THE EFFECTS OF USING A GONADOSOMATIC INDEX AS A METHOD OF SPAWNING-GROUP ASSIGNMENT ON THE CATCH-AT-AGE MATRICES FOR 4T HERRING

by

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Abstract

The catch-at-age matrices for spring- and fall-spawning herring in NAFO division 4T were revised for the years 1978 to 1989 after having used the gonadosomatic index (GSI) model (McQuinn, 1989) to assign spawning-group affinity of sampled fish. The spawning-group composition of commercial samples was altered most markedly for the mobile-gear fishery, to the extent that the predominant spawning element in the catch switched from spring- to fall-spawning fish in nearly 50% of the cases. Thus the numbers-at-age are generally increased for fall spawners with the use of the GSI model. The use of the model removed some irregularities in weights-at-age but contributed new ones. Overall, weight changes were minor and increases in one spawning group in the mobile-gear catch tended to complement decreases in the other's weight-at-age. Only minor differences in relative cohort strength were detected for either gear type between the GSI-generated matrices and the Gulf Region's standard matrices.

Résumé

Les matrices des prises en fonction de l'âge pour les géniteurs printemps et automne du hareng de la division 4T de l'OPANO ont été reconstruites pour les années 1978-1989 après s'être servi du modèle gonadosomatique (GSI) (McQuinn, 1989) pour déterminer le type géniteur des poissons échantillonnés. La composition des échantillons commerciaux, quant au groupe de frai, a subi le changement le plus marqué pour les prises des engins mobiles, à tel point que la composante principale des prises a changé du type printemps au type automne pour presque la moitié des cas. En général, les nombres selon l'âge des géniteurs automne ont donc augmenté avec l'emploi du modèle GSI. L'application du modèle a éliminé certaines irrégularités des poids en fonction de l'âge mais en a engendré de nouvelles. Dans l'ensemble, les changements de poids étaient minimes, et quant aux engins mobiles, les augmentations chez un groupe de frai avaient tendance à refléter les diminutions du poids selon l'âge chez l'autre. Quant à l'importance relative des cohortes, des différences mineures seulement ont été décelées, pour l'un ou l'autre type d'engin, entre les matrices engendrées par le modèle GSI et celles habituellement utilisées par la Région du golfe.

Introduction

The CAFSAC Steering Committee (Anon., 1986) recommended that the catch- and weight-at-age matrices for 4T herring be reconstructed. Several factors were suspected of having introduced inconsistencies in the matrices. The problems stemmed in part from successive transfers of responsibilities and information, lack of documentation about laboratory procedures, and differences in year-class and spawning-group assignment among laboratories and years. The 1974-1980 commercial samples for 4T were processed in St. Andrews and aged in St. John's. The 1981 samples were processed in St. Andrews and aged in both St. Andrews and St. John's (the final ages on file were from St. Andrews). The 1982 samples were processed in St. Andrews up to September and from then on in Quebec. The St. Andrews samples were aged by the Gulf Region's ager (transferred from St. Andrews). Starting in 1983, 4T samples were processed and aged, and data files stored, in Moncton. Starting in 1984, sampling for detailed information switched from random to stratified subsampling (Ahrens, 1985b).

Many changes in methodology for calculating weights-at-age took place between 1971 and 1985 (Ahrens, 1985a). From 1971 to 1973, weights for 4T herring were derived from samples drawn from the winter purse-seine fishery in Subdivision 3Pn. From 1974 to 1980, weights-at-age were estimated from the spring fishery along the Edge of the Laurentian Channel. When this fishery ended, weights were obtained from spring gillnet samples (1981 and 1982). For the 1983 and 1984 fisheries, weights were derived from the weighted averages of fish weights in all 4T fisheries. Such inconsistencies yielded a weight-at-age matrix that did not match reported landings when multiplied by the catch-at-age matrix. In 1985, the weight matrix was revised by applying the observed average weights for each year between 1971 and 1976, and by averaging the 1981-to-1984 weights for the period 1977 to 1984. In subsequent assessments, no mention was made of the methodology used to derive weights-at-age, and previous problems in the matrices persisted.

Changes in methodology used over the years to determine the spawning group of sampled individuals added to the mounting evidence against the reliability of the matrices. Starting with 1974, spawning group was assigned mainly by gonad maturity, using otolith type when maturity stage was ambiguous (Cleary et al., 1982). When the two methods gave different answers, the one that seemed most definite took precedence (the gonad-maturity schedule adopted by CAFSAC was followed, but the overwintering stages were considered less certain and were therefore likely to be discarded in favour of otolith type). In 1985, the Gulf Region started using Discriminant Analysis of otolith morphometrics, which replaced the ager's evaluation of otolith type when maturity stage was ambiguous. It was felt that using a Discriminant score would be an objective way of evaluating otolith morphology, not subject to within- and among- ager variability. The region was asked to document and justify this method. Messieh et al. (1989) have done so but provide little information on the selection of the classification data sets, which was inconsistent from year to year and often included the ager's opinion of otolith type (thus generating tautological classifications). The method was to be re-examined but this project had to be postponed. Instead, spawning group was reassigned for samples collected between 1985 and 1988 by a method more consistent with previous methodology, namely gonad ripeness in season or alternately otolith morphology as evaluated by the ager. These revised matrices were adopted by CAFSAC in 1990 (Dupuis and MacDougall, 1990) with the recommendation that the Gulf Region pursue its investigations on methods of assigning spawning group, including the use of McQuinn's (1989) GSI model.

This document outlines the application of the GSI method to the 4T herring samples for 1978-1989 and the resulting changes to the catch- and weight-at-age matrices. The next step could entail the use of these matrices instead of the standard ones with the 1990 assessment, to compare the results of the VPA. Further examination of otolith characteristics, with and without the use of Discriminant Functions, continues.

Methods

A) Spawning-group affinity

A SAS program was designed to read a detailed biological file for a given year of the 4T herring fishery. The first step read the maturity stage originally assigned to each fish by a laboratory technician. Stages 1, 2, 6 and 7 being necessarily excluded from the model (McQuinn, 1989), records with fish in these stages were left unaltered by the GSI model. The spawning-group affinity therefore remained as it was, group membership of fish in stages 6 or 7 being obvious according to date of capture (Cleary et al., 1982), and stages 1 and 2 (juveniles) being classified by visual inspection of otolith characteristics. Records without gonad weights were also left untouched.

All other individuals were classified by McQuinn's (1989) model, which involves the computation of a GSI incorporating Total Length. This is followed by computations of scores for each of several Discriminant Functions, which correspond to sex-specific stages and substages defined histologically by Landry and McQuinn (1988). The function yielding the highest score corresponds to the maturity stage of the fish. Spawning-group membership was then assigned following the maturity schedule currently used by CAFSAC (Cleary et al., 1982). When the combination of date of capture and maturity stage led to more than one possible group affinity (e.g. a stage 3 in November), the program sought the second-highest Discriminant Score. If this score corresponded to a stage more advanced than that of the highest score, the fish was said to be in an advanced phase of its stage, and it was concluded that it would have spawned again during the following spawning season. If the fish was deemed to be in an early phase of its stage (second-highest score corresponding to a less advanced stage), it was assigned to the group having spawned most recently (McQuinn, 1989).

The spawning group assigned by the GSI model thus replaced the previous assignment, and the age of the fish was revised accordingly, adding one to the number of otolith rings if it was a fall spawner (A) and setting the age to the ring count if it was a spring spawner (P). The new version of the detailed file now contained spawning-group assignments derived from three methods: 1) otolith characteristics for juveniles, 2) date of capture for spawning and spent fish, and 3) the GSI method for all remaining individuals.

B) Commercial sampling

Length-frequency samples were matched to their corresponding biological data to create a master data file, for each spawning group, of numbers aged at length in each sample. Samples for each gear, month,

and unit area were then pooled into "cells" defined by gear type (fixed and mobile), fishing season (spring and fall), and aggregated statistical unit areas (431-435, 436, 437-439) for each year.

Detailed samples were used to construct age-length relationships specific to each cell. When cell samples were missing or too small to be reliable, other samples had to be substituted to construct the age-length key. The substitutions to be applied were determined by the considerations listed below.

1 - The unknown spawning-group composition (percentage by number) of the landings from one cell was estimated by taking the average (weighted by sample size) of the percentages in the equivalent cell for the two most recent and the two subsequent years available (Table 1). We assume that population composition for a cell is similar across years.

2 - The age-length key for an empty cell is preferably derived from the samples from another cell in that year, rather than from the equivalent cell in another year, to avoid the possibility of interdependent age or size shifts between years. The possible choices in selecting a substitute cell were:

        a) the same season and gear in a different area,
        b) the same season and area but different gear,
        c) the same season but a different area and gear.

Because fixed and mobile gears usually targetted fish of different condition and maturity stages within the same area, the order of preference for these choices was usually as listed above but was determined in each case by comparing the size distributions and the regression coefficients of length-weight relationships in the relevant cells from better-sampled years. The final choice of a substitute sample was therefore particular to that case and was affected by the similarities noted among cells in other years.

3 - Partial substitutions were also required when a sample was available (and could therefore reveal spawning-group composition) but consisted almost exclusively of one group. In such cases, the sample size of the rare spawning-group was often inadequate for its age-length determination. The decision steps outlined in 2) above were followed and another subsample was substituted.

C) Catch-at-age matrices

Length-weight regressions were computed with the SAS REGression procedure for both spring and fall spawners in each cell. The percentages of spring and fall spawners at each length were also calculated. The options defining a particular cell (area, fishing season and gear type) selected the appropriate samples in the master file, which, along with the corresponding regression parameters, total landings, and percentages-at-length were input into the FORTRAN program 'AGELEN' (Wright, 1991). This set of programs calculates the catch-at-age from equations found in Gavaris and Gavaris (1983). It generated an age-length key for each spawning group and projected it onto the landings for that cell. The numbers-at-age thus obtained were then summed to yield corresponding annual totals for fixed, mobile and combined gears.

Average weight-at-age was simultaneously computed by AGELEN for each spawning group in each cell. Annual weight estimates for fixed, mobile and all gears combined were obtained by averaging the weights-

at-age (weighted by their corresponding catch) from all appropriate cells.

Results

A) Spawning-group composition of commercial samples

Landings for NAFO Division 4T are grouped by area, fishing season and gear type in Table 1, along with the revised spawning-group composition of commercial samples following the application of the GSI model to eligible fish. The percentages used by Claytor et al. (1990) for the 1990 assessment of 4T herring are also included for comparison. Minimal attention should be given to values followed by asterisks, as they represent averages of values observed in other years (or other areas when necessary), for lack of appropriate sampling.

Fixed-gear samples have retained spawning-group composition values very similar or identical to previous percentages. This was expected because these were mostly spawning or spent fish, which were excluded from the GSI model but whose spawning season was obvious, or ripening stage 5's which were included in the model but were also of obvious group affinity, given the date of capture (Cleary et al., 1982). The few observed differences are probably due to some stage 4 weights being deemed too low by the Discriminant Functions, which would reclassify them as stage 3 and in some instances would result in a spawning-group reclassification.

For mobile gear, group affinity has in some cases been altered quite dramatically. There is a 10-20% difference between the GSI and our standard method in most cases, but discrepancies can be as high as 30% and reach a maximum of 46% (in 1984). In half the cases, these differences have resulted in the predominant spawning element of the catch switching from one spawning group to the other.

B) Catch- and weight-at-age

Catch- and weight-at-age matrices obtained from the GSI method of spawning-group assignment are presented in Tables 2-7.

The GSI catch-at-age was compared to the revised matrices incorporated into the 1990 assessment of 4T herring (Claytor et al., 1990). As expected, the fixed-gear matrices (Table 8) have remained relatively unaffected by the GSI method, showing only slight increases in spring spawners, particularly since the mid-1980's. The purse-seine catches, however, show an increase in the number of fall spawners for most years (Table 9). This translates into a general increase in numbers of fall spawners when all gears are combined (Table 10), except that the pattern is erratic for 1979-1980: certain age classes show an increase in size but are separated by cohorts which were subjected to a reduction from their previous level.

While some previous irregularities in the weight-at-age have disappeared or improved following the application of GSI to spawning-group assignment, others persist, including unexpected changes in weight

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from one age to the next in a given year (Tables 5-7). These jumps are primarily due to small sample sizes rather than assignment method, but some erratic weights have developed as a result of the reassignment of fish by the GSI model, in the mobile fishery in particular (Table 6), which also affected the combined-gear matrix (Table 7).

The weights-at-age nonetheless remain relatively unchanged. For fixed gear, the only noticeable vaariations occur at the tails of the age distribution. Changes in one spawning group are not reflected in the other group's weight in any consistent fashion (Table 11). For the mobile fishery (Table 12) increases in weight of one group do tend to complement reductions in the other's, and when all gears are combined the pattern persists in early years but disappears in recent years (Table 13).

C) Percent-at-age   ·

Tables 14-16 and 17-19 are presented to facilitate comparisons of catch-at-age between the GSI method and the Gulf's standard method of spawning-group assignment.

As expected, the same cohorts can be followed diagonally through the fixed-gear matrices with both assignment methods (Tables 14 and 17): the 1974, 1979 and 1980 year-classes dominate the spring spawners, whether classified by GSI or by the standard method. Both methods lead to the same observations with fall spawners as well: the 1975, 1977, 1979 and 1980 year-classes are most prominent.

In the mobile fishery (Tables 15 and 18) the spring spawners' GSI matrix emphasizes the 1979 year-class slightly more, and the 1974 class less, than does the standard spring spawners' matrix but is otherwise similar to the latter. Likewise, the two methods yield similar percentages-at-age for fall spawners.

When both gear types are combined, the findings remain essentially the same: 1974, 1979 and 1980 are dominant year-classes for the spring spawners, although the 1974 class is of less consequence in the GSI matrix than in the standard matrix. As for the fall spawners, the percentages-at-age for the 1975 year-class are weaker in the GSI matrix than in the standard matrix, but otherwise most values are very similar, with the 1977, 1979 and 1980 year-classes being strongest.

Discussion

It is still impossible to resolve the question of which method of spawning-group assignment is best-suited to the biology of herring. The VPA run will determine whether the GSI numbers behave more cohesively than the standard matrices, but this does not necessarily correspond to the biological reasons for choosing one technique over another. The Gulf Region is aware of several limitations with the use of both otoliths and GSI in the assignment of spawning-group affinity, and these should be carefully evaluated by CAFSAC before recommending the adoption of a standard methodology.

Acknowledgements

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Table 1. Landings in metric tonnes (MT) for NAFO Division 4T by area, fishing season and gear type. 1987 - 1989 landings are provisional. Spring fishing: January-June, Fall fishing: July-December. Most fixed gears are gillnets; mobile gears are mainly purse seines. "GSI" %P: Percentage by numbers of spring spawners (P) in biological samples, as estimated by the "GSI method": gonad maturity for spawning and spent fish, by otolith characteristics for juveniles, and by McQuinn's (1989) GSI model for all remaining individuals. (Gulf %P): percentage of spring spring spawners (in brackets) as estimated by the Gulf's "standard" method: gonad maturity during spawning months, and otolith characteristics for all others (Dupuis and MacDougall, 1990). N: sample size; NS: no sample available (*), or inadequate for one of the spawning groups (A or P).

| | SOUTH (4Tf-4Tk) | | | | MIDDLE (4Tl) | | | | NORTH (4Tm-4To) | | | |
| | SPRING | | FALL | | SPRING | | FALL | | SPRING | | FALL | |
	FIXED	MOBILE	FIXED	MOBILE	FIXED	MOBILE	FIXED	MOBILE	FIXED	MOBILE	FIXED	MOBILE
1978 MT	1,114	4,648	933	4,885	6,261	0	630	3,491	1,172	3,399	3,578	23,379
"GSI" %P	99	78	0	32	93	--	6	25	100	78	2	24
(Gulf %P)	(97)	(9)	(0)	(39)	(81)		(3)	(31)	(100)	(20)	(2)	(52)
N	4275	1090	121	516	489	--	*	292	89	*	945	1487
NS							*			*		
1979 MT	1,241	13,901	2,305	78	5,246	0	1,069	5,738	1,137	0	2,701	14,803
"GSI" %P	98	50	1	30	92	--	4	3	92	--	8	38
(Gulf %P)	(90)	(31)	(1)	(39)	(85)		(5)	(18)	(88)		(12)	(66)
N	6081	1246	1311	*	499	--	193	345	*	--	287	3522
NS				*			P		*			
1980 MT	1,994	13,897	2,786	320	3,604	20	1,826	793	1,674	0	1,933	13,699
"GSI" %P	99	44	3	30	99	44	9	5	100	--	3	32
(Gulf %P)	(99)	(24)	(1)	(39)	(100)	(22)	(5)	(19)	(98)		(7)	(66)
N	4780	1487	*	*	1100	*	186	97	298	--	297	2346
NS			*	*	A	*	P					
1981 MT	2,386	21	3,272	3,081	4,028	0	2,381	14	1,087	0	5,572	93
"GSI" %P	97	47	14	30	93	--	4	13	89	--	2	13
(Gulf %P)	(97)	(27)	(1)	(39)	(84)		(1)	(18)	(83)		(3)	(16)
N	3157	*	399	*	494	--	694	*	1053	--	2291	759
NS		*		*					*			
1982 MT	2,015	0	5,241	0	2,836	0	1,105	9	1,072	62	6,636	2,569
"GSI" %P	98	--	0	--	100	--	0	13	99	47	5	13
(Gulf %P)	(98)		(0)		(100)		(0)	(18)	(99)	(27)	(2)	(12)
N	4070	--	298	--	396	--	75	*	772	*	1867	798
NS								*	A	*		
1983 MT	1,911	0	5,177	85	5,097	19	1,572	3,256	1,515	0	7,091	148
"GSI" %P	97	--	0	30	95	47	9	30	100	--	4	30
(Gulf %P)	(97)		(0)	(22)	(93)	(27)	(5)	(18)	(96)		(1)	(49)
N	*	--	812	*	683	*	175	*	114	--	1151	1200
NS	*			*		*		*				

Table 1. (cont'd)

		SOUTH (4Tf-4Tk)				MIDDLE (4Tl)				NORTH (4Tm-4To)			
		SPRING		FALL		SPRING		FALL		SPRING		FALL	
		FIXED	MOBILE	FIXED	MOBILE	FIXED	MOBILE	FIXED	MOBILE	FIXED	MOBILE	FIXED	MOBILE
1984	MT	663	3	7,939	0	4,192	1	1,338	114	427	0	6,697	2,164
"GSI"	%P	88	47	1	--	96	47	0	17	92	--	6	17
(Gulf	%P)	(76)	(27)	(0)		(96)	(27)	(1)	(18)	(85)		(6)	(63)
	N	157	*	459	--	*	*	405	*	143	--	1049	993
	NS		*	P		*	*		*				
1985	MT	2,352	0	9,362	0	3,902	0	1,413	0	963	0	12,932	7,022
"GSI"	%	80	--	7	--	100	--	0	--	78	--	26	29
(Gulf	%P)	(80)		(8)		(99)		(2)		(65)		(29)	(43)
	N	240	--	449	--	70	--	*	--	77	--	336	429
	NS							*					
1986	MT	3,336	0	12,265	44	3,389	0	1,570	0	1,825	0	26,056	10,871
"GSI"	%P	97	--	1	8	92	--	0	--	91	--	12	37
(Gulf	%P)	(93)		(0)	(22)	(100)		(2)		(85)		(13)	(62)
	N	192	--	664	36	204	--	*	--	281	--	577	693
	NS	A		P	P			*					
1987	MT	3,600	0	18,198	78	3,738	0	1,970	13	4,386	0	31,862	13,613
"GSI"	%P	78	--	1	30	100	--	0	32	96	--	7	32
(Gulf	%P)	(94)		(0)	(22)	(100)		(0)	(18)	(93)		(6)	(49)
	N	268	--	1724	*	230	--	32	*	328	--	1316	450
	NS			P	*				*				
1988	MT	2,050	0	15,034	226	3,967	1	3,785	1	6,616	0	22,266	17,423
"GSI"	%P	95	--	1	30	96	47	0	38	84	--	14	38
(Gulf	%P)	(93)		(1)	(22)	(94)	(27)	(0)	(18)	(70)		(14)	(48)
	N	572	--	685	*	425	*	94	*	527	--	763	530
	NS			P	*		*		* ·				
1989	MT	5,156	0	5,917	0	2,147	0	1,484	0	3,838	0	24,806	13,642
"GSI"	%P	96	--	0	--	97	--	0	--	90	--	6	29
(Gulf	%P)	(95)		(0)		(96)		(0)		(86)		(6)	(61)
	N	445	--	447	--	1027	--	*	--	517	--	1407	801
	NS							*					

Table 2. Catch-at-age (1000s) for herring caught with fixed gear in NAFO Division 4T. Spawning-group affinity assigned by gonad maturity for spawning and spent fish (stages 6 and 7), by otolith characteristics for juveniles (stages 1 and 2) and by McQuinn's (1989) GSI model for all remaining individuals.

SPRING SPAWNERS - FIXED GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0	425	0	14	10	0	0	0	0	0	58	0
2	14	198	169	394	162	248	84	330	10	270	491	0
3	5644	6922	10538	13093	23717	16174	4538	6009	3593	1679	3936	4091
4	25469	3140	6746	8353	4509	25937	13994	15844	18110	8029	8473	16489
5	1255	17307	2632	2688	1066	2097	8044	14353	12735	22056	11263	6210
6	1831	641	8501	1818	493	460	376	5198	11482	11182	15473	6133
7	1391	1242	1824	3363	323	102	58	1304	2932	8645	9106	7151
8	259	274	942	486	337	0	49	696	444	3666	6895	4473
9	447	136	851	454	123	0	4	61	32	515	1622	2626
10	1375	302	462	195	91	0	5	0	130	330	87	882
11+	1496	1454	699	961	571	0	0	1	205	161	521	275

FALL SPAWNERS - FIXED GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0	904	0	0	0	0	0	0	0	0	0	0
2	82	8	64	322	0	0	0	0	253	15	0	0
3	3592	474	7965	5753	2154	720	963	1117	1627	7995	1162	280
4	5548	9986	5224	24124	14985	20231	24882	8816	32871	38133	20362	13451
5	3484	5132	6097	6313	16883	9570	13445	24441	16497	30192	41791	21013
6	816	2924	994	2477	4922	13180	8306	14860	34428	20673	20182	28252
7	745	865	1733	1027	2523	2168	5978	9498	19251	36268	13194	13385
8	3911	1065	373	597	1050	1632	1335	4495	8212	15488	14206	6804
9	117	879	232	258	371	486	456	1212	4666	9365	6926	8600
10	157	278	304	239	117	124	200	727	341	4554	2726	3165
11+	1903	545	96	102	62	160	91	159	692	1874	1615	2468

Table 3. Catch-at-age (1000s) for herring caught with mobile gear in NAFO Division 4T. Spawning-group affinity assigned by gonad maturity for spawning and spent fish (stages 6 and 7), by otolith characteristics for juveniles (stages 1 and 2) and by McQuinn's (1989) GSI model for all remaining individuals.

SPRING SPAWNERS - MOBILE GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	1421	6687	630	0	0	0	0	211	50	0	2464	318
2	14571	9040	8390	1853	716	737	91	1010	1433	183	4805	379
3	4922	16130	12287	1302	827	3639	287	1490	1155	397	1392	1477
4	15957	12114	12639	137	48	993	844	1454	4071	1522	866	1835
5	2343	12528	5226	5	10	172	444	580	3132	4673	1243	723
6	4474	3329	6243	101	6	1	21	511	2368	3817	4801	2006
7	5129	1772	3588	230	4	16	0	58	719	3140	2834	3896
8	1190	1672	1767	390	19	36	15	0	82	1155	2399	1587
9	1314	410	1277	1	68	0	0	113	194	0	1628	1351
10	1107	145	299	253	1	0	0	0	0	0	0	409
11+	5446	1450	288	3	8	0	0	145	45	37	575	22

FALL SPAWNERS - MOBILE GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0	241	143	0	0	0	0	0	0	0	65	0
2	1422	2728	2393	78	200	126	34	253	157	47	3868	694
3	21439	13283	37179	4519	5022	3343	333	2037	974	911	2668	803
4	27442	20667	15174	4460	2494	4703	2456	4303	2238	1612	2944	3044
5	23096	16756	12141	623	2464	2080	2914	5103	6335	2612	2773	5573
6	4060	16685	7278	108	322	1048	1612	4897	6705	8282	3296	4832
7	4319	4409	7587	317	111	182	565	1950	6332	7536	8889	3847
8	10527	3701	5647	91	96	45	97	1760	2861	6249	7546	6411
9	1449	5276	3387	268	102	25	33	601	1106	2156	4182	4119
10	737	1249	1653	116	38	30	13	449	435	288	1242	2184
11+	11781	9864	911	65	122	19	2	372	210	60	2378	1306

Table 4. Catch-at-age (1000s) for all herring caught in NAFO Division 4T. Spawning-group affinity assigned by gonad maturity for spawning and spent fish (stages 6 and 7), by otolith characteristics for juveniles (stages 1 and 2) and by McQuinn's (1989) GSI model for all remaining individuals.

SPRING SPAWNERS - ALL GEARS

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	1421	7112	630	14	10	0	0	211	50	0	2522	318
2	14584	9238	8559	2248	877	985	175	1340	1443	453	5296	379
3	10566	23052	22826	14396	24545	19814	4825	7498	4748	2076	5328	5568
4	41426	15254	19385	8490	4557	26930	14838	17297	22181	9550	9339	18324
5	3598	29835	7858	2693	1076	2269	8487	14934	15867	26729	12506	6934
6	6305	3970	14743	1920	498	460	396	5708	13850	15000	20274	8139
7	6519	3014	5412	3593	327	118	58	1362	3651	11785	11940	11046
8	1448	1946	2709	876	356	36	63	696	526	4821	9294	6060
9	1761	546	2128	456	191	0	4	175	226	515	3250	3977
10	2482	447	761	449	92	0	5	0	130	330	87	1291
11+	6942	2904	987	964	579	0	0	146	250	199	1095	296

FALL SPAWNERS - ALL GEARS

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0	1144	143	0	0	0	0	0	0	0	65	0
2	1504	2736	2457	400	200	126	34	253	410	62	3868	694
3	25031	13757	45144	10272	7177	4063	1296	3154	2601	8906	3830	1083
4	32991	30653	20398	28584	17479	24934	27339	13119	35109	39745	23306	16496
5	26580	21888	18239	6936	19347	11650	16359	29545	22831	32804	44564	26586
6	4876	19609	8271	2584	5244	14227	9918	19758	41132	28954	23478	33084
7	5064	5274	9321	1344	2634	2350	6542	11447	25583	43804	22083	17231
8	14437	4766	6020	688	1146	1677	1432	6255	11073	21737	21751	13215
9	1566	6156	3619	526	473	511	489	1813	5772	11520	11108	12719
10	894	1527	1957	355	155	154	214	1175	777	4842	3968	5348
11+	13684	10409	1006	167	184	179	92	531	902	1934	3993	3774

Table 5. Weight-at-age (kg) for herring caught with fixed gear in NAFO Division 4T. Spawning-group affinity assigned by gonad maturity for spawning and spent fish (stages 6 and 7), by otolith characteristics for juveniles (stages 1 and 2) and by McQuinn's (1989) GSI model for all reamining individuals.

SPRING SPAWNERS - FIXED GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0	0.0195	0	0.1005	0.0366	0	0	0	0	0	0.0379	0
2	0.1418	0.1608	0.1816	0.1397	0.1953	0.1721	0.0933	0.2132	0.1073	0.1513	0.0798	0
3	0.1478	0.1698	0.1674	0.1834	0.1745	0.1554	0.1764	0.1836	0.1603	0.188	0.1606	0.1656
4	0.1888	0.2139	0.1861	0.2358	0.2105	0.2084	0.1957	0.2161	0.1959	0.1959	0.2032	0.2018
5	0.2109	0.2291	0.2284	0.2848	0.264	0.2423	0.2137	0.2456	0.2419	0.2175	0.2403	0.2313
6	0.2562	0.2441	0.2691	0.3269	0.3171	0.2675	0.2683	0.2789	0.2561	0.252	0.2663	0.2552
7	0.3221	0.3046	0.3067	0.3362	0.3717	0.3269	0.3029	0.3499	0.3194	0.2705	0.2876	0.2807
8	0.3076	0.3362	0.3319	0.3393	0.3794	0	0.3843	0.3705	0.3392	0.2781	0.3039	0.294
9	0.3114	0.343	0.3678	0.3787	0.4026	0	0.4429	0.4001	0.3486	0.2959	0.3234	0.3125
10	0.3308	0.3174	0.363	0.3986	0.406	0	0.3713	0	0.3159	0.2964	0.3754	0.3234
11+	0.3671	0.3529	0.3731	0.4082	0.446	0	0	0.4913	0.4181	0.3913	0.337	0.2978

FALL SPAWNERS - FIXED GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0	0.0231	0	0	0	0	0	0	0	0	0	0
2	0.0787	0.1066	0.2115	0.1288	0	0	0	0	0.1793	0.1328	0	0
3	0.1344	0.2015	0.2068	0.2048	0.222	0.1908	0.2362	0.2573	0.1958	0.2347	0.2309	0.226
4	0.2371	0.2554	0.2577	0.2468	0.266	0.2519	0.2484	0.2541	0.2485	0.247	0.2645	0.2601
5	0.2822	0.2934	0.3118	0.3101	0.3006	0.2853	0.2863	0.2917	0.2896	0.2789	0.2903	0.2954
6	0.3074	0.3201	0.3587	0.3679	0.337	0.3169	0.3219	0.3352	0.3248	0.3164	0.3252	0.3255
7	0.3191	0.3553	0.349	0.395	0.3739	0.3493	0.348	0.3611	0.3672	0.3434	0.3538	0.3532
8	0.3687	0.3982	0.3672	0.42	0.3825	0.3652	0.3974	0.3742	0.3848	0.3673	0.3795	0.3729
9	0.3711	0.4171	0.402	0.4585	0.3927	0.3724	0.4128	0.4102	0.4013	0.3818	0.4073	0.3846
10	0.3479	0.4274	0.4354	0.4717	0.37	0.4495	0.3794	0.4055	0.4315	0.3855	0.4095	0.406
11+	0.4324	0.4366	0.431	0.5211	0.4674	0.4295	0.4896	0.4969	0.4337	0.4257	0.4383	0.4064

Table 6. Weight-at-age (kg) for herring caught with mobile gear in NAFO Division 4T. Spawning-group affinity assigned by gonad maturity for spawning and spent fish (stages 6 and 7), by otolith characteristics for juveniles (stages 1 amd 2) and by McQuinn's (1989) GSI model for all remaining individuals.

SPRING SPAWNERS - MOBILE GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.079	0.0967	0.1054	0.0297	0.0366	0	0	0.0859	0.0866	0	0.081	0.0882
2	0.1281	0.151	0.1527	0.1749	0.14	0.1432	0.1384	0.1583	0.1349	0.1893	0.1128	0.1716
3	0.1725	0.1475	0.1582	0.214	0.2127	0.1843	0.1872	0.2033	0.2102	0.1961	0.1733	0.2178
4	0.2514	0.1774	0.2135	0.2389	0.2436	0.2159	0.2217	0.2319	0.2525	0.2733	0.2433	0.2586
5	0.2462	0.2486	0.2455	0.2698	0.2744	0.2813	0.2529	0.286	0.2816	0.2972	0.3109	0.2691
6	0.2733	0.2411	0.2681	0.4103	0.3241	0.2731	0.3022	0.3112	0.3159	0.3299	0.3226	0.3166
7	0.3027	0.282	0.2632	0.3286	0.3796	0.2455	0.3058	0.2824	0.3241	0.3375	0.3603	0.341
8	0.2984	0.3122	0.2784	0.2846	0.3336	0.2375	0.3189	0	0.3392	0.3713	0.3889	0.3543
9	0.3121	0.3525	0.3353	0.3839	0.3221	0	0.4036	0.5884	0.291	0	0.4024	0.3671
10	0.376	0.3114	0.3821	0.3251	0.4328	0	0.3668	0	0	0	0.3448	0.3829
11+	0.3594	0.3917	0.3425	0.4081	0.4472	0	0	0.3466	0.3933	0.5328	0.4281	0.5426

FALL SPAWNERS - MOBILE GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0	0.0692	0.0308	0	0	0	0	0	0	0	0.0753	0
2	0.0996	0.1191	0.1033	0.1144	0.096	0.1079	0.1109	0.1023	0.1065	0.1422	0.0959	0.1049
3	0.1492	0.1514	0.1414	0.1789	0.1709	0.1734	0.162	0.1886	0.1583	0.2033	0.1651	0.1585
4	0.2186	0.1852	0.1687	0.2255	0.2109	0.2076	0.2116	0.2142	0.2143	0.2427	0.225	0.2159
5	0.2552	0.2204	0.2267	0.2491	0.2607	0.2343	0.2368	0.2556	0.2514	0.2683	0.2603	0.249
6	0.2749	0.2514	0.2379	0.2872	0.2817	0.2849	0.2594	0.2829	0.2767	0.289	0.305	0.2832
7	0.2929	0.2588	0.2641	0.341	0.3748	0.3185	0.3032	0.317	0.2943	0.3148	0.3328	0.2946
8	0.3397	0.2965	0.2513	0.2568	0.3549	0.3675	0.3313	0.337	0.3224	0.3352	0.324	0.3082
9	0.3351	0.344	0.2772	0.2607	0.3079	0.3648	0.3701	0.3754	0.3451	0.3435	0.38	0.3297
10	0.3217	0.3343	0.2871	0.262	0.4223	0.2639	0.3278	0.4055	0.3288	0.4071	0.4042	0.3609
11+	0.3915	0.381	0.3584	0.2624	0.4439	0.4579	0.4236	0.4365	0.4098	0.4446	0.4108	0.3838

Table 7. Weight-at-age (kg) for all herring caught in NAFO Division 4T. Spawning-group affinity assigned by gonad maturity for spawning and spent fish (stages 6 and 7), by otolith characteristics for Juveniles (stages 1 and 2) and by McQuinn's (1989) GSI model for all remaining individuals.

SPRING SPAWNERS - ALL GEARS

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.079	0.0921	0.1054	0.1004	0.0366	0	0	0.0859	0.0866	0	0.08	0.0882
2	0.1281	0.1512	0.1533	0.1687	0.1502	0.1505	0.1167	0.1718	0.1347	0.1667	0.1097	0.1716
3	0.1593	0.1542	0.1624	0.1862	0.1758	0.1607	0.177	0.1875	0.1724	0.1895	0.1639	0.1794
4	0.2129	0.1849	0.2039	0.2359	0.2109	0.2086	0.1971	0.2174	0.2063	0.2082	0.2069	0.2075
5	0.2339	0.2373	0.2398	0.2848	0.2641	0.2453	0.2157	0.2472	0.2497	0.2315	0.2473	0.2353
6	0.2683	0.2416	0.2687	0.3313	0.3172	0.2675	0.27	0.2818	0.2663	0.2718	0.2797	0.2703
7	0.3068	0.2913	0.2778	0.3357	0.3718	0.3159	0.3029	0.3471	0.3203	0.2883	0.3049	0.302
8	0.3001	0.3156	0.297	0.315	0.377	0.2375	0.3693	0.3705	0.3392	0.3005	0.3258	0.3098
9	0.3119	0.3501	0.3483	0.3787	0.3741	0	0.4429	0.5225	0.2991	0.2959	0.363	0.331
10	0.3509	0.3154	0.3705	0.3571	0.4063	0	0.3713	0	0.3159	0.2964	0.3754	0.3423
11+	0.3611	0.3722	0.3642	0.4082	0.446	0	0	0.3475	0.4137	0.4179	0.3848	0.3158

FALL SPAWNERS - ALL GEARS

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0	0.0328	0.0308	0	0	0	0	0	0	0	0.0753	0
2	0.0985	0.1191	0.1061	0.126	0.096	0.1079	0.1109	0.1023	0.1514	0.14	0.0959	0.1049
3	0.1471	0.1531	0.1529	0.1934	0.1862	0.1765	0.2171	0.2129	0.1817	0.2315	0.1851	0.1759
4	0.2217	0.208	0.1915	0.2435	0.2581	0.2436	0.2451	0.241	0.2463	0.2468	0.2595	0.2519
5	0.2587	0.2375	0.2552	0.3046	0.2956	0.2762	0.2775	0.2854	0.279	0.2781	0.2884	0.2857
6	0.2803	0.2617	0.2524	0.3645	0.3336	0.3145	0.3117	0.3223	0.317	0.3085	0.3224	0.3193
7	0.2967	0.2746	0.2798	0.3823	0.3739	0.3469	0.3442	0.3536	0.3491	0.3385	0.3454	0.3401
8	0.3475	0.3192	0.2585	0.3983	0.3802	0.3652	0.3929	0.3637	0.3687	0.3581	0.3603	0.3415
9	0.3378	0.3544	0.2852	0.3577	0.3744	0.372	0.4099	0.3987	0.3906	0.3746	0.3971	0.3668
10	0.3263	0.3512	0.3102	0.4032	0.3827	0.4137	0.3762	0.4055	0.374	0.3868	0.4079	0.3876
11+	0.3972	0.3839	0.3653	0.4208	0.4518	0.4325	0.4885	0.4546	0.4281	0.4263	0.4219	0.3986

Table 8. Ratio of "GSI catch-at-age" to "standard" catch-at-age (+ 0.00001) used in the 1990 assessment (CAFSAC Res. Doc. 90/73), for herring caught with fixed gear in NAFO Division 4T.

SPRING SPAWNERS - FIXED GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.000	4.048	.000	.165	1.429	.000	.000	.000	.000	.000	1.018	.000
2	3.500	11.647	.824	.416	3.115	3.397	7.636	.917	.200	1.800	1.008	.000
3	1.018	1.159	.941	1.160	1.002	1.137	1.279	.988	1.187	1.267	.991	1.047
4	1.001	1.370	.953	1.134	1.062	1.003	1.000	.954	1.010	1.043	.948	1.001
5	1.099	.984	.977	1.317	1.009	1.108	.946	.949	1.109	.985	1.138	1.065
6	1.123	1.161	.924	1.313	1.069	.970	.814	1.010	.957	1.059	1.138	.993
7	6.128	1.023	.976	1.148	.976	1.889	1.318	.920	1.750	.889	1.161	1.044
8	1.008	1.522	1.056	1.012	1.018	.000	1.581	1.082	1.159	1.046	1.187	1.051
9	5.080	1.038	1.114	.989	.984	.000	2.000	.813	1.333	.756	1.171	1.064
10	.997	.997	1.013	1.043	1.000	.000	1.000	.000	1.111	.748	.444	1.178
11+	1.958	1.148	1.023	1.263	.979	.000	.000	.111	1.496	.953	.871	.836

FALL SPAWNERS - FIXED GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.000	1.001	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
2	1.025	1.333	.703	1.146	.000	.000	.000	.000	.628	1.000	.000	.000
3	1.020	.891	.977	1.064	.864	.725	1.047	.568	1.013	.979	.829	.727
4	.989	.929	.957	.939	.944	.919	.986	.627	.972	.992	.964	.978
5	.970	.887	.970	.878	.907	.936	1.011	.957	.933	.985	1.021	.969
6	.903	1.094	.972	.788	.955	1.035	1.009	1.437	.981	1.026	.928	1.002
7	.778	.954	1.393	.705	.976	1.125	.970	1.434	1.043	.989	.914	.966
8	.766	.997	1.387	.692	1.002	.966	.873	1.589	.866	1.053	.957	.955
9	1.000	.918	.792	1.697	.954	.927	.882	2.240	1.372	.984	.880	1.031
10	.301	1.049	1.007	.996	1.026	1.148	.948	1.511	.942	1.049	.963	.981
11+	.735	.768	1.846	.330	1.069	.988	1.230	5.889	.929	1.062	1.095	1.031

Table 9. Ratio of "GSI" catch-at-age to "standard" catch-at-age (+ 0.00001) for herring caught with mobile gear in NAFO Division 4T. *: not computed (division by zero).

SPRING SPAWNERS - MOBILE GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.991	1.001	.899	.000	.000	.000	.000	1.111	1.064	.000	1.022	1.016
2	.881	.570	.690	2.549	.994	3.177	.403	.823	.902	1.181	.922	.480
3	.621	1.906	.932	.999	1.110	1.719	.158	.552	.491	.384	.763	.444
4	.593	1.416	2.895	.178	.516	1.070	.323	.570	.602	.917	.446	.410
5	.903	.639	1.225	1.667	1.667	1.376	.321	.399	.591	.649	1.005	.238
6	1.069	.635	.616	.188	2.000	.056	.087	.775	.433	.627	.884	.523
7	4.369	.557	.453	.699	.211	1.600	.000	.211	.381	.642	.614	.562
8	1.374	1.021	.492	.574	1.118	2.118	.789	.000	.189	.559	1.159	.526
9	14.129	.640	.677	.004	67.999	.000	.000	.611	.882	.000	1.405	.724
10	.403	.309	.410	.776	1.000	.000	.000	.000	.000	.000	.000	1.415
11+	4.170	.780	.627	1.500	1.600	.000	.000	.993	.763	1.156	.449	.135

FALL SPAWNERS - MOBILE GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.000	1.137	.966	.000	.000	.000	.000	.000	.000	.000	.985	.000
2	.993	.995	1.053	1.013	.985	.600	.944	1.086	1.019	1.000	.971	1.015
3	1.098	2.050	1.172	.961	.982	.571	1.609	.853	1.079	.986	1.153	1.694
4	1.136	.733	1.184	1.021	.979	1.022	2.644	1.510	1.339	1.690	1.180	2.737
5	1.997	.829	.690	2.156	.986	2.229	2.572	1.099	1.942	1.030	1.059	1.763
6	1.078	1.725	1.089	.964	.958	.705	2.454	1.521	1.272	1.476	1.062	1.988
7	.961	1.774	2.229	2.457	.957	.809	1.552	1.245	2.398	1.472	1.044	1.769
8	.744	1.605	4.655	4.789	1.371	.726	1.617	2.301	1.927	1.460	1.339	1.913
9	.838	.989	2.364	3.190	.990	1.087	1.320	2.131	1.413	1.801	1.064	1.575
10	.397	1.228	1.837	*	.342	.714	*	1.087	2.175	1.548	.825	2.156
11+	.824	1.098	2.987	*	.992	.594	2.000	1.388	1.680	4.615	1.505	1.358

Table 10. Ratio of "GSI" catch-at-age to "standard" catch-at-age (+ 0.00001) for all herring caught in NAFO Division 4T.

SPRING SPAWNERS - ALL GEARS

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.991	1.048	.899	.165	1.429	.000	.000	1.111	1.064	.000	1.022	1.016
2	.882	.582	.692	1.343	1.136	3.230	.738	.844	.880	1.480	.930	.480
3	.784	1.597	.937	1.144	1.005	1.212	.899	.854	.883	.880	.919	.770
4	.791	1.406	1.694	1.044	1.050	1.005	.893	.903	.899	1.021	.858	.874
5	.963	.802	1.130	1.318	1.012	1.125	.859	.901	.945	.903	1.123	.784
6	1.084	.685	.762	.999	1.071	.935	.564	.983	.793	.901	1.066	.813
7	4.653	.686	.553	1.103	.934	1.844	.674	.804	1.025	.806	.958	.802
8	1.289	1.071	.604	.755	1.023	1.565	1.260	.893	.643	.865	1.180	.833
9	9.729	.707	.803	.652	1.516	.000	.235	.673	.922	.687	1.278	.917
10	.602	.579	.642	.877	1.011	.000	1.000	.000	.992	.648	.444	1.245
11+	3.354	.929	.864	1.263	.986	.000	.000	.942	1.269	.985	.583	.602

FALL SPAWNERS - ALL GEARS

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.000	1.026	.966	.000	.000	.000	.000	.000	.000	.000	.985	.000
2	.995	.996	1.039	1.117	.985	.600	.944	.958	.736	1.000	.971	1.015
3	1.086	1.962	1.132	1.016	.944	.593	1.150	.725	1.036	.980	1.031	1.261
4	1.108	.787	1.116	.951	.949	.937	1.045	.776	.989	1.009	.987	1.109
5	1.753	.842	.764	.928	.916	1.044	1.133	.979	1.090	.988	1.024	1.070
6	1.044	1.589	1.073	.794	.956	1.000	1.115	1.457	1.019	1.124	.945	1.080
7	.929	1.555	2.005	.848	.974	1.092	1.002	1.398	1.213	1.048	.962	1.075
8	.750	1.413	4.062	.780	1.025	.957	.902	1.740	1.010	1.145	1.062	1.261
9	.848	.978	2.097	2.229	.961	.932	.904	2.203	1.379	1.075	.941	1.161
10	.376	1.191	1.628	1.473	.689	1.034	1.014	1.314	1.383	1.070	.915	1.261
11+	.810	1.074	2.810	.540	1.017	.923	1.227	1.800	1.037	1.088	1.307	1.125

Table 11. Ratio of "GSI" weight-at-age to "standard" weight-at-age (+ 0.000001) for herring caught with fixed gear in NAFO Division 4T.

SPRING SPAWNERS - FIXED GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.000	1.005	.000	.891	1.158	.000	.000	.000	.000	.000	.982	.000
2	1.777	1.373	.802	.925	1.108	1.251	.831	.972	.592	1.670	.976	.000
3	.992	1.015	1.064	1.012	1.006	1.029	1.047	.998	1.018	1.073	.966	1.004
4	1.019	1.071	1.083	1.021	1.016	.996	1.009	.978	.976	1.040	.980	.991
5	1.035	.988	1.047	1.080	1.006	1.024	1.004	.994	1.013	1.007	1.018	.994
6	1.046	1.039	1.010	1.052	.999	.985	.885	1.005	.968	1.023	1.016	.988
7	1.106	1.000	1.046	1.018	.986	.973	.769	1.034	1.064	1.001	1.009	.983
8	1.029	.988	1.016	.994	.990	.000	.865	1.016	.984	1.013	1.016	.991
9	.952	.994	1.007	1.017	1.000	.000	1.135	.934	1.061	.977	.966	.991
10	1.034	.998	.975	1.010	1.001	.000	.972	.000	1.060	.969	.948	1.007
11+	1.016	1.006	.970	1.027	1.003	.000	.000	1.439	1.003	.980	1.061	.930

FALL SPAWNERS - FIXED GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.000	1.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
2	.974	1.063	1.100	.972	.000	.000	.000	.000	1.028	.945	.000	.000
3	.975	.994	.998	.981	1.060	1.024	1.009	.979	.976	1.001	.941	.996
4	.999	1.003	1.005	1.003	1.043	1.011	1.007	.930	.999	1.000	.999	1.007
5	.999	.996	1.002	1.005	1.094	1.003	1.004	.976	.992	.994	.994	1.003
6	1.005	.988	.997	1.014	1.053	1.004	1.001	1.009	.995	.991	1.002	1.009
7	1.012	.992	.976	1.011	1.022	1.001	1.004	.992	1.002	.999	1.007	1.011
8	1.012	.997	.952	1.027	1.035	1.004	1.005	.979	1.000	.985	1.006	1.014
9	.994	1.007	.985	1.023	1.050	1.011	1.006	1.024	1.003	1.001	1.015	1.006
10	1.029	.997	.973	1.001	1.059	.980	.968	1.059	.961	.994	1.031	1.007
11+	1.031	1.039	.922	1.227	1.205	1.006	1.002	1.048	1.043	.989	.973	1.008

Table 12. Ratio of "GSI" weight-at-age to "standard" weight-at-age (+ 0.000001) for herring caught with mobile gear in NAFO Division 4T. *: not computed (division by zero).

SPRING SPAWNERS - MOBILE GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	1.014	1.002	.774	1.057	1.158	.000	.000	.985	.973	.000	.959	.949
2	.980	.913	.944	1.059	1.004	1.041	.923	1.016	.970	1.000	.946	1.109
3	.931	1.094	.914	1.054	.996	.990	.912	1.022	1.010	.862	.946	.971
4	.945	1.126	1.033	.918	1.060	.962	.977	.977	1.017	1.099	.934	.993
5	.935	.983	1.005	1.036	1.001	1.054	1.013	1.059	1.030	1.013	1.138	.918
6	.936	1.026	1.008	1.092	1.010	.822	1.018	1.026	1.036	1.018	.956	1.027
7	.964	1.012	1.067	1.148	.816	.780	.871	.842	.984	1.000	1.056	1.023
8	.835	1.049	1.073	1.040	1.043	.939	.948	.000	.974	1.039	1.017	.977
9	.932	1.106	1.169	1.368	.780	.000	1.214	1.177	.928	.000	1.026	.983
10	1.004	.931	1.112	1.122	1.001	.000	1.044	.000	.000	.000	1.016	.972
11+	.892	.982	.839	1.029	1.004	.000	.000	1.065	1.046	1.053	1.003	1.231

FALL SPAWNERS - MOBILE GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.000	1.061	.969	.000	.000	.000	.000	.000	.000	.000	1.037	.000
2	1.015	1.055	1.047	1.010	1.012	1.006	1.059	.999	.995	1.009	1.027	1.031
3	1.013	1.314	.960	1.022	1.014	1.007	1.002	.981	1.016	1.000	.975	.872
4	1.007	1.046	.932	1.017	1.013	.950	.976	.965	.959	.974	.98	.972
5	.991	1.001	.900	.990	1.009	.935	.953	.984	.976	.935	.955	.988
6	1.007	.987	.844	1.000	1.015	.991	.948	.972	.977	.972	.946	.984
7	1.008	.887	.907	.975	1.017	1.008	.993	1.004	.964	.972	1.034	.935
8	1.047	.937	.797	1.078	1.042	1.016	1.047	.986	1.011	.976	.948	.984
9	1.069	.999	.833	1.009	1.012	.890	1.040	.960	1.010	.948	1.014	1.005
10	1.024	.952	.793	.379	1.289	1.183	*	.998	1.030	.983	.993	.969
11+	1.031	1.004	.882	*	1.008	1.013	1.022	.952	1.017	1.066	1.000	1.031

Table 13. Ratio of "GSI" weight-at-age to "standard" weight-at-age (+ 0.000001) for all herring caught in NAFO Division 4T.

SPRING SPAWNERS - ALL GEARS

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	1.014	.966	.774	.890	1.158	.000	.000	.985	.973	.000	.959	.949
2	.980	.914	.941	1.072	1.058	1.094	.788	1.009	.959	1.184	.946	1.109
3	.935	1.040	.979	1.015	1.006	1.033	.978	.994	.960	.956	.955	.933
4	.939	1.111	1.101	1.009	1.015	.994	.990	.974	.965	1.046	.954	.962
5	.955	.977	1.024	1.080	1.006	1.028	.990	.992	1.000	.986	1.030	.929
6	.962	1.029	1.009	1.008	.999	.977	.897	1.005	.961	.989	.986	.974
7	.989	1.019	1.087	1.030	.974	.950	.812	1.027	1.015	.985	.997	.976
8	.873	1.046	1.089	1.044	.992	.939	.918	.984	.979	.985	1.015	.956
9	.942	1.084	1.125	1.110	.929	.000	1.302	1.090	.949	.937	1.006	.973
10	.985	.962	1.045	1.089	1.001	.000	.972	.000	1.005	.902	.948	1.011
11+	.932	.981	.924	1.027	1.003	.000	.000	1.065	1.022	1.004	.981	.877

FALL SPAWNERS - ALL GEARS

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.000	1.055	.969	.000	.000	.000	.000	.000	.000	.000	1.037	.000
2	1.013	1.056	1.037	.981	1.012	1.006	1.059	.870	.972	.994	1.027	1.031
3	1.009	1.257	.958	1.002	1.024	1.013	.983	.950	.985	1.001	.934	.870
4	1.004	1.048	.941	1.004	1.038	.999	.998	.910	.995	1.000	.995	.986
5	.982	1.003	.954	.994	1.083	.981	.983	.975	.973	.990	.991	.989
6	1.004	.970	.864	1.012	1.051	1.006	.980	1.000	.989	.981	.994	.998
7	1.006	.887	.905	.987	1.022	1.005	1.000	.997	.973	.992	1.015	.986
8	1.037	.932	.788	.982	1.034	1.004	1.001	.973	.981	.978	.980	.975
9	1.065	.998	.825	.939	1.042	1.005	1.005	1.004	1.004	.988	1.012	.993
10	1.022	.956	.809	.854	1.130	1.053	.960	1.030	.929	.995	1.018	.979
11+	1.029	1.004	.879	.991	1.067	1.003	1.003	.989	1.035	.990	.981	1.011

Table 14. Proportion-at-age for herring caught with fixed gear in NAFO Division 4T when spawning-group affinity is assigned by the "GSI" method.

SPRING SPAWNERS - FIXED GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.01	.01	.01	.01	.01	.00	.01	.00	.00	.01	.00
3	.14	.22	.32	.41	.76	.36	.17	.14	.07	.03	.07	.08
4	.65	.10	.20	.26	.14	.58	.52	.36	.36	.14	.15	.34
5	.03	.54	.08	.08	.03	.05	.30	.33	.26	.39	.19	.13
6	.05	.02	.25	.06	.02	.01	.01	.12	.23	.20	.27	.13
7	.04	.04	.05	.11	.01	.00	.00	.03	.06	.15	.16	.15
8	.01	.01	.03	.02	.01	.00	.00	.02	.01	.06	.12	.09
9	.01	.00	.03	.01	.00	.00	.00	.00	.00	.01	.03	.05
10	.04	.01	.01	.01	.00	.00	.00	.00	.00	.01	.00	.02
11+	.04	.05	.02	.03	.02	.00	.00	.00	.00	.00	.01	.01

FALL SPAWNERS - FIXED GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.00	.04	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00
3	.18	.02	.35	.14	.05	.01	.02	.02	.01	.05	.01	.00
4	.27	.43	.23	.59	.35	.42	.45	.13	.28	.23	.17	.14
5	.17	.22	.26	.15	.39	.20	.24	.37	.14	.18	.34	.22
6	.04	.13	.04	.06	.11	.27	.15	.23	.29	.13	.17	.29
7	.04	.04	.08	.02	.06	.04	.11	.15	.16	.22	.11	.14
8	.19	.05	.02	.01	.02	.03	.02	.07	.07	.09	.12	.07
9	.01	.04	.01	.01	.01	.01	.01	.02	.04	.06	.06	.09
10	.01	.01	.01	.01	.00	.00	.00	.01	.00	.03	.02	.03
11+	.09	.02	.00	.00	.00	.00	.00	.00	.01	.01	.01	.03

Table 15. Proportion-at-age of herring caught with mobile gear in NAFO Division 4T when spawning-group affinity is assigned using the "GSI" method.

SPRING SPAWNERS - MOBILE GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.02	.10	.01	.00	.00	.00	.00	.04	.00	.00	.11	.02
2	.25	.14	.16	.43	.42	.13	.05	.18	.11	.01	.21	.03
3	.09	.25	.23	.30	.48	.65	.17	.27	.09	.03	.06	.11
4	.28	.19	.24	.03	.03	.18	.50	.26	.31	.10	.04	.13
5	.04	.19	.10	.00	.01	.03	.26	.10	.24	.31	.05	.05
6	.08	.05	.12	.02	.00	.00	.01	.09	.18	.26	.21	.14
7	.09	.03	.07	.05	.00	.00	.00	.01	.05	.21	.12	.28
8	.02	.03	.03	.09	.01	.01	.01	.00	.01	.08	.10	.11
9	.02	.01	.02	.00	.04	.00	.00	.02	.01	.00	.07	.10
10	.02	.00	.01	.06	.00	.00	.00	.00	.00	.00	.00	.03
11+	.09	.02	.01	.00	.00	.00	.00	.03	.00	.00	.02	.00

FALL SPAWNERS - MOBILE GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.01	.03	.03	.01	.02	.01	.00	.01	.01	.00	.10	.02
3	.20	.14	.40	.42	.46	.29	.04	.09	.04	.03	.07	.02
4	.26	.22	.16	.42	.23	.41	.30	.20	.08	.05	.07	.09
5	.22	.18	.13	.06	.22	.18	.36	.23	.23	.09	.07	.17
6	.04	.18	.08	.01	.03	.09	.20	.23	.25	.28	.08	.15
7	.04	.05	.08	.03	.01	.02	.07	.09	.23	.25	.22	.12
8	.10	.04	.06	.01	.01	.00	.01	.08	.10	.21	.19	.20
9	.01	.06	.04	.03	.01	.00	.00	.03	.04	.07	.10	.13
10	.01	.01	.02	.01	.00	.00	.00	.02	.02	.01	.03	.07
11+	.11	.10	.01	.01	.01	.00	.00	.02	.01	.00	.06	.04

Table 16. Proportion-at-age for all herring caught in NAFO Division 4T when spawning-group affinity is assigned using the "GSI" method.

SPRING SPAWNERS - ALL GEARS

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.01	.07	.01	.00	.00	.00	.00	.00	.00	.00	.03	.01
2	.15	.09	.10	.06	.03	.02	.01	.03	.02	.01	.07	.01
3	.11	.24	.27	.40	.74	.39	.17	.15	.08	.03	.07	.09
4	.43	.16	.23	.24	.14	.53	.51	.35	.35	.13	.12	.29
5	.04	.31	.09	.07	.03	.04	.29	.30	.25	.37	.15	.11
6	.06	.04	.17	.05	.02	.01	.01	.12	.22	.21	.25	.13
7	.07	.03	.06	.10	.01	.00	.00	.03	.06	.16	.15	.18
8	.01	.02	.03	.02	.01	.00	.00	.01	.01	.07	.11	.10
9	.02	.01	.02	.01	.01	.00	.00	.00	.00	.01	.04	.06
10	.03	.00	.01	.01	.00	.00	.00	.00	.00	.00	.00	.02
11+	.07	.03	.01	.03	.02	.00	.00	.00	.00	.00	.01	.00

FALL SPAWNERS - ALL GEARS

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.01	.02	.02	.01	.00	.00	.00	.00	.00	.00	.02	.01
3	.20	.12	.39	.20	.13	.07	.02	.04	.02	.05	.02	.01
4	.26	.26	.17	.55	.32	.42	.43	.15	.24	.20	.14	.13
5	.21	.19	.16	.13	.36	.19	.26	.34	.16	.17	.28	.20
6	.04	.17	.07	.05	.10	.24	.16	.23	.28	.15	.14	.25
7	.04	.04	.08	.03	.05	.04	.10	.13	.17	.23	.14	.13
8	.11	.04	.05	.01	.02	.03	.02	.07	.08	.11	.13	.10
9	.01	.05	.03	.01	.01	.01	.01	.02	.04	.06	.07	.10
10	.01	.01	.02	.01	.00	.00	.00	.01	.01	.02	.02	.04
11+	.11	.09	.01	.00	.00	.00	.00	.01	.01	.01	.02	.03

Table 17. Proportion-at-age of herring caught with fixed gear in NAFO Division 4T when spawning-group affinity is assigned using the "standard" method (gonad maturity or otolith characteristics).

SPRING SPAWNERS - FIXED GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.01	.03	.00	.00	.00	.01	.00	.00	.01	.00
3	.15	.20	.32	.40	.76	.33	.13	.13	.06	.02	.08	.08
4	.70	.08	.20	.26	.14	.61	.53	.37	.38	.14	.17	.35
5	.03	.59	.08	.07	.03	.04	.32	.33	.25	.40	.19	.12
6	.04	.02	.26	.05	.01	.01	.02	.11	.26	.19	.26	.13
7	.01	.04	.05	.10	.01	.00	.00	.03	.04	.17	.15	.15
8	.01	.01	.03	.02	.01	.00	.00	.01	.01	.06	.11	.09
9	.00	.00	.02	.02	.00	.00	.00	.00	.00	.01	.03	.05
10	.04	.01	.01	.01	.00	.00	.00	.00	.00	.01	.00	.02
11+	.02	.04	.02	.03	.02	.00	.00	.00	.00	.00	.01	.01

FALL SPAWNERS - FIXED GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.00	.04	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00
3	.15	.02	.35	.12	.05	.02	.02	.03	.01	.05	.01	.00
4	.24	.44	.24	.57	.34	.44	.45	.23	.28	.23	.17	.14
5	.16	.24	.27	.16	.40	.20	.24	.41	.15	.19	.32	.22
6	.04	.11	.04	.07	.11	.25	.15	.17	.29	.12	.17	.28
7	.04	.04	.05	.03	.06	.04	.11	.11	.15	.22	.11	.14
8	.22	.04	.01	.02	.02	.03	.03	.05	.08	.09	.12	.07
9	.01	.04	.01	.00	.01	.01	.01	.01	.03	.06	.06	.08
10	.02	.01	.01	.01	.00	.00	.00	.01	.00	.03	.02	.03
11+	.11	.03	.00	.01	.00	.00	.00	.00	.01	.01	.01	.02

Table 18. Proportion-at-age of herring caught with mobile gear in NAFO Division 4T when spawning-group affinity is assigned using the "standard" method.

SPRING SPAWNERS - MOBILE GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.02	.09	.01	.00	.00	.00	.00	.02	.00	.00	.09	.01
2	.25	.22	.20	.15	.45	.07	.04	.13	.07	.01	.19	.03
3	.12	.12	.22	.27	.46	.61	.29	.28	.10	.04	.07	.12
4	.41	.12	.07	.16	.06	.27	.41	.27	.28	.07	.07	.16
5	.04	.27	.07	.00	.00	.04	.22	.15	.22	.31	.05	.11
6	.06	.07	.17	.11	.00	.01	.04	.07	.23	.26	.20	.14
7	.02	.04	.13	.07	.01	.00	.01	.03	.08	.21	.17	.25
8	.01	.02	.06	.14	.01	.00	.00	.01	.02	.09	.08	.11
9	.00	.01	.03	.05	.00	.00	.00	.02	.01	.00	.04	.07
10	.04	.01	.01	.07	.00	.00	.00	.00	.00	.00	.00	.01
11+	.02	.03	.01	.00	.00	.00	.00	.02	.00	.00	.05	.01

FALL SPAWNERS - MOBILE GEAR

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.01	.03	.03	.01	.02	.02	.01	.01	.01	.00	.11	.04
3	.20	.07	.40	.48	.46	.43	.06	.14	.05	.04	.06	.03
4	.25	.32	.16	.45	.23	.34	.27	.17	.10	.05	.07	.06
5	.12	.23	.22	.03	.22	.07	.33	.28	.20	.12	.07	.18
6	.04	.11	.09	.01	.03	.11	.19	.19	.32	.27	.09	.14
7	.05	.03	.04	.01	.01	.02	.11	.09	.16	.25	.24	.12
8	.15	.03	.02	.00	.01	.00	.02	.05	.09	.21	.16	.19
9	.02	.06	.02	.01	.01	.00	.01	.02	.05	.06	.11	.15
10	.02	.01	.01	.00	.01	.00	.00	.02	.01	.01	.04	.06
11+	.15	.10	.00	.00	.01	.00	.00	.02	.01	.00	.04	.05

Table 19. Proportion-at-age for all herring caught in NAFO Division 4T when spawning-group affinity is assigned using the "standard" method.

SPRING SPAWNERS - ALL GEARS

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.01	.07	.01	.00	.00	.00	.00	.00	.00	.00	.03	.00
2	.16	.16	.13	.05	.02	.01	.01	.03	.02	.00	.07	.01
3	.13	.14	.26	.38	.75	.36	.16	.16	.08	.03	.07	.10
4	.51	.11	.12	.25	.13	.58	.50	.35	.35	.12	.14	.28
5	.04	.37	.07	.06	.03	.04	.30	.30	.24	.37	.14	.12
6	.06	.06	.20	.06	.01	.01	.02	.11	.25	.21	.24	.13
7	.01	.04	.10	.10	.01	.00	.00	.03	.05	.18	.16	.18
8	.01	.02	.05	.04	.01	.00	.00	.01	.01	.07	.10	.10
9	.00	.01	.03	.02	.00	.00	.00	.00	.00	.01	.03	.06
10	.04	.01	.01	.02	.00	.00	.00	.00	.00	.01	.00	.01
11+	.02	.03	.01	.02	.02	.00	.00	.00	.00	.00	.02	.01

FALL SPAWNERS - ALL GEARS

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.01	.02	.02	.01	.00	.00	.00	.00	.00	.00	.02	.01
3	.19	.06	.39	.19	.13	.11	.02	.06	.02	.05	.02	.01
4	.25	.35	.18	.55	.32	.42	.44	.21	.26	.21	.15	.13
5	.13	.23	.23	.14	.37	.17	.24	.38	.15	.18	.27	.21
6	.04	.11	.08	.06	.10	.22	.15	.17	.29	.14	.15	.26
7	.05	.03	.05	.03	.05	.03	.11	.10	.15	.23	.14	.14
8	.16	.03	.01	.02	.02	.03	.03	.05	.08	.10	.13	.09
9	.02	.06	.02	.00	.01	.01	.01	.01	.03	.06	.07	.09
10	.02	.01	.01	.00	.00	.00	.00	.01	.00	.02	.03	.04
11+	.14	.09	.00	.01	.00	.00	.00	.00	.01	.01	.02	.03