Canadian Atlantic Fisheries
Scientific Advisory Committee

CAFSAC Research Document 86/28

Comité scientifique consultatif des
pêches canadiennes dans l'Atlantique

CSCPCA Document de recherche 86/28

Georges Bank Scallop Stock Assessment - 1985

By

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ABSTRACT

The Canadian Georges Bank scallop catch for 1985 was 3812 t., a 100% increase over last year and a reversal of the four year declining trend that ended with the 1984 landings being the worst since 1959. This increase is due to the good 1981 and strong 1982 year-classes recruiting to the fishery. Research data indicates that the 1983 year-class is above the recent average as well and so catches should continue at this level or higher in 1986 as this year-class enters the fishery.

Yield per recruit and stock projections show that even with the reduction in the meat count from 39 meats per 500 grams to 33 the stock is still seriously overfished.

The revisions to the working paper shown in the appendix involve the use of a different growth rate in producing the catch at age matrix (compare table 5 from this paper with that in the appendix). Because of this change the results from the cohort and subsequent analysis are slightly different from those presented in the working paper. For the stock projection the starting numbers used in the appendix are from the research survey contouring analysis instead of the weighted average numbers per tow. Although the conclusions are not affected by these changes it was felt that the new values are an improvement and as such should be incorporated into the research document.

RÉSUMÉ

Les prises de pétoncles sur la partie canadienne du banc Georges pour 1985 étaient 3812 t., une augmentation de 100% sur l'année précédente et un renversement de la tendance de déclin de quatre ans qui s'est terminé avec les débarquements de 1984, les plus bas depuis 1959. Cette augmentation est dûe à une bonne classe d'âge en 1981 et une forte classe d'âge en 1982 qui se recrutent à la pêche. Les données de recherche indiquent que la classe d'âge 1983 est aussi au-dessus de la moyenne récente et les prises devraient continuer à ce niveau, ou plus haut, en 1986 lorsque cette classe d'âge recrutera à la pêche. Les analyses de rendement par recrue et de projection des stocks démontrent que même avec la réduction dans le compte de viande de 39 par 500 grammes à 33, le stock est encore sérieusement surpêché.

L'utilisation d'un taux de croissance différent pour produire la matrice de prises à l'âge a nécessité une revision du document de travail qui est incorporé dans l'appendice (comparez la table 5 du document avec celle dans l'appendice). À cause de ce changement, les résultats de l'analyse de cohortes et autres diffèrent légèrement de celles présentées dans le document de travail. En ce qui a trait aux projections de stock, les chiffres utilisé dans l'appendice proviennent de l'analyse des donné de recherche par contours au lieu de nombres pondérés moyens par trait. Ces changements n'affectent en rien les conclusions du document; les nouvelles valeurs l'améliorent et sont donc présentées dans le document de recherche.

INTRODUCTION

Two strong year-classes, those of 1957 and 1972, produced major peaks in landings in the last 30 years of the Georges Bank scallop fishery (Fig. 1 and Table 1). The more recent peak occurred in 1977 and 1978 with landings of over 17,000 t. Landings fell to about 10,000 t in 1980 but increased by almost 6,000 t to 16,000 t in 1981 as a result of increased Canadian and U.S. fishing effort and a relaxation of the enforcement of the meat count regulation on the Canadian fleet. U.S. catch levels have shown an upward trend since the early 1970's to over 8,000 t in 1981, representing an increase of 400% from 1976 to 1981 and a parallel increase in effort. From 1982 on, landings by the Canadian fleet decreased steadily to 1,945 t in 1984, its lowest level since 1959. Marked improvement in catches and catch-rates characterise the 1985 fishery; catches increased by 100%, to over 3,800 t. Another strong year-class is about to recruit to the fishery, which should continue this fishery's rising profile.

METHODS

Catch and effort data are compiled from logbooks. Those logs with complete effort data are called Class 1 and are used to determine catch rates (see Table 2). Also, data on size distribution of meats from the commercial fleet are derived from port samples. Canadian port sampling data were applied to the Canadian and U.S. total catch east of the ICJ line. This assumes similar fishing practices for both fleets. The annual changes in fishing practice can be seen in Table 3, which contains weight distribution in 2 gram intervals for the last seven years.

Catch in numbers at age (Table 4) for the cohort analysis are derived from the port sampling data and the sum of U.S. and Canadian catches in the Canadian zone. For more details on the method used to derive catch at age see Roddick and Mohn (1985). The total catch (U.S. and Canadian) from the Canadian zone is decomposed into weight frequencies. The weights were converted to shell heights using the allometric relationship derived from 1982 research cruise data. The values expressing meat weight as a function of shell height use the parameters 1.027E-5 for the constant and 3.09 for the exponent of height. These values agree closely with those of Serchuck et al. (1982) for the same stock. Von Bertalanffy growth coefficients relating shell height and age were taken from Brown et al. (1972) as had been done previously.

Traditionally, catch statistics are compiled on an annual basis and recruitment to a fishery is discussed in terms of year-class strength. It is generally accepted that Georges Bank scallops are born in October and the first annual ring is laid down the following March. This is typically less than 10 mm and becomes difficult to discern as the animal grows. For this reason the ring, which is approximately 25 mm from the umbo is often referred to as the first annulus (see, for example, Naidu 1970). The convention which we shall adopt is that animals born in the fall of a year will be of that year-class and it will be further assumed that they were born on January 1 of that year. The deposition of the ring less than 10 mm will take place during the first year of life. The data of the deposition will be assumed to take place on April 1. A back calculation is then made to estimate the shell height for January 1. The annual growth rates for weights, given in Table 5, are converted into rates for heights and this results in a 16% reduction of the ring size being used for the January 1 size. For example, an animal born in the fall of 1978 is of the 1978 year-class and will be approximately 25 mm on its second birthday (January 1, 1980) although the ring would not be deposited for a few months. Table 5, as well as all other age data, uses this convention, with correction of ring sizes back to January 1. For use in age/weight programs and projections the actual weights used are mid quarter values.

A research survey was carried out on Georges Bank during August 1985. The design of the survey was based on a stratification by commercial effort. The logbooks of the commercial fleet in the preceeding 9 months were analyzed to determine areas of high and low fishing intensity. The areas of high intensity were sampled more heavily as they represent the area most important to the fleet (and presumably the areas of greatest abundance). The estimate of abundance was formed by contouring the catch rates at age of the survey tows and expanding the mean by the area enclosed by a given contour (Robert et al. 1982). The average number of animals at age per tow is given in Table 6. The numbers per tow are converted into indices of abundance by weighting them by the appropriate contour areas. The indices are shown in Table 7.

A Thompson-Bell type yield per recruit analysis was carried out breaking growth down into quarters and using 1985 selectivity values. This was done in order to take into account the dynamic growth of the younger age-classes of scallops. This method also takes into account the average quarterly distribution of effort over the last 14 years, which was found to be 8, 44, 33 and 15%. However, this method cannot include the effects of blending.

The regulations operant on the offshore fleet are that the catch should average no more than 33 meats per 500 grams(down from 39 meats per 500 grams in 1985) which corresponds to an average weight of 15 grams per meat. Placing a limitation on the average instead of stipulating a minimum means that the fishermen may take small animals and then balance them with larger ones. Such a practice, called blending, renders the use of most yield models inappropriate. If there are not enough larger animals to blend in, then the mortality on the small ones will have to be reduced. Thus, the partial recruitment is a function of abundance at age. In order to take this practice into account, a stock projection program was written in 1984 (Mohn et al 1984) in which the mortality on the animals beneath the stipulated average is adjusted until the mean weight of the catch is within 1% of the required average. The only other way in which this program differs from the normal stock projection is that the variables are updated quarterly because of the very rapid growth of the young scallops. The annual growth is divided into quarterly components of 10, 35, 35 and 20% and annual effort is partitioned into quarters by the rates of 8, 44, 33 and 15%. Selectivity for the projections follows the pattern of the fishery as revealed from the cohort analysis instead of that of the gear (Caddy 1972). Starting numbers at age for the projections were derived by aging ahead the 1985 survey estimates to Jan. 1986.

Because cohort analyses deal only with the removals from a cohort and not the growth of the animals it is not appropriate to use this method for a dynamic species like scallops. In the first year of recruitment the animals experience approximately a 300% increase in weight. In order to reduce the magnitude of the errors caused by ignoring growth effects, the cohort analysis was carried out on a quarterly basis. This required that catch at age be determined on a quarterly basis. Also, the above mentioned quarterly distribution of effort had to be taken into account. Selectivity had to be determined on a quarterly basis also. This was done subjectively by smoothly interpolating annual values from the 1984 assessment. This pattern multiplied by the F for the last quarter year was used as a starting vector for the quarterly cohort analysis. Natural mortality was set at .025 per quarter and no attempt was made to include a seasonal effect.

RESULTS

Research survey data (Tables 6, 7 and 8) show a strong pulse of young animals, ages 2 and 3, and the near-absence of scallops older than age 5. Although age 2 animals do not fully recruit to the research gear, high numbers of this age-class may crudely estimate an improvement in year-class strength which may be confirmed in the next survey. The youngest year-class observed appears important, even if less numerous than the (age 3) 1982 year-class.

3+ Biomass Estimates From Research Survey And Cohort Analysis.

	1978	1979	1980	1981	1982	1983	1984	1985
Research	23929	9344	2265	6067	4145	2646	1913	5334
Cohort	18362	13165	11569	12096	7626	5520	5704	6394

The cohort analysis was tuned by regressing commercial CPUE versus 4+ biomass (Figure 2.) The regression coefficient was 0.97. The CPUE was from Canadian vessels inside the Canadian Zone. Extensive tuning was not carried out as the authors feel that the new methodology is still experimental, but it was encouraging to see a good relationship between these variables. Table 9 contains the population estimates for Jan. 1 of each year. Table 10 is the fishing mortalities. The quarterly estimated mortalities are higher, especially on the younger animals, than was seen in the annual based values derived last year (Mohn et al. 1985). These results suggest that the fishing mortality is of the order of 1.2 for the fully recruited 5-yr olds and also indicate that there has been a large shift of effort onto the older year-classes in 1985, probably due to a combination of the decreased meat count requiring more blending of larger animals, and enough of the strong 1977 year-class still being available as 8 year olds. Table 10 shows that the fleet has tended to track this year-class for the last five years and last year fished it extremely hard for an eight year old year-class.

The quarterly based yield per recruit analysis used mid-quarter meat weights and the expanded selectivity used both in the cohort analysis and in the projections. (See Figure 4.) The F_{max} was at an F of 0.7 and $F_{0.1}$ at 0.46. These values are both lower than reported in previous assessments but do agree with values in Sinclair et al. (1985).

Figure 5 shows the apparent lack of a stock recruit relationship, indicating that environmental factors are probably the control on year-class strength.

Two projections were run for a three year period, one at the current F level of 1.2, and the other at $F_{0.1}$ (Table 11). As expected the current F runs show a rapid removal of the strong incoming age-classes. The $F_{0.1}$ shows a sustainment of the pulse at a biomass approximately three times higher after three years.

CONCLUSIONS

A relatively strong recruitment was seen in the 1985 fishery. This is evidenced by the change in the monthly CPUE of 1985 compared to 1984 (Figure 6). The animals became increasingly 'blendable' as the season progressed. The CPUE also reversed the recent 4 year declining trend. The 1985 research survey indicates that the strong recruiting year-class of this year will be followed by an above average one which should further bolster the fishery.

New methodology was developed this year to enhance the determination of catch at age and the cohort anlysis. Although the respective computer programs were extensively checked using simulated data, the authors do not feel that sufficient testing has taken place to allow advice to be generated from this analysis. Therefore the projections were done using starting numbers based on the research survey results. There is a problem relating the research abundance indices and those derived from cohort analysis as is shown in Figure 3; although the most recent 5 years have tracked each other fairly well. The relative magnitude of the recent trends suggests that the research gear has an efficiency of approximately 0.5. It would be ill-advised to try to establish TAC's until these questions and uncertainties have been resolved.

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Table 1.- Catch statistics (t of meats) from Georges Bank, NAFO subdivision 5Ze. For Canada: Statistics from SA 5Z not separated into 5Ze and 5Zw prior to 1967. Source: Pre-1961, Bourne (1964); 1961 on, ICNAF and NAFO Statistical Bulletins.

YEAR	USA	CANADA	TOTAL
1953	7392	148	7540
1954	7029	103	7132
1955	8299	120	8419
1956	7937	318	8255
1957	7846	766	8612
1958	6531	1179	7710
1959	8910	1950	10860
1960	10039	3402	13441
1961	10698	4565	15263
1962	9725	5715	15440
1963	7938	5898	13836
1964	6322	5922	12244
1965	1515	4434	5949
1966	905	4878	5783
1967	1234	5011	6245
1968	998	4820	5818
1969	1329	4318	5647
1970	1420	4097	5517
1971	1334	3908	5242
1972	824	4161	4985
1973	1084	4223	5307
1974	929	6137	7066
1975	860	7414	8274
1976	1777	9675	11452
1977	4823	13089	17912
1978	5589	12189	17778
1979	6412	9207	15619
1980	5477	5221	10698
1981	8443	8013	16456
1982	6523	4307	10830
1983	4328	2748	7076
1984	3071	1945	5016
1985		3812	

Table 2.- Catch and effort data. Canadian catches (t of meats) in NAFO subdivision 5Ze. Total effort is derived from effort from Class 1 data.

YEAR	CATCH	EFFORT			CPUE
		days	hours 10^3	crhm 10^3	kg/crhm
1972	4161	8188	114	13971	0.298
1973	4223	7946	115	13541	0.312
1974	6137	8205	121	14610	0.420
1975	7414	8221	119	15216	0.487
1976	9675	7593	112	15142	0.639
1977	13089	8689	97	13001	1.007
1978	12189	8547	111	15207	0.802
1979	9207	8827	126	17315	0.532
1980	5221	6848	95	12951	0.403
1981	8013	8443	105	15247	0.526
1982	4307	6116	80	10968	0.393
1983	2748	5483	76	9876	0.278
1984	1945	5716	70	8598	0.226
1985	3812	7376	105	12644	0.301

Table 3.- Frequencies of numbers at weight in 2 gram intervals (normalized to 1000) by year.

	YEAR						
GRAMS	1979	1980	1981	1982	1983	1984	1985
1	0	0	0	0	0	0	0
3	2	15	16	2	12	7	0
5	31	99	84	26	66	96	10
7	96	172	204	99	110	205	57
9	137	169	253	146	118	169	113
11	140	128	177	159	125	108	119
13	112	92	96	132	111	69	93
15	86	67	52	103	90	55	66
17	66	51	31	73	70	46	46
19	50	38	20	55	53	41	36
21	42	32	15	45	44	37	26
23	38	24	11	33	36	30	19
25	30	20	8	27	27	25	16
27	25	17	6	21	23	20	12
29	23	13	5	17	18	18	10
31	20	11	4	13	15	15	8
33	17	9	3	11	13	12	7
35	15	7	3	8	10	11	6
37	13	6	2	6	8	8	5
39	10	5	2	5	8	6	4
41	9	4	1	4	6	5	2
43	7	3	1	3	6	4	2
45	7	3	1	2	5	3	2
47	5	3	1	2	4	2	2
49	4	2	1	1	4	2	1
51	3	2	1	1	2	2	1
53	3	2	1	1	3	1	1
55	2	1	1	1	3	1	1
57	1	1	0	0	1	1	0
59	1	1	0	1	2	0	0
61	1	1	0	0	2	0	0
63	1	1	0	0	1	0	0
65	1	0	0	0	2	0	0
67	0	0	0	0	1	0	0
69	0	0	0	0	1	0	0
71	0	0	0	0	0	0	0
73	0	0	0	0	1	0	0
75	0	0	0	0	0	0	0
77	0	0	0	1	0	0	0

Table 4.- Catch at age

Catch in numbers (10^6) east of ICJ line

AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
3	220	141	155	309	103	115	123	47	85	219	37	35	42	30
4	122	98	242	349	415	631	345	220	229	537	196	122	90	168
5	25	13	42	50	101	143	232	121	63	85	129	62	34	53
6	3	3	5	6	14	15	46	44	20	10	21	21	14	9
7	1	1	2	2	5	4	13	22	12	5	5	7	10	6
8	0	0	0	1	2	1	5	10	6	3	3	3	3	5
9	0	0	0	0	4	1	4	10	6	6	6	5	2	3
Total	371	256	446	717	644	910	768	474	421	868	397	255	195	274

Table 5.- Shell height (mm), meat weight (g) and meat count per 500 grams at age as used by projection and age/weight programs. Height and weight as of first day of quarter.

Cohort age	Height	Weight	Count
3.00	59.4	3.1	161
3.25	64.5	4.0	125
3.50	70.3	5.2	95
3.75	79.4	7.6	66
4.00	86.6	10.0	50
4.25	90.1	11.2	44
4.50	94.1	12.9	39
4.75	100.3	15.7	32
5.00	105.2	18.2	28
5.25	107.6	19.5	26
5.50	110.3	21.0	24
5.75	114.5	23.7	21
6.00	117.9	25.9	19
6.25	119.5	27.0	19
6.50	121.4	28.3	18
6.75	124.3	30.5	16
7.00	126.6	32.2	16
7.25	127.7	33.1	15
7.50	129.0	34.1	15
7.75	131.0	35.8	14
8.00	132.5	37.1	13
8.25	133.3	37.8	13
8.50	134.2	38.6	13
8.75	135.5	39.8	13
9.00	136.6	40.8	12
9.25	137.1	41.2	12
9.50	137.7	41.8	12
9.75	138.7	42.7	12
10.00	139.4	43.4	12

Table 6.- Total weighted average number of scallops at age per tow.

Sampling dates	Age (years)								
	2	3	4	5	6	7	8	9	10^+
1979	26	108	31	20	9	4	2	1	4
1980	432	56	34	6	2	1	0	0	1
1981	166	179	24	5	2	1	0	0	0
1982	22	41	20	5	1	0	0	0	0
1983	41	26	15	4	2	1	0	0	0
1984	175	25	9	2	1	0	0	0	0
1985	82	165	15	2	0	0	0	0	0

Table 7.- Indices of abundance of scallop age-classes by contour analysis; Numbers at age (10^6).

Sampling dates	Age (years)						
	2	3	4	5	6	7	8
1978	781.15	370.39	834.23	326.25	95.21	36.39	11.74
1979	106.18	327.06	184.39	137.46	44.97	22.71	8.25
1980	350.50	181.55	38.58	19.54	14.37		
1981	548.31	551.89	137.31	66.98			
1982	241.77	430.42	98.11	23.43	5.09		
1983	204.16	115.75	97.88	24.27	9.52		
1984	1166.26	183.36	48.08	11.06	3.59		
1985	737.04	779.10	83.09	8.74			

Table 8.- Stratified average number of scallops at age per tow and stratified total number of scallops per tow, N.

Stratum	Sampling dates	Age (years)									N	s.d.
		2	3	4	5	6	7	8	9	10^+		
Very Low	1979	3	18	6	9	8	4	2	1	5	39	40
	1980	39	5	6	4	2	2	1	1	2	62	92
	1981	71	92	48	6	1	1	0	0	0	239	325
	1982	6	6	20	10	1	0	0	0	0	64	200
	1983	26	19	8	3	2	1	0	0	0	69	175
	1984	74	14	8	2	1	0	0	0	0	125	295
	1985	32	79	6	1	0	0	0	0	0	170	375
Low	1979	17	36	26	26	9	4	3	2	7	130	229
	1980	65	28	18	8	3	1	1	0	1	125	256
	1981	24	26	9	2	1	1	0	0	0	78	102
	1982	14	18	20	5	1	0	0	0	0	86	138
	1983	81	59	19	5	2	1	0	0	0	172	230
	1984	151	27	11	2	1	0	0	0	0	253	445
	1985	74	64	11	2	0	0	0	0	0	188	324
Medium	1979	41	117	39	21	9	5	2	1	3	238	234
	1980	550	74	36	10	2	1	0	0	0	674	1725
	1981	377	279	24	7	2	1	0	0	0	712	1025
	1982	24	37	18	4	1	0	0	0	0	90	143
	1983	16	28	15	4	2	1	0	0	0	69	88
	1984	449	35	12	2	0	0	0	0	0	636	931
	1985	173	511	22	2	0	0	0	0	0	710	1164
High	1979	27	147	42	19	9	3	1	0	1	249	231
	1980	727	104	66	6	2	1	0	0	1	908	1256
	1981	133	285	32	5	2	1	0	0	0	458	674
	1982	30	68	21	4	1	0	0	0	0	129	143
	1983	60	24	20	5	1	0	0	0	0	112	113
	1984	215	52	8	1	1	0	0	0	0	277	400
	1985	110	255	22	2	0	0	0	0	0	392	481

Table 9.- Population numbers east of ICJ line from cohort analysis.

Year	Age							
	3	4	5	6	7	8	9	Total
1972	482	185	65	10	8	3	1	753
1973	636	225	52	35	6	6	2	963
1974	814	440	111	35	29	5	5	1439
1975	1133	586	168	60	27	24	4	2003
1976	1257	726	199	105	48	23	21	2379
1977	744	1037	263	85	82	39	18	2268
1978	518	561	335	103	63	70	34	1682
1979	493	349	179	83	49	44	59	1256
1980	934	401	108	48	33	23	30	1577
1981	575	764	147	38	25	18	15	1582
1982	244	306	183	52	25	16	12	839
1983	240	185	91	44	27	18	12	617
1984	415	184	53	24	19	18	14	728
1985	501	335	82	16	9	8	13	964

Table 10.- Fishing mortality east of ICJ line from cohort analysis.

Year	Age							
	3	4	5	6	7	8	9	Average
1972	0.662	1.161	0.512	0.400	0.184	0.173	0.239	0.476
1973	0.269	0.607	0.293	0.093	0.109	0.055	0.119	0.221
1974	0.229	0.862	0.512	0.170	0.085	0.093	0.098	0.292
1975	0.346	0.978	0.370	0.120	0.067	0.038	0.092	0.287
1976	0.092	0.914	0.759	0.153	0.118	0.122	0.228	0.341
1977	0.183	1.031	0.842	0.201	0.052	0.040	0.090	0.349
1978	0.295	1.043	1.292	0.645	0.248	0.071	0.141	0.534
1979	0.107	1.077	1.221	0.819	0.632	0.285	0.198	0.620
1980	0.101	0.904	0.942	0.563	0.486	0.330	0.221	0.507
1981	0.529	1.328	0.930	0.322	0.300	0.370	0.530	0.616
1982	0.178	1.111	1.329	0.555	0.230	0.252	0.751	0.630
1983	0.165	1.156	1.219	0.714	0.312	0.167	0.688	0.632
1984	0.115	0.715	1.101	0.865	0.789	0.217	0.189	0.570
1985	0.067	0.750	1.158	0.991	0.993	1.024	0.274	0.751

Table 11.- Stock projections at current F (1.2) and at $F_{0.1}$ (.46)

F=1.2	1986	1986	1986	1986	1987	1987
Rate on smalls	0.14	0.11	0.09	0.73	1.00	0.98
Mean Wgt. Catch	14.96	14.90	14.59	14.96	15.50	15.00
Catch (Mill.)	2.03	10.04	7.46	24.75	12.60	62.94
Catch (t)	30.40	149.62	108.49	370.27	195.32	944.14
Cum. Catch (t)	30.40	180.02	288.51	658.78	195.32	1139.46
Biomass (t)	2086.60	2200.50	2567.90	3170.20	3273.40	2637.70

	1987	1987	1988	1988	1988	1988
Rate on smalls	0.67	0.87	0.69	0.53	0.37	0.77
Mean Wgt. Catch	14.96	15.02	15.00	14.97	14.99	14.98
Catch (Mill.)	37.64	18.95	9.05	46.43	30.32	27.59
Catch (t)	563.20	284.57	135.73	695.19	454.34	413.34
Cum. Catch (t)	1702.66	1987.23	135.73	830.92	1285.26	1698.60
Biomass (t)	2595.80	3356.80	3563.60	3254.00	3475.60	4215.40

$F_{0.1}$=.46	1986	1986	1986	1986	1987	1987
Rate on smalls	0.15	0.14	0.15	0.93	1.00	1.00
Mean Wgt. Catch	14.97	14.93	14.73	14.97	15.95	15.84
Catch (Mill.)	0.80	4.80	4.74	10.42	5.68	31.98
Catch (t)	12.04	72.60	69.81	155.94	90.54	506.58
Cum. Catch (t)	12.04	84.64	154.45	310.39	90.54	597.12
Biomass (t)	2106.40	2305.60	2732.30	3597.00	3830.10	3702.10

	1987	1987	1988	1988	1988	1988
Rate on smalls	1.00	1.00	1.00	1.00	1.00	1.00
Mean Wgt. Catch	15.34	17.30	16.11	15.59	15.13	18.53
Catch (Mill.)	26.15	12.11	6.01	37.77	34.83	16.72
Catch (t)	401.32	209.48	96.76	588.97	527.04	309.65
Cum. Catch (t)	998.44	1207.92	96.76	685.73	1212.77	1522.42
Biomass (t)	3972.10	4933.00	5228.20	5099.50	5383.10	6317.80

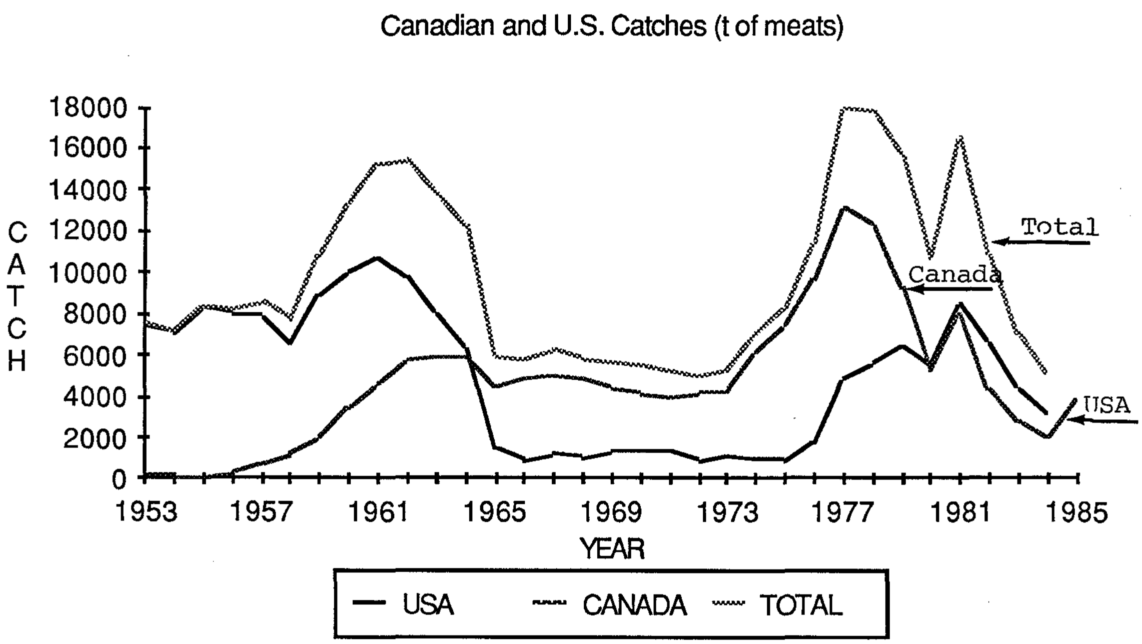

Figure 1.- Canadian and U.S. catches (t of meats)

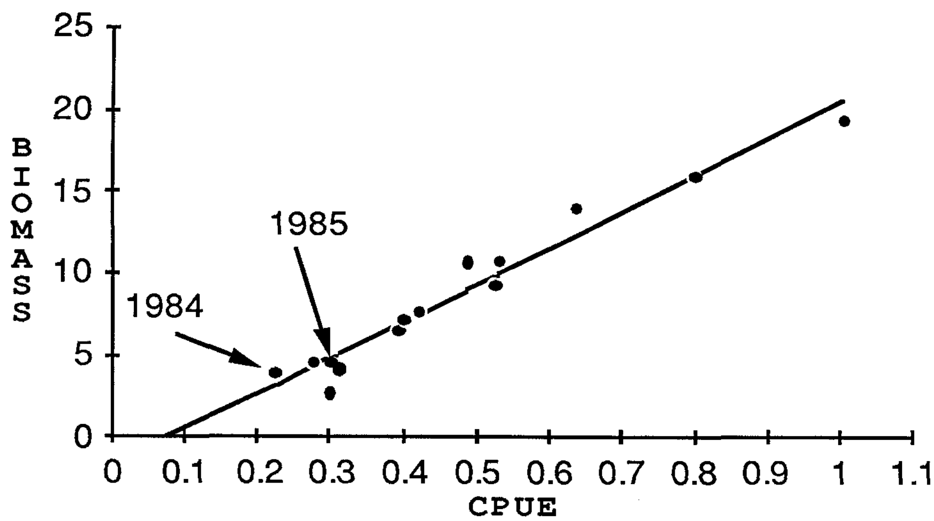

Figure 2.- Cohort biomass (t of meats * 1000) vs CPUE (kg/hr)

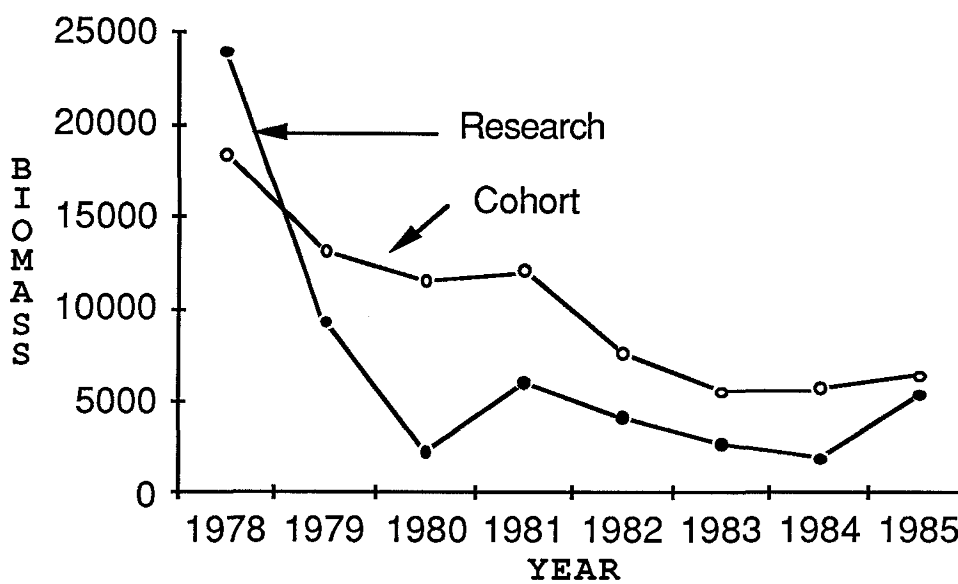

Figure 3.- Research and cohort biomass for ages 3 plus.

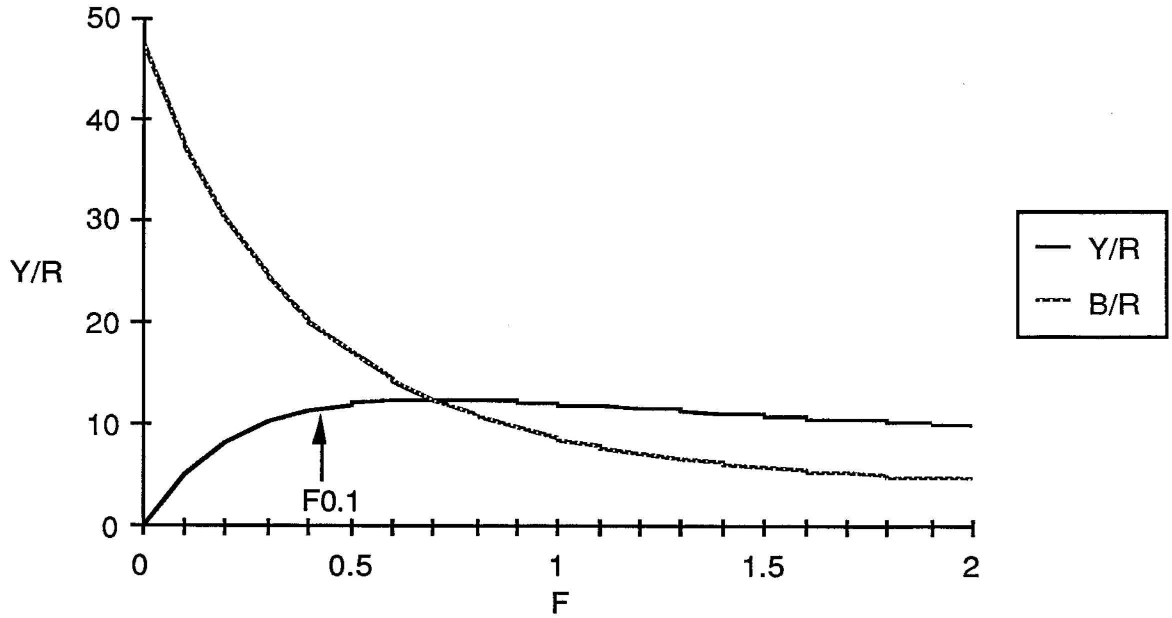

Figure 4.- Yield and biomass (/10) per recruit.

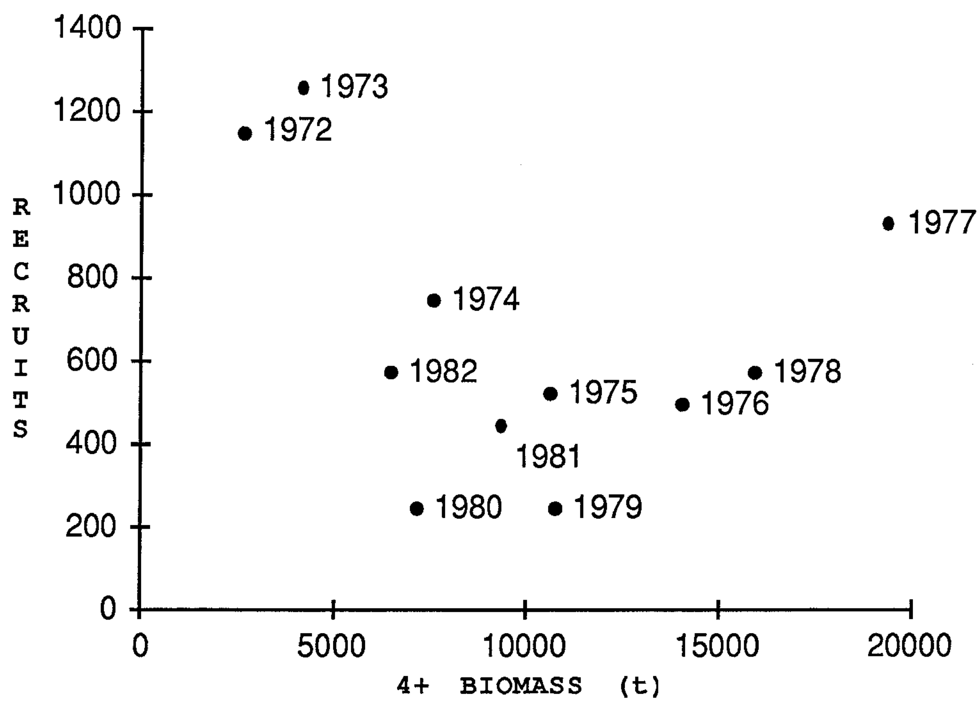

Figure 5.- Age 4^+ biomass versus recruits (lagged three years)

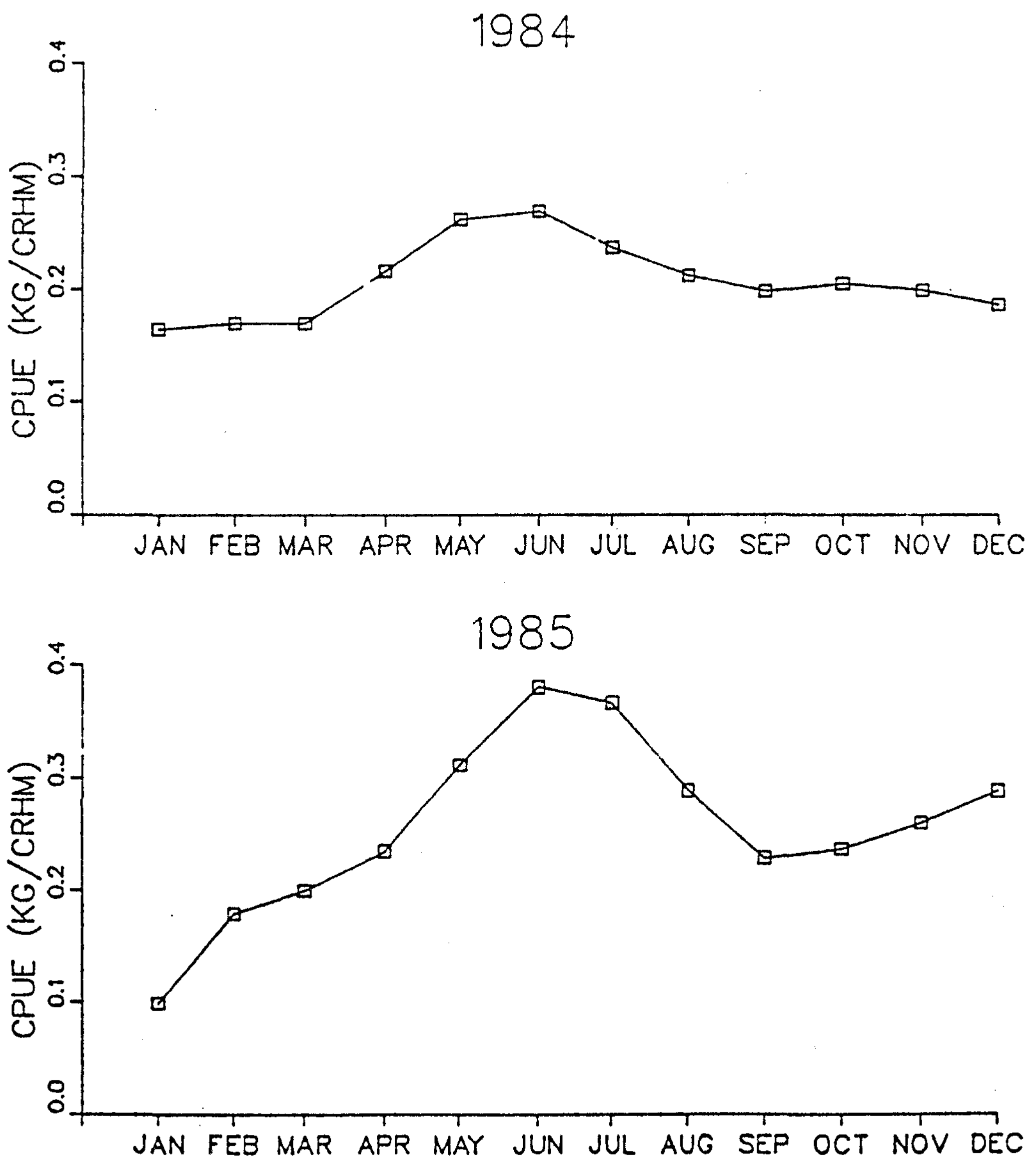

Figure 6. - Monthly CPUE for vessels over 19.8m L.O.A. fishing Georges Bank.

APPENDIX

Revisions to the data tables and figures are a result of using a different growth curve (see table 5) for the formation of the catch-at-age and weight-at-age matrices. For the stock projection there is also a difference due to the use of starting numbers from the research survey contouring analysis in place of the weighted average number per tow. These numbers have been aged forward to the first quarter of 1986.

These changes do not affect the conclusions drawn initially but give an improved fit to the data. Therefore it was felt that they should be incorporated into the research document.

3+ Biomass estimates from research survey and cohort analysis. Revised from page 5.

	1978	1979	1980	1981	1982	1983	1984	1985
Research	23929	9344	2265	6067	4145	2646	1913	5334
Cohort	18242	12698	11291	12212	7692	5376	5777	9216

Table 4 revised.- Catch at age

Catch in numbers (10^6) east of ICJ line

AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
3	260	170	222	429	180	224	178	82	135	350	68	51	71	74
4	86	71	185	243	366	571	346	211	185	437	206	117	68	147
5	22	11	33	38	78	100	192	109	62	55	98	60	30	34
6	2	2	4	5	12	10	36	37	18	12	12	14	15	8
7	1	1	2	1	5	3	9	18	10	6	5	4	7	6
8	0	0	0	1	2	1	4	8	5	5	4	3	2	4
9	0	0	0	0	4	1	4	8	4	5	5	6	2	2
Total	371	256	447	717	645	911	768	474	421	869	398	255	195	274

Table 5 revised.- Shell height (mm), meat weight (g) and meat count per 500 grams at age as used by projection and age/weight programs. Height and weight as of first day of quarter.

Cohort age	Height	Weight	Count
3.00	57.1	2.8	181
3.25	63.2	3.8	133
3.50	74.1	6.2	81
3.75	81.7	8.3	60
4.00	85.1	9.4	53
4.25	89.2	10.9	46
4.50	96.7	14.0	36
4.75	101.9	16.5	30
5.00	104.2	17.6	28
5.25	107.0	19.2	26
5.50	112.1	22.1	23
5.75	115.7	24.4	21
6.00	117.2	25.4	20
6.25	119.2	26.7	19
6.50	122.7	29.2	17
6.75	125.1	31.0	16
7.00	126.2	31.9	16
7.25	127.5	32.9	15
7.50	129.9	34.9	14
7.75	131.5	36.3	14
8.00	132.3	36.9	14
8.25	133.2	37.7	13
8.50	134.8	39.1	13
8.75	136.0	40.2	13
9.00	136.5	40.6	12
9.25	137.1	41.2	12

Table 9 revised.- Population numbers east of ICJ line from cohort analysis.

Year	Age							
	3	4	5	6	7	8	9	Total
1972	469	138	57	8	6	2	1	680
1973	557	175	44	31	5	5	2	818
1974	701	340	91	30	25	4	4	1195
1975	1118	419	132	51	23	21	3	1767
1976	1195	598	149	84	41	19	19	2105
1977	846	908	195	61	65	33	15	2123
1978	566	547	277	82	46	56	29	1602
1979	413	340	165	69	40	33	47	1107
1980	812	295	108	46	27	19	22	1329
1981	726	605	92	39	24	15	12	1514
1982	264	318	135	32	24	16	9	798
1983	193	173	93	30	17	17	11	534
1984	366	126	46	28	14	12	13	604
1985	735	263	50	13	11	6	9	1087

Table 10 revised.- Fishing mortality east of ICJ line from cohort analysis.

Year	Age							
	3	4	5	6	7	8	9	Average
1972	0.885	1.045	0.511	0.392	0.181	0.167	0.235	0.488
1973	0.393	0.551	0.292	0.088	0.117	0.055	0.116	0.230
1974	0.415	0.845	0.480	0.157	0.076	0.091	0.095	0.309
1975	0.526	0.933	0.354	0.110	0.064	0.033	0.089	0.301
1976	0.174	1.022	0.787	0.160	0.129	0.132	0.221	0.375
1977	0.337	1.087	0.768	0.183	0.051	0.040	0.091	0.365
1978	0.410	1.100	1.283	0.608	0.235	0.072	0.144	0.550
1979	0.236	1.049	1.175	0.830	0.652	0.286	0.203	0.633
1980	0.193	1.063	0.914	0.532	0.489	0.338	0.219	0.535
1981	0.724	1.400	0.962	0.368	0.325	0.394	0.522	0.671
1982	0.322	1.128	1.397	0.525	0.266	0.282	0.786	0.672
1983	0.325	1.219	1.114	0.667	0.278	0.206	0.760	0.653
1984	0.231	0.827	1.146	0.808	0.711	0.183	0.229	0.591
1985	0.114	0.886	1.222	0.964	0.916	0.904	0.254	0.751

Table 11 revised.- Stock projections at current F (1.2) and at $F_{0.1}$ (.46)

F=1.2	1986	1986	1986	1986	1987	1987
Rate on smalls	0.18	0.21	0.50	0.98	1.00	1.00
Mean Wgt. Catch	14.99	14.93	14.85	14.97	15.00	15.97
Catch (Mill.)	13.09	82.03	257.71	102.57	53.55	279.50
Catch (t)	196.28	1224.58	3826.57	1535.01	803.27	4464.80
Cum. Catch (t)	196.28	1420.86	5247.43	6782.44	803.27	5268.07
Biomass (t)	13663.70	15502.60	13115.10	13149.60	14302.60	11492.30

	1987	1987	1988	1988	1988	1988
Rate on smalls	1.00	1.00	1.00	1.00	1.00	1.00
Mean Wgt. Catch	17.15	18.61	17.95	18.83	19.24	20.90
Catch (Mill.)	195.37	69.69	30.93	147.07	93.46	38.02
Catch (t)	3350.71	1297.24	555.37	2768.81	1798.11	794.49
Cum. Catch (t)	8618.78	9916.02	555.37	3324.18	5122.29	5916.78
Biomass (t)	8811.60	8544.80	9015.60	7148.20	5749.20	5820.30

$F_{0.1}$=.46	1986	1986	1986	1986	1987	1987
Rate on smalls	0.18	0.26	0.65	1.00	1.00	1.00
Mean Wgt. Catch	14.99	14.96	14.95	15.79	15.90	17.12
Catch (Mill.)	5.17	38.86	118.17	53.12	28.15	160.96
Catch (t)	77.55	581.50	1766.33	838.69	447.60	2755.85
Cum. Catch (t)	77.55	659.05	2425.38	3264.07	447.60	3203.45
Biomass (t)	13798.30	16401.80	16352.20	17285.80	19243.50	18945.00

	1987	1987	1988	1988	1988	1988
Rate on smalls	1.00	1.00	1.00	1.00	1.00	1.00
Mean Wgt. Catch	18.47	20.50	19.78	21.19	22.42	26.44
Catch (Mill.)	131.96	55.74	23.92	124.32	88.92	47.61
Catch (t)	2436.78	1142.53	473.09	2634.41	1993.78	1258.57
Cum. Catch (t)	5640.23	6782.76	473.09	3107.50	5101.28	6359.85
Biomass (t)	17682.60	17822.30	18995.60	18030.10	16808.30	16324.80

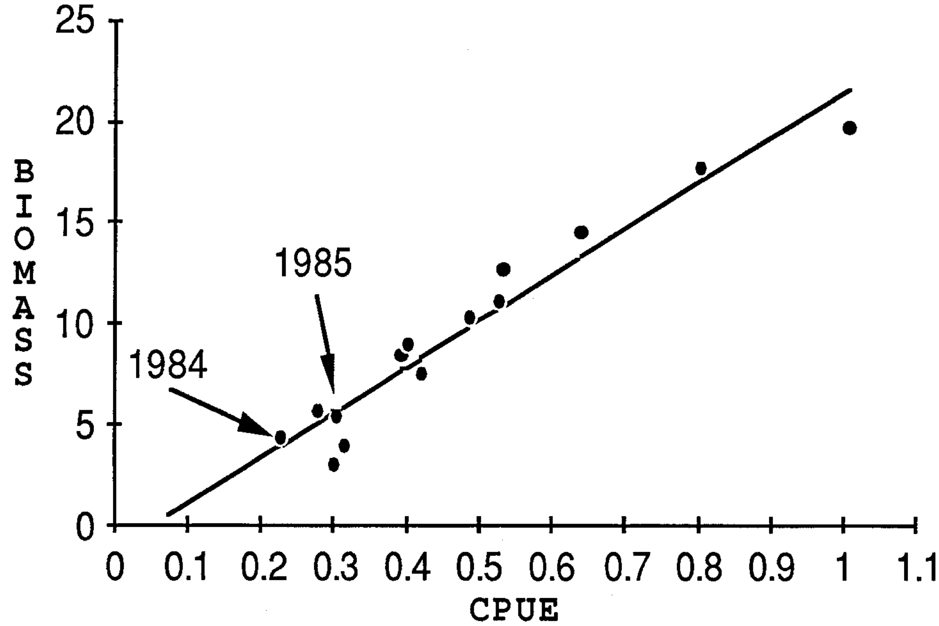

Figure 2 revised.- Cohort biomass (t of meats * 1000) vs CPUE (kg/hr)

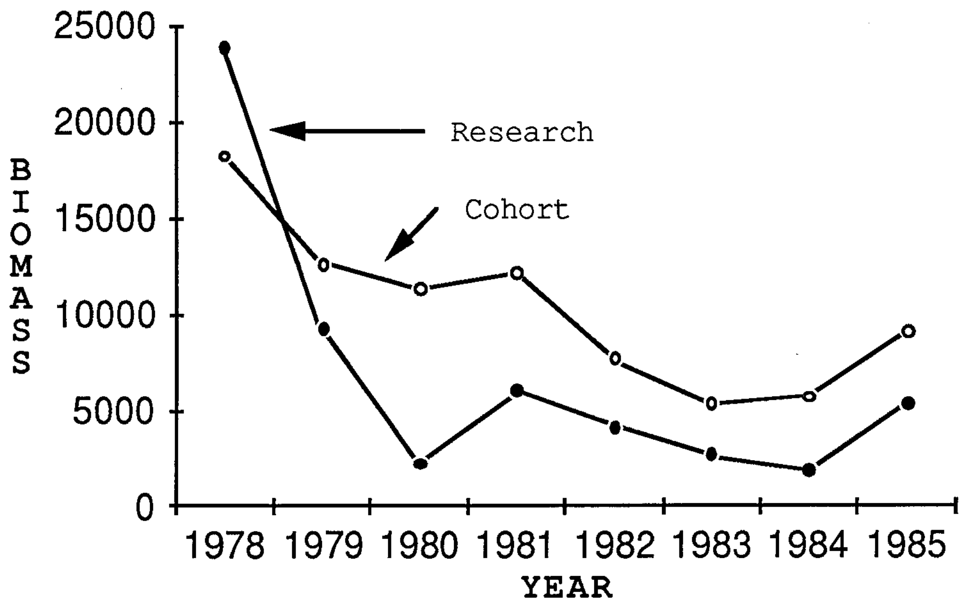

Figure 3 revised.- Research and cohort biomass for ages 3 plus.

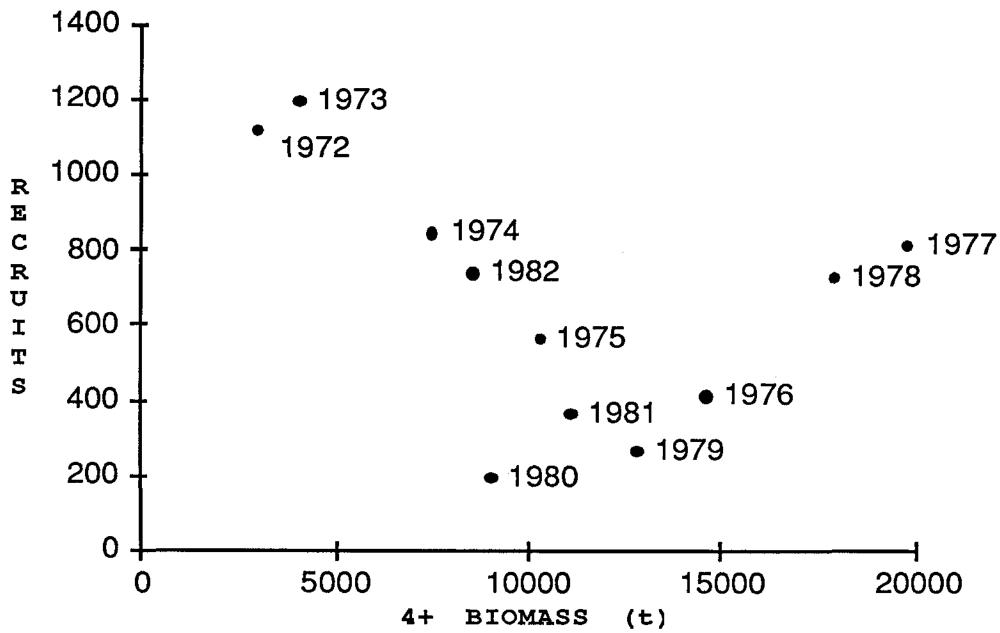

Figure 5 revised.- Age 4+ biomass versus recruits (lagged three years)