Production and yield of western Newfoundland herring stocks

by

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Introduction

Historically the west coast of Newfoundland and in particular the Bay of Islands, has been noted as a major herring fishing area. Landings reached a peak during the late 1940's with average landings (1945-50) of 32,000 mt (Templeman, 1966) and peak landings of 80,000 mt in 1946. During the same period all other areas of the west coast combined landed an average of less than 700 t per year. In the 50's and 60's landings declined. Templeman (1966) reports that for the period 1958-62 the average landings for the entire west coast was 6000 mt per year.

Tibbo (1957) attributed the large post World War II landings to increased effort due to good market conditions caused by aid programs. The decline in landings during the 1950's was due to reduced abundance (Olsen 1961) and to some extent by reduced effort.

Prior to 1950 all herring in Newfoundland were believed to be spring spawners (Tibbo, 1957). However during the late 50's Olsen (1961) noted that herring along the south and west coasts of Newfoundland displayed spawning over a wide range of months and were not distinctly spring or autumn spawners. Hodder (1966) in an examination of samples from the west coast found that the purse-seine fishery caught mainly spring spawners while large quantities of autumn spawners were present in gill net and otter trawl samples.

The west coast herring fishery has been prosecuted mainly with purse seiners and gill nets while recently herring traps are being utilized; herring are also being taken as a by-catch in shrimp trawls.

The major purse-seine fishery has shown a general northward shift. The major fishery in the 40's and early 50's was in the Bay of Islands and Port-au-Port Bay area. As these fisheries declined a major fishery started in Bonne Bay lasting through the 60's. In 1971 and 72 the fleet concentrated in Hawkes Bay and in 1973 they shifted into St. John Bay. It is difficult to conclude whether this northward movement of the fleet reflects a northward shift in herring distribution or a drastic reduction of 'local' stocks in the southern area, i.e. the fleet was moving from stock to stock. These recent fisheries have been fall and winter fisheries and are complicated by the extremes of weather conditions, lack of sheltered ports and distance from suitable offloading sites.

The St. Georges Bay fishery has developed in conjunction with the Southern Gulf-southwest Newfoundland fishery and was long held to be a part of the Southern Gulf stock.

Stock Definition

Many studies have been conducted on herring along the west coast of Newfoundland (Tibbo 1956, 1957, Olsen 1961, Hodder 1966, Parsons & Hodder 1971, Parsons 1973 and Winters and Parsons 1972). The results of these studies have been ambiguous possibly due to the limited data base from which they were working. Tibbo (1957) states that the west coast populations are distinct from the Gulf and southwest coast of Newfoundland stocks. Parsons and Hodder (1971) state that "from nematode abundance (in herring) it appears that herring along the northwest coast of Newfoundland are relatively distinct from the southwestern Newfoundland - Southern Gulf stock complex". From tag recaptures of herring, released in Hawkes Bay, and caught in the southwest coast winter fishery, the Gulf of St. Lawrence summer fishery and the lack of biological differences in the Magdalen Islands, Southern Gulf, southwest Newfoundland and Hawkes Bay herring, Winters and Parsons (1972) concluded that 'the autumn spawning component of the herring which support the Hawkes Bay autumn fishery includes herring which are enroute from the Southern Gulf to southwest Newfoundland'.

Since 1966 catch along the west coast (Port-au-Port north) has fluctuated widely from a low 2600 mt in 1969 to a high of 14,000 mt in 1973. (Table 1). Catches by inshore gear during the summer are predominantly autumn spawners while winter purse-seine fisheries take up to 90% spring spawners.

In previous assessments St. Georges Bay has generally been considered as part of the Southern Gulf stock based on analyses of sample compositions and tagging data. However since these analyses were made the fishing pattern in St. Georges Bay has altered. From 1972-74 the mobile fleet fished from Cape Anguille to Robinsons. In 1975 the fleet moved farther in the bay and in 1976 were fishing in the bottom of the bay.

A comparison of spawning type data for St. Georges Bay and the 'edge' (Table 2) shows that in 1973-74 the relative proportion of autumn spawners to spring spawners is similar. In 1975 the pattern changes with the St. Georges Bay samples being composed mainly of spring spawners (76%) while on the 'edge' autumn spawners are dominant (84%). This dichotomy was even more marked in 1976 samples when spring spawners represented 96% of the fish sampled in St. Georges Bay while autumn spawners were dominant in samples from the 'edge' (55%)

Two herring tagging experiments were conducted in the Southern Gulf area in 1976. In April 6400 tags were applied in the area of Sandy Point, St. Georges Bay. In May 3800 tags were applied to herring caught on the 'edge'. A total of 95 tags have been recovered from the St. Georges Bay tagging of which 92 were returned from St. Georges Bay. The remaining 3 tags were recaptured north of St. Georges Bay along the Port-au-Port Peninsula and in Port-au-Port Bay (Table 3). It is significant that no fish from this tagging were recaptured during the 'edge' fishery or from the Southern Gulf fishery. Returns from the 'edge' tagging came mainly from the 'edge' fishery (126 of 139 recoveries). The remaining 13 tags were recovered in the Chaleur Bay - Gaspé area (12) and Chedabucto Bay (1).

From taggings conducted in Hawkes Bay (Winters 1971) there appears to be some connection between Northern and Southern Gulf herring. To try and elucidate this matter a tagging experiment was conducted in St. John Bay in December 1976. A total of 10,000 tags were applied. No tags have been recovered to date but it is hoped that the fisheries in 1977 will shed some light on the question of stock interaction.

The analyses of spawning type and tagging data show that the stock exploited in St. Georges Bay in 1975 and 1976 were not part of the Southern Gulf stock.

Indeed in June spawning occurred at Sandy Point the same area in which the fishery was concentrated. It would appear that the stock exploited in 1976 in St. Georges Bay has a closer affinity to the Northern Gulf than to the Southern Gulf stock.

Based on these analyses it was decided to define the west coast of Newfoundland a unit stock for management purposes encompassing the area from Cape Ray to Cape Norman. Only 1975 and 1976 data from St. Georges Bay have been incorporated into this assessment; St. Georges Bay stocks may have been previously exploited in the Cape Anguille area and perhaps also southwest Newfoundland but available data do not permit partitioning of those catches.

Compilation of Assessment Data

Age data and No's-at-age. For the purpose of sample collection the west coast area is subdivided into four areas, K, L, M and N. Age data were available for most of these areas for the period 1966-76.

In all areas of the west coast the 1968 year-class is dominant among spring spawners representing 47% of the catch (Fig. 1) in 1976. The catch of autumn spawners was mainly composed of fish older than age 10. There are no indications of recent strong recruitment in either the spring or autumn spawners although it is realized that most of the fisheries are based on mature fish.

No's-at-age were generated separately for each of the four areas. For years when no age data were available from a particular area, age data from the nearest adjacent area were applied. Area K (St. Georges Bay) data were included for 1975 and 1976 when sample composition indicates that the stock fished was not part of the Southern Gulf stock. The numbers-at-age produced for each area were then combined for unit analysis.

Partial recruitment rates. Partial recruitment rates were estimated from cohort analysis using trial values of fishing mortality. Estimated F values by age were averaged over the period 1970-74 and expressed as a percent of the F in the last age (11). These percentages represent an estimate of the partial recruitment rates (Table 4).

Catch per unit effort, fishing effort and F. Log records of the purse-seine activity were available from 1966 to 1973 for areas M and N and from 1974 to 1975 for area K (Table 5). Fishing effort was calculated by dividing the CPUE into the total catch as given in Table 5.

Cohort analysis was run individually for both spring and autumn spawners at a range of F values from 0.15 to 0.40 with an M=0.20. An F_5+ for the population was calculated by proportioning the F_5+ of springs and autumns on the basis of number of 5+ of each in the total population. This fishing mortality rate was plotted against effort and regression analyses (omitting the apparently anomalous 1972 data) indicated a best fit at F_T=0.25 (Fig. 2).

Results of Assessment

Trends in biomass and F. A comparison of the biomass of spring spawners and autumn spawners indicate a reversal of the relative importance of each to the total stock for the period 1966-76. In 1966 autumn spawners were the major component of the population. Since 1966 the biomass of autumn spawners has declined steadily (Table 6. Fig. 3) from 97,000 mt (5+ biomass) in 1966 to 10,000 mt (5+ biomass) in 1976. Spring spawners have increased their relative contribution to the population biomass (Fig. 3) from 32% in 1966 to 79% in 1976.

The adult biomass of spring spawners declined from 1966 to a low of 29,500 mt in 1972 increasing sharply in 1973 (as the 1968 year-class entered the adult population) to 64,500 mt and declining steadily since then to its present level in 1976 of 40,700 mt (Table 6).

Fishing mortality ratio of both components have been low particularly in the earlier years and fluctuations in biomass have been little affected by fishery removals except since 1973 when moderately high fishing mortality rates have been observed.

Trends in relative recruitment. Autumn spawners have not displayed any substantial recruitment since the 1958 year-class (Fig. 4). This year-class was extremely large with 420 million recruits at age 2. In year-classes 1960 to 1964 recruitment averaged around 45 million and since 1965 recruitment has declined to the level of 5 million recruits.

Spring spawners have displayed an opposite recruitment pattern. Two strong year-classes are in evidence: 1959 (200 million recruits at age 2) and 1968 year-class (325 million recruits). Recruitment was lowest in the 1971 year-class (5 million recruits) but has consistently outranked that of autumn spawners since 1965. With the present trend in recruitment spring spawners will tend to be the major contributor to the population, at least for the next decade or so. It is of interest to note that the relative strength of the 1958 year-class of autumns to the 1959 year-class of springs is the same in the Northern Gulf as in 4T.

Estimation of F_{opt}. Preliminary analyses have indicated there are no significant differences in yield-per-recruit of spring and autumn spawners. Consequently yield-per-recruit analyses have been carried out using weighted averages of the various parameters. The results are shown in Fig. 5. The optimum fishing mortality rate (F_{opt}) is calculated to be 0.45.

Catch projections. Mean recruitment strengths and standard deviations of spring- and autumn-spawning herring have been calculated for the year-classes 1957-74 and 1964-74 respectively. Using a random number generator a 20 year projection of stock size and yield (at F_{opt}) has been calculated and the results are shown in Fig. 6.

From 1977 to 1997 the total biomass fluctuates from 36,000 mt to 58,000 mt with a mean of 47,000 mt. Projected biomass in 1977 is 52,000 mt.

The catch for the period 1977-1997 varies from 5000 mt to 12,600 mt with a mean at 7000 mt. For 1977 the projected catch is 12,580 mt which is our recommended TAC. Inshore catches over the past 3 years have averaged 2000 mt. Assuming inshore effort will remain constant in 1977 this would leave 10,500 mt for the mobile fleet. This remainder should be partitioned so that the effort will be exerted over the entire west coast. This would reduce the possibility of drastically reducing any local stocks.

Discussion and Conclusions

Within the west coast area there are several known spawning areas. Spring spawning is known to occur in June in St. Georges Bay and also in June in St. Paul's Inlet. Fall spawnings are not well documented as they occur offshore in depths of 20-40 fathoms.

The population of herring in the west coast area is now dominated by spring spawners. This is a return to the conditions reported by Tibbo (1957) and Olsen (1961) for herring populations of the 40's and early 50's when all Newfoundland stocks were reported to be spring spawners. It was only during the late 50's and 60's that a wide spread was noticed in the timing of spawning activities of herring (Olsen 1961). This extension of spawning activities from spring to fall occurred at a time when population biomasses were low and when extremely large year-classes occurred. The trend back toward spring spawning may indicate a return to more stable population biomasses and hopefully a steadier recruitment pattern. A similar trend towards spring spawning has been noted in the Southern Gulf stock (Winters et al, MS 1977).

The total west coast stock appears to be underexploited. This is particularly true for the northern area. Large concentrations of herring were observed in St. John Bay in December 1976 but to date, due to problems of weather and offloading areas, little effort has been expended in the area. On the other hand a great deal of effort has been expended in the St. Georges Bay area and has probably reached a level sufficient to harvest the resource.

The definition of a west coast unit stock is probably a tenuous one. Undoubtedly as defined it is composed of several stocks and is more aptly termed a stock complex. Until the individual stocks and the degree of intermix can be adequately defined, it is prudent to treat the area as a unit with partitioning of TAC into the various fisheries. A partitioning of this quota by geographical areas would prevent overexploitation of 'local' stocks which may be the sole support of restricted inshore fisheries. There is sufficient data, however, to separate the St. Georges Bay stock currently being exploited by the mobile fleet from the Southern Gulf stock. The placement of a partial quota on St. Georges Bay and the displacement of the Gulf quota west of the Laurential Channel would allow for rational exploitation of both areas with only a minimal effect on the activities of the herring industry.

References

Hodder, V.M. 1966. Newfoundland herring fisheries and research. Canadian Atlantic Fishery Conference.

Olsen, S. 1961. Contribution to the biology of herring (Clupea harengus L.) in Newfoundland waters. J. Fish. Res. Bd. Can. 18(1): 31-46.

Parsons, L.S. 1973. Meristic characteristics of Atlantic herring, Clupea harengus harengus; stocks in Newfoundland and adjacent waters. ICNAF Res. Bull. 10: 37-52.

Parsons, L.S. and V.M. Hodder. 1971. Variation in the incidence of larval nematodes in herring from Canadian Atlantic waters. ICNAF Res. Bull. 8: 5-14.

Templeman, W. 1966. Marine resources of Newfoundland. Bull. Fish. Res. Bd. Canada 154 pp 90-93.

Tibbo, S.N. 1957. Herring populations on the south and west coasts of Newfoundland *in* Report of the Atlantic Herring Investigation Committee. J. Fish. Res. Bd. Can. 111. pp 153-164.

Winters, G.H. and L.S. Parsons. MS. 1972. Interrelationship among Hawkes Bay, southwest Newfoundland and Southern Gulf of St. Lawrence herring stocks. ICNAF Res. Doc. 72/100 Ser. No. 2847.

Winters, G.H. and V.M. Hodder. 1975. Analysis of the Southern Gulf of St. Lawrence herring stock and implications concerning its future management. ICNAF Res. Bull. 11 pp 43-59.

Winters, G.H., D. Miller and J.A. Moores. MS. 1977. Analysis of stock size and yield in the Southern Gulf of St. Lawrence.

Table 1. Newfoundland west coast landings 1966-76

Herring Landings 1966-76 (mt)

Year	Area				Total	Inshore Catch
	K	L	M	N		
1966		103	5529	18	5650	373
1967		66	5540	13	5619	370
1968		59	3978	11	4048	291
1969		46	2549	40	2635	328
1970		27	3473	301	3801	897
1971		2424	1076	1963	5463	2684
1972		862	1544	3628	6034	4154
1973		2862	2067	9222	14,151	6570
1974		856	942	2842	4640	2536
1975	3613	113	242	1027	4995	1500
1976	(6460)	(2065)	(143)	(1086)	(9754)	(1630)

( ) Provisional catch figures for 1976.

Table 2. Proportions of spring and autumn spawners from samples taken from the commercial fishery in St. Georges Bay (K) and the 'edge' (T).

Year	% AS		% SS	
	K	T	K	T
1972	46	-	54	-
1973	45	44	55	56
1974	50	64	50	36
1975	16	76	84	24
1976	4	55	96	45

Table 3. Summary of tag recoveries from St. Georges Bay and the 'edge' tagging experiments 1976.

Area Released	Date Released	No. Released	Area of Recapture	No. Recaptured	Total Recaptured
St. Georges Bay	04/76	6400	St. Georges Bay,	92	
			Port-au-Port Bay	2	95
			off Port-au-Port Peninsula	1	
The 'edge'	05/76	3800	the 'edge'	126	
			Chaleur Bay	3	139
			Gaspé	9	
			Chedabucto Bay	1	

Table 4. Catch, Effort and F. Data for Newfoundland West Coast.

Year	Catch	Catch/op. day	Effort	Population F
1966	5649	63.3	89.2	.044
1967	5618	65.1	86.3	.047
1968	4046	63.0	64.2	.036
1969	2637	47.9	55.1	.024
1970	3798	38.9	97.6	.037
1971	5461	38.7	141.1	.072
1972	6033	31.7	190.3	.074
1973	14,103	53.1	265.6	.202
1974	4644	-	-	.072
1975	4995	(37.2)[2]	(134.3)[2]	.105
1976	(9754)[1]	(47.9)[2]	(203.6)[2]	

[1] Provisional

[2] St. Georges Bay

Table 6. Biomass and F_{5+} values generated from cohort analysis $F_{t.25}$

		Year										
		1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Biomass $_{5+}$	AS	97.1	81.4	75.9	69.3	58.8	49.2	37.6	29.0	17.5	13.9	10.0
	SS	43.9	38.5	34.6	29.9	28.0	31.6	29.5	64.5	56.4	48.7	40.7
(10^{-3} mt)	Total	141.0	119.0	110.5	99.2	86.8	80.8	67.1	93.5	73.9	62.6	50.7
F_{5+}	AS	0.025	0.029	0.027	0.017	0.023	0.105	0.091	0.396	0.118	0.175	.244
	SS	0.083	0.085	0.057	0.038	0.065	0.027	0.054	0.138	0.060	0.087	.244
	Total	.044	.047	.036	.024	.037	.072	.074	.202	.072	.105	.244
Est. F_{5+}		.045	.043	.024	.016	0.52	.089	.130	.193	-	0.083	.141

Table 5. Partial recruitment rates for area K-N.

Age	2	3	4	5	6	7	8	9	10	10^+
% recruited										
Spring spawners	5	15	25	50	75	90	100	100	100	100
Autumn spawners	5	15	40	65	90	100	100	100	100	100

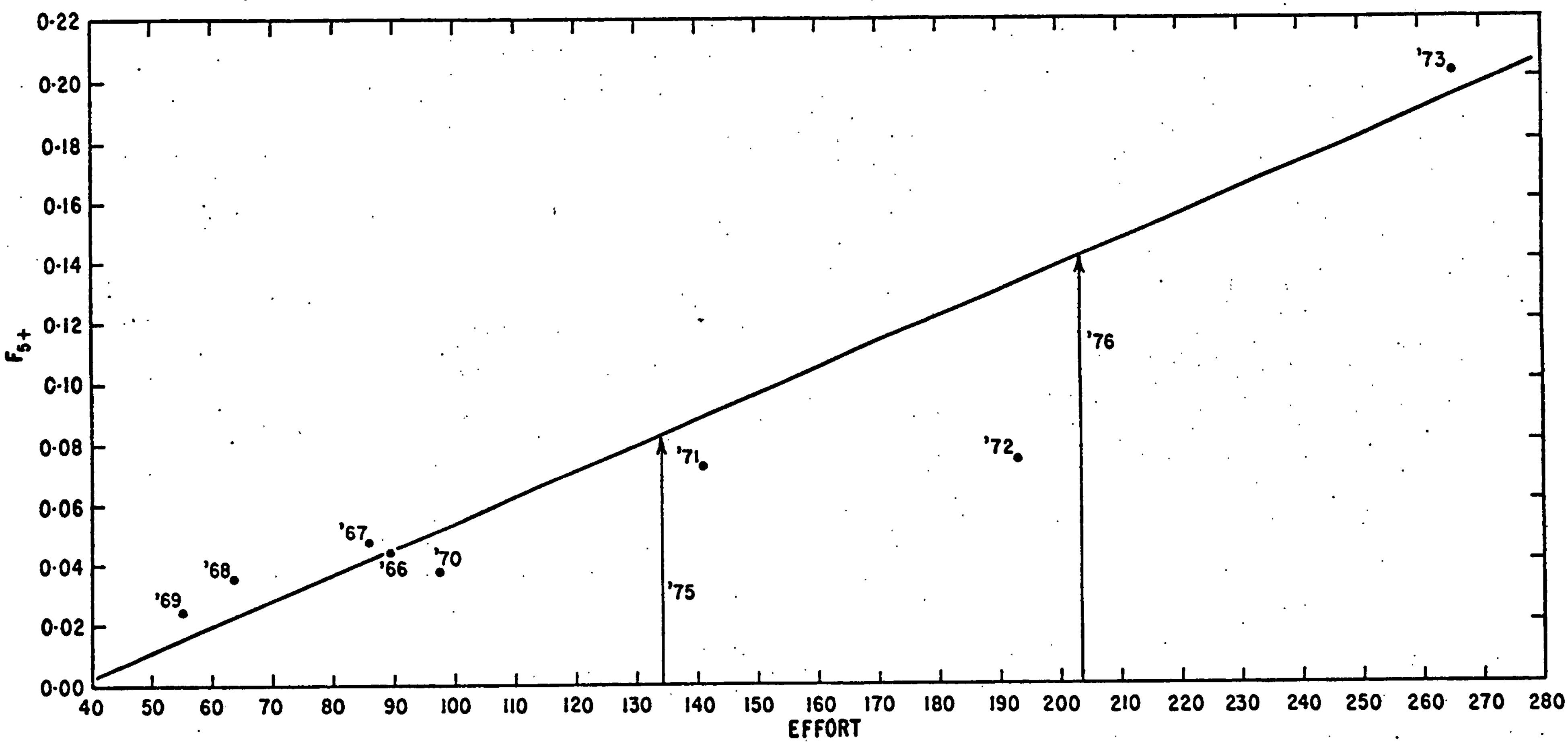

Fig. 2. Effort vs F_{5+} for westcoast Newfoundland.

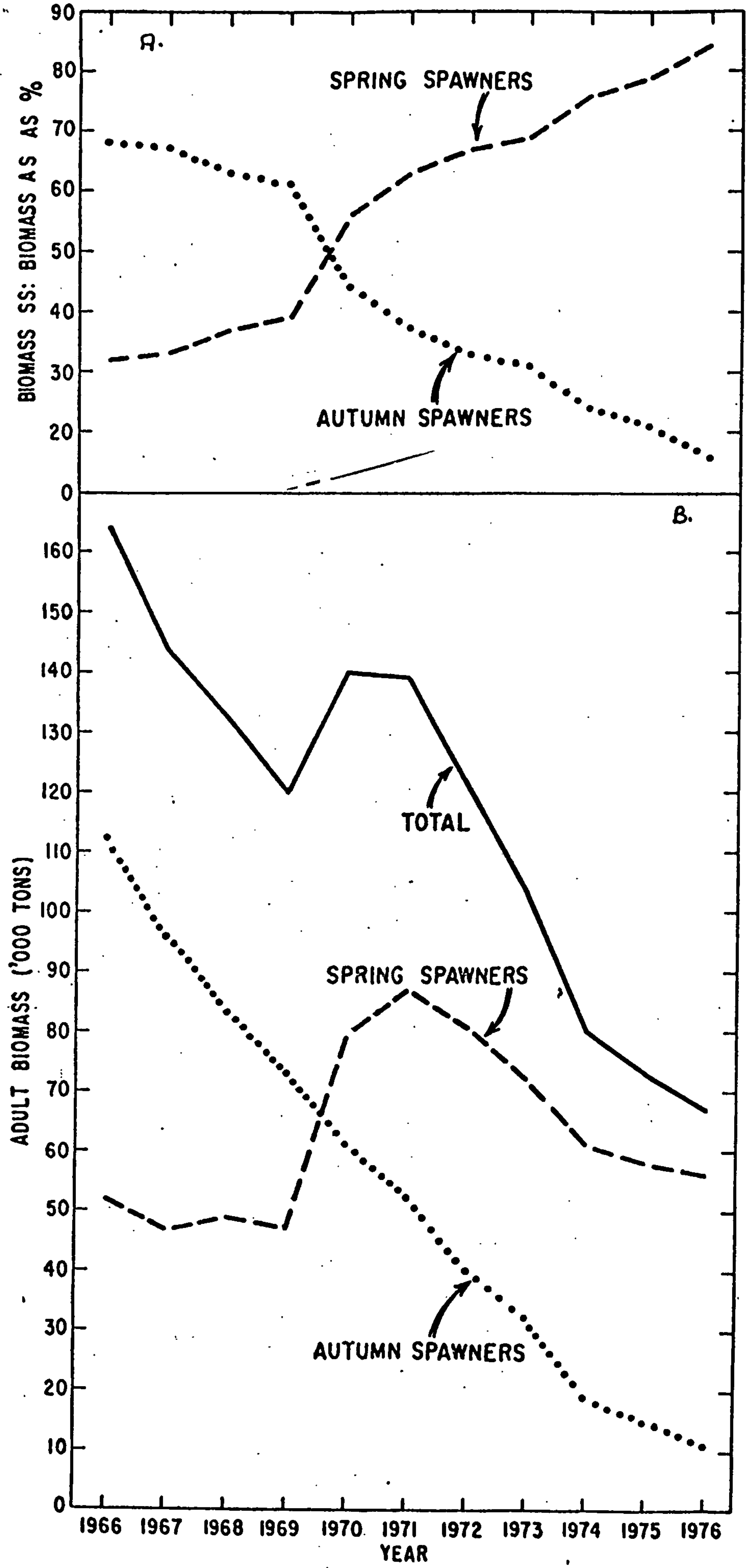

Fig. 3. A. Biomass of autumn and spring spawners expressed as a percent of total 2+ biomass.

B. Biomass of ~~2+~~ 5+ autumn and spring spawners and total biomass.

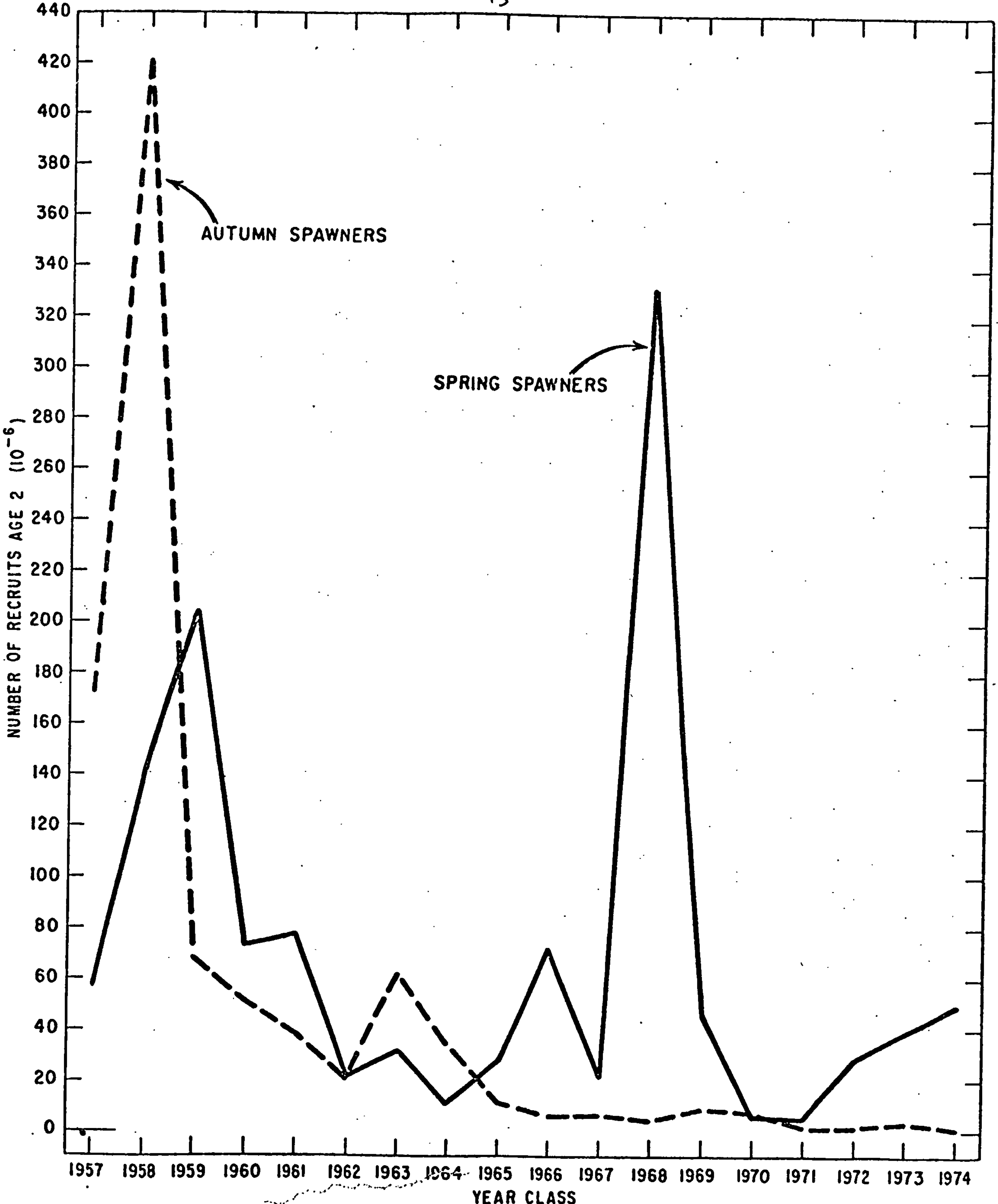

Fig. 4. Recruitment strength (age 2) by year-class.

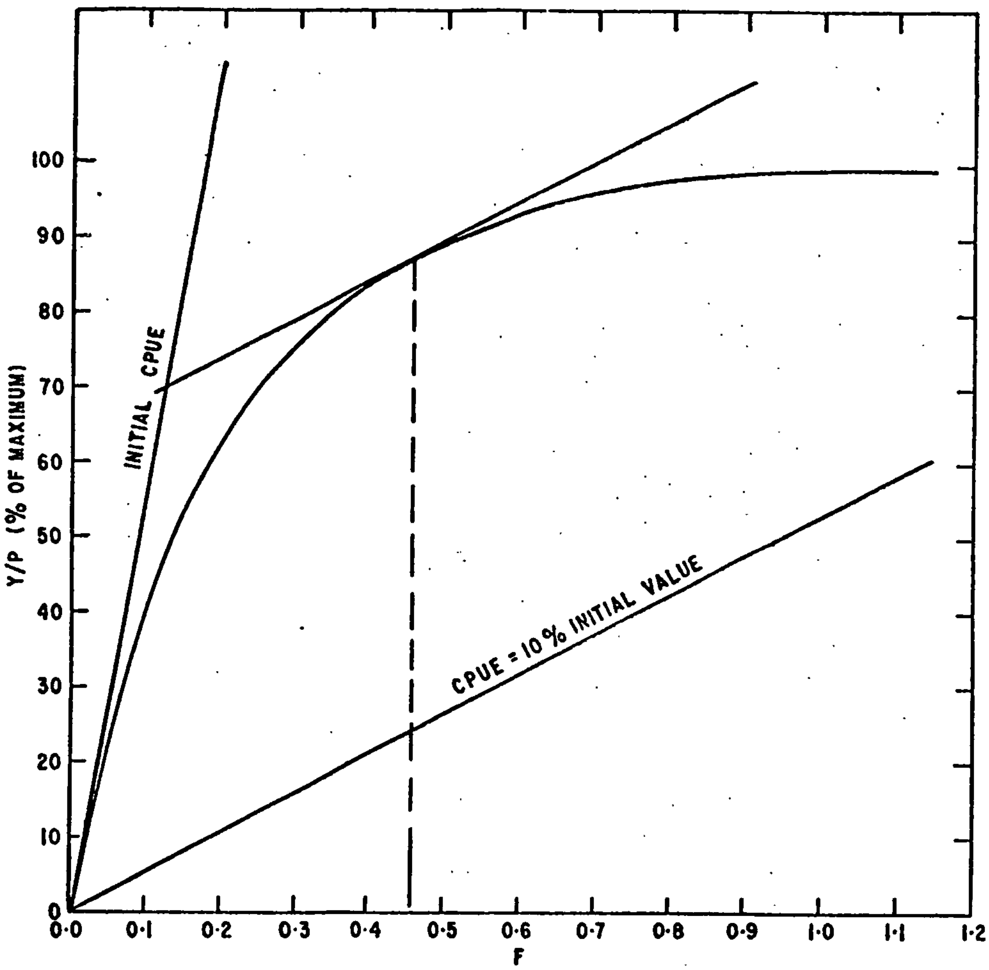

Fig. 5. F against yield per recruit for west coast herring.

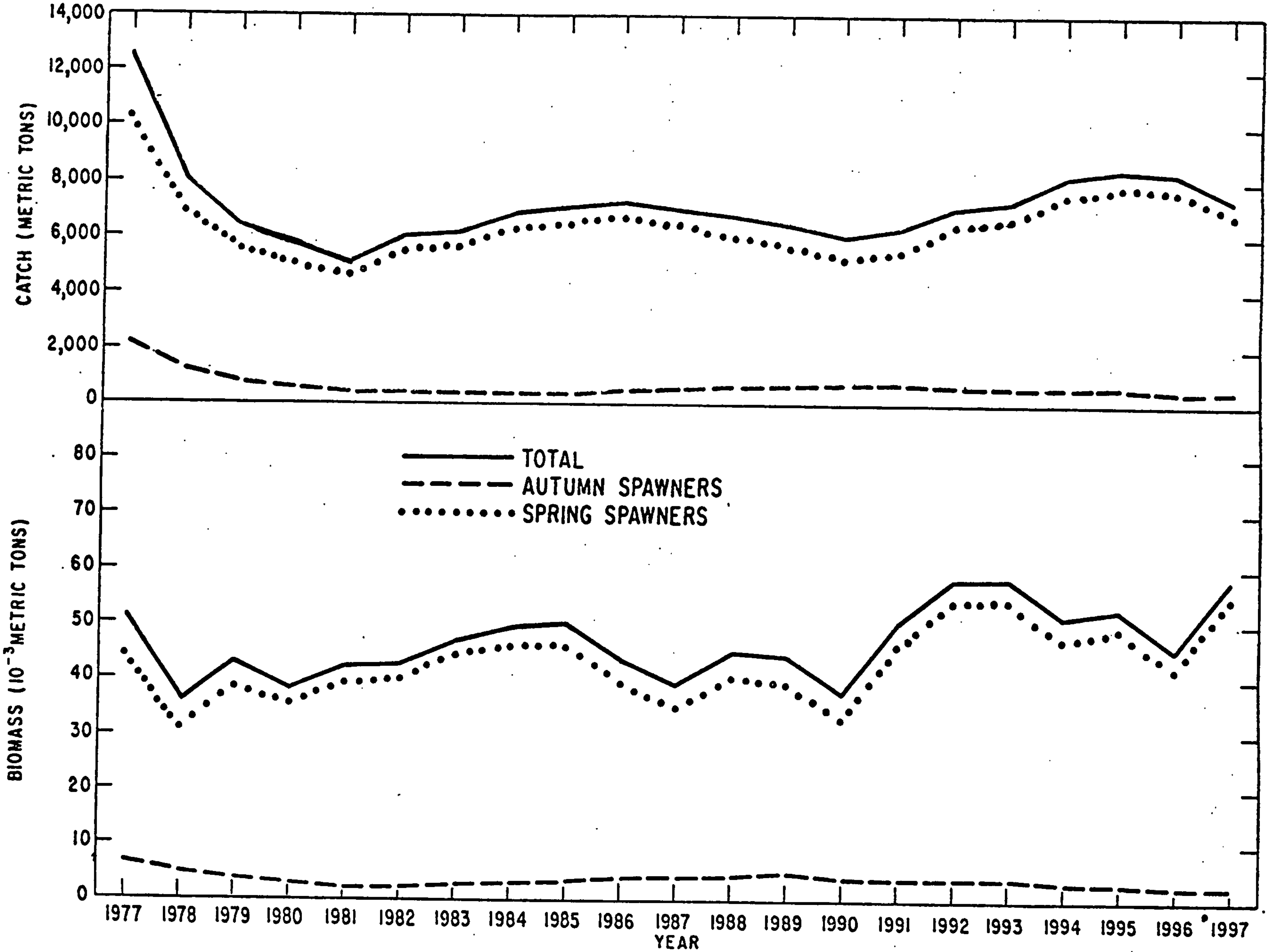

Fig. 6. Projection of catch and biomass for west coast herring stock.