FISHERIES INVESTIGATIONS
IN THE
MOTU RIVER

BY

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FISHERIES ENVIRONMENTAL REPORTS

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CONTENTS

FIGURES

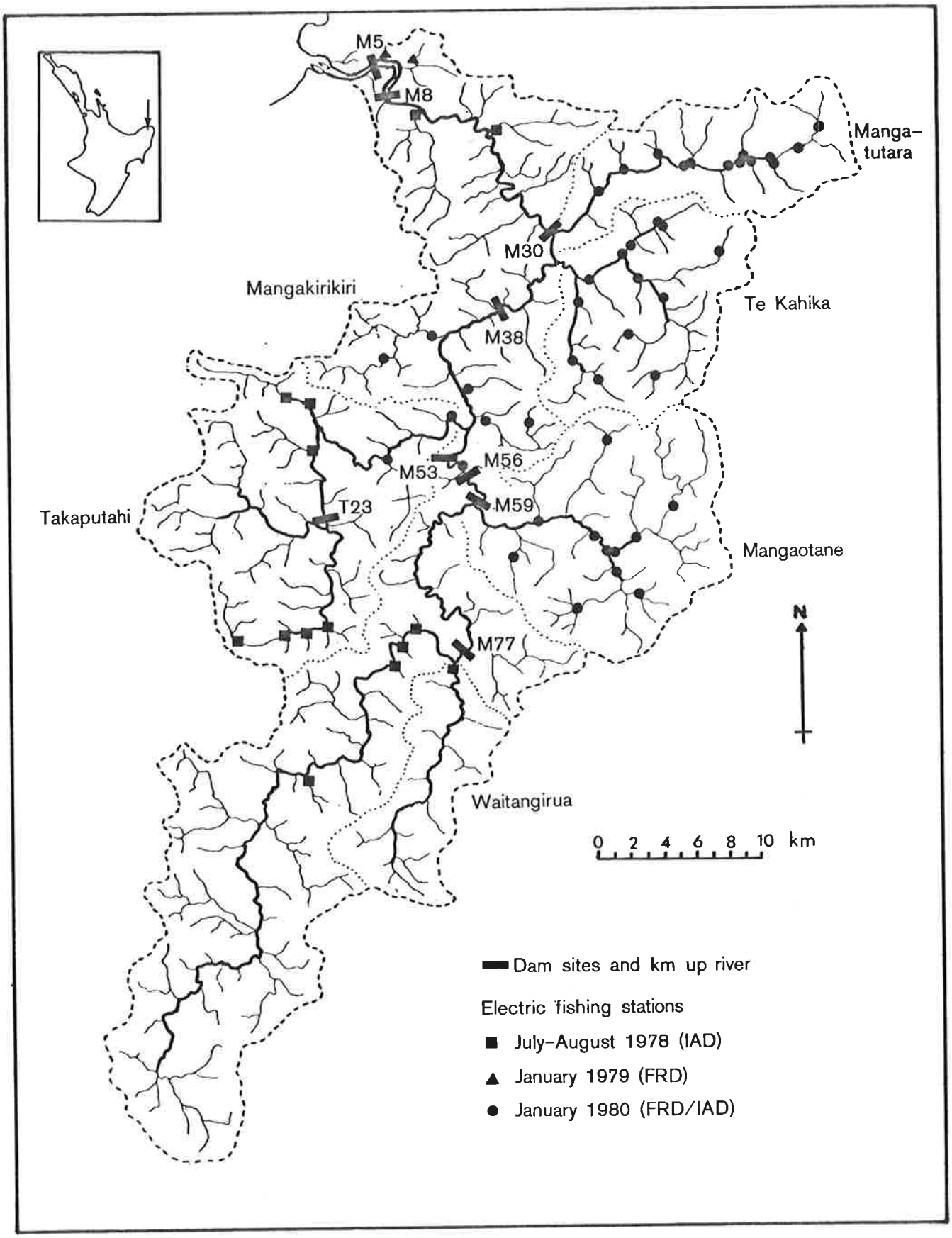
PLATES

1. INTRODUCTION

In 1977 the Ministry of Works and Development (MWD) re-opened investigations of the Motu River for hydro-electric power development. This river, on the northern side of East Cape, is one of the largest in the Bay of Plenty region and at present is comparatively unmodified. It supports fisheries for whitebait, kahawai and eels and, because of its relatively wild state and large area of bush clad catchment, may be an important source of recruitment to freshwater fisheries in other rivers of the region. As the dams or altered flows resulting from hydro-electric development will undoubtedly affect fish populations in the river, decision makers concerned with this scheme will need to consider the social, economic and political costs of loss of, or modification to, the fisheries. They may also need to consider ways and means of reducing impacts caused by dams or altered flows, as well the potential fisheries values of the impoundments created. Information will therefore be required on the existing fish populations and fisheries of the Motu, and on the changes that result from hydro-electric power development.

In 1978 various dam sites were being investigated by MWD but no firm plans existed for changes to the river. The Internal Affairs Department (IAD), Rotorua, had initiated fisheries investigations into the river but electric fishing surveys of the Takaputahi and Waitangirua catchments, carried out in 1978 by IAD revealed only two species, brown trout and eels (Ewing 1978). In 1979 the Fisheries Research Division (FRD) of the Ministry of Agriculture and Fisheries (MAF) also began a series of investigations with the aim of identifying the main freshwater fish populations in the Motu River. In January 1980 a joint IAD/FRD investigation surveyed the relatively inaccessible bush clad catchments close to possible dam sites and a further 45 sites were added to the 16 already electric fished (Fig. 1). These sites were spread throughout the major tributaries

FIG. 1 CATCHMENTS, DAM SITES AND STATIONS ELECTROFISHED IN THE MOTU RIVER



of the Motu and no attempt was made to sample fish in the large pools or rapids of the main stem of the Motu.

2. METHODS

Because of the difficulty of accessing the tributaries of the river, and of covering a large number of stations in a short time, a helicopter was used to transport two electric fishing teams and their gear between stations. Total flying time needed to cover the 45 stations (Fig. 1) totalled 15.7 hours and cost $5,530.

Stations were tentatively chosen before the survey to facilitate planning and to ensure adequate coverage. However, problems were encountered in locating some of these. Inch to the mile contour maps of each tributary were prepared showing the proposed stations, but where major features (e.g. tributaries, bends, confluences) could not be identified from the air, orientation was difficult. This was especially so in the upper reaches of the catchments where the streams were small and obscured by overhanging bush. As a result a number of stations could not be located exactly. Furthermore certain proposed stations were found to be inaccessible and alternatives had to be found nearby. The grid references used to identify stations actually fished, and to mark them on a map, therefore refer to mid-points of localities in which the stations occurred.

Two types of electric fishing methods were used to catch fish. The first involved fishing downstream with a back-pack, battery powered machine and allowing stunned fish to be swept into a hand-held seine net (Plate 1). The second involved a fixed, generator powered machine. Fishing was carried out in the upstream direction and stunned fish were caught in small wire mesh dip nets. Because the first method was more successful for sampling small native fish it was employed more often in the upper

PLATE 1. Electric fishing using a battery powered backpack machine. Fishing is generally carried out downstream and stunned fish, swept away in the current, are caught in the hand-held seine net.

reaches of the tributaries and the second method was used more often in the lower reaches where larger fish were likely to be found. Differences in catches obtained by the two methods are given in Table 1. In general each station took one hour to electric fish and during this time information on water temperature, water flows, substrate, stream structure, cover, bank stability, aquatic vegetation and wildlife was recorded. Samples of aquatic insects were obtained at each station and photographs were taken up, down and across each stream electric fished.

TABLE 1. Differences in catches obtained by the two methods of electric fishing (see text for descriptions of methods).

SPECIES	TOTAL NUMBER OF FISH CAUGHT	PERCENTAGE OF TOTAL CATCH	
		Method 1	Method 2
Longfinned eel (juv.)	220	78	22
Longfinned eel (adult)	29	45	55
Bluegilled bully	177	85	15
Koaro	114	91	9
Torrentfish	30	77	23
Brown trout (juv.)	12	33	67
Brown trout (adults)	3	0	100
Stations fished		26	23

All fish were kept and immediately preserved in formalin, except for large eels and trout, whose lengths and weights were recorded and whose stomach contents were removed and inspected. The samples of fish preserved were taken to the Rotorua laboratory of FRD and the numbers of fish of each species noted for each station. The length, weight and sex of each fish was recorded and stomach contents removed and represerved for later inspection.

3. RESULTS

Ten species of freshwater fish have been found in tributaries of the Motu River (Table 2) and, apart from brown trout, all are indigenous. Whereas the longfinned eel dominated the catch (Fig. 2A), relative abundance, either in terms of numbers or biomass, is not always a good indication of a species' importance. Some species have few individuals but are present at each station and where this occurs the 'representation', or the extent of a species spread within the system may be a more appropriate measure of dominance. Accordingly the fish species were also ranked in terms of their representation among the stations. Results of this ranking are provided in Figure 2B and both rankings show that the river is characterised by four native species of fish; the longfinned eel (*Anguilla dieffenbachii*), the koaro (*Galaxias brevipinnis*), the bluegilled bully (*Gobiomorphus hubbsi*) and the torrentfish (*Cheimarrichthys fosteri*).

TABLE 2. Checklist of freshwater fishes in the Motu River.

A. SPECIES CAUGHT IN ELECTRIC FISHING SURVEY

Scientific Name	Common Name
Galaxias brevipinnis	koaro
Galaxias fasciatus	banded kokopu
Galaxias postvectis	shortjawed kokopu
Anguilla dieffenbachii	longfinned eel
Anguilla australis	shortfinned eel
Gobiomorphus cotidianus	common bully
Gobiomorphus huttoni	redfinned bully
Gobiomorphus hubbsi	bluegilled bully
Cheimarrichthys fosteri	torrentfish
Salmo trutta	brown trout

B. SPECIES EXPECTED TO BE PRESENT NEAR MOUTH

Scientific Name	Common Name
Galaxias maculatus	inanga
Gobiomorphus gobioides	giant bully
Retropinna retropinna	common smelt

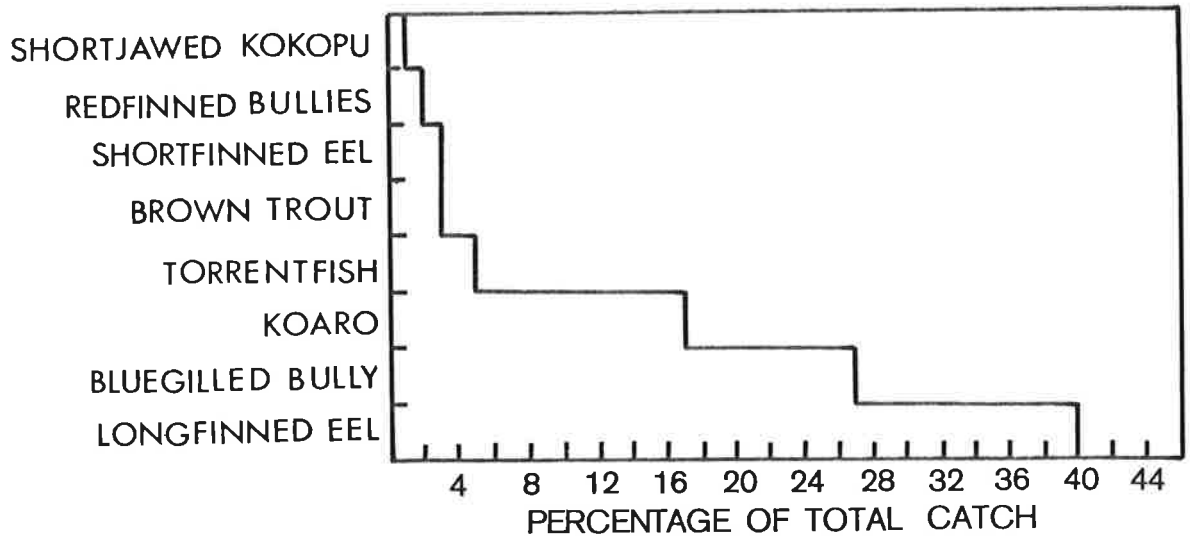
The length and weight of each fish caught were recorded and the total catch for each species pooled to provide information on population dynamics. Length frequency distributions of the four dominant species were calculated (see results for each species) and modes defined by a two point moving average. Differences in length related to age or sex are indicated, and variation in fish length with respect to other variables only occurred for the bluegilled bully, whose average length increased with distance up the river (Fig. 3). Length/weight relationships for the main species provide baseline information on the condition of the fish and so are included along with size frequency distributions in the results for each species.

Information on the distribution of each species within the river is provided by maps showing presence/absence of each species in each station (also included with results for each species) and although the stations were few and far apart, certain trends in distribution between species are apparent.

Major factors determining distribution and habitat of New Zealand native fish species within river systems have not been investigated extensively yet and what little is known about them stems mainly from casual observations. Juveniles of many native fish migrate from the sea into fresh water and these differ in their ability to penetrate a river system. Therefore distance up-river is likely to be one of the main factors limiting fish distribution, especially where falls or barriers occur.

FIG. 2 RELATIVE DOMINANCE OR ABUNDANCE OF FISH SPECIES IN THE MOTU RIVER

(A) ABUNDANCE OF FISH SPECIES IN OVERALL CATCH



(B) REPRESENTATION OF FISH SPECIES IN RIVER

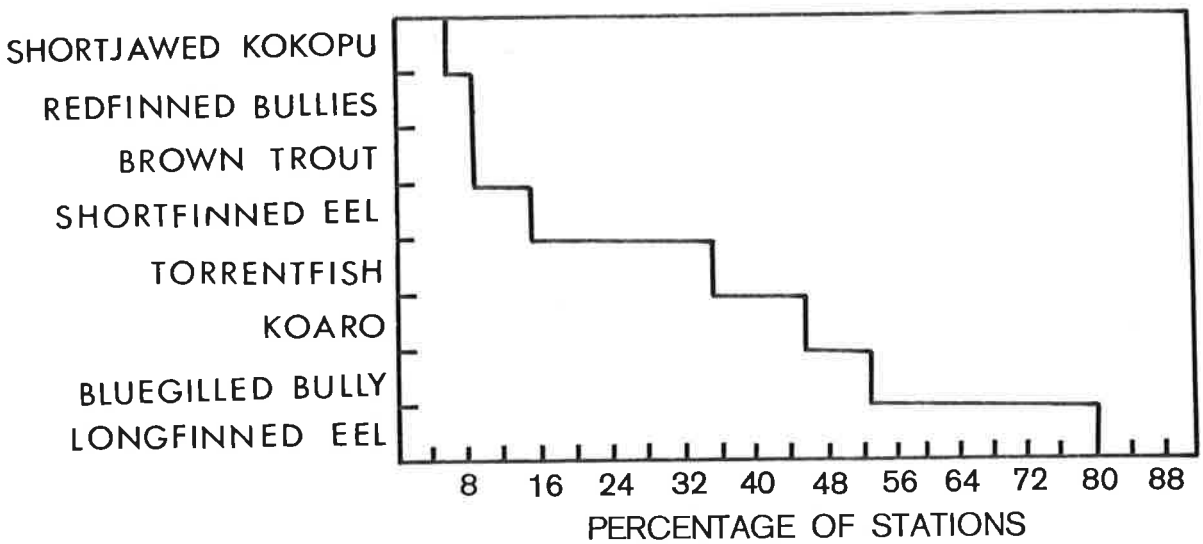


FIG. 3 VARIATION IN LENGTH OF BLUEGILLED BULLIES UP THE MANGATUTARA TRIBUTARY (SEX RATIO WAS RELATIVELY CONSTANT BETWEEN SAMPLES VIZ 60–77% FEMALES)

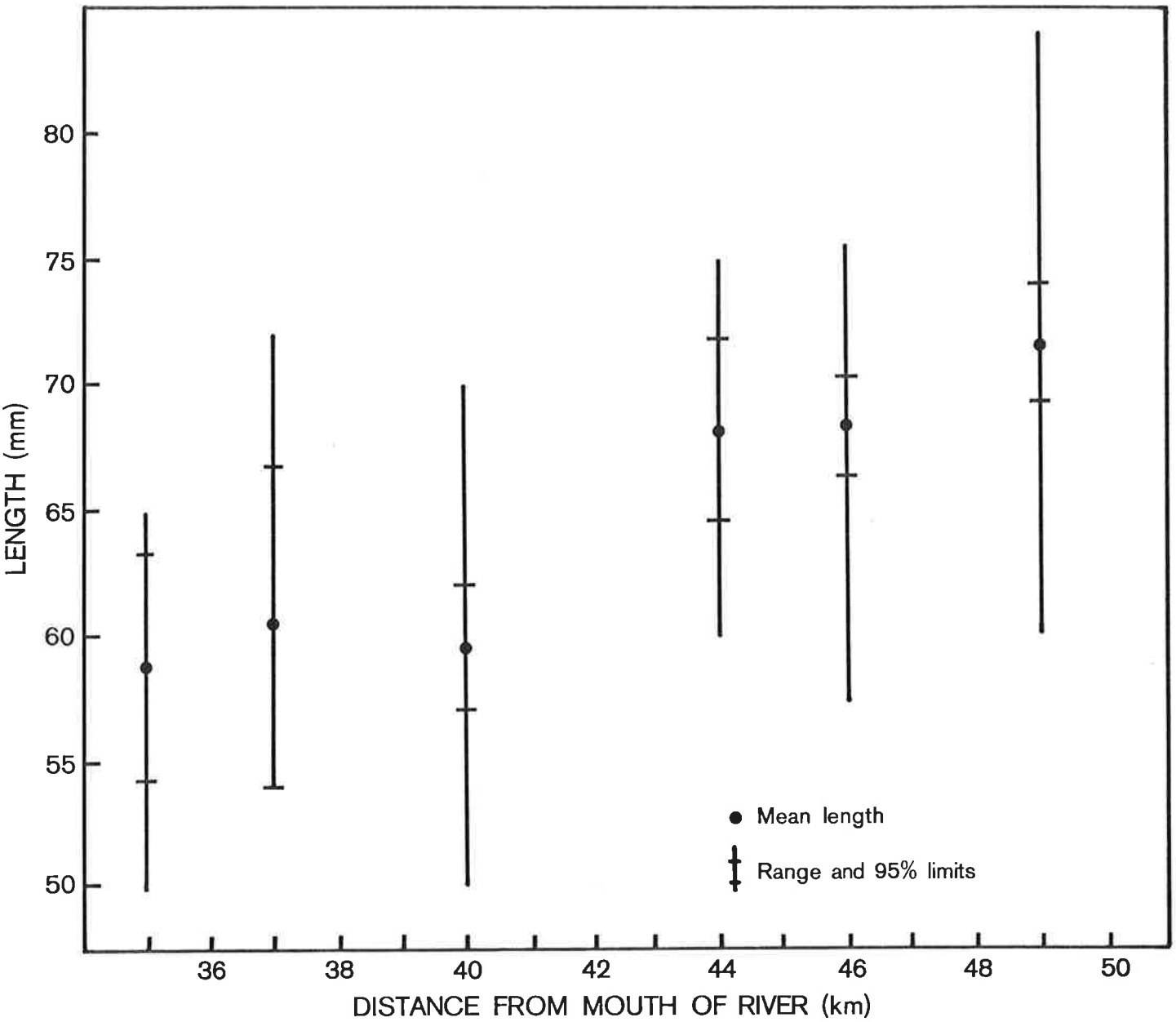


Figure 4 indicates the range of upstream penetration for the fish species caught in the Motu River's catchments and it is apparent that distance from the mouth of the river does not limit the distribution of these species in the areas of the river electric fished. Ranges overlap and other factors must be examined to explain the differing distribution patterns within these catchments.

Physical factors such as temperature, substrate and cover are likely to be major variables determining species habitats where their ranges overlap, but biological factors including competition, nocturnal behaviour or predation will also be important in determining habitat segregation. However, such biotic relationships are difficult to measure, especially in comparison to relationships involving physical variables. The latter, while inadequate for describing fish habitat, are nevertheless useful in that they often provide a quantitative basis for predicting species distributions in relation to measurable physical variables. Information on water temperature, instream cover, substrate conditions and water flow collected at each station therefore provide some basis for comparing stations in terms of these variables. In order to provide such a comparison only stations in which the catch for a species was greater than the overall mean catch for that species were selected. This ensured that inclusion of those stations containing few individuals of a species, (i.e. stations which might be less representative of that species habitat at this time of year) would not bias results. Mean values for each of the environmental variables recorded in the selected stations were calculated and these are compared for each fish species in Table 3.

These analyses reveal trends that suggest which of the measured physical factors are likely to be important in determining the preferred habitat of a particular species. Conversely they permit some prediction of a species habitat in terms of these physical variables. However,

FIG 4 DISTRIBUTION OF FISH SPECIES WITH RESPECT TO DISTANCE FROM THE MOUTH OF THE MOTU RIVER

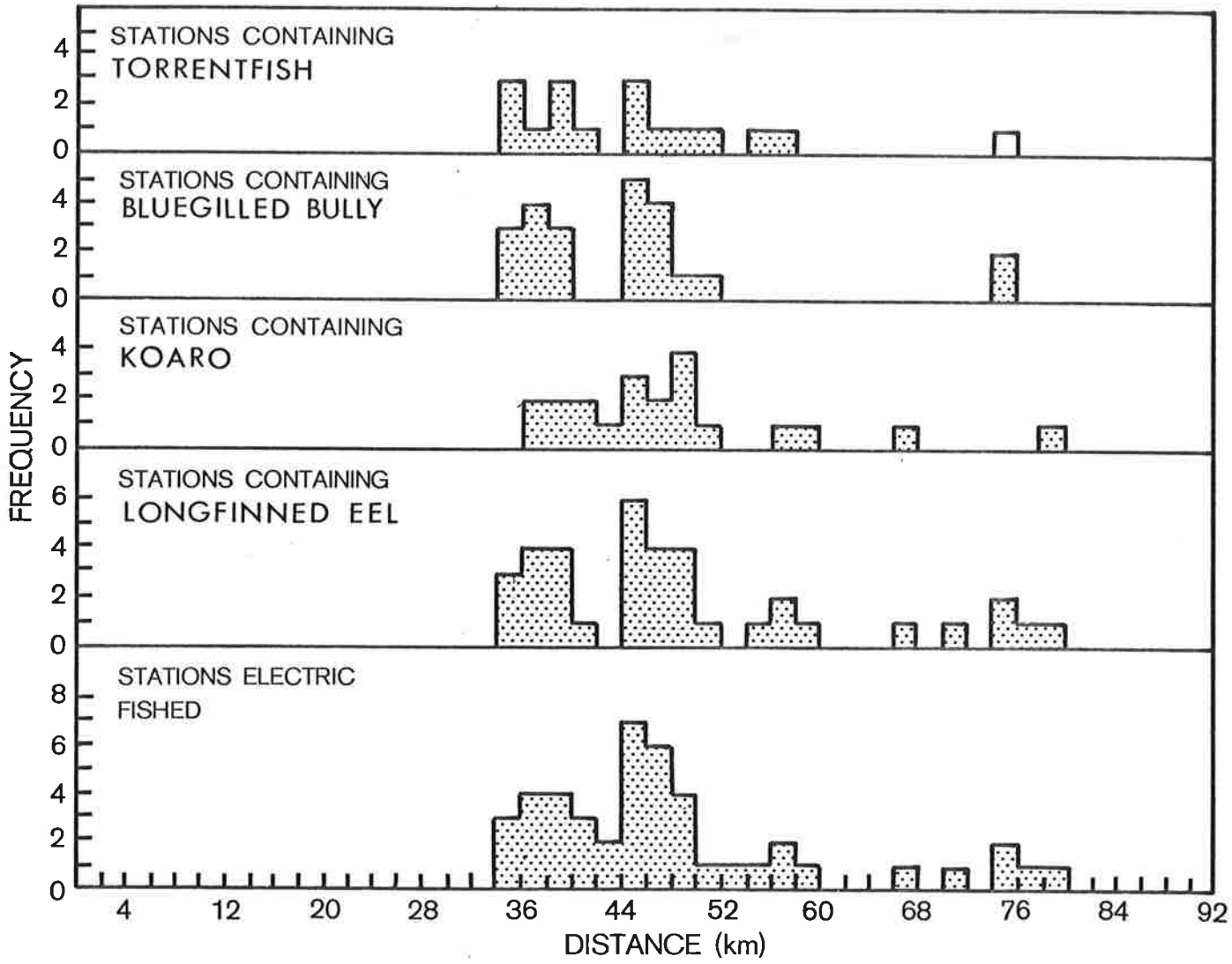


TABLE 3. Habitat segregation between small (0-20 cm) fish in the Motu River catchments.

SPECIES	JANUARY TEMPERATURE DIFFERENCES (°C)		INSTREAM COVER (% OF STATIONS)			PERCENT SUBSTRATE COMPOSITION (AVERAGE VALUE)				PERCENT FLOW TYPE (AVERAGE VALUE)			
	Mean	Range	Good	Fair	Bad	Bldr	Stone	Grvl	Sand	Rapid	Run	Riffle	Pool
Koaro	11.7	10.5-13.0	90	10	0	59	26	15	0	64	12	12	12
Bluegilled Bully	13.6	11.0-15.5	25	25	50	24	47	28	1	27	27	41	4
Torrentfish	14.3	13.0-15.5	66	0	33	27	47	26	0	34	28	38	0
Brown Trout juvs.	15.0	14.0-16.5	60	40	0	19	49	26	6	8	64	22	6
Shortfinned Eel) Redfinned Bully)	15.0	-	-	-	-	25	40	35	0	15	33	51	0

(NOTE: *Anguilla dieffenbachii* cosmopolitan throughout river)

they do not indicate tolerance limits for any variable and do not indicate whether interactions or "trade-offs" between variables occur (e.g. warm stream temperature could become less critical if a high percentage of boulders existed, creating for example a greater range of microhabitats or an increased abundance of foods). To provide such information, the data are presented in a different form in Figures 5 and 6. Here species presence or absence in a station is plotted against a two-dimensional matrix showing the stations position relative to stream temperature and boulder abundance. A straight line defining the boundary between a species presence or absence would, if parallel to either axis, indicate a fixed maximum or minimum limit. In comparison, sloped lines indicate a possible interactive component between variables determining habitat.

Whereas koaro occurred in 77% of stations below the boundary line (fitted by eye) in Figure 5, virtually no stations above this line contained koaro. Similarly torrentfish occurred in 74% of stations above the boundary line in Figure 6. Such lines are unlikely to be rigid when so few data are considered, nevertheless they do indicate that physical factors have a significant role in determining these species habitats. The fact that not all stations, within such limits defining a species habitat, contain that species is an indication that temperature and substrate composition are not always the most important variables and that other factors are involved in habitat suitability. Such factors as food supply, water chemistry, aquatic vegetation or the presence of other fish species are also likely to be important. As collections of benthic invertebrates were made at each station these, together with the gut contents of all fish caught at each station will be examined at a later date and will provide some information on the biotic aspects of fish habitat.

FIG. 5 EFFECT OF WATER TEMPERATURE AND SUBSTRATE COMPOSITION ON DISTRIBUTION OF KOARO (● present, o absent)

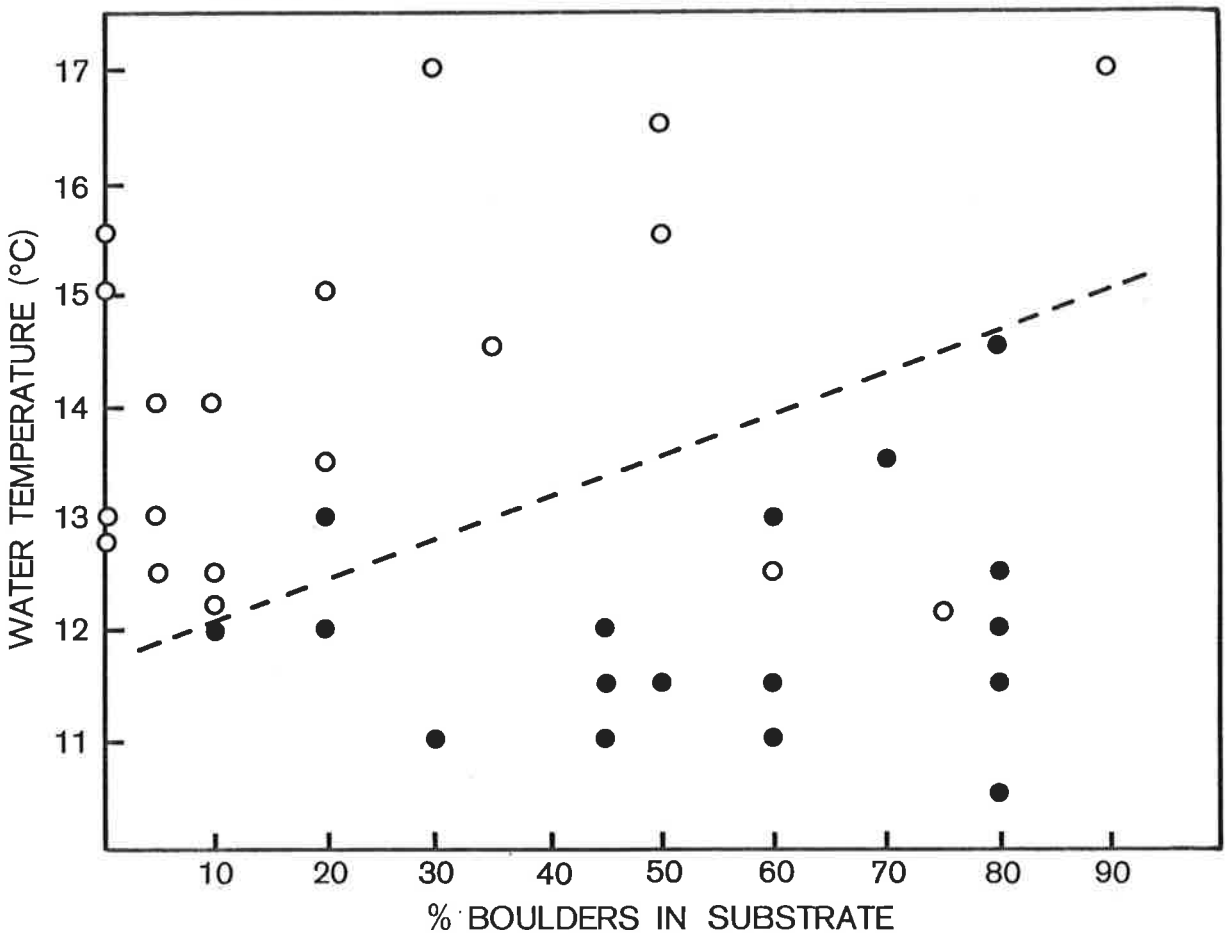
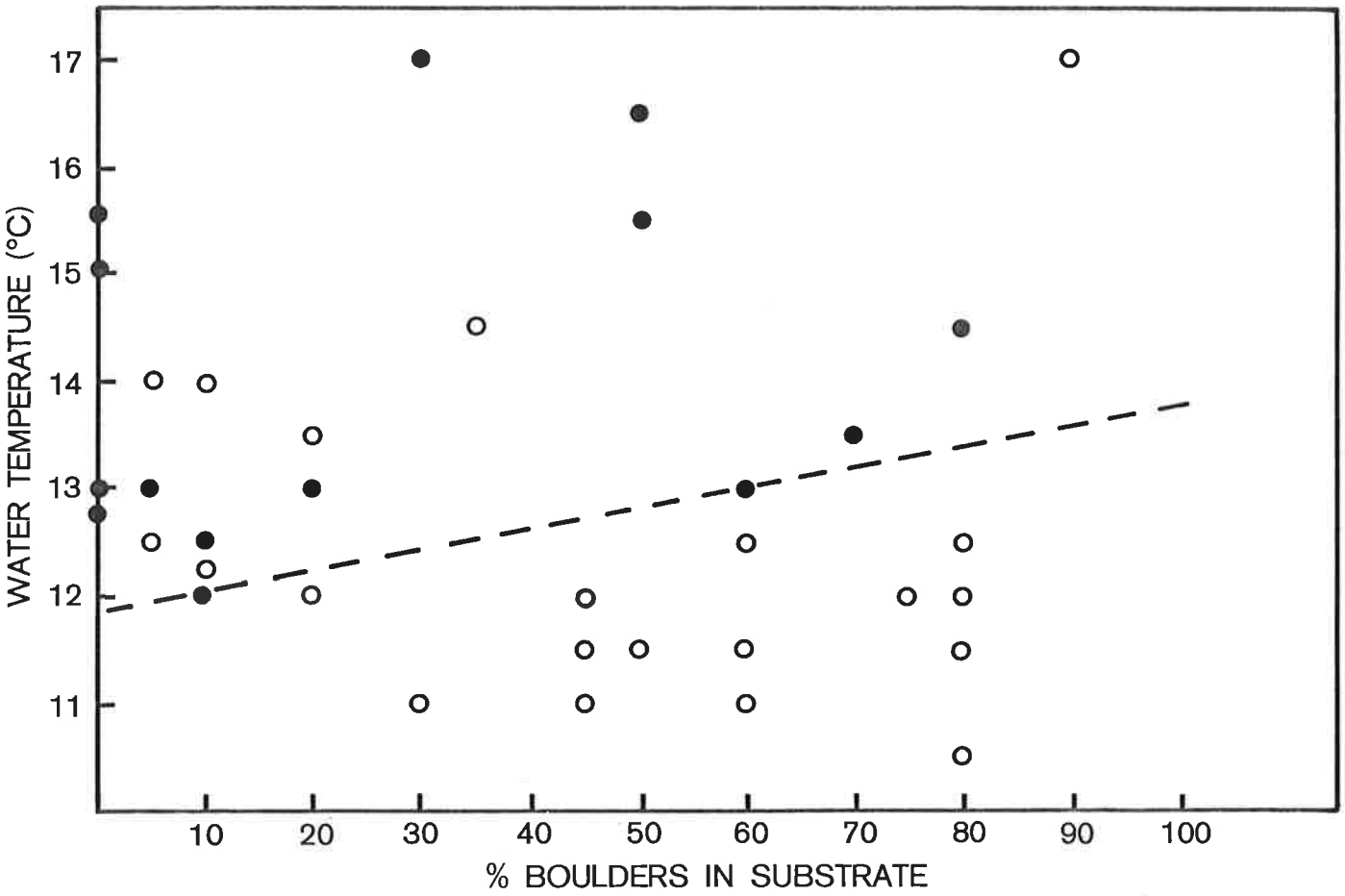


FIG. 6 EFFECT OF WATER TEMPERATURE AND SUBSTRATE COMPOSITION ON DISTRIBUTION OF TORRENTFISH (● present, o absent)



(i) Longfinned eel (*Anguilla dieffenbachii*)

Longfinned eels were present throughout the Motu River (Fig. 7). Apart from brown trout, this was the only species recorded in the upper waters of the Takaputahi tributary or above the confluence of the Waitangirua tributary with the Motu. In general it was observed that densities were higher than in other rivers electric fished.

Eels are known to be good climbers and were present in the highest stations fished (viz. the four southern-most stations of the Te Kahika tributary, altitude approximately 700 metres). Although post-larval migrants (50-70 mm) and eels in their first year of freshwater life (100-120 mm) were missed, the length frequency distribution (Fig. 8) shows six definable peaks with modal lengths of 150, 240, 290, 340, 400 and 470 mm. If these peaks represent age groups, the growth rate of these eels would have averaged 6.4 cm/year over the first seven years. Furthermore, growth rate would have decreased between the first four year classes but would have increased between the 4th and 7th year classes, after the eels had attained a length of approximately 300 mm. At this stage their mouth 'gape' could be sufficient to allow predation of small native fish, an event often correlated with an increased growth rate. The length/weight plot (Fig. 9) does not fit a straight line well, especially below 10 g or above 100 g, and it is likely that changes in the rate of growth in length and weight occur independently, resulting in growth stanzas. The Motu River is noted for its large eels. However, few mature eels were caught in this survey. The sexes could not be distinguished in the majority of eels, and only two of the six largest eels were female. In general all eels were electric-fished from beneath boulders and logs or from holes in stony substrates. They were not present where moving gravels dominated the substrate. Their widespread distribution and occurrence in stations that are characterised by a wide range of environmental conditions indicates that this species

FIG. 7 DISTRIBUTION OF LONGFINNED EEL IN THE MOTU RIVER

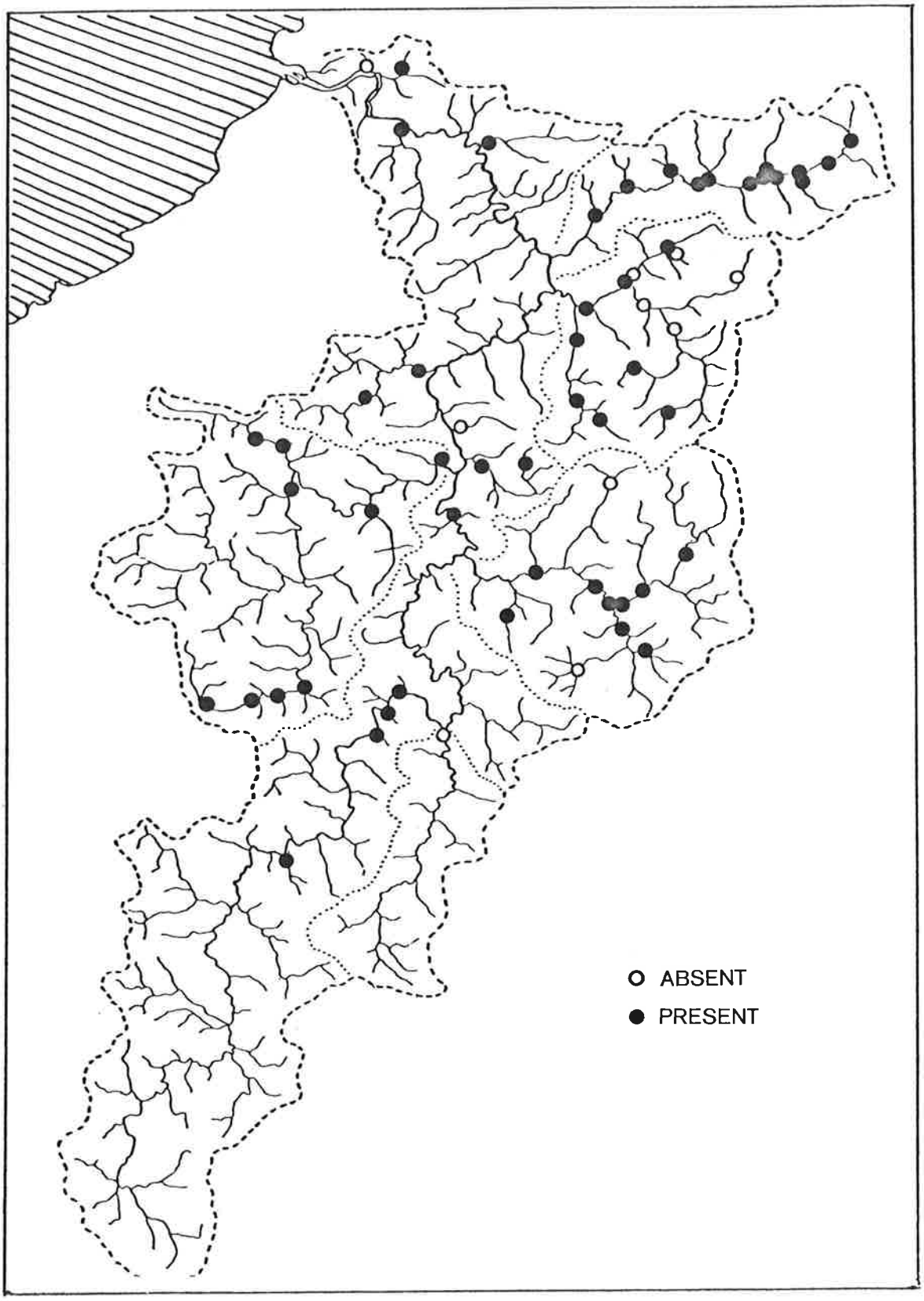


FIG. 8 LENGTH FREQUENCY DISTRIBUTION OF LONG AND SHORTFINNED EELS FROM THE MOTU RIVER

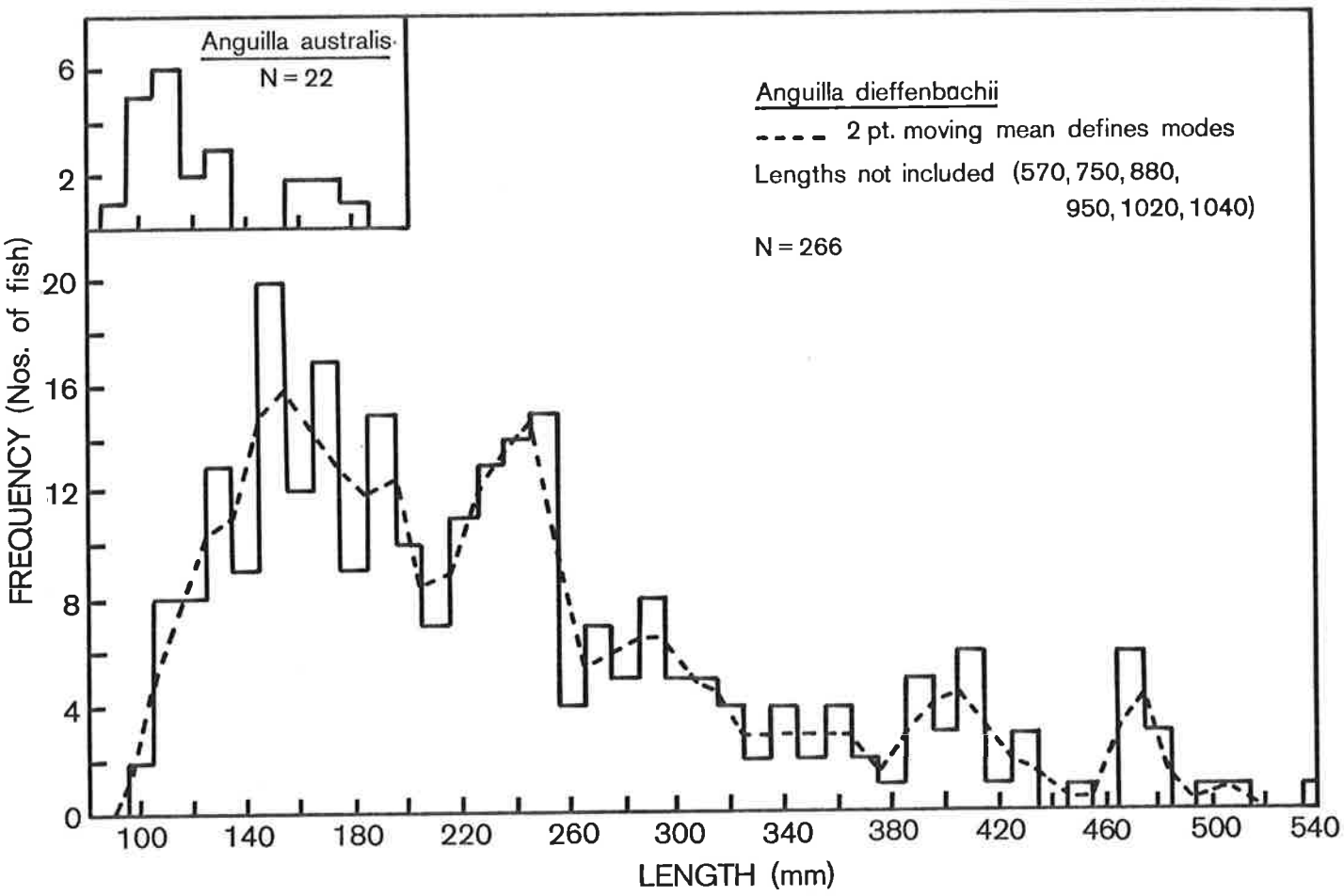
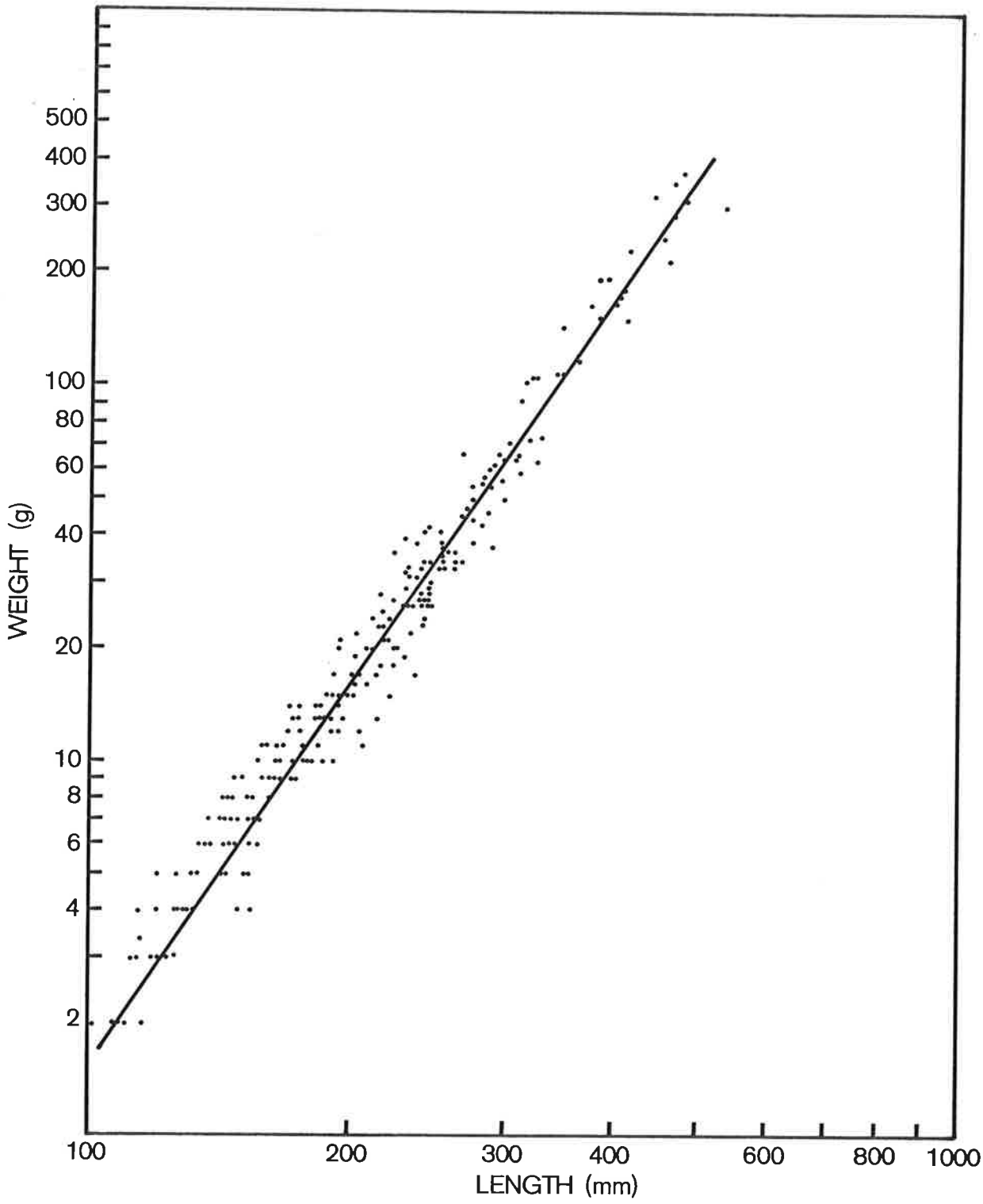


FIG. 9 LENGTH-WEIGHT RELATIONSHIP FOR LONGFINNED EELS



is cosmopolitan in the river.

(ii) Koaro *(Galaxias brevipinnis)*

In contrast to the longfinned eel's cosmopolitan distribution throughout these catchments, koaro were found mainly in small first or second order streams (Fig.10). Their distribution therefore tended to be towards the top of the catchments, but good catches were also obtained in small side streams draining into either the major tributaries or the river itself. Like the eel, the koaro is a good climber and was found in the highest stations along with the longfinned eel. Koaro were also present in stations near the mouth of the river but were not caught in the upper stations of the Takaputahi or Mangaotane tributaries, or above the confluence of the Waitangirua tributary with the Motu. This result could be due to selectivity in the areas electric fished, to the type of method employed, or to the absence of bush in these areas. This upper limit to the distribution of koaro is therefore in doubt and needs to be confirmed.

The length/frequency distributions for males and females (Fig. 11) show two main peaks with modes at 125 and 150 mm. It is possible that the first of these peaks represents fish of age 1+ and, assuming that the juvenile whitebait are approximately six months old and 45 mm long when they enter fresh water from the sea (R.M. McDowall, pers. comm.), growth rate in the first year of life in the river averages 80 mm/annum. The alternative to this is that the 1+ year class was not adequately sampled and that the first major peak represents fish aged 2+.

There is some evidence for this (viz. the small peaks with modal length at 95 mm for males and 100 mm for females). There was no significant difference in growth rate between males and females, however females had a slightly different length/weight relationship to males (Fig. 12).

FIG. 10 DISTRIBUTION OF KOARO AND SHORTJAWED KOKOPU IN THE MOTU RIVER

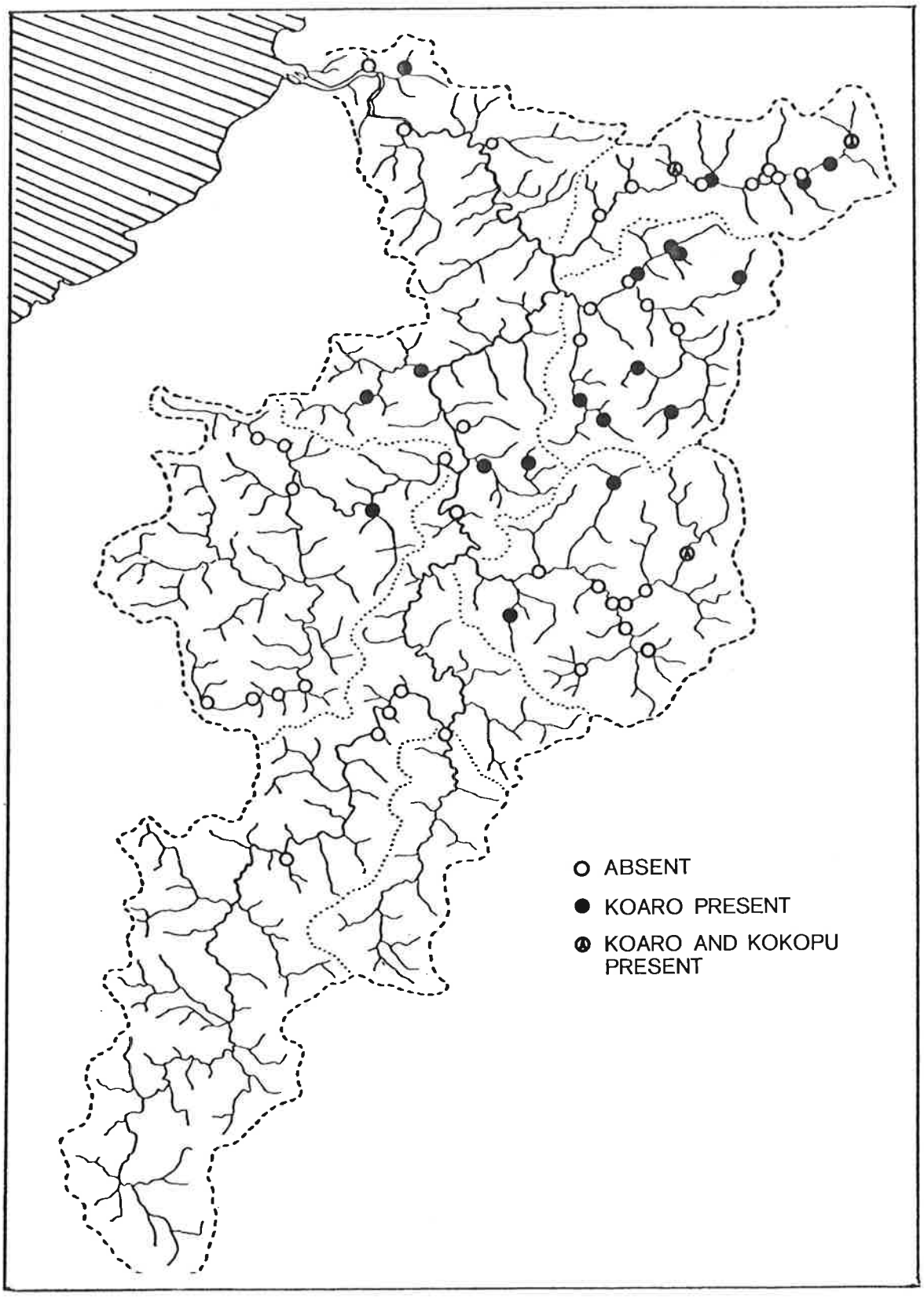


FIG. 11 LENGTH FREQUENCY DISTRIBUTION OF KOARO IN THE MOTU RIVER

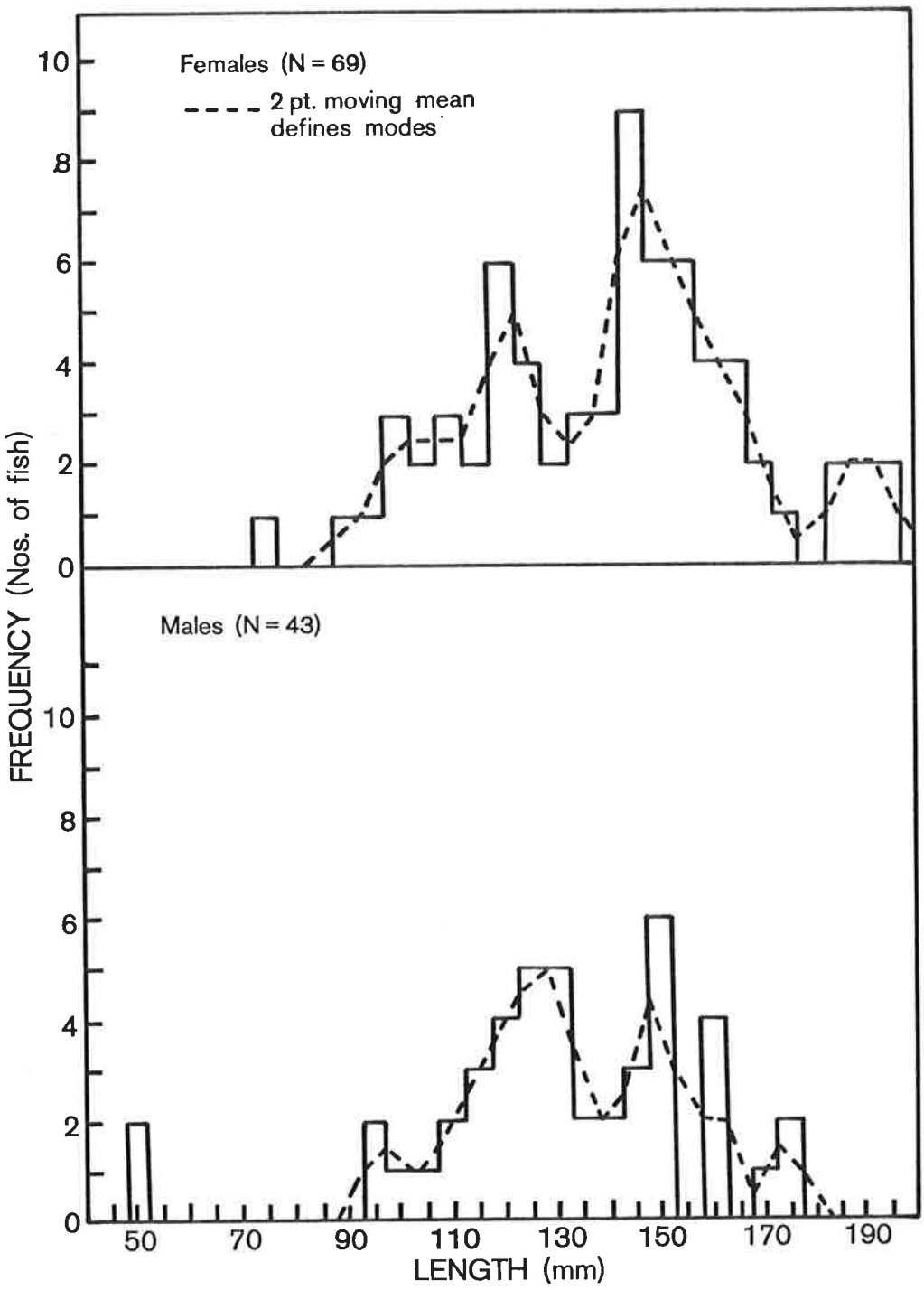
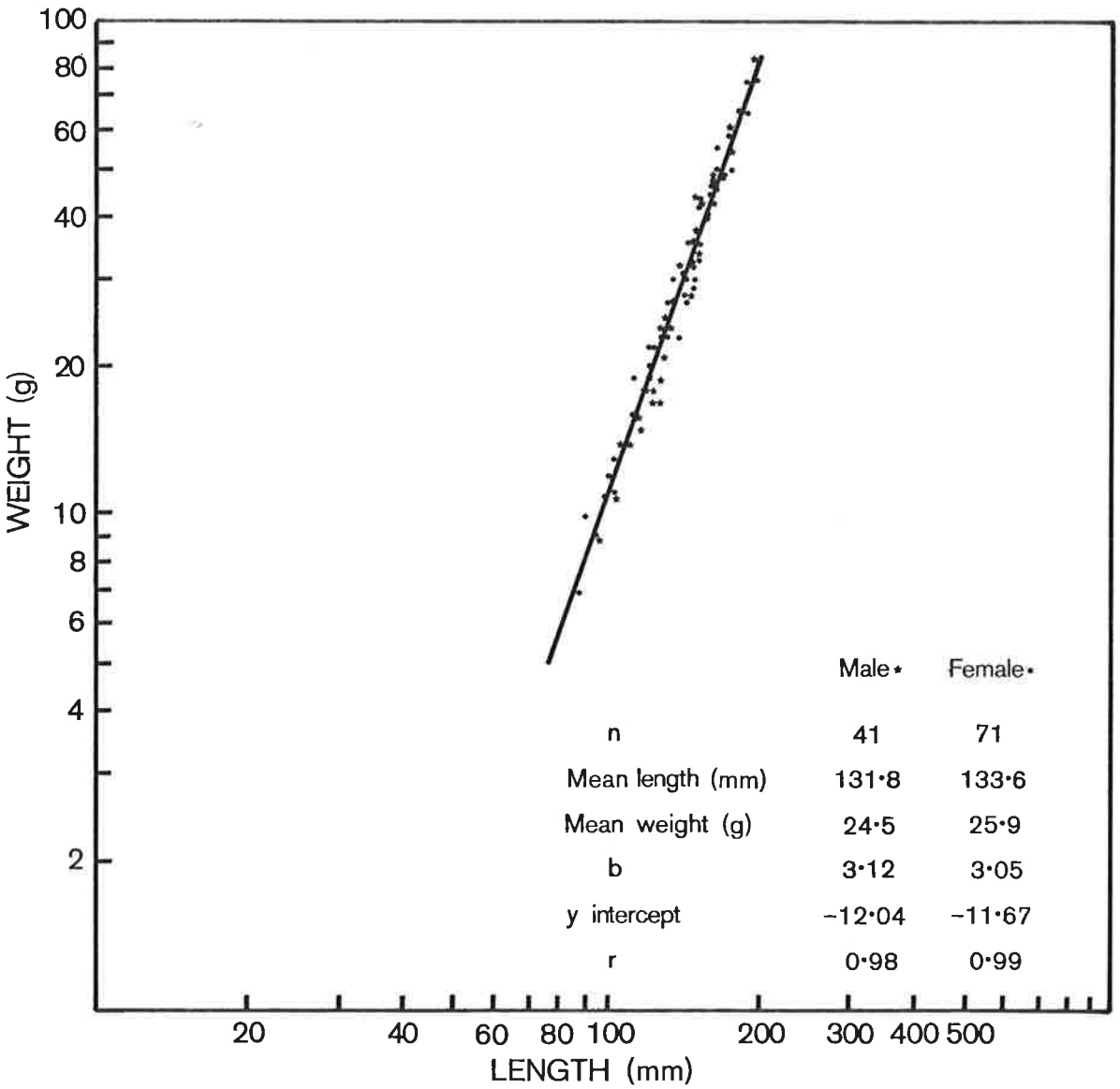


FIG. 12 LENGTH-WEIGHT RELATIONSHIP FOR KOARO



The females comprised 60% of the catch and therefore are likely to out-number males in the Motu River population. There was no trend in sex ratios with distance up the river or with stream order.

Compared to the other species present, high densities of koaro were associated with colder stream temperatures, good instream cover, a higher percentage of boulders in the substrate and a high percentage of rapids (Table 3). These features are usually associated with first or second order streams. However, it was noted that no *Galaxiids* occurred in a small first order stream in a farmed catchment. Substrate, instream cover and flow were comparable to other streams containing koaro but water temperatures were high, probably as a result of the stream's increased exposure. Figure 5 provides some evidence that temperature is limiting and is more critical where a bouldery substrate is sparse.

(iii) Bluegilled bully (*Gobiomorphus hubbsi*)

The bluegilled bully was more commonly found in the second or third order streams and in the shallow margins of the larger tributaries. In this respect its overall distribution (Fig. 13) tended to be further down the catchments than that of the koaro. However, the range of penetration for the bluegilled bully up the Motu River was only slightly less than that of the koaro (Fig. 4).

The bluegilled bully occurred in 43% of the stations where koaro were present indicating that habitat overlap is probably moderate. However, in contrast to the koaro, high densities of this species were associated with significantly warmer water temperatures, poor instream cover, a stony bottom and riffles (Table 3).

The length/frequency distribution of the bluegilled bully revealed distinct sexual dimorphism but did not indicate any age groups (Fig. 14). However, size did change with distance from the mouth of the Motu River (Fig. 3) and it is possible that age groups could be separated on this

FIG. 13 DISTRIBUTION OF BLUEGILLED BULLIES IN THE MOTU RIVER

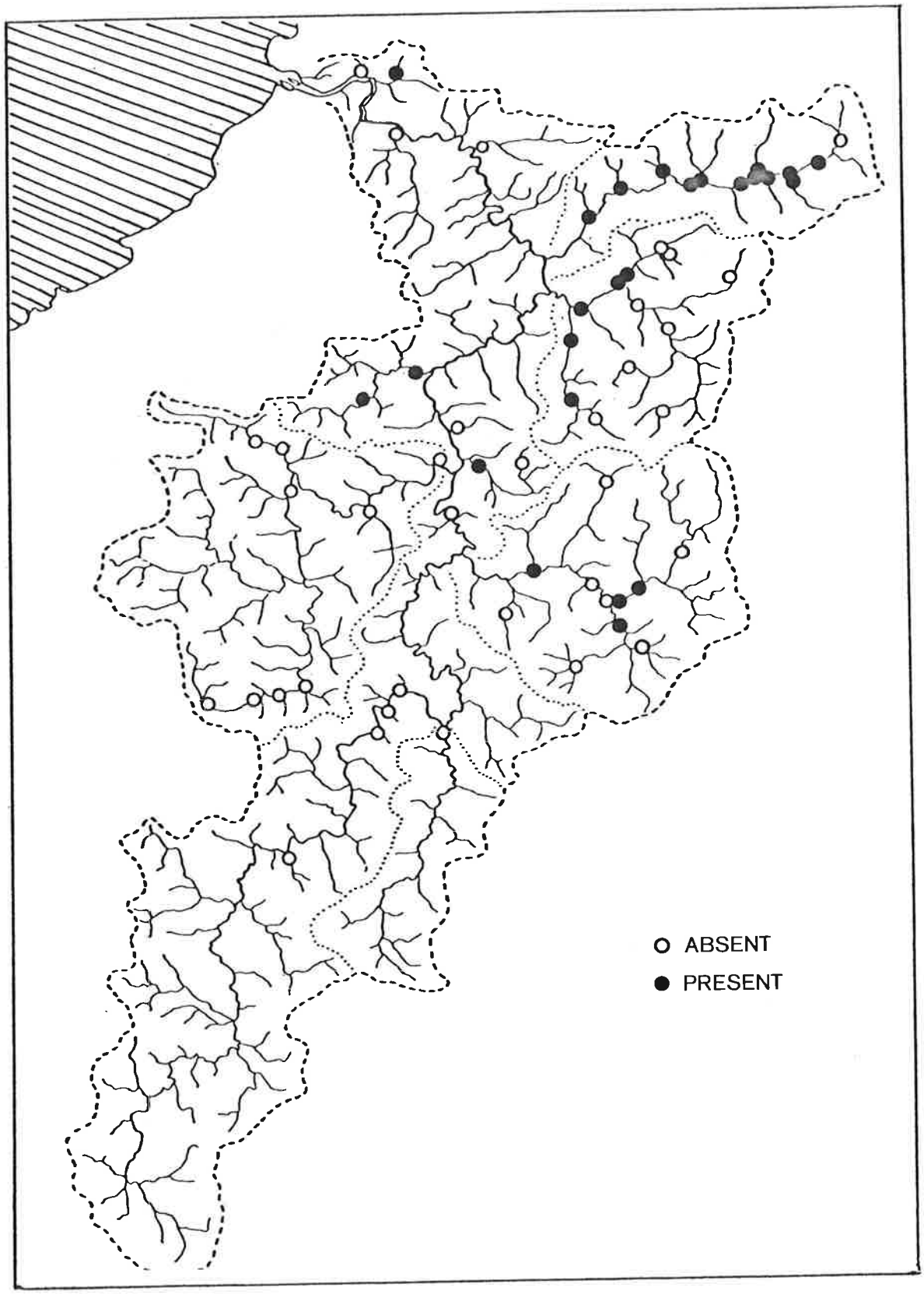


FIG. 14 LENGTH FREQUENCY DISTRIBUTION OF BLUEGILLED BULLIES IN THE MOTU RIVER

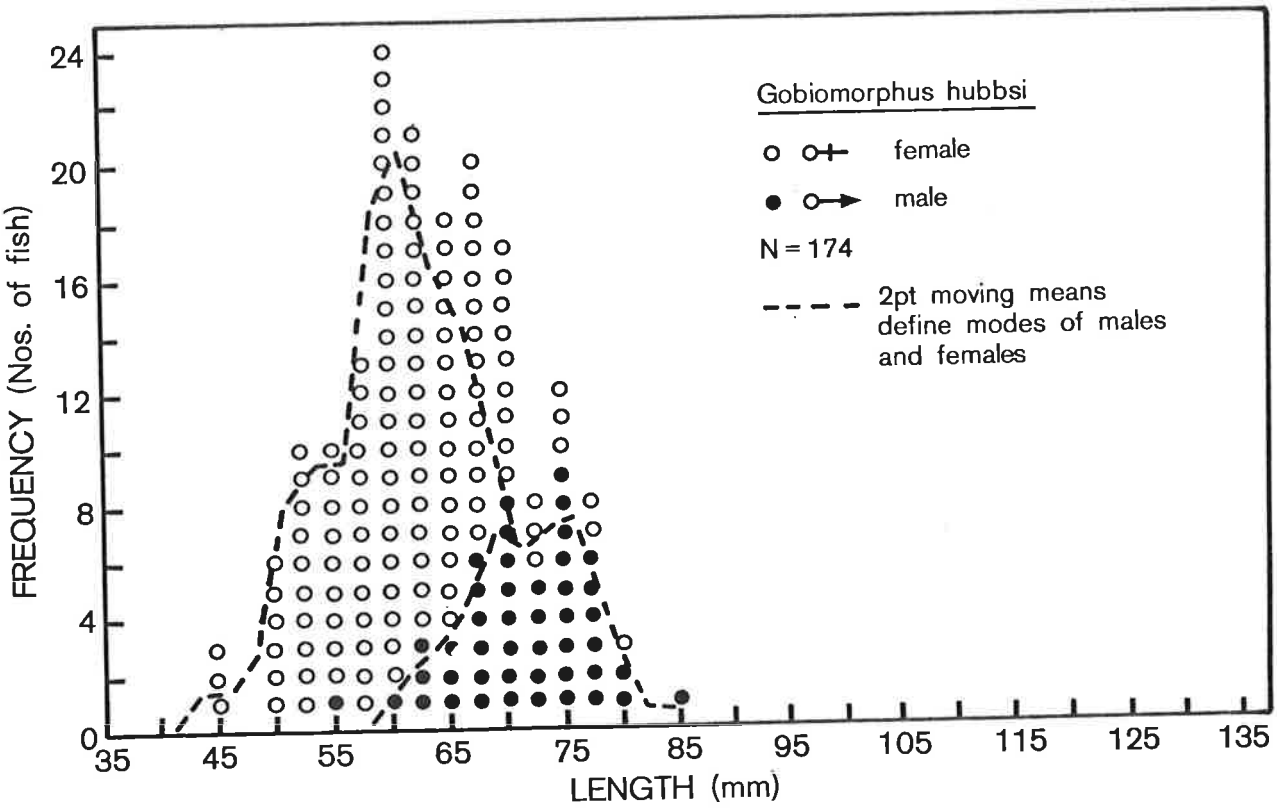
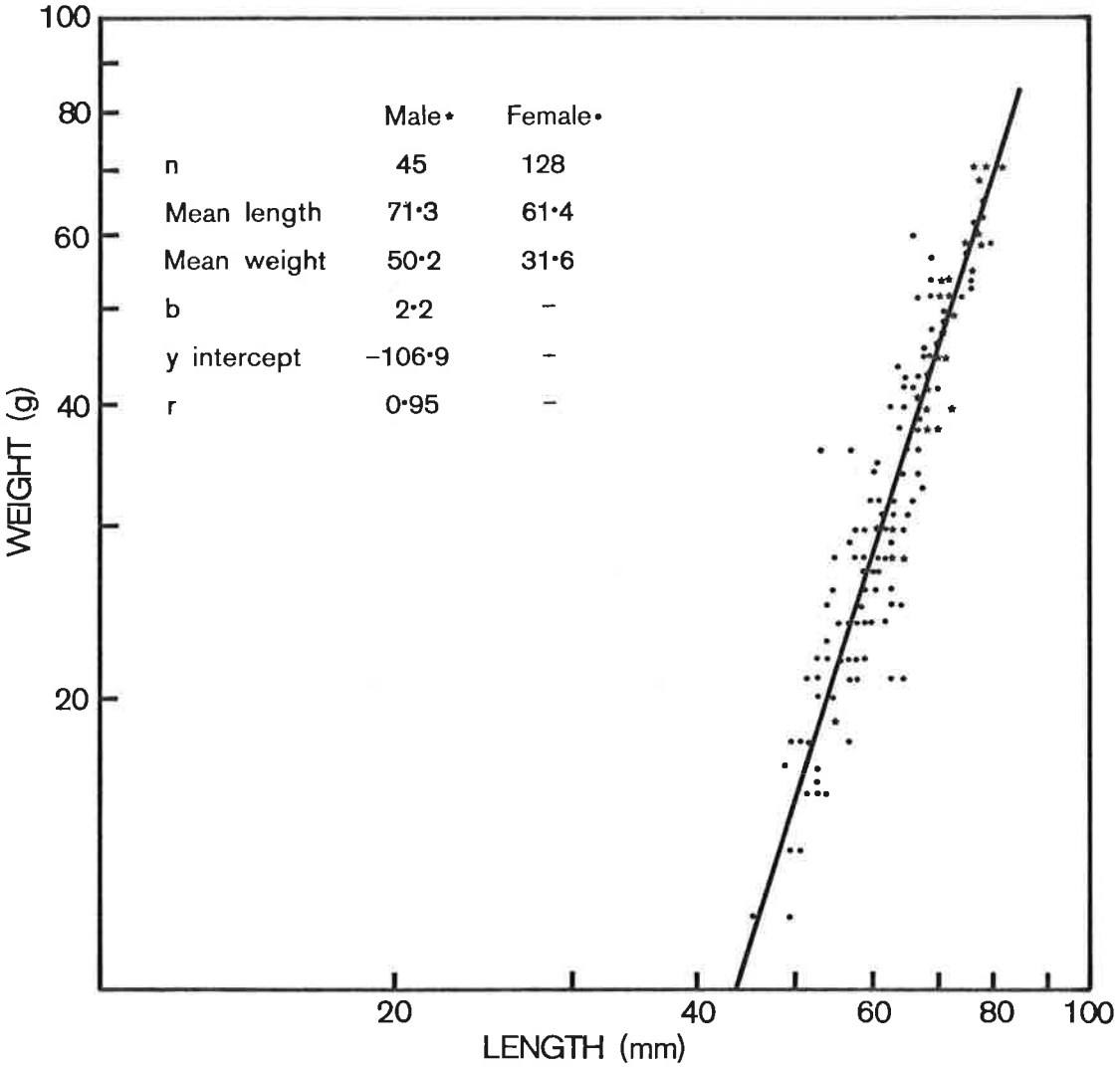


FIG. 15 LENGTH-WEIGHT RELATIONSHIP FOR BLUE-GILLED BULLIES



basis. As with the koaro, females dominated comprising 74% of the catch and the length/weight relationship for males and females was similar (Fig. 15).

(iv) Torrentfish (*Cheimarrichthys fosteri*)

Torrentfish tended to occur further down the catchment (Fig. 16) but were caught in fewer stations than the bluegilled bully. The extent of overlap between these two species is indicated by the fact that 76% of the stations containing torrentfish also contained bluegilled bullies. The range of the two species up the river was similar (Fig. 4) but the torrentfish is likely to be more restricted in its habitat requirements. Like the bluegilled bully it was associated with stony substrates and riffles (Table 3), but in contrast to the bluegilled bully was found more often in water of slightly higher temperature and in areas where instream cover was good.

Only female torrentfish were caught and the average length was 100 mm (Fig. 17). If torrentfish behaviour in the Motu is similar to their behaviour in the Rakaia River (Davis 1980), males will be found further down the river near the mouth of the Motu and a spawning migration will occur to 'bring the sexes together'.

(v) Brown trout (*Salmo trutta*)

Brown trout occurred in relatively few stations (16%) and were mostly juveniles.

Three adults were seen or caught in the lower catchments (the Mangatutara and Te Kahika) but a number of adult trout (presumably brown trout) were also observed from the air, in pools in the upper reaches of the Takaputahi tributary. Juveniles occurred in several stations on the main stem of the Mangaotane and the Takaputahi tributaries (Fig. 19).

FIG. 16 DISTRIBUTION OF TORRENTFISH IN THE MOTU RIVER

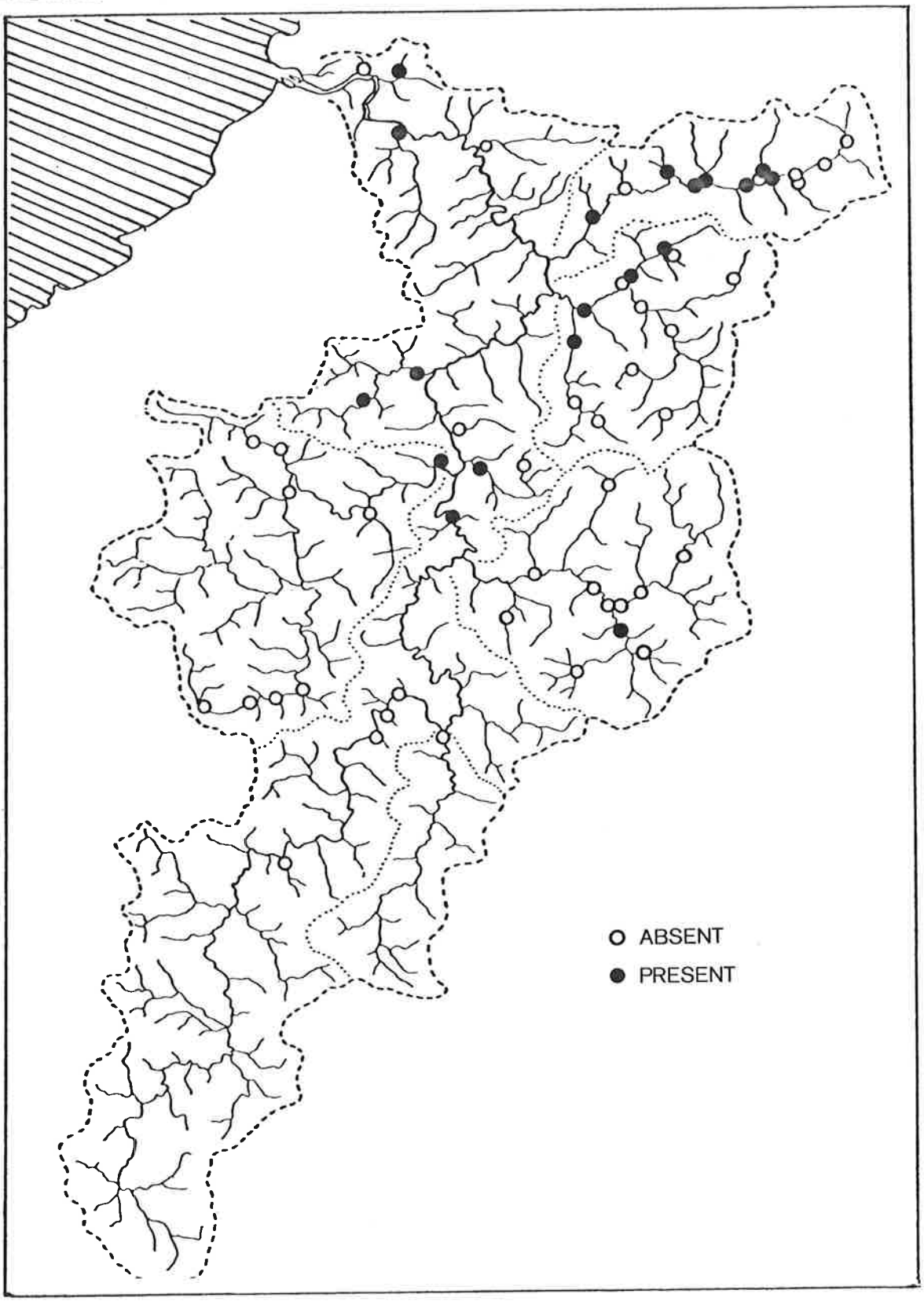


FIG. 17 LENGTH FREQUENCY DISTRIBUTION OF TORRENTFISH IN THE MOTU RIVER

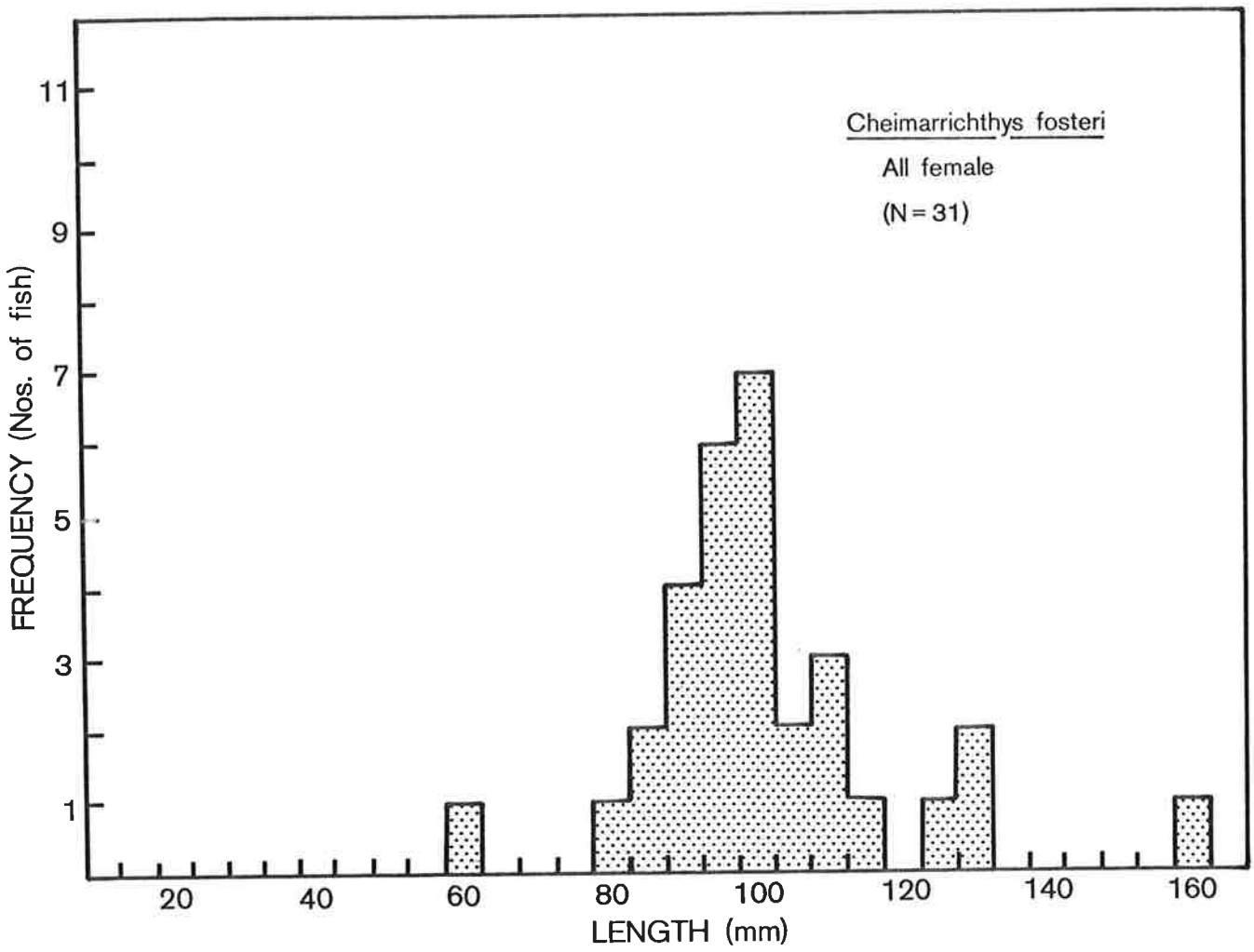


FIG. 18 LENGTH-WEIGHT RELATIONSHIP FOR TORRENTFISH

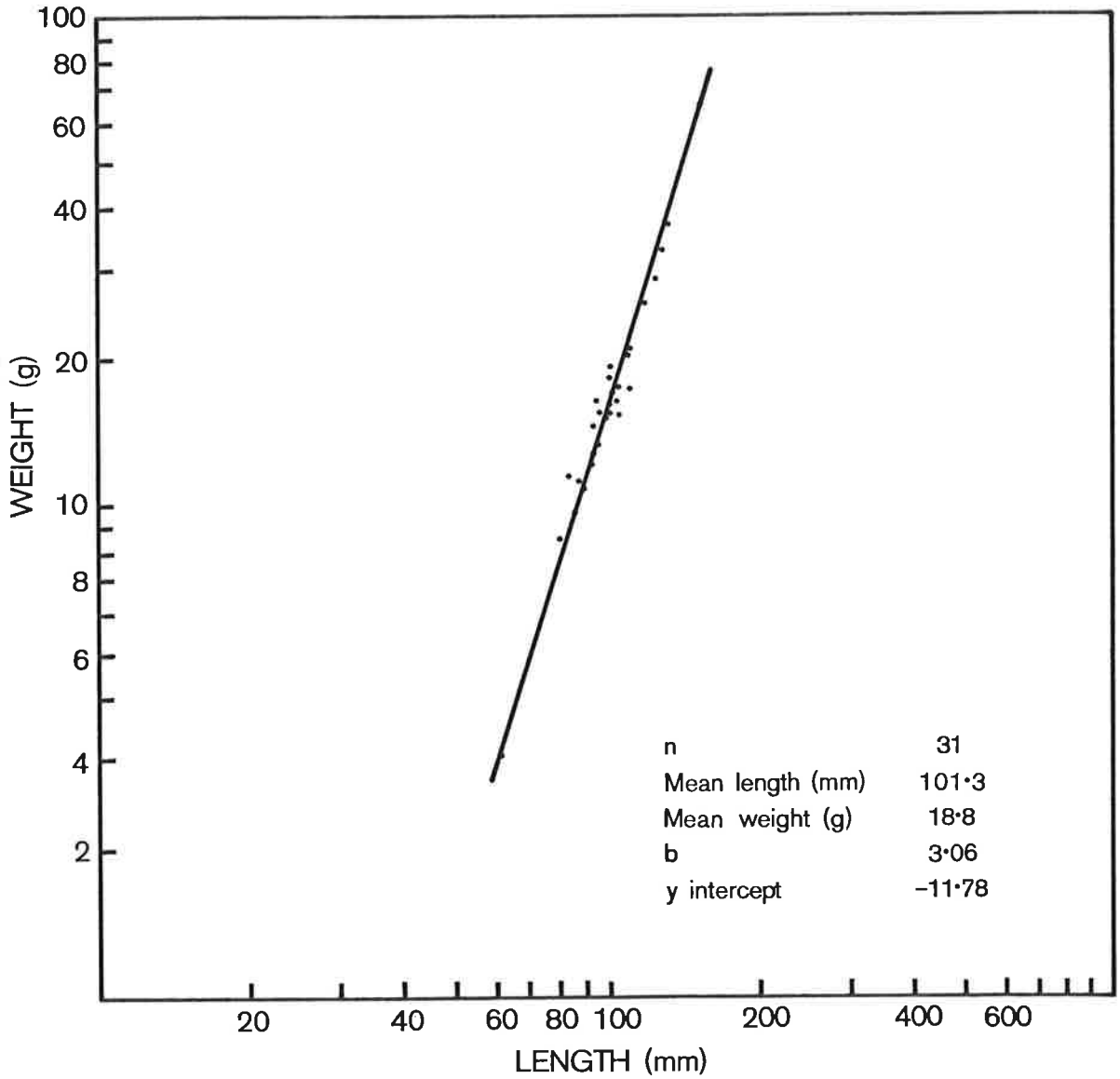
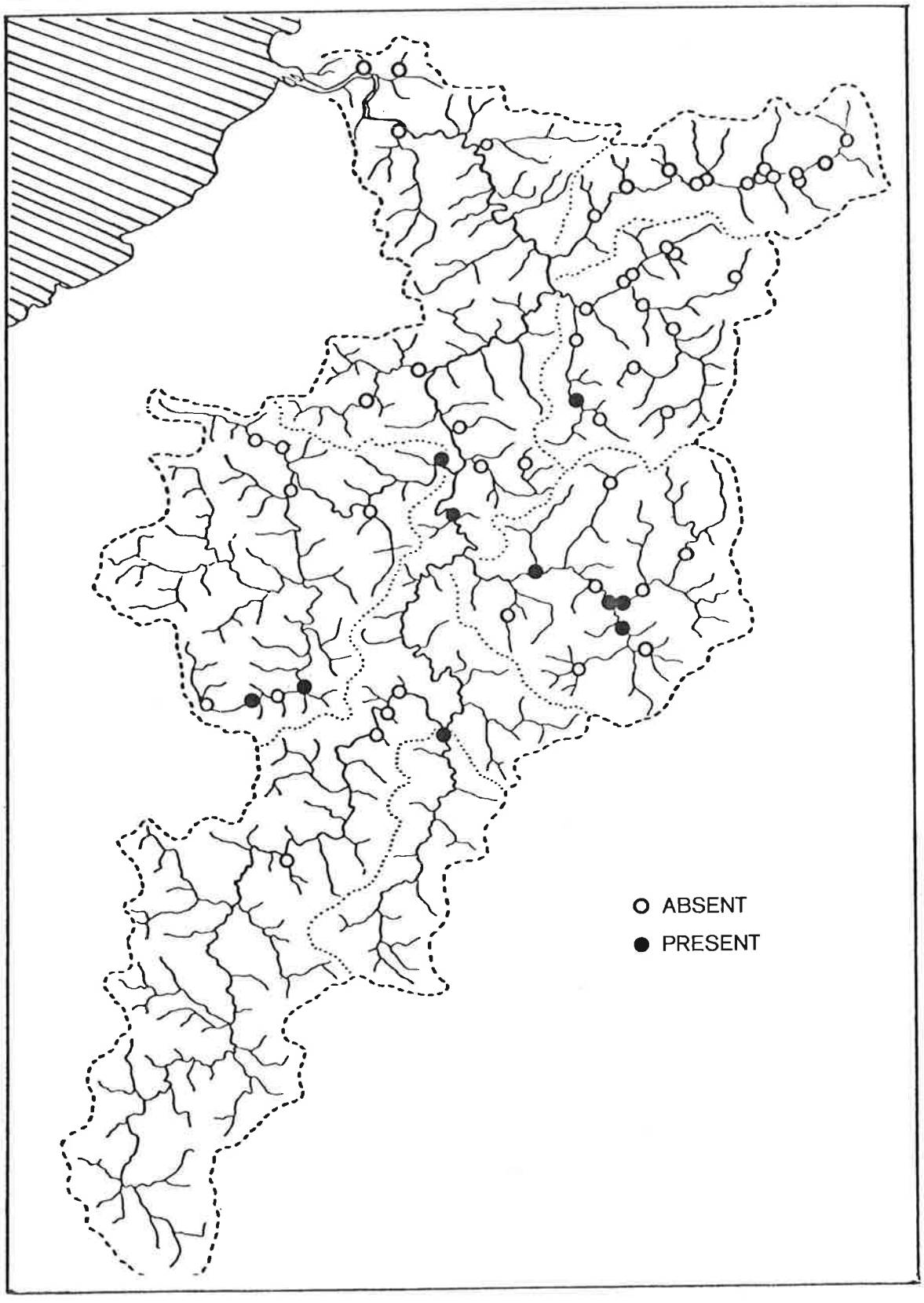


FIG. 19 DISTRIBUTION OF BROWN TROUT IN THE MOTU RIVER



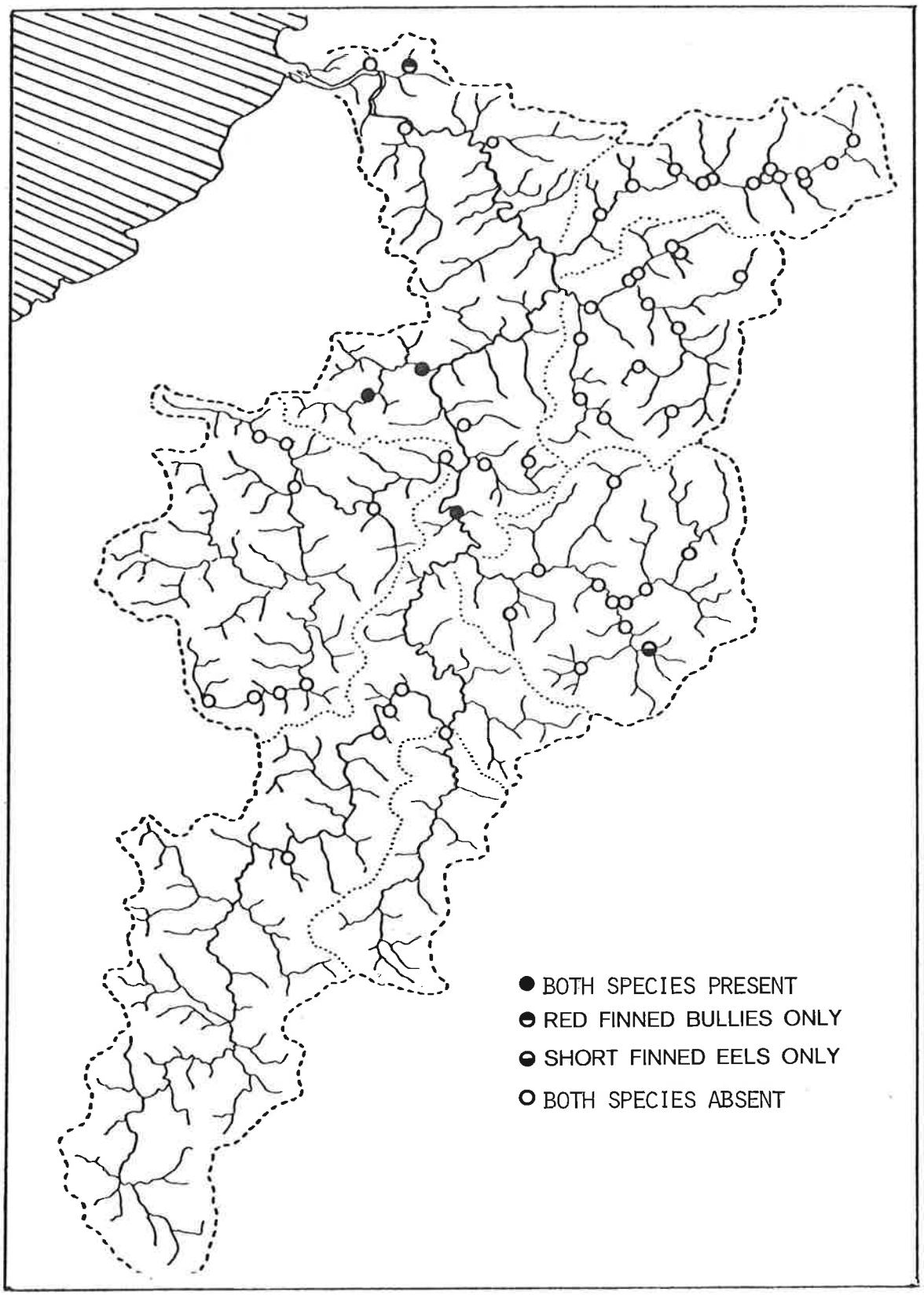
The juveniles were caught mainly in the margins of the main tributaries of the Motu itself, and these stations were characterised by warm water temperatures, good instream cover, stony substrates and runs (Table 3). Torrentfish occurred in three out of the five stations where juvenile brown trout occurred, but whereas both species were assocated with stations containing good instream cover and stony substrates, brown trout were found in stations with slightly warmer temperatures and slower flows. Average size of the trout fingerlings was 75 mm (range 54-107 mm).

(vi) Shortfinned eel (*Anguilla australis*) and Redfinned bully (*Gobiomorphus hubbsi*)

Shortfinned eels are generally found in slow flowing lowland waters and were found in only four stations in the middle Motu River catchments. Whereas both stations in the Mangakirikiri tributary contained a few individuals, shortfinned eels were common only in the station on the main stem of the river (Fig. 20). (The length frequency distribution is shown in Figure 8 .)

The redfinned bully occurred in three of these stations; consequently there is probably a common habitat requirement for these two species. The environmental data are few but there is some evidence that the presence of these species is associated with warm temperatures (Table 3). Furthermore, whereas brown trout juveniles were associated with predominantly stony substrates and runs, stations with shortfinned eels and redfinned bullies contained more gravel and were characterised by riffles. Shortfinned eels were found under rocks or buried in stony substrates whereas redfinned bullies tended to be behind rocks and boulders and were most commonly found in deeper waters (more than 20 cm). The shortfinned eel and the redfinned bully were found to have restricted distributions, at least in the catchments electric fished.

FIG. 20 DISTRIBUTION OF SHORTFINNED EELS AND REDFINNED BULLIES IN THE MOTU RIVER



They were not caught in large numbers but are likely to be more abundant in lower parts of the river.

(vii) Shortjawed kokopu (*Galaxias postvectis*)

Four individuals, all females, were found in three out of the forty-five stations sampled, and this species is likely to be rare within the Motu River.

Like the koaro the kokopu was found in first or second order streams which were generally cold. There was no clear association between this species and other measured environmental variables. However, it was noted that overhanging vegetation was a feature of all three stations containing shortjawed kokopu (See Fig. 10).

(viii) Common bully (*Gobiomorphus cotidianus*) and Banded kokopu (*Galaxias fasciatus*)

Two large (84 and 94 mm long) common bullies were caught in one station of the Te Kahika tributary and one banded kokopu was caught in a small tributary near the mouth of the Motu River. These species are usually found in slow moving waters in lowlands and consequently were not expected in high densities in the stations electric fished. Larger concentrations of both species are likely to occur in tributaries near the mouth of the Motu River.

4. DISCUSSION

(a) The Freshwater Fish Fauna of the Motu

Ten species of freshwater fish have been caught in the Motu River, brown trout being the only acclimatised species present. The nine native species fall into four families and typify the lack of species richness in New Zealand's river fauna. Freshwater fish species not found in the Motu during these investigations, yet expected to be present

include a number of estuarine-dwelling species (Table 2) as well as Cran's bully (*Gobiomorphus basalis*) and rainbow trout (*Salmo gairdnerii*). Although the estuarine species are likely to be present in the lowland catchments, Cran's bully, which is commonly found in upland rivers of the central North Island (McDowall 1978) was not found in the Motu, despite its presence in other East Coast rivers, north and south of this river. Rainbow trout have been liberated extensively into the Motu (Ewing 1978), however, none were seen or caught. This negative result indicates that densities of this species must be very low if rainbow trout are present at all in the Motu. Whereas lack of suitable habitat (because of high flood flows and the unstable geology of this area) could be responsible for the absence of rainbow trout, a few adult brown trout were present in some pools indicating that brown trout can survive in these catchments. Factors other than habitat may be responsible for the complete absence of rainbow trout.

Overall, the longfinned eel was the most abundant and widespread native species in the river with the bluegilled bully and the koaro ranking second and third respectively. The average size of the koaro was much greater than that of the bluegilled bully, however, and in terms of biomass the koaro is likely to be the second most important fish after the longfinned eel. The torrentfish was the fourth ranking fish. These four species thus constitute the main fish community in the Motu River, the remaining species (juvenile brown trout, redfinned bullies, shortfinned eels and the kokopu) each constituting less than 5% of the catch and being present in less than 15% of the stations. Of the few remaining species, only the shortjawed kokopu could be described as rare. Four individuals were found in three stations.

(b) Eastern Catchments

The fish populations of the main eastern tributaries (viz. the Mangatutara, Te Kahika, and Mangaotane in Figure 1) are very similar.

Each contained comparable densities of the four main fish species found in the Motu, and the rare shortjawed kokopu was found in both the Mangatutara and Mangaotane. These eastern catchments are characterised by a very high annual precipitation (in excess of 3 000 mm) and are formed of sedimentary Cretaceous rocks developed during the tectonic disruption of the New Zealand geosyncline. The eastern tributaries therefore extend upward to altitudes exceeding 900 m, through locally massive greywacke and argillite formations containing elements of the Torlesse supergroup. As the ages and hardness of the rocks decreases towards the east, the headwaters of the eastern tributaries, near the crown of the Raukumara Range, run through relatively soft geological formations. This feature together with the high annual precipitation is likely to have contributed greatly to the erosion of steep valleys and to the structure and substrate of the tributaries running through them. All first and second order streams have steep gradients and substrates of large boulders (Plate 2), and the main stem of the tributary into which they run contains large amounts of smaller gravels and stones (Plate 3). Where slips have recently occurred, as in both the Mangatutara and Te Kahika tributaries. The occurrence of large natural slips (Plate 5) and high concentrations of gravel and stone that form large unstable, stream-cut banks (Plate 4) provide some indication of this physical process and its resultant effect on stream flow and substrate.

Flood flows, steep gradients and unstable bouldery substrates combine to form a harsh environment for fish, but the eel and the koaro are likely to be particularly adapted to such conditions. They both have migratory juveniles which are good climbers, and the adults have a narrow elongate body which could permit them to more fully exploit the narrow sheltered spaces underneath and between boulders. The bluegilled bully and the torrentfish, generally present in the open, stony-bottomed tributaries below these bouldery streams, also have migratory juveniles

PLATE 2. Top-most station in the Mangatutara tributary, illustrating typical steepness and bouldery nature of 1st and 2nd order streams (good habitat for koaro).

PLATE 3. Gentler gradients further down the Mangatutara are characterised by riffles and substrates of stone and gravel (good habitat for bluegilled bullies).

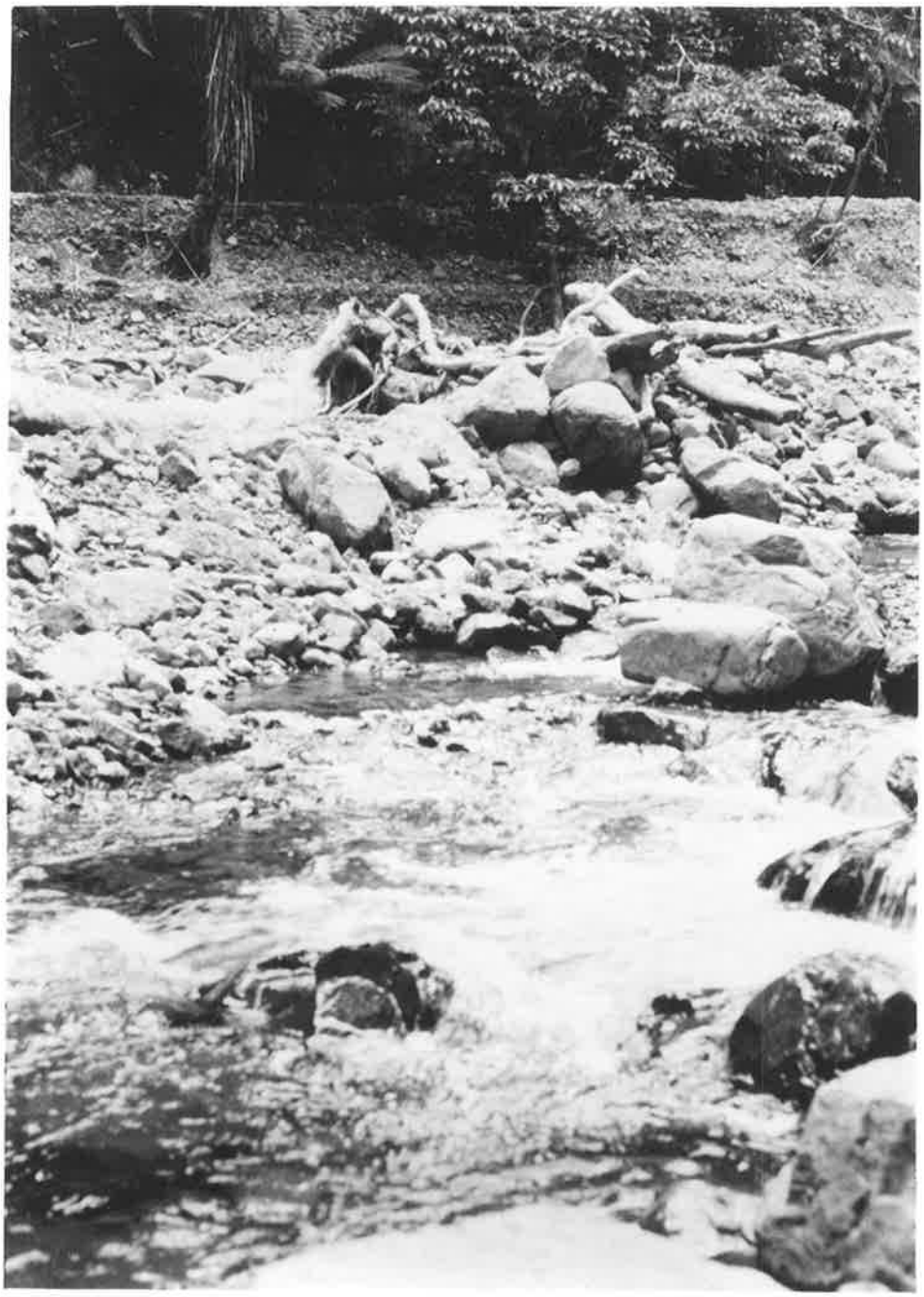


PLATE 4. The high, unstable, wavecut banks of stones and boulders provide evidence of large flood flows in this otherwise small branch of the Te Kahika tributary.

but these cannot climb like eels or koaro and so the distribution of adults can be limited. Both species are bottom-living fish found in fast flowing waters. The torrentfish is flattened ventrally giving it a greater streamlined contact with the rock surfaces, while the bluegilled bully is smaller, having a narrower more elongate body than other bully species inhabiting slower moving waters. The occurrence and morphology of these four native species reflects environmental conditions found within the Motu and demonstrates the intrinsic value of the Motu as a typical, wild, relatively unmodified New Zealand river.

This value is reflected in the absence of trout in much of the system. While brown trout were found in the Motu they are unlikely to be common, especially in the eastern catchments. Few adult trout were seen or caught in the Te Kahika or Mangatutara tributaries, and although the Mangaotane contained juvenile brown trout, a drift diving survey of the pools in the lower three kilometers of this tributary revealed only one adult trout. The substrate in the bottom of these pools typically consisted of an assortment of clean mobile boulders overlying bedrock. At times of high flow these rocks and boulders would be readily moved, limiting the build-up of fine materials and any embedding of boulders. Colonisation by aquatic invertebrates is likely to be severely restricted in such unstable conditions and casual inspection of the pools revealed relatively barren environments. Unfortunately it was difficult to inspect the rapids and so a comparison with these areas was not possible. Despite this, it is apparent that trout do not do as well in these catchments as they do in other East Coast rivers.

The character of the eastern tributaries is also due in part to the vegetative cover of their catchments. Whereas the Mangatutara and Te Kahika catchments were completely surrounded by native forest, the south-eastern corner of the Mangaotane has been cleared and is now in pasture, forming part of a sheep farm. Here koaro were absent despite apparently

favourable flow and substrate conditions and an adequate food supply. This association between catchment modification and the disappearance of koaro has been noted in other areas (McDowall 1978) and indicates that forest canopy is intimately related to the habitat of koaro.

(c) Western Catchments

In comparison to the eastern catchments, the Takaputahi and the Mangakirikiri (Fig. 1) draining into the western side of the river are both relatively stable. Annual precipitation is less than for the eastern tributaries and they run through older Cretaceous rock formations that typically reach altitudes less than 900 m. As a result, gradients are less than in the eastern catchments, stream banks are more stable and sediment loads appeared to be lighter than in the eastern tributaries.

The Mangakirikiri contained more fish species per station than any other catchment and such diversity is probably attributable to the more stable flow and substrate conditions. Stable bank formations, the absence of large boulders, a mild gradient and the generally shallow, stony, meandering nature of this tributary are illustrated in Plate 6. Few *Galaxiids* were caught in the Mangakirikiri however, and no trout were seen in the pools despite the apparently ideal nature of this tributary. An explanation of these observations could be that the waters of this tributary are relatively warm. This is suggested by the relatively high temperatures recorded in the stations electric fished here compared to stations in the rest of the river ($15^{o}C$ compared to overall mean of $12.9^{o}C$).

The Takaputahi is the largest tributary in terms of catchment size and flow and is also likely to be more stable than the eastern tributaries. Adult trout were observed in the large pools of the upper reaches but none were seen in the pools of the lower reaches where a series of gorges narrows the river and increases the velocity of its flow. Native

PLATE 5. A large slip in the Te Kahika tributary.

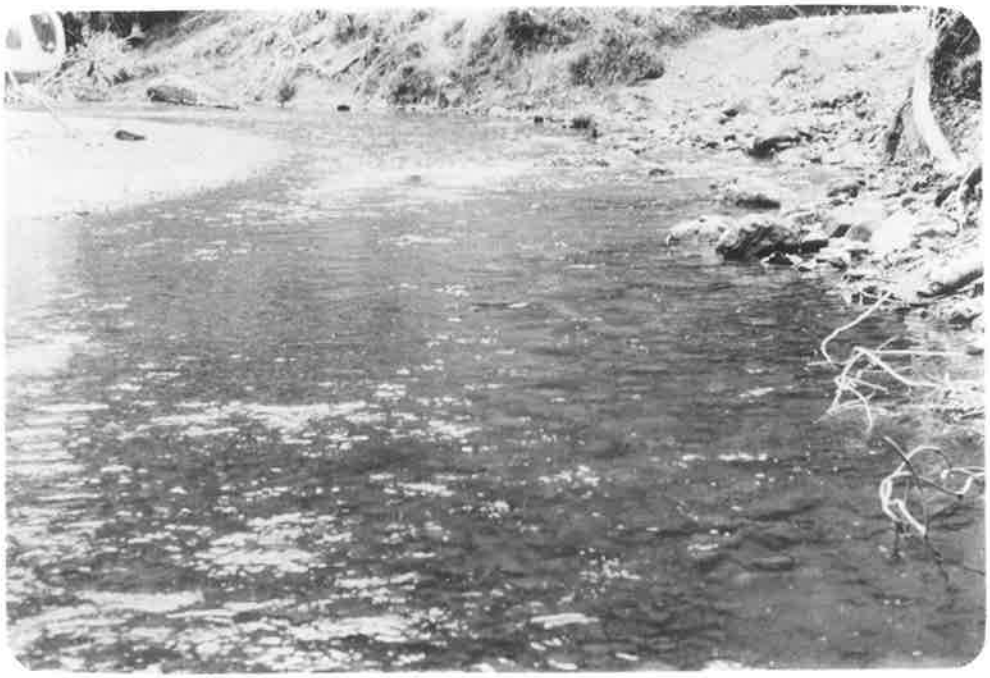


PLATE 6. Mild gradients, slow flows and more stable banks, typical of conditions in the Mangakirikiri tributary.

fish were present in small side streams here and in the braided bouldery margins of the main stem, but eels and brown trout were the only fish found above the gorges where the catchment is farmed.

(d) Impact of Hydro-electric Development

(i) Whitebait fisheries

Eels and brown trout were the only fish species found in the upper waters of the Takaputahi and above the confluence of the Waitangirua with the Motu (Fig. 1). If the koaro is not common in these waters it can be concluded that the bulk of its population will lie within the bush-clad streams of the eastern tributaries. Dams in the lower reaches of the river (M5, M8, M30 in Figure 1) would thus prevent upstream migration of juveniles into these tributaries unless wet-concrete fish passes can be installed. However, such dams would also be likely to interrupt downstream migrations. It is not known whether adult koaro spawn near where they live or migrate to specific spawning areas such as pools. Consequently if the adults migrate downstream, dams could limit such migrations and therefore future recruitment. Assuming that the koaro spawns more than once, the dams would also prevent their return upriver and could result in the elimination of koaro populations above the dams. Alternatively if koaro do not migrate to spawning areas, or if these are above dams, then downstream movement of eggs or larvae could be affected by the impoundment of water behind dams. In this event, reservoir-bound populations of the koaro could be created which would not contribute to whitebait fisheries but which may contribute to new fisheries in the impoundments.

The identification of major effects of dams on the adult populations of *Galaxiids* and hence the whitebait fishery therefore depends on finding the answers to the following questions:

1. Is the whitebait fishery of the Motu based on the koaro (*Galaxias brevipinnis*)?

2. Are the main populations of the koaro restricted to the bush-clad eastern tributaries?

3. Where do adult koaro spawn?

4. Will the dams affect downstream movement of eggs or larval koaro?

Furthermore, as many of the rivers adjacent to the Motu are either small or modified in some way (agriculture, forestry, dams, effluent disposal), and are unlikely to contain large populations of adult koaro and, as whitebait are thought not to home into their river of origin, the stocks of adult koaro in the Motu may contribute significantly to whitebait fisheries in adjacent rivers. Attempts should be made to determine the relative value of the whitebait fishery in the Motu River (i.e. the extent of usage) as well as the extent of 'seeding', should this occur, to other river fisheries in the region.

(ii) Eel fisheries

The longfinned eel is cosmopolitan throughout the Motu and high densities have been observed in the river and its tributaries (Ewing 1978). The longfinned eel is the dominant fish in the Motu and this river could be described as an eel river (c.f. trout, salmon or whitebait rivers).

As eel stocks in other parts of New Zealand are being steadily depleted through increased fishing pressure, eel stocks in wild rivers such as the Motu will gain increasing importance as sources of spawning adults and hence recruitment to the eel fishery throughout New Zealand. Initial observations indicate that the Motu could have an unusually high density of relatively fast-growing eels compared to other rivers, but the relative importance of the Motu stocks to the longfinned eel fishery in New Zealand cannot be determined in the near future. Because of this, the wild unexploited eel population here is a potentially

important one and adequate protection for migration will be required if hydro-electric development proceeds.

(iii) Trout fisheries

Results of this survey reinforce and confirm earlier conclusions on the trout fishery (Ewing 1978). Rainbow trout have not been found in the Motu and, although isolated pockets of these fish may exist, they would be negligible in terms of fisheries.

Brown trout have been found throughout the system but densities capable of supporting a fishery were seen only in the upper Takaputahi. Spawning areas for these trout need to be determined as the proposed dam at T23 (Fig. 1) may affect recruitment to this localised fishery. Other brown trout fisheries may exist in the Waitangirua tributary and the upper Motu. However, these would be above any proposed dams. If angler interest in these fisheries is likely to be high, then spawning areas for these fisheries should also be checked to ensure that they are above the influence of dam sites.

(iv) Kahawai fishery

The Motu River mouth is known to be popular with locals, tourists and possibly commercial fishermen for its kahawai fishery. The kahawai (*Arripis trutta*) is a marine fish, but large schools regularly enter freshwater on high tides during summer months. At this time many are taken for local consumption and the fishery is an important tourist asset to the region. If the runs of kahawai are linked to biological factors associated with the ecology of the river (e.g. smelt or *Galaxiid* runs), then they too could be affected by dams further up the river. There is a need to determine the regional value of this fishery and to find out whether runs of kahawai depend on the upstream ecology of the river.

5. ACKNOWLEDGEMENTS

This report owes much to the large number of stations electric fished, and such coverage would not have been possible without the support of the MWD, including the financing of a helicopter. In this respect I would like to thank Bob Torr for his skillful flying. The field work for this survey was carried out as a joint exercise between the Department of Internal Affairs and the Fisheries Research Division of MAF and I am grateful to Messrs N. Ewing, P. Mylechreest and W. Nissen of the Department of Internal Affairs who, together with Mr R. Ashworth and Mr B. Penlington of the Fisheries Research Division (MAF) helped carry out the electric fishing. I am especially thankful for the help provided by Mr B. Penlington in the subsequent processing of fish and data and to Mr Ashworth for his guidance with the electric fishing.

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