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A Review of the West Coast
of Newfoundland (NAFO Division 4R)
Herring Fishery and Biological Trends in 1989

by

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ABSTRACT

Concentrations of herring are exploited in NAFO Division 4R from April to December, by both fixed and mobile gears. Landings reached only 17,700 t in 1989, despite a TAC of 37,000 t, mainly due to poor market and weather conditions. A limited market demand for gillnetted herring has reduced the fixed gear landings to < 20% of the total since 1985. The traditional barrelled-product market has been slowly replaced by over-the-side sales to the Soviet Union, and frozen-round products for the Japanese. Spring spawners have dominated the annual catch 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. Abundance indices were estimated, for both spring and fall spawners, from commercial gillnet catch and effort data, and indexed gillnet fishermen logbooks. The spring catch-rate series showed a significant increase from 1981 to 1986-1987, and a subsequent decreasing trend to 1989. The fall-spawner series showed a major increase to 1986, followed by a decline to 1989. Population estimates from the cohort analysis were considered unreliable due to the unconverged population numbers and high values in the correlation matrices. However, it is notable that the mean age for these stocks is now 8 years old, suggesting that recent catch levels have not been detrimental to these populations. Also, it is implicit from the non-converged population estimates that fishing mortalities have been low in recent years.

RESUME

Les concentrations 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 37,000t, les débarquements de hareng n'ont atteint que 17,700t en 1989, particulièrement à cause des marchés restreints et des mauvaises conditions météorologiques. 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 du hareng en baril a été remplacé graduellement par les ventes directes à l'URSS et par les ventes de poissons gelés entiers aux Japonais. Les reproducteurs de printemps dominant 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 1983. 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. Les indices d'abondance ont été estimés pour les deux groupes reproducteurs à partir des données de prise et effort commerciales, ainsi que des données similaires compilées par les pêcheurs-repères. Les indices pour les reproducteurs de printemps ont démontré une augmentation d'abondance significative entre 1981 et 1986-1987, et une diminution subséquente jusqu'à 1989. Les indices du groupe d'automne ont démontré une augmentation majeure jusqu'à 1986, suivie par un déclin jusqu'à 1989. Les estimations de population produites par l'analyse de cohorte ont été considérées peu fiables étant donné les estimations des effectifs non-convergentes et les valeurs élevées dans les matrices de corrélations. Cependant, l'âge moyen de 8 ans pour ces stocks suggère que le niveau des prises récent n'a pas été nuisible aux populations. De plus, le fait que l'analyse de cohorte produise des estimations de population non-convergées implique que les taux de mortalité sont demeurés faibles au cours des dernières années.

INTRODUCTION

Herring 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 St. George's Bay 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 evaluated separately. It is generally accepted that spring and fall spawners in the northwest Atlantic have different 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 by both fixed (mostly gillnets) and mobile (mostly purse seines) gears 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 94% in 1989.

Total herring landings from the west coast of Newfoundland were relatively small from 1966 to 1970, ranging between 3,000 and 6,000 t (Table 1, Figure 2). A marked increase in catches began in 1971 which peaked at 27,000 t 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; a trend which was 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 t in 1986, but which has leveled off at between 16,581 t and 18,145 t in the last three years.

The fishing pattern of the purse seine fleet has fluctuated considerably over time in response to shifting concentrations of herring schools and their accessibility to buyers. In the latter half of the 1960's, almost 100% of the purse seine catches came from the Bonne Bay area (4Rb) (Figure 3a). During the 1970's, the fleet shifted its fishing activity northward to St. John Bay (4Ra) and southward to St. Georges Bay (4Rd), where most of the catch was reported. In the early 1980's, the proportion of market size fish decreased in St. Georges Bay due to the presence of large schools of juvenile herring (the abundant 1980 and 1982 year-classes). Consequently, in 1983 and 1984, the purse seiners concentrated most of their efforts during the spring fishery in the Bay of Islands area (4Rc) (Table 2a) on mixed schools of spring and fall spawners

(Table 3). However, as a proportion of the total catch, the spring fishery was declining in importance. From 1982 to 1987, the majority of the purse seine catches were taken from overwintering concentrations of mixed spring and fall spawners (Table 3) in areas 4Rb and 4Rc from October to December (Table 2a) reaching 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 to the Soviet Union, and by the development of a spring frozen-round fishery for the Japanese. This, along with some fishing by the fleet of purse seiners based in the southern Gulf of St. Lawrence, explained the considerable increase in landings from the spring fishery (from approximately 2000 t in 1987 to 9000 t in 1989), which accounted for over 50% of the total purse seine catch in 1989 (Table 2a). Also, landings in the late fall of 1989 decreased due to exceptionally poor weather conditions.

The nearshore fishery (mostly gillnets) has also gone through pronounced changes since 1966. In the late sixties, the proportion of the total gillnet catch taken in the southern areas rapidly declined, falling from 80% to 25% from 1968 to 1969 (Figure 3). From 1971 to 1978, most of the catch was reported from area 4Ra. After 1975, a major spring gillnet fishery developed south of Cape St. Gregory (Moore and Winters, 1980), resulting in a steady increase in landings reported from areas 4Rc and 4Rd until 1982. In recent years, almost equal proportions of the total gillnet catch have been taken from spawning concentrations (Table 4) in St. Georges Bay and Port-au-Port Bay in April and May, and north of Pointe Riche from July to September (Table 2b; Figure 3b), although a relatively active late fall fishery on mixed spring- and fall-spawner concentrations (Table 4) has occurred sporadically in areas 4Ra to 4Rc throughout this period.

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. In 1989, the late fall (October-December) fishery was almost non-existent, although this was at least in part due to extremely poor weather conditions.

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 between gear sectors 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. In 1989, an additional 2000 t allocation was made for an experimental inshore purse seine fishery. Compliance with these management measures has been variable, as the TAC was exceeded in 1978, 1979, 1982, 1985 and 1986 by between 21 and 48% (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 gillnet fishermen hired to keep detailed catch and effort data on herring caught throughout the fishing season, covering most of the major commercial landings (Annex 1). These samples were frozen and sent to the Quebec Region laboratory in Mont Joli 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 (GSI) (McQuinn, 1989a), 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. The 1989 catch at age (Table 5) was generated (CATAGE v1.0, Anon, 1986) for spring and fall spawners as described by McQuinn (1987b).

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 proportion has been over 80 % of the catch in numbers since 1988 due to the active spring fishery in St. Georges Bay. The 1968 year-class was the largest ever observed in the spring-spawner catch and completely dominated from 1973 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 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 in numbers, maintaining the mean age of the spring spawners (assuming ages 11+ to be 11) at 7.6 years old in 1989.

c) Fall-Spawner Catch at Age:

Herring of the 11+ age group have historically dominated the fall-spawner catch (Table 6). In 1984, the 1979 year-class strongly recruited into the fishery and contributed to more than 49% of the catch in numbers. In 1985, this same cohort increased its dominance to an historical high of 63%, declining steadily to 31% in 1989. The mean age of fall spawners in the catch has therefore risen in recent years, from 6.0 years old in 1985 to 8.0 years old in 1989. However, there has yet to be signs from the commercial catch of another strong recruiting year-class.

POPULATION ABUNDANCE INDICES

Abundance indices were estimated, for both spring and fall spawners, from commercial gillnet catch and effort data, and from detailed logbooks of daily catch and effort compiled by indexed gillnet fishermen, covering most of the

fishing season.

a) Commercial Data

Annual gillnet catch rates were estimated using all available purchase slips from 1981 to 1989. 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). In addition, slips which represented a weekly sum of landings rather than a daily trip were excluded.

The estimated number of nets fished/day between 1982 to 1989 were obtained from written surveys sent between 1984 to 1988 to all licensed fishermen along the west coast. In addition, estimates of the numbers of nets fished for each fishermen were also available between 1981 and 1983 from the licence application forms. In order to weight the mean number of nets used in the multiplicative model by the number of landings of each fisherman, the purchase slip and questionnaire files were merged. This involved matching the Commercial Fishing Vessel (CFV) number from the questionnaires with the individual purchase slips to produce a combined data set where effort was the number of nets/fisherman/day rather than a daily trip.

A multiplicative model was then fitted to these catch and effort data to yield standardized annual catch rates for each spawning stock (Gavaris, 1980). The category types for the model were month, unit area and year.

b) Logbook Data

Indexed gillnet fishermen have been hired since 1984 to complete daily logbooks, recording their catch and effort (number of nets/day) as well as their location, mesh-size, size of nets and water depth. Annual gillnet catch rates were also estimated from these data and standardized using the multiplicative model. The category types for the model were year and each fisherman. As each fisherman fished in the same area and during the same time period each year, the category types month (or week) and area were highly correlated with the fisherman category type and could not be used in the model. Catches in each category type were proportioned to spring and fall spawners in the same manner as with the commercial purchase slip data (Table 4).

ASSESSMENT RESULTS

The commercial and logbook catch-rate series exhibited very similar trends, both for spring and autumn spawners, although the commercial catch rates have been more variable over time (see text table below and Figure 5).

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989
Spring Spawners									
Commercial	.38	.36	.69	.63	.61	1.51	1.36	.82	1.07
Indexed Fishermen				.62	.84	1.21	1.30	1.02	1.01
Fall Spawners									
Commercial	.71	.57	.51	.86	.71	1.74	.98	.73	.98
Indexed Fishermen				.66	.92	1.37	1.21	.93	.90

The spring catch-rate series showed a significant increase from 1981 to 1986-1987, and a subsequent decreasing trend to 1989. The fall-spawner series showed a major increase to 1986, followed by a decline to 1989.

Cohort analyses were calibrated age by age using the adaptive framework (Gavaris, 1988). The formulation was the same as described by McQuinn (1989b). Using either the logbook catch rates alone or combined with the commercial index resulted in significant parameter estimates (except for age 4 numbers) for both the spring and autumn spawners. However, most of the correlations between parameters were above 0.5, presumably due to the short time series of catch-rate data. Also, although the fishing mortalities were higher on some age-classes, in general, the cohort analyses did not converge. These low fishing mortalities also imply that the assumption used to estimate the oldest-age F vector, i.e. F at age 10 equal to that at 11+, may have a significant effect on the analyses. In situations where this assumption is violated and the population numbers from the VPA are unconverged, significant biases may be introduced into the estimates. Therefore, due to the non-convergence of the population numbers and the high values in the correlation matrix, it would be ill-advised to accept population estimates derived from VPA.

PROGNOSIS

With an unconverged F-matrix from the analytical assessment, it was not possible to have confidence in the historical population estimates nor the catch projections for 1991. However, it is notable that the mean age for these stocks is now 8 years old, suggesting that recent catch levels of between 14,000-22,000 t have not been detrimental to these populations. Also, it is implicit from the non-converged population numbers that fishing mortalities have been low in recent years. However, a point of caution must also be mentioned. No significant recruitment has been detected since the 1982 year-class. This has resulted in a gradual decline in the catch rates since 1987. In the absence of greater than average recruitment, this trend is expected to continue.

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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 1988.

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	10000
1983	0	1410	2	1412	3269	873	46	4188	3223	226	108	3557	787	1438	34	2259	7279	3947	190	11416	10000
1984	0	1006	1	1007	3023	902	0	3925	4166	554	2	4722	15	790	4	809	7206	3252	7	10465	10000
1985	1720	398	0	2118	1733	164	0	1897	9718	348	4	10070	0	295	6	301	13171	1205	10	14386	10000
1986	1854	273	0	2127	1586	1069	0	2655	15830	468	0	16298	0	337	0	337	19270	2147	0	21417	17000
1987	222	550	0	772	3183	1137	0	4320	10164	327	5	10496	164	829	0	993	13733	2843	5	16581 ¹	30600
1988	2019	435	0	2454	13197	592	0	13789	1093	256	0	1349	44	509	0	553	16353	1792	0	18145 ¹	30600
1989	9111	177	0	9288	6589	444	0	7033	947	69	0	1016	13	337	0	350	16660	1027	0	17687 ¹	37000

* Includes shrimp trawl, bar seine, trap, midwater trawl and otter trawl.

¹ Preliminary

Table 2.a. Herring landings (t) by purse seines in NAFO division 4R by unit area and month from 1983 to 1989.

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								482		526	5577	3133	9718
	4Rb										170			1733
	4Rc					1464	99							1720
	4Rd					1720								1720
	Total					3184	99		482		696	5577	3133	13171
1986	4Ra										3091	10608	2131	15830
	4Rb													1586
	4Rc					1400		186						1854
	4Rd				185	1669								
	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										312	437	273	1093
	4Rc				639	5342	70		6	71	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

Table 2.b. Herring landings (t) by gillnets in NAFO division 4R by unit area and month from 1983 to 1989.

YEAR	AREA	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
1983	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

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 1989.

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						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						
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						

Table 4. Proportion (%) of spring- and fall-spawning herring in the gillnet catch by month and fishing area, NAFO division 4R from 1973 to 1989.

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	
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	

Table 5. Spring- and fall-spawner catch at age ($\times 10^3$) and proportion of spring spawners in NAFO division 4R herring landings from 1973 to 1989.

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

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

		TOTAL (SPRING AND FALL)																
		1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
		93937	23303	18477	35489	39326	44520	51245	48288	32173	38062	31223	32286	49978	73366	50859	53475	49292

		PERCENT SPRING SPAWNERS																
YEAR		1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
%		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

Table 6. Age composition (%) and mean age* of (A) spring and (B) fall spawners in NAFO division 4R herring landings from 1973 to 1989. 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
1	.0	.0	.0	.0	.1	.0	.0	.0	.1	.0	.0	.2	.1	.5	.8	.4	.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	.8	1.7	7.9	2.4	1.8	.1	.1	2.2	1.6	8.0	<u>13.8</u>	2.2	13.2	4.1	.9	1.2	1.4
4	2.0	.9	3.3	3.0	1.8	5.9	.6	.3	8.1	2.3	<u>16.5</u>	<u>39.8</u>	2.3	<u>24.3</u>	7.2	1.0	1.9
5	<u>52.3</u>	2.5	.8	.7	1.4	.6	<u>28.7</u>	.9	.5	8.3	5.2	19.5	<u>62.5</u>	5.9	<u>39.8</u>	5.6	1.2
6	4.8	<u>63.2</u>	8.4	1.2	1.0	2.0	1.6	<u>35.1</u>	1.4	1.4	5.1	3.0	11.5	<u>50.8</u>	9.1	<u>34.5</u>	7.6
7	6.0	2.1	<u>66.8</u>	9.9	1.2	.7	2.9	1.0	<u>34.0</u>	7.3	1.4	4.2	1.3	9.3	<u>33.8</u>	9.3	<u>46.8</u>
8	6.1	5.7	2.5	<u>54.8</u>	14.4	6.4	1.5	3.4	.7	<u>21.9</u>	3.3	1.1	1.1	.8	4.5	<u>33.9</u>	7.7
9	4.9	5.2	2.7	2.7	<u>52.8</u>	24.2	7.4	.6	2.0	2.4	<u>13.9</u>	3.4	.7	.3	.5	6.4	<u>27.3</u>
10	9.0	3.3	1.9	11.0	5.6	<u>45.1</u>	19.6	3.6	1.1	3.2	3.7	3.9	1.1	.5	.1	1.1	1.9
11+	10.7	14.5	5.3	12.6	19.9	15.0	<u>37.2</u>	<u>52.1</u>	<u>50.5</u>	<u>43.3</u>	<u>37.0</u>	21.6	5.1	2.9	2.1	4.9	3.5

MEAN AGE* OF INDIVIDUALS IN CATCH

YEAR	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
MEAN AGE	6.50	7.02	6.81	8.14	9.00	9.29	8.61	8.74	8.76	8.43	7.69	6.31	5.25	5.59	5.90	7.05	7.57

B) FALL SPAWNER AGE COMPOSITION (%)

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

MEAN AGE* OF INDIVIDUALS IN CATCH

YEAR	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
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

* assuming ages 11+ to be 11.

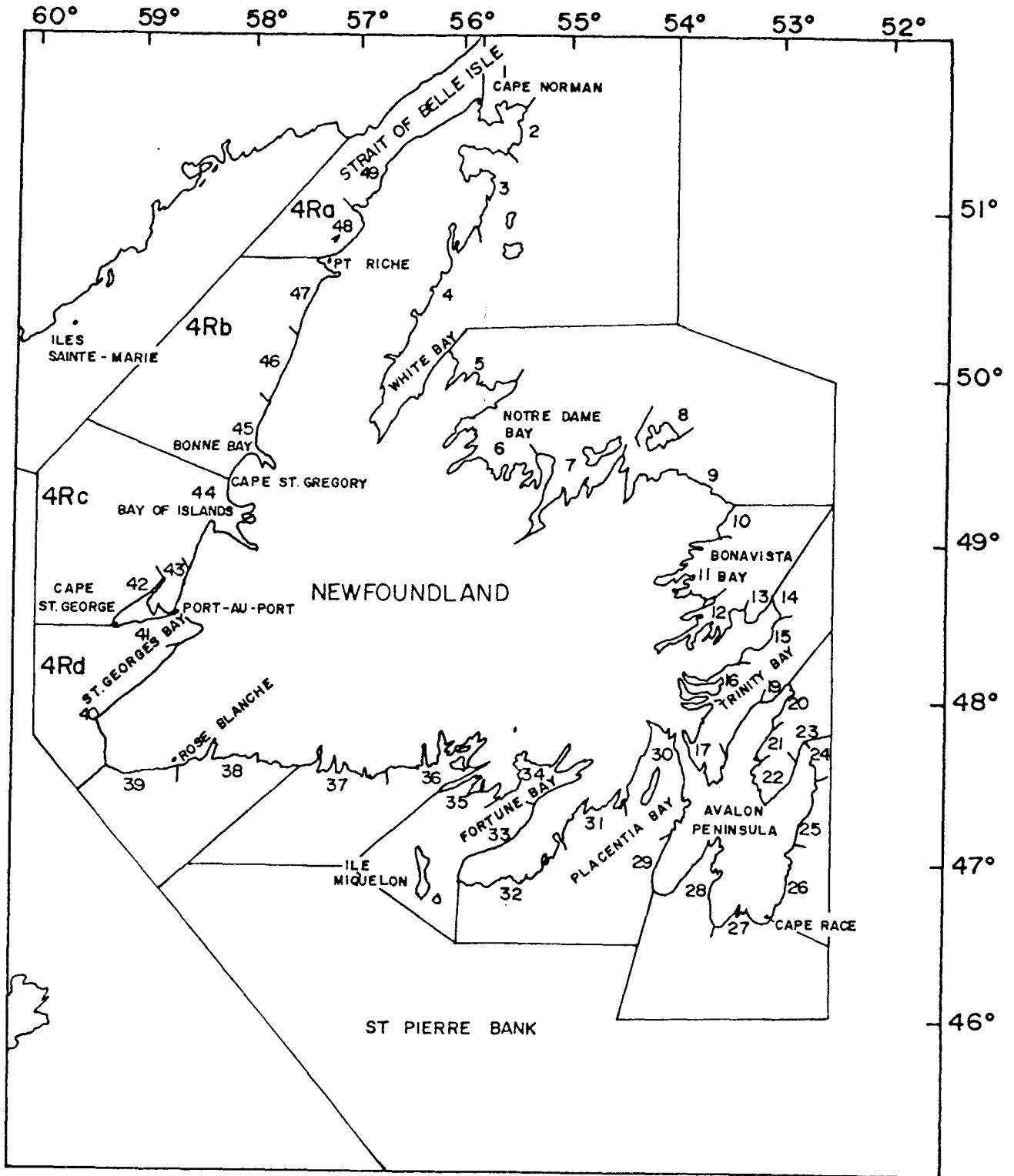


Figure 1. West coast of Newfoundland unit areas and statistical districts.

Commercial Herring Landings

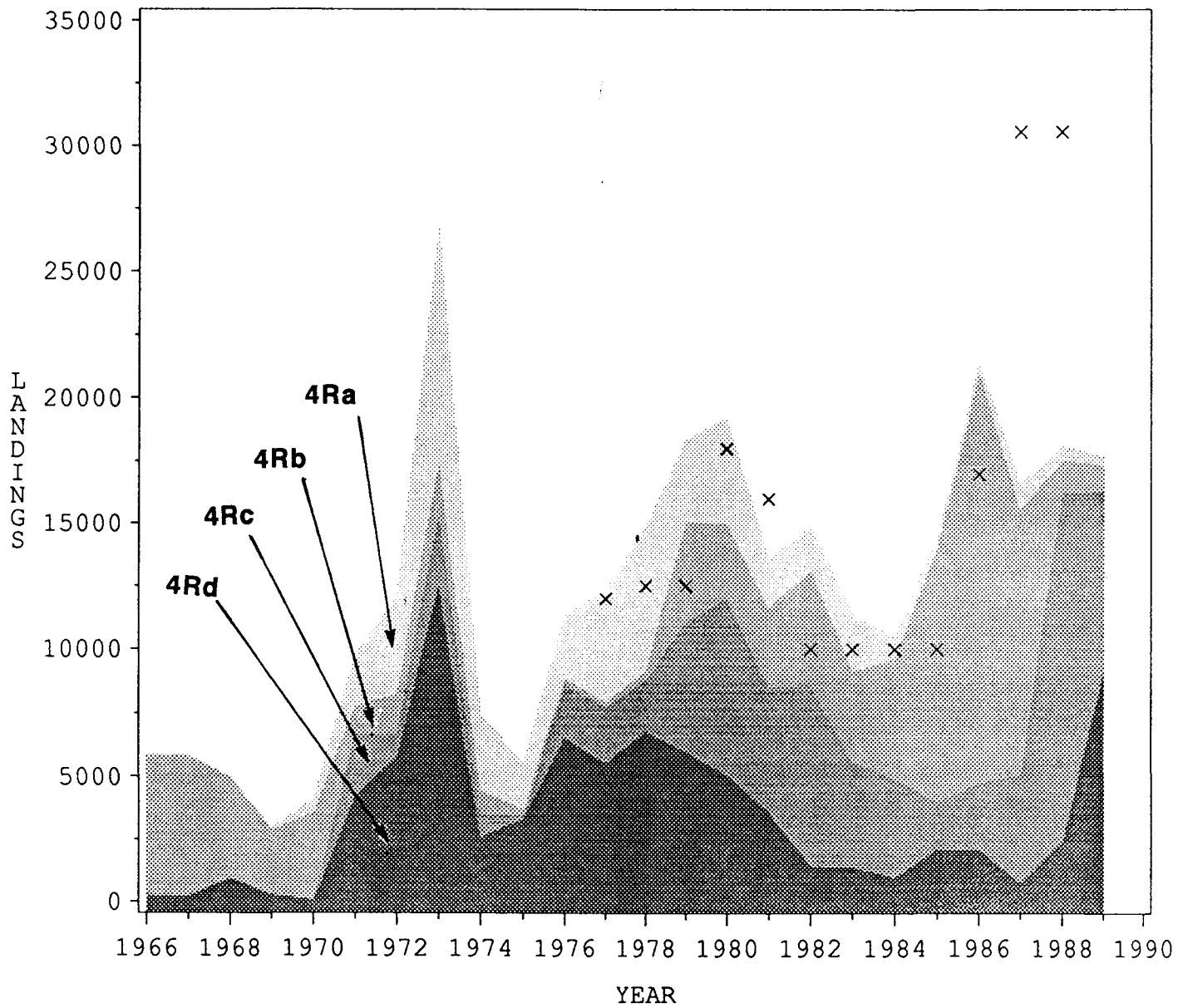


Figure 2. Cumulative commercial herring landings (t) by fishing area in NAFO Division 4R from 1966 to 1989. "X" indicates annual TAC.

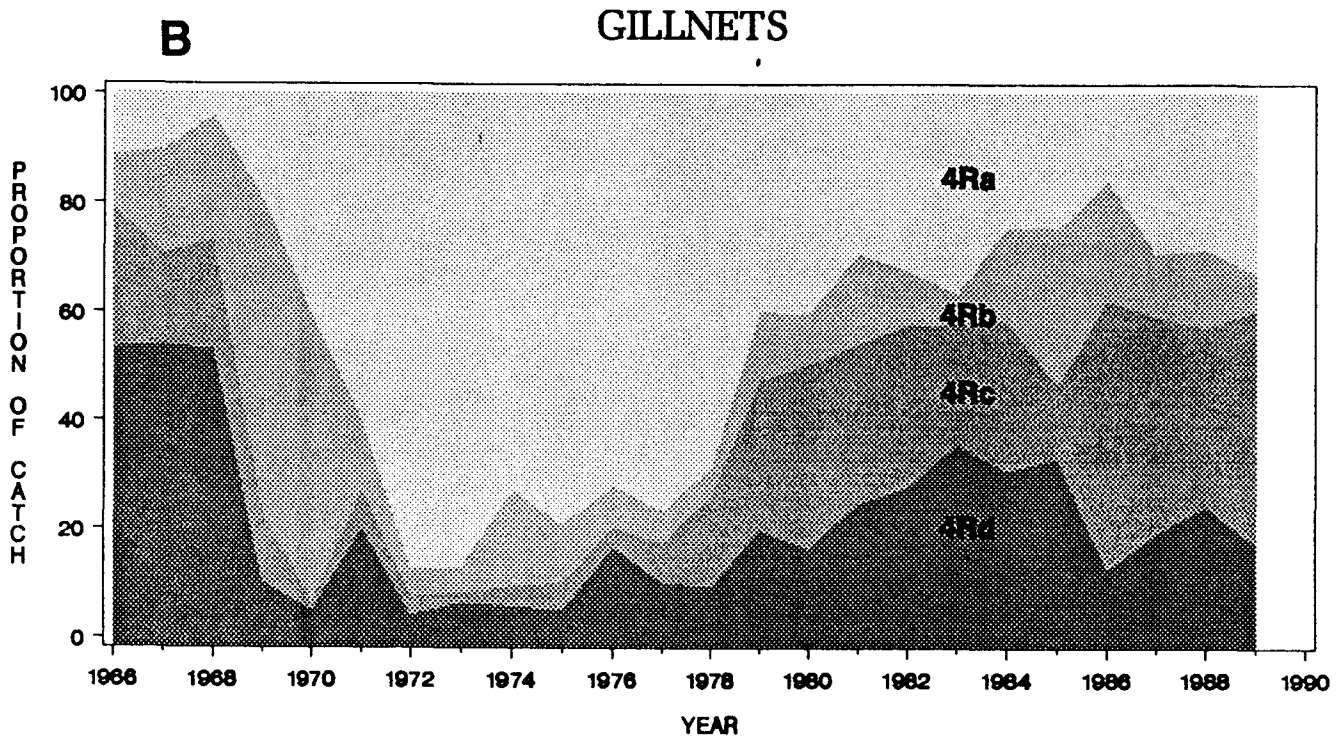
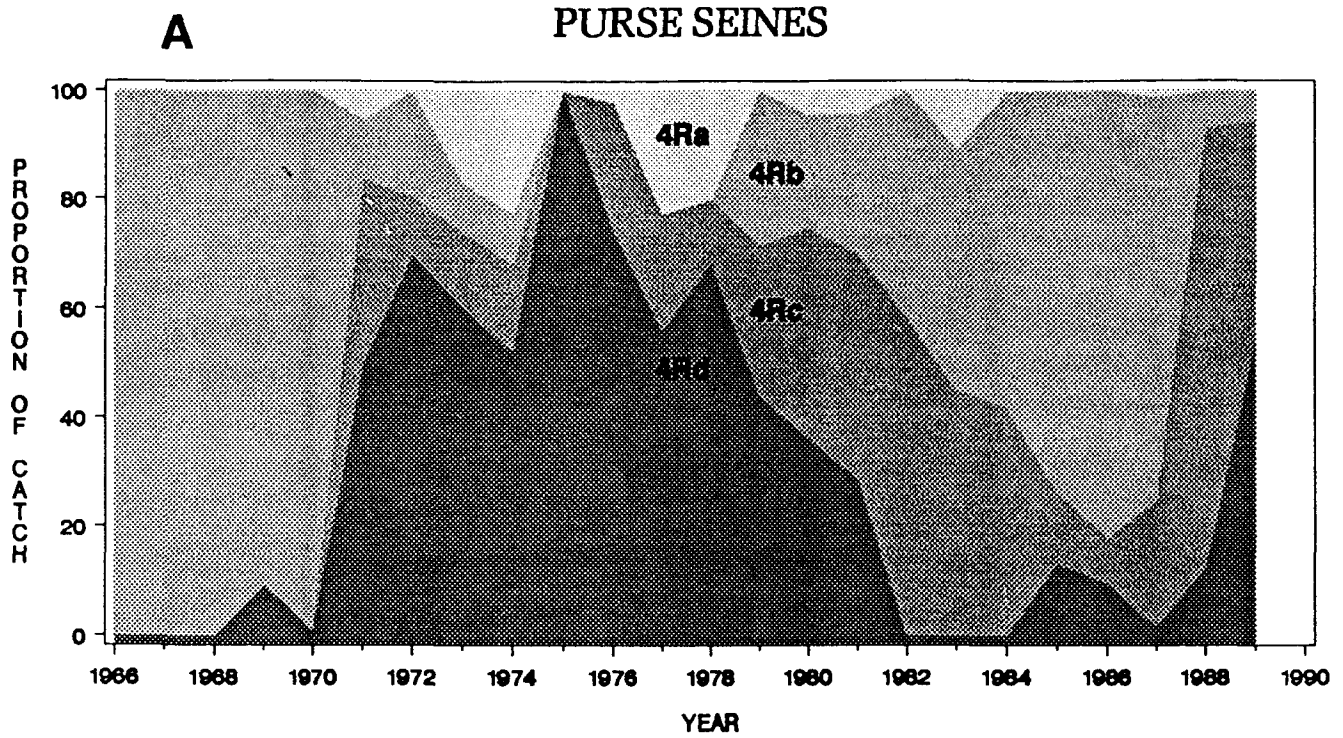


Figure 3. Proportion of (a) purse seine and (b) gillnet herring landings by fishing area in NAFO Division 4R from 1966 to 1989.

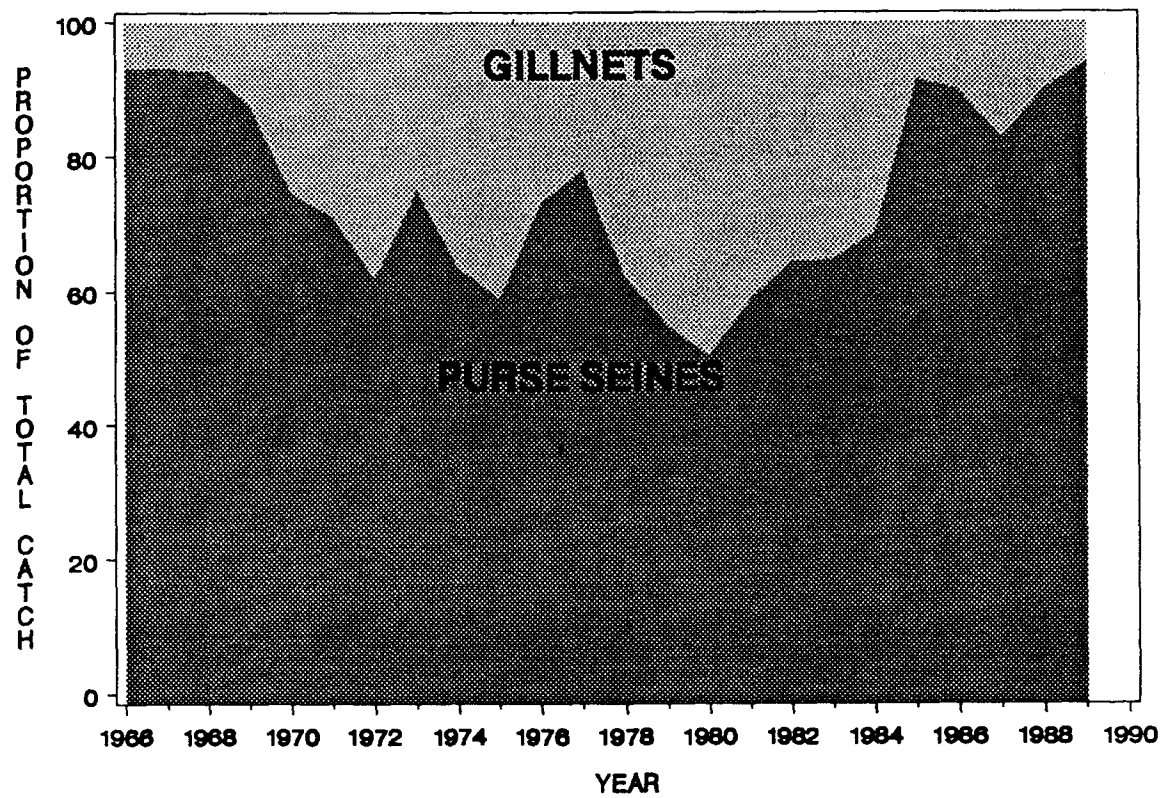
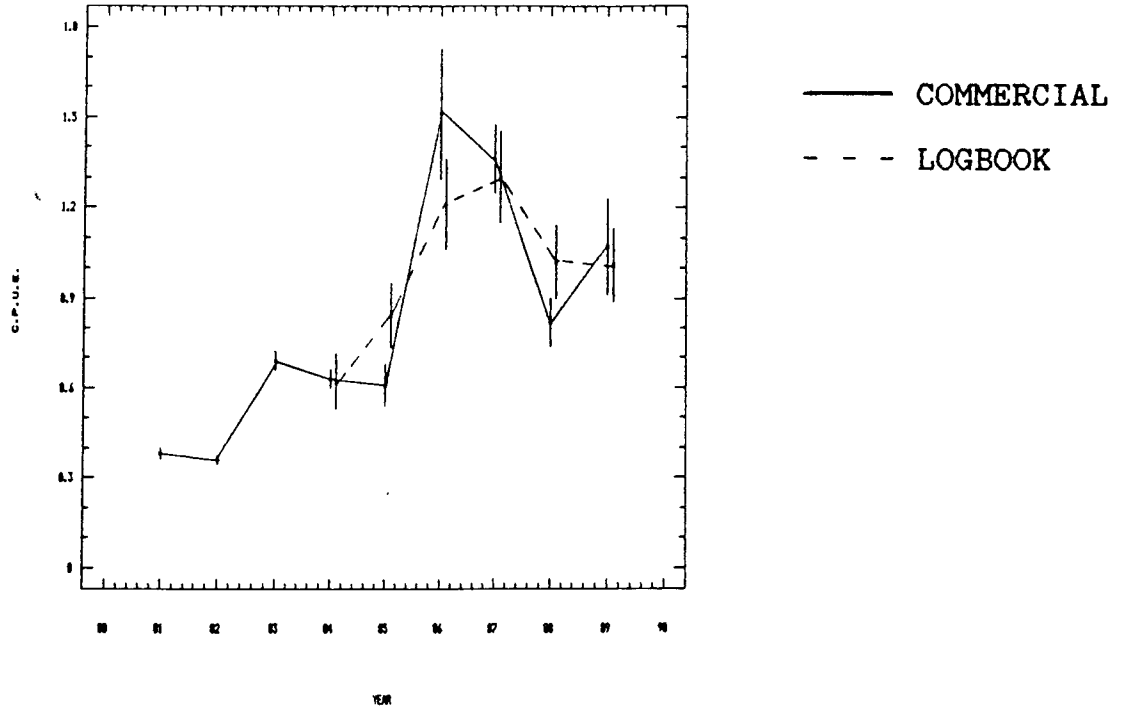


Figure 4. Proportion of total herring landings taken by gillnets and purse seines in NAFO Division 4R from 1966 to 1989.

(A) SPRING SPAWNERS



(B) FALL SPAWNERS

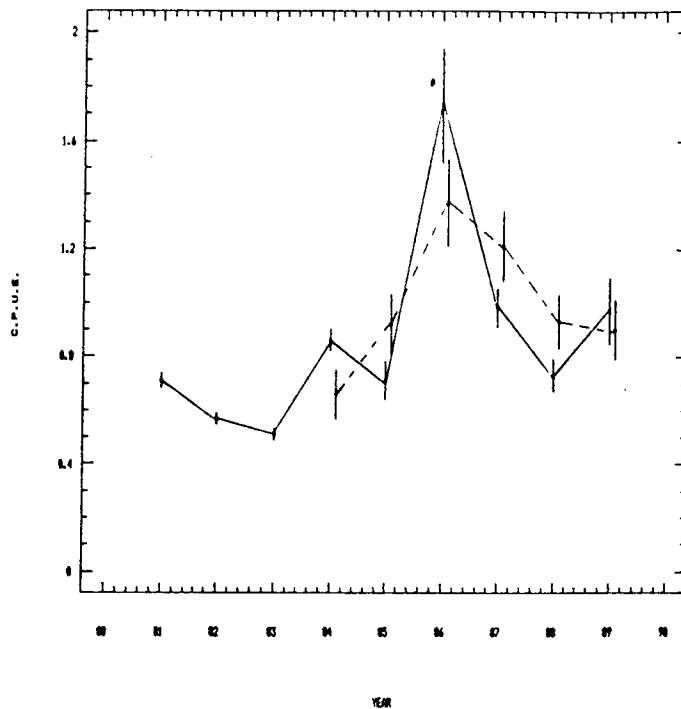


Figure 5. Standardized gillnet catch per unit effort and standard deviations for (a) spring- and (b) fall-spawning herring in NAFO Division 4R as calculated from commercial purchase slip and questionnaire data, and research logbook data.

Annex 1. Number of herring sampled (**bold print**) and commercial landings (t) in NAFO division 4R by gear, area and month in 1989. (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					4	1 34	121 13	2 276	3 120	4 50 4	100 182	100
	4Rb		6 1	2	8	16	7 24	8	2	1	5 93 7	150 114	
	4Rc				50 10	593 213	422 101	108		11		1	
	4Rd				8 2	199 107	191 36	19	7	5		1	
PS	4Ra								1* 13				
	4Rb				2 33	97					3 149 81	4 294 347	5 298 486
	4Rc				6 35	47	51		7 6	137 514	8 136 776	3080	2127
	4Rd				9 379	550 8587	145						

* Spawning group proportions determined from sampling in same area, month and gear in 1988; mean weight and composition from Box 7.