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Revisions to the 4R Herring Catch-at-Age Matrices

by

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ABSTRACT

The NAFO division 4R herring catch-at-age matrices have been recalculated for spring and fall spawners using a spawning group determination method based on the gonadosomatic index. In addition to changes in the spawning group assignments, the purse seine landings from 1982 to 1986 have also been revised, using additional landings provided by industry. The methodology used to calculate the gear-specific as well as the annual catch-at-age matrices is described. Comparisons made between the revised catch at age and the previous catch at age showed some substantial differences due to both the more precise and objective method employed for the separation of the spawning groups and the inclusion of the previously unreported purse seine landings.

RESUME

Les matrices de captures à l'âge du hareng de la division 4R de l'OPANO ont été recalculées pour les reproducteurs de printemps et d'automne en utilisant une méthode de détermination des groupes reproducteurs basée sur le rapport gonadosomatique. En plus des changements dans la détermination des groupes reproducteurs, les débarquements des seines bourses entre 1982 et 1986 ont été révisés également, en ajoutant des données de débarquements additionnels fournies par l'industrie. La méthodologie utilisée pour le calcul des matrices de captures à l'âge par engin et par année est décrite. Les comparaisons effectuées entre les matrices de captures à l'âge révisées et celles obtenues précédemment ont montré des différences importantes dues à la méthode plus précise et objective pour la séparation des groupes reproducteurs ainsi qu'à l'inclusion de débarquements des seines bourses non rapportées par le passé.

INTRODUCTION

Analytical assessments, based on cohort analyses, have been performed separately on the spring and fall spawning components of the NAFO division 4R (Figure 1) herring stocks since 1977 (Moores and Winters, 1977). The separation of the two spawning components in the commercial samples had been made by visually determining the maturity stage of individual herring and estimating when it had or would have spawned. McQuinn (in preparation) showed that errors could occur in the assignment of spawning group using this method due firstly to the misclassification of the maturity stages and secondly from inaccuracies in the assumed rate of development of the gonads throughout the year. He showed that determining maturity stages using the gonadosomatic index (GSI) was both objective and more precise than the visual method, especially when treating frozen samples. By tracking the gonadal development of 4R spring and fall spawning herring throughout the year, as measured by the GSI, McQuinn (1987a) showed that the actual rates of gonadal development of each spawning group differed, in some cases substantially, from the generalized chart used by CAFSAC (Cleary *et al.*, 1982).

As all the necessary data was available in the historical data series (gonad weight, total length and age), the 4R herring catch-at-age matrices have been recalculated using the spawning group determination method as described by McQuinn (1987b). In addition to changes in the spawning group assignments, the purse seine landings from 1982 to 1986 have also been updated, using records provided by industry.

MATERIAL AND METHODS

Calculation of the Catch at Age

a) Source of landing information:

Landings from 1973 to 1981 were supplied by J. Moores (Fisheries Research Branch, Newfoundland Region). These data originated from the Statistics Branch (Newfoundland Region) although certain landings were reallocated for some gear categories in some years due to coding errors. Gillnet landings from 1982 to 1986 were provided by Statistics Branch (Newfoundland and Gulf Regions).

Information from Protection Branch personnel (Gulf Region) and observers aboard the purse seines indicated that the purse seine landings had been under-reported from 1982 to 1985, in some years by as much as 85%. Industry spokesmen claimed that under-reporting of purse seine catches began in 1982 due to the lowering of the TAC to 10,000 t in that year, of which only 5,500 t were allocated to the purse seine fleet. After several meetings with industry between 1985 and 1987, total purse seine catches were supplied independently by each purse seine operator and each producer, which were then cross-referenced in the presence of the author. An examination of recent TAC's, purse seine allocations, and purse seine reported and adjusted catches (Table 1) revealed that the purse seine allocation had dropped from 9,000 t in 1981 to 5,500 t in 1982 although the actual purse seine catch

remained relatively constant throughout the early 1980's. The proportion of misreporting from these records was equal to or less than estimates made by observers aboard the vessels during the same time period (Table 2) indicating that the data supplied by industry was not an overestimate of the actual landings.

As the revised landing information was only available by fishing season (spring, summer and fall), these catches were allocated by month and unit area in the same proportions as the landings reported to Statistics Branch.

b) Sample strata:

A series of tables were produced to assign landings to their respective commercial samples (sample strata). The distribution of samples and landings were tabulated for each month, unit area, gear sector (mainly purse seines and gillnets) and year (Table 3). Where there was no sample corresponding to a landing, the landing was grouped to the sample(s) which was judged to best represent that catch. An analysis of the samples over the years revealed general similarities in spawning group composition between samples within a given quarter (McQuinn, 1987b) ie. April to June, July to September and October to December (few catches or samples were recorded between January and March). Similarities in spawning group composition were also noted within the southern (4Rb, 4Rc and 4Rd) and northern (4Ra and 2Jo) unit areas (Figure 1). As less variation was observed in the percent spring and fall spawners between adjacent months within a given unit area and quarter than between adjacent unit areas within a given month, the following hierarchy was used for the grouping of landings where sufficient samples were available:

- a) across months within a unit area and quarter
- b) across unit areas within a month
- c) across months and unit areas within a quarter
- d) across months and quarters within the northern or southern zone

c) Calculations of the Catch at Age and Weight at Age:

Percent spring and fall spawners, as determined by the GSI method for spawning group assignments, was derived for each sample stratum, gear sector and year. The mean percent at age, mean weight and mean weight at age were then determined for each spawning component within each sample stratum (FREQAGE v.1.0, Anon, 1986). The catch at age was then calculated for each spawning component within each sample stratum and then summed across strata to produce a gear-specific catch at age (CATAAGE v. 1.0, Anon, 1986) (Tables 4 and 5), which were then summed for all gears to produce the annual catch at age (Table 6). In addition, the total catch at age was recalculated excluding the additional purse seine landings for 1982 to 1985 provided by industry (Table 7). These matrices were then compared to the catch at age presented in last years assessment (McQuinn, 1986) (Table 8).

The annual weight at age for each spawning component was estimated as the mean of the weight at age of each stratum and gear sector, weighted by landings (Table 9). These weight-at-age matrices were used to estimate the catch and total biomasses. Weight-at-age matrices were also calculated

from the weighted mean gillnet weight at age of each stratum in the second quarter for spring spawners and the third quarter for fall spawners (Table 10). These matrices were used to estimate gillnet fishable biomass for each spawning component for the calibration of the cohort analyses.

RESULTS

Comparisons Between the New and Old Catch at Age

Comparing the differences produced by the reassignment of spawning groups (and possible differences in the definition of the sample strata) showed important changes throughout the matrices (Table 11). The extent of the revisions is best illustrated by an examination of the catches of the largest year-classes. Major changes in the spring spawner matrix included the large 1980 year-class which increased by 21 and 18% in 1984 and 1985, respectively and the large 1974 year-class which increased by 80% at age 9 in 1983. For the fall spawners, the strong 1979 year-class decreased by 23% in 1985 and 11% in each of 1984 and 1983. The moderately strong 1973 year-class increased from 6 to 177% from age 4 through 8 and decreased 13 and 33% at age 9 and 10, respectively.

The addition of the unreported purse landings from 1982 to 1985 showed even more drastic deviations from the previous catch at age (Table 12). The strong 1980 spring spawner year-class almost doubled in both 1984 and 1985. Similarly, the catch of the 1974 year-class was 1.3 times the previous 1983 value. A comparison of the revised catch at age matrices with and without the revised landings (Table 13) showed how important the misreporting had become, with increases of between 12 and 101%.

DISCUSSION

The comparisons made between the revised 4R herring catch-at-age matrices (with and without the updated purse seine landing information) and the last years catch-at-age matrices showed several major changes. An indication of the improvements achieved by the reassignment of the spawning groups is demonstrated by the greater consistency in the relative annual strength of the strong 1974 spring spawner and the moderately strong 1970 and 1973 fall spawner year-classes. These improvements resulted from the more accurate and objective method employed for the separation of the spawning groups. In addition, the inclusion of the previously unreported purse seine landings has afforded a more realistic view of the exploitation pattern of these two spawning components in recent years.

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Table 1. Recent TACs, purse seine allocations, and purse seine reported and adjusted catches for NAFO division 4R herring.

YEAR	1978	1979	1980	1981	1982	1983	1984	1985
TAC	12.5	12.5	18.0	16.0	10.0	10.0	10.0	10.0
P.S. ALLOCATION			10.0	9.0	5.5	5.5	5.5	5.5
REPORTED P.S. CATCH	9.1	10.0	9.6	7.9	5.6	4.6	4.7	8.1 ¹
ADJUSTED P.S. CATCH					9.5	7.3	7.2	13.2

¹ Purse Seine Landings from Quota Reports

Table 2. Estimates of purse seine misreporting, as calculated from reported herring landings and industry supplied landings, compared to estimates obtained from observer logbooks in NAFO division 4R.

YEAR	1982	1983	1984	1985
REPORTED LANDINGS	5584	4611	4784	8160
INDUSTRY LANDINGS	9548	7279	7206	13171
ESTIMATES OF MISREPORTING (%)	71	58	51	61
OBSERVER ESTIMATES (%)	-	-	53	86

Table 3. Sample-landing combinations used for weighting the catch at age for 4R herring (number of fish sampled in bold face, tonnes landed in normal script, stratum number in superscript).

GILLNET														
YEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1973	2Jo						² 200 14	76	229	³ 459				
	4Ra						50 63	902	2568	365	406	739 714	742	
	4Rb	¹ 3	1	1		78	41	⁴ 288 69	25		⁵ 100 1	21	⁶ 597 55	10
	4Rc				12	80	9	5	8	4	4			
	4Rd				190	181	6	5	3	37	6	1		
1974	4Ra						⁴ 6	¹ 390	545 490	406	² 23	50 74	³ 50 583	
	4Rb						100 230	189		11	16	18	150 15	
	4Rc				1	31	50	15	1	1	1	1		
	4Rd				1	72	83	2				1		
1975	4Ra					¹ 2	20	² 185	907	410	⁴ 192	42	6	
	4Rb						150 31	52	100 112	6	6	17	15	1
	4Rc					³ 96	12	2				2		
	4Rd					50 1	103	10	1			1		

Table 3. (con't)

GILLNET

YEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1976	4Ra						123	¹ 300 269	593	626	² 268	150 263	1
	4Rb					³ 84	100 37	8	2	2	30	62	1
	4Rc			⁴ 2	19 64	35				7	1	2	
	4Rd				29 15	434	41			4	2	3	
1977	2Jo						¹ 200 50	² 37	466	250 85	3		
	4Ra				³ 1	50 2	⁴ 485 340	⁵ 100 558	⁶ 400 157	⁷ 350 366	⁸ 200 546	⁹ 59	
	4Rb			¹⁰ 4	87	90 21	¹¹ 50 3			1	29	9	50 4
	4Rc		¹² 1	823	115	36				17			
	4Rd				45	152	65			10			
1978	2Jo						¹ 100 10	179	250	34	2		
	4Ra				² 1	50 70	³ 700 695	⁴ 1148	³ 645	⁵ 725	350 482	29	
	4Rb			⁶ 77 66	⁷ 100 25		20	1	35	71	69	1	
	4Rc		⁸ 199	491	16		21	1	66	128	9		
	4Rd				100 41	437	2	4		23	12	3	

Table 3. (con't)

GILLNET

YEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1983	4Ra			¹				53	² 219	³ 219	⁴ 219	⁵ 219	⁶ 55 137
					9	5	43	235	535	233	82	159	
	4Rb			¹⁰						⁷ 30	⁸ 78	⁹ 111	55 39
					29	48	9	23	18	6	25	29	
4Rc	2	1	5	394	358	44		36	26		2	2	3
4Rd					56								
		1	2	15	887	429	29	25	12	3	5		2
1984	4Ra							¹	1132	² 445	³ 100	⁴ 50	⁵ 294
								99	154	131	225	122	11
	4Rb										⁶ 98	50	⁷ 99
					64	117	82	3	2	59	76	138	13
	4Rc					303					⁹ 100		
				248	208	47	24	15	7	199	106	48	
4Rd					¹⁰	101							
					253	673	30	21	9	8	8	3	1
3PN									50				
				9					2	6	1	1	
1985	4Ra							¹	50	² 656	³ 243	⁴	100
										20	152	2	112
												2	4
	4Rb												
				⁵		⁶							
				1	22	38	2	11	6	26	234	8	
4Rc					327	220							
				2	93	28	11	9	4	11	1	5	
4Rd													
					⁷ 355								
					324	28	19	5	11	10		1	

Table 3. (con't)

PURSE SEINE

YEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1973	4Ra											⁴ 16	¹ 400 3437
	4Rb	² 450 46				⁸ 72	96			³ 23	100 440	250 1086	
	4Rc				⁵ 150 434	150 2247	59						
	4Rd		47		⁷ 446 9373	2689				3			
1974	4Ra												¹ 300 1071
	4Rb											95	50 344
	4Rc					² 50 98	553			100		6	
	4Rd				³ 200 1879	400 586							
1975	4Ra												
	4Rb												
	4Rc												
	4Rd				¹ 50 229	² 550 3266							
1976	4Ra												¹ 300 184
	4Rb												
	4Rc					² 150 1956							
	4Rd				³ 740 2147	⁴ 450 3920							

Table 3. (con't)

PURSE SEINE

YEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1977	4Ra								¹ 2	150 136	² 50 1254	938	
	4Rb												100
	4Rc					³ 695 2009							
	4Rd		⁴ 16	1140 3349		⁵ 300 1924							
1978	4Ra										¹ 774 1491	² 450 1145	
	4Rb												
	4Rc				³ 94 1037								
	4Rd				⁴ 721 6252								
1979	4Ra										¹ 100	² 150	
	4Rb										150 2225	604	
	4Rc				³ 278 1517	⁴ 96 1256							
	4Rd				⁵ 1069 4387								
1980	4Ra									¹ 1	427		
	4Rb										400 2002		
	4Rc				² 247 3440	19						³ 1085 245	
	4Rd				⁴ 849 3481			19					

Table 3. (con't)

PURSE SEINE

YEAR	AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1985	4Ra												
	4Rb								¹ 250	² 800 344	¹ 950 3382	⁴ 650 2050	
	4Rc					⁵ 965 682	⁶ 165 46		50 477	⁷ 150 111	³ 267		
	4Rd					⁸ 250 801							

Table 4. Purse seine catch at age ($\times 10^{-3}$) for spring and fall spawning herring in NAFO division 4R from 1973 to 1985 using the GSI model and revised landings for 1982 to 1985.

SPRING SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	1833	141	57	484	10	0	167	296	40	594	13	197	362
3	427	250	994	667	521	38	25	783	358	2055	2123	420	4586
4	918	129	330	846	538	1608	172	56	1309	548	1792	6357	754
5	25724	293	88	201	370	125	7728	231	76	1573	663	2323	20422
6	2342	7658	842	335	251	546	169	8375	191	315	578	353	3602
7	1997	207	7550	2221	207	176	466	180	4835	1813	237	345	378
8	2463	468	227	13777	3321	1406	210	722	106	3993	694	142	306
9	1814	644	269	636	14279	6527	1135	100	323	475	1790	437	211
10	4322	401	196	2596	1370	10962	3966	474	170	694	549	483	318
11+	2866	965	490	2252	4291	2523	7161	12249	9698	8720	4824	2334	1474
2+	44706	11156	11043	24015	25158	23911	21199	23466	17106	20780	13263	13391	32413

FALL SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	0	0	0	0	0	0	0	15	0	84	15	0	15
3	1798	20	18	48	0	8	7	181	33	550	59	55	235
4	1148	287	33	272	130	15	104	90	183	1420	1101	585	1337
5	935	340	660	279	103	239	83	12	44	433	824	3940	1858
6	1860	275	338	244	313	200	1397	18	66	345	682	818	8468
7	1196	382	61	369	253	644	299	373	49	59	363	511	768
8	1992	220	23	97	177	975	783	127	356	178	81	146	529
9	3147	109	39	92	103	347	1319	68	107	418	298	82	89
10	6403	232	17	0	153	178	152	36	53	95	419	173	34
11+	10712	2887	681	1968	3999	2275	3246	603	932	1080	2243	2649	353
2+	29191	4752	1870	3369	5231	4881	7390	1523	1823	4662	6085	8959	13686

Table 5. Gillnet catch at age ($\times 10^{-3}$) for spring and fall spawning herring in NAFO division 4R from 1973 to 1985 using the GSI model.

SPRING SPAWNERS													
	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	0	0	0	0	0	0	0	3	0	0	21	1	0
3	7	10	0	13	13	3	0	71	59	319	842	13	1
4	145	0	89	0	4	368	42	50	805	145	1770	1416	33
5	2148	76	10	0	39	82	2980	123	53	879	468	1486	1220
6	228	1781	219	15	53	132	441	5485	163	106	513	242	391
7	1225	111	878	581	141	63	606	225	4038	340	57	469	67
8	769	383	89	1790	1041	751	337	620	83	2495	19	67	75
9	784	130	66	123	1680	1659	1597	146	192	229	1200	236	44
10	467	89	48	540	325	4228	3403	927	113	256	249	271	62
11+	2830	1210	172	1336	1712	2408	6726	8291	3484	4144	3151	1892	290
2+	8603	3790	1571	4398	5008	9694	16132	15941	8990	8913	8290	6093	2183
FALL SPAWNERS													
	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	0	0	0	0	0	0	0	0	0	16	0	0	0
3	0	0	0	0	3	0	0	0	0	16	24	0	0
4	32	106	6	0	39	9	11	43	342	405	1229	83	4
5	179	190	200	11	30	296	260	73	201	523	531	2319	49
6	766	49	586	178	90	193	1289	153	24	164	627	329	1211
7	331	207	46	191	467	463	218	1342	245	81	143	397	134
8	639	38	134	228	228	708	504	120	876	199	78	74	93
9	683	198	108	161	239	156	527	603	46	554	169	64	26
10	1862	80	201	88	140	147	315	272	71	220	199	95	2
11+	6941	2719	2683	2826	2647	3624	3018	4552	2396	1529	581	442	115
2+	11433	3587	3964	3683	3883	5596	6142	7158	4201	3707	3581	3803	1634

Table 6. Annual catch at age ($\times 10^{-3}$) for spring and fall spawning herring in NAFO division 4R from 1973 to 1985 using the GSI model and revised purse seine landings for 1982 to 1985.

SPRING SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	1833	141	57	484	10	0	167	300	40	594	34	198	362
3	435	261	996	680	534	47	25	854	417	2374	2965	433	4587
4	1063	130	420	846	541	1987	214	106	2114	693	3562	7773	787
5	27872	371	100	201	409	207	10828	355	129	2452	1131	3809	21642
6	2570	9445	1063	350	304	679	617	13872	354	421	1091	595	3993
7	3222	318	8431	2802	348	241	1075	407	8872	2153	293	814	445
8	3232	851	317	15567	4362	2162	547	1344	188	6488	713	209	381
9	2598	774	336	759	15959	8208	2772	247	515	704	2990	672	255
10	4789	490	244	3136	1694	15260	7404	1427	283	950	798	755	380
11+	5696	2175	665	3588	6003	5062	14032	20574	13181	12863	7975	4226	1764
2+	53310	14955	12629	28413	30165	33851	37681	39486	26093	29692	21552	19485	34597

FALL SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	0	0	0	0	0	0	0	15	0	101	15	0	15
3	1798	20	19	48	3	10	7	181	33	567	83	55	235
4	1180	393	40	272	169	27	116	136	524	1824	2330	668	1340
5	1114	530	865	290	134	545	345	86	245	956	1356	6259	1907
6	2626	325	925	422	404	393	2689	176	90	509	1309	1147	9678
7	1527	592	107	561	721	1108	520	1729	295	140	506	908	902
8	2631	258	157	325	405	1689	1287	250	1234	377	159	220	622
9	3830	308	147	253	342	503	1847	675	153	972	467	146	115
10	8265	313	218	88	293	341	468	308	124	315	618	268	36
11+	17653	5610	3371	4818	6646	6051	6286	5243	3369	2609	2824	3091	468
2+	40626	8348	5848	7076	9116	10668	13564	8799	6067	8371	9667	12762	15319

Table 7. Annual catch at age ($\times 10^{-3}$) for spring and fall spawning herring in NAFO division 4R from 1973 to 1985 using the GSI model only.

SPRING SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	1833	141	57	484	10	0	167	300	40	315	28	118	232
3	435	261	996	680	534	47	25	854	417	1313	2128	259	2922
4	1063	130	420	846	541	1987	214	106	2114	459	2903	4900	509
5	27872	371	100	201	409	207	10828	355	129	1684	912	2812	13587
6	2570	9445	1063	350	304	679	617	13872	354	300	886	499	2536
7	3222	318	8431	2802	348	241	1075	407	8872	1281	211	691	273
8	3232	851	317	15567	4362	2162	547	1344	188	4878	475	162	248
9	2598	774	336	759	15959	8208	2772	247	515	503	2350	498	188
10	4789	490	244	3136	1694	15260	7404	1427	283	682	621	620	237
11+	5696	2175	665	3588	6003	5062	14032	20574	13181	9972	6244	3664	1042
2+	53310	14955	12629	28413	30165	33851	37681	39486	26093	21387	16758	14223	21774

FALL SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	0	0	0	0	0	0	0	15	0	56	9	0	10
3	1798	20	19	48	3	10	7	181	33	282	59	29	159
4	1180	393	40	272	169	27	116	136	524	1083	1915	410	835
5	1114	530	865	290	134	545	345	86	245	734	1072	4665	1267
6	2626	325	925	422	404	393	2689	176	90	330	1078	823	6623
7	1527	592	107	561	721	1108	520	1729	295	110	381	708	648
8	2631	258	157	325	405	1689	1287	250	1234	285	129	189	427
9	3830	308	147	253	342	503	1847	675	153	769	376	123	85
10	8265	313	218	88	293	341	468	308	124	266	490	229	32
11+	17653	5610	3371	4818	6646	6051	6286	5243	3369	2056	2093	2718	395
2+	40626	8348	5848	7076	9116	10668	13564	8799	6067	5971	7602	9894	10481

Table 8. Annual catch at age ($\times 10^{-3}$) for spring and fall spawning herring in NAFO division 4R from 1973 to 1985 from CAFSAC Res. Doc. 86/68.

SPRING SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	4384	137	96	511	11	0	143	320	51	0	23	100	240
3	910	235	738	997	664	40	30	992	317	433	2776	200	2350
4	1177	108	345	982	533	2097	176	85	1832	510	3400	4043	392
5	30697	294	190	229	516	210	10967	327	97	1960	1300	2495	11495
6	2820	10512	1283	319	287	749	575	14894	318	420	649	572	2115
7	3139	254	8261	2745	346	287	1039	412	8773	1811	215	649	284
8	3018	857	237	15428	4160	2266	456	1304	250	5000	812	130	258
9	1796	689	360	764	16333	8617	2710	258	593	957	1309	524	122
10	1502	195	140	2851	926	15951	7042	991	215	574	738	583	231
11+	6271	2143	671	3134	5547	4380	14466	21735	15134	9112	4566	3820	1103
2+	55714	15424	12321	27960	29323	34597	37604	41318	27580	20777	15788	13116	18590

FALL SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	0	0	0	0	0	0	0	16	0	0	7	2	8
3	810	16	96	59	3	15	19	215	28	43	58	36	150
4	769	269	174	47	61	53	70	83	337	954	2153	485	1460
5	1102	388	1110	102	113	452	288	143	158	562	1144	5232	1401
6	2596	284	327	338	302	311	2542	253	82	337	968	1287	8648
7	2028	288	78	470	746	1130	626	1542	191	121	450	745	1108
8	2525	222	112	108	388	1841	1396	224	717	316	186	278	408
9	5196	293	67	158	214	589	2038	691	120	879	410	177	97
10	8047	336	63	52	99	379	552	282	98	260	730	267	56
11+	17386	4202	2229	3969	7213	5681	6824	5027	2716	2139	2928	2568	482
2+	40459	6298	4256	5303	9139	10451	14355	8476	4447	5611	9034	11077	13818

Table 9. Annual spring and fall spawner weight at age (weighted by landings) in NAFO division 4R herring landings from 1973 to 1985.

ANNUAL SPRING SPAWNER WEIGHT AT AGE (g)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	101	129	77	69	64	103	115	117	85	95	142	134	109
3	158	172	156	122	156	184	121	201	196	216	190	206	168
4	224	223	197	193	208	228	234	247	262	263	263	239	247
5	222	236	242	241	247	275	268	298	327	290	305	297	283
6	268	262	243	252	278	305	319	321	344	357	337	348	329
7	303	300	279	269	262	313	343	354	385	386	385	379	373
8	322	324	301	299	290	318	357	380	415	395	424	406	404
9	333	351	335	315	313	340	366	398	430	423	434	431	434
10	350	335	350	334	332	362	373	389	429	434	492	437	425
11+	367	384	382	382	353	393	409	430	472	454	475	485	477

ANNUAL FALL SPAWNER WEIGHT AT AGE (g)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	131	131	131	131	131	131	131	122	131	166	105	131	50
3	105	171	120	107	250	161	218	222	204	150	205	164	155
4	156	218	188	155	229	238	216	242	280	252	218	209	202
5	231	259	266	282	250	282	281	360	328	306	268	249	258
6	274	265	297	271	255	316	308	341	358	328	309	293	292
7	297	284	352	287	301	345	355	404	406	449	338	343	326
8	329	307	323	277	321	367	381	419	436	441	374	359	347
9	334	355	370	308	308	366	405	461	485	444	430	429	374
10	346	378	391	426	330	390	408	468	498	485	462	450	444
11+	382	422	465	454	421	471	458	534	515	507	503	494	432

Table 10. Spring and fall spawner weight at age (weighted by landings) for the second and third quarter, respectively, in NAFO division 4R gillnet herring landings from 1973 to 1985.

SECOND QUARTER SPRING SPAWNER WEIGHT AT AGE (g)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	89	105	77	67	64	84	101	94	85	85	84	84	71
3	103	166	156	112	134	172	121	190	189	177	198	203	163
4	229	223	262	193	200	216	225	221	257	249	248	237	226
5	208	229	239	240	296	248	255	281	312	270	284	292	252
6	265	251	244	251	287	288	298	301	333	307	289	349	303
7	293	307	287	285	264	311	320	337	368	376	379	377	349
8	308	321	349	297	274	290	337	357	395	378	411	363	349
9	328	326	369	285	291	308	345	389	413	371	446	437	400
10	349	315	470	331	321	335	358	366	413	403	487	423	397
11+	369	372	411	377	381	348	388	408	458	446	458	473	433

THIRD QUARTER FALL SPAWNER WEIGHT AT AGE (g)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	131	131	131	131	131	131	131	122	131	166	105	131	50
3	105	171	120	107	250	161	218	222	204	147	242	164	149
4	156	242	222	155	269	238	241	242	297	294	266	283	281
5	267	281	281	299	276	294	300	376	365	330	301	311	302
6	316	273	311	285	299	348	355	363	379	366	333	364	330
7	352	299	385	300	338	377	396	425	454	432	411	382	390
8	401	299	343	298	376	399	434	429	493	472	413	422	380
9	389	379	396	316	350	395	471	487	540	513	460	465	392
10	428	392	416	426	388	428	476	482	516	538	482	485	422
11+	461	467	494	499	456	540	535	569	590	590	533	518	512

Table 11. Percent difference between the annual catch-at-age matrices calculated using the GSI model and from CAFSAC Res. Doc. 86/68 for spring and fall spawning herring (999 represents values which could not be computed; see text for underlined values).

SPRING SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	-58	3	-40	-5	-12	0	17	-6	-22	999	23	18	-3
3	-52	11	35	-32	-20	17	-15	-14	31	203	<u>-23</u>	29	24
4	-10	20	22	-14	2	-5	21	24	15	-10	-15	<u>21</u>	30
5	-9	26	-48	-12	-21	-1	-1	9	33	-14	-30	13	<u>18</u>
6	-9	-10	-17	10	6	-9	7	-7	11	-28	37	-13	20
7	3	25	2	2	1	-16	3	-1	1	-29	-2	6	-4
8	7	-1	34	1	5	-5	20	3	-25	-2	-41	25	-4
9	45	12	-7	-1	-2	-5	2	-4	-13	-47	<u>80</u>	-5	54
10	219	151	74	10	83	-4	5	44	32	19	-16	6	3
11+	-9	1	-1	14	8	16	-3	-5	-13	9	37	-4	-6

FALL SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	0	999	0	0	0	0	0	-5	0	999	26	-100	24
3	122	22	-80	-18	0	-30	-62	-16	16	556	2	-21	6
4	53	46	-77	478	<u>177</u>	-50	65	63	56	14	<u>-11</u>	-15	-43
5	1	37	-22	185	18	<u>21</u>	20	-40	55	31	-6	<u>-11</u>	-10
6	1	14	183	25	34	26	<u>6</u>	-30	10	-2	11	-36	<u>-23</u>
7	-25	105	37	19	-3	-2	-17	<u>12</u>	54	-9	-15	-5	-42
8	4	16	40	201	4	-8	-8	12	<u>72</u>	-10	-31	-32	5
9	-26	5	119	60	60	-15	-9	-2	27	<u>-13</u>	-8	-30	-12
10	3	-7	246	70	196	-10	-15	9	27	2	<u>-33</u>	-14	-42
11+	2	34	51	21	-8	7	-8	4	24	-4	-29	<u>6</u>	-18

Table 12. Percent difference between the annual catch-at-age matrices calculated using the GSI model with updated purse seine landings for 1982 to 1985, and from CAFSAC Res. Doc. 86/68 for spring and fall spawning herring (999 represents values which could not be computed; see text for underlined values).

SPRING SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	-58	3	-40	-5	-12	0	17	-6	-22	999	46	98	51
3	-52	11	35	-32	-20	17	-15	-14	31	448	7	116	95
4	-10	20	22	-14	2	-5	21	24	15	36	5	<u>92</u>	101
5	-9	26	-48	-12	-21	-1	-1	9	33	25	-13	53	<u>88</u>
6	-9	-10	-17	10	6	-9	7	-7	11	0	68	4	89
7	3	25	2	2	1	-16	3	-1	1	19	36	25	57
8	7	-1	34	1	5	-5	20	3	-25	<u>30</u>	-12	61	48
9	45	12	-7	-1	-2	-5	2	-4	-13	-26	<u>128</u>	28	109
10	219	151	74	10	83	-4	5	44	32	65	8	<u>29</u>	65
11+	-9	1	-1	14	8	16	-3	-5	-13	41	75	11	<u>60</u>

FALL SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	0	999	0	0	0	0	0	-5	0	999	113	-100	89
3	122	22	-80	-18	0	-30	-62	-16	16	999	43	53	56
4	53	46	-77	478	<u>177</u>	-50	65	63	56	91	8	38	-8
5	1	37	-22	185	18	<u>21</u>	20	-40	55	70	18	20	36
6	1	14	183	25	34	26	<u>6</u>	-30	10	51	35	-11	12
7	-25	105	37	19	-3	-2	-17	<u>12</u>	54	16	12	22	-19
8	4	16	40	201	4	-8	-8	12	<u>72</u>	19	-15	-21	53
9	-26	5	119	60	60	-15	-9	-2	27	<u>11</u>	14	-17	19
10	3	-7	246	70	196	-10	-15	9	27	21	<u>-15</u>	0	-35
11+	2	34	51	21	-8	7	-8	4	24	22	-4	<u>20</u>	-3

Table 13. Percent difference between the annual catch-at-age matrices calculated using the GSI model alone and the GSI model with updated purse seine landings for 1982 to 1985 for spring and fall spawning herring (see text for underlined values).

SPRING SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	0	0	0	0	0	0	0	0	0	<u>88</u>	19	68	56
3	0	0	0	0	0	0	0	0	0	81	39	67	57
4	0	0	0	0	0	0	0	0	0	51	23	59	55
5	0	0	0	0	0	0	0	0	0	46	24	35	59
6	0	0	0	0	0	0	0	0	0	40	23	19	57
7	0	0	0	0	0	0	0	0	0	68	39	18	63
8	0	0	0	0	0	0	0	0	0	33	50	29	53
9	0	0	0	0	0	0	0	0	0	40	27	35	35
10	0	0	0	0	0	0	0	0	0	39	29	22	61
11+	0	0	0	0	0	0	0	0	0	29	28	<u>15</u>	69

FALL SPAWNERS

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	0	0	0	0	0	0	0	0	0	78	69	0	53
3	0	0	0	0	0	0	0	0	0	<u>101</u>	41	92	48
4	0	0	0	0	0	0	0	0	0	68	22	63	61
5	0	0	0	0	0	0	0	0	0	30	26	34	50
6	0	0	0	0	0	0	0	0	0	54	21	39	46
7	0	0	0	0	0	0	0	0	0	28	33	28	39
8	0	0	0	0	0	0	0	0	0	32	23	16	46
9	0	0	0	0	0	0	0	0	0	27	24	19	35
10	0	0	0	0	0	0	0	0	0	18	26	17	<u>12</u>
11+	0	0	0	0	0	0	0	0	0	27	35	14	18

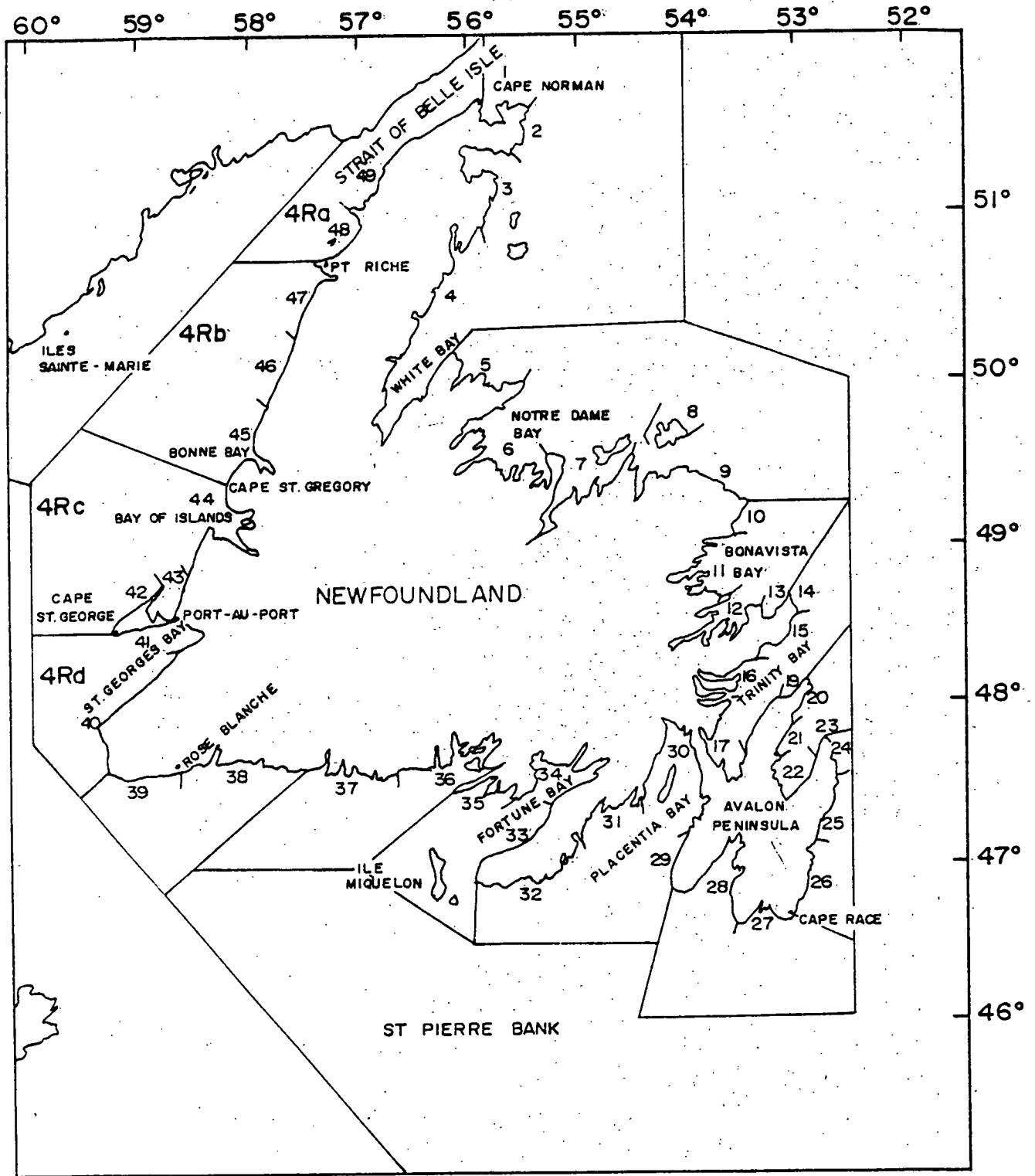


Figure 1. West coast of Newfoundland unit areas and statistical districts.