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Mackerel biology and history of the fishery in Subarea 4[1]

by

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INTRODUCTION

Atlantic mackerel (Scomber scombrus) landings in ICNAF Subarea 5 and Statistical Area 6 have undergone an almost exponential increase from 1,000 MT in 1962 to nearly 386,000 MT in 1972. This increase was due primarily to the development of a large winter fishery near the edge of the Continental Shelf. In an attempt to prevent uncontrolled exploitation of this species a total allowable catch (TAC) of 450,000 MT was recommended by ICNAF for 1973, and at the annual meeting in June 1973, the Assessments Subcommittee recommended a reduction in the TAC for 1974 to 245,000 MT in these two areas.

However, since the work of Sette (1950), it has been tacitly accepted that although there is a separate northern and southern contingent of the population from April to November, with one contingent spawning in the Gulf of St. Lawrence and the other south of Cape Cod, the two contingents are partially mixed during the winter in Subarea 5. That some mixing does occur has been more recently substantiated by the recovery in Statistical Area 6 of a mackerel tagged in Newfoundland waters (Parsons and Moores, 1973).

It seems probable, therefore, that the winter fishery in Subarea 5 and Statistical Area 6 exploits some proportion of the Subarea 4 mackerel although Paciorkowski et al (1973) suggest that it is not substantial. As well, the current total effort limitation recommendations for Subarea 5 and Statistical Area 6 are likely to divert effort into Subareas 3 and 4, thus necessitating the implementation of measures to prevent the uncontrolled exploitation of mackerel in these areas.

The purpose of this paper is to provide some background information on the history of the fishery and biological parameters for mackerel in Subarea 4.

CATCH STATISTICS

Statistics on the history of the fishery were obtained from the ICNAF Statistical Bulletins and for the 1973 Canadian fishery from the Canadian Fisheries Information Branch.

The mackerel fishery in Subarea 4 has been a relatively small one, with catches increasing in a step-wise manner from 6,000 metric tons in the early 1960's to 20,000 mt in 1968 (Table 1); since 1968 catches have averaged 20,000 mt annually. The Canadian mackerel fishery in Subarea 4 has existed since the

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1800's, but more recently Canada and the U.S.S.R. have been the principle exploiters. Since 1964 Canadian landings in most of Subarea 4 have increased gradually, to about 14,000 mt annually. In 1968 the U.S.S.R. initiated a mackerel fishery in Division 4W which has since fluctuated between 3800-9300 mt (Table 5). Other countries have been entering the fishery,generally on a small scale, since 1968. Landings by country by Division from 1961-72 are given in Tables 2-6.

Tables 7-10 present the Canadian mackerel landings from 1969-73 by Division by month and gear. Most of the Canadian fishery occurs in coastal waters with no landings from Division 4Vs. Landings in Division 4T have shown the greatest increases from 3700 mt in 1969 to 8100 mt in 1973. This is primarily a purse seine and gillnet fishery operating on the spawning adults in July and August (Table 7). The fishery actively avoids taking young-of-the-year and yearlings with both gears, thus accounting for the decline in catches after the major spawning period. In Division 4Vn (Table 8), of the two major gears, traps exploit the fish moving toward the Gulf of St. Lawrence in June and purse seines exploit fish moving out of the Gulf in September and October. Catches in Division 4W (Table 9) are primarily by gillnets operating on migrating fish in June and October. In Division 4X (Table 10) catches are primarily by weirs and gillnets operating from June to October on both migrating and non-migrating fish.

The period of operation in all Divisions of the Canadian fishery changed somewhat in 1973, probably due to the general decreased availability and quota induced closure of the herring fisheries.

BIOLOGY

Prior to 1973 biological information on the Canadian mackerel fishery is very limited. However, during the 1973 season an intensive sampling program was initiated to collect data from catches in ICNAF Divisions 4T, 4V, 4W and 4X. This report summarizes data for 1973 and attempts an analysis of basic biological parameters. Information available for study included length frequency samples (18374 fish) and length-stratified samples (3083 fish) for detailed analysis of various biological factors including length, weight, sex, maturity and otolith age. All length measurements were of fork length to the nearest half-centimeter group for length frequencies and, when possible, two fish from each length group were retained for detailed analysis.

Since age determinations were from fish of selected length, a length frequency for the total catch was determined by weighting (see AppendixI) and combining samples. Age data were then fitted to the resultant length distribution. Catch data and sampling coverage indicated that a summary of the data by ICNAF Divisions 4T (Gulf of St. Lawrence), 4V-4W (Atlantic Coast), and 4X (Bay of Fundy-Gulf of Maine) was warranted. In addition, available literature on mackerel migration (Sette, 1950; MacKay, 1967) suggested a size and time segregation of the northern continent and thus to allow comparison of the data on a time basis, three arbitrary time intervals were selected: early May to July 15, July 16 to September 15 and September 16 to early November. Biological data for 1973 is thus summarized in terms of three areas and three time periods.

Estimates of age were made from otoliths by counting the nucleus and hyaline (winter) zones following the method described for herring by Hunt et al (1973), where year class is defined as the year sampled minus (age -1). In this context, a fish spawned in the spring and caught in the same year would be aged as a one year old. The age data for each area and time period was combined with the appropriate length frequency by apportioning each length group in the length frequency on the basis of the corresponding

length group in the age data. This calculated age-length key was used to determine mean length and weight values and year class composition. Values for mean length in the last time period were used to estimate Von Bertalanffy growth parameters for each area.

Numbers at age were calculated by determining total numbers in the catch (catch % average weight per fish) and then apportioning by the year class composition.

Length Composition

In Division 4X the catches indicate a significant difference in length distribution when compared to other areas (Table 11 and Fig. 1) with a strong representation of 15.3 cm fish. However, a large proportion of the catch is taken by inshore gear (see Appendix II) which probably exerts a greater effort on the generally inshore juveniles (Sette, 1950). The increasing abundance of young-of-the-year (< 20 cm) in the catch suggests some degree of spawning in the area and the continued presence of substantial numbers of large adults further supports the possibility of spawning in the area as well as suggesting a possible connection with adults from the southern contingent which spend the summer in the Gulf of Maine (Sette, 1950). However, the large fish represent the greatest proportion of the catch to mid-July with a mode similar to that in other areas during this period. The decreasing proportion of these large fish in subsequent time periods suggests that they have moved out of the area, probably to spawn in the Gulf of St. Lawrence.

In Divisions 4V-4W there is a distinct shift in the length distribution between the three time intervals. This shift probably indicates movement through the area of large adult fish from June to mid-July followed by smaller fish and a return movement of mixed sizes at the end of the season. The proportion of small fish (< 30 cm) is much higher than in 4T and the continued presence of small fish in 4V-4W suggests that a large proportion of this group do not complete the migration to the Gulf.

Since both types of gear (inshore-fixed and offshore-mobile) are active in the area over the entire season, it is reasonable to assume that all lengths are susceptible to capture and that the length frequency adequately reflects the size distribution over the season. Thus,the disappearance of large fish and subsequent re-appearance at the end of the season does indicate a migration through the area. The occurrence of smaller fish (25 - 30 cm) in the middle of the season and their absence earlier in the season suggests an inshore migration from over-wintering areas along the edge of the Scotian shelf as suggested by Sette (1950), particularly since a comparable mode is not present in the 4X catch.

In Division 4T a strong mode near 35 cm is evident in the length frequency throughout the season and a second mode near 31 cm develops after mid-July. The absence of small fish (< 25 cm) and the small proportion (25%) of fish less than 30 cm is probably due to selective fishing. The high proportion of gill net catches (Appendix II) up to mid-July and the subsequent prominence of purse seine catches and complete absence of inshore gear could account for the size distribution of the catch. Since this area is a major spawning region (Sette, 1950; MacKay, 1967; Arnold, 1970), young-of-the-year are to be expected and usually appear near the surface in large schools according to local fishermen (pers. comm.). However, purse seine fishermen claim that they actively avoid small fish because seines are easily plugged with enmeshed small fish.

However, purse seines were the dominant gear used in 4T and 4V-4W after mid-July and so length frequencies are comparable during this period and indicate a greater abundance of large

fish in Division 4T during July to September. The decreasing proportion of large fish in 4T after mid-September corresponds to the increasing proportion observed in 4V-4W. In general, the changes in the length frequency from 4T and 4V-4W do indicate a movement into and out of the Gulf during the season. The data from Division 4X suggest a northward migration of larger fish along the Nova Scotia coast while smaller individuals appear later and remain in 4X.

Year Class Composition

Year class composition (Table 14) shows some consistent trends in year class strength between areas, but other year classes indicate varying degrees of representation. An increasing contribution of younger fish to the catch is to be expected in moving from 4T to 4X based on our length frequency data. MacKay (1967) similarly found a greater proportion of small fish in the catch from 4X which follows Sette's (1950) suggestion that smaller mackerel are not as abundant in northern waters. This is best demonstrated by the 1972 year class which represented less than 1% in Division 4T but greater than 34% in Division 4X. The size of the 1971 year class represents a much smaller proportion of the 4X catch, but as discussed earlier fish of that length interval appeared only in Divisions 4V-4W and 4T.

The 1967 year class is the most prominant in all areas, representing 21% of the total Canadian catch in Subarea 4 and the 1966 year class still contributes substantially to the total catch. The relative sizes of these year classes are in agreement with the findings of other researchers (Anderson, 1973; Isakov, 1973) for mackerel in Subarea 5 and Statistical Area 6 and indicates at least some degree in conformity in estimating age by various countries.

Considering the overall age composition, it is evident that the bulk of the catch consists of relatively young fish (1966-72 year classes) as shown below.

	Year class							
	72	71	70	69	68	67	66	65+
% composition of total catch	10.7	21.1	9.1	9.0	14.7	21.4	8.2	5.8

Since the mean fork length of fish in the 1971 year class is 29.9 cm (Table 12), about 20% of the Canadian catch is less than 30 cm in length.

The total number of fish caught in the 1973 Canadian fishery amounts to 43,751,000 individuals with a calculated mean length of 32.2 cm and a mean weight of 379.1 gms.

Mean Length At Age And Growth

Mean length at age values (Table 12) were derived from the combined age and length frequency in each area for the last time interval (September-November) and represent mean length near the end of the 1973 growing season. The average of these values was calculated and probably best represents the length at age for the Sub-area 4 stock. Von Bertalanffy growth parameters were also calculated and the resultant equation was used to plot growth curves for each area (Fig. 2). Good agreement in estimates of length at age is evident although poor representation of some age groups, in particular young fish in Division 4T, causes some degree of divergence in the curves. Using values of average growth parameters yields the equation

$$I_t = 40.39 \left[1 - e^{-0.270 (t + 1.563)} \right]$$

which probably best represents age and length of mackerel in the Canadian fishery.

Comparison of the above growth parameters with those provided by Anderson (1973) and Isakov (1973) indicates considerable variation between Sub-areas 4 and 5. Environmental differences resulting in variable growth rates could account for some effect but it is also probable that changes in stock composition during the winter fishery in Sub-area 5 and Statistical area 6 are equally important. In addition, it is expected that differences in analysis and preparation of data are of equal significance in producing variation. Ageing techniques for mackerel have not as yet been properly defined and interpretation of otoliths is subject to considerable difference of opinion. In this report, fish have been aged to at least 15 years (1959 year class) and excluded from estimates if ages could not be assigned. Two effects on growth parameters arise from this procedure, the first being to increase the age at which maximum length is achieved and the second is to reduce the maximum observed length through exclusion of older and larger fish because of ageing difficulties. Also, since fish were aged on the basis of growing seasons, direct comparison of growth curves is not possible. Age 1 fish in this report refer to fish at the end of their first growing season while in other reports this age refers to fish in their second growing season. The effect of this ageing technique is to lower the mean length at age value in comparison to that reported by other authors. Differences in the sampling season (summer for Canadian data vs. winter for other reports) may also contribute to the variation in growth rates.

Sexual Maturity

During the 1973 fishery in Subarea 4, 2885 mackerel were examined for sexual maturity. Only 4 categories, comparable to those used by Sette (1943) and MacKay (1967), were used to facilitate classifying by personnel not familiar with mackerel. The four categories used were as follows: 1 - immature juveniles and virgin adults; 2 - maturing virgins and recovering spents; 3 - ripe and running; 4 - spent fish. Since all maturing individuals were grouped into a single category (stage II), data on the progression of sexual development in the various areas (4T, 4VW, 4X) are not available. Steven (1952) classified the maturity stages of mackerel into eight categories and in 1974 our sampling will follow his classification.

Due to the small numbers of fish at maturity stages 3 and 4 in some areas at certain periods, the data have been examined for monthly variations with only brief consideration being given to sex or area. Ripe and running fish were observed in samples from the Gulf of St. Lawrence from late June to mid-August, and spent fish from July to mid-September. Arnold (1970) conducted egg and larval surveys in the Gulf of St. Lawrence in 1968 and 1969 and concluded that concentrated spawning occurred in Division 4T from mid-June to mid-July and tapered off thereafter in most years; few eggs were found during August cruises. In Divisions 4V, W, and X ripe and running, and spent fish were first observed over a month later, in August, and disappeared from 4X by the end of September, but the presence of both stages in samples from 4VW extended into October. The smallest ripe fish examined were females at 29.5 cm and males at 32.0 cm but at these lengths, both sexes occurred in numbers insufficient to indicate differential maturation.

The fish sampled for sexual maturity ranged in length (fork lengths) from 17.0-45.0 cm. The majority of fish at stages 2, 3, and 4 were greater than 30 cm in length in all months (Figure 3).

Mackerel taken in May were primarily large maturing fish. Smaller fish appeared from June through to October primarily at stage 1, although fish up to 38.5 cm were found at this stage. Fish smaller than 17.0 cm were not in the samples because fishermen actively avoid taking small fish, thus these sizes represent a small proportion of the catch. As the season progressed, a tendency can be noted for smaller fish to enter maturity stages 3 or 4, thus suggesting that smaller fish spawn later.

Stage 2 fish are well represented throughout the season. This could be due to the prolonged and multiple spawnings by the females (Bigelow and Welsh; 1925, p. 208) which may appear as stage 2 fish between spawnings. Also, late in the season, some fish which spawned earlier may be entering the recovery phase (stage 2). In most months, the stage 4 category included smaller fish than those represented in stage 3. This difference could be due to either a lack of sampling at the appropriate times to obtain small stage 3 fish, or more probably to the occurrence of false stage 4 fish as noted by Steven (1952).

One of the difficulties in determining length at sexual maturity is deciding at what stage of sexual development a fish is committed to spawn that year. Sette (1943) considered only fish that were "ripe" or "spent" as mature. Steven (1952), however, quite reasonably also considered mackerel in the later stages of maturation in the spawning group. Since our samples were collected throughout the season, it would be appropriate to include some of the maturing fish also, but such consideration is difficult since we have only one category for maturing fish while Steven had four. Consequently, two alternatives:- 1) that all fish at maturity stages 2, 3, and 4 will spawn in the current year, and 2) that only fish at stages 3 and 4 will spawn.

Assuming that all fish in stages 2, 3, and 4 will spawn, mackerel less than 30 cm represented less than 12% of the spawning froup (Table 15) over the season with monthly values fluctuating between 1.1% (May) and 19.8% (July). Those fish between 30-35 cm and those greater than 35 cm represented 52% and 36% of the season total respectively. Considering the second case in which only fish at stages 3 or 4 will spawn (Table 16), fish less than 30 cm represented less than 4% of the spawning group during the season. Obviously neither case adequately describes the spawning group since some, but not all, of the stage 2 fish will spawn. Some spawning fish may appear as stage 2 between successive spawnings and some early spawning fish may be in the recovery phase (stage 2) in September and October. But not all of the fish in stage 2 will spawn, and some small fish classified at stage 4 will not have spawned (Steven, 1952). The correct value for the proportion of the spawning stock less than 30 cm in length must be between the extremes of 4 and 12%.

Similarly in Table 17, although almost 35% of the fish less than 30 cm are at stages 2 and 3 and 4, most are at stage 2 and only a proportion of these fish will spawn. Throughout the season only 20% were found at stages 3 and 4. It is also notable that even in the 30-35 cm length interval almost 15% of the fish are immatures.

The low estimates of the percentage of fish spawning at lengths less than 30 cm agree with the data of other workers. Sette (1943) found only 5% of the fish less than 30 cm to be mature; Steven (1952) noted few ripe fish less than 27.5 cm,[1] a point that agreed well with the inflection points in the

[1] Converted from 30 cm T.L. using a conversion factor of 0.916 x T.L. (from MacKay, 1967).

length-age and length-weight relationships which he associated with the onset of sexual maturity; and MacKay (1967), working in Canadian waters, stated that sexual maturity occurred at a size larger than 30 cm.

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TABLE 1. Mackerel nominal catches in ICNAF Subarea 4 by country and gear (metric tons). Only countries reporting catches are included.

	ICNAF DIVISION						COUNTRY						
Year	4RST	4Vn	4Vs	4W	4X	Total	Canada	FRG	Poland	Romania	U.S.S.R.	GDR	Non - Mem.
1961	1,967	583	-	723	1,176	4,449	4,449	-	-	-	-	-	-
1962	1,777	723	-	827	2,888	6,215	6,215	-	-	-	-	-	-
1963	2,764	907	-	751	1,678	6,100	6,089	-	-	-	11	-	-
1964	5,386	1,070	-	1,492	2,166	10,114	9,967	-	-	-	147	-	-
1965	4,641	1,088	-	1,698	3,976	11,403	11,001	-	-	-	402	-	-
1966	5,331	1,235	-	2,016	4,146	12,728	11,494	-	-	-	1,234	-	-
1967	3,203	2,047	-	2,176	3,763	11,189	11,127	-	-	-	62	-	-
1968*	5,157	1,765	42	10,557	2,928	20,449	10,932	-	98	-	9,419	-	-
1969*	3,772	2,085	1,089	6,379	4,990	18,315	12,946	2	27	-	4,075	1,265	-
1970	5,888	2,759	497	5,624	5,376	20,144	14,853	208	49	-	3,987	1,047	-
1971	6,054	1,915	163	10,159	4,699	22,990	13,436	32	2	18	9,492	10	-
1972	7,735	2,074	64	6,582	4,325	20,780	14,698	-	245	-	5,769	31	37

* Not included are 19 mt and 1 mt taken by Japan in 1968 and 1969.

TABLE 2. Nominal catches (metric tons) in Divisions 4RST.

Year	COUNTRY								
	Canada		F.R.G.	Poland	Romania	U.S.S.R.	GDR	Non. Mem.	Total
	4RS	4T							
1961	45	1,922	-	-	-	-	-	-	1,967
1962	142	1,635	-	-	-	-	-	-	1,777
1963	438	2,326	-	-	-	-	-	-	2,764
1964	292	5,094	-	-	-	-	-	-	5,386
1965	19	4,622	-	-	-	-	-	-	4,641
1966	73	5,258	-	-	-	-	-	-	5,331
1967	84	3,119	-	-	-	-	-	-	3,203
1968	494	4,663	-	-	-	-	-	-	5,157
1969	33	3,739	-	-	-	-	-	-	3,772
1970	76	5,812	-	-	-	-	-	-	5,888
1971	272	5,782	-	-	-	-	-	-	6,054
1972	384	7,351	-	-	-	-	-	-	7,735
Total 1963-1972	2,165	47,766	-	-	-	-	-	-	49,931
Total 1970 1972	732	18,945	-	-	-	-	-	-	19,667

TABLE 3. Nominal Catches (metric tons) in Division 4Vn.

Year	Canada	FRG	Poland	Romania	U.S.S.R.	G.D.R.	Non-Mem	Total
1961	583	-	-	-	-	-	-	583
1962	723	-	-	-	-	-	-	723
1963	907	-	-	-	-	-	-	907
1964	1,070	-	-	-	-	-	-	1,070
1965	1,088	-	-	-	-	-	-	1,088
1966	1,235	-	-	-	-	-	-	1,235
1967	2,047	-	-	-	-	-	-	2,047
1968	1,765	-	-	-	-	-	-	1,765
1969	2,084	1	-	-	-	-	-	2,085
1970	2,746	13	-	-	-	-	-	2,759
1971	1,883	32	-	-	-	-	-	1,915
1972	2,074	-	-	-	-	-	-	2,074
Total 1963-1972	15,899	46	-	-	-	-	-	16,945
Total 1970-1972	6,703	45	-	-	-	-	-	6,748

TABLE 4. Nominal catches (metric tons) in Division 4Vs.

Year	Canada	FRG	Poland	Romania	U.S.S.R.	G.D.R.	Non-Mem.	Total
1961	-	-	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-
1965	-	-	-	-	-	-	-	-
1966	-	-	-	-	-	-	-	-
1967	-	-	-	-	-	-	-	-
1968	-	-	-	-	42	-	-	42
1969	-	1	15	-	22	1,052	-	1,089
1970	-	190	-	-	60	247	-	497
1971	-	-	-	-	163	-	-	163
1972	-	-	-	-	64	-	-	64
Total 1963-1972	-	191	15	-	351	1,299	-	1,856
Total 1970-1972	-	190	-	-	287	247	-	724

TABLE 5. Nominal catches (metric tons) in Division 4W.

Year	Canada	FRG	Poland	Romania	U.S.S.R.	G.D.R.	Non Mem.	Total
1961	723	-	-	-	-	-	-	723
1962	827	-	-	-	-	-	-	827
1963	740	-	-	-	11	-	-	751
1964	1,370	-	-	-	122	-	-	1,492
1965	1,300	-	-	-	398	-	-	1,698
1966	1,997	-	-	-	19	-	-	2,016
1967	2,133	-	-	-	43	-	-	2,176
1968	1,138	-	98	-	9,321	-	-	10,557
1969	2,124	-	-	-	4,042	213	-	6,379
1970	938	5	49	-	3,832	800	-	5,642
1971	1,307	-	2	18	8,822	10	-	10,159
1972	1,015	-	245	-	5,269	31	22	6,582
Total 1963-1972	14,062	5	394	18	31,879	1,054	22	47,434
Total 1970-1972	3,260	5	296	18	17,923	841	22	22,365

TABLE 6. Nominal catches (metric tons) in Division 4X.

Year	Canada	FRG	Poland	Romania	U.S.S.R.	GDR	Non Mem.	Total
1961	1,176	-	-	-	-	-	-	1,176
1962	2,888	-	-	-	-	-	-	2,888
1963	1,678	-	-	-	-	-	-	1,678
1964	2,141	-	-	-	25	-	-	2,166
1965	3,972	-	-	-	4	-	-	3,976
1966	2,931	-	-	-	1,215	-	-	4,146
1967	3,744	-	-	-	19	-	-	3,763
1968	2,872	-	-	-	56	-	-	2,928
1969	4,966	-	12	-	11	1	-	4,990
1970	5,281	-	-	-	95	-	-	5,376
1971	4,192	-	-	-	507	-	-	4,699
1972	3,874	-	-	-	436	-	15	4,325
Total 1963-1972	35,651	-	12	-	2,368	1	15	38,047
Total 1970-1972	13,347	-	-	-	1,038	-	15	14,400

Table 7. Canadian nominal mackerel catches (metric tons) by month and gear in ICNAF Divisions 4ST. No catches were made prior to May.

Division 4S & T

Gear	Month								Total
	5	6	7	8	9	10	11	12	
1969									
Trawl	-	-	-	-	-	-	-	-	-
Purse Seine	-	7	983	236	102	276	104	-	1708
Handline	-	5	7	34	25	76	2	-	149
Gillnet	-	419	442	307	198	49	2	-	1417
Trap, Weir	-	1	-	79	32	14	-	-	126
Miscellaneous	5	136	45	64	74	18	-	-	342
Total	5	568	1477	720	431	433	108	-	3742
1970									
Trawl	-	-	-	-	-	-	-	-	-
Purse Seine	-	24	574	732	575	362	176	-	2443
Handline	-	10	14	8	37	25	1	-	95
Gillnet	-	922	394	254	178	80	3	-	1831
Trap, Weir	-	12	186	109	3	-	-	-	310
Miscellaneous	-	11	188	152	642	147	1	-	1141
Total	-	979	1356	1255	1435	614	181	-	5820
1971									
Trawl	-	-	-	-	-	4	-	-	4
Purse Seine	-	51	2259	503	233	315	15	-	3376
Handline	-	1	13	21	57	27	15	-	134
Gillnet	8	783	426	293	269	73	3	-	1855
Trap, Weir	-	1	-	8	-	6	-	-	15
Miscellaneous	-	103	90	90	150	84	2	-	519
Total	8	939	2788	915	709	509	35	-	5903
1972									
Trawl	3	1	-	-	-	-	-	-	4
Purse Seine	-	42	3411	879	254	86	-	-	4672
Handline	3	-	12	32	36	34	8	-	125
Gillnet	4	482	488	328	218	88	1	-	1609
Trap, Weir	-	1	34	90	10	-	-	-	135
Miscellaneous	-	33	442	221	203	85	-	-	984
	10	559	4387	1550	721	293	9	-	7529
1973 *									
Trawl	1	1	1	-	-	4	-		7
Purse Seine	-	12	2450	1464	774	230	-		4930
Handline	-	-	43	157	189	25	6		420
Gillnet	-	677	745	372	204	47	4		2049
Trap, Weir	-	18	-	7	3	-	-		28
Miscellaneous	-	14	489	172	39	12	-		726
Total	1	722	3728	2172	1209	318	10		8160

* data as available to November

Table 8. Canadian nominal mackerel catches (metric tons) by month and gear in ICNAF Division 4Vn. No catches were made prior to May.

Division 4Vn

Gear	Month								Total
	5	6	7	8	9	10	11	12	
1969									
Trawl	-	-	-	-	-	1	-	-	1
Purse Seine	-	-	6	3	42	324	72	-	447
Handline	-	1	-	5	74	564	5	-	649
Gillnet	12	96	13	-	2	-	11	-	134
Trap, Weir	-	547	90	1	2	-	-	-	640
Miscellaneous	-	105	1	5	64	38	-	-	213
Total	12	749	110	14	184	927	88	-	2084
1970									
Trawl	-	-	-	-	-	-	-	-	-
Purse Seine	-	-	-	5	105	394	405	-	909
Handline	-	-	-	3	30	208	11	-	252
Gillnet	6	264	43	-	2	26	-	-	341
Trap, Weir	2	942	109	-	-	13	34	-	1100
Miscellaneous	-	41	6	5	43	32	17	-	144
Total	8	1247	158	13	180	673	467	-	2746
1971									
Trawl	-	-	-	-	-	-	-	-	-
Purse Seine	-	-	-	7	128	335	106	-	576
Handline	-	-	4	13	113	145	12	-	287
Gillnet	16	66	37	7	-	37	-	-	163
Trap, Weir	3	459	44	-	-	-	-	-	506
Miscellaneous	-	309	1	2	14	21	-	4	351
Total	19	834	86	29	255	538	118	4	1883
1972									
Trawl	-	-	-	-	-	-	-	-	-
Purse Seine	-	-	-	151	355	456	38	-	1000
Handline	-	5	1	27	143	144	-	-	320
Gillnet	19	93	30	2	3	-	6	-	153
Trap, Weir	-	437	80	-	5	13	-	-	535
Miscellaneous	-	4	-	9	13	8	32	-	66
Total	19	539	111	189	519	621	76	-	2074
1973*									
Trawl	-	-		-	-	-	-		-
Purse Seine	-	-	636	152	287	826	-		1901
Handline	-	-	4	29	105	140	-		278
Gillnet	13	96	35	3	2	5	9		163
Trap, Weir	-	368	559	37	-	-	-		964
Miscellaneous	3	33	25	70	47	4	-		182
Total	16	497	1259	291	441	975	9		3488

* data as available to November

Table 9. Canadian nominal mackerel catches (metric tons) by month and gear in ICNAF Division 4W. No catches were made prior to May.

Division 4W

Gear	Month								Total
	5	6	7	8	9	10	11	12	
1969									
Trawl	-	-	-	-	-	-	-	-	-
Purse seine	-	-	-	-	1	-	-	-	1
Handline	-	-	1	29	35	31	-	-	96
Gillnet	169	704	255	4	3	97	38	-	1270
Trap,Weir	-	256	182	28	7	26	7	-	506
Miscellaneous	1	141	94	-	1	14	-	-	251
Total	170	1101	532	61	47	168	45	-	2124
1970									
Trawl	-	-	-	-	-	-	-	-	-
Purse seine	-	-	-	-	-	-	-	-	-
Handline	-	1	13	40	29	19	1	-	103
Gillnet	64	373	33	10	2	11	184	4	681
Trap, Weir	2	55	14	18	16	1	19	1	126
Miscellaneous	-	14	-	11	1	-	2	-	28
Total	66	443	60	79	48	31	206	5	938
1971									
Trawl	-	1	-	-	-	-	-	-	1
Purse seine	-	-	-	-	-	-	-	-	-
Handline	-	1	3	7	31	24	2	-	68
Gillnet	26	467	121	34	31	34	217	-	930
Trap, Weir	-	-	-	-	-	-	-	-	-
Miscellaneous	19	48	155	19	16	37	14	-	308
Total	45	517	279	60	78	95	233	-	1307
1972									
Trawl	-	-	-	-	-	-	-	-	-
Purse seine	-	-	-	-	-	-	-	-	-
Handline	-	1	3	8	36	14	-	-	62
Gillnet	77	302	50	31	38	107	196	-	801
Trap, Weir	3	27	48	18	13	16	9	-	134
Miscellaneous	-	12	2	2	-	2	-	-	18
Total	80	342	103	59	87	139	205	-	1015
1973*									
Trawl	-	-	-	-	-	-	-		-
Purse seine	-	15	-	-	-	3	-		18
Handline	-	-	1	59	63	27	1		151
Gillnet	98	238	66	66	87	50	53		658
Trap, Weir	1	97	67	20	21	10	12		228
Miscellaneous	9	11	14	4	13	104	172		327
Total	108	361	148	149	184	194	238		1382

*data as available to November

Table 10. Canadian nominal mackerel catches (metric tons) by month and gear in ICNAF Division 4X. No catches were made prior to May.

Division 4X

Gear	Month								Total
	5	6	7	8	9	10	11	12	
1969									
Trawl	-	-	-	1	-	-	-	-	1
Purse Seine	-	-	-	-	-	-	-	-	-
Handline	-	17	15	1	3	4	-	-	40
Gillnet	347	388	184	169	29	26	79	17	1239
Trap, Weir	17	458	389	141	191	141	231	22	1590
Miscellaneous	463	783	345	135	235	100	23	12	2096
Total	827	1646	933	447	458	271	333	51	4966
1970									
Trawl	-	-	-	-	-	-	-	-	-
Purse Seine	-	-	36	19	4	-	-	-	59
Handline	-	1	1	2	4	2	2	-	12
Gillnet	235	282	106	144	190	35	314	16	1322
Trap, Weir	17	212	386	1305	829	180	21	12	2962
Miscellaneous	67	61	129	305	202	30	127	5	926
Total	319	556	658	1775	1229	247	464	33	5281
1971									
Trawl	-	-	-	-	-	-	-	-	-
Purse Seine	-	-	3	-	-	-	-	-	3
Handline	-	3	7	3	1	5	1	-	20
Gillnet	112	319	257	123	98	86	114	29	1138
Trap, Weir	24	642	573	548	360	88	17	-	2252
Miscellaneous	18	445	152	25	44	25	66	4	779
Total	154	1409	992	699	503	204	198	33	4192
1972									
Trawl	-	1	-	9	1	-	-	-	11
Purse Seine	-	-	-	2	-	-	-	-	2
Handline	1	10	4	5	3	7	3	-	33
Gillnet	100	146	95	118	152	128	192	27	958
Trap, Weir	12	225	392	640	282	62	59	-	1672
Miscellaneous	126	346	231	100	223	149	23	-	1198
Total	239	728	722	874	661	346	277	27	3874
1973*									
Trawl	-	-	-	-	3	-	-		3
Purse Seine	-	-	-	-	-	-	-		-
Handline	1	2	1	3	3	1	1		12
Gillnet	140	149	82	106	232	314	71		1094
Trap, Weir	169	272	254	486	278	270	4		1733
Miscellaneous	227	306	48	15	74	43	12		725
Total	537	729	385	610	590	628	88		3567

*data as available to November

Table 11 Length frequency distribution by area and time (A = up to July 15, B = July 16-Sept. 15, C = Sept. 16-Nov).

Length Group	4T			4V-4W			4X		
	A	B	C	A	B	C	A	B	C
15.0	-	-	-	-	-	-	-	-	.3
15.5	-	-	-	-	-	-	-	-	.6
16.0	-	-	-	-	-	-	-	-	1.4
16.5	-	-	-	-	-	-	-	-	.9
17.0	-	-	-	-	-	-	-	-	.9
17.5	-	-	-	-	-	.1	-	-	.3
18.0	-	-	-	-	-	.1	-	-	.3
18.5	-	-	-	-	-	.1	.1	1.6	-
19.0	-	-	-	-	.1	.1	.3	.4	.6
19.5	-	-	-	-	.1	.1	.4	3.9	-
20.0	-	-	-	-	.2	.1	.8	2.8	-
20.5	-	-	-	-	.5	.1	.6	6.3	-
21.0	-	-	-	-	.6	.1	1.7	2.4	-
21.5	-	-	-	-	.2	.1	2.2	2.8	.9
22.0	-	-	-	-	.3	.1	3.6	3.2	-
22.5	-	-	-	-	.3	.1	3.0	2.0	.6
23.0	-	.1	.3	-	.9	.1	2.2	1.6	1.5
23.5	-	.1	-	-	.8	.1	1.4	.8	5.4
24.0	-	.1	-	-	1.4	.1	.5	3.2	7.6
24.5	-	.1	-	-	1.1	.3	.3	.8	7.3
25.0	-	.1	.1	-	2.2	.4	.4	3.6	6.4
25.5	-	.1	-	-	1.4	.1	.1	.8	6.0
26.0	-	.2	.2	-	3.7	.5	.1	2.4	3.1
26.5	-	-	.5	.5	2.0	.1	.2	2.2	1.2
27.0	-	.6	.3	2.2	5.4	.7	.2	.8	2.0
27.5	-	.1	.4	1.1	4.6	.6	.6	.1	1.8
28.0	-	2.3	1.0	1.6	7.9	1.0	.5	.2	1.3
28.5	-	1.0	.8	2.7	6.2	.3	.8	.2	1.0
29.0	-	7.3	2.4	1.1	9.3	2.3	1.0	.2	.7
29.5	-	2.7	4.7	1.1	6.2	3.0	.4	.8	.6
30.0	1.6	9.0	9.3	1.1	7.0	6.1	.5	1.9	.8
30.5	2.8	5.2	9.5	-	3.8	4.9	.2	1.1	.6
31.0	1.6	5.0	7.3	-	4.3	3.5	.7	1.4	1.9
31.5	.5	2.6	4.2	.5	1.7	3.3	.6	.2	1.8
32.0	1.7	3.1	3.2	1.1	2.7	3.4	.9	1.4	2.5
32.5	2.3	3.0	3.5	3.8	2.4	2.6	3.4	2.6	1.6
33.0	5.0	7.3	6.5	4.8	4.2	5.7	5.6	5.3	4.0
33.5	6.7	7.7	9.4	9.7	2.0	4.7	6.7	6.4	5.5
34.0	9.9	11.1	11.9	5.9	4.4	10.9	8.0	6.7	5.3
34.5	13.2	7.8	10.5	7.0	1.9	6.1	7.5	5.2	5.4
35.0	13.2	7.9	5.9	8.0	2.2	11.8	8.0	6.8	5.0
35.5	10.9	5.5	4.7	8.6	1.6	5.0	7.2	3.6	4.2
36.0	9.1	4.7	1.9	10.2	2.1	7.8	6.4	6.2	2.7
36.5	5.6	1.9	.6	4.3	.6	3.0	5.0	3.0	2.1
37.0	4.1	1.1	.4	6.5	1.0	3.7	4.3	2.8	1.8
37.5	2.4	.4	.1	5.4	.4	1.5	2.7	.6	.5
38.0	2.2	.5	.1	4.3	1.0	.8	2.9	.6	.8
38.5	1.3	.2	.1	3.2	.2	-	1.7	1.0	.2
39.0	2.0	.2	.1	1.6	.4	1.4	1.6	-	.2
39.5	1.2	.2	-	1.1	.1	-	1.3	-	.2
40.0	1.4	.4	.1	1.6	.2	1.3	1.3	-	.2
40.5	.4	.2	-	.5	.1	.6	.5	.1	-
41.0	.4	.1	-	-	.1	.3	.6	-	-
41.5	.2	.1	-	-	.1	.5	.1	-	-
42.0	.1	-	-	.5	.1	.1	.3	-	-
42.5	.1	-	-	-	-	-	-	-	-
43.0	.1	-	-	-	-	-	-	-	-
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table12. Mean length (cm.) at age values for September

AREA	YEAR CLASS												
	73	72	71	70	69	68	67	66	65	64	63	62	61
4T	-	27.2	29.5	31.3	33.1	34.4	34.5	35.2	36.0	38.3	39.3	39.9	39.8
4V-4W	20.3	27.3	30.6	32.7	34.1	34.8	35.1	36.6	38.2	37.7	40.6	40.6	40.7
4X	16.7	25.5	29.6	32.2	33.4	34.6	35.2	36.0	36.0	38.7	40.0	-	-
Average	18.5	26.7	29.9	32.1	33.6	34.6	35.0	35.9	36.7	38.2	40.0	40.3	40.4

Table13. Calculated Von Bertalanffy growth parameters

AREA	K	L_∞	t_o
4T	0.109	45.88	-6.652
4V-4W	0.249	41.06	-2.032
4X	0.419	38.10	-0.456
Average	0.270	40.39	-1.563

TABLE 14. Numbers at age (x 10^{-3}) by area and time interval

(a) Area 4T	YEAR CLASS														
	73	72	71	70	69	68	67	66	65	64	63	62	61	60^+	Total
to July 15	-	-	158	17	142	627	985	441	126	48	45	23	9	23	2644
July 16-Sept. 15	-	50	4245	2455	1535	2295	4257	1326	322	65	33	25	12	80	16700
Sept. 16-Nov.	-	34	439	95	100	234	223	102	6	1	-	-	-	-	1236
Total	-	84	4842	2567	1777	3158	5465	1869	454	114	78	48	21	103	20580
(b) Area 4V-4W															
to July 15	-	10	395	179	278	672	731	648	278	142	167	20	20	39	3579
July 16-Sept. 15	10	788	2282	541	372	325	231	35	72	17	30	13	-	2	4718
Sept. 16-Nov.	16	214	1066	320	393	808	1018	298	61	18	9	9	9	96	4335
Total	26	1012	3743	1040	1043	1805	1980	981	411	177	206	42	29	137	12632
(c) Area 4X															
to July 15	-	608	108	204	182	643	971	372	145	83	63	22	23	17	3441
July 16-Sept. 15	-	1320	234	29	481	514	408	205	39	13	-	-	-	-	3243
Sept. 16-Nov.	195	1697	284	160	456	320	518	173	26	21	5	-	-	-	3855
Total	195	3625	626	393	1119	1477	1897	750	210	117	68	22	23	17	10539

Table 15. The percentage of mackerel at maturity stages 2, 3, and 4 is given for selected length intervals by month. The total monthly sample size (in parentheses) and the percentage represented by these three stages are also given.

Month	No. of fish in stages 2, 3, and 4	% at length (cm)			% of total sample	
		<30	30-35	>35		
May	93	1.1	40.9	58.0	100.0	(93)
June	374	2.7	40.1	57.2	98.4	(380)
July	698	19.8	55.2	25.0	66.9	(1044)
August	562	10.5	53.6	35.9	76.5	(735)
September	322	11.5	57.8	30.7	70.3	(458)
October	139	10.1	56.8	33.1	79.4	(175)
Total	2188	11.8	52.1	36.1	75.8	(2885)

Table 16. The percentage of mackerel at maturity stages 3 and 4 is given for selected length intervals by month. The total monthly sample size (in parentheses) and the percentage represented by these two stages are also given.

Month	No. of fish in stages 2, 3, and 4	% at length (cm)			% of total sample	
		<30	30-35	>35		
May	0	0	0	0	0	(93)
June	9	0	33.3	66.7	2.4	(380)
July	63	4.8	55.5	39.7	6.0	(1044)
August	164	4.9	48.2	46.9	22.3	(735)
September	127	1.6	60.6	37.8	27.7	(458)
October	56	5.4	51.8	42.8	32.0	(175)
Total	419	3.6	53.2	43.2	18.3	(2885)

TABLE 17 The percentage of mackerel at maturity stage is given for selected length intervals for the 1973 fishing season.

Length (cm)	Sample Size	% at Maturity Stage		
		1	2	3 and 4
<30	748	65,2	32.8	2.0
30-35	1338	14.9	68.4	16.7
>35	799	1.5	75.8	22.7
Total	2885	24.2	61.3	14.5

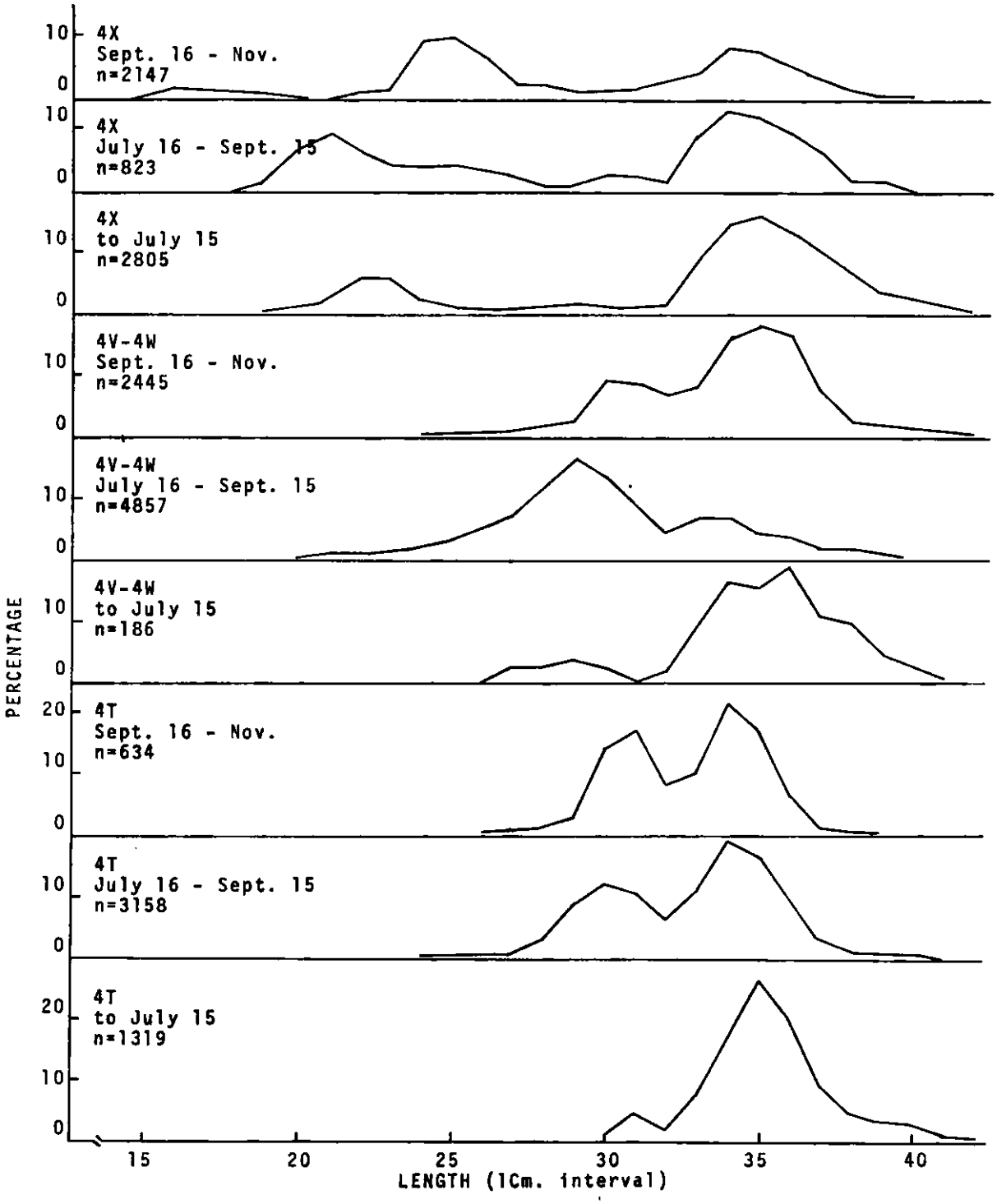


Fig. 1. Length frequency distribution weighted for gear and sample size by area and time.

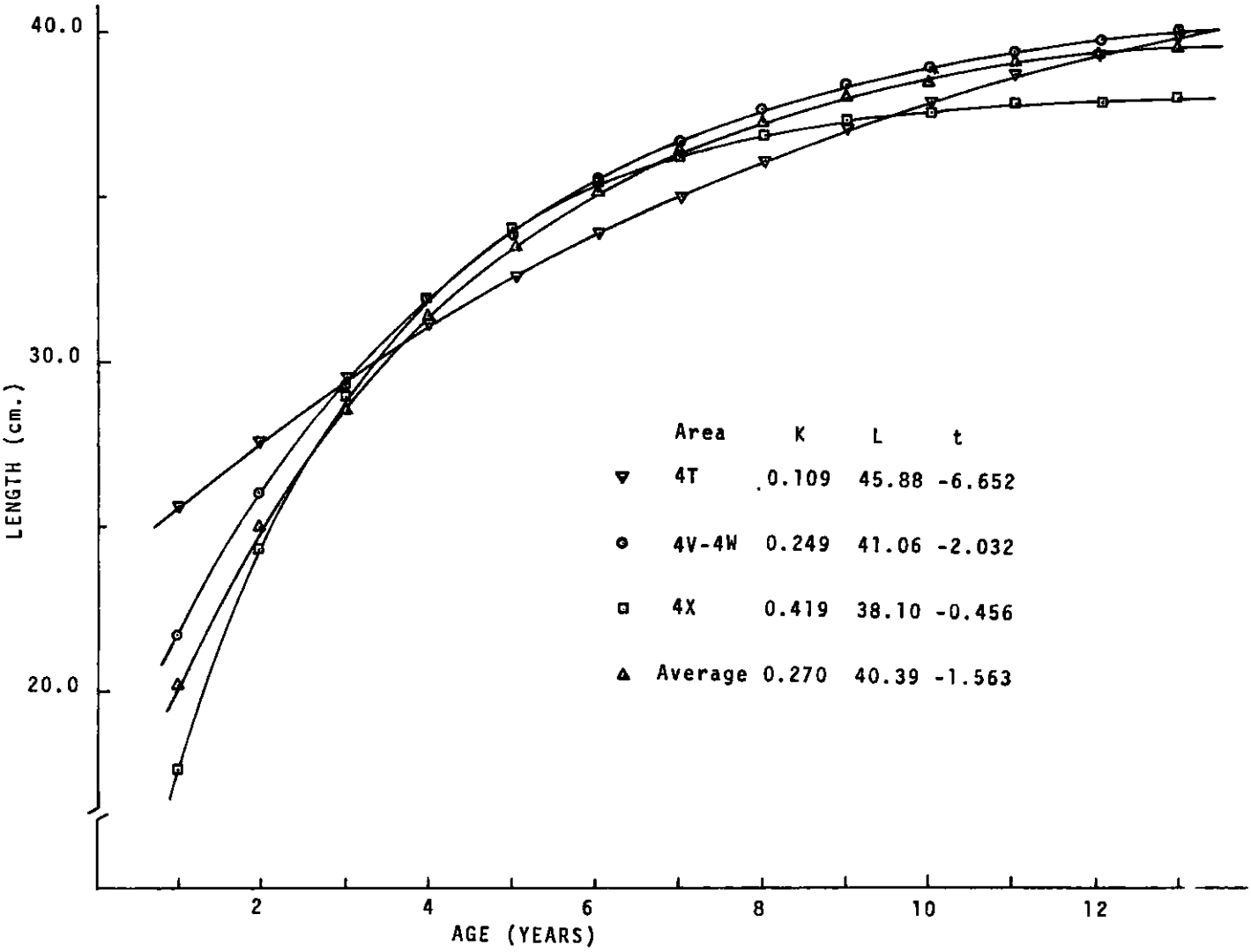
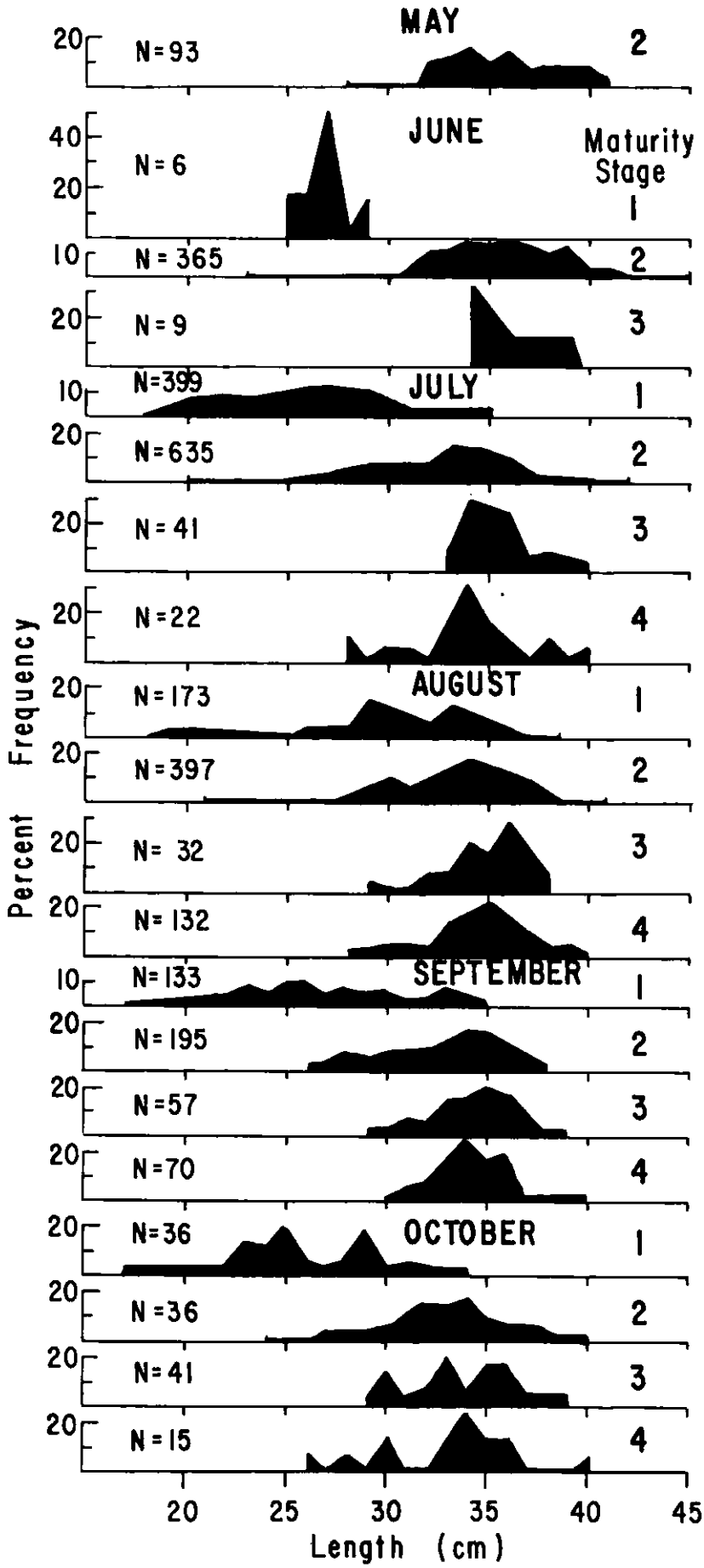


Fig. 2. Comparison of growth curves by area (calculated values).



F 8

Fig. 3. Frequency distribution of mackerel at maturity stages 1-4 by month.

APPENDIX I

Length frequency weighting procedures for Subarea 4 mackerel samples

Length frequency samples of 85-230 fish were obtained from commercial catches and measured for fork length to the nearest half-centimeter group. At least one and when possible, two fish were retained from each length group for age determination. Since the age data was not proportional to year class composition, it was necessary to fit an age-length key to the length frequency distribution for specified areas and time intervals. To minimize sample size bias, each length frequency was reduced to a per cent basis and then combined by gear type. Since stationary gears tend to exploit a different component of the stock than mobile gears, it was felt necessary to weight for this factor by combining samples by gear in the same proportion as the total catch by gear in each area and time period. Gear proportions used for this purpose are listed in Appendix II. The resultant weighted length frequency has been used for all subsequent calculations.

Mackerel catches by gear and time interval in metric tons
Total catch all areas = 16,587 m.t.

Gear	Up to July 15		July 16-Sept. 15		Sept. 16-Nov.		Total	
(a) Area 4T	Catch	Proportion	Catch	Proportion	Catch	Proportion	Catch	Proportion
Trawl	3	.002	-	-	4	.008	7	.001
Purse Seine	33	.026	5084	.795	344	.714	5461	.670
Handline	-	-	388	.061	58	.120	446	.055
Gillnet	1220	.958	911	.142	76	.158	2207	.271
Trap	18	.014	11	.002	-	-	29	.004
Total	1274	1.000	6394	1.000	482	1.000	8150	1.000
(b) Area 4V-4W								
Trawl	-	-	-	-	-	-	-	-
Purse Seine	64	.038	863	.653	1094	.587	2021	.415
Handline	-	-	165	.125	328	.176	493	.101
Gillnet	559	.332	128	.097	370	.198	1057	.217
Trap	1060	.630	166	.125	73	.039	1299	.267
Total	1683	1.000	1322	1.000	1865	1.000	4870	1.000
(c) Area 4X								
Trawl	-	-	3	.003	-	-	3	.001
Purse Seine	-	-	-	-	-	-	-	-
Handline	6	.004	5	.005	3	.003	14	.004
Gillnet	566	.377	202	.210	619	.560	1387	.389
Trap	744	.496	273	.284	417	.377	1434	.402
Weir	184	.123	479	.498	66	.060	729	.204
Total	1500	1.000	962	1.000	1105	1.000	3567	1.000