ISSN 1170-2001

NEW ZEALAND FRESHWATER FISHERIES MISCELLANEOUS REPORT NO. 124

STRUCTURE OF THE EEL POPULATION IN LAKE WAAHI - 1992

by

B.L. Chisnall
D. West
J.A.T. Boubee

Report to: New Zealand Coal Corporation

Freshwater Fisheries Centre
MAF Fisheries
PO Box 6016
Rotorua

Servicing freshwater fisheries and aquaculture

June
1992

NEW ZEALAND FRESHWATER FISHERIES MISCELLANEOUS REPORTS

This report is one of a series initiated in January 1989, and issued by the Freshwater Fisheries Centre, MAF Fisheries. The series was established to ensure that reports prepared for clients, tribunal hearings, internal use, etc., are collected together and available to future users. They are for limited circulation, and some may be confidential.

ISBN 0-477-08625-X

MAF

MAF Fisheries is the fisheries business group of the New Zealand Ministry of Agriculture and Fisheries. The name MAF Fisheries was formalised on 1 November 1989 and replaces MAFFish, which was established on 1 April 1987. It combines the functions of the former Fisheries Research and Fisheries Management Divisions, and the fisheries functions of the former Economics Division of MAF.

Enquiries to: The Librarian
Freshwater Fisheries Centre
PO Box 8324
Riccarton, Christchurch
New Zealand

CONTENTS

TABLES

FIGURES

APPENDICES

SUMMARY

A fisheries survey of Lake Waahi was carried out from 24-27 February 1992 to monitor any changes in the eel population since the previous surveys in February 1987 and 1990. Three fine meshed fykes (superfykes), three trap nets and four standard fykes were set in rotation at three of the sites fished previously. In addition, on 26 February 1992, four panel gill nets were set along the shoreline at one site. Two weeks later 10 superfykes were distributed throughout the lake to obtain a wider sample.

Shortfinned eels, mullet, catfish, goldfish, rudd, smelt, inanga, bullies and mosquitofish were caught in the lake. These nine species were also common in past surveys. As in 1990, rudd were the most abundant fish caught in gill nets.

Superfykes caught fewer eels than traps (35% less) but were much more cost effective to use. Superfykes also caught fewer of the small fish species than traps probably because of their lack of entrance wings and hoods.

The mysid biomass declined markedly prior to February 1990 and has remained at a very low level since. The biomass of mosquitofish also declined during that time. These two species formed significant components of eel diet in 1987, and their reduced availability provides indirect evidence that the eel diet has changed in recent years. Since 1987, the size frequency of the bully population has shifted towards smaller fish, possibly as a result of increased predation by eels.

The total catch of eels, especially of small eels, in traps declined markedly between 1987 and 1992. Possible reasons for this include: Eel removal/transplant, recruitment block, natural fluctuation in recruitment, increased cannibalism following the mysid crash, changed behaviour of juveniles with improved water clarity, and effects of past commercial fishing pressure.

RECOMMENDATIONS

1. *To ensure that monitoring of the eel population continues, an annual sampling programme should be maintained in Lake Waahi.*

2. *To help determine what factors are contributing to the decline in the eel population of Lake Waahi, it is essential that a comparable sampling program be established in other Waikato lowland lakes (eg. Lake Whangape for which some previous records are available).*

3. *To make full use of the historical catch data, we recommend the continued use of trap nets in future studies. Superfykes should be modified and their effectiveness reassessed in 1993.*

4. *Future studies should ensure that the diet and population structure of all abundant fish species be determined.*

1. INTRODUCTION

Increased suspended solids caused a collapse in submerged macrophytes in Lake Waahi during 1978. The eel fishery of the lake boomed immediately after it became turbid, but declined markedly during 1979-80 (Kingett 1984, Ward et. al. 1987). A lacustrine form of the common smelt (*Retropinna retropinna*), also disappeared from the lake at that time (Northcote & Ward 1985, Ward et. al. 1987). A 1987-88 study of the fish communities of Lake Waahi showed that mysids were the main food resource of a diverse and healthy fish community (Hayes et. al. in press). A follow-up fish study of Lake Waahi was made in February 1990 (Hayes et. al. 1990). The mysid population in Lake Waahi had declined markedly at this time, but the fish community appeared to be largely unchanged.

This report presents the results of the first of three, annual samplings of Lake Waahi for the N.Z. Coal Corporation. It assesses the size distribution and catch rates of eels in the lake, and relates these to historical records. A comparison of different fishing methods is provided to highlight differences in catch rate and composition between large fine meshed fyke nets (superfykes, which are to be the main sampling tools employed in future studies), and box-trap nets used in previous studies. Information on bycatch species is also presented.

2. METHODS

2.1 Gear Comparison

A comparison of three fishing methods was undertaken in Lake Waahi from February 24 to 27, 1992. Three 0.72 mm square mesh superfykes (see Appendix 1) were set along with three 0.50 mm square mesh box trap nets (Hayes 1989), and 12 standard commercial fyke nets (12 mm stretched mesh). Each gear type was fished overnight at 3 positions (shoreline, 100 m from shoreline, 200 m from shoreline) and in each of 3 locations around the shoreline (Fig. 1A). These 3 locations were also used for the 1987 and 1990 fish studies (Hayes et. al. 1992 & 1990). Combined leader lengths for the different gear types were: superfykes 3 x 12.5 m = 37.5 m; traps 3 x 15 m = 45 m; fykes 12 x 2.5 m = 30 m. Traps used at all middle and outer positions were equipped with hoods to increase their efficiency in deeper water.

Small (< 100 mm) and large fish in the catch of each net were separated on collection. The total catch of small fish and mysids was weighed. A sub-sample was retained and the remainder returned live to the lake. Shortfinned eels from all nets were separated into 4 size grades in a grading box (Chisnall 1987). Grading was by fish diameter: < 10 mm, 10-15 mm, 15-20 mm, > 20 mm. The catch in each grade was counted and a subsample anaesthetized (benzocaine solution) for measurement of length and weight. Total weight (W_T) of each catch was calculated from $W_T = \Sigma W_i N_i$ where W_i is the average fish weight for grade i, and N_i is the number of eels in grade i.

Condition factor for allometric growth is given by $k = 100W/L^b$, where W is the weight in grams, L the length in mm and b the slope of the weight-length relationship. As eel growth was usually isometric, b=3 was used to calculate condition factors for eels. Condition of fish collected in this and previous studies was compared by factorial analysis of variance (ANOVA) of the weight-length relationships for each species.

The diet of common bullies and smelt was assessed by number and points methods (Hyslop 1980).

2.2 Superfyke Sampling

Two weeks after the gear comparison trials, 10 superfykes were set overnight to fish as much of the lake area as possible (Fig. 1B). Catches were processed as described above, and combined with superfyke catches from the gear comparison for overall analysis.

2.3 Additional Sampling

On 26 February, 4 panel-gill-nets (each with three 10 x 2 m panels of 62, 87, and 112 mm stretched mesh) were set to fish overnight in and near reed beds along the shoreline at net site 3 (Fig. 1A). Catches were identified and counted and all live fish returned to the lake.

3. RESULTS

3.1 Gear Comparison

On average, superfykes caught 35% fewer eels and mysids than the traps (Table 1). Futhermore, they caught only about 30% of the catch of bullies and mosquitofish, 8% of inanga, and 2% of smelt that were caught in traps. However, in the shoreline positions, superfykes caught the same quantity of eels and mysids as the traps. In the 100 m and 200 m positions the superfykes caught about 15% of the bullies caught by traps, and none of the other fish species (Appendix 2).

The proportion of eels in each grade from traps and superfykes was comparable (Table 1 part A).

Standard fykes caught fewer small eels (grade 4) and more larger eels (grades 1 and 2) than the fine-meshed traps and superfykes (Table 1, part A). Standard fykes also failed to retain any small fish or mysids. Even after excluding the smaller eels (grade 4), it is still clear that the standard fykes caught a larger proportion of large eels (grade 1) than the fine meshed nets, and that superfykes caught a slightly smaller proportion of grades 1 and 2 eels than traps (Table 1 part B).

3.2 Catch and Population Structure

3.2.1 Eels

Between 1987 and 1990 the catch of eels from Lake Waahi was nearly halved, both in terms of biomass and number (Table 2). Catches have since continued to decline with catches in 1992 being a third of the catch recorded in 1987. The proportion of small eels in the catch has also declined considerably between 1987 and 1992 (Fig. 2). Catches of eels larger than 150 g have declined but the proportion of eels in the catch which exceed 150 g (grades 1, 2 and part of 3) has increased (ie. the small eels present in 1987 have grown into the next size grade but there has been reduced recruitment of small eels, Table 2).

3.2.2 Other Species

In addition to shortfinned eels, four other fish species as well as mysid shrimps were caught in traps and superfykes (Table 3 and Appendix 2). The increased CPUE of mysids between 1990 and 1992 indicates that the population has increased slightly since 1990, but remains at a considerably lower level than that recorded in 1987. The population of bullies increased between 1987 and 1990, but has declined slightly since. Mosquitofish CPUE has declined substantially since 1987, but that of smelt has increased. All smelt were of the 'riverine' type. Inanga catches have remained static over the six year period sampled.

Four additional fish species (grey mullet, rudd, catfish and goldfish), were caught in gill nets (Appendix 4). Rudd were the most abundant in the lake with an average of 23 caught per net. Juvenile grey mullet were present in the catch.

3.3 Condition

The condition factor (k) of common bullies and mosquitofish declined significantly between 1987 and 1990 (Table 4). Bully condition remained low in 1992. Smelt and inanga condition has not changed since 1987. Shortfinned eel condition declined significantly between 1987 and 1990, but by 1992 was not significantly different to that recorded in 1987 (Table 4).

Both mean length and weight of grade 1 in 1992 was unduly biased by two large individuals (L = 912, 818, W = 1200, 1600), which were subsequently omitted when obtaining means for grades. There was little change in the mean length or weight of graded eels over the three years sampled (Appendix 3).

3.4 Common Bully and Smelt Diet

There was little change in the diet of bullies between 1987 and 1992 (Fig. 3). However, smelt consumed fewer mysids and proportionately more detritus, terrestrial invertebrates and other aquatic species in 1992 (Fig. 3). The occurrence of empty stomachs in both bullies (49%) and smelt (68%) was significantly greater in 1992 than in 1987 samples (Fig. 3).

4. DISCUSSION

4.1 Gear Comparison

Although superfykes did not catch as many eels as traps did (35% less), they were set and retrieved in a fifth of the time. The ease with which superfykes are handled permits more nets to be set and more habitats to be sampled on each sampling occasion. However, superfykes are significantly more selective and catch fewer smaller fish species than traps. This is probably because they lack the entrance wings and hoods present on the traps (Appendix 1). Modifications may be necessary to improve the catching efficiency of superfykes.

Comparable information on the eel population in Lake Waahi was gained from catches obtained with superfykes and traps (Fig. 2). If modifications overcome the selectivity of superfykes, they will prove a useful sampling tool in future studies of eel populations.

Fine meshed traps and fykes caught fewer large eels than standard fykes. We had observed previously that small eels tended to avoid nets which held large eels. There are therefore major difficulties in separating cause and effect when monitoring eel populations.

4.2 Catch and Population Structure

4.2.1 Eels

Eel catches have declined markedly since the first survey in 1987. Possible reasons for reduced catches, particularly of small eels include:

i. Current fishing pressure This is unlikely to be the main cause of declining total catch because the catch of harvestable eels (ie. > 150 g, size grades 1, 2 and a proportion of 3) has increased (Fig. 2, Table 2). The decrease in the catch of smaller eels could be attributable to transplantation of small eels caught in Lake Waahi to other water bodies for 'fish farming' purposes (such as farm dams, or other lakes where eel stocks are purported to be depleted, e.g. Lake Waikare).

ii. Restricted access to the lake The reduced catches of smaller eels may partly be an effect of poor recruitment to the lake. Eels are diadromous, that is they need to migrate to and from the sea to complete their life cycle. Physical and chemical factors could have hindered access to the lake. Of relevance here are:

1. The flood gates on the outlet stream which were installed in 1978. A fish pass was mounted on one wall at the same time, but at low water levels it did not work. Clogging of trash screens has also caused intermittent blockages.

These two problems were hopefully remedied in 1989 by the construction of a rock weir below the gates and the provision of slots in the gates (A. Meredith Waikato Regional Council, pers. comm.). However, irregular clearing of the trash screens by the controlling body may still present an intermittent problem.

We note however that juvenile grey mullet were found in the lake. This indicates that this fish (one of the most easily restricted species) is capable of negotiating the lake outlet structure. It is therefore unlikely that the gate or weir are significant barriers to elvers.

2. The Huntly power station discharges heated water immediately downstream of the outlet from Lake Waahi. This thermal plume may hinder or even block access to the lake. A comparison of the eel populations in other lowland lakes of the Waikato would help determine if the power station is having such an impact.

iii. Natural fluctuations in recruitment Factors such as climate change and oceanic current diversion (El Nino cycle) could no doubt affect recruitment, but this would affect recruitment to all rivers, not just the Waikato.

iv. Cannibalism With the crash of the mysid food resource, larger eels may have increased predation on juvenile eels.

v. Improved water clarity Decreasing turbidity may have caused a change in juvenile eel behaviour and distribution in the lake. Where they once foraged throughout the lake because turbid waters provided cover, small eels may now be actively seeking cover in reed beds where they would be less vulnerable to capture by predators. They would also be less vulnerable to netting in such environments.

vi. Historical fishing pressure Female shortfinned eels mature at about 20 years of age. Eel harvest in New Zealand peaked some 20 years ago. The decline in the number of small eels captured could therefore be the first indication of the effect of past fishing pressure on stock-recruitment relationships and eel spawning success. If this is the case, recruitment nationwide would be expected to be declining. Anecdotal evidence from whitebaiters and power plant operators lends support to this theory.

4.2.2 Other Species

A large biomass of mysid shrimps was thought to be at the base of a healthy fish community observed in Lake Waahi in 1987 (Hayes et. al. 1992). The mysid population crashed before the 1990 sampling, probably as a result of increased predation associated with improved water clarity (average secchi readings 1987 = 0.37 m, 1990 = 0.46 m). By 1992, water clarity had increased further in the main body of the lake (Secchi disc = 0.52 m), but not in the north western arm (Secchi = 0.37 m; at site 3, Fig. 1A). Catches of mysids in the NW arm, were considerably greater than at the other two sites and caused the slight increase in CPUE in 1992 over the 1990 figure (Table 3).

The population decline of mosquitofish may also be related to increased eel predation following improved water clarity.

The bully population increased between 1987 and 1990. A small decline occurred in 1992, but densities were still much higher than in 1987. The increase in density between 1987 and 1990/92 was associated with a change in fish size. More small bullies were captured in 1990 and 1992 than in 1987 (Fig. 4, Table 3). Thus population density may be influenced by the abundance of large bullies, which are known predators of juveniles. This in turn would be dependent on factors such as food availability and predation by eels, especially following the mysid collapse.

Size frequencies of smelt and inanga do not appear to have changed since 1987 (Fig's 5 & 6). All smelt caught were migratory, so the large increase in the CPUE since 1987 may indicate improved access from the Waikato River (Table 3).

Rudd appear to have further increased in number since the 1990 study and were by far the most abundant fish species caught in gillnets.

4.3 Condition

Mysid shrimps were a dominant component of the diets of both bully and mosquitofish in 1987 (Hayes & Rutledge 1991). The continued low level of mysids since 1987 is likely to be the main cause of the decline in condition of common bullies and mosquitofish (Table 4). In addition, competition for food resulting from the relatively large populations of bullies recorded in 1990 and 1992 (Table 3), may have contributed to the reduced condition (Table 4).

The improvement in condition of shortfinned eels in 1992 may be because densities were greater in previous years and food could have been a limiting factor. The relatively low eel density in 1992 may thus have resulted in reduced competition for food and thereby improved growth and condition. Another possible explanation for this improvement in condition is that eels have switched from a mysid dominated diet (Hayes & Rutledge 1991) to one dominated by fish. Assimilation efficiency for piscivorous fish is lower for crustacean than fish diets (Kelso 1992). Diet studies are required to clarify this point.

4.4 Common Bully and Smelt Diet

The greater proportion of bullies and smelt with empty stomachs in 1992 compared with 1987, indicates a decline in abundance of food for these fish. The diversification of smelt diet since 1987 (Fig. 3), probably reflects the declining mysid abundance.

5. ACKNOWLEDGEMENTS

We especially thank Erina Watene for help with the fish sampling and processing. Our thanks also go to Bob van Boven for help with draughting, and to Dave Rowe for constructive criticism of the draft.

6. REFERENCES

Chapman, M.A., Lasenby, D.L. and Hayes, J.W. 1988. *Tenagomysis chiltoni* and fish in the Waikato region in New Zealand: some consequences of environmental disturbance. Presented to a Mysid-fisheries symposium, American Fisheries Society 118th Annual Meeting, September 12-15 1988, Toronto, Ontario.

Chisnall, B.L. 1987. Juvenile eel biology in the backwaters of the Waikato River. M.Sc. thesis, University of Waikato. 151p.

Hayes, J.W. 1989. Comparison between a fine mesh trap net and five other fishing gears for sampling shallow-lake fish communities in New Zealand. *New Zealand journal of marine and freshwater research 23:* 321-324.

Hayes, J.W., Chisnall, B.L., Boubee, J.A.T. and Ingram, J.R. 1990. Review of the fish and fisheries of Lake Waahi. Report to Kingett Mitchell and associates, for New Zealand Coal Corporation. 22p.

Hayes, J.W., Rutledge, M.J., Chisnall, B.L. and Ward, F.J. in press. Effect of elevated turbidity on shallow lake fish communities. *Environmental biology of fishes.*

Hayes, J.W. and Rutledge, M.J. 1991. Relationship between turbidity and fish diets in Lakes Waahi and Whangape, New Zealand. *New Zealand Journal of marine and freshwater research, 25*: 297-304.

Hyslop, E.T. 1980. Stomach content analysis - a review of methods and their application. *Journal of Fish Biology, 17*: 411-429.

Kelso, J.R.M. 1972. Conversion, maintenance and assimilation for walleye (*Steizostedion vitreum vitreum*) as affected by size, diet and temperature. *Journal of the fisheries research board Canada, 29*: 1181-1192.

Kingett, P.D. 1984. Lake Waahi. An environmental history. Mines division, Ministry of Energy, New Zealand. 201p.

Northcote, T.G. and Ward, F.J. 1985. Lake resident and migratory smelt, *Retropinna retropinna* (Richardson), of the lower Waikato River system, New Zealand. *Journal of Fish Biology 27:* 113-129.

Ward, F.J., Northcote, T.G. and Chapman, M.A. 1987. The effects of recent environmental changes in Lake Waahi on two forms of the common smelt *Retropinna*, and other biota. *Water, air, and soil pollution 32:* 427-443.

Table 1 Size distribution (mean % ± SE) of shortfinned eels caught in Lake Waahi, February 1992. **A** = entire catch; **B** = small eels omitted; n, number of nets set; N, total number of shortfinned eels caught.

	Net		Eel grade				
	Type	n	1	2	3	4	N
A	Traps	9	0.6±0.2	9.0±1.7	32.3±6.4	55.7±8.0	981
	Superfykes	9	0.2±0.2	7.3±0.7	44.0±8.5	48.7±9.5	621
	Fykes	12	2.7±1.8	13.0±1.3	49.0±3.3	32.0±2.9	527
B	Traps	9	1.6±0.4	22.0±1.2	76.3±1.0		458
	Superfykes	9	0.3±0.3	16.7±3.0	83.0±2.9		370
	Fykes	12	4.0±2.5	19.0±1.9	77.3±2.6		357

Table 2 Average catch (n and kg trap^{-1} night^{-1}) of shortfinned eels and the proportions of total catch (%) greater than 150 g (legal limit) and 220 g (commercial grade) in Lake Waahi, for February 1987, 1990 and 1992.

Date	Average catch		Catch exceeding			
			150 g		220 g	
	n	kg	kg	%	kg	%
February 1987	360	33.049	7.575	22.9	2.587	7.8
1990	187	18.777	5.767	30.7	3.099	16.5
1992	109	12.644	4.918	38.9	3.031	24.0

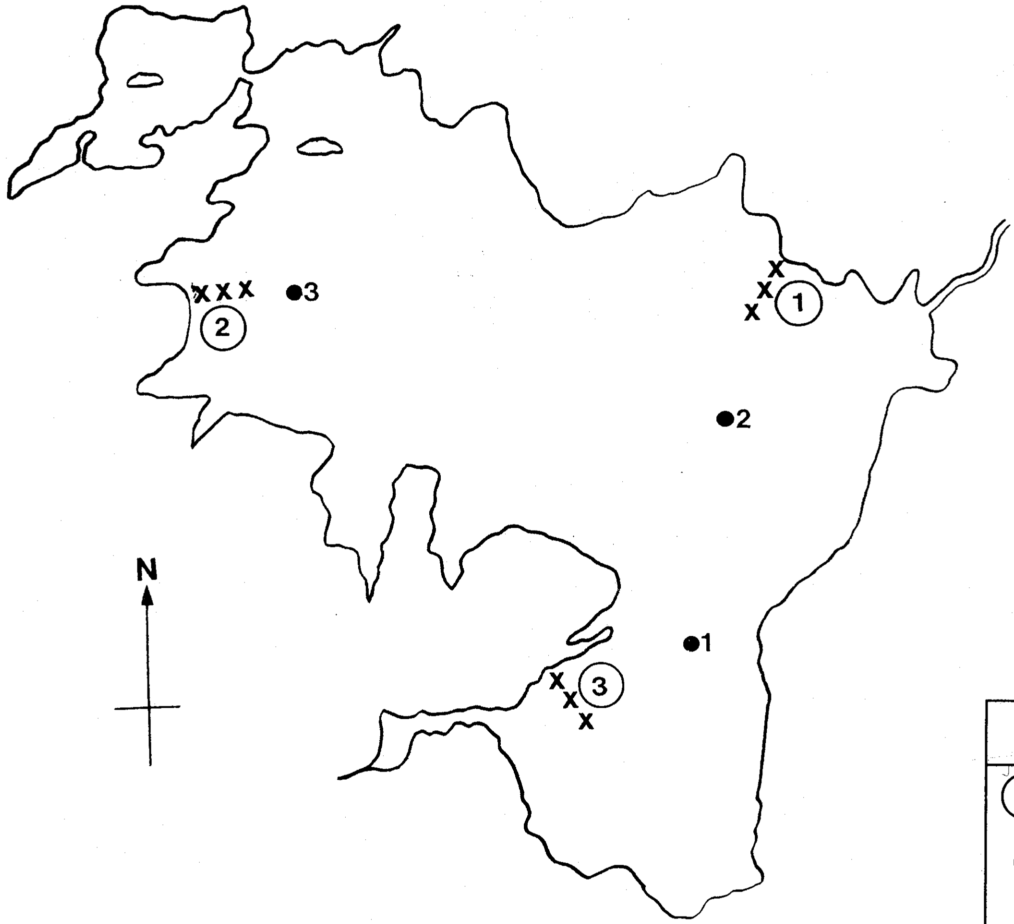
Table 3 Mean catch per unit effort (CPUE) ± SE for five species of fish and for mysid shrimps caught in fine-meshed traps set in Lake Waahi, February 1987, 1990 and 1992.

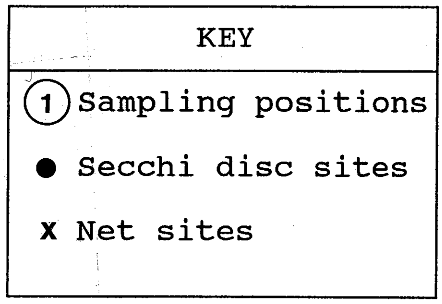
	CPUE trap (g net^{-1} h^{-1})		
Species	1987	1990	1992
Mysid	14.1 ± 6.0	0.1 ± 0.01	1.2 ± 0.4
Shortfinned eel	1886.1 ± 257.0	1045.5 ± 207.9	789.2 ± 206.3
Common bully	82.1 ± 14.9	171.1 ± 48.6	101.4 ± 15.5
Common smelt	4.2 ± 1.8	2.4 ± 1.1	19.3 ± 6.6
Inanga	1.1 ± 0.5	1.0 ± 0.4	1.4 ± 0.6
Mosquitofish	9.4 ± 2.7	5.5 ± 2.3	0.3 ± 0.03

Table 4 Comparison of condition factors (k) ± SE for five fish species caught in Lake Waahi in February 1987, 1990 and 1992. ANOVA P values for comparisons of logged weight-length relationships between years. N, number of fish analysed.

	1987			1990			1992	
Species	N	k	P	N	k	P	N	k
Shortfinned	65	0.185 ± 0.003	**0.001**	105	0.179 ± 0.002	**0.000**	214	0.182 ± 0.001
Common bully	351	0.833 ± 0.008	**0.000**	201	0.794 ± 0.011	0.994	79	0.686 ± 0.010
Common smelt	155	0.200 ± 0.003	0.116	184	0.193 ± 0.002	0.062	137	0.174 ± 0.002
Inanga	47	0.159 ± 0.004	0.685	71	0.150 ± 0.002	0.400	10	0.144 ± 0.006
Mosquitofish	293	1.148 ± 0.013	**0.000**	204	1.052 ± 0.014			-

A. Gear comparison trials (24-27 February, 1992).





B. Superfyke sampling (17-18 March, 1992).

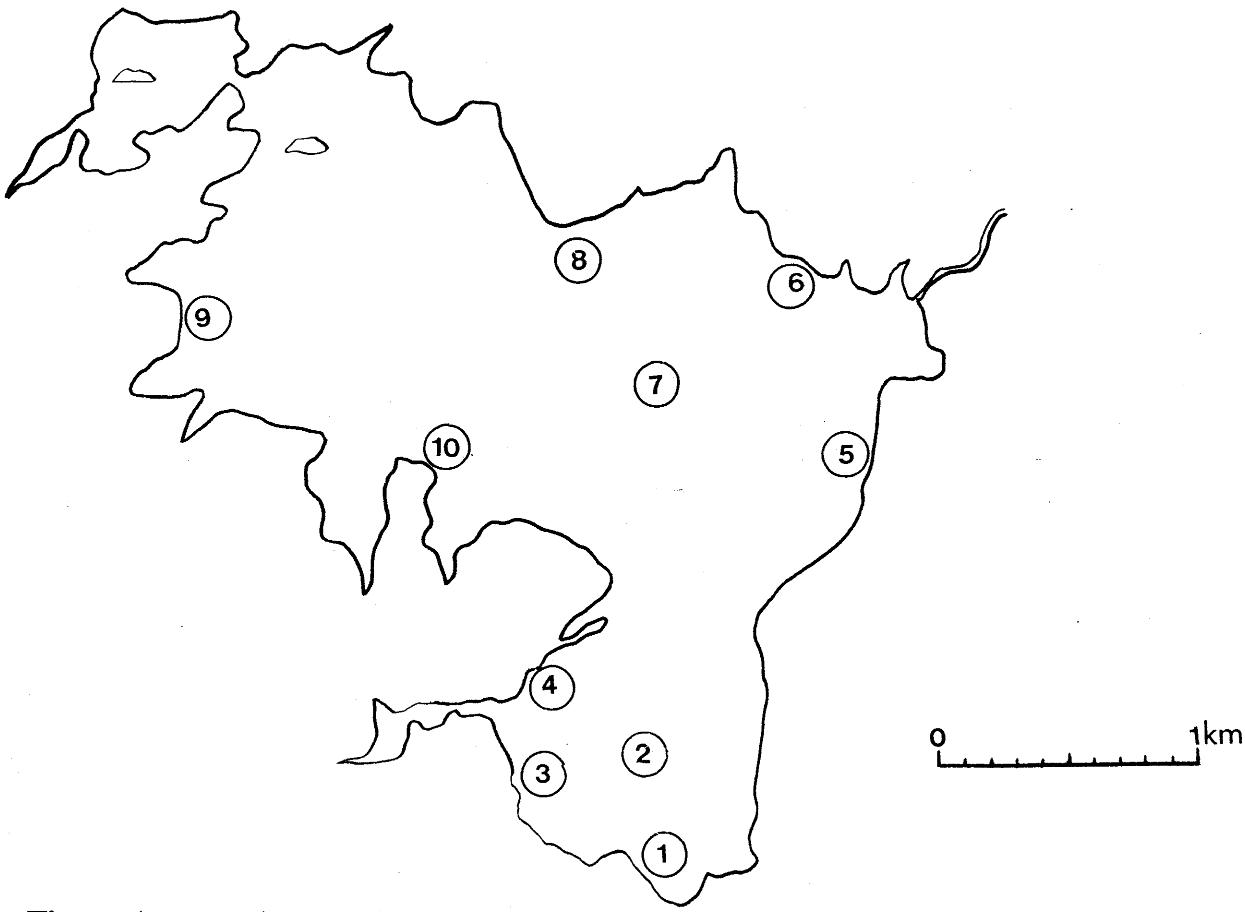


Figure 1. Lake Waahi sampling, February - March 1992.

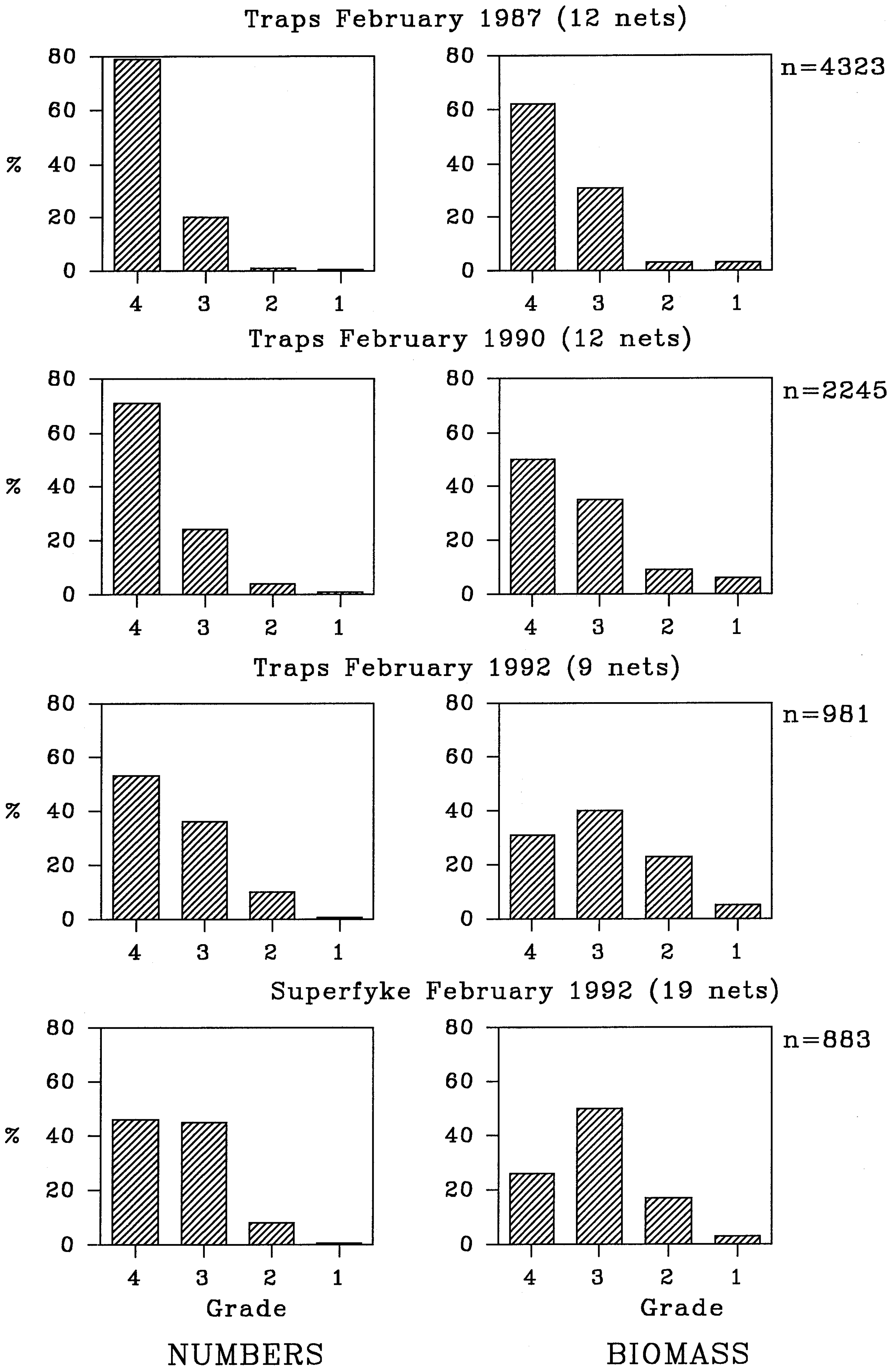


Figure 2. Percentage of shortfinned eels by number and by biomass in four size grades (Appendix 3), from trapnet samples taken from Lake Waahi in February 1987 (n=4323), 1990 (n=2245) and 1992 (n=981), and in superfyke net samples in 1992 (n=883).

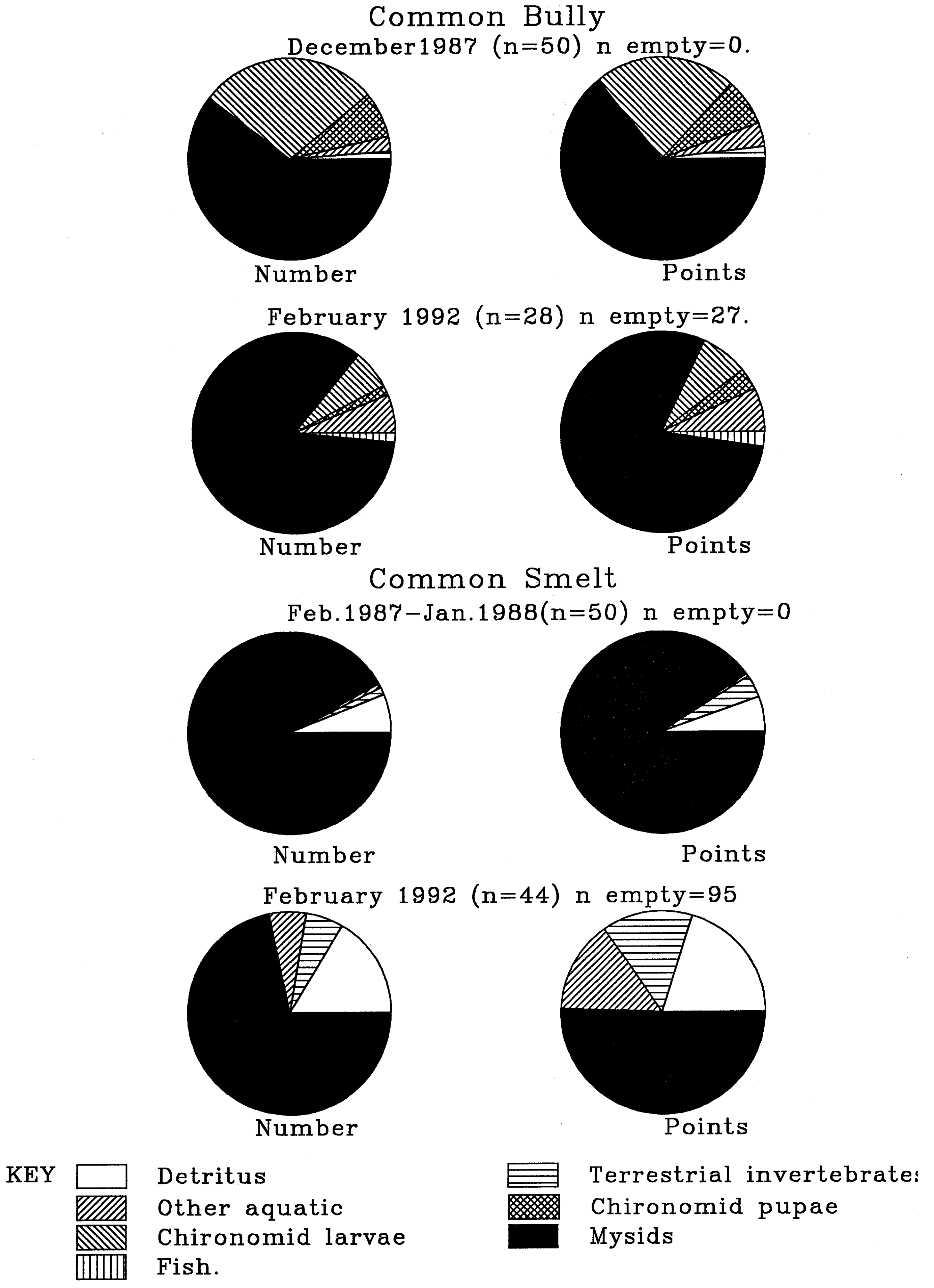


Figure 3. Percent of number and points for 7 food catergories in the diet of common bullies and common smelt from Lake Waahi.

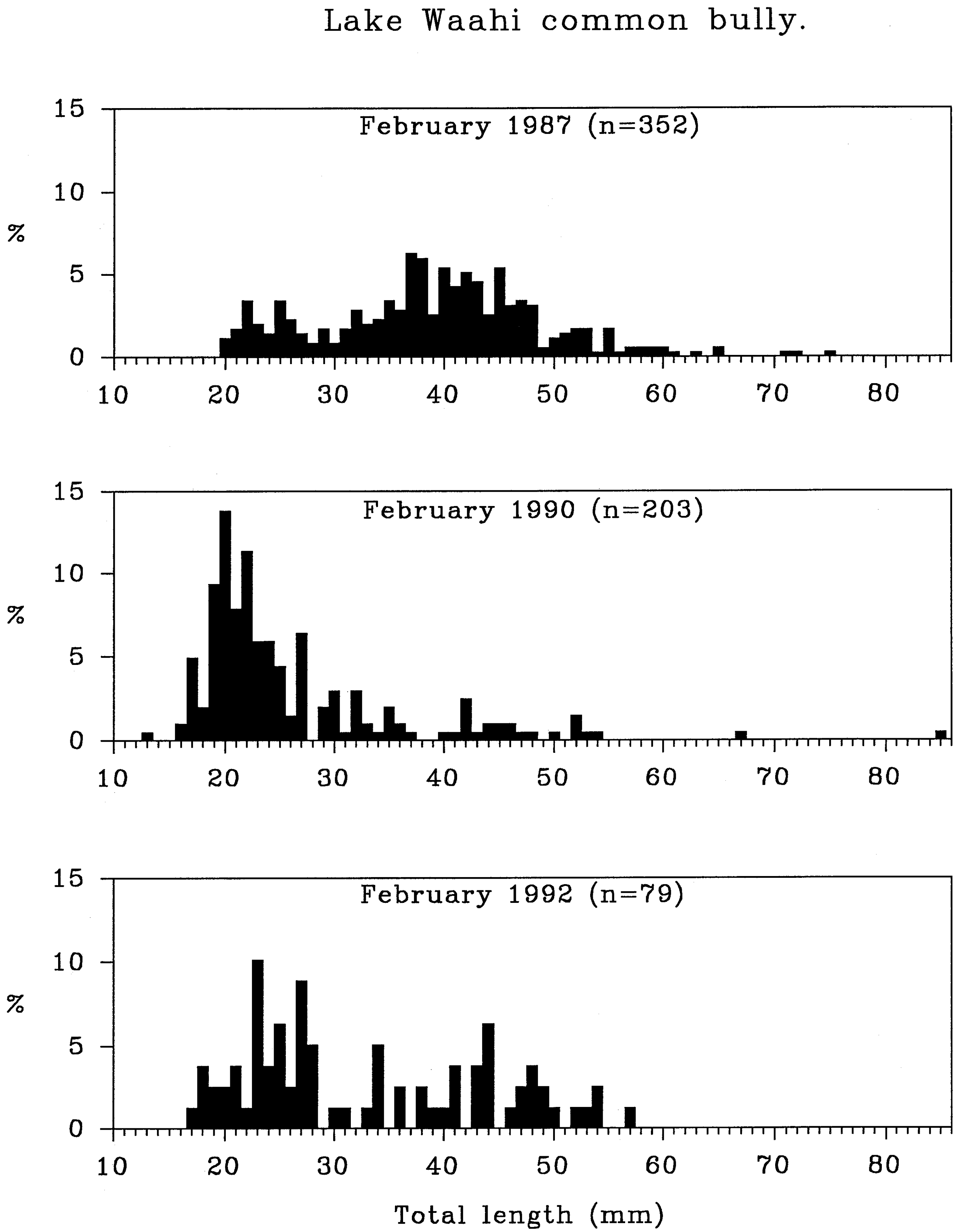


Figure 4. Length frequency distribution of common bullies in trap net samples from Lake Waahi, February 1987, 1990 and 1992.

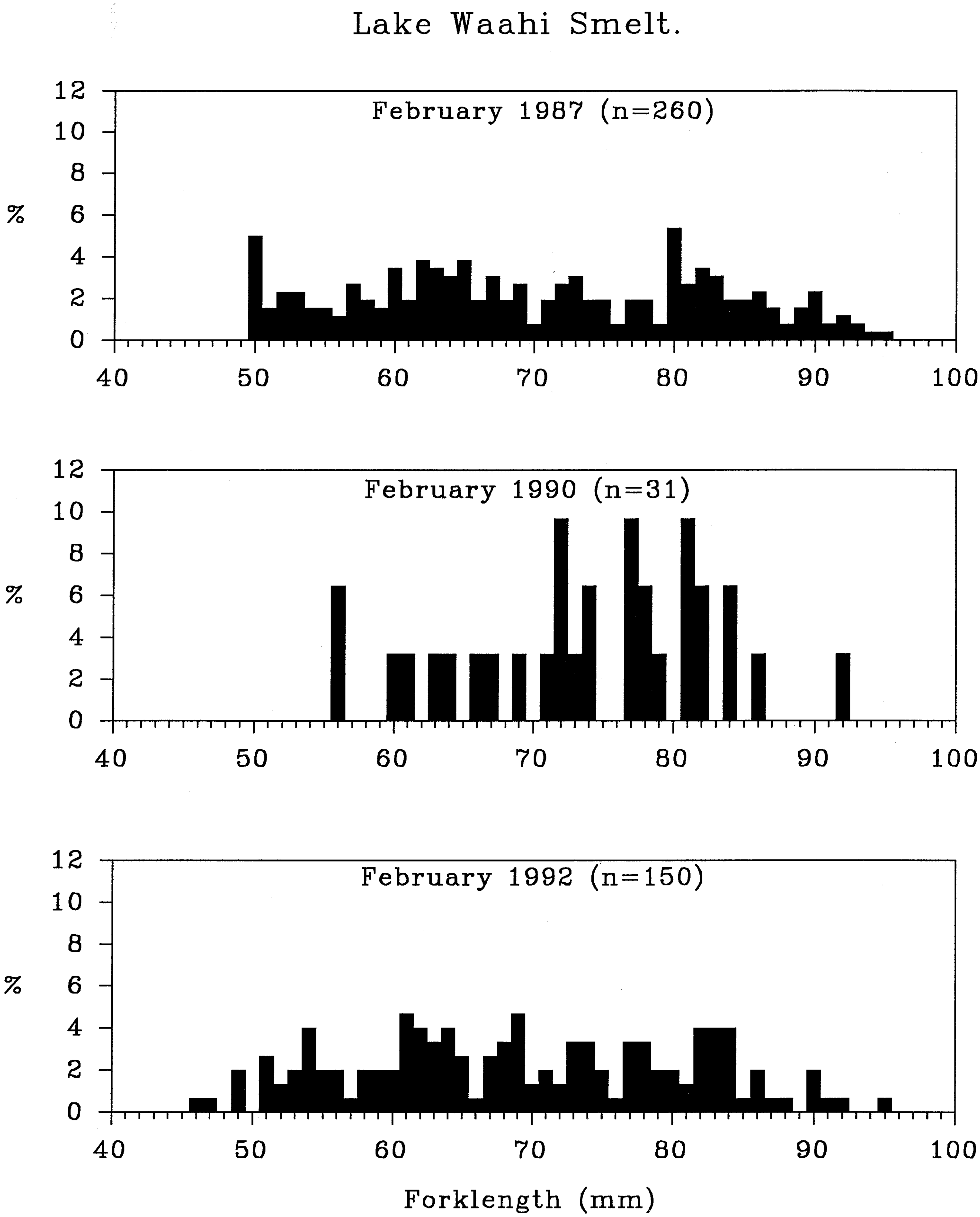


Figure 5. Length frequency distribution of common smelt in trap net samples from Lake Waahi, February 1987, 1990 and 1992.

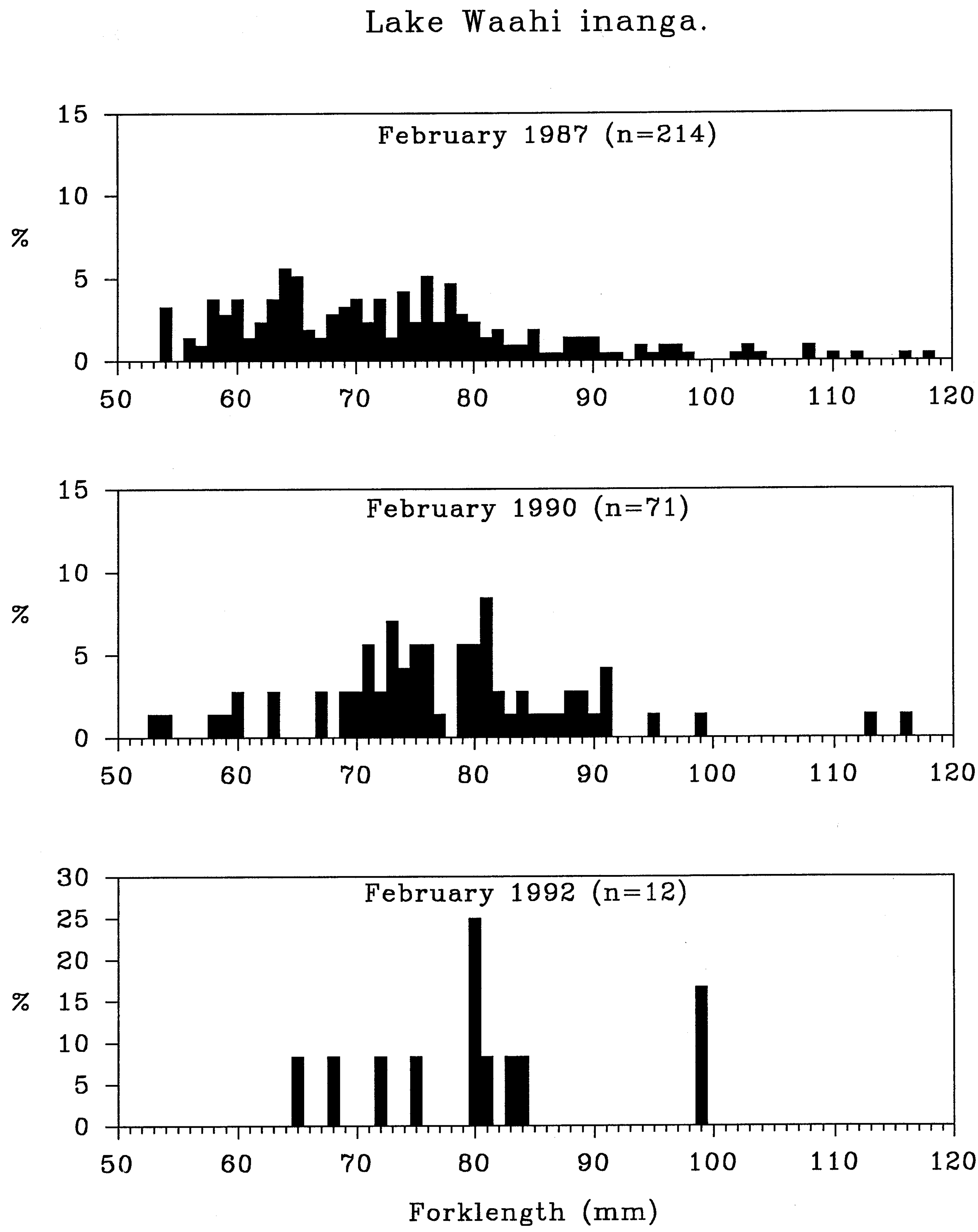
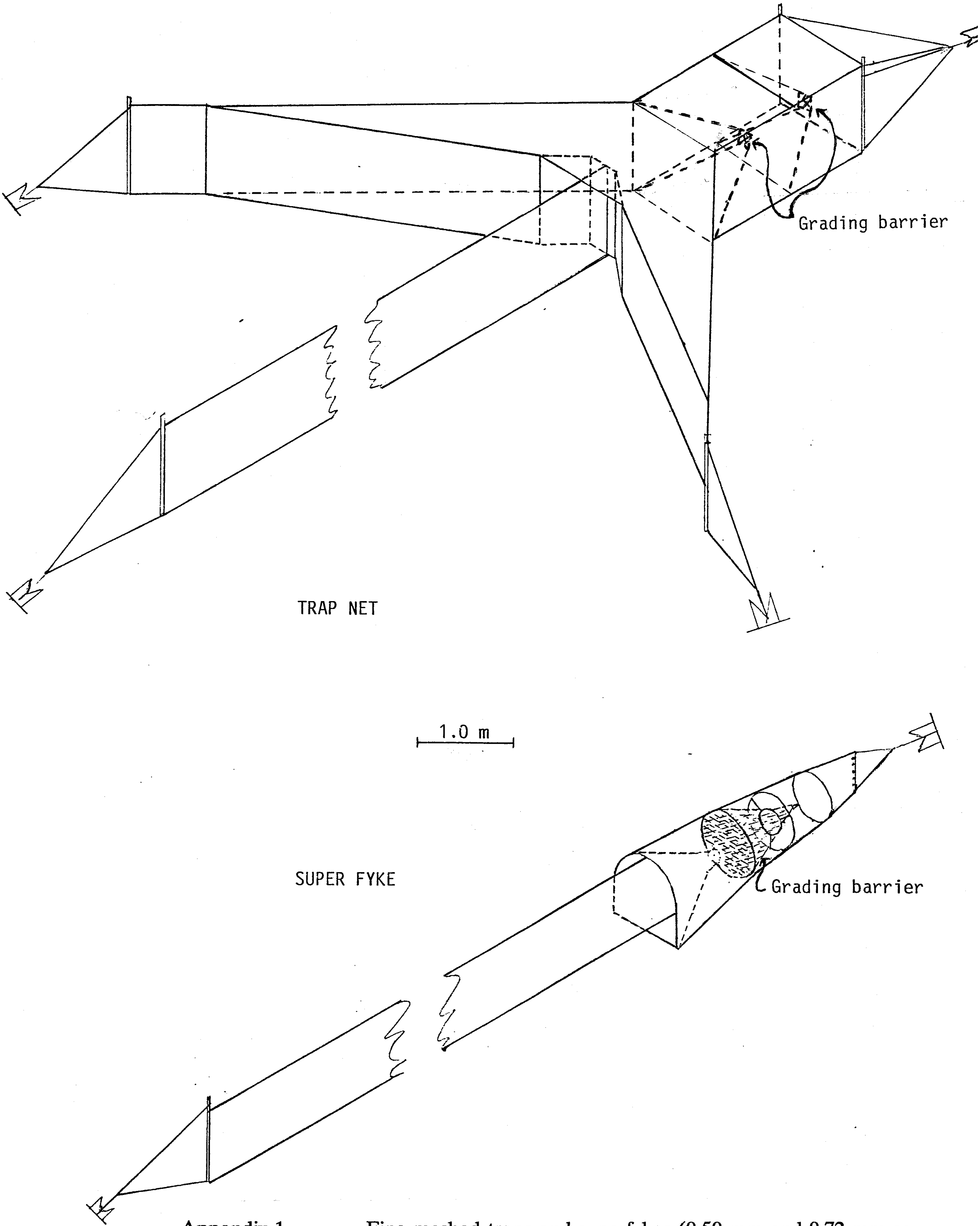


Figure 6. Length frequency distribution of inanga in trap net samples from Lake Waahi, February 1987, 1990 and 1992.



Appendix 1. Fine meshed traps and superfykes (0.50 mm and 0.72 mm square mesh respectively).

Appendix 2 Total weight (g) of four fish species and mysid shrimps caught in traps and superfykes set in Lake Waahi, February 1992.

	Traps				Superfykes			
Species	Shore	Middle	Outer	Total	Shore	Middle	Outer	Total
Bullies	5935	3856	4112	13903	1504	551	360	2415
Smelt	1197	1001	576	2774	28	-	-	28
Inanga	95	11	96	202	8	-	-	8
Mosquitofish	36	-	-	36	12	-	-	12
Mysids	62	58	48	168	40	35	20	95

Appendix 3 Mean lengths (mm ± SE) and weights (g ± SE) of the four grades of shortfinned eels collected from Lake Waahi in February 1987, 1990 and 1992.

	Grades							
	4	3	2	1	4	3	2	1
Year	Mean length				Mean weight			
1987	321±7	419±5	512±10	631±15	72±4	146±5	271±15	559±32
1990	341±8	435±8	503±8	628±22	70±4	147±9	248±9	534±62
1992	355±3	414±3	510±38	620±28	86±3	131±5	264±9	617±60

Appendix 4 Fish caught in four panel gill nets set in reed beds in Lake Waahi, February 1992.

Species	N	Length range (mm)
Rudd	89	≈200 - 350
Mullet	7	173 - 390
Catfish	6	-
Goldfish	3	-