

Production and yield of the Placentia-St. Mary's herring stock

by

J. A. Moores and G. H. Winters
Research and Resource Services
Fisheries and Marine Service, Nfld. Region
3 Water Street
St. John's, Newfoundland
A1C 1A1

Introduction

The St. Mary's-Placentia Bay area has traditionally been an active herring fishing region yielding an average of 14,000 m tons during the period 1945-50 when the post World War II demand for pickled herring was high. Landings dropped considerably in the 1950's due to low demand for food herring and remained at a low level until the mid 1960's when a reduction plant was built at Riverhead, St. Mary's Bay (Pinhorn 1976). Landings increased throughout the 1960's, peaking in 1968 with landings of 7100 m tons. The bulk of this catch (6200 m tons) was taken by purse-seiners mainly in St. Mary's Bay.

In 1969, fishermen reported large quantities of "red herring" in Placentia Bay. The cause of the "disease" was traced to the ERCO phosphorus reduction plant at Long Harbour, Placentia Bay (Jangaard 1972). This disaster caused a severe reduction in the stock and landings remained at the 1000 m ton level until 1972 (Table 1). In 1972, the mobile purse-seiners returned to the Placentia-St. Mary's area and landings increased to 6200 m tons.

Quota regulations were introduced in 1973 resulting in a stabilization of catches at about 6500 m tons from 1973 to 1975, declining to 4100 m tons in 1976 (TAC = 4800 m tons) and 3300 m tons in 1977 (TAC = 3400 m tons). Ring-netting was introduced in 1974 and has gradually increased in importance, accounting for 50% of the catch in 1977. These ring-seiners have concentrated mainly on St. Mary's Bay and as a result the major portion of the catch from this stock now occurs in St. Mary's Bay (Table 1, Fig. 1).

Stock Definition

The fishery in Placentia Bay occurs primarily during the months of January-March on overwintering fish. These schools gradually disperse during early spring at a time coincidental with the beginning of the St. Mary's Bay herring fishery which takes place from April to June, concentrating mainly on spawning schools. The apparent connection between the two bays was first confirmed during the ERCO disaster of 1969. The "red herring" were first observed in Placentia Bay in February but in April herring with the same condition were observed in St. Mary's Bay (Hodder et al. 1972). As the currents

in the area would not have transported contaminants from Placentia Bay to St. Mary's Bay, it was concluded that there was a movement of herring between the two areas.

A series of tagging studies from 1974 to 1977 further elucidated the movements of this stock complex (Table 2). The migrations of individuals were found to be very extensive, including both systematic and incidental movements. In addition to movement between Placentia and St. Mary's bays, tags were recovered along the Southern Shore, in Conception Bay and occasionally as far away as Trinity Bay. In spite of this straying, the bulk of the stock appears to stay within the St. Mary's-Placentia area. As the rate of migration out of this area and the rate of movement from Conception Bay and the Southern Shore into the area cannot be quantified accurately, the four areas are treated as two stocks for management purposes: (1) St. Mary's-Placentia stock, and (2) Conception Bay-Southern Shore stock (Winters and Moores 1977).

Compilation of Assessment Data

(i) Age and numbers-at-age

Numbers-at-age were calculated separately for St. Mary's and Placentia bays spring-spawners (which comprise 95% of the catches) using commercial age frequencies and catches by gear. The numbers-at-age were subsequently combined for cohort analysis. Age frequencies for the years 1975-77 are shown in Fig. 2. The 1968 year-class has been dominant in the fishery since 1972 but its relative contribution during the period 1975-77 has declined from 59% in 1975 to 37% in 1977. The 1972 year-class which appeared fairly strongly in 1976 as 4-year-olds has failed to become a major contributor to the 1977 catch. The 1974 year-class represented 18% of the 1977 catch and appears to be relatively stronger than most recent year-classes since 1968.

(ii) Partial recruitment rate

Partial recruitment rates for spring-spawners were estimated from cohort analysis for the period 1972-75 from trial values of fishing mortality. These are given in the table below.

Age	2	3	4	5	6	7	8	9	10	10+
P/R rate (%)	10	30	50	100	100	100	100	100	100	100

(iii) Catch-per-unit effort, fishing effort

Log records of the purse-seine fleets activity were available from 1972 to 1977. As log records for the purse-seine fleet were unavailable for St. Mary's Bay in 1973, 1976 and 1977, only Placentia Bay logs were used in this analysis. In 1977 the MV CANADA 100 was the only large purse-seiner remaining in this fishery - a regression of fleet CPUE on CANADA 100 CPUE for the years 1974-76 allowed calculation of the fleet CPUE for 1977 (Table 3). Total fishing effort was then calculated by dividing the total catch by the CPUE (Table 3).

(iv) Selection of Terminal F

Cohort analysis was performed for spring-spawners at a range of F values from 0.10 to 0.40 ($M = 0.20$). A plot of effort on F_{5+} (1972 = 4+ to take into account the large contribution by the 1968 year-class) results in a non-linear relationship (Fig. 3), indicating the influence of learning, resulting from ground familiarity and (more importantly) an increase in the efficiency of the operating day as vessels began landing mainly (and from 1975 solely) at Arnold's Cove, a port in close proximity to the fishing grounds. To adjust for learning, a line was drawn through the 1972 and 1973 points (assuming very little learning) with the ratio of the adjusted 1975 value to the actual 1975 value used to adjust the 1977 effort. This yielded an $F_T = 0.18$.

Paloheimo Z's were calculated for 1972-76 and yielded a mean Z value of 0.35 which corresponded to an $F_T = 0.15$.

	1972	1973	1974	1975	1976	Z
Paloheimo Z(4+)	0.54	0.26	0.26	0.49	0.22	0.35

A further calculation of mortality rates was obtained from an analysis of the catch curve (\log_e CPUE versus age) for the 1968 year-class, resulting in a slope of 0.37 equivalent to an $F_T = 0.17$.

As the range of F_T values given by these analyses indicates that F_T is in excess of 0.15, a conservative value of $F_T = 0.20$ was selected.

Results of Assessment

(i) Trends in biomass and F

III

Since 1972, the stock biomass has been declining due both to fishery removals and poor recruitment. The 1977 biomass was estimated at 2100 m tons which is 30% of the 1972 level of 70,000 m tons (Table 4).

The F_{5+} values have shown an increasing trend from a low of 0.028 in 1971 to a high of 0.262 in 1976 (Table 4).

(ii) Trends in recruitment

The 1968 year-class has dominated the Placentia-St. Mary's Bay fishery since 1972. No year-class since then has approached the magnitude of this year-class. The 1972 year-class which appeared to be promising is now estimated to be only one sixteenth the size of the 1968 year-class. The 1974 year-class was the second largest contributor to the 1977 fishery. Although this year-class has not fully entered the fishery, it is currently estimated to be almost three

times as large as the 1972 year-class but still only one sixth the size of the 1968 year-class. Similar patterns of recruitment are evident in all spring-spawning stocks of herring from eastern Newfoundland to the southern Gulf of St. Lawrence, suggesting wide environmental control of recruitment strengths.

(iii) Estimation of F_{opt}

A yield-per-recruit curve was calculated for Placentia-St. Mary's Bay spring-spawning herring. The resultant curve (Fig. 4) indicated F_{opt} to be 0.40 and 80% F_{opt} equal to 0.30.

(iv) Catch projection

Mean recruitment strengths and standard deviations of spring-spawning herring have been calculated for the years 1969-76 and, using a random number generator, a 10-year projection of stock size and yield (at 80% F_{opt}) has been calculated. The results are shown in Fig. 5.

From 1978 to 1988, the spring-spawning biomass fluctuates from 21,000 m tons to 46,000 m tons with a mean of 36,000 m tons. Projected biomass in 1978 is 21,700 m tons (Table 5).

Catches from the projection have been prorated to the total catch using the 1977 ratio of total catch to catch of spring-spawners, i.e. $3284/2876 = 1.14$ (Fig. 5). The average predicted catch for the period 1978-88 is 6252 m tons with a 1978 projection of 4000 m tons. Inshore catches of this stock during the past 3 years have averaged 1400 m tons, suggesting a residual TAC of 2600 m tons.

Discussion and Conclusions

The St. Mary's-Placentia herring stock has been declining since 1973 as the 1968 year-class, which will be age 10 in 1978, transits the fishery. Recruitment in recent years has been poor and insufficient to maintain the stock at the level of the early 1970's. The 1972 year-class which initially appeared promising has failed to be as strong as expected and biomass levels in the near future will depend largely on the 1974 year-class. The full impact of the 1974 year-class will be difficult to assess until it is fully recruited in 1979 but preliminary indications suggest that it is not strong. However, given the temporal coincidence of strong year-classes in widely-separated stocks of spring-spawning herring in various stages of exploitation in the Newfoundland area, there would appear to be little chance of current exploitation levels causing recruitment overfishing.

The changing pattern of fishing on this stock also bears close watching. If the trend towards an increasing proportion of the catch being harvested in St. Mary's Bay continues, efforts should be made to proportion the quota equitably between the two bays thereby minimizing the possible overexploitation of particular components of this stock complex.

- Hodder, V. M., L. S. Parsons and J.H.C. Pippy. 1972. The occurrence and distribution of "red" herring in Placentia Bay, February-April 1969. p. 45-52. In Effects of elemental phosphorus on marine life. Fish. Res. Board Can. (Atlantic Regional Office) Circular No. 2: 313 p.
- Jangaard, P. M. (ed). 1972. Effects of elemental phosphorus on marine life. Fish. Res. Board Can. (Atlantic Regional Office) Circular No. 2: 313 p.
- Pinhorn, A. T. (ed). 1976. Living marine resources of Newfoundland-Labrador: status and potential. Bull. Fish. Res. Board Can. 194: 64 p.
- Winters, G. H. and J. A. Moores. 1977. Assessment of yield potential of eastern Newfoundland herring stocks. CAFSAC Res. Doc. 77/12.

Table 1. Catches (metric tons) from Placentia Bay and St. Mary's Bay by gear for the period 1969-77.

Year	Area	Purse seine	Ring net	Bar seine	Gillnet	Trap	Total
1969	SMB	-	-	40	258	-	298
	PB	25	-	-	802	-	827
	Total	25	-	40	1060	-	1125
1970	SMB	-	-	45	351	2	398
	PB	358	-	-	486	-	844
	Total	358	-	45	837	2	1242
1971	SMB	-	-	-	254	14	268
	PB	-	-	-	594	-	594
	Total	-	-	-	848	14	862
1972	SMB	2194	-	24	382	-	2600
	PB	2072	-	44	1462	-	3578
	Total	4266	-	68	1844	-	6178
1973	SMB	734	-	97	95	10	936
	PB	4557	-	-	699	39	5295
	Total	5291	-	97	794	49	6231
1974	SMB	1710	51	271	470	37	2539
	PB	3200	-	212	510	11	3933
	Total	4910	51	483	980	48	6472
1975	SMB	1032	711	554	674	243	3214
	PB	2638	-	225	450	188	3501
	Total	3670	711	779	1124	431	6715
1976	SMB	-	920	158	352	25	1455
	PB	2056	172	242	177	-	2647
	Total	2056	1092	400	529	25	4102
1977*	SMB	-	1131	221	525	29	1906
	PB	739	519	44	76	-	1378
	Total	739	1650	265	601	29	3284

*Provisional statistics

Table 2. Tag returns by year from Placentia Bay, St. Mary's Bay and related areas, excluding returns in year of release.

Area tagged	Year of recapture	Area recaptured			
		St. Mary's Bay	Placentia Bay	Conception Bay	Southern Shore
St. Mary's Bay	1975	92	15	5	2
	1976	32	7	-	-
	1977	25	3	1	11
Placentia Bay	1975	-	6	-	-
	1977	1	8	-	-
Conception Bay	1976	13	1	55	2
	1977	3	1	3	4
Southern Shore	1975	37	-	5	6
	1976	20	-	4	3
	1977	8	1	2	14

Table 3. Summary of catch per unit effort (CPUE) and effort for the Placentia-St. Mary's stock. (a) includes all boats in Placentia Bay fishery (b) CANADA 100 only

Year	C/op. day (m. tons)		Total catch	Effort	
	P.B. (a)	CANADA 100 (b)		(a)	(b)
1972	81.7	-	6178	76	-
1973	51.5	-	6224	121	-
1974	51.1	78.2	6672	131	85
1975	43.6	68.7	6715	154	98
1976	38.3	49.3	4102	107	83
1977	35.3*	43.5	(3284)	93*	(76)

*from regression of CANADA 100 and Placentia Bay CPUE

HERRING AREA G&H 1969-77 AGES 2-18 SS

NATURAL MORTALITY = 0.20

ASSUMED FISHING MORTALITY FOR LAST AGE = 0.20

ESTIMATED POPULATION FOR LAST YEAR

6. 6. 6. 6. 6. 6. 485. 740.

PREDETERMINED FISHING MORTALITY USED FOR LAST YEAR

0.20000
0.20000
0.20000
0.20000
0.20000
0.20000
0.20000
0.20000
0.20000
0.20000
0.20000
0.20000
0.20000
0.20000
0.20000
0.10000
0.06000
0.02000

ESTIMATED POPULATIONS
AGE 1969 1970

AGE	1969	1970	1971	1972	1973	1974	1975	1976	1977
2	18890.	248555.	27768.	2551.	2774.	15012.	3509.	40702.	1671.
3	118781.	15465.	203037.	22734.	2081.	2201.	11379.	2805.	33009.
4	13621.	96644.	12560.	165727.	18492.	1405.	1543.	7283.	2002.
5	10195.	11100.	74950.	10174.	117115.	15070.	935.	833.	4526.
6	13260.	8296.	9032.	59325.	7435.	83722.	11812.	628.	516.
7	2909.	10479.	6720.	7318.	44149.	2742.	55647.	8207.	303.
8	2504.	2318.	7971.	5464.	5318.	29731.	1614.	32890.	5988.
9	3663.	1999.	1835.	6294.	4078.	3056.	19116.	1188.	22270.
10	5658.	2904.	1569.	1491.	4628.	3171.	2362.	12555.	807.
11	3532.	4299.	2332.	1264.	1141.	3577.	2385.	1611.	8560.
12	32.	2560.	3474.	1878.	966.	883.	2689.	1628.	1098.
13	25.	25.	2051.	2814.	1436.	746.	664.	1834.	1110.
14	20.	20.	20.	1650.	2206.	1110.	561.	453.	1250.
15	15.	15.	15.	15.	1255.	1742.	835.	383.	309.
16	12.	12.	12.	12.	12.	966.	1353.	569.	261.
17	9.	9.	9.	9.	9.	9.	722.	997.	388.
18	6.	6.	6.	6.	6.	6.	6.	485.	740.

Biomass(S⁺)

11900.0 12548.5 29145.7 27356.7 49556.3 40951.7 28376.0 19179.2 15119.2

F(S⁺)

0.039 0.029 0.028 0.097 0.167 0.184 0.262 0.188

Table 4

Table 5

STOCK PROJECTION AREA G&H SPRING SPAWNERS '000

NATURAL MORTALITY# 0.2000		YEAR 1977					
AGE	POP. NO. XX10-3<	CATCH NO. XX10-3<	FISHING MORT.	MEAN WT. KG.	POP. WT. %METRIC TONS<	CATCH WT. %METRIC TONS<	RESIDUAL POP. NOS.
2	1671.	30.	0.021	0.079	132.0	2.4	1339.7
3	33009.	1744.	0.060	0.154	5083.4	268.6	25451.6
4	2002.	173.	0.101	0.242	484.5	41.9	1481.6
5	4526.	746.	0.200	0.286	1294.4	213.4	3033.9
6	516.	85.	0.200	0.298	153.8	25.3	345.9
7	303.	50.	0.201	0.304	92.1	15.2	202.9
8	5988.	987.	0.200	0.310	1856.3	306.0	4013.9
9	22270.	3671.	0.201	0.318	7081.9	1167.4	14913.1
10	807.	133.	0.200	0.323	260.7	43.0	540.9
11	8560.	1411.	0.200	0.351	3004.6	495.3	5737.9
12	1098.	181.	0.201	0.351	385.4	63.5	735.3
13	1110.	183.	0.201	0.351	389.6	64.2	743.3
14	1250.	206.	0.200	0.351	438.7	72.3	837.9
15	309.	51.	0.201	0.351	108.5	17.9	206.9
16	261.	43.	0.200	0.351	91.6	15.1	175.0
17	388.	64.	0.201	0.351	136.2	22.5	259.8
18	740.	122.	0.201	0.351	259.7	42.8	495.5
TOTAL	84808.	9880.			21253.3	2876.6 (x1.14)	60515.2

NATURAL MORTALITY# 0.2000		YEAR 1978					
AGE	POP. NO. XX10-3<	CATCH NO. XX10-3<	FISHING MORT.	MEAN WT. KG.	POP. WT. %METRIC TONS<	CATCH WT. %METRIC TONS<	RESIDUAL POP. NOS.
2	57703.	1546.	0.030	0.079	4558.5	122.2	45847.1
3	1340.	105.	0.090	0.154	206.3	16.1	1002.4
4	25452.	3221.	0.150	0.242	6159.3	779.5	17935.5
5	1482.	350.	0.300	0.286	423.7	100.0	898.7
6	3034.	716.	0.300	0.298	904.1	213.4	1840.1
7	346.	82.	0.300	0.304	105.1	24.8	209.8
8	203.	48.	0.300	0.310	62.9	14.8	123.1
9	4014.	948.	0.300	0.318	1276.4	301.3	2434.5
10	14913.	3521.	0.300	0.323	4816.9	1137.2	9045.3
11	541.	128.	0.300	0.351	189.9	44.8	328.1
12	5738.	1355.	0.300	0.351	2014.0	475.5	3480.2
13	735.	174.	0.300	0.351	258.1	60.9	446.0
14	743.	175.	0.300	0.351	260.9	61.6	450.8
15	838.	198.	0.300	0.351	294.1	69.4	508.2
16	207.	49.	0.300	0.351	72.6	17.1	125.5
17	175.	41.	0.300	0.351	61.4	14.5	106.1
18	260.	61.	0.300	0.351	91.2	21.5	157.6
TOTAL	117723.	12717.			21755.6	3474.9 (3967)	84938.6

-10-

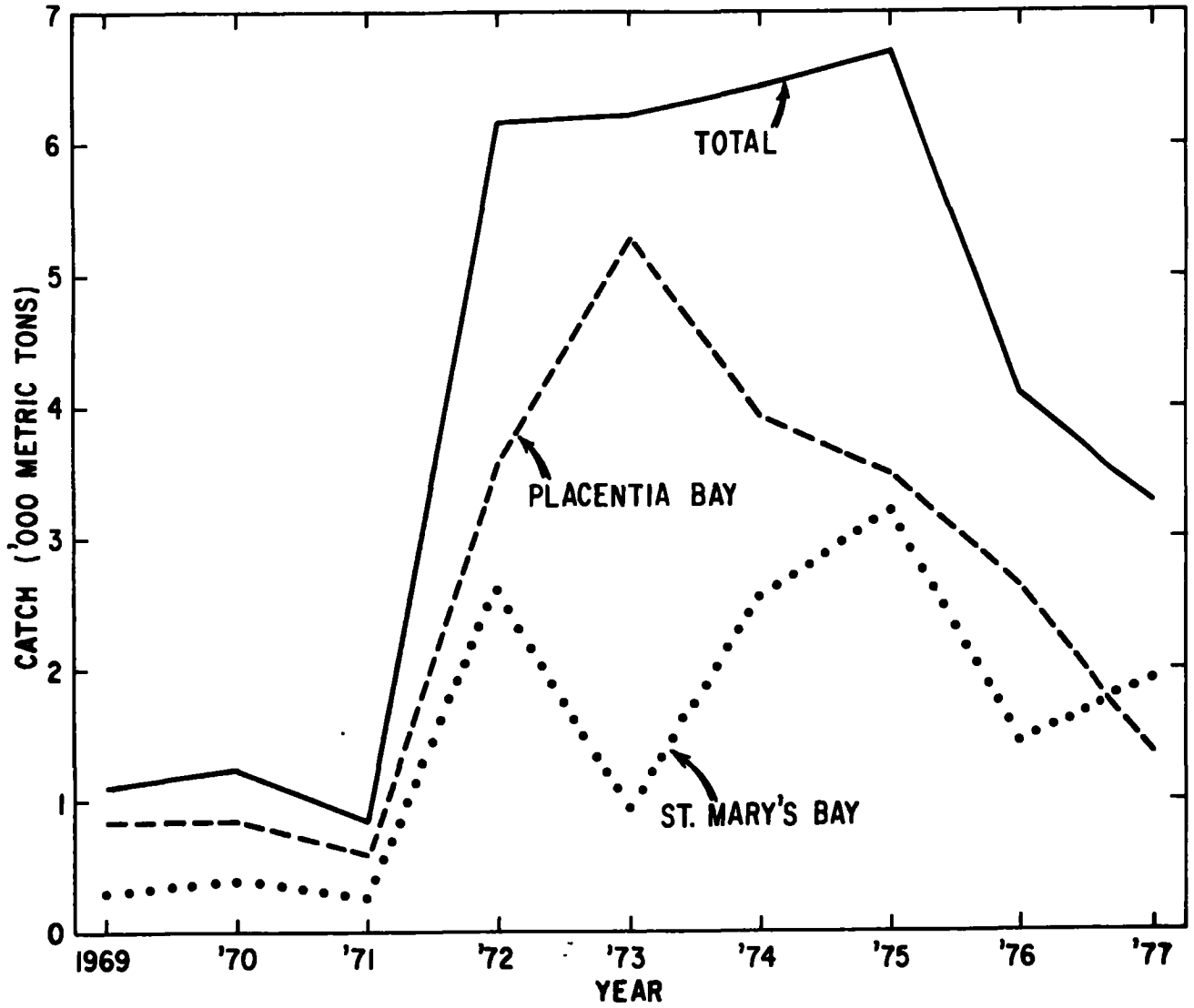


Fig. 1. Herring catches from Placentia-St. Mary's Bays for the period 1969-1977.

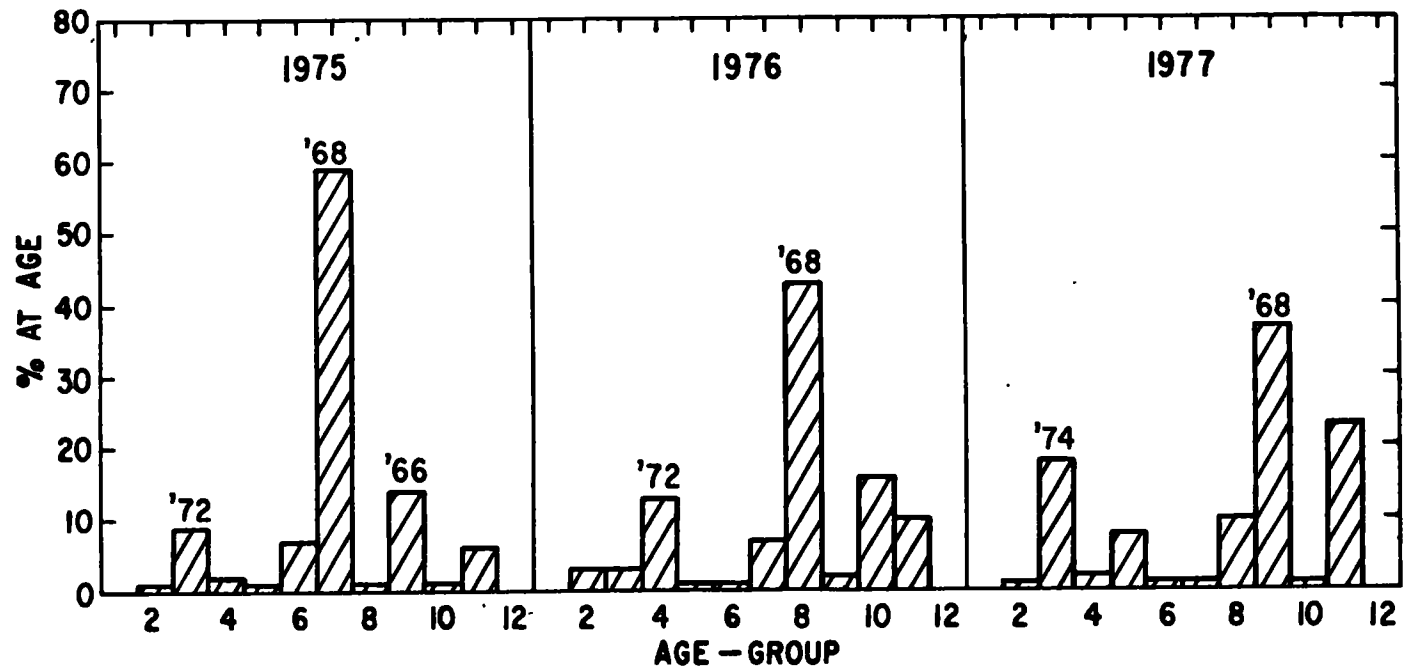


Fig. 2. Age-group frequency from commercial herring catches in Placentia-St. Mary's Bays.

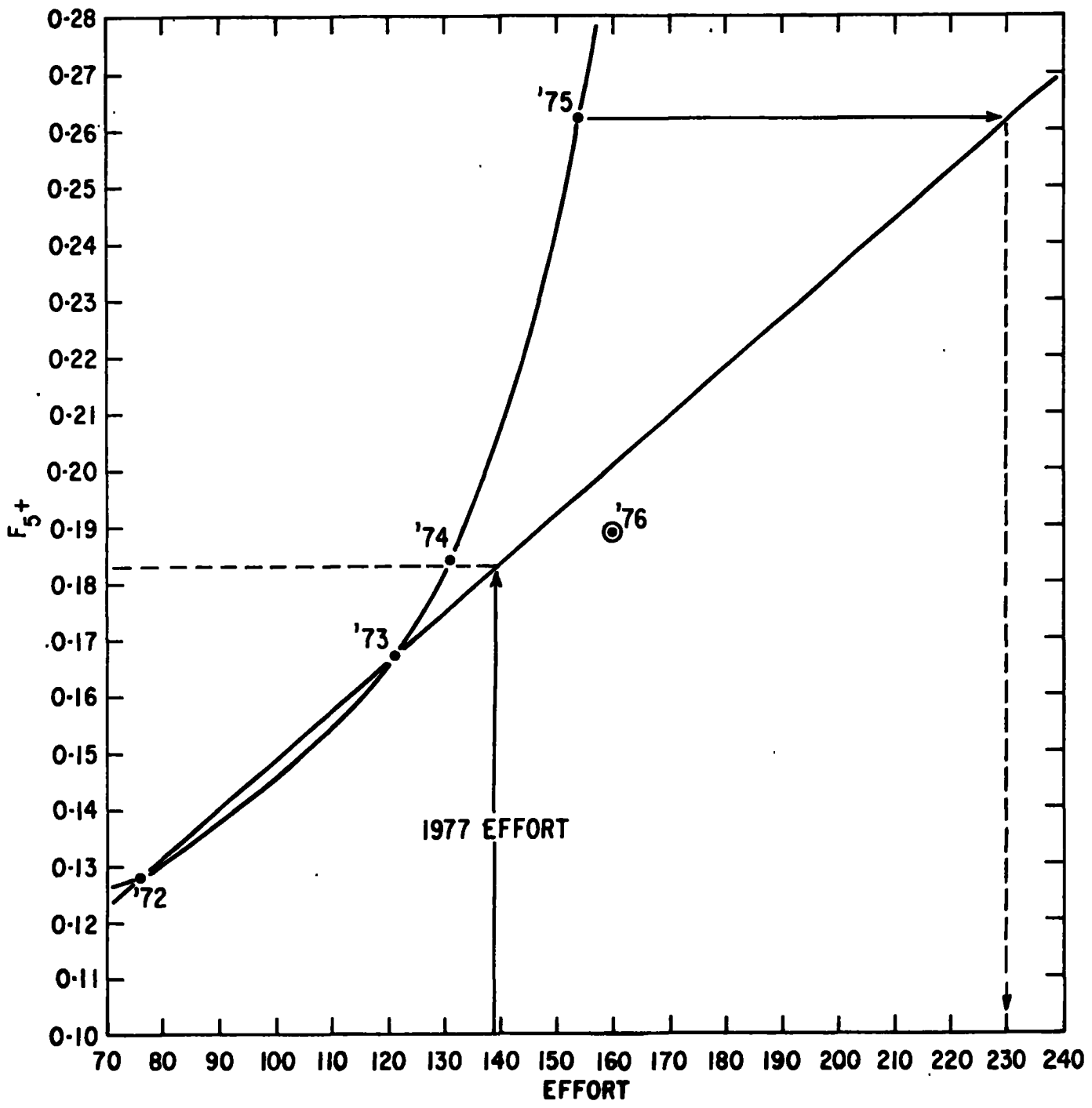


Fig. 3. F_{5+} vs. Effort for Placentia-St. Mary's Bays.

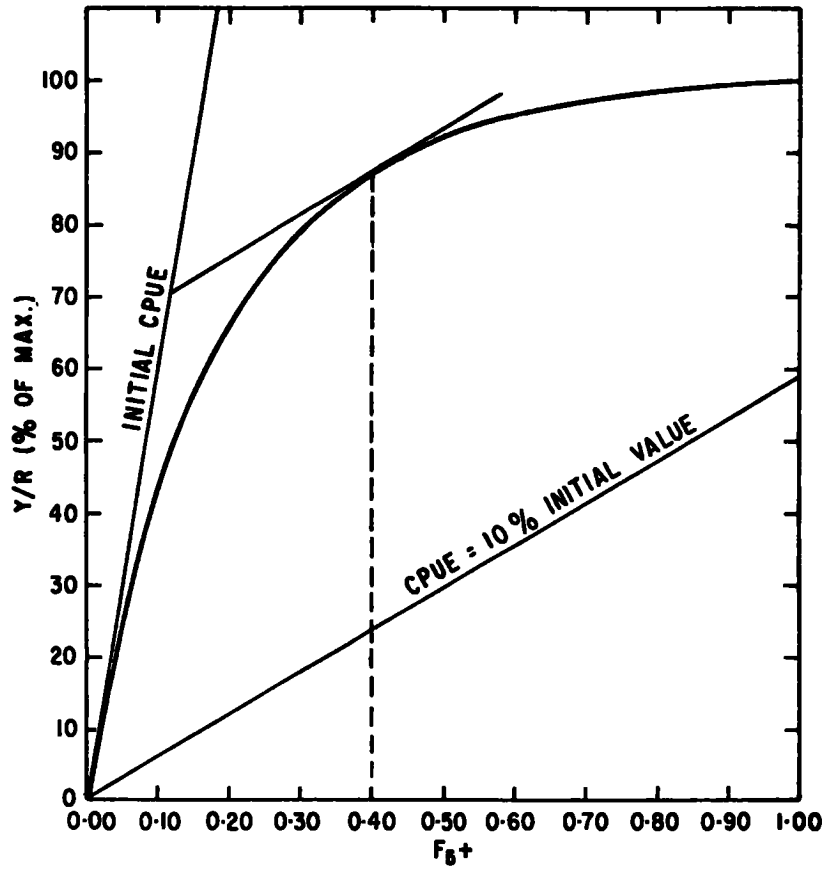


Fig. 4. F vs. Yield per recruit for Placentia-St. Mary's stock complex.

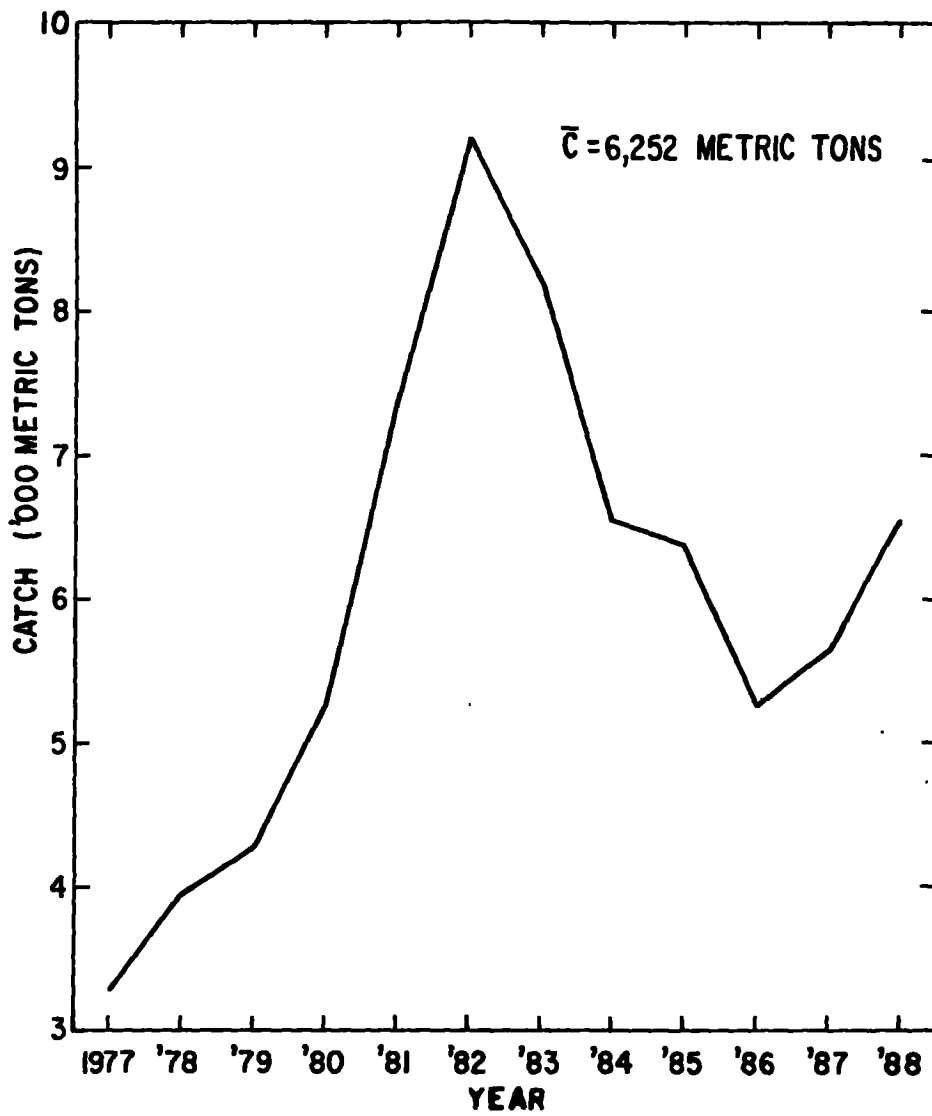


Fig. 5. Catch projection (1977-1988) for the Placentia-St. Mary's Bays herring stock.