STATUS OF THE 4R HERRING STOCK IN 1982

by

D. Tremblay, H. Powles
Fisheries & Oceans
P.O. Box 15,500
Quebec City, Quebec G1K 7Y7

and

J. Moores
Fisheries & Oceans
P.O. Box 5667
St. John's, Newfoundland A1C 5X1

ABSTRACT

Reported catches from the Newfoundland west coast herring stock were 10 004 T. in 1982. Catches of both spawning components were still dominated by age group 11^+ with an increased contribution of the 1978 year-class in the autumn-spawners. Due to difficulties with tuning sequential population analysis with different abundance indices terminal F (0.20 for both spawning components) was selected using Paloheimo Z's calculated from the data set best representing population phenomena (M + N fall gillnet data). The results of cohort analysis show a continuing decline of stock biomass with no significant recruitment occurring in recent years.

RESUME

Le stock de hareng de la côte ouest de Terre-Neuve a donné, en 1982, des prises rapportées de 10 004 tonnes. Le groupe d'âge 11^+ domine encore les 2 groupes reproducteurs, le seul changement étant la contribution accrue de la classe d'âge 1978 chez les frayeurs d'automne. En raison de la faible sensibilité des techniques d'ajustement de l'analyse de population séquentielle en utilisant les différents indices d'abondance, le F de dernière année a été choisi à partir de calculs de Z de Paloheimo à l'aide des données représentant d'une façon la plus acceptable la population (i.e. les captures et l'effort de pêche d'automne aux filets maillants dans M + N). Le F de 1982 était de 0.20 pour les 2 composantes reproductrices. L'analyse des cohortes indique un déclin constant du stock et l'absence de recrutement notable ces dernières années.

1- INTRODUCTION

a) Historical fishery patterns

The west coast of Newfoundland (Fig. 1) has supported a herring fishery for decades. Both inshore fixed-gear (anchored gillnets) and mobile fisheries (purse seine) showed increases in landings from 1975 to 1980 followed by declines under quota management (Fig. 2, Tables 1, 2). In general, the fishery is exploited in two areas and season: a spring fishery in the southern part of the coast (Areas K and L), primarily on spawning and pre-spawning concentrations, and a fall fishery further north (Areas M + N) on mixed spring and fall-spawners. In recent years (ca. 1978-81) fall allocations could not be taken in the northern area and were transferred to the area south of Cape St.Gregory after a period of attempting to take the allocation in the northern area. Relative contribution of the various areas and gear types to the fishery has been variable over the years since 1966 (Fig. 2, Tables 1, 2).

b) The 1982 fishery

Reported landings for 1982 were 10 004 t on a quota of 10 000 t (Table 3). Fixed gear landings were 113% of the 4 500 t allocation while reported purse seine landings were 90% of the 5 500 t allocation.

Purse seine landings were, however, substantially under-reported. Estimates of the landings range to 8 700 t for the year for a 60% overrun on the quota. Most under-reporting apparently occurred in the fall fishery. Over-running of the purse seine quota apparently resulted from a combination of good markets, low quotas, and a belief by industry that quota allocations were lower than justified by stock abundance. In particular, fishermen reported (as in 1980 and 1981) very substantial abundance of pre-recruit sized fish in the area; since the market here is for large fish, these smaller fish are not landed and thus do not show up in the commercial sampling data in numbers representative of their abundance at sea. Under-reporting was apparently much more serious in 1982 than in earlier years although some may have occurred earlier. Since the under-reported catches could not be broken down by areas, the official figures were used in the cohort analysis.

The purse seine fishery pattern was influenced by market and quality requirements; purchasers were accepting only limited daily catches, with the result that catches per day were lower than would have occurred in an "open" fishery. As a result, purse seine CPUE data (catch/operating day) were apparently biased downward.

In the spring purse seine fishery, no catches were landed from Bay St.George (Area K), where landings have been on the decline since 1978. This was reportedly due to small-sized fish in this area. Catches from Port-au-Port (Area L) were good. The fall fishery showed a return to a pattern not seen in some years, with good catches in Areas M + N and in particular the Bonne Bay area. Searching in St.John's Bay indicated light concentrations and predominantly small fish. This situation is in particularly marked contrast to 1981, when fish were in very low abundance along the coast in the fall, vessels went as far afield as subdivision 4S in search of herring, and the purse seine quota for the year was not taken (Moores et al. 1982). Although the total purse seine allocation for 1982 was officially not taken, 4 individual boat allocations were taken by November 4 and these vessels were not permitted to fish further. The two remaining vessels fished more or less sporadically and did not attain their allocations.

Gillnet allocations were taken or slightly overrun in all areas in 1982 (Table 3). Total catch was slightly lower than in 1981 (5 100 t 1982, 5 400 t in 1981); 1982 gillnet catches were 400 t higher in St.George's Bay (Area K) than those of 1981, and some 500 t lower north of Cape Gregory (areas M + N). No closure was enforced on gillnet fisheries in 1982. Gillnet fishermen also reported that abundance was greater than catches indicated, and that abundance of pre-recruits was very high.

c) Observer program

An observer program during the fall purse seine fishery covered three boats out of six participating in this fishery. A total of 25 nights of active searching and fishing were covered. Herring length frequency and biological data were taken at each successful set. Areas where sets were made are shown in Fig. 3. Data concerning position, depth, presence and size of schools were also taken at each half-hour. A total of 10 biological samples was collected. This program furnished useful information on fishing patterns and sets' location in relation to characteristics of fish caught, and should be continued next year for both spring and fall fisheries. Some 20% of sets in the areas covered (Bonne Bay and Port-au-Port Bay) were on 12-20 cm fish which were released at sea.

d) Stock definition

The Newfoundland west coast herring management area has been defined based on the results of tagging studies (Moores 1979). A tagging experiment in December 1981 at Mecatina in area 4S (6 000 fish tagged, see Fig. 3) has suggested limited interchange between stocks

from this area and other management areas: in 1982, 8 tags were returned from 4S, 2 from 4R (area of return subject to confirmation) and 1 from 4T (Northumberland Strait) (Moores, pers. com.). In December 1982 an additional 1 000 juvenile herring were tagged in subdivision 4S.

2- INPUT DATA AND PARAMETERS FOR COHORT ANALYSIS

a) Age compositions

Although age compositions in the 1982 catch continued to resemble those of earlier years, with strong dominance of 11^+ fish in both spring- and fall-spawning components (Fig. 4), there was some indication of new recruits (age 4, 1978 year-class) in the fall-spawning component. These fish made up 14% of the fall spawner catch (numbers) and were from the fall purse seine fishery. Following the dominant 11^+ group in contribution to 1982 catch were 1974 year-class fish for spring-spawners (26%) and 1973 fall-spawners (17%). The 1978 year-class for the fall-spawners represent the first appearance of appreciable numbers of young fish in several years and may correspond to the large numbers of pre-recruits reported by fishermen in recent years and picked up on a winter ground-fish survey (Moores and Lilly 1982).

b) Numbers-at-age

Catch sampling data for the 1982 fishery and provisional landing statistics were combined to produce numbers of fish captured at age as in previous years (Moores et al. 1982). Numbers-at-age for 1981 were re-calculated based on final landings statistics. The 11^+ fish were pro-rated to ages 11-27 by proportions from earlier years.

For the early years of the catch matrix (1975 and earlier), two sets of numbers-at-age figures were available. The first set (Moores et al. 1982) had been calculated assuming that all Area K landings were from the 4T herring stock prior to 1975, and from the 4R stock from 1975 onwards. The second matrix (Table 4) resulted from a re-examination of area K landings and re-apportionment to 4R and 4T stocks (Moores 1983). Trial cohort analyses were made with the two matrices and no substantive differences in results for the recent period (1980-82) were obtained. As a result, all further cohort analyses were made with the revised catch matrix.

While under-reporting of purse seine catches was not compensated for in the 1982 numbers-at-age figures, it is apparent that "real" numbers at age could have been substantially higher than indicated here for both spring and fall spawners.

c) Weights-at-age

Mean weights-at-age were calculated from 1st and 2nd quarter commercial sampling data (Table 5).

d) Partial recruitment vector

Four options for partial recruitments were considered for each spawning component: the vector from the most recent assessment (Moores et al. 1982), two vectors based on mean F's 1974-79 from trial cohort analyses, and a vector calculated from relative contribution of year-classes to the fall purse seine fishery (taken to represent population age composition) and to the total catch. The latter vector showed two maxima in partial recruitment (age 5-6 and ages 9 and older); this pattern did not appear to represent age-specific impact of the fishery and was rejected. Two vectors were calculated from mean historical F's: a smoothed, and an unsmoothed vector. The unsmoothed vector (Table 5) shows full recruitment in spring at age 8, with a substantial increase between ages 7 and 8; the smoothed vector assumed a lesser difference between ages 7 and 8 and other values were calculated according. While the unsmoothed vector appears to represent the historical data well, and is not unreasonable for 1982, the smoothed vector may be more representative of "average" conditions. Fall PR's did not change substantially compared to the 1982 assessment.

e) Abundance indices

i) Purse seiners

Logbook coverage of the purse seine fishery was partial, with 2 logbooks submitted for the spring fishery and 4 for the fall (of a total of 6 vessels participating). In addition to those factors generally considered to bias the CPUE-abundance relationship in purse seine fisheries both fishing according to market requirement and under-reporting of catches acted to bias purse seine catch rates downward. Calculated catch rates were higher for the Area M + N (fall) fishery in 1982 than in 1981 and were close to the long-

term (1966-82) average for this fishery component (Table 6). Catch rates for the spring fishery were lower than at any time previously in the available series (1975-1982) but were based on only 2 logbooks.

ii) Gillnets

Purchase slip data for the 1982 fishery were analysed to obtain mean catch per landing by area and month (Table 7). Similar data were available for the period 1978-81 (Moores et al. 1982). Mean catches per landing used in analyses were calculated as weighted by total catch (by month/area) and were adjusted for fleet size (Table 8). The adjustment factor for fleet size (number of nets) for 1978-81 was based on surveys carried out on the Newfoundland east coast. No such survey was done in 1982 but interviews on the west coast indicated that fleet size had not increased in 1982. These interviews, although of limited coverage, indicated that the adjustment factors used here are applicable. The recent increase in fleet size corresponds to an increase observed in other areas (4T, Cleary & O'Boyle 1981 ; 4S, Tremblay & Powles 1982) although it is not of the same magnitude. Similarity of market conditions and inshore fishing patterns between Newfoundland's east and west coast herring fisheries suggests that the east coast adjustment factor is applicable here.

Although bias may be less of a problem than with purse seine catch rates, considerable variability is associated with the mean gillnet catch rates. In particular, number of nets per landing is unknown and may be variable between fishermen or between landings for the same fisherman (because of weather, markets, fishing for other species, etc.). Bias in gillnet catch rates may result to some extent when the fishery is on spawning beds since concentration of effort on fish concentrations is likely to be heavy in this situation.

f) Natural mortality

M was assumed to be 0.2 for both spring and fall-spawners based on studies from other herring stocks (Lea, 1930; Runnstrom, 1936; Beverton, 1963).

g) Terminal fishing mortalities

i) Paloheimo Z calculations

Calculations of total mortality rates were performed using age specific catch (5+)and effort data from various components of the fishery. Fall gillnet data were considered to represent population phenomena better than other data sets since the fishery is on mixed spawning components. Paloheimo Z's were calculated for the period 1977-82 using M + N fall gillnet catches and effort data; those produced Z's in a range of 0.21 - 0.43 for both spawning components combined (Table 9). Thus F values in the order of 0.20 would appear appropriate since Z's value for 1982 was 0.41.

ii Tuning cohort analysis with catch rates and effort

Results from trial runs of cohort analysis were compared with fishing effort and catch-per-unit effort data from various components of the fishery by linear regression analysis, for a range of terminal F values from 0.10 to 0.35. Results for F_T's from 0.1-0.2 are shown (Table 10). In general, changes of F_T over these ranges were accompanied by rather small changes in correlation coefficients.

From a biological point of view, the "best" data sets are those for gillnets (since bias is likely less than for purse seine) and for the Area M + N fishery since this is on mixed spring- and fall-spawners and not primarily on spawning fish. This judgment is somewhat confirmed by the relatively high correlation coefficients (0.65 - 0.91) for both spring-and fall-spawners using M + N gillnet data.

Intercepts were examined in addition to regression coefficients in an attempt to discriminate between cohort results at different F_T values, but discrimination was not enhanced.

For all regression analyses, only "recent" (1975-81) data points were used. There is a marked divergence in the relationships between purse seine data and cohort results between historical and recent periods (Moores et al. 1982) and for gillnets data are only available from the recent period. Since these analyses did not permit discrimination between F_T values, Paloheimo Z calculation was used to set terminal F for 1982.

3- RESULTS OF COHORT ANALYSIS

Cohort analysis was carried out separately for spring and fall spawners using F_T's from 0.10 to 0.35 and other inputs as described above. Results for F_T = 0.20 are shown (Tables 11, 12, Appendices 1-10) and discussed in more detail below.

a) Trends in biomass and F

The autumn-spawning component has shown a decline in biomass (Table 11) from 1966 to 1982. The 5+ biomass has declined from 179.5 x 10^3 t. in 1966 to 14.2 x 10^3 t. in 1982 (Table 11). Among spring-spawners, 5+ biomass peaked in 1974 with the contribution of 1968 and 1969 year-classes and has declined to 47.3 x 10^3 t. in 1982. The total stock 5+ biomass is at its lowest level since 1966 (61.5 x 10^3 t.) in 1982.

b) Trends in recruitment

Recruitment in the autumn-spawning component has always been poor during the time period covered by this analysis (Appendix). This trend of low recruitment has led to a decline in this group from 957.4 x 10^6 individuals (2+) in 1966 to 64.5 x 10^6 individuals in 1982.

The trend among spring-spawners has been better than among the autumn component. The largest year-class has been the 1968 year-class with 891.8 x 10^6 individuals at age 2. Since that time the 1974 year-class has been the strongest which represents 21% of the 1968 year-class. The abundance of the spring-spawning component has declined from 1 320.3 x 10^6 individuals (2+) in 1971 to 133.3 x 10^6 individuals in 1982.

Despite the apparent trend of low recruitment, reports from the observer program in the fall period of 1982, showed that young herring were again abundant in Port-au-Port Bay and St.John's Bay areas. The strength of these year-classes is not determined yet but their may be grounds for some optimism for the future of this fishery.

c) Catch projection

(1) Partial recruitment rates

The partial recruitment rates used for the projection were the same as those used for cohort analysis (Table 5).

(2) Average weight-at-age

Since no data were available for year-classes older than 11 years, a von Bertalanffy relationship was fitted to age 2 to 10 data both for autumn and spring spawners (mean weights 1980 to 1982). Weights for fish 11 yrs and older were then derived from those relations to include the predominant year-classes (e.g. 1968 and 1969) (Table 13).

Preliminary calculations indicated substantial differences between results with projected weight-at-age vectors and those treating 11+ as one year-class (e.g. $F_{0.1}$ for spring-spawners 0.33 with "projected" weight-at-age vs 0.41 for 11+ pooled).

(3) Calculation of $F_{0.1}$

The $F_{0.1}$ level was calculated using the new average weight-at-age data with M = 0.20 for both spawning components. These calculations gave $F_{0.1}$ levels of .33 and .29 for spring- and autumn-spawners, respectively.

(4) Catch projection

Catch projections were performed at the $F_{0.1}$ level for both spring- and autumn-spawners with recruitment set at the geometric mean of population numbers at age 2 for years 1971-1981. A comparison of the calculated catch (summation of the catch at age multiplied by the weight-at-age) in 1982 to the observed 1982 catch gave a correction factor of 1.0343. The results of the projection for 1983 and 1984 are shown in Table 14. Detailed catch projections are given in the Appendices.

This projection indicates that 24% (in biomass) of the 1983 catch would be composed of autumn-spawners which is very close to the previous years level of 20%. This would produce a TAC of 11 800 t. in 1983 which is higher than projected in 1982 (Moores et al. 1982).

DISCUSSION

The west coast of Newfoundland herring stock status appears better than in 1982. Quotas were easily taken in 1982 (not in 1981) and the total was reportedly overrun by 60% by the purse seine fleet. Also, some new recruitment was seen in the purse seine fall fishery and 18% of the sets made during the observers program were composed of pre-recruits (120 to 220 mm), in Port-au-Port Bay and St.John's Bay. Finally assessment of the present status indicate biomasses not as low as assessed in 1982 (e.g. 18 461 t. 1982 assessment as opposed to 49 300 t. in present paper for spring-spawners), and the catch projection is about 20% higher for 1983 as in 1982. Assessment parameter changes which have contributed to this more optimistic assessment include partial recruitment vectors (those used here resemble those of the 1980 assessment rather than those of the 1981-82 assessments) and the recruitment assumption for catch projections (geometric mean instead of dummy value - i.e. 5 millions).

As in earlier years, it is questionable whether $F_{0.1}$ is the appropriate strategy since major year-classes (e.g. 1968) will eventually be lost to M, suggesting that the optimal utilization of the resource might well mean higher exploitation level. This has however to be balanced against maintenance of spawning biomass. The $F_{0.1}$ values calculated here are lower than in earlier assessments, mainly because of the greater age spawn used in the calculation (to age 17 instead of age 11 in earlier years). This method of calculation is considered to better represent long-term conditions, on which $F_{0.1}$ should be based.

Like other Atlantic coast herring stocks, data are lacking in critical areas. Accurate partial recruitment rates will be particularly important to stock status assessments in the situation where incoming year-classes will largely influence stock size, as shown in present assessment of autumn-spawners. Experimental gillnet surveys are proposed as a means of more accurately determining PR's. Those surveys would be carried out by commercial fishermen.

Finally abundance indices need to be improved; inshore logbooks combined with the gillnet surveys, encompassing a subsample of coastal fishermen, have been proposed as a possible means of improving indices.

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Table 1. Newfoundland west coast herring catches (tons) 1966-1982.

Year	Areas				Total catch
	K	L	M	N	
1966	216	103	5529	18	5866
1967	216	66	5540	13	5835
1968	156	59	3978	11	4204
1969	277	46	2549	40	2912
1970	79	27	3473	301	3880
1971	3830	2424	1076	1963	9293
1972	4921	862	1544	3628	10955
1973	12537	2862	2067	9222	26688
1974	2611	856	942	2842	7251
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	6032	5043	3996	3250	18321
1980	5097	6943	2967	4113	19120
1981	3638	4900	3088	1967	13593
1982 [1]	2394	4211	1784	1615	10004

[1] Provisional data

Table 2. Herring catches (tons) from 4R subarea by gear type.

Year	K		L		M		N		Combined		Total
	Purse seine	Inshore	Purse seine	Inshore	Purse seine	Inshore	Purse seine	Inshore	Purse seine	Inshore	
1966		216		103	5490	39		18	5490	376	5866
1967		216		66	5464	76		13	5464	371	5835
1968		156		59	3776	202		11	3776	428	4204
1969	241	36		46	2344	205		40	2585	327	2912
1970	28	51	12	15	2939	534		301	2979	901	3880
1971	3287	543	2239	185	725	351	356	1607	6607	2686	9293
1972	4743	178	727	135	1330	214	--	3628	6800	4155	10955
1973	12112	425	2740	122	1763	304	3453	5769	20068	6620	26688
1974	2453	158	756	100	439	503	1071	1771	4719	2532	7251
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	4387	1645	2773	2270	2829	1167	--	3250	9989	8332	18321
1980	3480	1617	3702	3241	2001	966	427	3686	9610	9510	19120
1981	2269	1369	3277	1623	2037	1051	342	1625	7925	5668	13593
1982 [1]	897	1497	2762	1449	1280	504	0	1615	4939	5064	10004

[1] Provisional data

Table 3. A comparison of catch and quotas for the Newfoundland west coast herring stock in 1982 (allocations in brackets).

Area	Purse seine	Fixed gear	Total
St-George's Bay	897 (2200)	1497 (1000)	2394 (3200)
Port-au-Port	2762 (1650)	1449 (1500)	4211 (3150)
Cape Gregory North	1280 (1650)	2119 (2000)	3399 (3650)
Total	4939 (5500)	5065 (4500)	10004 (10000)

Table 4. Removals at age ($X10^{-3}$) from 4R herring stock (SS = Spring-spawners; AS = Autumn-spawners). Revised from earlier (Moores et al. 1982) catch matrix.

	Age	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
SS	1	0	0	0	0	0	0	372	0	0	0	0	29	0	0	4	0	0
	2	189	1	103	240	3 011	0	375	4 384	137	96	511	11	0	143	320	51	0
	3	390	8	296	1 093	1 458	3 238	254	910	235	738	997	664	40	30	992	317	181
	4	298	337	336	1 910	438	271	7 843	1 177	108	345	982	533	2 097	176	85	1 832	442
	5	586	70	583	965	660	544	1 341	30 697	294	190	229	516	210	10 967	327	97	1 605
	6	2 052	296	206	314	261	572	1 577	2 820	10 512	1 283	319	287	749	575	14 894	318	275
	7	4 127	3 545	616	173	201	453	1 879	3 139	254	8 261	2 745	346	287	1 039	412	8 773	1 540
	8	2 158	3 039	1 304	439	234	1 194	1 113	3 018	857	237	15 428	4 160	2 266	456	1 304	250	5 007
	9	1 670	1 429	2 282	975	1 015	98	1 099	1 796	689	360	764	16 333	8 617	2 710	258	593	832
	10	303	860	508	372	1 012	908	476	1 502	195	140	2 851	926	15 951	7 042	991	215	594
	11+	505	969	433	446	1 755	1 062	4 400	6 271	2 143	671	3 134	5 547	4 380	14 466	21 735	15 134	8 889
	Total	12 278	10 554	6 667	6 927	10 045	8 340	20 729	55 714	15 424	12 321	27 960	29 352	34 597	37 604	41 322	27 580	19 365
AS	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	104	0	0	17	0	31	29	0	0	0	0	0	0	0	16	0	0
	3	181	28	226	300	890	0	102	810	16	96	59	3	15	19	215	28	17
	4	639	51	131	642	176	81	113	769	269	174	47	61	53	70	83	337	743
	5	277	529	201	355	142	368	403	1 102	388	1 110	102	113	452	288	143	158	570
	6	274	306	1 037	692	250	590	755	2 596	284	327	338	302	311	2 542	253	82	297
	7	277	116	294	519	493	2 144	1 218	2 028	288	78	470	746	1 130	626	1 542	191	96
	8	1 007	322	223	158	173	3 562	1 275	2 525	222	112	108	388	1 841	1 396	224	717	296
	9	1 105	927	288	122	128	1 899	2 097	5 196	293	67	158	214	589	2 038	691	120	906
	10	926	1 128	1 208	164	228	1 273	1 254	8 047	336	63	52	99	379	552	282	98	263
	11+	2 781	3 155	2 568	1 411	2 171	14 105	9 513	17 386	4 202	2 229	3 969	7 213	5 681	6 824	5 027	2 716	2 139
	Total	7 571	6 562	6 176	4 380	4 651	24 053	16 759	40 459	6 298	4 256	5 303	9 139	10 451	14 355	8 476	4 447	5 327
Total AS + SS		19 849	17 116	12 843	11 307	14 696	32 393	37 488	96 173	21 722	16 577	33 263	38 491	45 048	51 959	49 798	32 027	24 692

Table 5. Partial recruitment rates utilized in cohort analysis for spring and autumn-spawners and average weights for 1982. PR_1 = as in Moores et al. 1982. PR_2 = mean F from trial cohorts, 1974-79. PR_3 = PR_2 smoothed.

SPAWNING TYPE		AGE									
		2	3	4	5	6	7	8	9	10	11^+
Spring-spawners											
average weight (g)		72	155	248	270	337	358	365	393	406	432
	PR_1	0.10	0.20	0.30	0.60	1.00	1.00	1.00	1.00	1.00	1.00
	PR_2	0.02	0.18	0.25	0.35	0.38	0.46	1.00	1.00	1.000	1.00
	PR_3	0.02	0.30	0.42	0.58	0.63	0.77	1.00	1.00	1.00	1.00
Autumn-spawners											
average weight (g)		50	154	223	301	326	389	424	443	501	530
	PR_1	0.01	0.05	0.10	0.20	0.50	1.00	1.00	1.00	1.00	1.00
	PR_2	0.001	0.05	0.17	0.39	0.65	1.00	1.00	1.00	1.00	1.00

Table 6. CPUE and effort data for the Newfoundland west coast fishery based on data from the purse seine fleet.

Year	Catch (t)	Catch/op. day		Effort (op. days)	
		K + L	M + N	K + L	M + N
1966	5866		63.2		92.8
1967	5835		67.5		86.4
1968	4204		65.4		4.3
1969	2912		47.8		60.9
1970	3880		38.3		101.3
1971	9293		38.6		240.8
1972	10955		31.7		345.6
1973	26688		53.0		503.5
1974	7251		--		--
1975	4995	92.6	--	53.9	--
1976	10109	89.5	--	113.0	--
1977	12286	79.8	(70.2) [2]	154.0	(175.0) [2]
1978	15610	68.5	114.7	227.9	136.1
1979	18321	73.5	54.2	249.3	338.0
1980	19120	106.5	62.9	179.5	304.0
1981	13593	68.4	24.9	198.7	545.9
1982	10004	38.8 [1]	60.5	257.8 [1]	165.4

[1] Data from 2 logs only
[2] Data from landing slips

Table 7. Monthly gillnet CPUE data (unadjusted for changes in fleet size) expressed as catch per landing for each of the four statistical areas of 4R for 1982. (Numbers of Landings in brackets.)

Area	April	May	June	July	August	September	October	November
K	0.09 (5)	1.05 (914)	--	--	--	0.14 (15)	0.10 (36)	--
L	0.54 (29)	0.66 (694)	--	0.28 (14)	--	0.17 (79)	0.21 (110)	--
M	--	0.72 (40)	0.29 (39)	0.30 (166)	0.41 (17)	0.56 (3)	0.56 (343)	0.67 (101)
N	--	--	0.39 (64)	0.52 (939)	0.58 (547)	0.40 (98)	0.92 (616)	0.56 (57)

Table 8. Gillnet catch rates from the Newfoundland west coast combined for the spring and fall fisheries and over the entire area. All values are weighted averages adjusted for increases in gang size.

Year	Adjustment factor for gang size	Area K + L (Apr.-May)			Area M + N (Oct.-Nov.)			K+L+M+N combined
		K	L	K + L	M	N	M + N	
1977	1.00	0.17	0.38	0.36	--	0.82	0.82	0.76
1978	1.10	0.58	1.13	0.89	0.77	0.62	0.65	0.80
1979	1.27	0.49	0.98	0.81	0.76	0.43	0.62	0.77
1980	1.45	0.51	0.97	0.92	0.71	0.37	0.51	0.85
1981	1.60	0.53	0.51	0.52	0.59	0.43	0.52	0.52
1982	1.60	0.66	0.41	0.58	0.37	0.56	0.49	0.54

Table 9. Paloheimo Z calculations using fall M + N gillnet effort and fall M + N gillnet catches for the period 1977-1982.

Year	Z_{5+}
1977-78	0.21
1978-79	0.34
1979-80	0.43
1980-81	0.23
1981-82	0.41

Table 10. Analyses performed to fine tune cohort analysis in 1982.

F fully recruited ages vs EFFORT

DATA UTILIZED		Ft = 0.10			Ft = 0.15			Ft = 0.20	
		SS	AS		SS	AS		SS	AS
K + L gillnet	Yo	.08	—	Yo	.12	—	Yo	.12	—
	r	.42	—	r	.42	—	r	.37	—
K + L purse seine	Yo	.01	—	Yo	.006	—	Yo	-.001	—
	r	.79	—	r	.80	—	r	.80	—
M + N gillnet	Yo	.04	.05	Yo	.06	.06	Yo	.08	.07
	r	.91	.56	r	.78	.61	r	.65	.62
M + N purse seine	Yo	.06	.14	Yo	.13	.18	Yo	.16	.22
	r	.46	-.16	r	.51	-.13	r	.49	-.11
K + L + M + N gillnet	Yo	.01	.04	Yo	.003	.04	Yo	-.007	.04
	r	.75	.32	r	.72	.39	r	.67	.43

5 + BIOMASS vs CPUE

DATA UTILIZED		Ft = 0.10			Ft = 0.15			Ft = 0.20	
		SS	AS		SS	AS		SS	AS
K + L gillnet	Yo	588	—	Yo	272	—	Yo	113	—
	r	.72	—	r	.76	—	r	.78	—
K + L purse seine	Yo	568	—	Yo	271	—	Yo	145	—
	r	.68	—	r	.67	—	r	.65	—
M + N gillnet	Yo	621	-8.84	Yo	-1085	-97	Yo	-258	-140
	r	.63	.89	r	.87	.90	r	.74	.91
M + N purse seine	Yo	1161	219	Yo	803	+139	Yo	625	99
	r	.18	.81	r	.30	.79	r	.36	.79
K + L + M + N gillnet	Yo	455	68	Yo	153	-15	Yo	0.62	-57
	r	.78	.68	r	.81	.68	r	.83	.68

Table 11. Population biomass from cohort analysis. F_t = 0.20 and M = 0.20.

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Biomass 2+ ($x10^{-3}$ t.)																	
SS	75.7	72.4	77.3	80.7	144.0	201.4	238.3	200.8	175.9	157.8	148.9	126.9	117.2	108.3	89.5	72.7	49.3
AS	226.3	211.8	193.8	172.9	151.0	142.9	97.1	85.6	68.3	59.6	47.0	39.5	34.6	27.7	24.4	21.7	20.3
Total	302.0	284.2	271.1	253.6	295.0	344.3	335.4	286.4	244.2	217.4	195.9	166.4	151.8	136.0	113.9	94.4	69.6
Biomass 5+ ($x10^{-3}$ t.)																	
SS	61.0	55.2	53.5	49.4	49.0	59.6	59.0	148.2	165.4	150.3	128.5	102.4	90.2	99.4	83.3	66.0	47.3
AS	179.5	166.3	180.0	166.9	146.6	138.0	90.8	77.9	61.9	54.8	42.6	34.6	33.1	26.1	20.1	15.8	14.2
Total	240.5	221.5	233.5	216.3	195.6	197.6	149.8	226.1	227.3	205.1	171.1	137.0	123.3	125.5	103.4	81.8	61.5

Table 12. Fishing mortalities (fully recruited ages) from cohort analysis with F_t = 0.20 and M = 0.20 for spring and autumn spawners.

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
SS	.110	.111	.069	.023	.048	.039	.100	.206	.047	.019	.086	.098	.146	.164	.223	.212	.200
AS	.015	.015	.014	.008	.009	.079	.066	.212	.043	.024	.053	.115	.168	.289	.224	.148	.200

Table 13. Average weights-at-age (g) utilized for catch projection in 1982 and 1983. Weights for ages 2-10 are 1980-82 means from commercial sampling; those for ages 11-17 are from von Bertalanffy relationships fitted to age 2-10 data.

Age	Spring - spawners	Autumn - spawners
2	81	50
3	163	134
4	234	220
5	280	262
6	319	300
7	355	359
8	370	394
9	392	420
10	398	456
11	421	496
12	430	522
13	438	545
14	443	566
15	448	584
16	451	600
> 17	451	600

Table 14. Catch projections for the west coast of Newfoundland herring stock. F_t = 0.20 and M = 0.20.
Correction factor = 1.0343. $F_{0,1}$ = 0.33 (SS) and 0.29 (AS).
Recruitment at age 2: 9.6×10^6 (SS) 9.4×10^6 (AS) averaged from 1978-81.

1983 Catch projection

	Catch (tons)	Residual biomass (tons)	
		2+	5+
Spring - spawners	8 927	23 041	21 903
Autumn - spawners	2 873	11 726	10 552
Total	11 800	34 767	32 455

1984 Catch projection

	Catch (tons)	Residual biomass (tons)	
		2+	5+
Spring - spawners	5 777	15 576	13 917
Autumn - spawners	2 409	9 506	7 601
Total	8 186	25 082	21 518

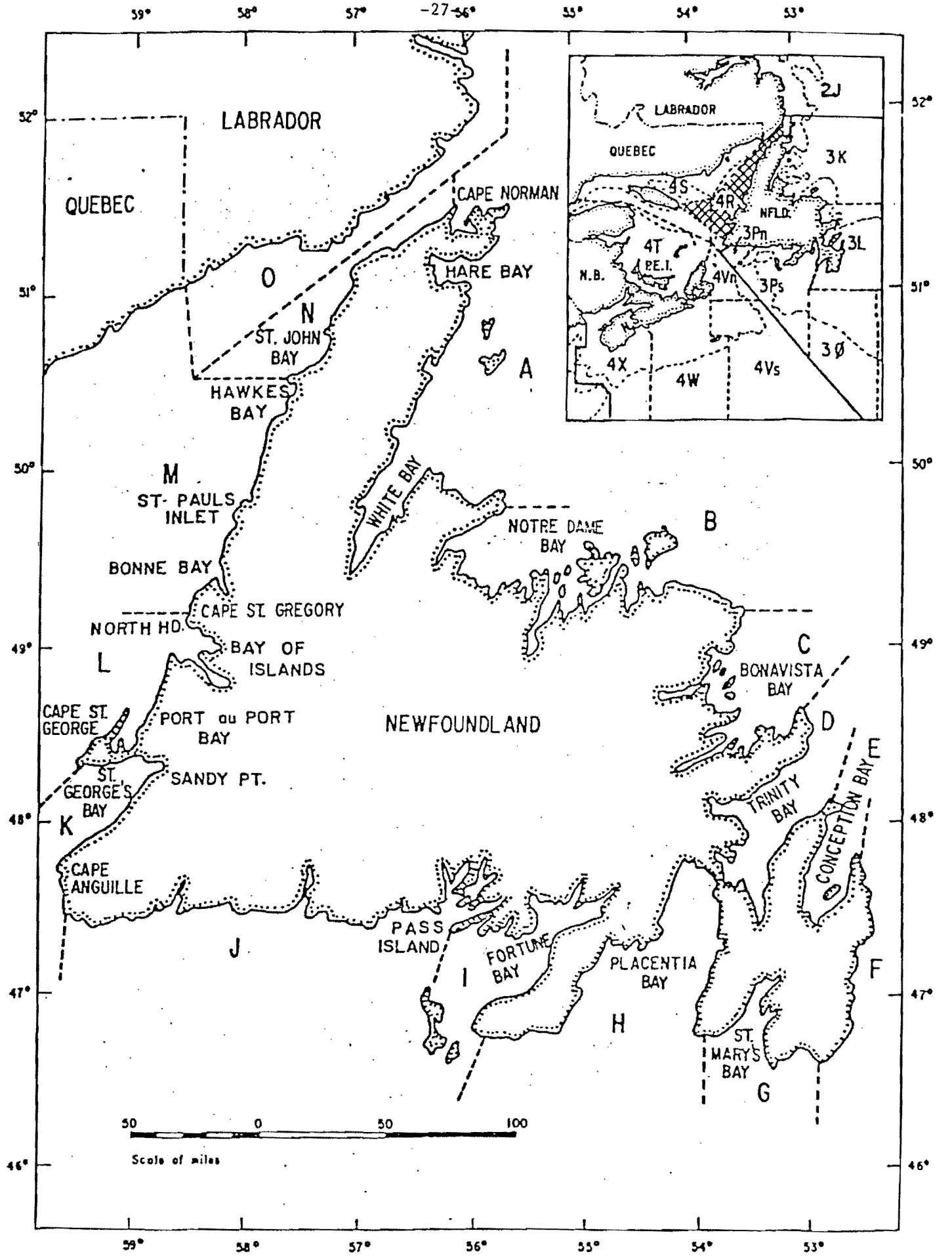

Fig. 1. Area map of Newfoundland.

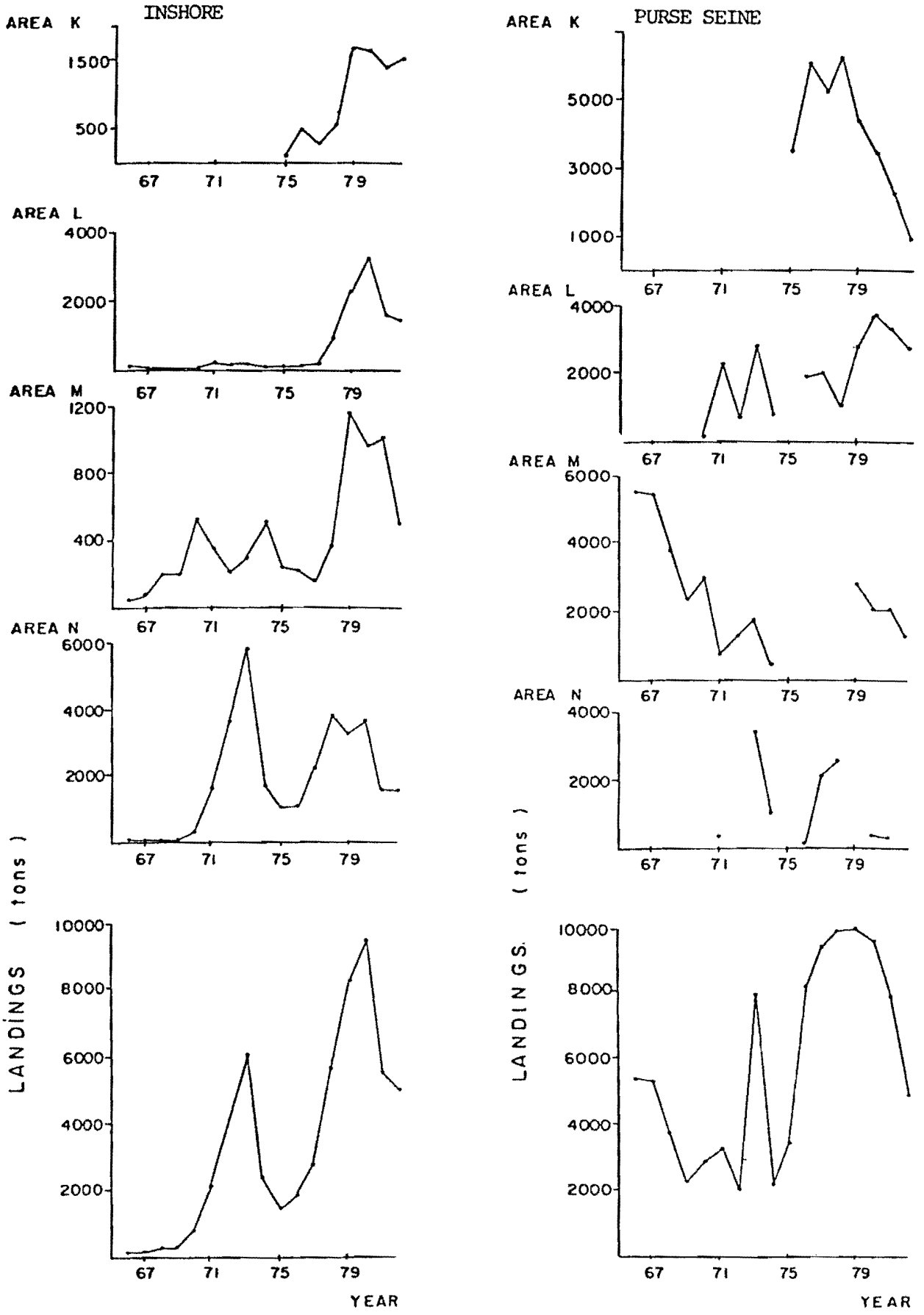

Fig. 2. Yearly landings on the west coast of Newfoundland.

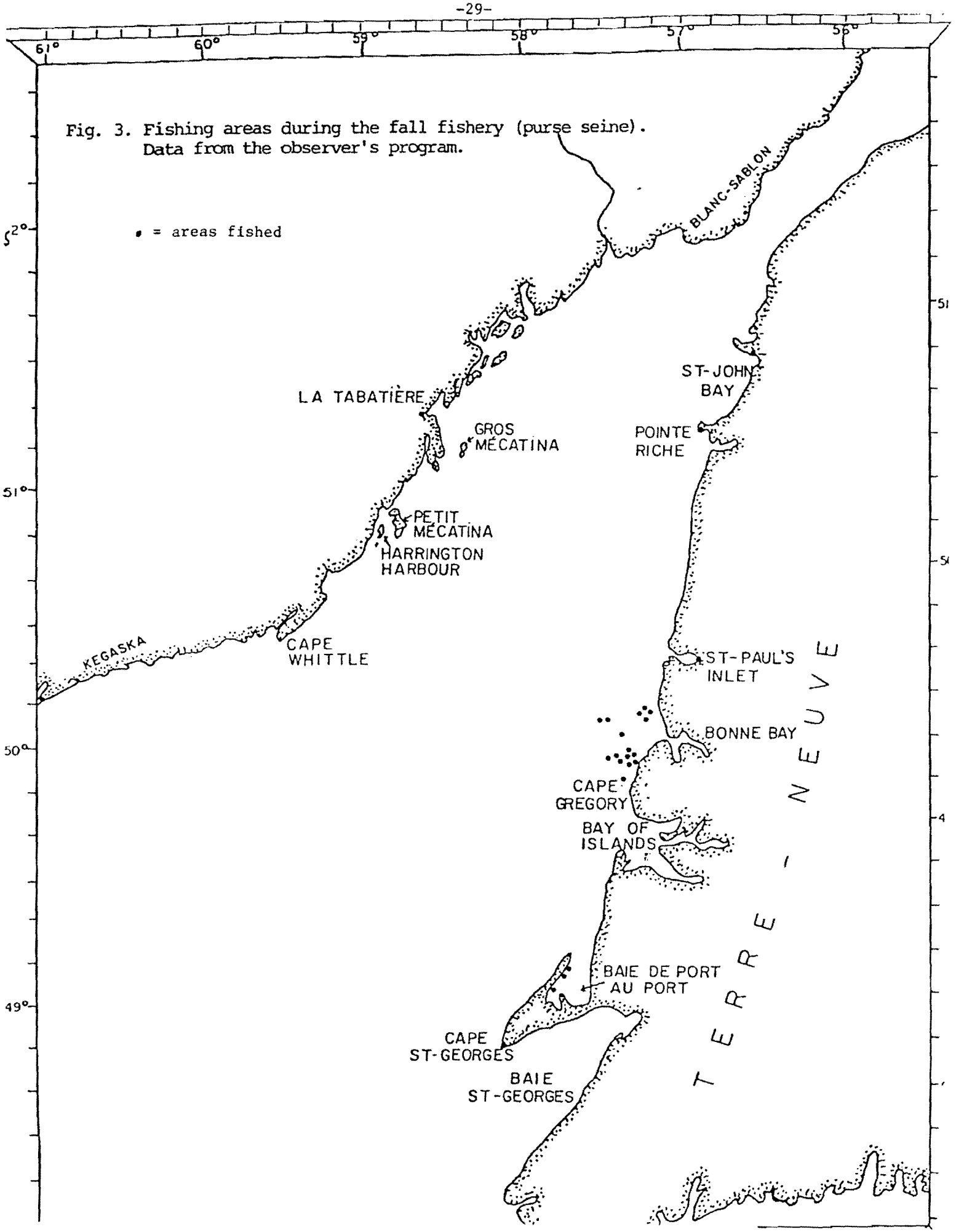

Fig. 3. Fishing areas during the fall fishery (purse seine). Data from the observer's program.

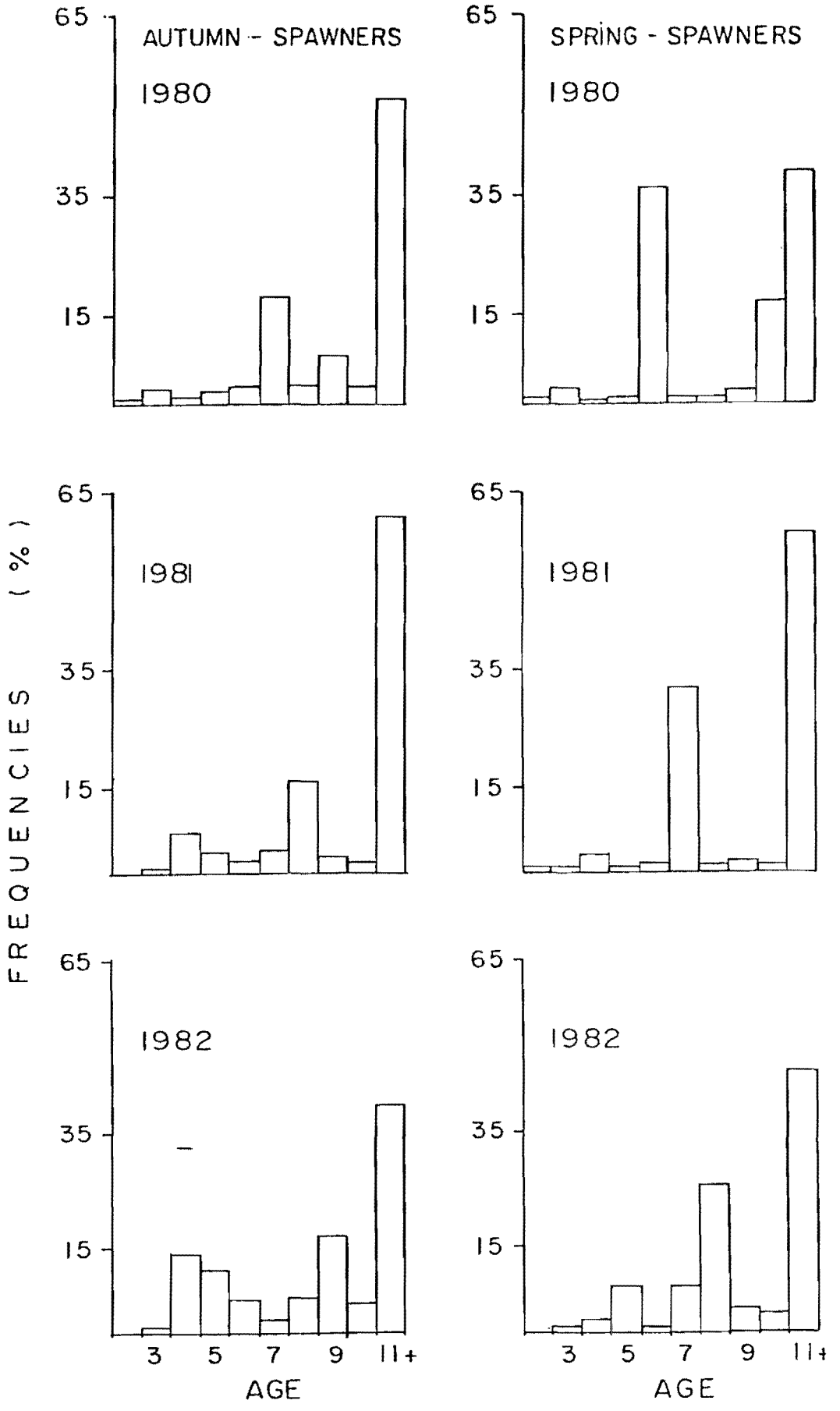

Fig. 4. Age composition of the west coast of Newfoundland herring stock (1980-1982).

CATCH MATRIX (000 NUMBERS) SPRING-SPAWNERS 15/ 3/83

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
2	189	1	103	240	3011	1	375	4384	137	96	511	11	1	143	320	51	1
3	390	8	296	1093	1458	3238	254	910	235	738	997	664	40	30	992	317	181
4	298	337	336	1910	438	271	7843	1177	108	345	982	533	2097	176	85	1832	442
5	586	70	583	965	660	544	1341	30697	294	190	229	516	210	10967	327	97	1605
6	2052	296	206	314	261	572	1577	2820	10512	1283	319	287	749	575	14894	318	275
7	4127	3545	616	173	201	453	1879	3139	254	8261	2745	346	287	1039	412	8773	1540
8	2158	3039	1304	439	234	1194	1113	3018	857	237	15428	4160	2266	456	1304	250	5007
9	1670	1429	2282	975	1015	98	1099	1796	689	360	764	16333	8617	2710	258	593	832
10	303	860	508	372	1012	908	476	1502	195	140	2851	926	15951	7042	991	215	594
11	505	363	204	241	798	389	2028	613	414	56	541	2643	628	11350	7116	660	125
12	1	606	86	97	517	306	869	2608	169	119	216	502	1789	447	11470	4739	382
13	1	1	143	41	208	198	683	1118	719	49	460	200	339	1273	452	7638	2744
14	1	1	1	67	88	80	442	878	308	206	189	426	135	241	1286	301	4424
15	1	1	1	1	144	34	179	568	242	88	796	175	288	96	244	856	174
16	1	1	1	1	1	55	76	230	157	69	340	738	118	205	97	162	496
17	1	1	1	1	1	1	123	98	63	45	267	315	499	84	207	65	94
18	1	1	1	1	1	1	1	158	27	18	174	247	213	355	85	138	38
19	1	1	1	1	1	1	1	1	44	8	70	161	167	152	359	57	80
20	1	1	1	1	1	1	1	1	1	13	31	65	109	119	154	239	29
21	1	1	1	1	1	1	1	1	1	1	50	29	44	78	120	103	174
22	1	1	1	1	1	1	1	1	1	1	1	46	20	31	79	80	42
23	1	1	1	1	1	1	1	1	1	1	1	1	31	14	31	53	30
24	1	1	1	1	1	1	1	1	1	1	1	1	1	21	14	21	17
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21	9	20
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	13	8
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	11

WEIGHT-AT-AGE (GRAMS) SPRING-SPAWNERS 15/ 3/83

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
2	76	76	76	76	76	76	76	88	76	72	71	64	76	87	98	72	72
3	150	150	150	150	150	150	196	157	150	149	135	122	167	125	158	176	155
4	196	196	196	196	196	196	203	194	196	196	177	194	172	234	221	234	248
5	225	225	225	225	225	215	210	204	225	233	227	219	247	241	261	308	270
6	257	257	257	257	257	250	275	250	240	237	238	250	279	287	291	329	337
7	278	278	278	278	278	278	277	309	299	270	259	252	289	319	341	367	358
8	296	296	296	296	296	296	279	324	313	300	290	267	292	334	351	394	365
9	322	322	322	322	322	322	317	351	318	334	310	289	314	340	367	416	393
10	333	333	333	333	333	334	346	370	333	339	319	297	328	357	375	412	406
11	363	363	363	363	363	370	363	389	371	392	380	338	344	389	409	463	432
12	363	363	363	363	363	370	363	389	371	392	380	338	344	389	409	463	432
13	363	363	363	363	363	370	363	389	371	392	380	338	344	389	409	463	432
14	363	363	363	363	363	370	363	389	371	392	380	338	344	389	409	463	432
15	363	363	363	363	363	370	363	389	371	392	380	338	344	389	409	463	432
16	363	363	363	363	363	370	363	389	371	392	380	338	344	389	409	463	432
17	363	363	363	363	363	370	363	389	371	392	380	338	344	389	409	463	432
18	363	363	363	363	363	370	363	389	371	392	380	338	344	389	409	463	432
19	363	363	363	363	363	370	363	389	371	392	380	338	344	389	409	463	432
20	363	363	363	363	363	370	363	389	371	392	380	338	344	389	409	463	432
21	363	363	363	363	363	370	363	389	371	392	380	338	344	389	409	463	432
22	363	363	363	363	363	370	363	389	371	392	380	338	344	389	409	463	432
23	363	363	363	363	363	370	363	389	371	392	380	338	344	389	409	463	432
24	363	363	363	363	363	370	363	389	371	392	380	338	344	389	409	463	432
25	363	363	363	363	363	370	363	389	371	392	380	338	344	389	409	463	432
26	363	363	363	363	363	370	363	389	371	392	380	338	344	389	409	463	432
27	363	363	363	363	363	370	363	389	371	392	380	338	344	389	409	463	432

Appendix 1. Catch matrix and weight-at-age for spring spawners.

POPULATION NUMBERS

21/ 3/8

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
2	33988	58921	159943	52678	891818	343220	51448	16354	34060	26791	190840	34074	6069	33922	8878
3	53683	27656	48240	130857	42912	727434	281004	41783	9423	27762	21848	155785	27688	4968	27643
4	20831	43599	22635	39227	106147	33814	592643	229837	33386	7502	22062	16985	126945	22796	4040
5	95562	16785	35391	18228	30358	86510	27440	478118	187109	27236	5830	17174	13424	102036	18505
6	47408	77709	13677	28448	14051	24283	70336	21252	363674	152926	22127	4566	13594	10901	73617
7	41155	36758	63355	11013	23007	11268	19363	56159	14848	288240	124044	17823	3479	10452	8323
8	23488	29960	27051	51313	8960	18655	8915	14153	43139	11927	228516	99075	14293	2588	7217
9	12666	17278	21780	20968	41615	7042	14193	6210	8857	34544	9550	173133	77352	9643	1707
10	4924	9859	12853	15767	16285	33153	5877	10626	3459	6628	27956	7128	126971	55533	5443
11	7619	3759	6475	10064	12572	12417	26322	4217	7340	2656	5300	20309	4996	89522	39095
12	165	5780	2749	5117	8021	9571	9814	19715	2898	5635	2124	3950	14236	3524	63024
13	142	134	4184	2173	4102	6099	7559	7249	13782	2220	4506	1543	2678	10037	2481
14	110	115	109	3296	1742	3170	4815	5571	4923	10633	1773	3273	1083	1902	7066
15	109	89	93	88	2638	1347	2523	3542	3767	3752	8519	1221	2294	764	1339
16	97	89	72	76	71	2030	1072	1904	2386	2865	2772	6255	890	1618	537
17	93	79	72	58	61	57	1612	809	1350	1811	2283	2142	4453	622	1139
18	93	75	63	56	47	49	46	1208	573	1049	1442	1628	1469	3194	433
19	83	75	61	51	46	37	39	37	846	445	842	1023	1109	1010	2294
20	29	67	60	49	41	37	30	31	29	653	357	626	692	757	689
21	29	23	54	49	39	33	29	23	25	23	523	264	454	468	512
22	29	23	18	43	39	31	26	23	18	19	18	383	190	332	313
23	29	23	18	14	35	31	25	20	18	14	15	14	272	138	244
24	29	23	18	14	10	27	24	19	16	14	11	11	10	195	100
25	17	23	18	14	10	8	22	19	15	12	10	8	8	8	140
26	13	13	18	14	10	8	5	17	15	11	9	8	5	6	5
27	8	10	10	14	10	7	5	3	13	11	8	6	5	4	4
2+	342398	328124	419017	389689	1204578	1320338	1124887	918902	735971	615380	683508	566373	444872	366839	275190
3+	308411	269203	259075	337010	312760	977118	1073439	902547	701911	588589	492667	534298	438803	332918	266312
4+	254728	241547	210835	206154	269848	249684	792435	860764	692488	560827	470820	378514	310915	327950	238669
5+	233897	197948	188200	166926	163701	215869	199792	630928	659102	553325	448758	361523	283970	305153	234629

	1981	1982
2	4241	276
3	6979	3426
4	21735	5427
5	3231	16137
6	14855	2559
7	46798	11874
8	6441	30375
9	5057	5047
10	1164	3603
11	3560	758
12	25569	2317
13	41221	16646
14	1622	26838
15	4621	1056
16	876	3009
17	363	570
18	745	231
19	278	485
20	1533	176
21	425	1056
22	311	255
23	185	182
24	171	103
25	69	121
26	76	49
27	3	67
2+	192157	132843
3+	187917	132567
4+	180937	128941
5+	159203	123514

Appendix 2. Population numbers from cohort analysis, spring spawners (F_t = 0.2 , M = 0.2).

FISHING MORTALITY 21/ 3/83

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
2	0.006	0.000	0.001	0.005	0.004	0.000	0.006	0.351	0.004	0.004	0.003	0.000	0.000	0.005	0.041	0.013	0.004
3	0.008	0.000	0.007	0.009	0.038	0.005	0.001	0.024	0.028	0.030	0.052	0.005	0.002	0.007	0.040	0.052	0.060
4	0.016	0.009	0.017	0.055	0.005	0.009	0.015	0.006	0.004	0.052	0.050	0.035	0.016	0.009	0.024	0.098	0.094
5	0.007	0.005	0.013	0.060	0.024	0.007	0.056	0.074	0.002	0.008	0.044	0.034	0.017	0.126	0.020	0.034	0.116
6	0.049	0.004	0.017	0.012	0.021	0.226	0.025	0.139	0.032	0.007	0.016	0.072	0.063	0.061	0.258	0.024	0.126
7	0.117	0.112	0.011	0.018	0.010	0.045	0.113	0.064	0.019	0.032	0.025	0.022	0.096	0.116	0.056	0.232	0.154
8	0.107	0.119	0.055	0.010	0.030	0.073	0.150	0.269	0.022	0.022	0.078	0.048	0.193	0.217	0.210	0.044	0.220
9	0.157	0.096	0.123	0.053	0.027	0.015	0.089	0.385	0.090	0.012	0.093	0.110	0.131	0.372	0.183	0.139	0.300
10	0.070	0.113	0.045	0.026	0.071	0.031	0.097	0.170	0.064	0.024	0.120	0.135	0.119	0.151	0.225	0.228	0.200
11	0.076	0.113	0.035	0.027	0.073	0.035	0.089	0.175	0.064	0.024	0.120	0.155	0.150	0.151	0.225	0.229	0.200
12	0.007	0.123	0.035	0.021	0.074	0.036	0.103	0.158	0.067	0.021	0.119	0.156	0.150	0.151	0.225	0.229	0.200
13	0.008	0.008	0.039	0.021	0.038	0.037	0.105	0.137	0.059	0.025	0.120	0.155	0.150	0.151	0.225	0.229	0.200
14	0.010	0.010	0.010	0.023	0.057	0.023	0.107	0.191	0.072	0.022	0.125	0.155	0.148	0.151	0.225	0.230	0.200
15	0.010	0.013	0.012	0.013	0.062	0.028	0.032	0.195	0.074	0.026	0.109	0.164	0.149	0.149	0.225	0.229	0.200
16	0.011	0.013	0.015	0.015	0.016	0.030	0.082	0.143	0.076	0.027	0.134	0.140	0.158	0.151	0.222	0.229	0.200
17	0.012	0.014	0.016	0.019	0.018	0.019	0.088	0.144	0.053	0.028	0.138	0.177	0.132	0.162	0.224	0.227	0.200
18	0.012	0.015	0.018	0.019	0.024	0.023	0.024	0.156	0.053	0.019	0.143	0.164	0.175	0.131	0.244	0.229	0.200
19	0.013	0.015	0.018	0.022	0.024	0.030	0.029	0.039	0.059	0.020	0.096	0.191	0.182	0.182	0.190	0.257	0.200
20	0.039	0.017	0.018	0.023	0.027	0.030	0.038	0.036	0.039	0.022	0.101	0.122	0.191	0.191	0.284	0.186	0.220
21	0.039	0.049	0.021	0.023	0.029	0.035	0.038	0.049	0.046	0.049	0.112	0.129	0.113	0.204	0.300	0.312	0.229
22	0.039	0.049	0.064	0.026	0.029	0.036	0.044	0.049	0.063	0.059	0.063	0.140	0.124	0.109	0.327	0.335	0.210
23	0.039	0.050	0.064	0.084	0.032	0.036	0.046	0.056	0.063	0.082	0.077	0.083	0.135	0.119	0.152	0.382	0.200
24	0.039	0.050	0.064	0.084	0.113	0.041	0.046	0.059	0.073	0.083	0.111	0.103	0.110	0.127	0.168	0.145	0.229
25	0.069	0.050	0.064	0.085	0.113	0.158	0.053	0.060	0.078	0.099	0.111	0.154	0.142	0.157	0.181	0.155	0.200
26	0.091	0.091	0.065	0.085	0.114	0.159	0.234	0.068	0.078	0.104	0.134	0.155	0.228	0.207	0.233	0.162	0.229
27	0.157	0.123	0.123	0.085	0.114	0.159	0.234	0.385	0.090	0.104	0.143	0.191	0.228	0.372	0.327	0.382	0.200
8+	0.110	0.111	0.069	0.023	0.048	0.039	0.100	0.206	0.047	0.019	0.086	0.098	0.146	0.164	0.223	0.212	0.200

Appendix 3. Fishing mortalities from cohort analysis, spring spawners (F_t = 0.2, M = 0.2).

HERRING AREA KLMN 83/1
CATCH PROJECTION FOR 1983

AGE	POPULATION NUMBERS	POPULATION WEIGHT	FISHING MORTALITY	CATCH NUMBERS	CATCH WEIGHT	RESIDUAL NUMBERS	RESIDUAL WEIGHT
2	9600.	778.	.007	57.	5.	7808.	632.
3	225.	37.	.099	19.	3.	167.	27.
4	2641.	618.	.139	311.	73.	1883.	441.
5	4550.	1274.	.191	721.	202.	3076.	861.
6	11765.	3753.	.208	2009.	641.	7824.	2496.
7	1846.	655.	.254	377.	134.	1172.	416.
8	8334.	3084.	.330	2135.	790.	4906.	1815.
9	20361.	7981.	.330	5215.	2044.	11985.	4698.
10	3383.	1347.	.330	867.	345.	1991.	793.
11	2415.	1017.	.330	619.	260.	1422.	599.
12	508.	219.	.330	130.	56.	299.	129.
13	1553.	680.	.330	398.	174.	914.	400.
14	11159.	4943.	.330	2858.	1266.	6568.	2910.
15	17990.	8060.	.330	4608.	2064.	10589.	4744.
16	708.	319.	.330	181.	82.	416.	188.
17	2017.	916.	.330	517.	235.	1187.	539.
18	382.	174.	.330	98.	44.	225.	102.
19	155.	70.	.330	40.	18.	91.	41.
20	325.	148.	.330	83.	38.	191.	87.
21	118.	54.	.330	30.	14.	69.	32.
22	708.	321.	.330	181.	82.	416.	189.
23	171.	78.	.330	44.	20.	101.	46.
24	122.	55.	.330	31.	14.	72.	33.
25	69.	31.	.330	18.	8.	41.	18.
26	91.	37.	.330	21.	9.	48.	22.
27	77.	35.	.330	20.	9.	45.	21.
TOTAL	101265.	36683.		21587.	8431.	83508.	32277.

Appendix 4. Catch projection for 1983, spring-spawners.

HERRING AREA KLMN SS/I
CATCH PROJECTION FOR 1984

AGE	POPULATION NUMBERS	POPULATION WEIGHT	FISHING MORTALITY	CATCH NUMBERS	CATCH WEIGHT	RESIDUAL NUMBERS	RESIDUAL WEIGHT
2	9600.	778.	.007	57.	5.	7808.	632.
3	7808.	1273.	.099	668.	109.	5790.	944.
4	167.	39.	.139	20.	5.	119.	28.
5	1883.	527.	.191	298.	83.	1273.	356.
6	3076.	981.	.208	525.	168.	2046.	653.
7	7824.	2779.	.254	1598.	567.	4969.	1764.
8	1172.	434.	.330	300.	111.	690.	255.
9	4906.	1923.	.330	1257.	493.	2887.	1132.
10	11985.	4770.	.330	3070.	1222.	7054.	2808.
11	1991.	838.	.330	510.	215.	1172.	493.
12	1422.	611.	.330	364.	157.	837.	360.
13	299.	131.	.330	77.	34.	176.	77.
14	914.	405.	.330	234.	104.	538.	238.
15	6568.	2942.	.330	1682.	754.	3866.	1732.
16	10589.	4776.	.330	2712.	1223.	6233.	2811.
17	416.	189.	.330	107.	48.	245.	111.
18	1187.	539.	.330	304.	138.	699.	317.
19	225.	102.	.330	58.	26.	132.	60.
20	91.	41.	.330	23.	11.	54.	24.
21	191.	87.	.330	49.	22.	113.	51.
22	69.	32.	.330	18.	8.	41.	19.
23	416.	189.	.330	107.	48.	245.	111.
24	101.	46.	.330	26.	12.	59.	27.
25	72.	33.	.330	18.	8.	42.	19.
26	41.	18.	.330	10.	5.	24.	11.
27	93.	42.	.330	24.	11.	55.	25.
TOTAL	73108.	24524.		14117.	5585.	47167.	15059.

Appendix 5. Catch projection for 1984, spring-spawners.

CATCH MATRIX (000 NUMBERS) AUTUMN-SPAWNERS 15/ 3/83

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
2	104	1	1	17	1	31	29	1	1	1	1	1	1	1	16	1	1
3	181	28	226	300	890	1	102	810	16	96	59	3	15	19	215	28	17
4	639	51	131	642	176	81	113	769	269	174	47	61	53	70	83	337	743
5	277	529	201	355	142	368	403	1102	388	1110	102	113	452	288	143	158	510
6	274	306	1037	692	250	590	755	2596	284	327	338	302	311	2542	253	82	297
7	277	116	294	519	493	2144	1218	2028	288	78	470	739	1130	626	1542	191	96
8	1007	322	223	158	173	3562	1275	2525	222	112	108	387	1841	1396	224	717	296
9	1105	927	288	122	128	1899	2097	5196	293	67	158	214	589	2038	691	120	906
10	926	1128	1208	164	228	1273	1254	8047	336	63	52	99	379	552	282	98	263
11	2781	788	677	452	226	1341	788	2026	1330	165	109	93	78	428	377	145	74
12	1	2367	472	253	623	1329	830	1272	335	653	286	194	73	88	292	193	110
13	1	1	1419	176	349	3663	822	1340	210	165	1131	509	152	82	60	149	147
14	1	1	1	530	243	2052	2266	1327	221	103	286	2014	398	171	56	31	113
15	1	1	1	1	730	1429	1269	3659	219	109	178	509	1576	448	117	29	24
16	1	1	1	1	1	4291	884	2049	605	108	189	317	398	1775	305	60	22
17	1	1	1	1	1	1	2654	1427	339	297	187	337	248	448	1210	156	46
18	1	1	1	1	1	1	1	4286	236	167	514	333	264	279	305	619	119
19	1	1	1	1	1	1	1	1	707	116	289	915	261	297	190	156	470
20	1	1	1	1	1	1	1	1	1	346	201	515	716	294	202	97	118
21	1	1	1	1	1	1	1	1	1	1	599	358	403	806	200	103	74
22	1	1	1	1	1	1	1	1	1	1	1	1065	280	454	549	102	78
23	1	1	1	1	1	1	1	1	1	1	1	1	834	315	309	281	78
24	1	1	1	1	1	1	1	1	1	1	1	1	1	939	215	158	214
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	640	110	120
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	327	84
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	248

WEIGHT-AT-AGE (GRAMS) AUTUMN-SPAWNERS 15/ 3/83

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
2	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
3	120	120	120	120	120	120	120	161	120	114	91	120	120	114	122	126	154
4	174	174	174	174	174	174	174	181	215	164	156	163	174	165	224	212	223
5	226	226	226	226	226	226	226	254	225	221	190	224	228	239	229	257	301
6	253	253	253	253	253	272	238	293	235	248	240	231	252	270	287	288	326
7	284	284	284	284	284	308	239	306	284	273	255	258	315	321	321	368	389
8	307	307	307	307	307	328	275	315	307	278	307	277	319	348	357	400	424
9	319	319	319	319	319	362	280	324	319	305	319	319	323	361	380	436	443
10	337	337	337	337	337	378	287	349	376	372	337	337	337	370	381	486	501
11	405	405	405	405	405	448	376	362	415	432	393	382	418	415	497	524	530
12	405	405	405	405	405	448	376	362	415	432	393	382	418	415	497	524	530
13	405	405	405	405	405	448	376	362	415	432	393	382	418	415	497	524	530
14	405	405	405	405	405	448	376	362	415	432	393	382	418	415	497	524	530
15	405	405	405	405	405	448	376	362	415	432	393	382	418	415	497	524	530
16	405	405	405	405	405	448	376	362	415	432	393	382	418	415	497	524	530
17	405	405	405	405	405	448	376	362	415	432	393	382	418	415	497	524	530
18	405	405	405	405	405	448	376	362	415	432	393	382	418	415	497	524	530
19	405	405	405	405	405	448	376	362	415	432	393	382	418	415	497	524	530
20	405	405	405	405	405	448	376	362	415	432	393	382	418	415	497	524	530
21	405	405	405	405	405	448	376	362	415	432	393	382	418	415	497	524	530
22	405	405	405	405	405	448	376	362	415	432	393	382	418	415	497	524	530
23	405	405	405	405	405	448	376	362	415	432	393	382	418	415	497	524	530
24	405	405	405	405	405	448	376	362	415	432	393	382	418	415	497	524	530
25	405	405	405	405	405	448	376	362	415	432	393	382	418	415	497	524	530
26	405	405	405	405	405	448	376	362	415	432	393	382	418	415	497	524	530
27	405	405	405	405	405	448	376	362	415	432	393	382	418	415	497	524	530

Appendix 6. Catch matrix and weight-at-age for autumn-spawners.

POPULATION NUMBERS

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	84671	32033	16131	15253	21060	23664	30188	16124	12344	36896	7830	2209	6451	14493	38618	2303
3	249927	69245	26225	13206	12473	17241	19346	24690	13200	10135	30207	6410	1809	5281	11965	23967
4	72418	204459	56667	21267	10540	9467	14115	15747	19481	10763	8196	24678	5245	1467	4306	9520
5	44459	58713	167351	46277	16831	8471	7628	11454	12197	15707	8579	6660	20149	4247	1138	3451
6	46758	36182	47591	126833	37567	13651	6602	5881	8331	9633	11855	7014	5351	16088	3215	802
7	46889	38034	29547	88026	111403	30531	10643	4722	2466	6605	7572	9400	5469	4079	10971	2484
8	109917	38139	31035	23761	30664	90763	23057	7612	2031	1758	5337	5791	7028	3455	2790	7506
9	74348	105456	30934	25207	19311	24949	71088	17724	3947	1462	1338	4272	4391	4098	1566	2081
10	51973	59871	85501	25066	20528	15695	18708	56304	9809	2967	1136	953	3304	3062	1503	657
11	154937	41718	47999	68909	20374	16600	11698	14182	33817	7727	2372	983	690	2362	2068	975
12	256	124336	33443	38685	56009	16476	12378	8364	9778	30577	6177	1843	639	495	1547	1303
13	169	209	99656	26954	31443	45293	12297	9383	6107	7703	24444	4799	1334	457	325	1002
14	124	137	170	80307	21908	25428	33768	9316	6470	4810	6157	18989	3468	954	309	213
15	130	100	111	138	65270	17717	18962	25597	6427	5097	3845	4782	13725	2479	627	195
16	132	105	81	90	112	52778	13213	14376	17646	5063	4074	2987	3455	9811	1625	407
17	189	77	85	66	73	91	39329	10018	9916	13909	4049	3165	2158	2468	6426	1054
18	302	153	37	69	53	59	74	29798	6911	7812	11112	3145	2265	1543	1616	4167
19	150	247	125	70	55	42	47	59	20519	5444	6248	8832	2274	1633	1011	1047
20	39	122	201	101	57	44	34	38	48	16159	4353	4851	6240	1625	1068	656
21	69	31	99	164	82	45	36	27	30	38	12917	3382	3606	4461	1065	672
22	48	55	25	80	133	66	36	28	21	24	30	10034	2445	2506	2923	691
23	268	39	44	19	65	108	53	29	22	16	19	24	7251	1748	1641	1375
24	354	218	31	36	15	52	88	43	23	17	12	14	19	5182	1146	1064
25	119	207	178	24	28	11	42	71	34	18	13	9	11	14	3393	744
26	89	96	169	145	19	22	8	33	57	27	14	10	7	8	11	2199
27	75	72	78	137	118	15	17	6	26	46	21	10	7	5	6	8
2+	958774	810084	673361	560890	476191	409220	343444	282125	206706	200405	160013	134746	108710	94031	100610	77001
3+	874083	778052	647231	545637	455131	385557	313255	266001	194363	163599	160183	132737	102258	89538	83991	74693
4+	624156	709607	631006	532431	442659	368313	293909	241312	181163	153404	129976	126326	100450	84257	72126	66731
5+	551739	504348	574339	511164	432118	358909	279794	225565	161631	142611	121790	101649	95295	79790	67819	56211

	1982
2	5517
3	1835
4	24509
5	7469
6	2682
7	582
8	1796
9	5496
10	1595
11	449
12	667
13	892
14	686
15	146
16	133
17	179
18	702
19	2851
20	716
21	449
22	473
23	473
24	1298
25	728
26	510
27	1504
2+	64529
3+	59012
4+	57177
5+	32668

Appendix 7. Populations numbers from cohort analysis, autumn-spawners (F_t = 0.2, M = 0.2).

FISHING MORTALITY 21/ 3/83

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
2	0.001	0.000	0.000	0.001	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000
3	0.001	0.000	0.010	0.025	0.082	0.000	0.006	0.037	0.001	0.011	0.002	0.001	0.009	0.004	0.020	0.001	0.010
4	0.010	0.000	0.003	0.034	0.019	0.010	0.009	0.055	0.015	0.018	0.006	0.003	0.011	0.054	0.022	0.040	0.034
5	0.007	0.010	0.001	0.009	0.009	0.049	0.060	0.112	0.036	0.081	0.013	0.019	0.025	0.078	0.150	0.052	0.078
6	0.006	0.009	0.024	0.006	0.007	0.049	0.135	0.269	0.038	0.038	0.030	0.049	0.066	0.192	0.091	0.120	0.130
7	0.007	0.003	0.011	0.015	0.005	0.081	0.135	0.344	0.139	0.013	0.071	0.091	0.259	0.185	0.170	0.092	0.203
8	0.009	0.009	0.008	0.007	0.006	0.144	0.063	0.457	0.129	0.073	0.023	0.077	0.342	0.592	0.093	0.112	0.200
9	0.017	0.010	0.019	0.005	0.007	0.068	0.033	0.392	0.086	0.052	0.140	0.057	0.160	0.801	0.587	0.366	0.200
10	0.020	0.021	0.016	0.007	0.012	0.094	0.077	0.172	0.039	0.024	0.052	0.122	0.136	0.222	0.232	0.180	0.200
11	0.020	0.021	0.016	0.007	0.012	0.094	0.077	0.172	0.039	0.024	0.052	0.124	0.133	0.223	0.233	0.179	0.200
12	0.004	0.021	0.016	0.007	0.012	0.093	0.077	0.173	0.039	0.024	0.053	0.124	0.135	0.219	0.234	0.179	0.200
13	0.007	0.005	0.016	0.007	0.012	0.094	0.077	0.172	0.039	0.024	0.052	0.125	0.133	0.221	0.228	0.180	0.200
14	0.009	0.008	0.007	0.007	0.012	0.093	0.077	0.171	0.038	0.024	0.053	0.125	0.136	0.221	0.231	0.176	0.200
15	0.009	0.011	0.010	0.008	0.012	0.093	0.077	0.172	0.038	0.024	0.053	0.125	0.136	0.223	0.231	0.179	0.200
16	0.008	0.011	0.014	0.012	0.010	0.094	0.077	0.171	0.039	0.024	0.053	0.125	0.136	0.223	0.233	0.178	0.200
17	0.006	0.010	0.013	0.017	0.015	0.012	0.078	0.171	0.039	0.024	0.052	0.125	0.136	0.224	0.233	0.179	0.200
18	0.004	0.007	0.013	0.016	0.021	0.019	0.015	0.173	0.038	0.024	0.052	0.124	0.137	0.223	0.234	0.179	0.200
19	0.007	0.004	0.009	0.016	0.020	0.026	0.024	0.017	0.039	0.024	0.052	0.125	0.136	0.224	0.233	0.180	0.200
20	0.029	0.009	0.006	0.011	0.020	0.025	0.033	0.030	0.023	0.024	0.052	0.125	0.136	0.223	0.234	0.179	0.200
21	0.016	0.036	0.011	0.007	0.014	0.025	0.032	0.042	0.037	0.029	0.053	0.124	0.136	0.223	0.233	0.180	0.200
22	0.023	0.020	0.046	0.014	0.008	0.017	0.031	0.040	0.054	0.048	0.037	0.125	0.135	0.223	0.233	0.178	0.200
23	0.004	0.029	0.025	0.059	0.017	0.010	0.021	0.039	0.051	0.070	0.062	0.047	0.136	0.222	0.233	0.179	0.200
24	0.004	0.005	0.037	0.032	0.077	0.021	0.013	0.026	0.050	0.066	0.093	0.081	0.061	0.223	0.232	0.179	0.200
25	0.009	0.005	0.006	0.047	0.040	0.104	0.027	0.016	0.033	0.065	0.087	0.127	0.108	0.080	0.234	0.178	0.200
26	0.012	0.012	0.007	0.008	0.060	0.051	0.143	0.034	0.020	0.042	0.085	0.118	0.181	0.151	0.107	0.180	0.200
27	0.015	0.015	0.014	0.008	0.009	0.078	0.066	0.207	0.043	0.024	0.053	0.114	0.166	0.276	0.220	0.148	0.200
7+	0.015	0.015	0.014	0.008	0.009	0.079	0.066	0.212	0.043	0.024	0.053	0.115	0.168	0.289	0.224	0.146	0.200

Appendix 8. Fishing mortalities from cohort analysis, autumn-spawners (F_t = 0.2, M = 0.2).

HERRING AREA KLMN AS/1
CATCH PROJECTION FOR 1983

AGE	POPULATION NUMBERS	POPULATION WEIGHT	FISHING MORTALITY	CATCH NUMBERS	CATCH WEIGHT	RESIDUAL NUMBERS	RESIDUAL WEIGHT
2	9400.	470.	.000	2.	0.	7694.	385.
3	4516.	605.	.014	59.	8.	3644.	488.
4	1528.	336.	.049	67.	15.	1191.	262.
5	19395.	5082.	.113	1883.	493.	14182.	3716.
6	5671.	1701.	.188	686.	206.	3846.	1154.
7	1928.	692.	.290	442.	159.	1181.	424.
8	390.	154.	.290	89.	35.	239.	94.
9	1204.	506.	.290	276.	116.	738.	310.
10	3684.	1480.	.290	845.	395.	2257.	1029.
11	1069.	530.	.290	245.	122.	655.	325.
12	301.	157.	.290	69.	36.	184.	96.
13	447.	244.	.290	103.	56.	274.	149.
14	598.	338.	.290	137.	78.	366.	207.
15	460.	269.	.290	105.	62.	282.	165.
16	98.	59.	.290	22.	13.	60.	36.
17	89.	53.	.290	20.	12.	55.	33.
18	187.	112.	.290	43.	26.	115.	69.
19	484.	290.	.290	111.	67.	296.	178.
20	1911.	1147.	.290	438.	263.	1171.	702.
21	480.	288.	.290	110.	66.	294.	176.
22	301.	181.	.290	69.	41.	184.	111.
23	317.	190.	.290	73.	44.	194.	117.
24	317.	190.	.290	73.	44.	194.	117.
25	870.	522.	.290	199.	120.	533.	320.
26	488.	293.	.290	112.	67.	299.	179.
27	1350.	810.	.290	310.	186.	827.	496.
TOTAL	57494.	16899.		6789.	2778.	40954.	11337.

Appendix 9. Catch projection for 1983, autumn spawners.

HERRING AREA KLMN AS/1
CATCH PROJECTION FOR 1984

AGE	POPULATION NUMBERS	POPULATION WEIGHT	FISHING MORTALITY	CATCH NUMBERS	CATCH WEIGHT	RESIDUAL NUMBERS	RESIDUAL WEIGHT
2	9400.	470.	.000	2.	0.	7694.	385.
3	7694.	1031.	.014	100.	13.	6209.	832.
4	3644.	802.	.049	159.	35.	2840.	625.
5	1191.	312.	.113	116.	30.	871.	228.
6	14182.	4254.	.188	2215.	665.	9616.	2885.
7	3846.	1381.	.290	882.	317.	2356.	846.
8	1181.	465.	.290	271.	107.	724.	285.
9	239.	100.	.290	55.	23.	146.	61.
10	738.	336.	.290	169.	77.	452.	206.
11	2257.	1119.	.290	517.	257.	1383.	686.
12	655.	342.	.290	150.	78.	401.	209.
13	184.	100.	.290	42.	23.	113.	62.
14	274.	155.	.290	63.	36.	168.	95.
15	366.	214.	.290	84.	49.	224.	131.
16	282.	169.	.290	65.	39.	173.	104.
17	60.	36.	.290	14.	8.	37.	22.
18	55.	33.	.290	13.	8.	33.	20.
19	115.	69.	.290	26.	16.	70.	42.
20	296.	178.	.290	68.	41.	182.	109.
21	1171.	702.	.290	268.	161.	717.	430.
22	294.	176.	.290	67.	40.	180.	108.
23	184.	111.	.290	42.	25.	113.	68.
24	194.	117.	.290	45.	27.	119.	71.
25	194.	117.	.290	45.	27.	119.	71.
26	533.	320.	.290	122.	73.	327.	196.
27	1126.	676.	.290	258.	155.	690.	414.
TOTAL	50354.	13785.		5858.	2329.	35955.	9191.

Appendix 10. Catch projection for 1984, autumn spawners.