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REVISIONS TO THE 4T HERRING CATCH-AT-AGE MATRICES

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 1974 to 1988 and the procedures used are documented here. Commercial samples were handled by three laboratories at various times during this period, resulting in inconsistent age or spawninggroup assignment between years and laboratories. Errors in data files were corrected and landings were updated before proceeding with the catch-at-age calculations. Fish sampled in 1985-1988 were reassigned to a spawning group by gonadal maturity stage or by visual inspection of otolith characteristics to be consistent with prior methodology.

The new catch-at-age differs slightly from previous matrices, the more notable differences being found at extreme ages. Despite the spawning-group reassignment applied to some years, the numbers-at-age for those years were not altered to any greater extent than those of other years.

Résumé

Les matrices de capture à l'âge pour les géniteurs printemps et automne du hareng de la division 4T de l'OPANO ont été reconstruites pour les années 1974-1988, et les méthodes employées pour ce faire sont présentées. Les échantillons tirés de la pêche commerciale ont été analysés par trois laboratoires différents au cours de cette période, ce qui a créé des différences dans la classification du type géniteur et de l'âge entre les laboratoires et au cours des années. Les erreurs découvertes dans les fichiers ont été corrigées et les prises ont été mises à jour avant de procéder à la révision des matrices. Le type géniteur des poissons échatillonnés entre 1985 et 1988 a été révisé en se servant soit du stade de maturité des gonades ou des caractères de l'otolithe, pour mieux se conformer aux méthodes employées par le passé.

Les nouvelles matrices diffèrent quelque peu des antécédentes, notamment pour les âges extrêmes. Les changements apportés à la méthode de classification du type géniteur pour les années 1985-1988 ne semblent guère avoir augmenté les différences entre les nouveaux et anciens chiffres de capture à l'âge.

Introduction

The CAFSAC Advisory Document 86/19 (Anon., 1986) recommended that the catch- and weight-at-age matrices for 4T herring be Several factors were suspected of having reconstructed. 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 between 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. The 1982 samples were processed in St. Andrews up to Andrews). The St. Andrews samples September and from then on in Quebec. were aged by the Gulf Region's ager (transferred from St. Andrews). Starting in 1983, 4T samples were processed and aged in Moncton, and the data files were stored on site. 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 In 1985, the weight matrix was revised by applying the matrix. observed average weights for each year between 1971 and 1976, and by averaging the 1981-to-1984 weights for the period 1977 to In subsequent assessments, no mention was made of the 1984. methodology used to derive weights-at-age, and previous symptoms in the matrices persisted.

Furthermore, 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 a "clear-cut" In 1985, the Gulf Region started using otolith type. Discriminant Analysis of otolith morphometrics, which was meant to replace 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 we know 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 and documented here as well but this could not be done in the time available and 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 (see Methods below).

This document outlines the revisions to the previous (in effect up to 1989) catch- and weight-at-age matrices. Unexpected errors in the data files and in the landings were discovered and were edited before reconstructing the matrices. The effect of each revision step on the matrices is being documented with the revised 1989 assessment (Claytor and Dupuis, 1990).

Methods

a) Catch data

The landings for particular gear types, fishing seasons and unit areas (or "cells") that had been used to generate the catchat-age for the 4T herring assessments up to 1989 rarely added up to the total landings for that year. The compilation method was not documented in the assessment documents. Landing statistics were therefore recompiled. Updated landing statistics for 4T from 1974 to 1982 were drawn from McMillan et al. (1984). Quebec's 1982 statistics were not included in this report and were therefore obtained from Table 5 in the NAFO Statistical Bulletin (NAFO, 1984). Starting with 1983, Maritime landings were compiled from the Gulf Region's purchase slip files, to which Quebec totals were added. The latter were obtained either from Statistical Bullletins (1983-1985), NAFO data tape (1986) or ZIFF file (1987). Landings for 1987 and 1988 are preliminary.

Landings (round weight in kg) for each gear, month, and unit area were 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. They were later rounded off to the nearest metric tonne (MT). When the statistical unit area of a landing was unknown ('4Tu'), as sometimes occurred in the Maritimes or Quebec Region's reports, it was reallocated proportionally to specific 4T pooled areas fished with the same gear and in the same season. In 1975 and 1977, there were no landings reported for fixed gear during any month, in any specific area, but such landings listed under '4Tu' were considerable. They were reallocated to specific pooled areas by calculating, for 1974, 1976 and 1978, the average relative catches in the three areas and applying these proportions to the catch recorded for 4Tu. The averages were based on only those years because the relative importance of the two fishing seasons and gear types shifted in subsequent years.

b) Commercial sampling

Data files, consisting of random length-frequency samples from which random detailed samples were drawn, were copied from the CYBER at BIO for 1974 to 1982, except for the years 1978-1981, which were obtained from the St. Andrews magnetic tape collection. Data files generated before 1974 cannot be used because the errors, missing data and unreliable spawning-group and age assignments cannot be corrected.

Attempts to match length-frequency with detailed biological data revealed pervasive errors and missing information for identifying samples in these data files. Length-frequency and biological samples were therefore renumbered and obvious keypunching and coding errors were corrected by checking photocopies of data sheets filled out by samplers and laboratory For 1980 and 1981, several data sheets had not been technicians. keypunched or had been deleted, and therefore were restored. Once data files had been reorganized, length-weight regressions were executed to flag outliers. Such data points were examined in concert with gonad maturity and weight, and were either retained (if the length-weight relationship seemed plausible), edited (if a keypunching error was found), or deleted (if the error was untraceable).

There have been several changes in the procedures used to determine age and spawning-group affinity over the years, which reduce consistency across years. Thus the reconstruction of the catch-at-age matrices was based on the method most consistently applicable to all years, namely maturity stage if unambiguous (stages 5,6 and 7, with July 1 delineating the spring and fall spawning seasons), or alternately otolith type as evaluated by the ager (Cleary et al., 1982). This technique was applied to the 1985-1988 samples to regenerate age and spawning-group data. In 1985, however, maturity stages were determined in part by unsupervised temporary helpers, with the result that maturity stages seemed unreliable and were deleted from the current file altogether. For 1985, therefore, all fish were assigned to a spawning group by the ager's evaluation of otolith type, whereas normally 50-80% the fish sampled in a given year get classified according to maturity stage (weighted average for the 1980s, excluding 1985, is 63%).

After editing the data files, the 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 were then pooled by area, fishing season and gear type (or "cells"). The corrections outlined above usually increased the effective sample sizes, but unfortunately did not rectify the sampling deficiency for certain cells (Table 1).

The detailed samples were used to construct age-length relationships specific to each cell (some of the fish that were used for regressing weight on length could not be aged, and were therefore subsequently excluded from the age-length key). When cell samples were missing or too small to be reliable (because of a low r^2 for the length-weight regression or very few length groups represented in the sample), 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). As an example, the South Spring Mobile catch in 1976 would be estimated by averaging the percentages observed in the equivalent cell in 1974, 1975, 1977 and 1978. Table 1 indicates, however, that there was no sampling in 1974 or 1977, limiting the number of "most recent" cells to one (1975) and shifting the two "subsequent" available years to 1978 and 1979. The percentage estimate is required to adjust the numbers-at-age calculated with the substitute sample, as the latter is rarely composed of the same proportions of spring and fall spawners as those estimated for the missing sample. We assume that population composition for a cell is similar across years. This seems more likely than relying on a population from a different area, season or gear. For unit area 436 and unit areas 437-439, however, the Spring, Mobile-gear fishery was never sampled, preventing any estimation of spawning-group composition based on adjacent years (Table 1). In this instance the percentage of spring spawners in the catch had to be estimated from the Southern samples collected sporadically over the 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,
- d) for mobile gear only, the same area and gear but a different season, or
- e) the same season, gear, and area in a different year.

Because fixed and mobile gears usually targetted fish of different 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 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 package 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 selected the appropriate samples in the master file, gear type) which, along with the corresponding regression parameters, total landings, and percentages-at-length were input into the FORTRAN program 'AGELEN' (Wright, 1990). This set of programs calculates the catch-at-age from equations found in Gavaris and Gavaris It generated an age-length key for each spawning group (1983).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 all 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 and Discussion

Updated landings for NAFO Division 4T are grouped by area, fishing season and gear type in Table 1, along with the revised spawning-group composition and size of the biological samples available for each cell. In most cases the landings have increased from those previously used, but some values, most often in the north, show a decline. The most probable explanation for such reductions is the '4Tu' landings, which may have been allocated to specific areas differently in the past (the procedures were not documented).

In general, the corrections made to the data files have altered sample sizes and spawning-group composition by only a small percentage, when compared with Table 2 in CAFSAC Res. Doc. 89/63 (Chadwick et al., 1989). Sample sizes increased substantially in 1980 and 1981 due to newly keypunched samples. Other notable changes were found in 1985 and 1986: a few samples originally allocated to 4Tl or to 4Tq in fact belonged to 4Tj or 4Tg respectively, thereby increasing the south's sample size by 200%. The percentage of spring spawners in this area also changed from 100% to 80%. This drop and the 10-15% differences observed in most cells of 1986 are the result of the spawninggroup reassignment. It was discovered while editing the biological files that the 1987 and 1988 results of the Discriminant Analyses were inadvertently omitted from the assignment process, such that the reassignment incorporated into the revised matrices affected the spawning-group composition of 1985 and 1986 samples only.

The catch-at-age matrices (Tables 2-4) begin with 1974, although it is apparent from Table 1 that many cells were not sampled that year and therefore several substitutions for agelength keys were required. Mean weights-at-age are found in Table 5-7. The unusual changes in weight observed as one follows some cohorts across the years are attributable either to a low sample size for that cohort in a given year, or to the cohort's poor fit with the length-weight relationships observed in a given year. The new catch-at-age for spring and fall-spawning herring differs somewhat from that found in previous 4T herring assessments (Table 8), and the largest deviations tend to occur at extreme ages and represent minor catches. Despite the reassignment of spawning group using a more traditional method instead of Discriminant Analysis on otolith morphometrics, the numbers-at-age for 1985 and 1986 have not been altered to any greater extent than those of other years.

The impact of edited data files, updated landings and spawning-group reassignment upon the revised catch-at-age matrices are being documented individually, in conjunction with the revised 1989 assessment (Claytor and Dupuis, 1990). In addition, otolith characteristics, the application of Discriminant Analysis to otolith morphometrics, and the GSI model (McQuinn, 1989) as methods of assigning spawning group are being compared by the Gulf Region. The method deemed most useful will be subject to CAFSAC approval before being applied retroactively to historical data sets.

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Table 1. Landings in metric tonnes (MT) for NAFO Division 4T by area, fishing season and gear type. 1987 - 1988 landings are provisional. Spring fishing: January-June, Fall fishing: July-December. Most fixed gears are gillnets; mobile gears are mainly purse seines. %P: Percentage (by numbers) of spring spawners (P) in biological samples; N: sample size; NS: no sample available (*), or inadequate for one of the spawning group (A or P).

			SOUTH (4Tf-4Tk)			MIDD	LE (4TL))		NORTH (4Tm-4To)	
		SF	RING	F	ALL	SF	PRING	F	ALL	SP	RING	F	ALL
		FIXED	MOBILE	FIXED	MOBILE	FIXED	MOBILE	FIXED	MOBILE	FIXED	MOBILE	FIXED	MOBILE
1974	мт	3,572	8,762	497	17	2,767	5	792	0	1,954	31	2,914	13,974
	%P	- 96	. 12	11	39	. 99	12	0		100	12	. 0	39
	N	1096	*	*	*	658	*	234		344	*	439	1994
	NS		*	*	*	A	*				*		
1975	MT	1,939	18,565	573	0	3,539	0	619	0	1,539	0	2,605	14,149
	%P	100	16	0		98		3		100		0	83
	N	1592	660	100		2691		*		*		808	780
	NS							*		*			
1976	MT	1,766	16,871	527	173	2,940	0	604	0	1,875	345	2,286	12,034
	%P	100	20	22	39	87		3		98	20	0	56
	N	2276	*	98	*	717		*		156	*	598	1018
	NS		*		*			*		A	*		
1977	MT	1,361	19,887	492	0	2,484	0	531	106	1,080	0	2,237	16,645
	%P	100	20	2		100		3	48	99		6	70
	N	1189	*	*		671		*	239	*		298	2040
	NS		*	*				*		*		Р	
1978	мт	1,114	4,648	933	4,885	6,261	0	630	3,491	1,172	3,399	3,578	23,379
	%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
	%P	90	31	1	39	85		5	18	88		12	66
	N	6082	1246	1311	*	499		192	345	*		287	3520
	NS				*			Ρ		*			
1980	МТ	1,994	13,897	2,786	320	3,604	20	1,826	793	1,674	0	1,933	13,699
	%P	99	24	1	39	100	22	5	19	98		7	66
	N	4780	1488	*	*	1100	*	186	97	300		297	2346
	NS			*	*		*	Р		A			

Table 1. (cont'd)

			SOUTH ((4Tf-4Tk))		MIDD	LE (4TL))		NORTH (4Tm-4To))
		SP	RING	f	ALL	SP	RING	F	FALL	SF	RING	F	ALL
		FIXED	MOBILE	FIXED	MOBILE	FIXED	MOBILE	FIXED	MOBILE	FIXED	MOBILE	FIXED	MOBILE
1981	MT	2,386	21	3,272	3,081	4,028	0	2,381	14	1,087	0	5,572	93
	%P	97	27	1	39	84		1	18	83		3	16
	N	3157	*	400	*	494		694	*	1053		2291	759
	NS		*	Ρ	*			Ρ	*				
1982	MT	2,015	0	5,241	0	2,836	0	1,105	9	1,072	62	6,636	2,569
	%P	98		0		100		0	18	99	27	2	12
	N	4069		298	••	397		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
	%P	97		0	22	93	27	5	18	96		1	49
	N	*		743	*	683	*	175	*	114		1151	1200
	NS	*			*		*	P	*	A		Р	
1984	MT	663	3	7,939	0	4,192	1	1,338	114	427	0	6,697	2,164
	%P	76	27	0		96	27	1	18	85		6	63
	N	157	*	446		*	*	406	*	143		925	992
	NS		*			*	*	P	*				
1985	MT	2,352	0	9,362	0	3,902	0	1,413	0	963	0	12,932	7,022
	%	80		8	••	99		2		65		29	43
	N	240		449	••	70		*		77		336	429
	NS					A		*					
1986	MT	3,336	0	12,265	44	3,389	0	1,570	0	1,825	0	26,056	10,871
	%P	93		0	22	100		2		85		13	62
	N	192		663	36	204		*	••	281		578	693
	NS							*					
1987	MT	3,600	0	18,198	78	3,738	0	1,970	13	4,386	0	31,862	13,613
	%P	94		0	22	100		0	18	93		6	49
	N NS	258		1692	*	232		32	*	325		1309	445
1988	MT	2,050	0	15,034	226	3,967	· 1	3,785	1	6,616	0	22,266	17,423
	%P	93		1	22	94	27	0	18	70		14	48
	N	572		685	*	425	*	95	*	527		763	530
	NS			Р	*		*		*				

Table 2. Annual catch-at-age (1000s) of spring and fall spawners in 4T, all gears combined.

ALL GEARS - SPRING SPAWNERS

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
														• • •	
1	107	0	35	1131	1434	6787	701	85	7	0	0	190	47	0	2467
2	2616	1058	16335	3541	16542	15870	12366	1674	772	305	237	1587	1639	306	5697
3	4932	20105	6679	58151	13469	14435	24371	12588	24424	16343	5366	8782	5379	2360	5797
4	4081	10670	36486	8676	52354	10846	11445	8131	4339	26786	16610	19159	24684	93 57	10883
5	1978	2053	5117	8359	3736	37186	6957	2044	1063	2017	9884	16581	16783	29599	11132
6	22693	11944	1528	888	5814	5795	19340	1921	465	492	702	5804	17456	16648	19027
7	7646	21774	204	2569	1401	4393	9782	3258	350	64	86	1693	3561	14614	12458
8	4209	3082	7439	315	1123	1817	4482	1160	348	23	50	779	818	5572	7878
9	4968	3314	860	3584	181	772	2649	699	126	5	17	260	245	750	2544
10	605	4802	480	3873	4125	772	1185	512	91	0	5	4	131	509	196
11+	5363	5837	3736	3459	2070	3125	1142	763	587	0	0	155	197	202	1878

ALL GEARS - FALL SPAWNERS

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
. 															
1	101	0	0	0	0	1115	148	0	0	0	0	0	0	0	66
2	2421	23	71	195	1512	2747	2364	358	203	210	36	264	557	62	3984
3	4478	4149	164	6995	23044	7010	39878	10107	7606	6850	1127	4353	2510	9090	3714
4	26000	5110	1976	10091	29774	38935	18275	30067	18424	26606	26157	16904	35492	39403	23612
5	9632	30464	5872	19178	15160	26002	23878	7476	21118	11157	14436	30191	20940	33195	43538
6	5032	8896	17483	8318	4672	12342	7705	3255	5488	14225	8892	13562	40368	25761	24846
7	18672	4122	4491	14338	5452	3392	4648	1585	2703	2152	6526	8188	21094	41792	229 50
8	974	7228	3022	6408	19244	3374	1482	882	1118	1753	1588	3594	10967	18992	20477
9	4621	3049	5327	2484	1847	6294	1726	236	492	548	541	823	4185	10713	11800
10	3082	4490	1181	4884	2377	1282	1202	241	225	149	211	894	562	4526	4338
11+	8962	19984	33949	19963	16893	9695	358	309	181	` 194	75	295	870	1778	3054

Table 3. Annual catch-at-age (1000s) for spring and fall spawners in fixed gear.

FIXED GEAR - SPRING SPAWNERS

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
. 	· · · · · · · · · · · · · · · · · · ·														
1	1	0	0	17	0	105	0	85	7	0	0	0	0	0	57
2	107	51	0	40	4	17	205	947	52	73	11	360	50	150	487
3	3454	14335	1410	18158	5544	5974	11194	11285	23679	14226	3549	6085	3026	1325	3972
4	3160	3189	16902	2901	25449	2292	7078	7363	4246	25857	14001	16610	17926	7697	8942
5	1352	926	2610	4121	1142	17595	2693	2041	1057	1892	8501	15127	11485	22395	9895
6	15869	1737	528	489	1631	552	9204	1385	461	474	462	5145	11 99 4	10559	13598
7	2674	6581	114	9 0	227	1214	1869	2929	331	54	44	1418	1675	9722	7842
8	2952	1360	3737	117	257	180	892	480	331	5	31	643	383	3504	5807
9	2951	1043	505	1082	88	131	764	459	125	1	2	75	24	681	1385
10	332	1497	300	22	1379	303	456	187	91	0	5	4	117	441	196
11+	541	1211	2632	803	764	1266	683	761	583	0	0	9	137	169	598

FIXED GEAR - FALL SPAWNERS

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
					·····								····		
1	0	0	0	0	0	903	0	0	0	0	0	0	0	0	0
2	0	0	0	0	80	6	91	281	0	0	0	31	403	15	0
3	157	0	8	434	3520	532	8149	5406	2492	993	920	1966	1606	8166	1401
4	5577	1437	344	3164	5608	10754	5460	25698	15876	22006	25228	14054	33820	38450	21118
5	1764	6601	1845	480	3593	5789	6285	7187	18618	10225	13303	25547	17678	30658	40919
6	534	968	5052	384	904	2672	1023	3142	5152	12739	8235	10342	35098	20148	21742
7	2125	634	625	4013	958	907	1244	1457	2586	1927	6162	6622	18454	36671	14437
8	145	605	221	222	5103	1068	269	863	1048	1690	1529	2829	9483	14711	14841
9	1635	435	573	92	117	958	293	152	389	524	517	541	3402	9517	7868
10	383	475	72	664	521	265	302	240	114	108	211	481	362	4340	2832
11+	2582	1671	2500	1000	2589	710	52	309	58	162	74	27	745	1764	1475

Table 4. Annual catch-at-age (1000s) for spring and fall spawners in mobile gear.

MOBILE GEAR - SPRING SPAWNERS

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
- 															
1	106	0	35	1114	1434	6681	701	0	0	0	0	190	47	0	2410
2	2508	1007	16335	3501	16538	15853	12161	727	720	232	226	1227	1589	155	5210
3	1478	5771	5269	39993	7925	8461	13177	1303	745	2117	1818	2697	2353	1035	1825
4	921	7481	19584	5775	26905	8555	4366	768	93	928	2609	2549	6758	1659	1941
5	627	1127	2507	4238	2594	19591	4265	3	6	125	1383	1454	5298	7204	1237
6	6824	10207	1000	400	4184	5243	10136	536	3	18	240	659	5463	6089	5429
7	4971	15193	90	2479	1174	3179	7913	329	19	10	42	275	1886	4892	4616
8	1257	1722	3702	199	866	1637	3590	679	17	17	19	136	435	2068	2070
9	2017	2271	355	2501	93	641	1885	239	1	4	14	185	220	69	1159
10	273	3305	179	3851	2746	469	729	326	1	0	0	0	14	68	0
11+	4822	4625	1104	2656	1306	1859	459	2	5	0	0	146	59	32	1280

MOBILE GEAR - FALL SPAWNERS

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
!-													<u>_</u>		
1	101	0	0	0	0	212	148	0	0	0	0	0	0	0	66
2	2421	23	71	195	1432	2741	2273	77	203	210	36	233	154	47	3984
3	4320	4149	155	6561	19524	6478	31729	4702	5114	5857	207	2387	903	924	2313
4	20423	3673	1632	6927	24166	28182	12815	4369	2548	4600	929	2850	1672	954	2494
5	7868	23863	4027	18698	11567	20212	17593	289	2500	933	1133	4644	3262	2537	2619
6	4498	7928	12431	7934	3767	9 670	6682	112	336	1486	657	3220	5271	5613	3104
7	16547	3488	3866	10325	4494	2485	3404	129	116	225	364	1566	2640	5121	8514
8	829	6623	2801	6185	14142	2306	1213	19	70	62	60	765	1485	4281	5635
9	2985	2614	4754	2392	1730	5336	1433	84	103	23	25	282	783	1197	3932
10	2699	4015	1110	4220	1856	1017	900	1	111	42	0	413	200	186	1506
11+	6380	18314	31449	18963	14305	8986	305	0	123	32	1	268	125	13	1580

Table 5. Mean weight-at-age (kg) of spring and fall spawners caught in 4T, all gears combined.

ALL GEARS - SPRING SPAWNERS

AGE	1974	1975	1976	1977	1978	197 9	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	0.0537	0	0.064	0.101	0.0779	0.0953	0.1361	0.1128	0.0316	0	0	0.0872	0.089	0	0.0834
2	0.125	0.086	0.1405	0.1401	0.1307	0.1654	0.1629	0.1573	0.142	0.1376	0.1481	0.1702	0.1404	0.1408	0.116
3	0.1606	0.1526	0.1626	0.1832	0.1704	0.1483	0.1658	0.1834	0.1747	0.1556	0.1809	0.1886	0.1796	0.1982	0.1716
4	0.2084	0.1742	0.1888	0.1965	0.2268	0.1665	0.1852	0.2338	0.2077	0.2099	0.1991	0.2231	0.2137	0.1990	0.2168
5	0.2299	0.2091	0.2108	0.2347	0.245	0.243	0.2342	0.2636	0.2624	0.2386	0.2179	0.2492	0.2498	0.2348	0.2401
6	0.2537	0.2026	0.2301	0.2638	0.2789	0.2349	0.2662	0.3288	0.3175	0.2738	0.3011	0.2803	0.2771	0.2748	0.2837
7	0.2818	0.2547	0.2674	0.2847	0.3103	0.2859	0.2555	0.326	0.3816	0.3326	0.373	0.3379	0.3156	0.2928	0.3058
8	0.2864	0.2937	0.2963	0.2786	0.3439	0.3018	0.2728	0.3016	0.3801	0.2528	0.4025	0.3767	0.3466	0.3052	0.3209
9	0.2963	0.3212	0.3169	0.311	0.3311	0.3231	0.3095	0.3411	0.4028	0.426	0.3401	0.4793	0.3152	0.3158	0.3609
10	0.3077	0.3176	0.3185	0.3238	0.3563	0.328	0.3546	0.3279	0.4058	0	0.3818	0.386	0.3143	0.3287	0.3959
11+	0.3429	0.3623	0.3189	0.3468	0.3876	0.3793	0.394	0.3973	0.4445	0	0	0.3262	0.4046	0.4163	0.3922

ALL GEARS - FALL SPAWNERS

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
 	· · · · ·												·		
1	0.0498	0	0	0	0	0.0311	0.0318	0	0	0	0	0	0	0	0.0726
2	0.0665	0.0566	0.0887	0.1178	0.0972	0.1128	0.1023	0.1284	0.0949	0.1073	0.1047	0.1176	0.1558	0.1408	0.0934
3	0.1352	0.1103	0.1802	0.138	0.1458	0.1218	0.1596	0.1931	0.1819	0.1742	0.2208	0.2242	0.1845	0.2313	0.1981
4	0.1968	0.2	0.1866	0.214	0.2208	0.1984	0.2036	0.2425	0.2486	0.2439	0.2455	0.2647	0.2476	0.2469	0.2608
5	0.2333	0.2388	0.2219	0.2249	0.2634	0.2368	0.2676	0.3065	0.2729	0.2816	0.2824	0.2928	0.2867	0.2810	0.2909
6	0.2637	0.2662	0.2722	0.2583	0.2793	0.2697	0.2921	0.3601	0.3175	0.3126	0.3182	0.3224	0.3206	0.3145	0.3244
7	0.2629	0.2994	0.2875	0.2974	0.2949	0.3095	0.309	0.3873	0.3659	0.3453	0.3443	0.3548	0.3588	0.3414	0.3404
8	0.316	0.3028	0.3192	0.2995	0.3351	0.3426	0.3281	0.4054	0.3677	0.3636	0.3924	0.3737	0.3759	0.3663	0.3676
9	0.314	0.3269	0.328	0.3203	0.3173	0.355	0.3455	0.3809	0.3594	0.3701	0.4079	0.3972	0.3892	0.3793	0.3925
10	0.3071	0.3337	0.3551	0.328	0.3194	0.3673	0.3836	0.472	0.3386	0.3929	0.3918	0.3938	0.4027	0.3889	0.4008
11+	0.352	0.3653	0.3812	0.3545	0.386	0.3824	0.4155	0.4246	0.4236	0.4311	0.4869	0.4597	0.4138	0.4305	0.43

Table 6. Mean weight-at-age (kg) of spring and fall spawners caught in 4T with fixed gear.

FIXED GEAR - SPRING SPAWNERS

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
!				<u></u>											<u></u>
1	0.0537	0	0	0.101	0	0.0194	0	0.1128	0.0316	0	0	0	0	0	0.0386
2	0.1129	0.1146	0	0.16	0.0798	0.1171	0.2265	0.1511	0.1762	0.1376	0.1123	0.2193	0.1811	0.0906	0.0818
3	0.1573	0.1536	0.1594	0.1562	0.149	0.1673	0.1573	0.1812	0.1735	0.151	0.1684	0.184	0.1575	0.1752	0.1663
4	0.2057	0.1941	0.1854	0.1882	0.1852	0.1997	0.1719	0.231	0.2072	0.2093	0.1939	0.2209	0.2007	0.1883	0.2073
5	0.2254	0.2292	0.2177	0.2217	0.2038	0.2319	0.2182	0.2636	0.2623	0.2367	0.2128	0.2472	0.2389	0.2159	0.236
6	0.2507	0.2493	0.2488	0.2611	0.2449	0.235	0.2664	0.3106	0.3175	0.2716	0.3032	0.2774	0.2645	0.2463	0.2622
7	0.2735	0.2773	0.2587	0.2629	0.2912	0.3047	0.2933	0.3304	0.3768	0.3358	0.3937	0.3384	0.3001	0.2703	0.2849
8	0.2849	0.2893	0.2868	0.274	0.299	0.3404	0.3268	0.3412	0.3833	0.2528	0.4444	0.3647	0.3448	0.2744	0.299
9	0.2937	0.3022	0.3087	0.2969	0.3271	0.345	0.3653	0.3725	0.4027	0.426	0.3903	0.4283	0.3285	0.3028	0.3347
10	0.3043	0.3115	0.2965	0.2998	0.3199	0.318	0.3723	0.3946	0.4057	0	0.3819	0.386	0.2981	0.3060	0.3959
11+	0.3281	0.3383	0.3115	0.3239	0.3614	0.3507	0.3845	0.3973	0.4445	0	0	0.3414	0.4169	0.3991	0.3177

FIXED GEAR - FALL SPAWNERS

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
!_															
 1	0	0	0	0	0	0.0231	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0.0808	0.1003	0.1922	0.1325	0	0	0	0.2332	0.1745	0.1405	0
3	0.1669	0	0.2134	0.1705	0.1378	0.2027	0.2072	0.2087	0.2094	0.1863	0.234	0.2629	0.2007	0.2345	0.2454
4	0.2227	0.2383	0.2609	0.2375	0.2373	0.2547	0.2565	0.246	0.255	0.2492	0.2466	0.2733	0.2488	0.2469	0.2647
5	0.2696	0.2772	0.2898	0.2791	0.2825	0.2945	0.3113	0.3087	0.2748	0.2844	0.2852	0.2988	0.292	0.2805	0.2921
6	0.2972	0.3155	0.3142	0.2873	0.306	0.3239	0.3597	0.3627	0.3201	0.3156	0.3217	0.3322	0.3263	0.3192	0.3247
7	0.3089	0.3341	0.3429	0.3222	0.3153	0.3583	0.3575	0.3906	0.3658	0.3488	0.3466	0.364	0.3665	0.3439	0.3512
8	0.3363	0.3436	0.3489	0.3375	0.3642	0.3992	0.3857	0.409	0.3694	0.3637	0.3953	0.3824	0.3849	0.3729	0.3774
9	0.3501	0.3732	0.3775	0.3598	0.3734	0.4143	0.4082	0.4482	0.374	0.3683	0.4104	0.4005	0.4001	0.3814	0.4013
10	0.3381	0.3783	0.3604	0.3699	0.3382	0.4288	0.4474	0.4712	0.3495	0.4588	0.3918	0.383	0.4488	0.3878	0.3973
11+	0.3753	0.4007	0.4074	0.3927	0.4195	0.4201	0.4677	0.4246	0.388	0.427	0.4884	0.4741	0.4157	0.4306	0.4504

Table 7. Mean weight-at-age (kg) of spring and fall spawners caught in 4T with mobile gear.

MOBILE GEAR - SPRING SPAWNERS

AGE	1974	1975	1976	1977	1978	19 79	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	0.0537	0	0.064	0.101	0.0779	0.0965	0.1361	0.0281	0.0316	0	0	0.0872	0.089	0	0.0845
2	0.1255	0.0846	0.1405	0.1399	0.1307	0.1654	0.1618	0.1652	0.1395	0.1376	0.1499	0.1558	0.1391	0.1893	0.1192
3	0.1683	0.1499	0.1634	0.1955	0.1853	0.1348	0.173	0.2031	0.2135	0.1862	0.2053	0.199	0.2081	0.2276	0.1831
4	0.2178	0.1657	0.1917	0.2006	0.2661	0.1576	0.2066	0.2602	0.2298	0.2245	0.2269	0.2373	0.2484	0.2486	0.2606
5	0.2396	0.1927	0.2036	0.2474	0.2632	0.253	0.2443	0.2604	0.274	0.2669	0.2497	0.27	0.2735	0.2934	0.2732
6	0.2605	0.1947	0.2203	0.2672	0.2921	0.2349	0.266	0.3759	0.3208	0.3322	0.297	0.3033	0.3049	0.3242	0.3376
7	0.2862	0.2449	0.2784	0.2854	0.314	0.2787	0.2466	0.2863	0.465	0.3147	0.3509	0.3354	0.3293	0.3376	0.3412
8	0.2901	0.2972	0.3059	0.2814	0.3572	0.2975	0.2594	0.2736	0.3198	0.2528	0.3364	0.4335	0.3482	0.3574	0.3823
9	0.3	0.3298	0.3285	0.3171	0.3349	0.3187	0.2868	0.2807	0.4132	0.426	0.3324	0.4999	0.3137	0.4454	0.3923
10	0.3119	0.3203	0.3553	0.324	0.3745	0.3344	0.3435	0.2897	0.4322	0	0.3515	0	0.4544	0.4769	0.3394
11+	0.3445	0.3686	0.3365	0.3537	0.4029	0.3987	0.4081	0.3966	0.4456	0	0	0.3253	0.376	0.5062	0.427

MOBILE GEAR - FALL SPAWNERS

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
) 					······					-					
1	0.0498	0	0	0	0	0.0652	0.0318	0	0	0	0	0	0	0	0.0726
2	0.0665	0.0566	0.0887	0.1178	0.0981	0.1129	0.0987	0.1133	0.0949	0.1073	0.1047	0.1024	0.107	0.1409	0.0934
3	0.134	0.1103	0.1784	0.1358	0.1473	0.1152	0.1473	0.1751	0.1685	0.1722	0.1617	0.1923	0.1558	0.2032	0.1694
4	0.1897	0.185	0.1709	0.2033	0.217	0.177	0.181	0.2218	0.2082	0.2186	0.2168	0.222	0.2234	0.2493	0.2278
5	0.2252	0.2281	0.1908	0.2235	0.2575	0.2202	0.252	0.2516	0.2584	0.2507	0.2484	0.2598	0.2575	0.2869	0.2725
6	0.2597	0.2602	0.2551	0.2569	0.273	0.2547	0.2818	0.2872	0.2775	0.2875	0.2736	0.2909	0.2833	0.2974	0.3223
7	0.257	0.2931	0.2786	0.2878	0.2905	0.2918	0.2913	0.3497	0.3684	0.3161	0.3053	0.3157	0.3053	0.3238	0.3219
8	0.3125	0.299	0.3169	0.2981	0.3246	0.3163	0.3153	0.2383	0.3407	0.3618	0.3163	0.3417	0.3188	0.3436	0.3418
9	0.2942	0.3192	0.322	0.3188	0.3135	0.3444	0.3326	0.2583	0.3043	0.4101	0.3558	0.391	0.3417	0.3623	0.3748
10	0.3027	0.3284	0.3548	0.3214	0.3141	0.3513	0.3622	0.6919	0.3275	0.2231	0	0.4064	0.3192	0.4143	0.4072
11+	0.3426	0.362	0.3791	0.3525	0.3799	0.3794	0.4065	0	0.4404	0.4518	0.4143	0.4583	0.403	0.417	0.4109

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
 	····,	••• • • • • • • • • • • • • • • • • • •									
2	1.1460	.7300	.5783	.2726	.8355	.7193	1.1449	12.6960	5.2032	1.1250	13.0068
3	.9538	1.0545	.5724	.7082	.7316	1.5103	1.5437	1.0365	1.0713	1.0328	1.2199
4	.8017	1.8521	2.0118	.9856	.6997	.8584	1.5055	1.6910	1.4297	1.1118	.7379
5	.7962	1.0952	2.2471	1.5675	.7202	.5127	.7143	1.4163	.8127	1.0171	.7898
6	.8358	2.7207	1.2265	2.2131	1.3798	.4457	.4652	1.0812	1.0877	.9523	.9267
7	1.0971	1.4300	2.9924	.7331	1.6129	.9143	.7414	.8315	.6143	.9736	1.1663
8	.9501	2.5700	2.2046	1.5364	1.0265	.4600	4.5455	2.1401	.4907	.9556	.9692
9	.9476	3.8030	3.5797	.9246	1.1053	.2941	1.5455	1.0442	.4554	1.0260	1.2272
10	1.1509	1.0752	3.7031	4.7407	45.4998	.0000	.2273	4.0000	1.1197	1.1114	.4516
11+	1.0392	.8959	.3924	.6369	5.3364	.0000	.0000	154.9985	.4273	1.0306	1.1804

Table 8. Ratio of new annual catch-at-age numbers to old catch-at-age (see CAFSAC Res. Doc. 89/63).

SPRING SPAWNERS - ALL GEARS

FALL SPAWNERS - ALL GEARS

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	.9987	.9453	1.7268	3.2844	1.1033	6.0000	4.0000	8.8000	1.6828	1.0877	120.7272
3	1.1910	1.1276	1.2297	1.0032	.8202	1.4325	.9930	1.1651	.5741	.9709	2.3869
4	1.0875	1.1114	1.8284	.9055	.8559	1.1142	.9505	.9554	.9879	.9942	.8696
5	1.0758	.9411	1.0258	1.2521	.8077	1.0170	.8885	1.2542	.7973	1.0004	.8290
6	1.1759	1.1110	.9235	1.2490	.9691	1.0427	.6855	1.0742	1.1523	.9975	.9522
7	1.5734	1.4602	1.1254	1.6207	1.1532	.8933	.9714	1.4122	1.0506	1.0076	1.1922
8	1.3892	1.0786	2.3265	.9028	1.1135	.9389	1.1457	1.6763	1.0812	0.9971	1.1158
9	1.1501	1.2007	2.0354	1.0926	.7676	.8796	1.1271	1.9095	1.2651	1.0059	1.1585
10	2.6708	1.8262	3.7562	2.2315	1.7045	1.3070	1.3701	4.4039	1.0505	0.9725	1.4407
11+	1.0390	.9335	.1207	.3544	1.1173	.6278	.4310	294.9971	1.3043	1.0131	1.3794