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## **Status of the 1991 4X Cod Fishery**

**by**

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## Abstract

The 1991 nominal catch of 4X cod was 27,470 t. The TAC of 26,000 t was exceeded only slightly under ITQ management of the small mobile gear fishery, although the catch statistics are believed to be as accurate as those of 1989. Due to the presence of the strong 1985 and 1987 year-classes, stock biomass is at an all-time high, having recovered from the record-low levels of 1985. Entry of the very weak 1988 year-class into the fishery has now reversed the biomass increases of recent years. Calibration of the SPA with the ADAPT framework indicated a terminal 5+ fishing mortality of 0.38. This estimate is well below the long-term mean, but is consistent with the catch restrictions on the small mobile gear fishery and the size of the 1985-1987 year-classes. An analysis of retrospective F's in this stock indicates that previous assessments have provided consistent estimates of terminal F. The fishable biomass of 4X cod will remain relatively high through 1992 and 1993 as the strong year-classes move through the fishery. However, the stock is now declining; the rate of the decline will depend heavily upon the strength of the incoming year-classes.

## Résumé

En 1991, les prises nominales de morue dans la division 4X ont été de 27 470 t. Le TPA de 26 000 t n'a été que légèrement dépassé dans le cadre du régime de CIT de la petite pêcherie aux engins mobiles. Cependant, les données statistiques sur les prises sont jugées presque aussi précises que celles de 1989. À cause de la présence des fortes classes d'âge de 1985 et 1987, la biomasse du stock, qui était tombée à son plus bas en 1985, a atteint un niveau record. Toutefois, le recrutement de la très faible classe d'âge de 1988 a maintenant inversé la tendance à la hausse observée depuis quelques années. L'étalonnage de l'ASP à l'aide de la méthode ADAPT a abouti à une mortalité terminale 5 + due à la pêche de 0,38. Cette estimation est bien inférieure à la moyenne à long terme, mais correspond aux restrictions sur les prises imposées aux petits bateaux pêchant aux engins mobiles et à la grosseur des classes d'âge de 1985-1987. Une analyse rétrospective des valeurs F dans ce stock révèle que les évaluations antérieures ont fourni des estimations cohérentes de la mortalité terminale. La biomasse exploitante de morue dans la division 4X demeurera assez élevée en 1992 et en 1993, alors que les fortes classes d'âge s'intégreront à la pêche. Toutefois, la situation subséquente du stock dépendra grandement de la force des classes d'âge à venir.

## Nominal Catches

Historically, the cod fishery in Division 4X (Figure 1) has been prosecuted by the Canadian inshore fleet. Between 1947 and 1961, nominal catches for the Division averaged 15,000 t, with less than 3,000 t estimated as having come from the offshore grounds. The introduction of large Canadian and foreign trawlers in 1962 resulted in a rapid increase in catches, which peaked at 35,543 t in 1968 (Table 1). Imposition of quotas on 4X haddock by ICNAF in 1970 substantially reduced cod catches (to approximately 22,000 t), emphasizing the by-catch nature of many cod catches. Since 1976, the fishery has been nearly 100% Canadian and catches increased to almost 33,000 t; however, there was a marked decline in catches after 1982 to about 20,000 t, where it remained between 1985 and 1990 (Figure 2). The nominal catch in 1991 increased to 27,470 t as a result of a TAC of 26,000 t; the latter was not based on the usual biological reference points, but on the perceived need by managers for increased quota associated with the introduction of Individual Transferable Quotas (ITQ's).

All gear sectors caught close to their allocated catch (Table 2). Only FG<65' exceeded their allocation, and that was by a reasonably small amount. As in past years, the cod fishery in SW Nova Scotia was heavily regulated (Table 3).

The accuracy of the 4X cod catch statistics was good in 1991, in keeping with the statistics of 1989 and 1990. In 1987 and 1988 in particular, substantial quantities of cod were either unreported during the year or incorrectly reported as other species such as white hake. Comments by fishermen, industry representatives, and port samplers all indicate that the 1991 catch statistics were relatively accurate, due both to the introduction of licensed weighmasters for recording landings, and the ITQ system for much of the small mobile gear (MG<65') fleet. The introduction of the "3:2:1" system, through which excessive ITQ catches of cod, haddock or pollock could be legally landed and applied against the prorated ITQ of one of the remaining two species, may also have improved the accuracy of the catch statistics and reduced dumping. The small mobile gear sector has misreported 4X cod to 5Y in previous years (documented in Campana and Simon, MS 1985), necessitating adjustment of reported catches for stock assessment purposes. The problem has not been significant since 1986; nevertheless, the adjustment procedure was continued for the current assessment.

A breakdown of nominal catches by gear, tonnage class, and unit area over recent years is presented in Table 4. Landings have been split relatively evenly between otter trawlers and fixed gear since about 1983 (Figure 3). Catches by TC-1 vessels accounted for 40% of the total in 1991, with gillnets (GN) accounting for over 2700 t of the total catch. Catches in each of the fixed gear categories peaked in the summer months, while that of the mobile gear was greatest in the first quarter (Figure 4).

## Stock Abundance Indices

## Research Vessel Surveys

Random stratified surveys of the Scotian Shelf have been conducted in July since 1970; Strata 70-95 comprise the offshore and Bay of Fundy region of 4X (Figure 5). Inshore regions are not surveyed due to the prevalence of rough bottom. Surveys between 1970 and 1981 were carried out by the A.T. Cameron, while the Lady Hammond was used in 1982 and the Alfred Needler in subsequent years. All research vessel (RV) data have been presented in terms of Alfred Needler trawlable units (41' wingspread). As per the recommendation of the Statistics, Sampling and Surveys Subcommittee of CAFSAC, RV data prior to 1983 were multiplied by an inter-vessel conversion factor of 0.8.

Age-structured survey population indices were based on 2-10 sets in each stratum (Table 5). The 1991 indices of number and weight per tow were somewhat higher than those of the long-term mean, and appeared to be distributed among strata in a pattern similar to that of other years (Tables 6, 7; Figs. 6, 7). As has been observed in previous years, peak abundances of cod were observed near the mouth of the Bay of Fundy and on the offshore banks (Figs. 6, 7). There was no suggestion of a shift in distribution to deeper waters, as has been suggested for other cod stocks.

Survey 3-7 numbers and biomass have increased from a 1987 low to a level which is comparable to that of the long-term mean (Table 8; see also Figure 13). Both age 5+ population numbers (Figure 8) and a total biomass index (Figure 9) were slightly above the long-term mean. Coefficients of variation around the age-structured survey estimates were uniformly low (0.21-0.38) across ages 1-7 (Table 9).

The 1985 and 1987 year-classes have appeared strong in each of the last four survey years, while the 1986 year-class may be above average (Table 8; Figure 10). The 1988 year-class has appeared to be very weak in each of the past two survey years.

Analysis of the RV length at age data between 1970-91 indicated that there were consistent differences in size at age between cod in the two major fishing areas (Bay of Fundy and Browns Bank) (Figure 19). Cod in the Bay of Fundy were about 20% larger at age, reaching a size of about 86 cm at age 6.

## Commercial Catch Rates

Given the historic misreporting problem in the region, the multiple closures and fishery restrictions in recent years, and the low number of C/E observations per gear category (Campana and Hamel, MS1989), commercial C/E is not a reliable indicator of abundance for this stock.

## Age Composition of the Catch

In previous assessments, quarterly age-length keys were calculated for each of the major gear types (pooled among tonnage classes) for the period 1948-88. Details of key construction and

sample aggregation policy are described elsewhere (Campana and Simon, MS 1986). Ninety one samples went into the construction of comparable keys for 1991. Length-weight relationships were derived from seasonal RV data on an annual basis; in years where spring or fall surveys were not conducted, seasonal means were applied.

Quarterly landings data, sample information, and the calculated numbers at age for each of the major gear categories in 1991 are presented in Table 10. Catch numbers-at-age for the miscellaneous gear category was calculated quarterly, through a pro-rated comparison of miscellaneous landings with the sum of OT, LL, and GN landings. Foreign catches were treated similarly, but were pro-rated only on the basis of OT landings (since all foreign catches employed trawl gear). The data for previous years has been presented elsewhere (Campana and Simon, MS 1986, 1987, 1988; Campana and Hamel MS 1989, 1990, 1991).

Total catch numbers and percent catch numbers-at-age for the period 1948-91 are presented in Tables 11 and 12. A comparison of the 1991 catch composition and that predicted last year for 1991 indicates good agreement (Figure 11). Fish of ages 4-6 (1985-87 year-classes) made up 75% of the catch numbers in 1991 (Table 12). Catch composition curves indicate that age 5 fish were fully recruited to the fishery. No recent trends in mean weight-at-age in the catch (Table 13; Figure 12) were noted, although there have been long-term trends (Table 13).

#### Estimation of Stock Size

##### Calibration of the SPA

The SPA was calibrated against RV population numbers through use of the ADAPT framework (Gavaris MS 1988). As was done in previous assessments, the SPA-RV regression slopes and population numbers at ages 3-7 were estimated. All data were ln transformed. The ADAPT formulation used is summarized in Table 14.

The calibration model reached a stable optimum when fitted; the parameters remained constant after removal of the penalty function and were uncorrelated among themselves (Table 15). All but one of the estimated parameters had less than 6% bias (Table 15). All parameters were significantly different from 0. Examination of the age-by-age weighted calibration plots indicated that the model fit the data well. The residuals were usually randomly distributed across year, predicted values, and SPA population numbers. A comparison of the predicted and observed population numbers for ages 3-7 is presented in Figure 13.

The estimate of terminal F (5+) = 0.38 was smaller than those of previous years, but was consistent with the increased catch restrictions on the small mobile gear fishery and the size of the 1985 and 1987 year-classes. To determine if the accuracy of the 1989-1991 catch statistics (compared to the relative inaccuracy of the 1987-88 statistics) influenced the results, the SPA was recalibrated assuming the 1987-88 nominal catches by MG < 65' were 50% of the true value and that 1984-86 and 1990 catches were 80% of the true value. The simulation resulted in about a 10-15% increase in terminal F and a corresponding decrease in the 1991 population. While the

degree of misreporting assumed in the simulation was somewhat arbitrary, the results indicated that our perception of current stock status is probably slightly optimistic.

The results of the calibration indicated that the 1985 and 1987 year-classes were among the largest of the 44-year time series. The 1986 year-class was estimated as being average in size, while the 1988 year-class was estimated as being very weak. Due to expected recent changes in partial recruitment, the sizes of the 1989 and 1990 year-classes were set to the geometric means between 1948-88.

### Assessment Results

Population numbers and fishing mortalities corresponding to  $F_t = .38$  are presented in Tables 16 and 17. Enhanced enforcement and the presence of strong recruitment appear to have reduced the fishing mortalities of the past 3 years to levels well below that of the long-term mean of 0.55 (Figure 14). An analysis of retrospective F's for this stock indicated that previous assessments have provided consistent estimates of  $F_t$  (Figure 15). The mean weight in the catch is well below that expected of both  $F_{max}$  and  $F_{0.1}$  (Figure 16).

Biomass reached near record-high levels in the past two years, and while still high, has begun to decline (Figure 17). The influence of the very weak 1984 year-class has now largely dissipated. The 1985 and 1987 year-classes are believed to be the two strongest year-classes on record since that of 1963, while the 1988 year-class is among the weakest (Figure 18).

### Prognosis

The fishable biomass of 4X cod will decline slightly through 1992 and 1993 as the strong 1985 year-class exits the fishery and the weak 1988 year-class enters the fishery. Subsequent stock status will continue to depend heavily upon the strength of the incoming year-classes. However, even average recruitment levels will result in a decline in fishable biomass after 1993. The rate of decline in 1993 will depend heavily upon the strength of incoming recruitment, particularly the 1989 and 1990 year-classes. Based on past experience, this stock is subject to rapid population shifts, due to its rapid rate of growth (Figure 19) and dependence upon incoming recruitment. These population shifts are difficult to predict in the absence of a reliable pre-recruit index.

The introduction of 130 mm square mesh gear in 1990, and a partial adoption of 140 mm square in 1991 (145 mm diamond mesh on the offshore vessels), suggests that a decline in partial recruitment will follow. However, there is as yet insufficient information to recalculate a partial recruitment vector.

Catch projections were made on the basis of the existing multi-year management plan. Catches of 26000 t in each of 1992 and 1993 correspond to fishing mortalities of 0.44 and 0.46, respectively (Table 18). These values are above  $F_{MAX}$ , but are lower than historic levels. Population biomass under this management plan would decrease slightly from the Jan 1992 level

of 96,900 t to 95,400 t in Jan 1993 and 94,100 t in Jan 1994. Alternative scenarios are presented in Figure 20. Note that only 49% of the projected 1993 population biomass is based on current population estimates.

Expected annual yield (long-term) at  $F_{0.1}$  is 21,000 t for this stock (Campana and Hamel MS 1989).

### Conclusions

Stock status as indicated by this assessment confirms the trends noted in last year's assessment. Over the past few years, biomass has increased to near record-high levels in response to the entry of two strong year-classes. Biomass levels have now stabilized and begun to decline as the weak 1988 year-class enters the fishery. The rate of decline will depend heavily upon the strength of the incoming year-classes, particularly those of 1989 and 1990. If the population dynamics history of this stock is any indication, it is likely that major shifts in population size will continue to occur more rapidly than we can predict or detect. In the absence of predictions of incoming recruitment, late detection is likely to continue, making it difficult to react to shifts in population growth until after they have become pronounced. Research to define early predictors of incoming 4X cod recruitment, such as the possible correlation with 5Z cod recruitment, appears to be warranted.

Historic assessments of this stock have always reported overexploitation (Halliday, MS 1971, MS 1974; Sinclair, MS 1980; de Lafontaine, MS 1981; Gagne et al., MS 1983; Campana and Simon, MS 1984). This view of the fishery was substantiated in 1985 when the first analytical assessment of the 4X stock complex was presented (Campana and Simon, MS 1985). Extension of the SPA back to 1948 revealed a long history of overexploitation (Campana and Simon, MS 1986, MS 1987, MS 1988; Campana and Hamel, MS 1989, MS 1990, MS 1991). The relative long-term stability of the stock is thus testament to its resilience. Resilience is further demonstrated by the rapid shift in stock status over the past 5 years, from a near record-low biomass in 1986 to a record-high biomass in 1990. There has been no apparent relationship between stock and recruitment to this point (Campana and Hamel, MS 1989; Campana et al., 1989). Given the high rate of exploitation, the status of this stock is inexorably linked to the strength of the recruiting year-classes.

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Table 1. 4X cod nominal catches (t) by country.

Year	Canada										% Canada TAC		
	M&Q	Nfld	Spain	USSR	USA	FRG	France	Japan	Other	Total			
1948	17761				1999					19760	89.9		
49	14282				1799					16081	88.9		
1950	19088				1581					20669	92.4		
51	16543				1639					18182	91.0		
52	16570				1651					18221	90.9		
53	12903				1461					14364	89.8		
54	14406				2523					16948	85.0		
55	13432				1378					14810	90.7		
56	14849				1663					16512	89.9		
57	13619				1083					14702	92.6		
58	11103				1110					12213	90.9		
59	12866				862					13728	93.7		
1960	12123				1605					13728	88.3		
61	12424			2	9	1263				13698	90.7		
62	14656			3	80	1157				15896	92.2		
63	15849			1	684	1301	9			17844	88.8		
64	20767				2922	1413	338			15	25455	81.6	
65	24221			144	1553	871	125				26914	90.0	
66	24244			803	4961	966				5	30979	78.3	
67	27813			2536	667	1445					32461	85.7	
68	30770			2829	1061	859					35543	86.6	
69	24056			8217	1	448				1	32726	73.5	
1970	18001			3647	10	499				22309	80.7		
71	20180			2615	337	239				23377	86.3		
72	20490			1547	30	323	2			22392	91.5		
73	20002			1519	562	136				22224	90.0		
74	19005			1640	119	385	15	5		21171	89.8		
75	19493			900	207	480	3			21088	92.4		
76	16138			175		339				3	16655	96.9	
77	22002				4	760		185			22951	95.9	
78	23719	10			6	276	2			3	24017	98.8	
79	28647	28				46				1	28722	99.8	
1980	30735	355	2	94	75					10	6	31277	99.4
81	31043	47			125					5		31220	99.6
82	32701	9			234					1		32945	99.3
83	28963				11	286				1		29261	99.0
84	25068				5	189						25262	99.2
85	21370					9						21379	100.0
86	19869					43						19912	99.8
87	18671					11						18682	99.9
88	19766					4						19770	100.0
89	19581					4						19585	100.0
1990*	23499			5	138							23642	99.4
91*	27470											27470	100.0
92													26000

Sources: 1948-53 ICNAF Suppl. Ann. Proc. 11 (Appendix) (1962).

1954-66 NAFO Statistical Bulletins.

1967-91 MFD Statistics: Foreign catches from NAFO Statistical Bulletins.

\* = Preliminary

Table 2. Canadian quota allocation and reported Maritime landings (t) by gear category for cod in 4X and 5Y. Landings are derived from Atlantic quota reports (FG = fixed gear; MG = mobile gear).

Year	Gear	4X Allocation	4X Reported Landings	5Y Allocation	5Y Reported Landings
1981	All gear	Unlimited	30742	192	599
1982	All gear, FG < 65' MG < 65' FG 65-100' MG 65-100' > 100'	30000 20250 6000 200 400 3150	31520 20505 7942 168 150 2494	200 - 200 - - -	871 - 871 - - -
1983	All gear FG < 65' MG < 65' FG 65-100' MG 65-100' > 100'	30000 20250 8000* 200 400 3150	25610 14892 9167 54 192 1305	1500 700 700 - - 100	2578 176 2394 - - 8
1984	All gear FG < 65' MG < 65' FG 65-100' MG 65-100' > 100'	30000 20250 6000 200 400 3150	24088 12206 10201 5 88 1588	1500 700 700 - - 100	1404 164 1240 - - 0
1985	All gear FG < 65' MG < 65' FG 65-100' MG 65-100' > 100'	30000 17000 8900 200 400 3500	20810 9843 9683 6 38 1240	1500 500 900 - - 100	1474 78 1392 - - 4
1986	All gear FG < 65' MG < 65'** FG 65-100' MG 65-100' > 100'	20000 9381* 8646 8619* 130 270 1600	18190 8646 8381 0 37 1126	1500 700 700 - - 100	686 103 583 - - 0
1987	All gear FG < 65' MG < 65'*** FG 65-100' MG 65-100' > 100'	17500 9690 5870 48 160 1732	17531 9654 6360 48 98 1371	1500 700 700 - - 100	449 257 161 - - 31
1988	All gear FG < 65' MG < 65'** FG 65-100' MG 65-100' > 100'	14000 7915 4340 70 190 1485	19158 10888 7598 0 10 662	1500 700 700 - - 100	803 203 600 - - 0
1989 <sup>1</sup>	All gear FG < 65' MG < 65'** FG 65-100' MG 65-100' > 100'	12500 7390 4050 55 120 885	19365 10027 8513 0 30 795	965 750 215 - - -	341 261 80 - - -
1990 <sup>1</sup>	All gear FG < 65' MG < 45'*** MG 45-64'** FG 65-100' MG 65-100' > 100'	22000 <sup>2</sup> 13000 3940 3190 51 157 1662	22509 14708 3865 3399 0 25 512	1500 750 215 535 - - -	316 148 168 0 - - -
1991 <sup>1</sup>	All gear FG < 65' MG < 65' (4X,5Y ITQ) MG < 45' (4X,5Y Generalists) MG < 65' (4X,5Y Quota Reserve) FG 65-100' MG 65-100' > 100'	26000 13000 10486 420 224 79 204 1587	27624 15698 9895 498 0 55 140 1388	750 750 - - - - - -	108 108 - - - - - -

Table 2 continued.

Year	Gear	4X Allocation	4X Reported Landings	5Y Allocation	5Y Reported Landings
1992	All gear	26000		750	
	FG < 65'	13000		750	
	MG < 45'	3940		-	
	MG 45'-65'	3190		-	
	MG < 65' (Quota Reserve)	4000		-	
	FG 65-100'	140		-	
	MG 65-100'	300		-	
	>100'	1430		-	

\* Adjusted in mid-year

\*\* Fishery closed or restricted several times during the year

<sup>1</sup> Preliminary <sup>2</sup> Initially set at 12000 t, increased by 10000t on July 25/90. <sup>3</sup> Quota reserve for MG < 65' = 4000 t.

Table 3. Restrictions and closures of the 4X cod fishery in 1991.

Vessel class	Date	Article No.	Restrictions and options	
<u>Fixed Gear &lt;45' (Scotia-Fundy based)</u>				
A1-A49	Nov 18	1991-127	1500 kg	
A1-A49	Dec 6	1991-133	1500 kg	
A4 (HL) Cod, Had, Pol 4VWX5	March 1	Lic.Cond.	450 kg	
A4 (HL) Cod, Had, Pol 4VWX5Y	June 1	Lic.Cond.	2270 kg Cod; 1500 kg Had	
A4 (HL) Cod, Had, Pol 4VWX5Y	Nov 21	Lic.Cond. & 1991-129 (4X Cod only)	1500 kg combined Cod & Had	
A4 (HL) All Groundfish 4VWX5	May 1	Lic.Cond.	2000 kg	
<u>45' - 65' Vessels - Fixed</u>				
A160 - A199	Nov 18	1991-126	10% bycatch	
A160 - A199	Dec 6	1991-134	10% bycatch	
A160 - A199 (5Y)	Dec 6	1991-136	10% bycatch	
A160 - A199 (4X5Y)	Nov 21	Lic.Cond.	6800 kg; 1991-129 revokes 1991-126	
Cod, Had, Pol 4VWX5	March 1	Lic.Cond.	450 kg	
Cod, Had, Pol 4VWX5Y	June 1	Lic.Cond.	2270 kg Cod; 1500 kg Had	
All Groundfish 4VWX5	May 1	Lic.Cond.	2000 kg	
<u>Mobile &lt;45' Scotia-Fundy based</u>				
Cod, Had, Pol 4X5Y	C1 (Generalist)	Jan 1	Lic.Cond.	Cod 700 kg; Had 700 kg; Pol 10% bycatch, 1 trip/7 days.
Cod, Had, Pol 4X5Y	C1 (Generalist)	Jan 23	Lic.Cond.	3300 lbs combined Cod & Had; Pol 10% bycatch, 1 trip/7 days.
Cod, Had, Pol 4X5Y	C1 (Generalist)	Feb 6	Lic.Cond.	3300 lbs combined Cod & Had, but Had not to exceed 1,100 lbs/trip; Pol 10% bycatch, 2 trips/7 days.

Table 3 continued.

Vessel class		Date	Article No.	Restrictions and options
Cod, Had, Pol 4X5Y	C1 (Generalist)	March 6	Lic.Cond	No licence
Cod, Had, Pol 4X5Y	C1 (Generalist)	March 19	Lic.Cond	3300 lbs combined Cod & Had, but Had not to exceed 1,100 lbs/trip; Pol 10% bycatch, 2 trips/7 days.
Cod, Had, Pol 4X5Y	C1 (Generalist)	May 1	Lic.Cond	3000 kg combined Cod, Had & Pol/7 day period.
Cod, Had, Pol 4X5Y	C1 (Generalist)	July 17	Lic.Cond	10% bycatch only (Cod, Had & Pol).
Cod, Had, Pol 4X5Y	C1 (Generalist)	July 24	Lic.Cond	1500 kg combined Cod, Had & Pol/7 day period.
Cod, Had, Pol 4X5Y	C1 (Generalist)	Sept 25	Lic.Cond	680 kg combined Cod, Had & Pol/7 day period.
Cod, Had, Pol 4X5Y	C1 (Generalist)	Nov 6	Lic.Cond	2270 kg combined Cod, Had & Pol/7 day period.

Other mobile vessels on ITQs or Enterprise Allocations.

Table 4. Nominal catch (t) of 4X cod by Maritime vessels.

Unit <sup>a</sup>		OTB					LL/LHP <sup>b</sup>				GN			Misc.	Total	5Y <sup>c</sup>
Year Area		1	2	3	4	5-7	1	2	3	4-5	1	2-3				
1988	M	4	67	85	-	146	537	77	1	-	446	9	80	1452		
	N	-	161	229	49	104	1	368	64	-	3	40	49	1068		
	O	57	218	123	31	38	4205	143	41	-	199	132	28	5215		
	P	2	456	255	18	99	49	238	98	-	-	54	1	1270		
	Q	96	262	112	49	36	327	103	55	-	2	-	39	1081		
	R	184	52	26	-	-	463	11	-	-	7	-	1	744		
	S	87	293	66	-	-	424	36	-	-	146	45	8	1105		
	U	18	2300	2437	7	-	9	2136	406	-	-	140	29	7482		
	Total	448	3809	3333	154	423	6015	3112	665	-	803	420	235	19417	348	
1989	M	7	14	15	1	-	554	70	19	-	618	1	69	1368		
	N	-	199	227	33	80	1	266	69	40	1	25	78	1019		
	O	66	576	230	-	91	4081	126	28	-	260	41	8	5507		
	P	-	797	1017	15	494	1	350	129	-	-	-	16	2819		
	Q	25	398	499	3	25	196	93	8	-	-	88	22	1357		
	R	143	225	302	-	-	436	1	-	-	1	-	3	1111		
	S	150	134	74	-	-	334	6	-	-	193	24	1	916		
	U	11	1504	1567	3	-	63	1421	343	-	-	253	9	5174		
	Total	402	3847	3931	55	690	5666	2333	596	40	1073	432	206	19271	310	
1990	L	-	9	-	-	-	-	-	-	-	-	-	-	9		
	M	12	13	18	33	-	634	143	64	-	899	1	28	1830		
	N	-	118	122	7	14	-	303	59	103	2	23	4	742		
	O	61	745	271	11	43	6138	150	41	-	332	65	43	7878		
	P	18	380	506	22	86	4	484	194	-	-	31	19	1651		
	Q	73	802	618	4	12	380	149	16	-	36	88	58	2186		
	R	159	165	297	13	-	971	1	-	-	86	-	30	1684		
	S	186	147	121	-	-	554	16	-	-	484	208	5	1715		
	U	9	1088	1600	13	-	82	1970	313	59	6	218	10	5359		
	Total	517	3467	3563	103	156	8764	3219	687	162	1843	634	193	23308	190	
1991	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	M	-	17	22	4	24	977	219	44	-	1199	4	37	2548		
	N	2	270	341	9	114	4	574	167	22	1	22	14	1541		
	O	84	852	662	12	332	5999	351	90	-	492	43	26	8944		
	P	3	521	498	149	151	61	759	200	-	-	85	9	2437		
	Q	84	1077	629	30	31	319	332	136	-	3	103	20	2765		
	R	118	1107	2361	3	3	547	2	15	-	65	12	6	4240		
	S	99	528	1036	-	-	371	35	3	-	410	76	-	2559		
	U	15	76	128	45	22	1	1535	176	-	4	213	12	2228		
	Total	405	4447	5675	252	680	8278	3806	830	22	2173	565	128	27264	203	

<sup>a</sup> LHP = handline<sup>b</sup> See Figure 1 for location of unit area; U = unspecified<sup>c</sup> Catch reported in area 5Y by OTB tonnage class 2 and 3.



Table 6.

## MEAN NUMBERS PER TOW BY STRATUM IN RV SURVEYS

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
70	.0	3.5	.6	3.9	.0	.4	.0	2.3	.0	.8	.0	.0	.0	1.6	.0
71	.0	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.3	.0	.0	1.2
72	3.7	2.4	.0	.0	3.6	2.6	8.8	2.2	1.5	4.2	8.4	14.7	2.3	4.6	5.2
73	2.9	7.0	2.9	5.8	6.8	5.6	9.2	8.6	8.0	4.2	2.0	4.6	1.7	12.1	2.7
74	7.3	2.6	4.0	16.8	5.9	8.0	9.9	9.2	1.9	11.4	2.1	15.1	5.4	24.1	.0
75	22.8	9.1	9.4	9.4	10.2	2.6	9.4	5.4	7.4	7.5	7.3	10.7	5.7	.0	9.4
76	49.5	65.3	21.8	3.6	9.8	9.4	14.0	3.9	2.7	.0	7.4	5.2	.4	24.3	10.3
77	1.3	3.8	1.0	4.2	4.0	2.4	6.0	4.1	5.2	3.7	2.4	1.4	3.7	5.7	12.4
78	.0	.0	.0	.0	.2	.2	1.2	.8	6.1	1.1	.6	5.0	.3	.0	1.1
80	6.1	12.9	7.4	10.7	4.1	7.6	6.2	24.7	9.1	11.1	14.5	11.7	3.0	20.9	8.2
81	9.4	1.3	9.0	8.4	14.0	10.5	1.5	2.3	3.7	5.7	3.4	1.6	4.5	8.5	17.0
82	3.1	.0	.0	.0	1.5	9.8	1.3	2.6	1.8	3.0	3.1	.5	3.0	.5	2.4
83	.3	.0	7.0	.0	.0	.0	.0	1.3	.9	.0	.6	1.2	.4	.0	1.0
84	.0	.8	.5	.8	1.3	.4	2.8	.3	.0	2.2	.0	1.0	.4	.0	2.4
85	6.8	1.7	1.2	6.0	.9	4.8	.9	12.4	2.0	3.5	5.7	9.6	6.9	2.3	13.1
90	10.7	6.1	10.5	4.4	19.3	37.8	4.1	15.2	14.0	10.4	6.2	31.9	16.3	10.8	13.7
91	1.9	3.0	9.5	4.9	2.9	4.8	13.2	16.1	14.8	60.0	16.3	14.5	7.6	18.3	46.9
92	2.4	2.7	6.3	1.4	5.2	11.1	4.7	11.5	3.7	13.4	1.2	10.4	26.0	11.0	3.1
93	.0	.3	1.9	1.4	3.9	9.9	8.4	1.5	6.3	6.3	7.2	7.1	13.6	9.9	24.7
94	1.1	5.8	2.4	4.8	.8	16.4	12.6	3.9	2.9	1.6	12.4	3.4	.4	.0	13.9
95	2.5	7.7	14.9	4.7	18.0	9.8	7.4	24.0	.0	26.7	36.9	19.8	4.9	.9	21.6

	1985	1986	1987	1988	1989	1990	1991
70	.0	3.6	.0	.3	.0	2.1	1.0
71	.0	.0	.0	.6	.0	.5	.6
72	15.6	1.0	1.3	2.6	.2	3.6	.7
73	10.1	4.5	2.6	4.5	2.0	25.3	2.9
74	13.1	15.9	1.1	5.2	9.0	4.4	1.5
75	18.2	6.2	7.3	7.7	21.1	4.5	23.5
76	1.5	3.9	.8	6.0	23.2	8.0	6.6
77	4.0	7.9	6.5	11.4	10.2	2.7	9.0
78	1.0	.0	.0	.0	.0	.4	.0
80	4.2	11.8	16.0	286.3	12.8	13.5	11.2
81	2.3	3.4	3.7	34.5	11.4	11.4	11.2
82	.0	.0	.4	3.2	5.5	3.9	2.6
83	.5	.0	.0	.0	1.8	.0	
84	.0	.0	2.5	1.1	.2	.3	.0
85	7.5	5.9	4.0	8.9	7.8	19.7	6.5
90	120.9	30.7	15.0	58.0	57.6	15.9	12.6
91	32.4	10.6	8.6	20.0	4.6	29.1	5.9
92	22.2	9.7	3.0	37.7	4.6	12.7	8.4
93	40.6	9.3	5.9	10.3	41.2	2.2	2.5
94	4.1	1.0	10.9	2.1	2.1	5.6	8.4
95	35.3	7.2	5.7	7.5	4.4	6.6	10.9

Table 7.

MEAN WEIGHT (KG) PER TOW BY STRATUM IN RV SURVEYS

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
70	.0	8.9	.9	12.7	.0	2.3	.0	6.5	.0	.3	.0	.0	.0	1.6	.0
71	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
72	10.6	4.6	.0	.0	4.9	6.6	14.4	2.2	2.9	8.0	19.2	7.9	1.6	6.5	5.7
73	3.2	10.6	7.8	12.4	7.5	8.3	25.0	28.7	13.4	17.3	5.3	3.8	2.2	7.5	3.3
74	19.9	10.3	14.3	19.2	12.8	14.5	27.8	26.0	5.7	29.4	9.9	33.7	16.5	38.5	.0
75	70.1	26.5	22.5	16.1	23.0	14.0	14.1	8.7	15.3	20.9	10.8	31.9	15.2	.0	19.3
76	121.1	52.5	51.2	7.1	32.1	22.3	26.2	9.0	10.5	.0	12.1	16.0	.0	38.5	19.0
77	3.0	9.6	1.2	8.5	7.0	3.1	9.3	17.7	4.9	7.9	15.6	2.8	10.8	10.8	22.7
78	.0	.0	.0	.0	.2	.4	2.4	2.2	10.7	2.8	3.5	19.7	2.0	.0	1.0
80	17.3	17.7	15.9	30.4	11.3	11.3	11.0	43.4	18.0	28.8	48.3	15.9	9.8	35.1	15.9
81	25.7	3.5	26.8	18.1	23.9	25.0	3.3	5.0	7.4	32.0	9.1	4.1	13.1	14.4	17.8
82	12.8	.0	.0	.0	2.3	39.7	5.2	11.1	4.6	14.0	14.3	1.1	3.7	1.0	6.8
83	3.2	.0	15.6	.0	.0	.0	.0	6.1	6.1	.0	5.2	8.6	.4	.0	5.2
84	.0	3.9	1.3	3.0	13.1	1.1	9.9	.6	.0	7.4	.0	2.1	.7	.0	6.5
85	19.8	6.5	5.4	18.4	2.5	19.1	.9	26.9	6.7	8.7	21.6	28.0	15.2	7.0	18.6
90	17.7	10.8	27.3	7.4	42.2	59.9	6.2	30.8	43.0	12.9	21.4	42.0	41.5	25.3	19.3
91	10.6	9.7	38.9	14.0	10.4	13.4	65.8	37.3	42.5	64.0	44.6	40.9	22.1	34.1	74.9
92	12.0	14.8	25.5	4.9	17.4	42.0	16.7	47.1	13.3	45.2	5.7	45.7	101.2	48.4	13.7
93	.0	.0	6.5	3.2	7.4	28.1	30.7	4.2	33.4	9.2	25.0	28.2	40.3	36.1	44.2
94	.6	6.0	12.9	13.7	4.7	32.6	33.8	13.1	8.0	6.2	.4	3.1	1.1	.0	30.5
95	17.8	8.5	36.6	14.6	32.8	14.9	18.5	50.2	.0	52.3	16.8	47.5	7.5	1.4	33.4

	1985	1986	1987	1988	1989	1990	1991
70	.0	6.2	.0	.3	.0	1.5	2.1
71	.0	.0	.0	.0	.0	.0	
72	16.0	.0	1.8	1.9	.0	3.2	.9
73	20.6	9.3	9.3	10.8	4.4	40.7	4.9
74	30.3	44.9	2.2	8.2	20.6	5.9	2.4
75	23.5	4.6	4.9	10.3	43.8	14.7	43.4
76	2.4	6.4	3.4	10.8	19.6	17.9	9.6
77	7.5	19.0	17.9	22.4	7.8	7.6	17.9
78	6.8	.0	.0	.0	.4	.0	
80	12.3	40.4	14.4	265.4	28.5	25.5	20.5
81	4.4	5.8	8.0	47.1	11.4	21.4	20.4
82	.0	.0	1.1	9.7	13.4	12.4	10.4
83	1.0	.0	.0	.0	.0	5.1	.0
84	.0	.0	8.7	2.2	.7	.3	.0
85	26.9	10.4	12.1	11.4	16.7	49.2	16.1
90	153.0	60.5	21.0	62.6	77.5	40.8	38.3
91	93.4	29.5	45.0	53.9	11.1	114.0	24.8
92	39.9	32.1	20.1	100.1	16.4	56.6	41.1
93	78.0	17.4	21.0	18.1	71.5	5.3	13.7
94	6.2	1.0	17.8	7.2	2.6	10.3	11.9
95	45.9	14.9	14.4	7.3	16.4	15.3	27.0

TABLE B. STRATIFIED MEAN NUMBER PER TOW FROM MID-YEAR RV 20/ 2/92

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	.01	.00	.00	.01	.06	.00	.00	.00	.01	.00	.93	.03
1	.48	.18	.15	.06	.21	.52	.08	.13	.10	1.39	.10	1.13
2	.76	3.58	.73	1.07	.49	1.43	.64	1.09	.54	1.75	.45	1.22
3	1.19	1.99	1.62	.57	2.29	.82	1.43	2.16	.88	.89	1.43	1.16
4	2.09	.32	1.28	1.13	.54	1.50	1.18	1.32	1.26	1.01	.58	1.30
5	.92	.74	.36	.36	.82	1.27	1.04	.40	.68	.91	.53	.68
6	1.22	.34	.25	.14	.48	.50	.42	.65	.25	.51	.72	.44
7	.53	.47	.11	.08	.06	.40	.21	.18	.19	.23	.23	.24
8	.26	.02	.27	.03	.00	.08	.12	.11	.05	.16	.11	.20
9	.09	.00	.20	.09	.02	.05	.03	.02	.04	.03	.06	.05
10	.05	.01	.08	.02	.01	.00	.03	.01	.00	.03	.00	.05
11	.01	.00	.01	.01	.02	.06	.01	.01	.00	.04	.04	.01
12	.00	.00	.01	.00	.00	.01	.00	.01	.00	.00	.00	.00
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991		
0	.04	.09	.00	.04	.02	.00	.18	.20	.01	.00		
1	.37	.09	.52	.31	.48	.24	1.66	.50	.30	.35		
2	.91	.68	3.44	5.57	.64	1.49	6.06	3.89	.42	1.01		
3	.90	2.62	2.25	2.67	1.67	.37	10.24	2.12	3.47	.70		
4	.94	1.50	1.30	.95	.81	.72	1.77	1.66	1.63	1.95		
5	.78	.93	1.23	.97	.23	.38	1.08	.28	1.56	.73		
6	.44	.58	.45	.50	.40	.17	.33	.31	.20	.49		
7	.12	.24	.32	.34	.29	.14	.13	.03	.28	.09		
8	.13	.00	.04	.19	.14	.20	.19	.02	.04	.08		
9	.11	.05	.04	.10	.06	.05	.04	.05	.03	.01		
10	.03	.02	.02	.01	.01	.03	.00	.03	.00	.01		
11	.02	.00	.00	.00	.00	.04	.00	.01	.01	.01		
12	.01	.00	.00	.00	.00	.00	.00	.00	.02	.00		

TABLE 9. COEFFICIENT OF VARIATION FOR RV STRATIFIED MEAN NO/TOW 20/  
2/92

		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	1	1.00	.00	.00	1.02	.93	.00	.00	.00	1.01	.00	.86	1.00	.90	.75
1	1	.33	.37	.47	.67	.69	.32	.63	.38	.60	.80	.68	.69	.51	.72
2	1	.64	.82	.66	.25	.33	.28	.40	.27	.34	.38	.43	.28	.30	.37
3	1	.66	.83	.45	.26	.26	.26	.40	.25	.33	.29	.29	.28	.27	.24
4	1	.66	.55	.32	.25	.32	.26	.40	.24	.24	.25	.29	.21	.24	.18
5	1	.57	.46	.29	.31	.19	.29	.27	.31	.23	.25	.19	.25	.23	.42
6	1	.50	.40	.28	.25	.33	.33	.24	.27	.19	.26	.21	.19	.25	.35
7	1	.46	.28	.42	.43	.82	.46	.38	.35	.29	.48	.24	.30	.18	.38
8	1	.47	.52	.22	.38	.00	.67	.47	.52	.50	.75	.31	.31	.30	.00
9	1	.51	.00	.47	.54	.74	.59	.51	.45	.29	.85	.57	.49	.48	.59
10	1	.69	1.01	.39	.60	.63	.00	.35	.70	.00	.68	.00	.52	.56	.38
11	1	1.04	.00	.58	.50	.69	1.00	.98	.80	.00	.72	.93	1.01	.49	.00
12	1	.00	.00	.58	.95	.00	.59	.00	.96	.00	.00	.00	.97	1.01	.00
		1984	1985	1986	1987	1988	1989	1990	1991						
0	1	.00	.72	.99	1.07	.53	.60	.00	.00						
1	1	.52	.44	.67	.64	.42	.33	.41	.38						
2	1	.43	.47	.37	.25	.65	.37	.33	.28						
3	1	.45	.42	.32	.26	.52	.29	.28	.24						
4	1	.32	.34	.30	.25	.55	.27	.21	.21						
5	1	.30	.26	.35	.33	.38	.26	.29	.24						
6	1	.27	.27	.26	.40	.39	.38	.48	.22						
7	1	.31	.36	.32	.35	.55	.42	.30	.31						
8	1	.71	.54	.32	.30	.59	.00	.52	.58						
9	1	.62	.55	.67	.62	.62	.67	.62	.00						
10	1	.99	1.03	1.01	.65	.00	.43	.00	.83						
11	1	.00	.00	.00	.67	.00	.00	.50	.00						
12	1	.00	.96	.00	.00	.00	.00	.69	.00						

Table 10. a) Input data used for the construction of the 1991 catch at age matrix; b) Numbers at age ('000) by gear type.

a)	Gear	Period	Length-weight coefficients			Number measured	Number aged	Catch (t)
			a	b	# of Samples			
OTB		Q1	.0081	3.0503	18	4553	745	3195
		Q2	.0084	3.041	13	2948	366	3088
		Q3	.0087	3.0233	8	1864	416	2877
		Q4	.0063	3.1152	6	1669	187	2507
LL, LHP		Q1	.0081	3.0503	8	2091	245	2323
		Q2	.0084	3.041	10	3044	371	3249
		Q3	.0087	3.0233	15	3016	369	5208
		Q4	.0063	3.1152	4	1102	150	2158
GN		Q1	.0081	3.0503	-	-	-	65
		Q2	.0084	3.041	4	570	90	626
		Q3	.0087	3.0233	5	325	86	1624
		Q4	.0063	3.1152	-	-	-	421
Miscellaneous		Q1	.0081	3.0503	-	-	-	32
		Q2	.0084	3.041	-	-	-	64
		Q3	.0087	3.0233	-	-	-	21
		Q4	.0063	3.1152	-	-	-	10
Foreign	Annual	-	-	-	-	-	-	27,470

b)

AGE	OT	LL	GN	MISC	FOREIGN
1	6	0	0	0	0
2	224	255	0	2	0
3	811	831	29	8	0
4	2068	2469	407	24	0
5	628	1070	172	8	0
6	461	794	155	6	0
7	76	113	32	1	0
8	37	115	15	1	0
9	8	20	2	0	0
10	5	10	1	0	0
11	2	28	9	0	0
12	3	10	2	0	0
13	0	8	0	0	0
14	0	1	0	0	0
15	0	0	0	0	0
16	0	0	0	0	0

TABLE 11. CATCH NUMBERS AT AGE (THOUSANDS).

13/ 4/92

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
1	0	0	0	1	0	0	0	5	0	0	0	0	0	0	0	0
2	36	489	660	295	763	120	260	54	105	0	160	0	0	11	2	0
3	806	1475	1947	2626	1265	860	482	1279	622	211	831	326	0	265	792	396
4	1617	1431	3274	1898	2927	724	2024	662	2395	365	1257	1986	275	409	2057	1972
5	1639	930	1441	1465	1189	1407	909	1236	731	1442	585	1726	966	1940	2734	1576
6	676	908	773	500	557	450	1051	521	584	234	805	1093	804	901	1183	1083
7	270	67	732	468	361	222	358	583	505	602	84	417	273	320	513	927
8	364	105	40	277	170	74	139	190	470	288	168	409	336	97	237	301
9	363	150	51	82	254	175	129	58	116	341	149	87	196	79	81	222
10	265	162	91	26	30	219	136	34	40	288	94	0	107	41	55	39
11	103	52	13	107	21	73	91	60	78	0	23	25	51	18	6	41
12	50	16	67	71	13	16	35	32	78	94	10	16	13	9	0	33
13	51	30	6	16	28	0	31	16	47	136	7	0	30	0	12	17
14	74	9	1	16	6	27	23	4	9	64	0	0	0	0	3	7
15	26	23	31	7	0	0	13	0	0	0	7	0	0	0	3	4
16	0	0	1	0	0	0	2	4	0	0	0	0	0	0	0	0
	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
2	0	32	15	17	11	456	272	553	358	331	101	766	410	1609	285	326
3	106	1498	1909	1601	1690	2557	1341	1302	2446	1857	2193	1556	1693	3063	1803	1294
4	751	2576	4703	6321	2575	2047	1398	1031	3071	2432	2088	2955	2476	1683	2274	3405
5	3104	2903	3372	3690	6149	2277	1565	1324	1903	1952	1814	1022	1401	1606	1991	2632
6	2550	2194	1753	1271	2554	2014	980	1062	953	676	1171	679	467	775	2188	1217
7	852	701	1108	480	459	595	435	452	165	295	267	365	190	272	636	703
8	768	271	357	388	191	195	78	388	122	75	209	88	122	257	199	218
9	385	78	44	142	246	140	215	165	141	159	116	58	74	101	55	99
10	78	41	65	36	59	229	52	159	67	68	109	35	18	81	49	79
11	27	23	26	46	40	25	17	32	4	52	98	26	7	36	9	23
12	83	7	24	11	31	8	26	72	2	15	39	14	2	39	16	13
13	8	9	5	2	6	8	0	87	1	7	9	8	4	10	6	3
14	0	1	0	1	6	5	0	0	4	8	13	0	1	25	2	7
15	0	0	0	0	3	10	0	43	0	15	20	0	2	2	1	0
16	10	0	3	5	10	20	0	7	18	0	17	1	0	12	1	7
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991				
1	0	0	0	4	39	0	0	0	0	10	0	6				
2	885	886	982	766	804	888	147	1055	439	519	101	480				
3	4773	4063	2549	3896	2381	1594	3129	784	2996	2305	2195	1679				
4	1952	4424	4476	2112	3243	1488	2204	2140	1665	3763	2463	4968				
5	2476	1684	3332	2376	1845	2458	906	1016	1534	709	2633	1878				
6	1288	1017	873	1148	923	1159	985	472	686	615	586	1417				
7	426	535	398	620	444	491	343	478	211	158	370	222				
8	242	299	301	251	159	174	164	230	207	83	76	168				
9	86	165	140	136	54	66	82	111	96	54	43	30				
10	51	65	99	71	50	44	37	56	59	17	35	16				
11	12	27	52	52	31	26	15	31	35	7	12	39				
12	16	18	27	9	22	8	15	8	9	6	12	15				
13	4	20	18	18	6	8	9	7	10	2	1	8				
14	1	6	0	5	2	2	0	4	2	0	2	1				
15	1	2	4	0	4	1	2	3	1	1	0	0				
16	3	6	0	2	15	4	0	2	1	0	0	0				

Table 12.

PERCENT CATCH NUMBERS AT AGE

13/ 4/92

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.01	.08	.07	.04	.10	.03	.05	.01	.02	.00	.04	.00	.00	.00	.00	.00
3	.13	.25	.21	.33	.17	.20	.08	.27	.11	.05	.20	.05	.00	.06	.10	.06
4	.25	.24	.36	.24	.39	.17	.36	.14	.41	.09	.30	.33	.09	.10	.27	.30
5	.26	.16	.16	.19	.16	.32	.16	.26	.13	.35	.14	.28	.32	.47	.36	.24
6	.11	.16	.08	.06	.07	.10	.18	.11	.10	.06	.19	.18	.26	.22	.15	.16
7	.04	.01	.08	.06	.05	.05	.06	.12	.09	.15	.02	.07	.09	.08	.07	.14
8	.06	.02	.00	.04	.02	.02	.02	.04	.08	.07	.04	.07	.11	.02	.03	.05
9	.06	.03	.01	.01	.03	.04	.02	.01	.02	.08	.04	.01	.06	.02	.01	.03
10	.04	.03	.01	.00	.00	.05	.02	.01	.01	.07	.02	.00	.04	.01	.01	.01
11	.02	.01	.00	.01	.00	.02	.02	.01	.01	.00	.01	.00	.02	.00	.00	.01
12	.01	.00	.01	.01	.00	.00	.01	.01	.01	.02	.00	.00	.00	.00	.00	.00
13	.01	.01	.00	.00	.00	.00	.01	.00	.01	.03	.00	.00	.01	.00	.00	.00
14	.01	.00	.00	.00	.00	.01	.00	.00	.00	.02	.00	.00	.00	.00	.00	.00
15	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
16	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.00	.00	.00	.04	.04	.08	.04	.04	.01	.10	.06	.17	.03	.03
3	.01	.14	.14	.11	.12	.24	.21	.19	.26	.23	.27	.21	.25	.32	.19	.13
4	.09	.25	.35	.45	.18	.19	.22	.15	.33	.31	.25	.39	.36	.18	.24	.34
5	.36	.28	.25	.26	.44	.22	.25	.20	.21	.25	.22	.13	.20	.17	.21	.26
6	.29	.21	.13	.09	.18	.19	.15	.16	.10	.09	.14	.09	.07	.08	.23	.12
7	.10	.07	.08	.03	.03	.06	.07	.07	.02	.04	.03	.05	.03	.03	.07	.07
8	.09	.03	.03	.03	.01	.02	.01	.06	.01	.01	.03	.01	.02	.03	.02	.02
9	.04	.01	.00	.01	.02	.01	.03	.02	.02	.02	.01	.01	.01	.01	.01	.01
10	.01	.00	.00	.00	.00	.02	.01	.02	.01	.01	.01	.00	.00	.01	.01	.01
11	.00	.00	.00	.00	.00	.00	.00	.00	.00	.01	.01	.00	.00	.00	.00	.00
12	.01	.00	.00	.00	.00	.00	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00
13	.00	.00	.00	.00	.00	.00	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00
14	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
15	.00	.00	.00	.00	.00	.00	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00
16	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991				
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.07	.07	.07	.07	.08	.11	.02	.16	.06	.06	.01	.04				
3	.39	.31	.19	.34	.24	.19	.39	.12	.38	.28	.26	.15				
4	.16	.33	.34	.18	.32	.18	.27	.33	.21	.46	.29	.45				
5	.20	.13	.25	.21	.18	.29	.11	.16	.19	.09	.31	.17				
6	.11	.08	.07	.10	.09	.14	.12	.07	.09	.07	.07	.13				
7	.03	.04	.03	.05	.04	.06	.04	.07	.03	.02	.04	.02				
8	.02	.02	.02	.02	.02	.02	.02	.04	.03	.01	.01	.02				
9	.01	.01	.01	.01	.01	.01	.02	.01	.01	.01	.01	.00				
10	.00	.01	.01	.00	.01	.00	.01	.01	.00	.00	.00	.00				
11	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00				
12	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00				
13	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00				
14	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00				
15	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00				
16	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00				

Table 13.

TABLE 14. MEAN WEIGHT AT AGE (kg).

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Table 14. Input values for the ADAPT calibration.

The adaptive framework was used to estimate stock size according to the following formulation:

*Parameters of the ADAPT framework*

- Year-class estimates: -  $N_{i,1991}$      $i = 3-7$
- Calibration coefficients for summer RV stratified mean number per tow  
-  $K_i$      $i = 3-7$

*Structure Imposed*

- Error for catch assumed negligible;
- Population numbers in 1991 at ages 1 and 2 set to the geometric mean; ages 5+ assumed to be fully recruited;
- F on oldest age group calculated as a weighted F for ages 5-7;
- Model did not include an intercept term;
- M = 0.2.

*Input*

- $C_{i,t}$      $i = 1-13$ ;     $t = 1970-91$
- $RV_{i,t}$  (mean number/tow)     $i = 3-7$ ;     $t = 1970-91$

*Objective function*

- Minimize

$$\sum_i \sum_t ((\ln RV_{i,t}) - (\ln K_i N_{i,t}))^2$$

where the summation is for  $t = 1970$  to  $1991$  and  $i = 3$  to  $7$ .

*Summary*

- Number of observations = 110
- Number of parameters = 10

Table 15. ADAPTIVE FRAMEWORK 2 INDEX TUNING  
4X COD

4/18/92 11:48

ESTIMATED PARAMETERS AND STANDARD ERRORS  
APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

ORTHOGONALITY OFFSET..... 0.013759  
MEAN SQUARE RESIDUALS ..... 0.256073

PAR. EST.	STD. ERR.	T-STATISTIC	BIAS %
6658.101059	2819.888423	2.361	11.58
17795.254081	5829.081713	3.053	6.55
6797.417419	1950.822499	3.484	4.09
5062.849852	1498.076506	3.380	4.38
553.377498	163.447412	3.386	5.88
.000145	.000016	8.843	.40
.000176	.000020	8.942	.48
.000213	.000024	8.932	.51
.000265	.000030	8.904	.48
.000258	.000029	8.877	.49

## Parameter Correlation Matrix

	1	2	3	4	5	6	7	8	9	10
1	1.000	.030	.024	.016	.008	.217	.010	.007	.006	.007
2	.030	1.000	.038	.026	.013	.140	.177	.012	.011	.011
3	.024	.038	1.000	.048	.039	.110	.139	.193	.081	.149
4	.016	.026	.048	1.000	.046	.075	.096	.137	.220	.115
5	.008	.013	.039	.046	1.000	.037	.050	.073	.119	.203
6	.217	.140	.110	.075	.037	1.000	.047	.035	.030	.032
7	.010	.177	.139	.096	.050	.047	1.000	.044	.039	.041
8	.007	.012	.193	.137	.073	.035	.044	1.000	.055	.058
9	.006	.011	.081	.220	.119	.030	.039	.055	1.000	.060
10	.007	.011	.149	.115	.203	.032	.041	.058	.060	1.000

## Standardized Residuals for RV index (s.e.=1 for log model)

	1970	1971	1972	1973	1974	1975	1976	1977	1978
3	.093	.165	.128	.664	.381	.875	.069	.135	.714
4	.869	-1.009	.013	.113	.347	.303	.295	.054	.146
5	.394	.211	.410	.790	.313	.937	.361	-1.091	.230
6	.970	.020	.315	.798	.020	.306	.189	.249	-1.049
7	.369	.739	.430	.683	.925	.537	.029	.097	.234
	1979	1980	1981	1982	1983	1984	1985	1986	1987
3	.407	.494	.596	.513	.311	.977	.992	.210	.752
4	.251	.601	.197	.364	.286	.114	.536	.225	.263
5	.035	.321	.008	.067	.218	.522	.202	.379	.026
6	.016	.289	.115	.040	.339	.041	.215	.135	.142
7	.283	.093	.036	.373	.343	.589	.548	.452	.397
	1988	1989	1990	1991					
3	1.385	.131	.176	.000					
4	1.154	.172	.115	.135					
5	.602	.241	.131	.344					
6	.590	.213	.056	.658					
7	.456	.767	.353	.039					

Table 16.

## POPULATION NUMBERS

10/ 8/92

	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
1   17476	23200	12451	15922	8931	18609	9667	14395	16709	19432	16044	23768	
2   13489	14308	20632	10194	13035	7312	15236	7914	11781	13680	15910	13135	
3   9061	11012	11272	16295	8079	9982	5878	12239	6431	9551	11200	12881	
4   8313	6689	7681	7467	10965	5470	7395	4377	8863	4702	7628	8418	
5   7296	5343	4182	3327	4396	6329	3823	4222	2984	5090	3520	5109	
6   1615	4491	3534	2120	1398	2523	3908	2307	2338	1782	2863	2352	
7   811	710	2855	2194	1283	641	1658	2249	1418	1386	1247	1616	
8   1087	419	521	1675	1372	724	324	1034	1314	704	590	945	
9   1011	560	248	390	1121	970	526	140	674	651	316	331	
10   527	498	323	157	246	688	636	314	62	447	224	124	
11   177	192	261	182	105	174	365	398	226	15	105	99	
12   111	52	110	202	52	67	76	217	271	114	12	65	
13   119	46	29	30	102	31	40	31	149	151	8	1	
14   117	51	10	18	10	58	26	5	11	80	1	1	
15   29	29	34	7	0	3	23	0	0	1	8	0	
16   0	0	2	0	0	0	2	7	0	0	0	0	
	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1   29599	18876	22948	33581	43224	20643	16573	16175	14400	20796	19598	15196	
2   19460	24234	15454	18788	27493	35389	16901	13568	13243	11790	17026	16046	
3   10754	15932	19831	12651	15382	22510	28945	13824	11094	10832	9240	13694	
4   10251	8805	12804	15520	9999	12497	17074	21971	9869	7354	6553	6331	
5   5095	8144	6839	8622	10922	7307	7901	9724	12269	5751	4332	4102	
6   2621	3298	4913	3125	5633	6134	3520	3417	4622	4481	2648	2131	
7   937	1418	1885	2952	1579	2305	2036	1296	1648	1473	1846	1282	
8   946	520	871	1079	1578	522	1253	1483	627	934	668	1118	
9   403	471	338	499	611	597	182	703	863	340	588	477	
10   192	153	313	203	208	152	419	109	447	484	152	287	
11   101	61	88	207	131	100	88	284	57	313	189	78	
12   58	37	33	66	132	83	61	48	191	10	233	139	
13   39	36	23	27	25	33	62	28	30	128	1	167	
14   1	5	29	8	7	13	19	46	21	19	98	1	
15   0	0	4	21	0	5	9	16	37	12	11	80	
16   0	0	0	0	13	0	4	8	13	28	0	9	
	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1   20703	24222	20446	25427	24652	17213	32501	29567	21166	27514	13312	14158	
2   12441	16950	19872	16740	20818	20183	14090	26610	24208	17329	22526	10898	
3   12637	9862	13578	16179	13013	16573	15069	11279	21491	19018	13387	17554	
4   10034	8133	6394	9133	11838	9122	10879	10705	8063	13276	11895	8654	
5   4267	5437	4458	3346	4803	7452	3946	6850	5684	4835	6867	5689	
6   2161	1771	2685	2008	1815	2665	4648	3066	3227	2414	2435	2607	
7   784	906	839	1139	1030	1063	1481	1826	1409	1477	1056	1204	
8   641	493	475	445	603	671	625	637	859	769	725	504	
9   565	415	336	199	285	383	317	331	324	484	359	321	
10   241	335	195	170	111	166	222	210	182	187	246	168	
11   91	137	212	61	108	75	63	137	100	102	94	113	
12   35	71	66	85	27	82	28	44	91	71	59	30	
13   49	26	45	18	57	20	32	9	24	61	42	24	
14   59	39	15	28	7	43	8	21	4	16	32	18	
15   0	44	25	0	23	5	13	4	11	3	8	26	
16   26	0	22	2	0	17	2	10	4	8	0	3	
	1984	1985	1986	1987	1988	1989	1990	1991				
1   20076	10164	34071	24365	36494	10011	19796	19858					
2   11589	16402	8322	27895	19948	29878	8187	15934					
3   8230	8761	12825	6681	21884	15935	23993	6611					
4   10847	4584	5730	7506	4760	15206	10961	17657					
5   5174	5947	2407	2697	4209	2391	9045	6745					
6   2507	2567	2645	1151	1289	2058	1316	5023					
7   1095	1218	1052	1274	515	434	1128	547					
8   424	496	553	551	611	231	212	589					
9   186	204	249	304	243	312	114	105					
10   140	103	107	129	148	112	206	54					
11   73	69	45	54	54	68	76	138					
12   45	32	34	23	16	13	49	52					
13   17	17	19	14	12	5	5	29					
14   4	8	7	7	4	1	2	4					
15   10	1	5	5	2	1	0	0					
16   21	5	0	2	1	0	0	0					

Table 17.

## FISHING MORTALITY

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Table 18.

## CATCH PROJECTIONS

	PR	MEAN WT, 1985-91	CATCH NUMBERS			POPULATION NUMBERS		
			1991	1992	1993	1991	1992	1993
1	1	.001	.52					
2	1	.044	.89					
3	1	.352	1.42					
4	1	.760	2.07	1	6	5	19858	19858
5	1	1.000	2.82	2	480	283	15934	16253
6	1	1.000	3.88	3	1679	1630	12612	13051
7	1	1.000	5.26	4	4968	1004	17657	3905
8	1	1.000	7.76	5	1878	3226	6745	9997
9	1	1.000	9.51	6	1417	1238	5023	3837
10	1	1.000	11.36	7	222	917	547	2031
11	1	1.000	13.19	8	168	81	589	250
12	1	1.000	15.55	9	30	107	105	132
13	1	1.000	15.99	10	16	19	54	175
14	1	1.000	17.32	11	39	10	138	31
15	1	1.000	19.22	12	15	25	52	16
16	1	1.000	20.58	13	8	9	29	41
			14	1	5	5	4	16
			15	0	1	3	0	9
			16	0	0	0	0	1
	1+1	10926	8558	8338			73348	70097
	2+1	10921	8553	8333			53490	50239
	3+1	10440	8270	8035			37556	33986
	4+1	8761	6641	6264			30945	21374
		FISHING MORTALITY	CATCH BIOMASS			POPULATION BIOMASS AT BEGINNING OF YEAR		
			1991	1992	1993	1991	1992	1993
			1991	1992	1993	1991	1992	1994
1	1	.000	.000	.000				
2	1	.034	.019	.020	1	3	7980	7980
3	1	.327	.153	.162	2	427	252	265
4	1	.369	.331	.349	3	2381	2312	2511
5	1	.364	.436	.460	4	10271	2076	4922
6	1	.370	.436	.460	5	5297	9100	2179
7	1	.585	.436	.460	6	5496	4803	6908
8	1	.376	.436	.460	7	1167	4823	3595
9	1	.376	.436	.460	8	1307	625	3927
10	1	.376	.436	.460	9	285	1016	423
11	1	.376	.436	.460	10	177	216	670
12	1	.376	.436	.460	11	519	130	138
13	1	.376	.436	.460	12	232	388	85
14	1	.376	.436	.460	13	135	151	220
15	1	.376	.436	.460	14	19	92	90
16	1	1.225	.436	.460	15	2	13	57
			16	2	1	8		
	1+1	.194	.159	.156				
			1+1	27720	26000	26000		
			2+1	27717	25998	25997		
			3+1	27290	25746	25732		
			4+1	24909	23434	23221		
							100092	96900
							95381	94077

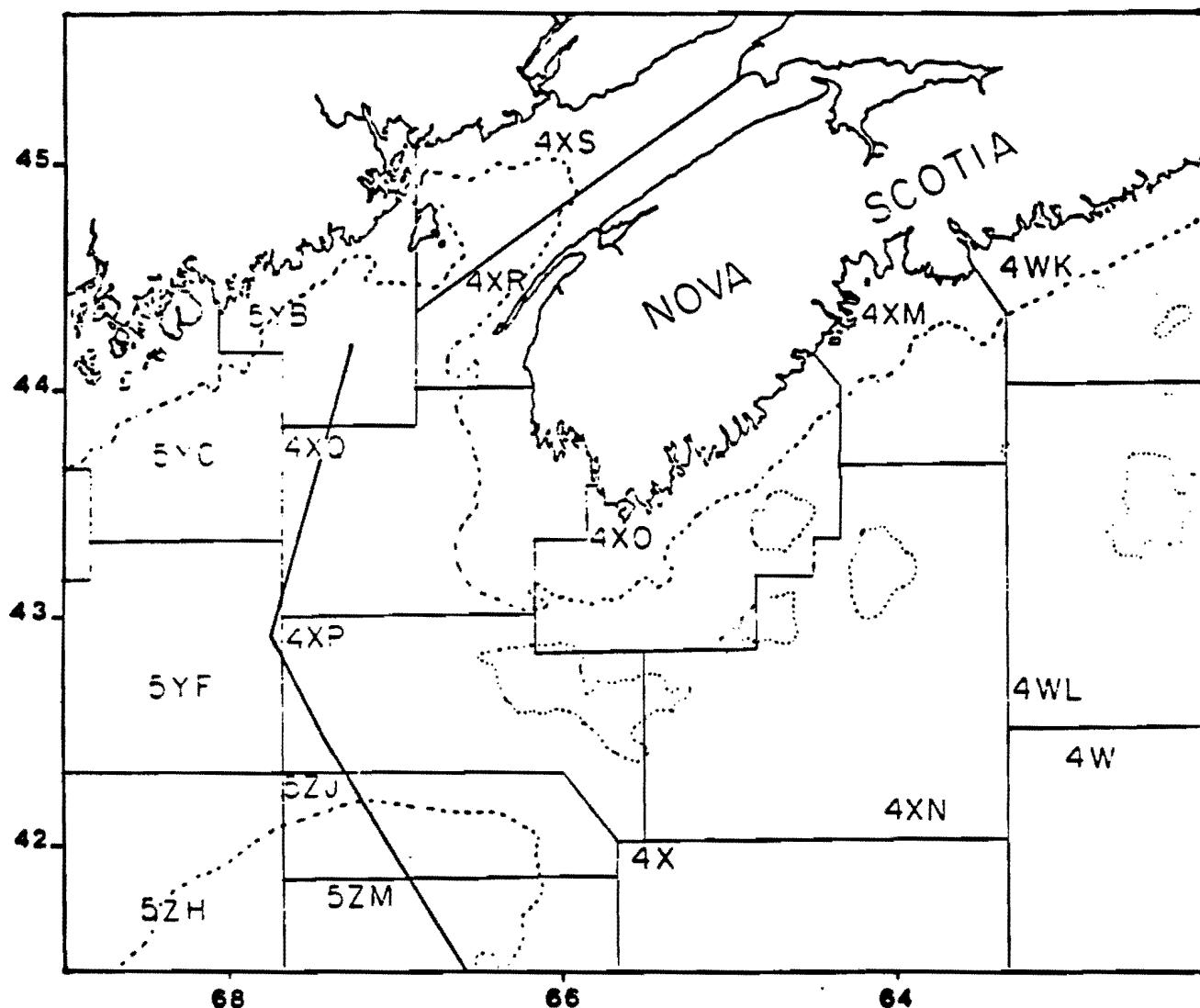


Figure 1. Unit areas in NAFO Division 4X in reference to the ICJ Canada-US boundary.

FIG. 2. 4X COD NOMINAL CATCH AND TAC

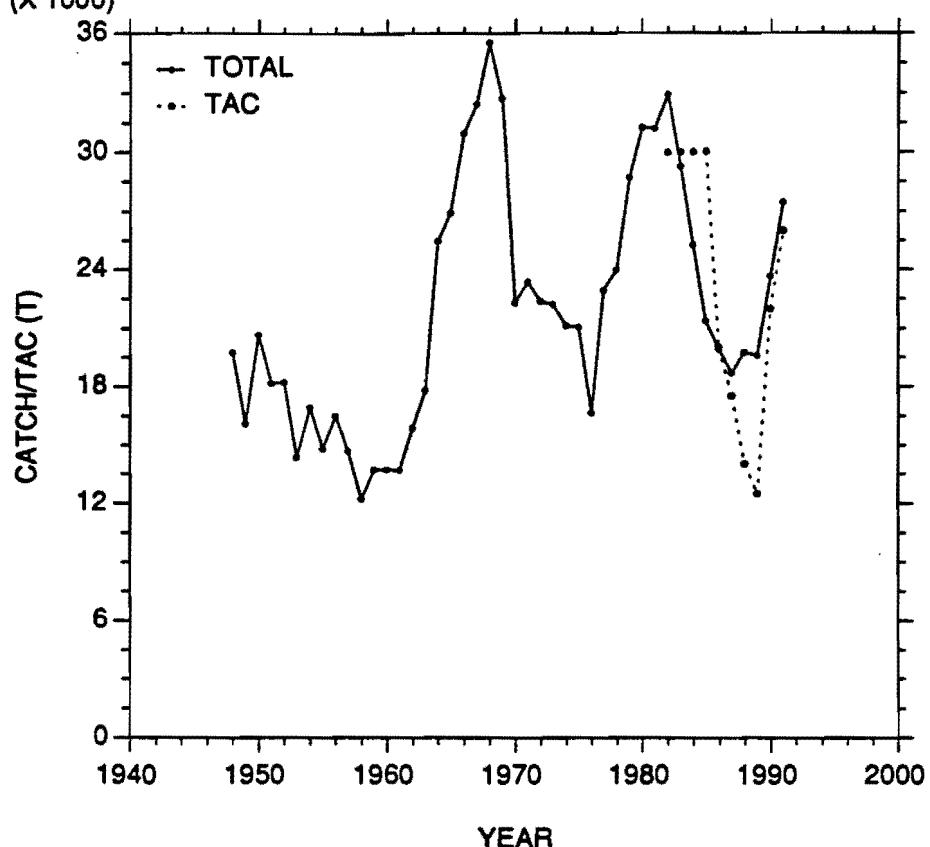
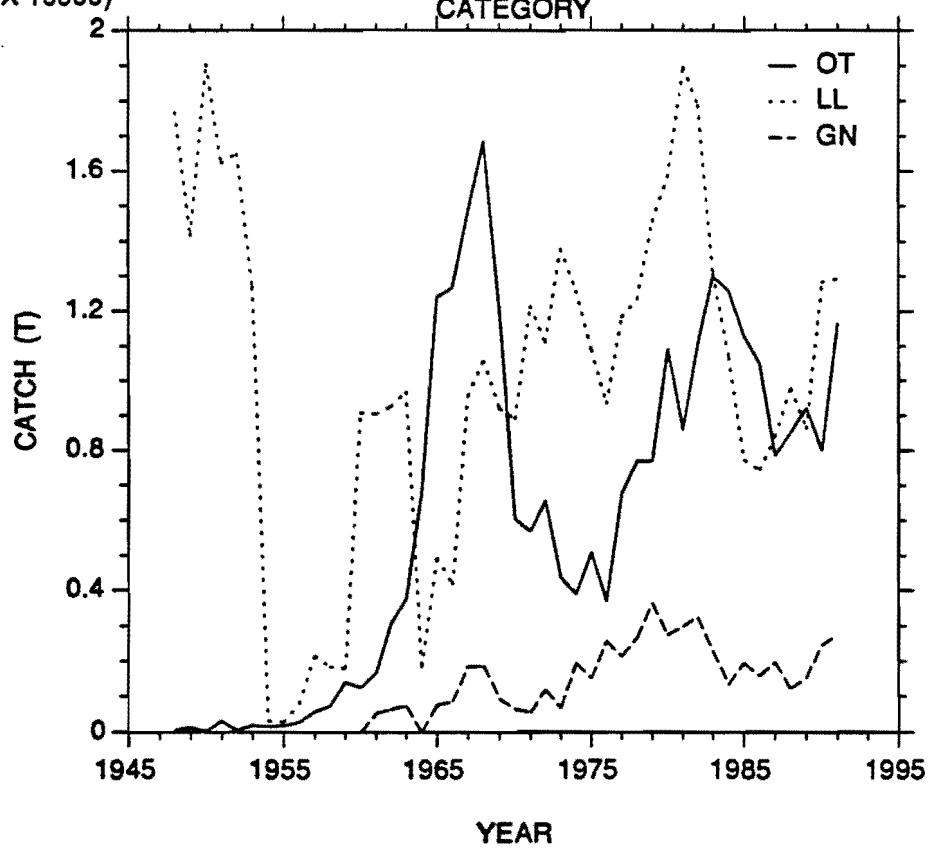
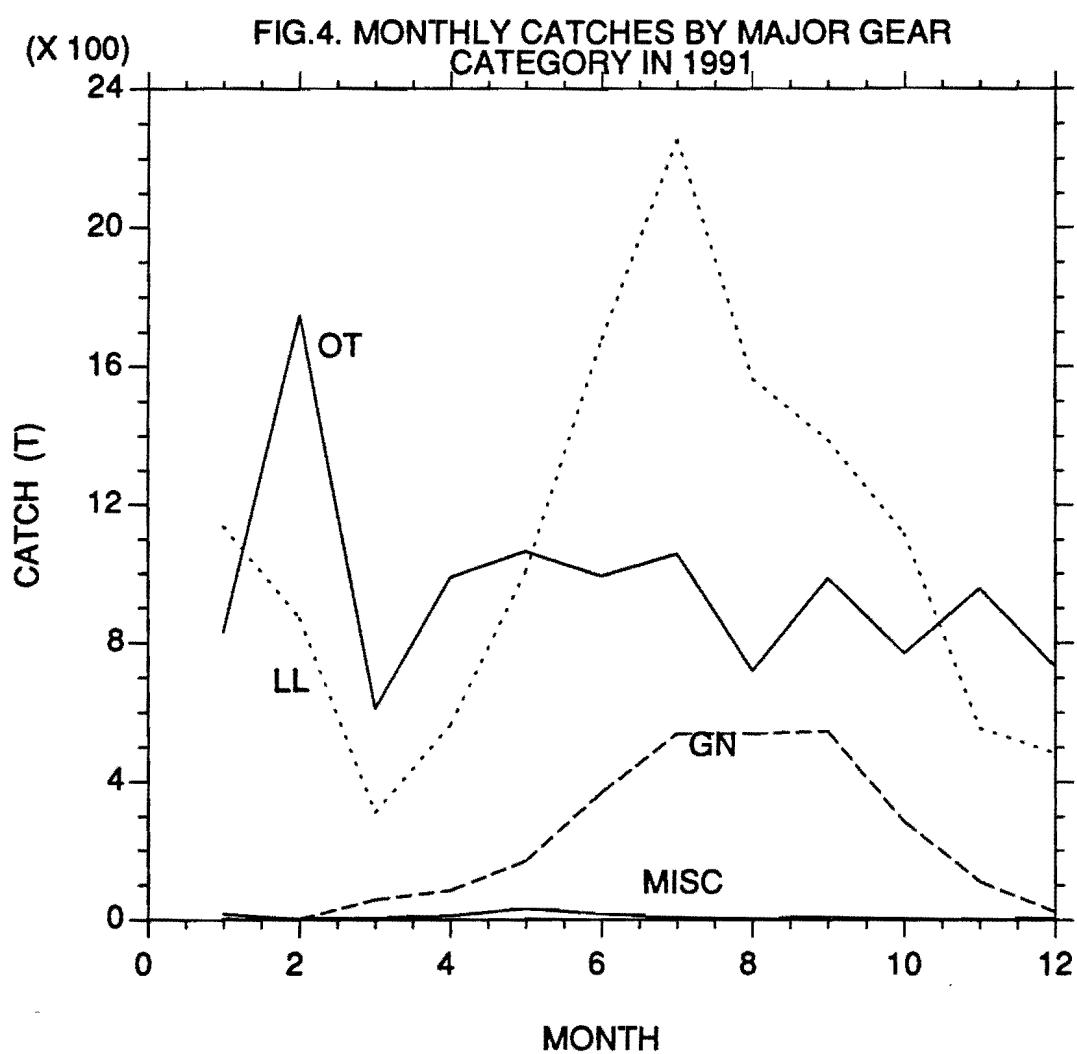


FIG. 3. NOMINAL CATCH BY MAJOR GEAR CATEGORY





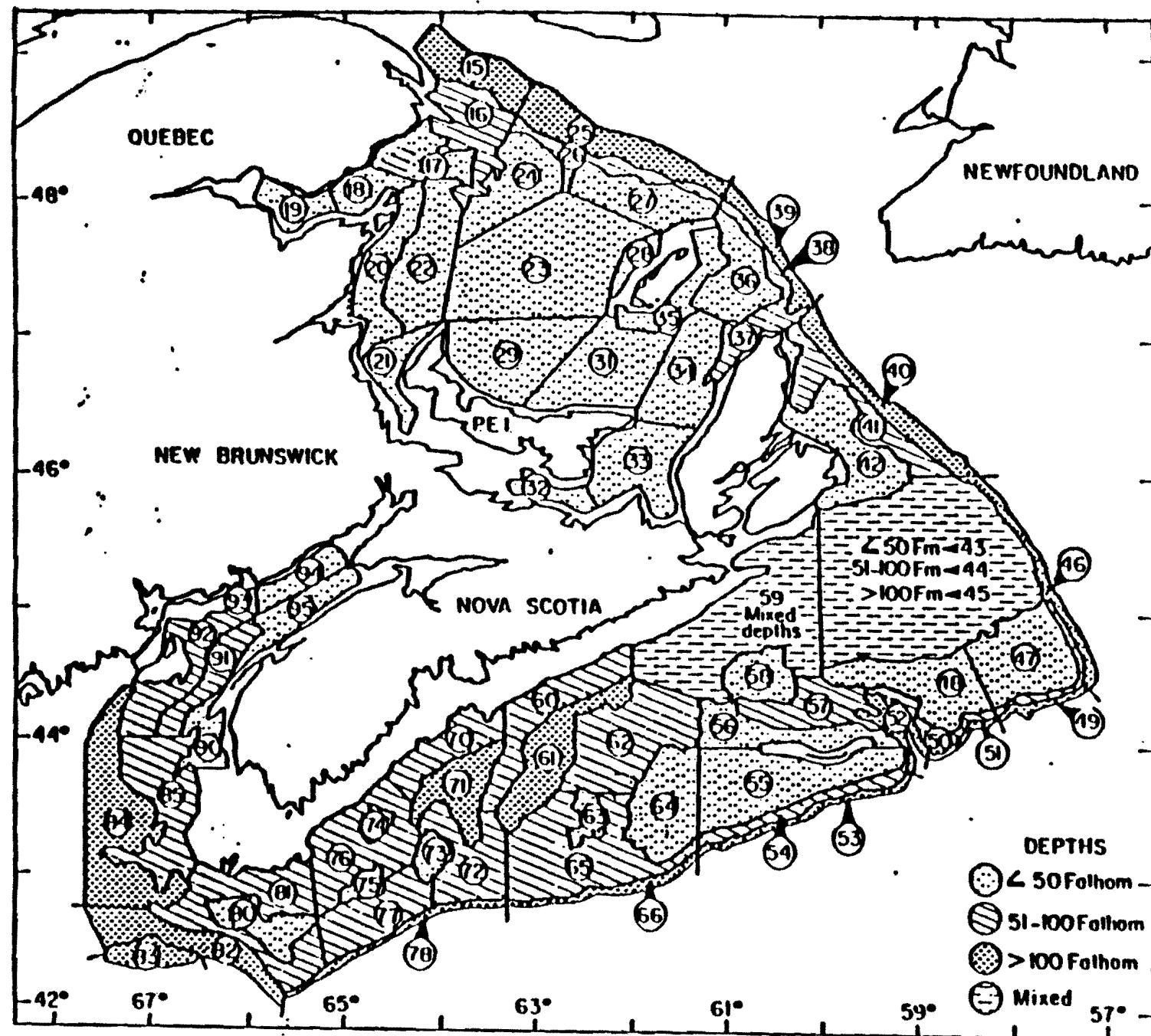


Figure 5. Stratification scheme used for the research groundfish surveys.

Fig. 6 Mean weight (Kg) per tow of 4X cod from 1970 to 1991.

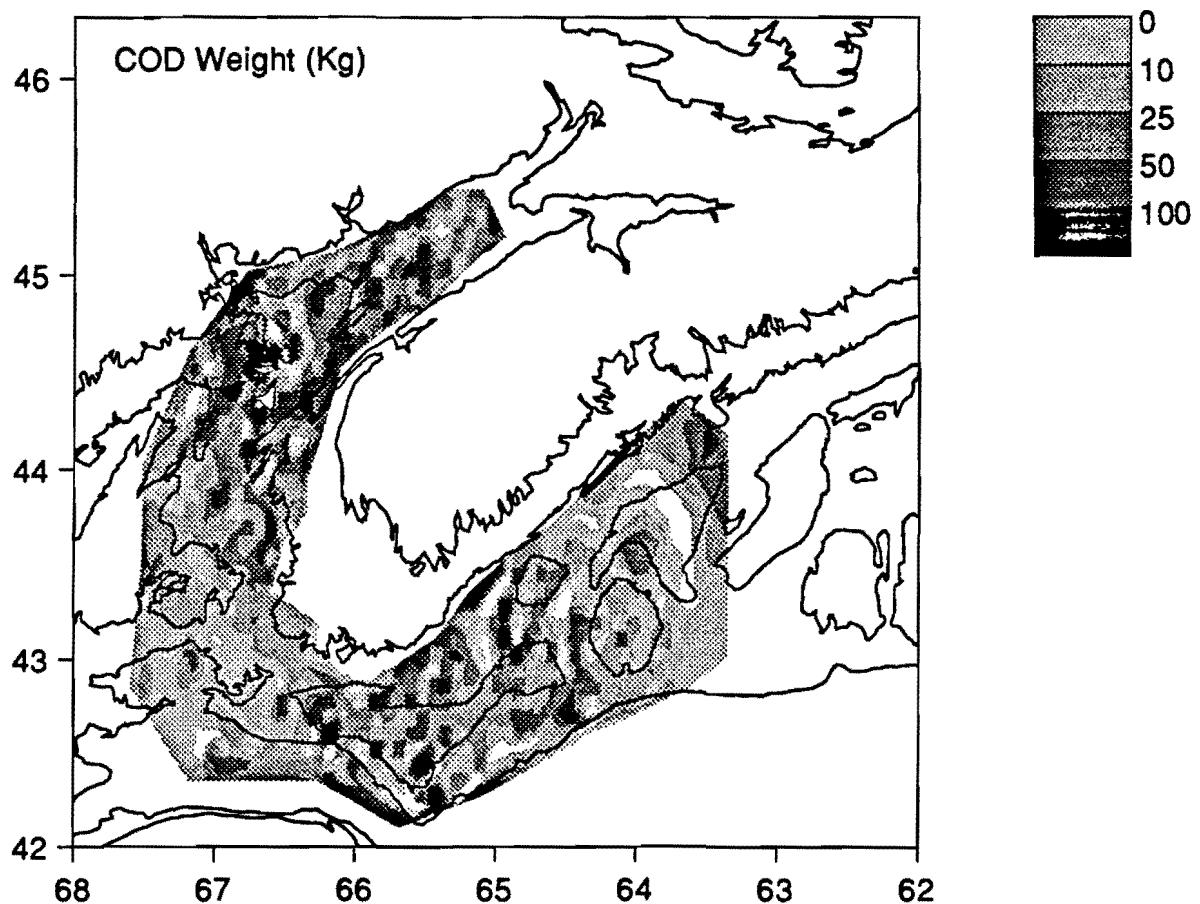


Fig.7, Mean weight (Kg) per tow of 4X cod in 1991.

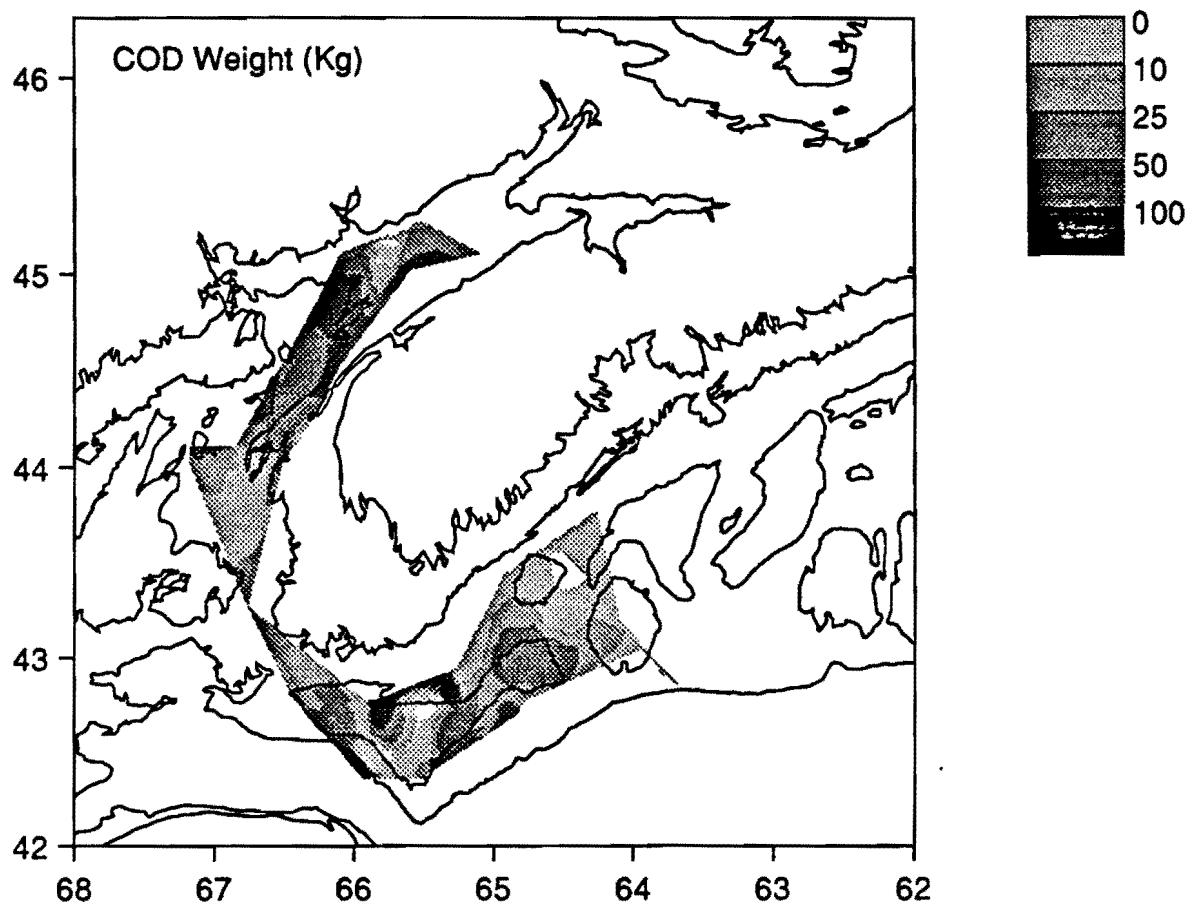


FIG.8. RV 5+ NUMBERS PER TOW

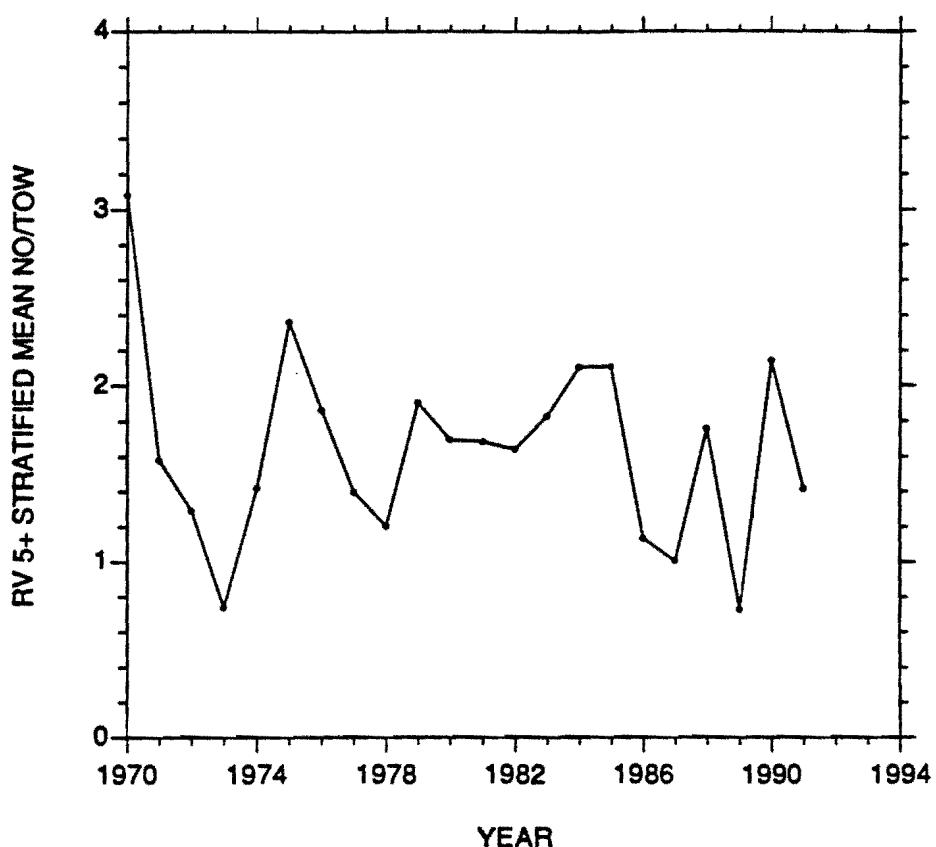


FIG.9. RV WEIGHT PER TOW

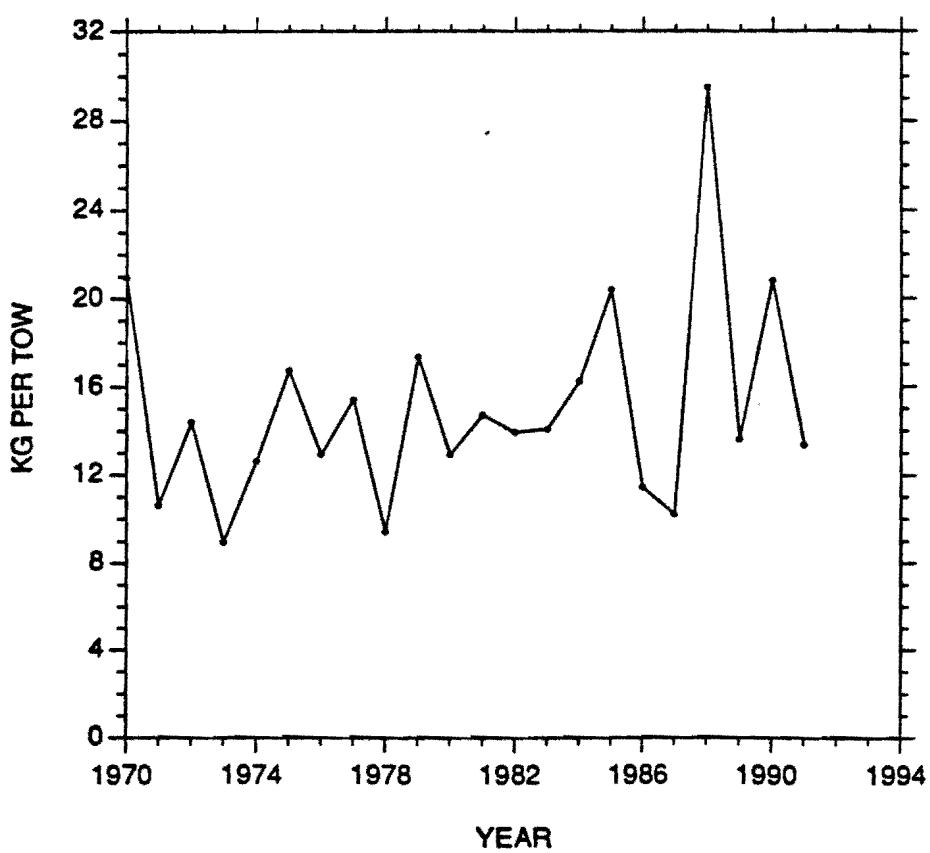


FIG.10. RV NUMBERS PER TOW AT AGES 2-4

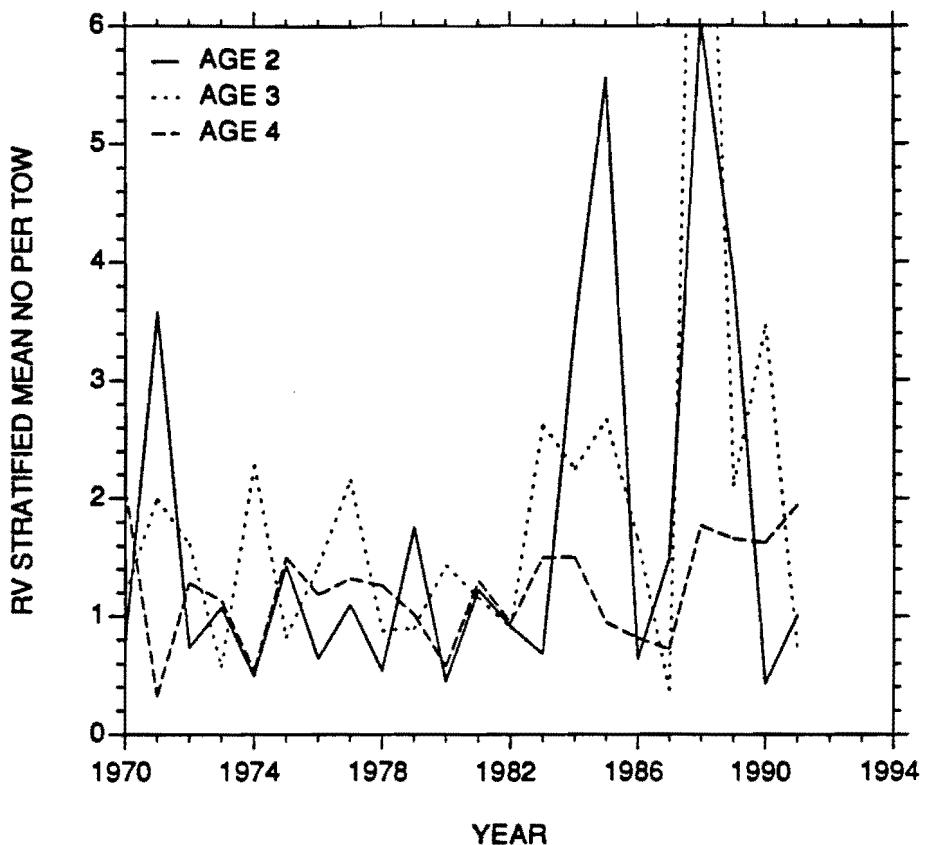
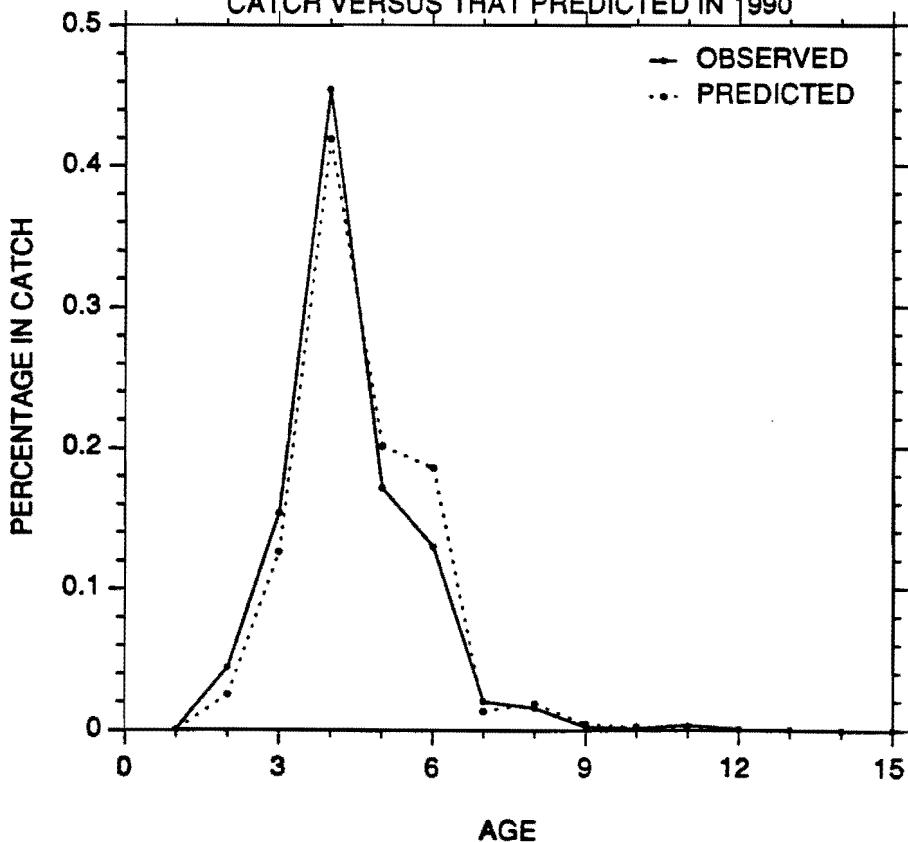
FIG.11. OBSERVED AGE COMPOSITION IN 1991  
CATCH VERSUS THAT PREDICTED IN 1990

FIG.12. WEIGHT AT AGE IN CATCH

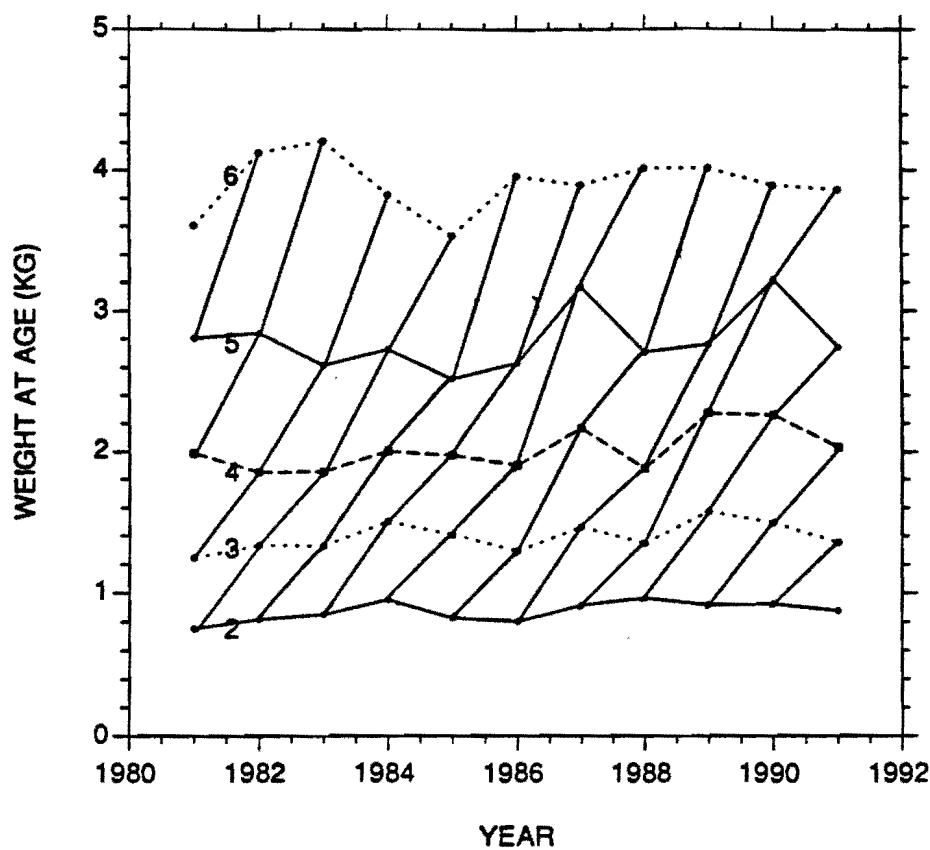
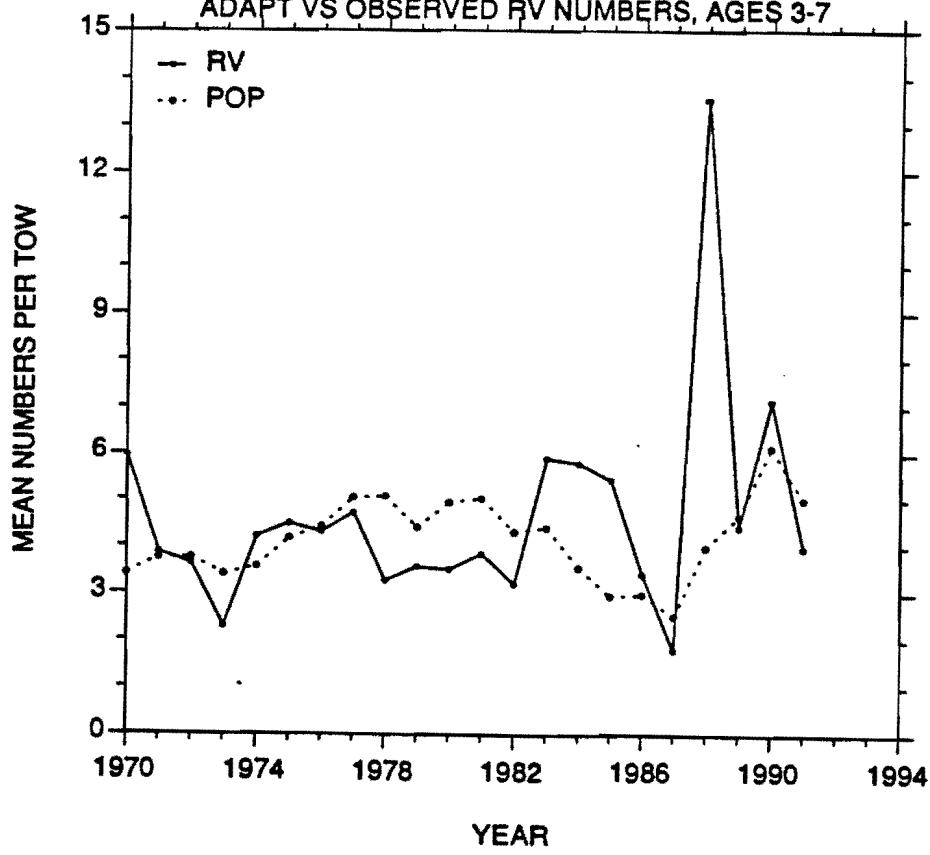
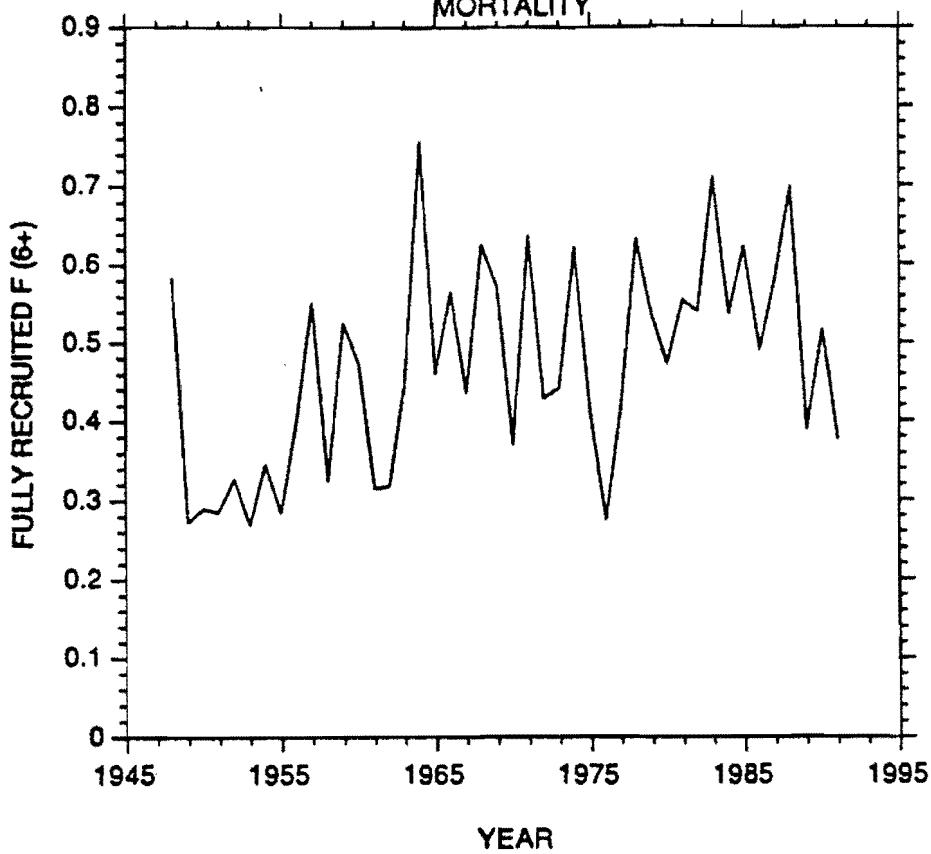


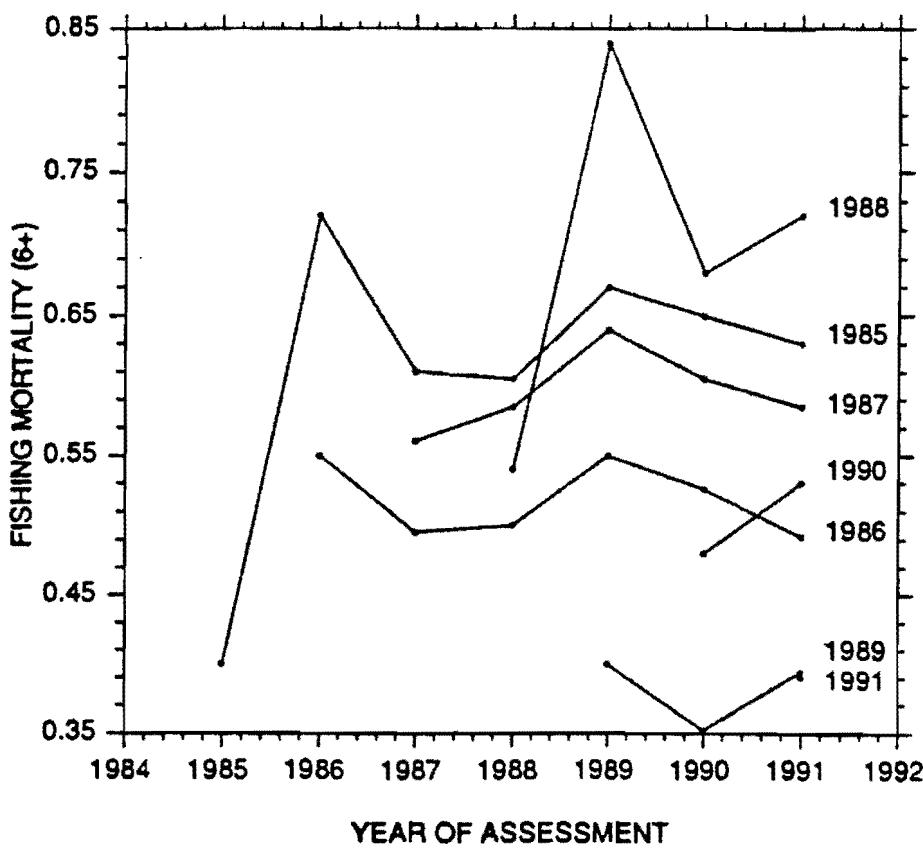
FIG.13. SCALED POPULATION NUMBERS FROM ADAPT VS OBSERVED RV NUMBERS, AGES 3-7

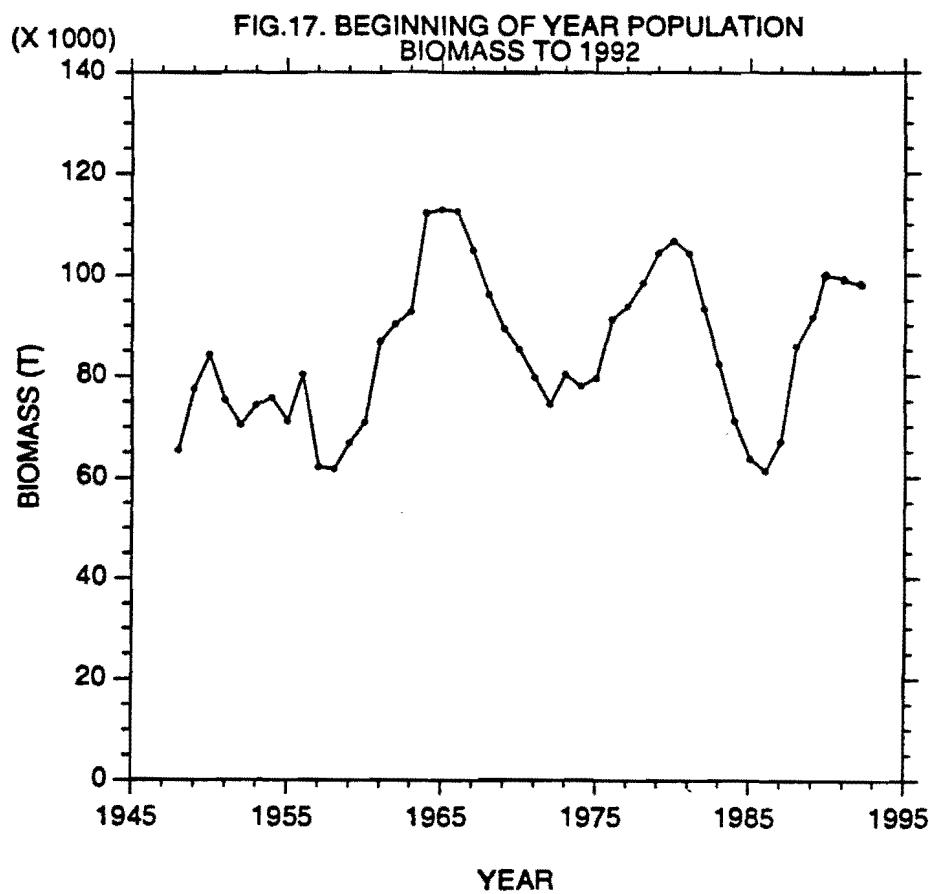
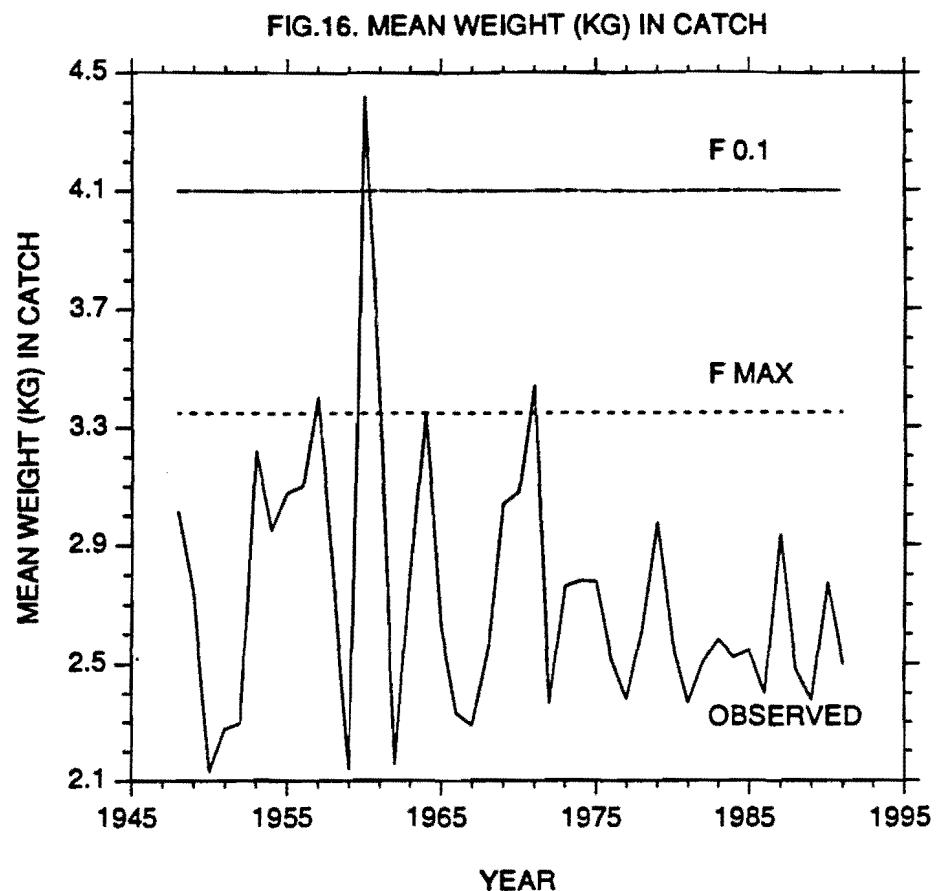


**FIG.14. FULLY RECRUITED (6+) FISHING MORTALITY**



#### FIG.15. RETROSPECTIVE FISHING MORTALITY





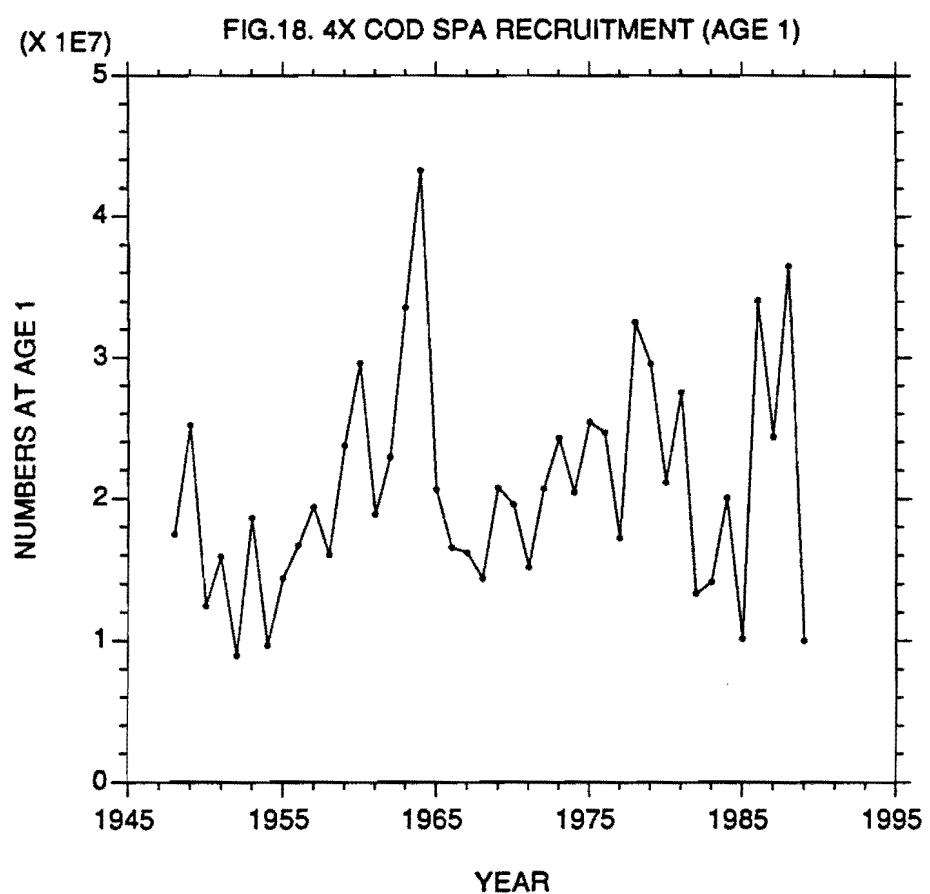


Fig 19. Mean length at age of 4X cod during the period 1970-91: (TOP) Browns Bank and the other offshore banks (Strata 70-81); (BOTTOM) Bay of Fundy and its approaches (Strata 84-95).

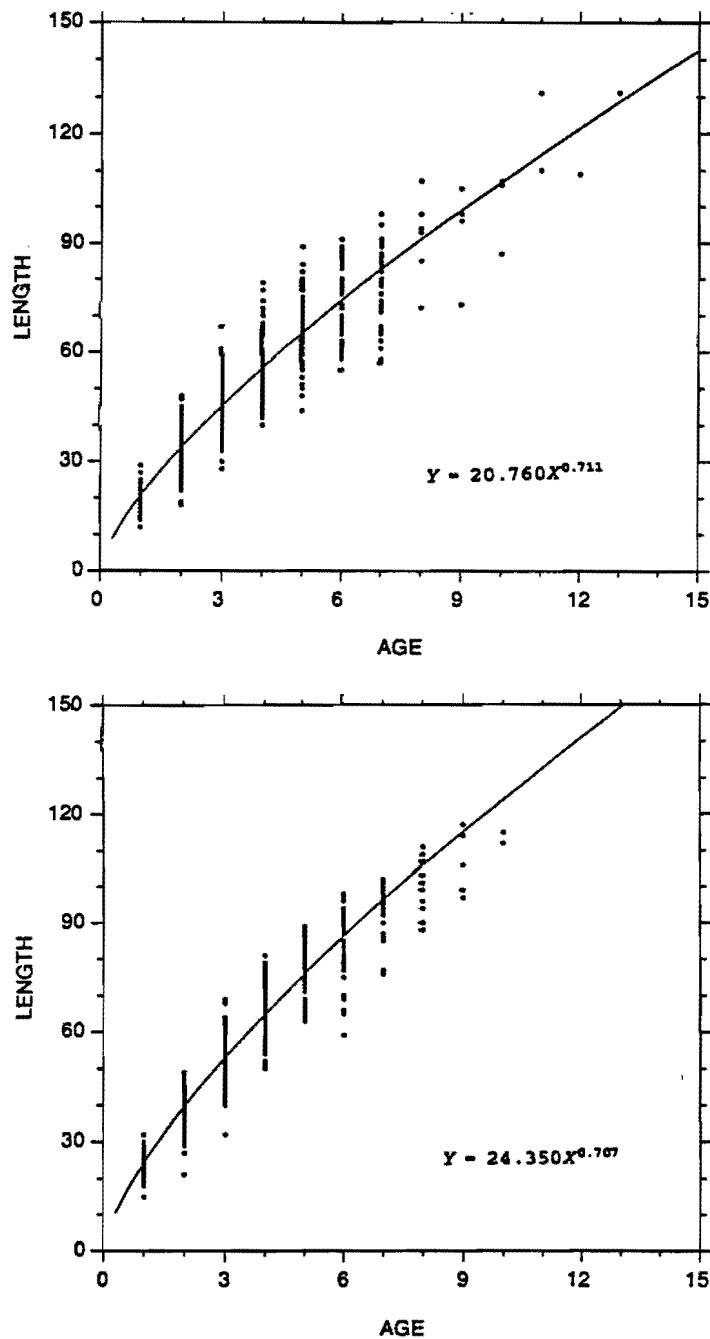


Fig. 20. Yield and biomass projections for 4X cod given a 1992 catch equal to the TAC of 26,000 t.

