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# Analysis of the Status of the Newfoundland West Coast Herring Stock

by

J.A. Moores
Fisheries and Marine Service, Nfld. Region
Newfoundland Environment Center
St. John's, Newfoundland
A1C 5X1

## INTRODUCTION

Both the inshore and mobile components of the herring fishery in the Newfoundland west coast stock area experienced an increase in catch in 1978 despite a declining trend in stock abundance (Moores and Winters 1978). Total catch in 1978 was 15,922 metric tons, an increase of 30% above the 1977 catch of 12,286 m tons (Table 1). The large increase in catch is primarily attributable to the inshore components (gillnet, bar seine, trap) which landed 5596 m tons in 1978, double the 1977 catch (2822 m tons). While the largest total increase occurred north of Cape Gregory inshore catches are showing marked increases throughout the area (Table 2).

The purse-seine fleet catch of 10,326 m tons, an increase of 9% over the 1977 landings of 9464 mt, represented an over-run of 3% of the quota. While the total quota was not seriously exceeded, a major over-run occurred in the subarea of St. George's Bay. Due to low availability of herring along the 'edge', 25 vessels participated in the fishery in St. George's Bay. The 5000 mt quota lasted less than 7 days and resulted in a 25% over-run in the quota (6252 mt). This over-run was compensated for by a reduction in the quota in the area north of St. George's Bay.

### Tagging Results and Stock Area:

Since 1975, the Newfoundland Biological Station has conducted 7 tagging experiments in the Gulf of St. Lawrence with a total of 38,550 tagged herring being released. At the end of December 1978, 1053 recoveries had been reported. The results of these studies indicate only minimal interchange between the two recognized Gulf stock units and between adjacent stocks (Table 3).

From a single Southern Gulf stock tagging 98 percent of the returns have occurred in the Southern Gulf stock area with the remaining 2% being accounted for by 1 recapture in the area of Port-au-Port and 3 from ICNAF area 4W.

Six tagging experiments have been conducted in sites within the Newfoundland west coast stock area. Of 874 returns received, 99% (868) were recaptured within the area with the remaining returns coming from the Quebec North Shore (1), ICNAF area 4W (1), St. Anthony area (3) and Notre Dame Bay (1).

Three recoveries from Newfoundland east coast taggings have been reported from the Gulf of St. Lawrence. Of two recaptures from St. Goerge's Bay, one was tagged in Hare Bay and the second in White Bay. The third recapture was from a Notre Dame Bay tagging recaptured in Labrador.

From the results of these experiments, it would appear that the boundaries for the Newfoundland west coast stock are reasonable. While the southern boundary of this stock (Cape Anguille to Anticosti) has been well defined the Northern and western boundaries have not. Fig. 1 indicates the area presently under consideration in this assessment; it should, however, be noted that catches from the Labrador side of the straits have not been included in this cohort analysis. These catches have historically been small (Table 2).

Compilation of Assessment Data:

Age Data and Numbers-at-age: Samples are collected from the commercial fisheries in each of the three quota areas (Cape Anguille-Cape St. George, Cape St. George-Cape Gregory, Cape Gregory-Cape Norman). Numbers-at-age in the catch were generated separately for each quota area then combined for a unit assessment.

The 1968 year-class remained dominant (46%) among the spring spawning component of the stock followed closely by the 1969 year-class (29%). The 1974 year-class appeared weakly in the St. George's Bay area (2%) but contributed significantly to the winter fishery in St. John Bay (12%) (Fig. 2).

The fall spawners continued to be dominated by age groups 10 and older, but amongst younger age groups the 1970 year-class was the major contributer (17%) to the fishery.

Partial Recruitment Rates: The partial recruitment rates were re-examined but did not display any significant change from those reported in 1978 (Table 4).

Catch-Per-Unit-Effort and Fishing Effort: The effort data available for this area (Table 5) present several problems in interpretation due to changes in the pattern of exploitation on this stock. This historical effort data (1966-73) are consistent both in fleet composition and mode of operation. During this period the fishery occurred primarily during the late fall in the Cape Gregory to Cape Norman area and exploited post feeding concentrations. In addition, carriers were extensively used to reduce time spent by seiners in transporting fish to the plants. Since 1975, the fishery has undergone several changes: in St. George's Bay the fleet has been expanded and exploits primarily pre-spawning concentrations of herring while in the northern area improved handling facilities have eliminated the use of carriers and reduced steaming time to and from off-loading ports. While both recent data sets are inconsistent with the historical data set, they are also inconsistent with each other. The St. George's Bay data show a steady decline in catch per operating day while the St. John Bay data show an increase from 1977 to 1978. The differences between these two areas may in part be due to differences in fleet composition. Up to 25 vessels take part in the spring fishery but generally not more than 6 operate in the fall fishery. In order to generate a consistent

effort series a correction factor was produced to bring the recent St. George's Bay effort data (K + L) into line with the historical time series for the fall fishery. This was done by using the ratio of $5^+$ biomass in 1973 (last year of historical fall fishery) to the $5^+$ biomass in 1975 (the first year of the spring fishery). This ratio was applied to the 1973 calculated effort to generate an exploited effort in 1975. The effort data from the spring fishery in subsequent years were adjusted on a proportional basis:

$$\frac{\text{Effort year n + 1}}{\text{Effort year n}} = \frac{\text{adj. effort year n + 1}}{\text{adj. effort year n}}$$

Calculation of Terminal F: Cohort analysis was performed individually for both spring and autumn spawners at a range of $F_T$ values from 0.15 to 0.40 with a natural mortality rate of 0.20 for spring spawners and 0.15 for autumn spawners. The lower M value for autumn spawners is consistent with the age structure observed in the population. The autumn spawning component is composed of large numbers of very old fish suggesting an M lower than 0.2 for autumn spawners. An $F_{5+}$ for the total population was calculated by proportioning the $F_{5+}$ for both spring and autumn spawners on the number of individuals aged 5+ of each in the population.

The population $F_{5+}$ values were plotted against two measures of effort: (1) St. George's Bay effort non-adjusted (1975-77) and (2) adjusted effort series (fall fishery and adjusted St. George's spring) (1971-77). Under option 1, an increasing trend of R values with increasing $F_T$ was observed (Table 6) however, projecting to 1978 produced closest agreement with $F_T$ = 0.35 (Fig. 3).

The best correlation of $F_{5+}$ and effort under option 2 was at $F_T$ = 0.25 (Fig. 4). Predicting a 1978 value from the regression line also achieved closest agreement at $F_T$ = 0.25 (Table 6).

The results of these two analyses indicate $F_T$ should lie between $F_T$ = 0.25 and $F_T$ = 0.35. In both cases $F_T$ = 0.25, the predicted F for 1978 was greater than 0.25 and was below 0.35 at $F_T$ = 0.35.

Paloheimo $\bar{z}$ values were calculated (Table 6) but did not show any trend which was useful in refining the evaluation of terminal F. Based on the results of the regression analysis, it was concluded that a terminal F = 0.30 (average level as $0.25 > F_T < 0.35$) would most accurately reflect the situation in 1978.

Results of Assessment:

Trends in Biomass and F: This stock is presently in a state of decline. The decline has been most precipitous among the autumn spawning component in which the $5^+$ biomass has declined to 16% (13,365 mt) of the 1966 level (85,976 mt). The highest observed $5^+$ biomass among spring spawners was 111,500 mt in 1974 which was primarily composed of the large 1968 year-class. The 1978 $5^+$ biomass of 46,300 mt represents 42% of the 1974 level but is equal to or greater than that observed in the period from 1967-72 (Fig. 5, Table 7).

The trend towards an increase in the proportion of the spring spawning component of the population (Moores and Winters 1978) has appeared to stabilize with autumn spawners representing slightly in excess of 20% of the population since 1974.

The trend of $F_5+$ for both components is similar with low values in the early years of the analysis and increasing during the recent years under conditions of an expanding fishery.

Trends in Recruitment: In recent years recruitment to both components of this stock has been poor. The last significant year-class among autumn spawners was the 1970 year-class which at age 2 was only 25% of the 1958 year-class at age 8 in 1966.

Among spring spawners the 1974 year-class is the strongest observed in recent years, however, it represents only about 10% of the strong 1968 year-class.

Estimation of $F_{0.1}$: The yield per recruit curve remained unchanged from 1978 (Moores and Winters) for spring spawners and yielded an $F_{0.1}$ level of 0.45. A new yield per recruit curve was calculated for autumn spawners using M = 0.15 and gave an $F_{0.1}$ value of 0.35 (Fig. 6).

Catch Projection: Using the population structure produced under two options of terminal F in 1978 ($F_T$ = 0.30 and 0.35) and a variable recruitment generation, catch projections were performed at the $F_{0.1}$ level. The projected catch in 1979 is 14,938 mt using a terminal F = 0.30 in 1978 and 12,487 mt at the level of $F_T$ = 0.35 (Table 8).

Both options, despite the declining stock abundance, result in TACs equal to or above those established in previous years. This is a consequence of being overly conservative in previous assessments in the estimation of the terminal F used to establish population size. A comparison of terminal F used in previous assessments and $F_5+$ generated from cohort analysis indicates that terminal F was overestimated resulting in an underestimate of population size (Table 9). The error was greatest in the 1976 assessment and while partially corrected for 1978 the recommended TAC (Moores and Winters 1978) was reduced due to considerations of the input data and concern for the spawning stock. While the actual 1978 catch was well above the recommended TAC, it was only slightly in excess of the catch projection at $F_{0.1}$ presented in 1978. The 1979 projections, therefore, rather than being in opposition to the earlier assessments, reflect the declining status of the stock.

## DISCUSSION

The pattern of exploitation of this stock has varied greatly and is continuing to do so. There are two aspects of particular concern: the rapid expansion of effort by the mobile fleet in St. George's Bay, with its potential for exceeding the quotas, and the marked expansion of insnore effort. While mobile gear can be monitored reasonably well and its effort distributed over the stock by sub-area allocation, no such controls are available for inshore gears. Past attempts to estimate inshore catch have been highly variable and are a source of concern if management strategy is to attempt to maintain fisheries at the $F_{0.1}$ level.

## REFERENCES

Moores, J.A. and G.H. Winters. 1978. The Newfoundland West Coast Herring Stocks. CAFSAC Res. Doc. 78/2.

Table 1. Newfoundland west coast herring catches (m. tons) 1966-78.

| | AREA | | | | Total Catch |
|---|---|---|---|---|---|
| | K[1] | L[1] | M[1] | N[1] | |
| 1966 | | 103 | 5529 | 18 | 5650 |
| 1967 | | 66 | 5540 | 13 | 5619 |
| 1968 | | 59 | 3978 | 11 | 4048 |
| 1969 | | 46 | 2549 | 40 | 2635 |
| 1970 | | 27 | 3473 | 301 | 3801 |
| 1971 | | 2424 | 1076 | 1963 | 5463 |
| 1972 | | 862 | 1544 | 3628 | 6034 |
| 1973 | | 2862 | 2067 | 9222 | 14,151 |
| 1974 | | 856 | 942 | 2842 | 4640 |
| 1975 | 3613 | 113 | 242 | 1027 | 4995 |
| 1976 | 6565 | 2067 | 226 | 1251 | 10,109 |
| 1977 | 5569 | 2203 | 156 | 4358 | 12,286 |
| 1978 | (6833)[2] | (1956) | (290) | (6843) | (15,922) |

[1] see Figure 1.
[2] provisional data

Table 2. Herring catches (mt.) from the Newfoundland west coast herring stock.

| Year | K[1] | | L[1] | | M[1] | | N[1] | | Total | | | O[1] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P. Seine | Inshore | P. Seine | Inshore | P. Seine | Inshore | P. Seine | Inshore | P. Seine | Inshore | Combined | Inshore |
| 1966 | | | | 103 | 5490 | 39 | | 18 | 5490 | 160 | 5650 | |
| 1967 | | | | 66 | 5464 | 76 | | 13 | 5464 | 155 | 5619 | |
| 1968 | | | | 59 | 3776 | 202 | | 11 | 3776 | 272 | 4048 | |
| 1969 | | | | 46 | 2344 | 205 | | 40 | 2344 | 291 | 2635 | |
| 1970 | | | 12 | 15 | 2939 | 534 | | 301 | 2951 | 850 | 3801 | |
| 1971 | | | 2239 | 185 | 725 | 351 | 356 | 1607 | 3320 | 2143 | 5463 | |
| 1972 | | | 727 | 135 | 1330 | 214 | - | 3628 | 2057 | 3977 | 6034 | |
| 1973 | | | 2740 | 122 | 1763 | 304 | 3453 | 5769 | 7956 | 6195 | 14,151 | 335 |
| 1974 | | | 756 | 100 | 439 | 503 | 1071 | 1771 | 2266 | 2374 | 4640 | 156 |
| 1975 | 3495 | 118 | - | 113 | - | 242 | - | 1027 | 3495 | 1500 | 4995 | 66 |
| 1976 | 6067 | 498 | 1955 | 112 | - | 226 | 184 | 1067 | 8206 | 1903 | 10,109 | 528 |
| 1977 | 5289 | 280 | 2008 | 195 | - | 156 | 2167 | 2191 | 9464 | 2822 | 12,286 | 401 |
| 1978 | (6252)[2] | (581) | (1039) | (917) | - | (290) | (3035) | (3808) | (10326) | (5596) | (15922) | 237 |

[1] see Figure 1.

[2] provisional data

Table 3. Results of herring tagging experiments conducted in the Gulf of St. Lawrence (see Fig. 1 for area locations).

A. West Coast

| Location Tagged | Date Tagged | No. Released | No. Recapture | Nfld. Areas | | | | | | | ICNAF Areas | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | K | L | M | N | A | B | O | S | W | T |
| Reef Ht. (N) | July '75 | 2350 | 10 | 1 | | | 8 | | 1 | | | | |
| Bay St. George (K) | April '76 | 6400 | 151 | 148 | 2 | | 1 | | | | | | |
| St. John Bay (N) | Dec. '76 | 10,000 | 169 | 127 | 11 | 1 | 25 | 3 | | | 1 | 1 | |
| Sandy Pt. (K) | April '77 | 7500 | 417 | 402 | 11 | 1 | 3 | | | | | | |
| Port-au-Port (L) | May '77 | 2000 | 18 | 5 | 6 | | 7 | | | | | | |
| St. Paul's Inlet (M) | May '78 | 6500 | 109 | | | 104 | 5 | | | | | | |
| TOTAL | | 34,750 | 874 | 683 | 30 | 106 | 49 | 3 | 1 | - | 1 | 1 | - |

B. Southern Gulf

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Edge (T) | May '76 | 3800 | 179 | | 1 | | | | 3 | | | | 175 |

C. Nfld. East Coast

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sops Arm (A) | June '76 | 5600 | 402 | 1 | | | | | | | | | |
| Hare Bay (A) | Oct. '76 | 5000 | 221 | 1 | | | | | | | | | |
| Lawrenceton (B) | June '77 | 5000 | 86 | | | | | | | | | 1 | |

Table 4. Partial recruitment rates and average weights used in the cohort analysis.

| | | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | >10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Autumn Spawners | % Recruit | 5 | 15 | 40 | 65 | 90 | 100 | 100 | 100 | 100 | 100 |
| | Ave. Wgt. | .112 | .162 | .205 | .249 | .253 | .291 | .299 | .302 | .313 | .383 |
| Spring Spawners | % Recruit | 5 | 15 | 25 | 50 | 75 | 90 | 100 | 100 | 100 | 100 |
| | Ave. Wgt. | .121 | .161 | .219 | .234 | .265 | .270 | .286 | .310 | .315 | .364 |

Table 5. Effort data for the Nfld. West Coast Fishery.

| Year | Total Catch (mt.) | Catch/op. day | | Effort | | Adj. K + L[1] c/op. day | adj. Effort |
|---|---|---|---|---|---|---|---|
| | | K + L | M + N | K + L | M + N | | |
| 1966 | 5650 | - | 63.2 | - | 89.4 | - | - |
| 1967 | 5619 | - | 67.5 | - | 86.5 | - | - |
| 1968 | 4048 | - | 65.4 | - | 61.9 | - | - |
| 1969 | 2635 | - | 47.8 | - | 55.1 | - | - |
| 1970 | 3801 | - | 38.3 | - | 99.2 | - | - |
| 1971 | 5463 | - | 38.6 | - | 141.5 | - | - |
| 1972 | 6034 | - | 31.7 | - | 190.4 | - | - |
| 1973 | 14151 | - | 53.0 | - | 267.0 | - | - |
| 1974 | 4640 | - | - | - | - | - | - |
| 1975 | 4995 | 92.6 | - | 53.9 | - | 44.1 | 113.4 |
| 1976 | 10109 | 89.5 | - | 113.0 | - | 42.6 | 237.4 |
| 1977 | 12286 | 79.8 | 70.2[2] | 154.0 | 175.0 | 38.0 | 323.6 |
| 1978 | 15922 | 68.5 | 89.0[2] | 232.4 | 178.9 | 32.6 | 488.6 |

[1] see text for explanation

[2] from landing slips

Table 6. Population F values by year at various levels of terminal F and the resultant $R^2$ values and predicted 1978 F from effort data.

| Year | Terminal F | | | | |
|---|---|---|---|---|---|
| | $F_{.20}$ | $F_{.25}$ | $F_{.30}$ | $F_{.35}$ | $F_{.40}$ |
| 1971 | .046 | .052 | .057 | .062 | .065 |
| 1972 | .042 | .049 | .054 | .058 | .062 |
| 1973 | .080 | .093 | .104 | .112 | .121 |
| 1974 | .021 | .024 | .028 | .031 | .033 |
| 1975 | .034 | .039 | .044 | .048 | .051 |
| 1976 | .087 | .100 | .109 | .122 | .132 |
| 1977 | .162 | .185 | .206 | .225 | .244 |
| 1978 | | | | | |
| (adj. effort data) | | | | | |
| $R^2$ 71-77 | .8231 | .8225 | .8315 | .8267 | .8296 |
| Predicted 78 | .2262 | .2597 | .2885 | .3154 | .3435 |
| (non-adj. effort data) | | | | | |
| $R^2$ 75-77 | .9594 | .9611 | .9534 | .9612 | .9619 |
| Predicted 78 | .2514 | .2872 | .3181 | .3489 | .3793 |

Table 7. Biomass and $F_5+$ values from cohort analysis $F_T = 0.30$.

| | | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Biomass 5+ | AS | 86.0 | 78.1 | 78.7 | 75.1 | 67.3 | 58.9 | 48.0 | 39.9 | 31.3 | 29.7 | 26.0 | 20.6 | 13.4 |
| ($10^{-3}$ mt.) | SS | 52.8 | 46.4 | 42.8 | 37.5 | 36.0 | 45.0 | 42.7 | 108.5 | 111.5 | 96.9 | 80.4 | 64.2 | 46.3 |
| | Total | 138.8 | 124.5 | 121.5 | 112.6 | 103.3 | 103.9 | 90.7 | 148.7 | 142.8 | 126.6 | 106.4 | 84.8 | 59.7 |
| $F_5+$ | AS | .025 | .029 | .026 | .015 | .020 | .086 | .071 | .173 | .037 | .062 | .116 | .327 | |
| | SS | .063 | .064 | .042 | .028 | .047 | .018 | .035 | .078 | .025 | .038 | .110 | .168 | |
| | Combined | .039 | .042 | .032 | .019 | .029 | .057 | .054 | .104 | .028 | .044 | .109 | .206 | |
| Paloheimo Z | | 0.11 | -0.08 | 0.44 | 0.61 | -0.28 | 0.25 | -0.69 | - | - | 0.62 | -0.91 | -0.10 | |

Table 8. Catch projection Nfld. west coast herring stock 1979-80, AS: M = .15, F = 0.35; SS: M = .2, F = 0.45) under two options of terminal F in 1978.

| Year | $F_T$ = 0.30 | | | $F_T$ = 0.35 | | |
|---|---|---|---|---|---|---|
| | AS | SS | Total | AS | SS | Total |
| 1978 | 3499 | 12423 | 15922 | 3499 | 12423 | 15922 |
| 1979 | 2633 | 12275 | 14938 | 2224 | 10263 | 12487 |
| 1980 | 1733 | 8040 | 9773 | 1453 | 6794 | 8247 |

Table 9. A comparison of (A) terminal F selected in previous assessments (Moores and Winters 1977, 1978) with corresponding $F_5$+ for spring spawners from present analysis and (B) $_5$+ biomass from previous assessments and present analysis.

| A. | Last year assessed | Terminal F selected | Corresponding $F_5$+ from 1978 analysis | |
|---|---|---|---|---|
| | | | $F_T$ 1978 = 0.30 | $F_T$ 1978 = 0.35 |
| | 1976 | 0.25 | .110 | .122 |
| | 1977 | 0.20 | .168 | .188 |

| B. | Last year assessed | Biomass | Corresponding biomass from 1978 analysis | |
|---|---|---|---|---|
| | | | $F_T$ 1978 = 0.30 | $F_T$ 1978 = 0.35 |
| | 1976 | 50.7 | 106.4 | 96.2 |
| | 1977 | 75.0 | 84.4 | 75.9 |

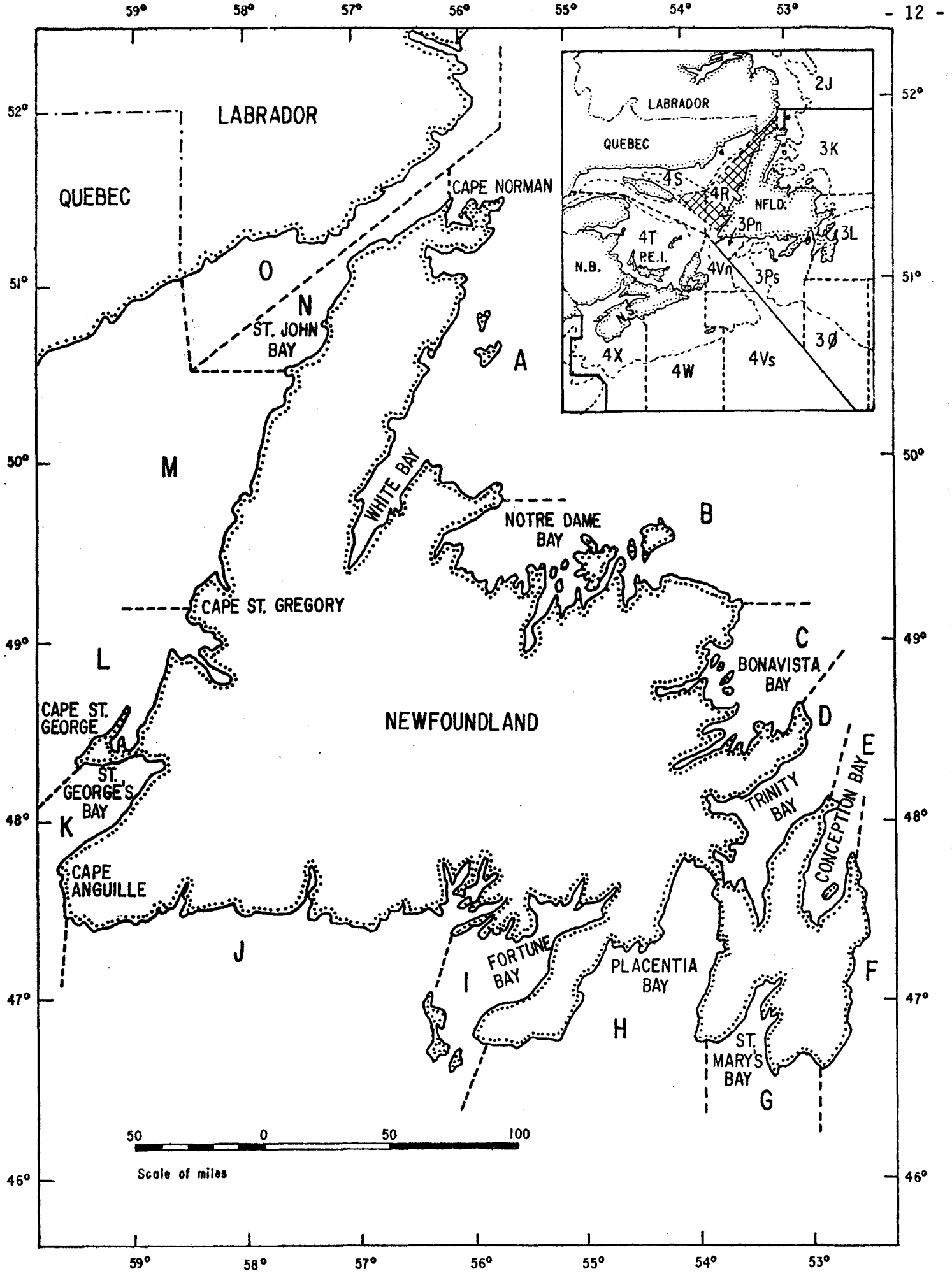


Fig. 1. Statistical areas and place names for Newfoundland region.
Inset: ICNAF areas and Nfld. West Coast stock area (hatched region).

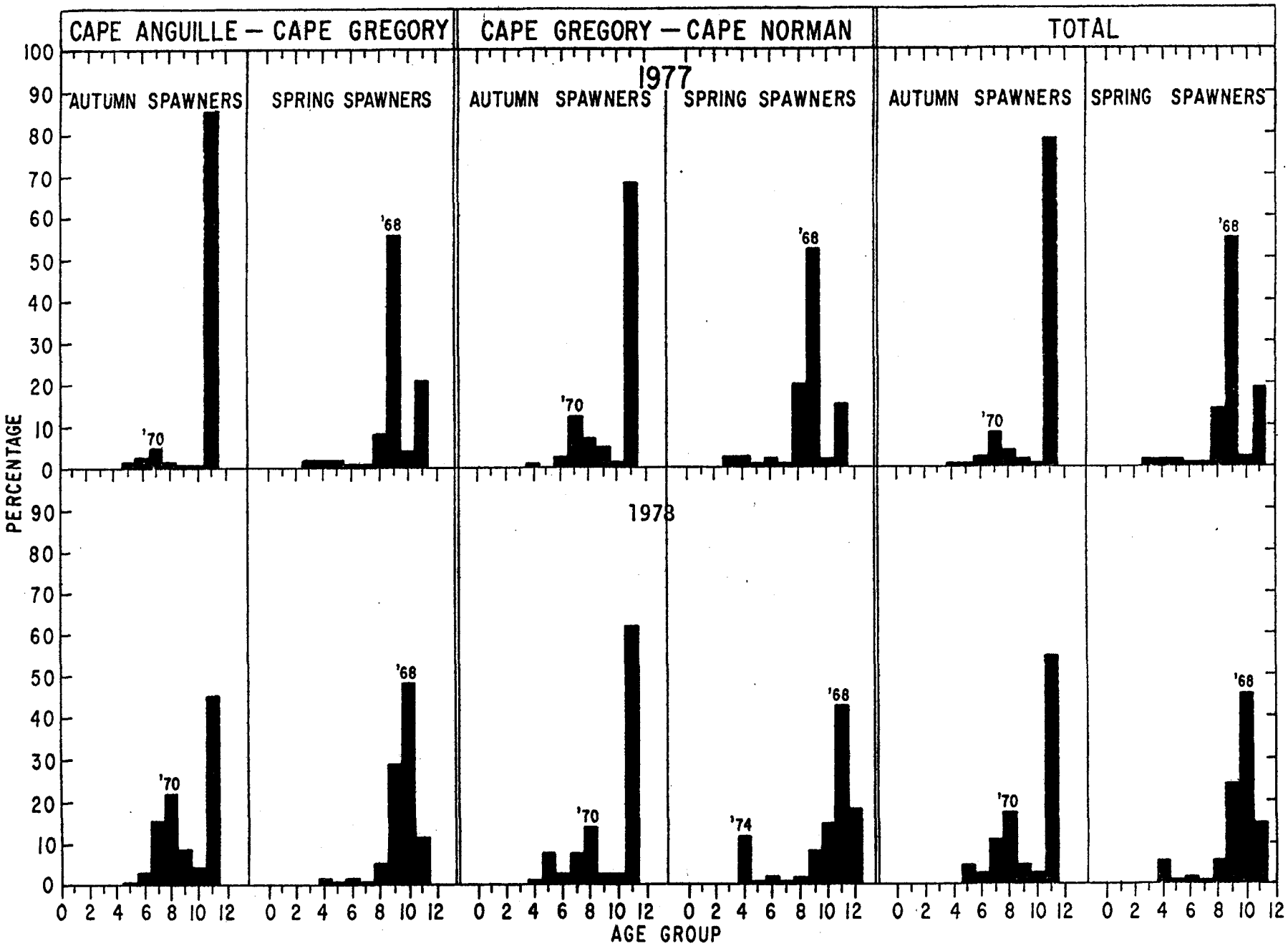


Fig. 2. Age frequencies (adjusted to landings) for sub-areas of the Nfld. west coast herring stock 1977 and 1978.

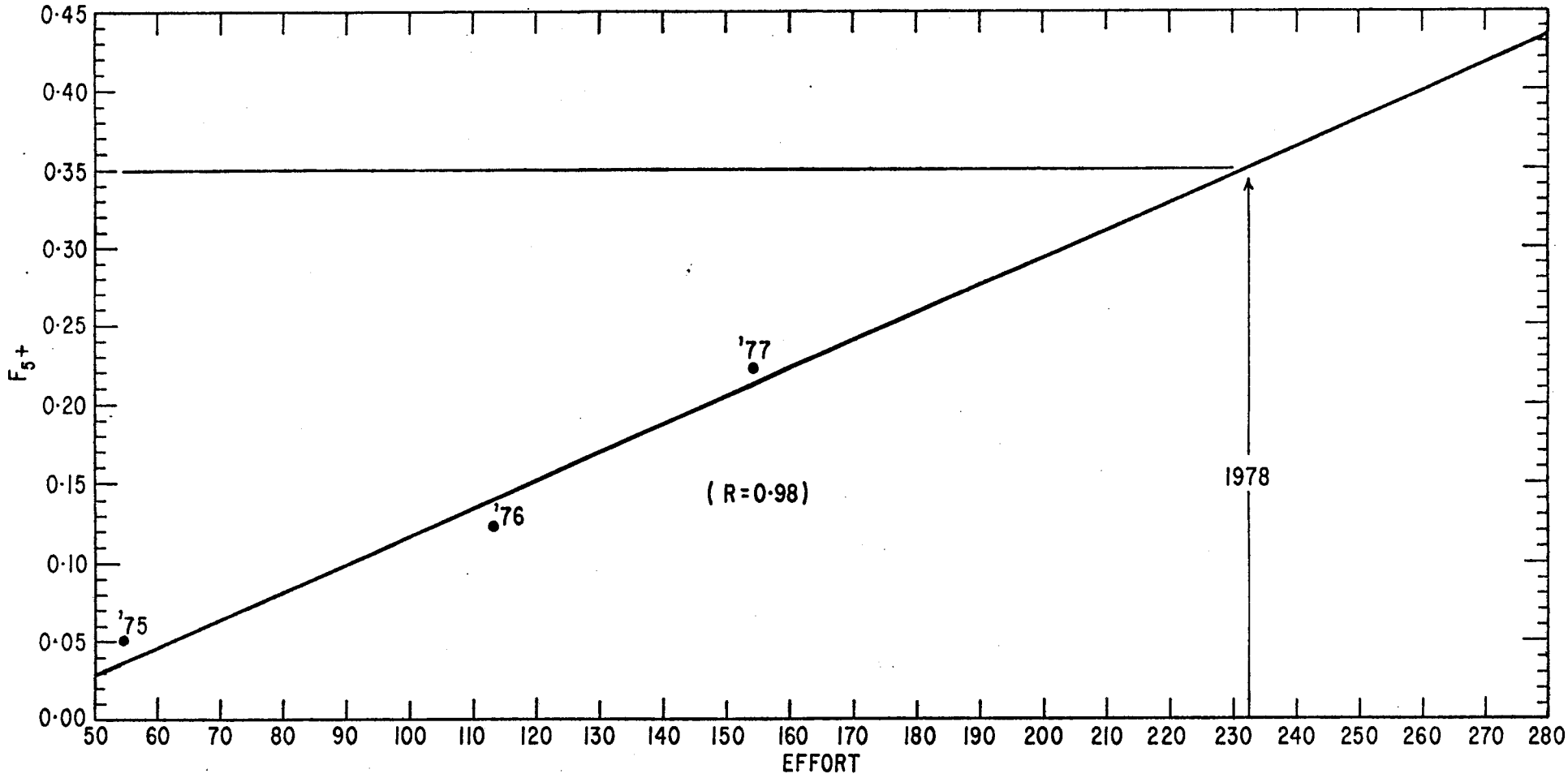


Fig. 3. Effort vs $F_5+$ using non-adjust St. George's Bay effort data 1975-77.

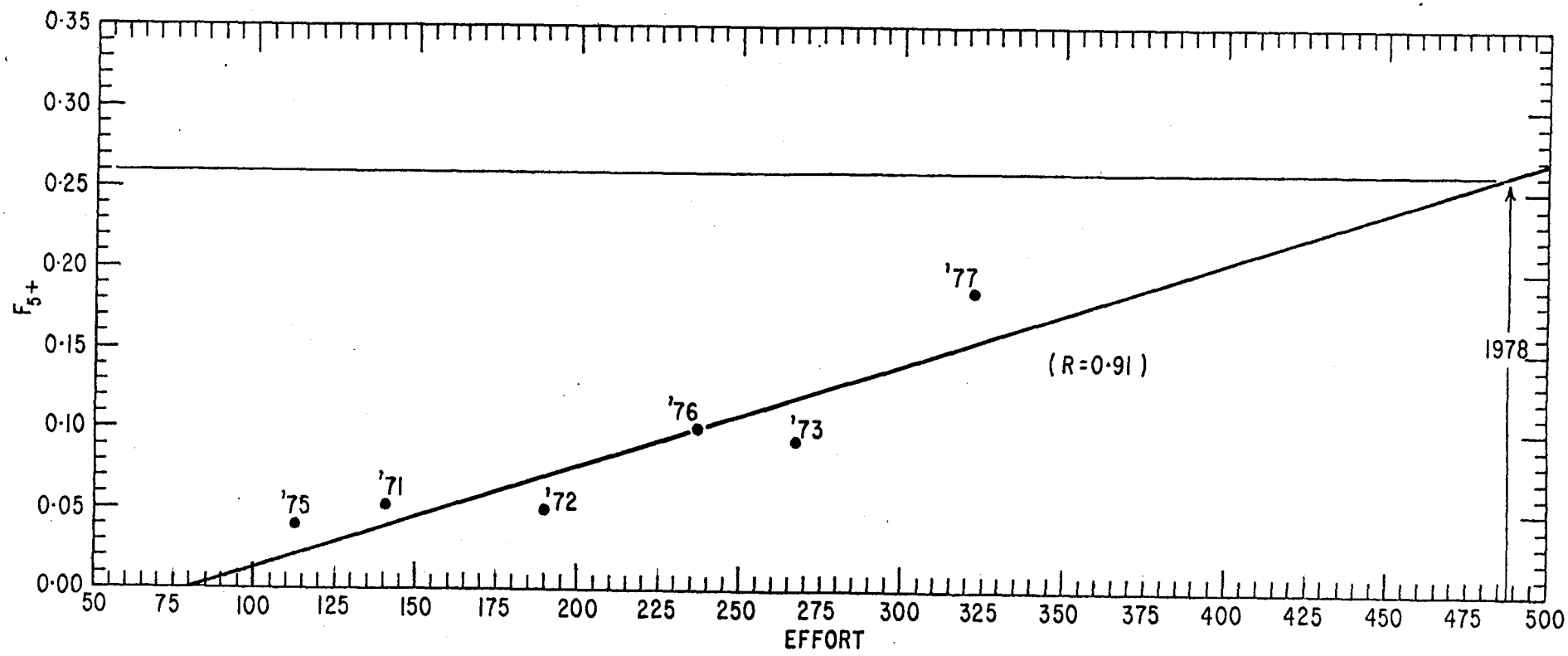


Fig. 4. Effort vs $F_{5+}$ using northern Gulf adjusted effort data 1971-77.

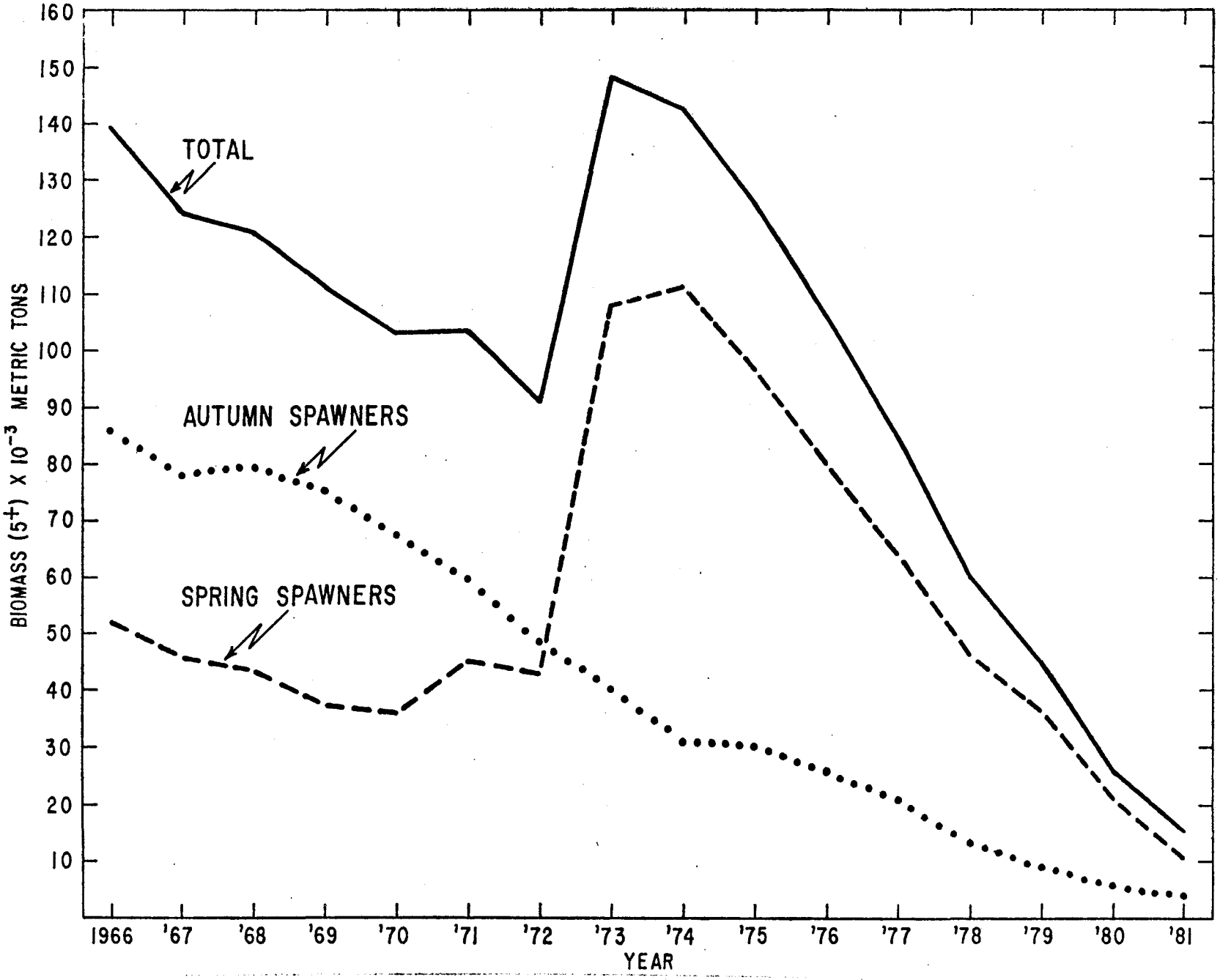


Fig. 5. 5+ biomass of autumn, spring spawning components and total 5+ biomass by year.

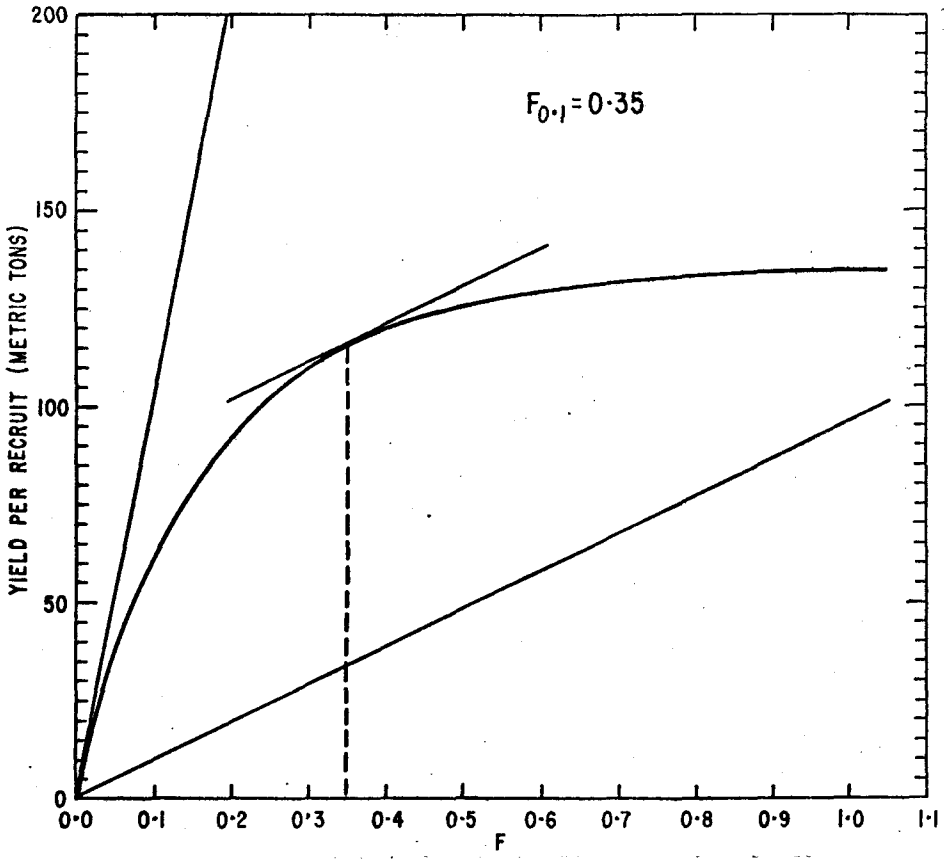


Fig. 6. Yield per recruit at various levels of F and $F_{0\cdot1}$ point for autumn spawners (M = 0.15).