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Recent events in the yellowtail fishery in ICNAF Divisions 3L, 3N and 3Ø

by

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Introduction

Yellowtail catches from Divisions 3L, 3N and 3Ø increased very rapidly from very low levels in the mid-1960s to a peak of approximately 39,000 tons in 1973 and down to about 23,000 tons in 1974 and 1975 (Table 1). It should be pointed out that the reported catch probably indicates minimal removals only since there is a distinct possibility of substantial non-reported catches of yellowtail by countries catching and salting cod with the by-catch, principally flatfish, not being recorded (Pitt 1975).

Total Allowable Catches were recommended at 50,000, 40,000 and 35,000 tons for 1973 to 1974 respectively. When the 1974 data were added and presented at the 1975 Assessments Subcommittee Meeting, the recommended TAC was reduced to 10,000 tons and was subsequently set at 9,000 tons by the Commission.

Material and Methods

Indices of abundance from research vessel surveys (Table 2 and Fig. 4 and 5) are given as mean values per half-hour set weighted by the area of the strata surveyed. The following strata were used (Fig. 1):

YEAR	DIVISION 3L					DIVISION 3N						
	350	363	371	372	384	361	362	373	374	375	376	383
1971	X	X	X	X	X	X	X	X	X	X		X
1972	X	X	X	X	X	X	X	X	X	X		X
1973	X	X		X	X	X	X	X	X	X		X
1974	X	X		X	X	X	X	X	X	X		X
1975	X	X		X	X	X	X		X	X	X	

All commercial data were collected from sampling catches by Newfoundland-based commercial trawlers with age-length keys and length frequencies collected and processed by the Newfoundland Biological Station. Total catches used in estimating numbers caught were those reported in the ICNAF Statistical Bulletin.

To calculate fishing mortalities and stock size, Pope's (1972) Cohort Analysis method was used. This is a modification of the "virtual population" method. A value of 0.3 was used for natural mortality (M). The selection of a terminal F value (Fishing Mortality on the fully recruited age groups in the final year for which data were available) as usual was difficult and really only approximate.

The determination of this value for the 1975 data was based in part on catch prediction for 1975 using the 1973 stock size from a previous assessment and projecting catches to 1975 using a range of terminal F and partial recruitment values to produce a catch equivalent to that reported for 1975. The value of F that produced the 1975 catch was about 1.1. This is probably a minimal value since higher values were evident from previous years in the Cohort Analysis (Table 3) and survival rates from research vessel data indicate high total mortality (Table 4).

Weight at age was calculated from average annual length at age. These were calculated by weighting the average lengths at age for the quarter by the Canadian (N) landings in each quarter. Length was converted to weight by the following relationship:

$$\text{Log } W = 3.044 \text{ Log } L = 5.080$$

(W = whole weight; L = length)

To calculate spawning biomass, the following percent mature at age array was used:

AGE	5	6	7	8	9	10
% mature	32	71	94	100	100	100

Results and Discussion

For the directed yellowtail fishery the catch per hour for Canada (N) commercial otter trawlers (Fig. 2) declined rapidly 1965-69 and then stabilized until 1973 when it again declined drastically. For the catch rate associated with total effort (yellowtail recorded in the catch) the decline in the initial years of the fishery was drastic, but with some fluctuations has remained at about 300 kg per hour since 1967.

Up to 1971 the stock was increasing in abundance (Fig. 3) and spreading to most of the shallow (<50 fath - 91 m) habitat of the Grand Bank (Pitt 1975). Research vessel surveys since 1971 confirm a general downward trend in abundance at least up to 1973 (Fig. 4). However, the research vessel data reveal that the most drastic reduction in abundance was in Division 3L (Fig. 5) with some stabilization at a higher level in Division 3N.

A further breakdown of the results of research vessel surveys is given in Table 2 where the mean number per set at the different age groups is presented. Because the gear used was not particularly efficient in catching small fish, it was possible that the numbers recorded as 3-year and probably 4-year-old fish may not be particularly indicative of the actual abundance.

The result of Cohort Analysis using number at age for 1968-75 is presented in Table 3. The average abundance of 5-year-olds for 1971-73 was approximately 84 million fish and this was the value used for the projections in Table 5. It should be noted here that in an assessment presented in 1973 (Pitt 1975) average recruitment at age 5 was projected at approximately 130 million fish. This was based on the population number at age 5 in 1970 and using the assumption that a stock that had been expanding up to that time could reasonably be expected to at least stabilize at that level.

Fishing mortality rates were quite high ranging from 0.73 in 1971 to 1.9 in 1972. The value in 1972 and in 1974 (1.85) appears to be abnormally high and may have resulted from poor sampling of some of the older age groups however the total mortality rates from research survey data also indicate high mortality rates for 1971 ($Z = 2.08$, $F = 1.77$) and for 1973 ($Z = 1.93$, $F = 1.63$) (Table 4). In any case, the F values are all well above $F_{0.1}$ (0.55; Fig. 6).

The total allowable catches projected for 1974 and 1975 of 40,000 and 35,000 tons respectively were based on assessments using catch data up to 1972 and 1973 respectively thus giving less than reliable stock sizes for 1971 and 1972. This is inherent in the model used because of the uncertainty about fishing mortality in the current year and the level of recruitment. The population numbers at the recruiting ages suggested that the population was increasing so that projections were made based on optimistic recruitment levels.

However, indications of stock size from Cohort Analysis (Fig. 3) and from research vessel surveys indicate a decline since 1971. This decline became especially acute in 1974 (Fig. 4 and 5). The mean number of fish at age 4-6 from survey data in 1973-75 were lower than in the two previous years.

Bottom temperatures during 1972-74 were unusually low especially in ICNAF Division 3L and this may have had some effect on the behaviour of the fish in relation to the trawl or may have contributed to a high natural mortality thus accounting for the high rates of F calculated in recent years with an assumed M of 0.3.

When the numbers caught age in 1974 were added, a new Cohort Analysis calculated, and projections made for 1976 total allowable catch, it was evident that the stock was declining and because of this current removal rates could not be maintained. Thus, using a more conservative recruitment level than in the previous projection (70 million fish at age 5) and fishing at $F_{0.1}$ indicated a TAC of 10,000 tons for 1976.

Making realistic 2-year projections for a species which has a fishery almost exclusively on 6 age groups (5-10 years) only and with very little indication of recruitment levels is difficult is not impossible. The only indication of recruitment prospects comes from research vessel surveys, and here the time series is not long enough to give proper correlation with population numbers from Cohort Analysis. Because of the minimal numbers of fishing stations from these surveys the variance of the abundance indices is quite high.'

However, as a rough estimate of the possible recruitment level for 1975 the average number per set from research vessel surveys at age 5 (Table 2) is compared with the population numbers 1971-73 from Cohort Analysis (Table 3).

		1971	1972	1973	1974	1975
A.	Research Ave. No./Set	32.8	44.7	21.6	21.3	27.7
B.	Population No. (Millions of fish)	73.5	83.4	92.3		
	B/A	2.2	1.9	4.3	Average 2.8	

This gives a very rough estimate for recruitment in 1975 at age 5 of about 77.6 million fish.

Because of the uncertainty of the strength of the 1970 year-class in 1975 (age 5) a series of projected TAC's for 1977 is presented using a range of recruitment levels (Table 5). These indicate a range of probable catch levels for 1977 from about 10,300 tons for 50 million recruits to 15,500 tons for 80 million.

In addition to Figure 3, some indication of stock size expressed as biomass (tons), and the biomass of the spawning stock for recent years with a projection to 1981, is given in Table 6. Thus the total biomass (5 years and older) declined from 105,500 tons in 1971 to 62,300 tons in 1974 and 56,400 tons in 1975, a drop of nearly 50% in four years, with an even greater decline in the spawning biomass (76,800 tons to 36,600 tons).

With the meager knowledge of recruitment presently available, management strategy for this stock is difficult to formulate. Obviously any long-term projections depend on the strength of the incoming year-classes so that for the next year or two it might be prudent to assume a relatively low level of recruitment and thus begin a rebuilding of the stock, and if in fact higher levels of recruitment are in fact realized, then the stock can rebuild to a level comparable to that of the early 1970s with a resulting higher yield.

References

Pitt, T. K. 1975. Status of the yellowtail flounder fishery in ICNAF Divisions 3L, 3N and 3Ø. Intern. Comm. Northw. Atlant. Fish. Res. Bull. No. 11, 125-134.

1975. Possible effects of non-reported discards of flatfish on TAC of plaice and yellowtail in Divisions 3L, 3N and 3Ø. Intern. Comm. Northw. Atlant. Fish. Res. Doc. 75/28, Ser. No. 3483, 9 pp.

Pope, J. G. 1972. An investigation of the accuracy of Virtual Population Analysis using Cohort Analysis. Intern. Comm. Northw. Atlant. Fish. Res. Bull. No. 9, 65-74.

Table 1. Nominal catches of yellowtail, ICNAF Divisions 3LNO (1965-74 from Sum. Doc. 76/10).

YEAR	CAN	FRA	POR	USSR	OTHER	TOTAL
1965	3075	-	-	55	-	3130
1966	4185	-	-	2834	7	7026
1967	2122	-	-	6736	26	8878
1968	4180	14	-	9146	-	13340
1969	10494	1	-	5207	6	15708
1970	22814	17	-	3426	169	26426
1971	24206	49	-	13087	-	37342
1972	26939	358	-	11929	33	39259
1973	28492	368	406	3545	4	32815
1974	17053	60	248	6952	-	24313
1975	18424	-	342	3891		22694*

*Preliminary

Table 2. Mean number of yellowtail per set for Strata 50 fathoms or less. (Weighted by strata area) (ICNAF Divisions 3LNO).

AGE \ YEAR	1971	1972	1973	1974	1975
3	1.14	2.80	0.23	0.75	0.62
4	13.95	22.13	2.06	11.04	6.98
5	32.80	44.70	21.62	21.26	27.71
6	62.86	48.70	34.90	35.19	25.38
7	53.50	24.63	27.72	14.71	25.74
8	9.11	9.63	10.78	1.64	6.99
9	3.04	1.99	4.15	0.19	0.50
10	0.04	0.05	0.21	-	0.02

Table 3. Cohort Analysis of yellowtail, ICNAF Divisions 3L, 3N, and 3Ø using numbers caught 1968-75, age 5-10. M = 0.3 Terminal F = 1.10

Age	Par Rec	No. Caught x 10^{-3}							
		1968	1969	1970	1971	1972	1973	1974	1975
4	0.01	573	80	141	169	1,943	3,734	1,374	855
5	0.15	6,202	2,993	2,776	7,534	10,128	21,280	19,800	11,240
6	0.45	12,483	13,035	19,839	30,369	12,502	23,709	18,100	20,931
7	1.00	9,154	12,076	20,615	22,117	29,416	17,053	11,200	12,737
8	0.96	1,421	3,150	4,557	5,869	10,553	4,718	2,400	2,536
9	0.89	47	326	610	2,152	4,206	862	850	372
10	0.89	1	40	68	245	1,110	300	130	23
		Population No. x 10^{-3}							
5		109,694	115,879	130,062	73,554	83,427	92,316	(84,000)	
6		55,470	75,925	83,269	93,963	48,006	53,087	50,074	
7		17,885	30,345	43,306	44,612	43,471	24,803	18,921	
8		2,372	5,371	12,086	14,339	14,013	6,885	3,697	
9		146	534	1,267	5,031	5,571	1,298	1,040	
10		2	68	115	414	1,875	507	220	
TOTAL 7 & over		20,405	36,318	56,774	64,396	64,930	33,493	23,878	
5		0.07	0.03	0.03	0.13	0.15	0.31	0.25	
6		0.30	0.26	0.32	0.47	0.36	0.73	0.54	
7		0.90	0.62	0.81	0.85	1.54	1.60	1.16	
8		1.19	1.14	0.58	0.65	2.07	1.59	1.40	
9		0.47	1.23	0.82	0.69	2.10	0.48	(2.98)	
10		(1.10)	1.10	1.10	1.10	1.10	1.10	1.10	
Mean F (7 & over)		0.85	1.00	0.74	0.73	1.90	1.22	1.85	
Effort (Total) ('000 hours)		47.3	64.4	58.0	102.0	107.9	80.4	(1.28) 87.3	81.6
Catch (Tons)		15,800	17,800	25,600	37,300	39,300	32,800	24,100	22,700

Table 4. Total mortality from survey data.

AGE \ YEAR	1972/1971	1973/1972	1974/1973	1975/1974
		SURVIVAL		
4/3	19.413	0.736	48.000	9.307
5/4	3.204	0.977	10.320	2.510
6/5	1.484	0.781	1.165	1.194
7/6	0.392	0.569	0.421	0.731
8/7	0.180	0.438	0.059	0.475
9/8	0.218	0.431	0.018	0.305
10/9	0.016	0.216	-	0.105
Mean Z				
7/6 & over	2.077	0.946	1.928	1.118

Table 5. Stock and catch predictions using 1974 population and catches for 1974 and 1975 and predicting to 1977 on the basis of 50, 60, 70 and 80 million recruits in B, C, D and E respectively in 1976, 1976, and 1977.

A.

Age	Par Rec	Ave. Wt	1974 Stock No x 10^{-3}	1974 Fishing Mortality	1974 Catch No. x 10^{-3}	1975 Stock No x 10^{-3}	1975 Fishing Mortality	1975 Catch No x 10^{-3}
						(50,000)	(0.30)	
						(60,000)	(0.24)	
5	0.15	0.298	84,000	0.32	19,800	(70,000)	(0.21)	11,240
						(80,000)	(0.18)	
6	0.45	0.450	50,074	0.53	18,100	45,369	0.74	20,931
7	1.00	0.569	18,921	1.10	11,200	21,769	1.08	12,737
8	0.96	0.743	3,697	1.30	2,400	4,666	0.95	2,536
9	0.89	0.953	1,040	2.29	850	744	0.84	372
10	0.89	1.111	220	1.10	130	78	0.41	23
TOTAL NO.			157,952		52,480			47,839
TOTAL WT. (tons)			62,314		23,156			22,280

B.

Age	Ave. Wt.	1976 Stock No x 10^{-3}	1976 Fishing Mortality	1976 Catch No. x 10^{-3}	1977 Stock No x 10^{-3}	1977 Fishing Mortality	1977 Catch No x 10^{-3}
5	0.298	(50,000)	0.08	(3,328)	(50,000)	0.08	(3,328)
6	0.450	(27,468)	0.23	(4,904)	(34,193)	0.25	(6,575)
7	0.569	15,972	0.50	5,497	(16,168)	0.55	(5,990)
8	0.743	5,483	0.48	1,827	7,177	0.53	2,584
9	0.953	1,332	0.45	422	2,513	0.49	851
10	1.111	239	0.45	76	629	0.49	213
TOTAL NO.		100,493		16,053	110,680		19,542
TOTAL WT. (tons)		41,956		8,170	47,913		10,327

C.

		1976			1977		
5							
5	0.298	(60,000)	0.08	(3,993)	(60,000)	0.08	(3,993)
6	0.450	(34,860)	0.23	(6,224)	(41,032)	0.25	(7,890)
7	0.569	15,972	0.50	5,497	20,519	0.55	(7,602)
8	0.743	5,483	0.48	1,827	7,177	0.53	2,584
9	0.953	1,332	0.45	422	2,513	0.49	851
10	1.111	239	0.45	76	629	0.49	213
TOTAL NO.		117,885		18,038	131,869		23,135
TOTAL WT. (tons)		48,263		8,962	56,446		12,034

D.

		1976			1977		
5	0.298	(70,000)	0.08	(4,659)	(70,000)	0.08	4,659
6	0.450	(42,245)	0.23	(7,542)	(47,870)	0.25	9,205
7	0.569	15,972	0.50	5,497	(24,866)	0.55	9,213
8	0.743	5,483	0.48	1,827	7,177	0.53	2,584
9	0.953	1,332	0.45	422	2,513	0.49	851
10	1.111	239	0.45	76	629	0.49	213
TOTAL NO.		135,270		20,022	153,055		26,726
TOTAL WT. (tons)		54,566		9,753	64,976		13,741

E.

		1976			1977		
5	0.298	(80,000)	0.08	5,324	(80,000)	0.08	5,324
6	0.450	(49,651)	0.23	8,864	(54,709)	0.25	10,520
7	0.569	15,972	0.50	5,497	(29,225)	0.55	10,828
8	0.743	5,483	0.48	1,827	7,177	0.53	2,584
9	0.953	1,332	0.45	422	2,513	0.49	851
10	1.111	239	0.40	69	629	0.49	213
TOTAL NO.		152,676		22,003	174,253		30,321
TOTAL WT. (tons)		60,879		10,539	73,514		15.450

Table 6. Comparison of total biomass, spawning biomass and catches during a period of recent fishing activity with projections for 1976-78 and 1981 at various levels of recruitment at age 5 in 1975.

Recruits in 1975 (millions of fish at age 5)	1971 (F = 0.73) Biomass	Tons Sp.Biomass	Catch	1973 (F = 1.55) Biomass	Tons Sp.Biomass	Catch	1974 (F = 1.17) Biomass	Tons Sp.Biomass	Catch	1975* (F = 1.10) Biomass	Tons Sp.Biomass	Catch
	105,500	76,800	37,300	72,400	45,900	32,800	62,300	38,100	23,200	56,400	36,600	22,300
	1976 (F = 0.50)			1977 (F = 0.55)			1978 (F = 0.55)			1981 (F = 0.55)		
50	42,000	28,100	8,200	47,900	32,800	10,300	50,900	35,627	11,400	53,100	37,900	12,200
60	48,300	31,000	8,900	56,400	38,200	12,000	60,600	42,300	13,500	63,800	45,400	14,600
70	54,600	34,300	9,800	65,000	43,700	13,700	70,300	48,900	15,600	74,400	53,000	17,100
80	60,900	37,600	10,500	73,500	49,200	15,500	79,400	54,100	18,900	84,200	59,300	20,400

*Using average recruitment
65 million at age 5

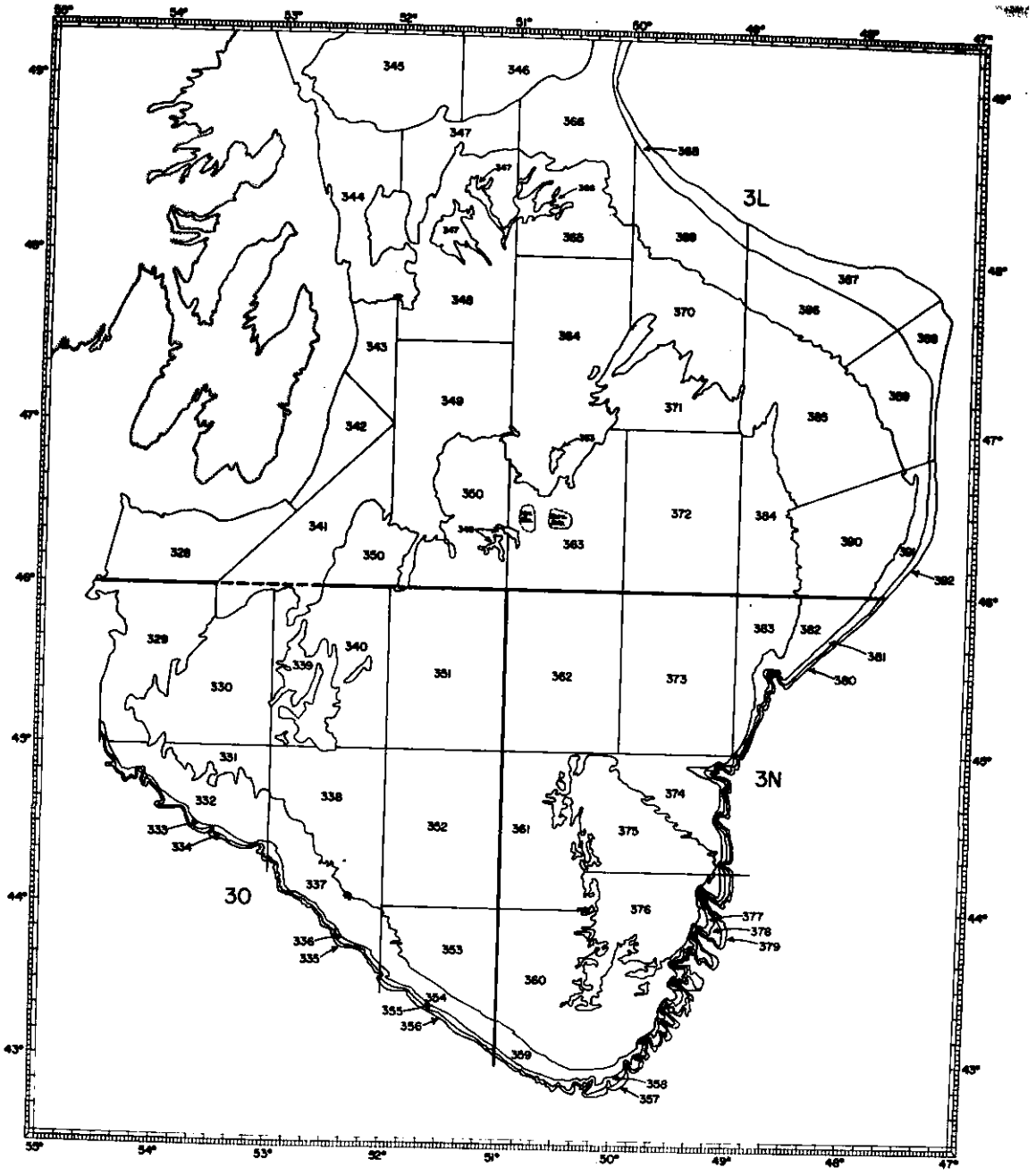

Fig. 1. Map of strata used for random stratified surveys of the Grand Bank.

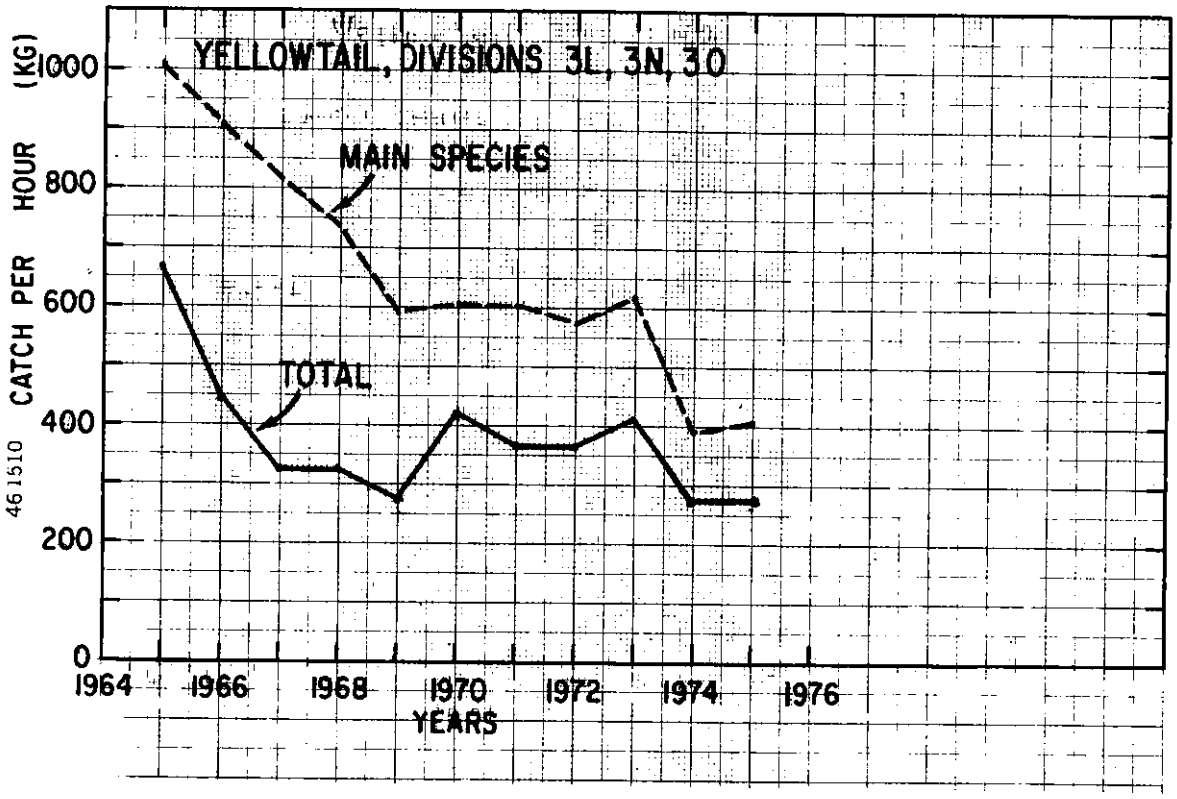

Fig. 2. Catch per hour of yellowtail by Canada (N) otter trawlers. Broken lines directed fishery; solid lines total catch and effort

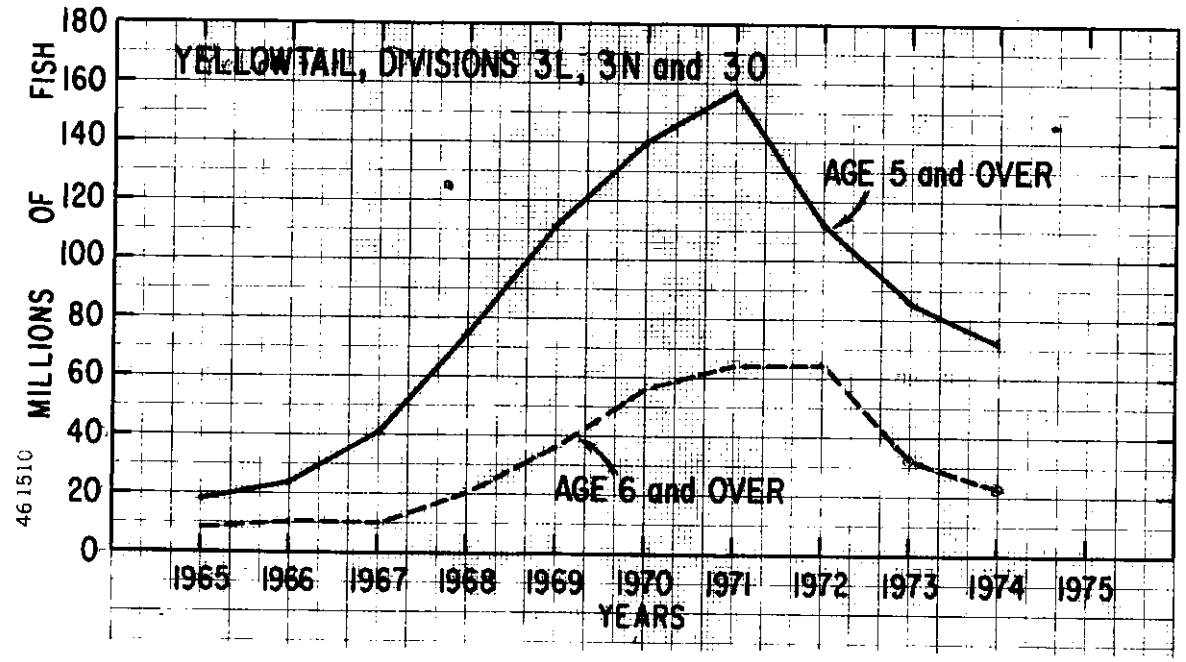

Fig. 3. Population size of yellowtail, Divisions 3LNØ from Cohort Analysis.

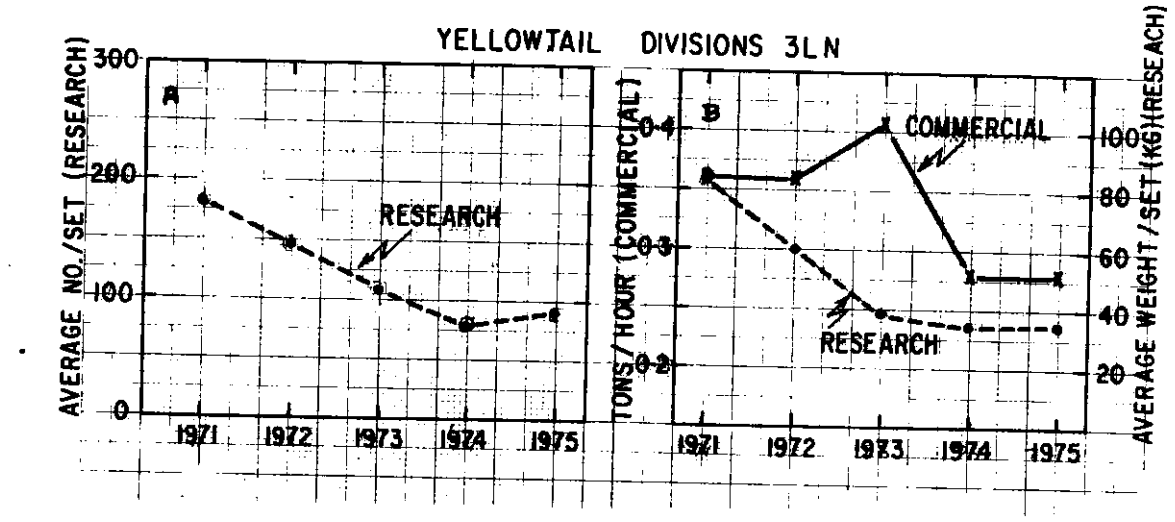

Fig. 4. A. Average number per set (weighted by area) for research vessel surveys;
B. Average weight per set (kg) for research vessels and a comparison with catch/hour (tons) by Canada (N) trawlers

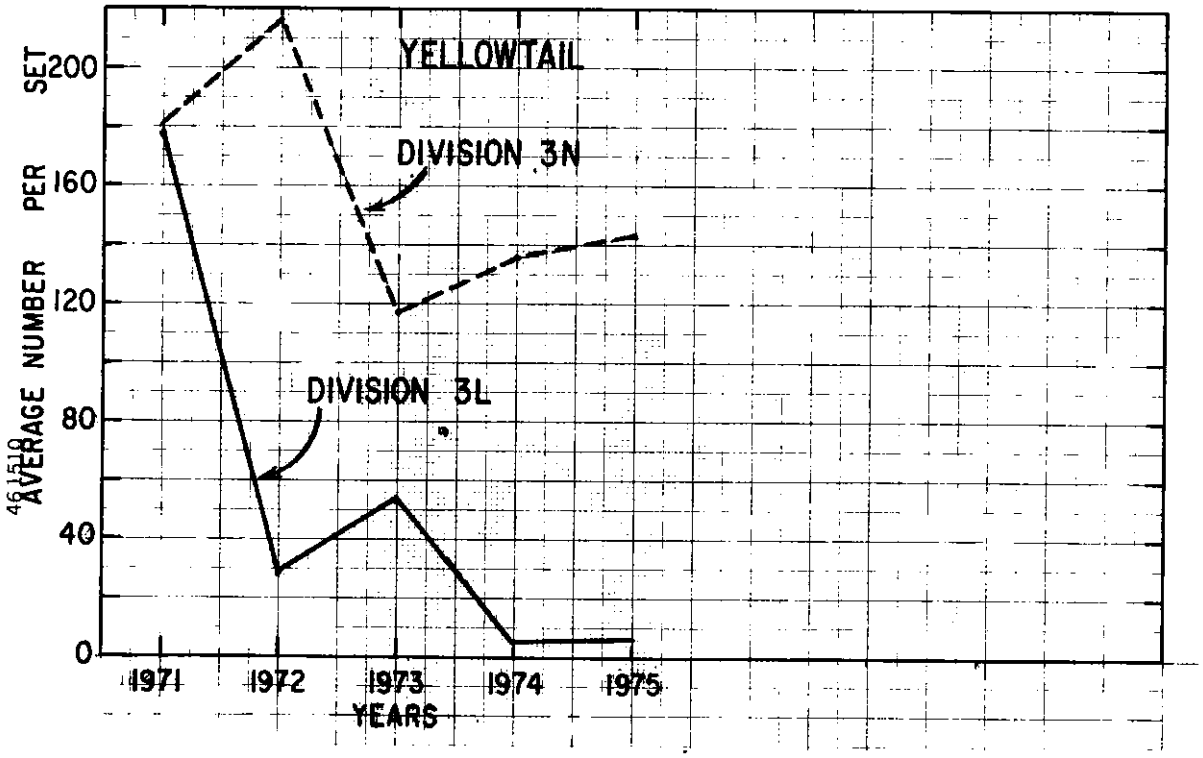

Fig. 5. Average number per set from research vessel surveys for Divisions 3L and 3N separately.

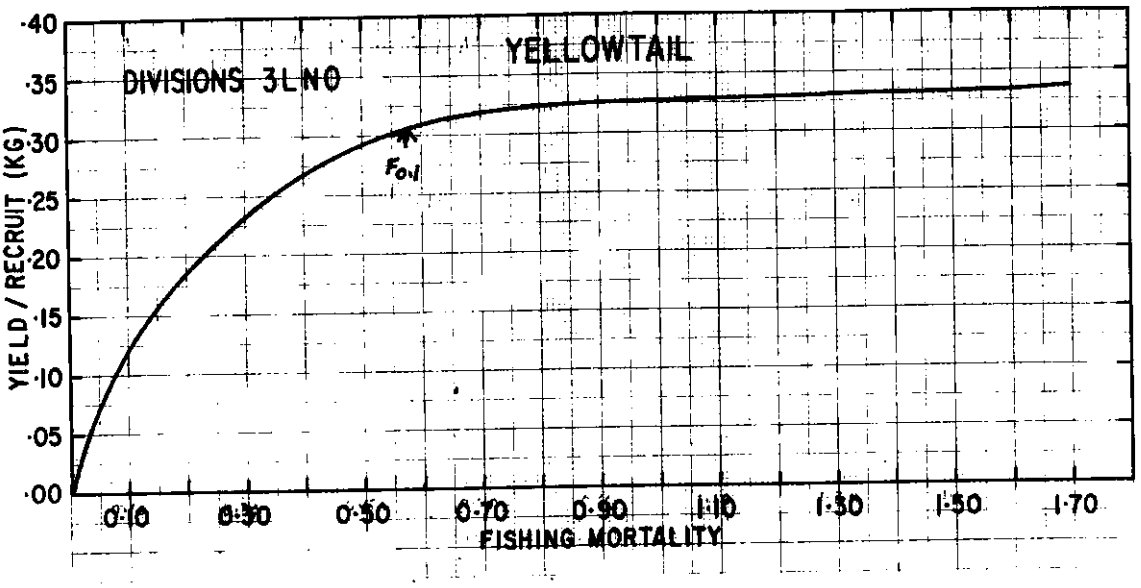

Fig. 6. Yield per recruit (using partial recruitment) for yellowtail, Divisions 3LNØ.