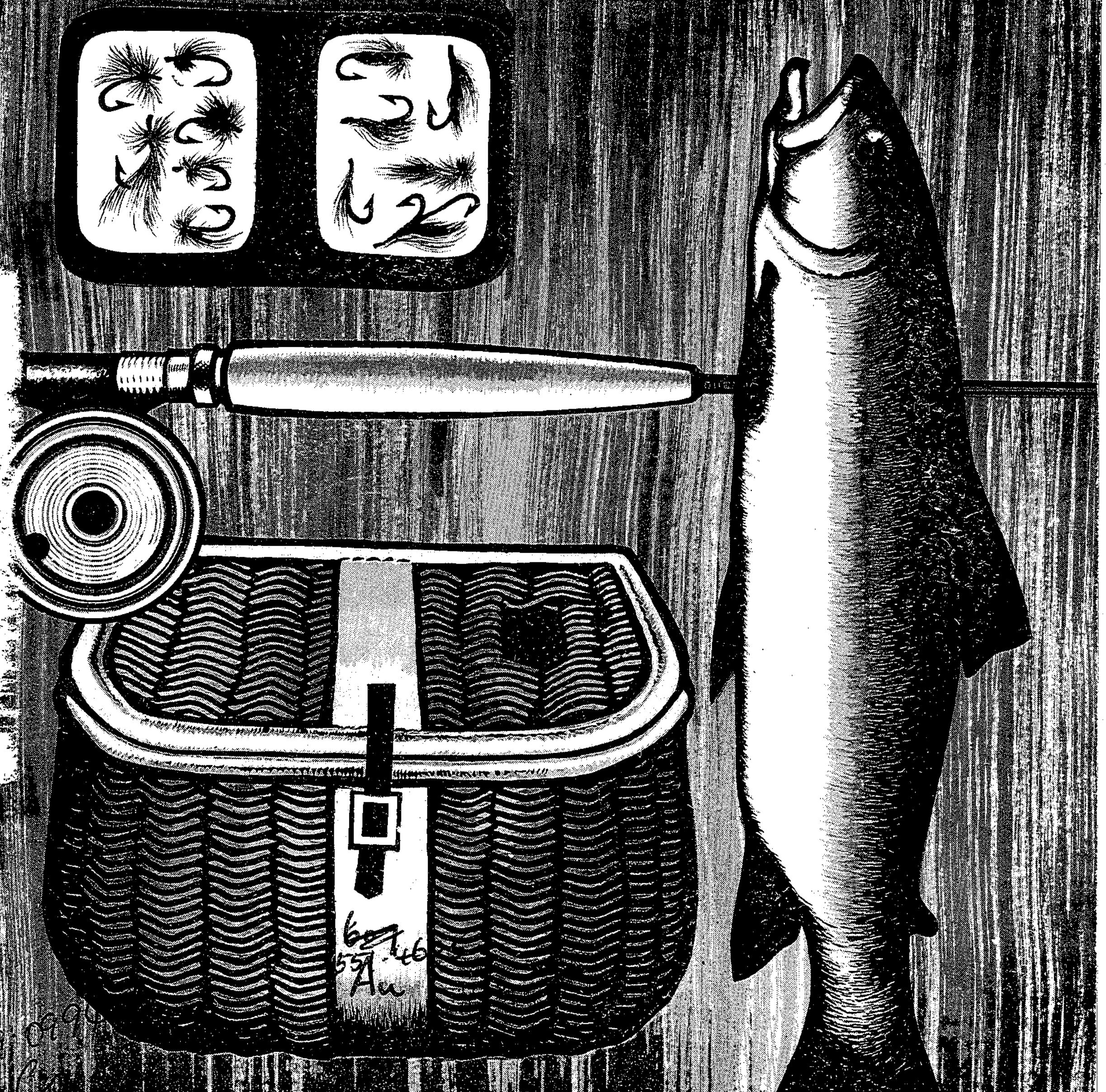
# THE TROUT FISHERY IN TASMANIA



DIVISION OF FISHERIES AND OCEANOGRAPHY

CIRCULAR NO. [illegible]

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION, AUSTRALIA

MELBOURNE [illegible]

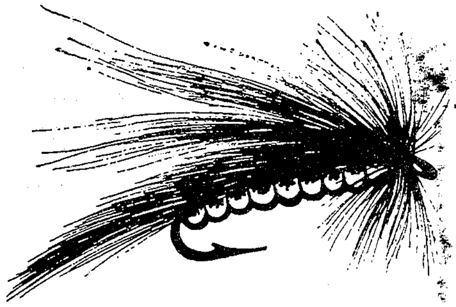
THE TROUT FISHERY OF TASMANIA HAS been closely studied for several years by Dr. A. G. Nicholls, of the C.S.I.R.O. Division of Fisheries and Oceanography, at the request of the Salmon and Freshwater Fisheries Commissioners of Tasmania. He has examined the fish population to see if overfishing is occurring and to provide information for the planning of measures aimed at conserving and improving the fishery.

Studies of this kind are complex and time-consuming, and the sorting out of data and the preparation of detailed reports are slow processes. Four reports have already been prepared: an introductory report, two dealing with the fishery in the north of the State, and one concerned with the fish population of the North Esk River in relation to the release of hatchery fish. The results have not yet been worked out in detail for the south of the State and for the lakes, but the general conclusions which have been formulated are of interest even though they may require some modification after more careful study.

This Circular has been prepared to give anglers a brief account of the main results set out in the detailed reports which have already been issued and of the general conclusions which have been reached as a result of the work that has yet to be published.

Special attention has been given here to the question of stocking with hatchery fish, since this is of considerable interest to anglers as well as to those who will administer the fishery in the future.





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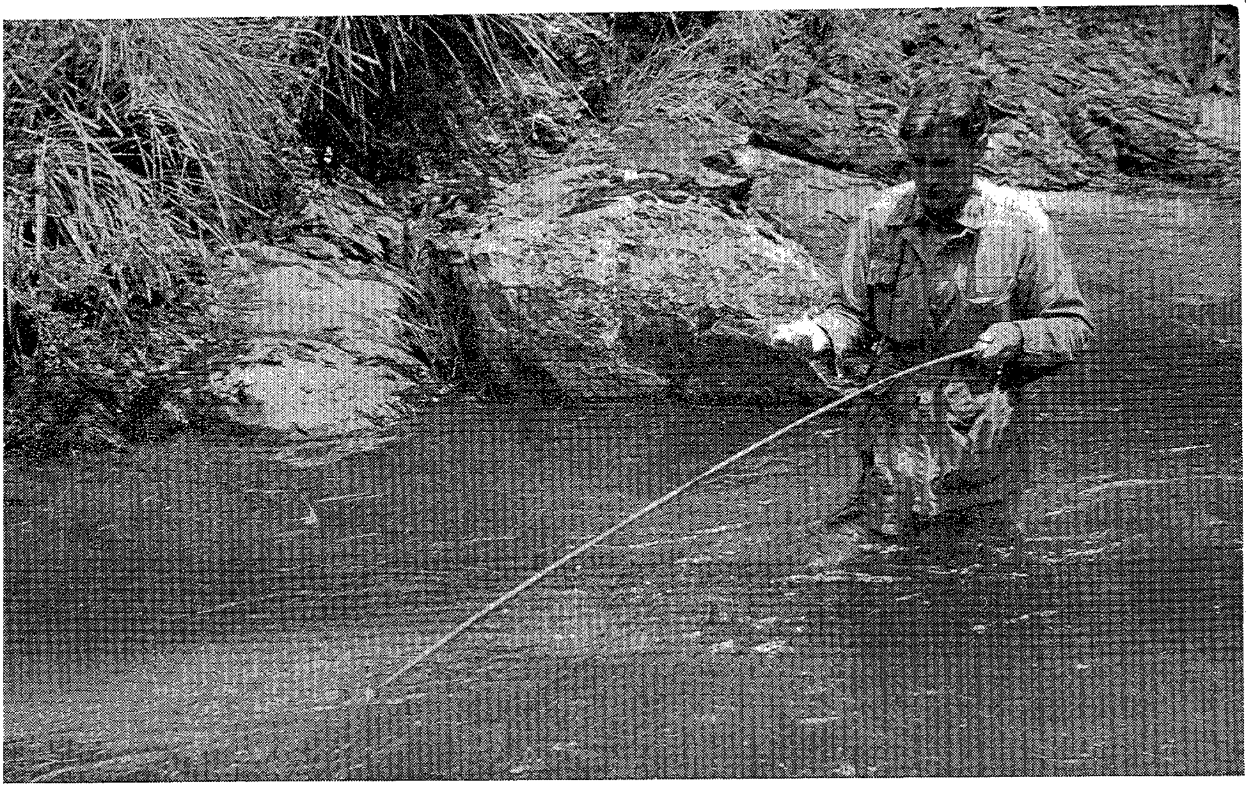


(*Photo: Victorian Railways.*)

# The Trout Fishery in Tasmania

TROUT were introduced into Tasmania nearly 100 years ago and since then interest in angling has steadily increased until now one person in every 30 of the State's total population spends some leisure time engaged in it. As well as being popular among Tasmanians, angling could be a major tourist attraction. The State is well endowed with rivers and lakes, and the Hydro-Electric Commission is continually creating new lakes and building more canals which increase the angler's opportunities.

Several years ago an investigation into the trout fishery was begun at the request of anglers who thought the fish were becoming fewer and smaller. It has shown that in most rivers and lakes the fish population is not affected by the present pressure of angling, and even though the number of anglers and their total catch are increasing each year there is at present no need for concern about decreasing numbers or size of fish. The investigation has also revealed that, because the rivers and lakes are well stocked with wild fish, releases of fry, fingerlings, or yearlings from hatcheries do little to provide additional takable fish.

In spite of these findings, it is of concern to the angling community to know whether anything can be done to improve the fishery in addition to conserving it.

# Methods of Investigation

To determine whether fish were really fewer and smaller than in previous years, it was necessary to know the average number and size of fish caught in the past. The only information available when the investigation began was the record books of fish taken at the Great Lake and Lake Leake, and simple returns of anglers' catches for the four preceding years. Neither source provided sufficient information for a detailed study.

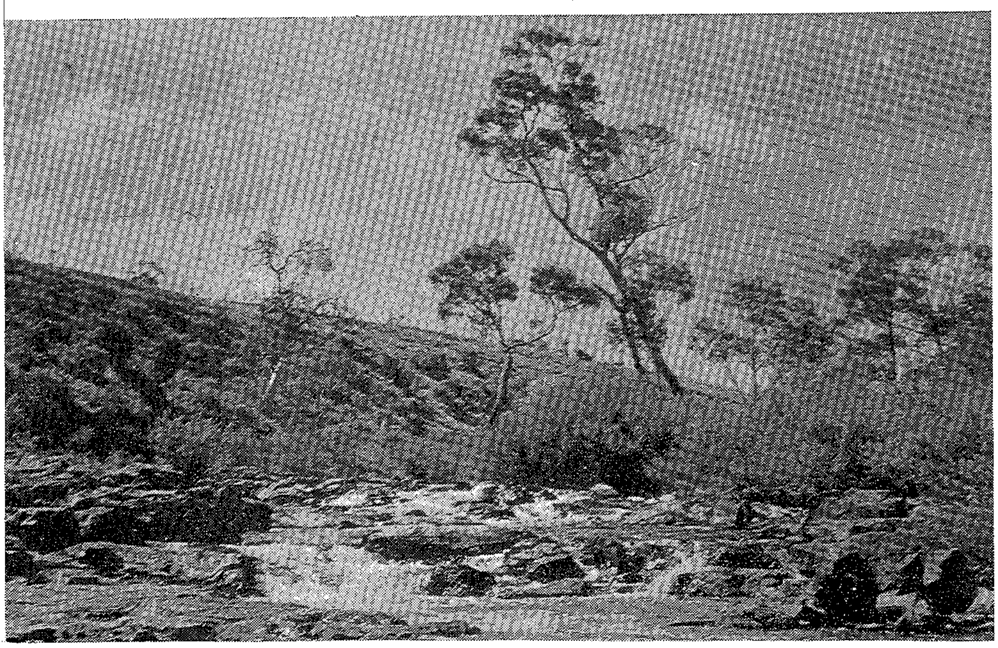
In 1949–50 a creel census was begun for the purpose of obtaining reliable information on the rate of catching and the size of the fish caught in the lakes and rivers of Tasmania. Every angler was asked to record his catch. Some undertook to collect scales from the fish they caught, for use in age determination and rate-of-growth studies. Because of natural fluctuations in fish populations, due to the success or failure of natural spawning or to droughts or floods affecting the fishing, it was necessary to collect information for at least five years.

An excellent opportunity for observing fish occurs when they congregate for spawning, and studies of fish populations were made at various places where they could be collected during spawning runs. Many of these fish were labelled with numbered tags to provide information on their growth between tagging and recapture. The theory that a tag around the jaw of a fish will prevent it from feeding and so cause it to lose condition was proved incorrect.

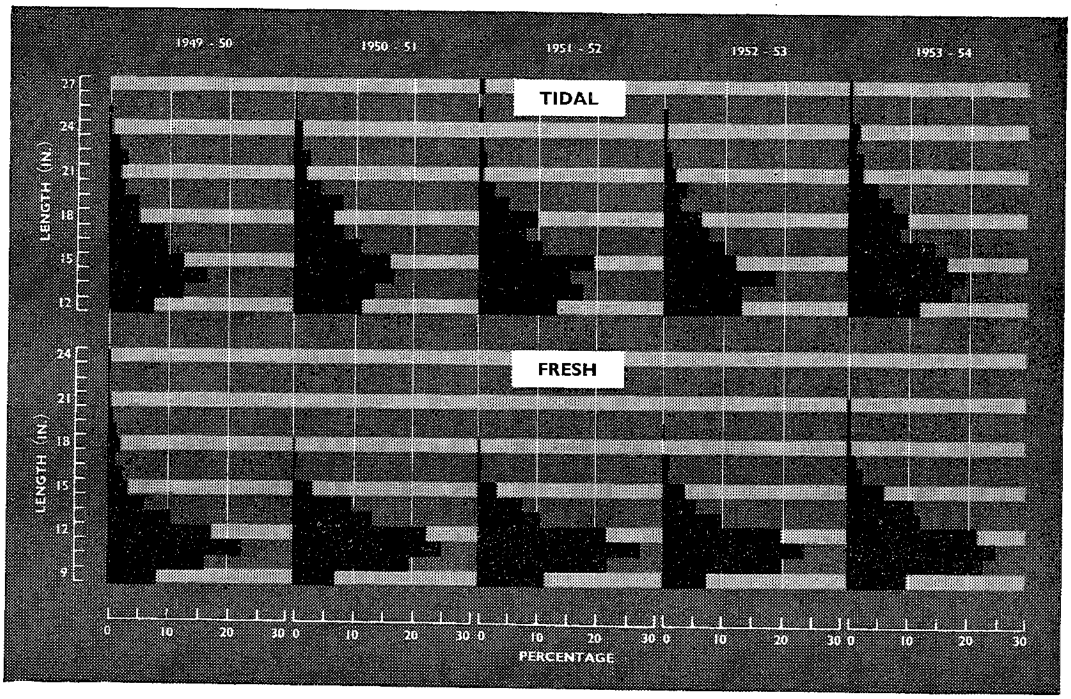
Many thousands of yearling fish were marked by the removal of one or more fins and then released into waters in different parts of the State. Marking fish in this way has no ill effect and enables them to be recognized when captured. It is not as useful a method as tagging, because it does not yield as much information, but it allows greater numbers of fish to be examined.

Fishing by electricity is a most useful means of gaining reliable information on the population in a stretch of water and it was used in these investigations for several purposes. In any population study it is necessary to assess the relative numbers of individuals of all ages in the whole population, information which cannot be derived from anglers' returns because of the minimum legal length which prevents them from keeping small fish.

The faster growth of trout in summer and the slower growth in winter produce characteristic markings on the scales of a fish and from these its age can be determined. It is also possible, by measurement, to discover the length of a fish at the end of each winter of its life. Studies on hatchery fish have shown that the ages of river fish and most lake fish in Tasmania can be reliably determined by reading their scales.



*Typical trout stream—the Clyde River near Bothwell.*




*Percentage of fish at each length caught in tidal and fresh waters of the north-west rivers from 1949–50 to 1953–54.*

# Results of the Investigation

Anglers' responses to the request for information were very disappointing. Only about 2 per cent. of licence-holders responded and very few made returns for the whole five-year period. It was therefore very difficult to derive correct results from the creel census and the data it yielded were examined very carefully.

### RIVERS OF THE NORTH-WEST

The most significant feature emerging from the census is that both in the tidal waters and in the fresh waters of the north-west rivers there was in this five-year period no change in the relative numbers of fish of each length caught, that is, the composition of the population was undisturbed by angling. From 1949–50 to 1953–54 the majority caught in fresh waters were between 10 and 12 in. and in tidal waters between 13 and 15 in.

In this period the number of anglers for the whole State increased, as shown on the inside back cover of this Circular. The number of anglers in the north-west began to grow vigorously in 1945–46, when only 1012 licences had been issued.

Although the census results suggest that the number of fish taken by each angler per day or per season has decreased in the northern part of the State, the total number of fish taken by all anglers per season has on the whole increased over the years, as shown in the table overleaf.

As the total number of fish taken each year corresponds with the increase in the number of anglers, it might seem that each season most of the fish of takable size in the rivers are being caught, so that a limited number of fish has to be shared among more and more anglers. If this were so, few fish would have had a chance to grow larger than nine inches, because as soon as they reached that size they would probably have been caught. These fish would have been only two years

Mean Daily and Seasonal Catch per Angler and Estimated Total Catch from the North-west Rivers

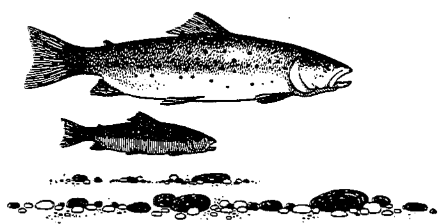
| Season | Mean Daily Catch per Angler | | | Mean Seasonal Catch per Angler | Estimated Total Catch |
|---|---|---|---|---|---|
| | Tidal Waters | Fresh Waters | Combined | | |
| 1945–46 | | | 3·3 | 51·3 | 52,000 |
| 1946–47 | | | 3·7 | 35·7 | 38,000 |
| 1947–48 | | | 2·9 | 37·2 | 55,000 |
| 1948–49 | | | 3·5 | 62·0 | 121,000 |
| 1949–50 | 1·9 | 3·4 | 2·7 | 36·2 | 84,000 |
| 1950–51 | 2·0 | 2·9 | 2·3 | 32·1 | 89,000 |
| 1951–52 | 1·9 | 2·9 | 2·5 | 45·8 | 127,000 |
| 1952–53 | 1·8 | 2·9 | 2·4 | 30·4 | 76,000 |
| 1953–54 | 1·5 | 2·8 | 2·3 | 28·3 | 73,000 |

old, so that the average size of the fish taken would have declined each year until it was close to nine inches and the catch would have been composed almost entirely of two-year-old fish. The results of the census, shown in the diagram on page 3, show this to be quite untrue; on the contrary, the conclusion to be drawn from them is that in the northern rivers there has been no decline in either the size or number of the trout.

The creel census for the north-western rivers showed an overall fall in the number of fish taken per day by the average angler. This decline affected the fishery only in tidal waters; that in the inland waters remained steady after 1950–51.

The total catch per angler per season, however, showed a steady fall. This would appear to support the belief that fewer fish are available to be taken, but this conclusion is erroneous and there is a simple explanation of the decline. The creel census was not representative of anglers and conclusions drawn from it as to the catches cannot be regarded as reliable. This was clearly shown in one district where a personal canvass of about 50 anglers who had not sent in returns showed an average catch for the season of over 250 fish per angler, whereas the creel census showed an average of about 20 fish per angler for the district. The ability of anglers varies greatly, for success depends not only on constant practice and skill in technique, but also on understanding the habits of trout.

For four years before the creel census began, anglers had been asked to send in much simpler returns of their catches, and these have been used in this investigation to cover a greater period than the five years of the creel census. Most of the anglers who sent in returns for the first four seasons did not do so for the last five. In fact, anglers usually sent in returns for only one or two seasons; each season more than half the returns came from anglers who had not previously made a return. There was, therefore, a continual change in the representation of anglers and probably an increase in the number of newly licensed anglers fishing for their first season, who could not be expected to be as successful as more experienced anglers. It is certain that anglers who take good catches every year did not send in returns, for this was clearly shown in the district where the personal canvass was made. While the first four seasons' returns were probably representative of all anglers, the last five seasons' were not.



## THE LAKES

Although the study of the fishery in the lakes is not complete, several interesting points have already emerged from it. The most striking is the failure of fish in the Great Lake to continue to grow after they have spawned. The young grow reasonably well until they reach maturity, but then growth practically ceases. This was discovered as a result of the tagging programme and would not otherwise have become apparent.

This cessation of growth occurs only in the Great Lake. Mature tagged fish have also been released in the Plenty River and in Lake Leake. Lengths of a typical mature fish from each source in successive years are, in inches:

| | | | | | |
|---|---|---|---|---|---|
| Plenty River | $18\frac{3}{4}$ | 20 | $20\frac{3}{4}$ | $21\frac{1}{4}$ | $21\frac{3}{4}$ |
| Lake Leake | $18\frac{1}{4}$ | $20\frac{1}{4}$ | $21\frac{3}{4}$ | | |
| Great Lake | $20\frac{3}{4}$ | $20\frac{3}{4}$ | $20\frac{3}{4}$ | — | 21 |

These figures show that while fish in the Plenty River and Lake Leake grew steadily, those in the Great Lake showed no growth over a period of five years. While the condition of the Plenty River fish remained constant, that of the Great Lake fish went down.

It is not certain why the fish in the Great Lake fail to grow after reaching maturity, but evidence from their scales suggests that this failure to grow may be related to a nutritional deficiency. To test this possibility, fish from the Great Lake were tagged and released into the Plenty River to make their way to the estuary. One fish, 19 in. when tagged, had grown $1\frac{3}{4}$ in. a year later, and another, $18\frac{3}{4}$ in. when tagged, had grown 3 in. two years later. Both had put on weight. This shows that the deficiency is probably related to food and to the nature rather than the quantity of the food, for it is known that the fish grow well up to maturity.

In most of the larger Tasmanian lakes, especially those formed by the Hydro-Electric Commission and those with levels raised by impassable dams, fish are barred from access to the estuary. This may be a cause of the nutritional deficiency.

Another point made evident by the study of marked fish released in the Great Lake and Lake Leake is that the majority spawned for the first time at four years of age in the Great Lake and at three years of age in Lake Leake.

It appears likely that anglers are not taking more than about one-fifth of the population of takable rainbow trout in the Great Lake. The removal of the majority of the older fish, which are living up to 10 to 12 years of age and not growing, would permit better survival and better growth in the younger fish. There is little doubt that the brown trout population exceeds the rainbow. Anglers appear to take more rainbows than browns, but this might be because the majority of anglers fish from the shore, which rainbows apparently frequent more than brown trout.

While any assessment of the population is a little premature, present indications are that the lake is underfished rather than overfished. The lake may be regarded as containing a population which has increased up to its capacity to support fish.

If the late maturity and low growth rate of mature fish are indeed due to the presence of too many large fish, the remedy would lie in the removal of a substantial proportion of these older fish. This could be done either by netting on a large scale or by the destruction of the majority of fish which run to spawn in the Liawenee Canal each year, care being taken to select the older and less well-conditioned fish. If, however, the cause of the cessation of growth is related to a deficiency of any particular nutrient, the remedy should be sought by attempting to make good this deficiency.

## THE ARTIFICIAL REARING OF FISH

When trout were originally introduced they were cared for in a hatchery and as they matured they were stripped by hand and their ova were hatched and then reared for release into rivers and lakes. Eventually all the major water systems were stocked by this process. Anglers came to regard the artificial stripping and rearing of fish for release in the fishing waters as essential to the success of the fishery, but it is not essential at all.

Investigations in Tasmania and overseas show quite clearly that very large percentages of both wild and hatchery fish die each year. About 99 per cent. of all eggs spawned die within the first year, and in every subsequent year about 80 per cent. of the survivors die from one cause or another. It has been shown, too, that fish reared in a hatchery suffer a higher mortality when released into streams containing a resident population than do the naturally spawned fish. Moreover, released fish do not attain the same condition as the resident fish.

From the data that have been collected, and making allowance for the natural mortality that occurs each year, it has been possible to calculate the maximum possible contribution to the total population of takable fish that survive from the hatchery releases into the north-western rivers of the State. The results show this to be about 2 per cent. If, as seems likely, anglers take about 15 or 20 per cent. of the takable fish available each season, then the actual contribution that released fish make to the anglers' catches would be about 3 or 4 per thousand. The very considerable cost and effort involved in rearing and releasing fish into these river systems have thus resulted in only an insignificant increase in takable fish in the total catch.

Clearly, in any well-stocked river system the number of pairs of breeding fish contributing to the new generations will be much greater than the number of fish stripped for the hatcheries. Less than half the 1,000,000 ova which 500 female fish will produce can be raised in the hatchery to the fingerling or yearling stage. If these are released as fry they will be subject to a high first-year mortality, and only a small proportion—probably less than 2 per cent.—of all yearlings released will survive to add to the reproductive capacity of the streams which are already carrying enough fish to maintain the population by natural means.

In the North Esk River it has been found that the release of 10,000 yearling fish might yield 200 mature fish, a contribution amounting to 1/60 of the population of three-year fish or less than 1/100 of the population of takable fish. There are over 200 miles of water in this river system, so the result of such a large release is one additional fish in each mile of stream. To increase the population by one extra fish in every 10 yards of stream, 1,760,000 yearlings would have to be released in this one river. The effect of such an influx on the existing total population of something less than half a million can well be imagined.

It was because of the appreciation of these biological principles that in November 1951 the Commissioners agreed to cease stocking the rivers of the north-west for a period of several years. The returns from anglers during the years which followed showed no change in the fishery, and observant and successful anglers agree that the cessation of stocking has not affected their catches.

The addition of hatchery fish to a well-stocked lake makes only a small contribution to the population. In both 1951 and 1952, 15,000 marked rainbow yearlings were released in the Great Lake. They were watched for in subsequent spawning runs at the Liawenee Canal, and the numbers of marked fish recaptured in relation to the total numbers of fish handled at each run are shown in the table on this page. Only one of the fish marked in 1951 was seen in 1953, and small numbers were seen in the next three years. Of those released in 1952 only one was seen later.

MARKED RAINBOW YEARLINGS IN THE GREAT LAKE

| Year | Fish Handled | Marked Fish Found | Mean Length of Marked Fish (in.) |
|---|---|---|---|
| 1953 | 725 | 1 | 16¼ |
| 1954 | 860 | 12 | 19¼ |
| 1955 | 353 | 6 | 20½ |
| 1956 | 450 | 5 | 20¾ |

In a newly-formed lake the natural mortality of young fish is much lower than usual, and under these circumstances the population will increase rapidly. This build-up in population can be aided by stocking, but in Tasmania, where all the major rivers have been stocked long enough for the fish to have established themselves in even minor tributaries, it is not always necessary to release fish in lakes formed by damming a stream for hydroelectric storage.

This has been confirmed by observations in the Bronte Park district where a series of lakes has been formed. The top lake, Bronte Lagoon, receives water from the Nive River by means of a canal and it was not stocked with fish.

The three lower lakes are all at the same level and are connected by wide canals. One of these, Brady's Lake, was stocked with 9100 brown yearlings when it was first formed in 1950. It was subsequently shown, however, to have already had a small resident population at that time. It was estimated in 1954 (see report to the Commissioners made in April 1954 and published by the Northern Tasmanian Fisheries Association in their 56th Annual Report) that by 1957 these three lakes would have become stocked to capacity as a result of natural spawning.

That this has occurred is suggested by the reports of local anglers. The Annual Report of the Southern Tasmanian Licensed Anglers' Association for 1955–56 referring to Brady's Lake states: "Compared with previous years, the size of the fish taken from this water was disappointing, but a large number of fish were caught. There is evidence to show that this water is becoming reasonably well stocked, as for the first time a complete range of fish sizes appeared to be available to anglers."

Even more striking is the report that the Bronte Lagoon, which was not stocked, is equally well supplied with fish. The same report states: "It would appear from observations and results that this stretch of water is fully stocked."

Although scientific evidence has not yet been obtained in full support of these statements, it appears that earlier estimates of the population increase under natural conditions are being confirmed.

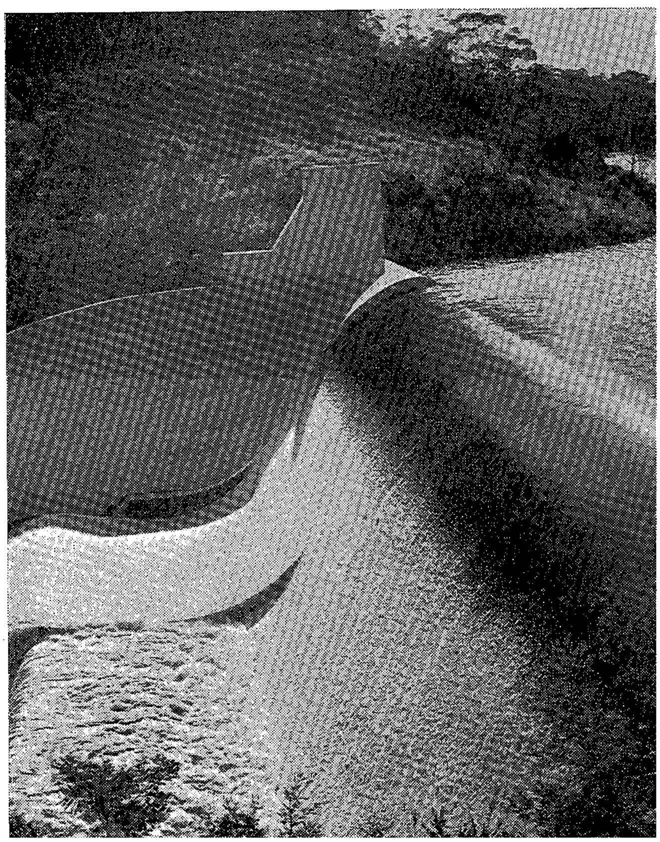
Some indication of the extent of natural spawning in this area can be obtained from the estimates of young fish on the spawning grounds above Brady's Lake made as a result of electro-fishing in February 1955. On this occasion 653 brown trout less than one year old were taken from about 1000 square yards of stream, representing a population density of about 3100 per acre. The main stream has an area of about four acres and there are many side channels, so that the contribution of yearlings from that spawning ground would probably exceed 12,000.

Further confirmation is given by observations on Lake King William. This was formed in 1952 by the completion of the Clark Dam at Butler's Gorge and it covers 12 square miles when full. It dams the Derwent River, the first river to receive the newly introduced trout in the 1860s. Just before the dam was completed, nearly 19,000 marked rainbow yearlings were released in this lake; not one of the marked fish has been reported captured.

In the 1954–55 season anglers became concerned that this lake might be overstocked in view of the large proportion of undersized fish taken. The latest annual reports of both the northern and southern anglers' associations agree that the lake is well stocked and is providing excellent fishing.

It is clear, however, that as the population has built up, the growth rate has declined. Four two-year-old brown trout taken in November 1950 had a mean length of 15·4 in. and a mean weight of 1 lb 10 oz, whereas 11 three-year-old brown trout taken in November 1954 had a mean length of 15·44 in. and a mean weight of 1 lb 9½ oz, that is they were nearly identical with two-year-old fish taken four years earlier. A similar decline in growth rate occurred in rainbow trout, and in both species this is probably related to the greater population density.

*Trevallyn Dam on the South Esk River near Launceston.*



# The Remedy

Although the facts outlined above indicate that, except in the Great Lake, there is nothing to remedy at present, there are anglers who complain of insufficient fish as well as those who adhere to the belief that stocking is essential. This poses the questions: what can be done to increase the fish population? and is it desirable to increase it?

Stocking from hatcheries is clearly wasteful. To strip fish, transport the ova to hatcheries, and spend months tending, feeding, and distributing them, is uneconomic when it results in such an insignificant increase in the population and even more insignificant returns to the angler. It is more uneconomic than ever when natural reproduction is much more efficient and quite adequate to maintain the population, as it is in all the rivers and major lakes of Tasmania (the exceptions are small lagoons, usually near the coast in sandy country not fed by creeks suitable for spawning fish, and any other bodies of water with similar conditions). Tasmania is abundantly supplied with fishing waters and spawning grounds.

The problem therefore becomes one of lowering the immense natural mortality and of reducing the amount—unknown but probably large—of illegal fishing. It is probable that the number of fish taken legally is not less than half a million a year, and it is not unlikely that an equal number is taken illegally.

It is not uncommon to find evidence of set lines in less frequented streams. Fish that run into small streams for spawning are easy to take and certainly are often taken under these conditions. A local inhabitant, living near the upper waters of a stream, volunteered the information that May was the best month for fishing, but the season closes at the end of April, during which month many fish ascend the rivers for spawning. Poaching by means of shooting, spearing, and gaffing at night with the aid of lamps is extensively carried on, and explosives are used in the streams in country that is difficult of access. Nets also are used occasionally.

Reports of these activities come from all parts of the State, apart from cases given publicity as a result of the work of the bailiffs. It is reasonable to ask how much protection can be afforded by a staff of only four bailiffs covering two-thirds of a State with a total area of 26,000 square miles. Members of the police force assist at times, but cannot be expected to patrol the waters.

Even a total of a million fish a year taken legally or otherwise is negligible compared with the natural mortality, without which the waters would be filled with multitudes of half-grown, starving fish. Of every 1000 eggs spawned, about 10 survive to yearlings and two can be expected to attain two years of age; in other words, for every fish which reaches six years of age over 300,000 eggs must have been spawned. All that is required to maintain a stationary population is that two of the eggs spawned by each mating pair should survive to become adults. If more or less survive, the population increases or decreases.

What causes this tremendous mortality? First, there is some loss, probably very small, through infertility. Some ova may escape deposition in the redds owing to swift currents or other causes, one of which is the presence of young males not participating in the spawning but waiting to feed on ova when opportunity offers. Then there is the loss due to the disturbance of existing redds by later spawners, the risk of this increasing with high densities of population. Too many fish on a spawning ground cause redds to be made in unsuitable positions, from which the water may recede before the ova have hatched. The young in the redds may be eaten by platypuses which disturb the redds for this purpose, and even the freshwater lobster may penetrate between the stones and eat the ova. Heavy floods may wash out established redds.

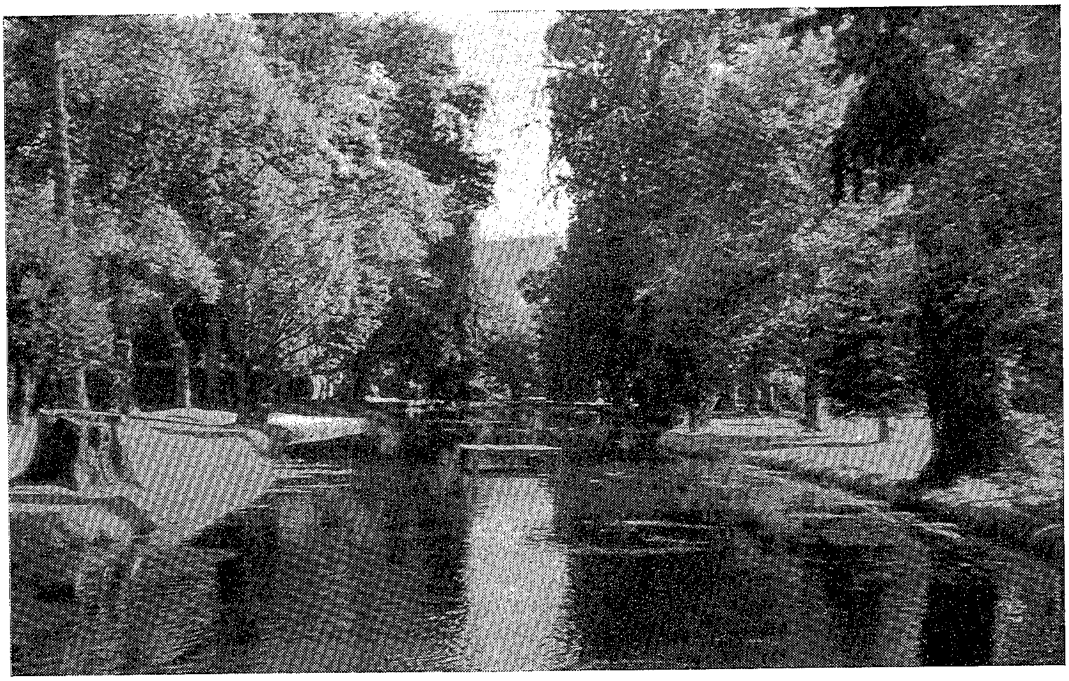
Once the young have hatched and need to seek their food they are exposed to attack by other predators. Platypuses and water-rats catch and eat them, and such birds as cormorants, ducks, herons, and gulls take their share. Larger fish of the same or other species prey on smaller ones.

Climatic conditions play a large part in determining survival, especially during the first two years and probably to some extent in later years. Heavy rainfall may cause sudden rises in river levels which carry part of a population downstream to reaches inhabited by older fish, where the rate of predation increases. Such conditions also reduce the food supply, so that even if the young are not washed downstream they may have to move in search of food. Above-normal summer river levels, even without flooding, enable larger fish to move upstream into nursery creeks and feed on the young.

Droughts either prevent the young from escaping to deeper water or force them to do so. If a stream becomes a succession of pools, temperatures may rise above the lethal level and with increasing congestion the fish are more accessible to predators. Young fish forced to leave nursery streams and enter the main river prematurely are subject to attack from the larger residents.

## CONTROL OF PREDATORS

The control of predators might raise the survival rate among fish, but even if control by destruction is desirable it is not always easy to achieve and may be expensive. Moreover, it is difficult to justify the destruction of native fauna peculiar to Tasmania for the benefit of one section of the community.



*Rearing pond at the Salmon Ponds fish hatchery.*

The results of destroying predators are not, however, easy to predict. It might be supposed, for example, that a group of cormorants living on the banks of a river would remain there to feed until they had reduced the population to a comparatively low level by taking most of the fish that were neither too small to catch nor too large to handle, and would then leave the district. This would reduce considerably the number of fish available to anglers, possibly for the rest of the season. The damage, however, would not be permanent because the survival rate of the young which were too small to be caught would be relatively greater. Also their growth rate would increase owing to the reduced competition for food not only from older fish but also from eels, lobsters, and other competitors eaten by cormorants. If the cormorant population were destroyed these competitors for food would increase.

There is much still to be discovered about the predation of other animals on fish. It is doubtful whether control measures to reduce the high natural mortality of trout and allow greater numbers to survive would be desirable even if there were sufficient information available to make them possible. In most rivers the result would be extensive over-population, with great numbers of fish surviving but, since they would all be competing for the same amount of food, growing very slowly. The population would be stunted and in poor condition.

It is probable that the population in some newly-formed lakes has increased rapidly because the greater depth of water gives young fish more protection from birds than shallower waters. If young fish do get greater protection, their survival rate will be so much greater that the trend will be towards rapid over-population. This will last until a balance is restored by greater competition for spawning space and for food among the resulting fry and by greater predation by the older fish on the young, with a consequent reduction in the number of young fish that survive to reach the protection of the deeper waters. Continued and unrestricted increase in any population rapidly reaches such proportions that the population may be jeopardized to the extent of self-extermination.

## IMPROVING THE FOOD SUPPLY

It is doubtful whether there is any need for additional food under present conditions. Available food and food eaten by trout were studied over a period of five years by J. W. Evans, who concluded in 1942 that there was no scarcity of food in the Great Lake, Shannon River, Shannon Lagoon, Penstock Lagoon, and Lake Leake. He stated, "If there has been any depreciation in the fisheries of the State of recent years, it cannot be due to depletion of trout food."

Increasing the number of fish by lowering the natural mortality would lead to an increased demand for food. This could be supplied within limits. Experimental work in Lake Dobson has shown that in a certain type of highland lake which is naturally unproductive and incapable of supporting large fish populations, an improvement can be effected by adding fertilizers to the bottom to supply food for the rooted aquatic plants on which fish food can grow. Adding fertilizers directly to the water had little apparent effect because the water in the lake was rapidly replaced by the flow from incoming creeks.

In a river where the whole body of water was continually on the move, the addition of fertilizer to the bottom in suitable pools might repay the cost and effort but if it were successful it would almost certainly cause massive growths of aquatic plants, which would make angling more difficult and might have unforeseen effects in times of heavy flow. In a body of water as large as the Great Lake, the amount of fertilizer required to produce results comparable with those achieved in Lake Dobson would be something like 3000 tons. It might be more practicable to enrich the bottom in small areas, with correspondingly less effort.

Can the quantity of food be increased by spreading native species or by introducing new species? Under natural conditions, native species would have colonized all the suitable localities where they were able to survive.

The snowflake caddis, for example, though most abundant in the Shannon River, is known in several places in Tasmania and probably exists in many others. Efforts to establish it elsewhere would almost certainly fail. It succeeded so well in the Shannon River because where it already existed, man extended conditions suitable for it, by increasing the quantity of water and maintaining it at a constant level so that the population rapidly increased to occupy all the newly-made space. This produced the famous Shannon rise. When reduction of water flow caused a return to the natural conditions which existed before the Miena Dam was built, the population was reduced.

The introduction of new animal species into conditions favouring their survival is undoubtedly possible, but generally only at the expense of the existing population. This has been shown by the introduction of trout into Tasmanian streams. The native fish—blackfish, sandy flathead (pike), and many species of *Galaxias*—still exist, but in greatly reduced numbers. It would be the same with any introduction, insect, crustacean, or fish. The new species would survive and build up at the expense of existing species, which would fall in numbers owing to competition for food. The overall result would be more variety in the trout food rather than an increase in its quantity.

### INCREASING THE CATCH

Several methods of improving the fishery, such as increasing the numbers of fish released from hatcheries, reducing natural mortality, and increasing food supplies, have been considered and shown to be either uneconomic or impracticable. There is, however, another method, which appears to be of value in some cases but still needs further investigation.

The study of the North Esk system showed that a considerably greater weight of fish could have been taken by anglers if the size limit had been lower. Under the existing nine-inch size limit an average of 23 lb of fish per acre was takable from the sections studied. This would have been increased to 32 lb per acre under an eight-inch limit, and to 41 lb per acre under a seven-inch limit. Since the majority of the younger fish are wasted to natural mortality a reduction of the size limit to seven inches in these streams would permit anglers to take 80 per cent. more fish by weight than they can at present, without harming the fishery and possibly benefiting it by permitting an improved growth rate.

This is so in the North Esk system where the growth rate is low, but because of this factor results cannot be extended directly to all Tasmanian streams and it is necessary to make reliable estimates of existing populations and their growth and mortality rates for each system separately. It seems probable that a lowered size limit would not damage the fishery in most rivers or lakes and could improve it.

# The Rise

When anglers fail to see fish rising, they commonly think there are no fish in the water, but an angler who spends a few days at a lake and argues that because there was no rise there were no fish may be mistaken. Had he been a week earlier or later he might have seen fish rising everywhere. This has been borne out by reports from different anglers whose visits to Lake Leake were only a week apart.

Trout rise only when feeding on surface food, for which there are two sources, one above and one within the water. Land insects, such as grasshoppers, ants, and beetles are carried over the water by wind and fall on the surface, or if a stream is heavily overgrown with trees some insects fall into the water.

Most of the aquatic food—the second source—is insect life in the larval stages. The young insects live on the bottom, feeding on the plant and animal food growing there. When they have finished their aquatic life they come to the surface and hatch into winged adults, which lay their eggs on or in water. Such insects are dragonflies, stone flies, damsel flies, lacewings, mayflies, caddis flies, mosquitoes, and midges.

Trout do not rise for other living things which spend all their lives in the water, such as water beetles, water boatmen, water snails, and various shrimp-like forms, or those which spend part of their lives in the water, such as frogs.

Since many of the insects which provide surface food spend the greater part of their lives on the bottom and only a very short time in the air, rises due to hatches of insects must be comparatively infrequent. The snowflake caddis, for instance, hatches once a year over about a fortnight. Other insects may have more than one brood in a year. Where many kinds of insect are present in one body of water, a series of hatches will occur.

Allen, summarizing his study of the Horokiwi stream in New Zealand, states: "Surface food was found to be most often eaten by trout during the summer. But even at this time it made up only about 5 per cent. of the food which the trout ate, and during the rest of the year it was rarely more than about 2 per cent."

At most, then, trout can be expected to feed on surface life, and so be visible to anglers, for only one-twentieth of the time that they are feeding. Naturally this will occur only when conditions are right, when the wind blows terrestrial insects on the water or a hatch of aquatic insects takes place, and always provided the fish are hungry and feeding.

In a study of the factors affecting the rise of brown trout in an English lake it was shown that, other factors being equal, the hatch of "fly" was the limiting factor. Strong winds, mist on the river, rain at the time of rise, and perhaps turbidity, had an adverse effect by limiting the extent of the hatch. Rain during the day had a beneficial effect when other conditions were favourable, but thundery weather was detrimental. It is clear that many factors are involved.

# Conclusion

In spite of the increase in the number of anglers, there is no evidence of an overall decline in catch, nor has the increasing fishing intensity had any observable effect on the distribution of age groups in the trout population. There has been no observable decline in the numbers of takable fish, and the fish taken are no smaller.

The trout populations in streams and the older lakes have achieved stability, but are subject to the normal fluctuations in number that may be regarded as seasonal or cyclic changes. These are brought about by variations in the survival rate of fish born in different years, due to climatic conditions or to fluctuations in predators.

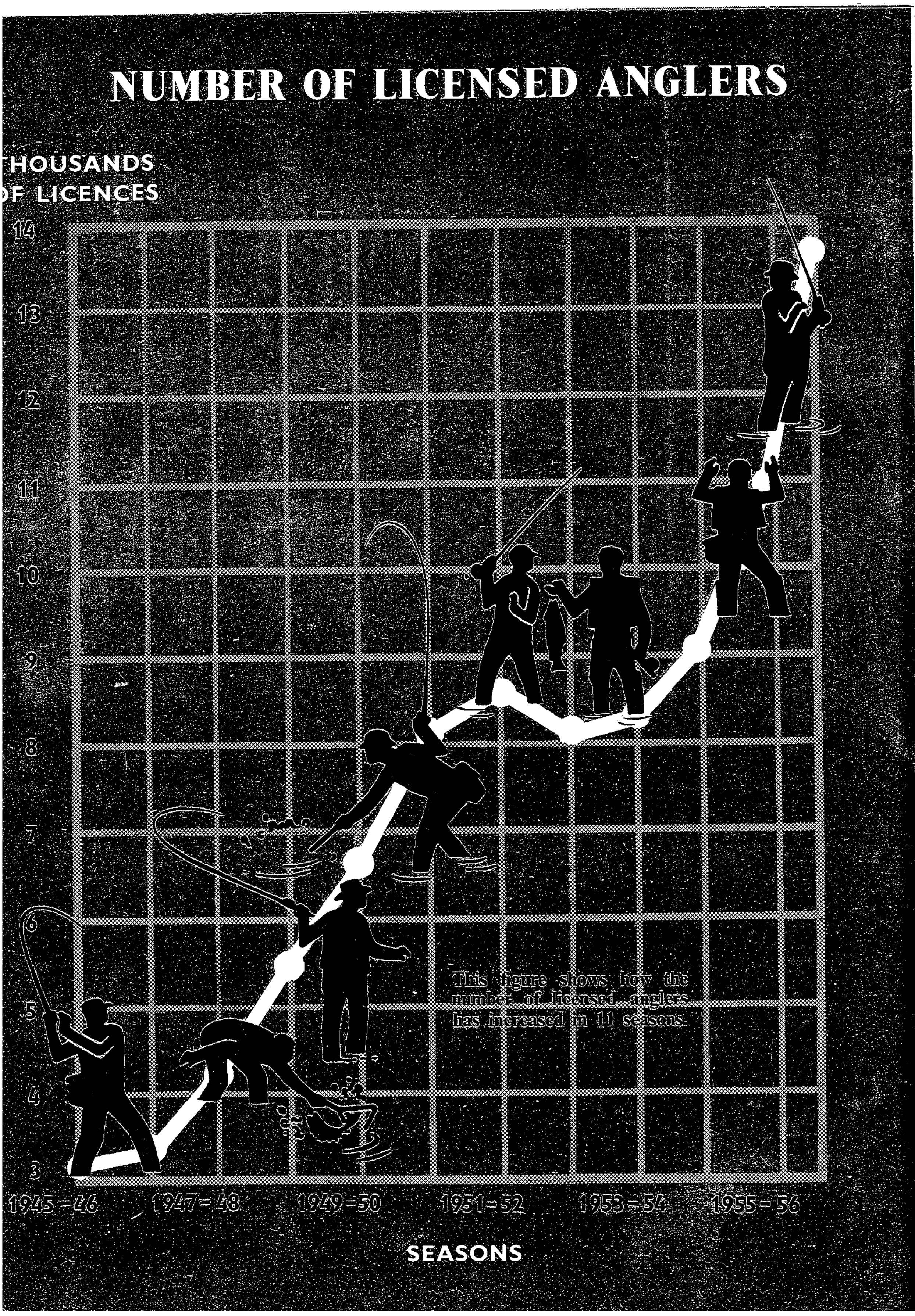
The trout population might be increased by the destruction of predators or of competitors for food, but this, if practicable, would involve an increased demand for food which would be difficult to satisfy. The quantity of fish taken could probably be improved without harm to the fishery by a reduction in the minimum legal lengths, though this would reduce the average size of fish taken.

Although the present fishing intensity is high in comparison with other Australian States on the percentage of population basis, there is no need for concern about depletion of stocks by overfishing. Anglers still convinced that hatchery liberations are needed may point out that bigger and better hatcheries are still being built overseas, but Tasmania is far from reaching the conditions existing in, for instance, California. A few points from the 42nd Biennial Report of the Department of Fish and Game in California may help to place things in perspective.

California, with an area of 157,000 square miles, had in 1952 a population of 11 million, of whom 1 million were licensed anglers. The density of population is six times that of Tasmania and the fishing intensity is three times that of Tasmania, so that the overall impact on the fishery is 18 times that of Tasmania, assuming both States have proportionally the same amount of fishing waters, equally suitable for carrying fish. California has 5000 lakes and 25,000 miles of streams, and to correspond with this Tasmania should have about 1000 lakes and 4000 miles of streams. The number of lakes is meaningless unless their total area is known, but it is not unlikely that Tasmania has the requisite area and its total length of streams considerably exceeds 5000 miles (excluding minor tributaries), the majority of which have been stocked with fish and now have established trout populations.

As the overall fishing intensity in California is 18 times as great as in Tasmania, many anglers may be surprised to learn that the great majority of trout caught by anglers in California still result from natural propagation, even though hatcheries play an important role in supplying fish to a number of waters incapable of producing satisfactory angling by natural propagation. When the number of licensed anglers in Tasmania reaches 180,000 conditions will be comparable with those in California now.

Printed by C.S.I.R.O., Melbourne


NUMBER OF LICENSED ANGLERS
THOUSANDS OF LICENCES
14
13
12
11
10
9
8
7
6
5
4
3
This figure shows how the number of licensed anglers has increased in 11 seasons.
1945-46
1947-48
1949-50
1951-52
1953-54
1955-56
SEASONS