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An assessment of the Div. 4Vs–W cod stock complex

by

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INTRODUCTION

The cod fishery in ICNAF Divisions 4Vs and W is not based on a single cod stock but on a complex of stocks (Templeman, 1962; Martin and Jean, 1964). However, considerable mixing takes place among adults of these stocks and possibly also during the pelagic egg and larval stages. Thus, in the present state of knowledge, it is most practical to consider this complex as a single unit for assessment purposes.

This document analyses the fishery during the 1960–71 period.

LANDINGS

Landings have fluctuated between approximately 50,000 and 80,000 metric tons in the 1960–71 period, averaging 62,205 metric tons (Table 1). Almost equal quantities have been taken from Div. 4Vs and Div. 4W. Spain has been the principal exploiter of the stock, taking 63% of the catch in the 12-year period. Canada is the only other country taking substantial quantities from the stock (28% of the catch). Canada has taken 75% of her catch from Div. 4W, whereas Spain has taken 60% of her catch from Div. 4Vs.

SIZE AND AGE COMPOSITION OF LANDINGS

Sampling of landings for size and age composition (Table 2) has been well below minimum ICNAF requirements as set out in the Assessments Subcommittee report for 1970, and the results of the present assessment should be considered with this in mind. As there was inadequate material to treat the two Divisions, different countries, or different seasons, separately, annual landings were weighted by all the otter and pair trawl samples available for that year. The hook and line fishery, due to its insignificance and the virtual absence of samples from it, has been ignored.

The bulk of landings were formed by fish of 40–70 cm (Fig. 1), mean lengths of annual landings varying between 54 and 59 cm (Table 3). Ages 4, 5, and 6 predominated numerically (Fig. 2), average age varying between 5.2 years and 6.1 years. Mean weight of fish landed varied from 1.6 kg to 2.2 kg.

ABUNDANCE

Catch per unit effort

Two data series on catch per unit effort (c.p.e.) are available as indicators of abundance changes of the stock, that of Spanish pair trawlers of 151–500 gross tons and that of Canadian side otter trawlers of 151–500 gross tons.

The c.p.e. of Spanish pair trawlers in Div. 4Vs has been closely similar to that in Div. 4W (Fig. 3) with apparent abundance being slightly higher in Div. 4Vs in the 1962–67 period. Canadian c.p.e. in the two Divisions is also very similar from 1961 onwards with indications that abundance was slightly higher in Div. 4Vs than in Div. 4W in the 1963–65 period. Thus, for each country separately the c.p.e. was averaged for the two Divisions in each year to give abundance indices for the entire stock.

The Canadian and Spanish c.p.e. for Div. 4Vs–W have little in common (Fig. 4). Canadian data indicate that population abundance, which was fairly stable in the 1960–67 period was considerably lower in 1968–71. Spanish data indicate a gradual trend in increased abundance from 1958 to 1967, a sharp increase in 1968, and moderate declines in 1969–70.

The Canadian fishery in Div. 4Vs–W has been a mixed one with haddock being a prime species and with flounders also of importance. Thus, Canadian c.p.e. data may well be a poor reflection of cod abundance due to interactions with these other species fisheries. The Spanish fishery which had cod as its prime species is likely to give the more accurate indication of cod abundance.

Thus, c.p.e. data indicate that cod abundance in Div. 4Vs–W has not varied greatly over the period 1961–70 with the possible exception of a temporary increase in 1968.

Population estimates

An independent check on abundance changes is provided by population abundance estimates from cohort analysis (Pope, MS. 1971). Numbers landed at age (Table 4) were used with an assumed value of natural mortality of $M = 0.20$ and, after several trials, an assumed fishing mortality for the oldest age groups of $F = 0.50$, to give population numbers (Table 5).

The population has remained stable over the 1960–69 period, numbers of 3–11 year olds fluctuating close to the mean of 186 million fish. The numbers of the older fully recruited (see below) age groups 6–11 years old have also remained stable, although in the most recent years 1966–69 their abundance has been below the average of 39 million fish.

Estimates of "available biomass" were obtained from population numbers and mean weight at age, adjusting for partial recruitment, giving:

Year	"Available biomass" (metric tons $x10^{-3}$)	
1960	169	
1961	193	
1962	225	Mean = 191
1963	186	
1964	180	
1965	158	
1966	157	
1967	158	Mean = 161
1968	175	
1969	157	

These data should be more comparable to catch per unit effort data which are also expressed in terms of weight.

While confirming the general conclusion from c.p.e. data that abundance has not changed greatly between 1960 and 1969, these data are in contrast with Spanish c.p.e. data in indicating a lower abundance in the 1965–69 period than in 1960–64 by about 16% on average.

MORTALITY

Estimates of fishing mortality (F), obtained from cohort analysis, averaged 0.49 for fully recruited age groups for the 1960–69 period (Table 6). There was little year to year variation. It is notable that the peak landings of 80,000 metric tons in 1968 are not reflected by any substantial increase in F of fully recruited or partially recruited age groups.

AGE AT RECRUITMENT

Three year olds are only slightly recruited to the fishery, full recruitment occurring at age 6 (Table 6). A graphical estimate from these data give an age at 50% recruitment of 4.2 years.

GROWTH

There were no consistent trends in mean length at age among commercial landings in the 1960–71 period.

A von Bertalanffy growth curve was fitted to data for ages 6–10, i.e. those fully recruited age groups best represented in the fishery, giving the following estimates of growth parameters:

$$K = 0.14$$

$$t_0 = 0.07$$

$$L_\infty = 105 \text{ cm}$$

The length-weight relationship:

$$\log W = 3.0748 \quad \log L - 2.1571$$

obtained for this stock on a July 1971 research vessel survey, was used to obtain a value of $W_\infty = 11.41$ kg by substituting the above value of $L_\infty = 105$ cm.

YIELD PER RECRUIT

The values of parameters derived in earlier sections were substituted in the Beverton and Holt constant parameter yield per recruit model as follows to estimate yield per recruit:

$K = 0.14$

$t_0 = 0.07$

$W_\infty = 11.41$ kg

$t_\rho = 4.2$ yrs (= age at recruitment to the fishing area)

$t_{\rho'} = 4.2$ yrs (= age at recruitment to the exploited phase)

$t_\lambda = 13$ yrs (= maximum age of significant contribution to the fishery)

The value of instantaneous natural mortality, M, is not known for this stock. However, in those cod stocks in the northwest Atlantic for which M has been estimated, the value obtained has been close to 0.20. The values 0.10, 0.20 and 0.30 were used in the yield equation giving the results shown in Fig. 5.

Assuming $M = 0.20$, maximum yield per recruit is obtained from this stock at $F = 0.45$, slightly lower than current values of F (0.49).

If $M = 0.10$, the stock is considerably overexploited, and if $M = 0.30$, the present yield per recruit is slightly below the maximum (95% of maximum).

RECRUITMENT

The mean recruitment to the fishery at age 3 in the 1960–69 period was 61 million fish, showing only moderate variation between 37 million and 79 million fish (Table 5). The 1959 and 1962 year-classes were good while those of 1960 and 1966 were poor.

Quantitative research vessel surveys undertaken in the Div. 4Vs–W region in July of 1970 and 1971 have been cursorily analyzed to determine the relative abundance of year classes currently entering or about to enter the fishery. Mean catch per tow for each year class for each stratum was adjusted by the ratio of stratum area : area swept by the trawl and the stratum totals summed to give population estimates for the entire area.

The total population of all age groups estimated in 1971 was almost exactly x2 the 1970 estimate reflecting the large error of survey estimates. However, for individual age groups from age 2 onwards the ratio was also close to x2, indicating that the relative strengths of year classes were very similar in the two surveys, implying that survey results can give a fairly accurate estimate of relative year-class strength. The much larger increase in apparent abundance of 2 year olds in 1971 over 1 year olds in 1970 indicates that 1 year olds are not fully recruited to the survey trawl.

The estimated numbers of each year class in the two surveys were averaged to give the following values:

Year class	"Abundance"	
1966	11,759,000	
1967	6,639,000	
1968	26,026,000	
1969	5,760,000	(adjusted for partial recruitment of 1 yr olds in 1970)

It was pointed out above that the 1966 year-class was among the poorest at age 3 among those of 1957–66. The contribution of each year class at age 4 and at age 5 is roughly proportional to its estimated abundance at age 3 (Fig. 6). The 1966 year-class made lower contributions than average to the 1970 and 1971 landings at ages 4 and 5 respectively, confirming that it is a poor year class. The 1967 year-class made an even lower contribution at age 4 (to the 1971 landings) than did the 1966 year-class, suggesting that it is even poorer than that of 1966.

The survey estimates of year-class strength confirm that the 1967 year-class is poorer than that of 1966. The 1968 year-class, however, appears to be strong. First indications are that the 1969 year-class is weak, perhaps comparable to that of 1967 or worse.

DISCUSSION

The Div. 4Vs–W cod fishery was moderately stable over the period of investigation. Landings have not varied greatly, nor have the sizes and age compositions of landings (although there is some uncertainty about this due to poor sampling). Abundance and mortality have also remained fairly constant as has recruitment.

Although there is some doubt as to the value of natural mortality, there is no reason to expect this to be much different from other cod stocks in the northwest Atlantic, i.e. $M = 0.20$. Thus, it is likely that current fishing mortality rates are slightly higher than that giving maximum yield per recruit. A reduction in fishing mortality of 25% would not significantly affect the long-term yield but would result in obvious and substantial economic benefits.

Some crude recruitment predictions can also be given. Fishing success in 1971 was probably poorer than average due to the poor recruiting year classes of 1966 and 1967. These year classes are age 5 and 6 in 1972 and it is these age groups which normally support the bulk of the fishery. Thus, the 1972 fishery is likely to be poorer than that of 1971 although the good 1968 year-class may be fished heavily at age 4 due to the low abundance of older age groups. As the 1969 year-class is apparently also poor, the 1973 fishery will depend largely on the 1968 year-class.

If these recruitment predictions are broadly correct there is cause for concern that, for the first time in the period studied, three out of four successive year classes are poor. This new instability in the system makes it extremely important that the 1968 year-class be only moderately exploited to prevent a substantial reduction in stock abundance.

A regulatory proposal that a 1973 quota of 60,000 metric tons be set for this stock is before the Commission's 1972 Annual Meeting. In view of the above yield per recruit calculations and recruitment predictions this quota is higher than that desirable for this stock.

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POPE, J.G. MS. 1971. An investigation of the accuracy of virtual population analysis. ICNAF Res. Doc. 71/116.

TEMPLEMAN, W. 1962. Division of cod stocks in the northwest Atlantic. ICNAF Redbook (1962) Part III : 79-123.

TABLE 1

Div. 4Vs-W cod : nominal catches

Year	Canada	France	Portugal	Spain	USSR	Others	Total	Div. 4Vs	Div. 4W
1960	18,390	1,018	1,720*1	29,391	-	126	50,645	27,689	22,956
1961	19,697	3,252	2,321*1	40,884	113	42	66,309	34,237	32,072
1962	17,579	2,645	341*1	42,146	2,383*1	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*2	17,064	.....	.....	30,864	.....	(3,672)	51,600	......	......

*1 Landings reported as Div. 4V assigned as in Res. Doc. 72/57.

*2 Spanish and Canadian landings as reported to ICNAF Secretariat, landings of other countries estimated from 1969–70 landings.

TABLE 2 .....

Div. 4Vs–W cod : Commercial samples of landings (trawl gear only).

Year	Country	Div. 4W			Div. 4Vs		
		No. of samples	No. of lengths	No. of ages	No. of samples	No. of lengths	No. of ages
1960	Canada	5	2,365	493	2[a]	550	110
	Spain	1	258	-	-	-	-
1961	Canada	7	2,326	398	-	-	-
	France (M)	-	-	-	16	606	-
	Spain	-	-	-	3	878	-
1962	Canada	4	916	223	1	395	70
	Spain	17	2,320	-	3	398	-
1963	Canada	4	1,098	341	1	375	47
1964	Canada	2	298	213	1	330	59
	Spain	-	-	-	3	654	-
1965	Canada	8	3,101	631	3	1,092	123
1966	Canada	6	2,245	304	2	590	121
1967	Canada	3	857	197	6[b]	1,841	188
1968	Canada	8	2,717	354	5[c]	1,443	184
1969	Canada	3	960	130	-	-	-
	France (S.P.)	-	-	-	3	4,264	-
1970	Canada	5	1,626	212	3	928	139
1971	Canada	2	711	92	10	3,178	467

a = includes 1 sample from 4Vs-W combined
b = includes 2 samples from 4Vs-W combined
c = includes 1 sample from 4Vs-W combined

TABLE 3. DIV. 4Vs—W cod : annual mean length, weight and age of commercial landings.

Year	Mean length (cm)	Mean weight (kg)	Mean age (yrs)
1960	58.1	2.04	5.83
1961	59.0	2.17	5.87
1962	53.8	1.73	5.30
1963	55.4	1.78	5.49
1964	59.2	2.24	5.99
1965	54.5	1.79	5.42
1966	55.3	1.75	5.19
1967	57.1	2.00	5.58
1968	56.6	1.93	5.37
1969	53.9	1.62	5.15
1970	57.0	1.97	5.63
1971	58.9	2.22	6.12

TABLE 4

DIV. 4Vs–W cod : numbers landed at age ($x10^{-3}$)

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
2	-	-	-	-	136	35	-	-	79	-	-	117
3	889	242	2,339	337	1,337	5,435	1,972	285	2,379	1,277	81	1,080
4	3,569	5,260	12,072	9,681	2,598	9,573	13,496	6,020	10,300	9,426	5,699	2,975
5	7,364	9,345	6,922	13,246	9,788	7,261	12,027	11,409	13,379	10,508	11,631	5,960
6	5,737	7,507	7,152	6,372	5,088	9,176	4,915	4,254	8,637	6,198	5,572	4,831
7	3,623	3,174	2,458	5,134	3,603	2,960	3,225	1,389	3,624	2,066	3,341	3,776
8	2,633	2,340	2,188	2,602	3,401	2,199	1,401	1,624	1,098	513	1,517	2,317
9	454	1,659	841	505	1,475	1,532	748	802	990	278	578	931
10	166	185	494	207	426	819	508	709	437	537	210	408
11	202	190	216	155	206	289	519	356	251	101	221	241
12	116	144	94	63	102	170	60	120	371	34	171	174
13	6	131	97	35	66	112	7	22	100	14	45	187
14	20	8	-	-	-	51	-	15	50	-	59	83
15	-	-	3	-	-	74	4	17	4	-	38	31
16+	9	18	2	6	49	23	3	5	8	-	14	103
Total	24,786	30,203	34,878	38,343	28,274	39,709	38,886	27,026	41,705	30,952	29,179	23,211

TABLE 5

DIV. 4Vs–W cod : population numbers ($x10^{-3}$) per age group, 1960–69 from Pope's cohort analysis.

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	Mean
3	55,783	68,669	72,113	37,070	60,025	78,843	70,154	68,518	60,307	38,056	60,954
4	57,265	44,867	56,002	56,925	30,046	47,935	59,633	55,653	55,840	47,222	51,139
5	36,788	43,655	31,975	34,927	37,846	22,248	30,584	36,612	40,117	36,398	35,115
6	17,510	23,456	27,286	19,915	16,610	22,129	11,645	14,157	19,652	20,739	19,310
7	10,016	9,145	12,411	15,868	10,539	8,996	9,815	5,087	7,742	8,274	9,789
8	6,953	4,922	4,615	7,937	8,346	5,369	4,687	5,118	2,908	3,059	5,391
9	1,440	3,310	1,912	1,799	4,144	3,756	2,406	2,569	2,720	1,387	2,544
10	684	768	1,209	804	1,015	2,058	1,689	1,293	1,378	1,331	1,223
11	620	409	461	542	471	446	944	923	417	733	597
Σ 6–11	37,224	42,010	47,894	46,865	41,125	42,754	31,196	29,147	34,817	35,523	38,856
Σ 3–11	187,060	199,201	207,984	175,787	169,042	191,780	191,567	189,930	191,081	157,199	186,063

TABLE 6

DIV. 4Vs—W cod : instantaneous fishing mortality (F) per age group, 1960—69, from Pope's cohort analysis.

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	Mean 1960—69	Percentage recruitment
3	0.02	0.00	0.04	0.01	0.02	0.08	0.03	0.00	0.04	0.04	0.03	6
4	0.07	0.14	0.27	0.21	0.10	0.25	0.29	0.13	0.23	0.25	0.19	39
5	0.25	0.27	0.27	0.53	0.34	0.45	0.57	0.42	0.46	0.38	0.39	80
6	0.45	0.44	0.34	0.44	0.41	0.61	0.63	0.40	0.66	0.40	0.48	100
7	0.51	0.48	0.25	0.44	0.47	0.45	0.45	0.36	0.73	0.32	0.45	100
8	0.54	0.75	0.74	0.45	0.56	0.60	0.40	0.43	0.54	0.20	0.52	100
9	0.43	0.81	0.67	0.37	0.50	0.60	0.42	0.42	0.51	0.25	0.50	100
10	0.31	0.31	0.60	0.33	0.62	0.58	0.40	0.93	0.43	0.59	0.51	100
11	0.45	0.72	0.73	0.38	0.66	1.26	0.93	0.56	1.09	0.17	0.70	100
Mean 6—10	0.45	0.56	0.52	0.41	0.51	0.57	0.46	0.51	0.57	0.35	Overall mean ages 6—10 = 0.49	

Fig. 1 Length Composition of Cod Landings, 1960 -'71
Div 4Vs - 4W

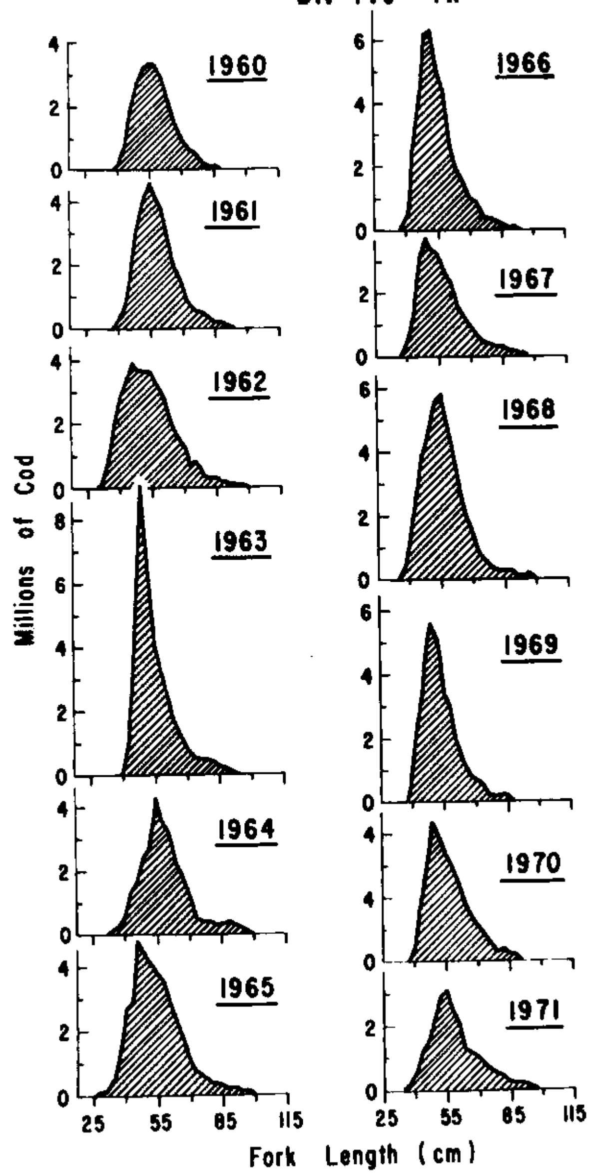
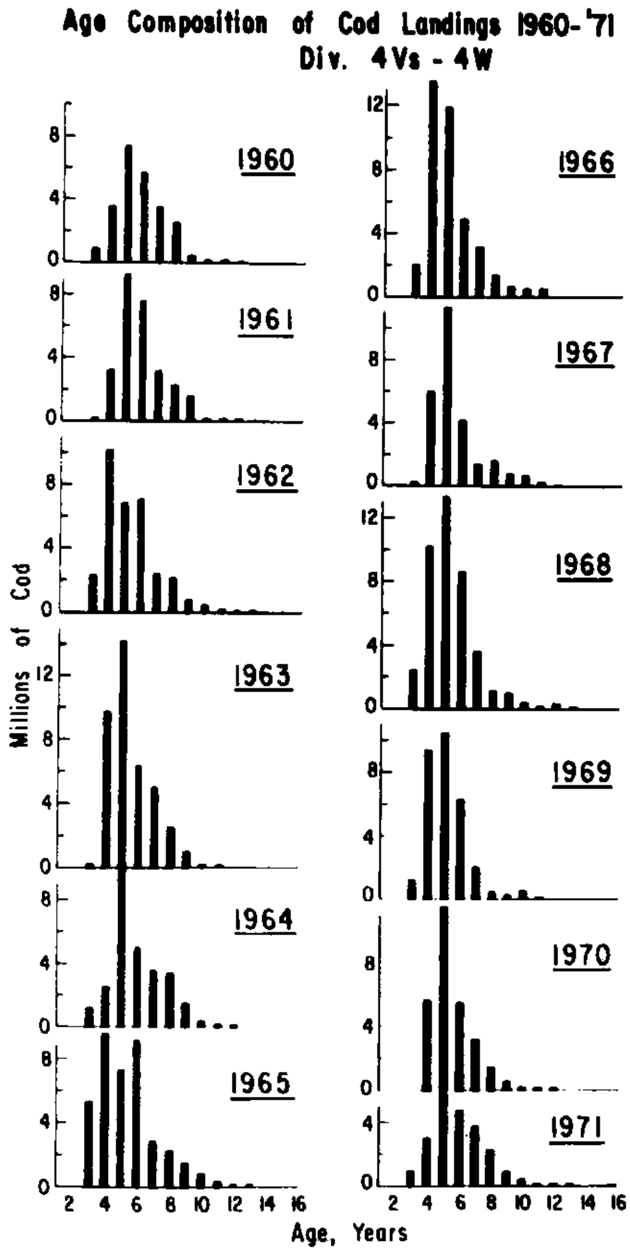


Fig. 2


Age Composition of Cod Landings 1960-'71
Div. 4Vs - 4W
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
Millions of Cod
Age, Years

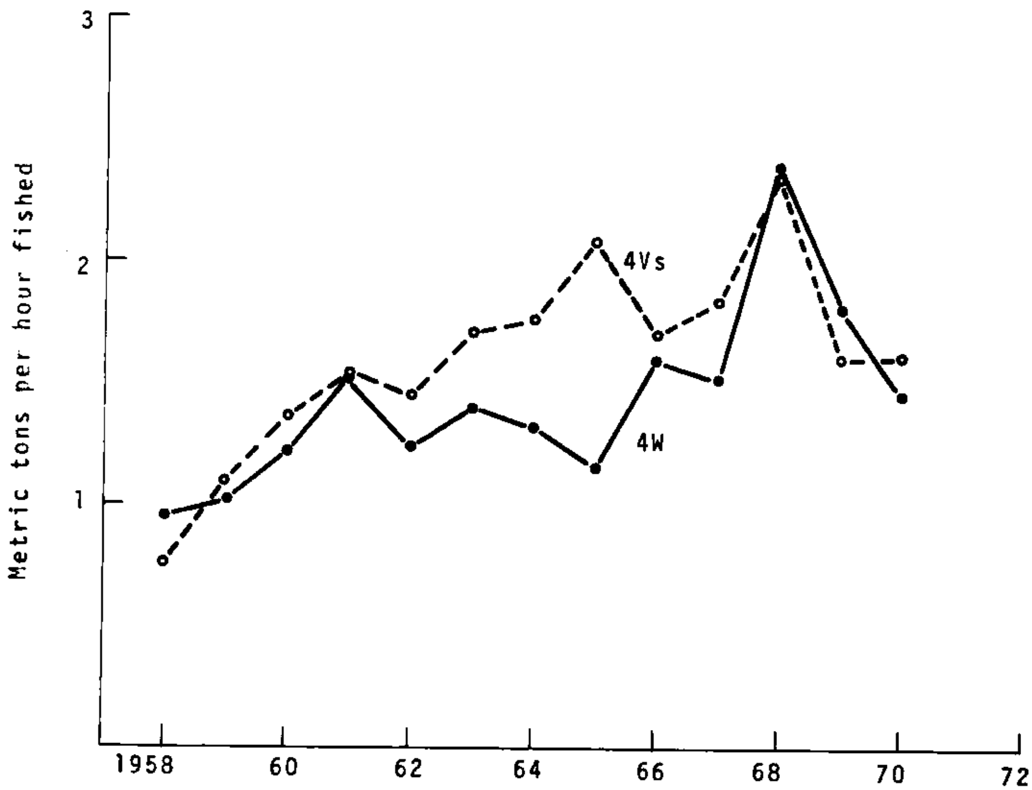


Fig. 3. DIV. 4Vs—W Cod : Catch per unit effort of Spanish pair trawlers 151—500 gross tons from February to April inclusive.

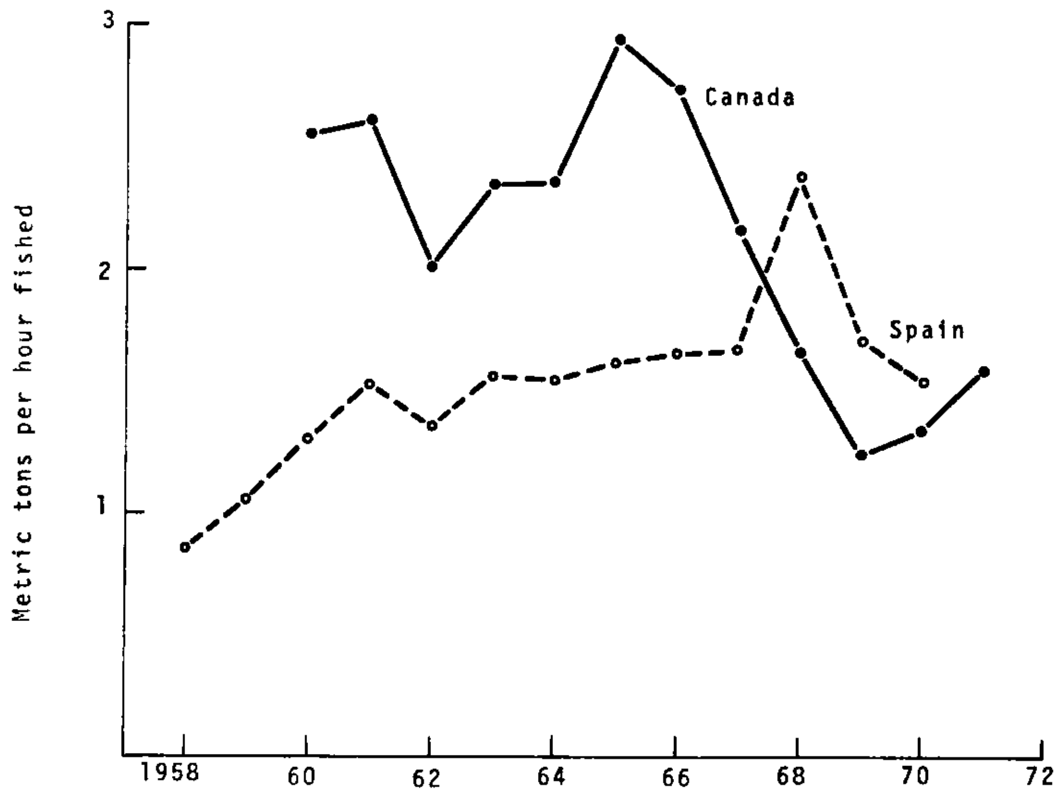


Fig. 4. DIV. 4Vs–W Cod – Catch per unit effort Canadian side otter trawlers and Spanish pair trawlers, 151–500 gross tons.
(Canadian c/e x 10, Spanish c/e for Feb.–April only.)

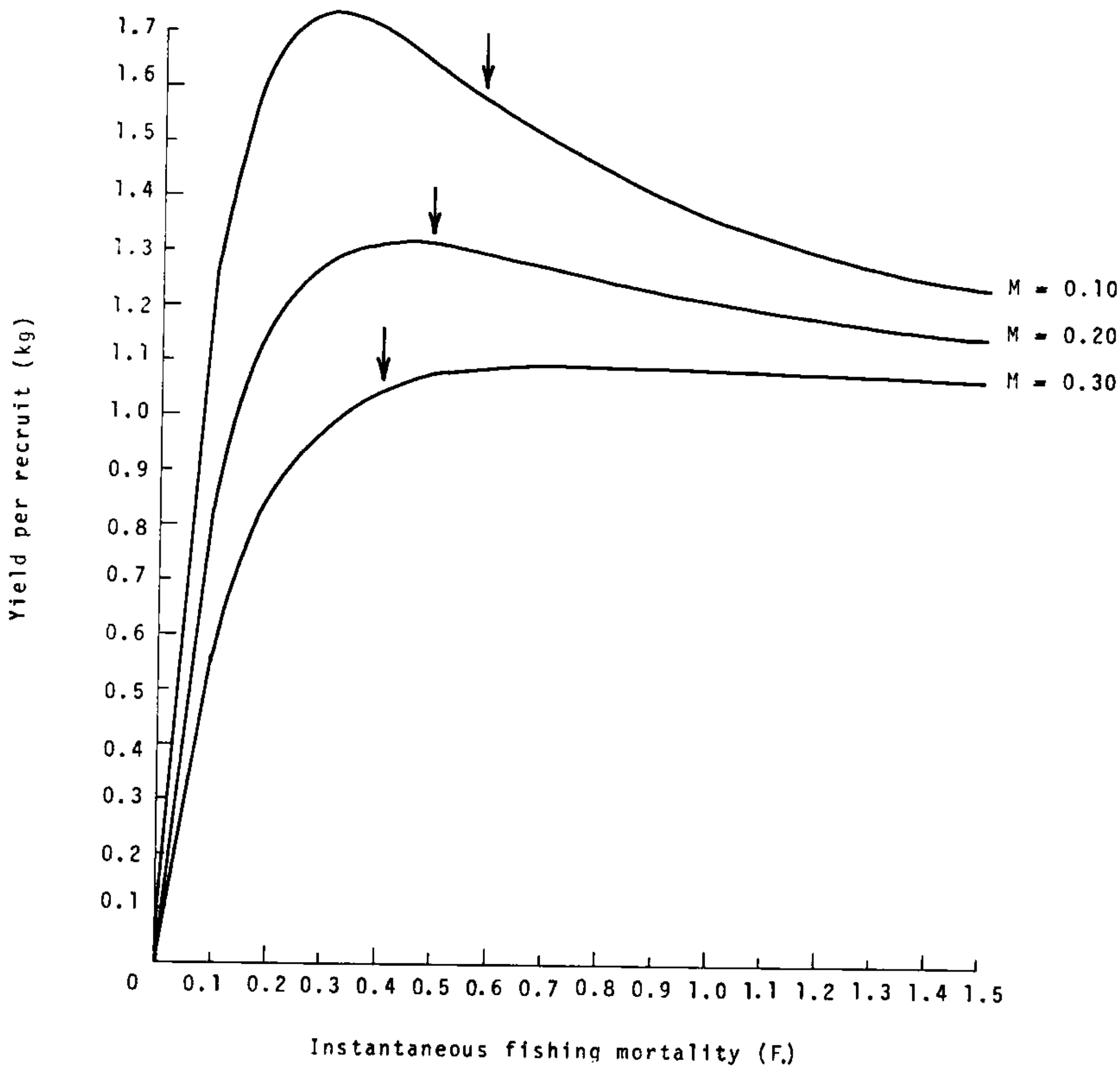


Fig. 5. DIV. 4Vs–W Cod : Yield per recruit

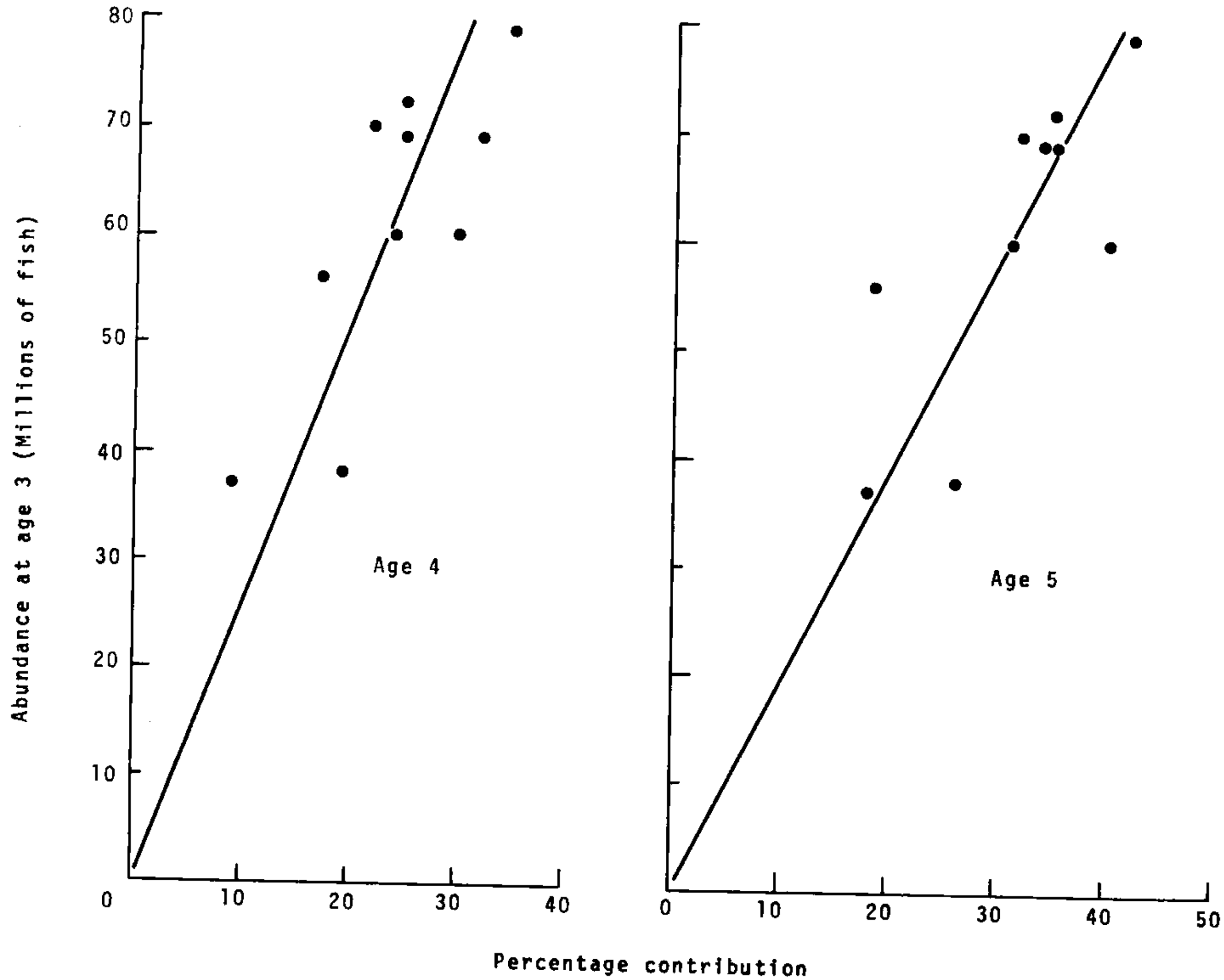


Fig. 6. DIV. 4Vs—W cod : relationship between abundance at age 3 and contribution to the fishery at ages 4 and 5.