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### The 4X Cod Fishery: A Biological Update

by

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## Abstract

Nominal landings of 4X cod were 26,489 t in 1983 -- a substantial decline from the 31,528 t landed in 1982. Part of the decline may be attributable to reduced availability to longline gear and/or misreporting by fishermen whose quota had been reached. As in past years analysis of commercial catch rates produced results that were not consistent among gear types or unit areas. Population and mortality estimates derived from research surveys suggest that offshore cod abundance has been relatively stable for the past 13 years, although the region remains overexploited. Long-term population increases in the Bay of Fundy have levelled off in recent years perhaps due to heavier exploitation. The presence of multiple stocks, absence of reliable landing and catch/effort data, and limits on research survey coverage due to untrawlable bottom, continue to constrain the production of an accurate cod assessment.

## Résumé

Les débarquements nominaux de morue de 4X ont été de 26 489 t en 1983 -- une diminution substantielle par rapport aux 31 528 t débarquées en 1982. Cette diminution serait en partie attribuable à une accessibilité moindre aux palangres ou à des rapports inexacts de pêcheurs ayant atteint leur quota, ou encore aux deux. Comme par les années passées, l'analyse des taux de capture commerciaux a produit des résultats qui manquent d'uniformité entre types d'engins ou zones unitaires. Les estimations de population et de mortalité découlant des relevés par navires de recherche donnent à penser que l'abondance de la morue du large est demeurée relativement stable depuis 13 ans, bien que la région demeure surexploitée. Les augmentations à long terme de population dans la baie de Fundy ont atteint récemment un plateau, peut-être à cause d'une exploitation plus intense. La présence de stocks multiples, l'absence de données fiables sur les débarquements et les prises/effort et enfin la couverture limitée des relevés par navires de recherche due à la présence de fonds non chalutables imposent toujours des restrictions à une évaluation précise de la morue de cette région.

## Introduction

Several factors complicate the assessment of cod in NAFO Area 4X. First of all, stock identification has not yet been completed, although there appear to be 1 or 2 offshore components and a complex of inshore stocks (Templeman 1962; Gagné et al. 1983). Inshore and offshore components cannot yet be differentiated among the landings. Secondly the fishery is mainly composed of small vessels (TC1) not required to carry log books. This limits availability to effort data. Further, landing slips are often completed as to unit area landed, not that fished. Finally, much of the inshore area is rough-bottomed, and consequently unavailable to research survey gear.

The net result of the above is a fishery which exploits an unknown number of stocks while providing little in the way of catch/effort data or reliable areas of capture.

## Stock Structure

Previous studies have suggested the presence of an offshore component(s) and a multiplicity of local inshore units. Cod from Georges Bank may also mix with inshore fish, especially during the summer (Wise 1963). As a result, assessment by unit stock is currently impossible. Unpublished results of a 1966 tagging study in 4Xs (Bay of Fundy, N.B. side) add yet another local stock to the inshore list (Table 1). As was the case with other inshore stocks identified through tagging, seasonal and/or annual migrations of these fish were minimal. The offshore stock question is being addressed through a major tagging study: 4500 mature cod were tagged on Browns Bank and 2000 on Georges Bank in the spring of 1984.

## Nominal Catches

Historically, the cod fishery in 4X has been prosecuted by a Canadian inshore fleet. Between 1947 and 1961, total landings for the Division averaged close to 15,000 t, with less than 3,000 t estimated as coming from the offshore grounds. The introduction of large foreign trawlers in 1962 resulted in a rapid increase in catches, which peaked at 35,500 t in 1968 (Table 2). Imposition of quotas on 4X haddock in 1970 substantially reduced cod catches (to approximately 22,000 t), emphasizing the by-catch nature of many cod landings. Since 1976, the fishery has been essentially 100% Canadian, while post-1979 landings have been relatively high and stable. However, total landings for 1983 were down substantially from 1982 -- from 31,528 to 26,489 t.

Small vessels now constitute most of the cod fishery. These TC 1 vessels fish the offshore banks of 4X and even Georges Bank in the summer. Since these small vessels are not required to carry log books, their catch locations generally remain unknown. Purchase slips very often list the unit area of landing, not of capture. Therefore, an unknown percentage of 12,400 t of cod landed by TC 1 vessels in 1983 may have been caught in

areas other than those reported (Table 3). For this reason, offshore and inshore catches have not been subdivided as was suggested by de Lafontaine (MS 1981). Instead, landings have been partitioned by unit area (Figure 1A).

Catches among gear types were split fairly evenly in 1983. Otter trawls dominated the Bay of Fundy (4Xq, r & s) and some of the offshore region (4Xn, p), while longliners and fixed gear (both TC1) generally caught the majority inshore (4Xm, o) and on Browns Bank (4Xp) (Table 3). The 1983 catch of longliners and fixed gear was substantially lower than in 1982, although otter trawlers reported increased landings (except TC 5). Discussions with fishermen suggested that this may have resulted from an availability problem, perhaps due to abnormally high water temperatures. In 1983, the OT catch was 39% of the total, while longliners and fixed gear caught 36% and 25% respectively. Most of this was caught in the summer; longliners also had a strong spring fishery (Figure 2).

Although catches dropped substantially between 1982 and 1983, some of the "lost" catch may have been reported as caught in the Gulf of Maine when the inshore dragger fleet quota was reached. As indicated in Appendix 1, mobile gear 65' was the only gear category that approached or exceeded their quota in 1983. When that fishery was restricted, reported landings from the Gulf of Maine increased sharply (Appendix II). Although there is little doubt that some of the inshore dragger fleet redirected their effort to other areas when their 4X quota was met, discussions with fishermen and port samplers indicate that an unknown proportion of fishermen continued to land cod caught in 4X.

### Commercial Catch Analysis

The number of aged commercial samples was down from last year (Table 4), but the situation should be rectified for next year's assessment. Due to the low sample numbers, an unequal trimester system was applied to the age-length keys used in the derivation of numbers-at-age: January-April, May-September, and October-December. Samples from different tonnage classes within a given gear type were pooled. The length-weight relationship was determined from groundfish research surveys (Table 4). A month by month analysis of LL catches in 4Xo shows substantial inter-month variability in age composition. Variability among gear types was of a similar magnitude. The variability observed among unit areas may have been due to differences in stock composition; since unit stocks in 4X have not yet been identified, samples were not combined from among unit areas. However, both the inshore and offshore fisheries appear to be supported by a number of year-classes (Figure 3), with no major shift in age composition apparent over the last 3-4 years (Tables 5-10). Full recruitment to the fishery occurred at ages 3-4. Trends in weight-at-age were equivocal, but if anything, showed a slight decrease in weight-at-age for fish in 4Xo (Table 11).

Commercial catch rates are probably of minimal value in most of 4X,

since trends showed little correlation among gears within a given unit area and quarter (Figures 3-7). Trends were consistent neither within areas, gear types, or season, even when only the most recent years were examined. The exception was 4Xq, where there appears to have been a decline in catch rates since 1977. Due to the possibility of stock differences between unit areas, pooling catch rates from different areas could result in values of questionable accuracy. Nevertheless, in order to calibrate these catch rates with an independent estimate of cod abundance some pooling must be attempted. Since the Bay of Fundy comprises a relatively discrete geographic area, strata/unit areas within the region were arbitrarily assumed to be homogeneous. When 4Xq, Xr, and Xs catch rates for OT (TC 3, 2nd quarter) were combined and compared with fishable biomass estimates (3+ fish) from research surveys (Strata 84-95) (Figure 1B), there were some inexplicable inconsistencies between the two data sets (Figure 8). Therefore, the reliability of even the pooled catch rates must be questioned. In all cases, catch/effort data were assessed only for that quarter where catch was maximal for a given gear and unit.

### Research Surveys

Population estimates were derived from groundfish surveys in 2 ways: in the regular fashion, through calculation of an arithmetic mean of fish/stratum, and through calculation of a geometric mean ( $\ln(x+1)$ ). The latter was used in this assessment since it greatly reduced the variability of the population estimates (Table 13, Figure 11). However, geometric means were not used for the age-structured data.

Since a number of groundfish surveys were conducted in 4X in 1983 (in conjunction with the Fisheries Ecology Programme), an estimate of research survey variability was derived. Note however, that the various surveys differed with respect to date, and therefore are not strictly comparable. Nevertheless, the results show that individual population estimates could differ by as much as 37% from a mean value (Table 12a). Further, a comparison of the 2 survey vessels demonstrated little difference in overall catchability (Table 12b), although individual stratum catch rates differed markedly (Table 12a). Again the seasonal variation in cruise dates limits the comparability of these results. Therefore, a conversion factor of 1.39 was applied to the 1983 Alfred Needler survey data as determined from the preliminary results of the Alfred Needler-Lady Hammond comparative survey (Fanning unpublished).

Offshore population levels appear to be at or above the mean level of the past 13 years depending on which conversion factor is used (Figure 9). In contrast, estimates for the Bay of Fundy have shown a marked increase since 1970, although numbers may have levelled off in recent years (Figure 10). Combined, Strata 70-93 appear to have increased slightly since 1970 (Figure 11). Total mortality rates are variable from year-to-year (Tables 14 and 15); however, smoothed values show high Z values for the offshore recently (Figure 12). Unsmoothed Bay of Fundy Z values have been increasing recently and may reflect the elevated effort by inshore draggers in the region (Table 15); smoothed values show the opposite trend (Figure

13). Nevertheless, the Bay of Fundy Region has a much lower mortality rate than the offshore. The 1980 year-class is relatively strong, but subsequent year-classes are not (Tables 14 and 15; Figures 14 and 15).

### Overall Assessment

Although the cod stocks in 4X do not appear to be strong, there is little evidence that they have declined substantially in the past 12 years. Moreover, abundance estimates for the Bay of Fundy have climbed steadily since 1971, although population numbers now appear to have levelled off. Recent increases in effort in this region are evidence of the perceived abundance. The offshore region remains over-exploited however, and effort should be further restricted in this region. Data concerning the inshore areas of 4Xo and 4Xm are limited, and no assessment of stock status in those regions can be made. However, we note with concern that the TAC for cod in 4X was not reached in 1983. Although misreporting and availability problems may have been partially responsible for this situation, it is also possible that overexploitation is more severe than we now realize.

In all areas, improved commercial statistics would greatly assist in the provision of more precise stock assessments. Given poor catch data, either through misreporting, incomplete purchase slips or the absence of log books on TC 1 vessels, 4X cod will continue to be a "problem" stock in the upcoming year. Note however, that an alternate form of research survey for the large expanse of untrawlable bottom in 4X could greatly assist in the assessment of cod abundance in this region.

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### References

- Gagné, J.A., L. Currie, and K. Waiwood. 1983. The offshore cod fishery in 4X: A biological update. CAFSAC Research Document 83/43.
- de Lafontaine, Y. 1981. 1981 analyses of offshore cod stock in Division 4X. CAFSAC Research Document 81/45.
- Templeman, W. 1962. Divisions of cod stocks in the northwest Atlantic. ICNAF Redbook III: 79-123.
- Wise, J.P. 1963. Cod groups in the New England area. Fish. Bull. 63: 189-203.

Table 1. Unpublished results of cod tagging in Passamaquoddy Bay, N.B. (Area 4Xs); 504 cod were released during May, 1966. Length range of releases was 32 to 98 cm.

Area of Recapture	Quarter / Year						
	2nd/66	3rd/66	4th/66	1st/67-77	2nd/66-77	3rd/66-77	4th/66-77
<u>Bay of Fundy</u>							
4Xr	1	3			3	1	1
4Xs	35	44	3	36	8	13	6
<u>Gulf of Maine</u>							
5Yb	1	5					3
5Yd				1		1	
5Ye					1		1
<u>South Shore</u>							
4Xq			3	1		2	1
4Xo					1	1	
<u>Browns Bank</u>							
4Xp				3			
<u>Georges Bank</u>							
5Z			1	1	2	3	
<u>Scotian Shelf</u>							
4Xn						2	
4W				1			
<u>Total Recaptures = 189</u>				<u>37% Recovery</u>			

Table 2. 4X cod nominal catches (t) by country, 1958-1983.

Year	Canada	Spain	USSR	USA	FRG	France	Japan	UK	Others	Total	% Canada (M&Q)
1958	11074	-	-	1147	-	-	-	-	-	12221	90.6
1959	12866	-	-	862	-	-	-	-	-	13728	93.7
1960	12123	-	-	1605	-	-	-	-	-	13728	88.3
1961	12423	2	9	1261	-	-	-	-	-	13695	90.7
1962	14549	3	80	1197	-	-	-	-	-	15829	91.9
1963	15790	1	684	1301	9	-	-	-	-	17785	88.8
1964	21067	-	2922	1413	338	-	-	7	8	25755	81.8
1965	24221	144	1553	871	125	-	-	-	-	26914	90.0
1966	24164	803	4961	966	-	-	-	-	5	30899	78.2
1967	27814	2536	667	1445	-	-	-	-	-	32462	85.7
1968	30770	2829	1061	859	-	24	-	-	-	35543	86.6
1969	24056	8217	1	448	-	3	-	-	1	32726	73.5
1970	17994	3647	10	499	-	-	152	-	-	22302	80.7
1971	20181	2615	337	239	-	-	6	-	-	23378	86.3
1972	20479	1547	30	323	2	-	-	-	-	22381	91.5
1973	20002	1519	562	136	-	-	5	-	-	22224	90.0
1974	19005	1640	119	385	15	5	-	2	-	21171	89.8
1975	19493	900	207	483	3	-	-	-	5	21091	92.4
1976	16138	175	-	341	-	-	-	-	3	16657	96.9
1977	21884	-	4	760	-	185	-	-	-	22833	95.8
1978	23348	-	6	279	2	-	3	-	1	23639	98.8
1979	28337	-	-	48	-	-	1	-	-	28386	99.8
1980	30929	2	94	75	-	-	10	-	-	31110	98.3
1981	30790	-	-	127	-	-	5	-	-	30922	99.4
1982	31528	-	-	-	-	-	-	-	-	31528	100.0
1983	26414	-	11	63	-	-	1	-	-	26489	99.7

Table 3. Nominal Catch ( $t$ ) of 4X cod in the Maritimes. Underlined catches are those representing the most successful gear/TC in a given unit area.

1 9 8 2

Unit	O T B					L L				M I S C.				
	1	2	3	4	5	1	2	3	4	Mobile	1	2	3,4	Total
M	16	47	29	1	606	1962	89	16	0	41	<u>2428</u>	20	0	5255
N	0	198	204	111	<u>1142</u>	4	982	244	17	13	0	4	2	2922
O	171	314	82	225	364	<u>5141</u>	461	81	2	5	3413	192	0	10451
P	1	146	105	26	91	2	<u>1200</u>	507	0	0	0	0	0	2079
Q	205	593	<u>1040</u>	24	0	503	515	128	0	28	674	4	0	3715
R	468	1352	<u>1454</u>	0	0	708	24	0	0	3	562	0	0	4571
S	20	214	232	0	0	<u>795</u>	64	90	0	12	564	17	1	2009
U	0	169	229	0	3	0	112	0	0	2	0	2	1	518
<b>Total</b>	<b>880</b>	<b>3034</b>	<b>3375</b>	<b>387</b>	<b>2207</b>	<b>9115</b>	<b>3448</b>	<b>1067</b>	<b>18</b>	<b>105</b>	<b>7642</b>	<b>238</b>	<b>4</b>	<b>31520</b>

1 9 8 3

Unit	O T B					L L				M I S C.				
	1	2	3	4	5	1	2	3	4	Mobile	1	2	3	Total
M	4	19	29	1	321	1062	256	187	-	85	<u>1469</u>	4	-	3437
N	-	146	109	92	379	3	<u>609</u>	180	2	118	-	9	-	1647
O	81	402	220	65	307	<u>3399</u>	359	140	3	6	3344	211	-	8537
P	-	<u>891</u>	<u>444</u>	15	84	7	714	337	3	-	-	2	-	2497
Q	234	721	<u>921</u>	26	-	339	328	23	-	16	530	22	-	3160
R	266	1162	<u>1647</u>	15	-	350	32	-	-	-	302	13	-	3787
S	52	252	339	11	-	<u>578</u>	39	6	-	5	351	31	11	1675
U	1	529	<u>564</u>	75	-	1	415	7	2	11	-	54	-	1659
<b>Total</b>	<b>638</b>	<b>4122</b>	<b>4273</b>	<b>300</b>	<b>1091</b>	<b>5739</b>	<b>2752</b>	<b>880</b>	<b>10</b>	<b>241</b>	<b>5996</b>	<b>346</b>	<b>11</b>	<b>26399</b>

Table 4. Number of aged commercial samples collected in 1983 and available for this analysis. Numbers in brackets refer to number of 1982 samples. Values for A and B parameters were derived from groundfish survey results of corresponding season.

Period	Gear	Unit Area						Total
		Xm	Xn	Xo	Xp	Xq	Xr	
Jan-Apr	OTB			1(3)		(4)		1 (7)      A = .007*
	LL		1(1)	3(5)	1(1)		(1)	5 (8)      B = 3.05*
	Other							0 (0)
May-Sept	OTB		(1)	1(2)	4	6(5)	3(1)	14 (9)      A = .009699
	LL			6(5)				6 (5)      B = 3.003066
	Other	(3)		3(3)	1		(1)	4 (7)
Oct-Dec	OTB			1		(1)	2	3 (1)      A = .007*
	LL		(1)	(2)				0 (3)      B = 3.05*
	Other	(2)						0 (2)
Total		0(5)	1(3)	15(20)	6(1)	6(10)	5(2)	0(1)      33 (42)

\* 1983 values not available; therefore estimated from same season of other years.

	LL	IN	4XN	26/	4/84		LL	IN	4XP	26/	4/84
	1	1980	1981	1982	1983		1	1981	1982	1983	
1	1	0	0	0	0		1	1	0	0	0
2	1	14	33	0	0		2	1	0	0	0
3	1	76	214	43	41		3	1	96	154	202
4	1	60	193	107	59		4	1	233	195	36
5	1	70	35	56	51		5	1	43	94	44
6	1	40	15	9	29		6	1	21	26	46
7	1	4	0	9	5		7	1	25	21	7
8	1	7	0	1	2		8	1	3	9	9
9	1	0	2	1	1		9	1	3	4	2
10	1	0	1	0	2		10	1	1	1	1
11	1	0	0	0	1		11	1	0	1	0
12	1	0	0	0	0		12	1	0	0	0
13	1	0	0	0	0		13	1	0	0	0
14	1	0	0	0	0		14	1	0	0	0
15	1	0	0	0	0		15	1	0	0	0
16	1	0	0	0	0		16	1	0	0	0
1+1		272	494	226	191		1+1		426	505	347
2+1		272	494	226	191		2+1		426	505	347
3+1		258	460	226	191		3+1		426	505	347
4+1		181	246	183	150		4+1		330	351	145
5+1		121	52	76	91		5+1		97	155	109
6+1		51	18	20	41		6+1		54	61	65
7+1		11	3	10	11		7+1		32	35	19

Table 5 .      Numbers-at-age of cod from 4Xn and 4XP (offshore).  
 Landings were made between Jan. - Apr.

LL IN 4XO 26/ 4/84

HANLINES IN 4XO 26/ 4/84

	1980	1981	1982	1983
1	0	0	0	0
2	0	68	12	0
3	276	543	90	255
4	69	607	356	206
5	70	79	277	171
6	57	69	28	50
7	28	22	12	12
8	10	6	4	5
9	1	5	2	1
10	0	2	3	0
11	0	0	1	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0

	1980	1981	1982	1983
1	0	0	0	0
2	463	233	663	0
3	1173	1513	651	191
4	184	471	320	201
5	184	71	119	331
6	44	25	6	202
7	3	26	5	54
8	0	19	6	14
9	0	2	9	5
10	3	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	1	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0

	1+1	2055	2364	1980	997
2+1	531	1402	785	703	2+1 2055 2364 1980 997
3+1	531	1333	772	703	3+1 1591 2130 1117 997
4+1	255	790	682	449	4+1 419 615 467 806
5+1	166	184	326	241	5+1 235 144 147 605
6+1	96	105	50	69	6+1 50 73 27 274
7+1	39	36	22	19	7+1 6 48 21 73

OT IN 4XO 26/ 4/84

	1980	1981	1982	1983
1	0	0	0	0
2	0	0	12	5
3	21	23	52	33
4	22	39	89	33
5	50	21	28	104
6	43	13	3	47
7	20	7	1	4
8	28	1	0	1
9	8	2	1	4
10	5	0	0	7
11	2	1	0	1
12	1	0	0	0
13	1	0	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0

1+1	201	108	186	240
2+1	201	108	186	240
3+1	201	108	175	235
4+1	180	85	123	202
5+1	153	46	33	169
6+1	108	24	5	65
7+1	65	11	2	17

Table 6. Numbers-at-age of cod caught in 4Xo. Period of landings was Jan-Mar except for handline fish landed between May-Sept.

	CT	IN	4XQ	26/ 4/84		CT	IN	4XR	26/ 4/84
	1	1981	1982	1983		1	1981	1982	1983
1	1	0	0	0		1	1	0	0
2	1	178	81	442		2	1	40	629
3	1	328	347	627		3	1	646	530
4	1	152	230	89		4	1	235	216
5	1	32	90	47		5	1	76	121
6	1	14	18	16		6	1	1	58
7	1	2	1	4		7	1	2	63
8	1	1	2	0		8	1	1	29
9	1	0	0	0		9	1	1	5
10	1	0	0	0		10	1	0	0
11	1	0	0	0		11	1	0	0
12	1	0	0	0		12	1	0	0
13	1	0	0	0		13	1	0	0
14	1	0	0	0		14	1	0	0
15	1	0	0	0		15	1	0	0
16	1	0	0	0		16	1	0	0
1+1		706	770	1224		1+1		1004	1576
2+1		706	770	1224		2+1		1004	1576
3+1		529	689	782		3+1		964	947
4+1		201	342	156		4+1		318	417
5+1		49	112	67		5+1		83	201
6+1		17	21	20		6+1		4	197
7+1		3	4	4		7+1		3	106
									42

Table 7. Numbers-at-age of cod caught in  $4X_Q$  and  $4X_R$  between May-Sept.

	LL	IM	4XN	25/ 4/84		LL	IM	4XP	26/ 4/84	
	1980	1981	1982	1983		1981	1982	1983		
1	1	0	0	0		1	1	0	0	
2	1	10	12	0	0	2	1	0	0	
3	1	77	169	36	34	3	1	88	109	200
4	1	38	292	161	91	4	1	441	305	56
5	1	160	61	161	114	5	1	122	269	103
6	1	120	54	43	102	6	1	101	110	158
7	1	23	0	41	20	7	1	129	97	50
8	1	38	0	5	16	8	1	29	78	64
9	1	3	16	6	11	9	1	24	31	18
10	1	2	8	0	14	10	1	12	5	16
11	1	2	0	2	10	11	1	7	11	3
12	1	0	0	0	0	12	1	0	0	0
13	1	0	0	2	0	13	1	3	0	0
14	1	0	0	0	0	14	1	3	0	0
15	1	0	0	0	0	15	1	0	0	0
16	1	0	0	0	0	16	1	0	0	0
1+1	522	612	458	411		1+1	957	1016	669	
2+1	522	612	458	411		2+1	957	1016	669	
3+1	511	600	458	411		3+1	957	1016	669	
4+1	434	430	422	377		4+1	869	907	469	
5+1	347	138	261	286		5+1	429	602	413	
6+1	186	78	99	172		6+1	307	333	310	
7+1	66	24	57	70		7+1	206	223	152	

Table 8. Biomass-at-age of offshore cod (4Xn + 4xp) caught between Jan.-Sept.

HAND LINES IN 4XO 25/ 4/84

	1980	1981	1982	1983
1	0	0	0	0
2	324	148	664	0
3	1348	1651	969	265
4	344	1191	813	424
5	459	294	429	1026
6	187	155	33	749
7	20	180	28	365
8	0	140	38	141
9	3	22	40	56
10	10	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	11	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0
1+1	2697	3793	3015	3226
2+1	2697	3793	3015	3226
3+1	2373	3645	2351	3226
4+1	1024	1994	1381	2960
5+1	680	802	568	2536
6+1	221	509	139	1511
7+1	33	354	106	562

Table 9. Biomass-at-age for 4Xo cod caught between Jan-Apr (LL &amp; OT) and May-Sept. (handline).

LL IN 4XO 25/ 4/84

	1980	1981	1982	1983
1	0	0	0	0
2	0	29	6	0
3	248	413	83	176
4	99	807	448	239
5	144	171	603	286
6	162	198	108	126
7	92	95	58	45
8	40	38	30	31
9	6	36	14	4
10	0	15	22	2
11	2	5	7	4
12	0	4	1	0
13	0	3	3	1
14	0	0	0	1
15	0	1	1	0
16	0	1	0	3
1+1	793	1814	1384	919
2+1	793	1814	1384	919
3+1	793	1785	1378	919
4+1	545	1373	1296	743
5+1	446	565	847	504
6+1	302	394	244	218
7+1	140	196	136	92

OT IN 4XO 26/ 4/84

	1980	1981	1982	1983
1	0	0	0	0
2	0	0	6	2
3	25	23	54	27
4	42	70	145	64
5	119	57	80	292
6	151	46	13	181
7	35	31	4	23
8	139	7	2	9
9	49	12	4	30
10	32	3	0	30
11	22	7	0	6
12	11	0	0	0
13	12	0	0	0
14	2	0	0	0
15	0	0	0	0
16	1	0	0	0
1+1	690	256	307	665
2+1	690	236	307	665
3+1	690	256	301	663
4+1	665	233	247	636
5+1	623	162	102	572
6+1	504	106	22	280
7+1	353	60	10	99

	OT IN 4XQ 26/ 4/84			OT IN 4XR 26/ 4/84			
	1981	1982	1983		1981	1982	1983
1	0	0	0	1	0	0	0
2	147	84	340	2	29	415	148
3	478	544	871	3	840	753	651
4	404	564	201	4	513	530	323
5	125	350	148	5	264	411	316
6	74	87	77	6	7	274	323
7	16	10	21	7	13	133	195
8	9	13	1	8	13	38	44
9	2	4	2	9	7	0	48
10	0	2	0	10	0	0	20
11	0	1	0	11	0	0	9
12	0	0	0	12	0	0	0
13	0	0	0	13	0	0	0
14	0	0	0	14	0	0	0
15	0	0	0	15	0	0	0
16	0	0	0	16	0	0	0
1+1	1256	1661	1662	1+1	1686	2553	2278
2+1	1256	1661	1662	2+1	1686	2553	2278
3+1	1109	1577	1322	3+1	1657	2139	2129
4+1	630	1033	451	4+1	817	1386	1278
5+1	226	469	250	5+1	305	856	955
6+1	101	118	102	6+1	40	445	639
7+1	27	31	24	7+1	34	171	316

Table 10. Biomass-at-age of cod caught in 4X<sub>Q</sub> and 4X<sub>R</sub> during May-September.

Table 11 . Weight-at-ages 3 and 5 for cod caught by various gears. 1st/2nd/3rd refers to trimester of capture during the year. 0 values represent missing data.

	WEIGHT-AT-AGES 3 + 5				27/ 4/84		
	1977	1978	1979	1980	1981	1982	1983
Xp-LL-1st-3	0.00	0.00	0.00	0.00	0.91	0.71	0.99
-5	0.00	0.00	0.00	0.00	2.84	2.85	2.37
XQ-OT-2nd-3	0.00	0.00	0.00	0.00	1.46	1.57	1.39
-5	0.00	0.00	0.00	0.00	3.93	3.89	3.13
XR-OT-2nd-3	0.00	0.00	0.00	0.00	1.30	1.42	1.63
-5	0.00	0.00	0.00	0.00	3.38	3.40	3.45
Xn-LL-1st-3	0.58	1.00	0.84	1.01	0.79	0.83	0.83
-5	2.31	2.58	2.46	2.28	1.75	2.88	2.24
Xo-LL-1st-3	0.67	0.94	1.08	0.90	0.76	0.92	0.69
-5	1.70	1.86	2.32	2.06	2.17	2.18	1.67
Xo-LL-2nd-3	0.00	0.00	1.23	1.07	1.06	1.03	0.96
-5	0.00	0.00	3.00	2.80	2.55	2.74	2.42
Xo-LHP-2nd-3	0.00	0.00	1.41	1.15	1.09	1.49	1.39
-5	0.00	0.00	2.65	2.49	4.13	3.60	3.10
Xo-OT-1st-3	0.00	0.00	0.00	1.22	1.01	1.05	0.81
-5	0.00	0.00	0.00	2.38	2.66	2.83	2.80

Table 12a. Variability among estimates of cod abundance derived from 6 groundfish cruises conducted in NAFO area 4X during 1983. Since 3 of the cruises did not cover the entire survey grid, strata 71, 78, and 82-84 were not considered to insure comparability among cruise coverages. Estimates = no. x  $10^{-6}$ .

Cruise	Strata 70-85		Strata 90-95	
	Arithmetic Mean	Geometric Mean	Arithmetic Mean	Geometric Mean
H085 (Oct/82)	4.61	4.05	5.02	4.30
H088/089 (Jan/83)	6.51	4.83	3.42	2.82
H095 (Apr/83)	9.58	6.44	6.13	5.03
N010 (June/83)	5.99	4.45	3.72	3.73
N012 (July/83)	7.69	7.10	3.14	2.54
N015 (Sept/83)	9.77	6.15	6.04	5.57
Mean	7.36	5.50	4.58	4.00
S	2.05	1.22	1.33	1.20
95% C.I.	5.21-9.41	4.22-6.78	3.18-5.98	2.74-5.26

CV = 0.27; note that individual estimates can differ by as much as 37% from the mean.

Table 12b. Hammond-Needler comparison (identical gears) for above cruises and strata (70-95 summed). Mean population estimates for each vessel are presented.

	Arithmetic Mean	Geometric Mean
Hammond	$\bar{X} = 11.76$ $S = 3.43$	$\bar{X} = 9.16$ $S = 2.03$
Needler	$\bar{X} = 12.12$ $S = 3.25$	$\bar{X} = 9.85$ $S = 1.78$

Hammond:Needler catches = 0.97 (GM = 0.93). However since the "real" comparative survey resulted in the Hammond outfitting the Needler by a factor of 1.39 (N012 and H101), no conversion factor has been used.

Table 13. Comparison of multiple cod population estimates ( $\times 10^{-6}$ ) from 7 groundfish cruises conducted in NAFO area 4X during 1983.

Cruise	Strata 70-85		Strata 90-95		Strata 70-95	
	Arithmetic Mean	Geometric Mean	Arithmetic Mean	Geometric Mean	Arithmetic Mean	Geometric Mean
H085 (Oct/82)	5.55	5.25	5.02	4.30	10.57	9.55
H088/089* (Jan/83)	6.51	4.83	3.42	2.82	9.92	7.65
H095 (Apr/83)	11.05	7.57	6.13	5.03	17.17	12.60
N010* (June/83)	5.99	4.45	3.72	3.73	9.71	8.18
N012 (July/83) <sup>1</sup>	7.83	7.47	3.14	2.54	10.98	10.01
H101* (July/83)	5.55	4.96	5.82	4.01	11.37	8.97
N015* (Sept/83)	9.77	6.15	6.04	5.57	15.81	11.72
Mean	7.46	5.81	4.76	4.00	12.22	9.81
S	2.19	1.28	1.30	1.10	3.00	1.81

\* incomplete coverage of survey grid

<sup>1</sup> regularly scheduled groundfish survey

Table 14. Div. 4X offshore cod: Research survey estimates of population numbers at age ( $\times 10^{-3}$ ) and estimated mortality (Strata 70-85 Inclusive).

Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	-	-	-	-	190	-	-	-	27	-	-	72	59	228
1	891	286	19	74	115	225	143	87	164	176	-	1685	380	178
2	1588	7604	1320	2040	593	705	628	1620	438	1148	365	869	725	957
3	2660	4265	2871	1188	4186	999	1998	2887	1504	472	2295	1462	817	5304
4	4375	574	1988	1972	664	2264	1968	1432	1449	1502	968	1776	1061	3370
5	1935	1465	413	696	1820	1780	1485	611	864	1116	1055	846	846	1579
6	2610	638	414	218	927	908	456	753	190	561	1456	536	353	989
7	1148	855	95	101	167	628	189	199	234	438	377	418	39	235
8	578	28	385	59	-	150	99	248	31	293	182	123	39	-
9	202	-	214	116	-	144	-	53	-	30	74	90	144	22
10	110	-	99	40	-	32	42	-	-	72	-	45	80	-
11	16	-	3	34	8	194	15	-	-	66	59	-	-	-
12	-	-	3	7	-	140	-	14	-	-	-	8	-	-
13+	-	-	161	24	151	9	7	40	-	60	-	-	-	-
Total	16112	15715	7985	6569	8821	8178	7030	7944	4901	5934	6831	7930	4543	12862
Biomass														
(t)	43890	19090	21010	15190	22630	22560	16500	18899	11624	20188	20744	15615	10477	21338
Z 4+/5+*	1.29	.79	1.05	.08	-0.02	0.95	.81	.92	.10	.22	.69	.93	-.10	
Z 5+/6+*	1.47	.90	1.04	.11	.35	1.51	.59	1.41	-0.10	.16	.95	1.15	.18	
Z 6+/7+*	1.66	.64	1.22	1.18	-0.16	1.85	.44	1.56	-0.68	0.75	1.14	1.39	.93	

\* 6 age-groups were used to calculate the Z values; Ex.: ages 4 to 9 for 4+, ages 5 to 10 for 5+, etc.

Table 15. Div<sub>3</sub> 4X cod in the Bay of Fundy: Research survey estimates of population numbers at age ( $\times 10^{-3}$ ) and estimated mortality (Strata 90-95 inclusive).

Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	-	-	-	27	-	-	-	-	-	-	2134	0	29	0
1	213	106	276	60	367	1032	23	285	68	3215	240	910	498	57
2	170	635	512	536	547	2367	703	1144	814	3244	661	1951	1436	834
3	109	314	726	177	1459	811	835	2069	566	1723	1008	1198	1318	1606
4	557	162	1201	458	644	1266	362	1628	1564	820	358	1226	1177	584
5	233	219	421	75	372	595	673	293	897	903	170	727	994	881
6	301	126	156	89	249	435	451	681	440	555	211	482	701	551
7	82	219	52	83	17	235	276	219	248	90	159	142	249	390
8	24	25	257	-	-	132	153	-	76	57	66	333	258	-
9	-	-	50	95	54	32	65	-	84	29	74	36	113	106
10	-	20	26	13	26	-	24	31	-	-	-	63	-	62
11	-	-	26	-	33	-	-	45	-	31	22	31	37	-
12	-	-	26	-	-	32	-	-	-	-	-	-	32	-
Total	1689	1826	3729	1613	3768	6937	3565	6395	4757	10667	5103	7099	6842	5071
Biomass (t)	-	4627	12534	3578	9499	15897	12792	16462	15594	11392	9056	18251	22537	15790
Z 4+/5+*	.68	-0.22	1.80	.11	-0.07	.50	.48	.48	.71	1.28	-0.54	.24	.56	
Z 5+/6+*	.50	.07	1.23	-0.06	-0.15	.39	.52	.40	.83	1.12	-0.47	.29	.74	
Z 6+/7+*	.43	-0.11	1.13	.77	-0.13	.51	1.19	.87	1.41	.86	-0.13	.50	.87	

\* 6 age-groups were used to calculate the Z values; Ex.: ages 4 to 9 for 4+, ages 5 to 10 for 5+, etc.

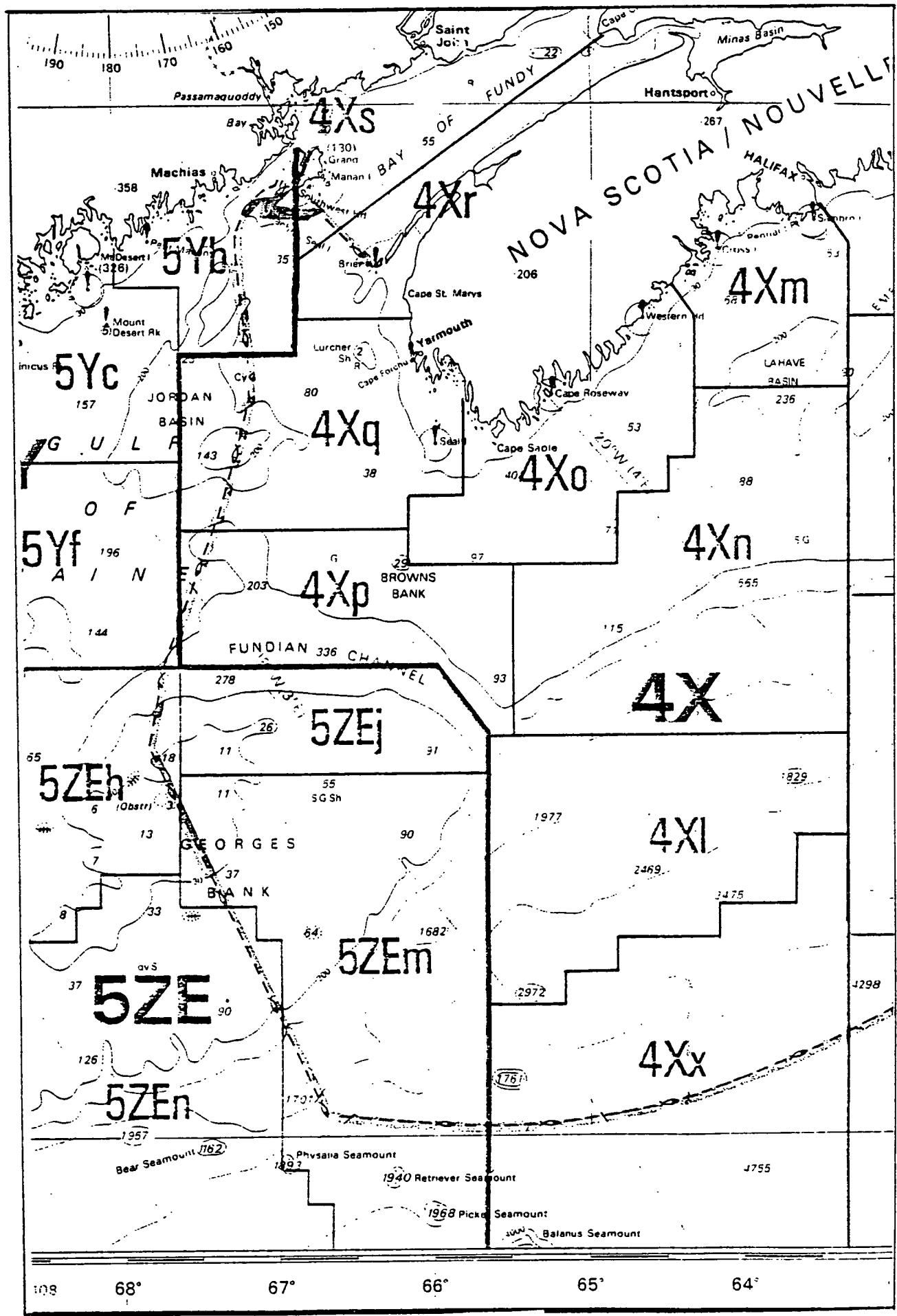


Figure 1A. Unit areas in Division 4X.

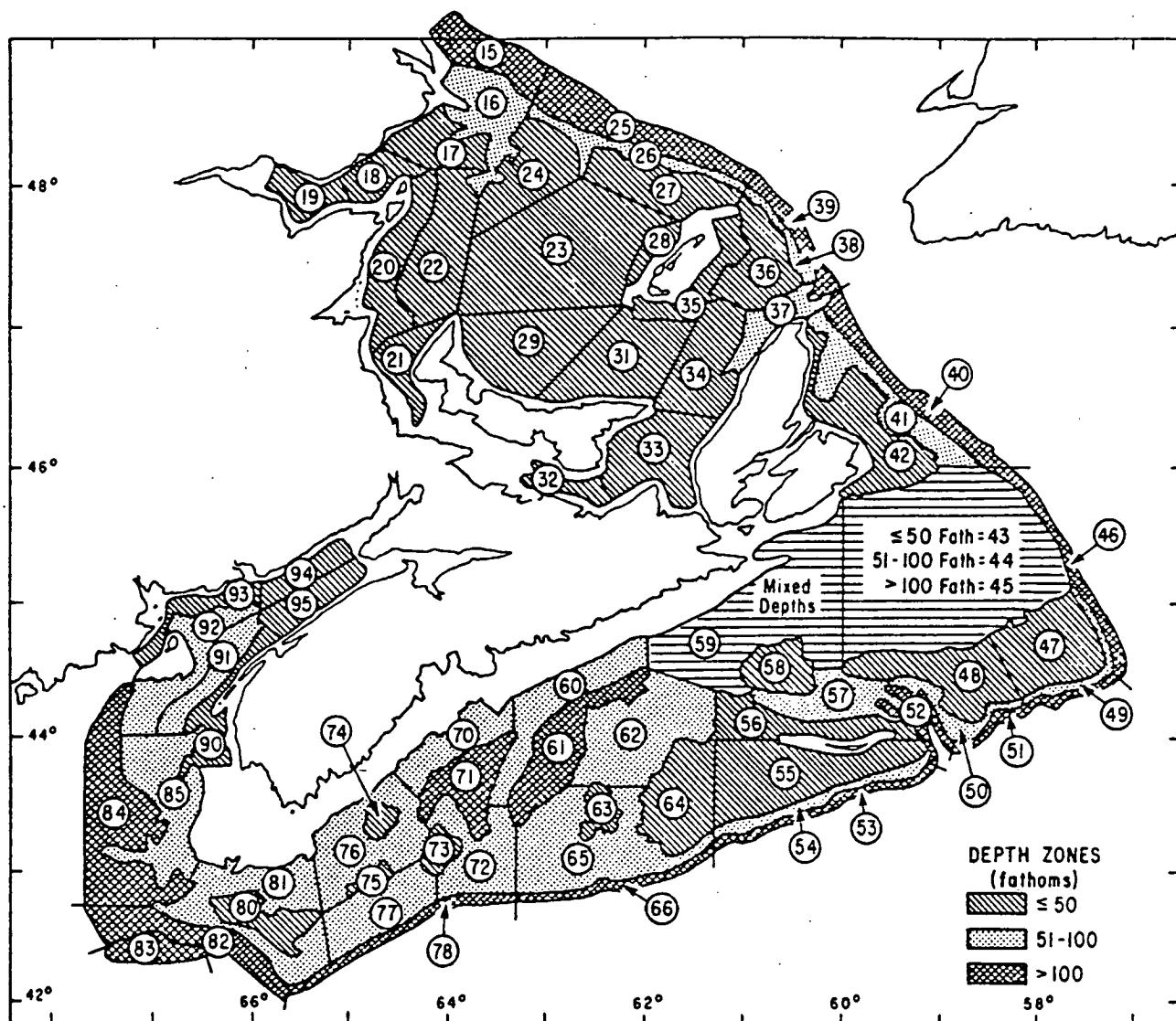


Figure 1B Stratification scheme used for the Canadian bottom-trawl surveys.

Figure 2. . Landings of 4X cod by month for the 3 major gear categories.

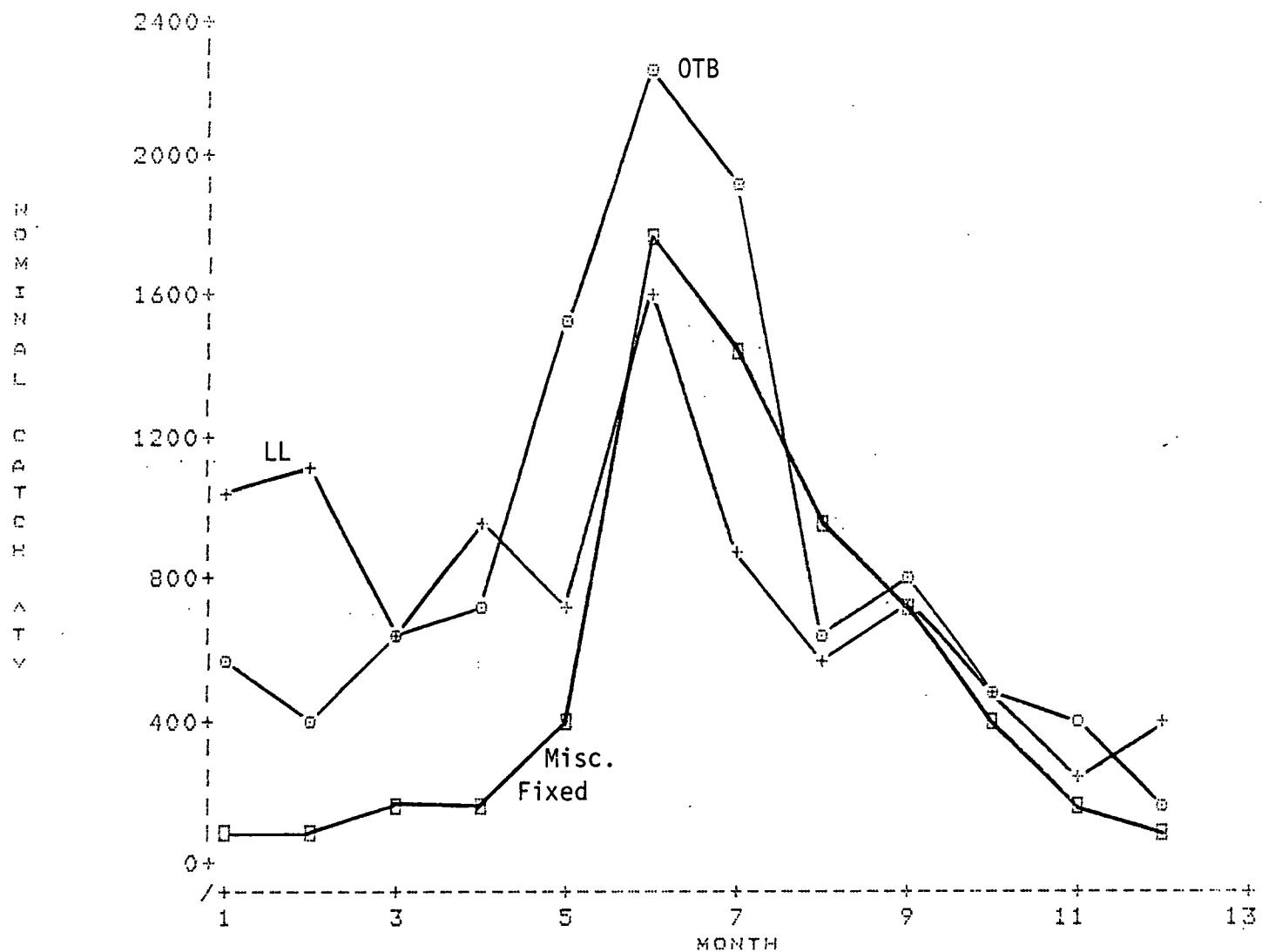


Figure 3. Age compositions of 4X cod by gear and time for 1983

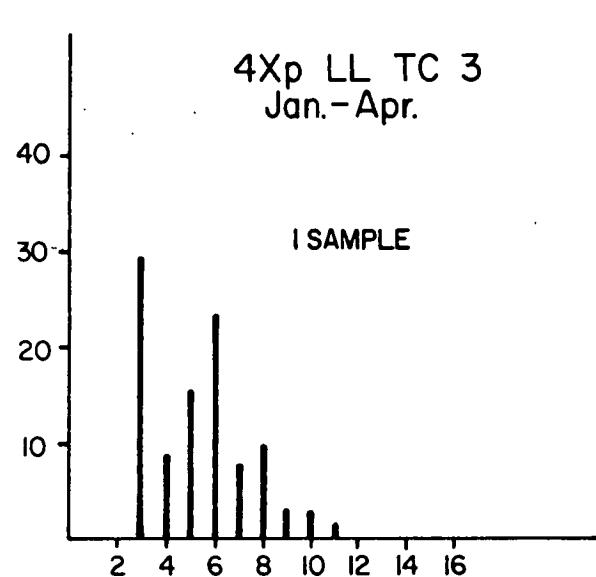
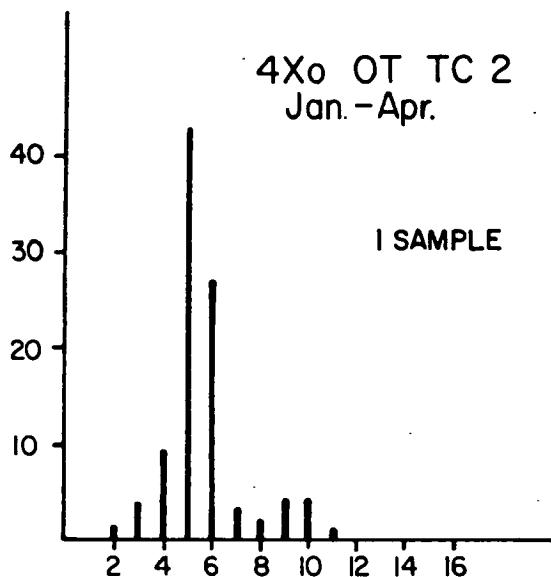
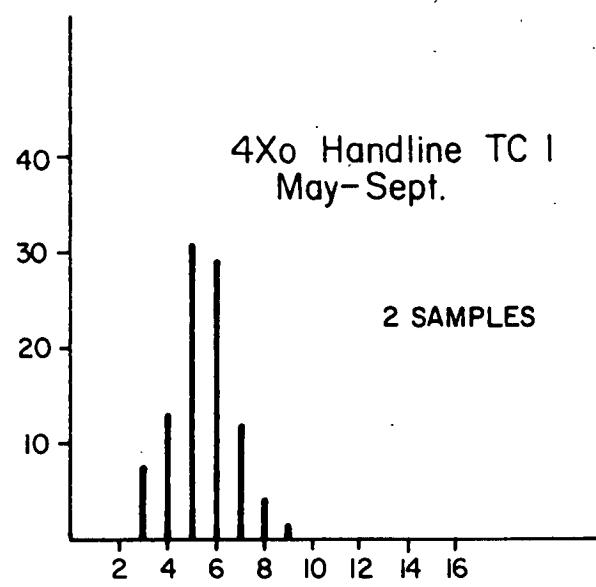
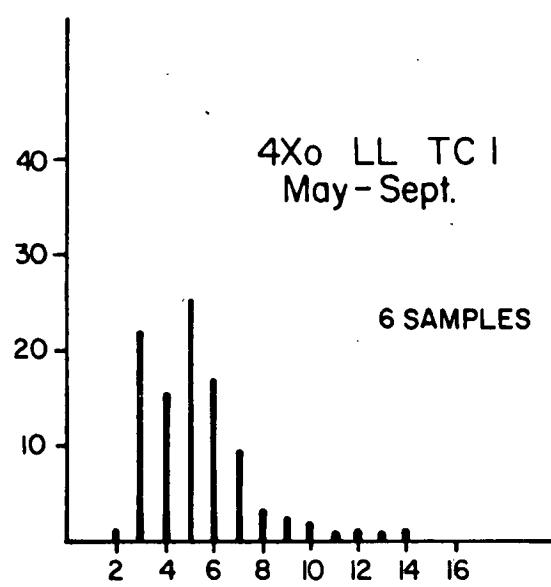
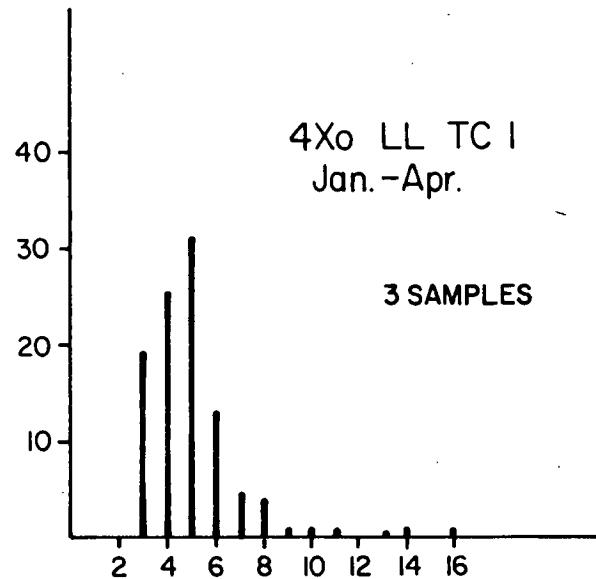
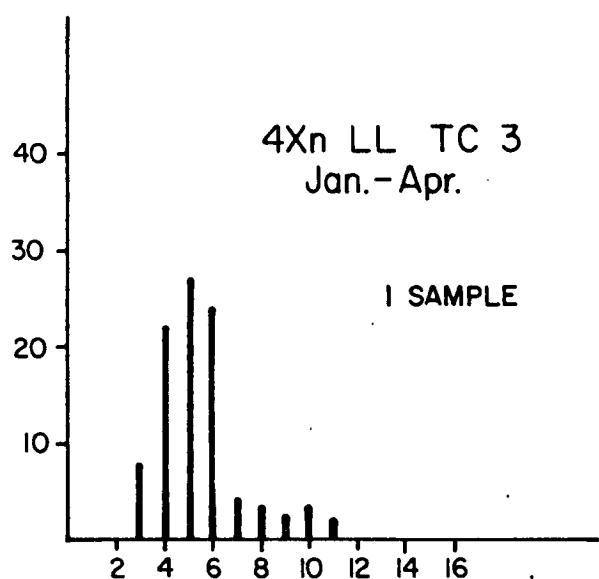


Figure 3. (Continued)

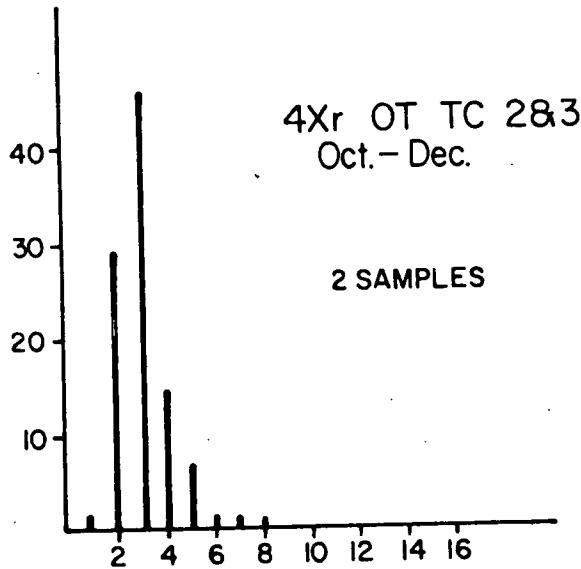
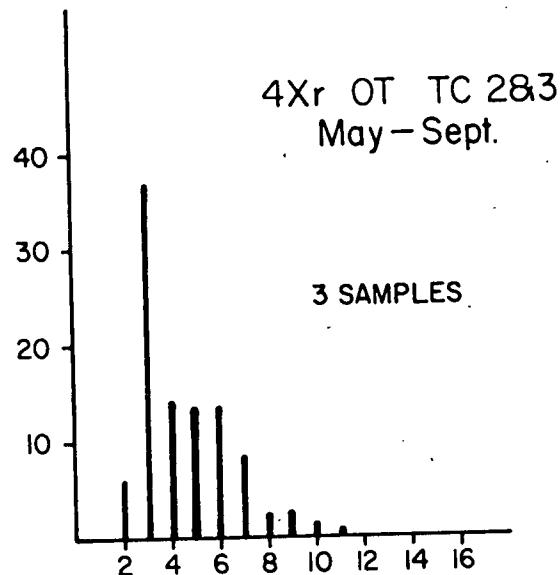
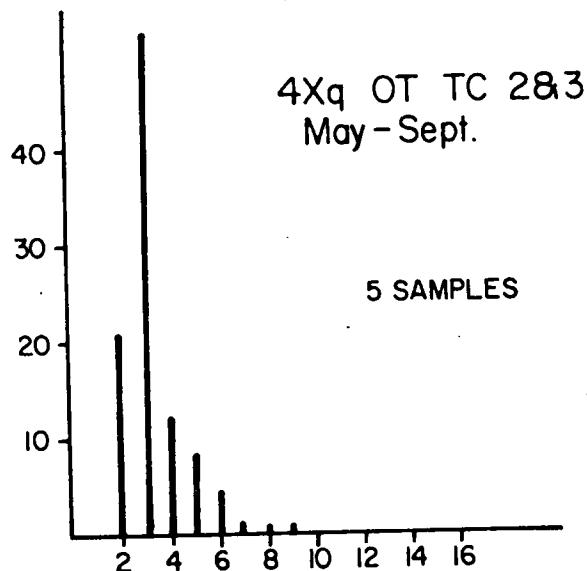
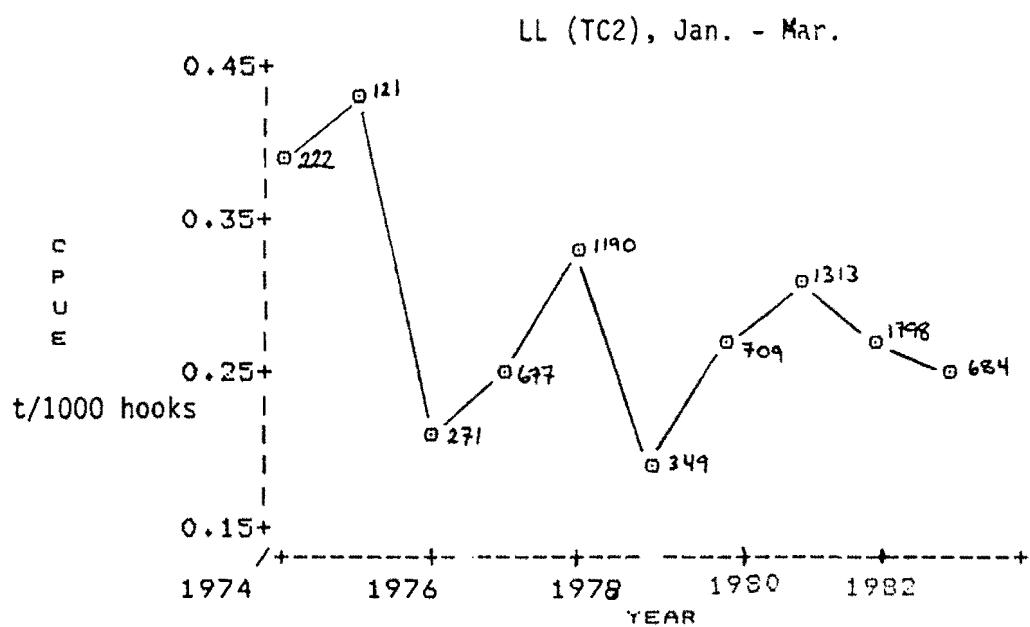


Figure 4a . Commercial catch rates of offshore cod in area 4Xn and 4Xp combined. Numbers beside points refer to effort in 1000's of hooks.



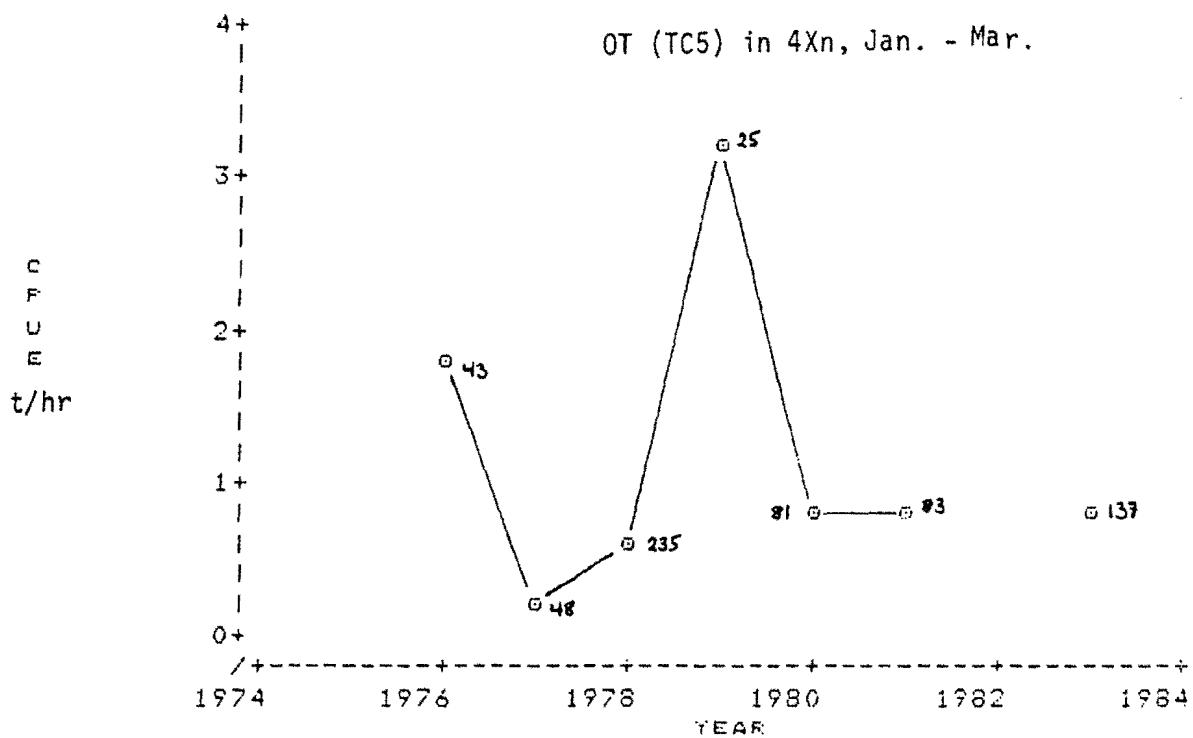
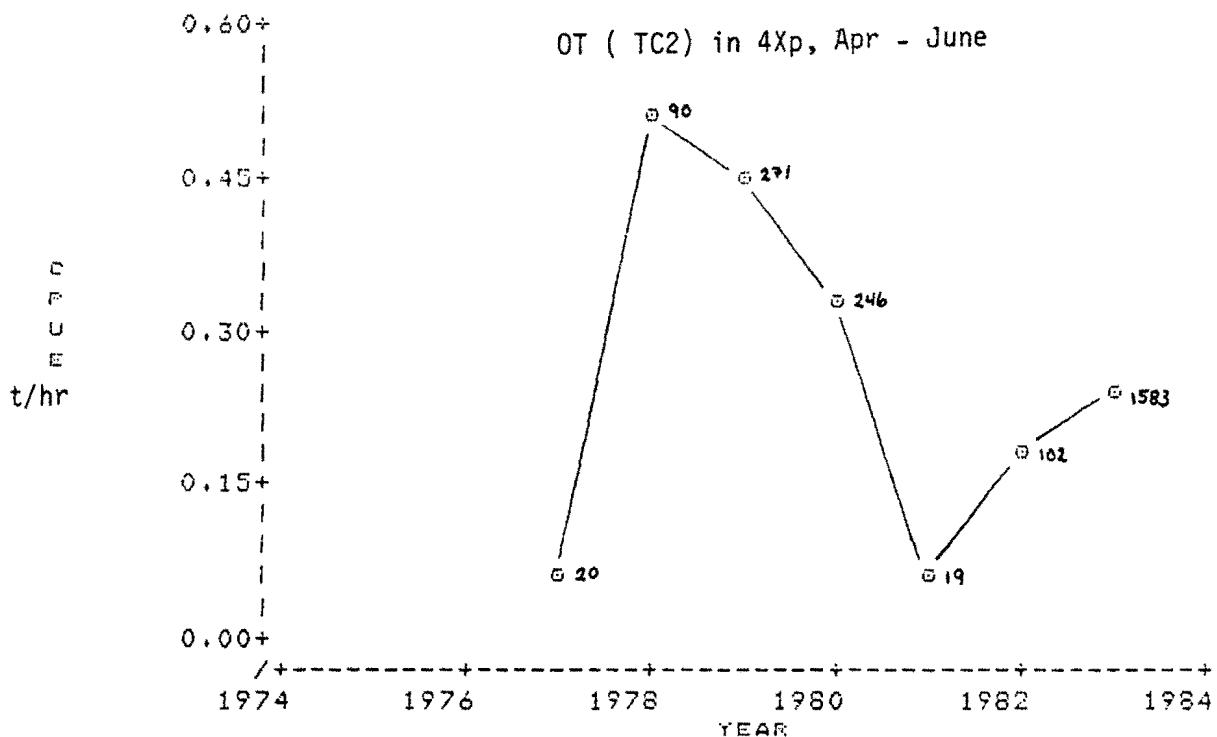


Figure 4b . Commercial catch rates of offshore cod in areas 4Xn and 4Xp. Numbers beside points refer to effort in hrs .

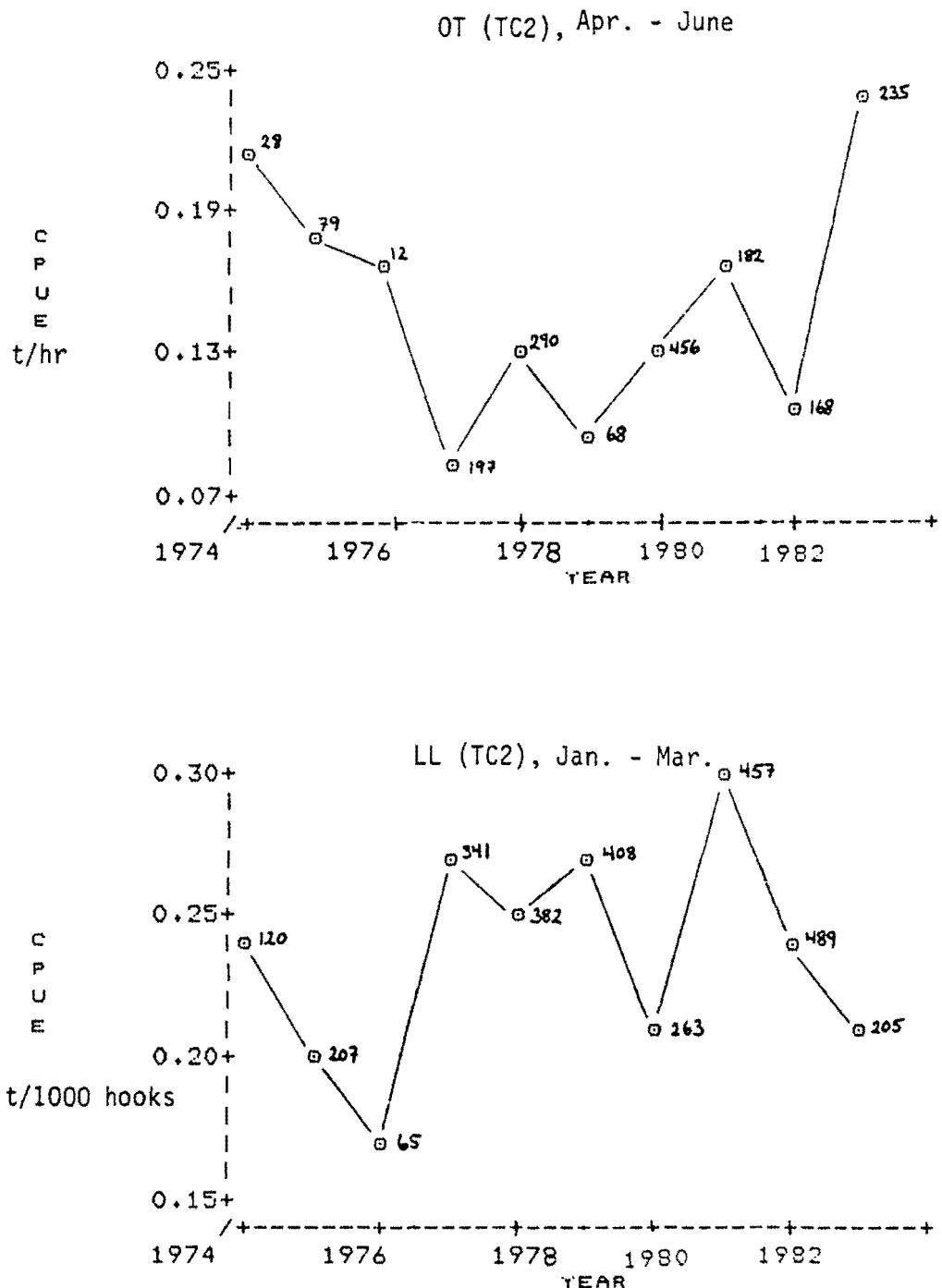


Figure 5 . Commercial catch rates of cod in 4X0. Numbers beside points refer to effort in hrs. (OT) or 1000's of hooks (LL).

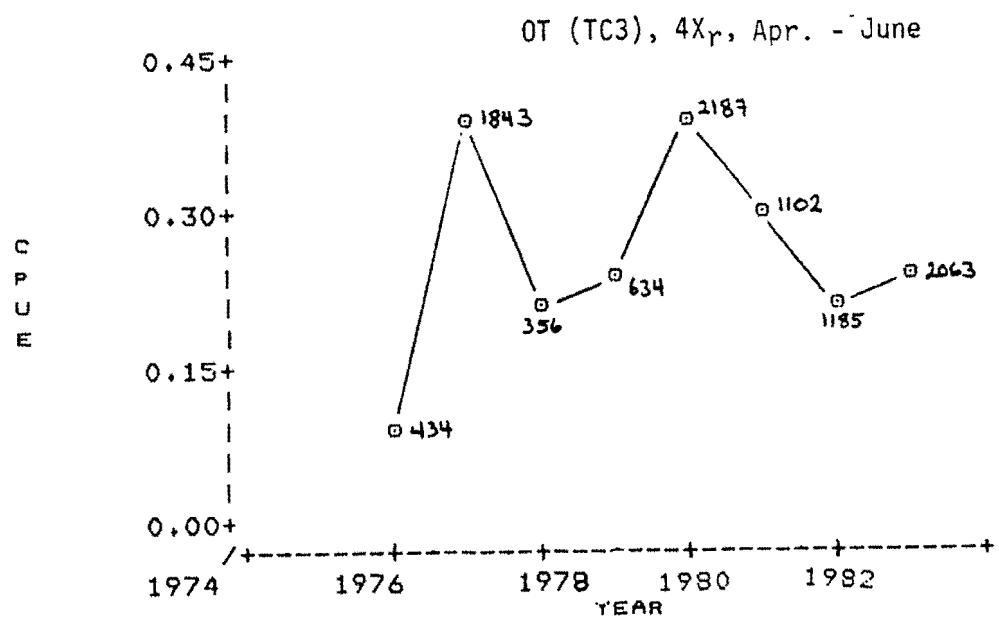


Figure 6. Commercial catch rates (t/hr) in 4Xr. Numbers beside points refer to effort in hrs.

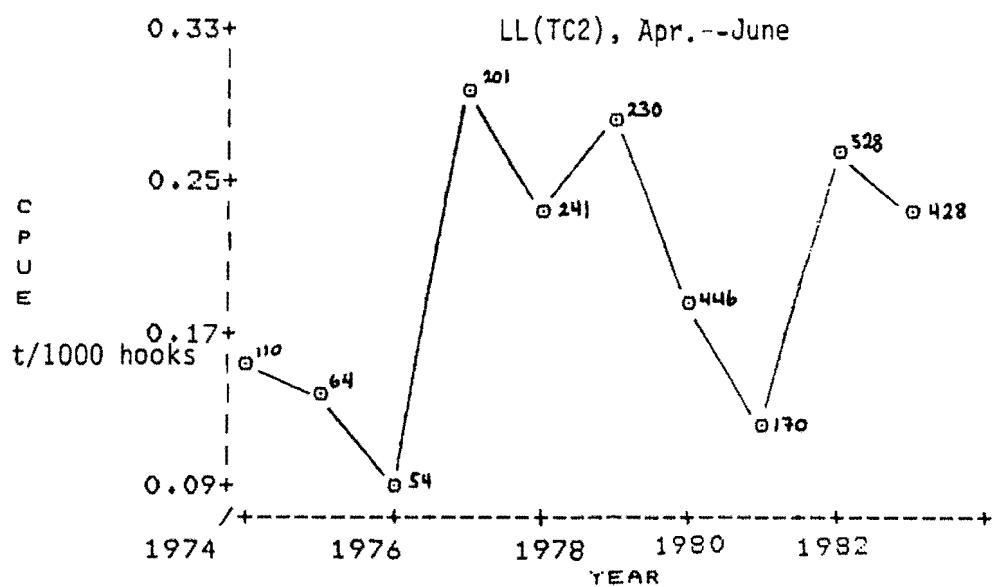
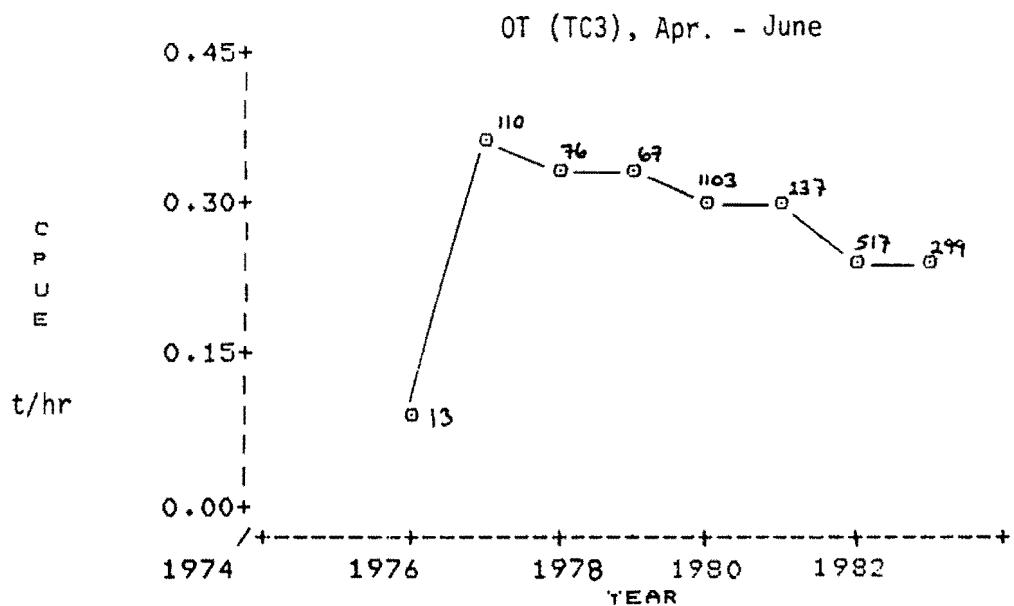


Figure 7 . Commercial catch rates of cod in 4XQ. Numbers beside points refer to effort in hrs. (OT) or 1000's of hooks (LL).

## 4Xq, Xr + Xs Combined (Strata 84-95)

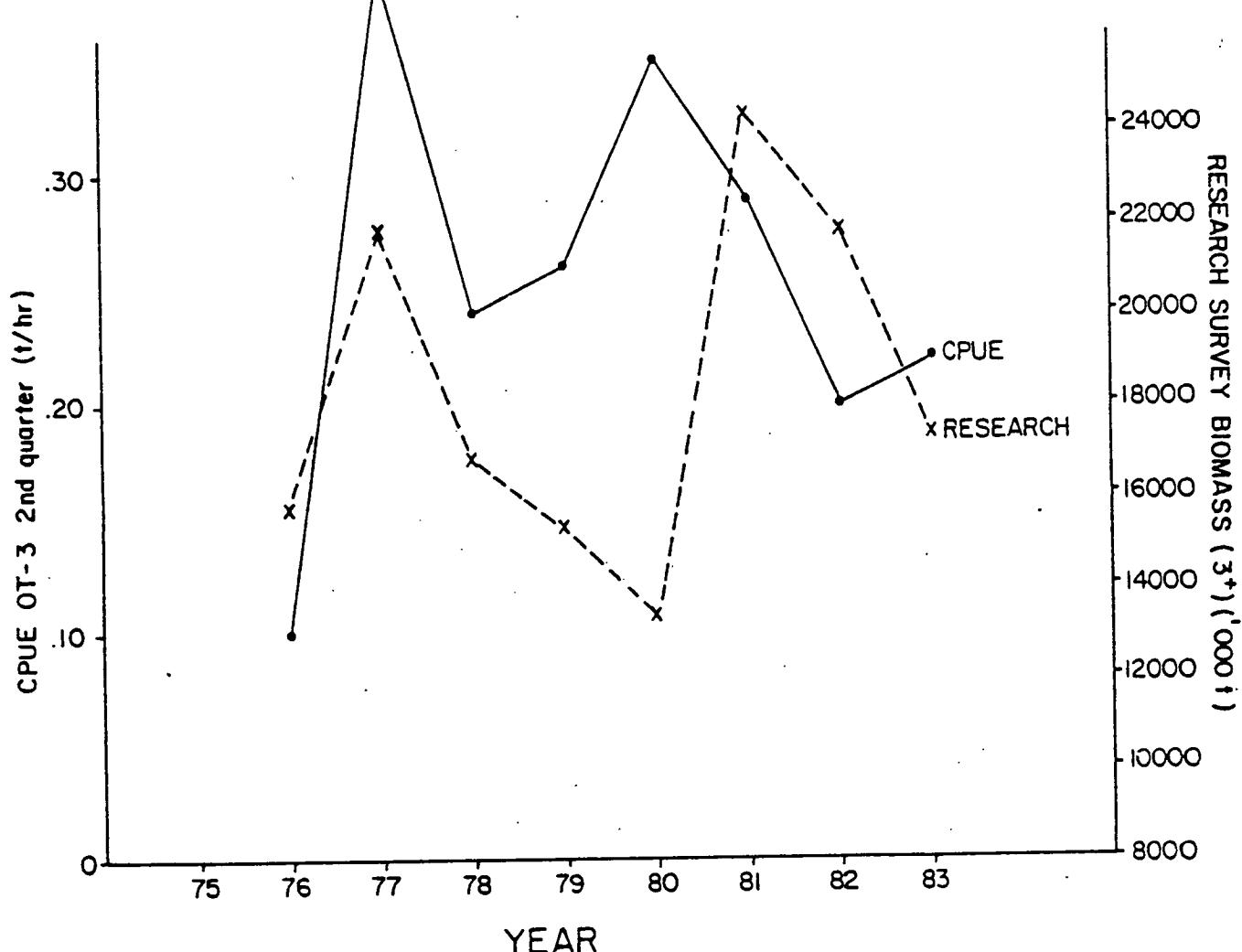


Figure 8. Commercial catch rate of OT(TC3) vs fishable biomass (3+fish) from research surveys for 4xq, Xr+Xs combined (strata 84-95)

Figure 9

Research survey population estimates (G.M.) for offshore cod in 4X (Strata 70-85) over 3 seasons.  $\Delta$  denotes 1983 Hammond-Needler conversion factor of 1.0 (instead of 1.39).

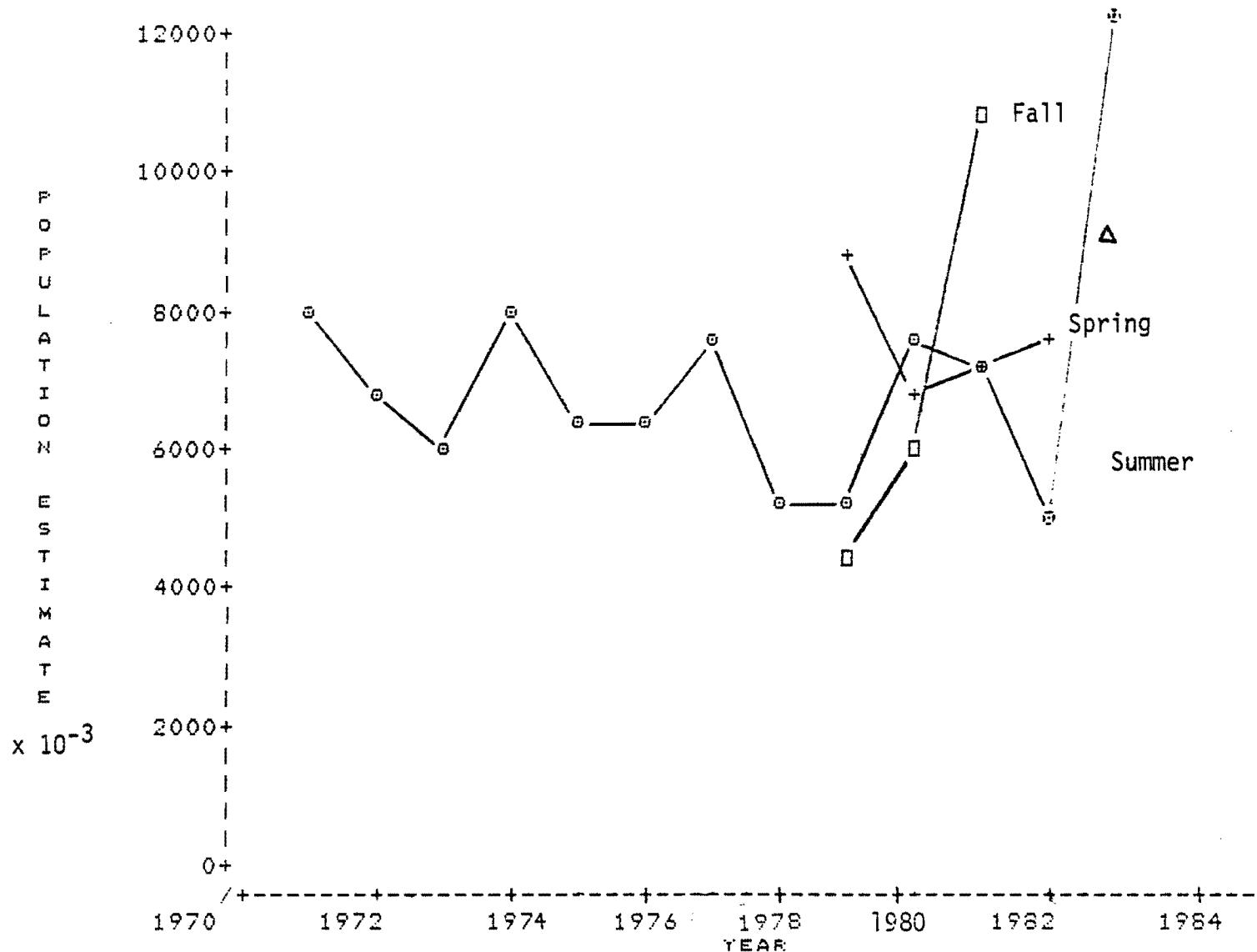


Figure 10

Research survey population estimates(G.M.)  
for the Bay of Fundy (Strata 90-93) over  
3 seasons.  $\Delta$  denotes 1983 Hammond-Needler  
conversion factor of 1.0 (instead of 1.39).

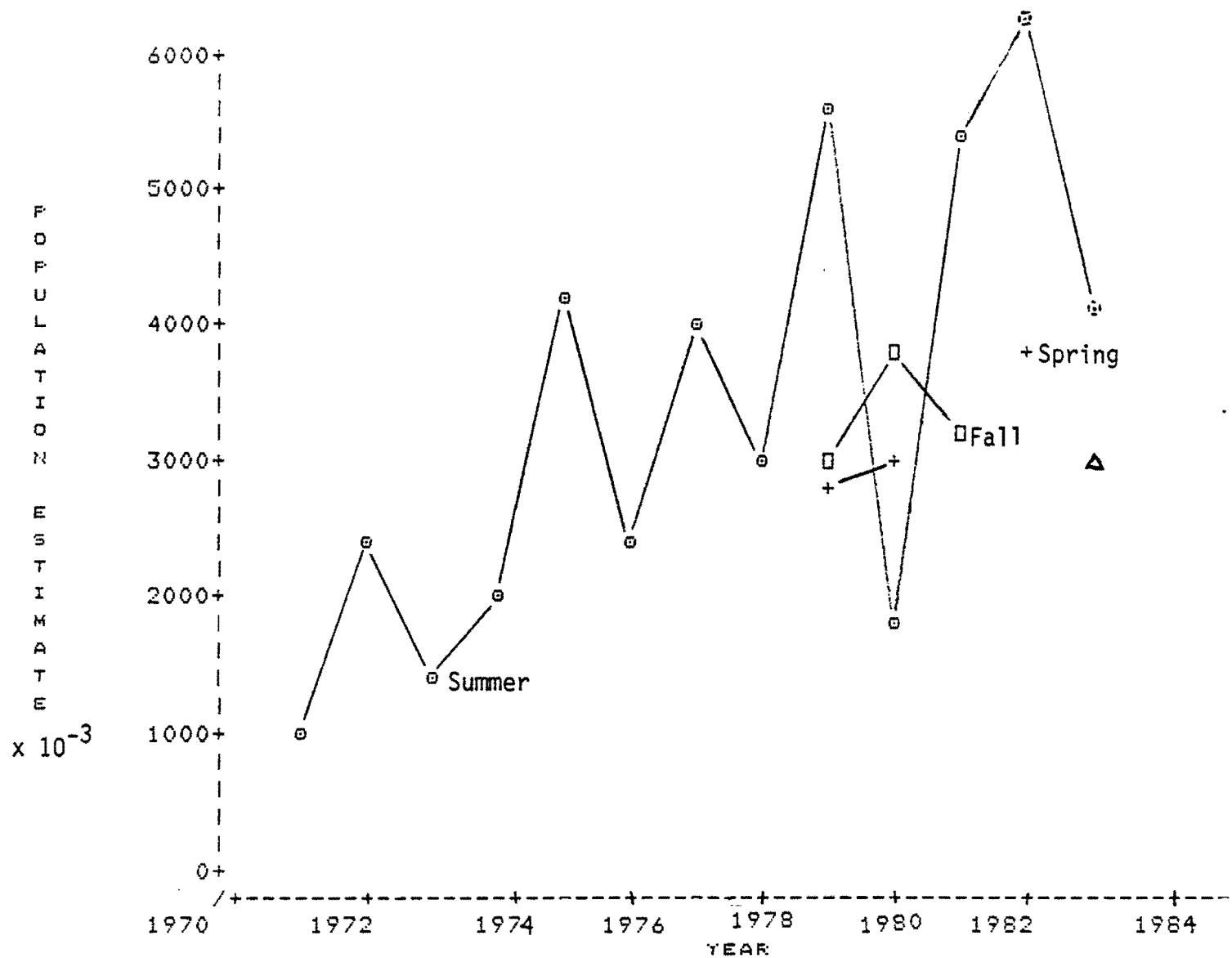
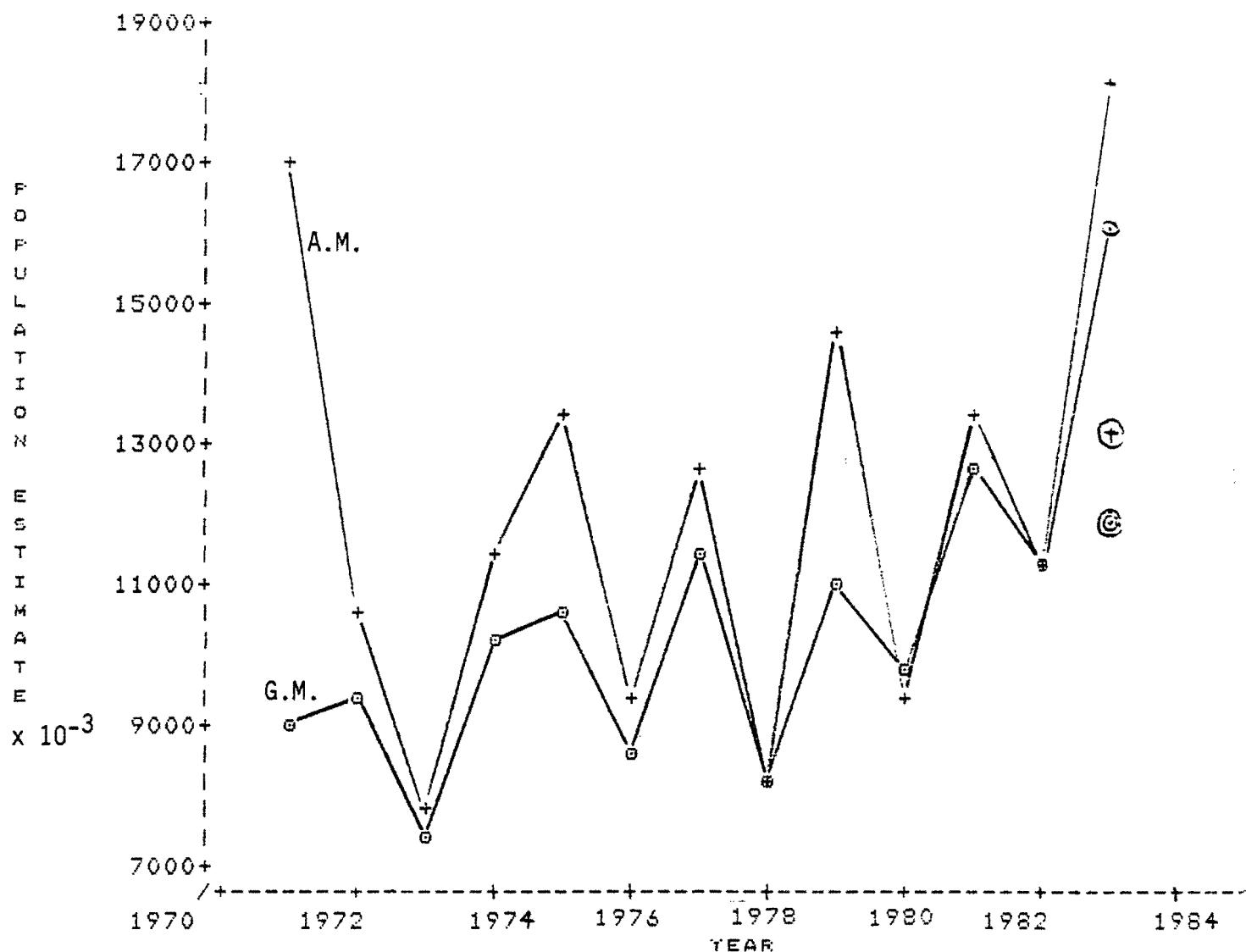


Figure 11 .

Research survey population estimates for 4X cod in strata 70-93. Strata 94-95 (upper Bay of Fundy) were not included since they have not been sampled on a regular basis. Both arithmetic (A.M.) and geometric (G.M.) means were used to calculate cod number per stratum. @/◎ denote a 1983 Hammond-Needler conversion factor of 1.0 (instead of 1.39).



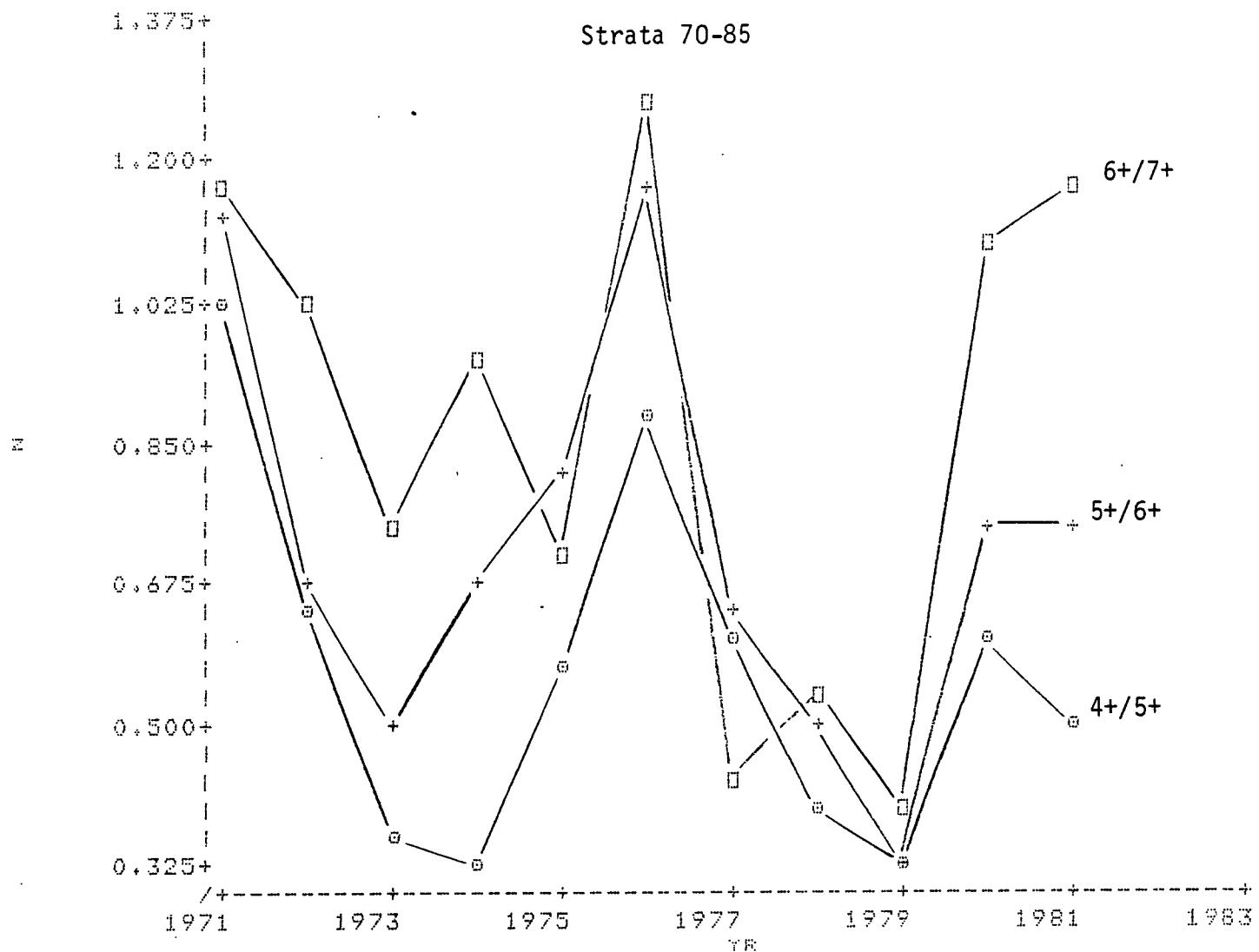


Figure 12

Three year running average of Z values  
for Strata 70-85 (offshore) from research  
survey data.

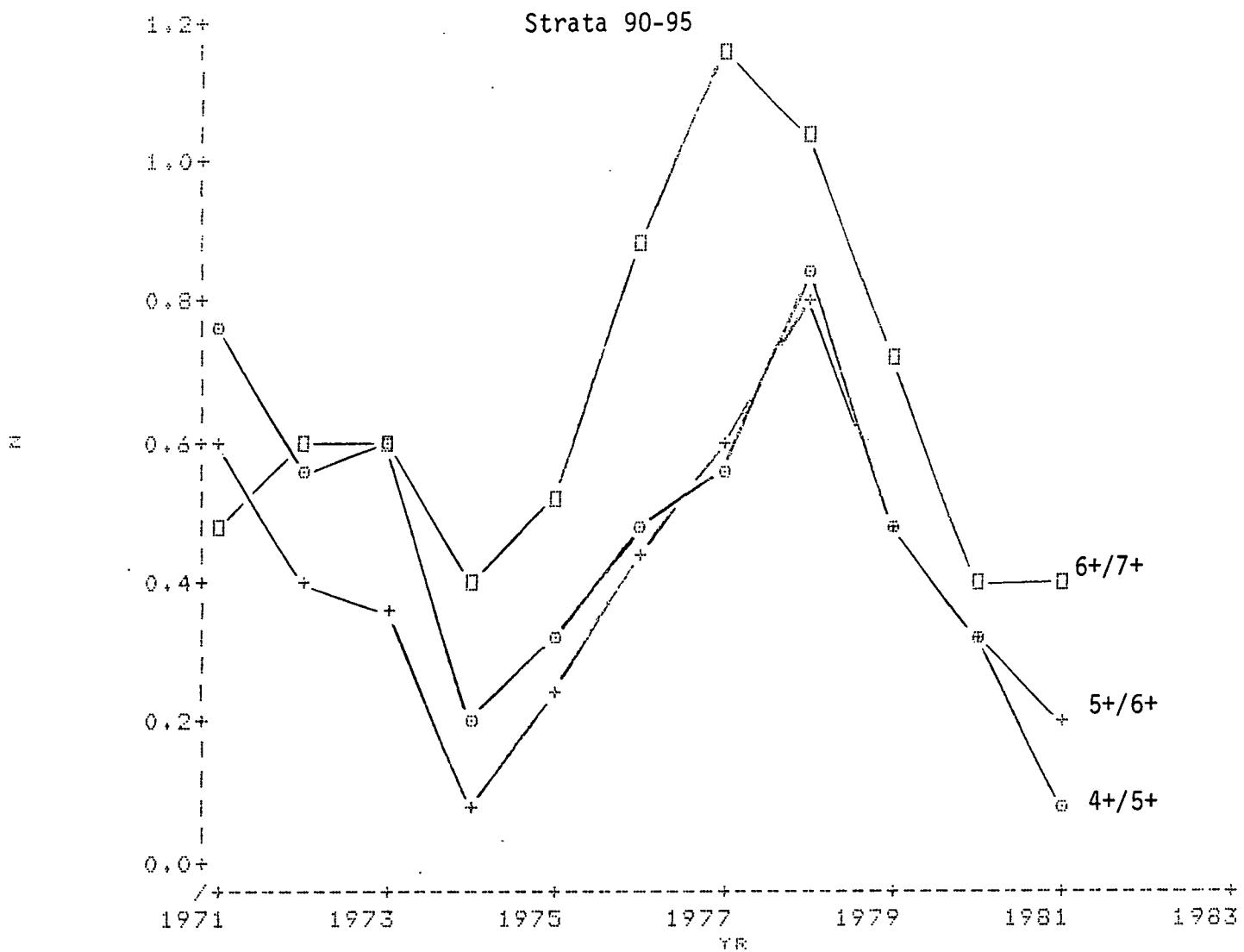


Figure 13      Three year running average of Z values for Strata 90-95 (Bay of Fundy) from research survey data.

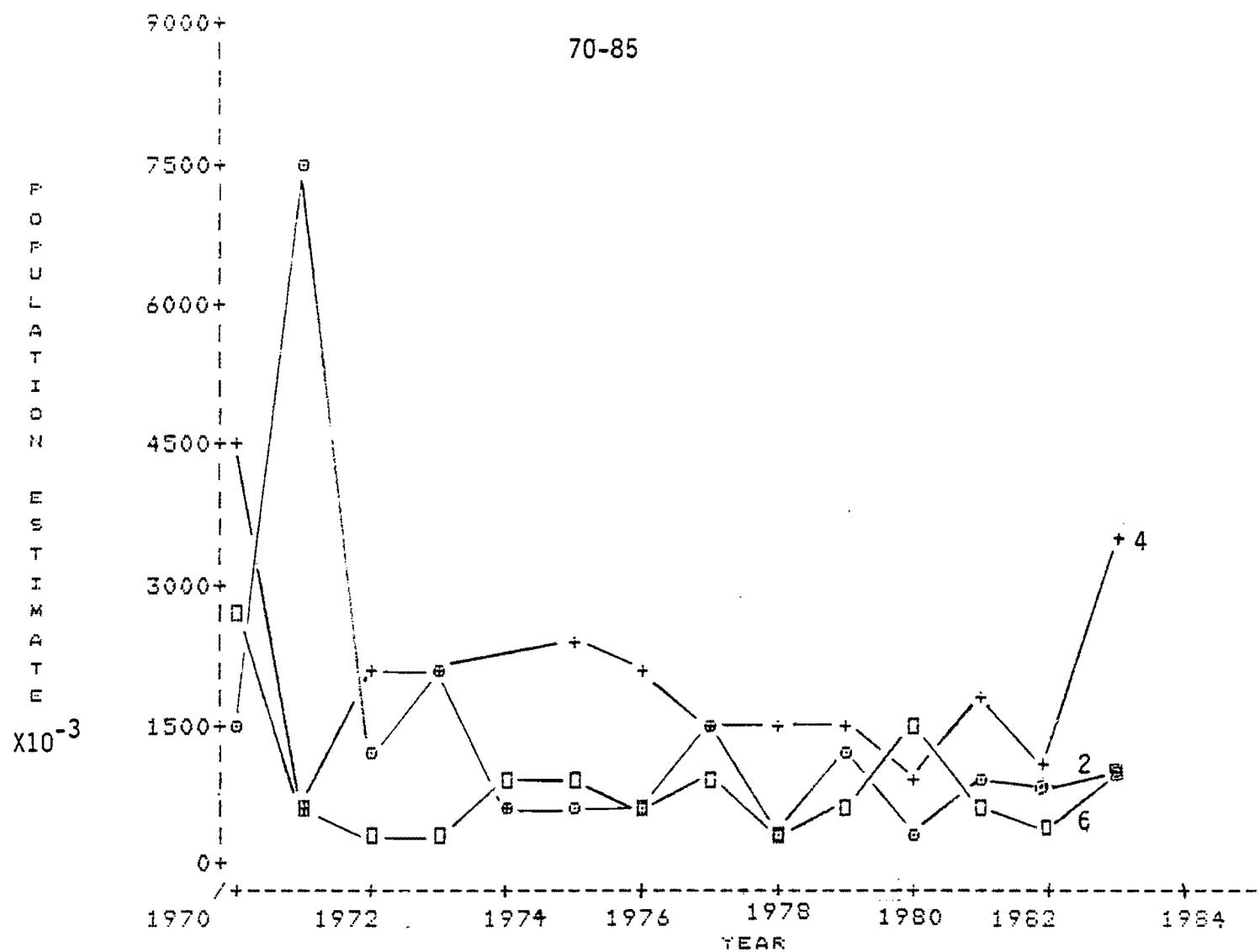


Figure 14. Research survey population estimates for offshore cod in 4X (Strata 70-85). Ages 2, 4 and 6 presented.

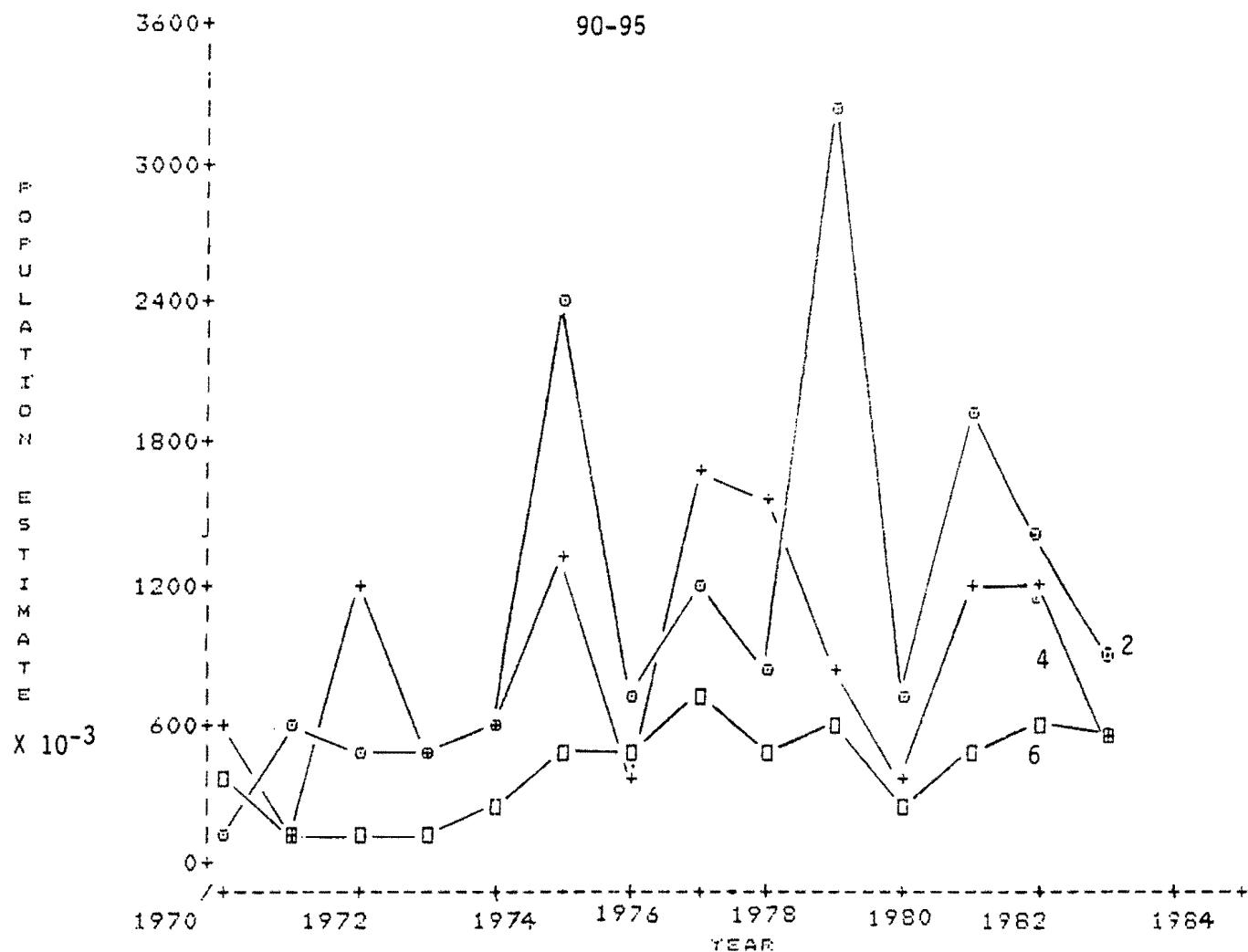


Figure 15. Research survey population estimates for cod in the Bay of Fundy (Strata 90-95). Ages 2, 4 and 6 presented

Appendix I. Quotas and landings of 4X cod by gear category for 1983\*.

	Vsls >100'	Mobile Gear 65'-100'	Fixed Gear 65'-100'	Mobile Gear <65'	Fixed Gear <65'
Landings	1442	192	55	9200**	15581
Quota	3150	400	200	8000	20250

\* Preliminary

\*\* Closure date August 10

Appendix II. Quota and landings of 5Y cod by gear category.

	Vsls >100' (By-Catch Only)	Mobile Gear 65'-100'	Fixed Gear 65'-100'	Mobile Gear <65'	Fixed Gear <65'
<u>1983</u>					
Landings	8	-	-	2525	178
Quota	100	-	-	700	700
<u>1982</u>					
Landings	-	-	-	871	-
Quota	-	-	-	200	-