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ATLANTIC SALMON AND TROUT INVESTIGATIONS 1939

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ATLANTIC SALMON AND TROUT INVESTIGATIONS

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ATLANTIC SALMON AND TROUT INVESTIGATIONS

1939

Report No. X. Oecology of Goldmine brook.

By J. A. Colin Nicol

Introduction.

During the summer of 1939 a careful survey of Goldmine brook was made in order to form a background for salmon planting experiments. Temperatures, water levels and biotic conditions were followed as closely as field conditions permitted and are described under the various sections below.

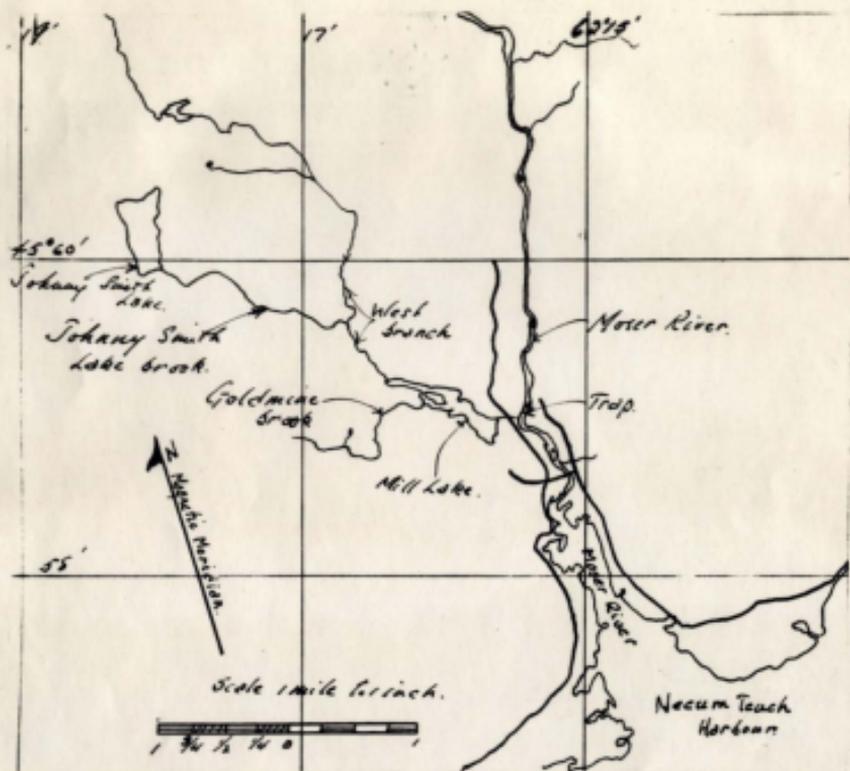
Topography.

Goldmine brook is a small woodland stream emptying into the west side of Mill lake three-quarters of the distance from its southern end (vide map 1). One and one-half miles in length, it runs entirely through an area of ferruginous and graphitic slates (Nova Scotian sheet number 38, Geological Surv. Canada, 1886) which are exposed in the cascades - the region of maximum descent - and, forming shelves and ledges, cause the water in this region to pour down in little falls and riffles.

Following the course of the brook from mouth to headwaters the following regions may be distinguished (vide map 2).

1. Silty section at mouth.
2. Gravel section in open peat bog between alders and lake.
3. Lower stony. Bottom of stones and gravel.
4. Cascades or rocky section. Solid rock and boulders. Upper stony.
5. First still water which broadens out into a pool forty feet in width.

Msp. 1.



Msp. 1. Moser River and vicinity, shewing the location of Goldmine brook.

Above this point there occurs a second stony stretch leading into a second long still-water which receives on its north side a tributary draining a small bog pond. This second still leads into a stony rill which soon breaks up, palmately, into a number of feeders draining a sphagnum-alder swamp.

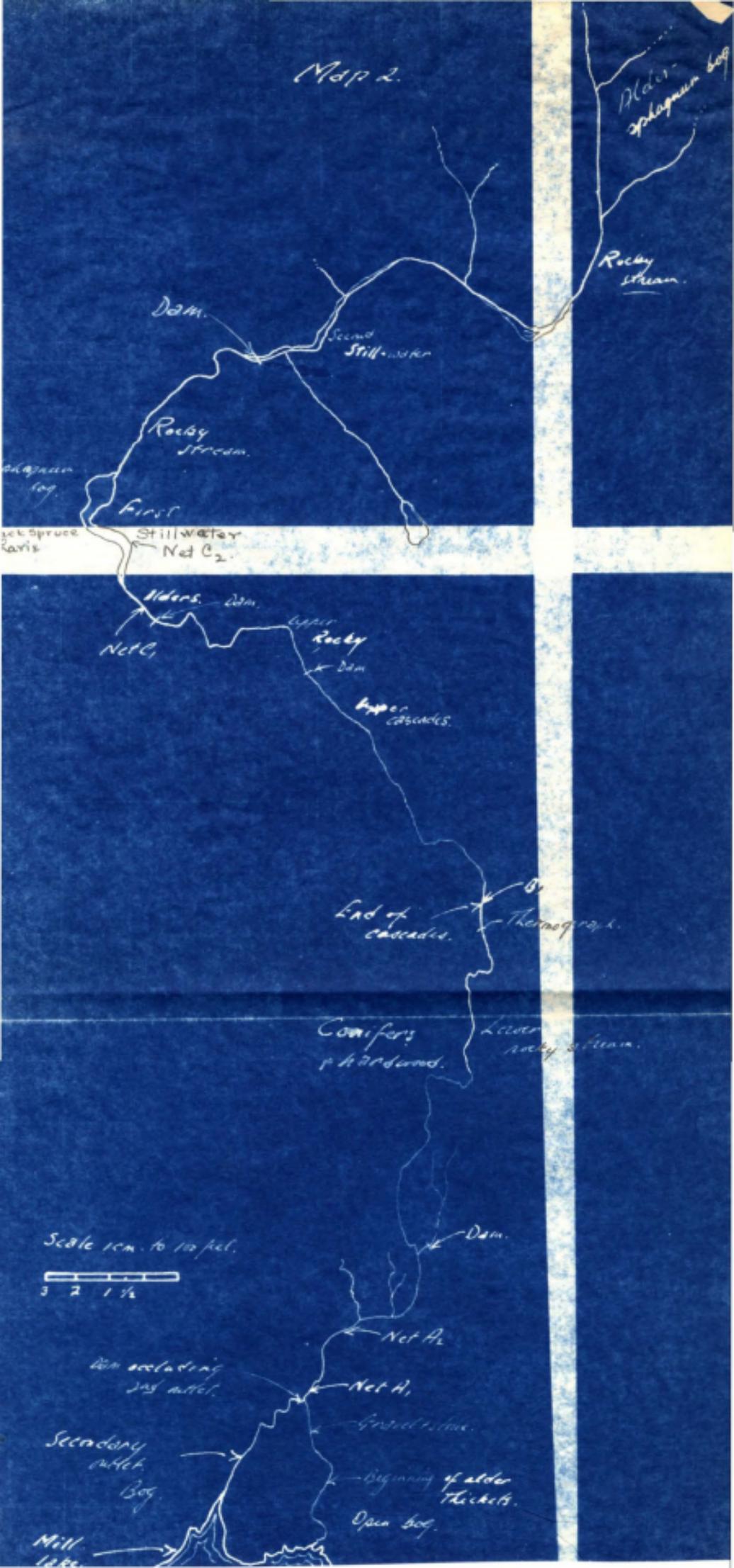
The above regions may be subdivided into niches according to their biotic content.

Flora.

The brook alternates in its course through areas of woodland and bog and is bordered by plants characteristic of the Canadian zone. The bog bordering the lower reaches is formed mostly of grasses, Scirpus and Eriophorum. This is followed by alders (Alnus incana) but, where the descent is more rapid, white and yellow birch (Betula papyrifera and B. lutes), balsam fir (Abies balsamea), red and mountain maple (Acer rubrum and A. spicatum) clothe the banks. Some of the herbaceous plants present include Chiogenes hispidula, Linnaea borealis, Clintonia borealis, Aralia nudicaulis, Oxalis Acetosella, Coptis trifolia, Aspidium spinulosum, Onoclea sensibilis, Osmunda Claytoniana, O. cinnamomea, Phegopteris polypodioides and Polypodium vulgare. The still-waters run through areas of sphagnum bog and Larix and the banks are overgrown with alders, Myrica gale, Andromeda glaucophylla, Kalmia polifolia, Ledum groenlandicum and Chamaedaphne calyculata.

The vegetation cover is important in regulating the amount of sunlight which reaches the stream. Stretches of the stream bed which are brightly illuminated support rich algal growth, other factors being favorable. The still-waters, fully exposed to the light and

Map 2.



and becoming heated, form a reserve of warm water which is slowly cooled as it passes through the shaded portions of the stream.

The floral composition of the stream itself is limited in numbers and species. Examination of the water at the mouth by Mr. H. Leverin of the Department of Mines and Resources revealed a pH of 6.0 and this low figure is perhaps significant in view of the absence of such calciphiles as Chara and Lobelia Kalmii.

Collections of algae were made during August from various parts of the brook. Different species were abundant in illuminated and exposed places; and during the latter part of the summer the upper rocky stretch became choked with Chlorophyceae, Rhodophyceae, and Bacillariaceophyceae.

Long jelly-like strings and masses of Tetraspora occur in the slower current of the rocky and stony stretches and fill the quiet side pools till they have a gelatinous consistency. This plant prefers bright sunlight and extends its range as the water level falls and the water becomes less turbulent.

Zygnema. Long cords of this alga were found in the sunlit area of the upper and lower stony sections where it is attached to rocks in flowing water.

Another species of green alga, Bulbochaete, was found in abundance associated with Retrochospernum in the rocky stream. It was fruiting in early August.

Other Chlorophyceae were rarely observed. A few specimens of Mougeotia were seen in the collections and some desmids (Closterium and Staurostrum).

Cyanophyceae were not common.

A single species of Rhodophyceae, Batrachospermum, was collected. This plant grows abundantly in tufts on the rocks of the upper rocky section. It varies markedly in colour, ranging from Olive-green to deep blue-green depending on the amount of illumination.

Long ribbons and cords of a colonial diatom (Denticula?) flourish in the cascades and in the stony portion of the stream. It seemingly has low light toleration and will grow thickly in shaded situations free from other algal growth.

In both shaded and sunny portions of the stream the stones were found to be covered with a greenish algal growth. Scrapings and examination revealed desmids (Staurostrum, Closterium), filamentous Chlorophyceae, and filamentous and non-colonial diatoms. Such growth is important as furnishing food for many insect larvae; and the main limiting factor in its abundance, aside from animal browsing, is the amount of sunlight, small in amount throughout the shaded lower stony and cascades sections of the stream where the majority of the salmon fry were planted.

Several species of aquatic mosses form thick mats in the cascades and rills where the water pours over the stones. They constitute a distinct niche and harbour many large tipulid and trichopteran larvae.

~~Phanerogams~~ are restricted to the stills and slow-flowing portions of the brook. At the mouth where the brook debouches into the lake and the bottom is silty, Nymphaea advena is the dominant plant. ^{Sparganium,}
In the rocky stretch occur Ericocaulon articulatum, and the two

bladderworts, Utricularia vulgaris and U. intermedia. The still is bordered by Pontederis cordata and Nymphaea advena, the latter extending out into deeper water, and contains several species of Potamogeton and Utricularia.

Fauna.

Four species of fish were observed in the brook: Salmo salar, Salvelinus fontinalis, Anguilla rostrata and Fundulus diaphanus. Only one specimen of the last named was found and that occurred in the mouth where it and some of the lake cyprinids probably ascend infrequently.

Eels are comparatively few in number and were infrequently observed. Four specimens were collected and an examination of the brook at night (July 28) showed ten present. These were all under twelve inches in length and were observed only in the lower part of the stream. There is probably some movement to and from the lake during the course of the summer since a trap set at the mouth and effectively blocking the entrance to the stream secured several individuals.

Brook trout were systematically removed by H. C. White and myself to prevent predation on the salmon fry. Seining and angling were employed. The total numbers of trout caught or observed in the various portions of the stream are as follows: Gravel section and cascades 132; still-water 21.

Salmon fry are concentrated in the gravel stretch between the alders and the mouth. Twenty-five were estimated to be present at the end of July. Parr are well-distributed along the course of the stream as far as the first still-water and were counted by H. C. White and myself on the night of September seventh.

Three salmon were reported by Mr. White as spawning in the lower gravel stretch last fall and the redds were examined this spring.

Amphibia. The mink frog (Rana septentrionalis) occurs abundantly in the lake at the mouth of the brook and in the lower portion. Rana sylvatica and R. palustris were found in the woods along the stream's edge, the former being comparatively rare, the latter common; while the green frog (Rana clamitans) is well distributed along the whole course of the brook and is particularly abundant in the still-waters where it breeds. Bufo americana was occasionally observed swimming in the brook.

The birds observed were typically those of the Canadian zone. Predatory species detrimental to fish are very few; bitterns occur at the mouth of the brook while the great blue heron was observed both at the mouth and a quarter of a mile upstream. The last two species probably consume some salmon and trout fry and larger trout near the mouth.

Smaller birds mentioned because of their indirect effect on the fauna of the stream are:

| | |
|-------------------------------|----------------------------|
| Red-eyed and solitary vireos. | Yellow-bellied flycatcher. |
| Black-poll'd warbler. | Olive-sided flycatcher. |
| Black and white warbler. | Wood peewee |
| Magnolia warbler. | Winter wren |
| Myrtle warbler. | Ruby-crowned kinglet. |
| Black-throated green warbler. | |
| Northern yellowthroat. | |
| Redstart. | |
| Alder flycatcher | |

Insect fauna. Special attention was devoted to the insects of the brook during the summer. Different sectors of the stream bed were periodically examined; imagoes of various groups were collected with a hand-net; and a series of cheese-cloth bags were suspended over the stream in different localities for catching emerging adults. These nets were five in number, two feet in diameter, and were arranged along the stream as follows (vide map 2):

Net A₁. Gravel - shallow, shaded pool with a stony bottom.

Net A₂. Similar location a short distance upstream.

Net B. Cascades - small pool between riffles. Bottom of stones and exposed bed-rock. Shaded.

Net C₁. Cascades or rocky passing into first still-water. Bottom of stones covered with a deposition of silt. Exposed to full sunlight.

Net C₂. First still-water. Bottom of soft silt. In full sunlight.

The nets were examined once a week or oftener as time permitted and it is believed that they give a good indication of the stream fauna except for wholly aquatic species and such forms as live in the riffles, e.g. simuliids which only occur on rocks in a fast current and large tipulid larvae which occur in moss among the riffles.

Collembola. Members of both suborders, Arthropleona and Gamphyleona, were present in quiet waters throughout the length of the brook. Species of the former group were found abundantly on the surface of the water during July and August while individuals of the latter group were relatively scarce.

Ephemeroptera. Ephemerids were less common than the other two dominant aquatic groups, Trichoptera and Plecoptera. A few individuals were obtained from the still-waters; but the most abundant species was *Stenonema*, a form adapted to fast water and occurring in large numbers under the stones in the cascades. It was also observed to a lesser extent in the lower stony section. The greatest emergence of this group occurred from July seven to twenty-one (vide figure 1).

Odonata. Species of Sympetrum and Boyeria occurred throughout the length of the brook. Both these species were common in the bog about the mouth and coursed back and forth in the sunny parts of the brook; they were also collected in numbers from the first and second stills.

Boyeria nymphs were collected near the mouth, lower and upper rocky parts and in the first still water and were ubiquitous in distribution, occurring wherever the current was slack.

Sympetrum nymphs were observed in the first still-water and in the silty pool discharging into the lake.

Lestes and Enallagma were abundant forms about the mouth of the brook and in the first still-water. Calopteryx was observed on several occasions in the lower rocky area and the rocky stream above the first still, comparable ecological habitats.

Plecoptera. Stonefly nymphs were the characteristic forms found on the underside of stones in the rocky and cascades sections of the stream. Two species were observed: a small green perlid emerging during the month of June in large numbers and absent thereafter (vide figure 2); and a small brown nemourid which was

Figure 1

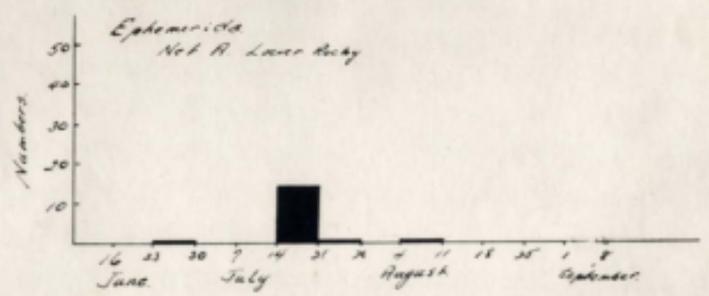
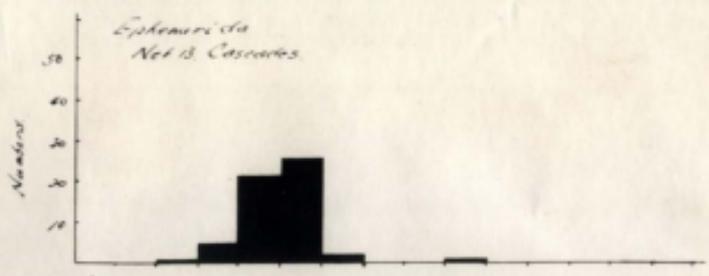
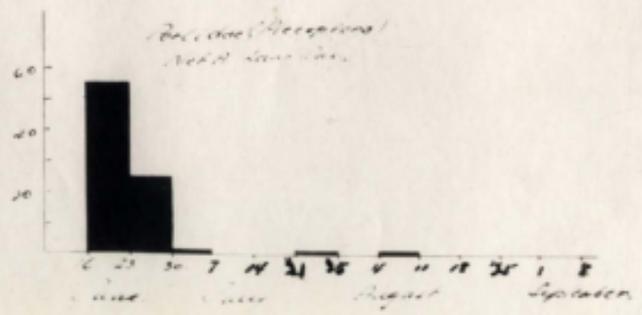
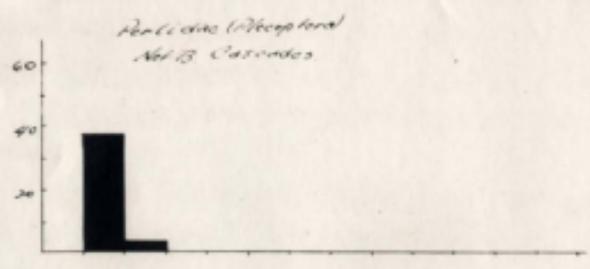


Figure 2



found in the nets all summer (A, B, C₁), but emerged in maximum numbers during July (figures 3 and 4). This species is tolerant of slow current and rather silty bottom for it was found frequently in the net at the base of the first still (C₁) where perliids were wholly absent (figure 4).

Hemiptera. Species of this order were few in number. Gerris occurred throughout the length of the brook, colonies being in each of the pools and in the still-waters. They are actively predacious and individuals were seen attacking large tipulids and other flies which were caught on the surface film and being carried downstream.

A few corixid nymphs and adults were collected in the pool near the mouth and in the first still-water.

Coleoptera. Four species of beetles were found in the brook. These include members of the following families: Halipidse, Dytiscidae, Chrysomelidae, and Gyrinidae.

Halipus. One specimen was collected from the first still-water.

Gyrinus. Larvae and adults of this genus occurred in abundance in the still-waters, being observed about the mouth and in the first and second stills.

Donacia (Chrysomelidae). This beetle occurs commonly on the leaves of the cowlily (Nymphaea advena) near the mouth and in the still-waters.

A single specimen each of a small dytiscid larva and adult were found in the first still.

Figure 1

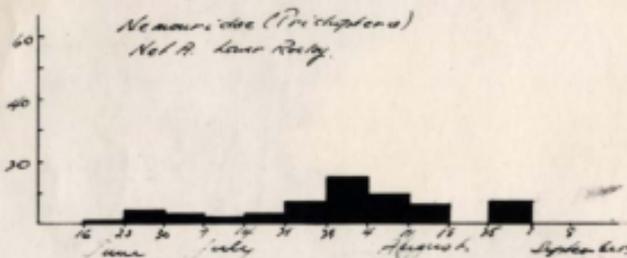
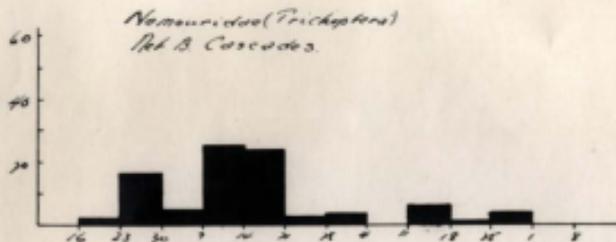
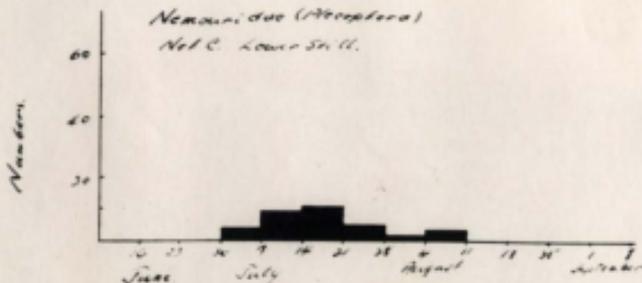


Figure 2



Trichoptera. Species of Polycentropidae were the most abundant members of this group obtained in the fixed nets, occurring in all parts of the stream but particularly in the lower part of the first still (figure 5). A small number of limnophilid and large phryganeid imagoes were caught in the first still (net 6₂) and cases of limnophilid larvae were found attached to the underside of lily pads about the mouth of the brook.

Throughout the summer minute hydroptilids were caught in all the nets, but particularly in the still-waters.

During June there was a small emergence of mollanids in the lower rocky section. Eighteen specimens were secured from June twenty-two to twenty-seven, a comparatively small number.

Lepidoptera. Small pyralid moths (a group containing species with aquatic larvae) were found on the lily pads about the mouth of the brook.

Diptera.

Chironomidae. This group is biologically most important among the aquatic insects present in the brook. Numerous species, some of them microscopic in size were present in large numbers in all the nets throughout the summer (vide figures 6 and 7). During July the stones in the brook were covered with silt cases inhabited by chironomid larvae and in this month a large emergence for the lower rocky section (July seven to twenty-one, figure 6.). These flies were abundant, though to a lesser extent, in the cascades, and were found commonly in the still-water nets during June, decreasing greatly in numbers during the rest of the summer in this location.

Figure 5

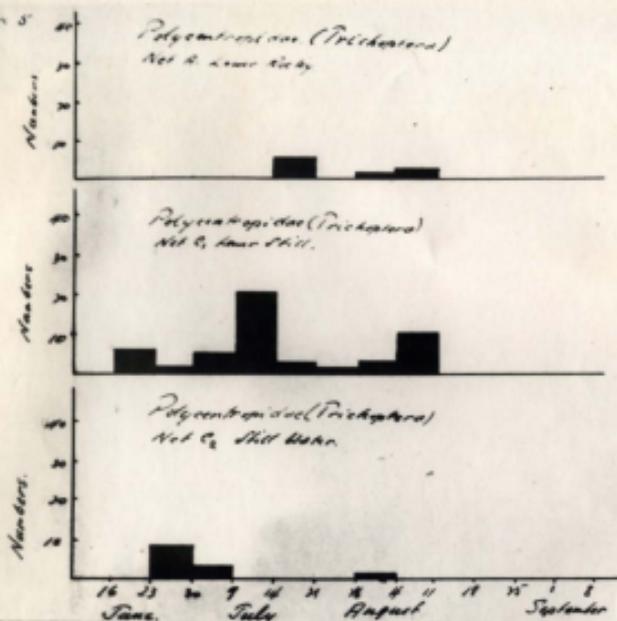
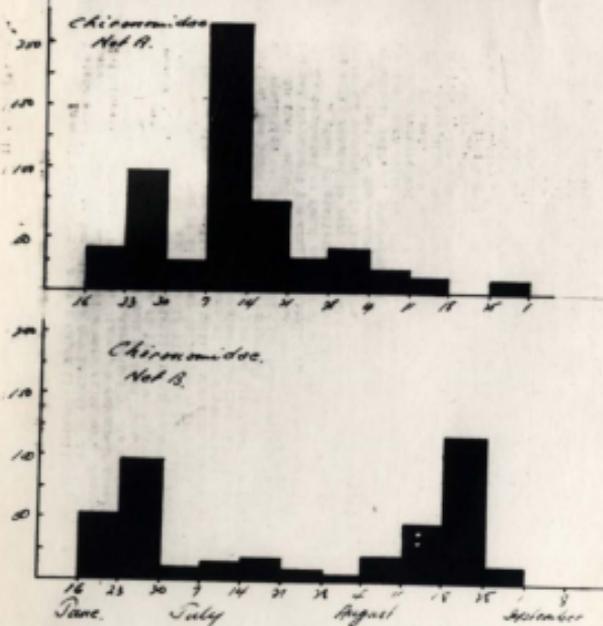


Figure 6



Simuliidae. Very few simuliids were caught in the nets since these were, of necessity, placed in situations uninhabited by larvae of this group. However, larvae were present in abundance throughout the summer on the surface of stones in the riffles and little falls of the cascades and lower rocky sections of the stream.

Dolichopodidae. A total of five individuals of this family were caught in net C₁ at the lower part of the first still from the latter part of June to the end of August. The group is considered to be of minor importance in the biology of the brook.

Tipulidae. The only species of this family caught in the nets was a small greenish species emerging in some abundance in net C₁ during late July and early August and absent thereafter (figure 8). A large tipulid larva was collected frequently in the thick moss which flourishes in the fast water of the cascades, and several imagoes were caught in this location.

Culicid imagoes were collected throughout the length of the brook in June and July and they breed in the still-waters; but none were found in the fixed nets.

Summary of Insect Investigation.

It is considered that chironomids, being very abundant in numbers, would afford a plentiful food supply for salmon fry; and are biologically very important, forming as they do the basis of a food chain. Collembola are another abundant group. Stoneflies are next most numerous, perlids during the early part of the season, nemourids throughout the summer. Trichopteran cases of various species are abundantly distributed along the course of the brook;

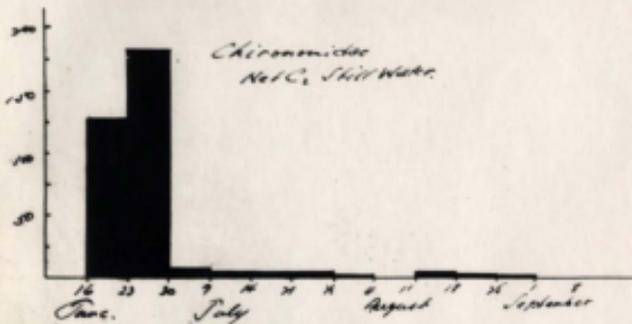
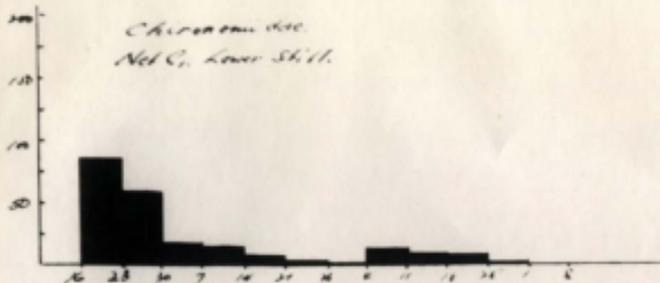
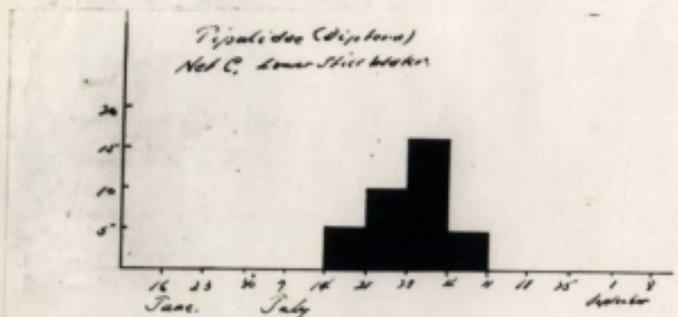


Figure 8



of
silken houses, psychomyids are present in all the suitable niches on the surfaces of the stones; and the sandy cylindrical cases of another species are often conglomerated together on the surface of the rocks. Ephemeroidea are most abundant in the faster water where they vie with the stoneflies in number.

Other invertebrates.

Planaria sp. is abundant on the undersurface of stones in the rocky and cascade sections. A few leeches and annelids were observed in the lower part of the stream. Hyalella dentata occurs in the still-water as well as a small fauna of plankton, ostracods and copepods. A fresh-water sponge which grows abundantly in Mill lake also occurs in the still-waters and slower portions of the stream.

Temperature.

A thermograph was left in the lower rocky section of the stream a short distance below the cascades (vide map 2) from July eight to August twenty-eight. The maximum variation in temperature for this period was from 73.0°F. (22.8°C) on July eight, 3 p.m. to 53.0°F. (11.6°C) on July eight, 5 a.m. The water is coldest from 5 to 7 a.m. when the curve flattens out, beginning to rise again at 8 a.m. and reaching a peak at 2 to 3 p.m. when it drops again (cf. thermograph records at end of report).

A series of temperatures taken on July twenty-nine every 30 paces (68 feet) along the length of the brook during the peak of the day reveals a marked lowering of the temperature as the water passes down the cascades (figure 9, curve I, and table 1). As the

water passes from the shaded stream above the first still into the sunlit still-water it becomes heated 4.5°C. In passing down the shaded cascades it drops 6°C. until, in the lower rocky stretch, the temperature becomes fairly constant at 18°C. Again, on leaving the shade of the trees and entering the open, sunlit bog, it becomes heated gradually to lake temperature (26.0°C.).

There are springs along the course of the brook discharging both through side-rills and through the gravel bed of the stream itself. That they have some local effect on the temperature is shown by curve I, figure 9, where some of the marked depressions in the curve may be correlated with visible springs. But there is another factor involved, probably cooling of the water by evaporation as it passes over the many small falls of the cascade region.

Graph II, figure 9, shows a similar series of temperatures taken on August fifteen at 5.30 to 6.30 a.m. when the temperature of the stream is at its lowest. The temperature throughout the length of the brook is fairly even, 1°C. higher in the still-water than in the rest of the stream.

In an attempt to evaluate the relative effect of sunlight and shade on the temperature of the brook, detailed temperatures were taken over a small section of the stream on both sides in the lower rocky region. These are plotted in figure 10. One visible spring discharges into this section of the brook on the south side and its effect is shown in curve II where there is a depression at this point. No cooling occurred on the north side here.

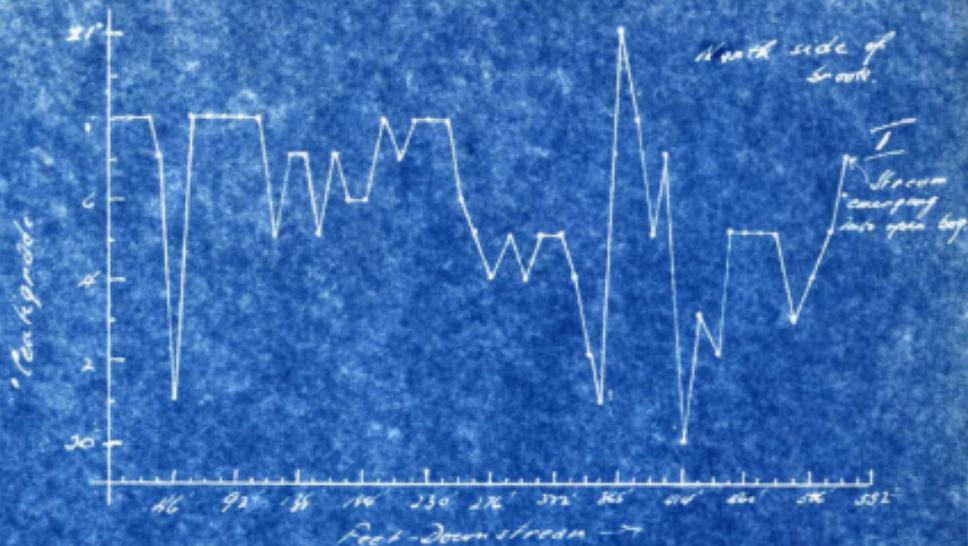
A small correlation can be seen between the amount of sunlight and the temperature of the brook, the water becoming warmer after passing through lighted areas, and cooling after passing through a shaded region. The brook also tends to be warmer on one side when that side is illuminated and the other side shaded by overhanging vegetation.

Summary of temperature.

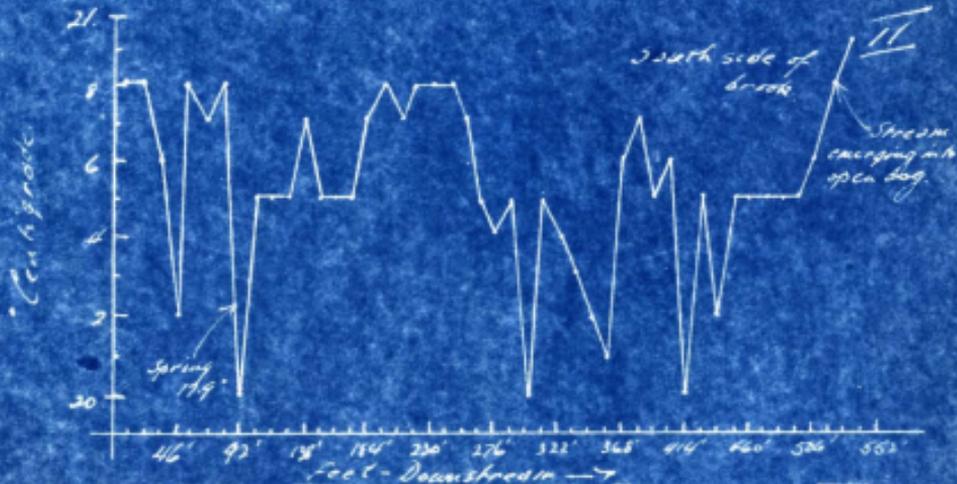
The portion of the brook most accessible and suitable for fry planting lies below the first still-water. The maximum temperature variation for this region during the summer months (based on thermograph records and isolated readings) is calculated to be 30.0°C to 12.5°C for water leaving the still and entering the upper rocky stretch; 22.8°C to 11.6°C at the foot of the cascades; and 20.0°C to 12.0°C in the lower rocky stretch near the mouth. None of these temperatures are lethal for salmon fry and but few were planted immediately below the first still where the water is warmest.

The still, fully exposed to the sunlight, becomes heated during the day and forms a reserve of warm water which elevates

Water Temperatures, N. S. side of Gold mine brook.
 Lower rocky section. 245-535 pm, 7 August.



All sunlight
 partly shaded
 fully shaded



All sunlight
 partly shaded
 shaded



the temperature of the lower part of the stream particularly during the day, to a small extent at night. Cooling of the water as it passes through the cascades and rocky sections is probably due largely to evaporation; a small initial cooling may be due to irradiation when the water first leaves the still and enters the shaded portion with lower air temperature.

Colour of the water.

Goldmine brook drains coniferous woodland and sphagnum bog and passes through two still-waters with thick silty bottoms where there is a considerable deposition of organic sediment. There are also exposed ferruginous rocks along its course. The bog water in the second still is deep brown in colour, becoming lighter in shade as it passes through the first still and quite clear in the lower part of the stream. It never entirely loses its colour.

A series of water samples were taken from the brook on August eighteen from the mouth to the head of the first still and these showed, with two exceptions, a graded change in colour intensity. The water was darkest in colour in the rocky rill above the first still and became increasingly lighter as it passed through the still, the upper rocky stream and the cascades. It was almost clear in the gravel stretch outside the alders but after passing through the silty pool immediately preceding its discharge into the lake it again became darker.

This colour is due to organic matter resulting from vegetal decomposition; and it is considered, from field observations that iron oxides carried to the surface by spring seepage are soon precipitated and add nothing to the colour of the stream.

Water levels.

A record was kept of the water level in a pool in the lower part of the stream during the month of August. The water varied one and one-half inches in height during this period, rising rapidly after each rain. Owing to a particularly dry summer the water level was very low and left two-thirds of the stream bed exposed in the lower part of the brook.

Summary.

In order to form a background for salmon fry planting experiments an ecological survey of Goldmine brook was made during the summer of 1939. Temperature and other physical and conditions, the fauna and flora were studied. Special attention was devoted to the aquatic insects since they constitute the food of the young salmon. An attempt has been made to evaluate some of the factors insofar as they affect this species of fish.

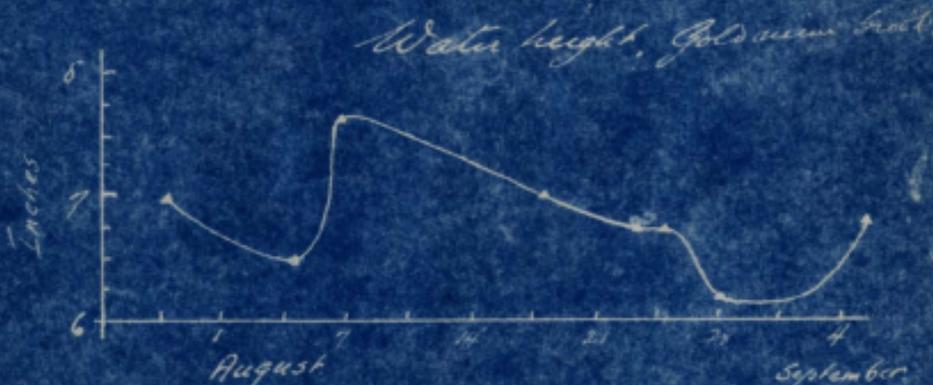


Table 1.

Water temperatures of Goldmine brook, taken every 68'.

July 26, 1.45 to 3.35 p.m. Sky clear. Air temp., 2 p.m. 21.2°C.

| Temp. | Remarks. | Temp. | Remarks. |
|---------|---------------------------|---------|--------------------------------|
| 25.0°C. | Rocky stream | 19.8°C. | |
| 25.0 | Mouth of rocky stream | 19.1 | |
| 28.8 | Upper still | 19.4 | |
| 28.8 | Surface 7' from shore | 19.5 | |
| 26.2 | Same position, 1' deep. | 20.0 | |
| | A spring discharges here. | 19.3 | |
| | 21.0°C. | 19.3 | Mouth of a spring 14.9°C |
| 28.0 | Spring, 17.5°C | 19.9 | |
| 29.1 | | 19.8 | |
| 27.8 | | 19.4 | |
| 27.4 | | 19.1 | Mouth of a spring, 16.4°C |
| 27.8 | | 19.5 | |
| 27.4 | | 19.6 | |
| 27.8 | | 19.0 | |
| 30.0 | | 19.1 | |
| 29.4 | | 18.9 | |
| 29.4 | | 19.0 | |
| 29.8 | | 20.6 | |
| 28.0 | | 21.8 | Open bog |
| 27.1 | Lower still | 23.8 | Temperature at mouth |
| 26.7 | Beginning of upper rocky | 26.2 | Lake temperature at the mouth. |
| 25.7 | | | |
| 25.2 | | | |
| 25.1 | | | |
| 25.1 | | | |
| 25.0 | | | |
| 24.4 | | | |
| 25.0 | | | |
| 23.9 | | | |
| 23.6 | | | |
| 23.0 | Upper cascades | | |
| 23.1 | | | |
| 23.2 | | | |
| 22.8 | | | |
| 22.1 | | | |
| 22.8 | | | |
| 21.3 | | | |
| 20.5 | | | |
| 21.2 | Foot of cascades | | |
| 20.9 | Thermograph pool | | |
| 20.6 | | | |
| 20.1 | | | |
| 19.5 | | | |
| 19.1 | | | |
| 18.5 | | | |
| 19.5 | | | |
| 20.0 | | | |

Table 2.

Water Temperatures of Goldmine Brook.

15 August, 5.23 to 6.30 a.m. Sky clear. Air temperature 10.0°C.

Temperatures taken every 30 paces (68 feet) downstream.

| Temperature | Remarks. | Temperature | Remarks. |
|-------------|--------------------------------------|-------------|--------------------|
| 15.7°C | Rocky stream. | 15.9°C | Outlet of spring |
| 16.2 | Upper still-water | | 14.9°C |
| 16.4 | Outlet of spring 10.4°C | 15.8 | |
| 15.4 | | 15.8 | |
| 16.1 | Outlet of spring 13.4°C | 15.7 | |
| 16.4 | | 15.7 | Outlet of spring |
| 16.6 | | | 15.0°C |
| 16.6 | | 15.5 | |
| 16.8 | | 15.2 | Outlet of spring |
| 17.0 | | | 15.0°C |
| 17.0 | | 15.4 | |
| 17.0 | | 15.2 | |
| 17.1 | | 15.5 | |
| 17.2 | | 15.8 | |
| 17.0 | | 15.6 | |
| 16.9 | | 15.6 | |
| 16.7 | | 15.3 | |
| 16.1 | | 15.3 | |
| 16.2 | Beginning of upper rocky stretch. | 15.3 | |
| 16.1 | | 15.3 | |
| 16.0 | | 15.0 | Mouth of the brook |
| 15.9 | | | Lake temperature |
| 15.8 | | | 7 feet from the |
| 15.8 | | | mouth. |
| 15.8 | | | |
| 15.7 | | | |
| 15.6 | | | |
| 15.6 | | | |
| 15.8 | Foot of cascades | | |
| 15.8 | Thermograph pool. | | |
| 16.0 | Lower rocky | | |
| 15.9 | | | |
| 16.4 | | | |
| 16.2 | | | |
| 16.1 | | | |
| 16.1 | | | |
| 16.0 | | | |
| 16.0 | | | |
| 16.1 | | | |
| 16.0 | | | |
| 15.9 | | | |
| 15.8 | | | |

Table 3.

Water temperatures of Goldmine brook. Lower rocky section.
August 7, 2.45 to 3.35 p.m. Partly cloudy. Temperatures of north
and south sides taken every 5 paces (16.5 feet) down stream.

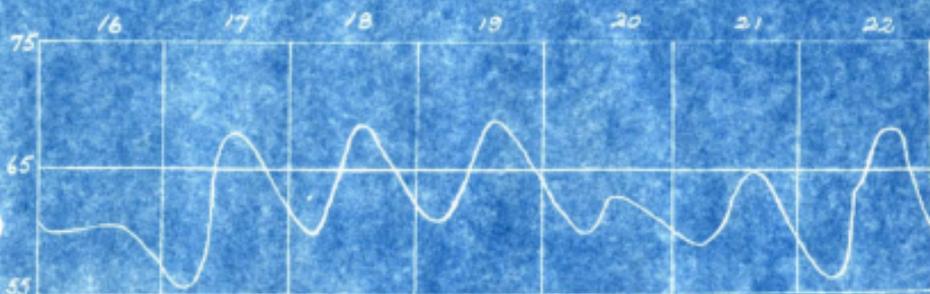
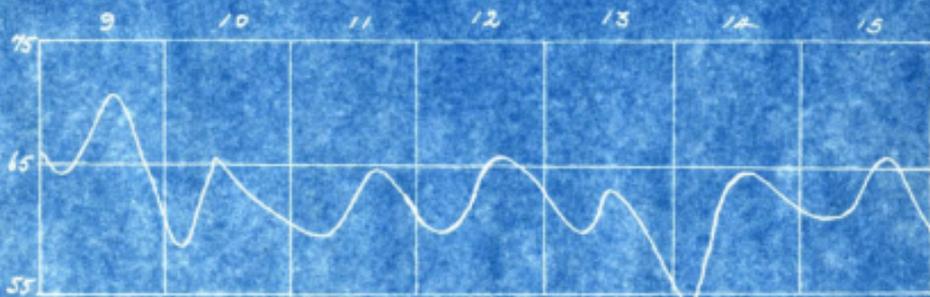
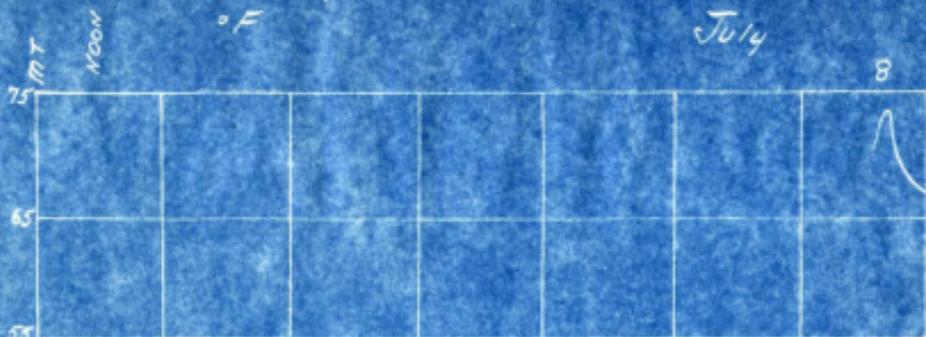
| Temperature | North Side Remarks | Temperature | South Side Remarks |
|-------------|-----------------------|-------------|---------------------------------|
| 20.8°C. | Deep shade | 20.8°C | Deep shade |
| 20.8 | Medium shade | 20.8 | Medium shade |
| 20.7 | Deep shade | 20.7 | Deep shade |
| 20.1 | Deep shade | 20.2 | Deep shade |
| 20.8 | Full sunlight | 20.8 | Full sunlight |
| 20.8 | Full sunlight | 20.7 | Full sunlight |
| 20.8 | Full sunlight | 20.8 | Full sunlight |
| 20.8 | Full sunlight | 20.0 | Full sunlight; spring 17.9°C |
| 20.5 | Medium shade | 20.5 | Medium shade |
| 20.7 | Medium shade | 20.5 | Medium shade |
| 20.7 | Full sunlight | 20.5 | Full shade |
| 20.5 | Full sunlight | 20.7 | Full sunlight |
| 20.7 | Medium shade | 20.5 | Full sunlight |
| 20.6 | Medium shade | 20.5 | Medium shade |
| 20.6 | Deep shade | 20.7 | Deep shade |
| 20.8 | Deep shade | 20.8 | Deep shade |
| 20.7 | Deep shade | 20.7 | Deep shade |
| 20.8 | Medium shade | 20.8 | Deep shade |
| 20.8 | Medium shade | 20.8 | Medium shade |
| 20.8 | Medium shade | 20.8 | Medium shade |
| 20.6 | Deep shade | 20.7 | Deep shade |
| 20.5 | Deep shade | 20.5 | Deep shade |
| 20.4 | Deep shade | 20.4 | Deep shade |
| 20.5 | Deep shade | 20.0 | Deep shade |
| 20.4 | Deep shade | 20.5 | Deep shade |
| 20.5 | Medium shade | 20.0 | Deep shade |
| 20.5 | Deep shade | 20.5 | Medium shade |
| 20.4 | Deep shade | 20.4 | Deep shade |
| 20.2 | Medium shade | 20.3 | Deep shade |
| 20.1 | Deep shade | 20.2 | Deep shade |
| 21.0 | Full sunlight | 20.1 | Deep shade |
| 20.8 | Medium shade | 20.6 | Full sunlight |
| 20.5 | Medium shade | 20.7 | Medium shade |
| 20.7 | Medium shade | 20.5 | Medium shade |
| 20.0 | Deep shade | 20.6 | Medium shade |
| 20.3 | Deep shade | 20.0 | Deep shade |
| 20.2 | Deep shade | 20.5 | Deep shade |
| 20.5 | Deep shade | 20.2 | Deep shade |
| 20.5 | Deep shade | 20.5 | Deep shade |
| 20.5 | Deep shade | 20.5 | Deep shade |
| 20.5 | Deep shade | 20.5 | Deep shade |
| 20.5 | Deep shade | 20.5 | Deep shade |
| 20.3 | Deep shade | 20.5 | Deep shade |
| 20.4 | Deep shade | 20.5 | Deep shade |
| 20.5 | Deep shade | 20.6 | Deep shade |
| 20.7 | Full sunlight | 20.8 | Medium shade |
| | | 20.9 | Full sunlight |

Goldmine brook, Moser river, N.S. 1930

Thermograph records

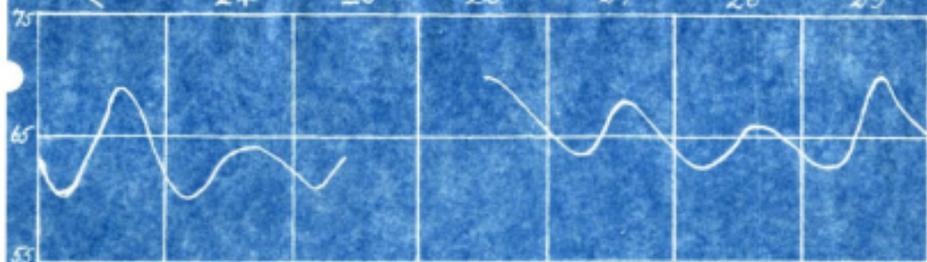
°F

July

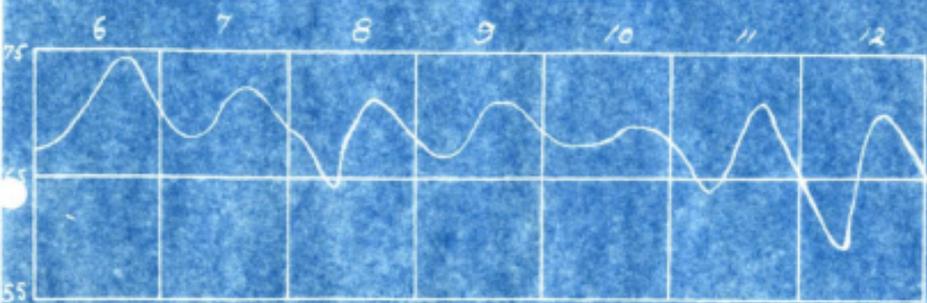
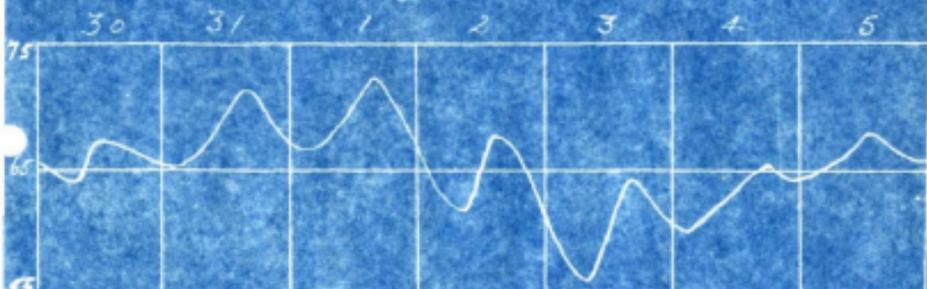


July Goldmine brook.

MT
MOON



August



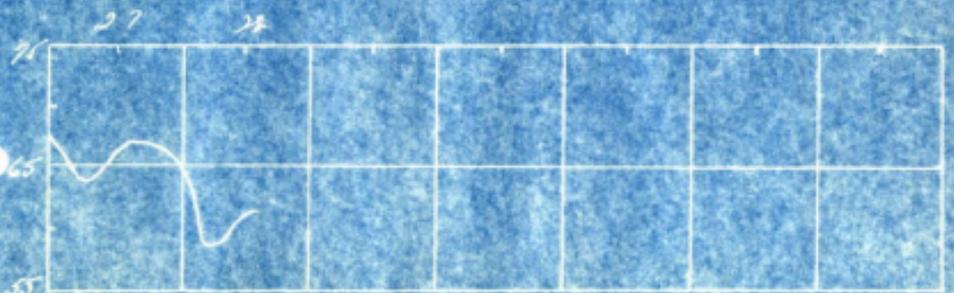
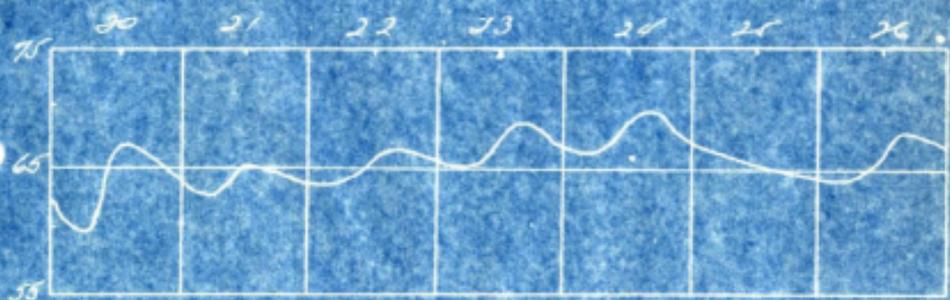
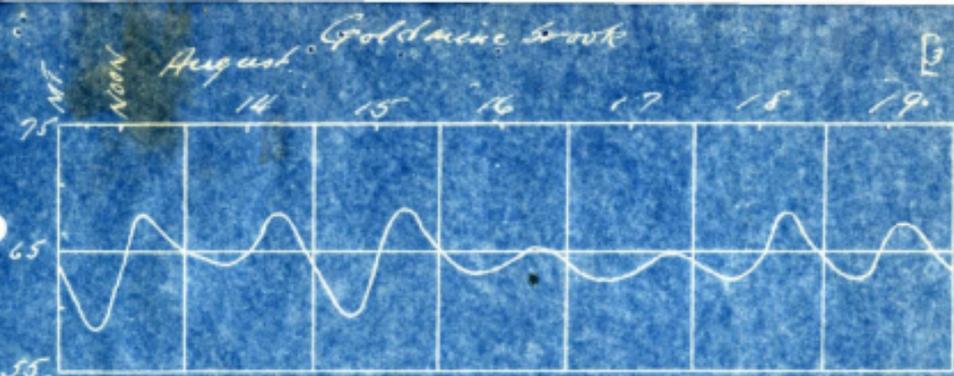




Figure 11. Goldmine brook showing mouth and neighbouring region of Mill lake. The gravel section of the brook runs through the grassy bog in background.



Figure 12. Goldmine brook. Gravel section, passing through open peat bog.



Figure 13. Goldmine brook. Lower stony section showing one of the fixed insect nets.



Figure 14. Goldmine brook. Lower stony section.



Figure 15. Goldmine brook. Cascades in region of bed rock and large boulders.



Figure 16. Goldmine brook. Upper part of cascades.



Figure 17. Goldmine brook. Upper end of first still water. The mouth of the stream leading to the second still water may be seen in the middle background.

Appendix 1.

List of plants collected at Moser river and vicinity.

Leontodon autumnalis. Moser r., fields. Aug. 10. In flower.

Osmunda Claytoniana. Goldmine b. Aug. 30. Woods.

O. cinnamomea. Goldmine b. Aug. 30. Woods.

Onoclea sensibilis. Goldmine b. Aug. 30. Woods and bog.

Phacopteris polypodioides. Goldmine b. Aug. 30. Woods.

Polypodium vulgare. Goldmine b. Aug. 30. Woods.

Aspidium Thelypteris. Goldmine b. Aug. 30. Wet woods

Aspidium spinulosum. Goldmine b. Aug. 30. Woods

Dicksonia punctilobula. Mill lake. July 17. Woods and fields

Osmunda regalis. Moser r. banks. Aug. 15.

Pteris squillina. Moser r. July 20. Woods and clearings.

Aspidium noveboracense. Goldmine b. Aug. 30. Woods.

Kalmia polifolia. Goldmine b. 26 June. Bogland. In flower.

Calla palustris. West branch. June 26. Marsh. In flower.

Cyrtopodium acule. Goldmine b. June 26. Bog. In flower.

Euphorbia polygonifolia. Halibut is. June 25. In flower. Rocks.

Vaccinium Oxycoccus. Mill lake. June 26. Bog.

Andromeda glaucophylla. Mill lake. 28 June. Bog. In flower.

Epigaea repens. Moser r. Sept. 6. Woods.

Chiogenes hispidula. July 7. Goldmine b. Woods, moist ground.

Linnaea borealis. July 7. Goldmine b. Woods. In flower.

Ledum groenlandicum. Mill lake. June 28. Bog. In flower.

Aralia nudicaulis. July 7. Goldmine b. In flower. Woods.

Chamaedaphne calyculata. Mill lake. July 7. Bog.

Myrica gale. Goldmine b. July 7. Moist banks.

Appendix I. (continued):

- Drosera rotundifolia. Goldmine b. July 7 Moist woods. In flower.
D. longifolia. Mill lake. July 7. Bog. In flower.
Eriocaulon articulatum. Goldmine b. and Moser r. July 14. In flower.
Lobelia Dortmanna. Goldmine b. July 14. In water.
Utricularia intermedia. Goldmine b. July 14. Water and bog.
Nymphaea advena. Mill lake. July 14. In shallow water; flowering.
Castalia odorata. Moose head. Sept. 9. In flower. Pond.
Utricularia vulgaris var. americana. Mill lake. July 14.
Pontederis cordata. Mill lake. July 14.
Calypogon pulchella. Mill lake, July 14. In flower.
Necum Teuch. July 23. In flower.
Sarracenia purpurea Mill lake. July 14. Pest bog. In flower.
Nympheoides lacunosum. Moser r. July 15. In flower.
Habenaria clavellata. Mill lake. Aug. 7. In flower.
H. lacera. Mill lake. Aug. 7. In flower.
Aster nemoralis. Mill lake. Aug. 7. Pest bog. In flower.
Vaccinium Vitis-Idaea. Necum Teuch. Aug. 27. In fruit. On rocks.
Lysimachia terrestris. Mill lake. Aug. 7. Bog. In flower.
Utricularia purpurea. Mill lake. Aug. 18. In flower.
U. cornuta. Mill lake. Aug. 18. Bog. In flower.
Sagittaria latifolia. Mill lake. July 31. In flower.
Xyris montana. Mill lake. July 31. Bog. In flower.
Hypericum ellipticum. Mill lake. July 31. Bog. In flower.
Menyanthes trifoliata. Ecum Secum. July 31. Bog. In flower.
Galeopsis tetrahit. Moser r. Aug. 8.
Spiranthes secunda. Mill lake. Aug. 2. Dry fields. In flower.
S. Romanzoffiana. White ls. Aug. 21. In flower.

Appendix I (continued):

Habensria obtusata. White is. Aug. 21. In flower.

Ranunculus repens. Moser r. banks. Aug. 23. In flower.

R. flammula var. reptans. Moser r. banks. Aug. 23. In flower.

Appendix II.

Stomach analysis of nine elvers.

Collected at the Mill lake brook dam. 29 June, 11 a.m.

| Length | Food content | Percentage. |
|------------|-----------------------|-------------|
| 1. 5.5 cm. | Chironomid larvae - 1 | 80% |
| | Simuliid larvae - 1 | 20 |
| 2. 6.7 cm. | Chironomid larvae - 4 | 100 |
| 3. 5.5 cm. | Chironomid larvae - 1 | 100 |
| 4. 5.8 cm. | Empty | |
| 5. 5.4 cm. | Chironomid larva - 1 | 100 |
| 6. 5.5 cm. | Chironomid larvae - 6 | 70 |
| | Simuliid larvae - 7 | 30 |
| 7. 5.6 cm. | Chironomid larvae - 2 | 100 |
| 8. 5.6 cm. | Chironomid larvae - 1 | 100 |
| 9. 6.8 cm. | Simuliid larvae - 1 | 50 |
| | Quartz pebble - 1 | 50 |

ATLANTIC SALMON AND TROUT INVESTIGATIONS 1939.

Report No. XI. Preliminary Report on the Fish-eating birds
of Moser River, Nova Scotia.

By H. C. White

Previous investigations on the Margaree river, N. S. have shown that control of the fish-eating birds may save from destruction large numbers of salmon and trout. In other areas similar to the Margaree river where salmon and trout are the dominant fishes in flood-swept streams which are specially subject to bird attack, bird control may be considered a necessary part of fish conservation. However, on streams with large areas of sluggish water and aquatic vegetation and with numerous species of fishes, considerable investigations on the interrelationships of the various species of fishes and on the feeding habits of the birds would be required before any conclusions regarding the economic status of the fish-eating birds would be justified. Moser river, Nova Scotia, like other streams of the south-east shore is one of the latter type.

This past summer (1939) our observations were largely confined to the lower part of the river and only a few trips were made to any of the upper parts. Most species of fish-eating birds are scarce on the lower parts and few opportunities were offered for a study of these birds.

Kingfishers (Megasceryle alcyon)

Kingfishers are scarce in the Moser river area as they are along much of the south shore. There were probably at any one time

throughout the summer not more than two kingfishers on the lower part of the river. No nests or nesting sites were found on the river and this absence of suitable nesting sites undoubtedly accounts for their scarcity. During August a single kingfisher began feeding in the vicinity of the fish traps and it was observed many times. Apparently it was feeding almost exclusively upon young gaspereau (Pomolobus pseudoharengus) which often congregated in great numbers above the weirs where we observed it striking repeatedly into the schools.

American Mergansers (Mergus merganser americanus)

During the latter part of April and early May a few American mergansers, locally called "guzards" were seen feeding in the upper part of the estuary. Later these disappeared and none was seen on the lower part of the river until late in August. In the fall a small flock of about fifteen fed along the lower mile of the river. Residents state that "guzards" are common throughout the winter feeding wherever there is open water.

The river has areas resembling the flood-swept streams where elsewhere we have found American mergansers rearing their young. The nearest approach to these conditions on the Moser is found on North brook which is the best salmon rearing spawning area we have found on the river. During a survey of this branch in August 1938, we found there a flock of well-grown young mergansers. We did not examine this stream during the summer of 1939 but lumbermen working in the vicinity reported that mergansers were on the stream throughout the summer.

On September 2, we found at the Salmon Hole, a long stillwater just below the mouth of North brook, a flock of twenty-one American mergansers. These ducks which were well grown but still unable to fly were actively feeding at the time they were observed. Thirteen of these were killed and their stomachs were preserved for food analyses.

On the Margaree river we found that the American merganser often reared their young on the smaller tributary streams and the young as they matured extended their feeding range to the main river. Apparently this flock of mergansers at the Salmon Hole were young which had been reared on North brook and its tributary, East brook.

On October 7th two mergansers were shot from a flock of some 15 found feeding in the river just above the head of tide. The food analyses of these and also the ducks killed on September 2 are given in an accompanying table.

Food.

The food taken by the mergansers in the Salmon Hole is fairly representative of the fishes which we would expect to be found in that part of the stream. The food included three salmon parr (*S. salar*), 3 trout (*S. fontinalis*), 4 horned dace (*Semotilus atromaculatus*), 3 gaspereau fry (*Pomolobus pseudoharengus*), 2 killifish (*Fundulus diaphanus*), 1 stickleback (*Pungitius pungitius*) and 11 suckers (*Catostomus commersonii*). Both in numbers taken and in volume suckers constituted their main food. Suckers found in their gullets ranged up to 17 cms. in length. Horned dace of which 4 were taken rated second in numbers but their total volume was small. Trout were second in volume since two of the three trout found were



Mergansers shot at Salmon Hole, September 2, 1939

at least 18 and 23 cms. respectively. Scales from these fish showed that they had returned from the sea. The third trout was a fingerling. The three salmon parr all showing three summers' growth were third in volume. Other fishes found were of minor importance. Bones of one amphibian evidently leg bones of a frog were found in one gizzard. This is the first time in our numerous analyses of mergansers' stomachs that we have found the remains of a frog. This may be accounted for by the fact that our other specimens of mergansers have nearly all been from waters having no marginal vegetation.

The two mergansers shot on October 7th on the lower part of the stream each contained a mass of gaspereau fry-of-the-year and these were mostly macerated. Either duck contained a volume representing upwards of 100 fry. These ducks were feeding in fast water during the downward migration of young gaspereau.

The analyses of the food of the mergansers shot on the Margaree show that they were utilizing the available food fishes. The analyses do not give any comprehensive picture of the feeding habits of these birds throughout the season or over much of the river system since only two localities and two dates are represented. However, it is worth noting that they had taken agile game fishes although there were other fishes present. The other fishes taken by the ducks were not voracious fishes and may be considered as forage fishes for the salmon and trout. Sucker fry in particular have been found to constitute in some localities an important part of the food of salmon parr and the smaller trout.

Red-breasted Merganser. (Mergus serrator)

No red-breasted mergansers were identified on the Moser river system. Only one was seen in the vicinity and that one at Smith brook some four miles from Moser river. The wardens of Liscombe Game Preserve report that there are many mergansers reared on the head water lakes of Moser river and it is probable that some of those are red-breasted mergansers.

Goldeneyes (Glaucionetta clanguli)

Goldeneyes which are locally known on the Moser river as "pie ducks" are said to be winter residents on the open parts of the river. On the Margaree river gold^seyes were found to feed upon young salmon but no specimens from Moser river have been secured for stomach analyses.

Great Blue Herons (Ardea herodias)

Great Blue Herons fed along the estuary throughout the season. They were observed on Millbrook several times during the summer and were found also up the main river. Like conditions observed on the Margaree river, their distribution was found to be more general after mid-August when the broods of the year had left the nests. As has been our repeated observations elsewhere this bird appears to show a preference for trout. This however does not apply to the young birds when they are beginning to forage as at that time they are fairly omnivorous and appear to feed upon any available vertebrates or insects.

Although many species of fishes were present in the estuary and at least the gaspereau were very abundant, a number of the trout taken on their return from the estuary showed fresh scars made by herons. Similar observations were made at the Margaree river. Herons were repeatedly observed feeding in a still water on Mill brook which was a favorite place for trout and also on the main river at the upper end of the salmon hole.

In Johnny Smith lake, manure splashes of herons indicated intensive fishing by these birds at one spot along the lake where the only cool water rivulet entered the lake. This place was evidently a congregating place for trout at night.

One young heron fed regularly during the later part of the summer just above the rack on the main river. The point at which it fed had been a congregating place also for eels which were feeding on the gaspereau fry but after the heron had been feeding there for some weeks the eels largely disappeared.

Only one great blue heron was taken at Moser river for stomach analysis. This was a young bird shot on Sept. 4th some ^{3½} miles up the river. Its stomach contained 6 gaspereau fry-of-the-year, 2 killifish (F. diaphanus), 7 very small eels, 1 small sucker and 1 salmon parr. The parr was a 2-winter fish about 12 cm. long which by bulk was the dominant food. The finding of 7 elvers in the stomach of this bird raises a new question in connection with the economic status of the herons on these waters.

Eels are known to eat young salmon and trout and also to be competitors for the food of these fishes. Thus if herons are destroying any considerable number of eels they may be compensating for the

trout and salmon which they themselves destroy. The status of the great blue heron on the Moser river can be determined only after we have a thorough knowledge of the interrelationships of the trout, salmon, eel and heron.

Osprey (Pandion haliaeetus)

Ospreys fed regularly along the Moser through the summer. They began feeding in the estuary and the lower part of Mill lake early in May and continued feeding in the river until the first of September. At least three pairs carried fish from the lower part of the Moser to their nests. We observed these ospreys many times with fish and when identifications were possible the fish identified were suckers or gaspereaux.

They undoubtedly kill trout during the run of sea trout and also an occasional grilse. During the trapping of the fish both grilse and trout were taken with osprey wounds in their backs and several such dead or dying trout lodged on the racks.

Besides feeding in the river and estuary they also do considerable feeding along the seashore in the shallow bays.

Fairly accurate observations on their feeding habits in the Moser river could be made with the aid of high-power binoculars.

Gulls (Larus argentatus)

Herring gulls fed regularly throughout the summer in the lower part of the river. Their food consists largely of gaspereaux, especially wounded and spawned fish. They ate also any other fish which died. We found no evidence on the Moser that they were feeding upon any healthy fish. However, on the nearby Smith brook where

there is a large run of spawning smelts great flocks of gulls congregate there and feed upon the spawning smelts. There they undoubtedly destroy vast numbers of the smelts.

Bitterns (*Botsurus lentiginosus*)

Bitterns are rare along the Moser. An occasional one was seen along Mill lake. They were not abundant enough to be of any significance.

Conclusions

American mergansers and great blue herons are the only birds on the lower part of the Moser river which, at this writing, appear to have any considerable economic bearing on the fishes of the river. Considerable study of the food of both of these species as well as a thorough understanding of the interrelationships of the indigenous fishes should be made before drawing any conclusions as to the economic status of either of these birds.

H.C. White,

Toronto, March, 1940.

Stomach Analyses of Mergus americanus, Moser river (Salmon hole)
Sept. 2, 1939.

| Specimen number | <u>Selyselinus fontinalis</u> | <u>Salmo salar</u> (parr) | <u>Semotilus atromaculatus</u> | <u>Pomolobus pseudoharengus</u> (fry) | <u>Fundulus diaphanus</u> | <u>Pungitius pungitius</u> | <u>Salientra</u> | <u>Anisoptera</u> | <u>Catostomus commersonii</u> | Remarks |
|-----------------|-------------------------------|---------------------------|--------------------------------|---------------------------------------|---------------------------|----------------------------|------------------|-------------------|-------------------------------|---|
| 1 | 1 | | | | | | | | | (23-24 cm. with scales show- ing growth) partly digested |
| 2 | | | 1 | | | | | | 1 | s. atromaculatus 15 cm., C. commersonii (yearling) |
| 3 | | 1 | | | | | | | | parr 1 W+ (12 cm.) |
| 4 | | | 1 | | | | | | | pharyngeal teeth only (stomach nearly empty) |
| 5 | 1 | | | | | | | 1 | | leg bones (frag?) 1 fingerling trout about 7 cm. dentaries only. stomach nearly empty |
| 6 | | | 1 | | | | | | | also fish bones. sp? pharyn- geal teeth-Semotilus. nearly empty |
| 7 | 1 | | | | | | | | | trout 2W+ l.e. sea growth 18-20 cm. partly digested salmon yearling parr. |
| 8 | + | 1 | | 1 | | | | | 1 | gasperau 4 cm. trout-teeth only |
| 9 | | | | 2 | | | 1 nymph | | 3 | 1 sucker entire 18 cm. |
| 10 | | 1 | | | | 1 | | | 1 | s.s. parr 1W+ partly digested C. commersonii rays and scales |
| 11 | | | | | | | | | 2 | C. commersonii (10 or 12 cm.) |
| 12 | | | 1 | | | | | | 2 | C. commersonii 1 entire 20 cm Semotilus. pharyngeal bones and teeth |
| 13 | | | | | 1 | | | | 1 | C. com. 1-17. Fundulus 8 cm. |
| Totals | 3 | 3 | 4 | 3 | 1 | 1 | 1 | | 11 | |

Analyses made at University of Toronto
January 11, 12, 1940.

ATLANTIC SALMON AND TROUT INVESTIGATIONS 1939

Report No. XII. Salmon redds and fry production of Moser river, N.S.

By H. C. White

Our investigations on the salmon at Apple river and at the North-east Margaree river had shown that in these flood-swept streams with large areas of clean gravel salmon fry were abundant and the most important losses of the young fish occurred among the yearling and older parr.

The Moser river, on the south shore of Nova Scotia, is a stream which is not flood-swept and clean gravel areas are very limited. Our first observations there in 1938 indicated a scarcity of both fry and older parr so in the fall of that year we began investigations on the spawning of the salmon in an effort to determine the causes of the fry scarcity.

After the salmon had spawned surveys were made of the spawning areas on the lower part of the river, and on Mill and North brooks. It was found that the salmon had utilized various types of gravel for the making of their redds and many of them appeared to be very unsuitable for the incubation of the eggs. Some of the places which seemed the least desirable were on the lower parts of the main river below Oak island where a number of redds had been made in gravel which was partly covered with the bark from pulp wood. In the making of their redds the salmon had dislodged the pulp bark when forming the excavation, but when covering the eggs they had washed over them pieces of bark and detritus mixed with the gravel.

At the lower ends of the stillwaters there are areas of fine gravel mixed with fine sand and detritus and on both the river and Mill brook the salmon had spawned in these areas. The current in such places is too weak to separate the fine material from the gravel and when the salmon cover their eggs the fine material settles into the pockets containing the eggs and cuts off their water supply. At the lower end of Salmon Hole "still" there were 15 redds of this type. They represented some of the most unfavourable places which had been used by the salmon.

In the lower part of the river the gravel areas are not extensive and the gravel contains much sand. All of these areas were utilized by the salmon for making their redds.

North brook seemed to be one of the most satisfactory spawning areas on the river and many redds were found in the lower half mile. East brook which empties into North brook appeared to be equally satisfactory and had numerous redds in the lower part.

A more complete survey of the spawning areas of Mill brook was made. Four redds only were found on this brook below the outlet of Johnny Smith lake brook. Two of these were in fairly good gravel but two were at the foot of the stillwater in a very unsatisfactory location. At the upper end of the stillwater were some nine redds. A fairly satisfactory spawning area is located just above Second lake where the stream channel is narrowed by the encroachment of alders and the gravel is cleaner than in other areas. This part is scarcely 10 rods in length but in 1938 it contained 10 or 12 separate redds.

For about a half mile above this there are scattered gravel areas some of which contain much sand, yet most of them had been used by the salmon.

Johnny Smith lake brook is small and there are only limited spawning areas. The gravel of these contained much fine and coarse sand but little detritus. There were in 1938, 17 redds made by grilse in this stream. In the lower part of Goldmine brook which empties into Mill lake there were 3 small redds evidently those of small grilse. These redds were in fairly clean gravel and appeared to be satisfactory. During the survey of 1938 the exact locations of a number of redds were noted so that they could be located for observation in the spring of 1939.

Successive redds

On May 17, 1939, two salmon redds on the lower river above the mouth of Mill brook were opened. One large redd, the location of which had been marked the previous fall, had changed but slightly in shape during the winter. This was carefully opened. About three inches in the gravel a dead salmon alevin was found. At depths from 6 to 10 in. we found alevins abundant and the redd was carefully covered and not further disturbed. A second small redd was partly opened and alevins were found at a depth of 4 to 6 in. Both of these redds contained much sand with the gravel as well as considerable detritus which was partly composed of broken down pulp bark.

On June 6 when fry were beginning to emerge from the redds on the lower parts of the river a further examination of the redds there was made. Many of the redds which had not been marked the previous fall were easily recognized. At this time an occasional fry was found out of the redds and these were dark in color. In

several redds a very few light coloured fry were found in the upper layers of the gravel where they should have been at that stage but at the bottom of the redds among the larger stones of the egg pocket there were many fry which were also light in colour and were associated in the egg pocket with the dead and decomposing eggs. Apparently these fry were unable to escape from the egg pocket on account of the fine material which filled the interstices of the gravel.

At the lower end of the Salmon hole where the gravel is fine and mixed with sand and detritus, the bottom is largely covered with aquatic plants especially Scirpius but the salmon had torn these out in the making of their redds. A search and seining of this area was made but only an occasional fry could be found out of the redds. Several of the redds were opened by carefully removing the top layers of the gravel a few inches at a time and washing it so that all the lighter material was carried by the current into a fine-meshed seine. Only a few fry were found in the gravel above the egg pockets. In two shovelful from the bottom of one redd including part of the gravel and sand from the egg pocket 50 dead eggs and 12 fry were found. Most of the eggs were not badly decomposed and the dead embryos, especially their eyes, could be readily seen. This area with a slow current and fine gravel mixed with sand and silt was one of the poorest hatching areas which we found. It appeared that here most of the embryos had died when they had reached an advanced stage. The death of these was probably caused by suffocation in the sand and silt. The fry which had managed to hatch and reach the stage when they should emerge were evidently entombed with the dead eggs in the egg pockets.

Above the Salmon hole there is a fairly swift rapids with a coarse gravel bottom and 12 redds had been located there. Since

the previous fall these had been partly levelled by the freshets and in these we found many of the fry in the uppermost inch or two of the gravel. It is possible that freshets may perform an important function in the liberation of the fry.

In North brook which we have called the best spawning area of the lower river the fry at this time had not yet absorbed their yolk-sacs, yet many of them were in the upper layers of the redds.

Similar observations were made on the spawning areas of Mill brook and they like some of those of the river lacked sufficient current and contained too much sand, silt and detritus. Some of the best spawning areas of Mill brook were on Johnny Smith lake brook, but even these contained too much fine gravel and we found fry entombed in the redds.

As a whole the Moser river lacks suitable spawning areas and this deficiency may in large part be the reason for the observed scarcity of salmon fry and parr.

Remedial Measures.

The deficiency might be circumvented by the planting of artificially hatched fry, the placing of artificially fertilized eggs in specially prepared beds or by correcting the deficiency by modifying the natural spawning beds so that natural spawning might be more efficient.

Two of these methods were attempted experimentally this past fall (1939). During the run of salmon several ripe fish were taken and the eggs were artificially fertilized. These were immediately deposited in prepared beds. The beds were made by forming a barrier of small boulders for about three feet across the rapids where the current was not too fast. Above this barrier a layer of gravel which had been washed over a quarter of an inch meshed screen was banked against the

upstream side of the stone barrier. The eggs were put into a container and submerged over the gravel and were then liberated into the gravel. They immediately disappeared into the interstices. A deep layer of clean gravel was then spread over this and finally some larger stones were added to make it more resistant to the current. In several of the beds eggs were placed in screen containers filled with gravel and these were placed in the beds. The object of the container was to make them more available for examination.

Two types of gravel beds were prepared for the salmon to use as sites for their redds. One of these was made by placing parallel rows of boulders up and down the stream about two feet apart and thoroughly washing the gravel between the rows.

The other type was made similar to the artificial redds described above. No salmon used the first type but the second type was readily accepted by the salmon for the making of their redds. The advantages of this latter construction are that the salmon have clean gravel in which to deposit their eggs where there is a good circulation of water through the gravel and the interstices are sufficiently large for the fry to escape. Moreover since these artificial beds are raised somewhat above the stream bed there is little danger of their becoming silted. Their disadvantages might be from freezing during the winter. However on the Moser river there appears to be little likelihood of loss from this cause.

Winter Killing of Eggs.

While examining the redds in the fall of 1938 we had noted that some of the redds were in very shallow water. On Nov. 15 after the first severe frost the water in the river became fairly low and the

tops of some of the redds were above the water level but the eggs were in water down in the redd. We photographed one redd which projected most and in which we thought the eggs were most likely to be killed by freezing or destroyed by ice (Fig. 1). On June 6 this redd was opened and more fry were found above the egg pocket than in any other redd examined in the lower part of the river. Since this redd had been located in shallow fast water the salmon when covering the eggs had washed most of the finer materials from the gravel, thus making better conditions for the escape of the fry from the egg pocket.

It is quite evident that there is little freezing of the bottom of the rapids in the shallower parts of the Moser. Most of the bottom is fairly well carpeted with aquatic plants and these show no evidence of winter killing. Moreover we found few places where ice had lifted the bottom during the winter or spring freshet and many of the salmon redds were found to have been but slightly altered during the winter. Thus any serious losses from the freezing of eggs such as has been recorded for other rivers apparently does not occur in the Moser.

Number of natural redds in 1938-39.

In making counts of natural salmon redds we have counted only covered redds and have not taken into consideration numerous unfinished redds. Covered redds are those where egg pockets have been made, eggs deposited and then covered with gravel. Considerable familiarity with redd construction is necessary in order to distinguish covered redds from places where egg pockets have been made but not used. The gravel removed when the salmon is making an

egg pocket resembles a covered redd, but it is merely piled back over the surface gravel. When in doubt the difference may be found by digging down at the point where the egg pocket should be and looking for eggs. This should not be followed as a practice as many eggs may be destroyed by disturbing them during the tender stage.

In November, 1938, counts of covered redds were made on parts of the river, but special attention was given to the number in Mill brook. Examinations of the spawning areas were made also on North brook and East brook. In 1939 again after the salmon had completed their spawning another survey of the spawning areas was made and the redds were counted over the same areas. A comparison of these results in these two years may be indicative of the sizes of the runs of salmon for the two years. In the following table the number of redds in the two years are given.

| Place | Number of Redds | | |
|-------------------------------|-----------------|------|------------|
| | 1938 | 1939 | |
| Below Salmon Hole | 15 | 5 | River |
| Island above Salmon Hole | 12 | 6 | |
| Mill brook Mill lake at still | 2 | 0 | Mill brook |
| Foot of Stillwater | 2 | 0 | |
| Below Second lake | 3 | 1 | |
| Above Second lake | 40 | 20 | |
| Johnny Smith lake brook | 17 | 14 | |
| Totals | 91 | 46 | |

From the counts in the definite spawning areas in the two years it would appear that there was twice as many spawners in 1938 as in 1939. However as each female salmon ^{may} make a number of redds and different salmon use the same redd these numbers cannot be regarded as absolute, although it may fairly safely be stated that many more salmon spawned in 1938 than in 1939. No counts of redds ^{were} made in North and East brooks in either year, but in both years we judged that these better spawning areas had been well utilized by the salmon. In the lower part of the main river where the areas are comparatively poor, i.e. between the mouth of Mill brook and Oak island, we judged that there were not more than half as many redds as in 1938. Since North and East brooks which contain the best spawning areas had been fairly well utilized in both years and the poorest spawning areas were those where the greatest ⁿ discrepancy occurred, fry resulting from the spawning in the two years might tend to become equalized.

Size of Salmon Redds

One hundred and fourteen redds were measured for length and breadth. There was a noticeable difference in the sizes and shapes of the redds in the different habitats. In the small Johnny Smith lake brook the redds were very small, containing only one or two distinct egg pockets. These redds ranged in size from 2 to 4 feet in length with breadth from 1.5 to 2 ft. and averaged 2.86 to 1.75 ft.

North brook redds ranged from 4 to 6.5 ft. in length and 2 to 3 ft. in width averaging 5.2 by 2.50 ft. However in North brook a very unusual redd was found measuring 13 ft. in length but 2.5 ft. in width. This was probably a redd made by several salmon and has not been included in our calculations.

In the river below Oak island, redds ranged from 3.5 to 11 ft. in length and from 2 to 6.5 ft. in width and averaged 5.8 to 3 ft.

These redds show a rather definite relation to the sizes of the streams in which they occur. Very small redds were found in the small Johnny Smith lake brook, medium sized redds in the larger North brook and the largest redds in the river. There was some indication that the smaller fish were using the smaller streams. In Johnny Smith lake brook during the spawning of the salmon only the smaller grilse were found.

We attempted to correlate the size of the redds with the sizes of the eggs since grilse produce smaller eggs than the larger salmon. Four redds opened in Johnny Smith lake brook yielded eggs ranging from 5.4 to 5.7 mm. A large redd in the river measuring 7 by 3 ft. contained eggs measuring 5.4 mm. However the largest redd found on the North brook contained eggs averaging 6.2 mm. Since we were unable to distinguish large compound redds from large single redds any individual measurements are not particularly significant. A considerable number of egg measurements would have to be taken to arrive at any conclusion by this method. However large salmon do make redds much larger than the grilse and the redd measurements indicate that most of the larger fish spawned in the larger waters.

H. C. White

Toronto, March 1940



Top of salmon redd showing
above water, Moser River,
N. S., Nov. 14, 1938



Top of salmon redd showing
above water, Nov. 14, 1938.
This redd was one of the
best redds opened on June 6,
1939.

ATLANTIC SALMON AND TROUT INVESTIGATIONS 1939

Report No. XIII. Nova Scotia records of stoneflies, Goldmine
brook, 1939.

By J. A. C. Nicol.

Moser River, Mill Lake, N. S.

Alloperla mediana (Bks.)

Lower stony section: June 19, 6♂, 7♀; June 22, 2♂, 1♀,
1 N; June 26, 7♂, 7♀; June 29, ♂.

Hastoperla brevis (Bks.)

Lower stony section: June 22, 10♂, 10♀; June 26♂♂, ♀♀;
July 9, 1♂; June 19, 1♂.

Cascades: June 23, 5♂, 13♀.

Leuctra decepta (Clan.)

Lower stony section: Aug. 3, 1♂.

Cascades: July 19, 17♂.

Lower stillwater: July 19, 1♂.

Leuctra hamula (Clan.)

Lower stony section: July 6, 1♂; June 26, 1♂.

Leuctra tenuis (Pictet)

Lower stony section: July 29, 1♂, 7♀; Aug. 3, 1♂.

Cascades: July 19, 3♂; July 29, 1♂, 1♀; Aug. 8, 3♂, 4♀.

Lower still water: July 19, 4♂; July 29, 2♂, 2♀.

Nemoura wii (Clan.)

Lower cascades: June 19, 2N; June 30, 7♂, 2♀.

Lower stony section: June 26, 2♂; July 6, 6♂, 1♀, 1 N.

Leuctra sp. July, Cascades 26 (nymphs)

ATLANTIC SALMON AND TROUT INVESTIGATIONS 1939

Report No. XIV. Comparative chemistry of the waters of Moser river.

By A. G. Huntsman

When Moser river, Nova Scotia was selected in 1938 for intensive salmon investigations, it was expected that it would furnish varied conditions representative of the waters of the Maritime provinces, and in particular of the contrasted inner and outer parts of Nova Scotia. The criterion used was the nature of the vegetation, the drainage basin of the river having hardwood hills as well as meadows, bogs, half-barrens and barrens. Undoubtedly the streams of the river system vary in character from sluggish or stillwater types through sandy or gravelly ones (resembling good salmon rivers of the inner part of the province) to stony and rocky types. There remained to be determined the character of the water itself that forms the streams.

The Department of Mines and Resources was having Mr. H. A. Leverin, Chemical Engineer of its Industrial Minerals Division analyse certain surface waters of Nova Scotia during the summer of 1939, and he was able to include samples from parts of the Moser river system in his work. He has furnished his analyses of these samples as well as of samples from certain other waters, particularly the large salmon rivers of New Brunswick. These latter are very useful for comparison. These are all given in the attached table (Report XV).

The main Moser river sample (taken at the trap) and the West brook sample may be taken to represent the region as a whole, and their waters are quite similar. Goldmine brook, which arises from a

marshy or boggy area, is more acid (a low pH), has less silica and carbonates, and more chlorides and nitrates. It would probably be much more productive if it were opened up to sunlight by clearing away the trees along its course. Its high acidity is unfavourable and would probably be corrected in this way. Mill lake brook drains Mill lake, into which West brook and Goldmine brook discharge. Its character reflects this, but is peculiar in showing high contents of iron, calcium and chloride. The latter is perhaps the result of cultivation of some of the land that drains directly into the lake.

The waters of the Moser river system as well as that of Herring Cove lake, which is in the outer half of Nova Scotia near Liverpool, all differ from the waters of the St. John, Nipisiquit and Miramichi rivers of New Brunswick in being low in pH, alkalinity as CaCO_3 , silica, calcium, hydrocarbonate, carbonate hardness, and calcium hardness, and in being high in free carbonic acid, alkalies as sodium (Na), and chloride. Some of these are quite definitely interconnected, and the most significant feature would appear to be the low amount of calcium, which doubtless largely determines the low pH, that is the high acidity. It is desirable to make a further survey of the waters of the separate parts of the Moser river system in order to discover, if possible, some that more nearly resemble the large salmon rivers of New Brunswick. In this search, pH and calcium are probably the most important indicators. Whether there should be search for a condition more extreme than Goldmine brook in the opposite direction is doubtful, although streams in the granite regions of outer Nova Scotia (e.g. the Sambro peninsula) may show more extreme conditions.

ATLANTIC SALMON AND TROUT INVESTIGATIONS 1939

Report No. XV. Report on investigation of the waters of the Moser river watershed for the Fisheries Research Board of Canada.

By H. A. Leverin.

The investigation of the waters of the Moser river and its tributaries made at the request of Dr. A. G. Huntsman, Secretary and Consulting Director of the Fisheries Research Board of Canada has been completed and the results are herewith submitted.

The Moser river watershed is located at the eastern end of Halifax county, Nova Scotia. Samples of water were collected from the main Moser river at the salmon trap and from Mill lake brook, Goldmine Creek and Westbrook at their outlets. Determinations were made, at the time of sampling, of constituents and characteristics that change or disappear on standing. These were, temperature, pH value, free carbonic acid, dissolved oxygen and colour. As these analyses yielded divergent values, especially as was the case with free carbonic acid and pH value, re-sampling and checking of the analyses were done two days later, with results agreeing closely with those of the first tests. Complete analyses of the samples appear in the attached table.

The chemical composition of the waters of the Moser river system is of a similar type to that of the northern surface waters of the provinces of Quebec and Ontario, i.e. of waters that flow over siliceous rock and through forests, marshes and muskegs. Thus the

waters of the Moser river system are low in calcium, magnesium, iron, bound and half bound carbonic acid, and sulphates. They contain only small quantities of suspended matter. On the other hand the free carbonic acid is high, especially in samples Nos. 647 and 648, with consequent low pH value, and except for No. 645, the waters are highly coloured. Chlorides and alkalis are high. The waters are soft, having about half of the total hardness, or less, than the limit set for soft water in the classification of waters according to their hardness.

The objectionable constituents in these waters are free carbonic acid and organic matter rendering them distinctly acid. To what extent, if any, these could be eliminated, it is difficult to say. Free carbonic acid occurs already in the rain water absorbed by the particles of water while floating in the atmosphere, but the high amount present in these waters is in all probability derived from decomposition of leaves, organic soil wash, etc. Had the waters passed over basic minerals containing calcium, magnesium, iron, etc., they would have been neutralized, the free carbonic acid forming bicarbonates with these bases, thus increasing the pH value and lowering the acidity. Suggestions have been made that the acidity could be corrected by clearing the river banks of trees and thick bush, opening it up to the action of the sunlight, and incidentally freeing the waters from falling leaves. Whether these means would bring the desired effect is in my opinion doubtful. As a parallel case, I may cite the St. Maurice river water which is identical in composition with these waters, especially as regards pH value, free carbonic acid and colour. Samples taken at La Tuque, Grande Mere and Three Rivers, show no changes in these value, and the woods have been cleared far back from the river

banks, especially at and below Grande Mere.

The high colour of the waters denotes presence of organic matter which in these types of waters consists of ^{the} humus acid series. The humus acids add to the acidity of the water and are compounds not easily oxidized or broken up. As a consequence, the elimination of colour in a water is one of the more complicated processes in water purification. The humus acids are dissolved in the water on its course through marsh lands and muskegs, and consequently its presence in the water is unavoidable.

Dissolved oxygen is low as compared with sea water which in combination with the high, free carbonic acid must have deleterious effect on fish life, similar to that of a polluted atmosphere on animal life on land. Sea water with a pH value of over 7.0 would have practically no free carbonic acid. Nevertheless the saturation of dissolved oxygen in a water depends on several factors, temperature, pressure, and the nature of dissolved solids, the saturation ranging from 5.4 ml. at N.T.P. per litre and of distilled water at 30°C to 8.6 ml. at 5°C. Comparative saturation figures for the samples taken would be, in ml., 5.2, 6.3, 5.3, and 5.3 to 5.6, 5.8, 6.3 and 5.9; three are below saturation and one shows super saturation. Generally dissolved oxygen in surface waters runs close to saturation, while waters from wells and springs are deficient in oxygen. Super saturation is not unusual in surface waters, especially when plankton is present.

Of other characteristics in these waters I may mention the content of chlorides and alkalis which is appreciably higher than is usual in Canadian surface waters, but not excessively so, as compared

with those on the Nova Scotia east coast, and is due principally to the proximity of the ocean from which salt spray is carried inland.

Analyses of four samples of water collected at Moser river village, Nova Scotia, August 12-13, 1939, for the Fisheries Research Board of Canada.

| Sample No. | 645 | 646 | 647 | 648 |
|---|-----------------|----------------------------------|----------------|-------------|
| Date of sampling | 12,13/8/39 | | | |
| Source | Mill lake brook | Main Moser river | Goldmine creek | West brook |
| Sample collected | Midstream | Midstream above Mill brook mouth | Midstream | Midstream |
| Gauge | low | low | low | low |
| Temperature °C. | 26.0 | 25.0 | 20.0 | 23.0 |
| pH | 6.1 | 6.7 | 6.0 | 6.5 low |
| Dissolved oxygen, ml. per litre | 5.2 | 6.3 | 5.3 | 5.3 |
| Free carbonic acid(CO ₂) p.p.m. | 3.0 | 2.0 | 5.0 | 5.0 high |
| Turbidity " | none | none | none | none |
| Colour " | 25.0 | 60.0 | 65.0 | 65.0 |
| Alkalinity as CaCO ₃ | 0.5 | 1.0 | none | 0.5 low |
| Suspended matter p.p.m. | 3.0 | 1.8 | none | 0.6 |
| Total dissolved solids dried at 110°C. | " 41.0 | 32.6 | 52.4 | 40.3 |
| Silica(SiO ₂) | " 2.6 | 2.6 | 1.7 | 2.9 low |
| Iron (Fe) | " 0.20 | 0.15 | 0.12 | 0.12 |
| Calcium (Ca) | " 7.8 | 4.3 | 4.3 | 4.3 low |
| Magnesium(Mg) | " 4.7 | 3.3 | 4.2 | 4.9 |
| Alkalies as sodium(Na) | " 6.4 | 4.9 | 6.4 | 7.4 al.high |
| Hydrocarbonate(HCO ₃) | " 0.6 | 1.2 | none | 0.6 low |
| Sulphate (SO ₄) | " 5.2 | 5.7 | 5.7 | 5.0 |
| Chloride (Cl) | " 10.0 | 4.5 | 8.5 | 7.5 high |
| Nitrate (NO ₃) | " 0.44 | 0.44 | 0.80 | 0.35 |
| Hardness as CaCO ₃ : | | | | |
| Total hardness | " 38.8 | 24.3 | 28.0 | 30.9 |
| Carbonate hardness | " 0.5 | 1.2 | none | 0.5 low |
| Non-carbonate hardness | 38.3 | 23.1 | 28.0 | 30.4 |
| Calcium hardness | " 19.5 | 10.8 | 10.8 | 10.8 low |
| Magnesium hardness | " 19.3 | 13.5 | 17.2 | 20.1 |

ATLANTIC SALMON AND TROUT INVESTIGATION 1939

Report No. XVI. Salmon movement through the Margaree estuary.

By A. G. Huntsman

The problem of the availability of salmon for angling in a river such as the Margaree involves their movement from outer waters through the estuary. The Margaree estuary has a very narrow and shallow mouth, opening between two breakwaters and through or over an outer gravel bar. Tidal water extends inland a distance of about five miles from this mouth, but sea water does not reach much farther than the first mile, for which distance the estuary is quite broad, but shallow. At the end of this mile where the estuary narrows is situated the trap which fishermen operate in the fall to secure salmon for sale to the Fish Cultural Service.

Since salmon angling is allowed to continue in the Margaree river until October 15, the anglers have naturally had the idea that the operation of this trap, although purely for maintaining the stock of salmon, should be curtailed in order to provide a larger number of fish in the river for angling. This idea is based upon the view that the salmon taken in the trap are proceeding through the estuary and up the river and that angling is dependent upon a steady access of fish fresh from the sea.

This view, however, is of doubtful validity. In Great Britain, as is well known, salmon may remain for a long time in the tidal waters of an estuary before ascending the river. Some of those that have ascended the river may return to the estuary or even to the open sea

and be taken in coastal nets, and these are known as "droppers". The tagging of salmon in recent years in relation to some Canadian rivers has shown that those taken in the estuaries may remain there for considerable periods or may move into outer waters rather than up the river.

Salmon tagged and liberated from nets in the estuary of the St. Paul river, Quebec, in 1937 (see Belding and Prefontaine, Contr. Inst. Zool Univ. Montreal, No. 2, 1938, p. 44) showed about as much outward movement as inward movement and quite a number of the fish went well out (5 to 10 miles) to various points among the islands at or outside the river mouth, although they did not leave the region so far as any recaptures show. Similarly, salmon in the estuary of the Restigouche river in 1939 and 1939 moved outwards as well as inwards and some even went out into Chaleur bay for distances as great as over 50 miles. Salmon tagged in the season of 1938 in Saint John harbour, that is inside the mouth of the Saint John river, N. B. but in tidal waters, moved outwards into the bay of Fundy as well as into the river, and some were still out in the bay more than a month later.

Since it cannot be taken for granted that the salmon captured in the Margaree estuary are about to ascend the river, actual tests are necessary to determine whether or not those taken in the net for hatchery purposes in late September or October would otherwise contribute significantly to the angling catch. Such tests were carried out in 1938 and 1939 by the Fish Cultural Service tagging some of the fish taken and liberating them above the trap. As the netting on the outer coast ceased on August 15 in each year, there was no means of

ascertaining whether any of the fish left the estuary. They might be recaptured in the estuarial trap or they might be recaptured by anglers in the river above the head of tide.

In 1938 200 salmon were tagged and liberated on October 3 and 4 above the estuarial trap. Eleven of these were recaptured, three in the trap, and eight by anglers in the river at various pools up as far as the Forks during the remainder of the season, from October 5 to 15. During this period 89 salmon were reported by guardians as taken in the river by angling, with details of the pools, anglers and weights of the fish. Previous study has given reasons for believing that the guardians get information on only ^a part, perhaps around 25% of the fish taken and, indeed, their records fail to show five of the tagged fish that were recaptured in angling. Reports of recaptures of the tagged fish may also be incomplete, but so far as we can judge from thorough inquiry, very few are unreported. The available facts give the result that 200 salmon liberated in the estuary instead of being taken for hatchery purposes gave 8 fish out of 94 (89+5) taken by the anglers during the remaining eleven days of the season, that is they increased the catch 9%, and it may be that the increase was really less than 3%, if the total catch were known.

The contribution of the liberated salmon of the estuary to the angling catch would evidently have been less had it not been for a marked freshet in the river on October 1 and 2, which was subsiding as they were liberated. Of 97 liberated the morning of October 3, 6 were taken by anglers, one as far up as the Forks pool on October 5, and also another on October 6, but none higher up although caught as late as October 13. Of 60 fish liberated the afternoon of October 3, only

one was recaptured in the river, and again of 43 liberated on October 4, only one was recaptured. Both of these were not very far above the head of tide (McDaniel pool). Also the three recaptured in the estuarial trap were of those liberated on the afternoon of October 3 and on October 4, not of those of the forenoon of October 3. It is evident, therefore, that those liberated closely after the freshet went up river in larger proportion and farther and so were chiefly responsible for the contribution to angling as compared with those liberated later.

In 1939, 220 salmon were tagged and liberated above the trap from September 9 to October 9. Of these 37 were recaptured, 27 in the trap and 10 by anglers in the river. The angling recaptures were all in October and from 3 to 16 days after liberation. On the whole the earlier they were liberated, the larger was the percentage taken by anglers, 38 liberated from September 19 to 27 giving 2 or about 8% recaptured by anglers, 61 liberated from September 28 to October 1 giving 4 or about 7%, and 121 liberated from October 2 to 9 giving 3 or only about 2½%. This was in spite of the fact that there were more favourable freshets toward the end of the season to take the fish up.

The effect of a freshet in taking fish up and making them available to anglers is shown by the percentages recaptured in angling of those tagged on successive days in relation to a moderate freshet on September 27. The data are given in the following table.

| Dates in September and October | 26 | 27 | 28 | 29 | 30 | 1 | 2 | 3 |
|------------------------------------|-----|------|-----|-----|-----|-----|-----|-----|
| Discharge at Frixzleton (sec./ft.) | 190 | 438 | 363 | 324 | 282 | 262 | 270 | 223 |
| No. tagged and liberated | 12 | 14 | 11 | 27 | 20 | 3 | 8 | 17 |
| No. recaptured in angling | 0 | 2 | 1 | 2 | 1 | 0 | 0 | 0 |
| Percentage so recaptured | 0 | 14.3 | 9 | 7.4 | 5 | 0 | 0 | 0 |

It will be apparent from the table that with the freshet (the discharge of the river more than doubling) the percentage taken up the river in angling rises abruptly to a rather high figure and gradually drops as the freshet subsides.

That the salmon were moved up out of the estuary to a greater extent during this freshet than before or after is evidenced by the percentages recaptured in the estuarial trap. Of 24 fish liberated before (from September 19 to 26) six or 25% were so recaptured; of 72 fish liberated while the freshet was acting (September 27 to 30) five or 7% were so recaptured; and of 124 liberated after (October 1 to 9), sixteen or 13% were so recaptured. Clearly the freshet reduced the number in the estuary available for subsequent recapture. The likelihood of recapture of those remaining in the estuary would decrease as the trapping season progressed, since they would be exposed to recapture for a shorter and shorter period; yet the percentage nearly doubles after the freshet.

Previous to October 1, 98 tagged salmon had been liberated in the estuary. During October, that is from October 1 to October 15, when the angling season terminated, 76 salmon were taken by angling as reported by Inspector Murphy (the guardians list 67). During this period 7 of ^{the} 98 salmon were reported recaptured in angling. They did not form more than 10% of the fish taken, and, if the total catch were known, it might prove that they formed a much smaller percentage.

The salmon recaptured in the estuarial net should perhaps be called "droppers", since they would have to drop seaward in order to be recaptured. That such a large percentage (12% of all those liberated) did drop back is noteworthy. How many dropped back and failed to

re-enter the trap cannot be known.

The following conclusions may be safely drawn as to the movements of salmon in the Margaree estuary during the latter half of September and the first half of October, in relation to angling.

(1) They move both riverward and seaward.

(2) To the extent to which they remain in the estuary or move seaward they are unavailable for angling.

(3) With progress of the season the likelihood of their being available for angling diminishes.

(4) Even of those in the estuary in September only about eight out of a hundred are likely to be caught by anglers.

(5) A freshet sets upon those in the estuary at the time, taking them upriver and making a larger proportion of them available for angling.

Presumably the desire is to have the estuarial trap operated so as to ensure a sufficient number of salmon for hatchery purposes, and yet not to operate the net when there is a good chance of the fish ascending the river and contributing significantly to the angling catch. The two objects need not conflict to any great extent.

To ensure the requisite number of salmon for stipping, past experience is undoubtedly the best general guide as to the time when the trap should be started fishing. It is possible that study of the coastal net catch of the current season and of the river discharge during the third and fourth previous summer seasons would give a good idea as to the relative abundance of the stock upon which the catch for the particular year must depend. The most important thing, however, is to see that the trap is in operation when the salmon are entering

the estuary from the gulf in large numbers. This has been shown (Huntman, Bull. Fish. Res. Bd., No. 57, 1939, pp. 51-56) to occur when there is a sharp freshet out from the estuary (as a result of a downpour over the estuary, as well as with a sudden descent of such water from up river) and particularly with northerly wind as a general freshet is subsiding.

It becomes important to permit salmon to ascend and be available in significant numbers for angling when there have not previously been the conditions favouring entrance and ascent of the salmon, that is when there are few salmon already up the river. Given such a situation, it would be desirable to render the trap inoperative when a fair freshet descends the main river ~~the main river~~ into the estuary and for perhaps two days thereafter.

ATLANTIC SALMON AND TROUT INVESTIGATIONS 1939

Report No. XVII. Local Temperature Differences in Moser
River, 1939.

By A. Colin Nicol

1. Time 9-11 a.m. Weather: clear and bright. June 5

Mill lake (dam) 17.8

Mill lake brook (trap) 17.8

Pool on Mill lake brook below bridge 16.5-17.0

Springs draining into this pool 9.9, 10.8

| Main river | East bank | Channel | West bank |
|---------------------|-----------|------------------------|-----------|
| Thermograph | 16.8 | 17.0 | 17.1 |
| Mouth of Mill brook | 16.9 | 17.0 | 17.9 |
| Foot of Claybank | 17.2 | 18.2 | 18.2 |
| Pye's | 17.3 | 17.4 | 18.2 |
| Woodem's | 17.3 | 17.4, 17.5, 18.2, 18.8 | |
| Head of island | 17.9 | 17.7 | 18.4 |
| Miller's | 18.0 | 18.0, 18.8, 19.0 | |
| Bridge | 17.8 | 18.0, 18.2 | 18.4 |
| White's | 18.1 | 18.3 | 18.4 |
| Sharp's | 18.1 | 18.5 | 18.8 |

Thermographs 9-11 a.m.

Main river (trap) 17.0-19.2

Mill brook 17.8-18.4

2. Time: 2.30-3.10 p.m. Weather: clear and bright. June 10.

Mill lake (dam) 16.1

Mill lake brook (trap) 16.2

Mill lake brook (mouth) 16.8

| Main river | East bank | Channel | West bank |
|---------------------|-----------|---------|-----------|
| Thermograph | 20.7 | 20.3 | 19.8 |
| Mouth of Mill brook | 20.7 | 20.2 | 17.0 |
| Foot of Claybank | 20.7 | 20.3 | 17.2 |
| Pye's | 20.7 | 19.9 | 18.7 |
| Wooden's | 20.9 | 20.2 | 19.2 |
| Miller's | 21.1 | 20.0 | 20.0 |
| Bridge | 20.7 | 20.1 | 20.0 |
| White's | 20.5 | 20.2 | 20.2 |
| Sharp's | 20.8 | 20.4 | 20.1 |

3. Time: 4-5 p.m. Weather: clear and bright. June 10

| | |
|--------------------------|------|
| Mill lake brook (bridge) | 16.7 |
| Mill lake brook (mouth) | 16.8 |

| Main river | East bank | Channel | West bank |
|---------------------|-----------|---------|-----------|
| Rapids above trap | 20.0 | 20.0 | 19.2 |
| Trap | 20.2 | 20.0 | 19.3 |
| Thermograph | 20.4 | 20.0 | 19.2 |
| Mouth of Mill brook | 20.4 | 20.0 | 17.0 |
| Foot of Claybank | 20.4 | 20.0 | 17.0 |
| Pye's | 20.2 | 19.4 | 17.9 |
| Wooden's | 20.2 | 19.8 | 18.5 |

4. Time: 12.30-1.30 p.m. Weather: clear and bright. June 11.

| | |
|--------------------|------|
| Mill brook (trap) | 18.5 |
| Mill brook (mouth) | 19.0 |

| Main river | East bank | Channel | West bank |
|---------------------|-----------|---------|-----------|
| Rapids above trap | 20.0 | 20.0 | 20.0 |
| Thermograph | 20.8 | 20.4 | 20.4 |
| Mouth of Mill brook | 20.8 | 20.4 | 19.8 |
| Pye's | 20.4 | 20.8 | 21.0 |

| Main river | East bank | Channel | West bank |
|------------|-----------|---------|-----------|
| Wooden's | 20.9 | 20.6 | 21.4 |
| Miller's | 21.4 | 20.9 | 21.6 |
| White's | 21.1 | 21.0 | 21.4 |
| Sharp's | 21.2 | 21.2 | 21.2 |

5. Time: 11.30 p.m.-12.30 a.m. June 11.

Mill lake brook (bridge) 17.0

Mill lake brook (mouth) 17.0

| Main river | East bank | Channel | West bank |
|---------------------|-----------|---------|-----------|
| Hydrograph | 17.4 | 17.7 | 17.6 |
| Mouth of Mill brook | 17.6 | 17.8 | 17.6 |
| Foot of Claybank | 17.6 | 17.7 | 17.0 |
| Pye's | 17.3 | 17.8 | 17.0 |
| Wooden's | 17.4 | 17.4 | 16.9 |
| Miller's | 17.0 | 17.3 | 17.0 |
| Bridge | 17.3 | 17.3 | 17.0 |
| White's | 17.0 | 17.3 | 17.1 |
| Sharp's | 16.9 | 17.3 | 17.0 |

Discussion

In the extent examined (first cascades above the trap to tide water below the bridge), Moser river shows a fluctuating temperature closely dependent upon solar radiation. The water slowly heats during the morning, reaches its maximum temperature between 2-3 p.m., and then cools off again until a low is reached during early morning. On cloudy days its temperature rise is much less marked.

During the day, flowing water in the centre of the river has a lower temperature than the relatively stagnant water towards the

banks, with the exception noted below. This effect may, in part be due to evaporation as the water passes over the numerous cascades in the river. The slower water towards either bank will, on the other hand, tend to be heated to a greater extent by the sun. At night, the channel water is slightly warmer than shore water. The effect of the stills in the upper reaches of the river is here evident; these still waters will alter their temperature but slowly; water passing down stream will be slowly cooled but more particularly towards either bank where the current is slow and its exposure to colder air longer.

There is a marked contrast between the temperatures of the two sides of the river on sunny days, however, which may be as high as 1.2°C. This effect is most pronounced during late morning and late afternoon and is due to differential illumination of the two banks. The river runs largely north and south and during the morning the east bank is relatively shaded and its temperature lower than that of the west bank and even the main channel owing to its slower current. These conditions are reversed during the afternoon, a period of equilibrium being reached between 12 to 1 p.m. when the temperature across the whole river is rather uniform. During the afternoon uniformly cool water was found to extend out from the west bank for a distance of approximately twelve feet, slowly heating from that distance to the east shore where the maximum temperatures were reached.

The effect of Mill brook on the temperature of the river is very slight and transitory. Its temperature during the day is somewhat lower than that of the main river and it tends to lower the temperature of the west bank for about 300 yards downstream, after

which its effect is not noticeable. The volume discharge of Mill lake brook is only about one tenth that of the main river (25 cu. ft./sec. as compared with 275 cu. ft./sec. for the river) which accounts for the unimportant role it plays in regulating the river temperature.