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Assessment of the 4T Herring Stock

by

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ABSTRACT

Landings from the 4T herring stock declined from 270 000 mt in 1970 to 40 500 mt in 1980 and in 1981, due to quota restrictions, to 22 000 mt. An analysis of the commercial catch rates revealed that the abundance indices from the purse seiner fishery have slightly increased after 1979-1980, at which point they had reached a historical low. However, the catch rates from the inshore fishery are relatively stable, with some indices showing a slight increase from 1980 to 1981, and others a slight decrease. The groundfish research cruise catch rate has been declining since 1978.

The catch-at-age matrix shows that the late 1970's fishery has been sustained mainly by the 1974 spring spawner year-class. Since 1978, the proportion of young fish in the spring spawner catch has been increasing (less than 4 years old: 26% in 1978, 58% in 1981) with no evidence of a particularly strong recruitment entering the fishery. The fall spawner catch matrix however shows the dominance of the 1977 year-class in the 1980 and 1981 fishery. Consequently, the mean age of the fish caught for all spawning groups has gone from 9 years old in 1969 to 4 years old in 1981. Total mortality coefficients (Z) were calculated for fully recruited herring, using different fishing effort indices. All the Z values have decreased since 1979-1980. A new partial recruitment vector, which reflected the change in the fishery from mainly offshore to mainly inshore, was calculated and used in cohort analysis. The estimated herring biomass and population numbers were correlated with purse seiner and gillnet catch rates, with most of the coefficients being above 0.9. Estimated fishing mortality of fully recruited fish has increased from about 0.20 in 1969 to 0.88 in 1980 and gone down to 0.46 in 1981. A Thompson and Bell yield-per-recruit analysis gave a value of $F_{0.1} = 0.38$. The stock biomass, ages 4 to 11, has declined to 49 000 mt in 1981 (weight for the first quarter of the year), 5 percent of the maximum level estimated in 1969.

RESUME

Les captures de hareng du stock 4T ont passé de 270 000 tonnes métriques en 1970 à 40 500 tonnes métriques en 1980, et à 22 000 tonnes métriques en 1981, à cause de la réduction du total des prises admissibles. Les taux de capture des seineurs après avoir atteint un niveau historiquement faible, ont légèrement augmenté depuis 1979-1980. Cependant, les taux de capture de la pêche côtière sont demeurés relativement stables; certains indices d'abondance ont augmenté en 1981, tandis que d'autres ont diminué légèrement. Les taux de capture de hareng provenant de la croisière de recherche des poissons de fond continuent à décliner depuis 1978.

La classe d'âge 1974 des frayeurs de printemps a contribué à maintenir la pêche depuis la fin des années 1970. Cependant, depuis 1978, la proportion des jeunes harengs (moins de 4 ans) a augmenté dans la capture des frayeurs de printemps: 26% en 1978 et 58% en 1981 de la capture totale en nombre. Chez les frayeurs d'automne, la classe d'âge 1977 a dominé dans les captures de 1980 et 1981. Par conséquent, l'âge moyen des captures pour les deux groupes reproducteurs a baissé de 9 ans à 4 ans entre 1969 et 1981. Le taux de mortalité totale (Z) a été calculé pour les harengs pleinement recrutés, à l'aide de divers indices d'effort de pêche. Tous les taux calculés ont diminué depuis 1979-1980. Le recrutement partiel a été estimé de façon à tenir compte du changement de la pêche, autrefois hauturière, et dominée par les engins côtiers en 1981. Ce recrutement partiel a été utilisé dans une analyse de cohorte. Les estimations de biomasse et d'abondance en nombre de la population ont été corrélées à divers taux de capture. Dans la majorité des cas, les coefficients de corrélation étaient supérieurs à 0.9. La mortalité par la pêche des harengs pleinement recrutés a été estimée à 0.20 en 1969, 0.88 en 1980 et 0.46 en 1981. Un taux de mortalité $F_{0.1}$ = 0.38 a été calculé avec l'analyse de rendement par recrue de Thompson et Bell. La biomasse pour les poissons de 4 à 11 ans (calculée à partir des poids à l'âge pour le premier semestre de l'an) est passée à 49 000 tonnes métriques en 1981, soit cinq pourcent de la biomasse maximale estimée en 1969.

LANDINGS

Landings from the Southern Gulf of St.Lawrence herring stock were historically reported in the spring by fixed inshore gears (Figures 1 and 2). By the mid 1960's, the stock was also exploited by a purse seiner fishery, mainly in the fall, and all along its migratory route (Winters and Hodder, 1975). The result was a slow shift from a spring inshore fishery to year-round fishery dispersed over all the Southern Gulf and up to Southwest Newfoundland.

Accurate catch statistics were always difficult to obtain; most of the herring used for bait is not reported, and fishing restrictions led, in some instances, to undereporting by the fishermen. However, the problems associated with data collection are now being documented (O'Boyle, unpublished) and catch statistics for the Southern Gulf herring stock are available from different sources: NAFO Statistical Bulletins, Fisheries Technical report etc.

In Newfoundland, 4T herring catches were reported in NAFO area 3Pn until 1973. Consequently, the herring landings reported in NAFO areas 4T and 3Pn are presented in this document (Tables 1, 2 and 3).

Between 1968 and 1972, catches from the NAFO area 3Pn purse seiners represented between 23 and 37 percent of the total catch. This percentage has dropped below 1 percent since 1973.

Recently the purse seiners were the gear taking most of the landings: up to 81 percent of the total catch in division 4T, and before 1974 as much as 97% in subdivision 3Pn. The proportion of total landings attributed to the inshore fishery decreased from 1966 to 1980 while the seiner fleet was active. However, in 1981, most of the catch was attributed to inshore gears, because of quota restrictions (Table 4).

POPULATION ABUNDANCE INDICES

Catch rate indices for the inshore and offshore fishery for different areas of the Southern Gulf and a catch rate index from an annual groundfish research trawl survey were used, in an attempt to detect fishable biomass trends. (It should be remembered that until 1981 any data pertinent to the inshore fishery is related only to a low proportion of the total herring catch).

PURSE SEINER FISHERY

Log-book records of catch and effort data for purse seiner fleet operating in the spring, along the "Edge", and in the fall in Southern Gulf area, have been analysed for trends in abundance. The spring catch rates (Cleary, unpublished data), expressed as catch per set (Table 5, Figure 3) dropped continuously between 1969 and 1972, and then remained more or less stable until 1980. However, these catch rates may not reflect the overall abundance of the stock:

this fishery does not exploit a stationary herring population, but schools which are migrating from overwintering and spawning areas, and the seiner fleet has recently changed its area of fishing (Cleary, unpublished data).

The purse seiner fall fishery occurs between the months of June and December, with the exact fishing time varying from one year to the next. However, fishing always occurred during the months of September and October from 1970 to 1979 and from September to November between 1974-1979. In order to minimize the effect of seasonal fluctuations on the calculation of the abundance indices, the catch rates were derived for two limited periods of fishing: September to November, and October only.

The catch rates for the September to November fishery declined between 1971 and 1975, increased in 1976 and then remained stable until 1978 (Table 5, Figure 3). This abundance index dropped to the lowest historical point in 1980, and increased again in 1981. When only the October fishery is considered, even more fluctuations are noted in the catch rate. However, both September-November and October indices show a general declining trend in the available population from the early seventies up to 1979, and an increase in 1981.

The validity of seiners catch rates as representative of the fish population abundance has often been discussed (Powles, 1981; Pope, 1978; Ulltang, 1978). Several factors reduce the reliability of the indices: fishing fleet behavior, increase in searching powers, learning capacity etc. Further, data recorded in seiner log-books are often inaccurate and difficult to analyse. Important details like the fact that seiners voluntarily stop fishing whenever the herring caught has fed on "redfeed", or is too small to be sold to fish plants, are most of the time not recorded, and anyway impossible to quantify, leading to uncertainties in catch rates.

GILLNET FISHERY

The gillnet fishery is now responsible for most inshore landings. In the past few years, many studies have been conducted to evaluate the fishing effort from the gillnetters. These studies have also provided catch rate series from different fisheries in the Southern Gulf (Figure 4).

Southern Gulf questionnaire survey

In 1979, dockside interviews with herring gillnet fishermen were conducted in New Brunswick, Prince Edward Island and Nova Scotia. Following this, a questionnaire was sent to all herring gillnetters licenced in 1979 in the

Southern Gulf. From these questionnaires an effort index was calculated with the number of days fished and the number of nets used. The catch rate index developed covered both the spring and fall fishery, and used exclusively the data provided by those fishermen who sell to processors (O'Boyle and Cleary, 1981). The catch rate was adjusted to account for the total number of fishermen active in the fishery. The results (Table 6, and Figure 5A) tend to indicate that the available herring biomass was stable in the period 1973-1977, reached a maximum abundance in 1977, and declined steadily thereafter.

Southern Gulf purchase slip survey

Messieh (1981) calculated gillnet catch rates from spring and fall fisheries in the Southern Gulf, using the information on all the purchase slips available. His catch rate index (expressed in mt/trip) also indicates a general decline (3-fold) between 1977 and 1980 (Table 6, and Figure 5B). However, as in the purse seine fishery, an increase in catch rate was noted in 1981. The catch rates for two of the major fisheries included in Messieh's analysis are shown in Table 7. The catch rate from the Caraquet fishery shows a different trend in the spring and in the fall. The spring catch rate is very stable up to 1980, while the fall catch rate follows the general declining pattern seen everywhere else. In Escouminac, the spring catch rate declined between 1977 and 1981.

Messieh's overall index is biased because it does not take into account the number of nets fished per trip. In an attempt to minimize the bias, the data used by Messieh were modified to include the average number of nets used by the fishermen. The new abundance index calculated is very similar to the original one, except that it shows that the decline in herring abundance would have started in 1974 instead of 1977 (Table 6, and Figure 5E).

Magdalen Islands surveys

A catch rate index for the spring inshore fishery was calculated with data provided by questionnaires sent to all fishermen licensed. The results show that after a decrease between 1970 and 1973, the catch rates remained stable (Table 6, and Figure 5C). However, this index is based on a relatively small number of answers from fishermen who reported their catch as well as their fishing effort.

Pictou gillnet survey

In Pictou, Nova Scotia, over 90% of the herring catch is taken in fall fishery. The catch rate for that fishery is calculated by dividing the landings by the number of fishing boats using gillnets. This catch rate increased between 1968 and 1971, declined until 1977 (8.6 mt/boat), and stabilized to about 22 mt/boat in 1980-1981 (Table 6, and Figure 5D). This index does not compensate for either number of nets per boat or number of days fished.

None of the gillnet fishery catch rates are adjusted for the fact that recently, more and more fishermen are using drift nets with acoustic equipment to locate the fish, at least during the fall fishery. The abundance indices are thus probably biased upward for the most recent years.

TRAP FISHERY

The herring trap fishery in the Magdalen Islands offers several advantages over other commercial fisheries for the study of herring catch rates. Firstly, the effort of the trap fishery has remained relatively constant over the last decade and is more easily quantifiable than for any other gear. Traps are fixed gear and there has been no marked increase either in their numbers or in their efficiency due to changes in design (size, shape, mesh size) or fish search techniques (Spênard, 1979). Secondly, since no discarding of fish is practiced by trap fishermen (H. Cyr, personal communication) and since there is a commercial trap fishery for which landing data are available, an estimate of catch and ultimately catch per unit effort (CPUE) can be easily obtained. Thirdly, traps are less size selective than gillnets and thus sampling of the herring population is more representative.

In the Magdalen Islands, traps historically reported most of the catch. This gear exploits only spring spawning herring. The trap fishery can thus provide a reliable abundance index for the spring spawners since the fishing effort of this fixed gear has been very stable over time: traps have remained in the same emplacements without being moved to concentrate on area where fish are abundant. However the catch is subject to the migration and behavior of herring as well as the timing of the fishery with the spawning period. Catch rates were calculated by dividing the reported trap landings by the number of traps in operation. This index (Table 8 and Figure 6) clearly indicates a drop in available abundance since 1970.

GROUNDFISH TRAWL SURVEYS

The Southern Gulf groundfish trawl research survey was designed to obtain basic biological information for groundfish stocks (Halliday & Koeller, 1981). Any catch of herring is incidental, and catch rates should be accepted with caution (Table 9 and Figure 7). However, if the 1978 point is not considered there is a general declining trend in herring catch rates since 1970. If the survey was completely inadequate for herring one would expect that accidental catch of herring would produce fluctuating catch rates with time rather than a series with a trend. In 1981, the research vessel herring abundance index was at its lowest point of the last decade.

AGE COMPOSITION OF THE COMMERCIAL CATCH

Catch at age data were provided by Dr. G. Winters. The age composition matrix shows that for spring spawners, the 1974 year-class has contributed substantially to the fishery in recent years (Table 10). Fish of age one have been caught since 1977. The mean age of the catch has gone from 8 years in 1969 to 4 years in 1978-81, even with the apparently strong 1974 year-class supporting the fishery from 1977 to 1979. The proportion of fish younger than 4 years old has gradually increased from 26% in 1978 to 59% in 1981. This increase in not due to the presence of one young dominant year-class, but rather to an increase in proportion of the catch of two and three-year-olds. Although the 1977 year-class represented a high (42%) proportion of the total catch in numbers in 1980, this year-class was replaced in importance in the 1981 catch by the 1978 year-class.

In the fall spawner catch (Table 11), fish of age one have been seen in 1979-80. The mean age of the catch has also dropped, going from 9 years in 1969 to 4 years in 1981. The proportion of fish younger than 4 years old has increased to 40% in 1980, due to the presence of the 1977 year-class which represents 38% of the total catch in number. In 1981, this same year-class comprised 60% of the catch in numbers.

Up to 1981 , a shift in population age structure towards younger age classes could result from heavy fishing pressure, as in the case of the Pacific sardine (Murphy, 1966). Since the seiner fleet has the capacity to search for schools of herring, and since there is no market for fish smaller than 10 inches, it appears probable that no more larger older fish were available to the fishery, forcing the seiners to catch smaller younger fish. Besides, in 1981, although most of the catch (80%) was taken by gillnetters, the mean age of the catch was still low and the proportion of young fish still high compared to the early 1970's. This could also reflect the fact that larger older fish are scarce in the population.

The catch matrix for spring and fall spawners was combined (Table 12) to perform the cohort analysis. Also, since fish older than 11 years represented up to 43% of the fall spawner catch in 1969, and 38% of the spring spawner catch in 1970, numbers of 11+ fish were broken down into numbers up to age 16. To do so, the following assumption was made: the ratio of number of fish at age 10 to the number of fish 10+ in 1969 equals the ratio of fish 11 to 11+ in 1970, and so on. The numbers prorated in this way were used in the cohort analysis.

MORTALITY RATES

An estimate of 0.2 for the instantaneous natural mortality rate (M) was assumed for the present analysis. This value was used in preceding assessments (Winters and Hodder, 1975, Cleary, 1981) and is consistent with that for other herring stocks (Lea, 1930; Runnstrom, 1936; Beverton, 1963). The possibility of fluctuations with time in the natural mortality rate cannot be excluded, but since no accurate calculations of such a change could be done, M was assumed constant.

Total mortality rates (Z) were calculated according to the Paloheimo linear formula (1961), using the combined spring and fall spawner catch-at-age stated above and the effort derived from catch rates of fisheries where both spring and fall spawner herring are caught:

a) the purse seiner fall fishery: September-October-November
b) the combined gillnet fishery in the Southern Gulf

The average mortality rates were calculated for fish of ages 5 to 9, in order to cover the range of ages that were under direct fishing pressure since 1969 (Table 13). Up to 1973, negative rates were calculated, indicating that at least part of the data were not suitable for the calculations. The 1981 data were corrected to account for the fact that the selectivity of the gears mostly used in 1981 was different from the purse seiner selectivity (cf partial recruitment section). From the three different mortality series calculated, two show a decrease in herring total mortality rate in 1980-1981 compared to 1979-1980.

PARTIAL RECRUITMENT

Since the fishery changed from predominantly offshore to predominantly inshore gears in 1981, partial recruitment could not be estimated from previous years data. Consequently, a selectivity vector was calculated for fish ages 1 to 11 and used as partial recruitment. The selectivity vector was derived as given in the following paragraphs.

The proportion of gillnet mesh sizes used in different areas and seasons was calculated from various sources (Cleary and Worgan, 1981; Greendale and Powles, 1980; O'Boyle and Cleary, 1981). The landings for these same areas and months were broken down according to the proportion of the different mesh sizes employed, and used as a weighing factor in the calculation of a "combined" selectivity ogive. The selectivity ogives for the major gillnet mesh sizes used were obtained from Olsen (1959), and fish caught by purse seiner were assumed to be fully recruited at age 3. The final selectivity ogive was

age	1	2	3	4	5	6	7	8	9	10	11
pr	.05	.31	.63	.82	1.0	1.0	.92	.86	.80	.74	.74.

Since only spawning fish are available to the gillnet fishery, the selectivity vector for the 1981 fishery had to be adjusted for the proportion of mature fish available to the dominant gear.

In order to do so, the proportion of fully mature fish in the purse seiner catch was calculated, and considered as representative of the population maturity composition. The selectivity factor for gillnets only was thus multiplied by the proportion of mature fish in the population to give an "ajusted selectivity vector". The resulting vector for gillnets and purse seiner catch was

age	1	2	3	4	5	6	7	8	9	10	11
pr	.05	.16	.51	.76	1.0	1.0	.93	.87	.87	.78	.78.

YIELD PER RECRUIT

A Thompson and Bell yield per recruit relationship was calculated using partial recruitment values and weights at age (weighted averages for spring and fall spawners) from Winters (pers. comm.). These weights were calculated for fish caught in gillnets and are quite different from the previous year's weights at age (Table 14).

$F_{0.1}$ was calculated using partial recruitment values for ages 1 and 2 derived from the cohort analysis:

PR age 1	PR age 2	$F_{0.1}$
.0016	.048	.38

COHORT ANALYSIS

The cohort analysis was run with a trial 1981 F (for ages 5-8) equal to 0.456. This value was derived from Z-M which is 0.656-0.2. The cohort was iterated until the average F's ages 5 to 8, were stable. This was done by replacing the fishing mortality rate at age 16 by the average F's for ages 5 to 8 for each trial run. After three runs the average F's were stable. The partial recruitment values used in the first run were those calculated with the selectivity factor. Once average F's were stable, the partial recruitment was calculated again for the ages 1 and 2, by taking the geometric mean of the population numbers from 1969 to 1976. A final run was then made with these new values of PR (Table 15). The population numbers went from 6106 x 10^3 in 1969 to 893 x 10^3 in 1981, the biomass dropped from 1117x10^3 mt to 117x10^3 mt for the same period, while the fully recruited F increased from 0.20 in 1969 to 0.88 in 1980 and dropped to 0.46 in 1981.

Average F's were then correlated with the effort data derived from the gillnet fishery and from the purse seiner fishery (Figures 8 and 9a). In the early 1970's older fish (ages 10^+) represented a higher proportion of the population than in the most recent years. Consequently the catchability of fish at ages 5 to 8, in relation to fish of ages 10^+ was then lower than in the late 1970's. We thus adjusted the 1969-1972 effort data for this change in q. The effort values were multiplied by the ratio of their respective annual q to the 1973 to 1980 average q. The F versus effort relationship was then very evident (Figure 9b).

The mid-year population biomass and fishable biomass, as well as the population number estimates were respectively correlated with the purse seiner and gillnet catch rates and the research vessel number/tow. Most of the coefficients of correlation were above 0.93. (Figures 10, 11, 12, 13, 14a, 14b).

Since all correlations between cohort analysis estimates and the independant variable were high, and since in most graphs, the 1981 data point was very close to the regression line, the need to fine tune the analysis was not evident, and the trial F = 0.456 was accepted as final.

CATCH PROJECTIONS

Projections were done using the population number estimates in 1981, with the partial recruitment values used in the cohort analysis. All the projections were calculated at $F_{0.1}$ (Table 16). Catches of 22 000 mt in 1982, 26 000 mt in 1983 and 29 000 mt in 1984 will allow the 4T population biomass to increase from 57 000 mt in 1982 to 87 000 mt in 1984.

CONCLUSION

The 4T herring stock assessment is based on much imprecise data: the real total catch is not known, the various catch rate indices are biased, the spawning type and age assignment of fish is still often subjective (Cleary et al. 1982) and recruitment is almost impossible to predict.

However, the overall analysis shows that the stock biomass is presently at a much lower level than in the early seventies. Further, TAC's although fixed at 50% of $F_{0.1}$ have rarely been reached. The recent increase in fishing effort (Greendale and Powles, 1980; Cleary and Worgan, 1981; Messieh, 1981; O'Boyle and Cleary, 1981) has not resulted in an appreciable increase of the overall landing. Since 1978 a higher proportion of the catch is composed of young fish and many catch rates are at a historical low. However, there is a possibility that the 1977 fall spawner year-class is at least moderately strong, and if the stock is fished at $F_{0.1}$, the mature population biomass (ages 4+) should increase to approximately 87 000 mt in 1984.

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Table 1: Herring Landings* (mt) from NAFO division 4T, 1967 to 1981.

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1967	1742	-	-	409	25220	8764	5679	10718	4620	1358	3095	1131	62736
1968	546	442	806	6455	24239	2566	15847	19768	22350	5284	13057	770	112130
1969	-	-	73	9329	17701	6568	35476	46987	22448	4169	11543	121	154415
1970	-	55	-	21211	15782	2545	51002	36860	24959	18506	3831	746	175497
1971	-	-	42	10644	11895	4809	41521	23067	36282	5163	1053	370	134846
1972	-	-	-	400	6102	2583	11034	9092	14453	7777	2108	41	53590
1973	-	-	-	1876	12801	4221	2135	7737	9436	2079	69	3	40357
1974	-	-	-	1302	14474	1190	2958	3143	7282	3081	1714	9	35153
1975	-	-	-	4028	20229	1428	289	2398	4646	8986	2256	305	44565
1976	-	-	-	8461	14406	961	193	1082	1807	5244	6973	326	39453
1977	-	-	-	7625	8338	8850	244	2125	1148	7166	8726	602	44824
1978	240	-	-	2046	13363	883	526	2487	10095	13672	6981	2848	53141
1979	-	-	-	14072	6158	1113	680	1766	6381	5071	9904	2598	47743
1980	80	-	15	10458	9220	1033	910	2223	1958	9006	5000	540	40443
1981			15	1925	3910	715	1584	5085	4015	2771	2023	-	22043**

* From ICNAF statistical bulletin no 17 to 30
** Provisional

Table 2: Herring Landings* (mt) from NAFO subdivision 3Pn, 1967 to 1981.

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1967	24	69	8	-	28	21	1	27	26	7	4	44	259
1968	712	9152	20696	3253	22	10	7	31	-	21	190	1902	35996
1969	26507	25581	19934	8352	354	2	27	2	224	43	1017	13416	95459
1970	32179	26491	28806	3457	4	4	1	2	-	-	585	2695	94224
1971	21835	23563	19192	3711	1	1	2	-	2	7	26	1572	69912
1972	8327	1053	424	3136	5061	-	1	3	1	2	661	324	18993
1973	222	103	4	40	1	2	3	5	4	6	3	2	395
1974	-	-	-	2	3	2	3	37	21	5	1	-	74
1975	-	-	-	3	5	2	3	2	4	5	-	-	24
1976	-	-	-	4	3	3	1	2	1	1	-	-	15
1977	-	-	-	1	2	3	1	2	2	1	64	-	76
1978	-	1	-	2	1	-	-	-	-	-	-	-	4
1979	-	-	-	2	3	1	2	-	-	-	-	-	8
1980	-	-	-	11	-	-	-	-	-	-	-	-	11
1981													9**

* From ICNAF statistical bulletin no 17 to 30
** Provisional

Table 3: Herring Landings* (mt) from NAFO division 4T and subdivision 3Pn, 1967 to 1981.

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1967	1766	69	8	409	25248	8785	5680	10745	4646	1365	3099	1175	62995
1968	1258	9594	21502	9708	24261	2576	15854	19799	22350	5305	13247	2672	148126
1969	26507	25581	20007	17681	18055	6570	35503	46989	22672	4212	12560	13537	249874
1970	32179	26546	28806	24668	15786	2549	51003	36862	24959	18506	4416	3441	269721
1971	21835	23563	19234	14355	11896	4810	41523	23067	36284	5170	1079	1942	204758
1972	8327	1053	424	3536	11163	2583	11035	9095	14454	7779	2769	365	72583
1973	222	103	4	1916	12802	4223	2138	7742	9440	2085	72	5	40752
1974	-	-	-	1304	14477	1192	2961	3180	7303	3086	1715	9	35227
1975	-	-	-	4031	20234	1430	292	2400	4650	8991	2256	305	44589
1976	-	-	-	8465	14409	964	194	1084	1808	5245	6973	326	39468
1977	-	-	-	7626	8340	8853	245	2127	1150	7167	8790	602	44900
1978	240	1	-	2048	13364	886	526	2487	10095	13672	6981	2848	53145
1979	-	-	-	14074	6161	1114	682	1766	6381	5071	9904	2598	47751
1980	80	-	15	10469	9220	1033	910	2223	1958	9006	5000	540	40454
1981	-	-	15	1934	3910	715	1584	5085	4015	2771	2023	-	22052**

* From ICNAF statistical bulletin no 17 to 30
** Provisional

Table 4: Preliminary herring landings (mt) for NAFO division 4T, in 1981.

Gear	January	February	March	April	May	June	July	August	September	October	November	December	Total
FIX	-	-	-	1	12	2	-	9	-	-	-	-	24
GND	-	-	-	525	1429	225	60	414	638	141	27	-	3459
GNS	-	-	15	1395	2449	485	1519	4582	3285	172	63	-	13965
HL	-	-	-	-	-	1	1	10	-	-	-	-	12
MIX	-	-	-	-	-	1	-	1	3	-	-	-	5
NK	-	-	-	4	-	-	-	-	-	-	-	-	4
OTB1	-	-	-	-	-	-	-	35	89	8	-	-	132
OTB2	-	-	-	-	20	-	1	-	-	-	-	-	21
LL	-	-	-	-	-	1	1	-	-	-	-	-	2
PS*	-	-	-	-	-	-	2	-	-	2450	1933	-	4385
SDN	-	-	-	-	-	-	-	34	-	-	-	-	34
TOTAL	-	-	15	1925	3910	715	1584	5085	4015	2771	2023	0	22043

*From recorded landings: 2626 mt; from fishermen pers. comm.: 4385 mt.

Table 5. Purse Seiner catch rates for 4T herring.

Year	Spring "edge"		Sept.-Oct.-Nov.[b]	October[a]	
	catch/set[a]	catch/night[a]	catch/set	catch/set	catch/night
1967	73.1	169.3			
1968	38.1	72.2		68.1	48.7
1969	41.6	75.5		—	--
1970	38.7	74.2		62.6	77.5
1971	35.1	85.5	56.7	40.1	70.3
1972	25.9	67.4	45.1	56.2	79.6
1973	40.2	126.3	41.5	146.0	146.0
1974	33.2	97.1	37.9	23.4	40.5
1975	56.6	102.8	34.5	35.0	45.5
1976	34.9	78.2	40.6	40.1	57.1
1977	32.1	60.5	44.4	50.2	78.4
1978	33.2	51.4	44.3	31.9	50.9
1979	32.0	102.4	24.5	20.2	13.9
1980	35.7	76.2	18.7	24.2	31.8
1981			26.6[c]	33.9[c]	44.6[c]

[a]from Cleary (unpublished)

[b]from Winters, pers. comm.

[c]from the observers' program

Table 6. Gillnet catch rates for 4T herring.

Year	kg/net [a]	mt/s. trip [b]	c/net	lb/net-days [c]	mt/boat [d]
1968					25.7
1969					28.7
1970				100.0	44.2
1971				100.0	73.3
1972				57.7	62.2
1973	96.4	2.2	0.25	57.7	45.5
1974	92.2	1.7	0.43	46.4	17.4
1975	83.3	2.1	0.40	45.9	22.6
1976	89.4	2.0	0.28	56.1	15.2
1977	124.8	2.6	0.22	53.0	8.6
1978	89.3	2.4	0.21	52.1	11.7
1979	50.7	1.6	0.12	60.4	32.9
1980	33.5	1.0	0.07	47.7	23.4
1981		1.5	0.10	46.6	20.6

a Messieh and O'Boyle, pers. comm.
b Messieh, 1981 and Murdoch pers. comm.
c Magdalen Islands, spring fishery
d Pictou fall fishery, R. Crawford, pers. comm.

Table 7. CPUE* from purchase slips (as taken from Messieh, 1981).

	Caraquet spring fishery	Caraquet fall fishery	Escouminac spring fishery
1973	3.802	3.109	2.107
1974	2.291	7.143	1.617
1975	1.118	6.797	1.606
1976	2.280	5.496	2.103
1977	3.974	6.176	2.333
1978	4.744	4.200	2.700
1979	2.275	2.753	1.731
1980	3.184	1.781	1.188
1981**	0.772	2.367	0.875

* t/purchase slip
** from Murdoch and Randall, pers. comm.

Table 8. Magdalen Islands trap catch rates (mt/trap) for herring

1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
204.8	328.8	123.3	90.9	80.2	59.0	40.3	72.0	33.6	7.3	2.1	1.0

Table 9. Trawl groundfish survey catch rates (no/set) for 4T herring

1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
88.7	98.7	39.1	48.4	4.9	40.8	15.5	16.5	83.7	18.9	3.7	3.3

Table 10. Catch-at-age and age composition for spring spawner herring in NAFO Division 4T, 1969-1981.

Age group	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
	Catch-at-age ($x10^{-6}$)												
1	-	-	-	-	-	-	-	-	2.0	1.5	8.0	2.0	0.2
2	0.1	0.1	3.2	0.1	5.8	4.7	1.6	17.3	3.3	14.3	21.7	20.3	5.7
3	17.2	8.4	66.0	2.1	2.5	8.8	26.8	9.1	60.3	14.7	13.3	39.8	16.4
4	18.4	40.7	6.8	29.1	3.0	3.4	19.2	29.3	7.4	67.7	5.7	5.3	7.6
5	12.9	12.7	13.6	6.4	46.9	1.8	3.2	7.2	10.8	4.8	32.9	2.9	1.2
6	29.3	16.6	9.6	5.8	7.7	26.8	16.8	2.4	3.6	7.1	2.1	14.7	0.8
7	25.1	32.6	9.1	4.3	4.5	3.9	20.1	0.5	0.6	1.3	3.0	3.1	4.1
8	8.5	35.6	15.3	4.8	7.9	4.2	2.5	9.4	0.5	1.2	0.7	1.9	0.7
9	48.6	10.2	15.0	5.1	2.9	6.2	3.3	1.1	6.6	0.2	0.2	0.7	0.7
10	155.4	39.3	5.6	5.3	3.1	1.1	5.3	1.6	0.5	3.7	0.7	0.3	0.1
11+	17.8	121.4	67.8	7.4	7.3	2.7	6.2	21.4	13.5	2.1	3.4	2.7	1.0
Total	333.3	317.6	212.0	70.4	91.6	63.6	105.0	99.3	109.1	118.7	91.8	93.8	38.4
Mean age	8.4	8.5	7.0	6.2	5.9	5.9	5.6	5.7	4.7	4.1	4.0	3.9	4.0
	Age composition (%)												
1	-	-	-	-	-	-	-	-	1.8	1.3	8.7	2.1	0.5
2	*	*	1.5	0.2	6.3	7.4	1.5	17.4	3.0	12.1	23.6	21.6	14.7
3	5.2	2.6	31.2	3.0	2.7	13.8	25.5	9.2	55.2	12.4	14.5	42.4	42.9
4	5.5	12.8	3.2	41.3	3.3	5.4	18.3	29.5	6.8	57.0	6.2	5.7	19.7
5	3.9	4.0	6.4	9.1	51.2	2.8	3.1	7.3	9.9	4.0	35.9	3.1	3.2
6	8.8	5.2	4.5	8.2	8.4	42.1	16.0	2.4	3.3	6.0	2.3	15.7	2.1
7	7.5	10.3	4.3	6.1	4.9	6.1	19.1	0.5	0.6	1.1	3.3	3.3	10.7
8	2.6	11.2	7.2	6.8	8.6	6.6	2.4	9.5	0.5	1.0	0.8	2.0	1.7
9	14.6	3.2	7.1	7.3	3.2	9.8	3.1	1.1	6.1	0.2	0.2	0.8	1.7
10	46.6	12.4	2.6	7.5	3.4	1.7	5.1	1.6	0.5	3.1	0.8	0.3	0.2
11+	5.3	38.3	32.0	10.5	8.0	4.3	5.9	21.5	12.4	1.8	3.7	2.9	2.6
< 4	5.2	2.6	32.7	3.2	9.0	21.2	27.0	26.6	60.0	25.8	46.8	66.1	58.1

* 0.1%

Table 11. Catch-at-age and age composition of fall spawner herring in NAFO Division 4T, 1969-1981.

Age group	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
	Catch-at-age ($x10^{-6}$)												
1											0.1	0.1	-
2	2.4	2.2	4.9	5.7	1.7	4.7	0.1	0.1	0.2	1.5	2.9	1.3	0.1
3	21.9	42.2	33.1	5.2	3.8	5.0	2.2	0.3	3.0	19.2	6.2	30.6	9.3
4	20.0	59.0	92.9	15.6	4.8	16.3	4.1	1.9	7.9	27.6	34.6	9.4	30.6
5	19.5	30.2	35.6	51.4	8.3	6.0	25.5	5.4	3.6	14.3	27.4	22.0	5.5
6	91.1	25.4	60.0	21.3	21.8	4.0	7.0	31.2	3.6	4.0	11.0	7.9	2.4
7	119.7	160.4	88.8	29.4	10.0	9.9	3.3	4.5	22.4	3.5	2.3	3.9	0.9
8	38.4	103.2	115.8	27.0	13.2	2.7	5.0	2.0	2.2	14.1	3.1	0.6	0.9
9	50.5	42.9	58.6	24.5	10.2	5.3	2.2	3.8	1.4	1.6	5.2	0.8	0.2
10	94.0	61.8	31.5	12.5	15.3	4.0	3.7	0.8	2.8	0.9	0.7	0.3	0.1
11+	338.0	326.5	227.8	76.4	22.3	19.7	21.4	17.9	16.6	14.6	11.4	3.2	0.9
Total	795.5	853.8	749.0	269.0	111.4	77.6	74.5	67.9	63.5	101.3	104.9	80.0	50.9
Mean age	8.9	8.4	7.9	7.7	7.8	6.9	7.4	7.5	7.5	5.8	5.6	4.6	4.3
	Age composition (%)												
1	-	-	-	-	-	-	-	-	-	-	0.1	0.1	-
2	0.3	0.3	0.6	2.1	1.5	6.1	0.1	0.1	0.3	1.5	2.8	1.6	0.1
3	2.7	4.9	4.4	1.9	3.4	6.4	3.0	0.4	4.7	19.0	5.9	38.2	18.2
4	2.5	6.9	12.4	5.8	4.3	21.0	5.5	2.8	12.4	27.2	32.9	11.7	60.2
5	2.4	3.5	4.8	19.1	7.5	7.7	34.2	7.9	5.6	14.1	26.1	27.5	10.8
6	11.5	3.0	8.0	7.9	19.6	5.2	9.4	46.0	5.6	3.9	10.5	9.9	4.7
7	15.1	18.8	11.9	10.9	9.0	12.8	4.4	6.6	35.2	3.5	2.2	4.9	1.8
8	4.8	12.1	15.5	10.1	11.8	3.5	6.7	3.0	3.5	13.9	3.0	0.7	1.9
9	6.4	5.0	7.8	9.1	9.2	6.8	3.0	5.6	2.2	1.6	4.9	1.0	0.3
10	11.8	7.2	4.2	4.7	13.7	5.2	5.0	1.2	4.4	0.9	0.7	0.4	0.2
11+	42.5	38.2	30.4	28.4	20.0	25.3	28.7	26.4	26.1	14.4	10.9	4.0	1.8
<4	3.0	5.2	5.0	4.0	4.9	12.5	3.1	0.5	5.0	20.5	8.8	39.9	18.3

Table 12. Catch-at-age for spring and fall spawner herring in NAFO Division 4T, 1969-1981.

Age group	Catch-at-age in numbers $x10^{-6}$												
	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1									2.0	1.5	8.1	2.1	0.2
2	2.5	2.3	8.1	5.8	7.5	9.4	1.7	17.4	3.5	15.8	24.6	21.6	5.7
3	39.1	50.6	99.1	7.3	6.3	13.8	29.0	9.4	63.3	33.9	19.5	70.4	25.8
4	38.4	99.7	99.7	44.7	7.8	19.7	23.3	31.2	15.3	95.3	40.3	14.7	38.2
5	32.4	42.9	49.2	57.8	55.2	7.8	28.7	12.6	14.4	19.1	60.3	24.9	6.7
6	120.4	42.0	69.6	27.1	29.5	30.8	23.8	33.6	7.2	11.1	13.1	22.6	3.2
7	144.8	193.0	97.9	33.7	14.5	13.8	23.4	5.0	23.0	4.8	5.3	7.0	5.0
8	46.9	138.8	131.1	31.8	21.1	6.9	7.5	3.4	2.7	15.3	3.8	2.5	1.6
9	99.1	53.1	73.6	29.6	13.1	11.5	5.5	4.9	8.0	1.8	5.4	1.5	0.8
10	249.4	101.1	37.1	17.8	18.4	5.1	9.0	2.4	3.3	4.6	1.4	0.6	0.11
11+	355.8	447.9	295.6	83.8	29.6	22.4	27.6	39.3	30.1	16.7	14.8	5.9	1.9
Total	1,128.8	1,171.4	961.0	339.4	203.0	141.2	179.5	159.2	172.8	219.9	196.6	173.8	89.2
Proportion (%) of													
Spring spawners	30	27	22	21	45	45	58	59	63	54	47	54	43
Fall spawners	70	73	78	79	55	55	42	41	37	46	53	46	57

Table 13. Total mortality rates (Z) for 4T herring calculated with effort indices derived from commercial catch rates.

	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81
PS c/set (Oct.)	0.279	-0.336	-0.867	2.340	-0.180	0.318	0.192	0.984	0.950	0.559	0.650
PS c/set (Sept-Nov)		0.231	0.171	0.599	0.316	0.291	0.327	0.532	1.085	1.010	0.665
GN c/net				- 0.016	0.285	0.813	0.631	0.607	1.046	1.292	0.652

Table 14. Average weights at age for 4T herring for the first quarter of the year (from Winters, pers. comm.).

WEIGHTS AT AGE (g) FOR 4T HERRING SPRING SPAWNERS 20/3/82

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.00	0.00
2	75.00	67.00	75.00	75.00	87.00	95.00	90.00	104.00	92.00	94.00	62.00	93.00	123.50
3	126.00	146.00	103.00	140.00	141.00	160.00	154.00	177.00	157.00	150.00	138.00	140.00	172.70
4	197.00	184.00	185.00	207.00	184.00	202.00	185.00	210.00	185.00	202.00	181.00	180.00	231.80
5	200.00	208.00	221.00	233.00	219.00	238.00	229.00	247.00	236.00	243.00	234.00	220.00	277.10
6	238.00	237.00	243.00	274.00	267.00	275.00	266.00	275.00	265.00	293.00	262.00	250.00	318.10
7	250.00	266.00	268.00	311.00	282.00	291.00	298.00	271.00	272.00	305.00	288.00	303.00	345.70
8	270.00	274.00	292.00	318.00	310.00	319.00	304.00	304.00	279.00	323.00	328.00	328.00	366.20
9	276.00	285.00	290.00	339.00	327.00	320.00	316.00	310.00	296.00	341.00	341.00	341.00	375.90
10	294.00	298.00	301.00	323.00	332.00	328.00	329.00	333.00	309.00	343.00	345.00	356.00	366.50
11	323.00	318.00	319.00	344.00	374.00	348.00	357.00	353.00	322.00	373.00	373.00	415.00	413.30

WEIGHTS AT AGE (g) FOR 4T HERRING FALL SPAWNERS 20/3/82

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00	0.00
2	40.00	40.00	40.00	40.00	40.00	47.00	40.00	35.00	40.00	40.00	37.00	76.00	0.00
3	63.00	88.00	93.00	53.00	100.00	126.00	115.00	111.00	99.00	128.00	83.00	109.00	143.40
4	149.00	133.00	142.00	168.00	170.00	190.00	169.00	184.00	166.00	191.00	168.00	172.00	241.60
5	171.00	188.00	189.00	194.00	206.00	235.00	215.00	217.00	202.00	231.00	217.00	224.00	273.40
6	197.00	202.00	129.00	238.00	242.00	255.00	248.00	253.00	229.00	260.00	262.00	257.00	316.70
7	225.00	221.00	234.00	253.00	269.00	283.00	272.00	276.00	260.00	288.00	288.00	300.00	326.10
8	236.00	244.00	248.00	262.00	292.00	314.00	288.00	283.00	276.00	315.00	312.00	329.00	347.80
9	247.00	255.00	264.00	277.00	295.00	327.00	314.00	300.00	287.00	313.00	329.00	346.00	394.00
10	254.00	262.00	272.00	287.00	313.00	331.00	325.00	323.00	285.00	322.00	333.00	375.00	327.50
11	281.00	290.00	297.00	312.00	342.00	354.00	362.00	349.00	324.00	363.00	380.00	386.00	426.80

COMBINED WEIGHTS AT AGE (g) FOR 4T HERRING SPRING AND FALL SPAWNERS 20/3/82

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.40	
2	41.40	41.20	53.80	40.60	76.30	71.00	84.90	103.60	89.00	88.90	59.10	92.00	123.10
3	90.70	97.60	99.70	78.00	116.30	147.70	136.40	174.90	154.30	137.50	120.50	126.50	163.50
4	172.00	153.80	144.90	193.40	175.40	192.10	182.20	208.40	175.20	198.80	169.80	174.90	239.50
5	182.50	193.90	197.80	198.30	217.80	235.70	216.60	234.10	227.50	234.00	226.30	223.50	274.10
6	207.00	215.80	144.70	245.70	248.50	272.40	260.70	254.60	247.00	281.10	262.00	252.40	317.10
7	229.30	228.60	237.20	260.40	273.00	285.30	294.30	275.50	260.30	292.60	288.00	301.30	342.50
8	242.20	251.70	253.10	270.50	298.70	317.00	293.30	291.60	276.60	315.60	314.90	328.20	358.90
9	261.20	260.80	269.30	287.70	302.10	323.20	315.20	302.20	294.40	316.10	329.40	343.70	378.50
10	278.90	276.00	276.40	297.70	316.20	330.40	327.40	329.70	288.60	338.90	339.00	365.50	398.45
11	283.10	297.60	302.00	314.80	349.90	353.30	368.90	350.70	327.60	364.30	378.40	399.30	418.40

Table 15. Population numbers and fishing mortality rates as estimated from cohort analysis for 4T herring.

POPULATION NUMBERS x 10^3

Age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	719	192	421	178	235	181	586	228	128	400	233	342	296
2	571	589	157	344	145	193	149	480	187	103	326	183	278
3	422	465	480	121	277	112	149	120	377	150	70	245	130
4	542	310	335	303	93	221	79	96	90	252	92	40	137
5	468	409	164	184	208	69	163	44	50	60	120	39	19
6	902	354	296	89	99	120	49	107	25	28	32	44	9
7	568	629	251	179	49	54	71	19	58	14	13	14	15
8	238	334	340	117	116	27	32	37	11	26	7	6	5
9	403	152	148	160	67	76	16	19	27	6	8	2	3
10	740	241	77	55	104	43	52	8	11	15	4	1	0
11	533	380	105	29	29	69	31	34	4	6	8	2	1
1+	6106	4055	2774	1759	1422	1165	1377	1192	968	1060	913	918	893

FISHING MORTALITY

Age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.004	0.039	0.007	0.001
2	0.005	0.004	0.059	0.019	0.059	0.055	0.013	0.041	0.021	0.186	0.087	0.140	0.023
3	0.108	0.128	0.259	0.069	0.025	0.146	0.242	0.090	0.205	0.288	0.367	0.382	0.245
4	0.082	0.439	0.399	0.178	0.098	0.104	0.392	0.445	0.209	0.542	0.663	0.526	0.365
5	0.080	0.123	0.404	0.426	0.347	0.134	0.216	0.381	0.380	0.436	0.812	1.239	0.480
6	0.160	0.141	0.301	0.408	0.402	0.332	0.764	0.424	0.391	0.570	0.613	0.852	0.480
7	0.331	0.414	0.563	0.233	0.399	0.332	0.456	0.349	0.582	0.494	0.595	0.803	0.446
8	0.246	0.614	0,554	0.356	0.224	0.336	0.303	0.108	0.322	1.027	0.961	0.632	0.418
9	0.317	0.486	0.796	0.229	0.242	0.182	0.492	0.332	0.398	0.370	1.484	1.509	0.418
10	0.466	0.625	0.764	0.445	0.217	0.140	0.212	0.414	0.391	0.420	0.553	0.621	0.375
11	0.204	0.739	0.808	0.468	0.268	0.153	0.216	0.513	0.540	0.493	0.514	0.600	0.375
F_{5-8}	0.201	0.315	0.443	0.353	0.343	0.284	0.435	0.315	0.419	0.632	0.745	0.882	0.456

BIOMASS (first quarter of the year)

Age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	30486	8141	17850	7547	9964	7674	24846	9667	5427	16960	9879	14501	12550
2	23639	24267	8447	13966	11064	13703	12650	49728	16643	9157	19267	16836	34222
3	38257	45422	47871	9452	32180	16582	20369	21004	58229	20579	8447	30996	21311
4	93402	47672	48576	58686	16242	42424	14472	20011	15736	50037	15598	6952	32789
5	86424	79470	32352	36539	45301	16206	35303	10289	11463	13968	27119	8659	5274
6	192296	77342	42939	21964	24492	32782	12836	27362	6072	7934	8277	10993	2914
7	131657	148963	60588	46865	13286	15406	20796	5173	14990	3983	3763	4221	5209
8	57968	85344	90832	32607	34905	8472	9305	10696	3001	8312	2142	1937	1844
9	104464	40037	40938	50405	21123	24752	4929	5799	7935	2035	2543	732	972
10	207288	65626	21460	17226	36887	14998	17122	2581	3255	5026	1235	524	149
11	150893	113934	31165	9444	10941	27862	11747	12160	1388	2276	3019	685	264
1+	1116774	736218	443018	304701	256385	220861	184375	174470	143139	140267	101289	97036	117498
4+	1024392	658388	368850	273736	203177	182902	126510	94071	63840	93571	63696	34703	49415

Table 16. Catch and population estimates for 4T herring in 1982 to 1984, assuming a fishing mortality rate at $F_{0.1} = 0.381$.

AGE	POPULATION NUMBERS (n x 10^3)				POPULATION BIOMASS* (mt)			
	1981	1982	1983	1984	1981	1982	1983	1984
1	296	296	296	296	20 238	20 269	20 269	20 269
2	278	242	242	242	38 465	33 413	33 469	33 469
3	130	223	194	195	23 921	40 883	35 681	35 741
4	137	83	150	131	36 806	22 448	40 355	35 220
5	19	78	51	92	5 919	23 935	15 739	28 294
6	9	10	44	29	3 270	3 469	15 486	10 183
7	15	5	5	24	5 847	1 790	2 096	9 355
8	5	8	3	3	2 069	3 210	1 077	1 261
9	3	3	5	2	1 091	1 177	1 990	668
10	0	1	2	3	172	619	728	1 231
11	1	0	1	1	296	106	395	465
1+	893	949	993	1 018	138 094	151 319	167 285	176 156
4+	189	188	261	285	55 470	56 754	77 866	86 677

AGE	CATCH NUMBERS (n x 10^3)				CATCH BIOMASS* (mt)				FISHING MORTALITY			
	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984
1	0	0	0	0	14	11	11	11	0.001	0.001	0.001	0.001
2	6	4	4	4	788	544	545	545	0.023	0.018	0.018	0.018
3	26	36	31	31	4 735	6 578	5 741	5 751	0.245	0.195	0.195	0.195
4	38	19	34	30	10 270	5 147	9 252	8 075	0.365	0.290	0.290	0.290
5	7	22	15	27	2 061	6 918	4 549	8 178	0.480	0.381	0.381	0.381
6	3	3	13	8	1 139	1 003	4 476	2 943	0.480	0.381	0.381	0.381
7	5	1	1	7	1 922	487	570	2 545	0.446	0.354	0.354	0.354
8	2	2	1	1	645	826	277	324	0.418	0.332	0.332	0.332
9	1	1	1	0	340	303	512	172	0.418	0.332	0.332	0.332
10	0	0	0	1	45	145	171	289	0.335	0.298	0.298	0.298
11	0	0	0	0	85	25	93	109	0.375	0.298	0.298	0.298
1+	87	89	101	109	22 043	21 986	26 197	28 942				

* Calculated with weights at age adjusted so that the 1981 catch equals 22 043 mt.

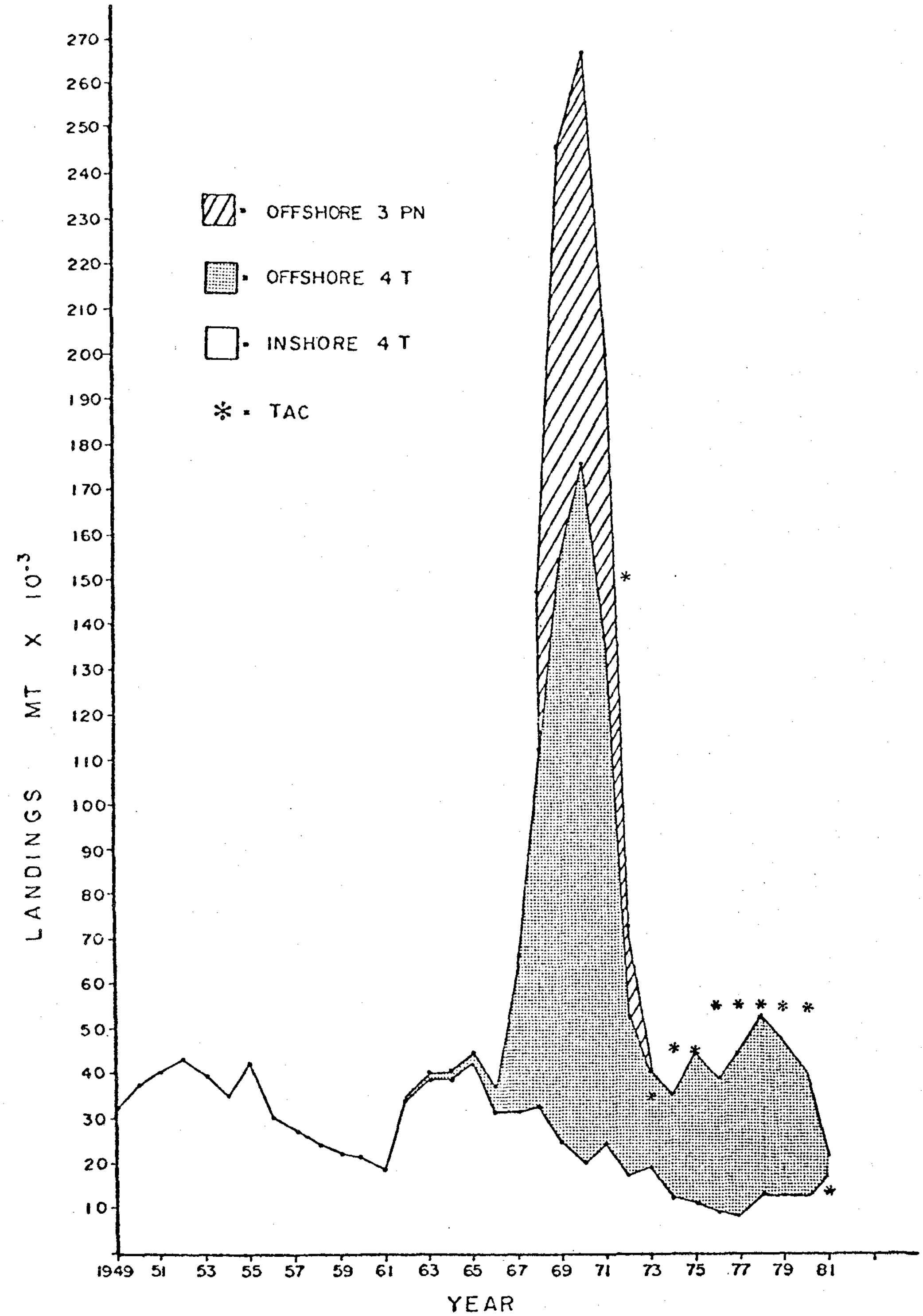


Figure 1. Commercial landings of 4T-3Pn herring, from the inshore and offshore fishery.

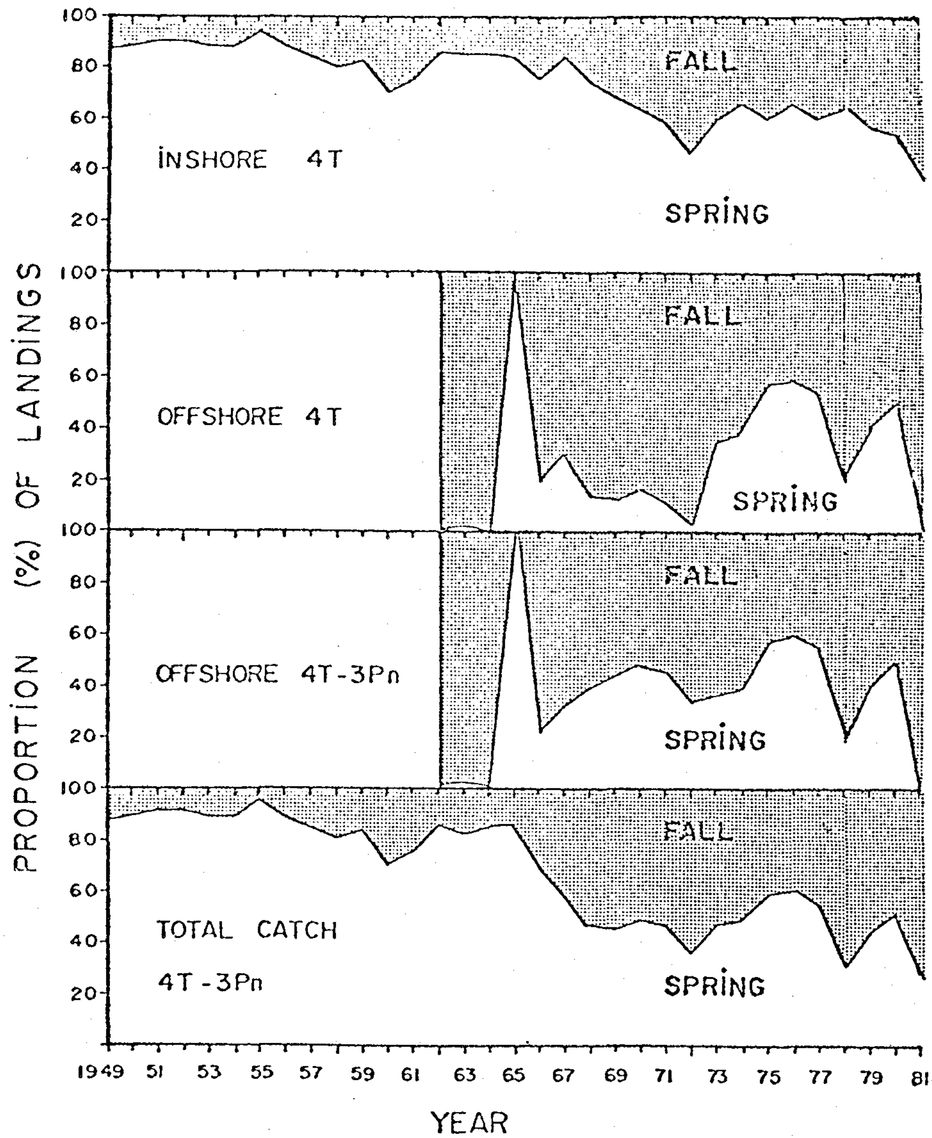


Figure 2. Proportion of herring caught during the spring and fall fishing seasons in NAFO areas 4T and 3Pn.

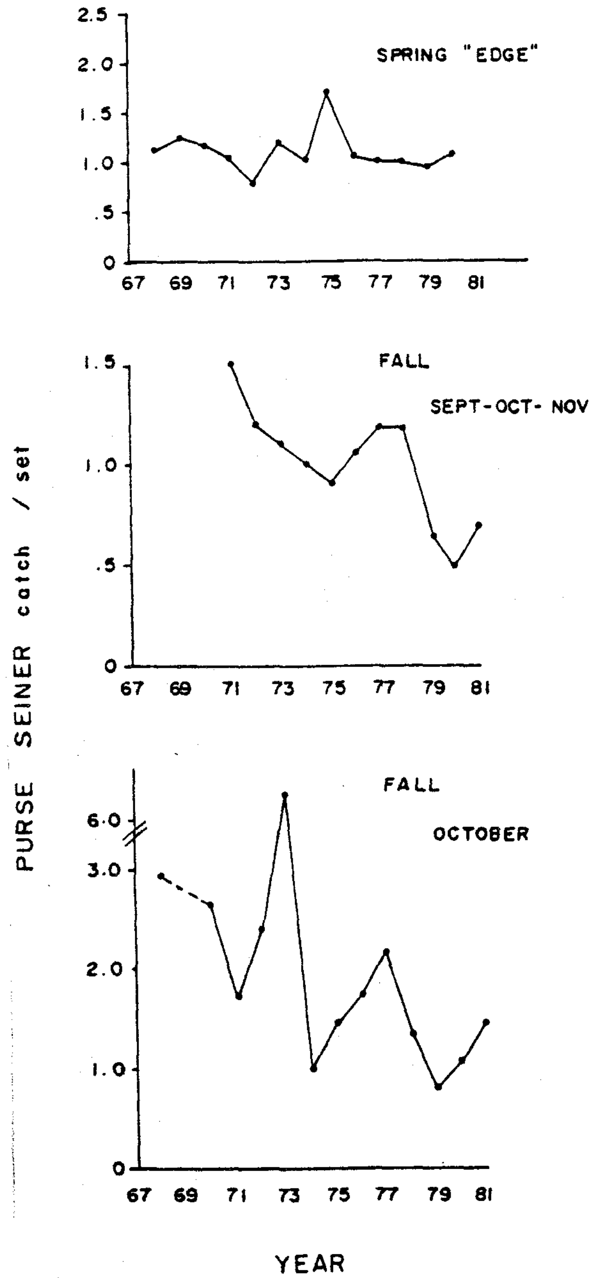


Figure 3. Herring catch rates, standardized to 1974, from the purse seiner fishery, in the spring and fall seasons in the Southern Gulf of St.Lawrence.

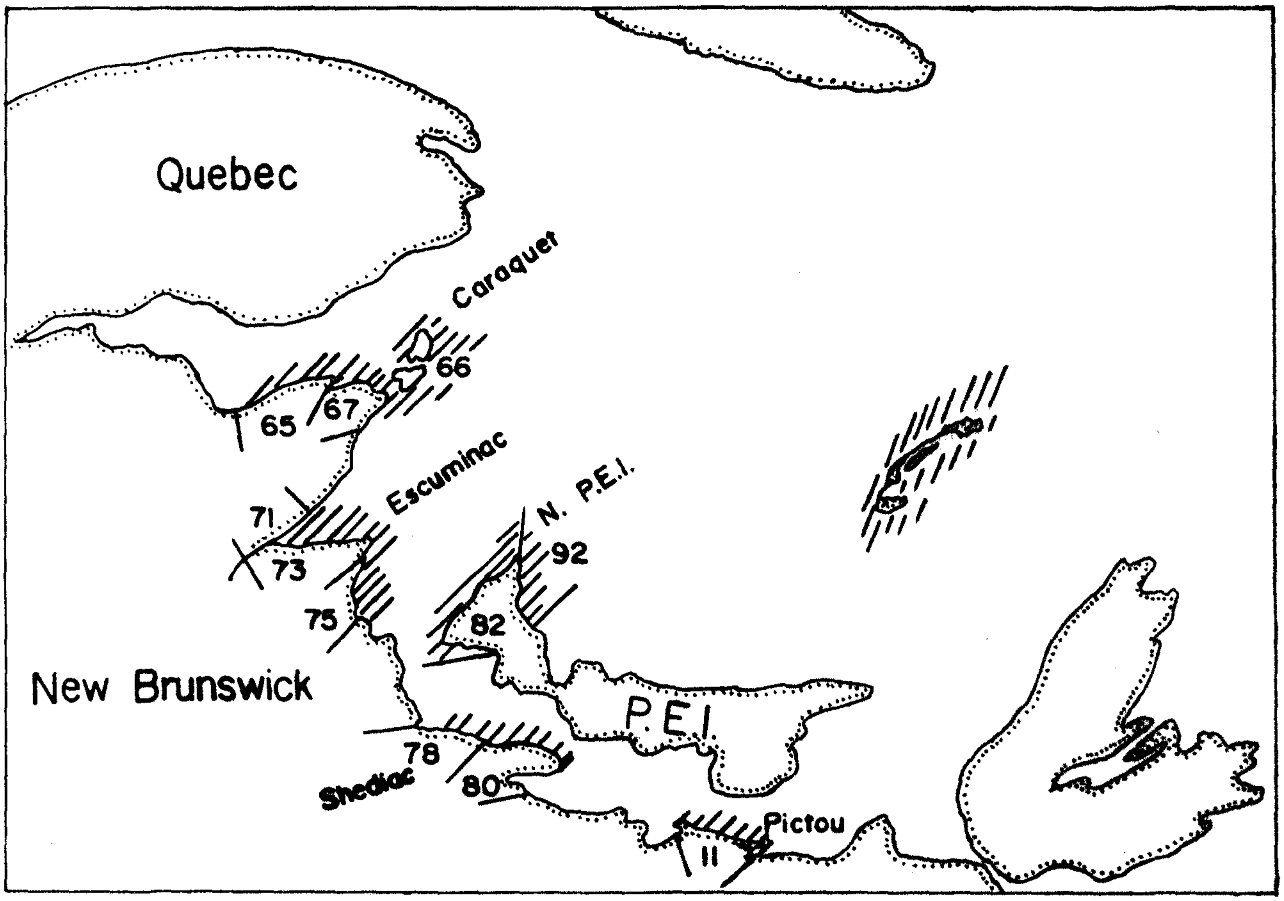


Figure 4. Map of the southern Gulf of St.Lawrence showing the areas where the major gillnet landings are made each year, and for which catch rates were calculated.

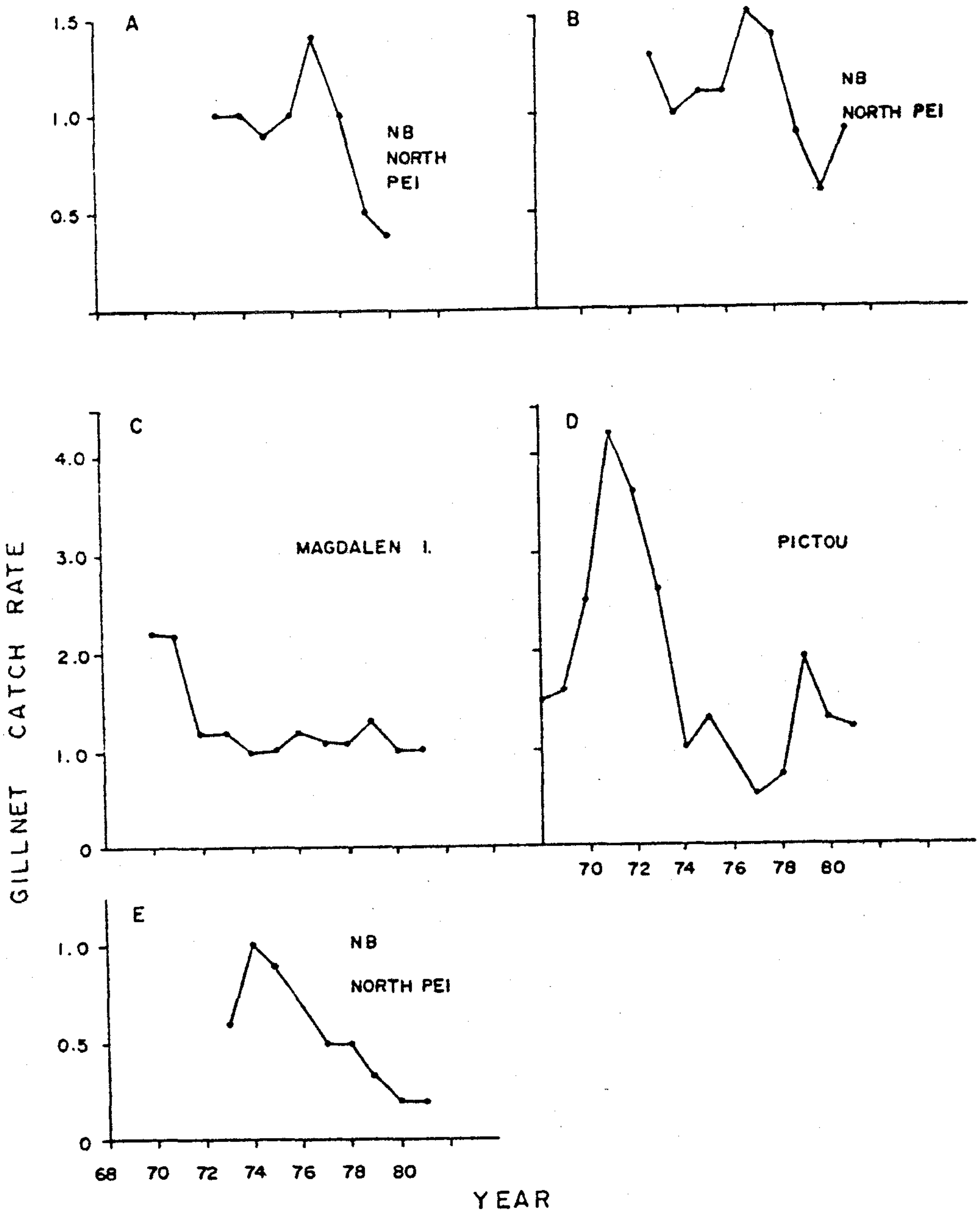


Figure 5. Herring catch rates (standardized to 1974) from the gillnet fishery in the Southern Gulf of St.Lawrence.

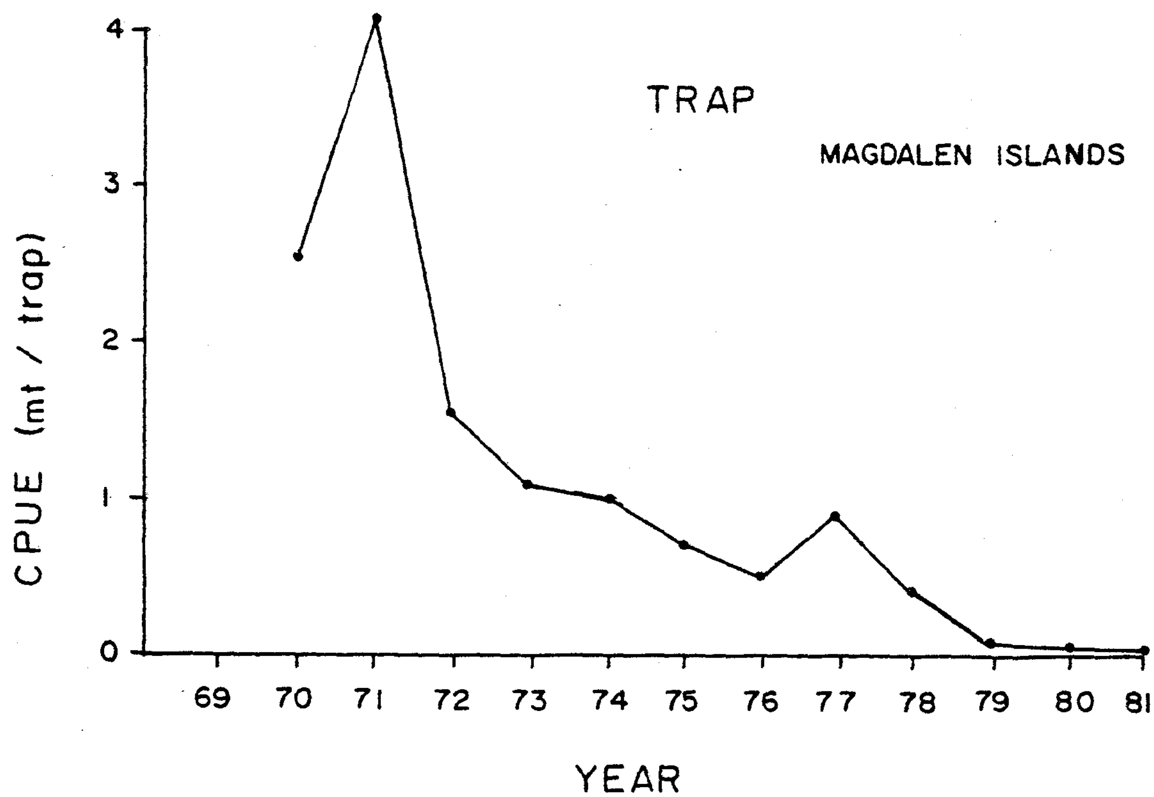


Figure 6. Herring catch rates (standardized to 1974) from the Magdalen Islands trap fishery.

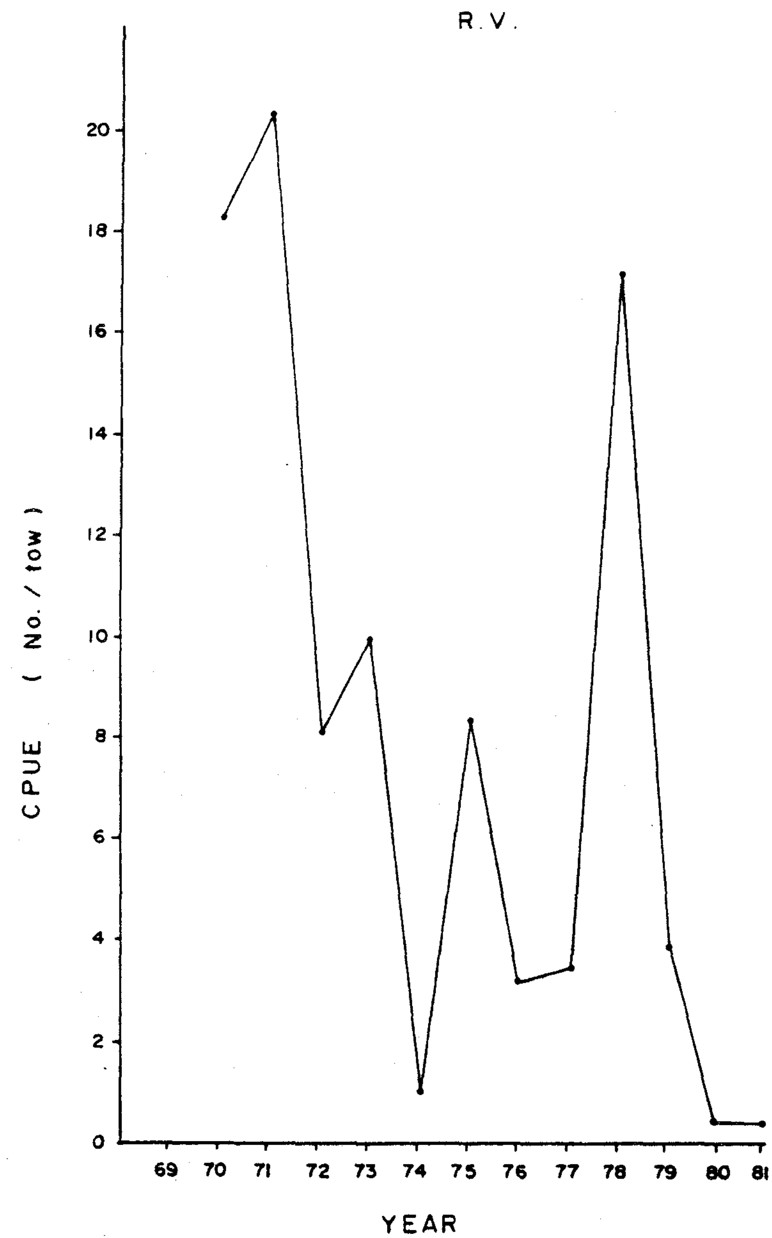
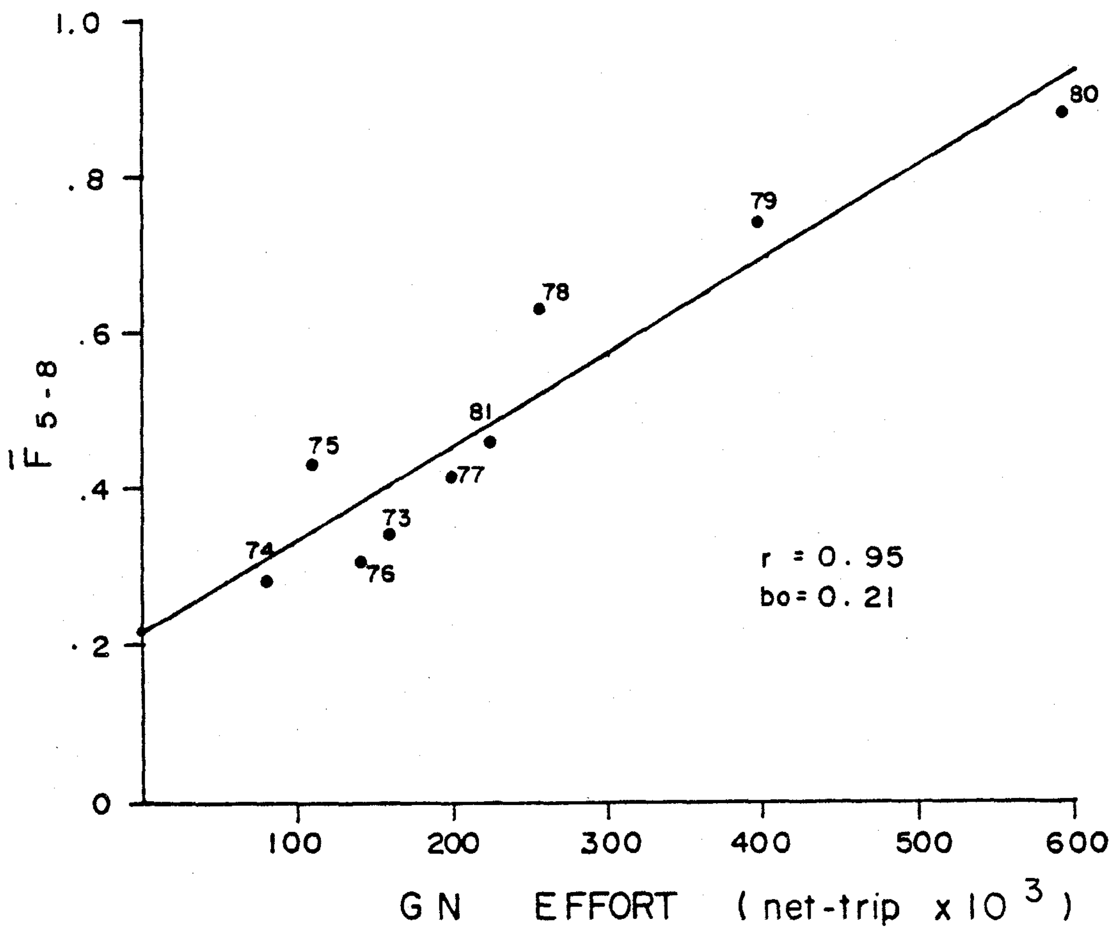
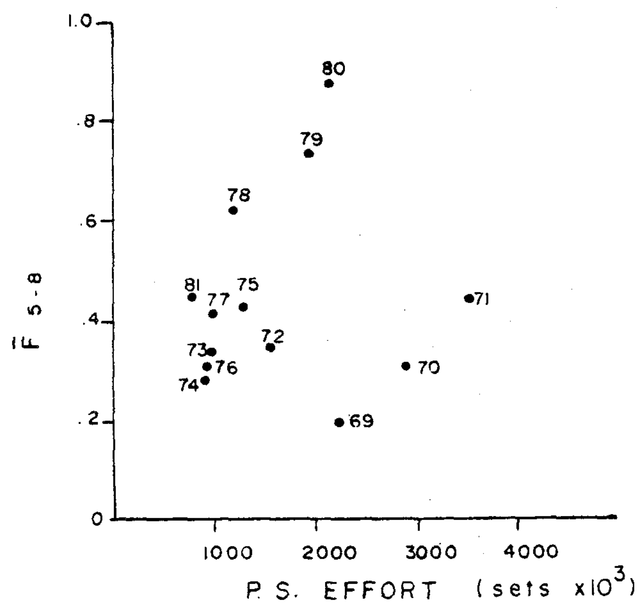


Figure 7. Herring catch rate (standardized to 1974) from the research groundfish trawl survey in the Southern Gulf of St.Lawrence.



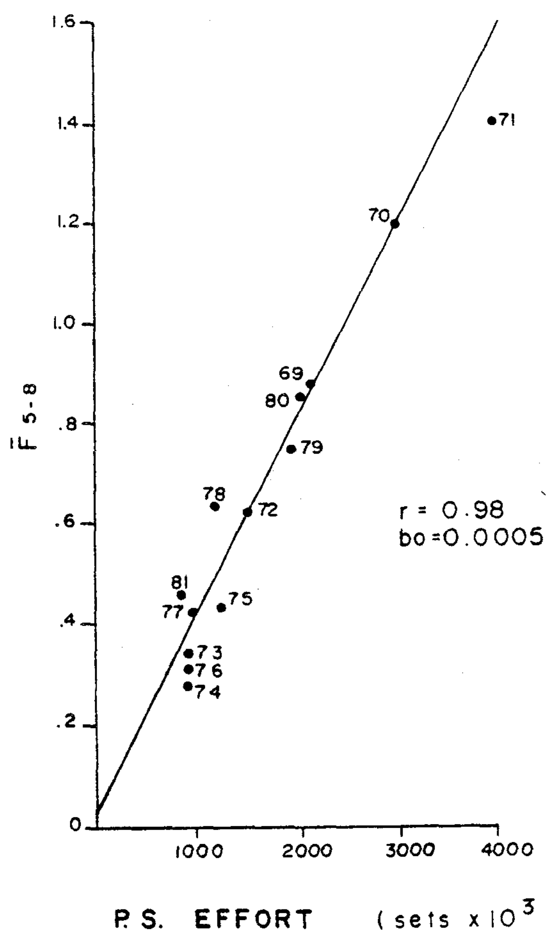
	1973	1974	1975	1976	1977	1978	1979	1980	1981
EFFORT	161	83	112	142	200	256	400	593	225
$\bar{F}$	.343	.284	.435	.315	.419	.632	.745	.882	.456

Figure 8. Relationship between herring fishing mortality rate, for ages 5 to 8, and the gillnet fishing effort in the Southern Gulf of St. Lawrence.



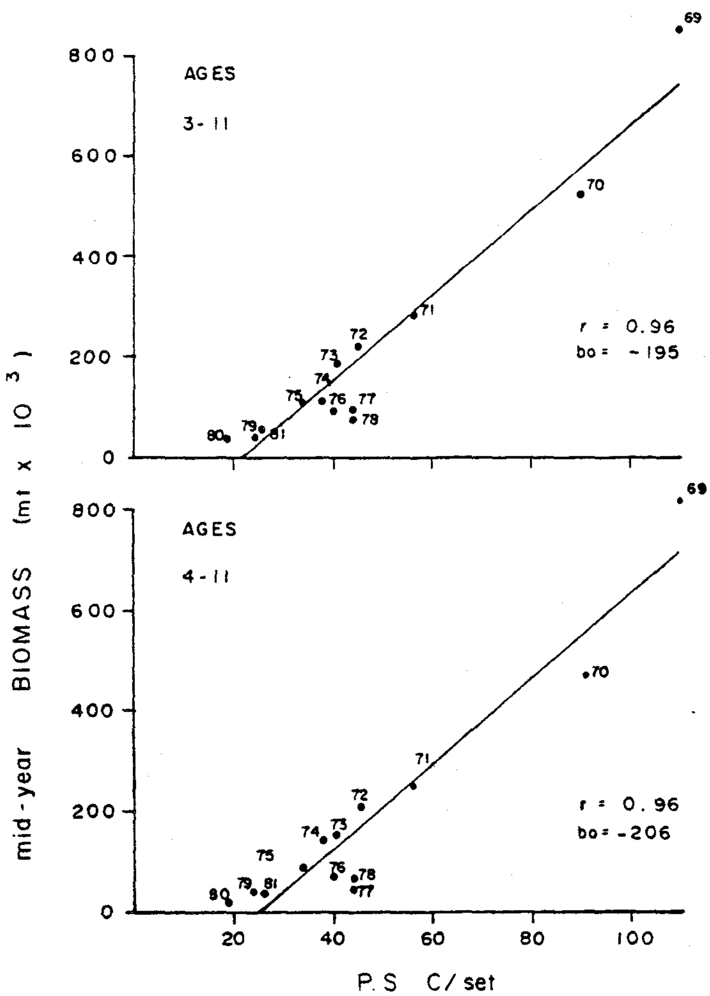
	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
EFFORT	2247	2939	3563	1576	972	927	1291	972	1009	1199	1949	2163	829
$\bar{F}$	.201	.315	.443	.353	.343	.284	.435	.315	.419	.632	.745	.882	.456

Figure 9a. Relationship between herring fishing mortality rate, for ages 5 to 8, and the purse seiner fishing effort in the Southern Gulf of St. Lawrence, 1969-1981.



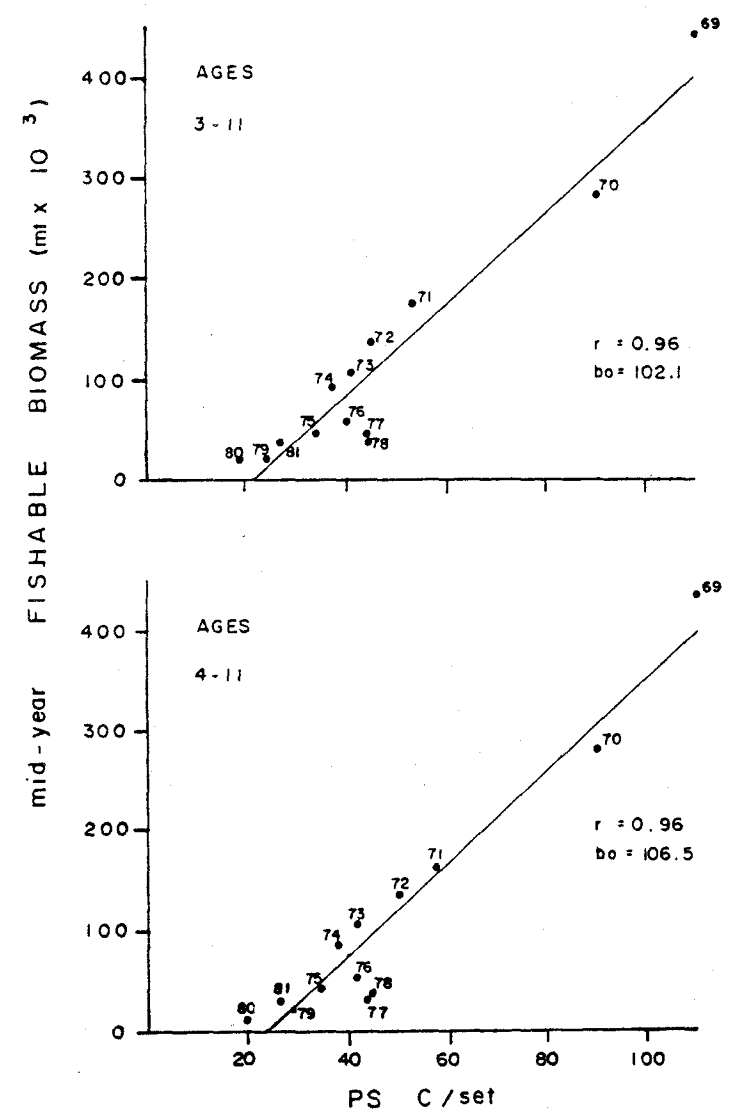
	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
EFFORT	2247	2939	3563	1576	972	927	1291	972	1009	1199	1949	2163	829
$\bar{F}$	.899	1.176	1.426	.631	.343	.284	.435	.315	.419	.632	.745	.882	.45

Figure 9b. Relationship between herring fishing mortality rate, for ages 5 to 8, and the purse seiner fishing effort corrected for catchability changes, in the Southern Gulf of St. Lawrence, 1969-1981.



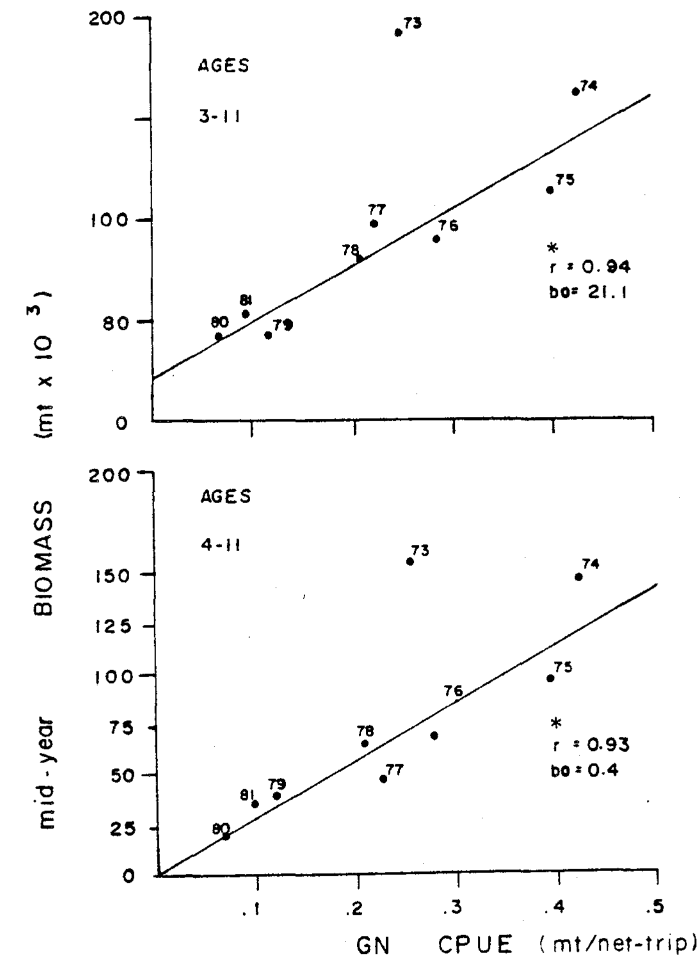
	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
BI 3	850	517	293	222	189	164	113	88	95	80	46	44	54
BI 4	818	478	255	215	161	150	97	70	48	64	40	21	37
CPUE	110.2	90.9	56.7	45.1	41.5	37.9	34.5	40.6	44.4	44.3	24.5	18.7	26.6

Figure 10. Relationship between the mid-year biomass of 4T herring and the purse seiner catch rates during the September-October-November fishery.



	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
BI 3	443	286	173	135	108	91	47	56	48	39	21	17	39
BI 4	435	279	161	134	106	85	42	53	31	34	20	11	30
CPUE	110.2	90.9	56.7	45.1	41.5	37.9	34.5	40.6	44.4	44.3	24.5	18.7	26.6

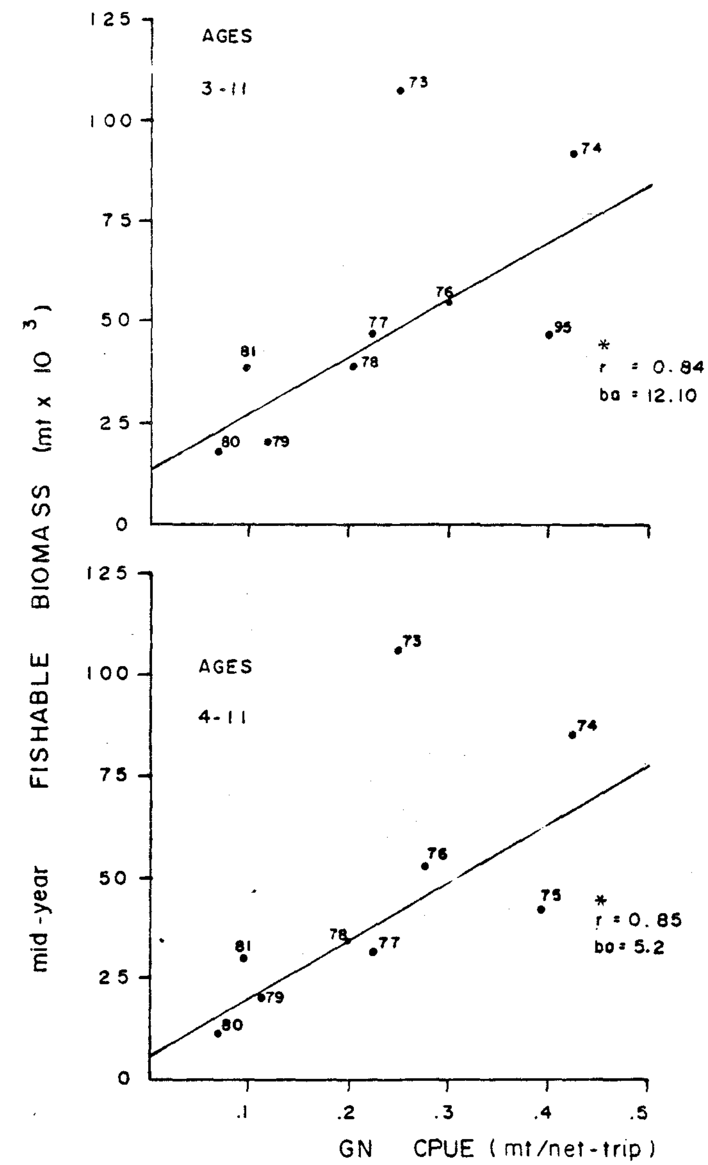
Figure 11. Relationship between the mid-year fishable biomass of 4T herring and the purse seiner catch rates during the September-October-November fishery.



	1973	1974	1975	1976	1977	1978	1979	1980	1981
BI 3	189	164	113	88	95	80	46	44	54
BI 4	161	150	97	70	48	64	40	21	37
CPUE	.251	.426	.398	.278	.224	.208	.119	.069	.098

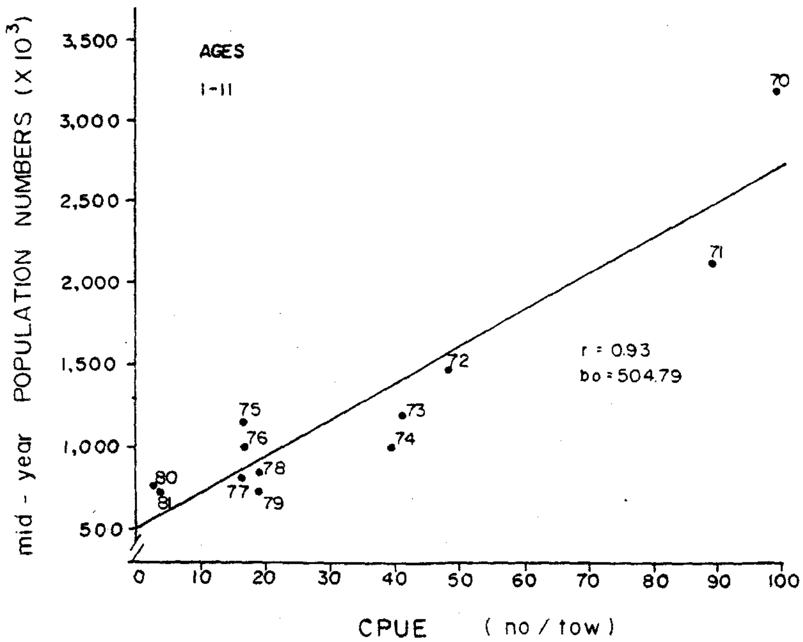
Figure 12. Relationship between the 4T herring biomass and the gillnet catch rates during the spring and fall fishery.

* The 1973 point was excluded from the correlation.



	1973	1974	1975	1976	1977	1978	1979	1980	1981
BI 3	108	91	47	56	48	39	21	17	39
BI 4	106	85	42	53	31	34	20	11	30
CPUE	.251	.426	.398	.278	.224	.208	.119	.069	.098

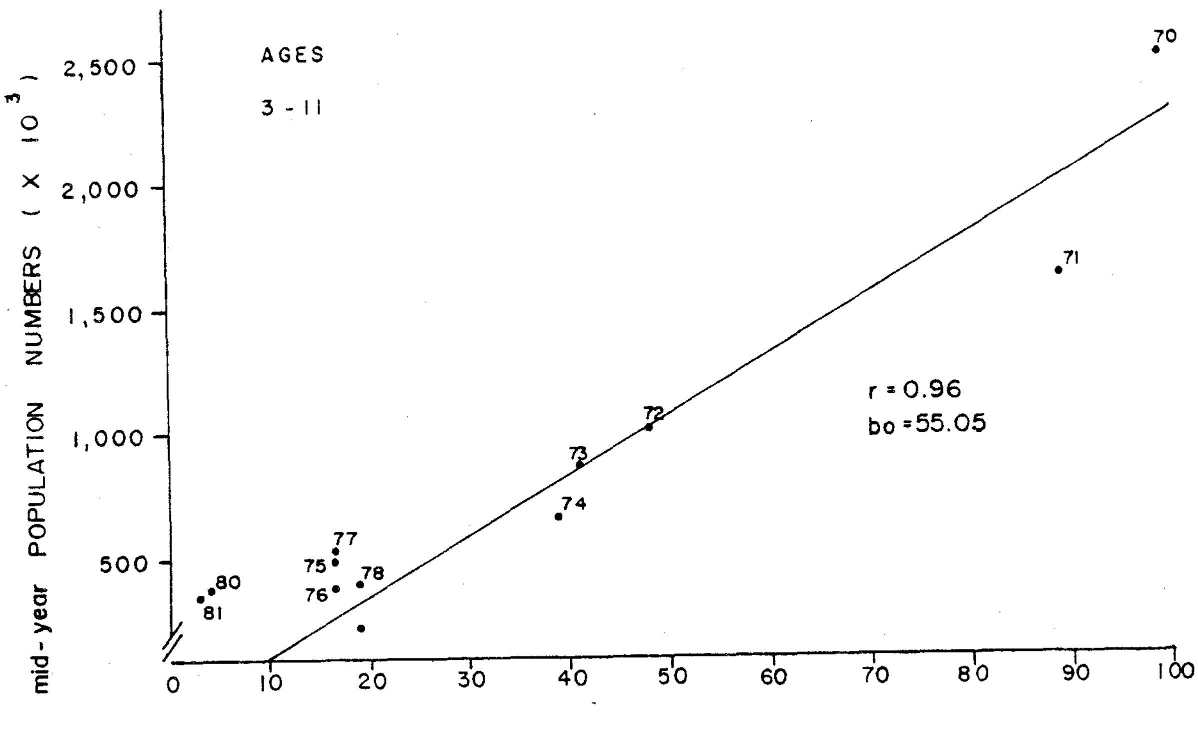
Figure 13. Relationship between the 4T herring fishable biomass and the gillnet catch rates during the spring and fall fishery.
* The 1973 point was excluded from the correlation.



AGES 1-11

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
POP. I	3193	2130	1471	1207	999	1162	1007	798	844	769	734	762
CPUE	98.74	88.72	48.36	40.80	39.07	16.51	16.51	16.51	18.90	18.90	3.72	3.27

Figure 14a. Relationship between the Southern Gulf herring mid-year population numbers, ages 1 to 11, and the groundfish research catch rates.



AGES 3-11

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
POP. 3	2488	1612	1002	866	665	497	375	516	398	230	271	245
CPUE	98.74	88.72	48.36	40.80	39.07	16.51	16.51	16.51	18.90	18.90	3.72	3.27

Figure 14b. Relationship between the Southern Gulf herring mid-year population numbers, ages 3 to 11, and the groundfish research catch rates.