SUBDIVISION 4Vn COD (MAY - DECEMBER):
STATUS REVIEW FOR THE 1985 FISHING YEAR

by

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ABSTRACT

Nominal catch of cod in 4Vn (May-December) was 12,366 t in 1985, an increase of 1839 t from 1984. All gear categories with the exception of longlines shared in the increase. The longline catch remained much the same as last year. Age information was available from most major gears for the second year in a row allowing for some preliminary comparisons between gears. A short-term forecasting method for estimating the projected catch for 1986 was applied to this age information. The method which assumes that fishing mortality in 1986 will be equal to the fishing mortality in 1984, resulted in an estimated catch biomass for 1986 of 10,700 t. This estimate, although based on different assumptions than the general production model used in the past, was comparable to past estimates of the long term yield from the latter method. However, total mortality estimates imply that fishing mortality has been in excess of $F_{0.1}$ and the estimated catch at $F_{0.1}$ was estimated to be 6,100 t.

RESUME

Les prises nominales de morue dans la division 4Vn (mai à décembre) ont été de 12 366 t en 1985, soit une augmentation de 1 839 t par rapport à 1984. Toutes les catégories d'engin de pêche, à l'exception de la palangre, ont connu une augmentation de prises. Dans le cas de cet engin, les prises sont demeurées sensiblement les mêmes que l'année dernière. Les données sur l'âge disponibles pour deux années consécutives et pour la plupart des engins nous permettent d'établir certaines comparaisons préliminaires. On a appliqué à ces données sur l'âge une méthode de prévision à court terme pour évaluer les prises prévues pour 1986. La méthode, qui suppose que la mortalité due à la pêche en 1986 sera égale à celle de 1984, a permis d'établir à 10 700 t la biomasse des prises prévue pour 1986. Bien qu'elle s'appuie sur des hypothèses autres que le Modèle de production généralisée utilisé par le passé, cette estimation se compare aux estimations du rendement à long terme établies antérieurement par cette méthode. Cependant, les estimations de la mortalité totale laissent supposer que la mortalité due à la pêche a dépassé la valeur $F_{0.1}$ et les prises projetées à ce niveau ont été fixées à 6 100 t.

Introduction

Previous advice on this stock has been based on the apparent strengths of incoming year-classes to the fishery from research surveys and the results of a general production model analysis. The general production model was fitted to total catch and an effort series derived from stratified mean weight caught per tow estimates. The calculated $2/3\ E_{MSY}$ yield for the 1984 and 1985 assessments were 10,200 t and 10,500 t respectively. The TAC for 1985 was 12,000 t. Total mortality estimates from the survey data and longline catch-per-unit-effort at age have indicated that fishing mortalities in recent years have exceeded $F_{0.1} = 0.2$.

The nature of the fishery has been changing over the last five years. In 1980 and 1981 the longliner component predominated over the otter trawlers. In the last three years otter trawlers particularly tonnage class 2 and 3 vessels have become a major part of this fishery. Catches of these vessels have been increasing in recent years while the longline catch has dropped to about half of the 1981 level. The Assistant Deputy Minister (AFS) has requested that CAFSAC investigate these trends and try to determine how they are related. Some preliminary results are presented here.

Nominal Catch

The nominal catches by country for the period 1970-1985 are presented in Table 1 and plotted in Figure 1. The only foreign catch reported for 1985 was the small bycatch from the Japanese redfish fishery. Total landings for 1985 were up by 1839 t over the previous year. This increase was realized by all major gears with the exception of the longliners whose catch decreased marginally from the previous year (Table 2). The percent composition of catch by gear over the period 1970-1985 is presented in Figure 2. Note the recent increase in percent catch on the part of the otter trawls.

Landings by gear and tonnage class are presented for 1984 and 1985 in Table 3. Tonnage class 1 otter trawlers are all but gone from the fishery while the other tonnage classes continue to increase their share of the landings. The tonnage class 3 vessels continue to be the major part of this gear component. For longliners, only the tonnage class 1 vessels showed an increase in catch.

The monthly breakdown of landings by gear component given in Tables 4a and 4b show a change in pattern for the longliners. Previously landings for this fishery started out high in May, then decreased over the summer and then increased again in the fall. Many of these boats would participate in the crab fishery in the summer months. In 1985 longliner landings peaked in the summer instead. The abrupt drop in the otter trawl landings after August was due to the closure of this fishery effective August 23. The temporal trends for the handlines and seines are similar to those of previous years.

Research Surveys

Estimates of mean numbers/tow by age and estimated total numbers/tow and weight/tow from the summer research surveys for 1970-1985 are presented in Table 5. Variance estimates are not included here but planned modifications to STRAP and other software used for this assessment will make it possible to provide them in the future. Note that the estimates given in Table 5 are arithmetic averages.

The 1985 mean catch/tow for both numbers and weights are the highest recorded for this survey. The bulk of this estimate was made up of 5 year olds (1980 year-class) although the mean/tows for ages 6, 7, and 8 are also relatively high for those ages. In Table 6 the stratum means (numbers) are given for 1970-1985. The means for strata 40 and 41 are in line with previous results, however the mean in stratum 42 is well beyond any previous values. There was one large set in stratum 42 containing 1460 cod, 55% of which were 5 year olds, 22% and 9% were 6 year olds and 7 year olds respectively. These percentages of fairly old fish in this stratum are unusual. In the past there has been a general trend of year-classes moving to deeper waters as they grow older (Smith and Sinclair, MS1985). Stratum 42 is the shallowest stratum of the three in 4Vn. Catches in stratum 41 were also dominated by 5 year olds. Comparison of age-length keys from the 1983, 1984 and 1985 surveys indicate that fish of the 1980 year-class appear smaller in size than previous year-classes at the same age. Lengths for age 5 fish had generally ranged from 43 cm. to 63 cm. with a peak around 52-55 cm. The 1980 year-class fish range from 34 cm. to 58 cm. with a peak at 46-49 cm.. Lengths at age from the commercial samples were similar. The department's port sampler in Sydney has commented to us about the smaller size of these fish and reported that the fisherman had also noted this phenomena. Obviously more investigation has to be carried out on this apparent trend.

Commercial Catch at Age

Sampling coverage of the commercial catch was good for 1985 with most major gears being adequately covered. However, only two samples were reported for tonnage class 2 longliners and these were collected in the fall. There were no handline samples collected. The data used to generate the age-length keys are summarized in Table 7. In order to maximize the age information available, all otoliths were used regardless of the gear the samples were taken from to convert the length frequencies to age compositions. Both age and length samples were separated into two time periods; May-September and October-December. The length-weight parameters were obtained from analysis of the 1985 groundfish survey data.

The longliner catch at age remains the only longterm time series of data reflecting the age composition of this stock. However we now have two years of information for otter trawlers and seines. The longliner series is presented in Table 8 and average weight at age for this gear is presented in Table 9. The longliners continue to concentrate on the older year-classes particularly the 1977, 1978 and 1979 year-classes. Note that the 1980 year-class was also a significant proportion of the catch.

Catch at age for the otter trawls and seines are presented in Table 10 along with their 1984 estimates. The catch at age for longliners, otter trawls and seines are presented in Figure 3. The available catch-at-age information indicated that the longliners concentrated on 7, 6, 5 and 8 year olds in that order (mean= 7.2 years) while the otter trawls mainly caught 5, 7 and 6 year olds (mean= 6.3 years).

Catch per Unit Effort

The CPUE estimates for longliner tonnage class 2 vessels for 1968 to 1985 are given in Table 11. The trend in longliner effort is presented in Figure 4 for the period 1980-1985. Note the increase in effort over last year while catch (Table 2) has remained fairly stable.

Mortality Estimates

Total mortality estimates were calculated from CPUE (numbers) at age for the longline catch for 1980-1985 (Table 12). Although there is a great deal of variability between years the mean estimates indicate a leveling off of mortality levels at age 8 which appears to be consistent with the recruitment pattern for this type of gear. Assuming that natural mortality is 0.2 the total mortality estimates for age 8+ indicate a fishing mortality in excess of 0.4 which is twice $F_{0.1}$ = 0.2.

Estimates of mortality from the survey data were not included here because the high catches in the survey this year gave negative estimates of mortality for most age groups.

Total mortality was also calculated from a catch curve obtained from a multiplicative analysis of longliner catch at age for the same time period. The methodology is sumarized in the report of the 1985 ICES Working Group on Methods of Fish Stock Assessments (Anon. 1986). The model expresses catch at age as a multiplicative function of year, age, and year-class effects. The output includes a catch curve (age effects) corrected for variations in estimated year-class sizes. The resulting catch curve indicates full recruitment to the gear at age 6 (Figure 5). A regression through ages 6-12 indicates total mortality of 0.61. Assuming natural mortality of 0.2 this indicates fishing mortality of 0.41.

Interaction between Longlines and Otter Trawls

In a memo received from the Chairman of the Groundfish Subcommittee we were directed to give advice on the possible effect of the annual transfer of quota from the small fixed gear fishery to the small mobile gear fishery in 4Vn. This practice has been occurring since 1981. It was suggested that this practice may have contributed to the decrease experienced by the small fixed gear fishery.

The allocation history of this fishery is presented in Table 13. The sources for this material are the Department's Quota reports and Groundfish management plans. The final catches given in the table are taken from the Dec. 31 Quota reports. TAC's for the management unit were increased in mid-season in 1981 and 1982. The fixed gear component

(<65') exceeded it's quota in 1981 despite the mid-season increase. Since then the small fixed gear fleet has not reached it's quota. Beginning in 1983 the mobile gear (<65') fleet has consistently exceeded its quota despite large transfers from the fixed gear (<65') fleet. These were both initial and mid-season transfers. Thus the fixed gear (<65') fleet has experienced both absolute and proportional decreases in it's allocation. On the other hand the quota and catch for the small mobile fleet has increased and thus it is exerting proportionally higher fishing mortalities than it had in the past. Generally, otter trawlers concentrate on younger fish than the longliners do (Table 10 and Fig. 3) and possibly reduce the stock before they are old enough for the longliners to take full advantage of them.

Unfortunately we have only two years of data on age composition to compare and therefore can say very little about past trends. Comparison of total mortality estimates in Table 14 offers little assistance. The estimates for the otter trawls appear to be unrealistically low since all but one are below 0.2. For longliners the estimates indicate high fishing mortalities. Little is known about the temporal/spatial distributions of these gear categories and at this time little can be said about how they may be competing. Therefore any formal advice on this question will have to wait for the collection of more age composition data and the analysis of any positional and seasonal information we may have on hand. Further data collection may be warranted for the latter investigation.

Estimation of Total Allowable Catch

Previous advice on setting catch levels for this stock were partly based on results from a general production analysis of total catch and an effort series derived from survey mean weight per tow. The large mean weight per tow for 1985 would correspond to a drop in effort in 1985 contrary to indications given by the catch rates from the longliners and otter trawls. Therefore the general production model may provide an erroneous view of the status of this stock and because of this an alternate approach was applied here.

The lack of catch at age information for this stock has always hampered efforts to carry out an analytical assessment. In the last two years efforts have been made to rectify this situation. Given that we now have two years of reasonably complete age composition data for the major gears in this fishery the opportunity arises to use one of the short-term forecasting methods currently popular in ICES. The method chosen for use here is known as the Leap-Frog TAC (Pope, 1983). This method assumes that we have two years of data for year t and t-1 and wish to estimate the projected catch for year t+1. Assuming that $F_t = F_{t-1}$ we can estimate the catch, C, in year t+1 at age j+1 by,

$$C_{t+1, \, j+1} = \frac{C_{t,j+1} \; C_{tj}}{C_{t-1,j}} \left(\frac{F_{t-1}}{F_t} \right)^2$$

The basic requirements for this method are catch at age for the two years, an estimate of recruitment for the youngest age in the fishery

for year t+1, average weight at age over the two years and a measure of the relative change in F from year t-1 to year t. Pope suggests using the ratio of effort for these two years if constant catchability can be assumed.

The catch at age for 1984 and 1985 was constructed from the basic data given in Table 10. The total catch at age for all gears was estimated by prorating the catch for available gears to the total landings given in Table 1. The results are presented in Table 15. The average weight over the two years 1984 and 1985 was also calculated from the commercial age and length samples. Effort is available for longliners and tonnage class 2 and 3 otter trawlers. Total effort for each year was calculated for each of these gears and then combined by using the coefficients obtained from the multiplicative analysis for the 4VsW cod assessment. These coefficients were used to express the effort units of the longliners and tonnage class 2 otter trawlers in the same scale as the tonnage class 3 otter trawlers. The recruitment to age 3 was estimated from the average catch at age 3 from 1984 and 1985. The TAC was estimated following Pope's formula as,

$$TAC = \sum_{j=3}^{16} W_j \, C_{t+1,j} \; .$$

The estimated catch of 10,710 t falls within values suggested in the past by the general production model and indeed appears reasonable given the recent history of this stock. Since the method also provides us with a projected catch at age we will be able to evaluate the potential usefulness of this method next year. For the moment given the paucity of data on age composition this method is the best we have.

An alternative approach which uses information from the total mortality estimates was carried out as follows. The estimated fishing mortality on this stock is approximately twice $F_{0.1}$. Abundance indices from both research surveys and commercial catch rates indicate relative stability in the population in the last 6 years. The average catch over the same period has been 11,200 t. Using the catch equations the biomass (B) may be estimated as,

$$\hat{B} = \frac{C \, Z}{F \, (1 - e^{-Z})}$$

$$= 37,235$$

where,
C = average catch (11,200 t)
Z = current total mortality (0.6)
F = current fishing mortality (0.4)

Therefore one could estimate the $F_{0.1}$ catch as

$$\hat{C} = \frac{F_{0.1}}{Z_{0.1}} \, \hat{B} \left(1 - e^{-Z_{0.1}} \right)$$

$$= 6138 \text{ t}$$

This estimate is made with the assumptions that biomass has been relatively stable in the recent past, age structure is stable, recruitment has been stable and there has been no changes in partial recruitment.

Summary

Abundance indices from the research surveys indicate higher than usual levels for this stock. The 1980 year-class predominates but older year-classes remain relatively abundant. This year was unusual in that older fish than is usually expected were caught in the shallow stratum (42).

Commercial catch per unit effort from longliners decreased from the 1984 level. The number of records that this is based on remains small.

This is the second year in which the major gears have been sampled for length and age. This year it appears that although the otter trawlers were catching substantial numbers of 5 year olds they also were concentrating on the older fish much like the longliners. Monitoring of sampling will continue in order to ensure that all major gears continue to be covered.

For the moment little can be said about the effect of the annual transfers of quota from the small fixed gear component to the small mobile component of this fishery. Further research must be done on the temporal and spatial distributions of these vessels and more age composition data must be collected.

Given that we now have two years of age composition information a semi-analytical assessment was attempted. The Leap-Frog TAC method was applied to this information and resulted in a projected catch of 10,710 t for 1986 which is line with previous advice based on a general production analysis. This method provides an estimated catch at age for 1986 and therefore will be validated once the 1986 information is analyzed.

Both the $2/3E_{msy}$ obtained from past analysis using a general production model and the projected catch from the Leap-Frog method appear to reflect exploitation of the stock at high fishing mortality rates. Total mortality estimates over the last five years continue to indicate that fishing mortality has been in excess of $F_{0.1}=0.2$. The $F_{0.1}$ catch is estimated to be 6,100 t.

References

Anon., 1986. Report of the Working Group on Methods of Fish Stock Assessments. C.M. 1986/Assess:10

Pope, J.G. 1983. Analogies to the status quo TAC's: their nature and variance, p.99-113. In W.G. Doubleday and D. Rivard [ed.] Sampling commercial catches of marine fish and invertebrates. Can. Spec. Publ. Fish. Aquat. Sci. 66.

Smith, S.J. and A.F. Sinclair. MS. 1985. 4Vn Cod (May-December): Status review for the 1984 fishing year. CAFSAC Res. Doc. 85/63. 28p.

Table 1. Nominal cod catch (t) by countries in Subdivision 4VN (May – December).

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Canada	8701	8469	6729	5245	4836	3363	5746	7786	5496	6301	9976	12476	12101	9192	10527	12361
Spain	1141	2161	1171	241	852	89	-	-	-	-	-	-	-	-	-	-
Portugal	-	-	459	189	84	360	-	-	-	-	-	-	-	-	-	-
France	34	1	745	-	-	-	211	135	53	73	214	172	232	170	-	-
Norway	-	-	-	-	137	186	-	-	-	-	-	-	-	-	-	-
U.K.	-	-	-	-	61	-	-	-	-	-	-	-	-	-	-	-
F.R.G.	-	-	-	73	14	-	-	-	-	-	-	-	-	-	-	-
U.S.A.	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poland	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Japan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
TOTALS	9888	10631	9104	5748	5984	3998	5957	7921	5549	6374	10190	12648	12333	9362	10527[1]	12366[1]
% Canadian	88	80	74	91	81	84	95	98	99	99	99	99	99	99	100	100
TAC	-	-	-	-	10000	10000	10000	3500	3500	3400	5000	*	**	14000	14000	12000

* Initially set at 7500 t, increased in September to 10,000 t.
** Initially set at 10500 t, increased November 1 to 14,000 t.

[1] Preliminary statistics

Table 2. Nominal catch (t) of cod in Subdivision 4Vn (May-December) by
gear type for all countries, 1970-1985.

Year	Otter Trawl	Seines	Longlines	Handlines	Misc.	TOTAL
1970	4859	83	3229	495	1222	9888
1971	5308	109	3728	696	790	10631
1972	4418	121	3185	286	1094	9104
1973	2099	143	1982	404	1120	5748
1974	2842	138	1469	568	967	5984
1975	1851	100	875	360	812	3998
1976	4375	83	620	310	569	5957
1977	4613	554	1805	595	354	7921
1978	1600	326	3035	466	122	5549
1979	624	278	4483	640	349	6374
1980	1150	561	6440	1820	219	10190
1981	1488	557	9801	741	61	12648
1982	2785	724	7287	1360	177	12333
1983	2448	863	5101	924	26	9362
1984	3400	1084	4831	1112	100	10527[1]
1985	4903	1174	4825	1407	52	12366[1]

[1] Preliminary statistics.

Table 3. Nominal catch by Canada of cod in 4Vn (May-Dec) by vessel size and gear. Percentage of gear total catch by tonnage class is in parenthesis.

Tonnage Class (GT)	Otter Trawls	Seines	Longlines	Handlines	Other	TOTAL
1984						
0-24.9	163 (5)	474 (44)	3146 (65)	1110 (100)	45 (45)	4938
25-49.9	1132 (33)	594 (55)	1605 (33)	2 (10)	-	3333
50-149.9	1652 (49)	16 (1)	80 (2)	-	55 (55)	1803
150-499.9	115 (3)	-	-	-	-	115
500-999.9	338 (10)	-	-	-	-	338
Total	3400	1084	4831	1112	100	10527
1985						
0-24.9	5 (0)	555 (47)	3524 (73)	1402 (100)	23 44)	5509
25-49.9	1314 (27)	566 (48)	1255 (26)	5 (0)	-	3140
50-149.9	2918 (60)	53 (5)	46 (1)	-	29 (56)	3046
150-499.9	308 (6)	-	-	-	-	308
500-999.9	358 (7)	-	-	-	-	358
Total	4903	1174	4825	1407	52	12361

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Table 4. Nominal catch (Canada) for cod fishery in 4Vn (May-December) by months and year.

a) 1984

Gear	May	June	July	Aug	Sept	Oct	Nov	Dec	TOTALS
Longlines	697	557	399	452	535	871	756	564	4831
Handlines	1	65	271	374	119	241	24	17	1112
Otter Trawls	512	453	390	103	518	703	342	379	3400
Seines	611	174	52	49	32	49	29	88	1084
Shrimp trawl	17	17	13	7	-	1	-	-	55
Other	18	22	2	1	-	2	-	-	45
TOTAL	1856	1288	1127	986	1204	1867	1151	1048	10527

b) 1985

Gear	May	June	July	Aug	Sept	Oct	Nov	Dec	TOTALS
Longlines	437	514	443	631	1048	698	625	429	4825
Handlines	1	22	266	437	472	192	16	1	1407
Otter Trawls	380	221	1171	2022	162	384	293	270	4903
Seines	412	255	256	39	68	30	20	94	1174
Shrimp Trawl	3	5	10	3	7	1	-	-	29
Other	3	5	7	-	3	4	1	-	23
TOTAL	1236	1022	2153	3132	1760	1309	955	794	12361

Table 5. 4Vn cod (May-Dec) Research vessel abundance indices (mean catch per tow) by age group.

AGE	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	-	-	-	-	-	-	-	-	-	-	-	0.33	-	-	2.83	-
2	6.35	1.17	0.52	-	-	0.61	6.49	0.13	0.66	1.30	1.88	4.36	2.53	4.37	7.25	0.48
3	1.77	42.40	0.28	2.91	0.61	6.42	2.25	7.12	9.13	0.79	10.52	16.91	1.74	22.11	10.02	3.75
4	4.78	10.09	2.35	4.58	1.36	8.58	1.48	4.19	19.31	5.15	3.97	36.48	5.77	7.90	10.48	19.10
5	10.90	26.51	0.30	21.20	2.79	4.65	1.93	2.90	5.54	2.51	23.58	12.02	10.22	10.64	13.51	125.95
6	10.46	16.16	1.61	2.61	3.21	0.81	1.55	2.05	4.38	0.59	16.40	25.45	7.61	10.04	8.75	52.13
7	4.50	10.65	1.47	2.98	0.40	1.00	0.73	0.84	1.53	1.72	5.15	11.50	9.25	1.70	3.58	22.38
8	2.59	3.59	0.39	3.08	0.50	0.58	1.79	0.19	1.17	0.56	1.16	1.26	3.41	3.41	1.81	7.26
9	0.84	1.97	0.27	0.46	0.26	0.21	1.65	0.28	0.44	0.29	0.45	0.93	1.32	1.52	1.58	1.44
10	-	0.54	0.25	0.15	0.22	0.33	1.41	0.14	0.43	0.15	0.37	0.86	0.45	0.66	0.85	0.77
11	0.29	-	0.19	-	0.11	-	0.24	0.19	-	-	0.37	0.24	0.10	0.25	0.32	0.67
12	0.14	-	-	-	-	0.11	0.23	0.25	-	0.17	-	0.16	0.23	-	0.41	-
13+	0.13	0.56	0.37	-	-	-	0.47	0.22	0.11	0.45	-	0.31	-	0.43	0.46	0.37
UK	0.21	0.40	0.37	0.22	-	0.16	-	0.07	0.12	-	-	0.17	0.10	0.27	0.23	3.63
No./tow	42.96	114.05	8.39	38.18	9.47	23.47	20.21	18.58	42.84	13.66	63.84	110.98	42.73	63.30	52.14	237.94
kg./tow	57.47	128.20	22.12	53.25	14.44	32.75	43.41	26.58	67.55	27.58	85.55	161.81	74.82	78.60	102.30	295.97

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Table 6. A comparison of the mean numbers of cod caught per tow for each stratum from the 4Vn summer survey (Numbers corrected for distance towed).

Stratum no.		40	41	42
Percent of area:		27.5%	29.8%	42.7%
Depth range:		>100 fm.	51-100 fm.	≤50 fm.
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Year	Vessel			
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1970	ATC	0.49	107.81	25.02
1971	ATC	1.25	320.84	41.99
1972	ATC	5.07	8.81	10.16
1973	ATC	1.01	79.92	33.32
1974	ATC	8.12	14.50	6.83
1975	ATC	0.00	71.88	4.86
1976	ATC	0.00	16.58	35.73
1977	ATC	0.36	19.05	29.83
1978	ATC	2.53	62.40	55.16
1979	ATC	2.72	15.62	19.34
1980	ATC	0.34	135.79	54.44
	LH	0.29	127.99	69.37
1981	ATC	79.19	37.39	182.64
	LH	123.88	80.37	60.86
1982	LH	6.74	75.70	42.93
1983	AN	7.63	113.18	64.30
	LH	7.62	149.24	44.03
1984	AN	2.31	99.29	74.76
1985	AN	0.77	76.55	502.88

Table 7. Data used to generate 1985 catch at age estimates for 4Vn (M-D) cod.
Length-weight parameters: a=0.00769, b=3.033.

Gear	Time Period	# of samples Length (age)	No. Measured	No. Aged	Catch (t)
Longline TC 1	May-Sept	14 (14)	3622	646	2133
Longline TC 2	May-Sept	0	0	0	840
Longline TC 1	Oct-Dec	7 (7)	1122	276	1391
Longline TC 2	Oct-Dec	2 (7)	594	276	461
Otter Trawls	May-Oct	14 (14)	3173	646	3956
	Oct-Dec	7 (7)	1829	276	947
Seines	May-Sept	5 (14)	1639	646	1030
Seines *	Oct-Dec	2 (7)	627	276	144

*Used Otter Trawl tonnage class 2 samples.

Table 8. 4Vn Cod(May-Dec): catch at age by longlines(thousands)

AGES	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2	–	–	–	–	–	1	–	–	–	–	–	1	–	–	–	–
3	3	10	–	7	15	44	–	–	35	–	–	85	32	8	5	20
4	62	43	676	133	179	177	–	–	277	17	8	221	227	69	116	56
5	322	236	39	437	181	127	5	–	265	208	105	310	662	412	306	339
6	314	492	604	87	184	73	10	–	197	480	532	409	477	436	438	341
7	181	600	444	193	54	36	25	–	120	305	747	672	805	294	400	469
8	208	63	209	230	66	17	27	–	76	185	386	529	507	492	228	283
9	56	152	2	51	82	13	17	–	49	91	219	267	209	163	250	174
10	40	48	21	17	26	11	15	–	54	17	127	151	78	137	152	141
11	82	14	50	9	–	4	10	–	20	39	32	57	50	35	69	60
12	21	7	2	5	4	–	10	–	18	8	8	52	22	33	23	27
13	17	28	1	6	1	–	–	–	13	4	8	53	8	11	8	15
14	11	1	–	1	1	1	–	–	3	4	–	5	3	5	4	4
15	1	7	1	–	1	–	–	–	8	–	–	8	2	5	4	5
16	–	5	1	2	1	–	10	–	4	–	–	18	15	11	6	7

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Table 9. 4Vn Cod(May-Dec): mean weight at age for longline catch(kg.)

AGES	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	0.28	-	-	-	-	-	0.21	-	-	-	-
3	0.60	0.48	-	0.40	0.49	0.53	-	-	0.56	-	-	0.50	0.58	0.65	0.51	0.53
4	0.79	0.77	0.82	0.72	0.81	0.84	-	-	0.99	0.93	0.73	0.90	0.91	0.84	0.83	0.75
5	1.09	1.04	0.91	1.17	1.28	1.29	1.82	-	1.40	1.63	1.22	1.35	1.33	1.22	1.28	1.16
6	1.67	1.45	1.72	1.75	1.72	1.79	2.46	-	2.14	2.54	2.03	2.15	1.79	1.63	1.64	1.61
7	2.14	2.01	1.66	1.78	2.65	2.29	3.08	-	3.27	3.78	2.49	2.94	2.09	2.12	2.12	2.27
8	3.11	4.33	2.10	2.14	2.40	2.00	4.18	-	4.14	3.92	3.14	4.28	3.01	2.31	2.60	2.82
9	4.38	3.60	9.29	2.79	2.50	3.18	4.23	-	4.97	4.99	4.55	5.21	4.09	3.50	2.97	3.30
10	4.39	5.24	6.91	5.33	3.14	3.50	6.19	-	5.27	6.95	6.21	6.23	5.87	3.95	3.98	4.11
11	5.15	6.29	3.46	5.98	7.72	4.41	6.07	-	6.27	7.78	6.99	7.75	6.22	6.41	5.71	4.95
12	8.07	8.55	9.29	5.68	4.15	7.72	7.50	-	6.45	9.78	7.65	9.29	7.39	8.53	8.64	7.69
13	8.79	4.84	15.23	7.24	11.06	11.06	-	-	7.98	10.72	8.36	8.80	8.91	9.75	9.82	8.32
14	9.49	13.45	-	10.15	10.26	8.79	-	-	8.93	6.88	-	8.53	8.60	10.22	11.39	10.51
15	12.02	12.03	11.06	13.03	11.37	-	-	-	9.16	-	-	9.45	11.94	11.34	10.50	9.51
16	-	10.71	15.23	7.01	6.08	8.48	9.39	-	14.09	-	-	11.59	10.80	12.24	11.73	14.22

Table 10. 4Vn cod(May-Dec): catch at age by longlines, handlines,
         otter trawls and seiners for 1984 and 1985 (thousands).

		Gear						
Age	Longlines		Handlines		Otter Trawls		Seiners	
	1984	1985	1984	1985*	1984	1985	1984	1985
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	5	20	3	-	6	50	-	22
4	116	56	39	-	247	150	10	59
5	306	339	95	-	658	768	104	257
6	438	341	128	-	804	702	223	161
7	400	469	120	-	301	711	113	121
8	228	283	32	-	148	288	36	53
9	250	174	42	-	31	130	37	22
10	152	141	22	-	28	61	15	13
11	69	60	20	-	6	20	4	3
12	23	27	4	-	1	3	2	1
13	8	15	2	-	-	1	1	-
14	4	4	1	-	-	-	-	-
15	4	5	1	-	1	-	-	-
16	6	7	1	-	1	-	1	-

* No samples collected.

Table 11. Longliner catch of cod and associated catch-per-unit-effort
         for 1968-1985, 4Vn(May-Dec).

Year	Longliner Catch (t)	Proportion of catch with effort reported	CPUE (t/1000 hks)
1968	2455	0.066	0.452
1969	3300	0.097	0.646
1970	3229	0.130	0.625
1971	3728	0.071	0.507
1972	3185	0.138	0.440
1973	1982	0.192	0.338
1974	1469	0.197	0.325
1975	875	0.022	0.232
1976	620	0.011*	0.084
1977	1805	0.027	0.499
1978	3035	0.141	0.422
1979	4483	0.169	0.545
1980	6440	0.111	0.504
1981	9801	0.028	0.666**
1982	7287	0.077	0.408
1983	5101	0.105	0.319
1984	4831	0.111	0.435
1985	4825	0.099	0.357

* based on one log record
** calculated for records from May to September only.

Table 12. 4Vn Cod: Total mortality estimates from CPUE-at-age
         (numbers) from longline catches.

			Years			
Age Groups	80/81	81/82	82/83	83/84	84/85	Mean
4+/5+	⁻0.011	0.163	0.3	⁻0.256	0.269	0.093
5+/6+	0.116	0.345	0.449	⁻0.113	0.41	0.241
6+/7+	0.27	0.462	0.497	⁻0.015	0.486	0.34
7+/8+	0.434	0.901	0.534	0.102	0.665	0.527
8+/9+	0.386	1.274	0.694	0.183	0.738	0.655
9+/10+	0.277	1.427	0.38	0.044	0.886	0.603
10+/11+	0.044	1.43	0.467	0.368	1.01	0.663
11+/12+	⁻0.9	1.545	0.321	0.434	0.873	0.455

Table 13. Allocation history for 4Vn Cod (May-Dec.)

Year	Gear Category	Initial	Final	Closure Date	Final Catch (Quota Report)
1981	Vessels > 100				
	Mob. gear 65-100	500	700		600
	Fixed gear 65-100				
	Mob. gear < 65	800	1100		1221
	Fixed < 65	6100	8100	17/10	10603
Total		7400	9900		
1982	Vessels > 100	800	1500		1716
	Mob. gear 65-100	100	100	27/11	108
	Fixed gear 65-100	100	100		17
	Mob. gear < 65	900	1850		1526
	Fixed < 65	8500	10350		8667
Total		10400	13900		
1983	Vessels < 100	800	800		733
	Mob. gear 65-100	100	100	16/09	145
	Fixed gear 65-100	100	100		95
	Mob. gear < 65	1900	1900		2322
	Fixed gear < 65	11000	11000		6084
Total		13900	13900		
1984	Vessels > 100	800	800		451
	Mob. gear 65-100	100			
	Fixed gear 65-100	100	200		200
	Mob. gear < 65	1900	3100	01/11	4115
	Fixed gear < 65	11000	9800		5991
Total		13900	13900		
1985	Vessels > 100	800	800		592
	Mob. gear 65-100	100	250	17/08	313
	Fixed gear 65-100	200	50		-
	Mob. gear < 65	3000	3500		5185
	Fixed gear < 65	7800	7300		6416
Total		11900	11900		

Table 14. Total mortality estimates for longliner and otter trawl catch
at age 1984-1985.

	longline	otter trawl
3+/4+	0.241	‾0.079
4+/5+	0.269	‾0.027
5+/6+	0.410	0.192
6+/7+	0.486	0.244
7+/8+	0.665	0.187
8+/9+	0.738	0.165
9+/10+	0.886	‾0.063
10+/11+	1.010	0.593
11+/12+	0.873	0.971

Table 15. Results from using Leap Frog TAC Method.

Age	1984	1985	1986 (predicted)	Avg. Weight
1	0	0	0	0
2	0	0	0	0
3	14	107	44*	0.55
4	416	309	1605	0.82
5	1174	1589	809	1.20
6	1608	1403	1302	1.57
7	943	1516	906	2.03
8	448	727	801	2.47
9	364	330	422	2.83
10	219	251	179	3.16
11	100	97	76	4.44
12	30	36	24	7.19
13	11	19	15	8.20
14	5	5	5	10.23
15	6	6	4	8.62
16	9	8	5	13.20

TAC = 10,710 (t)

$$\left(\frac{F_{84}}{F_{85}}\right)^2 \quad = \quad \left(\frac{f_{84}}{f_{85}}\right)^2 \quad = 0.686$$

* Recruitment was estimated from average age 3 from 1984 and 1985.

Figure 1: 4Vn Cod (May-Dec): Nominal Catch
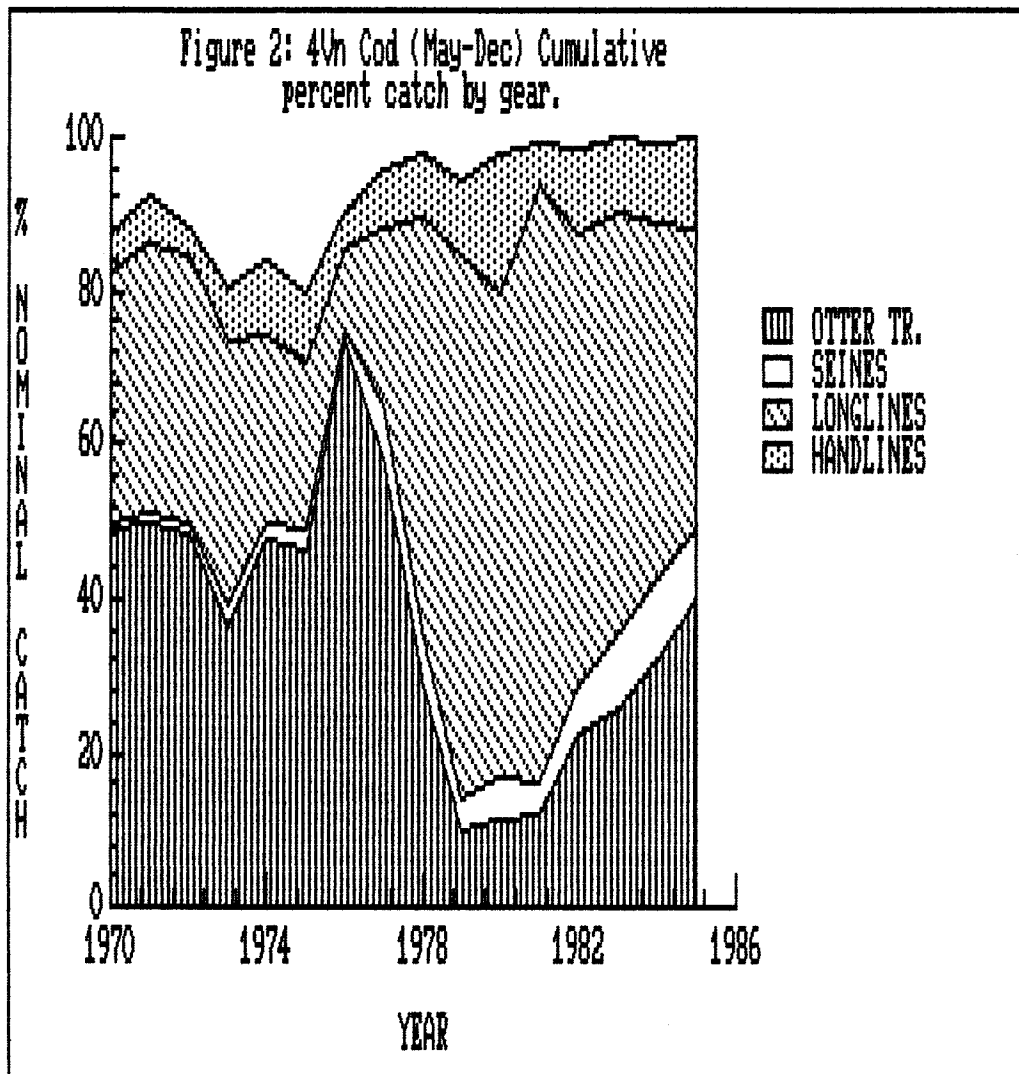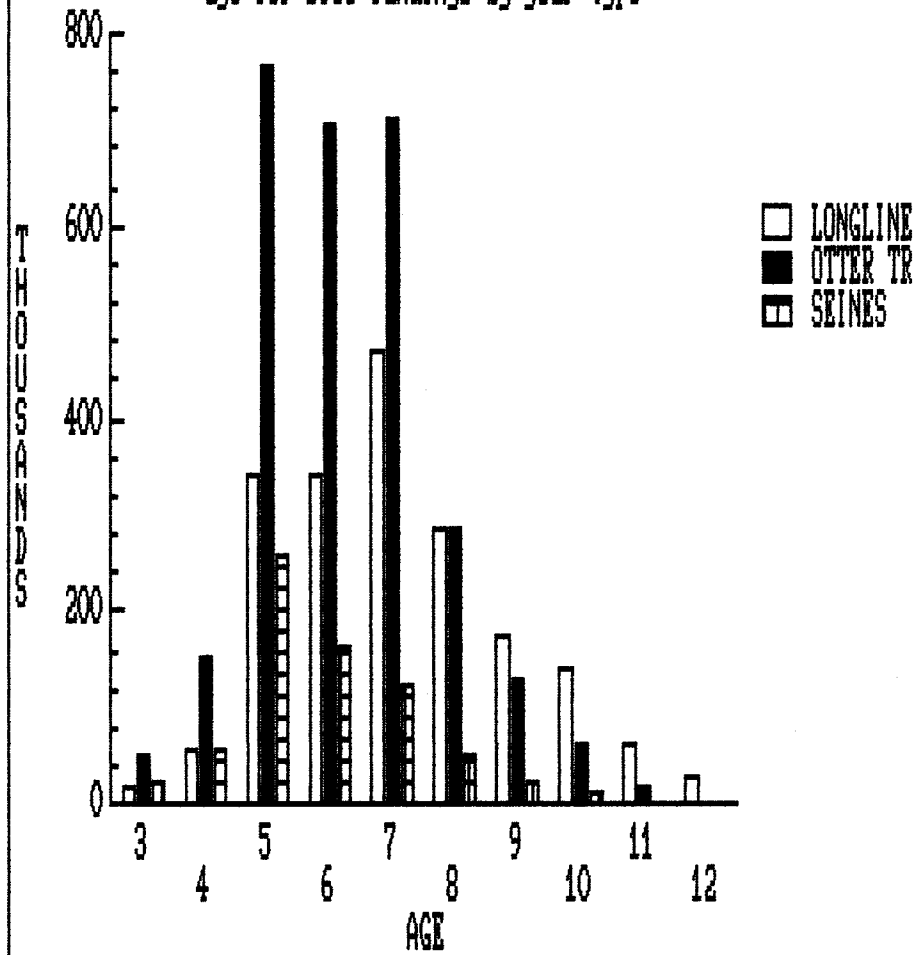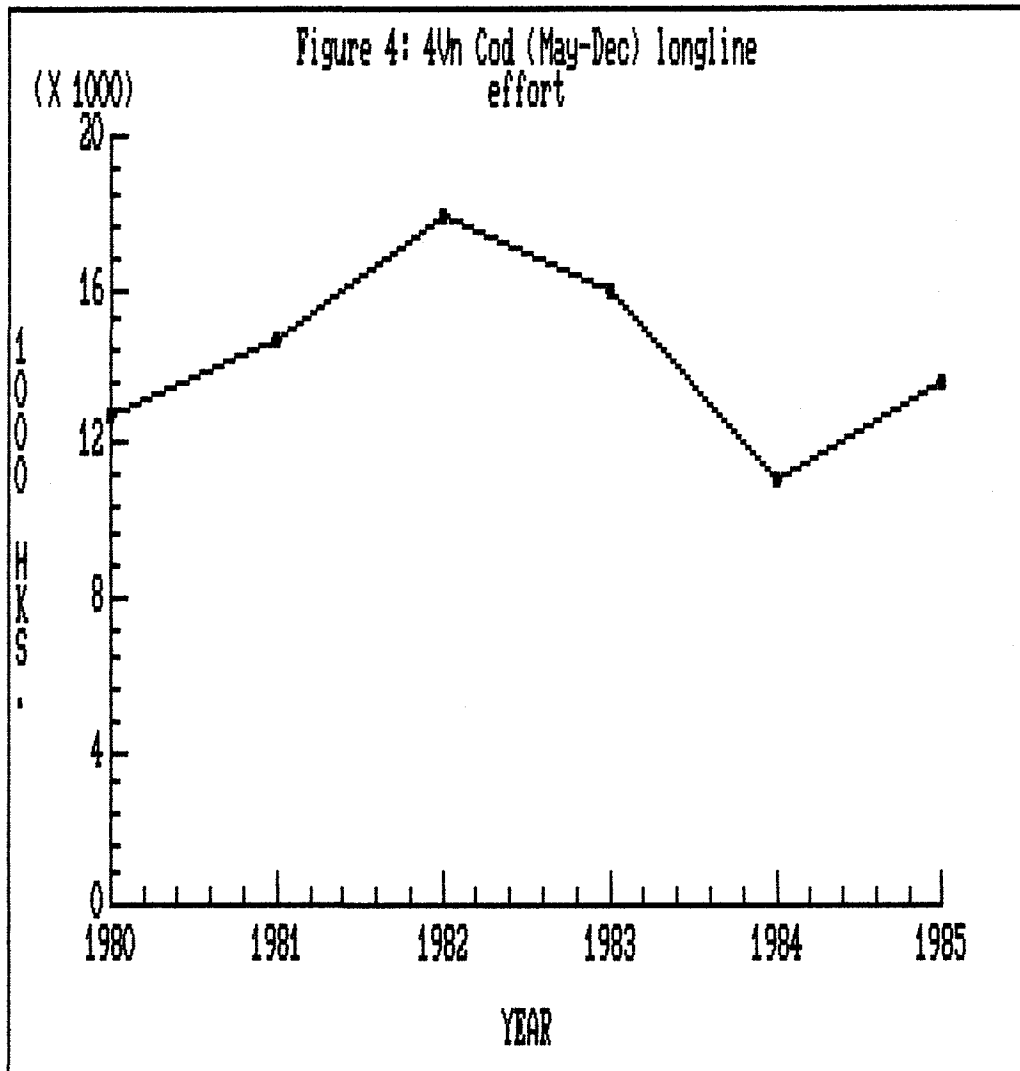
Figure 2: 4Vn Cod (May-Dec) Cumulative percent catch by gear.
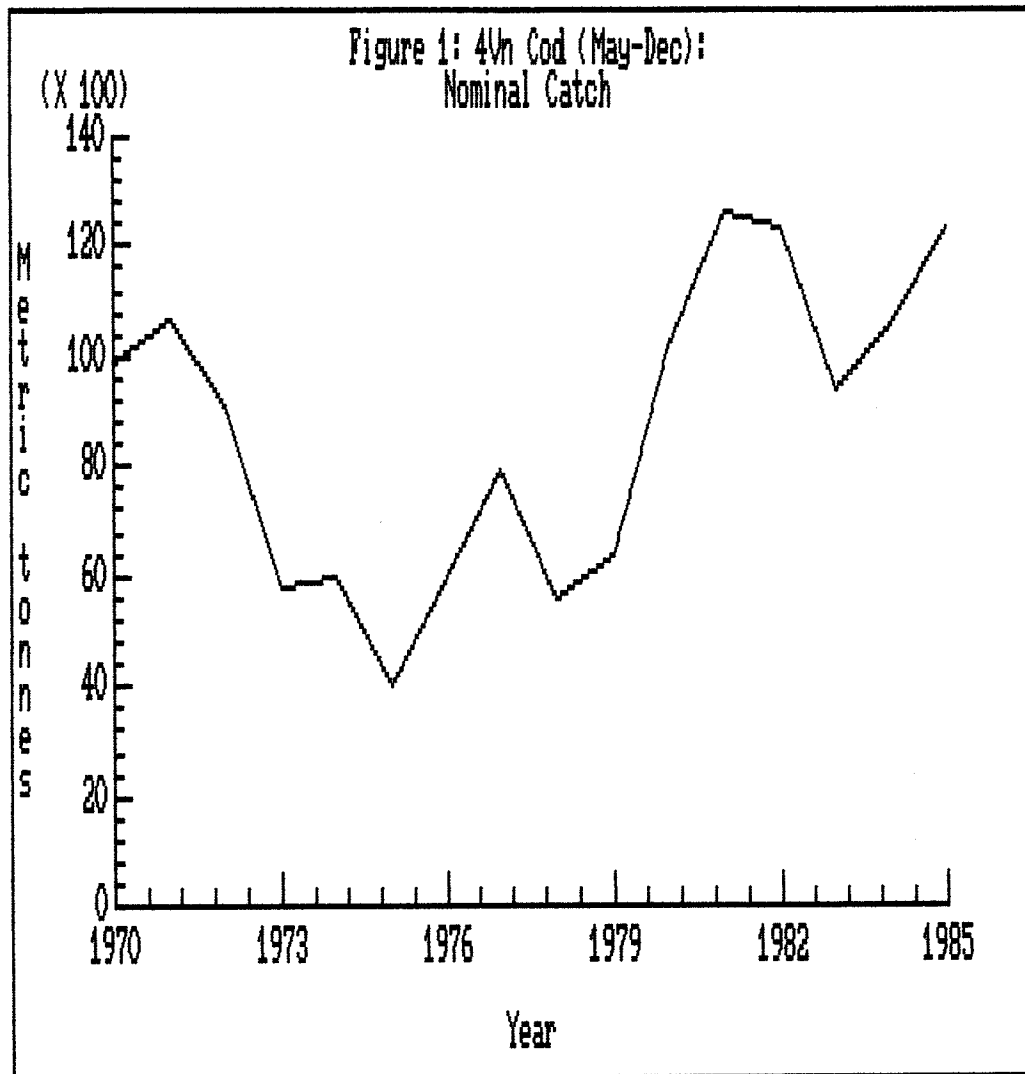
Figure 3: 4Vn Cod (May-Dec) Numbers at age for 1985 landings by gear type
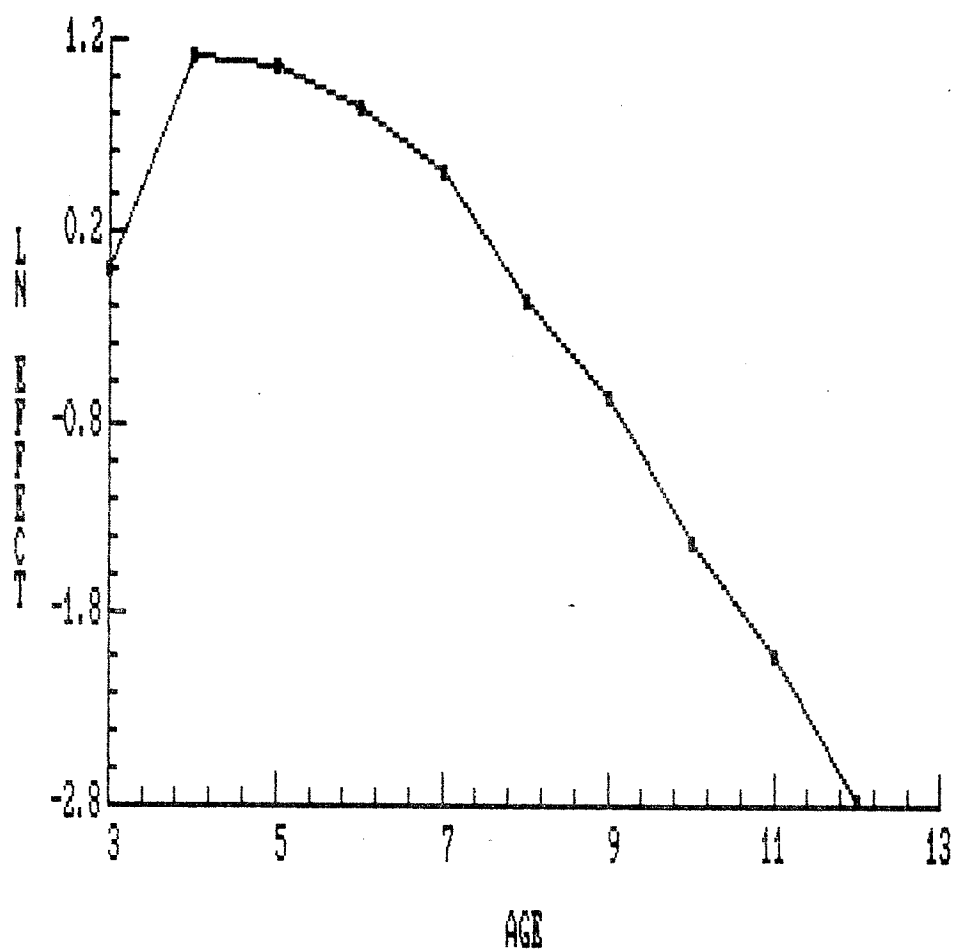
Figure 4: 4Vn Cod (May-Dec) longline effort

Figure 5. Catch curve for 4Vn (M-D) cod estimated from
longliner catch at age 1980-85. For ages 6-12
total mortality was estimated to be 0.61 using
linear regression.