Canadian Atlantic Fisheries Scientific Advisory Committee

CAFSAC Research Document 86/81

Comité scientifique consultatif des pêches canadiennes dans l'Atlantique

CSCPCA Document de recherche 86/81

Assessment of Gulf White Hake: NAFO Division 4T / 1986

by

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ABSTRACT

Since 1970 landings from this predominently small vessel inshore fishery have ranged from 3,616 tonnes in 1978 to a high of 14,039 tonnes in 1981. The 1985 nominal landings (5,379 tonnes) dropped by 1,200 tonnes (18%) from 1984. In 1982 the first precautionary TAC was set at 12,000 tonnes. A first analytical assessment carried out in 1985 indicated this level may have been too high.

Gillnet fishermen landed 34% of the total 1985 catch. Otter trawlers are the other major gear category (31% of landings) in this fishery at present. The current market (1985) for Gulf hake is depressed, especially in the salt fish portion, which may have lead to a decline in effort.

A commercial catch rate series was derived from landings per purchase slip (receipt) using all available data (1978 to 1985). Research vessel abundance indices were available and used with the commercial CPUE in calibration of the VPA model. The strong contribution made by the gillnet portion of the fishing fleet leads to the dome shaped partial recruitment pattern observed for this fishery. The terminal F was estimated to be approximately 0.40. The Fo.1 falls below this value at 0.32.

A relationship between total mortality (from catch curves) and effort gives a good relationship, the 1985 Z is calculated as 0.60 also indicating an F in the range of 0.4.

The yield per recruit of 1.042 kg with the geometric mean recruitment from 1978 to 1984 of 6.5 million fish gives a long term equilibrium yield for this stock of approximately 6,750 tonnes. Projections for the next 5 years at the Fo.1 level indicate a slowly recovering stock with projected landings climbing from approximately 4,000 to 6,000 tonnes.

RESUME

Depuis 1970 les débarquements pour cette pêche côtière effectuée principalement par de petits bateaux ont varié de 3 616 tonnes en 1978 à un maximum de 14 039 tonnes en 1981. Les prises nominaux pour 1985 (5 379 tonnes) ont diminué de 1 200 tonnes (18 %) par rapport à ceux de 1984. En 1982, l'on a fixé à 12 000 tonnes le premier TPA de précaution. Une première évaluation analytique effectuée en 1985 a indiqué que cette limite peut avoir été trop élevée.

Les pêcheurs au filet maillant ont débarqué 34 % des prises totaux en 1985. Les chalutiers constituent actuellement l'autre catégorie majeure d'engins pour cette pêche (31 % des débarquements). Actuellement le marché pour le merlu du golfe est déprimé, surtout quant au poisson destiné au salage, ce qui pourrait entraîner un déclin de l'effort de pêche.

L'on a obtenu une succession de taux de prises commerciales à partir des débarquements par journaux de bord (reçus) en utilisant toutes les données disponibles (1978 à 1985). Des indices d'abondance obtenus par les navires de recherche étaient disponibles et ont été utilisés avec les PUE commerciales pour l'étalonnage du modèle APV. La contribution importante de la pêche au filet maillant dans l'effort de la flotte de pêche donne la configuration de recrutement partiel en forme de dôme observée pour cette pêche. L'on a estimé que le F de dernière année s'établissait approximativement à 0,40. Le $F_{0,1}$ tombe en deçà de cette valeur pour s'établir à 0,32.

L'on constate une bonne relation entre la mortalité totale (d'après les courbes de prises) et l'effort de pêche, la valeur calculée de Z pour 1985 s'établissant à 0,60 ce qui indique également une valeur de F de l'ordre de 0,4.

Une rendement par recrue de 1,042 kg, associé à une moyenne géométrique du recrutment de 6,5 millions de poissons de 1978 à 1984, donne pour ce stock un rendement à l'équilibre à long terme d'approximativement 6 750 tonnes. Les projections pour les 5 prochaines années au niveau $F_{0,1}$ indiquent une lente récupération du stock et des débarquements projetés passant d'environ 4 000 à 6 000 tonnes.

INTRODUCTION

The fishery for white hake (Urophycis tenuis, Mitchill) in the southern Gulf of St. Lawrence usually does not commence until May. Landings peak between July and September and decline through October and November: the exceptionally high landings of November 1984 did not re-occur in 1985. Landings have ranged from a low of 3,616 tonnes in 1974 to a high of 14,039 tonnes in 1981 (Fig. 1).

This fishery is carried out mainly by small inshore vessels making it extremely dependent upon weather and local market conditions. Winter ice conditions preclude inshore fishing from December until April of most years. The majority of the fishery is carried out in the Northumberland Strait area, and on both the eastern and western ends of Prince Edward Island (P.E.I.). This fishery tends to be conducted by tonnage class 0 and 1 vessels using two main gear types. The first group uses gillnets and longlines in the summer and, if the weather permits, longlines in the fall; the second group (>30% of the fishery), particularly that based in southeastern New Brunswick and Nova Scotia, uses small (<20m) draggers and seiners.

Gillnetters have steadily increased their proportion of the catch from 25% in the early 1970's to over 50% in 1984. A drop to 34% occurred in 1985, corresponding to a rise in seiner landings which doubled (as a percentage) in 1985. This may possibly be due to different fishing locations; the gillnetters almost exclusively fish the inshore, while the seiners being larger tonnage class 2 & 3 vessels fish the deep waters between Cheticamp and Cape St. Lawrence as well as the slope waters along the southern edge of Cabot Strait.

The provisional nominal landings in 1985 (Table 1) were 5,379 tonnes, a drop of 18% from the 6,592 tonne catch of 1984 (Table 2). This fishery was not managed by a TAC until the precautionary quota of 12,000 tonnes was placed upon this stock in 1981 for the 1982 season. A first analytical assessment was carried out on this stock in 1985 (Clay et al., MS 1985a) and the exploitation level recommended at that time was a long term level no higher than 8,000 to 9,000 tonnes annually.

SAMPLING

Sampling was carried out in a manner similar to that of the previous year (Clay et al., MS 1985b). Samples were collected by 3 sources:-

1) the P.E.I. provincial Department of Fisheries and Labour who provided 157 length frequency samples totalling 13,506 fish,
2) the Department of Fisheries and Oceans (DFO) port samplers who collected 32 length frequency samples totalling 5,683 fish and 767 otoliths, and
3) the authors who collected an additional 18 length frequency samples totalling 1,517 fish and 286 otoliths.

Much of the hake landed in the southeastern Gulf is gutted and be-headed at sea. Because of this, 'sexes combined' samples were all that could be collected. No sea sampling was carried out in 1985. Be-headed fish were measured in terms of dorsal length (length from tip of tail to the anterior portion of the first dorsal fin) or otolith weight which was used to estimate total length according to the relationships outlined in Clay et al. (MS 1985b).

SAMPLING SUMMARY

source	length frequency samples	fish measured	aging material samples/otoliths
1) P.E.I.	157	13,506	0 / 0
2) DFO	32	5,683	24 / 767
3) authors	18	1,517	5 / 286
TOTAL	207	20,706	29 /1053

Low sampling intensity did not allow an area by area breakdown of the landings. Seven combinations of time and gear (Table 3) were chosen from the available samples. In order to have approximately 400 ages in each age-at-length key, these keys were combined by similar gear types for the entire year - all otter trawl and seiner (Scottish and Danish) samples were combined for age as were gillnet and longline samples. These two age-at-length keys were then used to determine the age composition of the landings in each of the seven time/gear combinations above. Although sexually dimorphic growth rates have been identified in our work, the landed form (gutted, head-off) and the low sampling intensity did not allow age-at-length keys or catch-at-age calculations to be conducted on sexed samples.

The catch at age and the weight at age were calculated for each key (Table 4) by the computer system ALSYSX for sexes combined. These data were added together for the final catch numbers at age and averaged by weighting (by numbers in each age group) for the weights at age.

CATCH PER EFFORT - COMMERCIAL

A commercial catch per unit of effort (CPUE) series can be used as an indicator of stock abundance. Gulf hake are caught mainly by tonnage class 0 and 1 vessels; these vessels are not required to complete log books and therefore no estimate of fishing effort is normally available. Daily landings are, however, recorded on the purchase slips for the inshore components of the fishing fleet. These data came from the 'transaction files' of the DFO Statistics Branch of the Martimes region (1978 - 1983) and the Gulf region (1984 and 1985) and they were transformed to 'NAFO Table 5' type format using the computer system NAFSYS. Each purchase slip is assumed to represent 1 day's fishing effort, generally 1 trip for the small vessels of the inshore fleet, and thus the catch and effort by trip (slip) were

derived from these data. Due to the variable nature of this fishery no single fleet component makes up a large enough percentage of the catch to be taken as representative of the entire stock (Table 2). The multiplicative model (Gavaris, 1980) was used to develop a CPUE series based on all major fleet components of the fishery (Table 5). The coded X-matrix (raw catch and effort data prepared for the multiplicative model) was generated using the computer system NAFSYS.

All individual daily purchase slips representing catches of 40 kg or less were dropped from the time series. This was done as fishermen often take small catches of hake home for personal use; this results in catches of less than 40 kg not being fully represented in the transaction file data set. As the Gulf region Statistics Branch has assumed all seiners in the Gulf are Danish, the Scottish and Danish seiners were combined for all years for this analysis. The summed fortnightly catch, from the remaining purchase slips, was expressed in hundreds of kg and rounded to the nearest hundred. Nine observations with extreme values were dropped. The resulting CPUE series indicates the highest level occurring in 1980 and the lowest level in 1978 and the second lowest in 1985.

This model (Table 5) with standards for statistical district, gear and time chosen as east St. Georges Bay, seiners, January to May$_2$14, 1978 respectively, gives a low correlation coefficient (r^2 = 0.303) (Table 6), however, the residual plots indicate a relatively normal non-biased distribution (Fig 2 & 3). The un-weighted results (Fig 4) indicated weighting would improve the relationship. Weighting by the effort did improve the coefficient of correlation and the F levels of the regression from 0.218 to 0.303 and 16.6 to 26.0 respectively. The weighted CPUE and effort series were used for all tuning in the VPA runs (Fig 5).

The resulting CPUE is highly correlated with annual landings (r^2 = 0.88). This is what would be expected in an unregulated fishery (never limited by TAC) or a fishery with constant effort.

RESEARCH DATA

The September groundfish cruise in the southern Gulf of St. Lawrence in 1985 was conducted with similar survey protocols to those of previous years on the RV E.E. Prince. A series of analysis was made on this 16 year data set (1970 to 1985) using the computer system RVAN (version 2.2+). These data include abundance estimates by numbers and weight; CPUE (by tow) by numbers and weight; and age composition (Clay, MS 1986).

Annual fluctuations in the stratified mean number of hake per standard tow are not strongly correlated with the CPUE from the Gavaris multiplicative model. Even after smoothing with a running average of 3 the relationship has a correlation coefficient of only 0.4. As many of these data points represent only 200 to 300 fish caught during an entire fall groundfish

cruise (generally between 60 and 70 sets), it is not felt that they are adequate indicators of annual variations in fishable population abundance.

The annual percent age composition of the RV population was found to be not significantly different ($p<0.05$) from the percent composition of the VPA population estimates. This was tested over the 'converged' part of the population-at-age matrix (1971 to 1980) using the Chi-squared test. These research vessel data are, therefore, considered to be representative of annual age composition but not of the annual variation in abundance.

ESTIMATION OF PARAMETERS

Catch and Weights at age

The 1985 weights at age were calculated from length frequencies sampled from the commercial landings, the weight at length being calculated from the length/weight relationship taken from the 1985 research vessel survey data:-

$$W(g) = 0.004239 \times TL(cm)^{3.147}; \quad n = 700 \quad r^2 = 0.98$$

The weights at age for all years prior to 1983 were taken as equal to the mean of 1983 to 1985 (Table 7). These are slightly different from those used in the 1985 assessment. Weights at age for 1970 to 1982 were extremely variable and unrealistic due to the sparse and thus poor sampling data prior to 1983. With the better sampling of the last three years, annual weights at age are now possible. The weights at age have varied slightly over the last three years, but, except for those of the oldest age, they have not shown any trend.

The starting catch-at-age matrix (Table 8a) for the Gulf hake ages 3 to 13+ from 1970 to 1984 was taken from Clay et al. (MS 1985a). The 1985 catch numbers at age (Table 4a) were added to this earlier series. Sampling data were limited in earlier years and thus 1970 to 1977 catch at age were used only for historic perspective (Clay et al., MS 1985b).

The catch numbers-at-age table was adjusted to match the slightly altered weights at age and the changes reported in the statistical landings for 1983 and 1984. This adjustment made the cross products of the catch-at-age and weight-at-age tables match the reported nominal landings.

The percent composition of the catch at age (Table 8b) indicates stability in the composition of the landings over the last six years ie. no year class effect. This is surprising considering the highly variable nature of the between year population percent composition as shown from the research vessel surveys. The 1985 catch at age predicted from both the 1985 assessment Fo.1 level and the 1985 actual landings compared to the observed 1985 catch at age shows the partial recruitment was under estimated for age 6 and slightly so for age 7 (Fig 11).

Partial recruitment

The partial recruitment (PR) was estimated using three techniques. The first used the average of 1981 to 1984 catch at age, estimated from commercial sampling, divided by the population at age, estimated from research vessel surveys. These were standardized on a yearly basis to the largest age-group of the catch at age (Fig. 6a). A variation of this technique used the standardized mean of the 6, 7 and 8 year old values. In the latter case all values over 1 were set to 1. The smoothed mean PR reflects the importance of the gillnet component of the fishery in its domed shape (Fig 6b).

The second technique used iterative historical averaging of the last 3 years in the F table until little change was noted. This technique produced a sharply peaked PR at ages 7 and 8 (Fig. 7a).

The last technique averaged the estimated selectivity for white hake in gillnets and trawl nets weighted by their respective landings in 1985 (Fig. 7b).

Using a chi-squared test, the percent composition of the RV population in the 5 most recent years was tested against the percent composition of the corresponding VPA population calculated from each of these 3 PR vectors. The selectivity estimated PR had the poorest overall relationship between population compositions while the catch over population technique had the best fit. This latter PR (smoothed) was therefore chosen for this assessment.

Partial Recruitment

AGE	3	4	5	6	7	8	9	10	11	12	13
PR	.03	.17	.65	1	1	1	.90	.75	.75	.70	.70

This PR is substantially different from that of last year (Fig 8) although the technique was similar. These differences may be attributable to the shift in gill net composition.

Mortality: Natural

The natural mortality (M) was assumed to be 0.2 as is the case with other gadoid stocks of the northwest Atlantic.

: F oldest

The fishing mortality (F) on the oldest age group was chosen by the iterative technique 'AutoF' at age 10 (Rivard and Joly, MS 1982).

STARTING F oldest

70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
0.46	0.50	0.53	0.67	0.46	0.57	0.36	0.31	0.24	0.34	0.52	0.60	0.44	0.17	0.14

: Total

The total mortality (Z) was calculated from the CPUE at age (catch-at-age matrix divided by standardized effort from the multiplicative model) and the annual catch curves. These two estimates of Z were very similar over the common years. The Z's from catch curves were regressed on effort (Fig 9) to test the hypothesis that F (Z - M) was related to effort for this hake stock. Although not high, the relationship is significant and indicates a Z over the ages 7 to 12 for 1985 in the range of 0.60, subsequently an F of 0.4. The years 1978 and 1983 appear to be outliers. The Z's from CPUE at age (Fig 10) indicate a 1984/85 Z in the range of 0.65.

: F Terminal

The fully recruited or terminal F (F_t) was chosen by regressing the commercial CPUE index, from the Gavaris multiplicative model, against both the total 6+ and exploitable 3+ VPA population biomass (Table 9a). The highest correlation coefficient and the lowest residual(s) for the last three years were used as the main evaluation criteria. No difference was found when standardized residuals were used, therefore the actual values are shown in this analysis. The 3+ exploitable VPA biomass indicates an F in the range of 0.35 to 0.40 while the 6+ total VPA biomass indicates an F in the range of 0.325 to 0.375.

The research vessel population numbers were also regressed against the 5+ and 6+ VPA population numbers (Table 9b). The 6+ numbers indicated a terminal F in the range of 0.375 to 0.44 while the 5+ numbers indicated a lower range of 0.325 to 0.375. Neither of these relationships were strong and they had no discriminating power in their coefficients of determination. These regressions were not felt to be reliable calibration techniques.

The F weighted by population numbers regressed against standardized effort (from the multiplicative model) indicates an F of 0.4 based on residuals (Table 9b). The mean F versus standardized effort gives a relationship with a correlation coefficient of 0.45 (1978 to 1985) and 0.75 (1981 to 1985). Both relationships have the 1985 point almost on the line with a terminal F of 0.4.

This tuning process and consideration of the estimated Z value resulted in a final terminal F of 0.4 being selected.

Yield per recruit

Several values of yield per recruit (YPR) were calculated using weights at age for the years 1983, 1984, and 1985 and the 3 partial recruitment vectors discussed above with an M = 0.2. The Fo.1 level ranged from 0.28 to 0.41 and the Fmax from 0.85 to 1.80. The Fo.1 appears not to be overly sensitive to either the PR or the weights at age over the range tested, using the 1985

weights at age and the PR calculated as catch over population standardized to ages 6, 7 and 8, the YPR calculations give:

Fo.1 YIELD = 1.042 kg Fo.1 = 0.3205

Fmax YIELD = 1.173 kg Fmax = 1.2300

With a geometric mean (1978 to 1984) recruitment of 6.5 million fish the long term equilibrium yield would be slightly over 6,750 tonnes, very close to the average of the landings of the last 16 years - 6,673 tonnes (Table 2).

ASSESSMENT RESULTS

Virtual population analysis (using the APL assessment system - Watcom version, Rivard and Jolly, MS 1984) using the above data are listed in Appendix I.

The exploitable biomass (Table 10) was calculated from the VPA population numbers multiplied by the historical partial recruitment (Table 11) calculated for each year by standardizing the annual mean F between ages 6 to 8 to 1.0 and setting all other values over 1.0 to 1.0. The percent composition of the population numbers, catch biomass, and population biomass are presented in Tables 12,13,14.

The population numbers (Appendix I.) indicate a marked change in recruitment over the last 15 years, however, those estimates from 1977 onwards are the only ones assumed to be representative of the fishery. The GM recruitment from 1978 to 1984 is approximately 6.5 million fish at age 3. Recruitment appears relatively strong in 1977 and 1978 (the 74 and 75 year classes) with a steady decline since that time. The range of recruitment values appears to vary by about a factor of 3.

Interpretations such as these must be viewed very critically, for as was pointed out by Clay et al. (MS 1985b), there is great variability in length frequency distribution between NAFO unit areas and between months. Thus, inconsistent sampling could produce the illusion of strong or weak year classes from time to time. Unfortunately sampling levels in 1986 precluded any such area breakdowns.

CATCH PROJECTIONS

Two series of catch projections were run. The first (Appendix II.) used a catch level set at an Fo.1 of 0.32 - more than 25% lower than recent fishing levels. With the geometric mean (GM) recruitment of 6.5 million fish (GM of 1978 to 1984), an M = 0.2, and the partial recruitment selected above and weights at age of 1985 the projected catch for 1987 is 4,761 tonnes with steady but small increases into the future. The population biomass also shows a steady increase (nearly 1000 tonnes per annum).

The second scenario (Appendix III.) with a fixed catch level of 10,000 tonnes (less than the 12,000 tonne provisional quota) results in a rapidly decreasing population biomass, falling at nearly 3,000 tonnes per annum. The only apparent way for this stock to rebound quickly will be for it to receive 1 or 2 years of well above average recruitment.

The long term equilibrium yield would be in the range of 7,000 tonnes - a five thousand tonne reduction from the current estimate. As this stock appears to be very dependent on only 3 or 4 year classes - it is a fishery which will be very sensitive to annual fluctuations in recruitment.

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ACKNOWLEDGEMENTS

Jim Murchison, P.E.I. Department of Fisheries and Labour, permitted the use of the 1985 provincial commercial port sampling data for Gulf hake landed in the province of P.E.I. Without these samples no assessment would have been possible.

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Table 1. Nominal landings of white hake from NAFO division 4T in 1985 by gear, region and month. All data are provisional statistics. Quebec (292 tonnes) and Scotia Fundy (15 tonnes) data are combined on a monthly basis. No landings were reported from the Newfoundland region.

	GULF REGION					
MONTH	TRAWL	SEINE	LINE	GILLNET	OTHER	TOTAL
JANUARY	0	0	0	0	0	0
FEBRUARY	0	0	0	0	0	0
MARCH	0	0	0	0	0	0
APRIL	0	0	0	0	0	0
MAY	13	72	0	9	0	94
JUNE	43	502	7	100	27	679
JULY	808	129	98	741	34	1810
AUGUST	355	61	236	360	33	1045
SEPTEMBER	361	71	117	288	11	848
OCTOBER	53	48	70	46	6	223
NOVEMBER	2	121	185	64	0	372
DECEMBER	0	0	0	0	0	0
sub-total	1635	1004	713	1608	111	5071

	QUEBEC & SCOTIA FUNDY REGIONS					
MONTH	TRAWL	SEINE	LINE	GILLNET	OTHER	TOTAL
JANUARY	0	0	0	0	0	0
FEBRUARY	0	0	0	0	0	0
MARCH	0	0	0	0	0	0
APRIL	.3	0	0	10.4	0	10.7
MAY	1.5	.1	.3	45.9	0	47.8
JUNE	.4	.2	.4	19.3	0	20.3
JULY	.1	1.6	3.8	59.8	0	65.3
AUGUST	.1	.1	17.2	83.2	0	100.6
SEPTEMBER	2.3	.1	22.8	14.6	0	39.8
OCTOBER	0	0	6.4	1.9	0	8.3
NOVEMBER	15.0	0	0	0	0	15.0
DECEMBER	0	0	0	0	0	0
sub-total	19.7	2.1	50.9	235.1	0	307.8
TOTAL	1655	1006	764	1843	111	5379

Table 2. Nominal landings of white hake from NAFO division 4T by gear and year. All data from 1984 and 1985 are provisional.

YEAR :GEAR	TRAWL	SEINE	LINE	GILLNET	OTHER	TOTAL
1970	1463	382	385	2149	1289	5668
1971	1523	632	702	1622	1228	5707
1972	1140	863	1604	1190	960	5757
1973	2468	211	1045	1265	713	5702
1974	1454	305	345	1100	412	3616
1975	1576	306	324	1285	634	4125
1976	1429	398	183	1147	601	3758
1977	1227	408	231	1300	818	3984
1978	1303	729	456	1829	508	4825
1979	2826	912	479	3189	704	8110
1980	3430	1615	832	4831	1715	12423
1981	4733	1922	799	6174	411	14039
1982	2885	994	1027	4625	245	9776
1983	2141	906	753	2959	546	7305
* 1984	1614	592	674	3631	81	6592
* 1985	1655	1006	764	1843	111	5379
AVERAGE	2054	761	663	2509	686	6673
PERCENT	31	11	10	38	10	

* provisional

Table 3. Keys selected in 1985 for gear/time combinations and their groupings to produce age-at-length keys with at least 400 fish ages per key. The lower table indicates the keys and associated landings for catch composition applied to the two age-at-length keys.

KEY	FISHERY/PERIOD	TYPE	SIZE	AGE/LENGTH KEY
1	OTB:Jan.- July	Length	1182	
		Age	189	
2	OTB:Aug.- Dec.	Length	1636	OTB/SNU:Jan.- Dec.
		Age	25	Lengths-7802
3	SNU:Jan.- June	Length	1153	Aged-432
		Age	110	
4	SNU:Jul.- Dec.	Length	3831	
		Age	108	
5	LL:Jun.- Dec.	Length	755	
		Age	157	
6	GN:Jan.- Jul.	Length	4956	LL/GN:Jan.- Dec.
		Age	25	Lengths-12522
7	GN:Aug.- Dec.	Length	6811	Aged-621
		Age	439	

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KEY	....AL k e y..... DATE	GEAR	...LF c a t c h... DATE	GEAR		TONNES
1	01/12	OTB/SNU	01/07	OTB		896
2	01/12	OTB/SNU	08/12	OTB		813
3	01/12	OTB/SNU	01/06	SNU		574
4	01/12	OTB/SNU	07/12	SNU		432
5	01/12	LL/GN	06/12	LL		763
6	01/12	LL/GN	01/07	GN		1015
7	01/12	LL/GN	08/12	GN		882
					TOTAL	5375

NOTE:- the total number of fish measured do not agree with the totals given on page 4 due to the exclusion of 6 hand line samples (LHP) in the above keys.

Table 4. Catch at age (a) and weight at age (b) of white hake in 1985 from NAFO division 4T as estimated from dockside sampling of the commercial fisheries. The seven keys refer to the keys of Table 3.

4a. White Hake:Catch Numbers at Age (000's)

Age	Key 1	Key 2	Key 3	Key 4	Key 5	Key 6	Key 7	Sum
1	0	0	0	0	0	0	0	0
2	3	4	0	2	0	0	0	9
3	20	25	2	14	3	3	6	73
4	39	55	17	37	8	14	19	189
5	77	92	46	64	44	92	94	509
6	68	60	57	53	53	109	109	509
7	63	38	45	29	39	83	66	363
8	38	27	26	13	32	55	42	233
9	20	13	11	7	17	24	16	108
10	6	6	4	2	12	11	7	48
11	2	5	1	1	4	2	2	17
12	7	8	3	1	6	2	1	28
13	2	1	0	0	3	0	0	6
14	0	0	0	0	1	1	1	3
Sum (From Keys)	347	333	212	223	222	395	364	
No. in L-F	1182	1636	1153	3831	755	4956	6811	
No. Aged	432	432	432	432	621	621	621	
Mean Age	6.19	5.83	6.38	5.57	6.99	6.53	6.27	

4b. Average Weight at Age (kg)

Age	Key 1	Key 2	Key 3	Key 4	Key 5	Key 6	Key 7	Ave.Wt.
1	.00	.00	.00	.00	.00	.00	.00	.00
2	.82	.84	1.00	.89	.00	.00	.00	.84
3	.89	.97	1.30	.99	1.58	1.43	1.47	1.05
4	1.30	1.22	1.65	1.37	1.66	1.63	1.56	1.39
5	1.94	1.62	2.21	1.63	2.37	2.35	2.11	2.01
6	2.47	2.32	2.51	2.02	2.48	2.48	2.28	2.37
7	3.01	3.18	2.91	2.53	3.12	2.60	2.54	2.81
8	3.59	4.41	3.52	3.18	3.82	2.96	3.11	3.45
9	3.72	4.64	3.53	3.10	4.81	2.94	3.28	3.70
10	5.20	5.76	4.13	4.17	5.75	3.14	3.78	4.60
11	6.69	6.65	6.38	6.77	8.00	3.24	4.30	6.29
12	5.39	7.24	4.61	5.14	8.31	4.17	4.83	6.34
13	8.77	7.79	7.99	7.84	8.99	8.77	9.30	8.72
14	10.04	.00	10.04	10.04	5.94	3.24	3.28	4.15
Mean wt (From Keys)	2.58	2.44	2.70	1.94	3.44	2.57	2.43	
No. in L-F	1182	1636	1153	3831	755	4956	6811	
No. Aged	432	432	432	432	621	621	621	
Mean Age	6.19	5.83	6.38	5.57	6.99	6.53	6.27	

Table 5. Three of the category types and their associated categories used to run the Gavaris multiplicative model for the Gulf hake using commercial catch and effort data from 1978 to 1985. (Note: fourth category type is years.)

STATISTICAL DISTRICT		GEAR		TIME PERIODS	
CODE	AREA	CODE	NAME	CODE	PERIOD
2	CHETICAMP	41	GN	0	*JAN 1-MAY 14
3	*EAST ST GEORGES BAY	11	OTB-1	1	MAY 15-MAY 31
12	PICTOU	12	OTB-2	2	JUN 1-JUN 14
13	WEST ST GEORGES BAY	21	*SDN	3	JUN 15-JUN 30
65	CARAQUET	22(21)	SSC	4(3)	JUL 1-JUL 14
66	MISCOU/SHIPPAGAN			5	JUL 15-JUL 31
67	TRACADIE, N.B.			6	AUG 1-AUG 14
75(67)	RICHIBUCTO			7	AUG 15-AUG 31
76	BOUCTOUCHE			8	SPT 1-SPT 14
77(76)	SHEDIAC			9	SPT 15-SPT 30
80(76)	CAPE TORMENTINE			10(9)	OCT 1-OCT 14
82	TIGNISH			11	OCT 15-OCT 31
87	MURRAY HARBOUR			12	NOV 1-DEC 31
88(2)	SOURIS				
92	COW POND				
93	MALPEQUE				
94	RUSTICO				
95	TRACADIE, P.E.I.				

* standard category
( ) combined category

Table 6. Output for Gulf hake catch and effort data 1978 to 1985 from the Gavaris multiplicative model. See Table 5 for category types and codes.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... .551
MULTIPLE R SQUARED..... .303

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	4.224E0003	4.224E0003	
REGRESSION	32	4.783E0002	1.495E0001	26.042
TYPE 1	12	2.765E0002	2.304E0001	40.145
TYPE 2	3	4.613E0000	1.538E0000	2.679
TYPE 3	10	1.047E0002	1.047E0001	18.251
TYPE 4	7	3.399E0001	4.855E0000	8.460
RESIDUALS	1916	1.100E0003	5.739E-001	
TOTAL	1949	5.802E0003		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	3	INTERCEPT	0.404	0.195	1949
2	21				
3	0				
4	78				
1	2	1	0.368	0.062	467
	12	2	0.595	0.180	19
	13	3	0.315	0.103	80
	65	4	-0.820	0.093	86
	66	5	0.197	0.082	277
	67	6	0.122	0.093	182
	76	7	0.849	0.122	55
	82	8	0.050	0.078	120
	87	9	0.930	0.090	155
	92	10	-0.028	0.078	106
	93	11	-0.341	0.087	123
	96	12	-0.533	0.088	76
2	11	13	0.137	0.140	62
	12	14	-0.199	0.084	168
	41	15	-0.030	0.050	970
3	1	16	0.361	0.210	78
	2	17	0.628	0.193	148
	3	18	0.851	0.183	388
	5	19	0.689	0.186	208
	6	20	0.598	0.186	187
	7	21	0.706	0.187	175
	8	22	0.663	0.188	162
	9	23	0.879	0.184	322
	11	24	1.188	0.195	142
	12	25	1.614	0.198	104
4	79	26	0.123	0.082	207
	80	27	0.405	0.078	224
	81	28	0.382	0.075	267
	82	29	0.286	0.077	245
	83	30	0.205	0.079	194
	84	31	0.190	0.076	285
	85	32	0.034	0.076	344

Table 7. The weight-at-age matrix (grams) of Gulf hake from NAFO division 4T.

weight at age of Gulf hake 22/ 5/86

:	70	71	72	73	74	75	76	77	78	79	80
3 :	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050
4 :	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343	1343
5 :	1863	1863	1863	1863	1863	1863	1863	1863	1863	1863	1863
6 :	2267	2267	2267	2267	2267	2267	2267	2267	2267	2267	2267
7 :	2767	2767	2767	2767	2767	2767	2767	2767	2767	2767	2767
8 :	3297	3297	3297	3297	3297	3297	3297	3297	3297	3297	3297
9 :	3567	3567	3567	3567	3567	3567	3567	3567	3567	3567	3567
10 :	4483	4483	4483	4483	4483	4483	4483	4483	4483	4483	4483
11 :	5850	5850	5850	5850	5850	5850	5850	5850	5850	5850	5850
12 :	6900	6900	6900	6900	6900	6900	6900	6900	6900	6900	6900
13+:	9493	9493	9493	9493	9493	9493	9493	9493	9493	9493	9493

:	81	82	83	84	85
3 :	1050	1050	1060	1040	1050
4 :	1343	1343	1350	1290	1390
5 :	1863	1863	1910	1670	2010
6 :	2267	2267	2220	2210	2370
7 :	2767	2767	2810	2680	2810
8 :	3297	3297	3210	3230	3450
9 :	3567	3567	3470	3530	3700
10 :	4483	4483	4460	4390	4600
11 :	5850	5850	6670	4590	6290
12 :	6900	6900	8350	6010	6340
13+:	9493	9493	10730	9030	8720

Table 8a. The catch-at-age matrix of Gulf hake from NAFO division 4T.

catch matrix of Gulf hake 22/ 5/86

	70	71	72	73	74	75	76	77
3 :	86	84	91	79	49	56	81	86
4 :	705	711	631	496	249	214	297	332
5 :	794	794	744	660	378	389	432	470
6 :	454	446	483	458	295	342	332	361
7 :	371	377	402	451	312	378	291	301
8 :	143	144	165	190	136	170	131	136
9 :	73	77	84	107	78	98	67	66
10 :	42	43	44	50	33	41	28	29
11 :	12	14	12	12	8	8	5	5
12 :	7	8	8	9	5	7	9	8
13+:	6	6	6	8	5	5	3	3

	78	79	80	81	82	83	84	85
3 :	79	90	90	66	5	57	56	73
4 :	354	469	451	426	112	128	396	189
5 :	579	830	1025	1072	543	595	742	509
6 :	545	969	1657	1970	1129	787	806	509
7 :	345	670	1192	1386	1098	609	489	363
8 :	172	314	538	603	548	398	248	233
9 :	61	101	137	153	149	233	147	108
10 :	26	47	75	94	78	71	50	48
11 :	4	8	7	4	21	5	19	17
12 :	8	11	6	1	9	4	9	28
13+:	2	7	9	13	15	1	1	9

Table 8b. The percent composition of the catch at age of Gulf hake from NAFO division 4T.

percent composition of catch at age of Gulf hake 22/ 5/86

:	70	71	72	73	74	75	76	77	78	79
3 :	0.032	0.031	0.034	0.031	0.032	0.033	0.048	0.048	0.037	0.026
4 :	0.262	0.263	0.236	0.197	0.161	0.125	0.178	0.185	0.163	0.133
5 :	0.295	0.294	0.279	0.262	0.244	0.228	0.258	0.262	0.266	0.236
6 :	0.169	0.165	0.181	0.182	0.191	0.201	0.198	0.201	0.250	0.276
7 :	0.138	0.139	0.151	0.179	0.201	0.221	0.174	0.168	0.158	0.191
8 :	0.053	0.053	0.062	0.075	0.088	0.100	0.078	0.076	0.079	0.089
9 :	0.027	0.029	0.031	0.042	0.050	0.057	0.040	0.037	0.028	0.029
10 :	0.016	0.016	0.016	0.020	0.021	0.024	0.017	0.016	0.012	0.013
11 :	0.005	0.005	0.005	0.005	0.005	0.005	0.003	0.003	0.002	0.002
12 :	0.002	0.003	0.003	0.003	0.003	0.004	0.005	0.004	0.004	0.003
13+:	0.002	0.002	0.002	0.003	0.003	0.003	0.002	0.002	0.001	0.002

:	80	81	82	83	84	85
3 :	0.017	0.011	0.001	0.020	0.019	0.035
4 :	0.087	0.074	0.030	0.044	0.134	0.091
5 :	0.198	0.185	0.147	0.206	0.250	0.244
6 :	0.319	0.340	0.305	0.272	0.272	0.244
7 :	0.230	0.240	0.296	0.211	0.165	0.174
8 :	0.104	0.104	0.148	0.138	0.084	0.112
9 :	0.026	0.026	0.040	0.081	0.050	0.052
10 :	0.014	0.016	0.021	0.025	0.017	0.023
11 :	0.001	0.001	0.006	0.002	0.006	0.008
12 :	0.001	0.000	0.002	0.001	0.003	0.013
13+:	0.002	0.002	0.004	0.000	0.000	0.004

Table 9. VPA calibration results for NAFO division 4T white hake. The intercept, correlation coefficient, and residuals for the last 3 years were used as selection criteria for selected terminal F levels.

9a. These regressions were run with the commercial CPUE series from the multiplicative model against the 6+ total VPA population biomass, and the 3+ exploitable VPA population biomass.

6+ VPA POPULATION BIOMASS VS CPUE : RAW RESIDUALS

TERM F	INT	SLOPE	R2	RES83	RES84	RES85
0.28	2010	5885	0.686	-1073	-1216	1960
0.30	557	6284	0.717	-1235	-1650	1221
0.33	-655	6616	0.710	-1370	-2012	604
0.36	-1682	6898	0.689	-1484	-2319	82
0.39	-2563	7140	0.664	-1582	-2581	-367
0.41	-3328	7349	0.639	-1667	-2809	-756
0.44	-3998	7533	0.616	-1741	-3008	-1097
0.47	-4589	7696	0.596	-1806	-3184	-1398
0.50	-5116	7841	0.578	-1864	-3340	-1666
0.52	-5589	7971	0.562	-1915	-3479	-1907

3+ EXPLOITABLE VPA BIOMASS VS CPUE : RAW RESIDUALS

TERM F	INT	SLOPE	R2	RES83	RES84	RES85
0.28	2936	5905	0.319	-4767	1433	5192
0.30	1079	6429	0.412	-4751	795	4204
0.33	-470	6866	0.484	-4738	264	3380
0.36	-1781	7236	0.533	-4726	-185	2682
0.39	-2906	7553	0.564	-4717	-571	2084
0.41	-3881	7829	0.581	-4708	-905	1565
0.44	-4735	8070	0.589	-4700	-1197	1110
0.47	-5490	8283	0.592	-4694	-1454	709
0.50	-6161	8473	0.590	-4687	-1683	351
0.52	-6763	8643	0.586	-4682	-1887	32

9b. These regressions were run with the F (weighted by VPA population numbers) and effort, and the 6+ and 5+ VPA population numbers against the research vessel population numbers.

6+ VPA POP NB VS RV POP NB : RAW RESIDUALS

TERM F	INT	SLOPE	R2	RES83	RES84	RES85
0.28	2896	1	0.288	1771	1028	1013
0.30	2813	1	0.306	1616	772	651
0.33	2744	1	0.319	1487	559	349
0.36	2685	1	0.329	1378	378	93
0.39	2635	1	0.337	1284	223	-126
0.41	2592	1	0.342	1203	89	-316
0.44	2554	1	0.346	1132	-29	-482
0.47	2520	1	0.349	1070	-133	-629
0.50	2490	1	0.351	1014	-225	-760
0.52	2463	1	0.352	965	-307	-877

5+ VPA POP NB VS RV POP NB : RAW RESIDUALS

TERM F	INT	SLOPE	R2	RES83	RES84	RES85
0.28	5117	1	0.311	2653	472	1035
0.30	4969	1	0.323	2384	73	477
0.33	4845	1	0.332	2160	-259	12
0.36	4741	1	0.337	1971	-541	-382
0.39	4651	1	0.341	1808	-782	-719
0.41	4573	1	0.343	1668	-990	-1012
0.44	4505	1	0.344	1545	-1173	-1268
0.47	4445	1	0.345	1437	-1334	-1494
0.50	4392	1	0.345	1341	-1478	-1695
0.52	4344	1	0.344	1255	-1606	-1875

F<WEIGHTED> POP NB VS EFFORT<STANDARD> : RAW RESIDUALS

TERM F	INT	SLOPE	R2	RES83	RES84	RES85
0.28	-63	0	0.687	34	55	-17
0.30	-49	0	0.632	36	62	-14
0.33	-36	0	0.577	38	68	-10
0.36	-22	0	0.523	40	74	-6
0.39	-9	0	0.471	41	80	-3
0.41	4	0	0.421	42	86	2
0.44	18	0	0.374	42	91	6
0.47	31	0	0.330	43	96	11
0.50	44	0	0.289	43	101	15
0.52	56	0	0.251	43	105	20

Table 10. The fishable or exploitable population biomass of Gulf hake from NAFO division 4T calculated from the historical partial recruitment (Table 11) and the VPA population biomass (Appendix I).

exploitable biomass :tonnes 22/ 5/86

:	70	71	72	73	74	75	76	77	78	79
3 :	187	189	193	146	128	116	211	255	244	223
4 :	1966	2058	1717	1167	833	567	996	1252	1392	1486
5 :	3073	3187	2809	2152	1753	1431	2005	2459	3157	3650
6 :	2138	2177	2218	1817	1666	1534	1876	2296	3611	5183
7 :	1732	1848	1844	1864	1692	1665	1748	1905	2764	4374
8 :	950	979	1045	964	1032	959	931	1102	1176	1697
9 :	532	501	512	494	453	540	495	521	639	614
10 :	343	319	278	262	255	234	311	326	339	476
11 :	150	180	147	127	112	89	70	79	66	106
12 :	96	113	107	104	83	92	119	101	155	172
13+:	113	109	102	108	99	80	68	77	53	150
3+:	11278	11659	10971	9206	8107	7306	8829	10372	13595	18132

:	80	81	82	83	84	85
3 :	171	102	7	116	128	192
4 :	1093	851	229	333	1120	657
5 :	3445	2970	1539	2185	2718	2559
6 :	6773	6638	3893	3358	3798	3018
7 :	5476	5153	4235	3135	2877	2552
8 :	2754	2791	2371	2044	1760	2011
9 :	823	813	806	901	1040	1000
10 :	268	378	534	610	454	552
11 :	71	34	150	61	188	267
12 :	72	10	80	61	123	444
13+:	148	177	211	20	21	505
3+:	21094	19918	14055	12823	14227	13756

Table 11. The historical partial recruitment for Gulf hake from NAFO division 4T calculated by standardizing to the mean of the F values at ages 6,7, and 8 and setting all values over 1 to 1.

historical partial recruitment - standard ages 6 7 8 22/ 5/86

:	70	71	72	73	74	75	76	77	78	79	80
3 :	0.039	0.044	0.051	0.041	0.029	0.017	0.023	0.023	0.022	0.029	0.028
4 :	0.396	0.458	0.424	0.329	0.236	0.127	0.141	0.132	0.123	0.134	0.140
5 :	0.737	0.732	0.728	0.616	0.531	0.414	0.447	0.335	0.316	0.310	0.305
6 :	0.738	0.745	0.725	0.688	0.653	0.603	0.693	0.628	0.578	0.624	0.751
7 :	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.935	1.000
8 :	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9 :	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.947	1.000	1.000
10 :	1.000	1.000	1.000	1.000	1.000	1.000	0.952	1.000	0.937	1.000	1.000
11 :	0.721	0.782	0.701	0.775	0.734	0.502	0.474	0.291	0.241	0.348	0.186
12 :	0.663	0.803	0.682	0.755	0.763	0.900	1.000	1.000	0.698	0.802	0.285
13+:	0.956	1.000	1.000	1.000	1.000	1.000	0.895	0.868	0.690	0.802	0.934

:	81	82	83	84	85
3 :	0.020	0.002	0.029	0.035	0.030
4 :	0.141	0.043	0.076	0.299	0.170
5 :	0.395	0.256	0.394	0.728	0.650
6 :	0.835	0.752	0.749	1.000	1.000
7 :	1.000	1.000	1.000	0.984	1.000
8 :	1.000	1.000	1.000	0.987	1.000
9 :	0.565	0.573	1.000	1.000	0.900
10 :	1.000	0.518	0.601	1.000	0.750
11 :	0.260	1.000	0.059	0.276	0.750
12 :	0.029	1.000	0.635	0.171	0.700
13+:	0.891	0.669	0.321	0.308	0.700

Table 12. Percent composition of the VPA population numbers.

percent composition of population numbers of Gulf hake 22/ 5/86

	70	71	72	73	74	75	76	77	78	79	80
3	0.321	0.303	0.286	0.297	0.362	0.445	0.452	0.417	0.351	0.249	0.212
4	0.282	0.270	0.264	0.249	0.236	0.229	0.273	0.285	0.288	0.283	0.219
5	0.184	0.200	0.194	0.191	0.168	0.137	0.133	0.164	0.190	0.224	0.239
6	0.105	0.111	0.126	0.121	0.109	0.087	0.069	0.071	0.102	0.138	0.175
7	0.057	0.063	0.070	0.079	0.066	0.054	0.040	0.033	0.040	0.068	0.095
8	0.025	0.027	0.032	0.034	0.033	0.026	0.018	0.016	0.015	0.023	0.041
9	0.013	0.013	0.015	0.017	0.014	0.014	0.009	0.007	0.007	0.008	0.011
10	0.007	0.007	0.007	0.007	0.006	0.005	0.004	0.003	0.003	0.004	0.004
11	0.003	0.003	0.003	0.003	0.003	0.002	0.001	0.002	0.002	0.002	0.002
12	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
13+	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.001	0.001

	81	82	83	84	85
3	0.214	0.220	0.242	0.251	0.399
4	0.202	0.218	0.209	0.218	0.187
5	0.196	0.190	0.201	0.184	0.144
6	0.195	0.156	0.152	0.150	0.100
7	0.112	0.115	0.090	0.094	0.071
8	0.050	0.055	0.053	0.048	0.046
9	0.021	0.026	0.024	0.026	0.023
10	0.006	0.015	0.017	0.009	0.012
11	0.001	0.002	0.010	0.011	0.004
12	0.002	0.001	0.001	0.009	0.007
13+	0.001	0.002	0.000	0.001	0.006

Table 13. Percent composition of the catch biomass (tonnes).

percent composition of catch biomass of Gulf hake 22/ 5/86

	70	71	72	73	74	75	76	77	78	79	80
3	0.016	0.015	0.017	0.015	0.014	0.014	0.023	0.023	0.017	0.012	0.008
4	0.167	0.167	0.147	0.117	0.093	0.070	0.106	0.112	0.099	0.078	0.049
5	0.261	0.259	0.241	0.216	0.195	0.176	0.214	0.220	0.224	0.191	0.154
6	0.182	0.177	0.190	0.182	0.185	0.188	0.200	0.205	0.256	0.271	0.302
7	0.181	0.183	0.193	0.219	0.238	0.254	0.214	0.209	0.198	0.229	0.266
8	0.083	0.083	0.094	0.110	0.124	0.136	0.115	0.113	0.118	0.128	0.143
9	0.046	0.048	0.052	0.067	0.077	0.085	0.064	0.059	0.045	0.044	0.039
10	0.033	0.034	0.034	0.039	0.041	0.045	0.033	0.032	0.024	0.026	0.027
11	0.013	0.015	0.013	0.013	0.012	0.011	0.007	0.007	0.005	0.006	0.003
12	0.008	0.009	0.009	0.010	0.009	0.011	0.016	0.013	0.011	0.009	0.003
13+	0.010	0.009	0.009	0.013	0.013	0.011	0.007	0.007	0.004	0.008	0.007

	81	82	83	84	85
3	0.005	0.000	0.008	0.009	0.014
4	0.041	0.015	0.024	0.077	0.049
5	0.142	0.104	0.156	0.188	0.190
6	0.318	0.262	0.239	0.270	0.224
7	0.273	0.311	0.234	0.199	0.190
8	0.141	0.185	0.175	0.122	0.150
9	0.039	0.054	0.111	0.079	0.074
10	0.030	0.036	0.043	0.033	0.041
11	0.002	0.013	0.004	0.013	0.020
12	0.000	0.006	0.004	0.009	0.033
13+	0.008	0.014	0.001	0.001	0.015

Table 14. Percent composition of the fishable biomass (Table 10) of Gulf hake in NAFO division 4T.

percent composition of fishable biomass of Gulf hake 22/ 5/86

	70	71	72	73	74	75	76	77	78	79	80
3	0.017	0.016	0.018	0.016	0.016	0.016	0.024	0.025	0.018	0.012	0.008
4	0.174	0.177	0.156	0.127	0.103	0.078	0.113	0.121	0.102	0.082	0.052
5	0.272	0.273	0.256	0.234	0.216	0.196	0.227	0.237	0.232	0.201	0.163
6	0.190	0.187	0.202	0.197	0.206	0.210	0.212	0.221	0.266	0.286	0.321
7	0.154	0.158	0.168	0.202	0.209	0.228	0.198	0.184	0.203	0.241	0.260
8	0.084	0.084	0.095	0.105	0.127	0.131	0.105	0.106	0.086	0.094	0.131
9	0.047	0.043	0.047	0.054	0.056	0.074	0.056	0.050	0.047	0.034	0.039
10	0.030	0.027	0.025	0.028	0.031	0.032	0.035	0.031	0.025	0.026	0.013
11	0.013	0.015	0.013	0.014	0.014	0.012	0.008	0.008	0.005	0.006	0.003
12	0.008	0.010	0.010	0.011	0.010	0.013	0.013	0.010	0.011	0.009	0.003
13+	0.010	0.009	0.009	0.012	0.012	0.011	0.008	0.007	0.004	0.008	0.007

	81	82	83	84	85
3	0.005	0.001	0.009	0.009	0.014
4	0.043	0.016	0.026	0.079	0.048
5	0.149	0.110	0.170	0.191	0.186
6	0.333	0.277	0.262	0.267	0.219
7	0.259	0.301	0.244	0.202	0.185
8	0.140	0.169	0.159	0.124	0.146
9	0.041	0.057	0.070	0.073	0.073
10	0.019	0.038	0.048	0.032	0.040
11	0.002	0.011	0.005	0.013	0.019
12	0.000	0.006	0.005	0.009	0.032
13+	0.009	0.015	0.002	0.001	0.037

Figure 1. Cumulative nominal landings by gear and year of NAFO division 4T Gulf hake.

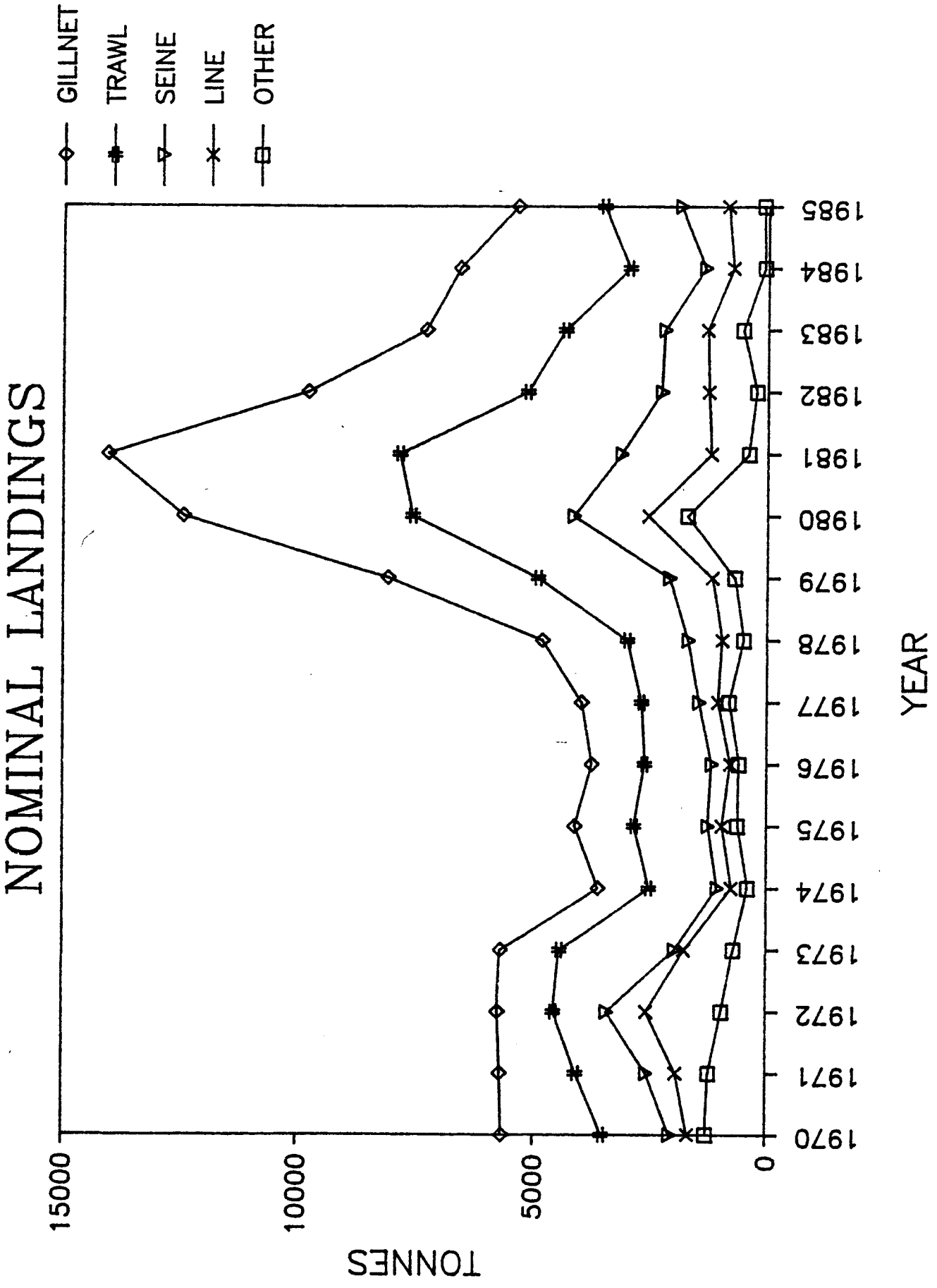


Figure 2. Residual plot from Gavaris multiplicative model Table 6.

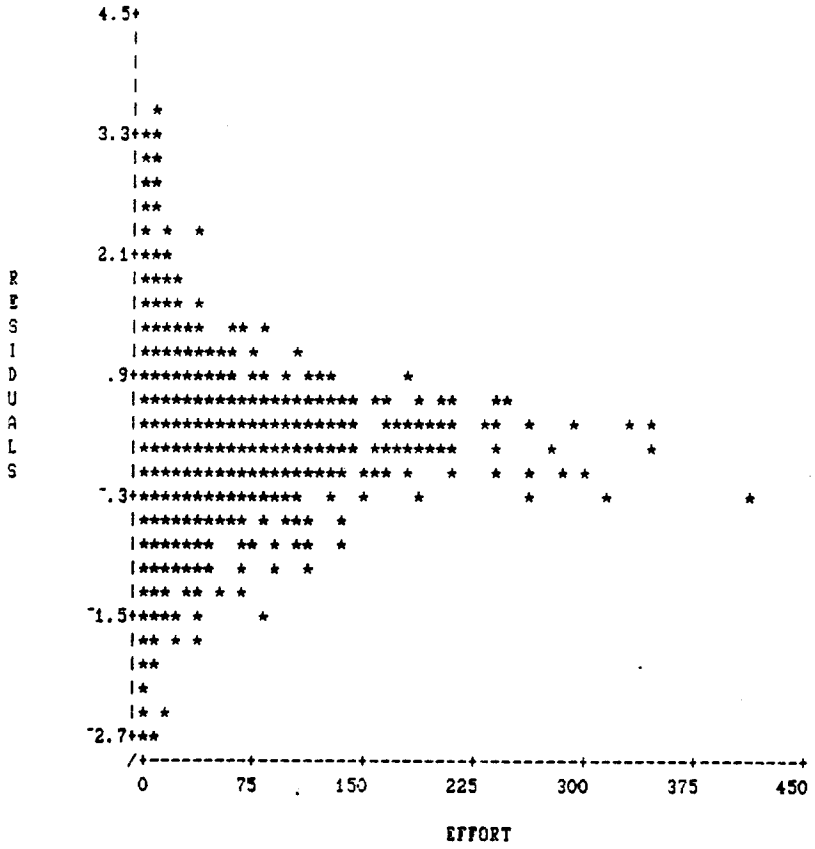


Figure 3. Residual - expected normal plot of data shown in Figure 2.

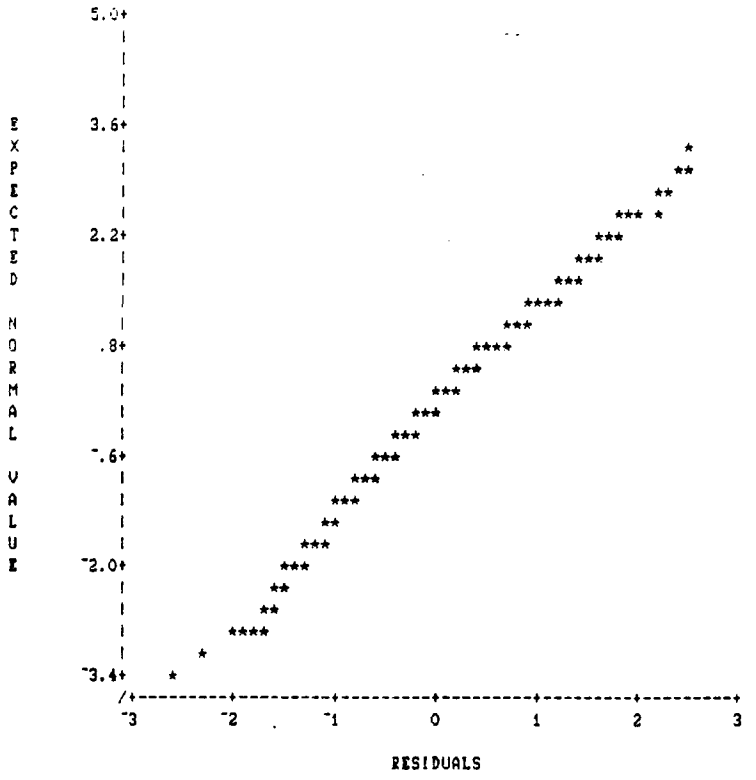


Figure 4. Residuals at successive fishing effort levels in the 2nd to last run of the Gavaris multiplicative model.

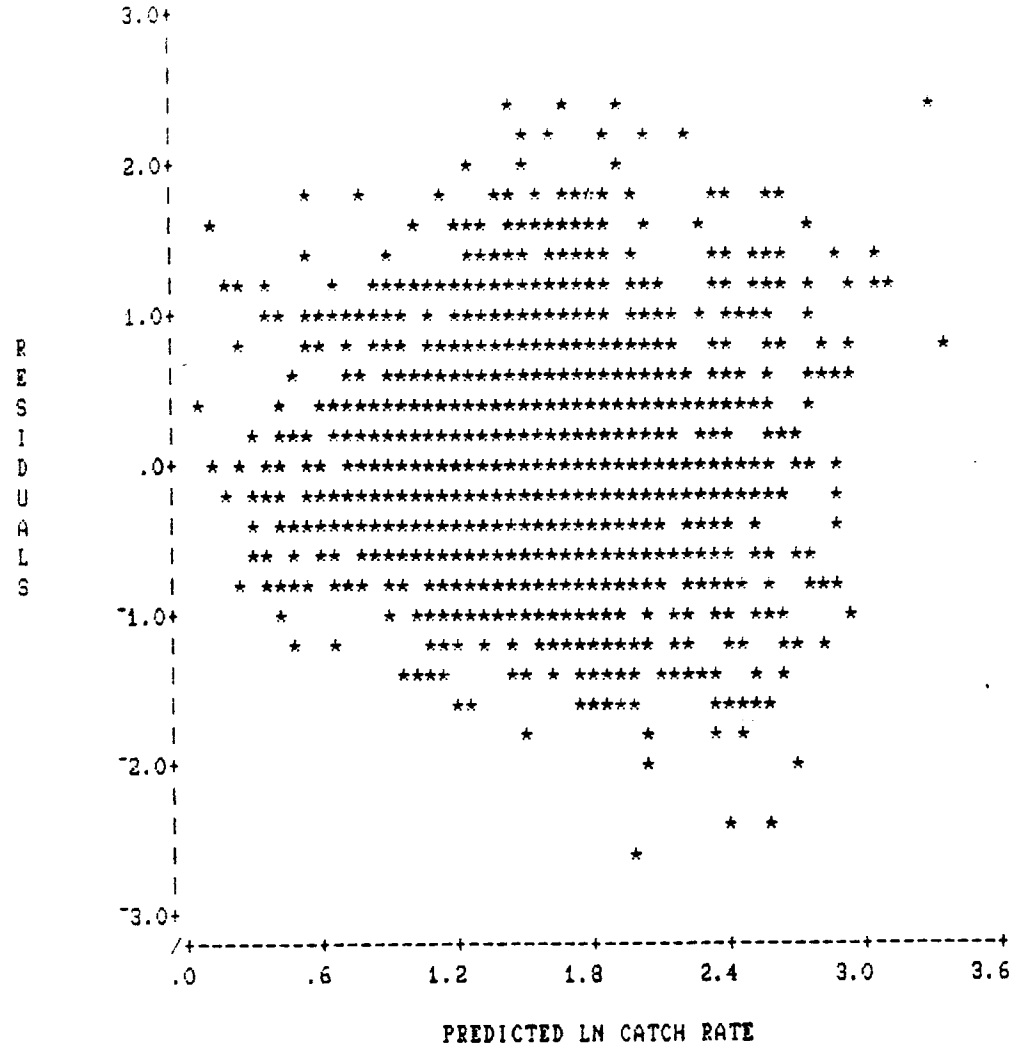


Figure 5. Catch rates from Gavaris multiplicative model for Gulf hake in NAFO division 4T. All catches are expressed in hundred's of kg.

PREDICTED CATCH RATE

STANDARDS USED VARIABLE NUMBERS: 3 21 0

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	S.E.	EFFORT
78	48250	0.366	1.957	0.379	24649
79	81100	0.337	2.215	0.426	36616
80	124230	0.435	2.938	0.558	42287
81	140390	0.437	2.870	0.538	48916
82	97760	0.491	2.607	0.495	37506
83	73050	0.423	2.404	0.460	30389
84	65920	0.675	2.369	0.446	27825
85	53790	0.746	2.028	0.383	26529

AVERAGE C.V. FOR THE MEAN: .190

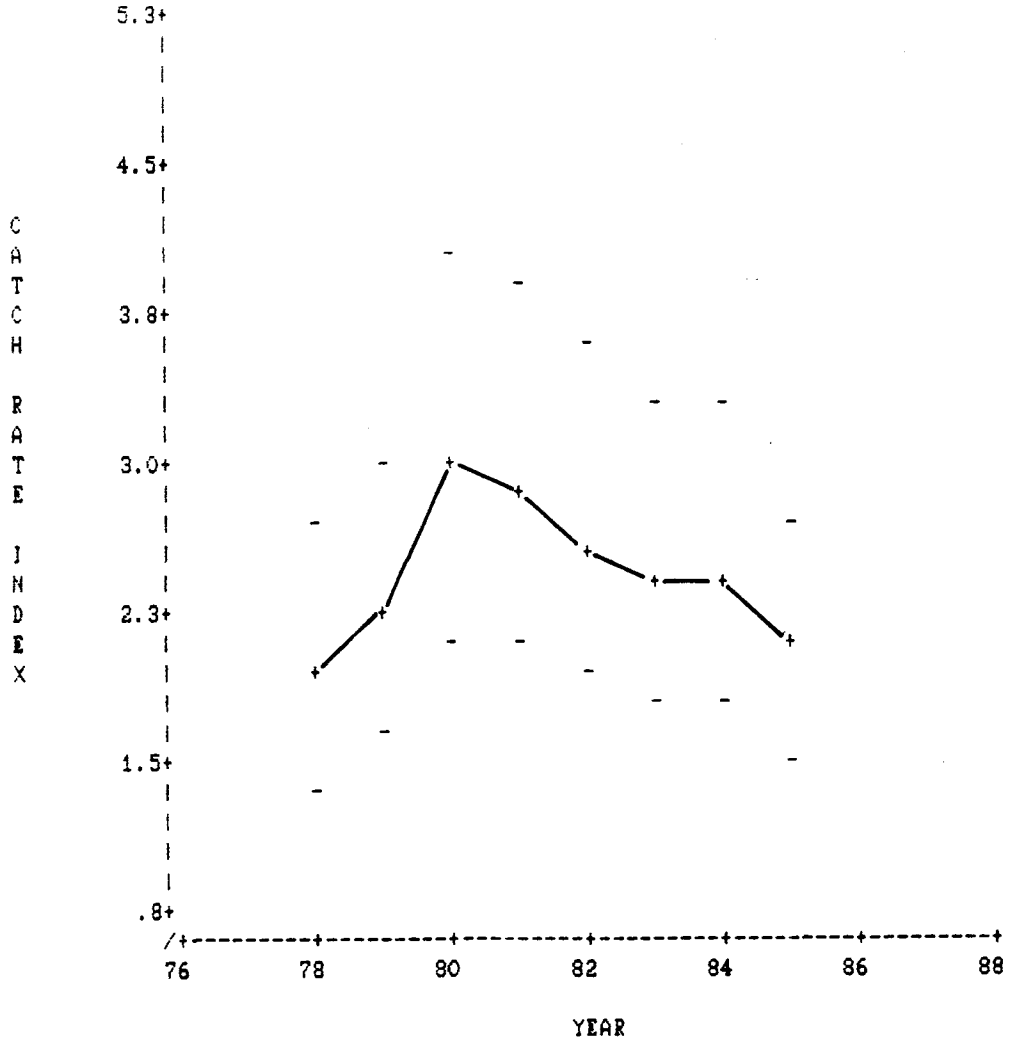


Figure 6a. Partial recruitment calculated by commercial catch at age divided by research population at age all standardized to the age group with the highest value.

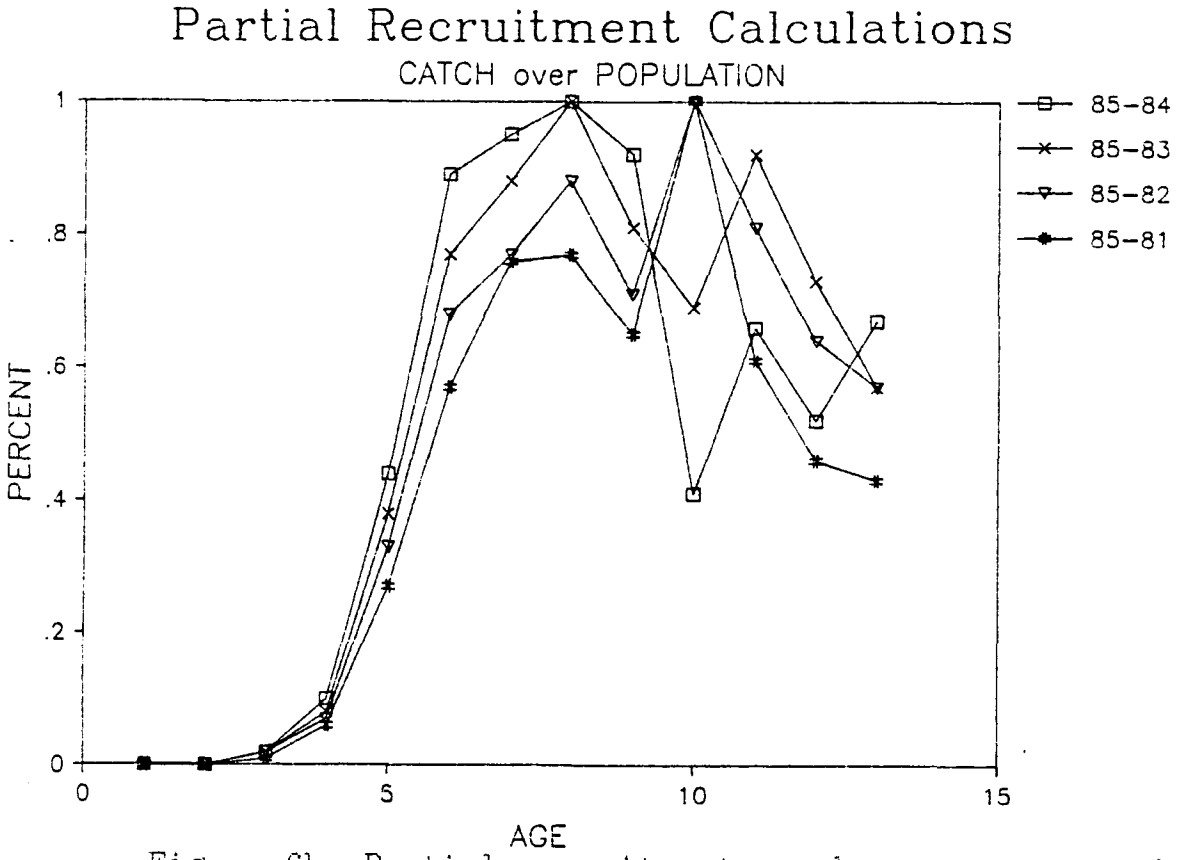


Figure 6b. Partial recruitment as above except standardized to the mean of the F values at ages 6, 7, and 8 with all values over 1 set to 1.

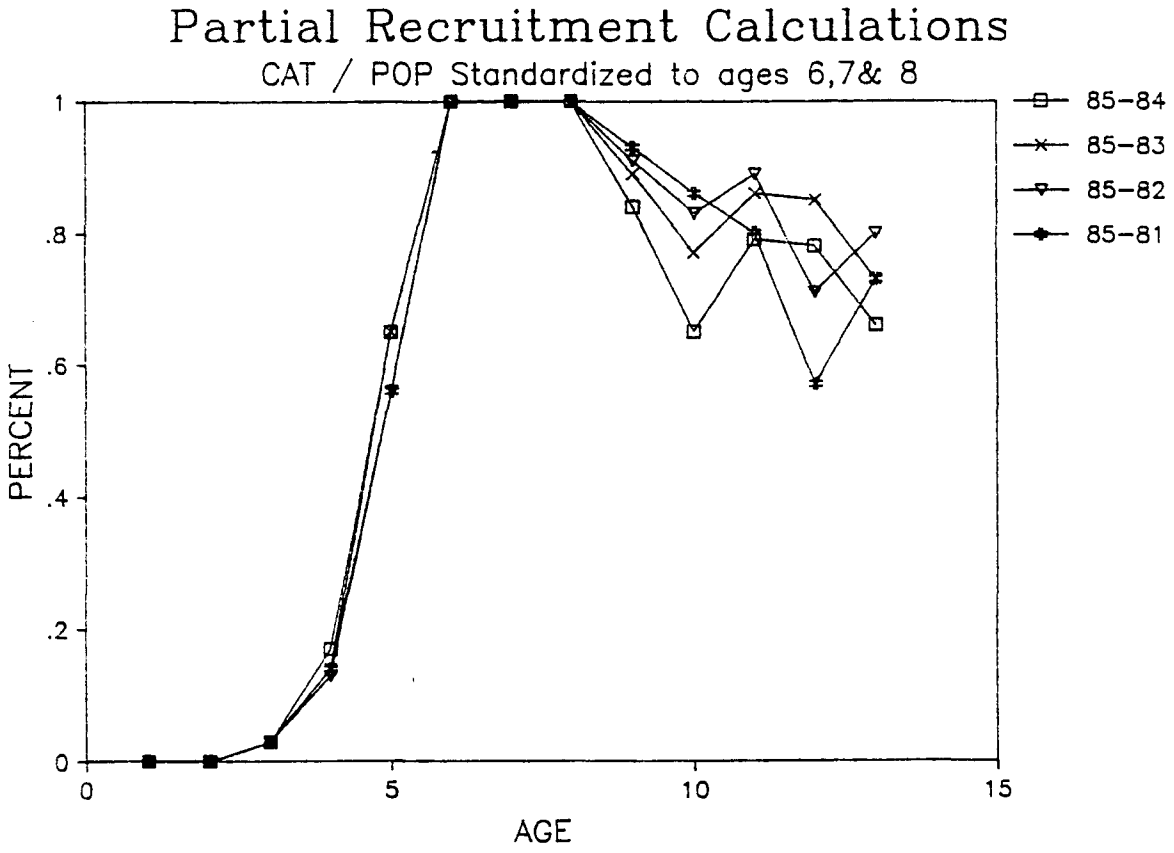


Figure 7a. Partial recruitment calculated by iterative historical averaging of the VPA using 1984 values as starting points.

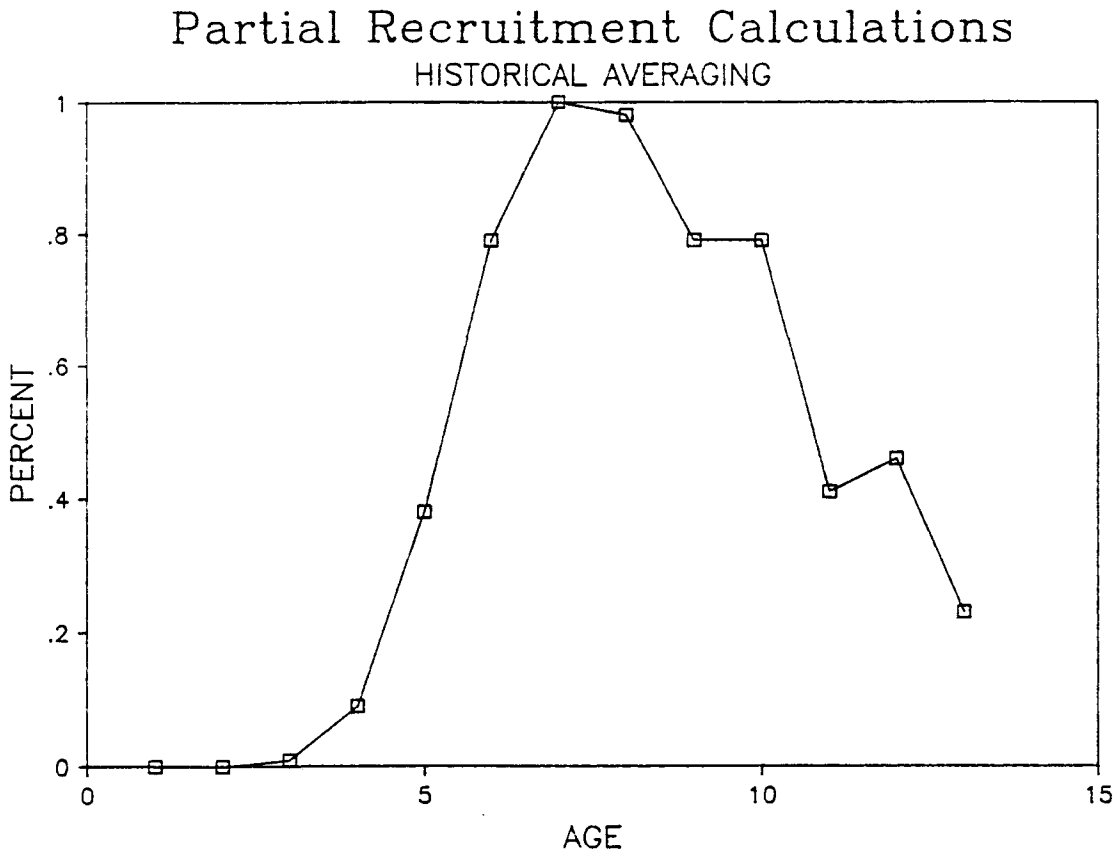


Figure 7b. Partial recruitment calculated from weighted mean of the estimated selectivity of gill nets and otter trawls on Gulf hake.

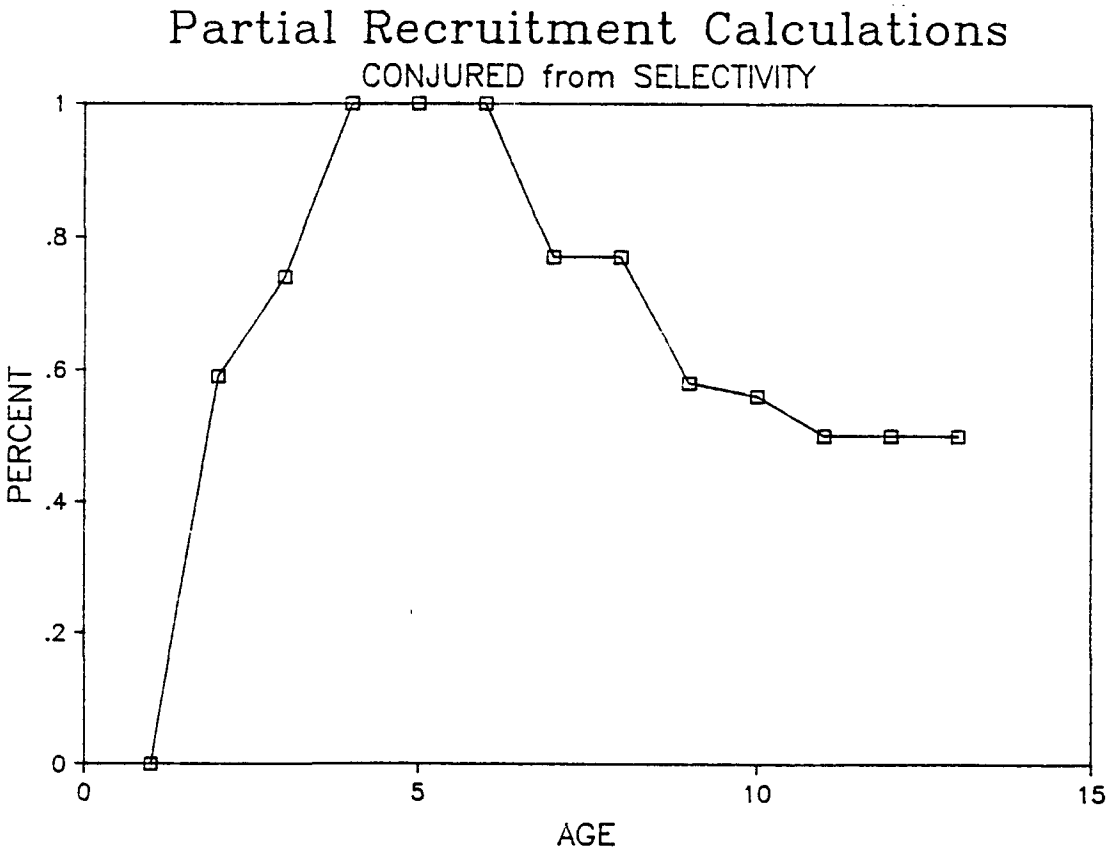


Figure 8. The partial recruitment used in the 1985 assessment (Clay et al., MS 1985a) compared to that chosen for the 1986 assessment.

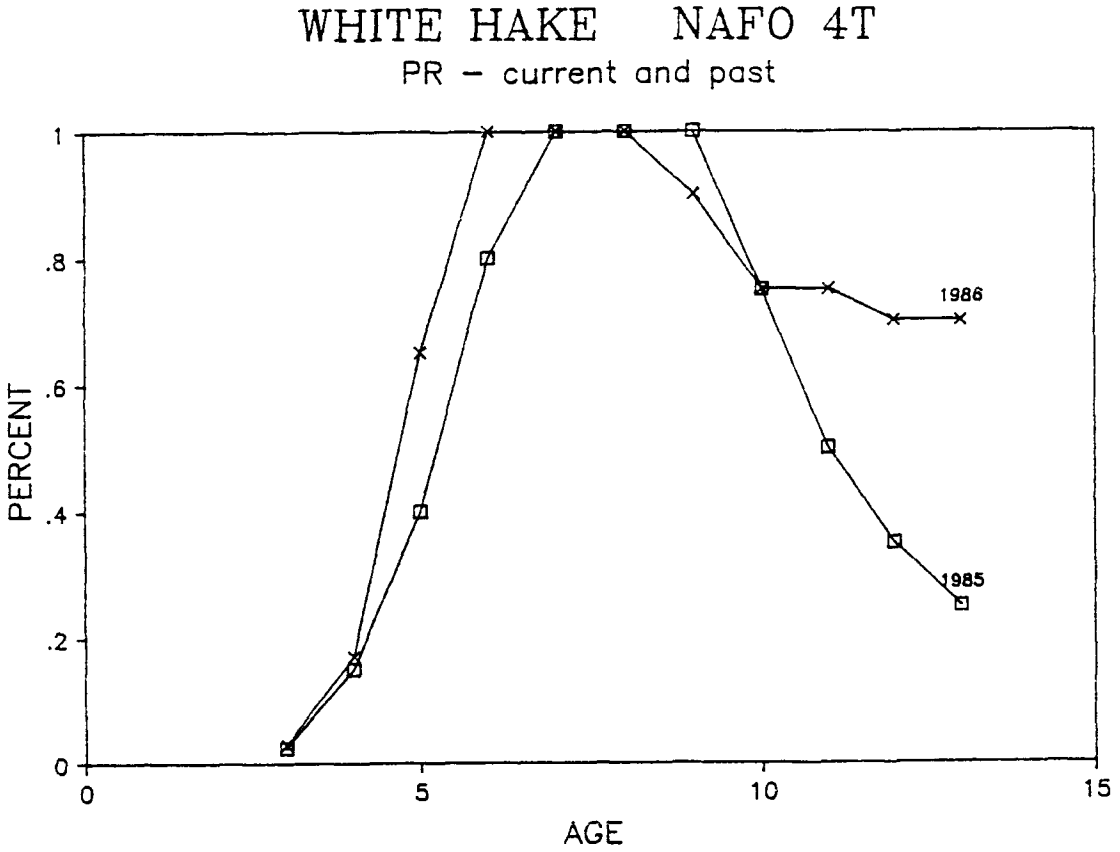


Figure 9. Total mortality (Z) from catch curves of white hake from NAFO division 4T. The years 1978 and 1983 are slightly off the line.

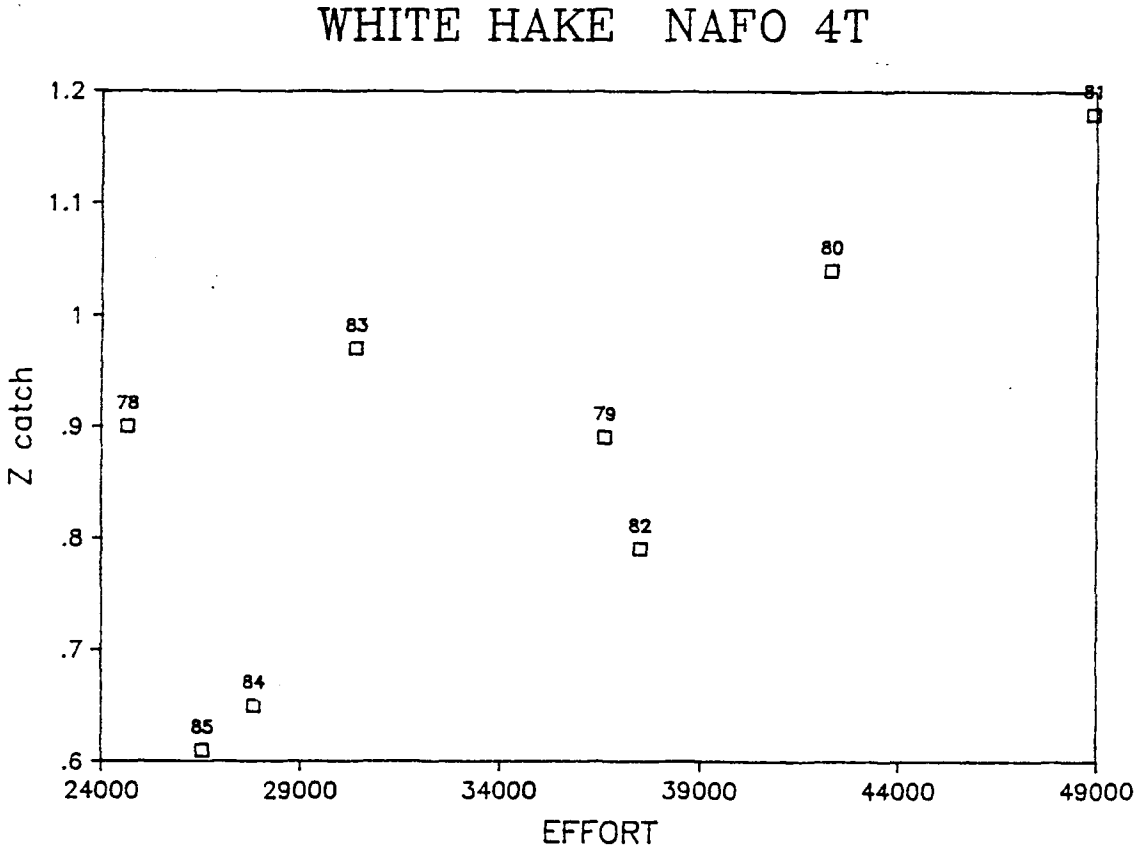


Figure 10. Total mortality (Z) from CPUE at age of white hake from NAFO division 4T. The year 1981/1982 is a distant outlier in this relationship.

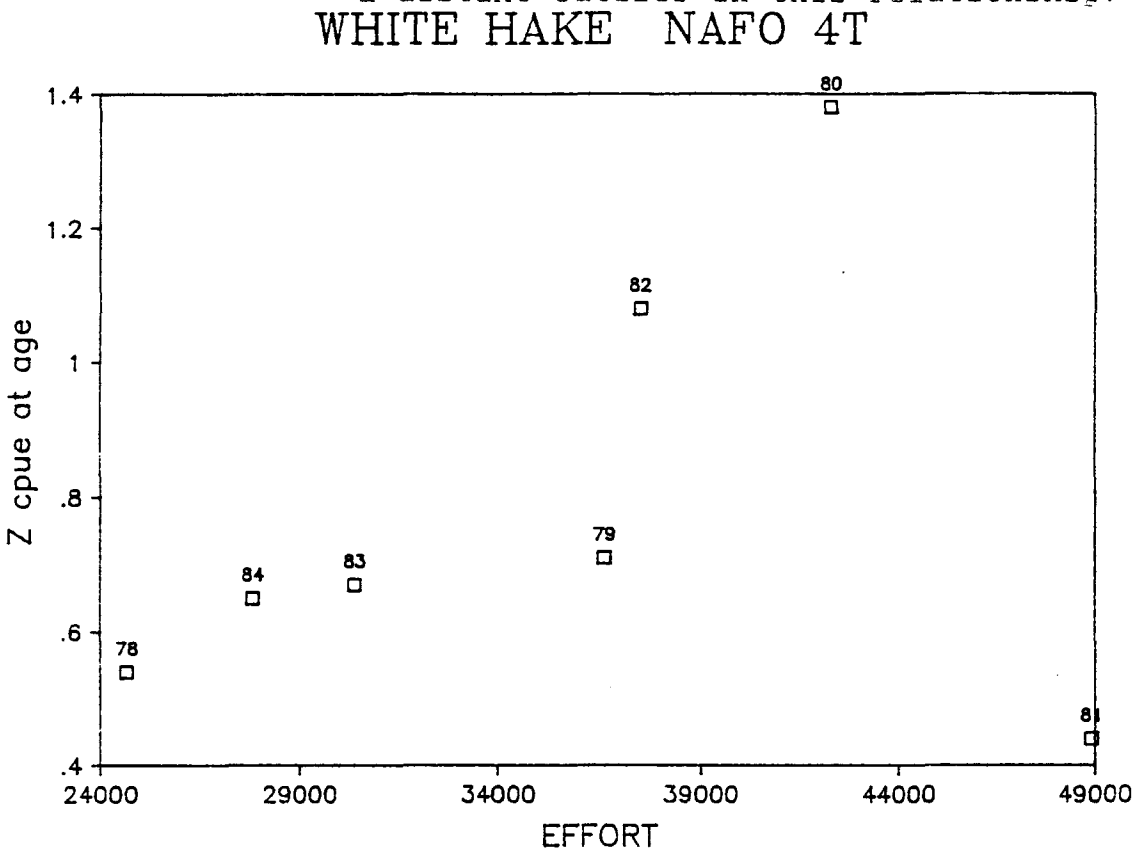
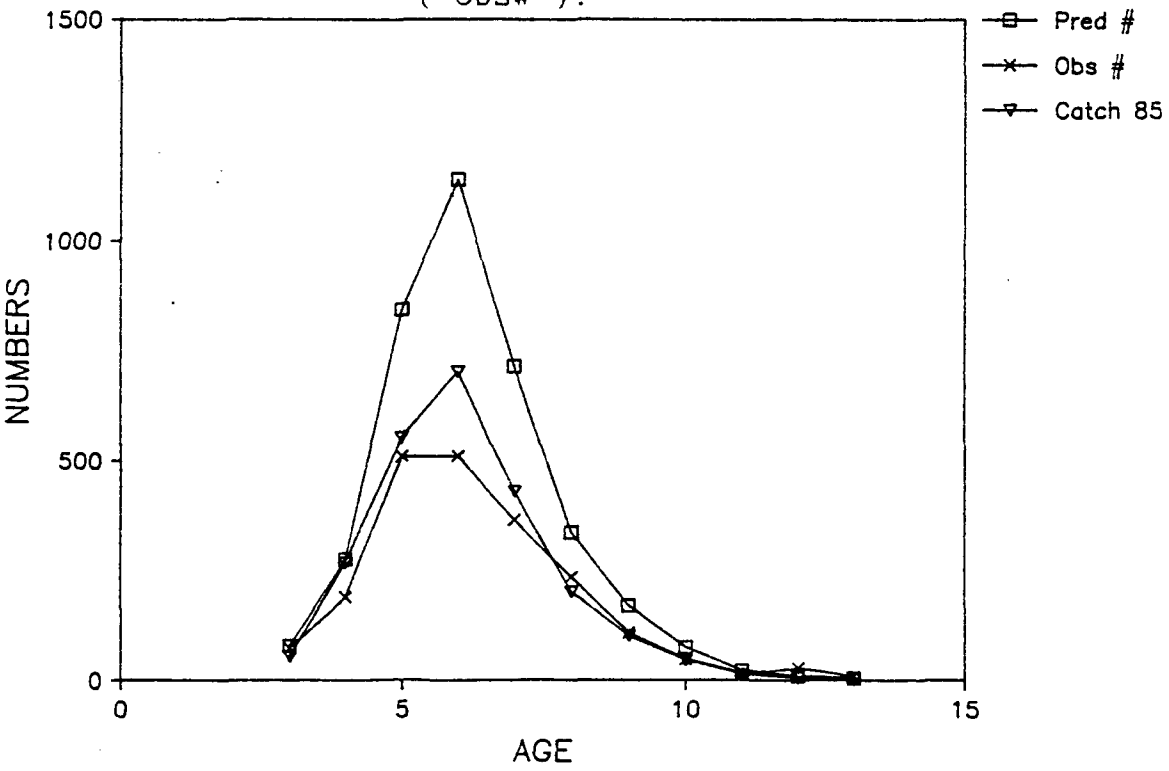


Figure 11. Comparison of the 1985 catch at age as
1) observed in the 'Catch of 1985',
2) predicted from the Fo.1 projections in the 1985 assessment ('Pred #'), and
3) predicted from the 1985 assessment using the actual landings of 1985 for projections ('Obs#').



APPENDIX I

VPA run with the parameters from the text and a terminal F of 0.4.

population numbers (000's) 22/ 5/86

:	70	71	72	73	74	75	76	77	78	79
3 :	5083	4580	3992	3796	4657	7323	9834	11650	11528	8238
4 :	4468	4084	3674	3187	3037	3768	5946	7979	9460	9367
5 :	2916	3023	2703	2440	2162	2262	2892	4599	6233	7425
6 :	1665	1674	1762	1545	1405	1430	1502	1979	3342	4581
7 :	907	955	970	1009	854	885	863	931	1296	2246
8 :	400	410	445	434	423	420	387	446	492	751
9 :	207	199	207	217	186	224	192	199	243	249
10 :	109	103	94	94	82	82	96	97	103	144
11 :	46	51	46	38	33	38	30	54	53	61
12 :	27	27	29	27	20	20	24	21	40	40
13+:	17	16	15	17	14	12	10	12	10	26
3+:	15843	15123	13938	12804	12872	16465	21776	27966	32801	33127
4+:	10761	10543	9946	9007	8215	9142	11942	16316	21273	24889
5+:	6293	6459	6272	5821	5179	5373	5997	8337	11813	15522
6+:	3377	3436	3569	3381	3016	3112	3104	3738	5580	8097

:	80	81	82	83	84	85
3 :	6435	5494	4477	4240	3934	6755
4 :	6663	5187	4439	3661	3420	3170
5 :	7246	5049	3862	3533	2882	2444
6 :	5331	5009	3169	2673	2357	1693
7 :	2879	2878	2338	1583	1482	1207
8 :	1237	1290	1120	935	751	775
9 :	334	532	519	428	410	392
10 :	113	151	298	291	143	203
11 :	76	26	41	173	174	72
12 :	43	56	18	15	138	126
13+:	23	30	45	7	9	104
3+:	30381	25704	20326	17539	15700	16942
4+:	23946	20210	15850	13299	11766	10187
5+:	17282	15023	11410	9638	8345	7017
6+:	10037	9974	7548	6105	5463	4573

mid-year population biomass : tonnes 22/ 5/86

:	70	71	72	73	74	75	76	77	78	79
3 :	4793	4316	3753	3572	4407	6941	9318	11043	10931	7794
4 :	4969	4495	4050	3548	3533	4448	7044	9497	11286	11097
5 :	4170	4353	3857	3495	3300	3458	4485	7337	9996	11777
6 :	2895	2924	3061	2641	2551	2545	2706	3658	6251	8305
7 :	1732	1848	1844	1864	1692	1665	1748	1905	2764	4680
8 :	950	979	1045	964	1032	959	931	1102	1176	1697
9 :	532	501	512	494	453	540	495	521	675	614
10 :	343	319	278	262	255	234	327	326	362	476
11 :	209	230	209	164	153	177	148	271	272	304
12 :	144	141	156	138	108	102	119	101	221	214
13+:	118	109	102	108	99	80	76	88	77	187
3+:	20854	20214	18868	17251	17582	21149	27396	35849	44009	47146
4+:	16060	15898	15115	13678	13176	14208	18078	24806	33078	39352
5+:	11092	11403	11065	10130	9643	9760	11034	15309	21792	28255
6+:	6922	7050	7207	6635	6343	6302	6549	7972	11797	16478

:	80	81	82	83	84	85
3 :	6078	5195	4258	4045	3680	6391
4 :	7817	6035	5332	4395	3747	3866
5 :	11290	7521	6021	5550	3732	3937
6 :	9020	7947	5180	4483	3798	3018
7 :	5476	5153	4235	3135	2923	2552
8 :	2754	2791	2371	2044	1783	2011
9 :	823	1439	1405	901	1040	1111
10 :	268	378	1031	1016	454	736
11 :	382	129	150	1032	683	357
12 :	252	346	80	96	722	634
13+:	159	198	315	61	67	722
3+:	44318	37134	30378	26758	22630	25333
4+:	38240	31939	26120	22713	18951	18942
5+:	30424	25904	20788	18318	15203	15077
6+:	19134	18383	14767	12768	11471	11140

catch biomass : tonnes 22/ 5/86

:	70	71	72	73	74	75	76	77	78	79	80
3 :	90	88	95	83	51	59	85	91	83	95	95
4 :	947	956	848	667	335	287	400	446	476	630	606
5 :	1480	1480	1387	1229	704	724	804	875	1080	1547	1910
6 :	1030	1011	1095	1038	669	776	752	817	1235	2197	3755
7 :	1028	1042	1113	1248	862	1046	804	833	954	1854	3298
8 :	471	473	544	627	447	561	433	449	568	1037	1775
9 :	262	275	299	382	278	350	240	236	219	359	487
10 :	188	192	197	223	147	185	125	129	116	211	336
11 :	72	83	72	73	45	45	28	28	22	45	39
12 :	46	53	53	59	33	46	60	53	53	73	40
13+:	54	54	54	73	46	46	27	27	18	64	82
3+:	5668	5707	5757	5702	3616	4125	3758	3984	4825	8110	12423
4+:	5578	5619	5662	5619	3565	4066	3673	3893	4742	8015	12328
5+:	4631	4663	4814	4952	3230	3780	3274	3448	4265	7386	11722
6+:	3151	3184	3427	3723	2526	3056	2469	2572	3186	5839	9813

:	81	82	83	84	85
3 :	69	5	60	58	77
4 :	572	151	173	510	263
5 :	1998	1012	1136	1238	1024
6 :	4464	2560	1746	1781	1207
7 :	3835	3037	1712	1311	1021
8 :	1986	1806	1276	802	804
9 :	547	530	810	521	400
10 :	419	351	317	219	221
11 :	23	123	32	86	107
12 :	7	63	32	56	178
13+:	119	138	10	9	79
3+:	14039	9776	7305	6592	5379
4+:	13970	9771	7245	6534	5302
5+:	13398	9621	7072	6023	5039
6+:	11400	8608	5935	4785	4016

production 22/ 5/86

source	:	70	71	72	73	74	75	76
recruitment biomass	:	4718	4252	3706	3524	4323	6798	9129
growth	:	4950	4889	4520	4131	4182	5111	6757
total production	:	9668	9141	8226	7656	8504	11909	15886
loss through fishing	:	5668	5707	5757	5702	3616	4125	3758
surplus production	:	5498	5098	4452	4206	4988	7680	10407
net production	:	-170	-609	-1305	-1496	1372	3555	6649

source	:	77	78	79	80	81	82
recruitment biomass	:	10814	10702	7648	5974	5100	4156
growth	:	8899	10830	11404	10423	8596	7106
total production	:	19714	21532	19052	16397	13696	11262
loss through fishing	:	3984	4825	8110	12423	14039	9776
surplus production	:	12544	12730	9623	7533	6270	5186
net production	:	8560	7905	1513	-4890	-7769	-4590

source	:	83	84	85
recruitment biomass	:	3927	3780	6076
growth	:	5558	5157	7856
total production	:	9484	8937	13932
loss through fishing	:	7305	6592	5379
surplus production	:	4133	4411	8866
net production	:	-3172	-2181	3487

production/biomass ratio 22/ 5/86

:	70	71	72	73	74	75	76	77	78	79	80	81
:	0.46	0.45	0.44	0.44	0.48	0.56	0.58	0.55	0.49	0.40	0.37	0.37

:	82	83	84	85
:	0.37	0.35	0.39	0.55

fishing mortality 22/ 5/86

:	70	71	72	73	74	75	76	77	78	79
3 :	0.019	0.020	0.025	0.023	0.012	0.008	0.009	0.008	0.008	0.012
4 :	0.191	0.213	0.209	0.188	0.095	0.064	0.057	0.047	0.042	0.057
5 :	0.355	0.340	0.360	0.352	0.213	0.209	0.179	0.119	0.108	0.131
6 :	0.356	0.346	0.358	0.393	0.262	0.305	0.278	0.223	0.198	0.265
7 :	0.593	0.564	0.603	0.670	0.510	0.628	0.460	0.437	0.345	0.396
8 :	0.496	0.483	0.520	0.651	0.433	0.585	0.465	0.407	0.483	0.611
9 :	0.492	0.549	0.585	0.774	0.613	0.648	0.484	0.453	0.324	0.584
10 :	0.548	0.601	0.708	0.850	0.574	0.793	0.382	0.395	0.321	0.442
11 :	0.347	0.363	0.346	0.443	0.295	0.254	0.190	0.104	0.083	0.148
12 :	0.320	0.373	0.337	0.431	0.306	0.455	0.502	0.523	0.239	0.340
13+:	0.460	0.498	0.534	0.669	0.459	0.573	0.359	0.309	0.236	0.340
3+:	0.221	0.232	0.252	0.265	0.153	0.137	0.096	0.079	0.080	0.133

:	80	81	82	83	84	85
3 :	0.016	0.013	0.001	0.015	0.016	0.012
4 :	0.077	0.095	0.028	0.039	0.136	0.068
5 :	0.169	0.266	0.168	0.205	0.332	0.260
6 :	0.416	0.562	0.494	0.390	0.469	0.400
7 :	0.602	0.744	0.717	0.546	0.448	0.400
8 :	0.645	0.712	0.762	0.625	0.450	0.400
9 :	0.592	0.380	0.377	0.899	0.500	0.360
10 :	1.255	1.108	0.341	0.312	0.482	0.300
11 :	0.103	0.175	0.816	0.031	0.126	0.300
12 :	0.158	0.019	0.788	0.330	0.078	0.280
13+:	0.518	0.600	0.440	0.167	0.141	0.280
3+:	0.229	0.318	0.258	0.223	0.248	0.159

APPENDIX II

Projections run with parameters listed in the text and an Fo.1 of 0.32.

population numbers (000's) 22/ 5/86

:	85	86	87	88	89	90
3 :	6500	6500	6500	6500	6500	6500
4 :	3170	5256	5271	5271	5271	5271
5 :	2444	2425	4075	4087	4087	4087
6 :	1693	1543	1613	2710	2718	2718
7 :	1207	929	917	959	1611	1616
8 :	775	663	552	545	570	958
9 :	392	425	394	328	324	339
10 :	203	224	261	242	202	199
11 :	72	123	144	168	156	130
12 :	126	44	79	93	108	100
13+:	104	78	29	52	61	71
3+:	16687	18210	19836	20955	21607	21988
4+:	10187	11710	13336	14455	15107	15488
5+:	7017	6454	8065	9184	9836	10217
6+:	4573	4029	3990	5097	5749	6130

population biomass :tonnes 22/ 5/86

:	85	86	87	88	89	90
3 :	6148.67	6157.20	6157.20	6157.20	6157.20	6157.20
4 :	3865.55	6450.31	6468.87	6468.87	6468.87	6468.87
5 :	3937.16	4002.30	6726.06	6745.42	6745.42	6745.42
6 :	3017.51	2850.96	2980.05	5008.12	5022.53	5022.53
7 :	2551.50	2036.05	2009.63	2100.62	3530.20	3540.36
8 :	2010.75	1782.75	1486.17	1466.88	1533.30	2576.79
9 :	1110.62	1245.35	1153.47	961.58	949.10	992.08
10 :	736.41	833.32	971.70	900.01	750.29	740.55
11 :	356.63	627.88	733.86	855.72	792.60	660.74
12 :	634.35	225.81	410.63	479.94	559.64	518.35
13+:	785.24	554.05	203.25	369.61	431.99	503.73
3+:	25154.41	26765.99	29300.90	31513.98	32941.13	33926.60
4+:	19005.74	20608.79	23143.70	25356.78	26783.93	27769.40
5+:	15140.19	14158.48	16674.84	18887.91	20315.06	21300.54
6+:	11203.03	10156.18	9948.77	12142.49	13569.65	14555.12

catch biomass : tonnes 22/ 5/86

:	85	86	87	88	89	90
3 :	77	59	59	59	59	59
4 :	263	351	352	352	352	352
5 :	1024	832	1399	1403	1403	1403
6 :	1207	912	954	1603	1607	1607
7 :	1021	652	643	672	1130	1133
8 :	804	570	476	469	491	825
9 :	400	359	332	277	273	286
10 :	221	200	233	216	180	178
11 :	107	151	176	205	190	159
12 :	178	51	92	108	125	116
13+:	79	124	46	83	97	113
3+:	5379	4261	4761	5447	5907	6230
4+:	5302	4202	4702	5388	5848	6171
5+:	5039	3851	4350	5036	5496	5819
6+:	4016	3018	2951	3633	4093	4416

fishing mortality 22/ 5/86

:	85	86	87	88	89	90
3 :	0.012	0.010	0.010	0.010	0.010	0.010
4 :	0.068	0.054	0.054	0.054	0.054	0.054
5 :	0.260	0.208	0.208	0.208	0.208	0.208
6 :	0.400	0.320	0.320	0.320	0.320	0.320
7 :	0.400	0.320	0.320	0.320	0.320	0.320
8 :	0.400	0.320	0.320	0.320	0.320	0.320
9 :	0.360	0.288	0.288	0.288	0.288	0.288
10 :	0.300	0.240	0.240	0.240	0.240	0.240
11 :	0.300	0.240	0.240	0.240	0.240	0.240
12 :	0.280	0.224	0.224	0.224	0.224	0.224
13+:	0.100	0.224	0.224	0.224	0.224	0.224
3+:	0.160	0.115	0.122	0.132	0.138	0.141

production 22/ 5/86

source	:	85	86	87	88	89	90
recruitment biomass	:	5932	5932	5932	5932	5932	5932
growth	:	6124	6771	7455	7858	8117	8274
total production	:	12056	12703	13386	13790	14049	14206
loss through fishing	:	5379	4261	4761	5447	5907	6230
surplus production	:	7025	7350	7526	7487	7461	7420
net production	:	1646	3089	2765	2040	1553	1191

production/biomass ratio 22/ 5/86

:	85	86	87	88	89	90
:	0.48	0.47	0.46	0.44	0.43	0.42

summary of projections 22/ 5/86

year	:	85	86	87	88
population numbers	:	16687.38	18209.64	19835.64	20955.10
population biomass	:	25154.41	26765.99	29300.90	31513.98
catch	:	5379.00	4260.85	4761.35	5446.87
f or quota	:	5379.00	0.32	0.32	0.32

year	:	89	90
population numbers	:	21607.32	21988.09
population biomass	:	32941.13	33926.60
catch	:	5907.35	6229.73
f or quota	:	0.32	0.32

age groups considered>3+

APPENDIX III

Projections with the parameters listed in the text assuming landings equal to 10,000 tonnes 1987 to 1990 - 2,000 tonnes below the precautionary TAC.

population numbers (000's) 22/ 5/86

:	85	86	87	88	89	90
3 :	6500	6500	6500	6500	6500	6500
4 :	3170	5256	5175	5126	5068	4963
5 :	2444	2425	3674	3428	3181	2794
6 :	1693	1543	1085	1338	972	575
7 :	1207	929	498	255	214	78
8 :	775	663	300	117	41	17
9 :	392	425	214	71	19	3
10 :	203	224	151	57	13	2
11 :	72	123	91	48	14	2
12 :	126	44	50	29	12	2
13+:	104	78	19	17	8	2
3+:	16687	18210	17758	16989	16042	14938
4+:	10187	11710	11258	10489	9542	8438
5+:	7017	6454	6083	5362	4474	3475
6+:	4573	4029	2409	1934	1293	681

population biomass :tonnes 22/ 5/86

:	85	86	87	88	89	90
3 :	6148.67	6103.17	6075.39	6041.85	5981.96	5864.39
4 :	3865.55	6140.71	5896.43	5666.48	5308.36	4684.20
5 :	3937.16	3348.74	4648.54	3917.54	3061.40	1990.74
6 :	3017.51	2190.57	1359.27	1454.53	839.65	340.89
7 :	2551.50	1564.43	740.48	329.24	219.57	54.76
8 :	2010.75	1369.80	547.60	185.72	51.47	14.83
9 :	1110.62	979.72	439.59	127.25	27.30	3.32
10 :	736.41	679.96	414.87	140.12	27.05	2.78
11 :	356.63	512.33	343.34	162.70	38.16	3.82
12 :	634.35	186.57	195.63	102.45	34.02	4.19
13 :	785.24	457.76	99.83	82.63	30.73	5.50
3+:	25154.41	23533.76	20760.97	18210.52	15619.65	12969.41
4+:	19005.74	17430.58	14685.58	12168.67	9637.68	7105.02
5+:	15140.19	11289.88	8789.14	6502.19	4329.33	2420.83
6+:	11203.03	7941.14	4140.61	2584.65	1267.93	430.08

catch biomass : tonnes 22/ 5/86

:	85	86	87	88	89	90
3 :	77	170	227	296	417	654
4 :	263	971	1249	1571	2098	2959
5 :	1024	2024	3765	4153	4626	4808
6 :	1207	2037	1694	2372	1952	1267
7 :	1021	1455	923	537	510	203
8 :	804	1274	682	303	120	55
9 :	400	820	493	187	57	11
10 :	221	474	388	171	47	8
11 :	107	357	321	199	67	11
12 :	178	121	171	117	55	11
13+:	79	298	87	94	50	14
3+:	5379	10000	10000	10000	10000	10000
4+:	5302	9830	9773	9704	9583	9346
5+:	5039	8859	8524	8133	7485	6388
6+:	4016	6835	4758	3980	2858	1580

fishing mortality 22/ 5/86

:	85	86	87	88	89	90
3 :	0.012	0.028	0.037	0.049	0.070	0.111
4 :	0.068	0.158	0.212	0.277	0.395	0.632
5 :	0.260	0.604	0.810	1.060	1.511	2.415
6 :	0.400	0.930	1.246	1.631	2.325	3.716
7 :	0.400	0.930	1.246	1.631	2.325	3.716
8 :	0.400	0.930	1.246	1.631	2.325	3.716
9 :	0.360	0.837	1.122	1.468	2.092	3.344
10 :	0.300	0.697	0.935	1.223	1.744	2.787
11 :	0.300	0.697	0.935	1.223	1.744	2.787
12 :	0.280	0.651	0.872	1.142	1.627	2.601
13+:	0.100	0.651	0.872	1.142	1.627	2.601
3+:	0.160	0.333	0.405	0.497	0.638	0.879

production 22/ 5/86

source	:	85	86	87	88	89	90
recruitment biomass	:	5932	5932	5932	5932	5932	5932
growth	:	6124	6238	5900	5394	4867	4278
total production	:	12056	12170	11832	11326	10799	10210
loss through fishing	:	5379	10000	10000	10000	10000	10000
surplus production	:	7025	7464	7680	7684	7675	7616
net production	:	1646	-2536	-2320	-2316	-2325	-2384

production/biomass ratio 22/ 5/86

:	85	86	87	88	89	90
:	0.48	0.52	0.57	0.62	0.69	0.79

summary of projections 22/ 5/86

year	:	85	86	87	88
population numbers	:	16687.38	18209.64	17758.10	16988.60
population biomass	:	25154.41	23533.76	20760.97	18210.52
catch	:	5379.00	10000.00	9999.99	10000.00
f or quota	:	5379.00	10000.00	10000.00	10000.00

year	:	89	90
population numbers	:	16041.61	14938.30
population biomass	:	15619.65	12969.41
catch	:	9999.99	9999.99
f or quota	:	10000.00	10000.00

age groups considered>3+