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# Recent changes in stock composition of Atlantic salmon (*Salmo salar*) in the Miramichi River, New Brunswick

by

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## SUMMARY

The recent decline in Miramichi Atlantic salmon (*Salmo salar*) abundance has been accompanied by changes in the composition of the stock entering the river. Increased fishing mortality of large salmon, which spend two or more winters in the sea, is believed to have shifted the river escapement in favour of grilse which spend only one winter at sea. The result has been a reduction in reproductive potential and declines in the fall-runs of both salmon and grilse.

## INTRODUCTION

There are two well recognized population characteristics of Atlantic salmon (*Salmo salar*) found in the Miramichi River, New Brunswick, Canada. The first involves the segregation of the return migration of adults from the sea into an early-run component, which enters fresh water in early July, and a late-run component, which enters the river in September. Both the early and late-run components spawn at approximately the same time during October and

November in the freshwater reaches of the river. The second readily-observed population characteristic involves the number of years at sea an individual spends prior to reaching sexual maturity. Many salmon return to spawn after spending only one winter at sea. These fish weigh from 3 to 5 pounds and are called "grilse". The remainder, spend two or more winters at sea and return to the river usually weighing more than 7 pounds. These fish are locally referred to as "salmon" and in this paper they are designated as large salmon.

The tendency for the spawning run to segregate into early and late-run components or for the adult fish to mature as large salmon or grilse is not unique to the Miramichi River system; in fact, these population characteristics are common to various Atlantic salmon populations in both Europe and North America. Data collected at a fish trapping facility situated in the Miramichi estuary indicate that both these population characteristics have changed during recent years. It is important that these changes be noted in view of their fundamental role in the reproduction of this valuable Atlantic salmon stock.

The relatively large size of the Miramichi River system (Figure 1) makes the interception of the total Atlantic salmon run entering the river impractical. The Fisheries Research Board of Canada experimented with various types of sampling traps in the estuary between 1950 and 1953 in an attempt to devise an indirect method of following changes in stock abundance. In 1954 they settled on a modified commercial trap as the best practical means of estimating abundance and stock composition entering the Miramichi River estuary. Although some commercial exploitation occurs after the fish pass this location, it is relatively insignificant in terms of the total fishery. There is an additional angling exploitation which takes place within the river system itself. The data gathered by this sampling trap provides the best available information on the relative abundance, timing and stock composition for the Atlantic salmon entering the total Miramichi River system.

The Resource Development Branch of the Fisheries Service assumed responsibility for the trapping facility in the fall of 1965 and have been responsible for its operation ever since. All catch data in Fisheries Research Board files were turned over to the Resource Development Branch in 1966. The authors wish to acknowledge their debt to Fisheries Research Board personnel for the use of data collected by them prior to 1966.

## RESULTS

The total number of large salmon and grilse captured at the estuarial sampling trap in each year, 1954 to 1971 inclusive, along with the potential egg deposition represented by these fish is plotted in Figure 2. In recent years there has been a decline in the sampling catch, particularly in the large salmon portion of the stock during 1969, 1970 and 1971. The potential egg deposition has shown a downward trend over the past eleven years. Potential egg deposition reflects the abundance of large salmon, since 86% of these fish are female and their relatively larger size provides a greater fecundity than the smaller grilse female. The large runs of grilse during the period 1963 to 1967, therefore, did not reverse the decline in potential egg deposition, since only 22% of the grilse are female and their relatively small size represent a lower fecundity than that of large salmon females.

In Figure 3 the percentage of large salmon and grilse in the total sampling catch for each year is plotted. From 1954 to 1962 the catch of grilse and large salmon, although fluctuating from year to year, was composed of about equal numbers of large salmon and grilse. Since 1963, however, the sampling catch has been composed of an average of 87% grilse. This dominance of grilse has persisted, uninterrupted for nine years. These data substantiate the changes in grilse to large salmon ratios between

1950 and 1968 reported by Kerswill (1971). Furthermore, these new data identify the specific year in which the change occurred.

The seasonal pattern of the salmon and grilse run entering the Miramichi sampling trap is depicted in Figure 4. Also shown in this figure is the timing of the local commercial fishing season for both the drift-net fishery and the trap net fishery. The data represent the average bi-monthly catch per fishing day for the period 1954 to 1970.

Grilse enter the Miramichi estuary about the end of May or early in June; form a first peak of abundance in the first week of July; taper off during the latter part of July; are relatively scarce in August; then rise to a second, larger peak of abundance during September. The run of grilse declines in October and by the first week of November the catch in the sampling trap has fallen to less than 0.5 fish per day. The grilse are not captured in any significant numbers by the drift-net fishery, but some exploitation occurs in the trap-net fishery and it is interesting to note that the peak catch in the early portion of the grilse run coincides with the 2-week closure of the trap-net fishery.

The catch of large salmon at the sampling trap shows a similar pattern; however, the large salmon arrive earlier and the first peak of abundance is relatively undeveloped. The fall peak of abundance is more abrupt and occurs somewhat later. The intensive local commercial fishery exploiting predominantly large salmon is believed to account for the difference in timing pattern between the grilse and large salmon entering the sampling trap. Direct evidence of the effect this fishery had on river escapement was gained in 1971 when the commercial season was closed for 10 days in June. The average catch of large salmon per day at the sampling trap for the month of June rose from a 17-year average of 2.2 fish per day to 11.3 fish per day, despite the fact that the overall abundance of large salmon in 1971 was extremely low (Figure 2).

The average catch of large salmon and grilse per fishing day per month at the sampling trap, 1954 to 1971 inclusive, is presented in Table 1. The average daily catch of large salmon in May, June, July and August show no particular trends; however, the catch in recent years for September and October were the lowest recorded over the 18-year period. Grilse catches in September during the period 1968 to 1971 have been particularly low. Similarly, the catch of large salmon has fallen off during September and October in 1969, 1970 and 1971.

In order to examine more closely the early and late portions of the salmon and grilse run, the total number of early and late run large salmon and grilse for each year (1954 to 1971) are plotted in Figure 5. An arbitrary separation was made with those fish captured in May, June and July being designated "early-run" and those fish captured in September, October and November being designated "late-run". The fish captured in August are assumed to be a mixture and are omitted from the totals graphed.

The large salmon component of the sampling catch is comprised of predominantly late-run fish. Early-run large salmon have made up a small portion of the sampling catch and no trend in relative abundance has occurred in these early-run fish over the 1954 to 1971 period. The late-run component has been below the 17-year average for the past 10 years with catches in 1969, 1970 and 1971 being particularly low. For example, the average catch in 1969, 1970 and 1971 was 157 large salmon, while the average catch for the period 1954 to 1968 was 2,174 large salmon. Recent declines in the numbers of large salmon entering the Miramichi River system, therefore, can be accounted for by a decline in the fall-run portion of the large salmon stock.

The grilse component of the sampling catch is more evenly divided between early and late-running fish. The early portion of the grilse run appears to be maintaining itself at relatively high levels of abundance, however, the late-run portion shows a striking decline occurring in 1968, one year in advance of a similar decline identified in the fall-run large salmon. Declines in Miramichi grilse abundance since 1968, therefore, can be attributed to the serious decline of the fall-run portion of the grilse run during the period 1968 to 1971.

It is important to note that the late-run grilse decline occurred one year in advance of the late-run large salmon decline, indicating that the cause of these events acted upon a succession of complete year-classes composed of both large salmon and grilse. Since commercial fishing is largely confined to large salmon, it is clear that commercial fishing is not the direct cause for the recent low levels of abundance in late-run large salmon and grilse.

## DISCUSSION

If one assumes that the population characteristics of a salmon run are a result of natural selection and that they represent some form of "optimum" adjustment of that particular race or population to conditions in the natural environment, then any change in these population characteristics would result in a lowering of the general productivity of that particular population. The shift in the grilse to large salmon ratio reported in this paper represents a significant change in the natural population characteristics of the Miramichi salmon run. The fact that this change occurred abruptly in 1963 and has persisted up to the present time offers an opportunity to examine the effects of such a change on subsequent generations of salmon.

The life history of Miramichi salmon is such that the first major effect from the shift in salmon-grilse ratio occurring in 1963 would manifest itself in the grilse returns five years later and in salmon returns six years later. The major effect on the grilse population would first be felt in 1968 and on the large salmon population in 1969. Judging from Figure 3, the effect should continue for nine years with some possible adjustment occurring in the sixth year due to a slight "improvement" in the salmon-grilse ratio occurring in 1968. The observed decline in the late-run portion has continued for the past four years in the grilse and for the past three years in the large salmon (Figure 5). The first year in which partial recovery might be expected would be 1973 for grilse and 1974 for large salmon. The fact that most of the spawning escapement is from the late-run portion of the run,may explain why the effect of this change in proportion is reflected in only the late-run component of the grilse and large salmon sampling catch.

The observed shift in the salmon-grilse ratio must be the result of either a basic change in the age at which Miramichi salmon first reach maturity, or a shift in the relative mortality rates between salmon and grilse, or perhaps a combination of these factors. If either of these factors has changed, then the relationship between potential egg deposition and either returning grilse, or salmon, must have changed after 1963.

The relationship of potential eggs to returning grilse in the sampling catch was examined to see first, if a relationship between potential eggs and returning grilse could be established, and secondly, if any deviation from this relationship had occurred corresponding to the change in salmon and grilse abundance in 1963.

Scale reading from grilse captured in the sampling trap, revealed that 79% spend three years in freshwater prior to going to sea and 16% spend two years in freshwater prior to going to sea. Any given egg deposition, therefore, would contribute significantly to two year classes of grilse. Figure 6 is a graph representing a regression of the sampling catch of grilse against the potential egg deposition of the parent generation. Each point is identified as to the two years the specific egg deposition contributed to the grilse catch and the numbers of grilse plotted reflect the relative abundance of the two year classes.

These data demonstrate that there is a decided tendency for the number of grilse to increase as the potential egg deposition increases. The relationship is variable and an analysis of correlation gives an r value of 0.679 ($P<0.02$). The deviations from this regression do not occur in a manner that would account for a shift to higher grilse abundance since 1963.

In a similar manner, the relationship of potential eggs to returning large salmon captured at the sampling trap was examined. No significant relationship could be established between the potential egg deposition and subsequent catches of large salmon in the sampling trap, $r = -0.331$ ($P>0.1$). The fact that no significant relationship was found between potential egg deposition and the escapement of large salmon, while such a relationship has been demonstrated for grilse, suggests that differential mortality between large salmon and grilse is an important factor in the life history of Miramichi salmon. If, for example, the mortality rate of large salmon exceeded the ability of the stock to compensate reproductively, then a shift in favour of grilse reproduction might occur.

Since it was known (Saunders, 1969, and Kerswill, 1971) that commercial exploitation of Miramichi large salmon was high, the relationship between potential egg deposition and the subsequent catch in the local commercial salmon fishery was examined. Figure 7 is a graph representing a regression of the commercial catch of large salmon against the potential egg deposition of the parental generation. The catches have been adjusted to account for the two major freshwater age groups represented in Miramichi large salmon (25% spend two years in freshwater and 70% spend three years in freshwater). Each point is identified as to the two years the specific egg deposition contributed to the commercial salmon catch and the number of salmon plotted reflect the relative abundance of the two year classes.

These data demonstrate that there is a tendency for the catch of large salmon in the local commercial fishery to increase as the potential egg deposition increases, especially in more recent years. Although the regression is not statistically significant, variations from the regression show an interesting pattern. The four points represented by the years '59-'60, '60-'61, '61-'62 and '62-'63 lie well below the regression line and display no tendency for the catch to reflect different levels of potential egg deposition. The majority of years after 1963-64 lie above the regression line, indicating that relatively more salmon were caught per unit of egg deposition in later years by the local commercial fishery than was the case prior to 1963-64. This apparent increase in fishing efficiency could account, at least in part, for the shift in the age composition of the escapement of fish to the river, since an increase in fishing mortality would favour the escapement of proportionately more grilse.

In 1963 a new commercial salmon licencing policy was introduced which was designed to limit the commercial effort and, over the long term, reduce it. One requirement in the new policy was that the salmon fishing privilege must be exercised at least every second season in order to remain in good standing. The immediate result was an increase in the number of active fishermen in the fishery and a subsequent increase in fishing effort. For example in 1963, 256 licences were issued but only 199 were active in the fishery; whereas in 1964, 241 licences were issued and 235 were actively engaged in the fishery. Since 1964 there has been a gradual decrease in "active licencees" with 221 in this category reported in 1968 and 206 in 1971.

Besides an increase in the local exploitation of large salmon, there has been, in recent years, an added exploitation of Miramichi large salmon in a distant commercial fishery. The salmon fishery off the west coast of Greenland began in 1960 and has grown to where it is now believed to be the largest commercial Atlantic salmon fishery in the world. The development of this fishery is depicted in Figure 8. Turner (1972) found that an average of 27.4% of all tag returns from large salmon recaptures based on tagging of wild Miramichi smolts in 1968 and 1969, came from this west Greenland fishery. Taking non-reporting of tags into consideration, Turner estimates that the fishery in recent years at west Greenland accounts for 39.9% of all Miramichi large salmon captured.

During recent years the Greenland salmon fishery has accounted for a significant proportion of the fishing mortality of Miramichi large salmon. The fact that this added source of mortality occurred at a time when local exploitation was at a relatively high rate, compounds the effect of differential mortality between large salmon and grilse. We believe that increased fishing mortality of large salmon in both home and distant commercial fisheries has changed the age composition of the river escapement from 50% large salmon prior to 1963, to 13% large salmon after 1963. This change in composition of potential spawners has reduced the reproductive capacity of the stock. The major effect of this reduced reproductive capacity has been a rapid decline in fall-run stocks of grilse and large salmon.

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Table 1 Average catch of large salmon (S) and grilse (Gr) per fishing day per month at the Miramichi estuarial trap, 1954-1971.

| Year | May | | June | | July | | August | | September | | October | | November | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gr. | S | Gr. | S | Gr. | S | Gr. | S | Gr. | S | Gr. | S | Gr. | S |
| 1954 | 0.1 | 0.7 | 8.1 | 3.2 | 18.7 | 5.4 | 8.2 | 4.4 | 28.9 | 53.8 | 8.2 | 17.1 | 0 | 2.2 |
| 1955 | 0 | 0.5 | 7.8 | 3.2 | 15.7 | 0.6 | 1.6 | 0.2 | 37.3 | 87.1 | 5.6 | 14.6 | 0.2 | 0 |
| 1956 | 0 | 2.3 | 12.5 | 1.6 | 20.4 | 2.0 | 15.9 | 5.9 | 69.2 | 98.3 | 16.2 | 16.8 | 0 | 0.9 |
| 1957 | 0 | 0.2 | 1.5 | 1.6 | 24.8 | 4.7 | 25.4 | 12.8 | 56.3 | 70.8 | 45.2 | 54.3 | 0 | 0.8 |
| 1958 | 0.2 | 3.6 | 19.8 | 3.0 | 37.1 | 5.7 | 24.7 | 9.1 | 204.5 | 114.1 | 40.5 | 34.4 | 0.8 | 1.5 |
| 1959 | 0 | 0.8 | 4.7 | 1.3 | 19.3 | 2.7 | 4.0 | 3.3 | 31.3 | 90.7 | 17.1 | 51.6 | not | fished |
| 1960 | 0 | 3.3 | 16.2 | 1.5 | 23.0 | 3.6 | 1.2 | 0.5 | 71.5 | 67.5 | 44.9 | 78.3 | 2.8 | 6.4 |
| 1961 | 0 | 1.8 | 7.3 | 4.3 | 59.0 | 5.2 | 10.4 | 2.9 | 148.5 | 79.5 | 15.9 | 13.5 | 0.3 | 0.3 |
| 1962 | 0.1 | 0.1 | 4.0 | 1.0 | 43.9 | 6.1 | 6.3 | 1.5 | 47.4 | 51.5 | 6.4 | 12.3 | 0.1 | 0.1 |
| 1963 | 0.1 | 0.5 | 51.6 | 3.3 | 54.5 | 1.2 | 19.3 | 2.3 | 387.5 | 46.9 | 3.8 | 3.4 | not | fished |
| 1964 | 0 | 1.6 | 31.7 | 3.1 | 103.4 | 1.9 | 34.2 | 2.2 | 127.5 | 14.6 | 25.8 | 14.4 | 0.3 | 0 |
| 1965 | 0 | 0.4 | 19.7 | 5.9 | 121.2 | 5.6 | 41.0 | 2.5 | 376.2 | 45.1 | 26.8 | 7.9 | not | fished |
| 1966 | 0.1 | 0.5 | 25.0 | 3.4 | 101.9 | 4.5 | 34.8 | 2.7 | 217.7 | 42.3 | 31.7 | 16.1 | not | fished |
| 1967 | 0 | 0.2 | 5.0 | 1.0 | 38.2 | 1.2 | 18.7 | 0.8 | 191.5 | 22.8 | 29.2 | 10.0 | 0.7 | 0 |
| 1968 | 0 | 0.8 | 8.5 | 1.4 | 48.4 | 3.7 | 30.0 | 4.6 | 13.6 | 14.4 | 13.3 | 26.5 | 0 | 0.8 |
| 1969 | 0 | 1.3 | 24.5 | 2.4 | 64.4 | 7.2 | 19.8 | 1.6 | 37.4 | 10.3 | 3.5 | 1.7 | not | fished |
| 1970 | 0 | 0.7 | 21.6 | 1.8 | 37.9 | 2 | 6.3 | 4.5 | 23.0 | 3.4 | 2.4 | 1.2 | 0 | 0 |
| 1971 | 0 | 0 | 17.2 | 11.3 | 49.2 | 1.5 | 3.0 | 0.1 | 3.5 | 0.4 | 1.0 | 0.4 | 0.1 | 0.1 |

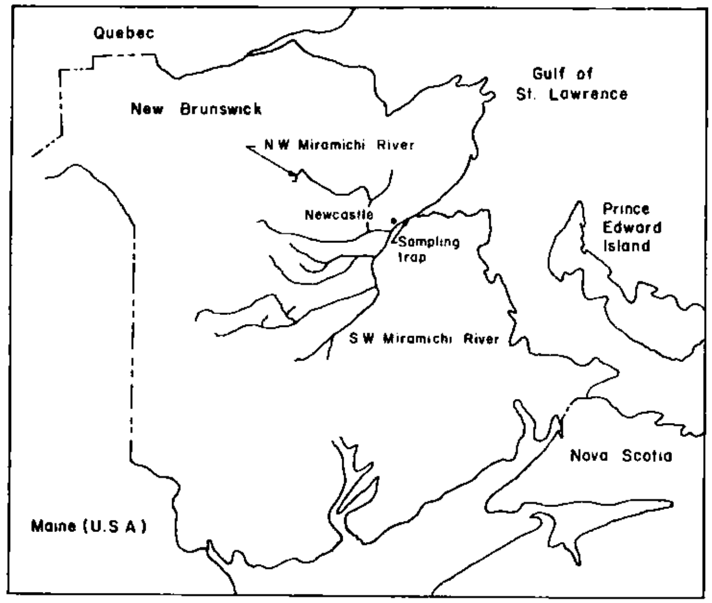


Figure 1. Location of Miramichi River system, New Brunswick, showing site of estuarial sampling trap.

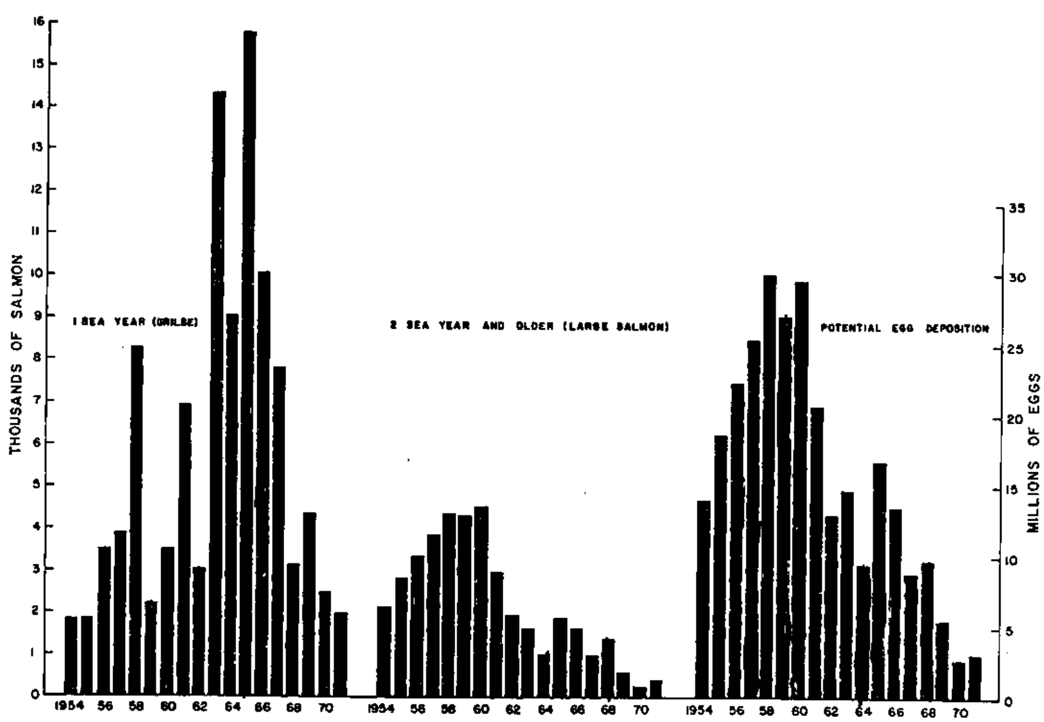


Figure 2. Atlantic salmon catch at Miramichi sampling trap for the period 1954 to 1971 and the potential egg deposition represented by these fish.

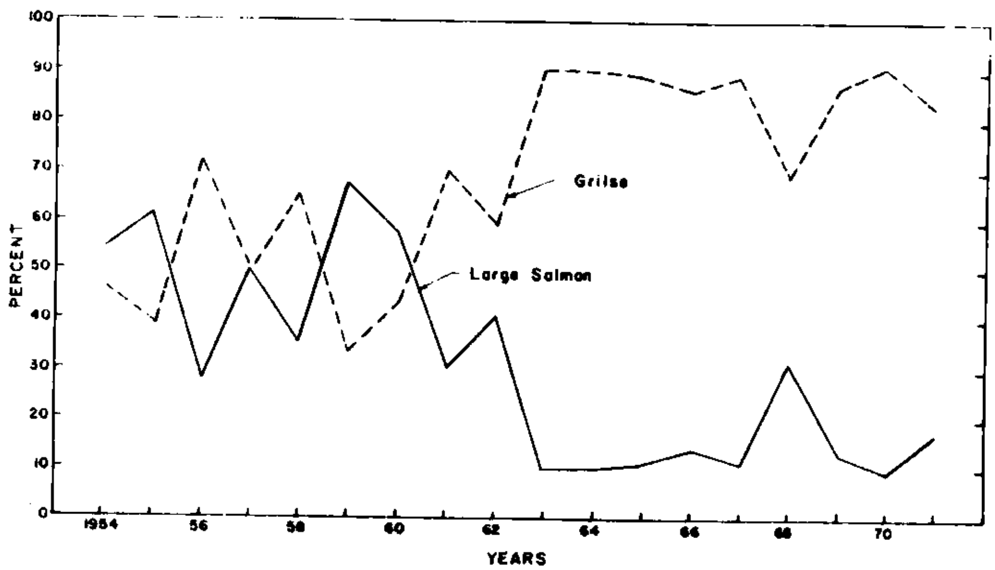


Figure 3. Percentage composition of large salmon and grilse in the sampling trap catch.

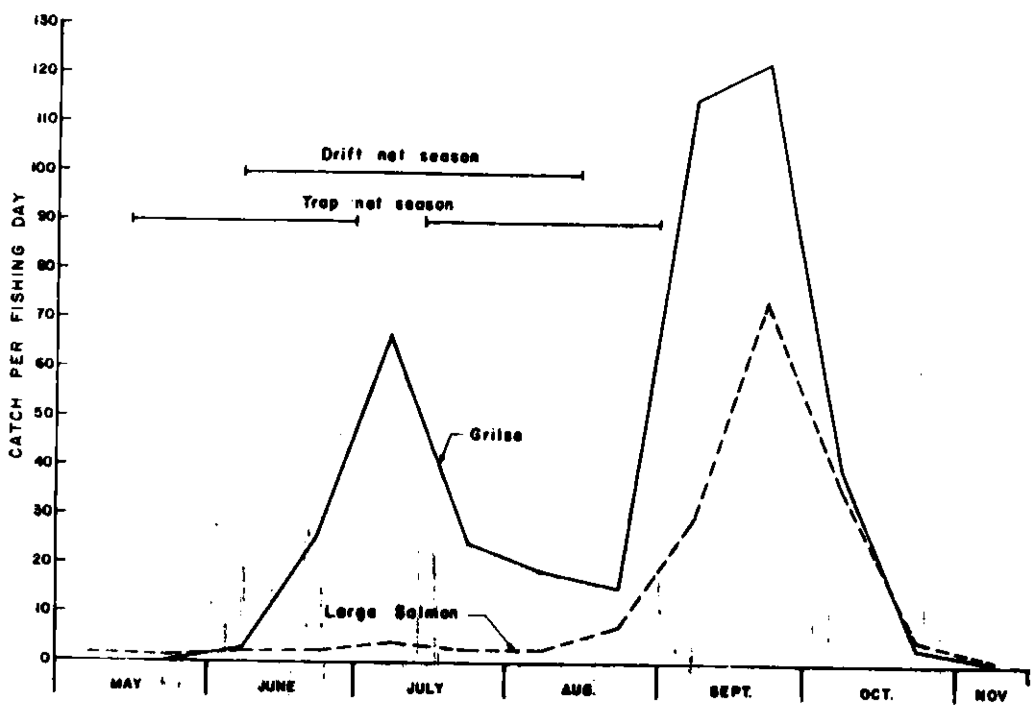


Figure 4. Seasonal timing and relative abundance of grilse and large salmon entering the inner Miramichi estuary, based on average bi-monthly catch per fishing day at the sampling trap for the 1954 to 1970 period, inclusive.

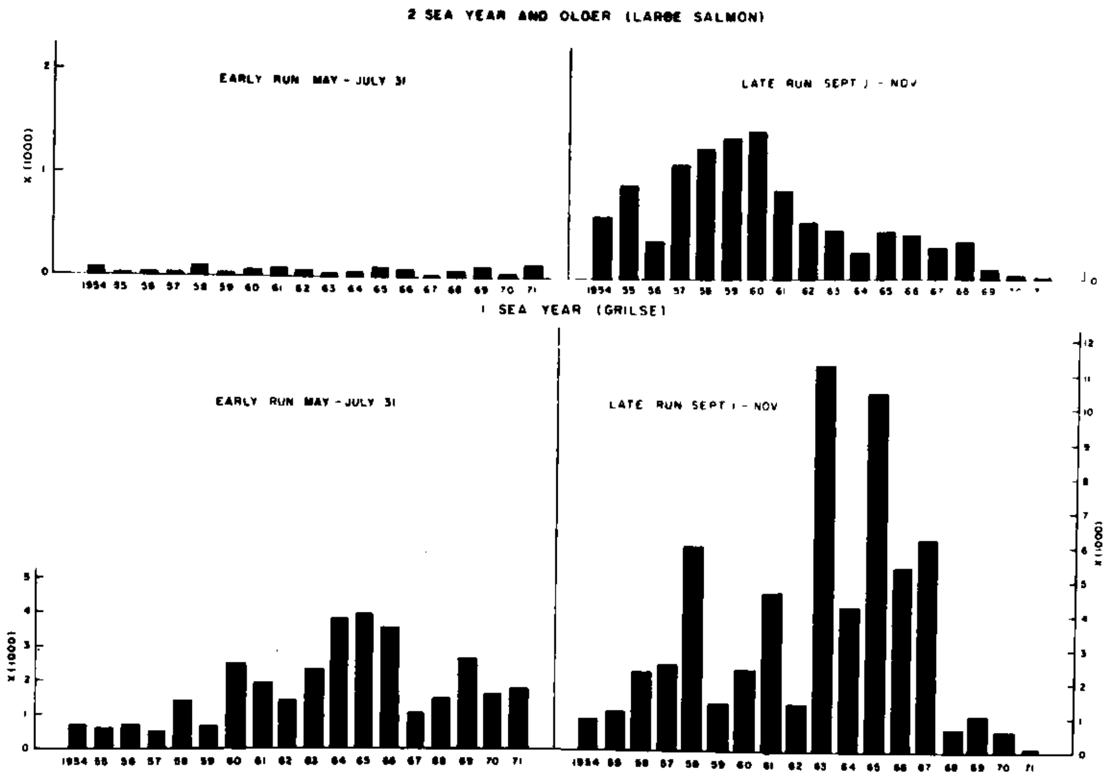


Figure 5. A comparison of Miramichi early and late-run large salmon and grilse abundance based on catches at the sampling trap 1954 to 1971.

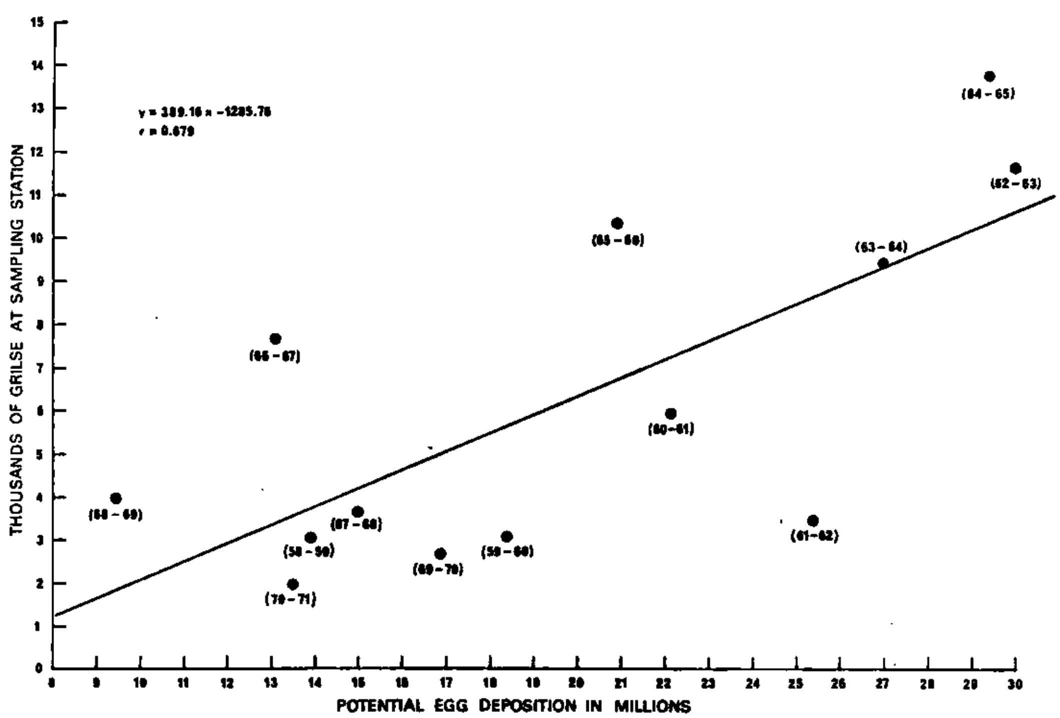


Figure 6. Relationship between number of grilse and potential egg deposition of parental generation at the sampling trap. Each point is identified as to the two years the specific egg deposition contributed to the grilse catch (n = 13).

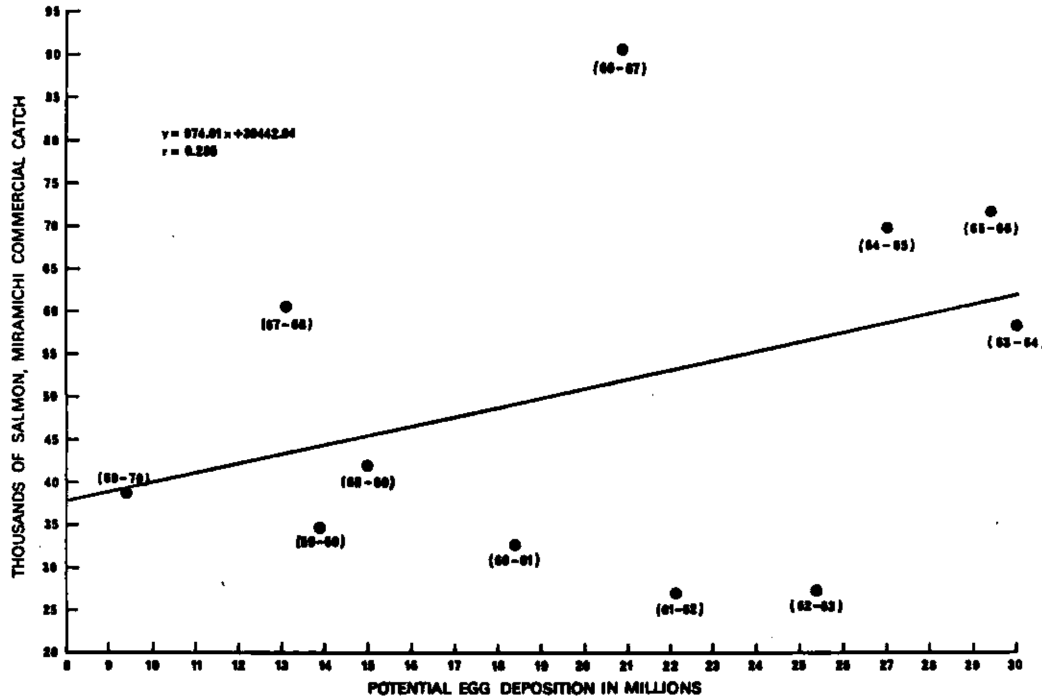


Figure 7. Relationship between number of large salmon captured in the local commercial fishery and the potential egg deposition of the parental generation at the sampling trap. Each point is identified as to the two years the specific egg deposition contributed to the fishery (n = 11).

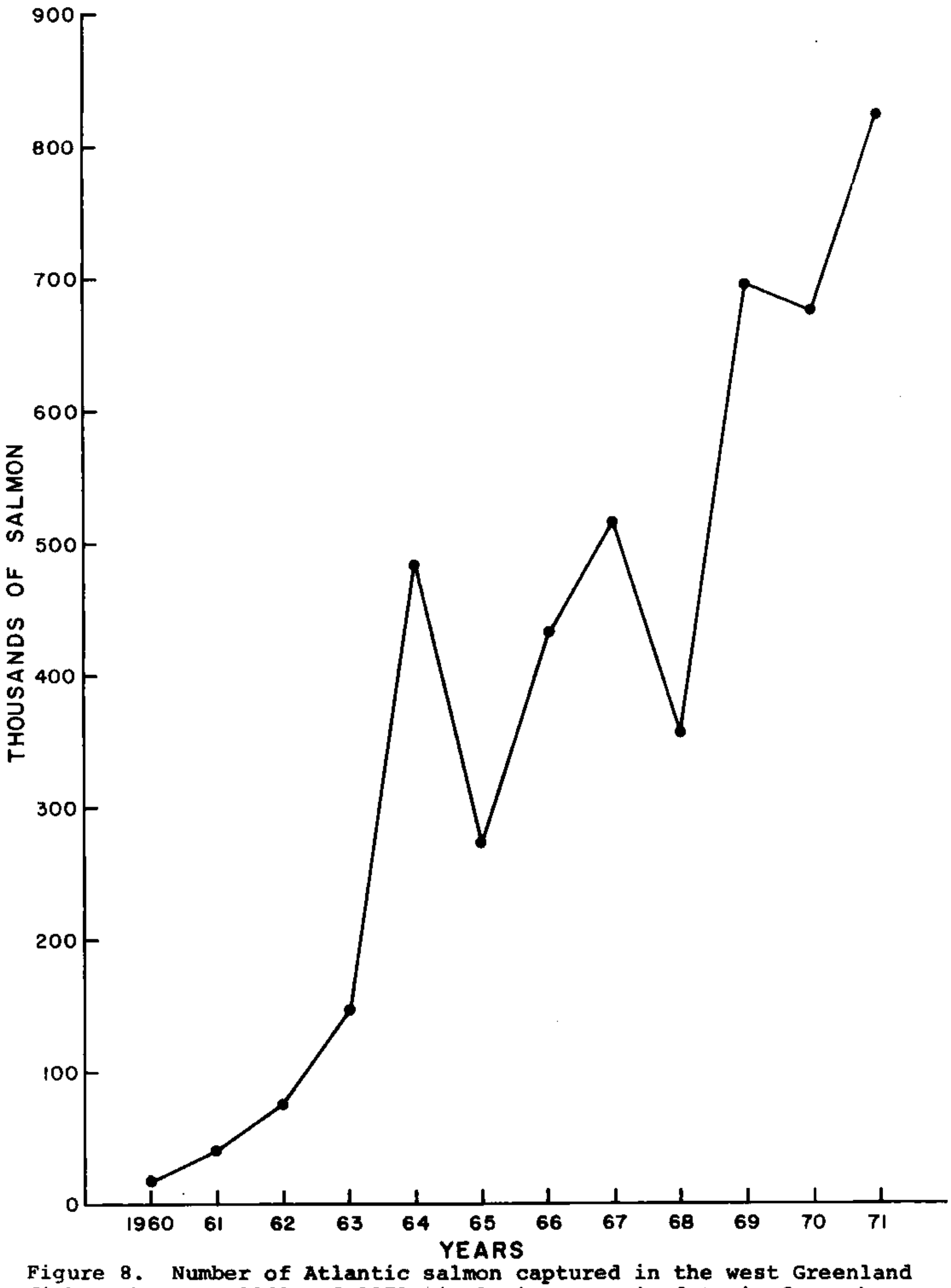


Figure 8. Number of Atlantic salmon captured in the west Greenland fishery between 1960 and 1971, inclusive. Basic data is from the March 1972 Report of the ICES/ICNAF Joint Working Party on North Atlantic Salmon. Weight of fish has been converted to numbers of fish by assuming an average weight of 7 pounds.