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A Review of the West Coast of Newfoundland (NAFO Division 4R) Herring Fishery Data up to 1991

by

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ABSTRACT

Herring stocks are exploited in NAFO Division 4R from April to December, by both fixed and mobile gears. Landings reached only 19,400 t in 1991, despite a TAC of 35,000 t, mainly due to poor market and late-fall weather conditions. A limited market demand for gillnetted herring has reduced the fixed gear landings to < 20% of the total since 1985. The traditional U.S. barrelled-product market has been slowly replaced by over-the-side sales to the Russians, and frozen-round products for the Japanese. Spring spawners have been prevalent in the annual catches since 1973. Historically, this spawning group has been dominated by the 1968 and 1974 year-classes. Since 1985, the 1980 and 1982 year-classes have comprised > 68% of the catch in numbers. The fall spawners had been dominated by the 11+ age group until 1983, when the 1979 year-class became the single most important cohort in the catch. The spring index-fishermen gillnet catch-rate series showed a significant increase from 1984 to 1987, a subsequent decreasing trend to 1990 and an increase in 1991. The fall-spawner series showed an increase to 1985, followed by a declining trend between 1987 and 1990, increasing again in 1991. Cohort analysis were not attempted as the population numbers were unconverged in the last analytical assessment. However, the 1987 spring-spawner year-class, and 1986 fall-spawner cohort, have appeared in the purse seine catches in numbers not seen since the 1980 cohort recruited to the fishery. This is a promising sign for the continued good health of these stocks.

RÉSUMÉ

Les stocks de hareng de la division 4R de l'OPANO sont exploitées d'avril à décembre, à l'aide d'engins fixes et mobiles. Malgré un TPA de 35,000 t, les débarquements de hareng n'ont atteint que 19,400 t en 1991, particulièrement à cause des marchés restreints et des mauvaises conditions météorologiques à l'automne. Un marché restreint pour les harengs capturés au filet maillant a réduit les débarquements associés aux engins fixes à moins de 20% du total depuis 1985. Le marché traditionnel américain du hareng en baril a été remplacé graduellement par les ventes directes aux Russes et par les ventes aux Japonais de poissons gelés entiers. Les reproducteurs de printemps dominent les captures depuis 1973. Les classes d'âge de 1968 et 1974 ont dominé historiquement les captures de ce groupe reproducteur. Cependant, les classes d'âge de 1980 et 1982 ont représenté plus de 68% de la capture en nombre depuis 1985. Les captures de reproducteurs d'automne entre 1966 et 1983 étaient constituées d'une forte proportion de poissons âgés de 11 ans et plus. Depuis 1983, la classe d'âge de 1979 a dominé les captures. L'indice d'abondance des reproducteurs de printemps calculé à partir des données des pêcheurs-repères a démontré une augmentation d'abondance significative entre 1984 et 1987, une diminution subséquente jusqu'à 1990, et ensuite une augmentation jusqu'à 1991. L'indice du groupe d'automne a démontré une augmentation jusqu'à 1985, suivie par un déclin entre 1987 et 1990, et encore une augmentation jusqu'à 1991. L'analyse de cohorte n'a pas été considérée cette année étant donné les estimations des effectifs non-convergentes produites par la dernière évaluation analytique. Cependant, les classes d'âge de 1987 et 1986 des reproducteurs de printemps et d'automne, respectivement, ont paru dans les prises de la senne bourse dans des quantités non observées depuis le recrutement de la classe d'âge de 1980. Ceci est un signe révélateur de bonne santé de ces stocks.

INTRODUCTION

Atlantic herring (*Clupea harengus* L.) in NAFO Division 4R (Figure 1) have been assessed by CAFSAC as a single management unit since 1977 (Moores and Winters, 1977). The 4R herring management unit was defined essentially on the basis of tagging studies conducted between 1975 and 1980 (Moores and Winters, 1984). These studies indicated that herring tagged during the pre-spawning, spawning and overwintering seasons along the west coast of Newfoundland were primarily (99.2%) recaptured within Division 4R. This division was therefore considered to be "an appropriate reference for [herring] stock assessment purposes" (Moores and Winters, 1984). Although there were indications from sampling and tagging data that herring concentrations exploited in Bay St. Georges in the spring fishery between 1967 and 1972 were possibly a mixture of west coast and southern Gulf stocks, Moores (1983) concluded that herring caught in this area since 1973 were primarily of west coast origin.

As in previous assessments, the spring- and fall-spawning components of the west coast of Newfoundland herring resource have been reviewed separately. It is generally accepted that sympatric spring and fall spawners in the northwest Atlantic have different adult life histories and therefore should be treated as separate stocks within each management unit.

DESCRIPTION OF THE FISHERY AND HISTORICAL FISHING PATTERNS

The herring stocks in NAFO Division 4R are exploited mainly by large (>85') purse seiners and to a much lesser extent by fixed gillnetters from April to December on both spawning and overwintering concentrations. Since 1985, the proportion of the total catch taken by the purse seines has been in excess of 80%, and reached 97% in 1991.

Total herring landings from the west coast of Newfoundland were relatively small from 1966 to 1970, ranging between 3,000 and 6,000 mt (Table 1, Figure 2). A marked increase in catches began in 1971, peaking at 27,000 mt in 1973, as plant processors shifted from fish meal production to barrelled products for human consumption subsequent to the decline of the North Sea herring stocks. Landings in 4R decreased sharply in 1974 and 1975 as the purse seine fleet shifted its activities to the overwintering herring concentrations in NAFO subdivision 4Vn. Again, landings steadily increased between 1976 and 1980, this trend being reversed in 1981, mainly due to depressed markets. Augmented sales to eastern block countries in 1985 stimulated another increasing trend in landings which peaked at 21,400 mt in 1986, but which has levelled off at between 16,500 mt and 19,400 mt in the last five years.

From 1983 to 1987, the majority of the purse seine catches were taken in areas 4Rb and 4Rc from October to December (Table 2a) from overwintering concentrations of mixed spring and fall spawners (Table 3). This fishery contributed to over 80% of the purse seine landings in 1986 and 1987. In recent years, the traditional barrelled-product market for Newfoundland herring has been slowly replaced by an expansion in over-the-side sales (OSS) to the Russians, and by the development of a spring frozen-round market for the Japanese. This, along with some quota sharing with the purse seine fleet based in the southern Gulf of St. Lawrence, explains the considerable

increase in landings from the spring fishery in 4Rc and 4Rd (from approximately 2,000 mt in 1987 to 12,400 mt in 1991). This spring fishery accounted for 75 and 66% of the total purse seine catch in 1990 and 1991, respectively (Figure 3a), up from 50-55% in the previous two years.

Concurrent with these developments in the large purse seine fleet has been an increase in the activity of the smaller (<65') purse seiners along the west coast. These vessels, which have traditionally fished capelin, have been issued "experimental" herring licences under the inshore allocation since 1989. Actual annual landings have not exceeded 800 mt since the programme began.

From 1979 to 1989, almost equal proportions of the total gillnet catch was taken from spawning concentrations (Table 4) in Bay St. Georges and Port-au-Port Bay (4Rd,4Rc) in April and May, and north of Pointe Riche (4Ra,4Rb) from July to September (Table 2b; Figure 3b). A late fall fishery on mixed spring- and fall-spawner concentrations (Table 4) has also occurred, although sporadically, in areas 4Ra to 4Rc throughout this period. In 1990, gillnet landings in Bay St. Georges and Port-au-Port Bay were marginal (Table 2b), representing only 26% of the gillnet catch and 1% of the total catch. In 1991, only 7 mt were recorded for this spring fishery.

Total gillnet landings (Table 1), and therefore the proportion of the total catch taken by gillnets (Figure 4), have dwindled since 1980. Due to a limited market demand for gillnetted herring, less than 10% of the total 4R landings have been reported from the fixed gear sector since 1985, except for 1987 when this proportion topped 17%. The inshore fishery is now almost exclusively oriented toward filling the traditional role of supplying bait for the active lobster fishery. Since 1989, the late fall (October-December) fishery has been extremely limited, although this was at least in part due to exceptionally poor weather conditions. In 1991, the market for gillnetted herring is essentially moribund, with recorded landings totalling only 450 mt.

MANAGEMENT PLAN

Total allowable catches (TAC) have been in effect since 1977. Since 1981, 45% of the TAC has been allocated to the fixed gear sector and 55% to the mobile gear sector, although transfers from the fixed gear sector to the mobile fleet have been allowed since the early 1980's. In addition, the purse seine quota has been proportioned among the five active vessels and the gillnet allocation has been divided evenly between the regions north and south of Cape St. Gregory. Since 1989, an additional inshore allocation has been made for the experimental, small-purse-seine fishery. The allocation for this gear sector has come from the inshore (fixed gear) quota and has increased from 2,000 to 3,500 to 7,000 mt from 1989 to 1991. Large purse-seine allocations to the OSS programme have also increased, from 8,000 mt in 1990 to 10,000 mt in 1991. The TAC has not been exceeded since 1986 (Table 1; Figure 2).

COMMERCIAL FISHERY DATA

a) Age Composition of the Commercial Catch:

Random samples from the commercial fishery were collected by port samplers, and by index gillnet fishermen hired to keep detailed catch and effort data on herring caught throughout the fishing season, covering most of the major commercial landings. These samples were frozen and sent to the Maurice Lamontagne Institute (MLI) in Mont-Joli, Quebec for analyses (length, weight, gonad weight, maturity stage, and otolith collection for age determination).

Individual herring were assigned as either spring or fall spawners by relating the maturity stage, estimated from a gonadosomatic index (McQuinn, 1989), to the date of capture, using the 4R maturity cycle chart (McQuinn, 1987a). In the case of immature fish, otolith characteristics were used as described by Cleary *et al.* (1982). Ages were determined from the otoliths as the number of winter rings for spring spawners and the number of winter rings plus one for fall spawners (Cleary *et al.*, 1982). All herring age 11 or more were aggregated into an 11+ age-group. As in previous years, the 1991 catch at age (Table 5) was generated (CATΔAGE v1.0, Anon, 1986) for spring and fall spawners as described by McQuinn (1987b).

Inconsistencies in the 1990 catch at age led us to speculate that a possible ageing bias had occurred (McQuinn and Lambert, 1991). A workshop was organized to compare the ageing between the primary ager and three secondary agers at the MLI using selected samples from 1990 and 1991. In addition, an inter-regional workshop was convened for the first time between the agers from MLI and the agers from the Newfoundland Region to compare ageing techniques. Results of both these workshops did reveal a bias towards younger ages by the primary ager (Annex 1). A subsample of the 1990 and 1991 otoliths were therefore re-read by the secondary agers and both the 1990 and 1991 catches at age have been reconstructed (Table 5), weighted by landings as depicted in Annex 2 and 3.

b) Spring-Spawner Catch at Age:

Spring spawners have dominated the catch in every year since 1973 (Table 5), averaging 73% of the catch in numbers. This percentage was over 80% of the catch in numbers between 1988 and 1990 due to the active spring fishery in Bay St. Georges, which traditionally exploits pre-spawning and spawning concentrations. However in 1991, less than 70% of the total removals consisted of spring spawners (Table 5) primarily due to a higher catch of autumn spawners in the Bay St. Georges spring fishery (Table 3). Typically herring schools at the head of Bay St. Georges near the spawning beds consist predominately of spring spawners, while autumn spawners are concentrated near the mouth of the bay or north of Cape St. Georges (4Rc). In 1991, the purse seine fleet increased their fishing effort near the mouth of the bay (Ray Dumphy, Seafreeze fleet manager, pers. com) thus encountering more autumn spawners.

The 1968 year-class was the largest ever observed in the spring-spawner catch and completely dominated from 1973 (the beginning of the time series) to 1982 (Table 6). During these years, the only significant recruitment to the spring-spawning stock came from the 1974 year-class.

In 1983 about 30% of the catch consisted of the 1979 and 1980 year-classes. The strength of the 1980 year-class became apparent in 1984, when at age 4 it represented 40% of the catch in numbers. In 1985, the 1980 year-class was the single most important cohort since the 1968 year-class, contributing to 63% of the catch in numbers, and again 51% in 1986. Since 1987, the 1982 year-class has also contributed strongly to the spring-spawner catch, maintaining the mean age of the spring spawners (assuming ages 11+ to be 11) at 8 years old in 1990. In 1991, the 1987 year-class has strongly recruited at 22% of the spring-spawner catch, lowering the mean age of the catch to 7 years old. The 1987 cohort has also recruited strongly in the southern Gulf herring (Claytor *et al.*, in press), along the Newfoundland east coast (Wheeler *et al.*, 1992), as well as in the Atlantic mackerel stock (Grégoire, 1991).

c) Fall-Spawner Catch at Age:

Herring of the 11+ age group have historically dominated the fall-spawner catch (Table 6). In 1983, the 1979 year-class strongly recruited into the fishery and contributed to more than 24% of the catch in numbers at age 4. Between 1984 and 1989, this cohort has constituted between 31 and 63% of the fall-spawner catch at age. The mean age in the catch of fall spawners has therefore risen in recent years, from 6 years old in 1985 to over 8 years old in 1990. In 1990, the 1986 year-class strongly recruited to the fall- spawner catch at age. This cohort was the largest single year-class in 1991 and the strongest since the 1979 year-class. However, this year-class has yet to recruit significantly to the gillnet fishery (Table 7).

POPULATION ABUNDANCE INDICES

Abundance indices were estimated, for both spring and fall spawners from detailed logbooks of daily catch and effort compiled by index gillnet fishermen, covering most of the fishing season.

Logbook Data

Index gillnet fishermen have been hired since 1984 to complete daily logbooks, recording their catch and effort as well as their location, mesh-size, size of nets and water depth. A detailed analysis of these data has recently been completed as partial fulfilment of a Masters Degree in Maritime Resource Management at the Université de Québec à Rimouski (Konan, 1992). Annual gillnet catch rates were also estimated from these data and standardized using a multiplicative model (Gavaris, 1980). Analyses were conducted to determine the best measure of effort to be used for the standardization of these data. The category types for the model were year and fisherman (Table 8). As each fisherman fished in the same area and during the same time period each year, temporal and spatial category types (eg. month or week, and unit area) were highly correlated with the fisherman category type and thus could not be used in the model. Prior to these analyses, catches were proportioned to spring and fall spawners using the percent spawning-stock composition determined from the commercial samples (Table 4).

The measures of effort considered were (1) number of nets fished, (2) net*days fished,

(3) net*hours fished, (4) surface area of nets fished, (5) surface area*days fished and (6) surface area*hours fished (Table 9). The criteria used to judge the best unit of effort were the r^2 and the coefficient of variation (CV), with emphasis on the CV. The analyses were conducted for both the spring spawner- and autumn-spawner datasets. The units of effort which gave the best CV for both datasets were those using a function of surface area (Table 9). Within this grouping, surface area*hours or surface area*days resulted in the best combination of r^2 and the CV for the fall spawners, although the choice was less obvious for the spring spawners. As the criteria values were very close using either of the surface area, surface area*days or surface area*hours models, and as all of these models yielded similar estimates of annual catch per unit effort, the surface area*hours model was selected given the improved CV (Tables 10 and 11).

Both catch-rate series increased between 1984 and 1985, were more or less constant or increasing between 1985 and 1987, decreased significantly to 1990 and increased in the last year (Table 12, Figure 5). These trends have followed the recruitment and subsequent decline of the 1980 and 1982 spring-spawning, and 1979 fall-spawning year-classes, and the recent recruitment of the 1987 spring-spawning and 1986 fall spawning year-classes.

PROGNOSIS

Cohort analyses performed on these data in 1990 revealed that fishing mortalities at age have been generally below 0.2 since 1985. At these light exploitation levels, the analyses did not produce converged population-number estimates. Since very little has changed in the intervening years, i.e. landings have remained relatively stable, and the index-fisherman catch rates have increased in 1991, cohort analyses were not attempted this year. Without estimates of population size, catch projections for 1993 could not be estimated. However, as was noted by McQuinn and Lambert (1990), "recent catch levels of between 14,000-22,000 mt have not been detrimental to these populations". With the stable landings and increasing index-fisherman catch rates in 1991, this assertion still applies.

The 1986 and 1987 year-classes for the autumn and spring spawners, respectively have been important contributers to the purse seine fishery for two years now (Table 5). These year-classes will support the fishery over the next 5-6 years as the 1979, 1980 and 1982 cohorts diminish in importance. Their strength has not yet been fully felt in the gillnet fishery, due to the older age of recruitment to this gear sector. This is seen by the rather marginal increase in the gillnet catch rates in 1991. The size of these year-classes should be more apparent from the 1992 catch rates, when these fish will be 5 and 6 years old, respectively, and more available to gillnets.

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Table 1. Herring catches (t) by gear type and fishing area and total allowable catches from NAFO Division 4R from 1966 to 1991.

YEAR	4Rd				4Rc				4Rb				4Ra				COMBINED				TAC
	Purse seine	Gill-net	Other gears*	Total	Purse seine	Gill-net	Other gears*	Total	Purse seine	Gill-net	Other gears*	Total	Purse seine	Gill-net	Other gears*	Total	Purse seine	Gill-net	Other gears*	Total	
1966	0	216	0	216	0	103	0	103	5491	39	0	5530	0	45	0	45	5491	403	0	5894	
1967	0	215	0	215	0	66	0	66	5464	76	0	5540	0	40	0	40	5464	397	0	5861	
1968	0	156	789	945	0	59	0	59	3776	67	136	3979	0	11	0	11	3776	293	925	4994	
1969	241	36	6	283	0	46	0	46	2344	201	4	2549	0	68	1	69	2585	351	11	2947	
1970	28	51	3	82	12	15	17	44	2939	534	4	3477	0	407	92	499	2979	1007	116	4102	
1971	3287	543	427	4257	2239	185	24	2448	725	338	21	1084	356	1598	11	1965	6607	2664	483	9754	
1972	4743	178	866	5787	727	135	64	926	1330	214	0	1544	0	3628	146	3774	6800	4155	1076	12031	
1973	12112	429	0	12541	2740	122	0	2862	1763	305	2	2070	3453	5760	15	9228	20068	6616	17	26701	
1974	2465	159	0	2624	756	101	4	861	439	479	47	965	1071	1972	5	3048	4731	2711	56	7498	
1975	3221	116	3	3340	0	112	16	128	0	240	26	266	0	1764	22	1786	3221	2232	67	5520	
1976	6067	499	3	6569	1956	111	2	2069	0	226	20	246	184	2143	140	2467	8207	2979	165	11351	
1977	5289	272	7	5568	2009	193	3	2205	0	158	31	189	2155	2028	183	4366	9453	2651	224	12328	12000
1978	6252	522	33	6807	1037	931	16	1984	0	288	81	369	1834	3795	22	5651	9123	5536	152	14811	12500
1979	4387	1642	3	6032	2774	2267	2	5043	2829	1048	121	3998	0	3258	7	3265	9990	8215	133	18338	12500
1980	3499	1558	41	5098	3703	3224	17	6944	2002	879	88	2969	428	3810	5	4243	9632	9471	151	19254	18000
1981	2269	1368	2	3639	3277	1622	0	4899	2037	913	140	3090	342	1600	27	1969	7925	5503	169	13597	16000
1982	0	1463	3	1466	5575	1572	11	7158	3973	519	58	4550	0	1695	1	1696	9548	5249	73	14870[2]	10000
1983	0	1410	2	1412	3269	873	46	4188	3223	226	108	3557	787	1438	34	2259	7279	3947	190	11416[2]	10000
1984	0	1006	1	1007	3023	902	0	3925	4166	554	2	4722	15	790	4	809	7206	3252	7	10465[2]	10000
1985	1720	398	0	2118	1733	164	0	1897	9718	348	4	10070	0	295	6	301	13171	1205	10	14386[2]	10000
1986	1854	273	0	2127	1586	1069	0	2655	15830	468	0	16298	0	337	0	337	19270	2147	0	21417[2]	17000
1987	222	550	0	772	3183	1137	0	4320	10164	327	5	10496	164	829	0	993	13733	2843	5	16581	30600
1988	2019	435	0	2454	13197	592	0	13789	1093	256	0	1349	44	509	0	553	16353	1792	0	18145	30600
1989	9111	177	0	9288	6589	444	0	7033	947	69	0	1016	13	337	0	350	16660	1027	0	17687[1]	37000
1990	5156	97	0	5253	7495	79	0	7574	3404	181	6	3591	28	323	133	484	16084	677	140	16903[1]	35000
1991	11871	37	0	11918	1557	31	0	1588	5342	59	0	5401	98	323	54	377	18877	450	54	19381[1]	35000

* Includes shrimp trawl, bar seine, cod trap, midwater trawl and otter trawl.
1 Preliminary
2 Purse seine landings adjusted according to industry records

Table 2.a. Herring landings (t) by purse seines in NAFO division 4R by unit area and month from 1983 to 1991.

YEAR	AREA	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
1983	4Ra											604	183	787
	4Rb										480	2263	480	3223
	4Rc				2289	980								3269
	4Rd													
	Total				2289	980					480	2867	663	7279
1984	4Ra											15		15
	4Rb				24						1090	1763	1289	4166
	4Rc	309			2714									3023
	4Rd													
	Total	309			2738						1090	1778	1289	7204
1985	4Ra													
	4Rb								482		526	5577	3133	9718
	4Rc					1464	99				170			1733
	4Rd					1720								1720
	Total					3184	99		482		696	5577	3133	13171
1986	4Ra													
	4Rb										3091	10608	2131	15830
	4Rc					1400		186						1586
	4Rd				185	1669								1854
	Total				185	3069		186			3091	10608	2131	19270
1987	4Ra											164		164
	4Rb					25			14		748	4426	4951	10164
	4Rc					1319	596			153	565	379	171	3183
	4Rd					222								222
	Total					1566	596		14	153	1313	4969	5122	13733
1988	4Ra							22	22					44
	4Rb									71	312	437	273	1093
	4Rc				639	5342	70		6		990	1985	4165	13197
	4Rd				1308	711								2019
	Total				1947	6053	70	22	28	71	1302	2422	4438	16353
1989	4Ra								13					13
	4Rb				33						81	347	486	947
	4Rc				35		51		6	514	776	3080	2127	6589
	4Rd				379	8587	145							9111
	Total				447	8587	196		19	514	857	3427	2613	16660
1990	4Ra						14	14						28
	4Rb						138				379			3404
	4Rc					6536	450	205	27	17	261	2888		7495
	4Rd					4799	335				23			5156
	Total					11335	798	357	27	17	662	2888		16084
1991	4Ra							62	36					98
	4Rb					8	42	113	18	45	501	3285	1330	5342
	4Rc					490	87	127		107	130	161	463	1567
	4Rd				6090	5567	214							11871
	Total				6090	6065	345	303	54	152	631	3446	1793	18877

Table 2.b. Herring landings (t) by gillnets in NAFO division 4R by unit area and month from 1983 to 1991.

YEAR	AREA	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
1984	4Ra				9	5	43	235	535	233	82	159	137	1438
	4Rb				29	48	9	23	18	6	25	29	39	226
	4Rc	2	1	5	394	358	44	36	26		2	2	3	873
	4Rd	1	2	15	887	429	29	25	12	3	5		2	1410
	Total	3	3	20	1319	840	125	319	591	242	114	190	181	3947
1984	4Ra	19				1	47	99	154	131	225	122	11	809
	4Rb				64	117	82	3	2	59	76	138	13	554
	4Rc				248	208	47	24	15	7	199	106	48	902
	4Rd				253	673	30	21	9	8	8	3	1	1006
	Total	19			565	999	206	147	180	205	508	369	73	3271
1985	4Ra					1	4		20	152	2	112	4	295
	4Rb				1	22	38	2	11	6	26	234	8	348
	4Rc				2	93	28	11	9	4	11	1	5	164
	4Rd					324	28	19	5	11	10		1	398
	Total				3	440	98	32	45	173	49	347	18	1205
1986	4Ra					65	84	19	48	28	68	14	11	337
	4Rb				6	48	46	14	9	8	136	171	30	468
	4Rc				132	319	105	21	10	8	141	319	14	1069
	4Rd				100	83	49	21	10	10				273
	Total				238	515	284	75	77	54	345	504	55	2147
1987	4Ra					19	21	14	142	65	192	353	23	829
	4Rb	1		1	15	22	23	11	7	5	87	135	20	327
	4Rc				146	580	96	77	52	13	55	117	1	1137
	4Rd				146	319	30	22	8	8	13	4		550
	Total	1		1	307	940	170	124	209	91	347	609	44	2843
1988	4Ra					14			18	5	208	225	38	508
	4Rb				11	15	23	7	4	2	60	114	21	257
	4Rc				34	61	227	186	10	4	7	18	45	592
	4Rd				108	113	43	142	8	8	11	1		434
	Total				153	203	293	335	40	19	286	358	104	1791
1989	4Ra					4	34	13			4	182	100	337
	4Rb		1	2	8	16	24	8	2	1	7			69
	4Rc				10	213	101	108		11		1		444
	4Rd				2	107	36	19	7	5		1		177
	Total		1	2	20	340	195	148	9	17	11	184	100	1027
1990	4Ra					4	9	3	13	49	28	216		323
	4Rb				10	13	23	14	3	1	1	117		181
	4Rc					4	19	46	3	2	5			79
	4Rd					34	11	40	9	2	1			97
	Total				10	55	62	102	28	54	35	333		679
1991	4Ra						21	169	40	23	24	45		323
	4Rb									1	12	46		59
	4Rc								6	19	5			31
	4Rd				2	4	1		9	12	6	4		37
	Total				2	4	22	169	56	56	47	95		450

Table 3. Proportion (%) of spring- and fall-spawning herring in the purse seine catch by month and fishing area, NAFO Division 4R from 1973 to 1991.

SPAWNING GROUP	FISHING AREA 4Rd		4Rc								4Rb							4Ra				
SPRING	APR	MAY	JAN	APR	MAY	JUN	JUL	SEP	OCT	DEC	JAN	APR	AUG	SEP	OCT	NOV	DEC	JUL	AUG	OCT	NOV	DEC
1973	51.3			36.7	64.7						91.3				91.0	90.8						76.7
1974	68.3	39.1															92.6					
1975	98.0	84.7																				
1976	90.4	97.8			52.3																	87.7
1977	95.4	99.0			32.4															47.3	89.3	
1978	82.4			81.9																	85.8	84.4
1979	86.2			43.2	26.0											93.3					91.6	86.7
1980	95.2			98.0						73.4						88.2						
1981	96.4	92.0		97.3											87.3	63.5	55.7					
1982				99.8	98.0			65.0							78.8	77.7						
1983				61.0	54.5				73.8							79.8	68.9				74.7	62.7
1984			76.4	43.9								40.9			76.9	64.5	60.5				62.0	
1985		92.0			66.0	49.7			82.6				23.8		71.0	70.0	67.7					
1986	77.0	100.0			93.6		78.0								77.3	74.8	71.0					
1987		97.0		100.0	93.0	100.0		65.3	84.7				0.0		74.5	76.9	72.1				28.0	
1988	83.6	99.5			34.0	100.0						37.5		62.0	41.3	65.8	72.1	28.0	2.0			
1989		91.3			34.0			79.5	66.9						68.5	70.1	70.1					
1990		89.8					78.0		88.0						74.0	55.3	66.0					
1991		71.6					72.0	48.0	66.0	80.0					56.3	65.3	63.4					
FALL																						
1973	48.7			63.3	35.3						8.7				9.0	9.2						23.3
1974	31.7	60.9															7.4					
1975	2.0	15.3																				
1976	9.6	2.2			47.7																	12.3
1977	4.6	1.0			67.6															52.7	10.7	
1978	17.6			18.1																	14.2	15.6
1979	13.8			56.8	74.0											6.7					8.4	13.3
1980	4.8			2.0						26.6						11.7						
1981	3.6	8.0		2.7											12.7	36.5	44.3					
1982				0.2	2.0			35.0							21.2	22.3						
1983				39.0	45.5				26.2							20.2	31.1				25.3	37.3
1984			23.6	56.1								59.1			23.1	35.5	39.5				38.0	
1985		8.0			34.0	50.3			17.4				76.2		29.0	30.0	32.3					
1986	23.0	0.0			6.4		22.0								22.7	25.2	29.0					
1987		3.0		0.0	7.0	0.0		34.7	15.3				100.0		25.5	23.1	27.9				72.0	
1988	16.4	0.5			66.0	0.0						62.5		38.0	58.7	34.2	27.9	72.0	98.0			
1989		8.7			66.0			20.5	33.1						31.5	29.9	29.9					
1990		10.2					22.0		12.0						26.0	44.7	34.0					
1991		28.4					28.0	52.0	34.0	20.0					43.7	34.7	36.6					

Table 4. Proportion (%) of spring- and fall-spawning herring in the gillnet catch by month and fishing area, NAFO division 4R from 1973 to 1991.

SPAWNING GROUP	FISHING AREA 4Rd			4Rc						4Rb							4Ra							
SPRING	APR	MAY	JUN	APR	MAY	JUN	JUL	SEP	OCT	MAY	JUN	JUL	SEP	OCT	NOV	DEC	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1973												32.3		29.0	81.2				14.4				62.4	
1974											99.0					86.5				14.3			50.0	
1975		90.0									55.3	12.0												
1976		100.0									98.0								5.3				76.7	
1977											83.3	18.0				86.0		66.0	32.2	8.0	25.7	56.6	78.0	
1978		99.0								85.7	98.0							52.0	33.6				78.9	
1979	84.0			92.8						95.0					84.0				38.7	11.7	44.0	56.0		
1980	96.4			91.1						100.0					81.8		63.3	55.6	34.1	3.0	42.9	72.0	66.0	
1981				95.8						82.4	91.0							37.0	24.9	0.7			43.8	
1982					97.2										64.9				2.7					
1983		95.7											80.0	46.1	41.8				39.6	1.4	46.3	56.9	56.3	68.2
1984		94.1			78.5				84.0					60.2		44.9				8.6	27.9	63.0	36.0	52.7
1985		97.7			86.5	90.0													80.0		9.5	15.7		28.0
1986	84.4	98.4		50.0	83.7			66.0	80.0						54.4				16.8	10.1	32.0	44.1	27.1	
1987	92.0	99.4		52.0	84.7	88.6								52.2						14.2	26.0	49.5	37.5	
1988	98.0	99.6	96.0	73.5	78.3	81.4	76.0								68.1				28.0	11.8	27.0	41.3	52.8	42.0
1989		99.0	91.1	86.0	85.3	79.6								71.0	56.7				22.3	11.6	23.3	44.0	40.0	
1990		96.9	99.3		92.0	88.5	34.5								44.0				15.5	17.8	10.8	18.0	32.5	
1991		95.9	96.0		88.8	59.2							32.0	44.0	70.0				4.5	27.0	38.1	50.0	43.4	
FALL																								
1973												67.7		71.0	18.8				85.6				37.6	
1974											1.0					13.5				85.7			50.0	
1975		10.0									44.7	88.0												
1976		0.0									2.0								94.7				23.3	
1977											16.7	82.0				14.0		34.0	67.2	92.0	74.3	43.4	22.0	
1978		1.0								14.3	2.0							48.0	66.4				21.1	
1979	16.0			7.2						5.0					16.0				61.3	88.2	56.0	44.0		
1980	3.6			8.9						0.0					18.2		36.7	44.4	65.9	97.0	57.1	28.0	34.0	
1981				4.2						17.6	9.0							63.0	75.1	99.3			56.3	
1982					2.8										35.1				97.3					
1983		4.3											20.0	53.9	58.2				60.4	98.6	53.7	43.1	43.7	31.8
1984		5.9			21.5				16.0					39.8		55.1				91.4	72.1	37.0	64.0	47.3
1985		2.3			13.5	10.0													20.0	90.5	84.3		72.0	
1986	15.6	1.6		50.0	16.3			34.0	20.0						45.6				83.2	89.9	68.0	55.9	72.9	
1987	8.0	0.6		48.0	15.3	11.4								47.8						85.8	74.0	50.5	62.5	
1988	2.0	0.4	4.0	26.5	21.7	18.6	24.0								31.9				72.0	88.2	73.0	58.7	47.2	58.0
1989		1.0	8.9	14.0	14.7	20.4								29.0	43.3				77.7	88.4	76.7	56.0	60.0	
1990		3.1	0.7		8.0	11.5	65.5								56.0				84.5	82.2	89.2	82.0	67.5	
1991		4.1	4.0		11.2	40.8							68.0	56.0	30.0				95.5	72.1	61.9	50.0	56.6	

Table 5. Spring- and fall-spawner catch at age ($x10^3$) and proportion of spring spawners in NAFO division 4R herring landings from 1973 to 1991.

SPRING SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0	0	0	0	45	0	0	3	13	0	4	39	48	265	323	183	0	0	0
2	1833	141	57	484	10	0	167	300	40	594	34	198	362	323	455	734	305	100	507
3	435	261	996	680	534	47	25	854	417	2374	2965	433	4587	2348	329	519	574	2056	1742
4	1063	130	420	846	541	1987	214	106	2114	693	3562	7773	787	13762	2781	417	763	610	8446
5	27872	371	100	201	409	207	10828	355	129	2452	1131	3809	21642	3349	15257	2400	461	412	1205
6	2570	9445	1063	350	304	679	617	13872	354	421	1091	595	3993	28781	3507	14830	3036	983	858
7	3222	318	8431	2802	348	241	1075	407	8872	2153	293	814	445	5241	12952	4004	18705	5002	6344
8	3232	851	317	15567	4362	2162	547	1344	188	6488	713	209	381	465	1736	14606	3072	16049	4555
9	2598	774	336	759	15959	8208	2772	247	515	704	2990	672	255	167	182	2734	10910	3782	9666
10	4789	490	244	3136	1694	15260	7404	1427	283	950	798	755	380	260	37	480	779	6472	1632
11+	5696	2175	665	3588	6003	5062	14032	20574	13181	12863	7975	4226	1764	1661	806	2123	1380	2130	3899
1+	53310	14955	12629	28413	30210	33851	37681	39488	26106	29692	21556	19523	34645	56621	38365	43030	39985	37594	38853

FALL SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0
2	0	0	0	0	0	0	0	15	0	101	15	0	15	35	0	483	43	38	0
3	1798	20	19	48	3	10	7	181	33	567	83	55	235	426	156	186	599	463	1136
4	1180	393	40	272	169	27	116	136	524	1824	2330	668	1340	1431	487	520	540	1391	1864
5	1114	530	865	290	134	545	345	86	245	956	1356	6259	1907	2671	1354	490	923	387	5223
6	2626	325	925	422	404	393	2689	176	90	509	1309	1147	9678	2292	2009	1026	808	312	715
7	1527	592	107	561	721	1108	520	1729	295	140	506	908	902	8421	1728	1267	749	466	1209
8	2631	258	157	325	405	1689	1287	250	1234	377	159	220	622	794	5927	1503	828	323	907
9	3830	308	147	253	342	503	1847	675	153	972	467	146	115	384	474	3798	961	1028	430
10	8265	313	218	88	293	341	468	308	124	315	618	268	36	66	163	501	2873	442	2325
11+	17653	5610	3371	4818	6646	6051	6286	5243	3369	2609	2824	3091	468	227	196	671	983	4223	4499
1+	40626	8348	5848	7076	9116	10668	13564	8799	6067	8371	9667	12762	15333	16745	12494	10445	9307	9072	18307

TOTAL (SPRING AND FALL)

YEAR	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
TOTAL REMOVALS	93937	23303	18477	35489	39326	44520	51245	48288	32173	38062	31223	32286	49978	73366	50859	53475	49292	46666	57160
% SPRING SPAWNERS	56.8	64.2	68.4	80.1	76.8	76.0	73.5	81.8	81.1	78.0	69.0	60.5	69.3	77.2	75.4	80.5	81.1	80.6	68.0

Table 6. Age composition (%) and mean age* of (A) spring and (B) fall spawners in NAFO division 4R herring landings from 1973 to 1991. Dominant year-classes have been underlined.

A) SPRING SPAWNER AGE COMPOSITION (%)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	.0	.0	.0	.0	.1	.0	.0	.0	.1	.0	.0	.2	.1	.5	.8	.4	.0	.0	.0
2	3.4	.9	.5	1.7	.0	.0	.4	.8	.2	2.0	.2	1.0	1.0	.6	1.2	1.7	.8	.3	1.3
3	.8	1.7	7.9	2.4	1.8	.1	.1	2.2	1.6	8.0	13.8	2.2	13.2	4.1	.9	1.2	1.4	5.5	4.5
4	2.0	.9	3.3	3.0	1.8	5.9	.6	.3	8.1	2.3	16.5	39.8	2.3	24.3	7.2	1.0	1.9	1.6	21.7
5	52.3	2.5	.8	.7	1.4	.6	28.7	.9	.5	8.3	5.2	19.5	62.5	5.9	39.8	5.6	1.2	1.1	3.1
6	4.8	63.2	8.4	1.2	1.0	2.0	1.6	35.1	1.4	1.4	5.1	3.0	11.5	50.8	9.1	34.5	7.6	2.6	2.2
7	6.0	2.1	66.8	9.9	1.2	.7	2.9	1.0	34.0	7.3	1.4	4.2	1.3	9.3	33.8	9.3	46.8	13.3	16.3
8	6.1	5.7	2.5	54.8	14.4	6.4	1.5	3.4	.7	21.9	3.3	1.1	1.1	.8	4.5	33.9	7.7	42.7	11.7
9	4.9	5.2	2.7	2.7	52.8	24.2	7.4	.6	2.0	2.4	13.9	3.4	.7	.3	.5	6.4	27.3	10.1	24.9
10	9.0	3.3	1.9	11.0	5.6	45.1	19.6	3.6	1.1	3.2	3.7	3.9	1.1	.5	.1	1.1	1.9	17.2	4.2
11+	10.7	14.5	5.3	12.6	19.9	15.0	37.2	52.1	50.5	43.3	37.0	21.6	5.1	2.9	2.1	4.9	3.5	5.7	10.0

MEAN AGE* OF INDIVIDUALS IN CATCH

YEAR	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
MEAN AGE	6.5	7.0	6.8	8.1	9.0	9.3	8.6	8.7	8.8	8.4	7.7	6.3	5.3	5.6	5.9	7.0	7.6	8.0	7.0

B) FALL SPAWNER AGE COMPOSITION (%)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0	.0	.0	.0	.0
2	.0	.0	.0	.0	.0	.0	.0	.2	.0	1.2	.2	.0	.1	.2	.0	4.6	.5	.4	.0
3	4.4	.2	.3	.7	.0	.1	.1	2.1	.5	6.8	.9	.4	1.5	2.5	1.3	1.8	6.4	5.1	6.2
4	2.9	4.7	.7	3.8	1.9	.2	.9	1.5	8.6	21.8	24.1	5.2	8.7	8.5	3.9	5.0	5.8	15.3	10.2
5	2.7	6.4	14.8	4.1	1.5	5.1	2.5	1.0	4.0	11.4	14.0	49.0	12.4	15.9	10.8	4.7	9.9	4.3	28.5
6	6.5	3.9	15.8	6.0	4.4	3.7	19.8	2.0	1.5	6.1	13.5	9.0	63.1	13.7	16.1	9.8	8.7	3.4	2.9
7	3.8	7.1	1.8	7.9	7.9	10.4	3.8	19.7	4.9	1.7	5.2	7.1	5.9	50.3	13.8	12.1	8.0	5.1	6.6
8	6.5	3.1	2.7	4.6	4.4	15.8	9.5	2.8	20.3	4.5	1.6	1.7	4.1	4.7	47.4	14.4	8.9	3.6	5.0
9	9.4	3.7	2.5	3.6	3.8	4.7	13.6	7.7	2.5	11.6	4.8	1.1	.7	2.3	3.8	36.4	10.3	11.3	2.3
10	20.3	3.8	3.7	1.3	3.2	3.2	3.5	3.5	2.0	3.8	6.4	2.1	.2	.4	1.3	4.8	30.9	4.9	12.7
11+	43.5	67.2	57.6	68.1	72.9	56.7	46.3	59.6	55.5	31.2	29.2	24.2	3.1	1.4	1.6	6.4	10.6	46.5	24.6

MEAN AGE* OF INDIVIDUALS IN CATCH

YEAR	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
MEAN AGE	9.2	9.6	9.0	9.6	10.0	9.5	9.0	9.5	9.2	7.4	7.3	6.8	6.0	6.3	7.1	7.6	7.9	8.5	7.3

* assuming ages 11+ to be 11.

Table 7. Spring- and fall-spawner gillnet catch at age ($x10^3$) in NAFO division 4R herring landings from 1973 to 1991.

SPRING-SPAWNER GILLNET CATCH AT AGE

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	3	0	0	21	1	0	0	0	0	0	0	0
3	7	10	0	13	13	3	0	71	59	319	842	13	1	3	0	4	8	30	3
4	145	0	89	0	4	368	42	50	805	145	1770	1416	33	296	125	30	46	26	70
5	2148	76	10	0	39	82	2980	123	53	879	468	1486	1220	143	1714	600	58	35	5
6	228	1781	219	15	53	132	441	5485	163	106	513	242	391	2909	602	1436	349	75	2
7	1225	111	878	581	141	63	606	225	4038	340	57	469	67	662	2388	561	996	78	37
8	769	383	89	1790	1041	751	337	620	83	2495	19	67	75	78	418	1139	165	433	36
9	784	130	66	123	1680	1659	1597	146	192	229	1200	236	44	55	26	132	396	53	67
10	467	89	48	540	325	4228	3403	927	113	256	249	271	62	45	18	27	51	112	19
11	2830	1210	172	1336	1712	2408	6726	8291	3484	4144	3151	1892	290	261	175	98	53	36	36
1+	8603	3789	1573	4398	5007	9695	16131	15942	8988	8912	8290	6094	2183	4452	5466	4026	2121	880	275

FALL-SPAWNER GILLNET CATCH AT AGE

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0
3	0	0	0	0	3	0	0	0	0	16	24	0	0	0	0	0	0	0	1
4	32	106	6	0	39	9	11	43	342	405	1229	83	4	3	36	2	8	43	12
5	179	190	200	11	30	296	260	73	201	523	531	2319	49	102	178	102	32	70	58
6	766	49	586	178	90	193	1289	153	24	164	627	329	1211	189	354	251	63	119	69
7	331	207	46	191	467	463	218	1342	245	81	143	397	134	1596	473	202	108	79	52
8	639	38	134	228	228	708	504	120	876	199	78	74	93	135	1909	169	187	132	120
9	683	198	108	161	239	156	527	603	46	554	169	64	26	84	194	679	174	228	60
10	1862	80	201	88	140	147	315	272	71	220	199	95	2	31	74	89	182	51	154
11+	6941	2719	2683	2826	2647	3624	3018	4552	2396	1529	581	442	115	160	54	68	55	654	343
1+	11434	3586	3964	3684	3884	5595	6142	7159	4201	3708	3582	3803	1633	2299	3273	1561	809	1376	870

Table 8. Frequency of observations of logbook catch and effort data by fisherman and year herring in NAFO Division 4R.

FISHER-MAN	Frequency	Percent	Cumulative Frequency	Cumulative Percent
1	311	18.4	311	18.4
2	213	12.6	524	31.0
3	52	3.1	576	34.1
4	91	5.4	667	39.5
5	113	6.7	780	46.2
6	147	8.7	927	54.9
7	147	8.7	1074	63.6
8	114	6.7	1188	70.3
9	127	7.5	1315	77.8
10	4	0.2	1319	78.0
11	128	7.6	1447	85.6
12	141	8.3	1588	94.0
13	44	2.6	1632	96.6
14	11	0.7	1643	97.2
15	47	2.8	1690	100.0

YEAR	Frequency	Percent	Cumulative Frequency	Cumulative Percent
84	96	5.7	96	5.7
85	195	11.5	291	17.2
86	216	12.8	507	30.0
87	268	15.9	775	45.9
88	312	18.5	1087	64.3
89	252	14.9	1339	79.2
90	256	15.1	1595	94.4
91	95	5.6	1690	100.0

Table 9. Coefficients of variation and correlation coefficients for selected measures of effort used in a multiplicative model for the standardization of logbook catch rates for spring and autumn spawning herring in NAFO Division 4R.

UNIT OF EFFORT	SPAWNING GROUP			
	SPRING		AUTUMN	
	C.V.	r^2	C.V.	r^2
NETS	44.37	.44	47.56	.51
NET*DAYS	49.79	.41	54.58	.53
NET*HOURS	226.45	.41	176.62	.52
SURFACE	20.46	.54	19.17	.41
SURFACE*DAYS	20.08	.52	19.11	.44
SURFACE*HOURS	13.89	.52	13.32	.42

Table 10. Analysis of variance and regression coefficients for the 1984 to 1991 logbook spring-spawning 4R herring catch rate data (catch/(surface*hours)).

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	21	3405.024868	162.144041	85.15	0.0001
Error	1662	3164.835598	1.904233		
Corrected Total	1683	6569.860467			

R-Square	C.V.	Root MSE	CATRATE Mean
0.518280	-13.88581	1.379940	-9.937765

Source	DF	Type III SS	Mean Square	F Value	Pr > F
FISHERMAN	14	2696.608019	192.614859	101.15	0.0001
YEAR	7	174.100039	24.871434	13.06	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		-10.77988497 B	-47.85	0.0001	0.22526669
FISHERMAN	1	-0.19019839 B	-0.83	0.4057	0.22866884
	2	-0.74254841 B	-3.14	0.0017	0.23666259
	3	-0.90103537 B	-2.97	0.0030	0.30366958
	4	-2.05799732 B	-7.62	0.0001	0.26998110
	5	-0.55592729 B	-2.18	0.0296	0.25527493
	6	2.21435288 B	9.09	0.0001	0.24350202
	7	1.19641111 B	4.82	0.0001	0.24829236
	8	2.96125978 B	11.81	0.0001	0.25075598
	9	0.47848381 B	1.91	0.0564	0.25059499
	10	3.39426340 B	4.63	0.0001	0.73344822
	11	-0.08944952 B	-0.35	0.7284	0.25756137
	12	1.88818133 B	7.61	0.0001	0.24803881
	13	1.70185432 B	6.21	0.0001	0.27395961
	14	-0.24983263 B	-0.52	0.6019	0.47888041
	15	0.00000000 B	.	.	.
YEAR	84	0.09068942 B	0.43	0.6678	0.21130416
	85	0.48008278 B	2.45	0.0144	0.19599972
	86	0.53703204 B	2.79	0.0053	0.19251448
	87	0.72153272 B	4.01	0.0001	0.18007723
	88	0.25275726 B	1.45	0.1464	0.17395958
	89	0.22556255 B	1.25	0.2127	0.18092567
	90	-0.41597844 B	-2.36	0.0183	0.17606007
	91	0.00000000 B	.	.	.

Table 11. Analysis of variance and regression coefficients for the 1984 to 1991 logbook fall-spawning 4R herring catch rate data (catch/(surface*hours)).

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	21	2128.276441	101.346497	54.02	0.0001
Error	1608	3016.986466	1.876235		
Corrected Total	1629	5145.262908			

R-Square	C.V.	Root MSE	Mean Catch Rate
0.413638	-13.31993	1.369757	-10.28352

Source	DF	Type III SS	Mean Square	F Value	Pr > F
FISHERMAN	14	1874.811399	133.915100	71.37	0.0001
YEAR	7	305.773538	43.681934	23.28	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		-9.029999166 B	-40.50	0.0001	0.22297080
FISHERMAN	1	-0.500784489 B	-2.21	0.0269	0.22614497
	2	-1.345018741 B	-5.80	0.0001	0.23175562
	3	-1.595350827 B	-5.39	0.0001	0.29598123
	4	-2.764125706 B	-10.46	0.0001	0.26421130
	5	-0.823704737 B	-3.26	0.0011	0.25250431
	6	-3.387473902 B	-13.74	0.0001	0.24655542
	7	-2.785644611 B	-11.30	0.0001	0.24646987
	8	-2.725119777 B	-10.68	0.0001	0.25505846
	9	-3.158737851 B	-12.62	0.0001	0.25029591
	10	-2.791180905 B	-3.83	0.0001	0.72834065
	11	-0.342277884 B	-1.34	0.1808	0.25565585
	12	-1.965908146 B	-7.97	0.0001	0.24657551
	13	-3.432303847 B	-11.43	0.0001	0.30029982
	14	-0.653945705 B	-1.37	0.1696	0.47585428
	15	0.000000000 B	.	.	.
YEAR	84	0.622218995 B	2.97	0.0030	0.20939874
	85	1.023820981 B	5.22	0.0001	0.19601103
	86	0.937232957 B	4.88	0.0001	0.19223592
	87	0.979513016 B	5.47	0.0001	0.17914845
	88	0.574435848 B	3.31	0.0010	0.17375907
	89	0.626075490 B	3.46	0.0006	0.18085307
	90	-0.380559481 B	-2.21	0.0273	0.17229006
	91	0.000000000 B	.	.	.

Table 12. Predicted mean logbook catch rate estimates for spring- and fall-spawning herring in NAFO Division 4R.

	SPRING SPAWNERS		FALL SPAWNERS	
YEAR	CATCH RATE	STANDARD ERROR	CATCH RATE	STANDARD ERROR
84	0.81697	0.13603	0.97731	0.15975
85	1.21009	0.17531	1.46495	0.20990
86	1.28178	0.18037	1.34442	0.18580
87	1.54431	0.19670	1.40513	0.17430
88	0.96705	0.11786	0.93761	0.11234
89	0.93965	0.12569	0.98584	0.12955
90	0.49477	0.06571	0.36069	0.04414
91	0.74537	0.12854	0.52405	0.08873

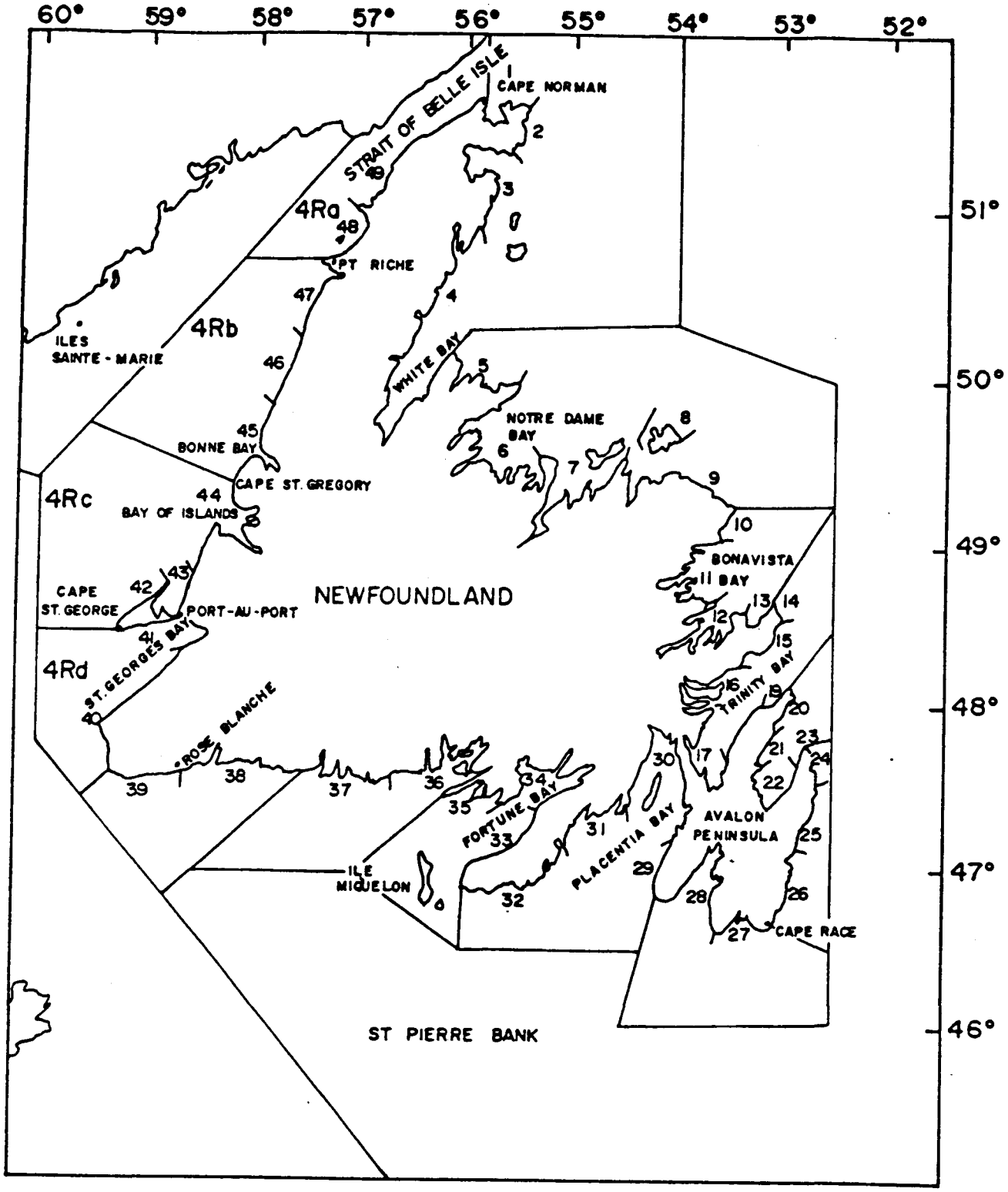


Figure 1. West coast of Newfoundland unit areas and statistical districts.

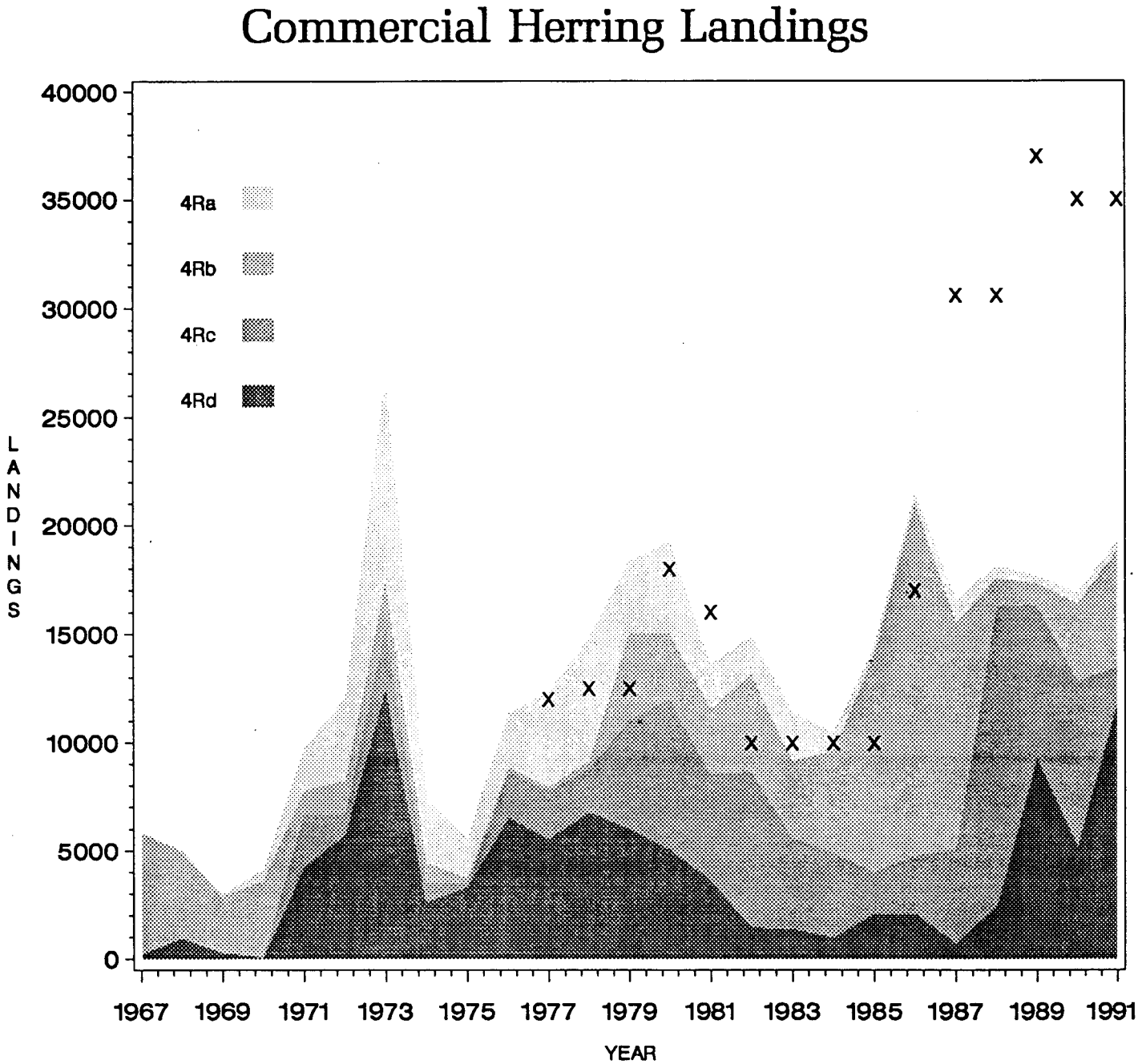
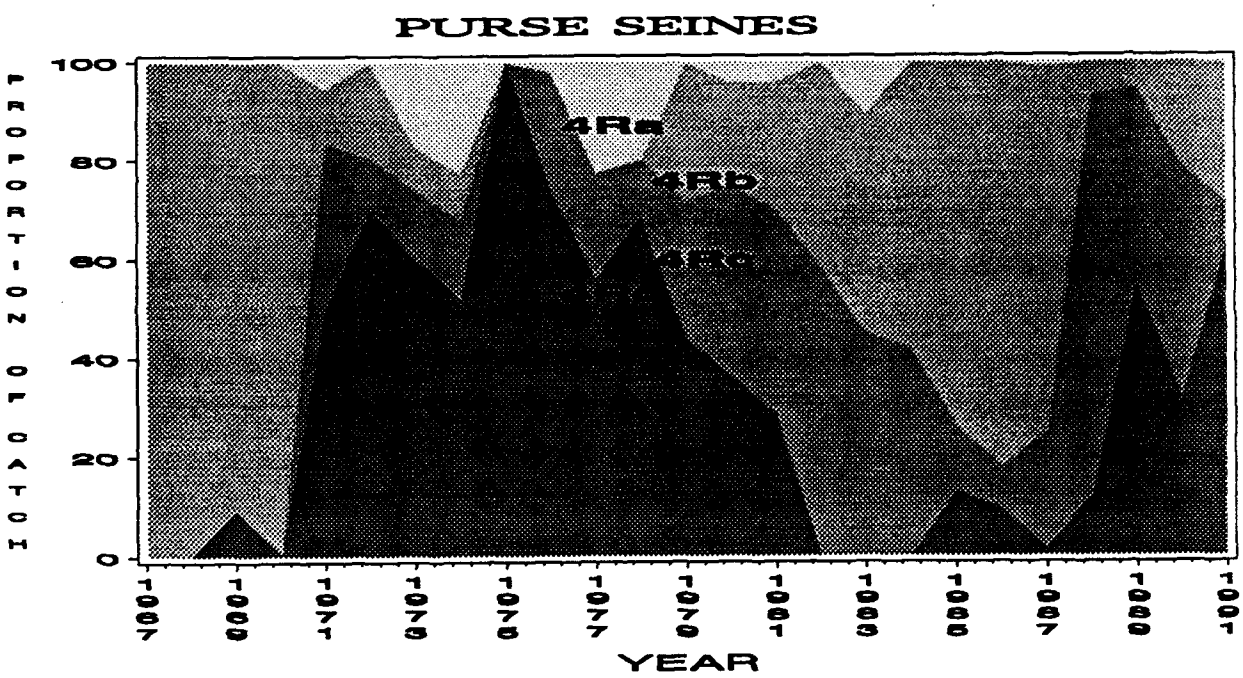


Figure 2. Cumulative commercial herring landings (t) by fishing area in NAFO Division 4R from 1967 to 1991. "X"indicates annual TAC.

A.



B.

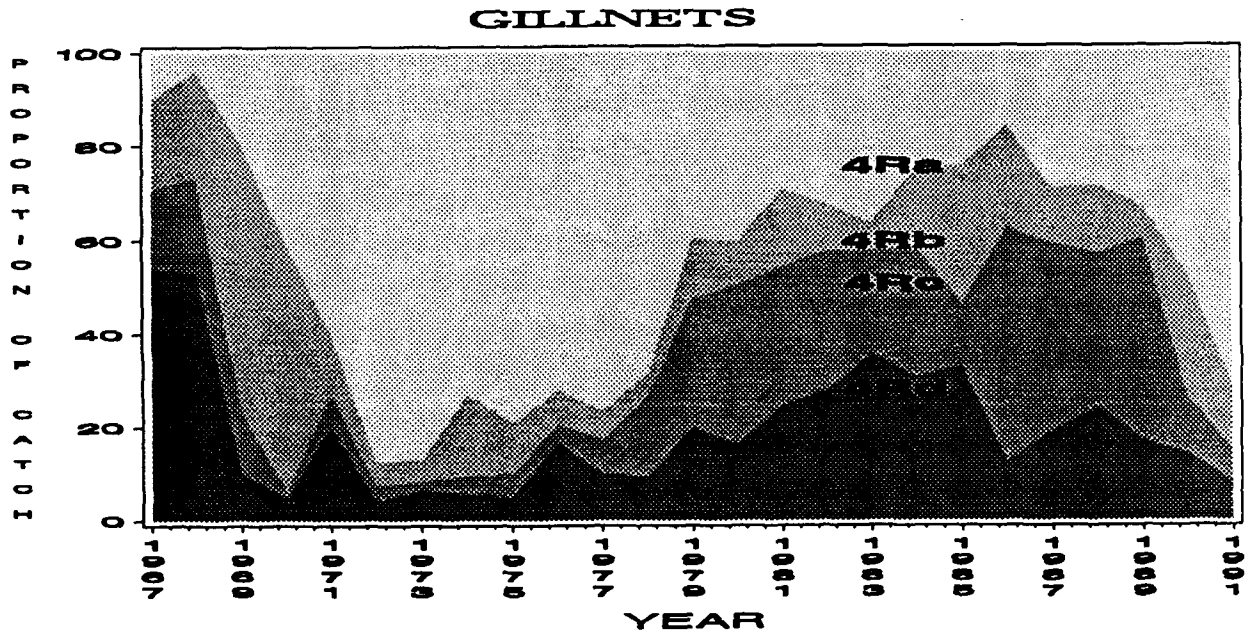


Figure 3. Proportion of (a) purse seine and (b) gillnet herring landings by fishing area in NAFO Division 4R from 1967 to 1991.

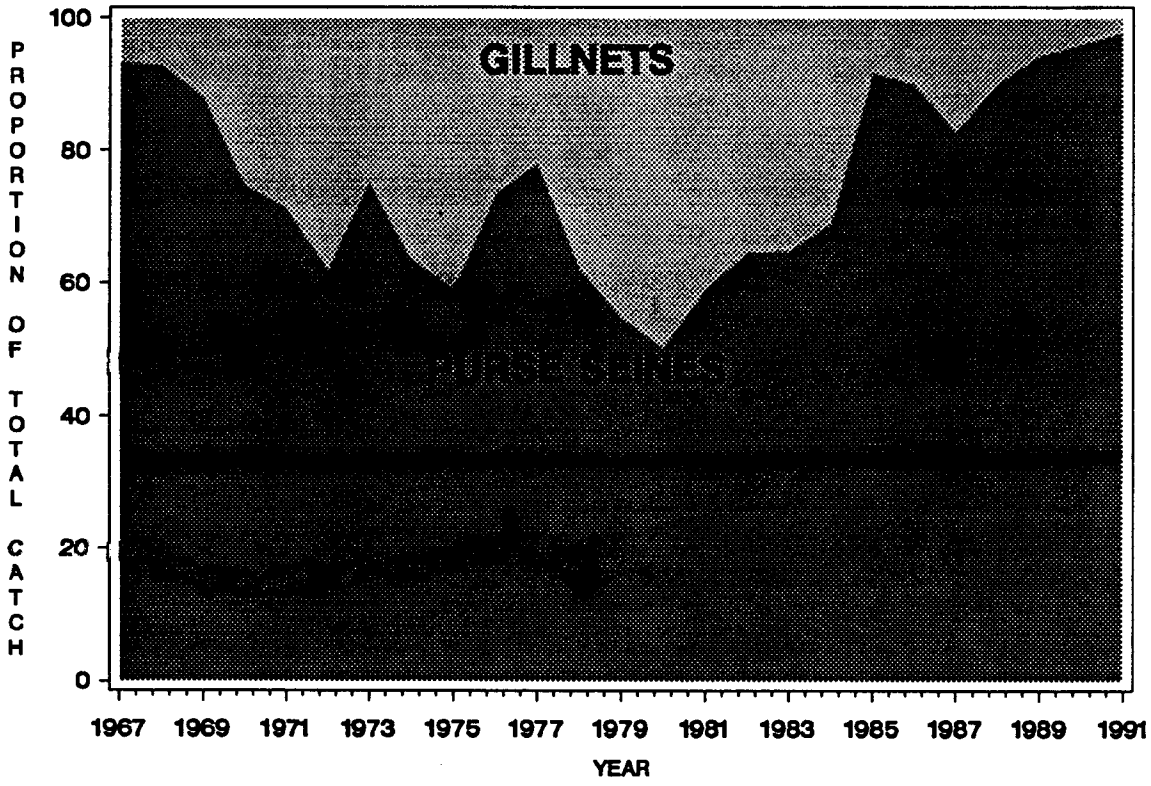
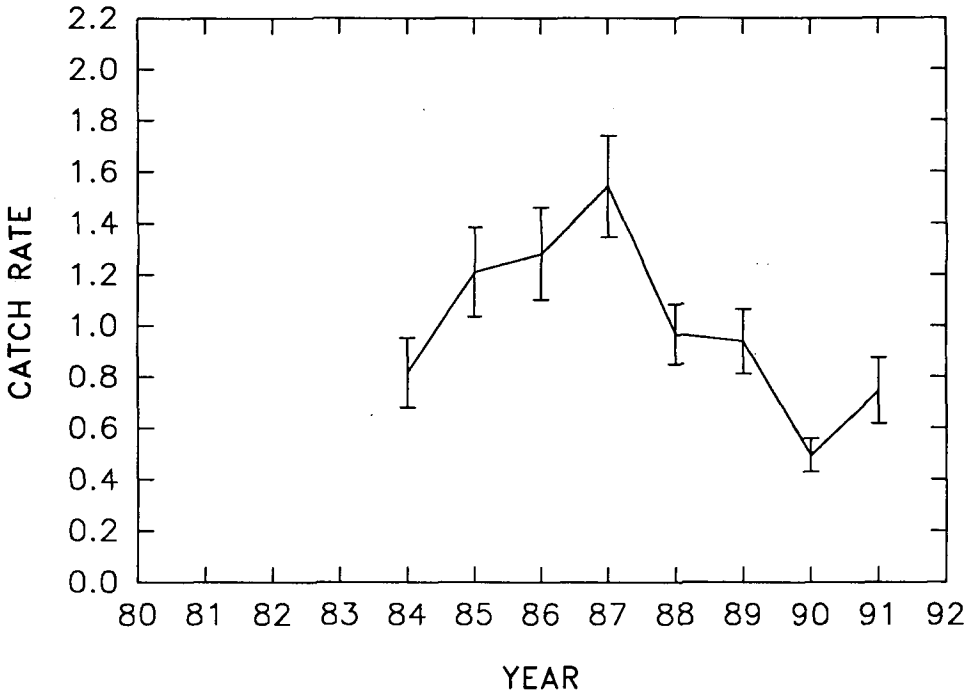


Figure 4. Proportion of total herring landings taken by gillnets and purse seines in NAFO Division 4R from 1967 to 1991.

A) Spring Spawners



B) Autumn Spawners

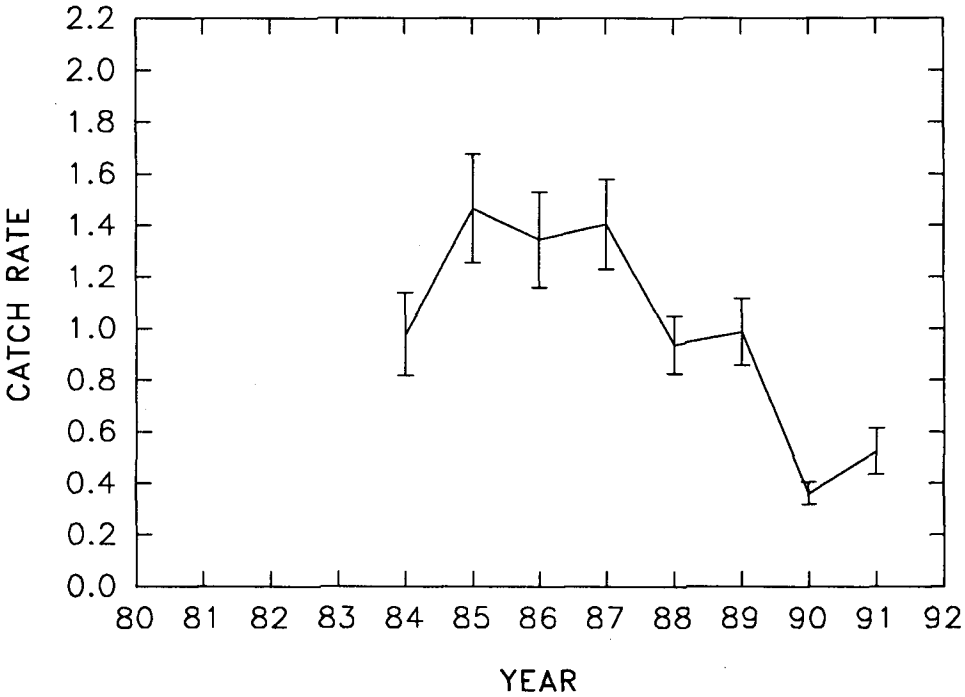


Figure 5. Standardized gillnet catch per unit effort and 2 S.E. for (a) spring-spawning and (b) autumn-spawning herring in NAFO Division 4R as calculated from index-fisherman logbook data.

Annex 1a. Agreement between agers for the number of rings on 4R herring otoliths in 1990 (Percent agreement in bold).

		Primary ager											
	rings	1	2	3	4	5	6	7	8	9	10	11+	Total
Secondary agers	1	1 **100**											1
	2	3 **20**	11 **73**	1 **7**									15
	3	3 **3**	24 **26**	66 **71**									93
	4			30 **65**	14 **30**	1 **2**	1 **2**						46
	5			5 **13**	23 **61**	8 **21**	2 **5**						38
	6			1 **2**	13 **22**	30 **50**	13 **22**	3 **5**					60
	7			1 **1**	8 **6**	35 **26**	75 **56**	15 **11**					134
	8			2 **1**	15 **4**	77 **21**	160 **44**	96 **26**	14 **4**	1 **1**	2 **1**		367
	9				1 **1**	8 **10**	33 **40**	21 **25**	17 **20**	3 **4**			83
	10				11 **5**	41 **18**	70 **30**	39 **17**	54 **23**	12 **5**	3 **1**		230
	11+				1 **2**	8 **12**	13 **20**	12 **18**	10 **15**	4 **6**	18 **27**		66
	Total	7	35	106	86	208	367	186	95	20	23		1133

Annex 1b. Agreement between agers for the number of rings on 4R herring otoliths in 1991 (Percent agreement in bold).

		Primary ager											
	rings	1	2	3	4	5	6	7	8	9	10	11+	Total
Secondary agers	1												
	2		14 **82**	3 **18**									17
	3			42 **91**	4 **9**								46
	4			8 **5**	165 **94**	3 **2**							176
	5				9 **18**	36 **73**	3 **6**	1 **2**					49
	6					5 **16**	21 **68**	5 **16**					31
	7					13 **11**	41 **35**	49 **42**	15 **13**				118
	8					8 **7**	38 **31**	51 **41**	27 **22**				124
	9					21 **9**	74 **33**	78 **34**	28 **12**	17 **8**	7 **3**	3 **1**	228
	10				2 **2**	9 **7**	29 **23**	42 **33**	15 **12**	11 **9**	13 **10**	5 **4**	126
	11+					5 **6**	26 **30**	22 **25**	14 **16**	1 **1**	4 **5**	15 **17**	87
	Total		14	53	180	100	232	248	99	29	24	23	1002

Annex 2. Number of herring sampled (**bold print**) and commercial landings (t) in NAFO division 4R by gear, area and month in 1990. (Boxed areas indicate sample-landing combinations for the weighting of the catch at age)

GEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
GN	4Ra							1 **49** 135	2 **50** 14	3 **47** 50	4 **49** 29	5 **49** 216	
	4Rb				7 10	4 16	9 25	17	3	1	1	6 **49** 117	
	4Rc					**49** 4	**50** 19	**44** 47	3	2	5		
	4Rd					10 **50** 34	11 **49** 12	40	9	2	1		
PS	4Ra						14	14	1				
	4Rb							138			1 **92** 379	2 **99** 2888	**100**
	4Rc					6536	450	3 **92** 205	26	17	261		
	4Rd					4 **247** 4799	335				23		

Annex 3. Number of herring sampled (**bold print**) and commercial landings (t) in NAFO division 4R by gear, area and month in 1991. (Boxed areas indicate sample-landing combinations for the weighting of the catch at age)

GEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
GN	4Ra						1 **48** 27 205		2 **92** 52	3 **45** 24	4 **49** 24	5 **49** 45	
	4Rb									**48** 1	**48** 12	6 **49** 6	
	4Rc								6	19	5		
	4Rd				7 2	**45** 4	**48** 1		9	12	6	4	
PS	4Ra							63	36				
	4Rb					8	42	113	18	1 45	**48** 501	2 **97** 3285	3 **95** 1330
	4Rc					490	89	4 **97** 127	5 **49** 1	6 107	**50** 130	7 **50** 161	463
	4Rd				8 6090	**236** 5667	214						