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NOTES ON THE STATUS OF COD AND HADDOCK STOCKS OF THE SCOTIAN SHELF[1]

by

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INTRODUCTION

The following notes on status of the cod and haddock stocks of the Scotian Shelf are based primarily on Canadian research vessel surveys conducted in the months of June and July in the years 1969 to 1972. In 1969 the survey was limited to Div. 4W and was conducted by the research vessel *E.E. Prince*. The 1970-72 surveys covered all of the Scotian Shelf and Bay of Fundy and were conducted by the research vessel *A.T. Cameron*. Specifications of survey design, methodology, gear, and vessels are given by Halliday and Kohler (ICNAF Res. Doc. 71/35, Serial No. 2520). The stratification scheme used is shown in Fig. 1.

DIV. 4X COD — OFFSHORE STOCK

Results of tagging experiments on Div. 4X cod [reviewed by Templeman (ICNAF Redbook (1962) Part III pp. 79-123)] imply that the cod of the offshore banks mix little with inshore cod and can be considered as belonging to a separate stock for assessment purposes. This conclusion is open to criticism as the tagging was conducted at a time when fishing intensity on the offshore banks of Div. 4X was low. However preliminary results of taggings in 1969 and 1972 (Figs 2 and 3) confirm the separation of inshore and offshore stocks.

The area of distribution of the offshore cod stock in Div. 4X is approximated by Strata 70-85 inclusive. Estimated population numbers in this area from 1970-72 surveys indicate continued low stock abundance (Table 1). It is noteworthy that commercial catch per unit effort (cpe) data indicate a slight

[1] Revision of Sp.Mtg.Res.Doc.73/7 presented at Special Commission Meeting, FAO, Rome, January 1973.

increase in abundance of the exploited stock between 1970 and 1972 (Table 5, Fig. 4B) whereas survey data indicate a decline in the adult population (age 5+) of 74%. This may reflect a change in emphasis towards cod due to restrictive haddock regulations in the area and the decline of the haddock stock.

Mortality rate (Z) continued at the high level of the late 1960's (Halliday, ICNAF Res. Doc. 71/12, Serial No. 2499), estimates being 1.47 in 1970-71 and 0.82 in 1971-72.

An earlier stock assessment indicated that the year classes of 1964-65 were considerably poorer than those which supported the development of this fishery in the mid-1960's. While a sufficiently long time series is not available to accurately predict the strength of currently incoming year classes to the fishery, indications are that these are not significantly stronger than those of 1964-66.

Thus, adult stock abundance is low, expected recruitment is poor and mortality rates are excessively high. Landings in 1970-71 were in the region of 10,000 metric tons. Assuming natural mortality is M = 0.20, the fishing mortality giving maximum yield per recruit is F = 0.35 (Halliday, ICNAF Res. Doc. 71/12). At present stock levels this implies that a reduction in removals to about 3,500 tons is required to achieve maximum yield per recruit.

DIV. 4X HADDOCK

Div. 4X haddock are distributed widely in the summer months, including inshore and in the Bay of Fundy as well as on the offshore banks. This area is approximated by strata 70-95 inclusive. Estimated population numbers varied irregularly between 22 and 44 million fish in 1970-72 surveys (Table 2). Relative year-class strength remained remarkably constant, the 1963 year class predominating among adult age groups. Commercial cpe declined in Canadian otter-trawl fisheries both in the Bay of Fundy and on the offshore banks through 1972 (Table 5, Fig. 5) (with the exception of one vessel category in the Bay of Fundy).

All post-1963 year classes appear weak. The 1969 and 1971 year classes at age 1 are equally represented, with that of 1970 considerably poorer. This is in close agreement with similar U.S. research vessel results which also indicate that the 1969 and 1971 year classes, although the best since that of 1963, are poor by pre-1963 standards.

Estimated Z = 0.60 (Table 2), is slightly lower than that of the late 1960's but considerably higher than the very low values indicated by U.S. surveys in 1969-71 (Heyerdahl, ICNAF Assessments Subcommittee, January 1972, Contribution No. 20). While the high variation in survey estimates of Z indicate that little reliance can be placed on individual estimates, it is likely that Z has declined since the introduction of quota regulation, possibly close to that giving maximum yield per recruit.

DIV. 4W HADDOCK

The eastern Scotian Shelf haddock stock is distributed throughout Div. 4W and Div. 4V and to some extent inshore around eastern Nova Scotia and in the Gulf of St. Lawrence in the summer months. As the 1969 survey covered only Div. 4W, the data from strata 54-58, 62-65 collected in 1969-72 are taken as representative of the entire stock. It is assumed that the same proportion of the population remains in Div. 4W in each year.

Abundance of age groups on which the fishery is primarily based (age 5+) continued to decline between 1969 and 1972 from 8.7 million to 1.9 million, i.e. by almost 80% (Table 3) Year classes which have yet to enter the fishery are of low abundance. The strength of the 1971 year class, for which a first estimate was obtained on the 1972 survey, is of comparable strength to those of 1968-70. Commercial cpe declined by 46% during the 1969-72 period (Table 5, Fig. 4A).

Mortality rate of recruited age groups in 1971-72 was Z = 1.25, comparable to that in 1969-70 and 1970-71, the mean of the three estimates being about 1.10 (Table 3). Maximum yield per recruit is obtained when Z = 0.50 for this stock (Halliday, 1971 ICNAF Res. Bull. No. 8).

Mortality rate estimates for individual year classes between successive years are highly variable, reflecting the variation in population estimates. However, pooled estimates for particular age groups throughout the 1969-72 period are fairly constant and are as follows"

Ages	Z	
1-2	0.08)	Mean = 0.38
2-3	0.67)	
3-4	0.59	
4-5	1.32)	
5-6	1.01)	
6-7	1.23)	
7-8	0.88)	Mean = 1.23
8-9	1.50)	
9+-10+	1.45)	

(i.e. the sum of population estimates in 1970-72 for age X were compared to the sum of population estimates in 1969-71 for age X-1 to obtain a pooled estimate of Z between ages X-1 and X in the 1969-72 period.) This calculation estimates a Z for fully recruited age groups of 1.23. Mortality rate between ages 3 and 4 is close to the value expected from the recruitment pattern of the 1960's when 4 yr-olds were about 40% recruited to the fishery. However the mean mortality rate on 1-3 yr-olds of Z = 0.38 is higher than in the 1958-60 period when Z = 0.25. Halliday (ICNAF Redbook 1970, Part III) considered this latter value to be an estimate of natural mortality rate. A substantial silver hake fishery was prosecuted in Div. 4W in 1969-71, and probably also in 1972. In areas which overlap to a considerable extent areas in which juvenile haddock are distributed. Thus a first estimate of the incidental fishing mortality of juvenile haddock caused by the silver hake fishery is F = 0.13.

Thus, conditions of declining adult stock abundance, poor recruitment and high mortality rates continue for the Div. 4W haddock stock, and complete closure of the fishery in 1974 is warranted.

DIV. 4Vs-W COD

Estimates of population numbers for the Div. 4Vs-W cod stock complex vary widely due predominantly to sampling variation (Table 4). Relative year class strengths however, are fairly constant from year to year.

The 1968 year class dominates the estimates in all years (43-46% of total). The next strongest year class is that of 1966.

A sufficient overlap is not yet available in survey and commercial data series to allow calibration of relative year class strengths of prerecruits with subsequent performance in the fishery with much confidence. However, it does appear that recruitment prospects are more likely than not to be poor. Percentage contribution to the commercial fishery at ages 4 and 5 is roughly proportional to the abundance of a year class at age 3 (Fig. 6) calculated by virtual population analysis (Halliday, 1972, ICNAF Res. Doc. 72/111, Serial No. 2828). The VPA calculation indicated that the 1966 year class is among the poorest of those of 1957-66. (As this estimate was based on only a couple of years' performance in the fishery it can be considered only a crude approximation.) The percentage contribution of the 1967 and 1968 year classes to the fishery in 1971 and 1972 (based on age composition of Canadian landings, 1972) indicate that the 1967 year class is comparable in strength to the 1966 year class, while that of 1968 is of average strength.

Survey results indicate that the 1967 year class is indeed poorer than that of 1966. However, the 1968 year class must be at least twice as strong as that of 1966, and thus at least of average abundance. The 1969 and 1970 year classes appear to be no stronger than that of 1967.

Thus, if the 1966 year class is taken as most likely being below average, then three of the succeeding four are also of below average abundance. The 1968 year class, while strong, is not exceptional. Thus stock abundance is likely to decline over the next few years.

Catch per unit effort data for Spanish pair trawlers declined in both Div. 4Vs and Div. 4W from 1968 through 1971 (Table 5, Fig. 7). Cpe of Canadian trawlers in Div. 4Vs increased from 1969 to 1971 then declined slightly in 1972 (Table 5, Fig. 8). In Div. 4W, cpe increased substantially in 1972 over a low level in 1969-71. The Canadian 1972 results are difficult to interpret as research surveys indicate the bulk of the 1968 year class is distributed in Div. 4Vs, and the Div. 4W commercial samples do not show domination by a strong incoming year class which could cause a large increase in cpe.

Mortality rate estimates from surveys are very variable reflecting the high variation of population estimates (Table 4). Estimates of Z for fully recruited age groups (age 6+) are 0.50-0.57. This is slightly lower than the 1960-69 average of 0.69 (F = 0.49) and also lower than that giving maximum yield per recruit (Z = 0.65).

Data on length-frequency of Spanish catches for 1971 have become available. In Halliday's (1972, ICNAF Res. Bull., 9:117-124) analysis of the fishery for the 1960-71 period, it was necessary to assume that the size composition of removals by Canada and Spain were the same due to lack of data from the Spanish fleet. The 1971 size compositions confirm the hypothesis that Spain catches cod which are significantly smaller than those caught by Canada (Table 6), implying that yield-per-recruit is in fact less than that estimated in earlier assessments.

DIV. 4T-Vn COD

The Div. 4T-Vn cod stock reached a peak abundance in 1970 but declined in 1971-72 to average levels (Table 5, Fig. 9).

Table 1. DIV. 4X COD - OFFSHORE STOCK: estimated population numbers ($X10^{-3}$) and mortality rates from Canadian research vessel survey cruises. (Strata 70-85 inclusive.)

Year Class	1970 survey	1971 survey	1972 survey
1972	-	-	-
1971	-	-	19
1970	-	286	1320
1969	891	7604	2871
1968	1588	4265	1988
1967	2660	574	413
1966	4375	1465	414
1965	1935	638	95
1964	2610	855	385
1963	1148	28	214
1962	578	-	99
1961	202	-	3
1960	110	-	3
1959 and older	16	-	99
Total	16,112	15,715	7,923
$Z_{Age\ 5+}$	1.47	0.82	Mean = 1.15

Table 2. DIV. 4X HADDOCK: estimated population numbers ($X10^{-3}$) and mortality rates from Canadian research vessel survey cruises. (Strata 70-95 inclusive.)

Year Class	1970 survey	1971 survey	1972 survey
1972	-	-	-
1971	-	-	7248
1970	-	161	319
1969	7989	15191	4598
1968	6429	6483	1988
1967	1883	2925	1276
1966	3554	4230	1401
1965	1445	1990	905
1964	3253	3026	1446
1963	8477	8373	2206
1962	1191	1046	77
1961	483	128	9
1960	438	56	7
1959	112	156	19
1958	28	-	-
Total	35,282	43,765	21,609
$Z_{Age\ 5+}$	0.04	1.14	Mean = 0.60
$Z_{Age\ 6+}$	0.09	1.14	Mean = 0.62

Table 3. DIV. 4W HADDOCK: estimated population numbers ($X10^{-3}$) and mortality rates from Canadian research vessel surveys. (Strata 54-58, 62-65 inclusive.)

Year Class	1969 survey	1970 survey	1971 survey	1972 survey
1972	-	-	-	123
1971	-	-	-	2626
1970	-	-	3689	491
1969	-	6151	8936	1313
1968	2330	1779	2858	865
1967	4529	3656	3888	988
1966	7465	2973	1491	414
1965	6638	1108	796	237
1964	3332	959	360	125
1963	3366	901	599	102
1962	1336	354	30	49
1961	216	125	-	-
1960 and older	427	86	-	-
Total	29,640	18,094	22,647	7,333
$Z_{Age\ 5+}$	1.27	0.68	1.26	Mean = 1.07
$Z_{Age\ 6+}$	1.29	0.90	1.25	Mean = 1.15

Table 4. DIV. 4Vs-W COD: estimated population numbers ($X10^{-3}$) and mortality rates from Canadian research vessel survey cruises (Strata 43-66 inclusive).

Year Class	1970 survey	1971 survey	1972 survey
1971	-	-	6210
1970	-	1539	9657
1969	1480	7680	9635
1968	16388	35664	33848
1967	5250	8027	5571
1966	7669	15803	6111
1965	3735	5771	1688
1964	1217	3459	547
1963	1502	1475	495
1962	462	638	153
1961	104	70	-
1960 and older	711	401	-
Total	38518	80531	73915
$Z_{Age\ 5+}$	-0.424	1.12	Mean = 0.35
$Z_{Age\ 6+}$	-0.413	1.41	Mean = 0.50

Pooled estimate of $Z_{Age\ 5+}$ = 0.53

Pooled estimate of $Z_{Age\ 6+}$ = 0.57

Table 5. Catch per unit effort of cod and haddock stocks in ICNAF Subarea 4.

HADDOCK

Year	4X—NOP Can(M) 151-500 gt side O.T. m.t./hour	4X—R Can(M) 26-50 gt O.T. m.t./trip	4X—R Can(M) 51-150 gt O.T. m.t./trip	4X—S Can(M) 26-50 gt O.T. m.t./trip	4X—S Can(M) 51-150 gt O.T. m.t./trip	4W Can(M) 151-500 gt side O.T. m.t./hour
1960	-	.79	1.46	1.14	(2.75)	.38
1961	-	1.00	(1.70)	(1.27)	(2.19)	.36
1962	-	2.13	2.57	1.58	2.37	.30
1963	.49	4.39	5.14	2.20	3.13	.27
1964	.39	2.41	2.68	2.67	2.41	.32
1965	.30	1.99	2.75	2.84	4.45	.24
1966	.32	2.36	3.75	3.66	5.81	.25
1967	.30	2.45	3.66	2.74	4.89	.21
1968	.28	2.32	3.70	1.93	2.89	.21
1969	.25	1.50	2.18	(1.08)	1.53	.24
1970	.22	1.17	1.19	0.59	1.22	.18
1971	.20	.98	1.10	0.42	0.79	.15
1972	.18	.87	1.23	0.34	0.39	.13

COD

Year	4X Can(M) 151-500gt side O.T. m.t./hour	4W Can(M) 151-500gt side O.T. m.t./hour	4Vs Can(M) 151-500gt side O.T. m.t./hour	4W Spain 151-500gt P.T. m.t./hour	4Vs Spain 151-500gt P.T. m.t./hour	4T Can(M) 26-50gt O.T. m.t./trip	4Vn Spain 901-1800g O.T. m.t./hou
1960	-	.22	.29	1.22	1.37	8.1	1.37
1961	-	.25	.27	1.51	1.53	9.5	1.73
1962	-	.21	.20	1.24	1.45	10.9	1.97
1963	.49	.22	.25	1.40	1.72	10.5	2.96
1964	.34	.22	.26	1.32	1.77	9.2	2.83
1965	.34	.27	.32	1.15	2.08	8.8	1.65
1966	.32	.28	.27	1.59	1.70	6.4	1.08
1967	.32	.24	.19	1.51	1.83	7.0	1.56
1968	.29	.18	.15	2.39	2.36	9.1	1.23
1969	.24	.13	.12	1.80	1.60	12.2	2.33
1970	.17	.13	.14	1.45	1.61	12.8	2.13
1971	.19	.13	.18	1.32	1.18	9.2	1.22
1972	.21	.29	.16	-	-	9.8	-

Table 6. Div. 4Vs-W cod : Length frequency of commercial landings by Spain and Canada in January–June, 1971

Length (cm)	Canada	Spain
25	-	.50
28	-	2.65
31	-	3.81
34	-	4.96
37	.02	7.66
40	.22	12.12
43	1.73	13.57
46	3.88	13.67
49	6.76	12.52
52	10.18	10.87
55	17.93	6.86
58	13.45	4.51
61	11.24	2.70
64	7.34	2.15
67	5.09	.80
70	4.50	.35
73	4.14	.05
76	2.92	.20
79	2.06	-
82	2.06	-
85	1.00	-
88	1.49	-
91	1.10	-
94	.85	-
97	.41	-
100	.58	.05
103	.20	-
106	.32	-
109	.15	-
112	.13	-
115	.13	-
118	-	-
121	-	-
124	-	-
127	.11	-
130	-	-
133	.02	-
Mean length (cm)	61.7	45.8

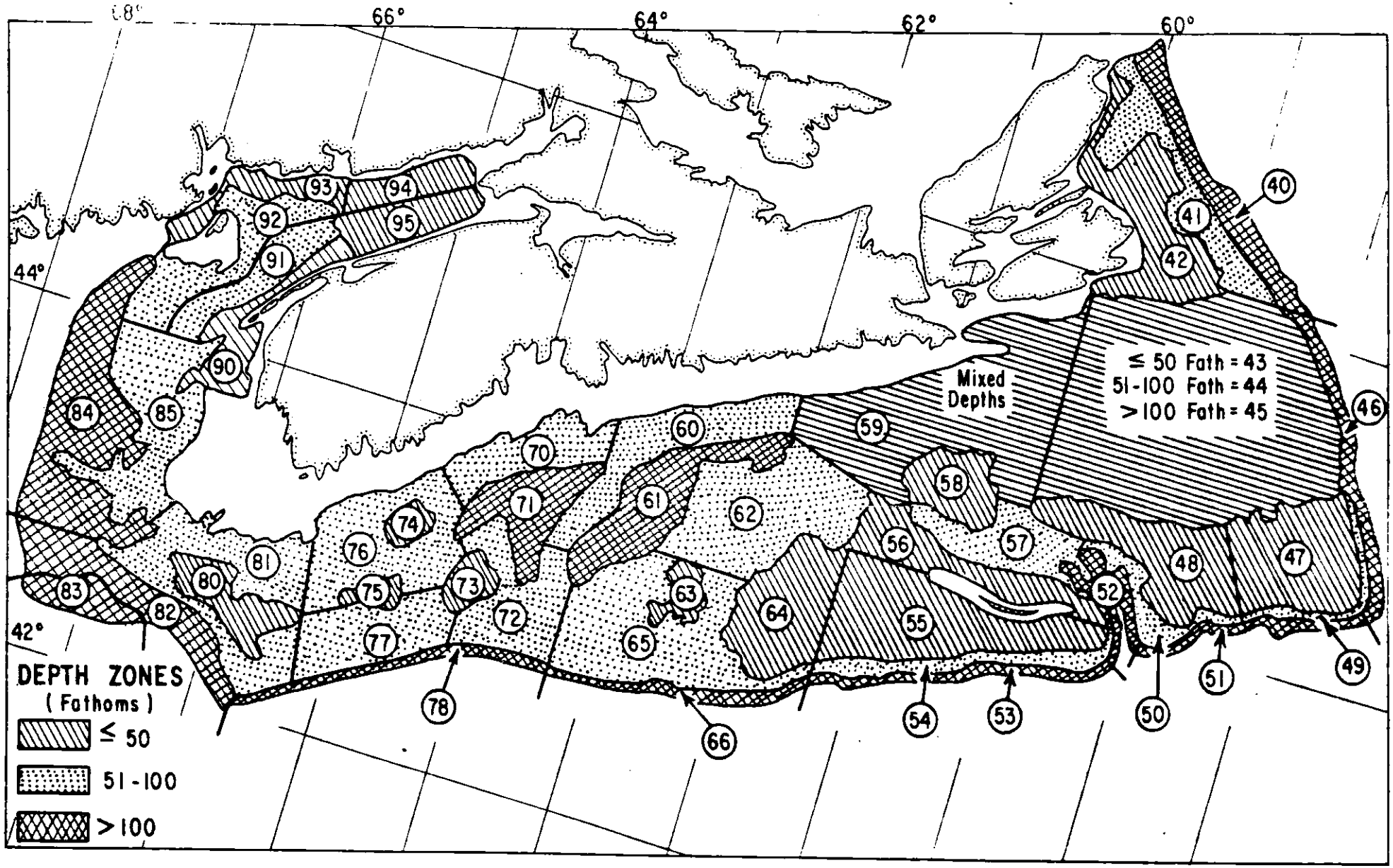

Fig. 1. Canadian stratification scheme of the Scotian Shelf for research vessel surveys.

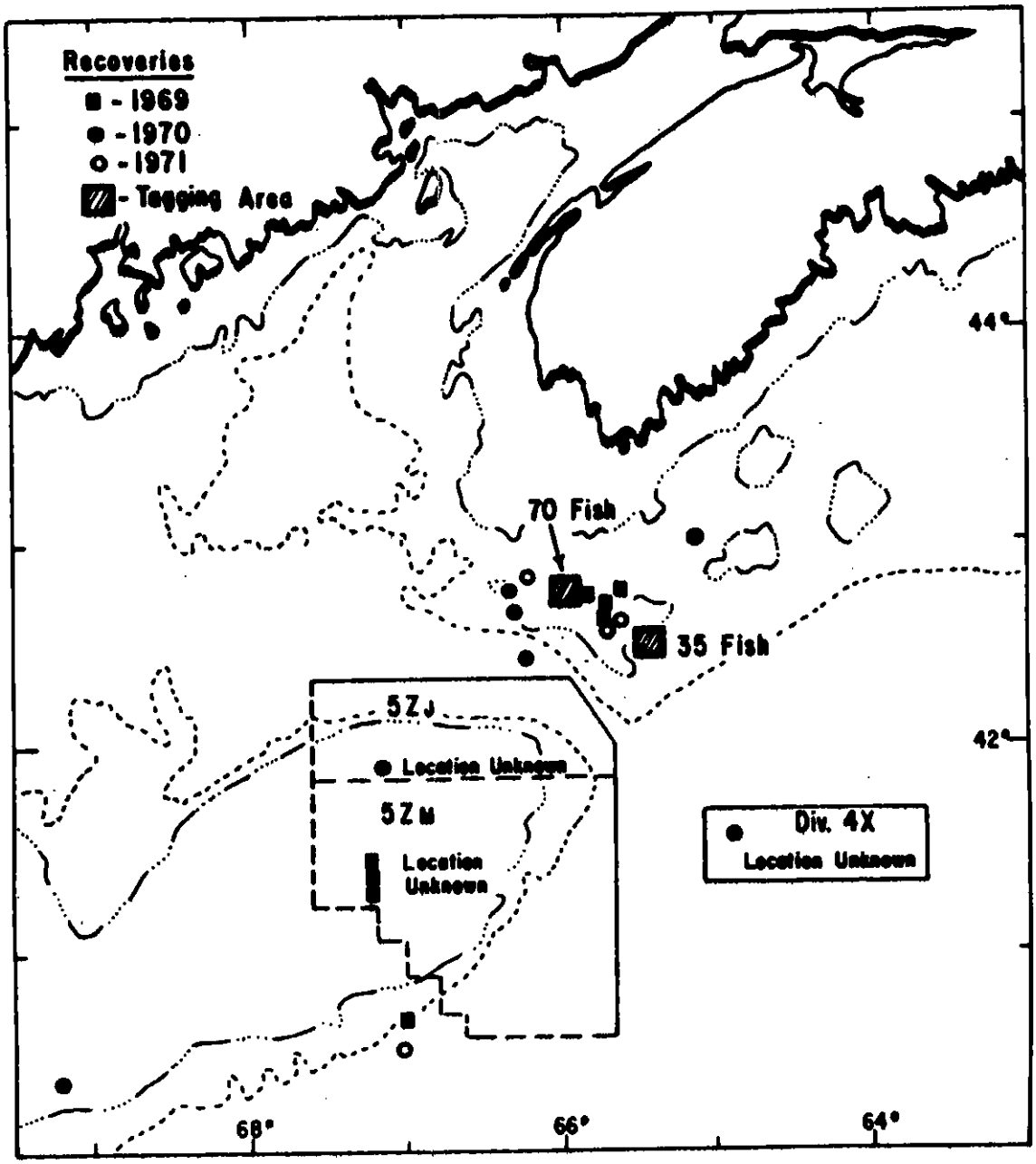

Fig. 2. Recaptures to April 1973 of cod tagged on Browns Bank in June 1969.

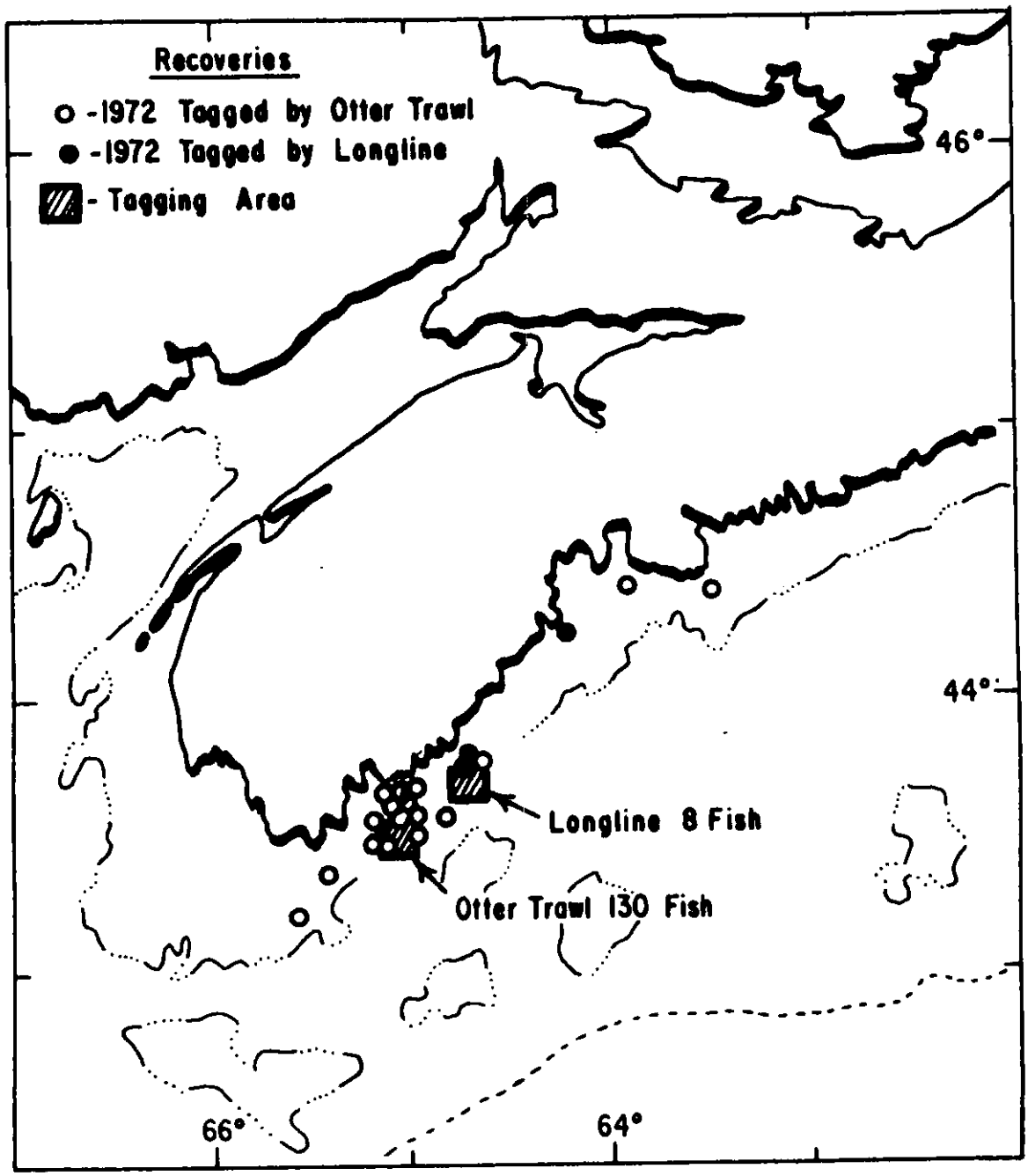

Fig. 3. Recaptures to April 1973 of cod tagged inshore off southern Nova Scotia in April 1972.

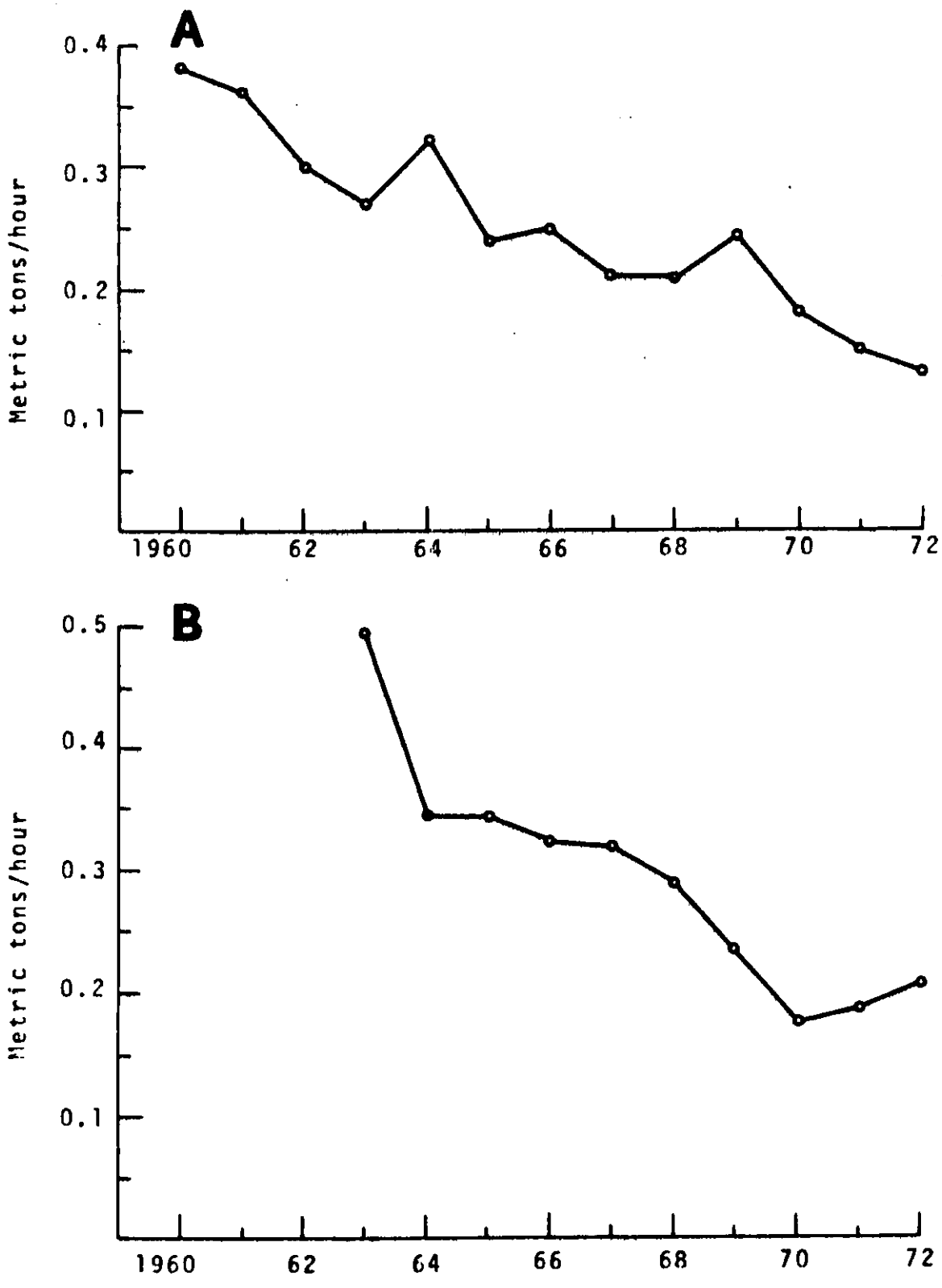

Fig. 4. Catch per unit effort (metric tons/hour) of Canadian side otter trawlers of 151-500 gross tons.
A. Div. 4W haddock B. Div. 4X offshore cod.

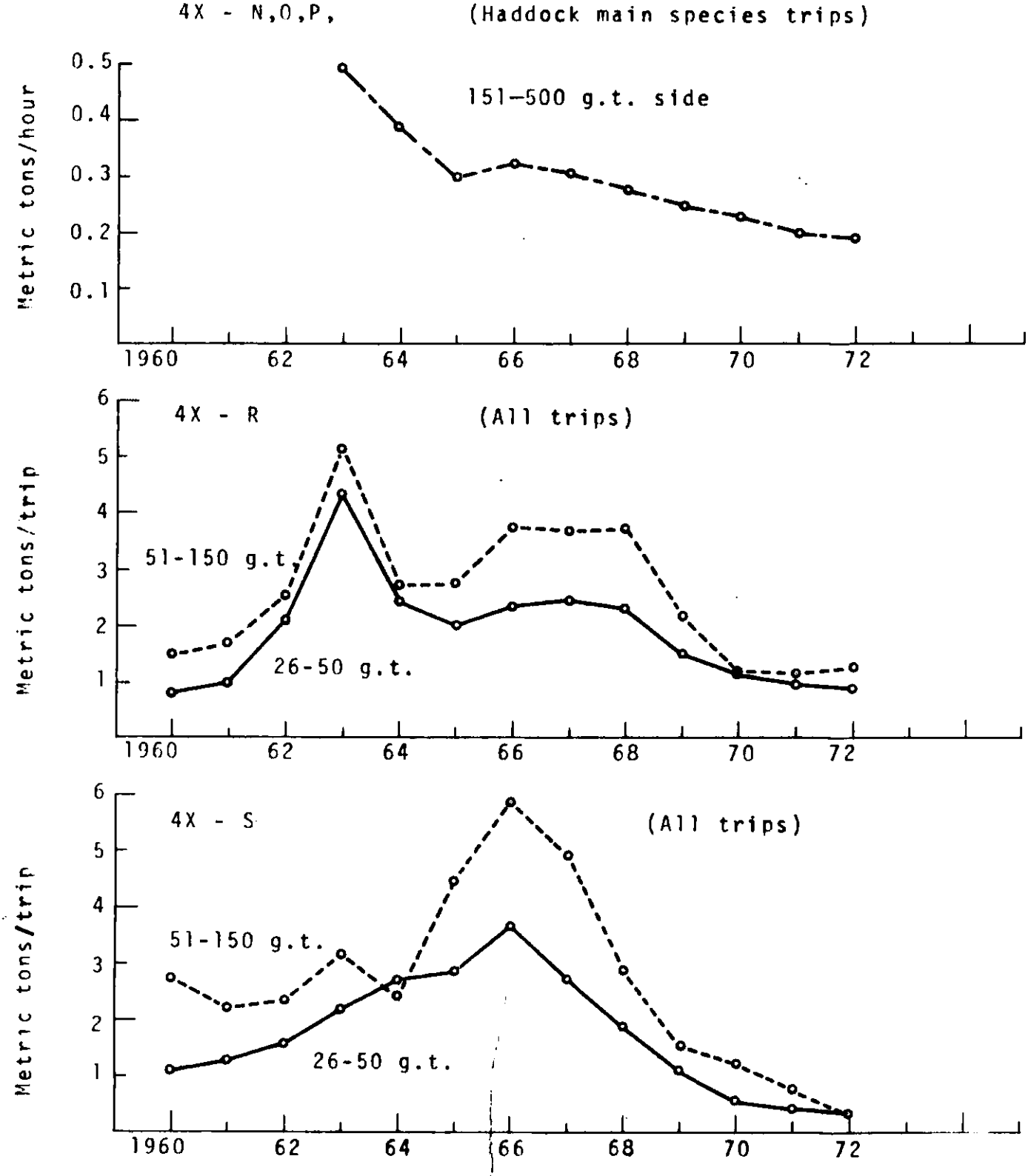

Fig. 5. Div. 4X haddock : catch per unit effort — metric tons per hour of Canadian side otter trawlers of 151-500 gross tons on the offshore banks (Div. 4X-NOP), and metric tons/trip of Canadian otter trawlers of 26-50 and 51-150 gross tons in the Bay of Fundy (Div. 4X-R — Nova Scotia side, Div. 4X-S — New Brunswick side.

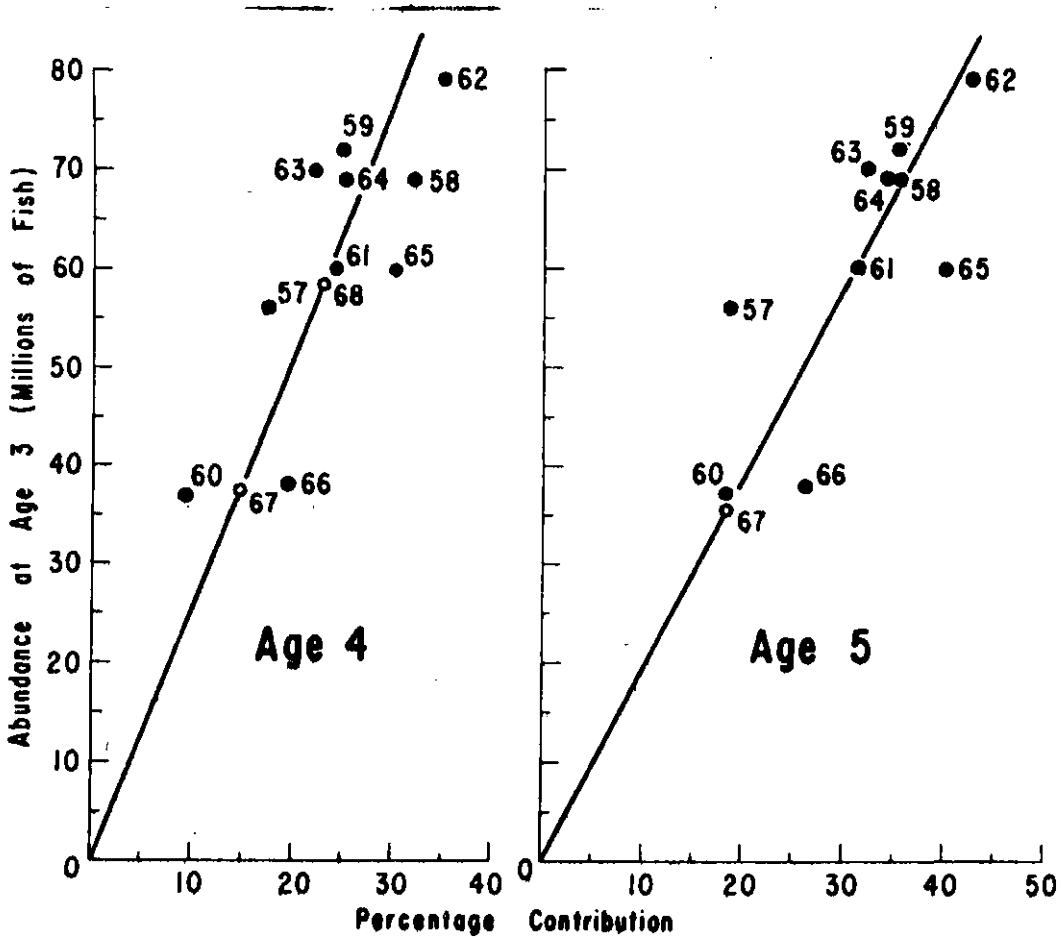

Fig. 6. Div. 4Vs-W cod : relationship between percentage contribution to the fishery at ages 4 and 5 and abundance at age 3 from virtual population analysis.

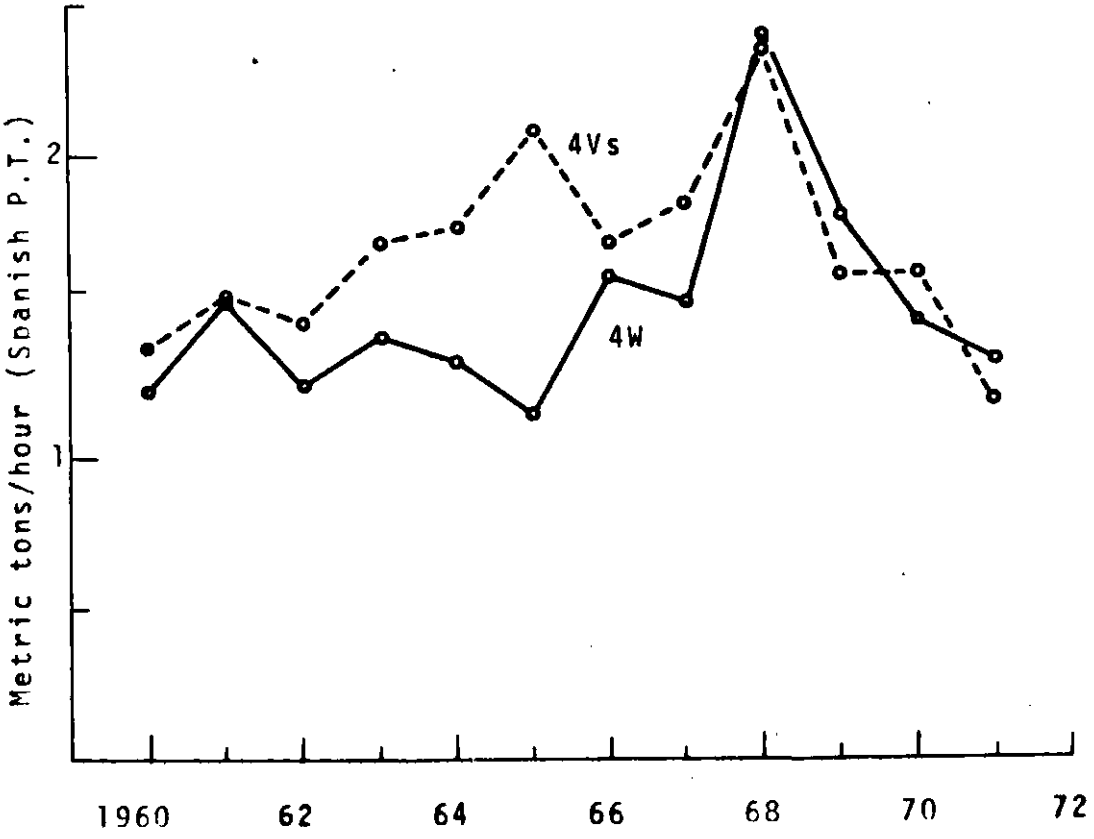

Fig. 7. Div. 4Vs-W cod – Catch per unit effort of Spanish Pair trawlers 151–500 gross tons in February to April inclusive.

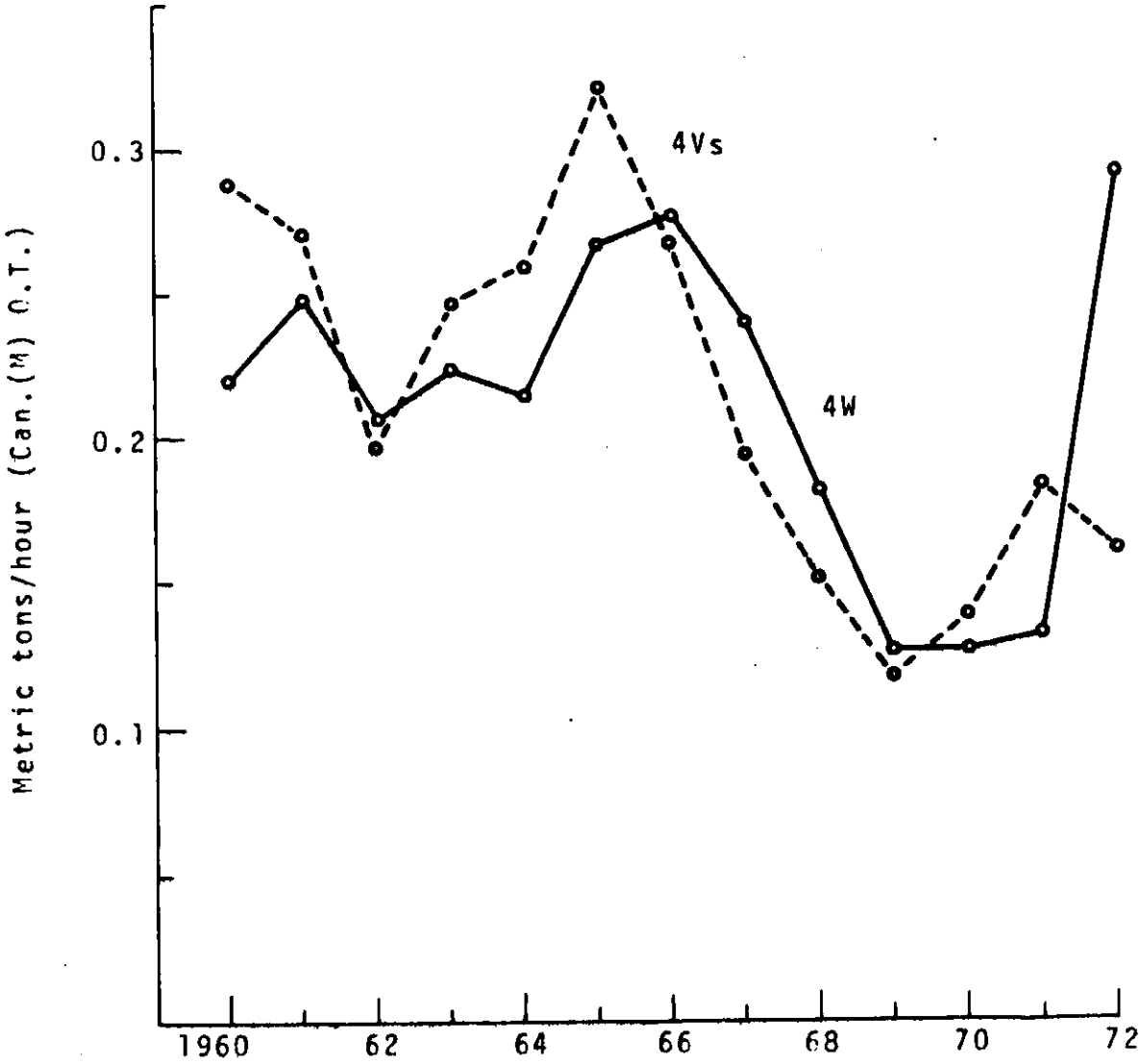

Fig. 8. Div. 4Vs-W cod : catch per unit effort of Canadian side otter trawlers, 151-500 gross tons.

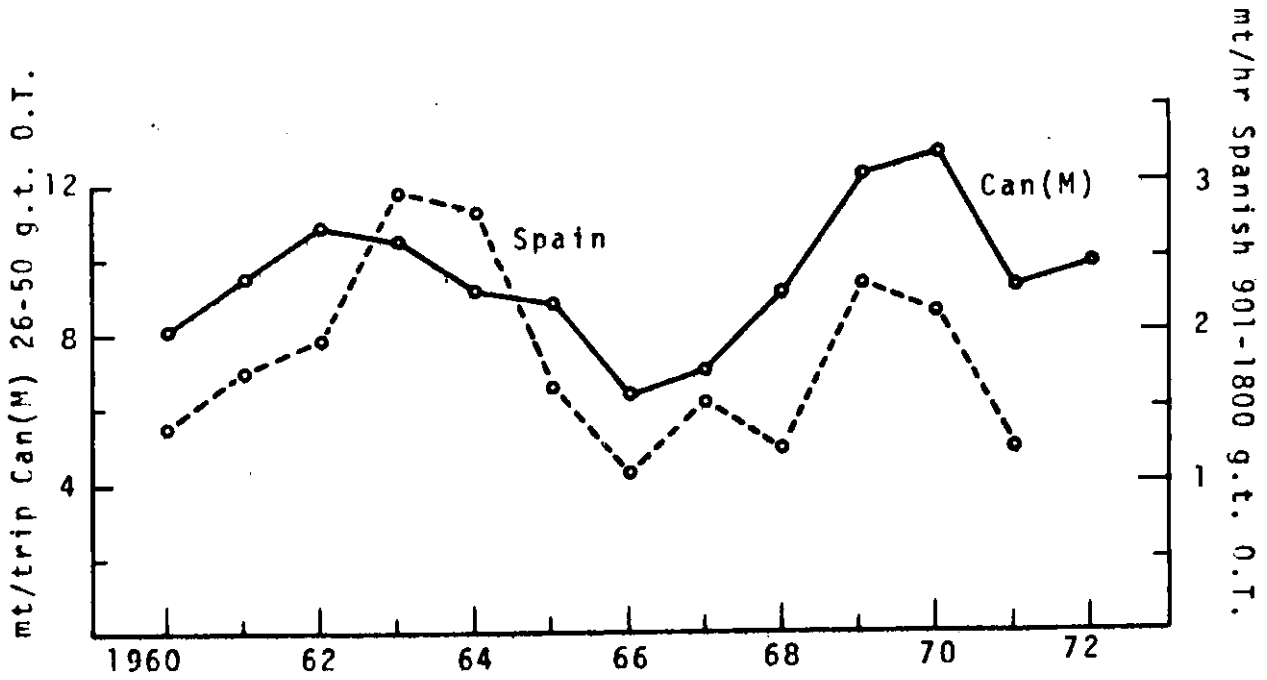

Fig. 9. Div. 4T-4Vn cod : catch per unit effort of Spanish 901-1800 gross ton otter trawlers in Div. 4Vn in January—April inclusive, and of Canadian 26-50 gross ton otter trawlers in Div. 4T in May—November inclusive.