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The fishery on the southern Gulf of St. Lawrence cod stock, 1960-70

by

R.G. Halliday
Fisheries Research Board of Canada
Biological Station, St. Andrews, N.B.

INTRODUCTION

The southern Gulf of St. Lawrence cod population is migratory, spending the summer months in the Magdalen Shallows region (ICNAF Div. 4T) and overwintering in deep water off Cape Breton Island (ICNAF Div. 4Vn and eastern Div. 4T). In the 1940's landings from this stock ranged from 30,000-50,000 metric tons. The stock was fished solely by Canada mainly by hand-line and long-line gear. In the early 1950's landings increased rapidly, reaching 110,000 metric tons in 1956, due to the entry of Canadian and foreign otter trawlers to the fishery. Landings subsequently declined to about 60,000 metric tons in 1965 due to declines in foreign otter trawl and Canadian line landings. The dynamics of this stock during the 1949-65 period have recently been studied by Paloheimo and Kohler (1968). They described major changes in size and age composition of the population, growth, and recruitment during this period. The present document describes events in the fishery during the 1960-70 period and considers their implications.

LANDINGS

Landings from the southern Gulf of St. Lawrence cod stock were obtained from ICNAF Statistical Bulletins for the years 1960-69, and from unpublished landings statistics on file at ICNAF Headquarters for 1970. All Div. 4T landings and those from Div. 4Vn for the months January to April inclusive were referred to this stock.

Landings in 1960-62 averaged 66,000 metric tons. In 1963 they increased to 70,000 tons, and then declined to 41,000 tons by 1967. Slight increases occurred in 1968 and 1969 and a substantial increase in 1970 to 64,000 metric tons (Table 1). Canada's share increased from 61% of landings in 1960 to 96% in 1969, dropping to 73% in 1970. The remainder was shared among France and Spain and to a lesser extent by Portugal.

By far the largest part of Canadian landings came from the summer fishery in Div. 4T, whereas most foreign landings came from the winter fishery in Div. 4Vn and eastern Div. 4T.

Annual landings by trawlers comprised from 57% to 77% of total landings, while seiners landed from 1% to 5% of the total (Table 2). Long-line and hand-line landings declined in importance from 1960 to 1968 (38% to 9% of landings) but increased in 1969-70. Gillnet landings increased from 1960 to 1968 (< 1% to 28% of landings) but declined in 1969-70. All gillnet, line, and seine landings were made by Canada.

LENGTH AND AGE COMPOSITION OF LANDINGS AND NUMBERS LANDED

Methods

In weighting the landings by commercial samples six categories of landings were considered, otter trawl landings in the periods January-April, May-August, and September-December, seine, line, and gillnet, landings. Sampling coverage was good only for otter-trawl landings in the latter two periods, i.e. for the Magdalen Shallows summer trawl fishery (Table 3). It was considered more appropriate to treat the winter Cape Breton fishery separately despite poor sampling coverage. Danish and Scottish seine landings were treated separately when samples were available and combined with otter-trawl landings when there were no seine samples. Seine landings differed slightly from trawl caught fish, being smaller and younger (Fig. 1). However, seine landings formed such a small part of the total that the error introduced by combining seine with trawl landings is small. Gillnet and line landings could not be combined with trawl landings when sampling was inadequate as length and age composition of landings by these gears differed markedly from those of trawl caught fish and from each other (Fig. 1). When there were no length frequency samples from line or gillnet landings in a particular year, those of the preceding and subsequent years were combined (and some 1971 samples were applied in this way to the immediately preceding years). When age samples were inadequate or missing for a landings category, the most appropriate ages from within the same year were applied to the length-frequency.

Results

Annual mean lengths of total landings ranged from 52.0-56.3 cm (Table 4), 85-95% of the fish lying in the range 40-70 cm. Modal length of landings was 46 cm or 49 cm in all years except 1960 (Fig. 2).

Mean ages of landings ranged from 5.8-7.0 years. Modal age group was normally age 5 or age 6, but on occasion age 4 or age 7 were the most abundant in landings (Fig. 3).

Variations in length and age composition of landings are attributable to variations in the importance of different gears, and to substantial differences in growth rate, during the period.

Number landed increased from 38 million fish in 1960 to 49 million in 1963, declined to 26 million in 1967, then rose again to 40 million in 1970 (Table 5).

DISCARDS

Information on discards of small cod at sea in the 1960-70 period is missing or incomplete for all sectors of the fishery. It can reasonably be assumed for all gillnet and line catches that discards were essentially zero. Reported discards in the Div. 4Vn trawl fishery by Spain, France, and Portugal were low (frequently 0-2%) (e.g. ICNAF, 1968-70). Canadian discards from Div. 4Vn must also have been low as landings from this fishery normally contained small ungraded and ungutted cod. As these sizes were apparently acceptable to the processor it is unlikely that large numbers were discarded. Canadian discard data for Div. 4Vn as submitted to ICNAF does not give an accurate measure of discard rates due to substantial biases in collection methods. This is also true of Canadian Div. 4T data subsequent to 1964. However, in the 1960-64 period fairly accurate measures of discards were obtained for the Div. 4T otter-trawl fishery by intensive sea and shore sampling of commercial catches and landings (Paloheimo and Kohler, 1968). Discards declined from 10.5% by numbers in 1960 to 1.6% in 1964. There is no reason to believe that discards subsequently increased much above that low value.

Estimated total discards from the Div. 4T otter-trawl fishery declined from almost one million fish in 1960 to 325,000 in 1964. They were mainly fish of 35-45 cm length, and of 3 and 4 years old (Table 6).

Thus, as far as can be judged from inadequate data, wastage due to discarding small fish at sea is not an important factor in analysis of this fishery in the 1960's.

CATCH-PER-UNIT-EFFORT

There is no available measure of gillnet nor longline and hand-line effort in the 1960-70 period, and the Danish and Scottish seine fishery is probably too small and too localized to accurately reflect abundance changes of the entire cod stock. Among otter trawlers the most consistent data series are available for Gloucester class vessels fishing from New Brunswick ports. These vessels of 25-50 gross tons entered the summer Magdalen Shallows fishery in the late 1940's and the fleet composition remained virtually unchanged until the early 1960's when vessels were progressively retired from the fishery or diverted to the developing snow crab fishery in the area. Comparable vessels of 25-50 gross tons fishing from Quebec ports have maintained a high level of effort in the summer fishery in recent years. Fairly reliable catch-per-unit-effort data are available for both groups of vessels for the six years 1962-65, 1967-68. Trends in catch-per-effort values were similar for both series, the correlation coefficient being 0.71 (with a probability, $P = 0.12$, of so high a value occurring by chance). The ratio of Gloucester class vessel catch-per-effort to that of Quebec 26-50 gross ton vessels was 0.93. A composite catch-per-effort series was obtained by adjusting Quebec values by 0.93, averaging these with Gloucester values in the years when both were available, using adjusted Quebec values alone for 1969-70, and Gloucester values alone for other years (Fig. 4).

Taking catch-per-effort as a measure of stock abundance indicates that cod became more abundant from 1960 to 1962, declined in abundance until 1966, then increased again to the highest value for the period in 1970.

Although landings from the winter Cape Breton fishery were moderately high between 1960 and 1970, no country exploited the fishery in a consistent manner throughout the period. Catch-per-effort data series for different countries showed different trends indicating that cod abundance was not the prime factor affecting catch-per-effort in some series. A combined catch-per-effort series was obtained by adjusting the effort of each country by the ratio of its catch-per-effort to that of the Spanish otter-trawl fleet. International catches were divided by the sum of the adjusted national efforts to arrive at overall catch-per-effort values (Fig. 4, Table 7). However, these values were not correlated with the corresponding catch-per-effort values for Div. 4T. Among national fleets, the catch-per-effort values of Spanish otter trawlers, despite large fluctuations in effort among years, were most similar to those of Div. 4T (Table 7). The correlation coefficient of Div. 4Vn Spanish values with Div. 4T values for the following summer was 0.60, with values for the previous summer it was 0.67, and with the mean of the previous and following summer values it was 0.68. All correlations were significant at the 5% level.

MORTALITY

Number of cod caught per trip at each age in the May-December Div. 4T otter-trawl fishery were derived from the appropriate age compositions and weight caught per trip data (Table 8), and survival rates between successive ages of each year class calculated (Table 9). Ages greater than 10 years have been omitted from the calculations of Table 9 because they are poorly represented in the catches, and those younger than 7 years have been omitted to remove the effects of partial recruitment on the means.

Survival rates of 7–10 year-olds (Table 10) showed considerable fluctuation without apparent trends, the 11-year average being 0.52, equivalent to an instantaneous total mortality rate (Z) of 0.65. The catch curve of mean numbers at age over the period, fitted from ages 7 to 13, gave an estimate of $Z = 0.70$.

Independent estimates of mortality rates were derived from numbers landed at age (Table 5) by Pope's cohort analysis technique (Pope, MS 1971). An assumed value of natural mortality (M) of 0.20 was used. (Paloheimo and Kohler (1968) derive a value of $M = 0.19$ from 1949–65 data.) For year classes which had passed through the fishery a starting value of fishing mortality (F) of 0.50 was assumed. For year classes still contributing to the fishery starting F values were obtained by averaging previously claculated F values for that age group.

This calculation gave more consistent results than that based on catch-per-unit-effort – results which can be reasonably interpreted in terms of the events in the fishery. In the 1960-65 period full recruitment of year classes to the fishery occurred at about age 7, and mortality of cod 7–10 years old was greater than that of ages 11–14. (The results of 1961 are anomalous in this regard.) The decrease in F of 7–10 year olds in 1961 and 1962 coincided with increased abundance but fairly constant landings while increased mortality in 1963-65 coincided with continuing high landings and declining abundance. The decline in F for 7–10 year olds in 1966–69 corresponded with the decline in otter trawl and line landings and increasing abundance. In this 1966–68 period F on 11–14 year olds increased

becoming substantially greater than that on 7–10 year olds reflecting the increasing importance of the gillnet fishery on large cod. Also in the 1966–68 period cod became fully recruited to the trawl fishery at a younger age being almost fully recruited at age 5, a reflection of increased growth rate at this time (see below). From the mortality rates of Table 10 the following changes in age at recruitment to the trawl fishery were discerned.

Age	Percentage recruited		
	1960-62	1963-65	1966-68
3	0	2	3
4	10	14	52
5	38	44	97
6	73	80	100
7	100	100	100

In summary, F of 7–10 year olds increased to 0.50 in 1963-65 from 0.40 in 1960-62, then declined to 0.31 in 1966-68. F of ages 11-14 year olds increased substantially in recent years to 0.57. The average F for 7-14 year olds in 1960-68 was 0.43, which is in reasonable agreement to the 0.45 obtained from catch-per-unit-effort analysis.

THE RELATIONSHIP OF MORTALITY TO EFFORT

Paloheimo and Kohler (1968) could not derive a satisfactory relationship between mortality and effort from 1949-65 data and concluded that year-to-year variations in the catchability coefficient, q, or in M, were greater than variations in Z due to changes in fishing effort. However, in their analysis, numbers landed at age were obtained by weighting total landings by age compositions obtained from the Div. 4T summer otter-trawl fishery only. Total effort was calculated by dividing total catch of all age groups by catch-per-unit-effort of Canadian Div. 4T otter trawlers of 26-50 gross tons. Relative abundance of particular age groups in successive years was obtained by multiplying total numbers caught per unit effort by the proportion of these age groups in the respective catches. This method does not take account of the substantial differences in age composition among gears, fleets, and areas, and assumes that the relative catchability of different age groups is constant between and within different parts of the fishery. Garrod (1967), in his analysis of the Arcto-Norwegian cod stock, found that modified methods of catch-per-effort analysis which took account of these and other factors, were successful in describing the relationship of mortality to effort, whereas earlier attempts had been less than satisfactory.

Estimated total annual effort was calculated for the 1960-70 period by the method of Paloheimo and Kohler. There was no correlation between these values and the mean F for 7-14 year olds obtained by cohort analysis. However, as described previously, the development of the gillnet fishery has had an obvious effect in increasing mortality on the oldest

age groups. Thus, in recalculating total effort, gillnet landings were discounted, and these values related to the mean F for ages 7–10 (Table 10). Most of the mortality of these age groups was generated by trawl and line fisheries. These effort and mortality data were significantly correlated ($r = 0.69$, d.f. $= 7$, $P = 0.05$). The intercept of the regression, 0.06, suggests that the value of M used in the initial calculations of F was slightly low (Fig. 5).

The success of this minor modification in analysis in demonstrating a relationship between effort and mortality encourages the view that more rigorous analysis would be successful in accurately describing this relationship.

POPULATION NUMBERS

Population numbers by age group in each year were also derived using Pope's technique of cohort analysis (Table 11).

Abundance of 3–14 year olds declined from 433 million in 1960 to 199 million in 1966 then increased to 313 million by 1968. These data are in good agreement with abundance by weight estimates from catch-per-effort data. The high population numbers in 1960-61 were largely due to large year class only partially recruited to the fishery. As these became more fully recruited, weight caught per trip increased, but subsequently decreased with the entry of poor year classes. The entry of better year classes in 1967 and 1968 reversed the trend of decreasing abundance by weight.

The year classes of 1958–63 were all of comparable strength varying from 45-65 million fish at age 3. The preceding three-year classes (at least), i.e. those of 1955–57, were more than twice as strong. The 1964 and 1965 year classes may also prove to be about twice as strong as those of the prededing six years.

GROWTH

In the above discussion increased growth rate in the post-1965 period has been brought forward in explaining several aspects of the data. Figure 6, showing substantial changes in mean length at age between 1960 and 1970, is presented to support these arguments.

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TABLE 1. ICNAF DIV. 4T-VN COD LANDINGS (METRIC TONS ROUND) BY COUNTRY AND DIVISION, 1960-70. (DIV. 4VN JANUARY-APRIL LANDINGS ONLY.)

Year	Canada (M)	Canada (N)	Spain	Portugal	France (M)	Others	Total	4T	4Vn
1960	40,451	3	8,526	3,927	13,276	240	66,423	43,022	23,401
1961	41,836	617	7,883	1,974	13,272	1	65,583	51,750	13,833
1962	50,331	1,243	6,941	2,700	5,213	236	66,664	53,218	13,446
1963	50,902	2,761	11,814	4,496	228	1	70,202	50,715	19,487
1964	43,792	6,201	8,583	-	1,356	615	60,547	41,618	18,929
1965	47,124	9,217	2,962	1,392	1,132	1,200	63,027	46,471	16,556
1966	42,852	4,813	2,185	138	3,806	1,057	54,851	38,248	16,603
1967	34,713	1,071	3,281	85	1,879	285	41,314	34,245	7,069
1968	39,721	3,960	2,317	25	130	398	46,551	37,910	8,641
1969	41,154	4,612	1,060	307	326	53	47,512	40,905	6,607
1970*	43,814	3,531	11,666	2,474	2,964	7	64,456	43,048	21,048

*Preliminary statistics.

TABLE 2. ICNAF DIV. 4T-VN COD LANDINGS (METRIC TONS ROUND) BY GEAR, 1960-70. (PERCENTAGE OF ANNUAL LANDINGS IN PARENTHESES.)

Year	Otter and pair trawls	Danish and Scottish seines	Long- and hand-lines	Gillnet	Total
1960	41,019 (62)	229 (<1)	25,171 (38)	4 (<1)	66,423
1961	42,808 (65)	716 (1)	21,888 (33)	171 (<1)	65,583
1962	43,526 (65)	1,475 (2)	20,517 (31)	1,146 (2)	66,664
1963	50,862 (72)	1,621 (2)	15,323 (22)	2,396 (3)	70,202
1964	45,325 (75)	1,985 (3)	10,237 (17)	3,000 (5)	60,547
1965	48,373 (77)	2,673 (4)	8,410 (13)	3,571 (6)	63,027
1966	36,684 (67)	2,391 (4)	6,362 (12)	9,414 (17)	54,851
1967	23,982 (58)	2,212 (5)	5,178 (13)	9,942 (24)	41,314
1968	28,217 (61)	982 (2)	4,419 (9)	12,933 (28)	46,551
1969	27,075 (57)	1,204 (3)	9,655 (20)	9,578 (20)	47,512
1970*	43,009 (67)	1,721 (3)	9,937 (15)	9,789 (15)	64,456

*Preliminary statistics.

TABLE 3. COMMERCIAL SAMPLES FROM THE DIV. 4T-VN COD STOCK, 1960-70.

ear	Country	Jan.-Apr. trawl			May-Aug. trawl			Sept.-Dec. trawl			Seine			Line			Gillnet		
		No. of Samp.	No. Meas.	No. Aged	No. of Samp.	No. Meas.	No. Aged	No. of Samp.	No. Meas.	No. Aged	No. of Samp.	No. Meas.	No. Aged	No. of Samp.	No. Meas.	No. Aged	No. of Samp.	No. Meas.	No. Aged
960	Portugal	9	1284	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Spain	21	9848	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Canada	-	-	-	12*	5490*	856*	*May-Dec. incl.			-	-	-	14	4533	477	-	-	-
961	Portugal	4	550	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	France(M)	10	541	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Canada	-	-	-	18	8125	819	5	1475	104	-	-	-	12	2428	217	1	589	-
962	Canada	2	850	123	15	7051	640	7	2062	209	3	932	185	7	2592	184	5	1554	69
963	Canada	3	1326	199	22	8832	553	11	4999	190	2	735	87	5	1103	-	4	368	-
964	Spain	5	1233	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Canada	8	2638	124	23	8886	614	6	2630	71	-	-	-	3	1275	-	-	-	-
965	Canada	8	2678	163	21	7787	645	13	4840	228	2	733	70	3	545	-	6	1023	-
966	Canada	7	2424	281	17	5006	457	13	3220	437	-	-	-	-	-	-	3	1065	-
967	Canada	2	806	106	17	3544	492	18	4379	572	1	345	27	1	195	-	2	448	-
968	Canada	2	661	128	19	4467	781	9	1848	467	-	-	-	-	-	-	2	554	-
969	Canada	4	1208	204	7	1399	287	7	1834	303	3	717	98	-	-	-	1	58	28
970	Canada	2	596	102	5	1274	206	4	730	148	8	1704	305	-	-	-	-	-	-

TABLE 4. DIV. 4T-Vn COD. MEAN AGE, LENGTH (CM), AND WEIGHT (KG) OF LANDINGS.

Year	Trawl Jan.-Apr. Mean Length	Trawl Jan.-Apr. Mean Age	Trawl May-Aug. Mean Length	Trawl May-Aug. Mean Age	Trawl Sept.-Dec. Mean Length	Trawl Sept.-Dec. Mean Age	Seine May-Dec. Mean Length	Seine May-Dec. Mean Age	Line May-Dec. Mean Length	Line May-Dec. Mean Age	Gillnet May-Dec. Mean Length	Gillnet May-Dec. Mean Age	All gears January-December Mean Length	All gears January-December Mean Age	All gears January-December Mean Weight
1960	53.7	6.0	54.9*	6.0*	-	-	-	-	62.5	6.9	-	-	56.3	6.2	1.73
1961	50.1	5.9	53.6	6.1	52.9	5.9	-	-	63.3	7.3	77.7	9.3	53.7	6.2	1.58
1962	53.9	6.8	51.2	6.1	50.6	5.6	49.4	5.9	57.7	6.6	67.9	7.5	53.2	6.3	1.44
1963	51.5	6.9	51.3	6.6	50.4	5.9	48.0	5.8	61.5	7.5	65.0	7.9	52.8	6.7	1.44
1964	49.5	7.1	53.0	6.9	50.9	6.3	-	-	69.6	8.4	80.6	9.4	52.8	7.0	1.48
1965	49.9	7.3	52.3	6.7	49.4	5.6	47.8	6.1	67.6	8.5	86.2	10.3	52.0	6.9	1.42
1966	50.1	5.9	53.2	6.3	50.1	4.8	-	-	67.6	8.0	92.1	10.8	53.2	6.1	1.57
1967	51.5	6.1	51.4	5.5	49.5	4.7	-	-	67.6	7.7	69.0	7.9	54.3	6.0	1.61
1968	53.1	6.2	48.1	5.1	50.1	4.8	-	-	67.5	7.7	72.0	8.4	53.8	5.9	1.62
1969	47.9	5.5	53.7	5.6	51.9	5.2	51.9	5.0	67.5	7.4	82.0	8.5	54.2	5.8	1.65
1970	51.8	5.9	50.6	5.6	54.1	5.6	49.7	4.9	67.5	7.4	75.9	8.4	54.4	6.1	1.61

*May-Dec. inclusive.

TABLE 5. DIV. 4T-Vn COD. NUMBERS LANDED $X10^{-3}$ PER AGE GROUP, 1960-70.

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
2	-	-	22	-	-	-	-	-	-	-	-
3	75	-	16	255	100	464	1498	700	310	327	26
4	3967	3304	1720	2123	970	5504	7055	7068	8140	4936	3395
5	8983	13921	10887	4352	6728	6148	10689	5503	8086	12530	14972
6	12515	9475	18889	16021	5863	9292	4505	4586	4674	3571	11925
7	7144	8313	7870	14742	12038	4481	3423	3040	2916	2516	4194
8	1736	2661	4290	6390	9261	8524	1841	1735	1276	2136	1905
9	795	777	1480	3108	3760	5534	2262	407	753	917	1444
10	1012	506	589	984	1133	1845	1890	1021	434	785	727
11	388	741	153	392	347	1004	867	901	899	212	569
12	279	385	178	137	149	423	357	383	698	283	360
13	76	188	37	102	103	150	242	171	259	292	239
14	93	174	26	37	88	52	76	82	139	55	139
15	51	33	36	50	24	124	42	23	65	21	30
16+	39	130	2	35	56	49	79	17	43	40	42
Total	37953	40608	46195	48728	40620	43594	34826	25637	28692	28621	39967

TABLE 9. DIV. 4T-VN COD. SURVIVAL RATES FROM DIV. 4T OTTER TRAWL CATCH AND EFFORT DATA

Years	A G E S 4-5	5-6	6-7	7-8	8-9	9-10	Mean (ages 7-10)	Σ8-13 / Σ7-12
1960-61	3.06	1.25	0.85	0.49	0.33	0.55	0.46	0.49
1961-62	4.80	1.65	0.63	0.39	0.35	0.46	0.40	0.36
1962-63	1.73	1.10	0.65	0.80	0.60	0.49	0.63	0.73
1963-64	2.48	1.01	0.62	0.51	0.56	0.59	0.55	0.53
1964-65	3.33	0.81	0.67	0.60	0.52	0.50	0.54	0.56
1965-66	0.86	0.44	0.29	0.44	0.25	0.28	0.32	0.30
1966-67	1.12	0.69	0.74	0.54	0.25	0.29	0.36	0.41
1967-68	1.22	0.60	0.51	0.52	0.57	0.66	0.58	0.55
1968-69	1.20	0.48	0.61	0.66	0.78	1.23	0.89	0.76
1969-70	2.14	0.76	0.55	0.34	0.57	0.78	0.56	0.48
Mean	-	-	-	0.53	0.48	0.58	0.53	0.52
							(Z=0.64)	(Z=0.66)

TABLE 10. DIV. 4T-VN COD. INSTANTANEOUS FISHING MORTALITY (F) BY AGE GROUP AND YEAR DERIVED BY POPE'S COHORT ANALYSIS

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	$\bar{F}$ 60-62	$\bar{F}$ 63-65	$\bar{F}$ 66-68	$\bar{F}$ 60-68
3	< .01	-	< .01	.01	< .01	.01	.03	.01	< .01	<.01	.01	.01	.01
4	.03	.03	.05	.05	.03	.12	.20	.17	.10	.04	.07	.16	.09
5	.15	.15	.15	.17	.21	.27	.37	.24	.29	.15	.22	.30	.22
6	.34	.24	.30	.34	.36	.50	.32	.26	.34	.29	.40	.31	.33
7	.50	.40	.32	.41	.46	.51	.34	.37	.27	.41	.46	.33	.40
8	.37	.35	.38	.46	.49	.71	.40	.29	.26	.37	.55	.32	.41
9	.39	.28	.34	.52	.54	.61	.40	.14	.20	.34	.56	.25	.38
10	.60	.45	.35	.40	.36	.56	.43	.32	.26	.47	.44	.34	.41
11	.39	.52	.24	.42	.24	.63	.57	.38	.52	.38	.43	.49	.43
12	.43	.86	.22	.35	.28	.50	.48	.54	.58	.50	.38	.53	.47
13	.20	.59	.17	.19	.48	.51	.61	.45	.88	.32	.39	.65	.45
14	1.14*	.94	.14	.26	.26	.48	.53	.43	.84	.54	.33	.60	.49
$\bar{F}$ 7-10	.47	.37	.35	.45	.46	.60	.39	.28	.25	.40	.50	.31	.40
$\bar{F}$ 11-14	.34	.73	.19	.31	.32	.53	.55	.45	.71	.44	.38	.57	.46
$\bar{F}$ 7-14	.41	.55	.27	.38	.39	.56	.47	.37	.48	.42	.44	.44	.43

* Omitted from averages.

TABLE 6. DISCARDS OF COD FROM THE DIV. 4T OTTER-TRAWL FISHERY, 1960-64, AS TOTAL NUMBERS PER AGE GROUP $X10^{-3}$.

	Age							
Year	1	2	3	4	5	6	7	Total
1960	-	12	212	620	101	2	1	948
1961	7	44	115	323	154	18	-	661
1962	-	4	223	292	197	14	1	731
1963	-	11	122	277	51	31	7	499
1964	-	2	200	98	18	3	4	325

TABLE 7. DIV. 4T-Vn COD. CATCH-PER-UNIT EFFORT, 1960-70

	Div. 4T	Div. 4Vn metric tons/hour	
Year	Metric tons/trip Gloucester class equivalents	Spanish otter trawlers	All countries Spanish O.T. equivalents
1960	8.1	1.37	1.58
1961	9.5	1.73	1.64
1962	10.9	1.97	1.92
1963	10.5	2.96	2.55
1964	9.2	2.83	2.63
1965	8.8	1.65	2.46
1966	6.4	1.08	2.30
1967	7.0	1.56	1.76
1968	9.1	1.23	2.37
1969	12.2	2.33	2.49
1970	12.8	2.13	2.07

TABLE 8. NUMBER OF COD CAUGHT PER TRIP AT AGE IN DIV. 4T OTTER-TRAWL FISHERY, 1960-70.

	Age												
Year	3	4	5	6	7	8	9	10	11	12	13	14+
1960	19	746	1317	1639	914	246	73	158	38	32	8	3
1961	-	605	2279	1647	1388	452	80	40	66	53	20	7
1962	-	473	2902	3760	1039	538	160	37	7	11	1	1
1963	41	594	817	3178	2454	836	325	78	45	12	15	5
1964	33	315	1474	824	1980	1254	472	192	31	20	7	15
1965	148	1552	1048	1189	551	1196	652	235	94	34	13	7
1966	374	1399	1327	458	342	244	303	184	57	28	15	9
1967	269	2076	1560	916	338	184	61	88	91	39	13	13
1968	156	3733	2528	929	470	175	104	40	79	35	10	14
1969	85	1659	4479	1224	565	308	136	128	22	59	34	17
1970	-	1764	3545	3416	672	194	177	106	31	41	36	18
Mean	-	-	2116	1744	974	512	231	117	51	33	16	-

TABLE 11. DIV. 4T-VN COD. POPULATION NUMBERS ($X10^{-3}$) BY AGE GROUP, 1960-70, DERIVED BY POPE'S COHORT ANALYSIS

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968
3	134,963	48,907	61,785	45,084	64,983	51,924	63,405	119,469	131,256
4	143,111	110,431	40,042	50,571	36,681	53.113	42.092	50,556	97.180
5	70,667	113,580	87,424	31,227	39,483	29,154	38,505	28,078	34,996
6	47,602	49,729	80,395	61,726	21,629	26,238	18,306	21,853	18,009
7	19,983	27,649	32,141	48,730	36,040	12,403	13,074	10,911	13,742
8	6,224	9,896	15,115	19,194	26,557	18,614	6,100	7,607	6,182
9	2,751	3,525	5,694	8,493	9,933	13,363	7,527	3,353	4,658
10	4,460	1,533	2,183	3,323	4,141	4,730	5,933	4,116	2,376
11	1,330	2,012	797	1,254	1,830	2,365	2,203	3,147	2,446
12	880	738	977	514	672	1,184	1,028	1,019	1,761
13	468	468	256	639	297	416	587	519	488
14	152	314	213	176	431	150	205	262	270
Totals									
4–14 incl.	297,628	319,875	265,237	225,847	177,694	161,730	135,560	131,421	182,108
3–14 incl.	432,591	368,782	327,022	270,931	242,677	213,654	198,965	250,890	313,364

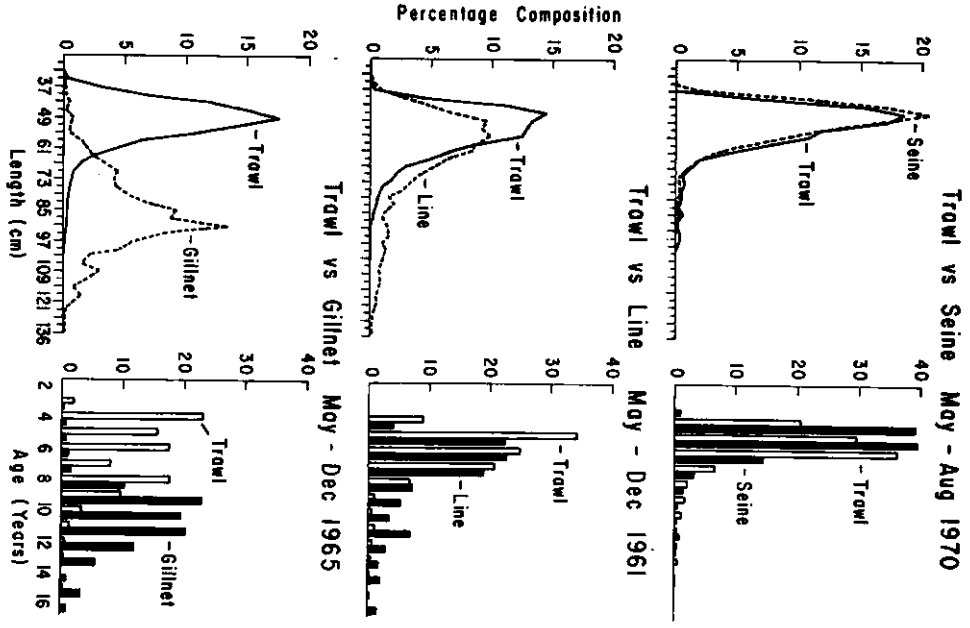

FIG. 1. Comparisons of Length and Age Compositions of Cod Landings by Gear Div 4T + 4VN

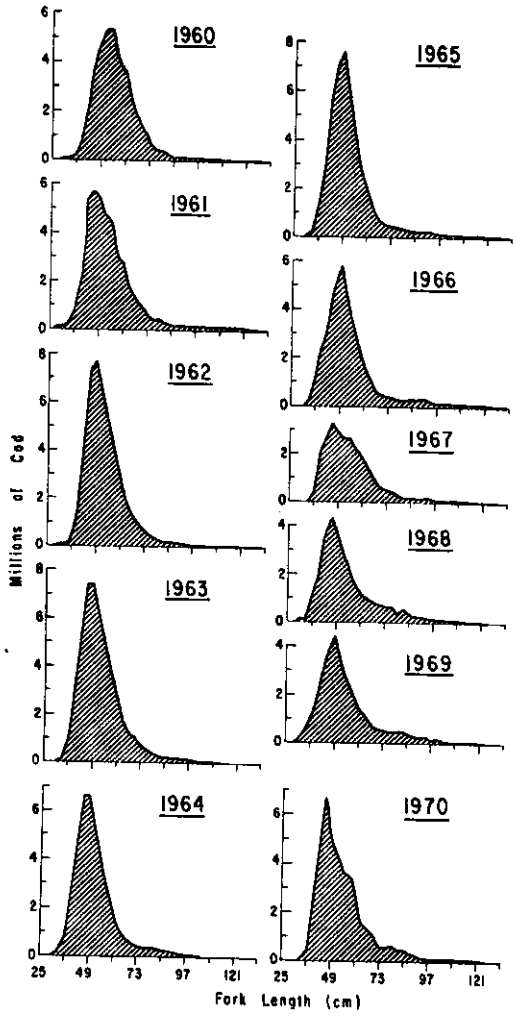

FIG. 2 Length Composition of Cod Landings, 1960-'70
Div 4T - 4V$_N$

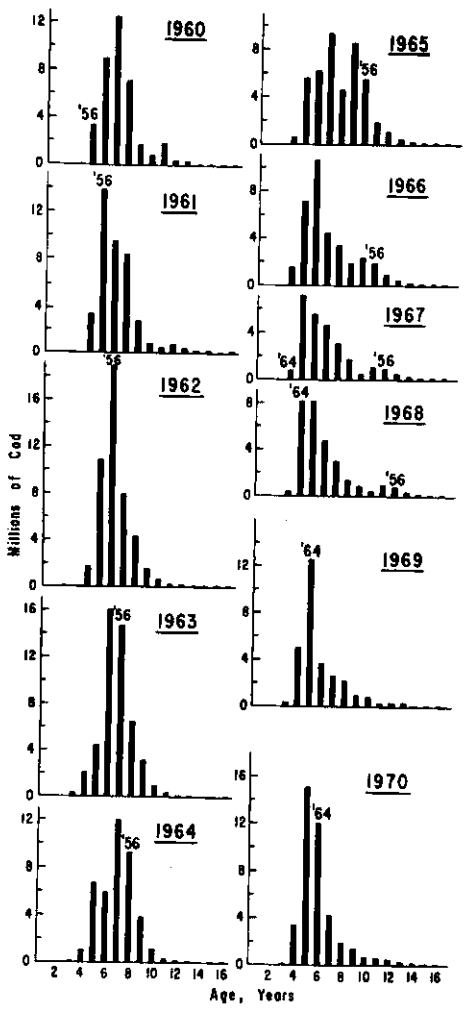

FIG. 3 Age Composition of Cod Landings, 1960-'70
Div 4T - 4V$_N$

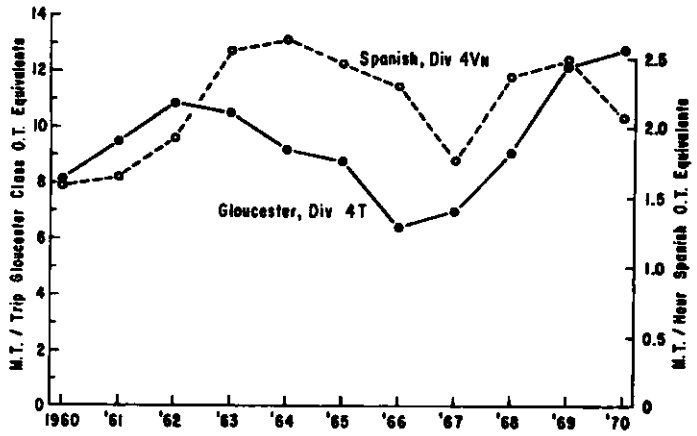

FIG. 4.

Div 4T - Vn COD
Catch per Unit Effort, 1960 - '70

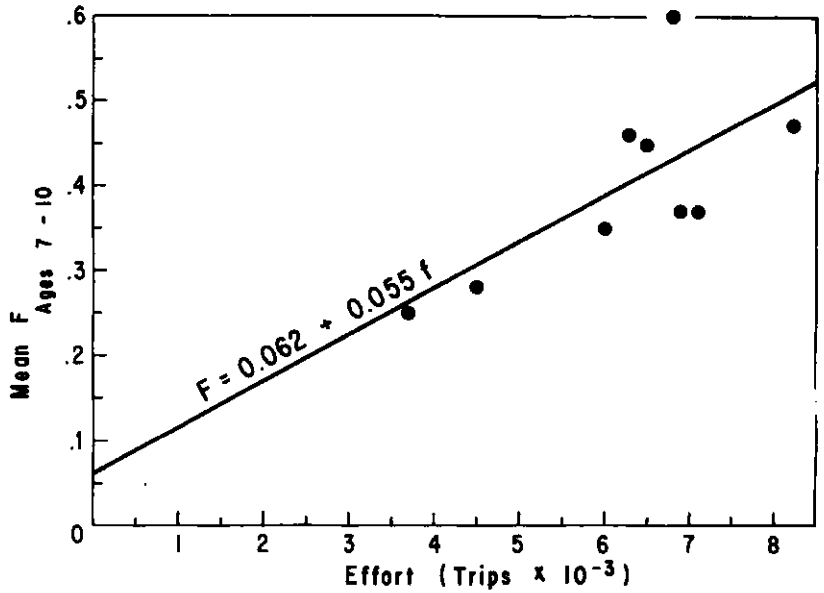

FIG. 5 DIV. 4T-Vn COD. THE REGRESSION OF FISHING MORTALITY, F, OF 7-10 YEAR OLDS ON FISHING EFFOPT.

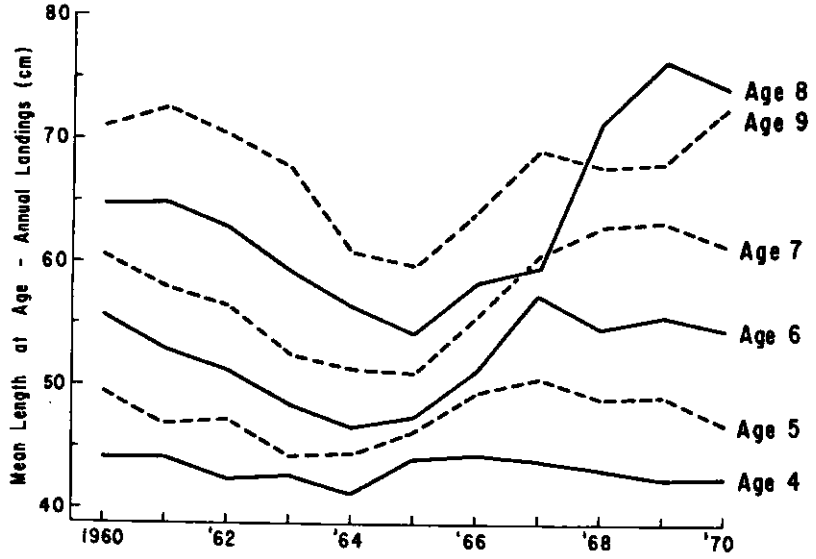

FIG. 6 DIV. 4T-Vn COD. MEAN LENGTH AT AGE IN ANNUAL LANDINGS FOR AGES 4-9, 1960-70.