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ASSESSMENT OF GULF WHITE HAKE FROM NAFO DIVISION 4T IN 1987 (Including an investigation of otolith size to fish length relationships)

by

Douglas Clay

Marine and Anadromous Fisheries Division
Department of Fisheries and Oceans
Gulf Fisheries Center
P.O. Box 5030
Moncton, N.B.
Canada, E1C 9B6

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ABSTRACT

Since 1970 landings from this predominently small vessel inshore fishery have ranged from 3,616 tonnes in 1974 to a high of 14,039 tonnes in 1981. The 1986 nominal landings (4,601 tonnes) dropped by 1,300 tonnes (22%) from 1985. 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 38% of the total 1986 catch. Otter trawlers, seiners, and longliners are the other major gear categories (about 20% of landings for each gear) in this fishery at present.

A commercial catch rate series was derived from landings per purchase slip (receipt) using all available data (1978 to 1986). Research vessel abundance indices were available, however only the commercial CPUE was used 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 0.50. The Fo.1 falls below this value at 0.30.

The yield per recruit of 1.000 kg with the geometric mean recruitment from 1978 to 1984 of 5.5 million fish gives a long term equilibrium yield for this stock of approximately 5,500 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 prises de cette pêche intérieure effectuée principalement à partir de petites embarcations ont varié de 3 616 tonnes en 1974 à un maximum de 14 039 tonnes en 1981. Les prises nominales de 1986 (4 601 tonnes) ont chuté de 1300 tonnes (22 %) par rapport à 1985. En 1982, le premier TPA prudent a été fixé à 12 000 tonnes. Une première évaluation analytique effectuée en 1985 a révélé que ce chiffre aurait été trop élevé.

Les pêcheurs aux filets maillants ont débarqué 38 % des prises totales de 1986. Le chalut, la senne et la palangre sont les trois principaux autres engins (environ 20 % des débarquements par engin) dans ce type de pêche actuellement.

Une série de taux de prises commerciales basée sur le nombre de débarquements par fiches de débarquements (reçu) a été établie à l'aide de toutes les données disponibles (1978 à 1986). Même si des indices d'abondance de navire de recherche étaient disponibles, seules les PUE commerciales ont été utilisées dans l'étalonnage du modèle APV. La part élevée de la pêche aux filets maillants donne la courbe de recrutement partiel en forme de dôme qui est observée pour cette pêche. Le F_t a été évalué à environ 0,50. Le $F_{0,1}$, à 0,30, est inférieur à cette valeur.

Le rendement par recrue de 1,000 kg avec le recrutement moyen géométrique pour 1978 à 1984 de 5,5 millions de poissons donne un rendement d'équilibre à long terme pour ce stock d'environ 5 500 tonnes. Les projections pour les 5 prochaines années au niveau $F_{0,1}$ indiquent un rétablissement lent du stock et une remontée des débarquements prévus 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 (Table 1). Landings have ranged from a low of 3,616 tonnes in 1974 to a high of 14,039 tonnes in 1981 (Table 2 and Fig. 1).

This fishery is carried out mainly by small inshore vessels making it 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, particularly that based in southeastern New Brunswick and Nova Scotia, uses small (<20m) draggers and seiners.

Gill netters and long liners have increased their proportion of the catch by 16% over that of 1985 despite their tonnage landed being down. The greatest decrease occurred in the small trawler portion of the fishery accompanied by a lesser decline in the seiner landings which remain at a relatively high historic level of 17%. This may be due to different fishing locations utilized by these various gear types; the small trawlers fish almost exclusively inshore, while the seiners being larger (tonnage class 2 & 3) vessels fish the deeper waters between Cheticamp and Cape St. Lawrence as well as the slope waters along the southern edge of Cabot Strait. The gillnetters and longliners catch generally larger fish than the trawlers - thus the decrease in trawler landings may reflect poor recruitment or a high level of discarding in the past. The Quebec Region portion of the landings have increased to nearly 10% of the total landings from about 5% in 1985.

The provisional nominal landings in 1986 (Table 1) totalled 4,601 tonnes, a decrease of 22% from the 5,379 tonne catch of 1985 (Table 2). This fishery has sustained a long term annual decrease of 15 to 20% since 1981. The stock 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 long term harvesting level recommended at that time was no higher than 8,000 to 9,000 tonnes annually. The second assessment (Clay et al., MS1986) suggested a long term yield of about 7,000 tonnes. The TAC for 1987 has been reduced to 9,400 tonnes.

SAMPLING

Sampling was carried out in a similar manner to that of previous years (Clay et al., MS 1985b and MS 1986) except that samples were collected from only 2 sources:-

1) the P.E.I. provincial Department of Fisheries and Labour who provided 114 length frequency samples totalling 9,132 fish, and
2) the Department of Fisheries and Oceans (DFO) port samplers who collected 64 length frequency samples totalling 7,424 fish and 1356 otoliths.

Much of the hake landed in the southeastern Gulf is gutted and beheaded at sea. Because of this, 'sexes combined' samples were all that could be collected. No sea sampling was carried out in 1986. The dorsal length (length from tip of tail to the anterior portion of the first dorsal fin) of beheaded fish was measured to the nearest cm. Otolith weight was used to estimate total length in 1985 according to the relationships outlined in Clay et al. (MS 1985b). Concern was expressed in 1986 that the sexually dimorphic growth of white hake may influence otolith morphology. Samples of whole round fish were therefore collected during 1986 and otoliths removed in association with morphometric measurements being taken on the fish. The otoliths of these fish were measured for both length and weight. The results of an analysis of co-variance indicate there is a significant difference between the otolith weights of males and those of females. A similar analysis showed no significant difference ($P>0.05$) between the otolith lengths of males and females (see Appendix III).

The difference in fish length calculated from a sex combined relationship relative to that from the appropriate sexed relationship ranges from 1 to 2.5% with the maximum occurring in fish over 70 cm fork length. The coefficient of determination in the sexed fish length to otolith weight relationships are 0.98 and 0.99 for males and females respectively. A 1 to 2% bias in estimated fish length is considered acceptable - especially in view of the standard procedure of rounding of measured fish lengths to the nearest cm.

SAMPLING SUMMARY

source	length frequency samples	fish measured	aging material samples/otoliths
1) P.E.I.	114	9,132	0 / 0
2) DFO	64	7,424	42 / 1,356
TOTAL	178	16,556	42 / 1,356

Prior to 1986 age determination was conducted by personnel under contract. During 1986 DFO staff were trained in age determination techniques for white hake. During the training period the agreement between readers was 70 to 80%. However, upon completion of the 1986 age reading differences were observed between the historic lengths and weights at age and those of 1986. As an interim measure the 1985 research and commercial ages have been used with the appropriate 1986 length frequency samples.

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.

DISTRIBUTION OF LANDINGS: White hake by statistical district

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 catch or fishing effort by individual vessel is normally available. Daily landings are, however, recorded on the purchase slips for the inshore components of the fishing fleet. These data are available from the 'transaction files' of the DFO Statistics Branch of the Scotia-Fundy region (1978 - 1983) and the Gulf region (1984 and 1986). They have been transformed to 'NAFO Table 5' type format using a modification of the computer system NAFSYS. During this process the data were aggregated by 2 weekly intervals by Statistical Districts (Fig 2). This data base generally only includes 75 to 90% of the official landings. The balance of the landings are reported on Supplemental 'A' and 'B' slips - these have not been included in the present analysis as they do not represent individual vessel days of activity - but rather 'roll ups' of many vessels over various time periods.

Data from 1978 to 1986 were investigated and 7 districts selected, these districts combined represent more than 75% of the landings reported on the 'Purchase Slip' data base. Between 1978 and 1981 there was no major change in distribution of the landings (Fig 3a). Eastern P.E.I. accounted for approximately 50% of the total with 25% coming from each of districts 87 and 88. A slight shift occurred in 1981 with district 87 increasing to 33% and 88 dropping to 17%.

In 1982 and 1983 landings from the two districts of eastern P.E.I. declined to 35% of the total, the major loss occurring in district 88 (Souris). District 2 (Cheticamp) increased in importance climbing to 27% by 1983 (Fig 3b). During 1984 and 1985 landings in eastern P.E.I. almost recovered to earlier levels, however, in 1986 it has declined again to less than 20% with district 87 (Murray Harbour) taking the major loss (Fig 3c). District 2 maintained its share in 1984 and 1985 and has increased to 36% of the total in 1986. A summary of the 9 years (Fig 3c) indicates districts 2, 87, and 88 represent the majority of the landings with each district accounting for about 20% of the total.

Comparing this data in absolute (Fig 3d) and relative (Fig 3e) terms shows a different aspect of the situation. From 1981 to 1986 most districts have had a relatively steady decrease in landings, however as a percentage of the total, district 2 with relatively steady landings has increased its percentage share from 10 to over 20%. District 87 is the most variable region in the fishery.

CATCH PER EFFORT - COMMERCIAL

A commercial catch per unit of effort (CPUE) series can be used as an indicator of stock abundance. For the above catch and "effort" data set, each purchase slip is assumed to represent 1 day's fishing effort, generally 1 trip for the small vessels of the inshore fleet. Due to the variable nature of this fishery no single fleet component makes up a large enough percentage of the catch to be considered 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 50 kg or less were not 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 50 kg not being fully represented in the transaction file data set. As the Gulf region Statistics Branch has assumed that 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. The resulting CPUE series indicates the highest level occurred in 1981 and the lowest level in 1986.

This model (Table 5) with standards for statistical district, gear and time chosen as Cheticamp, gillnetters, January 1 to May 14, 1978 respectively, gives a correlation coefficient (r^2) 0.412 (Table 6), however, the residual plots indicate a normal non-biased distribution (Fig 4). Weighting by the effort did improve the coefficient of correlation and the F levels of the regression from 0.238 to 0.412 and 15 to 45 respectively. The weighted CPUE and effort series were used for all tuning in the VPA runs (Fig 5).

The resulting CPUE is correlated with annual landings ($r^2 = 0.75$). 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 1986 was conducted with similar survey protocols to those of previous years, however this year the survey was conducted on the RV Lady Hammond rather than the RV E.E. Prince. The data set for 1970 to 1985 (Clay, MS 1986) has been extended to 1986 providing abundance estimates by numbers and weight; stratified CPUE (by tow) by numbers and weight (Fig 6). Differences due to the change in vessel have not yet been assessed, although an interim conversion factor of 1.00 by weight and 1.25 by numbers have been used in this provisional data set. Age composition has not been tested for variation due to the change in vessels.

Clay et al. (MS 1986) showed the RV CPUE and biomass to be highly variable and not correlated with the commercial CPUE series. Because of that, little importance is attached to the VPA calibrations carried out with the RV data set. However, in 1986 no significant difference ($P<0.05$) was found between the RV population composition and that of the VPA population estimates. This could not be further tested this year due to the problems with the aging of the 1986 samples.

An attempt was made to identify possible recruitment indices using the research vessel numbers at age 1 and age 2 with VPA population numbers at age 3 in year + 2 and + 1 respectively. (Only the years from 1978 were used in this regression.) No significant relationship was found.

ESTIMATION OF PARAMETERS

Catch and Weights at age

The 1986 weights at age were calculated from 1986 length frequencies sampled from the commercial landings and the samples collected for age determination in 1985, 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). Weights at age for 1970 to 1982 were extremely variable and unrealistic due to the sparse and thus non representative sampling data prior to 1983.

With the better sampling of the last four years, annual weights at age are now possible. The weights at age have varied slightly over the last three years. However, the variation was not substantial except for the oldest ages.

The starting catch-at-age matrix for the Gulf hake ages 3 to 13+ from 1970 to 1985 was taken from Clay et al. (MS 1986). The 1986 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 matrix (Table 8a) 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 plus group was removed for 1987 and the numbers in the oldest age are now those of the age 13 fish only and not the 13+ age groups.

The percent composition of the catch at age (Table 8b) indicates stability in the composition of recent landings. The percent composition of the 1986 catch at age predicted from the 1986 assessment compared to the observed 1986 catch at age indicates the partial recruitment was very close to the actual fishery. (The use of the 1985 age length key has no doubt confounded the picture, however it does indicate the length frequency is in the correct range if one assumes that growth was similar in 1985 and 1986.)

Percent composition of catch at age

age	3	4	5	6	7	8	9	10	11	12	13
actual	4	11	23	23	17	11	5	3	1	1	.5
predicted	3	9	24	24	17	11	5	2	1	1	.5

Partial recruitment

The partial recruitment (PR) was estimated using two techniques. The first used the average of 1981 to 1985 catch at age, estimated from commercial sampling, divided by the population at age, estimated from research vessel surveys. The smoothed mean PR of this time series reflects the importance of the gillnet component of the fishery in its domed shape, however using only 1986 data a near flat top curve results. Although this is a sudden shift from earlier years, there was a coincident shift in 1986 in the contribution made by longlines to the total landings - 16% to 27%.

The second technique used iterative historical averaging of the last 4 years in the F table until little change was noted. This technique indicated full recruitment at ages 7, and 8. Further analysis standardizing the PR vector to ages 7, 8, and 9 did not result in great variation (Fig. 7a).

The PR values for the youngest ages calculated from the catch over the RV population results appear to be too low as the resulting VPA populations would be the highest on record. Thus the choice for this assessment was the historical PR for ages 3 to 7 and the smoothed average of the catch/pop and historical estimates for ages 8 to 13 (Fig 7b).

Partial Recruitment

AGE	3	4	5	6	7	8	9	10	11	12	13
PR	.025	.125	.40	.75	1.0	1.0	.95	.95	.90	.90	.80

This PR differs slightly from that of last year with lower PR's for ages 3 to 6 and higher PR's for ages 10 to 13.

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 1984).

STARTING F oldest

70	71	72	73	74	75	76	77	78	79
0.46	0.50	0.54	0.68	0.48	0.60	0.40	0.35	0.27	0.45

80	81	82	83	84	85
0.69	0.78	0.89	0.48	0.32	0.49

: 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 for 1986 from the catch curve is 0.56 while the unweighted Z from the CPUE at age (85/86) is 0.63. These indicate an F in the range of 0.4.

: F Terminal

The fully recruited or terminal F (F_t) was chosen by regressing the commercial CPUE index, from the Gavaris multiplicative model, against the total 6+ and the exploitable 3+ VPA population biomass (Table 9a). The correlation coefficient had little discriminating power, therefore the intercept value 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 0.50 to 0.55 (see Fig. 8a) while the 6+ total VPA biomass indicates an F in the range of 0.45 to 0.50 (see Fig 8b). The residuals were not large nor were they in any one direction.

The research vessel population numbers and population biomass were also regressed against the 6+ VPA population numbers and biomass respectively (Table 9b). These relationships were not significant.

The F weighted by population numbers regressed against standardized effort (from the multiplicative model) did not give significant relationships this year.

This tuning process (with the commercial CPUE) resulted in a final terminal F of 0.5 being selected.

Yield per recruit

The yield per recruit (YPR) was calculated using the mean weight at age for 1983 to 1986 and the mean smoothed partial recruitment vector covering the period 1983 to 1986 with an M = 0.2 (Table 10). The Fo.1 level was 0.30 and the Fmax was 1.16.

Fo.1 =	0.3039	Fo.1 YIELD =	1.000	kg	Ave Wt. =	2.729 kg
Fmax =	1.1559	Fmax YIELD =	1.120	kg	Ave Wt. =	2.005 kg

With a geometric mean (1978 to 1985) recruitment of 5.5 million fish the long term equilibrium yield would be slightly over 5,500 tonnes, a thousand tonnes below the average of the landings of the last 17 years - 6,551 tonnes (Table 2).

The annual average weight of a white hake landed can give an indication of the level of fishing mortality. The 1970 to 1986 mean weights have been under the mean weight expected when fishing at the Fo.1 level and above the mean weight of Fmax (Fig 9).

ASSESSMENT RESULTS

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

The exploitable biomass (Table 11) was calculated from the VPA population numbers multiplied by the historical partial recruitment (Table 12) calculated for each year by standardizing the annual mean F between ages 7 to 9 to 1.0 and setting all other values over 1.0 to 1.0. The percent composition of the catch biomass, population numbers, and exploitable population biomass are presented in Tables 13, 14, and 15.

The population numbers (Appendix I.) indicate a high degree of variabilty in recruitment over the historical time series, however, those estimates from 1977 onwards are the only ones assumed to be representative of the fishery. The GM recruitment from 1978 to 1985 is approximately 5.5 million fish at age 3 (recruitment from 1970 to 1985 is 5.6 million fish). 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 critically, for as was pointed out by Clay et al. (MS 1985b), there is great variability in length frequency distribution between statistical 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

Three series of catch projections were run. The first (Appendix II.) used a catch level set at an Fo.1 of 0.30 - about 40% lower than recent fishing levels. With the geometric mean (GM) recruitment of 5.5 million fish (GM of 1978 to 1985), an M = 0.2, and the partial recruitment selected above and mean weights at age of 1984 to 1986 the projected catch for 1988 is about 3,500 tonnes with steady but small increases into the future. The population biomass also shows a steady increase (nearly 2000 tonnes per annum).

The second scenario with a fixed catch level of 6,500 tonnes (equal to the long term mean landings but less than the 9,400 tonne TAC for 1987) and all other parameters as above results in a decreasing population biomass, falling at about 500 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 last scenerio, following the 'rule for setting the TAC' (Anon, 1986), using the above parameters and assuming the TAC of 9,400 t for 1987 being taken and an F of 0.6 in 1988 suggests a 1988 yield of 5,000 t.

The long term equilibrium yield now appears to be in the range of 5,000 to 6,000 tonnes - a three thousand tonne reduction from the current TAC. As this stock appears to be dependent on only 3 or 4 year classes - it is a fishery which will be sensitive to annual fluctuations in recruitment.

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Table 1. Nominal landings of white hake from NAFO division 4T in 1986 by gear, region and month. All data are provisional statistics. Quebec (443 tonnes) and Scotia Fundy (21 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	16	65	3	5	1	90
JUNE	54	322	3	105	58	542
JULY	406	79	54	716	125	1380
AUGUST	227	62	301	329	33	952
SEPTEMBER	81	60	141	209	52	543
OCTOBER	37	40	179	36	9	301
NOVEMBER	6	95	159	60	5	325
DECEMBER	0	0	3	0	0	3
sub-total	827	723	843	1460	283	4136

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	0	0	0	3.0	0	3.0
MAY	7.5	0	4.9	50.5	0	62.9
JUNE	3.2	.1	7.7	20.6	0	31.6
JULY	1.2	.4	32.8	39.6	0	74.0
AUGUST	.1	4.7	59.9	63.5	0	128.2
SEPTEMBER	6.0	.1	25.7	81.5	0	113.3
OCTOBER	1.0	4.8	15.6	25.2	0	46.6
NOVEMBER	.5	1.6	2.2	0	0	4.3
DECEMBER	0	0	0	0	0	0
sub-total	19.5	11.7	148.8	283.9	0	463.9
TOTAL	847	735	992	1744	283	4601
PERCENT	18.5	16	21.5	38	6	100

Table 2. Nominal landings of white hake from NAFO division 4T by gear and year. All data from 1985 and 1986 are provisional.

:GEAR YEAR	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	1734	588	865	3789	74	7050
* 1985	1655	1006	764	1843	111	5379
* 1986	847	735	992	1744	283	4601
AVERAGE	1983	760	682	2464	662	6551
PERCENT	30	12	10	38	10	

* provisional

Table 3. Keys selected in 1986 for gear/time combinations and their groupings to produce age-at-length keys with at least 400 fish ages per key (1985 aging was used and therefore these data should be considered provisional). 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	653	
		Age	189	
2	OTB:Aug.- Dec.	Length	1390	OTB/SNU:Jan.- Dec.
		Age	25	Lengths-6147
3	SNU:Jan.- June	Length	2884	Aged-432
		Age	110	
4	SNU:Jul.- Dec.	Length	1220	
		Age	108	
5	GN:Jan.- Jul.	Length	4971	
		Age	25	
6	GN:Aug.- Dec.	Length	4601	LL/GN:Jan.- Dec.
		Age	439	Lengths-11198
7	LL:Jun.- Dec.	Length	1626	Aged-621
		Age	157	

::::::::::::::

	....AL k e y......		...LF c a t c h...		
KEY	DATE	GEAR	DATE	GEAR	TONNES
1	01/12	OTB/SNU	01/07	OTB	488
2	01/12	OTB/SNU	08/12	OTB	359
3	01/12	OTB/SNU	01/06	SNU	466
4	01/12	OTB/SNU	07/12	SNU	264
5	01/12	LL/GN	01/07	GN	939
6	01/12	LL/GN	08/12	GN	882
7	01/12	LL/GN	06/12	LL + LHP	1203
				TOTAL	4601

Table 4. Catch at age (a) and weight at age (b) of white hake in 1986 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	1	0	1	0	0	0	0	2
3	9	18	5	26	0	3	5	66
4	35	49	21	59	11	10	14	199
5	61	57	46	54	60	72	55	405
6	55	40	48	27	84	88	65	407
7	30	22	37	14	91	59	51	304
8	18	10	20	5	52	45	50	200
9	10	4	11	2	21	17	30	95
10	2	3	3	1	8	9	31	57
11	2	0	1	0	1	2	8	14
12	1	1	2	0	6	2	15	27
13	1	0	1	0	0	0	4	6
14	0	0	0	0	0	1	2	3
Sum (From Keys)	225	206	195	189	334	308	329	1785
No. in L-F	653	1390	2884	1220	4971	4601	1626	
No. Aged	432	432	432	432	621	621	621	
Mean Age	5.86	5.37	6.20	4.87	6.75	6.51	7.33	

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	.91	.00	.93	.00	.98	.00	.00	.92
3	1.13	1.03	1.02	.99	1.19	1.56	1.27	1.07
4	1.37	1.08	1.49	1.06	1.91	1.72	1.52	1.28
5	1.64	1.53	1.82	1.33	2.57	2.25	2.27	1.94
6	2.02	1.90	2.24	1.70	2.66	2.35	2.52	2.30
7	2.58	2.24	2.67	2.03	2.83	2.63	3.37	2.76
8	3.57	3.20	3.26	3.16	3.20	3.20	4.12	3.47
9	4.04	3.48	3.75	3.14	2.96	3.38	5.23	3.98
10	3.92	4.59	4.22	4.75	3.35	3.91	6.42	5.26
11	6.71	6.36	6.43	3.65	6.08	3.83	7.39	6.62
12	5.05	6.74	4.75	4.94	3.39	4.69	7.67	6.15
13	7.62	8.95	7.58	7.44	5.33	7.84	8.42	8.15
14	.00	3.25	9.49	5.49	.00	3.49	6.10	5.23
Mean wt (From Keys)	2.16	1.74	2.39	1.40	2.81	2.60	3.91	
No. in L-F	653	1390	2884	1220	4971	4601	1626	
No. Aged	432	432	432	432	621	621	621	
Mean Age	5.86	5.37	6.20	4.87	6.75	6.51	7.33	

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 1986. (Note: fourth category type is years.)

STATISTICAL DISTRICT		GEAR		TIME PERIODS	
CODE	AREA	CODE	NAME	CODE	PERIOD
2	*CHETICAMP	41	*GN	0(1)	*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(5)	AUG 15-AUG 31
76	BOUCTOUCHE			8(5)	SPT 1-SPT 14
77(76)	SHEDIAC			9	SPT 15-SPT 30
80(76)	CAPE TORMENTINE			10	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(92)	MALPEQUE				
94	RUSTICO				
95	TRACADIE, P.E.I.				

* standard category
( ) combined category

Table 6. Output for Gulf hake catch and effort data 1978 to 1986 from the Gavaris multiplicative model. See Table 5 for category types and codes.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R............. .642
MULTIPLE R SQUARED..... .412

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	4.662E0003	4.662E0003	
REGRESSION	30	4.012E0002	1.337E0001	45.033
TYPE 1	11	1.844E0002	1.676E0001	56.433
TYPE 2	3	9.430E0000	~~3.143E0000~~	10.584
TYPE 3	8	5.646E0001	7.057E0000	23.762
TYPE 4	8	6.635E0001	8.293E0000	27.925
RESIDUALS	1925	5.717E0002	2.970E¯001	
TOTAL	1956	5.635E0003		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	2	INTERCEPT	1.254	0.113	1956
2	41				
3	4				
4	78				
1	3	1	¯0.365	0.045	212
	12	2	0.230	0.125	26
	13	3	¯0.025	0.065	98
	55	4	¯1.166	0.064	123
	56	5	¯0.118	0.083	207
	57	6	¯0.075	0.086	205
	76	7	0.469	0.080	69
	82	8	¯0.304	0.045	139
	87	9	0.416	0.069	176
	92	10	¯0.389	0.037	192
	95	11	¯0.701	0.064	74
2	11	12	0.115	0.154	87
	12	13	¯0.078	0.053	233
	31	14	0.231	0.044	651
3	2	15	0.314	0.120	141
	3	16	0.420	0.104	380
	5	17	0.224	0.103	566
	6	18	0.156	0.106	190
	9	19	0.343	0.110	158
	10	20	0.372	0.117	149
	11	21	0.645	0.124	141
	12	22	1.058	0.119	112
4	79	23	0.084	0.066	210
	80	24	0.320	0.061	192
	81	25	0.416	0.061	226
	82	26	0.307	0.061	207
	83	27	0.277	0.064	170
	84	28	0.225	0.062	259
	85	29	¯0.012	0.063	281
	86	30	¯0.213	0.063	242

Table 7. The weight-at-age matrix (grams) of Gulf hake from NAFO division 4T (1986 values are provisional). Prior to 1983 the weights at age are an average of data from 1983 to 1985 (see text).

weight at age matrix of Gulf hake 5/ 5/87

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

:	80	81	82	83	84	85	86
3 :	1050	1050	1050	1060	1040	1050	1070
4 :	1343	1343	1343	1350	1290	1390	1280
5 :	1863	1863	1863	1910	1670	2010	1940
6 :	2267	2267	2267	2220	2210	2370	2300
7 :	2767	2767	2767	2810	2680	2810	2760
8 :	3297	3297	3297	3210	3230	3450	3470
9 :	3567	3567	3567	3470	3530	3700	3980
10 :	4483	4483	4483	4460	4390	4600	6000
11 :	5850	5850	5850	6670	4590	6290	7000
12 :	6900	6900	6900	8350	6010	6340	8000
13 :	9493	9493	9493	10730	9030	8720	8150

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

catch matrix of Gulf hake 5/ 5/87

:	70	71	72	73	74	75	76	77	78	79
3 :	86	84	91	79	49	56	81	86	79	90
4 :	705	711	631	496	249	214	297	332	354	469
5 :	794	794	744	660	378	389	432	470	579	830
6 :	454	446	483	458	295	342	332	361	545	969
7 :	371	377	402	451	312	378	291	301	345	670
8 :	143	144	165	190	136	170	131	136	172	314
9 :	73	77	84	107	78	98	67	66	61	101
10 :	42	43	44	50	33	41	28	29	26	47
11 :	12	14	12	12	8	8	5	5	4	8
12 :	7	8	8	9	5	7	9	8	8	11
13 :	3	3	4	4	3	3	2	2	2	4

:	80	81	82	83	84	85	86
3 :	90	66	5	57	56	73	65
4 :	451	426	112	128	396	189	195
5 :	1025	1072	543	595	742	509	397
6 :	1657	1970	1129	787	806	509	399
7 :	1192	1386	1098	609	489	363	298
8 :	538	603	548	398	248	233	196
9 :	137	153	149	233	147	108	93
10 :	75	94	78	71	50	48	56
11 :	7	4	21	5	19	17	14
12 :	6	1	9	4	9	28	26
13 :	5	8	9	1	1	6	6

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

percent composition of catch matrix of Gulf hake 15/ 6/87

:	70	71	72	73	74	75	76	77	78	79
3 :	0.032	0.031	0.034	0.032	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	0.245	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	0.202	0.222	0.174	0.168	0.158	0.191
8 :	0.053	0.053	0.062	0.076	0.088	0.100	0.079	0.076	0.079	0.090
9 :	0.027	0.029	0.031	0.043	0.050	0.058	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 :	0.001	0.001	0.001	0.002	0.002	0.002	0.001	0.001	0.001	0.001

:	80	81	82	83	84	85	86
3 :	0.017	0.011	0.001	0.020	0.019	0.035	0.037
4 :	0.087	0.074	0.030	0.044	0.134	0.091	0.112
5 :	0.198	0.185	0.147	0.206	0.250	0.244	0.228
6 :	0.320	0.341	0.305	0.272	0.272	0.244	0.229
7 :	0.230	0.240	0.297	0.211	0.165	0.174	0.171
8 :	0.104	0.104	0.148	0.138	0.084	0.112	0.112
9 :	0.026	0.027	0.040	0.081	0.050	0.052	0.053
10 :	0.014	0.016	0.021	0.025	0.017	0.023	0.032
11 :	0.001	0.001	0.006	0.002	0.006	0.008	0.008
12 :	0.001	0.000	0.002	0.001	0.003	0.013	0.015
13 :	0.001	0.001	0.002	0.000	0.000	0.003	0.003

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.

3+ exploitable vpa biomass vs cpue > raw residuals

term f	int	slope	r2	res84	res85	res86
0.20	20399	-773	0.041	-536	2249	5007
0.25	13896	297	0.011	-1407	1288	3448
0.30	9560	1011	0.149	-1988	647	2409
0.35	6463	1521	0.303	-2403	189	1667
0.40	4139	1903	0.399	-2714	-155	1110
0.45	2331	2201	0.452	-2956	-421	677
0.50	884	2439	0.482	-3149	-634	330
0.55	-300	2634	0.499	-3307	-808	46
0.60	-1286	2797	0.510	-3438	-953	-191
0.65	-2121	2935	0.517	-3548	-1074	-392
0.70	-2837	3053	0.522	-3642	-1178	-564

6+ vpa population biomass vs cpue > raw residuals

term f	int	slope	r2	res84	res85	res86
0.20	14586	201	0.005	-1654	631	3877
0.25	9299	1066	0.160	-2358	-71	2524
0.30	5773	1644	0.319	-2827	-539	1622
0.35	3254	2056	0.401	-3163	-874	978
0.40	1365	2366	0.442	-3415	-1124	495
0.45	-105	2606	0.463	-3611	-1319	119
0.50	-1281	2799	0.475	-3767	-1475	-182
0.55	-2244	2957	0.482	-3895	-1601	-429
0.60	-3046	3088	0.487	-4001	-1706	-634
0.65	-3725	3200	0.490	-4091	-1795	-808
0.70	-4307	3295	0.492	-4167	-1870	-958

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	res84	res85	res86
0.20	3016	0	0.234	980	1361	2108
0.25	2791	0	0.290	588	719	1088
0.30	2641	0	0.322	327	290	409
0.35	2534	0	0.338	140	-16	-77
0.40	2453	0	0.345	0	-245	-441
0.45	2391	0	0.347	-109	-424	-724
0.50	2340	0	0.347	-196	-567	-951
0.55	2300	1	0.345	-267	-683	-1136
0.60	2266	1	0.342	-326	-780	-1291
0.65	2237	1	0.340	-376	-862	-1422
0.70	2212	1	0.337	-419	-932	-1534

6+ vpa population biomass vs rv bio > raw residuals

term f	int	slope	r2	res84	res85	res86
0.20	8926	0	0.155	2388	4719	8092
0.25	8286	0	0.207	1372	2783	4881
0.30	7859	0	0.241	694	1493	2741
0.35	7554	0	0.261	210	570	1212
0.40	7326	0	0.271	-153	-121	65
0.45	7148	0	0.276	-436	-659	-828
0.50	7005	0	0.277	-661	-1088	-1542
0.55	6889	0	0.276	-845	-1440	-2127
0.60	6792	0	0.274	-998	-1732	-2614
0.65	6710	0	0.272	-1128	-1978	-3027
0.70	6640	0	0.270	-1238	-2189	-3381

Table 10. Summary of yield per recruit calculations using the mean weights from 1983 to 1986 and the smoothed mean partial recruitment from 1983 to 1985 with an M of 0.2.

summary>

age	weight_at_age	partial recruitment
3	1.050	0.023
4	1.330	0.125
5	1.880	0.442
6	2.270	0.805
7	2.770	1.000
8	3.330	1.000
9	3.650	1.000
10	4.790	0.931
11	6.080	0.637
12	7.120	0.940
13	9.220	0.865

natural mortality rate > 0.2
F0.1 computed as 0.3039 at YPR of 1.0000
Fmax computed as 1.1559 at YPR of 1.1201

yield per recruit analysis

	fishing mortality	catch :number	yield :kg	avg. weight :kg	yield per unit effort
	0.1000	0.183	0.592	3.237	1.798
	0.2000	0.293	0.867	2.958	1.318
	0.3000	0.364	0.997	2.737	1.010
F0.1___	0.3039	0.366	1.000	2.729	1.000
	0.4000	0.413	1.059	2.565	0.804
	0.5000	0.448	1.089	2.431	0.662
	0.6000	0.475	1.104	2.325	0.559
	0.7000	0.496	1.112	2.240	0.483
	0.8000	0.514	1.116	2.172	0.424
	0.9000	0.529	1.118	2.115	0.378
	1.0000	0.542	1.120	2.067	0.340
	1.1000	0.553	1.120	2.025	0.309
Fmax___	1.1559	0.559	1.120	2.005	0.295
	1.2000	0.563	1.120	1.989	0.284
	1.3000	0.572	1.120	1.957	0.262
	1.4000	0.580	1.119	1.929	0.243
	1.5000	0.588	1.119	1.903	0.227

Table 11. The fishable or exploitable population biomass of Gulf hake from NAFO division 4T calculated from the historical partial recruitment (Table 12) and the VPA population biomass (Appendix I).

exploitable biomass: tonnes 15/ 6/87

:	70	71	72	73	74	75	76	77	78	79
3 :	161	156	159	111	91	80	150	175	188	165
4 :	1692	1698	1417	887	591	392	706	860	1075	1101
5 :	2645	2629	2318	1636	1244	989	1423	1690	2437	2704
6 :	1840	1796	1831	1381	1182	1060	1331	1578	2788	3839
7 :	1685	1792	1815	1661	1523	1428	1422	1608	2153	3240
8 :	842	841	908	835	790	766	766	853	1139	1653
9 :	467	457	472	445	428	415	389	406	456	582
10 :	268	264	233	220	207	208	202	219	245	248
11 :	129	148	121	97	79	61	50	54	51	78
12 :	73	90	81	79	59	61	69	76	95	103
13 :	45	43	53	43	47	39	34	37	43	59
3+:	9848	9915	9408	7395	6240	5499	6541	7556	10670	13773

:	80	81	82	83	84	85	86
3 :	130	90	7	90	97	162	144
4 :	829	746	219	258	847	556	520
5 :	2614	2603	1471	1695	2055	2166	1604
6 :	5140	5818	3720	2606	2955	2554	1847
7 :	4515	4998	3787	2554	2175	2159	1655
8 :	1996	2163	2624	1624	1330	1457	1369
9 :	667	712	770	1209	669	846	772
10 :	231	336	361	472	363	348	698
11 :	54	29	108	47	142	226	200
12 :	54	9	45	47	93	110	441
13 :	53	86	82	16	15	103	28
3+:	16283	17590	13195	10619	10741	10687	9277

Table 12. The historical partial recruitment for Gulf hake from NAFO division 4T calculated by standardizing to the mean of the F values at ages 7,8, and 9 and setting all values over 1 to 1.

historical partial recruitment: standard ages 7 8 9   15/ 6/87

:	70	71	72	73	74	75	76	77	78	79
3 :	0.034	0.037	0.045	0.031	0.021	0.013	0.017	0.015	0.018	0.022
4 :	0.349	0.387	0.360	0.267	0.169	0.089	0.111	0.096	0.092	0.103
5 :	0.639	0.624	0.621	0.487	0.408	0.289	0.320	0.257	0.260	0.222
6 :	0.648	0.620	0.627	0.549	0.489	0.463	0.499	0.437	0.507	0.500
7 :	1.000	1.000	1.000	0.967	0.971	0.934	0.954	0.861	0.792	0.826
8 :	0.934	0.900	0.916	0.892	0.883	0.915	0.957	1.000	1.000	1.000
9 :	0.976	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10 :	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
11 :	0.831	0.977	0.798	0.822	0.720	0.483	0.408	0.385	0.319	0.435
12 :	1.000	1.000	1.000	0.968	0.915	1.000	1.000	1.000	1.000	1.000
13 :	1.000	1.000	1.000	1.000	1.000	0.990	0.961	0.951	0.885	1.000

:	80	81	82	83	84	85	86
3 :	0.023	0.018	0.002	0.027	0.039	0.052	0.031
4 :	0.108	0.134	0.044	0.062	0.282	0.217	0.176
5 :	0.241	0.352	0.268	0.327	0.585	0.726	0.672
6 :	0.546	0.775	0.736	0.660	0.857	0.924	1.000
7 :	0.933	0.900	1.000	0.850	0.908	0.986	1.000
8 :	1.000	1.000	0.951	1.000	0.800	1.000	1.000
9 :	0.850	0.903	0.884	0.978	1.000	0.846	0.931
10 :	1.000	1.000	1.000	1.000	0.462	1.000	0.776
11 :	0.369	0.307	1.000	0.196	0.613	0.305	0.776
12 :	0.411	0.073	1.000	0.959	0.682	1.000	0.724
13 :	1.000	1.000	1.000	0.799	0.572	1.000	0.724

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

percent composition of catch biomass of Gulf hake 15/ 6/87

:	70	71	72	73	74	75	76	77	78	79
3 :	0.016	0.015	0.017	0.015	0.014	0.014	0.023	0.023	0.017	0.012
4 :	0.168	0.168	0.148	0.118	0.093	0.070	0.107	0.112	0.099	0.078
5 :	0.262	0.260	0.242	0.217	0.196	0.176	0.215	0.220	0.224	0.191
6 :	0.183	0.178	0.191	0.183	0.186	0.189	0.201	0.206	0.256	0.272
7 :	0.182	0.183	0.194	0.220	0.239	0.255	0.214	0.210	0.198	0.229
8 :	0.083	0.083	0.095	0.111	0.124	0.137	0.116	0.113	0.118	0.128
9 :	0.046	0.048	0.052	0.067	0.077	0.085	0.064	0.059	0.045	0.044
10 :	0.033	0.034	0.034	0.039	0.041	0.045	0.033	0.032	0.024	0.026
11 :	0.013	0.015	0.013	0.013	0.013	0.011	0.007	0.007	0.005	0.006
12 :	0.008	0.009	0.009	0.010	0.009	0.011	0.016	0.013	0.011	0.009
13 :	0.005	0.005	0.007	0.007	0.008	0.007	0.005	0.005	0.004	0.005

:	80	81	82	83	84	85	86
3 :	0.008	0.005	0.000	0.008	0.009	0.014	0.015
4 :	0.049	0.041	0.015	0.024	0.077	0.049	0.055
5 :	0.154	0.143	0.104	0.156	0.188	0.191	0.168
6 :	0.303	0.319	0.263	0.239	0.270	0.225	0.201
7 :	0.266	0.274	0.312	0.234	0.199	0.191	0.180
8 :	0.143	0.142	0.186	0.175	0.122	0.150	0.149
9 :	0.039	0.039	0.055	0.111	0.079	0.075	0.081
10 :	0.027	0.030	0.036	0.043	0.033	0.041	0.073
11 :	0.003	0.002	0.013	0.004	0.013	0.020	0.021
12 :	0.003	0.000	0.006	0.004	0.009	0.033	0.046
13 :	0.004	0.005	0.009	0.001	0.001	0.010	0.011

Table 14. Percent composition of the VPA population numbers.

percent composition of population numbers of gulf hake 15/ 6/87

:	70	71	72	73	74	75	76	77	78	79
3 :	0.321	0.303	0.281	0.305	0.371	0.431	0.455	0.441	0.350	0.252
4 :	0.282	0.271	0.267	0.243	0.242	0.242	0.265	0.277	0.306	0.281
5 :	0.187	0.200	0.196	0.191	0.162	0.145	0.140	0.153	0.184	0.238
6 :	0.106	0.113	0.126	0.120	0.108	0.085	0.073	0.072	0.094	0.133
7 :	0.057	0.063	0.072	0.077	0.065	0.054	0.037	0.034	0.040	0.060
8 :	0.025	0.027	0.032	0.034	0.030	0.025	0.017	0.013	0.015	0.023
9 :	0.012	0.013	0.015	0.016	0.014	0.012	0.008	0.006	0.006	0.007
10 :	0.006	0.006	0.006	0.007	0.006	0.005	0.003	0.003	0.002	0.003
11 :	0.002	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001
12 :	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
13 :	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000

:	80	81	82	83	84	85	86
3 :	0.204	0.212	0.224	0.220	0.206	0.294	0.396
4 :	0.225	0.197	0.219	0.221	0.214	0.189	0.218
5 :	0.240	0.204	0.186	0.211	0.211	0.170	0.130
6 :	0.189	0.197	0.163	0.153	0.168	0.140	0.092
7 :	0.090	0.124	0.114	0.097	0.098	0.095	0.068
8 :	0.034	0.045	0.065	0.051	0.055	0.053	0.045
9 :	0.011	0.014	0.019	0.034	0.023	0.032	0.023
10 :	0.004	0.006	0.007	0.010	0.017	0.010	0.016
11 :	0.001	0.001	0.002	0.003	0.005	0.012	0.004
12 :	0.001	0.001	0.001	0.001	0.002	0.003	0.008
13 :	0.000	0.001	0.001	0.000	0.000	0.001	0.000

Table 15. Percent composition of the fishable biomass (Table 11) of Gulf hake in NAFO division 4T.

percent composition of fishable biomass of Gulf hake 15/ 6/87

:	70	71	72	73	74	75	76	77	78	79
3 :	0.016	0.016	0.017	0.015	0.015	0.015	0.023	0.023	0.018	0.012
4 :	0.172	0.171	0.151	0.120	0.095	0.071	0.108	0.114	0.101	0.080
5 :	0.269	0.265	0.246	0.221	0.199	0.180	0.217	0.224	0.228	0.196
6 :	0.187	0.181	0.195	0.187	0.189	0.193	0.203	0.209	0.261	0.279
7 :	0.171	0.181	0.193	0.225	0.244	0.260	0.217	0.213	0.202	0.235
8 :	0.085	0.085	0.097	0.113	0.127	0.139	0.117	0.113	0.107	0.120
9 :	0.047	0.046	0.050	0.060	0.069	0.075	0.059	0.054	0.043	0.042
10 :	0.027	0.027	0.025	0.030	0.033	0.038	0.031	0.029	0.023	0.018
11 :	0.013	0.015	0.013	0.013	0.013	0.011	0.008	0.007	0.005	0.006
12 :	0.007	0.009	0.009	0.011	0.009	0.011	0.011	0.010	0.009	0.007
13 :	0.005	0.004	0.006	0.006	0.007	0.007	0.005	0.005	0.004	0.004

:	80	81	82	83	84	85	86
3 :	0.008	0.005	0.001	0.008	0.009	0.015	0.016
4 :	0.051	0.042	0.017	0.024	0.079	0.052	0.056
5 :	0.161	0.148	0.111	0.160	0.191	0.203	0.173
6 :	0.316	0.331	0.282	0.245	0.275	0.239	0.199
7 :	0.277	0.284	0.287	0.241	0.203	0.202	0.178
8 :	0.123	0.123	0.199	0.153	0.124	0.136	0.148
9 :	0.041	0.041	0.058	0.114	0.062	0.079	0.083
10 :	0.014	0.019	0.027	0.044	0.034	0.033	0.075
11 :	0.003	0.002	0.008	0.004	0.013	0.021	0.022
12 :	0.003	0.000	0.003	0.004	0.009	0.010	0.048
13 :	0.003	0.005	0.006	0.002	0.001	0.010	0.003

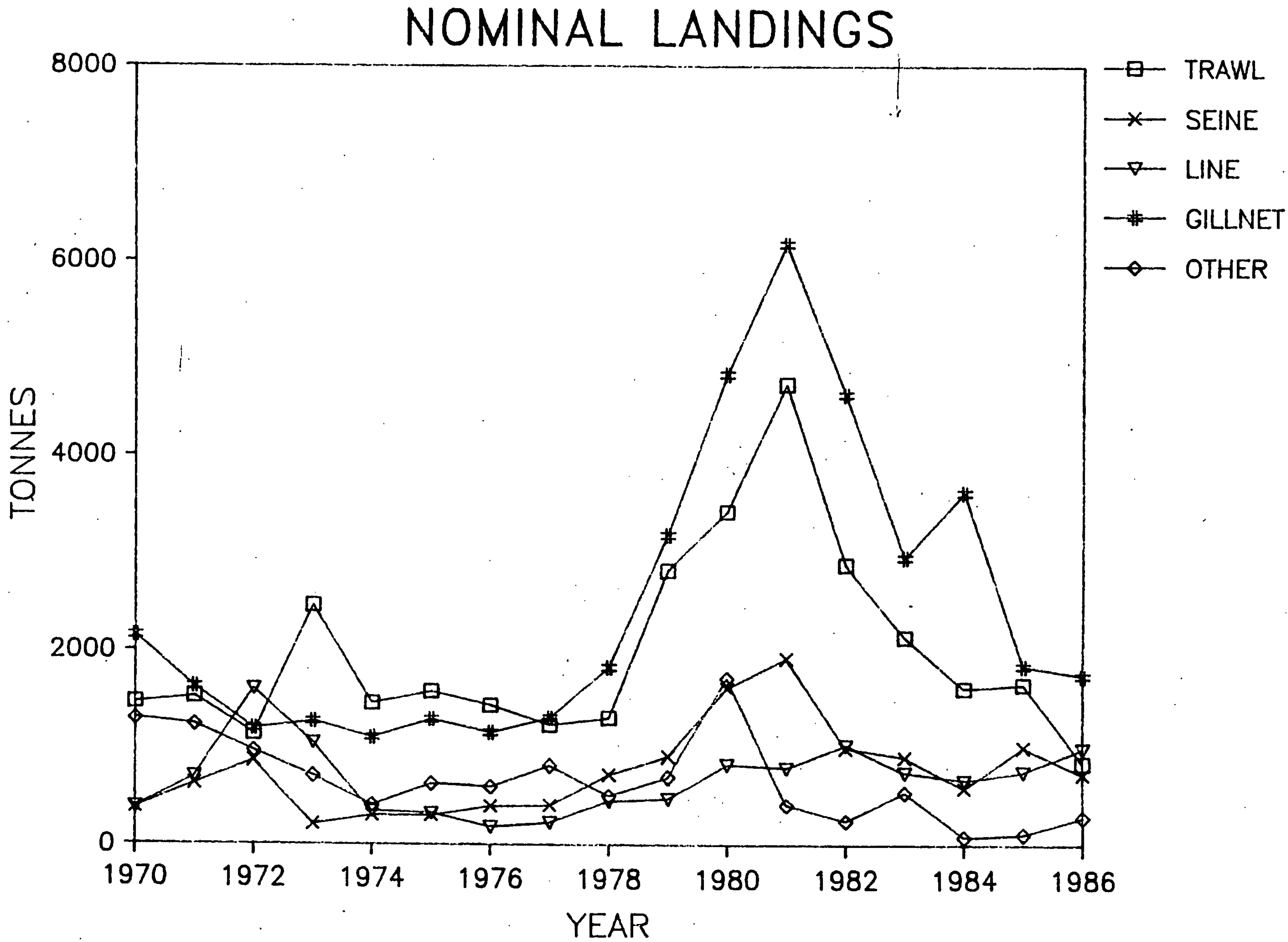


Figure 1. Nominal landings by gear and year of NAFO division 4T Gulf white hake.

Figure 2. Statistical Districts of the southern Gulf of St. Lawrence used in aggregation of commercial landings per trip data.

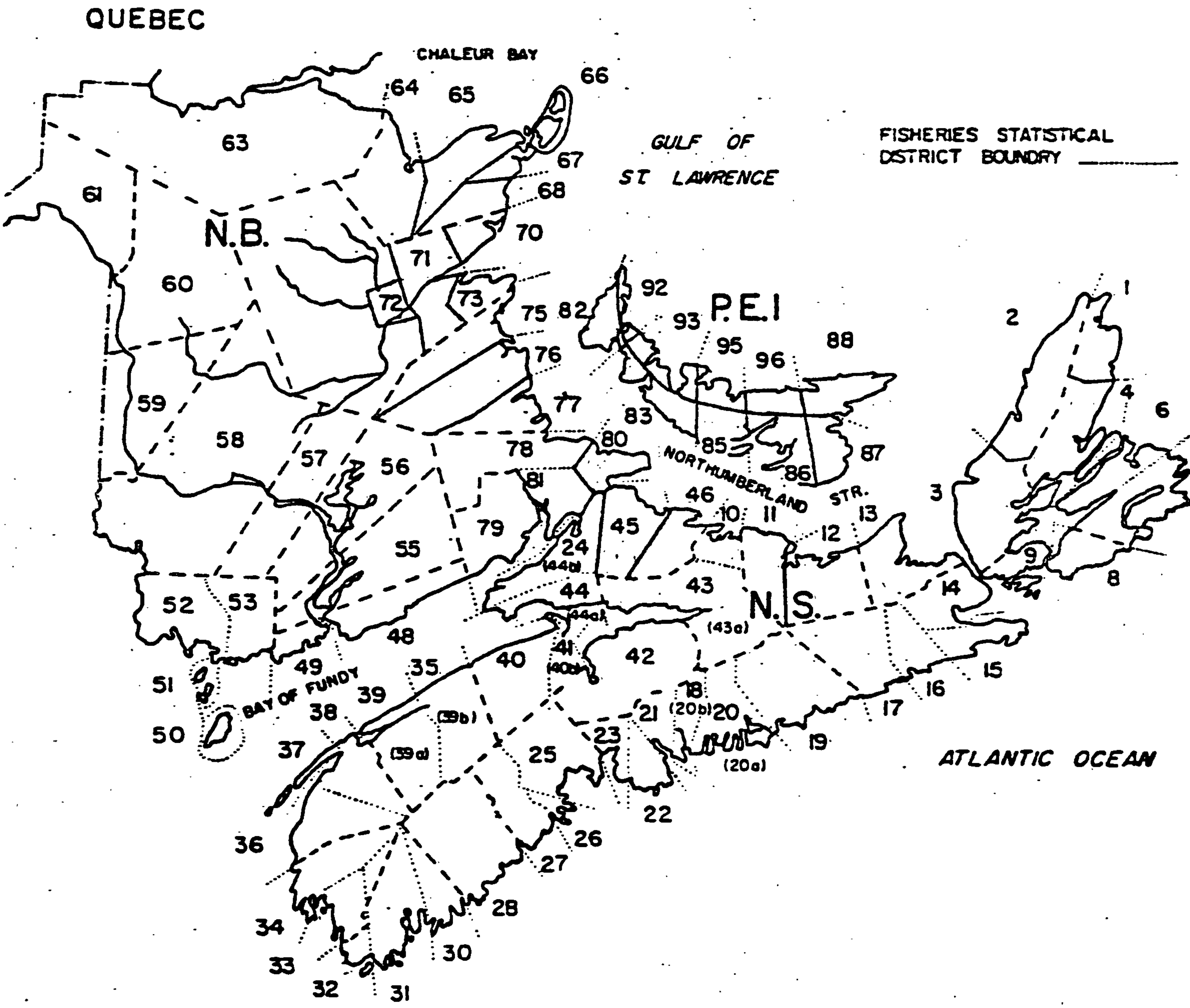


Figure 3a. Distribution of landings by statistical district of Gulf hake in NAFO division 4T as derived from 'Purchase Slips'.

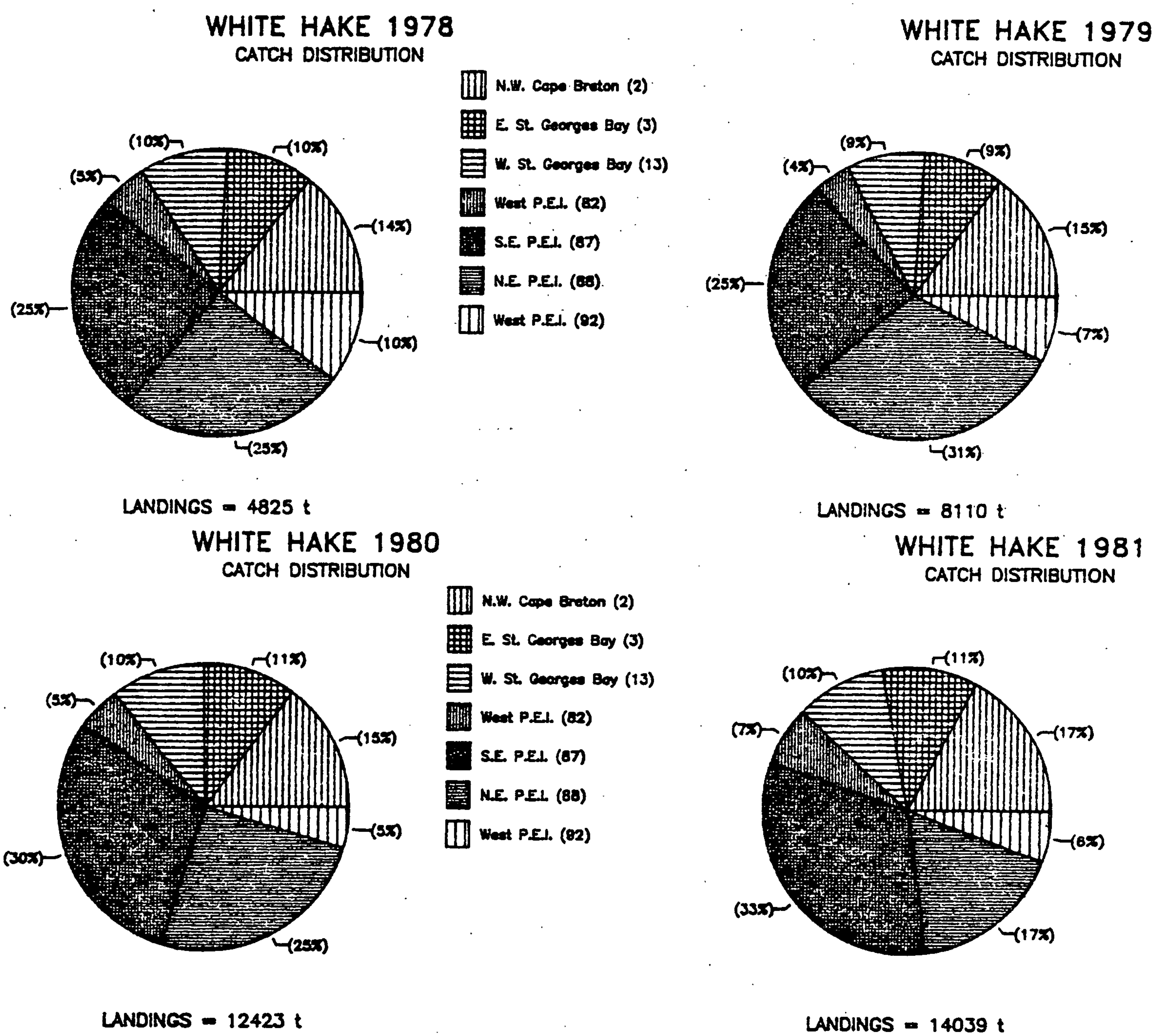


Figure 3b. Distribution of landings by statistical district of Gulf hake in NAFO division 4T as derived from 'Purchase Slips'.

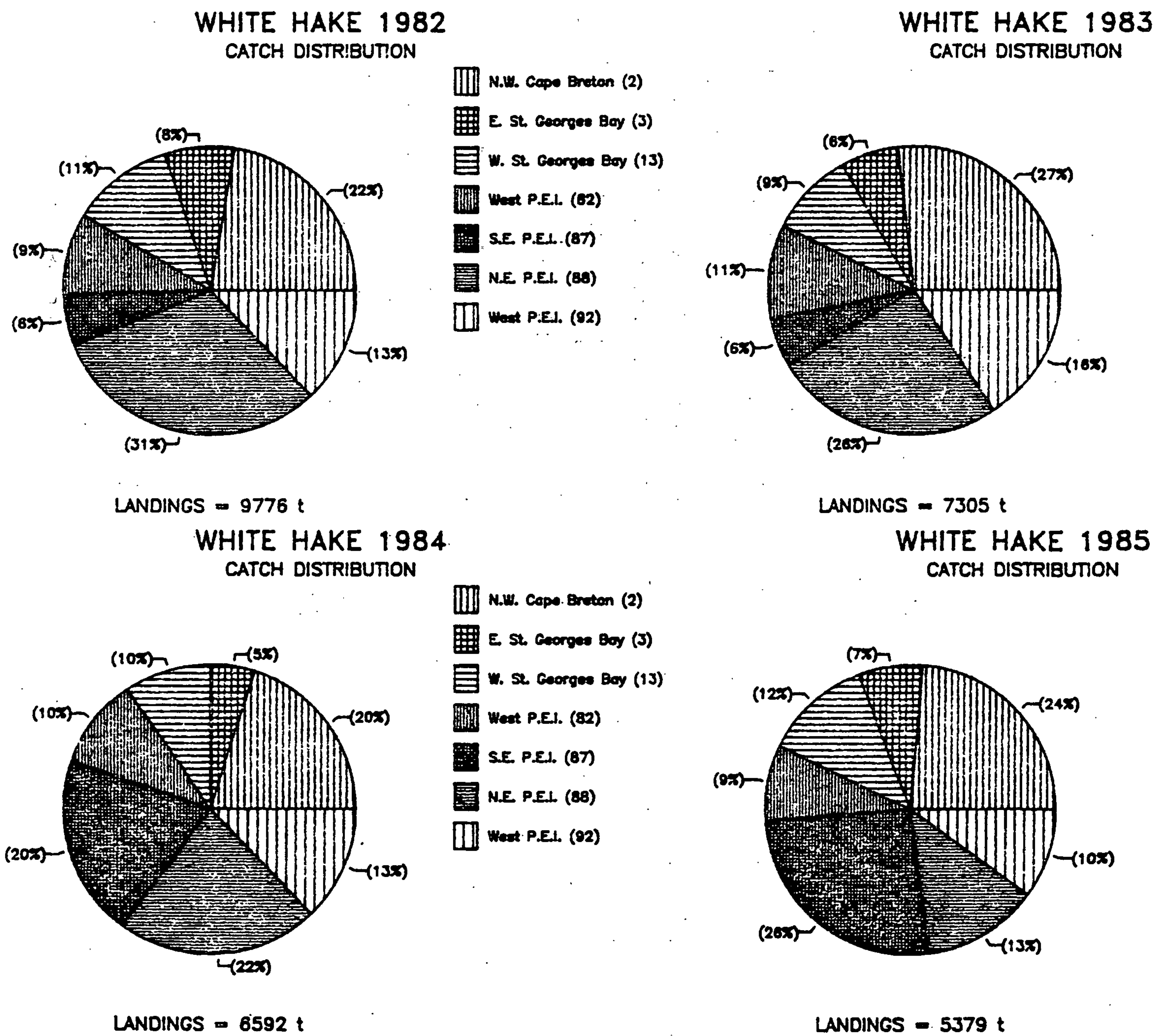
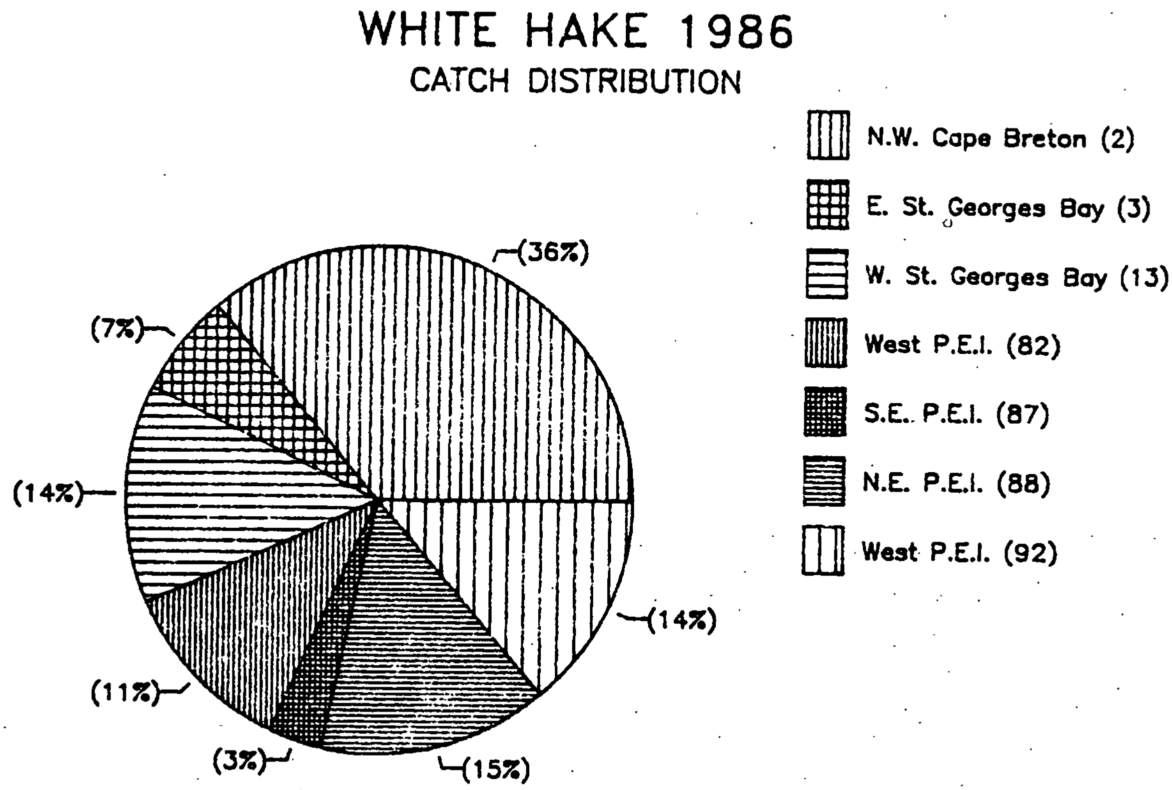
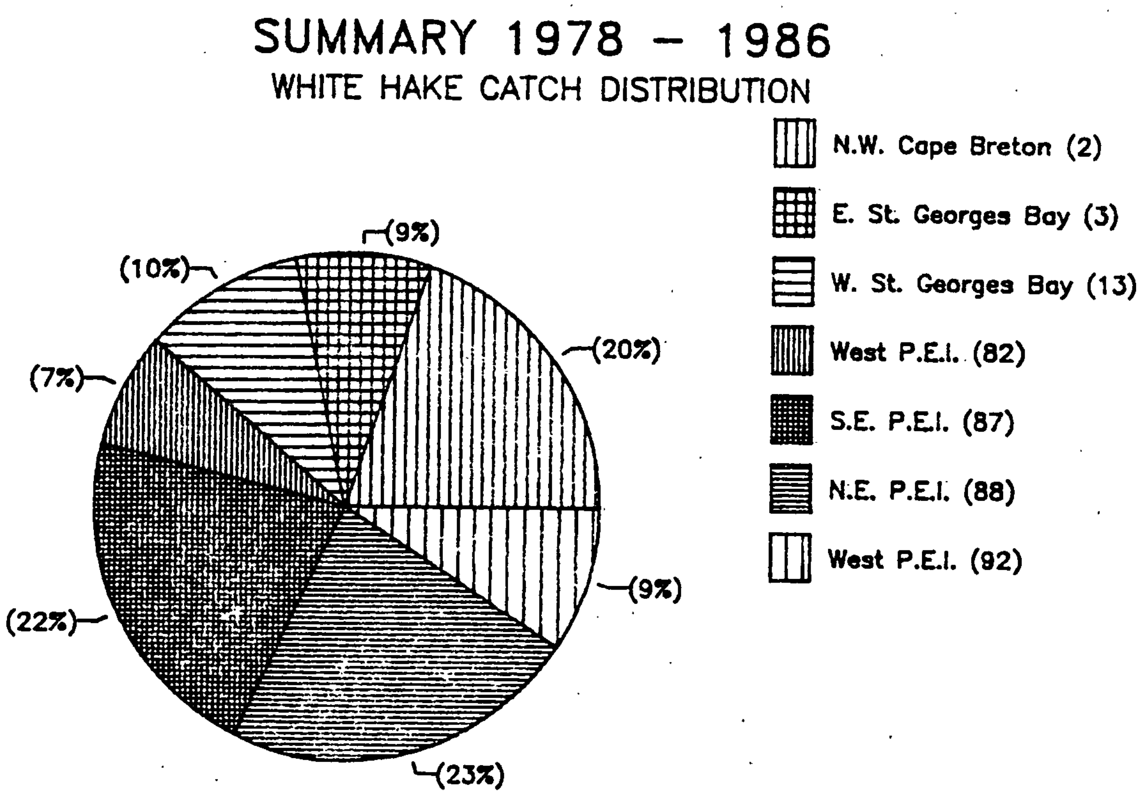


Figure 3c. Distribution of landings by statistical district of Gulf hake in NAFO division 4T as derived from 'Purchase Slips'.



LANDINGS = 4601 t



AVERAGE ANNUAL LANDINGS = 8116 t

Figure 3d,e. Summary of 9 years of landing statistics of Gulf hake in NAFO division 4T (data derived from 'Purchase Slips'). Same data is used in both figures - (d) being absolute values and (e) being relative values.

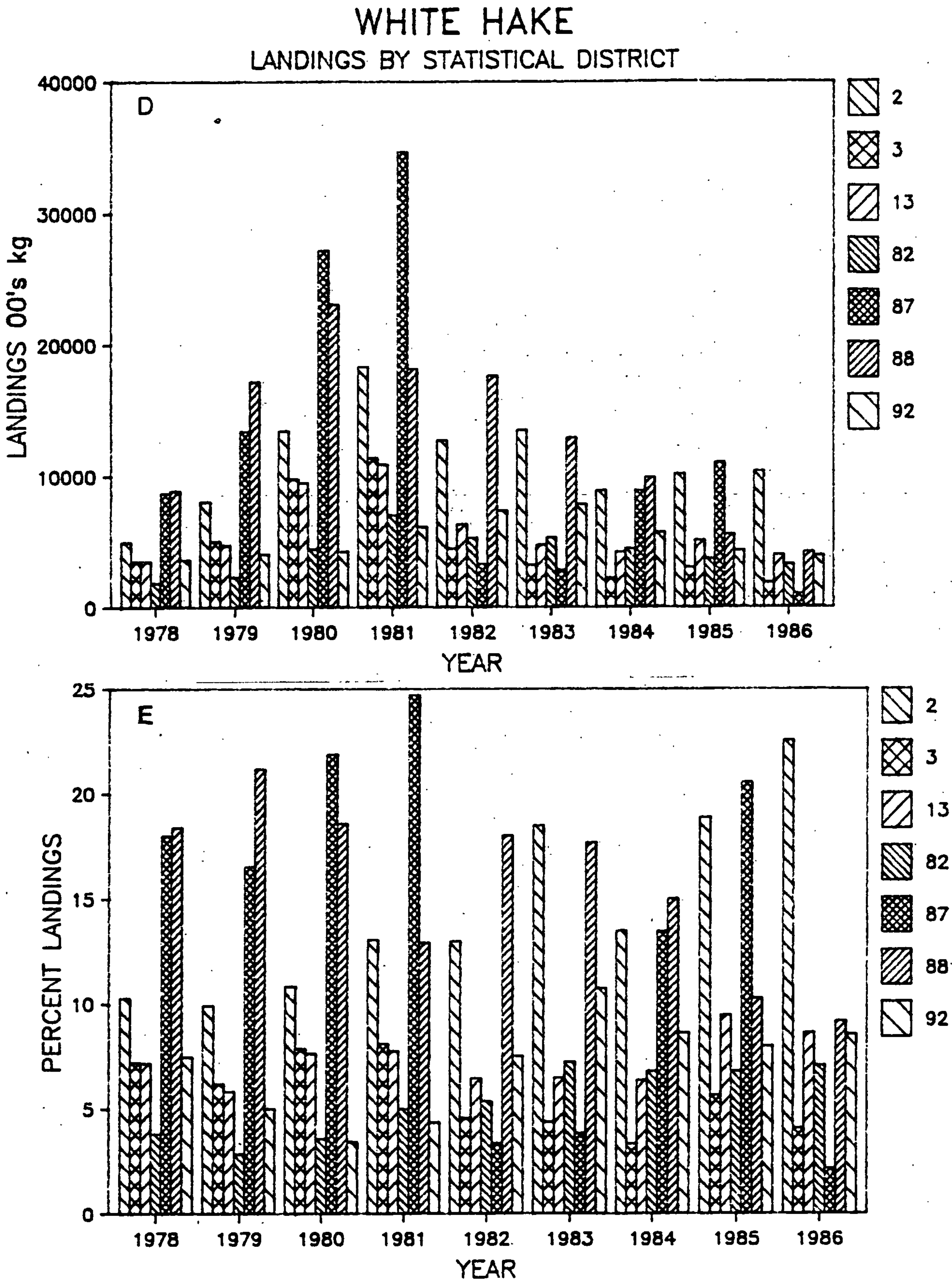


Figure 4. Residuals at successive CPUE levels in the last run of the Gavaris multiplicative model.

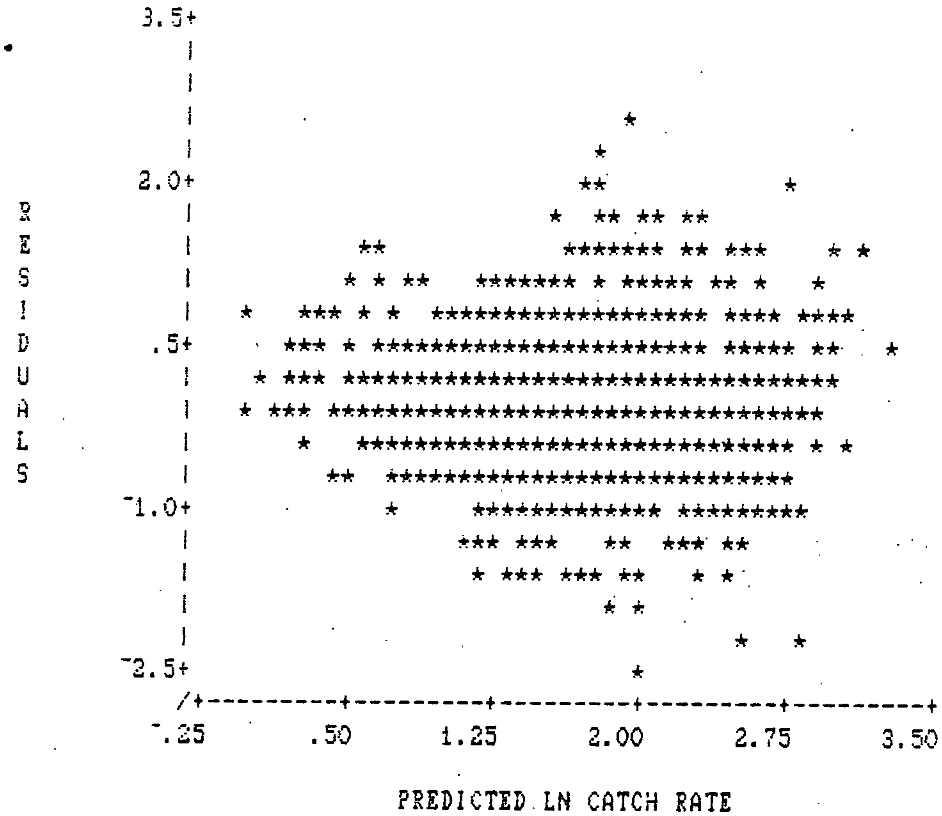
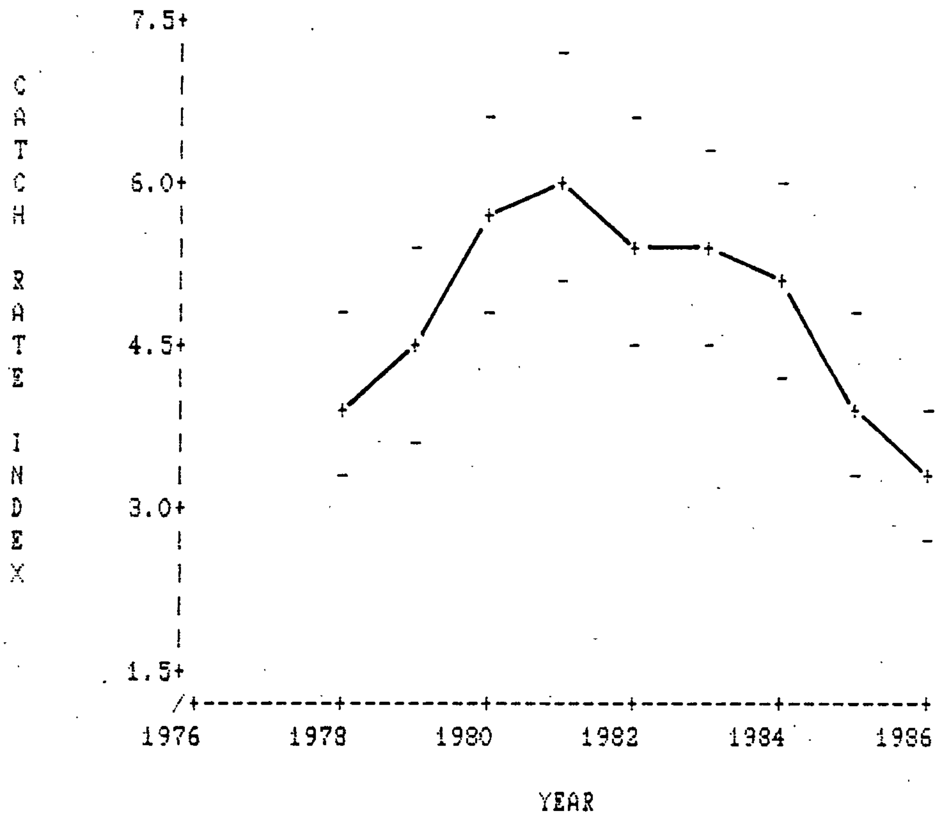


Figure 5. Catch rates from Gavaris multiplicative model for Gulf hake in NAFO division 4T. All catches are expressed in hundred's of kg.



PREDICTED CATCH RATE

STANDARDS USED VARIABLE NUMBERS: 2 41 0

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	CATCH RATE S.E.	EFFORT
1978	48250	0.403	4.041	0.454	11941
1979	81100	0.342	4.397	0.484	18446
1980	124230	0.435	5.569	0.597	22307
1981	140390	0.530	6.128	0.647	22909
1982	97760	0.473	5.497	0.582	17784
1983	73050	0.436	5.332	0.575	13700
1984	65920	0.741	5.063	0.538	13021
1985	53790	0.873	3.993	0.430	13472
1986	45970	0.566	3.266	0.350	14076

AVERAGE C.V. FOR THE MEAN: .108

Figure 6. Catch per unit of effort of Gulf hake from research surveys of the southern Gulf of St. Lawrence in September of each year. The values are given as stratified numbers and weight per tow.

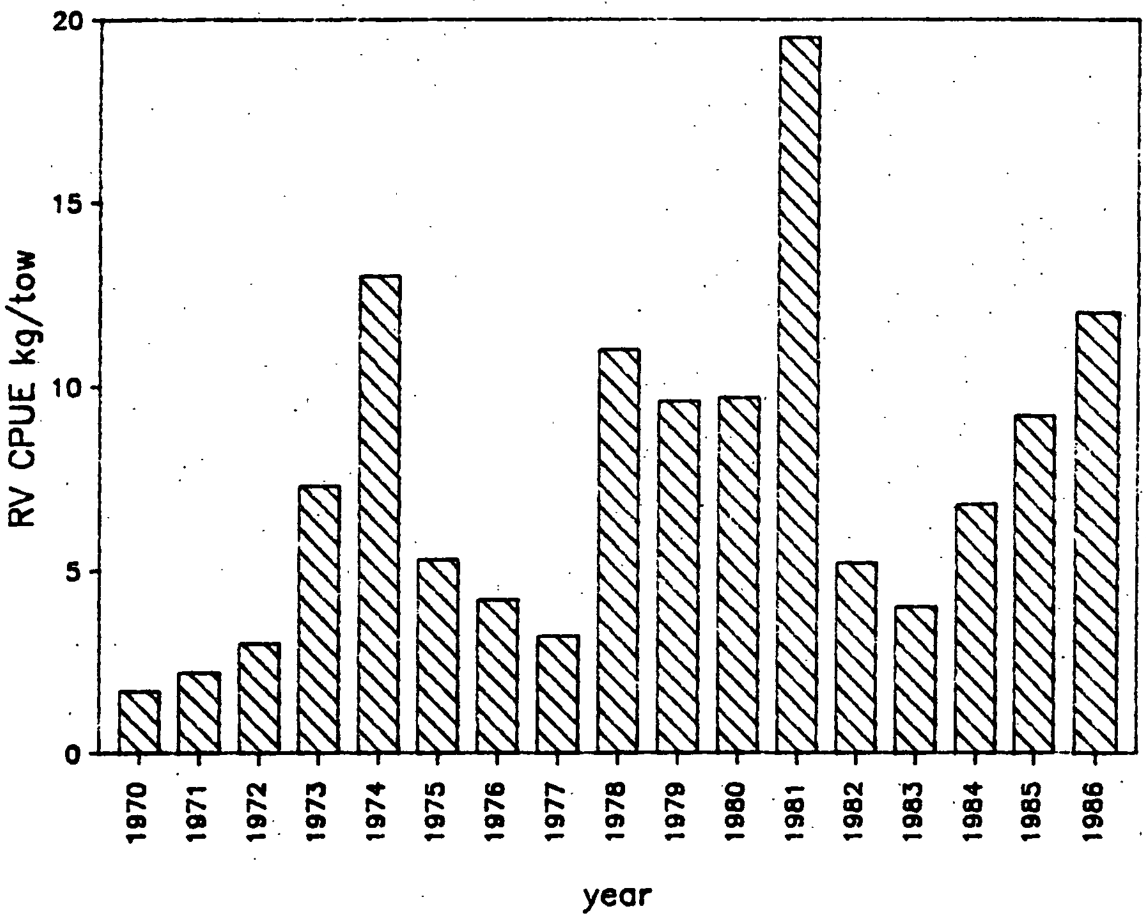


Figure 7a. Partial recruitment calculated by three different methods (see text).

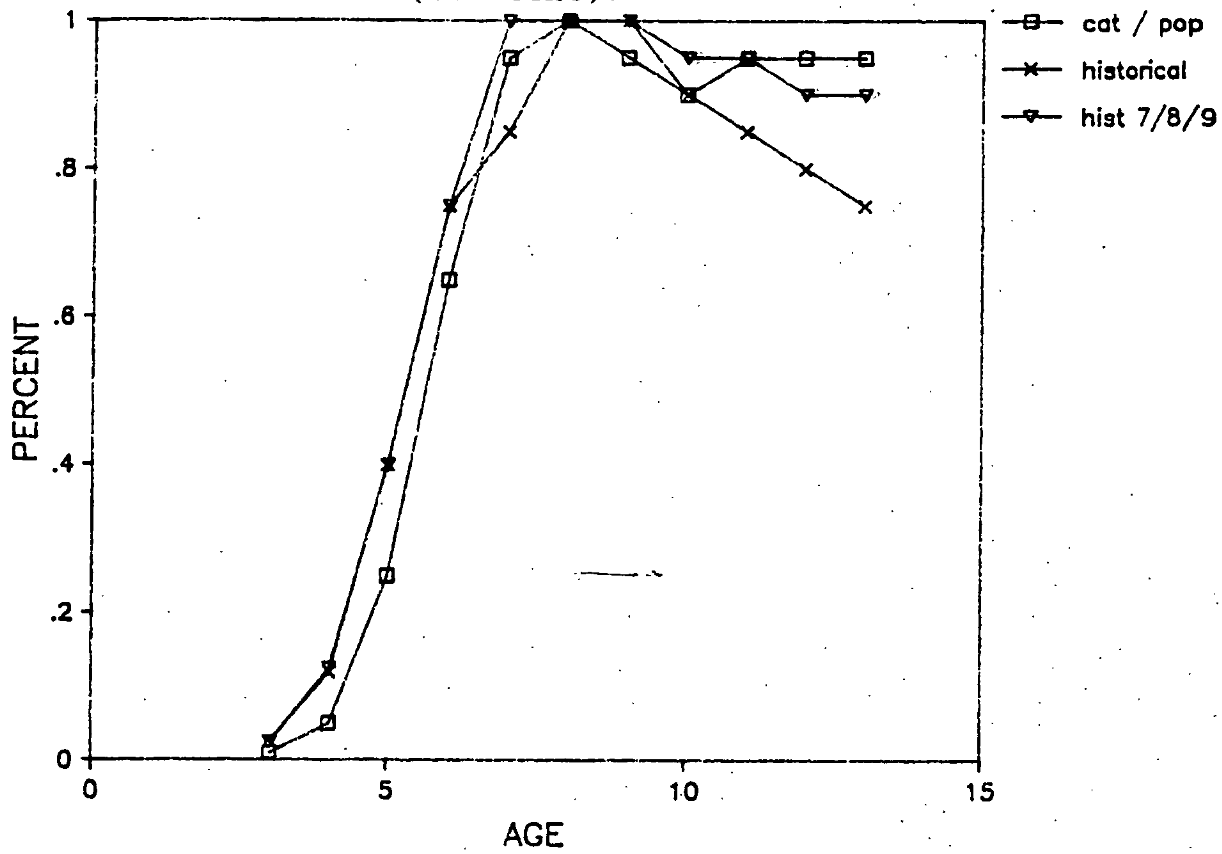


Figure 7b. The partial recruitment used in the 1986 assessment (Clay et al., MS 1986) compared to that chosen for the 1987 assessment.

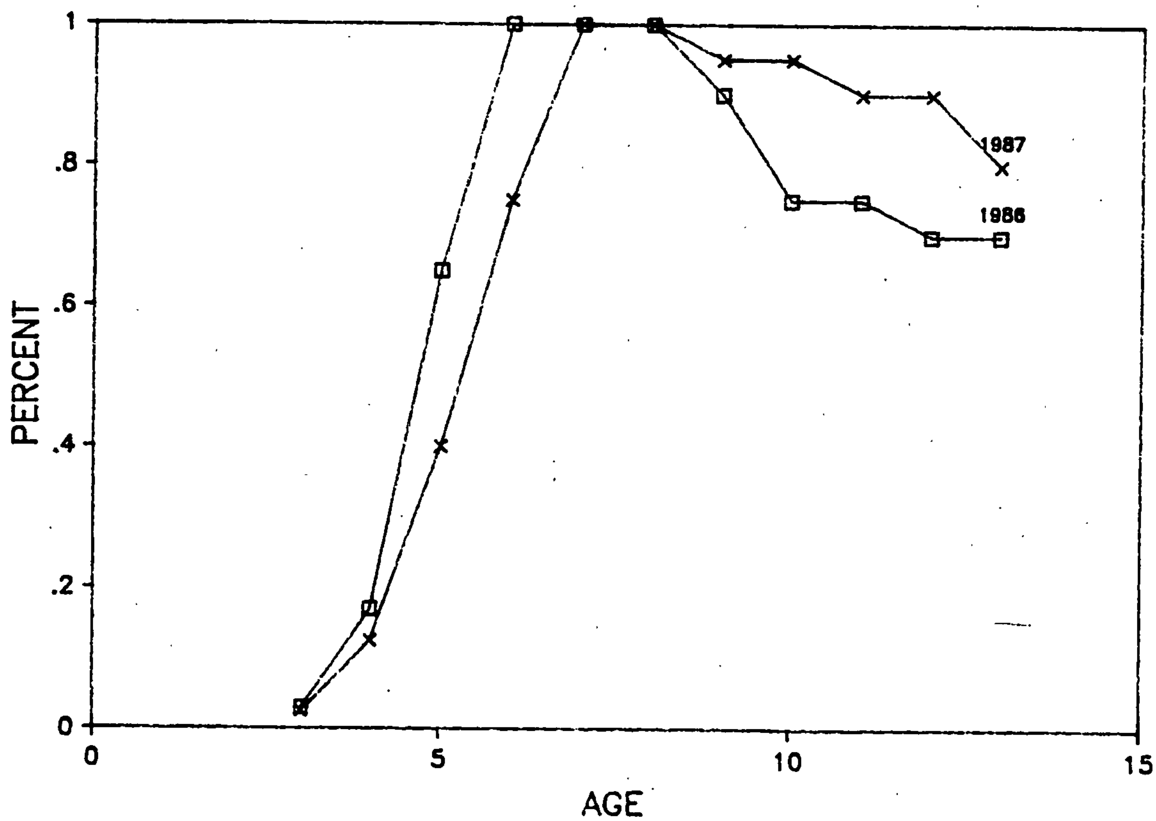


Figure 8. Calibration plots at Ft of 0.5 for the 3+ exploitable and 6+ total population biomass as estimated by VPA against the commercial CPUE index from a multiplicative model.

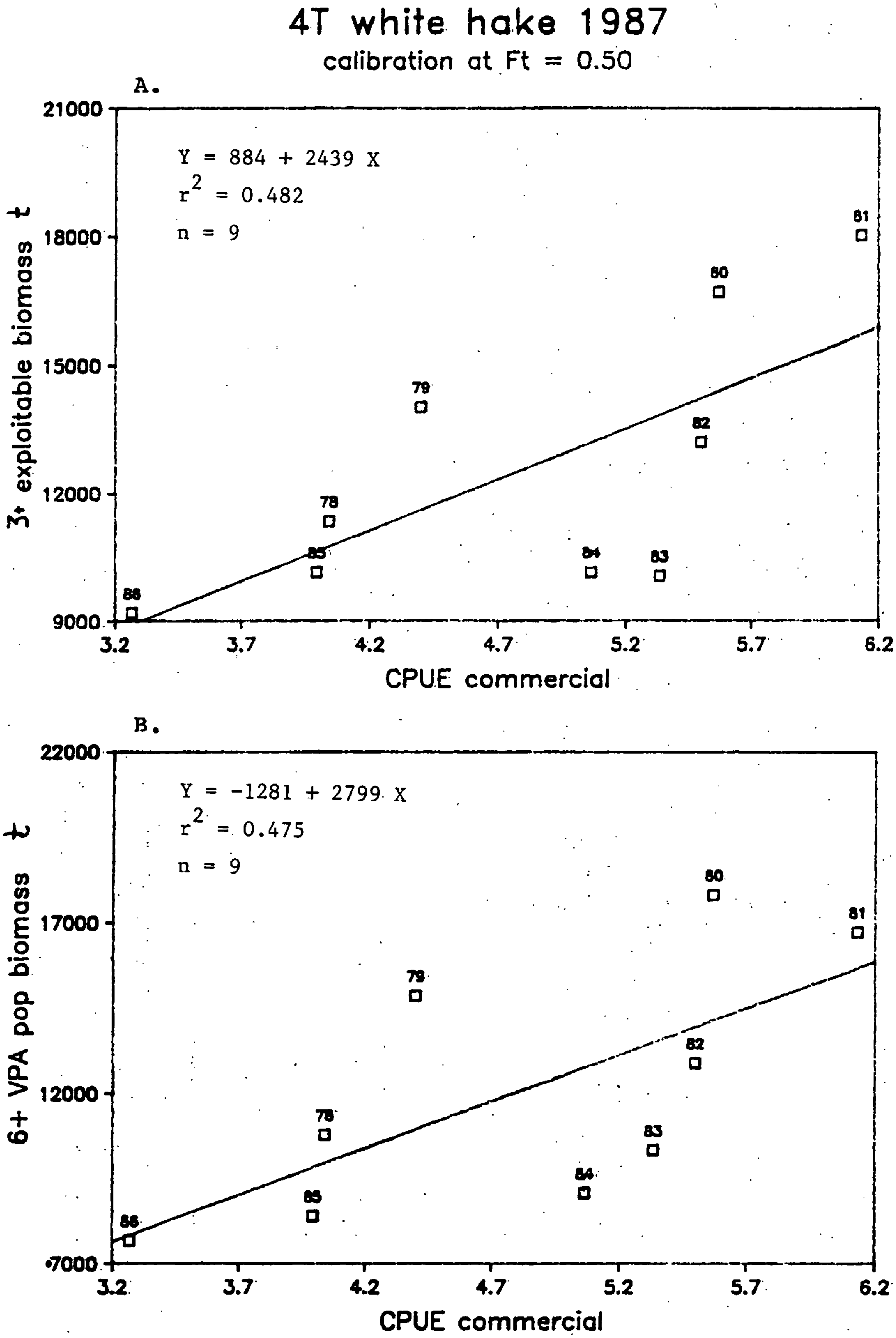
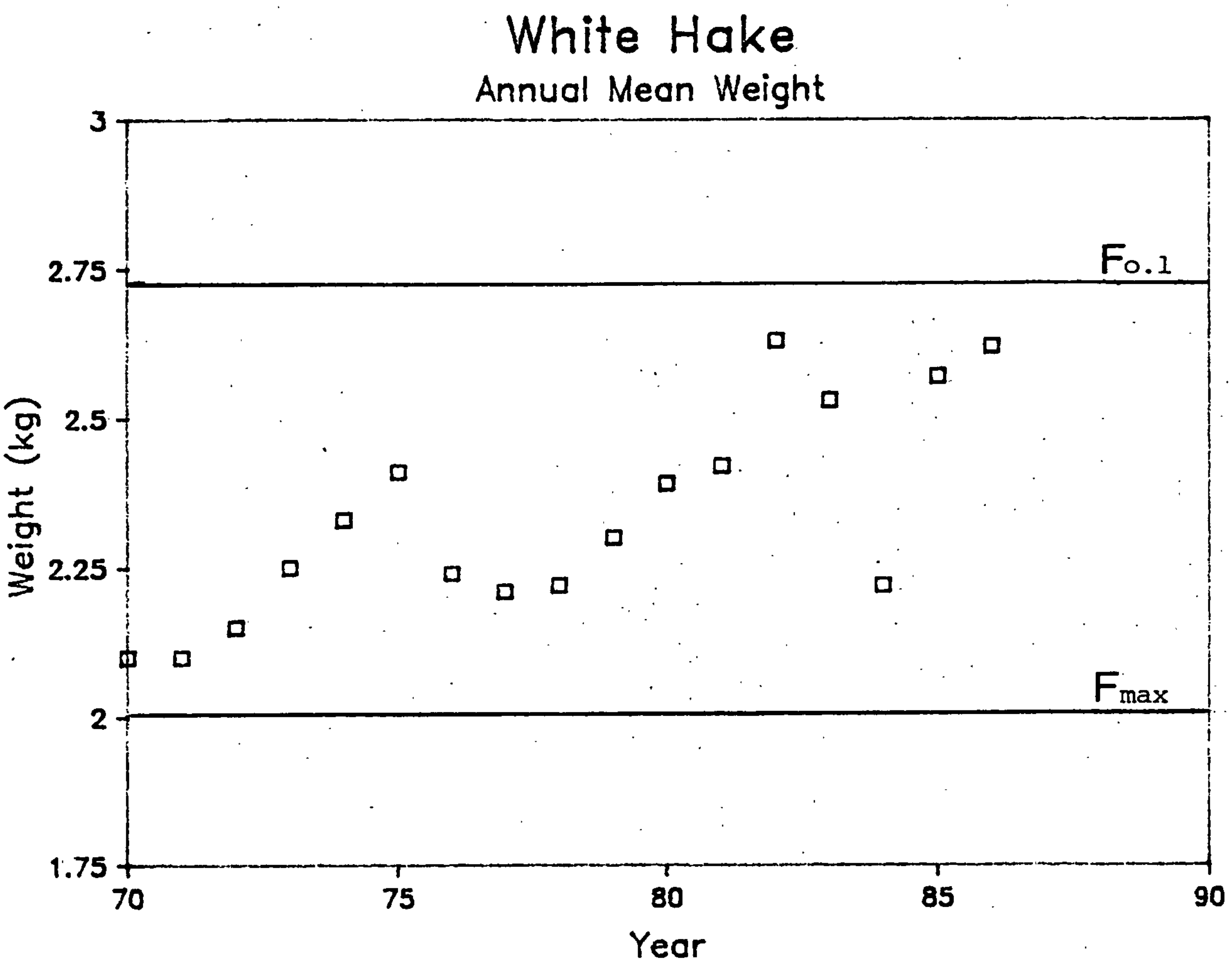


Figure 9. Mean weights at age by year for the NAFO division 4T Gulf hake as compared to the mean weights estimated if fishing at Fo.1 and Fmax.



APPENDIX I

VPA run with the parameters from the text and a terminal F of 0.5.

population numbers (000's) 14/ 5/87

:	70	71	72	73	74	75	76	77	78	79
3 :	4974	4462	3768	3764	4618	6659	9285	11880	11110	7986
4 :	4366	3995	3578	3003	3010	3736	5402	7529	9649	9024
5 :	2899	2940	2631	2361	2012	2240	2866	4154	5865	7580
6 :	1639	1660	1694	1486	1341	1307	1484	1958	2978	4279
7 :	889	934	959	953	805	832	763	916	1279	1948
8 :	384	395	427	425	377	381	344	364	480	737
9 :	191	186	195	202	178	187	159	164	176	239
10 :	91	90	84	85	70	76	66	71	75	89
11 :	36	37	36	29	25	28	26	29	32	38
12 :	16	19	17	18	13	14	16	17	20	23
13 :	7	7	9	7	7	6	5	6	7	9
3+:	15491	14725	13396	12333	12457	15468	20416	27087	31669	31952
4+:	10516	10263	9628	8569	7839	8808	11131	15207	20559	23966
5+:	6150	6268	6051	5567	4829	5072	5729	7679	10911	14942
6+:	3251	3328	3420	3205	2817	2832	2863	3524	5046	7362

:	80	81	82	83	84	85	86
3 :	5918	5182	4264	3994	3932	4442	5781
4 :	6457	4763	4183	3487	3219	3169	3571
5 :	6965	4880	3516	3324	2739	2279	2424
6 :	5457	4780	3031	2389	2186	1576	1408
7 :	2632	2982	2152	1470	1251	1068	834
8 :	994	1090	1203	783	659	586	549
9 :	322	334	356	496	287	317	271
10 :	105	142	137	159	198	103	163
11 :	31	20	33	42	66	117	42
12 :	24	20	13	9	30	38	80
13 :	9	15	15	3	4	17	6
3+:	28916	24207	18904	16156	14570	13712	15129
4+:	22998	19025	14640	12162	10638	9270	9348
5+:	16541	14262	10457	8675	7419	6101	5777
6+:	9576	9382	6941	5351	4680	3822	3353

mid-year population biomass : tonnes 14/ 5/87

:	70	71	72	73	74	75	76	77	78	79
3 :	4690	4204	3539	3541	4370	6309	8795	11262	10532	7554
4 :	4844	4387	3933	3324	3500	4409	6382	8949	11516	10680
5 :	4141	4210	3734	3360	3045	3421	4441	6584	9373	12038
6 :	2841	2896	2919	2518	2418	2291	2669	3614	5500	7682
7 :	1685	1792	1815	1719	1568	1529	1491	1868	2720	3922
8 :	901	935	992	936	895	838	801	853	1139	1653
9 :	479	457	472	445	428	415	389	406	456	582
10 :	268	264	233	220	207	208	202	219	245	248
11 :	156	152	152	118	110	127	122	141	159	180
12 :	73	90	81	82	64	61	69	76	95	103
13 :	45	43	53	43	47	39	35	39	48	59
3+:	20123	19430	17923	16306	16651	19647	25396	34009	41783	44702
4+:	15433	15226	14384	12765	12282	13338	16601	22747	31250	37148
5+:	10589	10839	10451	9441	8781	8928	10219	13798	19734	26468
6+:	6448	6628	6717	6081	5736	5508	5778	7214	10361	14430

:	80	81	82	83	84	85	86
3 :	5586	4898	4055	3808	3678	4190	5573
4 :	7565	5519	5020	4182	3511	3864	4020
5 :	10815	7234	5434	5186	3514	3635	3875
6 :	9283	7463	4890	3905	3449	2764	2462
7 :	4839	5422	3746	2840	2350	2191	1655
8 :	1996	2163	2631	1586	1510	1410	1369
9 :	784	789	872	1125	634	856	785
10 :	231	336	361	473	675	313	710
11 :	146	96	108	240	232	614	215
12 :	132	119	45	49	137	110	473
13 :	53	86	82	20	26	103	37
3+:	41431	34125	27244	23415	19718	20050	21177
4+:	35845	29226	23189	19607	16039	15859	15604
5+:	28281	23708	18169	15425	12528	11996	11584
6+:	17466	16474	12735	10239	9014	8361	7708

catch biomass : tonnes 14/ 5/87

:	70	71	72	73	74	75	76	77	78	79
3 :	90	88	95	83	51	59	85	91	83	95
4 :	947	956	848	667	335	287	400	446	476	630
5 :	1480	1480	1387	1229	704	724	804	875	1080	1547
6 :	1030	1011	1095	1038	669	776	752	817	1235	2197
7 :	1028	1042	1113	1248	862	1046	804	833	954	1854
8 :	471	473	544	627	447	561	433	449	568	1037
9 :	262	275	299	382	278	350	240	236	219	359
10 :	188	192	197	223	147	185	125	129	116	211
11 :	72	83	72	73	45	45	28	28	22	45
12 :	46	53	53	59	33	46	60	53	53	73
13 :	28	28	38	38	28	28	19	19	19	38
3+:	5642	5681	5741	5667	3599	4108	3750	3976	4826	8084
4+:	5552	5593	5646	5584	3547	4049	3665	3885	4742	7990
5+:	4605	4638	4798	4918	3213	3762	3265	3439	4266	7360
6+:	3125	3158	3411	3688	2509	3038	2461	2564	3187	5813

:	80	81	82	83	84	85	86
3 :	95	69	5	60	58	77	70
4 :	606	572	151	173	510	263	251
5 :	1910	1998	1012	1136	1238	1024	775
6 :	3755	4464	2560	1746	1781	1207	923
7 :	3298	3835	3037	1712	1311	1021	828
8 :	1775	1986	1806	1276	802	804	685
9 :	487	547	530	810	521	400	373
10 :	336	419	351	317	219	221	337
11 :	39	23	123	32	86	107	97
12 :	40	7	63	32	56	178	213
13 :	47	76	85	11	9	52	49
3+:	12388	13996	9723	7306	6592	5353	4601
4+:	12293	13927	9718	7245	6533	5276	4531
5+:	11688	13355	9568	7072	6023	5013	4280
6+:	9778	11357	8555	5936	4784	3990	3505

mean weight of individuals in catch : kg 14/ 5/87

:	70	71	72	73	74	75	76	77	78	79
:	2.10	2.10	2.15	2.25	2.33	2.41	2.24	2.21	2.22	2.30

:	80	81	82	83	84	85	86
:	2.39	2.42	2.63	2.53	2.22	2.57	2.62

production 14/ 5/87

source	:	70	71	72	73	74	75
recruitment biomass	:	4618	4142	3497	3494	4287	6182
growth	:	4771	4703	4300	3910	3979	4787
total production	:	9389	8845	7798	7404	8266	10969
loss through fishing	:	5642	5681	5741	5667	3599	4108
surplus production	:	5364	4960	4213	4143	4936	7040
net production	:	-278	-722	-1528	-1525	1337	2932

source	:	76	77	78	79	80	81
recruitment biomass	:	8619	11028	10313	7413	5494	4811
growth	:	6279	8460	10351	10871	9822	7974
total production	:	14898	19488	20664	18285	15315	12784
loss through fishing	:	3750	3976	4826	8084	12388	13996
surplus production	:	9818	12687	12308	9344	7029	5959
net production	:	6069	8711	7482	1260	-5359	-8037

source	:	82	83	84	85	86
recruitment biomass	:	3958	3699	3778	3996	5498
growth	:	6337	4967	4625	5561	5003
total production	:	10295	8666	8403	9557	10501
loss through fishing	:	9723	7306	6592	5353	4601
surplus production	:	4846	3983	4460	5547	6266
net production	:	-4877	-3323	-2132	194	1665

production/biomass ratio 14/ 5/87

:	70	71	72	73	74	75	76	77	78	79	80
:	0.47	0.46	0.44	0.45	0.50	0.56	0.59	0.57	0.49	0.41	0.37

:	81	82	83	84	85	86
:	0.37	0.38	0.37	0.43	0.48	0.50

fishing mortality 14/ 5/87

:	70	71	72	73	74	75	76	77	78	79
3 :	0.019	0.021	0.027	0.024	0.012	0.009	0.010	0.008	0.008	0.013
4 :	0.195	0.218	0.216	0.201	0.096	0.065	0.063	0.050	0.041	0.059
5 :	0.357	0.351	0.372	0.366	0.231	0.212	0.181	0.133	0.115	0.129
6 :	0.363	0.349	0.375	0.412	0.277	0.339	0.282	0.226	0.225	0.286
7 :	0.610	0.581	0.613	0.726	0.550	0.684	0.539	0.446	0.351	0.473
8 :	0.523	0.507	0.548	0.670	0.500	0.670	0.541	0.526	0.499	0.627
9 :	0.546	0.601	0.634	0.858	0.649	0.843	0.616	0.582	0.479	0.617
10 :	0.700	0.727	0.844	1.013	0.708	0.892	0.616	0.590	0.474	0.850
11 :	0.465	0.550	0.477	0.618	0.408	0.354	0.231	0.199	0.141	0.249
12 :	0.633	0.586	0.649	0.727	0.518	0.766	0.861	0.700	0.558	0.705
13 :	0.630	0.663	0.713	0.876	0.609	0.725	0.543	0.492	0.392	0.646
7+:	0.584	0.573	0.609	0.741	0.554	0.705	0.550	0.484	0.399	0.531

:	80	81	82	83	84	85	86
3 :	0.017	0.014	0.001	0.016	0.016	0.018	0.013
4 :	0.080	0.104	0.030	0.041	0.145	0.068	0.063
5 :	0.177	0.276	0.186	0.219	0.352	0.282	0.200
6 :	0.404	0.598	0.524	0.447	0.516	0.437	0.375
7 :	0.682	0.707	0.811	0.603	0.558	0.466	0.500
8 :	0.889	0.918	0.686	0.805	0.531	0.570	0.500
9 :	0.621	0.693	0.608	0.720	0.821	0.467	0.475
10 :	1.454	1.247	0.973	0.672	0.324	0.707	0.475
11 :	0.270	0.236	1.140	0.132	0.369	0.174	0.450
12 :	0.300	0.056	1.400	0.642	0.411	1.616	0.450
13 :	0.893	0.887	1.037	0.536	0.344	0.507	0.400
7+:	0.742	0.769	0.765	0.673	0.555	0.509	0.491

APPENDIX II

Projections run with parameters listed in the text using the 50% rule to give an F of 0.4 ($F_{0.1}$ of 0.3).

population numbers 14/ 5/87

:	86	87	88	89	90	91	92
3 :	5781	5500	5500	5500	5500	5500	5500
4 :	3571	4675	4458	4458	4458	4458	4458
5 :	2424	2747	3641	3472	3472	3472	3472
6 :	1408	1625	1916	2540	2422	2422	2422
7 :	834	792	985	1162	1541	1469	1469
8 :	549	414	435	541	638	845	806
9 :	271	272	227	239	297	350	464
10 :	163	138	153	127	134	166	196
11 :	42	83	77	85	71	75	93
12 :	80	22	47	44	49	41	43
13 :	6	42	12	27	25	28	23
3+:	15129	16310	17452	18196	18607	18827	18947
4+:	9348	10810	11952	12696	13107	13327	13447
5+:	5777	6135	7494	8238	8649	8869	8989
6+:	3353	3388	3853	4766	5176	5397	5517

mid-year population biomass : tonnes 14/ 5/87

:	86	87	88	89	90	91	92
3 :	5573.08	5308.15	5308.15	5308.15	5308.15	5308.15	5308.15
4 :	4020.32	5294.25	5049.10	5049.10	5049.10	5049.10	5049.10
5 :	3875.29	4474.81	5931.29	5656.64	5656.64	5656.64	5656.64
6 :	2462.46	2940.50	3468.38	4597.27	4384.40	4384.40	4384.40
7 :	1655.35	1644.11	2045.13	2412.27	3197.42	3049.37	3049.37
8 :	1369.20	1080.65	1134.42	1411.12	1664.45	2206.19	2104.04
9 :	785.22	822.83	686.40	720.56	896.31	1057.22	1401.33
10 :	710.25	628.92	694.53	579.37	608.20	756.55	892.36
11 :	214.83	444.25	414.56	457.80	381.90	400.90	498.68
12 :	473.50	133.47	290.01	270.63	298.86	249.31	261.71
13 :	3.42	267.05	79.09	171.86	160.38	177.11	147.74
3+:	21142.93	23038.99	25101.06	26634.79	27605.81	28294.94	28753.53
4+:	15569.84	17730.84	19792.91	21326.64	22297.66	22986.79	23445.38
5+:	11549.52	12436.59	14743.81	16277.53	17248.55	17937.68	18396.27
6+:	7674.23	7961.77	8812.52	10620.89	11591.91	12281.04	12739.63

catch biomass 14/ 5/87

:	86	87	88	89	90	91	92
3 :	70	53	53	53	53	53	53
4 :	251	265	252	252	252	252	252
5 :	775	716	949	905	905	905	905
6 :	923	882	1041	1379	1315	1315	1315
7 :	828	658	818	965	1279	1220	1220
8 :	685	432	454	564	666	882	842
9 :	373	313	261	274	341	402	533
10 :	337	239	264	220	231	287	339
11 :	97	160	149	165	137	144	180
12 :	213	48	104	97	108	90	94
13 :	49	85	25	55	51	57	47
3+:	4601	3851	4371	4930	5339	5608	5780
4+:	4531	3798	4318	4877	5286	5555	5727
5+:	4280	3533	4065	4625	5033	5303	5474
6+:	3505	2817	3116	3720	4128	4398	4569

fishing mortality 14/ 5/87

:	86	87	88	89	90	91	92
3 :	0.013	0.010	0.010	0.010	0.010	0.010	0.010
4 :	0.063	0.050	0.050	0.050	0.050	0.050	0.050
5 :	0.200	0.160	0.160	0.160	0.160	0.160	0.160
6 :	0.375	0.300	0.300	0.300	0.300	0.300	0.300
7 :	0.500	0.400	0.400	0.400	0.400	0.400	0.400
8 :	0.500	0.400	0.400	0.400	0.400	0.400	0.400
9 :	0.475	0.380	0.380	0.380	0.380	0.380	0.380
10 :	0.475	0.380	0.380	0.380	0.380	0.380	0.380
11 :	0.450	0.360	0.360	0.360	0.360	0.360	0.360
12 :	0.450	0.360	0.360	0.360	0.360	0.360	0.360
13 :	14.375	0.320	0.320	0.320	0.320	0.320	0.320
3+:	0.155	0.117	0.126	0.136	0.142	0.145	0.147

production 14/ 5/87

source	:	86	87	88	89	90	91	92
recruitment biomass	:	5656	5381	5381	5381	5381	5381	5381
growth	:	4912	5425	5962	6189	6406	6567	6691
total production	:	10568	10805	11342	11570	11787	11948	12072
loss through fishing	:	4601	3851	4371	4930	5339	5608	5780
surplus production	:	6339	6198	6322	6243	6266	6289	6321
net production	:	1738	2347	1951	1313	927	680	541

production/biomass ratio 14/ 5/87

:	86	87	88	89	90	91	92
:	0.50	0.47	0.45	0.43	0.43	0.42	0.42

summary of projections 14/ 5/87

year	:	86	87	88	89
population numbers	:	15129.13	16309.55	17452.23	18195.82
population biomass	:	21142.93	23038.99	25101.06	26634.79
catch	:	4601.00	3850.92	4370.58	4930.34
f or quota	:	4601.00	0.40	0.40	0.40

year	:	90	91	92
population numbers	:	18606.76	18826.99	18947.26
population biomass	:	27605.81	28294.94	28753.53
catch	:	5338.77	5608.12	5779.90
f or quota	:	0.40	0.40	0.40

age groups considered>3+

APPENDIX III

Otolith size related to fish size in Gulf white hake (*Urophysis tenuis*)

by

Douglas Clay
Department of Fisheries and Oceans
Gulf Fisheries Center, Moncton, New Brunswick

INTRODUCTION

Landings of white hake in the southern Gulf of St. Lawrence has been an important contributor to the inshore groundfish fishery for well over 50 years. In the past, hake were predominantly salted and dried for export. In the late 1970's and 1980's due to increased concern over quality (as new fresh fish markets were being developed) and the new regulations prohibiting the dumping of offal in the nearshore areas, more of the hake landings are being made after gutting and beheading at sea. This sea processing has resulted in difficulties in obtaining the traditional commercial port samples routinely collected by Departmental staff.

The 'traditional' sample is collected by a 'port sampler' who randomly select approximately 200 fish from the catch. While measuring all of these fish for length the sampler takes a stratified sub-sample of otoliths from these fish (usually 1 per cm grouping). Without heads two problems arise, that of the length of fish and that no otoliths are available. Clay et al. (MS 1985) derived two conversions for head off lengths to total lengths. These alternate forms of length measurement have been used since 1984, they obviously do not solve the problem of obtaining hard parts (otoliths) for age determination. In order to supplement the limited number of otoliths available from routine sampling a program was developed whereby random samples of hake heads were obtained from the fishermen. All otoliths from this sample were collected and the average individual weight for each pair of otoliths was used to determine the equivalent total length of the fish. The ages can then be determined from either the entire collection or from a stratified sub-sample.

METHODS

Otoliths were collected from fish from research vessel surveys in 1985 and 1986 and commercial sampling in 1984 for this study. The 1971 collection of white hake otoliths from the research survey on the RV E.E. Prince (cruise P091) was also examined.

Whole otolith weight to the nearest mg and length to the nearest 0.01 mm were measured. For each fish the total length rounded to the nearest cm, weight to the nearest 10 g and sex were recorded.

Regression analysis was used to derive formula for transforming otolith parameters to total length of fish. Analysis of co-variance (Snedecor and Cochran, 1978) was used to determine if differences existed between data sets.

RESULTS

The formula used to convert otolith weight to total length is:-

$$TL = a \times OW^{b}$$

and the equation to convert otolith length to total length is:-

$$TL = a \times OL^{b}$$

where TL is total length in cm, OW is mean otolith weight in mg, OL is otolith length in mm and 'a' and 'b' are the parameters given below.

<u>Otolith weight and length versus fish total length paramters</u>

Source*		H159	H159	N014	N014
Date		Sept/86	Sept/86	Jun-Sept/86	Jun-Sept/86
Sex		M	F	M	F
OTOLITH LENGTH					
	a	1.52504	1.41152		
	b	1.14562	1.17528		
	r	0.989	0.984		
	n	232	184		
OTOLITH WEIGHT					
	a	4.10108	3.85320	3.13279	3.04376
	b	0.45531	0.47180	0.50812	0.51776
	r	0.989	0.983	0.992	0.994
	n	247	201	298	220

table con't

Source*	A005	P091	P091	Comm.Samples	
Date	Jul/86	Sept/71	Sept/71	Jun/84	Jun/84
Sex	M	M	F	M	F
OTOLITH WEIGHT					
a	3.28991	3.52142	3.00570	6.38077	1.74314
b	0.49994	0.48893	0.52049	0.38637	0.61201
r	0.972	0.971	0.974	0.843	0.862
n	246	20	17	63	18

*Note H159 - research vessel RV Lady Hammond: cruise H159 survey of entire southern Gulf
N014 - research vessel MV Navicula: cruise 87-14 survey of St. Georges Bay (Nova Scotia)
P091 - research vessel RV E.E.Prince: cruise P091 survey of entire southern Gulf
A005 - charter vessel survey in 1985, Baie Verte, NB
Comm.Samples - commercial samples from Cape Tormentine, NB

--x--

Analysis of co-variance was conducted on the Lady Hammond / Navicula data sets to compare cruise/area and sex differences in the data. The following table summarizes the results.

Comparison between	Bartlett's X^2	F		df
SEX - H159 *	7.01			1
(otolith length)		slope	4.60	1,412
		elev	2.10	1,413
SEX - H159	7.86			1
(otolith weight)		slope	8.23	1,444
		elev	14.49	1,445
SEX - N014	14.74			1
(otolith weight)		slope	1.99	1,514
		elev	25.27	1,515
AREA - H159/N014	9.90			1
(male-otolith weight)		slope	74.81	1,541
		elev	3.28	1,542
AREA - H159/N014	12.66			1
(female-otolith weight)		slope	23.82	1,417
		elev	0.35	1,418

* no significant difference at 5% level (P>0.05)

All of the above relationships except the comparison of otolith lengths from the Lady Hammond are statistically different (see Figures 1 through 4). This indicates there is some form of sexually dimorphic growth in the otoliths of white hake. To test this hypothesis, samples of each sex were randomly split into two approximately equal groups and an analysis conducted within sexes. Both males and females for the Lady Hammond and Navicula samples were found to have no significant difference within sexes. This implies there is definitely sexual dimorphism in otolith size at fish length within the southern Gulf white hake population.

Differences also result between areas sampled. This suggests possible distinct stocks within the southern Gulf. From personal observations, hake in the southern Gulf appear to have definite seasonal movements within the southern Gulf from area to area. The differences observed between areas may really be differences between seasons. Further analysis will be required to identify the determining factor.

Although significant differences were found between the sexes the actual differences were slight, being in the order of less than 1 cm for fish in the most common commercial size range for Gulf white hake (40 to 50 cm). The difference ranged from 1 to 2.5 % with the greatest difference occurring in fish over 70 cm in total length (fish in that size range comprise less than 10% of the landings). Thus, for a sex combined relationship the difference for any individual fish should be less than 0.5 cm. This is considered an acceptable error - especially in view of our protocols of rounding all measurements to the nearest cm.

Otolith weight is an easier measurement to collect than otolith length and less subject to errors due to chipping and operator misreading. For these reasons the following sexes-combined otolith weight to fish length relationship is proposed for conversion of otolith measurements to total length for the Gulf white hake:-

$$TL = 3.48756 \times OW^{0.48884}, \quad r^2 = 0.977, \quad n = 966.$$

---xXx---

ACKNOWLEDGEMENTS

The weighing of all the otoliths except those of the RV Lady Hammond was carried out through the summers of 1985 and 1986 by Elizabeth Clay. The lengths and weights of the otoliths from Lady Hammond was completed by Debbie Haight, who also carried out some of the statistical analysis.

REFERENCES

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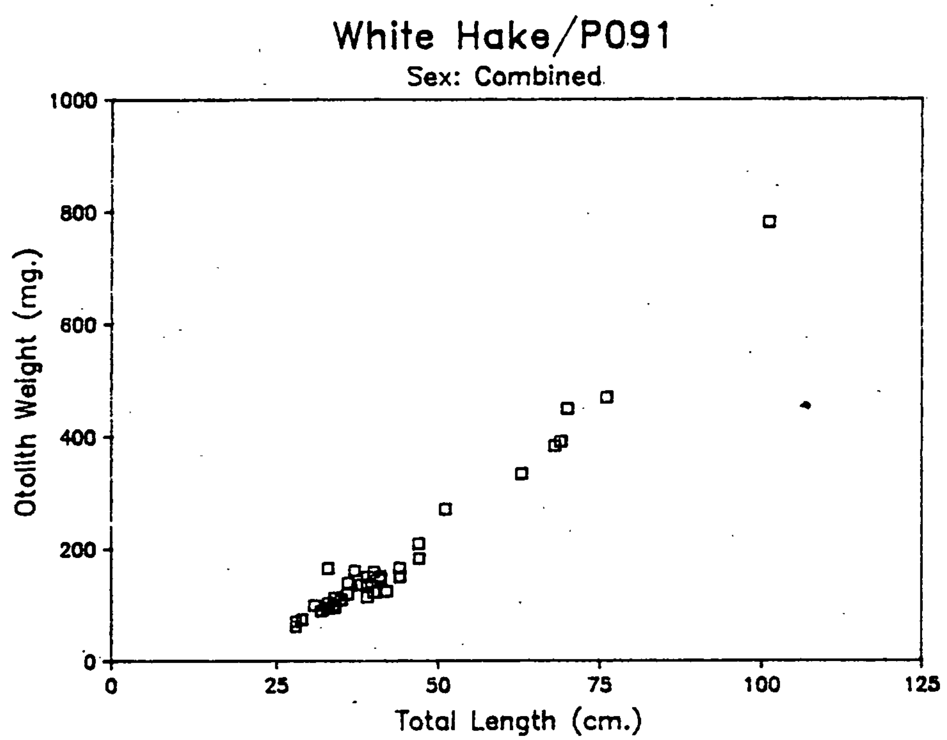
Snedecor,G.W. and G.Cochran (1978) Statistical Methods. The Iowa State University Press. Ames, Iowa, USA. 593pp.

Figure 1. Otolith weight and total fish length for sex combined data from the 1971 cruise of the RV E.E.Prince and commercial sampling data from Cape Tormentine, NB.



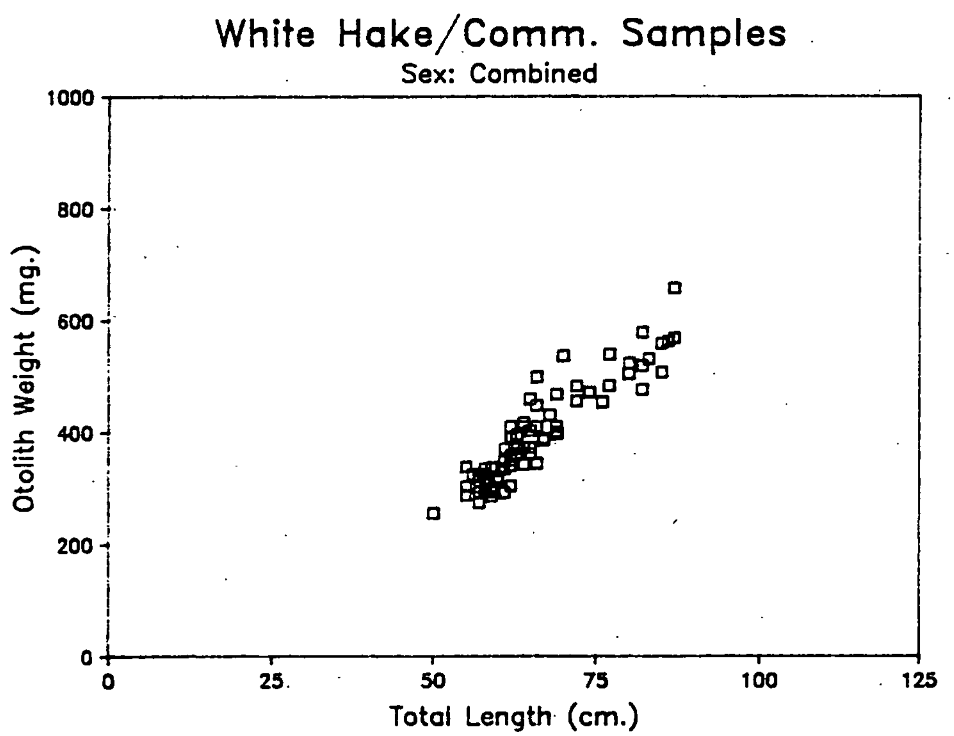
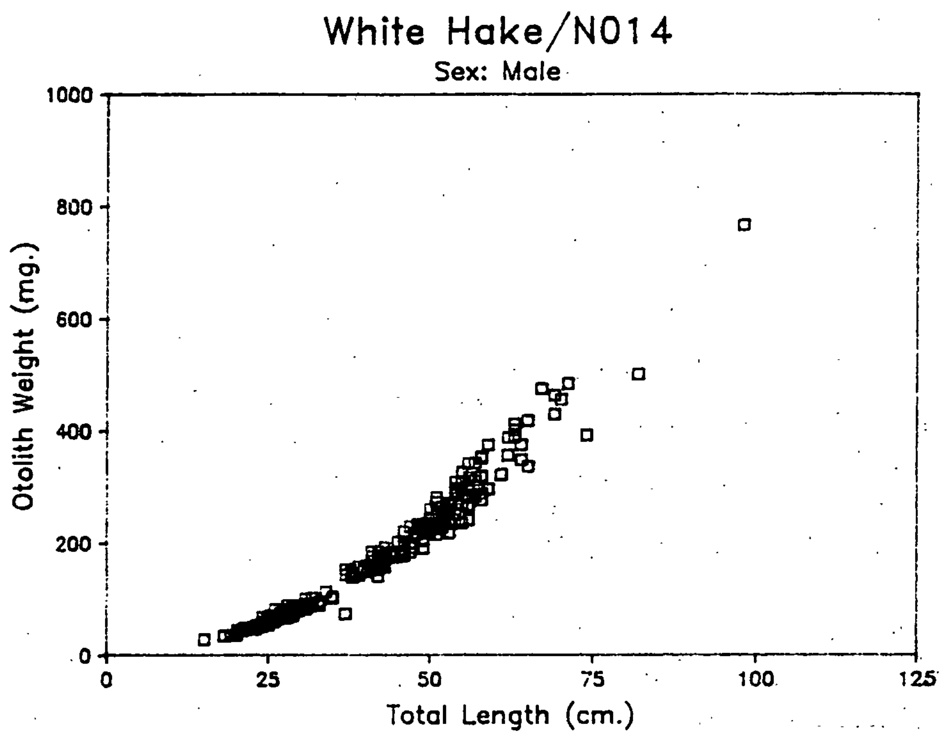


Figure 2. Otolith weight and total fish length for male and female white hake collected from the 1986 cruise on the RV Navicula in St. Georges Bay, NS



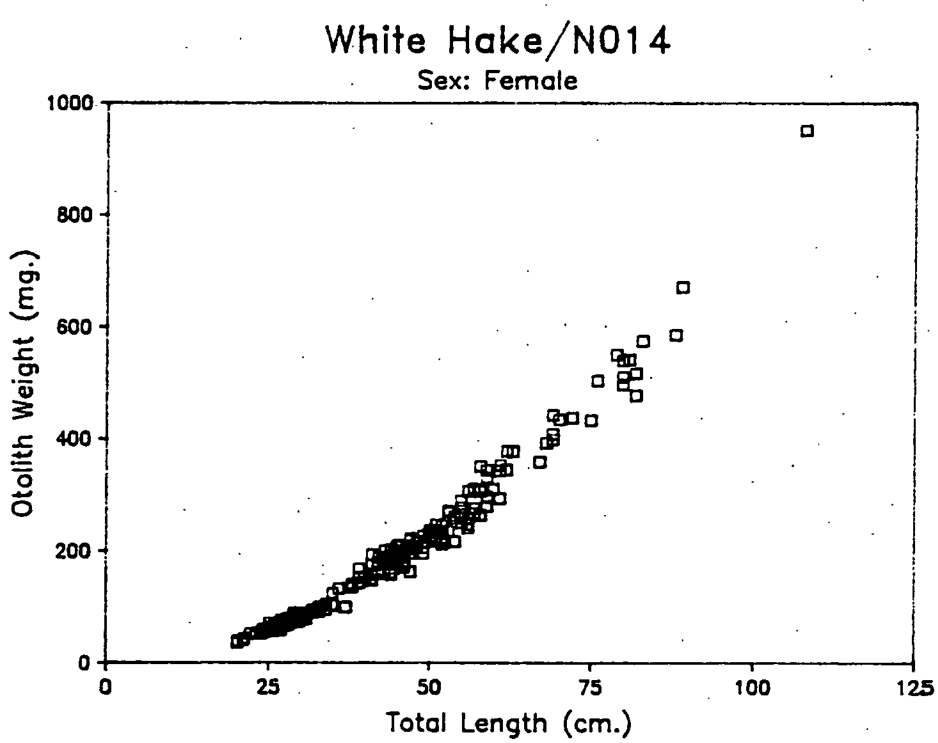
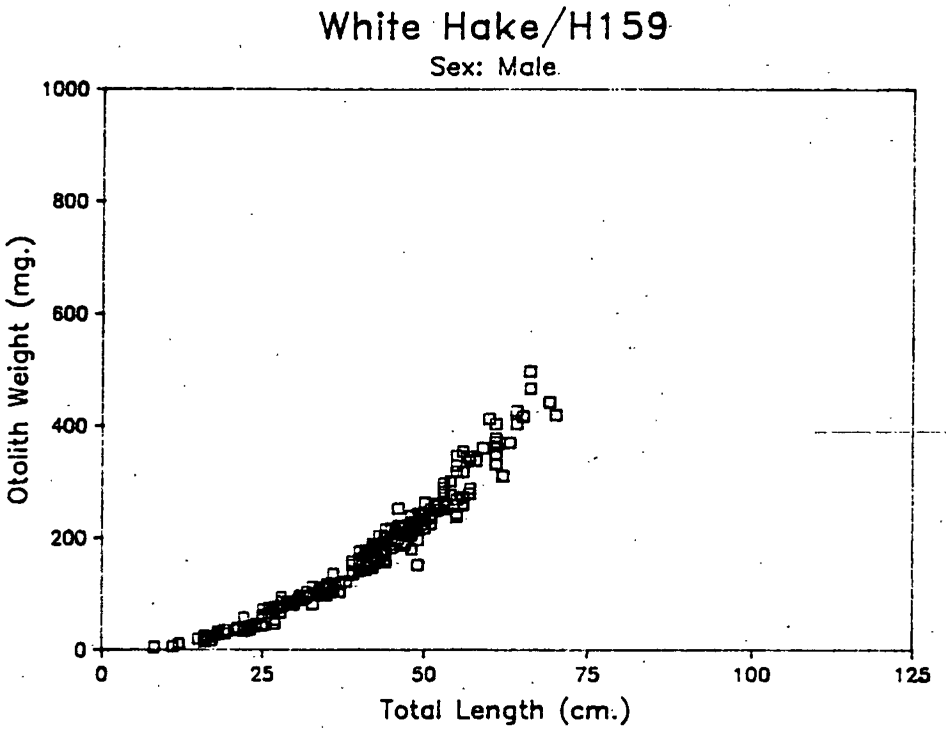


Figure 3. Otolith weight and total fish length for male and female white hake collected from the 1986 cruise on the RV Lady Hammond throughout the southern Gulf of St. Lawrence.



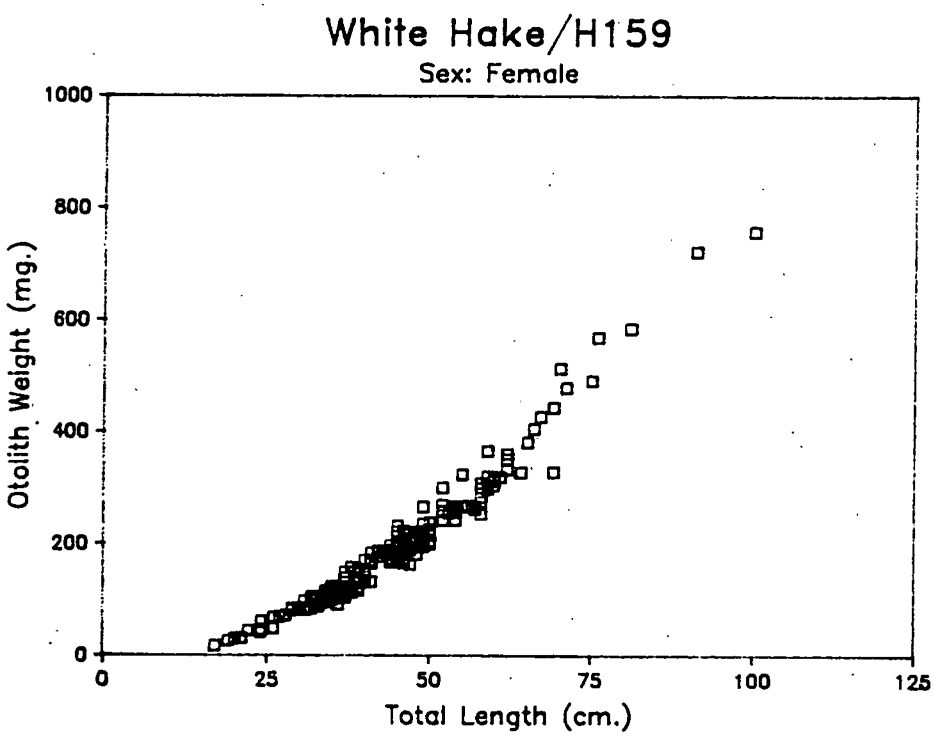


Figure 4. Otolith length and total fish length for male and female white hake collected from the 1986 cruise on the RV Lady Hammond throughout the southern Gulf of St. Lawrence.