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Fortune Bay herring: A stock in the process of
executing the limbo

by

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Abstract

During the past pentad (1975-80) annual landings of herring in Fortune Bay averaged about 750 t compared with an average of 8000 t for the previous pentad (1969-74). Recently bar seines have replaced purse-seines as the major gear component.

The moderate 1974 year-class continues to dominate removals; year-classes since 1974 have been extremely poor. Analyses of biomass levels based on gillnet catch-rate data (1978-80) indicate that the abundance of Fortune Bay herring have been relatively low since the mid-1970's due mainly to a combination of excessive fishing mortalities during the early 1970's and to a sequential production of extremely weak year-classes since then. Biomass levels are projected to decline to an historical low of 2000 t in 1981. Management action should therefore be directed towards reducing the 1981 catch to the lowest practical level to ensure maximum egg deposition.

Résumé

Au cours de la dernière période de 5 ans (1975-80), les débarquements annuels de hareng de la baie Fortune ont été en moyenne d'environ 750 t, comparés à une moyenne de 8 000 t les 5 années précédentes (1969-74). Les sennes de barrage ont récemment remplacé les sennes coulissantes.

La classe d'âge modérée de 1974 continue de dominer les prises; les classes d'âge subséquentes sont très pauvres. Des analyses de niveau de biomasse, fondées sur le taux de capture des filets maillants (1978-80), indiquent que la population de harengs de la baie Fortune est relativement peu abondante depuis le milieu des années 1970. Ceci est dû en grande partie à une forte mortalité par pêche au début des années 1970, combinée avec une série de classes d'âge excessivement pauvres par la suite. Une projection des niveaux de biomasse laisse prévoir un creux de 2 000 t en 1981. Les gestionnaires devraient donc orienter leur action vers une diminution des prises au plus bas niveau possible, afin d'assurer une ponte maximale.

Introduction

The populations of herring in Fortune Bay (Fig. 1) are predominantly spring-spawners which differ significantly in both meristic and morphometric characteristics from those herring in adjoining areas (Parsons and Hodder 1973). Recent external tagging experiments (Moores and Winters 1979) have confirmed this unit stock concept of Fortune Bay herring.

Traditionally Fortune Bay has been one of the main centres of the Newfoundland herring fishing with landings averaging 16,000 mt during the period 1945-50 at a time when there was a great demand for salted herring for food immediately following World War II (Templeman 1966). During the 1950's and early 1960's, however, herring landings dropped substantially to less than 700 mt reflecting not only reduced fishing effort (due to decreased demand) but also reduced abundance due to the effects a widespread fungus disease (Sinderman 1958) and perhaps to overfishing during the late 1940's. With the widespread extension

of purse seining during the mid-1960's catches of herring in Fortune Bay
increased substantially to peaks of approximately 15,000 mt in 1968 and 1971
subsequently declining to a low of 462 mt in 1976. Prior to 1976 the purse
seine fleet was the dominant component in the Fortune Bay herring fishery but
since then bar seines have been the major gear component.

Recent catch statistics

During the past pentade (1975-80) annual landings have averaged about
750 mt (Table 1) compared with an average of 8000 t for the previous pentade
(1969-74). The 1980 provisional catch is the lowest recorded since 1966.
Gillnet catches continue to remain at low levels although they have been
increasing during the past several years due to increased effort. The purse
seine catches are generally taken early in the winter whereas bar seines are
highly variable but usually concentrate on pre-spawning and spawning concentrations
of herring in a similar seasonal fishing pattern as the gillnet fishery.

Catch composition

Age composition data of catches of spring-spawning herring in Fortune Bay
for the period 1966-80 are shown in Table 2 and these are shown graphically
for both spring- and fall-spawners for the recent period (1977-80) in Fig. 2.
Since 1977 the 1974 year-class has been the major contributor to the landings,
accounting for 75% of the catch in 1980. Year-classes since 1974 have been
anemic in strength and contributed less then 3% of the 1980 catch in terms of
numbers landed. Unlike other stocks of herring in the Newfoundland area the
1968 year-class has been of little significance in Fortune Bay landings in
recent years due to its heavy exploitation as 2- and 3-yr-olds.

Assessment Parameters

1. Weight-at-age

Age-specific weights are those from samples of herring taken in the first and second quarters and are given below:

				Age					
2	3	4	5	6	7	8	9	10	11*
Wt (gm) 70	138	206	240	276	310	335	345	360	390

2. Partial recruitment rates

The partial recruitment rates used were unchanged from those calculated by Winters and Moores (1978). They are as follows:

				Age					
2	3	4	5	6	7	8	9	10	11*
PR (%) 5	50	80	100	100	100	100	100	100	100

A perusal of fishing mortality matrices from trial runs of cohort analyses indicates that these selectivity factors are still valid and, in any event, have little impact on the 1980 stock status evaluation due to the virtual absence of young fish in the 1980 commercial catches.

3. Selection of terminal F

Historical catch rate data for the purse seine fleet are available for the period 1967-73. Such data, albeit scanty, are also available from three purse seiners operating in Fortune Bay in the 1st quarter of 1980. The catch rate time-series is listed below:

	Year							
	1967	1968	1969	1970	1971	1972	1973	1980
catch/op.day (mt)	63.7	69.2	53.7	62.2	49.5	33.7	24.8	16.1

From trial runs of cohort analyses the relationship between CPUE and 2+ biomass was established by regression analyses for the period 1967-73. This relationship was found to be insensitive to input parameter values in 1980 and hence was used to predict the 1980 2+ biomass from the 1980 CPUE estimate (Fig. 3). The results indicated a 2+ biomass in 1980 of approximately 4000 mt at $F_T = 0.12$. This estimate is not considered particularly reliable due to the low catch and reduced effort associated with the 1980 CPUE estimate.

An alternative estimate of F_T was derived from analyses of catch rates of gillnet fisheries in Fortune Bay (Table 3). The results (Table 4) indicated average total mortalities of 1.22 (4+ to include the dominant 1974 year-class) for 1978-79 and 0.53 (5+) for 1979-80. Given the much higher incidence of landings in 1979 and 1980 compared to 1978 (Table 3), the 1979-80 estimate of $\bar{Z}$ was considered to be more reliable than the 1978-79 value. Consequently cohort analyses were run such that the mean $\bar{Z}$ for 1979-80 corresponded with the estimate of 0.53 from gillnet catch rate data for 1979-80. The results indicated an $F_T = 0.23$.

Results of Assessment

The population matrix for Fortune Bay herring for the period 1966-80 is shown in Table 5 and the corresponding F-matrix is given in Table 6.

Biomass levels for this stock have been relatively low since the mid-1970's and are projected to decline to about 2000 mt in 1981, the lowest observed in the historical time-series. With the exception of the 1974 year-class, all

year-classes since the very strong 1968 year-class have been extremely poor
and the short-term prognosis for the early 1980's is not optimistic. The
strength of the 1974 year-class estimated in the above assessment (28.4 million
fish at age 2) is almost identical to the estimate of this year-class by
Moores and Winters (1979) from a comparison of relative year-class strengths
of Fortune Bay herring to the adjoining Placentia-St. Mary's Bay stock complex.

Catch Projection

Yield-per-recruit analyses have been conducted using the growth and
partial recruitment values given above (and extended to age 18). The resulting
$F_{0.1}$ value ($F_{0.1} = 0.275$) was then used to calculate the $F_{0.1}$ catch for 1981
(Table 7).

Conclusions

The substantial attrition in abundance of Fortune Bay herring since the
early 1970's has been due to a combination of excessive fishing mortalities
during the early 1970's and to a sequential production of extremely weak
year-classes since the late 1960's. The 1974 year-class, which has been the
strongest to appear in this stock during the 1970's, is estimated to be only
one-fifth as strong as the 1968 year-class and has not been productive enough
to allow stock rebuilding. Stock rebuilding will only emanate from significantly
improved recruitment in the near future and therefore management action should
be directed towards reducing the 1981 catch to the lowest practical level to
ensure maximum egg deposition in the event that at such low levels of stock
abundance, recruitment may in some way be positively correlated with spawning
potential.

Acknowledgments

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Table 1.   Fortune Bay herring landings, 1976-80.

Year	Gear				
	P. Seine	Gillnet	B. Seine	Trap	Total
1976	109	43	310	-	462
1977	188	22	364	5	579
1978	105	42	853	-	1000
1979	286	76	829	1	1192
1980*	97	84	265	-	446

* provisional

Table 2. Age composition data of spring spawning herring from Fortune Bay 1966-80.

Age	Catch at age ($\times 10^{-4}$)														
	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
2	<1	<1	655	52	4238	17	154	222	39	<1	8	3	<1	<1	2
3	23	9	13	1198	800	2409	26	92	133	28	2	211	4	<1	2
4	1	2476	32	9	1043	631	1998	7	54	58	32	3	271	18	<1
5	2	5	4856	19	9	2436	294	567	12	11	23	33	6	383	7
6	9	5	22	1304	19	121	1094	46	457	9	13	17	24	2	111
7	7	42	12	19	731	20	36	175	12	149	1	3	4	17	1
8	9	45	61	26	24	939	11	8	112	2	34	4	14	1	18
9	3	51	77	69	2	14	540	5	1	14	4	19	5	2	<1
10	<1	36	92	194	23	15	4	79	2	2	19	1	33	<1	1
11+	2	14	85	706	26	54	37	17	33	21	14	25	21	16	5

Table 3. Monthly catch rates (mt/landing) of gillnet fisheries for herring in Fortune Bay, Newfoundland.

Year	April			May			June			Mean	
	C	L	C/L	C	L	C/L	C	L	C/L	C	/L (mt)
1977				0.36	1	0.36					0.36
1978	0.57	4	0.14	0.58	1	0.58	4.03	1	4.03		0.86
1979	0.79	4	0.20	11.63	48	0.24	4.61	8	0.58		0.28
1980	1.89	12	0.16	10.30	45	0.23	2.87	21	0.14		0.19

Table 4. Calculation of total instantaneous mortality rates of Fortune Bay herring by the method of Paloheimo.

Year	Catch rate (Nos./day)			$\bar{Z}$ 4+	$\bar{Z}$ 5+
	4+	5+	6+		
1978	3.34	1.01	0.96	}1.22	2.42
1979	1.03	0.99	0.09		
1980	0.61	0.60	0.58	}0.52	0.53

Table 5. Population matrix of Fortune Bay herring (spring-spawners) as derived from cohort analyses 1966-81.

Age	Population size ($\times 10^{-6}$) at beginning of year															
	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	3.2	5.4	131.1	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)
3	215.9	2.6	4.4	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	2.2	176.6	2.1	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
5	2.1	1.8	122.2	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
6	5.6	1.7	1.4	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
7	7.3	4.5	1.3	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
8	4.8	5.9	3.3	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
9	3.2	3.8	4.4	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
10	0.1	2.6	2.7	2.9	1.1	0.4	0.1	2.4	0.1	0.1	0.9	0.1	0.7	0.1	0.1	0.1
11+	1.1	1.0	2.4	2.5	1.2	1.4	1.0	0.5	1.4	0.9	0.6	0.9	0.5	0.5	0.2	0.2
2+ Biomass ('000 mt)	37.9	44.0	44.9	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
5+ Biomass ('000 mt)	7.5	6.9	34.7	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
Ct (mt)	194	5668	14727	6866	9388	15004	10570	3254	2268	909	462	579	1000	1192	446	-

Table 6. Fishing mortality matrix of Fortune Bay herring for the period 1966-80.

Age	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
2	-	-	.06	.02	.39	.13	.38	.50	.07	.01	<.01	.03	.04	<.01	.01
3	<.01	.04	.03	.14	.47	.40	.29	.41	.64	.07	.06	.11	.06	.05	.12
4	.01	.17	.19	.03	.17	.85	.70	.11	.46	.65	.10	.14	.19	.38	.18
5	.01	.03	.58	.16	.04	.78	1.46	.43	.31	.16	.58	.14	.65	.46	.23
6	.02	.03	.19	.30	.24	.94	1.05	.97	.76	.38	.28	1.22	.15	.31	.23
7	.01	.11	.11	.25	.27	.44	.82	.45	.72	.60	.07	.08	1.46	.14	.23
8	.02	.09	.23	.36	.57	.68	.46	.41	.58	.20	.25	.47	.83	.61	.23
9	.01	.16	.21	.44	.03	.76	1.10	.39	.07	.13	.89	.22	1.97	.32	.23
10	.02	.17	.48	1.31	.26	.49	.44	.44	.26	.26	.25	.22	.75	.16	.23
11+	.02	.16	.48	1.30	.28	.52	.53	.45	.26	.22	.26	.30	.55	.35	.23
F_{5+}	.02	.11	.54	.35	.25	.74	1.07	0.45	0.63	0.38	0.29	0.22	0.42	0.42	0.23

Table 7. 1981 catch projection for Fortune Bay herring.

| Age	Population numbers (1980)	Population weight (mt)	Fishing mortality	Catch numbers	Catch weight (mt)	Residual numbers	Residual weight
2	5000.	350.	.014	62.	4.	4038.	283.
3	1171.	162.	.137	137.	19.	836.	115.
4	118.	24.	.220	21.	4.	78.	16.
5	13.	3.	.275	3.	1.	8.	2.
6	237.	65.	.275	52.	14.	147.	41.
7	3866.	1198.	.275	846.	262.	2404.	745.
8	24.	8.	.275	5.	2.	15.	5.
9	626.	216.	.275	137.	47.	390.	134.
10	3.	1.	.275	1.	0.	2.	1.
11	38.	15.	.275	8.	3.	24.	9.
12	3.	1.	.275	1.	0.	2.	1.
13	90.	35.	.275	20.	8.	56.	22.
14	3.	1.	.275	1.	0.	2.	1.
15	45.	18.	.275	10.	4.	28.	11.
16	3.	1.	.275	1.	0.	2.	1.
17	3.	1.	.275	1.	0.	2.	1.
18	26.	10.	.275	6.	2.	16.	6.
Total	11273.	2112.		1311.	373.	8051.	1394.
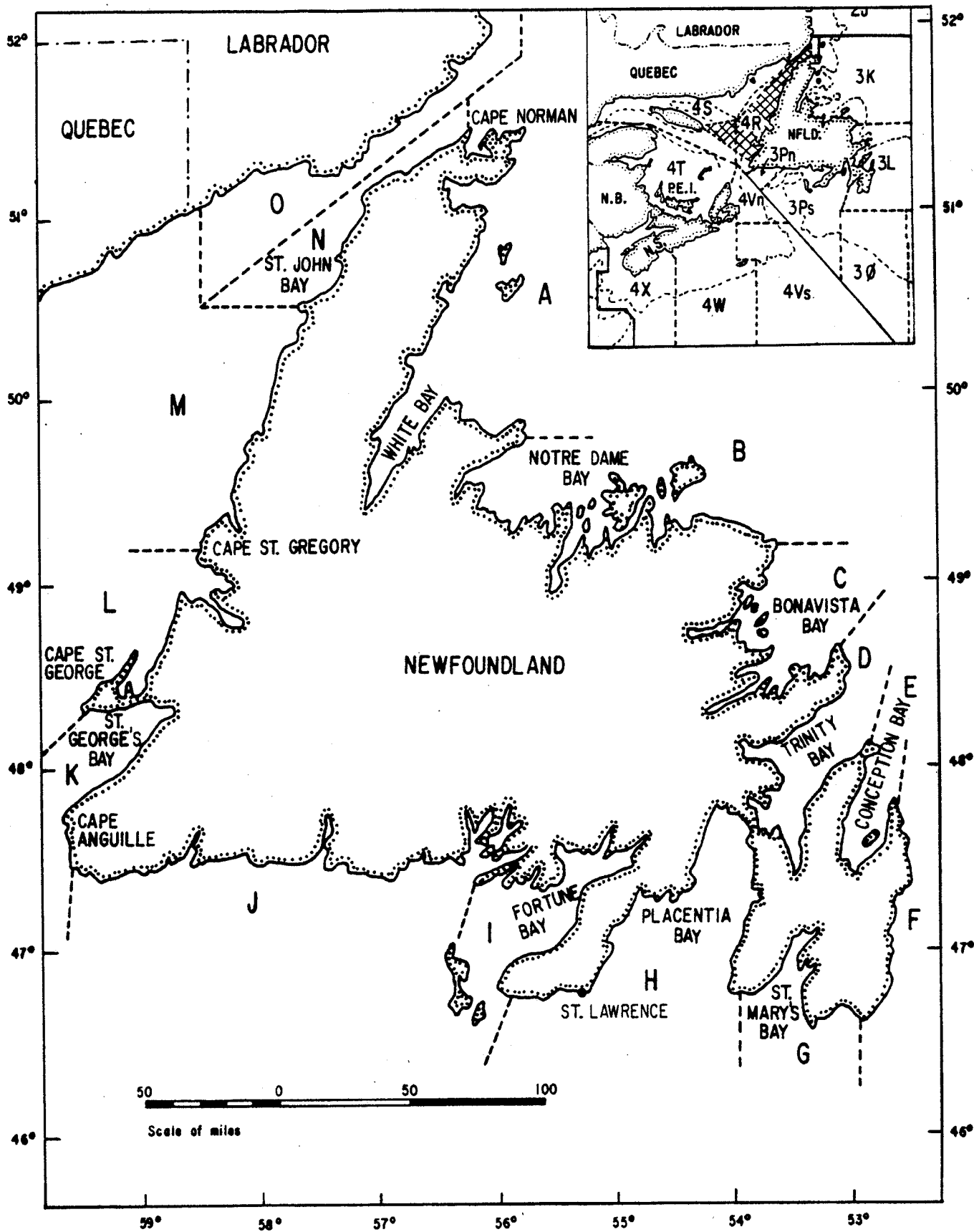
Fig. 1. Newfoundland area map.
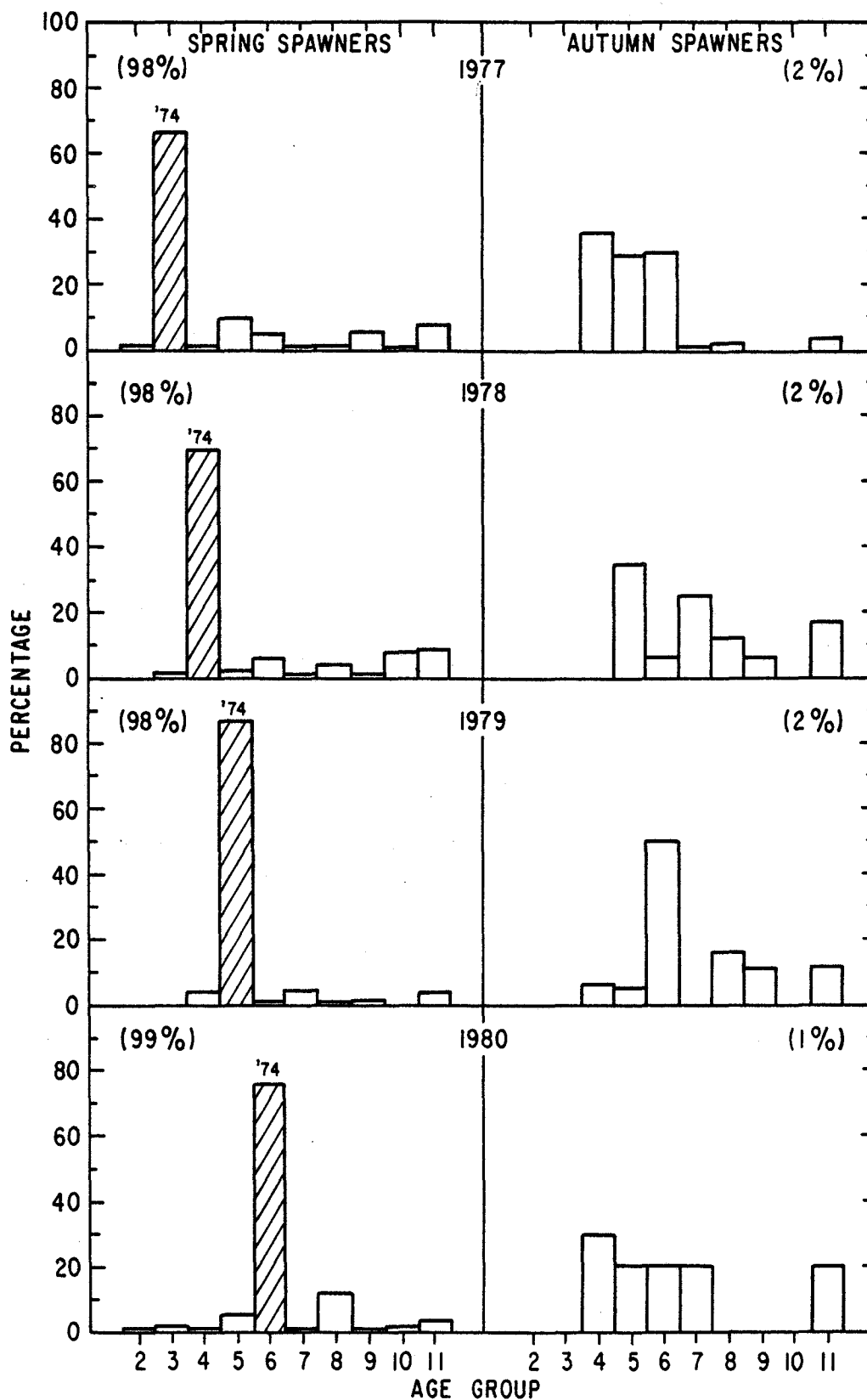
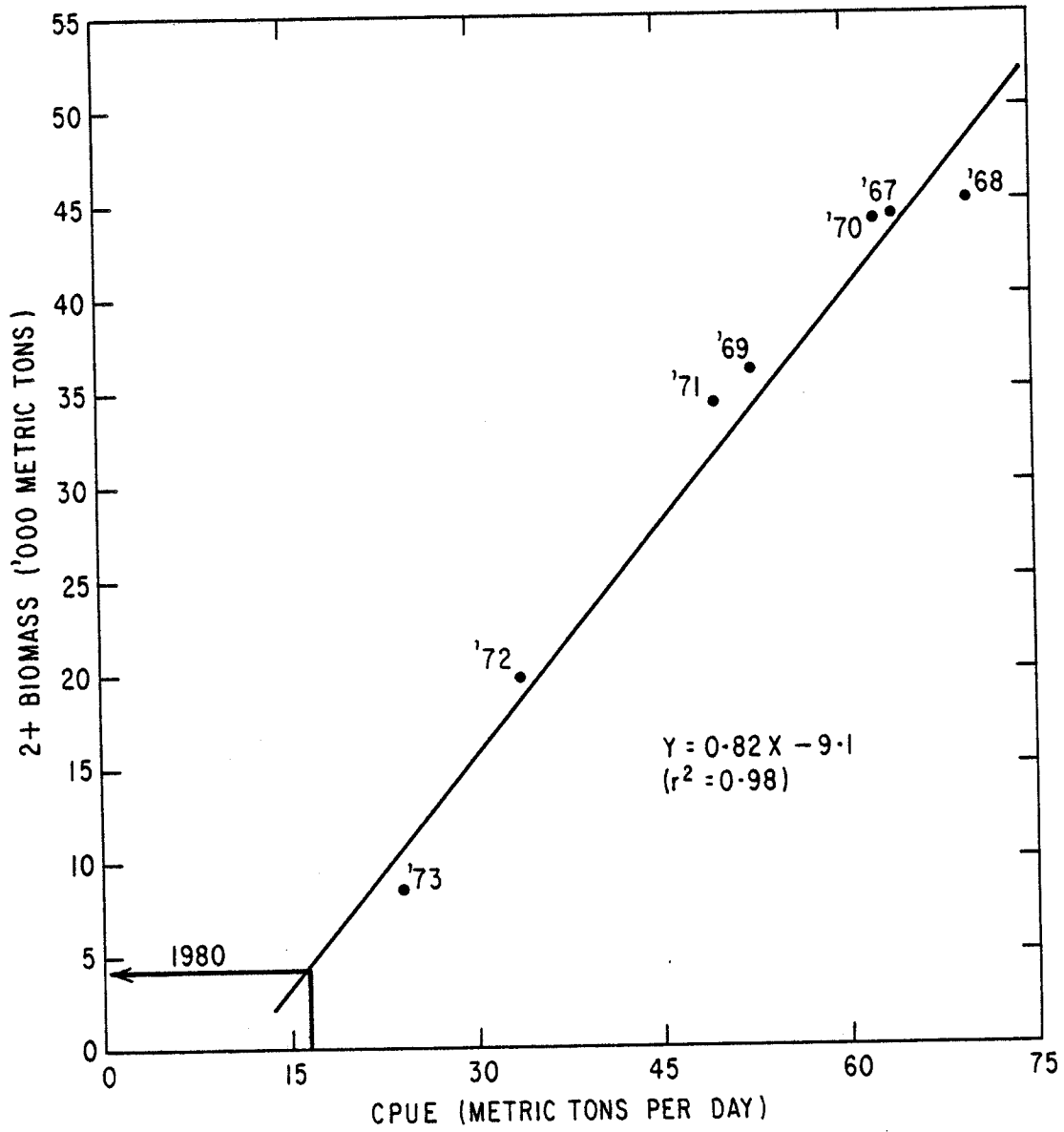Fig. 2. Age composition of Fortune Bay herring catches, 1977-80.

Fig. 3. Relationship between 2+ biomass and purse seine catch rates of Fortune Bay herring 1966-80.