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Recent trends in stock size, recruitment and biological characteristics of Southern Gulf herring

by

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Introduction

Landings from this stock complex decreased from peak levels of 300,000 m tons in 1970 to about 40,000 m tons since 1973. Research studies (Winters and Hodder 1975) have revealed that the large purse-seine fisheries which developed on this stock complex in the late 1960's were based on the accumulation of biomass produced by two very large year-classes spawned in the late 1950's. These studies also showed that the sharp decline in catches during the 1970's was due to a combination of high fishing mortalities and successively poor recruitment to both spawning components. More recent studies (Winters et al. 1977) have indicated divergent recruitment patterns in the two spawning components during the last decade, resulting in a predominance of spring-spawners, a pattern which characterized this stock complex prior to apparently anomalous production characteristics of these populations in the late 1950's and early 1960's. A similar diminution in the relative abundance of fall-spawners has also been demonstrated in the Northern Gulf stock complex of herring (Moores and Winters 1977), the general conclusion being that these stocks are now normalizing both their biomass and spawning group composition. This document presents new information derived from 1977 research studies.

Age composition of 1977 catches

Total catches in 1977 (Table 1) were 43,000 m tons, an increase of 3000 m tons from 1976 but substantially below the 1977 TAC of 60,000 tons. Purse-seine catches increased from 30,000 tons in 1976 to nearly 35,000 tons in 1977 (TAC = 45,000 tons) whereas inshore catches continued to decline from 10,000 tons in 1976 to 9000 tons in 1977 (TAC = 15,000 tons). This decline was most evident in catches from the spring fishery in the Chaleur Bay area. The major reduction in the purse-seine catch occurred at the "edge" area where seiners took less than half of their seasonal quota (27,000 tons).

Age composition data of the purse-seine fisheries along the "edge" and in the Gaspe area for the period 1975-77 are shown in Fig. 1. Amongst spring-spawners the "edge" fishery continued to exploit mainly the older age-groups (11+) whereas the Southern Gulf catches tend to be characterized by much younger age-groups, particularly the 1974 year-class which accounted for nearly 75% of the spring-spawning component in that fishery. The 1970 year-class continued to dominate the fall-spawning component in both seasonal fisheries but the continued importance of old fish (11+) suggests that recruitment to this component does not look encouraging.

Inshore catches by traps and gillnets (Fig. 2) were comprised mainly of the 1974 year-class (70%) in the Gaspe-Chaleur Bay area whereas in the Magdalen the 1972 year-class predominated but with good representation of older age-groups.

Catch/effort analysis

Log-book records of catch and effort data for the purse-seine fleet exploiting the various Southern Gulf herring fisheries have previously been presented as catch-per-operating day (Winters et al. 1977). These have been re-analyzed in terms of catch-per-set as an evaluation of possible changes in the efficiency of an operating day insofar as changes in the number of sets per day are concerned (Tables 2 and 3). A regression analysis of catch/set on catch/day (Fig. 3) for the Southern Gulf fishery indicates a linear relationship of high correlation, suggesting that both indices are consistent in the representation of abundance changes over the period considered.

The catch/set in the "edge" fishery declined substantially in 1977 reflecting the dispersed concentrations observed in that area by the commercial purse-seine fleet. In the Southern Gulf fishery, however, catch/set has increased steadily since 1975 to a level equivalent to that observed in 1972. A summary of catch-per-unit effort and effort data (adjusted as in Winters et al. 1977) is given in Table 4.

Calculation of assessment parameters

(i) Partial recruitment rates. The Southern Gulf fall purse-seine fishery has traditionally exploited a wide spectrum of age-groups, including the younger age-groups and may be considered to be fairly representative of the population age-structure. Age composition data from this fishery are compared with the age composition of the total catch in Table 5. The ratio of the relative abundance of an age-group in the total catch to the purse-seine catch is therefore an estimate of the selectivity factors of the fishery as a whole. The general increase in selectivity factors with age is consistent with earliest observations of this phenomenon (Winters and Hodder 1975, Winters et al. 1977).

(ii) Terminal fishing mortality (F_T). Using the selectivity factors given in Table 5, trial values of F_T were used to obtain estimates of fishing mortality rates (spring and fall combined and weight by population size) for ages 5 and older for the period 1969-75. These are plotted against fishing effort in Fig. 4 and regression analyses indicate a linear relationship described by the following equation:

$$F = .000097\ E + 0.06 \quad (r^2 = .99)$$

From the effort data given in Table 4, fishing mortality rates for 1976 and 1977 were calculated to be 0.15.

Total instantaneous mortalities (Z) were also computed by the linear formula of Paloheimo (1961) for age-groups 5+ for the period 1969-70 to 1976-77 (spring- and fall-spawners combined). These are shown below and are plotted against fishing effort in Fig. 5.

	Year							
	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
Z	0.32	0.66	0.37	0.51	0.33	0.28	0.08	0.36

Total mortality in 1976-77 is calculated from the regression line to be 0.28 equivalent to $F_T = 0.08$ ($M = 0.20$). The direct estimate of Z for 1976-77 is $Z = 0.36$ equivalent to $F_T = 0.16$. This value was selected as the estimate of fishing mortality in 1977.

Results of assessment

The 2+ biomass of the Southern Gulf stock complex decreased from 1758 KT in 1960 to above 370 KT in 1975 (Tables 6 and 7) and has stabilized at that level since then. Fall-spawners have shown a continuous decline in abundance over this period and are now estimated to be about 10% of pre-1970 levels. Spring-spawning biomass levels (2+) have been increasing since 1975 and are now estimated to be above one-half pre-1970 levels. Adult (5+) biomass levels have shown more dramatic declines than total biomass levels and are now calculated to be less than 15% of pre-1970 levels.

Amongst fall-spawners, year-classes since 1970 appear to be very poor and the decline in this spawning component can be expected to continue in the next few years, particularly in the adult stock. Recent year-classes of spring-spawners, however, appear to be relatively strong, particularly the 1974 year-class which is estimated to be about twice as strong as the 1968 year-class and about 35% of the strength of the 1959 year-class. Thus some improvement in biomass levels of spring-spawners may be expected in the next several years and, combined with a continuing decline in fall-spawners, will result in a stock complex heavily predominated by spring-spawning herring.

Catch projection

A projection of 1978 catches (spring- and fall-spawners combined) in relation to fishing mortality rates in 1978 and 1979 adult biomass levels (assuming that the 1974 year-class of spring-spawners is one-half of the estimated strength of that year-class) is shown in Fig. 6. It suggests that a catch of 80,000 tons could be taken in 1978 if management objectives were to stabilize the adult population biomass at the 1978 level in 1979. In view of the declining catches by inshore gears in recent years, some reduction in yields below this level would appear to be desirable. Under any fishing strategy, however, a continued attrition in adult fall-spawning biomass can be expected in the short-term at least. Partitioning of the Southern Gulf TAC between the "edge" and western Gulf area remains a desirable biological objective if undue exploitation of juvenile herring in the western Gulf purse-seine fishery is to be avoided. This strategy has direct implications on the Magdalens inshore fishery which depends on a local spring-spawning population of herring exploited by the "edge" fishery prior to its appearance inshore in the Magdalens spawning areas. In the longer term, however, such a fishing strategy should produce ameliorating effects on inshore catches in the Magdalens herring fisheries.

Acknowledgments

The staff of the St. John's and St. Andrews Pelagic Research Sections assisted in the collection, tabulation and collation of the basic data used in this report and their help is gratefully acknowledged.

Table 1. Catch statistics for 4T herring in 1977 (Provisional)

	Magdalens - Edge		Southern Gulf		Total
	Inshore	P. Seine	Inshore	P. Seine	
April	747	6797	298		7842
May	1111	6797	2291		10199
June	7		467	9	483
July			233		233
Aug.			1730	383	2113
Sept.			987	158	1145
Oct.			105	9146	9251
Nov.			201	10599	10800
Dec.				602	602
TOTAL	1865	13594	6312	20897	42668

Table 2. Monthly CPE data (catch/set) as evaluated from log records of purse-seiners operating in the Southern Gulf 1971-77.

Year	Catch-per-unit effort (CPE)						Unweighted mean Sept.-Nov.
	June	July	August	Sept.	Oct.	Nov.	
1971	17.3	34.9	25.4	47.2	59.4	(54.9)	53.9
1972		37.0	12.9	37.1	53.9	44.3	45.1
1973		26.4	-	49.1	-	-	-
1974		19.4	40.2	28.3	35.4	50.0	37.9
1975			23.6	32.1	37.8	33.5	34.5
1976				27.3	44.5	50.6	40.8
1977				(41.3)	53.1	40.5	45.0
Unweighted mean	17.3	29.4	25.5	36.9	47.4	43.8	

Table 3 . Monthly catch-per-set data from log records of purse-seiners operating on the "Edge".

Year	Catch-per-set April	Catch-per-set May	Mean Unweighted	Mean Weight
1969	63.7	58.2	61.0	62.3
1970	62.9	32.5	47.7	55.8
1971	38.9	-	-	-
1972		29.7	-	-
1973	21.5	48.8	35.2	43.3
1974	34.8	33.4	34.1	33.6
1975	47.1	61.3	54.2	59.1
1976	44.5	47.1	45.8	45.3
1977	33.3	37.2	35.3	35.3

Table 4. CPE for the various fisheries exploiting the Southern Gulf stock complex. See text for explanation.

Year	CPE			Effort (sets)
	SW Nfld.	Edge	S. Gulf	
1969	50.3	61.0	(110.2)	2549
1970	41.5	47.7	(90.9)	3263
1971	24.6	-	53.9	4365
1972	13.4	-	45.1	1951
1973	9.2	35.2	41.0*	1422
1974	-	34.1	37.9	982
1975	-	54.2	34.5	1273
1976	-	45.8	40.8	966
1977	-	35.3	45.0	956

* interpolated

Table 5. Comparison of age compositions of purse-seine catches in the fall Southern Gulf fishery with total catches for all areas.

	% at age					
	Spring			Autumn		
Age	S. Gulf (PS)	Total	Ratio	S. Gulf (PS)	Total	Ratio
2	5.3	3.3	0.62	0.9	0.4	0.44
3	71.8	56.5	0.79	9.9	4.4	0.44
4	5.4	6.8	1.26	17.4	12.0	0.69
5	8.2	9.7	1.18	5.6	5.7	1.02
6	0.7	3.1	4.42	4.5	5.6	1.24
7	0.1	0.5	5.00	33.1	35.4	1.07
8	0.1	0.4	4.00	1.5	3.6	2.40
9	2.9	5.8	2.00	0.8	2.3	2.88
10	0.2	0.4	2.00	3.7	4.6	1.24
11	2.2	11.7	5.32	22.5	26.1	1.16

Table 6

ESTIMATED POPULATIONS (Spring-spawners)

AGE	1969	1970	1971	1972	1973	1974	1975	1976	1977
2	1030.	6209.	646.	282.	985.	3565.	1583.	15955.	5693.
3	1711.	842.	5082.	500.	230.	754.	2876.	1281.	12990.
4	2454.	1246.	613.	3564.	391.	166.	538.	2112.	999.
5	1193.	1843.	652.	441.	2655.	293.	105.	267.	1515.
6	1522.	860.	1394.	410.	303.	1749.	223.	57.	145.
7	1461.	981.	554.	1054.	284.	178.	1189.	31.	22.
8	414.	969.	508.	371.	824.	191.	111.	792.	22.
9	1651.	262.	471.	278.	261.	603.	119.	68.	556.
10	5346.	912.	122.	250.	181.	187.	438.	67.	42.
11	518.	2971.	391.	49.	157.	120.	143.	311.	42.
12	66.	263.	1412.	167.	28.	118.	96.	101.	195.
13	53.	53.	137.	724.	109.	15.	94.	74.	64.
14	42.	42.	42.	85.	566.	66.	10.	74.	46.
15	34.	34.	34.	34.	68.	441.	46.	7.	46.
16	27.	27.	27.	27.	27.	55.	353.	24.	4.
17	21.	21.	21.	21.	21.	21.	44.	275.	14.
18	16.	16.	16.	16.	16.	16.	16.	33.	212.

ESTIMATED POPULATIONS (Fall-Spawners)

AGE	1969	1970	1971	1972	1973	1974	1975	1976	1977
2	5326.	1354.	906.	6213.	769.	640.	1308.	596.	159.
3	2721.	4338.	1089.	698.	5035.	628.	482.	1070.	487.
4	3814.	2029.	3170.	592.	524.	4088.	469.	375.	873.
5	4013.	2941.	1128.	1755.	343.	386.	3200.	347.	290.
6	8134.	3109.	2135.	601.	972.	206.	262.	2389.	242.
7	4687.	5835.	2315.	1205.	299.	598.	132.	151.	1709.
8	2183.	2754.	3326.	1092.	721.	155.	400.	79.	85.
9	2761.	1440.	1321.	1676.	650.	471.	102.	283.	46.
10	4065.	1803.	790.	551.	1150.	440.	337.	64.	193.
11	10858.	2477.	917.	362.	338.	803.	324.	243.	44.
12	1651.	6252.	1267.	427.	223.	216.	603.	233.	169.
13	40.	936.	3108.	499.	221.	157.	154.	445.	161.
14	31.	31.	585.	1459.	256.	156.	110.	105.	308.
15	25.	25.	25.	365.	889.	180.	110.	74.	73.
16	19.	19.	19.	19.	268.	667.	127.	75.	51.
17	15.	15.	15.	15.	15.	212.	504.	86.	51.
18	11.	11.	11.	11.	11.	11.	169.	375.	59.
19	8.	8.	8.	8.	8.	8.	8.	135.	278.

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Table 7 . Biomass ('000 m tons) estimates of Southern Gulf herring from cohort analysis 1969-77.

Spawning Group	Year								
	1969	1970	1971	1972	1973	1974	1975	1976	1977
S. Spawners (2+)	467	380	277	203	173	167	165	200	240
(5+)	381	286	178	121	153	120	95	70	82
A. Spawners (2+)	1291	939	597	355	274	232	203	171	135
(5+)	1167	846	526	306	201	151	183	149	114
Total (2+)	1758	1319	874	558	447	399	368	371	375
(5+)	1548	1132	704	427	354	271	278	219	196
Mean F (5+)	.26	.37	.47	.26	.20	.14	.18	.20	.16

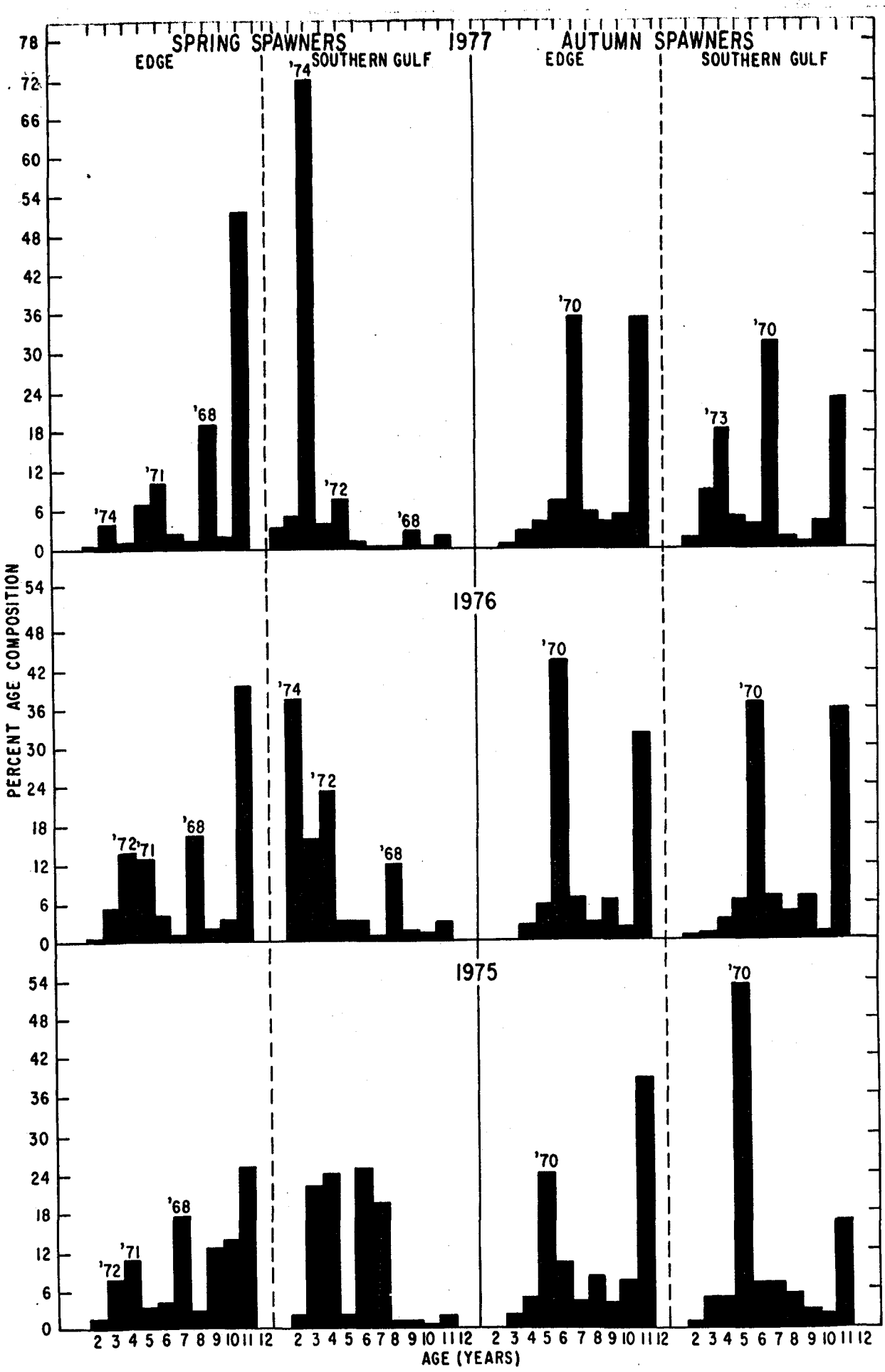

Fig. 1. Age composition data of purse-seine catches along the "edge" and in the Southern Gulf, 1975-77.

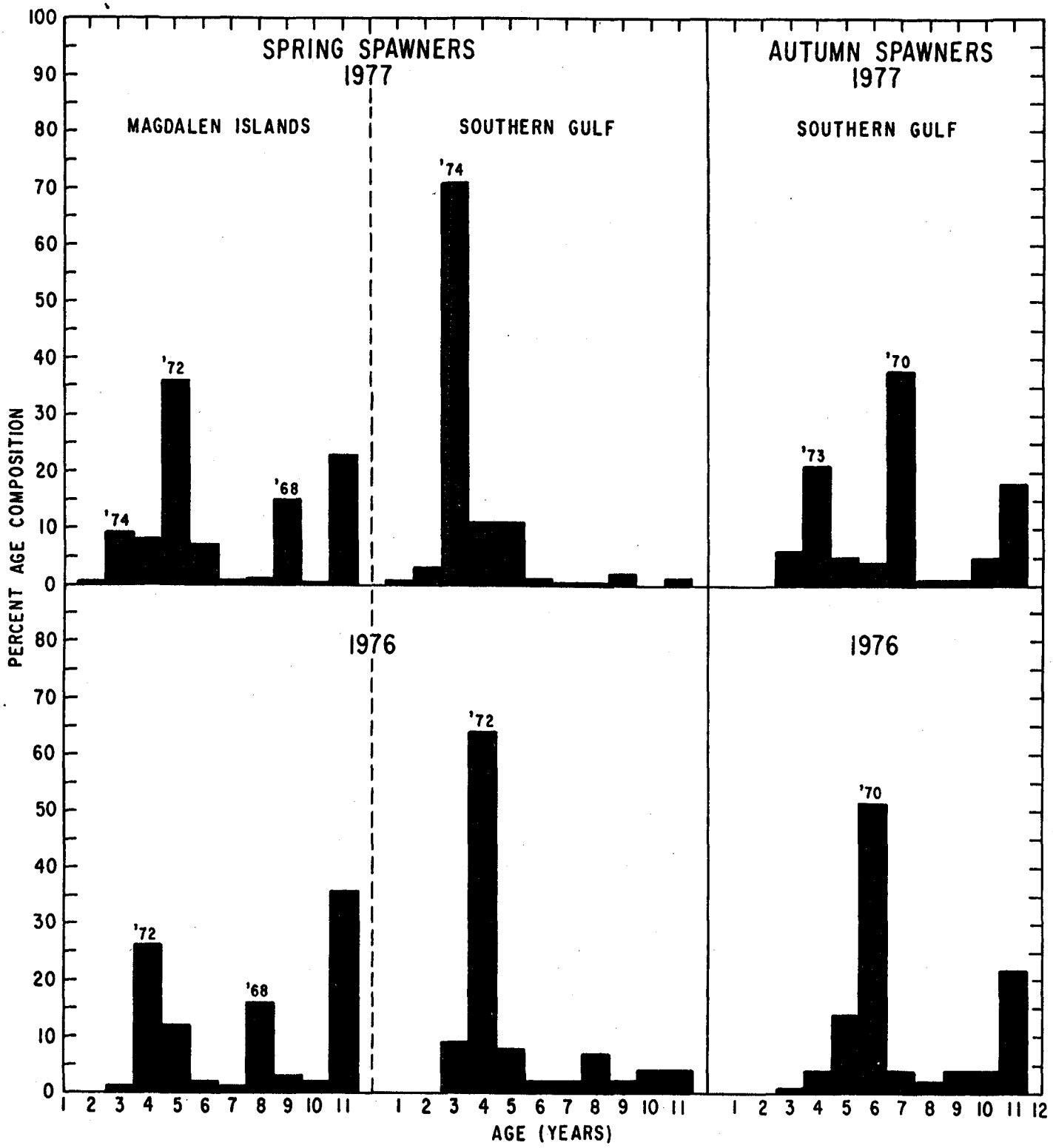

Fig. 2. Age composition data of inshore catches of herring at the Magdalens and in the Southern Gulf.

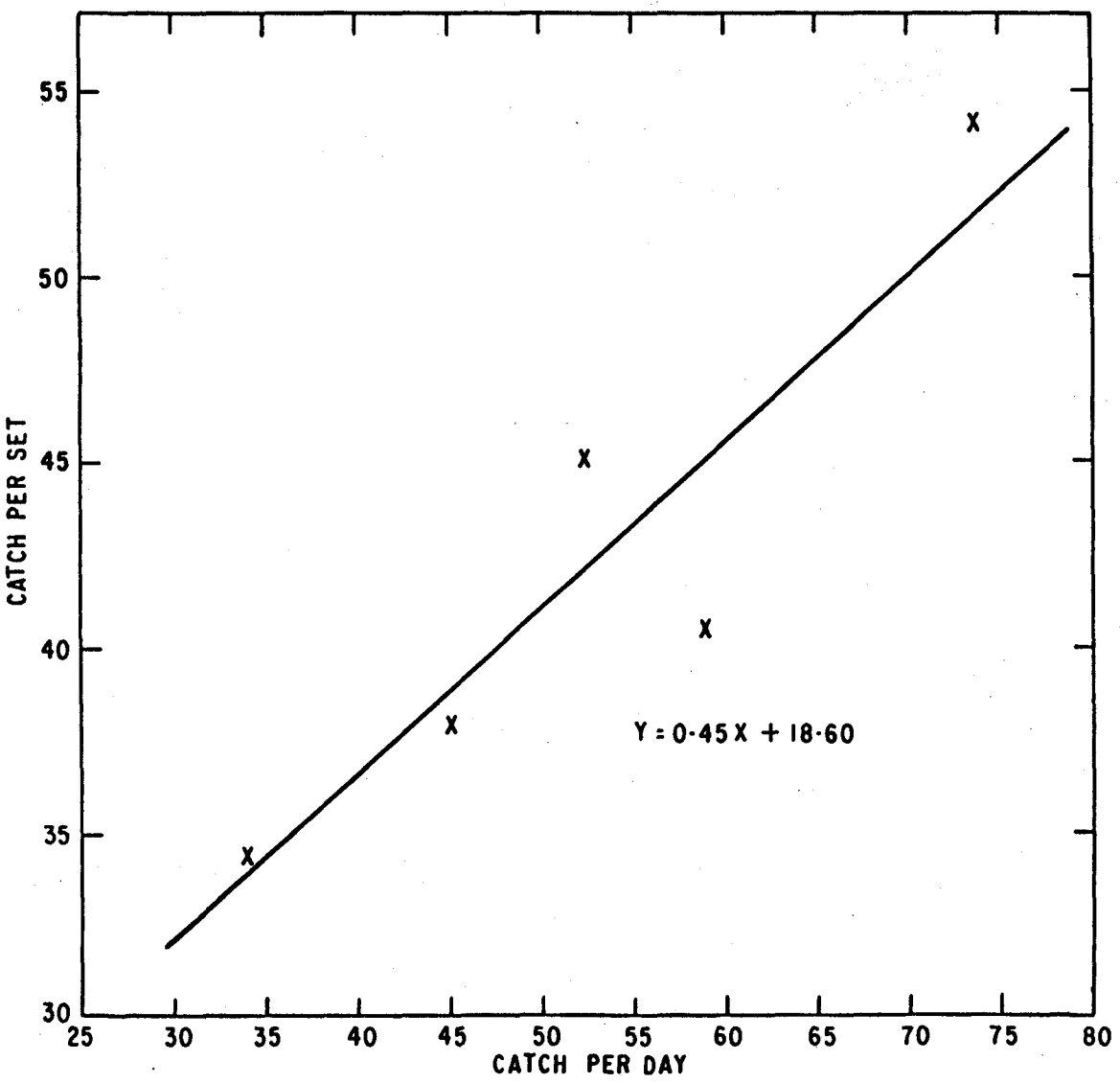

Fig. 3. Relationship between catch-per-set and catch-per-day in purse-seine fisheries in the Southern Gulf.

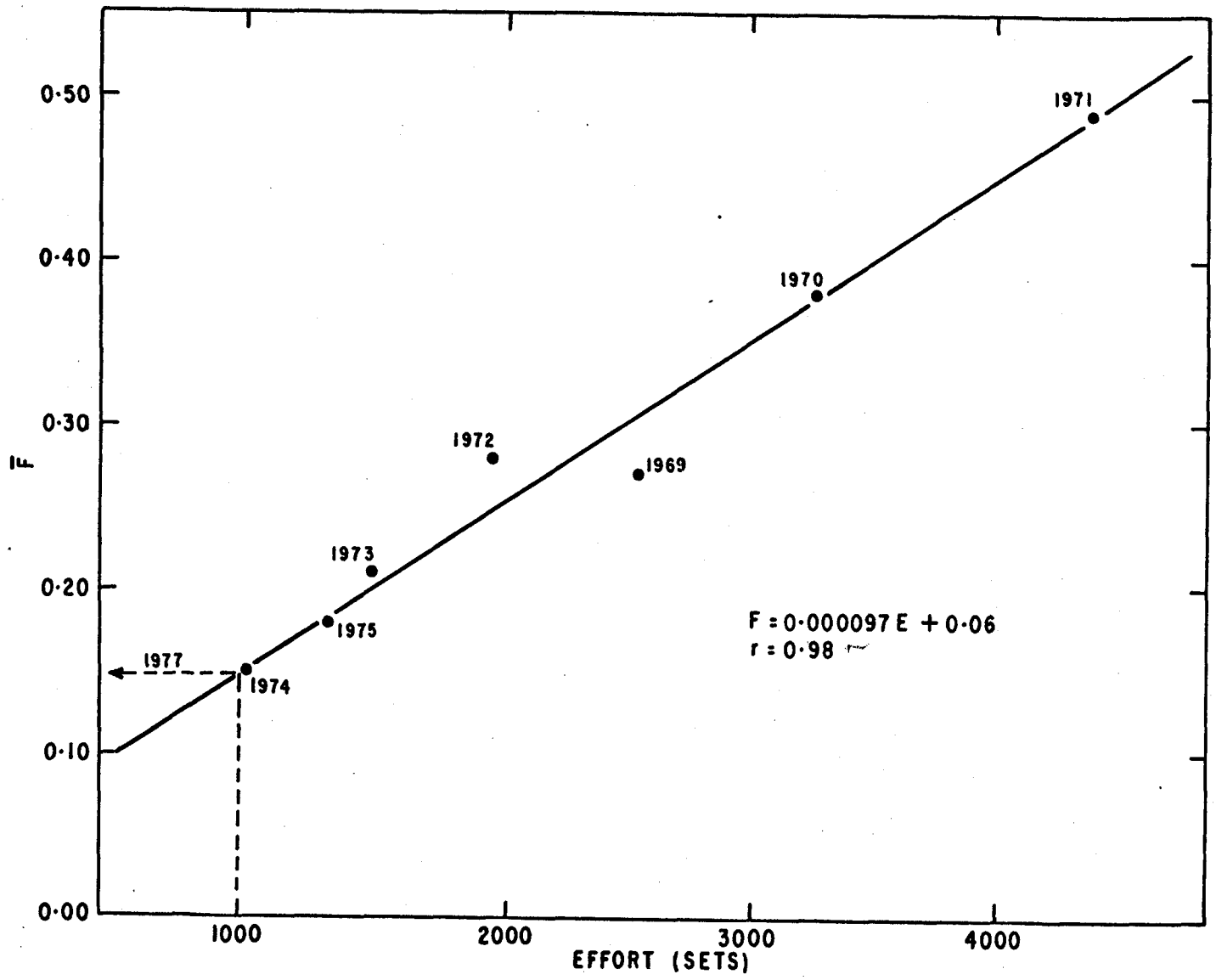

Fig. 4. Regression of fishing mortality rate of 5+ herring (spring- and fall-spawners combined) and fishing effort.

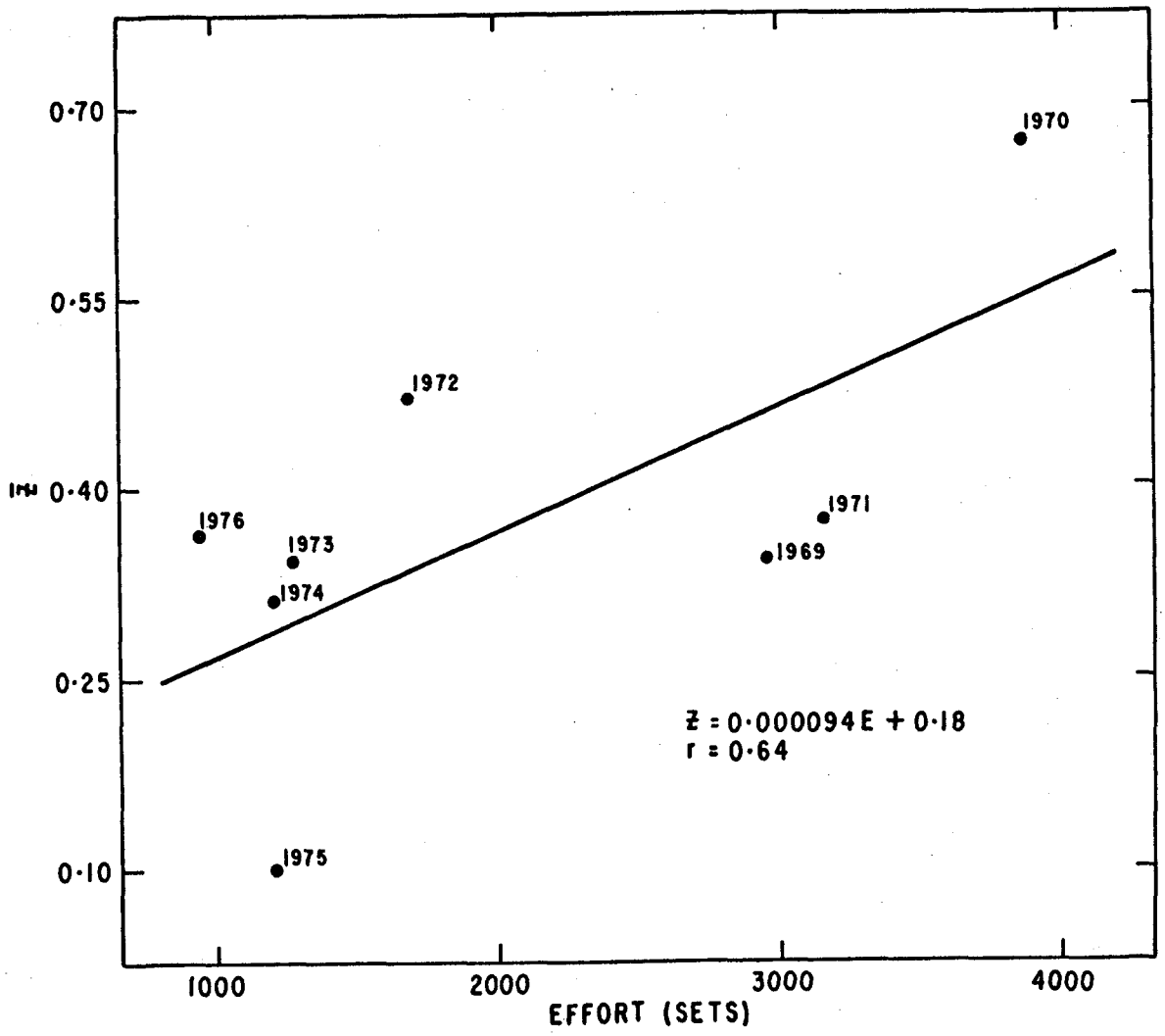

Fig. 5. Relationship between total instantaneous mortality (Ż) as calculated by the Paloheimo (1961) linear formula and fishing effort.

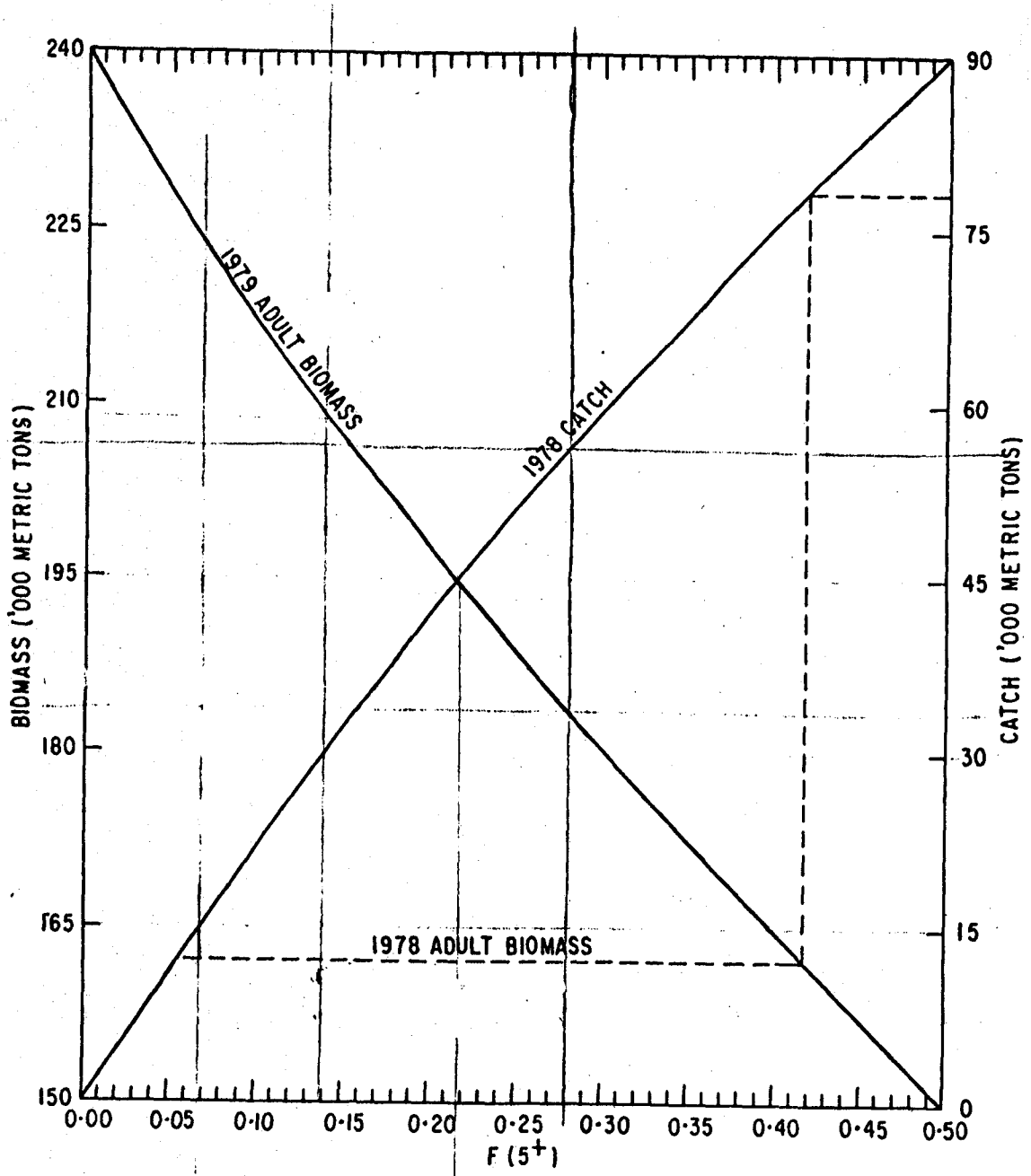

Fig. 6. Relationship between fishing mortality and catch in 1978 and the subsequent 1979 adult biomass level (spring- and fall-spawners combined).