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Subdivision 4Vn Cod (May-December): Status Review for the 1986 Fishing Year

by

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Abstract

The nominal catch of cod in 4Vn (May-December) was 11,756 t, a decrease of 610 t from the catch in 1985. The longliner catch in 1986 was 1,047 t higher than that reported for this gear in 1985 while the 1986 Canadian otter trawler catch was 1,718 t less than in 1985. The mobile gear fleet fishery (<65') was closed in May and operated under trip limits for the rest of the year while the fixed gear fleet (<65') was under trip limits from August to December.

This report summarizes the available information for this fishery in 1986. Fishing mortality was estimated to be in excess of F(0.1). An estimated F(0.1) catch of 6,200 t was recommended for 1988.

Résumé

La prise nominale de morues dans 4Vn (mai-décembre) a été de 11 756 t, ce qui représente une diminution de 610 t par rapport à la prise de 1985. En 1986, la pêche à la palangre a dépassé de 1 047 t les chiffres enregistrés en 1985, mais en 1986, les chalutiers ont récolté 1 718 t de moins qu'en 1985. En mai, ont été fermées les pêches par engins mobiles; elles ont repris le reste de l'année dans des conditions de parcours restreint; la flottille à engin fixe (< 65') a été soumise à de telles conditions de parcours restreint d'août à décembre.

Dans ce rapport, est présentée sous forme résumée l'information disponible sur ces pêches, en 1986. On a estimé que la mortalité à la pêche dépassait F(0,1). On a recommandé pour 1988 des prises estimées de 6 200 t, avec F(0,1).

Introduction

This document presents information on the cod fishery in NAFO subdivision 4Vn (May-Dec) for 1986. In addition research recommendations made at the 1986 groundfish meeting are addressed here. These are;

1) Test the Leap-Frog TAC method on this and other stocks in order to evaluate the usefulness of the method.

2) Attempt to quantify the effect of otter trawlers on the potential catch of longliners.

3) Compare the 1986 predicted catch at age from the Leap-Frog method with the observed 1986 catch at age.

Nominal Catch

The nominal landings for Canada and selected countries for the period 1970-1986 are presented along with TAC information to 1987 in Table 1. Note that for the years 1977-1980 the TAC was actually an allowance for the fixed gear component only. Total nominal landings for the same period are presented in Figure 1. The TAC trend on this Figure includes the changes made during 1981 and 1982 as explained in Table 1. Landings for 1986 showed a negligible decrease of 610 t over 1985. There were no landings reported for France even though 100 t were allocated, however Japan landed 1 t in its redfish fishery.

Otter trawlers and longliners continue to be the major gear components of this fishery (Figure 2 and Table 2). In 1986 landings for the otter trawlers were 1,723 t less than in 1985 while the longliners landed 1,047 t more than in 1985. Landings for the other components remained relatively stable.

Landings by tonnage class and gear for Canadian vessels for 1985 and 1986 are presented in Table 3. Large trawlers (tonnage class 6 and 7) reported landings in 1986 and these were mainly bycatch from the pollock fishery. Tonnage class 3 trawlers showed the largest decrease from 1985 while all tonnage classes of longliners experienced increases with tonnage class 2 vessels realizing the largest increase.

The monthly breakdown of landings by gear component is given in Table 4 for 1985 and 1986. The seasonal pattern of fishing by mobile gears specifically those vessels less than 65 ft. has been modified by the current allocation schedule. Details of this system are given in the table below.

Gear	Period	Quota (t)	Comments
All vessels >100'	May-Dec.	800	No closure
fixed 65-100'	May-Dec.	100	No catch
fixed <65'	May-Dec.	7300	Closed 1/8*
mobile 65-100'			
Shrimp fleet	May-Dec.	100	No Closure
Groundfish fleet	May-Dec.	100	Closed 27/8
mobile <65'			
Sector Overlap (4R, 3Pn)	May-Dec.	300	Closed 1/5
mobile <65'	May 1 - June 15	1200	Closed 2/5
	June 16 - Aug. 31	500	Closed 16/6
	Sept. 1 - Oct. 31	1000	Closed 12/9
	Nov. 1 - Dec. 31	500	Closed 9/10

* date of closure (day/month)

The closure of the fixed gear <65' resulted in the setting of 9000 kg. trip limits until the end of the year. The situation for the mobile gear <65' was more complex. Trip limits of 4500 kg., 7000 kg. and 1500 kg. (with 10% bycatch) were set on May 2, June 16 and July 19, respectively. On August 26 the fleet was restricted to a 10% bycatch only. A trip limit of 7000 kg. was set in September but this was eliminated on October 9 and a 10% bycatch was enforced. The effect of these restrictions is quite evident in Table 4b where landings by otter trawlers were only 390 t from October to December compared to 947 t for the same period in the previous year. Note that the mobile gear fishery was closed in 1985 as of August 23.

Research Surveys

Estimated stratified mean numbers/tow by age, stratified mean numbers/tow and mean weight/tow from the July surveys are presented in Table 5.

Trends for the mean numbers and mean weight for the July survey are presented in Figure 3. The 1985 point is the largest in the series while the 1986 point is in line with the 1982-1984 values. The results from 1986 support the observation made last year that the 1985 survey estimate appears to be anomously high.

The 1980 year-class appears to be strong when compared to other year-classes at age 6 in recent years with the exception of the 1985 survey (Table 5). The 1982 year-class appears to be fairly strong in the 1986 survey, however this year-class does not look exceptional in the 1985 survey.

This survey, like those for other stocks and species indicates unrealistically rapid changes in abundance over time when compared to catches. There are only three strata in this area and for most years only 9 sets in total were fished, although the 1986 survey successfully completed 15 sets in the area. No doubt, the routinely small number of sets contributes to the high variability of the series. In order to assess the usefulness of this measure of stock abundance it is desirable to express both the survey estimates and the catch trends on the same scale. A robust method of scaling both series is to centre each series by its median and then scale by their respective median absolute deviatian. This was done and is presented in Figure 4. Note that the spikes in the survey are still present but we can now assess how serious they are against concurrent changes in landings. The high points in 1971, 1981 and 1985 are of particular note since each appears to be coincident with modest increases in the landings series. In all three of these years there were larger than usual survey catches made with 1981 being especially unusual in that the large catch occurred in strata 40 where catches are for the most part small (Table 6).

The possibility that environmental conditions influence survey catches was considered for 4VsW cod by Sinclair and Smith (MS 1987) and was also investigated here for 4Vn cod. For the present this study was confined to looking at the effect of temperature and depth. Observed temperatures and depths from survey sets for 1970-1985 are given by stratum in Figure 5. The three strata appear to be characterized by unique temperature patterns with depth. Temperatures in the deepest stratum (40) appear to be stable and in general range between 4.5-5.7 degrees C. The temperatures in stratum 41 tend to increase with depth whereas in stratum 42 they were quite variable with depth, with the majority being less than 4.0 degrees C. The shallow set (<50 fm.) in stratum 41 and the deep set (>50 fm.) in stratum 42 were in the correct strata but in unusual depths for these strata. The large catch in stratum 40 in 1981 (see above) was associated with a temperature of 2.9 degrees C. and a depth of 120 fms. Apparently this was an unusual temperature for this depth and temperature.

The temperatures and depths associated with the other large catches discussed above suggest that in the surveys at least, such occurrences are never associated with temperatures greater than 4.5 degrees C. In fact sets made in areas where the temperatures are in excess of 5 degrees C. rarely contain any cod. Therefore it would appear that the warmer water in stratum 40 and in the deeper parts of stratum 41 may be a barrier to cod distribution. The occurrence of the large set in the relatively cool waters in stratum 40 in 1981 is interesting because of reports from the commercial fishery of the longliner fleet concentrating in the same general area (Smith and Sinclair, MS 1985). Since then the longliners have shifted their activities closer inshore.

One important impact that temperature could have on this survey is related to the set-to-strata allocation scheme and the associated stratum weights. The percent area covered by each stratum is given at the top of Table 6. The current practise is to allocate the same number of sets to each of the strata which results in observations in stratum 42 having the largest weights with respect to the estimate of abundance. If conditions in this stratum are such that large aggregations of cod and hence large catches are more likely then the large stratum weight will result in such sets dominating the abundance estimate. Although this estimate may reflect true abundance it may also be confounded with the possible aggregating effects of temperature. The small sample size in this area makes it difficult to study these effects any further with the data at hand.

Commercial Catch at Age

Sampling coverage of the commercial catch covered all of the major gear components although there were few samples from the fall probably due to the restricted fishing at that time. Details of the data used to estimate the age compositions are given in Table 7. Longline and handline age samples were combined in the May to Sept. period as were the otter trawl and seine age samples. All of the age samples for all of the gears were combined for the Oct. to Dec. period. The length-weight parameters were estimated from the July groundfish cruise.

The longline age compositions and weight at age for the period 1970-1986 are presented in Tables 8 and 9, respectively. The 1980 year-class dominated the 1986 landings with strong representation from the 1981 and 1979 year-classes. Weights at age do not appear to indicate any trends over the last three years.

The age compositions for the major gear sectors for 1984-1986 are presented in Table 10 and for 1986 in Figure 6. There were no samples collected in 1977. The 1980 year-class figured prominantly in all but the handline landings. The 1979 and 1981 year-classes were also strong in the otter trawl and seine age compositions. The 1978 year-class was strong in the 1985 otter trawl catch but was less so in the 1986 catch. Although the otter trawl catch in weight was less than the longline, more 1980 and 1981 year-class fish in numbers were landed by the otter trawlers.

Catch per Unit Effort

The longliner CPUE estimates for tonnage class 2 vessels for the period 1968-1986 are presented in Table 11. The proportion of the catch with effort reported continues to be low for this gear category with only 6.8% of the longliner catch being represented in 1986.

An analysis of catch rate estimates from the longliners and the otter trawlers for the period 1981-1986 was carried out using a Multiplicative model. The analysis was done using the GLIM (Generalized Linear Interactive Modelling) software (Payne, 1986). Smith and Sinclair (MS 1987) discuss the use of this system to explore and evaluate linear models.

Four factors were identified for evaluation in this model. These factors were: GEAR (longlines, stern otter trawls and side otter trawls); TON (tonnage classes 2-5); MONTH (May-December) and YEAR (1981-1986). All observations with either catch or effort less than 10 units were omitted. The multiplicative model of ln(catch rate) as a function of these factors was evaluated through the successive fitting of the various factors. The associated analyses of deviance (see Payne, 1986 or Sinclair and Smith, MS 1987) are given in Table 12.

In analysis (i) the factor MONTH was not significant at the 5% level after GEAR and TON was entered into the model. The effect due to TON was confined to differences between tonnage class 3 vessels and the other classes. The effect of GEAR was due to the catch rates for both types of otter trawls being on the average greater than those for the longliners. Although, YEAR was significant once GEAR and TON were entered, the individual coefficients for YEAR were not, suggesting possible interactions between YEAR and one or both of the other two factors.

The possibility of interaction between YEAR and the other factors was explored in analysis (ii) (Table 12). When YEAR is entered into the model first or after GEAR it was not siginificant at the 5% level. Therefore it appears that TON and YEAR are related in some way. However the interaction term YEAR.TON was not significant once GEAR and TON were accounted for. When a model of the form 1 + GEAR + YEAR.TON was fitted, the interaction term was marginally significant but this was due to two observations in 1985 for tonnage class 4 side trawlers. There were only two observations for this gear in that year and both catch rates were much higher than those of the other two gears in the same year.

The fact that a few observations may be exerting a large amount of influence or leverage on the predicted values was explored further by identifying high leverage points from the diagonal elements of the hat matrix (Sinclair and Smith, MS 1987). Fifteen points were so identified and removed from the

analysis (analysis (iii)). Now TON is marginally significant at the 5% level while YEAR was not. The high leverage points were identified as being the larger otter trawls TC4 and TC5 but the bulk of the observations consists of TC2 and TC3 longliners and stern otter trawlers. The model for the latter group is simply ln(catch rate)=1 + GEAR + TON and does not show any relation to year.

Mortality Estimates

Total mortality estimates were estimated from CPUE (numbers) for the longline and otter trawl catch for 1984-1986 (Table 13). Year by year estimates were calculated as well as average mortality over the two years. The large catch of the 1980 year-class in the 1986 longliner catch resulted very small estimates of mortality for 5+/6+ and 6+/7+. The drop in the 1979, 1978 and 1977 year-class representation in the otter trawl catch in 1986 relative to 1985 resulted in estimates of mortality in excess of 1.0 in 1985/1986. Averaged estimates over the two time periods indicate fishing mortality to be in excess of F(0.1).

Total mortality estimates from longliner CPUE (numbers) for the period 1980-1986 are given in Table 14. The longer term average estimates indicate that fishing mortality for this gear have been in excess of the F(0.1) for some time.

The suitability of the above calculations for the most recent year must be questionned especially for the otter trawlers, given the imposition of trip limits for most of the year. The same point may be made for the longliners however it is not known how restrictive their trip limits were. Under the current management scheme it is likely that effort and catch per unit effort measures will mean very little.

Interaction between Longlines and Otter trawls

The effects of the annual transfer of quota from the small fixed gear fishery to the mobile fleet which had been occurring in recent years in 4Vn, was investigated (Sinclair, MS 1986) and reported to the Groundfish Subcommittee in September of 1986. There was a lack of the necessary data for the 4Vn cod fishery to carry out the study and therefore data from the 4VsW cod fishery was used to investigate the interaction between longliners and otter trawlers. Sinclair concluded that adding otter trawl effort to a predominantly longline fishery would have serious effects with respect to the expected decrease in longterm yield to both gear components. The reverse situation, that of adding longline effort to an otter trawl fishery was judged to be less serious.

The decline of the catch of the fixed gear component relative to the increase of the mobile gear catch appears to have been halted for the present.

Estimation of Total Allowable Catch

Previous to last year, catch levels for this stock had been based on a general production analysis which had estimated a long term yield at 2/3 E(msy). In Smith and Sinclair (MS 1986) a short term forecasting method known as the Leap-Frog TAC method was used. This method which assumes that the fishing mortality in the current year is equal to that in the previous year and uses the catch for the current year and the previous year to project the catch for the following year.

The method was tested on three stocks (4VsW cod, 4VW haddock and 4VWX +5 pollock) for which sequential population analyses (SPA) were routinely carried out. The method essentially breaks down into two components. The first is the estimation of age compositon of the forecasted catch and the second involves the scaling of this composition to give numbers at age. Average weights at age are used to estimate the TAC. The study concluded that the estimate of age composition compared favourably with SPA for the above stocks. However the TAC prediction was very sensitive to the assumptions made in estimating the scaling factor. This factor is essentially a Paloheimo Z type of estimate and is a much more variable estimate than that obtained from SPA.

The projected and observed age composition for the 1986 catch is given in Figure 7. The projection underestimated the 4, 5 and 6 year olds while overestimating the other ages. The differences between the projected and observed is mainly due to the unexpectedly large catch of 5 and 6 year olds relative to the trends noted between 1984 and 1985 and the marked decrease of the 8 and 9 year olds (Table 15).

The scale factor used in Smith and Sinclair (MS 1986) was derived from total effort estimates for 1984 and 1985 using the coefficients for the different gears obtained from the multiplicative model for 4VsW cod, to express effort in the same units. The scale factor was simply the ratio of the effort in 1984 and in 1985 squared. This is given as estimate 1) in Table 15. The results of the multiplicative analysis for 4Vn given earlier indicates that catch rate is not related to year and therefore the ratio of the effort can be simply estimated as the ratio of the catches in 1984 and 1985. This estimate is given as 2) in the Table. The Leap-Frog projection to 1987 was made using the same approach as in estimate 2).

An alternative approach to estimate the F(0.1) catch was used in Smith and Sinclair (MS 1986) last year. For an average catch over the last 6 years and current total mortality at 0.6, biomass was estimated using the catch equations. This estimate was used to give an F(0.1) catch of approximately 6000 t. The average catch for 1980-1986 was 11,299 t which results in an estimated biomass of 37,564 t. Assuming that total mortality is 0.6 and the current fishing mortality is at least 0.4 the F(0.1) catch is estimated to be 6,192 t. It should be reiterated that this method assumes that biomass has been relatively stable over the last 7 years, age structure is stable, recruitment is stable and there has been no changes in partial recruitment.

Summary

The 1986 landings showed a small decrease from 1985. The major changes were an increase in landings by longliners while the otter trawler landings decreased. Both gear components were placed under trip limits early in the year.

The research surveys indicate that the stock has been relatively stable over the last 5 years. The 1980 year-class still appeared to be strong with 1982 being the only other promising year-class for the moment. Further study on the effect of temperature on the survey indices may help us to understand the variability of the series.

The 1980 year-class figured strongly in the longliner, otter trawler and seine catches. The 1981 and 1979 also appeared to be strong but the 1978 year-class decreased dramatically in the 1986 otter trawl catch compared to 1985. The 1982 year-class appeared promising in the longliner catch only.

Trends in catch per unit effort are becoming less reliable and the restriction of the fleets to trip limits over much of the fishing year will probably render them useless. The same can be said for recent estimates of total mortality estimates CPUE estimates are required for them.

An analysis of the interaction between longliners and otter trawlers was reported in Sinclair (MS 1986).

The Leap-Frog method can give reasonable estimates of the age composition of the projected catch but the estimate of the scaling factor required to adjust this age composition to numbers at age was less reliable. Comparison of the projected and observed 1986 age composition appeared to confirm the first finding. Lack of reasonable CPUE estimates in order to derive total effort estimates makes it difficult to use the method for this stock.

The estimated fishing mortality remains at approximately twice the F(0.1) level and therefore the estimated F(0.1) catch is 6,200 t for 1988.

References

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Table 1. Nominal cod catch (t) by country in Subdivision 4Vn (May-Dec.)

Year	Canada	France	Spain	Portugal	Others	Total	TAC
1970	8701	34	1141	-	12	9888	-
1971	8469	1	2161	-	-	10631	-
1972	6729	745	1171	459	-	9104	-
1973	5245	-	241	189	73	5748	-
1974	4836	-	852	84	212	5984	10000
1975	3363	-	89	360	186	3998	10000
1976	5746	211	-	-	-	5957	10000
1977	7786	135	-	-	-	7921	3500
1978	5496	53	-	-	-	5549	3500
1979	6301	73	-	-	-	6374	3400
1980	9976	214	-	-	-	10190	5000
1981	12476	172	-	-	-	12648	*
1982	12101	232	-	-	-	12333	**
1983	9192	170	-	-	-	9362	14000
1984	10443	-	-	-	1	10444	14000
1985 a	12361	-	-	-	5	12366	12000
1986 a	11755	-	-	-	1	11756	12000
1987							9000

* initially set at 7500 t, increased in September to 10,000 t.
** initially set at 10500 t, increased November 1 to 14,000 t.
a Preliminary statistics

Table 2. Nominal catch (t) of cod in Subdivision 4Vn (May-December) by gear type for all countries, 1970-1986.

Year	Otter Trawls	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	3344	1112	4831	1112	45	10444
1985 *	4908	1174	4825	1407	52	12366
1986 *	3185	1277	5872	1191	231	11756

* Preliminary statistics.

Table 3. Nominal catch by Canadian vessels of cod in 4Vn (May-Dec.) by tonnage class and gear. Percentage of gear total catch by tonnage class is in parentheses.

Tonnage Class (GT)	Otter Trawls	Seines	Longlines	Handlines	Other	Total
1985						
1) 0-24.9	5 (0)	555 (47)	3524 (73)	1402 (100)	23 (44)	5509
2) 25-49.9	1314 (27)	566 (48)	1255 (26)	5 (0)	-	3140
3) 50-149.9	2918 (60)	53 (5)	46 (1)	-	29 (56)	3046
4) 150-499.9	308 (6)	-	-	-	-	308
5) 500-999.9	358 (7)	-	-	-	-	358
Total	4903	1174	4825	1407	52	12361
1986						
1) 0-24.9	65 (2)	479 (38)	3590 (61)	1175 (98)	71 (31)	5380
2) 25-49.9	1101 (35)	687 (54)	2098 (36)	7 (1)	160 (69)	4053
3) 50-149.9	1386 (44)	111 (8)	184 (3)	9 (1)	-	1690
4) 150-499.9	363 (11)	-	-	-	-	363
5) 500-999.9	236 (7)	-	-	-	-	236
6-7) 1000+	33 (1)	-	-	-	-	33
Total	3184	1277	5872	1191	231	11755

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

a) 1985

Gear	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Totals
Longlines	437	514	443	631	1048	698	625	429	4825
Handlines	1	22	226	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

b) 1986

Gear	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Totals
Longlines	592	529	542	760	1056	1100	980	313	5872
Handlines	12	64	289	372	278	139	33	4	1191
Otter Trawls	807	387	747	224	629	292	42	56	3184
Seines	527	274	232	59	139	39	6	1	1277
Shrimp Trawl	13	9	4	3	6	6	-	-	41
Other	103	29	23	-	33	-	2	-	190
Total	2054	1292	1837	1418	2141	1576	1063	374	11755

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

	AGE															
Year	1	2	3	4	5	6	7	8	9	10	11	12	13+	UK	NO. tow	Kg. tow
1970	-	6.35	1.77	4.78	10.90	10.46	4.50	2.59	0.84	-	0.29	0.14	0.13	0.21	42.96	57.47
1971	-	1.17	42.40	10.09	26.51	16.16	10.65	3.59	1.97	0.54	-	-	0.56	0.40	114.05	128.20
1972	-	0.52	0.28	2.35	0.30	1.61	1.47	0.39	0.27	0.25	0.19	-	0.37	0.37	8.39	22.12
1973	-	-	2.91	4.58	21.20	2.61	2.98	3.08	0.46	0.15	-	-	-	0.22	38.18	53.25
1974	-	-	0.61	1.36	2.79	3.21	0.40	0.50	0.26	0.22	0.11	-	-	-|	9.47	14.44
1975	-	0.61	6.42	8.58	4.65	0.81	1.00	0.58	0.21	0.33	-	0.11	-	0.16	23.47	32.75
1976	-	6.49	2.25	1.48	1.93	1.55	0.73	1.79	1.65	1.41	0.24	0.23	0.47	-|	20.21	43.41
1977	-	0.13	7.12	4.19	2.90	2.05	0.84	0.19	0.28	0.14	0.19	0.25	0.22	0.07	18.58	26.58
1978	-	0.66	9.13	19.31	5.54	4.38	1.53	1.17	0.44	0.43	-	-	0.11	0.12	42.84	67.55
1979	-	1.30	0.79	5.15	2.51	0.59	1.72	0.56	0.29	0.15	-	0.17	0.45	-|	13.66	27.58
1980	-	1.88	10.52	3.97	23.58	16.40	5.15	1.16	0.45	0.37	0.37	-	-	-|	63.84	85.55
1981	0.33	4.36	16.91	36.48	12.02	25.45	11.50	1.26	0.93	0.86	0.24	0.16	0.31	0.17	110.98	161.81
1982	-	2.53	1.74	5.77	10.22	7.61	9.25	3.41	1.32	0.45	0.10	0.23	-	0.10	42.73	74.82
1983	-	4.37	22.11	7.90	10.64	10.04	1.70	3.41	1.52	0.66	0.25	-	0.43	0.27	63.30	78.60
1984	2.83	7.25	10.02	10.48	13.51	8.75	3.58	1.81	1.58	0.85	0.32	0.41	0.46	0.28	62.14	102.30
1985	-	0.48	3.75	19.10	125.95	52.13	22.38	7.26	1.44	0.77	0.67	-	0.37	3.63	237.94	295.97
1986	-	1.33	6.36	11.13	8.11	17.55	6.38	4.92	2.17	1.02	0.55	0.10	0.22	0.09	59.93	83.83

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.
Year	Vessel			
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
1986	AN	1.65	153.55	32.26

Table 7. Data used to generate 1986 catch at age estimates for 4Vn (M-D) cod. Length-weight parameters: a=0.01349, b=2.8927.

Gear	Time Period	# of samples Length	(age)	No. Measured	No. Aged	Catch (t)
Longline TC 1	May-Sept	7		2564	667	2057
Longline TC 2,3	May-Sept	4	(11)	1639	667	1422
Handlines	May-Sept	2		478	667	1015
Otter Trawls	May-Sept	8		3125	540	2794
Seines	May-Sept	5	(11)	1578	540	1231
Longline TC 1-3	Oct-Dec	4		1504	230	2401
Handlines	Oct-Dec	2		592	230	176
Otter Trawls	Oct-Dec	2	(5)	651	230	390
Seines *	Oct-Dec	0		0	0	46

*Used Otter Trawl Oct-Dec 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	1986
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-
3	3	10	-	7	15	44	-	-	35	-	-	85	32	8	5	12	3
4	62	43	676	133	179	177	-	-	277	17	8	221	227	69	116	48	102
5	322	236	39	437	181	127	5	-	265	208	105	310	662	412	306	317	434
6	314	492	604	87	184	73	10	-	197	480	532	409	477	436	438	335	838
7	181	600	444	193	54	36	25	-	120	305	747	672	805	294	400	469	530
8	208	63	209	230	66	17	27	-	76	185	386	529	507	492	228	309	323
9	56	152	2	51	82	13	17	-	49	91	219	267	209	163	250	176	181
10	40	48	21	17	26	11	15	-	54	17	127	151	78	137	152	153	117
11	82	14	50	9	-	4	10	-	20	39	32	57	50	35	69	61	59
12	21	7	2	5	4	-	10	-	18	8	8	52	22	33	23	28	43
13	17	28	1	6	1	-	-	-	13	4	8	53	8	11	8	16	16
14	11	1	-	1	1	1	-	-	3	4	-	5	3	5	4	4	8
15	1	7	1	-	1	-	-	-	8	-	-	8	2	5	4	5	5
16	-	5	1	2	1	-	10	-	4	-	-	18	15	11	6	7	21

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	1986
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	0.56	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	0.80	0.79	0.90
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	1.27	1.14	1.21
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	1.61	1.45	1.55
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	2.04	2.00	2.01
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	2.55	2.38	2.51
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	3.19	2.77	3.15
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	3.70	3.15	4.15
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	5.37	4.22	5.50
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	8.29	7.10	6.06
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	9.87	8.21	6.79
14	9.49	13.45	-	10.15	10.26	8.79	-	-	8.93	6.88	-	8.53	8.60	10.22	10.99	10.75	9.44
15	12.02	12.03	11.06	13.03	11.37	-	-	-	9.16	-	-	9.45	11.94	11.34	10.93	12.84	11.00
16	-	10.71	15.23	7.01	6.08	8.48	9.39	-	14.09	-	-	11.59	10.80	12.24	10.81	13.92	9.61

Table 10. 4Vn cod(May-Dec): catch at age by longlines, handlines, otter trawls and seiners for 1984-1986 (thousands).

Age	GEAR											
	Longlines			Handlines			Otter Trawls			Seiners		
	1984	1985	1986	1984	1985*	1986	1984	1985	1986	1984	1985	1986
1	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-
3	5	12	3	3	-	1	6	3	-	-	1	-
4	116	48	102	22	-	14	243	64	64	11	21	42
5	306	317	434	83	-	31	645	756	442	107	207	179
6	438	335	838	115	-	75	795	790	967	236	186	346
7	400	469	530	112	-	103	295	791	359	116	174	134
8	228	309	323	41	-	109	144	364	184	37	141	79
9	250	176	181	52	-	56	31	136	82	37	33	42
10	152	153	117	28	-	25	27	100	30	15	23	19
11	69	61	59	12	-	12	6	25	9	4	6	9
12	23	28	43	4	-	7	1	4	3	2	1	3
13	8	16	16	2	-	1	-	1	2	1	-	2
14	4	4	8	1	-	-	-	-	-	-	-	-
15	4	5	5	1	-	-	1	-	-	-	-	-
16	6	7	21	1	-	5	1	-	-	1	-	0

* No samples collected.

Table 11. Longliner catch of cod and associated catch-per-unit-effort for 1968-1986, 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
1986	5872	0.068	0.519

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

Table 12. Analysis of Deviance for Multiplicative Model of Catch rates from 4Vn cod (May-Dec) fishery.

Analysis (i)

Model	Deviance	df	P-level
1			
+GEAR	419.28	2	0.00
+TON	1.95	3	0.04
+MONTH	1.67	7	0.43
+YEAR	2.96	5	0.02

Analysis (ii)

Model	Deviance	df	P-level
1			
+YEAR	10.47	5	0.67
+GEAR	419.28	2	0.00
+YEAR	2.53	5	0.06
+GEAR	419.28	2	0.00
+TON	1.95	3	0.04
+YEAR.TON	6.09	20	0.13
+YEAR.TON	8.04	23	0.04

Analysis (iii) (15 high leverate points removed)

Model	Deviance	df	P-level
1			
+GEAR	383.70	2	0.00
+TON	1.81	3	0.04
+YEAR	2.183	5	0.08

Table 13. Total mortality estimates for longliner and otter trawl catch at age (CPUE numbers) 1984-1986.

	Longline			Otter Trawl		
	84/85	85/86	Mean	84/85	85/86	Mean
4+/5+	0.261	-0.467	-0.103	-0.094	0.302	0.104
5+/6+	0.386	-0.307	0.039	0.082	0.520	0.301
6+/7+	0.450	0.005	0.227	0.122	1.120	0.621
7+/8+	0.607	0.286	0.446	-0.009	1.447	0.719
8+/9+	0.700	0.345	0.523	-0.022	1.534	0.756
9+/10+	0.830	0.337	0.584	-0.453	1.724	0.635
10+/11+	0.985	0.412	0.698	0.392	2.153	1.273
11+/12+	0.839	0.086	0.462	0.798	1.716	1.257

Table 14: Total mortality estimates for longliner CPUE (numbers) at age, 1980-1986.

Age Groups	80/81	81/82	82/83	83/84	84/85	85/86	Mean
4+/5+	⁻0.011	0.163	0.300	⁻0.256	0.261	⁻0.467	⁻0.002
5+/6+	0.116	0.345	0.449	⁻0.113	0.386	⁻0.307	0.146
6+/7+	0.269	0.462	0.497	⁻0.015	0.450	0.005	0.278
7+/8+	0.434	0.901	0.534	0.102	0.607	0.286	0.477
8+/9+	0.386	1.274	0.694	0.183	0.700	0.345	0.597
9+/10+	0.277	1.427	0.380	0.044	0.830	0.337	0.549
10+/11+	0.044	1.430	0.467	0.368	0.985	0.412	0.617
11+/12+	⁻0.900	1.545	0.321	0.434	0.839	0.086	0.387

Table 15. Results from using Leap Frog TAC method.

a) Projecting to 1986

Age	1984	1985	1986 1)	1986 2)	Obs. 1986	Avg. Weight
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	14	18	16	16	4	0.53
4	394	151	133	138	230	0.8
5	1146	1452	382	397	1130	1.2
6	1591	1487	1292	1344	2317	1.53
7	927	1627	1043	1085	1172	2.02
8	452	923	1111	1156	724	2.46
9	372	391	548	570	376	2.96
10	223	313	226	235	198	3.4
11	91	104	100	104	93	4.75
12	30	37	29	30	58	7.65
13	11	19	16	17	20	8.97
14	5	5	6	6	9	10.86
15	6	6	4	4	5	11.96
16	9	8	5	6	28	12.5

1) TAC = 10796 (t)
   Scale Factor = 0.686

2) TAC = 11237 (t)
   Scale Factor = 0.713

b) Projecting to 1987

Age	1985	1986	1987 1)	Avg. Weight
1	0	0	0	0
2	0	0	0	0
3	18	4	11	0.52
4	151	230	57	0.83
5	1452	1130	1904	1.14
6	1487	2317	1995	1.49
7	1627	1172	2021	2
8	923	724	577	2.38
9	391	376	326	2.83
10	313	198	211	3.4
11	104	93	65	4.47
12	37	58	57	6.61
13	19	20	35	7.46
14	5	9	10	10.19
15	6	5	10	12.84
16	8	28	26	12.51

1) TAC = 13,735 (t)
   Scale Factor = 1.106

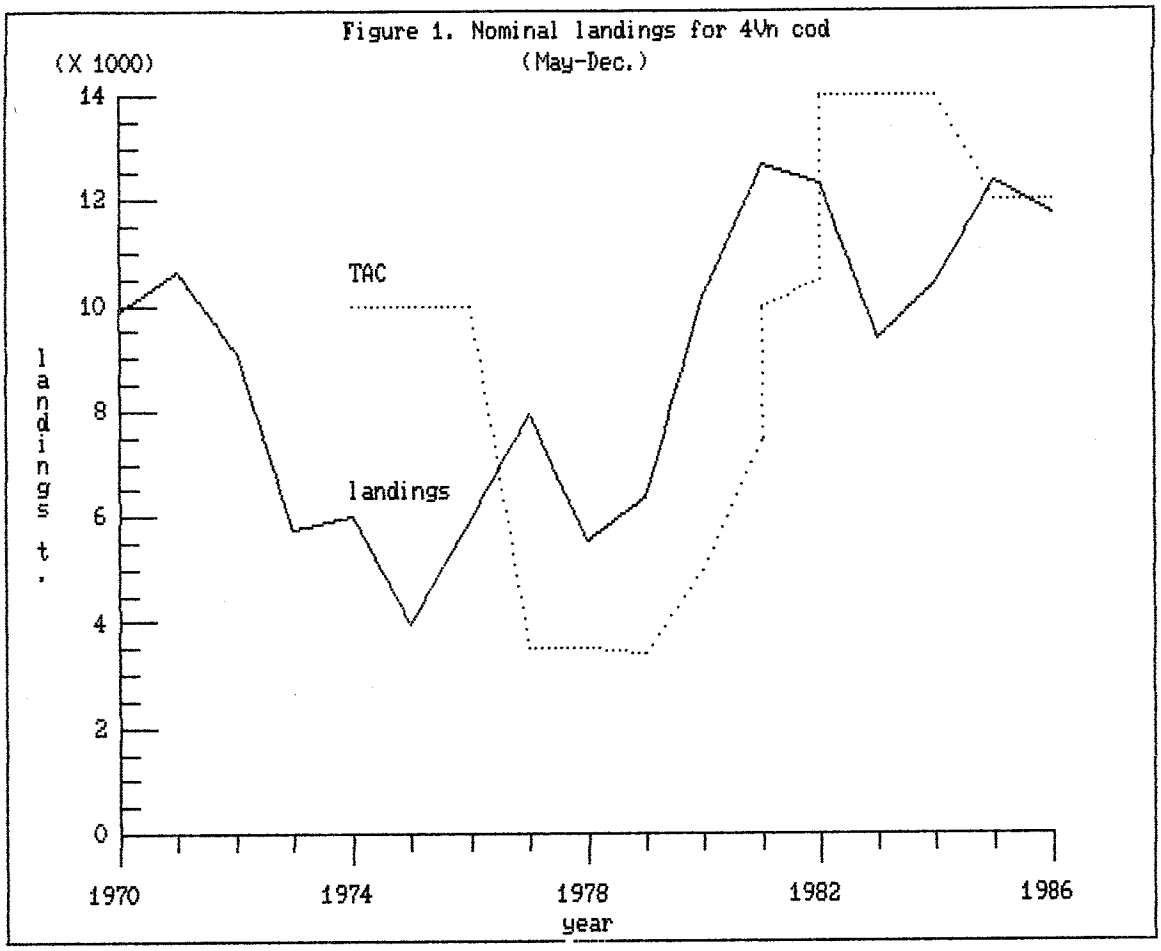
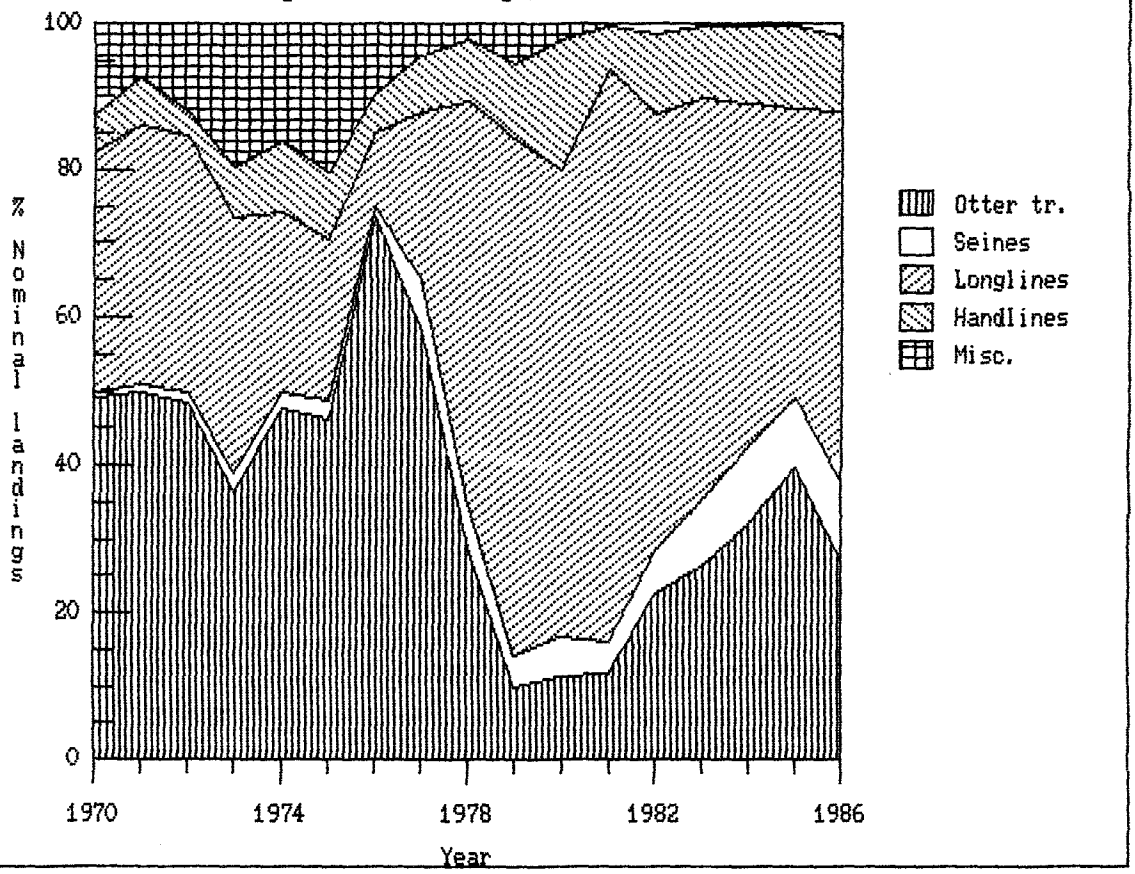


Figure 1. Nominal landings for 4Vn cod
(May-Dec.)
(X 1000)
14
12
10
8
6
4
2
0
landings t.
TAC
landings
1970
1974
1978
1982
1986
year

Figure 2. Cumulative percent catch by gear. 4Vn cod (May-Dec.) 1986



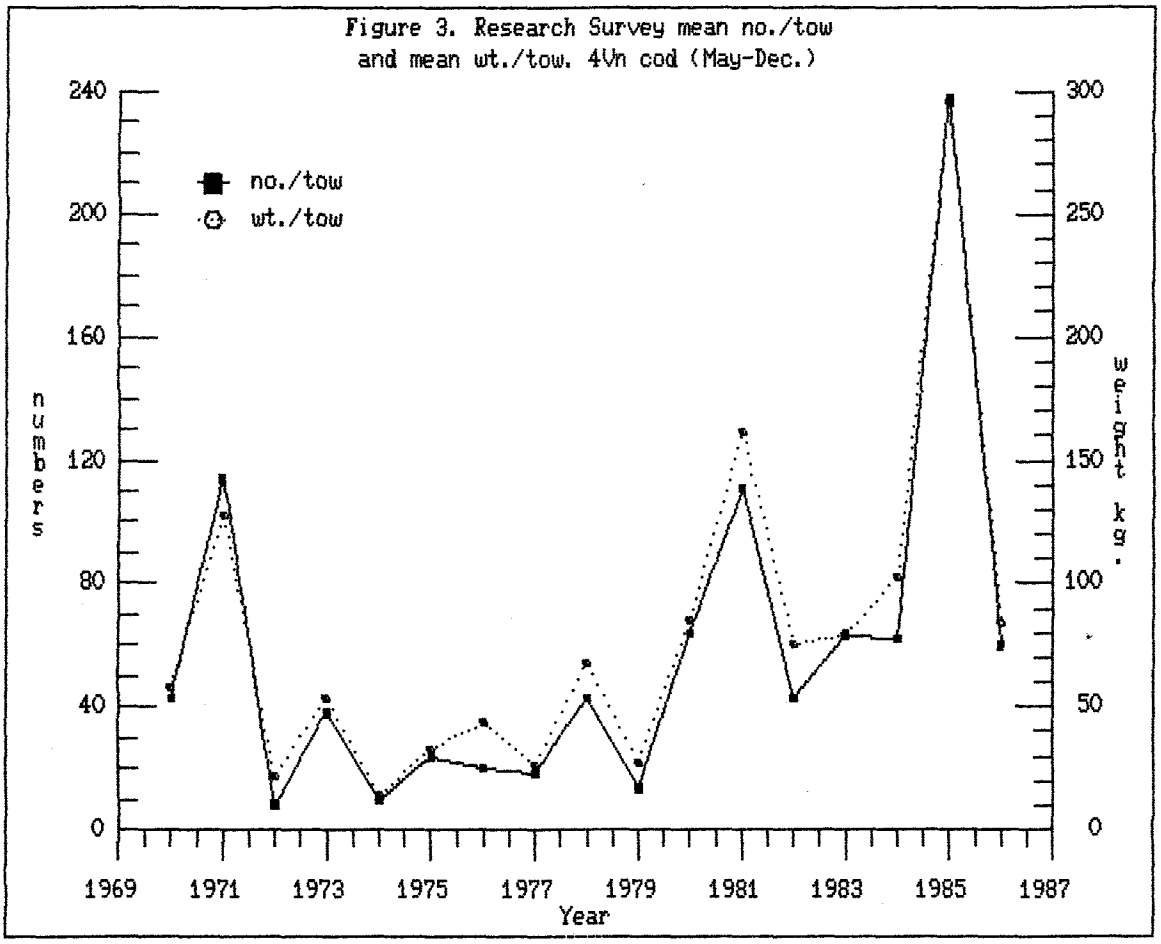


Figure 3. Research Survey mean no./tow
and mean wt./tow. 4Vn cod (May-Dec.)
no./tow
wt./tow
numbers
weight kg.
Year
240
200
160
120
80
40
0
300
250
200
150
100
50
0
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987

Figure 4. Comparison of standardized trends for landings and survey indices.

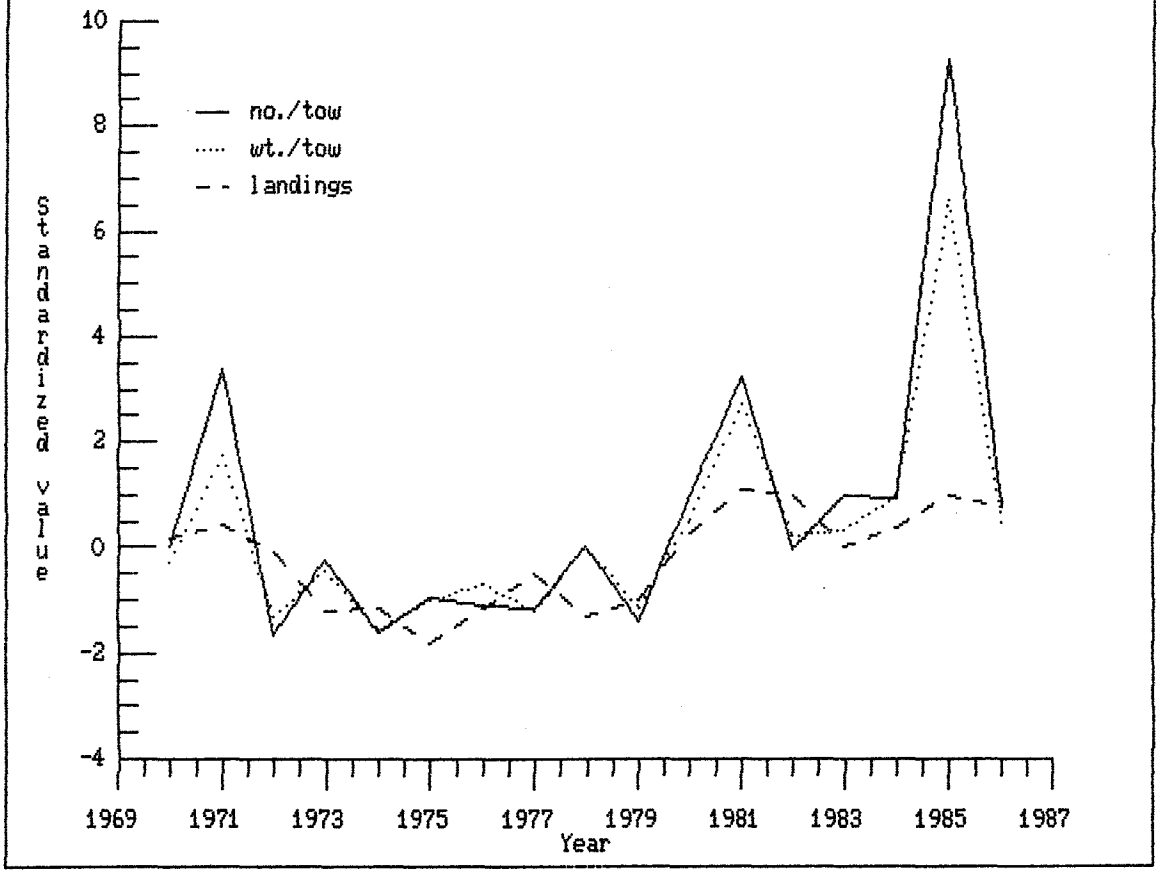


Figure 5. Observed temperatures and depths by stratum from the July cruises.

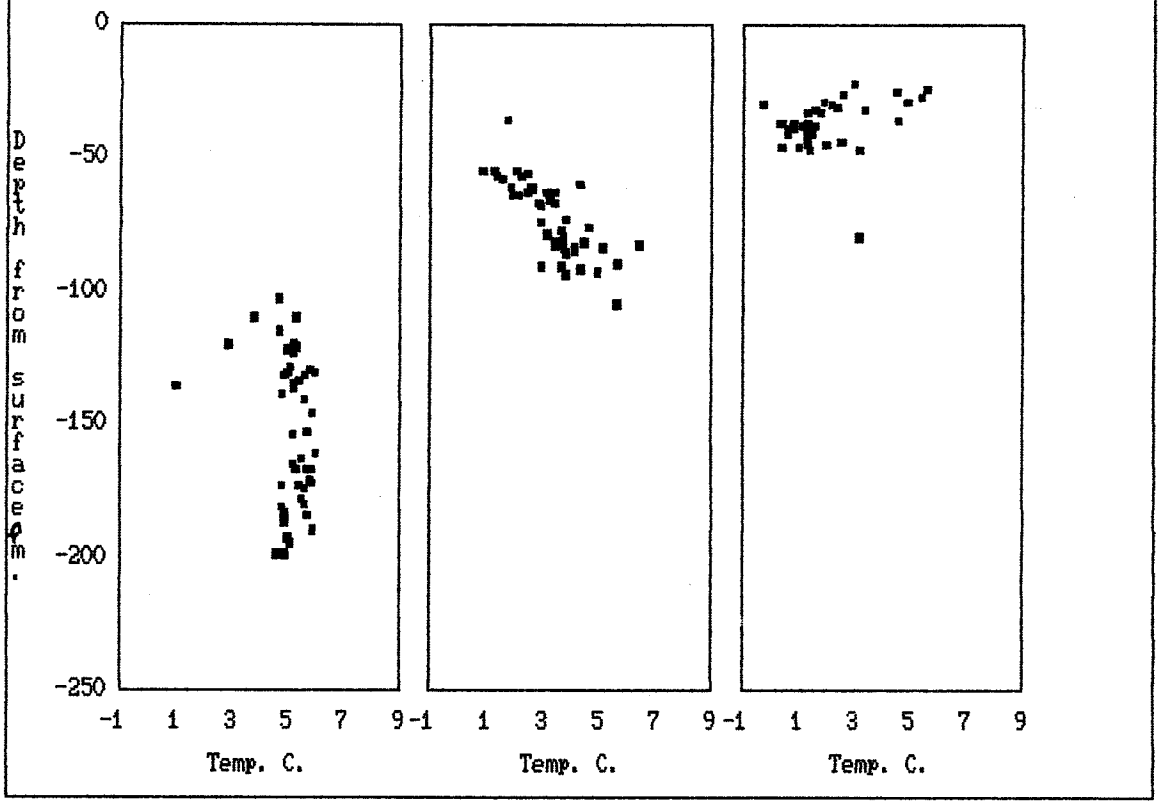


Figure 6. Numbers at age by gear type
4Vn cod (May-Dec.) landings.

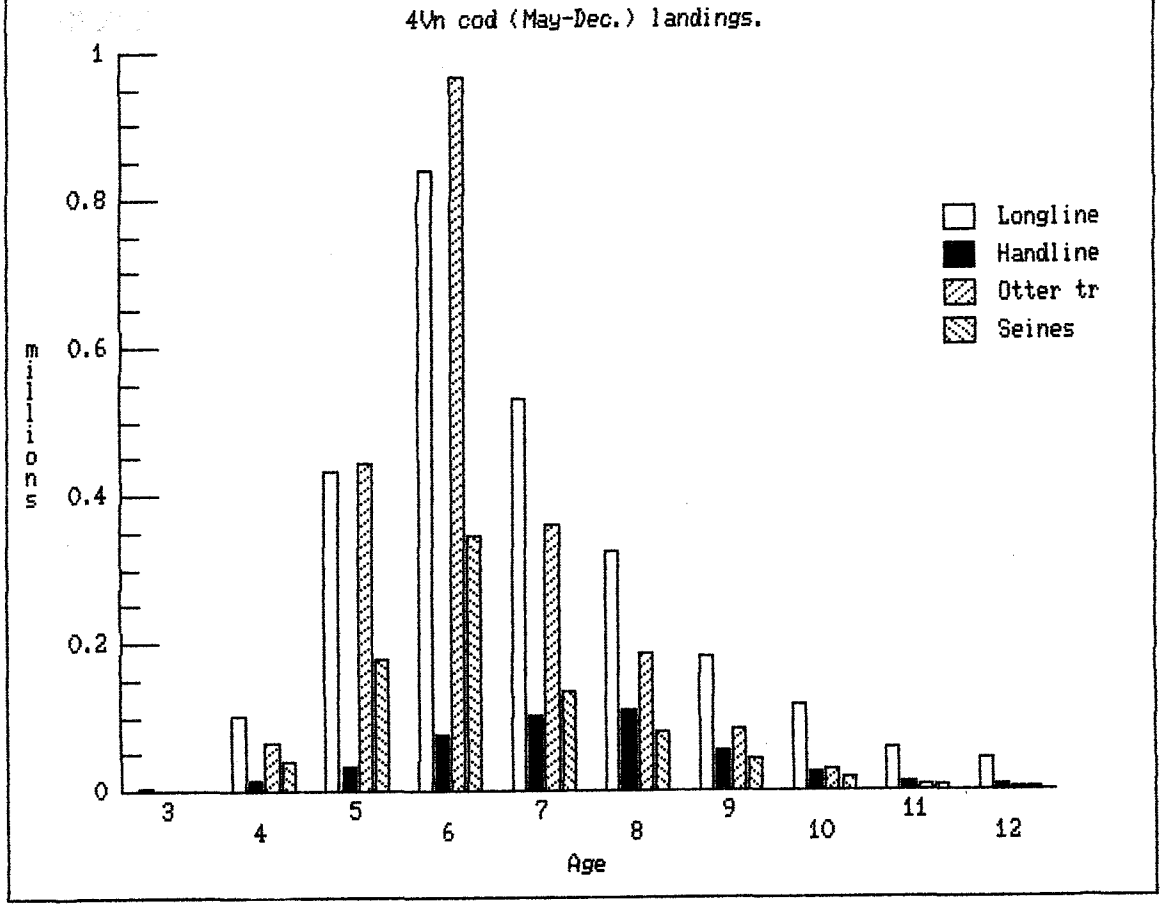


Figure 7. Comparison of Leap Frog
projected and observed age composition