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SALMON FOR ANGLING IN THE MARGAREE RIVER

BY
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INTRODUCTION

Our object has been to discover how to have salmon for angling in the Margaree river of Cape Breton island. For river after river the need has been felt of having more salmon, and the opinion has been widely held that the salmon are nearly all gone. It was realized that the problem involved is very complex and difficult, that its solution is apt to come but slowly, and that one cannot hope to solve it except by scientific impartiality and thoroughness. It was felt necessary to keep an open mind regarding every factor that might be suggested by others or by oneself as affecting the numbers of salmon in the river, and to make a critical study of the effect of each factor that gave any prospect of being significant.

The anglers interested in the Margaree river placed in first position the factor of capture of salmon by nets on the coast outside the river mouth. Principal attention has, therefore, been given to the effect of the nets. However, in the preliminary season (1934) of our contact with the problem, complete cessation of net fishing on August 31 was followed by week after week of even poorer angling than there had been previously, which showed that, whatever might be its importance, capture by nets was not the only important factor responsible for poor angling.

The catches improved significantly only in October when the river rose with successive freshets. It became evident that, as was generally believed, the condition of the river was very important and would need to be studied. It was soon found that one could not safely confine attention merely to nets and river condition. Some anglers maintained that poaching was very important and this possibility could not be ignored. Much effort has been spent in attempting to increase the abundance of the stock by hatching the eggs and planting the fry of the salmon; therefore, the effect of varying abundance of the stock needed to be considered. When, in the second season, a late spring seemed to show that temperature has a very definite influence, it was seen as necessary to devote some attention to this factor. Also, there was found to be general recognition of the effect of wind on salmon fishing not only on the outer coast, but also in the estuary, and this has required very extended study.

It should not be supposed that the factors that have been mentioned are all that influence the numbers of salmon in the river. They seem, however, to be the more significant ones and sufficiently significant for one reason or another to be included in this bulletin on salmon for angling in the Margaree river. I am sure that the reader of this bulletin will agree with me as an investigator of the problem

that the matter of getting salmon for angling would be very much easier to understand if there were not so many factors determining the numbers of salmon in the river.

The Complaint

The persons interested in salmon angling on the Margaree river in Cape Breton island have for many years complained that there are now fewer salmon in the river during the angling season than there were twenty to forty years ago. The blame has generally been placed upon the fixed nets or traps, locally known as "salmon fleets", which are operated along the coast outside the river mouth from June to August.

A real shortage in the stock of salmon is not usually in mind, since the statement is frequently heard that "as soon as the nets are put out of commission by storms or are taken up at the end of the season, the river is full of fish". With such views prevailing, it is natural that there has been an insistent demand by the anglers for the removal of some of the nets nearest the river mouth.

The anglers claimed that, with salmon on the coast, there should be at least some in the river. They definitely affirmed that they would be satisfied if there were *some* to be caught, as it was their task to catch the fish so long as they were there.

The Condition

The angling season in the Margaree river extends from June to mid-October. Beginning in the year 1925, the local Inspector of Fisheries, Mr. A. J. Murphy, has regularly obtained information from the various river guardians concerning the numbers of salmon taken by angling in the river. The general course of the angling throughout the season as shown by the monthly means of the numbers of salmon reported taken during each five-year period since 1924 (the last one for only four years) is shown in figure 1 (left). It is quite apparent that the angling catch is heaviest toward the end of the season, after the netting has ceased. This condition is most pronounced for the recent period (1935 to 1938), and least pronounced for the middle period.

The years 1932 and 1934 were the poorest years, with reported totals for the whole season of only 167 and 144 salmon respectively. The smallest total for June, July and August was 28 for the year 1932. The year 1936 was notable as giving not a single salmon in June.

Repeatedly during our investigation in 1935 the river was examined when the anglers were saying that there were "no salmon in the river". Invariably salmon were found to be present though few, even during weeks when not a single salmon was reported as being taken by angling. The angler's "no salmon in the river" clearly does not mean what the words ordinarily imply. He considers that there are salmon in the river only when they are rising to a fly. At least, that is the best interpretation I have been able to make of his use of the words.

It is naturally expected that "salmon on the coast" will be followed in a short

time by "salmon in the river". The mean monthly landings of salmon on the north Inverness coast, consisting mainly of fish caught in relation to the Margaree river, are plotted in figure 1 (right) for each of the same three periods as for the angling catches. It is quite evident that salmon are most abundant on the coast in July. Whatever may be the explanation, there is the anomalous condition that salmon are quite regularly most abundant on the coast outside the river mouth during

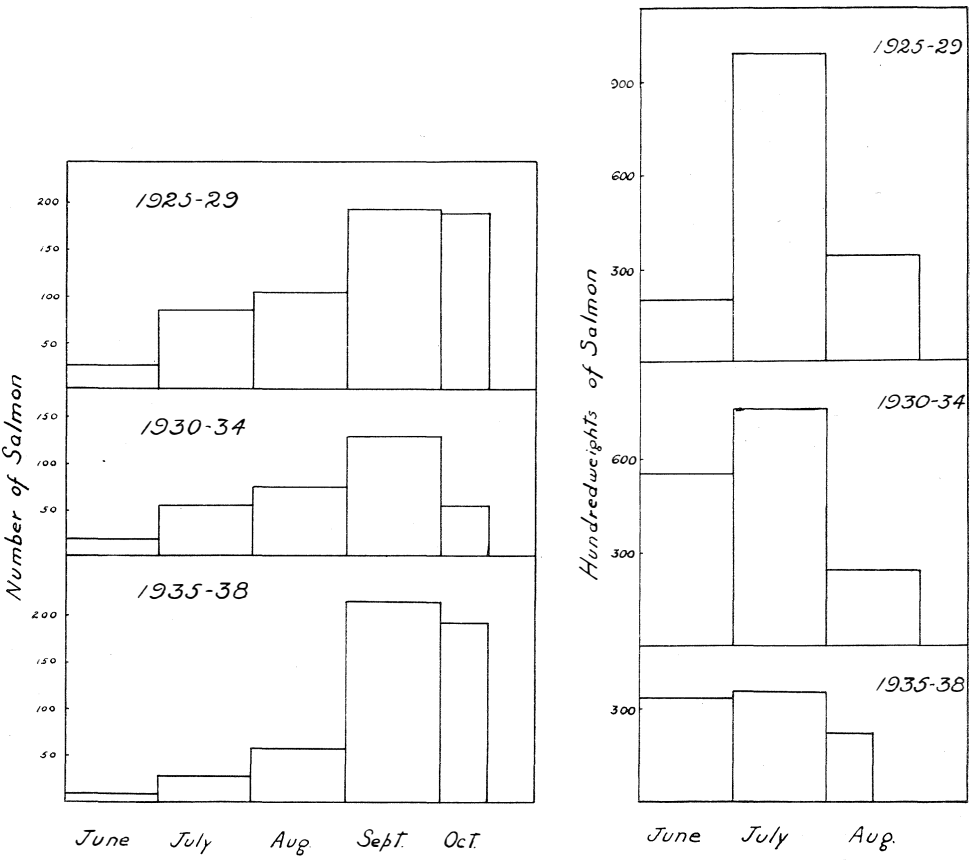

FIGURE 1. Seasonal changes in the Margaree angling catch (left) and in the catch of salmon on the north Inverness coast (right) as shown by the monthly means of the salmon reported taken in each of the three periods,—1925 to 1929, 1930 to 1934, and 1935 to 1938.

July, and usually they are not abundant in the river until September. We have clearly established the fact of their scarcity in recent years in the river during July when excellent catches were being made on the coast. Anglers, who have perhaps made a long journey to catch salmon in the Margaree river in July, have been confronted with this contrast of few or no salmon rising to a fly in the river at the same time that large numbers are to be seen being landed from the nets only a few miles away.

The Objective

In 1934, the Biological Board of Canada undertook to investigate the matter and made preliminary surveys. As a result of these the Board decided to make a rather thorough study of the Margaree river as more or less typifying the many salmon rivers for which angling presents a problem. The stated objective was to discover if possible *how salmon could be assured in the river for angling.*

When it developed that the demand was not merely for salmon in the river, but for really good fishing, it became quite apparent that it was impossible to satisfy the large number of anglers now going to the Margaree as the result of improved roads, not to speak of the much larger number that would go if the fishing improved. It was realized, however, that, although the salmon are comparatively abundant on the coast as early as late June or July, when they are in excellent condition, they have for the most part not been available in the river except in small numbers until late in the season near the spawning time, when they are in very poor condition for eating. The objective was then seen as being the discovery of *how to bring the salmon into the river early in the season,* as well as how to have more salmon generally in the river.

DESCRIPTION

Cape Breton island lies between the gulf of St. Lawrence on the northwest and the Atlantic ocean on the southeast. It is separated to the northeast from Newfoundland by the broad Cabot strait, the main entrance to the gulf, and to the southwest from the mainland of Nova Scotia by the narrow gut of Canso. The northern or northwestern part of the island consists largely of a tableland about one thousand feet high, from which the principal drainage into the gulf is through the Margaree river. This river (figure 2) consists of two principal branches running roughly parallel to the gulf coast, the Northeast Margaree and the Southwest Margaree, which join at Margaree Forks to form the eight-mile long main river, over half of which is tidal.

The Northeast Margaree River

This is the important part of the river system for salmon angling. It drains an area thirty miles long and about seven miles broad by means of rather many brooks entering it from both sides along its course. Throughout its length of more than twenty-five miles it is without falls, but has sufficient slope to be continuously rapid. Its deeper parts constitute the numerous and varied salmon pools (figures 3 to 8), from the Thornbush pool at the Forks to the Last or Two Brooks pool where the river proper arises from the junction of two brooks.

For the upper ten miles the river runs through a deep gorge (figures 3 and 4), which it has cut in the tableland, and this part is to be reached only on foot from the Head of Settlement at the Big Intervale. The remainder of the river traverses a beautiful, arable valley (figure 6) and is rather readily accessible from the roads

that run along both sides excepting below the Big Intervale, where for a few miles the Sugarloaf mountain intrudes to force the river into a narrow defile (figure 5).

The water is somewhat cool, since much of it is from springs, which arise even

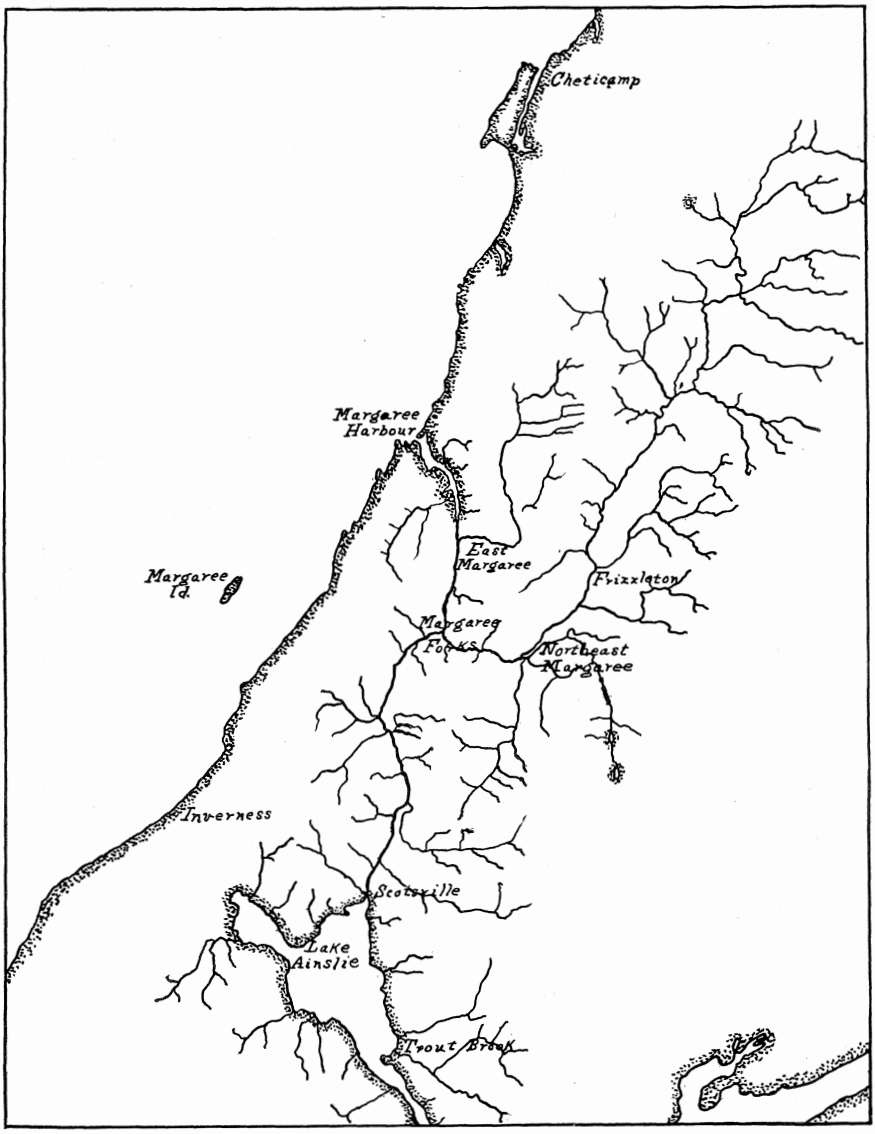

FIGURE 2. Margaree river system and neighbouring coast of Cape Breton island. Scale: one inch equals 7.5 miles.

in the bed of the river. The flat "intervale" land of the valley is underlain by gravel to such an extent that streams of fair size originate from it. The freshets are so pronounced that the river is more or less constantly changing its course

through the "intervale" land, removing the land on one side and building it up on the other. The salmon pools (figure 7) are frequently altered and new beds formed of clean gravel.

The Southwest Margaree River

This river drains an area twenty-five miles long, but so broad in its upper part as to be little smaller, though of less elevation, than that drained by the Northeast. It rises from lake Ainslie, a body of water twelve miles long, four miles across at its widest point, and little more than thirty feet deep anywhere. While

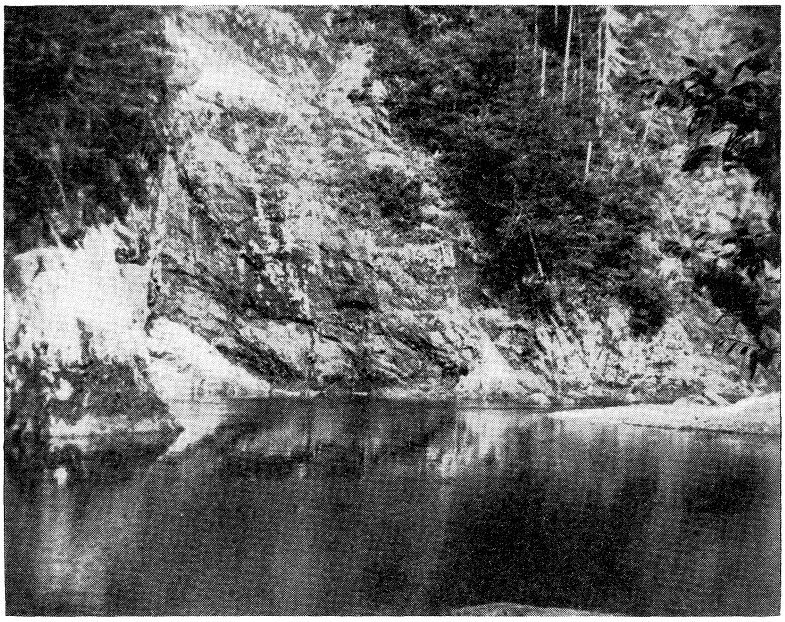

Figure 3. McKay or McCoy salmon pool, Northeast Margaree river, in the gorge 5 miles above the head of settlement.

salmon spawn in brooks entering the east side and the head of the lake, as well as in the river and the brooks connected therewith, this part of the river system is negligible for salmon angling. A few salmon may be caught near the Forks at the beginning of the season, but that seems all, since for the most part they seem not to ascend this branch until near spawning time.

Except for the first mile at its source, this Southwest Margaree river has a declivity similar to that of the Northeast, with almost continuous rapids and pools, and it traverses a more or less arable valley. Owing to storage of water in the lake, the freshets are not very pronounced, and the channel of the river shows little evidence of change. Its water has a higher summer temperature than that of the Northeast, and in comparison with the latter it is well populated with gaspereaux

(*Pomolobus pseudoharengus*), eels (*Anguilla rostrata*), and white perch (*Morone americana*).

The Main Margaree River

This part takes a northerly course from the Forks (figure 8) to its mouth at Margaree Harbour. It is at the bottom of a rather narrow cultivated valley, which cuts through the high land to reach the coastal plain a mile or so wide. The upper

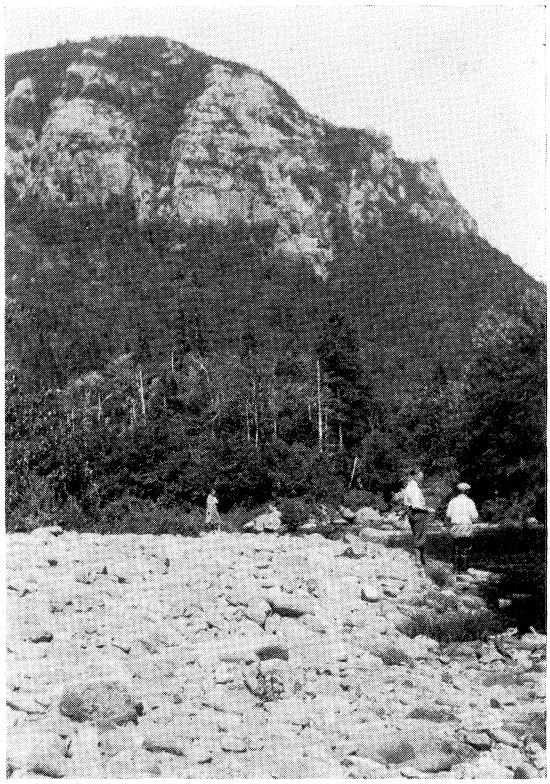

FIGURE 4. Northeast Margaree river, in the gorge at First Forks pool about 1 mile above the head of settlement.

three-mile long non-tidal portion (figure 9) is rapid and has some excellent salmon pools. There was formerly a good one, the Barracks pool, about a mile below the head of tide at the mouth of Galant brook, but a marked change in that mouth, that made the water take a long course through the "intervale" land before reaching the river, is said to have made the pool useless.

The tidal portion or river estuary is about five miles long and quite shallow. The narrow mouth (figure 11) is flanked with breakwaters and so shallow that it must occasionally be dredged to permit even small vessels to enter the harbour.

This mouth is in fact only sufficiently large to permit the estuary to rise and fall with the tide in the gulf. All the conditions are such that the estuarial water is practically fresh (unless near the bottom) except for the broad, mile-and-a-half long outer part (figure 10) that traverses the coastal plain. So much of this outer

(Royal Canadian Air Force Photograph)

FIGURE 5. Northeast Margaree river from the air, where it leaves the Big Intervale to pass in the defile between Sugar Loaf mountain (below) and the high tableland (above). Ward's Rock pool is to be seen about the centre and Old Bridge pool to the left.

part consists of flats exposed at really low tides that the ebb of spring tides takes out about three-quarters of the water from the estuary.

THE MARGAREE COAST

The gulf coast of Cape Breton island is rather straight and trends from southwest to northeast. The Margaree portion of this may be somewhat arbitrarily taken as extending from Chimney Corner about five miles southwest, to La Pointe

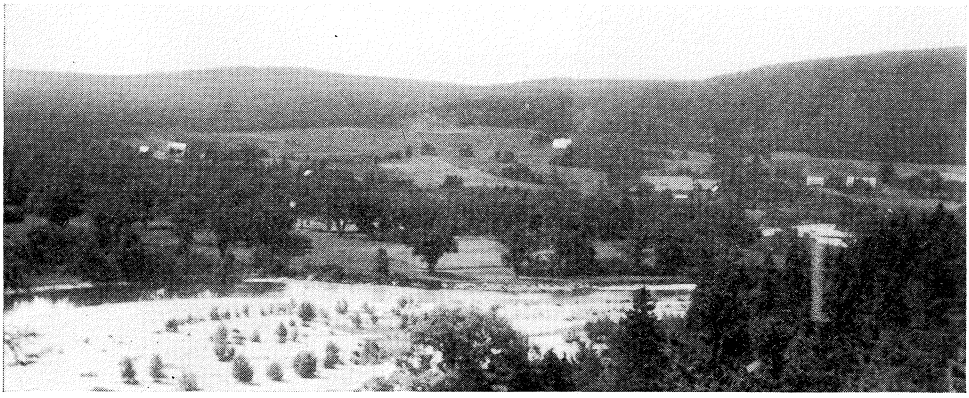

FIGURE 6. Northeast Margaree river, winding through the meadows of the "intervale" land, and showing extensive clean gravel bars or beaches.

or Cheticamp point about twelve miles northeast of Margaree Harbour (see figure 2).

This Margaree coast in the restricted sense is nearly straight and freely exposed to winds from west to north. The water deepens somewhat gradually, reaching a depth of twenty-five fathoms about five miles off. There are fishing banks, but of no very pronounced character.

With the ebbing tide, the water of the Margaree estuary passes out from the

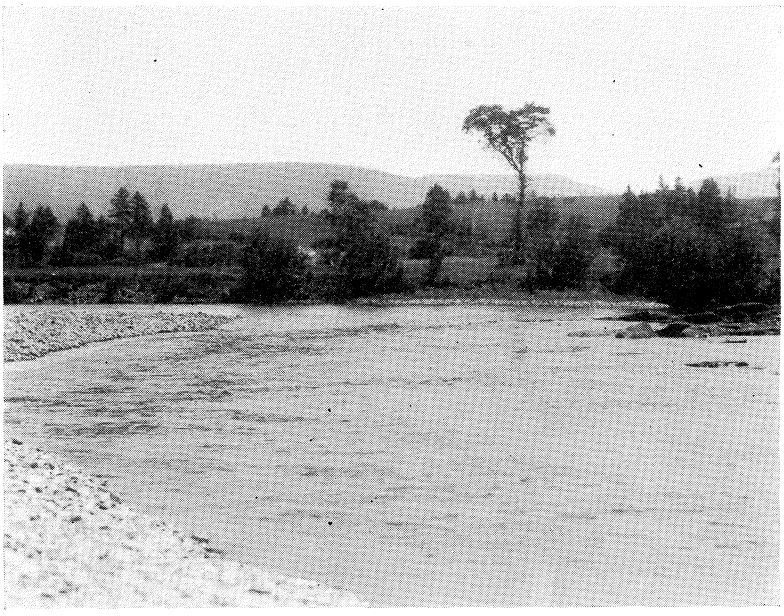

FIGURE 7. Upper part of Garden pool, Northeast Margaree river.

(Royal Canadian Air Force Photograph)

FIGURE 8. Margaree Forks from the air, the Southwest Margaree river from the left and the Northeast Margaree river (with extensive gravel bars, showing white) from the right, joining to form the main Margaree river, which runs north. The water appears dark. In the main river are the Thornbush (Forks) and Long pools. The system of roads (white) and the cultivated fields of the valleys that come together here are clearly evident.

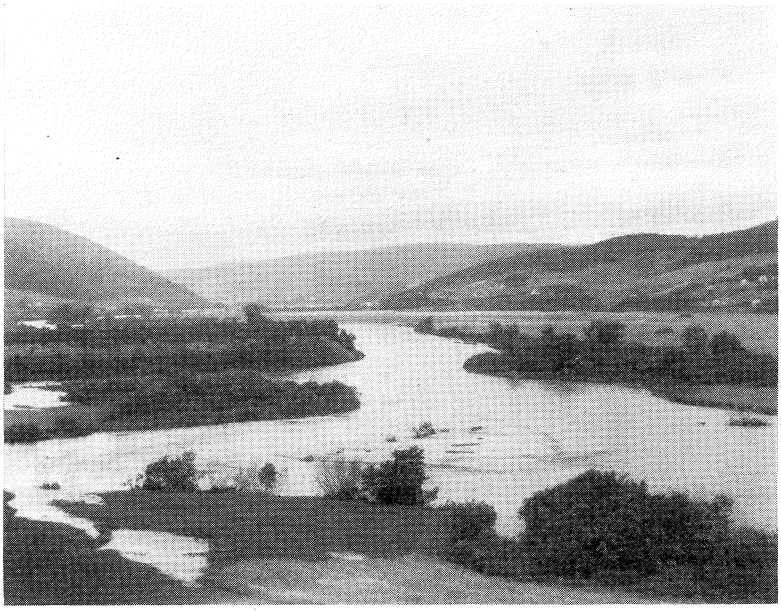

FIGURE 9. Looking down the main Margaree river from the Forks.

mouth and is carried with the outer current along the coast to the northeast. Apart from the tidal ebb and flow, the set of the water is northeastward to Cabot strait. The Margaree river water, therefore, extends its influence northeastward along the coast rather than southwestward. No rivers other than the Margaree discharge their waters along this coast, and the brooks that do so are insignificant except three that are from eight-and-a-half to eleven miles to the northeast. The first (Grand Etang brook) and the third (Farm brook) of these are the only streams of this coast, other than the Margaree, in which salmon are known to spawn.

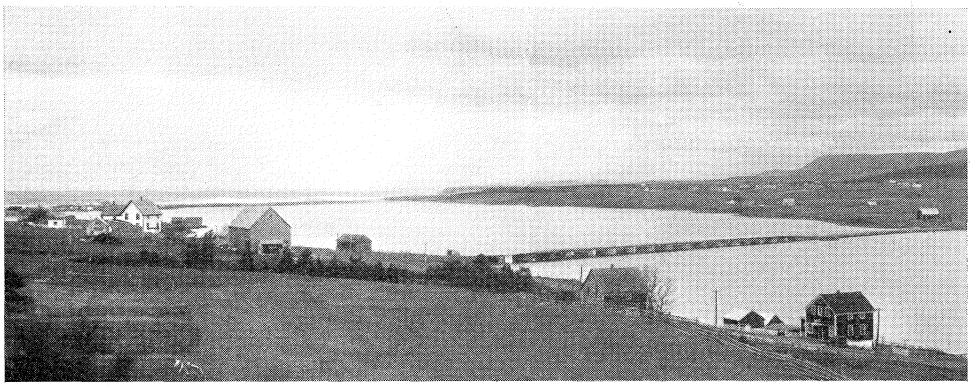

FIGURE 10. Looking north across outer part of estuary to the gulf and the coastal plain.

The Salmon

ORIGIN

The salmon that are taken along the coast may be presumed to be chiefly of Margaree river origin. The only method of being sure that they are Margaree fish

(Royal Canadian Air Force Photograph)

FIGURE 11. The mouth of the river estuary at Margaree Harbour from the air. The breaking of the waves on the seashore shows white. The breakwaters that narrow the mouth, are clearly in evidence. The varying depth of the estuary is faintly apparent, the tortuous deep channel being dark and the flats that emerge at low water being fairly light.

would be to clearly mark *all* the salmon smolts descending the Margaree river, and this does not seem feasible (30,000 of the smolts were marked in 1938 in order to discover where they will be taken in the sea when maturing in 1940 and 1941). It is to be expected that a certain proportion of the salmon will come not only from

Grand Etang and Farm brooks, but also from Broad Cove and other rivers to the southwest, and from Cheticamp and other rivers to the northeast.

The limited tagging experiments (part in Appendix) that have been carried out show how much mixing of the salmon occurs. Salmon tagged on the other side of Cabot strait near Port-aux-Basques have been taken on the Margaree coast, and salmon tagged on the Margaree coast have been taken at Aspy bay on the Cape Breton side of Cabot strait, in Chedabucto bay on the outer coast of Nova Scotia, on the Antigonish and Pictou shores of the gulf coast of Nova Scotia, and even off Richibucto, New Brunswick. Even more confusing has been the recapture, in the Margaree estuary or on the Margaree coast, of salmon tagged after spawning in Morell river, Prince Edward Island, and in Sackville river, which empties into Bedford basin inside Halifax harbour, about 350 miles away by the water route.

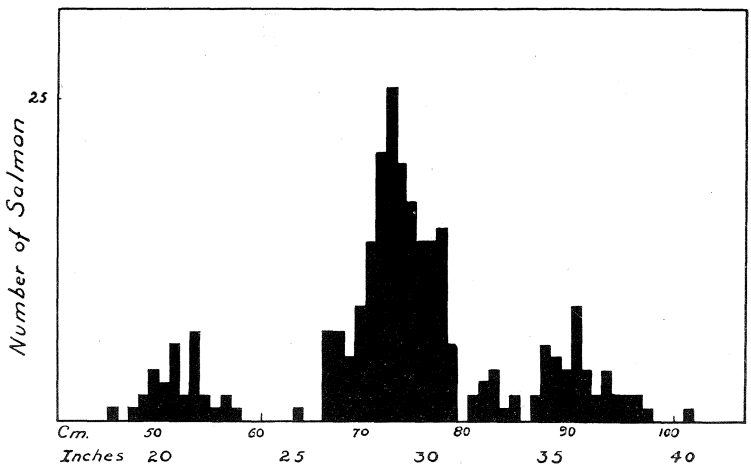

FIGURE 12. Numbers of salmon of different lengths as taken on the Margaree coast with nets of small mesh in 1937.

CHARACTER

Grilse, that is, salmon that have grown in the sea for a year or somewhat more and that weigh from two to six pounds, are rare both on the coast and in the river. The ordinary nets have meshes too large to take them, but nets with heads of smaller mesh have been used for special purposes and have shown their rarity. In 1937 (figure 12) they were more numerous than is usual. The three principal sea-year groups, namely grilse, salmon and big salmon, are readily distinguished in figure 12, which is based upon the salmon tagged in that year.

The majority of the salmon (table I) are fish that have been two years in the sea, and there is regularly a considerable proportion of three-sea-year fish, that is, big salmon. Other classes, e.g., previously spawned fish, are present in but small numbers.

TABLE 1. Age analysis by Dr. W. H. Johnson from scale samples of salmon taken on the Margaree coast in 1935

		June 13 to July 8					August 1 to 14				
		Years as parr					Years as parr				
		1	2	3	4	%	1	2	3	4	%
Two sea years	No.	0	183	107	8	75.4	1	144	57	4	53.8
	%	0	61.4	35.0	2.7		0.5	69.9	27.7	1.9	
Three sea years	No.	3	33	41	4	20.5	1	81	63	9	40.2
	%	3.7	40.7	50.6	4.9		0.6	52.6	40.9	5.8	
Four sea years		0	0	1	0	0.25	0	0	0	0	0
Previously spawned		0	5	10	0	3.8	0	0	12	0	6.0

The fishermen affirm and the facts (figure 13) show that on the whole the fish are of similar character as to size throughout the season. This is decidedly

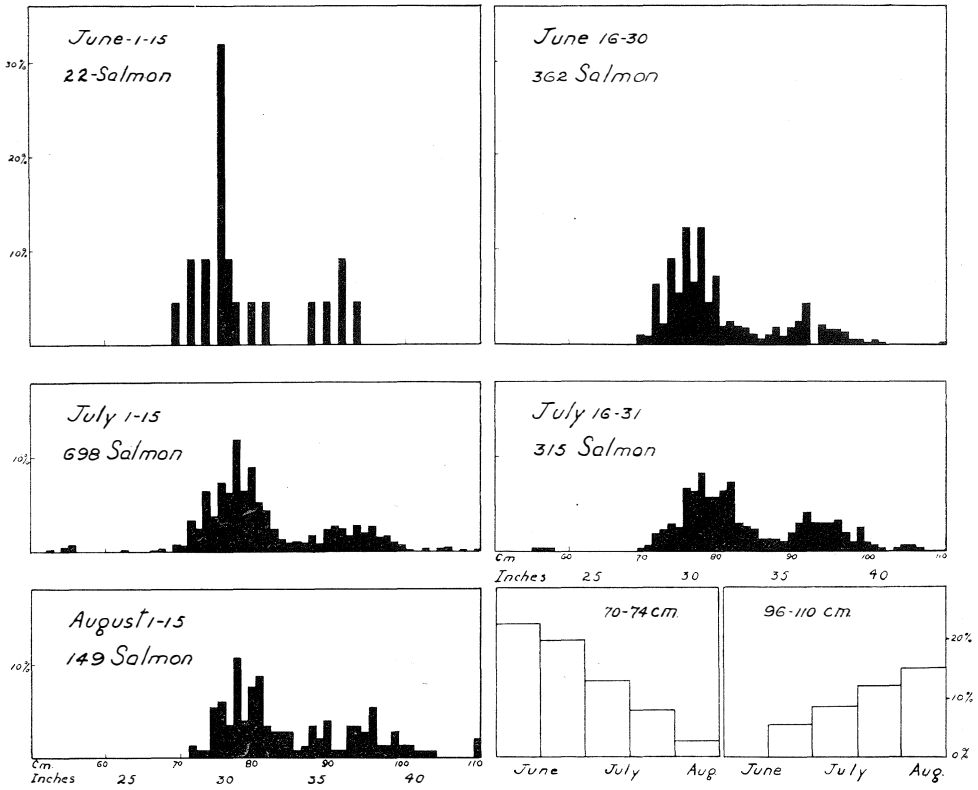

FIGURE 13. Numbers of salmon of different lengths as taken on the Margaree coast during successive half-monthly periods in 1937. Also at lower right the changes in proportions of small and large fish with the season.

unusual, for one expects that to some extent the big salmon will come first and the grilse and previously spawned fish last, or that the size of the ordinary salmon will increase. The only change with season that I have discovered is that the proportion of the salmon from 70 to 74 cm. (27 to 29 in.) long (small two-sea-year fish) becomes less as the season progresses and the proportion of salmon above 95 cm. (37½ in.) (various old fish) becomes greater. It is not readily evident in figure 13 except as brought out in the lower right hand part.

Quite a proportion of the ordinary or two-sea-year fish are small, weighing only seven or eight pounds. In 1937 these small salmon were particularly numerous on the coast (figure 12). The net fishermen sometimes refer to them as "Newfoundland salmon". According to Drs. D. L. Belding and Georges Préfontaine [*Report on the salmon of 1937 Port-aux-Basques (Newfoundland) Drift-Net Fishery. Contr. Inst. Zool. Univ. Montréal, No. 3, pages 27 and 28, 1938*] the two-sea-year salmon of the south and west coasts of Newfoundland are of a surprisingly small size, and those taken at Port-aux-Basques were smaller in 1937 than in 1936, as is true for those on the Margaree coast. The anglers on the river call these poor fish "New Brunswick salmon" on the basis of New Brunswick salmon fry having been planted in the Margaree in the eighties of the last century before the local stock began to be used for the hatchery. However, no such fish are known in the New Brunswick rivers whose salmon provided the eggs for the Margaree. Salmon that are so small after being two full years in the sea are evidence of poor conditions for feeding and growth.

HISTORY

The local anglers support their demands for the application of measures to improve the angling by general statements of the former abundance of salmon in the river. Some, however, state that there were always years of abundance and years of great scarcity. Mr. Duncan McDonald affirms that there was a long period of scarcity in the nineties. "In August of 1897 two boats were torching from Cranton bridge to the Forks pool and did not see a single salmon. In 1896 or 1897 a New Yorker offered a fifty-dollar bill to anyone who would show him a live salmon from the Margaree in July, and no one took the offer".

Better than memory are records made at the time. There are official records in the Annual Reports of the Dominion Department of Fisheries going back as far as 1868, the year after Confederation. The condition of the angling in the Margaree river was not reported every year, but sufficiently often in the latter part of the last century to give a fair picture of what it was then. As contrasted with recent years there was during that period much poaching along the river and about twenty-five nets were set in the estuary, but angling was less intensive and netting on the coast was less efficient. The following excerpts from the reports show the condition of the angling in various years.

1872. "abundant . . . about 400 salmon taken".
1873. "over a thousand fish . . . caught by anglers".
1874. "not as plentiful as last year".
1875. "scarce . . . sportsmen much disappointed".
1876. "much better than last year".
1877. "did not ascend . . . until the first of September sportsmen did nothing".
1881. "fly fishing . . . better than during the previous year'.
1882. "fly fishing . . . much better this year than usual".
1883. "scarce during the first part of the season . . . In September and October there were several fine runs".
1884. "Scarce in the river the first part of the season; afterwards . . very plentiful".
1885. "few ascended the river the first part of the season. . Late in September and October . . . unusually large numbers".
1886. "few fish entered . . . until the latter part of July".
1887. "July run . . . unusually small . . . anglers met with poor success".
1888. "the number of salmon found on the 1st July . . . has been equalled within memory".
1889. "fly fishing . . . never better . . . pools were filled with salmon".
1890. "fly fishing was not good".
1891. "angling on the Margaree was fair".
1892. "very few salmon entered the river the first part of the season. . . . During . . . September and October . . . salmon entered in large numbers".
1893. "very few ascended the river in July. . . . Between the middle of August and September . . . fish began to ascend".
1894. "Angling was poor throughout the summer . . . Fish ascended the rivers in large numbers in October".
1895. "scarcity . . . in mid-summer . . . In . . . October and November salmon ascended . . . in . . . large numbers".

Although it is not possible to make any accurate comparison between conditions forty years or more ago, and those in recent years, it is evident that then as now it was usual to have large numbers in the early fall and that they were frequently scarce during the summer. In no very recent season, however, does there seem to have been so many salmon in mid-summer as there evidently were in 1872, 1873, 1888 and 1889. The condition has been more nearly like that reported for the nineties. It would be a mistake, nevertheless, to consider that the salmon no longer enter early in the season. While only 28 were reported as taken in 1932 from June to August, in 1931 there were 50 in June, 171 in July, and 126 in August, making 347 for these first three months of the season.

The year 1915 is generally remembered as giving exceptionally good angling. The records of certain anglers, who have rather regularly fished the lower pools on the river during the summer months, give the following average numbers of salmon per rod per 10 days for each of six consecutive years, showing that 1915 was exceptionally good: 1914,—5; 1915,—14; 1916,—6; 1917,—0.4; 1918,—4; 1919,—0.6. This can be expressed as twenty-five days being required for one man to catch a salmon in 1917, but little more than two-thirds of a day in 1915. Such evidence as there is fails to show that angling on the Margaree river differed greatly twenty, forty or sixty years ago from what it has been in recent years. The historical record makes it plain that the condition to be remedied, namely scarcity of salmon in the river in mid-summer, has occurred for longer or shorter periods throughout the last seventy years with all the changes there have been in the administration and conduct of the fishery.

EFFECT OF THE NETS

The anglers in general are firmly convinced that the nets are responsible for the fewness of the salmon in the river during the first part of the season in recent years. They consider it a *direct* effect, since the large numbers of salmon entering the river late in the season provide evidence that the stock is not greatly reduced. As it happens, not only the abundance of salmon in the fall, but also the results of our investigations of the outcome of spawning for the years 1934 to 1937 indicate that any *indirect* effect of the nets operated, on the numbers of salmon in succeeding generations may be safely disregarded.

Theory of the Effect

The theory that the reduction of netting near a river mouth will result in an increase in the numbers of salmon in the river is very generally accepted and has for many years formed the basis of governmental regulation of the netting. The firmness with which this theory is believed is well illustrated by the letter of a fishery officer who had reported that there was better angling as a result of an estuarial net being made inoperative. When requested to give the evidence on which he based his statement he wrote: "There is no doubt that it (putting the net out of commission) greatly improved angling, owing to the fact that when the net was raised the course was left clear for the fish to ascend." In other words, he considered that the angling was better, because according to theory it ought to be, whether or not there were any facts to show that it was. Many anglers also reason in this way; for them, irrespective of the facts, there are necessarily more salmon in the river when the nets are up.

The basis for the theory is simple,—that the salmon near the river mouth are bound for, or on their way to, the river and will shortly enter and ascend it if not caught. Unfortunately this basis is itself only a theory, so that we are on no firmer ground. Facts are much needed. The weakness of the theory is that we do not know when, or how many of the salmon taken in a particular net at a particular time would have entered the river and been taken by the anglers.

Do Nets Stop the Salmon?

The nets are visualized as a more or less impenetrable barrier to the salmon in their progress riverward. What are the facts?

CHARACTER OF THE NETS

The usual "salmon fleet" (figure 14) has a run or leader of straight netting extending from the shore out to sea from 100 to 150 fathoms. The top line is well provided with corks and the bottom line is held down with stones fastened to it every 4 or 5 feet. The net is held in position by several pairs of anchors, attached through long ropes to the top of the net, with a small keg as a buoy where the two ropes of each pair reach the top. At the outer end is the head in the shape of a diamond,

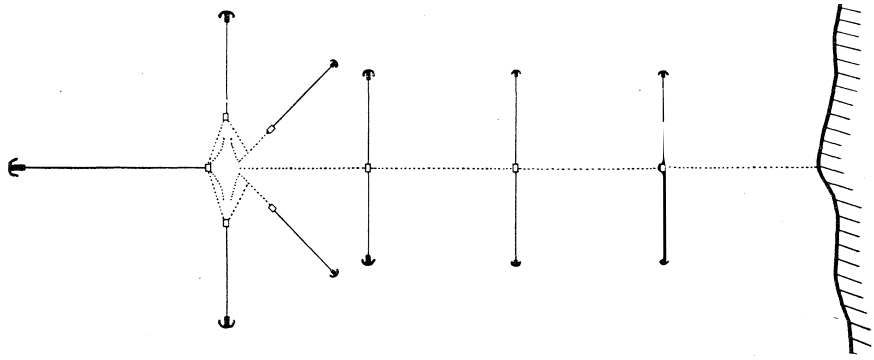

FIGURE 14. Plan of usual "salmon fleet" of the Margaree coast.

which has wings extending obliquely shoreward on each side of the mouth which is at the end of the leader. The head has at each end a little trap, with funnel-shaped entrance, and both head and wings are well buoyed and anchored.

The mesh of the net is 7 inches when stretched. This stops or meshes fish over some 28 inches long and 8 pounds in weight. The leader is not fastened to the bottom and therefore lifts whenever the tide runs at all strongly. As salmon will go both under and over nets, it is quite certain that the net will really stop them only near high and low tide, that is at the slacks. This means (and it is the experience of the fishermen) that the net fishes, that is turns the salmon into the head, roughly from one-third to two-thirds of the time, the amount varying with the location of the net and with the strength of the tide from springs to neaps.

LOCATION OF THE NETS

This is naturally of importance in determining to what extent salmon will be prevented from entering the river. If the river is totally blocked at any point, all salmon are stopped. The nets (figure 16) are all outside the river mouth and none nearer than half-a-mile. With the mouth only about 150 feet wide and a mile wide stretch of coast just outside free from nets, the nets are very far from presenting any

physical barrier whatever to the *entrance* of the salmon, however they may affect their movements along the coast.

BEHAVIOUR OF THE SALMON

This is of the greatest importance. If the salmon reach the river by travelling close to the shore, as many believe, the many nets scattered along the coast both northeast and southwest of the river mouth will effectively bar their progress riverward during slack tide at least. The net fishermen state that salmon "trim the shore in calm weather". This means that it is in calm weather that they catch their fish, and that the fish stay offshore when the inshore water is disturbed by wave action. Similarly, fishermen of the Saint John river state that, when salmon have the choice between clear water and roily or muddy water, they are to be found in the clear water.

The bag-nets used for the capture of salmon along the east coast of Scotland may be placed one outside the other and a series of them may extend out at right angles to the coast for half-a-mile from shore. I am informed by Mr. W. J. M.

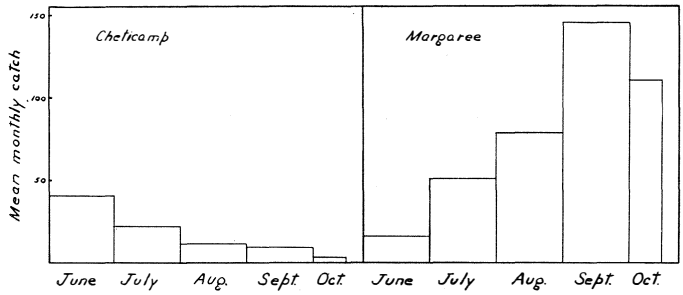

FIGURE 15. Mean monthly numbers of salmon reported as taken in angling on the Margaree and Cheticamp rivers from 1928 to 1936.

Menzies, Inspector of Salmon Fisheries of Scotland, that there may be as many as eight different bag-nets in the one series and that they take the fish about equally well. This would not be true if the fish were travelling close to the shore.

That the great majority of the salmon on the Margaree coast travel outside the nets well away from shore is indicated by the recaptures of fish tagged and liberated at the nets. Only an occasional fish was taken in the same or a neighbouring net. Nearly all had passed from several to many nets before being recaptured.

It can be concluded that nets do stop salmon, but that any such action on the Margaree coast is slight for preventing salmon from entering the Margaree river.

DO NETS MAKE SALMON RUN LATE?

That the main run of salmon entering the Margaree river occurs in September and October is attributed by the anglers to the nets keeping them out during June, July and August. Anglers classify rivers as being early rivers or late rivers, depending upon when the majority of the salmon enter. Is the Margaree a late river because of the nets?

In the Saint John river the salmon run early, starting before the end of May, although they are exposed to capture by drift nets in the bay of Fundy, weirs on the outer coast, drift nets, weirs and set nets in Saint John harbour, set nets in the tidal part of the river, and set nets for a considerable distance above the head of tide. The Cheticamp river, eighteen miles northeast of the Margaree, with a relation of nets to the river mouth similar to that of the Margaree, has an early rather than a late run of salmon as shown by the angling reports. In figure 15 will be seen a comparison of the two rivers as to seasonal distribution of the angling catch. In the

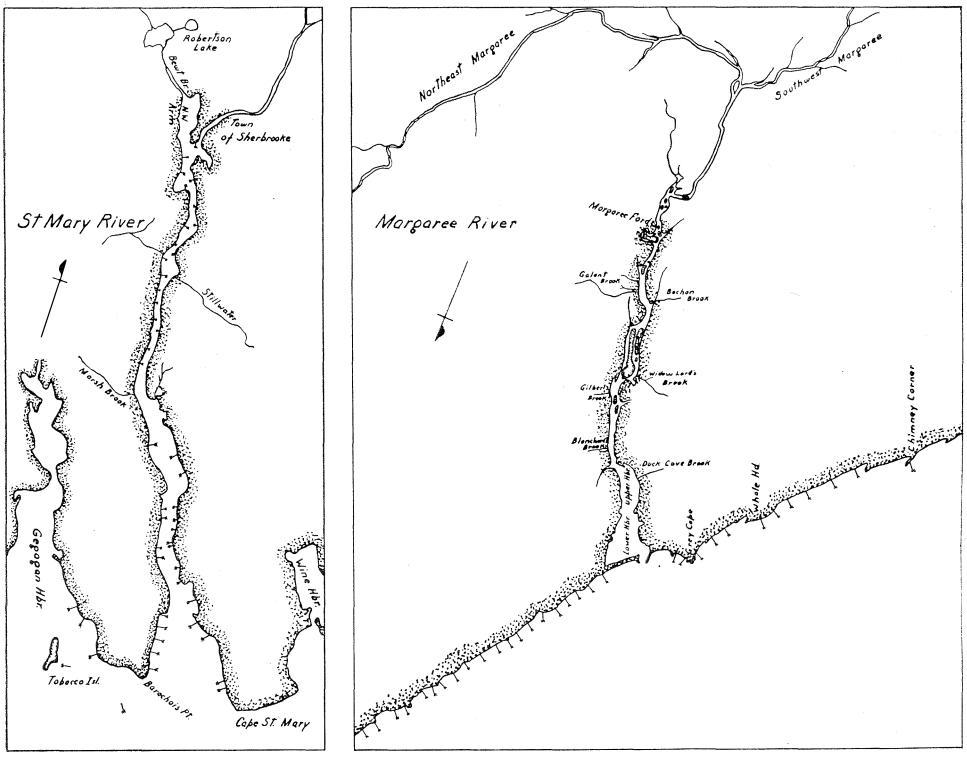

FIGURE 16. Estuaries and neighbouring coasts of the Margaree and St. Mary rivers, showing locations of the nets. Scale: one inch equals 3.15 miles.

Margaree the catch increases from June to September, while in the Cheticamp it decreases.

The St. Mary river of the outer coast of Nova Scotia has two main branches and is about the same size as the Margaree, and competes with it for the reputation of being the best salmon angling river in Nova Scotia. In figure 16 are shown the locations of the nets in relation to each river, and in figure 17 the seasonal distribution of the angling catches for each, as well as the catches of the nets near the river mouths.

Although the St. Mary, unlike the Margaree, has nets not only on the outer

coast but throughout its tidal portion or estuary, its angling catches are highest during June, July and August, when the nets are being operated.

There is, therefore, no relation between the season when most of the salmon ascend a river and freedom from nets in the river or the river estuary. That nets on the outer coast affect the season would appear to be out of the question.

Is Netting More Intensive than Formerly?

The claim is sometimes made that there are now more nets and more effective nets on the Margaree coast than in former times. No data are available for comparison either as to number of nets or as to their effectiveness, but it is generally reported that the heads or traps of the nets are of definitely better and more complex type than those used many years ago.

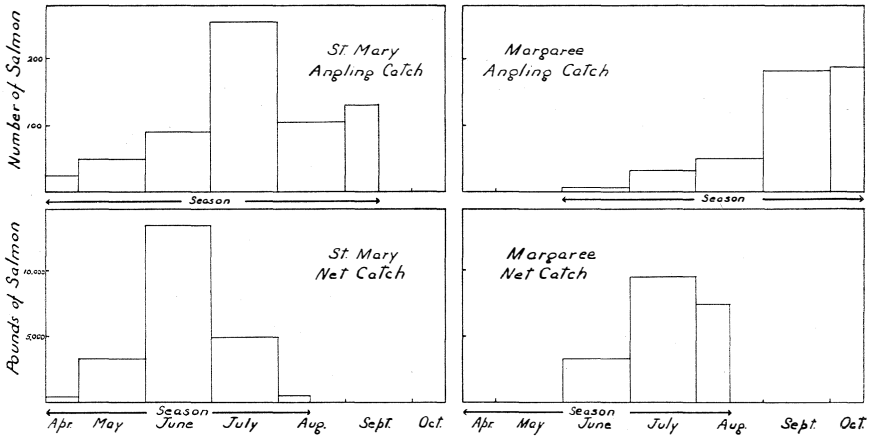

Figure 17. Mean monthly numbers of salmon reported taken in angling on the Margaree and St. Mary rivers in 1936, 1937 and 1938. Also, mean monthly pounds of salmon reported taken by nets near the mouths of these rivers in the same years.

The point is not so much the effectiveness of the nets as the number of salmon that they take. Records of the net catches have been made yearly as far back as 1870. Their study shows that for the Margaree region, as for the Maritimes as a whole, the catches were high in the seventies of the last century, remained rather low for thirty years or more, rose on the whole from 1910 to 1930, and have since declined. No basis is found for the belief that fishing is now more intensive.

To judge by the numbers of salmon reported to enter the river late in the season both in recent years and many years ago, a large proportion of the stock remains in the sea, after the nets have made their catches. This is perhaps only to be expected, since, with the salmon scattered in the water from the shore outward for an indeterminate distance, nets on an open coast can scarcely be very effective agencies for their capture. It is a different matter when the nets are in narrow waters through which the salmon pass. The tagging experiments of 1935, 1936 and 1937, in which salmon were liberated near the mouth of the Margaree estuary, showed that the fish largely failed to enter the river during the netting season and scattered far

along the coast in both directions to be exposed to many nets. Yet omitting those below 74 cm. in length which are not adequately captured by the nets, the results show that the proportion recaptured by nets, whether on the Margaree coast or elsewhere, was 21, 27, and 26 per cent respectively in 1935, 1936 and 1937. This is not a high proportion in comparison with what has been found on other parts of our coast and in Europe.

Does Reduction of Netting improve Angling?

This straight question as to the effect of the nets on angling could in the opinion of most of the anglers be answered directly by doing away with the nets to see whether the angling will or will not improve. Should we not, however, find out what has been the outcome of reduction of netting in the past? Has demonstrable improvement in the angling resulted?

Stoppage of commercial netting in Margaree estuary

Up to the year 1908 there were about twenty-five straight nets set each year in the five-mile-long tidal portion or estuary of the Margaree river. We have no data of their catches in the later years of their fishing, but statistics for the seventies and eighties, in which Margaree river is separated from Northeast Margaree, Margaree Forks and Margaree Harbour, indicate that around a thousand pounds were taken each year.

In 1909 the Government acceded to a request of the anglers that these nets be eliminated, and recompensed the fishermen by undertaking to purchase for hatchery purposes salmon which the fishermen would catch with a trap net operated in the estuary in the fall. This was a rather drastic experiment to improve the early angling, since it stopped the netting of salmon in the river during the summer and substituted the netting of salmon in the river in the fall. Of all the salmon captured by nets those in the tidal portion of the river were most likely to ascend after capture ceased and improve the angling. No evidence is available to show whether or not angling did improve when the nets were stopped in 1909, but the records of the angling in the seventies, eighties and nineties, and the detailed data we have for recent years, show that both without and with the estuarial nets there are seasons with good as well as with poor angling in the summer months and the anglers even claim that the salmon are fewer now with the nets out.

Earlier closing of the netting season

It happens that in recent years a practical experiment in reducing the netting has been carried out on the Margaree, and data are available for a study of the effect. In 1935 a change was made which shortened the netting season for all the nets on the coast by half-a-month, the season closing on August 15 instead of August 31. The guardians' reports of the salmon taken by angling each week are available for three years before the change as well as for the four years after. If the nets near the river mouth have much effect on the angling, the removal of *all* the nets would certainly be expected to show an improvement in the angling catch. Their removal

half-a-month earlier would then show in a correspondingly earlier rise in the angling catch.

In figure 18 are given the average courses of the angling from week to week for three years before and for the four years after the change was made. It might be argued that an improvement is shown for early September. But why should the angling be so much lower in August? Examination of the courses of the angling in the various years shows that during the last four years, only in 1935 (figure 19) was there good angling at the end of August and in that year it was phenomenal and definitely associated with very heavy rains from August 23 to 25. In 1930, with the nets fishing throughout August, the angling catch rose rapidly through that month

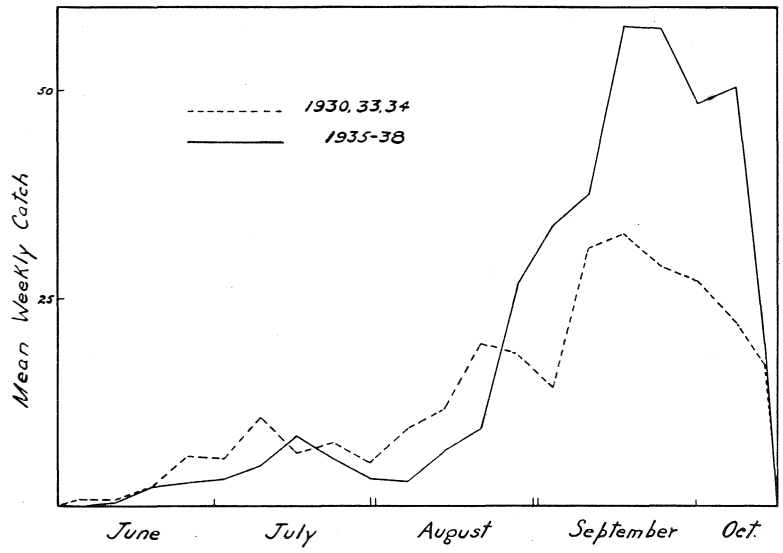

FIGURE 18. Mean weekly numbers of salmon reported taken in angling for the years 1930, 1933 and 1934 (- - - - - - -) and for the years 1935 to 1938 (————).

(figure 20), and in correspondence with quite good freshets on August 5, August 10 and August 18. In 1937, with the nets up on August 15, the angling catch remained poor throughout August and early September (figure 21), and rose rapidly as repeated freshets of increasing size occurred.

Undoubtedly other factors are obscuring whatever effect removal of the nets may have, and it is uncertain that angling has improved earlier in the fall as a result of the netting season closing half-a-month earlier.

REDUCTION OF NETTING ON OTHER RIVERS

Failure to get any clear evidence that reduction in netting on the Margaree river has improved the angling has raised the question of what it has done on other rivers. If a favourable effect has been clearly demonstrated elsewhere, perhaps the method used could be applied to the Margaree. There has been much and varied

curtailment of netting over a period of at least eighty years in Canada, mostly through government regulation, but also through fishing clubs eliminating nets by purchase. Have these reductions been demonstrably effective?

I have made enquiries not only for this country but also for Great Britain, as to the best cases of reduction in netting having been effective, particularly in improving the angling. For the most part it is an indirect effect through an increase in the numbers of succeeding generations of salmon, or a combination of direct and indirect effects that has been in mind. Also reliance for demonstration of a favourable result from net reduction has been placed not on increased angling catches, but on increased net catches. We must take the cases as they stand.

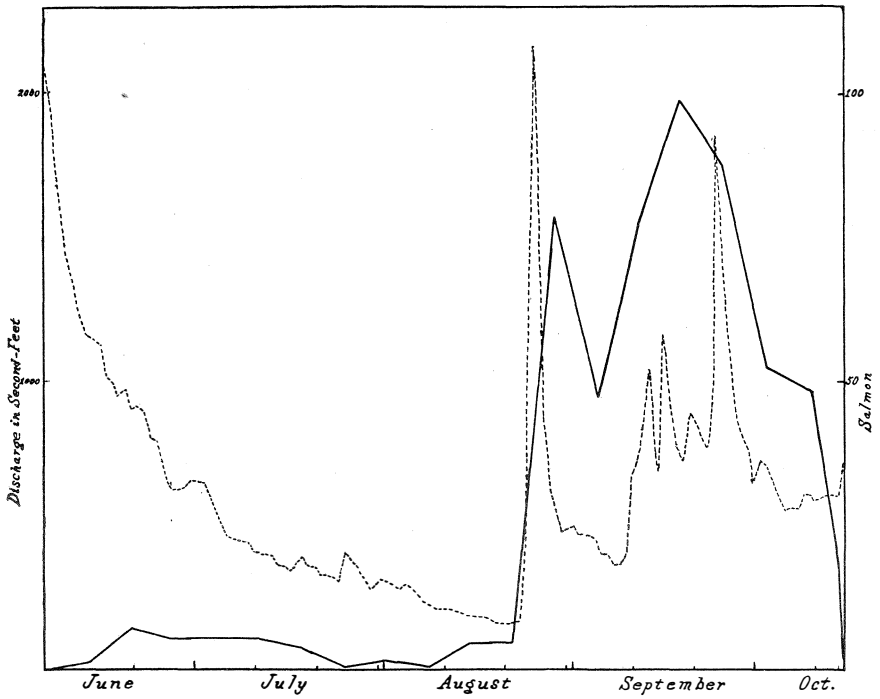

FIGURE 19. The Margaree weekly angling catch (————) in relation to water discharge (- - - - - - -) of the Northeast Margaree at Frizzleton for the year 1935.

In 1873 the *Moisie* river of the north shore of the gulf of St. Lawrence, so famous for its salmon, was featured by the Department of Marine and Fisheries *(6th Annual Report, for the year ended 30th June 1873, Ottawa, 1874, p. lxxx)* as an example of the beneficial effects of net reduction. "In some districts it (the salmon fishery) has increased in yield nearly three hundred per cent. This results from reducing the nets and protecting the fish whilst breeding. It is most remarkable in the Restigouche and Moisie districts." The Moisie was then cited as the plainest example of the beneficial effects of reducing the netting and the changes were pictured (figure 22). "The yield has been increasing each year whilst the

netting was in course of restriction. At present the stream has probably attained its maximum of production in a natural state; but successful operations in artificial salmon culture will no doubt double its present yield." This, therefore, has seemed to be an exceptionally good case to investigate.

Previous to 1859 there had been almost unrestricted fishing with nets in the river as well as on the outer coast, but in that year the inside nets were reduced to those of the lessee, Mr. Holliday, 42 nets being eliminated, and the angling rights were also leased. This was a very striking change. The fishing the following year was reported as not being very successful, but in 1861 and 1862 the netting was very good, but apparently yielded little if any more than in 1857. There was then a slight decline to the year 1867, but the catch rose rather abruptly around the

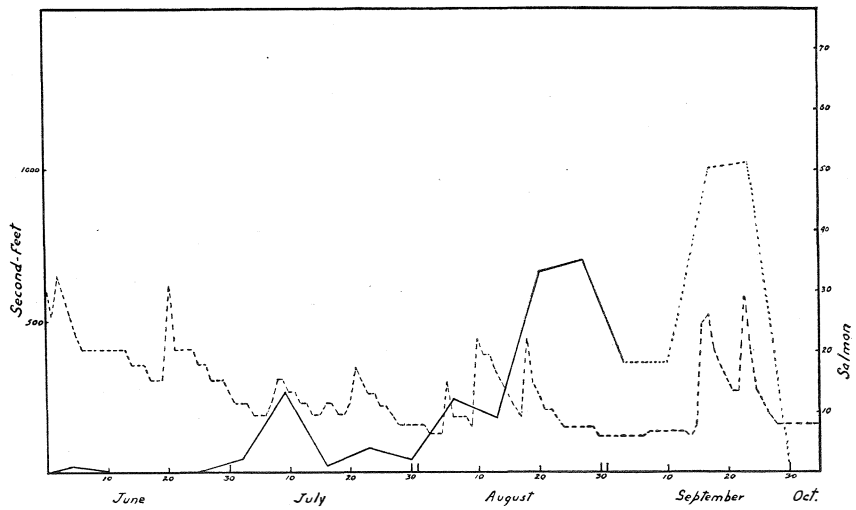

FIGURE 20. The Margaree weekly angling catch (————————) in relation to water discharge (- - - - - - -) of the Northeast Margaree at Frizzleton for the year 1930.

beginning of the seventies, good netting and angling continuing for 5 years, when the claim of marked improvement was made. The catch for the best year (1870) was somewhat more than twice the catch reported for 1857. This seems a very good case; but is the story complete?

After 1873, both netting and angling dropped to quite low levels in 1876, rose again to higher levels in 1878 and 1879, and then declined rapidly to unprecedently low levels in 1881, 1882 and 1883. The statistics for all parts of the Canadian Atlantic coast show that there were exceptionally high catches in the seventies and very low catches at the beginning of the eighties irrespective of any regulation of the fishery. This is shown by the following figures for the hundredweights of salmon landed at the Moisie and in each of the five different areas of our Maritime region during 1872 and 1873 as compared with 1880 and 1881:

	Moisie	Fundy	Atlantic	Eastern Gulf	Western Gulf
1872	2,565	7,173	6,478	6,091	15,902
1873	2,478	10,340	4,919	10,491	32,006
1880	974	2,894	1,690	1,860	7,870
1881	606	1,304	1,002	1,596	6,852

We must conclude that reduction of nets cannot be properly credited with having caused the increased catch of salmon in the Moisie river in the seventies.

Mr. John Hall Kelly and Dr. David L. Belding, who have been connected with the salmon angling clubs of northern New Brunswick and Quebec, inform

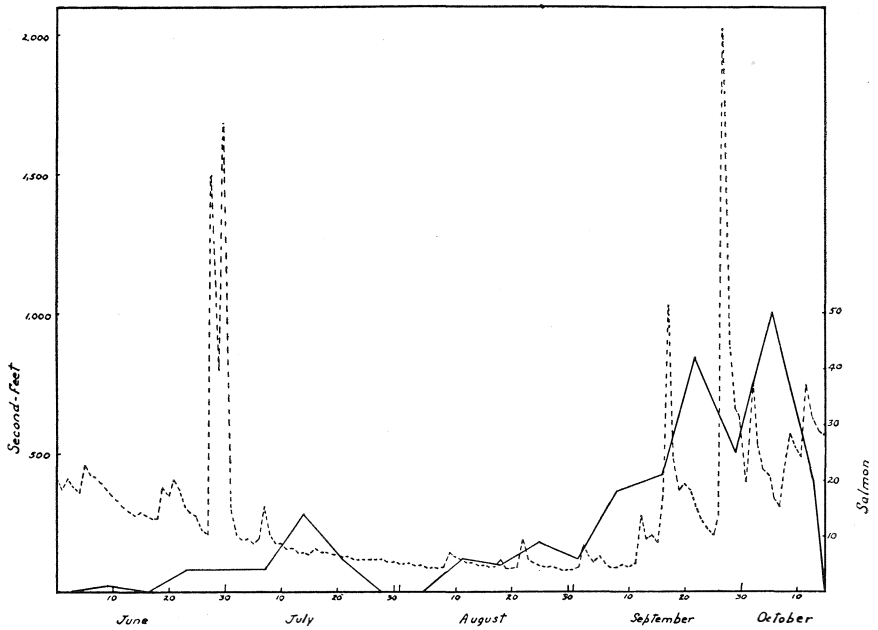

FIGURE 21. The Margaree weekly angling catch (————) in relation to water discharge (- - - - - -) of the Northeast Margaree at Frizzleton for the year 1937.

me that in their opinion the best evidence of the beneficial effects of net reduction on angling is for the *Restigouche* river. The Riparian Association took action around 1910 "which resulted in freeing the lower river from most of the shore nets about that time" *(E. B. Phelps and D. L. Belding, "A statistical study of the records of salmon fishing on the Restigouche river", privately printed June 11, 1931).* Drs. Phelps and Belding found a distinct improvement following 1910 in the upward trend of the angling catch, as judged by the rate of fishing per rod-day and they stated their belief that it was due to net removal. There is no claim, and there seems to be no evidence of a direct or sudden effect of net removal. Unfortunately for any significance of the upward trend from 1910 to 1930, such a trend was fairly general in the catch of salmon along the whole coast *(Bull. No. XXI,*

Biol. Board of Canada) and occurred in districts where there was no reduction in netting. Since 1930 there has been a general decline. Proof is, therefore, lacking that the improvement in fishing was due to net reduction.

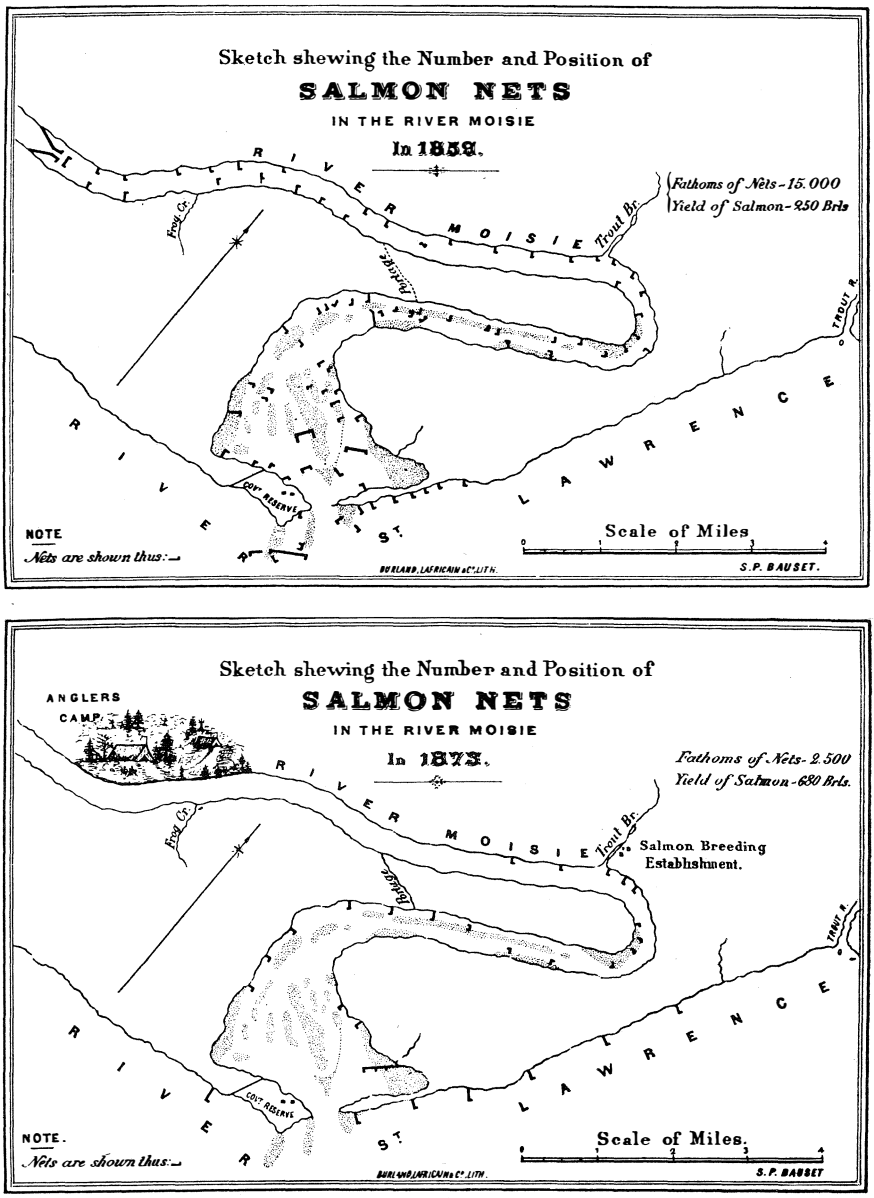

FIGURE 22. The Moisie river before and after reduction in netting (from 6th Ann. Rep. Dept. Mar. Fisher., 1874), when it was believed that net reduction had given all the salmon possible with natural reproduction.

Major D. H. Sutherland, Chief Supervisor of Fisheries for the Maritime Provinces, has been asked to furnish facts concerning the best case within his knowledge showing that reduction in netting improves angling. The only one that has seemed likely to have adequate proof is for the *Miramichi* river of New Brunswick, where "in 1934 the first restrictions were placed on tidal net fishing, in that the nets had to be taken up during the first half of July, July 1 to 15; also, the netters were prohibited from taking grilse less than five pounds round weight". The data for the numbers of pounds reported taken in the river by angling and by the nets are given in table II. They show a most marked improvement in the angling after the

TABLE II. Salmon catches of Miramichi river

Year	1930	1931	1932	1933	1934	1935	1936	1937	1938
Net catch (lb.)	29,900	25,500	38,200	18,900	20,000	22,300	32,100	31,600	34,500
Angling catch (lb.)	35,634	23,392	13,474	21,430	25,535	49,276	133,974	85,704	115,135
Salmon (no.)	...	...	448	1,233	1,823	3,735	4,758	5,192	8,253
Grilse (no.)	...	...	2,388	2,780	1,750	4,526	22,989	9,818	9,549

reduction, and seem to constitute decisive proof of a favourable effect. But the question naturally arises: whence came all the fish taken by angling after 1934? The net catches, as will be seen in the table, were for a shorter season as large as before, and yet the angling catches became greater than angling and net catches combined had been previously! Also, why was there no improvement the year (1934) that the change came into effect? Since there had not been time for an indirect effect, only a direct effect was possible, which should have appeared at once. It seems necessary to reserve judgment on this case.

In response to an enquiry as to there being for Great Britain "some well-documented cases, for which the results of net removal are scientifically reliable and not open to question", Mr. W. J. M. Menzies, Inspector of Salmon Fisheries of Scotland, writes that while there are a number of instances of apparent improvement in angling corresponding to a reduction in netting, there has never been a proper experiment to provide the facts necessary to settle the question. He instances the case of the *Conon* river in Scotland, which has been reported by Col. the Hon. I. M. Campbell *(Salmon and Trout Magazine, No. 72, September, 1933, p. 226)*. The latter's account furnishes the following details. The river has, about one-and-a-half miles above the head of tide, a "cruive", which is a stone dyke with openings or boxes, closed by gratings "which make them into absolute traps and every fish that attempts to ascend is captured", except during the weekly close time and possibly during a spate. Also the pools below the "cruive" were netted more or less regularly. There is a netting station in the tidal portion of the river and two or three farther out in the Cromarty Firth, all these being for sweep nets. The coast

outside the Cromarty Firth "bristles with stakenets and bag nets". Since 1910, the "cruive" has been kept open for the salmon to pass through and no netting done above the head of tide, while netting in the tidal waters has been reduced. With the reduction in tidal netting, the total catch of the tidal nets decreased for about five years, but after ten years an increase in the total catch was noticeable and progressive, becoming by 1932 nearly double the average for a thirty-year period. The author considered such a course to be expected in recovery from dangerous depletion of the stock. He was unable to state whether the angling catch had improved. Mr. Menzies has kindly given me access to data of net catches, which show quite clearly that distinct improvement has occurred and in the salmon related to the Conon river rather than to other districts. This seems a very good example of increase in the stock of a river by reduction in netting, when it had been dangerously depleted by thorough trapping and netting above the head of tide. This case is different, however, from that in which only coastal nets are concerned.

CONCLUSION

The removal of nets from the tidal waters of the Margaree river in 1909 failed to stop the occurrence of summer seasons of very poor angling, and there is no evidence of a favourable effect from the removal.

Closing the netting season for the Margaree coast half a month earlier has had no clear effect in an earlier rise of the angling catch in the latter part of the season, pronounced differences from year to year continuing to occur.

No case has been found of reduction in netting being clearly responsible for an improvement in angling in a river, except probably in the case of a river badly depleted through excessive netting, not only in coastal waters but within tidal and also non-tidal waters.

Do Storms that Stop Netting Improve Angling?

It is frequently stated by Margaree anglers that, if the nets are put out of commission by a storm, they get good fishing in the river. This is used as an argument for the removal of nets to improve the angling. A storm may be a wind-storm, a rain-storm, or a combination of wind and rain. A strong northwesterly onshore wind produces a heavy surf on the Margaree coast, putting the nets out of commission, and should according to the anglers' theory improve the angling by stopping the netting. A rainstorm with little wind, at least onshore, will not put the nets out of commission, and, in accordance with the theory, would not be expected to improve the angling with the nets stopping the fish.

In 1936, the weather conditions provided a test of the theory. After the salmon had come on the coast there occurred on June 17 the heaviest storm of the season, with strong onshore wind and little rain, and it put the nets out of commission, so that there were practically no salmon caught for two days (figure 23). This had no observable effect on the angling, for the river was as definitely without salmon for the remainder of the month as it had been previously.

On July 14 and 15 there was a rather heavy rainstorm with scarcely any onshore wind, and the nets continued in good fishing order. There followed a definite improvement in the angling, as is shown in figure 23. It will be noticed that the beginning of angling and its improvement definitely follow rain and freshets in the river.

It may be concluded that in a storm the rain gives salmon for the angler, and that it is merely a coincidence if there is a strong, onshore wind putting the nets out of commission. However, wind has an effect otherwise, if not through the nets, as is shown later.

Significance of Salmon Capture by Shore Gear

Mr. W. J. M. Menzies describes (*Salmon of the East Coast of Sutherland, Fisheries, Scotland, Salmon Fish. 1915, II, December 1916, pages 3 and 4*) how bag nets on the coast practically ceased to take salmon when heavy rains produced floods in the rivers. In the bay of Fundy shore weirs of brush and netting erected on the south shore of Minas channel are effective in capturing salmon, there being no river influence owing to distance from rivers and heavy tidal mixing in the channel. On the shore of the same bay near the mouth of the Saint John river whence a large volume of fresh water issues, such weirs are useless for catching salmon although very large numbers are caught offshore with drift nets in the river influence. In contrast, the weirs in Saint John harbour, through which the river flows, take the salmon very effectively.

The effect of rain on coastal nets, as described by Mr. Menzies, occurs on the Margaree coast. In table III are shown the catches of near and of far nets on successive days in relation to two rather heavy rains, one in July, 1936, and the other in July, 1937. The heavier (and more general) rain of 1936 had the more

Table III. Effect of rain on catches of salmon nets near the mouth of the Margaree estuary

1936 July	13	14	15	16	17	18
Rain (in.)	0.008	1.179	0.526	0.003	0.008	0
Salmon in first 10 nets	12	6	13	1	12	38
Salmon in next 23 nets	37	41	29	18	1	66
1937 July	5	6	7	8	9	10
Rain (in.)	0.02	0.53	0.64	0	0	0
Salmon in first 10 nets	37	29	10	19	10	22
Salmon in next 23 nets	123	100	36	23	23	34

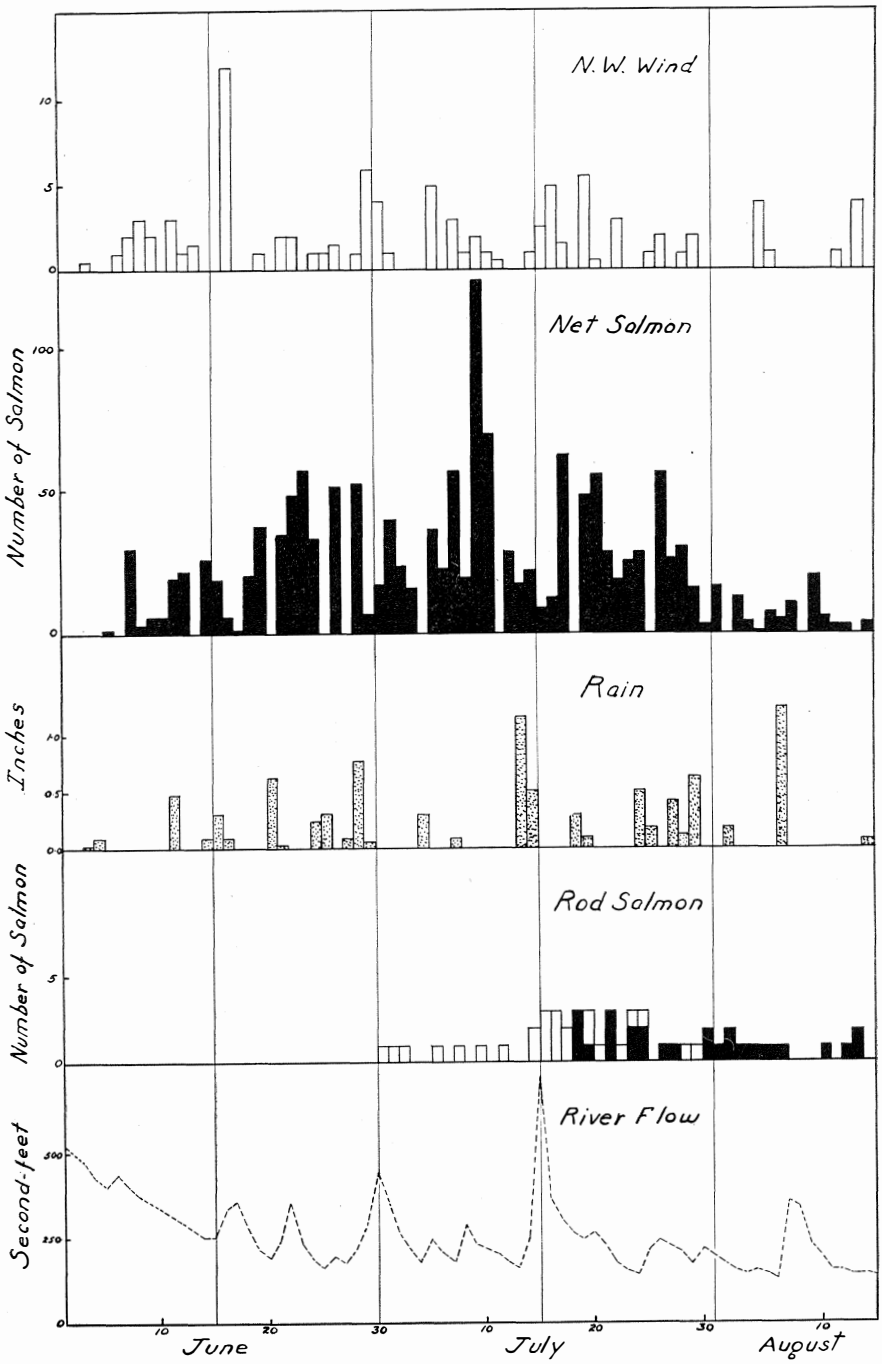

FIGURE 23. Daily values for wind, rain, salmon and river flow, season of 1936: Wind from northwest, as recorded thrice daily at Margaree Harbour; net salmon, numbers taken in 20 coastal nets,—the first 8 nets southwest and the first 12 nets northeast, of the river mouth; rain, as recorded at Margaree Harbour; rod salmon, numbers as reported for the river by guardians (outline only for those whose day of capture in the week is unknown and arbitrarily assigned); river flow as recorded for the Northeast Margaree at Frizzleton.

pronounced effect. The drop in catch developed later and in more regular fashion for the far nets than for the near nets. This is to be expected, since the increased amount of river water would reach the vicinity of the near nets first. Also it would have a varying effect depending upon whether under the influence of winds it actually flowed close to the shore and through the net or kept somewhat offshore. The effect of river water in the sea is considered at greater length on pages 49 to 55.

It seems quite clear that with definite river influence offshore regularly (outside Saint John harbour), weirs or nets on the shore are ineffective for taking salmon, and with river influence acting temporarily during a freshet (Sutherland and Margaree coasts), the nets on the shore become more or less inoperative for that period. The success of the salmon nets on the Margaree coast is evidence of lack of the river influence (either regularly or temporarily).

Measuring the Effect

It should not be hastily concluded that reduction of netting has no direct effect on angling since none has been demonstrated. The facts that have been under consideration only justify the conclusion that any effect must at least be so small as to be obscured by other factors. We may state with confidence that there must be a direct effect to the extent to which the salmon taken by the nets would otherwise ascend the river and be taken by the anglers.

When the investigations were started, it was decided to make a definite test of the theoretical basis for net removal, which is that the salmon taken in nets near the river mouth are bound for, or on their way to, the river and would otherwise shortly enter and ascend it. The test has consisted in tagging salmon taken in the nets nearest the river mouth, liberating them just outside the nets, and learning of their presence in the river by their capture by anglers. While the experiments are defective for showing the full extent to which the tagged salmon enter the river, since only part of them will be taken by the anglers, they provide a definite measure of the effect of the netting on the angling catch. When salmon taken in the nets are tagged and permitted to proceed, we can know by the number of those recaptured by the anglers what would have been the loss to the angling catch if the salmon had been kept by the net fishermen.

It has been claimed by some that tagging experiments are not reliable for the reason that tagged salmon do not behave normally. The facts show that it does not stop them from entering the river; in fact for the Saint John river, which has nets operated inside the river mouth which show when they enter, more of the tagged salmon released just outside the mouth were taken in the river the day after tagging than on any subsequent day. Salmon taken in gill nets, where they have become exhausted through struggling, take about a week to recover before they move about much, but in the tagging done at the Margaree the salmon were trapped, not gilled, and were therefore fresh like those tagged from weirs outside the mouth of the Saint John river.

Insofar as anglers fail to report the recapture of tagged salmon, the effect as

calculated from tagging experiments will be short of the reality. We believe that very few recaptures have been unreported.

Removal of nets and other methods of reducing netting have been practised for at least eighty years, and yet, so far as can be judged, such practical experiments have never been clearly shown as effective in directly improving the angling, and have been shown as indirectly beneficial only where the netting had been most extreme. In contrast we now have the method of testing the direct effect by appropriate tagging experiments, a method that has not been used previously and that measures the effect rather precisely.

In order to obtain a fairly representative result the experiments were made in each of three successive years. As the complaint was of scarcity of the early fish, the tagging was limited to the first part of the season.

EXPERIMENT OF 1935 (Appendix, page 71, table VII)

In this year 100 salmon taken in five of the ten nets nearest the river or estuary mouth were tagged and liberated outside the nets during the period from June 25 to July 11. Eight of these were recaptured in the river by anglers on the following dates: September 7th, 8th, 18th, 19th, 22nd, 28th, October 2nd, 7th.

The ten nets within two miles of the river mouth, from among which the salmon were tagged, recaught four of the fish, leaving 96 free to enter the river. Of the 96 salmon eight were caught by anglers. If these results are typical for salmon caught in nets the total catch made in 1935 by the ten nets, amounting to 1,091 salmon, would have meant an addition of $\frac{1,091}{96} \times 8 = 91$ salmon to the angling catch if the nets had not been operated. These would have been taken only in September and October, when there were plenty of salmon otherwise, so that there would have been no appreciable betterment of the angling during June, July and August.

The thirty-three nets within five miles of the river mouth would as a whole not be expected to have any greater, if as great, a proportion of their salmon caught by anglers when freed to enter the river than the ten nets. They recaught ten of the 100 fish tagged from the nearer nets, which left 90 free to enter the river. On this basis the 3,044 salmon they took would have meant, if not removed from the sea, $\frac{3,044}{90} \times 8 = 270$ more salmon caught by the anglers, but again only in September and October, when the angling was excellent without them.

To estimate the proportional increase, the total angling catch is required. The guardians' reports cannot be relied upon for this, since they are clearly unable to learn of all the fish caught, particularly when fish, and therefore anglers, are numerous and generally distributed. I had in 1935 personal knowledge (the fish were examined, measured, and a sample of the scales taken) of salmon captured by angling during weeks when no salmon were reported by the guardians for the whole river. Also when salmon were numerous I had similar knowledge of many fish that had clearly not been reported. In one instance I knew of seven salmon being

taken from a certain pool during a week for which the local guardian reported only one, and my knowledge was casual with no attempt at thoroughness.

The tagged salmon provide a rough means of estimating the total angling catch. They moved in both directions coastwise from the places of liberation near the river mouth so as to become quite mixed with the other salmon at least within a few miles of the river mouth. This is shown by the fact that they formed as constant a percentage of those caught within five miles from the river mouth in each half-month period as could be expected from the small numbers taken. The figures are: July 1 to 15, the catch was 549 salmon, of which three were tagged fish, making 0.55 per cent; July 16 to 31, 507 salmon, of which two were tagged fish, making 0.40 per cent; August 1 to 15, 1,197 salmon, of which six were tagged fish, making 0.50 per cent. Also, among the 560 salmon taken from the estuary for the hatchery from September 17 to November 1, there were three tagged fish, making 0.54 per cent. The percentage of tagged fish in the total of these salmon is 0.50, which may be considered the most reliable figure. It would be expected that the tagged salmon would form the same percentage of those taken by angling in the river. Eight salmon were taken by the anglers; therefore, as these should form 0.5 per cent of the total, that total must have been around 1,600 salmon. To this should be added all those caught before September. If the salmon taken before September were reported to the same degree as those taken in September and October, there must have been about 300 of them. This would make 1,900 for the season.

If the ten nets nearest the river mouth had not been operated, there would, as calculated above, have been 91 more salmon taken by the anglers, that is an increase of about 5 per cent. If the thirty-three nets within five miles of the river mouth had not been operated, there would have been 270 more salmon taken by the anglers, an increase of 14 per cent.

EXPERIMENT OF 1936 (Appendix, pages 72, 73, table VIII)

In this year 161 salmon taken in four of the ten nets nearest the river mouth were tagged and liberated outside the nets during the period from June 23 to July 15. Six of these were recaptured in the river on the following dates: July 26th, August 20th, 25th, September 4th, 13th, 20th.

The ten nets within two miles of the river mouth from among which the salmon were tagged, recaptured four of the fish, leaving 157 free to enter the river. Of these, six were caught by anglers. On this basis the total catch made in 1936 by the ten nets, amounting to 811 salmon, would have meant an addition of $\frac{811}{157} \times 6 = 31$ salmon to the angling catch, if the nets had not been operated. Nearly all of these would have been taken in late August and September, when the best angling of the season was being experienced.

The thirty-three nets within five miles of the river mouth would not be expected to have any greater proportion of their salmon caught by anglers when freed to enter the river. They recaptured 15 of the 161 fish tagged, which left 146 free to enter the river. On this basis the 2,479 salmon they took would have meant

if not removed from the sea, $\frac{2,479}{146} \times 6 = 102$ more salmon caught by the anglers, but mostly in late August and September when the angling was best.

As for 1935, the proportional increase is to be estimated on the basis of the total catch, for which again the guardians' reports must be considered as inadequate through inability to learn of all the captures. The proportions that the tagged salmon formed of the total taken by the nets within five miles of the river mouth during each half-monthly period were as follows: July 1 to 15, 754 salmon, of which five were tagged fish, making 0.66 per cent; July 16 to 31, 721 salmon, of which seven were tagged fish, making 0.97 per cent; August 1 to 15, 166 salmon, of which two were tagged fish, making 1.12 per cent. Also among the 402 salmon taken from the estuary for the hatchery from September 17 to November 18, there were six tagged fish, making 1.5 per cent. Tagged fish were, however, absent from the estuarial catch toward the end of the season as they were also from the angling catch. The precentage should clearly be calculated for separate half-monthly periods for the estuarial catch, which gives: September 16 to 30, 154 salmon, six with tags, giving 4 per cent; October 1 to 15, 179 salmon, none with tags, giving 0 per cent; October 16 to 31, 53 salmon, none with tags, giving 0 per cent; and November 1 to 18, 16 salmon, none with tags, giving 0 per cent.

The tagged fish, therefore, formed of the salmon near the estuary mouth and in the estuary a percentage which rose from 0.66 in the first half of July to 4.0 in the last half of September, and then fell to zero for the remainder of the season. The movement of the tagged fish in the sea was strikingly different from that in 1935, in that a large proportion went far to the southwest during the netting season. Whatever may have been the reason for them, these changes through the season in the salmon related to the Margaree river make it practically useless to attempt to calculate from the numbers of tagged salmon what was the total angling catch in the river in 1936.

In 1935, somewhat less than a third of the salmon estimated to have been caught in the river were reported by the guardians. On the basis of that proportion, there will have been around 900 salmon taken in 1936. This means that elimination of the ten nets nearest the river mouth would have increased the angling catch about 3.5 per cent, and elimination of the thirty-three nets within five miles of the mouth would have increased the angling catch 11.5 per cent.

EXPERIMENT IN 1937 (Appendix, pages 74, 75, table IX)

In this year 209 salmon taken in four of the ten nets nearest the river mouth were tagged and liberated outside the nets during the period from June 18 to July 22. Thirteen of these were recaptured in the river by anglers on the following dates: July 14th, 20th, August 9th, 28th, September 5th, 15th, 18th, 19th, 23rd, 24th, (?), October 2nd, 5th.

One salmon deserves special mention. No. 0467 was caught and liberated from the first net northeast of the river mouth on July 12, was again caught and

liberated from the same net on July 15, and was finally caught by an angler in the river on some unknown day in September.

The ten nets within two miles of the river mouth, from among which the salmon were tagged, recaptured to remove from the sea six of the tagged salmon, leaving 203 free to enter the river. Of these, thirteen were caught by anglers. On this basis the total catch made in 1937 by the ten nets, amounting to 941 salmon, would have meant an addition of $\frac{941}{203} \times 13 = 60$ salmon to the angling catch, if the nets had not been operated. About 50 of these would have been taken late in the season when there was the best angling.

The thirty-three nets within five miles of the river mouth would not be expected to have any greater proportion of their salmon caught by anglers when freed to enter the river than the ten nets. For this year some salmon were tagged and liberated from nets more than two miles from the river mouth, namely the 6th, 9th and 11th nets to the northeast, giving an opportunity to compare these farther nets with the nearer ones. From these farther nets, 58 salmon were tagged and liberated from July 6 to 17. Only one of these was recaptured in the river by angling (on September 14). This is only one-third as large a proportion as were caught in the river from the nearer nets. If we take the results from the 267 salmon tagged as representing the thirty-three nets, we will be overestimating the effect on the angling. They recaptured and removed 14 of the fish, leaving 253 salmon free to enter the river. On this basis, the 2,382 salmon they took would have meant if not removed from the sea $\frac{2,382}{259} \times 14 = 132$ more salmon caught by the anglers.

For 1937 as for 1936, the tagged salmon do not provide a satisfactory means of estimating the total angling catch. They moved southwestward in smaller proportion (4 per cent as compared with 7 per cent were recaptured as far as Mabou or farther, even to Antigonish and Chedabucto bay). The percentage they formed of the catch of the nets within five miles of Margaree harbour and of the estuarial net in the fall, did not vary greatly, was at its lowest level in late July after the movement and rose to the highest level in early October. The numbers were: July 1 to 15, ten in 849 fish, making 1.2 per cent; July 16 to 31, three in 394 fish, making 0.76 per cent;August 1 to 15, two in 217 fish, making 0.92 per cent; September 20 to 30, two in 141, making 1.4 per cent; October 1 to 15, four in 267 fish, making 1.5 per cent; and October 16 to 27, one in 107 fish, making 1 per cent. An additional fish taken in the estuarial net on an uncertain date, would make one of the last three percentages higher still. Unlike the condition in 1936, the tagged fish continued in both angling and estuarial catches to the end of the season.

While there was sufficient constancy in the percentage that the tagged fish formed of the coastal net and estuarial net catches in 1937 to warrant using it as a basis for estimating the angling catch, another factor made it of little value for this purpose. In 1935, it was quite clear that none of the tagged salmon entered the river until more than a month after they were liberated, and by that time they were well distributed through the stock of fish near the Margaree coast. In 1936 one was

taken rather far up the river (Cranton bridge) fifteen days after it was liberated. As has already been described, a heavy rain on July 14 and 15 in that year was followed by a definite improvement in the angling. The fish in question was liberated on July 11 and was doubtless influenced by the rain to enter and ascend the river. The salmon that were liberated shortly before the freshet evidently entered the river at that time and to a greater extent than those liberated earlier that had scattered farther from the river mouth. Of the 54 salmon liberated from July 10 to 15, four, that is 7.4 per cent, were taken in the river by anglers, whereas of the 107 salmon liberated earlier, only two, that is 1.9 per cent, were so taken. This means that the nets near the river mouth will have a greater detrimental effect on the angling when they take the salmon shortly before a freshet. The 140 salmon taken by the ten nets nearest the river mouth from July 10 to 15 would have meant 10 salmon for the anglers, but the 367 salmon taken by the same nets before July 10 would have meant only 7 salmon for the anglers.

In 1937 there was a somewhat similar and more pronounced occurrence of this kind. A rather heavy rain fell in the region of the river mouth on July 6 and 7 (1.17 inches). As is shown in table IV, the proportion taken by angling of the

TABLE IV. Numbers of salmon tagged and liberated during various periods in 1937, and percentages of each that were recaptured on the coast, in the estuary, and in the river

	June			July		
Period	18-24	25-26	28-3	5-8	9-13	15-22
Salmon tagged	27	33	24	92	57	34
Per cent caught on coast	15	15	8	6.5	7	6
Per cent caught in estuary	0	0	4	0	7	9
Per cent caught in angling	4	3	0	9.8	3.5	6

salmon liberated from the nets near the river from July 5 to 8 was very much higher than for those liberated either earlier or later, and at the same time the proportions taken by nets on the coast and by the estuarial net in the fall were low. It seems certain that a considerable proportion of the salmon in the vicinity of the river mouth from July 5 to 8 entered the estuary with the freshet from the river mouth that followed the rain. Of these salmon the tagged fish liberated at that time will have formed a particularly high percentage, since they were liberated near the river mouth and had not had an opportunity of scattering far along the coast. For

this reason the tagged salmon are for this year unsatisfactory for estimating the angling catch.

If the guardians reported a similar proportion of the salmon in 1937 to the proportion reported in 1935, about 1,000 salmon must have been taken. This means that elimination of the ten nets nearest the river mouth would have increased the angling catch perhaps 6 per cent, and elimination of the thirty-three nets within five miles of the mouth would have increased the angling catch about 13 per cent. Under the circumstances these figures can be considered as giving only a very rough idea of the percentage increase that would have resulted from reduction of the nets.

CONCLUSION

Failure of net reduction in the past to show clearly any direct effect in improving angling is now easily understood, since the effect is slight and distributed over a long period. Elimination of the ten nets nearest the Margaree river mouth would increase the angling catch by from 30 to 90 salmon per year, a percentage increase of perhaps 3.5 to 5.

Elimination of the thirty-three nets within five miles of the river mouth would increase the angling catch by from 100 to 300 salmon per year, a percentage increase of perhaps 11.5 to 14.

In each case the increase would be chiefly for the periods when the salmon are in greatest numbers, that is late in the season, so that there would be very little improvement in the angling early in the season, when it is most needed.

A higher proportion of the salmon taken by nets near the river mouth shortly before a freshet, would otherwise enter the river and be caught by anglers than of those taken at other times.

General Conclusions

Any action of the nets in stopping salmon is relatively slight for those entering the Margaree river.

The netting season does not determine when salmon enter a river, and does not explain the lateness of the Margaree angling season.

Although reduction in netting has been repeatedly put into effect on many rivers in the past eighty years or more, no case has been found where it has clearly been responsible for improvement in angling in the river, even when the reduction has been in netting in the lower part of the river or the estuary.

A heavy wind storm that puts the nets out of commission makes no apparent increase of salmon in the river unless accompanied by rain, whereas a heavy rainstorm that does not put the nets out of commission improves angling.

That the coastal nets near the Margaree river take salmon is evidence of failure of a strong river influence (either regularly or temporarily), since such influence makes them ineffective.

Tagging experiments warrant the conclusion that there would be from 30 to 90 more salmon taken each year by anglers if the ten nets nearest the river mouth were removed, and from 100 to 300 more salmon if the thirty-three nets within five

miles of the river mouth were removed; but this is estimated to improve the angling only from 3.5 to 14 per cent and not to alter the time of the season when most salmon are taken.

Conservation of the stock is not involved. Large numbers of salmon remain to enter the river in the fall to spawn, and the accessible parts of the river system are well populated with salmon fry.

The choice, for the most pronounced effect demonstrated, that for 1935, is between taking 3,044 salmon from the sea with nets between June 1 and August 15 when they are in good condition for eating, and taking 270 of them (additional to perhaps 1900 salmon caught otherwise) from the river by angling in September and October when they are in poor condition because of the nearness of spawning.

EFFECT OF POACHING

In 1868, Mr. W. H. Rogers, Fishery Officer for Nova Scotia, reported for the Margaree river: "The spear, bag and sweep nets are in almost universal and constant use, still despite this indiscriminate destruction, large numbers of fish are taken every year" (*Ann. Rep. Dep. Mar. Fish. for the year 1868, p. 32*). Residents along the river do not hesitate at the present day to confess that in former years they were inveterate poachers. It is naturally difficult to obtain information about the extent of poaching now, but undoubtedly spears and nets are still in use. A salmon spear was found near an important pool in 1935. Such information as I have been able to obtain indicates that there is least poaching in the intermediate part of the river, where the angling is of most value to the residents. Towards the upper and lower ends of the river there does not seem to be as great a desire to protect the fish.

The shallowness of the river makes poaching comparatively easy, particularly in dry weather when the water is low. At such times poaching may have a considerable effect on the numbers of salmon taken by angling, and the river is usually lowest in the most important months for angling, July and August. The lower part of the river needs particular attention as being the portion from which the remainder receives its supply. The five-mile long estuary is nearly as shallow as the river above tide, and needs very careful watching if the fish that are in it during a dry season are to be preserved for angling.

At the present time, with no netting in the estuary, there are no data to show whether or not salmon enter the estuary and remain there a long time. For 1885, when there was estuarial netting, Overseer James Coady reported that the salmon "were known to come in the Margaree Harbor in large schools, yet very few ascended the river the first part of the season. This was owing to the season being unusually dry, the water being so low that the fish did not ascend, much to the disappointment of anglers. . . ."

In 1935, I was surprised to find that there was a larger proportion of the smaller salmon in the anglers' catches during the summer than in the catches of the small-meshed traps used to procure salmon for tagging (table V). After the

freshet of August 23 to 25, salmon ascended the river, starting above the head of tide. The proportion of small fish was high for the first week and then dropped. These small fish, called New Brunswick salmon by the guides, frequently showed the marks of struggling in a net, those with a length of 73 or 74 cm. being marked around the body just in front of the back fin and sometimes having the back fin torn and bloody as if recently injured.

TABLE V. Numbers of salmon of various sizes measured in 1935, as caught outside for tagging, and in the river by anglers (70 cm. equals 27½ in.)

	Length in cm.								
	50-68	69	70	71	72	73	74	75	76-100
Caught in nets for tagging.....	5	3	4	4	6	4	5	6	63
Caught by anglers before Aug. 25.....	10	1			2		4		7
August 26.....						1		1	
27.....					1		1		
28.....	1				2	1			5
29.....					1		1	1	2
30.....	2			2		2	2		5
31.....	1				1				2
Sept. 1.....							2		1
2.....									1
3.....							1		4
4.....		1					1		2
5.....									3
6.....						1			2

As the salmon taken in traps near the river mouth did not show this condition, it could not be properly attributed to the coastal nets, and also the apparently fresh injury was found on salmon several weeks after the coastal nets had been taken up. The cause for this was difficult to understand.

The summer of 1935 was very dry, and that of 1937 almost equally so. In the latter year it happened that at the beginning of the long dry period, there was a rather heavy rain over the estuary and but little rain up river, at a time when we were getting many salmon near the estuary mouth for tagging. It happened also that there was an unusually large proportion of the small salmon on the coast that season (figure 13). The rain fell on July 6 and the following night, and, as described in the account of the tagging experiment of that year and shown in table IV, the proportion of the tagged salmon taken by angling was very much higher for those liberated from July 5 to 8 than for those liberated earlier or later, and it has been concluded that they must have entered the estuary as a result of the freshet caused by the rain. Nine of these salmon were caught up the river and on

the following dates: July 14th, 20th, August 9th, 28th, September 14th, 15th, 18th, 19th, October 5th. They were quite evidently in the lower part of the river for a longer or shorter time while the water was low.

It is a curious fact that, as shown in table VI, all these nine salmon were 73 cm. or less in length, while all those of the same lot that were taken in the coastal nets were 74 cm. or more in length. It is rare for the nets to take any

TABLE VI. Numbers of salmon of various lengths tagged in 1937

Length (cm.).....	50-68	69	70	71	72	73	74	75	76-103
Tagging July 5 to 8, 1937									
Liberated.....	16	2	5	7	8	8	10	6	30
Recaptured in nets.....							2		10
Recaptured by angling.	2		2	1	2	2			
Other tagging in 1937									
Recaptured by angling.	1					2			2
Tagging in 1935									
Recaptured in nets.....					1		1	2	13
Recaptured by angling.	1					1	1		5
Tagging in 1936									
Recaptured in nets.....							2	1	33
Recaptured by angling.			1			1			4

salmon under 74 cm., but the anglers take them of all sizes and the other tagged fish recaptured by the anglers in this year as well as in 1935 and 1936, as given in the table, were to a considerable extent large fish. That the salmon caught up river from the tagging of July 5 to 8, 1937, were all below the size captured by the coastal nets, which have a 7-inch mesh, can, I believe, only be explained by the larger fish of those that presumably entered the estuary at that time having been removed with an illegal net of 7-inch mesh, when in the estuary or lower part of the river, with the water low. This will also explain the occurrence of a large proportion of small salmon in the river during the dry season of 1935, as well as the net marks frequently observed on them.

Salmon tend to be fewest when the river is low. Since poaching is then easiest, it is likely to emphasize scarcity. Nevertheless, it cannot be considered responsible for the great difference in numbers of salmon between the early and the late months of the season.

EFFECT OF VARYING ABUNDANCE OF THE STOCK

It would seem obvious that the larger the stock of salmon in the sea along the Margaree coast, the more would enter the river and the better would be the angling. On this assumption poor angling would be the result of the stock being low. As

the nets fish quite steadily during the season, their catches should represent fairly well the abundance of the stock. On studying the records of the past fourteen years, I have been unable to discover either a direct or a converse relationship between the net catches on the one hand, and either the summer angling catch or the total angling catch on the other. It seems evident that any effect of variations in the abundance of the stock is obscured by the greater effects of other factors.

This confirms the rather general view that poor angling in the river is not to be attributed mainly to a lack of salmon in the sea. Nevertheless, abundance of the stock is important for both those who net salmon and those who angle for salmon. Methods of increasing the stock are under investigation and another Bulletin in this series (No. 58) deals with experimental work in bird control, which may be of value in this connection.

EFFECT OF TEMPERATURE

Temperature has a most important influence on life activities. The temperature of the environment is particularly important in determining the activity of a cold-blooded animal such as the salmon whose temperature approximates and varies with that of its environment, the water in which it lives. Only a very little is as yet known of the complex effect of temperature on the activity of the salmon.

Sea Temperature

The principal variation in temperature is the yearly cycle, rising from winter through spring to summer and falling through autumn to the next winter. Rise in temperature usually results in increased activity and the salmon season begins during the spring rise. In the western part of the outer coast of Nova Scotia, where there is practically no ice in the sea at any time, the temperature is least low for our whole Atlantic coast during the winter and salmon may be sufficiently active to enter the rivers every month. The large amount of floating ice in the gulf of St. Lawrence lowers its temperature during the winter close to its freezing point, which, owing to the salt in the water, is 30° F. or less. As a consequence the salmon are inactive on the Cape Breton coast through a long winter season and until late in the spring, owing to the winter's accumulation of ice in the gulf passing out along that coast.

No data are available to show the course of the temperature of the water on the Margaree coast, but the Atlantic Biological Station has records of the temperature of the water issuing from the gulf as it passes Scatari island near Cape Breton, and also at Sambro island, midway along the outer coast of Nova Scotia. The mean daily temperatures of the water at these two points during the spring months over the period from 1930 to 1936 are plotted in figure 24. It will be seen that the spring rise through about 40° F. is three weeks or so later at Scatari than at Sambro. Records for several places in the gulf of St. Lawrence show equally striking differences in the spring warming of the water. Such differences render it probable that the lateness of the salmon netting season on the Margaree coast as

compared with the St. Mary river estuary (figure 17) is to be attributed to temperature.

There is definite evidence that the beginning of the salmon season on the Margaree coast is determined by temperature. The ice was reported to have left this coast unusually late in 1935, and the various fisheries were said to have begun late as a consequence. In figure 25, the courses of the spring rise in temperature at Scatari island and of the development of the salmon fishery on the Margaree coast in 1935 and 1936 are compared. It is evident that both were about a week later in 1935.

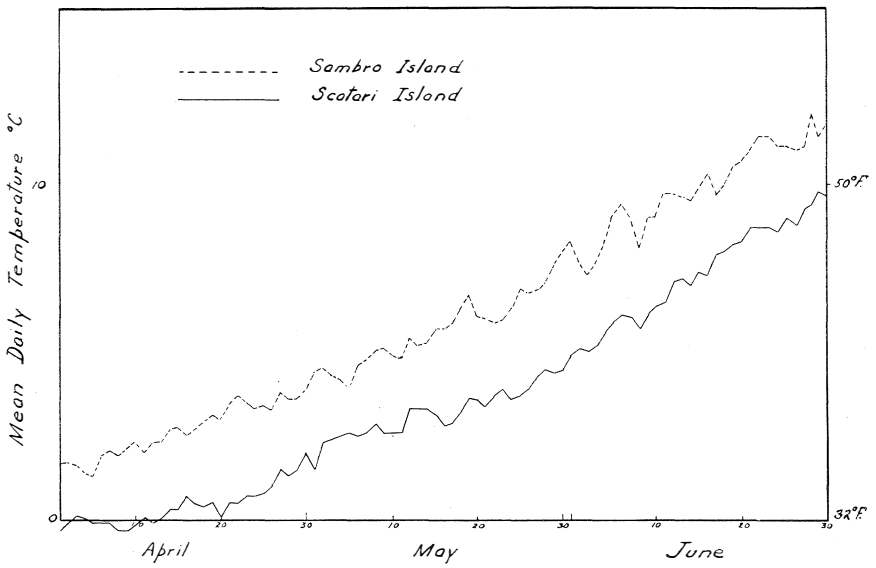

FIGURE 24. Mean courses of spring rise in temperature at Scatari island (————) and Sambro island (- - - - - -), 1929 to 1936.

Although no opportunity has presented itself for following the temperatures of the water all along the coast during the critical period, it seems probable that the capture of salmon near the mouth of Cheticamp harbour earlier than elsewhere on the coast, either to the northeast or to the southwest (figures 27 and 28A), is an effect of temperature. This harbour is extensive, shallow, and without much fresh water, and it opens into a definite embayment of the coast, into which the Cheticamp river discharges. It is to be expected that the water of this embayment will become warm earlier with such conditions. Along its shore the salmon are first taken, and this helps to explain why angling is earlier in the Cheticamp than in the Margaree river.

Salmon angling on the Margaree river is primarily dependent upon the warming of the sea along the Margaree coast, which becomes progressively more favourable through the month of June.

River Temperature

The river is probably always warm enough for the salmon to enter and ascend even before the rise in sea temperature has made them sufficiently active. Also, the comparatively large proportion of cool, spring water that enters the river prevents its temperature rising to a distinctly unfavourable level.

In spring and summer the water of the Southwest Margaree river is regularly several degrees warmer than that of the Northeast Margaree river, which is definitely referable to the supply for the former river being largely stored in lake Ainslie, exposed to the sun, while the supply for the latter is largely stored under-

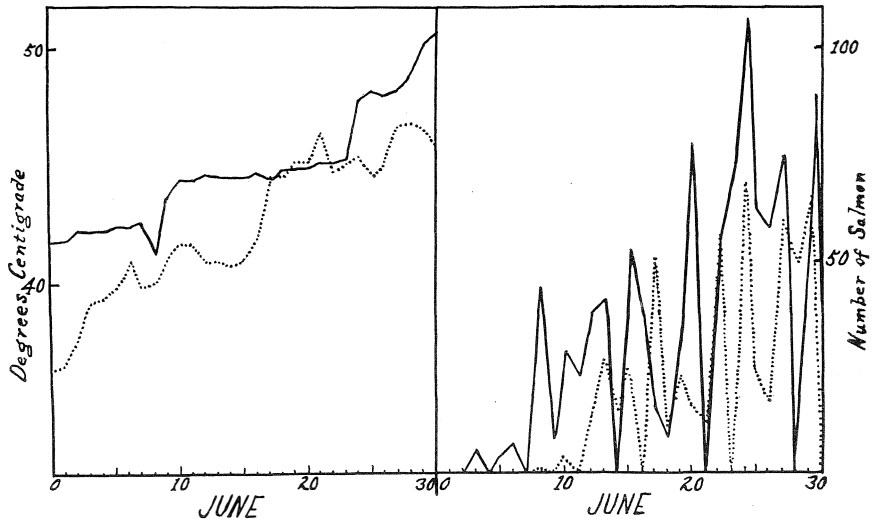

Figure 25. Left: Rise in temperature of water at Scatari island during June in 1935 (.....) and 1936 (————). Right: Development of salmon fishery on Margaree coast in 1935 (.....) and 1936 (————), as shown by catches of 34 nets near Margaree Harbour.

ground to emerge as springs. It is stated that in an occasional year, when the salmon first ascend, they go up the Southwest rather than the Northeast, the latter being still ice-cold. Usually they are to be taken throughout the angling season only in the Northeast. Since they spawn throughout both branches, and since salmon ascend other rivers arising from lakes, it would seem that the differences between the two branches, perhaps in temperature, result in the salmon, when they reach the Forks, choosing one branch or the other, depending upon the conditions.

EFFECT OF WIND

Anglers sometimes see a relation between wind and good angling and a wind may arouse the salmon so that they take the fly more readily. We are here concerned only with a possible effect of wind in getting more salmon into the river

for angling. Such is apt to be indirect, and the stages in the progress of the salmon riverward will be taken in order.

Effect on Coastal Net Fishing

Attention has been called to the action of a strong northwest wind on June 17, 1936, in putting the coastal nets out of commission and largely stopping their catch of salmon (figure 23). Apart from the unfavourable direct action of the surf on the nets, an onshore wind creates conditions inshore, such as surf and dirty or roily water, which the salmon avoid, as has been described. The net fishermen commonly remark that the salmon "trim the shore in calm weather". Another effect of winds is to increase the strength of the tidal currents and this prevents good fishing by nets that are in the currents affected.

In spite of these unfavourable effects, the fishermen recognize the benefit of onshore winds. It has been stated in this way: "A storm is bad, but choppy water is good". Offshore winds are said to have no particular effect, but coastwise and onshore winds have a variable effect depending upon their strength and direction and upon the location of the particular net. Added to this complexity is the frequency with which the wind changes direction and force, and the variability of the wind near the water surface along the coast, owing to the irregular character of the neighbouring land surface, much of which is quite high.

Notwithstanding the complexity of the matter, study of the records shows quite clearly that onshore winds, particularly those lasting for several days and initially strong but decreasing in intensity, increase the catches of salmon. The daily catches of salmon by nets for the season of 1936, as shown in figure 23, on the whole increased up to July 10 and decreased thereafter. The increase during June at least can be considered as due to more and more salmon becoming available as a result of warming of the water, and the decrease toward the end of the season as due to the movement of the salmon away, either elsewhere in the sea or into the estuary and river, as well as being caught. When the salmon are fully available and before they are moving away to any great extent, the effect of winds is more clearly observable. From July 6 to July 12 there were onshore winds, rather strong at the start and decreasing rather steadily in intensity. The catches on the whole increased through this period and reached much the highest values for the whole season.

In the season of 1935, the water, as has been described, was late in warming, and the salmon were, therefore, late in becoming available. Onshore winds of decreasing intensity from July 1 to July 10 failed to build up very large catches, although there was a definite increase. After a period almost without onshore wind, there were from July 25 to August 10 repeated onshore breezes, at first moderately strong, and decreasing in intensity. The catches built up rapidly, and reached the highest levels on August 12 almost at the end of the season.

How the onshore wind gives more salmon on the coast is not known. The choppy water may cause the salmon to be more active, or the salmon may be

affected by the currents produced by the wind, a slow surface current going with the wind and a very slow, deep return current going against it. Nets held firmly across a slow tidal current have the salmon entering with the current rather than against it as is well shown by the experience of the fishermen at Gulliver cove, near Digby, Nova Scotia. From this it seems certain that salmon go with such slow movements in the sea. The salmon are near or at the surface, and the wind causes a surface current going in the same direction. It seems probable that the salmon go with this surface current, and so reach the shore when winds blow onshore.

Effect on Estuarial Fishing

As nets are not now permitted in the estuary during the netting season, knowledge of the conditions that determine entrance of salmon into the estuary is dependent upon the memory of those who operated nets in it before 1909, and to the operation of the trap, by means of which fishermen take salmon a mile inside the estuary mouth in the fall, to sell to the Department of Fisheries for hatchery purposes.

The estuary cannot have salmon until they reach the coast and we have seen that onshore winds increase the catches of the coastal nets. Four men, who formerly fished nets at various points in the estuary from near the mouth to the head, all stated that they could not expect to get many salmon without having a good north (or northwest) wind. A north wind blows directly from the open gulf to the river mouth.

Study of the daily catches of the estuarial trap operated in September and October shows that in each year from 1935 to 1938 more salmon on the average were taken on the day after north or northwest winds than on the day of the wind or on the second day after. The wind records used have been those made at Margaree island (1935) by the lighthouse keeper and those made at Cheticamp (1935 to 1938) by the observer for the Meteorological Service, but these seem sufficient to corroborate the report of the fishermen that northerly winds improve estuarial fishing. While this improvement may be considered as the result of salmon entering the estuary when brought near or to its mouth by the wind, the action of the wind is involved with that of river water.

Effect on Angling in the River

The river with its angling pools cannot have salmon until they enter and traverse the estuary. Northerly winds, which cause salmon to enter the estuary, will, therefore, have an effect on angling. However, there will be no effect until the salmon ascend the river, and, as we have seen, their ascent may be delayed a long time during a dry season.

To judge from the Meteorological Records for Baddeck and Cheticamp and the Hydrometric record of the Northeast Margaree river at Frizzleton, the season of 1938 was not dry except during the first three weeks of August. The freshets that occurred about every ten days might have brought salmon up to the angling pools if the freshet reached the estuary and if salmon were available there. The

angling improved very slowly until about the end of August (figure 26). Were the conditions such as to have many salmon in the estuary before that time?

There was no investigation in 1938 of the conditions at the mouth of the estuary, but we have available the daily catches of the nets and the Meteorological Records made at Cheticamp. The nets near the mouth of the estuary (figure 27) did not have their best catches until August instead of in July, the usual time. There was, therefore, no large body of salmon near the mouth of the estuary until that time. As is to be seen in figure 26, there was no northerly wind recorded at

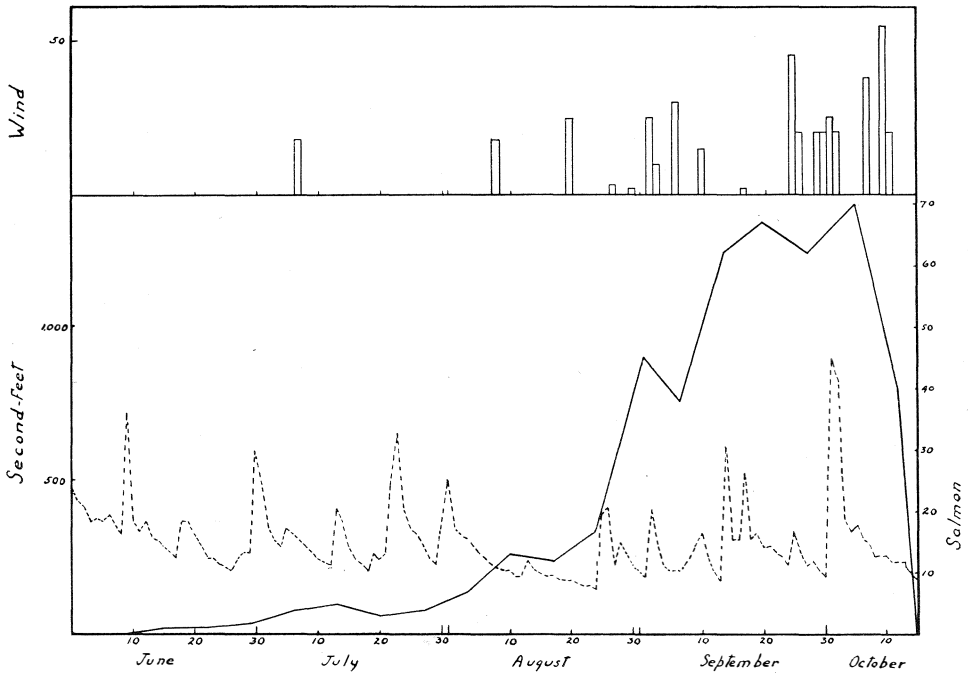

FIGURE 26. Weekly course of salmon angling (————) in the Margaree river in 1938 in relation to current (discharge in cubic feet per second) (- - - - - -) on the Northeast Margaree river, and to northerly winds (above) as recorded at Cheticamp.

Cheticamp during June and for only one day was there a record in July. For no other of the four years, for which there are records, was there so little northerly wind in those months. With such conditions, one would not expect many salmon to enter the estuary before August. There was evidence of many up the river only when rains and freshets came toward the end of that month.

Figure 26 shows that northerly winds increased in number and force from June to October during 1938. To judge from the records for 1935 to 1938, this is the usual condition, although in no other year was the gradation so extreme and so regular. It seems certain that this is a factor in making the Margaree a late river. It will readily be seen in figure 26 that northerly winds are followed shortly by improvement in the angling.

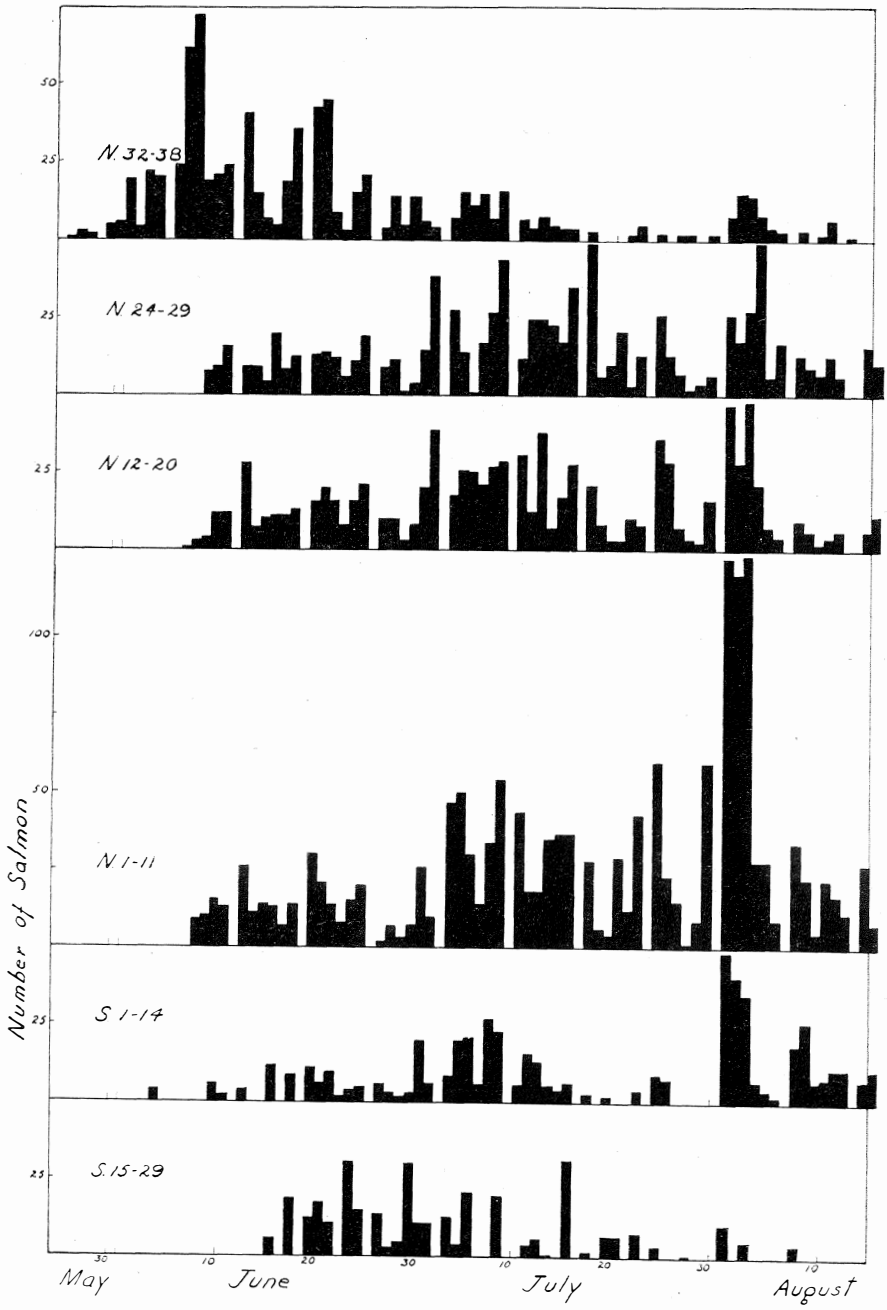

FIGURE 27. Courses of the net catches of salmon on different parts of the west coast of Cape Breton island during the season of 1938. Nets are numbered northeast and southwest from Margaree Harbour. Nets N1-11 are in closest relation to the Margaree river and nets N32-38 to the Cheticamp river.

EFFECT OF FRESH OR RIVER WATER IN THE SEA

It has been shown in dealing with the significance of the capture of salmon in the sea by weirs or nets on the shore that such fishing is ineffective when river water is present offshore, as along the coast of Saint John county, New Brunswick. Also, as found experimentally by Mr. Menzies on the Sutherland coast of Scotland, it becomes ineffective when the rivers are in flood or freshet. On the Margaree coast there is a drop in the catch of the nets near the river mouth after a heavy rain, as appears in table III.

Fish Attracted by River Water?

The fact that certain fish enter fresh water from the sea might be considered proof that they are attracted by the fresh water, whatever may be the feature in it that affects them. Mr. H. M. Rogers, who has taken part in these investigations, made a study of the estuarine fishes of the Margaree and found as he has reported in *"Science" (volume 89, page 412, May 5, 1939)*, that all of them, namely sticklebacks (*Gasterosteus*), killifish (*Fundulus*) and silversides (*Menidia*) show, when given a choice in an experiment, a concentration in the fresher water of the estuary. He has observed this for the sticklebacks in the sea near the south breakwater at the mouth of the Margaree estuary and considers it an important feature in their behaviour to bring them into the estuary to spawn or back into the estuary after spawning, if swept out to sea by strong ebb tides. Investigation in 1938 of the drift-net fishery for salmon in the bay of Fundy off the mouth of the Saint John river, New Brunswick, showed a very precise relation between the area of successful fishing and the distinctly recognizable presence of the river water in the sea. The salmon were definitely concentrated in the bay where the river water was in greater amount, whether that was near or far from the river mouth, and the greatest concentration of all was in the harbour, that is, at the river mouth where there was most river water. There can be no doubt that river or fresh water is of great importance in effecting local concentration of salmon in the sea and so facilitating their entrance into the river.

Salmon Concentrate in River Water near Margaree Coast

No matter on which side of the estuary mouth they were liberated, the salmon tagged on the Margaree coast in 1935, 1936 and 1937, were chiefly recaptured along the coast northeastward from the estuary mouth, as is apparent in B and C of figure 28. Along this part there is not only a greater concentration of nets, but also a larger catch per net than to the southwest or farther to the northeast (figure 28A). The salmon are definitely concentrated along this part.

The explanation of this is to be found in the fact that with ebbing tide the river water flows out of the estuary and northeastward along the coast. Moreover, the general set of the water is also northeastward. While the river influence tends to spread at the surface in all directions from the estuary mouth, it is more pro-

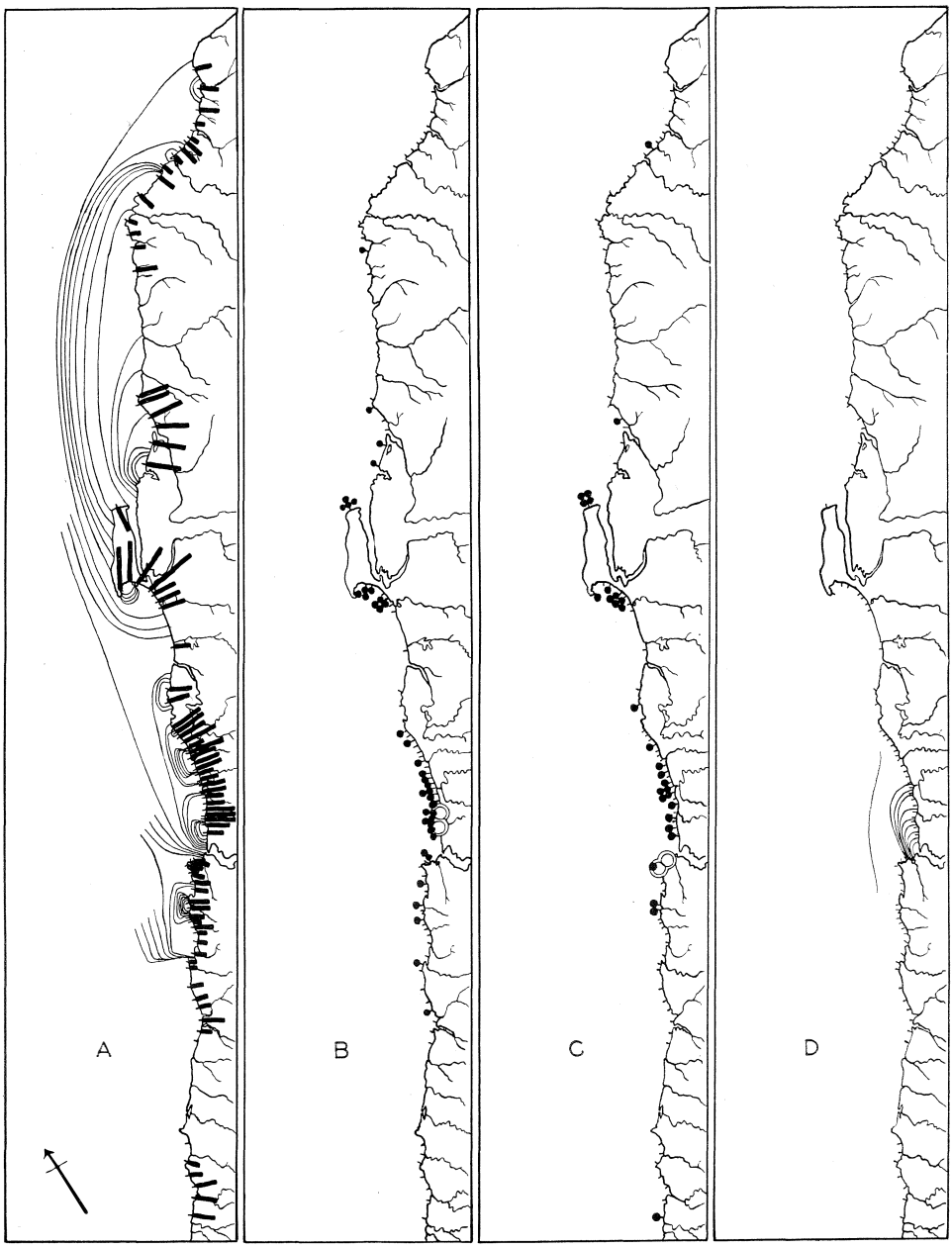

FIGURE 28. The Margaree and neighbouring coast, showing relation of salmon to the river mouth (one-third the way up from the bottom) and to Cheticamp island (over half-way up). A,—catches of salmon by individual nets in 1936, and order in commencement of fishery, the successive lines out from coast representing successive days. B,—recaptures in 1935, 1936 and 1937 of salmon liberated just north of river mouth. C,—recaptures in the same years of salmon liberated just south of river mouth. D,—distribution of surface water of low salinity with ebbing tide, going north from river mouth. The locations of the nets are shown.

nounced to the northeast as compared with the southwest, and particularly so during ebb tide (figure 28D). The salmon, it is evident, concentrate in this water.

The salmon appear generally along the shore as the water warms up, and earlier or later depending upon the rate of local warming. They are quite clearly moving to and fro both coastwise and at right angles to the shore. No matter where they are liberated, tagged salmon are recaptured in both directions along the coast, skipping few to many nets on the way. The view that they come in along the coast from the Atlantic is substantiated neither by the times of their appearance in the successive nets along the route nor by the times of their maximum abundance in these nets, since they appear a week or so later (figure 28A) and reach their height about two weeks later at Pleasant bay than they do at Cheticamp fifteen miles farther into the gulf.

Nor do the movements of the tagged fish give any support to such a view. Some of the salmon liberated near the mouth of the Margaree estuary travelled *out* of the gulf around the north side of the island to St. Lawrence and Aspy bays and around the south side through the gut of Canso to Chedabucto bay.

The salmon appear on the shore at places quite far removed from rivers, as at the southwestern end of Cheticamp island and at Ste. Rose, about eight miles southwest of the mouth of the Margaree estuary. The fisheries at these places may develop early or late but, as the season progresses, their catches drop while those of the nets near the Margaree may be still rising, as will be seen in figures 27 and 29 (nets N24-29 and S15-29 respectively). If, as occurred in 1935 and 1938, the salmon fail to enter the estuary in any quantity until well into August, their numbers are not so likely to decrease as when they enter early, and they are indeed in greatest quantity near the estuary mouth at the beginning of that month rather than in July as is usual, as the statistics of the catches show. That they collect there is clearly due to the fish tending in their to and fro movements to concentrate where there is more fresh or river water, that is near the estuary mouth, but particularly to the northeast.

Entrance of Salmon into Margaree Estuary

Salt water barrier with flood tide

Unfortunately for the guidance of the salmon into the estuary, the bodies of surface water recognizable through their lower salinity as having more river water are connected with the estuary only part of the time, during the ebbing tide. When the flood tide begins to flow strongly, it stops the outflow of fresher water, and fills the estuary mouth with deep, salt water that rises to the surface in the inward tidal movement over the bar outside the estuary mouth. This movement is very strong, since the estuary is so extensive and falls and rises fully with the tide outside. This salter water intervenes between the river water in the estuary and the bodies of surface water with recognizable river influence that are outside and are the result of outflows of river water during ebb tides. This is a very important matter for an understanding of the slowness with which most of the salmon that reach the

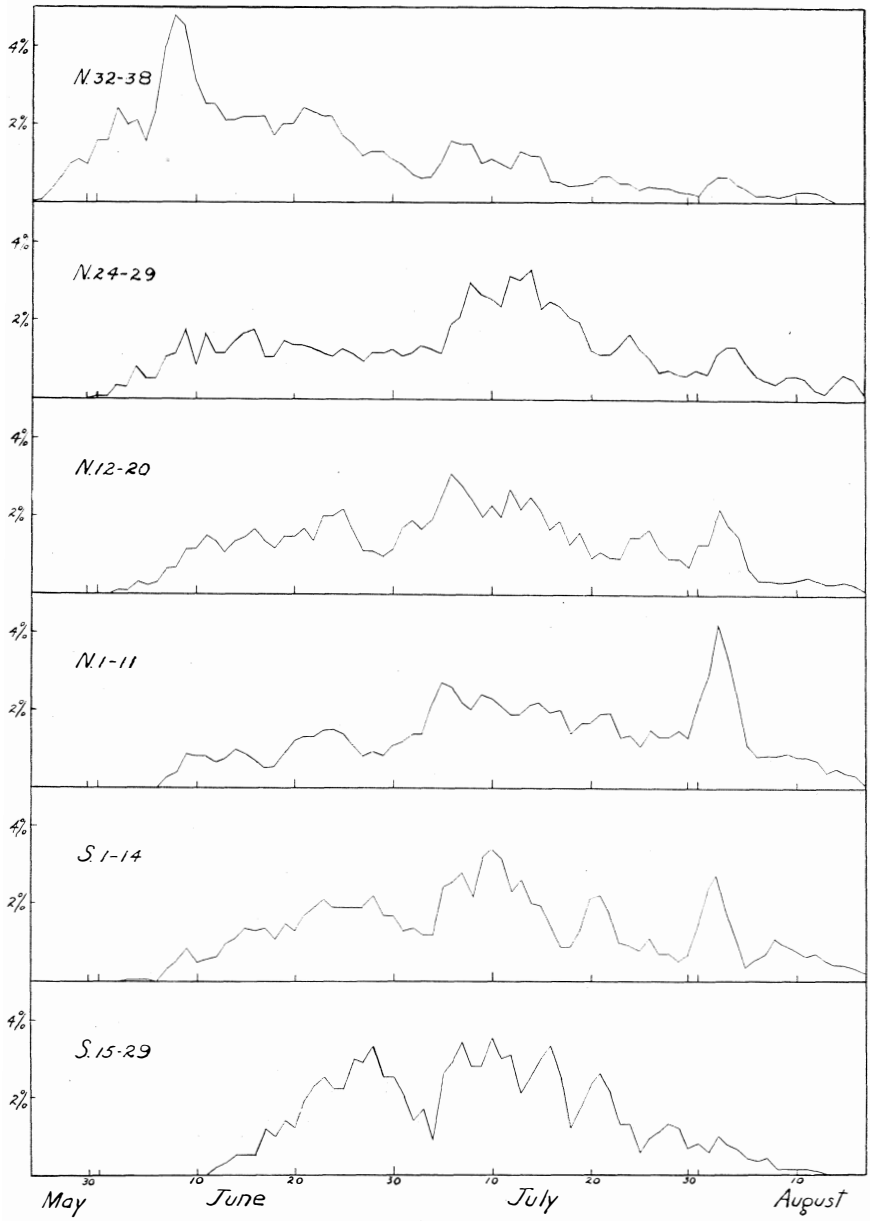

FIGURE 29. Course of net fishery for salmon on different sections of the west coast of Cape Breton island, based upon the records for 1936, 1937 and 1938. Nets are numbered northeast and southwest from Margaree Harbour. The curves have been smoothed by using a moving average for three-day periods, and the amounts expressed as percentages of the total. Nets N1-11 are in closest relation to the Margaree river and nets N32-38 to the Cheticamp river.

coast enter the estuary and river, although it is only part of the explanation. This slowness is clearly shown by the angling catch in the river reaching its peak about two months after the peak has been reached in the catches of the coastal nets. It may be taken for granted that the larger the volume of water discharged by the river into the estuary, the larger will be the amount of comparatively fresh water issuing from the estuary, the longer will be the period during which it issues, and the shorter will be the time during which outside bodies of "river" water with salmon concentrated in them will be definitely separated from the "river" water of the estuary. Heavy floods will thus aid the entrance of salmon into the estuary.

EFFECT OF MORE FRESH WATER IN THE ESTUARY

It is difficult to separate the effects of the mere presence of "river" water in the sea from the effect of the current produced by its discharge from the river. Apparently in many Scottish rivers, as described by Mr. Menzies, a spate or freshet is almost at once effective in stopping the capture of salmon by the coastal nets and in giving salmon in the river for angling. Doubtless, if it were possible to have the river water appear in larger volume in the sea without an increase in the current from the river, capture by shore nets might stop without the appearance of salmon in the river, but such is difficult of accomplishment and not apt to occur in nature.

Actually, however, something approximately of this sort did occur in July of 1937. The Margaree estuary may properly be considered as an arm of the sea containing a large proportion of river water, in which the salmon may concentrate. As has been described, heavy rains fell over the estuary on July 6 and 7 without there being much increase in the current from the river (little rain fell up river). This arm of the sea thus received quite directly a large amount of fresh water similar to that from the river. Evidence has been given to show that salmon in considerable numbers left the coastal waters near the estuary mouth (the net catches dropped) and concentrated in the estuary, and that, with little river current, few ascended the river until late in the season.

Freshets in the river will add more fresh water to the estuary, so that less salt water requires to enter during flood tide to fill the estuary. The outflow during ebb tide will be markedly fresher. The volume of the outflow will depend more upon change in the tides from neaps to springs that upon freshwater discharge. The action of a freshet at the mouth of the estuary can, therefore, be regarded as increase in proportion of river water rather than increase in current. That it acts in causing salmon to enter the estuary is affirmed by those with experience of fishing in the estuary before 1909. The records of the Department of Fisheries for the daily catches of the estuarial trap operated by fishermen in the fall show an increase in the number of salmon on the day following a freshet. This is evident in figure 30. Since this figure was prepared, the records for 1936 and 1937 have been studied, and they give substantially the same result,—not only a rise on the day after the freshet, but also one reaching its height on the sixth or seventh day later. Not only the possible, but the actual variety of changes in the amount of fresh water

leaving the estuary are very many and the reactions of the salmon to these are far from simple. Also the wind is involved with the issuance of fresh water. However, I believe the detailed facts warrant the following statement of what happens.

A sudden increase in the proportion of fresh water in the outflow causes the salmon near the mouth to enter promptly. Continuing increase to a very high proportion diminishes the number entering, presumably through producing large masses of "river" water outside, in which the salmon congregate rather than enter the estuary. That condition, however, causes many salmon to be congregated near the estuary mouth, and, as the "river" water outside diminishes in amount, they are more and more likely to forsake it and enter the estuary.

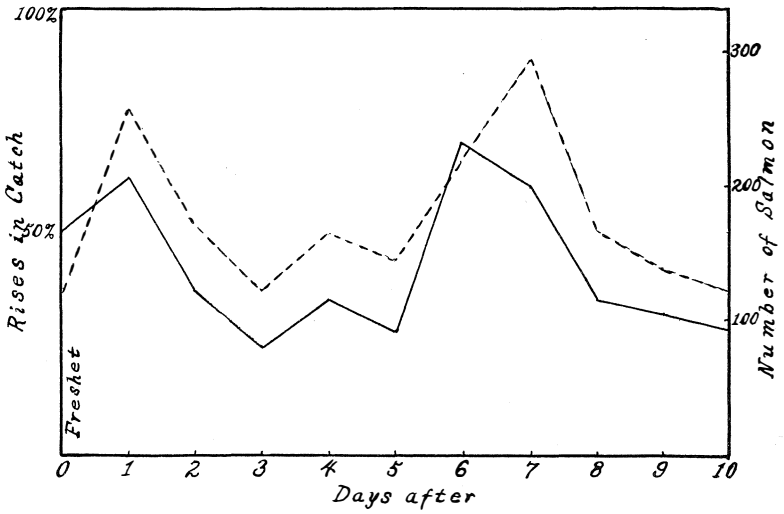

FIGURE 30. Salmon capture in Margaree estuary, autumns of 1932, 1933, 1934 and 1935, in relation to freshets; ———— percentages of rises in catch, - - - - - - - numbers of salmon taken.

LIMITED VALUE OF RIVER WATER IN THE SEA

Important as it may be to have river water in the sea, such concentration is quite ineffective for angling unless conditions are such that the salmon proceed riverward. Concentration in masses of "river" water along the coast are worth while only to the extent to which the salmon find their way from these masses into the estuary. Even concentration in the estuary may be quite without effect until conditions come that result in the salmon ascending the river, and these may be long delayed.

WHY DO SALMON CONCENTRATE IN RIVER WATER?

It is not definitely known why the salmon concentrate in river water. Various explanations have been given for salmon entering rivers, such as differences in temperature, oxygen, carbon dioxide, or merely a lower amount of salt. It has also been suggested that substances from the land may be responsible for the salmon

entering river water and that these may enable the salmon to distinguish the water of their own river from those of other rivers. We are mainly concerned with the fact that they do tend to remain where there is most river water.

EFFECT OF RIVER WATER AND WIND

It is difficult to separate the effect of river water and wind in the entrance of salmon into the Margaree estuary. Northerly winds, which blow directly into the

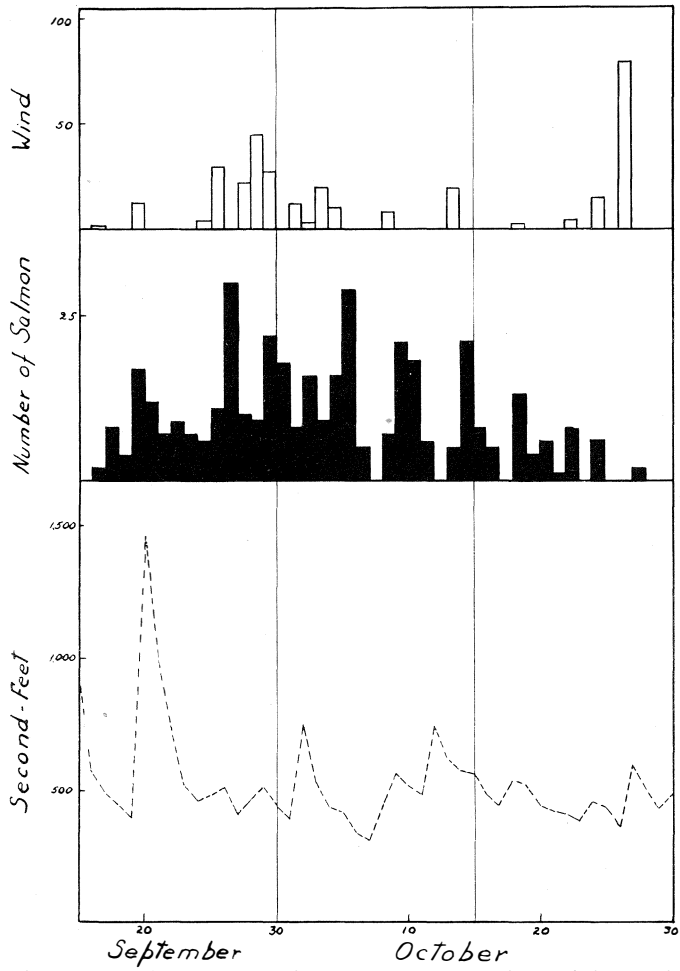

FIGURE 31. Daily catches of salmon trap in Margaree estuary in 1936, in relation to northerly wind as recorded at Cheticamp, rain at Cheticamp and discharge of the Northeast Margaree river at Frizzleton.

estuary mouth from the sea, hold the issuing river water close to the mouth and facilitate the entrance of salmon in that way as well as by causing a surface current with which the salmon will go to the estuary mouth. The combined action is best appreciated by studying figure 31, which shows the daily catches of the estuarial

trap in relation to river discharge at Frizzleton and to northerly winds as recorded for Cheticamp. The difficulty of separating wind and river water influence is made even greater by the fact that the northerly wind and the freshet usually occur together.

The underlying need is to have the salmon concentrated on the coast and reasonably near the estuary mouth, which is effected by onshore winds (west to north) and plenty of "river" water from previous large freshets. The immediate condition for entrance of large numbers of salmon is to have a northerly wind (northwest to northeast) with or without a freshet. It should not be difficult to discover in figure 31 that the comparatively high catches on September 27th, 30th, October 3rd, 6th, 10th, 15th, 19th, 25th and 28th can be thus understood. The entire run may be considered as consisting of those collected near the estuary mouth by the high freshet of September 20, with significant additions by the next highest freshets, those of October 2 and 12. The wind seems to have a more immediate and precise effect in determining the catch than the freshet.

With salmon scattered in the offshore waters, the best conditions for bringing them into the estuary would seem to be a heavy freshet, and in a few days a westerly wind, shifting through northwest to north, perhaps with a slight freshet at that time.

EFFECT OF TURBULENT CURRENT OR RIVER DISCHARGE

Rheotropism

The way in which a fish, such as a salmon, holds its position in the current of a stream is so striking that it has been very thoroughly investigated from the scientific standpoint and has been given the name of rheotropism. The fish heads upstream and swims just fast enough not to change its relation to the bottom.

If the water is still, as in a glass dish, and the apparent bottom outside the dish moves, the fish will swim through the water to keep its relation to such "bottom", as long as it is able to see. The subject is quite a complex one and it seems never to have been proved to general satisfaction whether or not a fish in a surface current with no bottom visible will orient itself against it (turn with its head up current), when the water is moving as one mass without turbulences, even slight and unapparent ones. Observations of herring in the sea in the Passamaquoddy region of southern New Brunswick have shown me that under these conditions herring at least do not head against the current, but, as soon as the current becomes turbulent through proximity to some stationary object such as a weir stake, they at once orient themselves with their heads against the current. Owing to the amount of space involved, it is difficult to get these conditions in an experiment. I believe that the facts are in harmony with the view that the blinded fish, through the sensory organs of its skin, orients itself against the current when the water has sufficient fine turbulence through having been in contact with stationary objects. The whole of the water of a river, unless it has only a slight flow, will have such turbulence.

Congregation of Salmon in a Current

We are concerned not so much with rheotropism as with movement of the fish upstream. Scientific attention has been concentrated on orientation and maintenance of position by the fish to the practical exclusion of the matter of what causes the fish to move up or down stream. Such a matter is undoubtedly very complex, since we know that a great variety of stimuli will cause the fish to move more rapidly. Nevertheless, when the fish is taken as having a certain degree of activity, the problem is comparatively simple. It is a common observation that salmon or trout in a pond, as at Frizzleton Hatchery, collect in the inflowing turbulent current. I have stated this behaviour as being one of coming to a stationary position with reference to the bottom where the strength of the current matches their activity.

Ascent of a Stream

Salmon fry in the Margaree estuary have been observed not only to collect at the mouths of the tributary brooks, but also to ascend them. Apart from taking a position where the issuing current matches their activity, they make dashes up swifter currents and come to rest in slower eddies or cling to the bottom in the very rapid current. That turbulent current suddenly applied stimulates them to great activity was well demonstrated in an unintended simple experiment performed in 1935. I was carrying salmon fry in a pail along the Margaree river and wished to change the water in the pail. The fry remained quite still at the bottom of the pail while the water was being poured out and until some water was permitted to pour in. Then they became extremely active, leaping up the "falls", which was in height about four times their length, and so escaping. Mr. H. C. White, who was accompanying me at the time, stated his familiarity with this behaviour and doubtless those who handle fry know it well. This behaviour is comparable to that of the adult, which ascends rivers and leaps falls.

Salmon in Tidal Currents

We have seen that there is evidence of the salmon going to and fro in the sea. This shows their activity. If they come into "river" water, they tend to remain, but continue going to and fro. If they reach a turbulent stream issuing from a river, they will head into it and come to rest where it matches their activity, which may be increased by the stimulus of coming into contact with the turbulent water. If the river runs or falls directly into the open sea, the salmon may at one dash be in a river pool and available for angling.

Usually and very definitely for the Margaree, conditions are not so simple. The river water in the sea may be under tidal action and flow forwards and backwards. Rutter (*Natural History of the Quinnat Salmon. Bulletin of the United States Fish Commission, volume 22, pages 65 to 141, 1904*) describes his observations of the movements of the adult spring salmon—"when the salmon enter San Francisco Bay they come in against the ebb tide, stem the current till the tide changes, and then run out against the flood tide, losing much of the distance gained

on the ebb." It is necessary to appreciate the fact that salmon, as well as other similar fishes, are apt to move up current no matter where it leads. I have observed salmon smolt, considered as on their migratory journey to sea, collect at the end of the breakwater at the mouth of the Margaree estuary, and, as the outflowing current slackened, stem it and return to the estuary. Mr. Rogers, when observing in the same place the sticklebacks that were presumably entering the estuary to spawn, found that as the outflowing current slackened to less than 1½ feet per second, their "cruising speed" was sufficient to carry them into the estuary. When the tide ceased to flow they ceased to head inwards, and when the tide began to flow inwards they not only headed outwards, but swam back against the current out of the estuary. Such behaviour will not result in rapid progress riverward, the fish going against the current wherever it takes them. They will do this not only on the outer coast, but throughout the five-mile long estuary or tidal portion of the river.

Freshets Improve Angling

Knowledge of the behaviour of the salmon in turbulent current is essential for an understanding of the movements of the salmon into the river, both tidal and non-tidal, which is almost wholly turbulent current. Very much remains to be discovered, but we have definite facts as to the action of variations in turbulent current or river discharge in improving the angling. There is very general appreciation of the importance for angling of the condition of the river, although there is wide divergence of opinion as to what exactly constitutes a good condition, whether it is the height of the water, its colour, or the debris it carries. The Fishery Officers, who have had charge of the river, did not at first understand the importance of the condition of the river, the report for 1877 by A. Ross stating "for some unaccountable reason, they (the salmon) did not ascend the Margaree River until the first of September". By 1883, however, the officer felt able to state "salmon were scarce during the first part of the season, the rivers being unusually low and clear". Since that time there has been clear recognition of the connection between good angling and the condition of the river.

The following statements were made to me in 1934 by persons with experience on the Margaree river.

Main river.

Mr. P. A. Gillis: "If the river is in condition, the weather doesn't matter. While the water is rising in a freshet, it is useless to fish,—not until it gets sufficiently clear on going down".

Mr. Duncan McDonald: "For entrance of salmon, high water is the important thing".

Mr. Peter McDaniel: "To bring the salmon, you require a combination of a good storm from off-shore and a rise of water".

Northeast Margaree river.

Mr. Lawrence Bennett: "Rise in water brings fish up and makes them run far up, starting from tidal waters and travelling at night".

Mr. Duncan McKenzie: "In about two or three days, with rainy, blowy, stormy weather, you will get good fishing. Best condition for fishing is dark water".

Mr. D. H. Ross: "Always when enough water there are fish in the river".

Mr. Roderick McKay: "Best fishing is after a good big freshet".

All persons on the river, who were interviewed, agreed as to the importance of the condition of the river for angling, and most, particularly well up the river, were even more emphatic that the nets kept the fish out. It was necessary to test both opinions. I returned to the river in the closing days of the netting season (end of August) to see the river filling with fish, which I had been told happened when the nets were removed. Instead of there being an improvement, the angling declined

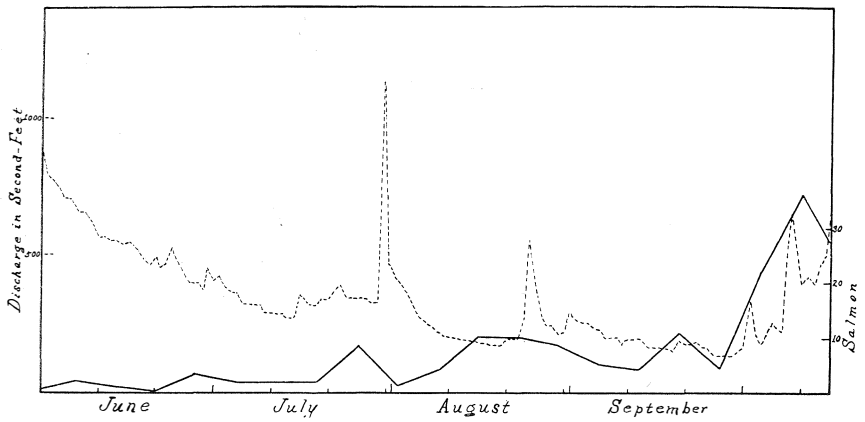

FIGURE 32. The Margaree weekly angling catch (————) in relation to river discharge (- - - - - -) of the Northeast Margaree at Frizzleton for the year 1934.

and not until October was there any particular improvement. The greatest possible change in netting, namely complete removal of the nets, had occurred with no apparent result. The guardians' reports of salmon taken by angling and the records of the Dominion Hydrometric Bureau for the daily discharge of the river at Frizzleton for that year (1934) are plotted in figure 32. On the one hand the failure of the angling to improve during September after the end of the netting season is apparent. On the other hand the freshet shown near the end of July was *not* followed by an improvement, nor was the smaller one that occurred in the latter part of August. In October, however, with a succession of freshets and rising water, the catch mounted rather rapidly. It was clear that even a marked rise in the water at Frizzleton when occurring in a general decline of level was not effective, although freshets occurring in a general rise seemed to be.

No *extreme* change in river condition occurred during the season of 1934, but there was one in 1935, which we were able to follow in some detail. In figure 19

are shown the courses of the angling and of the river discharge at Frizzleton for that year. The season was so dry that the discharge dropped quite steadily through June, July and most of August, and the angling was correspondingly poor as all accounts had led me to expect. Then a general rain, amounting to more than five inches, fell on August 23, 24, and 25, and resulted in a freshet of spring-like proportions, flooding much of the intervale land and carrying away much of the hay. There was an almost immediate transformation in the angling, as will be seen in the figure, the catch for the following week being more than twice as great as for the whole season to that date. The angling and the discharge varied somewhat and together, but both continued high until the end of the season. The netting season ended on August 15, but there was no change in the angling until the freshet came. As stated to be the rule by Mr. Gillis, who lives near the head of tide, good angling began only when the freshet was subsiding. The first fish were taken just above the head of tide and the best fishing there was on the second day. Going up the river the best angling at any one point was progressively later and more diffuse in time. About twelve miles up fishing did not reach its height until the second week, in which all days seemed about equally good.

This left no doubt as to what a "good, big freshet" could accomplish, at least after the nets were up. Would it be effective during the netting season? Records for the year 1930 have been available and are plotted in figure 20. While there was no heavy freshet, there were repeated slight freshets during the first two-thirds of August with a general rise in water, the netting season continuing till the last of that month. This change in condition was similar to that in October of 1934 (figure 32) and like the latter it gave a rather rapid rise in angling of similar proportions to that in October, 1934. With no more freshets and with the nets removed, the angling dropped abruptly in the first week of September. It has seemed proper to conclude from these facts that with or without the nets, the angling is greatly dependent upon certain conditions of the river associated with rise in water.

With this clear demonstration of the positive action of freshets in improving angling, it seemed desirable to study the details of their action which were seen as likely to be complex (1) owing to the great variability of the freshets in size, course and frequency as well as in locality of occurrence in the river system, (2) owing to the variability of the underlying general level of the water and (3) owing to the varied distribution and numbers of the salmon in the sea, in the estuary, and in the river proper. Experiments in water control were greatly to be desired, but the expense of carrying them out on such a large river as the Margaree proved to be prohibitive. Investigations of the action of freshets in the Margaree river have been continued and have revealed some of the details.

In 1936 (figure 33) there was in general a correspondence between improvement in angling and at least the larger freshets, the best fishing following the largest freshets with high-water, in September. As in 1934, some of the freshets seemed to be quite without effect.

In 1937 (figure 21) a large double freshet at Frizzleton at the end of June seemed quite without effect, while a smaller one on July 7 was fairly effective. Fortunately for getting the explanation of this anomaly, records were being made of the height of the water in the main river a short distance above the head of tide. In figure 34 the daily angling catches in five different districts along the river from below upward are seen in relation to water height of the lower end of the river and discharge at Frizzleton well up the Northeast branch, along which the angling extends. It will be seen that the heavy double freshet recorded at Frizzleton failed to show in the main river, and it can only be concluded that it was caused by very local downpours and that the water was all taken up in filling storage places, perhaps

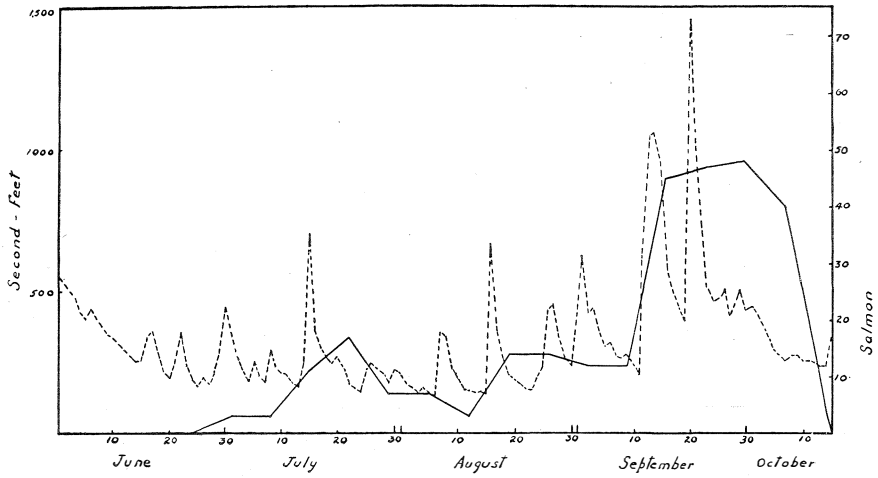

FIGURE 33. The Margaree weekly angling catch (————) in relation to river discharge (- - - - - -) of the Northeast Margaree at Frizzleton for the year 1936.

the underground water table, before reaching the main river. This freshet, large as it was, could not be expected to improve the angling except locally and there were indeed catches in the two uppermost districts, where the freshet occurred. The freshet of July 7 was quite small at Frizzleton, but quite definite in the main river, and was evidently rather widespread. It was followed by slightly improved angling in four of the five districts with some indication of the fish moving upstream during the following week or so. Slighter, general freshets on August 9, August 22 and early in September had only very limited effects. This shows very definitely the necessity of following the course of the freshet close to the place where are the salmon to be affected by it. As, through having other work, we did not attempt this in 1938, and have merely the records of the discharge at Frizzleton (figure 26), we cannot be sure to what degree the freshets that are shown for that year were represented in the main river. Only a good freshet in the main river can be expected to provide many fish in the river, and then only if the salmon are in the estuary or near the estuary mouth.

The freshet undoubtedly causes the salmon to be more active. They are not apt however, to ascend far, if at all, when the freshet is in full strength, nor until the current has lessened to a strength matching their activity or "cruising speed". This seems a proper explanation, although not the only possible one, of the salmon

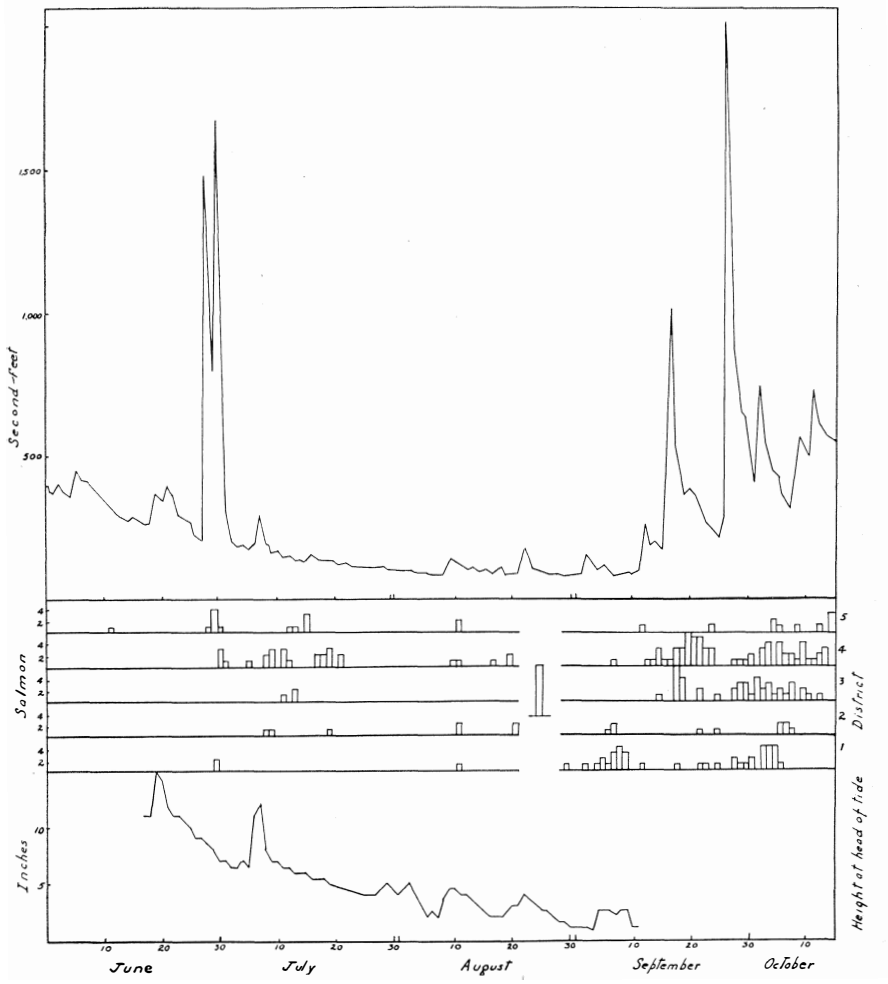

FIGURE 34. Salmon reported as caught by angling for each day during the season of 1937 in five different districts along the river, numbered from below upward, in relation to height of river just above the head of tide (below) and discharge of the Northeast Margaree at Frizzleton (above).

moving up from the estuary and being caught above the head of tide only when the freshet is subsiding. Fish already up the river may be stimulated by the increasing current to take the fly, giving an improvement in angling while the freshet is developing.

COMPARISON OF MARGAREE AND CHETICAMP RIVERS

We have not been able to make an investigation of the Cheticamp, but its nearness to the Margaree, and the fact that it is so frequently quoted by anglers as providing a contrast to the Margaree in having salmon early in the season, make it desirable to compare the two. If the need for the Margaree is to have salmon early in the season, and if the Cheticamp river has them early, why cannot the Margaree also? Figure 15 leaves no doubt that over a long period of years the Cheticamp river has its best angling in June, within a month of their appearance, and the Margaree river its best angling in September, fully three months later. Inspector Murphy assures me that the progressively poorer catches in the Cheticamp river as the season advances are really due to a scarcity of fish and not to lack of effort on the part of the anglers. The Cheticamp river and the Northeast Margaree river arise side by side and traverse similar country. Their salmon descend into and ascend from the same sea, not many miles apart. What reason can there be for such different behaviour?

It has been customary to ascribe such a difference to there being different races or hereditary strains of salmon in the various rivers. No proof of a hereditary difference between the Atlantic salmon of two rivers has yet been furnished, and a crucial experiment in transferring the young of Restigouche salmon (large fish, running early) to the Apple river (with small fish, running late) at the head of the bay of Fundy proved that the transplanted fish behaved, not like their parents, but like the local fish.

Can the difference in behaviour between the salmon of the Margaree and Cheticamp rivers be explained by the factors that have been shown to determine when the salmon are available for angling in the Margaree? If so, the features that delay the entrance of salmon into the Margaree must be absent from the Cheticamp river. The little knowledge we have of the latter makes this quite probable.

Mention has already been made under "the effect of temperature" that sea conditions near the mouth of the Cheticamp lead one to expect the water there to warm earlier than elsewhere on the coast, and it is a fact that the salmon appear in the nets of that district about a fortnight earlier than they do near the Margaree river (figure 29).

This is not enough to explain the difference in angling, since for the Cheticamp the angling is best in the very month (June) that the net catches are highest, while for the Margaree the angling is best in September two months after the net catches have been at their height. The explanation would seem to be in the character of the estuary. That of the Cheticamp is quite short and has a bar across its mouth that prevents its water lowering to low tide level. As a result comparatively little salt water enters it and it very steadily discharges river water into the gulf. In fact it approximates those rivers whose waters flow abruptly into the sea.

Because of the embayment of the coast into which the estuary empties, tidal movements are little apt to dissipate its water, when poured into the sea. Salmon that reach its influence (they may be most abundant there as early as June 8) have,

instead of the delaying to and fro current of the tides, only a steady, short stretch of seaward current to stem and then they are in the estuary, almost away from tidal influence. The width and depth of the estuary are so great in comparison with the amount of water entering from the sea that there must be very little tidal current. The shortness of the estuary brings all the salmon in it into close proximity to the increasing, outward current of a freshet. As the spring freshets usually continue into June, the salmon are apt to ascend the river soon after their entrance in the estuary early in that month.

The Cheticamp river does indeed offer a great contrast to the Margaree in the conditions that determine early entrance of salmon, and nothing more seems necessary to explain the fact that its best angling is so much earlier than that of the Margaree.

DISCUSSION

Solution of the problem of salmon angling in the Margaree river can come only through knowledge of the conditions under which the salmon returns to fresh water at the end of the period of from one to three years that it spends in the sea. It needs to be stressed that the prevailing conception of how it returns has never had an adequate basis in fact and is not in harmony with some of the available facts. It has been necessary not only to avoid accepting the prejudice of entrenched opinion, but also to attempt to strike through to the significant underlying behaviour of the salmon as determined practically. Conclusions have had to be reached concerning this behaviour even though in one direction after another there has been found a lack of the thorough scientific knowledge that is so desirable, that will probably be necessary to assure general conviction, and that will require many years of work to obtain. However, I am confident that the essential conclusions reached are solidly founded upon fact.

If we have sufficient knowledge of how the salmon return, and of what are the Margaree conditions, we can state why there are so few in that river early in the season. Then should come consideration of the possibilities of improving that state of affairs.

The varied facts that have been considered show that salmon behave in such a way in relation to varying temperature, wind, freshwater influence in the sea and current that ordinarily, irrespective of their abundance or the capture of some by the coastal nets, few enter the Margaree river until late in the season. The Margaree is thus intermediate in conditions between such an early river as the St. Mary, with its angling at its best in July and such a late river as the Baddeck, scarcely any of whose salmon ever ascend early enough for angling.

Some improvement in angling can be effected by reducing the netting, by increasing the stock of salmon, and by better protection of the river, but all such action will not assure good angling early in the season. That can come only by providing the conditions necessary for early entrance of the salmon.

To make the sea become warm earlier in the season is plainly out of the ques-

tion. To control the winds that concentrate the salmon on the coast is equally so. There are, however, possibilities of controlling the freshwater influence in the sea and the current in and from the river. If the Margaree estuary were made more like the Cheticamp estuary, a larger proportion of the salmon would enter early. It would be necessary to reduce the tidal action by a bar towards the outer end of the estuary. This might interfere with the effectiveness of the harbour, the entrance to which is kept reasonably deep by the scouring action of the tidal currents. Lake Ainslie provides storage for a large amount of water, which could be used in artificial freshets to increase the river influence in the sea at the proper time and to produce the changes in river current that will cause the salmon to ascend. Experimental work is necessary to determine the effectiveness of various kinds of freshets and the most economical method of controlling the water discharge.

ACKNOWLEDGMENTS

It is a pleasure to express my appreciation of the varied assistance received during these investigations from many persons in diverse positions in relation to the problem. If I free them from responsibility for the conclusions herein expressed, I greatly appreciate their help, without which this account would not have been possible.

Scientific investigators in this and other countries have freely discussed with me the underlying problems. I owe much to Mr. W. J. M. Menzies, Inspector of Salmon Fisheries of Scotland, and to Dr. D. L. Belding of Boston University, both of whom have studied the Atlantic salmon for many years and have visited the Margaree river during my work there.

My several collaborators in the investigations have done a very great deal of work, and have provided much of the factual basis for the conclusions. They have been rather steadily available for discussion of the problem and have made distinct contributions to the development of certain aspects of it. In especial should be mentioned Messrs. H. C. White, P. F. Elson, W. S. Hoar, and H. M. Rogers, who have been with me, at least in the summer season, through most of the period of nearly five years since the problem was undertaken.

The Department of Fisheries has made available all its data pertinent to the problem and its officers have always been ready to help in any way. The local officer, Inspector A. J. Murphy, deserves especial mention for his unfailing willingness to do all in his power to forward the work, and to assist wherever possible. The Meteorological Service and the Dominion Hydrometric Bureau have freely furnished their records, and the former has loaned us instruments for our local use.

The agencies that handle the salmon taken on the coast have very kindly furnished data concerning the daily deliveries of salmon from the various nets. These are: Margaree Salmon Union, W. S. Laurence, Grand Etang Salmon Union, F. W. Leslie, Limited, and Robin, Jones and Whitman, Limited.

There has been much and varied assistance from many persons living along the river or on the coast, or spending their summers there. Only a few can be mentioned

to represent all. On the river, Mr. D. J. Murray of Big Intervale, Messrs. W. S. Bogart and Merrill Ingraham of Frizzleton, Messrs. Duncan McKenzie, Lawrence Bennett and David Tompkins of North East Margaree, Messrs. Allan McDonald, Leo Carroll and Joseph Doyle of Margaree Forks, and Messrs. Duncan McDonald, P. A. Gillis and Peter McDaniel of Margaree Ford. On the coast, principally Mr. W. S. Laurence, and also Messrs. John McKinnon, Angus McKinnon and Haverstock McLean of Margaree Harbour; Mr. Thos. Aucoin of Belle Cote, and Messrs. William Arsenault and Philip Deveaux of Terre Noire.

The Cape Breton Fish and Game Protective Association urged that the investigation be undertaken and the Sydney Fish and Game Protective Association has been particularly active in the matter.

I am much indebted to Prof. J. R. Dymond of the University of Toronto for critical reading of the manuscript.

SUMMARY

Anglers complain that there have been in recent years in the Margaree river fewer salmon during the first part of the angling season (June to August) than there were twenty to forty years ago. This condition has been blamed on the nets set along the coast near the river mouth. That larger numbers of salmon enter the river late in the season is regarded by the anglers as proof that the nets, which are not operated after August, prevent the salmon entering earlier.

The history of angling in the Margaree indicates that for at least seventy years there has tended to be a scarcity during the summer, with large numbers in the early fall. In no very recent season, however, does there seem to have been so many salmon in the river in the summer as there evidently were in particular years in the past,—1872, 1873, 1888 and 1889.

The general history of salmon in the Maritime provinces indicates that there has been considerable fluctuation in their abundance. The records show that for the Margaree region, as for the Maritimes as a whole, the catches were highest in the seventies, remained low for thirty years or more, rose from 1910 to 1930, and have since declined.

The Margaree river has, throughout the summer, what may well be termed ideal conditions for salmon angling,—in temperature and flow of water, in fine and accessible pools, and in facilities in general.

The investigations show that salmon have recently been decidedly scarce in June and July at the time when they are in the most desirable condition for food, although usually they have been numerous in September. Salmon scarcity early in the season has the appearance of being more pronounced but this is probably an illusion, since in recent years the river has become more accessible and the few salmon have had to be divided among a larger number of anglers.

Comparison of rivers shows no relation between the operation of coastal or even estuarial nets and the season when salmon are most abundant in the river.

Heavy windstorms that stop netting make no apparent increase of salmon in

the river. Heavy rainstorms, which do not affect the operation of the nets, make an evident increase of salmon in the river.

Neither the removal of the nets from the Margaree estuary in 1909, nor the shortening of the season for coastal netting in 1935 appear to have had any clear effect either in increasing the numbers of the salmon in the river or in having them enter earlier.

Enquiry has failed to reveal any river where curtailment of netting has been clearly demonstrated to have had a direct effect in improving angling. This shows that whatever effect there may be is so small as to be obscured by other factors.

The tagging and liberating of salmon from nets on the Margaree coast in 1935, 1936, and 1937 have made it possible to measure rather accurately the effect of the netting on angling. Elimination of the ten nets nearest the estuary mouth would increase the angling catch by from 30 to 90 salmon per year, a percentage increase of perhaps 3.5 to 5, but would not make the proportionate distribution throughout the season different from what it has been. The smallness of this effect fully explains why net removal in the past has not been clearly demonstrated to improve angling directly.

Poaching does not affect the season of best angling in the river. When in the lower part of the river it is most likely to affect the angling. In dry summers when salmon remain in the estuary or lower pools for a considerable time before ascending, illegal use of nets in the lower part of the river seems responsible for giving a large proportion of salmon below a length of about 29 inches.

Abundance of the stock of salmon as judged by the numbers taken each year by the nets has no demonstrable relation to abundance of salmon in the river either early or for the whole season. It cannot, therefore, be deemed to have been a major factor for any observed scarcity of salmon in the river. Investigations with the object of increasing the stock are under way.

Low winter temperature of the sea along the Margaree coast, in part the result of drifting ice, is responsible for salmon not appearing in the nets near the Margaree estuary until sometime in June, and for them not becoming fully abundant until sometime in July. This factor has a very definite effect on the time of entrance of salmon into the river, but control seems out of the question.

Onshore winds with northwest as a central direction concentrate the salmon against the Margaree coast. Northerly winds concentrate the salmon at the mouth of the estuary, facilitating their entrance. This factor has a definite effect upon the time when the salmon enter the river in abundance, but control seems again to be out of the question.

Salmon tend to concentrate in masses of sea water containing a high proportion of river water. This causes the salmon to occur in larger numbers near the estuary mouth on the northeast side than elsewhere along the coast, as shown by numbers of nets operated, by the catch per net, and by the recaptures of tagged fish. Such concentration when near the estuary mouth facilitates entrance of the salmon. Usually these masses of "river" water in the sea are during flooding tide separated from the

river water in the Margaree estuary, where also the salmon concentrate, by the upwelling of salter water just outside the mouth, and this keeps the salmon from entering the estuary. This condition is seen as very definitely preventing early entrance of large numbers of salmon. Its correction would involve either making the mouth very much wider and deeper, or closing it to exclude tidal action so that fresh water would be flowing from it quite constantly. Neither of these measures seems feasible, although they are possible.

In currents that are more or less turbulent from recent contact with solid objects, and at points where the strength of the current matches their activity or cruising speed salmon tend to collect with head upstream. They lose ground in stronger currents and make headway against weaker ones. In tidal currents, which go to and fro, salmon also will go to and fro against the current. This must delay the salmon in passing through the five-mile long tidal part or estuary of the river. Shortening the estuary by stopping tidal inflow at any point should improve this condition.

Salmon are made active or incited to greater activity by greater flow or turbulence of the water, which may thus cause them to leap falls. Freshets increase flow and turbulence, thus inciting salmon to ascend, which they do when the freshet has subsided sufficiently for the strength of the current to be less than their cruising speed. This factor, which is usually combined with increased river influence in the sea, is clearly the most important one for bringing more fish to the angler (as well as for making them rise to a fly), provided the salmon are sufficiently far along in their course towards the head of the estuary to be affected by whatever freshet there may be. Lack of freshets may be corrected by storage of the water with such control of its discharge as will make possible whatever type of freshet may be required.

We may, therefore, sum up and conclude as follows:

As neither netting, poaching, nor abundance of the stock determine the time of entrance of salmon into the river, *there is no prospect whatever that either reduction in netting, better protection of the river, or increase in abundance of the stock will give earlier salmon fishing in the Margaree river.*

It seems obvious, nevertheless, that increasing the abundance of the salmon through fish cultural measures will result in *pro rata* improvement of both angling and netting.

Netting affects angling by decreasing the abundance either of the stock as a whole or of a portion of the stock that happens to be exposed to conditions causing its entrance into the river.

Poaching affects angling by decreasing the abundance of that portion of the stock that happens to have entered the river.

Temperature of the sea and direction and force of the wind definitely affect the time of entrance of the salmon, but are not susceptible to control.

The character of the estuary, particularly at the mouth, and the occurrence of freshets are both important factors in determining early entrance of salmon, and both are susceptible to control. It remains to be determined whether control of one or both of these will give results commensurate with the cost.

APPENDIX

SALMON TAGGING NEAR MARGAREE RIVER, 1935, 1936 AND 1937

The object of the tagging experiments was to find out to what extent the salmon taken in nets on the coast near the mouth of the estuary would otherwise ascend the Margaree river. These nets are provided with heads, which are actually traps. Since netting of seven-inch mesh (stretched) is used throughout, the salmon that are trapped in the head of the net are usually also gilled. Heads made of netting of four-inch mesh have been used by some of the fishermen to catch salmon for sale alive to the Department of Fisheries for hatchery purposes. These have been used to obtain all the salmon for tagging. They have the advantage not only of taking the fish uninjured, but also of taking all sizes indiscriminately. The ordinary nets, which depend for capture largely upon gilling the fish, are definitely selective.

In 1935 and 1936 the Department of Fisheries, which had for many years been tagging salmon in connection with its fish cultural work, not only furnished the tags (silver strap with two pins, attached to the dorsal fin), but also obtained the salmon and had Mr. Jos. P. Chiasson, Superintendent of the Margaree Salmon Pond, carry out the tagging. He was assisted by Messrs. P. F. Elson and W. S. Hoar of the investigational staff.

In 1937 the Board assumed the whole responsibility and developed a somewhat different type of tag, based upon that used by the Department of Fisheries, but utilizing the experience of Mr. R. A. Nesbit of the staff of the United States Bureau of Fisheries in developing fish tags made of celluloid. The tag consists of two straps of red celluloid, placed one on either side of the dorsal fin of the salmon and held together and to the fin by two pins of pure nickel wire. One strap bears the number and *"Biological Board of Canada"* on one side, but nothing on the other. The other strap has on one side the number and *"Reward, Mail to Biological Board of Canada, St. Andrews, N.B."*, and on the other side *"State when and where caught, also length and weight, and send sample of scales from side"*. Experience does not seem to show that the type of tag is of great importance. Doubtless the most important matter is to have the tag securely fastened to the fish. As this factor cannot well be measured, and probably varies considerably even with the one operator, it is apt to obscure any differences there may be between different types of tags. The new tag is considered to have the advantages of low cost (when purchased in large quantity), conspicuousness, and suitability for carrying any desirable instructions for reporting capture, etc. Also one of the straps can be retained by the finder as a souvenir without preventing accurate record. It is conceivable that this tag might be found more difficult to handle than the simpler type, but our staff has not found it so.

The tagging in 1937 was carried out by the same staff as in the previous years,

and in the following way. The fishermen transferred the salmon from the traps to pontoons, which were anchored about fifty yards out from the heads of the respective nets. The tagging was done from a small motorboat, the nets being visited twice daily, unless it was known that there were no fish.

The salmon were removed from the pontoon, placed on a straw mattress to prevent injury while struggling, and then placed in a wooden straight-jacket. Two holes were made in the dorsal fin, close to the body, with a double-pointed awl. The pins of the tag were then passed through these holes, twisted securely with pliers and the excess length cut off. With the celluloid tag there was also the placing of the second strap on the far side of the fin. In nearly every case the fish were returned to the water within two minutes of removal from the pontoon. Only very rarely did a fish struggle so vigorously as to be exhausted. Usually they swam away at once.

Those reporting recaptures of the tagged salmon were given a reward of $1.00 when sending a sample of the scales of the fish as well as information, otherwise only 50c.

The data of liberation and of recapture are given in tables VII, VIII, and IX.

TABLE VII. Records of salmon tagged and recaptured in 1935. Nets are numbered as northeast (N) or southwest (S) of the estuary mouth. Numbers of tags were all in the F series of silver tags, namely F5388-F5487. M. refers to Margaree river

Liberated		
Tag Nos.	Date	Net
5388.....	June 25	S1
5389, 5399, 5400	June 27	S1
5390, 5392.....	" "	N1
5391, 5393-5398	" "	S3
5401, 5404, 5406	June 28	N5
5403, 5405, 5408	" "	N3
5407, 5409	" "	N1
5410, 5411	June 29	S1
5412	" "	N1
5414, 5415	" "	N5
5416-5422	" "	S3
5423-5428	July 1	N5
5429, 5430	" "	N3
5431, 5433	" "	N1
5432	" "	S1
5434-5437	July 3	N5
5438-5440	" "	N3
5441-5442	" "	N1
5443-5449	" "	S3
5450, 5402	July 5	N1
5451-5457	" "	N5
5458-5462	" "	S1
5463-5465	" "	S3
5466	July 8	N5
5467	" "	N3
5468	" "	N1
5469-5471	" "	S1
5472-5477	" "	S3
5478	July 9	N1
5479	" "	S1
5480	" "	S3
5481	July 10	N1
5482, 5483	" "	N3
5484-5486	" "	N5
5487	July 11	N5

Recaptured			
Tag No.	Date	Place	Name
5393	Sept. 8	Ross pool, M.	P. Hannigan
5396	Sept. 7	Falls pool, M.	W. S. Bogart
5406	Sept. 8	Rock pool, M.	E. Cranton
5409	July 5	Net S1 or 5	J. L. McKinnon
5411	Aug. 2	Net N12 or 14	Martin Doucet
5416	July 1	Net S3 or 4	A. J. McKinnon
5419	July 5	Net S1 or 5	J. L. McKinnon
5421	July 31	St. Lawrence bay	Thos. Capstick
5429	Oct. 2	McKenzie pool, M.	R. Y. McKenzie
5432	Aug. 12	Net N24, 25 or 26	P. J. Deveaux
5435	July 15	Net N20	Pepin Romard
5436	Sept.22	McKenzie pool, M.	Lawrence Bennett
5440	Aug. 8	Net N24, 25 or 26	P. J. Deveaux
5441	Aug. 12	Net N4 or 5	Thos. Aucoin
5442	Aug. 5	Net N24, 25 or 26	P. J. Deveaux
5443	Fall	Estuarial trap	
5447	"	" "	
5454	"	" "	
5455	July 26	Net N31	J. P. Lefort
5462	Aug. 9	Net S7 or 8	H. McLean
5466	Aug. 8	Net S7 or 8	H. McLean
5474	Sept.19	Upper McDaniel pool, M.	J. A. Bennett
5476	July 18	Net N8 or 9	P. Deveaux
5477	July 18	Net N8 or 9	P. Deveaux
5479	Sept.18	McDaniel pool, M.	Mr. Miller
5482	Aug. 13	Net S1 or 5	J. L. McKinnon
5486	Oct. 7	Hut pool, M.	L. D. Carroll
5487	Aug. 7	Net N8 or 9	P. Deveaux

TABLE VIII. Records of salmon tagged and recaptured in 1936. Nets are numbered as n orth-east (N) or southwest (S) of the estuary mouth. Numbers on tags were all in the F series of silver tags, namely F6309 to F6999. M. refers to Margaree river

Liberated		
Tag Nos.	Date	Net
6309	June 23	N2
6310, 6311	" "	N5
6312-6318	June 24	N5
6319	" "	N2
6321, 6322	" "	S1
6323-6329	" "	S3
6330-6338	" "	N5
6339-6341	June 25	N5
6342	" "	S1
6343-6353	" "	S3
6354-6358	June 26	N5
6359, 6360	" "	N2
6361	June 27	S1
6362, 6422-6428	" "	S3
6417-6420	" "	N5
6421	" "	N2
6429-6432	June 29	S3
6433-6435, 6438	July 2	N5
6436	" "	S1
6437, 6439-6443	" "	S3
6444	July 3	S1
6445-6447	" "	S3
6448	July 4	S1
6449, 6453	July 6	S1
6450-6452, 6454-6457	" "	S3
6458, 6460	July 7	S1
6459	" "	S3
6461-6468	July 8	N5
6469	July 9	S1
6470	" "	N5
6471, 6472	July 10	N5
6473-6491	" "	S1
6492-6497	" "	S3
6498-6508	July 11	S1
6509, 6510	" "	S3
6511, 6512, 6988-6995	" "	N5
6996, 6998	July 13	N5
6997	" "	S1
6999	July 15	N5

Recaptured			
Tag No.	Date	Place	Name
6310	Sept.20	McDaniel pool, M.	E. J. Kempf
6316	July 16	Net N12 or 14	Martin Doucet
6318	June 27	Richibucto, N.B.	A. Landry
6322	Aug. 3	Net N8 or 9	P. Deveaux
6324	July 22	Net N33 or 35	M. Chiasson
6326	Aug. 15	Big id., Pictou	John McLean
6334	July 13	La Pointe	W. A. Bourgeois
6335	July 29	Net N10 or 11	D. Leblanc
6337	July 11	Net S1 or 5	J. L. McKinnon
6343	June 29	Net S3 or 4	A. J. McKinnon
6359	Sept.23	Estuarial trap	
6360	July 27	Net N1	S. Leblanc
6419	July 22	Net S14 or 15	J. W. McKay
6425	July 29	Net N24, 25 or 26	P. J. Deveaux
6427	July 13	Judique South	D. R. Graham
6433	July 13	Net N12 or 14	Martin Doucet
6437	July 17	Guysborough	J. Callahan
6442	Aug.14(?)	Net N6 or 7	P. Deveaux
6451	Sept.19	Estuarial trap	
6452	Sept.19	Estuarial trap	
6455	July30(?)	Net N28	P. E. Lefort
6456	July 17	Guysborough	H. Scranton
6458	Sept. 4	Tingley pool, M.	P. Hannigan
6460	July 30	Sandy cove, Pictou Co.	H. Cameron
6464	July 18	Net N32 or 34	C. L. Aucoin
6468	July29(?)	Net N8 or 9	P. Deveaux
6473	Sept.27	Estuarial trap	
6477	Aug. 14	Livingstone cove, Antigonish Co.	R. J. Brown
6479	July 26	Monk's Head, Antigonish Co.	John Delory
6482	Sept.28	Estuarial trap	
6483	Aug. 11	Livingstone cove, Antigonish Co.	R. J. Brown
6485	July 20	Net N31	J. P. Lefort
6486	Aug. 20	Cranton pool, M.	D. McKenzie
6488	July 27	Net N17	Jos. Doucet
6490	July 27	Mabou	Roy Smith
6491	July 14	Net N6 or 7	J. Arsenault
6492	July 13	Net N1	S. Leblanc
6495	July 31	Mabou	F. S. Beaton
6497	July30(?)	Net N28	P. E. Lefort

(*Continued* 73)

TABLE VIII.—*Continued*

Recaptured			
Tag No.	Date	Place	Name
6498	July 13	Net N10 or 11	D. Leblanc
6503	Sept.13	Gillis pool, M.	J. Gillis
6508	Sept.20	Estuarial trap	
6511	July 26	Cranton pool, M.	D. McKenzie
6989	Aug.25	McKay pool, M.	R. Y. McKenzie
6990	Aug. 3	Net N24, 25 or 26	P. J. Deveaux
6994	July 16	Net N10 or 11	D. Leblanc
6996	July 29	Net N31	J. P. Lefort
6998	July 17	Net N28	P. E. Lefort

TABLE IX. Records of salmon tagged and recaptured in 1937. Nets are numbered as north esat (N) or southwest (S) of the estuary mouth. Tags were of the Biological Board double strap type of red celluloid. M. refers to the Margaree river.

Liberated			Recaptured			
Tag Nos.	Date	Net	Tag No.	Date	Place	Name
0251-0254	June 18	N5	0252	July 17	Net N6 or 7	J. Arsenault
0255-0257	June 19	N5	0256	July 1	St. Lawrence bay	Thos. Capstick
0258, 0259	" "	S1	0258	July 26	Net N30	Edward Lefort
0260-0262	June 21	N5	0261	July13(?)	Net N30	Edward Lefort
0263-0267	" "	N2	0266	Sept. 5	Forks Pool, M.	Jos. Doyle
0268	June 22	N5	0269	Aug. 2	Net S18	A. C. McKinnon
0269-0274, 0299	June 24	N5	0270	June 28	Net N35	M. Chiasson
0275, 0276	" "	N2	0276	July 14	Net N3, 4 or 5	Aucoin Bros.
0277-0287	June 25	S3	0283	July 3	Aspy bay	Wm. Dunphy
0288-0292	" "	N5	0286	July 5	Net S29	J. A. McFarlane
0293-0296	June 26	N5	0287	July 8	Mabou	F. S. Beaton
0297	" "	N2	0289	July 18	Cheticamp river	C. DeVouge
0298, 0300-0308	" "	S1	0298	July 5 (?)	Net N24, 25 or 26	P. J. Deveaux
0309, 0310	" "	S3	0300	July 2	Net S7 or 8	H. McLean
0311-0313	June 28	N5	0301	Aug. 7 (?)	Net N13 or 15	J. J. Cormier
0314, 0315	" "	S1	0304	July 3	Net N31	J. P. Lefort
0316-0318	July 1	N5	0306	July 21	Pleasant bay	A. W. Moore
0319	" "	S1	0307	July 9	Net N1	S. Leblanc
0320-0325	" "	S3	0308	July 6 (?)	Net N21 or 22	F. L. Cormier
0326-0329	July 2	N5	0309	July 7	Net N31	J. P. Lefort
0330-0334	July 3	N5	0312	July 5	Net N8 or 9	P. Deveaux
0335, 0337, 0338	July 5	N5	0321	Aug. 12	St. Lawrence bay	Thos. Capstick
0339	July 5	S1	0322	July 14	Net N3, 4 or 5	Aucoin Bros.
0340-0342	" "	S3	0332	July19(?)	Net N39 or 40	A. Bourgeois
0336, 0395-0399	July 6	N5	0334	Oct. 6	Estuarial trap	
0343-0369	" "	N2	0339	Oct. 5	McKinnon pool, M.	H. Poirier
0370-0393	" "	N11	0349	July 20	Net N31	J. P. Lefort
0394	" "	N6	0350	July 19	Canso	E. Lumsden
0400	" "	S1	0352	Sept.18	Upper McDaniel pool	M. R. Jackson
0401-0404	July 7	N5				
0405-0410	" "	N2	0358	July 9 (?)	Net N8 or 9	P. Deveaux
0411-0414	July 8	N11	0359	July19(?)	Net N18	Arsene Aucoin
0415-0418	" "	N6	0361	July 20	Hatchery pool, M.	Jos. Doyle
0419-0421	" "	N5	0363	Aug. 9	Forks pool, M.	G. Carroll
0422-0426	" "	N2	0368	July 14	Hatchery pool, M.	G. W. Barter
0427-0430	July 9	N11	0369	July 21	Net S19 or 21	J. A. McKinnon
0431, 0432	" "	N9	0375	July 21	Net N20	P. Romard
0433	" "	N6	0385	Aug. 5	Mabou	Duncan Rankin
0434-0436	" "	N5	0386	July 21	Mabou	D. F. Rankin
0437-0443	" "	N2	0389	July 8	Net N3, 4 or 5	Aucoin Bros.
0444-0446	" "	S1	0392	Sept.14	Cranton pool, M.	P. Hannigan
0447-0450	" "	S3	0394	July14(?)	Net N24	J. P. Deveaux
0451-0453	July 10	N9	0395	July 16	Queensport	Wm. Ehler

(*Continued 75*)

TABLE IX.—*Continued*

Liberated		
Tag Nos.	Date	Net
0454, 0455	" "	N5
0456-0458	July 12	N11
0459-0462	" "	N9
0463, 0464	" "	N6
0465, 0466	July 12	N5
0467-0470	" "	N2
0471	" "	S1
0472-0474	July 13	N6
0475-0479	" "	N5
0480-0483	" "	N2
0484	July 15	S1
0485-0493	" "	S3
0494-0499, 0101	" "	N2
0102,0103	" "	N9
0104	July 17	N2
0105	" "	N9
0106, 0107	" "	S3
0108	July 20	S1
0109-0111	" "	S3
0112-0114	July 21	N5
0115-0118	July 22	S1

Recaptured			
Tag No.	Date	Place	Name
0397	Sept.15	Ross pool, M.	J. Atherton
0398	July 21	Monk Head, Antigonish	G. Beaton
0400	July 12	Net N31	J. P. Lefort
0405	July 13	Net N28	P. H. Boudreau
0410	Sept.19	Near Hatchery, M.	G. H. Chislett
0415	Aug. 6	Mabou	D. F. Rankin
0424	Aug.28	Forks pool, M.	L. D. Carroll
0427	July 17	Pleasant bay	Walter Moore
0431	July 14	Pleasant bay	Geo. MacIntosh
0432	Oct. 6	Estuarial trap	
0433	Aug.7 (?)	Net N13 or 15	J. J. Cormier
0441	Aug. 9	Guysborough	V. J. Martin
0442	Aug. 2	Net N32	C. L. Aucoin
0448	July 19	Mabou	F. S. Beaton
0453	July 24	Net N31	J. P. Lefort
0454	Sept.23	Big Intervale, M.	J. M. Perkins
0455	Sept.24	Seal pool, M.	H. W. Bridges
0459	Aug. 4	Livingstone cove, Antigonish Co.	C. Murdoch
0466	Oct. 16	Estuarial trap	
0467	July 15	Net N2	
0467	Sept.—	Margaree river	J. L. Cosseboom
0468	Sept.22	Estuarial trap	
0470	July 13	Net N5	Aucoin Bros.
0473	Oct. 6	Estuarial trap	
0475	July 14	Net N5	
0491	Fall	Estuarial trap	
0496	Oct. 7	Estuarial trap	
0497	July 17	Net S6 or 9	Allen McLean
0498	Oct. 2	McKenzie pool, M.	R. Y. McKenzie
0109	Aug. 7	Net N28	P. H. Boudreau
0110	Sept.22	Estuarial trap	
0112	Aug.10	Antigonish	Duncan Dunn