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JUVENILE SALMON IN THE ESTUARY AND LOWER NABISIPI RIVER AND SOME RESULTS OF TAGGING

par

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Juvenile Salmon in the Estuary and Lower Nabisipi River and Some Results of Tagging[1,2]

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ABSTRACT

Morphometric and hydrographic conditions indicated Nabisipi River, Quebec, has a fjord-type estuary with warm surface water of low salinity flowing out over cold saline water from the Gulf of St. Lawrence at all phases of the tidal cycle. The age, weight, and condition factors of 231 juvenile salmon from the estuary and 200 from the lower reaches of the river are given. Ages ranged from 1+ to 4+, condition factors (100 × weight in grams divided by the length in centimeters cubed) were slightly below 1.0 in the river and slightly higher in the estuary. Amphipods and capelin eggs were important constituents in the diet in the estuary, Corixidae in the river. Tagging indicated a growth rate of about 0.8 mm/day in the estuary. Both tagging and the handling of marked fish retarded growth. Tagging retarded growth for approximately 20 days. Tagging returns indicated a population of between 700 and 2500 fish near the mouth of the estuary in June and July 1961. These were thought to be remnants of the spring smolt run. In addition there was a small resident population of salmon parr living in the estuary. Numbers of fish in the estuary changed considerably from year to year.

SOMMAIRE

Selon les relevés morphométriques et hydrographiques, la rivière Nabisipi possède un estuaire en forme de fjord dont les eaux de surface, chaudes et de basse salinité, s'écoulent en tout temps de la marée audessus des eaux froides et salines du golfe Saint-Laurent. La détermination de l'âge, du poids et du coefficient de condition de jeunes saumons capturés dans l'estuaire (231) et dans la partie basse de la rivière (200) révèlent que l'âge varie de 1+ à 4+ et que les coefficients de condition sont légèrement plus bas que 1.0 dans la rivière et légèrement plus haut dans l'estuaire. Dans l'estuaire, amphipodes et oeufs de capelan constituent une part importante du régime alimentaire, alors que dans la rivière ce sont les Corixidae. Dans l'estuaire, l'étiquetage indique un taux de croissance de 0.8 mm par jour. L'étiquetage des jeunes saumons et leur manipulation subséquente influent sur leur croissance. L'étiquetage retarde la croissance pendant une vingtaine de jours. En juin et juillet 1961, les recaptures de poissons étiquetés indiquent une population variant entre 700 et 2500 individus. On croit que ces poissons faisaient partie de la migration printanière des saumonneaux. De plus, il y a une petite population de jeunes saumons vivant dans l'estuaire. Le nombre de poissons à cet endroit change considérablement d'année en année.

INTRODUCTION

In 1960 the Quebec Department of Fish and Game established a research station in the estuary of the Nabisipi River which flows into the north shore of the Gulf of St. Lawrence about 180 miles east of Sept-Iles (Bourassa, 1963).

[1]Received for publication January 26, 1966.
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The river is about 100 miles long and has a mean annual rate of discharge of about 2750 ft^3/sec. The purpose of the station is to find means of improving stocks of Atlantic salmon (*Salmo salar* L.) in north shore rivers. Preliminary observations in 1960 indicated there was a large population of rapidly growing salmon parr in the estuary and these fish were felt to be important because they might influence the salmon producing capacity of the river. Work was undertaken in 1961 to obtain data on the age and growth of parr living in the estuary. In addition information was gathered on sex ratios and feeding habits. A tagging program was started in 1961 and continued in 1962. In this report the preliminary results of the 1961 tagging only are considered, because these are pertinent to a consideration of the status of stocks of salmon parr present in the estuary that year.

MATERIAL AND METHODS

Description of the Estuary

The estuary is 9000 ft long and averages 425 ft wide. There is a 40-ft waterfall at its head and the other extremity is marked by a bar in the river mouth over which there is a maximum depth of 6.5 ft at mean water level. The channel is relatively deep, with steep rocky sides except in a few sheltered places and at the mouth where there are sand beaches. Depths of over 10 ft are commonly encountered within 25 ft of the shore. Figure 1 shows estuary with depth countours, at mean water level, in 5-ft intervals. For clarity the east–west scale of the chart is twice that of the north–south. The bed of the estuary is composed largely of bare rock and sand. Mud and gravel are present in some places. Rooted aquatic vegetation (*Potamogeton* sp.) is restricted to a few shallow areas.

There is a well-marked thermal and chemical stratification of water in the estuary. Stratification remains stable throughout the tidal cycle and probably over a wide range of river discharge. While the tide is rising a wedge of cold, highly saline water enters the estuary by flowing over the bar in the river mouth and penetrates to its head. During the summer the temperature of this water varies from 3 to 9 C. The salinity is between 20 and 28‰. Above this is a layer of water approximately 5 ft thick which separates a surface wedge of warm brackish river water from the underlying sea water. The change in salinity across this discontinuity layer is at least 15‰ while the variation in temperature in summer exceeds 5 C degrees. The upper wedge of water has a salinity between 1 and 6‰ and a temperature of 15–17 C. There is a constant surface current flowing out of the estuary with a midstream velocity of between 6 and 12 inches/sec. The velocity varies in different parts of the estuary and is possibly influenced by the tide and the wind. As the tide falls, the wedge of cold, saline bottom water retracts allowing the other layers to settle at a lower level. Minor differences due to seasonal variations in temperature and runoff will affect conditions during the early and late parts of the season. The overall pattern may remain the same throughout the year, as

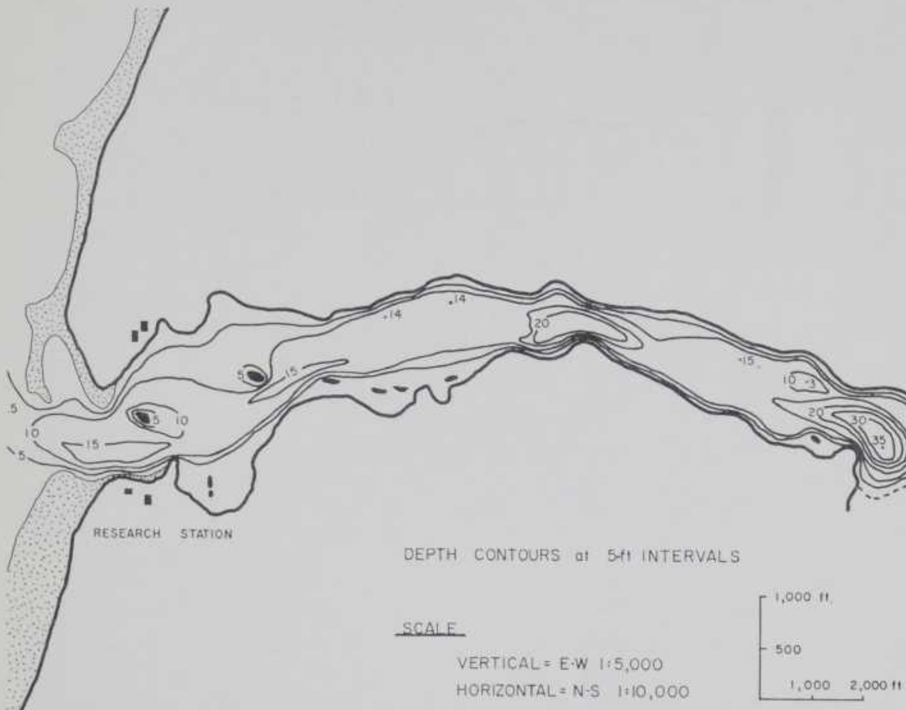

FIG. 1. Chart of the Nabisipi estuary.

salinity differences are probably sufficient to maintain the equilibrium of the water masses during winter, when temperature differences will disappear or even be reversed.

TAGGING

Between May 26 and August 21, 797 juvenile salmon were marked with numbered orange Carlin tags in the estuary of Nabisipi River. The fish were caught in a large 0.75-inch-mesh seine operated from sand banks near the mouth of the estuary and occasionally in other suitable locations. They were carefully transferred to 10-gal plastic tanks and held in these until tagged. The tags were attached by stainless steel wire threaded through the basal cartilages at anterior ends of the dorsal fin. The fork length of each fish was recorded in millimeters. Immediately after tagging the fish were released from the beach in front of the research station, which is on the east bank of the estuary about 100 yards from the sea. During the summer 348 marked fish were recaptured, measured, and re-released. Some fish were handled as many as six times giving a total of 598 recaptures.

COLLECTION AND EXAMINATION OF FISH

An attempt was made to obtain three samples of 100 parr at 14-day intervals from the group of fish that were tagged in the marking experiment.

The first sample, obtained between July 20 and 22, was drawn from that group which could easily be recognized because about 50% of its members bore tags. Most tagged fish had disappeared from the seining areas by early August and were not encountered again during the remainder of the summer. Subsequent samples of parr were very difficult to obtain in the estuary. Fifty-six parr were examined between August 3 and 5, and 75 between August 17 and 21. Almost total absence of tagged fish from the catches at these times, coupled with a decrease in the average size of the catch, indicates these samples were not drawn from the original group.

Two samples of 100 parr were obtained from the lake-like section of Nabisipi River immediately above the falls at the head of the estuary. The first was taken between July 24 and 26 and the second 28 days later. The majority of these fish were captured along the edge of the river at night using a dip net and a lantern. It was found impossible to capture sufficient specimens using a small seine either by day or night. These fish were intended to provide data for comparison with the estuarine population.

Routine examination of each fish consisted of: measuring the fork length to the nearest millimeter, weighing to the nearest tenth of a gram, making note of the stomach contents, the sex, and the state of maturity. Scales for age determination were removed from an area of the back just anterior to the dorsal fin and above the lateral line. The scales were cleaned immediately and smeared onto cellophane folders. Prepared in this way, they are ready for direct examination.

RESULTS

Age, Size, and Condition

Interpretation of scales from the juvenile salmon proved to be difficult. In order to prevent bias in favour of clearer scales, which may belong to faster-growing fish, the age of every fish was estimated from its scale smear. Initially, only about 70% agreement between first and second estimates of age was obtained, but with practice agreement reached between 90 and 95%. With this level of correspondence, some confidence can be placed in the results.

The results (Tables I and II) show that it is best to treat each sample of fish individually. In the estuary, the size of fish in any particular age-group decreased between the first and second samples. Evidence from tagging showed the two groups of fish came from different populations. There was an increase in the size of the 1+ and 3+ age-groups, between the second and third samples, but the 2+ group, which was poorly represented, appeared to decrease in size. It is uncertain whether these samples can be regarded as having been drawn from the same population. In the river, two groups of parr were examined. During the 28-day period between samples, no increase in size can be demonstrated within age-groups and there was, if anything, a decrease in condition. This is difficult to explain unless it is again assumed that the two samples were obtained from different populations, or little or no growth occurred during the interval.

TABLE I. Age, length, weight, and condition of salmon parr from the estuary of Nabisipi River.

	Female					Male				
Age	No.	Mean length (*mm*)	SD	Mean weight (*g*)	Mean K	No.	Mean length (*mm*)	SD	Mean weight (*g*)	Mean K
July 20–22, 1961										
1+	13	87	6.5	7.4	1.12	11	84	7.4	6.9	1.15
2+	8	115	13.3	16.3	1.03	6	120	13.4	18.5	1.03
3+	35	138	16.1	27.8	1.02	20	142	19.2	30.3	1.02
4+	3	139	–	27.5	1.02	4	165	–	50.0	1.00
August 3–5, 1961										
1+	4	78	–	5.1	1.06	6	80	2.6	5.5	1.06
2+	7	100	12.3	10.9	1.03	3	121	–	17.8	1.00
3+	20	126	12.6	21.2	1.03	10	128	15.4	21.9	1.02
4+						6	138	15.3	27.6	1.01
August 17–21, 1961										
1+	15	100	9.7	10.4	1.02	9	94	11.0	8.9	1.07
2+	4	101	–	10.3	0.94	10	101	15.3	11.3	1.02
3+	19	139	11.4	27.6	1.02	15	137	10.5	27.7	1.07
4+	1	120	–	20.0	1.16	2	154	–	29.2	1.08
5+	1	143	–	29.5	1.01					

TABLE II. Age, length, weight, and condition of salmon parr from the lower reaches of Nabisipi River.

	Female					Male				
Age	No.	Mean length (*mm*)	SD	Mean weight (*g*)	Mean K	No.	Mean length (*mm*)	SD	Mean weight (*g*)	Mean K
July 24–26, 1961										
1+	8	73	5.0	4.6	1.19	5	79	2.8	5.6	1.15
2+	9	100	7.7	10.6	1.03	10	104	7.8	11.5	1.02
3+	38	112	6.6	14.1	0.99	27	111	7.6	14.1	1.02
4+	1	123	–	16.5	0.89	2	115	–	16.3	1.06
August 21–22, 1961										
1+	7	80	12.6	5.6	1.04	3	76	–	4.8	1.09
2+	9	101	7.0	9.9	0.95	7	106	13.3	11.6	0.95
3+	45	113	7.6	13.8	0.94	27	114	7.2	14.2	0.94
4+	2	119	–	15.0	0.90	1	109	–	12.5	0.97

When the length of parr taken in the lower reaches of the river is plotted against age, a curve is produced (Fig. 2) which indicates growth rate declined rapidly with increasing age. This is largely an artefact due to the fact that older age-groups consist mainly of slowly growing parr whose more successful siblings have migrated at an earlier age. This is a common phenomenon and has been well documented by Elson (1957). It is not possible to demonstrate the same effect in the estuary because the higher growth rate and heterogeneous background of the parr obscures the patterns.

Mean condition factors (K) for all groups of parr are given in Tables I and II. These have been calculated using the formula:

$$\text{mean K} = \frac{\sum \frac{100W}{L^3}}{N}$$

where W = weight in grams, L = length in centimeters, and N = number in sample.

In the river, condition factors are generally less than 1.0, and in the estuary slightly above 1.0.

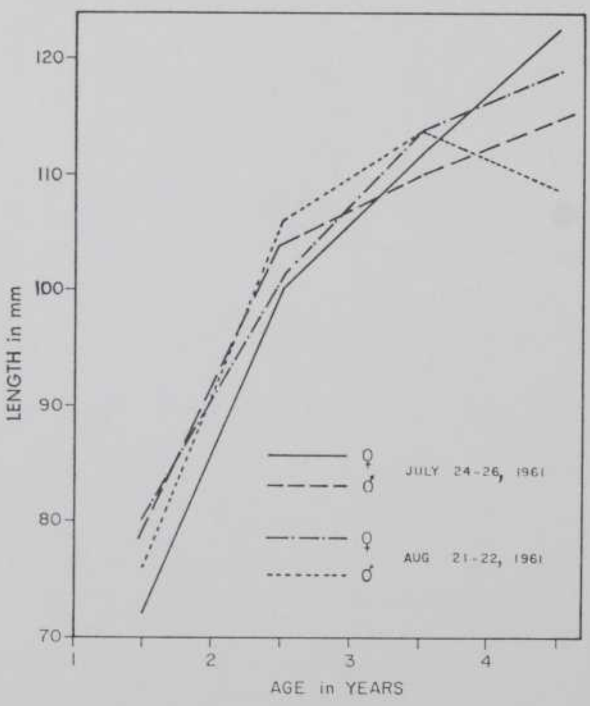

FIG. 2. Age–length relationship of salmon parr in the lower reaches of Nabisipi River.

Sex Ratios and Maturity

All information pertaining to sex ratios can be extracted from Tables I and II. A total of 432 parr were examined of which 249 or 57.6% were females and 183 or 42.4% males. This is broken down into age-groups in Table III.

Males predominate only in the 4+ age-group. Belding (1937) working in Newfoundland and Jones (1949) working in Great Britain, have both found that males tend to predominate in the oldest age-groups of parr.

All the parr examined during this investigation had undeveloped gonads. No males showed even a slight enlargement of the testes.

Diet

Routine examination of each fish included inspection of the contents of the stomach. Recognizable food organisms were noted and recorded with other data on the specimen. From each batch of fish, a representative sample of stomach contents was preserved in 5% formalin. These samples were later analysed in the laboratory to provide a more detailed inventory of the diet. The procedure adopte was as follows: Each sample was placed in a petri dish and floated out in water. It was examined carefully under a binocular microscope. In this way, almost all the food organisms could be identified, and listed so as to indicate the approximate order of abundance. Finally, an estimate was made of the percentage by bulk of each constituent in the sample, thereby giving an indication of the relative importance of each type of food.

Table III. Sex ratios of salmon parr in the estuary and lower reaches of Nabisipi River.

	Females		Males	
Age	Number	Percentage	Number	Percentage
1+	47	58	34	42
2+	37	50.7	36	49.3
3+	157	61.6	98	38.4
4+	7	31.8	15	68.2
5+	1			

The results are presented in two ways. Table IV summarizes the data obtained during routine inspection. The numbers opposite each food item indicate the number of stomachs in which this item was recorded. It is at once obvious that the diet of parr living in the estuary is not the same as that of parr in the river. Different food organisms are available to the two groups and this is reflected in the feeding habits. Table V gives the results of analysis

TABLE IV. Frequency of occurrence of food organisms recognized during routine examination of stomachs of salmon parr.

	Estuary			River	
No. of stomachs examined:	100 (July 20–22)	56 (Aug. 3–5)	76 (Aug. 17–21)	84 (July 24–26)	59 (Aug. 21–22)
Unidentified insects	11	22	...	67	41
Calypterate Diptera	15	5	...	2	...
Chironomids	12	2	5	13	...
Corixidae	1	...	...	15	25
Terrestrial Coleoptera	1	...	...	2	...
Ephemeroptera	...	...	...	6	...
Plecoptera	...	...	...	4	...
Homoptera	...	...	...	6	...
Lepidoptera	...	...	...	3	1
Hymenoptera	...	...	...	2	...
Trichoptera	...	...	...	1	2
Amphipoda	9	24	64	...	...
Mysidacea	...	6	1	...	...
Mollusca	...	1	...	...	2
Capelin eggs	57	3	...	...	...
Fish remains	3	3	2	...	...
Sticklebacks	...	...	3	...	...
Unknown	7	...	1	...	...
Empty	11	2	5	...	2

TABLE V. Analysis of the diet of salmon parr showing the percentage by bulk of various items in representative stomach samples.

	Estuary			River	
	July 20–22	Aug. 3–5	Aug. 17–21	July 24–26	Aug. 21–22
Corixidae	...	...	...	31.4	69.6
Chironomid larvae	4.2	7.5	1.5	2.4	0.8
Chironomid pupae	...	9.0	6.0	0.9	0.6
Chironomid imago	0.3	...	...	3.7	...
Calypterate Diptera	16.5	4.5	...	7.9	10.0
Calypterate larvae	6.2	...	...	...	...
Terrestrial Coleoptera	...	...	...	6.4	1.0
Coleoptera larvae	...	0.1	...	...	...
Ephemeroptera nymph	...	...	...	18.6	...
Ephemeroptera imago	...	...	...	...	1.0
Trichoptera larvae	...	0.8	...	3.6	4.0
Trichoptera imago	...	...	...	16.3	...
Lepidoptera	...	...	...	...	5.0
Homoptera	...	0.4	...	7.4	2.0
Plecoptera imago	...	...	...	...	1.0
Hymenoptera	...	0.5	1.0	...	2.0
Simulium larvae	...	0.2	...	...	...
Total insects:	27.2	23.0	8.5	98.6	97.0
Arachnida	...	...	...	1.4	...
Mysidacea	...	31.7	...	...	...
Amphipoda	0.3	40.0	91.5	...	...
Gastropoda	...	1.8	...	...	3.0
Capelin eggs	47.5	0.5	...	...	...
Ammodytes	25.0	3.0	...	...	...
Total others:	72.8	77.0	91.5	1.4	3.0

of stomach samples. A more detailed list of constituents of the diet is presented. The overall picture is the same.

An observation not demonstrated in the tables is that parr in the estuary have a greater quantity of food in their stomachs than those in the river. This is certainly related to a greater abundance of food in this habitat. Amphipods are particularly plentiful and parr in the estuary are often gorged with them. In the river, although almost all stomachs examined contained some food, many contained only a small amount. It should be emphasized, however, that the lake-like section of river immediately above the estuary is not typical salmon habitat. The bottom is mostly muddy with grass growing along the banks, and the current is slight. Corixids, which form the major constituent of the diet of parr in this section of the river, are typically pond-dwelling insects and are not normally available in quantity for salmon to feed on. Stream-dwelling insects are probably more abundantly represented in the diet of parr in other parts of the river.

Growth Rate of Tagged Juvenile Salmon

All tagged fish are referred to as juveniles with no attempt to distinguish between parr pre- or post-smolt stages. All were above 10 cm in length, and most had the appearance of parr or pre-smolts. A few were smolts. Biologically perhaps all of them should be considered smolts. The growth curves of all fish recaptured more than three times (Fig. 3) show a variety of growth rates from zero, over intervals of a few to several days, to a high rate: 19 mm for one fish in 10 days, and 8 mm in 5 days for another. The average rate for all the fish included in this figure is 0.53 mm/day. A number of fish which were handled frequently grew only slowly and some others grew slowly at first but more rapidly later, indicating that tagging and frequent handling has an adverse effect on growth.

Effect of Tagging on Growth

The first few days after tagging, normal behaviour of young salmon is upset. What happens is not known but the chances of recapturing a tagged fish during the first 4 days after release are considerably less than during the subsequent 4 days. In Fig. 4 the interval between tagging and first recapture is shown for 335 of the 348 fish recaptured at least once. Thirteen fish are excluded because of incomplete data. Most fish are recaptured for the first time 6, 7, or 8 days after tagging. It seems that immediately on being released after marking, a fish avoids the normal feeding and swimming activities of the other juvenile salmon, until it has recovered from the operation and adjusted to the presence of the tag. After about 4 days it begins to participate in normal activities again and is vulnerable to recapture. During the period of adjustment the growth rate is reduced. In Fig. 5 the daily growth increment and the total increment are plotted against the interval between tagging and first recapture for the 335 fish in Fig. 4. The points on the graph are means over 3-day intervals. The

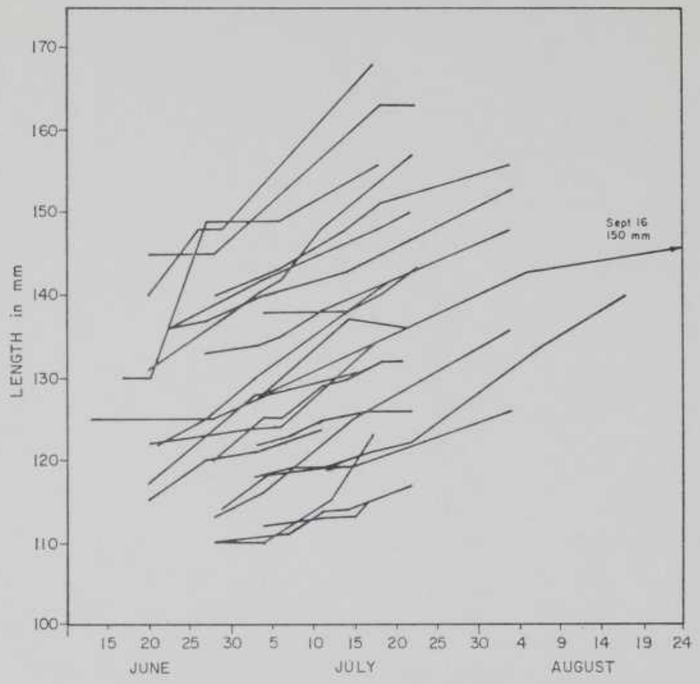

FIG. 3. Growth curves for all tagged juvenile salmon recaptured more than three times (Nabisipi estuary 1961).

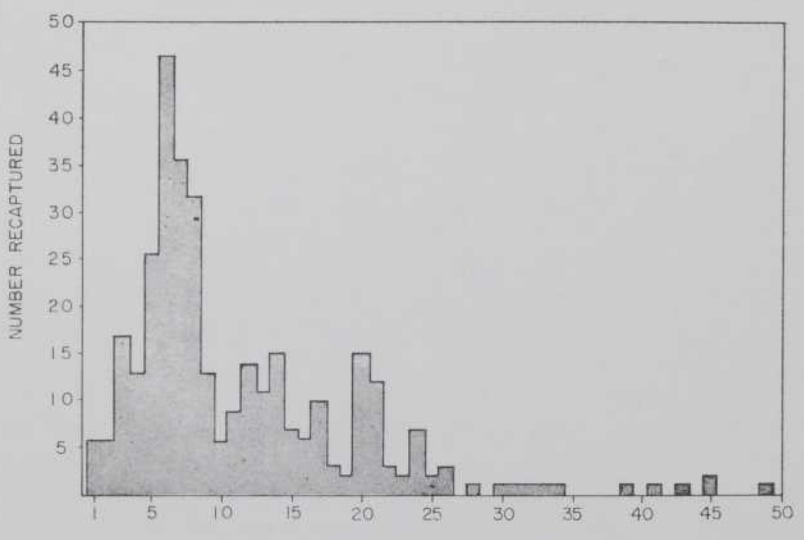

FIG. 4. The interval between tagging and first recapture for juvenile salmon tagged in Nabisipi estuary, June and July 1961.

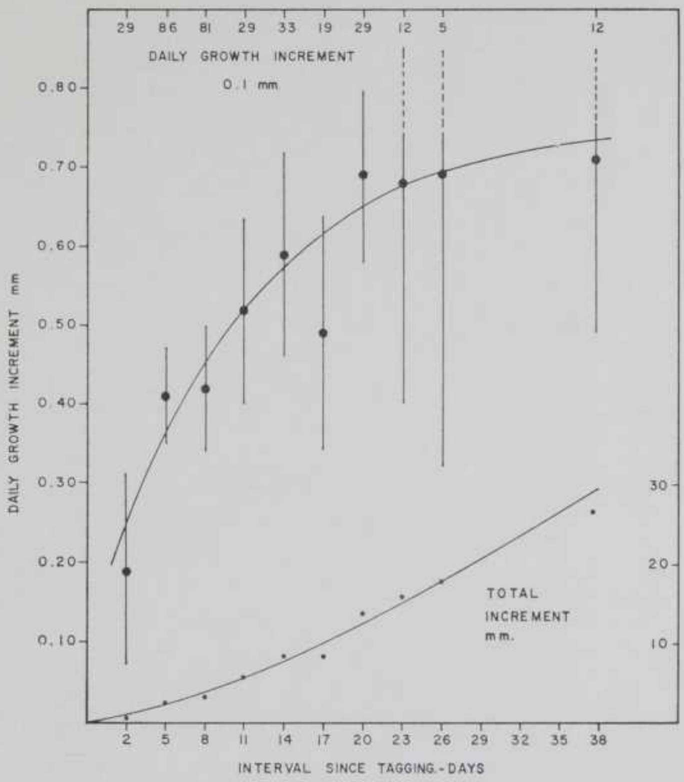

FIG. 5. Daily growth increment, and total growth increment for young salmon tagged in Nabisipi estuary in 1961. The number of measurements for each interval is given along the top of the figure; vertical lines on either side of the points on the curve for daily increment mark the 95% confidence intervals about the means.

curves are drawn freehand. The number of measurements included in each point are given along the top of the graph. Confidence intervals at the 95% level of probability are shown as vertical lines on either side of the means for the daily increment. The confidence intervals are widely spaced because there is a great deal of variation in the growth rates of individual fish and in their reaction to tagging. The confidence intervals, however, confirm that the trends shown in the graph are quite reliable.

Daily growth increments increase as the interval between tagging and first recapture lengthens to about 20 days, when the increment is 0.7 mm/day. This increment presumably approaches the rate of growth of undisturbed fish in the population, which during the period of June and July may grow about 0.8 mm/day. A 120- or 130-mm parr that enters the estuary in early June will grow to a size of 170–180 mm by August and, if it remains in the estuary much longer, may exceed 200 mm in length. In 1960 some fish of this size were caught in the estuary in late August so that a growth rate of 0.8 mm/day seems to agree with observations. This increment is higher than the average of 0.53 mm/day for the multiple recaptures (Fig. 3). Some of the difference is probably the result of handling which, like tagging, reduces the growth rate of the fish.

Effect of Handling on Growth

To show the effect of handling, the adverse effect of tagging must be eliminated. By leaving an interval of 18 days between tagging and first handling the number of observations is reduced to 46, but it is hoped the effect of tagging will be removed. In order to test the effect of frequent handling, contingency tables have been prepared which clearly indicate an association between frequent handling and small daily growth increments. Table VI shows the association between handling at intervals of less than 5 days with growth increments of

Table VI. Contingency tables showing the association between frequent handling and poor growth of tagged juvenile salmon.

Handling at intervals of	Daily growth increment (*mm*)		
	<0.4	>0.4	Totals
Less than 5 days	16	5	21
More than 5 days	7	18	25
Totals:	23	23	46
$\chi^2 = 10.6$ P is less than .005			
Less than 10 days	23	7	30
More than 10 days	3	13	16
Totals:	26	20	46
$\chi^2 = 14.2$ P is less than .005			

less than 0.4 mm/day and the same association when the interval is extended to less than 10 days. In both cases the value of Chi-squared with one degree of freedom gives a probability of less than .005 and it must be concluded that frequent handling is associated with small growth increments. While it is not possible to express the effect of handling in reliable numerical values, an indication of the effect can be obtained from the following figures. Thirty fish handled at intervals of less than 10 days (mean interval 4.1 days) had a mean daily increment of 0.29 mm and 16 fish handled at intervals of 10 or more days (mean interval 20.25) had a mean daily increment of 0.52 mm.

Estimate of Size of Population

One of the aims of the tagging experiment was to determine the number of juvenile salmon over 100 mm in length resident in the estuary of Nabisipi

River. For a number of reasons this could not be done except in a very general way. The major sources of potential error were: the possibility that the group of salmon in the estuary was not stable, that tagged fish behaved differently than untagged fish, at least for a few days following marking, and the fact that returns from tagging on different days varied considerably. Eight estimates of the population, using results from days when it was felt that over 30 fish had been successfully tagged and adequate recaptures accumulated, range from 741 to 2525. Combined results for these days gives an estimated population of slightly over 1000. This is felt to be a fair estimate of the number of young salmon over 100 mm in length resident near the mouth of the estuary of Nabisipi River in June and July 1961. There were more salmon in the estuary than this. Seining in other parts of the estuary produced a few salmon parr, but the numbers were insignificant compared with the concentration found near the mouth.

DISCUSSION

Before deciding whether stocks of young salmon living in the estuary of Nabisipi River can influence the salmon-producing capacity of the river it is worth considering the origin of these fish. Hydrographic and physical conditions preclude the possibility of salmon spawning in the estuary. Physical conditions make it probable that no spawning occurs in the lake-like section of river immediately above the estuary. It is unlikely that any spawning occurs in the falls separating the estuary from the rest of the river. It must be concluded that most of the young salmon in the lower reaches of the river and estuary have migrated there from spawning areas farther up stream. The predominance of 3-year-old fish in these parts of the river suggests that this is the most mobile age-group. Many are fish which, judging by their size, just failed to become smolts in the spring or are on the point of becoming smolts. Scales of 844 adult salmon taken in the estuary of Nabisipi River in the years 1960–64 show that 32% of them migrated after 3 years in the river and 56% after 4 years. In view of this, it seems probable that the majority of the 3-year old parr in the river spend another winter in fresh water before migrating, whereas it is likely that those already in the estuary migrate the same year.

It appears probable that two kinds of young salmon were encountered in the estuary in 1961. The stock that was tagged, and from which the sample of July 22–23 was drawn, is part of the spring run of migrants from the river which have remained in the estuary because of favourable conditions or because they had not completed metamorphosis. In addition, there is a small resident stock of salmon parr in the estuary which has moved or been accidentally washed into the estuary from the river. Parr of this type populating the estuary of the Margaree River were described by Huntsman (1945). He quotes unpublished data by P. F. Elson which indicate freshets are important in stimulating downstream movement but that some downstream movement of parr occurs in the absence of this stimulus.

The number of juvenile salmon in the estuary of Nabisipi River changes considerably from year to year. In 1960, the sand spit across the western part of the estuary was well developed and a large population of young salmon was present in the estuary into late August. The summer of 1960 followed severe flooding in the river. In 1961, the number of young salmon in the estuary was considerably reduced and the number diminished still more in 1962. It is possible that 1960 was an unusual situation resulting from the floods. Alternatively, spring migrants may remain much longer in the estuary in certain years, perhaps being influenced by the degree of impoundment provided by the sand spit. This could result in the situations observed during the years 1960–62.

It is concluded that, although the estuary provides a suitable habitat for young salmon, it is certain the number maturing there is insignificant compared with the number in the rest of the river. The estuary may be a temporary haven for partly metamorphosed smolts during the early summer, until they are physiologically ready to move off into the sea. There appears to be an ample supply of food and young salmon grow well in this habitat. They do not, however, grow well enough to excite the possibility of deliberately introducing young salmon into the estuary, or trying to delay the departure of young salmon arriving there normally. In contrast to the estuary it seems that the lower reaches of Nabisipi River are not productive salmon water. The stock of young salmon is low, the stomachs of parr living there contain little food, and their condition factors appear low.

The tagging experiment designed to provide information on the numbers of young salmon in the estuary and on movements of Nabisipi fish produced some interesting data on the effects of tagging on behaviour and growth of young salmon. As far as is known this is the first time this has been demonstrated in a salmon-marking experiment in the field. Mills (1958), on the basis of a few results obtained in a hatchery, concluded that tagging had little effect on the growth of salmon parr. Our results show that, while tagging can give a general indication of the growth rate of wild fish, the rate will always be low compared with untagged fish, particularly if there is frequent handling. For intervals of time in excess of 4 weeks the rate approaches that of unmolested fish. Only when the interval is long will the effect of tagging become negligible.

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