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Calculation of total allowable catches  
(TAC's) for 1975 for the cod stocks in Subareas 2 and 3

by

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Divisions 2GH

Recommended TAC for 1974 was based on the fact that abundance of old fish had decreased in recent years and with the 1964-66 year-classes poor but the 1967 stronger the TAC was set at 20,000 tons, below the MSY level of 30,000 tons to allow a re-building of the stock. Since no sampling data were available for 1972 and only scanty data for 1973 no formal quota calculation was possible but it is recommended that the TAC for 1975 be at the same level as 1974 (i.e. 20,000 tons) to allow further re-building of the stock.

Divisions 2J-3KL

Estimation of numbers caught at age, 1972 and 1973

The method of estimation of numbers caught at age for 1972 was similar to that described by Pinhorn (1971). In 1973, no age-length key was available for Division 2J; the USSR age composition was estimated from the length frequency by application of the FRG age-length key for November, 1973 with an adjustment of one year for growth. Also age compositions were not available for the inshore catches in Division 3K in 1973. Therefore, the inshore age compositions were estimated from the offshore compositions.

Estimation of F in 1973 and stock sizes in 1970-73

No survey was available for Divisions 2J-3KL cod to provide independent estimates of F in either 1972 or 1973. Similarly, effort data was only available for 1972 and estimates of Z in 1972 and 1973 could not be derived from commercial catch/effort data. However, a correlation of F value from previous assessments for the stock complex with catches produced a correlation coefficient ( $r$ ) = 0.75, significant at the .05 level. This correlation was used to estimate F for 1973 from the catch in 1973; the value estimated was 0.25. Since the last reasonably reliable F in fully recruited age-groups from previous assessments was that in 1969 ( $F = 0.9$ ), the ratio of catches in 1969 and 1973 was used to estimate the exploitation rate in 1973 from that in 1969; the value estimated was 0.33. The average of these two values was used as the terminal F in 1973 (0.30). Virtual population analyses were then performed for 1969-73 catch data to provide revised estimates of F at each age which were used to calculate stock size from catch data (Tables 1-2).

#### Estimates of recruitment of 1968-71 year-classes at age 4

Recruitment estimates for 1968 and 1969 year-classes were identical to those used in the Assessment at the 1973 Annual Meeting (see stock records, this meeting). The recruitment estimate for the 1970 year-class was derived from Table 8 of Summ.Doc 74/26 and the correlations of Pinhorn and Wells (1973). The recruitment estimate for the 1971 year-class was derived from the number per hour of 2-year-olds in Division 3K in USSR surveys for 1973 (Summ.Doc. 74/26) and the average ratio of 3-year-olds to 2-year-olds for the 1960-69 year-classes.

#### Calculation of TAC for 1975

Stock sizes for 1970-73 were calculated from catches and F values in each year. The stock sizes at age 4 for 1972 and 1973 were derived from recruitment estimates as described above. Stock sizes and fishing mortalities for 1973 were used to derive stock sizes at the beginning of 1974; an estimate of stock size from pre-recruit surveys as described above was used for 4-year-olds in 1974.

Since it seems evident from the 1971-72 fishing mortality estimates that fishing mortality on younger ages may have increased relative to the older ages in the most recent years, two sets of partial recruitment values were used to calculate catches in 1974 and 1975. One set of partial recruitment estimates was derived from F values in the 1968-73 period and the other set of estimates was derived from the F values in 1971-72. The latter estimates indicate that recruitment to the fishery may have been earlier with full recruitment at age 5 and this has implications for yields beyond 1975. Assuming a catch in 1974 of 450,000 tons considering ice conditions in 1974 were improved over 1973, the fishing mortality necessary to generate this catch with the stock sizes calculated was estimated for fully recruited age-groups and pro-rated for partially recruited age-groups by the two sets partial recruitment estimates discussed above. Stock sizes at beginning of 1975 were derived from stock sizes and fishing mortalities in 1974 and fishing at  $F_{max} = 0.40$  with the recruitment pattern of 1968-73 implies a yield of 583,000 tons in 1975, whereas fishing at  $F_{max} = 0.40$  with the recruitment pattern of 1971-72 implies a yield of 619,000 tons in 1975 (Tables 1 and 2). However, recalculation of yield per recruit with the 1971-72 partial recruitment value produces a curve with  $F_{max} = 0.30$  (Fig. 6). Although the difference between the yield per recruit at 0.3 and 0.4 is small. Fishing at  $F_{max} = 0.30$  in 1975 implies a yield of 487,000 tons.

#### Division 3M

Recommended TAC for 1974 from the 1973 Annual Meeting was based on an estimate of long-term average yield (MSY) since no sampling data was available for 1969-71. Therefore, the virtual population analyses performed earlier for years up to 1968 could not be updated at this time. Although some sampling data were available for 1972, no commercial data were forthcoming for 1973 and considering the gaps in the data for recent years, no formal TAC calculation could be performed at this time. Therefore, it is recommended that the TAC for 1975 be the same as 1974, i.e. 35,000 tons.

#### Divisions 3NO

##### Estimation of numbers caught at age, 1973

Numbers of length and age samples were insufficient in 1971 and 1972 to be used in the estimation of numbers caught at age. In the calculation of TAC for 1974 the age distribution of the commercial catches was estimated from Canada (N) survey cruises using the relationship between survey length distributions and commercial length distributions in years when both were available (Pinhorn, Pitt and Wells, 1973).

However, in 1973 a total of 16 samples, 5 from May, 3 from June and 8 from July, representing 6006 length measurements and 618 otoliths, were available for the first time from the Spanish pair trawl fishery which accounts for most of the catch in Divisions 3NO. The % age compositions for May and June from Division 3N were used as reported. Since only 25 otoliths were reported in the age-length key for July from Division 3N, the age-length key for the second quarter was used to estimate the age composition for July in Division 3N. Although 4 samples comprising 1621 fish were reported for Division 3O, about 25% of the length frequency mainly at the lower sizes was not represented in the age-length key. Therefore, it was impossible to use this age-length key. An age-length key available from a Canada (N) survey cruise to Division 3O in the second quarter could not be used to estimate the % age composition because the two age-length keys were significantly different, the research key containing slower growing fish than the commercial key. This may have been because the stratified-random survey fished the area of Division 3O randomly whereas the commercial fishery from which the samples were taken may have been concentrated in an area of faster growing fish. This was rather unfortunate because as Figure 1 shows, the length frequency for Division 3O in July contains smaller fish than the other length frequencies and this fact could not be taken into consideration in the assessment. On the other hand it may be just as well not to use these samples because 4 samples in July may not be representative of the catch in Division 3O for the year.

The % age compositions for the various months from Division 3N were used to estimate the age distribution of Spanish pair trawl catches in these months and the sum of these frequencies was adjusted to the total catch by all gears and countries in Divisions 3NO.

Subdivision 3Ps

Estimation of numbers caught at age, 1973

Numbers of length and age samples from the offshore commercial fishery were insufficient in 1971 and 1972 to be used in the estimation of numbers caught at each age; also no commercial samples were available in 1969 and only a limited number in 1970. The only samples available in 1971 and 1972 were those from the Canada (N) inshore fishery which represents only about half the total catch. In the calculation of TAC for 1974 at the 1973 Annual Meeting an estimate of numbers at age for the offshore commercial fishery in 1971 was derived from comparisons with inshore numbers at age and from ratios of catches at successive ages (Pinhorn, Pitt and Wells, 1973).

However, in 1973 a total of 7 samples, 3 from April and 4 from December, representing 2922 length measurements and 262 otoliths, were available for the first time from the Spanish pair trawl fishery which accounts for most of the catch in the offshore fishery. Since only 42 otoliths were available from the April sample, the age-length key from a Canada (N) survey at the same time was used to estimate the age-composition for April from the length composition. The age composition for December was used as reported. The ‰ age composition for April was used to estimate the numbers caught at each age for the offshore catch in the first, second and third quarters while the ‰ age composition for December was used to estimate the numbers at each age in the offshore fishery for the fourth quarter. This procedure was used because the age composition for the December samples contained 20% age 2 fish and these would only be expected to be caught in the fourth quarter when they would have grown large enough to be retained by the gear; essentially they would have been age 3 as far as size in December. The numbers at age in the inshore fishery were estimated as before using the commercial samples from this fishery.

Estimation of F and stock size in 1973

Since 1973 was the first year in which significant samples were available from the Spanish pair trawl fishery and no samples of any kind were available for the 1969, 1971 and 1972 offshore fishery and only limited samples for 1970, the usual procedure of updating virtual population estimates of F and stock size for 1970-73 was not followed. Instead, the calculation of TAC for 1975 commenced at 1973.

The fishing mortality in fully recruited age-groups in the period 1967-71 was estimated to be stable at 0.5; in fact F in fully recruited age-groups in the entire period 1959-71 was stable at 0.4-0.5 (Pinhorn, 1972, and stock records (this meeting)). The average catch in the 1967-71 period was 68,600 tons. The catch in 1972 was 46,300 tons. In spite of this, catch curves from commercial age compositions in 1971-72 and survey age compositions in 1972-73 produced estimates of  $F = 0.8$  for 1972 (Table 6). In view of the decline in catch in 1972 due mainly to a decline in inshore catches it does not seem reasonable to assume that the F in 1972 increased; in fact it probably decreased. The high apparent F from catch data may have resulted partly from inaccurate estimates of the commercial age compositions in 1972 and partly from change in availability of fish as discussed below. Therefore, F in fully recruited age-groups for 1972 was calculated from the ratio of catches in 1967-71 and 1972 and was estimated at 0.30. The partial recruitment rates used in the previous assessment were then applied to this F to estimate F in partially recruited age-groups. Stock sizes were then calculated from the catch equation (Table 8+9):

$$N_n = \frac{C_n}{E(1-e^{-Z})}$$

Estimates of recruitment of 1970 and 1971 year-classes in 1974 and 1975

Two estimates of recruitment for the 1970 and 1971 year-classes were used in the assessment:

(a) Year-classes up to and including 1968 were estimated from standard line surveys for Canada (N) research vessel surveys and correlations with USSR young fish surveys for the same year-classes were good (Pinhorn and Wells, 1973). However, correlations for the 1969-71 year-classes were very poor with the estimates from Canada (N) surveys being well below those predicted from the USSR surveys, using the correlation of Pinhorn and Wells (1973). The Canada (N) surveys from which the 1969-71 year-class estimates were derived were conducted with the stratified-random method of surveying and one explanation of this difference is that these type surveys possibly produce lower overall estimates of pre-recruit fish than the line surveys. The estimates obtained from the stratified-random surveys were thus adjusted by a factor which was the ratio of the average numbers of age 2-4 year-olds caught in these surveys to the average numbers caught in the previous line surveys during 1962-70 (Table 7). These adjusted figures correlated very well with the USSR survey estimates on the same correlation line as used previously.

### Estimation of F and stock size in 1973

Since 1973 was the first year in which significant samples were available from the Spanish pair trawl fishery and no commercial samples were available in 1971 or 1972, the usual procedure of updating virtual populations estimates of F and stock size for 1970-73 was not followed. Instead, the calculation of TAC for 1975 commenced at 1973.

The fishing mortality in fully recruited age-groups for 1972 was estimated from catch curves derived from Canada (N) survey cruises in 1971-73 (Table 3). Estimates of Z in 1971-72 and 1972-73 resulted in an estimate of F for 1972 of 0.52. Since the catch declined from 102,000 tons in 1972 to about 70,000 tons in 1973 due almost entirely to a decline in Spanish catches because of quota restrictions, the F in 1973 was estimated to have declined to 0.30 and this value was used as F in fully recruited age-groups in 1973. The partial recruitment rates derived from the previous assessment for Divisions 3N0 cod were then applied to F = 0.30 to estimate F in partially recruited age-groups. Stock sizes in 1973 were then calculated from the equation (Table 4).

$$N_n = \frac{C_n}{E(1-e^{-Z})}$$

### Estimates of recruitment of 1970 and 1971 year-classes in 1974 and 1975

Estimates of recruitment for the 1970 and 1971 year-classes were calculated from number/unit fishing (3-year-olds) in Canada (N) and USSR surveys using correlations from Pinhorn and Wells (1973) (Table 5). Estimates from both surveys were averaged for the 1970 year-class (82,000,000); the 1971 year-class was calculated from average ratio of 3-year-olds to 2-year-olds and the correlations from Pinhorn and Wells (1973).

### Calculation of TAC for 1975

Stock sizes and fishing mortalities for 1973 were used to derive stock sizes at the beginning of 1974; an estimate of stock size from pre-recruit surveys as described above was used for 4-year-olds in 1974. Assuming a catch in 1974 similar to 1973, the fishing mortality necessary to generate this catch with the stock sizes calculated was estimated for fully recruited age-groups and pro-rated for partially recruited age-groups by the partial recruitment values derived from the earlier assessment. Stock sizes at the beginning of 1975 were derived from stock sizes and fishing mortalities in 1974 and fishing at  $F_{max}$  (0.20) with recruitment pattern similar to that in earlier years implies a yield of about 90,000 tons (Table 4).

### Trends in recruitment and CPUE

Because there was some doubt expressed as to the strength of the 1968 year-class at the 1973 Annual Meeting (Redbook, 1973, Pt. 1, p. 70), since the 1972 catch did not increase as would be expected with a strong 1968 year-class recruiting, Figure 2 compares trends in recruitment and catch per unit effort from both the commercial fishery and research surveys. Generally, from both the Canada (N) and the USSR surveys, recruitment as 4-year-olds in the 1967-72 period (1963-68 year-classes) should have been higher than in the previous 1959-66 period (1955-62 year-classes). However, catch per unit effort from the commercial Spanish pair trawl fishery declined from about 1.6 tons per hour in 1965-68 to 1.25 in 1969-71 and then more sharply to slightly over 1 ton per hour in 1972. Catches per standard set of age 4+ fish from Canada (N) surveys also declined from slightly over 100 kg in 1967-69 sharply to 25 kg in 1970, increased slightly in 1971 and 1972 and then declined to about 12 kg in 1973. There are at least two possible explanations for these apparent contradictory results:

- (1) The strength of the 1963-68 year-classes was grossly overestimated from surveys.
- (2) Some change in availability of the fish to the gear occurred such that when these year-classes were recruited to the fishery they could not be as successfully caught as in the earlier period.

The first explanation is highly unlikely since two independent sets of surveys in several years produced remarkably similar trends in recruitment. Thus, these fish were there in abundance at age 3. However, the second explanation is quite possible. Figure 3 shows the average temperature throughout the period 1959-73 on a line of hydrographic stations across the top of the Grand Bank to the slope of the Bank in the vicinity of the southeastern edge, i.e. across the Southeast Shoal. The result indicates that at 50 m, 100 m and 150 m the average temperature declined by 1.5-2.5 degrees between 1969 and 1973, with 1972 and 1973 having the lowest average temperature (0.5°C at 50 m and 100 m in 1973; 1.8°C at 150 m in 1973) for the entire period. These colder temperatures may have affected the availability of the cod to the gear.

(b) However, another explanation for the lack of correlation of the 1969-71 year-classes is that these year-classes were actually small in size as indicated by the Canada (N) surveys and the USSR surveys overestimated them. Thus, as a second set of recruitment figures the Canada (N) survey results for the 1970 and 1971 year-classes were used without adjustment (Table 7).

#### Calculation of TAC for 1975

Two calculations of TAC in 1975 were performed using the different estimates of recruitment of the 1970 and 1971 year-classes. The procedure was identical to that described for 3NO cod above. Using estimates of recruitment adjusted for the Canada (N) stratified surveys and averaged with the USSR estimate resulted in a TAC of about 62,000 tons, while using Canada (N) recruitment estimates unadjusted only resulted in a TAC of 55,000 tons for 1975 (Table 8).

#### Trends in recruitment and CPUE

As in Divisions 3NO cod, some doubt was expressed at the 1973 Annual Meeting about the strength of the 1968 year-class (Redbook, 1973, Pt. 1, p. 70) since the 1972 catch in fact decreased in Subdivision 3Ps. Therefore, trends in recruitment and catch per unit effort from both the commercial fishery and research surveys are summarized in Figure 4. As estimated from both Canada (N) and USSR surveys recruitment should have been higher as 4-year-olds in the 1967-72 period (1963-68 year-classes) than in the previous 1960-66 period (1956-62 year-classes) and the 1968 year-class was especially strong. However, the catch per hour for the Spanish pair trawl fishery has steadily declined since 1968 from 1.75 tons in 1968 to 1.1 tons in 1972. Similarly, catch per standard set of age 4+ fish from Canada (N) surveys declined from 35 kg in 1967 to 6 kg in 1973. Again, at least two explanations are possible:

- (1) The strength of the 1963-68 year-classes was grossly overestimated from surveys.
- (2) Some change in availability of fish to the gear occurred such that they were unable to be caught in abundance by the commercial fishery after they had recruited.

Again, the agreement between the two independent sets of surveys is such that it is difficult to conclude that both sets were biased to the extent of grossly overestimating recruitment. Thus, one must conclude that these year-classes were abundant at ages 2 and 3. Some change in availability is quite possible, however, since the average temperature at 50 m and 100 m showed a decline of about 2°C between 1969 and 1973 and a decline of 1.5°C at 150 m between 1969 and 1972, although the temperature at this depth in 1973 was as warm as in 1969 probably because of incursion of Gulf Stream water (Fig. 5). Water temperature changes are known to affect distribution and behaviour of cod and these changes may have affected the behaviour and distribution of the cod in relation to the fishing gear in these years causing lower catch rates. The colder temperatures in 1972 and 1973 was also probably the cause of the poorer inshore fishery in 3Ps in these years.

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Table 1. Stock sizes, catches and F values for 1970-75 using partial recruitment estimates averaged for 1968-73; Divisions 2J3KL cod.

Age	1970		1971		1972		1973		1974		1975								
	Stock numbers	F	Stock numbers	Catch numbers	F	Stock numbers	Catch numbers	F	Stock numbers	Catch numbers	F	Catch weight							
4	604600	.12	509700	69000	.16	1053500	79800	.09	656000	48600	.09	508000	52300	.12	29800				
5	482700	.19	418700	92100	.28	358500	116600	.44	764000	85700	.13	465800	76900	.20	374100	80400	.27	70800	
6	322800	.38	330100	94400	.38	256100	76200	.39	189100	58800	.42	556600	135300	.31	312500	95900	.41	118000	
7	196100	.58	183800	55700	.40	183300	56000	.41	143400	33600	.30	101000	27900	.36	334500	116400	.48	193200	
8	82300	.44	89600	24100	.35	101600	29600	.38	99100	23400	.30	86300	22700	.34	57800	19500	.46	41300	
9	38000	.34	43900	11300	.33	51700	11800	.29	57400	13000	.29	60000	14200	.30	50300	15100	.40	40000	
10	19900	.22	22200	4300	.24	26000	6400	.31	31400	7500	.30	34700	7000	.25	36400	9300	.33	29600	
11	12500	.18	13000	2100	.20	14300	3000	.26	15800	3700	.30	19300	3700	.24	22100	5500	.32	20600	
12	5500	.35	6900	1200	.30	8700	1700	.23	9000	2100	.30	9600	2300	.30	12400	3700	.40	15500	
13	2900	.35	3500	1100	.30	3200	1400	.64	5800	1300	.30	5400	1300	.30	5800	1700	.40	10600	
13+	4500	.35	6000	2100	.30	8300	3000	.50	5500	1400	.31	6800	1600	.30	7400	2200	.40	13500	
																			583000

Notes (1) Stock size of 4-year-olds for 1971 year-class from 2-year-olds in USSR 1973 surveys and ratio 3-year-olds to 2-year-olds in same survey (Summ.Doc. 74/26).

(2) Stock sizes of 4-year-olds for 1970 year-class from Summ.Doc. 74/26 and correlations of Pinhorn and Wells (1973).

(3) Stock size of 4-year-olds of the 1968-70 year-classes from Pinhorn and Wells (1973).

(4) Estimated catch in 1974 - 450,000 tons.

Table 2. Stock sizes, catches and F values for 1974-75, using partial recruitment estimates averaged for 1971-72; Divisions 2J3KL cod.

Age	1974		1975 (F <sub>max</sub> = 0.40)			1975 (F <sub>max</sub> = 0.30)			Catch weight
	Stock	Catch numbers	F	Stock	Catch numbers	F	Stock	Catch numbers	
4	500000	43000	.10	508000	64500	.15	508000	48300	27500
5	465800	106700	.29	370400	115900	.42	370000	92600	81500
6	556600	135300	.31	285000	96100	.46	285000	76700	94300
7	101000	25200	.32	334500	114700	.47	334500	90000	149400
8	86300	19800	.29	60200	19600	.44	60200	15400	32600
9	60000	12100	.25	52800	14600	.36	52800	11300	30000
10	34700	6500	.23	38200	10000	.34	38200	7900	25300
11	19300	2900	.18	22600	4900	.27	22600	3700	13900
12	9600	2100	.27	13200	4000	.40	13200	3100	12900
13	5400	1200	.27	6000	1800	.40	6000	1400	8500
13+	6800	1500	.27	7600	2300	.40	7600	1800	10900
									486800
									619000

Note: Estimated catch in 1974 - 450,000 tons.

Table 3. Estimate of total mortality using catch curves from survey cruises, 1971-73. Cod. Divisions 3NO.

Age	No. per standard set		
	1971	1972	1973
3	42.14	9.01	2.44
4	5.80	19.28	1.48
5	4.43	1.72	2.53
6	1.06	0.71	0.76
7	1.08	0.58	0.34
8	0.48	0.41	0.23
9	0.24	0.30	0.22
10	0.03	0.17	0.15

$$(a) \frac{\sum \text{Ages 7-10 (1972)}}{\sum \text{Ages 6-9 (1971)}} = \frac{1.46}{2.86} = 0.51 = s$$

$$Z_{1971-72} = 0.67$$

$$(b) \frac{\sum \text{Ages 7-10 (1973)}}{\sum \text{Ages 6-9 (1971)}} = \frac{0.94}{2.00} = 0.47 = s$$

$$Z_{1972-73} = 0.76$$

$$\bar{Z}_{1972} = 0.72$$

$$F = 0.52$$

Table 4. Calculation of total allowable catch for 1975. Cod. Divisions 3NO. Using average of USSR and Canada (N) recruitment estimates for 1970 and 1971 year-classes.

Age	1973			1974			1975			W Kg	Re- cruit Rate
	Stock	Catch	F	Stock	Catch	F	Stock	Catch	F		
2		100									
3		700									
4	122700	14600	0.14	(82000)	7100	0.10	(92000)	7900	0.10	1.07	6
5	87200	15000	0.21	87300	10400	0.14	(60700)	7200	0.14	1.71	71
6	25200	7100	0.37	57900	11600	0.25	62100	12500	0.25	2.97	123
7	9100	1900	0.26	14300	2100	0.18	36900	5500	0.18	3.75	88
8	1900	500	0.35	5700	1100	0.23	9800	1800	0.23	5.00	115
9	1600	300	0.23	1100	100	0.15	3700	500	0.15	6.00	75
10				1000	200	0.20	800	100	0.20	6.90	100
11							700	100	0.20	7.80	100
N	247700	39400		249300	32600		254700	34600			
(4-11)											
W	408500	73700		504600	75200		594400	92000			
(4-11)											
F			0.30			0.20			0.20		



Table 5. Calculation of recruitment estimates from Canada (N) and USSR surveys used in calculation of 1975 TAC. Cod. Divisions 3N0.

Year-Class	Canada (N) Surveys	
	No/Unit (Age 3)	Estimated Stock Size
1969	9	72000000
1970	3	42000000
1971	(4) <sup>1</sup>	(50000000) <sup>1</sup>

Correlation Equation

$$Y = 24.6 X^{0.49}$$

Y = Stock size at age 4

X = No/Unit at age 3

$$\text{Ratio 3-year-olds/2-year-olds} = 2.20$$

Year-Class	USSR Surveys	
	No/Unit (Age 3)	Estimated Stock Size
1969	26	125000000
1970	21	120000000
1971	(16) <sup>2</sup>	(133000000) <sup>2</sup>

Correlation Equation

$$Y = 65.1 X^{0.20}$$

1. Estimated from no/hr 2-year-olds in 1973 survey and average ratio 3-year-olds to 2-year-olds in 1955-70 year-classes.
2. Estimated from no/hr 2-year-olds in 1973 survey and average ratio 3-year-olds to 2-year-olds for 1960-69 year-classes (Res. Doc. 73/22).

Table 6. Estimate of total mortality using catch curves from survey and commercial data. Cod. Subdivision 3Ps, 1971-73.

Age	Spain-Pt-No/Hr		Can(N) Survey-No/Std Set	
	1971	1972	1972	1973
3	58	18	1.8	2.0
4	129	121	3.5	3.0
5	172	112	2.3	2.8
6	146	87	1.6	0.8
7	165	112	2.2	1.5
8	63	64	1.4	0.6
9	26	20	0.7	0.8
10	11	11	0.4	0.2
11	2	5	0.2	0.1

(a) Commercial - 1971-72

$$\frac{\sum \text{Ages 8-11 (1972)}}{\sum \text{Ages 7-10 (1971)}} = \frac{100}{265} = 0.38 = S$$

$$Z_{1971-72} = 0.97$$

(b) Research - 1972-73

$$\frac{\sum \text{Ages 8-11 (1973)}}{\sum \text{Ages 7-10 (1972)}} = \frac{1.70}{4.90} = 0.35 = S$$

$$Z_{1972-73} = 1.06$$

$$\bar{Z}_{1972} = 1.02$$

$$F = 0.82$$

Table 7. Method of adjusting Canada (N) survey pre-recruit indices of abundance for stratified-random effect and estimates of stock size from Canada (N) and USSR surveys used in calculation of 1975 TAC.

Canada (N) Surveys										
Age	1962	1963	1964	1965	1967	1968	1969	1970	1972	1973
Number of Fish (000's)										
2	461	2738	2995	2018	1093	10931	1657	5186	380	561
3	968	1267	3059	1505	3851	3890	8021	2458	651	217
4	831	358	1395	823	1768	3103	3244	2580	641	325
Total	2260	4363	7449	4346	6712	17924	12922	10224	1672	1103

$$CF = \frac{8275}{1388} = 6.08$$

Age	Number from Stratified-Random Survey		Adjusted to Line Survey		No/Unit	
	1972	1973	1972	1973	1972	1973
	2	380000	561000	2280000	3366000	50.31
3	651000	217000	3906000	1302000	86.18	28.73

Correlation Equation

$$Y = 3.89 X^{0.64} \text{ (from Pinhorn and Wells, 1973)}$$

Y = Stock size at age 4

X = No/Unit at ages 2 + 3

$$\text{Ratio age 3 to age 2} = 1.41$$

Year-Class	No/Unit			Estimated Stock Size
	Age 2	Age 3	Ages 2 + 3	
1969	(61.12)	86.18	147.30	95000000
1970	50.31	28.73	79.04	64000000
1971	74.27	(104.72) <sup>1</sup>	178.99	(108000000) <sup>1</sup>

Unadjusted Stock Size Estimates

Year-Class	No/Unit			Estimated Stock Size
	Age 2	Age 3	Ages 2 + 3	
1969	(10.18)	14.36	24.54	30000000
1970	8.38	4.79	13.17	20000000
1971	12.38	(17.46)	29.84	34000000

USSR Surveys

Year-Class	No/Hr			Estimated Stock Size
	Age 2	Age 3	Ages 2 + 3	
1969	50	25	75	97000000
1970	9	3	12	47000000
1971	6	(6) <sup>2</sup>	(12) <sup>2</sup>	(47000000) <sup>2</sup>

Correlation Equation

$$Y = 17.93 X^{0.39} \text{ (from Pinhorn and Wells, 1973)}$$

- Footnote:
1. Estimated from no/unit 2-year-olds in 1973 survey and average ratio 3-year-olds to 2-year-olds for 1954-68 year-classes.
  2. Estimated from no/hr 2-year-olds in 1973 survey and average ratio 3-year-olds to 2-year-olds for 1960-69 year-classes.

Table 8. Calculation of total allowable catch for 1975. Cod. ICNAF Subdivision 3Ps. Using average of USSR and Canada (N) recruitment estimates. 1970 and 1971 year-classes from Canada (N) surveys adjusted for stratified-random surveys.

Age	1973			1974			1975			W Kg	Recruit rate
	Stock	Catch	F	Stock	Catch	F	Stock	Catch	F		
2	(164000)	(1100)	(0.007)							.08	2
3	(74000)	(1000)	(0.015)	(133500)	(1800)	(0.015)				.28	5
4	49500	4700	0.11	(55000)	5200	.11	(78000)	7400	.11	.69	35
5	69700	11500	0.20	36300	6000	.20	(40300)	6600	.20	1.08	65
6	25500	4000	0.19	46700	7300	.19	24300	3800	.19	1.68	63
7	16500	3900	0.30	17300	4100	.30	31600	7500	.30	2.40	100
8	9300	2200	0.30	10000	2400	.30	10500	2500	.30	3.21	100
9	8500	2000	0.30	5600	1300	.30	6100	1400	.30	4.10	100
10	2100	500	0.30	5200	1200	.30	3400	800	.30	5.08	100
11	800	200	0.30	1300	300	.30	3200	800	.30	6.03	100
11+	400	100	0.30	500	100	.30	1100	300	.30	8.58	100
N	182300	29100		182900	30000		232200	34400			
(4-11+)											
W	275500	51600		294200	54500		343400	61900			
(4-11+)											
F			0.30			0.30			0.30		
fully recruit											

Table 9. Calculation of total allowable catch for 1975. Cod. ICNAF Subdivision 3Ps. Using Canada (N) recruitment estimate unadjusted for 1970 and 1971 year-classes.

Age	1973			1974			1975			W Kg	Recruit rate
	Stock	Catch	F	Stock	Catch	F	Stock	Catch	F		
2	(53000)	(1100)	(0.023)							.08	8
3	(26000)	(1000)	(0.045)	43000	(1700)	(0.045)				.28	15
4	49500	4700	0.11	(20000)	1900	0.11	(34000)	3200	0.11	.69	35
5	69700	11500	0.20	36300	6000	0.20	(14700)	2400	0.20	1.08	65
6	25500	4000	0.19	46700	7300	0.19	24300	3800	0.19	1.68	63
7	16500	3900	0.30	17300	4100	0.30	31600	7500	0.30	2.40	100
8	9300	2200	0.30	10000	2400	0.30	10500	2500	0.30	3.21	100
9	8500	2000	0.30	5600	1300	0.30	6100	1400	0.30	4.10	100
10	2100	500	0.30	5200	1200	0.30	3400	800	0.30	5.08	100
11	800	200	0.30	1300	300	0.30	3200	800	0.30	6.03	100
11+	400	100	0.30	700	200	0.30	1200	300	0.30	8.58	100
N	182300	29100		143100	24700		129000	22700			
(4-11)											
W	275500	51600		268300	52600		261600	54400			
(4-11)											
F			0.30			0.30			0.30		
fully recruit											

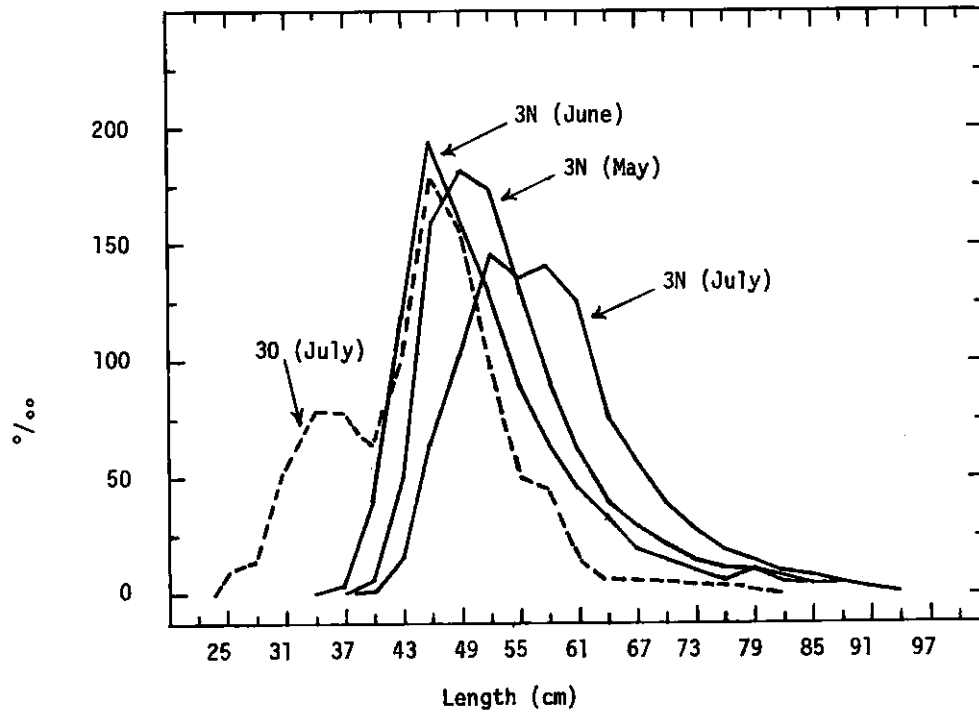


Fig. 1. % Length frequencies from the Spanish pair trawl fishery, 3N0 cod, 1973.

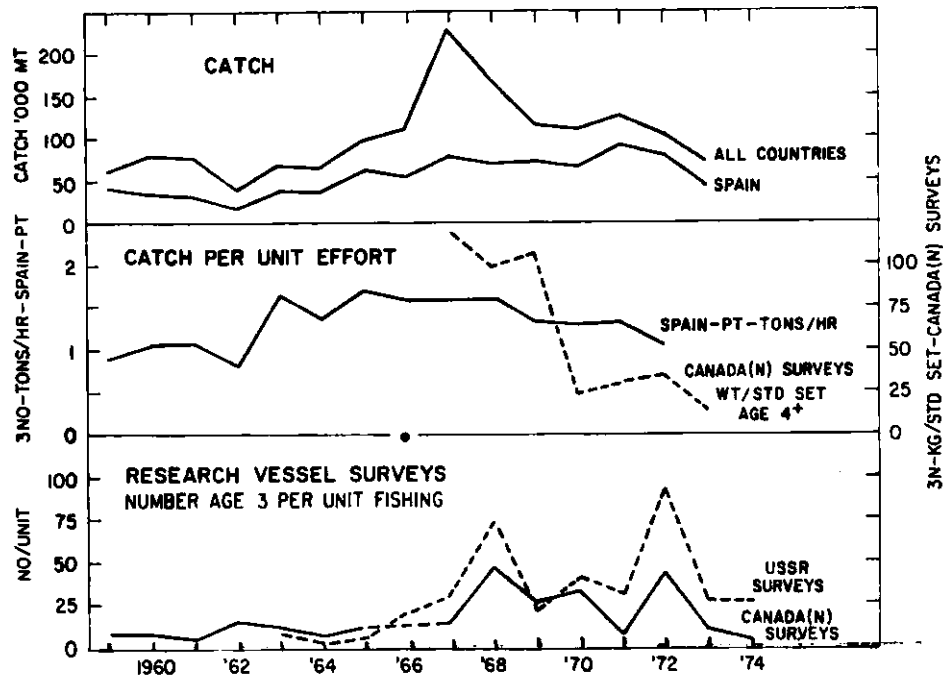


Fig. 2. Trends in catch, catch per effort and recruitment for Division 3N0 cod, 1959-73.

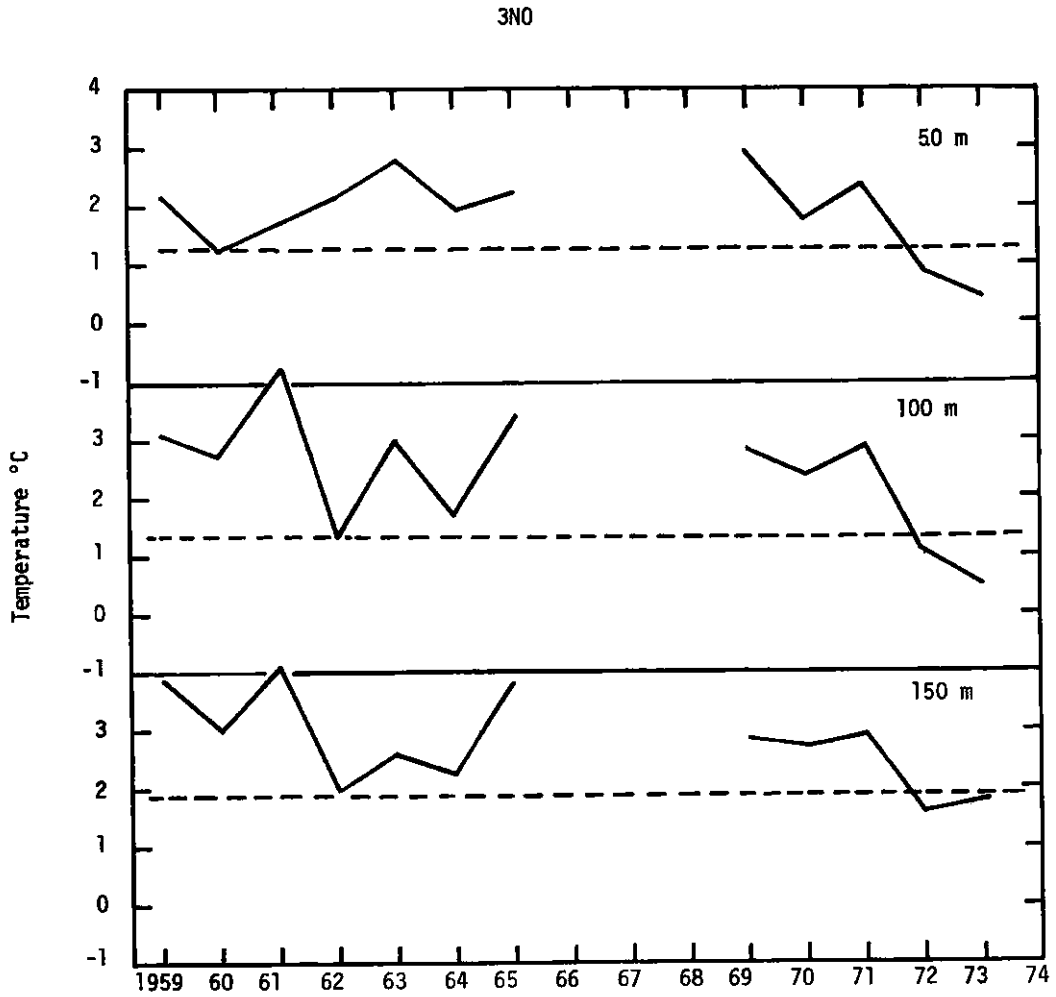


Fig. 3. Temperatures at selected depths on a line of stations across the top of Grand Bank to southeastern edge, 1959-73.

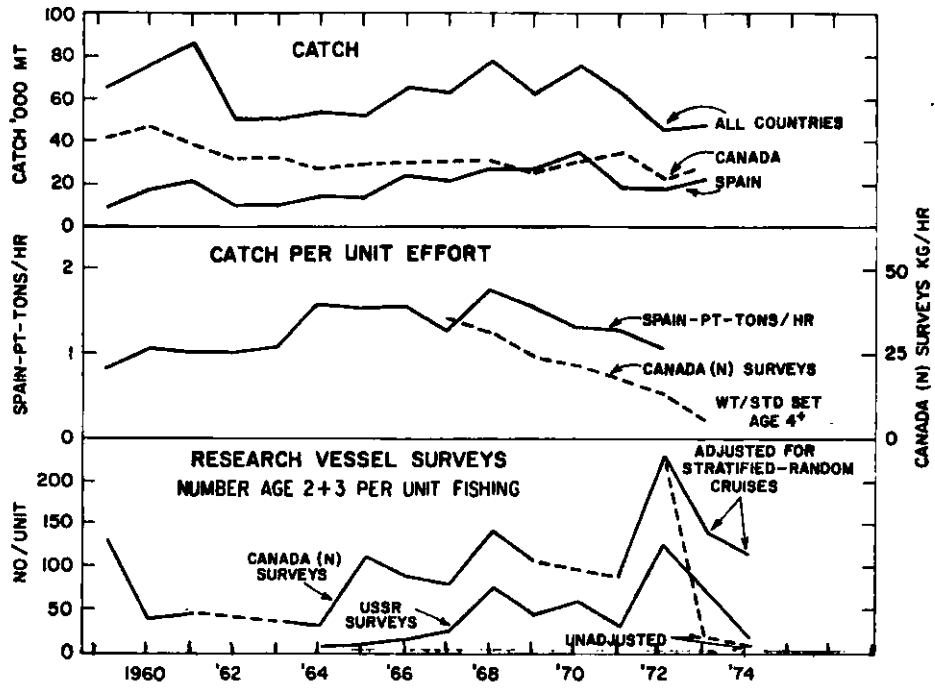


Fig. 4. Trends in catch, catch per effort and recruitment for Subdivision 3Ps cod, 1959-73.

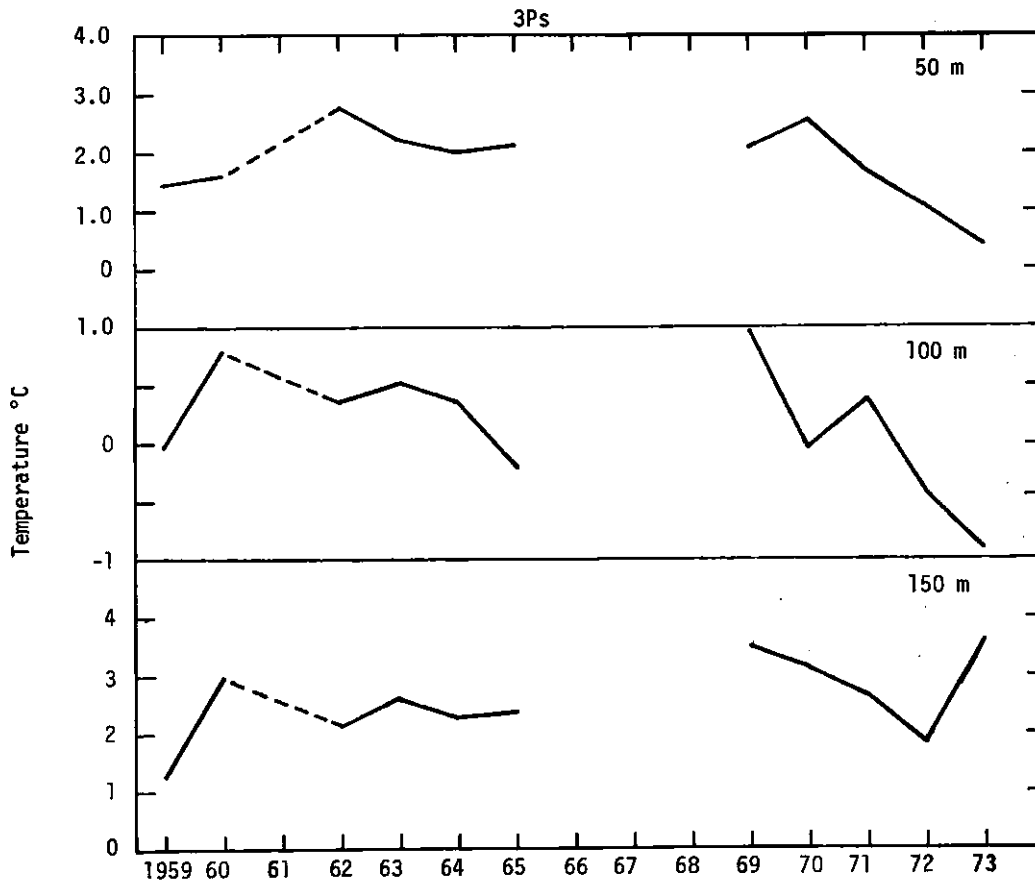


Fig. 5. Temperatures at selected depths at random stations in the area of St. Pierre Bank, 1959-73.

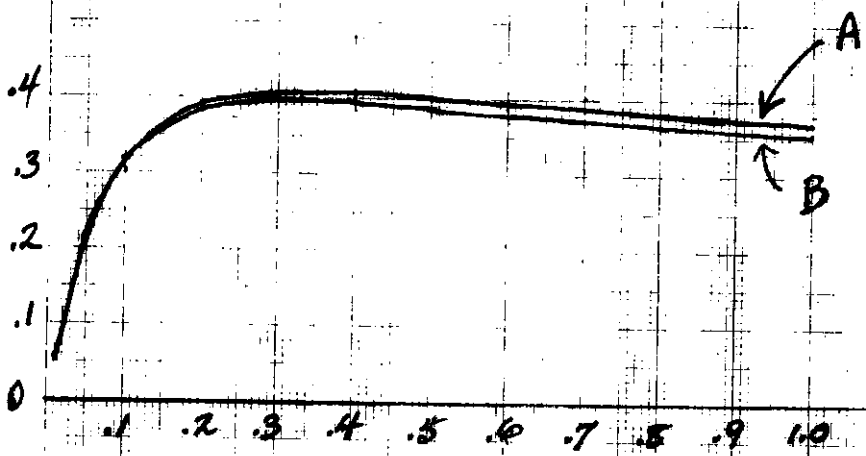


Fig. 6. YIELD PER RECRUIT VALUES FOR VARIOUS F VALUES. CURVE A INCORPORATES PARTIAL RECRUITMENT ESTIMATES AVERAGED FOR THE PERIOD 1968-73; CURVE B FOR THE PERIOD 1971-72.