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CAFSAC
Research Document 80/51

An Assessment of the Status of the Newfoundland West Coast Herring Stock

by

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Abstract

During the past four years herring catches from the Newfoundland west coast stock have risen steadily from 10,000 t in 1976 to 18,300 t in 1979. Much of the increase in catch is attributable to expansion in the fixed gear component. The age composition of the catch showed an improving recruitment pattern with significant contributions from the 1974 year-class of spring-spawners and the 1973 year-class of autumn-

spawners, however, age-groups 10+ remained dominant in the catch from both components.

Cohort analysis was performed separately for both components with M = 0.20 and partial recruitment rates derived from both empirical estimates and an examination of the F matrix. Terminal F was found to lie between 0.35 and 0.40 based on the relationship of 5+ biomass to purse-seine CPUE. Yield-per-recruit calculations were performed giving $F_{0.1}$ values of 0.55 for spring-spawners and 0.64 for autumn-spawners. Catch projections were performed using the population structure generated at F_T = 0.40 and gave a 1980 catch of $F_{0.1}$ of 18,000 mt.

Résumé

Les prises de hareng des stocks de la côte ouest de Terre-Neuve ont augmenté régulièrement durant les quatre dernières années, passant de 10,000 t en 1976 à 18,300 t en 1979. La plupart de l'augmentation est attribuable à un accroissement de l'effort exercé par la pêche à engins fixes. La composition en âge des prises indique que la classe d'âge de 1974 pour le hareng de printemps et celle de 1973 pour le hareng d'automne sont abondantes. Toutefois les groupes d'âge de 10 ans et plus continuent de dominer les deux composantes de la pêche.

Les deux composantes de la pêche ont été traitées séparément. Un taux de mortalité naturelle égal à 0.2 et des coefficients de recrutement partiels dérivés à la fois d'estimations empiriques et d'un

examen de la matrice des F servirent de paramètres à l'analyse des cohortes. La relation entre la biomasse de 5 ans et plus et la P.U.E. dans la pêche à la seine coulissante indique que la mortalité par pêche, en 1979, se situait entre 0.35 et 0.40. Les calculs de rendement par recrues donnent des valeurs de $F_{0.1}$ = 0.55 pour le hareng de printemps et de $F_{0.1}$ = 0.64 pour le hareng d'automne. L'abondance de la population calculée par l'analyse des cohortes avec, F_T = 0.40 fut utilisée pour effectuer des prévisions avec comme résultat des prises de 18,000 t à $F_{0.1}$ en 1980.

INTRODUCTION

Catches from the Newfoundland west coast herring stock have been increasing steadily during the past 4 years (Table 1) from 10,000 mt in 1976 to 18,300 mt in 1979. This increase in catch is mainly attributable to the rapid expansion in fixed gear effort which has occurred in the past two years. The 1979 catch of 18,300 mt represents a 5,800 mt overrun in the 1979 TAC of 12,500 mt.

The fishing pattern of the purse-seine fleet in 1979 was slightly different during the fall fishery with the bulk of the catch being taken south of Pt. Riche (Fig. 1) rather than in St. John Bay as has occurred since 1976.

The pattern of the fixed gear fishery has shown marked changes since 1978. Traditionally the main gillnet fishery has occurred north of Cape Gregory during the summer and fall. While this fishery in that area has remained relatively stable a major gillnet fishery has developed south of Cape Gregory during the spring. This fishery has expanded from 230 mt in 1975 to 3,900 mt in 1979 (Table 2). Total inshore catch in 1979 was 8,300 mt as compared to the estimated allowance of 2,500 mt.

Compilation of Assessment Data:

(a) Numbers-at-age:

Samples were collected from the commercial fisheries in each of the three subareas (Cape Anguille-Cape St. George, Cape St. George-Cape Gregory, and Cape Gregory-Cape Norman). Numbers-at-age in the catch were calculated separately for each year and area then combined to give total removals from the stock (Table 3).

(b) Age frequency of the catch:

The 1974 year-class of spring-spawners and the 1973 year-class of autumn-spawners were major contributors to the 1979 catch (Fig. 2). The 1974 year-class of spring-spawners represent 27% of the catch in the area south of Cape Gregory and 35% of the catch north of Cape Gregory. A similar trend is evident in autumn-spawners in which the 1973 year-class represented 16% of the catch in the southern area and 28% in the northern

area. In 1978 (Fig. 2) both these year-classes were virtually absent (<2%) in the southern area and only moderate contributors to the fall fishery.

In spite of the increased contribution by these year-classes, age groups 10+ were dominant in both the spring- and autumn-spawning components in 1979.

(c) Weight-at-age:

Average weight-at-age values were calculated for each spawning component using data from the first and second quarter including all gears (Table 4).

(d) Partial recruitment rates:

Estimates of partial recruitment were obtained from examining the F matrix (from a trial run of cohort analysis) for the period 1975-77 and from a comparison of the percent-at-age in the total catch to that in the fall purse-seine fishery (Winters and Moores, 1979). Good agreement was found between the two techniques and the resultant partial recruit rates are presented in Table 4. These recruitment rates indicate full recruitment at age 9 with low recruitment at the younger age groups. This pattern reflects the increasing gillnet fishery which would exploit primarily the fully mature, older age groups.

(e) CPUE and effort data:

Effort data were available from log records for the fall purse-seine fishery for the period 1966-73 and 1979 and for the spring purse-seine

fishery for the period 1975-79 (Table 5). In the spring data series the 1979 CPUE indicates a reversal of the decline in CPUE observed from 1975-78. Although the CPUE data for the fall purse-seine fishery are sparse in recent years the 1979 data indicate the catch rate to be similar to those reported in 1973 and lend support to an improvement in stock abundance.

(f) Natural mortality rate:

A natural mortality rate of 0.20 was used for both spawning components. In the previous assessment of this stock (Moores, 1979) a natural mortality rate of 0.15 had been assumed for autumn-spawners to reflect the large proportion of 11+ fish in this component. However, an examination of the relationship of F on effort indicated an M above 0.15 and with the large contribution by the 1973 year-class an M = 0.20 was deemed more appropriate and marks a return to the value of M used prior to 1979 (Moores and Winters, 1978).

Selection of Terminal F:

Cohort analysis was performed separately for both spring- and autumn-spawners with a range of F_T values from 0.20 to 0.60 using the age specific weights and partial recruitment rates shown in Table 4. The relationship between CPUE, from the spring fishery for the period 1975-78 and 5+ biomass was examined for each option of F_T using linear regression for spring- and autumn-spawners, both individually and combined. The closest

agreement with the predicted total biomass level occurred at an F_T level between 0.35 and 0.40 (Table 6, Fig. 3).

A similar analysis was performed using the historical CPUE series from the fall purse-seine fishery for the period 1966-73 and predicted the 1979 biomass level from the 1979 CPUE. The R^2 values increased slightly with increasing F but in all cases the predicted 1979 biomass level was well above that obtained from cohort analysis (Table 7).

Paloheimo $\bar{z}$ values were calculated for the time series (Table 8). While these values did not show a clear relationship, they did indicate a low level of mortality in recent years.

Given that the CPUE data would more accurately reflect recent events in the stock dynamics the relationship, they did indicate a low level of mortality in recent years.

Given that the CPUE data would more accurately reflect recent events in the stock dynamics the relationship between the spring CPUE and 5+ biomass was used to select F_T. As the difference between the predicted 1979 biomass levels at the .35 and .40 level was indistinguishable the more conservative level of F_T = 0.40 was selected.

Results of the Assessment

Trends in biomass and F:

The 5+ biomass of autumn-spawners has shown a continuous decline from 104.0 x 10^3 mt in 1970 to 13.0 x 10^{-3} mt at the start of 1980 (Table 8). The decline in the 5+ biomass of the spring-spawners since 1975 was reversed in 1979 with the recruitment of the strong 1974 year-class and resulted in an increase in total 5+ biomass in 1979 to 80.2 x 10^3 mt.

The level of fishing mortality (F_5+) on the autumn-spawners has generally been low (< 0.10) with the exception of 1973 (Table 8). The fishing mortality rate (5+) for spring-spawners was low during the early part of the series but increased markedly with the introduction of a spring purse-seine fishery in 1975. The mortality rate declined in 1979.

Trends in Recruitment:

Recruitment has generally been poor among the autumn-spawners with the exception of the 1970 and 1973 year-classes. The 1973 year-class is the largest in the series at 57 million recruits at age 2 (Table 9). Among the spring-spawners, the 1974 year-class is moderately strong being about one-half the strength of the 1968 year-class which has been the strongest year-class in this fishery in recent years.

Estimation of $F_{0.1}$:

Yield-per-recruit curves were constructed for both spring- and autumn-spawners utilizing the values in Table 3 and $F_{0.1}$ levels were calculated (Fig. 4). The $F_{0.1}$ level derived for spring-spawners was 0.55 and 0.64 for autumn-spawners.

Catch Projection:

Using the population structure produced at F_T = 0.40 and assuming a low level of recruitment at age 2 (1 x 10^6 recruits) and a similar partial recruitment pattern to 1979, catch projections were performed for 1980. Projections were performed separately for each spawning type (Table 10 and 11) and gave a combined yield of 15,579 mt. Adjusting the catch for change

in weight during the season on the basis of the ratio of the actual 1979 catch to that calculated with first and second quarter weights (1.16) gives a 1980 yield of 18,132 mt.

This catch level would leave a 5+ biomass of 31.5 x 10^3 mt at the start of 1981. This level should be viewed as very conservative due to the option of recruitment utilized. Reports of large quantities of small fish in inshore areas, from the purse-seiner logs and from length frequencies of herring taken in a shrimp survey in February 1980 (Sandeman, pers. comm.), indicate an improving recruitment picture in the Northern Gulf.

DISCUSSION

A catch level of 18,000 mt while substantially above previous TAC levels of 12,500 mt reflect the improved stock situation yet may still be regarded as conservative. In previous assessments the strength of the 1974 year-class has been underestimated and may still, at 50% of the 1968 year-class, be underestimated. Parallelism in year-class strengths has been noted between this stock and the southern Gulf stock where the 1974 year-class of spring-spawners has been estimated to be larger than the 1968 year-class (Winters and Moores, 1979). If this were the case with regard to the west coast of Newfoundland the biomass estimates for 1979 based on the historical CPUE rather than being too high may in fact be realistic.

ACKNOWLEDGMENTS

The authors would like to acknowledge the technical staff of the Pelagic Section of the St. John's laboratory who were instrumental in the collection and preliminary analysis of the data incorporated in this document.

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Table 1. Newfoundland west coast herring catches (m tons) 1966-79.

Year	K	L	M	N	Total Catch
1966		103	5529	18	5650
1967		66	5540	13	5619
1968		59	3978	11	4048
1969		46	2549	40	2635
1970		27	3473	301	3801
1971		2424	1076	1963	5463
1972		862	1544	3628	6034
1973		2862	2067	9222	14151
1974		856	942	2842	4640
1975	3613	113	242	1027	4995
1976	6565	2067	226	1251	10109
1977	5569	2203	156	4358	12286
1978	6808	1984	365	6453	15610
1979[1]	(6032)	(5043)	(3068)	(4157)	18300

[1] Provisional data

Table 2. Herring catches (mt) from the west coast Newfoundland area by gear type.

	K		L		M		N		Combined		
Year	Purse Seine	Inshore	Purse Seine	Inshore	Purse Seine	Inshore	Purse Seine	Inshore	Purse Seine	Inshore	Total
1966				103	5490	39		18	5490	160	5650
1967				66	5464	76		13	5464	155	5619
1968				59	3776	202		11	3776	272	4048
1969				46	2344	205		40	2344	291	2635
1970			12	15	2939	534		301	2951	850	3801
1971			2239	185	725	351	356	1607	3320	2143	5463
1972			727	135	1330	214	-	3628	2057	3977	6034
1973			2740	122	1763	304	3453	5769	7956	6195	14151
1974			756	100	439	503	1071	1771	2266	2374	4640
1975	3495	118	-	113	-	242	-	1027	3495	1500	4995
1976	6067	498	1955	112	-	226	184	1067	8206	1903	10109
1977	5289	280	2008	195	-	156	2167	2191	9464	2822	12286
1978	6252	556	1037	947	-	365	2636	3817	9925	5685	15610
1979[1]	4387	1645	2773	2270	1905	1163	924	3233	9989	8311	18300

[1] Provisional data

Table 3. Catch matrix Newfoundland west coast ($x10^{-3}$).

Spawning group	Age group	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Spring-spawners	2	212	3377	1	405	211	62	117	509	11	1	119
	3	1109	1565	3076	265	98	113	951	994	666	45	30
	4	1525	386	282	6332	764	26	525	983	538	2012	209
	5	341	545	589	751	16215	201	293	230	530	222	11432
	6	318	237	289	806	1270	5548	1541	332	305	703	551
	7	176	195	150	940	2873	146	8410	2820	364	248	1014
	8	441	240	307	208	1311	773	235	15555	4226	2241	493
	9	963	988	92	499	1404	484	366	777	16452	8479	2703
	10	368	952	315	135	806	58	138	2858	934	16460	7184
	11+	445	1680	797	1094	4272	2041	701	3229	5666	5164	14249
Total		5898	10165	5898	11435	29224	9452	13277	28287	29692	35575	37984
Autumn-spawners	2	17	1	30	12	1	1	1	1	1	1	1
	3	299	770	1	81	292	12	94	63	3	10	32
	4	531	141	2	93	466	141	183	51	61	30	118
	5	272	145	55	69	628	110	1188	119	118	407	308
	6	613	214	343	248	585	57	350	338	298	296	2578
	7	517	468	950	326	973	117	83	462	727	1018	607
	8	157	177	2058	422	1040	58	112	105	373	1608	1403
	9	119	129	1093	893	2223	195	70	157	207	482	1931
	10	168	239	714	256	2016	205	59	50	95	298	459
	11+	1254	2122	7583	6265	8975	2161	1842	3742	6926	5018	5398
Total		3947	4406	12829	8665	17199	3057	3982	5088	8809	9168	12835

Table 4 . Average weight-at-age (gms) and partial recruit rates used for 1979.

		Age									
		2	3	4	5	6	7	8	9	10	>10
Spring-spawners	Average Wgt.	71	135	177	227	238	259	291	311	319	380
	% Recruited	5	10	15	25	40	60	95	100	100	100
Autumn-spawners	Average Wgt.	50	91	156	190	240	255	265	275	280	393
	% Recruited	1	5	10	20	30	45	65	100	100	100

Table 5. Effort data for the Newfoundland west coast fishery.

Year	Total Catch (mt)	Catch/op. day		Effort	
		K + L	M + N	K + L	M + N
1966	5650		63.2		89.4
1967	5619		67.5		86.5
1968	4048		65.4		61.9
1969	2635		47.8		55.1
1970	3801		38.3		99.2
1971	5463		38.6		141.5
1972	6034		31.7		190.4
1973	14151		53.0		267.0
1974	4640	-	-		-
1975	4995	92.6	-	53.9	-
1976	10109	89.5	-	113.0	-
1977	12286	79.8	(70.2)[1]	154.0	(175.0)[1]
1978	15610	68.5	(89.0)[1]	227.9	(175.4)[1]
1979	18300	73.5	54.2	249.0	337.6

[1] from landing slips

Table 6. Combined 5+ biomass ($x10^{-3}$ mt) of the Newfoundland west coast stock for the period 1975-79 at various levels of F_T and the resultant r^2 and predicted 1979 biomass levels using CPUE from the spring purse-seine fishery.

	Terminal F					
Year	.25	.30	.35	.40	.45	.50
1975	169.3	151.9	139.5	130.3	123.2	117.4
1976	149.1	133.3	122.1	113.7	107.2	102.0
1977	124.5	110.3	100.2	92.7	86.9	82.2
1978	102.3	89.1	79.6	72.7	67.2	62.8
1979	122.9	103.9	90.4	80.2	72.3	66.0
r^2	.960	.963	.965	.967	.968	.970
Predicted '79	112.4	98.7	88.9	81.7	76.1	71.5

Table 7. Combined 5+ biomass ($x10^{-3}$ mt) for the period 1966-73 at various levels of FT and the resultant r^2 and predicted 1979 biomass levels using CPUE data from the fall purse-seine fishery.

Year	Terminal F			
	.20	.30	.40	.50
1966	280.8	221.4	191.9	174.2
1967	249.3	196.3	169.9	154.1
1968	239.1	188.0	162.5	147.5
1969	221.8	174.4	150.7	136.6
1970	205.6	161.3	139.3	126.1
1971	189.7	149.7	129.8	118.0
1972	161.0	126.7	109.6	99.3
1973	218.6	174.7	152.8	139.7
1979	151.5	103.9	80.2	66.0
r^2	.804	.808	.809	.810
Predicted '79	229.2	180.7	156.6	142.4

Table 8. 5+ biomass and F_{5+} (F_T = 0.40) from cohort analysis and Paloheimo Z values.

		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Biomass 5+	AS	104.1	87.4	69.9	56.3	44.4	40.3	35.5	29.0	25.7	18.9	13.0
($x10^{-3}$ mt)	SS	35.2	42.4	39.7	96.5	99.2	90.8	78.2	63.7	47.0	61.3	42.5
	Total	139.3	129.8	109.6	152.8	143.6	130.3	113.7	92.7	72.7	80.2	55.5
F_{5+}	AS	.013	.058	.049	.122	.027	.032	.044	.093	.093	.211	
	SS	.048	.019	.037	.084	.026	.039	.111	.163	.284	.203	
Paloheimo Z_{5+}	AS	-0.94	0.72	-0.29	-	-	0.47	-0.24	0.39	-0.22		
	SS	1.26	-0.07	-0.65	-	-	-0.04	0.23	0.24	0.34		
	Combined	-0.21	0.53	-0.43	-	-	0.06	0.14	0.27	0.19		

Table 9. Population estimates of spring- and autumn-spawning herring from the Newfoundland west coast stock.

Spawning Group	Age Group	Estimated Population Size ($x10^{-5}$)										
		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
SS	2	5289	1861	478	89	200	119	2459	60	10	66	10
	3	277	4300	1524	388	71	163	97	2009	49	8	53
	4	727	213	3493	1245	316	57	125	70	1638	40	7
	5	182	592	172	2802	1012	259	42	93	53	1323	31
	6	54	144	479	134	2148	827	209	32	72	41	980
	7	131	42	115	385	98	1708	663	168	24	52	29
	8	74	106	33	86	289	79	1322	517	135	17	34
	9	177	58	84	25	59	230	62	942	385	90	10
	10	163	136	47	64	8	44	185	44	622	239	49
	11+	355	400	429	378	316	247	230	282	203	474	391
	N_t ($x10^{-5}$)	7429	7852	6854	5596	4517	3733	5394	4217	3191	2350	1594
	W_t (10^{-3} tons)	89.3	117.4	125.0	124.4	107.1	94.1	99.1	92.5	76.7	62.6	43.4
AS	2	108	145	380	267	122	569	81	50	22	3	10
	3	55	89	118	311	219	100	466	66	41	18	2
	4	53	38	73	96	252	179	81	381	54	33	14
	5	93	42	31	59	74	205	145	66	311	44	26
	6	220	74	34	25	42	60	157	117	53	251	33
	7	384	179	58	25	15	34	46	126	93	41	182
	8	80	310	138	44	12	11	27	33	96	67	28
	9	144	64	235	109	27	9	8	21	24	64	43
	10	156	117	42	185	69	20	7	5	16	15	35
	11+	1953	1705	1417	1136	981	839	680	511	317	179	107
	N_t	3246	2763	2526	2257	1813	2026	1698	1376	1027	715	480
	W_t	105.9	89.5	74.0	62.0	50.9	46.8	41.4	35.8	27.0	19.6	13.3
SS + AS	N_t	10675	10615	9380	7853	6330	5759	7092	5593	4218	3065	2074
	W_t	195.2	206.9	199.0	186.4	158.0	140.9	140.5	128.3	103.7	82.2	56.7

TABLE 10.

CATCH PROJECTION FOR 1980 **SPRING SPAWNERS**

AGE	POPULATION NUMBERS	POPULATION WEIGHT	FISHING MORTALITY	CATCH NUMBERS	CATCH WEIGHT	RESIDUAL NUMBERS	RESIDUAL WEIGHT
2	1000.	71.	.027	25.	2.	797.	57.
3	5319.	718.	.055	258.	35.	4122.	556.
4	664.	117.	.083	48.	8.	500.	89.
5	3050.	692.	.137	356.	81.	2176.	494.
6	98028.	23331.	.220	17610.	4191.	64409.	15329.
7	2861.	741.	.330	733.	190.	1684.	436.
8	3363.	979.	.523	1251.	364.	1633.	475.
9	957.	298.	.550	370.	115.	452.	141.
10	4932.	1573.	.550	1908.	609.	2330.	743.
11	13108.	4981.	.550	5072.	1927.	6192.	2353.
12	19789.	7520.	.550	7657.	2910.	9348.	3552.
13	879.	334.	.550	340.	129.	415.	158.
14	2503.	951.	.550	969.	368.	1182.	449.
15	465.	177.	.550	180.	68.	220.	84.
16	66.	25.	.550	25.	10.	31.	12.
17	365.	139.	.550	141.	54.	172.	66.
18	212.	80.	.550	82.	31.	100.	38.
19	489.	186.	.550	189.	72.	231.	88.
20	1230.	467.	.550	476.	181.	581.	221.
TOTAL	159280.	43381.		37691.	11345.	96576.	25340.

TABLE 11.

CATCH PROJECTION FOR 1980 **AUTUMN SPAWNERS**

AGE	POPULATION NUMBERS	POPULATION WEIGHT	FISHING MORTALITY	CATCH NUMBERS	CATCH WEIGHT	RESIDUAL NUMBERS	RESIDUAL WEIGHT
2	1000.	50.	.006	6.	.	814.	41.
3	225.	21.	.032	6.	1.	179.	16.
4	1430.	223.	.064	80.	13.	1099.	171.
5	2610.	496.	.128	285.	54.	1880.	357.
6	3336.	801.	.192	530.	127.	2254.	541.
7	18229.	4648.	.288	4154.	1059.	11190.	2853.
8	2772.	735.	.416	861.	228.	1497.	397.
9	4250.	1169.	.640	1840.	506.	1835.	505.
10	3523.	986.	.640	1525.	427.	1521.	426.
11	837.	329.	.640	363.	143.	362.	142.
12	553.	217.	.640	239.	94.	239.	94.
13	126.	49.	.640	55.	21.	54.	21.
14	122.	48.	.640	53.	21.	53.	21.
15	283.	111.	.640	122.	48.	122.	48.
16	761.	299.	.640	329.	129.	328.	129.
17	1465.	576.	.640	634.	249.	633.	249.
18	257.	101.	.640	111.	44.	111.	44.
19	542.	213.	.640	235.	92.	234.	92.
20	5740.	2256.	.640	2485.	977.	2478.	974.
TOTAL	48063.	13328.		13915.	4234.	26881.	7120.

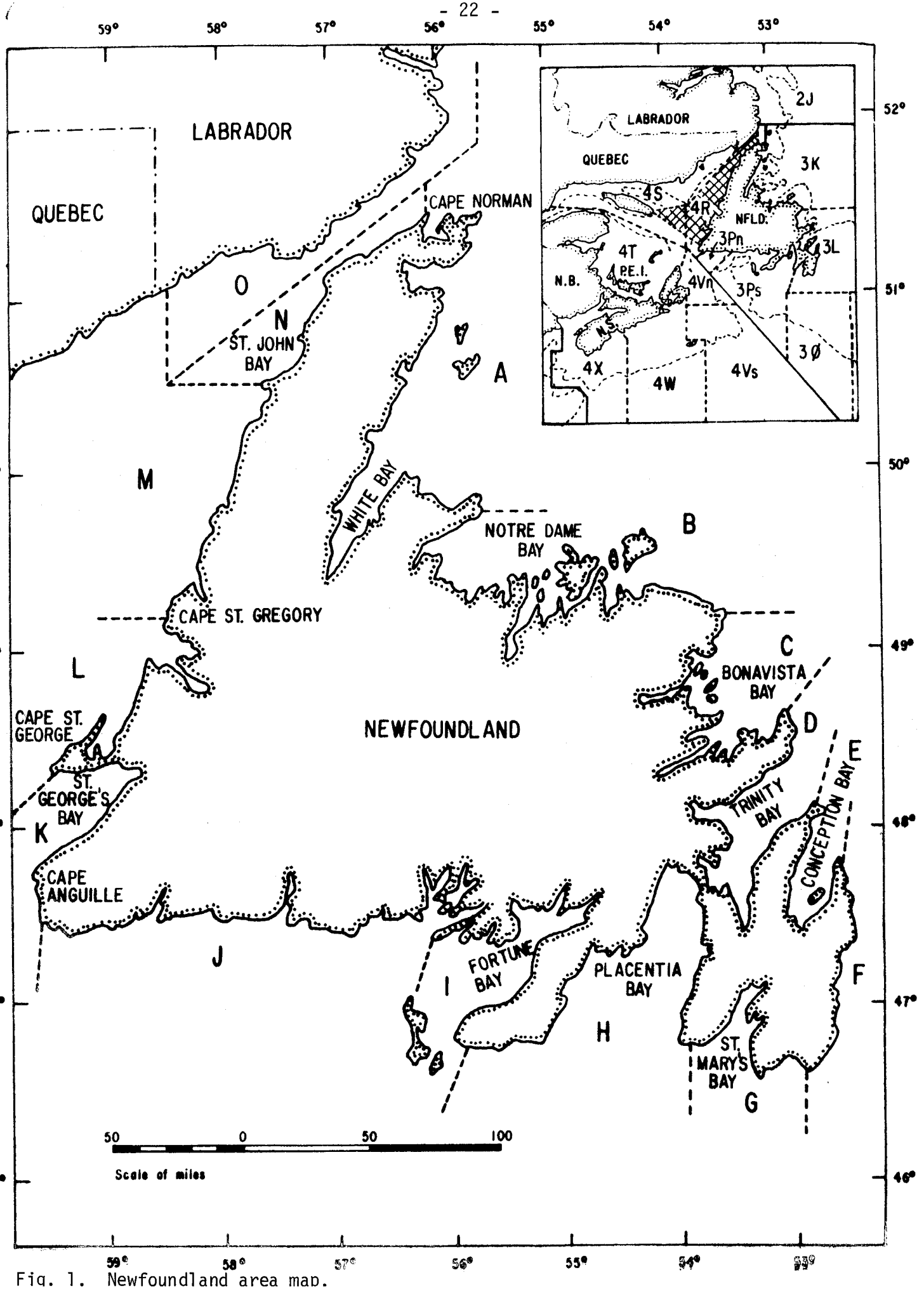

Fig. 1. Newfoundland area map.

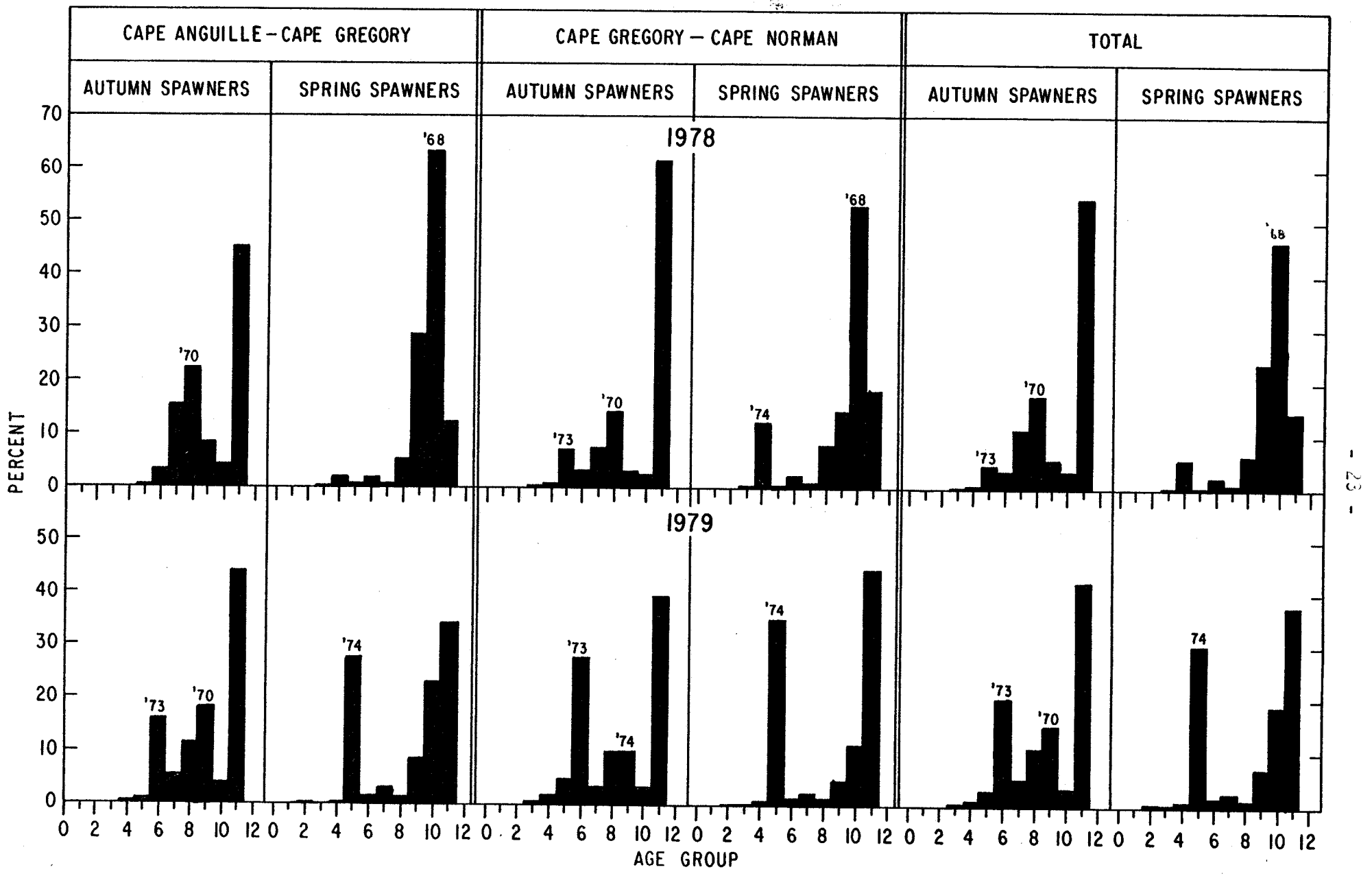

Fig. 2. Age frequency distribution of the catch from the Newfoundland west coast stock area for 1978 and 1979.

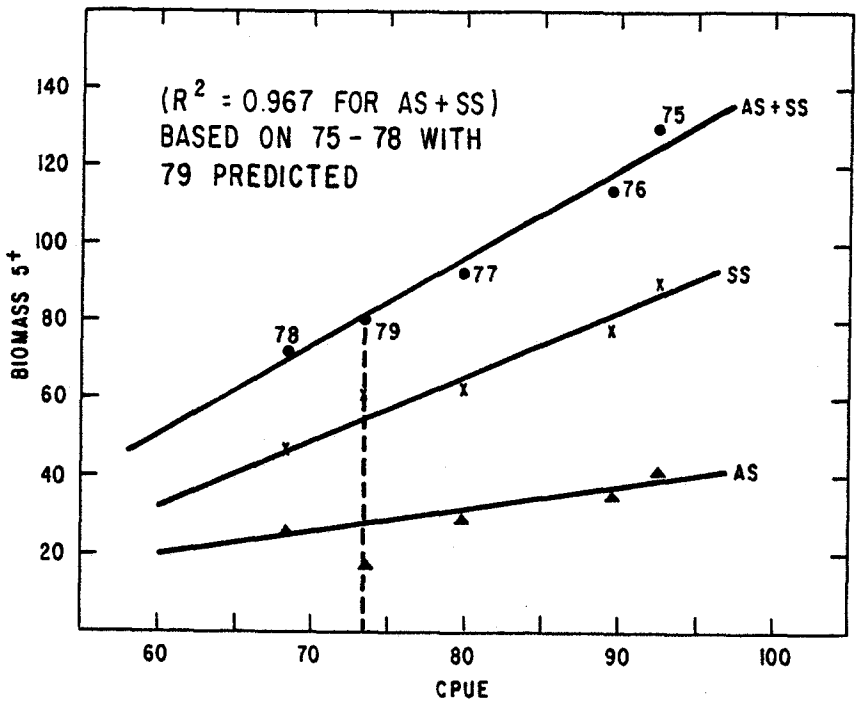

Fig. 3. Relationship between CPUE from the spring purse-seine fishery and 5+ biomass for spring-spawners, autumn-spawners and combined. (F_T = 0.40)

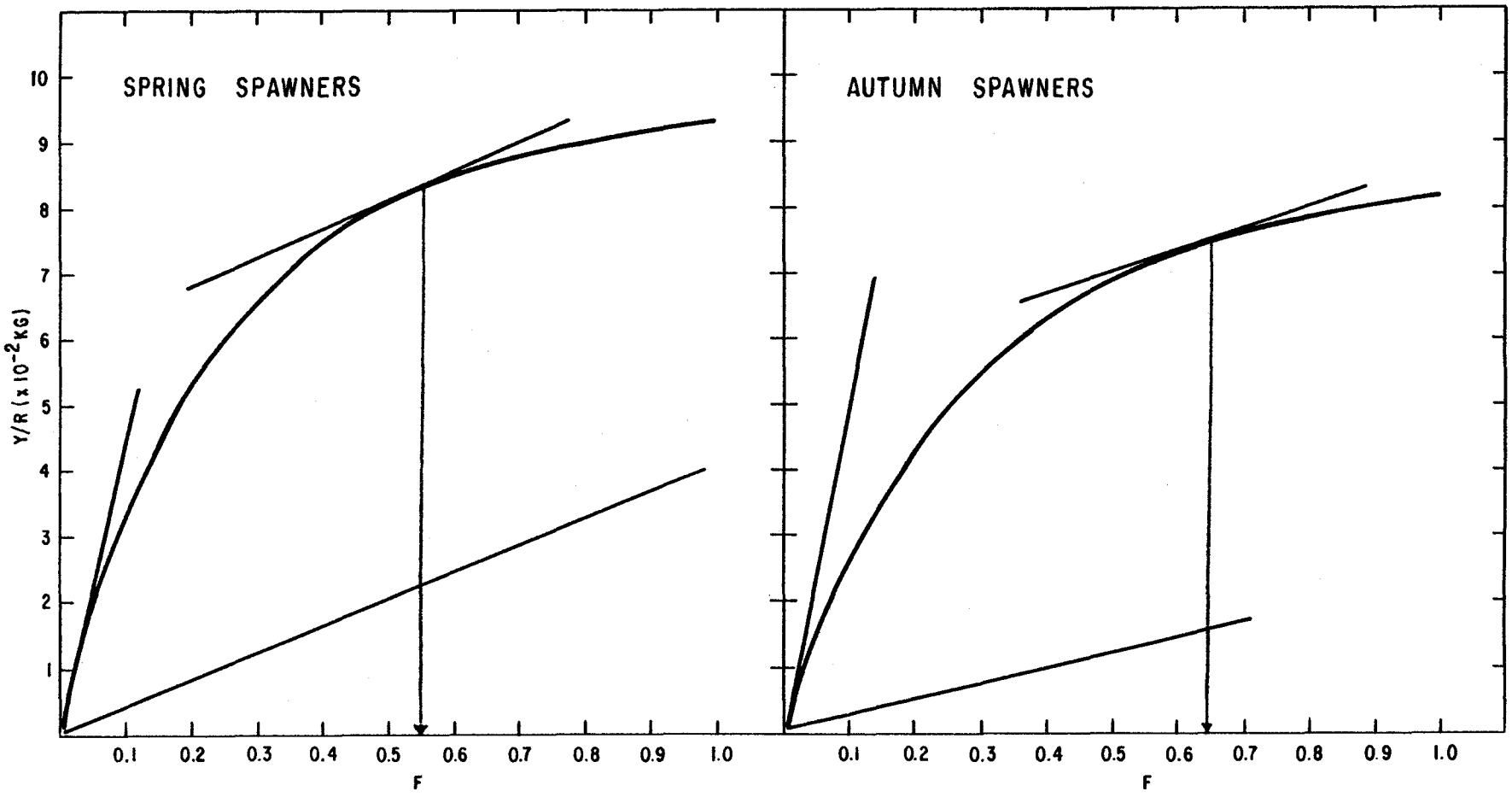

Fig. 4. Yield-per-recruit curves and $F_{0.1}$ levels of spring- and autumn-spawners from the Newfoundland west coast stock.