.

## WATER TURBIDITY

Water turbidity varied broadly, depending partly on rainfall and run-off and partly (in snow-fed rivers) on the spring snow thaw.

Water turbidity was estimated visually (1969-72 in various rivers; Table 42 in Appendix 5) and recorded on a five-point scale. In 1971-72 we also made Secchi disc transparency readings in the Waiatoto River, using a standard white 30-cm disc.

In 1972 two further methods of estimating turbidity were used. Transparency of water samples from the river was measured with a "Spectronic 20" spectrophotometer against a standard of distilled water, 2.5-cm-diameter tubes being used. Transparency was measured at wavelengths of from 350 to 600 nm at intervals of 50 nm.

In addition 90 litres of river water was passed through a Sharples continuous centrifuge at 23 000 r.p.m. The sediment removed was dried for 24 hours at 25 °C and weighed to the nearest 0.01 g. This method gave an estimate of the absolute quantity of sediment in the water (Table 30 in Appendix 5).

The visual sediment estimations (1971-72) were compared with Secchi disc transparency readings, and these comparisons indicated that the visual estimates have value, though there is broad overlap between categories.

The visual turbidity scale, and its relationship to Secchi disc values, is as follows:

1. **Clear:** Water clear, no turbidity evident; Secchi disc reading 190 cm and greater.

2. **Slightly turbid:** Water slightly milky, a greenish grey colour; Secchi disc reading 150-230 cm.

3. **Moderately turbid:** Water obviously carrying sediment, often visible as flocculence in the water, water grey to greenish grey; characteristic of a minor fresh or falling river after a flood; Secchi disc reading 75-190 cm.

4. **Grey turbid:** Water carrying a heavy sediment load, lacking flocculence, but uniformly turbid and grey; characteristic of a substantial fresh or small flood or a falling river after a large flood; Secchi disc reading 70-150 cm.

5. **Brown turbid:** Water grey-brown to yellow-brown, turbid, and obviously carrying a heavy sediment load; characteristic of a peak flood and usually persisting for only a few hours unless there is sustained heavy rainfall; Secchi disc reading 45-80 cm.

This sort of estimation has problems, as the criteria for each turbidity level are neither precise nor mutually exclusive, and estimations vary between observers and from day to day. The results of estimating turbidity and sediment load by other methods suggest that in the snow-fed rivers flood turbidity and snow-thaw turbidity have different characteristics and appearance.

The data on sediment weights (Table 30 in Appendix 5; Fig. 46) show that the relationship between sediment quantities and both Secchi disc readings and the visual turbidity estimates is good, the log of sediment weights rising curvilinearly in relationship to either

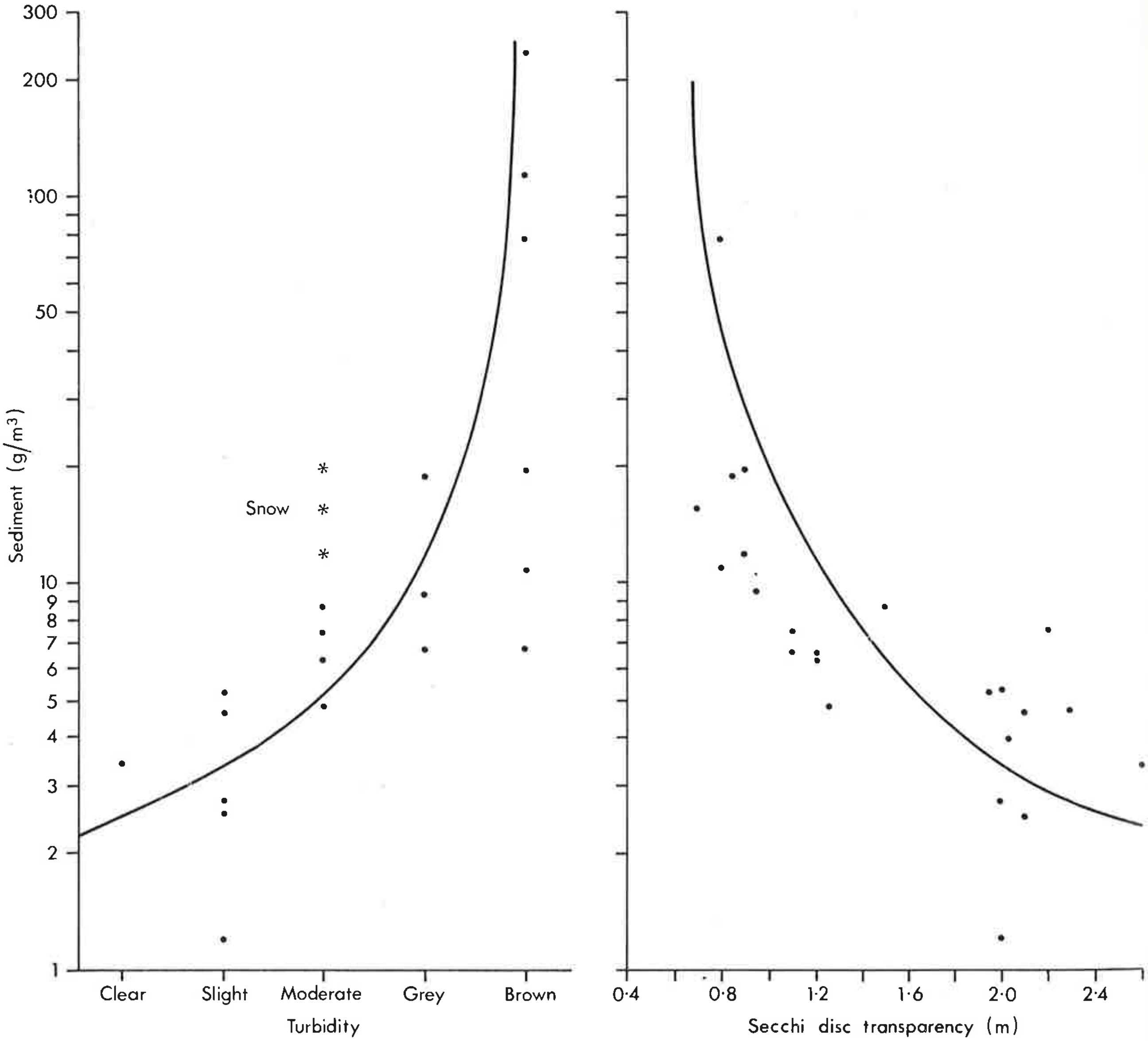



Fig. 46: Relationship between sediment loads (g/m³), turbidity categories (1 to 5), and Secchi disc transparency (m). The asterisks denote days when the water appeared to be affected by snow thaw.

Secchi disc reading or turbidity scale. There is rapid increase in the amount of sediment present between the grey turbid and brown turbid categories.

Comparison of the Secchi disc and spectrophotometer data shows a moderately good relationship (Fig. 46), though there is a surprisingly broad range of Secchi disc readings at any level in the spectrophotometer data. This suggests that the Secchi disc data are subject to rather broad variations in accuracy.

Several readings of turbidity as "moderately turbid snow" and "grey turbid snow" were made and these gave Secchi disc readings of 60–70 cm for grey turbid and 50–90 cm for moderately turbid. The very fine suspension in water of glacial origin gives the water the false appearance of being much less turbid than that with flood sediment. The varying contributions of glacial snow water to the turbidity of the water no doubt increased the overlap in the turbidity scales.

The asterisks in Fig. 46 denote days when the water appeared to be affected by snow thaw. The great effects of snow thawing on turbidity and transparency are evident.

The onset of snow thaw varies from year to year, depending on spring temperatures. In 1969 the snow-fed rivers remained relatively clear well into November. Comparison of turbidity readings for the six study rivers shows that the Waita, Okuru, and Turnbull Rivers cleared after a flood about 10 November, but the Haast, Arawata, and Waiatoto

Rivers had already been turbid for 3-4 days before the flood and remained turbid until records were terminated on 22-24 November.

By contrast in 1970 turbidity due to snow thaw was evident in the Waiatoto River from about mid October, and though the nearby Okuru became clear several times and was clear for long periods in late October and early to mid November, the Waiatoto remained slightly to moderately turbid for the whole period. The same is true for 1971. In 1972 rain during November meant that the Waiatoto River remained turbid from flooding. Snow thaw was not as evident, though it did occur and could be identified visually between floods in the river in early to mid November 1972.

For all rivers except the Waiatoto only visual estimations of turbidity were made. The rivers fall into three distinct categories:

1. Ship Creek and its tributaries, the Waita River, and, to a less extent, the Jackson Bay Stream are brown stained, but translucent, and they carry little apparent sediment unless in flood.

2. The Okuru and Turnbull Rivers are colourless and naturally very translucent, especially the Turnbull.

3. The Haast, Waiatoto, and Arawata Rivers are also naturally colourless, but originate, in part in glaciers, so that during the snow thaw they may carry much fine, flour-like sediment. Thus some rivers are turbid only when in flood with raised levels, but the Haast, Waiatoto, and Arawata may be very turbid when running at near, or a little above, average levels.

### pH

Measurements of pH were taken sporadically in the various waters studied (Table 43 in Appendix 5). In 1969-71 a "Radiometer PHM 22" was used, and in 1972 a Beckman "Electromate". Both instruments are fully portable and allow measurement *in situ*. Values for pH varied from 3.9 to 7.7, strongly acid to slightly alkaline. Mean pH varied from 4.3 to 7.2. The major rivers — Waita, Haast, Okuru, Turnbull, Waiatoto, and Arawata — tended to be much closer to neutral pH than the small streams and tributary streams. A close relationship is evident between size of the six major rivers and pH; the smaller rivers have lower pH (Fig. 47). This is a product of the relative contributions to the river of snow and mountain water and lowland and coastal swamp water (see page 98).

The pH of the streams is closely related to the origin of the water.

Variation in pH can be seen in the data from tributaries of the Waiatoto River, which were subject to more intensive study. The Waiatoto River itself has neutral pH (mean 7.0 from 28 measurements), but all the tributaries studied had lower values. Small, rocky streams tumbling through the forest were usually slightly acid, for example, Gliding Rivulet (6.6), Hubbub Torrent (6.5), and Brewer Water (6.2) (Table 43 in Appendix 5). The lake branch of Nisson Creek was acid (5.4), but Branch Brook was much less so (6.3). Because of the varying contributions of the two streams to the combined flow, the pH of Nisson Creek as measured below the confluence varied widely.

Two high pH readings for Nolans Creek (6.7 and 6.8) contrast with 19 others of 6.0 or below. One of these was taken at high tide, when the Waiatoto River pushes back into the lower reaches of Nolans Creek, where readings were taken, and the pH of 6.8 almost certainly reflects influence of Waiatoto River water; the pH of 6.7 may also, and these two values have been ignored in calculating mean pH of Nolans Creek.

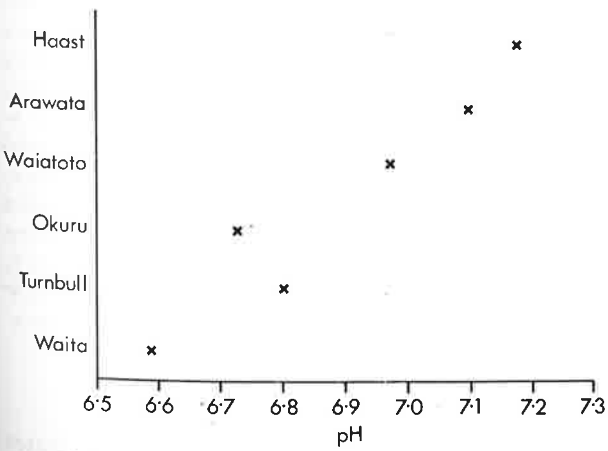



Fig. 47: Relationship between river size and pH. The rivers are listed in order of estimated size from small (Waita) to large (Haast).

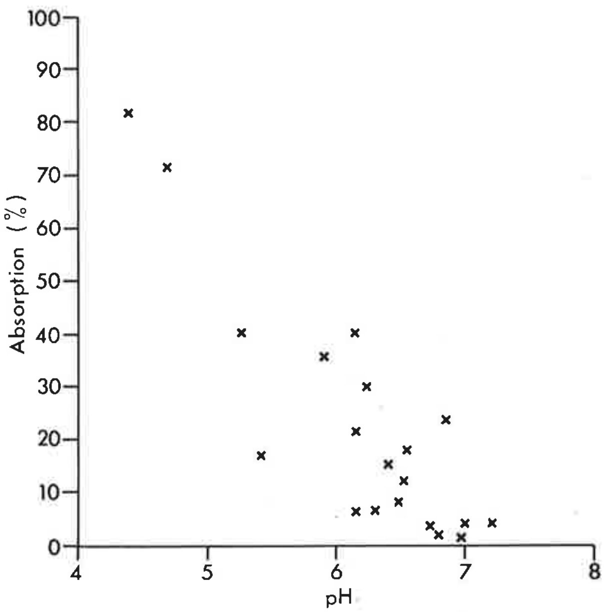



Fig. 48: Relationship between pH and light absorption at 350 nm.

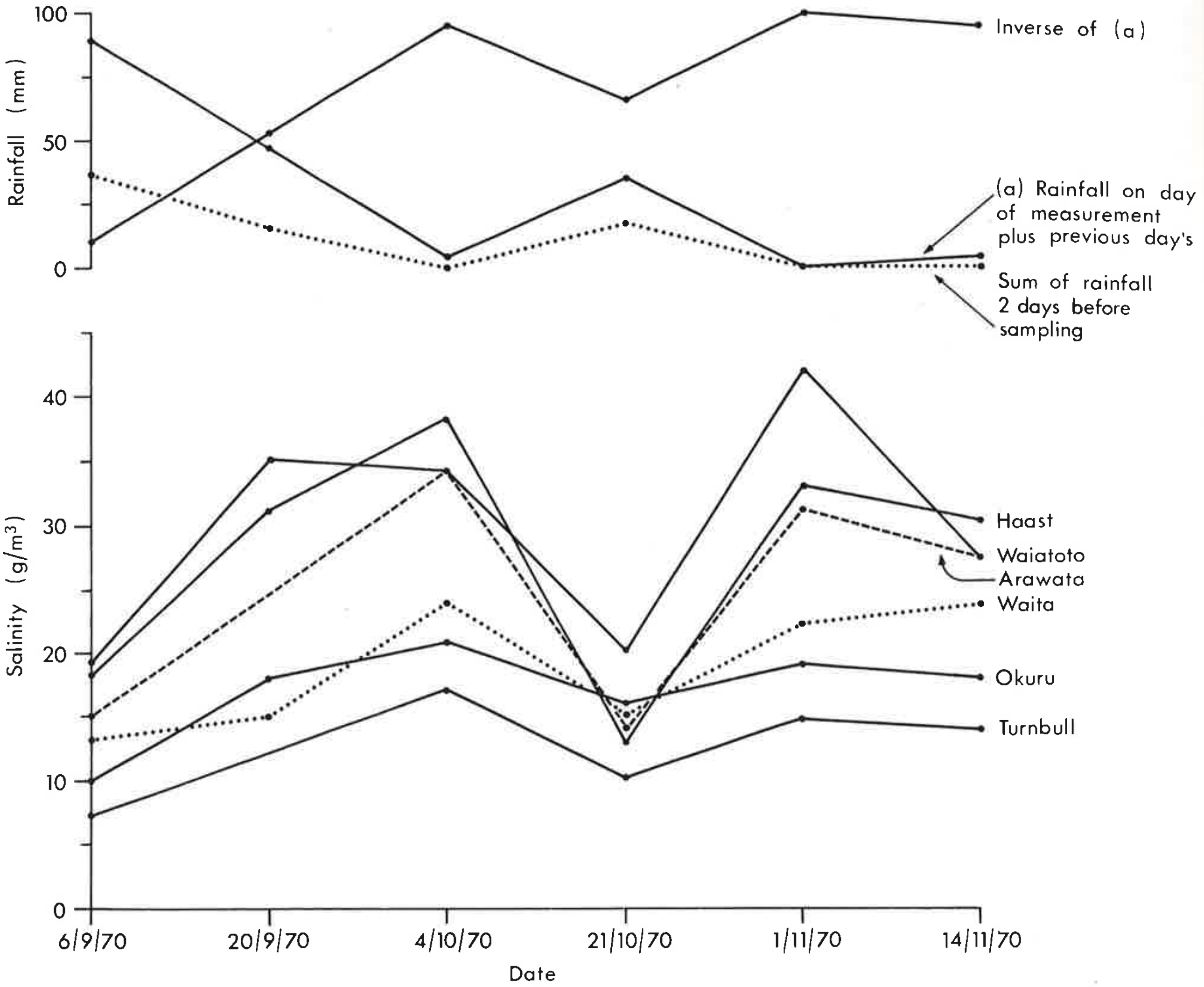



Fig. 49: Correlation in fluctuations in the salinities of the study rivers and their relationship to rainfall.

The lowland streams, brown stained and draining lowland boggy forest, coastal swamps, or lakes, were consistently strongly acid (Content Creek, Dawn Rivulet, Nolans Creek, and the lake branch of Nisson Creek).

Water pH was found to be closely related to water colour (Fig. 48); those rivers in which there was intense brown staining were more acid than clearer waters. This is logical, as the brown staining is caused primarily by organic acids leached from litter of the forest floor and rotting plant material in swamps.

## OXYGEN

Dissolved oxygen in the waters was measured *in situ* with an EIL Model 15A portable oxygen meter (Table 44 in Appendix 5). (As few measurements were made, all data are given.) Oxygen levels varied widely between waters, though they tended to be consistent in any one water. The large rivers (such as the Waita, Haast, and Okuru) and the small, tumbling streams (Hubbub, Gliding, Brewer, and Jackson Bay) tended to be supersaturated; the slower-flowing streams were less so (Content, Nisson, and Nolans) and the standing water of the Ship Creek swamp was very low in oxygen.

Oxygen levels correlate closely with those of pH ($r = 0.7306$, for $n = 20$, $P < 0.001$). However, this should not be regarded as a functional relationship; rather, the acid waters tend to be waters derived from lakes and swamps where aeration of the water in broken rapids does not occur. The Ship Creek tributary, though very acid (pH 4.65), has broken turbulent flow and, as a result, high oxygen levels (108.3% saturation).

## WATER CHEMISTRY

Two approaches were made to studying water chemistry, neither of which was particularly intensive.

During the broad-ranging exploratory survey of

1969 conductivity was measured in the study rivers with a conductivity bridge. In 1970 similar series were taken from the Waiatoto River and its tributaries.

Water samples were collected in 2-litre polythene bottles, and conductivity was measured on return to the field station or laboratory after water temperature had been standardised at 20 °C.

Salinity was calculated from conductivity (as NaCl equivalents; see Table 45 in Appendix 5).

Salinities were generally low and sometimes extremely so, for example, minima for Hindley Creek and Nolans Creek of 6 $g/m^3$ and of 7 or 8 $g/m^3$ for several other streams or rivers and an average of 9 $g/m^3$ for 15 observations on Hubbub Torrent. The snow-fed rivers, for example, Haast, Waiatoto, and Arawata, tended to have higher salinity than average. Although some of the brown-stained waters were high -- Ship Creek swamp and Nolans Creek — others, for example, Content Creek, were extremely low. High salinities were observed occasionally at Ship Creek. These probably reflect incursions of sea water into the lower reaches of the stream or salt spray from the surf and are probably meaningless as an indicator of ionic content of Ship Creek water. If Ship Creek figures are disregarded, salinities varied between 7 and 49 $g/m^3$ (compare Wellington City mains water supply on 9 January 1970 of 56 $g/m^3$).

The salinities in the six main rivers (Waita, Haast, Okuru, Turnbull, Waiatoto, and Arawata) were found to fluctuate together (Fig. 49). This suggests that salinity was partly related to an environmental parameter common to all; this was logically weather and in particular rainfall. Figure 49 and Table 31 (Appendix 5) show clearly that there is a close inverse relationship between rainfall and salinities, which suggests that salinities respond rather directly to rainfall. Calculations of correlations between salinity and rainfall, either the sum of rainfall on the day of sampling and the day preceding it or on the 2 days preceding sampling, for the Okuru and Waiatoto Rivers showed that the relationship is close (Table 31 in Appendix 5).

The most obvious fact emerging from study of water salinities is that differences between rivers are no greater than fluctuations within a river; for this reason study of water salinities was pursued no further.

A series of chemical analyses was carried out for us by the Government Analyst's Laboratory of the Department of Scientific and Industrial Research in Christchurch. Two sets of analyses were done on the Waiatoto River and its tributaries in 1971, a further set on Dawn Rivulet and Hindley Creek in 1972 (Table 47 in Appendix 5), and two sets on the Ship Creek to Jackson Bay series of waters (1969 study series) in 1972 (Table 48 in Appendix 5).

The differences between the waters revealed by pH and water colour, as already discussed, are consistent with differences in chemical analysis. The acid brown waters were shown to have high nitrate, high total organic nitrogen, high oxygen absorbed, low alkalinity and hardness, and high iron. By contrast, the clear rivers had lower nitrate and organic nitrogen, low oxygen absorbed, much higher alkalinity and hardness, and lower iron. It is not known to what extent these chemical differences are important to the fish (a critical question), but these analyses indicate that the impressions gained from superficial appearance, colour, and pH are consistent with the chemistry of the waters. In other words, our partly subjective classification of the waters reflects differences in water chemistry.

# APPENDIX 2

## WEST COAST RIVERS SAMPLED

### GENERAL DESCRIPTION OF RIVERS

Data on which descriptions of the rivers are based vary in detail and dependability. Some rivers were explored for several kilometres by foot, road, or jet boat; others were not. All rivers were studied from aerial photographs or inch-to-the-mile topographical maps (N.Z.M.S. 1). Water temperatures, water colour and clarity, water chemistry, pH, and oxygen content were examined. Information on flow volumes is derived primarily from an unpublished report, "A Broad Survey of Hydro-electric Resources of the West Coast", prepared by the former New Zealand Electricity Department.

**Buller River**

The Buller River is large, with a mean annual flow of 507 $m^3/s$ (at Te Kuha, about 14 km from the mouth). It has its source in Lakes Rotoiti and Rotoroa, 130–150 km from the sea. Snow water is not evident in the Buller, which is clear except during floods. Its lower reaches flow through open farm land, but upper tributaries drain beech and beech-podocarp-broadleaf forest. The river bed is deep and narrow, with no braiding, and in many parts it is confined to a narrow channel between steep rocky cliffs. The origin of the river in cool lakes and forested hills suggests that the water is moderately cool. The deep water, extensive forest cover, and precipitous rocky margins indicate that temperatures are diurnally fairly stable.

**Hokitika River**

The Hokitika River is of moderate size, with an estimated mean annual flow of 30 $m^3/s$ (at Collier Creek, 24 km from the mouth). It is about 60 km long and drains catchments on the western flanks of the Southern Alps, one branch originating in several small glaciers. The headwaters drain forested hills, and in the lower reaches the river flows through some forest and some open pasture land, where it becomes braided. Snow water seems to have little effect on clarity of the river during the spring snow thaw.

**Ship Creek**

Ship Creek is a small stream about 8–9 km long, with very low flow. It drains lowland forest and swamp, and the water is deeply brown stained (Table 41 in Appendix 5) and moderately acid (Table 43 in Appendix 5). The water is oxygen saturated (Table 44 in Appendix 5). In accessible down-stream reaches it is deep and gently flowing and entrenched, with steep banks a metre or more high. Forest grows to the water's edge. The lower few hundred metres are tidal, though they do not appear to be much affected by influx of sea water. The stream drains across a built-up sandy beach and through a narrow passage to the sea. The opening tends to be obstructed by beach sand in heavy westerly seas. Records from 1969 show that temperatures are moderate, with moderate diurnal amplitude (Table 39 in Appendix 5). Two small tributaries enter the upper estuary, one draining forest, the other being overflow from an extensive coastal swamp. Both are brown, the swamp water being particularly dark (Table 41 in Appendix 5), and both are much more acid than the main stream, the swamp water having an average pH of 4.3 (Table 43 in Appendix 5). We have no temperature data for the forest tributary, but the swamp water was much warmer than Ship Creek itself. The tributary was oxygen saturated, but the swamp water was very low in oxygen (Table 44 in Appendix 5).

**Waita River**

The Waita is a small river about 17 km long. Its water has a dual origin, much draining off the western side of a range of coastal hills (Thomas Range) and the remainder coming from a group of lowland swampy lakes (Tawharekiri Lakes). Because of these lakes the water of the Waita is moderately brown (Table 41 in Appendix 5) and moderately acid (Table 43 in Appendix 5); oxygen appears to be saturated (Table 44 in Appendix 5). In its lowland reaches the river flows across extensive gravelly flats and is shallow and moderately braided. The bed is generally gravelly and built up to the level of the surrounding river flats. There are extensive, though intermittent, grassy flats which are grazed by cattle, but in places forest reaches the margins of the river bed. The water is exposed to the sun, and our 1969 observations showed this water to be relatively warm and subject to moderate diurnal fluctuations (Table 39 in Appendix 5). Owing to the small flow volume of the river, the mouth is subject to closure during heavy seas and also to changes of position along the coast, depending on the prevailing wind.

Although variable, the estuary is mostly small with little ponded area up stream from the mouth at high tide. In addition to the stream carrying overflow from the Tawharekiri Lakes, a few small tributaries enter the river in several kilometres of its lower stretch. Some are clear flowing, and others are brown-stained bush and coastal swamp streams.

**Haast River**

The Haast is a large river, with a mean annual flow of about 240 $m^3/s$ (at Big Bluff, about 14 km from the mouth). The flood plain is 1 km or more across and the river is about 70 km long. The Landsborough River, a major upper tributary, is more than 50 km long. The Haast and its tributaries reach high into the Southern Alps, the Landsborough having its source in the McKerrow Glacier, just south of Mount Cook. Much of the Haast River's water originates in glaciers. During winter and early spring the water is extremely clear, showing no influence of the brown forest swamp water (Table 41 in Appendix 5). But in spring, especially after warm rain or a spell of warm, fine weather, snow thaw results in great turbidity in the water. We have no measurements, but our observations indicate that snow turbidity in the Haast considerably exceeds that in the Waiatoto at comparable times (Table 30 in Appendix 5). The water has pH near neutral (Table 43 in Appendix 5) and oxygen above saturation (Table 44 in Appendix 5).

For many kilometres in its lower course the Haast is braided and flows across built-up gravel flats, bordered in places by extensive areas of grassy flats on which cattle are grazed. The flow throughout is swift, with many long, gravelly rapids, long, deep runs of fast water, and pools only on sharp bends. The river bed is largely gravel, except near the mouth, where it becomes increasingly sandy. The estuary is small. We observed, and were told by fishermen, that river water continues to flow out of the mouth throughout the rising tide. Observations in 1969 showed that the water is cold at its source (low mean daily minimum), but because of the open river bed and braided channels it is subject to moderate diurnal fluctuation (Table 39 in Appendix 5).

**Okuru River**

The Okuru River is small, having a mean annual flow of 51 $m^3/s$; it is about 40 km long and drains western spurs of the Southern Alps. Little, if any, of its water has glacial origins, and, unless it is affected by heavy rain, its water is very clear and little affected by brown forest water (Table 41 in Appendix 5). Its pH is a little below neutral (Table 43 in Appendix 5) and oxygen above saturation (Table 44 in Appendix 5). In its lower reaches the river flows in a confined channel 30-40 m wide and entrenched 1-3 m deep, with a sand-gravel bed and gravel beaches along the margins. Grassy flats border the river in places, but are not extensive, and forest reaches the river's edge in many parts. Flow in lower parts of the river is gentle, with long pools and brief rapids. The river has a large and shallow estuary, which it shares with the nearby Turnbull River, and both drain into the sea through a single, narrow mouth. A few small brown-water tributaries enter the lower reaches of the Okuru. Water in the river is relatively warm and shows moderate diurnal fluctuations (Table 39 in Appendix 5).

**Turnbull River**

The Turnbull River is smaller than the Okuru (mean annual flow of 29 $m^3/s$), with a length of about 30 km. It resembles the Okuru in colour (Table 41 in Appendix 5), lack of snow water, pH (Table 43 in Appendix 5), temperature (Table 39 in Appendix 5), and oxygen saturation (Table 44 in Appendix 5). It drains a group of spurs along western flanks of the Southern Alps. Its major tributary, Hapuka River, enters the southern side of the Turnbull estuary. This is a brown-water stream draining large areas of open coastal swamp.

**Waiatoto River**

The Waiatoto River is a moderate-sized river with a mean annual flow of 71 $m^3/s$ and a length of about 55 km. It drains numerous glaciers high along the western face of the Southern Alps near Mount Aspiring. Its water is largely free from brown forest water (Table 41 in Appendix 5), with pH about neutral (Table 43 in Appendix 5) and oxygen above saturation (Table 44 in Appendix 5); the glacial origin of much of its water makes it very turbid during the spring snow thaw (see "Water Turbidity", Appendix 1, page 93). The upper river valley, above a gorge 15 km from the mouth, is reported to be fairly broad, with extensive areas of grassy flats, but there is also extensive forest cover to the river margins. Photographs (for example, Wardle, Hayward, and Herbert 1972) show some braiding, but the river is largely confined to a fairly deep and narrow channel. Below the gorge the river is entrenched to a depth of 6 m or more, with much of the forest reaching the water's edge. Marginal grassy flats occur in a few places. The river runs mostly as a deep, narrow, unbraided channel, swiftly flowing, with few rapids. The bed is mostly sand and gravel, with bedrock or very large boulders in some places. There is an expansive estuarine area with a deep channel, extensive tidal lagoons, and moderately broad estuarine sandy flats. The position of the mouth is highly variable.

Tributaries enter the Waiatoto River throughout the reaches below the gorge. Water characteristics and whitebait movements were studied in eight of these. The distances up stream from the river mouth of the localities where our traps and thermometers were installed are given in Table 2.

**Hindley Creek** drains lowland forest swamp, with a substantial contribution of water also coming from coastal hills. The stream is almost completely enclosed within forest canopy, except for the lower few kilometres, and even then has forest along the banks. Its water is cool and shows moderate diurnal fluctuation (Table 39 in Appendix 5) and the mixed origin of its water gives it a greenish brown colour (Table 41 in Appendix 5). It is moderately acid (Table 43 in Appendix 5) and oxygen levels are usually saturated (Table 44 in Appendix 5).

**Dawn Rivulet** (known locally as Weedy Creek) is a tributary of Hindley Creek and is very brown (Table 41 in Appendix 5) and acid (Table 43 in Appendix 5). Oxygen level tends to be below saturation (Table 44 in Appendix 5). The bed of Dawn Rivulet is deep and surrounded by rushes and flax swamps; flow is very slow, almost imperceptible at times. The water is derived wholly from open coastal flax swamps, and because of extensive exposure to sunshine and the slow flow rate the water shows broad diurnal fluctuations and may become warm (Table 39 in Appendix 5).

**Content Creek** drains lowland forest and has a heavy cover of forest. It is brown (Table 41 in Appendix 5), strongly acid (Table 43 in Appendix 5), cool, and is subject to very low diurnal temperature fluctuations (Table 39 in Appendix 5); its oxygen level approaches saturation (Table 44 in Appendix 5). All these three streams are gently flowing, with mud, sand, or fine gravel beds. Dawn Rivulet has swampy margins, but Hindley and Content Creeks are slightly entrenched, with forest (usually on firm banks) along the margins.

**Nolans Creek** is a very small stream consisting of little more than seepage from forest near the river margins. Flow rate and volume are both very low, but because of a complete forest canopy the water is cool and has moderately stable temperatures (Table 39 in Appendix 5). The water is brown (Table 41 in Appendix 5) and acid (Table 43 in Appendix 5) and oxygen levels are well below saturation (Table 44 in Appendix 5).

**Nisson Creek** has water of composite origins. The main stream channel receives its water from Lake Nisson, a small, open, and probably shallow lake enclosed by forest. The water from this lake is very brown (Table 41 in Appendix 5), acid (Table 43 in Appendix 5), warm, and subject to broad diurnal fluctuations (Table 39 in Appendix 5). Its oxygen level almost reaches saturation (Table 44 in Appendix 5). After rain it contributes a large proportion of the water entering the Waiatoto River from Nisson Creek.

Not far from its confluence with the Waiatoto, Nisson Creek is joined by **Branch Brook,** which is spring fed, relatively uncoloured (Table 41 in Appendix 5), cool, and probably thermally stable; it is not nearly as acid as the lake branch (Table 43 in Appendix 5), but like the lake branch it is almost saturated with oxygen (Table 44 in Appendix 5). Its flow appeared to be much more stable than that of the lake stream, so that after long periods without rain, when flow from the lake branch had dropped, Branch Brook contributed a relatively much greater proportion of the water finally joining the Waiatoto River. Thus the characteristics of the water entering the Waiatoto River from Nisson Creek vary widely according to which of the two tributaries is making the greater contribution to the combined flow. We did not monitor the relative flows of the two streams.

The differences between the two types of water can be seen by comparing the temperature data for Nisson Creek for 1970 and 1971 (Table 39 in Appendix 5). Quite by chance the trap and thermometer were sited on the left bank of the stream in 1970 and the right bank in 1971, so that in 1970 we were fishing and recording temperatures primarily in water of lake origin and in 1971 primarily in water of spring creek origin. Thus the mean daily maximum and minimum and mean amplitudes for 1970 are much higher than for 1971 (Table 39 in Appendix 5).

**Brewer Water** is a small, gravelly stream tumbling down from forested hills and elevated river terraces. It is slightly brown stained (Table 41 in Appendix 5) and slightly acid (Table 43 in Appendix 5), and the water is thoroughly oxygen saturated (Table 44 in Appendix 5), cool, and thermally stable (Table 39 in Appendix 5).

**Gliding Rivulet** and **Hubbub Torrent** are similar in character, but even smaller than Brewer Water. They comprise water cascading rapidly down among large rocks, with some small pools, but mostly broken and turbulent water. Like Brewer Water they are completely enclosed within forest canopy, are cool, thermally stable, slightly brown stained and acid, and are thoroughly oxygen saturated.

### Arawata River

The Arawata is a large river, with a mean annual discharge of about 106 $m^3/s$. It is about 70 km long and drains the Snowball Glaciers, just south of Mount Aspiring. Like that of the Waiatoto and Haast, Arawata water is almost colourless (Table 41 in Appendix 5), but becomes very turbid during the spring thaw of glacial ice and snow. The pH is about neutral (Table 43 in Appendix 5) and oxygen is above saturation (Table 44 in Appendix 5). The river flows down a broad, open valley, is moderately braided, and flows across built-up gravelly flats on to which extensive areas of grassy flats encroach. It flows swiftly, with some deep, long pools, long, fast runs, and large rapids. The river bed is gravelly. There is a broad and long tidal estuary which opens to the sea through a small mouth. A major tributary, the Jackson River, enters about 7 km from the sea. This river runs clear, but is slightly brown stained. Its water comes from a range of coastal hills and from Lake Ellery; in addition, many small brown-water forest creeks drain into the lower Arawata. Because of its glacial origin the water in the Arawata is originally cool (as indicated by low mean daily minimum temperature), but its broad, open valley and rather shallow, braided waters mean that daily amplitudes are relatively high, higher than those in any other major river studied (Table 39 in Appendix 5).

**Jackson Bay Stream**

The Jackson Bay Stream is a tiny creek flowing out of forest. It drains a hilly forested area and is at the most a metre wide, mainly only half this, and a few centimetres deep. It is completely enclosed within forest canopy and is a typical forest stream with alternating small, sandy pools and rocky cascades and rapids. Like the small tributaries of the Waiatoto (Gliding Rivulet, Brewer Water, and Hubbub Torrent), it is slightly brown (Table 41 in Appendix 5), slightly acid (Table 43 in Appendix 5), cool, and extremely stable thermally (Table 39 in Appendix 5). Its oxygen level almost reaches saturation (Table 44 in Appendix 5).

**Cascade River**

The Cascade River is relatively small, about 60 km long, with a mean annual flow of 24 $m^3/s$. In its lower reaches it is deep and runs through a fairly confined bed. There are large expanses of swamp along the margins. Fishermen sometimes described the water as "black", which indicates acid swamp water. As none of the water originates in snow fields or glaciers, it is unlikely that there is turbidity caused by spring snow thaw. Water temperatures are moderate and amplitudes very low (Table 40 in Appendix 5).

# APPENDIX 3

## FISHING METHODS

Fishermen in South Westland use several types of fishing gear. In the principal fishery they work on registered sites (New Zealand Statutory Regulations 1964). In deeper rivers (Waiatoto, Okuru, and Turnbull and in parts of the Haast and Arawata) they build a wooden stand or "trench". This consists of a wooden catwalk supported by wooden piles driven into the river bed and which may extend out into the river channel only 2–3 m or as much as 20-30 m. The down-stream face of the stand is covered by vertical screens — wooden frames covered by mosquito gauze (1.5-mm mesh) — which can easily be removed during floods or for cleaning.

Although the regulations permit use of up to six nets, few fishermen use more than two or three and many only one. When a single net is used it is placed at

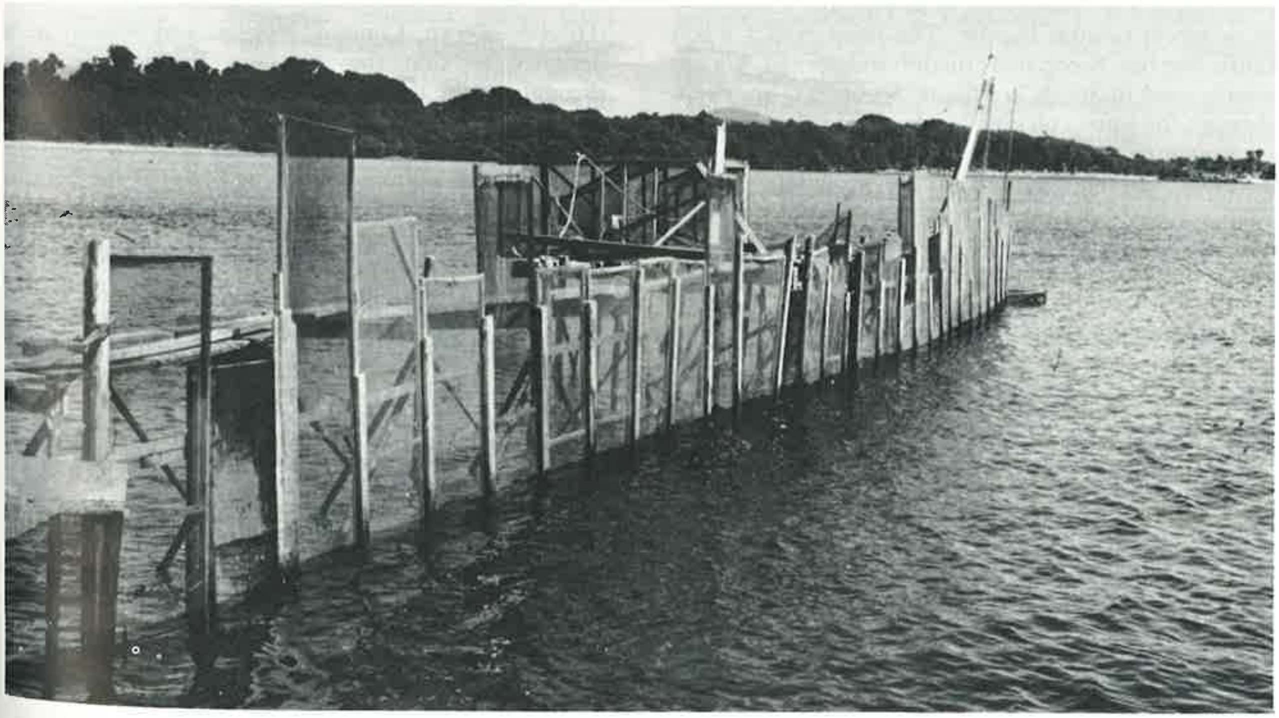


Fig. 50: A standard wooden-framed whitebait net as used by fishermen in South Westland.

the mid-river end of the stand. When more than one net is used, additional nets are inserted in gaps in the screens. The usual net is about 1 m square (mouth size is restricted by regulation) and 1½ m long, is cuboidal, is constructed of wooden stakes 2.5 cm square, and is covered with mosquito gauze (Fig. 50). There are two traps to retain the fish in the net. The front trap opening is usually 20–30 cm square and the inner one, leading into the chief holding compartment in the net, has an opening about 6–8 cm square. These nets are heavy, especially when wet and full of fish, and are difficult to handle, particularly in windy weather or when there is a surge in the river. To ease handling and also to facilitate holding them in the water in the correct position in relation to the rising and falling tide, the nets are suspended from a long sloping boom by a block and tackle. During fishing the nets are left in place, often for the entire tide during the day.

In rivers like the Haast and Arawata some fishermen fish the rapids by placing a small trap net at the edge of the water just below a channel with rapid, shallow flow. Ordinary open-mouthed, trapless nets usually with wire frames and gauze covers are used in similar fashion, though the lack of a trap means that the net needs constant attention and must be lifted and emptied frequently. Surf whitebaiters also use nets of this type. They catch fish by throwing their nets down into the surf at the river mouth as a wave surges shoreward and then lifting the net as soon as the wave passes through the net.

Scoopers use nets with a tubular aluminium alloy hoop about 1½ m long and ½ m wide and a long (2–3 m or more) tubular handle. The hoop carries a soft fabric bag net. Scoop nets, though widespread, are not greatly used in South Westland. Scoop nets are swept through the water, picking up shoals of fish swimming up stream near the river bank.

Almost all the commercial fish production comes from registered stands with screens, a large trap net, and a block and tackle; smaller amounts are caught by fishermen using single trap nets on the falls or open-mouthed nets in the surf.

Our sampling fishermen in various places used all types of nets — scoop nets in the Buller River, trapless, box nets in the Hokitika, trapless, wire-framed nets in the Waita, and box nets with traps in the other rivers of South Westland.

Samples collected by research personnel were also captured by a variety of methods. On the experimental fishing stands in the Waiatoto River a three-level trap was built in which three traps each with a front opening of 60 cm by 90 cm were placed one on top of the other so that when the trap was fishing, fish migrating at different levels in the water were caught separately (Fig. 51). Traps for major tributary streams

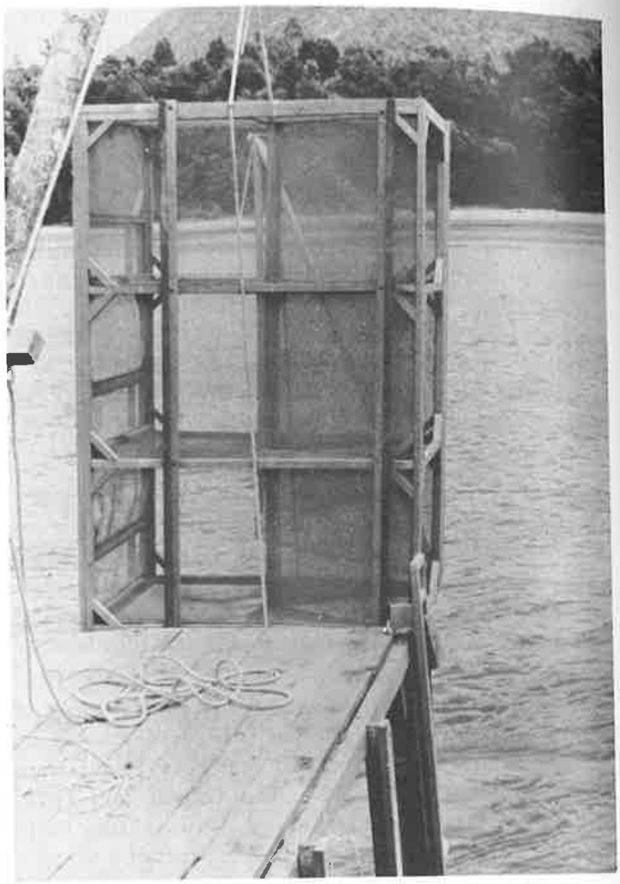


Fig. 51: A three-level wooden-framed whitebait net as used in research in the Waiatoto River.

(Hindley, Dawn, Content, Nolans, and Nisson) were designed so that the trap was fishing effectively throughout the tide. These traps were about 2 m high and 1 m wide, with the entrance, a narrow vertical slit about 5 cm wide, running the full height of the trap except for the bottom 5 cm. The apron at the bottom of the net in front of the trap was elevated at an angle to inhibit fish movement out of the trap. All these large traps, in the Waiatoto River and its tributaries, were worked in similar fashion to commercial trap nets, except for minor modifications to ease handling. The nets were run down the face of the fishing stand on angle-iron rails.

Small wooden-framed box traps were used in the Jackson Bay Stream, the Ship Creek forest tributary, and Brewer Water. In Gliding Rivulet and Hubbub Torrent we used small "Ulstron" mosquito netting fyke nets. Sometimes scoop nets were used and also a small one-man push-seine net. This comprised 2 m of "Ulstron" mosquito netting suspended between two poles, with a length of chain to weight the lower edge. This net was used mainly for collection of Ship Creek samples.

# APPENDIX 4

## SORTING AND IDENTIFICATION OF SAMPLES

### SEPARATION OF FRESH-RUN FISH

When whitebait first enter fresh water they are translucent and very lightly pigmented. Within a few days melanophores develop on the head and dorsal and, later, lateral trunk. These melanophores, initially uniformly spread, soon become resolved into fine V-shaped bands coinciding with the myotomes, and later distinctive banding or blotching patterns develop, characteristic of each species. Separation of fresh-run fishes from those in which pigmentation is developing (post-migratory juveniles) means arbitrary subdivision of a continuum in pigment development and is therefore not easy.

Woods (1968) also faced this problem and established a series of stadia based on pigmentation, calcification of the skeleton, and changes in length and in relative head length. We have found Woods's stadia problematical, as the criteria he nominated vary in their applicability from species to species. He suggested, for instance, that the skeleton was not calcified during the "marine growth stage", but we have found that bones of fresh-run whitebait stain readily with alizarin, which indicates that the skeleton is well calcified when the fish leave the sea. Woods defined one stadium, in part, by occurrence of lateral line melanophores, but presence of lateral line melanophores in fresh-run whitebait varies from species to species. They are always present at migration in *G. maculatus* and are clearly visible in examples caught in the sea (McDowall, Robertson, and Saito 1975). *Galaxias fasciatus* often has well-developed lateral line melanophores at migration, but *G. brevipinnis* usually has weakly developed melanophores or none at all.

Because of these difficulties we were unable to apply Woods's stadia.

It is important to be able to separate fresh-run whitebait from post-migratory juveniles if we are to assess the relative quantities of each species entering the rivers and moving up stream on any day. At times, especially late in the spring, the catch may include large quantities of post-migratory juveniles which are living, or have spent several days, in fresh water. This is especially true of *G. maculatus* in most rivers, but may apply to *G. brevipinnis* in some, for example, Haast River. Inclusion of post-migratory juveniles in the catch distorts estimates of the relative numbers of each species entering the river on that day.

Fresh-run whitebait cannot, in our experience, be separated with precision from post-migratory juveniles in samples collected as the fish migrate up stream. Thus an arbitrary level must be established for this separation. Very soon after melanophores develop on the trunk of the fish, V-shaped lines of melanophores develop along the myotomes, and the absence or presence of these lines was used to separate fresh-run and post-migratory whitebait. This procedure undoubtedly places more fish in the fresh-run category than is realistic, but the ease of sorting is so increased that loss of accuracy incurred through use of myotomal bands as a criterion seems justified.

### SPECIFIC IDENTIFICATION OF GALAXIID JUVENILES

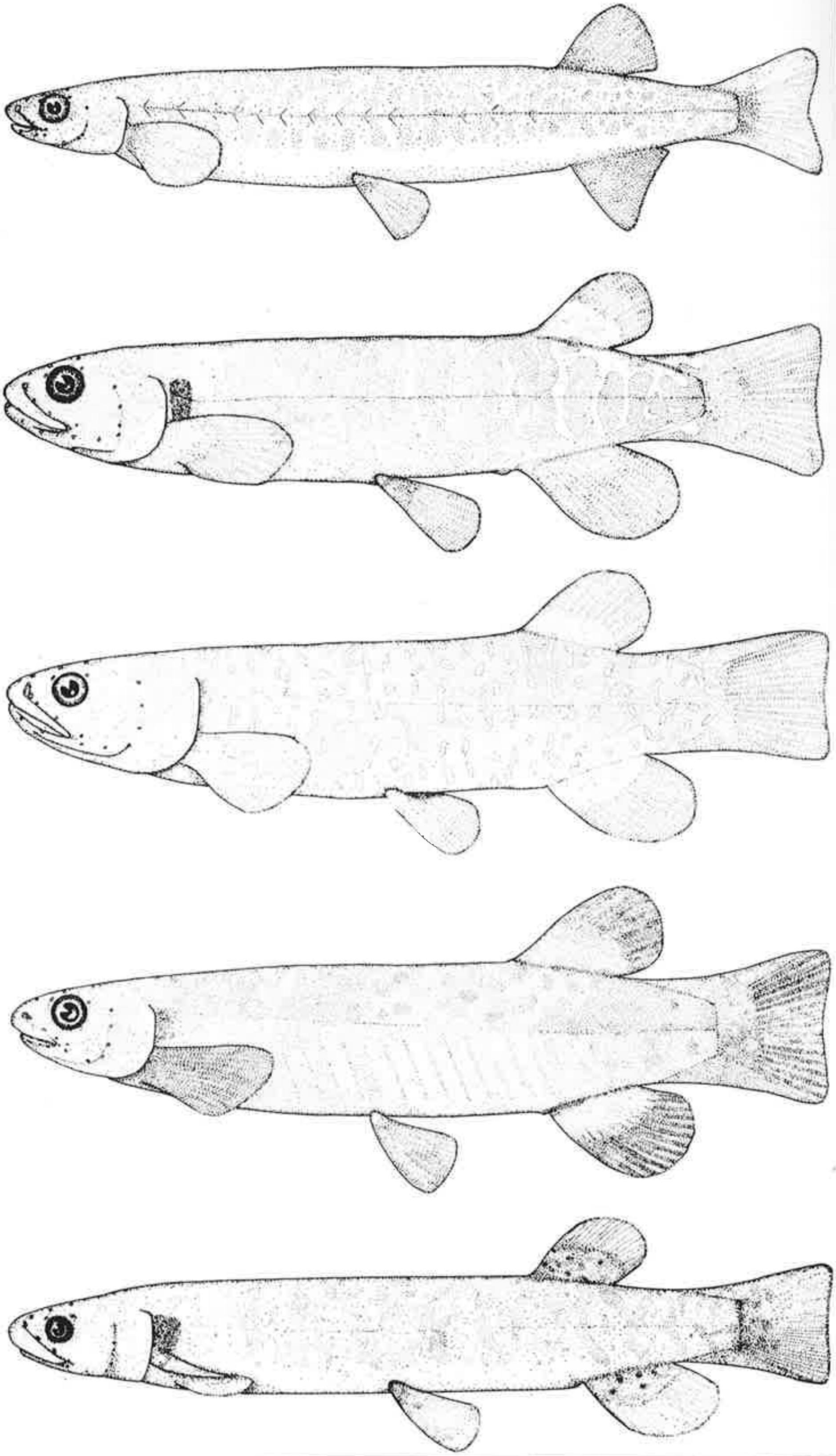
Once fresh-run whitebait had been separated from post-migratory juveniles, specific identification of fishes in each category was required.

#### Fresh-run Whitebait

Identification of the five whitebait species at migration has been a persistent and thorny problem. Initial proof of the existence of five species came from rearing of all five from a small sample of fresh-run whitebait collected from the Buller River in October 1964 and chosen as far as possible to exclude *G. maculatus*, which is easily distinguished. The 11 survivors of this sample comprised 1 *G. maculatus*, 1 *G. brevipinnis*, 1 *G. argenteus*, 3 *G. postvectis*, and 5 *G. fasciatus* (McDowall 1966).

A taxonomic review of the New Zealand Galaxiidae (McDowall 1970a) did not reveal characters by which fresh-run whitebait of each of the five species can be recognised with ease and precision. Separation of adults of *G. maculatus*, *G. brevipinnis*, *G. argenteus*, *G. fasciatus*, and *G. postvectis* is simple and straightforward on the basis of coloration alone (Fig. 52). But conventional taxonomic characters, like vertebral and fin-ray counts, overlap broadly between the species and show clinal variation with latitude. Use of body proportions for separation of juveniles is largely precluded by striking allometric growth in the post-migratory juveniles (McDowall 1968, Benzie 1968a, Woods 1968, present study, "Early Growth of Whitebait in Fresh Water", page 31). The whitebait stages lack many of the characters diagnostic of their respective adults, for example, definitive pigmentation, dentition, and size of pyloric caeca. Thus meristic characters, body proportions, coloration, and general structural characteristics of the adults of the five species are of limited usefulness in identifying their respective juveniles.

Fig. 52: Adults of whitebait galaxiids.



*Galaxias maculatus*,
94 mm L.C.F.

*Galaxias fasciatus*,
155 mm L.C.F.

*Galaxias argenteus*,
280 mm L.C.F.

*Galaxias postvectis*,
178 mm L.C.F.

*Galaxias brevipinnis*,
185 mm L.C.F.

Woods (1968) published a key for identifying diadromous *Galaxias* whitebait, in which distribution of melanophores and absolute lengths were used. This key does not work, mainly because the range of sizes observed by Woods for the five species is more limited than the range that these species show. Key characters for *G. argenteus* were derived from a single specimen! Furthermore, there are interseasonal and intraseasonal variations of considerable magnitude, as well as geographical variation in size at migration from the sea (McDowall 1968, present study, "Size at Migration", page 21). In short, whitebait juveniles of each species cannot be identified with keys of the type produced by Woods (1968).

In a previous attempt to resolve this identification problem McDowall (1970a) was unable to isolate "particular characters by which individual specimens of the four problematical species can be identified with any assurance", but expressed confidence that "it is possible to separate the species when they occur in mixed-species samples". This confidence has been short lived, and we are now far from sure of the identification and separation of fresh-run whitebait of *G. brevipinnis* and *G. postvectis* after preservation. We know of no character, or group of characters, by which whitebait of these two species can be distinguished reliably and consistently. This was accomplished for material examined in the 1970 study

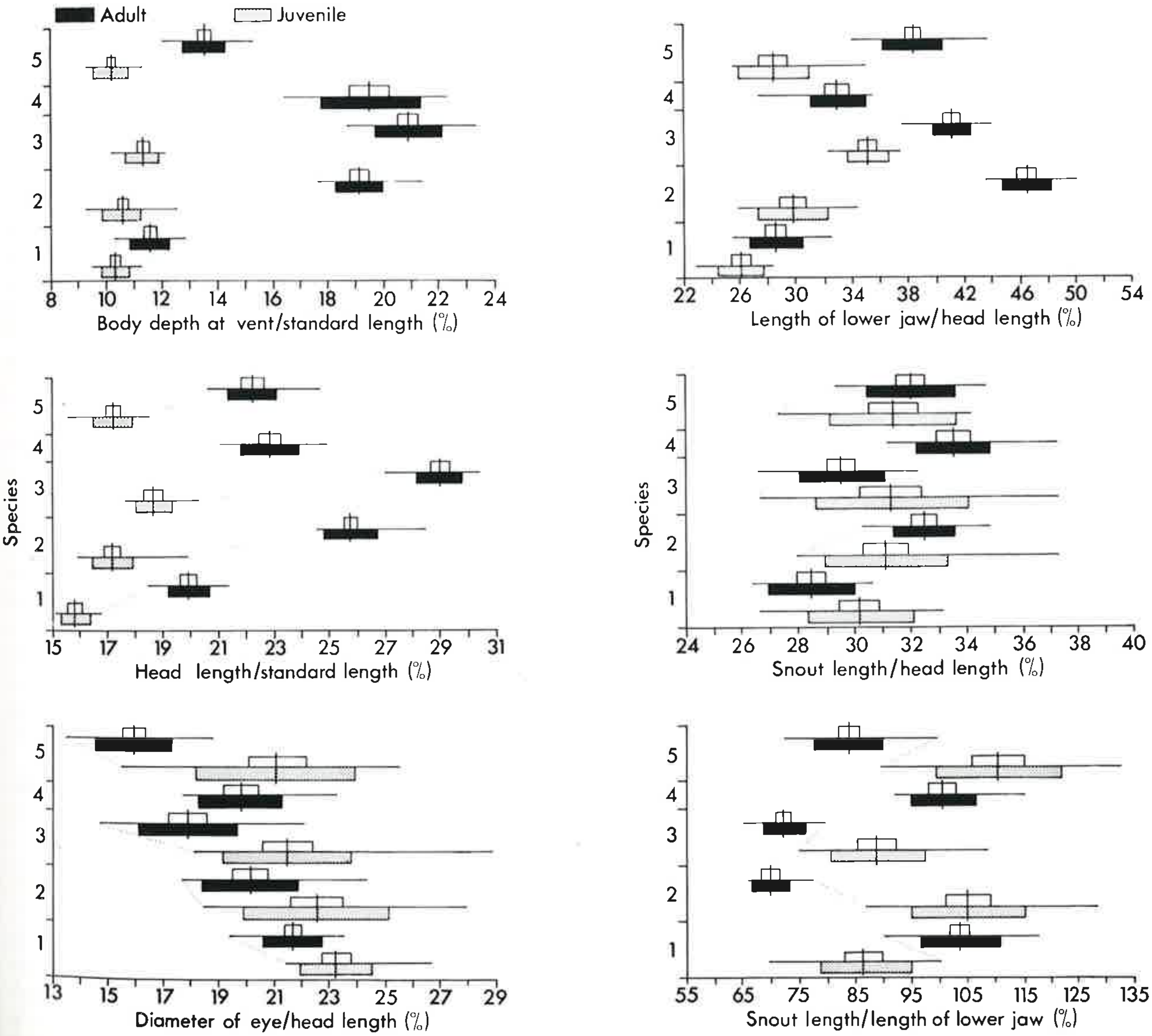



Fig. 53: Differences in body proportions in adult and migratory juveniles of whitebait galaxiids: 1. *G. maculatus*, 2. *G. fasciatus*, 3. *G. argenteus*, 4. *G. postvectis*, 5. *G. brevipinnis*. (The horizontal line represents the range, the vertical line the mean, the closed rectangle the standard deviation each side of the mean, and the open rectangle twice the standard error each side of the mean.)

(McDowall 1970a), but with the same methods applied then we have since had little success. The problem, in part, is probably that *G. postvectis* is relatively uncommon. Certainly, it is rarely collected as an adult, so that the practical problem apparently becomes one of separating an occasional *G. postvectis* from a large mass of *G. brevipinnis*. The abundance of *G. postvectis* in the whitebait samples seems to vary. As noted above, 3 of 11 whitebait from the Buller River sample in 1964 were *G. postvectis*. In 1965 a further selected sample was collected from the Buller River and reared. Among these were 28 *G. postvectis*, 7 *G. brevipinnis*, 1 *G. argenteus*, and 1 *G. maculatus*.

Possibly in these 2 years *G. postvectis* was abundant in the Buller River samples, though it is equally possible that the appearance of *G. postvectis* whitebait made them conspicuous and readily selected as non-*G. maculatus* and therefore they were more abundant in our samples than in the catch. However, in 1972 we reared samples of fish from the Arawata River and none of the fish was *G. postvectis* (all were *G. brevipinnis*). A sample of 305 fish was collected from the Buller River in early November 1972 and reared and of these, again, none was *G. postvectis* (213 *G. brevipinnis*, 86 *G. maculatus*, 5 *G. fasciatus*, and 1 *G. argenteus*).

The study of McDowall (1970a) produced familiarity with the characters of some species, which enables separation of *G. maculatus*, *G. fasciatus*, and *G. argenteus* and leaves mixed samples of *G. brevipinnis* and *G. postvectis*.

In this investigation *G. postvectis* and *G. brevipinnis* have remained inseparable. Very occasionally a fish is present that, to the eye, is obviously a *G. postvectis*; it has a large eye and different snout shape. In view of the general apparent rareness of *G. postvectis* adults, we have assumed that *G. postvectis* forms an insignificant proportion of the samples examined, and any whitebait of this species have been treated as *G. brevipinnis* for the purpose of analysis.

The adults of the five species may be separated by means of various combinations of characters (Table 50 in Appendix 5; Fig. 53). Although body proportions of adults differ from those of juveniles because of allometric growth, it seems reasonable to assume that body proportions of juveniles of the five species will bear a similar relationship to one another as do the adults; for example, the lower jaw of *G. postvectis* and *G. brevipinnis* is much shorter than the upper, is only very slightly shorter in *G. fasciatus*, but is equal in *G. maculatus* and *G. argenteus*. As this is so in the adults, we should expect it in the juveniles also. This feature, and others by which the adults of various pairs of the species may be separated (Fig. 53), provided the most fruitful area in searching for distinguishing characters for the juveniles. However, the small size of many body structures requiring measurement produced broad variation and thus broad overlap between the species for each character in the juveniles.

In practice preliminary visual sorting separated *G. maculatus* from the other species. It can be distinguished simply by coloration alone, the pattern of melanophores being quite distinctive (see below and Fig. 54). By comparison the remaining four species are very similar.

The residue of the samples after removal of *G. maculatus* contained four species, two of which, *G. brevipinnis* and *G. postvectis*, have proved inseparable, as outlined above, so that there were, in effect, three categories for separation. In practical terms *G. argenteus* was completely insignificant, as it made up less than 0.01% of the material examined during the study. As *G. argenteus* was present in the samples only from about the beginning of the second week in November, identification of this species in the samples was a minor difficulty. Thus the chief practical problem in identification of the non-*G. maculatus* whitebait is separation and identification of *G. brevipinnis* and *G. fasciatus*. *Galaxias brevipinnis* is generally considerably longer than *G. fasciatus* (Fig. 55), though both species show seasonal and geographical variation in length. Sorting can usually be accomplished on the basis of length. Additional useful characters are that the lower jaw is much shorter than the upper in *G. brevipinnis*, and only a little shorter in *G. fasciatus*, and that the origin of the anal fin is below about the middle of the dorsal fin base in *G. brevipinnis*, but below the origin of the dorsal fin in *G. fasciatus*. The samples were sorted by use of these criteria.

*Galaxias argenteus* appeared in small numbers during November each year. The whitebait of *G. argenteus* is intermediate in size between *G. brevipinnis* and *G. fasciatus*, and though it might seem that it would therefore complicate sorting and identification problems, this characteristic draws attention to the presence of *G. argenteus* in the samples. Because some fish in the samples are difficult to assign to either of the commoner categories on the basis of size, more careful examination is needed. The whitebait of *G. argenteus* is distinguished by its long, slender snout and equal jaws, with the cleft of the mouth reaching behind the anterior eye margin; in other species it barely reaches to the anterior eye margin.

Following are the distinctive characteristics of fresh-run galaxiid whitebait.

*G. maculatus* (Fig. 54A)

**Colour.** This is more extensive and intense than in other species; in particular, very large melanophores are present along the dorsal surface of the trunk anterior to the dorsal fin origin; these are absent in other species. Lateral line melanophores are large and bold. Body musculature tends to be a translucent blue-green when fresh.

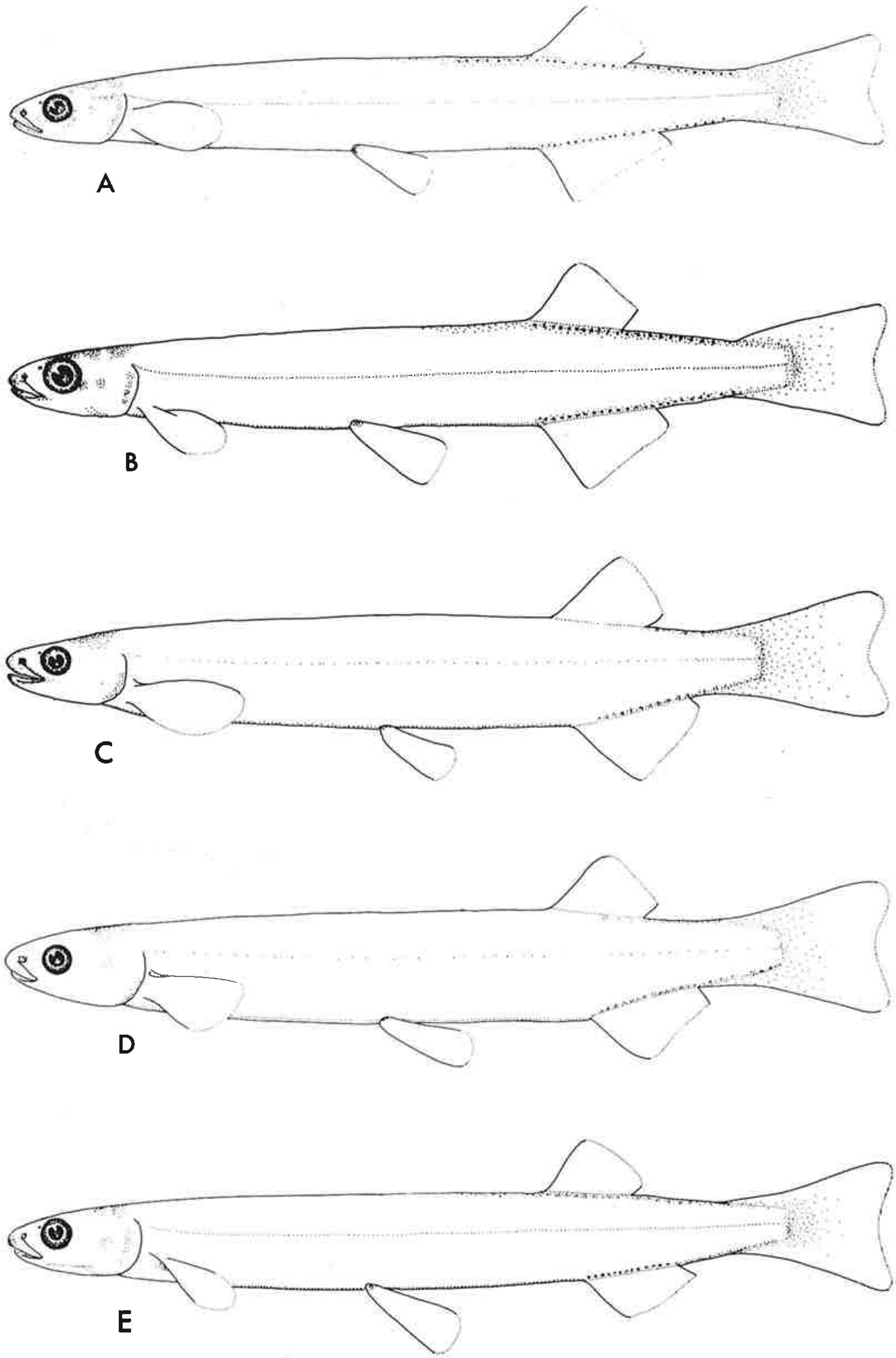



Fig. 54: Whitebait of the five galaxiids. A: *Galaxias maculatus*, 53 mm L.C.F. B: *Galaxias fasciatus*, 48 mm L.C.F. C: *Galaxias argenteus*, 50 mm L.C.F. D: *Galaxias postvectis*, 54 mm L.C.F. E: *Galaxias brevipinnis*, 50 mm L.C.F.

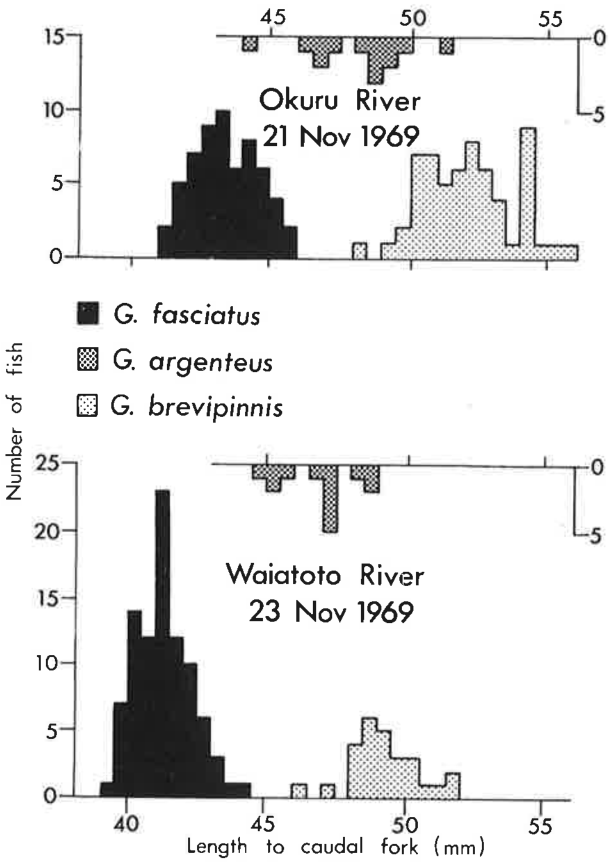


Fig. 55: Length-frequency distribution of mixed-species samples of whitebait after removal of *G. maculatus*.

**Form**. The anal fin is long based (14–18 rays, mean 16.0), usually originating immediately below the dorsal fin origin; pectoral fins are inserted rather high laterally behind the head, with the fin base vertical; the snout is short, jaws are equal, and the cleft of the mouth reaches to about the anterior eye margin, with the mouth rather small. Size is variable, between 44 and 61 mm length to caudal fork, mean 52.24 mm from measurements of 13 904 Haast area whitebait; generally it is a large whitebait.

Since the remaining four species are virtually identical in pigmentation pattern, this character is of no use in their separation. They are lightly pigmented, with a few small melanophores dorsally in front of the dorsal fin and no large ones; lateral line pigmentation is weak or absent. Melanophore patterns are shown in Fig. 54. They are also similar in having insertion of the pectoral fins lower on the sides, the fin base tending to become horizontal; the surface of the fin, which is held against the trunk in *G. maculatus*, is ventral in the other species.

*G. fasciatus* (Fig. 54B)

**Colour**. Body musculature tends to be pale amber when it is fresh.

**Form**. The anal fin base is of moderate length (12–15 rays, mean 13.0), the fin originating usually immediately beneath the dorsal fin origin; the snout is of moderate length, and the mouth is small to moderate in size; the lower jaw is a little shorter than the upper, the cleft of the mouth reaching to about the anterior eye margin; size is small (it is the smallest of the five species), though it is variable, between 38 and 47 mm length to caudal fork, mean 41.74 mm from 3092 measurements of Haast area whitebait.

*G. argenteus* (Fig. 54C)

**Colour**. Body musculature tends to be pale amber when it is fresh.

**Form**. The anal fin base is of moderate length (12–15 rays, mean 12.8); the anal fin is usually a little behind the dorsal origin; the snout is long, the mouth large, with the jaws about equal, and the cleft of the mouth reaches beyond the anterior eye margin, as far as one-quarter eye diameter or more; 44 to 51 mm length to caudal fork, mean 47.7 mm from 155 measurements of West Coast whitebait; it is a moderately large, stout whitebait.

*G. postvectis* (Fig. 54D)

**Colour**. We have no observations.

**Form**. The anal fin base is short (10–13 rays, mean 11.5) and the anal fin origin is set back a little from the dorsal origin; the snout is long, the mouth small, the lower jaw distinctly shorter than the upper, and the cleft of the mouth reaches to about the anterior eye margin; no length measurements are available, but it is a moderately large and stout whitebait.

*G. brevipinnis* (Fig. 54E)

**Colour.** Body musculature tends to be slightly opaque or milky when it is fresh.

**Form.** The anal fin base is short (10–13 rays, mean 11.6), the anal fin originating moderately to well back from the dorsal fin origin, usually below about the middle of the dorsal base; the snout is short, the mouth rather small, and the lower jaw distinctly shorter than the upper, the cleft of the mouth reaching to about the anterior eye margin; size is variable, 45 to 58 mm length to caudal fork, mean 49.39 mm from 5965 measurements of Haast area whitebait (one specimen 64 mm length to caudal fork); it is a moderately large whitebait.

### Post-migratory Juveniles

After the fish have been in fresh water for a few days pigmentation in all species quickly intensifies, and identification problems are no longer serious. Some characters that separate adults develop in juveniles, and distinctive juvenile colour patterns become evident. The most difficult species to separate at this stage are *G. fasciatus* and *G. argenteus*, but they proved to be separable once diagnostic characters were identified.

*G. maculatus*

**Colour.** Pigmentation intensifies to a general covering of melanophores; these eventually concentrate along the myotomes to form very fine chevron-shaped bands and eventually fragment to produce an irregular mottling pattern on the dorsum of the trunk, spreading latero-ventrally towards the lateral line; myotomal banding may persist below the lateral line.

**Form.** Form changes little during early growth in fresh water, though the diagnostic characters of the adult become more evident. The small mouth and head, the lateral position of the pectoral fins, the origin of the anal fin below the dorsal origin, the anal fin long based and low, with the distal margin straight, all facilitate identification of post-migratory to subadult *G. maculatus*.

*G. fasciatus*

**Colour.** After development of myotomal pigmentation, vertical pale bands develop along the trunk, which continue across the back to form a complex reticulum; that is, the banding on each side is continuous over the back.

**Form.** With growth the trunk becomes stouter; the equal jaws are obvious, as is the small mouth. Low lateral placement of the pectoral fins and the moderately long anal fin, originating directly below the dorsal origin, assist the identification of this species, though its separation from *G. argenteus* requires careful observation.

*G. argenteus*

**Colour.** Recently metamorphosed individuals look very like *G. fasciatus* at a comparable size. Bold, pale vertical bands develop along the trunk. But, unlike those in *G. fasciatus*, they do not extend on to the dorsum of the trunk. As the fish grows, the bands become broader and more blotch-like and are increasingly restricted to the lateral trunk.

**Form.** Changes in form are similar to those in *G. fasciatus*, the principal change being increasing stoutness. *Galaxias argenteus* has a prominent mouth that is evident in juveniles, the pectoral fin is rather low laterally, the anal fin is deep and rounded, originating a little behind the dorsal origin, and the caudal peduncle tends to be deep.

*G. postvectis*

**Colour.** Myotomal lines develop, but these are lost as the fish becomes increasingly covered uniformly in dark melanophores and is a dusky grey-brown. Rather obscure darker bands or blotches develop along the sides of the trunk.

**Form.** Initially the post-migratory juvenile retains very much the form of the whitebait; so it is more slender than either *G. fasciatus* or *G. argenteus*, but stouter than *G. brevipinnis*. The most characteristic feature is the long, slender snout, with a much shortened lower jaw; the anal fin originates a little behind the dorsal fin and is deep and rounded. As the fish grows, it becomes stouter like *G. argenteus* and *G. fasciatus*.

*G. brevipinnis*

**Colour.** After myotomal chevron bands develop they broaden to produce alternating dark and pale bands along the trunk, which remain chevron shaped. This is diagnostic for *G. brevipinnis*, though the bands subsequently become fragmented to form a distinctive, irregular blotching pattern. The markings become progressively more irregular as the fish grows.

**Form.** Diagnostic characters become more clear cut with growth. The fish becomes much more slender, the mouth is better developed, and the shorter lower jaw is much more obvious. The eye is noticeably small, the pectoral fins are held low and horizontally, and the anal fin is rounded and short based and is set well back from the dorsal origin.

# APPENDIX 5

## ANALYTICAL DATA

In the following tables a rule at the top and bottom of a column denotes the dates yearly data recording began and finished respectively, and, unless otherwise specified, a dash denotes that no data were recorded.

TABLE 30: Sediment quantities from Waiatoto River water samples

| Date | Sediment ($g/m^3$) | Secchi disc transparency (m) | Turbidity* |
|---|---|---|---|
| Sep 20 | 7.48 | 1.10 | M.T. |
| 21 | 8.80 | 1.50 | M.T. |
| 22 | 5.28 | 2.00 | S.T. |
| 23 | 9.46 | 0.95 | G.T. |
| 26 | 18.81 | 0.85 | G.T. |
| 29 | 6.27 | 1.20 | M.T. |
| 30 | 4.84 | 1.25 | M.T. |
| Oct 1 | 5.28 | 1.95 | S.T. |
| 2 | 1.21 | 2.00 | S.T. |
| 3 | 2.75 | 2.00 | S.T. |
| 6 | 11.00 | 0.80 | B.T. |
| 7 | 6.71 | 1.20 | G.T. |
| 11 | 4.62 | 2.10 | S.T. |
| 12 | 6.71 | 1.10 | B.T. |
| 12 | 19.36 | 0.90 | B.T. |
| 18 | 4.62 | 2.30 | S.T. |
| 19 | 3.41 | 2.60 | C. |
| 29 | 2.53 | 2.10 | S.T. |
| 31 | 234.38 | - | B.T. |
| 31 | 114.94 | - | B.T. |
| Nov 3 | 78.09 | 0.80 | B.T. |
| 11 | 15.51 | 0.70 | M.T., snow |
| 12 | 12.10 | 0.90 | M.T., snow |
| 13 | 19.80 | - | M.T., snow |

*C.: Clear.
S.T.: Slightly turbid.
M.T.: Moderately turbid.
G.T.: Grey turbid.
B.T.: Brown turbid.

TABLE 31: Relationship between rainfall and salinity in Okuru and Waiatoto Rivers*

| River | Salinity/rainfall 2 previous days (summed) | Salinity/rainfall sampling day and previous day (summed) |
|---|---|---|
| Okuru | $r = -0.927$<br>$0.01 > P > 0.001$ | $r = -0.893$<br>$P < 0.001$ |
| Waiatoto | $r = -0.782$<br>$0.05 > P > 0.02$ | $r = -0.769$<br>$0.05 > P > 0.02$ |

*Salinity data from Table 46.

TABLE 32: Seasonal rainfall at Haast meteorological station in 1969 and at Waiatoto field station from 1970 to 1972

| Date | Rainfall (mm) 1969 | 1970 | 1971 | 1972 |
|---|---|---|---|---|
| Sep 1 | 1 | 51 | 23 | 10 |
| 2 | 24 | 5 | 2 | 28 |
| 3 | 51 | 0 | 4 | 0 |
| 4 | 6 | 0 | 41 | 0 |
| 5 | 31 | 25 | 18 | 0 |
| 6 | 59 | 47 | 13 | 0 |
| 7 | 85 | 19 | 5 | 2 |
| 8 | 36 | 19 | 0 | 68 |
| 9 | 20 | 11 | 4 | 106 |
| 10 | 53 | 4 | 10 | 6 |
| 11 | 33 | 43 | 38 | 9 |
| 12 | 55 | 7 | 28 | 2 |
| 13 | 6 | 7 | 5 | 8 |
| 14 | 17 | 35 | 2 | 22 |
| 15 | 38 | 15 | 1 | 21 |
| 16 | 40 | 19 | 32 | 12 |
| 17 | 9 | 53 | 5 | 16 |
| 18 | 3 | 19 | 16 | 0 |
| 19 | 13 | 47 | 78 | 42 |
| 20 | 35 | 5 | 13 | 24 |
| 21 | 2 | Trace | Trace | 37 |
| 22 | 0 | 1 | 101 | 0 |
| 23 | 0 | 10 | 8 | 31 |
| 24 | 1 | 88 | Trace | 17 |
| 25 | 0 | 1 | 17 | 13 |
| 26 | 0 | 0 | 17 | 18 |
| 27 | 0 | 2 | 54 | 1 |
| 28 | 0 | 0 | 28 | 15 |
| 29 | 0 | 1 | 5 | 0 |
| 30 | 0 | Trace | 0 | 9 |
| Oct 1 | 0 | 0 | 1 | 0 |
| 2 | 0 | Trace | 41 | 1 |
| 3 | 0 | 3 | 91 | 19 |
| 4 | 4 | 28 | 43 | 4 |
| 5 | 28 | 2 | 26 | 0 |
| 6 | 2 | 1 | 1 | 71 |
| 7 | 23 | 43 | 0 | 36 |
| 8 | 16 | 41 | 0 | 17 |
| 9 | 1 | 16 | 20 | 1 |
| 10 | 0 | 1 | 28 | 0 |
| 11 | 0 | 2 | 25 | 0 |
| 12 | 1 | 2 | 13 | 33 |
| 13 | Trace | 12 | 0 | 41 |

| Date | Rainfall (mm) 1969 | 1970 | 1971 | 1972 |
|---|---|---|---|---|
| Oct 14 | Trace | 19 | 17 | 3 |
| 15 | 28 | 29 | 34 | 6 |
| 16 | 13 | 1 | 2 | 9 |
| 17 | 16 | 10 | 71 | 2 |
| 18 | Trace | 5 | 7 | 2 |
| 19 | 0 | 41 | 1 | 14 |
| 20 | 18 | Trace | 0 | 0 |
| 21 | 19 | 24 | 0 | 0 |
| 22 | 16 | 147 | 1 | 2 |
| 23 | 23 | 73 | 0 | 25 |
| 24 | 5 | 12 | 0 | 16 |
| 25 | 12 | 6 | 0 | 5 |
| 26 | 42 | 1 | 11 | 15 |
| 27 | 0 | Trace | 0 | 18 |
| 28 | 16 | 0 | 59 | 0 |
| 29 | 0 | 6 | 22 | 0 |
| 30 | 0 | 9 | 1 | 0 |
| 31 | 0 | 0 | 12 | 95 |
| Nov 1 | 0 | 8 | 2 | 21 |
| 2 | 0 | 24 | 21 | 5 |
| 3 | 0 | 28 | 0 | 48 |
| 4 | 0 | 14 | 0 | 1 |
| 5 | 6 | 0 | 2 | 37 |
| 6 | 0 | 0 | 0 | 14 |
| 7 | 0 | 0 | 0 | 30 |
| 8 | 0 | 0 | 0 | 12 |
| 9 | 45 | 0 | 0 | 21 |
| 10 | 19 | 2 | 0 | 1 |
| 11 | 1 | 36 | 0 | Trace |
| 12 | 0 | 49 | 0 | 1 |
| 13 | 0 | 0 | 2 | 59 |
| 14 | 3 | 27 | 23 | 103 |
| 15 | 0 | 4 | 0 | 1 |
| 16 | 0 | 2 | 0 | |
| 17 | 0 | 8 | 0 | |
| 18 | 0 | 34 | 0 | |
| 19 | 0 | 6 | 0 | |
| 20 | 9 | 4 | 0 | |
| 21 | 59 | | 0 | |
| 22 | | | 0 | |
| 23 | | | 16 | |
| 24 | | | 42 | |
| 25 | | | 44 | |

TABLE 33: Seasonal rainfall at Awarua River from 1959 to 1961

| Date | Rainfall (mm) 1959 | 1960 | 1961 |
|---|---|---|---|
| Sep 1 | 76.2 | 0 | 0 |
| 2 | 12.7 | 25.4 | 0 |
| 3 | 50.8 | 12.7 | 0 |
| 4 | 0 | 12.7 | 0 |
| 5 | 0 | 12.7 | 50.8 |
| 6 | 6.4 | 0 | 50.8 |
| 7 | 12.7 | 12.7 | 31.8 |
| 8 | 0 | 88.9 | 38.1 |
| 9 | 0 | 50.8 | 0 |
| 10 | 0 | 0 | 0 |
| 11 | Trace | 0 | 0 |
| 12 | Trace | 0 | 0 |
| 13 | 25.4 | Trace | 0 |
| 14 | Trace | 0 | 0 |
| 15 | 76.2 | 0 | Trace |
| 16 | 12.7 | Trace | 31.8 |
| 17 | 152.4 | 0 | 0 |
| 18 | 25.4 | Trace | 0 |
| 19 | 0 | 0 | 0 |
| 20 | 0 | 0 | 0 |
| 21 | 0 | 0 | 25.4 |
| 22 | Trace | 0 | 25.4 |
| 23 | 76.2 | 0 | 31.8 |
| 24 | 25.4 | Trace | 0 |
| 25 | 0 | 0 | 0 |
| 26 | Trace | 19.0 | 44.4 |
| 27 | Trace | 0 | 0 |
| 28 | 0 | 0 | 0 |
| 29 | Trace | 0 | 19.0 |
| 30 | 25.4 | 19.0 | 0 |
| Oct 1 | 25.4 | Trace | 0 |
| 2 | 38.1 | 0 | 25.4 |
| 3 | 19.0 | 0 | 0 |
| 4 | 12.7 | 0 | 0 |
| 5 | Trace | 25.4 | 6.4 |
| 6 | 0 | 6.4 | 19.0 |
| 7 | 0 | 19.0 | 0 |
| 8 | 0 | Trace | 0 |
| 9 | 0 | 38.1 | 0 |
| Oct 10 | 0 | 12.7 | 38.1 |
| 11 | Trace | 25.4 | 0 |
| 12 | 12.7 | 12.7 | 0 |
| 13 | 19.0 | Trace | 38.1 |
| 14 | 0 | 0 | Trace |
| 15 | 0 | 0 | Trace |
| 16 | 0 | 0 | 69.8 |
| 17 | 0 | 0 | 0 |
| 18 | 0 | 19.0 | 0 |
| 19 | 0 | 0 | 0 |
| 20 | 0 | 6.4 | Trace |
| 21 | 0 | 0 | Trace |
| 22 | 0 | 0 | 31.8 |
| 23 | 0 | 0 | Trace |
| 24 | 25.4 | Trace | 0 |
| 25 | 6.4 | 0 | Trace |
| 26 | 6.4 | 0 | 69.8 |
| 27 | 0 | 19.0 | 57.2 |
| 28 | 0 | 31.8 | 6.4 |
| 29 | 0 | Trace | Trace |
| 30 | 0 | | 25.4 |
| 31 | 0 | | |
| Nov 1 | 0 | | |
| 2 | 19.0 | | |
| 3 | 0 | | |
| 4 | Trace | | |
| 5 | 88.9 | | |
| 6 | 6.4 | | |
| 7 | 12.7 | | |
| 8 | 25.4 | | |
| 9 | 6.4 | | |
| 10 | 6.4 | | |
| 11 | 0 | | |
| 12 | 0 | | |
| 13 | 50.8 | | |
| 14 | Trace | | |
| 15 | 50.8 | | |
| 16 | 25.4 | | |
| 17 | 6.4 | | |

TABLE 34: Levels of all Haast area rivers in 1969

| Date | River levels (cm) Waita | Haast | Turn-bull | Okuru | Waia-toto | Arawata |
|---|---|---|---|---|---|---|
| Sep 1 | 15 | 21 | 15 | 6 | 2 | 18 |
| 2 | 13 | 16 | 4 | 1 | 16 | 10 |
| 3 | 12 | - | - | 101 | - | - |
| 4 | 27 | - | - | 261 | - | - |
| 5 | 106 | - | - | 51 | - | 32 |
| 6 | 47 | - | - | - | - | - |
| 7 | 61 | - | - | - | - | - |
| 8 | 116 | - | - | - | - | - |
| 9 | 106 | - | - | - | - | - |
| 10 | 86 | - | - | - | - | - |
| 11 | 106 | - | - | - | - | - |
| 12 | 86 | - | - | - | - | - |
| 13 | 111 | - | - | - | - | - |
| 14 | 96 | 116 | 104 | - | - | - |
| 15 | 71 | 74 | - | - | - | - |
| 16 | 76 | 96 | - | - | - | - |
| 17 | 71 | 86 | - | - | - | 40 |
| 18 | 52 | 58 | 74 | 67 | 59 | 11 |
| 19 | 46 | 48 | 61 | 50 | 40 | 76 |
| 20 | 62 | 64 | 54 | 44 | 40 | 106 |
| 21 | 46 | 61 | - | 76 | 59 | 97 |
| 22 | 46 | 44 | 59 | 48 | 36 | 77 |
| 23 | 37 | 36 | 50 | 40 | 29 | 68 |
| 24 | 27 | 26 | 54 | 33 | 24 | 61 |
| 25 | 23 | 27 | 49 | 28 | 42 | 56 |
| 26 | 19 | 26 | 47 | 25 | 25 | - |
| 27 | 16 | 23 | 34 | 24 | 16 | 48 |
| 28 | 15 | 21 | 24 | 19 | 7 | 46 |
| 29 | 12 | 18 | 16 | 10 | 13 | 40 |
| 30 | 11 | 15 | 12 | 11 | 8 | 35 |
| Oct 1 | 10 | 11 | 9 | 9 | 7 | 27 |
| 2 | 9 | 6 | 6 | 1 | 4 | 30 |
| 3 | 7 | 7 | 4 | 3 | 3 | 26 |
| 4 | 6 | 5 | 0 | 0 | 0 | 15 |
| 5 | 6 | 4 | 0 | 0 | 0 | 24 |
| 6 | 13 | 7 | 10 | 8 | 1 | 37 |
| 7 | 10 | 4 | 6 | 2 | 3 | 27 |
| 8 | 40 | 32 | 44 | 45 | 22 | 70 |
| 9 | 45 | 55 | 83 | 70 | 3 | 2 |
| 10 | 27 | 18 | 25 | 21 | 5 | 45 |
| 11 | 13 | 7 | 10 | 10 | 7 | 32 |
| Oct 12 | 9 | 3 | 11 | 3 | 0 | 26 |
| 13 | 6 | 1 | 10 | 1 | 45 | 23 |
| 14 | 7 | 0 | 70 | 0 | 45 | 22 |
| 15 | 6 | 1 | 0 | 0 | 44 | 25 |
| 16 | 48 | 111 | 97 | 181 | 25 | 60 |
| 17 | 33 | 36 | 44 | 37 | 85 | 76 |
| 18 | 37 | 46 | 54 | 41 | 82 | 70 |
| 19 | 20 | 20 | 26 | 20 | 64 | 50 |
| 20 | 11 | 11 | 15 | 11 | 65 | 40 |
| 21 | 76 | - | - | 114 | - | 140 |
| 22 | 46 | 68 | 90 | 67 | - | 20 |
| 23 | 57 | - | 68 | 57 | 99 | 0 |
| 24 | 53 | 65 | 89 | 67 | 125 | 26 |
| 25 | 37 | 39 | 45 | 40 | 82 | 65 |
| 26 | 50 | 59 | 46 | 62 | 82 | 66 |
| 27 | 55 | 75 | 108 | 141 | 145 | 36 |
| 28 | 47 | 43 | 55 | 48 | 88 | 75 |
| 29 | 37 | 33 | 41 | 34 | 74 | 60 |
| 30 | 21 | 25 | 29 | 24 | 66 | 92 |
| 31 | 15 | 21 | 23 | 20 | 59 | 47 |
| Nov 1 | 11 | 17 | 27 | 14 | 56 | 44 |
| 2 | 9 | 16 | 14 | 13 | - | 42 |
| 3 | 7 | 16 | 14 | 13 | 55 | 45 |
| 4 | 6 | 17 | 13 | 12 | 55 | 45 |
| 5 | 6 | 15 | 8 | 6 | 55 | 42 |
| 6 | 8 | 19 | 16 | 12 | 65 | 54 |
| 7 | 5 | 22 | 21 | 15 | 70 | 53 |
| 8 | 4 | 16 | 16 | 7 | 61 | 45 |
| 9 | 2 | 20 | 16 | 11 | - | 52 |
| 10 | 55 | 58 | 110 | 71 | 139 | |
| 11 | 41 | 59 | 63 | 64 | 115 | |
| 12 | 31 | 43 | 36 | 31 | - | |
| 13 | 17 | 31 | 37 | 18 | - | |
| 14 | 11 | 26 | | 14 | 79 | |
| 15 | 7 | 19 | | 8 | - | |
| 16 | 5 | 22 | | 9 | 71 | |
| 17 | 4 | 22 | | 9 | - | |
| 18 | 2 | 22 | | 8 | 70 | |
| 19 | 1 | 22 | | 7 | 71 | |
| 20 | 0 | 22 | | 6 | | |
| 21 | 46 | 60 | | | | |

TABLE 35: Levels of Waiatoto River from 1970 to 1972

| Date | River levels (cm)* 1970 | 1971 | 1972 |
|---|---|---|---|
| Aug 28 | | 108 | |
| 29 | | 65 | |
| 30 | | - | 25 |
| 31 | | 97 | 18 |
| Sep 1 | | 73 | 30 |
| 2 | 149 | 58 | - |
| 3 | 118 | 53 | - |
| 4 | 103 | 112 | 0 |
| 5 | 164 | 128 | 0 |
| 6 | 205 | 92 | 0 |
| 7 | 218 | 63 | 20 |
| 8 | 197 | 71 | 175 |
| 9 | 136 | 50 | Flood |
| 10 | 122 | 69 | Flood |
| 11 | - | Snow 418 | 95 |
| 12 | 160 | 153 | 75 |
| 13 | 130 | 98 | 145 |
| 14 | 248 | 78 | Flood |
| 15 | 115 | 68 | 215 |
| 16 | 241 | - | 137 |
| 17 | 216 | 63 | 95 |
| 18 | 238 | - | 70 |
| 19 | Flood | - | Flood |
| 20 | 153 | - | 105 |
| 21 | 125 | 97 | 90 |
| 22 | 108 | Flood | - |
| 23 | 102 | 108 | 175 |
| 24 | Flood | - | 90 |
| 25 | 153 | - | 100 |
| 26 | 117 | 83 | 175 |
| 27 | 100 | - | - |
| 28 | - | 148 | 165 |
| 29 | 53 | 88 | 70 |
| 30 | 45 | 60 | 55 |
| Oct 1 | 38 | 63 | 50 |
| 2 | 35 | 108 | 43 |
| 3 | 32 | Flood | 55 |
| 4 | - | Flood | 55 |
| 5 | - | 165 | 40 |
| 6 | 45 | 133 | 195 |
| 7 | 110 | 108 | 135 |
| 8 | 216 | 103 | 100 |
| 9 | - | 86 | 75 |
| 10 | 71 | 143 | 57 |
| 11 | - | 118 | 50 |
| Oct 12 | 42 | 83 | 140 |
| 13 | - | 75 | 110 |
| 14 | 53 | 73 | 70 |
| 15 | - | 180 | 55 |
| 16 | 70 | 80 | 75 |
| 17 | 57 | 209 | 60 |
| 18 | 45 | 131 | 41 |
| 19 | 60 | 105 | 45 |
| 20 | 44 | 185 | 35 |
| 21 | 103 | 75 | 35 |
| 22 | 207 | 68 | 60 |
| 23 | - | 58 | 110 |
| 24 | 236 | 57 | 85 |
| 25 | 145 | 58 | 65 |
| 26 | 105 | 56 | 76 |
| 27 | 79 | 53 | 65 |
| 28 | 69 | 133 | 50 |
| 29 | 88 | 183 | 40 |
| 30 | - | 163 | 35 |
| 31 | - | 88 | 160 |
| Nov 1 | - | 78 | 300 100 |
| 2 | 135 | 108 | 85 |
| 3 | - | 88 | Flood |
| 4 | 88 | 81 | 105 |
| 5 | - | 78 | - |
| 6 | 61 | 66 | - |
| 7 | - | 68 | 190 |
| 8 | - | 63 | 155 |
| 9 | 51 | 63 | 195 |
| 10 | 52 | 63 | - |
| 11 | 88 | 63 | 95 |
| 12 | - | 58 | 80 |
| 13 | - | 66 | - |
| 14 | | 103 | 500 200 |
| 15 | | 70 | |
| 16 | | 58 | |
| 17 | | 59 | |
| 18 | | 58 | |
| 19 | | 55 | |
| 20 | | 60 | |
| 21 | | 54 | |
| 22 | | 48 | |
| 23 | | - | |
| 24 | | 109 | |

*Figures calibrated to 1970 level.

TABLE 36: Levels of Okuru River in 1970 and 1971

| Date | River levels (cm)* 1970 | 1971 |
|---|---|---|
| Sep 1 | 83 | 43 |
| 2 | 39 | 38 |
| 3 | 13 | 30 |
| 4 | 0 | 62 |
| 5 | 55 | 81 |
| 6 | 131 | 40 |
| 7 | 53 | 30 |
| 8 | 72 | 24 |
| 9 | 43 | 18 |
| 10 | 13 | 24 |
| 11 | Flood | 210 |
| 12 | 55 | 70 |
| 13 | 23 | 55 |
| 14 | 12 | 37 |
| 15 | 25 | 28 |
| 16 | 114 | 49 |
| 17 | Flood | 29 |
| 18 | 78 | 55 |
| 19 | 173 | 185 |
| 20 | 52 | 77 |
| 21 | 21 | 45 |
| 22 | 6 | 205 |
| 23 | 71 | 65 |
| 24 | Flood | 46 |
| 25 | 123 | 40 |
| 26 | 85 | 49 |
| 27 | - | 45 |
| Sep 28 | 60 | 0 |
| 29 | 49 | 55 |
| 30 | - | 40 |
| Oct 1 | - | 35 |
| 2 | - | 70 |
| 3 | 40 | 185 |
| 4 | 79 | 170 |
| 5 | 51 | 125 |
| 6 | - | 75 |
| 7 | 48 | 56 |
| 8 | 96 | 46 |
| 9 | 95 | 46 |
| 10 | - | 85 |
| 11 | - | 68 |
| 12 | - | 50 |
| 13 | - | 37 |
| 14 | 62 | 35 |
| 15 | 120 | 63 |
| 16 | 72 | 45 |
| 17 | 65 | 234 |
| 18 | 52 | 86 |
| 19 | 74 | 19 |
| 20 | 54 | 41 |
| 21 | 53 | 36 |
| 22 | Flood | 30 |
| 23 | Flood | 30 |
| 24 | 190 | 27 |
| Oct 25 | 101 | 25 |
| 26 | 79 | 25 |
| 27 | 63 | 10 |
| 28 | 53 | 82 |
| 29 | - | 15 |
| 30 | 74 | 50 |
| 31 | 60 | 40 |
| Nov 1 | - | 32 |
| 2 | 131 | 45 |
| 3 | 88 | - |
| 4 | 73 | 31 |
| 5 | 58 | 25 |
| 6 | - | 20 |
| 7 | 49 | - |
| 8 | 47 | - |
| 9 | 44 | - |
| 10 | 40 | - |
| 11 | Flood | - |
| 12 | 205 | - |
| 13 | Flood | - |
| 14 | Flood | 29 |
| 15 | 80 | |
| 16 | - | |
| 17 | 89 | |
| 18 | 122 | |

*Figures calibrated to 1970 level.

TABLE 37: River conditions in Cascade River from 1959 to 1973

| Date | | Categories of conditions* | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
| Sep | 1 | 2 | | 2 | 3 | 6 | | | | 6 | 3 | 2 | 6 | 5 | 4 | 3 |
| | 2 | 4 | | 2 | 3 | 5 | | | | 5 | 3 | 2 | 5 | 3 | 5 | 3 |
| | 3 | 6 | | 2 | 4 | 3 | | | | 3 | 3 | 5 | 5 | 3 | 3 | 3 |
| | 4 | 5 | | 2 | 6 | 3 | | | | 3 | 6 | 6 | 3 | 4 | 3 | 3 |
| | 5 | 3 | | 4 | 6 | 3 | 3 | | | 3 | 3 | 5 | 4 | 6 | 2 | 5 |
| | 6 | 3 | | 6 | 6 | 2 | 3 | 3 | | 3 | 3 | 6 | 6 | 5 | 2 | 6 |
| | 7 | 3 | 4 | 6 | 6 | 2 | 2 | 3 | | 3 | 3 | 6 | 5 | 3 | 2 | 5 |
| | 8 | 6 | 5 | 5 | 6 | 2 | 4 | 2 | | 3 | 5 | 6 | 5 | 3 | 4 | 3 |
| | 9 | 3 | 6 | 3 | 6 | 3 | 3 | 2 | | 2 | 5 | 6 | 3 | 2 | 6 | 3 |
| | 10 | 3 | 5 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 | 6 | 4 | 2 | 5 | 3 |
| | 11 | 3 | 4 | 3 | 3 | 4 | 3 | 2 | 2 | 2 | 3 | 6 | 6 | 6 | 5 | 2 |
| | 12 | 3 | 3 | 3 | 3 | 6 | 3 | 4 | 2 | 2 | 3 | 6 | 5 | 5 | 5 | 3 |
| | 13 | 4 | 3 | 2 | 4 | 6 | 6 | 6 | 2 | 2 | 2 | 6 | 3 | 5 | 6 | 3 |
| | 14 | 3 | 2 | 2 | 6 | 5 | 5 | 5 | 2 | 2 | 2 | 5 | 4 | 5 | 6 | 5 |
| | 15 | – | 2 | 2 | 3 | 3 | 3 | 5 | 2 | 2 | 2 | 4 | 5 | 3 | 5 | 5 |
| | 16 | – | 2 | 2 | 3 | 6 | 3 | 6 | 2 | 2 | 3 | 5 | 6 | 3 | 5 | 3 |
| | 17 | – | 2 | 2 | 3 | 5 | 3 | 6 | 6 | 6 | 3 | 5 | 6 | 2 | 3 | 3 |
| | 18 | – | 2 | 2 | 2 | 3 | 3 | 6 | 6 | 6 | 3 | 3 | 6 | 4 | 4 | 2 |
| | 19 | 5 | 2 | 2 | 2 | 3 | 3 | 5 | 5 | 5 | 2 | 3 | 6 | 6 | 6 | 2 |
| | 20 | 5 | 2 | 2 | 2 | 2 | 2 | 5 | 3 | 5 | 2 | 5 | 5 | 5 | 5 | 2 |
| | 21 | 5 | 2 | 2 | 3 | 2 | 2 | 3 | 3 | 3 | 4 | 3 | 3 | 3 | 5 | 5 |
| | 22 | 3 | 2 | 4 | 3 | 2 | 3 | 3 | 4 | 3 | 6 | 3 | 3 | 6 | 3 | 3 |
| | 23 | 4 | 2 | 5 | 3 | 2 | 4 | 5 | 5 | 3 | 5 | 2 | 2 | 5 | 6 | 3 |
| | 24 | 4 | 2 | 3 | 2 | 3 | 6 | 6 | 5 | 3 | 3 | 2 | 6 | 3 | 5 | 2 |
| | 25 | 4 | 2 | 3 | 2 | 3 | 5 | 5 | 3 | 2 | 5 | 2 | 5 | 3 | 5 | 2 |
| | 26 | 3 | 3 | 3 | 2 | 3 | 5 | 3 | 3 | 2 | 3 | 2 | 5 | 3 | 5 | 2 |
| | 27 | 3 | 3 | 5 | 2 | 2 | 3 | 5 | 2 | 2 | 3 | 2 | 3 | 5 | 5 | 2 |
| | 28 | 3 | 2 | 3 | 3 | 2 | 3 | 5 | 2 | 3 | 2 | 2 | 3 | 5 | 3 | 5 |
| | 29 | 3 | 2 | 3 | 3 | 2 | 2 | 6 | 2 | 3 | 2 | 2 | 2 | 3 | 3 | 3 |
| | 30 | 3 | 2 | 3 | 4 | 2 | 4 | 6 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| Oct | 1 | 6 | 3 | 3 | 4 | 2 | 6 | 5 | 1 | 5 | 4 | 2 | 2 | 2 | 2 | 3 |
| | 2 | 6 | 3 | 3 | 4 | 2 | 5 | 6 | 1 | 5 | 6 | 2 | 2 | 4 | 2 | 5 |
| | 3 | 3 | 3 | 3 | 5 | 4 | 5 | 6 | 1 | 6 | 5 | 2 | 2 | 6 | 3 | 5 |
| | 4 | 3 | 2 | 3 | 6 | 3 | 6 | 6 | 1 | 5 | 6 | 2 | 3 | 6 | 2 | 3 |
| | 5 | 3 | 2 | 3 | 5 | 3 | 5 | 5 | 4 | 3 | 5 | 2 | 2 | 5 | 2 | 3 |
| | 6 | 3 | 6 | 5 | 3 | 2 | 5 | 3 | 5 | 3 | 3 | 2 | 2 | 3 | 6 | 3 |
| | 7 | 3 | 6 | 3 | 3 | 2 | 3 | 3 | 5 | 5 | 3 | 3 | 3 | 3 | 5 | 3 |
| | 8 | 2 | 6 | 3 | 5 | 2 | 3 | 3 | 3 | 6 | 5 | 3 | 5 | 2 | 3 | 3 |
| | 9 | 2 | 5 | 3 | 3 | 2 | 3 | 2 | 3 | 5 | 3 | 2 | 5 | 2 | 3 | 2 |
| | 10 | 2 | 5 | 3 | 3 | 2 | 2 | 2 | 2 | 5 | 3 | 2 | 3 | 3 | 2 | 2 |
| | 11 | 4 | 4 | 2 | 3 | 2 | 2 | 5 | 2 | 3 | 3 | 2 | 3 | 5 | 2 | 2 |
| | 12 | 6 | 6 | 2 | 2 | 2 | 3 | 3 | 2 | 3 | 2 | 1 | 2 | 3 | 5 | 4 |
| | 13 | 5 | 5 | 4 | 2 | 2 | 2 | 3 | 2 | 5 | 4 | 1 | 2 | 3 | 5 | 6 |
| | 14 | 3 | 3 | 6 | 2 | 5 | 2 | 3 | 1 | 3 | 5 | 1 | 2 | 2 | 3 | 6 |
| | 15 | 3 | 3 | 5 | 4 | 5 | 2 | 2 | 1 | 3 | 5 | 1 | 5 | 2 | 3 | 5 |
| | 16 | 3 | 2 | 6 | 3 | 3 | 2 | 4 | 1 | 3 | 3 | 6 | 3 | 4 | 3 | 5 |
| | 17 | 2 | 2 | 5 | 3 | 3 | 2 | 5 | 1 | 2 | 3 | 5 | 2 | 6 | 2 | 5 |
| | 18 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 1 | 4 | 4 | 5 | 3 | 5 | 2 | 3 |
| | 19 | 2 | 2 | 3 | 4 | 3 | 3 | 2 | 5 | 6 | 5 | 3 | 3 | 3 | 3 | 3 |
| | 20 | 2 | 2 | 3 | 5 | 3 | 2 | 2 | 3 | 5 | 3 | 3 | 2 | 2 | 2 | 2 |
| | 21 | 2 | 2 | 2 | 3 | 5 | 2 | 5 | 4 | 5 | 3 | 6 | 4 | 2 | 2 | 6 |
| | 22 | 2 | 2 | 2 | 3 | 3 | 4 | 3 | 5 | 5 | 4 | 5 | 6 | 2 | 3 | 6 |
| | 23 | 2 | 2 | 3 | 4 | 6 | 5 | 5 | 5 | 3 | 6 | 5 | 6 | 2 | 3 | 5 |
| | 24 | 2 | 2 | 3 | 6 | 5 | 5 | 3 | 3 | 3 | 5 | 5 | 5 | 2 | 3 | 5 |
| | 25 | 2 | 2 | 2 | 5 | 3 | 5 | 3 | 3 | 3 | 5 | 3 | 5 | 2 | 3 | 3 |
| | 26 | 3 | 2 | 4 | 3 | 3 | 3 | 6 | 3 | 2 | 6 | 4 | 3 | 2 | 3 | 5 |
| | 27 | 3 | 6 | 6 | 3 | 6 | 3 | 5 | 3 | 2 | 5 | 3 | 3 | 2 | 2 | 3 |
| | 28 | 3 | 6 | 6 | 3 | 5 | 2 | 3 | 4 | 2 | 5 | 3 | 2 | 6 | 2 | 3 |
| | 29 | 3 | 6 | 5 | 6 | 6 | 2 | 3 | 5 | 2 | 6 | 2 | 2 | 5 | 2 | 2 |
| | 30 | 2 | 5 | 5 | 6 | 5 | 2 | 2 | 3 | 6 | 5 | 2 | 2 | 5 | 2 | 2 |
| | 31 | 2 | 5 | 3 | 5 | 5 | 2 | 2 | 3 | 6 | 5 | 2 | 2 | 3 | 4 | 5 |

TABLE 37: River conditions in Cascade River from 1959 to 1973 (continued)

| Date | Categories of conditions | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
| Nov 1 | 2 | 4 | 3 | 3 | 3 | 1 | 6 | 3 | 5 | 3 | 1 | 4 | 3 | 6 | 6 |
| 2 | 2 | 5 | 2 | 3 | 3 | 1 | 5 | 4 | 5 | 2 | 1 | 5 | 5 | 5 | 6 |
| 3 | 2 | 3 | 2 | 3 | 3 | 1 | 5 | 6 | 6 | 2 | 1 | 5 | 3 | 6 | 5 |
| 4 | 2 | 3 | 2 | 5 | 4 | 1 | 5 | 5 | 5 | 2 | 1 | 3 | 3 | 5 | 5 |
| 5 | 4 | 2 | 4 | 5 | 6 | 1 | 3 | 5 | 5 | 2 | 1 | 2 | 2 | 5 | 5 |
| 6 | 6 | 2 | 5 | 3 | 5 | 1 | 3 | 5 | 6 | 2 | 1 | 2 | 2 | 6 | 6 |
| 7 | 5 | 2 | 6 | 3 | 3 | 1 | 6 | 3 | 6 | 6 | 1 | 2 | 2 | 5 | 6 |
| 8 | 6 | 2 | 6 | 4 | | 4 | 5 | 3 | 5 | 6 | 1 | 2 | 2 | 6 | 5 |
| 9 | 5 | 2 | 5 | 3 | | 5 | 3 | 3 | 5 | 5 | 1 | 2 | 2 | 5 | 3 |
| 10 | 3 | 2 | 3 | 3 | | 3 | 3 | 2 | 6 | 5 | 4 | 2 | 2 | 3 | 3 |
| 11 | | 2 | | | | 6 | 4 | 2 | | 3 | 5 | 2 | 1 | 3 | 4 |
| 12 | | | | | | 5 | 5 | 1 | | 3 | 3 | 6 | 1 | 3 | 5 |
| 13 | | | | | | 3 | 6 | 1 | | 2 | 3 | 5 | 3 | 6 | 5 |
| 14 | | | | | | | 5 | 1 | | 2 | 2 | 6 | 2 | 6 | 5 |
| 15 | | | | | | | 5 | 4 | | 4 | 2 | 5 | 2 | 5 | 3 |
| 16 | | | | | | | 6 | 6 | | 5 | 2 | | | 3 | 3 |
| 17 | | | | | | | 6 | 5 | | 5 | 2 | | | 3 | 2 |
| 18 | | | | | | | 5 | 5 | | 5 | 2 | | | 2 | 2 |
| 19 | | | | | | | 5 | 3 | | 5 | 1 | | | 2 | 2 |
| 20 | | | | | | | 3 | 3 | | 3 | 1 | | | 2 | |
| 21 | | | | | | | 3 | 3 | | 5 | 4 | | | 5 | |
| 22 | | | | | | | 2 | 3 | | 5 | 5 | | | 5 | |
| 23 | | | | | | | 2 | 2 | | 3 | 3 | | | | |
| 24 | | | | | | | | 2 | | 6 | 3 | | | | |
| 25 | | | | | | | | 3 | | 5 | 3 | | | | |
| 26 | | | | | | | | | | 5 | 2 | | | | |
| 27 | | | | | | | | | | 3 | 2 | | | | |
| 28 | | | | | | | | | | 3 | | | | | |
| 29 | | | | | | | | | | 2 | | | | | |

*The categories applied by fishermen were:

1: Very low.
2: Low.
3: Normal.
4: Rising.
5: High.
6: Flood.

TABLE 38: Levels of Awarua River from 1951 to 1961

| Date | 1951 | 1952 | 1953 | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | River levels (cm) | | | | | | |
| Sep 1 | 28 | 0 | 10 | | 18 | 13 | 8 | 20 | 10 | 16 | 10 |
| 2 | 20 | 0 | 10 | | 15 | 13 | 8 | 20 | 48 | 15 | 10 |
| 3 | 13 | 0 | 10 | | 13 | 13 | 8 | 19 | 56 | 21 | 10 |
| 4 | 10 | 0 | 13 | | 13 | 15 | 6 | 18 | 44 | 21 | 9 |
| 5 | 18 | 0 | 31 | | 13 | 20 | 6 | 17 | 28 | 21 | 14 |
| 6 | 20 | 8 | 41 | | 15 | 15 | 5 | 15 | 23 | 18 | 47 |
| 7 | 20 | 8 | 64 | | 13 | 13 | 5 | 15 | 18 | 18 | 39 |
| 8 | 13 | 5 | 48 | | 13 | 10 | 4 | 14 | 21 | 72 | 59 |
| 9 | 10 | 0 | 36 | | 12 | 10 | 4 | 13 | 18 | 92 | 40 |
| 10 | 10 | 0 | 38 | | 10 | 10 | 3 | 12 | 16 | 72 | 25 |
| 11 | 10 | 0 | 31 | 15 | 8 | 9 | 2 | 12 | 14 | 41 | 19 |
| 12 | 8 | 0 | 25 | 13 | 8 | 38 | 2 | 10 | 14 | 28 | 18 |
| 13 | 8 | 0 | 20 | 10 | 13 | 33 | 2 | 18 | 21 | 23 | 16 |
| 14 | 10 | 8 | 18 | 10 | 18 | 33 | 2 | - | 33 | 21 | 15 |
| 15 | 41 | 5 | 18 | 9 | 18 | 20 | 2 | - | 47 | 21 | 14 |
| 16 | 71 | 8 | 18 | - | 23 | 15 | 2 | - | 61 | 19 | 12 |
| 17 | 89 | 5 | 15 | - | 25 | 13 | 2 | - | 84 | 19 | 17 |
| 18 | 46 | 8 | 13 | - | 31 | 16 | 2 | - | 127 | 18 | 16 |
| 19 | 49 | 51 | 13 | - | 26 | 18 | 5 | - | 74 | 17 | 14 |
| 20 | 49 | 25 | 13 | 8 | - | 20 | 4 | - | 51 | 17 | 14 |
| 21 | 46 | 21 | 10 | 13 | - | 15 | 3 | - | 33 | 16 | 13 |
| 22 | 31 | 0 | 10 | 10 | - | 13 | 2 | - | 28 | 15 | 25 |
| 23 | 25 | 0 | 31 | 10 | 84 | 18 | 2 | - | 25 | 14 | 36 |
| 24 | 21 | 0 | 51 | 8 | 117 | 59 | - | - | 72 | 13 | 59 |
| 25 | 21 | 0 | 31 | 13 | 94 | 43 | - | - | 54 | 13 | 30 |
| 26 | 21 | 0 | 20 | 20 | 71 | 28 | - | - | 39 | 12 | 30 |
| 27 | 18 | 21 | 15 | 33 | 43 | 20 | - | - | 31 | 13 | 39 |
| 28 | 18 | 18 | 18 | 25 | 28 | 18 | - | 18 | 25 | 12 | 27 |
| 29 | 28 | 18 | 20 | 18 | 23 | 15 | - | 18 | 23 | 11 | 22 |
| 30 | 31 | 18 | 18 | 13 | 20 | 13 | - | 94 | 25 | 11 | 23 |
| Oct 1 | 49 | 16 | 15 | 10 | 18 | 13 | 18 | 56 | 31 | 12 | 19 |
| 2 | 36 | 23 | 13 | 10 | 18 | 13 | 33 | 31 | 36 | 11 | 18 |
| 3 | 28 | 18 | 10 | 10 | 28 | 13 | 31 | 23 | 44 | 11 | 38 |
| 4 | 26 | 46 | 10 | - | 36 | 10 | 38 | 19 | 39 | 10 | 26 |
| 5 | 23 | 41 | 8 | - | 28 | 10 | 25 | 18 | 39 | 9 | 23 |
| 6 | 21 | 31 | 8 | 10 | 36 | 9 | 18 | 17 | 33 | 11 | 36 |
| 7 | 18 | 21 | 8 | 10 | 28 | 8 | 14 | 46 | 28 | 14 | 28 |
| 8 | 16 | 18 | 8 | 8 | 18 | 6 | 13 | 33 | 25 | 14 | 21 |
| 9 | 16 | 16 | 8 | 56 | 15 | 6 | 12 | 31 | 25 | 17 | 18 |
| 10 | 13 | 16 | 5 | 56 | 15 | 6 | 12 | 23 | 23 | 37 | 17 |
| 11 | 13 | 13 | 5 | 46 | 15 | 6 | 20 | 20 | 21 | 30 | 17 |
| 12 | 13 | 25 | 10 | 53 | 15 | 5 | 31 | 18 | 36 | 32 | 23 |
| 13 | 11 | 21 | 15 | - | 15 | 5 | 89 | 17 | 39 | 31 | 19 |
| 14 | 11 | 21 | 10 | 41 | 15 | 4 | 61 | 17 | 28 | 33 | 41 |
| 15 | 11 | 33 | 8 | 31 | 13 | 4 | 33 | 15 | 23 | 12 | 32 |
| 16 | 13 | 66 | 5 | 23 | 13 | 3 | 23 | 14 | 22 | 30 | 79 |
| 17 | 11 | 49 | 5 | 20 | 13 | 3 | 23 | 14 | 21 | 27 | 87 |
| 18 | 31 | 33 | 13 | 18 | 12 | 3 | 89 | 14 | 19 | 25 | 40 |
| 19 | 23 | 39 | 43 | 15 | 10 | 8 | 53 | 13 | 18 | 28 | 27 |
| 20 | 16 | 31 | 28 | 15 | 10 | 20 | 33 | 13 | 17 | 28 | 23 |
| 21 | 13 | 23 | 15 | 18 | 10 | 25 | 23 | 17 | 16 | 27 | 19 |
| 22 | 13 | 21 | 10 | 15 | 10 | 18 | 25 | 18 | 14 | 26 | 25 |
| 23 | 11 | 25 | 10 | 15 | 23 | 12 | 23 | 69 | 13 | 25 | 23 |
| 24 | 11 | 21 | 10 | 15 | 18 | 8 | 20 | 51 | 16 | 25 | 19 |
| 25 | 11 | 18 | 10 | 13 | 13 | 18 | 20 | 28 | 18 | 24 | 17 |
| 26 | 16 | 16 | 8 | 10 | 13 | 13 | 20 | 20 | 18 | 23 | 28 |
| 27 | 25 | 16 | 8 | 25 | 23 | 12 | 20 | 99 | 17 | 23 | 99 |
| 28 | 25 | 13 | 5 | 18 | 15 | 23 | - | 71 | 16 | 27 | 77 |
| 29 | 16 | 13 | 5 | 13 | 13 | 25 | 53 | 53 | 14 | 36 | 46 |
| 30 | 18 | 11 | 5 | 13 | 12 | 33 | 59 | 36 | 13 | 30 | 28 |
| 31 | 31 | 13 | 5 | 13 | 10 | 71 | 59 | 28 | 12 | 25 | 23 |

TABLE 38: Levels of Awarua River from 1951 to 1961 (continued)

| Date | River levels (cm) 1951 | 1952 | 1953 | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nov 1 | 25 | 13 | 5 | 69 | 23 | 43 | 89 | 48 | 11 | 12 | 31 |
| 2 | 23 | 13 | 4 | 76 | 23 | 41 | 79 | 41 | 11 | 18 | 22 |
| 3 | 23 | 13 | 4 | 25 | 18 | 28 | 56 | 61 | 13 | 21 | 21 |
| 4 | 21 | 13 | 4 | 20 | 13 | 48 | 38 | 41 | 13 | 19 | 18 |
| 5 | 21 | 13 | 3 | 18 | 12 | 51 | 31 | 33 | 13 | 14 | 23 |
| 6 | 21 | 13 | 3 | 15 | 12 | 33 | 23 | 28 | 97 | 16 | 22 |
| 7 | 21 | 11 | 1 | 13 | 10 | 23 | 20 | 38 | 66 | 11 | 99 |
| 8 | 28 | 11 | 3 | 13 | 10 | 18 | 18 | 31 | 39 | 12 | 120 |
| 9 | 31 | 11 | 10 | 38 | 9 | 20 | 15 | 23 | 54 | 11 | 61 |
| 10 | 23 | 11 | 15 | 43 | 25 | | 18 | 22 | 44 | 14 | 36 |
| 11 | 46 | 8 | 13 | 69 | 23 | | 18 | 20 | 33 | 12 | 28 |
| 12 | 36 | 8 | 10 | 61 | 15 | | 18 | 20 | 25 | 12 | 25 |
| 13 | 28 | 5 | 15 | 36 | | | 15 | 19 | 22 | 11 | 23 |
| 14 | 26 | 5 | 28 | 25 | | | 15 | 18 | 51 | 49 | 27 |
| 15 | 21 | 5 | 25 | 31 | | | 31 | 28 | 39 | 44 | 25 |
| 16 | 18 | 5 | 15 | 31 | | | - | 51 | 82 | 33 | 56 |
| 17 | 21 | 5 | 15 | 25 | | | - | 56 | 77 | 23 | 51 |
| 18 | 28 | 5 | 13 | | | | - | 42 | 54 | | 47 |
| 19 | 39 | 5 | 13 | | | | - | | | | 31 |
| 20 | 28 | 5 | 18 | | | | 152 | | | | 25 |
| 21 | 21 | 41 | 13 | | | | - | | | | 22 |
| 22 | 21 | 31 | 13 | | | | - | | | | 18 |
| 23 | | 18 | 25 | | | | 76 | | | | 14 |
| 24 | | 16 | | | | | 61 | | | | |
| 25 | | | | | | | 66 | | | | |

TABLE 39: Temperatures of all rivers except Cascade River from 1969 to 1972

| | Water temperatures (°C) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Min. | Mean daily min. | Max. | Mean daily max. | Min. amplitude | Mean amplitude | Max. amplitude |
| 1969 | | | | | | | |
| Ship Creek | 5.5 | 9.8 | 18.5 | 12.1 | 0.5 | 2.4 | 4.5 |
| Ship Creek swamp | 8.0 | 11.7 | 22.5 | 15.2 | 0 | 3.4 | 6.5 |
| Waita River | 6.5 | 10.4 | 18.5 | 13.2 | 0.5 | 2.7 | 4.5 |
| Haast River | 6.0 | 8.8 | 16.0 | 11.4 | 1.0 | 2.6 | 4.0 |
| Okuru River | 6.0 | 9.3 | 16.0 | 11.3 | 1.0 | 2.1 | 4.5 |
| Turnbull River | 6.0 | 8.7 | 16.0 | 11.3 | 1.0 | 2.7 | 4.5 |
| Waiatoto River* | 6.0 | 8.8 | 12.5 | 10.4 | 0.5 | 1.7 | 2.5 |
| Content Creek | 6.5 | 9.5 | 15.0 | 11.1 | 0 | 1.4 | 3.0 |
| Arawata River | 6.0 | 8.6 | 16.0 | 11.7 | 0 | 3.0 | 5.0 |
| Jackson Bay Stream | 6.0 | 9.1 | 14.0 | 10.7 | 0.5 | 1.6 | 2.5 |
| Sea | 8.0 | 11.6 | 18.0 | 13.3 | 0.5 | 1.7 | 2.5 |
| 1970 | | | | | | | |
| Okuru River | 5.0 | 8.2 | 13.0 | 10.2 | 1.0 | 2.1 | 4.5 |
| Waiatoto River* | 6.0 | 7.9 | 13.5 | 10.0 | 0.5 | 2.5 | 4.0 |
| Site 2† | 7.0 | 9.7 | 18.0 | 13.1 | 0.5 | 3.8 | 5.5 |
| Site 5† | 5.5 | 8.0 | 15.0 | 10.9 | 0.5 | 3.1 | 6.5 |
| Content Creek | 4.5 | 7.2 | 14.0 | 10.7 | 1.0 | 2.2 | 3.5 |
| Hindley Creek | 6.0 | 7.6 | 13.5 | 10.6 | 0 | 2.1 | 3.0 |
| Nisson Creek | 6.5 | 10.9 | 17.5 | 13.7 | 1.0 | 4.2 | 6.5 |
| Nolans Creek | 7.5 | 8.7 | 15.5 | 11.9 | 1.5 | 2.3 | 4.5 |
| Brewer Water | 7.0 | 8.5 | 12.0 | 10.3 | 0.5 | 2.0 | 3.0 |
| Hubbub Torrent | 6.5 | 9.2 | 12.5 | 10.2 | 0 | 1.4 | 3.0 |
| Gliding Rivulet | 8.0 | 9.4 | 12.0 | 10.4 | 1.0 | 1.7 | 2.5‡ |
| Sea | 9.5 | 10.8 | 14.5 | 12.6 | 0 | 2.1 | 3.5 |
| 1971 | | | | | | | |
| Okuru River | 6.5 | 8.8 | 14.5 | 10.6 | 0 | 2.4 | 5.5 |
| Waiatoto River* | 6.0 | 8.3 | 12.5 | 9.6 | 0 | 1.5 | 3.0 |
| Site 2† | 8.0 | 9.9 | 16.0 | 11.7 | 0 | 2.0 | 5.0 |
| Site 4† | 6.0 | 8.0 | 14.0 | 11.1 | 1.0 | 3.3 | 5.0 |
| Site 5† | 4.5 | 8.8 | 15.0 | 10.8 | 0 | 2.4 | 5.5 |
| Content Creek | 7.0 | 9.8 | 14.5 | 10.3 | 0 | 0.8 | 2.5 |
| Hindley Creek | 6.0 | 9.0 | 17.5 | 11.1 | 1.0 | 1.3 | 4.5 |
| Dawn Rivulet | 6.0 | 9.3 | 16.5 | 11.9 | 1.0 | 2.8 | 6.0 |
| Nisson Creek | 6.5 | 8.3 | 13.5 | 10.5 | 0 | 2.2 | 4.0 |
| Nolans Creek | 6.0 | 8.4 | 14.0 | 10.7 | 0.5 | 2.3 | 3.5 |
| Brewer Water | 8.5 | 9.0 | 12.0 | 10.5 | 0.5 | 1.5 | 2.0 |
| Hubbub Torrent | 8.0 | 9.4 | 13.0 | 11.2 | 0.5 | 1.9 | 3.0 |
| Gliding Rivulet | 7.5 | 9.3 | 13.0 | 11.1 | 1.0 | 1.9 | 3.0 |
| Sea | 8.0 | 11.6 | 16.5 | 13.3 | 0 | 0.8 | 2.5 |

TABLE 39: Temperatures of all rivers except Cascade River from 1969 to 1972 (continued)

| | Water temperatures (°C) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Min. | Mean daily min. | Max. | Mean daily max. | Min. amplitude | Mean amplitude | Max. amplitude |
| 1972 | | | | | | | |
| Waiatoto River* | 5.0 | 7.1 | 11.2 | 8.4 | 0 | 1.4 | 4.5 |
| Site 1† | 5.5 | 9.1 | 14.5 | 11.9 | 0 | 2.8 | 7.5 |
| Content Creek | 6.5 | 9.0 | 15.0 | 10.1 | 0 | 1.0 | 3.0 |
| Hindley Creek | 5.5 | 8.3 | 14.0 | 10.3 | 0 | 2.5 | 4.5 |
| Dawn Rivulet | 7.5 | 9.8 | 15.5 | 12.4 | 1.0 | 2.6 | 4.0 |
| Nolans Creek | 6.0 | 8.8 | 13.0 | 10.0 | 0 | 1.6 | 3.0 |
| Sea | 9.5 | 11.0 | 14.5 | 12.3 | 0.5 | 1.2 | 3.5 |

*The temperature at a water level stake up stream from the limits of tidal influence.

†Sampling sites in the Waiatoto River; see Table 2.

‡Records began on 10 October 1970.

TABLE 40: Temperatures of Cascade River from 1959 to 1972

| | Water temperatures (°C) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Min. | Mean daily min. | Max. | Mean daily max. | Min. amplitude | Mean amplitude | Max. amplitude | Period of observation |
| 1959 | 1.5 | 7.5 | 16.0 | 10.8 | 0 | 3.3 | 10.0 | 1/9-10/11 |
| 1960 | - | - | - | - | - | - | - | - |
| 1961 | 3.5 | 9.6 | 13.0 | 11.5 | 0 | 1.9 | 6.5 | 2/9-10/11 |
| 1962 | 6.0 | 9.2 | 13.0 | 10.9 | 0 | 1.7 | 6.0 | 1/9-10/11 |
| 1963 | 7.0 | 9.4 | 13.0 | 11.3 | 0 | 1.9 | 3.5 | 1/9- 1/11 |
| 1964 | 6.5 | 8.8 | 14.0 | 10.8 | 0.5 | 2.1 | 4.5 | 17/9-13/11 |
| 1965 | 5.5 | 8.2 | 12.0 | 10.0 | 0.5 | 1.7 | 4.5 | 13/9-23/11 |
| 1966 | 7.0 | 10.1 | 14.5 | 11.2 | 0 | 1.1 | 4.0 | 11/9-25/11 |
| 1967 | 8.0 | 9.7 | 12.0 | 10.9 | 0 | 1.2 | 3.5 | 26/9-10/11 |
| 1968 | 6.0 | 8.1 | 13.0 | 9.7 | 0 | 1.6 | 4.5 | 1/9-29/11 |
| 1969 | 7.0 | 10.3 | 15.5 | 11.2 | 0 | 0.9 | 4.5 | 1/9-27/11 |
| 1970 | 6.5 | 9.3 | 14.5 | 10.5 | 0 | 1.1 | 3.0 | 1/9-15/11 |
| 1971 | 6.5 | 9.5 | 14.5 | 11.0 | 0 | 1.6 | 4.0 | 1/9-15/11 |
| 1972 | 7.0 | 9.1 | 14.5 | 10.9 | 0 | 1.8 | 5.0 | 1/9-22/11 |

TABLE 41: Water colour of Haast area rivers (% light loss at each wavelength)

| River | Wavelength (nm) 350 | 400 | 450 | 500 | 550 | 600 | Average light loss (%) | No. of samples measured | Mean APHA values |
|---|---|---|---|---|---|---|---|---|---|
| Ship Creek trib. | 28.3 | 55.3 | 77.0 | 87.3 | 92.8 | 95.5 | 27.3 | 4 | 200 |
| Ship Creek swamp | 18.3 | 45.3 | 53.8 | 81.5 | 88.3 | 92.8 | 36.7 | 4 | 225 |
| Ship Creek | 70.5 | 83.0 | 91.5 | 95.3 | 96.8 | 98.3 | 10.8 | 4 | 20 |
| Jackson Bay Stream | 76.0 | 87.8 | 94.5 | 96.3 | 97.5 | 98.5 | 8.2 | 7 | 37.5 |
| Okuru River | 96.3 | 98.8 | 99.5 | 99.5 | 97.8 | 100.0 | 1.0 | 4 | 12.5 |
| Turnbull River | 97.8 | 99.0 | 99.8 | 99.8 | 100.0 | 99.8 | 0.6 | 4 | 0 |
| Arawata River | 96.3 | 98.0 | 98.5 | 99.0 | 99.8 | 99.8 | 1.4 | 4 | 0 |
| Waita River | 81.8 | 89.5 | 94.3 | 96.5 | 97.8 | 98.5 | 6.9 | 4 | 17.5 |
| Haast River | 95.8 | 97.8 | 98.5 | 98.5 | 98.8 | 99.3 | 1.9 | 4 | 2.5 |
| Waiatoto River | 98.7 | 97.1 | 98.3 | 98.6 | 98.7 | 99.3 | 2.1 | 7 | 0 |
| Nolans Creek | 59.6 | 78.1 | 88.6 | 93.3 | 95.8 | 97.0 | 14.6 | 8 | 47.5 |
| Content Creek | 64.1 | 81.2 | 90.3 | 94.1 | 96.7 | 97.7 | 12.6 | 11 | 35 |
| Gliding Rivulet | 88.7 | 94.9 | 97.1 | 98.6 | 99.3 | 99.7 | 3.6 | 7 | 5 |
| Hubbub Torrent | 91.3 | 96.3 | 97.7 | 98.7 | 99.1 | 99.6 | 2.9 | 7 | 5 |
| Brewer Water | 94.0 | 97.4 | 98.4 | 99.1 | 99.7 | 99.9 | 1.9 | 7 | 5 |
| Nisson Creek (lake branch) | 78.3 | 88.6 | 94.0 | 96.6 | 97.7 | 98.6 | 7.7 | 7 | - |
| Branch Brook | 93.3 | 96.6 | 98.1 | 99.0 | 99.4 | 100.0 | 2.3 | 7 | - |
| Nisson-Branch combined | 83.0 | 90.8 | 95.2 | 97.0 | 97.8 | 98.8 | 6.2 | 5 | 15 |
| Dawn Rivulet | 59.2 | 77.3 | 87.7 | 92.3 | 95.2 | 97.0 | 15.2 | 9 | 65 |
| Hindley Creek | 84.9 | 92.8 | 96.3 | 98.1 | 98.6 | 99.2 | 5.0 | 12 | 11.6 |

TABLE 42: Visual turbidity estimates of Haast area rivers from 1969 to 1972

| Date | 1969 Waita River | 1969 Haast River | 1969 Okuru River | 1969 Turnbull River | 1969 Waiatoto River | 1969 Arawata River | 1970 Okuru River | 1970 Waiatoto River | 1971 Okuru River | 1971 Waiatoto River | 1972 Waiatoto River |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Aug 31 | 1* | 1 | 1 | 1 | | 1 | | | | | |
| Sep 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | | | | |
| 2 | 1 | 2 | 1 | 1 | 1 | 1 | 3 | | | | |
| 3 | 2 | 5 | 2 | 3 | 4 | 4 | 1 | 4 | | | 1 |
| 4 | 5 | 3 | 3 | 4 | - | - | 1 | 4 | | | 1 |
| 5 | 3 | 3 | 2 | 2 | 5 | 3 | 2 | 5 | | | 1 |
| 6 | 5 | 3 | 4 | 4 | 5 | 4 | 5 | 4 | | | 1 |
| 7 | 5 | 4 | 2 | 2 | 4 | 4 | 2 | 4 | | 1 | 1 |
| 8 | 5 | 4 | 5 | 5 | 5 | 5 | 4 | 4 | | 1 | 5 |
| 9 | 5 | 4 | 4 | 3 | 4 | 4 | 2 | 4 | | 1 | - |
| 10 | 5 | 4 | 4 | 5 | 4 | 4 | 1 | 4 | | 1 | - |
| 11 | 5 | 4 | 4 | 2 | 4 | 4 | 5 | 4 | | 5 | - |
| 12 | 5 | 4 | 3 | 1 | 4 | 4 | 2 | 3 | | 4 | 4 |
| 13 | 5 | 4 | 2 | 1 | 4 | 4 | 2 | 3 | 2 | - | 5 |
| 14 | 5 | 4 | 2 | 1 | 4 | 4 | 1 | 5 | 1 | - | - |
| 15 | 3 | 3 | 1 | 1 | 4 | 4 | 2 | 4 | - | - | - |
| 16 | 3 | 4 | 1 | 1 | 4 | 4 | 5 | 5 | 1 | - | - |
| 17 | 2 | 4 | 5 | 1 | 5 | 3 | 5 | 4 | 1 | 2 | - |
| 18 | 1 | 4 | 5 | 1 | 5 | 3 | 2 | 5 | 1 | 2 | - |
| 19 | 1 | 3 | 4 | 1 | 4 | 3 | 5 | 4 | 5 | 5 | - |
| 20 | 3 | 3 | 4 | 1 | 4 | 3 | 4 | 3 | 2 | 4 | 3 |
| 21 | 1 | 3 | 4 | 1 | 4 | 3 | 2 | 3 | 1 | 3 | 3 |
| 22 | 1 | 3 | 3 | 1 | 3 | 3 | 1 | 3 | 5 | 5 | 2 |
| 23 | 1 | 3 | 3 | 1 | 3 | 3 | 1 | 2 | 2 | 3 | 4 |
| 24 | 1 | 3 | 2 | 1 | 2 | 3 | 5 | 5 | 1 | - | 3 |
| 25 | 1 | 3 | 1 | 1 | 2 | 2 | 4 | 4 | 1 | 2 | 3 |
| 26 | 1 | 1 | 1 | 1 | 2 | - | 3 | 3 | 1 | 2 | 4 |
| 27 | 1 | 1 | 1 | 1 | 3 | 2 | - | 3 | 2 | 2 | - |
| 28 | 1 | 1 | 1 | 1 | 3 | 2 | 1 | 2 | 2 | 3 | 4 |
| 29 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | - | 1 | 2 | 3 |
| 30 | 1 | 1 | 1 | 1 | 2 | 1 | - | 2 | 1 | 2 | 3 |
| Oct 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 |
| 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 |
| 3 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 4 | 4 | 2 |
| 4 | 1 | 1 | 1 | 1 | 2 | 1 | 4 | - | 4 | 3 | 3 |
| 5 | 1 | 1 | 1 | 1 | 2 | 1 | 4 | 2 | 3 | 3 | 2 |
| 6 | 1 | 2 | 1 | 1 | 2 | 1 | 4 | 2 | - | 3 | 5 |
| 7 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 4 | - | 2 | 4 |
| 8 | 5 | 4 | 4 | 4 | 4 | 4 | - | 5 | 1 | 2 | 3 |
| 9 | 5 | 4 | 3 | 4 | 4 | 3 | 2 | 4 | 1 | 1 | 3 |
| 10 | 2 | 1 | 1 | 1 | 3 | 1 | - | 2 | 3 | 3 | 2 |
| 11 | 1 | 1 | 1 | 1 | 3 | 1 | - | - | 1 | 2 | 4 |
| 12 | 1 | 1 | 1 | 1 | 3 | 1 | - | 2 | 1 | - | 5 |
| 13 | 1 | 1 | 1 | 1 | 2 | 1 | - | 2 | 1 | 1 | 2 |
| 14 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | - | 1 | 1 | 2 |
| 15 | 1 | 5 | 1 | 1 | 2 | 1 | 4 | 5 | - | - | 2 |
| 16 | 4 | 3 | 5 | 2 | 4 | 5 | 3 | 3 | - | 2 | 4 |
| 17 | 2 | 2 | 2 | 2 | 3 | 4 | 1 | 2 | 5 | 4 | 2 |
| 18 | 2 | 2 | 2 | 2 | 3 | 3 | 1 | 2 | 2 | 3 | 1 |
| 19 | 2 | 2 | 1 | 1 | 3 | 2 | 3 | 3 | 1 | 2 | 1 |
| 20 | 1 | 1 | 1 | 1 | 3 | 2 | 1 | 3 | 1 | 2 | 1 |
| 21 | 5 | 5 | 4 | 5 | 4 | 4 | 1 | 3 | 1 | 2 | 4 |
| 22 | 5 | 4 | 2 | 2 | 4 | 3 | 5 | 5 | 1 | 1 | 4 |
| 23 | 5 | 3 | 2 | 2 | 3 | 2 | 4 | - | 1 | 2 | 4 |
| 24 | 5 | 3 | 5 | 2 | 3 | 3 | 5 | 4 | 1 | 2 | 4 |
| 25 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | - | 2 | 4 |
| 26 | 5 | 2 | 1 | - | 3 | 2 | 4 | 3 | 1 | 2 | 2 |
| 27 | 3 | 4 | 3 | 2 | 3 | 3 | 1 | 2 | 1 | 1 | 2 |
| 28 | 1 | 3 | 2 | 1 | 3 | 2 | 1 | 2 | 4 | 4 | - |
| 29 | 1 | 1 | 1 | 1 | 2 | 2 | - | 3 | 3 | 3 | 4 |
| 30 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 3 | 1 | - | 4 |
| 31 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 2 | 5 |

TABLE 42: Visual turbidity estimates of Haast area rivers from 1969 to 1972 (continued)

| | 1969 | | | | | | 1970 | | 1971 | | 1972 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Waita River | Haast River | Okuru River | Turn-bull River | Waia-toto River | Arawata River | Okuru River | Waia-toto River | Okuru River | Waia-toto River | Waia-toto River |
| Nov 1 | 1 | 1 | 1 | 1 | 1 | 1 | - | 4 | 1 | 2 | 4 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | - | 5 | 1 | 3 | 3 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | - | 3 | 1 | 2 | 5 |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | - | - | 3 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 4 |
| 6 | 1 | 1 | 1 | 1 | 1 | 2 | - | 2 | 1 | 2 | 3 |
| 7 | 1 | 3 | 1 | 1 | 3 | 2 | 1 | 2 | 1 | 2 | 4 |
| 8 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 1 | 2 | 3 |
| 9 | 1 | 1 | 1 | 1 | 2 | 3 | 1 | 2 | 1 | 2 | 4 |
| 10 | 5 | 4 | 3 | 3 | 3 | 5 | 1 | 2 | 1 | 2 | 3 |
| 11 | 5 | 3 | 3 | 1 | 4 | 4 | 1 | 3 | 1 | 2 | 3 |
| 12 | 5 | 3 | 1 | 1 | - | 4 | 5 | 3 | - | 2 | 3 |
| 13 | 1 | 2 | 1 | 1 | 3 | 4 | 2 | 3 | 1 | 2 | - |
| 14 | 1 | 2 | 1 | 1 | 4 | 4 | 2 | 3 | - | 3 | 4 |
| 15 | 1 | 3 | 1 | 1 | 4 | 4 | 2 | | 1 | 3 | |
| 16 | 1 | 4 | 1 | 1 | 4 | 4 | 1 | | 1 | 3 | |
| 17 | 1 | 4 | 1 | 1 | - | 3 | 1 | | | | |
| 18 | 1 | 4 | 1 | 1 | 4 | 3 | 3 | | | | |
| 19 | 1 | 4 | 1 | 1 | 4 | 3 | | | | | |
| 20 | 1 | 3 | 1 | 1 | 4 | 3 | | | | | |
| 21 | 5 | 4 | 4 | 2 | 3 | 5 | | | | | |
| 22 | 5 | 4 | 2 | 1 | 4 | 4 | | | | | |
| 23 | 1 | 4 | 1 | 1 | | 4 | | | | | |
| 24 | 1 | 3 | 1 | 1 | | 3 | | | | | |

*For explanation of visual turbidity scale see "Water Turbidity", Appendix 1.

TABLE 43: pH of Haast area rivers

| River | No. of samples | Min. | pH Mean | Max. | S.D. |
|---|---|---|---|---|---|
| Ship Creek | 6 | 5.8 | 6.2 | 6.7 | 0.41 |
| Ship Creek swamp | 6 | 4.0 | 4.3 | 4.9 | 0.33 |
| Ship Creek trib. | 4 | 4.2 | 4.7 | 5.6 | 0.65 |
| Waita River | 6 | 6.3 | 6.6 | 7.0 | 0.29 |
| Haast River | 6 | 6.9 | 7.2 | 7.5 | 0.20 |
| Turnbull River | 5 | 6.5 | 6.8 | 7.3 | 0.32 |
| Okuru River | 15 | 6.2 | 6.7 | 7.5 | 0.29 |
| Waiatoto River | 28 | 6.5 | 7.0 | 7.7 | 0.28 |
| Arawata River | 4 | 6.8 | 7.0 | 7.4 | 0.26 |
| Jackson Bay Stream | 7 | 6.7 | 6.9 | 7.3 | 0.22 |
| Gliding Rivulet | 13 | 6.3 | 6.6 | 7.0 | 0.23 |
| Hubbub Torrent | 19 | 6.1 | 6.5 | 7.2 | 0.36 |
| Brewer Water | 19 | 6.2 | 6.2 | 7.4 | 0.32 |
| Nisson Creek | 17 | 4.3 | 6.1 | 7.0 | 0.63 |
| Nisson Creek (lake branch) | 6 | 3.9 | 5.4 | 6.4 | 0.89 |
| Branch Brook | 6 | 6.0 | 6.3 | 6.6 | 0.20 |
| Nolans Creek | 19 | 4.1 | 5.2 | 6.8 | 0.47 |
| Content Creek | 23 | 4.7 | 5.9 | 7.0 | 0.54 |
| Dawn Rivulet | 13 | 5.4 | 6.1 | 6.7 | 0.36 |
| Hindley Creek | 25 | 5.6 | 6.4 | 6.9 | 0.35 |

TABLE 44: Oxygen concentrations in Haast area rivers

| River | | Oxygen concentrations (% saturation) | | | |
|---|---|---|---|---|---|
| | | 14/10/72 | 20/10/72 | 29/10/72 | Mean |
| Ship Creek | | 100 | 114 | 101 | 105.0 |
| Ship Creek swamp | | 57 | 99 | 44 | 63.7 |
| Ship Creek trib. | | 106 | 112 | 107 | 108.3 |
| Waita River | | 101 | 111 | 103 | 105.0 |
| Haast River | | 108 | 115 | 113 | 112.0 |
| Okuru River | | 112 | 112 | 106 | 110.0 |
| Turnbull River | | 112 | 115 | 110 | 112.3 |
| Arawata River | | 112 | 107 | 119 | 112.7 |
| Jackson Bay Stream | | 107 | 102 | 104 | 104.3 |
| | 14/11/71 | 16/10/72 | 21/10/72 | 27/10/72 | |
| Waiatoto River | 104 | 111 | 112 | 108 | 108.8 |
| Gliding Rivulet | 103 | 114 | 116 | 110 | 110.8 |
| Hubbub Torrent | 105 | 113 | 115 | 110 | 110.8 |
| Brewer Water | 104 | 112 | 114 | 110 | 110.0 |
| Nisson Creek | 95 | 101 | 105 | 102 | 100.8 |
| Nisson Creek (lake branch) | - | 100 | 99 | 104 | 101.0 |
| Branch Brook | - | 101 | 102 | 99 | 100.7 |
| Nolans Creek | 81 | 98 | 92 | 93 | 91.0 |
| Content Creek | 99 | 100 | 102 | 95 | 99.0 |
| Dawn Rivulet | 99 | 95 | 101 | 94 | 97.3 |
| Hindley Creek | 100 | 106 | 102 | 97 | 101.3 |

TABLE 45: Summary of water salinities of Haast area rivers

| River | Salinity ($g/m^3$ NaCl equivalents) Min. | Mean | Max. | S.D. | No. of samples |
|---|---|---|---|---|---|
| Ship Creek swamp | 25 | 31.3 | 37 | 5.3 | 6 |
| Ship Creek | 13 | -* | 470 | - | 6 |
| Waita River | 13 | 18.8 | 24 | 5.0 | 6 |
| Haast River | 13 | 27.2 | 38 | 9.6 | 6 |
| Okuru River | 10 | 17.0 | 21 | 3.8 | 6 |
| Turnbull River | 7 | 12.6 | 17 | 4.0 | 6 |
| Arawata River | 14 | 24.2 | 34 | 9.2 | 5 |
| Jackson Bay Stream | 22 | 36.6 | 49 | 11.8 | 5 |
| Waiatoto River | 13 | 22.1 | 42 | 7.4 | 31 |
| Hindley Creek | 6 | 14.2 | 28 | 5.2 | 15 |
| Content Creek | 8 | 11.5 | 15 | 2.0 | 20 |
| Nolans Creek | 6 | 23.7 | 49 | 12.5 | 13 |
| Nisson Creek | 7 | 10.6 | 15 | 2.6 | 13 |
| Brewer Water | 8 | 13.8 | 17 | 2.2 | 15 |
| Hubbub Torrent | 7 | 9.0 | 10 | 0.8 | 15 |
| Gliding Rivulet | 7 | 10.8 | 14 | 1.8 | 9 |

*-: Mean was not calculated.

TABLE 46: Salinities and rainfall recorded at Haast area rivers in 1969

| River | Conductivity and salinity | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6 Sep | | 20 Sep | | 4 Oct | | 21 Oct | | 1 & 2 Nov | | 14 & 15 Nov | |
| | Cond.* | Sal.† | Cond. | Sal. | Cond. | Sal. | Cond. | Sal. | Cond. | Sal. | Cond. | Sal. |
| Ship Creek swamp | 7.3 | 37 | 4.9 | 25 | 5.0 | 25 | 6.2 | 31 | 7.0 | 35 | 6.8 | 35 |
| Ship Creek | 2.5 | 13 | 5.6 | 30 | 20.0 | 105 | 23.0 | 120 | 7.2 | 37 | 85.0 | 470 |
| Waita River | 2.6 | 13 | 3.0 | 15 | 4.7 | 24 | 3.0 | 15 | 4.4 | 22 | 4.8 | 24 |
| Haast River | 3.5 | 18 | 6.1 | 31 | 7.5 | 38 | 2.7 | 13 | 6.6 | 33 | 6.1 | 30 |
| Okuru River | 1.9 | 10 | 3.5 | 18 | 4.2 | 21 | 3.2 | 16 | 3.8 | 19 | 3.7 | 18 |
| Turnbull River | 1.5 | 7 | - | - | 3.4 | 17 | 1.9 | 10 | 2.9 | 15 | 2.8 | 14 |
| Content Creek | 1.6 | 8 | 2.0 | 11 | 3.0 | 15 | 2.4 | 13 | 2.8 | 14 | 2.6 | 13 |
| Waiatoto River | 3.8 | 19 | 5.0 | 25 | 6.8 | 34 | 4.2 | 20 | 8.2 | 42 | 5.4 | 27 |
| Arawata River | 2.9 | 15 | - | - | 6.7 | 34 | 2.7 | 14 | 6.1 | 31 | 5.4 | 27 |
| Jackson Bay Stream | 5.9 | 29 | 4.5 | 22 | - | - | 7.0 | 35 | 9.4 | 48 | 9.6 | 49 |
| **Recording period** | **Rainfall (cm)** | | | | | | | | | | | |
| 1‡ | 8.96 | | 4.78 | | 0.36 | | 3.68 | | 0 | | 0.28 | |
| 2 | 3.68 | | 1.55 | | 0 | | 1.78 | | 0 | | 0 | |

The Wellington City mains supply on 9 Jan 1970 gave a conductivity reading of 11.0 millisiemens/$m^3$, which represents 56 g/$m^3$ of NaCl equivalents.

*Conductivity (Cond.): millisiemens/$m^3$.

†Salinity (Sal.): g/$m^3$ as NaCl equivalents.

‡Rainfall recorded at Haast.
1: Rainfall for the day of salinity recordings and for the day before.
2: Rainfall for 2 days before salinity recordings.

TABLE 47: Water analyses of samples taken from the Waiatoto River and its tributaries in 1971 and 1972 (in parts per million)

| Compounds measured | | Waiatoto River | Content Creek | Hindley Creek | Dawn Rivulet* | Nolans Creek | Nisson Creek | Hubbub Torrent | Brewer Water | Gliding Rivulet |
|---|---|---|---|---|---|---|---|---|---|---|
| Nitrate N | (1)† | 0.04 | 0.04 | 0.05 | 0.10 | 0.04 | 0.03 | 0.03 | 0.06 | 0.03 |
| | (2) | -‡ | - | - | - | - | - | - | - | - |
| Nitrite N | (1) | <0.001 in all analyses | | | | | | | | |
| | (2) | - | - | - | - | - | - | - | - | - |
| Ammoniacal N | (1) | <0.005 in all analyses unless otherwise listed | | | | | 0.006 | | | |
| | (2) | - | - | - | - | - | - | - | - | - |
| Albuminoid N | (1) | <0.005 | <0.005 | <0.005 | 0.019 | <0.005 | <0.005 | <0.005 | <0.006 | <0.005 |
| | (2) | - | - | - | - | - | - | - | - | - |
| Total organic N | (1) | 0.20 | 0.06 | 0.08 | 0.35 | 0.22 | 0.32 | 0.16 | 0.04 | 0.04 |
| | (2) | 0.15 | 0.08 | 0.08 | 0.20 | 0.17 | 0.20 | 0.16 | 0.13 | 0.10 |
| Oxygen absorbed, 4 h at 27° C | (1) | 0.65 | 5.10 | 1.90 | 5.10 | 6.10 | 2.80 | 1.70 | 1.50 | 1.80 |
| | (2) | 0.25 | 6.00 | 1.15 | 4.50 | 4.50 | 0.45 | 1.20 | 0.85 | 0.35 |
| Alkalinity (total) | (1) | 19 | 2 | 8 | 11 | 1 | 4 | 3 | 6 | 4 |
| | (2) | 21 | 3 | 10 | 14 | 1 | 5 | 3 | 7 | 4 |
| Hardness (total, EDTA) | (1) | 22 | 5 | 10 | 15 | 5 | 6 | 4 | 9 | 5 |
| | (2) | 24 | 6 | 12 | 19 | 6 | 7 | 4 | 9 | 5 |
| Chloride | (1) | 1 | 3 | 3 | 8 | 5 | 2 | 2 | 2 | 2 |
| | (2) | 3 | 5 | 3 | 9 | 10 | 4 | 3 | 3 | 4 |
| Total solids | (1) | 55 | 30 | 35 | 65 | 45 | 40 | 30 | 40 | 35 |
| | (2) | 45 | 30 | 35 | 55 | 45 | 35 | 20 | 45 | 30 |
| Iron as Fe | (1) | 0.02 | 0.24 | 0.06 | 1.40 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| | (2) | <0.02 | 0.04 | 0.20 | 0.50 | 0.08 | 0.14 | <0.02 | <0.02 | <0.02 |

*Series 2, 3/10/72.

†(1): 27/9/71.
(2): 31/10/71.

‡-: No analysis.

TABLE 48: Water analyses of samples taken from Haast area rivers in 1969
(in parts per million)

| Compounds measured | | Ship Creek swamp | Ship Creek trib. | Ship Creek | Waita River | Haast River | Okuru River | Turn-bull River | Waia-toto River | Arawata River | Jackson Bay Stream |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nitrate N | (1)* | 0.20 | 0.15 | 0.05 | 0.20 | 0.05 | 0.10 | 0.05 | - | 0.05 | 0.15 |
| | (2) | -† | - | - | - | - | - | - | - | - | - |
| Nitrite N | (1) | <0.01 in all analyses | | | | | | | | | |
| | (2) | - | - | - | - | - | - | - | - | - | - |
| Total organic N | (1) | 0.13 | 0.20 | 0.08 | 0.11 | 0.02 | 0.05 | 0.05 | - | <0.02 | 0.15 |
| | (2) | - | - | - | - | - | - | - | - | - | - |
| Oxygen absorbed, 4 h at 27° C | (1) | 20.50 | 13.60 | 2.60 | 1.85 | 0.70 | 1.45 | 0.65 | - | 0.20 | 6.80 |
| | (2) | 25.30 | 24.90 | 2.75 | 1.65 | 0.35 | 0.05 | 0.40 | 0.10 | 0.10 | 2.00 |
| Alkalinity (total) | (1) | <1 | 3 | 17 | 11 | 24 | 11 | 10 | - | 21 | 11 |
| | (2) | - | - | 18 | 12 | 25 | 12 | 10 | 18 | 18 | 14 |
| Hardness (total, EDTA) | (1) | 14 | 11 | 20 | 12 | 26 | 16 | 12 | - | 26 | 19 |
| | (2) | 7 | 15 | 20 | 12 | 25 | 20 | 11 | 23 | 22 | 19 |
| Chloride | (1) | 31 | 22 | 7 | 4 | 1 | 20 | 10 | - | 3 | 15 |
| | (2) | 17 | 8 | 7 | 2 | <1 | 18 | 1 | <1 | 1 | 15 |
| Total solids | (1) | 115 | 60 | 45 | 40 | 40 | 65 | 45 | - | 40 | 60 |
| | (2) | - | - | - | - | - | - | - | - | - | - |
| Iron as Fe | (1) | 0.28 | 0.24 | 0.24 | 0.24 | <0.02 | <0.02 | <0.02 | - | <0.02 | <0.02 |
| | (2) | 0.16 | 0.12 | 0.40 | 0.24 | 0.26 | 0.08 | 0.06 | 1.00 | 0.28 | 0.60 |

*(1): 3/10/72.
(2): 12/11/72.
†-: No analysis.

TABLE 49: Relationship between fishermen's diaries and buyers' records of whitebait catch

| Year | Fishermen's diaries kg | Fishermen's diaries days | Buyers' records kg | Buyers' records days | % sold kg | % sold days |
|---|---|---|---|---|---|---|
| 1969 | 120 | 29 | 118 | 30 | 98.3 | 103.4 |
| | 347 | 40 | 288 | 36 | 83.0 | 90.0 |
| | 241 | 64 | 200 | 51 | 83.0 | 79.7 |
| | 808 | 61 | 534 | 37 | 66.1 | 60.7 |
| | 195 | 28 | 126 | 12 | 64.6 | 42.9 |
| | 93 | 43 | 52 | 14 | 55.9 | 32.6 |
| | 66 | 21 | 31 | 10 | 47.0 | 47.6 |
| | 155 | 28 | 38 | 11 | 24.5 | 39.3 |
| | 143 | 41 | 34 | 5 | 23.8 | 12.2 |
| | 101 | 46 | 14 | 2 | 13.9 | 4.3 |
| | 105 | 49 | 0 | 0 | 0 | 0 |
| 1970 | 598 | 59 | 582 | 51 | 97.3 | 86.4 |
| | 311 | 42 | 296 | 35 | 99.2 | 83.3 |
| | 89 | 12 | 83 | 13 | 93.3 | 108.3 |
| | 136 | 39 | 121 | 31 | 89.0 | 79.5 |
| | 530 | 57 | 465 | 46 | 87.7 | 80.7 |
| | 511 | 40 | 444 | 31 | 86.9 | 77.5 |
| | 264 | 44 | 224 | 30 | 84.9 | 68.2 |
| | 769 | 64 | 538 | 47 | 69.9 | 73.4 |
| | 142 | 40 | 98 | 24 | 69.0 | 60.0 |
| | 180 | 75 | 122 | 37 | 67.8 | 49.3 |
| | 145 | 25 | 83 | 17 | 57.2 | 68.0 |
| | 567 | 59 | 321 | 38 | 56.6 | 64.4 |
| | 696 | 51 | 265 | 23 | 38.1 | 45.1 |
| | 308 | 32 | 114 | 19 | 37.0 | 59.4 |
| | 501 | 53 | 61 | 10 | 12.2 | 18.9 |
| 1971 | 337 | 28 | 338 | 28 | 100.3 | 100.0 |
| | 151 | 21 | 147 | 21 | 97.4 | 100.0 |
| | 104 | 42 | 100 | 31 | 96.2 | 73.8 |
| | 83 | 23 | 79 | 17 | 95.2 | 73.9 |
| | 289 | 55 | 269 | 31 | 93.1 | 56.4 |
| | 76 | 37 | 67 | 31 | 88.2 | 83.8 |
| | 110 | 28 | 80 | 17 | 72.7 | 60.7 |
| | 106 | 15 | 73 | 10 | 68.9 | 66.7 |
| | 368 | 23 | 246 | 17 | 66.9 | 73.9 |
| | 310 | 43 | 194 | 28 | 62.6 | 65.1 |
| | 335 | 25 | 153 | 17 | 45.7 | 68.0 |
| | 101 | 56 | 41 | 13 | 40.6 | 23.2 |
| | 28 | 28 | 10 | 11 | 35.7 | 39.3 |
| Total | 10 519 | 1 566 | 7 049 | 932 | 67.08 | 59.49 |
| Weighted percentages | | | | | 65.69 | 62.06 |

TABLE 50: Proportional measurements of the five species of whitebait in the catch

| Species | Adult Min. | Adult Mean | Adult Max. | Adult S.D. | Adult No. of fish measured | Juvenile Min. | Juvenile Mean | Juvenile Max. | Juvenile S.D. | Juvenile No. of fish measured |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **Body depth at vent/standard length (%)** | | | | | |
| *G. brevipinnis* | 12.1 | 13.6 | 15.4 | 0.70 | 49 | 9.3 | 10.2 | 11.3 | 0.52 | 30 |
| *G. postvectis* | 16.4 | 19.6 | 22.4 | 1.81 | 25 | - | - | - | - | - |
| *G. argenteus* | 18.7 | 21.0 | 23.4 | 1.22 | 36 | 10.2 | 11.3 | 12.2 | 0.57 | 25 |
| *G. fasciatus* | 17.7 | 19.2 | 21.4 | 0.80 | 30 | 9.3 | 10.6 | 12.7 | 0.66 | 30 |
| *G. maculatus* | 10.3 | 11.6 | 12.9 | 0.67 | 40 | 9.5 | 10.4 | 11.3 | 0.52 | 30 |
| | | | | | **Head length/standard length (%)** | | | | | |
| *G. brevipinnis* | 20.7 | 22.3 | 24.8 | 0.86 | 50 | 15.6 | 17.3 | 18.6 | 0.71 | 30 |
| *G. postvectis* | 21.2 | 23.0 | 25.0 | 1.03 | 25 | - | - | - | - | - |
| *G. argenteus* | 27.0 | 29.1 | 30.5 | 0.81 | 36 | 17.6 | 18.8 | 20.4 | 0.71 | 25 |
| *G. fasciatus* | 24.5 | 25.9 | 28.6 | 0.96 | 60 | 16.0 | 17.3 | 18.3 | 0.70 | 30 |
| *G. maculatus* | 18.5 | 20.0 | 21.6 | 0.74 | 40 | 15.1 | 15.9 | 16.9 | 0.50 | 30 |
| | | | | | **Diameter of eye/head length (%)** | | | | | |
| *G. brevipinnis* | 13.5 | 16.0 | 18.9 | 1.38 | 50 | 15.6 | 21.2 | 25.8 | 2.79 | 30 |
| *G. postvectis* | 17.8 | 19.9 | 23.5 | 1.57 | 25 | - | - | - | - | - |
| *G. argenteus* | 14.8 | 18.0 | 22.2 | 1.74 | 36 | 18.2 | 21.6 | 29.0 | 2.29 | 25 |
| *G. fasciatus* | 17.8 | 20.2 | 24.5 | 1.70 | 30 | 18.5 | 22.7 | 28.0 | 2.62 | 30 |
| *G. maculatus* | 19.5 | 21.8 | 23.7 | 1.03 | 40 | 21.4 | 23.4 | 26.7 | 1.37 | 30 |
| | | | | | **Length of lower jaw/head length (%)** | | | | | |
| *G. brevipinnis* | 34.1 | 38.4 | 43.9 | 2.12 | 49 | 25.0 | 28.5 | 35.5 | 2.49 | 30 |
| *G. postvectis* | 27.5 | 33.0 | 35.7 | 1.88 | 25 | - | - | - | - | - |
| *G. argenteus* | 37.7 | 41.3 | 43.9 | 1.33 | 36 | 32.4 | 35.2 | 37.5 | 1.47 | 25 |
| *G. fasciatus* | 43.9 | 46.5 | 50.0 | 1.70 | 30 | 25.9 | 29.8 | 34.6 | 2.45 | 30 |
| *G. maculatus* | 25.6 | 28.6 | 32.5 | 1.92 | 40 | 22.6 | 26.0 | 28.6 | 1.63 | 30 |
| | | | | | **Snout length/head length (%)** | | | | | |
| *G. brevipinnis* | 29.4 | 32.1 | 34.8 | 1.53 | 50 | 27.3 | 31.5 | 34.3 | 2.31 | 30 |
| *G. postvectis* | 31.3 | 33.6 | 37.2 | 1.39 | 25 | - | - | - | - | - |
| *G. argenteus* | 26.6 | 29.6 | 32.4 | 1.43 | 36 | 26.7 | 31.4 | 37.5 | 2.68 | 25 |
| *G. fasciatus* | 30.4 | 32.5 | 35.0 | 1.11 | 30 | 28.0 | 31.2 | 37.5 | 2.18 | 30 |
| *G. maculatus* | 26.5 | 28.5 | 33.3 | 1.50 | 40 | 26.7 | 30.2 | 33.3 | 1.92 | 30 |
| | | | | | **Snout length/length of lower jaw (%)** | | | | | |
| *G. brevipinnis* | 72.4 | 84.4 | 100.0 | 6.32 | 50 | 90.0 | 111.2 | 133.3 | 11.49 | 30 |
| *G. postvectis* | 92.3 | 101.0 | 116.1 | 5.60 | 25 | - | - | - | - | - |
| *G. argenteus* | 65.4 | 72.3 | 80.0 | 3.22 | 36 | 75.0 | 89.2 | 109.1 | 8.72 | 25 |
| *G. fasciatus* | 65.6 | 70.2 | 77.5 | 3.04 | 30 | 87.5 | 105.5 | 128.6 | 10.25 | 30 |
| *G. maculatus* | 90.5 | 103.3 | 118.1 | 7.19 | 39 | 70.0 | 87.0 | 100.0 | 8.20 | 30 |

TABLE 51: Seasonal length-frequency distribution of whitebait

| | *G. maculatus* | | | | | | | | | | | *G. brevipinnis* | | | | | | | *G. fasciatus* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Length (mm) | Waita River | Haast River | Okuru River | Waia-toto River | Arawata River | Waia-toto River | Nisson Creek | Waia-toto River | Nisson Creek | Waia-toto River | Buller River | Haast River | Waia-toto River | Arawata River | Waia-toto River | Waia-toto River | Waia-toto River | Buller River | Waia-toto River | Waia-toto River | Buller River |
| | 1969 | | | | | 1970 | | 1971 | | 1972 | | 1969 | | | 1970 | 1971 | 1972 | | 1971 | 1972 | |
| 38 | | | | | | | | | | | | | | | | | | | 1 | | |
| 39 | | | | | | | | | | | | | | | | | | | 166 | 5 | |
| 40 | | | | | | | | | | | | | | | | | | | 475 | 41 | |
| 41 | | | | | | | | | | | | | | | | | | | 516 | 181 | 5 |
| 42 | | | | | | | | | | | | | | | | | | | 539 | 269 | 14 |
| 43 | | | | | | | | | | | | | | | | | | | 315 | 197 | 49 |
| 44 | | | | | | | | 1 | 1 | 2 | | | | | | | | | 140 | 114 | 56 |
| 45 | | | | 1 | | | | 6 | 6 | 1 | | | | | 6 | 1 | 2 | | 42 | 64 | 75 |
| 46 | | | | 2 | | 1 | | 20 | 15 | 6 | | 1 | | | 4 | 0 | 19 | | 12 | 15 | 59 |
| 47 | | 2 | 1 | 5 | | 2 | | 33 | 35 | 40 | | 5 | 4 | 7 | 15 | 5 | 42 | | | 2 | 22 |
| 48 | | 14 | 4 | 33 | 6 | 9 | 10 | 58 | 62 | 81 | | 15 | 21 | 17 | 59 | 71 | 118 | | | | 1 |
| 49 | 5 | 37 | 17 | 91 | 25 | 18 | 17 | 147 | 106 | 148 | 3 | 43 | 53 | 63 | 136 | 148 | 146 | 2 | | | |
| 50 | 34 | 122 | 61 | 152 | 51 | 66 | 33 | 256 | 159 | 250 | 21 | 153 | 133 | 150 | 311 | 377 | 356 | 5 | | | |
| 51 | 67 | 236 | 118 | 254 | 122 | 147 | 53 | 310 | 162 | 403 | 51 | 275 | 221 | 275 | 266 | 237 | 441 | 27 | | | |
| 52 | 39 | 320 | 169 | 319 | 200 | 264 | 100 | 309 | 164 | 527 | 126 | 299 | 315 | 306 | 268 | 176 | 501 | 60 | | | |
| 53 | 234 | 354 | 207 | 390 | 219 | 323 | 98 | 242 | 104 | 501 | 222 | 238 | 256 | 251 | 156 | 51 | 373 | 157 | | | |
| 54 | 305 | 281 | 205 | 345 | 250 | 347 | 95 | 146 | 49 | 344 | 236 | 118 | 102 | 131 | 55 | 20 | 219 | 202 | | | |
| 55 | 291 | 170 | 158 | 283 | 192 | 262 | 72 | 76 | 24 | 213 | 207 | 36 | 29 | 36 | 17 | | 89 | 200 | | | |
| 56 | 255 | 107 | 93 | 206 | 125 | 154 | 37 | 31 | 3 | 83 | 122 | 12 | 3 | 9 | 2 | | 38 | 130 | | | |
| 57 | 159 | 34 | 42 | 96 | 57 | 55 | 12 | 10 | 1 | 25 | 46 | 2 | 1 | 3 | | | 2 | 52 | | | |
| 58 | 72 | 13 | 22 | 52 | 27 | 12 | 1 | 1 | | 2 | 10 | | 1 | | | | | 11 | | | |
| 59 | 35 | 1 | 2 | 22 | 6 | 2 | 1 | | | | 1 | | | | | | | 2 | | | |
| 60 | 7 | 1 | 1 | 4 | 2 | | 1 | | | | | | | | | | | | | | |
| 61 | 1 | | | | 1 | | | | | | | | | | | | | | | | |
| n | 1 504 | 1 692 | 1 100 | 2 255 | 1 283 | 1 662 | 530 | 1 646 | 891 | 2 626 | 1 045 | 1 197 | 1 139 | 1 248 | 1 295 | 1 086 | 2 346 | 848 | 2 206 | 888 | 281 |
| Mean | 54.74 | 52.86 | 53.38 | 53.21 | 53.55 | 53.44 | 52.99 | 51.46 | 50.80 | 52.14 | 53.91 | 51.87 | 51.84 | 51.84 | 50.96 | 50.47 | 51.51 | 54.33 | 41.46 | 42.46 | 44.61 |
| S.D. | 1.98 | 1.92 | 2.01 | 2.34 | 2.06 | 1.87 | 2.01 | 2.11 | 2.07 | 2.06 | 1.66 | 1.56 | 1.53 | 1.60 | 1.68 | 1.35 | 1.96 | 1.57 | 1.46 | 1.39 | 1.42 |

TABLE 52: Length-weight relationship in *Galaxias maculatus*

| | Waiatoto River 1969 | | Waiatoto River 1970 | | Waiatoto River 1971 | | Waiatoto River 1972 | | Waiatoto River 1973 | | Buller River 1972 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Length (mm) | No. measured | Mean weight (g) | No. measured | Mean weight (g) | No. measured | Mean weight (g) | No. measured | Mean weight (g) | No. measured | Mean weight (g) | No. measured | Mean weight (g) |
| 45 | 3 | 0.267 | | | | | | | | | | |
| 46 | 7 | 0.343 | | | | | 14 | 0.314 | | | | |
| 47 | 11 | 0.364 | | | | | 50 | 0.348 | 26 | 0.346 | | |
| 48 | 54 | 0.363 | | | 124 | 0.363 | 97 | 0.379 | 58 | 0.390 | | |
| 49 | 104 | 0.383 | 24 | 0.500 | 113 | 0.389 | 143 | 0.403 | 100 | 0.408 | | |
| 50 | 143 | 0.409 | 92 | 0.504 | 98 | 0.418 | 164 | 0.429 | 139 | 0.453 | 20 | 0.455 |
| 51 | 156 | 0.452 | 99 | 0.530 | 92 | 0.435 | 127 | 0.445 | 130 | 0.465 | 47 | 0.479 |
| 52 | 134 | 0.493 | 184 | 0.544 | 150 | 0.447 | 130 | 0.483 | 122 | 0.490 | 105 | 0.543 |
| 53 | 163 | 0.560 | 170 | 0.569 | 116 | 0.460 | 143 | 0.513 | 125 | 0.504 | 117 | 0.586 |
| 54 | 180 | 0.587 | 178 | 0.598 | 113 | 0.467 | 127 | 0.546 | 102 | 0.569 | 113 | 0.619 |
| 55 | 148 | 0.631 | 108 | 0.611 | 80 | 0.491 | 134 | 0.572 | 109 | 0.605 | 112 | 0.639 |
| 56 | 100 | 0.671 | 68 | 0.654 | 29 | 0.545 | 123 | 0.632 | 99 | 0.660 | 108 | 0.686 |
| 57 | 38 | 0.668 | | | | | 81 | 0.667 | 45 | 0.676 | 54 | 0.732 |
| 58 | 13 | 0.777 | | | | | 26 | 0.712 | 16 | 0.688 | 12 | 0.808 |
| 59 | 4 | 0.813 | | | | | | | | | | |

TABLE 53: Length-weight relationship in *Galaxias brevipinnis*

| | Waiatoto River | | | | | | | | | | Buller River | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1969 | | 1970 | | 1971 | | 1972 | | 1973 | | 1972 | |
| Length (mm) | No. measured | Mean weight (g) | No. measured | Mean weight (g) | No. measured | Mean weight (g) | No. measured | Mean weight (g) | No. measured | Mean weight (g) | No. measured | Mean weight (g) |
| 46 | | | 9 | 0.339 | 5 | 0.360 | 31 | 0.381 | 8 | 0.350 | | |
| 47 | 9 | 0.411 | 16 | 0.394 | 5 | 0.400 | 46 | 0.430 | 22 | 0.400 | | |
| 48 | 28 | 0.493 | 47 | 0.406 | 44 | 0.461 | 111 | 0.454 | 83 | 0.461 | | |
| 49 | 49 | 0.531 | 98 | 0.498 | 100 | 0.488 | 122 | 0.492 | 113 | 0.501 | | |
| 50 | 105 | 0.587 | 158 | 0.549 | 177 | 0.536 | 111 | 0.542 | 109 | 0.530 | 6 | 0.567 |
| 51 | 175 | 0.634 | 202 | 0.595 | 171 | 0.570 | 124 | 0.604 | 108 | 0.584 | 25 | 0.632 |
| 52 | 163 | 0.680 | 200 | 0.654 | 92 | 0.599 | 141 | 0.662 | 125 | 0.620 | 54 | 0.694 |
| 53 | 142 | 0.754 | 130 | 0.697 | 22 | 0.646 | 142 | 0.713 | 114 | 0.680 | 99 | 0.783 |
| 54 | 61 | 0.800 | 50 | 0.758 | 5 | 0.660 | 130 | 0.768 | 50 | 0.716 | 104 | 0.831 |
| 55 | 8 | 0.850 | 10 | 0.800 | | | 103 | 0.816 | 7 | 0.672 | 104 | 0.884 |
| 56 | | | | | | | 44 | 0.845 | 3 | 0.733 | 103 | 0.920 |
| 57 | | | | | | | | | | | 60 | 0.938 |
| 58 | | | | | | | | | | | 16 | 0.950 |

TABLE 54: Length-weight relationship in *Galaxias fasciatus*

| | Waiatoto River | | | | | | | | | | Buller River | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1969 | | 1970 | | 1971 | | 1972 | | 1973 | | 1972 | |
| Length (mm) | No. measured | Mean weight (g) | No. measured | Mean weight (g) | No. measured | Mean weight (g) | No. measured | Mean weight (g) | No. measured | Mean weight (g) | No. measured | Mean weight (g) |
| 38 | 8 | 0.213 | | | | | | | | | | |
| 39 | 31 | 0.252 | | | 177 | 0.267 | | | 3 | 0.233 | | |
| 40 | 98 | 0.282 | 21 | 0.233 | 377 | 0.289 | 29 | 0.272 | 8 | 0.275 | | |
| 41 | 94 | 0.304 | 64 | 0.281 | 312 | 0.304 | 77 | 0.296 | 48 | 0.300 | 4 | 0.300 |
| 42 | 63 | 0.352 | 188 | 0.317 | 213 | 0.327 | 129 | 0.331 | 145 | 0.328 | 15 | 0.327 |
| 43 | 59 | 0.352 | 230 | 0.357 | 134 | 0.343 | 112 | 0.353 | 153 | 0.368 | 46 | 0.359 |
| 44 | 23 | 0.404 | 170 | 0.372 | 107 | 0.383 | 70 | 0.367 | 118 | 0.393 | 55 | 0.375 |
| 45 | 8 | 0.450 | 70 | 0.391 | | | 62 | 0.398 | 84 | 0.412 | 71 | 0.411 |
| 46 | | | | | | | 17 | 0.429 | 13 | 0.415 | 57 | 0.451 |
| 47 | | | | | | | 5 | 0.440 | 4 | 0.425 | 20 | 0.440 |

TABLE 55: Length-frequency distribution of *Galaxias maculatus* in live box

| Length (mm) | 28 Sep | 1 Oct | 9 Oct | 13 Oct | 20 Oct |
|---|---|---|---|---|---|
| 46 | | | | | 1 |
| 47 | | 1 | 2 | | 5 |
| 48 | | | 1 | 5 | 3 |
| 49 | | | 6 | 10 | 9 |
| 50 | 3 | 5 | 11 | 8 | 13 |
| 51 | 5 | 5 | 12 | 17 | 9 |
| 52 | 7 | 13 | 13 | 7 | 6 |
| 53 | 17 | 11 | 3 | 1 | 1 |
| 54 | 9 | 8 | 2 | 1 | 1 |
| 55 | 6 | 5 | | | 1 |
| 56 | 3 | 2 | | 1 | |
| Mean | 53.08 | 52.60 | 50.82 | 50.48 | 49.97 |

TABLE 56: Length of *G. maculatus* in the Waiatoto River estuary and Nisson Creek in 1970

| | Waiatoto River estuary Length (mm) | | | | | Nisson Creek Length (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Date | Min. | Mean | Max. | S.D. | S.E. | Min. | Mean | Max. | S.D. | S.E. |
| Sep 3 | 48 | 52.89 | 56 | 1.604 | 0.227 | | | | | |
| 5 | 50 | 53.22 | 58 | 1.912 | 0.270 | | | | | |
| 9 | 50 | 53.48 | 59 | 2.025 | 0.286 | | | | | |
| 10 | - | - | - | - | - | 48 | 52.43 | 56 | 2.145 | 0.303 |
| 12 | 48 | 52.65 | 58 | 1.890 | 0.267 | - | - | - | - | - |
| 13 | 49 | 53.22 | 57 | 1.509 | 0.213 | - | - | - | - | - |
| 16 | 51 | 54.12 | 57 | 1.692 | 0.239 | - | - | - | - | - |
| 19 | 50 | 53.13 | 56 | 1.474 | 0.208 | - | - | - | - | - |
| 22 | - | - | - | - | - | 49 | 52.53 | 57 | 1.825 | 0.258 |
| 23 | 50 | 54.55 | 58 | 1.858 | 0.263 | - | - | - | - | - |
| 26 | 48 | 54.13 | 57 | 1.625 | 0.230 | - | - | - | - | - |
| 27 | - | - | - | - | - | 48 | 52.47 | 55 | 2.255 | 0.319 |
| 28 | 50 | 53.99 | 58 | 1.586 | 0.224 | - | - | - | - | - |
| 30 | 50 | 54.35 | 59 | 1.575 | 0.223 | - | - | - | - | - |
| Oct 3 | 50 | 53.93 | 58 | 1.462 | 0.207 | - | - | - | - | - |
| 4 | - | - | - | - | - | 51 | 54.13 | 57 | 1.504 | 0.213 |
| 6 | 51 | 54.00 | 57 | 2.050 | 0.290 | - | - | - | - | - |
| 7 | - | - | - | - | - | 49 | 53.58 | 57 | 1.664 | 0.235 |
| 9 | 51 | 54.46 | 59 | 1.759 | 0.249 | - | - | - | - | - |
| 10 | - | - | - | - | - | 50 | 53.53 | 57 | 1.489 | 0.211 |
| 12 | 50 | 53.66 | 56 | 1.550 | 0.219 | - | - | - | - | - |
| 14 | 51 | 53.55 | 57 | 1.461 | 0.207 | 48 | 53.20 | 57 | 1.815 | 0.257 |
| 18 | 51 | 53.49 | 56 | 1.433 | 0.203 | - | - | - | - | - |
| 19 | - | - | - | - | - | 52 | 53.78 | 60 | 1.555 | 0.220 |
| 20 | 51 | 54.25 | 58 | 1.492 | 0.211 | - | - | - | - | - |
| 21 | 51 | 53.12 | 57 | 1.699 | 0.240 | - | - | - | - | - |
| 25 | 48 | 52.95 | 57 | 2.279 | 0.322 | - | - | - | - | - |
| 26 | 50 | 53.94 | 58 | 1.634 | 0.231 | - | - | - | - | - |
| 27 | - | - | - | - | - | 49 | 52.35 | 56 | 1.598 | 0.226 |
| 28 | 50 | 53.93 | 57 | 1.512 | 0.214 | - | - | - | - | - |
| 31 | 52 | 54.40 | 57 | 1.421 | 0.201 | - | - | - | - | - |
| Nov 2 | 51 | 53.33 | 57 | 1.842 | 0.260 | 48 | 51.10 | 55 | 1.747 | 0.247 |
| 3 | 52 | 54.66 | 57 | 1.401 | 0.198 | - | - | - | - | - |
| 5 | 52 | 54.54 | 57 | 1.195 | 0.169 | - | - | - | - | - |
| 6 | 50 | 53.61 | 58 | 1.699 | 0.240 | - | - | - | - | - |
| 8 | 51 | 52.30 | 56 | 1.667 | 0.236 | - | - | - | - | - |
| 9 | 49 | 52.33 | 56 | 2.462 | 0.348 | 49 | 52.35 | 57 | 1.757 | 0.248 |
| 11 | 50 | 51.42 | 57 | 1.525 | 0.216 | | | | | |
| 13 | 48 | 51.82 | 57 | 1.752 | 0.248 | | | | | |
| 14 | 48 | 51.77 | 56 | 1.686 | 0.238 | | | | | |
| 16 | 47 | 51.11 | 55 | 1.518 | 0.215 | | | | | |
| 20 | 47 | 50.78 | 54 | 1.777 | 0.251 | | | | | |
| Overall mean | | 53.33 | | | | | 52.86 | | | |

TABLE 57: Length of *G. maculatus* in the Waiatoto River estuary and Nisson Creek in 1971

| Date | Waiatoto River estuary Length (mm) Min. | Mean | Max. | S.D. | S.E. | Nisson Creek Length (mm) Min. | Mean | Max. | S.D. | S.E. |
|---|---|---|---|---|---|---|---|---|---|---|
| Sep 2 | 47 | 50.65 | 55 | 1.641 | 0.232 | | | | | |
| 4 | 45 | 51.30 | 55 | 2.040 | 0.288 | | | | | |
| 6 | 48 | 51.58 | 55 | 1.573 | 0.222 | 46 | 50.49 | 55 | 1.834 | 0.259 |
| 8 | 47 | 51.22 | 55 | 2.193 | 0.310 | 47 | 51.28 | 56 | 1.941 | 0.274 |
| 9 | 47 | 52.32 | 58 | 2.109 | 0.298 | - | - | - | - | - |
| 10 | 48 | 52.13 | 57 | 2.043 | 0.289 | 46 | 50.87 | 55 | 1.919 | 0.271 |
| 12 | - | - | - | - | - | 47 | 51.59 | 55 | 1.976 | 0.279 |
| 13 | 47 | 51.70 | 57 | 1.948 | 0.275 | - | - | - | - | - |
| 14 | 49 | 52.16 | 57 | 2.054 | 0.290 | - | - | - | - | - |
| 15 | 49 | 52.31 | 56 | 1.820 | 0.257 | 47 | 50.09 | 57 | 2.403 | 0.340 |
| 17 | 50 | 52.85 | 56 | 1.600 | 0.226 | - | - | - | - | - |
| 21 | 49 | 52.86 | 56 | 1.852 | 0.262 | - | - | - | - | - |
| 23 | 49 | 52.67 | 56 | 1.479 | 0.209 | - | - | - | - | - |
| 25 | 47 | 52.22 | 56 | 1.985 | 0.281 | - | - | - | - | - |
| 26 | - | - | - | - | - | 44 | 49.97 | 54 | 2.479 | 0.351 |
| 30 | 49 | 53.11 | 57 | 1.969 | 0.278 | - | - | - | - | - |
| Oct 1 | - | - | - | - | - | 46 | 51.28 | 56 | 1.933 | 0.273 |
| 6 | 48 | 51.93 | 55 | 1.348 | 0.191 | 45 | 50.63 | 55 | 2.217 | 0.314 |
| 8 | 48 | 51.49 | 56 | 1.621 | 0.229 | - | - | - | - | - |
| 9 | - | - | - | - | - | 46 | 50.57 | 55 | 1.190 | 0.270 |
| 10 | 50 | 51.80 | 55 | 1.366 | 0.193 | - | - | - | - | - |
| 11 | - | - | - | - | - | 45 | 51.22 | 55 | 2.043 | 0.288 |
| 16 | 48 | 51.29 | 55 | 1.694 | 0.240 | - | - | - | - | - |
| 19 | 47 | 50.81 | 56 | 1.744 | 0.247 | - | - | - | - | - |
| 21 | 49 | 52.87 | 57 | 1.809 | 0.256 | - | - | - | - | - |
| 23 | 49 | 52.63 | 57 | 1.889 | 0.267 | 48 | 50.07 | 54 | 1.446 | 0.204 |
| 26 | 49 | 51.91 | 56 | 1.829 | 0.259 | - | - | - | - | - |
| 27 | - | - | - | - | - | 47 | 51.36 | 56 | 1.747 | 0.247 |
| 29 | - | - | - | - | - | 48 | 52.09 | 57 | 1.873 | 0.265 |
| 31 | 50 | 52.41 | 56 | 1.402 | 0.198 | - | - | - | - | - |
| Nov 2 | 47 | 51.28 | 55 | 1.534 | 0.217 | - | - | - | - | - |
| 4 | 49 | 51.72 | 56 | 1.896 | 0.268 | - | - | - | - | - |
| 6 | 49 | 51.23 | 55 | 1.226 | 0.173 | 47 | 51.44 | 55 | 1.803 | 0.255 |
| 9 | 47 | 50.86 | 55 | 1.552 | 0.219 | 50 | 51.84 | 55 | 1.167 | 0.165 |
| 10 | 48 | 50.82 | 55 | 2.577 | 0.364 | 48 | 51.15 | 54 | 1.447 | 0.205 |
| 12 | 47 | 51.30 | 55 | 1.738 | 0.246 | 48 | 50.00 | 52 | 1.227 | 0.181 |
| 16 | 46 | 49.30 | 53 | 1.720 | 0.243 | - | - | - | - | - |
| 18 | 45 | 49.10 | 54 | 2.121 | 0.300 | - | - | - | - | - |
| 20 | 46 | 49.55 | 54 | 1.804 | 0.255 | - | - | - | - | - |
| 22 | 45 | 48.22 | 53 | 1.922 | 0.272 | 46 | 48.91 | 53 | 1.556 | 0.220 |
| Overall mean | | 51.50 | | | | | 50.83 | | | |

TABLE 58: Daily whitebait catch in the Waita, Haast, and Okuru Rivers from 1969 to 1973

| | | Catch (kg) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Waita River | | | | | Haast River | | | | | Okuru River | | | | |
| Date | | 1969 | 1970 | 1971 | 1972 | 1973 | 1969 | 1970 | 1971 | 1972 | 1973 | 1969 | 1970 | 1971 | 1972 | 1973 |
| Sep | 1 | 3.6 | 0 | 0 | 0.2 | 3.6 | 8.7 | 0 | 0 | 0.2 | 0 | 8.2 | 0.9 | 0.2 | 0.9 | 0 |
| | 2 | 4.8 | 2.5 | 0 | 0 | 5.4 | 2.8 | 0 | 0.2 | 2.3 | 0 | 6.4 | 1.4 | 0 | 2.3 | 0.2 |
| | 3 | 7.3 | 17.9 | 0 | 0.5 | 1.1 | 0 | 0 | 0.2 | 1.8 | 0 | 9.1 | 3.4 | 0.2 | 1.6 | 0 |
| | 4 | 0 | 11.6 | 0 | 2.0 | 0.2 | 0 | 0 | 0.2 | 0 | 0.9 | 2.5 | 30.2 | 0.5 | 2.9 | 0.9 |
| | 5 | 1.1 | 0.9 | 0 | 0 | 0 | 0 | 0.9 | 0.2 | 0 | 1.4 | 1.6 | 14.5 | 7.9 | 8.7 | 3.9 |
| | 6 | 0 | 0 | 0 | 0 | 0.5 | 0 | 0 | 0.2 | 8.4 | 2.3 | 0 | 0.9 | 1.1 | 6.6 | 0 |
| | 7 | 0 | 0 | 29.5 | 1.1 | 0 | 0 | 0 | 3.4 | 14.8 | 0 | 0 | 26.6 | 7.0 | 59.5 | 0 |
| | 8 | 0 | 0 | 107.6 | 5.0 | 0 | 0 | 0 | 4.8 | 4.8 | 0 | 0 | 7.7 | 3.0 | 0 | 1.4 |
| | 9 | 0 | 0.5 | 73.5 | 0 | 0 | 0 | 0 | 3.4 | 6.6 | 1.6 | 0 | 10.0 | 1.4 | 16.0 | 0.9 |
| | 10 | 0 | 1.4 | 27.5 | 0.5 | 0 | 0 | 0 | 2.7 | 0 | 1.6 | 1.6 | 19.1 | 2.3 | 41.3 | 1.6 |
| | 11 | 0 | 0 | 10.7 | 5.7 | 18.8 | 0 | 0.5 | 0 | 0.5 | 7.5 | 0 | 9.1 | 0 | 52.9 | 3.4 |
| | 12 | 0 | 13.4 | 4.5 | 2.3 | 28.1 | 0 | 0 | 0 | 8.9 | 27.9 | 9.1 | 26.8 | 0.5 | 22.9 | 5.2 |
| | 13 | 0 | 24.5 | 0 | 3.0 | 45.4 | 0 | 0 | 0 | 3.6 | 35.6 | 0 | 66.7 | 0.7 | 44.1 | 23.8 |
| | 14 | 15.2 | 75.4 | 0 | 0 | 4.3 | 21.4 | 0.9 | 0.7 | 0 | 2.3 | 36.1 | 38.4 | 2.3 | 0 | 4.8 |
| | 15 | 7.7 | 52.0 | 1.6 | 1.1 | 4.1 | 3.7 | 0.5 | 1.1 | 0 | 8.2 | 29.5 | 69.5 | 0.7 | 28.1 | 0.9 |
| | 16 | 10.2 | 25.7 | 1.6 | 0 | 0.9 | 5.3 | 0.9 | 2.7 | 0.2 | 1.1 | 19.1 | 14.3 | 1.8 | 13.2 | 4.1 |
| | 17 | 36.7 | 11.6 | 15.2 | 0 | 9.3 | 2.5 | 0 | 2.3 | 0.9 | 6.4 | 3.9 | 0 | 7.0 | 24.5 | 3.0 |
| | 18 | 13.2 | 4.3 | 4.1 | 1.1 | 12.0 | 5.0 | 0 | 0.9 | 12.3 | 5.4 | 345.9 | 9.1 | 1.6 | 27.2 | 7.0 |
| | 19 | 36.7 | 0 | 0.9 | 0.5 | 5.0 | 70.6 | 0 | 0 | 0 | 2.3 | 278.5 | 4.1 | 0 | 1.6 | 20.0 |
| | 20 | 4.3 | 12.0 | 28.8 | 0 | 4.1 | 4.8 | 0 | 2.3 | 1.8 | 1.1 | 239.3 | 44.9 | 0.9 | 50.2 | 1.1 |
| | 21 | 2.5 | 133.0 | 29.1 | 0 | 0 | 18.7 | 11.6 | 1.1 | 0 | 0.5 | 184.8 | 79.5 | 5.9 | 86.0 | 0 |
| | 22 | 27.4 | 119.9 | 9.5 | 4.1 | 0 | 23.9 | 9.3 | 0.9 | 7.3 | 1.6 | 160.0 | 200.0 | 3.4 | 52.4 | 0 |
| | 23 | 91.9 | 39.7 | 0 | 4.3 | 0 | 36.8 | 4.8 | 0 | 0 | 0.7 | 144.8 | 68.1 | 4.5 | 26.6 | 0 |
| | 24 | 214.8 | 0 | 29.3 | 22.9 | 4.3 | 40.9 | 0 | 0.7 | 18.6 | 2.5 | 74.5 | 0 | 8.6 | 49.9 | 5.0 |
| | 25 | 41.1 | 2.5 | 0.4 | 51.8 | 25.9 | 23.2 | 0 | 2.5 | 14.1 | 42.2 | 98.7 | 3.6 | 10.9 | 78.5 | 5.9 |
| | 26 | 37.9 | 3.4 | 0.9 | 34.5 | 13.8 | 92.4 | 0.5 | 1.8 | 5.9 | 62.8 | 66.1 | 3.2 | 7.0 | 66.5 | 16.3 |
| | 27 | 17.2 | 42.2 | 0 | 33.1 | 18.4 | 11.4 | 5.4 | 1.4 | 10.7 | 25.9 | 59.0 | 81.9 | 3.0 | 101.9 | 31.3 |
| | 28 | 15.2 | 19.7 | 9.5 | 37.7 | 0 | 15.5 | 13.4 | 2.3 | 18.2 | 20.9 | 32.5 | 42.4 | 1.8 | 53.1 | 14.1 |
| | 29 | 20.6 | 217.5 | 57.9 | 5.2 | 3.0 | 28.4 | 10.9 | 0.7 | 18.6 | 9.5 | 20.7 | 22.7 | 129.6 | 95.1 | 2.0 |
| | 30 | 0 | 563.9 | 109.6 | 5.9 | 0.9 | 10.9 | 22.0 | 3.2 | 24.7 | 0 | 61.5 | 95.6 | 107.6 | 131.4 | 3.0 |
| Oct | 1 | 10.9 | 111.9 | 72.4 | 28.4 | 1.6 | 4.1 | 56.1 | 5.0 | 102.8 | 14.5 | 11.4 | 86.0 | 41.5 | 78.5 | 4.5 |
| | 2 | 3.7 | 100.8 | 44.7 | 68.6 | 0 | 7.1 | 55.8 | 3.6 | 151.6 | 0 | 14.1 | 69.5 | 3.9 | 67.4 | 0 |
| | 3 | 8.7 | 37.5 | 2.7 | 27.2 | 0 | 5.9 | 42.0 | 0 | 233.1 | 2.0 | 12.9 | 14.1 | 7.5 | 128.5 | 0 |
| | 4 | 22.7 | 56.3 | 0 | 32.2 | 0 | 10.9 | 35.9 | 0 | 128.0 | 8.6 | 11.1 | 33.8 | 3.6 | 195.9 | 5.9 |
| | 5 | 19.3 | 19.5 | 57.0 | 26.1 | 0 | 11.4 | 22.5 | 0 | 57.7 | 2.0 | 5.9 | 24.5 | 0.8 | 62.7 | 1.1 |
| | 6 | 16.1 | 15.2 | 208.8 | 18.6 | 3.2 | 15.2 | 8.6 | 1.4 | 8.6 | 9.1 | 7.0 | 38.1 | 107.6 | 28.8 | 13.4 |
| | 7 | 0 | 15.7 | 173.2 | 11.8 | 0.9 | 7.8 | 5.2 | 21.8 | 0 | 11.8 | 15.9 | 33.1 | 140.1 | 30.9 | 2.3 |
| | 8 | 2.5 | 8.2 | 36.3 | 2.3 | 11.6 | 3.0 | 30.4 | 8.2 | 0 | 27.7 | 8.2 | 3.6 | 62.0 | 74.0 | 11.6 |
| | 9 | 3.9 | 7.5 | 14.8 | 141.0 | 16.1 | 1.4 | 16.1 | 2.3 | 20.0 | 45.8 | 13.8 | 35.2 | 5.4 | 74.7 | 3.9 |
| | 10 | 1.6 | 0 | 2.3 | 349.4 | 29.5 | 0.2 | 1.8 | 0 | 105.1 | 37.4 | 5.2 | 12.9 | 4.1 | 138.0 | 16.3 |
| | 11 | 42.7 | 10.2 | 16.1 | 225.2 | 20.0 | 0.2 | 0.7 | 0 | 418.4 | 52.6 | 9.8 | 14.3 | 1.4 | 429.9 | 21.3 |
| | 12 | 267.6 | 16.3 | 1.1 | 41.3 | 12.9 | 4.6 | 7.9 | 0 | 53.6 | 20.0 | 117.8 | 59.2 | 2.5 | 41.5 | 27.9 |
| | 13 | 111.6 | 323.7 | 3.2 | 3.9 | 0 | 108.1 | 79.5 | 0 | 25.9 | 0 | 102.8 | 49.3 | 2.0 | 47.2 | 0 |
| | 14 | 86.9 | 81.0 | 0 | 27.2 | 0.9 | 135.6 | 127.3 | 0 | 55.2 | 0 | 128.5 | 153.5 | 0.2 | 35.9 | 1.6 |
| | 15 | 26.1 | 34.3 | 4.5 | 5.7 | 64.7 | 98.1 | 66.5 | 0 | 40.0 | 23.6 | 81.9 | 121.5 | 18.8 | 305.5 | 29.0 |
| | 16 | 11.4 | 66.3 | 88.8 | 14.1 | 108.0 | 32.0 | 77.0 | 0.5 | 88.8 | 49.5 | 25.2 | 28.1 | 36.1 | 209.7 | 61.3 |
| | 17 | 3.0 | 30.6 | 25.4 | 76.3 | 15.2 | 17.7 | 68.6 | 2.3 | 664.7 | 44.2 | 57.2 | 5.7 | 0 | 718.9 | 12.9 |
| | 18 | 5.7 | 3.0 | 26.3 | 135.1 | 16.6 | 10.9 | 7.0 | 0.2 | 618.3 | 139.1 | 44.7 | 3.4 | 15.2 | 363.4 | 58.5 |
| | 19 | 17.3 | 0 | 28.6 | 46.3 | 0 | 52.9 | 14.8 | 0.2 | 366.8 | 185.8 | 25.7 | 39.3 | 7.3 | 99.7 | 16.8 |
| | 20 | 14.6 | 3.9 | 115.0 | 212.0 | 10.9 | 25.5 | 12.3 | 18.2 | 391.1 | 111.2 | 4.5 | 54.3 | 48.7 | 124.2 | 27.9 |
| | 21 | 0 | 5.0 | 143.9 | 317.1 | 0 | 43.6 | 6.1 | 8.4 | 177.3 | 16.3 | 3.9 | 41.5 | 49.9 | 29.5 | 2.7 |
| | 22 | 0 | 0 | 141.4 | 51.3 | 0 | 4.8 | 0 | 26.1 | 109.9 | 0 | 27.2 | 1.4 | 115.2 | 35.6 | 0 |
| | 23 | 0 | 0 | 111.3 | 23.6 | 10.2 | 1.4 | 0 | 23.2 | 29.3 | 0 | 23.2 | 2.5 | 37.2 | 21.1 | 27.2 |
| | 24 | 0 | 1.4 | 46.5 | 40.4 | 33.4 | 1.4 | 0 | 15.2 | 38.8 | 2.3 | 9.8 | 0.9 | 19.5 | 40.2 | 21.1 |
| | 25 | 22.7 | 0.9 | 24.3 | 13.4 | 38.3 | 17.1 | 0 | 37.9 | 18.6 | 9.3 | 19.5 | 1.6 | 18.4 | 21.3 | 42.4 |
| | 26 | 13.9 | 86.0 | 0.9 | 3.4 | 85.1 | 25.2 | 11.8 | 23.8 | 5.0 | 21.1 | 31.8 | 29.5 | 2.7 | 6.1 | 28.1 |
| | 27 | 25.7 | 190.7 | 0.9 | 0 | 32.0 | 8.4 | 49.0 | 4.1 | 2.0 | 19.3 | 14.3 | 61.3 | 6.8 | 2.1 | 28.1 |
| | 28 | 3.2 | 92.8 | 1.6 | 0 | 39.2 | 15.5 | 485.3 | 0 | 0 | 26.1 | 6.1 | 150.5 | 12.0 | 3.4 | 18.2 |
| | 29 | 8.4 | 66.3 | 0 | 0 | 17.9 | 5.0 | 178.2 | 0 | 1.4 | 44.2 | 21.3 | 97.2 | 9.3 | 3.2 | 8.9 |
| | 30 | 63.3 | 80.6 | 6.8 | 0 | 22.9 | 49.5 | 103.1 | 0 | 3.2 | 44.0 | 26.1 | 79.2 | 12.3 | 4.3 | 6.8 |
| | 31 | 43.8 | 256.5 | 7.0 | 0 | 0 | 26.1 | 179.3 | 5.9 | 0 | 31.3 | 19.5 | 151.4 | 18.2 | 3.2 | 13.8 |

TABLE 58: Daily whitebait catch in the Waita, Haast, and Okuru Rivers from 1969 to 1973 (continued)

| | Catch (kg) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Waita River | | | | | Haast River | | | | | Okuru River | | | | |
| Date | 1969 | 1970 | 1971 | 1972 | 1973 | 1969 | 1970 | 1971 | 1972 | 1973 | 1969 | 1970 | 1971 | 1972 | 1973 |
| Nov 1 | 56.3 | 149.4 | 75.8 | 0.7 | 0 | 13.4 | 133.7 | 33.4 | 5.7 | 7.7 | 8.4 | 110.5 | 75.6 | 23.7 | 0 |
| 2 | 78.5 | 16.1 | 115.8 | 4.3 | 0 | 30.9 | 0 | 29.7 | 4.8 | 0 | 17.2 | 93.1 | 77.9 | 27.9 | 7.7 |
| 3 | 18.6 | 7.3 | 72.2 | 3.6 | 0 | 8.9 | 12.7 | 28.8 | 0 | 1.4 | 12.9 | 61.3 | 27.2 | 5.0 | 21.6 |
| 4 | 15.2 | 19.3 | 35.0 | 1.4 | 12.9 | 8.0 | 58.6 | 16.6 | 0 | 0 | 9.5 | 28.1 | 15.9 | 78.3 | 13.6 |
| 5 | 11.8 | 39.5 | 2.7 | 0 | 10.9 | 5.0 | 34.5 | 0.5 | 0 | 0 | 8.4 | 150.7 | 23.9 | 22.0 | 2.3 |
| 6 | 7.5 | 49.5 | 0.9 | 0 | 9.8 | 0 | 59.2 | 14.3 | 0 | 0 | 1.6 | 75.6 | 10.4 | 18.4 | 17.2 |
| 7 | 20.5 | 36.1 | 1.6 | 0 | 10.0 | 13.9 | 41.5 | 7.5 | 0 | 0 | 6.6 | 33.8 | 11.8 | 109.5 | 38.8 |
| 8 | 13.7 | 20.8 | 7.7 | 36.5 | 91.4 | 2.0 | 13.6 | 17.4 | 0 | 0 | 2.7 | 29.1 | 10.0 | 20.7 | 16.1 |
| 9 | 11.4 | 12.7 | | 45.4 | 36.8 | 12.5 | 30.4 | 6.4 | 0 | 0.9 | 2.7 | 55.6 | 11.8 | 24.5 | 17.5 |
| 10 | 4.6 | 5.7 | | 24.7 | 143.8 | 14.8 | 15.0 | 5.7 | 0 | 32.2 | 2.9 | 18.4 | 8.6 | 31.1 | 7.5 |
| 11 | 2.3 | 3.6 | | 5.0 | 68.7 | 0.5 | 6.8 | 1.8 | 4.3 | 3.2 | 7.7 | 9.8 | 1.1 | 52.7 | 0 |
| 12 | 20.7 | 0.9 | | 5.2 | 0 | 2.3 | 0 | 1.4 | 3.2 | 0 | 11.1 | 1.4 | 0.5 | 30.1 | 0 |
| 13 | 24.1 | 53.3 | | 0.5 | 0 | 14.3 | 8.6 | | 0.5 | 0 | 7.0 | 51.0 | 0.9 | 2.5 | 0 |
| 14 | 13.0 | 5.2 | | 5.4 | 14.1 | 3.9 | | | 0 | 0 | 4.3 | 5.9 | 0.5 | 9.5 | 6.8 |
| 15 | 11.4 | 14.5 | | 9.8 | 0 | 10.0 | | | 2.7 | 5.4 | 5.0 | 3.2 | 0.2 | 33.9 | 5.4 |
| 16 | 18.0 | 28.1 | | 16.8 | 3.4 | 9.8 | | | 3.6 | | 3.2 | 4.1 | 0.7 | 51.5 | |
| 17 | 30.9 | 4.5 | | 25.0 | | 10.5 | | | 1.8 | | 1.4 | 0.9 | 1.4 | 39.5 | |
| 18 | 18.9 | | | 11.6 | | 10.0 | | | 0.5 | | 0.7 | 0 | | 8.7 | |
| 19 | 6.8 | | | 5.2 | | 4.5 | | | | | 0.2 | 2.0 | | 6.3 | |
| 20 | 13.9 | | | 9.1 | | 1.9 | | | | | 1.1 | 0.5 | | 1.4 | |
| 21 | 2.8 | | | | | 4.5 | | | | | | 5.9 | | 0.7 | |
| 22 | | | | | | 1.8 | | | | | | 3.4 | | 0.7 | |
| 23 | | | | | | | | | | | | | | 0.2 | |

TABLE 59: Daily whitebait catch in the Turnbull, Waiatoto, and Arawata Rivers from 1969 to 1973

| | Catch (kg) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Turnbull River | | | | | Waiatoto River | | | | | Arawata River | | | | |
| Date | 1969 | 1970 | 1971 | 1972 | 1973 | 1969 | 1970 | 1971 | 1972 | 1973 | 1969 | 1970 | 1971 | 1972 | 1973 |
| Sep 1 | 11.4 | 0 | 0 | 0.9 | 0 | 16.6 | 0 | 0.2 | 0 | 3.6 | 19.6 | 0 | 5.2 | 0 | 0.7 |
| 2 | 4.1 | 0.7 | 0 | 0.7 | 0.2 | 19.8 | 0.3 | 0.5 | 1.6 | 2.7 | 6.4 | 0 | 0 | 0 | 2.0 |
| 3 | 0 | 2.7 | 0 | 0.7 | 0 | 0.5 | 14.8 | 0.5 | 0.2 | 13.4 | 0 | 0 | 0 | 2.5 | 1.4 |
| 4 | 0 | 13.6 | 0 | 1.1 | 0.9 | 0.5 | 8.4 | 0 | 1.6 | 10.2 | 0 | 2.1 | 0 | 0 | 1.1 |
| 5 | 0 | 8.6 | 0 | 4.8 | 3.9 | 0 | 2.3 | 0 | 17.7 | 2.5 | 0.9 | 0 | 0.9 | 4.5 | 0.5 |
| 6 | 0 | 1.8 | 0 | 3.0 | 0 | 0 | 0 | 0.2 | 12.9 | 0 | 0 | 0 | 0 | 22.5 | 0.5 |
| 7 | 0 | 5.9 | 0 | 31.1 | 0 | 0 | 0 | 3.0 | 31.3 | 1.8 | 0 | 7.9 | 0 | 37.7 | 0 |
| 8 | 0 | 16.1 | 0.9 | 0 | 1.4 | 0 | 0 | 11.4 | 0 | 3.4 | 0 | 0.7 | 2.5 | 0 | 0 |
| 9 | 0 | 5.9 | 1.8 | 0 | 0.9 | 0 | 47.2 | 11.1 | 0 | 0.9 | 0 | 2.7 | 0.5 | 0 | 1.4 |
| 10 | 0 | 2.7 | 1.8 | 7.3 | 1.6 | 0 | 22.5 | 8.4 | 23.1 | 8.2 | 0 | 3.2 | 0.9 | 11.6 | 3.4 |
| 11 | 0 | 0 | 0 | 14.3 | 3.4 | 0 | 6.1 | 1.1 | 13.2 | 39.5 | 0 | 3.2 | 0 | 10.4 | 17.2 |
| 12 | 0 | 29.1 | 0 | 1.6 | 5.2 | 0 | 28.8 | 0 | 47.2 | 43.3 | 0 | 2.7 | 0 | 20.9 | 24.3 |
| 13 | 0 | 9.5 | 0 | 9.5 | 23.8 | 0 | 84.2 | 0.2 | 3.6 | 45.8 | 0 | 6.4 | 0 | 3.0 | 17.9 |
| 14 | 53.2 | 12.7 | 0 | 0.2 | 4.8 | 0 | 36.6 | 2.7 | 0 | 56.5 | 0 | 1.1 | 0 | 0 | 14.7 |
| 15 | 11.4 | 67.6 | 2.7 | 2.3 | 0.9 | 0 | 42.7 | 13.2 | 0.5 | 11.8 | 0 | 3.6 | 0.5 | 0 | 23.1 |
| 16 | 17.5 | 5.9 | 1.8 | 7.9 | 4.1 | 27.9 | 29.5 | 29.7 | 2.9 | 25.2 | 0 | 9.1 | 2.0 | 4.8 | 14.1 |
| 17 | 6.4 | 0.9 | 0 | 10.9 | 3.0 | 114.4 | 4.1 | 24.3 | 6.1 | 63.1 | 7.3 | 0.9 | 0 | 1.8 | 26.8 |
| 18 | 84.3 | 5.7 | 0.5 | 2.0 | 7.0 | 336.5 | 20.2 | 12.9 | 3.9 | 52.6 | 19.6 | 1.1 | 0 | 3.2 | 16.1 |
| 19 | 88.8 | 0 | 0 | 4.5 | 20.0 | 443.7 | 24.1 | 13.6 | 8.6 | 30.9 | 14.1 | 0 | 0 | 2.3 | 12.9 |
| 20 | 38.2 | 10.4 | 0 | 15.4 | 1.1 | 59.2 | 76.0 | 30.6 | 0.5 | 22.5 | 6.9 | 0.5 | 0 | 2.7 | 11.3 |
| 21 | 122.6 | 46.1 | 3.6 | 21.8 | 0 | 58.1 | 151.2 | 80.8 | 0.5 | 8.2 | 25.0 | 22.9 | 1.4 | 1.8 | 9.8 |
| 22 | 178.0 | 31.3 | 0 | 20.4 | 0 | 308.5 | 98.5 | 5.4 | 67.4 | 6.6 | 35.9 | 10.0 | 2.3 | 12.0 | 4.8 |
| 23 | 122.8 | 16.6 | 1.1 | 22.5 | 0 | 588.2 | 53.6 | 21.8 | 157.6 | 17.7 | 48.4 | 1.1 | 7.0 | 30.9 | 1.1 |
| 24 | 88.3 | 0 | 5.0 | 12.9 | 5.0 | 97.4 | 6.1 | 189.5 | 110.7 | 62.2 | 47.5 | 0.7 | 25.4 | 130.9 | 5.7 |
| 25 | 20.9 | 2.5 | 12.9 | 62.4 | 25.9 | 45.2 | 11.8 | 131.9 | 10.9 | 121.1 | 36.4 | 0.5 | 25.9 | 24.0 | 13.2 |
| 26 | 11.4 | 7.9 | 2.9 | 9.5 | 13.8 | 42.0 | 57.9 | 38.8 | 6.8 | 90.7 | 119.9 | 0 | 42.7 | 18.4 | 39.7 |
| 27 | 25.2 | 13.4 | 0.9 | 20.0 | 18.4 | 110.7 | 106.7 | 13.6 | 26.1 | 173.8 | 163.7 | 3.4 | 3.9 | 34.7 | 49.2 |
| 28 | 13.9 | 14.5 | 1.8 | 8.9 | 0 | 123.2 | 95.6 | 45.6 | 38.8 | 40.2 | 33.6 | 9.8 | 7.7 | 64.4 | 29.5 |
| 29 | 8.4 | 5.0 | 20.0 | 14.3 | 3.0 | 38.4 | 207.5 | 94.4 | 145.6 | 43.3 | 23.9 | 82.4 | 9.1 | 47.9 | 41.3 |
| 30 | 6.9 | 27.0 | 69.9 | 16.1 | 0.9 | 12.7 | 331.6 | 325.3 | 403.2 | 57.4 | 24.1 | 45.6 | 123.7 | 66.9 | 31.1 |
| Oct 1 | 10.9 | 25.7 | 24.9 | 17.3 | 0 | 19.8 | 143.2 | 320.3 | 169.4 | 3.6 | 13.9 | 35.2 | 104.6 | 73.7 | 5.2 |
| 2 | 6.2 | 35.9 | 3.6 | 36.0 | 0 | 42.9 | 178.0 | 72.9 | 134.0 | 0 | 11.4 | 53.6 | 0.5 | 223.2 | 5.0 |
| 3 | 3.9 | 22.2 | 0 | 23.4 | 3.2 | 21.6 | 141.4 | 4.5 | 232.5 | 7.0 | 3.9 | 89.9 | 1.6 | 47.6 | 4.1 |
| 4 | 5.5 | 11.6 | 0 | 36.1 | 0 | 50.2 | 441.1 | 0 | 125.4 | 8.4 | 7.5 | 8.2 | 0 | 155.8 | 7.3 |
| 5 | 13.4 | 27.0 | 0 | 34.3 | 1.8 | 112.3 | 86.3 | 0 | 245.4 | 23.8 | 20.7 | 4.8 | 0 | 74.6 | 7.3 |
| 6 | 5.7 | 6.4 | 24.1 | 19.3 | 2.3 | 49.7 | 213.2 | 110.1 | 89.8 | 11.1 | 32.7 | 1.1 | 21.6 | 22.6 | 26.5 |
| 7 | 11.2 | 19.1 | 123.3 | 1.8 | 2.5 | 37.0 | 79.2 | 780.0 | 27.0 | 14.3 | 45.9 | 1.4 | 266.3 | 13.2 | 68.1 |
| 8 | 3.4 | 0.5 | 39.3 | 42.0 | 17.9 | 12.5 | 21.8 | 293.1 | 49.9 | 68.1 | 28.2 | 3.6 | 203.8 | 29.0 | 70.1 |
| 9 | 4.8 | 6.6 | 11.8 | 119.4 | 1.1 | 18.0 | 40.6 | 37.7 | 180.1 | 55.6 | 8.7 | 0 | 93.5 | 142.7 | 64.2 |
| 10 | 14.6 | 6.6 | 0 | 53.6 | 8.6 | 97.1 | 102.6 | 0.2 | 283.3 | 70.8 | 13.9 | 7.5 | 0 | 262.7 | 71.2 |
| 11 | 21.6 | 0.9 | 0 | 126.7 | 6.1 | 465.1 | 59.7 | 0 | 540.2 | 44.0 | 20.7 | 12.0 | 0 | 180.3 | 30.2 |
| 12 | 17.7 | 7.7 | 1.4 | 3.2 | 0 | 329.6 | 122.6 | 0 | 367.6 | 2.7 | 60.2 | 31.3 | 0 | 33.6 | 0 |
| 13 | 41.8 | 13.2 | 0 | 2.5 | 0 | 173.1 | 306.9 | 0.7 | 8.6 | 0 | 65.2 | 21.3 | 0.9 | 4.8 | 0 |
| 14 | 36.8 | 64.5 | 0 | 12.9 | 0 | 275.4 | 201.1 | 0.2 | 83.9 | 0 | 122.6 | 27.2 | 2.5 | 44.9 | 0 |
| 15 | 50.9 | 35.0 | 0 | 14.1 | 22.9 | 189.5 | 125.8 | 1.8 | 288.9 | 44.7 | 27.7 | 22.9 | 0 | 197.8 | 1.8 |
| 16 | 0 | 70.8 | 2.7 | 76.3 | 0 | 5.3 | 91.9 | 14.3 | 542.5 | 99.1 | 35.5 | 44.9 | 3.6 | 99.6 | 33.1 |
| 17 | 29.6 | 11.4 | 0 | 124.4 | 9.3 | 123.4 | 75.8 | 5.4 | 592.6 | 373.8 | 27.5 | 29.7 | 4.8 | 150.2 | 49.5 |
| 18 | 34.5 | 6.4 | 0.9 | 113.3 | 2.7 | 147.3 | 114.9 | 8.4 | 573.6 | 156.8 | 60.6 | 2.5 | 6.1 | 178.8 | 21.3 |
| 19 | 2.8 | 10.0 | 2.9 | 28.8 | 20.9 | 102.6 | 70.4 | 143.5 | 198.7 | 375.4 | 44.8 | 15.0 | 73.8 | 143.1 | 116.4 |
| 20 | 4.4 | 23.2 | 10.4 | 38.4 | 9.5 | 38.1 | 249.7 | 444.9 | 191.0 | 75.8 | 58.6 | 43.4 | 251.5 | 225.0 | 32.2 |
| 21 | 13.7 | 23.8 | 9.2 | 34.5 | 0.2 | 33.8 | 63.3 | 228.4 | 128.6 | 4.1 | 8.0 | 0 | 148.7 | 72.1 | 0 |
| 22 | 8.2 | 0 | 10.6 | 5.7 | 0 | 19.8 | 4.5 | 254.2 | 56.2 | 25.0 | 1.9 | 2.7 | 161.2 | 25.4 | 0 |
| 23 | 11.6 | 0 | 5.6 | 4.1 | 0 | 52.4 | 20.2 | 141.6 | 15.0 | 88.2 | 0 | 1.8 | 90.8 | 17.0 | 3.2 |
| 24 | 7.1 | 0.5 | 11.6 | 2.3 | 0 | 22.3 | 0 | 193.6 | 69.4 | 51.0 | 3.9 | 0 | 142.6 | 15.9 | 10.7 |
| 25 | 8.4 | 1.8 | 3.3 | 8.2 | 9.3 | 54.0 | 26.1 | 103.1 | 67.1 | 141.0 | 11.4 | 0.9 | 75.6 | 33.1 | 74.2 |
| 26 | 22.1 | 8.2 | 2.7 | 0.9 | 1.6 | 61.7 | 287.4 | 67.9 | 33.6 | 178.8 | 21.2 | 1.4 | 31.3 | 6.4 | 73.3 |
| 27 | 8.7 | 26.6 | 0 | 2.5 | 0 | 34.7 | 622.9 | 4.3 | 51.5 | 86.7 | 10.5 | 62.2 | 8.4 | 10.9 | 76.0 |
| 28 | 11.2 | 68.8 | 0 | 3.9 | 5.4 | 75.8 | 211.6 | 0 | 101.6 | 27.7 | 18.2 | 262.2 | 0.9 | 15.9 | 42.9 |
| 29 | 11.4 | 25.4 | 0 | 5.7 | 11.1 | 41.1 | 96.5 | 0.2 | 67.4 | 111.4 | 41.6 | 185.2 | 5.0 | 23.8 | 38.6 |
| 30 | 19.6 | 11.1 | 5.0 | 2.3 | 5.4 | 49.0 | 133.0 | 0 | 31.5 | 37.7 | 51.6 | 166.2 | 5.2 | 15.4 | 10.9 |
| 31 | 11.8 | 199.3 | 2.7 | 0.5 | 0 | 27.0 | 704.4 | 45.9 | 0 | 7.7 | 36.4 | 493.7 | 1.4 | 5.4 | 0 |

TABLE 59: Daily whitebait catch in the Turnbull, Waiatoto, and Arawata Rivers from 1969 to 1973 (continued)

| | Catch (kg) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Turnbull River | | | | | Waiatoto River | | | | | Arawata River | | | | |
| Date | 1969 | 1970 | 1971 | 1972 | 1973 | 1969 | 1970 | 1971 | 1972 | 1973 | 1969 | 1970 | 1971 | 1972 | 1973 |
| Nov 1 | 7.8 | 62.9 | 10.7 | 0 | 0 | 30.4 | 175.7 | 151.0 | 0.9 | 0 | 5.7 | 43.1 | 41.1 | 13.2 | 14.7 |
| 2 | 6.6 | 31.6 | 12.3 | 0 | 0 | 31.6 | 126.9 | 49.9 | 9.7 | 41.5 | 44.3 | 8.9 | 1.6 | 0 | 1.2 |
| 3 | 6.9 | 14.1 | 13.6 | 0 | 0 | 42.0 | 224.0 | 142.3 | 12.7 | 4.3 | 11.2 | 6.4 | 33.6 | 0 | 0 |
| 4 | 3.2 | 34.1 | 11.4 | 2.7 | 2.3 | 15.2 | 415.2 | 122.1 | 22.0 | 2.7 | 21.6 | 188.2 | 32.5 | 0.9 | 10.2 |
| 5 | 0.9 | 115.8 | 4.5 | 0 | 1.1 | 10.2 | 734.8 | 38.1 | 2.0 | 0 | 10.5 | 250.2 | 15.4 | 0 | 2.0 |
| 6 | 0.5 | 142.1 | 8.2 | 0 | 0 | 14.1 | 401.6 | 52.9 | 0 | 14.5 | 5.5 | 86.3 | 33.8 | 0 | 2.5 |
| 7 | 2.3 | 89.9 | 2.7 | 0 | 0 | 9.8 | 412.5 | 60.8 | 0.5 | 18.4 | 10.3 | 58.1 | 24.5 | 0 | 2.0 |
| 8 | 2.3 | 59.9 | 2.0 | 0 | 1.4 | 2.1 | 332.6 | 46.5 | 12.0 | 242.0 | 12.3 | 83.3 | 13.6 | 0 | 3.9 |
| 9 | 2.5 | 35.9 | 1.4 | 3.6 | 4.3 | 6.2 | 132.6 | 6.8 | 24.9 | 204.4 | 6.4 | 49.0 | | 1.4 | 48.8 |
| 10 | 1.8 | 14.3 | 0 | 0 | 11.1 | 2.7 | 43.8 | 5.4 | 235.9 | 3.4 | | 29.1 | | 17.7 | 159.3 |
| 11 | 3.0 | 4.5 | 0 | 0.7 | 0 | 0.5 | 12.9 | 13.2 | 299.1 | 50.1 | | 1.6 | | 86.7 | 42.4 |
| 12 | 2.3 | 2.3 | 0.5 | 10.4 | 0 | 0.2 | 0 | 5.2 | 90.5 | 30.6 | | 5.0 | | 29.0 | 5.7 |
| 13 | 2.5 | 4.3 | | 14.5 | 0 | 0.5 | 6.8 | 1.4 | 0 | 70.8 | | | | 0 | 75.1 |
| 14 | 0.2 | 0 | | 20.2 | 1.6 | 4.8 | 11.8 | 0 | 0 | 16.6 | | | | 0 | 20.2 |
| 15 | 0.7 | 0 | | 11.4 | | 2.7 | 1.4 | 0.5 | 10.9 | 1.8 | | | | 0 | 6.6 |
| 16 | 0 | 2.3 | | 0 | | 4.1 | 8.6 | 0.5 | 156.7 | | | | | 15.9 | |
| 17 | 0.5 | 0.9 | | 0 | | 0.7 | 0.9 | 0.7 | 83.9 | | | | | 94.6 | |
| 18 | 1.4 | 0 | | 1.8 | | 2.3 | 1.8 | | 77.8 | | | | | 12.7 | |
| 19 | | 0 | | 60.4 | | 24.5 | 2.7 | | 14.5 | | | | | 10.0 | |
| 20 | | 0 | | 21.8 | | | 0 | | 0.2 | | | | | 2.7 | |
| 21 | | 2.3 | | 4.3 | | | 1.8 | | 0 | | | | | 0 | |
| 22 | | | | 8.6 | | | 0.9 | | 0.5 | | | | | 0 | |
| 23 | | | | 1.6 | | | | | 0.2 | | | | | 0 | |
| 24 | | | | 0.5 | | | | | 0.5 | | | | | 0.9 | |
| 25 | | | | | | | | | | | | | | 0.9 | |

TABLE 60: Daily whitebait catch in the Cascade River from 1959 to 1973

| Date | | Catch (kg) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
| Sep | 1 | 5.0 | | 29.0 | 5.4 | 0 | | | | 0 | 16.3 | 40.8 | 93.2 | 0 | 7.0 | 63.5 |
| | 2 | 0 | | 18.1 | 10.9 | 7.2 | | | | 0 | 40.8 | 32.6 | 315.3 | 5.4 | 45.1 | 96.2 |
| | 3 | 0 | | 9.1 | 18.1 | 36.3 | | | | 0 | 81.6 | 0 | 396.7 | 23.6 | 22.2 | 157.6 |
| | 4 | 2.3 | | 10.9 | 108.9 | 95.2 | | | | 0 | 89.8 | 0 | 624.2 | 33.6 | 8.2 | 41.7 |
| | 5 | 4.5 | | 27.2 | 217.7 | 145.2 | 10.9 | | | 0 | 89.8 | 12.2 | 101.6 | 2.9 | 69.2 | 60.8 |
| | 6 | 27.2 | | 0 | 72.6 | 174.2 | 1.8 | | | 13.6 | 163.3 | 0 | 59.9 | 19.5 | 230.2 | 41.5 |
| | 7 | 90.7 | 0 | 0 | 145.2 | 145.2 | 3.6 | 29.0 | | 108.3 | 0 | 0 | 162.4 | 38.1 | 161.1 | 26.5 |
| | 8 | 9.1 | 0 | 0 | 290.3 | 90.7 | 0 | 43.5 | | 76.2 | 0 | 0 | 17.9 | 43.5 | 10.0 | 38.6 |
| | 9 | 18.1 | 0 | 10.9 | 108.9 | 18.1 | 1.8 | 72.6 | | 38.1 | 0 | 0 | 109.5 | 37.6 | 0 | 32.7 |
| | 10 | 18.1 | 0 | 18.1 | 72.6 | 18.1 | 1.8 | 72.6 | 5.4 | 57.2 | 4.1 | 28.6 | 131.5 | 34.5 | 12.0 | 381.0 |
| | 11 | 54.4 | 10.9 | 72.6 | 272.2 | 36.3 | 3.6 | 72.6 | 4.1 | 76.2 | 61.2 | 49.0 | 8.2 | 0 | 3.9 | 50.4 |
| | 12 | 36.3 | 10.9 | 90.7 | 497.1 | 0 | 0 | 36.3 | 13.6 | 40.8 | 93.9 | 130.6 | 240.0 | 3.6 | 196.2 | 0 |
| | 13 | 18.1 | 10.9 | 90.7 | 72.6 | 0 | 0 | 0 | 16.3 | 20.4 | 32.6 | 253.1 | 252.0 | 9.3 | 15.0 | 427.5 |
| | 14 | 9.1 | 25.4 | 79.8 | 18.1 | 18.1 | 0 | 3.6 | 27.2 | 0 | 36.7 | 979.8 | 66.5 | 10.4 | 83.9 | 134.3 |
| | 15 | 0 | 29.0 | 54.4 | 72.6 | 290.3 | 10.9 | 1.8 | 27.2 | 27.2 | 69.4 | 1 265.5 | 205.7 | 26.3 | 0 | 61.0 |
| | 16 | 0 | 163.3 | 36.3 | 217.7 | 127.0 | 90.7 | 0 | 16.3 | 81.6 | 65.3 | 506.2 | 98.0 | 30.6 | 10.2 | 0 |
| | 17 | 0 | 217.7 | 9.1 | 254.0 | 145.2 | 108.9 | 2.7 | 0 | 0 | 61.2 | 816.5 | 248.1 | 59.0 | 15.4 | 154.5 |
| | 18 | 0 | 130.6 | 30.8 | 239.5 | 290.3 | 83.5 | 1.8 | 2.7 | 5.4 | 73.5 | 1 306.4 | 244.5 | 53.8 | 34.3 | 39.2 |
| | 19 | 36.3 | 90.7 | 29.0 | 101.6 | 145.2 | 79.8 | 3.6 | 54.4 | 19.0 | 69.4 | 1 171.6 | 41.5 | 44.5 | 181.0 | 71.7 |
| | 20 | 54.4 | 163.3 | 36.3 | 72.6 | 272.2 | 94.3 | 36.3 | 87.1 | 244.9 | 265.4 | 506.2 | 80.7 | 59.2 | 18.1 | 44.2 |
| | 21 | 622.3 | 145.2 | 29.0 | 18.1 | 156.0 | 79.8 | 72.6 | 176.9 | 149.7 | 234.8 | 326.6 | 535.5 | 184.2 | 63.1 | 42.4 |
| | 22 | 344.7 | 145.2 | 0 | 72.6 | 127.0 | 95.2 | 217.7 | 81.6 | 212.3 | 0 | 673.6 | 466.1 | 93.9 | 59.0 | 33.1 |
| | 23 | 72.6 | 217.7 | 0 | 217.7 | 83.5 | 101.6 | 76.2 | 1.4 | 375.6 | 57.2 | 342.9 | 288.7 | 25.4 | 175.8 | 40.8 |
| | 24 | 81.6 | 264.9 | 0 | 87.1 | 54.4 | 18.1 | 0 | 0 | 217.7 | 171.5 | 285.8 | 0 | 154.5 | 246.6 | 86.6 |
| | 25 | 696.3 | 181.4 | 5.4 | 254.0 | 18.1 | 14.5 | 18.1 | 13.6 | 258.6 | 77.6 | 179.6 | 39.2 | 171.5 | 54.0 | 117.3 |
| | 26 | 734.8 | 188.7 | 18.1 | 254.0 | 54.4 | 18.1 | 98.0 | 144.2 | 277.6 | 69.4 | 191.9 | 39.0 | 181.9 | 107.1 | 70.5 |
| | 27 | 683.6 | 156.0 | 18.1 | 159.7 | 101.6 | 29.0 | 79.8 | 13.6 | 244.9 | 98.0 | 89.8 | 184.8 | 69.2 | 143.6 | 52.2 |
| | 28 | 638.7 | 112.5 | 54.4 | 137.9 | 199.6 | 54.4 | 18.1 | 108.9 | 250.4 | 147.0 | 40.8 | 191.9 | 81.0 | 140.6 | 92.8 |
| | 29 | 381.0 | 152.4 | 36.3 | 225.0 | 61.7 | 43.5 | 0 | 68.0 | 111.6 | 155.1 | 32.6 | 159.4 | 116.6 | 83.3 | 66.5 |
| | 30 | 263.1 | 90.7 | 54.4 | 117.8 | 36.3 | 18.1 | 7.3 | 54.4 | 326.6 | 175.5 | 20.4 | 149.9 | 250.2 | 85.7 | 68.0 |
| Oct | 1 | 9.1 | 145.2 | 108.9 | 221.4 | 43.5 | 0 | 21.8 | 40.8 | 108.9 | 216.4 | 16.3 | 85.3 | 225.9 | 125.0 | 96.2 |
| | 2 | 0 | 145.2 | 72.6 | 119.8 | 36.3 | 0 | 0 | 27.2 | 190.5 | 0 | 4.1 | 53.1 | 225.4 | 296.7 | 0 |
| | 3 | 63.5 | 156.0 | 18.1 | 87.1 | 29.0 | 1 651.1 | 0 | 13.6 | 81.6 | 114.3 | 16.3 | 24.9 | 61.2 | 187.4 | 4.5 |
| | 4 | 145.2 | 217.7 | 72.6 | 127.0 | 21.8 | 0 | 0 | 16.3 | 217.7 | 122.5 | 49.0 | 68.5 | 0 | 286.7 | 24.7 |
| | 5 | 190.5 | 264.9 | 108.9 | 275.8 | 83.5 | 18.1 | 9.1 | 8.2 | 299.4 | 1 673.8 | 40.8 | 9.1 | 34.5 | 25.9 | 47.2 |
| | 6 | 235.9 | 0 | 0 | 134.3 | 72.6 | 399.2 | 14.5 | 13.6 | 416.4 | 959.4 | 69.4 | 7.3 | 461.8 | 127.0 | 81.4 |
| | 7 | 326.6 | 0 | 108.9 | 210.5 | 72.6 | 544.3 | 27.2 | 40.8 | 285.8 | 792.0 | 10.0 | 7.5 | 619.2 | 147.7 | 137.0 |
| | 8 | 331.1 | 145.2 | 308.4 | 598.8 | 65.3 | 1 161.2 | 108.9 | 68.0 | 337.5 | 963.4 | 134.7 | 4.5 | 260.8 | 23.4 | 9.1 |
| | 9 | 272.2 | 127.0 | 283.0 | 156.0 | 36.3 | 885.4 | 43.5 | 16.3 | 675.0 | 175.4 | 73.5 | 20.4 | 134.0 | 227.1 | 200.0 |
| | 10 | 163.3 | 72.6 | 199.6 | 246.8 | 29.0 | 874.5 | 36.3 | 24.5 | 440.9 | 498.0 | 89.8 | 22.5 | 94.3 | 84.4 | 104.1 |
| | 11 | 54.4 | 246.8 | 145.2 | 257.6 | 32.6 | 591.5 | 27.2 | 174.2 | 571.5 | 175.4 | 130.6 | 7.5 | 68.7 | 198.5 | 0 |
| | 12 | 0 | 145.2 | 225.0 | 152.4 | 36.3 | 413.7 | 50.8 | 261.3 | 223.2 | 653.2 | 49.0 | 4.3 | 23.4 | 84.4 | 141.1 |
| | 13 | 15.9 | 406.4 | 210.5 | 159.7 | 32.6 | 370.1 | 94.3 | 136.1 | 261.3 | 498.0 | 65.3 | 40.6 | 11.1 | 56.5 | 4.5 |
| | 14 | 36.3 | 544.3 | 0 | 319.3 | 0 | 1 103.2 | 181.4 | 149.7 | 217.7 | 32.6 | 24.5 | 134.9 | 9.3 | 369.3 | 0 |
| | 15 | 45.4 | 489.9 | 290.3 | 134.3 | 29.0 | 1 106.8 | 174.2 | 163.3 | 435.4 | 81.6 | 8.2 | 102.1 | 85.3 | 811.4 | 801.1 |
| | 16 | 20.4 | 453.6 | 0 | 36.3 | 72.6 | 725.8 | 76.2 | 114.3 | 612.4 | 32.6 | 0 | 16.0 | 37.0 | 560.8 | 520.1 |
| | 17 | 18.1 | 264.9 | 275.8 | 181.4 | 54.4 | 598.8 | 25.4 | 98.0 | 334.8 | 130.6 | 8.2 | 16.0 | 129.0 | 558.3 | 322.7 |
| | 18 | 18.1 | 326.6 | 725.8 | 145.2 | 72.6 | 580.6 | 68.9 | 27.2 | 231.3 | 330.7 | 69.4 | 46.5 | 11.8 | 489.8 | 1 382.1 |
| | 19 | 18.1 | 235.9 | 1 016.1 | 72.6 | 58.1 | 591.5 | 166.9 | 32.6 | 0 | 473.6 | 32.7 | 49.7 | 424.8 | 277.2 | 763.6 |
| | 20 | 39.4 | 174.2 | 580.6 | 72.6 | 79.8 | 315.7 | 199.6 | 95.2 | 89.8 | 612.4 | 28.6 | 69.4 | 477.6 | 201.2 | 220.0 |
| | 21 | 18.6 | 145.2 | 275.8 | 341.1 | 36.3 | 290.3 | 145.2 | 62.6 | 174.2 | 0 | 32.7 | 24.5 | 193.2 | 243.2 | 488.3 |

TABLE 60: Daily whitebait catch in the Cascade River from 1959 to 1973 (continued)

| Date | | Catch (kg) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
| Oct | 22 | 37.6 | 90.7 | 36.3 | 348.4 | 32.7 | 47.2 | 79.8 | 0 | 149.7 | 0 | 57.2 | 6.4 | 133.4 | 162.9 | 27.2 |
| | 23 | 44.4 | 108.9 | 54.4 | 72.6 | 0 | 50.8 | 90.7 | 95.2 | 244.9 | 0 | 44.9 | 0 | 91.9 | 146.3 | 1 287.1 |
| | 24 | 28.1 | 290.3 | 87.1 | 0 | 58.1 | 18.1 | 90.7 | 154.4 | 239.5 | 53.1 | 28.6 | 4.1 | 21.8 | 75.3 | 1 670.6 |
| | 25 | 19.0 | 225.0 | 61.7 | 72.6 | 119.8 | 21.8 | 83.5 | 114.3 | 168.7 | 171.5 | 32.7 | 16.9 | 61.7 | 0 | 1 423.9 |
| | 26 | 43.1 | 181.4 | 0 | 52.6 | 145.2 | 43.5 | 27.2 | 103.4 | 62.6 | 0 | 77.6 | 112.9 | 44.5 | 52.2 | 928.1 |
| | 27 | 290.3 | 108.9 | 0 | 362.9 | 0 | 72.6 | 130.6 | 54.4 | 54.4 | 20.4 | 36.7 | 256.7 | 44.9 | 90.7 | 36.7 |
| | 28 | 453.6 | 36.3 | 0 | 261.3 | 54.4 | 290.3 | 87.1 | 13.6 | 27.1 | 73.5 | 32.7 | 217.7 | 10.2 | 43.1 | 192.8 |
| | 29 | 408.2 | 0 | 290.3 | 0 | 0 | 217.7 | 228.6 | 29.9 | 21.8 | 0 | 16.3 | 142.9 | 6.1 | 21.6 | 92.1 |
| | 30 | 240.9 | 290.3 | 435.4 | 0 | 95.2 | 185.1 | 272.2 | 40.8 | 0 | 24.5 | 81.6 | 126.3 | 16.3 | 12.5 | 374.5 |
| | 31 | 186.0 | 489.9 | 308.4 | 36.3 | 301.2 | 54.4 | 116.1 | 46.3 | 19.0 | 514.4 | 28.6 | 139.3 | 6.1 | 56.0 | 178.0 |
| Nov | 1 | 54.4 | 159.7 | 595.1 | 90.7 | 145.2 | 47.2 | 0 | 36.3 | 24.5 | 1 143.1 | 24.5 | 222.9 | 162.2 | 0 | 0 |
| | 2 | 22.7 | 79.8 | 573.4 | 181.4 | 108.9 | 43.5 | 27.2 | 40.8 | 54.4 | 326.6 | 16.3 | 44.2 | 78.7 | 1.4 | 0 |
| | 3 | 13.6 | 21.8 | 384.6 | 181.4 | 72.6 | 25.4 | 246.8 | 10.9 | 0 | 318.4 | 28.6 | 82.6 | 136.3 | 44.2 | 0 |
| | 4 | 9.1 | 108.9 | 246.8 | 174.2 | 14.5 | 18.1 | 257.6 | 19.0 | 68.0 | 326.6 | 4.1 | 177.6 | 106.1 | 0 | 192.1 |
| | 5 | 0 | 72.6 | 290.3 | 18.1 | | 20.0 | 72.6 | 32.6 | 68.0 | 334.8 | 4.1 | 67.1 | 53.1 | 87.3 | 327.1 |
| | 6 | 0 | 94.3 | 127.0 | 18.1 | | 0 | 0 | 54.4 | 16.3 | 277.6 | 0 | 105.0 | 62.1 | 25.9 | 104.3 |
| | 7 | 0 | 116.1 | 174.2 | 54.4 | | 0 | 0 | 76.2 | 0 | 351.1 | 0 | 98.9 | 12.2 | 234.1 | 0 |
| | 8 | 0 | 145.2 | 50.8 | 36.3 | | 0 | 301.2 | 84.4 | 27.2 | 0 | 1.8 | 76.0 | 4.1 | 509.5 | 1 573.1 |
| | 9 | 0 | 108.9 | 174.2 | 18.1 | | 1.8 | 889.0 | 108.9 | 40.8 | 53.1 | | 61.2 | 28.6 | 718.9 | 1 360.6 |
| | 10 | 4.5 | 50.0 | 54.4 | 18.1 | | 3.6 | 947.1 | 149.7 | | 0 | | 47.6 | 4.1 | 384.7 | 775.2 |
| | 11 | | 36.3 | | | | 0 | 428.2 | 125.2 | | 69.4 | | 4.1 | 8.2 | 519.0 | 433.6 |
| | 12 | | | | | | 10.9 | 90.7 | 62.6 | | 130.6 | | | 8.2 | 296.5 | 240.9 |
| | 13 | | | | | | | 0 | 117.0 | | 187.8 | | | 6.1 | 319.2 | 356.5 |
| | 14 | | | | | | | 174.2 | 59.9 | | 163.3 | | | | 0 | 45.1 |
| | 15 | | | | | | | 185.1 | 8.2 | | 36.7 | | | | 18.6 | 32.0 |
| | 16 | | | | | | | 3.6 | 49.0 | | 32.6 | | | | 376.8 | 27.2 |
| | 17 | | | | | | | 18.1 | 108.9 | | 396.0 | | | | 138.1 | |
| | 18 | | | | | | | 199.6 | 117.0 | | 257.2 | | | | 235.0 | |
| | 19 | | | | | | | 268.5 | 95.2 | | 212.3 | | | | 112.7 | |
| | 20 | | | | | | | 90.7 | 54.4 | | 155.1 | | | | 63.5 | |
| | 21 | | | | | | | 98.0 | 89.8 | | 571.5 | | | | 10.2 | |
| | 22 | | | | | | | 10.9 | 27.2 | | 163.3 | | | | | |
| | 23 | | | | | | | | 2.7 | | 49.0 | | | | | |
| | 24 | | | | | | | | 19.0 | | 0 | | | | | |
| | 25 | | | | | | | | 32.6 | | 175.4 | | | | | |
| | 26 | | | | | | | | | | 236.8 | | | | | |
| | 27 | | | | | | | | | | 167.4 | | | | | |
| | 28 | | | | | | | | | | 155.1 | | | | | |
| | 29 | | | | | | | | | | 57.2 | | | | | |

TABLE 61: Daily whitebait catch in the Awarua River from 1948 to 1961

| Date | | Catch (kg) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1948 | 1949 | 1950 | 1951 | 1952 | 1953 | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 |
| Sep | 1 | 0 | 27.2 | 6.8 | 0.4 | 20.4 | 13.2 | 5.9 | 211.4 | 12.2 | 3.6 | 2.3 | 4.5 | 88.4 | 34.0 |
| | 2 | 0 | 36.3 | 5.4 | 2.3 | 13.6 | 10.4 | 10.4 | 122.5 | 5.4 | 4.1 | 2.3 | 0 | 88.4 | 27.2 |
| | 3 | 0 | 45.4 | 5.4 | 12.2 | 5.4 | 12.7 | 43.1 | 161.5 | 4.5 | 3.2 | 3.2 | 0 | 43.1 | 24.9 |
| | 4 | 6.8 | 40.8 | 0.4 | 21.8 | 9.1 | 7.7 | 21.8 | 153.8 | 1.8 | 2.7 | 2.3 | 4.5 | 20.4 | 27.2 |
| | 5 | 13.6 | 63.5 | 0 | 8.2 | 13.6 | 12.2 | 30.8 | 109.3 | 3.6 | 3.6 | 3.2 | 6.8 | 11.3 | 13.6 |
| | 6 | 15.9 | 36.3 | 0 | 10.9 | 3.6 | 16.3 | 18.1 | 114.8 | 9.5 | 10.4 | 3.2 | 4.5 | 22.7 | 2.3 |
| | 7 | 18.1 | 22.7 | 1.8 | 1.8 | 4.5 | 8.6 | 20.4 | 80.7 | 6.4 | 26.3 | 1.4 | 6.8 | 18.1 | 11.3 |
| | 8 | 3.6 | 36.3 | 6.4 | 20.0 | 1.8 | 8.6 | 11.3 | 61.7 | 8.2 | 59.4 | 2.3 | 4.5 | 0 | 4.5 |
| | 9 | 9.1 | 81.6 | 16.3 | 6.4 | 0 | 44.4 | 29.0 | 35.4 | 12.2 | 59.0 | 6.8 | 13.6 | 0 | 18.1 |
| | 10 | 0 | 54.4 | 12.7 | 28.1 | 1.8 | 59.9 | 48.1 | 37.2 | 5.9 | 67.1 | 6.8 | 18.1 | 6.8 | 52.2 |
| | 11 | 2.3 | 86.2 | 6.8 | 18.1 | 1.4 | 50.8 | 22.7 | 40.8 | 12.2 | 68.5 | 6.8 | 11.3 | 24.9 | 38.6 |
| | 12 | 22.7 | 104.3 | 6.4 | 10.9 | 1.8 | 147.0 | 24.9 | 31.8 | 3.6 | 40.8 | 18.1 | 11.3 | 22.7 | 54.4 |
| | 13 | 27.2 | 90.7 | 20.0 | 14.5 | 0.9 | 87.1 | 12.2 | 24.0 | 0.9 | 29.9 | 2.3 | 11.3 | 9.1 | 34.0 |
| | 14 | 31.8 | 77.1 | 37.2 | 14.1 | 0.9 | 49.4 | 8.2 | 51.7 | 1.8 | 21.8 | 0 | 4.5 | 31.8 | 36.3 |
| | 15 | 31.8 | 122.5 | 30.4 | 9.5 | 1.4 | 98.4 | 3.6 | 42.2 | 7.2 | 20.4 | 0 | 2.3 | 43.1 | 29.5 |
| | 16 | 9.1 | 81.6 | 16.3 | 0 | 6.8 | 46.3 | 5.4 | 36.3 | 14.5 | 34.5 | 0 | 4.5 | 22.7 | 15.9 |
| | 17 | 77.1 | 95.2 | 27.7 | 0 | 14.1 | 43.1 | 3.6 | 62.6 | 38.1 | 24.0 | 6.8 | 0 | 34.0 | 15.9 |
| | 18 | 63.5 | 81.6 | 11.3 | 3.2 | 5.4 | 38.6 | 2.3 | 37.2 | 86.2 | 17.2 | 4.5 | 2.3 | 38.6 | 15.9 |
| | 19 | 54.4 | 63.5 | 7.2 | 5.4 | 0 | 35.4 | 6.4 | 107.5 | 50.8 | 34.4 | 11.3 | 24.9 | 99.8 | 13.6 |
| | 20 | 36.3 | 68.0 | 5.4 | 2.3 | 12.7 | 13.6 | 5.0 | 25.4 | 61.7 | 31.8 | 13.6 | 68.0 | 90.7 | 20.4 |
| | 21 | 36.3 | 43.1 | 10.0 | 0 | 14.5 | 10.4 | 2.3 | 53.5 | 64.9 | 40.4 | 18.1 | 131.5 | 61.2 | 29.5 |
| | 22 | 0 | 40.8 | 6.8 | 10.4 | 0 | 6.4 | 4.1 | 67.6 | 43.1 | 38.6 | 13.6 | 106.6 | 56.7 | 9.1 |
| | 23 | 0 | 13.6 | 28.1 | 12.2 | 0 | 18.1 | 4.1 | 9.5 | 48.1 | 60.8 | 18.1 | 61.2 | 77.1 | 0.9 |
| | 24 | 3.6 | 9.1 | 83.5 | 4.1 | 25.4 | 3.2 | 1.8 | 0 | 10.4 | 20.9 | 20.4 | 2.3 | 60.0 | 4.5 |
| | 25 | 0 | 9.1 | 102.1 | 10.0 | 31.8 | 37.6 | 2.7 | 11.3 | 44.0 | 0 | 11.3 | 52.2 | 61.2 | 45.4 |
| | 26 | 0 | 54.4 | 134.7 | 9.1 | 69.8 | 50.8 | 1.8 | 87.5 | 57.2 | 73.9 | 81.6 | 192.8 | 52.2 | 72.4 |
| | 27 | 0 | 9.1 | 104.8 | 14.1 | 37.2 | 39.0 | 0 | 202.3 | 75.3 | 132.0 | 36.3 | 188.2 | 56.7 | 15.9 |
| | 28 | 0 | 0 | 109.3 | 14.5 | 76.2 | 16.8 | 1.8 | 142.4 | 76.2 | 51.7 | 29.5 | 473.1 | 38.6 | 40.8 |
| | 29 | 0 | 0 | 12.7 | 3.2 | 15.4 | 12.2 | 8.6 | 129.7 | 71.2 | 22.7 | 2.3 | 442.7 | 43.1 | 31.8 |
| | 30 | 0 | 4.5 | 108.9 | 4.5 | 17.2 | 19.5 | 10.4 | 223.6 | 123.4 | 95.7 | 2.3 | 375.1 | 43.1 | 38.6 |
| Oct | 1 | 13.6 | 36.3 | 78.0 | 5.4 | 33.1 | 18.6 | 8.6 | 140.2 | 113.4 | 52.2 | 68.0 | 47.6 | 72.6 | 11.3 |
| | 2 | 93.0 | 63.5 | 34.0 | 14.5 | 19.0 | 69.4 | 5.4 | 78.9 | 119.3 | 29.5 | 47.6 | 61.2 | 93.0 | 9.1 |
| | 3 | 165.6 | 45.8 | 39.5 | 35.8 | 28.6 | 56.2 | 10.4 | 96.2 | 45.4 | 41.7 | 54.4 | 72.6 | 115.7 | 18.1 |
| | 4 | 88.4 | 87.5 | 47.6 | 77.1 | 2.7 | 79.4 | 0.4 | 89.4 | 84.8 | 25.8 | 183.7 | 104.3 | 117.9 | 15.9 |
| | 5 | 59.0 | 88.4 | 59.4 | 195.0 | 9.1 | 54.4 | 3.6 | 88.0 | 39.0 | 54.4 | 117.9 | 45.4 | 88.4 | 31.8 |
| | 6 | 74.8 | 0 | 46.3 | 139.2 | 6.8 | 29.5 | 9.1 | 308.4 | 40.4 | 147.0 | 104.3 | 131.5 | 52.2 | 22.7 |
| | 7 | 52.2 | 82.6 | 42.2 | 108.9 | 11.7 | 20.0 | 11.3 | 149.6 | 47.6 | 260.8 | 83.9 | 102.1 | 24.9 | 34.0 |
| | 8 | 39.5 | 164.2 | 47.6 | 101.6 | 17.2 | 8.6 | 20.0 | 107.9 | 34.9 | 86.2 | 358.3 | 106.6 | 24.9 | 95.2 |
| | 9 | 18.1 | 164.2 | 45.8 | 57.2 | 24.9 | 17.2 | 2.3 | 102.5 | 38.1 | 116.1 | 258.6 | 88.4 | 18.1 | 93.0 |
| | 10 | 24.9 | 225.4 | 112.5 | 39.0 | 27.2 | 7.2 | 5.4 | 54.4 | 70.3 | 88.0 | 669.1 | 47.6 | 6.8 | 47.6 |
| | 11 | 29.5 | 151.0 | 131.5 | 23.6 | 30.8 | 18.6 | 5.9 | 123.8 | 60.3 | 40.8 | 578.8 | 45.4 | 29.5 | 113.4 |
| | 12 | 16.3 | 103.4 | 116.6 | 21.8 | 5.9 | 10.9 | 10.4 | 105.7 | 73.9 | 38.6 | 372.0 | 27.2 | 38.6 | 167.8 |
| | 13 | 24.5 | 197.3 | 142.9 | 10.0 | 17.2 | 2.7 | 0 | 64.4 | 62.6 | 3.6 | 201.8 | 29.5 | 47.6 | 115.7 |
| | 14 | 31.8 | 155.6 | 64.0 | 5.9 | 18.1 | 10.9 | 5.0 | 60.3 | 64.9 | 18.6 | 90.7 | 15.9 | 68.0 | 79.4 |
| | 15 | 61.2 | 93.4 | 20.9 | 3.6 | 6.8 | 25.4 | 35.4 | 165.1 | 54.4 | 106.6 | 47.6 | 9.1 | 97.5 | 70.3 |
| | 16 | 70.3 | 205.9 | 13.6 | 1.8 | 3.2 | 74.4 | 66.2 | 243.1 | 120.6 | 97.1 | 40.8 | 9.1 | 70.3 | 34.0 |
| | 17 | 120.2 | 145.2 | 64.9 | 0 | 87.5 | 67.1 | 66.2 | 107.0 | 147.2 | 37.6 | 31.6 | 6.8 | 81.6 | 129.3 |
| | 18 | 333.4 | 0 | 164.6 | 0.9 | 184.2 | 45.4 | 41.7 | 135.6 | 139.2 | 6.4 | 43.1 | 9.1 | 54.4 | 213.2 |
| | 19 | 263.1 | 204.1 | 89.8 | 2.3 | 78.9 | 10.0 | 26.8 | 381.9 | 105.7 | 129.3 | 31.6 | 4.5 | 63.5 | 95.2 |
| | 20 | 0 | 571.5 | 141.5 | 2.7 | 573.8 | 172.8 | 15.0 | 199.6 | 54.4 | 195.0 | 27.2 | 6.8 | 40.8 | 81.6 |
| | 21 | 0 | 335.7 | 93.0 | 6.4 | 589.7 | 83.9 | 47.6 | 162.4 | 40.8 | 242.2 | 13.6 | 11.3 | 56.7 | 140.6 |
| | 22 | 0 | 98.9 | 132.4 | 11.3 | 307.1 | 47.2 | 20.9 | 90.7 | 260.4 | 115.2 | 24.9 | 11.3 | 115.7 | 147.4 |
| | 23 | 0 | 169.2 | 88.4 | 14.5 | 480.8 | 24.9 | 68.0 | 174.2 | 111.6 | 140.6 | 6.8 | 15.9 | 90.7 | 181.4 |
| | 24 | 0 | 123.4 | 121.6 | 29.0 | 333.8 | 26.3 | 73.9 | 156.9 | 112.0 | 120.6 | 2.3 | 15.9 | 99.8 | 95.2 |
| | 25 | 0 | 313.0 | 82.6 | 24.5 | 219.5 | 35.8 | 114.3 | 131.1 | 56.7 | 53.5 | 27.2 | 9.1 | 79.4 | 140.6 |
| | 26 | 0 | 210.9 | 73.0 | 44.4 | 111.1 | 51.7 | 81.6 | 93.4 | 78.9 | 45.4 | 52.2 | 18.1 | 40.8 | 56.7 |
| | 27 | 54.4 | 175.5 | 88.0 | 28.1 | 121.6 | 50.8 | 127.9 | 186.4 | 52.2 | 52.2 | 70.3 | 20.4 | 20.4 | 9.1 |
| | 28 | 453.6 | 176.0 | 53.1 | 49.9 | 108.0 | 25.8 | 116.6 | 114.3 | 24.9 | 68.0 | 90.7 | 56.7 | 11.3 | 36.3 |
| | 29 | 0 | 101.2 | 21.3 | 136.5 | 128.8 | 31.8 | 18.6 | 337.5 | 29.5 | 36.3 | 331.2 | 113.4 | 20.4 | 93.0 |
| | 30 | 0 | 148.3 | 13.6 | 84.8 | 83.0 | 21.8 | 46.7 | 125.6 | 57.2 | 55.3 | 349.3 | 152.0 | 52.2 | 74.8 |
| | 31 | 0 | 112.0 | 28.6 | 42.2 | 37.6 | 23.6 | 46.7 | 136.1 | 51.7 | 42.6 | 174.6 | 83.9 | 54.4 | 95.2 |

TABLE 61: Daily whitebait catch in the Awarua River from 1948 to 1961 (continued)

| Date | Catch (kg) 1948 | 1949 | 1950 | 1951 | 1952 | 1953 | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nov 1 | 0 | 449.1 | 27.2 | 186.0 | 44.4 | 19.5 | 0 | 112.9 | 139.7 | 7.2 | 95.2 | 45.4 | 65.8 | 86.2 |
| 2 | 0 | 469.0 | 17.7 | 106.6 | 24.5 | 14.5 | 16.3 | 48.5 | 292.1 | 78.5 | 122.5 | 18.1 | 22.7 | 104.3 |
| 3 | 308.4 | 270.3 | 8.6 | 39.5 | 31.8 | 18.6 | 200.9 | 26.3 | 118.8 | 140.6 | 60.0 | 4.5 | 24.9 | 156.5 |
| 4 | 526.2 | 281.2 | 29.9 | 84.4 | 21.8 | 31.8 | 222.7 | 83.5 | 54.9 | 148.3 | 167.8 | 2.3 | 38.6 | 83.9 |
| 5 | 0 | 243.6 | 13.2 | 55.8 | 16.3 | 20.0 | 155.6 | 61.7 | 55.3 | 204.6 | 158.8 | 6.8 | 34.0 | 104.3 |
| 6 | 508.0 | 199.6 | 20.0 | 24.5 | 9.1 | 52.2 | 212.3 | 53.1 | 67.6 | 173.7 | 60.0 | 0 | 31.8 | 61.2 |
| 7 | 362.9 | 132.9 | 19.1 | 41.3 | 13.6 | 64.9 | 172.4 | 64.9 | 61.2 | 162.4 | 29.5 | 6.8 | 34.0 | 43.1 |
| 8 | 90.7 | 189.2 | 23.6 | 34.0 | 13.6 | 64.9 | 163.7 | 41.3 | 21.3 | 121.6 | 52.2 | 13.6 | 31.8 | 0 |
| 9 | 0 | 97.1 | 18.1 | 6.8 | 15.9 | 86.6 | 202.3 | 17.2 | 9.1 | 23.6 | 31.8 | 40.8 | 36.3 | 149.7 |
| 10 | 0 | 75.3 | 16.3 | 36.3 | 8.6 | 30.8 | 104.3 | 10.4 | | 13.6 | 34.0 | 29.5 | 15.9 | 106.6 |
| 11 | 181.4 | 58.1 | 11.3 | 11.3 | 16.3 | 34.9 | 86.2 | 26.3 | | 11.3 | 24.9 | 15.9 | 13.6 | 38.6 |
| 12 | 580.6 | 55.3 | 2.3 | 13.6 | 19.5 | 27.2 | 78.0 | 13.6 | | 14.5 | 20.4 | 11.3 | 9.1 | 27.2 |
| 13 | 217.7 | 41.7 | 9.1 | 36.3 | 15.9 | 36.3 | 42.2 | | | 9.1 | 6.8 | 13.6 | 6.8 | 22.7 |
| 14 | 217.7 | 23.6 | 2.7 | 52.2 | 10.0 | 20.9 | 121.6 | | | - | 3.2 | 4.5 | 0 | 13.6 |
| 15 | 344.7 | 18.6 | 0.9 | 24.0 | 10.0 | 54.0 | 48.5 | | | - | 2.3 | 4.5 | 2.3 | 15.9 |
| 16 | 417.3 | 12.2 | 0.9 | 27.2 | 7.2 | 34.5 | 13.6 | | | - | 0 | | 2.3 | 15.9 |
| 17 | 308.4 | 40.8 | | 14.1 | 9.5 | 16.3 | 8.2 | | | - | 4.5 | | 0.9 | 4.5 |
| 18 | 199.6 | 11.8 | | 2.3 | 5.9 | 4.5 | 3.2 | | | - | 2.3 | | | 6.8 |
| 19 | 81.6 | 18.1 | | 16.8 | 0 | 8.2 | 3.6 | | | - | 3.2 | | | 15.9 |
| 20 | 40.8 | 25.4 | | 92.1 | 0 | 4.5 | | | | - | | | | 34.5 |
| 21 | 77.1 | 21.8 | | 27.2 | 0 | 0 | | | | - | | | | 18.1 |
| 22 | 54.4 | 21.3 | | 27.7 | 1.8 | 1.8 | | | | - | | | | 11.3 |
| 23 | 36.3 | 18.1 | | 7.2 | 0 | 1.8 | | | | 10.9 | | | | 9.1 |
| 24 | 28.6 | 5.4 | | 21.8 | 0.4 | | | | | 22.7 | | | | 2.3 |
| 25 | 25.9 | 3.6 | | 32.6 | | | | | | 24.5 | | | | |
| 26 | 36.3 | | | 32.2 | | | | | | | | | | |
| 27 | 18.1 | | | 41.3 | | | | | | | | | | |
| 28 | 36.3 | | | 18.6 | | | | | | | | | | |
| 29 | 36.3 | | | 6.8 | | | | | | | | | | |
| 30 | 11.8 | | | 0.9 | | | | | | | | | | |

TABLE 62: Daily catch composition in the Waiatoto River in 1969

| Date | Site 2* m.† (%) | Site 2* b.‡ (%) | Site 2* f.§ (%) | Site 2* No. in sample | Site 6 m. (%) | Site 6 b. (%) | Site 6 f. (%) | Site 6 No. in sample | Site 7 m. (%) | Site 7 b. (%) | Site 7 f. (%) | Site 7 No. in sample |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sep 1 | 96.6 | 3.4 | 0 | 412 | | | | | 97.8 | 2.2 | 0 | 181 |
| 2 | 97.9 | 2.1 | 0 | 292 | | | | | 80.9 | 19.1 | 0 | 257 |
| 3 | 95.2 | 4.8 | 0 | 147 | | | | | - | - | - | - |
| 4 | - | - | - | - | | | | | - | - | - | - |
| 5 | 99.1 | 0.9 | 0 | 219 | | | | | - | - | - | - |
| 6 | - | - | - | - | | | | | - | - | - | - |
| 7 | - | - | - | - | | | | | - | - | - | - |
| 8 | - | - | - | - | 83.1 | 16.6 | 0.3 | 256 | - | - | - | - |
| 9 | - | - | - | - | - | - | - | - | - | - | - | - |
| 10 | - | - | - | - | - | - | - | - | - | - | - | - |
| 11 | - | - | - | - | - | - | - | - | - | - | - | - |
| 12 | - | - | - | - | - | - | - | - | - | - | - | - |
| 13 | - | - | - | - | - | - | - | - | - | - | - | - |
| 14 | - | - | - | - | - | - | - | - | - | - | - | - |
| 15 | - | - | - | - | - | - | - | - | - | - | - | - |
| 16 | 99.6 | 0.3 | 0 | 311 | - | - | - | - | - | - | - | - |
| 17 | 99.2 | 0.8 | 0 | 364 | - | - | - | - | - | - | - | - |
| 18 | 86.7 | 11.8 | 1.5 | 271 | - | - | - | - | - | - | - | - |
| 19 | 98.5 | 1.5 | 0 | 397 | - | - | - | - | - | - | - | - |
| 20 | 99.0 | 1.0 | 0 | 191 | 60.5 | 39.5 | 0 | 304 | - | - | - | - |
| 21 | 99.7 | 0.3 | 0 | 312 | 66.0 | 34.0 | 0 | 262 | - | - | - | - |
| 22 | 97.5 | 2.5 | 0 | 318 | 90.7 | 9.3 | 0 | 290 | - | - | - | - |
| 23 | 94.3 | 5.7 | 0 | 246 | 92.1 | 7.9 | 0 | 381 | - | - | - | - |
| 24 | 93.3 | 6.2 | 0.6 | 178 | 85.2 | 14.8 | 0 | 345 | - | - | - | - |
| 25 | 98.6 | 0.9 | 0.5 | 222 | 86.8 | 12.4 | 0.8 | 363 | - | - | - | - |
| 26 | 91.2 | 7.5 | 1.3 | 229 | 79.7 | 19.2 | 1.1 | 355 | - | - | - | - |
| 27 | 92.2 | 6.9 | 1.0 | 204 | 76.9 | 20.1 | 3.0 | 363 | - | - | - | - |
| 28 | 93.9 | 6.1 | 0 | 165 | 79.1 | 19.2 | 1.7 | 417 | - | - | - | - |
| 29 | 98.4 | 1.0 | 0.5 | 188 | 55.3 | 41.6 | 3.0 | 358 | - | - | - | - |
| 30 | 81.1 | 18.1 | 0.8 | 249 | 60.4 | 37.9 | 1.8 | 391 | - | - | - | - |
| Oct 1 | 89.5 | 9.2 | 1.3 | 152 | 59.9 | 37.7 | 2.5 | 324 | - | - | - | - |
| 2 | 94.8 | 3.8 | 1.4 | 213 | 36.0 | 62.0 | 2.0 | 403 | - | - | - | - |
| 3 | 86.9 | 8.8 | 4.4 | 160 | 54.3 | 43.2 | 2.0 | 407 | - | - | - | - |
| 4 | 94.1 | 2.0 | 3.9 | 304 | 63.0 | 36.7 | 0.3 | 300 | - | - | - | - |
| 5 | 81.5 | 17.9 | 0.5 | 195 | 57.6 | 42.4 | 0 | 264 | - | - | - | - |
| 6 | 88.5 | 11.1 | 0.4 | 262 | 78.6 | 21.4 | 0 | 383 | - | - | - | - |
| 7 | 98.6 | 0.7 | 0.7 | 144 | 83.2 | 16.8 | 0 | 398 | - | - | - | - |
| 8 | 98.4 | 0.8 | 0.8 | 129 | - | - | - | - | - | - | - | - |
| 9 | 95.6 | 4.4 | 0 | 113 | 73.2 | 26.5 | 0.3 | 332 | - | - | - | - |
| 10 | 93.0 | 7.0 | 0 | 142 | 59.5 | 40.5 | 0 | 331 | - | - | - | - |
| 11 | 99.0 | 1.0 | 0 | 206 | 75.8 | 23.9 | 0.3 | 448 | - | - | - | - |
| 12 | 93.4 | 5.6 | 1.0 | 198 | 87.5 | 12.2 | 0.3 | 312 | - | - | - | - |
| 13 | 93.0 | 7.0 | 0 | 227 | 88.6 | 11.4 | 0 | 316 | - | - | - | - |
| 14 | 90.2 | 9.8 | 0 | 173 | 96.7 | 3.0 | 0.3 | 362 | - | - | - | - |
| 15 | 96.1 | 2.9 | 1.0 | 204 | 95.4 | 3.9 | 0.7 | 284 | 77.4 | 22.6 | 0 | 190 |
| 16 | 97.2 | 1.9 | 0.9 | 216 | - | - | - | - | 13.1 | 86.9 | 0 | 252 |
| 17 | 94.1 | 5.4 | 0.5 | 405 | - | - | - | - | 25.2 | 74.8 | 0 | 115 |
| 18 | 90.7 | 9.3 | 0 | 129 | 53.2 | 46.5 | 0.3 | 346 | 22.8 | 77.2 | 0 | 127 |
| 19 | - | - | - | - | 73.2 | 26.8 | 0 | 310 | 24.2 | 75.8 | 0 | 165 |
| 20 | 90.1 | 9.1 | 0.8 | 263 | 37.5 | 62.5 | 0 | 277 | 32.6 | 67.4 | 0 | 92 |
| 21 | 66.7 | 32.7 | 0 | 171 | - | - | - | - | 42.5 | 57.5 | 0 | 228 |
| 22 | 94.1 | 5.9 | 0 | 255 | 31.9 | 68.1 | 0 | 326 | - | - | - | - |
| 23 | 95.1 | 4.9 | 0 | 244 | 62.3 | 37.7 | 0 | 326 | 43.0 | 57.0 | 0 | 186 |
| 24 | 97.5 | 2.5 | 0 | 236 | 68.5 | 31.5 | 0 | 390 | 34.6 | 65.4 | 0 | 231 |
| 25 | 94.2 | 5.8 | 0 | 258 | 84.7 | 15.3 | 0 | 301 | 79.0 | 21.0 | 0 | 138 |
| 26 | 96.0 | 3.7 | 0.4 | 273 | 85.4 | 14.4 | 0.2 | 471 | 41.5 | 58.5 | 0 | 193 |
| 27 | 96.4 | 3.6 | 0 | 253 | - | - | - | - | - | - | - | - |
| 28 | 85.4 | 12.3 | 2.3 | 298 | 59.5 | 40.5 | 0 | 328 | 46.6 | 53.4 | 0 | 119 |
| 29 | 96.5 | 1.4 | 2.1 | 284 | 50.0 | 49.6 | 0.4 | 230 | 31.2 | 68.8 | 0 | 186 |
| 30 | 97.2 | 1.0 | 1.7 | 289 | 77.9 | 22.1 | 0 | 267 | 38.2 | 61.4 | 0.4 | 267 |
| 31 | 98.1 | 0.8 | 1.1 | 263 | 92.4 | 6.3 | 1.3 | 384 | 86.7 | 13.3 | 0 | 241 |

TABLE 62: Daily catch composition in the Waiatoto River in 1969 (continued)

| Date | Site 2 | | | | Site 6 | | | | Site 7 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample |
| Nov 1 | 98.0 | 0.8 | 1.2 | 245 | 88.2 | 11.5 | 0.3 | 381 | 19.9 | 80.1 | 0 | 277 |
| 2 | 94.1 | 4.3 | 1.6 | 304 | 83.4 | 16.1 | 0.5 | 403 | 70.8 | 29.2 | 0 | 336 |
| 3 | 99.2 | 0.6 | 0.2 | 476 | 95.4 | 4.4 | 0.3 | 388 | 26.4 | 72.4 | 1.2 | 163 |
| 4 | 95.2 | 3.5 | 1.3 | 372 | 85.0 | 13.5 | 1.5 | 274 | 67.8 | 30.7 | 1.5 | 205 |
| 5 | 82.2 | 13.5 | 4.3 | 304 | 95.8 | 3.5 | 0.7 | 428 | 35.2 | 64.8 | 0 | 105 |
| 6 | 93.7 | 4.8 | 1.6 | 378 | 91.9 | 7.8 | 0.2 | 396 | 9.7 | 89.8 | 0.5 | 197 |
| 7 | 92.1 | 6.0 | 1.9 | 316 | 88.8 | 10.5 | 0.7 | 446 | 95.3 | 4.7 | 0 | 339 |
| 8 | 85.1 | 11.2 | 3.7 | 241 | 70.2 | 28.0 | 1.8 | 336 | 54.5 | 45.1 | 0.5 | 244 |
| 9 | 88.8 | 10.4 | 0.8 | 249 | 79.5 | 19.9 | 0.6 | 361 | 66.1 | 33.5 | 0.4 | 230 |
| 10 | 92.2 | 2.9 | 4.9 | 102 | - | - | - | - | 55.2 | 40.5 | 4.3 | 116 |
| 11 | 96.0 | 3.7 | 0.3 | 352 | - | - | - | - | 23.3 | 76.2 | 0.5 | 210 |
| 12 | 80.7 | 18.1 | 1.2 | 326 | 19.3 | 80.7 | 0 | 305 | 22.9 | 77.1 | 0 | 223 |
| 13 | 84.8 | 12.2 | 3.0 | 329 | 12.0 | 87.7 | 0.3 | 316 | 17.0 | 82.0 | 1.0 | 200 |
| 14 | 69.6 | 28.5 | 1.9 | 372 | 18.2 | 80.5 | 1.2 | 329 | 5.2 | 94.8 | 0 | 192 |
| 15 | 78.9 | 16.0 | 5.0 | 399 | 20.9 | 77.6 | 1.4 | 277 | 4.6 | 95.4 | 0 | 324 |
| 16 | 68.1 | 28.2 | 3.8 | 476 | 8.8 | 90.8 | 0.4 | 239 | | | | |
| 17 | 82.0 | 11.0 | 7.0 | 228 | 15.4 | 83.6 | 1.0 | 299 | | | | |
| 18 | 83.5 | 1.7 | 14.8 | 297 | 25.2 | 71.7 | 3.0 | 329 | | | | |
| 19 | 79.5 | 3.3 | 17.1 | 210 | 24.1 | 67.0 | 8.9 | 361 | | | | |
| 20 | 65.2 | 2.2 | 32.6 | 319 | 18.0 | 67.2 | 14.8 | 183 | | | | |
| 21 | - | - | - | - | | | | | | | | |
| 22 | - | - | - | - | | | | | | | | |
| 23 | 78.4 | 13.7 | 7.8 | 51 | | | | | | | | |
| 24 | 52.0 | 13.2 | 34.8 | 250 | | | | | | | | |
| 25 | - | - | - | - | | | | | | | | |
| 26 | - | - | - | - | | | | | | | | |
| 27 | 90.9 | 0 | 9.1 | 11 | | | | | | | | |

*The positions of the different sampling sites are shown in Fig. 2 and explained in Table 2.

†m.: *G. maculatus*.

‡b.: *G. brevipinnis*.

§f.: *G. fasciatus*.

TABLE 63: Daily catch composition in miscellaneous Haast area rivers in 1969

| Date | Ship Creek m.* (%) | Ship Creek b.† (%) | Ship Creek f.‡ (%) | Ship Creek No. in sample | Ship Creek trib. m. (%) | Ship Creek trib. b. (%) | Ship Creek trib. f. (%) | Ship Creek trib. No. in sample | Waita River m. (%) | Waita River b. (%) | Waita River f. (%) | Waita River No. in sample |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sep 1 | 100.0 | 0 | 0 | 3 | | | | | 99.7 | 0.3 | 0 | 359 |
| 2 | 100.0 | 0 | 0 | 2 | | | | | 100.0 | 0 | 0 | 375 |
| 3 | - | - | - | - | | | | | - | - | - | - |
| 4 | - | - | - | - | | | | | 100.0 | 0 | 0 | 70 |
| 5 | - | - | - | - | | | | | 99.3 | 0.7 | 0 | 291 |
| 6 | - | - | - | - | | | | | - | - | - | - |
| 7 | - | - | - | - | | | | | - | - | - | - |
| 8 | - | - | - | - | | | | | - | - | - | - |
| 9 | - | - | - | - | | | | | - | - | - | - |
| 10 | - | - | - | - | | | | | - | - | - | - |
| 11 | - | - | - | - | | | | | - | - | - | - |
| 12 | 100.0 | 0 | 0 | 66 | | | | | 97.5 | 2.5 | 0 | 321 |
| 13 | 100.0 | 0 | 0 | 49 | | | | | - | - | - | - |
| 14 | 82.7 | 17.3 | 0 | 52 | | | | | - | - | - | - |
| 15 | 99.3 | 0.7 | 0 | 306 | | | | | 97.8 | 2.2 | 0 | 223 |
| 16 | 100.0 | 0 | 0 | 3 | | | | | 94.1 | 5.9 | 0 | 306 |
| 17 | - | - | - | - | | | | | 99.1 | 0.9 | 0 | 111 |
| 18 | 79.3 | 19.1 | 1.6 | 246 | | | | | 77.9 | 22.1 | 0 | 339 |
| 19 | 84.9 | 14.2 | 0.9 | 338 | | | | | 81.6 | 18.4 | 0 | 343 |
| 20 | 90.9 | 0 | 9.1 | 33 | | | | | 99.1 | 0.9 | 0 | 113 |
| 21 | 100.0 | 0 | 0 | 3 | | | | | 99.1 | 0.9 | 0 | 223 |
| 22 | 54.4 | 37.4 | 8.1 | 270 | | | | | 98.1 | 1.9 | 0 | 212 |
| 23 | - | - | - | - | | | | | - | - | - | - |
| 24 | - | - | - | - | | | | | 98.8 | 0.6 | 0.6 | 160 |
| 25 | - | - | - | - | | | | | 97.1 | 2.1 | 0.9 | 341 |
| 26 | - | - | - | - | | | | | - | - | - | - |
| 27 | - | - | - | - | | | | | 99.2 | 0 | 0.8 | 122 |
| 28 | - | - | - | - | | | | | 100.0 | 0 | 0 | 1 |
| 29 | - | - | - | - | | | | | 98.6 | 1.4 | 0 | 71 |
| 30 | - | - | - | - | | | | | 100.0 | 0 | 0 | 130 |
| Oct 1 | - | - | - | - | | | | | - | - | - | - |
| 2 | - | - | - | - | | | | | - | - | - | - |
| 3 | - | - | - | - | | | | | 99.4 | 0.6 | 0 | 346 |
| 4 | - | - | - | - | | | | | 97.7 | 1.0 | 1.3 | 302 |
| 5 | - | - | - | - | | | | | 96.9 | 0.4 | 2.7 | 258 |
| 6 | - | - | - | - | | | | | 97.7 | 0 | 2.3 | 264 |
| 7 | - | - | - | - | 0 | 8.0 | 92.0 | 25 | - | - | - | - |
| 8 | - | - | - | - | - | - | - | - | - | - | - | - |
| 9 | 93.3 | 2.2 | 4.4 | 43 | - | - | - | - | - | - | - | - |
| 10 | - | - | - | - | - | - | - | - | - | - | - | - |
| 11 | 90.9 | 0 | 9.1 | 11 | 0 | 0 | 100.0 | 1 | - | - | - | - |
| 12 | 10.8 | 68.5 | 20.8 | 130 | 0 | 37.5 | 62.5 | 8 | 99.0 | 0.5 | 0.5 | 392 |
| 13 | 65.2 | 4.3 | 30.4 | 23 | 0 | 22.2 | 77.8 | 27 | 99.3 | 0.7 | 0 | 301 |
| 14 | 45.5 | 15.9 | 38.6 | 44 | 0 | 5.3 | 94.7 | 19 | 100.0 | 0 | 0 | 216 |
| 15 | 95.3 | 0 | 4.7 | 43 | 0 | 25.0 | 75.0 | 4 | 99.4 | 0.3 | 0.3 | 316 |
| 16 | 93.8 | 0 | 6.3 | 16 | 83.3 | 0 | 16.7 | 6 | - | - | - | - |
| 17 | - | - | - | - | 0 | 100.0 | 0 | 1 | 100.0 | 0 | 0 | 244 |
| 18 | 100.0 | 0 | 0 | 1 | 0 | 0 | 100.0 | 3 | - | - | - | - |
| 19 | 0 | 0 | 100.0 | 7 | 0 | 0 | 100.0 | 3 | - | - | - | - |
| 20 | 0 | 0 | 100.0 | 1 | - | - | - | - | 99.7 | 0.3 | 0 | 364 |
| 21 | 0 | 27.2 | 72.7 | 11 | - | - | - | - | - | - | - | - |
| 22 | - | - | - | - | 0 | 0 | 100.0 | 4 | - | - | - | - |
| 23 | 100.0 | 0 | 0 | 5 | - | - | - | - | 97.8 | 1.7 | 0.4 | 230 |
| 24 | 85.7 | 0 | 14.3 | 7 | - | - | - | - | 100.0 | 0 | 0 | 234 |
| 25 | - | - | - | - | 0 | 0 | 100.0 | 2 | - | - | - | - |
| 26 | 0 | 100.0 | 0 | 1 | 0 | 0 | 100.0 | 1 | 95.6 | 4.4 | 0 | 226 |
| 27 | 91.7 | 0 | 8.3 | 12 | - | - | - | - | 100.0 | 0 | 0 | 266 |
| 28 | 25.0 | 75.0 | 0 | 4 | 0 | 0 | 100.0 | 1 | - | - | - | - |
| 29 | 50.0 | 0 | 50.0 | 2 | 0 | 0 | 100.0 | 1 | 98.7 | 1.0 | 0.3 | 309 |
| 30 | 60.0 | 30.0 | 10.0 | 10 | 0 | 0 | 100.0 | 2 | 99.4 | 0.3 | 0.3 | 314 |
| 31 | 33.3 | 50.0 | 16.7 | 6 | - | - | - | - | - | - | - | - |

| Date | Haast River m. (%) | Haast River b. (%) | Haast River f. (%) | Haast River No. in sample | Turnbull River m. (%) | Turnbull River b. (%) | Turnbull River f. (%) | Turnbull River No. in sample | Arawata River m. (%) | Arawata River b. (%) | Arawata River f. (%) | Arawata River No. in sample | Jackson Bay Stream m. (%) | Jackson Bay Stream b. (%) | Jackson Bay Stream f. (%) | Jackson Bay Stream No. in sample |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sep 1 | 95.5 | 4.5 | 0 | 398 | 98.0 | 2.0 | 0 | 456 | 85.0 | 15.0 | 0 | 426 | | | | |
| 2 | 94.6 | 5.4 | 0 | 391 | 96.3 | 3.7 | 0 | 350 | 82.4 | 17.6 | 0 | 324 | | | | |
| 3 | 46.4 | 53.6 | 0 | 349 | - | - | - | - | - | - | - | - | | | | |
| 4 | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 5 | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 6 | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 7 | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 8 | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 9 | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 10 | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 11 | - | - | - | - | - | - | - | - | - | - | - | - | 100.0 | 0 | 0 | 17 |
| 12 | - | - | - | - | - | - | - | - | - | - | - | - | 100.0 | 0 | 0 | 35 |
| 13 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 14 | - | - | - | - | 80.6 | 19.4 | 0 | 320 | - | - | - | - | 100.0 | 0 | 0 | 25 |
| 15 | 20.1 | 79.9 | 0 | 244 | - | - | - | - | - | - | - | - | - | - | - | - |
| 16 | - | - | - | - | 91.0 | 9.0 | 0 | 454 | 5.1 | 94.5 | 0.4 | 256 | 100.0 | 0 | 0 | 33 |
| 17 | 65.6 | 34.4 | 0 | 334 | 100.0 | 0 | 0 | 248 | 10.7 | 89.3 | 0 | 177 | 91.7 | 8.3 | 0 | 12 |
| 18 | 86.7 | 13.3 | 0 | 339 | 98.0 | 2.0 | 0 | 254 | 91.9 | 8.1 | 0 | 123 | - | - | - | - |
| 19 | 89.2 | 10.8 | 0 | 344 | 95.2 | 4.8 | 0 | 292 | 88.1 | 11.9 | 0 | 193 | - | - | - | - |
| 20 | 66.9 | 33.1 | 0 | 366 | 98.3 | 1.7 | 0 | 406 | 82.7 | 17.3 | 0 | 225 | - | - | - | - |
| 21 | 82.4 | 17.6 | 0 | 363 | 99.7 | 0.3 | 0 | 303 | 95.2 | 4.8 | 0 | 270 | - | - | - | - |
| 22 | 94.0 | 6.0 | 0 | 369 | 98.6 | 1.4 | 0 | 355 | 83.5 | 16.5 | 0 | 273 | - | - | - | - |
| 23 | 63.0 | 36.8 | 0.3 | 397 | 88.2 | 11.5 | 0.3 | 339 | 96.2 | 3.4 | 0.3 | 290 | - | - | - | - |
| 24 | 81.5 | 18.1 | 0.4 | 486 | 92.2 | 7.8 | 0 | 270 | 94.9 | 5.1 | 0 | 257 | - | - | - | - |
| 25 | 94.3 | 5.5 | 0.2 | 488 | 97.1 | 2.9 | 0 | 340 | 87.8 | 12.2 | 0 | 246 | - | - | - | - |
| 26 | 92.0 | 8.0 | 0 | 415 | 92.8 | 7.2 | 0 | 181 | 90.1 | 9.9 | 0 | 202 | - | - | - | - |
| 27 | 67.4 | 32.6 | 0 | 414 | 81.2 | 18.5 | 0.4 | 271 | 87.0 | 12.4 | 0.5 | 185 | - | - | - | - |
| 28 | 33.3 | 64.8 | 1.9 | 423 | 91.4 | 7.3 | 1.4 | 220 | 84.3 | 15.7 | 0 | 229 | - | - | - | - |
| 29 | 41.0 | 59.0 | 0 | 344 | 93.8 | 4.8 | 1.4 | 209 | 87.4 | 8.2 | 4.3 | 231 | 0 | 0 | 100.0 | 1 |
| 30 | 57.0 | 40.7 | 2.2 | 356 | 92.4 | 5.2 | 2.4 | 288 | 61.3 | 32.2 | 6.5 | 261 | 0 | 25.0 | 75.0 | 4 |
| Oct 1 | 89.8 | 5.6 | 4.5 | 374 | 90.7 | 8.1 | 1.1 | 270 | 46.3 | 51.7 | 2.0 | 203 | - | - | - | - |
| 2 | 78.7 | 17.6 | 3.7 | 408 | 88.5 | 7.0 | 4.4 | 227 | 72.8 | 26.5 | 0.7 | 272 | 0 | 50.0 | 50.0 | 2 |
| 3 | 96.1 | 1.8 | 2.1 | 383 | 98.3 | 0.6 | 1.2 | 172 | 70.7 | 28.9 | 0.3 | 287 | - | - | - | - |
| 4 | 79.9 | 18.2 | 1.9 | 363 | 86.5 | 7.3 | 6.2 | 275 | 74.8 | 24.0 | 1.1 | 262 | - | - | - | - |
| 5 | 40.7 | 58.8 | 0.5 | 364 | 89.5 | 8.5 | 2.0 | 294 | 76.5 | 22.8 | 0.7 | 302 | - | - | - | - |
| 6 | 80.8 | 18.7 | 0.5 | 380 | 91.7 | 8.3 | 0 | 277 | 91.0 | 9.0 | 0 | 300 | 0 | 13.6 | 86.3 | 22 |
| 7 | 73.6 | 25.3 | 1.1 | 356 | 96.1 | 3.9 | 0 | 282 | 87.2 | 12.5 | 0.3 | 296 | 0 | 2.7 | 97.3 | 37 |
| 8 | 92.3 | 7.7 | 0 | 390 | 95.7 | 4.3 | 0 | 164 | 90.3 | 9.0 | 0.7 | 288 | - | - | - | - |
| 9 | 70.0 | 26.8 | 3.2 | 380 | 95.4 | 4.6 | 0 | 131 | 91.6 | 8.4 | 0 | 225 | 0 | 7.8 | 92.3 | 13 |
| 10 | 47.0 | 50.5 | 2.5 | 279 | 100.0 | 0 | 0 | 11 | 82.2 | 17.8 | 0 | 225 | - | - | - | - |
| 11 | 92.1 | 6.9 | 1.0 | 203 | 96.6 | 3.0 | 0.4 | 235 | 90.7 | 8.6 | 0.8 | 257 | 96.4 | 0 | 3.6 | 55 |
| 12 | 95.3 | 4.7 | 0 | 360 | 96.4 | 3.2 | 0.4 | 248 | 98.6 | 1.4 | 0 | 146 | 0 | 0 | 100.0 | 2 |
| 13 | 92.7 | 7.3 | 0 | 341 | 99.7 | 0.3 | 0 | 290 | 91.9 | 7.6 | 0.4 | 223 | 0 | 0 | 100.0 | 103 |
| 14 | 93.2 | 6.8 | 0 | 354 | 97.6 | 2.4 | 0 | 340 | 57.6 | 42.4 | 0 | 243 | 0 | 0 | 100.0 | 159 |
| 15 | 94.9 | 4.5 | 0.5 | 374 | 96.1 | 3.9 | 0 | 204 | 52.0 | 48.0 | 0 | 204 | - | - | - | - |
| 16 | 96.7 | 3.3 | 0 | 397 | 98.4 | 1.6 | 0 | 306 | 91.2 | 8.8 | 0 | 227 | - | - | - | - |
| 17 | 66.1 | 33.9 | 0 | 322 | 97.3 | 2.7 | 0 | 336 | 80.9 | 19.1 | 0 | 215 | - | - | - | - |
| 18 | 78.9 | 21.1 | 0 | 389 | 98.6 | 1.4 | 0 | 353 | 83.5 | 16.5 | 0 | 212 | - | - | - | - |
| 19 | 78.7 | 20.6 | 0.8 | 399 | 94.7 | 5.3 | 0 | 132 | 75.8 | 23.5 | 0.7 | 293 | - | - | - | - |
| 20 | 76.0 | 24.0 | 0 | 383 | 79.7 | 19.8 | 0.5 | 182 | 74.8 | 25.2 | 0 | 270 | - | - | - | - |
| 21 | 28.8 | 71.2 | 0 | 302 | - | - | - | - | 24.3 | 75.7 | 0 | 152 | - | - | - | - |
| 22 | 63.9 | 36.1 | 0 | 330 | - | - | - | - | 44.3 | 55.7 | 0 | 237 | 0 | 0 | 100.0 | 31 |
| 23 | 45.6 | 54.4 | 0 | 355 | 94.4 | 5.6 | 0 | 214 | 44.6 | 54.8 | 0.5 | 186 | - | - | - | - |
| 24 | 90.4 | 9.0 | 0.6 | 324 | 95.5 | 4.5 | 0 | 398 | 34.4 | 65.6 | 0 | 256 | - | - | - | - |
| 25 | 91.3 | 8.7 | 0 | 276 | 89.3 | 10.4 | 0.3 | 318 | 17.9 | 82.1 | 0 | 234 | 0 | 0 | 100.0 | 10 |
| 26 | 65.9 | 34.1 | 0 | 258 | 92.0 | 7.5 | 0.4 | 465 | 49.9 | 49.9 | 0.3 | 341 | 0 | 0 | 100.0 | 12 |
| 27 | - | - | - | - | 92.1 | 7.9 | 0 | 342 | 53.0 | 47.0 | 0 | 198 | - | - | - | - |
| 28 | 55.3 | 44.7 | 0 | 309 | 91.7 | 8.3 | 0 | 300 | 46.1 | 53.9 | 0 | 282 | 12.5 | 0 | 87.5 | 8 |
| 29 | 71.8 | 27.9 | 0.2 | 476 | 92.1 | 7.0 | 0.9 | 429 | 47.0 | 51.8 | 1.2 | 249 | 0 | 0 | 100.0 | 6 |
| 30 | 71.2 | 28.5 | 0.2 | 407 | 82.1 | 16.7 | 1.3 | 312 | 49.6 | 48.8 | 1.6 | 258 | 0 | 2.9 | 97.1 | 35 |
| 31 | 78.2 | 21.4 | 0.3 | 308 | 89.2 | 10.5 | 0.3 | 314 | 53.2 | 46.0 | 0.8 | 265 | 0 | 0 | 100.0 | 43 |

TABLE 63: Daily catch composition in miscellaneous Haast area rivers in 1969 (continued)

| Date | Ship Creek | | | | Ship Creek trib. | | | | Waita River | | | | Haast River | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample |
| Nov 1 | 100.0 | 0 | 0 | 1 | 0 | 0 | 100.0 | 2 | 98.7 | 0 | 1.3 | 234 | 89.1 | 10.5 | 0.4 | 514 |
| 2 | - | - | - | - | - | - | - | - | 100.0 | 0 | 0 | 231 | 96.4 | 3.2 | 0.4 | 502 |
| 3 | - | - | - | - | 0 | 16.6 | 83.3 | 6 | - | - | - | - | 97.8 | 1.6 | 0.7 | 451 |
| 4 | - | - | - | - | | | | | - | - | - | - | 53.5 | 46.3 | 0.2 | 419 |
| 5 | - | - | - | - | | | | | - | - | - | - | 65.5 | 33.1 | 1.3 | 447 |
| 6 | - | - | - | - | | | | | 100.0 | 0 | 0 | 287 | 52.2 | 47.6 | 0.2 | 416 |
| 7 | 71.9 | 1.7 | 26.4 | 121 | | | | | 99.8 | 0 | 0.2 | 412 | 95.3 | 4.4 | 0.3 | 361 |
| 8 | | | | | | | | | - | - | - | - | 66.0 | 32.3 | 1.7 | 403 |
| 9 | | | | | | | | | 99.0 | 0.7 | 0.3 | 289 | 94.9 | 5.1 | 0 | 451 |
| 10 | | | | | | | | | - | - | - | - | 91.8 | 8.0 | 0.2 | 451 |
| 11 | | | | | | | | | 97.4 | 2.6 | 0 | 234 | - | - | - | - |
| 12 | | | | | | | | | - | - | - | - | - | - | - | - |
| 13 | | | | | | | | | 98.4 | 0.6 | 1.0 | 310 | 43.5 | 56.5 | 0 | 317 |
| 14 | | | | | | | | | - | - | - | - | 14.4 | 85.6 | 0 | 298 |
| 15 | | | | | | | | | - | - | - | - | 14.0 | 86.0 | 0 | 299 |
| 16 | | | | | | | | | 99.0 | 0.5 | 0.5 | 204 | 42.5 | 57.2 | 0.3 | 299 |
| 17 | | | | | | | | | - | - | - | - | 88.8 | 10.7 | 0.4 | 456 |
| 18 | | | | | | | | | - | - | - | - | 16.9 | 82.5 | 0.6 | 343 |
| 19 | | | | | | | | | - | - | - | - | 69.2 | 29.2 | 1.6 | 487 |
| 20 | | | | | | | | | 99.1 | 0.9 | 0 | 219 | 82.9 | 16.1 | 1.0 | 491 |
| 21 | | | | | | | | | | | | | 64.6 | 33.4 | 2.0 | 350 |
| 22 | | | | | | | | | | | | | 96.9 | 3.1 | 0 | 607 |
| 23 | | | | | | | | | | | | | | | | |

| Date | Turnbull River | | | | Arawata River | | | | Jackson Bay Stream | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample |
| Nov 1 | 82.7 | 15.8 | 1.5 | 266 | 52.7 | 46.4 | 0.9 | 317 | 0 | 0 | 100.0 | 5 |
| 2 | 91.6 | 8.4 | 0 | 358 | 61.0 | 38.4 | 0.6 | 318 | 0 | 0 | 100.0 | 2 |
| 3 | 93.4 | 6.3 | 0.3 | 335 | 87.7 | 11.7 | 0.6 | 334 | - | - | - | - |
| 4 | 80.0 | 18.8 | 1.2 | 85 | 37.7 | 62.3 | 0 | 257 | - | - | - | - |
| 5 | 71.4 | 27.1 | 1.4 | 70 | 22.3 | 76.6 | 1.0 | 291 | - | - | - | - |
| 6 | 79.6 | 20.4 | 0 | 162 | 20.3 | 79.3 | 0.4 | 276 | - | - | - | - |
| 7 | 89.5 | 10.5 | 0 | 256 | 66.8 | 31.9 | 1.3 | 238 | 4.5 | 4.5 | 90.9 | 22 |
| 8 | 90.3 | 9.4 | 0.3 | 309 | 46.3 | 52.6 | 1.0 | 287 | - | - | - | - |
| 9 | 89.8 | 9.0 | 1.1 | 177 | 56.1 | 42.0 | 1.8 | 383 | - | - | - | - |
| 10 | - | - | - | - | - | - | - | - | - | - | - | - |
| 11 | 98.8 | 1.2 | 0 | 247 | 40.1 | 59.6 | 0.3 | 324§ | 1.4 | 5.5 | 93.2 | 73 |
| 12 | 93.9 | 5.6 | 0.5 | 375 | 47.3 | 52.3 | 0.4 | 283 | - | - | - | - |
| 13 | - | - | - | - | 42.1 | 57.2 | 0.7 | 290 | - | - | - | - |
| 14 | - | - | - | - | 46.3 | 50.8 | 2.9 | 240 | - | - | - | - |
| 15 | - | - | - | - | 48.9 | 48.2 | 2.9 | 311 | - | - | - | - |
| 16 | 93.6 | 6.0 | 0.4 | 669 | 26.5 | 70.0 | 3.5 | 260 | - | - | - | - |
| 17 | | | | | 18.3 | 75.2 | 6.5 | 306 | - | - | - | - |
| 18 | | | | | 27.6 | 68.2 | 4.2 | 261 | 0 | 2.4 | 97.6 | 40 |
| 19 | | | | | 31.0 | 60.7 | 8.3 | 290 | - | - | - | - |
| 20 | | | | | 21.9 | 61.9 | 16.3 | 215 | - | - | - | - |
| 21 | | | | | | | | | 0 | 0 | 100.0 | 5 |
| 22 | | | | | | | | | 39.2 | 0 | 60.8 | 51 |
| 23 | | | | | | | | | 0 | 0 | 100.0 | 11 |

*m.: *G. maculatus*.

†b.: *G. brevipinnis*.

‡f.: *G. fasciatus*.

§Samples from site on north bank of river from 11/11/69.

TABLE 64: Daily catch composition in Waiatoto River in 1970

| Date | Site 2* | | | | Site 3 | | | | Site 5 | | | | Site 6 | | | | Site 7 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m.† (%) | b.‡ (%) | f.§ (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample |
| Sep 1 | | | | | | | | | | | | | 88.7 | 10.5 | 0.8 | 399 | | | | |
| 2 | | | | | | | | | | | | | - | - | - | - | | | | |
| 3 | | | | | | | | | | | | | - | - | - | - | 98.7 | 1.3 | 0 | 379 |
| 4 | | | | | | | | | 99.8 | 0 | 0.2 | 650 | - | - | - | - | 98.8 | 0.6 | 0.6 | 310 |
| 5 | | | | | | | | | 98.4 | 1.6 | 0 | 191 | - | - | - | - | 97.8 | 0.9 | 1.3 | 227 |
| 6 | | | | | | | | | 100.0 | 0 | 0 | 34 | - | - | - | - | - | - | - | - |
| 7 | | | | | | | | | - | - | - | - | - | - | - | - | - | - | - | - |
| 8 | | | | | | | | | 97.4 | 2.6 | 0 | 151 | - | - | - | - | - | - | - | - |
| 9 | 96.8 | 2.4 | 0.8 | 125 | 96.5 | 3.5 | 0 | 230 | 99.2 | 0.6 | 0.2 | 619 | - | - | - | - | 97.0 | 3.0 | 0 | 203 |
| 10 | - | - | - | - | - | - | - | - | 97.9 | 2.1 | 0 | 429 | - | - | - | - | - | - | - | - |
| 11 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 12 | 98.6 | 0 | 1.4 | 357 | 98.8 | 1.2 | 0 | 415 | - | - | - | - | - | - | - | - | 98.1 | 1.9 | 0 | 310 |
| 13 | 99.6 | 0.4 | 0 | 244 | 99.0 | 1.0 | 0 | 390 | 99.1 | 0.9 | 0 | 2 823 | - | - | - | - | 99.4 | 0.6 | 0 | 511 |
| 14 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 93.7 | 6.3 | 0 | 224 |
| 15 | 99.5 | 0 | 0.5 | 218 | - | - | - | - | 99.2 | 0.8 | 0 | 531 | 97.8 | 2.2 | 0 | 409 | 98.4 | 1.6 | 0 | 256 |
| 16 | 96.5 | 0.5 | 3.0 | 197 | - | - | - | - | - | - | - | - | 93.7 | 6.3 | 0 | 317 | 95.1 | 4.9 | 0 | 223 |
| 17 | 97.6 | 0 | 2.4 | 166 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 18 | 99.6 | 0 | 0.4 | 247 | - | - | - | - | 97.7 | 2.2 | 0.1 | 849 | - | - | - | - | - | - | - | - |
| 19 | 95.6 | 1.3 | 3.1 | 229 | - | - | - | - | 85.7 | 14.3 | 0 | 28 | - | - | - | - | - | - | - | - |
| 20 | 98.8 | 0 | 1.2 | 260 | - | - | - | - | 94.3 | 5.7 | 0 | 617 | 63.1 | 36.9 | 0 | 344 | 89.7 | 10.3 | 0 | 223 |
| 21 | 94.2 | 2.0 | 3.8 | 240 | - | - | - | - | - | - | - | - | 87.1 | 12.9 | 0 | 372 | - | - | - | - |
| 22 | 94.9 | 1.0 | 4.1 | 296 | - | - | - | - | 93.8 | 5.9 | 0.3 | 578 | 89.1 | 10.9 | 0 | 386 | 94.5 | 5.2 | 0.3 | 325 |
| 23 | 96.0 | 1.3 | 2.7 | 226 | - | - | - | - | - | - | - | - | 86.4 | 13.0 | 0.6 | 330 | 55.5 | 44.5 | 0 | 119 |
| 24 | 92.9 | 1.7 | 5.4 | 239 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 25 | 98.8 | 0.6 | 0.6 | 170 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 26 | 98.6 | 1.1 | 0.3 | 276 | 93.2 | 6.4 | 0.3 | 311 | 80.7 | 19.2 | 0.1 | 820 | - | - | - | - | - | - | - | - |
| 27 | - | - | - | - | - | - | - | - | 96.8 | 2.8 | 0.4 | 2 263 | 77.2 | 22.8 | 0 | 377 | - | - | - | - |
| 28 | - | - | - | - | 93.0 | 4.1 | 2.9 | 417 | 97.3 | 0.5 | 2.2 | 414 | 90.2 | 9.8 | 0 | 420 | 83.3 | 15.7 | 1.0 | 210 |
| 29 | - | - | - | - | 97.4 | 1.8 | 0.8 | 384 | 94.3 | 4.6 | 1.1 | 194 | 89.4 | 10.1 | 0.5 | 415 | 83.4 | 16.6 | 0 | 235 |
| 30 | 96.1 | 3.1 | 0.8 | 256 | 99.3 | 0.7 | 0 | 305 | 92.7 | 5.3 | 2.0 | 302 | 95.9 | 4.1 | 0 | 391 | 85.5 | 14.5 | 0 | 330 |
| Oct 1 | 98.5 | 1.5 | 0 | 273 | 98.6 | 1.1 | 0.3 | 354 | 92.6 | 6.6 | 0.8 | 243 | - | - | - | - | 82.6 | 17.4 | 0 | 350 |
| 2 | 98.0 | 1.6 | 0.4 | 245 | 97.9 | 2.1 | 0 | 340 | 91.4 | 0 | 8.6 | 187 | 90.6 | 9.1 | 0.3 | 374 | 76.0 | 22.5 | 1.5 | 258 |
| 3 | 99.6 | 0 | 0.4 | 247 | 99.4 | 0.3 | 0.3 | 346 | 92.5 | 6.7 | 0.8 | 240 | 86.8 | 12.1 | 1.1 | 379 | 96.2 | 3.8 | 0 | 320 |
| 4 | 98.3 | 0.7 | 1.0 | 302 | 99.7 | 0 | 0.3 | 364 | 98.2 | 1.4 | 0.5 | 441 | 96.1 | 3.6 | 0.2 | 415 | 88.7 | 10.5 | 0.8 | 133 |
| 5 | 98.8 | 1.2 | 0 | 259 | 98.0 | 1.8 | 0.2 | 508 | - | - | - | - | 97.4 | 2.4 | 0.3 | 382 | 93.6 | 6.4 | 0 | 204 |
| 6 | 98.2 | 1.4 | 0.4 | 281 | 97.4 | 2.6 | 0 | 230 | - | - | - | - | 88.5 | 11.2 | 0.3 | 312 | 98.0 | 1.6 | 0.4 | 257 |
| 7 | 99.2 | 0.8 | 0 | 369 | 97.6 | 2.4 | 0 | 330 | 96.0 | 4.0 | 0 | 600 | - | - | - | - | - | - | - | - |
| 8 | 97.4 | 0.4 | 2.2 | 268 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 9 | 98.1 | 1.3 | 0.6 | 160 | 98.5 | 1.1 | 0.4 | 265 | 90.7 | 0 | 9.3 | 150 | 69.2 | 30.8 | 0 | 341 | - | - | - | - |
| 10 | 97.3 | 0.4 | 2.3 | 487 | - | - | - | - | 97.4 | 2.6 | 0 | 271 | 76.9 | 23.1 | 0 | 294 | 69.2 | 30.8 | 0 | 91 |
| 11 | 96.8 | 0 | 3.2 | 253 | 99.1 | 0.3 | 0.6 | 317 | - | - | - | - | 97.7 | 1.7 | 0.6 | 349 | 90.8 | 9.2 | 0 | 260 |
| 12 | 97.0 | 0.4 | 2.6 | 265 | 99.0 | 1.0 | 0 | 292 | 98.6 | 1.4 | 0 | 441 | 94.6 | 4.8 | 0.6 | 314 | 93.3 | 6.7 | 0 | 300 |
| 13 | 99.0 | 0.5 | 0.5 | 190 | 99.2 | 0 | 0.8 | 261 | 98.8 | 1.1 | 0.2 | 571 | 99.0 | 1.0 | 0 | 315 | 98.8 | 1.2 | 0 | 335 |
| 14 | 98.3 | 1.7 | 0 | 172 | 99.0 | 0.7 | 0.3 | 291 | 99.3 | 0.7 | 0 | 297 | 99.3 | 0.7 | 0 | 425 | 98.0 | 2.0 | 0 | 252 |
| 15 | 98.9 | 1.1 | 0 | 363 | - | - | - | - | 98.0 | 2.0 | 0 | 102 | 81.9 | 18.1 | 0 | 403 | 93.8 | 6.2 | 0 | 211 |
| 16 | 99.1 | 0 | 0.9 | 231 | 98.4 | 1.3 | 0.3 | 379 | 95.7 | 3.5 | 0.8 | 635 | 81.3 | 17.7 | 1.1 | 379 | 93.2 | 6.5 | 0.3 | 367 |
| 17 | 94.4 | 2.8 | 2.8 | 178 | 97.1 | 2.4 | 0.5 | 411 | 95.9 | 1.1 | 3.0 | 269 | 95.4 | 4.6 | 0 | 373 | 89.5 | 9.2 | 1.3 | 238 |
| 18 | - | - | - | - | 96.4 | 3.1 | 0.5 | 360 | 97.9 | 1.7 | 0.4 | 1 003 | 94.9 | 4.5 | 0.6 | 332 | 86.6 | 12.3 | 1.1 | 253 |
| 19 | - | - | - | - | 94.1 | 5.3 | 0.6 | 339 | 91.2 | 8.5 | 0.3 | 603 | 83.0 | 16.5 | 0.5 | 406 | 94.6 | 4.8 | 0.6 | 165 |
| 20 | 91.3 | 6.6 | 2.1 | 183 | 89.3 | 9.7 | 1.0 | 298 | 92.2 | 5.6 | 2.2 | 641 | 92.3 | 7.4 | 0.3 | 363 | 81.2 | 18.3 | 0.5 | 213 |
| 21 | 99.0 | 0.5 | 0.5 | 197 | - | - | - | - | 92.8 | 3.5 | 3.8 | 692 | 87.4 | 9.8 | 2.8 | 356 | 81.3 | 18.0 | 0.7 | 256 |
| 22 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 23 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 24 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 25 | 96.8 | 2.3 | 0.9 | 221 | 97.3 | 0.7 | 2.0 | 300 | 61.9 | 19.1 | 19.1 | 21 | - | - | - | - | - | - | - | - |
| 26 | 95.8 | 0.8 | 3.4 | 236 | 84.5 | 15.1 | 0.4 | 265 | - | - | - | - | - | - | - | - | - | - | - | - |
| 27 | 99.5 | 0 | 0.5 | 199 | 95.9 | 1.4 | 2.7 | 218 | 88.1 | 11.4 | 0.6 | 2 807 | 93.9 | 5.8 | 0.3 | 380 | 33.5 | 66.1 | 0.4 | 221 |
| 28 | 84.4 | 5.2 | 10.4 | 230 | 91.3 | 2.9 | 5.8 | 173 | 95.6 | 4.0 | 0.4 | 2 798 | 91.7 | 8.3 | 0 | 337 | 25.6 | 74.4 | 0 | 90 |
| 29 | 95.1 | 4.2 | 0.7 | 143 | 93.5 | 3.0 | 3.5 | 231 | 93.2 | 5.6 | 1.2 | 1 031 | 88.8 | 11.2 | 0 | 242 | 84.8 | 15.2 | 0 | 138 |
| 30 | 95.6 | 3.1 | 1.3 | 229 | 94.0 | 3.4 | 2.6 | 235 | - | - | - | - | 50.3 | 49.2 | 0.5 | 187 | 76.2 | 23.4 | 0.4 | 274 |
| 31 | 98.8 | 1.2 | 0 | 172 | 97.1 | 1.5 | 1.5 | 275 | 96.7 | 1.6 | 1.6 | 61 | 88.3 | 10.9 | 0.8 | 239 | 80.6 | 19.0 | 0.4 | 284 |

TABLE 64: Daily catch composition in Waiatoto River in 1970 (continued)

| Date | Site 2 | | | | Site 3 | | | | Site 5 | | | | Site 6 | | | | Site 7 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample |
| Nov 1 | 97.5 | 0.3 | 2.2 | 276 | 91.8 | 1.7 | 6.5 | 292 | 89.0 | 7.3 | 3.7 | 937 | 93.7 | 4.7 | 1.6 | 379 | 77.4 | 18.7 | 3.9 | 203 |
| 2 | 96.9 | 0.2 | 2.9 | 410 | 89.9 | 2.4 | 7.7 | 287 | - | - | - | - | - | - | - | - | - | - | - | - |
| 3 | 98.5 | 0 | 1.5 | 394 | 97.1 | 1.7 | 1.2 | 241 | 94.2 | 5.8 | 0 | 171 | 77.4 | 21.7 | 0.9 | 337 | - | - | - | - |
| 4 | 98.0 | 0.3 | 1.7 | 295 | 98.1 | 1.5 | 0.4 | 269 | - | - | - | - | 84.9 | 14.5 | 0.6 | 345 | 80.3 | 19.3 | 0.4 | 233 |
| 5 | 98.4 | 0 | 1.6 | 251 | 99.6 | 0 | 0.4 | 265 | 97.2 | 0.9 | 1.9 | 1 809 | 93.6 | 6.4 | 0 | 235 | 80.2 | 19.2 | 0.6 | 177 |
| 6 | 94.9 | 0.7 | 4.4 | 410 | 97.7 | 0.6 | 1.7 | 350 | - | - | - | - | 92.4 | 4.3 | 3.4 | 328 | 95.0 | 4.6 | 0.4 | 262 |
| 7 | 89.5 | 0 | 10.5 | 277 | 92.1 | 1.4 | 6.5 | 292 | 97.4 | 0.5 | 2.1 | 2 659 | 96.4 | 1.5 | 2.1 | 332 | 92.6 | 7.1 | 0.3 | 340 |
| 8 | 93.9 | 0.6 | 5.5 | 326 | 94.1 | 0.3 | 5.6 | 339 | 97.0 | 0.5 | 2.5 | 442 | 97.4 | 0.9 | 1.8 | 457 | | | | |
| 9 | 88.7 | 0.8 | 10.5 | 238 | 92.8 | 1.7 | 5.5 | 289 | 98.4 | 0.5 | 1.1 | 380 | 97.6 | 0.7 | 1.7 | 297 | | | | |
| 10 | 89.7 | 0 | 10.3 | 243 | 91.3 | 1.8 | 6.9 | 333 | 93.3 | 0.5 | 6.1 | 923 | 96.5 | 0.8 | 2.8 | 395 | | | | |
| 11 | 90.9 | 0.6 | 8.5 | 319 | 93.0 | 1.6 | 5.4 | 315 | 95.7 | 1.5 | 2.8 | 745 | 97.9 | 1.0 | 1.2 | 420 | | | | |
| 12 | - | - | - | - | - | - | - | - | - | - | - | - | | | | | | | | |
| 13 | 96.0 | 0 | 4.0 | 374 | 90.3 | 0 | 9.7 | 422 | 95.2 | 4.8 | 0 | 62 | | | | | | | | |
| 14 | | | | | 90.1 | 0.4 | 9.5 | 453 | 84.2 | 13.2 | 2.6 | 38 | | | | | | | | |
| 15 | | | | | | | | | - | - | - | - | | | | | | | | |
| 16 | | | | | | | | | 95.5 | 3.7 | 0.7 | 134 | | | | | | | | |
| 17 | | | | | | | | | 98.1 | 1.3 | 0.6 | 472 | | | | | | | | |
| 18 | | | | | | | | | - | - | - | - | | | | | | | | |
| 19 | | | | | | | | | - | - | - | - | | | | | | | | |
| 20 | | | | | | | | | 95.0 | 5.0 | 0 | 20 | | | | | | | | |

*The positions of the different sampling sites are shown in Fig. 2 and explained in Table 2.

†m.: *G. maculatus*.

‡b.: *G. brevipinnis*.

§f.: *G. fasciatus*.

TABLE 65: Daily catch composition in Waiatoto River tributaries in 1970

| Date | Content Creek | | | | Nisson Creek | | | | Brewer Water | | | | Hubbub Torrent | | | | Gliding Rivulet | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m.* (%) | b.† (%) | f.‡ (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample |
| Sep 3 | | | | | | | | | 100.0 | 0 | 0 | 1 | | | | | | | | |
| 4 | 99.6 | 0 | 0.4 | 237 | | | | | 100.0 | 0 | 0 | 3 | | | | | | | | |
| 5 | 95.7 | 0.1 | 4.2 | 1 244 | | | | | - | - | - | - | | | | | | | | |
| 6 | - | - | - | - | | | | | - | - | - | - | | | | | | | | |
| 7 | 95.1 | 0 | 4.9 | 779 | | | | | - | - | - | - | | | | | | | | |
| 8 | 98.6 | 0 | 1.4 | 910 | | | | | 100.0 | 0 | 0 | 3 | 100.0 | 0 | 0 | 1 | | | | |
| 9 | 98.5 | 0 | 1.5 | 949 | | | | | - | - | - | - | - | - | - | - | | | | |
| 10 | 98.3 | 0 | 1.7 | 1 419 | 100.0 | 0 | 0 | 127 | - | - | - | - | - | - | - | - | | | | |
| 11 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 12 | 97.6 | 0 | 2.4 | 1 310 | - | - | - | - | - | - | - | - | 0 | 100.0 | 0 | 1 | | | | |
| 13 | 94.7 | 0 | 5.3 | 114 | - | - | - | - | 100.0 | 0 | 0 | 2 | - | - | - | - | | | | |
| 14 | 99.7 | 0 | 0.3 | 2 025 | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 15 | - | - | - | - | - | - | - | - | 100.0 | 0 | 0 | 1 | - | - | - | - | | | | |
| 16 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 17 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 18 | - | - | - | - | - | - | - | - | 100.0 | 0 | 0 | 1 | - | - | - | - | | | | |
| 19 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 20 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 21 | - | - | - | - | - | - | - | - | 100.0 | 0 | 0 | 1 | - | - | - | - | | | | |
| 22 | - | - | - | - | 95.7 | 4.3 | 0 | 117 | 100.0 | 0 | 0 | 1 | 0 | 100.0 | 0 | 1 | | | | |
| 23 | - | - | - | - | 100.0 | 0 | 0 | 42 | - | - | - | - | - | - | - | - | | | | |
| 24 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 25 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 26 | 100.0 | 0 | 0 | 8 | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 27 | - | - | - | - | 100.0 | 0 | 0 | 30 | - | - | - | - | - | - | - | - | | | | |
| 28 | 99.7 | 0 | 0.3 | 389 | 90.0 | 10.0 | 1 | 10 | - | - | - | - | - | - | - | - | | | | |
| 29 | 95.5 | 0 | 4.5 | 201 | 93.8 | 6.2 | 0 | 32 | 40.0 | 60.0 | 0 | 5 | - | - | - | - | | | | |
| 30 | 80.2 | 0.3 | 19.5 | 344 | 100.0 | 0 | 0 | 9 | 0 | 100.0 | 0 | 1 | - | - | - | - | 50.0 | 50.0 | 0 | 2 |
| Oct 1 | 74.5 | 0.5 | 25.0 | 427 | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 100.0 | 0 | 1 |
| 2 | 95.3 | 3.4 | 1.3 | 232 | - | - | - | - | 0 | 100.0 | 0 | 2 | - | - | - | - | 0 | 100.0 | 0 | 1 |
| 3 | - | - | - | - | - | - | - | - | 0 | 100.0 | 0 | 3 | - | - | - | - | - | - | - | - |
| 4 | - | - | - | - | 99.0 | 1.0 | 0 | 97 | 14.3 | 85.7 | 0 | 7 | - | - | - | - | - | - | - | - |
| 5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 6 | 99.5 | 0 | 0.5 | 915 | 85.2 | 14.6 | 0.2 | 417 | 11.1 | 88.9 | 0 | 9 | 0 | 100.0 | 0 | 1 | 0 | 100.0 | 0 | 1 |
| 7 | 97.0 | 0 | 3.0 | 336 | 96.1 | 3.9 | 0 | 204 | 50.0 | 50.0 | 0 | 2 | - | - | - | - | - | - | - | - |
| 8 | - | - | - | - | - | - | - | - | 50.0 | 50.0 | 0 | 2 | - | - | - | - | 0 | 100.0 | 0 | 8 |
| 9 | 98.2 | 0 | 1.8 | 164 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 10 | - | - | - | - | 94.6 | 5.4 | 0 | 93 | 0 | 100.0 | 0 | 2 | - | - | - | - | 25.0 | 75.0 | 0 | 4 |
| 11 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 12 | 98.8 | 0 | 1.2 | 663 | 96.3 | 3.7 | 0 | 27 | - | - | - | - | - | - | - | - | - | - | - | - |
| 13 | 95.6 | 0.2 | 4.2 | 480 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 14 | - | - | - | - | 98.0 | 2.0 | 0 | 504 | 0 | 100.0 | 0 | 4 | - | - | - | - | - | - | - | - |
| 15 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 16 | 99.3 | 0 | 0.7 | 1 361 | 96.7 | 3.3 | 0 | 509 | - | - | - | - | - | - | - | - | 0 | 100.0 | 0 | 1 |
| 17 | 99.0 | 0 | 1.0 | 477 | - | - | - | - | - | - | - | - | 0 | 100.0 | 0 | 1 | - | - | - | - |
| 18 | 99.2 | 0 | 0.8 | 238 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 19 | 100.0 | 0 | 0 | 158 | 98.8 | 1.2 | 0 | 2 004 | - | - | - | - | - | - | - | - | - | - | - | - |
| 20 | 97.1 | 0 | 2.9 | 245 | 100.0 | 0 | 0 | 8 | - | - | - | - | - | - | - | - | - | - | - | - |
| 21 | 97.9 | 0 | 2.1 | 142 | - | - | - | - | 0 | 100.0 | 0 | 2 | 0 | 100.0 | 0 | 1 | 6.7 | 93.3 | 0 | 15 |
| 22 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 23 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 24 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 25 | 95.7 | 0 | 4.3 | 162 | - | - | - | - | - | - | - | - | 50.0 | 50.0 | 0 | 2 | - | - | - | - |
| 26 | 98.5 | 0 | 1.5 | 1 442 | - | - | - | - | 14.3 | 85.7 | 0 | 7 | - | - | - | - | - | - | - | - |
| 27 | 97.3 | 0.2 | 2.5 | 590 | 80.3 | 19.7 | 0 | 61 | - | - | - | - | - | - | - | - | - | - | - | - |
| 28 | 95.3 | 0 | 4.7 | 321 | 95.8 | 4.2 | 0 | 24 | - | - | - | - | - | - | - | - | 0 | 100.0 | 0 | 1 |
| 29 | 95.6 | 0 | 4.4 | 45 | 75.5 | 24.5 | 0 | 49 | 25.0 | 75.0 | 0 | 8 | 0 | 100.0 | 0 | 1 | 8.3 | 91.7 | 0 | 11 |
| 30 | 96.8 | 0 | 3.2 | 155 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 31 | 94.7 | 0 | 5.3 | 374 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

TABLE 65: Daily catch composition in Waiatoto River tributaries in 1970 (continued)

| Date | Content Creek | | | | Nisson Creek | | | | Brewer Water | | | | Hubbub Torrent | | | | Gliding Rivulet | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample |
| Nov 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2 | 85.6 | 0 | 14.3 | 934 | 93.9 | 6.1 | 0 | 82 | 0 | 100.0 | 0 | 10 | 0 | 100.0 | 0 | 10 | 5.1 | 94.9 | 0 | 39 |
| 3 | 92.1 | 0 | 7.9 | 567 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 4 | 97.0 | 0 | 3.0 | 1 061 | 69.0 | 31.0 | 0 | 58 | 0 | 100.0 | 0 | 3 | - | - | - | - | 0 | 100.0 | 0 | 10 |
| 5 | 97.9 | 0 | 2.1 | 327 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 6 | 97.4 | 0 | 2.6 | 584 | 85.7 | 14.3 | 0 | 14 | 0 | 100.0 | 0 | 40 | 0 | 100.0 | 0 | 2 | 4.2 | 95.8 | 0 | 24 |
| 7 | 96.3 | 0 | 3.7 | 408 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 8 | - | - | - | - | - | - | - | - | 3.3 | 96.7 | 0 | 30 | 0 | 100.0 | 0 | 10 | 0 | 100.0 | 0 | 7 |
| 9 | - | - | - | - | 96.7 | 2.9 | 0.4 | 277 | 0 | 100.0 | 0 | 12 | 0 | 100.0 | 0 | 9 | 0 | 100.0 | 0 | 4 |
| 10 | - | - | - | - | 100.0 | 0 | 0 | 19 | - | - | - | - | - | - | - | - | - | - | - | - |
| 11 | 89.5 | 0 | 10.5 | 38 | 93.2 | 5.9 | 0.9 | 118 | 16.7 | 83.3 | 0 | 12 | 0 | 100.0 | 0 | 7 | 50.0 | 25.0 | 25.0 | 4 |
| 12 | - | - | - | - | | | | | | | | | | | | | - | - | - | - |
| 13 | 95.2 | 0.1 | 4.7 | 1 218 | | | | | | | | | | | | | - | - | - | - |
| 14 | - | - | - | - | | | | | | | | | | | | | - | - | - | - |
| 15 | 95.9 | 0 | 4.1 | 2 013 | | | | | | | | | | | | | - | - | - | - |
| 16 | - | - | - | - | | | | | | | | | | | | | 44.4 | 55.6 | 0 | 9 |
| 17 | 92.4 | 0 | 7.6 | 329 | | | | | | | | | | | | | | | | |
| 18 | - | - | - | - | | | | | | | | | | | | | | | | |
| 19 | 96.4 | 0 | 3.6 | 2 481 | | | | | | | | | | | | | | | | |
| 20 | 97.9 | 0 | 2.1 | 419 | | | | | | | | | | | | | | | | |
| 21 | - | - | - | - | | | | | | | | | | | | | | | | |
| 22 | - | - | - | - | | | | | | | | | | | | | | | | |
| 23 | 96.8 | 0 | 3.2 | 249 | | | | | | | | | | | | | | | | |

*m.: *G. maculatus*.

†b.: *G. brevipinnis*.

‡f.: *G. fasciatus*.

TABLE 66: Daily catch composition in Waiatoto River in 1971

| Date | Site 2* | | | | Site 3 | | | | Site 4 | | | | Site 5 | | | | Site 6 | | | | Site 7 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m.† (%) | b.‡ (%) | f.§ (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample |
| Aug 29 | | | | | | | | | | | | | 99.0 | 1.0 | 0 | 298 | | | | | | | | |
| 30 | | | | | | | | | | | | | 100.0 | 0 | 0 | 55 | | | | | | | | |
| 31 | | | | | | | | | | | | | 100.0 | 0 | 0 | 63 | | | | | | | | |
| Sep 1 | | | | | | | | | | | | | 100.0 | 0 | 0 | 79 | | | | | | | | |
| 2 | | | | | | | | | | | | | 97.2 | 1.2 | 1.7 | 121 | | | | | | | | |
| 3 | | | | | | | | | | | | | 96.6 | 0 | 3.4 | 29 | | | | | | | | |
| 4 | | | | | | | | | | | | | 97.5 | 1.8 | 0.7 | 755 | | | | | | | | |
| 5 | | | | | | | | | | | | | - | - | - | - | | | | | | | | |
| 6 | | | | | | | | | | | | | - | - | - | - | 94.7 | 4.7 | 0.6 | 360 | | | | |
| 7 | | | | | | | | | 97.2 | 2.1 | 0.7 | 568 | 98.5 | 1.5 | 0 | 68 | 95.5 | 4.5 | 0 | 374 | | | | |
| 8 | 98.9 | 0 | 1.1 | 180 | 97.9 | 1.8 | 0.2 | 340 | 96.5 | 3.0 | 0.5 | 368 | 98.3 | 0.4 | 1.3 | 231 | 97.1 | 2.9 | 0 | 339 | | | | |
| 9 | 95.3 | 0.4 | 4.3 | 211 | 98.1 | 0.7 | 1.3 | 153 | 99.0 | 0.6 | 0.4 | 669 | 98.2 | 0.5 | 1.3 | 399 | 93.6 | 4.0 | 2.4 | 373 | 95.5 | 3.0 | 1.5 | 332 |
| 10 | 97.1 | 1.2 | 1.7 | 172 | - | - | - | - | 98.8 | 0.7 | 0.5 | 819 | 96.9 | 2.6 | 0.5 | 193 | 97.1 | 1.7 | 1.2 | 414 | 94.5 | 5.1 | 0.4 | 273 |
| 11 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 12 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 13 | - | - | - | - | - | - | - | - | - | - | - | - | 98.2 | 1.8 | 0 | 168 | - | - | - | - | - | - | - | - |
| 14 | - | - | - | - | - | - | - | - | 96.2 | 1.9 | 1.9 | 680 | 94.7 | 4.5 | 0.8 | 1 066 | 84.6 | 15.4 | 0 | 280 | - | - | - | - |
| 15 | - | - | - | - | - | - | - | - | 96.3 | 2.4 | 1.3 | 1 109 | 96.4 | 2.3 | 1.3 | 530 | 83.0 | 16.8 | 0.2 | 399 | - | - | - | - |
| 16 | 97.1 | 1.4 | 1.4 | 208 | 98.4 | 0 | 1.6 | 321 | 97.3 | 0.8 | 1.9 | 703 | 97.0 | 1.2 | 1.8 | 596 | 91.2 | 8.0 | 0.8 | 365 | - | - | - | - |
| 17 | - | - | - | - | 98.6 | 0.4 | 1.0 | 291 | - | - | - | - | 99.3 | 0.5 | 0.2 | 1 235 | 96.1 | 3.7 | 0.2 | 408 | - | - | - | - |
| 18 | - | - | - | - | - | - | - | - | 98.1 | 0.9 | 1.0 | 700 | 98.6 | 1.1 | 0.3 | 505 | 96.4 | 3.6 | 0 | 418 | - | - | - | - |
| 19 | 96.8 | 1.6 | 1.6 | 184 | - | - | - | - | - | - | - | - | 87.4 | 12.6 | 0 | 87 | - | - | - | - | - | - | - | - |
| 20 | 98.8 | 0 | 1.2 | 171 | 99.2 | 0.8 | 0 | 133 | 96.0 | 0.7 | 3.3 | 693 | - | - | - | - | 80.1 | 19.9 | 0 | 307 | - | - | - | - |
| 21 | - | - | - | - | 94.6 | 3.1 | 2.3 | 299 | 95.3 | 1.7 | 3.0 | 635 | 94.1 | 4.5 | 1.4 | 1 309 | 88.7 | 11.1 | 0.2 | 433 | - | - | - | - |
| 22 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 23 | 99.6 | 0 | 0.4 | 253 | 97.3 | 2.2 | 0.5 | 185 | 95.5 | 1.9 | 2.6 | 641 | 94.4 | 0.5 | 5.1 | 591 | 54.1 | 45.6 | 0.3 | 307 | - | - | - | - |
| 24 | 98.2 | 0.3 | 1.5 | 341 | 91.7 | 6.1 | 2.2 | 360 | 94.0 | 2.6 | 3.4 | 648 | 95.4 | 2.9 | 1.7 | 1 242 | 91.2 | 8.8 | 0 | 317 | - | - | - | - |
| 25 | 99.0 | 1.0 | 0 | 201 | - | - | - | - | 98.2 | 0.9 | 0.9 | 636 | 77.5 | 19.0 | 3.5 | 1 923 | 68.2 | 30.7 | 1.1 | 365 | - | - | - | - |
| 26 | - | - | - | - | - | - | - | - | 97.1 | 2.6 | 0.3 | 583 | 94.4 | 2.8 | 2.8 | 362 | 86.4 | 12.8 | 0.8 | 374 | 80.1 | 19.4 | 0.5 | 381 |
| 27 | - | - | - | - | - | - | - | - | 97.9 | 1.1 | 1.0 | 515 | 99.6 | 0.4 | 0 | 233 | 96.4 | 3.6 | 0 | 394 | - | - | - | - |
| 28 | - | - | - | - | - | - | - | - | 95.7 | 2.1 | 2.2 | 629 | - | - | - | - | - | - | - | - | - | - | - | - |
| 29 | 91.4 | 2.9 | 5.7 | 105 | 92.4 | 7.2 | 0.4 | 237 | 94.1 | 1.5 | 4.4 | 1 242 | 98.1 | 1.9 | 0 | 108 | 81.7 | 18.0 | 0.3 | 333 | - | - | - | - |
| 30 | 92.1 | 3.0 | 5.0 | 101 | 95.7 | 3.0 | 1.3 | 230 | 96.6 | 1.1 | 2.3 | 1 220 | 97.9 | 1.3 | 0.8 | 1 982 | 93.4 | 5.1 | 1.5 | 395 | - | - | - | - |
| Oct 1 | 95.7 | 0.7 | 3.6 | 139 | 83.7 | 7.8 | 8.5 | 331 | 97.8 | 0.5 | 1.7 | 576 | 95.3 | 4.0 | 0.7 | 1 199 | 94.9 | 5.1 | 0 | 369 | - | - | - | - |
| 2 | 99.3 | 0 | 0.7 | 139 | 98.1 | 0.3 | 1.6 | 309 | 99.1 | 0.3 | 0.6 | 630 | 99.2 | 0.3 | 0.5 | 592 | 91.6 | 8.2 | 0.2 | 453 | - | - | - | - |
| 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 6 | 100.0 | 0 | 0 | 133 | 84.0 | 16.0 | 0 | 231 | 97.8 | 1.7 | 0.5 | 629 | 95.0 | 5.0 | 0 | 720 | 82.4 | 17.6 | 0 | 353 | - | - | - | - |
| 7 | 97.8 | 0.5 | 1.7 | 181 | 98.0 | 2.0 | 0 | 203 | 98.2 | 0.8 | 1.0 | 611 | 96.8 | 3.0 | 0.2 | 2 916 | 96.3 | 3.7 | 0 | 519 | 86.7 | 13.3 | 0 | 309 |
| 8 | 99.3 | 0 | 0.7 | 142 | - | - | - | - | 99.4 | 0.4 | 0.2 | 787 | 96.6 | 2.7 | 0.7 | 5 234 | 90.9 | 9.1 | 0 | 372 | 90.9 | 9.1 | 0 | 274 |
| 9 | 98.8 | 0 | 1.2 | 164 | - | - | - | - | 97.4 | 0.1 | 2.5 | 681 | 100.0 | 0 | 0 | 27 | 97.3 | 2.0 | 0.7 | 410 | 96.0 | 4.0 | 0 | 303 |
| 10 | - | - | - | - | - | - | - | - | - | - | - | - | 98.3 | 1.2 | 0.5 | 406 | - | - | - | - | - | - | - | - |
| 11 | - | - | - | - | - | - | - | - | - | - | - | - | 72.7 | 27.3 | 0 | 22 | - | - | - | - | - | - | - | - |
| 12 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 13 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 98.7 | 0.3 | 1.0 | 294 | - | - | - | - |
| 14 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 15 | - | - | - | - | - | - | - | - | - | - | - | - | 88.1 | 9.5 | 2.4 | 42 | - | - | - | - | - | - | - | - |
| 16 | - | - | - | - | 87.4 | 12.6 | 0 | 223 | 90.9 | 6.7 | 2.4 | 670 | 91.3 | 7.4 | 1.3 | 1 184 | - | - | - | - | - | - | - | - |
| 17 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 18 | - | - | - | - | - | - | - | - | 94.6 | 4.0 | 1.4 | 505 | - | - | - | - | 62.9 | 36.9 | 0.2 | 423 | - | - | - | - |
| 19 | 96.2 | 0 | 3.8 | 156 | - | - | - | - | 98.8 | 0.6 | 0.6 | 684 | - | - | - | - | 38.6 | 61.1 | 0.3 | 316 | - | - | - | - |
| 20 | 97.5 | 0.6 | 1.9 | 157 | 97.5 | 1.9 | 0.6 | 360 | 99.4 | 0.4 | 0.2 | 554 | 100.0 | 0 | 0 | 38 | 87.6 | 12.4 | 0 | 437 | 47.2 | 52.8 | 0 | 322 |
| 21 | 96.8 | 0 | 3.2 | 157 | 99.0 | 0.5 | 0.5 | 206 | 99.0 | 0.3 | 0.7 | 670 | 98.6 | 1.0 | 0.4 | 1 798 | 93.3 | 6.7 | 0 | 403 | 82.8 | 17.2 | 0 | 192 |
| 22 | 96.6 | 0.9 | 2.6 | 117 | 99.5 | 0.5 | 0 | 200 | 99.7 | 0 | 0.3 | 595 | 98.8 | 0.6 | 0.6 | 2 802 | 97.1 | 2.0 | 0.9 | 345 | 91.1 | 8.9 | 0 | 258 |
| 23 | 99.5 | 0 | 0.5 | 193 | - | - | - | - | 99.7 | 0.2 | 0.2 | 602 | 98.3 | 1.2 | 0.5 | 4 884 | 97.1 | 1.5 | 1.5 | 344 | 95.3 | 4.7 | 0 | 360 |
| 24 | 96.4 | 0.6 | 3.0 | 166 | 98.3 | 1.0 | 0.7 | 291 | 99.5 | 0.5 | 0 | 630 | 98.1 | 1.0 | 0.9 | 2 337 | 97.1 | 1.8 | 1.1 | 455 | 91.9 | 8.1 | 0 | 356 |
| 25 | 97.3 | 0.7 | 2.1 | 146 | 99.4 | 0 | 0.6 | 333 | 98.2 | 0.8 | 1.0 | 730 | 97.5 | 1.4 | 1.1 | 3 212 | 98.0 | 1.2 | 0.8 | 517 | 96.7 | 3.3 | 0 | 363 |
| 26 | - | - | - | - | 95.4 | 0 | 4.6 | 239 | 95.5 | 1.2 | 3.3 | 514 | 98.3 | 1.2 | 0.5 | 1 655 | 90.6 | 7.9 | 1.5 | 392 | 95.9 | 3.8 | 0.3 | 290 |
| 27 | - | - | - | - | - | - | - | - | - | - | - | - | 99.2 | 0.3 | 0.5 | 615 | 98.5 | 0 | 1.5 | 404 | 98.7 | 1.3 | 0 | 317 |
| 28 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 29 | - | - | - | - | - | - | - | - | 99.1 | 0 | 0.9 | 336 | - | - | - | - | - | - | - | - | - | - | - | - |
| 30 | - | - | - | - | - | - | - | - | - | - | - | - | 98.6 | 1.4 | 0 | 73 | - | - | - | - | - | - | - | - |
| 31 | - | - | - | - | 97.8 | 1.3 | 0.9 | 228 | 99.9 | 0 | 0.1 | 984 | 97.4 | 2.2 | 0.4 | 1 434 | 99.1 | 0.5 | 0.5 | 437 | - | - | - | - |

TABLE 66: Daily catch composition in Waiatoto River in 1971 (continued)

| Date | Site 2 m. (%) | Site 2 b. (%) | Site 2 f. (%) | Site 2 No. in sample | Site 3 m. (%) | Site 3 b. (%) | Site 3 f. (%) | Site 3 No. in sample | Site 4 m. (%) | Site 4 b. (%) | Site 4 f. (%) | Site 4 No. in sample |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nov 1 | - | - | - | - | 98.2 | 0.9 | 0.9 | 225 | 99.7 | 0 | 0.3 | 670 |
| 2 | 88.4 | 0.5 | 11.1 | 190 | 99.6 | 0 | 0.4 | 232 | 99.6 | 0.2 | 0.2 | 562 |
| 3 | 92.2 | 0 | 7.8 | 232 | - | - | - | - | 99.5 | 0.3 | 0.2 | 658 |
| 4 | 90.5 | 0.7 | 8.8 | 147 | 98.3 | 0.3 | 1.4 | 286 | 99.4 | 0.2 | 0.5 | 651 |
| 5 | 88.4 | 0.6 | 11.0 | 172 | - | - | - | - | | | | |
| 6 | 90.2 | 0.9 | 8.8 | 215 | 98.9 | 0 | 1.1 | 269 | | | | |
| 7 | 89.2 | 1.3 | 9.6 | 240 | 96.2 | 0.4 | 3.4 | 234 | | | | |
| 8 | 94.1 | 0 | 5.9 | 254 | 94.8 | 0 | 5.2 | 251 | | | | |
| 9 | 94.5 | 0 | 5.5 | 273 | 95.2 | 0 | 4.8 | 231 | | | | |
| 10 | 92.9 | 0.4 | 6.7 | 254 | 84.8 | 1.6 | 13.6 | 184 | | | | |
| 11 | 93.7 | 0.3 | 6.0 | 302 | 92.9 | 0.4 | 6.7 | 254 | | | | |
| 12 | - | - | - | - | 92.1 | 0 | 7.9 | 254 | | | | |
| 13 | 86.0 | 1.2 | 12.8 | 243 | | | | | | | | |
| 14 | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | |
| 19 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 21 | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | |

| Date | Site 5 m. (%) | Site 5 b. (%) | Site 5 f. (%) | Site 5 No. in sample | Site 6 m. (%) | Site 6 b. (%) | Site 6 f. (%) | Site 6 No. in sample | Site 7 m. (%) | Site 7 b. (%) | Site 7 f. (%) | Site 7 No. in sample |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nov 1 | 99.0 | 0.5 | 0.5 | 402 | 94.0 | 5.4 | 0.6 | 351 | - | - | - | - |
| 2 | 99.9 | 0 | 0.1 | 829 | - | - | - | - | 96.7 | 2.9 | 0.4 | 243 |
| 3 | 99.0 | 0.6 | 0.4 | 708 | 99.2 | 0.8 | 0 | 363 | 98.4 | 1.3 | 0.3 | 314 |
| 4 | 98.9 | 0.8 | 0.3 | 531 | 99.3 | 0.5 | 2 | 406 | 97.7 | 2.0 | 0.3 | 394 |
| 5 | 96.8 | 0.1 | 2.2 | 477 | 96.0 | 1.2 | 2.8 | 396 | 96.9 | 2.3 | 0.8 | 355 |
| 6 | 98.8 | 0.3 | 0.9 | 632 | 95.3 | 2.1 | 2.6 | 379 | 98.5 | 0.6 | 0.9 | 323 |
| 7 | 96.4 | 0.6 | 3.0 | 638 | 96.8 | 0 | 3.2 | 434 | 99.4 | 0.3 | 0.3 | 311 |
| 8 | 97.9 | 0.3 | 1.8 | 607 | 97.7 | 0.5 | 1.8 | 397 | 99.2 | 0 | 0.8 | 263 |
| 9 | - | - | - | - | 98.3 | 0 | 1.7 | 415 | | | | |
| 10 | 96.4 | 0.4 | 3.2 | 500 | 96.6 | 1.0 | 2.4 | 507 | | | | |
| 11 | - | - | - | - | - | - | - | - | | | | |
| 12 | 96.7 | 0.3 | 3.0 | 607 | - | - | - | - | | | | |
| 13 | 95.0 | 0.4 | 4.6 | 700 | 97.7 | 0.4 | 1.9 | 477 | | | | |
| 14 | - | - | - | - | | | | | | | | |
| 15 | - | - | - | - | | | | | | | | |
| 16 | 86.8 | 0.6 | 12.6 | 676 | | | | | | | | |
| 17 | 79.4 | 0.5 | 20.0 | 631 | | | | | | | | |
| 18 | 81.1 | 0 | 18.9 | 397 | | | | | | | | |
| 19 | 93.8 | 0 | 6.2 | 32 | | | | | | | | |
| 20 | 83.7 | 0.9 | 15.4 | 123 | | | | | | | | |
| 21 | 74.4 | 0 | 25.6 | 86 | | | | | | | | |
| 22 | 81.6 | 0.3 | 18.1 | 310 | | | | | | | | |
| 23 | 63.6 | 0 | 36.4 | 33 | | | | | | | | |

*The positions of the different sampling sites are shown in Fig. 2 and explained in Table 2.

†m.: *G. maculatus*.

‡b.: *G. brevipinnis*.

§f.: *G. fasciatus*.

TABLE 67: Daily catch composition in Waiatoto River tributaries in 1971

| Date | Hindley Creek m.* (%) | Hindley Creek b.† (%) | Hindley Creek f.‡ (%) | Hindley Creek No. in sample | Dawn Rivulet m. (%) | Dawn Rivulet b. (%) | Dawn Rivulet f. (%) | Dawn Rivulet No. in sample | Content Creek m. (%) | Content Creek b. (%) | Content Creek f. (%) | Content Creek No. in sample | Nolans Creek m. (%) | Nolans Creek b. (%) | Nolans Creek f. (%) | Nolans Creek No. in sample |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aug 25 | | | | | 99.4 | 0 | 0.6 | 156 | 93.4 | 0 | 6.6 | 165 | 100.0 | 0 | 0 | 105 |
| 26 | 89.1 | 0 | 10.9 | 64 | 100.0 | 0 | 0 | 72 | - | - | - | - | - | - | - | - |
| 27 | - | - | - | - | - | - | - | - | 90.8 | 0 | 9.2 | 328 | 99.6 | 0 | 0.4 | 545 |
| 28 | 98.2 | 0 | 1.8 | 223 | 100.0 | 0 | 0 | 33 | - | - | - | - | 98.9 | 0 | 1.1 | 281 |
| 29 | - | - | - | - | - | - | - | - | 94.5 | 0 | 5.5 | 109 | - | - | - | - |
| 30 | - | - | - | - | - | - | - | - | 98.5 | 0 | 1.5 | 335 | - | - | - | - |
| 31 | 99.6 | 0 | 0.4 | 540 | 100.0 | 0 | 0 | 101 | 94.4 | 0 | 5.6 | 89 | 100.0 | 0 | 0 | 227 |
| Sep 1 | - | - | - | - | - | - | - | - | - | - | - | - | 97.7 | 0 | 2.3 | 86 |
| 2 | 99.7 | 0 | 0.3 | 789 | 97.5 | 0 | 2.5 | 80 | 93.8 | 0 | 6.2 | 16 | 100.0 | 0 | 0 | 24 |
| 3 | 94.9 | 0 | 5.1 | 450 | 100.0 | 0 | 0 | 36 | 100.0 | 0 | 0 | 20 | 99.5 | 0 | 0.5 | 187 |
| 4 | 96.8 | 0 | 3.2 | 94 | 100.0 | 0 | 0 | 32 | 82.1 | 0 | 17.9 | 78 | 100.0 | 0 | 0 | 108 |
| 5 | 100.0 | 0 | 0 | 42 | 100.0 | 0 | 0 | 9 | 73.0 | 0 | 27.0 | 37 | 100.0 | 0 | 0 | 12 |
| 6 | 95.2 | 0 | 4.8 | 21 | 98.2 | 0 | 1.8 | 110 | 95.8 | 0 | 4.2 | 72 | 100.0 | 0 | 0 | 83 |
| 7 | 98.0 | 0 | 2.0 | 199 | 100.0 | 0 | 0 | 39 | 94.1 | 0 | 5.9 | 34 | 100.0 | 0 | 0 | 26 |
| 8 | 99.2 | 0 | 0.8 | 123 | 97.6 | 0.6 | 1.8 | 164 | 92.9 | 0 | 7.1 | 113 | 99.1 | 0 | 0.9 | 107 |
| 9 | 95.2 | 0 | 4.8 | 63 | 93.1 | 0 | 6.9 | 29 | 100.0 | 0 | 0 | 42 | 100.0 | 0 | 0 | 12 |
| 10 | 97.8 | 0 | 2.2 | 602 | 96.4 | 0 | 3.6 | 28 | 46.2 | 0 | 53.8 | 13 | 100.0 | 0 | 0 | 6 |
| 11 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 12 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 13 | 92.3 | 0 | 7.7 | 26 | 100.0 | 0 | 0 | 8 | - | - | - | - | 100.0 | 0 | 0 | 17 |
| 14 | 100.0 | 0 | 0 | 18 | 100.0 | 0 | 0 | 19 | 100.0 | 0 | 0 | 123 | 100.0 | 0 | 0 | 122 |
| 15 | 99.1 | 0 | 0.9 | 578 | 100.0 | 0 | 0 | 150 | 97.0 | 0 | 3.0 | 246 | 98.6 | 0 | 1.4 | 146 |
| 16 | 99.1 | 0 | 0.9 | 468 | 98.9 | 0 | 1.1 | 183 | 99.7 | 0 | 0.3 | 214 | 97.6 | 1.2 | 1.2 | 249 |
| 17 | 98.7 | 0 | 1.3 | 671 | 100.0 | 0 | 0 | 53 | 98.7 | 0 | 1.3 | 205 | 100.0 | 0 | 0 | 58 |
| 18 | 99.3 | 0 | 0.7 | 561 | 98.6 | 0 | 1.4 | 144 | 98.6 | 0 | 1.4 | 352 | 100.0 | 0 | 0 | 199 |
| 19 | - | - | - | - | 99.5 | 0 | 0.5 | 397 | - | - | - | - | - | - | - | - |
| 20 | - | - | - | - | - | - | - | - | - | - | - | - | 100.0 | 0 | 0 | 50 |
| 21 | 99.4 | 0 | 0.6 | 502 | 99.6 | 0 | 0.4 | 482 | 96.3 | 0 | 3.7 | 569 | - | - | - | - |
| 22 | - | - | - | - | 99.1 | 0 | 0.9 | 110 | - | - | - | - | - | - | - | - |
| 23 | 99.4 | 0 | 0.6 | 680 | - | - | - | - | - | - | - | - | 100.0 | 0 | 0 | 6 |
| 24 | 98.4 | 0 | 1.6 | 688 | 99.5 | 0 | 0.5 | 595 | - | - | - | - | 96.4 | 2.7 | 0.9 | 112 |
| 25 | 91.6 | 0 | 8.4 | 635 | 98.6 | 0 | 1.4 | 555 | 98.0 | 0 | 2.0 | 1 080 | 97.5 | 0 | 2.5 | 40 |
| 26 | 97.9 | 0 | 2.1 | 834 | 99.0 | 0 | 1.0 | 859 | 93.6 | 0 | 6.4 | 471 | 94.6 | 2.7 | 2.7 | 112 |
| 27 | 97.6 | 0 | 2.4 | 412 | 99.5 | 0 | 0.5 | 221 | 97.1 | 0 | 2.9 | 35 | 99.1 | 0.9 | 0 | 333 |
| 28 | 99.0 | 0 | 1.0 | 885 | 97.9 | 0 | 2.1 | 48 | - | - | - | - | 96.4 | 3.6 | 0 | 56 |
| 29 | 98.8 | 0.2 | 1.0 | 503 | 99.6 | 0 | 0.4 | 456 | 92.2 | 0 | 7.8 | 397 | 100.0 | 0 | 0 | 9 |
| 30 | 99.1 | 0 | 0.9 | 574 | 99.6 | 0 | 0.4 | 235 | 93.0 | 0 | 7.0 | 278 | - | - | - | - |
| Oct 1 | 94.4 | 0.3 | 5.3 | 531 | 99.5 | 0 | 0.5 | 432 | 79.5 | 0 | 20.5 | 44 | 100.0 | 0 | 0 | 46 |
| 2 | 99.2 | 0 | 0.8 | 497 | 99.1 | 0.2 | 0.7 | 451 | 88.4 | 0 | 11.6 | 394 | 92.2 | 4.7 | 3.1 | 64 |
| 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 4 | - | - | - | - | 100.0 | 0 | 0 | 30 | - | - | - | - | - | - | - | - |
| 5 | - | - | - | - | - | - | - | - | - | - | - | - | 100.0 | 0 | 0 | 41 |
| 6 | 99.2 | 0.1 | 0.7 | 1 138 | 100.0 | 0 | 0 | 226 | 100.0 | 0 | 0 | 783 | 100.0 | 0 | 0 | 158 |
| 7 | 97.0 | 1.7 | 1.3 | 825 | 99.6 | 0 | 0.4 | 782 | 98.0 | 0.6 | 1.4 | 794 | 100.0 | 0 | 0 | 23 |
| 8 | 92.9 | 2.8 | 4.3 | 644 | 97.0 | 0.1 | 2.9 | 977 | 90.4 | 1.2 | 8.4 | 57 | 98.9 | 1.1 | 0 | 352 |
| 9 | 98.8 | 0.2 | 1.0 | 465 | 98.6 | 0 | 1.4 | 222 | 99.2 | 0 | 0.8 | 241 | 100.0 | 0 | 0 | 9 |
| 10 | 93.5 | 0 | 6.5 | 31 | 97.6 | 0 | 2.4 | 124 | 95.7 | 0 | 4.3 | 186 | 100.0 | 0 | 0 | 60 |
| 11 | 98.6 | 0 | 1.4 | 70 | 99.1 | 0 | 0.9 | 117 | 89.1 | 0 | 10.9 | 46 | 100.0 | 0 | 0 | 48 |
| 12 | 98.4 | 0 | 1.6 | 128 | - | - | - | - | 99.7 | 0 | 0.3 | 189 | 100.0 | 0 | 0 | 60 |
| 13 | 100.0 | 0 | 0 | 44 | 100.0 | 0 | 0 | 87 | - | - | - | - | 97.0 | 1.5 | 1.5 | 65 |
| 14 | 88.2 | 0 | 11.8 | 37 | 100.0 | 0 | 0 | 579 | 89.8 | 0 | 10.2 | 115 | 93.8 | 0 | 6.2 | 16 |
| 15 | - | - | - | - | 100.0 | 0 | 0 | 218 | - | - | - | - | 100.0 | 0 | 0 | 6 |
| 16 | 83.3 | 0 | 16.6 | 42 | 100.0 | 0 | 0 | 118 | 58.4 | 0 | 41.6 | 37 | 85.7 | 0 | 14.3 | 7 |
| 17 | 88.2 | 0 | 11.8 | 17 | 100.0 | 0 | 0 | 216 | - | - | - | - | 100.0 | 0 | 0 | 5 |
| 18 | - | - | - | - | 100.0 | 0 | 0 | 349 | - | - | - | - | 100.0 | 0 | 0 | 13 |
| 19 | 100.0 | 0 | 0 | 6 | 100.0 | 0 | 0 | 186 | - | - | - | - | 100.0 | 0 | 0 | 24 |
| 20 | 91.5 | 0 | 8.5 | 1 007 | 98.6 | 0.1 | 1.3 | 848 | 99.4 | 0 | 0.6 | 1 160 | 96.6 | 0 | 3.4 | 29 |
| 21 | 94.8 | 0 | 5.2 | 642 | 98.0 | 0 | 2.0 | 1 297 | - | - | - | - | - | - | - | - |
| 22 | 99.0 | 0.1 | 0.9 | 544 | 100.0 | 0 | 0 | 271 | 97.2 | 0 | 2.8 | 186 | 100.0 | 0 | 0 | 14 |
| 23 | 99.2 | 0.2 | 0.6 | 631 | 99.6 | 0 | 0.4 | 456 | 100.0 | 0 | 0 | 56 | 100.0 | 0 | 0 | 3 |
| 24 | 97.2 | 0.4 | 2.4 | 252 | 99.4 | 0 | 0.6 | 358 | 100.0 | 0 | 0 | 16 | 100.0 | 0 | 0 | 2 |
| 25 | 96.4 | 0 | 3.6 | 379 | 98.6 | 0 | 1.4 | 931 | - | - | - | - | 100.0 | 0 | 0 | 16 |
| 26 | 99.1 | 0 | 0.9 | 268 | 99.9 | 0 | 0.1 | 808 | - | - | - | - | 100.0 | 0 | 0 | 1 |
| 27 | 98.7 | 0 | 1.3 | 154 | 100.0 | 0 | 0 | 487 | 100.0 | 0 | 0 | 6 | 100.0 | 0 | 0 | 8 |
| 28 | 100.0 | 0 | 0 | 52 | 100.0 | 0 | 0 | 224 | - | - | - | - | 99.4 | 0.4 | 0.2 | 493 |
| 29 | 97.5 | 0 | 2.5 | 79 | 100.0 | 0 | 0 | 100 | - | - | - | - | 100.0 | 0 | 0 | 15 |
| 30 | 99.4 | 0 | 0.6 | 315 | 100.0 | 0 | 0 | 70 | 100.0 | 0 | 0 | 46 | 100.0 | 0 | 0 | 7 |
| 31 | 92.1 | 0 | 7.9 | 38 | 100.0 | 0 | 0 | 638 | 100.0 | 0 | 0 | 31 | 100.0 | 0 | 0 | 214 |

| Date | Nisson Creek m. (%) | Nisson Creek b. (%) | Nisson Creek f. (%) | Nisson Creek No. in sample | Brewer Water m. (%) | Brewer Water b. (%) | Brewer Water f. (%) | Brewer Water No. in sample | Hubbub Torrent m. (%) | Hubbub Torrent b. (%) | Hubbub Torrent f. (%) | Hubbub Torrent No. in sample | Gliding Rivulet m. (%) | Gliding Rivulet b. (%) | Gliding Rivulet f. (%) | Gliding Rivulet No. in sample |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sep 3 | 100.0 | 0 | 0 | 9 | | | | | | | | | | | | |
| 4 | 100.0 | 0 | 0 | 12 | | | | | | | | | | | | |
| 5 | - | - | - | - | | | | | | | | | | | | |
| 6 | 100.0 | 0 | 0 | 70 | | | | | | | | | | | | |
| 7 | - | - | - | - | | | | | | | | | | | | |
| 8 | 100.0 | 0 | 0 | 225 | | | | | | | | | | | | |
| 9 | - | - | - | - | | | | | | | | | | | | |
| 10 | 99.1 | 0 | 0.9 | 109 | | | | | | | | | | | | |
| 11 | - | - | - | - | | | | | | | | | | | | |
| 12 | 99.0 | 1.0 | 0 | 104 | | | | | | | | | | | | |
| 13 | 96.3 | 0 | 3.7 | 27 | | | | | | | | | | | | |
| 14 | 100.0 | 0 | 0 | 22 | | | | | | | | | | | | |
| 15 | 98.1 | 1.9 | 0 | 53 | | | | | | | | | | | | |
| 16 | 97.2 | 2.8 | 0 | 36 | | | | | | | | | | | | |
| 17 | 90.0 | 10.0 | 0 | 20 | | | | | | | | | | | | |
| 18 | - | - | - | - | | | | | | | | | | | | |
| 19 | - | - | - | - | | | | | | | | | | | | |
| 20 | - | - | - | - | | | | | | | | | | | | |
| 21 | 100.0 | 0 | 0 | 28 | | | | | | | | | | | | |
| 22 | - | - | - | - | | | | | | | | | | | | |
| 23 | 93.9 | 3.1 | 3.1 | 33 | | | | | | | | | | | | |
| 24 | - | - | - | - | | | | | | | | | | | | |
| 25 | - | - | - | - | | | | | | | | | | | | |
| 26 | 97.2 | 2.8 | 0 | 108 | 100.0 | 0 | 0 | 2 | | | | | | | | |
| 27 | - | - | - | - | - | - | - | - | | | | | | | | |
| 28 | - | - | - | - | - | - | - | - | | | | | | | | |
| 29 | 94.3 | 5.7 | 0 | 53 | - | - | - | - | | | | | | | | |
| 30 | - | - | - | - | - | - | - | - | | | | | | | | |
| Oct 1 | 95.2 | 4.8 | 0 | 125 | - | - | - | - | | | | | 0 | 100.0 | 0 | 1 |
| 2 | 96.5 | 3.5 | 0 | 58 | - | - | - | - | | | | | - | - | - | - |
| 3 | - | - | - | - | - | - | - | - | | | | | - | - | - | - |
| 4 | - | - | - | - | - | - | - | - | | | | | - | - | - | - |
| 5 | - | - | - | - | - | - | - | - | | | | | - | - | - | - |
| 6 | 94.1 | 5.9 | 0 | 68 | - | - | - | - | | | | | - | - | - | - |
| 7 | 33.3 | 66.7 | 0 | 6 | - | - | - | - | | | | | - | - | - | - |
| 8 | 48.1 | 51.9 | 0 | 27 | - | - | - | - | 0 | 100.0 | 0 | 2 | 0 | 100.0 | 0 | 3 |
| 9 | 76.1 | 23.9 | 0 | 46 | - | - | - | - | 0 | 100.0 | 0 | 1 | - | - | - | - |
| 10 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 11 | 86.7 | 14.3 | 0 | 42 | - | - | - | - | - | - | - | - | - | - | - | - |
| 12 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 13 | 78.6 | 21.4 | 0 | 28 | - | - | - | - | 0 | 100.0 | 0 | 1 | 0 | 100.0 | 0 | 1 |
| 14 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 15 | 60.0 | 40.0 | 0 | 15 | 0 | 100.0 | 0 | 2 | 0 | 100.0 | 0 | 3 | 0 | 100.0 | 0 | 3 |
| 16 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 17 | - | - | - | - | 20.0 | 80.0 | 0 | 10 | 0 | 100.0 | 0 | 4 | 0 | 100.0 | 0 | 2 |
| 18 | 75.0 | 25.0 | 0 | 12 | - | - | - | - | - | - | - | - | - | - | - | - |
| 19 | 66.7 | 33.3 | 0 | 12 | 25.0 | 75.0 | 0 | 4 | 100.0 | 0 | 0 | 1 | 0 | 100.0 | 0 | 6 |
| 20 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 21 | 40.7 | 59.3 | 0 | 27 | 16.7 | 83.3 | 0 | 6 | 0 | 100.0 | 0 | 14 | 0 | 100.0 | 0 | 23 |
| 22 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 23 | 72.2 | 27.8 | 0 | 72 | 0 | 100.0 | 0 | 4 | 0 | 100.0 | 0 | 3 | 0 | 100.0 | 0 | 2 |
| 24 | 38.5 | 53.8 | 7.7 | 13 | - | - | - | - | - | - | - | - | - | - | - | - |
| 25 | 91.8 | 8.2 | 0 | 49 | 25.0 | 75.0 | 0 | 12 | 0 | 100.0 | 0 | 15 | 0 | 100.0 | 0 | 5 |
| 26 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 27 | 97.8 | 1.1 | 1.1 | 90 | 25.0 | 75.0 | 0 | 4 | 0 | 100.0 | 0 | 7 | 0 | 100.0 | 0 | 5 |
| 28 | 100.0 | 0 | 0 | 20 | - | - | - | - | - | - | - | - | - | - | - | - |
| 29 | 96.8 | 2.1 | 1.1 | 94 | - | - | - | - | - | - | - | - | - | - | - | - |
| 30 | 100.0 | 0 | 0 | 114 | - | - | - | - | - | - | - | - | - | - | - | - |
| 31 | - | - | - | - | - | - | - | - | - | - | - | - | 13.3 | 86.7 | 0 | 15 |

TABLE 67: Daily catch composition in Waiatoto River tributaries in 1971 (continued)

| Date | Hindley Creek | | | | Dawn Rivulet | | | | Content Creek | | | | Nolans Creek | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample |
| Nov 1 | 96.6 | 0 | 3.4 | 268 | 100.0 | 0 | 0 | 38 | 97.2 | 0 | 2.8 | 71 | 100.0 | 0 | 0 | 25 |
| 2 | 99.5 | 0 | 0.5 | 588 | 99.6 | 0 | 0.4 | 477 | 96.3 | 0 | 3.7 | 81 | 97.9 | 0 | 2.1 | 48 |
| 3 | 98.9 | 0 | 1.1 | 449 | 98.8 | 0 | 1.3 | 80 | 99.7 | 0 | 0.3 | 334 | 100.0 | 0 | 0 | 7 |
| 4 | 95.3 | 0 | 4.7 | 232 | 100.0 | 0 | 0 | 70 | - | - | - | - | - | - | - | - |
| 5 | 95.1 | 0.6 | 4.3 | 375 | - | - | - | - | - | - | - | - | 100.0 | 0 | 0 | 5 |
| 6 | 92.6 | 0 | 7.4 | 54 | 96.4 | 0 | 3.6 | 165 | 91.7 | 0 | 8.3 | 12 | 100.0 | 0 | 0 | 1 |
| 7 | 95.9 | 0 | 4.1 | 368 | 96.6 | 0 | 3.4 | 559 | 93.3 | 0 | 6.7 | 15 | 100.0 | 0 | 0 | 6 |
| 8 | 96.6 | 0 | 3.4 | 445 | 97.7 | 0 | 2.3 | 525 | 81.3 | 0 | 18.7 | 16 | - | - | - | - |
| 9 | 94.3 | 0 | 5.7 | 300 | 98.3 | 0 | 1.7 | 650 | - | - | - | - | 100.0 | 0 | 0 | 2 |
| 10 | 92.1 | 0.6 | 7.3 | 165 | 100.0 | 0 | 0 | 157 | - | - | - | - | 100.0 | 0 | 0 | 2 |
| 11 | 87.2 | 0 | 12.8 | 47 | 98.1 | 0 | 1.9 | 216 | 90.9 | 0 | 9.1 | 11 | 90.9 | 0 | 9.1 | 22 |
| 12 | 93.7 | 0.6 | 5.7 | 174 | 99.6 | 0 | 0.4 | 491 | 87.6 | 0.3 | 12.1 | 294 | 97.8 | 0 | 2.2 | 45 |
| 13 | 93.8 | 0 | 6.3 | 64 | 98.2 | 0 | 1.8 | 394 | 96.5 | 0 | 3.5 | 115 | 99.5 | 0 | 0.5 | 187 |
| 14 | 83.8 | 0 | 16.1 | 757 | 96.6 | 0 | 3.4 | 223 | - | - | - | - | 97.5 | 0 | 2.5 | 40 |
| 15 | 78.5 | 0 | 21.5 | 293 | 97.0 | 0 | 3.0 | 266 | 90.0 | 0 | 10.0 | 20 | 100.0 | 0 | 0 | 18 |
| 16 | 77.5 | 0.2 | 22.3 | 574 | 95.9 | 0 | 4.1 | 147 | 100.0 | 0 | 0 | 5 | 97.6 | 0 | 2.4 | 42 |
| 17 | 78.3 | 0 | 21.7 | 161 | 84.8 | 0 | 15.2 | 33 | - | - | - | - | 100.0 | 0 | 0 | 13 |
| 18 | 71.2 | 0 | 28.8 | 545 | 95.4 | 0 | 4.6 | 109 | 76.0 | 0 | 24.0 | 25 | 100.0 | 0 | 0 | 2 |
| 19 | 76.5 | 0 | 23.5 | 51 | 98.3 | 0 | 1.7 | 119 | 91.3 | 0 | 8.7 | 23 | 100.0 | 0 | 0 | 25 |
| 20 | 59.6 | 0 | 40.4 | 94 | - | - | - | - | - | - | - | - | 95.2 | 0 | 4.8 | 21 |
| 21 | 79.4 | 0 | 20.6 | 63 | 97.4 | 0 | 2.6 | 76 | - | - | - | - | | | | |
| 22 | 81.8 | 0 | 18.2 | 121 | 100.0 | 0 | 0 | 30 | - | - | - | - | | | | |
| 23 | 75.0 | 0 | 25.0 | 24 | 96.7 | 0 | 3.3 | 122 | 100.0 | 0 | 0 | 41 | | | | |
| 24 | 86.8 | 0 | 13.2 | 38 | - | - | - | - | 79.2 | 0 | 20.8 | 77 | | | | |
| 25 | 85.5 | 0 | 14.5 | 76 | 93.5 | 0 | 6.5 | 31 | 71.7 | 0 | 28.3 | 60 | | | | |

| Date | Nisson Creek | | | | Brewer Water | | | | Hubbub Torrent | | | | Gliding Rivulet | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample |
| Nov 1 | 100.0 | 0 | 0 | 9 | - | - | - | - | - | - | - | - | - | - | - | - |
| 2 | - | - | - | - | 83.3 | 16.7 | 0 | 6 | 0 | 100.0 | 0 | 3 | 0 | 100.0 | 0 | 2 |
| 3 | 100.0 | 0 | 0 | 9 | - | - | - | - | - | - | - | - | - | - | - | - |
| 4 | 100.0 | 0 | 0 | 20 | - | - | - | - | 0 | 100.0 | 0 | 2 | 0 | 100.0 | 0 | 1 |
| 5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 6 | 100.0 | 0 | 0 | 57 | 22.2 | 77.8 | 0 | 9 | 0 | 100.0 | 0 | 8 | 0 | 100.0 | 0 | 4 |
| 7 | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 8 | 99.1 | 0.6 | 0.3 | 363 | 62.5 | 37.5 | 0 | 8 | 0 | 100.0 | 0 | 4 | | | | |
| 9 | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 10 | 96.7 | 0 | 3.3 | 245 | 100.0 | 0 | 0 | 1 | 0 | 100.0 | 0 | 1 | | | | |
| 11 | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 12 | 100.0 | 0 | 0 | 24 | 0 | 100.0 | 0 | 1 | 0 | 100.0 | 0 | 1 | | | | |
| 13 | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 14 | 100.0 | 0 | 0 | 2 | 100.0 | 0 | 0 | 1 | 0 | 100.0 | 0 | 2 | | | | |
| 15 | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 16 | 100.0 | 0 | 0 | 1 | 60.0 | 40.0 | 0 | 5 | - | - | - | - | | | | |
| 17 | - | - | - | - | - | - | - | - | - | - | - | - | | | | |
| 18 | - | - | - | - | 100.0 | 0 | 0 | 1 | - | - | - | - | | | | |
| 19 | - | - | - | - | | | | | - | - | - | - | | | | |
| 20 | - | - | - | - | | | | | - | - | - | - | | | | |
| 21 | - | - | - | - | | | | | - | - | - | - | | | | |
| 22 | 96.1 | 0 | 3.9 | 51 | | | | | 0 | 100.0 | 0 | 1 | | | | |
| 23 | | | | | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | | | |

*m.: *G. maculatus*.

†b.: *G. brevipinnis*.

‡f.: *G. fasciatus*.

TABLE 68: Daily catch composition in Waiatoto River in 1972

| Date | Site 1* | | | | Site 2 | | | | Site 3 | | | | Site 4 | | | | Site 6 | | | | Site 7 | | | | Site 8 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m.† (%) | b.‡ (%) | f.§ (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample |
| Aug 19 | | | | | | | | | | | | | | | | | | | | | | | | | 98.3 | 1.7 | 0 | 418 |
| 20 | | | | | | | | | | | | | | | | | | | | | | | | | - | - | - | - |
| 21 | | | | | | | | | | | | | | | | | | | | | | | | | 98.2 | 1.8 | 0 | 112 |
| 22 | | | | | | | | | | | | | | | | | | | | | | | | | - | - | - | - |
| 23 | | | | | | | | | | | | | | | | | | | | | | | | | 97.9 | 2.1 | 0 | 517 |
| 24 | | | | | | | | | | | | | | | | | | | | | | | | | - | - | - | - |
| 25 | | | | | | | | | | | | | | | | | | | | | | | | | 99.4 | 0.6 | 0 | 488 |
| 26 | 100.0 | 0 | 0 | 271 | | | | | | | | | | | | | | | | | | | | | 99.5 | 0.5 | 0 | 662 |
| 27 | - | - | - | - | | | | | | | | | | | | | | | | | | | | | - | - | - | - |
| 28 | - | - | - | - | | | | | | | | | | | | | | | | | | | | | 100.0 | 0 | 0 | 6 |
| 29 | 97.9 | 2.1 | 0 | 97 | | | | | | | | | | | | | | | | | | | | | - | - | - | - |
| 30 | - | - | - | - | | | | | | | | | | | | | | | | | | | | | 98.6 | 0.8 | 0.6 | 505 |
| 31 | 95.7 | 4.3 | 0 | 47 | | | | | | | | | | | | | | | | | | | | | 98.7 | 1.3 | 0 | 638 |
| Sep 1 | - | - | - | - | | | | | | | | | | | | | | | | | | | | | 100.0 | 0 | 0 | 10 |
| 2 | - | - | - | - | | | | | | | | | | | | | | | | | | | | | - | - | - | - |
| 3 | 98.7 | 1.1 | 0.2 | 546 | | | | | | | | | | | | | | | | | | | | | - | - | - | - |
| 4 | 98.6 | 1.4 | 0 | 660 | | | | | | | | | 97.5 | 2.5 | 0 | 276 | | | | | | | | | 100.0 | 0 | 0 | 53 |
| 5 | 99.1 | 0.7 | 0.2 | 453 | | | | | | | | | 100.0 | 0 | 0 | 214 | 97.7 | 2.3 | 0 | 387 | | | | | 86.3 | 13.7 | 0 | 51 |
| 6 | 99.6 | 0 | 0.4 | 493 | | | | | | | | | 99.5 | 0.5 | 0 | 424 | 99.0 | 1.0 | 0 | 310 | | | | | 96.6 | 3.4 | 0 | 468 |
| 7 | - | - | - | - | | | | | | | | | - | - | - | - | 99.2 | 0.8 | 0 | 387 | | | | | 99.2 | 0.8 | 0 | 486 |
| 8 | - | - | - | - | | | | | | | | | - | - | - | - | - | - | - | - | | | | | - | - | - | - |
| 9 | - | - | - | - | | | | | | | | | - | - | - | - | - | - | - | - | | | | | - | - | - | - |
| 10 | 98.6 | 1.4 | 0 | 624 | | | | | | | | | 99.5 | 0.5 | 0 | 214 | - | - | - | - | | | | | - | - | - | - |
| 11 | 98.3 | 1.6 | 0 | 496 | | | | | | | | | 98.2 | 1.8 | 0 | 776 | 94.9 | 5.1 | 0 | 373 | | | | | - | - | - | - |
| 12 | 98.9 | 1.1 | 0 | 612 | | | | | | | | | 100.0 | 0 | 0 | 244 | 96.1 | 3.9 | 0 | 360 | | | | | - | - | - | - |
| 13 | 98.3 | 1.7 | 0 | 991 | | | | | | | | | - | - | - | - | - | - | - | - | | | | | - | - | - | - |
| 14 | - | - | - | - | | | | | | | | | - | - | - | - | - | - | - | - | | | | | - | - | - | - |
| 15 | 93.6 | 6.4 | 0 | 188 | | | | | | | | | - | - | - | - | - | - | - | - | | | | | - | - | - | - |
| 16 | 89.9 | 10.1 | 0 | 238 | | | | | | | | | - | - | - | - | 35.1 | 64.9 | 0 | 154 | | | | | - | - | - | - |
| 17 | 96.0 | 3.8 | 0.2 | 530 | | | | | | | | | - | - | - | - | 74.2 | 25.8 | 0 | 403 | | | | | - | - | - | - |
| 18 | 92.3 | 7.2 | 0.4 | 470 | | | | | | | | | - | - | - | - | 24.5 | 75.5 | 0 | 375 | | | | | - | - | - | - |
| 19 | - | - | - | - | | | | | | | | | - | - | - | - | - | - | - | - | | | | | - | - | - | - |
| 20 | 98.8 | 1.2 | 0 | 84 | | | | | | | | | - | - | - | - | 3.7 | 96.3 | 0 | 270 | | | | | - | - | - | - |
| 21 | - | - | - | - | | | | | | | | | 97.2 | 2.8 | 0 | 494 | 13.0 | 87.0 | 0 | 269 | | | | | - | - | - | - |
| 22 | 98.2 | 1.8 | 0 | 279 | | | | | | | | | - | - | - | - | 80.6 | 19.4 | 0 | 391 | | | | | 96.3 | 3.7 | 0 | 109 |
| 23 | 98.2 | 1.3 | 0.6 | 541 | | | | | | | | | 98.9 | 1.1 | 0 | 591 | 86.1 | 13.9 | 0 | 296 | | | | | - | - | - | - |
| 24 | - | - | - | - | | | | | | | | | - | - | - | - | 93.2 | 6.8 | 0 | 412 | | | | | - | - | - | - |
| 25 | 99.3 | 0.7 | 0 | 1 208 | | | | | | | | | - | - | - | - | 92.8 | 6.9 | 0.3 | 375 | | | | | 93.2 | 6.8 | 0 | 453 |
| 26 | 98.5 | 1.5 | 0 | 1 053 | | | | | | | | | - | - | - | - | - | - | - | - | | | | | - | - | - | - |
| 27 | 97.6 | 2.4 | 0 | 372 | | | | | | | | | 97.0 | 2.7 | 0.3 | 370 | 92.2 | 7.8 | 0 | 446 | 78.6 | 21.4 | 0 | 187 | - | - | - | - |
| 28 | - | - | - | - | | | | | | | | | 97.1 | 2.9 | 0 | 309 | - | - | - | - | - | - | - | - | - | - | - | - |
| 29 | 98.6 | 1.3 | 0.1 | 1 377 | | | | | | | | | 95.5 | 3.9 | 0.6 | 334 | 87.6 | 12.4 | 0 | 387 | 84.0 | 16.0 | 0 | 282 | 97.3 | 2.7 | 0 | 74 |
| 30 | 97.3 | 2.5 | 0.3 | 1 099 | | | | | | | | | 99.5 | 0.3 | 0.2 | 658 | 94.2 | 5.8 | 0 | 429 | 88.4 | 11.6 | 0 | 250 | 99.2 | 0.8 | 0 | 125 |
| Oct 1 | 96.6 | 3.1 | 0.4 | 1 893 | | | | | | | | | 98.6 | 1.2 | 0.2 | 574 | 79.9 | 19.8 | 0.3 | 333 | 70.0 | 30.0 | 0 | 340 | 76.8 | 23.2 | 0 | 112 |
| 2 | 96.8 | 2.8 | 0.4 | 1 257 | | | | | | | | | 98.7 | 1.3 | 0 | 937 | 91.8 | 8.2 | 0 | 328 | 68.0 | 32.0 | 0 | 434 | 88.9 | 11.1 | 0 | 9 |
| 3 | - | - | - | - | | | | | | | | | 99.9 | 0.1 | 0 | 826 | 99.7 | 0.3 | 0 | 390 | 86.2 | 13.8 | 0 | 188 | 96.8 | 3.2 | 0 | 282 |
| 4 | 98.2 | 0.5 | 1.4 | 1 111 | | | | | | | | | 99.0 | 0.7 | 0.3 | 293 | 96.8 | 3.2 | 0 | 344 | - | - | - | - | 97.2 | 2.8 | 0 | 458 |
| 5 | 96.5 | 0 | 3.5 | 86 | | | | | | | | | 99.8 | 0.2 | 0 | 417 | 94.0 | 6.0 | 0 | 398 | - | - | - | - | 95.8 | 3.9 | 0.2 | 432 |
| 6 | 98.9 | 0.4 | 0.7 | 1 160 | | | | | 97.1 | 2.9 | 0 | 312 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 7 | 99.3 | 0.3 | 0.3 | 615 | | | | | 98.9 | 1.1 | 0 | 456 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 8 | 96.6 | 1.0 | 2.3 | 388 | | | | | - | - | - | - | 98.5 | 1.5 | 0 | 411 | - | - | - | - | - | - | - | - | - | - | - | - |
| 9 | 99.3 | 0 | 0.7 | 279 | | | | | 93.7 | 5.9 | 0.3 | 303 | 99.3 | 0.5 | 0.2 | 426 | 50.7 | 49.3 | 0 | 359 | 77.6 | 22.4 | 0 | 371 | 100.0 | 0 | 0 | 41 |
| 10 | 100.0 | 0 | 0 | 282 | | | | | - | - | - | - | 96.7 | 2.1 | 1.2 | 430 | 86.1 | 12.5 | 1.3 | 375 | 78.5 | 21.2 | 0.3 | 316 | 96.7 | 2.7 | 0.5 | 212 |
| 11 | - | - | - | - | | | | | - | - | - | - | 99.0 | 0.5 | 0.5 | 416 | 94.6 | 5.2 | 0.2 | 391 | 89.5 | 10.5 | 0 | 313 | 99.9 | 0.1 | 0 | 539 |
| 12 | 99.0 | 0.6 | 0.4 | 1 055 | | | | | 96.9 | 2.9 | 0.3 | 383 | 98.0 | 1.8 | 0.2 | 429 | - | - | - | - | - | - | - | - | - | - | - | - |
| 13 | 98.5 | 0.4 | 1.1 | 267 | | | | | - | - | - | - | - | - | - | - | 26.6 | 73.4 | 0 | 289 | - | - | - | - | - | - | - | - |
| 14 | 95.7 | 3.2 | 1.1 | 94 | | | | | - | - | - | - | 92.4 | 7.2 | 0.4 | 552 | 29.6 | 70.4 | 0 | 250 | 86.0 | 14.0 | 0 | 221 | - | - | - | - |
| 15 | 96.8 | 3.2 | 0 | 95 | | | | | 91.6 | 8.4 | 0 | 298 | 98.3 | 1.5 | 0.2 | 520 | 60.8 | 39.2 | 0 | 339 | 68.7 | 31.3 | 0 | 195 | 95.2 | 4.8 | 0 | 42 |
| 16 | 96.6 | 3.1 | 0.3 | 996 | | | | | 97.2 | 2.8 | 0 | 325 | 98.0 | 1.8 | 0.1 | 870 | 98.5 | 1.5 | 0 | 412 | 84.7 | 15.3 | 0 | 241 | 69.0 | 31.0 | 0 | 58 |
| 17 | 97.8 | 1.8 | 0.4 | 679 | | | | | 96.3 | 3.7 | 0 | 299 | 96.5 | 3.4 | 0.1 | 973 | 94.3 | 5.7 | 0 | 436 | 86.6 | 13.4 | 0 | 342 | 92.9 | 7.1 | 0 | 98 |

TABLE 68: Daily catch composition in Waiatoto River in 1972 (continued)

| Date | Site 1 m. (%) | Site 1 b. (%) | Site 1 f. (%) | Site 1 No. in sample | Site 2 m. (%) | Site 2 b. (%) | Site 2 f. (%) | Site 2 No. in sample | Site 3 m. (%) | Site 3 b. (%) | Site 3 f. (%) | Site 3 No. in sample |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oct 18 | 99.4 | 0.2 | 0.4 | 475 | | | | | 98.9 | 1.1 | 0 | 354 |
| 19 | 99.8 | 0.2 | 0 | 449 | | | | | - | - | - | - |
| 20 | - | - | - | - | | | | | - | - | - | - |
| 21 | 100.0 | 0 | 0 | 477 | | | | | 98.7 | 0.5 | 0.8 | 390 |
| 22 | 99.0 | 0.7 | 0.2 | 810 | | | | | - | - | - | - |
| 23 | 100.0 | 0 | 0 | 46 | | | | | - | - | - | - |
| 24 | 98.3 | 0.9 | 0.9 | 697 | | | | | 97.0 | 2.1 | 0.9 | 331 |
| 25 | 98.7 | 1.0 | 0.4 | 829 | | | | | 99.4 | 0.4 | 0.2 | 472 |
| 26 | - | - | - | - | | | | | 95.5 | 3.1 | 1.4 | 358 |
| 27 | 99.3 | 0 | 0.7 | 140 | 97.7 | 0.8 | 1.5 | 1 234 | 97.4 | 2.1 | 0.5 | 387 |
| 28 | - | - | - | - | 97.3 | 0.3 | 2.4 | 717 | 98.9 | 0.2 | 0.9 | 455 |
| 29 | 97.8 | 0 | 2.2 | 180 | - | - | - | - | 98.5 | 0.5 | 1.0 | 405 |
| 30 | 97.3 | 0.6 | 2.1 | 630 | - | - | - | - | 98.4 | 0.8 | 0.8 | 496 |
| 31 | - | - | - | - | - | - | - | - | - | - | - | - |
| Nov 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| 2 | 95.7 | 0 | 4.3 | 23 | - | - | - | - | 97.3 | 1.5 | 1.1 | 528 |
| 3 | 97.8 | 0.6 | 1.6 | 507 | - | - | - | - | - | - | - | - |
| 4 | 98.2 | 1.2 | 0.6 | 331 | - | - | - | - | 92.6 | 6.6 | 0.8 | 258 |
| 5 | 97.3 | 1.2 | 1.6 | 512 | - | - | - | - | 92.5 | 7.0 | 0.5 | 440 |
| 6 | 98.2 | 1.2 | 0.6 | 164 | - | - | - | - | - | - | - | - |
| 7 | 98.9 | 1.1 | 0 | 184 | - | - | - | - | - | - | - | - |
| 8 | 96.5 | 2.6 | 0.9 | 577 | - | - | - | - | - | - | - | - |
| 9 | 99.2 | 0.6 | 0.3 | 1 083 | 98.6 | 0.8 | 0.6 | 511 | - | - | - | - |
| 10 | 96.7 | 1.4 | 1.8 | 508 | 98.5 | 1.0 | 0.5 | 603 | 97.2 | 2.0 | 0.8 | 394 |
| 11 | 94.2 | 0.7 | 5.1 | 449 | - | - | - | - | 97.5 | 1.5 | 0.9 | 323 |
| 12 | 94.9 | 0 | 5.1 | 78 | 97.7 | 0.5 | 1.8 | 392 | 96.8 | 2.6 | 0.6 | 308 |
| 13 | - | - | - | - | - | - | - | - | | | | |
| 14 | 99.3 | 0 | 0.7 | 442 | - | - | - | - | | | | |
| 15 | | | | | 93.4 | 5.0 | 1.6 | 442 | | | | |
| 16 | | | | | 91.6 | 2.2 | 6.1 | 850 | | | | |
| 17 | | | | | 73.6 | 2.2 | 23.8 | 1 229 | | | | |
| 18 | | | | | | | | | | | | |
| 19 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 21 | | | | | | | | | | | | |

| Date | Site 4 m. (%) | Site 4 b. (%) | Site 4 f. (%) | Site 4 No. in sample | Site 6 m. (%) | Site 6 b. (%) | Site 6 f. (%) | Site 6 No. in sample | Site 7 m. (%) | Site 7 b. (%) | Site 7 f. (%) | Site 7 No. in sample | Site 8 m. (%) | Site 8 b. (%) | Site 8 f. (%) | Site 8 No. in sample |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oct 18 | 95.0 | 4.6 | 0.4 | 1 025 | 91.7 | 8.3 | 0 | 434 | - | - | - | - | 92.1 | 7.9 | 0 | 101 |
| 19 | 96.9 | 2.8 | 0.2 | 1 277 | 99.0 | 1.0 | 0 | 390 | 87.9 | 12.1 | 0 | 198 | 89.1 | 10.5 | 0.4 | 457 |
| 20 | 98.6 | 1.4 | 0 | 432 | 93.0 | 7.0 | 0 | 428 | 82.5 | 17.5 | 0 | 263 | 94.0 | 5.8 | 0.2 | 500 |
| 21 | 98.8 | 1.0 | 0.2 | 570 | 95.7 | 4.1 | 0.2 | 418 | 96.1 | 3.9 | 0 | 103 | 94.8 | 5.2 | 0 | 401 |
| 22 | 97.2 | 2.1 | 0.7 | 430 | 95.5 | 4.3 | 0.2 | 486 | 94.6 | 5.1 | 0.3 | 370 | 95.6 | 4.4 | 0 | 617 |
| 23 | 98.2 | 1.2 | 0.6 | 338 | 34.8 | 65.2 | 0 | 351 | 83.8 | 16.2 | 0 | 340 | - | - | - | - |
| 24 | 98.2 | 1.3 | 0.5 | 386 | 44.2 | 55.8 | 0 | 437 | - | - | - | - | - | - | - | - |
| 25 | 95.8 | 3.9 | 0.2 | 406 | 59.6 | 40.4 | 0 | 431 | 86.1 | 13.6 | 0.2 | 418 | 94.2 | 5.8 | 0 | 515 |
| 26 | 91.3 | 8.2 | 0.5 | 554 | 59.8 | 40.2 | 0 | 435 | - | - | - | - | 90.2 | 9.8 | 0 | 439 |
| 27 | 97.6 | 1.5 | 0.9 | 464 | 91.3 | 7.9 | 0.8 | 481 | 57.3 | 42.7 | 0 | 220 | 78.1 | 21.9 | 0 | 606 |
| 28 | 97.3 | 1.8 | 0.9 | 336 | 89.4 | 9.6 | 1.0 | 397 | 93.9 | 6.0 | 0.1 | 715 | 76.8 | 23.2 | 0 | 327 |
| 29 | 97.2 | 1.0 | 1.8 | 393 | 93.4 | 6.4 | 0.2 | 484 | - | - | - | - | 94.6 | 5.4 | 0 | 702 |
| 30 | 99.6 | 0.1 | 0.2 | 520 | 91.7 | 7.3 | 1.0 | 384 | 97.3 | 2.7 | 0 | 638 | 97.0 | 3.0 | 0 | 795 |
| 31 | - | - | - | - | - | - | - | - | | | | | | | | |
| Nov 1 | 89.9 | 6.1 | 4.0 | 99 | - | - | - | - | | | | | | | | |
| 2 | - | - | - | - | 95.0 | 5.0 | 0 | 419 | | | | | | | | |
| 3 | - | - | - | - | - | - | - | - | | | | | | | | |
| 4 | 94.8 | 3.8 | 1.4 | 577 | 94.2 | 5.6 | 0.2 | 449 | | | | | | | | |
| 5 | 85.9 | 11.1 | 3.0 | 396 | - | - | - | - | | | | | | | | |
| 6 | - | - | - | - | - | - | - | - | | | | | | | | |
| 7 | - | - | - | - | - | - | - | - | | | | | | | | |
| 8 | 93.7 | 6.1 | 0.2 | 607 | - | - | - | - | | | | | | | | |
| 9 | 94.4 | 5.4 | 0.2 | 468 | 14.5 | 85.5 | 0 | 283 | | | | | | | | |
| 10 | 98.1 | 1.0 | 1.0 | 427 | 80.3 | 19.2 | 0.5 | 391 | | | | | | | | |
| 11 | 93.7 | 3.4 | 2.9 | 379 | - | - | - | - | | | | | | | | |
| 12 | 93.5 | 2.1 | 4.0 | 475 | 75.1 | 22.7 | 2.1 | 466 | | | | | | | | |
| 13 | - | - | - | - | - | - | - | - | | | | | | | | |
| 14 | - | - | - | - | - | - | - | - | | | | | | | | |
| 15 | 97.8 | 1.5 | 0.7 | 410 | - | - | - | - | | | | | | | | |
| 16 | 97.8 | 0.7 | 1.5 | 540 | 90.7 | 8.2 | 1.1 | 450 | | | | | | | | |
| 17 | 96.5 | 1.2 | 2.3 | 604 | 87.7 | 10.4 | 1.9 | 413 | | | | | | | | |
| 18 | 95.4 | 1.1 | 3.6 | 366 | 83.4 | 15.6 | 1.0 | 416 | | | | | | | | |
| 19 | | | | | 80.1 | 14.8 | 5.1 | 453 | | | | | | | | |
| 20 | | | | | 75.2 | 15.3 | 9.5 | 471 | | | | | | | | |
| 21 | | | | | 66.4 | 30.2 | 3.4 | 262 | | | | | | | | |

*The positions of the different sampling sites are shown in Fig. 2 and explained in Table 2.

†m.: *G. maculatus*.

‡b.: *G. brevipinnis*.

§f.: *G. fasciatus*.

TABLE 69: Daily catch composition in Waiatoto River tributaries in 1972

| Date | Hindley Creek | | | | Dawn Rivulet | | | | Content Creek | | | | Nolans Creek | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m.* (%) | b.† (%) | f.‡ (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample |
| Aug 16 | 100.0 | 0 | 0 | 50 | | | | | 100.0 | 0 | 0 | 29 | 100.0 | 0 | 0 | 19 |
| 17 | 100.0 | 0 | 0 | 363 | 100.0 | 0 | 0 | 272 | - | - | - | - | - | - | - | - |
| 18 | 100.0 | 0 | 0 | 61 | - | - | - | - | - | - | - | - | - | - | - | - |
| 19 | 100.0 | 0 | 0 | 37 | 100.0 | 0 | 0 | 38 | - | - | - | - | 100.0 | 0 | 0 | 32 |
| 20 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 21 | 100.0 | 0 | 0 | 71 | - | - | - | - | 100.0 | 0 | 0 | 6 | 100.0 | 0 | 0 | 10 |
| 22 | 97.7 | 0 | 2.3 | 43 | - | - | - | - | - | - | - | - | - | - | - | - |
| 23 | 99.1 | 0 | 0.9 | 112 | 100.0 | 0 | 0 | 32 | - | - | - | - | 100.0 | 0 | 0 | 6 |
| 24 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 25 | 99.8 | 0.2 | 0 | 468 | 99.7 | 0 | 0.3 | 334 | 100.0 | 0 | 0 | 42 | 97.8 | 1.1 | 1.1 | 93 |
| 26 | 100.0 | 0 | 0 | 490 | 100.0 | 0 | 0 | 37 | - | - | - | - | 100.0 | 0 | 0 | 66 |
| 27 | - | - | - | - | 100.0 | 0 | 0 | 64 | - | - | - | - | 100.0 | 0 | 0 | 6 |
| 28 | - | - | - | - | 95.7 | 0 | 4.3 | 23 | 100.0 | 0 | 0 | 50 | 100.0 | 0 | 0 | 35 |
| 29 | 99.6 | 0 | 0.4 | 835 | 99.8 | 0 | 0.2 | 535 | 100.0 | 0 | 0 | 36 | - | - | - | - |
| 30 | 99.6 | 0 | 0.4 | 283 | 100.0 | 0 | 0 | 73 | 100.0 | 0 | 0 | 95 | - | - | - | - |
| 31 | 99.5 | 0.2 | 0.2 | 417 | 100.0 | 0 | 0 | 35 | - | - | - | - | 99.6 | 0.4 | 0 | 734 |
| Sep 1 | 100.0 | 0 | 0 | 38 | 100.0 | 0 | 0 | 116 | - | - | - | - | 100.0 | 0 | 0 | 31 |
| 2 | 99.7 | 0 | 0.3 | 312 | - | - | - | - | 99.1 | 0 | 0.9 | 113 | - | - | - | - |
| 3 | 100.0 | 0 | 0 | 71 | 100.0 | 0 | 0 | 159 | 99.0 | 0 | 1.0 | 312 | - | - | - | - |
| 4 | 100.0 | 0 | 0 | 24 | 100.0 | 0 | 0 | 90 | 99.2 | 0 | 0.8 | 126 | 100.0 | 0 | 0 | 513 |
| 5 | - | - | - | - | 100.0 | 0 | 0 | 34 | 100.0 | 0 | 0 | 71 | 100.0 | 0 | 0 | 208 |
| 6 | 99.7 | 0 | 0.3 | 292 | 100.0 | 0 | 0 | 400 | 99.0 | 0 | 1.0 | 502 | 100.0 | 0 | 0 | 283 |
| 7 | 100.0 | 0 | 0 | 50 | 100.0 | 0 | 0 | 39 | - | - | - | - | 99.2 | 0.6 | 0.2 | 489 |
| 8 | 99.5 | 0 | 0.5 | 211 | 100.0 | 0 | 0 | 221 | 100.0 | 0 | 0 | 116 | - | - | - | - |
| 9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 10 | 99.6 | 0 | 0.4 | 518 | 100.0 | 0 | 0 | 540 | - | - | - | - | - | - | - | - |
| 11 | - | - | - | - | 100.0 | 0 | 0 | 510 | 100.0 | 0 | 0 | 500 | 100.0 | 0 | 0 | 481 |
| 12 | 99.8 | 0.2 | 0 | 512 | 99.2 | 0.8 | 0 | 978 | 100.0 | 0 | 0 | 675 | 100.0 | 0 | 0 | 301 |
| 13 | 99.8 | 0.2 | 0 | 522 | 100.0 | 0 | 0 | 505 | 99.8 | 0.2 | 0 | 404 | 100.0 | 0 | 0 | 89 |
| 14 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 15 | 98.4 | 0.5 | 1.1 | 187 | 100.0 | 0 | 0 | 518 | 100.0 | 0 | 0 | 121 | - | - | - | - |
| 16 | 98.9 | 0.9 | 0.2 | 464 | 100.0 | 0 | 0 | 108 | 100.0 | 0 | 0 | 440 | 100.0 | 0 | 0 | 18 |
| 17 | 100.0 | 0 | 0 | 30 | 100.0 | 0 | 0 | 326 | - | - | - | - | 100.0 | 0 | 0 | 69 |
| 18 | 98.1 | 1.9 | 0 | 158 | 99.8 | 0 | 0.2 | 543 | 100.0 | 0 | 0 | 32 | - | - | - | - |
| 19 | - | - | - | - | 99.8 | 0 | 0.2 | 481 | - | - | - | - | 100.0 | 0 | 0 | 117 |
| 20 | - | - | - | - | 100.0 | 0 | 0 | 405 | 100.0 | 0 | 0 | 584 | 100.0 | 0 | 0 | 28 |
| 21 | - | - | - | - | 99.9 | 0.1 | 0 | 523 | - | - | - | - | 100.0 | 0 | 0 | 75 |
| 22 | 99.7 | 0.3 | 0 | 307 | 99.8 | 0.2 | 0 | 552 | - | - | - | - | 100.0 | 0 | 0 | 28 |
| 23 | 100.0 | 0 | 0 | 485 | 100.0 | 0 | 0 | 192 | 99.9 | 0 | 0.1 | 783 | 100.0 | 0 | 0 | 91 |
| 24 | 100.0 | 0 | 0 | 566 | 99.8 | 0 | 0.2 | 403 | 100.0 | 0 | 0 | 899 | 99.4 | 0.6 | 0 | 329 |
| 25 | 100.0 | 0 | 0 | 449 | 99.8 | 0.2 | 0 | 556 | 100.0 | 0 | 0 | 589 | 100.0 | 0 | 0 | 409 |
| 26 | 99.8 | 0 | 0.2 | 510 | 100.0 | 0 | 0 | 365 | 100.0 | 0 | 0 | 580 | - | - | - | - |
| 27 | 99.7 | 0 | 0.3 | 357 | 99.8 | 0 | 0.2 | 450 | 100.0 | 0 | 0 | 461 | 100.0 | 0 | 0 | 42 |
| 28 | - | - | - | - | 100.0 | 0 | 0 | 526 | 99.4 | 0 | 0.6 | 339 | 100.0 | 0 | 0 | 214 |
| 29 | 100.0 | 0 | 0 | 376 | 100.0 | 0 | 0 | 463 | 100.0 | 0 | 0 | 457 | 100.0 | 0 | 0 | 159 |
| 30 | 99.7 | 0.3 | 0 | 294 | 100.0 | 0 | 0 | 311 | 100.0 | 0 | 0 | 469 | - | - | - | - |

TABLE 69: Daily catch composition in Waiatoto River tributaries in 1972 (continued)

| | Hindley Creek | | | | Dawn Rivulet | | | | Content Creek | | | | Nolans Creek | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample | m. (%) | b. (%) | f. (%) | No. in sample |
| Oct 1 | 99.4 | 0 | 0.6 | 360 | 99.8 | 0.2 | 0 | 448 | - | - | - | - | - | - | - | - |
| 2 | 100.0 | 0 | 0 | 458 | 99.5 | 0.2 | 0.2 | 440 | 100.0 | 0 | 0 | 12 | 100.0 | 0 | 0 | 5 |
| 3 | 99.8 | 0 | 0.2 | 405 | 100.0 | 0 | 0 | 413 | 98.8 | 0 | 1.2 | 83 | 100.0 | 0 | 0 | 13 |
| 4 | 99.8 | 0 | 0.2 | 482 | 100.0 | 0 | 0 | 452 | 97.3 | 0 | 2.7 | 73 | 100.0 | 0 | 0 | 85 |
| 5 | 99.4 | 0.1 | 0.5 | 810 | 99.6 | 0 | 0.4 | 516 | 99.6 | 0 | 0.4 | 243 | 100.0 | 0 | 0 | 59 |
| 6 | 98.4 | 0.7 | 0.9 | 440 | 99.3 | 0 | 0.7 | 404 | 99.8 | 0 | 0.2 | 444 | 100.0 | 0 | 0 | 25 |
| 7 | 99.8 | 0 | 0.2 | 485 | 99.8 | 0 | 0.2 | 638 | - | - | - | - | 100.0 | 0 | 0 | 320 |
| 8 | 100.0 | 0 | 0 | 410 | 99.7 | 0 | 0.3 | 678 | 99.8 | 0 | 0.2 | 492 | - | - | - | - |
| 9 | 99.6 | 0.4 | 0 | 263 | 100.0 | 0 | 0 | 340 | 99.4 | 0 | 0.6 | 468 | 100.0 | 0 | 0 | 59 |
| 10 | 98.9 | 0 | 1.1 | 395 | 98.6 | 0 | 1.4 | 73 | 99.0 | 0 | 1.0 | 863 | 100.0 | 0 | 0 | 20 |
| 11 | 98.2 | 0.2 | 1.6 | 547 | 99.3 | 0 | 0.7 | 701 | 99.3 | 0 | 0.7 | 148 | 100.0 | 0 | 0 | 2 |
| 12 | 98.4 | 0 | 1.6 | 437 | 99.1 | 0.2 | 0.7 | 433 | 100.0 | 0 | 0 | 348 | 99.6 | 0.4 | 0 | 266 |
| 13 | 99.0 | 0.4 | 0.6 | 504 | 100.0 | 0 | 0 | 510 | 100.0 | 0 | 0 | 155 | 100.0 | 0 | 0 | 286 |
| 14 | 99.8 | 0.2 | 0 | 477 | 100.0 | 0 | 0 | 500 | 100.0 | 0 | 0 | 284 | 100.0 | 0 | 0 | 170 |
| 15 | - | - | - | - | 99.9 | 0.1 | 0 | 909 | 100.0 | 0 | 0 | 104 | 100.0 | 0 | 0 | 82 |
| 16 | 98.0 | 1.1 | 0.9 | 439 | 100.0 | 0 | 0 | 600 | 100.0 | 0 | 0 | 33 | 100.0 | 0 | 0 | 43 |
| 17 | 99.5 | 0.3 | 0.2 | 1 014 | 99.8 | 0.1 | 0.1 | 1 121 | 97.7 | 0 | 2.3 | 44 | 98.0 | 2.0 | 0 | 49 |
| 18 | 98.8 | 0.5 | 0.7 | 1 208 | 100.0 | 0 | 0 | 300 | 99.5 | 0 | 0.5 | 411 | 98.5 | 0.8 | 0.8 | 130 |
| 19 | 99.5 | 0 | 0.5 | 440 | 99.9 | 0.1 | 0 | 773 | 99.1 | 0 | 0.9 | 329 | 99.1 | 0 | 0.9 | 69 |
| 20 | 98.0 | 0.2 | 1.8 | 457 | 100.0 | 0 | 0 | 370 | 98.9 | 0 | 1.1 | 450 | 100.0 | 0 | 0 | 3 |
| 21 | 98.3 | 0 | 1.7 | 348 | 100.0 | 0 | 0 | 407 | 97.5 | 0 | 2.5 | 204 | - | - | - | - |
| 22 | 100.0 | 0 | 0 | 413 | 100.0 | 0 | 0 | 116 | - | - | - | - | - | - | - | - |
| 23 | 98.1 | 0.5 | 1.4 | 216 | 100.0 | 0 | 0 | 581 | 100.0 | 0 | 0 | 21 | - | - | - | - |
| 24 | 99.1 | 0.5 | 0.3 | 588 | 100.0 | 0 | 0 | 381 | 100.0 | 0 | 0 | 332 | 99.3 | 0 | 0.7 | 140 |
| 25 | 96.6 | 0 | 3.4 | 117 | 100.0 | 0 | 0 | 183 | 99.8 | 0 | 0.2 | 947 | 100.0 | 0 | 0 | 25 |
| 26 | 98.0 | 0.3 | 1.7 | 635 | 99.5 | 0 | 0.5 | 424 | - | - | - | - | 96.8 | 0 | 3.2 | 31 |
| 27 | 98.7 | 0.9 | 0.4 | 224 | 98.7 | 0.4 | 0.9 | 232 | 100.0 | 0 | 0 | 98 | 100.0 | 0 | 0 | 111 |
| 28 | 100.0 | 0 | 0 | 83 | 100.0 | 0 | 0 | 447 | 99.1 | 0 | 0.9 | 117 | 100.0 | 0 | 0 | 16 |
| 29 | 93.7 | 0 | 6.3 | 270 | 99.5 | 0 | 0.5 | 402 | 100.0 | 0 | 0 | 113 | 100.0 | 0 | 0 | 25 |
| 30 | 90.3 | 0 | 9.7 | 372 | 100.0 | 0 | 0 | 205 | 100.0 | 0 | 0 | 34 | 100.0 | 0 | 0 | 23 |
| 31 | 91.6 | 0.4 | 8.0 | 225 | 99.5 | 0 | 0.5 | 412 | - | - | - | - | - | - | - | - |
| Nov 1 | - | - | - | - | 100.0 | 0 | 0 | 107 | - | - | - | - | - | - | - | - |
| 2 | 97.7 | 0.9 | 1.4 | 214 | 100.0 | 0 | 0 | 26 | - | - | - | - | - | - | - | - |
| 3 | - | - | - | - | 97.7 | 0.6 | 1.8 | 170 | 100.0 | 0 | 0 | 19 | 100.0 | 0 | 0 | 1 |
| 4 | 99.6 | 0.4 | 0 | 527 | 98.6 | 1.4 | 0 | 573 | 97.0 | 0 | 3.0 | 535 | - | - | - | - |
| 5 | 98.8 | 0.4 | 0.7 | 1 095 | 98.3 | 0.3 | 1.4 | 777 | 98.0 | 0 | 2.0 | 561 | 92.3 | 0 | 7.7 | 13 |
| 6 | 99.6 | 0.2 | 0.2 | 489 | 100.0 | 0 | 0 | 189 | 94.6 | 0 | 5.4 | 203 | | | | |
| 7 | 98.9 | 0.9 | 0.1 | 850 | 99.1 | 0 | 0.9 | 108 | 99.3 | 0.1 | 0.6 | 1 010 | | | | |
| 8 | 98.1 | 1.6 | 0.2 | 917 | 98.7 | 1.2 | 0.1 | 935 | 100.0 | 0 | 0 | 505 | | | | |
| 9 | 99.3 | 0.7 | 0 | 555 | 100.0 | 0 | 0 | 337 | 99.7 | 0 | 0.3 | 576 | | | | |
| 10 | 55.3 | 34.2 | 10.5 | 38 | 100.0 | 0 | 0 | 160 | 99.0 | 0 | 1.0 | 302 | | | | |
| 11 | 97.4 | 1.1 | 1.4 | 349 | 98.6 | 0 | 1.4 | 215 | 99.2 | 0 | 0.8 | 477 | | | | |
| 12 | 96.0 | 0.7 | 3.3 | 549 | 97.2 | 0 | 2.8 | 398 | 91.9 | 0.3 | 7.8 | 358 | | | | |
| 13 | - | - | - | - | - | - | - | - | | | | | | | | |
| 14 | 100.0 | 0 | 0 | 373 | 98.1 | 0 | 1.9 | 471 | | | | | | | | |

*m.: G. maculatus.
†b.: G. brevipinnis.
‡f.: G. fasciatus.

TABLE 70: Daily catch composition in Waiatoto River in 1973

| Date | Site 2* m.† (%) | Site 2* b.‡ (%) | Site 2* f.§ (%) | Site 2* No. in sample | Site 4 m. (%) | Site 4 b. (%) | Site 4 f. (%) | Site 4 No. in sample | Site 6 m. (%) | Site 6 b. (%) | Site 6 f. (%) | Site 6 No. in sample |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sep 1 | 100.0 | 0 | 0 | 206 | | | | | 96.6 | 3.4 | 0 | 409 |
| 2 | 99.1 | 0.7 | 0.2 | 426 | | | | | 96.5 | 3.5 | 0 | 318 |
| 3 | - | - | - | - | 98.3 | 1.7 | 0 | 465 | 97.1 | 2.9 | 0 | 347 |
| 4 | - | - | - | - | 94.8 | 4.7 | 0.5 | 405 | - | - | - | - |
| 5 | - | - | - | - | 89.4 | 10.6 | 0 | 189 | 81.0 | 18.4 | 0.6 | 321 |
| 6 | - | - | - | - | - | - | - | - | - | - | - | - |
| 7 | - | - | - | - | 98.7 | 0.6 | 0.6 | 316 | - | - | - | - |
| 8 | - | - | - | - | 97.0 | 3.0 | 0 | 234 | 91.3 | 8.7 | 0 | 320 |
| 9 | - | - | - | - | 95.7 | 4.3 | 0 | 187 | 79.5 | 20.2 | 0.3 | 326 |
| 10 | 98.9 | 0.9 | 0.2 | 470 | 97.0 | 3.0 | 0 | 199 | 78.7 | 21.3 | 0 | 366 |
| 11 | - | - | - | - | 94.6 | 5.4 | 0 | 371 | 78.4 | 19.8 | 1.8 | 217 |
| 12 | 99.3 | 0.7 | 0 | 589 | 97.1 | 2.9 | 0 | 450 | 40.8 | 58.8 | 0.4 | 245 |
| 13 | 98.8 | 1.3 | 0 | 480 | 97.8 | 2.2 | 0 | 415 | 32.9 | 66.2 | 0.9 | 231 |
| 14 | - | - | - | - | 97.6 | 2.4 | 0 | 379 | - | - | - | - |
| 15 | 99.2 | 0.8 | 0 | 532 | 86.7 | 12.8 | 0.5 | 188 | - | - | - | - |
| 16 | 98.9 | 1.1 | 0 | 531 | 92.4 | 7.1 | 0.5 | 354 | - | - | - | - |
| 17 | 98.2 | 1.3 | 0.5 | 554 | 90.5 | 9.5 | 0 | 337 | - | - | - | - |
| 18 | 93.5 | 6.2 | 0.3 | 291 | 89.6 | 9.6 | 0.8 | 364 | - | - | - | - |
| 19 | 95.0 | 4.0 | 1.0 | 421 | 92.7 | 6.7 | 0.6 | 330 | - | - | - | - |
| 20 | 97.9 | 1.9 | 0.3 | 378 | 88.1 | 10.9 | 1.0 | 377 | - | - | - | - |
| 21 | - | - | - | - | 97.9 | 2.1 | 0 | 292 | - | - | - | - |
| 22 | - | - | - | - | 80.3 | 19.7 | 0 | 142 | - | - | - | - |
| 23 | - | - | - | - | 83.9 | 15.8 | 0.3 | 316 | - | - | - | - |
| 24 | - | - | - | - | 93.5 | 6.1 | 0.4 | 260 | - | - | - | - |
| 25 | 92.5 | 7.5 | 0 | 471 | 93.2 | 6.8 | 0 | 310 | - | - | - | - |
| 26 | 94.5 | 5.0 | 0.5 | 419 | 94.1 | 5.1 | 0.8 | 372 | - | - | - | - |
| 27 | - | - | - | - | 97.4 | 2.3 | 0.2 | 431 | - | - | - | - |
| 28 | 98.0 | 0.7 | 1.3 | 715 | 94.1 | 5.4 | 0.5 | 373 | - | - | - | - |
| 29 | - | - | - | - | 97.0 | 2.3 | 0.7 | 400 | - | - | - | - |
| 30 | 92.9 | 4.4 | 2.7 | 339 | 90.4 | 6.7 | 2.9 | 417 | - | - | - | - |
| Oct 1 | - | - | - | - | 78.1 | 15.4 | 6.5 | 228 | - | - | - | - |
| 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| 3 | 92.7 | 1.3 | 6.0 | 300 | 88.2 | 5.2 | 6.6 | 212 | 76.3 | 23.7 | 0 | 371 |
| 4 | - | - | - | - | 96.6 | 3.0 | 0.4 | 265 | 18.2 | 81.7 | 0 | 279 |
| 5 | 91.4 | 6.8 | 1.8 | 396 | 82.2 | 9.2 | 8.6 | 338 | 32.7 | 67.3 | 0 | 251 |
| 6 | - | - | - | - | - | - | - | - | 44.0 | 56.0 | 0 | 243 |
| 7 | 93.8 | 4.6 | 1.6 | 373 | 84.0 | 12.1 | 3.9 | 281 | - | - | - | - |
| 8 | - | - | - | - | 91.0 | 5.6 | 3.3 | 390 | 40.8 | 59.2 | 0 | 267 |
| 9 | 88.9 | 4.5 | 6.5 | 398 | 92.5 | 3.9 | 3.6 | 333 | 29.9 | 70.1 | 0 | 261 |
| 10 | 96.3 | 1.9 | 1.7 | 463 | 94.2 | 2.6 | 3.2 | 498 | 45.2 | 54.8 | 0 | 230 |
| 11 | 94.9 | 2.1 | 3.0 | 235 | 91.5 | 5.2 | 3.3 | 306 | - | - | - | - |
| 12 | - | - | - | - | - | - | - | - | - | - | - | - |
| 13 | - | - | - | - | - | - | - | - | - | - | - | - |
| 14 | - | - | - | - | - | - | - | - | - | - | - | - |
| 15 | - | - | - | - | - | - | - | - | 29.4 | 70.6 | 0 | 252 |
| 16 | 90.0 | 8.7 | 1.2 | 321 | 88.2 | 10.0 | 1.7 | 289 | 39.3 | 60.7 | 0 | 323 |
| 17 | 93.8 | 5.7 | 0.5 | 401 | 90.6 | 8.2 | 1.2 | 331 | 37.5 | 62.5 | 0 | 288 |
| 18 | 97.3 | 0.3 | 2.4 | 332 | 93.9 | 5.9 | 0.2 | 426 | 32.2 | 67.8 | 0 | 317 |
| 19 | 96.2 | 2.6 | 1.2 | 340 | 88.6 | 10.7 | 0.7 | 437 | 31.1 | 68.9 | 0 | 280 |
| 20 | 94.2 | 2.9 | 2.9 | 415 | 93.3 | 4.1 | 2.6 | 344 | 35.5 | 64.5 | 0 | 279 |
| 21 | - | - | - | - | - | - | - | - | - | - | - | - |
| 22 | - | - | - | - | - | - | - | - | - | - | - | - |
| 23 | - | - | - | - | - | - | - | - | - | - | - | - |
| 24 | - | - | - | - | 82.7 | 11.3 | 6.0 | 435 | - | - | - | - |
| 25 | 93.4 | 5.7 | 0.9 | 333 | 86.4 | 7.6 | 6.0 | 369 | 68.3 | 31.0 | 0.6 | 319 |
| 26 | - | - | - | - | 88.5 | 9.4 | 2.1 | 340 | 66.4 | 33.0 | 0.6 | 342 |
| 27 | 85.5 | 4.5 | 10.0 | 290 | 97.4 | 2.1 | 0.5 | 385 | - | - | - | - |
| 28 | 84.7 | 8.5 | 6.9 | 496 | 98.1 | 0.5 | 1.3 | 371 | - | - | - | - |
| 29 | 86.2 | 5.9 | 8.0 | 376 | 91.3 | 5.8 | 2.9 | 347 | 86.9 | 13.1 | 0 | 343 |
| 30 | 44.5 | 4.8 | 50.7 | 335 | 95.4 | 1.3 | 3.3 | 391 | 94.5 | 5.5 | 0 | 255 |
| 31 | - | - | - | - | - | - | - | - | - | - | - | - |

TABLE 70: Daily catch composition in Waiatoto River in 1973 (continued)

| Date | Site 2 m. (%) | Site 2 b. (%) | Site 2 f. (%) | Site 2 No. in sample | Site 4 m. (%) | Site 4 b. (%) | Site 4 f. (%) | Site 4 No. in sample | Site 6 m. (%) | Site 6 b. (%) | Site 6 f. (%) | Site 6 No. in sample |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nov 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| 4 | - | - | - | - | - | - | - | - | - | - | - | - |
| 5 | - | - | - | - | - | - | - | - | - | - | - | - |
| 6 | - | - | - | - | - | - | - | - | - | - | - | - |
| 7 | - | - | - | - | 19.5 | 80.1 | 0.4 | 251 | - | - | - | - |
| 8 | - | - | - | - | - | - | - | - | - | - | - | - |
| 9 | - | - | - | - | 93.6 | 4.3 | 2.1 | 328 | - | - | - | - |
| 10 | 99.0 | 0.5 | 0.5 | 404 | 93.9 | 2.8 | 3.2 | 280 | 93.8 | 6.2 | 0 | 338 |
| 11 | - | - | - | - | 94.1 | 1.4 | 4.5 | 358 | 93.4 | 5.5 | 1.1 | 349 |
| 12 | - | - | - | - | 97.7 | 0.8 | 1.5 | 513 | 93.2 | 4.9 | 1.9 | 365 |
| 13 | 94.7 | 1.6 | 3.7 | 318 | - | - | - | - | 94.1 | 5.4 | 0.5 | 408 |
| 14 | 93.1 | 1.2 | 5.8 | 431 | 98.2 | 1.3 | 0.4 | 455 | 91.2 | 6.0 | 2.8 | 430 |
| 15 | 93.6 | 2.0 | 4.4 | 296 | 98.9 | 0.5 | 0.5 | 567 | 93.0 | 6.2 | 0.8 | 372 |
| 16 | 90.1 | 2.9 | 7.0 | 445 | | | | | 93.7 | 4.9 | 1.4 | 363 |

*The positions of the different sampling sites are shown in Fig. 2 and explained in Table 2.

†m.: G. maculatus.

‡b.: G. brevipinnis.

§f.: G. fasciatus.

TABLE 71: Daily catch composition in Okuru River from 1969 to 1973

| Date | Site 1, 1969* m.† (%) | b.‡ (%) | f.§ (%) | No. in sample | Site 2, 1969 m. (%) | b. (%) | f. (%) | No. in sample |
|---|---|---|---|---|---|---|---|---|
| Sep 1 | | | | | 98.4 | 1.6 | 0 | 315 |
| 2 | | | | | - | - | - | - |
| 3 | | | | | - | - | - | - |
| 4 | | | | | - | - | - | - |
| 5 | | | | | - | - | - | - |
| 6 | | | | | - | - | - | - |
| 7 | | | | | - | - | - | - |
| 8 | | | | | - | - | - | - |
| 9 | | | | | - | - | - | - |
| 10 | | | | | - | - | - | - |
| 11 | | | | | - | - | - | - |
| 12 | | | | | - | - | - | - |
| 13 | | | | | - | - | - | - |
| 14 | 99.6 | 0.4 | 0 | 224 | - | - | - | - |
| 15 | 96.3 | 3.7 | 0 | 241 | - | - | - | - |
| 16 | 100.0 | 0 | 0 | 215 | - | - | - | - |
| 17 | 99.5 | 0.5 | 0 | 239 | - | - | - | - |
| 18 | 96.1 | 3.9 | 0 | 256 | - | - | - | - |
| 19 | 98.6 | 1.4 | 0 | 250 | - | - | - | - |
| 20 | 96.7 | 3.3 | 0 | 245 | - | - | - | - |
| 21 | 97.7 | 2.3 | 0 | 304 | - | - | - | - |
| 22 | - | - | - | - | - | - | - | - |
| 23 | - | - | - | - | - | - | - | - |
| 24 | - | - | - | - | - | - | - | - |
| 25 | - | - | - | - | - | - | - | - |
| 26 | - | - | - | - | - | - | - | - |
| 27 | - | - | - | - | - | - | - | - |
| 28 | - | - | - | - | - | - | - | - |
| 29 | - | - | - | - | - | - | - | - |
| 30 | - | - | - | - | - | - | - | - |
| Oct 1 | - | - | - | - | 79.2 | 18.3 | 2.5 | 323 |
| 2 | - | - | - | - | 81.6 | 13.8 | 4.6 | 217 |
| 3 | - | - | - | - | 87.1 | 6.8 | 6.1 | 426 |
| 4 | - | - | - | - | 83.2 | 15.5 | 1.3 | 297 |
| 5 | - | - | - | - | 92.2 | 7.5 | 0.3 | 306 |
| 6 | - | - | - | - | 84.3 | 13.9 | 1.8 | 166 |
| 7 | - | - | - | - | 82.0 | 17.4 | 0.6 | 172 |
| 8 | 90.3 | 9.4 | 0.3 | 288 | 85.2 | 14.8 | 0 | 27 |
| 9 | - | - | - | - | 90.8 | 9.2 | 0 | 184 |
| 10 | 94.6 | 5.1 | 0.3 | 296 | 86.9 | 9.4 | 3.7 | 107 |
| 11 | - | - | - | - | 92.8 | 6.1 | 1.1 | 378 |
| 12 | - | - | - | - | 95.4 | 2.9 | 1.7 | 238 |
| 13 | - | - | - | - | - | - | - | - |
| 14 | - | - | - | - | 97.7 | 1.7 | 0.6 | 171 |
| 15 | 97.5 | 2.5 | 0 | 401 | 99.0 | 1.0 | 0 | 101 |
| 16 | - | - | - | - | - | - | - | - |
| 17 | 97.8 | 2.2 | 0 | 231 | 95.0 | 5.0 | 0 | 20 |
| 18 | 99.4 | 0.6 | 0 | 337 | - | - | - | - |
| 19 | - | - | - | - | Site 3 | | | |
| 20 | - | - | - | - | 83.5 | 15.0 | 1.5 | 395 |
| 21 | - | - | - | - | 88.0 | 11.8 | 0.2 | 548 |
| 22 | - | - | - | - | 86.1 | 13.9 | 0 | 460 |
| 23 | 88.1 | 11.3 | 0.6 | 335 | 83.2 | 16.8 | 0 | 441 |
| 24 | 87.6 | 12.4 | 0 | 332 | 84.7 | 15.3 | 0 | 393 |
| 25 | - | - | - | - | 88.5 | 11.0 | 0.5 | 400 |
| 26 | - | - | - | - | 91.4 | 8.6 | 0 | 467 |
| 27 | 72.6 | 27.4 | 0 | 201 | 86.3 | 13.7 | 0 | 408 |
| 28 | - | - | - | - | 75.5 | 24.3 | 0.2 | 408 |
| 29 | 72.9 | 27.1 | 0 | 288 | 95.8 | 4.2 | 0 | 479 |
| 30 | - | - | - | - | 95.4 | 4.4 | 0.2 | 525 |
| 31 | 96.6 | 2.4 | 1.0 | 294 | 89.8 | 9.7 | 0.5 | 373 |

| Date | Site 3, 1970 m. (%) | b. (%) | f. (%) | No. in sample | Site 3, 1971 m. (%) | b. (%) | f. (%) | No. in sample |
|---|---|---|---|---|---|---|---|---|
| Sep 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | 98.6 | 0 | 1.4 | 360 | | | | |
| 5 | - | - | - | - | | | | |
| 6 | - | - | - | - | | | | |
| 7 | - | - | - | - | 99.2 | 0.8 | 0 | 357 |
| 8 | - | - | - | - | 99.0 | 1.0 | 0 | 414 |
| 9 | - | - | - | - | 95.6 | 1.3 | 3.1 | 320 |
| 10 | - | - | - | - | 94.1 | 0.9 | 5.0 | 358 |
| 11 | - | - | - | - | - | - | - | - |
| 12 | - | - | - | - | 95.5 | 2.8 | 1.7 | 354 |
| 13 | - | - | - | - | 98.0 | 1.4 | 0.6 | 346 |
| 14 | 97.6 | 0.3 | 2.1 | 373 | 96.4 | 3.6 | 0 | 363 |
| 15 | 96.7 | 0.6 | 2.7 | 449 | 99.1 | 0.3 | 0.6 | 345 |
| 16 | - | - | - | - | 96.5 | 1.3 | 2.2 | 369 |
| 17 | - | - | - | - | 98.6 | 0.8 | 0.6 | 367 |
| 18 | - | - | - | - | 97.8 | 0 | 2.2 | 366 |
| 19 | - | - | - | - | - | - | - | - |
| 20 | 97.3 | 2.7 | 0 | 408 | 98.1 | 0 | 1.9 | 274 |
| 21 | 96.7 | 2.6 | 0.7 | 301 | 96.9 | 1.1 | 2.0 | 356 |
| 22 | 99.1 | 0.8 | 0.2 | 665 | - | - | - | - |
| 23 | 94.4 | 2.9 | 2.7 | 338 | 95.1 | 2.6 | 2.3 | 306 |
| 24 | - | - | - | - | 90.4 | 5.9 | 3.7 | 354 |
| 25 | - | - | - | - | 89.1 | 2.7 | 8.2 | 331 |
| 26 | 97.4 | 2.0 | 0.6 | 346 | 95.9 | 1.7 | 2.4 | 293 |
| 27 | 90.5 | 6.2 | 3.3 | 275 | 97.2 | 0.8 | 2.0 | 246 |
| 28 | 95.3 | 1.4 | 3.3 | 359 | - | - | - | - |
| 29 | 96.9 | 1.4 | 1.7 | 350 | - | - | - | - |
| 30 | 98.9 | 1.1 | 0 | 266 | 88.1 | 11.9 | 0 | 312 |
| Oct 1 | 97.7 | 2.3 | 0 | 264 | 95.1 | 3.6 | 1.3 | 303 |
| 2 | 97.2 | 2.3 | 0.5 | 353 | 99.1 | 0 | 0.9 | 226 |
| 3 | - | - | - | - | - | - | - | - |
| 4 | 98.3 | 1.0 | 0.7 | 302 | - | - | - | - |
| 5 | 98.1 | 1.5 | 0.4 | 265 | - | - | - | - |
| 6 | 99.4 | 0.6 | 0 | 308 | 92.5 | 5.0 | 2.5 | 362 |
| 7 | 100.0 | 0 | 0 | 280 | 91.2 | 4.4 | 4.4 | 360 |
| 8 | - | - | - | - | 96.7 | 0.6 | 2.7 | 366 |
| 9 | 99.5 | 0 | 0.5 | 221 | 95.2 | 1.6 | 3.2 | 372 |
| 10 | 98.2 | 1.5 | 0.3 | 391 | - | - | - | - |
| 11 | 99.4 | 0.3 | 0.3 | 308 | - | - | - | - |
| 12 | 99.7 | 0.3 | 0 | 348 | - | - | - | - |
| 13 | 97.7 | 1.9 | 0.4 | 263 | - | - | - | - |
| 14 | 95.7 | 3.6 | 0.7 | 279 | 84.8 | 4.0 | 11.2 | 223 |
| 15 | 85.2 | 14.4 | 0.4 | 284 | 95.6 | 4.4 | 0 | 113 |
| 16 | 96.3 | 3.7 | 0 | 272 | 93.8 | 5.3 | 0.9 | 227 |
| 17 | 97.8 | 2.2 | 0 | 318 | - | - | - | - |
| 18 | 97.8 | 1.7 | 0.5 | 359 | 92.5 | 7.5 | 0 | 306 |
| 19 | 95.2 | 2.4 | 2.4 | 366 | 92.4 | 6.2 | 1.4 | 276 |
| 20 | 99.8 | 0.2 | 0 | 410 | 94.1 | 3.6 | 2.3 | 306 |
| 21 | 99.3 | 0.2 | 0.5 | 408 | 95.8 | 2.1 | 2.1 | 336 |
| 22 | - | - | - | - | 99.2 | 0 | 0.8 | 363 |
| 23 | - | - | - | - | 98.0 | 1.7 | 0.3 | 342 |
| 24 | - | - | - | - | 95.2 | 2.3 | 2.5 | 396 |
| 25 | - | - | - | - | 95.8 | 1.9 | 2.3 | 312 |
| 26 | - | - | - | - | 97.4 | 0.9 | 1.7 | 345 |
| 27 | 96.6 | 0.9 | 2.5 | 319 | 100.0 | 0 | 0 | 70 |
| 28 | 93.9 | 2.7 | 3.4 | 291 | 99.5 | 0.5 | 0 | 403 |
| 29 | 95.3 | 1.6 | 3.1 | 255 | - | - | - | - |
| 30 | 96.7 | 2.2 | 1.1 | 269 | 98.7 | 1.0 | 0.3 | 298 |
| 31 | 97.9 | 1.3 | 0.8 | 238 | 99.1 | 0.6 | 0.3 | 309 |

| Date | Site 3, 1972 m. (%) | b. (%) | f. (%) | No. in sample | Site 3, 1973 m. (%) | b. (%) | f. (%) | No. in sample |
|---|---|---|---|---|---|---|---|---|
| Sep 1 | | | | | 93.1 | 6.9 | 0 | 29 |
| 2 | | | | | 92.7 | 7.3 | 0 | 177 |
| 3 | 97.9 | 1.2 | 0.8 | 241 | - | - | - | - |
| 4 | 99.4 | 0.6 | 0 | 180 | - | - | - | - |
| 5 | 100.0 | 0 | 0 | 160 | 92.5 | 6.6 | 0.9 | 332 |
| 6 | 98.9 | 0.5 | 0.5 | 183 | 96.1 | 3.9 | 0 | 154 |
| 7 | 99.4 | 0 | 0.6 | 156 | - | - | - | - |
| 8 | - | - | - | - | 92.4 | 6.9 | 0.7 | 303 |
| 9 | - | - | - | - | 93.0 | 6.0 | 1.0 | 285 |
| 10 | 99.2 | 0.8 | 0 | 224 | 98.0 | 2.0 | 0 | 302 |
| 11 | 99.1 | 0.9 | 0 | 219 | 95.4 | 4.6 | 0 | 280 |
| 12 | 98.5 | 1.5 | 0 | 196 | 99.0 | 1.0 | 0 | 315 |
| 13 | 97.9 | 2.1 | 0 | 194 | 97.7 | 2.3 | 0 | 342 |
| 14 | - | - | - | - | 89.5 | 9.9 | 0.6 | 162 |
| 15 | - | - | - | - | 87.9 | 12.1 | 0 | 321 |
| 16 | 89.0 | 10.4 | 0.6 | 163 | 88.5 | 10.3 | 1.2 | 261 |
| 17 | 88.0 | 12.0 | 0 | 225 | 90.8 | 9.2 | 0 | 294 |
| 18 | 84.1 | 15.9 | 0 | 195 | 84.3 | 15.0 | 0.7 | 267 |
| 19 | - | - | - | - | 77.0 | 19.5 | 1.5 | 262 |
| 20 | 95.7 | 4.3 | 0 | 184 | 75.6 | 23.7 | 0.6 | 312 |
| 21 | 96.0 | 4.0 | 0 | 199 | 59.6 | 38.5 | 1.9 | 265 |
| 22 | 97.7 | 2.3 | 0 | 215 | 79.3 | 19.3 | 1.4 | 295 |
| 23 | - | - | - | - | 85.0 | 14.0 | 1.0 | 301 |
| 24 | 98.1 | 1.9 | 0 | 211 | - | - | - | - |
| 25 | 94.2 | 5.8 | 0 | 208 | - | - | - | - |
| 26 | 89.8 | 10.2 | 0 | 177 | 93.1 | 5.6 | 1.3 | 233 |
| 27 | 96.0 | 4.0 | 0 | 226 | 95.7 | 3.5 | 0.8 | 256 |
| 28 | 94.3 | 5.1 | 0.6 | 176 | 91.9 | 6.3 | 1.8 | 223 |
| 29 | 99.2 | 0.8 | 0 | 243 | - | - | - | - |
| 30 | 99.0 | 1.0 | 0 | 202 | 91.8 | 7.3 | 0.9 | 220 |
| Oct 1 | 97.2 | 1.4 | 1.4 | 218 | - | - | - | - |
| 2 | 94.7 | 3.6 | 1.8 | 225 | - | - | - | - |
| 3 | 99.6 | 0.4 | 0 | 231 | - | - | - | - |
| 4 | 99.2 | 0.8 | 0 | 243 | - | - | - | - |
| 5 | 97.9 | 0.5 | 1.5 | 194 | - | - | - | - |
| 6 | 96.7 | 3.3 | 0 | 150 | 43.6 | 52.3 | 4.0 | 298 |
| 7 | - | - | - | - | - | - | - | - |
| 8 | 99.6 | 0.4 | 0 | 247 | 89.0 | 9.4 | 1.6 | 254 |
| 9 | 94.2 | 4.9 | 0.9 | 225 | - | - | - | - |
| 10 | 98.4 | 1.6 | 0 | 182 | 83.2 | 11.2 | 5.6 | 285 |
| 11 | 100.0 | 0 | 0 | 163 | - | - | - | - |
| 12 | 97.1 | 2.4 | 0.5 | 207 | 90.8 | 6.5 | 2.7 | 338 |
| 13 | 87.9 | 11.6 | 0.6 | 173 | - | - | - | - |
| 14 | 98.9 | 1.1 | 0 | 189 | - | - | - | - |
| 15 | 97.1 | 2.9 | 0 | 207 | 45.0 | 55.0 | 0 | 109 |
| 16 | - | - | - | - | 77.4 | 21.2 | 1.4 | 288 |
| 17 | 98.8 | 1.2 | 0 | 166 | 71.7 | 24.3 | 4.0 | 226 |
| 18 | 99.1 | 0.9 | 0 | 219 | 91.0 | 8.3 | 0.7 | 277 |
| 19 | 98.6 | 0.9 | 0.5 | 211 | 70.2 | 23.0 | 6.7 | 282 |
| 20 | 97.4 | 2.1 | 0.4 | 234 | - | - | - | - |
| 21 | 98.1 | 1.9 | 0 | 214 | - | - | - | - |
| 22 | 90.8 | 8.4 | 0.8 | 249 | - | - | - | - |
| 23 | 95.2 | 3.9 | 0.9 | 228 | - | - | - | - |
| 24 | 94.0 | 5.5 | 0.5 | 217 | 95.9 | 4.1 | 0 | 270 |
| 25 | 87.8 | 11.2 | 1.0 | 196 | 35.5 | 63.0 | 1.5 | 265 |
| 26 | 92.8 | 6.3 | 0.9 | 112 | 70.2 | 25.2 | 4.6 | 158 |
| 27 | 92.7 | 6.2 | 1.1 | 177 | - | - | - | - |
| 28 | - | - | - | - | - | - | - | - |
| 29 | 98.5 | 0 | 1.5 | 198 | 94.7 | 2.8 | 2.5 | 284 |
| 30 | 97.0 | 1.3 | 1.7 | 238 | - | - | - | - |
| 31 | - | - | - | - | - | - | - | - |

TABLE 71: Daily catch composition in Okuru River from 1969 to 1973 (continued)

| Date | Site 1, 1969 m. (%) | b. (%) | f. (%) | No. in sample | Site 3, 1969 m. (%) | b. (%) | f. (%) | No. in sample | Site 3, 1970 m. (%) | b. (%) | f. (%) | No. in sample |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nov 1 | 71.1 | 27.6 | 1.3 | 456 | 89.6 | 10.0 | 0.4 | 500 | 98.3 | 1.4 | 0.3 | 286 |
| 2 | - | - | - | - | 80.0 | 19.8 | 0.2 | 431 | 95.6 | 3.7 | 0.7 | 272 |
| 3 | 96.6 | 3.2 | 0.2 | 407 | 84.4 | 15.1 | 0.5 | 404 | 97.7 | 0.9 | 1.4 | 215 |
| 4 | | | | | 73.6 | 26.4 | 0 | 372 | 97.9 | 0.5 | 1.6 | 371 |
| 5 | | | | | 87.5 | 12.2 | 0.3 | 352 | 96.5 | 0.3 | 3.2 | 309 |
| 6 | | | | | 82.4 | 17.0 | 0.6 | 324 | 97.9 | 0.3 | 1.8 | 337 |
| 7 | | | | | 85.4 | 14.1 | 0.5 | 377 | 97.6 | 0 | 2.4 | 252 |
| 8 | | | | | 88.0 | 10.9 | 1.1 | 351 | 96.9 | 0.6 | 2.5 | 324 |
| 9 | | | | | - | - | - | - | 96.3 | 1.0 | 2.7 | 298 |
| 10 | | | | | 92.3 | 7.4 | 0.3 | 324 | 95.5 | 0 | 4.5 | 264 |
| 11 | | | | | 83.4 | 15.1 | 1.5 | 529 | 94.8 | 0 | 5.2 | 307 |
| 12 | | | | | 88.0 | 12.0 | 0 | 326 | - | - | - | - |
| 13 | | | | | | | | | 95.3 | 0.6 | 4.1 | 315 |
| 14 | | | | | | | | | 96.2 | 0.5 | 3.3 | 394 |
| 15 | | | | | | | | | - | - | - | - |
| 16 | | | | | | | | | - | - | - | - |
| 17 | | | | | | | | | - | - | - | - |
| 18 | | | | | | | | | - | - | - | - |
| 19 | | | | | | | | | 94.3 | 0 | 5.7 | 406 |
| 20 | | | | | | | | | 96.5 | 0 | 3.5 | 231 |
| 21 | | | | | | | | | 96.6 | 0.3 | 3.1 | 326 |
| 22 | | | | | | | | | 95.5 | 0.3 | 4.2 | 312 |
| 23 | | | | | | | | | 92.0 | 0.9 | 7.1 | 338 |

| Date | Site 3, 1971 m. (%) | b. (%) | f. (%) | No. in sample | Site 3, 1972 m. (%) | b. (%) | f. (%) | No. in sample | Site 3, 1973 m. (%) | b. (%) | f. (%) | No. in sample |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nov 1 | 99.1 | 0 | 0.9 | 334 | 95.2 | 3.2 | 1.6 | 249 | - | - | - | - |
| 2 | 98.6 | 1.1 | 0.3 | 357 | 94.0 | 5.2 | 0.8 | 252 | - | - | - | - |
| 3 | 96.7 | 1.5 | 1.8 | 394 | - | - | - | - | - | - | - | - |
| 4 | 96.4 | 1.7 | 1.9 | 412 | 92.6 | 7.4 | 0 | 175 | 86.9 | 12.6 | 0.5 | 222 |
| 5 | 96.2 | 1.3 | 2.5 | 397 | - | - | - | - | 72.2 | 27.3 | 0.5 | 194 |
| 6 | 98.5 | 0.3 | 1.2 | 403 | - | - | - | - | - | - | - | - |
| 7 | 99.3 | 0 | 0.7 | 301 | - | - | - | - | - | - | - | - |
| 8 | 97.1 | 0.6 | 2.3 | 345 | - | - | - | - | - | - | - | - |
| 9 | 98.0 | 0 | 2.0 | 298 | - | - | - | - | 92.1 | 7.9 | 0 | 190 |
| 10 | 90.2 | 1.2 | 8.6 | 327 | - | - | - | - | 96.8 | 2.7 | 0.5 | 219 |
| 11 | 93.9 | 0.6 | 5.5 | 363 | - | - | - | - | 97.8 | 1.5 | 0.7 | 274 |
| 12 | 90.9 | 0 | 9.1 | 320 | 83.1 | 5.4 | 11.4 | 166 | - | - | - | - |
| 13 | 89.1 | 0.3 | 10.6 | 376 | - | - | - | - | 98.8 | 1.2 | 0 | 253 |
| 14 | 89.7 | 0.7 | 9.6 | 405 | 94.0 | 1.7 | 4.3 | 234 | - | - | - | - |
| 15 | - | - | - | - | | | | | 94.3 | 2.1 | 3.6 | 192 |
| 16 | - | - | - | - | | | | | | | | |
| 17 | - | - | - | - | | | | | | | | |
| 18 | - | - | - | - | | | | | | | | |
| 19 | 87.4 | 0 | 12.6 | 87 | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 21 | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | |

*For explanation of site numbers see "Influence of Sampling Sites on Catch Composition".

†m.: *G. maculatus*.

‡b.: *G. brevipinnis*.

§f.: *G. fasciatus*.

TABLE 72: Daily catch composition in Cascade River from 1970 to 1973

| Date | 1970 m.* (%) | 1970 b.† (%) | 1970 f.‡ (%) | 1970 No. in sample | 1971 m. (%) | 1971 b. (%) | 1971 f. (%) | 1971 No. in sample | 1972 m. (%) | 1972 b. (%) | 1972 f. (%) | 1972 No. in sample | 1973 m. (%) | 1973 b. (%) | 1973 f. (%) | 1973 No. in sample |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sep 1 | | | | | | | | | 99.5 | 0.3 | 0.2 | 590 | 99.8 | 0.2 | 0 | 512 |
| 2 | 98.2 | 0.6 | 1.2 | 326 | 98.6 | 0.5 | 0.9 | 559 | 98.9 | 1.1 | 0 | 463 | 99.8 | 0.2 | 0 | 444 |
| 3 | 99.7 | 0.3 | 0 | 328 | 97.9 | 1.7 | 0.4 | 480 | 98.5 | 1.5 | 0 | 537 | 99.2 | 0.6 | 0.2 | 627 |
| 4 | 99.7 | 0 | 0.3 | 369 | 98.2 | 0.9 | 0.9 | 451 | 99.1 | 0.7 | 0.2 | 549 | 98.1 | 1.9 | 0 | 477 |
| 5 | 100.0 | 0 | 0 | 382 | 98.5 | 1.5 | 0 | 452 | 99.8 | 0.2 | 0 | 514 | 98.8 | 0.8 | 0.4 | 495 |
| 6 | - | - | - | - | 98.4 | 0.9 | 0.7 | 436 | 99.3 | 0.7 | 0 | 534 | - | - | - | - |
| 7 | 100.0 | 0 | 0 | 342 | 97.4 | 2.1 | 0.5 | 431 | 99.3 | 0.7 | 0 | 589 | 98.8 | 1.2 | 0 | 498 |
| 8 | 98.2 | 1.8 | 0 | 382 | 100.0 | 0 | 0 | 461 | - | - | - | - | 99.6 | 0.4 | 0 | 559 |
| 9 | 99.7 | 0.3 | 0 | 382 | 97.2 | 1.4 | 1.4 | 429 | - | - | - | - | 99.1 | 0.9 | 0 | 644 |
| 10 | 94.9 | 4.6 | 0.5 | 409 | 98.1 | 1.1 | 0.8 | 522 | 99.8 | 0 | 0.2 | 569 | 99.4 | 0.6 | 0 | 617 |
| 11 | - | - | - | - | - | - | - | - | 98.7 | 1.3 | 0 | 551 | 98.7 | 1.3 | 0 | 549 |
| 12 | 99.2 | 0.8 | 0 | 395 | 98.1 | 1.4 | 0.5 | 413 | 99.2 | 0.8 | 0 | 629 | 98.9 | 1.1 | 0 | 658 |
| 13 | 98.0 | 1.7 | 0.3 | 350 | 96.6 | 2.3 | 1.1 | 443 | 96.7 | 3.3 | 0 | 523 | 99.5 | 0.5 | 0 | 629 |
| 14 | 98.3 | 1.4 | 0.3 | 357 | 95.1 | 3.2 | 1.7 | 567 | - | - | - | - | 98.8 | 0.9 | 0.3 | 658 |
| 15 | 97.9 | 1.6 | 0.5 | 382 | 97.4 | 0.7 | 1.9 | 430 | 95.9 | 4.1 | 0 | 654 | 99.2 | 0.8 | 0 | 618 |
| 16 | 97.6 | 2.2 | 0.2 | 448 | 97.2 | 1.5 | 1.3 | 459 | 99.8 | 0.2 | 0 | 624 | 97.3 | 2.5 | 0.2 | 671 |
| 17 | - | - | - | - | 98.5 | 1.2 | 0.3 | 572 | 98.8 | 1.2 | 0 | 592 | 98.1 | 1.7 | 0.2 | 700 |
| 18 | 94.9 | 5.1 | 0 | 276 | 99.5 | 0 | 0.5 | 405 | 99.2 | 0.8 | 0 | 598 | 98.8 | 1.2 | 0 | 677 |
| 19 | - | - | - | - | - | - | - | - | 99.2 | 0.8 | 0 | 590 | 97.9 | 1.9 | 0.2 | 622 |
| 20 | 96.9 | 3.1 | 0 | 355 | 98.3 | 0.5 | 1.2 | 401 | 98.9 | 1.1 | 0 | 647 | 96.8 | 3.2 | 0 | 648 |
| 21 | 96.7 | 3.3 | 0 | 301 | 99.2 | 0.6 | 0.2 | 487 | 99.3 | 0.5 | 0.2 | 611 | 96.9 | 2.5 | 0.6 | 649 |
| 22 | 99.2 | 0.8 | 0 | 381 | 100.0 | 0 | 0 | 439 | 98.1 | 1.6 | 0.4 | 567 | 98.5 | 0.5 | 1.0 | 598 |
| 23 | 95.6 | 4.4 | 0 | 412 | 98.8 | 0.4 | 0.8 | 484 | 99.2 | 0.8 | 0 | 656 | 98.3 | 0.6 | 1.1 | 653 |
| 24 | - | - | - | - | 99.8 | 0 | 0.2 | 461 | 98.8 | 0.8 | 0.4 | 510 | 98.1 | 0.3 | 1.6 | 627 |
| 25 | 94.6 | 5.4 | 0 | 222 | 98.0 | 1.0 | 1.0 | 515 | 98.7 | 1.2 | 0.2 | 609 | 98.7 | 1.0 | 0.3 | 689 |
| 26 | 94.6 | 5.4 | 0 | 352 | 97.7 | 2.0 | 0.3 | 564 | 97.8 | 1.5 | 0.7 | 596 | 99.6 | 0.2 | 0.2 | 624 |
| 27 | 98.5 | 1.5 | 0 | 409 | 97.4 | 2.1 | 0.5 | 422 | 99.4 | 0.6 | 0 | 642 | 98.5 | 0.4 | 1.1 | 726 |
| 28 | 99.4 | 0.3 | 0.3 | 371 | 98.1 | 1.4 | 0.5 | 425 | 99.3 | 0.4 | 0.3 | 708 | 97.9 | 0.7 | 1.4 | 699 |
| 29 | 100.0 | 0 | 0 | 364 | 99.2 | 0.2 | 0.6 | 614 | 100.0 | 0 | 0 | 550 | 98.6 | 0.3 | 1.1 | 635 |
| 30 | 99.0 | 1.0 | 0 | 395 | 98.1 | 1.3 | 0.6 | 638 | 99.3 | 0.5 | 0.2 | 613 | 91.8 | 5.9 | 2.3 | 610 |
| Oct 1 | 97.9 | 2.1 | 0 | 374 | 96.1 | 3.5 | 0.4 | 453 | 99.8 | 0.2 | 0 | 633 | 92.5 | 5.7 | 1.8 | 613 |
| 2 | - | - | - | - | 96.4 | 2.3 | 1.3 | 475 | 99.2 | 0.5 | 0.3 | 637 | 92.5 | 5.1 | 2.4 | 589 |
| 3 | 98.2 | 1.3 | 0.5 | 389 | 98.1 | 0.2 | 1.7 | 578 | 99.2 | 0.8 | 0 | 658 | 92.5 | 5.6 | 1.9 | 574 |
| 4 | 98.7 | 0.9 | 0.4 | 449 | 97.7 | 0.2 | 2.1 | 617 | 99.4 | 0.4 | 0.1 | 680 | 92.3 | 6.8 | 0.9 | 575 |
| 5 | 97.7 | 1.0 | 1.3 | 304 | 98.5 | 0.2 | 1.3 | 548 | 99.4 | 0.4 | 0.2 | 543 | 93.4 | 5.6 | 1.0 | 589 |
| 6 | - | - | - | - | 97.6 | 1.2 | 1.2 | 488 | 99.5 | 0.5 | 0 | 608 | 93.5 | 5.0 | 1.5 | 613 |
| 7 | 98.8 | 1.2 | 0 | 419 | 99.2 | 0.2 | 0.6 | 531 | 96.7 | 3.1 | 0.2 | 552 | 94.1 | 4.4 | 1.5 | 610 |
| 8 | - | - | - | - | 99.4 | 0 | 0.6 | 518 | 97.3 | 2.6 | 0.2 | 582 | 91.6 | 6.2 | 2.2 | 596 |
| 9 | - | - | - | - | 96.2 | 1.1 | 2.7 | 525 | 99.1 | 0.9 | 0 | 540 | 91.0 | 5.9 | 3.1 | 645 |
| 10 | 99.6 | 0.2 | 0.2 | 432 | 97.0 | 1.3 | 1.7 | 636 | 99.6 | 0.4 | 0 | 480 | 92.2 | 6.1 | 1.7 | 576 |
| 11 | 100.0 | 0 | 0 | 406 | 89.4 | 9.1 | 1.5 | 470 | 99.4 | 0.6 | 0 | 545 | 88.1 | 8.2 | 3.7 | 572 |
| 12 | 98.9 | 0.8 | 0.3 | 386 | 93.6 | 5.1 | 1.3 | 550 | 99.2 | 0.8 | 0 | 620 | 97.1 | 2.7 | 0.2 | 583 |
| 13 | 98.7 | 0.8 | 0.5 | 383 | 96.5 | 1.2 | 2.3 | 567 | 99.7 | 0.3 | 0 | 597 | - | - | - | - |
| 14 | 99.6 | 0.2 | 0.2 | 468 | 97.0 | 2.2 | 0.8 | 595 | 99.6 | 0.4 | 0 | 550 | 95.7 | 3.9 | 0.4 | 561 |
| 15 | - | - | - | - | 98.6 | 0.9 | 0.5 | 562 | 100.0 | 0 | 0 | 550 | 93.3 | 5.7 | 1.0 | 584 |
| 16 | 99.0 | 1.0 | 0 | 399 | 97.6 | 1.6 | 0.8 | 493 | 99.6 | 0.4 | 0 | 552 | 91.7 | 7.6 | 0.6 | 654 |
| 17 | 99.8 | 0 | 0.2 | 443 | 98.8 | 0.4 | 0.8 | 486 | - | - | - | - | 64.1 | 34.5 | 1.4 | 657 |
| 18 | 99.8 | 0 | 0.2 | 442 | 97.9 | 0.6 | 1.5 | 471 | 95.9 | 3.9 | 0.2 | 586 | 98.2 | 0.6 | 1.2 | 653 |
| 19 | 98.4 | 0.8 | 0.8 | 480 | 98.8 | 0.9 | 0.3 | 568 | 97.6 | 2.1 | 0.3 | 1 123 | 97.8 | 2.0 | 0.2 | 612 |
| 20 | 98.3 | 0.2 | 1.5 | 454 | 98.5 | 0.6 | 0.9 | 541 | 94.9 | 4.5 | 0.5 | 553 | 96.5 | 2.4 | 1.1 | 545 |
| 21 | 94.3 | 3.4 | 2.3 | 439 | 99.0 | 0.2 | 0.8 | 592 | 91.0 | 8.5 | 0.5 | 601 | 77.9 | 21.9 | 0.2 | 494 |
| 22 | - | - | - | - | 98.9 | 0 | 1.1 | 471 | 93.1 | 6.5 | 0.4 | 522 | - | - | - | - |
| 23 | - | - | - | - | 99.6 | 0 | 0.4 | 473 | 96.0 | 3.4 | 0.6 | 528 | 74.4 | 25.6 | 0 | 507 |
| 24 | - | - | - | - | 98.7 | 0.4 | 0.9 | 468 | - | - | - | - | 89.8 | 5.5 | 4.7 | 656 |
| 25 | 96.7 | 3.3 | 0 | 338 | 97.8 | 0.3 | 1.9 | 589 | 95.0 | 3.9 | 1.1 | 665 | 85.5 | 8.7 | 5.8 | 607 |
| 26 | 92.5 | 5.2 | 2.3 | 363 | 94.6 | 0 | 5.4 | 485 | 99.4 | 0.2 | 0.4 | 501 | 78.0 | 15.5 | 6.5 | 581 |
| 27 | 99.1 | 0 | 0.9 | 427 | 97.0 | 0 | 3.0 | 462 | 98.9 | 0 | 1.1 | 554 | 87.7 | 7.3 | 5.0 | 577 |
| 28 | 91.8 | 2.3 | 5.9 | 392 | 98.2 | 0 | 1.8 | 512 | 98.0 | 1.0 | 1.0 | 614 | 88.4 | 5.6 | 6.0 | 536 |
| 29 | 98.2 | 0.3 | 1.5 | 396 | 96.4 | 0 | 3.6 | 417 | 99.5 | 0 | 0.5 | 587 | 99.8 | 0 | 0.2 | 520 |
| 30 | 85.4 | 1.0 | 13.6 | 403 | 98.6 | 0.2 | 1.2 | 496 | 99.7 | 0 | 0.3 | 579 | 99.4 | 0.6 | 0 | 523 |
| 31 | 96.2 | 1.1 | 2.7 | 365 | 98.3 | 0.2 | 1.5 | 541 | 97.1 | 1.4 | 1.4 | 699 | 99.6 | 0.2 | 0.2 | 490 |

TABLE 72: Daily catch composition in Cascade River from 1970 to 1973 (continued)

| Date | 1970 m. (%) | 1970 b. (%) | 1970 f. (%) | 1970 No. in sample | 1971 m. (%) | 1971 b. (%) | 1971 f. (%) | 1971 No. in sample | 1972 m. (%) | 1972 b. (%) | 1972 f. (%) | 1972 No. in sample | 1973 m. (%) | 1973 b. (%) | 1973 f. (%) | 1973 No. in sample |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nov 1 | 88.4 | 0.3 | 11.3 | 336 | 98.9 | 0 | 1.1 | 440 | 97.1 | 1.0 | 1.9 | 627 | - | - | - | - |
| 2 | 86.6 | 0.6 | 12.8 | 468 | | | | | 98.8 | 0.6 | 0.6 | 693 | - | - | - | - |
| 3 | 92.8 | 0.2 | 7.0 | 402 | | | | | 98.2 | 1.4 | 0.5 | 649 | - | - | - | - |
| 4 | 92.7 | 0.7 | 6.6 | 542 | | | | | 97.0 | 1.7 | 1.4 | 666 | 99.8 | 0 | 0.2 | 509 |
| 5 | 90.6 | 0.9 | 8.5 | 531 | | | | | 95.8 | 0.4 | 3.8 | 475 | 99.2 | 0.2 | 0.6 | 516 |
| 6 | 83.0 | 0.4 | 16.6 | 522 | | | | | 97.5 | 0 | 2.5 | 566 | - | - | - | - |
| 7 | 84.5 | 0.4 | 15.1 | 511 | | | | | 98.4 | 0 | 1.6 | 512 | 99.8 | 0 | 0.2 | 542 |
| 8 | 87.7 | 0.4 | 11.9 | 546 | | | | | 96.2 | 0.5 | 3.3 | 632 | 94.4 | 4.5 | 1.1 | 468 |
| 9 | 91.9 | 1.0 | 7.1 | 493 | | | | | 96.7 | 0.2 | 3.1 | 637 | 97.4 | 1.9 | 0.7 | 569 |
| 10 | 91.9 | 0.6 | 7.5 | 466 | | | | | 97.6 | 0.5 | 1.9 | 617 | 97.6 | 1.4 | 1.0 | 496 |
| 11 | 96.9 | 0 | 3.1 | 454 | | | | | 93.0 | 2.7 | 4.3 | 644 | 97.5 | 1.8 | 0.7 | 598 |
| 12 | 96.5 | 0.2 | 3.3 | 548 | | | | | 93.2 | 2.6 | 4.2 | 637 | 97.9 | 1.7 | 0.3 | 580 |
| 13 | 97.8 | 0.1 | 2.1 | 572 | | | | | - | - | - | - | 96.1 | 2.6 | 1.2 | 643 |
| 14 | - | - | - | - | | | | | 98.2 | 0.7 | 1.1 | 452 | 96.3 | 2.6 | 1.1 | 567 |
| 15 | 97.0 | 0 | 3.0 | 332 | | | | | 97.8 | 0.2 | 2.0 | 592 | 96.5 | 2.8 | 0.7 | 282 |
| 16 | | | | | | | | | - | - | - | - | 94.4 | 5.2 | 0.4 | 268 |
| 17 | | | | | | | | | - | - | - | - | | | | |
| 18 | | | | | | | | | 93.8 | 0.6 | 5.6 | 354 | | | | |
| 19 | | | | | | | | | - | - | - | - | | | | |
| 20 | | | | | | | | | 90.9 | 3.0 | 6.1 | 164 | | | | |
| 21 | | | | | | | | | 92.6 | 2.1 | 5.3 | 376 | | | | |
| 22 | | | | | | | | | 90.5 | 3.9 | 5.6 | 484 | | | | |

*m.: *G. maculatus*.
†b.: *G. brevipinnis*.
‡f.: *G. fasciatus*.

TABLE 73: Occurrence of *G. argenteus* (all fish caught listed for all years)

| Date | No. of fish: Haast area rivers | Hokitika River | Buller River |
|---|---|---|---|
| Oct 18 | 1 | 0 | 0 |
| 19 | 0 | 0 | 2 |
| 25 | 0 | 0 | 1 |
| 27 | 1 | 0 | 0 |
| 30 | 2 | 0 | 0 |
| 31 | 1 | 0 | 0 |
| Nov 2 | 0 | 0 | 2 |
| 3 | 1 | 0 | 0 |
| 4 | 5 | 0 | 0 |
| 5 | 1 | 0 | 2 |
| 7 | 2 | 0 | 0 |
| 8 | 1 | 0 | 14 |
| 9 | 2 | 0 | 1 |
| 10 | 5 | 19 | 0 |
| 11 | 4 | 6 | 1 |
| 12 | 4 | 0 | 12 |
| 13 | 3 | 10 | 0 |
| 14 | 5 | 0 | 0 |
| 15 | 3 | 4 | 4 |
| 16 | 2 | 0 | 21 |
| 17 | 4 | 0 | 5 |
| 19 | 7 | 0 | 0 |
| 20 | 4 | 0 | 0 |
| 21 | 4 | 0 | 0 |
| 22 | 4 | 0 | 7 |
| 23 | 11 | 0 | 0 |
| 24 | 13 | 0 | 2 |
| 25 | 1 | 0 | 0 |

TABLE 74: Quadratic regression* of length on day for *G. maculatus*, *G. brevipinnis*, and *G. fasciatus* from 1969 to 1973

| | | *a* | $b_1$ | $b_2$ |
|---|---|---|---|---|
| *G. maculatus* | | | | |
| Waiatoto | 1969 | 54.637 9 | 0.030 2 | -0.001 1 |
| | 1970 | 52.424 6 | 0.092 9 | -0.001 2 |
| | 1971 | 50.957 2 | 0.092 3 | -0.001 4 |
| | 1972 | 51.740 4 | 0.060 4 | -0.000 8 |
| | 1973 | 51.374 7 | 0.080 2 | -0.001 1 |
| Nisson | 1970 | 52.174 0 | 0.110 2 | -0.001 9 |
| | 1971 | 50.762 7 | 0.026 5 | -0.000 4 |
| Buller | 1972 | 52.189 9 | 0.120 9 | -0.001 6 |
| *G. brevipinnis* | | | | |
| Waiatoto | 1969 | 50.966 3 | 0.084 7 | -0.001 2 |
| | 1970 | 49.715 7 | 0.029 5 | 0.000 12 |
| | 1971 | 50.443 8 | 0.023 6 | -0.000 5 |
| | 1972 | 49.231 2 | 0.139 9 | -0.001 5 |
| | 1973 | 49.830 3 | 0.085 0 | -0.001 2 |
| Buller | 1972 | 52.393 5 | 0.114 0 | -0.001 4 |
| *G. fasciatus* | | | | |
| Waiatoto | 1971 | 40.963 9 | 0.076 7 | -0.001 0 |
| | 1972 | 44.331 5 | -0.038 8 | 0.000 03 |
| | 1973 | 42.158 4 | 0.072 8 | -0.001 0 |
| Buller | 1972 | 44.561 1 | 0.056 5 | -0.001 0 |

*$y = a + b_1x + b_2x^2$, where *y* is length and *x* is day.

TABLE 75: Log/log regression* coefficients for length-weight relationship in *G. maculatus*, *G. brevipinnis*, and *G. fasciatus* from 1969 to 1973

| | | *a* | *b* |
|---|---|---|---|
| *G. maculatus* | | | |
| Waiatoto | 1969 | -16.917 1 | 4.104 3 |
| | 1970 | - 8.839 8 | 2.085 9 |
| | 1971 | - 9.353 4 | 2.160 9 |
| | 1972 | -13.779 5 | 3.304 5 |
| | 1973 | -13.697 6 | 3.289 7 |
| Buller | 1972 | -14.231 7 | 3.444 1 |
| *G. brevipinnis* | | | |
| Waiatoto | 1969 | -17.977 6 | 4.455 0 |
| | 1970 | -19.278 6 | 4.769 1 |
| | 1971 | -13.813 3 | 3.369 0 |
| | 1972 | -17.344 8 | 4.279 8 |
| | 1973 | -13.892 5 | 3.377 5 |
| Buller | 1972 | -13.567 5 | 3.349 4 |
| *G. fasciatus* | | | |
| Waiatoto | 1969 | -16.865 0 | 4.225 8 |
| | 1970 | -14.811 9 | 3.654 2 |
| | 1971 | -11.407 8 | 2.753 7 |
| | 1972 | -12.349 9 | 3.002 3 |
| | 1973 | -13.122 8 | 3.206 3 |
| Buller | 1972 | -13.000 0 | 3.180 4 |

*$y = a + bx$, where *y* is $l_n$ (weight) and *x* is $l_n$ (length).

TABLE 76: Commercial whitebait catch in West Coast subregions, 1951 to 1973

Catch

| Year | Karamea (kg) | Karamea % of year's catch | Westport (kg) | Westport % of year's catch | Greymouth (kg) | Greymouth % of year's catch | Hokitika (kg) | Hokitika % of year's catch | Ross (kg) | Ross % of year's catch | Whataroa (kg) | Whataroa % of year's catch | Okuru (kg) | Okuru % of year's catch | Awarua (kg) | Awarua % of year's catch | Total (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | 1 295 | 1.96 | 8 065 | 12.20 | 4 623 | 6.99 | 7 341 | 11.11 | 3 670 | 5.55 | 17 945 | 27.15 | 19 406 | 29.36 | 3 747 | 5.67 | 66 092 |
| 1952 | 6 807 | 6.71 | 17 983 | 17.72 | 7 518 | 7.41 | 13 056 | 12.86 | 2 286 | 2.25 | 22 504 | 22.17 | 25 857 | 25.48 | 5 486 | 5.41 | 101 497 |
| 1953 | 16 764 | 7.61 | 38 405 | 17.43 | 21 996 | 9.98 | 38 049 | 17.27 | 6 553 | 2.97 | 43 688 | 19.82 | 49 682 | 22.54 | 5 232 | 2.37 | 220 369 |
| 1954 | 14 986 | 6.85 | 35 916 | 16.42 | 18 593 | 8.50 | 36 982 | 16.91 | 5 690 | 2.60 | 47 854 | 21.88 | 55 270 | 25.27 | 3 404 | 1.56 | 218 695 |
| 1955 | 22 250 | 6.91 | 48 717 | 15.12 | 21 844 | 6.78 | 58 725 | 18.22 | 12 497 | 3.88 | 62 128 | 19.28 | 87 986 | 27.31 | 8 077 | 2.51 | 322 224 |
| 1956 | 18 644 | 10.26 | 37 744 | 20.77 | 23 165 | 12.74 | 19 101 | 10.51 | 4 978 | 2.74 | 32 207 | 17.72 | 41 504 | 22.83 | 4 420 | 2.43 | 181 763 |
| 1957 | 6 350 | 3.77 | 24 740 | 14.70 | 27 432 | 16.30 | 34 087 | 20.26 | 3 048 | 1.81 | 48 311 | 28.71 | 18 745 | 11.14 | 5 537 | 3.29 | 168 250 |
| 1958 | 7 925 | 6.88 | 24 130 | 20.96 | 9 652 | 8.38 | 15 189 | 13.19 | 813 | 0.71 | 13 919 | 12.09 | 36 627 | 31.82 | 6 858 | 5.96 | 115 113 |
| 1959 | 6 960 | 4.95 | 27 738 | 19.74 | 3 404 | 2.42 | 34 495 | 24.54 | 610 | 0.43 | 31 373 | 22.32 | 31 396 | 22.34 | 4 572 | 3.25 | 140 548 |
| 1960 | 2 489 | 4.85 | 8 433 | 16.42 | 1 270 | 2.47 | 1 016 | 1.98 | 762 | 1.48 | 10 516 | 20.48 | 23 368 | 45.50 | 3 505 | 6.82 | 51 359 |
| 1961 | 3 048 | 3.54 | 13 868 | 16.11 | 10 109 | 11.74 | 6 045 | 7.02 | 2 896 | 3.36 | 20 523 | 23.83 | 23 876 | 27.73 | 5 740 | 6.67 | 86 105 |
| 1962 | 559 | 1.46 | 4 776 | 12.49 | 1 067 | 2.79 | 864 | 2.26 | 152 | 0.40 | 5 232 | 13.68 | 17 881 | 46.74 | 7 722 | 20.19 | 38 253 |
| 1963 | 3 861 | 3.78 | 22 555 | 22.08 | 5 537 | 5.42 | 8 331 | 8.16 | 914 | 0.89 | 34 442 | 33.71 | 20 117 | 19.69 | 6 401 | 6.27 | 102 158 |
| 1964 | 5 842 | 4.08 | 33 325 | 23.25 | 19 761 | 13.78 | 21 692 | 15.13 | 11 278 | 7.87 | 12 548 | 8.75 | 35 052 | 24.45 | 3 861 | 2.69 | 143 359 |
| 1965 | 6 909 | 5.67 | 25 146 | 20.62 | 6 706 | 5.50 | 12 093 | 9.92 | 9 296 | 7.62 | 26 975 | 22.12 | 27 584 | 22.62 | 7 214 | 5.92 | 121 923 |
| 1966 | 4 166 | 8.71 | 9 500 | 19.87 | 1 575 | 3.29 | 1 829 | 3.83 | 914 | 1.91 | 12 751 | 26.67 | 14 122 | 29.54 | 2 946 | 6.16 | 47 803 |
| 1967 | 7 976 | 8.23 | 11 430 | 11.79 | 1 016 | 1.05 | 6 858 | 7.08 | 1 727 | 1.78 | 17 983 | 18.55 | 38 608 | 39.83 | 11 328 | 11.69 | 96 926 |
| 1968 | 16 104 | 10.49 | 25 095 | 16.35 | 4 724 | 3.08 | 11 633 | 7.58 | 2 540 | 1.65 | 27 178 | 17.70 | 60 096 | 39.15 | 6 147 | 4.00 | 153 517 |
| 1969 | 10 577 | 7.30 | 39 111 | 26.98 | 1 949 | 1.34 | 15 797 | 10.90 | 680 | 0.47 | 18 663 | 12.88 | 51 951 | 35.84 | 6 215 | 4.29 | 144 943 |
| 1970 | 2 845 | 3.35 | 7 062 | 8.31 | 661 | 0.78 | 1 220 | 1.44 | 762 | 0.90 | 28 810 | 33.89 | 40 495 | 47.64 | 3 150 | 3.71 | 85 005 |
| 1971 | 305 | 0.72 | 1 779 | 4.21 | 1 271 | 3.01 | 4 626 | 10.95 | 1 016 | 2.41 | 9 405 | 22.26 | 19 980 | 47.30 | 3 863 | 9.14 | 42 245 |
| 1972 | 3 404 | 3.40 | 13 515 | 13.52 | 965 | 0.97 | 3 862 | 3.86 | 406 | 0.41 | 25 964 | 25.97 | 47 101 | 47.10 | 4 776 | 4.78 | 99 993 |
| 1973 | 406 | 0.91 | 4 370 | 9.78 | 864 | 1.93 | 1 728 | 3.87 | 508 | 1.14 | 6 605 | 14.79 | 26 624 | 59.61 | 3 557 | 7.96 | 44 662 |

# INDEX

P. D. HASSELBERG, GOVERNMENT PRINTER, WELLINGTON, NEW ZEALAND—1980 30864C—1,200 bks/5/79 M

## No. BULLETINS OF THE FISHERIES RESEARCH DIVISION

1. The New Zealand Cetacea. By D. E. Gaskin. Published in 1968. 92 pp.
2. *Galaxias maculatus* (Jenyns), the New Zealand whitebait. By R. M. McDowall. Published in 1968. 84 pp.
3. Phytoplankton productivity in Tomahawk Lagoon, Lake Waipori, and Lake Mahinerangi. By S. F. Mitchell. Published in 1971. 87 pp.
4. Some aspects of the bionomics of fish in a brown trout nursery stream. By C.L. Hopkins. Published in 1970. 38 pp.
5. Reproduction, early life history, and age-growth relationships of the New Zealand pilchard, *Sardinops neopilchardus* (Steindachner). By Alan N. Baker. Published in 1972. 64 pp.
6. The biology of the New Zealand tarakihi, *Cheilodactylus macropterus* (Bloch and Schneider). By L. J. Tong and C. M. Vooren. Published in 1972. 60 pp.
7. An analysis of the statistics on the fishery for tarakihi, *Cheilodactylus macropterus* (Bloch and Schneider), in New Zealand waters from 1936 to 1969, with notes on the trawl fishery in general. By C. M. Vooren. Published in 1974. 44 pp.
8. Lakes Rotorua and Rotoiti, North Island, New Zealand: Their trophic status and studies for a nutrient budget. By G. R. Fish. Published in 1975. 72 pp.
9. A survey of the tarakihi, *Cheilodactylus macropterus* (Bloch and Schneider), in the East Cape area, New Zealand, 26-30 March 1971. By C. M. Vooren and L. J. Tong. Published in 1973. 28 pp.
10. The relation between primary productivity, nutrients, and the trout environment in some New Zealand lakes. By A. M. R. Burnet and Denise A. Wallace. Published in 1973. 28 pp.
11. Biology and distribution of the toheroa, *Paphies* (*Mesodesma*) *ventricosa* (Gray). By P. Redfearn. Published in 1974. 51 pp.
12. Studies on age and growth, reproduction, and population dynamics of red gurnard, *Chelidonichthys kumu* (Lesson and Garnot), in the Hauraki Gulf, New Zealand. By R. D. Elder. Published in 1976. 77 pp.
13. A study on age, growth, and population structure of the snapper, *Chrysophrys auratus* (Forster), in the Hauraki Gulf, New Zealand. By L. J. Paul. Published in 1976. 62 pp.
14. Variations in growth, mortality, and population density of snapper, *Chrysophrys auratus* (Forster), in the Hauraki Gulf, New Zealand. By C. M. Vooren and R. F. Coombs. Published in 1977. 32 pp.
15. The commercial fishery for snapper, *Chrysophrys auratus* (Forster), in the Auckland region, New Zealand, from 1900 to 1971. By L. J. Paul. Published in 1977. 84 pp.
16. A bibliography of the literature about New Zealand's marine and freshwater commercial fisheries, 1840-1975. By L. J. Paul. Published in 1979. 43 pp.
17. Age, growth, and condition of the common river galaxias, *Galaxias vulgaris* Stokell, in the Glentui River, Canterbury, New Zealand. By P. L. Cadwallader. Published in 1978. 35 pp.
18. Tagging experiments on the sand flounder, *Rhombosolea plebeia* (Richardson), in Canterbury, New Zealand, 1964 to 1966. By J. A. Colman. Published in 1978. 42 pp.
19. The life history of *Neochanna apoda* Günther (Pisces: Galaxiidae). By G. A. Eldon. Published in 1978. 44 pp.
20. The ecology of whitebait migrations (Galaxiidae: *Galaxias* spp.). By R. M. McDowall and G. A. Eldon. Published in 1980. 171 pp.
21. Hydrology and the quantitative distribution of planktonic eggs of some marine fishes of the Otago coast, south-eastern New Zealand. By D. A. Robertson. Published in 1980. 69 pp.
22. The number of snapper, *Chrysophrys auratus* (Forster), in the Hauraki Gulf, New Zealand, based on egg surveys in 1974-75 and 1975-76. By J. Crossland (in press).