Analysis of commercial landings of haddock caught off southern Nova Scotia by U. S. and Canadian fisheries; 1957-1961. - A Preliminary Report. 1/

R. C. Hennemuth and M. D. Grosslein
U. S. Bureau of Commercial Fisheries, Woods Hole, Massachusetts

1/ Prepared for meeting of U. S. and Canadian biologists in St. Andrews, N. B., December 1962.

WOODS HOLE LABORATORY
REPORT NO. 62-13

4x Haddock

Analysis of commercial landings of haddock caught off southern Nova Scotia by U.S. and Canadian fisheries; 1957-1961.- A Preliminary Report.1/

R. C. Hennemuth and M. D. Grosslein
U.S. Bureau of Commercial Fisheries, Woods Hole, Massachusetts

Introduction

Biologists of the Woods Hole Biological Laboratory, U.S. Bureau of Commercial Fisheries, and the St. Andrews Biological Station, Fisheries Research Board of Canada, initiated in 1956 a cooperative study of the haddock fishery off southern Nova Scotia, ICNAF Division 4x. Although investigations of this fishery had been conducted in previous years by each of the countries, the studies had neither been strongly emphasized, nor closely coordinated. The joint nature of the fishery, the landings of U.S. and Canada being nearly equal during the period under study, and the differential distribution of fishery effort of the two countries in seasons and areas made desirable a coordinated study. Primary emphasis was placed on the collection of statistics of landings and effort, and of samples of length and age frequencies of the landings.

This paper is a preliminary analysis of the data collected in the years 1957-1961. The results presented herein will provide a gross description of the commercially exploited stocks. A more refined analysis is now being made and a report for publication is being prepared.

Landings

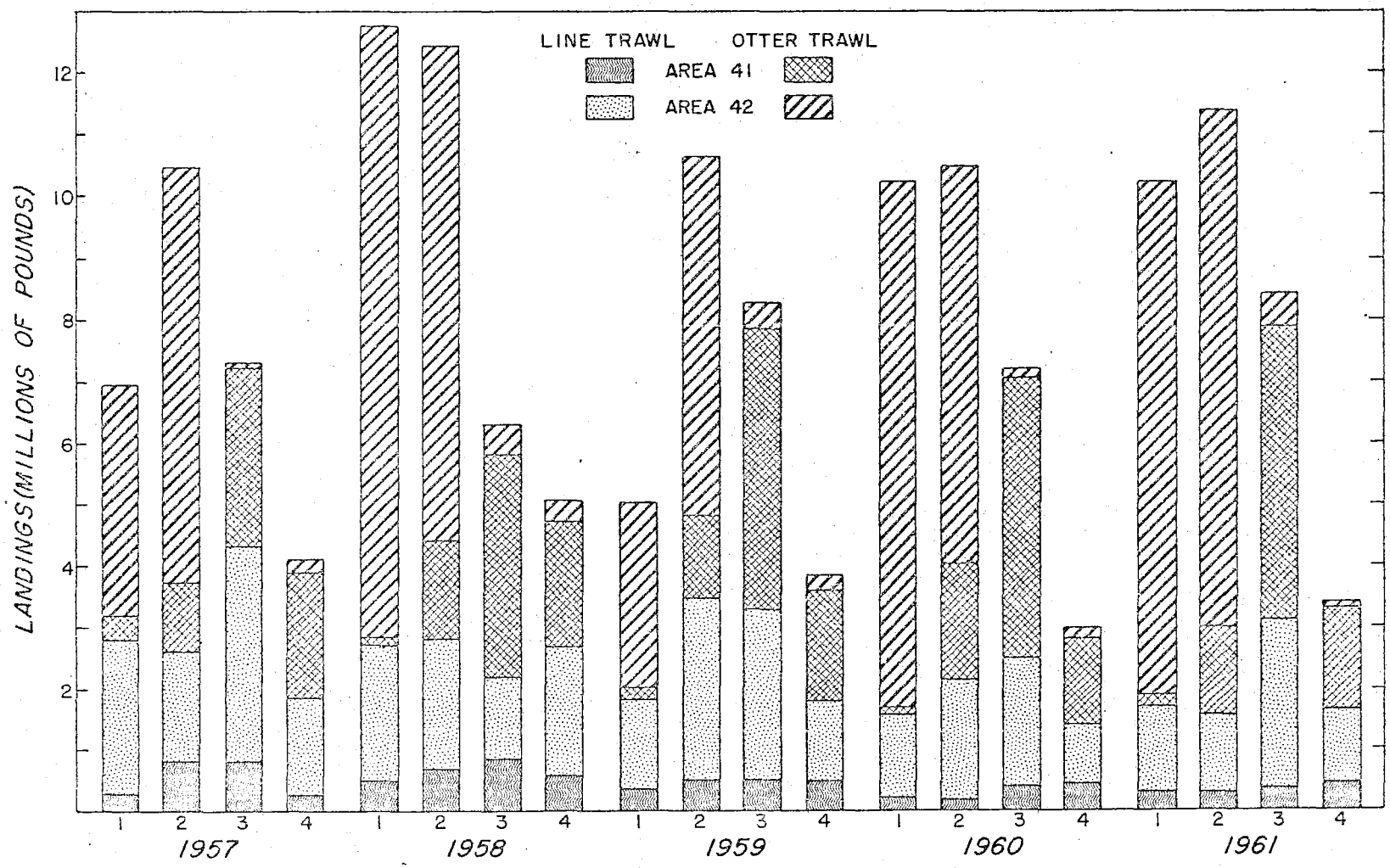
A historical summary of landings from ICNAF Division 4x is published in the statistical bulletins of the I-C-N-A-F. A quarterly summary of landings by type of gear and sampling area * for the years 1957 through 1961 (Table 1 and Figure 1) has been provided for reference to this analysis.

1/ Prepared for meeting of U.S. and Canadian biologists in St. Andrews, N.B., December 1962.

* For purposes of sampling, division 4x was divided into two areas. Sampling area 1 includes subareas Q, R, S, and T. Sampling area 2 includes subareas M, N, O, and P.

Table 1.--Landings in hundreds of pounds of haddock caught in Division 4x by quarter, sampling area, and type of gear, 1957 - 1961. U.S. and Canadian landings are combined.

		LINE TRAWL			OTTER TRAWL			TOTAL
Year	Qtr.	41	42	Total	41	42	Total	
1957	1	3223	25172	28395	3861	37565	41426	69821
	2	8454	18526	26980	11447	97367	108814	135794
	3	8628	35583	44211	29585	771	30356	74567
	4	2585	16288	18873	20427	2308	22735	41608
Totals		22890	95569	118459	65320	138011	203331	321790
1958	1	4958	22207	27165	1436	99439	100875	128040
	2	6858	21241	28099	16000	120140	136140	164239
	3	8338	13540	21878	36033	5453	41486	63364
	4	5907	21216	27123	20302	3662	23964	51087
Totals		26061	78204	104265	73771	228694	302465	406730
1959	1	3636	14843	18479	2014	30878	32892	51371
	2	4957	29865	34822	13225	58241	71466	106288
	3	5246	27782	33028	45933	4124	50057	83085
	4	5963	13373	19336	18174	2517	20691	40027
Totals		19802	85863	105665	79346	95760	175106	280771
1960	1	2021	13496	15517	1324	83641	84965	100482
	2	1419	19688	21107	18964	66650	85614	106721
	3	4224	21102	25326	45834	1671	47505	72831
	4	4174	9874	14048	14263	1765	16028	30076
Totals		11838	64160	75998	80385	153727	234112	310110
1961	1	3025	14294	17319	2083	83385	85468	102787
	2	3298	12394	15692	14738	83853	98591	114283
	3	3371	27510	30881	47372	5358	52730	83611
	4	4477	12248	16725	16931	892	17823	34548
Totals		14171	66446	80617	81124	173488	254612	335229
GRAND TOTAL		94762	390242	485004	379946	789680	1169626	1654630


LINE TRAWL
OTTER TRAWL
AREA 41
AREA 42
LANDINGS (MILLIONS OF POUNDS)
12
10
8
6
4
2
1
2
3
4
1957
1958
1959
1960
1961

Landings by line trawlers, exclusively Canadian, have gradually declined from 11.8 million pounds in 1957 to 8.1 million pounds in 1961. Most of the landings come from sampling area 42 and are greatest in the second or third quarter of the year.

Annual landings by otter trawlers, predominately U.S., have fluctuated between 17.5 and 30.2 million pounds, with no significant trend through the years under study. Landings from sampling area 42 are about twice as great as those from sampling area 41. Landings from sampling area 41 are consistently highest in the third quarter, and are practically nil in the first quarter. Landings from sampling area 42 are highest in the first or second quarter, and relatively very low in the third or fourth quarter.

Needless to say, the seasonal and geographical variations in catches have led to some vagaries in sampling, and complicate the analysis.

Sample Data

All ages are based on otolith readings by Norman McFarlane, St. Andrews, and John McDermott, Woods Hole. Out of 675 comparative readings between these readers there were 137 (20%) disagreements. Of these, McFarlane was higher and lower than McDermott in 9 and 11% of the cases respectively. Most of the discrepancies involved a difference of only one year. It was concluded that the observed differences between the two readers were of small consequence in the analysis.

For purposes of ageing, subsamples were taken from the age samples collected in 1957-1961 according to the following scheme. A maximum of five individual samples (each sample taken from one trip) were randomly selected from each sampling stratum in each quarter; there were 12 possible sampling strata formed by the two sampling areas (41 and 42), two types of gear (line and otter trawl) and three market categories (ungraded, large and scrod). In nearly all cases however, there were less than five trip-samples per stratum so that practically all samples were included. For otter trawl landings in sampling area 42 during spring months, up to 10 trips were selected at random in the scrod and large market categories when that many were available.

Within each selected sample in each stratum a maximum of 50 fish were aged. If more than 50 fish were available a stratified (by length) subsample of 50 was drawn.

Analysis of the 4x age-length composition was confined chiefly to otter trawl landings from sampling area 42 (4x, MNOP) in spring months, because this was the only category with sufficient sampling of major market categories at one season and in all five years. Furthermore these were

the only strata with data on fishing effort readily available to us. Sampling of line trawl landings, and otter trawl landings in other seasons and areas, was sparse or irregular throughout the year and between years.

Seasonal fluctuation of sampling corresponded in general with the seasonal variation in landings for otter trawls (Table 2). Unfortunately, sampling of landings of otter trawls in area 41 was insufficient to permit meaningful quarterly comparisons even between any two years.

Line trawl landings were more stable throughout the year with the major portion coming from area 42. Only a few samples of line trawl landings were taken from landings from area 42 (Table 2). Samples usually were not taken from all market categories in any one month, and again even quarterly comparisons were not feasible because of irregular coverage between years.

Although more of the data might be utilized in future studies by appropriate pooling procedures, it is questionable whether the results would be sufficiently reliable under the present level and distribution of sampling.

Methods of handling data

For the basic computations, data for each type of gear in each month and sampling area were treated independently.

Estimation of numbers of fish landed, mean length and weight, etc., was based on the following procedure. Percentage length and age frequencies were computed by one centimeter intervals for each market category in which sample data was available. The mean weight (in lbs.) per fish was estimated using length-weight data of Clark and Dietsch (ICNAF Annual Report,1959). Total numbers landed were computed by dividing the total weight landed by the mean weight per fish. Numbers landed at each length were then estimated by multiplying the respective percentage length frequencies by the total numbers landed. Numbers landed at each age within length were then estimated by multiplying the corresponding age frequencies by the number landed of each length.

In some instances, particularly at the smaller and larger length classes, there were no otoliths taken from fish of a given centimeter length class. In this analysis, these discrepancies were ignored, and as a consequence, a bias in subsequent estimation of average length and age composition has been introduced in the lowest and highest age groups. Although in most cases this is not serious, some procedure for supplying the missing estimates should be devised for the further analysis.

Table 2. --Length and age samples of haddock caught by otter trawls from subareas MNOP (sampling area 42) of Division 4x, by market category, month and year. Also shown are total quarterly landings (in hundreds of pounds) and landings by market category

			1957			1958			1959			1960			1961		
			Samples			Samples			Samples			Samples			Samples		
Qtr.	Mo.	Mkt. Cat.	No. lengths	No. ages	Landings	No. lengths	No. ages	Landings	No. lengths	No. ages	Landings	No. lengths	No. ages	Landings	No. lengths	No. ages	Landings
	01	0	--	--	0	--	--	0	--	--	0	--	--	0	--	--	0
		1	--	--	1593	--	--	3027	--	--	1270	--	--	300	--	--	686
		2	--	--	1481	56	15	3602	--	--	870	--	--	325	--	9	746
	02	0	--	--	0	--	--	0	--	--	256	--	--	0	--	--	0
1		1	191	--	7123	186	40	8908	211	39	2625	100	20	8115	509	80	14095
		2	102	15	5233	203	60	8695	117	27	2316	51	15	7703	215	45	16435
	03	0	--	--	0	--	--	1019	--	--	28	--	--	240	--	--	220
		1	510	60	12439	1479	153	39514	294	59	13446	671	157	33748	976	179	23323
		2	470	30	9696	468	73	34674	162	45	10067	680	150	33210	564	150	27877
					37565			99439			30878			83641			83385
	04	0	209	10	90	--	--	369	--	--	0	--	--	0	--	--	143
		1	1215	136	45016	867	--	54190	716	139	22465	668	59	22037	904	160	25009
		2	696	109	38525	457	--	48912	330	74	19937	346	30	23475	334	90	38798
	05	0	--	--	0	--	--	81	--	--	19	--	--	33	--	--	81
2		1	110	20	6552	--	--	5369	102	20	4491	314	58	8654	220	40	5934
		2	--	--	4175	--	--	5201	111	30	4211	56	15	7320	--	--	8010
	06	0	--	--	0	94	--	0	--	--	39	--	--	26	--	--	78
		1	--	--	1554	106	--	2801	513	120	3836	203	20	2889	--	--	2779
		2	--	--	1455	98	--	3217	215	85	3243	57	15	2416	--	--	3021
					97367			120140			58241			66650			83853

Table 2.--Length and age samples of haddock caught by otter trawls from subareas MNOP (sampling area 42) of Division 4x, by market category, month and year. Also shown are total quarterly landings (in hundreds of pounds) and landings by market category. (cont'd)

Qtr.	Mo		1957			1958			1959			1960			1961		
			Samples			Samples			Samples			Samples			Samples		
Qtr.	Mo.	Mkt. Cat.	No. lengths	No. ages	Landings	No. lengths	No. ages	Landings	No. lengths	No. ages	Landings	No. lengths	No. ages	Landings	No. lengths	No. ages	Landings
	07	0	--	--	0	--	--	0	--	--	27	--	--	59	--	--	82
		1	--	--	63	--	--	1344	96	20	1087	--	--	425	101	--	1202
		2	--	--	79	--	--	3128	63	15	1701	--	--	674	--	--	1944
	08	0	--	--	0	--	--	0	--	--	86	--	--	15	--	--	56
3		1	--	--	3	--	--	186	--	--	364	--	--	201	118	--	435
		2	--	--	2	--	--	351	--	--	652	--	--	286	52	--	855
	09	0	--	--	0	--	--	15	--	--	12	--	--	0	--	--	0
		1	--	--	204	--	--	213	--	--	102	--	--	8	--	--	213
		2	--	--	420	--	--	216	--	--	93	--	--	3	--	--	571
					771			5453			4124			1671			5358
	10	0	--	--	0	--	--	0	--	--	0	--	--	47	--	--	0
		1	--	--	387	--	--	46	--	--	112	--	--	241	--	--	76
		2	--	--	404	--	--	62	--	--	133	--	--	357	--	--	207
	11	0	--	--	0	--	--	47	--	--	0	--	--	0	--	--	0
4		1	--	--	560	--	--	597	--	--	719	--	--	475	--	--	2
		2	--	--	515	55	--	397	--	--	764	--	--	418	--	--	48
	12	0	--	--	0	--	--	0	--	--	0	--	--	0	--	--	126
		1	--	--	302	--	--	1150	110	--	434	--	--	135	--	--	259
		2	--	--	140	66	15	1363	--	--	355	--	--	92	--	--	174
					2308			3662			2517			1765			892

Table 2. --(cont'd) Otter trawl, subareas QRS (sampling area 41) (in hundreds of pounds)

			1957			1958			1959			1960			1961		
			Samples			Samples			Samples			Samples			Samples		
Qtr.	Mo.	Mkt. Cat.	No. lengths	No. ages	Land-ings	No. lengths	No. ages	Land-ings	No. lengths	No. ages	Land-ings	No. lengths	No. ages	Land-ings	No. lengths	No. ages	Land-ings
	01	0	--	--	257	--	--	558	--	--	415	--	--	66	--	--	119
		1	--	--	703	--	--	268	--	--	348	--	---	20	--	--	32
		2	--	--	529	--	--	66	--	--	59	--	--	0	--	--	22
	02	0	--	--	141	202	--	37	--	--	21	--	--	20	--	--	130
1		1	--	--	306	--	--	0	--	--	96	--	--	0	--	--	532
		2	--	--	190	--	25	0	--	--	45	--	--	0	--	--	298
	03	0	--	--	145	--	--	507	--	--	545	--	--	827	--	--	354
		1	--	--	921	--	--	0	--	--	306	45	20	321	--	--	393
		2	--	--	669	--	--	0	--	--	179	--	--	70	--	--	203
					3861			1436			2014			1324			2083
	04	0	--	--	170	--	--	170	--	--	595	--	--	1998	--	--	1056
		1	--	--	141	--	--	606	--	--	1172	--	--	567	--	--	313
		2	--	--	113	--	--	128	--	--	555	--	--	195	--	--	188
	05	0	--	--	96	--	--	3710	--	--	307	--	--	5726	--	--	4461
2		1	--	--	1777	40	8	668	--	--	3298	--	--	1111	--	--	339
		2	--	--	587	230	25	403	--	--	1357	--	--	565	--	--	497
	06	0	--	--	7832	--	--	5261	1600	94	1135	1800	267	6246	--	[illegible]	477
		1	63	--	322	57	10	3781	110	--	3105	--	--	1708	--	[illegible]	4886
		2	50	14	409	362	25	1273	350	--	1701	--	--	848	--	[illegible]	2521
					11447			16000			13225			18964			14738

Table 2. -- Otter trawl, subareas QRS (sampling area 41) (in hundreds of pounds). (cont'd).

			1957			1958			1959			1960			1961		
			Samples			Samples			Samples			Samples			Samples		
Qtr.	Mo.	Mkt. Cat.	No. lengths	No. ages	Land-ings	No. lengths	No. ages	Land-ings	No. lengths	No. ages	Land-ings	No. lengths	No. ages	Land-ings	No. lengths	No. ages	Land-ings
	07	0	--	--	1295	2372	195	5760	--	--	7561	--	--	8425	2500	268	6685
		1	--	--	3851	415	46	2772	296	--	4161	111	--	1563	100	20	1906
		2	--	--	2042	340	25	217	--	--	1273	114	15	573	50	15	1016
	08	0	--	--	0	--	--	7223	297	61	8090	--	--	12093	209	40	13377
3		1	--	--	6345	--	--	3953	--	--	4439	75	20	2631	--	--	3548
		2	--	--	2288	--	--	921	82	--	1987	50	15	1013	--	--	2376
	09	0	--	--	236	2400	205	8969	1000	162	7663	200	40	8401	108	40	10036
		1	482	--	10011	70	---	4182	320	--	6385	--	--	6583	422	59	4679
		2	385	33	3537	130	--	1536	161	--	3874	267	--	4552	160	45	3749
					29585			35533			45933			45834			47372
	10	0	--	--	0	--	--	5083	1100	210	4455	--	--	3279	--	--	7085
		1	--	--	8177	482	10	4558	--	--	4054	--	--	1397	100	20	701
		2	--	--	1856	162	18	3765	267	--	2004	--	--	770	150	25	932
	11	0	419	--	189	--	--	1819	173	35	3317	--	--	3483	150	48	5491
4		1	100	--	4899	100	20	1892	109	--	1695	194	--	2715	--	--	561
		2	50	35	2248	59	14	1403	113	--	1218	--	--	1120	--	--	145
	12	0	--	--	13	--	--	605	--	--	350	3000	472	1075	--	--	1822
		1	--	--	1988	--	--	704	200	--	550	--	--	304	--	--	164
		2	--	--	1057	--	--	473	100	--	531	--	--	120	--	--	30
					20427			20302			18174			14263			18931

Table 2.--(cont'd) Line trawl, subareas MNOP (sampling area 42) (in hundreds of pounds)

			1957			1958			1959			1960			1961		
			Samples			Samples			Samples			Samples			Samples		
Qtr.	Mo.	Mkt. Cat.	No. lengths	No. ages	Land-ings	No. lengths	No. ages	Land-ings	No. lengths	No. ages	Land-ings	No. lengths	No. ages	Land-ings	No. lengths	No. ages	Land-ings
	01	0	--	--	1538	--	--	780	--	--	2732	400	42	4827	--	--	1489
		1	--	--	3590	1200	--	3014	--	--	2597	--	--	0	625	105	1902
		2	--	--	374	70	14	164	--	--	96	--	--	0	125	15	161
	02	0	--	--	2392	--	--	1410	--	--	1997	--	--	1829	--	--	2050
1		1	185	35	6660	--	--	4990	799	--	1790	--	--	3574	--	--	4159
		2	15	4	562	--	--	313	165	--	88	--	--	187	--	--	256
	03	0	--	--	2333	--	--	3014	--	--	1359	--	--	356	--	--	2285
		1	738	151	7155	370	52	7724	--	--	4018	--	--	2588	--	--	1862
		2	60	10	568	30	--	798	--	--	166	--	--	135	--	--	130
	Total quarter landings				25172			22207			14843			13496			14294
	04	0	--	--	2098	--	--	1018	--	--	1580	--	--	362	--	--	4801
		1	--	--	6167	--	--	5936	300	50	8331	200	37	5828	--	--	1639
		2	--	--	632	--	--	350	32	5	365	30	10	180	--	--	87
	05	0	--	--	1609	--	--	2411	--	--	3167	--	--	4558	--	--	837
2		1	--	--	1172	270	50	1213	--	--	1865	570	116	3605	--	--	1167
		2	--	--	107	50	10	103	--	--	83	30	6	130	--	--	117
	06	0	--	--	5164	--	--	9361	--	--	13907	--	--	4709	200	[illegible]	3607
		1	--	--	1511	920	99	761	--	--	540	300	50	310	--	--	131
		2	--	--	66	75	15	88	--	--	27	100	20	6	--	--	8
	Total quarter landings				18526			21241			29865			19688			12394

Table 2. --(cont'd) Line trawl, subareas MNOP (sampling area 42) (in hundreds of pounds) (cont'd)

			1957			1958			1959			1960			1961		
			Samples			Samples			Samples			Samples			Samples		
Qtr.	Mo.	Mkt. Cat.	No. lengths	No. ages	Land-ings	No. lengths	No. ages	Land-ings	No. lengths	No. ages	Land-ings	No. lengths	No. ages	Land-ings	No. lengths	No. ages	Land-ings
	07	0	--	30	10934	--	--	4135	--	--	8367	--	--	6386	--	--	11875
		1	1000	20	353	185	37	515	--	--	481	--	--	58	--	--	33
		2	15	3	55	15	3	79	--	--	18	--	--	15	--	--	6
	08	0	--	--	11002	--	--	3018	--	--	9519	--	--	4060	--	--	9253
3		1	--	--	893	--	--	596	344	70	74	--	--	70	--	--	148
		2	--	--	116	--	--	104	81	16	3	--	--	6	--	--	17
	09	0	--	--	11782	--	--	4292	719	114	9000	--	--	10352	--	--	6077
		1	--	--	395	--	--	701	--	--	305	--	--	151	--	--	95
		2	--	--	53	--	--	100	--	--	15	--	--	6	--	--	6
					35583			13540			27782			21102			27510
	10	0	--	--	4534	--	--	5974	--	--	3239	--	--	2817	300	51	4129
		1	300	50	1420	--	--	2994	--	--	862	--	--	703	--	--	1016
		2	--	--	121	--	--	185	--	--	30	--	--	38	--	--	11
	11	0	365	36	2040	500	49	3807	--	--	3324	--	--	1844	--	--	3916
4		1	400	51	3396	--	--	3740	--	--	1513	--	--	1948	200	40	715
		2	100	20	205	--	--	313	--	--	92	--	--	161	--	--	22
	12	0	--	--	1069	--	--	889	300	--	2704	--	--	974	--	--	1040
		1	555	111	3289	600	46	3070	450	45	1712	--	--	1286	--	--	1363
		2	45	9	214	100	20	244	60	12	97	--	--	103	--	--	36
					16288			21216			13373			9874			12243

1/ Only 2 samples are recorded for line trawl, QRS.

All subsequent summations and calculations of mean length at age, or numbers landed by age group were based on the numbers of fish landed as estimated above. Thus all estimates apply only to the landings, and not necessarily to the underlying populations.

Comparison of length and age composition of different market categories.

The landings are classified by four market categories: large, scrod, medium, and ungraded. All U.S. landings are in the first two classifications, as are much of the Canadian landings. It has been assumed that the length distributions within each of these (large and scrod) are similiar for both country's landings; of course the samples from each of these categories have been weighed by the estimated numbers of fish landed in each before combining. There is a relatively small amount of fish landed in the medium category, and a visual inspection of length frequencies indicated that samples from this category could be combined with those from the large category without weighting.

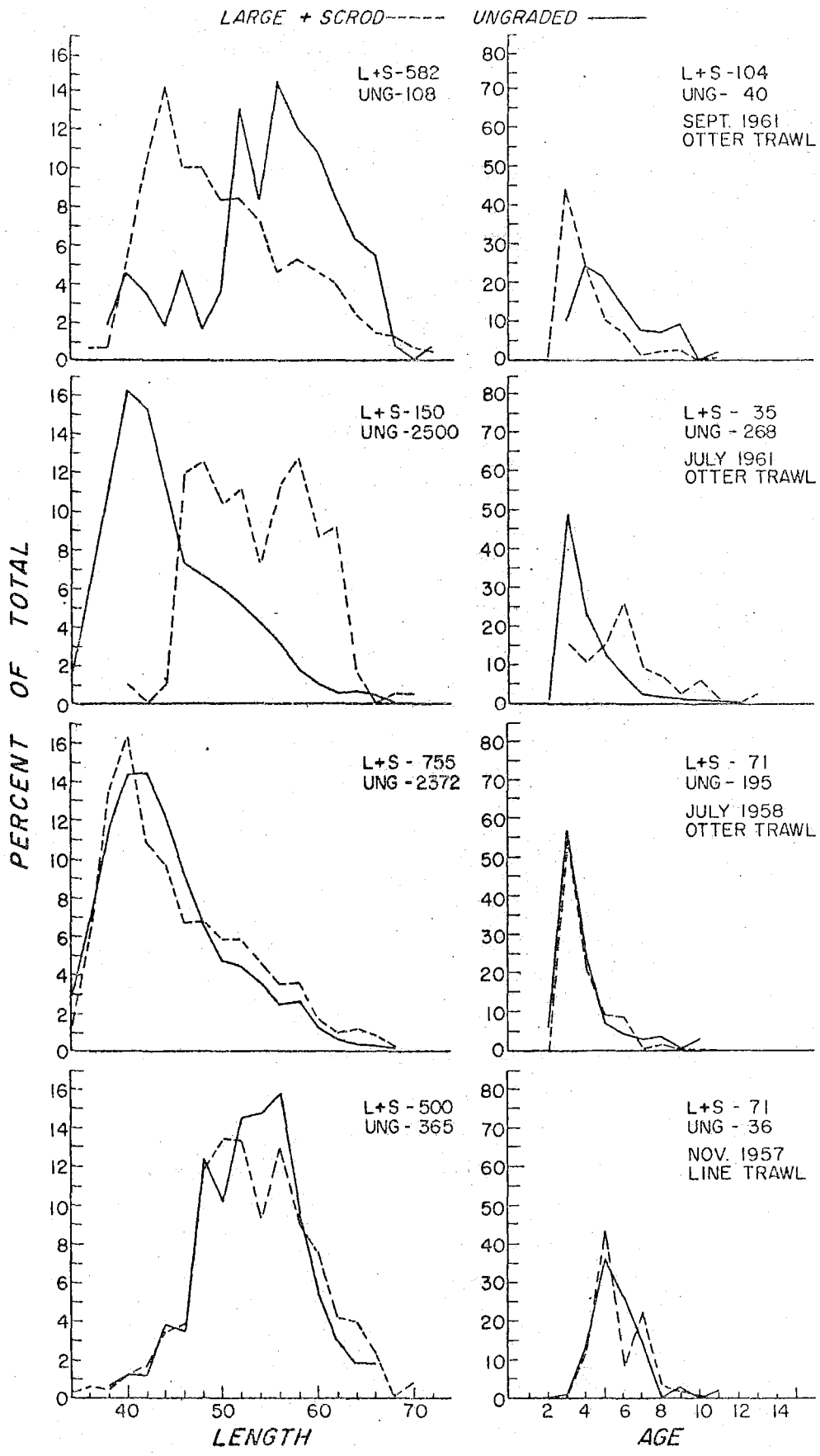
Much of the Canadian landings fall into the ungraded category; in some cases the whole of a months landings. It might be expected that the length composition of ungraded landings would be similiar to that of large and scrod combined. Four such comparisons are presented in Figure 2. Each panel is identified by the year, month and gear involved, and the numbers of fish measured or aged in each category are also indicated. Length and age compositions in two of the comparisons indicate a rather high degree of similarity between the two classifications. The other two comparisons indicate a high degree of disparity, in one the large-plus scrod has the larger fish, while in the other the ungraded category is comprised of larger fish. In both cases it would seem that small numbers in the sample (150 and 108) might be the cause of the differences observed. Data are available for further comparison, and this will be done to form a more firm conclusion. At any rate, subsequent analyses are based only on those months and areas where landings of all market categories were sampled.

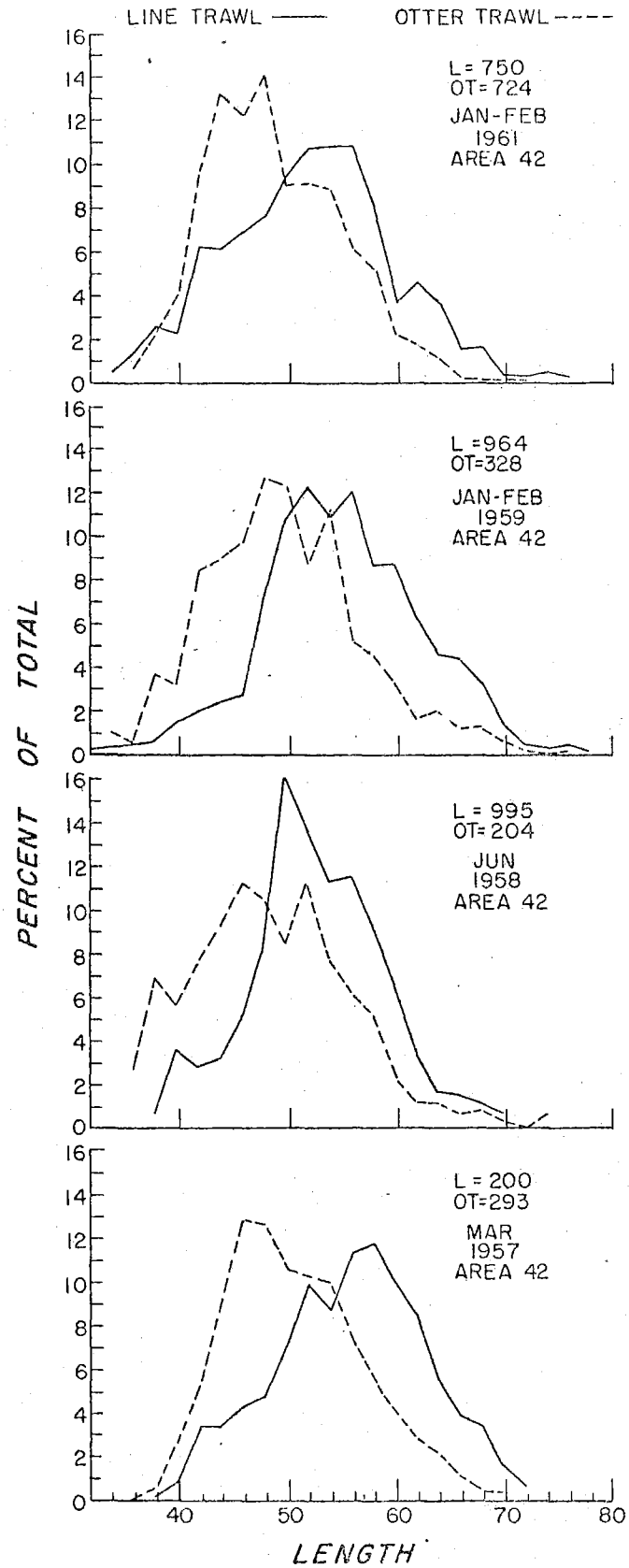
Comparison of length composition of landings by line trawl and otter trawl

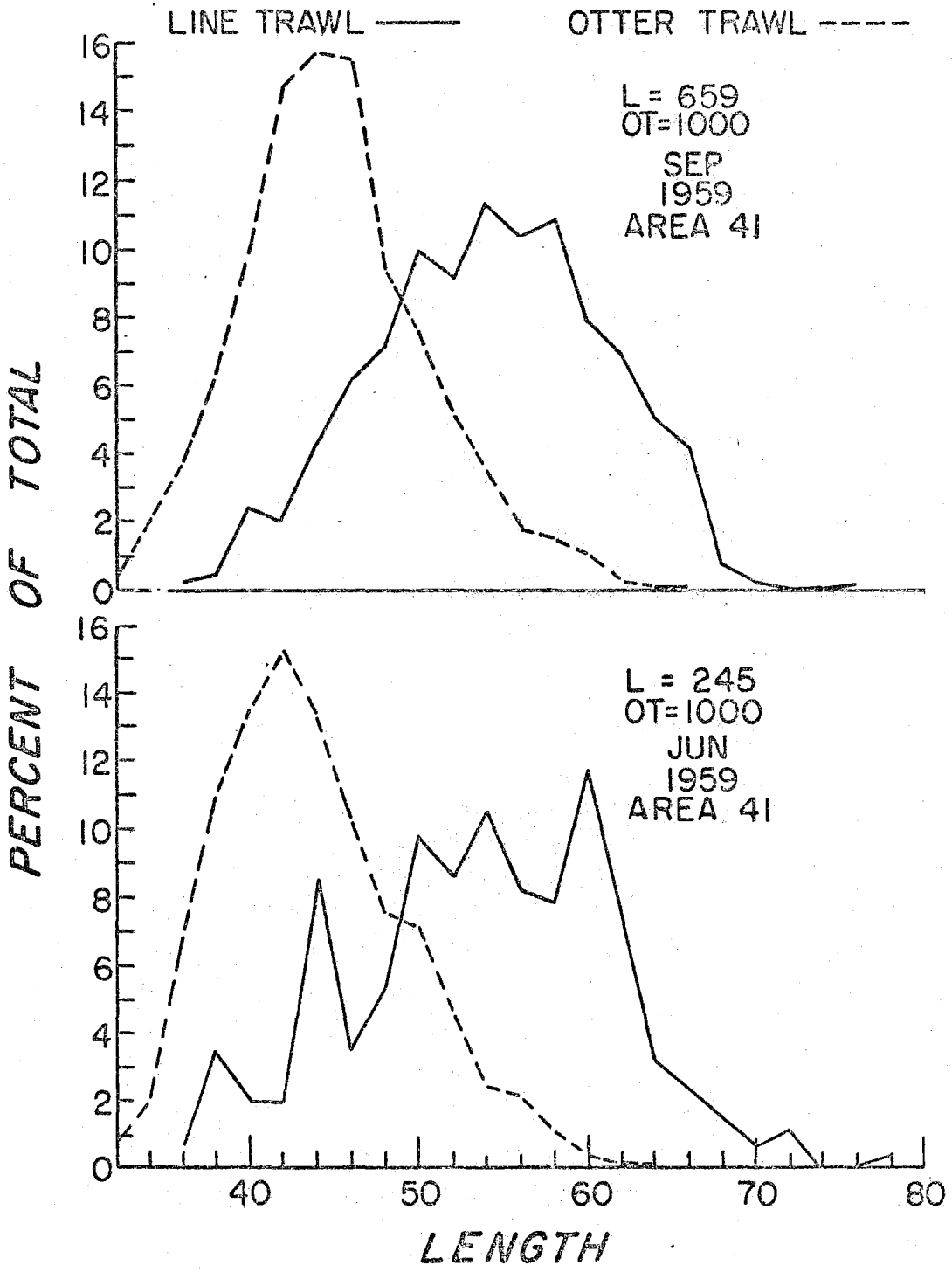
While line trawling has been diminishing in recent years, these landings are still an important segment of the fishery, particularly in some months and areas.

Several comparisons of the length compositions of landings of the two types of gear are illustrated in Figures 3 and 4.

It is a well known fact that in commercial operation line trawls land, and presumably catch, proportionately more larger fish than otter trawls. This is apparent in the comparisons. A precise study of the dynamics of 4x haddock should therefore, take the line trawl landings into account.


LARGE + SCROD------ UNGRADED ———
L+S-582
UNG-108
L+S-104
UNG- 40
SEPT. 1961
OTTER TRAWL
L+S-150
UNG-2500
L+S - 35
UNG - 268
JULY 1961
OTTER TRAWL
L+S - 755
UNG - 2372
L+S - 71
UNG - 195
JULY 1958
OTTER TRAWL
L+S - 500
UNG - 365
L+S - 71
UNG - 36
NOV. 1957
LINE TRAWL
PERCENT OF TOTAL
LENGTH
AGE


LINE TRAWL
OTTER TRAWL
L= 750
OT= 724
JAN-FEB
1961
AREA 42
L =964
OT=328
JAN-FEB
1959
AREA 42
L = 995
OT= 204
JUN
1958
AREA 42
L = 200
OT=293
MAR
1957
AREA 42
PERCENT OF TOTAL
LENGTH
0
2
4
6
8
10
12
14
16
40
50
60
70
80


LINE TRAWL
OTTER TRAWL
L= 659
OT=1000
SEP
1959
AREA 41
L = 245
OT=1000
JUN
1959
AREA 41
PERCENT OF TOTAL
LENGTH
0
2
4
6
8
10
12
14
16
40
50
60
70
80

Within the period under study, line trawlers have continued to land larger fish than otter trawlers, but the comparison for 1961 indicates that the difference may be tending to be of lesser magnitude. There has been some decrease in average length of landed fish for both types of gear.

Mean length at age

Average length at age in landings of otter trawlers from sampling area 42 is presented in Table 3 and Figure 5.

There seems to have been a uniform growth rate through the years. The average lengths compare faborably with those calculated from scales by Wise, 1957 (U.S. Bureau of Commercial Fisheries, Research Report 50). The back calculated length are smaller than those of the commercial landings at younger ages, probably because of the selective nature of the fishery, i.e., only the fastest growing fish of age groups 3, 4 and 5, are available or retained by the fishery.

Relative abundance of age groups and year classes

For reasons given in the previous section on sampling, estimates of year class and age groups abundance were restricted to otter trawler landings from area 42 (principally Browns Bank), in the first half of the year.

The estimated number landed at each age are presented in Table 4. These data provide a comparison of relative abundance of age groups within a month, but not among months or years.

An index of abundance was derived from certain large (150-600 gross tons) U.S. otter trawlers. The large U.S. otter trawlers account for a large share of the landings at the time and in the area concerned. Landings and effort (days fished, derived from vessel interviews) of the study boats for the first two quarters of the year were used to compute a relative index of abundance (landings per days fished) for each year. A relative index of effort was estimated by dividing the total otter trawl landings by the estimated landings-per-days-fished (Table 5).

Estimated numbers landed per-unit-effort (Table 6) at each age were then obtained by dividing the numbers landed by the effort index. Note that estimates for the months February, March and April were obtained for each year, but estimates for May and June were obtainable only for years 1959 and 1960.

Table 3.--Average length at age in landings of otter trawlers in sampling area 42.

Year	Mo.	AGE 3	4	5	6	7	8	9	10	11	12	13+
1957	03	41.7	46.4	48.8	49.7	56.8	55.9	60.2	63.1	51.0	58.0	61.0
	04	41.4	45.1	48.2	52.1	54.8	56.1	60.3	58.3	60.9	68.9	62.2
Average		41.6	45.8	48.5	51.0	55.8	56.0	60.3	60.7	56.0	63.5	61.6
1958	02	- -	45.4	47.3	50.7	53.0	60.1	57.0	- -	61.0	57.0	- -
	03	42.0	45.2	48.7	51.2	53.9	55.8	58.7	62.4	66.0	- -	64.0
Average		42.0	45.3	48.0	51.0	53.5	58.0	57.9	62.4	63.5	57.0	64.0
1959	02		45.2	50.8	48.5	54.0	54.0	56.4	- -	- -	- -	66.0
	03	43.0	45.5	48.7	51.2	53.3	55.6	59.2	58.0	62.7	54.0	65.0
	04		40.0	47.9	51.7	56.5	56.6	58.3	59.4	57.8	61.1	62.7
Average		43.0	43.6	49.1	50.5	54.9	55.4	58.0	58.7	60.3	57.6	64.6
1960	03	- -	45.7	46.9	49.7	53.0	56.1	58.8	60.0	58.2	- -	- -
	04	- -	45.2	47.5	48.9	53.1	57.6	57.6	60.8	60.2	58.0	67.0
Average		- -	45.4	47.2	48.3	53.0	56.8	58.2	60.4	59.2	58.0	67.0
1961	02	- -	46.3	48.7	48.5	52.1	54.9	56.5	55.7	62.0	- -	- -
	03	42.0	45.8	47.2	50.1	52.1	54.1	58.3	59.5	56.9	59.7	60.5
	04	41.1	45.7	47.1	47.7	51.7	53.4	55.3	53.5	61.0	59.6	58.7
Average		41.6	45.9	47.7	48.8	52.0	54.1	56.7	56.2	60.0	60.0	59.6
Grand Average		42.0	45.2	48.1	49.9	53.8	56.1	58.2	59.7	59.8	59.2	63.4

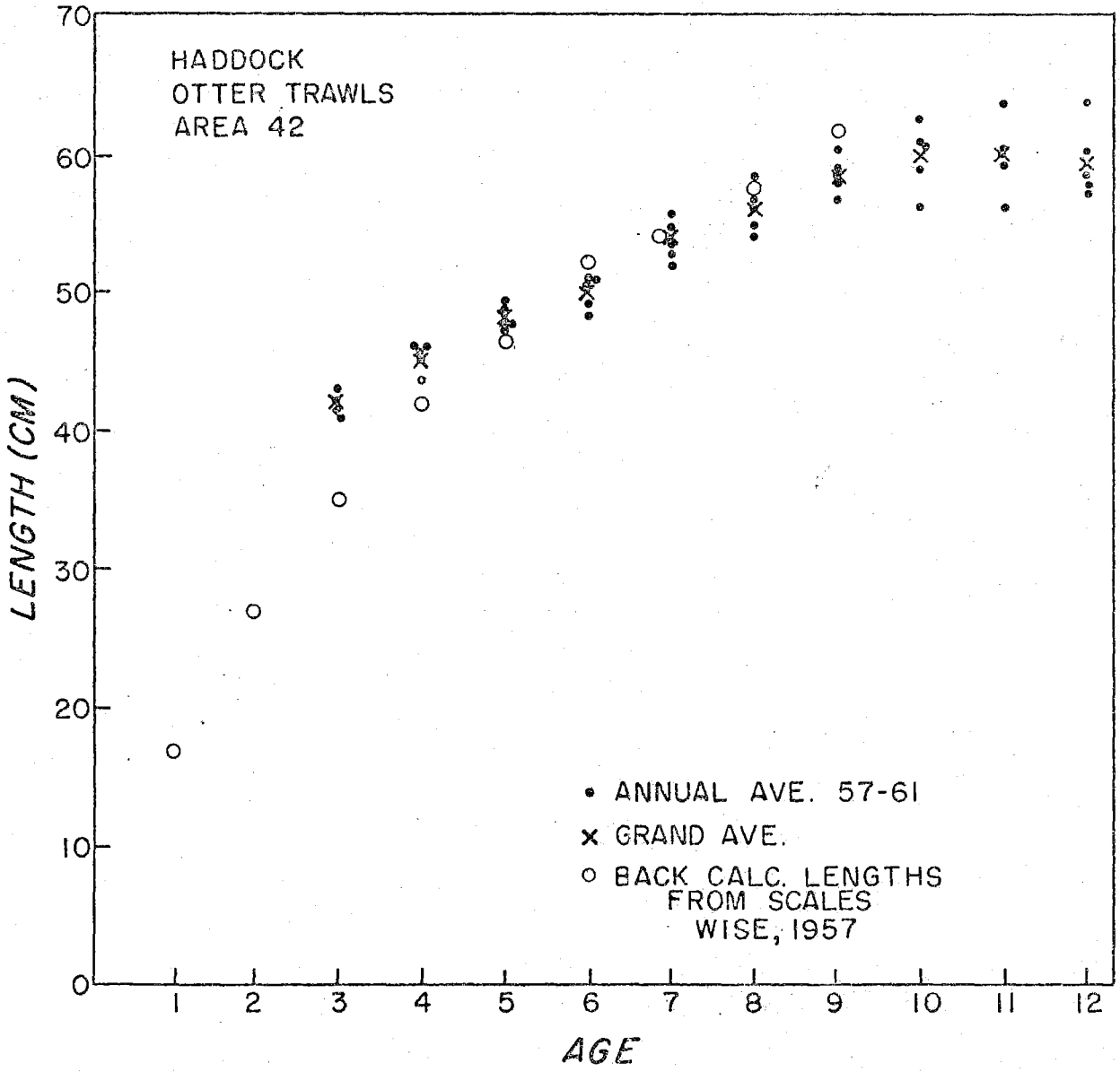

HADDOCK
OTTER TRAWLS
AREA 42
LENGTH (CM)
AGE
0
10
20
30
40
50
60
70
1
2
3
4
5
6
7
8
9
10
11
12
• ANNUAL AVE. 57-61
× GRAND AVE.
○ BACK CALC. LENGTHS FROM SCALES WISE, 1957

Table 4.--Estimated numbers (in hundreds) of haddock landed by otter trawlers from area 42.

Year	Mo.	Numbers at each age											Totals	
		3	4	5	6	7	8	9	10	11	12	13+	Age	Length
1957	03	176	1,058	2,649	560	698	948	397	78	64	85	23	6,737	7,614
	04	328	2,597	12,972	1,888	4,306	3,138	1,655	1,538	401	34	233	29,088	30,175
	T	504	3,655	15,621	2,448	5,004	4,086	2,052	1,616	465	119	256	35,825	37,789
1958	02		890	938	2,892	301	316	149	0	103	58	0	5,646	6,213
	03	96	2,130	3,513	9,727	2,625	1,574	819	711	19	0	67	21,283	24,289
	T	96	3,020	4,451	12,619	2,926	1,890	968	711	122	58	67	26,929	30,502
1959	02		134	529	265	302	22	62	0	0	0	13	1,327	1,764
	03	149	588	2,289	1,309	1,793	510	453	323	62	82	12	7,522	8,059
	04	114	1,011	3,442	4,252	3,417	625	847	692	402	111	285	15,198	15,587
	T	263	1,733	6,210	5,826	5,512	1,157	1,362	1,015	464	193	310	24,047	25,410
	05		298	1,043	384	422	216	166	197	96	0	0	2,821	3,456
	06	251	462	670	268	530	160	207	144	42	17	17	2,767	2,765
	T	251	760	1,713	652	952	376	373	341	138	17	17	5,588	6,221
1960	03		1,397	4,553	7,292	3,617	3,658	686	842	396	- -	65	22,506	22,927
	04		1,851	3,681	2,992	1,429	2,485	574	813	501	74	35	14,435	17,153
	T		3,248	8,234	10,284	5,046	6,143	1,260	1,655	897	74	100	36,941	40,080
	05		431	498	1,940	603	503	318	373	81	44	171	4,963	5,627
	06			267	295	184	447	11	88	137	0	0	1,429	1,756
	T		431	765	2,235	787	950	329	461	218	44	171	6,392	7,383
1961	02		951	2,782	3,063	1,490	762	959	252	76	0	0	10,334	11,659
	03	94	1,667	5,234	4,265	4,303	1,405	954	113	286	107	91	18,521	18,667
	04	929	2,858	8,121	6,044	4,672	953	2,087	361	138	130	109	26,401	27,084
	T	1,023	5,476	16,137	13,372	10,465	3,120	4,000	726	500	237	200	55,256	57,410

Table 5.--Estimated effort index for otter-trawls, area 42.

Year	Mo.	Total Otter-trawl landings (hundreds of pounds)	Study Boats D. F.	Land/D.F.		Est. Total D. F.
1957	03	22,135	89.1	176		125.8
	04	53,631	89.1	176		304.7
					Total	430.5
1958	02	17,603	129.7	212		83.0
	03	75,177	129.7	212		354.6
					Total	437.6
1959	02	5,197	74.7	121		43.0
	03	23,543	74.7	121		194.6
	04	42,402	74.7	121		350.4
					Total	588.0
	05	8,721	74.7	121		72.1
	06	7,118	74.7	121		58.8
					Total	130.9
1960	03	67,198	99.1	164		409.7
	04	45,512	99.1	164		277.5
					Total	687.2
	05	16,007	99.1	164		97.6
	06	5,131	99.1	164		31.3
					Total	128.9
1961	02	30,530	22.5	161		189.6
	03	50,925	22.5	161		316.3
	04	63,950	22.5	161		397.2
					Total	903.1

Table 6.--Estimated numbers (x 10^{-1}) landed per unit effort by otter trawls fishing in area 42.

Year	Months	Age 3	4	5	6	7	8	9	10	11	12	13+	Total	Effort
1957	03-04	12	85	362	57	116	95	48	38	11	3	6	831	430
1958	02-03	2	69	102	288	67	43	22	16	3	1	2	615	438
1959	02-04	4	30	106	99	94	20	23	17	8	3	5	409	588
	05-06	19	58	131	50	73	29	28	26	10	1	1	424	131
1960	03-04	- -	47	120	150	73	89	18	24	13	1	1	538	687
	05-06	- -	33	59	173	62	74	26	36	17	3	13	496	129
1961	02-04	11	61	179	148	116	35	44	8	6	3	2	613	903
T	02-04	29	292	869	742	466	282	155	103	41	11			
Ave.	02-04	7.2	58.4	173.8	148.4	93.2	56.4	31.0	20.6	8.2	2.2			

The age compositions thus derived are portrayed in Figure 6. One must realize there may be a large degree of error associated with these estimates. However, they are consistent enough among months and years to lend credence to them.

A few relatively large year classes are apparent, particularly the 1952 year class which enters the fishery in 1957 at age 5. This year class was notably large also in Subarea 5. The 1956 year class (age 5 in 1961) promises to be relatively large also.

The estimated average percentage age composition is presented below. Age groups 4 through 8 account for 89 percent of the landings.

Average percentage age distribution

Age	3	4	5	6	7	8	9	10	11	12
%	1.2	9.8	29.0	24.8	15.6	9.4	5.2	3.4	1.4	0.4

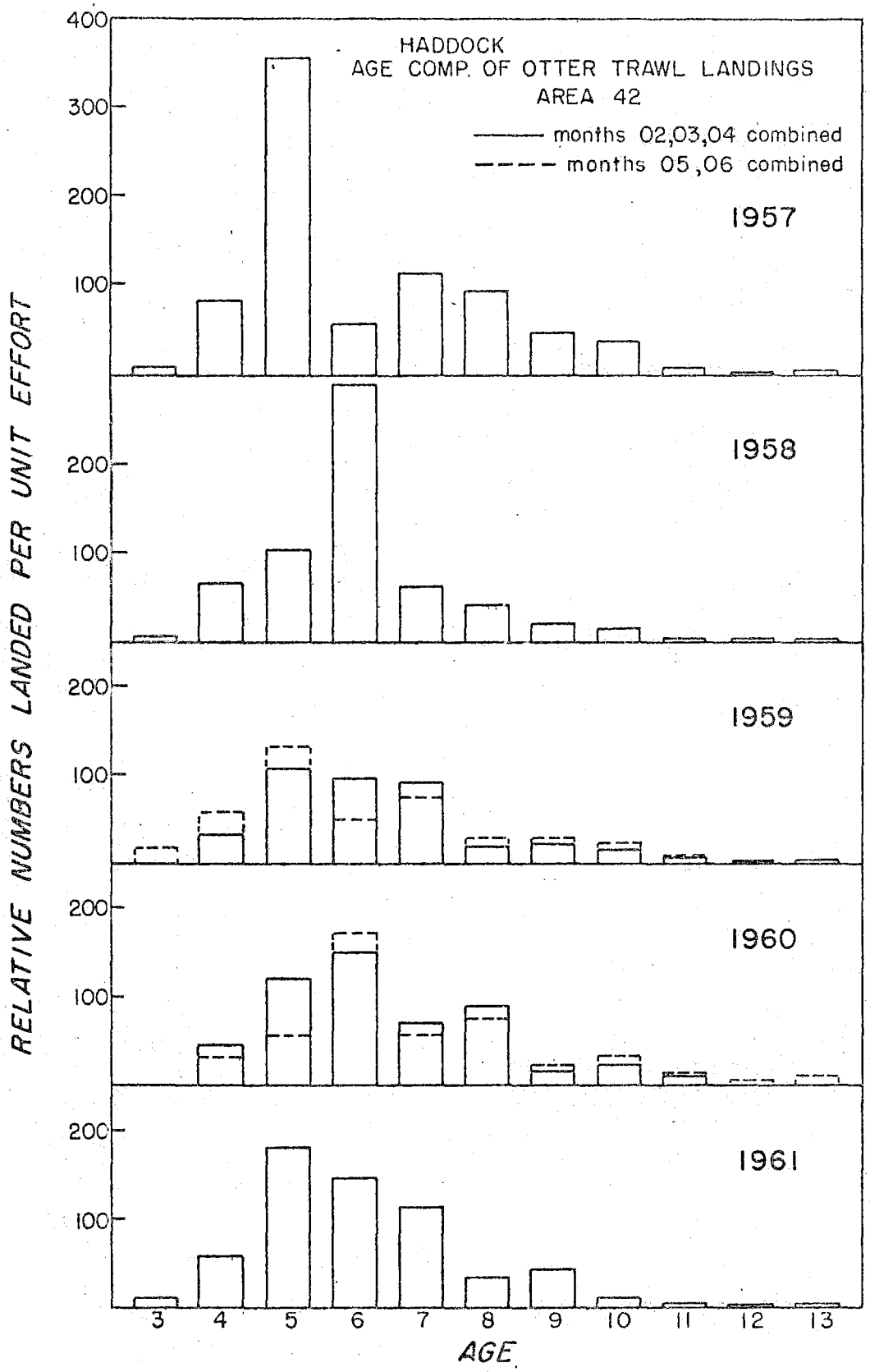
Total mortality

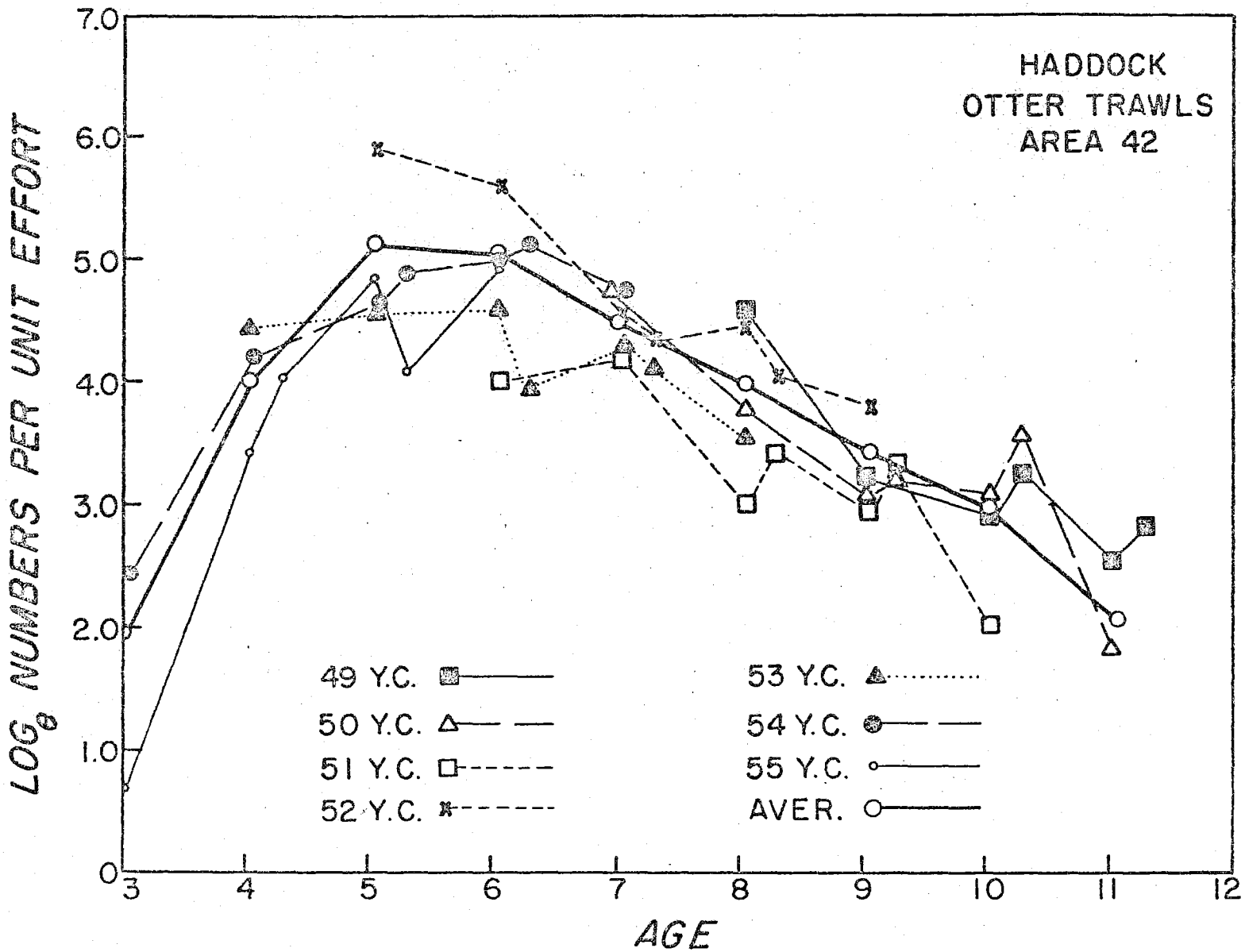
Catch curves for various year classes are plotted in Figure 7, and illustrate a remarkable degree of homogeneity. The fish appear to become fully recruited to the fishery between ages 5 and 6 (since these are landings data, the factor of discard, which is probably small, is included in the term recruitment).

Because of the observed homogeneity, an average catch curve was computed for purposes of estimating mortality. The slope of this average curve, from age 6 onwards, provides an estimate of total instantaneous annual mortality, $Z = 0.55$, corresponding to an annual rate of 58 percent. This is only slightly less than the average value of $Z = 0.7$ for Georges Bank over the last 30 years.

Future Sampling

Major decisions on future sampling in Division 4X must await review of this report. However the two major problems ought to be noted here. First, sampling of 4X landings (chiefly Canadian) must be increased if adequate coverage of Division 4X in its entirety is to be accomplished. If adequate coverage of all categories is not feasible it would be better to concentrate effort in one or two quarters and categories, and obtain sufficient samples in them. Second, if sampling is to be increased then there should be an increased staff available for maintaining a current analysis of the 4X data. With ADP methods this is essentially a problem of having sufficient age readers.


HADDOCK
AGE COMP. OF OTTER TRAWL LANDINGS
AREA 42
months 02,03,04 combined
months 05,06 combined
1957
1958
1959
1960
1961
RELATIVE NUMBERS LANDED PER UNIT EFFORT
AGE
400
300
200
100
3
4
5
6
7
8
9
10
11
12
13


HADDOCK
OTTER TRAWLS
AREA 42
LOG$_e$ NUMBERS PER UNIT EFFORT
AGE
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
3
4
5
6
7
8
9
10
11
12
49 Y.C.
50 Y.C.
51 Y.C.
52 Y.C.
53 Y.C.
54 Y.C.
55 Y.C.
AVER.

Another problem to be considered is the choice of scales vs. otoliths in assessing ages. Scales may be sampled more rapidly than otoliths in the ports but there may be some loss in accuracy of estimates of growth and survival through the use of scales instead of otoliths. Later annuli of older haddock appear to be less distinct on scales than on otoliths and therefore it would be expected that scales would yield a lower average age. This in fact does occur beyond about age 7 and consequently it is not unreasonable to suppose that age data based on scales might overestimate growth and mortality. However it seems unlikely that there would be a significant difference between estimates of growth and mortality based on the two methods.

Kohler and Clark (J. Fish. Res. Bd. Can., vol. 15, 1958) showed that 4X growth estimates from scales were only slightly higher on the average than estimates based on otoliths. Gulland (Min. of Agr. and Fish., Series II, vol. XVIII, No. 9, 1955) concluded that unless age errors change greatly from one age group to the next, the effect on estimates of growth and mortality is small. Unfortunately there appears to be no simple basis for predicting just how large errors must be or how fast they must change from age to age in order to produce specified errors in mortality estimates. The only suitable procedure appears to involve deterministic age-error models. In our case such models based on scale-otolith comparisons could be used to obtain some idea of the magnitude of differences in growth and mortality estimates between scale and otolith data. This analysis will be incorporated into the final report.

Scale reading consistency between different readers and also between different readings (of the same sample) by the same reader, appears to be lower than consistency obtained with otoliths. The magnitude and importance of this disadvantage of scales will be considered in the final report.