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REPORT 10

THE TASMANIAN TROUT FISHERY

III. THE RIVERS OF THE NORTH AND EAST

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Cronulla, Sydney
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SUMMARY

This report refers chiefly to the rivers of the South and North Esk systems.

A study of the daily catch from these rivers, as derived from anglers' returns, shows a general fall which is statistically significant in all rivers except the Meander, and this fall becomes increasingly important from west to east. It is accompanied by a fall in the annual catch per angler which is closely correlated with the increase in the number of licences, from which it might appear that these streams are being fished to their full capacity. A study of the mean length of fish at capture does not show any decrease conformable with over fishing, neither has there been any increase in growth rate, which might be expected under conditions of overfishing. The age distribution of the fish caught by anglers does not indicate any decrease in the proportions of older fish. A personal canvass of 53 anglers in one district showed a mean total catch per angler of 259 fish, whereas the figure derived from anglers' returns for the same season was 20 fish per angler. It is concluded that the apparent decline in catching rate was due to the returns from anglers being unrepresentative. It is shown that there was no real correlation between the catches of anglers and the fish available to anglers as a result of stocking these streams.

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THE TASMANIAN TROUT FISHERY

III. THE RIVERS OF THE NORTH AND EAST

By A. G. Nicholls

The fishery in the rivers of the north and east of Tasmania will be dealt with in the same way as that for the North West Region, described in the general introduction given in Part I of this series of reports (Nicholls 1957a).

On reference to the Regional Planning Atlas it will be apparent that while it was convenient to deal with the rivers of the north-west of the State under the North West Region as defined in that Atlas, for the remaining rivers which are of importance to the fishery a considerable departure from the defined regions will have to be made. This is because the majority of the rivers arise, in part at least, from the central plateau; this and highlands lying to the east of the agricultural midlands are included in the Midlands Region which is not a natural one as far as the rivers are concerned, though it does include all the more important lakes.

Reference to the map shows that the Midlands Region includes the headwaters of the Derwent River which flows southward to enter the sea in Storm Bay, and those of the South Esk River which flows northward to the head of the Tamar Estuary which opens into Bass Strait. These two rivers are the longest in the State, with larger basins than those of any other rivers.

The account of the fishery of the North and East will thus be largely a statement of the fishery of the South Esk and its several tributaries, and of the North Esk which flows independently into the Tamar at Launceston. The North Esk lies wholly in the North Region, which is also drained by a number of rivers flowing north and east to open independently into Bass Strait or the Tasman Sea respectively.

II. THE SOUTH ESK RIVER SYSTEM

(a) Environmental Characteristics

The main river, the South Esk, is about 100 miles in length. It rises on the slopes of Ben Nevis and flows for about 30 miles in a general south easterly direction to Fingal where it is joined by the Break O'Day Rivulet, a

tributary rising about 15 miles to the east within 4 miles of the east coast. From Fingal the South Esk flows in a generally south-westerly direction for about 16 miles to Avoca where it receives the St. Paul's Rivulet, a tributary about 30 miles in length draining country lying to the south and east of Fingal. After another 9 or 10 miles it changes direction near Llewellyn to flow approximately north west to Evandale, a distance of about 24 miles. During the latter part of this section the river meanders considerably. From Evandale to Launceston the river makes a large westerly loop, passing through Longford and Hadspen, at which towns it receives its two largest tributaries, the Macquarie and Meander respectively.

Below Mathinna (some 15 miles above Fingal) the South Esk has a mean gradient of about 10 ft per mile; above that point its descent from the headwaters is much more rapid and in its final descent to the sea it flows through the Cataract Gorge at Launceston, a short section of moderately steep gradient. Just above this point it has recently (1955) been dammed to produce hydro-electric power.

The headwaters of the Macquarie drain Tooms Lake and country lying to the north at an altitude of from 1500 to 2000 ft. After descending to below 900 ft in the first 20 miles it receives tributaries draining an area extending from the vicinity of Oatlands to Lake Sorell in the east, and changes to a generally north-westerly direction. Its first major tributary is the Elizabeth River which rises in Lake Leake at an altitude of 2000 ft and flows through Campbelltown. The Isis, a stream of moderate size, joins it below Campbelltown. Near Cressy it receives the Lake River, which drains Arthur's Lakes some 20 miles to the south west, but probably twice that distance along the river bed. Brumby's Creek, a small stream of local importance to the fishery, rises 10 miles to the west on the slopes of the Western Tiers (the eastern escarpment of the Central Plateau) and flows into the Macquarie at Cressy. In general, the Macquarie and its tributaries drain roughly the south western third of the South Esk basin. It joins the South Esk at Longford at about 500 ft above sea-level, so that the mean gradient over the last 60 miles of its course is about 5 ft per mile. It thus has a very low rate of fall and for most of its course it is a slowly moving stream, meandering through agricultural land, composed of a series of long deep pools joined by short stretches of shallow water, and subject to considerable flooding in winter. That section of the Macquarie lying below the point of entry of the Lake River is locally known by the latter name and is even so named on the State maps. That this is physiographically inaccurate is clearly seen from

both the 4 in/mile detailed map of the Longford district and the aerial photograph reproduced in Plate 1. The Lake River is, in fact, a moderate sized tributary of the Macquarie.

The most westerly component of the South Esk System is the Meander River which rises in Lake Meander at a height of 4200 ft on the northern edge of the Central Plateau. It descends 2700 ft in the first 2½ miles making a direct fall of about 500 ft at one point. During the next 6 or 7 miles it descends a further 600 ft and receives several small tributaries from the adjacent mountainous country, reaching the 1000 ft contour near the township of Meander. From there to Deloraine, a river distance of not less than 10 miles, it falls another 200 ft during the course of which it receives one major tributary of similar size to itself, the Dairy Rivulet (or Western Creek), and a few minor creeks. Together these drain an area of good agricultural land. From Deloraine to its confluence with the South Esk at Hadspen, a river distance of not less than 30 miles, it follows a meandering course in an easterly direction and descends to 440 ft above sea-level, with a mean gradient of about 10 ft per mile over the last 40 miles. Near Westbury, between Deloraine and Hadspen, it is joined by Quamby Brook, a major tributary rising in the mountains to the south, and at Carrick it receives another important tributary, the Liffey River, which while rising in similar mountainous country flows for much of its length through agricultural land. This river is about 25 miles in length and has a gradient of about 35 ft per mile through the last 16 miles. From the north the Meander receives several minor tributaries between Deloraine and Hadspen. The total area of its basin is about 600 sq. miles.

Apart from isolated patches of highlands lying above 3000 ft (including Ben Lomond over 5000 ft) the greater part of the South Esk basin lies below 2000 ft, and about one half is below 1000 ft. The average annual rainfall for most of the area is 30 in., reaching higher figures only in the headwaters of the South Esk and Meander. The average monthly flow over a period of 50 years for the South Esk at Launceston was 2435 cusecs (range 97 to 23,177). Much of the country comprises native pasture grazing lands, carrying sheep and cattle; there is a fair extent of rotational cropping and improved pastures, particulary in the Longford to Deloraine area. More intense cultivation, mainly orchards, is found on either side of the Tamar. Apart from the city of Launceston there are no large towns comparable with those of the North West Coast, and nowhere does the population density exceed 16 per sq. mile except,

of course, within the boundaries of the numerous country towns.

For the analysis of the fishery in this system, each group of tributaries will be dealt with separately in sub-systems and then compared.

(b) The Meander River Sub-system

(i) The Daily Catch.- Figures for the nine seasons from 1945-46 to 1953-54 are given in Table 1 and illustrated in Figure 1. Figures for the Meander River include the catches from all tributaries except the Liffey from which there are sufficient data to enable a separate examination, but the results for the Liffey cannot be regarded with a high degree of confidence owing to the few returns received for the last three seasons (3, 2, and 1 respectively).

TABLE 1

MEAN DAILY CATCH PER ANGLER FROM MEANDER RIVER SUB-SYSTEM

	Meander R.			Liffey R.			Meander Sub-system		
	No. Fish	No. Days	Fish /Day	No. Fish	No. Days	Fish /Day	No. Fish	No. Days	Fish /Day
1945-46	73	18	4.1	61	23	2.7	134	41	3.3
1946-47	121	48	2.5	300	51	5.9	421	99	4.3
1947-48	114	36	3.2	34	10	3.4	148	46	3.2
1948-49	130	42	3.1	26	12	2.2	156	54	2.9
1949-50	379	132	2.9	90	35	2.6	469	167	2.8
1950-51	316	85	3.7	161	53	3.0	477	138	3.5
1951-52	102	39	2.6	10	5	2.0	112	44	2.5
1952-53	155	62	2.5	2	2	1.0	157	64	2.5
1953-54	198	60	3.3	3	1	3.0	201	61	3.3

From this table it will be seen that the mean daily catch per angler over the period has been fairly constant for the Meander sub-system. Statistical analysis shows that any variation in the means is of the magnitude of the sampling error only, indicating that there has been no important change in the fishery. When the Meander and Liffey are examined separately the regression line for the Meander shows a slight upward slope suggesting an overall improvement rather than a decline in the fishing. For the Liffey, however, there has been a fall in the daily catch which is significant though

Plate 1. Aerial photograph showing the junction of the Lake River with the Macquarie River. The Latter is seen flowing in a northerly direction, and receiving the Lake River on its left bank in the lower portion of the photograph. The Lake River shows a number of minor flood channels and has a deltaic mouth with two main courses of which the more southerly is the large and more permanent.

not highly so.

(ii) Fish Lengths.- Table 2 gives the mean lengths of fish from the Meander and Liffey Rivers.

TABLE 2

MEAN LENGTHS OF FISH FROM MEANDER AND LIFFEY RIVERS

Season	Meander R. No. of Fish	Meander R. Mean L. (in)	Liffey R. No. of Fish	Liffey R. Mean L. (in)
1949-50	332	11.7	76	12.7
1950-51	362	11.5	150	11.3
1951-52	185	12.0	5	11.2
1952-53	142	11.9	4	12.5
1953-54	171	11.6	3	10.0

Statistical analysis shows no significant differences in the mean lengths of the fish from the Meander River as between seasons. The variation in the Liffey is greater, and these means were significantly different. However, the means for the last three seasons were based on so few fish that they cannot be regarded as representative of the population. There was a significant difference between the means for the first two seasons which shows a fall in length due possibly to the relatively better survival of one year class.

(iii) Growth and Age.- Scale samples are available from 214 fish from the Meander and Liffey Rivers; 69 were taken from the Meander at Deloraine and 82 at Westbury between September 1, 1949 and April 19, 1950, and 16 were taken from the Liffey in the same season; 5 only were taken from the Meander at Lemana in December 1950 and 42 from the Liffey between September 2, 1950 and March 24, 1951. The results obtained from reading these scales are set out in Table 3.

TABLE 3

MEAN LENGTH-FOR-AGE OF FISH FROM
MEANDER RIVER SUB-SYSTEM

Age (yr)	No. Fish	Mean Lengths (cm) L_1	L_2	L_3	L_4	L_5	At Capture L (cm)	W (g)	K
				Lemana: 1950-51					
5	1	12.5	21.0	27.0	31.0	35.0	37.0	480	0.97
3	4	9.6	21.4	25.6			28.5	243	1.02
G.M.		10.2	21.3	25.9	31.0	35.0	-	-	1.01
				Deloraine: 1949-50					
5	2	10.8	22.5	31.5	38.8	43.5	44.3	840	0.94
4	4	13.3	24.0	31.8	38.4		38.4	650	1.10
3	17	11.0	21.0	28.0			29.0	374	1.56
2	46	11.0	23.2				25.5	301	1.86
G.M.		11.1	22.7	28.9	38.5	43.5	-	-	1.72
				Westbury: 1949-50					
4	2	13.0	28.0	34.5	37.5		38.3	555	0.99
3	42	12.0	23.1	30.6			32.5	389	1.13
2	38	12.3	24.1				27.0	261	1.30
G.M.		12.2	23.7	30.8	37.5		-	-	1.21
				Liffey R.: 1949-50					
3	5	11.9	22.8	29.1			31.2	386	1.01
2	11	12.3	24.0				26.1	191	1.03
G.M.		12.2	23.6	29.1			-	-	1.02
				Liffey R.: 1950-51					
4	6	12.9	23.4	29.1	33.2		34.5	462	1.10
3	8	10.3	20.8	26.8			29.0	260	1.05
2	27	11.6	22.5				24.6	169	1.10
1*	1	11.0					20.5	85	1.02
G.M.	41	11.5	22.3	27.8	33.2		-	-	1.09
				Meander R. Sub-System: Summary					
5	3	11.4	22.0	30.0	36.2	40.7	41.9	720	0.95
4	12	13.1	24.4	30.9	35.7		36.4	540	1.08
3	76	11.5	22.3	29.3			31.1	364	1.20
2	122	11.7	23.4				25.8	249	1.44
1*	1	11.0					20.5	85	1.02
G.M.		11.7	23.0	29.5	35.8	40.7	-	-	1.33
Br.		4.6	9.1	11.6	14.1	16.0	-	-	48.0

* Excluded from Grand Means

Statistical analysis shows no significant difference between the mean lengths at capture of fish of the same age groups as between those taken at Lemana and those taken at Deloraine; on the other hand a similar comparison between those taken at Deloraine and at Westbury shows that the difference is significant.

For the Liffey River statistical analysis shows no significant difference between those taken in 1949-50 and those taken in the following season; these fish have therefore been pooled to represent this river. Compared with those taken from the Meander at Deloraine and at Westbury, the Liffey fish show no significant difference from the Deloraine fish, but they are significantly smaller than the fish from Westbury (at the 1 per cent. level). However, when the lengths-for-age of fish in each of these groups are compared it is found that the only significant difference is for the fish at 3 years of age in which those from the Meander at Westbury are significantly different (at the I per cent. level) from those taken elsewhere in the Meander and Liffey Rivers. It is probable that this difference is maintained in older fish but the numbers of observations in these groups are insufficient for reliable tests of significance. It has therefore been concluded that the mean growth of fish from the Meander and Liffey Rivers for the first three years may be expressed by the average of all the values obtained (Table 3) giving percentage increments of 97 and 28 respectively (based on metric measurements).

(iv) Condition.- The mean value of the condition factor for fish from this sub-system is 48.0, which is fairly high; in general the Meander fish show higher values than those from the Liffey. The values given in Table 3 show the usual downward trend with increasing age.

(v) Summary.- The daily catch per angler has shown variations which are not statistically significant and are probably due to sampling errors. There has been no change in the mean lengths of fish taken by anglers; a significant difference between two seasons in the Liffey was probably due to differences in the survival of consecutive year classes. The growth rate appears to be good and the condition factor of the fish is high.

(c) The Macquarie River Sub-system

(i) The Daily Catch.- It has been pointed out that physiographically that section of the river between Cressy and Longford, locally known as the Lake River, is undoubtedly the Macquarie and for purposes of this investigation

it is essential that they should be regarded as one and the same. Statistical tests on the lengths of fish from both sections of the river show that this view is justified. There is therefore no reason for separating these sections in the analysis of the daily catch. Brumby's Creek and the Elizabeth River are treated separately, the former because it is of interest to local anglers and the latter because it differs from the Macquarie in its nature and carried a smaller class of fish.

Figures for the nine seasons under review are given in Table 4 and illustrated in Figure 2.

TABLE 4

MEAN DAILY CATCH PER ANGLER: MACQUARIE RIVER SUB-SYSTEM

Season	Macquarie R.			Brumby's Ck.			Elizabeth R.		
	No. Fish	No. Days	Fish /Day	No. Fish	No. Days	Fish /Day	No. Fish	No. Days	Fish /Day
1945-46	40	11	3.6	84	35	2.4	-	-	-
1946-47	99	26	3.8	54	28	1.9	-	-	-
1947-48	5	5	1.0	230	63	3.7	-	-	-
1948-49	73	16	4.6	115	37	3.1	-	-	-
1949-50	217	88	2.5	115	56	2.1	101	25	4.0
1950-51	234	94	2.5	33	12	2.8	-	-	-
1951-52	68	24	2.8	21	9	2.3	-	-	-
1952-53	50	28	1.8	9	6	1.5	14	7	2.0
1953-54	125	63	2.0	2	2	1.0	31	17	1.8

The average number of returns from the Macquarie for the first four seasons was just over five (5, 9, 2, 6), and for the last five seasons it was ten (17, 18, 8, 7, 7); for Brumby's Creek the numbers were 4, 4, 7, 6, 10, 6, 3, 2, 1. It is clear that over the last three seasons there has been a decline in the number of anglers fishing Brumby's Creek who supplied information in spite of an increase in the number of licensed anglers. The low number of returns throughout probably reduces the value of this analysis, but as far as conclusions may be drawn from such figures it appears that fishing in the Macquarie has fluctuated more or less evenly about a mean of 2.5 fish per day. Brumby's Creek shows an overall mean of 2.7 fish per day, with a decline in daily catch occurring only during the last three seasons. Figures based on three or fewer returns are of

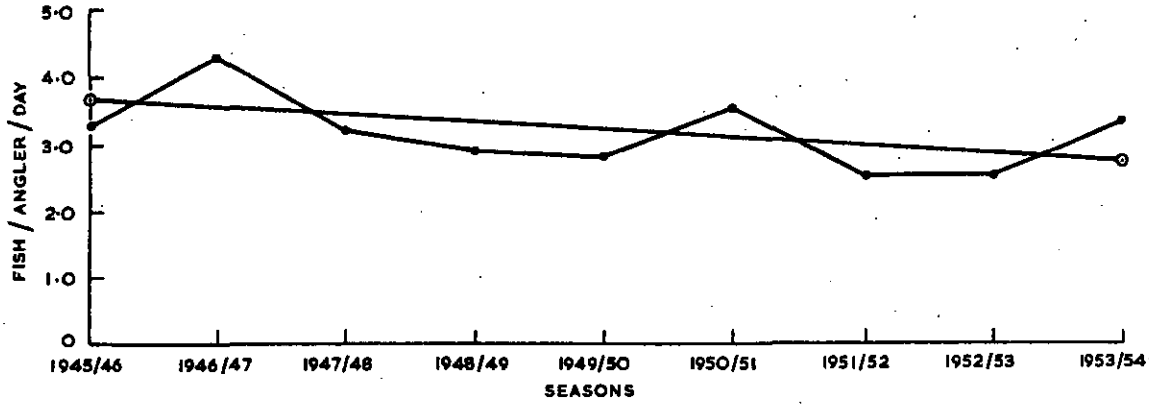

Fig. 1. Mean daily catch per angler from the Meander River Sub-system.

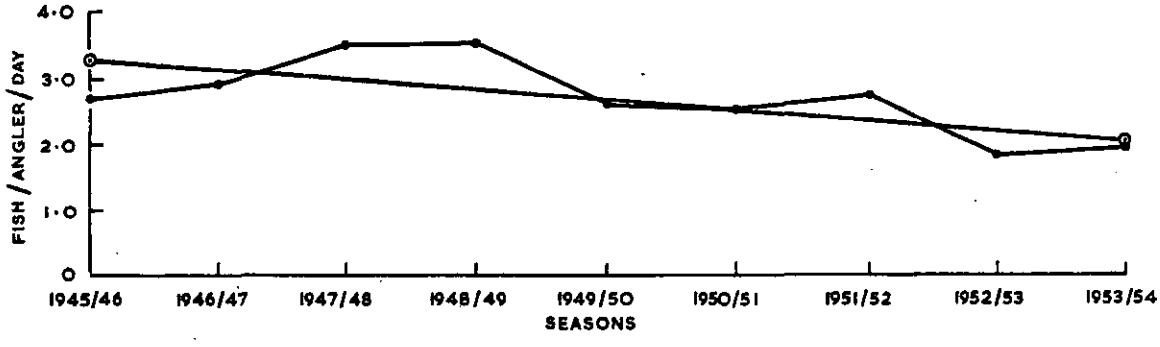

Fig. 2. Mean daily catch per angler from the Macquarie River Sub-system.

very doubtful value and are probably best ignored. The three sets of figures given for the Elizabeth River are based on 3, 4, and 3 returns; other returns from one angler in four other seasons have been omitted. If all the returns from this river system are combined there is some evidence of a fall since 1948-49.

Statistical analysis shows no significant difference between the means of the daily catch for the Macquarie sub-system. Separating the two major components discloses that the differences in the Macquarie River were highly significant, but that in Brumby's Creek there were no significant differences.

(ii) Fish Lengths.- The mean lengths of fish from the Macquarie (including the Lake), Brumby's Creek, and Elizabeth River for each season are given in Table 5.

TABLE 5

MEAN LENGTHS OF FISH FROM MACQUARIE R., BRUMBY'S CREEK, AND ELIZABETH R.

Season	Macquarie R.		Brumby's Creek		Elizabeth R.	
	No. Fish	Mean L. (in)	No. Fish	Mean L. (in)	No. Fish	Mean L. (in)
1949-50	186	13.6	122	14.3	93	12.5
1950-51	202	13.5	28	12.8	5	13.6
1951-52	62	12.4	13	14.6	5	12.2
1952-53	76	14.0	10	12.0	20	13.2
1953-54	105	13.5	2	19.0	40	11.5

Statistical analysis shows that the differences between the mean lengths for fish in the Macquarie were significant at the 5 per cent. level; for Brumby's Creek they were significant at the 1 per cent. level, and for the Elizabeth River the differences were not significant. In the Macquarie River the means went down for the first three seasons, rose in the fourth, and went down again in the last season. There was thus no continuous trend and the mean length in 1953-54 was the same as that at the beginning of this 5-year period. These facts do not indicate any progressive increase in size due to depletion of the population. The season 1951-52 (with the lowest mean length) was marked by the absence of any large fish (20 in. and over) recorded by those anglers making returns, but for the other four seasons the percentages of such fish were 6.5, 4.0, 7.9, and 6.7

respectively. Statistically there is no significant difference between these proportions which indicates that there was no significant change in the catch of large fish. Fewer fish were recorded in 1951-52 than in the other seasons but it had the highest daily catch rate for the last five seasons. Reliable seasonal comparisons of the fishery in Brumby's Creek and the Elizabeth River are not possible in view of the small numbers of fish recorded.

(iii) Growth and Age.- Scale samples are available for examination from these rivers; 93 were from the 'Lake' River between September 5, 1949 and April 23, 1950 and 5 in October and December 1950; 45 were from the Macquarie between October 2, 1950 and April 2, 1951; and 108 were from Brumby's Creek between September 1, 1949 and April 16, 1950. Statistical analysis of the lengths at capture within each age group shows that there is no reason why fish from the Lake and Macquarie should not be pooled. The differences for fish of 6, 5, and 3 years of age were not significant; for 4-year fish the difference was significant at the 5 per cent. level, and for 2-year fish it was significant at the 1 per cent. level. The pooled values indicate the mean sizes of fish at each year of age for each age group for all fish from the Macquarie. There is no difference between fish from the section of the river at Longford and those taken higher up. Fish taken from Brumby's Creek have been separated from the rest for comparison. The values are given in Table 6.

TABLE 6

MEAN LENGTH-FOR-AGE OF FISH FROM MACQUARIE RIVER AND BRUMBY'S CREEK

Age (yr)	No. of Fish	Mean Lengths (cm) L_1	L_2	L_3	L_4	L_5	L_6	L_7	At Capture L (cm)	W (g)	K
Macquarie River											
7	4	12.8	26.8	31.8	38.1	43.3	48.0	51.3	52.0	1285	0.93
6	9	12.8	22.9	29.9	36.5	42.0	46.8		47.7	1079	0.99
5	16	13.5	25.4	33.9	41.2	46.1			47.7	1135	1.01
4	31	10.7	22.8	30.4	36.1				38.2	610	1.07
3	53	11.9	22.9	29.6					32.4	414	1.19
2	28	11.6	23.2						27.7	262	1.20
1*	2	15.0							26.8	275	1.40
G.M.		11.8	23.3	30.5	37.6	44.4	47.2	51.3	-	-	1.13
Br.		4.6	9.2	12.0	14.8	17.5	18.6	20.2	-	-	40.8
Brumby's Creek											
6	1	10.0	21.0	33.0	38.5	45.0	50.0		53.5	1390	0.91
5	9	12.1	25.1	34.4	40.4	45.0			46.7	1064	1.00
4	18	13.6	27.0	37.1	42.7				44.9	941	1.02
3	49	11.6	23.0	30.6					33.3	415	1.09
2	29	12.8	25.3						29.7	294	1.08
1*	2	12.0							29.0	260	0.98
G.M.		12.3	24.5	32.6	41.8	45.0	50.0		-	-	1.07
Br.		4.8	9.6	12.8	16.5	17.7	19.7		-	-	38.7

*Excluded from Grand Means

It will be seen that the grand mean lengths of fish from Brumby's Creek are very similar to those of the Macquarie River, and statistical analysis shows that the differences are not significant for all ages except L_3 (significant at the 1 per cent. level) and L_4 (significant at 0.1 per cent.) This may indicate that fish grow better in Brumby's Creek than in the main river after their second year, and the grand means would suggest that growth there is somewhat better throughout life.

The percentage mean increments (based on metric

measurements) up to L_6 for each river are:-

	L_1-L_2	L_2-L_3	L_3-L_4	L_4-L_5	L_5-L_6
Macquarie	97	31	23	18	6
Brumby's	99	33	28	8	11

which indicate that up to 4 years of age fish do better in Brumby's Creek than in the Macquarie. The figures for later years are probably based on too few fish to be representative.

No data are available for the Elizabeth River.

(iv) Condition.- The mean value for the condition factor of fish from this sub-system is somewhat lower than might be expected. The values given in Table 6 suggest that it is higher in the Macquarie than in Brumby's, and while the values for the former show the usual downward trend with increasing age, those for Brumby's Creek appear to be close to the mean of 38.7 for all age groups.

(v) Summary.- There has been no change in the daily catch per angler in Brumby's Creek, but a statistically significant fall is shown in the Macquarie. There was no indication of any progressive change in the mean lengths of fish taken by anglers from the Macquarie and the data are insufficient for reliable comparisons in fish from Brumby's Creek. The growth rate of fish in the Macquarie was good, and slightly better in Brumby's Creek, but the condition factor was not as high in either as might have been expected.

(d) The South Esk River Sub-system

(i) The Daily Catch.- This river is fished fairly extensively and over the nine seasons returns were received from anglers whose numbers varied from 6 to 18; the figures for the daily catch per angler are given in Table 7.

TABLE 7

MEAN DAILY CATCH PER ANGLER FROM SOUTH ESK RIVER

Season	Number of Anglers	Number of Fish	Number of Days	Fish per Day
1945-46	9	160	55	2.9
1946-47	14	648	148	4.4
1947-48	18	722	190	3.8
1948-49	6	72	39	1.8
1949-50	16	551	146	3.8
1950-51	15	307	99	3.1
1951-52	11	155	55	2.8
1952-53	17	104	58	1.8
1953-54	8	51	18	2.8

Although there is considerable seasonal fluctuation it will be seen on reference to Figure 3 that there has been a statistically significant downward trend over the past nine years.

(ii) Fish Lengths.- The mean lengths of fish for five seasons are shown in Table 8. These measurements include a few fish taken occasionally from the Ben Lomand Rivulet, Nile River, and St. Paul's Rivulet, and 133 and 33 taken from the Break O'Day Rivulet in 1949-50 and 1950-51 respectively. There does not seem to be any need to dissect the main stream since the population of takable fish in this subsystem appears to be evenly distributed as regards size.

TABLE 8

MEAN LENGTHS OF FISH FROM SOUTH ESK RIVER

Season	Number of Fish	Mean L. (in)
1949-50	445	12.4
1950-51	316	12.4
1951-52	97	12.7
1952-53	111	13.6
1953-54	61	12.0

Statistical analysis shows that the differences between these mean lengths are quite significant, but if the 1952-53 season's figures are omitted the differences are not significant. It might seem from the slight rise which appeared in the previous season that there was an upward trend due to a lowered population, but if this were so it is surprising to discover the lowest mean for the period in the final season. These variations could be due to fluctuations in the survival of the 1950 and 1951 year classes, or to heavy artificial stocking about this time. This will be discussed below (Section II, (e) (ii) and (f)).

(iii) *Growth and Age.- From this river* 164 scale samples are available, taken from the upper reaches (Ormley to Mathinna) in 1950-51; from the Break O'Day Rivulet 2 were taken in September 1949, and 21 in the following season. The readings from the scales are summarized in Table 9.

TABLE 9

MEAN LENGTH-FOR-AGE OF FISH FROM SOUTH ESK RIVER AND BREAK O'DAY RIVULET

Age (yr)	No. Fish	Mean lengths (cm) L_1	L_2	L_3	L_4	L_5	L_6	L_7	At Capture L (cm)	W (g)	K
South Esk River											
7	1	15.0	29.0	39.0	43.0	45.5	47.5	48.5	48.5	740	0.65
6	2	11.0	19.0	26.5	32.3	38.8	42.0		43.8	910	1.08
5	10	10.7	20.2	25.4	29.6	33.3			34.3	536	1.25
4	28	10.9	20.6	26.5	31.3				33.3	421	1.11
3	72	10.4	20.0	26.3					28.8	303	1.27
2	51	11.2	22.0						25.1	231	1.44
G.M.		10.8	20.8	26.4	31.2	35.1	43.8	48.5	-	-	1.29
Br.		4.3	8.2	10.4	12.3	13.8	17.2	19.1	-	-	46.6
Break O'Day Rivulet											
6	1	6.5	17.0	30.0	36.0	38.5	40.5		40.5	880	1.31
5	3	11.7	27.7	35.8	39.8	41.8			42.2	880	1.17
4	5	8.8	20.6	29.4	34.9				37.2	652	1.22
3	7	9.8	20.6	28.9					31.0	347	1.14
2	7	10.9	25.0						30.5	371	1.29
G.M.		10.0	22.7	30.4	36.7	41.0	40.5		-	-	1.21
Br.		3.9	8.9	12.0	14.5	16.1	16.0		-	-	43.7

In this Table the fish from the Break O'Day Rivulet for the two seasons have been pooled. The differences between the grand means for these two rivers are not significant at L_1 and L_5; they are significant at L_3 and L_4, and at the 1 per cent. level at L_2. Thus it would appear that growth is better in the Break O'Day Rivulet than in the South Esk River during most of the life of the fish. The numbers of fish of 5 years of age and over available from these two rivers are too small for any reliable comparison. The percentage mean increments (based on metric measurements) up to L_6 for each river are:-

	L_1-L_2	L_2-L_3	L_3-L_4	L_4-L_5	L_5-L_6
South Esk	93	27	18	13	25
Break O'Day	127	34	21	12	-

(iv) Condition.- The mean values for the condition factors of fish from these sources, given in Table 9, are fairly high and are similar to those of the Meander subsystem. Fish from the South Esk appear to have a higher condition factor than those from the Break O'Day, and while there is some indication of a fall with increasing age in the former, it is not shown in fish from the Break O'Day, probably because of the smaller numbers of fish in each age group.

(v) Summary.- Considerable seasonal fluctuation in the daily catch per angler is found, with an overall downward trend which is statistically significant. With the exception of one season, which could represent a sampling error, there has been no statistically significant change in the mean lengths of fish taken by anglers. The growth rate of fish is better in the Break O'Day than in the South Esk, but in both it is considerably poorer than in the other streams of this system. The condition factor, on the other hand, is relatively high and better in the South Esk than in the Break O'Day.

(e) Summary of Results and Discussion

(i) The Daily Catch.- The data for this river and all its tributaries are summarized in Table 10 and illustrated in Figure 4.

TABLE 10

MEAN DAILY CATCH PER ANGLER FROM SOUTH ESK RIVER SYSTEM

Season	Number of Anglers	Number of Fish	Number of Days	Fish per Day
1945-46	15	418	142	2.9
1946-47	25	1241	302	4.1
1947-48	26	1100	304	3.6
1948-49	12	417	147	2.8
1949-50	42	1453	482	3.0
1950-51	41	1056	344	3.1
1951-52	22	361	134	2.7
1952-53	28	334	163	2.0
1953-54	22	410	161	2.5

It will be seen that there has been a general decline in the number of fish taken per angler per day. The highest rate of catching was in 1946-47 after which it declined for two seasons, then after rising slightly to 1950-51 it fell again for the next two seasons, rising again in 1953-54. The general trend has been downwards and statistical analysis shows that this fall is significant.

It is of interest here to examine the diary of one angler, residing in Launceston, who has kept a record of his fishing in the rivers of this district since the 1940-41 season. This is complete except for two seasons in the early part of the period and one towards the end during which no record was kept; very little fishing was done during 1953-54. The summarized data from this diary are illustrated in Figure 5. Statistical analysis shows that the difference between the means is significant at the 5 per cent. level only. The regression line fitted to the points shows a slight downward trend, falling from 3.95 fish per day in 1940-41 to 2.33 fish per day in 1953-54. This represents a steady fall at a rate of 0.125 fish per day each year.

Comparison of this analysis with that of all anglers making returns shows a final value the same in both cases, but with a higher initial value for all anglers in 1945-46. The regression for this angler's catch over the last nine seasons only, shows a close agreement with the line for the fourteen seasons, indicating that the fall in his catching rate has been steady and that there has not been any acceleration during the last nine seasons compared with the five preceding seasons.

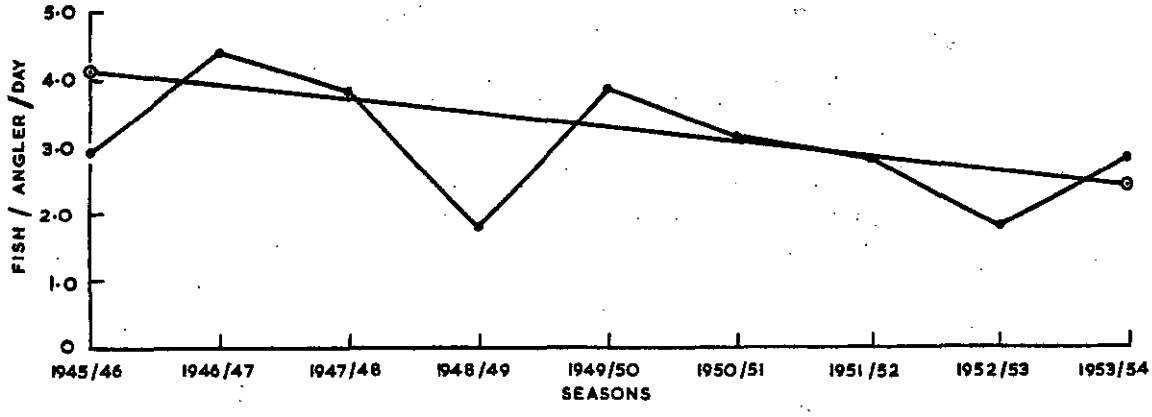

Fig. 3. Mean daily catch per angler from the South Esk River Sub-system.

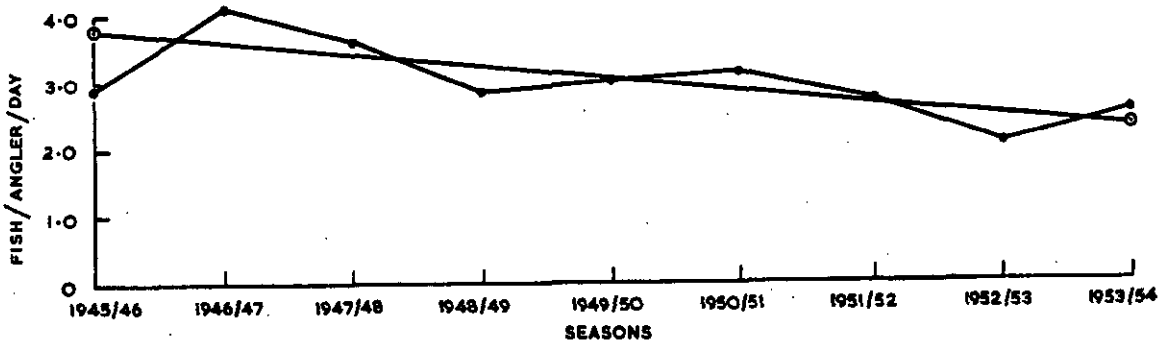

Fig. 4. Mean daily catch per angler from the South Esk System.

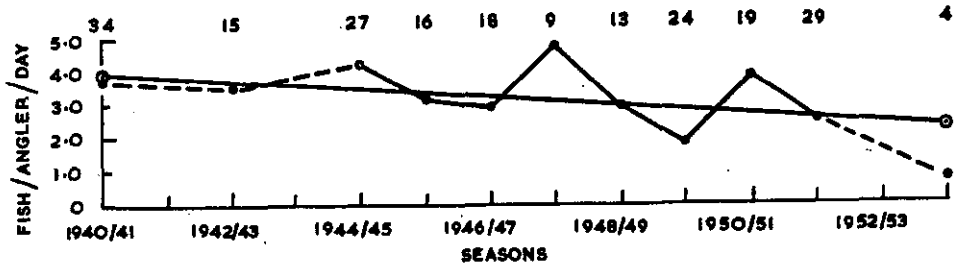

Fig. 5. Mean daily catch for one angler from the South Esk System over a period of 14 years. The figures at the top indicate the number of days fishing each season.

(ii) Fish Lengths.- Over 3,400 fish were measured from the rivers of the South Esk system during the last five seasons. The mean lengths are shown in Table 11.

TABLE 11

MEAN LENGTHS AT CAPTURE OF ALL FISH FROM THE SOUTH ESK RIVER SYSTEM

Season	Number of Fish	Mean L. (in)
1949-50	1254	12.6
1950-51	1063	12.2
1951-52	367	12.3
1952-53	363	12.9
1953-54	382	12.2

The results of comparing the means within rivers as between seasons have been given above, where it was shown that for the Meander River there were no significant differences, for the Macquarie River the differences were of only doubtful significance, and for the South Esk River they were not significant when one season was omitted. This exception can reasonably be regarded as due to a sampling effect. Comparison of the means between all rivers within seasons shows quite significant differences, indicating differential growth rates in different rivers.

It will be seen from Tables 2, 5, and 8 that in no case is there any evidence of a constant downward trend such as would be expected if there had been a marked depletion of the population during the period. There are, however, fluctuations, and it will be of interest to consider these in more detail for the three main rivers from which there are adequate data, on the assumption that such data are representative. These fluctuations can best be examined in percentage size-frequency diagrams of the fish taken by anglers, plotted for the Meander, Macquarie, and South Esk Rivers in Figure 6.

In general the changes in mean length are paralleled by changes in the composition of the population. In the Meander River, for example, in 1951-52 and 1952-53 when the means stood at their highest, there were smaller than normal proportions of fish in the smallest size group, and the drop in the following season was accompanied by a rise

in the proportion of small fish. The Macquarie shows stability during the first two seasons, an increase in the proportion of smaller fish in 1951-52 and a considerable decrease in this group in the next season, followed by a return in 1953-54 to the conditions found in the first two seasons. In the South Esk, again there was stability during the first two seasons, a decrease in the proportion of smaller fish in the third season, a further decrease in 1952-53, and a marked increase in the final season. It should be noted that some of the data presented in this Figure shows an even number bias, most evident for the South Esk in 1953-54, which suggests that some of the fish measurements were not made with care.

It is these variations in composition from year to year which produce the changes in the values for mean lengths of fish. It is possible that the smaller numbers of fish in the samples of some seasons may have been responsible for these changes (owing to their not being representative) and this is to some extent borne out by the figures for the Meander River which are consistently around 150 or more, and this river shows least variation - the differences were not statistically significant. Even here, however, there are variations in the proportions of small fish and it is possible that these may be related to the varying success in survival of particular year classes. The age distribution of fish taken from these three rivers over five seasons has been illustrated in Figure 11, and this may be compared with the data presented in Figure 6.

For the Meander it will be seen that the proportion of 9 in. fish was lower in 1951-52 and 1952-53 than in other seasons, suggesting a lower survival of the 1949 and 1950 year classes which would then be 2 years of age in each case. Figure 11 shows that there is some support for this suggestion. In the Macquarie it would appear that in 1951-52 there was an influx of small fish into the population suggesting a year of successful spawning in 1949; it would follow that 1950 was a year of poor survival and that 1951 showed some improvement. Figure 11 does not support this for the 1951-52 season which shows similar proportions of 1- and 2-year fish to those found in the preceding seasons, but it does indicate that 1950 was a year of less successful spawning since the proportions of 2-year fish in 1952-53 and of 3-year fish in 1953-54 were lower than in preceding seasons. At the same time there was in increase in the proportion of 2-year fish in 1953-54 supporting the suggestion of improved spawning success in 1951. The lower mean length in this river for 1951-52 is explained by the absence of larger fish (20 in. and over) from the catches

taken in that season. In the South Esk it appears from Figure 6 that 1959 was a season of less successful spawning, 1950 only moderately good, and 1951 would seem to have been very successful. Figure 11 shows that there was a fall in the proportions of 2-year fish in 1951-52, a further fall in the next season, and a pronounced rise in 1953-54. These facts suggest that, in general, changes in the mean lengths of fish caught can be related to variations in the success of natural spawning. It is certain that climatic conditions will influence the survival of young fish, from the time they are spawned until they enter the fishery; this question will be considered at more length in the final report. The possibility that changes in the abundance of fish are related to the rate of stocking with hatchery-reared fish will be considered below (Section II (f)).

(iii) Growth and Age.- The grand mean lengths of fish at each year of age are given in Table 12 for the three groups of streams comprising the South Esk system, together with the percentage mean increments.

TABLE 12

MEAN LENGTH-FOR-AGE OF FISH FROM SOUTH ESK RIVER SYSTEM

River	L_1	% Inc	L_2	% Inc	L_3	% Inc	L_4	% Inc	L_5	% Inc	L_6	% Inc	L_7
Meander & Liffey	11.7	97	23.0	28	29.5	21	35.7	14	40.7		-		-
S. Esk & Break O'Day	10.7	97	21.1	27	26.9	20	32.2	13	36.5	18	43.0	13	48.5
Macquarie & Brumby's	12.1	97	23.8	32	31.4	24	39.0	14	44.6	6	47.4	8	51.3

Statistical analysis shows significant differences between the mean lengths at each year as between the three rivers. For L_1 to L_5 the differences are highly significant; for L_6 they are significant only at the 5 per cent. level; and for L_7 they are not significant; however, only 5 fish are available for comparison in this group. It will be seen from Table 12 and Figure 7 that up to five years of age the best growth is found in the Macquarie River and Brumby's Creek; that the Meander and Liffey fish come next;

and that fish from the South Esk and Break O'Day show the lowest level of growth. For older fish, too few measurements are available to yield reliable results. Growth in the Meander and Macquarie is similar, but at L_3 the difference in mean length is quite significant; at L_2 and L_4 it is significant at the 5 per cent. level, and at L_1 and L_5 it is not significant. These differences in growth rate will affect the ages at which fish are caught in these rivers; this will be discussed below (Section II (e) (vi)).

(iv) Condition.- It has not been considered worthwhile to carry out statistical analyses of the condition factors for fish reported in this study because of doubts as to the overall reliability of the weights given. The general picture of condition as shown for each river is that it is best in the Meander and South Esk and poorest in the Macquarie. This would be in conformity with the general principles laid down by Huet (1954) in his study of stream gradients in relation to their habitation by fish. He has shown that most streams can be divided into four zones, of which the uppermost with the steepest gradient is occupied by trout, the next two being classified as 'grayling' and 'barbel' zones, while the lowest is the 'bream' zone. There is some overlap depending on width of stream and other species of fish which are normally present in European streams.

It would seem that in Tasmania these principles have a limited application since the majority of species listed by Huet are absent from these waters, and the only ones present have been introduced. Trout appear to have occupied the whole of the streams at the expense of the indigenous species, which have been unable to compete successfully and now just hold their own. Other introduced species (perch and tench) appear to inhabit the same stretches of water as the trout, except in the upper zones, and do not appear to have established any ascendancy even in those reaches which should provide conditions more suited to them. The application of Huet's principles here may possibly be seen in the condition of trout from different sections of the same system. The gradient and width of the Meander and South Esk are such as to fall within Huet's 'trout' and 'grayling' zones, and in these the condition factor of fish is higher than in the Macquarie which clearly belongs to the 'barbel' zone. It should be noted that trout in Tasmania occupy not only the three upper zones but also the lowest, or 'bream' zone, in which the width is greater than 25 m and the gradient is below 0.5 per mille; in fact, trout occur freely in the estuaries for at least part of the summer.

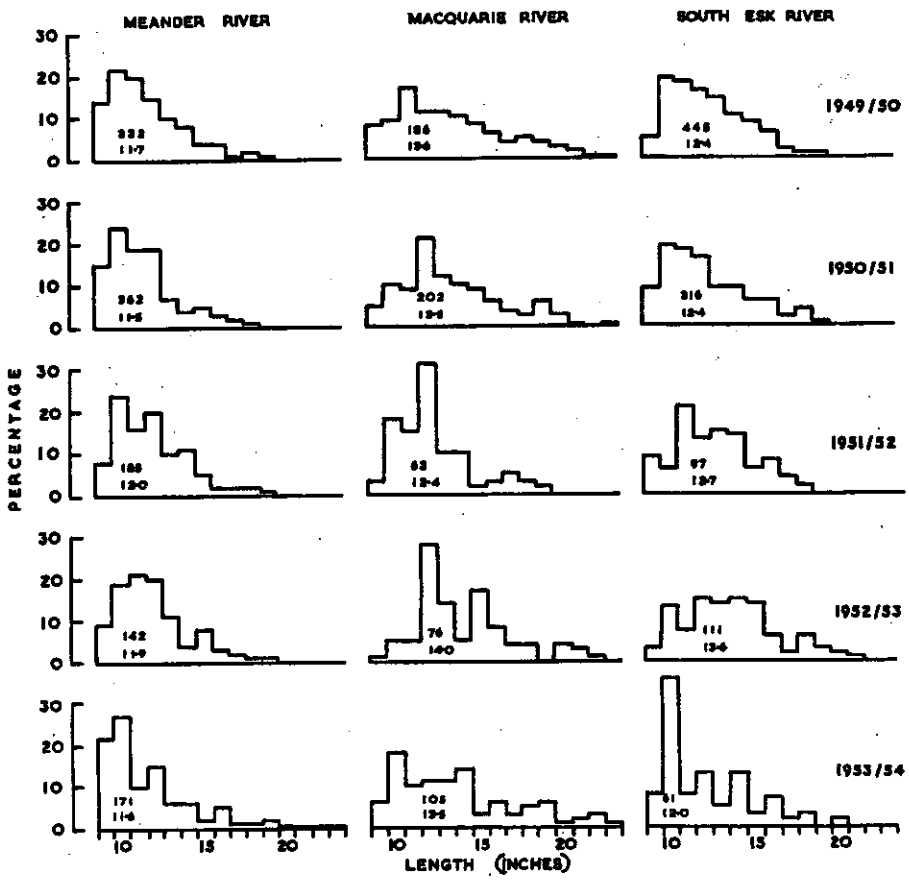

Fig. 6. Percentage size-frequency histograms of fish taken by anglers from the Meander, Macquarie, and South Esk Rivers during five seasons.

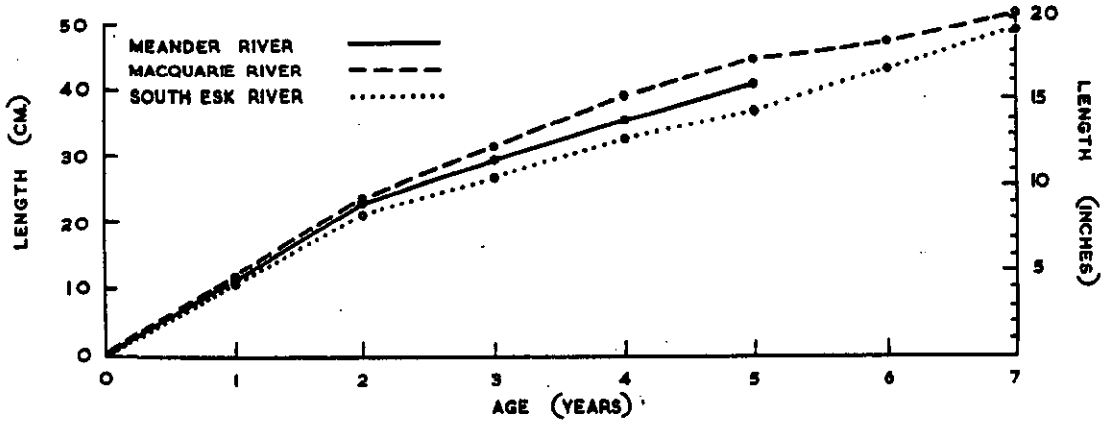

Fig. 7. Growth of fish in Meander, Macquarie and South Esk Rivers.

(v) Tagged and Marked Fish.- During the last five years over 21,000 marked fish have been released in this river system. The details are given in Table 13.

TABLE 13

RELEASES OF MARKED BROWN AND RAINBOW TROUT YEARLINGS

Date of Release	Brown or Rainbow	Number Released Marked	Number Released Tagged	River	Place
Sep. 1949	Br.	780	-	S. Esk	Clarendon
Sep. 1949	Br.	950	103	S. Esk	Native Point
Sep. 1949	Br.	803	-	S. Esk	Hadspen
Sep. 1951	Br.	1500	48	S. Esk	Llewellyn
Sep. 1951	Br.	1500	23	S. Esk	Ellerslie
Sep. 1951	Br.	2000	50	Lake	?
Sep. 1951	Br.	1550	48	Brumby's	-
Sep. 1952	Br.	3000	-	Macquarie	Stewarton
Sep. 1952	Br.	2000	-	Elizabeth	Campbelltown
Sep. 1952	R.	3000	-	S. Esk	Mathinna
Aug. 1952	R.	4000	-	Brumby's	Tributaries
Totals	-	21083	272		

Of the marked fish, six probable and one doubtful brown, and three rainbow trout have been reported as being captured. Two fish corresponding in age and mark to those released at Clarendon in 1949 were recaptured about a year later, one from the Break O'Day Rivulet at Fingal, the second from the Macquarie River at "Valleyfield". Two corresponding to those released at Hadspen in 1949, were recaptured from the South Esk River at Longford in March 1952. Two more, corresponding in mark and age to those released in the Macquarie at Stewarton in 1952, were recaptured at the same place in September 1955 and March 1956. The seventh was taken from the South Esk at Ormley in September 1953, and could have been one of those released at Native Point in 1949; no scales accompanied the report so that there is no certainty as to its identification. There has been plenty of evidence that anglers have marked fish on their own initiative during the period of this investigation, as in many cases marked fish reported have disagreed in mark and/or age with those known to have been released. It has therefore been necessary to accept as definite only those fish which corresponded both in mark and age to released fish. Of the rainbow trout recaptured two corresponding to those

released in Brumby's Creek in August 1952 were recaptured there about 4 months later; the third, taken at Mathinna in November 1954, was almost certainly one of those released at that place in September 1952. The single tagged fish reported was a brown trout yearling released in Brumby's Creek in September 1951, and was taken within a few weeks by a 2½ lb. brown trout and disgorged partly digested when the larger fish was landed by an angler fishing in Brumby's Creek.

Five of the recaptures reported indicate that over the course of a few years released fish had become dispersed throughout the river, judging from the distances which some appear to have travelled. Movement of this nature is not in accordance with the conclusions of Allen (1951) who found that in the Horokiwi River there was relatively little movement of tagged fish, and that "the great majority of fish were recaptured either at the point where they had been liberated or within a few hundred feet of it." (p. 75). It should, however, be borne in mind that his tagged fish were removed from the population for tagging and released in the same stretch of water, whereas in the present investigation the marked fish were additions to the population. Also, the river with which he was dealing is a comparatively small stream whereas the South Esk is a relatively large river. The maximum period of freedom in the Horokiwi fish was 333 days, whereas one of the South Esk fish was apparently free for four years and two were free for 3 and 3½ years. Still, Allen found no seasonal movements and tagged fish "recaptured while spawning were all taken at or near the point of liberation" (p. 76). The greatest distance travelled by any fish in the Horokiwi was about 4½ miles upstream in 195 days; the majority of those covering long distances moved upstream; but one appears to have moved downstream a similar distance in 51 days. In the present case, if the possibility of these fish having been marked by anglers can be excluded (by no means certain), for brown trout the movement of the two 2-year marked fish represents a distance of over 50 miles upstream in one case, and a distance of 20 miles downstream followed by a similar distance up a tributary in the other, within about one year; for two of the 4-year fish the distance travelled was about 10 miles upstream in 3 years while the other two were found near the place of release 3 and 3½ years later; and the fifth would have travelled at least 40 miles upstream in 4 years. The rainbows, on the other hand, which were almost certainly those marked in this investigation, apparently did little or no travelling even after 2 years.

Although Allen found spawning fish close to the point of liberation the difference in the size of the two rivers and

the greater time of freedom in the South Esk fish would have rendered more probable, and would have permitted, considerable seasonal movement. The marked yearlings liberated in the South Esk were mostly released in the lower stretches of the river where there is a considerable volume of water, not very suitable for spawning. Thus there would have been some inducement to move. Moreover, there is evidence that in the larger rivers of Tasmania a distinct spawning migration occurs, followed by a return to the lower reaches of the river or to the estuary. Thus the older fish taken many miles upstream could have made several such migrations during their period of freedom. Nevertheless, considerable doubt remains as to the reliability of some of the brown trout recaptures, especially in view of the known activity of anglers in marking fish by fin-clips which has continued during this investigation.

(vi) Mortality Rates.- The results of the scale readings have shown that the growth rates in different parts of this river system are significantly different, from which it follows that it will not be possible to allocate all the fish measurements made by anglers into age groups on the basis of the overall mean lengths from scale readings. This must be done for each river separately. It is, however, of interest to note that on the basis of fish lengths at capture as recorded by anglers (Tables 2, 5, and 8) the rivers fall into three groups so far as mean length is concerned: the Macquarie River and Brumby's Creek fish were very similar, so were those from the South Esk and Elizabeth Rivers, while those from the Meander and Liffey Rivers fell into a third group. When the means for the five seasons are grouped in this way (Table 14) it is found that the differences between the means within each of these pairs of rivers are not statistically significant.

Table 12 shows that the growth rate in the Meander and Liffey was better than that in the South Esk. The reversal of these two groups in the present case does not conflict with this conclusion. The data from anglers' catches must be regarded as representing the population, and the mean lengths at capture of the samples of fish used for age determination show the same order as that given here. It may be inferred that the fishery in the Meander is mainly centred on the younger fish.

TABLE 14

NUMBERS OF FISH AND MEAN LENGTHS AT CAPTURE IN SOUTH ESK RIVER SYSTEM FOR 5 SEASONS

	No. Fish	Mean L.
Macquarie R.	631	13.50
Brumby's Ck.	175	14.00
South Esk R.	1030	12.52
Elizabeth R.	163	12.36
Meander R.	1192	11.68
Liffey R.	238	11.76

It is therefore permissible to treat these groups as three separate units for apportionment into age groups from scale readings from the appropriate rivers as described in Part II (Nicholls 1957b). This results in the distribution shown in Table 15.

TABLE 15

NUMBERS OF FISH APPORTIONED TO EACH AGE GROUP

Name of River	Age Groups 1+	2+	3+	4+	5+	6+	7+	Totals
Macquarie	16	235	337	127	62	22	10	809
South Esk	-	266	483	262	122	44	18	1195
Meander	-	718	545	116	52	-	-	1431

The numbers have been plotted logarithmically against fish ages to give the catch curves shown in Figure 8. From these it will be seen that the slopes of the descending limbs are approximately the same in the Macquarie and South Esk groups of fish. Straight lines drawn through the points on the right limb of the curve (fish from 3 to 7 years of age) are practically parallel, indicating similar mortality rates, and these lines are extended to cross the lines for the 2 year and 1 year fish so that an estimate can be made of the

proportions of younger fish which were takable. The numbers of fish at each age read from this graph have been inserted at the appropriate places. From these the average mortality rate for these rivers can be calculated at 59 per cent.

The Meander and Liffey Rivers yield quite different results. There were no fish over 5 years of age in the scale samples from these rivers, so information on the mortality rates after the fifth year is lacking. The extent of the available data for these rivers makes the assessment of the mortality rate rather difficult, but it appears to be quite high (80 per cent.) from the third to fourth years, and to fall to about 55 per cent. from the fourth to fifth years. The curve based on the 3-, 4-, and 5-year fish suggests that the whole curve may be concave which would indicate a high initial mortality, decreasing with age, in which case the mortality for the second to third years would be in excess of 80 per cent. On the other hand the absence of fish over 5 years of age suggests a mortality increasing with age. It has been assumed that the mortality from the second to third years is the same as that from third to fourth and the line extrapolated accordingly to arrive at an approximate figure for the numbers of 2-year fish.

The difference in growth rates shown by these three groups of rivers will have an effect on the proportions of young fish protected by the minimum legal length. As would be expected, in the rivers in which the fish show a better growth rate a greater proportion of young fish reach takable size and are represented in catches. In Macquarie River and Brumby's Creek, where the growth rate was highest, all of the 3+ fish, about 30 per cent. of the 2+ fish, and less than 1 (0.8) per cent. of the 1+ fish were takable. In the South Esk and Elizabeth Rivers, with the lowest growth rate, only about 77 per cent. of the 3+ fish, 17 per cent. of the 2+ fish, and none of the 1+ fish were takable. For the Meander and Liffey Rivers, with an intermediate growth rate, there is some uncertainty, but if the mortality rate during the third year is no greater than that in the fourth (as assumed) it follows that all of the 3+ fish, about 28 per cent. of the 2+ fish, and no 1+ fish are takable. These figures are close to those of the Macquarie and it has been shown that growth in these two sub-systems is similar. It will be noted that no 1+ fish were taken and the number of 2+ fish was very high in proportion to the 3+ when compared with other rivers. The large proportion of young fish taken in this river and the apparent absence of fish over 5 years of age, suggest that this river is more heavily fished. As will be seen below (Section II (e) (viii)), this

is probably true. It should perhaps be noted that in 1950-51 one fish of 20 in., and in 1953-54 four fish from 20 to 23 in. were recorded by anglers from the Meander. One or more of these fish could have been older than 5 years but fish of such lengths fall within the size range of 5-year fish and without certainty that they were older, they have been regarded as 5-year fish. Any inaccuracy due to this allocation will not seriously affect the conclusions since they numbered only 5 in a total of nearly 1200 measurements.

These figures will be of significance in studying the survival rate for stocking with hatchery-reared fish. Allen and Cunningham (1957) have drawn attention to the possibility that catchability may increase with size. This would arise from the inherent selective nature of the fishery, whereby larger fish occupy the more favourable sites and drive off competitors. The angler, again exercising selection, would thus be more likely to hook the larger fish. If this were so it would affect the accuracy of the mortality rates from natural causes but it is doubtful if it has a practical application here since the mortality rates given must take this into account since they express the mortality from all causes, including angling. It might be argued that the data on size distribution presented in Figure 6 lend support to this hypothesis since the proportions of fish among the smaller size groups represented in the catches are less than might be expected from a normal distribution, indicating that they are less catchable. However, it has been shown in Part II, Figure 4 (Nicholls 1957b) that the poorer representation of the smaller fish arises from the operation of the size limit whereby only the quicker growing fish of the younger age groups, a relatively small proportion, enter the fishery.

(vii) Annual Catch per Angler.- From the returns submitted by anglers the mean annual catch from each river and from the system as a whole can be discovered and examined for any change. The figures are given for each river separately and grouped into sub-systems in Table 16 and are illustrated in Figure 9.

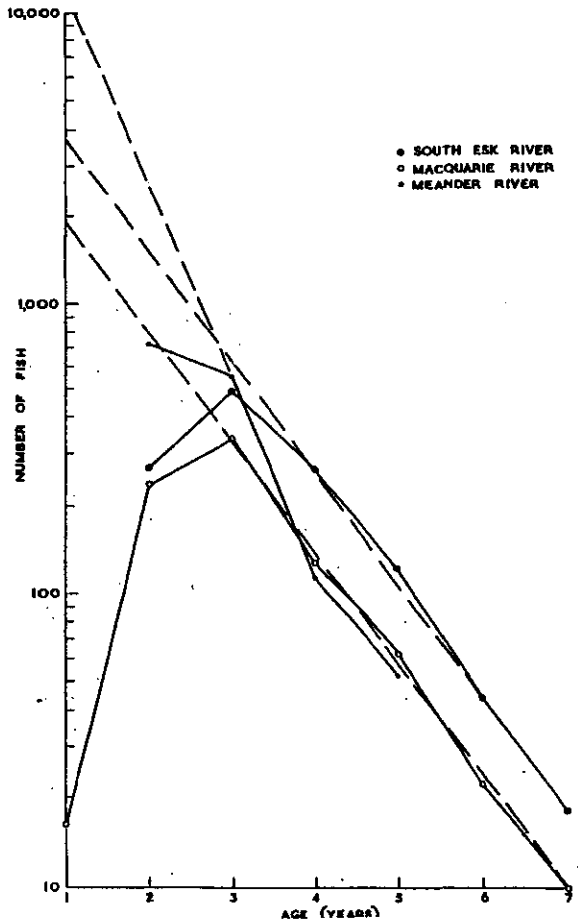

Fig. 8. Catch curves for Meander, Macquarie and South Esk Rivers.

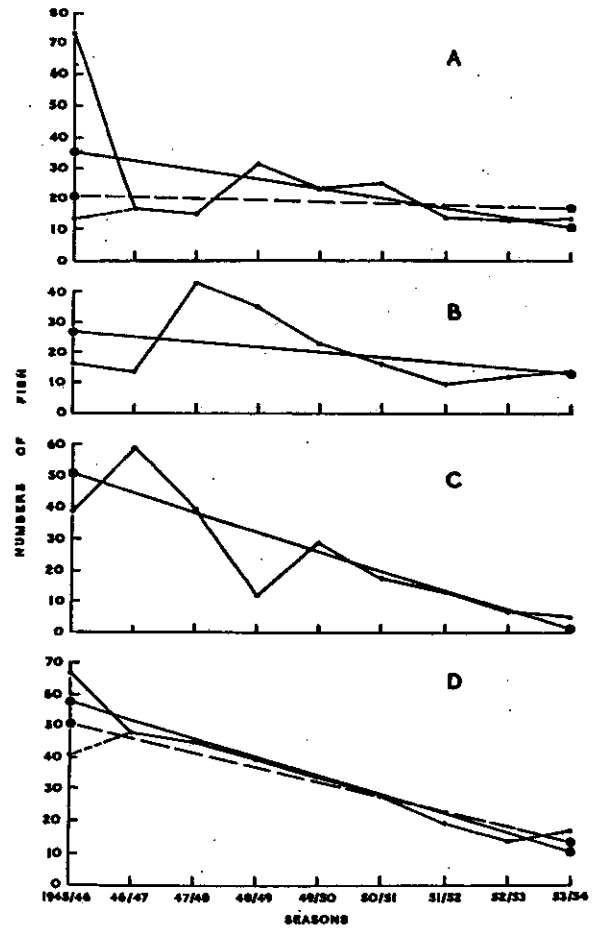

Fig. 9. Mean annual catch per angler from A, Meander River; B, Macquarie River; C, South Esk River; and D, South Esk River System. The broken lines indicate the values derived from excluding the single exceptionally high return from the Meander River in the first season.

TABLE 16

MEAN ANNUAL CATCH PER ANGLER

Season	Meander R. No. Fish	Meander R. No. Ang.	Meander R. Fish /Ang.	Liffey R. No. Fish	Liffey R. No. Ang.	Liffey R. Fish /Ang.	Total No. Fish	Total No. Ang.	Total Fish /Ang.
1945-46	519	6	86.5	61	3	20.3	580	8	72.5
1946-47	129	11	11.7	129	5	25.8	258	16	16.1
1947-48	114	7	16.3	34	6	5.7	148	10	14.8
1948-49	130	4	32.5	26	2	13.0	156	5	31.2
1949-50	393	19	20.7	129	11	11.7	522	23	22.7
1950-51	414	21	19.7	199	10	19.9	613	25	24.5
1951-52	214	15	14.3	30	5	6.0	244	18	13.6
1952-53	174	14	12.4	2	3	0.7	176	14	12.6
1953-54	208	15	13.9	3	1	3.0	211	16	13.2
Totals	2295	112	20.5	613	46	13.3	2908	135	21.5

	Macquarie R.			Brumby's Creek			Total		
1945-46	40	5	8.0	88	5	17.6	128	8	16.0
1946-47	108	9	12.0	54	4	13.5	162	12	13.5
1947-48	92	2	41.0	230	7	32.9	426	10	42.6
1948-49	134	7	19.1	111	5	22.2	245	7	35.0
1949-50	350	21	16.7	147	12	12.3	497	22	22.6
1950-51	259	18	14.4	27	5	5.4	286	18	15.9
1951-52	73	9	8.1	21	3	7.0	94	10	9.4
1952-53	145	13	11.2	10	3	3.3	155	13	11.9
1953-54	153	12	12.8	2	2	1.0	155	12	12.9
Totals	1343	96	14.0	694	47	14.8	2148	112	19.2

	South Esk R. & Tributaries No. Fish	No. Anglers	Fish/ Angler	South Esk River System No. Fish	No. Anglers	Fish/ Angler
1945-46	428	11	38.9	1136	17	66.8
1946-47	876	15	58.4	1296	27	48.0
1947-48	822	21	39.1	1396	31	45.0
1948-49	72	6	12.0	473	12	39.4
1949-50	576	20	28.8	1595	47	33.9
1950-51	352	20	17.6	1251	45	27.8
1951-52	157	12	13.1	495	26	19.0
1952-53	140	21	6.7	471	34	13.9
1953-54	54	11	4.9	420	26	16.2
Totals	3477	137	25.4	8533	265	32.2

The totals of fish and anglers in Table 16 do not necessarily correspond to the sums of the figures for separate rivers, because the same angler may have fished in more than one river and because some anglers have totalled their fish for the season for two or more rivers.

It will be seen that while there has been some fluctuation between seasons the general trend has been downwards in all cases. Statistical analysis, however, shows no significant difference between the means for the Meander River; differences which are significant at the 5 per cent. level only for the Macquarie; at the 1 per cent. level for the South Esk sub-system; and just significant at the 0.1 per cent. level for the whole system.

The reliability of these figures may be open to question for several reasons. In the first place, the rather high mean for 1945-46 was due to one return from the Meander recording the capture of 485 fish. Such a high figure has not been reported since, nor did this angler make any subsequent return during the period under review, though it is known that similar catches have been taken from this river, as will be shown later. When this catch is omitted the mean for this season falls to 13.6 for the Meander, and to 40.7 for the whole system. These points have been plotted in Figure 9, and the amended regression lines are also shown. Both assume a much less pronounced downward slope, that for the Meander approaching the horizontal, which shows why the statistical analysis yielded no significant difference for this river.

If the values for the mean catch per angler for the system as a whole can be regarded as reasonably reliable, it is of interest to note that the downward trend ceased in 1952-53 and there was an improvement in the following season.

(viii) Estimated Total Catch.- Using the available figures, and the method described in Part II (Nicholls 1957b), it is possible to calculate estimated total annual catches for these rivers. It is particularly desirable to do so for each river separately, in order to correlate these with the estimated survivors from stocking, for which detailed figures are available, but in the case of the Liffey River and Brumby's Creek it is probable that the numbers of returns are so low that the standard error will render them of little value.

The number of licenses issued in each season is given in Table 17. These have been extracted from the records of the Commissioners, in which they were grouped into four

districts: the north-west, north, north-east, and south. The grouping includes in the north-eastern district some centres which are within the basin of the South Esk System such as Avoca, Fingal, Mathinna, and St. Mary's. For three seasons (1949-50, 1951-52, and 1952-53) for which detailed statements are available, it is found that the numbers issued in these centres are more or less constant at about 5½ per cent. of the total issued in the northern district. This correction has therefore been made to the figures for the remaining seasons, so that on the whole the corrected figures given for licences issued in centres lying within the South Esk System are more nearly accurate than those for the north alone. All anglers taking out licences in the north district do not necessarily fish the South Esk, but the majority are taken out in Launceston and most of these anglers will fish in either the North or South Esk Systems. In order to arrive at an approximation to the numbers of anglers fishing in the South Esk it has been assumed that this number will bear the same ratio to the total of licences issued in that district as the number of anglers who sent in returns from the South Esk bears to the total of returns from that district, and similarly from the North Esk. These figures are shown in Table 17.

TABLE 17

CORRECTED NUMBERS OF LICENCES ISSUED IN NORTH AND SOUTH ESK RIVER AREAS

	Seasons								
	45-46	46-47	47-48	48-49	49-50	50-51	51-52	52-53	53-54
Number of Licences Issued	1126	1358	1583	2232	2628	3207	3334	3066	3159
Corrected Number	1188	1433	1670	2355	2777	3383	3543	3238	3333
Returns Received.-									
Total	19	30	35	13	55	53	35	39	28
S. Esk	17	27	31	12	47	45	26	34	26
N. Esk	9	18	17	3	23	17	16	16	9
Estimated Numbers Fishing.-									
S. Esk	1063	1290	1479	2174	2373	2872	2632	2823	3095
N. Esk	563	860	811	543	1161	1085	1620	1328	1071

Weekly and daily licences and returns are excluded from this Table.

In Table 18 are given the estimated total catches for each river separately, and combined in sub-systems, and for the whole of the South Esk System, based on the data provided in Tables 16 and 17.

TABLE 18

ESTIMATED TOTAL CATCHES FOR RIVERS OF SOUTH ESK RIVER SYSTEM

Season	Meander R. No. of Ang.	Meander R. Mean Fish /Ang.	Meander R. Est. Total Catch	Liffey R. No. of Ang.	Liffey R. Mean Fish /Ang.	Liffey R. Est. Total Catch	Sub-system No. of Ang.	Sub-system Mean Fish /Ang.	Sub-system Est. Total Catch
1945-46	375	86.5	32500	188	20.3	3800	500	72.5	36000
1946-47	526	11.7	6100	239	25.8	6200	764	16.1	12500
1947-48	33[illegible]	16.3	5400	286	5.7	1600	477	14.8	7100
1948-49	725	32.5	23500	362	13.0	4700	906	31.2	28500
1949-50	959	20.7	20000	555	11.7	6500	1161	22.7	26500
1950-51	1340	19.7	26500	638	19.9	12500	1596	24.5	39000
1951-52	1518	14.3	21500	506	6.0	3000	1822	13.6	25000
1952-53	1162	12.4	14500	249	0.7	200	1162	12.6	14500
1953-54	1786	13.9	25000	119	3.0	400	1905	13.2	25000
	Macquarie R.			Brumby's Creek			Sub-system		
1945-46	313	8.0	2500	313	17.6	5500	500	16.0	8000
1946-47	430	12.0	5200	191	13.5	2600	573	13.5	7700
1947-48	95	41.0	3900	334	32.9	11000	477	42.6	20500
1948-49	1268	19.1	24000	906	22.2	20000	1268	35.0	44500
1949-50	1060	16.7	17500	606	12.3	7500	1111	22.6	25000
1950-51	1149	14.4	16500	319	5.4	1700	1149	15.9	18500
1951-52	911	8.1	7400	304	7.0	2100	1012	9.4	9500
1952-53	1079	11.2	12000	249	3.3	800	1079	11.9	13000
1953-54	1428	12.8	18500	238	1.0	200	1428	12.9	18500

	South Esk River			South Esk River System No. of Ang.	Mean Fish /Ang.	Est. Total Catch	Coeff. Vari-ation	Stand-ard Error
1945-46	688	38.9	27000	1063	66.8	71000	0.437	31000
1946-47	717	58.4	42000	1290	48.0	62000	0.221	13500
1947-48	1002	39.1	39000	1479	45.0	66500	0.151	10000
1948-49	1087	12.0	13000	2174	39.4	85500	0.304	26000
1949-50	1010	28.8	29000	2373	33.9	80500	0.184	15000
1950-51	1276	17.6	22500	2872	27.8	80000	0.184	14500
1951-52	1214	13.1	16000	2632	19.0	50000	0.274	13500
1952-53	1744	6.7	11500	2823	13.9	39000	0.224	8500
1953-54	1309	4.9	6400	3095	16.2	50000	0.362	18000

In Table 18 numbers above 10,000 have been rounded to the nearest 500, and below to the nearest 100. In all cases the combined totals approximate to the sums of the separate totals within these limits, except for the Macquarie River and Brumby's Creek totals for 1947-48; this was due to returns from two anglers who stated their total catch from these two rivers together; they could not be apportioned to the separate rivers but were included in the total catch from the combined rivers. Coefficients of variation and standard errors have been calculated for the estimated total catch from the South Esk System for each season. In computing these, allowance has been made for the two sources of variation: (i) in computing mean catch per angler from anglers' returns, and (ii) in estimating the proportion of anglers fishing in this system from the returns, as set out in Table 17. It will be seen that the largest relative standard error is that applying to the 1945-46 season; this is due to the single return showing a large catch from the Meander River in that season.

These figures show a fall in the estimated total catch over the last five seasons (the means for the first four and last five seasons are 71,250 and 59,900 respectively) and this in spite of the marked increase in the number of licence holders, which rose in 1953-54 to nearly three times the number issued in 1945-46. The explanation of this apparent fall lies in the fact that the mean annual catch per angler and hence the estimated total catch, will be dependent on the number of days spent fishing each season. The figures for the mean annual catch per angler for the South Esk System given in Table 16 were based on all returns in order to obtain a more accurate assessment of the actual total catch, but in a comparison between the mean annual catch per angler and the mean number of days spent fishing by each angler, those returns from which the number of days were omitted must be excluded. This yields figures which differ from those given in Table 16, and are shown together with the mean number of days per angler in Table 19, and illustrated in Figure 10.

TABLE 19

MEAN ANNUAL CATCH AND MEAN NUMBER OF DAYS PER ANGLER

Mean No./ Angler	Season 45-46	46-47	47-48	48-49	49-50	50-51	51-52	52-53	53-54
Fish	27.9	49.2	42.3	34.8	34.6	25.8	16.4	11.9	18.6
Days	9.5	12.1	11.7	12.3	11.5	8.4	6.1	5.8	7.3

Figure 10 shows how close is the relationship between the annual catch and the number of days spent fishing. Only two points lie far off the fitted line, both for mean values of about 12 days fishing. One is higher and the other lower than might be expected, but both occur in the early part of the nine-year period, while during the later part when lower catches were recorded these are consistently correlated with fewer fishing days, indicating that the lower total catches of recent years are due not to there being fewer fish so much as to a lessened interest in fishing. In other words, the average angler has had smaller catches in recent years because he has fished less often. There are several possible explanations why the average angler might have fished the rivers less often. One is the possibility that the weather at week-ends and holidays, when it may be assumed most fishing is done, was more unsuitable during the later period. A comparison of the rainfall at such times for the eight months of the fishing season for the two periods 1946-7 to 1949-50 and 1950-51 to 1953-54 lends no support to this suggestion. The activities of the Hydro-Electric Commission in creating new lakes, which have come into production during the last few years, may have diverted some of the fishing from rivers, although this is more likely to have affected the southern part of the State. An analysis of the total fishing by anglers holding lakes licences who fished the South Esk System during these two four-year periods shows that there was a real fall in the total fishing done. The means of the number of days fishing per angler in each period were 20 and 17 respectively. During the first period the average amount of time spent fishing in lakes was 30 per cent. of the total, whereas in the second period it had increased to 40 per cent., but less than 1 per cent. of this time was spent at the newer lakes and this difference does not wholly account for the fall over the last four years shown in Table 19. A third alternative would be related to the fact that each year a greater proportion of returns came from 'new' anglers who had not previously submitted returns, and may be presumed not to have fished before since the number of licences issued has been rising steadily; such anglers might be expected to lose interest more quickly than the experienced angler. It may be concluded that the fall is partly accounted for by a change to lake fishery and partly by causes not readily identified but possibly related to the increase in 'new' anglers.

There is some evidence to show that anglers who regularly take good catches seldom if ever make returns. This evidence comes from the Deloraine district, from fishing in the Meander River only, between Meander and Exton during the 1950-51 season. A personal canvass of 53 regular anglers

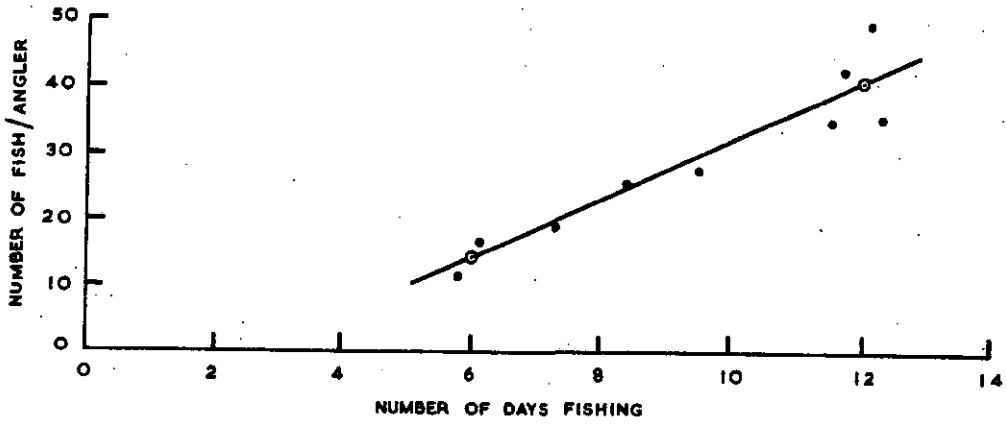

Fig. 10. Relationship between the annual catch per angler and the number of days spent fishing in the South Esk River System.

was made at the end of that season by the President and Secretary of the Deloraine Branch of the North Western Fisheries Association. The catches ranged from 50 to 728, and totalled 13,736, giving an average of 259 fish per angler for the season. Some of these anglers fish almost every night, which for an eight-month season indicates a mean daily catch of about 3 fish for the highest individual catch. None of these anglers sent in returns, except one in 1945-46 referred to in the previous sub-section (vii). Since these 53 records came from anglers who did not make returns it will be of interest to calculate a possible total catch for this river in that season, on the assumption that the mean catch per angler derived from the returns (19.7 for 1950-51) represents the mean for the balance of licensed anglers. It has been shown (Table 18) that an estimated 1340 anglers fished the Meander in that season. It is known that 53 of these were responsible for 13,736 fish and assuming that the remaining 1287 took an average of 19.7 fish the total estimated catch would be 39,000 compared with the previous estimate of 26,500. It is almost certain that this higher figure is an underestimate, since the personal canvass covered only licensed anglers known to the canvassers as members of the local branch of the anglers' association. It is estimated that 350 licences were issued in Deloraine in that season, and it is known that members of the association numbered 288, of which less than one fifth were canvassed. The total could thus be greatly in excess of 40,000, which represents about 1000 fish per mile of fishable stream between Meander and Hadspen, and even if only one half of the licensed anglers in Deloraine averaged the same as the one fifth canvassed, the grand total would be around 70,000. Fish taken illegally, for which there is some evidence, have not been taken into account.

This alternative approach to an assessment of the annual catch suggests that the figures given in Table 18 underestimate rather than overestimate because of the absence of returns from anglers who fish regularly and normally take good catches. It seems self-evident that such anglers, having no cause for complaint, are not interested in this investigation because they see no need for it; from their point of view there is nothing wrong with the fishery. In case the number of anglers calculated to fish the Meander each season appears to be high it should be noted that 84 were counted fishing in one evening in 2½ miles of river, or one to every 52 yards. If 1340 anglers all fished at the one time, 52 yards apart, they would need 40 miles of river which would be amply provided between Meander and Hadspen where it joins the South Esk. A similar canvass carried out for the 1955-56 season showed that 55 anglers

took an estimated catch of over 7100 fish, with a mean of 129 per angler, the highest being 348. Just over one half of these were taken in the first quarter of the season, after which the weather deteriorated and there were considerable periods of heavy rainfall.

(ix) Summary.- A statistically significant decline in the daily catch per angler was found, but the analysis of one angler's diary over 14 years shows only a slight downward trend. Mean lengths of fish taken by anglers indicate different growth rates in different rivers but in no case was there any constant trend over five seasons. Changes in the composition of the catch are related to variations in the survival of particular year classes or to variations in the occurrence of large fish in a season's catch. Marked fish recaptured have indicated extensive movement of fish within the system except in the case of rainbow trout. Mortality rates stand at about 60 per cent. per annum in the Macquarie and South Esk but are higher in the Meander at about 80 per cent. per annum. There are indications that this river is heavily fished, but not overfished. The annual catch per angler has shown a fall, and the estimated total catches are lower during the last five seasons than during the first four, but these changes are probably related to a fall in the number of days spent fishing. A canvass of anglers who had not made returns in one district showed that figures for annual catch per angler and total catch are probably considerably underestimated.

(f) Relationship Between Total Catch and Survivors from Stocking

As was shown in Part II of this series of reports (Nicholls 1957b), if the numbers of fish released in the rivers and the appropriate mortality rates for fish in these streams are known, it is possible to calculate the probable survival of such fish and the approximate numbers present in any season. In the present case different mortality rates have been found for the Meander sub-system and the rest of the South Esk System in which a lower mortality rate appears to operate. In order to obtain survival numbers for the system as a whole it has therefore been necessary to calculate the numbers for each river separately and sum the results. These are given in Table 20, in which allowance has been made for the fact that only about 30 per cent. of the 2-year fish and 1 per cent. of the 1-year fish are likely to be taken in any season in the Meander and Macquarie Rivers, and 80 per cent. of the 3-year, 20 per cent. of the 2-year, and no 1-year fish are likely to be taken in the South Esk and Elizabeth Rivers.

TABLE 20

NUMBERS OF TAKABLE SURVIVORS FROM STOCKING AND ESTIMATED TOTAL CATCHES FROM THE SOUTH ESK RIVER SYSTEM

Age	Numbers surviving in each season 1949-50	1950-51	1951-52	1952-53	1953-54
9+	-	6	2	-	1
8+	14	8	-	4	60
7+	23	-	11	154	149
6+	-	28	385	370	28
5+	69	966	922	71	178
4+	2412	2299	177	442	1089
3+	4730	389	1043	2605	3359
2+	292	832	1980	2365	-
1+	60	144	111	-	-
Total Survivors	7600	4672	4631	6011	4864
Estimated Total Catch	80500	80000	50000	39000	50000
Ratio	1:10.6	1:17.1	1:10.8	1: 6.5	1:10.3

Mean Ratio for 5 seasons: 1 : 11

The total numbers of fish surviving from stocking in each of the last five seasons are compared with the estimated total catches for these seasons in the same table, and the ratio between these shows the maximum possible contribution to the catch as a result of stocking. It may, therefore, be stated that under the stocking rate which existed between 1942 and 1954, and with the lower mortality rates found for much of the South Esk System, released fish could have contributed up to nearly 10 per cent. of the fish taken. This, of course, assumes that all the released fish are accounted for in the estimated total catches, which is highly improbable. In order to discover if this is true to any extent, it is only necessary to compare the age distribution of the population of fish taken by anglers (as shown by the fish measurements) with that of the survivors from stocking. These figures are set out in Table 21, in which the composition of each population has been expressed as percentages in order to make them comparable.

TABLE 21

PERCENTAGE AGE-DISTRIBUTION OF FISH TAKEN BY ANGLERS AND TAKABLE FISH SURVIVING FROM STOCKING

Age	Seasons 1949-50 Angled	1949-50 Released	1950-51 Angled	1950-51 Released	1951-52 Angled	1951-52 Released	1952-53 Angled	1952-53 Released	1953-54 Angled	1953-54 Released
Meander River										
1	-	11.2	-	10.9	-	6.1	-	-	-	-
2	47.1	23.5	53.7	62.0	45.0	53.3	46.2	44.6	55.7	-
3	39.8	61.1	36.9	14.5	42.4	33.7	39.7	43.6	31.2	68.0
4	9.3	1.7	6.6	11.1	9.1	2.3	9.9	8.2	7.3	20.1
5	3.7	1.4	2.7	0.8	3.6	4.2	4.1	1.3	5.7	8.3
6	-	-	-	0.5	-	0.2	-	2.3	-	1.2
7	-	0.8	-	-	-	0.2	-	-	-	2.4
8	-	0.3	-	0.3	-	-	-	-	-	-
Totals	99.9	100.0	99.9	100.1	100.1	100.0	99.9	100.0	99.9	100.0
Macquarie River										
1	2.3	0.5	1.7	4.7	2.5	3.4	2.9	-	2.7	-
2	30.6	-	28.9	12.9	32.9	51.0	24.8	35.6	37.4	-
3	40.6	41.3	43.8	-	44.3	16.0	47.6	50.6	36.1	65.5
4	15.5	57.7	14.5	38.7	13.9	-	16.2	5.0	11.6	27.1
5	7.3	-	6.8	43.3	5.1	14.0	5.7	-	8.8	2.7
6	2.8	-	3.0	-	1.3	15.6	2.9	4.2	2.0	-
7	1.0	0.2	1.3	-	-	-	-	4.7	1.4	2.2
8	-	0.2	-	0.1	-	-	-	-	-	2.5
9	-	-	-	0.2	-	-	-	-	-	-
Totals	100.1	99.9	100.0	99.9	100.0	100.0	100.1	100.1	100.0	100.0
South Esk River										
1	-	-	-	-	-	-	-	-	-	-
2	21.8	6.5	25.0	14.7	19.1	28.7	14.4	43.5	32.0	-
3	41.8	89.0	39.6	15.7	39.2	28.4	35.1	33.6	36.1	72.9
4	23.0	2.0	19.6	66.9	25.3	9.4	26.6	10.4	17.2	17.6
5	9.6	2.0	10.1	1.2	12.4	32.3	13.5	2.7	9.8	4.4
6	2.5	-	3.8	1.2	4.1	0.6	5.0	9.5	3.3	1.1
7	1.3	0.3	1.9	-	-	0.6	5.4	0.2	1.6	4.0
8	-	0.2	-	0.2	-	-	-	0.2	-	-
9	-	-	-	0.1	-	0.1	-	-	-	-
Totals	100.0	100.0	100.0	100.0	100.1	100.1	100.0	100.1	100.0	100.0

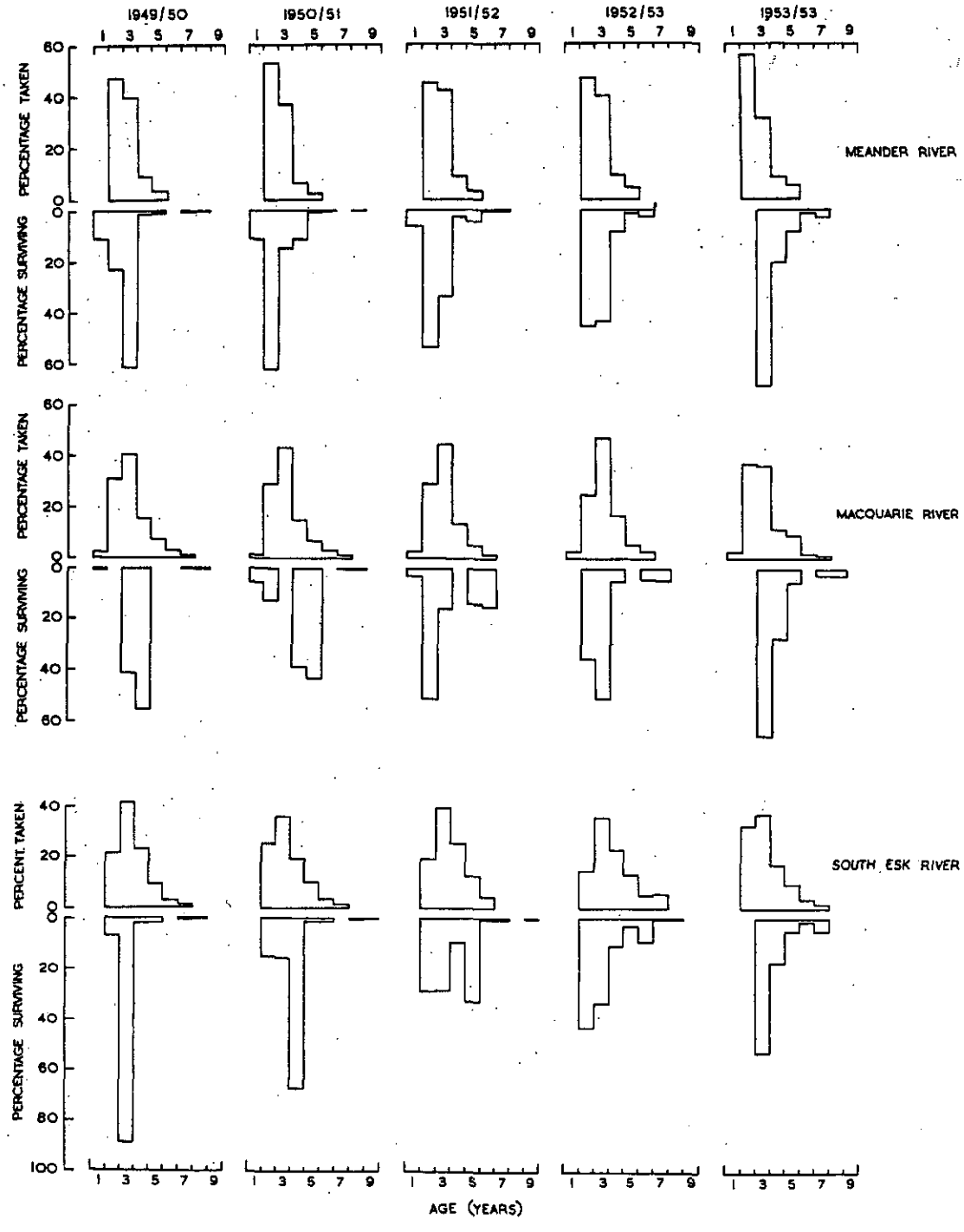

Fig. 11. Percentage age distribution histograms of fish taken by anglers (upper part) and takable fish surviving from stocking (below) during five seasons in A, the Meander; B, the Macquarie; and C, the South Esk Rivers.

If a close relationship existed between the anglers' catches and the results of stocking with hatchery-reared fish, the pairs of figures for each season in each river should be approximately the same, and the ratio of one to the other should be close to 1 for each age-group. These percentages have been shown graphically in Figure 11, in which the percentage age distribution of fish taken by anglers is indicated above the central line, and that of takable fish surviving from stocking below. If there were a close relationship these pairs of histograms should be approximately mirror images of one another. It is clear that this is not the case, though for 1952-53 there is a fairly close resemblance in the Meander and Macquarie Rivers. It will be seen that the figures for fish taken by anglers change little from season to season, whereas those for takable survivors from stocking show considerable seasonal variation. Statistical analysis shows no significant difference in the age-distribution between seasons for the Meander and Macquarie, and a difference significant at 1 per cent. for the South Esk, whereas the differences between the age-distribution of survivors from stocking were very highly significant in all these rivers. It will also be seen that the majority of fish in all three rivers are 2 or 3 years of age, with 2-year fish predominating in the Meander and 3-year fish predominating in the two other rivers, and that there are decreasing proportions of older fish with none over 5 years of age in the Meander. This relationship does not hold for the survivors from stocking. It will also be noticed that a small proportion of 1-year fish is taken in the Macquarie, and not in either of the other rivers, in conformity with the growth-rates shown above.

Statistical analysis shows a significant correlation between the catches by anglers and the survivors from stocking in the Meander River in 1950-51 and the two following seasons, and in the Macquarie River in 1952-53; the rest show no significant correlation. This does not necessarily mean that in these cases anglers' catches were dependent on fish released, it could be merely that the rate of stocking had been such as to resemble the composition of the normal populations which, as has been shown, are similar within each river throughout. If anglers' catches did depend on released fish there should have been a significant correlation in every case, which is clearly not so. The most striking discrepancy was in 1953-54 in which there were no 2-year fish available from stocking, because no yearlings were released in this system between July 1952 and June 1953, and no fry were released there in the previous season, yet the bulk of the fish taken by anglers were 2 years of age. It is fairly clear then that anglers' catches do not reflect

the number of fish released from hatcheries; thus there is little support for any claim that the fishery is dependent on such releases. The 2-year fish caught in 1953-54, representing 45 per cent. of all fish taken by anglers, must have been survivors of natural spawning. It will be remembered, too, that this season showed an improvement in both the daily catch and annual catch per angler over the preceding season.

It was pointed out in Section II (d) (ii) that the increase in mean length of fish in the South Esk from 1949-50 to 1952-53, followed by a sudden fall in the next season, could have been due to a steady reduction of the population followed by heavy restocking. This would imply that there was a decrease in the proportion of 2-year fish in the catches up to 1952-53, followed by an influx of fish of this age in 1953-54. Figure 11 shows that this is what happened, and explains the rise and subsequent fall in the mean length of the fish, but it also shows that there were no 2-year fish available from stocking in this season; the only survivors from stocking were 3 years and older. This confirms the statement made above (II (e) (ii)) that the 2-year fish which represented 32 per cent. of anglers' catches from this river in that season must have been the result of a successful natural spawning in 1951. It was also shown (Fig. 6) that in the Macquarie there was an influx of small fish (10 to 11 in.) in 1951-52, suggesting successful spawning in 1949. Table 6 shows that such fish would have been 2+ fish, and Figure 11 shows that there was an increase in the proportion of 2-year fish available from stocking, but this apparently had little effect on the catch which retained the same general composition as in previous years.

III. THE NORTH ESK RIVER SYSTEM

(a) Environmental Characteristics

The North Esk River rises on the slopes of Ben Nevis (3900 ft) and flows southwards for about 10 miles to a point at which it receives the Ford River, a tributary of similar size rising on Legges Tor (5160 ft) and draining the northern end of the Ben Lomond Range, and Rose's Tier. From the confluence the general direction of the river is westerly for a distance of 16 miles, during which it receives five minor tributaries: two from the south and three from the north. It then turns north-westerly to discharge into the Tamar Estuary at Launceston. Its one major tributary, the St. Patrick's River, rises in streams draining the country to the north of Ben Nevis, and after flowing somewhat north of west for some 12 miles it turns south west and later south to flow into the North Esk about 20 miles from

Launceston. It receives several small tributaries; five from the south and one from the north.

The two rivers are very similar, consisting of tumbling stretches interspersed with occasional pools, with in general a fairly steep gradient though there are places where the river floods during heavy winter rains. The gradient over the first 10 miles from the mouth is about 2 per mille, and the width is 25 m or more; this places it in the 'grayling' zone as defined by Huet (1954); over the next 30 miles the mean gradient is about 6 per mille, and the width is greater than 18 m, which places it wholly in the 'trout' zone. Above it is entirely of gradient and width appropriate to the trout zone. Grayling do not occur here, neither is their place taken by other species, and trout occupy the entire length of the river. The middle and upper reaches receive from 40 to 60 inches of rainfall per annum, and measurements of water flow in the middle reaches of the North Esk, made over the past 28 years, indicate a mean monthly flow of 183 cusecs (range 20-1066). As far as is known there are no falls in this system which could act as a barrier to the upstream migration of fish, though there are several stretches of rapids.

(b) Results and Discussion

(i) The Daily Catch.- Returns from an average of 12 anglers per season (range 2 to 19) yield the figures for mean daily catch per angler given in Table 22.

TABLE 22

MEAN DAILY CATCH PER ANGLER FOR NORTH ESK RIVER SYSTEM

Season	N. Esk R			St. Patrick's R.			N. Esk System		
	No. Fish	No. Days	Fish /Day	No. Fish	No. Days	Fish /Day	No. Fish	No. Days	Fish /Day
1945-46	71	33	2.2	101	13	7.8	172	46	3.7
1946-47	134	38	3.5	458	55	8.3	592	93	6.4
1947-48	366	54	6.8	335	46	7.3	701	100	7.0
1948-49	6	3	2.0	1	1	1.0	7	4	1.8
1949-50	352	97	3.6	159	25	6.4	511	122	4.2
1950-51	120	37	3.2	142	29	4.9	262	66	4.0
1951-52	156	61	2.6	140	25	5.6	296	86	3.4
1952-53	131	68	1.9	18	7	2.6	149	75	2.0
1953-54	17	9	1.9	25	11	2.3	42	20	2.1

These figures are illustrated in Figure 12, and indicate a downward trend in the daily catch, which statistical analysis has shown to be quite significant for the two rivers separately and for the system as a whole.

(ii) Fish Lengths.- Measurements are available of 734 fish taken from the North Esk, and 319 from the St. Patrick's over the past five seasons. The figures are given in Table 23.

TABLE 23

MEAN LENGTHS OF FISH FROM NORTH ESK RIVER SYSTEM

Season	N. Esk R.		St. Patrick's R.	
	No. of Fish	Mean L. (in)	No. of Fish	Mean L. (in)
1949-50	285	12.0	69	10.7
1950-51	113	11.1	132	10.5
1951-52	120	12.8	65	11.3
1952-53	179	12.8	28	10.5
1953-54	37	13.0	25	10.3

Statistical analysis shows that the differences between the means within each river are quite significant. While the upward trend in the St. Patrick's reached a maximum in 1951-52 and was followed by a decrease in the two succeeding seasons, in the North Esk there has been an upward trend from 1950-51 onwards, which may indicate a decrease in the population. It is doubtful if this is the case since the last three seasons were marked by the inclusion of fish of 24 in. and over, not recorded for previous seasons, and when these are excluded the means for these seasons are 12.6, 12.6, and 12.7 in. respectively, but the differences are still quite significant statistically. Examination of the scale readings will show if there has been any improved growth in the younger fish, such as would be expected as a result of a reduction of the population due to overfishing.

(iii) Growth and Age.- Scale samples were taken from 162 fish caught in the upper reaches of the North Esk, and from 21 fish taken in the St. Patrick's during the 1949-50 season. The results are given in Table 24, from which have been excluded 3 fish whose scales were replacements.

TABLE 24

MEAN LENGTH-FOR-AGE OF FISH FROM NORTH ESK RIVER SYSTEM

Age	No. Fish	Mean Lengths (cm) L_1	L_2	L_3	L_4	L_5	L_6	At Capture L. (cm)	W (g)	K
					North Esk River					
6	1	16.0	35.0	41.0	45.0	47.0	51.0	52.0	-	-
5	7	12.3	22.2	30.1	36.6	41.6		43.2	1016	1.24
4	23	11.0	21.5	28.7	33.2			35.0	561	1.33
3	90	10.9	20.6	26.2				28.0	300	1.36
2	32	11.2	21.4					24.6	*217	*1.48
1+	8	12.4						24.6	*191	*1.31
G.M.		11.1	21.1	27.0	34.3	42.3	51.0	-	-	1.38
Br.		4.4	8.3	10.6	13.5	16.7	20.1	-	-	49.9
					St. Patrick's Rivulet					
4	3	8.5	15.5	20.3	24.0			24.7	-	-
3	7	9.1	17.1	22.0				23.6		
2	11	10.0	20.4					22.7	-	-
G.M.		9.5	18.6	21.5	24.0			-	-	-
Br.		3.7	7.3	8.5	9.4			-	-	-

* Means based on fewer fish than indicated.
\+ Excluded from Grand Means.

It will be seen that the fish from the St. Patrick's are consistently smaller than those from the North Esk; this difference is statistically significant and the two groups cannot be pooled. Statistically the differences between age-groups within the North Esk are also significantly different, whereas in the St. Patrick's they are not.

In the preceding sub-section it was noted that there was a significant increase in lengths at capture of fish from both of these rivers. The fish whose lengths-for-age are given in Table 24 were all taken in the 1949-50 season, so there is no comparison between these fish and

those of later seasons. However, these figures do show that so far from there having been an increase in size over the four or five years preceding 1949-50 in the North Esk, there had been a decrease, which was shown within each age-group. The differences within each age-group were statistically quite significant for L_2 and L_3, at the 1 per cent. level for L_4, at the 5 per cent. level for L_1, and not significant for L_6. The increase found in the St. Patrick's was not statistically significant at any stage. Samples were taken from the St. Patrick's in 1950-51 but have been discarded owing to inaccuracies in recording. However, a large series of scales was taken from fish in both of these streams during December and January in 1954-55, in connection with a population study of these streams carried out by electro-fishing. The data from these will be presented in a later paper.

(iv) Condition.- The mean value for the condition factor of fish in the North Esk, given in Table 24, is very high and shows the usual downward trend with increasing age, though this is not as marked as in the rivers of the South Esk System. Insufficient reliable data are available for the St. Patrick's River fish.

No marked or tagged fish were liberated in this system prior to 1955.

(v) Mortality Rates.- Using the method already described, mortality rates have been calculated for the North Esk; unfortunately there are insufficient data for similar estimates for the St. Patrick's and the significant difference in mean lengths at capture between these two streams makes it impossible to pool the data, or to apply North Esk rates to the St. Patrick's. The data for the North Esk are set out in Table 25, and shown graphically in Figure 13.

TABLE 25

APPORTIONMENT OF FISH INTO AGE GROUPS: NORTH ESK RIVER

	Age Groups						
	1+	2+	3+	4+	5+	6+	Totals
Actual Numbers	37	84	408	152	41	12	734
Estimated Numbers	4000	1250	410	130	42	13	-
% Takable	0.9	6.7	100	100	100	100	-
% Mortality	69	67	68	68	69		

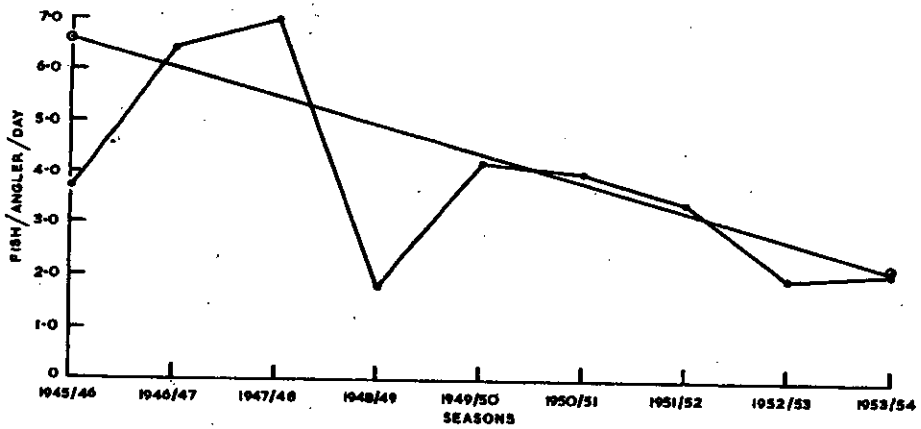

Fig. 12. Mean daily catch per angler from the North Esk System

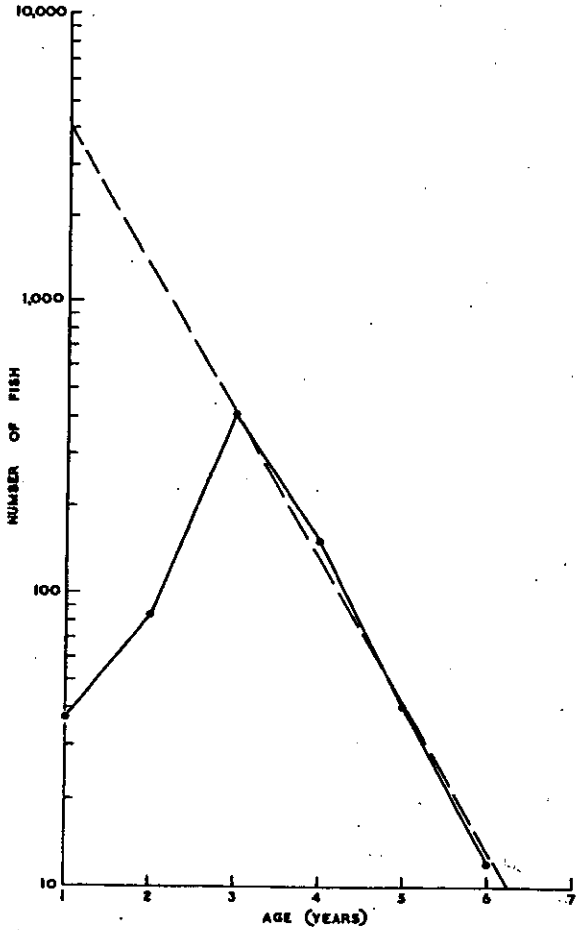

Fig. 13. Catch curve for the North Esk River.

The proportion of takable fish in relation to the estimated total available, derived from the catch curve for the North Esk, shows that only 7 per cent. of the 2-year and less than 1 per cent. of the 1-year fish are likely to be taken. The low value for the 2-year fish compared with other rivers is, of course, due to the smaller size attained by the fish in this stream. The approximate mortality rate in this stream is 70 per cent.

(vi) Annual Catch per Angler.- Data for the mean annual catch per angler over the nine seasons are given in Table 26, for each river separately, and for the system.

TABLE 26

MEAN ANNUAL CATCH PER ANGLER FROM NORTH ESK RIVER SYSTEM

Season	North Esk River			St. Patrick's Rvt.			System		
	No. Fish	No. Ang.	Fish /Ang.	No. Fish	No. Ang.	Fish /Ang	No. Fish	No. Ang.	Fish /Ang.
1945-46	224	8	28.0	146	7	20.9	370	9	41.1
1946-47	265	13	20.4	460	11	41.8	725	18	40.3
1947-48	753	12	62.8	492	11	44.7	1245	17	73.2
1948-49	11	3	3.7	1	1	1.0	12	3	4.0
1949-50	410	21	19.5	192	10	19.2	602	23	26.2
1950-51	134	14	9.6	132	10	13.2	266	16	16.6
1951-52	127	11	11.5	183	5	36.6	310	14	22.1
1952-53	100	12	9.2	23	6	3.8	123	15	8.2
1953-54	18	8	2.3	31	6	5.2	49	9	5.4

Statistical analysis shows that the differences between the means for the North Esk System are significant only at the 5 per cent. level, yet the regression line, plotted in Figure 14, shows a very marked downward trend. Examination of the returns shows that the high values of the early years were influenced by the returns of a few highly successful anglers who ceased to submit returns in later years, but even if the catches of these anglers are omitted, the differences between the means are still significant at the same level, and the regression line shows a similar trend. Had these anglers submitted returns in later years it is probable that the trend would not have been so marked. There must remain some hesitancy in accepting the fall as shown by the regression line in Figure 14 as representing the true state of affairs in this river system.

The mean annual catch and mean number of days spent fishing by each angler are shown in Table 27, and the results are plotted in Figure 15.

TABLE 27

MEAN ANNUAL CATCH AND MEAN NUMBER OF DAYS PER ANGLER

	Season								
	45-46	46-47	47-48	48-49	40-50	50-51	51-52	52-53	53-5
North Esk River									
No. Fish	10.1	11.2	33.3	3.0	20.7	9.2	15.6	10.1	2.3
No. Days	4.7	3.2	4.9	1.5	5.7	2.8	6.1	5.2	1.3
St. Patrick's Rivulet									
No. Fish	14.4	41.6	41.9	1.0	17.7	15.8	28.0	4.5	4.2
No. Days	1.9	5.0	5.8	1.0	2.8	3.2	5.0	1.8	1.8

The correlation coefficients are quite significant for the North Esk System, and when the two components are treated separately it is found to be quite significant for the St. Patrick's River, and significant at 2 per cent. for the North Esk.

(vii) Estimated Total Catch.- A corrected estimate of the anglers taking out licences who fished in the North Esk system for each season was given in Table 17. Using these figures, together with the mean annual catch per angler, it is possible to calculate estimated total catches for the whole system. This has been done, and the figures are given in Table 28, together with the coefficient of variation and standard error.

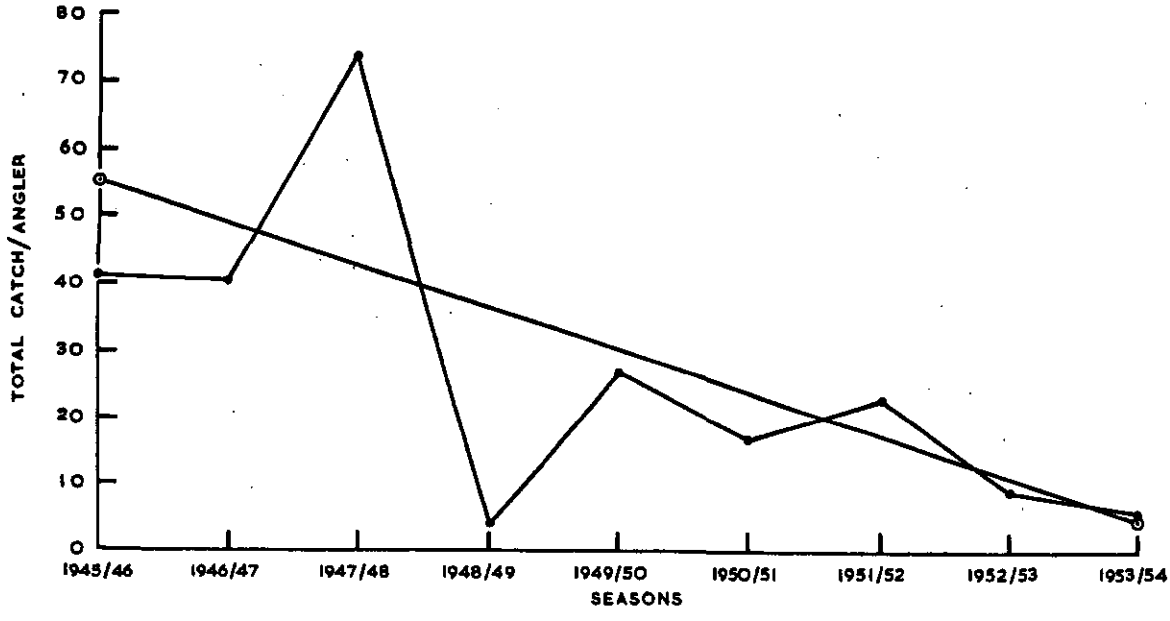

Fig. 14. Annual catch per angler from the North Esk System.

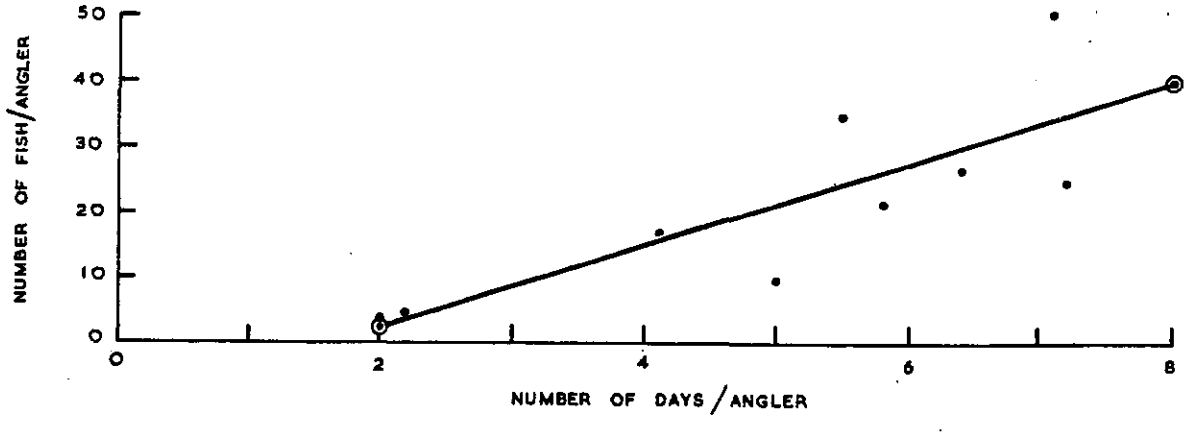

Fig. 15. Relationship between number of fish taken and number of days spent fishing in the North Esk System.

TABLE 28

ESTIMATED TOTAL CATCHES FROM THE NORTH ESK RIVER SYSTEM

Season	No. of Anglers	Mean No. of Fish /Angler	Estimated Total Catch	Coefficient of Variation	Standard Error
1945-46	563	41.1	23000	0.438	10000
1946-47	860	40.3	34500	0.339	11500
1947-48	811	73.2	59500	0.382	22500
1948-49	543	4.0	2200	0.663	1500
1949-50	1161	26.2	30500	0.376	11500
1950-51	1085	16.6	18000	0.315	5700
1951-52	1620	22.1	36000	0.751	27000
1952-53	1328	8.2	11000	0.354	3900
1953-54	1071	5.4	5800	0.515	3000

No great reliance can be placed on these figures; the coefficient of variation shows a considerable range, due to various causes. It is clearly most unlikely that 1948-49 was really as poor a season as the figures indicate; the estimated total catch for this season is based on the returns of only three anglers, who took 7, 3, and 2 fish respectively. Clearly then the number of anglers making returns has a considerable influence on the figure reached in calculating the estimated totals.

Allen and Cunningham (1957) found an upward bias in the estimate of catch associated with a reduction in the number of returns. While on general grounds it is doubtful if the number of anglers making returns contributes any consistent bias it is clear that the fewer the returns any bias they have will become of increasing importance. This is shown by the two cases quoted here, where, for different reasons bias may have influenced the results.

(viii) Summary.- The daily catch per angler shows a statistically significant downward trend. A slight increase in the mean length of fish taken by anglers is evident, and is statistically significant; the study of the scales, however, shows a decrease in mean length-for-age prior to 1949-50, but the results are inconclusive, mainly due to insufficient data. The growth rate is very similar to that found in the South Esk River, and the condition factor is also quite high. The approximate annual mortality rate is around 70 per cent. Estimates of annual catch per angler

and of total catch are of doubtful accuracy owing to insufficient data, but the catch per angler can be correlated with the number of days spent fishing.

(c) Relationship between Estimated Total Catch and Survivors from Stocking

Although estimated total catches have been calculated for both the North Esk and St. Patrick's it is possible to relate these to the probable numbers surviving from stocking for the North Esk only; this is because it has proved impossible to determine a mortality rate for the St. Patrick's because of the paucity of data on age and growth. Table 29 shows the numbers of takable survivors resulting from stocking the North Esk since 1942, and their relation to the estimated total catches over the same period.

TABLE 29

NUMBERS OF TAKABLE SURVIVORS FROM STOCKING AND ESTIMATED TOTAL CATCHES FROM THE NORTH ESK RIVER

Age	Numbers surviving in each season 1949-50	1950-51	1951-52	1952-53	1953-54
8+	1	-	-	-	-
7+	-	-	1	1	6
6+	-	2	2	21	-
5+	7	8	70	-	31
4+	27	233	-	101	39
3+	774	-	337	131	491
2+	-	79	87	114	116
1+	37	41	55	55	-
Total Survivors	846	363	552	423	683
Estimated Total Catch	20700	9100	14600	9800	2200
Ratio	1:24.5	1:25.1	1:26.4	1:23.1	1:2.2

Mean Ratio for 5 Seasons: 1 : 20.

It is clear that for the first four of these seasons, when returns were received from anglers who spent on the average at least three days fishing the North Esk, more reliable results are obtained than during the last season when the average number of days spent fishing by seven anglers making returns was 1.3. The annual catch and estimated total catch for this season have little value. The results show that whereas in the South Esk hatchery-released fish could not have contributed more than 10 per cent. of the takable fish, in the North Esk this value is between 4 and 5 per cent.

The percentage age-distribution of the fish taken by anglers and of the takable survivors from stocking are given in Table 30 and shown graphically in Figure 16. Although relatively few fish were recorded from the North Esk during 1953-54, when these are allocated to their age-groups they present a picture of the catch which very closely resembles those for the other seasons suggesting that they were representative of the population. It is clear that anglers' catches show the same picture from season to season, (although statistical analysis shows a quite significant difference between seasons in the age-distribution in anglers' catches and a very significant difference in the survivors from stocking), and that the main fishery is on the 3-year fish and older. At the same time it is clear that anglers' catches show no clear relationship to the takable survivors from stocking. Statistical analysis shows that there is a significant correlation between the two for 1949-50 and 1953-4, but not for the other seasons. A few fish of 24 inches and over (1 in 1951-52, 3 in the next season, and 1 in the last season) taken by anglers are not shown in Table 30 or Figure 16 because it has not been possible to allocate them to their age-groups with certainty. Their omission will not affect the results.

TABLE 30

PERCENTAGE AGE-DISTRIBUTION OF FISH TAKEN BY ANGLERS AND TAKABLE FISH SURVIVING FROM STOCKING IN THE NORTH ESK

Age	Seasons 1949-50 Angled	1949-50 Released	1950-51 Angled	1950-51 Released	1951-52 Angled	1951-52 Released	1952-53 Angled	1952-53 Released	1953-54 Angled	1953-54 Released
1	3.2	4.4	4.7	11.3	2.4	10.0	1.8	13.0	2.8	-
2	14.1	-	23.0	21.8	10.6	15.8	9.7	27.0	11.8	17.0
3	58.4	91.5	57.5	-	52.8	61.1	54.5	31.0	51.1	71.9
4	17.8	3.2	11.9	64.2	23.7	-	27.4	23.9	28.0	5.7
5	4.9	0.8	1.9	2.2	10.4	12.7	5.4	-	6.6	4.5
6	1.8	-	0.9	0.6	-	0.4	1.1	5.0	-	-
7	-	-	-	-	-	0.2	-	0.2	-	0.9
Totals	100.2	99.9	99.9	100.1	99.9	100.2	99.9	100.1	100.3	100.0

(d) Rainbow Trout

In 1948 7400 rainbow trout yearlings were released at the junction of the St. Patrick's and North Esk Rivers, and 3400 were released at Whisloca in the North Esk in 1952. Examination of the lengths of such fish as were recorded showed that they were all probably either 1+ or 2+ fish, and since they recurred in each season it follows that although later ones could have been descendants of the 1948 release, there must have been a resident population of rainbow trout in this system, and any attempt to relate them to releases is impracticable without more knowledge as to the extent of the population.

They were all taken either between Corra Linn and St. Leonard's, in which case they may have been released from the hatchery at Corra Linn, or in the upper stretches of the St. Patricks, suggesting that any resident population has its source in this stream. The earliest recorded captures in this district were of 1+ and 2+ fish between January and April in 1951, by which time the original stock would have been 3+ fish. Although these could have spawned at 2 years of age it is unlikely that they could have been the source of the 2+ fish taken in 1951. One of the fish taken from the North Esk at Corra Linn in February 1950 may have been 3+ in which case, again, it could hardly have been a descendant of the 1948 release. Although there are no other records of rainbow trout having been released in this system from 1942 onwards, and the hatchery at Corra Linn was first stocked with rainbow fry in 1948, it would seem probable that there had been an earlier release which gave rise to the existing population.

Of the 981 fish taken when the rivers were fished electrically in 1955, two were rainbow trout and both were found in the upper reaches of the St. Patrick's River. It would seem that this population is not of any great extent.

IV. THE LESSER RIVERS OF THE NORTH AND EAST

To the north and east of the Esk River Systems lies a coastal belt of varying width, drained by a number of smaller rivers flowing north into Bass Strait or east into the Tasman Sea. Most of these rivers are stocked with trout and are regularly fished, but very little information has been sent in from this district. This is probably due to the fact that it is, with the exception of an area around Lilydale and Scottsdale, a district of low population density, carrying not more than 8 persons to the sq. mile. This again is reflected in the number of licences sold which, in the 1952-53

season, amounted to 330 (excluding those centres lying within the South Esk basin referred to above), which represents only 4 per cent. of all licences sold within the State in that season.

In addition to those anglers who have taken out licences in the district a certain proportion obtain their licences elsewhere, particularly in Launceston, and a proportion of residents of that city fish in the rivers of this district. Of 24 anglers who reported fishing in any of these rivers during the nine seasons, 11 were residents of Launceston, and 1 resided on the north west coast; 10 were residents of this district, of which one took out his licence in Launceston; for the remaining no information is available. So little information has come from this district that it is impracticable to assess the daily and total annual catch, or to compare the size of fish from season to season, but information on the growth rate derived from samples of scales will be presented. The main rivers from which some information has been received are, from west to east, the Piper, Little Forester, Brid, Great Forester, Boobyalla, Ringarooma, and George. Altogether 33 returns reported fishing in these rivers, the number per season ranging from 0 to 10. This is insufficient to enable any reliable comparison between seasons and rivers, since these returns covered four or five more important streams.

(i) Fish Lengths.- Although 513 measurements of fish from these rivers were recorded over the last five seasons, their distribution was such that insufficient data were available from any one river to enable a reliable analysis for any changes.

(ii) Growth and Age.- Scales were taken from 13 fish in the Great Forester in September and October 1949; from 2 fish in the Ringarooma in September 1949, and from 74 fish in the Piper between September 16 and February 17, 1951. The results are summarized in Table 31.

TABLE 31

MEAN LENGTH-FOR-AGE OF FISH FROM SOME NORTH EAST STREAMS

Great Forester R.: 1949-50

Age (yr)	No. of Fish	Mean Length (cm) L_1	L_2	L_3	L_4	L_5	L_6	L_7	At Capture L (cm)	W (g)	K
7	1	9.0	18.0	25.0	37.0	51.0	57.0	63.0	64.0	2040	0.78
6	1	11.5	21.0	28.0	32.0	44.0	52.0		54.5	1640	1.02
4	9	13.3	22.8	34.2	43.0				44.7	894	0.99
3	2	13.8	20.8	30.5					35.0	455	1.05
G.M.		12.9	22.0	32.4	41.5	47.5	54.5	63.0	-	-	0.99
Br.		5.1	8.7	12.8	16.3	18.7	21.5	24.8	-	-	35.8

Piper R.: 1950-51

Age (yr)	No. of Fish	Mean Length (cm) L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	At Capture L (cm)	W (g)	K
9	1	14.0	23.5	30.5	36.0	40.5	44.5	49.5	52.5	57.0	58.5	2160	1.08
7	1	14.0	23.5	29.0	32.5	35.5	38.5	40.5			40.5	910	1.36
6	5	10.8	20.5	27.4	33.6	38.5	44.7				48.1	1246	1.10
5	4	12.9	22.5	29.6	33.9	37.0					37.9	560	1.07
4	18	11.5	22.1	29.2	34.6						38.1	715	1.23
3	28	11.0	21.2	27.2							30.0	313	1.12
2	16	11.9	23.2								27.5	235	1.13
1*	1	10.5									22.5	230	1.05
G.M.		11.5	22.0	28.1	34.3	37.9	43.8	45.0	52.5	57.0	-	-	1.15
Br.		4.5	8.7	11.1	13.5	14.9	17.2	17.7	20.7	22.4	-	-	41.5

*Excluded from Grand Means

Statistical analysis shows no significant difference between the mean values of the lengths at each age within the different age-groups, where there are five or more fish for comparison, in both rivers. The values can therefore be pooled to give grand mean values for each river. Only two 3-year fish were available from the Ringarooma River, and the absolute and percentage increments for the three rivers are presented in Table 32, for fish up to 6 years of age.

TABLE 32

MEAN ANNUAL INCREMENTS IN FISH FROM THREE RIVERS

River	Increments L_1 to L_2 (cm)	%	L_2 to L_3 (cm)	%	L_3 to L_4 (cm)	%	L_4 to L_5 (cm)	%	L_5 to L_6 (cm)	%
Forester	9.1	70.5	10.4	47.3	9.1	28.1	6.0	14.5	7.0	14.7
Piper	10.5	91.3	6.1	27.7	6.2	22.1	3.6	10.5	5.9	15.6
Ringarooma	10.0	100.0	4.8	24.0						

The data presented in these Tables suggest that growth throughout life is better in the Forester than in the Piper, although the percentage increment from first to second year was better in the Piper, and best in the Ringarooma. Little reliance can be placed on these results since only 13 fish were studied from the Forester, and only 2 from the Ringarooma.

Figures for releases in the rivers of this district from 1942 onwards show that 42,000 fry were shared between the Brid and Forester in 1949; 41,000 were released in the Piper, 50,000 shared between the Brid and Forester, 15,000 were released in the Legerwood, and 20,000 in the Ringarooma in 1951, in which year the last two also each received 1000 yearlings. In 1952 the George received 22,500 fingerlings, and the Anson, a small river to the north of the George, received 2,500 yearlings; and in 1953 the Forester and Ringarooma shared 9,000 yearlings and the Piper received 6,000 yearlings.

Little of any value can be discovered from these releases and the returns were not sufficiently numerous to show if there were any improvement in the daily catch following these releases.

V. CONCLUSIONS

It would seem that there has been a general fall in the daily catch per angler throughout this area, except in the Meander River; in the remaining rivers this fall becomes progressively more marked and of increasing statistical significance from west to east within the basins of the South and North Esk Rivers. Comparison between the fall in daily and annual catch per angler and the increase in the number of

licences issued shows a clear correlation. In order to show this more clearly the data from the North and South Esk Rivers may be combined. This is justified because with the majority of anglers from this district being resident in Launceston and both rivers being equally accessible, it is natural that some anglers should fish both rivers. The figures show that 21 per cent. of anglers making returns during the nine seasons fished in both rivers.

The combined data are presented in Table 33, and these figures together with the total numbers of licences issued (Table 17) are illustrated in Figure 17.

TABLE 33

DAILY AND ANNUAL CATCH PER ANGLER FROM NORTH AND SOUTH ESK RIVERS COMBINED

Season	No. of Licences	Mean Daily Catch per Angler			Mean Annual Catch per Angler		
		No. of Days	No. of Fish	Fish /Day	No. of Anglers	No. of Fish	Fish/ Angler
1945-46	1188	188	590	3.14	18	1021	56.7
1946-47	1433	395	1833	4.64	31	2021	65.2
1947-48	1670	404	1801	4.46	36	2641	73.4
1948-49	2355	151	424	2.81	13	485	37.3
1949-50	2777	604	1964	3.25	56	2197	39.2
1950-51	3383	410	1318	3.21	52	1517	29.2
1951-52	3543	220	657	2.99	33	805	24.4
1952-53	3238	238	683	2.87	39	594	15.2
1953-54	3333	181	452	2.50	28	469	16.8

This shows that the daily catch and annual catch per angler follow almost parallel courses, with very similar downward trends; at the same time the number of licences issued shows an equally clear upward trend. The negative correlation between number of licences and daily catch over the nine seasons is reasonably good (significant between 5 and 2 per cent.), and between number of licences and annual catch is very good (significant at 1 per cent.). There can be little escape from the conclusion that the increase in licences has been accompanied by a fall in the catching rate and annual catch.

At first sight this would lead to the conclusion that the more anglers there are the fewer fish there are for each

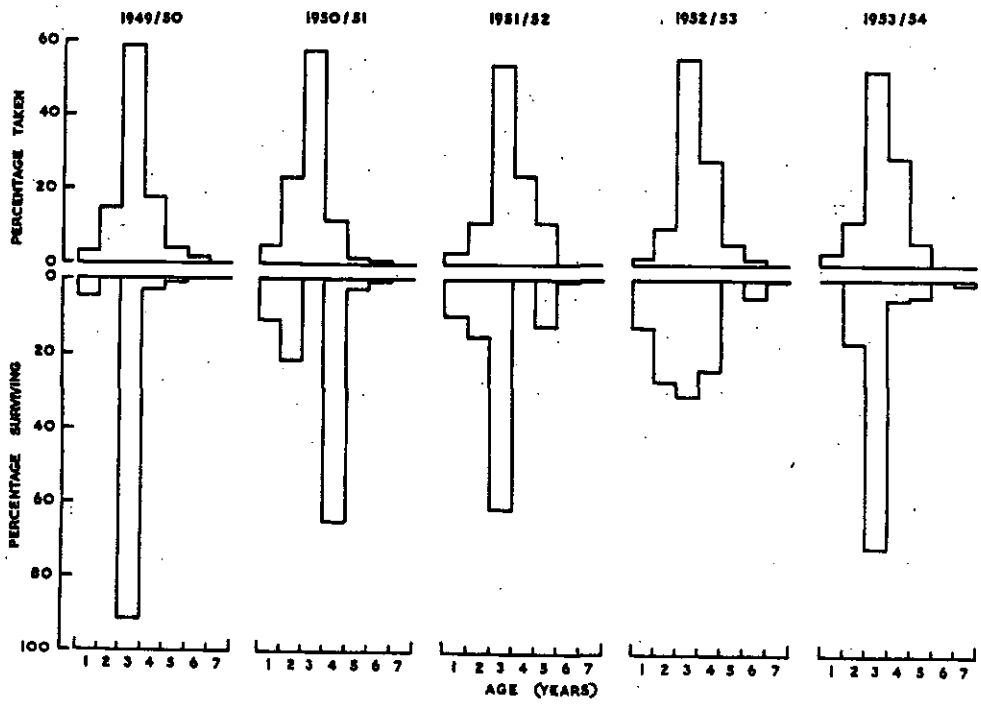

Fig. 16. Percentage age distribution histograms of fish taken by anglers (upper part) and takable fish surviving from stocking (below) during five seasons in the North Esk River.

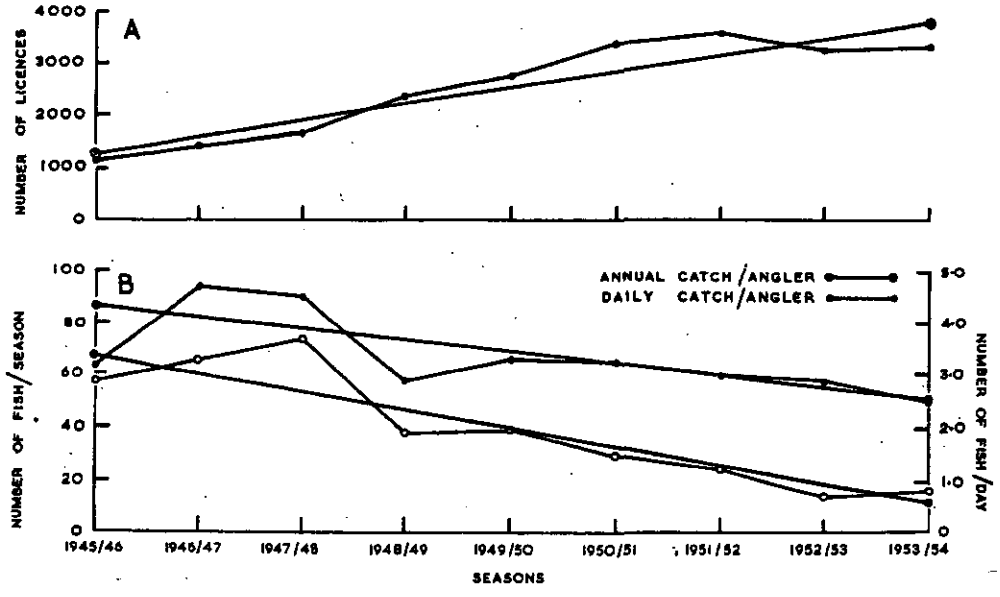

Fig. 17. A, number of licences; B, annual catch and daily catch per angler in the North and South Esk River Systems.

angler, which is equivalent to stating that these streams are being fished to their full capacity or even over-fished. Now, if this were so, it would follow that as fast as the fish attained the minimum legal length they would be removed from the population, and this would have two effects: (i) there would be no large fish, or, if any escaped the angler in one season, they would be taken in later seasons, so that they would appear in decreasing proportions over the period; and, (ii) because of the removal of large fish the average length of fish would fall to something a little over the minimum legal length. The effect of this removal of large fish, and overall reduction in the average length at capture, should result in less competition for food in the streams, with a consequent improved growth rate over the seasons.

It has been shown (Section II (e) (ii)) that in the South Esk System there has been no tendency over the last five seasons for the average length at capture to approach the minimum legal length of 9 inches, either for individual rivers, or for the system as a whole, and similarly for the North Esk (Section III (b) (ii)) in which any change has been in the other direction due, it may be noted, to the appearance of large fish in later seasons which had not been recorded earlier. It has also been shown in Figures 11 and 16 that there has been little or no change in the representation of the different age-groups in anglers' catches from any of the rivers studied. Moreover, where scale readings were available for two seasons no significant differences were found. All the available evidence, therefore, points to no change in the fish population over this period and discounts any possibility of over-fishing being responsible for the fall in catching rate.

Since this fall undeniably exists in the analysis of the returns received the most obvious explanation is that put forward in Part II (Nicholls, 1957b), namely, the returns have come largely from a new set of anglers each year, who were probably fishing for their first season and lacked experience in the art of angling. Of these anglers who fished in the South Esk System from 1949-50 onwards it is found that each year around 60 per cent. of the returns came from anglers who had not made returns in earlier years.

This raises again the question of the reliability of the returns and whether they are truly representative. It has been pointed out that the majority of those who submitted returns prior to 1949-50 have not done so since. After this season there was a change in the nature of the returns requested from anglers which may have influenced the results.

If the data for the nine seasons in the South Esk System are separated into two portions it is found that the mean daily catch per angler from 1945-46 to 1948-49 was 3.5 fish, and from 1949-50 to 1953-54 it was 2.8. Statistical analysis shows no significant difference between the means for the seasons within each period, which suggests that there was a real difference in the samples of anglers making returns in each period. Within the North Esk System also it is found that the mean daily catch up to 1948-49 was 6.1 fish and for the next five seasons it was 3.4; again statistical analysis shows no significant difference for the first four seasons, but for the last five it was quite significant. Doubts on the reliability of the returns are supported by the data quoted for anglers in the Deloraine district who had not submitted returns (Section II (e) (viii)). This question has a wider application, in particular to the data already presented for the North West District, and the whole matter will be reviewed in the final report.

VI. ACKNOWLEDGMENTS

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