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

by

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**Abstract**

We briefly review the biology of the Division 4X cod stocks and the fishery that they support. From statistics of the commercial fishery and research vessel survey data, we outline the current status of the offshore stock. While the catches have remained fairly stable, the biomass has been declining and the rate of fishing mortality has been increasing recently. It appears that the stock is rapidly diminishing and that incoming recruitment could be poor.

**Résumé**

Nous revoyons brièvement la biologie de la morue de la Div. 4X et la pêche commerciale qui en dépend. Nous esquissons, à l'aide des statistiques de pêche et des résultats des croisières de recherche, le bilan de santé du stock hauturier. Ces dernières années, les prises totales sont demeurées à peu près stables alors que la biomasse a apparemment diminué et que la mortalité par pêche s'est accrue. Il appert que l'état du stock se détériore rapidement et que le recrutement à court terme pourrait être plutôt pauvre.

## Introduction

Existing evidence suggests the presence of several cod stocks in NAFO Division 4X, one residing offshore in the Browns Bank area and several inhabiting different areas along the coast. The biological information currently available is insufficient to allow proper delineation of the various inshore stocks.

The Division 4X cod fishery exploits both the inshore and the offshore stocks. A large number of small vessels which do not have to report the location of their catch participate in that fishery. This and the biological uncertainty about the stock structure make it impossible to apportion the landings between the different inshore stocks and very difficult to assign catches to the offshore one. The research groundfish trawl survey, an essential tool in this assessment exercise, cannot cover most of the inshore grounds due to rough bottom. Because of these problems, it is impossible to assess the inshore stocks and the analysis must be restricted to the offshore component of the complex.

In this paper we review briefly some of these problems and summarise the recent history of the biological advice given on cod in Division 4X. We also analyse the present status of the offshore stock.

## Stock Delineation

In his review of the cod stocks in the Northwest Atlantic, Templeman (1962) summarises the information then accumulated from vertebral count analyses and tagging experiments. He proposes the existence of at least five stocks of cod in Division 4X, one offshore around Browns Bank and four along the coast: East Fundy-St. Mary's Bay, Seal Island, Lockeport, and Lunenburg-Jeddore. These data, however, were not appropriate to allow

evaluation of the degree of mixing among the various stocks.

Halliday (1973) reports on tagging experiments carried out in 1969 on Browns Bank and in 1972 along the South Shore of Nova Scotia. He concludes that the results confirm the separation of the offshore stock from those inshore but his analysis sheds no light on the inshore stock delineation problem.

Further studies of the stock structure are presently underway. Preliminary findings are now available for two separate tagging experiments carried out in June 1979. A total number of 147 and 722 tagged cod were released off Sandy Cove (4Xr) and Lockeport (4Xo) respectively (Figure 1). All data for tags recovered within two weeks of release were excluded from the analysis.

Both experiments resulted in high recovery rates, 24 and 32% respectively (Tables 1 and 2). In both cases, over 95% of the recovered tags were caught in the unit area in which they were released. This occurred throughout the year suggesting limited seasonal migration for these inshore stocks. No tags were recovered from Browns Bank.

Our results agree with those of previous studies in indicating the presence of discrete inshore and offshore stocks in 4X.

#### **History of Biological Advice**

Present analytical stock assessment models apply only to unit stocks. This has made the analytical assessment of most cod stocks in 4X impossible, their number and discreteness being undetermined. However, the evidence on the discreteness of the offshore, Browns Bank stock allowed an analytical approach.

In the early 1970s, the fishery on the offshore grounds was mainly

prosecuted by large trawlers, thus making possible the partitioning of the catch between the offshore stock and those inshore. This could not be achieved for the undetermined number of inshore stocks and it was decided to restrict the first analytical assessment of the cod in 4X to the offshore stock (Halliday 1973). Consequently, the biological advice was limited to that stock.

In 1977, the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) was given the responsibility of providing advice on the status of the Canadian Atlantic fish stocks. In its first Advisory Document on groundfish stocks, Advisory Document 77/3 (CAFSAC 1980), CAFSAC stated that the Canadian catch statistics from Division 4X were no longer provided to them with the detailed breakdown necessary to estimate the offshore cod catches, and that therefore an analytical assessment was no longer possible. The required commercial statistics being unavailable, CAFSAC had to depend solely on the results of the research vessel surveys. The identity of the inshore stocks being unknown, CAFSAC had to limit its advice to the offshore stocks only. The research survey data indicated that the offshore stock was overexploited and CAFSAC recommended that the TAC, first imposed on the stock in 1975, be kept at 4,000 t for 1978.

The basis and the nature of the advice remained the same until 1981 when it was realised that fishing mortality was about twice the target level of  $F_{0.1}$ . It was also observed that cod landings for the Division were rapidly approaching the reported historical high of 35,500 t and it was feared that if the harvest was not kept at the 1981 level, severe overexploitation of all the components could take place. Furthermore, the inshore stocks were the only important cod stocks

unregulated in Subarea 4, inviting the fishermen to misreport their catches from adjacent areas to keep these other fisheries open longer. For these reasons, CAFSAC recommended that a TAC be set for the entire 4X cod fishery. Being unable to estimate the biomass of the different cod stocks in the Division, CAFSAC suggested "... that a catch limitation of 30,000 t be instituted for cod in all of Division 4X in 1982 to provide a limit on expansion of catches until such time as the reasons for the recent upswing can be defined", Advisory Document 81/8, (CAFSAC 1982). Thirty thousand tons was only slightly less than the total catch of 31,000 t reported for 1981 and only 5,500 t less than the highest cod catch reported for the Division. CAFSAC's recommendation was an attempt at protecting the resource while, acknowledging the impossibility of assessing it quantitatively, minimising the inconvenience to the industry. The advice remained essentially the same for 1983.

Despite an important increase in biological research activities in the Division as well as the renewed availability of detailed catch statistics, two major difficulties still prevent the analytical assessment of the major cod stocks in 4X. First, the fundamental biological problem is still unresolved i.e. the number, the size and the discreteness of the inshore stocks have yet to be established. Second, the location of the catch made by the numerous tonnage class 1 vessels fishing in the Division cannot be determined since they do not have to submit log books. Until these problems are resolved, the advice will have to rely on abundance indices derived from commercial statistics and research survey data. Since only the offshore stock can be delimited with some confidence, any attempt at apportioning the available data between any combination of inshore stocks

might lead to completely erroneous conclusions. If such analyses are performed, extreme care should be applied in the interpretation of their results.

### Trends in Reported Landings

#### Definition of the Offshore Catch

In this paper we define "offshore" catches as in de Lafontaine (MS 1981); all the catches from unit areas 4Xn and 4Xp were added to the catches by vessels over 25 t in 4Xo. As pointed out by de Lafontaine, this certainly represents an under-estimate of the actual offshore catches of cod in Division 4X.

#### Trends in Landings

The cod fishery in Division 4X was historically a Canadian inshore fishery. 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 trawlers in 1962 resulted in a rapid increase of the catch (Table 3). Total landings peaked at 35,500 t in 1968 and in 1969, an estimated 18,000 t was harvested on the offshore grounds (Table 4). In 1970, quota and closure regulations were imposed on the 4X haddock fishery. Resulting at least partially from these regulations, the estimated offshore catches were reduced to less than 10,000 t one year later (Halliday, unpublished data).

Catches for all of 4X continued to decline until 1976 when total landings reached their lowest level since the early 1960s at 16,700 t (Figure 2).

#### The Offshore Fishery

Between 1970 and 1977, the offshore component of the fishery landed

around 30% of the total catches of cod in Division 4X. Since 1980, the offshore catches have averaged only 21% of the total catch.

Prior to 1980 the offshore fishery was dominated by otter trawlers but since then, their catch has dropped drastically and they are now landing cod in quantities similar to those of the longliners (Figure 3). Until 1973, the offshore catches by the trawler fleet were taken mainly by large vessels of tonnage classes 4 and 5 but since then, the catches have been similar for all tonnage classes (Figure 4). In the longliner fleet most of the catch has been taken by vessels of tonnage class 2 (Figure 5).

Tonnage class 1 vessels fish the offshore grounds of 4X and even Georges Bank in summer. Because these numerous small vessels are not required to keep log books, it is generally impossible to determine the actual location of their catch. Only in those cases where the statistical officer has detailed knowledge of the current fishing operations of the local boats can it be postulated. Most of it is therefore assigned to the statistical district of the port of landing. This results in an uncertain, somewhat biased distribution of these vessels catch. For reference purposes, we present in Appendix 1 a detailed breakdown of the catch by tonnage class 1 longliners and trawlers as reported for 1979 to 1982.

On the average over the last four years, 9,100 t of cod have been reported as caught by tonnage class 1 vessels of all gear-types in 4Xo (Table 5). 4Xo is a large unit area that covers both inshore and offshore grounds (Figure 1). Since it is impossible to separate the offshore catch from the inshore one within that unit area, the total catch is assumed to be taken from inshore stocks.

These two related problems certainly result in an underestimation of



the catch taken from the offshore stock, and possibly an important one. Until the uncertainty related to the catch of the small boats is resolved, it will be impossible to properly determine the offshore catch, hence preventing any analytical assessment of the offshore stock.

#### Age Composition of the Commercial Catch for the Offshore Stock

We did not try to determine the age composition of the catch for the inshore stocks due to the impossibility of assigning specific samples to the appropriate stock unit. Our effort was restricted to the offshore catch for the 1980-82 period. Any analysis for the years prior to 1980 is impossible due to the very small number of samples collected.

To generate the age-length keys, samples from the catches of all tonnage-class vessels fishing in unit areas 4Xn, o, and p were used (Table 6). Keys were produced for the otter trawler (side and stern) and the "line" (longline and handline) catches. The number of samples used in the production of each key is shown in Table 7. The 1980 and 1981 keys were generated using all the appropriate samples collected during these two years. For 1982, only a fraction of the samples collected had been processed and was available for the production of keys at the time of this analysis. Because only a few samples were taken from the otter trawler catch, the resulting catches at age are dubious. They could therefore not be added to the "line" catches at age.

In both the otter trawler and the longliner fishery, the fish appear in the catch at age 2 and are fully recruited by age 6 (Tables 8 and 9). In recent years, the offshore fishery has been supported mainly by the 1974, 1975, and 1977 year-classes. In 1982, the 1977 year-class provided about 30% of the catch of both gear types while the 1978 one accounted for

about 35% of the catch in number and 25% in weight (Table 9).

### Trends in Stock Abundance Indices

#### Canadian Summer Bottom-Trawl Survey

Stratified random bottom-trawl surveys have been conducted every summer in 4X since 1970. From 1970 to 1981 they were carried out by the A.T. Cameron. In 1982 the Cameron was replaced by the Lady Hammond. In 1980 and 1981, comparative fishing experiments were performed to determine how to join the Cameron and the Hammond data sets into a consistent time series. The results of a preliminary analysis by Koeller and Smith (in prep.) suggest that for cod, the estimates derived from the Hammond data are 20% lower than those calculated from the Cameron data. The results presented in Tables 10 and 11 have been adjusted to compensate for the vessel difference.

We compare in Figure 6 the catches at age of cod in 4X offshore by the two vessels. Although they are similar for 1980, important differences can be seen at ages one and four in 1981. However, despite these differences the general trends in the annual variations of the abundance of the main age-groups are the same (Figure 7). They show an increase in the number of young fish, possibly up to age 4, from 1978 to 1981 followed by a decrease between 1981 and 1982. A decline in the abundance of older fish is also observed but it started one year earlier and is proceeding at a slower rate. This reduction in the number of older fish indicated by the survey results for the last two years agrees with the age composition of the commercial catch which shows an increasing dependence on younger fish.

The numbers at age for the two main recruiting year-classes, the 1978 and 1979 ones, are not affected by the differences observed between the

catch of the two vessels. Both data sets show that the abundance of these two year-classes has been below average at all ages. Poor recruitment to the fishery must therefore be anticipated for the next few years.

The survey results indicate that the biomass of the offshore cod stock has been decreasing since 1980 (Tables 10 and 11; Figure 8). They also suggest a brisk increase in instantaneous mortality rates, the estimates of total mortality (Z) between 1981 and 1982 showing extremely high values around 1.3. Assuming a rate of natural mortality (M) of 0.2, this means that the rate of fishing mortality (F) for that period was around 1.0. F for the neighbouring 4VSW cod stock complex was estimated at 0.25 for the same period (CAFSAC Advisory Document 83/19).

### **Commercial Effort and Catch Rate Series**

#### **Bay of Fundy Stocks(s)**

As shown in the section describing the fishery, tonnage class 2 longliners and tonnage class 3 draggers land an important fraction of the offshore cod caught in 4X. To profile the general behaviour of the cod fishing fleet in the area, we looked at effort and catch per unit of effort series for these two vessel types for the Bay of Fundy and approaches (4Xq, r, and s), Browns Bank (4Xp) and Georges Bank (5Ze).

While preparing the present document, we realised that the data presented at the May 1983 subcommittee meeting were erroneous. All the indices derived from that data indicated either stable or increasing catch rates between 1981 and 1982 for the Bay of Fundy and approaches. Based on this, the subcommittee concluded that the cod biomass in these areas was probably stable and that the recent fishing effort did not have to be reduced.

The effort and catch rate series derived from the corrected data are presented in Tables 12 and 13. The total effort exerted by tonnage class 2 longliners in 4Xq, r, and s increased from 1978 to 1980, was low in 1981 and highest in 1982. It has increased rapidly on Browns Bank and sharply on Georges Bank since 1979. There is no indication from the associated catch rate data that these recent increases in effort are detrimental to the various 4X stocks, three of the four catch rates showing an increase between 1981 and 1982. On Georges Bank however, the catch rates have been decreasing for the last four years.

The effort series for tonnage class 3 draggers fishing in the Bay of Fundy and approaches show a large increase in total effort in 1980, the vessels apparently exploiting more intensively their favorite fishing grounds, 4Xq and especially 4Xr. Less effort was reported for 1981, probably mainly as a result of a strike by the 4X dragger fishermen in the summer of that year. The effort reported for 1982 is comparable to the 1980 values for 4Xq, r, and s but more than doubles for Georges Bank.

In 1982, quota regulations for cod were imposed for the first time on the 4X inshore areas. The quota for the mobile, less than 65 feet component of the fleet was 85% caught by mid-August and cod fishing in 4X was prohibited for these vessels on August 17. Information from fisheries field staff indicates that many boats kept fishing in spite of the closure. Since the Canadian regulations are not currently enforced in the Georges Bank area, the captains would have assigned their catch and effort to Divisions of Subarea 5. This suggests that a fraction of the large effort increase reported for Georges Bank may not be real. Statistics for that sector of the fleet might therefore be misleading and cannot be used. If

such misreporting took place, the catch of cod in Division 4X for 1982 would be higher than indicated by the official statistics used here, but no correction can be made at the moment.

Since the only evidence available, i.e. that from the longliner catch rates, does not indicate a deterioration of the status of the Bay of Fundy stocks, the Subcommittee recommendation of not reducing the effort applied to them is still appropriate.

#### Offshore Stock

The monthly distribution of the offshore catches of cod in Division 4X shows a bimodal shape with peaks in winter and summer for most years, as illustrated by the catches of 1977 and 1982 (Figure 9). The commercial catch rates presented below were chosen to reflect this seasonal variability as well as the increased importance of the small vessels. Recently, over 40% of the offshore catch has been taken in 4Xn (Table 4) and only 4Xn statistics were used in our calculations.

Four catch rate series were calculated to present the periods January to March and May to July, using the data for tonnage class 2 and 3 longliners (Figures 10 and 11). Another series was generated for the period October to December, using the statistics for the otter trawlers of tonnage class 5 (Figure 12). Because of the problems known to be associated with the statistics for the smaller druggers, no catch rate was derived from that data.

All the longliner catch rates are highly variable while the trawler one shows a more consistent trend. Of these five indices, two indicate an increase and three a decline between 1981 and 1982. No evidence as to the health of the stock can therefore be derived from these commercial

abundance indices. The evaluation of the status of the offshore stock will therefore have to be based on the research survey information.

#### Status of the Offshore Stock

The offshore catches of cod in Division 4X seem to have been fairly stable for the last five years (Figure 2). However evidence of misreporting by the inshore dragger fleet indicates that the actual landings for 1982 are probably higher than reported. Our analysis of the age composition of the catch reveals that the fishery is currently depending very heavily (60% of the catch in both numbers and weight) on four and five year-old fish. Although the evidence from both the commercial and the survey data indicates that the 1977 year-class (five year-old in 1982) is a good one, the research data set suggests that the two following year-classes may be poor ones. The research data also show that the biomass has been decreasing since 1980.

The ability of the fleet at keeping its catches fairly stable over that period resulted in rapidly increasing rates of fishing mortality. For most cod stocks along the Atlantic coast,  $F_{0.1}$  is about 0.2 and for the neighbouring 4VSW cod stock complex,  $F_{max}$  is around 0.28. At 1.1 the fishing mortality rate experienced by the 4X offshore stock is much higher than these values.

Three of the five commercial catch rates presented here also suggest a declining biomass. The evidence available therefore indicates that rather than improving as for most other cod stocks in Canadian waters, the status of the 4X offshore cod stock is deteriorating. This and the possibility that the fishery may soon depend mostly on one year-class predict a potentially disastrous situation for its immediate future. The fishing

pressure exerted on that stock must therefore be reduced. However, because of the impossibility of determining the status of this stock in quantitative terms, we cannot estimate the size of the reduction required to curb the current trends.

There is no information available to suggest a deterioration of the inshore stocks. Consequently, any measure adopted to alleviate the pressure on the offshore stock should be such that it will not affect the current exploitation rate applied to the inshore components of the complex; our analysis could not justify doing otherwise.

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Table 3. 4X cod nominal catches (t) by country, 1958-1982.

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	-	-	-	-	-	13965	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 <sup>1</sup>	31528	-	-	-	-	-	-	-	-	31528	100.0

<sup>1</sup> Foreign catches are preliminary.

Table 4. Nominal catch (t) of "offshore" cod in Div. 4X, 1968-1982.

Year	Canada (M & Q)			Canada Nfld.	Foreign	USA	Total Offshore
	4Xp	4Xn	4Xo				
1968	9335	2061	916	-	3914	859	17085
1969	5520	2923	924	-	8222	448	18037
1970	2305	1301	1251	-	3809	499	9165
1971	2157	1725	1156	-	2958	239	8235
1972	1418	1581	1710	-	1579	323	6611
1973	1173	1473	1451	-	2086	136	6319
1974	943	1127	1057	-	1781	385	5293
1975	1033	1379	962	-	1115	483	4972
1976	737	1403	1237	-	178	341	3896
1977	1488	1701	1224	-	189	760	5362
1978	3593	2859	1384	10	12	279	8139
1979	1748	2750	1512	28	1	48	6087
1980	1561	3324	1858	420	112	75	7350
1981	1830	2114	1461	47	5	127	5584
1982	2079	2922	1723	8	N/A	N/A	6732



Table 6 Number of samples collected in unit area 4Xn, 4Xo, and 4Xp and available at the time of this analysis.

Year	Gear	J	F	M	A	M	J	J	A	S	O	N	D	Total
1980	Ottertrawl		1	2		1							1	5
	Lines		2	2	1	3	1	1	1	1	2	3	3	20
1981	Ottertrawl	1	2	1										4
	Lines	4	2	3	4		3	1		1	2	3		23
1982	Ottertrawl		1	1		1	1	1						5
	Lines	1	2	1	1	1	1	1	1	4				13

Table 7 Number of samples included in the generation of the age-length keys and time-period covered by each one.

Year	Gear	Period Covered (Quarter)	Number of Samples
1980	Ottertrawl	1, 2, 3, 4	5
	Lines	1, 2	9
		3, 4	11
1981	Ottertrawl	1, 2, 3, 4	4
	Lines	1	9
		2	7
		3, 4	7
1982	Ottertrawl	1, 2, 3, 4	5
	Lines	1, 2	7
		3, 4	6

## A) OTB

	1980	1981	1982
1	0	0	0
2	41	0	15
3	230	35	205
4	232	109	467
5	349	96	354
6	190	100	85
7	67	85	41
8	95	48	19
9	28	47	11
10	19	10	5
11	6	21	3
12	5	4	2
13	6	2	2
14	2	2	1
15	0	0	0
16	0	0	0
1+	1273	557	1209
2+	1273	557	1209
3+	1231	557	1194
4+	1001	522	989
5+	769	413	522
6+	420	317	168

## B) LINES

	1980	1981	1982
1	0	0	0
2	91	29	47
3	385	277	221
4	161	449	435
5	232	139	350
6	139	137	87
7	45	69	64
8	32	34	36
9	7	26	23
10	8	13	16
11	2	5	5
12	2	3	4
13	0	3	4
14	0	1	0
15	0	1	0
16	1	0	0
1+	1105	1185	1292
2+	1105	1185	1292
3+	1014	1156	1245
4+	629	880	1024
5+	467	431	589
6+	235	292	239

Table 8. Numbers at age ( $10^{-3}$ ) of commercial catches of cod in 4X offshore.



## A) OTB

	1980	1981	1982
1	0	0	0
2	25	0	8
3	285	38	236
4	406	210	807
5	845	285	995
6	762	392	354
7	371	430	231
8	514	249	151
9	222	320	69
10	152	81	60
11	69	147	25
12	63	34	27
13	70	24	30
14	21	22	14
15	0	0	0
16	7	0	0
1+	3812	2230	3007
2+	3812	2230	3007
3+	3788	2230	3000
4+	3503	2192	2764
5+	3097	1982	1957
6+	2251	1697	962

## B) LINES

	1980	1981	1982
1	0	0	0
2	72	18	39
3	497	277	272
4	317	785	736
5	640	378	948
6	586	464	361
7	280	382	346
8	226	211	278
9	74	222	195
10	92	147	144
11	20	73	60
12	41	35	58
13	0	36	55
14	0	10	0
15	4	10	7
16	12	2	0
1+	2860	3048	3501
2+	2860	3048	3501
3+	2788	3031	3461
4+	2291	2754	3189
5+	1975	1968	2453
6+	1335	1590	1505

Table 9. Biomass at age (t) of commercial catches of cod in 4X offshore.

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

Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	-	-	-	-	190	-	-	-	27	-	-	72	59
1	891	286	19	74	115	225	143	87	164	176	-	1685	379
2	1588	7604	1320	2040	593	705	628	1620	438	1148	365	869	725
3	2660	4265	2871	1188	4186	999	1998	2887	1504	472	2295	1462	817
4	4375	574	1988	1972	664	2264	1968	1432	1449	1502	968	1776	1061
5	1935	1465	413	696	1820	1780	1485	611	864	1116	1055	846	846
6	2610	638	414	218	927	908	456	753	190	561	1456	536	352
7	1148	855	95	101	167	628	189	199	234	438	377	418	39
8	578	28	385	59	-	150	99	248	31	293	182	123	39
9	202	-	214	116	-	144	-	53	-	30	74	90	144
10	110	-	99	40	-	32	42	-	-	72	-	45	79
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	4540
Biomass (t)	43890	19090	21010	15190	22630	22560	16500	18899	11624	20188	20744	15615	10477
Z 4+/5+*	1.30	.78	1.05	.09	-0.07	0.95	.82	.92	.07	.22	.69		
Z 5+/6+*	1.47	.90	1.04	.14	.29	1.57	.59	1.41	-0.10	.18	.96		
Z 6+/7+*	1.66	.46	1.16	.57	-0.16	1.83	.37	1.56	-0.75	0.75	1.14		

\* 7 age-groups were used to calculate the Z values; Ex.:  $\Sigma$  ages 4 to 10 for 4+,  $\Sigma$  ages 5 to 11 for 5+, etc.

Table 11. Research vessel population estimates ('000) from Lady Hammond summer cruises (1980-1982).

	1980	1981	1982
1	0	21	379
2	774	744	725
3	2028	1977	817
4	798	3351	1061
5	1037	942	846
6	1051	618	352
7	461	332	39
8	166	154	39
9	194	0	144
10	0	0	79
11	102	0	0
12	0	0	0
1+	6610	8139	4481
2+	6610	8118	4102
3+	5836	7374	3377
4+	3808	5397	2560
5+	3010	2046	1499
6+	1973	1104	653
Biomass	24064	19572	10477
$\bar{Z}$ 4+/5+		.59	1.28
$\bar{Z}$ 5+/6+		.97	1.14
$\bar{Z}$ 6+/7+		1.35	1.30

Table 12. Total effort (cod directed) ('000 of hooks) and catch rates (t/'000 of hooks) of longliners tonnage class 2.

a) Total Effort

Area	1975	1976	1977	1978	1979	1980	1981	1982
<b>Bay of Fundy</b>								
4Xq	1087	65	304	294	627	504	265	1585
r				21			55	69
s					102	693	72	271
Total	1087	65	304	315	729	1197	392	1925
<b>Browns Bank</b>								
4Xp	764	700	653	1648	704	1014	1770	2710
<b>Georges Bank</b>								
5Ze	1012	1277	567	706	1047	1502	3716	7937

b) Catch Rates

Area	1975	1976	1977	1978	1979	1980	1981	1982
<b>Bay of Fundy</b>								
4Xq	.24	.09	.31	.24	.32	.20	.17	.22
r				.24			.13	.35
s					.15	.30	.56	.21
<b>Browns Bank</b>								
4Xp	.35	.19	.36	.36	.43	.33	.29	.32
<b>Georges Bank</b>								
5Ze	.39	.45	.59	.49	.66	.59	.53	.43

Table 13 . Total effort (cod directed) (h) and catch rates (t/h) of otter trawlers tonnage class 3.

a) Total Effort

Area	1975	1976	1977	1978	1979	1980	1981	1982
<b>Bay of Fundy</b>								
4Xq	340	73	231	273	453	2183	715	1488
r	352	1881	3396	1264	1640	4002	2284	3762
s		561		107	655	596	569	808
Total	692	2515	3627	1644	2748	6781	3568	6058
<b>Browns Bank</b>								
4Xp		144	175	562	336	341	330	64
<b>Georges Bank</b>								
5Ze	100		469	481	1159	1502	477	3351

b) Catch Rates

Area	1975	1976	1977	1978	1979	1980	1981	1982
<b>Bay of Fundy</b>								
4Xq	.33	.48	.54	.55	.25	.29	.19	
r	.20	.11	.38	.34	.25	.35	.32	
s		.03		.29	.40	.22	.20	
<b>Browns Bank</b>								
4Xp		.17	.82	.91	.76	.27	.30	
<b>Georges Bank</b>								
5Ze	.12		1.38	1.30	.60	.32	.59	

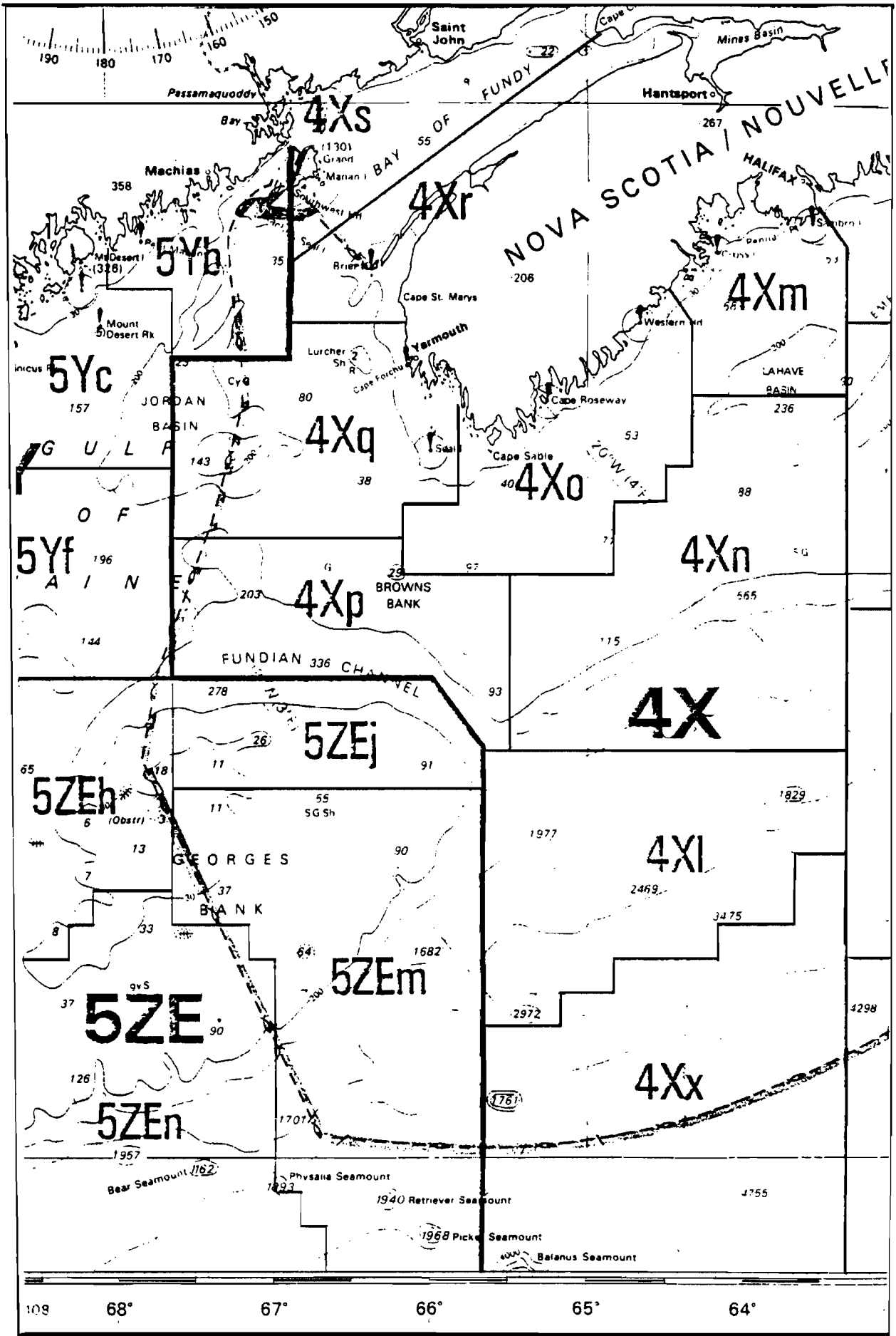


Figure 1. Unit areas in Division 4X.

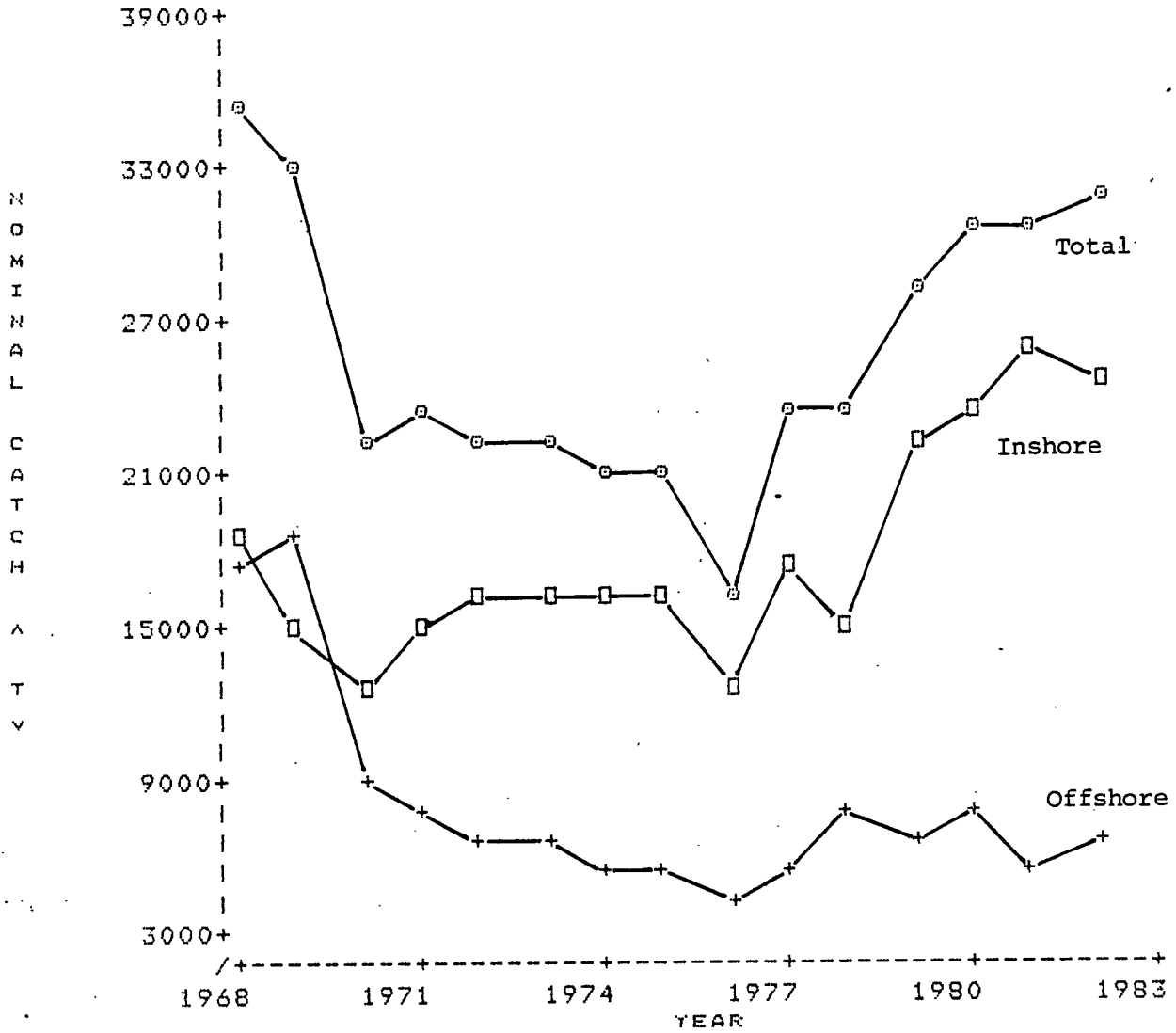


Figure 2. Cod catches in Div. 4X; offshore and inshore catches (t).

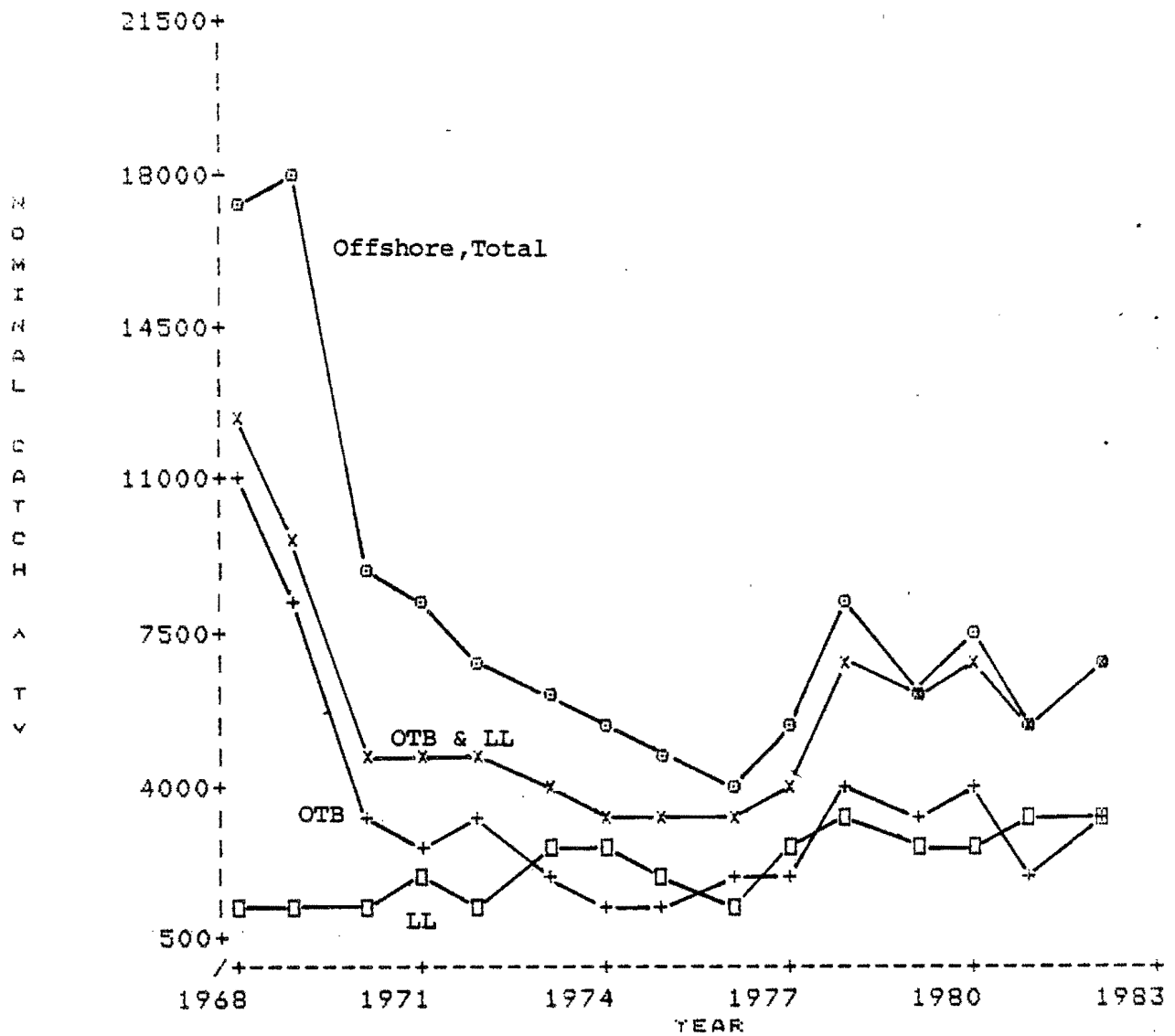


Figure 3. Repartition of offshore cod catches in Div. 4X among otter-trawlers (OTB) and long-liners (LL), (t).



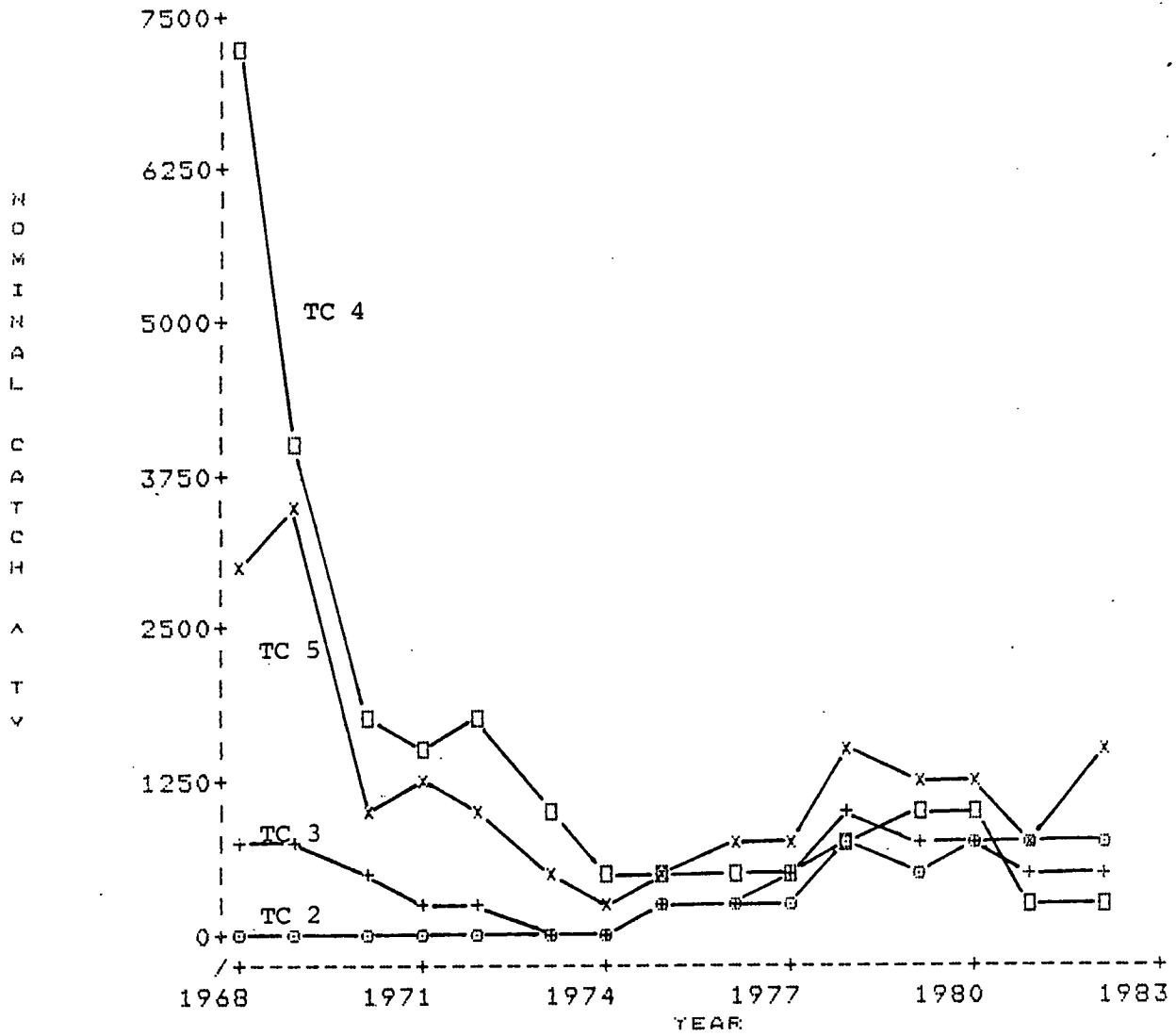


Figure 4. Offshore catches of cod in Div. 4X by otter trawlers of different tonnage classes (TC), (t).

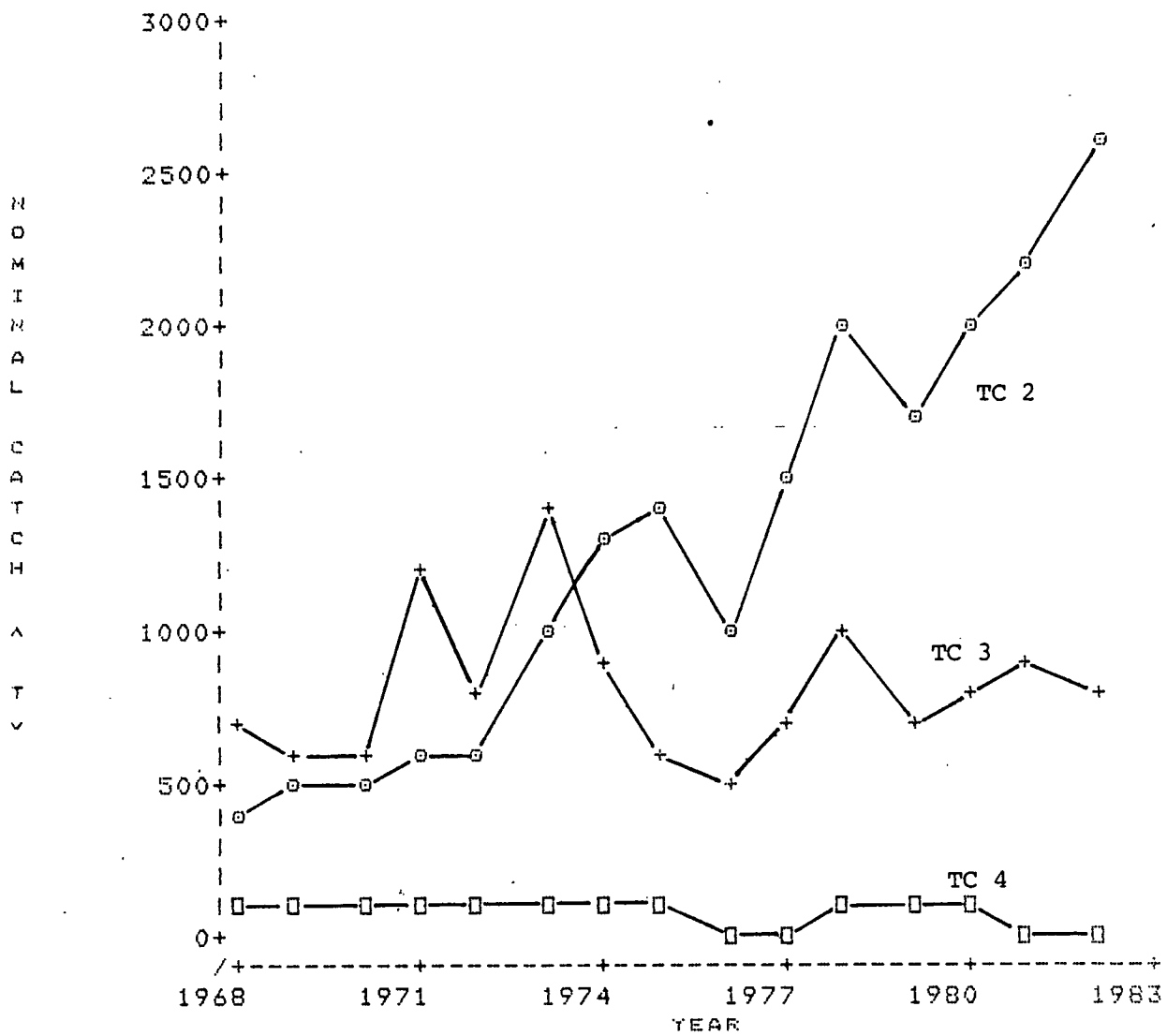


Figure 5. Offshore catches of cod in Div. 4X by long-liners of different tonnage classes (TC), (t).

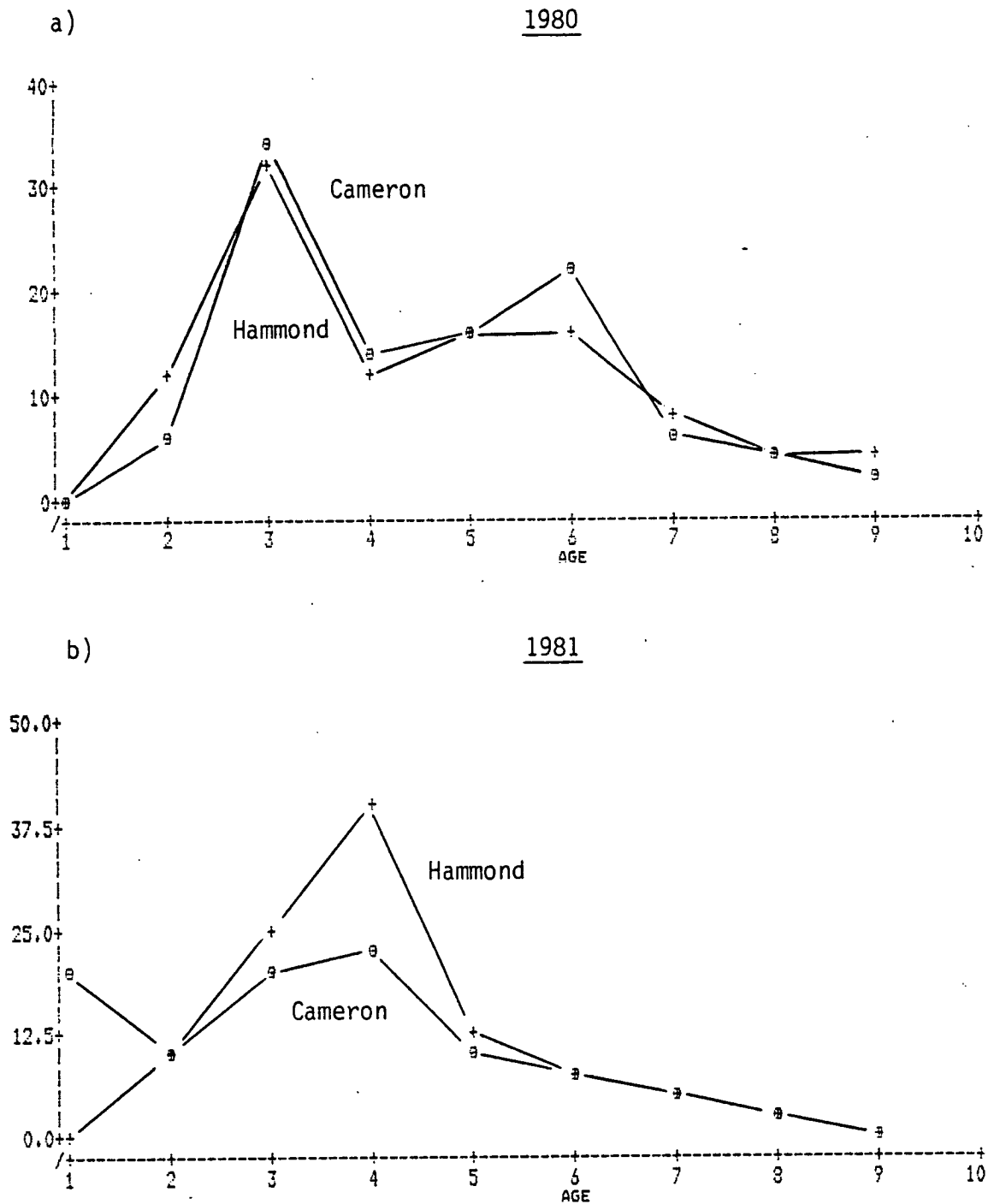


Figure 6. Catches at age of cod in 4X offshore by the A.T. Cameron and the Lady Hammond during the 1980 and 1981 summer groundfish surveys (percent of total catch of each vessel, in numbers).

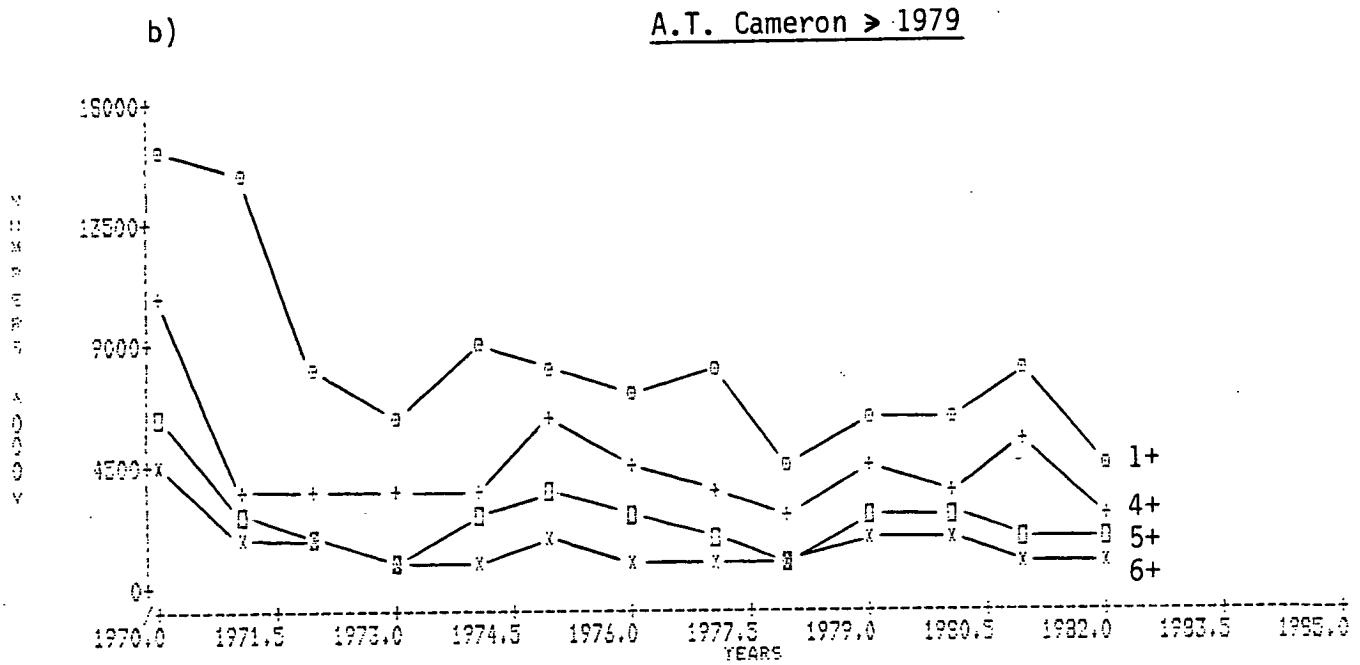
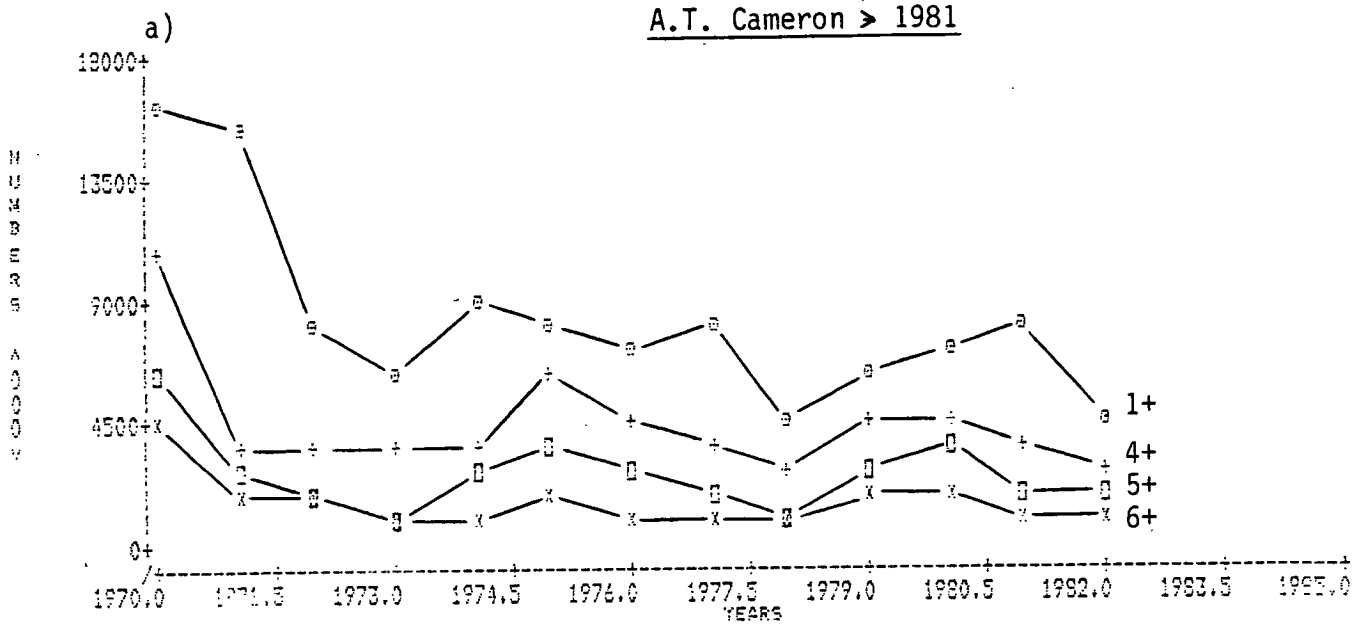


Figure 7. Research survey population estimates of offshore cod in Division 4X.

- a) Lady Hammond data used for 1982 only.
- b) Lady Hammond data used for 1980 to 1982.

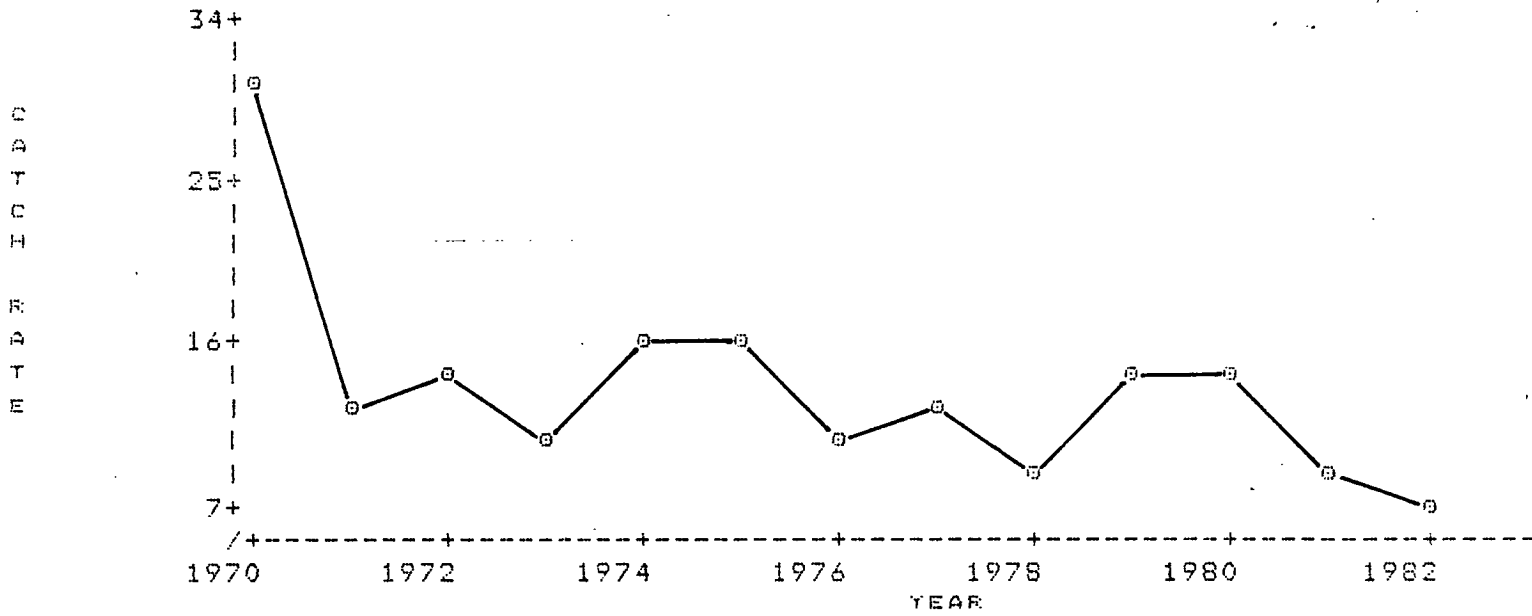


Figure 8. Offshore 4X. Catch rate (kg/tow) calculated from July research surveys (Strata 70 - 85).

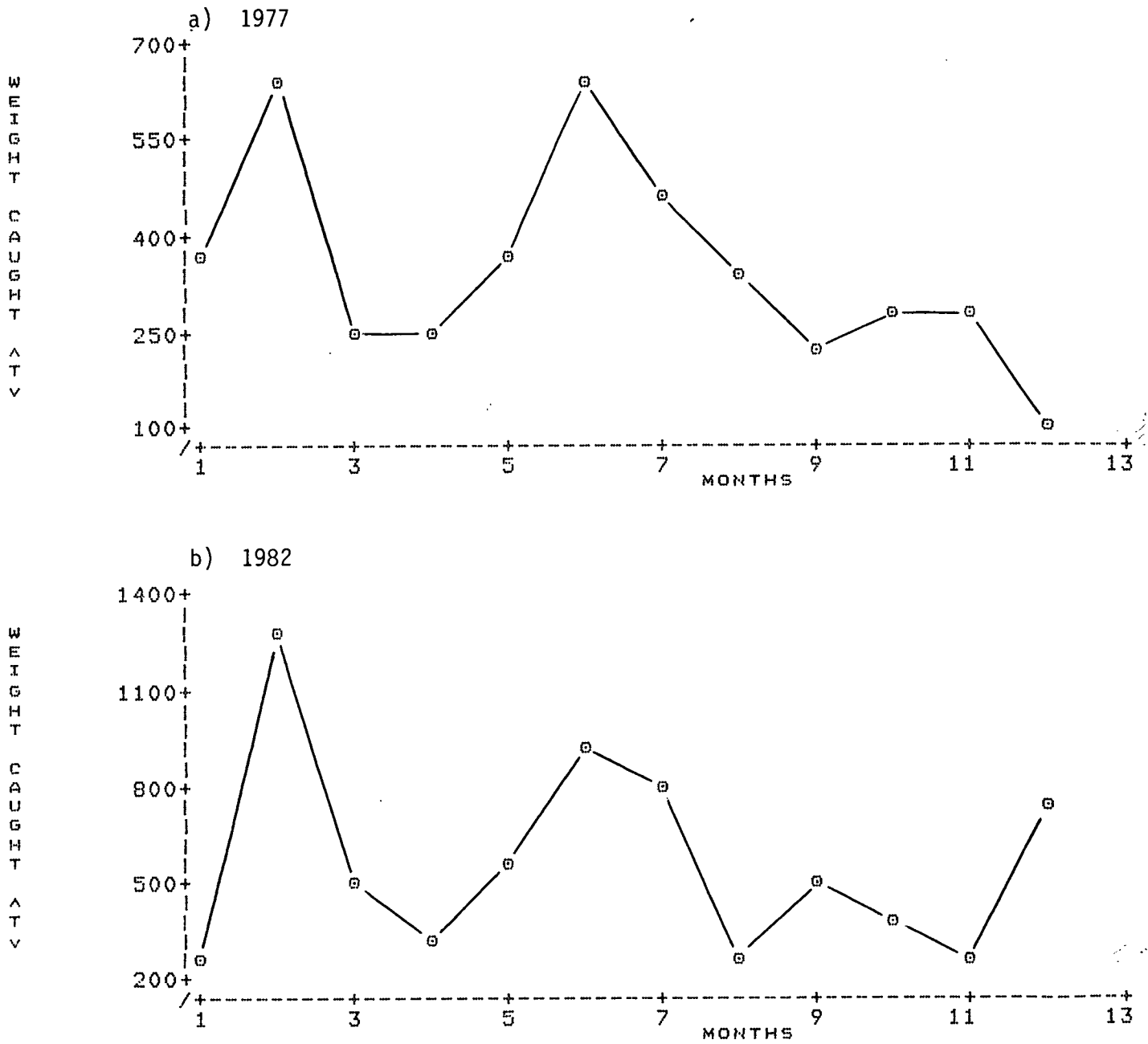
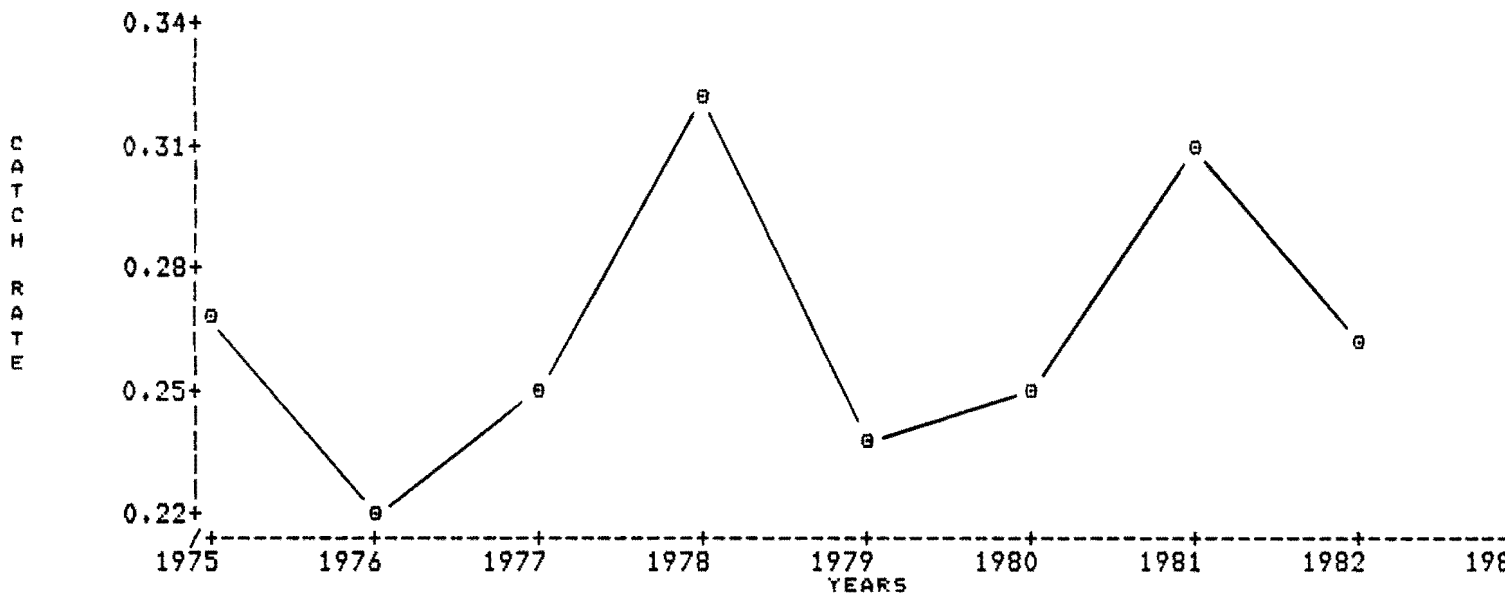


Figure 9. Monthly distribution of offshore catches of cod in Division 4X.

## A) TC-2



## B) TC-3

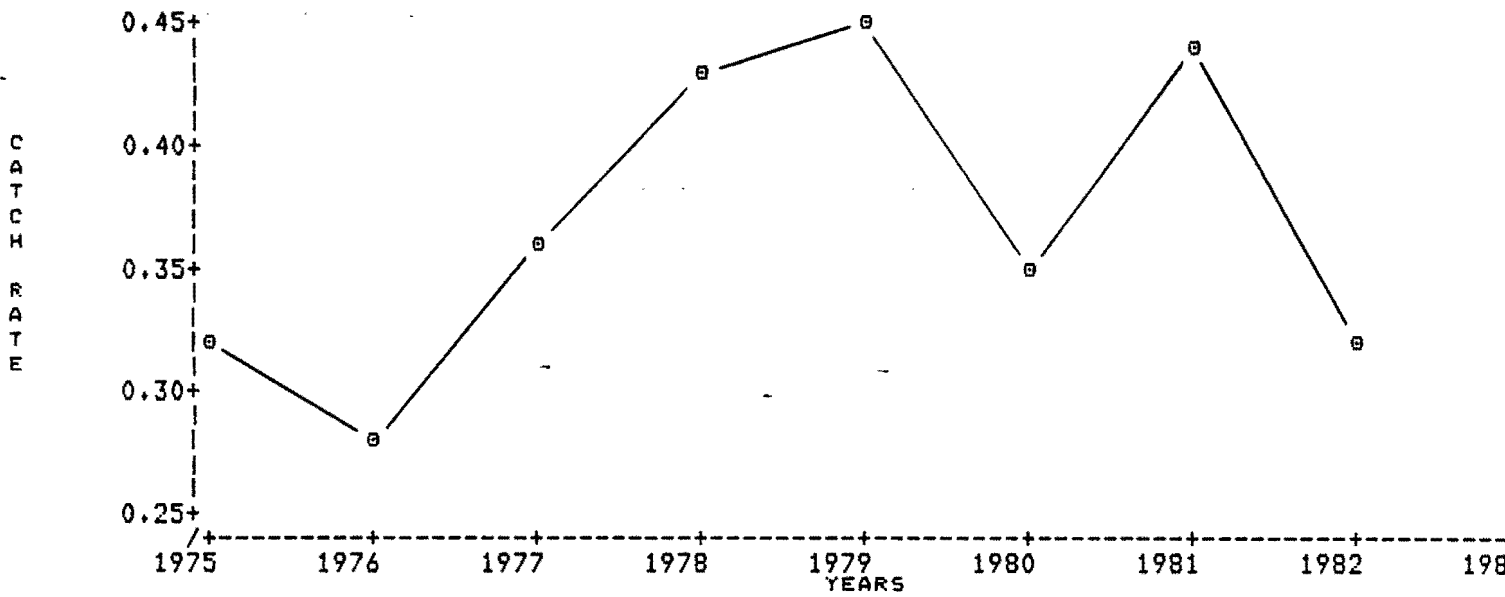


Figure 10. Catch rate (t per 1000 hooks) of longliners in 4Xnop for the period January-March. (Main species - cod)

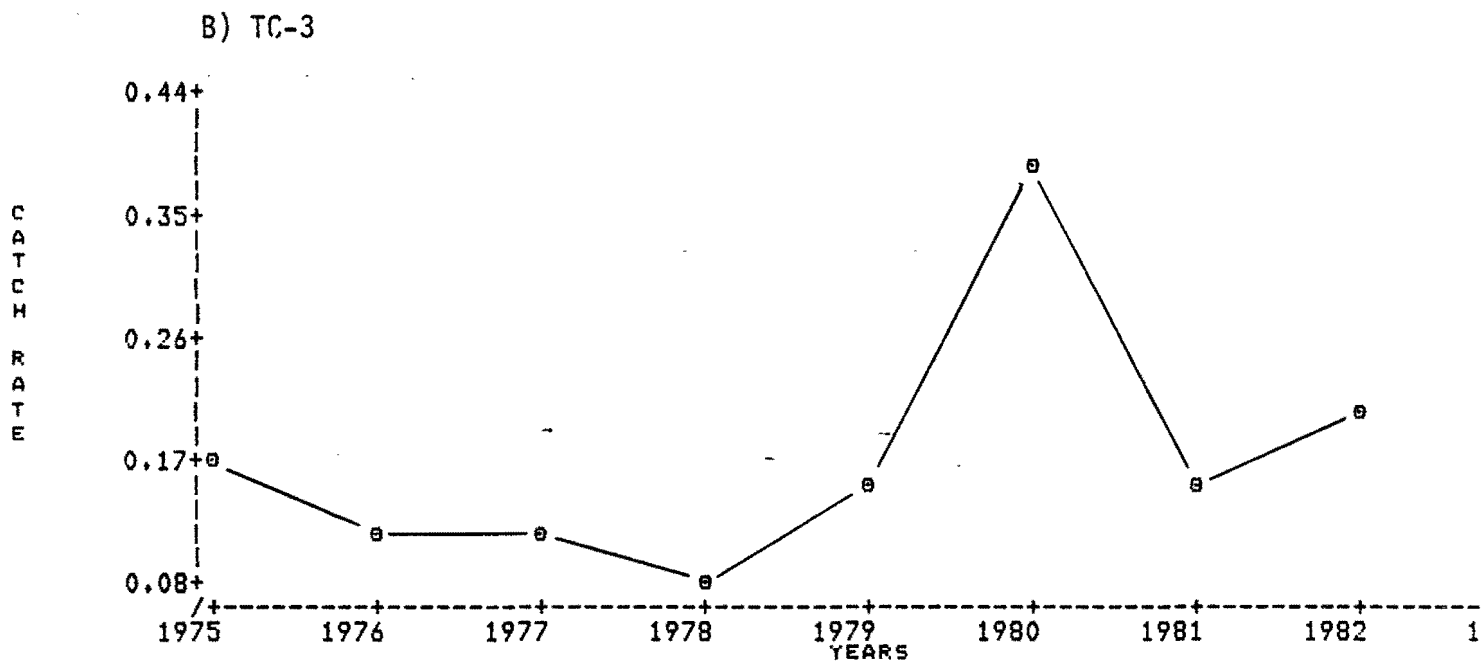
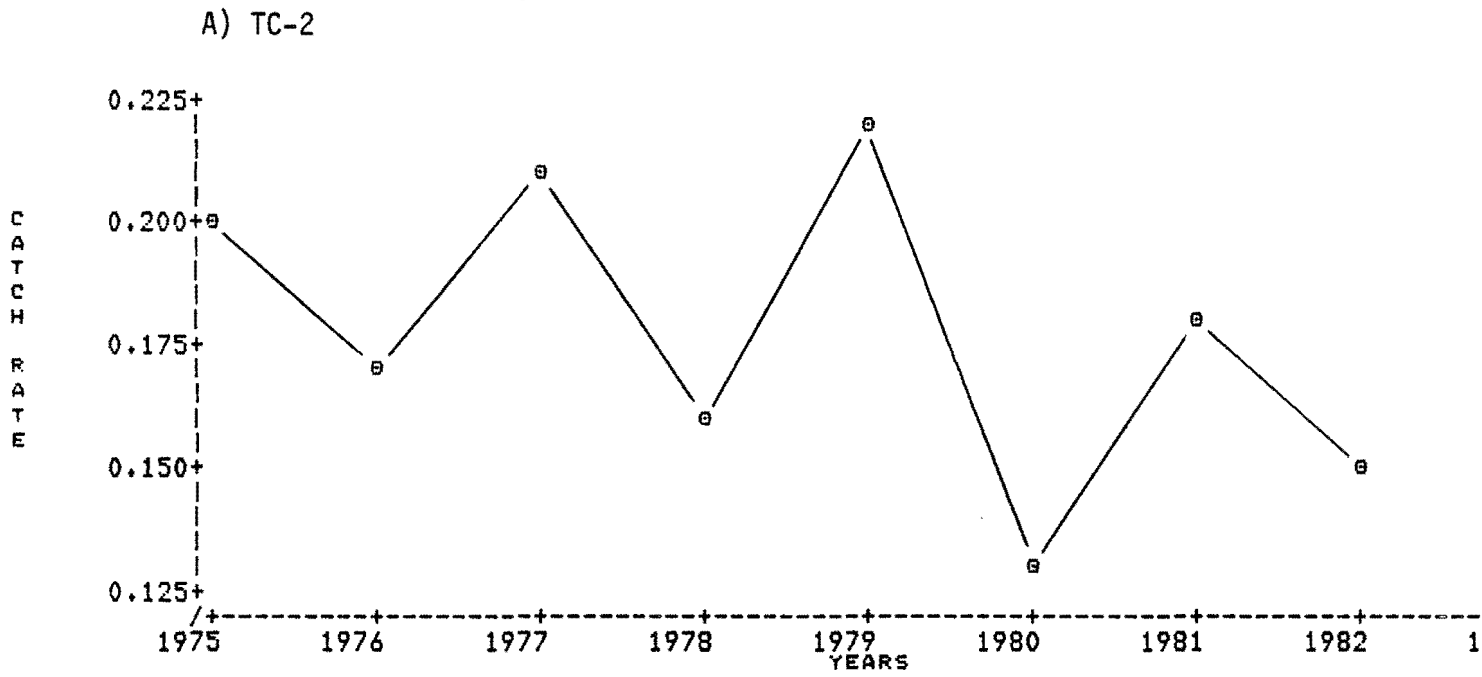


Figure 11. Catch rate (t per 1000 hooks) of longliners in 4Xn for the period May to July. (Main species - cod)



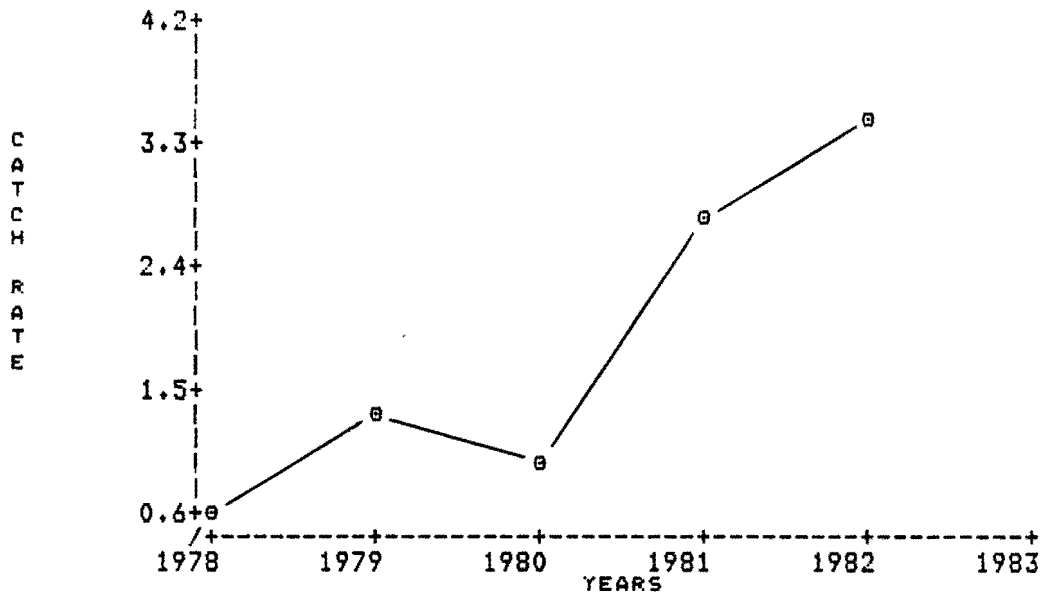


Figure 12. Catch rate (t per hour) of otter trawlers, TC-5, in 4Xn, for the period October to December. (Main species - cod)

## APPENDIX 1a

Total catch of longliners (TC1) in Division 4X and Division 5Ze by month

Unit Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
<b>1 9 7 9</b>													
4Xm	149	166	189	159	54	79	136	92	95	101	107	138	1465
n	1	0	0	14	7	0	0	0	0	0	0	0	22
o	38	4	160	232	295	890	807	1042	891	275	179	48	4861
p	0	0	0	0	0	0	0	0	0	0	0	0	0
q	0	3	63	9	36	141	57	56	4	3	0	0	372
r	0	0	0	10	12	28	80	72	51	38	10	0	301
s	0	7	55	217	135	48	9	7	11	5	1	0	495
5Ze	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>1 9 8 0</b>													
4Xm	166	257	125	160	212	118	175	115	92	193	132	172	1917
n	0	2	0	14	0	0	0	0	0	0	0	0	16
o	82	157	165	262	360	852	568	757	485	543	102	96	4429
p	0	0	0	0	0	0	0	0	0	0	0	0	0
q	0	12	3	8	49	259	181	51	5	2	0	0	570
r	0	0	37	120	163	99	92	99	70	39	1	0	720
s	4	12	68	173	256	93	15	26	29	16	2	11	705
5Ze	0	0	0	0	186	486	281	283	105	0	0	0	1341
<b>1 9 8 1</b>													
4Xm	275	248	243	117	128	191	107	98	73	207	134	133	1954
n	0	0	0	0	0	0	3	0	0	0	0	2	5
o	349	455	467	346	452	673	525	1073	537	757	236	95	5965
p	0	0	0	0	0	0	0	0	0	0	0	0	0
q	0	0	0	0	29	156	140	48	1	13	0	0	387
r	0	65	148	124	221	191	61	78	39	10	9	13	959
s	19	93	168	58	248	134	40	33	68	15	28	14	918
5Ze	0	0	0	0	306	672	348	168	59	35	0	0	1588
<b>1 9 8 2</b>													
4Xm	271	268	293	128	260	206	132	72	107	28	73	124	1962
n	0	0	0	0	0	0	0	4	0	0	0	0	4
o	57	346	410	274	561	834	674	498	792	474	140	81	5141
p	0	2	0	0	0	0	0	0	0	0	0	0	2
q	0	0	11	8	66	217	127	40	17	15	0	0	501
r	24	70	140	64	153	113	62	36	23	19	1	4	709
s	17	136	127	80	228	69	56	22	15	8	7	29	794
5Ze	0	0	0	0	0	69	125	158	15	0	0	0	367

## APPENDIX 1b

Total catch of otter trawlers (TC1) in Division 4X and Division 5Ze by month

Unit Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
<b>1 9 7 9</b>													
4Xm	0	2	1	11	9	0	0	0	0	0	0	0	23
n	0	0	0	0	0	0	0	0	0	0	0	0	0
o	0	0	0	3	9	10	34	18	7	11	4	0	96
p	0	0	0	0	0	0	0	0	0	0	0	0	0
q	0	0	1	1	13	94	35	58	25	15	1	0	243
r	0	0	0	2	73	68	17	21	32	10	2	0	225
s	0	0	0	0	19	19	10	2	0	5	1	0	57
5Ze	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>1 9 8 0</b>													
4Xm	0	5	53	6	0	3	5	0	0	0	0	0	72
n	0	0	0	0	0	0	0	0	0	0	0	0	0
o	0	7	22	42	30	89	14	22	16	26	0	5	273
p	0	0	0	0	0	0	0	0	0	0	0	0	0
q	0	5	10	48	73	91	119	96	20	30	0	0	492
r	0	0	2	78	147	127	63	33	17	13	2	0	482
s	0	0	0	0	0	0	0	1	1	1	0	0	3
5Ze	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>1 9 8 1</b>													
4Xm	0	0	0	0	2	2	9	1	0	0	0	0	14
n	0	0	0	0	0	0	0	0	0	0	0	1	1
o	9	15	18	30	12	17	115	26	11	9	3	5	270
p	0	0	0	0	0	0	0	0	0	0	0	0	0
q	0	5	30	12	56	103	77	54	27	6	0	2	372
r	16	27	12	54	133	37	34	75	12	62	26	2	490
s	0	0	0	3	0	2	6	3	0	2	0	0	16
5Ze	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>1 9 8 2</b>													
4Xm	0	0	0	0	0	0	4	2	8	1	0	0	15
n	0	0	0	0	0	0	0	0	0	0	0	0	0
o	7	16	22	23	20	8	17	17	24	9	6	4	173
p	0	0	0	0	0	0	0	0	0	0	0	0	0
q	0	0	0	3	30	48	56	34	30	3	0	0	204
r	4	4	6	31	115	146	70	50	25	12	4	1	468
s	0	0	0	0	0	0	3	10	3	4	0	0	20
5Ze	0	0	0	0	0	0	13	0	5	0	0	0	18