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Preliminary observations on the influence of smolt size on tag return rate and age at first maturity of Atlantic salmon (Salmo salar)

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SUMMARY

The influence of smolt size on tag return rates and age at first maturity is examined for 3 groups of hatchery-reared smolts released in the Miramichi River and 2 groups of wild smolts tagged in the same river.

Tag return rates increased with increasing smolt fork length up to 19 cm within groups of hatchery-reared and wild Atlantic salmon smolts. A positive relationship between smolt size and age at first maturity was observed for hatchery-reared smolts, but no significant relationship was evident from the results of wild smolt tagging. Within groups of 2-year-old hatchery-reared smolts, slower-growing fish tended to mature at an earlier age than did the faster-growing individuals. The dominance of some factor other than rate of growth in fresh water is also discussed, as 1 of 3 hatchery-reared groups produced very few grilse, despite the relatively small size of the smolts.

INTRODUCTION

As part of a program to increase their effectiveness, Atlantic salmon hatcheries in the Maritime Provinces of Canada are rearing larger smolts each year, often at the expense of numbers. Carlin (1968) and Peterson (1971) report that the rate of tag return for salmon smolts released from Swedish hatcheries is positively correlated with smolt size, but this relationship has never been well documented for Canadian-produced Atlantic salmon smolts. Similarly the influence of smolt size on the age at which anadromous salmonids mature is reported for hatchery-reared steelhead trout (*Salmo gairdneri*) (Wagner, 1967) on the west coast of North America, but not reported for hatchery-reared Atlantic salmon other than by Allen (1967) who states that the larger hatchery-reared smolts may be producing relatively fewer grilse than the smaller smolts.

This paper presents preliminary data on the relationships between smolt size and rate of tag return and smolt size and age at first maturity for 3 groups of hatchery-reared smolts and 2 groups of wild smolts. Data for the wild smolts are presented here for comparison.

Individual fork lengths to the nearest 1 mm were recorded with corresponding tag numbers at time of tagging for 18,750 hatchery-reared Atlantic salmon smolts. The hatchery-reared smolts were of 3 distinct stocks and all were released shortly after tagging in the southwest Miramichi River at Boiestown, New Brunswick, during the spring of 1968. Similarly, fork lengths were recorded for 5790 wild smolts trapped and tagged in the estuary of the Miramichi River at Millbank, New Brunswick, in 1968 and 1969. Smolts were tagged with the small (4.2 x 14.2 mm), modified Carlin-type tag (Saunders, 1968) attached with polyethylene monafilament. Hatchery-reared smolts were transported by tank truck from the rearing stations and released directly into the river while wild smolts were released after tagging back into the river at the point of capture. Background information on each group of tagged smolts is summarized in Table 1.

Table 1. Background information on the 3 groups of tagged hatchery-reared Atlantic salmon smolts and on the 2 groups of wild smolts. Age of hatchery-reared smolts was 2 years while age of wild smolts was 2, 3, and 4 years.

Group	Tagging Date	Release Date	Mean Fork Length (cm)
Restigouche stock Hatchery-reared	May 15-23, 1968	May 29-June 3, 1968	19.1
Miramichi stock Hatchery-reared	May 7-15, 1968	May 29-June 3, 1968	15.7
New Mills stock Hatchery-reared	May 23-28, 1968	May 29-June 3, 1968	15.9
Miramichi stock Wild 1968	May 27-June 13, 1968	May 27-June 13, 1968	14.6
Miramichi stock Wild 1969	May 23-June 11, 1969	May 23-June 11, 1969	14.1

Rates of return are determined from those tags recovered by commercial and sport fisheries with a few from sampling traps.

SMOLT SIZE AND RATE OF TAG RETURN

Data from the different groups of salmon discussed in this paper are analyzed separately since tag return rates are likely to vary considerably as a result of differences in the origin of the stock and release location (Ritter and Lister, 1971), the time of release (Peterson, 1971) and the rearing history (Burrows, 1971 and Peterson, 1971).

The rate of tag return (expressed as returns per 1000 smolts released) increased with increasing smolt fork length up to 19 cm within groups of hatchery-reared and wild Atlantic salmon smolts (Fig. 1). Among smolts of Restigouche stock, which averaged larger than the other 2 groups of hatchery-reared smolts, 19 cm fish produced the highest tag return, while smolts equal to or larger than 20 cm in the same group produced slightly lower return rates. This relationship between smolt size and rate of adult return is similar to that reported for Swedish hatchery-reared salmon smolts (Carlin, 1968), except that the Swedish return rates for smolts equal to or larger than 20 cm were slightly higher than the return rate for 19 cm fish. Also, return rates for Swedish releases were considerably higher than those for Canadian hatchery-reared smolts.

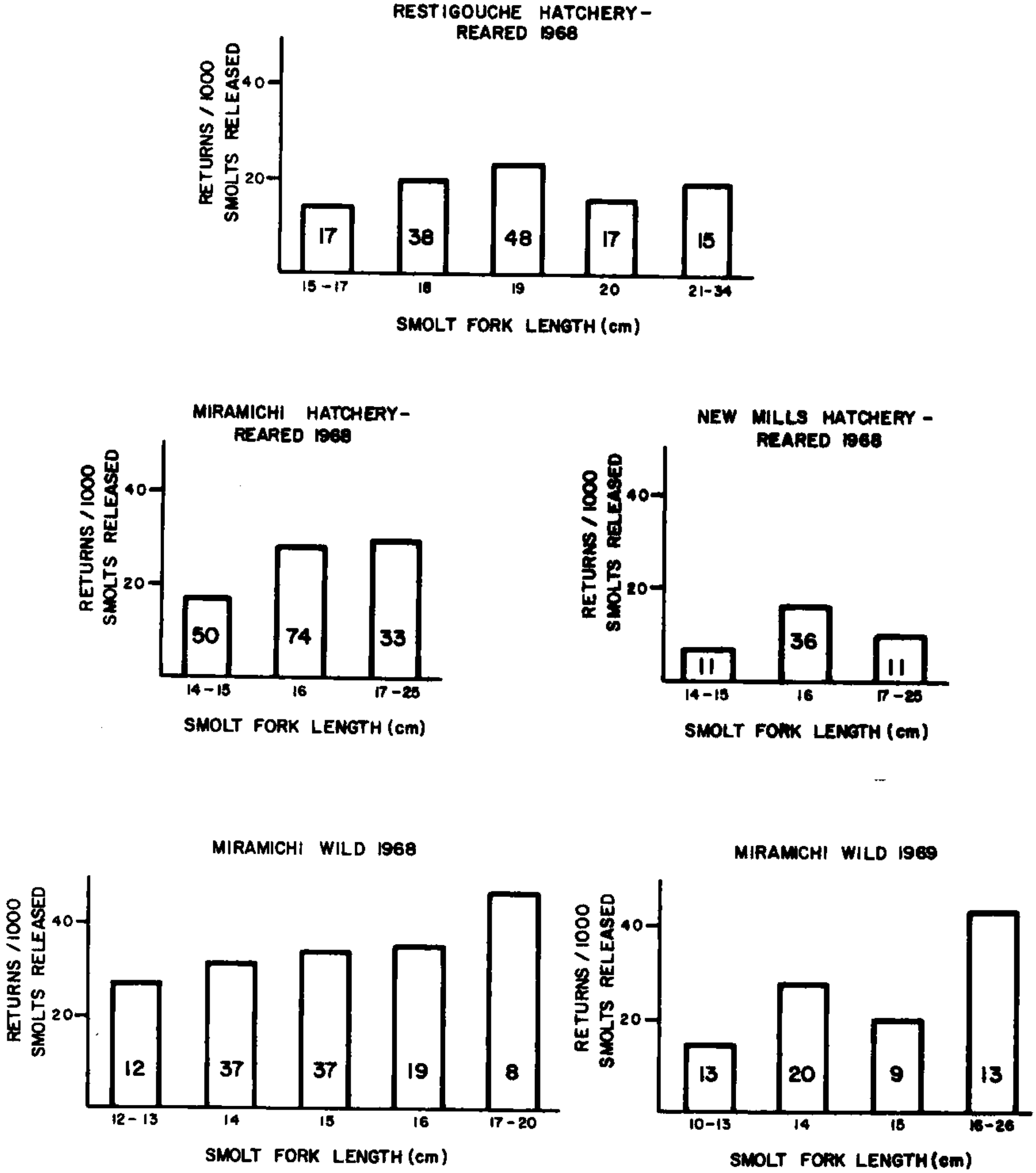

Figure 1. Changes in tag return rates with smolt fork length for 3 groups of hatchery-reared smolts and 2 groups of wild smolts. Numbers within the bars represent sample sizes. Smolt lengths were rounded off to the nearest cm for analysis (i.e. the 19 cm smolts include those with lengths 18.5 cm to 19.4 cm).

Although the data show a definite relationship between the rate of tag return and smolt size at release, it is unlikely that these data truly indicate the form of the relationship within a group of untagged smolts. Tag loss as well as the differential mortality which exists between tagged and untagged fish (Parker et al, 1963) may vary with smolt size, thus biasing estimates of relative survival based on tag returns. One would expect the magnitude of tagging error to be greater for smaller smolts. Thus the true differences in survival rates of smaller and larger smolts are likely to be less than the amount indicated by tag returns.

Since the total escapements were not included in the analysis, the data represents a relationship between contribution rates and smolt size more accurately than a relationship between total survival rates and smolt size.

SMOLT SIZE AND AGE AT FIRST MATURITY

To eliminate confusion regarding the meaning of terms used in this section, this first paragraph will define these terms. Each recapture, other than a recovery at the smolt or post-smolt stage, is identified as either grilse, large salmon or unknown. Grilse are defined as those 1-sea-winter fish recovered in the Miramichi system or within approximately 50 miles of the mouth of the Miramichi River. Recapture within close proximity to the home stream is taken as a definite indication of sexual maturity. The area within this 50-mile limit about the mouth of the Miramichi River is defined by the Statistical Districts 68, 70, 72, 73, and 75. Large salmon are defined as those fish which are recovered after having spent 2 or more winters at sea, plus those 1-sea-winter fish recovered in Greenland waters. Excluding fish recovered in Greenland waters, the maturity status of 1-sea-winter fish outside the 50-mile limit about the Miramichi River is unknown and they are therefore excluded from the analysis. Age at first maturity is expressed as the proportion of grilse among tag recaptures definitely identified as either grilse or large salmon.

All recoveries of large salmon were assumed to have not spawned previously as grilse. This is a fairly valid assumption since less than 4 percent of the fish tagged as grilse in the estuary of the Miramichi River during their spawning migration are captured again other than as grilse or grilse kelts (G. Turner, personal communication). Any error that may result because of mis-identification of grilse or virgin large salmon should be random with regard to smolt size and therefore would not bias the relationship between size and age at first maturity.

Within both Restigouche and Miramichi hatchery-reared groups the smaller smolts produced proportionately more grilse than the larger smolts. (Fig. 2). This relationship between smolt size and

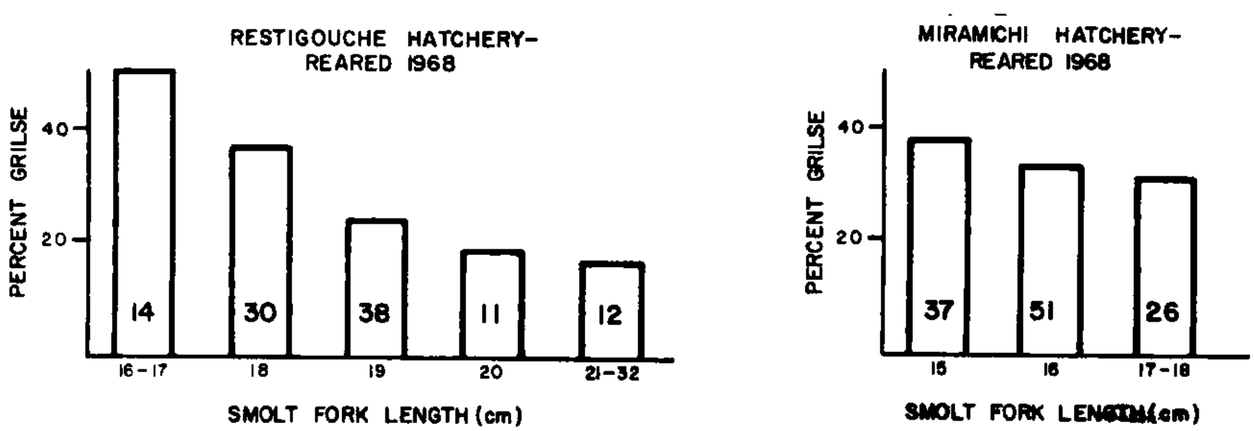

Fig. 2. Changes in the age at first maturity with smolt size for Restigouche and Miramichi hatchery-reared stocks as indicated by the proportion of grilse among tag recaptures identified as either grilse or large salmon. Those fish maturing after having spent only 1 winter at sea are identified as grilse while those spending 2 or more winters at sea are identified as large salmon. Numbers within the bars represent sample sizes. Small lengths are rounded off to the nearest cm for analysis (i.e. the 19 cm smolts include those with lengths 18.5 cm to 19.4 cm).

age at first maturity confirms Allen's (1967) suspicion that the larger hatchery-reared Atlantic salmon smolts tend to produce relatively few grilse and relatively more large salmon. The converse tends to be true for steelhead trout, in that the larger hatchery-reared steelhead smolts tend to mature at an earlier age than the smaller smolts (Wagner, 1967).

The age at first maturity for both the 1968 and 1969 groups of wild smolts of Miramichi stock also varied with smolt size, but only slightly (Fig. 3). The smaller wild smolts

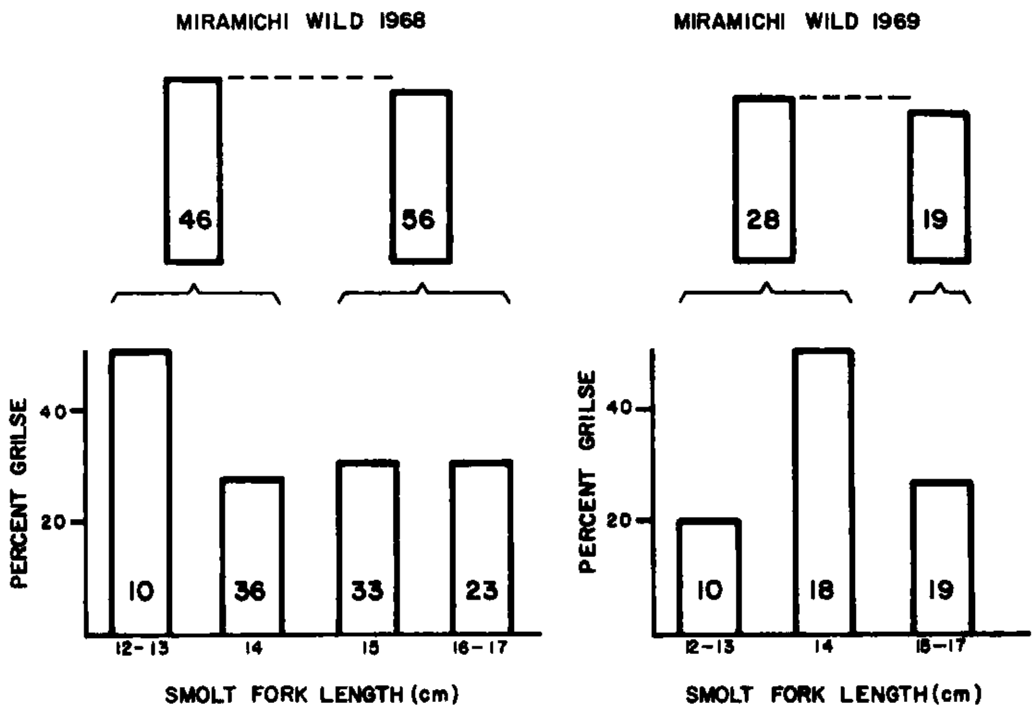

Fig. 3. Changes in the age at first maturity with smolt size for groups of Miramichi wild stock from 1968 and 1969 as indicated by the percent grilse of tag recaptures identified as either grilse or large salmon. Those fish maturing after having spent only 1 winter at sea are identified as grilse while those spending 2 or more winters at sea are identified as large salmon. Numbers within the bars represent sample sizes. Smolt lengths are rounded off to the nearest cm for analysis (i.e. the 19 cm smolts include those with lengths 18.5 cm to 19.4 cm).

(fork length from 11.5 to 14.4 cm) showed a small tendency to mature at an earlier age than the larger wild smolts (fork length from 14.5 to 17.4 cm).

The presence of a relationship between age at first maturity and smolt size for hatchery-reared salmon, and yet the near absence of a similar relationship in wild salmon suggests that age at first maturity may be influenced more by the rate of growth in fresh water than the actual size of the smolt at migration from the river. The hatchery-reared smolts were all 2-year-olds at time of release, whereas the wild smolts were a mixture of 2-, 3-, and 4-year olds at time of tagging and migration to the sea (G. Turner, personal communication). Among hatchery-reared smolts, smolt size was indicative of growth rate, whereas among wild smolts differences in size at migration did not necessarily reflect different rates of growth. The 2-year-old wild smolts may have been smaller at migration time than 3- and 4- year-old smolts, but yet the 2-year-old smolts would have experienced the highest growth rate of the 3 year classes.

The observation that younger smolts tend to mature after a greater number of years in the ocean than the older smolts was reported in Scotland (Blair, 1935). Calderwood (1927) did not find this to apply to salmon of the Cascapedia River in Quebec, but Menzies (1926) did note a slight tendency toward this phenomenon for salmon of the Moisie River in Quebec. Blair's (1935) age data from more than 1,300 maturing grilse and large salmon collected from the estuary and bay of the Miramichi system in 1931 do show a slight tendency for younger smolts to return to the Miramichi later than the older smolts, but Blair himself states that the results were not very conclusive.

Although the data presented do suggest that the growth rate in fresh water influences the age at which hatchery-reared salmon first mature, the results from a release of New Mills stock indicate that rate of growth is certainly not the only factor involved. Of the 51 tag recaptures of New Mills stock identified as either grilse or large salmon, only 4 were grilse. The New Mills smolts were relatively small compared to the Restigouche and Miramichi hatchery-reared smolts (Table 1), and as a result one would expect them to have produced more grilse. Since these relatively small smolts produce proportionately few grilse (<8% of those identified as grilse or large salmon) it would appear that other factors, other than size, such as heredity, are exerting a strong influence on the age at first maturity of cultured salmon stocks.

The relative influences of heredity and environment remain unknown at this time. More information will be available as ongoing controlled experiments, in which escapement data are being collected, are completed.

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