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Eastern Scotian Shelf Cod (ICNAF Div. 4VsW)  
- a reconstruction of possible events in  
the fishery in 1958 to 1974 and  
a re-estimation of potential yield.

by

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INTRODUCTION

Assessment of the status of the cod stock complex in ICNAF Subdivision 4Vs and Division 4W has been hindered by the low level of biological sampling of commercial catches. Increased sampling efforts by Spain and the USSR in the 1970's established that the catches of these countries are substantially different in size and age composition from those of Canada. An earlier yield assessment of these stocks (Halliday, 1972) was based on the assumption that Canadian sampling data were representative of all removals from the stocks. Inconsistencies in the results of that analysis imply that the differences in size and age compositions seen in the sampling data for the early 1970's were important also in the 1960's.

In the present analysis, Country, Division, and seasonal stratifications are used in applying sampling data to catches in estimation of removals from the stocks. Available sampling data are inadequate to meet the demands of this detailed stratification and a variety of assumptions are required. The primary assumptions are that the size compositions of Spanish and USSR catches in the 1960's were similar to those in the 1970's.

## GROWTH

Halliday (1972) fitted a von Bertalanffy growth curve to average mean lengths of ages 6-10 cod in 1960-71 Canadian commercial samples from Div. 4Vs-W combined. New data, particularly from research vessel surveys, allow refinement of growth estimates.

Mean length at age from Canadian commercial sampling data were calculated for each of three 5 year periods for January to June and July to December samples from Div. 4Vs and Div. 4W separately (Table 1). Mean lengths at age are also available from Canadian research vessel surveys conducted in July of 1970-74 in Div. 4Vs and Div. 4W (Table 2).

There are no consistent trends in length at age with time. Decreases in the size of 4 and 5 year olds between 1960-64 and 1970-74 in January-June in both Div. 4Vs and Div. 4W and increases in the size of these age groups in July-December in Div. 4W may reflect trends in the average time of sampling within the six month periods. Thus, the mean lengths in commercial samples between 1960 and 1974 and in surveys from 1970 to 1974 were used in constructing growth curves. Commercial January-June data were taken as an estimate of length of, say, 3 year olds at age 3.25, survey data at age 3.50, and commercial July-December data at age 3.75. There is close agreement between commercial and survey lengths at age (Fig. 1). Div. 4W cod are slightly larger than Div. 4Vs cod of the same age after age 1.

Von Bertalanffy growth curves were fitted to data for ages 1.5 to 9.25 for Div. 4Vs cod and for ages 1.5 to 10.25 for Div. 4W cod giving the following parameters:

	<u>Div. 4Vs</u>	<u>Div. 4W</u>
K	0.15	0.14
$t_0$	-0.21	-0.07
$L_\infty$	89.9 cm	102.5 cm
( $W_\infty$ )	(7.12 kg)	(10.37 kg)

## YIELD PER RECRUIT

Beverton and Holt yield per recruit isopleth diagrams were constructed to examine the effects of differences in growth parameters between Div. 4Vs and Div. 4W (Fig. 2). No estimate of natural mortality (M) is available for these stocks. Thus a value of  $M = 0.20$ , which appears to be generally applicable to northwest Atlantic cod stocks, was assumed. Other parameters used in the calculations were as follows:

- $t_p$  : 1.0 yr (= age at recruitment to the fishing area)
- $t_p'$  : varied between 1.0 and 6.0 yrs (=age at recruitment to the exploited phase)
- $t_\lambda = 25$  yrs (= maximum age of significant contribution to the fishery)

Yield per recruit from Div. 4W cod is higher than that from Div. 4Vs cod for the same age at recruitment to the fishery and fishing mortality rate ( $F$ ). Over the range of  $t'_p$  and  $F$  likely to prevail in the fishery the difference is approximately 20%.

The yield isopleth diagram presented by Halliday (1972) for Div. 4VSW combined gives intermediate values to those for Div. 4Vs and Div. 4W presented here, but is most similar to that for Div. 4W and thus, probably overestimates the yield per recruit from the eastern Scotian Shelf cod as a whole.

#### NOMINAL CATCHES

Cod catches from Div. 4VSW have averaged 60,000 mt over the 15 year period 1960-74 (Table 3), but have been lower in most recent years (1970-74 average = 54,000 mt), 1974 catches being only 43,700 mt. Catches have been fairly equally distributed between Divisions. Spain has been the major exploiter of these stocks taking 61% of the yield over the last 15 years, followed by Canada taking 28%. Catches by the USSR have not exceeded 10,000 mt in any year and, except in 1963-66, have been less than 5,000 mt. Catches by France and Portugal were significant in the late 1950's, and moderately large catches by Denmark have occurred in the early 1970's. Catches in Table 3 for 1958 particularly, but also up to 1962, are subject to error, as not all countries reported their catches from Div. 4Vn and Div. 4Vs separately until 1963. The catch breakdown given by Hodder (MS 1972) is used here.

#### CATCH PER UNIT EFFORT

Halliday (1972) reviewed available catch per effort data for cod in Div. 4VSW and chose the catch rates of Spanish pair trawlers of 151-500 gross tons during their peak fishing period of February to April inclusive as the most useful indicator of cod abundance.

Catch rates of these vessels in Div. 4Vs increased from 1.37 mt/df (metric tons per day fished) in 1960 to a peak of 2.08 mt/df in 1965, declined in 1966 but increased to a peak of 2.36 mt/df, in 1968. Subsequently, catch rates steadily declined to 0.74 mt/df in 1973, the lowest catch rate in the 14 year data series (Table 4). In Div. 4W, catch rates fluctuated between 1.15 and 1.59 mt/df in 1960-67, then peaked sharply in 1968 at 2.39 mt/df. Catch rates then declined steadily to a low of 0.68 mt/df in 1972, with a slight increase to 0.87 mt/df in 1973.

Interpreting these data in terms of cod abundance, it is apparent that there has been a serious decline in the cod stocks of both Divisions in the early 1970's to levels substantially below those prevailing in the 1960's.

Catch rates were slightly higher in Div. 4Vs than in Div. 4W from 1960 to 1967, although the Div. 4W catch rate was the higher in four of the subsequent six years. There are similarities in overall trends, particularly in the exceptionally high catch rates in both areas in 1968 and in the sharp declines in the following years.

## ESTIMATED REMOVALS FROM THE STOCKS

### Methodology

Review of Canadian commercial sample age compositions by five year periods, Division, and season (Table 5) revealed substantial differences in age composition between Divisions and seasons and trends with time, catches in Div. 4Vs having a progressively older mean age from 1960-64 to 1970-74, while those from Div. 4W became progressively younger. Examination of Spanish commercial length frequencies for October, 1964, from Div. 4Vs and Div. 4W in the ICNAF Sampling Yearbook indicates that smaller fish were caught by Spain in this season than in February to April for which Spanish samples are available for 1960-62 and 1964. Soviet samples are available for their commercial catches in 1973 and 1974 indicating that the Soviet fleet takes much smaller and younger cod than either Canadian or Spanish fleets.

Thus, country, Division, and seasonal stratification of the catches are of major importance in weighting by samples to obtain age compositions of removals. Sampling data are inadequate to sustain this degree of stratification. It is, therefore, necessary to make a number of assumptions on the age composition of catches for which sampling is not available.

USSR sampling data for 1973 and 1974 are consistent in indicating that their catch is largely composed of age 2 and age 3 cod. Labeled as commercial catch samples, the catches were taken with 40 mm mesh nets presumably as a bycatch in the silver hake fishery. The larger cod catches by the USSR in the early 1960's are also entered in ICNAF Statistical Bulletins as bycatches to silver hake effort. It is assumed then, that all USSR catches of cod have had a similar age composition to those of 1973-74, and catches in 1961-72 were attributed to age groups on the basis of the average 1973-74 age composition.

Spanish sampling data are available for some months in 1960, 1961, 1962, and 1964. In summary, there are, for Div. 4W, nine samples in the January to June season, and nine in the July to December season. For Div. 4Vs, there are seven samples in January-June, and two in July-December. These samples, combined as just described, were applied to Spanish catch data for 1958 to 1967 (except for 1962 for which sufficient data were available not to require the use of samples from other years).

Spanish samples are also available for 1971, 1973, and 1974. These are all from the January to June period, and of 16 samples, only one is from Div. 4W. These samples were applied to Spanish catches in January-June of the respective years in which they were collected. For 1972, the average of 1971 and 1973 samples was applied to catches. For 1968-70, the January-June catches were weighted by all 16 of the 1971-74 samples combined. In 1968-74, no samples were available for the July to December period, and Spanish catches were weighted by Canadian samples from the appropriate season and year.

Canadian sampling data is also sparse but distributed fairly evenly among years, Divisions, and seasons. Canadian Div. 4Vs catches are almost entirely taken by otter trawl but insufficient sampling data are available to weight catches by season. Thus, all Div. 4Vs catches

in a particular year were weighted by all the samples for Div. 4Vs in that year (except 1958, 1959, and 1971 when seasonal weighting was possible). Available samples ranged from one to ten. In two years, 1961 and 1969, when no samples were available, the averages of adjacent years were used.

Canadian catches in Div. 4W were predominantly by otter trawl between 1960 and 1968 but other, primarily inshore gears, were catching approximately 5,000 mt of cod annually during this period. Since 1968, gears other than otter trawls have taken the larger share of the catch and by 1974 only 22% of the Canadian Div. 4W catch was taken by otter trawlers (Table 6).

Almost all available sampling data are from otter trawl catches and it has been necessary to assume that catches of other gears had similar age compositions (in all years except 1974 when longline and hand-line samples were available). The degree of error introduced by this assumption can be judged from the comparisons in Table 7.

A seasonal breakdown was possible for Canadian Div. 4W catches, sampling gaps in the July-December period in 1961, 1964, and 1970 being filled by averaging samples from adjacent years for the same season.

The small catches of other countries are assumed to have had the same age composition as those of Canada. USSR samples are of length frequencies only. The season of capture was similar to that of Canadian research vessel survey operations. Thus Canadian survey age length keys for the appropriate years were used to obtain age compositions for USSR catches.

Spanish samples include age data but discrepancies between Spanish and Canadian ageing for cod in this area are substantial (Lopez-Veiga *et al.*, MS 1975). For consistency, Canadian ageing data were used throughout, the appropriate Canadian age length-key for a particular Division, year and season being applied to Spanish length frequency data.

## Results

Assuming USSR catches have been consistently of 2 and 3 year old fish, removals by the USSR were about  $23 \times 10^6$  fish in 1963, declining in the late 1960's but increasing to about  $11 \times 10^6$  in 1971 and 1972, then declining to about  $6.8 \times 10^6$  in 1974.

Removals by Spain increased from  $7.6 \times 10^6$  fish in 1958 to  $25.7 \times 10^6$  by 1963, fluctuating around this level until 1968 when they increased to  $38.8 \times 10^6$ . Removals have since declined to a low of  $19.3 \times 10^6$  by 1974.

Canadian removals fluctuated between  $8 \times 10^6$  and  $10 \times 10^6$  fish in 1958-64, increasing to  $15 \times 10^6$  in 1965. Subsequently, they varied between  $6.8 \times 10^6$  and  $13.6 \times 10^6$  fish, the lowest number being removed in 1974.

Total removals increased from  $19.5 \times 10^6$  in 1958 to  $57.1 \times 10^6$  in 1963, declining until 1968 when removals peaked at  $64.2 \times 10^6$ . They remained over  $40 \times 10^6$  until 1974 when  $34.5 \times 10^6$  fish were removed (Table 8).

#### RESEARCH VESSEL SURVEYS

Canada has conducted stratified-random groundfish surveys in Div. 4VsW since 1970. Estimates of population numbers at age from these surveys are very variable (Table 9). Relative year class strengths appear more stable than absolute abundance estimates, the 1966 and 1968 year classes consistently showing up as being stronger than those adjacent to them. It is possible that either the 1971 or 1972 year class is stronger than adjacent year classes.

It appears from Table 8 that cod of age 6, and in most recent years age 5, are fully recruited to the fishery. Estimates of F from survey data for fully recruited age groups are very variable. The average F for the period 1970-74 is estimated to be about  $F = 0.60$  (Table 9).

#### FISHING MORTALITY FROM COHORT ANALYSIS

Using the data from Table 8, several trial runs of cohort analysis were performed using different assumptions for F in 1974. It became apparent that F in 1972 and 1973 was high. Thus, a value of  $F = 0.60$  was chosen for fully recruited age groups in 1974, being the value obtained from research vessel surveys and a likely conservative estimate of 1974 mortality. The selection pattern at age in 1974 was taken as the average selection pattern in 1972 and 1973. The values used were:

Age	1	2	3	4	5+
Percentage selection	1	12	30	51	100

giving the results shown in Table 10. The population number at age estimates also obtained from this calculation are given in Table 11.

F on ages 4 and older (weighted by population numbers at age) increased from  $F = 0.23$  in 1958 to  $F = 0.50$  by 1965. A further peak in F occurred in 1968 ( $F = 0.57$ ). Lower values in 1969 to 1971 were followed by high F's of  $F = 0.60$  in 1972 and  $F = 0.67$  in 1973.

F on ages greater than age 4 were considerably higher than these means. F of 3 year olds ranged from  $F = 0.04$  to  $F = 0.25$ . F of 2 year olds was negligible until 1963 when it reached  $F = 0.16$ , was low in the mid-1960's, increasing again in 1971 and 1972 to  $F = 0.12$ .

### POPULATION SIZE FROM COHORT ANALYSIS

Population estimates of age 1+ cod increase from  $359 \times 10^6$  fish in 1958 to  $425 \times 10^6$  fish in 1966, then decline steadily to  $280 \times 10^6$  by 1974 (Table 11). Estimates for cod age 4 and older increase from  $95 \times 10^6$  in 1958 to  $132 \times 10^6$  in 1961. This is followed by a decline through 1965 ( $99 \times 10^6$ ) and then a second increase to  $128 \times 10^6$  by 1970. Subsequent to 1970 a substantial decline occurs to  $68 \times 10^6$  by 1974.

The data imply that there was a six year period, 1962-67, when the strength of year classes at one year old (i.e., the 1961-66 year classes) was over  $100 \times 10^6$  fish. The average strength was  $125 \times 10^6$  and the strongest year class was  $146.5 \times 10^6$ , that of 1965. The subsequent five year classes, those of 1967 to 1971, were all poorer, averaging  $84 \times 10^6$  fish.

Comparing estimated changes in population from cohort analysis with changes in abundance estimated from Spanish catch per effort data (Table 4), there are apparent inconsistencies. The high catch rates in 1968 should be reflected by a substantial increase in population estimates of fish age 3 and older. While some increase is shown in the population estimates, the increased catches of 1968 are reflected to a large extent as an increase in mortality (Table 10).

It is apparent that the demands placed on the sampling data were too great, and it has not been possible to obtain sufficient resolution to allow detailed interpretation of historical events. It is likely that an extremely strong year class entered the Spanish fishery in 1968, most likely that of 1965. This is substantiated by the fact that the Canadian fishery, which was based largely on age 4 and 5 fish, did not show an increase in catch rates (Halliday, 1972). In the cohort analysis, the strength of this year class has been spread over a number of adjacent year classes.

It is likely, then, that there has been considerably more fluctuation in year class strength than suggested by this analysis.

In the 1970 to 1974 period sampling coverage was substantially improved over that of the 1960's. It is encouraging that, in this period, Spanish catch rates and cohort analysis are in agreement, but unfortunate that they both indicate that there has been a substantial decline in population abundance.

### AGE AT RECRUITMENT

The selection at age estimated from the fishing mortalities calculated by cohort analysis for 1972 and 1973 are given above. Due to the quite different selection patterns of the major fishery components, these data give an asymmetrical selection ogive. The mean selection age was estimated graphically by equalisation of the areas under the lower and above the upper parts of the curve (e.g., Gulland, 1969) giving a mean selection age of 3.5 yrs. Similar calculations for the period 1969 to 1971 gave a value of 3.95 yrs.

### DISCUSSION

Both Spanish commercial catch rates and cohort analysis indicate that there has been a substantial decline in stock abundance in the 1970's. There also appears to have been a decrease in average recruitment during this period.

The mean age at recruitment decreased between 1969-71 and 1972-73 from almost 4.0 yrs to 3.5 yrs,  $F$  associated with maximum yield per recruit at a mean selection age of 3.5 yrs is  $F_{max} = 0.34$  for Div. 4Vs and  $F_{max} = 0.30$  for Div. 4W. This contrasts with the calculated mortality on fully recruited age groups (age 5+) in 1972-73 of  $F = 0.80$ . The 1969-71 mean selection age of 4.0 yrs is associated with  $F_{max} = 0.40$  for Div. 4Vs, and  $F_{max} = 0.36$  for Div. 4W while the average  $F$  in 1969-71 was 0.55 (ages 6+). Thus, the stocks have been exploited at levels above  $F_{max}$  for at least the last six years. With the 1972-73 selection pattern, a reduction in effort of approximately 60% is required to reduce mortality to  $F_{max}$ . A long-term increase in yield per recruit of approximately 10% could be anticipated. A reduction in the number of small fish caught, if this increased the mean selection age from 3.5 yrs to 4.5 yrs could increase yield per recruit by a further 10% and require a less severe reduction in effort.

It has not, as yet, proved possible to utilise research vessel survey data to predict likely recruitment success. It appears from cohort analysis, for which the most recent years are likely to be moderately reliable, that recent recruitment has ranged from about  $73 \times 10^6$  to  $100 \times 10^6$  fish at age 1 (Table 11). It is assumed in Table 11 that the 1972 and 1973 year classes are also of that order of magnitude ( $85 \times 10^6$  fish). The less reliable long-term (1957-72 year class) average from cohort analysis is  $108 \times 10^6$  fish.

Catch projections were performed using the 1972-73 selection at age and the following mean weights at age which are those observed in 1974 catches:

<u>Age</u>	<u><math>\bar{W}</math>(kg)</u>	<u>Age</u>	<u><math>\bar{W}</math>(kg)</u>	<u>Age</u>	<u><math>\bar{W}</math>(kg)</u>
1	0.14	5	1.61	9	4.06
2	0.31	6	2.11	10	4.71
3	0.70	7	2.70	11	5.25
4	1.08	8	3.60	12	5.55

Yield from Div. 4VsW has, on average over the last 17 years, come almost equally from the two Divisions. Research surveys over the last five years also indicate that, on average, the biomass of cod in Div. 4Vs and Div. 4W is similar. Thus, an unweighted average of  $F_{max}$  for the two Divisions is taken as a management objective. This implies  $F_{max} = 0.32$

for the selection pattern of 1972-73 and  $F_{\max} = 0.38$  for that of 1969-71. A value of  $F_{\max} = 0.35$  is chosen as representative of average conditions over the last six years, and is used as 1976 management objective, assuming that objective is to maximise yield per recruit.

An alternative objective is to set  $F$  at some value less than  $F_{\max}$  resulting in some loss of yield but also reductions in the cost of fishing. Thus, the implications of setting  $F$  at  $F_{0.1}$  which in this case is about  $F = 0.20$  is also investigated.

The 1975 TAC for Div. 4VsW cod is 60,000 mt. If the strength of 1972 and subsequent year class are similar to the recent average of  $85 \times 10^6$  at age 1, the 1975 TAC will generate an  $F = 0.80$  (Table 12). If these year classes approximate the long-term average of  $103 \times 10^6$ , 1975  $F = 0.75$ . The implications for 1976 of these two recruitment assumptions are summarised in Table 12. For the lower, fishing at  $F_{\max}$  in 1976 would yield 28,000 mt, for the higher, 31,000 mt. The long-term catches fishing at  $F_{\max}$  are 51,000 mt and 62,000 mt depending on recruitment assumptions. If the management decision is taken to reduce fishing to  $F_{0.1}$  in 1976, the appropriate catch is 17,000-19,000 mt. The long-term effects of fishing at  $F_{0.1}$  are to reduce potential yields by 10%, but the effort required to harvest this lesser yield is approximately 40% less than required to fish at  $F_{\max}$ .

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Table 1. Div. 4Vs-W cod. Mean length (cm) at age in Canadian commercial samples. Parentheses indicate representation in catch is less than 1%.

<u>4Vs Jan.-June</u>		AGE							
<u>Period</u>	3	4	5	6	7	8	9	10	
1960-64	(46.0)	47.0	53.3	56.7	63.6	62.3	63.2	(74.7)	
1965-69	37.5	45.7	52.1	55.9	61.3	60.2	63.4	66.1	
1970-74	(42.2)	44.2	50.7	55.9	61.5	65.0	72.6	75.9	
	(41.9)	45.6	52.0	56.2	62.1	62.5	66.4	(72.2)	
 <u>4Vs July-Dec.</u>									
1960-64	40.6	48.3	52.6	63.4	72.7	71.3	81.3	(94.0)	
1965-69	39.3	46.9	52.1	57.3	67.0	(73.4)	(85.0)	-	
1970-74	43.8	47.4	53.9	62.1	63.1	75.6	82.2	88.9	
	41.2	47.5	52.9	60.9	67.6	73.4	(82.8)	(91.5)	
 <u>4W Jan.-June</u>									
1960-64	(47.1)	49.8	55.7	60.6	65.1	69.0	76.2	87.7	
1965-69	42.8	48.9	54.7	60.4	67.0	74.2	79.8	86.5	
1970-74	39.0	45.6	51.6	57.5	63.4	64.8	67.7	77.4	
	(43.0)	48.1	54.0	59.5	65.2	69.3	74.6	83.9	
 <u>4W July-Dec.</u>									
1960-64	46.4	49.5	54.6	62.9	69.5	74.6	(87.3)	(81.4)	
1965-69	45.0	50.6	56.9	64.1	75.9	(82.5)	(86.0)	(73.2)	
1970-74	45.8	51.3	57.2	59.4	63.8	64.0	(92.8)	(77.6)	
	45.7	50.5	56.2	62.1	69.7	(73.7)	(88.7)	(77.4)	

Table 2. 4Vs-W cod. Research vessel survey mean length (cm) at age. Parentheses indicate representation in catch is less than 1%.

Div.	Year	AGE								
		1	2	3	4	5	6	7	8	9
4Vs	1970	(16.8)	26.2	40.3	48.3	53.5	58.6	64.3	(65.0)	-
	1971	-	28.6	36.3	44.1	52.1	57.0	56.6	62.9	(70.0)
	1972	(22.9)	31.8	41.9	44.8	53.0	57.1	57.0	(63.3)	(91.0)
	1973	21.6	31.5	41.2	47.9	55.9	-	-	-	-
	1974	21.1	31.1	38.4	47.0	53.1	58.8	(62.6)	67.5	(67.0)
	1970-4 ave.	21.4	29.8	39.6	46.4	53.5	57.9	59.3	65.2	-
4W	1970	20.6	35.7	45.7	51.7	59.3	69.4	77.8	(77.0)	(79.0)
	1971	16.7	24.6	38.7	51.2	56.1	59.9	67.1	67.8	74.9
	1972	19.7	31.3	43.2	55.0	59.7	65.9	(82.0)	(79.0)	(98.0)
	1973	21.6	29.5	38.9	48.0	52.1	(61.1)	(60.2)	(88.0)	-
	1974	20.3	32.2	38.6	47.5	54.5	(62.5)	(70.5)	(61.9)	(62.6)
	1970-4 ave.	19.8	30.7	41.0	50.7	56.3	65.1	72.5	67.8	74.9

Table 3. Div. 4Vs-W Cod - Nominal Catches (m.t.)

<u>Year</u>	<u>Canada</u>	<u>France</u>	<u>Portugal</u>	<u>Spain</u>	<u>USSR</u>	<u>Others</u>	<u>Total</u>	<u>Div. 4Vs</u>	<u>Div. 4W</u>	<u>Catch Quota</u>
1958 <sup>1/2</sup>	17,938	4,577	1,095	14,857	-	124	38,591	23,790	14,801	-
1959 <sup>1/2</sup>	20,069	16,378	8,384	19,999	-	1,196	66,026	47,063	18,963	-
1960 <sup>1/2</sup>	18,390	1,018	1,720	29,391	-	126	50,645	27,689	22,956	-
1961 <sup>1/2</sup>	19,697	3,252	2,321	40,884	113	42	66,309	34,237	32,072	-
1962 <sup>1/2</sup>	17,579	2,645	341	42,146	2,383	60	65,154	26,350	38,804	-
1963	13,144	72	617	44,528	9,505	307	68,173	27,566	40,607	-
1964	14,330	1,010	-	39,690	7,133	1,094	63,257	25,496	37,761	-
1965	23,104	536	88	39,280	7,856	124	70,988	36,713	34,275	-
1966	17,690	1,494	-	43,157	5,473	356	68,170	27,163	41,007	-
1967	18,464	77	102	33,934	1,068	512	54,157	26,607	27,550	-
1968	24,888	225	-	50,418	4,865	29	80,425	48,781	31,644	-
1969	14,188	217	-	32,305	2,783	664	50,157	22,309	27,848	-
1970	11,818	420	296	41,926	2,521	446	57,427	28,632	28,795	-
1971	17,064	4	18	30,864	4,506	107	52,563	24,128	28,435	-
1972	19,987	495	856	28,542	4,646	7,119	61,645	36,533	25,112	-
1973	15,929	922	849	30,883	2,918	2,569	54,070	23,401	30,669	60,500
1974 <sup>1/2</sup>	10,701	29	1,464	27,380	3,097	1,075	43,746	19,597	24,149	60,000

<sup>1/2</sup> Nominal catches reported as Div. 4V assigned as Res. Doc. 72/57.

<sup>1/2</sup> Preliminary statistics.

Table 4. Div. 4VsW cod. Catch rates (metric tons per hour fished) of Spanish 151-500 gross ton pair trawlers in the February to April period, 1960-73.

<u>Year</u>	<u>Div. 4Vs</u>	<u>Div. 4W</u>
1960	1.37	1.22
61	1.53	1.51
62	1.45	1.24
63	1.72	1.40
64	1.77	1.32
1965	2.08	1.15
66	1.70	1.59
67	1.83	1.51
68	2.36	2.39
69	1.60	1.80
1970	1.61	1.45
71	1.18	1.32
72	1.12	0.68
1973	0.74	0.87

Table 5. Div. 4Vsw cod. Percentage age compositions in Canadian commercial samples.

4Vs Jan. - June

	Mean age	2	3	4	5	6	7	8	9	10	11	12+
1960-64	5.7	-	0.9	25.6	23.5	22.8	11.0	11.7	2.9	0.8	0.4	0.5
1965-69	5.7	0.1	4.0	23.5	30.1	17.8	9.2	6.6	3.9	2.8	1.3	0.8
1970-74	6.3	-	0.5	12.4	27.6	24.1	13.9	12.9	3.8	2.2	1.1	1.8

4Vs July-Dec.

1960-64	4.8	1.1	12.0	32.9	39.1	4.7	2.2	5.9	1.3	0.3	0.3	0.3
1965-69	5.0	-	1.8	25.2	52.4	17.9	1.7	0.7	0.3	-	-	-
1970-74	5.7	-	12.5	13.6	29.5	15.6	14.2	7.0	3.0	2.8	0.6	1.1

4W Jan.-June

1960-64	6.4	-	0.4	7.5	25.7	25.0	18.7	13.5	5.6	1.4	1.0	1.1
1965-69	5.9	-	2.5	18.6	27.2	26.5	10.8	6.2	3.9	1.9	1.3	1.3
1970-74	5.8	-	2.1	18.6	34.7	15.4	11.9	9.6	4.6	1.3	1.6	0.3

4W July-Dec.

1960-64	4.7	-	13.7	37.8	26.8	12.5	5.9	2.3	0.4	0.4	0.1	0.1
1965-69	4.5	0.2	16.1	42.8	26.5	9.9	2.3	1.0	0.5	0.7	0.1	0.1
1970-74	3.8	10.6	35.2	33.0	10.8	6.0	2.8	1.4	+	0.2	-	+

Table 6. Div. 4Vs-W cod. Canadian nominal catches by otter trawls and other gears.

Year	Div. 4Vs		Div. 4W	
	Trawls	Other gear	Trawls	Other gear
1958	4258	2092	4892	5731
59	4181	1286	7294	7308
1960	1924	750	10228	5488
61	1135	136	12895	5531
62	1495	93	11762	4229
63	1258	34	7779	4063
64	2059	41	7324	4906
1965	7366	106	10293	5338
66	6375	156	6614	4545
67	6729	132	6463	5140
68	9501	66	8367	6954
69	3539	51	4424	6174
1970	3054	22	3596	5146
71	5826	41	4745	6452
72	9856	119	4732	5280
73	6397	77	4723	4731
1974	4640	60	1343	4658

Table 7. Div. 4VSW cod. Percentage age compositions of otter trawl versus long line and hand line caught cod in Canadian catches from Div. 4W.

Year	Season	Gear	AGE												Mean age	Mean length
			2	3	4	5	6	7	8	9	10	11	12+			
1959	Jan.-June	Hand line	-	0.4	8.4	13.3	16.5	16.5	13.4	7.7	12.3	6.2	5.3	7.5	71.6	
1959	Jan.-June	Otter trawl	-	0.6	6.1	11.9	10.8	33.2	9.4	6.1	16.7	2.8	2.4	7.4	67.2	
1964	Jan.-June	Long line	-	-	-	18.9	11.9	23.1	20.2	20.2	3.2	1.7	0.8	7.3	54.5	
1964	Jan.-June	Otter trawl	-	-	0.8	17.9	14.9	18.4	17.7	17.0	6.8	3.2	3.3	7.5	71.5	
1968	July-Dec.	Longline	-	1.0	17.8	21.0	40.3	9.7	6.8	2.5	0.5	0.4	-	5.8	56.6	
1968	July-Dec.	Otter trawl	1.8	32.2	31.8	22.9	8.3	1.8	0.8	-	0.2	-	0.2	4.2	53.0	
1969	July-Dec.	Longline	-	0.4	14.5	28.8	24.4	17.2	6.6	1.3	0.8	1.7	4.3	6.2	58.0	
1969	July-Dec.	Otter trawl	-	19.1	40.0	28.6	8.0	1.4	1.7	1.2	-	-	-	4.6	51.5	
1974	July-Dec.	Longline	2.0	25.0	31.3	20.6	7.3	4.2	5.6	2.4	1.1	0.4	0.1	4.6	55.1	
1974	July-Dec.	Otter trawl	1.6	45.7	38.2	11.3	1.6	0.5	1.1	-	-	-	-	3.7	49.9	

G 3

✓Includes handline sample

Table 8. 4Vs-W Cod. Removals x 10<sup>3</sup>

Age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	-	-	-	22	459	1832	1375	1514	1055	206	938	536	486	869	896	533	557
2	138	-	-	139	2928	11681	8874	9667	6726	2057	6120	3420	3488	6025	8261	4763	3298
3	2854	2499	7016	3350	4063	9120	8855	12250	10269	4858	10990	4010	5558	6634	8095	11111	8614
4	3534	8887	6118	9571	9978	10844	7862	11321	12660	7733	16616	13055	14196	8065	12245	6792	9217
5	2533	8811	6655	9334	6253	10441	11423	4953	10139	9370	15245	10026	13472	8449	9289	9441	7024
6	3726	6490	4525	6676	7887	5423	4596	6130	4461	4338	8297	6073	4539	10262	8780	3818	2718
7	1610	4384	2811	2885	2744	4875	2874	3135	3256	1467	3482	2144	1942	5160	3432	2979	944
8	1465	1467	1827	1882	2538	2183	2345	4477	1590	1239	895	510	759	1849	1919	3717	1320
9	2014	878	290	1212	686	346	1047	2127	856	664	816	237	236	496	358	1164	413
10	859	1101	133	169	478	134	312	1583	496	647	361	50	72	114	393	273	369
11	543	318	122	147	169	121	145	172	666	325	152	95	137	131	79	299	15
12	58	251	75	88	75	50	75	91	24	65	211	58	56	72	2	3	5
13	51	27	1	66	68	26	50	96	14	16	33	12	9	98	37	7	-
14	11	-	15	3	-	-	-	88	-	5	17	7	12	12	-	5	-
15	10	-	-	-	5	-	-	163	2	7	1	2	4	51	1	5	-
16+	53	21	6	-	-	1	11	7	1	2	10	2	3	17	1	20	-
<b>Totals</b>	19459	35134	29594	35544	38331	57077	49944	57774	52215	32999	64184	40237	44969	48304	53788	44930	34494

Table 9. Div. 4Vs  $\bar{3}$  W cod - survey population estimates (nos. at age x  $10^{-3}$ ) and mortality of fully recruited age groups

<u>Age</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
1	1,480	1,539	6,210	16,128	6,084
2	16,388	7,680	9,657	122,779	32,961
3	5,250	35,664	9,635	104,965	19,246
4	7,669	8,027	33,848	59,948	5,623
5	3,735	15,803	5,571	22,524	2,017
6	1,217	5,771	6,111	1,870	2,244
7	1,502	3,459	1,688	2,907	372
8	462	1,475	547	901	563
9	104	638	495	431	224
10+	711	471	153	910	340
Totals	38,518	80,531	73,915	333,363	69,574
$\bar{F} =$ 5+	-0.62	0.92	0.53	1.67	Mean = 0.63
$\bar{F} =$ 6+	-0.61	1.21	0.37	1.41	Mean = 0.60

Table 10. Div. 4Vs-W Cod - estimated fishing mortality.

Age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	197
1	-	-	-	-	-	0.02	0.01	0.01	0.01	-	0.01	0.01	0.01	0.01	0.01	(0.01)	(0.0
2	-	-	-	-	0.06	0.16	0.10	0.11	0.07	0.02	0.07	0.07	0.06	0.12	0.12	0.07	(0.0
3	0.05	0.04	0.12	0.06	0.07	0.25	0.17	0.20	0.17	0.07	0.14	0.06	0.15	0.15	0.23	0.24	0.1
4	0.11	0.20	0.12	0.23	0.26	0.27	0.35	0.34	0.32	0.19	0.36	0.24	0.34	0.33	0.47	0.31	0.3
5	0.13	0.42	0.23	0.28	0.24	0.48	0.50	0.39	0.59	0.42	0.69	0.38	0.41	0.35	0.79	0.83	0.6
6	0.26	0.56	0.40	0.38	0.40	0.33	0.41	0.56	0.73	0.55	0.83	0.66	0.30	0.64	0.74	0.92	0.6
7	0.40	0.57	0.51	0.48	0.27	0.46	0.29	0.54	0.66	0.57	1.26	0.53	0.46	0.66	0.46	0.61	0.6
8	0.60	0.80	0.49	0.79	1.08	0.36	0.42	1.04	0.59	0.57	0.85	0.61	0.36	1.11	0.55	1.47	0.6
9	0.73	0.91	0.35	0.72	0.78	0.39	0.29	0.88	0.56	0.53	0.97	0.57	0.64	0.42	0.66	0.77	0.6
10	0.85	1.27	0.32	0.36	0.70	0.33	0.75	0.96	0.51	1.17	0.63	0.13	0.34	0.74	0.71	2.05	0.6
11	1.02	0.92	0.43	0.72	0.75	0.38	0.72	1.38	1.76	0.77	1.01	0.33	0.63	2.27	2.74	3.15	0.6
Weighted mean 4+	0.23	0.38	0.29	0.32	0.32	0.36	0.40	0.50	0.48	0.34	0.57	0.34	0.37	0.47	0.60	0.67	0.4

Table 11. Div. 4Vs-W Cod - estimated population numbers x 10<sup>-6</sup>

Age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	104.1	92.9	99.9	72.8	109.4	126.8	122.3	129.8	146.5	114.7	73.0	82.0	73.5	99.5	93.1	(85.0)	(85.1)
2	91.3	85.2	76.0	81.8	59.6	89.2	102.2	98.9	104.9	119.0	93.8	58.9	66.7	59.8	80.7	75.4	(69.1)
3	68.2	74.7	69.8	62.2	66.9	46.1	62.5	75.6	72.2	79.8	95.6	71.2	45.1	51.4	43.5	58.6	57.1
4	38.5	53.3	58.9	50.8	47.9	51.1	29.5	43.1	50.8	49.8	61.0	68.3	54.7	31.9	36.1	28.3	37.1
5	23.1	28.3	35.6	42.7	32.9	30.2	32.0	17.1	25.1	30.2	33.8	34.9	44.1	31.9	18.8	18.5	17.1
6	17.8	16.6	15.2	23.1	26.5	21.3	15.3	15.9	9.5	11.3	16.2	13.9	19.5	23.9	18.5	7.0	6.1
7	5.4	11.2	7.7	8.4	12.9	14.5	12.5	8.3	7.4	3.7	5.4	5.8	5.9	11.8	10.3	7.2	2.1
8	3.6	2.9	5.2	3.8	4.2	8.1	7.5	7.7	3.9	3.1	1.7	1.2	2.8	3.0	5.0	5.3	3.1
9	4.3	1.6	1.1	2.6	1.4	1.2	4.6	4.0	2.2	1.8	1.5	0.6	0.6	1.6	0.8	2.4	1.1
10	1.7	1.7	0.5	0.6	1.0	0.5	0.7	2.9	1.4	1.0	0.9	0.4	0.3	0.2	0.9	0.3	0.1
11	0.9	0.6	0.4	0.3	0.4	0.4	0.3	0.3	0.9	0.7	0.3	0.4	0.3	0.2	0.1	0.3	-
<u>Total 4+</u>	95.3	116.2	124.6	132.3	127.2	127.3	102.4	99.3	101.2	101.6	120.8	125.5	128.2	104.5	90.5	69.3	68.1
<u>Total</u>	358.9	369.0	370.3	349.1	363.1	389.4	389.4	403.6	424.8	415.1	383.2	337.6	313.5	315.2	307.8	(288.3)	(279.1)

Table 12. Div. 4VSW cod. Implications of management options for 1976.

Recruitment 1972 and subsequent Year classes	1975 F	1976 F	1976 catch(mt)	Long-term catch(mt)
85 x 10 <sup>6</sup>	0.80	0.35	28,000	51,000
		0.20	17,000	46,000
103 x 10 <sup>6</sup>	0.75	0.35	31,000	62,000
		0.20	19,000	56,000

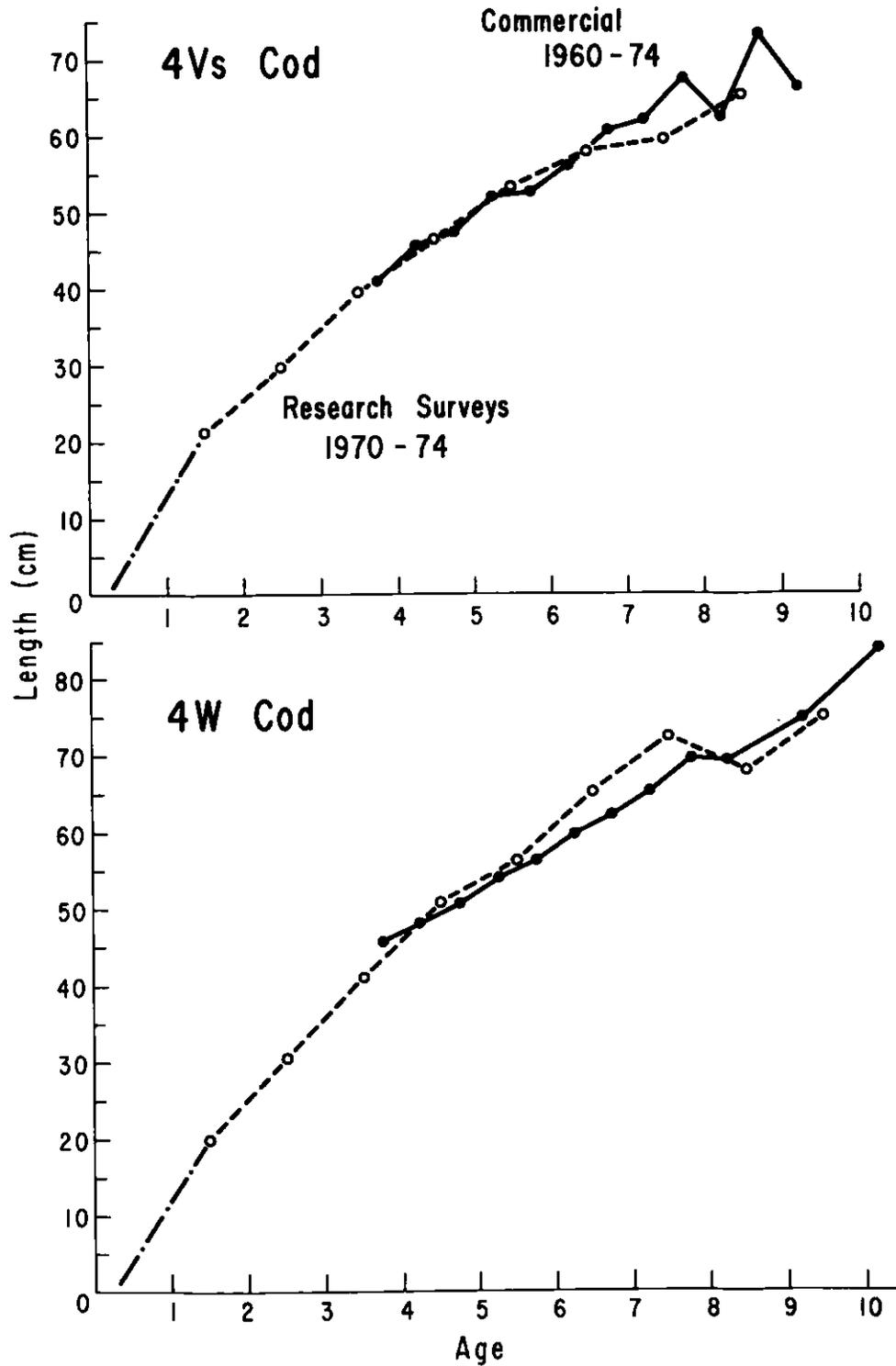


Fig. 1. Div. 4VSW cod. Mean length at age of Div. 4Vs and Div. 4W cod from Canadian research vessel surveys and Canadian commercial samples.

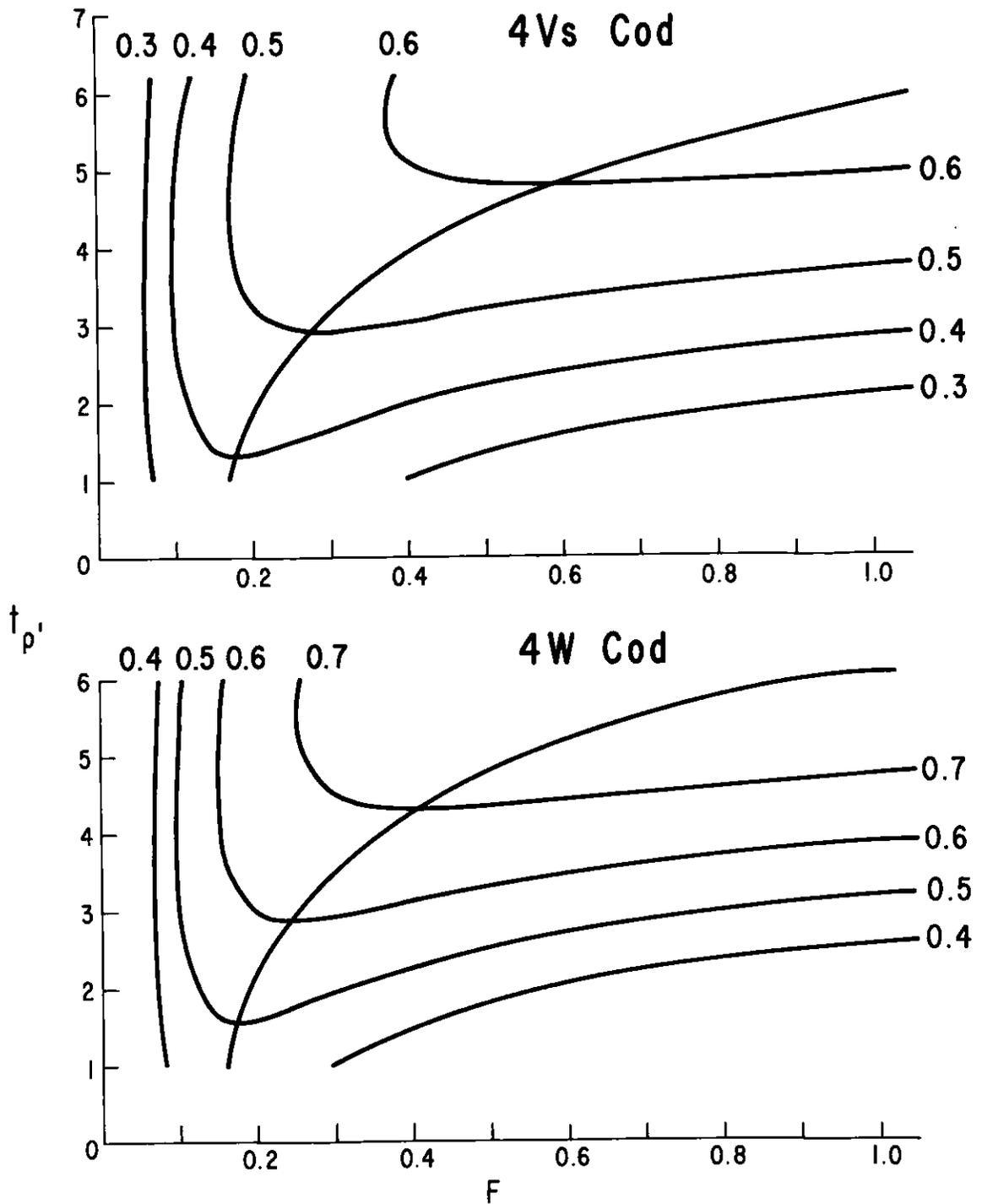


Fig. 2. Div. 4VsW cod. Yield per recruit isopleth diagrams for Div. 4Vs and Div. 4W cod.  $F$  = instantaneous fishing mortality,  $t_p$  = age at recruitment to the exploited stock, numbers in body of graph are yields per recruit in kg.

