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Where Have all the Herring Gone?
The Continued Decline of the Southeast Newfoundland Herring Stocks

by

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ABSTRACT

The northeast coast of Newfoundland encompasses two herring stock areas: (1) Fortune Bay, and (2) St. Mary's-Placentia bays. Catches from these stocks have declined markedly. In 1981 the total catch of herring in Fortune Bay was 64 mt with 650 mt being taken in Placentia and St. Mary's bays. In both areas the catch was below the TAC level.

Insufficient data were available to conduct an analytical assessment for the Fortune Bay stock. The population status, as determined in 1980, was assumed to be accurate and was projected to 1982 incorporating the 1981 catch.

The 11+ age-group of spring-spawners remained dominant in the catch from the St. Mary's-Placentia stock; however, there was a trend towards an increasing proportion of autumn-spawners in the catch. CPUE data were available from both the ring net and gillnet components of the fleet in 1981. The ring net data, however, were felt to be unreliable due to the limited duration of the fishery and the absence of a measure of searching time. The gillnet data showed a steady decline in CPUE and were used to calculate Paloheimo $\bar{z}$ values which indicate a 5+F in 1981 between 0.05 and 0.10. A CPUE index incorporating purse seine and gillnet data for the period 1974-81 was examined but had no

discriminatory power in establishing the 1981 biomass levels. Due to the low level of catch and the nature of the CPUE data, it was difficult to accurately determine the level of fishing mortality in 1981. However, from the analyses performed an $F_T = 0.10$ was selected to initiate cohort analysis.

The stocks in both areas have continued to decline and with the current pattern of poor recruitment, the decline is expected to continue at least for the near future.

RESUME

La côte nord-est de Terre-Neuve englobe deux stocks de harengs: (1) celui de la baie de Fortune et (2) celui des baies Sainte-Marie et de Plaisance. Les prises à même ces stocks ont notablement diminué. En 1981, elles étaient de 64 tm dans la baie de Fortune et de 650 tm dans les baies Sainte-Marie et de Plaisance. Dans les deux régions le TPA n'a pas été atteint.

Nos données ne nous permettent pas une évalutation analytique du stock de la baie de Fortune. Dans l'hypothèse que l'état de la population avait été déterminé avec précision en 1980, nous l'avons utilisé pour prédire celui de 1982, en tenant compte des prises de 1981.

Dans les prises prélevées à même le stock des baies Saint-Marie et de Plaisance, le groupe d'âge 11+ de reproducteurs de printemps a continué à dominer. Il y eut toutefois tendance vers une plus forte proportion de reproducteurs d'automne dans ces prises. Nous avions à notre disposition des données sur les PUE à la fois des bolinches et des filets maillants en 1981. On a cependant considéré les premières comme peu fiables à cause de la courte durée de cette pêcherie et de l'absence de mesure du temps consacré à la recherche du poisson. Les données des filets maillants montrent une diminution régulière des PUE. Nous les avons utilisées dans le calcul des valeurs du Z de Paloheimo, qui

indiquent un F5+ de 0,05 à 0,10 en 1981. Nous avons examiné un indice de PUE incorporant les données sennes coulissantes et des filets maillants pour la période de 1974-81. Cet indice manque toutefois de pouvoir discriminateur dans l'établissement des niveaux de biomasse de 1981. A cause du bas niveau de capture et de la nature des dònnées sur les PUE, il a été difficile de déterminer avec précision le niveau de mortalité par pêche en 1981. Cependant, à la suite des analyses effectuées, un F_T = 0,10 a été choisi pour commencer une analyse des cohortes.

Les stocks des deux régions ont continué à décliner et, à cause du faible recrutement actuel, on s'attend à ce que ce déclin se poursuive encore quelque temps.

INTRODUCTION

The southeast coast of Newfoundland encompasses two herring management units: (1) Fortune Bay, and (2) St. Mary's-Placentia bays (Fig. 1). Historically these areas have been among the most productive herring fishing areas in Newfoundland with catches averaging 30,000 mt during the period 1945-50 (Templeman 1966). In recent years peak landings of 21,900 mt were recorded in 1968, however, since 1976 landings have been below 5,000 mt annually.

Analytical assessments have been performed on these stocks since 1973. Recent assessments have indicated a marked decline in abundance for both of these stocks due primarily to poor recruitment in recent years (Winters and Moores 1980; Moores and Winters 1980). Management of these stocks has occurred through quota regulation with quotas initially being applied to the mobile sector of the fishery only. In 1980 all gear components were placed under quota control.

This paper examines the current status of each of these stock units and their potential for future exploitation.

FORTUNE BAY

THE 1981 FISHERY

With the decline in the abundance of the Fortune Bay herring stock, the TAC for Fortune Bay has been gradually reduced over the past few years. In 1981 the TAC was established at 200 mt split between bar seines and fixed gear with no quota for purse seines. The 1981 catch was 64 mt, well below the TAC, and was split fairly evenly between the two gear components (Table 1). This level of catch is the lowest which has been observed in recent years.

1981 ASSESSMENT

Age frequency of the catch

From 1978 to 1980 the catch has been predominantly spring-spawners (≥98%) with the 1974 year-class being dominant in the catch (Fig. 2) Due to the diffuse nature of the fishery and the low catch level, no samples of the commercial fishery were available for 1981. One research gillnet sample was available and the age composition is shown in Fig. 2. This sample was composed primarily of young fish which were taken by the small mesh nets of the research gillnets and showed a high proportion of autumn-spawners (29%). This sample, however, was not felt to be typical of the commercial fishery which primarily exploits mature fish in near-shore spawning concentrations and therefore it should not be used to generate an age composition of the 1981 catch.

Analysis of current stock status and projection

Due to the lack of accurate age composition data from the commercial fishery in 1981, no update of the Fortune Bay assessment was performed. The assessment presented in 1980 (Winters and Moores 1980) was assumed to be accurate and the stock structure was projected to 1981 with a catch of 64 mt and projected to 1982 at the $F_{0.1}$ level of 0.275 (Winters and Moores 1980). The projection was performed using the historical partial recruitment rates and an estimate of recruitment equal to 5×10^6 individuals as used by Winters and Moores (1980). The resultant stock structure is shown in Table 2. Over the period 1969 to 1981 the 2+ biomass has declined from a peak of 41.1×10^3 mt in 1970 to 1.6×10^3 mt in 1981. Assuming this stock structure is accurate, a fishery at the $F_{0.1}$ level (0.275) would produce a yield of 400 mt leaving a 5+ biomass of 1.0×10^3 mt at the end of 1982 (Table 3).

DISCUSSION

The decline in the Fortune Bay stock continues unabated with no evidence of improvement from recruiting year-classes. This low level of abundance is clearly evidenced by the catch levels currently being attained by the commercial fisheries. Additionally, studies on the early life of herring

which have been conducted in Fortune Bay for the past three years show no evidence of an improvement in recruitment. Larval surveys were carried out on the stock in June, August, December and February for both 1979 and 1980 year-classes and in June and August thus far for the 1981 year-class. These surveys were conducted using Bongos and the National Institute of Oceanography's 8 square meter midwater trawl with catches of larval herring in all surveys being minimal. It therefore appears that if this stock is to be maintained, exploitation should continue to be kept at a minimal level.

ST. MARY'S-PLACENTIA BAYS

THE 1981 FISHERY

As has been observed in Fortune Bay, the abundance of herring in the St. Mary's-Placentia stock complex has also been declining (Moores and Winters 1980). In 1981 the TAC was set at 1200 mt divided 650 mt for Placentia Bay (300 mt fixed gear, 50 mt bar seine and 300 mt ring net) and 500 mt for St. Mary's Bay (300 mt fixed gear, 50 mt bar seine and 200 mt ring net). No quota was allocated to the purse seine fleet. The total landings were 646 mt, of which 174 mt were taken in St. Mary's Bay and 472 mt from Placentia Bay (Table 4).

No gear component reached its quota in St. Mary's Bay where the ring net fleet caught only 22% (44 mt) of its quota while fixed gear took 41% (122 mt) of its quota. In Placentia Bay the ring net component exceeded its quota by 7% (22 mt) while the fixed gear component took only 50% (150 mt) of its allocation.

AGE AND SPAWNING TYPE COMPOSITION OF THE CATCH

The age composition was generated by gear and month separately for St. Mary's and Placentia bays, then combined to generate the total removals from the stock (Fig. 3). Among the spring-spawning component the 11+ age-group remained dominant in both bays, however, the proportion of fish in this age-group in 1981 compared to 1980 was lower in St. Mary's Bay, but higher in Placentia Bay. In Placentia Bay the 1974 year-class was the second most common year-class in 1981 while in St. Mary's Bay the 1974 year-class appeared only weakly with the 1978 year-class being second in importance. In the autumn-spawning component the 1977 and 1976 year-classes were dominant.

The relative proportion of spring- to autumn-spawners in the catch remained relatively constant for Placentia Bay and the total stock but has shown a marked change for St. Mary's Bay. A closer examination of the spawning type composition of the catch by gear was performed for each bay for the period 1976-81 (Fig. 4). While the results by gear were variable from year to year, there appears to be a general increase in the proportion of autumn-spawners particularly in the ring net fishery.

CATCH AND EFFORT STATISTICS

In the previous assessment (Moores and Winters 1980) three sources of effort data were utilized: (1) ring net sales slip data, (2) ring net log records, and (3) gillnet landing slip data. These sources were again examined and also, an attempt was made to increase the gillnet time series by standardizing it with the purse seine effort series as given by Winters and Moores (1979).

(1) Ring net sales slip data

Sales slip data were available for the ring net fleet of both Placentia and St. Mary's bays. Unlike previous years, 1981 catches were reported in only one month in each area (Table 5). The data do however show a decline in catch rates from 1980.

(2) Ring net log records

Only a limited number of log records were received in 1981. The logs (Table 6) show a decline in catch per operating day in St. Mary's Bay while there is an increase for Placentia Bay.

(3) Gillnet sales slip data

Gillnet sales slip data were available for both Placentia and St. Mary's bays and were used to derive catch rates by month for each bay (Table 7). The time series covers the period 1977-81 with fisheries occurring consistently in the months of April and May. An unweighted average of the catch rates in

these two months was taken as most representative of the activity of this gear component. The data show a steady decline in St. Mary's Bay from 1977 to 1981 and a decline in Placentia Bay from 1978 to 1981.

(4) Combined purse seine and gillnet data

A disadvantage of the gillnet data is the shortness of the time series. However, a series of purse seine effort exists for Placentia Bay covering the period 1974-78 which has previously been used with some success (Winters and Moores 1979). An examination of the data was performed to see if the two data series could be combined. For the time period covered by the gillnet data the St. Mary's Bay data were considered to be more reliable than Placentia Bay, particularly for 1977. Therefore only the St. Mary's Bay gillnet data were combined with the purse seine data. The data were combined by standardizing both data sets to 1977 and averaging the yearly values. The results (Table 8) shows a continuous decline from 1974 to 1981.

Of the four effort series available, only two were considered to be reliable. Both ring net series were felt to be biased. In the case of the ring net logs, only a very limited amount of information was available for 1981 while the sales slips give no indication of searching time, a consideration which would be of increasing importance due to the condition of the stock. Therefore only the gillnet sales slip and combined gillnet-purse seine series were utilized in subsequent analyses.

STOCK ANALYSIS

Cohort analysis

Trial runs of cohort were performed with F_T = 0.05, 0.10, 0.15 and 0.20 for spring-spawners only with the historical partial recruitment rates and average weight data from quarters 1 and 2 for each year of the analysis (see appendices).

Selection of F_T

Two methods were used in order to fine tune the analysis:

(1) Paloheimo Z's: Using the St. Mary's Bay April-May gillnet catch rate series Paloheimo Z values (Paloheimo 1961) were calculated for age-groups 5+for 1977-81. In order to utilize the entire time series, the Z values were converted to F values by subtracting the assumed constant natural mortality of 0.2 and compared to the 5+ mortality generated under the various options of F_T utilized in the trial runs of cohort (Table 9). Correlations gave a negative slope due to the high Paloheimo value for 1977-78. However the analysis does suggest that F in 1981 was low. The 1980-81 Paloheimo Z value of 0.352 (F = 0.152) would be generated with a starting F in 1981 between 0.05 and 0.10.

(2) CPUE (gillnet + purse seine) and 5+ biomass: A comparison of the standardized CPUE data and the 5+ biomass generated at the various options of F_T was performed (Table 10). While the correlations had no discriminatory power, the trend in r values appears to indicate an $F_T \geq 0.10$ in 1981. In all cases the predicted 5+ biomass in 1981 was higher than those generated by cohort analysis.

Due to the very low level of the 1981 catch and considering the crude nature of the gillnet CPUE (eg. unadjusted for any systematic temporal change in fleet size), it was not possible to estimate the 1981 level of fishing mortality with any degree of accuracy. However, the above analyses suggest the 1981 F was in the order of 0.10 and this value was used to initiate the cohort analysis.

Results of cohort analysis ($F_T = 0.10$)

Biomass: During the time period covered by the analysis (1969-81) the 2+ biomass has declined from a peak of 66.8×10^3 mt in 1972 to 7.2×10^3 mt in 1981 (Table 11). The spawning biomass (5+) rose from 16.4×10^3 mt in 1969 to a peak of 51.3×10^3 mt in 1973 and has subsequently declined to 5.8×10^3 mt in 1981.

Recruitment: With the exception of the 1966 and 1968 year-classes, recruitment has generally been poor. The 1972 and 1974 year-classes which initially appeared to be good have only been fair. This pattern of poor recruitment is a key factor in the decline of this stock.

Fishing mortality: The level of fishing mortality was low from 1969 to 1972 (Table 11) but shows a general increase from 1973 to 1980. The 1981 level of fishing mortality while appearing low, reflects the reduction in effort due to more stringent quota levels in recent years.

Stock projection: Using the 1981 population structure generated at $F_T = 0.10$, the 1981 partial recruitment rates and average weight values, a catch projection was performed at $F_{0.1} = 0.30$ (Winters and Moores 1979) with recruitment fixed at 5.0×10^6 recruits. The results (Table 12) give a 1982 catch of 1250 mt, leaving a residual biomass of 4.0×10^3 mt.

If a projection had been performed from the 1980 assessment (Moores and Winters 1980) as was done in the case of Fortune Bay, the projected 1982 catch level would have been 880 mt, and is comparable to the results which would be obtained if the cohort analysis had been initiated with $F_T = 0.15$ in 1981.

DISCUSSION

The St. Mary's-Placentia herring stock has been declining since 1973 with no indication of significant recruitment occurring in the stock. The decline in the stock appears to have had a greater effect in St. Mary's Bay where the 1981 fishery was extremely poor. This may in part be due to the failure of the 1974 year-class to appear in St. Mary's Bay. The apparent dicotomy in age distributions may indicate a change in the stock mixing pattern occurring in these areas due to the current low population levels. In light of the current stock levels, exploitation should be maintained at a low level.

CONCLUSION

Both stocks in southeastern Newfoundland are currently in a state of decline with only a low level of recruitment occurring. Until the recruitment picture improves the stocks will remain at low levels of abundance.

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Table 1. Fortune Bay herring landings, 1976-81.

Year	Gear				Total
	P. Seine	Gillnet	B. Seine	Trap	
1976	109	43	310	-	462
1977	188	22	364	5	579
1978	105	42	853	-	1,000
1979	286	76	829	1	1,192
1980	97	84	265	-	446
1981	-	34	30	-	64

Table 2. Population matrix of Fortune Bay herring (spring-spawners), 1969-82.

Age	Population size ($\times 10^{-6}$) at beginning of year													
	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
2	29.5	145.0	1.6	5.4	6.3	6.3	0.3	28.4	1.1	0.1	0.2	1.5	(5.0)	(5.0)
3	101.4	23.7	80.3	1.1	3.0	3.1	4.8	0.3	23.1	0.8	0.1	0.2	1.2	(4.1)
4	3.5	72.2	12.1	44.0	0.7	1.6	1.3	3.7	0.2	17.0	0.7	0.1	0.1	0.9
5	1.4	2.8	49.7	4.2	17.9	0.5	0.8	0.6	2.7	0.1	11.5	0.4	0.1	0.1
6	56.1	1.0	2.2	18.6	0.8	9.5	0.3	0.6	0.3	1.9	0.1	5.9	0.2	0.1
7	1.0	34.1	0.6	0.7	5.4	0.3	3.7	0.2	0.4	0.1	1.4	0.1	3.9	0.2
8	1.0	0.6	21.3	0.3	0.3	2.8	0.1	1.7	0.1	0.3	0.1	1.0	0.1	3.0
9	2.1	0.6	0.3	9.0	0.2	0.1	1.3	0.1	1.1	0.1	0.1	0.1	0.6	.1
10	2.9	1.1	0.4	0.1	2.4	0.1	0.1	0.9	0.1	0.7	0.1	0.1	.1	0.5
11+	2.5	1.2	1.4	1.0	0.5	1.4	0.9	0.6	0.9	0.5	0.5	0.2	.2	0.2
2+ biomass ('000 mt)	36.0	41.1	34.3	19.6	8.4	5.7	3.3	4.3	5.0	4.8	3.6	2.3	2.1	2.5
5+ biomass ('000 mt)	19.3	12.8	20.7	10.0	7.4	4.4	2.3	1.5	1.7	1.2	3.4	2.2	1.6	1.4
C_t (mt)	6866	9388	15004	10570	3254	2268	909	462	579	1000	1192	446	64	-

Table 3.

HERRING FORTUNE BAY SS
CATCH PROJECTION FOR 1982

AGE	POPULATION NUMBERS	POPULATION WEIGHT	FISHING MORTALITY	CATCH NUMBERS	CATCH WEIGHT	RESIDUAL NUMBERS	RESIDUAL WEIGHT
2	5000.	350.	.014	62.	4.	4038.	283.
3	4085.	564.	.137	477.	66.	2915.	402.
4	939.	193.	.220	169.	35.	617.	127.
5	94.	22.	.275	21.	5.	58.	14.
6	10.	3.	.275	2.	1.	7.	2.
7	186.	58.	.275	41.	13.	115.	36.
8	3034.	1016.	.275	664.	222.	1887.	632.
9	19.	7.	.275	4.	1.	12.	4.
10	491.	177.	.275	108.	39.	306.	110.
11	3.	1.	.275	1.	0.	2.	1.
12	30.	12.	.275	7.	3.	19.	7.
13	3.	1.	.275	1.	0.	2.	1.
14	71.	28.	.275	16.	6.	44.	17.
15	3.	1.	.275	1.	0.	2.	1.
16	35.	14.	.275	8.	3.	22.	9.
17	3.	1.	.275	1.	0.	2.	1.
18	25.	10.	.275	5.	2.	15.	6.
TOTAL	14030.	2457.		1584.	400.	10061.	1651.

Table 4. Herring landings by gear, St. Mary's-Placentia Bay, 1976-80.

Year	Area	Gear					Total
		P. Seine	R. Net	B. Seine	Gillnet	Trap	
1976	SMB	-	920	158	352	25	1455
	PB	2056	172	242	177	-	2647
	Total	2056	1092	400	529	25	4102
1977	SMB	-	1132	221	531	29	1912
	PB	740	524	14	78	-	1356
	Total	740	1655	235	609	29	3268
1978	SMB	-	1523	67	489	3	2082
	PB	558	613	30	212	34	1447
	Total	558	2136	97	701	37	3529
1979	SMB	-	1570	131	332	9	2042
	PB	359	891	17	307	1	1575
	Total	359	2461	148	639	10	3617
1980*	SMB	-	643	17	339	13	1012
	PB	182	861	11	309	30	1393
	Total	182	1504	28	648	43	2405
1981*	SMB	-	44	8	122	-	174
	PB	-	322	-	149	1	472
	Total	-	366	8	271	1	646

* provisional

Table 5. Catch per unit effort data (mt/landing) for ring netters in Placentia and St. Mary's Bays (from landing slips).

Year	Placentia Bay				Wgt. Ave.	St. Mary's Bay				Wgt. Ave.
	J	F	M	A		F	M	A	M	
1976	29.1	15.9	-	-	24.7	9.3	8.1	12.5	9.1	10.5
1977	8.0	8.3	8.7	11.4	8.9	-	13.3	22.8	-	21.6
1978	5.3	7.0	7.5	44.7	8.2	-	19.3	11.7	-	13.4
1979	16.2	22.0	21.3	-	19.0	14.4	15.7	8.2	-	13.2
1980	18.0	18.1	9.0	-	16.7	-	19.6	22.0	-	20.1
1981	10.8	-	-	-	10.8	-	-	8.8	-	8.8

Table 6. Catch per unit effort (mt/operating day) from ring net log records.

Area	Year	Month				Average	Weighted average
		Jan.	Feb.	Mar.	April		
St. Mary's Bay	1979	-	16.4	7.5	5.0	9.6	7.0
	1980	-	-	3.5	10.7	7.1	5.0
	1981	-	0.0	0.0	1.7	0.6	1.2
Placentia Bay	1979	12.0	8.4	27.3	-	15.9	10.9
	1980	3.4	11.3	1.3	-	5.3	5.6
	1981*	17.6	-	-	-	17.6	17.6

* logs from only one vessel

Table 7. Catch per unit effort (mt/landing) data for St. Mary's and Placentia Bays from gillnet sales slips.

Area	Year	Month									Unweighted average April-May
		Jan.	Feb.	Mar.	April	May	June	Oct.	Nov.	Dec.	
St. Mary's Bay	1977	.76	.61	.83	.82	.92	.52	-	.69	1.08	0.87
	1978	-	-	-	.38	.59	.53	-	-	-	0.49
	1979	-	-	-	.40	.32	.82	.22	-	-	0.36
	1980	-	-	-	.30	.25	.11	-	-	-	0.28
	1981	-	-	-	.33	.12					0.22
Placentia Bay	1977	.57	-	-	-	.19	.08	-	.25	.10	
	1978	-	-	-	.31	.28	.62	-	.36	.46	.30
	1979	.31	.55	.61	.37	.60	.35	.20	-	-	.49
	1980	-	.65	-	.45	.36	.47	-	-	-	.41
	1981	-	-	.52	.47	.26					.37

Table 8. Combined purse seine and gillnet catch rate data.

Year	Purse seine[1] Series (mt/day)	Gillnet (mt/day)	Standardized Purse seine	Standardized Gillnet	Combined
1974	98.2	-	1.84	-	1.84
1975	91.3	-	1.71	-	1.71
1976	85.9	-	1.61	-	1.61
1977	53.3	0.87	1.00	1.00	1.00
1978	26.4	0.49	0.50	0.56	0.53
1979	-	0.36	-	0.41	0.41
1980	-	0.28	-	0.32	0.32
1981	-	0.22	-	0.25	0.25

[1] from Winters and Moores 1979

Table 9. Mortality rates (5+) generated by the method of Paloheimo and from cohort analysis at various levels of F.

Year	Z_p	F_p (Z-M)	F_T 0.05	0.10	0.15	0.20
77-78	0.970	0.770	.129	.186	.217	.238
78-79	0.349	0.149	.156	.244	.301	.342
79-80	0.388	0.188	.168	.288	.381	.456
80-81	0.352	0.152	.102	.191	.269	.341

Table 10. Comparison of the 5+ biomass produced at various levels of F_T and the gillnet-purse seine CPUE series.

Year	Standardized CPUE	5+ biomass .05	.10	.15	.20
1974	1.84	50.0	41.5	38.8	37.3
1975	1.71	40.2	32.2	29.7	28.3
1976	1.61	28.9	22.1	19.9	18.7
1977	1.00	25.1	18.5	16.3	15.2
1978	0.53	20.0	13.9	12.0	11.0
1979	0.41	20.0	13.0	10.7	9.6
1980	0.32	15.5	9.0	6.9	5.8
1981	0.25	11.3	5.8	4.0	3.0
	1974-80 r^2	.826	.836	.839	.839
	Predicted '81	14.6	8.4	6.3	5.3

Table 11. Results of cohort analysis for St. Mary's-Placentia Bay herring for the period 1969-81, $F_T = 0.10$.

Age	Population numbers $x10^{-5}$												
	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	192	2623	231	71	28	169	24	235	24	35	18	89	1
3	1234	157	2142	189	58	22	129	19	189	19	28	14	72
4	141	1004	128	1749	154	44	16	85	13	143	14	17	9
5	108	115	780	103	1246	125	34	9	56	9	101	9	13
6	172	88	94	619	76	899	97	27	5	39	7	62	6
7	61	137	71	76	462	29	607	65	20	4	27	5	40
8	66	49	106	58	56	314	17	370	46	16	2	17	3
9	71	54	40	84	44	32	205	13	256	28	12	1	9
10	61	57	43	32	64	34	25	137	9	175	20	9	1
11+	38	75	107	122	122	147	140	120	179	125	194	124	79
N_2+	2144	4359	3742	3103	2310	1815	1294	1080	797	593	423	347	233
2+ biomass ($x10^{-3}$ mt)	38.7	52.8	63.7	66.8	55.6	44.0	34.8	26.2	21.9	17.9	14.0	10.6	7.2
5+ biomass ($x10^{-3}$ mt)	16.4	16.9	31.1	30.1	51.3	41.5	32.2	22.1	18.5	13.9	13.0	9.0	5.8
F_5+	.028	.022	.025	.086	.152	.170	.231	.156	.179	.193	.295	.281	.100

Table 12.

HERRING PLACENTIA/ST. MARYS SS
CATCH PROJECTION FOR 1982

AGE	POPULATION NUMBERS	POPULATION WEIGHT	FISHING MORTALITY	CATCH NUMBERS	CATCH WEIGHT	RESIDUAL NUMBERS	RESIDUAL WEIGHT
2	5000.	405.	.030	134.	11.	3973.	322.
3	90.	15.	.090	7.	1.	67.	11.
4	5722.	1247.	.150	724.	158.	4032.	879.
5	687.	206.	.300	162.	49.	416.	125.
6	943.	303.	.300	223.	71.	572.	184.
7	454.	162.	.300	107.	38.	276.	98.
8	2984.	1107.	.300	704.	261.	1810.	671.
9	240.	90.	.300	57.	21.	146.	54.
10	703.	267.	.300	166.	63.	426.	162.
11	51.	22.	.300	12.	5.	31.	13.
12	420.	176.	.300	99.	42.	255.	107.
13	514.	216.	.300	121.	51.	312.	131.
14	3027.	1268.	.300	715.	299.	1836.	769.
15	103.	43.	.300	24.	10.	62.	26.
16	1106.	463.	.300	261.	109.	671.	281.
17	137.	57.	.300	32.	14.	83.	35.
18	523.	219.	.300	123.	52.	317.	133.
TOTAL	22706.	6267.		3673.	1256.	15286.	4002.

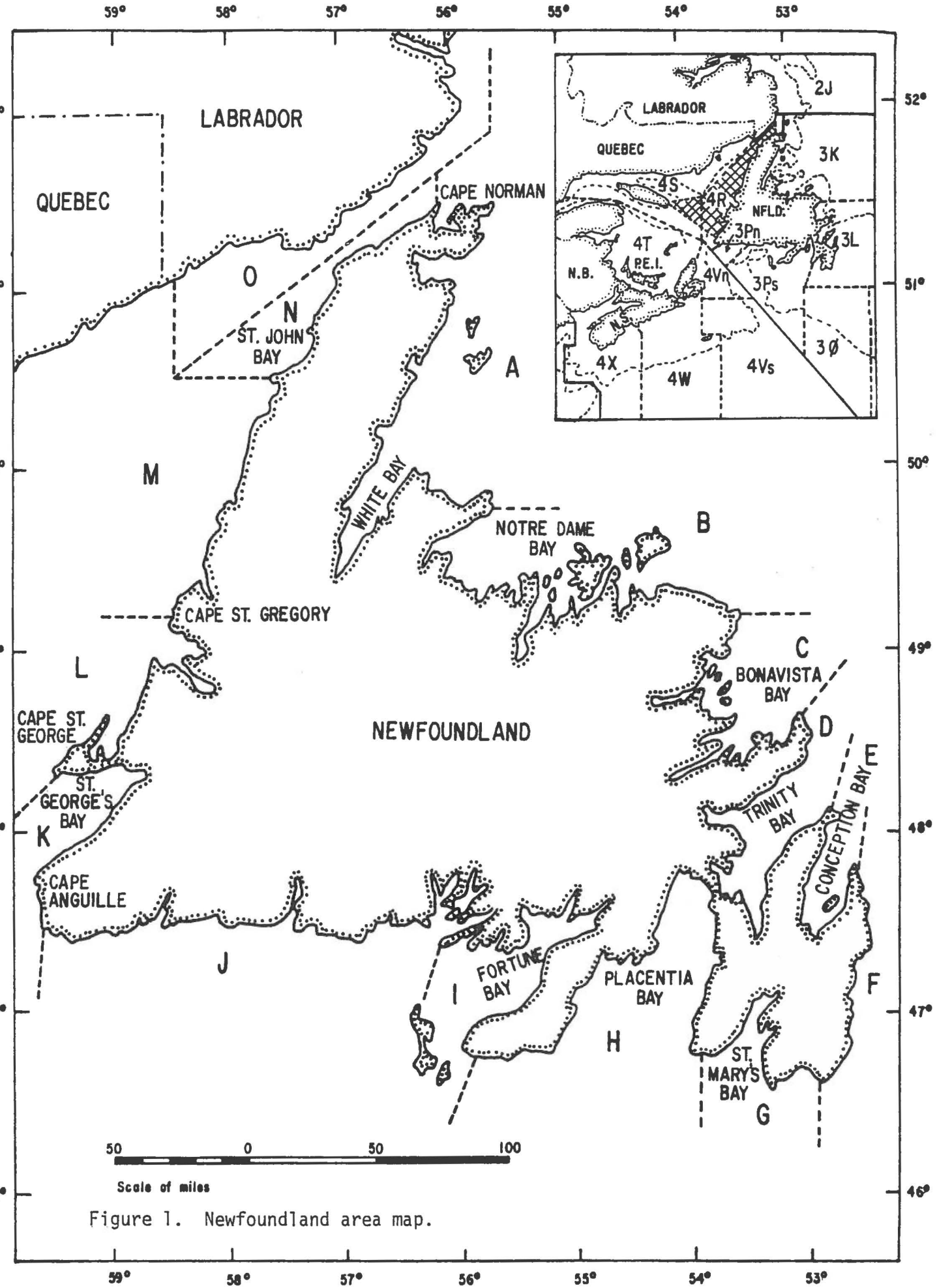

Figure 1. Newfoundland area map.

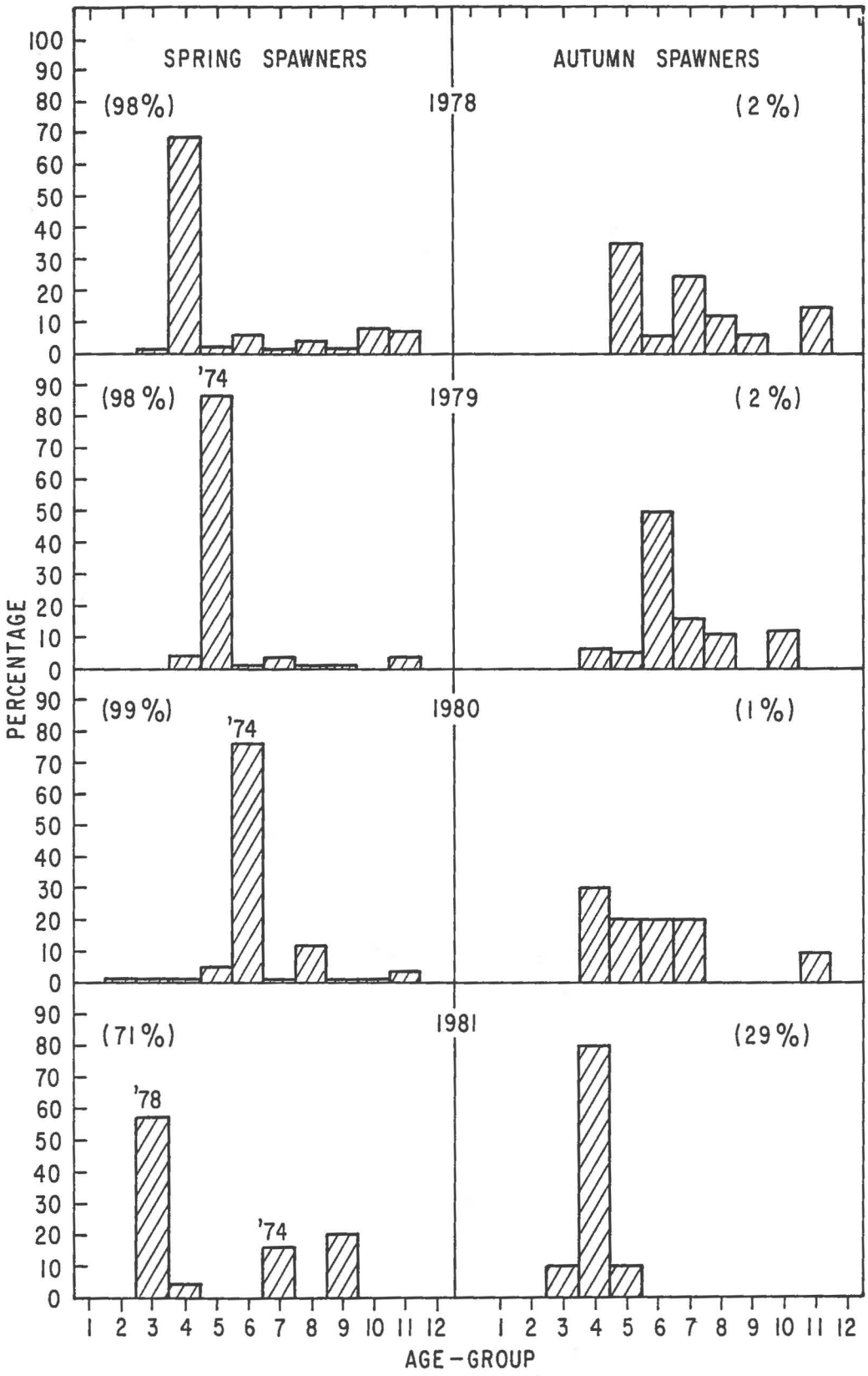

Fig. 2. Age frequency distribution for Fortune Bay (1981 based on one research sample. All other years based on data from the commercial fishery.)

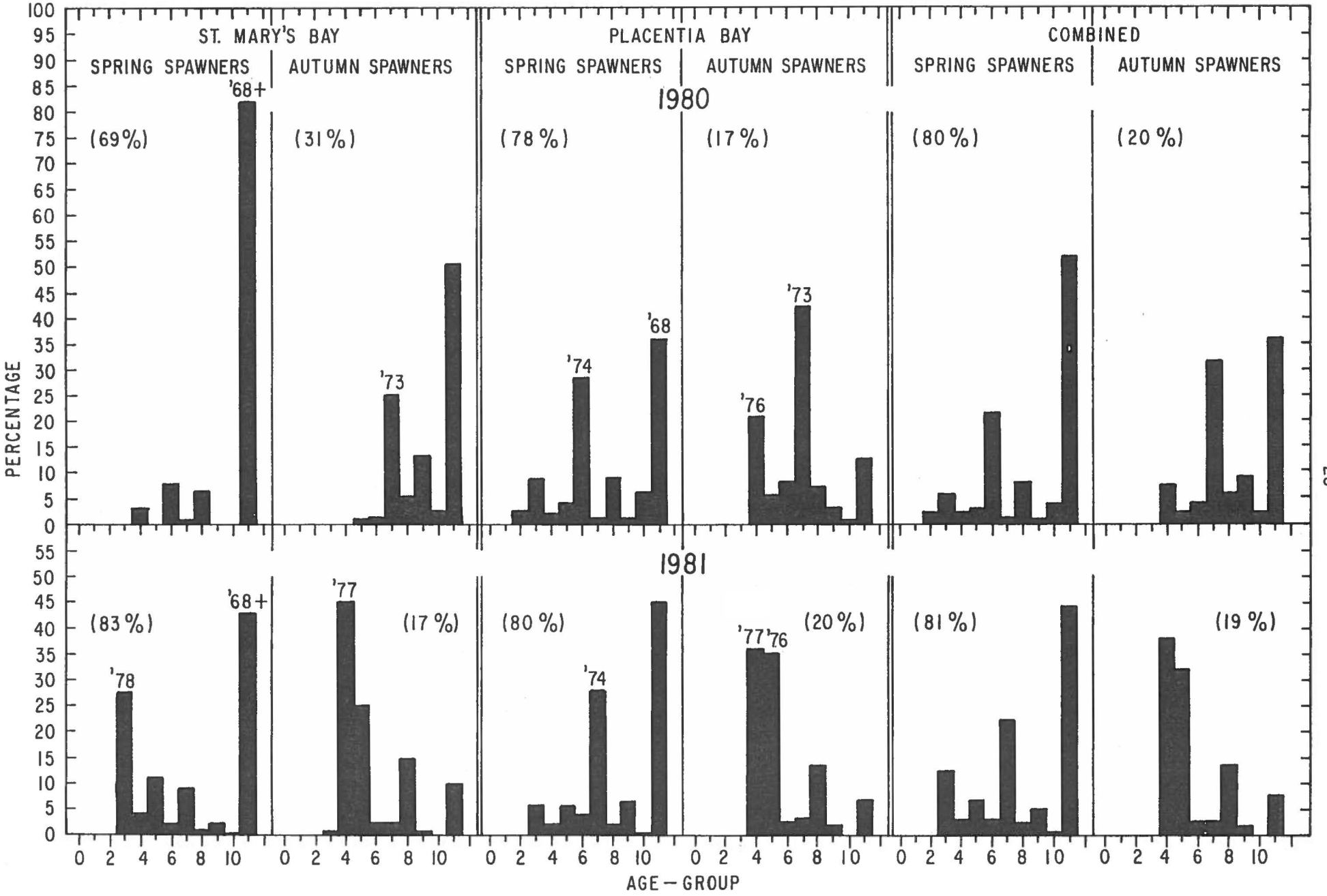

Fig. 3. Age frequency distribution for Placentia-St. Mary's Bays.

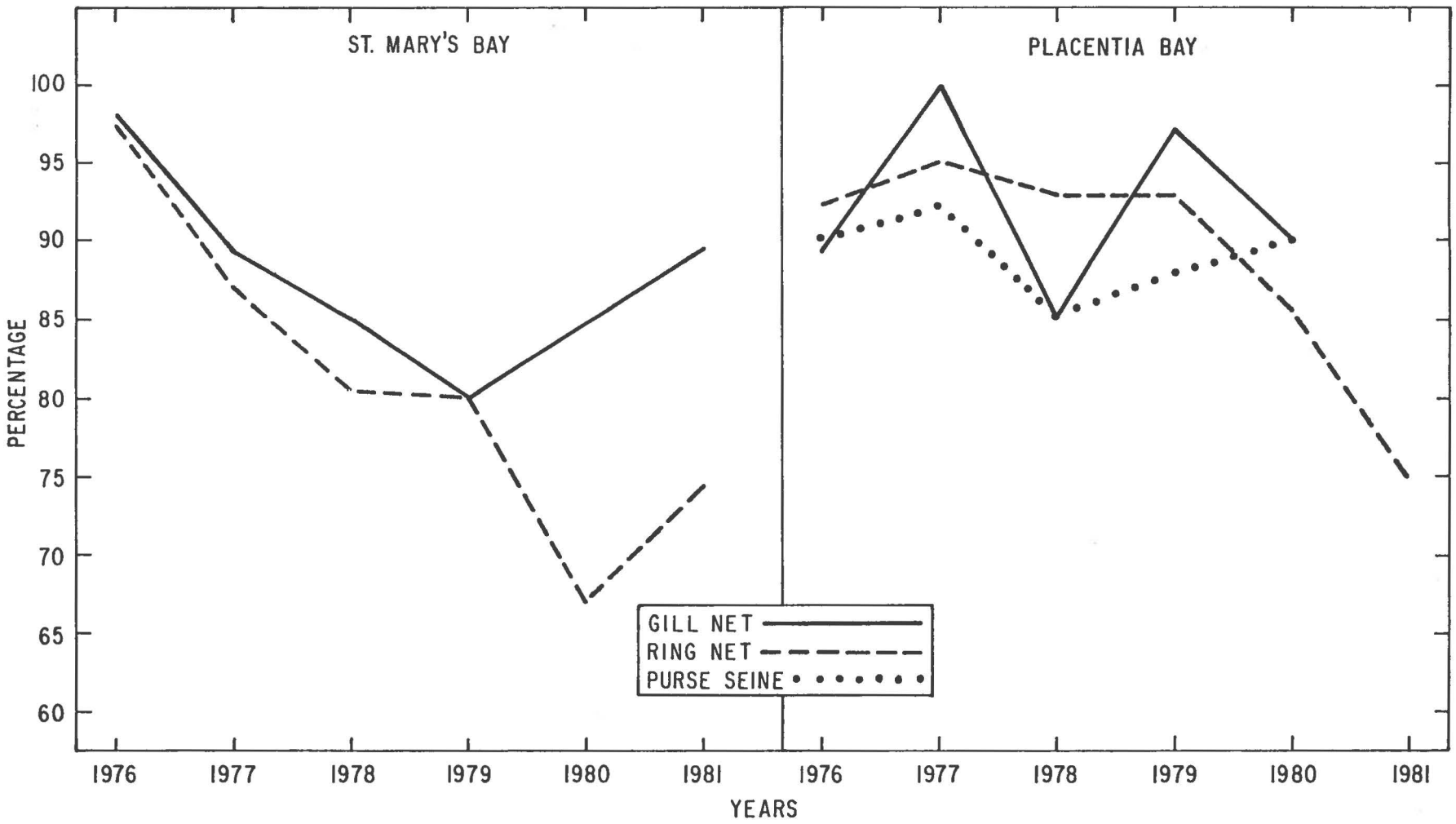

Fig. 4. Percentage occurrence of spring-spawning herring in the cathces of herring taken in various gear types in St. Mary's and Placentia Bays.

APPENDIX I

Placentia-St. Mary's Bays

Table 1: Catch matrix
Table 2: Mean weights
Table 3: Fishing mortalities

Table 1.

C A T C H M A T R I X

AGE/YEAR	1969	1970	1971	1972	1973	1974	1975
2	1.	512.	1.	9.	77.	1007.	75.
3	669.	112.	559.	134.	330.	287.	2248.
4	58.	4615.	121.	20524.	77.	238.	475.
5	56.	62.	2253.	989.	13442.	582.	152.
6	417.	80.	84.	4887.	3697.	14256.	1617.
7	70.	672.	42.	745.	7090.	697.	14002.
8	56.	69.	257.	437.	1434.	5775.	148.
9	105.	75.	13.	580.	186.	155.	3422.
10	368.	51.	23.	88.	235.	233.	357.
11	367.	51.	34.	76.	57.	264.	359.
12	1.	50.	33.	112.	49.	65.	407.
13	1.	1.	32.	109.	73.	55.	100.
14	1.	1.	1.	106.	71.	82.	85.
15	1.	1.	1.	1.	68.	80.	126.
16	1.	1.	1.	1.	1.	76.	123.
17	1.	1.	1.	1.	1.	1.	117.
18	1.	1.	1.	1.	1.	1.	1.

AGE/YEAR	1976	1977	1978	1979	1980	1981
2	348.	31.	29.	87.	128.	1.
3	325.	1365.	163.	661.	316.	193.
4	1588.	142.	1747.	278.	127.	39.
5	184.	737.	104.	2243.	145.	110.
6	233.	93.	532.	95.	1201.	53.
7	809.	50.	53.	609.	55.	348.
8	5148.	1046.	71.	85.	449.	28.
9	183.	3856.	377.	65.	36.	82.
10	1900.	139.	3125.	496.	224.	6.
11	244.	1529.	103.	2933.	272.	49.
12	246.	196.	1139.	97.	1608.	60.
13	278.	198.	146.	1069.	53.	353.
14	68.	224.	147.	137.	586.	12.
15	58.	55.	167.	138.	75.	129.
16	86.	47.	41.	157.	76.	16.
17	84.	69.	35.	38.	86.	17.
18	80.	131.	148.	171.	114.	44.

Table 2.

M E A N W E I G H T S

AGE/YEAR	1969	1970	1971	1972	1973	1974	1975
2	81.000	51.000	76.000	76.000	83.000	71.000	86.000
3	144.000	162.000	134.000	154.000	160.000	159.000	153.000
4	211.000	198.000	169.000	190.000	208.000	213.000	210.000
5	249.000	231.000	219.000	229.000	222.000	229.000	243.000
6	257.000	269.000	247.000	258.000	241.000	242.000	255.000
7	276.000	285.000	290.000	278.000	274.000	269.000	272.000
8	298.000	308.000	284.000	294.000	280.000	290.000	287.000
9	312.000	314.000	297.000	309.000	296.000	307.000	307.000
10	326.000	341.000	348.000	326.000	312.000	310.000	313.000
11	371.000	383.000	369.000	351.000	356.000	339.000	345.000
12	371.000	383.000	369.000	351.000	356.000	339.000	345.000
13	371.000	383.000	369.000	351.000	356.000	339.000	345.000
14	371.000	383.000	369.000	351.000	356.000	339.000	345.000
15	371.000	383.000	369.000	351.000	356.000	339.000	345.000
16	371.000	383.000	369.000	351.000	356.000	339.000	345.000
17	371.000	383.000	369.000	351.000	356.000	339.000	345.000
18	371.000	383.000	369.000	351.000	356.000	339.000	345.000

AGE/YEAR	1976	1977	1978	1979	1980	1981
2	73.000	79.000	80.000	99.000	106.000	81.000
3	163.000	154.000	155.000	154.000	182.000	168.000
4	236.000	242.000	240.000	242.000	235.000	218.000
5	250.000	286.000	295.000	293.000	310.000	300.000
6	273.000	298.000	315.000	328.000	337.000	321.000
7	262.000	304.000	325.000	363.000	362.000	356.000
8	282.000	310.000	330.000	392.000	392.000	371.000
9	302.000	318.000	335.000	386.000	408.000	373.000
10	325.000	323.000	350.000	350.000	377.000	370.000
11	349.000	351.000	380.000	391.000	437.000	419.000
12	349.000	351.000	380.000	391.000	437.000	419.000
13	349.000	351.000	380.000	391.000	437.000	419.000
14	349.000	351.000	380.000	391.000	437.000	419.000
15	349.000	351.000	380.000	391.000	437.000	419.000
16	349.000	351.000	380.000	391.000	437.000	419.000
17	349.000	351.000	380.000	391.000	437.000	419.000
18	349.000	351.000	380.000	391.000	437.000	419.000

Table 3.

HERRING PLACENTIA/ST. MARYS SS
F I S H I N G M O R T A L I T I E S

AGE/YEAR	1969	1970	1971	1972	1973	1974	1975
2	.000	.002	.000	.001	.031	.068	.035
3	.006	.008	.003	.008	.065	.152	.214
4	.005	.052	.011	.139	.006	.061	.403
5	.006	.006	.032	.112	.127	.053	.050
6	.027	.010	.010	.091	.776	.193	.203
7	.013	.056	.007	.115	.186	.315	.294
8	.009	.016	.027	.087	.336	.227	.101
9	.016	.016	.004	.079	.048	.054	.204
10	.069	.010	.006	.031	.042	.079	.170
11	.111	.012	.008	.024	.025	.060	.168
12	.030	.020	.010	.033	.019	.036	.124
13	.028	.037	.016	.040	.027	.027	.071
14	.020	.035	.048	.066	.033	.039	.053
15	.037	.025	.045	.062	.055	.047	.077
16	.031	.047	.031	.058	.081	.081	.096
17	.039	.039	.061	.039	.075	.108	.172
18	.050	.050	.050	.080	.050	.100	.150

AGE/YEAR	1976	1977	1978	1979	1980	1981
2	.016	.015	.009	.054	.016	.010
3	.206	.083	.099	.302	.281	.030
4	.230	.130	.145	.244	.086	.050
5	.268	.159	.133	.281	.194	.100
6	.102	.210	.164	.172	.239	.100
7	.148	.028	.178	.287	.143	.100
8	.167	.291	.051	.481	.356	.100
9	.175	.182	.161	.061	.385	.100
10	.166	.195	.220	.330	.306	.100
11	.169	.196	.216	.331	.303	.100
12	.166	.199	.219	.325	.305	.100
13	.116	.195	.223	.330	.297	.100
14	.063	.129	.217	.337	.304	.100
15	.047	.066	.135	.326	.312	.100
16	.069	.049	.064	.181	.300	.100
17	.087	.073	.046	.078	.142	.100
18	.170	.190	.220	.330	.350	.100