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Species composition and relative importance of whitebait fisheries in 13 Bay of Plenty rivers

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CONTENTS

TABLES

FIGURES

SUMMARY

Whitebait fisheries in 13 Bay of Plenty rivers were studied between 1981 and 1983 to determine their species composition and their relative importance in terms of both use by whitebaiters and yield of whitebait. The study was undertaken with the support of the Ministry of Works and Development (MWD) and formed part of a wider investigation into the potential impact of damming the Motu River (Bay of Plenty) for hydro-electric power generation. The Motu River fishery was dominated by *Galaxias brevipinnis*, the main species found in this river's catchment, and it is concluded that damming the Motu would significantly reduce the whitebait catch in this river. Whitebait catches in other Bay of Plenty rivers, west and east of the Motu River also contained *G. brevipinnis*, but in low numbers. Fisheries in these rivers were dominated by *Galaxias maculatus* which is the main species in most New Zealand rivers. The Motu River stocks of *G. brevipinnis* are unlikely to be contributing greatly to other Bay of Plenty river fisheries and so damming the Motu River would not have a significant effect on the whitebait fisheries in the other rivers. The Motu River is not visited by large numbers of whitebaiters, but this is thought to be because of its remoteness to large population centres. It has a reputation with whitebaiters as a good fishery and people travel from as far afield as Gisborne and Rotorua to fish it. The Rangitaiki River was the most popular whitebaiting river in the region and is expected to yield the most whitebait. It is largely a single species whitebait fishery (*G. maculatus*), but smelt are taken by some fishermen and are included in their whitebait catch. The significance of the Motu River being dominated by *G. brevipinnis* is discussed in terms of both the migratory behaviour of juvenile whitebait and differences in species-specific habitats of adults in river catchments.

1. INTRODUCTION

In late winter and spring each year vast shoals of juvenile whitebait migrate from the sea into many New Zealand rivers. These small fish are harvested as they enter river mouths and form the basis for a nationwide recreational, and in some areas commercial, fishery. Whitebait are a fairly expensive, seasonal delicacy in many fish shops, hotels, and restaurants in New Zealand and the fishery is an established part of this country's cultural heritage. Research into the life history and habitats of whitebait is needed so that the fishery can be conserved and protected. Such research is especially important when developments such as hydro-electric dams are contemplated. This report describes the results of investigations into whitebait fisheries of Bay of Plenty rivers initiated in response to MWD plans to build hydro-electric dams in the Motu River.

Whitebait includes the migratory juvenile stage of five species of native fish, of which the three main species are *Galaxias maculatus* (inanga), *Galaxias fasciatus* (banded kokopu), and *Galaxias brevipinnis* (koaro) (McDowall 1978). As juveniles these fish are all slender and transparent, and they range in length from 40 to 60 mm. They are similar in appearance to juvenile smelt (*Retropinna retropinna*) which are sometimes also included in the whitebait catch.

Adult galaxiids live in streams, rivers, and wetlands, and each species has specific habitat requirements. The juveniles of two of the three principal species (*G. fasciatus* and *G. brevipinnis*) are adept at climbing waterfalls and other natural barriers. Consequently adults are usually found well inland, where an important habitat requirement (especially for *G. brevipinnis*) is the presence of forest or bush cover

in much of the catchment. *G. maculatus* inhabits wetlands and the slow-moving waters of coastal rivers.

Extensive studies by McDowall (1968) and McDowall and Eldon (1980), have greatly increased our understanding of the biology and ecology of whitebait migrations. These studies have also provided much useful information on major whitebait fisheries, but most of those studied were in the South Island. There are significant fisheries for whitebait in North Island rivers, which have received little attention to date. The few studies of whitebait fisheries in the North Island include a synoptic survey of species composition of whitebait catches in 18 North Island rivers (McDowall 1965), a life history study of *G. maculatus* based on samples from the Waikanae River (McDowall 1968), and an estimate of whitebaiters fishing Taranaki rivers (Taranaki Catchment Commission 1981). Apart from these studies there is little information available on whitebait fisheries in North Island rivers and therefore advice cannot be given on either potential impacts of development proposals, or on the habitats and stocks of fish supporting the fisheries.

When proposals to dam the Motu River were raised by the MWD in 1977, Fisheries Research Division (FRD) of the Ministry of Agriculture and Fisheries (MAF) was asked for information on the whitebait fishery in the Motu River, to help determine whether the proposed dams would have any impacts on fisheries. An exploratory survey of fish and fish habitats in the Motu River was done with the support of MWD. The survey revealed high densities of *G. brevipinnis* throughout the largely unmodified, bush-covered catchment (Rowe 1981) and this suggested that the whitebait fishery at the mouth of the river could be based primarily on *G. brevipinnis* rather than the more usual *G. maculatus*. Dams would

prevent juveniles from completing their upstream migration, and the life cycle of *G. brevipinnis* in the Motu River would be broken, possibly resulting in a decline in the fishery at the river mouth. Although adult stocks above the dams could establish landlocked populations in the reservoirs, these would not contribute to the whitebait fishery at the river mouth. Rowe (1981) also pointed out that the Motu River catchment is the only large catchment in the Bay of Plenty, still fairly unmodified and unaffected by pollution. As such, it is likely to be the major habitat for *G. brevipinnis* in the region, and the adult population of these fish could be contributing to whitebait catches in other Bay of Plenty rivers. If so, dams could not only affect the fishery in the Motu River, but they could also affect fisheries in other rivers.

Further studies were therefore needed to:

1. Determine the species composition of the whitebait catch in the Motu River and other major Bay of Plenty whitebait fisheries.

2. To determine the size, use or popularity, and other characteristics of whitebait fisheries in Bay of Plenty rivers as a basis for determining their relative importance.

This report presents the results of the studies undertaken. The data collected enabled conclusions to be made about the impact of dams in the Motu River on whitebait fisheries in the region. In addition, by identifying the species of whitebait involved in the fisheries, the studies provide a basis for future conservation of the species, because the general habitat for the three main species can be identified and protected. Finally the data base on species composition is compared with a similar one obtained in South Island (west coast) rivers by McDowall and Eldon (1980) and provides new insights into the causes of variation in the species composition of whitebait in New Zealand rivers.

2. STUDY AREA

In most eastern Bay of Plenty rivers whitebait migrations form the basis for recreational fisheries. These fisheries are controlled by MAF under the Whitebait Fishing Regulations 1981. In the Bay of Plenty region the season runs for 4 months from August to November (inclusive), and whitebaiting is permitted between 0500-2000 hours. The two most commonly used whitebaiting methods are scoop nets and set nets. In general, scoop nets are more commonly used at river mouths, whereas set nets are more often used further upriver.

Thirteen of the Bay of Plenty rivers, known to support important whitebait fisheries, were examined in this study (Fig. 1). Each catchment's general characteristics (size, mean flow, land use patterns) are outlined in Table 1. Richmond (1984) has reviewed the major modifications to these catchments.

2.1 Motu River

The Motu River catchment of nearly 1400 km^2, is largely covered by indigenous forest, but the Motu is unusual compared with other New Zealand rivers in that headwaters of the main stem flow through a low gradient plateau, cleared and developed for grazing. Below this plateau the river descends down a fairly unmodified and steeper gorge section into which most of the tributaries flow. The river catchment and its tributaries below the plateau are characterised by a geologically unstable landform of steep valleys and ridges.

The river is flood prone with a 1000 year flood flow to mean flow ratio of 62 (Riddell 1980). The instability in flow and geology is

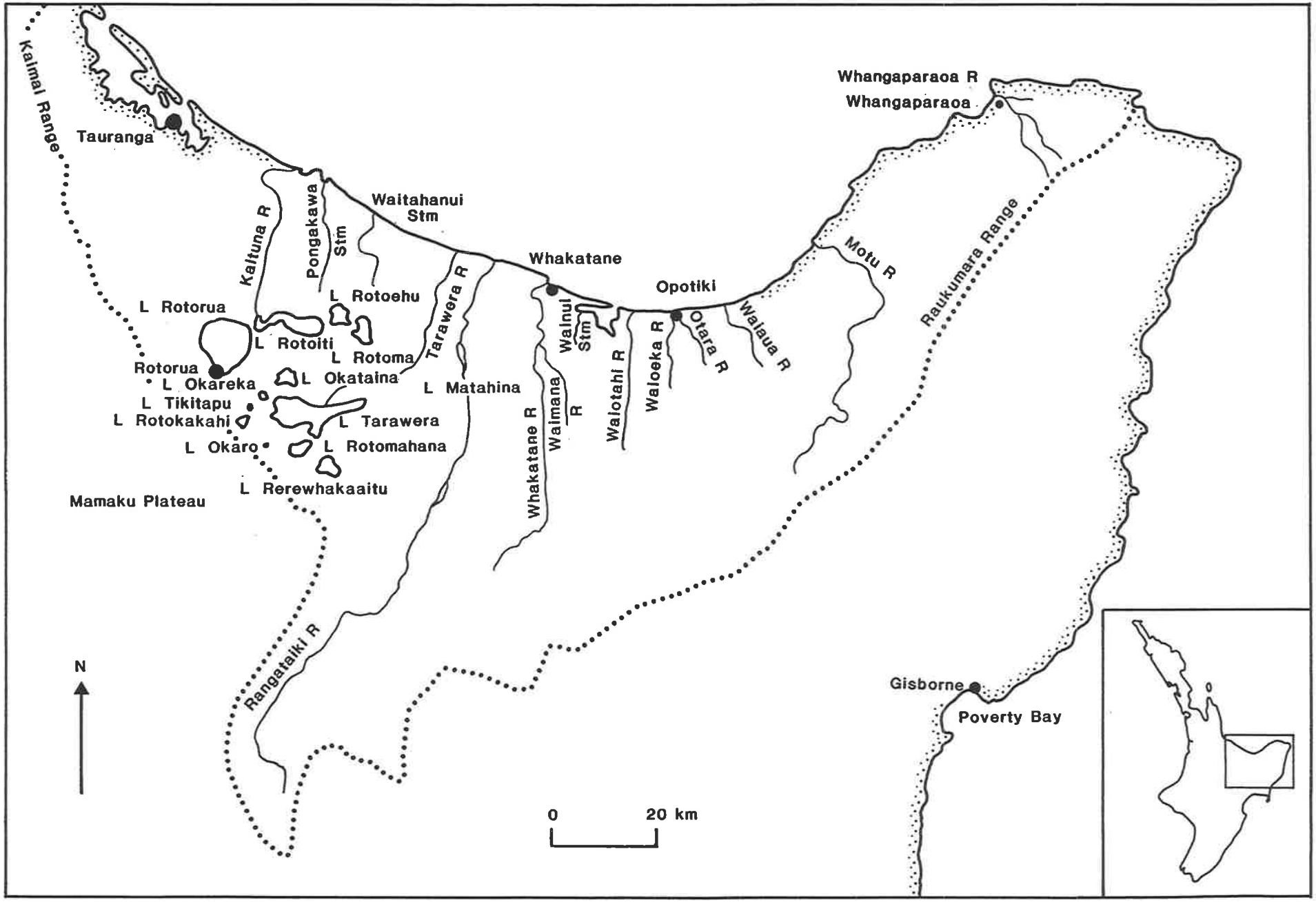

FIGURE 1. Location of whitebaiting rivers studied in the Bay of Plenty region, 1981-83.

TABLE 1. Catchment size, forest cover, annual mean flow, and modifications to Bay of Plenty rivers which support whitebait fisheries

Rivers	Catchment size (km^2)	Forest cover* (% area accessible to whitebait)	Annual mean flow† (m^3/s)	Modifications
Whangaparaoa	180	-	-	agriculture in parts of lower catchments
Motu	1 347	74	67	agriculture in headwater catchments, some forestry in lowland coastal areas
Waiaua	97	-	3	agricultural development of coastal plain
Otara	345	72	16	agriculture and forestry in lower catchment
Waioeka	842	73	29	agriculture and forestry in lower catchment (effluent from Opotiki township)
Waiotahi	160	-	4	agriculture & exotic forestry
Wainui Stm.	-	-	-	agriculture & exotic forestry
Whakatane	1 748	52	42	agriculture & river channelisation in bottom half of catchment, effluent from Whakatane city and industrial sources enters above mouth
Rangitaiki	2 950	0	65	3 dams, agriculture and swamp drainage in bottom half of catchment. Industrial effluent disposal from dairy company
Tarawera	1 088 (413)‡	6	25	swamp drainage and agriculture in bottom half of catchment, major pollution from pulp mill and paper factory
Waitahanui Stm.	100	-	5	agriculture in most of catchment
Pongakawa Stm.	125	-	4	agriculture in most of catchment
Kaituna	1 230 (617)‡	36	34	agriculture in lowland coastal part of catchment, effluent disposal, diversion away from estuary, extensive swamp drainage

* Exotic and native species.
† Data from MWD (Water and Soil Division) and Bay of Plenty Catchment Commission, 1980-84.
‡ Catchment accessible to whitebait species (i.e. not truncated by dams or large falls).

reflected in the fairly high sediment yield of 3.2 million tonnes per annum (Adams 1979). A diverse and abundant native fish fauna is present in the bush covered tributaries draining the steeper eastern catchments, and in the lower more stable western catchments (Rowe 1981). Rainbow trout *(Salmo gairdneri)* have been extensively stocked into the river, but they are rarely found in it. The modified headwaters, and the western Takaputahi tributary both contain brown trout populations, but trout are rare in other parts of the catchment.

2.2 Waioeka and Otara Rivers

The confluence of the Waioeka and Otara Rivers is just below the town of Opotiki, a few kilometres from the sea. As with the Motu River, their geologically unstable headwaters and main tributaries are largely protected by indigenous forest cover, but unlike the Motu River, lower reaches have been cleared and are now farmed. Below their confluence the rivers flow through Opotiki into a locally important harbour.

2.3 Whakatane River

The headwaters of the Whakatane River originate in the Huiarau Ranges of the Urewera National Park and are also fairly unmodified. However, the lower reaches have been extensively modified by agriculture, and, as with the Waioeka River, they run through an urban area (Whakatane City) into a harbour estuary. An industrial discharge from the Whakatane Paperboard Mill enters the river before it discharges through the Whakatane Harbour to the sea.

2.4 Rangitaiki River

The Matahina Dam on the Rangitaiki River prevents whitebait from moving upriver into the headwaters. Below the dam the lower reaches of the river are modified by land drainage and channelisation of streams. Agriculture is intensive here, and effluent from the Rangitaiki Plains Dairy Factory enters the river and creates problems with sewage fungus. Whitebaiters' nets often become choked with slimy fungus which has sloughed away from colonies upstream (Rowe 1983).

The mainly volcanic upper catchments and the alluvial lower catchments of the other central Bay of Plenty rivers studied have been largely converted from native forest to exotic forest plantations or pasture. In the Tarawera River, which drains Lake Tarawera, natural water quality is downgraded by effluents from the Tasman Pulp and Paper Mill, the Caxton Paper Mill, and Kawerau township. In the Kaituna River, which drains Lake Rotoiti and eutrophic Lake Rotorua, the Kaituna Falls constitute a natural barrier to fish movement; and water quality in the lower reaches is affected by industrial effluent, and intensive agriculture.

3. METHODS

3.1 Species Composition of Whitebait Fisheries

Samples of whitebait were collected during the August to November fishing season, in each of the 13 Bay of Plenty rivers where whitebaiting is popular. The Whangaparaoa and Motu Rivers were sampled for FRD on a once-a-week basis by local whitebaiters who fished these rivers during the 1981, 1982, and 1983 whitebaiting seasons. In 1982

MWD funded a consultant biologist to undertake sampling in 8 other Bay of Plenty rivers, and in 1983 the investigation was extended to include 13 rivers in total (Table 2). In 1982 whitebait sampling did not begin (except in the Motu and Whangaparaoa Rivers) until the consultant was appointed in mid September. Sampling was done in all rivers throughout the 1983 season (August-November inclusive).

TABLE 2. Seasons and rivers for which whitebait samples were collected

Rivers sampled	1981	1982*	1983
Whangaparaoa	X	X	X
Motu	X	X	X
Waiaua		X	X
Otara		X	X
Waioeka		X	X
Waiotahi		X	X
Wainui Stm.		X	X
Whakatane		X	X
Rangitaiki		X	X
Tarawera		X	X
Waitahanui Stm.			X
Pongakawa Stm.			X
Kaituna			X

* Sampling in all rivers apart from the Motu and Whangaparaoa started in mid September in 1982 only.

Rivers apart from the Motu and Whangaparaoa were separated into three main sampling zones based on distance from Whakatane:

Zone 1: Waiaua, Otara, Waioeka, Waiotahi Rivers

Zone 2: Wainui Stream, Whakatane, Rangitaiki, Tarawera Rivers

Zone 3: Waitahanui Stream, Pongakawa Stream, Kaituna River.

All rivers within a zone were visited on the same day, and each zone was visited about once every 3-5 days during the whitebait season. Whitebait samples were obtained either from whitebaiters and/or by the consultant netting a sample when fish could not be purchased from whitebaiters.

Because the number of whitebaiters fishing per day can depend on the state of the tide and the weather and on the occurrence of weekends and holidays (Davis 1980), a stratified random selection of days and times for visits to each river was used as a basis for planning sampling visits to rivers. In practice the timing of visits was inevitably modified by prevailing weather and river conditions. Timing of visits to each river and number of samples collected per visit are shown in Figures 2, 3, and 4 for 1981 and 1982 and 1983 respectively. The absence of samples at some visits was because whitebait were not running at that time.

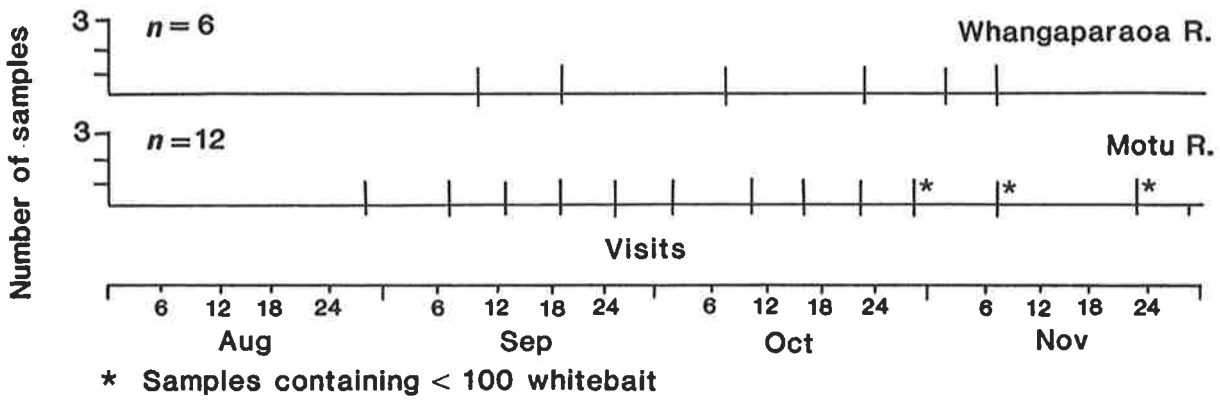

FIGURE 2. Timing of sampling visits and numbers of samples collected in the Motu and Whangaparaoa Rivers during the 1981 whitebait fishing season.

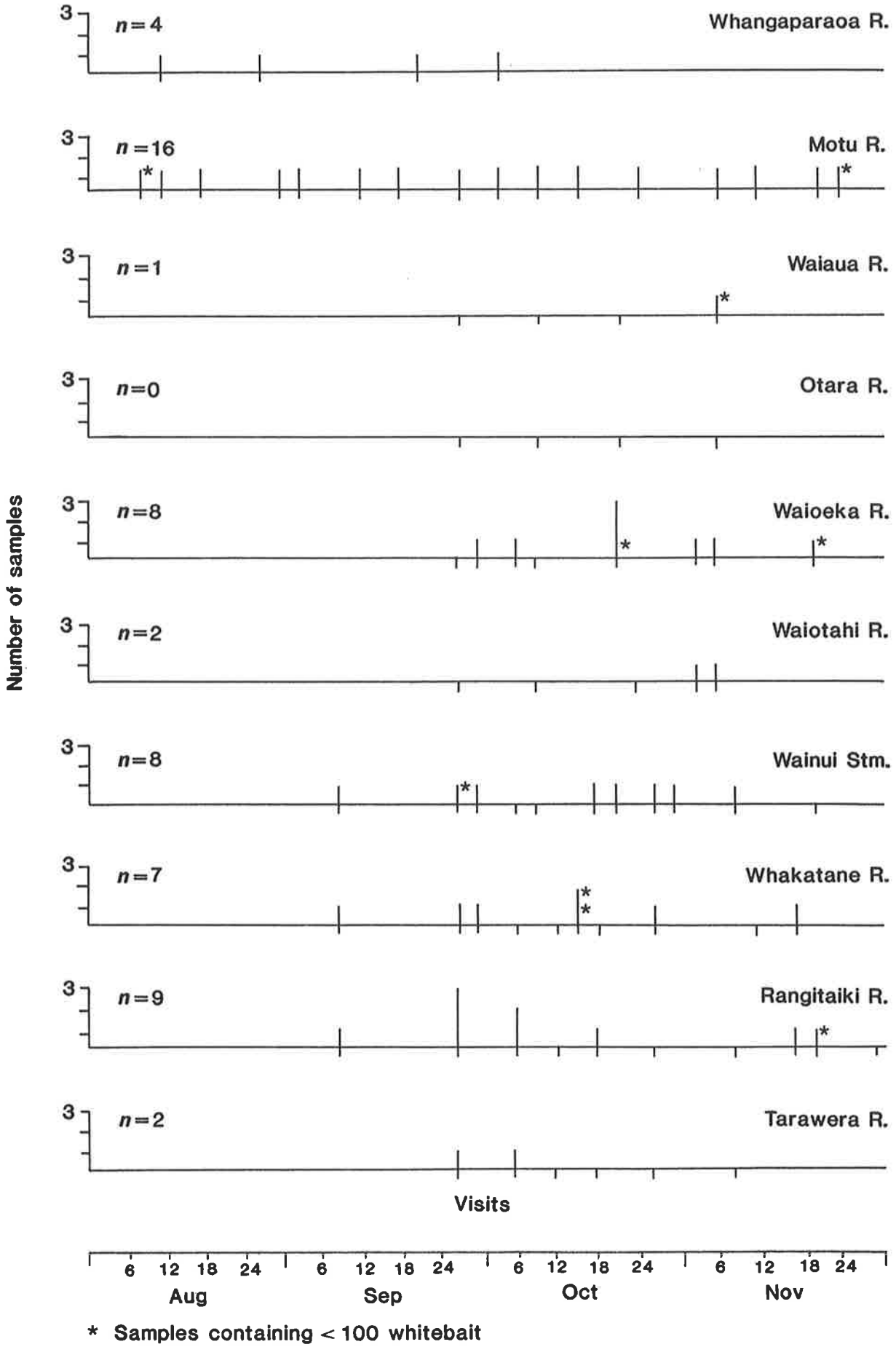

FIGURE 3. Timing of sampling visits and numbers of samples collected from Bay of Plenty rivers during the 1982 whitebait fishing season.

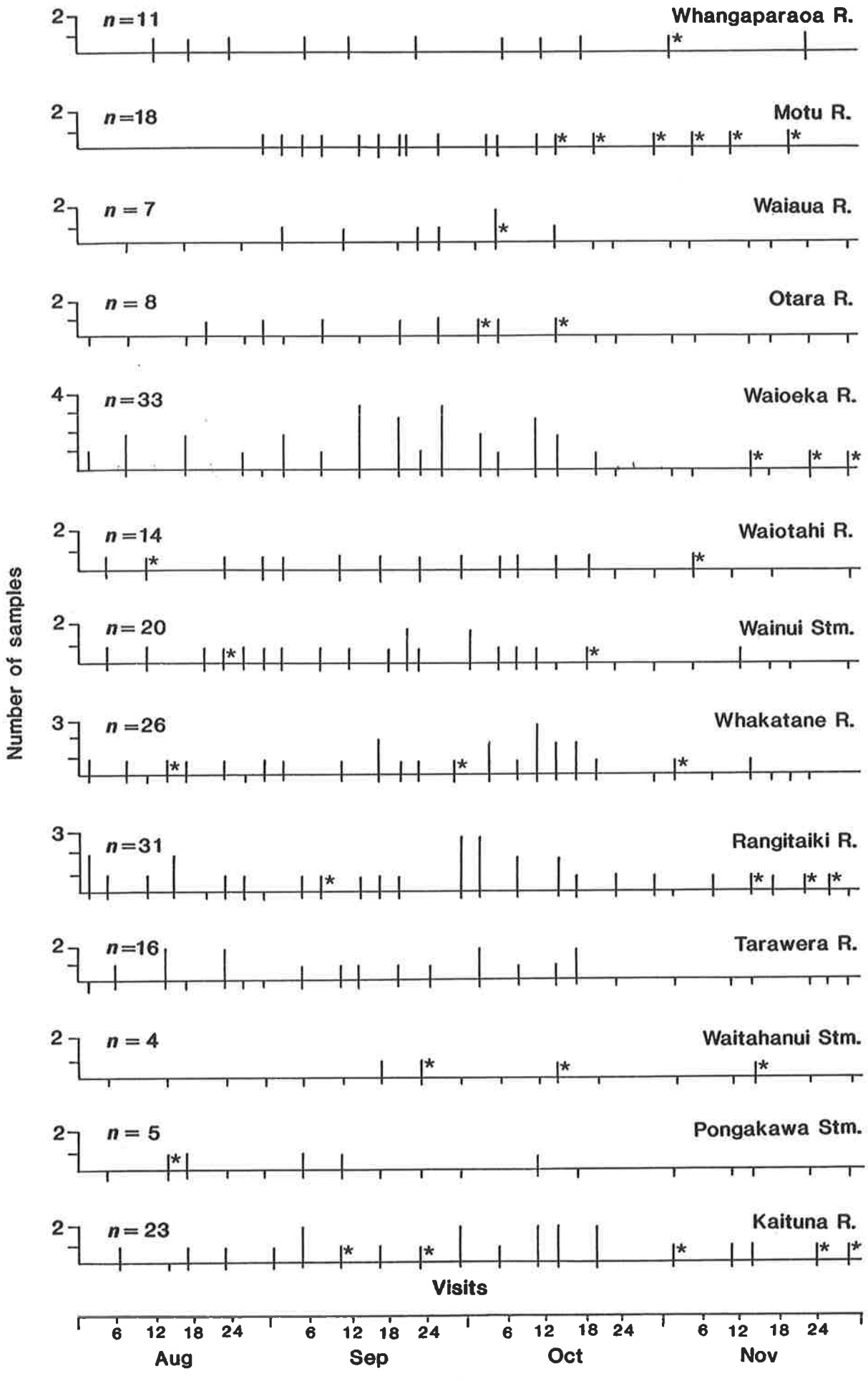

FIGURE 4. Timing of sampling trips and numbers of samples collected from Bay of Plenty rivers during the 1983 whitebait season.

An average sample consisted of 150-300 whitebait, taken from a well mixed catch, from which smelt had been removed. The catch was mixed before collection of a sample to prevent bias in species composition found by McDowall and Eldon (1980). This bias occurs when more active climbing species (*G. brevipinnis* and *G. fasciatus*) move to the top of the catch container, and create a stratification effect with *G. maculatus* on the bottom.

On eight occasions replicate samples were taken from the same mixed catch to test for bias in the sampling routine. On each occasion the differences in species composition were nil, or were too small to affect species rankings, which indicates that a single sample is representative of a whitebaiter's catch (Table 3).

TABLE 3. Variation in percent species composition of whitebait samples taken from the same catch

River and date	Method	Sample	% species composition *G. maculatus*	*G. fasciatus*	*G. brevipinnis*
Rangitaiki					
29/9/83	scoop net	(1)	89.8	3.0	7.2
		(2)	89.7	3.0	7.3
3/10/83	set net	(1)	95.5	1.5	3.0
		(2)	95.3	1.1	3.6
Whakatane					
16/10/83	set net	(1)	23.8	3.5	72.7
		(2)	22.1	3.1	74.8
Waioeka					
3/9/83	scoop net	(1)	28.9	66.0	5.1
		(2)	40.0	54.3	5.7
19/9/83	set net	(1)	60.5	16.7	22.8
		(2)	68.4	9.3	22.3
25/9/83	set net	(1)	85.3	6.2	8.5
		(2)	88.5	7.0	4.5
2/10/83	scoop net	(1)	10.6	3.0	86.4
		(2)	9.9	9.5	80.6
11/10/83	set net	(1)	1.8	2.1	96.1
		(2)	2.9	2.9	94.2

Whitebait samples were preserved in 10% formalin, and were then transferred to 30% isopropanol for storage. Samples were later sorted into the three major species (viz. *G. maculatus*, *G. fasciatus*, *G. brevipinnis*) by use of keys developed by Woods (1968) and McDowall and Eldon (1980).

Difficulties arose in distinguishing between juveniles of *G. brevipinnis* and those of the uncommon *G. postvectis*. As a result, numbers of *G. brevipinnis* may be overestimated. However, *G. postvectis* is a relatively rare species and large numbers of juveniles of this species have not been found to occur in whitebait fisheries studied elsewhere (McDowall and Eldon 1980). The adults of these two species live in similar stream habitats and so any conclusions relating species composition of the catch to adult habitat, and hence to the potential effects of habitat alterations, will not be greatly affected by any mis-identification.

Juveniles of *G. argenteus* and other, unidentifiable, whitebait species, were also counted and were all classed together as unidentifiable whitebait. *G. argenteus* was rarely found in the whitebaiters' catch and occurred in so few samples, and in such small numbers, as to be relatively insignificant.

Samples of less than 100 whitebait were deemed to be too small for assessing species composition and were not included in the results.

3.2 Relative Use and Importance of Rivers for Whitebait Fishing

Counts of whitebaiters at each river were done by the consultant while driving up roads flanking the rivers, and by walking along the banks in the tidal region of each river. Whitebaiters were defined as

people actually fishing, or people with nets who were otherwise involved in activities directly associated with fishing (e.g., emptying nets and sorting catch). People watching or assisting the person(s) fishing were also counted, but they were not included in estimates of the number of people actually fishing. Head counts were made during each visit to a river.

Counts of people fishing are likely to underestimate use of some rivers because of the difficulty of counting all people, on both banks, along the total length of the river and estuary over a short period of time. The number of people fishing a river at any one time varies widely depending on fishing success and whether runs are "on" or not. Both the overall mean and the range of head counts for each river were calculated from daily counts taken over the whitebaiting season. In a survey of whitebait fisheries in Taranaki rivers, peak or highest counts for each month were presented for each river and means of these were calculated to provide an overall mean peak count for each river (Taranaki Catchment Commission 1981). Counts of whitebaiters were obtained more regularly in Bay of Plenty rivers compared with Taranaki rivers. The peak count recorded for each river in a season is likely to be obtained during large runs and when the river is fishing at its best. Consequently the mean and range provide a better indication of overall relative use and popularity of the fisheries than the highest, or peak count.

3.3 Survey of Whitebaiters

On site interviews of whitebaiters were done during the 1983 whitebait season, August to November inclusive, to obtain further information on the fisheries: specifically on the time spent

whitebaiting, the frequency and duration of whitebaiting trips, and the sizes of catches. Questions on catch rates were phrased to obtain information on average and good daily catch rates over previous fishing seasons, and not for the 1983 season.

Most whitebaiters encountered were interviewed, but this depended on their accessibility and the time available. Whitebaiters were excluded if they had been interviewed previously. Some whitebaiters were reluctant to provide details of catches, and, assuming some people were reluctant to divulge details of large catches the quantities reported may be underestimated.

A copy of the questionnaire form is shown in Appendix I. Most interviews were conducted in August and September and the relative paucity of interviews conducted in October and November reflects the fact that most people approached in these months had already been interviewed.

4. RESULTS

4.1 Effects of Different Capture Methods and other Sources of Bias on Estimates of Species Composition

Estuaries in Bay of Plenty rivers are short and whitebaiting generally occurs near the river mouth, or in the estuary within 1 km of the river mouth. However, some samples in the Whakatane River were taken at locations up to 8 km from the river mouth. Species composition of whitebait runs changes with increasing distance upriver, where *G. brevipinnis* becomes more important in the catch, partly because *G. maculatus* juveniles move into tributaries just above the estuary (McDowall and Eldon 1980). Comparison of the species composition of

upstream and downstream samples taken from the Whakatane River on 13 October 1983 (Table 4) showed that the upstream sample contained proportionally more *G. brevipinnis*. However, such a difference may also have been due to the method of capture (i.e., set net versus scoop net).

TABLE 4. Variation in percent species composition of whitebait samples taken from the same catch

Date	Method	Place	% species composition *G. maculatus*	*G. fasciatus*	*G. brevipinnis*
11/10/83	scoop net	mouth	73.0	5.0	22.0
	scoop net	mouth	77.0	4.6	18.4
13/10/83	set net	upriver	0.5	0.5	99.0
	scoop net	mouth	85.1	2.9	12.0
16/10/83	set net	upriver	23.8	3.5	72.7
	set net	upriver	22.1	3.1	74.8

Samples of whitebait collected for us throughout the study were caught by two methods; scoop netting and set netting. The species composition of whitebait obtained by these methods would be biased if one of the whitebait species was more or less susceptible to capture by either of the two methods. This possibility was examined by comparing the species composition of samples collected in the same vicinity, on the same day, but by different methods. Paired comparisons were made for three rivers (Table 5) over the 1983 season.

In the Waioeka River there was a large difference between the species composition of samples taken by scoop and set nets on 25 September. The scoop net collected more *G. brevipinnis* relative to *G. maculatus* than did the set net. In the Rangitaiki River, differences in species composition of paired samples occurred on 3 October and 7 October, but not on 13 October. Where differences occurred, scoop net samples contained proportionally more *G. brevipinnis* than set net

samples. The one exception to this pattern occurred in the Whakatane River on 13 October when the scoop net sample contained proportionally less *G. brevipinnis* than the set net sample. However, this difference can be explained by the set net being further upriver than the scoop net. The few comparisons made suggest that scoop nets can be more selective for *G. brevipinnis*. Further work is needed to substantiate this, but these results indicate that care needs to be taken in interpreting results from different sampling methods, and from samples taken at locations more than 1 km upriver, or upstream from where tributary streams enter the main river.

Only three samples were obtained upriver in the Whakatane River, and as they all contained a higher proportion of *G. brevipinnis* than *G. maculatus*, they were excluded from the analysis of species composition. The proportion of samples collected by set and scoop nets in 1983 was calculated (Table 6) to assess the effect of bias in capture method. Scoop netting predominated in western rivers (i.e., Kaituna, Pongakawa Stream, Tarawera, Rangitaiki, and Whakatane), whereas set nets prevailed in eastern rivers (i.e., Waiotahi, Wioeka, Wainui Stream, Otara, Waiaua, Motu, Whangaparaoa). In the western rivers bias due to sampling method is not considered to be significant because *G. brevipinnis*, which would possibly have been overestimated, rarely occurred in the catches from these rivers. In comparison *G. brevipinnis* did occur in reasonable numbers in some catches from the eastern rivers where set netting prevailed. The proportion of *G. brevipinnis* in catches from these eastern rivers may therefore have been underestimated.

TABLE 5. Variation in percent species composition of whitebait samples taken by scoop net versus set nets

Date	Method	% species composition *G. maculatus*	*G. fasciatus*	*G. brevipinnis*
Rangitaiki River				
3/10/83	scoop net	73.8	3.6	22.6
	set net	95.5	1.5	3.0
7/10/83	scoop net	81.7	1.4	16.9
	set net	98.5	0.2	1.3
13/10/83	scoop net	97.1	0.0	2.9
	set net	97.6	0.4	2.0
Whakatane River				
13/10/83	scoop net	85.1	2.9	12.0
	set net *	0.5	0.5	99.0
Waioeka River				
25/9/83	scoop net	45.3	8.4	46.3
	set net	85.3	6.2	8.5

* At upriver location.

TABLE 6. Proportion of whitebait samples collected by set and scoop nets in each river in 1983

River	Number of samples analysed	% of total set net	scoop net
Whangaparaoa	10	100.0	0.0
Motu	12	100.0	0.0
Waiaua	6	100.0	0.0
Otara	6	100.0	0.0
Waioeka	30	50.0	50.0
Waiotahi	12	92.0	8.0
Wainui Stm.	18	77.8	22.2
Whakatane	23	30.0	70.0
Rangitaiki	27	18.5	81.5
Tarawera	16	12.5	87.5
Waitahanui Stm.	1	-*	-
Pongakawa Stm.	4	0.0	100.0
Kaituna	18	0.0	100.0

* Insufficient data.

4.2 Timing of Runs of the Three Main Species of Whitebait

In South Island west coast rivers whitebait migrate upriver mainly during spring, or from early September to mid November (McDowall and Eldon 1980). The proportion of *G. maculatus* in catches follows this overall spring pattern, but the other two species of whitebait tend to run during a more restricted period. For example the proportion of *G. brevipinnis* in catches begins to increase in early September reaching a peak in mid September. Runs can also occur in October, but this species is generally declining in numbers by late October. The proportion of *G. fasciatus* begins to increase in late October and reaches a peak by mid November. *G. fasciatus* therefore tends to be later than *G. brevipinnis* in its contribution to the catch in South Island rivers.

A similar pattern of seasonal abundance in the catch of the three main species was expected in the Bay of Plenty rivers. Sampling during the 1982 season started in mid September and therefore probably missed the early runs. However, in 1983 rivers were visited regularly from 1 August through to 30 November and, when whitebait were running, samples were collected every 3-6 days (Fig. 4). *G. maculatus* dominated the catch in most rivers, when whitebait were running from August through to mid November (Fig. 5). In comparison the proportion of *G. fasciatus* in catches was usually greatest between early to mid September (Fig. 6), and the proportion of *G. brevipinnis* was greatest between mid September and early October (Fig. 7).

The seasonal timing of maximum proportional abundance of *G. maculatus* and *G. brevipinnis* in Bay of Plenty river catches followed the general pattern found in South Island rivers. However, in Bay of

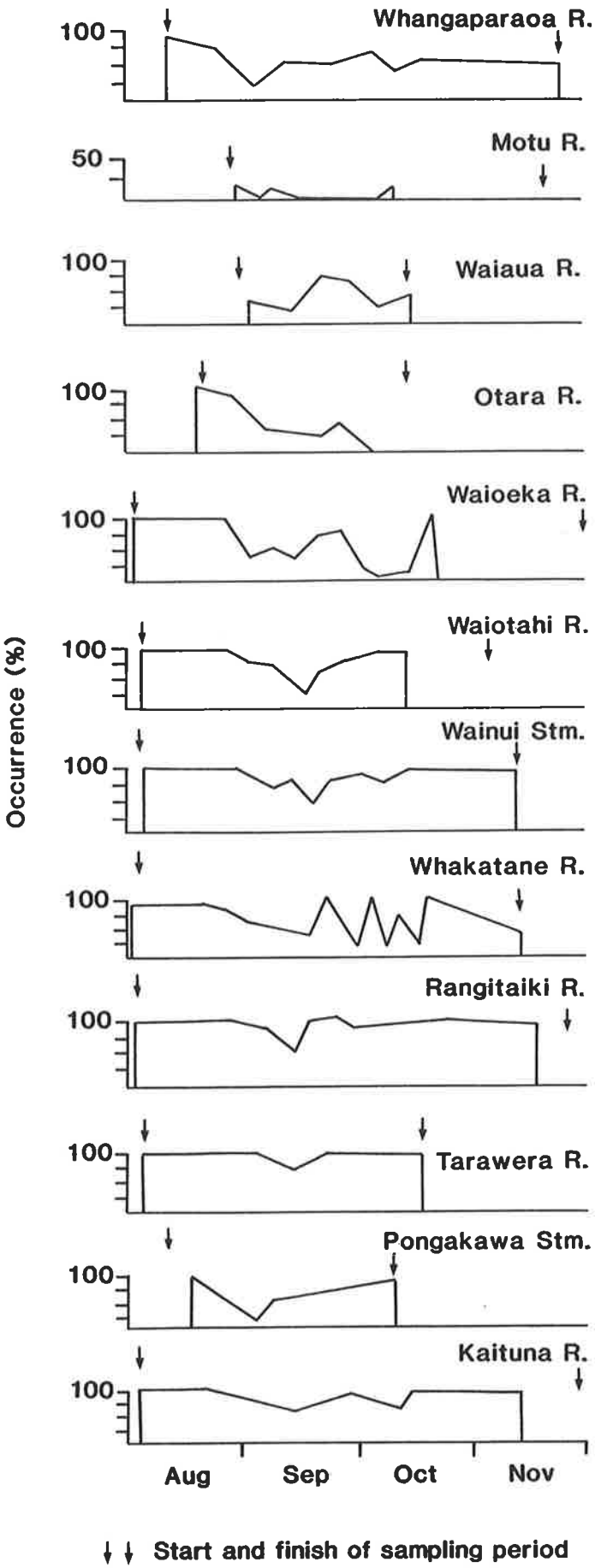

FIGURE 5. Changes in the percent occurrence of *G. maculatus* in whitebait catches from Bay of Plenty rivers during the 1983 whitebait fishing season.

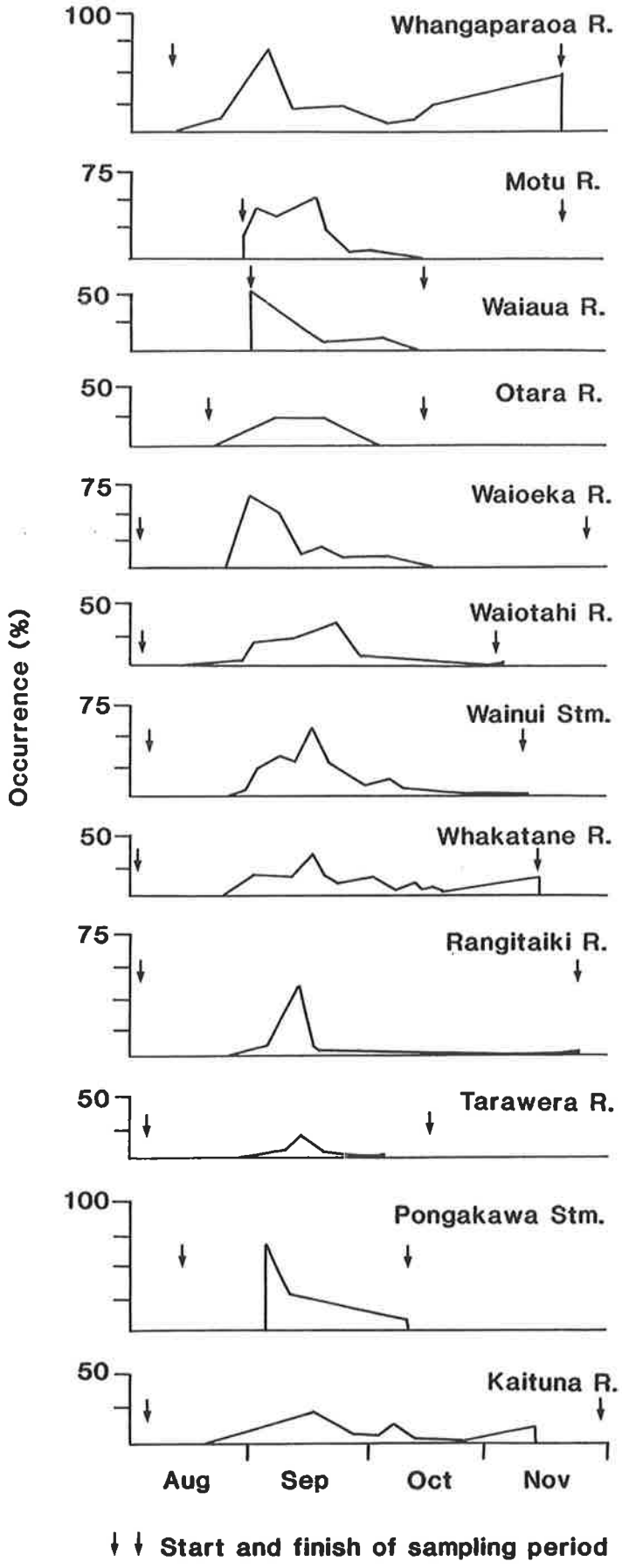

FIGURE 6. Changes in the percent occurrence of *G. fasciatus* in whitebait catches from Bay of Plenty rivers during the 1983 whitebait fishing season.

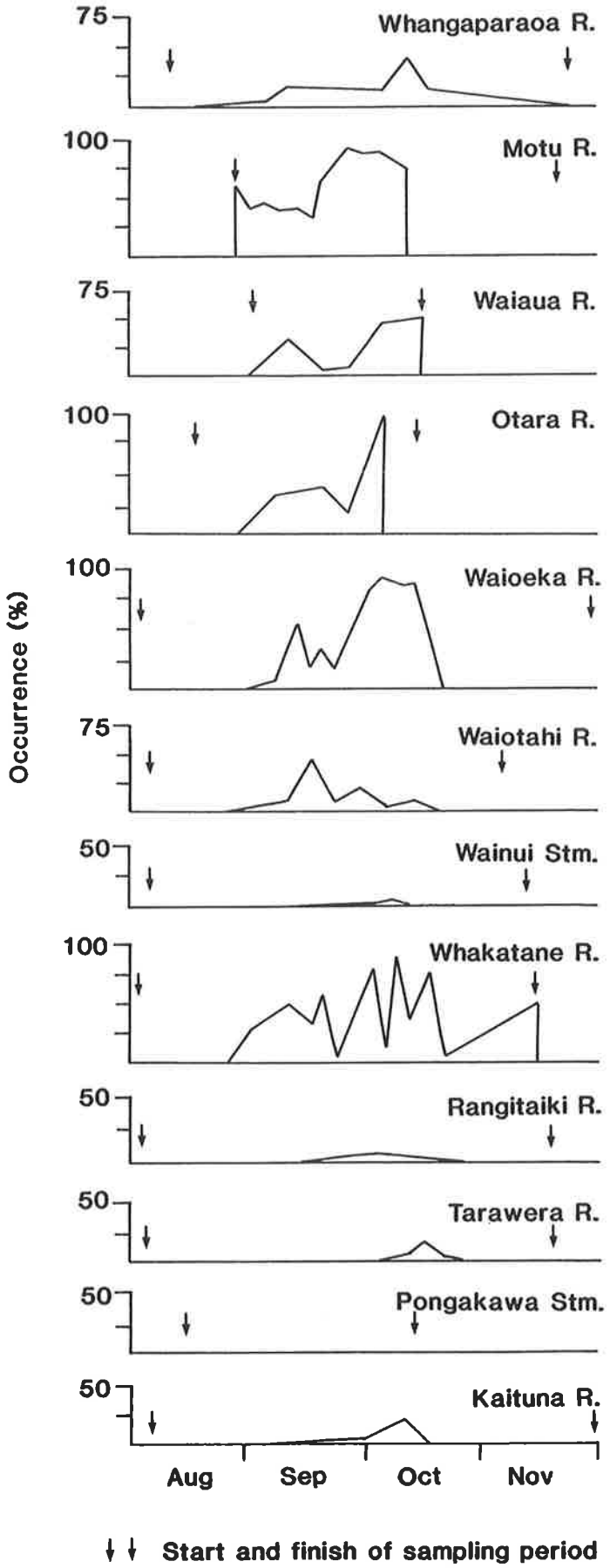

FIGURE 7. Changes in the percent occurrence of *G. brevipinnis* in whitebait catches from Bay of Plenty rivers during the 1983 whitebait season.

Plenty rivers the occurrence of *G. fasciatus* was greatest during October in 1981, all months in 1982, and September in 1983. *G. brevipinnis*, which formed a significant part of the catch in the Motu River, was generally more abundant in the catch during September in all 3 years.

4.3 Species Composition of Whitebait Catches in Bay of Plenty Rivers

The species composition of all samples containing more than 100 whitebait was calculated (Appendix II) and overall mean values were calculated for each river for each fishing season, or year (Table 7).

G. brevipinnis was the dominant species in catches from the Motu River for each of the 3 years of this study (Fig. 8). In all other rivers *G. maculatus* dominated the fishery, ranging from 52% to 99% mean percentage occurrence. (*G. fasciatus* dominated the single sample from the Waitahanui Stream, but this sample was not considered to be representative of whitebait catches in this river.)

The relative contribution of each species to the catch composition in the various rivers was consistent between years except on three occasions. In the Motu River, *G. fasciatus* was the second most abundant species in 1983, replacing *G. maculatus* which was the second ranked species in 1982. In the Waioeka and Whakatane Rivers, *G. brevipinnis* became the second most abundant species in 1983 replacing *G. fasciatus*.

In general, changes in the species composition of multi-species whitebait catches between rivers are related mainly to changes in abundance of *G. brevipinnis* and *G. maculatus*. The proportions of these two species vary inversely between rivers (Fig. 9) and the proportion of *G. fasciatus* in the rivers is relatively constant (mean 15.4%,

TABLE 7. Mean percent species composition of each season's whitebait catch from 13 Bay of Plenty rivers for 1981, 1982, 1983 seasons

River	Season	Number of samples analysed	Number of whitebait counted	*Galaxias maculatus* %	*Galaxias fasciatus* %	*Galaxias brevipinnis* %	Unidentified *Galaxias* spp. %
Whangaparaoa	1981	6	5 792	80.5	10.5	9.0	0.0
	1982	4	3 543	80.4	11.2	8.5	0.0
	1983	10	5 317	67.2	20.3	12.5	0.0
Motu	1981	9	3 571	14.3	7.6	78.1	0.0
	1982	14	5 796	35.0	22.3	42.7	0.1
	1983	12	5 881	7.2	28.8	64.0	0.0
Waiaua	1983	6	2 906	58.6	18.3	23.1	0.0
Otara	1983	6	2 693	55.3	13.1	31.7	0.0
Waioeka	1982	6	2 340	73.6	19.5	6.8	0.0
	1983	30	13 090	52.1	10.3	37.6	0.0
Waiotahi	1982	2	803	98.0	1.9	0.0	0.1
	1983	12	4 027	82.9	9.7	7.4	0.0
Wainui Stm.	1872	7	4 265	85.8	13.6	0.6	0.0
	1983	18	9 791	85.0	14.1	1.0	0.0
Whakatane	1982	5	1 592	81.2	16.9	1.8	0.0
	1983	23	7 240	66.1	8.3	25.6	0.0
Rangitaiki	1982	8	4 542	93.5	4.9	1.5	0.1
	1983	27	11 126	93.1	3.8	3.0	0.1
Tarawera	1982	2	1 729	99.8	0.2	0.0	0.0
	1983	16	6 064	98.1	1.9	0.0	0.0
Waitahanui Stm.	1983	1	282	2.5	97.5	0.0	0.0
Pongakawa Stm.	1983	4	770	70.7	29.3	0.0	0.0
Kaituna	1983	18	7 973	88.2	8.5	3.0	0.3

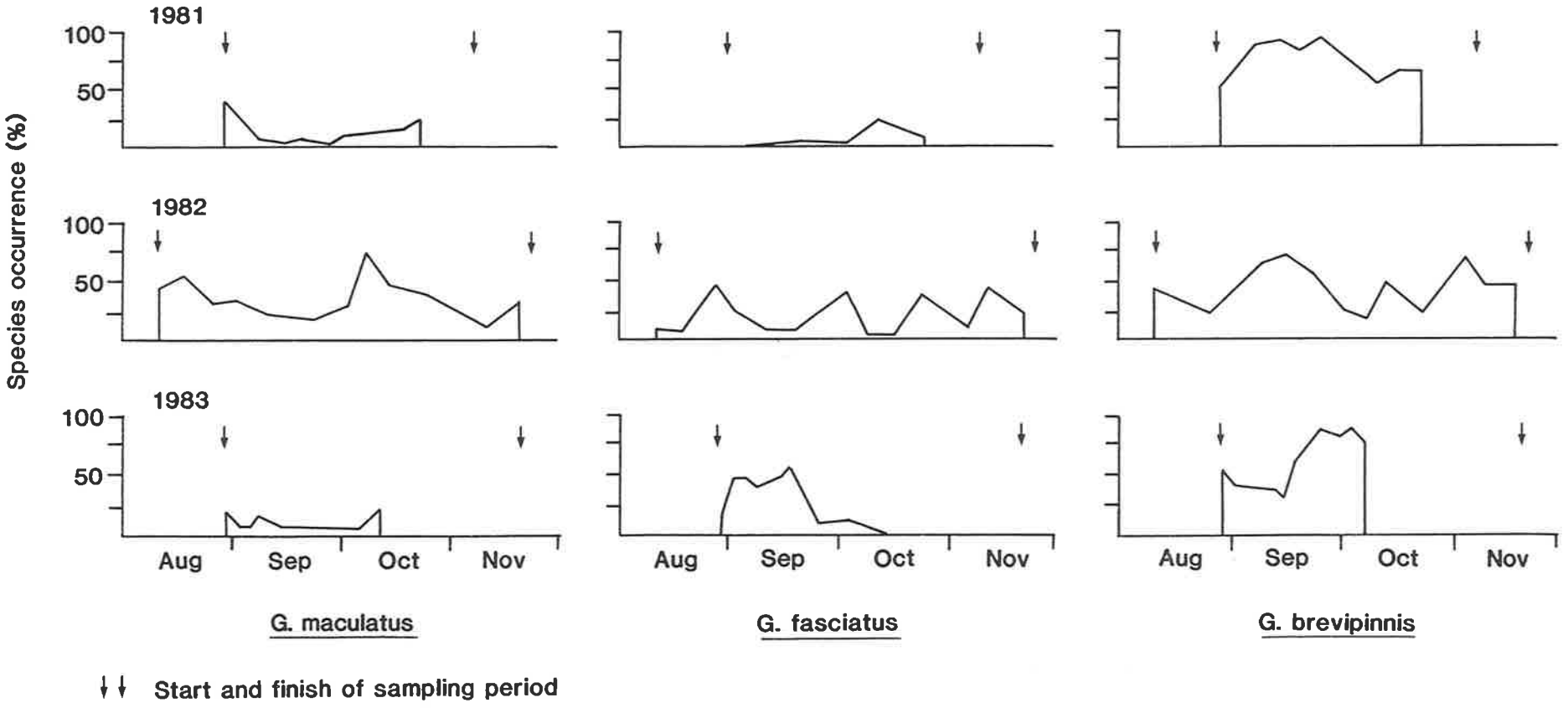

FIGURE 8. Changes in the percent species composition of whitebait catches between sampling years (1981-83) for the Motu River.

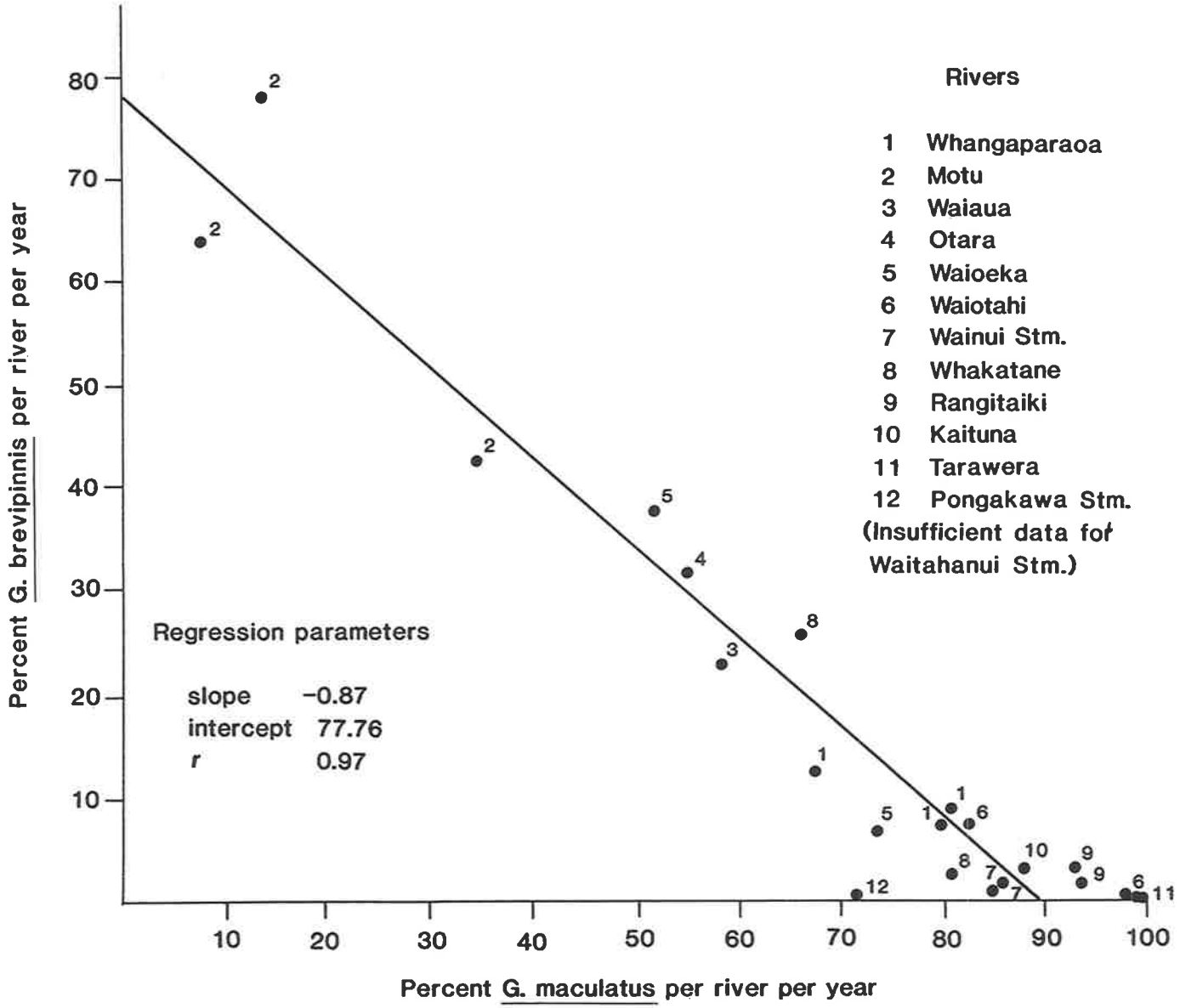

FIGURE 9. Relationship between the annual mean percent composition of *G. maculatus* and *G. brevipinnis* in whitebait catches from Bay of Plenty rivers.

s.d. 6.8). Several rivers are totally dominated by *G. maculatus* and the contribution of other species is insignificant in these. The Bay of Plenty rivers sampled (excluding the Waitahanui Stream) can therefore be classified on the basis of species composition of whitebait catches into three distinct groups:

1. Rivers completely dominated by *G. maculatus*, with no significant presence (less than 20%) of other species (Waiotahi, Wainui Stream, Rangitaiki, Tarawera, Kaituna).

2. Rivers dominated by *G. maculatus*, but with significant representation (over 20%) by other species (Whangaparaoa, Waiaua, Otara, Waioeka, Whakatane, Pongakawa Stream).

3. Rivers dominated by *G. brevipinnis*, but with significant representation (over 20%) by other species (Motu River).

Rivers in group 1 are essentially single-species fisheries and occur mainly on the western side of the Bay of Plenty. Those rivers in group 2 that contained more than 20% *G. brevipinnis* (viz., the Waiaua, Otara, Waioeka, and Whakatane, Table 7) were all within 50 km west of the mouth of the Motu River (Fig. 1). The Motu River is towards the eastern side of the Bay of Plenty and is the only New Zealand river in which *G. brevipinnis* is recorded as dominating whitebait catches throughout the fishing season. Rivers in groups 2 and 3 are multi-species whitebait fisheries.

4.4 Importance of Rivers in Terms of Relative Use for Whitebaiting

Counts of whitebaiters fishing in Bay of Plenty rivers over the 1982 and 1983 season provide a basis for ranking the various rivers in terms of their usage and/or popularity for whitebaiting (Figs. 10 and 11).

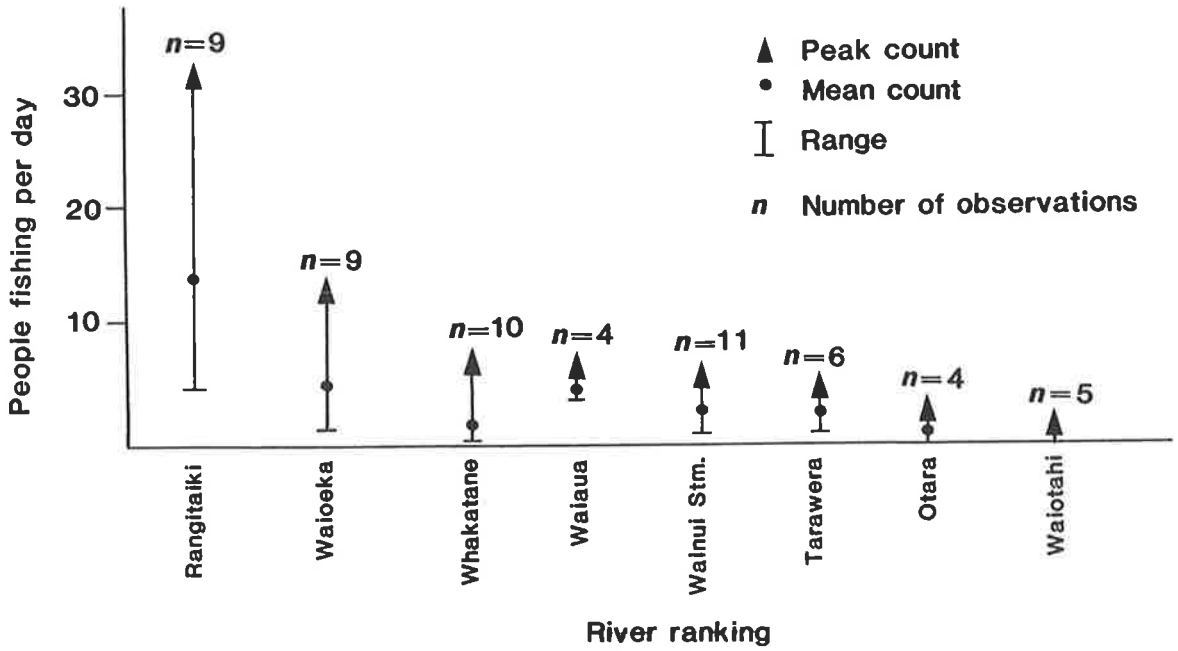

FIGURE 10. Ranking of whitebait fisheries in Bay of Plenty rivers on the basis of counts of whitebaiters made during the 1982 whitebait fishing season.

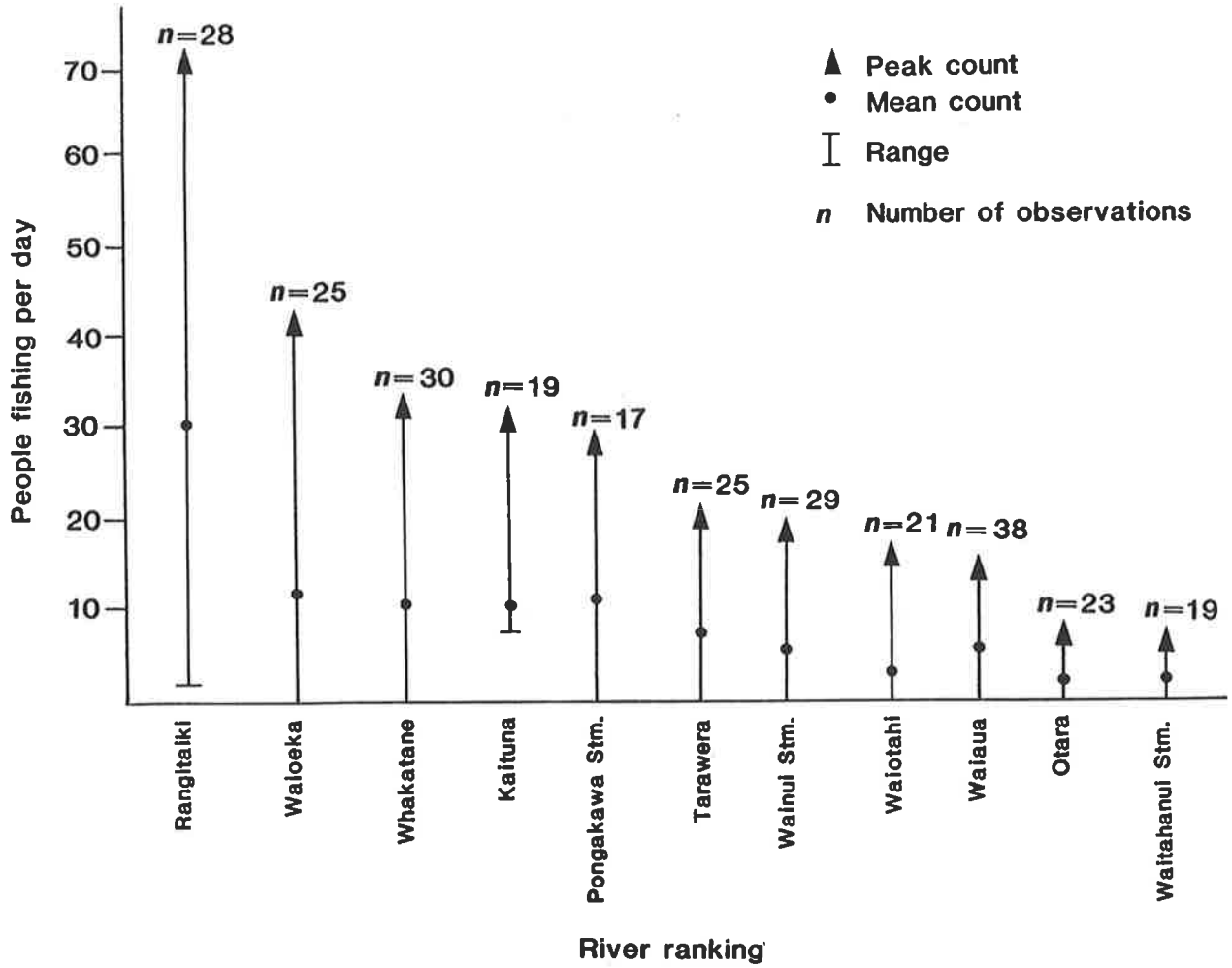

FIGURE 11. Ranking of whitebait fisheries in Bay of Plenty rivers on the basis of counts of whitebaiters made during the 1983 whitebait fishing season.

On the basis of both mean and peak counts the five main whitebaiting rivers in the Bay of Plenty are, in order of importance, the Rangitaiki, Waioeka, Whakatane, and Kaituna Rivers, and Pongakawa Stream. Counts of whitebaiters in the Motu River were not made regularly because of its distance from Whakatane, where the consultant was based. Nevertheless, some counts were obtained in 1983 and ranged from 1-23 with a mean of 6.0. On this basis the Motu River would have ranked sixth in the Bay of Plenty.

The Rangitaiki River stands out as the most popular river, attracting over twice as many whitebaiters as any other river. Daily head counts averaged 15 people per day in 1982 and 32 people per day in 1983; however, this difference between years probably reflects the more intensive sampling undertaken in 1983 (see Figs. 3 and 4), rather than an increase in whitebaiters fishing the river. Daily head counts of whitebaiters for the other four most popular rivers were all close to 10 with peak counts for these rivers ranging from 44 down to 32. Peak counts occur when the whitebait are running strongly. These counts can measure a river's "reputation" to produce large catches rather than its average or overall use.

4.5 Other Characteristics of Whitebait Fisheries

Both mean and peak head counts can be influenced by factors such as proximity of rivers to large population centres. The low head counts in the Motu River are thought to be because of its distance from large population centres, and caution is needed in assessing the importance of whitebaiting rivers from numbers of whitebaiters alone. Mean and peak head counts are useful mainly in assessing the relative usage of a fishery and therefore are only one aspect of its size and importance.

A second aspect of a fishery's importance concerns the quantity of whitebait harvested. The questionnaire filled in by the whitebaiters interviewed in 1983 provided data that permitted an estimate of the catch to be made for most of the rivers. However, there were too few returns (<5) for the Otara and Waiotahi Rivers, to permit any useful analysis of results for these rivers.

4.5.1 Time Spent Fishing per Season

Two hundred and twelve interviews were conducted with whitebaiters in the Bay of Plenty region during the 1983 season. Whitebaiters were asked to estimate the length of time spent whitebaiting per day (half day versus full day). Of the people interviewed, 82% fished for half a day or less. They were also asked to estimate the average number of days spent fishing per month. Responses were converted into days per month by using the following conversion table:

Frequency of fishing per month	days per month
Daily	30
Several days a week	8
Weekends	8
Once a week	4
Once a fortnight	2
Once a month	1

The frequency of visits to rivers and estimated mean number of days fished per person per month are shown in Table 8. In general most people tended to go whitebaiting several days a week throughout the fishing season, though virtually all rivers were fished daily by a few people. Weekend fishing was more popular in the Kaituna River.

TABLE 8. Time spent fishing for whitebait in Bay of Plenty rivers

River*	No. of respondents	Percent frequency of visits: Daily	Several days per week	Weekends	Once per week	Once per fortnight	Once per month	Total fishing days per week	Mean fishing days per month per person
Waiaua	8	50.0	37.5	12.5	0.0	0.0	0.0	152	19.0
Waioeka	29	10.4	62.0	10.4	6.9	6.9	3.4	271	9.3
Waiotahi	12	8.3	41.7	33.4	8.3	8.3	0.0	108	9.0
Wainui Stm.	21	9.5	61.9	9.5	9.5	4.8	4.8	191	9.1
Whakatane	41	14.6	53.7	19.5	9.8	2.4	0.0	438	10.7
Rangitaiki	35	14.3	45.7	5.7	11.4	17.1	5.7	324	9.3
Tarawera	14	0.0	78.6	0.0	21.4	0.0	0.0	100	7.1
Pongakawa Stm.	26	11.5	34.6	7.7	23.1	19.2	3.8	213	8.2
Kaituna	17	5.9	11.8	35.3	5.9	39.4	11.8	110	6.5

* No interviews conducted on Motu and Whangaparaoa Rivers. Insufficient data for Otara River and Waitahanui Stream.

Most rivers were fished on average between 8-11 days per person per month. Exceptions to this pattern were the Waiaua, which was fished on average for 19 days per person per month, albeit by few whitebaiters, and the Kaituna which was fished for only 6.5 days per person per month. These relatively high and low figures for time spent fishing contrast with the numbers of whitebaiters fishing these two rivers, and reflect the patterns of fishing in each river. The Waiaua River is fished regularly by a few people, whereas the Kaituna is fished mainly on weekends by fairly large numbers of people. The Tarawera River was also unusual in that relatively little time was spent fishing it, given the number of people whitebaiting on the river.

4.5.2 Quantities of Whitebait Caught

Whitebaiters surveyed were asked to estimate the quantities of whitebait they would expect to catch per day for both an average and a good days fishing. Estimated quantities expected to be caught were indicated against an 8 point scale which incorporated both volumetric units (e.g., cupful, pint, quart, bucketful, etc.) and weight, in metric and imperial units (see Appendix I). Histograms constructed from the responses (Appendix III) indicated the modal quantity of whitebait caught per person per day (for both average and good days), and the mean quantities were calculated for comparison with the modal values. Results for each river except the Otara and Waitahanui Stream, for which too few returns were received, are shown in Table 9.

On an average day, most whitebaiters expected to catch less than a cupful (250 g) of whitebait, but on good days they could expect to catch between a pint (500 g) and a quart (1 kg) in most rivers. Rivers where greater than average daily catches were expected include the

Waiotahi and Rangitaiki Rivers. On a good day large catches, of up to two bucketsful (16 kg) were expected in the Whakatane River by 12.5% of respondents, in the Rangitaiki River by 8.8%, and in the Tarawera River by 7.1% of respondents. Such large catches were not reported for other rivers and "good" fishing days for the above respondents are possibly equated with "best" days elsewhere. Mean estimates of the size of daily whitebait catches for an average day are generally higher than modal values (Table 9, Appendix III). This skew in the weight-frequency distribution of catches for each river indicates that a few people catch much more whitebait than the majority; however, the difference between modal and mean catches was large only in the Whakatane River.

The estimates of average daily catches of whitebait per person, together with estimates of days fished per person per season and the average number of people fishing per day for each river were used to calculate the relative quantity of whitebait caught in each river over a season (Table 10). Because of the positive skew in the weight-frequency distributions of individual catch quantities for each river, estimates of the yield of whitebait will be lower than actual quantities caught. Nevertheless, such estimates of the yield of whitebait from each river are expected to reflect the relative productivity of the rivers for whitebaiting and provide a basis for ranking the rivers in terms of the size of overall catch.

The Rangitaiki River was estimated to produce over 700 kg of whitebait a season which is four times as much as the next two most popular rivers, (i.e., Whakatane and Waioeka Rivers). In other Bay of Plenty rivers, for which sufficient data were collected to calculate quantities of whitebait caught, the overall yield ranged from 92 kg down

TABLE 9. Quantities of whitebait per person caught on good and average fishing days in Bay of Plenty rivers

River*	Average day			Good day	
	No. of respondents	modal catch (kg)	mean catch (kg)	No. of respondents	modal catch (kg)	mean catch (kg)
Waiaua	8	0.125	0.203	8	1.0	3.390
Waioeka	30	0.250	0.304	30	0.5	2.680
Waiotahi	11	0.500	0.500	11	8.0	4.295
Wainui Stm.	22	0.125	0.227	20	1.0	1.625
Whakatane	41	0.125	0.347	39	1.0	2.792
Rangitaiki	35	0.500	0.593	34	4.0	5.132
Tarawera	14	0.125	0.285	14	1.0	4.428
Pongakawa Stm.	27	0.125	0.218	25	0.5	1.180
Kaituna	17	0.125	0.234	17	0.5	2.765

TABLE 10. Relative yield of whitebait in Bay of Plenty rivers

River*	Mean number people fishing per day	Mean number days fished per person per season (days)	Mean catch per person per day (average season) (kg)	Relative yield (kg)
Waiaua	6.0	76.0	0.203	92.6
Waioeka	12.0	37.2	0.304	135.7
Waiotahi	2.7	36.0	0.500	48.6
Wainui Stm.	6.5	36.4	0.227	53.7
Whakatane	10.8	42.8	0.347	160.4
Rangitaiki	32.4	37.2	0.593	714.7
Tarawera	7.8	28.4	0.285	63.1
Pongakawa Stm.	12.0	32.8	0.218	85.8
Kaituna	12.4	26.0	0.234	75.4

* No interviews conducted on Motu and Whangaparaoa Rivers. Insufficient data for Otara River and Waitahanui Stream.

to 48 kg. In general the ranking for the rivers based on numbers of whitebaiters agreed with the ranking made on the basis of overall yield of whitebait. One exception to this trend was the Waiaua River which was fished by few people, but which produced a large overall yield. Mean daily catch per person was low for this stream compared with other rivers, and the high estimated yield is explained by the fact that half the people whitebaiting in this stream fished it on a daily basis. A high proportion of daily whitebaiters, and the few people fishing this stream combined to distort the estimate of relative yield. This example shows the need for caution in interpreting results and the advisability of measuring a number of characteristics of fisheries, if their relative importance is to be fairly assessed.

The high yield of whitebait in the Rangitaiki River compared to other Bay of Plenty rivers is due to the large number of people fishing it, as well as to a high catch rate per person. The figure of 714 kg, is an underestimate, but it is well below most records of overall catch per season reported by McDowall and Eldon (1980) for seven South Island west coast rivers. South Island catches of whitebait fluctuated distinctly from year to year and between rivers: they ranged from 312 kg (Turnbull River) to 19 619 kg (Cascade River) in 1973 alone (McDowall and Eldon 1980). The figure of 714 kg in the Rangitaiki River may well represent poor fishing seasons in past years, as reported by whitebaiters, but the yield of whitebait from Bay of Plenty rivers is still likely to be much less than in the seven South Island rivers studied by McDowall and Eldon (1980). This is especially so given that smelt are often a major component of whitebait catches in Bay of Plenty rivers.

4.5.3 Proportion of Whitebaiters Catching Smelt with Whitebait

The proportions of whitebaiters who actively exclude smelt and retain pure (first class) whitebait in Bay of Plenty rivers are listed in Table 11. In the Rangitaiki River only 28.6% of whitebaiters exclude smelt. This suggests that a major portion of the overall catch in this river is smelt. In comparison about half of the whitebaiters surveyed excluded smelt in the Waioeka and Whakatane Rivers, where yields of whitebait were a quarter of that estimated for the Rangitaiki River. The proportion of people excluding smelt from catches was highest in the Kaituna River (64.7%), Pongakawa Stream (73.1%), and the Wainui Stream (77.3%); it was lowest in the Tarawera, Waiaua, and Rangitaiki Rivers, which are fished mainly by Maori whitebaiters. The fairly small catches of whitebait in Bay of Plenty rivers are probaby responsible for the inclusion of smelt in the whitebait caught by many of the people fishing these rivers.

TABLE 11. Number of whitebaiters taking galaxiid species only versus galaxiids and smelt

River*	No. of respondents	Percent taking whitebait only
Waiaua	8	37.5
Waioeka	30	46.7
Waiotahi	11	54.5
Wainui Stm.	22	77.3
Whakatane	40	50.0
Rangitaiki	35	28.6
Tarawera	14	28.6
Pongakawa Stm.	26	73.1
Kaituna	17	64.7

* No interviews conducted on Motu and Whangaparaoa Rivers. Insufficient data for Otara and Waitahanui Stream.

5. DISCUSSION

The Motu River has a largely unmodified, bush covered catchment and the principal adult whitebait species found in its tributary streams is *G. brevipinnis* (Rowe 1981). *G. brevipinnis* is also the dominant species in whitebaiters' catches at the mouth of the Motu River, though both *G. maculatus* and *G. fasciatus* are present in appreciable numbers (over 20% of the catch).

The adult stocks of *G. brevipinnis* in the Motu River are likely to be responsible for most of the *G. brevipinnis* whitebait caught at the river mouth. Dams on the lower Motu River would break the natural life cycle of this species by preventing both downstream movement of eggs or larvae, and upstream movement by juvenile whitebait from the sea. Although *G. brevipinnis* forms landlocked populations in the reservoirs behind dams, such populations do not contribute to river-mouth whitebait fisheries. A dam on the lower Motu River would therefore result in a significant reduction in the quantity of whitebait which return to the Motu River and which support the fishery there.

Although the whitebait fishery in the Motu River is fairly small compared with those in other Bay of Plenty rivers, it is valued by whitebaiters who fish it and has a reputation as a productive fishery. It attracts whitebaiters from as far away as Gisborne to the east and Rotorua in the west, and its low ranking on the basis of use, compared with other popular Bay of Plenty rivers, is thought to be due more to its isolation from major population centres than to a lack of whitebait.

G. brevipinnis formed a significant proportion (over 20%) of whitebait catches in four other Bay of Plenty rivers (the Waiaua, Otara,

Waioeka, and Whakatane), but it was never a dominant component of the catch in these rivers as it was in the Motu River. Catches from these rivers, as well as catches from the remaining rivers (except Waitahanui Stream), were dominated by *G. maculatus*. Compared with these two main species, whose respective proportions in catches varied inversely, *G. fasciatus* tended to form a constant fraction of the catch, especially in mixed-species fisheries (i.e. where *G. maculatus* comprised 80% or less of the catch). The mixed-species fisheries which contained a significant number of *G. brevipinnis* occurred only in the rivers east of Whakatane, whereas west of Whakatane, *G. brevipinnis* comprised less than 3% of catches. One explanation for this east-west difference in the contribution of *G. brevipinnis* would be a "seeding" effect from the Motu River, with rivers either side of it, but within a 50 km radius of its mouth, benefiting from its production of *G. brevipinnis* larvae. However, this would imply a restricted distribution of larvae at sea in the Bay of Plenty. Alternatively, and more likely, the absence of *G. brevipinnis* in western rivers could be due to the greater extent of deforestation in these catchments combined with barriers to upstream migration of juveniles (e.g., dams or severe pollution). However, this would imply that the *G. brevipinnis* larvae avoid these rivers during their migration into freshwater. The whitebait fishery in the Motu River is unique in being the only one known to be dominated by *G. brevipinnis*. Other whitebait rivers examined in both this study and those of McDowall (1968) and McDowall and Eldon (1980) are all dominated by *G. maculatus*. Reasons for this difference are only speculative at present, but they can be narrowed down to several alternatives.

On an areal basis the extent of adult *G. brevipinnis* habitat in the Motu River is far greater than that for *G. maculatus*. If the species

composition of a whitebait fishery at a river's mouth reflects the relative amount of habitat for the three main whitebait species in the river's catchment, then *G. brevipinnis* would be expected to dominate the fishery in the Motu. Complementary evidence for such a habitat-based association is provided by McDowall and Eldon (1980). They found that *G. fasciatus* dominated whitebait catches in Jackson Bay Stream. This stream, which flows straight into the sea, was reported to contain a predominance of typical *G. fasciatus* habitat, and a large number of *G. fasciatus* adults compared with other species. However, several west coast South Island rivers studied by McDowall and Eldon (1980) (e.g., Hokitika, Okuru, Arawata, and Waiatoto) also have extensive areas of their catchment covered by native forest and contain many tributaries capable of supporting the bouldery, tumbling habitat associated with *G. brevipinnis* and *G. fasciatus*. Nevertheless, these rivers' whitebait fisheries were all clearly dominated by *G. maculatus*, at least at the river mouth. Catches further upstream contained higher proportions of *G. brevipinnis*, but McDowall and Eldon (1980) showed that the proportion of *G. brevipinnis* tends to increase with distance upriver, because *G. maculatus* juveniles do not penetrate as far inland as other whitebait. The association between the proportion of each adult whitebait species' habitat in a river's catchment and the representation of the juvenile species in the river's whitebait catch does not hold in these rivers. Therefore, predominance of *G. brevipinnis* in the Motu River may be related to less straightforward factors than the proportion of adult habitat in the catchment.

Samples of *G. brevipinnis* from the Motu River were all obtained within 700 m of the river mouth and well before any side tributaries entered the main stem. Therefore, distance upriver and an early exit

for *G. maculatus* is not a factor. However, the upriver migration of *G. maculatus* may well be limited at the river mouth and the Motu River could be *G. maculatus* limited rather than *G. brevipinnis* dominated. McDowall and Eldon (1980) found that in South Island rivers where turbidity is associated with spring snow melt and glacial "flour", *G. maculatus* was less tolerant of turbid waters than *G. brevipinnis*. The Motu River is renowned for its high turbidity and high suspended solids loading, especially after heavy rain (Adams 1979). The different tolerances of the juveniles of *G. maculatus* and *G. brevipinnis* and the turbid nature of the Motu River could explain the relative paucity of *G. maculatus* in this river.

A more quantitative investigation is now needed to determine whether the Motu River is *G. maculatus* limited or *G. brevipinnis* dominated, relative to other whitebait fisheries. The answer to this would pave the way for more important studies of whitebait habitat, which could well provide an understanding of the main factors responsible for the variations in species composition of catches and for the decline in whitebait fisheries in New Zealand rivers over the past 50 years.

6. ACKNOWLEDGMENTS

We gratefully acknowledge the financial support of the Ministry of Works and Development and the continual encouragement of John Galloway. The collection of samples in the Motu River and Whangaparaoa River was done for us by Peggy Powell and Mere Ruhia respectively. We thank them for their help which made our task so much easier. Finally this study owes much to the many whitebaiters in the Bay of Plenty who variously helped with sample collection and the survey of whitebait fishing rivers in the region.

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APPENDIX I. Questionnaire for whitebait survey 1983.

RIVER NAME: _____

DATE: _____ TIME: _____

1	What is your home town?	
2	How many years have you been whitebait fishing?	
3	On a typical whitebait trip how many other people do you normally travel with?	
4	How often do you normally go whitebaiting? (tick box) Other comment:	

Daily	
Several days a week	
Weekends only	
Once a fortnight	
Once a month	
School hols only	

5	What is the average length of stay for your whitebait trips?

Half day/or less	
Full day	
Up to two days	
More than two days (enter actual time	

APPENDIX I. (ctd.)

6 Which river do you fish most frequently for whitebait)

River name	Most freq (Tick one)	2nd best (Tick one)	3rd best (Tick one)	Others (Tick rivers fished)
Rangitaiki				
Tarawera				
Whakatane				
Wainui Stm				
Waiotahi				
Waioeka				
Waiaua				
Motu				
Kaituna				
Pongakawa Stm				
Waitahanui Stm				
Other				

7 What are our reasons for not fishing other rivers? (Tick columns)

River name	Too far away	Too crowded	Pollution	Access	Fewer whitebait	Other
Rangitaiki						
Tarawera						
Whakatane						
Wainui Stm						
Waiotahi						
Waioeka						
Waiaua						
Kaituna						
Pongakawa Stm						
Waitahanui Stm						
Other						

APPENDIX I. (ctd.)

8a How much do you expect to catch on an average day, and on a good day

		(Tick column) Avg day	Good day
A	Less than cupful		
B	Cupful = approx 250 g = approx ½ lb		
C	Pint = approx 500 g = approx 1 lb		
D	Quart = approx 1000 g = approx 2 lb		
E	½ bucket = approx 4000 g = approx 10 lb		
F	1 bucket = approx 8000 g = approx 20 lb		
G	2 buckets = approx 16000 g = approx 40 lb		
H	More than 2 buckets (state amount)		

8b About how much whitebait would you generally obtain in each season:

(Letters refer to amounts in question 8a)

	A	B	C	D	E	F	G	H
1. Good season								
2. Average season								
3. Bad season								

8c When was your last good whitebait season for this river?

Date

Any comments on the various seasons:

APPENDIX 1. (ctd.)

9 Approximately what proportion of last year's catch did you sell commercially? (Tick box)

all	
3/4	
half	
some	
none	

10 What names do you give to the different types of whitebait in your catch?

11a Do you prefer one type of whitebait to another?

yes	
no	

11b If yes, which type to you prefer the most and the least?

most	
least	

12a Do you include smelt (cucumber fish - cucumber smelling) in your whitebait catch?

yes	
no	

12b If yes, what proportion of your catch is generally smelt?

all	
3/4	
half	
some	
none	

APPENDIX II. Species composition of all samples of whitebait from Bay of Plenty rivers 1981-83.

Year	Date	*Galaxias maculatus* %	*Galaxias fasciatus* %	*Galaxias brevipinnis* %	Unidentified %	No. of whitebait per sample
Whangaparaoa River						
1981	10 Sep	69.6	9.4	21.0	0.0	738
	20 Sep	68.6	12.6	18.8	0.0	1 089
	9 Oct	83.2	8.7	8.1	0.0	1 073
	22 Oct	69.2	26.8	4.0	0.0	719
	1 Nov	94.2	4.7	1.1	0.0	1 083
	7 Nov	98.4	0.8	0.8	0.0	1 090
	$\bar{x}$ % (n = 6)	80.5	10.5	9.0	0.0	5 792
1982	10 Aug	99.9	0.1	0.0	0.0	1 152
	25 Aug	99.4	0.0	0.6	0.0	788
	20 Sep	63.9	17.8	18.3	0.0	977
	2 Oct	58.2	26.7	15.1	0.0	626
	$\bar{x}$ % (n = 4)	80.4	11.2	8.5	0.0	3 543
1983	12 Aug	100.0	0.0	0.0	0.0	600
	17 Aug	93.4	6.6	0.0	0.0	515
	24 Aug	90.2	9.7	0.1	0.0	765
	6 Sep	24.3	71.5	4.2	0.0	796
	12 Sep	63.3	176.9	18.8	0.0	341
	22 Sep	61.3	18.8	19.9	0.0	574
	5 Oct	75.8	6.6	17.6	0.0	672
	12 Oct	47.0	8.2	44.8	0.0	464
	18 Oct	67.1	17.8	15.1	0.0	483
	2 Nov	78.8	21.2	0.0	0.0	66*
	22 Nov	49.5	45.8	4.7	0.0	107
	$\bar{x}$ % (n = 10)	67.2	20.3	12.5	0.0	5 317
Motu River						
1981	31 Aug	42.2	1.0	56.8	0.0	296
	7 Sep	6.3	0.2	93.5	0.0	535
	13 Sep	1.6	2.9	95.5	0.0	582
	19 Sep	5.1	6.3	88.6	0.0	415
	27 Sep	0.2	1.8	98.0	0.0	496
	3 Oct	12.6	5.7	81.7	0.0	460
	10 Oct	16.9	25.1	58.0	0.0	338
	17 Oct	17.7	16.1	66.2	0.0	311
	23 Oct	26.1	9.4	64.5	0.0	138
	30 Oct	48.8	31.7	19.5	0.0	41*
	8 Nov	16.7	16.7	66.7	0.0	12*
	24 Nov	100.0	0.0	0.0	0.0	1*
	$\bar{x}$ % (n = 9)	14.3	7.6	78.6	0.0	3 571

APPENDIX II. (ctd.)

Year	Date	*Galaxias maculatus* %	*Galaxias fasciatus* %	*Galaxias brevipinnis* %	Unidentified %	No. of whitebait per sample
Motu River (ctd.)						
1982	7 Aug	68.2	0.0	31.8	0.0	22*
	11 Aug	46.6	9.1	44.3	0.0	275
	16 Aug	59.5	8.9	31.6	0.0	237
	27 Aug	29.2	48.5	22.3	0.0	476
	3 Sep	32.5	24.1	43.4	0.0	228
	10 Sep	22.8	10.4	66.3	0.5	653
	17 Sep	19.7	7.2	73.1	0.0	432
	24 Sep	17.8	25.1	57.1	0.0	247
	1 Oct	28.5	45.5	25.9	0.3	348
	8 Oct	28.5	45.5	25.9	0.3	348
	15 Oct	48.4	4.2	47.4	0.0	506
	22 Oct	41.5	40.3	18.2	0.0	785
	5 Nov	22.4	9.6	67.8	0.2	553
	12 Nov	12.2	47.2	40.3	0.3	367
	19 Nov	31.4	25.6	43.0	0.0	360
	22 Nov	60.0	20.0	20.0	0.0	15*
	$\bar{x}$ % (n = 14)	35.0	22.3	42.7	0.1	5 796
1983	28 Aug	19.3	20.8	59.9	0.0	337
	2 Sep	8.8	47.6	43.6	0.0	573
	5 Sep	5.0	47.9	47.1	0.0	520
	9 Sep	14.7	40.9	44.4	0.0	592
	13 Sep	6.2	50.5	43.3	0.0	648
	17 Sep	5.5	56.0	38.5	0.0	652
	20 Sep	6.1	40.9	53.0	0.0	574
	21 Sep	0.0	16.5	83.5	0.0	431
	25 Sep	0.0	5.3	94.7	0.0	586
	3 Oct	1.1	9.0	89.9	0.0	267
	4 Oct	0.9	7.7	91.4	0.0	560
	10 Oct	19.1	2.1	78.7	0.0	141
	14 Oct	0.0	24.6	75.4	0.0	69*
	19 Oct	0.0	0.0	100.0	0.0	2*
	31 Oct	16.7	0.0	83.3	0.0	6*
	5 Nov	100.0	0.0	0.0	0.0	5*
	12 Nov	100.0	0.0	0.0	0.0	1*
	21 Nov	0.0	0.0	100.0	0.0	1*
	$\bar{x}$ % (n = 12)	7.2	28.8	64.0	0.0	5 881
Waiaua River						
1982	5 Nov	95.9	4.1	0.0	0.0	49
	$\bar{x}$ % (n = 0)					

APPENDIX II. (ctd.)

Year	Date	*Galaxias maculatus* %	*Galaxias fasciatus* %	*Galaxias brevipinnis* %	Unidentified %	No. of whitebait per sample
Waiaua River (ctd.)						
1983	3 Sep	46.2	50.7	3.1	0.0	515
	11 Sep	40.6	28.6	30.8	0.0	483
	21 Sep	88.1	7.0	4.9	0.0	670
	25 Sep	83.2	10.0	6.8	0.0	561
	5 Oct	44.0	12.3	43.7	0.0	480
	6 Oct	100.0	0.0	0.0	0.0	1*
	14 Oct	49.5	1.0	49.5	0.0	196
	$\bar{x}$ % (n = 6)	58.6	18.3	23.1	0.0	2 906
Otara River						
1983	19 Aug	100.0	0.0	0.0	0.0	629
	29 Aug	90.7	9.1	0.2	0.0	496
	8 Sep	39.6	25.5	34.9	0.0	513
	19 Sep	33.3	26.1	40.6	0.0	433
	26 Sep	66.8	14.9	18.3	0.0	262
	2 Oct	30.1	18.1	51.8	0.0	83*
	6 Oct	1.1	2.8	96.1	0.0	360
	14 Oct	10.6	2.1	87.3	0.0	47*
	$\bar{x}$ % (n = 6)	55.3	13.1	31.7	0.0	2 693
Waioeka River						
1982	28 Sep	64.7	10.1	25.2	0.0	238
	6 Oct	98.8	0.3	0.6	0.3	329
	19 Oct	56.7	37.8	5.5	0.0	601
	20 Oct	(13.3	40.0	46.7	0.0	30*
		(58.7	36.4	4.9	0.0	588
	3 Nov	80.3	16.2	3.5	0.0	259
	4 Nov	82.5	16.3	1.2	0.0	326
	21 Nov	100.0	0.0	0.0	0.0	40*
	$\bar{x}$ % (n = 6)	73.6	19.5	6.8	0.0	2 340
1983	3 Aug	100.0	0.0	0.0	0.0	157
	8 Aug	99.9	0.0	0.1	0.0	667
	9 Aug	99.9	0.0	0.0	0.0	653
	18 Aug	(99.5	0.3	0.2	0.0	364
		(100.0	0.0	0.0	0.0	215
	25 Aug	98.8	0.7	0.5	0.0	666
	3 Sep	(28.9	66.0	5.1	0.0	374
		(40.0	54.3	5.7	0.0	648
	7 Sep	44.7	46.9	8.4	0.0	550
		(34.7	12.5	52.8	0.0	510
	13 Sep	(34.8	10.6	54.6	0.0	322
		(38.6	6.9	54.5	0.0	593

APPENDIX II. (ctd.)

Year	Date	*Galaxias maculatus* %	*Galaxias fasciatus* %	*Galaxias brevipinnis* %	Unidentified %	No. of whitebait per sample
Waioeka River (ctd.)						
1983	14 Sep	35.9	11.0	53.1	0.0	465
		(60.5	16.7	22.8	0.0	592
	19 Sep	(68.4	9.3	22.3	0.0	538
		(76.0	13.3	10.7	0.0	541
	24 Sep	57.9	8.8	33.3	0.0	114
		(92.5	3.7	3.7	0.0	509
	25 Sep	(85.3	6.2	8.5	0.0	539
		(45.3	8.4	46.3	0.0	439
		(88.5	7.0	4.5	0.0	572
	2 Oct	(10.6	3.0	86.4	0.0	360
		(9.9	9.5	80.6	0.0	265
	6 Oct	1.5	0.3	98.2	0.0	341
		(1.8	2.1	96.1	0.0	384
	11 Oct	(2.9	2.9	94.2	0.0	411
		(4.0	4.4	91.6	0.0	227
	14 Oct	(11.4	1.6	87.0	0.0	368
		(0.2	0.3	99.5	0.0	393
	19 Oct	91.4	1.3	7.3	0.0	314
	13 Nov	80.0	20.0	0.0	0.0	45*
	22 Nov	100.0	0.0	0.0	0.0	6*
	29 Nov	100.0	0.0	0.0	0.0	10*
	$\bar{x}$ % (n = 30)	52.1	10.3	37.6	0.0	13 090
Waiotahi River						
1982	3 Nov	97.5	2.5	0.0	0.0	322
	6 Nov	98.5	1.2	0.0	0.2	481
	$\bar{x}$ % (n = 2)	98.0	1.9	0.0	0.1	803
1983	4 Aug	100.0	0.0	0.0	0.0	171
	12 Aug	100.0	0.0	0.0	0.0	3*
	24 Aug	100.0	0.0	0.0	0.0	420
	28 Aug	97.8	1.8	0.4	0.0	488
	1 Sep	80.4	19.2	0.4	0.0	261
	12 Sep	69.3	22.6	8.1	0.0	504
	18 Sep	28.7	26.8	44.5	0.0	526
	23 Sep	59.2	33.8	7.0	0.0	157
	30 Sep	78.2	5.9	15.9	0.0	372
	4 Oct	92.5	2.6	4.9	0.0	307
	7 Oct	96.8	2.6	0.6	0.0	190
	14 Oct	95.3	0.6	41.	0.0	509
	18 Oct	96.7	0.8	2.5	0.0	122
	4 Nov	95.2	3.2	1.6	0.0	62*
	$\bar{x}$ % (n = 12)	82.9	9.7	7.4	0.0	4 027

APPENDIX II. (ctd.)

Year	Date	*Galaxias maculatus* %	*Galaxias fasciatus* %	*Galaxias brevipinnis* %	Unidentified %	No. of whitebait per sample
Wainui Stream						
1982	8 Sep	84.1	15.3	0.6	0.0	496
	27 Sep	100.0	0.0	0.0	0.0	20*
	28 Sep	84.2	13.4	2.4	0.0	734
	17 Oct	91.5	8.5	0.0	0.0	932
	19 Oct	97.9	2.1	0.0	0.0	682
	27 Oct	46.3	52.6	1.0	0.0	410
	31 Oct	96.7	3.3	0.0	0.0	843
	8 Nov	100.0	0.0	0.0	0.0	168
	$\bar{x}$ % (n = 7)	85.8	13.6	0.6	0.0	4 265
1983	4 Aug	100.0	0.0	0.0	0.0	779
	12 Aug	100.0	0.0	0.0	0.0	670
	19 Aug	99.8	0.2	0.0	0.0	478
	23 Aug	100.0	0.0	0.0	0.0	35*
	25 Aug	99.4	0.6	0.0	0.0	635
	28 Aug	94.3	5.7	0.0	0.0	617
	1 Sep	76.9	23.1	0.0	0.0	683
	8 Sep	67.7	31.7	0.6	0.0	473
	12 Sep	71.6	28.1	0.3	0.0	570
	18 Sep	41.6	57.9	0.5	0.0	644
	21 Sep	(68.3	30.6	1.1	0.0	568
		(76.9	21.6	1.5	0.0	611
	23 Sep	82.6	17.1	0.3	0.0	356
	30 Sep	(92.2	6.6	1.2	0.0	411
		(92.3	5.8	1.9	0.0	428
	4 Oct	82.2	11.9	5.9	0.0	494
	7 Oct	89.2	7.6	3.2	0.0	475
	11 Oct	96.5	2.0	1.5	0.0	407
	18 Oct	94.1	5.9	0.0	0.0	34*
	11 Nov	97.6	2.4	0.0	0.0	492
	$\bar{x}$ % (n = 18)	85.0	14.1	1.0	0.0	9 791
Whakatane River						
1982	9 Sep	59.4	34.4	6.2	0.0	128
	25 Sep	91.5	6.8	1.7	0.0	473
	30 Sep	99.6	0.2	0.1	0.1	728
	15 Oct	(83.3	16.7	0.0	0.0	6*
		(26.7	60.0	13.3	0.0	15*
	26 Oct	56.3	42.3	1.4	0.0	142
	17 Nov	99.2	0.8	0.0	0.0	121
	$\bar{x}$ % (n = 5)	81.2	16.9	1.8	0.0	1 592

APPENDIX II. (ctd.)

Year	Date	*Galaxias maculatus* %	*Galaxias fasciatus* %	*Galaxias brevipinnis* %	Unidentified %	No. of whitebait per sample
Whakatane River (ctd.)						
1983	2 Aug	99.5	0.5	0.0	0.0	191
	7 Aug	100.0	0.0	0.0	0.0	492
	14 Aug	100.0	0.0	0.0	0.0	33*
	16 Aug	99.5	0.0	0.5	0.0	399
	22 Aug	99.6	0.4	0.0	0.0	229
	27 Aug	93.6	6.2	0.2	0.0	498
	2 Sep	53.1	17.0	29.9	0.0	623
	11 Sep	37.9	13.8	48.3	0.0	348
	16 Sep	43.1	27.5	29.4	0.0	109
	17 Sep	19.1	44.5	36.4	0.0	299
	21 Sep	25.5	14.9	59.6	0.0	275
	23 Sep	89.6	7.9	2.5	0.0	280
	27 Sep	84.3	2.0	13.7	0.0	51*
	3 Oct	8.1	13.4	78.5	0.0	366
	4 Oct	91.1	6.2	2.7	0.0	338
	8 Oct	8.5	1.4	90.1	0.0	365
	10 Oct	42.6	1.5	55.9	0.0	263
		(0.5	0.5	99.0	0.0	394
	11 Oct	(73.0	5.0	22.0	0.0	459
	13 Oct	(77.0	4.6	18.4	0.0	392
		(85.1	2.9	12.0	0.0	417
	16 Oct	(23.8	3.5	72.7	0.0	315
		(22.1	3.1	74.8	0.0	294
	21 Oct	99.6	0.4	0.0	0.0	518
	3 Nov	7.7	7.7	53.9	30.7	26*
	14 Nov	37.8	13.8	48.1	0.3	349
	$\bar{x}$ % (n = 23)	57.8	8.2	34.0	0.0	8 323
Rangitaiki River						
1982	7 Sep	99.4	0.4	0.2	0.0	659
		(89.6	7.5	2.9		412
	26 Sep	(94.8	3.2	2.0		709
		(86.2	8.9	4.7	0.2	485
	4 Oct	(99.3	0.0	0.7	0.0	411
		(99.8	0.0	0.2	0.0	811
	17 Oct	79.5	18.7	1.0	0.7	697
	16 Nov	99.2	0.5	0.3	0.0	358
	19 Nov	97.8	0.0	0.0	2.2	93*
	$\bar{x}$ % (n = 8)	93.5	4.9	1.5	0.1	4 542
1983	1 Aug	100.0	0.0	0.0	0.0	332
	2 Aug	100.0	0.0	0.0	0.0	735
	5 Aug	100.0	0.0	0.0	0.0	573
	10 Aug	100.0	0.0	0.0	0.0	434
	15 Aug	100.0	0.0	0.0	0.0	580
	16 Aug	100.0	0.0	0.0	0.0	578
	22 Aug	100.0	0.0	0.0	0.0	103
	27 Aug	98.9	1.1	0.0	0.0	354
	5 Sep	92.5	7.3	0.2	0.0	372

APPENDIX II. (ctd.)

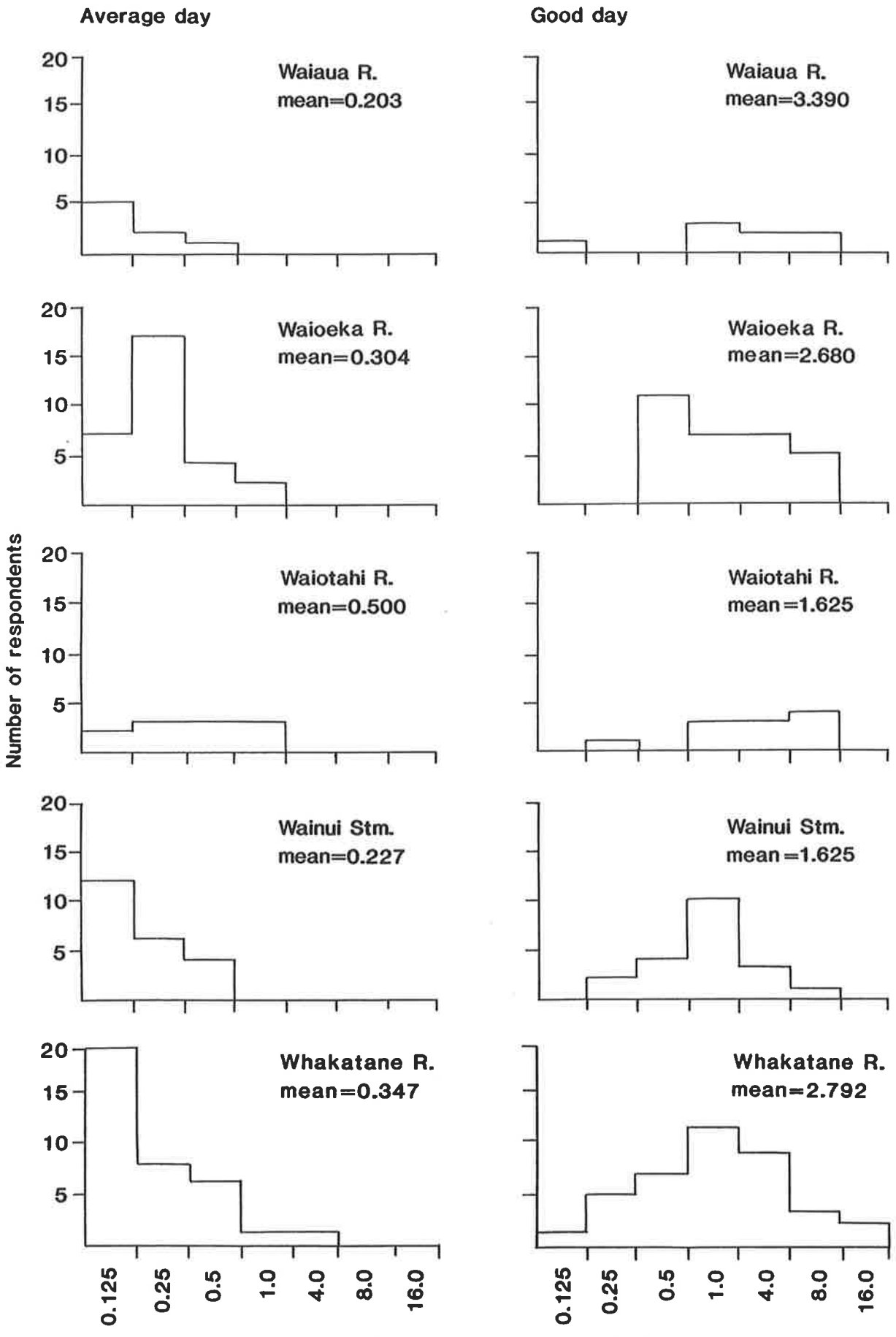
Year	Date	*Galaxias maculatus* %	*Galaxias fasciatus* %	*Galaxias brevipinnis* %	Unidentified %	No. of whitebait per sample
Rangitaiki River (ctd.)						
1983	9 Sep	88.9	9.5	1.6	0.0	63*
	15 Sep	36.0	62.1	1.9	0.0	470
	17 Sep	92.3	7.7	0.0	0.0	104
	21 Sep	98.0	2.0	0.0	0.0	249
	29 Sep	(89.8	3.0	7.2	0.0	597
		(89.7	3.0	7.3	0.0	493
		(87.8	3.9	8.3	0.0	467
		(73.8	3.6	22.7	0.0	419
	3 Oct	(95.5	1.5	3.0	0.0	465
		(95.3	1.1	3.6	0.0	527
	7 Oct	(98.5	0.2	1.3	0.0	532
		(81.7	1.4	16.9	0.0	213
	13 Oct	(97.6	0.4	2.0	0.0	453
		(97.1	0.0	2.9	0.0	415
	17 Oct	95.0	1.2	3.8	0.0	342
	23 Oct	(100.0	0.0	0.0	0.0	416
	30 Oct	98.1	0.9	1.0	0.0	103
	9 Nov	97.7	0.0	0.0	2.3	558
	14 Nov	100.0	0.0	0.0	0.0	57*
	17 Nov	98.3	1.7	0.0	0.0	179
	21 Nov	100.0	0.0	0.0	0.0	10*
	26 Nov	100.0	0.0	0.0	0.0	3*
	$\bar{x}$ % (n = 27)	93.1	3.8	3.0	0.1	11 196
Tarawera River						
1982	26 Sep	99.7	0.3	0.0	0.0	940
	4 Oct	99.8	0.1	0.1	0.0	789
	$\bar{x}$ % (n = 2)	99.8	0.2	0.0	0.0	1 729
1983	6 Aug	100.0	0.0	0.0	0.0	245
	15 Aug	(100.0	0.0	0.0	0.0	202
		(100.0	0.0	0.0	0.0	372
	22 Aug	100.0	0.0	0.0	0.0	445
	23 Aug	99.6	0.4	0.0	0.0	534
	5 Sep	97.9	2.1	0.0	0.0	281
	10 Sep	92.4	7.6	0.0	0.0	422
	15 Sep	82.6	17.4	0.0	0.0	167
	20 Sep	97.5	2.0	0.0	0.5	448
	24 Sep	99.6	0.4	0.0	0.0	554
	3 Oct	(100.0	0.0	0.0	0.0	563
		(99.8	0.2	0.0	0.0	406
	9 Oct	100.0	0.0	0.0	0.0	124
	13 Oct	100.0	0.0	0.0	0.0	517
	17 Oct	(100.0	0.0	0.0	0.0	402
		(100.0	0.0	0.0	0.0	382
	$\bar{x}$ % (n = 16)	98.1	1.9	0.0	0.0	6 064

APPENDIX II. (ctd.)

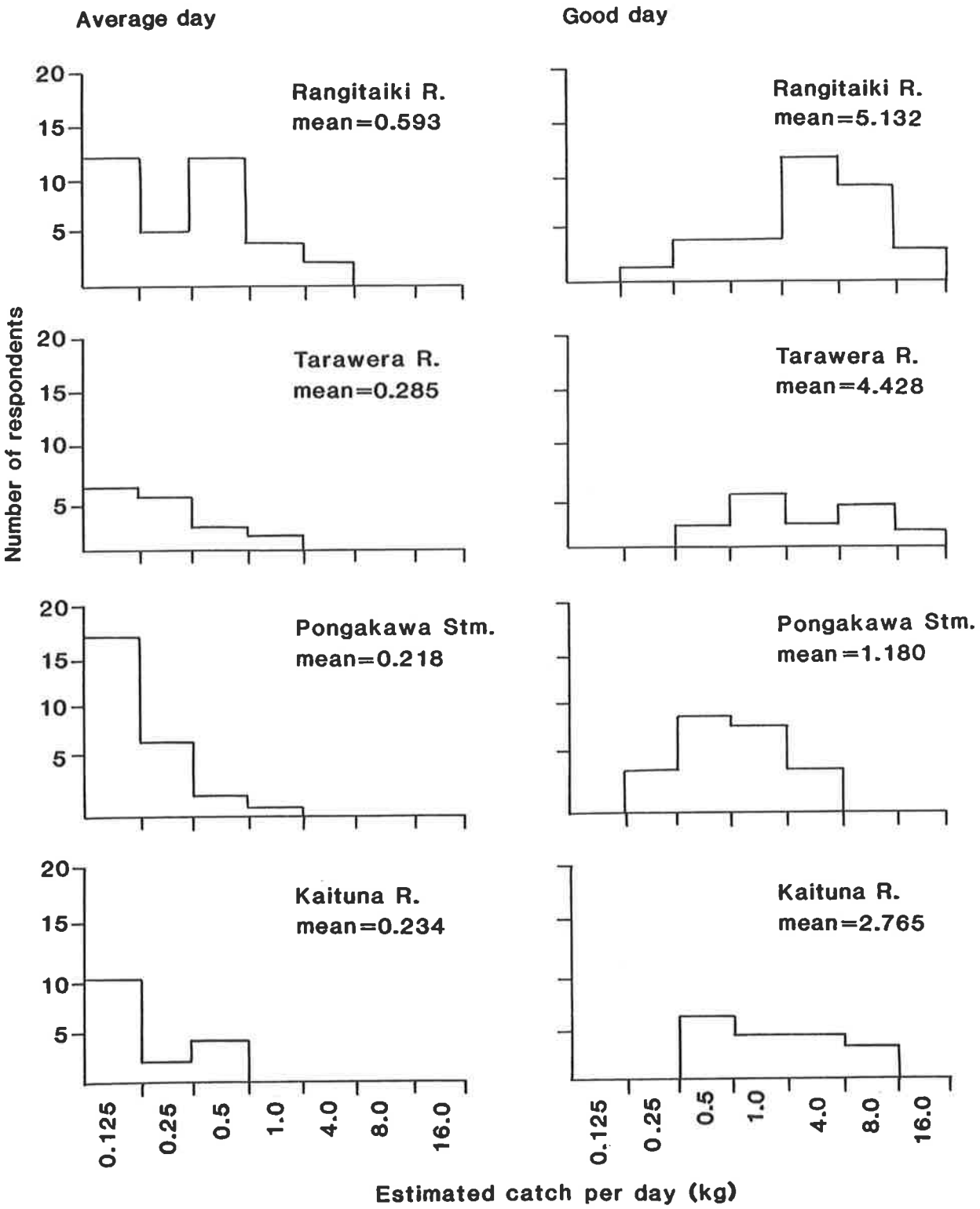
Year	Date	*Galaxias maculatus* %	*Galaxias fasciatus* %	*Galaxias brevipinnis* %	Unidentified %	No. of whitebait per sample
Waitahanui Stream						
1983	16 Sep	2.5	97.5	0.0	0.0	282
	22 Sep	19.2	72.3	8.5	0.0	47*
	15 Oct	94.7	4.2	1.1	0.0	95*
	15 Nov	82.6	17.4	0.0	0.0	46*
	$\bar{x}$ % (n = 1)	2.5	97.5	0.0	0.0	282
Pongakawa Stream						
1983	13 Aug	100.0	0.0	0.0	0.0	79*
	17 Aug	100.0	0.0	0.0	0.0	190
	4 Sep	25.1	74.9	0.0	0.0	355
	10 Sep	66.7	33.3	0.0	0.0	111
	10 Oct	91.2	8.8	0.0	0.0	114
	$\bar{x}$ % (n = 4)	70.74	29.3	0.0	0.0	770
Kaituna River						
1983	6 Aug	99.8	0.2	0.0	0.0	568
	17 Aug	99.4	0.6	0.0	0.0	533
	23 Aug	100.0	0.0	0.0	0.0	127
	30 Aug	90.2	9.8	0.0	0.0	369
	4 Sep	(84.0	15.3	0.7	0.0	764
		(84.3	14.3	0.0	1.4	512
	10 Sep	69.5	27.4	3.1	0.0	95*
	16 Sep	68.3	27.0	3.8	0.9	473
	22 Sep	94.1	5.9	0.0	0.0	17*
	28 Sep	(87.4	10.5	0.8	0.0	534
		(95.3	4.0	0.7	0.0	427
	5 Oct	81.0	10.3	8.1	0.6	458
	10 Oct	(65.5	16.2	18.3	0.0	388
		(66.7	13.1	20.2	0.0	381
	15 Oct	(96.5	2.9	0.6	0.0	346
		(97.9	2.1	0.0	0.0	470
	20 Oct	(99.5	0.5	0.0	0.0	399
		(99.4	0.6	0.0	0.0	507
	2 Nov	70.0	30.0	0.0	0.0	30*
	10 Nov	85.5	13.6	0.2	0.7	455
	15 Nov	87.4	12.6	0.0	0.0	262
	24 Nov	32.8	67.2	0.0	0.0	64*
	30 Nov	100.0	0.0	0.0	0.0	2*
	$\bar{x}$ % (n = 18)	88.2	8.5	3.4	0.3	7 973

* Denotes sample has been excluded from the calculation of mean percentage species composition.

APPENDIX III. Estimated quantities of whitebait expected to be caught per day by respondents questioned in the survey of Bay of Plenty whitebait fisheries.



APPENDIX III. (ctd.)



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