Canadian Atlantic Fisheries
Scientific Advisory Committee

Comité scientifique consultatif des
pêches canadiennes dans l'Atlantique

CAFSAC Research Document 89/52

CSCPCA Document de recherche 89/52

Assessment of Gulf White Hake from NAFO Division 4T in 1989 (Including an investigation of their distribution in the southern Gulf of St. Lawrence)

by

Douglas Clay and Thomas Hurlbut
Marine and Anadromous Fish Division
Department of Fisheries and Oceans
Gulf Fisheries Centre
P.O. Box 5030, Moncton, N.B.
CANADA, E1C 9B6

ABSTRACT

Since 1961, landings of white hake have ranged from 3,616 tonnes in 1974 to a high of 14,039 tonnes in 1981. The 1988 nominal landings (3,860 tonnes) decreased by 2,360 tonnes (38%) from 1987. In 1982 the first precautionary TAC was set at 12,000 tonnes. A first analytical assessment in 1985 indicated that this level may have been too high. Subsequent assessments have reaffirmed this fact.

This fishery is conducted by predominantly small inshore vessels (tonnage class 0 and 1). Gillnet fishermen landed 50% of the total 1988 catch. Otter trawlers, seiners, and longliners, the other major gear categories, accounted for 16%, 14%, and 19% respectively.

White hake in the Gulf of St. Lawrence are found northwards from the shallows of Northumberland Strait to the northern and western limits of the Esquimann and Anticosti Channels. Eastwards the fish in this management unit are continuous with the relatively large concentrations along the northern edge of the Nova Scotia shelf in NAFO Division 4V.

A commercial catch rate series was derived from landings per purchase slip (landing receipt) using only data from gillnet fishermen (1978 to 1988). A second index was derived from research vessel age specific abundance estimates, however these two indices gave divergent views of the stock status through calibration of the VPA model. The terminal F selected was 0.65, approximately half way between the two values. The Fo.1 falls considerably below this value at approximately 0.30.

The yield per recruit of approximately 1.000 kg and the geometric mean recruitment from 1978 to 1985 (from a range of possible partial recruitment vectors) gives a long term equilibrium yield for this stock of 5,000 to 6,000 tonnes. Projections for the next 5 years at the Fo.1 level indicate a slowly recovering or stable stock with projected landings ranging from approximately 4,000 to 6,000 tonnes.

A review of the research surveys of the southern Gulf (Magdalen Shallows) indicates a 'ring' shaped distribution around the periphery of the survey area. The management unit for white hake in NAFO Division 4T appears to comprise two geographically separate components: an offshore component along the slopes of the Laurentian Channel and an inshore component in areas around Northumberland Strait.

RÉSUMÉ

Depuis 1961, les débarquements de merluche blanche se sont échelonnés entre 3 616 tonnes, en 1974, et un sommet de 14 039 tonnes en 1981. Les débarquements nominaux de 1988 (3 860 tonnes) accusent une baisse de 2 360 tonnes (38 p. 100) par rapport à ceux de 1987. En 1982, le premier TPA préventif a été fixé à 12 000 tonnes. Or, une première évaluation analytique réalisée en 1985 révélait que ce niveau pouvait être excessif, ce qu'ont confirmé les analyses subséquentes.

La pêche de la merluche blanche est pratiquée surtout par de petits bateaux de pêche côtière (classe de jauge 0 et 1). Les pêcheurs qui utilisent le filet maillant ont débarqué 50 p. 100 de la totalité des prises de 1988. Les autres catégories d'engin, soit les chaluts à panneaux, les sennes et les palangres ont capturé respectivement 16, 14 et 19 p. 100 des prises.

Dans le golfe du Saint-Laurent, on trouve de la merluche blanche au nord, depuis les eaux peu profondes du détroit de Northumberland jusqu'aux extrémités nord et ouest des chenaux d'Esquiman et d'Anticosti. Vers l'est, le poisson de cette unité de gestion se confond avec celui des concentrations relativement vastes que l'on trouve sur le bord nord de la plate-forme néo-écossaise dans la division 4V de l'OPANO.

On a obtenu une série de taux de prises commerciales à partir des débarquements consignés dans les bordereaux d'achat (reçus) provenant uniquement des pêcheurs au filet maillant entre 1978 et 1988. De plus, les estimations d'abondance selon l'âge établies par les navires de recherche ont fourni un deuxième indice. Toutefois, après étalonnage du modèle d'APV, ces deux indices projettent des visions divergentes de l'état des stocks. On a établi à 0,65, soit à mi-chemin entre les deux valeurs obtenues, le taux F de la dernière année. Le taux $F_{0.1}$ est bien inférieur à ce chiffre, puisqu'il se situe à environ 0,30.

Le rendement par recrue d'environ 1 000 kg et le recrutement moyen géométrique de 1978 à 1985 (établi d'après une gamme de vecteurs de recrutement partiel possible) donnent un rendement d'équilibre à long terme pour ce stock de 5 000 à 6 000 tonnes. Les projections pour les cinq prochaines années au niveau $F_{0.1}$ indiquent une lente récupération ou une certaine stabilité du stock, les débarquements prévus variant entre environ 4 000 et 6 000 tonnes.

Un examen des relevés de recherche dans le sud du Golfe (bancs des îles de la Madeleine) révèle une distribution en anneau autour de la zone de recherche. L'unité de gestion de la merluche blanche dans la division 4T de l'OPANO semble comprendre deux éléments de stock d'origines géographiques distinctes, soit un élément du secteur hauturier le long des pentes du chenal Laurentien et un élément du secteur côtier aux alentours du détroit de Northumberland.

INTRODUCTION

The fishery for white hake (Urophycis tenuis, Mitchill) in the southern Gulf of St. Lawrence usually does not commence until May when the last of the sea ice has dispersed. 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 Figure 1).

This fishery is carried out mainly by small inshore vessels (tonnage class 0 and 1) making it dependent upon and susceptible to weather and local market conditions. Winter ice conditions preclude inshore fishing from December through April of most years. Two main gear types are used in this fishery, the first group uses gillnets and longlines in the summer and, if the weather permits, longlines in the fall. The second group, composed of vessels based in southeastern New Brunswick, Nova Scotia (Gulf coast) and eastern Prince Edward Island (P.E.I.) use small (<20m) draggers and seiners. The majority of the fishery is conducted in the Northumberland Strait, and on both the eastern and western ends of P.E.I. (1988 area breakdown of catch Figure 2).

Gillnetters have increased their dominant position in the fishery, longliners and seiners have decreased their proportion of the catch while the proportion caught by small draggers (OTB tonnage class 0 and 1) has increased. This may be due to varying stock abundance at the different fishing locations utilized by these various gear types. Small draggers fish almost exclusively inshore, while the seiners, being larger vessels (tonnage class 2 & 3), fish the deeper waters between Cheticamp and Cape St. Lawrence as well as the edge of the slope along the Laurentian Channel.

Gillnetters and longliners catch larger fish than draggers and seiners. This varies from year to year, in 1984 gillnetters caught smaller fish in about the same proportions as the latter gears (Clay, MS 1985b), while in 1988 the overlap in size frequency is minimal.

Anecdotal information indicates that significant quantities of small fish were landed in 1988. A decrease in both mean size and age has also been observed in the commercial fishery samples in recent years. The landings from OTB vessels have inceased to 16% of the total catch while that of seiners has decreased to 14% from 21% in 1987. However, the combined catch of these two similar (in catch composition) gears has remained at about 30% during the last three years. Thus the decrease in size in 1988 does not appear related specifically to a shift in gear composition. Some opinions from 'the wharf' suggest that these small fish might be the victims of fisheries targeting nursery

grounds. Many fishermen have expressed concern about the potentially high fishing mortalities this practice could be exerting on incoming year classes. Conservation of spawning grounds (both spawners and habitat) and nursery areas have been suggested as a possible means of improving this stock.

The provisional nominal landings in 1988 (Table 1) totalled 3,860 tonnes, a decrease of 38% from the 6,222 tonnes caught in 1987 (Table 2). This decrease in landings continues the declining trend apparent since 1981, 1987 was the only increase during this period. The increase in the 1987 catch over 1986 may have been due to additional fishing effort. The increase in effort is probably attributable to the higher prices paid for hake in 1987 relative to preceding years and to the frequent closures of the 1987 Gulf cod fishery. Prices paid in 1988 returned to the levels of years prior to 1987. DFO port samplers reported some fishermen not fishing for hake in 1988 due to the low 'economic' catch. However, we are unsure whether this referred to the low return per trip due to low abundance, or the low price paid by the fish buyers - we suspect a combination of the two.

The stock was not managed by a TAC (Total Allowable Catch) 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. Later assessments (Clay et al., MS 1986, MS 1987, MS 1988) suggested long term yields in the range of 5,000 to 6,000 tonnes. The TAC for 1987 was reduced to 9,400 tonnes and that of 1988 and 1989 was further reduced to 5,500 tonnes.

Paradoxically, the same management measures (ie. reduced TAC's) that were introduced to conserve this stock(s) may also be inadvertently contributing to its continued decline. Although the hake fishery is of extreme local importance in many ports, it is mainly an inshore by-catch fishery. This coupled with the low relative price paid for hake would tend to encourage fishermen to simply discard hake once the quota is taken. This would remove any conservation benefit of the management program. Possibly other management strategies should be considered for this stock.

SAMPLING

Sampling was carried out in a similar manner to that of 1987. Samples were obtained from 2 sources:

1) the P.E.I. provincial Department of Fisheries and Labour provided 65 length frequency samples, and
2) the Department of Fisheries and Oceans (DFO) port samplers collected 54 length frequency samples with a total of 616 readable otoliths.

Sexually dimorphic growth rates have been identified in our work, however, 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. No sea sampling was carried out in 1988. As much of the hake landed in the southeastern Gulf are gutted and beheaded at sea, the first dorsal length (length from tip of tail to the anterior origin of the first dorsal fin) of beheaded fish was measured to the nearest cm and later converted to total length.

Both the commercial port samples and research vessel survey otoliths collected in 1988 provided growth estimates which fall within the range of historic series for size at age. Quality control tests were carried out after every 200 to 250 otoliths. Intra reader agreement ranged from 81 to 90 % with a mean of 86% and agreement with the past control (contract) reader ranged from 55 to 91% with a mean of 74.5% when reference trays (50 otoliths) and repeat samples were re-aged.

Low sampling intensity did not allow an area by area breakdown of the landings. Due to lower sampling intensity than in recent years, otoliths from all gears for the year were combined.

An initial analysis was conducted separating the aged samples into two gear groupings. To determine which gears to combine, the length frequencies from otter trawls, seiners, gillnets and longlines were compared (Figure 3). From this comparison it was determined that the size distribution obtained from samples collected from otter trawls and seines should be comparable and those of gillnets and longlines should be more similar to each other than the former gears. In order to obtain the approximately 400 otoliths required for each age-at-length key, undesirable combinations of ages from these two gear types would have to be made. (Otoliths available (approx.): OTB and seiner, 200; gillnet, 300; and longline, 100). The groupings attempted were otter trawler, seiner, and gillnet ages for trawler and seiner length frequencies and gillnet and longliner ages for length frequencies from those gears. The authors felt this to be unsatisfactory. Thus all the aged samples were combined to produce a single key. The difference in these two options resulted in slightly heavier and thus fewer fish with the latter.

Six combinations of time and gear were chosen for the length frequency data from the available samples for 1988 (Table 3). The single age-at-length key was used to determine the age composition of the length frequencies of landings in the six time/gear combinations above.

The catch at age and the weight at age were calculated for each key (Table 4 and 5) by the computer system AGELEN (ver 1.6) for sexes combined. These data were added together for the final catch numbers at age and a weighted average (by numbers in each age group) calculated for the weights at age.

There appears to be reduced numbers of younger and older fish in the catch in recent years compared to earlier years. This trend also appears in the length frequencies from the dockside sampling (Figure 4).

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 and submit log books and therefore, no estimate of landings or fishing effort by individual vessel is available. Trip landings are, however, recorded on the purchase slips for the inshore as well as other 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 to 1988). 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 to biweekly intervals by Statistical Districts. 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 one or more vessels over various time periods.

Commercial catch rates

A commercial catch per unit of effort (CPUE) series can be used as an indicator of stock abundance. For the above landings data set, each purchase slip is assumed to represent one day's fishing effort, generally 1 trip for the small vessels of the inshore fleet. For the period 1978 to 1988 the gillnet component of this fishery comprised 58% of the observations (gear/time/district) while seiners and otter trawlers comprised 38 and 18% respectively. The index used for this analysis is based on the gillnet component of the fleet only, although a comparison was made between this and all gears combined. A multiplicative model (Gavaris, 1980) was used to develop a

standardized CPUE series based on the gillnet fleet component of the fishery. The coded X-matrix (raw catch and effort data prepared for the multiplicative model) was generated using the computer system NAFSYS.

All of the individual daily purchase slips representing landings of 50 kg or less were excluded 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. The summed fortnightly catch, from the remaining purchase slips, was expressed in hundreds of kg rounded to the nearest hundred. The resulting standardized CPUE series indicates that the highest catch rates occurred in 1981 and the lowest in 1987, marginally lower than in 1986. In 1988 an increase occurred in the CPUE implying an increase in abundance.

The model (Table 6) with standards for statistical district and time chosen as Cheticamp, Aug 1 to Aug 14, 1978 respectively, gives a correlation coefficient (r^2) of 0.27 (Table 7). The residual plots indicate a normal non-biased distribution (Figure 5). Using the APL routine EGLS from the workspace STANDARD, weighting was conducted on the catch, effort, and catch x effort data by the mean of the residuals (the residuals being previously divided into four groups providing equal sample size). Weighting by the catch made only a slight improvement in the coefficient of correlation and the F levels. The year to year trend did not change with weighting (Figure 6). Similar results were obtained using effort and catch x effort. The unweighted, standardized catch rate series was used for calibrating the VPA runs (Figure 6). The increase in catch rate noted for 1988 may have been affected by the low price paid for hake during the year; it is possible that this could have reduced fishing by less successful individuals in periods of lower abundance.

An independent analysis using the SAS routine PROC GLM and the same data set were compared to the above analysis. This analysis gave identical values to that presented above, and a further analysis with the three gears used in previous assessments also resulted in a similar trend (Figure 7).

This fishery is based on a relatively low value product that is often landed as a by-catch. The results of this multiplicative analysis are used in calibration of the assessment assumming that the catch rate is related to the abundance of the population in question. The standardized effort from this series when regressed on the cod fixed gear catch has a correlation coefficient (r^2) of 0.69. If the catch rate is partially determined by the availability of a more valuable species, this could bias our perspective. A by-catch fishery also suffers from the following management problem:- if the TAC is taken, the effort, and related fishing mortality, will not necessarily stop. The less valuable

species may tend to be discarded as the directed fishery continues. There may be no conservation benifit to TAC restrictions on a low (product) value by-catch fishery.

RESEARCH VESSEL DATA

The September groundfish cruise in the southern Gulf of St. Lawrence in 1988 was a random stratified 24 hour survey with 154 sets completed. These sets were conducted as day/night pairs. The surveys from 1971 to 1985 utilized the RV E.E.Prince for 12 hour (day only) random stratified sampling (except 1984 and 1985 when the survey was fixed station design) averaging approximately 60 sets; from 1985 to 1987 the RV Lady Hammond conducted a 24 hour fixed station survey averaging 120 sets. The data for 1970 to 1985 (Clay, MS 1986) were extended to 1988 providing abundance estimates by numbers and weight and stratified CPUE (by tow) by numbers and weight.

Previous analyses have found these data (derived from the cod/plaice orientated survey) to be variable for white hake and therefore the RV abundance has not been used in the calibration of this stock. In an attempt to reduce this high variability the research survey data were investigated in more detail with respect to white hake. The distribution of white hake forms a "ring" about the southern Gulf of St. Lawrence (Appendix I). A cross-tabulation of depth and numbers caught indicates that hake are virtually absent during September between 50 m and 100 m depth. This agrees with the observed "ring" distribution. The location of the statistical unit areas supporting the majority of the commercial catch closely follow this distribution (Figure 2). If an index of abundance of the commercially fished areas is of interest, one might take only the "ring" portion of the southern Gulf (the 10 strata of Figure 8) and estimate the biomass of these strata separately. When this selection is made, 38% of the sets surveyed and 68% of the sets with hake catches are kept; 83% of the hake aged and 85% of the hake caught are retained. This indicates that our selected 'hake survey' covers only 28% of the total southern Gulf survey area but includes over 90% of the hake caught in 9 of the last 14 years (Table 8). The limiting of the survey to the main areas where hake are found has the effect of reducing the variability associated with marginal habitat and low levels of abundance. The coefficients of variation (C.V.) of the mean catch per tow of white hake are lower for the selected 'hake surveys' than for the surveys of the entire area (see Table 9b and Table 1b of Appendix I).

This "ring" distribution (Figure 8) and the depth separation implies the southern Gulf hake are divided into two components, a shallow inshore group in the areas surrounding Northumberland Strait (stata 3, 20, 22, 32, and 33) and a deeper water offshore group along the southern slope of the Laurentian Channel (strata 15, 25, 37, 38, and 39). These two groups overwinter along the

slopes of the Laurentian Channel (below 200 m) (Clay 1989). The degree of mixing occuring between the two groups can be only conjectured at this time. It would appear that of these two areas the 'strait component' supports the larger portion of the commercial fishery. When we separated the estimated RV population biomass on the two component basis, the 'strait component' for the 1985 to 1988 series bore the closest relationship to the commercial CPUE and total catch (Figure 9). Unfortunately, the statistical unit area 4TG covers the main 'channel' and 'strait' fisheries and thus, precludes simple separation of the commercial catch into these two component areas.

If this partition of the southern Gulf hake is correct, then there is a serious mismatch in the SPA and the RV biomass estimates. The majority of the landings are from the Northumberland Strait component, however, in all years except 1984 the Laurentian Channel component appeared to have the greater biomass as estimated from research surveys.

The research vessel population estimates of percent composition and weight at age are listed in Table 9, these are for the selected 'hake survey'. The weight at age from research vessel surveys presented this year are different from those presented last year (Clay and Hurlbut, MS1988). This year the weights at age are weighted by catch numbers and by strata area, while last year the weights at age were based on the mean of the stratified sampled fish only.

In order to allow the use of a single RV abundance index for the calibration of the southern Gulf cod, Chouinard and Sinclair (MS 1988) used a series of 61 fixed stations fished in every year from 1984 to 1987 and daylight only sets in 1988. These were combined with the historic random stratified series (1971 to 1983). The data derived from the RV surveys selected to comprise this 'single index' for white hake are listed in Appendix I.

An estimation of yearly F was derived from the research vessel data from the following relationship

$$F = \ln \left(\frac{POP_{RVi}}{POP_{RVj}} \right) - M$$

where RVi is the research population estimates of ages 5 to 7, RVj is the population estimates of ages 6 to 8 in the following year, and M is the natural mortality assumed to be 0.2. The mean F from 1978 to 1988 is 0.58, which is very close to the terminal F selected in 1988.

The population composition has shifted to younger fish in recent years from the years of highest commercial landings (1980 to 1982) and inferred highest abundance (Figure 10). The same observation holds for length frequency data (Figure 11). During the last four years, 1988 and 1986 have younger and smaller fish than 1985 and 1987.

ESTIMATION OF PARAMETERS

Catch and Weights at age

The weight at length was calculated from the length/weight relationship (sexes combined) taken from the 1988 research vessel survey data:-

$$W(g) = 0.003236 \times TL(cm)^{3.210}; \quad n = 499 \quad r^2 = 0.98$$

The 1988 weights at age were calculated from this relationship applied to the dockside sampling of the commercial landings. The proportion of fish at a certain length in these length frequencies were allocated to ages from the age determination samples collected at the same time.

Weights at age for 1970 to 1982 were variable and unrealistic due to the sparse and thus non-representative sampling data prior to 1983. With the better sampling since 1983, annual weights at age have been possible. Thus, the weights at age for the commercial catch for all years prior to 1983 were taken as equal to the mean of 1983 to 1985 (Table 10).

The weights at age varied slightly between 1983 and 1985. However, the variation was not substantial except for the oldest ages. In 1986 and 1987 the weights of the younger age groups have decreased and in 1988 weight of the youngest age group (3) has declined to a third of that of 1987. The same trend is not noticeable in the older age groups. There does not appear to be a corresponding decrease in weight at age in the population as measured by research surveys (Figure 12).

The starting catch-at-age matrix for Gulf hake, ages 3 to 13 from 1970 to 1987, was taken from Clay and Hurlbut (MS 1988). The 1988 catch numbers at age (Table 4) were added to this earlier series. Sampling data were limited in earlier years and thus 1970 to 1977 catch at age have been included only for historical perspective (Clay et al., MS 1985b).

The catch numbers-at-age matrix (Table 11a) was not revised from the provisional landings estimates for 1986 and 1987 as final values are not yet available.

The percent composition of the catch at age (Table 11b) indicates both fewer small fish (3 and 4 year olds) and fewer large fish (8+ years old) than in recent years.

Exploitation pattern

The exploitation pattern (partial recruitment (PR)) was estimated using two techniques. The first used the ratio of yearly catch at age, estimated from commercial sampling, divided by the yearly population at age, estimated from research vessel surveys. This estimate of the exploitation pattern, standardized to the mean of ages 5, 6 and 7, for the last four years indicates a flat topped vector for the older age groups (all ages with values over 1 were set to 1). Only the last four years were used as the RV Lady Hammond had double the sampling rate of the previous surveys using the RV E.E.Prince and has only fished since 1985.

Yearly exploitation pattern estimated from Catch/Population

	year	1985	1986	1987	1988	MEAN
age	3	.066	.000	.011	.001	.020
	4	.171	.046	.139	.020	.094
	5	.570	.265	.572	.257	.416
	6	1	1	.803	.997	.950
	7+	1	1	1	1	1

This exploitation pattern indicates the first fully recruited age group is about 6. Standardizing to ages 6, 7, and 8 gives almost the same exploitation pattern in 1988 as the ratio of catch/population for age 5 is nearly the same as that for age 8.

The second method used involved averaging of the yearly F table. This technique involves iterative averaging of F values for each age standardized to the mean of ages 6,7, and 8 (weighted by population numbers) until little change was noted. This was done with the years 1983 to 1987. All ages with values over 1 were set to 1.

Yearly exploitation pattern estimated from historical averaging

	year	1983	1984	1985	1986	1987	1988	MEAN
age	3	.022	.014	.018	.000	.036	.020	.018
	4	.071	.199	.062	.056	.225	.137	.123
	5	.376	.603	.391	.221	.711	.517	.460
	6	.808	.911	.841	.659	.775	.901	.799
	7	1	1	.974	1	1	1	.995
	8+	1	1	1	1	1	1	1

This technique indicates that full recruitment at closer to age 7.

The exploitation pattern derived from these two methods are similar, the difference lies in the age of full recruitment, being 6 with the cat/pop method and 7 with historical averaging. We have selected the latter pattern for use in this analysis and for the yield per recruit calculations.

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

For the traditional calibration approach, the fishing mortality (F) on the oldest age group was chosen by the iterative technique 'AutoF' at age 9 (Rivard and Joly, MS 1984).

STARTING F oldest

70	71	72	73	74	75	76	77	78	79
0.63	0.68	0.71	0.95	0.70	0.90	0.66	0.62	0.49	0.68

80	81	82	83	84	85	86	87
0.74	0.82	0.75	0.87	0.77	1.03	1.61	1.26

: F Terminal

Clay et al. (MS 1986, MS 1988) showed that the RV CPUE and biomass are extremely variable and not correlated with the commercial CPUE series. Reviewing the biomass data with one additional year of information does not change this situation. In addition, when we separated this data into the two components (Strait and Channel), the only data series that does appear to agree with the catch and the commercial CPUE index is the four year RV Lady Hammond index for the 'strait' component of the southern Gulf of St. Lawrence. Although similar in trend, these two indices provide different views of the change in biomass from 1987 to 1988. The last year is very influential in this reduced time span (4 years).

Possible values of fully recruited or terminal F (F_t) were investigated by regressing the commercial standardized CPUE index against the exploitable 3+ VPA population biomass. When regressions were forced through the origin the correlation coefficient had little discriminating power. The minimum mean square error was the evaluation criteria. Residuals were standardized by dividing them by the square root of the mean square error (error sum of squares divided by the degrees of freedom). The relationship between 3+ exploitable VPA biomass (F table standardized over ages 6, 7, and 8 multiplied by the mid-year population biomass at age) and the standardized CPUE from Table 7 indicate an F_t of 0.35 at the minimum mean square error (Table 12).

To estimate the best fully recruited F using the research vessel biomass of the 'strait' component of the population we regressed total mid-year population biomass from VPA against the RV biomass. Using the minimum mean square error the best estimate of F_t appears to be in the range of 1.05.

Calibration of the terminal F was also carried out using the non-linear least squares (NLLS) minimization of the difference in series of observations (indices) and their predicted values from VPA. This adaptive framework (Gavaris, MS 1988) was attempted with two extreme formulations (Table 13 and 14). The first, based on age specific RV indices and the commercial catch rate, resulted in an F_t of 0.65 - approximately half way between the two above extremes. The second, only the commercial catch rate series gave an F_t of 0.38.

Yield per recruit

To provide a long term estimate of yield per recruit (YPR), calculations were carried out using the mean weight at age from the commercial fishery (ages 3 to 13) for 1983 to 1988 and the mean yearly exploitation pattern for the period 1983 to 1987 with an M = 0.2. These time periods were selected because there was a change in mesh regulations in 1982 and valid ageing of representative sampling commenced in 1983. The Fo.1 level was 0.26 and the Fmax was 0.54 (Table 15).

Fo.1 =	0.2605	Fo.1 YIELD =	0.976	kg	Ave Wt. =	2.847 kg
Fmax =	0.5427	Fmax YIELD =	1.059	kg	Ave Wt. =	2.301 kg

These yields are based on 3 year old recruits coming into the fishery. Using 1 year old recruits (mean weights of age 1 and 2 from research vessel data) the yield at Fo.1 is 0.654 kg and at Fmax 0.710 kg (Table 16).

With a geometric mean recruitment of approximately 5.5 to 6.0 million fish at age 3, the long term equilibrium yield would be within the range of 5,300 to 5,800 tonnes, 600 tonnes below the average of the landings of the last 19 years - 6,426 tonnes (Table 2).

The annual average weight of a white hake landed can give a general 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 13). The 1987 and 1988 mean weight indicates an F in excess of Fmax.

ASSESSMENT RESULTS

These two divergent views of the stock produced by the RV index and the standardized catch rate can not be easily reconciled. Taking the mean in such a case, as is done using the adaptive process, is also not the correct procedure although it would tend to minimize the risk in making the 'wrong' choice. The annual mean weight of a fish in the catch does provide an indication of the scale of F - it points to an F_t in 1988 in excess of F_{max} (ie > 0.54). Thus for illustrative purposes the VPA was run with an F_t of 0.65, a value similar to last years estimate and the value derived from the adaptive formulation.

Virtual population analysis (conducted with the APL assessment workspace FISH - STSC version, Rivard and Joly (MS 1984)) using the above data is shown in Appendix II. The shift in the last five years has been from a population with the youngest age in our matrix contributing the most numbers to the population to one in which age 5 is now the most numerous. This could be due to an erroneous exploitation pattern (although the research vessel population estimates indicate a similar pattern), low recruitment, or an unrecorded heavy mortality on the younger age groups.

CATCH PROJECTIONS

Two series of catch projections were investigated. The output is presented in Appendix III. The first used a catch level set at an Fo.1 of 0.30 - about 50% lower than recent fishing levels, and the following input parameters: 1) the weight at age taken as the mean of 1986 to 1988; 2) the exploitation pattern the same as used in the SPA run; 3) the starting population as that from the SPA run; 4) the recruitment, which was taken as the historic mean GM of 5.5 million fish at age 3; and 5) an M = 0.2.

In this scenario of lower fishing mortality and average recruitment (or above recent survival to age 3) the stock would slowly rebuild over the next five years. The catch in 1989 would equal about 2000 tonnes increasing steadily to about 4500 tonnes in five years. (This is based on recruitment not seen in recent years!)

The second scenario assumes an F of 0.6, about equal to the fishing mortality of recent years and the above parameters. In this scenario with F's in the current range - but with recruitment higher than recent years, the population also increases. However, at a much lower rate and the population biomass begins to stabilize at about 2/3 of the above scenario. The catch in 1989 would be about 3400 tonnes, increasing to 5200 tonnes in five years. The mean weight in this case would be about

500 g less than above. This fishery is based on 2 or 3 year classes, thus recruitment assumptions are the major driving force in these projections.

ACKNOWLEDGEMENTS

Dave Yonker, P.E.I. Department of Fisheries and Labour, provided the 1987 commercial port sampling for Gulf hake landed in the province of P.E.I.

REFERENCES

Chouinard,G.A. and A.F.Sinclair (MS 1988) Assessment of the 4T-Vn (Jan.-Apr.) cod stock for 1988. CAFSAC Res.Doc. 88/28, 47p.

Clay,D. (MS 1986) Biomass and population biology as observed from research surveys in the southern Gulf of St. Lawrence: cod, white hake, haddock, plaice, herring, and redfish. CAFSAC Res.Doc. 86/83.

Clay,D. (MS 1987) Assessment of Gulf white hake from NAFO division 4T in 1987 (Including an investigation of otolith size to fish length relationships). CAFSAC Res. Doc. 87/81.

Clay,D. (1989) Seasonal distribution of demersal fish (Osteichthyes) and skates (Chondrichthyes) in the southeastern Gulf of St. Lawrence. Paper presented at the symposium - The Gulf of St. Lawrence: Small Ocean or big Estuary. Maurice Lamontagne Institute, Mont Joli, Quebec. March 12 to 15, 1989.

Clay,D., L.Currie, and T.Hurlbut (MS 1985a) A first assessment of Gulf white hake: NAFO division 4T / 1985. CAFSAC Res. Doc. 85/64.

Clay,D., T.Hurlbut, L.Currie and J.Murchison (MS 1985b) Sampling Gulf white hake: 1970 to 1984 in NAFO division 4T. CAFSAC Res. Doc. 85/65.

Clay,D., T.Hurlbut, and L.Currie (MS 1986) Assessment of Gulf white hake: NAFO Division 4T/1986. CAFSAC Res. Doc. 86/81.

Clay,D. and T.Hurlbut (MS 1988) Assessment of Gulf white hake from NAFO division 4T in 1988. CAFSAC Res.Doc. 88/63.

Gavaris,S. (1980) Use of a multiplicative model to estimate catch rate and effort from commercial data. Can.J.Fish.Aquatic Sci.37:2272-2275.

Gavaris,S. (MS1988) An adaptive framework for the estimation of population size. CAFSAC Res.Doc. 88/29.

Rivard,D. and M.Joly (MS 1984) An adaptation of "APL programs for stock assessments" for an 8088 - based microcomputer. CAFSAC Res.Doc. 84/27.

Table 1. Nominal landings (t) of white hake from NAFO division 4T in 1988 by gear and month. All data are provisional statistics.

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	.2	.7	1.4	2.3	.0	4.6
MAY	8.1	50.2	14.1	139.7	.0	212.2
JUNE	64.8	204.3	29.0	368.0	.0	666.1
JULY	257.2	74.7	126.4	636.0	.1	1094.3
AUGUST	204.6	61.4	243.4	387.8	1.1	898.4
SEPTEMBER	52.4	27.8	149.5	237.9	9.8	477.4
OCTOBER	39.8	75.1	127.5	117.9	2.9	363.3
NOVEMBER	1.8	55.8	37.8	48.2	.0	143.6
DECEMBER	.0	.0	.7	.0	.0	.7
TOTAL	629.0	550.0	729.6	1937.9	13.9	3860.5
PERCENT	16.3	14.2	18.9	50.2	.4	100.0

Table 2. Nominal landings (t) of white hake from NAFO division 4T by gear and year and TAC (total allowable catch). All data from 1986 to 1988 are provisional.

YEAR	TRAWL	SEINE	LINE	GILLNET	OTHER	TOTAL	TAC
1960						2015+	
1961						5333+	
1962						7244+	
1963						6546+	
1964						6205+	
1965						4706"	
1966						7024	
1967						6550	
1968						4260	
1969						4208	

+ referred to as hake unspecified in NAFO statistical bulletins
" referred to as red hake in NAFO statistical bulletins

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	12000
1983	2141	906	753	2959	546	7305	12000
1984	1614	592	674	3631	81	6592	12000
1985	1639	1008	799	2480	88	6014	12000
* 1986	847	735	992	1744	283	4601	12000
* 1987	795	1339	1521	2292	275	6222	9400
* 1988	629	550	730	1938	14	3860	5500
1989							5500

1970 to 1988

AVERAGE	1849	779	731	2461	607	6426
PERCENT	29	12	11	38	9	
88 Percent	16	14	19	50	0	

* provisional

Table 3. Keys selected for gear/time combinations and their groupings to produce age at length keys with at least 400 fish ages.
Lower table shows the keys and associated landings for catch composition applied to each of these age at length keys.

KEY	FISHERY/PERIOD	TYPE	SIZE	AGE/LENGTH KEY
1	OTB:Jan.- July	Length	2362	
		Age	52	
2	OTB:Aug.- Dec.	Length	778	
		Age	0	
3	SNU:Jan.- July	Length	1122	
		Age	159	
3	SNU:Aug.- Dec.	Length	41	ALL GEARS: Jan.- Dec.
		Age	0	Lengths -
4	GN:Jan.- July	Length	5339	Aged - 616
		Age	179	
5	GN:Aug.- Dec.	Length	4880	
		Age	130	
6	LL:Jan.- July	Length	978	
		Age	56	
6	LL:Aug.- Dec.	Length	369	
		Age	40	

....AL key.....			...LF catch...		Sub-total	TOTAL
KEY	DATE	GEAR	DATE	GEAR	TONNES	TONNES
1	01/12	OTB/SNU/GN	01/07	OTB	330	330
2	01/12	OTB/SNU/GN	08/12	OTB	299	299
3	01/12	OTB/SNU/GN	01/07	SNU	330	
3	01/12	OTB/SNU/GN	08/12	SNU	220	550
4	01/12	LL/GN	01/07	GN	1146	1146
5	01/12	LL/GN	08/12	GN	792	792
6	01/12	LL/GN	01/07	LL	171	
6	01/12	LL/GN	08/12	LL	573	744
				Total	3861	3861

Table 4. Catch at age of white hake in NAFO division 4T as estimated from dockside sampling of the commercial fisheries in 1988. The six keys refer to the keys of Table 3.

	White Hake:Catch Numbers at Age (000's)							*
Age	Key 1	Key 2	Key 3	Key 4	Key 5	Key 6	Sum	Variance
1- 2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	11	11	10	1	4	12	48	45
5	101	119	127	13	57	91	508	320
6	72	70	122	123	142	114	642	305
7	18	11	43	210	109	87	479	92
8	5	1	10	51	22	20	109	18
9	1	0	1	6	4	5	17	0
10	0	0	0	2	1	2	5	0
11	0	0	0	0	0	1	2	0
12	0	0	0	0	0	0	1	0
13-14	0	0	0	0	0	0	0	0
Sum	208	212	313	405	340	334	1813	
(From Keys)								
No.in LF	2362	778	1122	5339	4880	1347		
No. Aged	616	616	616	616	616	616		
Mean Age	5.57	5.39	5.75	6.80	6.32	6.15		

* in last years assessment (Clay and Hurlbut, MS 1988) this column was titled C.V., it should have been titled variance.

Table 5. Weight at age (kg) of white hake in NAFO division 4T estimated from dockside sampling of the commercial fisheries in 1988. The six keys refer to the keys of Table 3.

Age	Key 1	Key 2	Key 3	Key 4	Key 5	Key 6	Weighted Ave.Wt.
1	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.20	.00	.00	.00	.20
3	.00	.00	.27	.00	.00	.00	.27
4	.96	.99	.95	.92	.98	.94	.96
5	1.24	1.23	1.29	1.63	1.40	1.26	1.28
6	1.63	1.59	1.72	2.29	2.00	1.93	1.90
7	2.67	2.35	2.74	2.93	2.75	2.81	2.83
8	4.02	3.20	3.69	3.68	3.80	3.87	3.75
9	5.53	6.19	6.12	4.79	5.37	6.10	5.46
10	5.63	3.68	4.30	5.11	6.09	6.84	6.01
11	6.98	8.51	9.00	7.39	8.55	8.55	8.42
12	10.58	.00	10.90	.00	10.74	10.77	10.80
13	.00	.00	.00	8.79	8.79	10.52	10.15
14	.00	.00	.00	9.07	.00	9.07	9.07
Mean	1.58	1.41	1.75	2.83	2.33	2.23	2.13
(From Keys)							
No.in LF	2362	778	1122	5339	4880	1347	
No.Aged	616	616	616	616	616	616	
Mean Age	5.57	5.39	5.75	6.80	6.32	6.15	

Table 6. The two category types and their associated categories used to run a multiplicative model for the Gulf hake using commercial catch and effort data from 1978 to 1988. (Note: third category type is years.)

STATISTICAL DISTRICT

CODE	AREA
2	*CHETICAMP
3	EAST ST GEORGES BAY
{12	PICTOU}
13	WEST ST GEORGES BAY
65	CARAQUET
66	MISCOU/SHIPPAGAN
67	TRACADIE, N.B.
75	RICHIBUCTO
76	BOUCTOUCHE
{77	SHEDIAC}
{80	CAPE TORMENTINE}
82(92)	TIGNISH
87	MURRAY HARBOUR
88	SOURIS
92(93)	COW POND
93(95)	MALPEQUE
95	TRACADIE, P.E.I.

TIME PERIODS

CODE	PERIOD
{0	JAN 1-MAY 14}
1	MAY 15-MAY 31
2	JUN 1-JUN 14
3	JUN 15-JUN 30
4(5)	JUL 1-JUL 14
5	JUL 15-JUL 31
6(7)	*AUG 1-AUG 1
7(8)	AUG 15-AUG 31
8	SPT 1-SPT 14
9(10)	SPT 15-SPT 30
10	OCT 1-OCT 14
11	OCT 15-OCT 31
12	NOV 1-DEC 31

*	standard category
( )	combined category
{ }	reduced category

Table 7. Analysis of variance and parameter estimation for catch rate standardization of Gulf hake from 1978 to 1987. See Table 6 for category types and codes.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... .524
MULTIPLE R SQUARED..... .274

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	2.666E0003	2.666E0003	
REGRESSION	27	3.078E0002	1.140E0001	19.295
TYPE 1	10	2.116E0002	2.116E0001	35.811
TYPE 2	7	3.805E0001	5.436E0000	9.201
TYPE 3	10	3.395E0001	3.395E0000	5.746
RESIDUALS	1379	8.147E0002	5.908E-001	
TOTAL	1407	3.788E0003		

PREDICTED CATCH RATE

STANDARDS USED VARIABLE NUMBERS: 2 6

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	CATCH RATE S.E.	EFFORT
78	48250	0.271	7.469	0.810	6460
79	81100	0.229	8.606	0.872	9423
80	124230	0.316	11.248	1.129	11045
81	140390	0.270	9.924	0.987	14147
82	97760	0.366	8.294	0.820	11788
83	73050	0.351	8.588	0.862	8506
84	70500	0.358	8.478	0.840	8316
85	60140	0.238	7.852	0.785	7659
86	46010	0.266	6.963	0.701	6608
87	62220	0.218	6.259	0.572	9941
88	38460	0.405	7.426	0.555	5179

AVERAGE C.V. FOR THE MEAN: .098

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS
1	2	INTERCEPT	1.721	0.109	1407
2	6				
3	78				
1	3	1	-0.508	0.094	115
	13	2	-0.333	0.113	66
	65	3	-1.291	0.096	115
	66	4	0.070	0.101	96
	67	5	-0.269	0.124	52
	75	6	-0.459	0.129	49
	76	7	0.148	0.156	30
	82	8	-0.769	0.073	429
	87	9	-0.009	0.104	86
	88	10	-0.372	0.084	191
2	1	11	-0.505	0.155	27
	2	12	-0.163	0.090	89
	3	13	-0.067	0.077	128
	4	14	0.109	0.054	359
	9	15	0.146	0.062	233
	11	16	0.257	0.097	74
	12	17	0.834	0.153	28
3	79	18	0.141	0.116	104
	80	19	0.409	0.115	108
	81	20	0.283	0.113	115
	82	21	0.104	0.113	120
	83	22	0.139	0.115	106
	84	23	0.126	0.114	111
	85	24	0.049	0.115	107
	86	25	-0.071	0.116	104
	87	26	-0.178	0.104	201
	88	27	-0.009	0.100	253

Table 8. The percentage of data that is retained from the routine southern Gulf of St. Lawrence September groundfish survey when only the 10 selected 'hake strata' are analysed.

	Year	Cruise	# Sets fished	% Sets selected	% Hake sets selected	% Aged hake selected	% Hake selected
	76	P172	66	.38	.78	.71	.75
	77	P188	72	.33	.71	.92	.95
	78	P204	63	.38	.64	.85	.92
	79	P229	80	.35	.68	.85	.90
	80	P244	74	.35	.56	.70	.63
	81	P260	72	.36	.57	.70	.76
	82	P278	73	.36	.75	.73	.57
	83	P296	69	.39	.72	.88	.91
*	84	P312	108	.42	.65	.82	.86
*	85	P327"	85	.40	.69	.82	.95
*	85	H141"	140	.36	.65	.88	.89
*	86	H159	173	.45	.71	.92	.98
*	87	H179	163	.37	.73	.87	.89
+	88	H192	166	.37	.69	.90	.97
	Average			.38	.68	.83	.85

* fixed station survey
\+ random stratified (day night paired sets)
" comparative survey

Table 9a. Population at age for white hake estimated from research vessel surveys in the southern Gulf of St. Lawrence (NAFO division 4T) (based on selected 'hake' strata).

Population at age (Survey) White hake

AGE	RV E.E. Prince year 1978	1979	1980	1981	1982	1983	1984
0	0	0	0	0	0	186	41
1	108	0	0	91	13	1555	70
2	4050	559	379	912	459	1494	901
3	2751	4194	1434	2171	1175	1512	2212
4	4624	4060	2428	4658	1460	618	2737
5	3680	3594	3465	5258	841	387	2283
6	1349	1840	1374	3194	669	217	958
7	336	819	665	1242	314	80	360
8	141	141	222	385	171	100	282
9	42	36	147	268	0	0	95
10	83	0	82	22	29	0	73
11	0	18	0	30	0	0	23
12	0	97	23	0	0	0	0
13	0	0	33	69	0	0	0
total	17164	15358	10252	18300	5131	6149	10035

AGE	RV E.E. Prince year 1985	RV Lady Hammond 1985	1986	1987	1988
0	52	8	818	0	15
1	180	18	2326	43	384
2	3227	1722	11771	612	4974
3	6848	5488	10351	1995	5094
4	4380	5477	12467	2675	5429
5	1159	4427	5895	1840	3776
6	704	2339	1487	928	1258
7	407	1331	634	211	552
8	130	867	231	50	93
9	101	423	118	38	34
10	33	542	48	25	15
11	0	56	22	0	0
12	16	113	27	17	10
13	0	188	0	5	0
total	17237	22999	46195	8439	21634

Table 9b. Mean catch per tow for white hake estimated from research vessel surveys in the southern Gulf of St. Lawrence (NAFO division 4T) (based on selected 'hake' surveys).

Mean catch per tow (Survey) White hake

AGE	RV E.E. Prince year 1978	1979	1980	1981	1982	1983	1984
0	.00	.00	.00	.00	.00	.32	.08
1	.18	.00	.00	.16	.02	2.65	.13
2	6.89	.95	.65	1.55	.78	2.54	1.58
3	4.68	7.14	2.44	3.69	2.00	2.58	3.78
4	7.87	6.91	4.22	7.93	2.51	1.12	4.66
5	6.26	6.12	6.15	8.95	1.45	.74	3.89
6	2.30	3.31	2.51	5.44	1.19	.39	1.63
7	.57	1.39	1.23	2.11	.59	.24	.61
8	.17	.18	.44	.66	.31	.36	.48
9	.07	.06	.28	.46	.00	.00	.16
10	.14	.00	.15	.04	.05	.00	.12
11	.00	.03	.00	.05	.00	.00	.04
12	.00	.17	.05	.00	.00	.00	.00
13	.00	.00	.06	.12	.00	.00	.00
total	29.14	26.08	18.18	31.20	8.91	11.07	17.17

AGE	RV E.E. Prince year 1985	RV Lady Hammond 1985	1986	1987	1988
0	.09	.02	1.60	.00	.03
1	.3	.03	4.55	.08	.75
2	5.39	3.68	23.03	1.20	9.73
3	11.44	11.55	20.25	3.90	9.96
4	7.31	10.92	24.39	5.23	10.62
5	1.94	8.70	11.53	3.60	7.39
6	1.18	4.60	2.91	1.81	2.46
7	.68	2.66	1.24	.41	1.08
8	.22	1.75	.45	.10	.18
9	.17	.84	.25	.07	.08
10	.05	1.12	.12	.03	.03
11	0	.12	.05	.00	.00
12	.03	.23	.00	.02	.02
13	0	.25	.07	.01	.00
total	28.79	45.03	90.44	16.46	42.33

Table 9b. con't
Coefficient of variation of mean catch per tow for white hake estimated from research vessel surveys in the southern Gulf of St. Lawrence (NAFO division 4T) (based on selected 'hake' surveys).

Coefficient of variation of mean catch per tow (Survey) White hake

AGE	RV E.E. Prince year 1978	1979	1980	1981	1982	1983	1984
0						33.11	33.26
1	35.20			82.10	100.00	42.84	32.16
2	37.86	50.05	41.39	45.63	31.64	20.74	27.90
3	53.15	47.43	37.85	42.99	26.87	17.47	28.30
4	46.48	43.71	12.96	45.10	30.55	14.35	24.06
5	33.88	34.80	18.17	39.68	30.12	18.45	21.93
6	20.67	43.05	21.50	40.72	33.65	35.63	21.36
7	17.40	43.64	25.56	43.55	26.90	12.35	24.10
8	48.52	46.21	47.54	46.90	42.48	12.14	26.70
9	24.89	50.37	31.14	59.71			27.96
10	24.89		33.53	49.36	39.51		27.96
11		100.00		51.11			40.30
12		54.62	100.00				
13			51.29	75.42			

AGE	RV E.E. Prince year 1985	RV Lady Hammond 1985	1986	1987	1988
0	99.99	100.00	56.49		55.06
1	55.87	63.82	28.04	36.30	34.93
2	52.05	61.95	15.34	29.14	40.37
3	35.70	49.20	25.60	26.40	25.20
4	29.58	36.01	42.01	25.00	19.84
5	30.85	37.30	32.67	22.20	14.18
6	29.47	34.11	18.34	19.58	13.20
7	33.30	38.10	21.67	37.01	13.47
8	42.58	45.38	30.95	56.96	24.70
9	44.92	49.60	29.94	41.06	51.40
10	70.14	59.94	39.47	48.20	78.70
11		85.84	50.78		
12	100.00	60.86		43.10	100.00
13		82.10	61.42	100.00	

Table 9c. Weight at age (kg) of white hake from research vessel surveys in the southern Gulf of St. Lawrence (NAFO division 4T) (based on selected 'hake' strata).

Mean weight at age (Survey) White hake

AGE	RV E.E. Prince year 1978	1979	1980	1981	1982	1983	1984
0							.252
1	.196			.070	.044	.158	.187
2	.280	.315	.343	.242	.361	.326	.316
3	.419	.448	.487	.470	.602	.602	.554
4	.914	.781	.984	.852	.994	1.070	.881
5	1.446	1.340	1.317	1.280	1.291	1.804	1.352
6	1.814	1.761	1.695	1.745	1.825	2.121	1.902
7	2.205	2.026	2.060	2.185	2.707	2.962	2.387
8	3.921	3.679	3.093	3.114	2.884	3.237	3.025
9	2.216	2.891	2.473	3.201		4.118	2.719
10	2.216		2.115	3.276	2.216		5.079
11		4.635		10.906			3.346
12		2.363	8.410				
13				9.952			

AGE	RV E.E. Prince year 1985	RV Lady Hammond 1985	1986	1987	1988
0	.013	.006	.048		.046
1	.105	.080	.122	.112	.128
2	.206	.192	.218	.197	.213
3	.304	.246	.391	.440	.403
4	.714	.498	.692	.689	.685
5	1.159	.774	1.085	1.169	1.045
6	1.705	1.089	1.738	1.959	1.745
7	2.382	1.625	2.450	2.743	2.489
8	2.156	2.115	3.065	3.825	3.502
9	3.824	2.279	3.523	5.865	5.629
10	4.535	2.611	5.384	5.965	8.547
11		4.688	5.534		
12	7.208	3.743	7.471	7.365	8.666
13		4.835			

Table 10. Commercial weight at age (g) of white hake from NAFO division 4T. Prior to 1983 the weights at age are an average of data from 1983 to 1985 (see text).

Weight at age: NAFO 4T hake

:	79	80	81	82	83	84	85	86	87	88
3 :	1050	1050	1050	1050	1060	1040	1050	993	632	270
4 :	1343	1343	1343	1343	1350	1290	1390	971	821	960
5 :	1863	1863	1863	1863	1910	1670	2010	1473	1305	1280
6 :	2267	2267	2267	2267	2220	2210	2370	2222	2042	1900
7 :	2767	2767	2767	2767	2810	2680	2810	2779	2885	2830
8 :	3297	3297	3297	3297	3210	3230	3450	3705	3792	3750
9 :	3567	3567	3567	3567	3470	3530	3700	4435	4276	5460
10 :	4483	4483	4483	4483	4460	4390	4600	5595	5895	6010
11 :	5850	5850	5850	5850	6670	4590	6290	6567	8103	8420
12 :	6900	6900	6900	6900	8350	6010	6340	7153	8672	10800
13 :	9493	9493	9493	9493	10730	9030	8720	7744	10407	10150

Table 11a. Catch at age ('000) of white hake from NAFO division 4T.

Catch at age: NAFO 4T hake

:	70	71	72	73	74	75	76	77	78
3 :	86	84	91	80	49	56	81	86	79
4 :	708	715	633	499	250	214	298	332	354
5 :	798	798	747	664	380	390	433	471	579
6 :	456	448	485	461	297	344	333	361	545
7 :	373	378	403	454	313	380	291	302	345
8 :	144	144	165	191	136	171	132	136	172
9 :	74	77	84	108	78	99	67	66	61
10 :	42	43	44	50	33	42	28	29	26
11 :	12	14	12	13	8	8	5	5	4
12 :	7	8	8	9	5	7	9	8	8
13 :	3	3	4	4	3	3	2	2	2

:	79	80	81	82	83	84	85	86	87	88
3 :	90	91	66	5	57	60	82	1	27	1
4 :	470	452	427	113	128	423	212	174	457	48
5 :	833	1028	1075	546	595	793	572	475	1296	508
6 :	972	1661	1976	1136	787	862	572	479	917	642
7 :	672	1196	1391	1104	609	523	408	322	422	479
8 :	315	540	604	551	398	265	262	233	159	109
9 :	101	137	154	149	233	158	121	79	70	17
10 :	47	75	94	79	71	53	54	47	16	5
11 :	8	7	4	21	5	20	19	23	3	2
12 :	11	6	1	9	4	10	31	14	2	1
13 :	4	5	8	9	1	1	7	6	1	1

Table 11b. Composition of the catch at age of white hake from NAFO division 4T.

Composition of catch at age: NAFO 4T hake

:	70	71	72	73	74	75	76	77	78
3 :	0.032	0.031	0.034	0.032	0.032	0.033	0.048	0.048	0.037
4 :	0.262	0.263	0.236	0.197	0.161	0.125	0.178	0.185	0.163
5 :	0.295	0.294	0.279	0.262	0.245	0.228	0.258	0.262	0.266
6 :	0.169	0.165	0.181	0.182	0.191	0.201	0.198	0.201	0.250
7 :	0.138	0.139	0.151	0.179	0.202	0.222	0.174	0.168	0.158
8 :	0.053	0.053	0.062	0.076	0.088	0.100	0.079	0.076	0.079
9 :	0.027	0.029	0.031	0.043	0.050	0.058	0.040	0.037	0.028
10 :	0.016	0.016	0.016	0.020	0.021	0.024	0.017	0.016	0.012
11 :	0.005	0.005	0.005	0.005	0.005	0.005	0.003	0.003	0.002
12 :	0.002	0.003	0.003	0.003	0.003	0.004	0.005	0.004	0.004
13 :	0.001	0.001	0.001	0.002	0.002	0.002	0.001	0.001	0.001

:	79	80	81	82	83	84	85	86	87	88
3 :	0.026	0.017	0.011	0.001	0.020	0.019	0.035	0.001	0.008	0.000
4 :	0.133	0.087	0.074	0.030	0.044	0.134	0.091	0.094	0.136	0.026
5 :	0.236	0.198	0.185	0.147	0.206	0.250	0.244	0.256	0.385	0.280
6 :	0.276	0.320	0.341	0.305	0.272	0.272	0.244	0.259	0.272	0.354
7 :	0.191	0.230	0.240	0.297	0.211	0.165	0.174	0.174	0.125	0.264
8 :	0.090	0.104	0.104	0.148	0.138	0.084	0.112	0.126	0.047	0.060
9 :	0.029	0.026	0.027	0.040	0.081	0.050	0.052	0.043	0.021	0.009
10 :	0.013	0.014	0.016	0.021	0.025	0.017	0.023	0.025	0.005	0.003
11 :	0.002	0.001	0.001	0.006	0.002	0.006	0.008	0.012	0.001	0.001
12 :	0.003	0.001	0.000	0.002	0.001	0.003	0.013	0.007	0.001	0.000
13 :	0.001	0.001	0.001	0.002	0.000	0.000	0.003	0.003	0.000	0.000

Table 12. VPA calibration results for NAFO division 4T white hake. The correlation coefficient, mean square error and residuals for the last 3 years were investigated for use as selection criteria for selected terminal F levels.

RV ABUNDANCE INDEX (SLOPE) VS VPA BIOMASS : STANDARDIZED RESIDUALS

TERM F	INT	SLOPE	R2	RES86	RES87	RES88	MEAN SQU ERROR
.15	.0	5251.4	.870	¯.143	.880	.949	372460053362132
.20	.0	4272.9	.897	¯.174	.920	.917	189676016221839
.25	.0	3686.0	.918	¯.208	.963	.880	109778041647028
.30	.0	3294.9	.934	¯.245	1.007	.837	68930525630215
.35	.0	3015.8	.947	¯.285	1.052	.787	45843830269757
.40	.0	2806.7	.957	¯.328	1.097	.727	31864546812587
.45	.0	2644.2	.965	¯.373	1.141	.659	22972091806926
.50	.0	2514.4	.971	¯.420	1.182	.580	17108291064715
.55	.0	2408.4	.975	¯.468	1.218	.490	13139076235713
.60	.0	2320.2	.979	¯.515	1.246	.390	10402376180312
.65	.0	2245.8	.982	¯.560	1.264	.280	8493238972978
.70	.0	2182.1	.984	¯.600	1.269	.164	7154308357880
.75	.0	2127.1	.985	¯.635	1.262	.045	6216713034457
.80	.0	2079.0	.986	¯.663	1.241	¯.074	5566605327915
.85	.0	2036.8	.986	¯.683	1.209	¯.190	5125438357073
.90	.0	1999.4	.987	¯.697	1.167	¯.298	4837930853713
.95	.0	1966.0	.987	¯.703	1.118	¯.397	4664498908544
1.00	.0	1936.0	.987	¯.704	1.064	¯.486	4576369775724
1.05	.0	1909.0	.986	¯.700	1.009	¯.565	4552353135412 ←
1.10	.0	1884.6	.986	¯.694	.954	¯.634	4576663105002

CPUE VS 3+ EXPLOITABLE VPA BIOMASS : STANDARDIZED RESIDUALS

TERM F	INT	SLOPE	R2	RES86	RES87	RES88	MEAN SQU ERROR
.15	.0	1871871.3	.866	¯.633	1.547	2.007	46702118696148
.20	.0	1746581.1	.918	¯.952	1.375	1.596	23560647984953
.25	.0	1671362.6	.938	¯1.200	1.084	1.041	15992788855399
.30	.0	1621196.0	.943	¯1.334	.751	.481	13582345116231
.35	.0	1585354.0	.943	¯1.378	.455	.018	13152278736244 ←
.40	.0	1558470.8	.939	¯1.376	.220	¯.330	13536570095777
.45	.0	1537564.0	.934	¯1.353	.041	¯.585	14254436526943
.50	.0	1520843.4	.929	¯1.325	¯.095	¯.774	15092611452537
.55	.0	1507169.5	.924	¯1.297	¯.200	¯.916	15952699855886
.60	.0	1495781.9	.920	¯1.270	¯.282	¯1.025	16789078990895
.65	.0	1486154.2	.915	¯1.246	¯.347	¯1.111	17581521642134
.70	.0	1477910.2	.911	¯1.225	¯.401	¯1.181	18322367448448
.75	.0	1470773.8	.907	¯1.206	¯.445	¯1.238	19010227580622
.80	.0	1464537.8	.904	¯1.190	¯.481	¯1.285	19646789764448
.85	.0	1459043.8	.900	¯1.175	¯.513	¯1.325	20235160608642
.90	.0	1454168.3	.897	¯1.162	¯.539	¯1.359	20778997059140
.95	.0	1449814.1	.895	¯1.150	¯.562	¯1.388	21282053761365
1.00	.0	1445903.1	.892	¯1.139	¯.583	¯1.414	21747953725487
1.05	.0	1442372.1	.890	¯1.129	¯.600	¯1.436	22180080116397
1.10	.0	1439169.4	.887	¯1.120	¯.616	¯1.456	22581533767980

Table 13. Summary table for calibration of sequential population analysis using non-linear least squares for NAFO division 4T white hake.

Parameters estimated: First formulation

Parameter index	Index	Description
1	population size estimate	age 4 in 1989
2	"	" 5 "
3	"	" 6 "
4	"	" 7 "
5	calibration constant for RV nos.	age 3
6	"	" 4
7	"	" 5
8	"	" 6
9	calibration constant for CPUE (q)	exploitable biomass

Structure imposed

- F on age 8+ set equal to F on age 7
- F on oldest age group (13) set equal the mean of ages 6 to 8 (mean weighted by population numbers)
- relationships forced through the origin

Input data

- catch at age (ages 3 to 13; years 1978 to 1988)
- RV mean number per tow (ages 3 to 6; years 1978 to 1988)
  - standard errors of RV numbers per tow
- standardized catch rate (CPUE) series (years 1978 to 1988)
  - standard errors of CPUE

Objective function
- residuals weighted by standard error
- no penalty function
- minimization of residual sum of squares

Summary
- number of observations 55
- number of parameters 9

Table 13. con't

Summary table for calibration of sequential population analysis using non-linear least squares for NAFO division 4T white hake.

Parameters estimated: Second formulation

Parameter index	Index	Description
1	population size estimate	age 5 in 1989
2	calibration constant for CPUE (q)	exploitable biomass

Structure imposed

- F on all ages from mean exploitation pattern
- F on oldest age group (13) set equal the mean of ages 7 and 8 (mean weighted by population numbers)
- relationships forced through the origin

Input data

- catch at age (ages 3 to 13; years 1978 to 1988)
- standardized catch rate (CPUE) series (years 1978 to 1988)
- standard errors of CPUE

Objective function
- residuals weighted by standard error
- no penalty function
- minimization of residual sum of squares

Summary
- number of observations 11
- number of parameters 2

Table 14. Parameter estimates and standard error levels for the adaptive framework. (Second formulation Table 13.)

APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

1 1 1 1 1 1
1 1 1 1 1 1
ORTHOGONALITY OFFSET..... 0.002010
MEAN SQUARE RESIDUALS 9.905724

PAR. EST.	STD. ERR.	T-STATISTIC
1.01862E0003	2.96118E0002	3.43992E0000
7.99706E-007	8.73448E-008	9.15574E0000

1	-0.4912748264
-0.4912748264	1

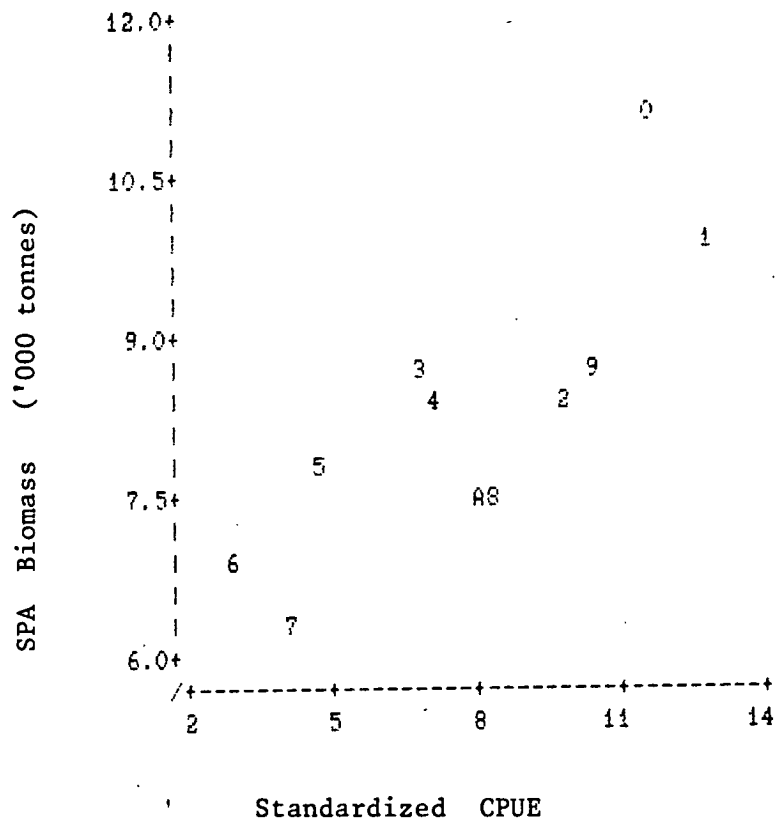
FISHING MORTALITY 3/ 5/89

	78	79	80	81	82	83	84	85	86	87	88
3	.008	.013	.018	.015	.001	.014	.010	.012	.000	.019	.008
4	.042	.058	.083	.110	.031	.043	.133	.042	.032	.112	.051
5	.113	.132	.175	.290	.200	.230	.404	.267	.125	.347	.182
6	.223	.282	.421	.596	.569	.496	.612	.578	.375	.377	.308
7	.350	.472	.671	.768	.812	.698	.736	.669	.773	.673	.383
8	.496	.629	.897	.890	.819	.801	.769	1.094	1.093	1.216	.383
9	.458	.618	.626	.705	.567	1.064	.905	1.036	1.313	1.302	.383
10	.458	.790	1.492	1.304	1.027	.586	.750	.952	1.982	1.116	.383
11	.135	.246	.247	.254	1.317	.149	.321	.671	1.762	.669	.383
12	.509	.665	.295	.050	1.587	1.010	.499	1.257	1.976	.718	.383
13	.391	.520	.742	.820	.833	.750	.762	.805	.903	.781	.387

BEGINING OF YEAR POPULATION NUMBERS 3/ 5/89

	78	79	80	81	82	83	84	85	86	87	88	
3	11281	7752	5632	4999	4109	4660	7011	7615	5815	1600	29	1
4	9479	9164	6265	4529	4033	3359	3764	5686	6161	4760	1285	24
5	5987	7441	7078	4721	3321	3200	2635	2699	4463	4886	3484	1000
6	3013	4378	5338	4865	2892	2225	2081	1439	1692	3224	2828	2378
7	1292	1973	2705	2868	2195	1340	1110	924	661	952	1810	1702
8	486	746	1008	1133	1089	798	546	435	387	250	398	1011
9	184	242	326	336	381	393	293	207	119	106	61	222
10	78	95	107	143	136	177	111	97	60	26	24	34
11	35	41	35	20	32	40	81	43	31	7	7	13
12	22	25	26	23	13	7	28	48	18	4	3	4
13	7	11	11	16	18	2	2	14	11	2	2	2

Table 14. con't



0 - 1980
1 - 1981

8 - 1978
9 - 1979
ect.

Table 15 . Yield per recruit analysis for NAFO division 4T white hake based on ages 3 to 13. The weights at age are the mean over the years 1983 to 1988, the exploitation pattern is the mean of 1983 to 1987.

SUMMARY:

AGE	WEIGHT-AT-AGE	PARTIAL RECRUITMENT
3	.841	.018
4	1.132	.121
5	1.602	.457
6	2.142	.797
7	2.767	.995
8	3.477	1.000
9	4.072	1.000
10	5.078	1.000
11	6.620	1.000
12	7.649	1.000
13	9.289	1.000

NATURAL MORTALITY RATE : 0.2
F0.1 COMPUTED AS .2605 AT Y/R OF .9760
FMAX COMPUTED AS .5427 AT Y/R OF 1.0593

YIELD PER RECRUIT ANALYSIS

	FISHING MORTALITY	CATCH (NUMBER)	YIELD (KG)	AVG. WEIGHT (KG)	YIELD PER UNIT EFFORT
	.1000	.187	.634	3.379	1.691
	.2000	.297	.899	3.024	1.200
F0.1---	.2605	.343	.976	2.847	1.000
	.3000	.367	1.007	2.745	.896
	.4000	.414	1.047	2.529	.699
	.5000	.448	1.058	2.361	.565
FMAX---	.5427	.460	1.059	2.301	.521
	.6000	.475	1.058	2.230	.471
	.7000	.496	1.053	2.126	.402
	.8000	.513	1.047	2.041	.349
	.9000	.528	1.040	1.972	.309
	1.0000	.540	1.034	1.913	.276
	1.1000	.551	1.027	1.863	.249
	1.2000	.561	1.022	1.820	.227
	1.3000	.570	1.016	1.782	.209
	1.4000	.578	1.011	1.748	.193
	1.5000	.586	1.006	1.718	.179

Table 16. Yield per recruit analysis for NAFO division 4T white hake based on ages 1 to 13. The weights at age for ages 1 and 2 are from the research vessel surveys, the weights at age are the mean over the years 1983 to 1988, the exploitation pattern is the mean of 1983 to 1987.

SUMMARY:

AGE	WEIGHT-AT-AGE	PARTIAL RECRUITMENT
1	.120	.000
2	.250	.000
3	.841	.018
4	1.132	.121
5	1.602	.457
6	2.142	.797
7	2.767	.995
8	3.477	1.000
9	4.072	1.000
10	5.078	1.000
11	6.620	1.000
12	7.649	1.000
13	9.289	1.000

NATURAL MORTALITY RATE : 0.2
F0.1 COMPUTED AS .2605 AT Y/R OF .6542
FMAX COMPUTED AS .5425 AT Y/R OF .7100

YIELD PER RECRUIT ANALYSIS

	FISHING MORTALITY	CATCH (NUMBER)	YIELD (KG)	AVG. WEIGHT (KG)	YIELD PER UNIT EFFORT
	.1000	.126	.425	3.379	1.691
	.2000	.199	.603	3.024	1.200
F0.1---	.2605	.230	.654	2.846	1.000
	.3000	.246	.675	2.745	.896
	.4000	.278	.702	2.528	.699
	.5000	.301	.709	2.360	.565
FMAX---	.5425	.309	.710	2.301	.521
	.6000	.318	.709	2.229	.471
	.7000	.332	.706	2.125	.402
	.8000	.344	.702	2.041	.349
	.9000	.354	.697	1.971	.309
	1.0000	.362	.693	1.912	.276
	1.1000	.370	.689	1.862	.249
	1.2000	.376	.685	1.819	.227
	1.3000	.382	.681	1.781	.209
	1.4000	.388	.677	1.747	.193
	1.5000	.393	.674	1.717	.179

Figure 1. Nominal landings by gear and year (from 1970) and TAC (total allowable catch) of NAFO division 4T white hake.

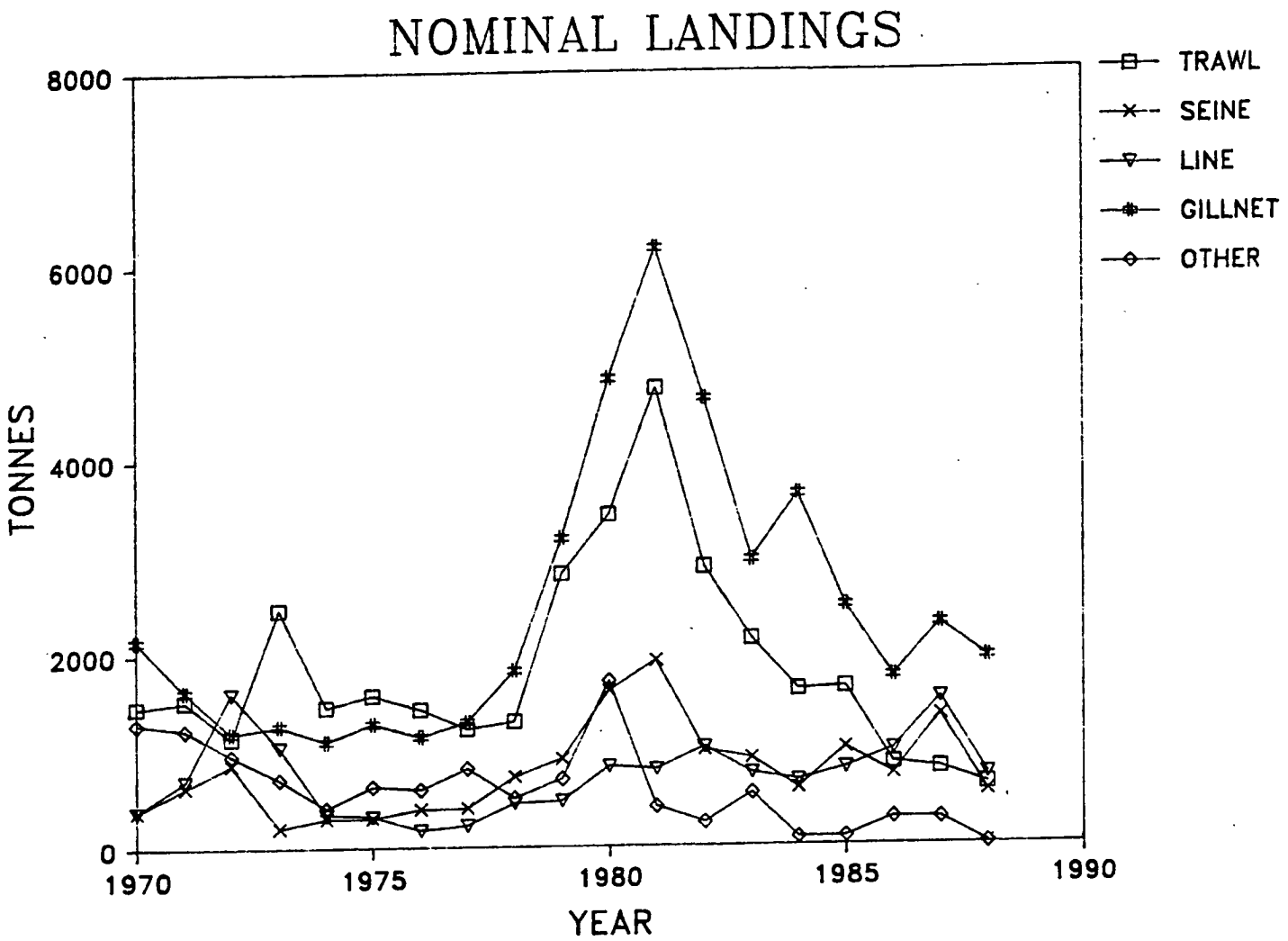
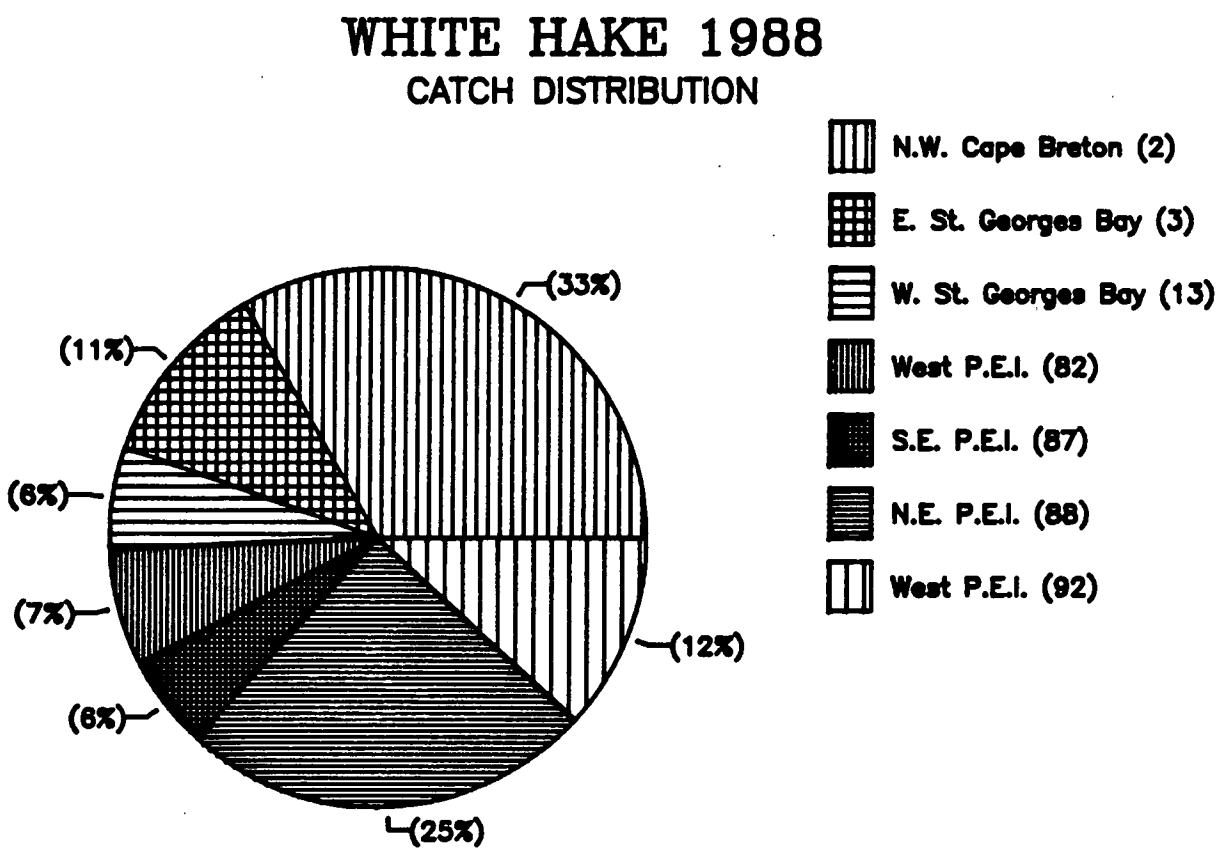
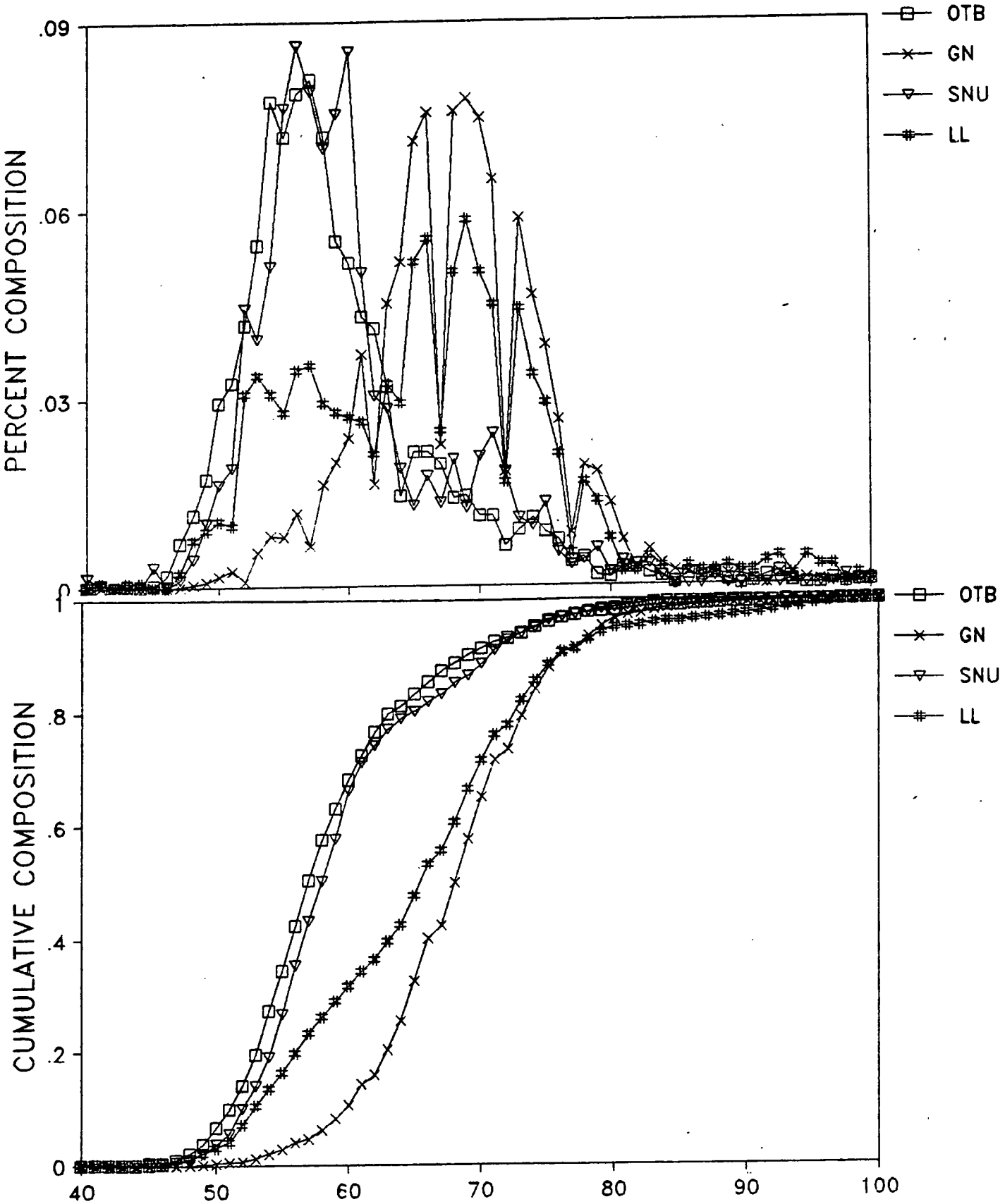


Figure 2. Distribution of 1988 landings by statistical district and gear for white hake in NAFO division 4T as derived from 'Purchase Slips'. This data represents 3400 tonnes of the 3860 tonnes provisional landings.



WHITE HAKE CATCH DISTRIBUTION

Figure 3. Length frequency by gear of the 1988 commercial catch derived from dockside sampling of NAFO division 4T white hake.



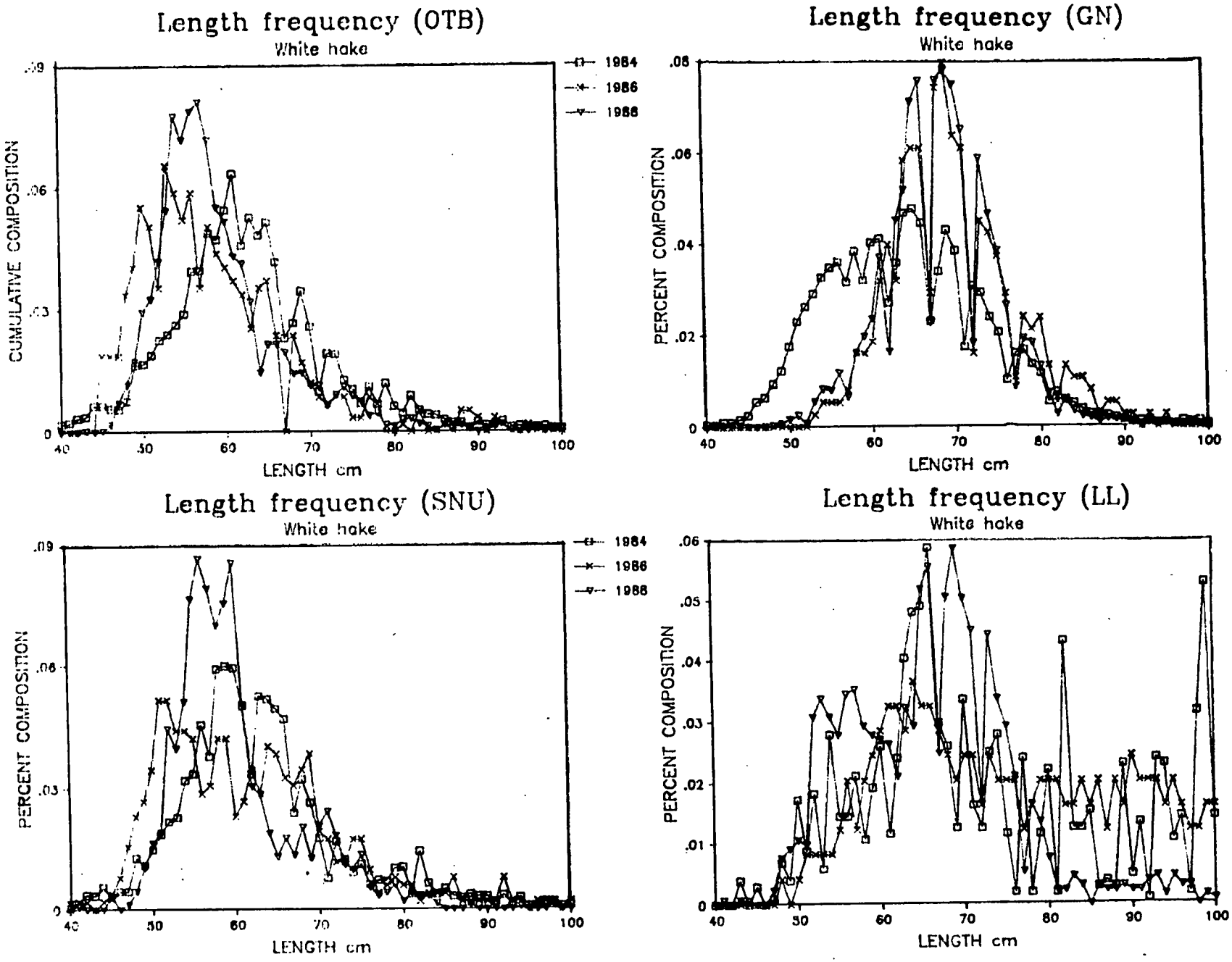


Figure 4. Length frequencies by gear for the 1984, 1986 and 1988 commercial catch derived from dockside sampling of NAFO division 4T white hake.

Figure 5. Residuals at successive CPUE levels in the last run of the Gavaris multiplicative model.

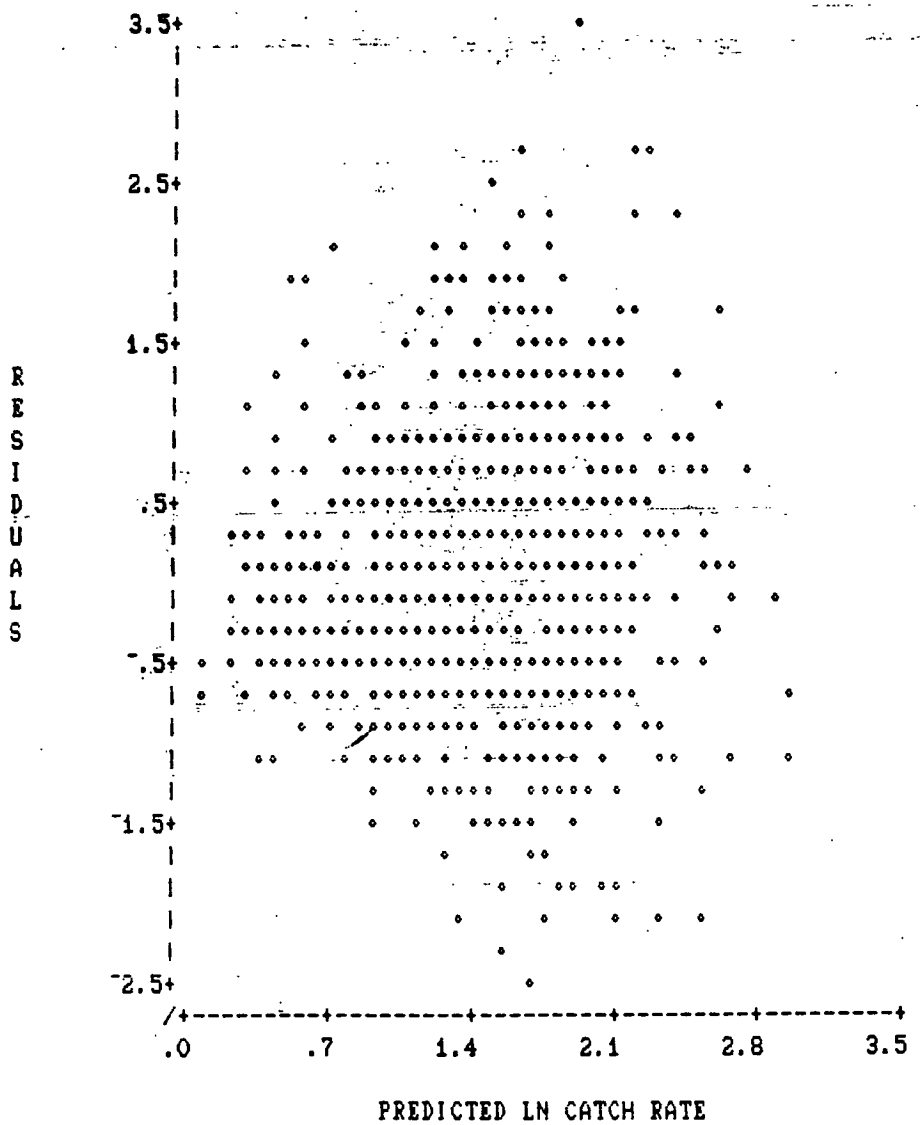


Figure 6. Standardized catch rates for Gulf hake in NAFO division 4T. All catches are expressed in hundred's of kg.

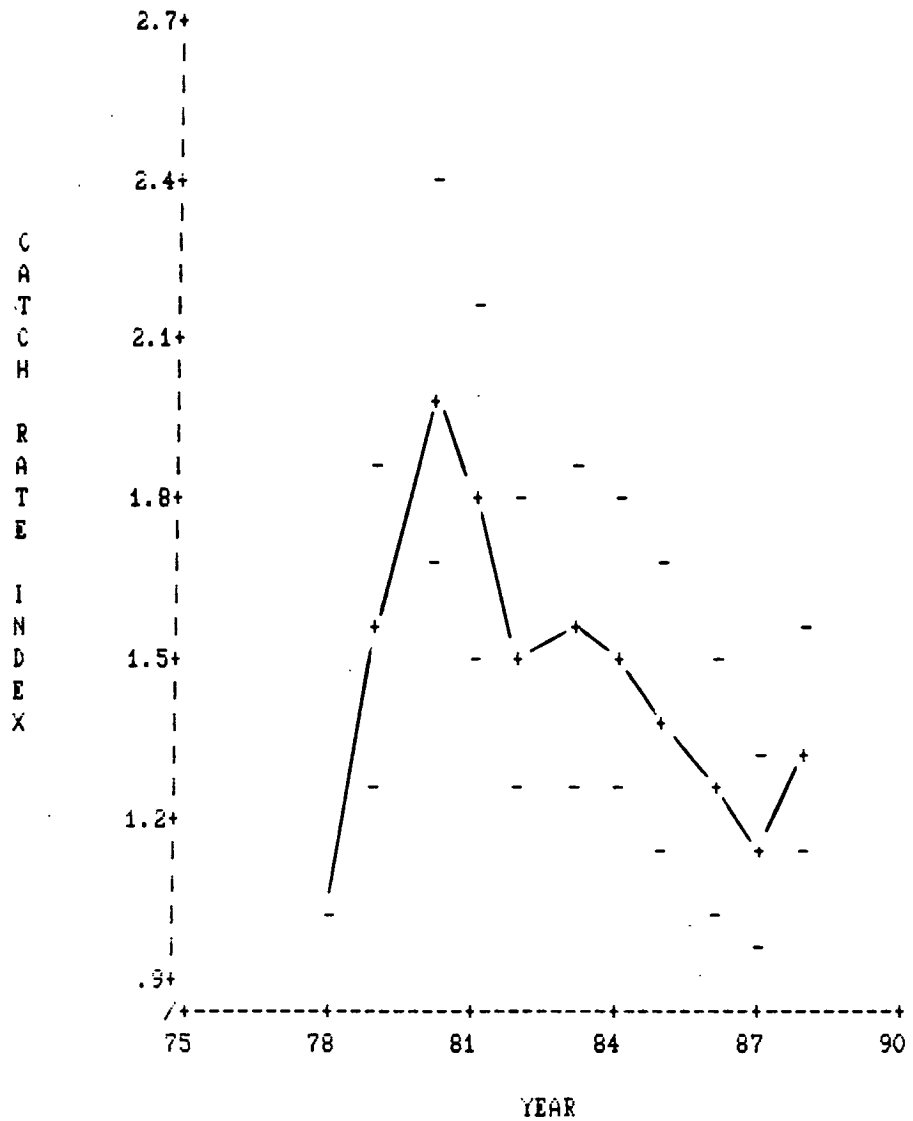


Figure 7. Comparision of the standardized catch rate of Figure 6 with those estimated with alternate computer software (SAS) and that of all gears.

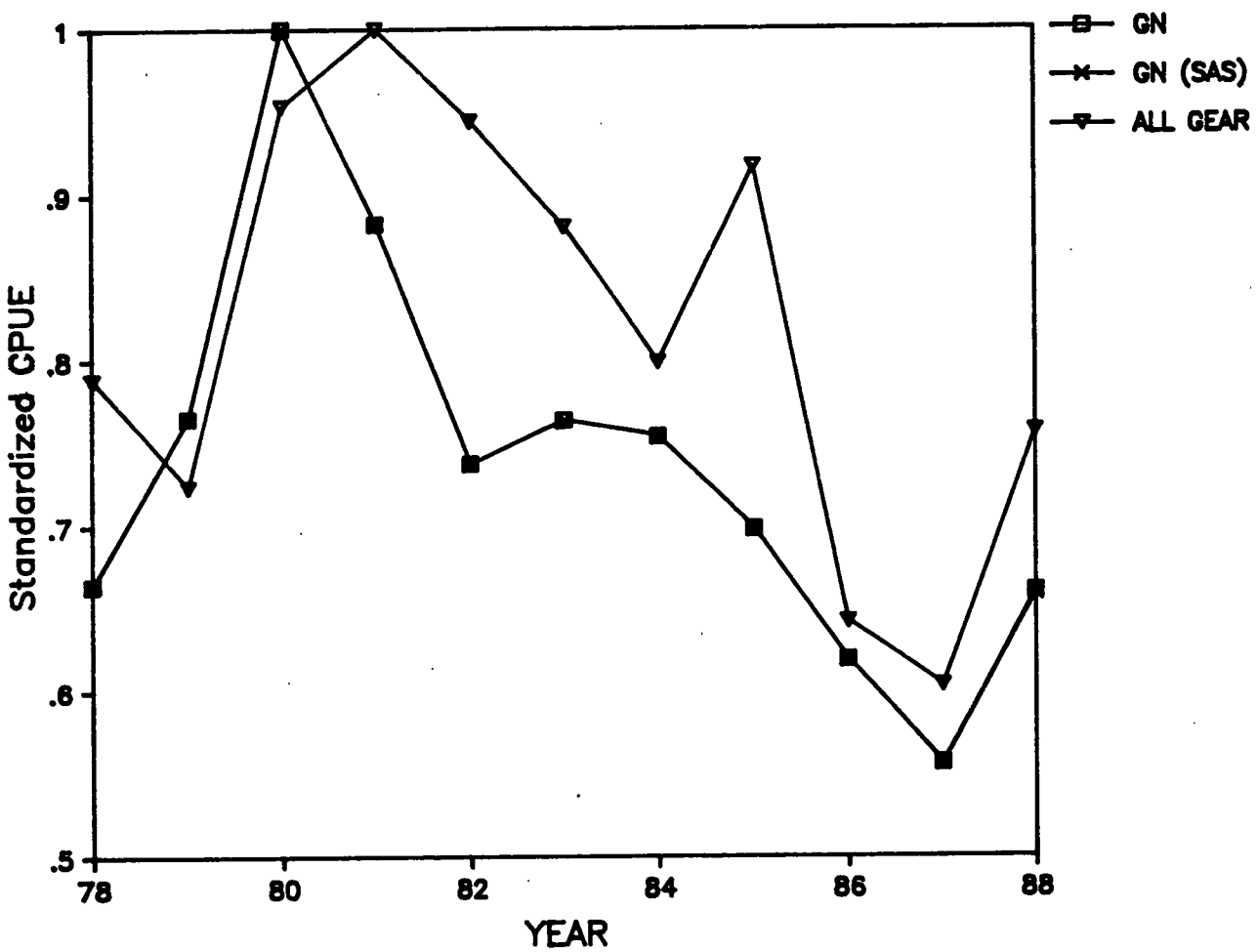


Figure 8. Selected strata for 'hake' survey in southern Gulf of St. Lawrence. These strata are the basis for separation of the abundance indices into two components, the 'strait' (strata 3, 20, 22, 32, 33) and the 'slope' (strata 15, 25, 37, 38, 39).

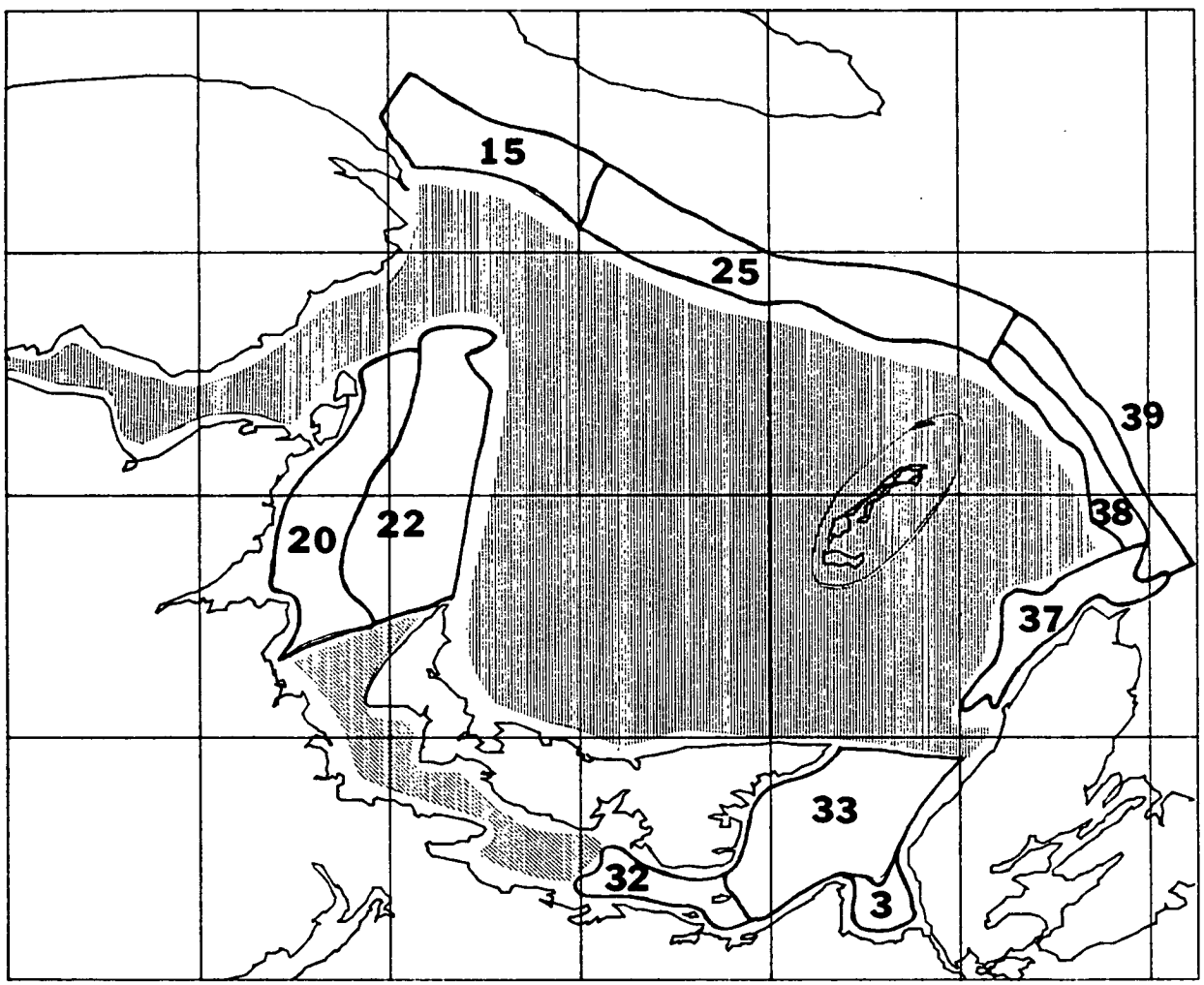


Figure 9. Research vessel biomass estimates of white hake from NAFO division 4T (southern Gulf of St. Lawrence) in September of each year. The values are in tonnes, each years estimate is presented based on the entire survey of that year. The entire survey (Gulf) is split into the 'strait' and 'channel' components.

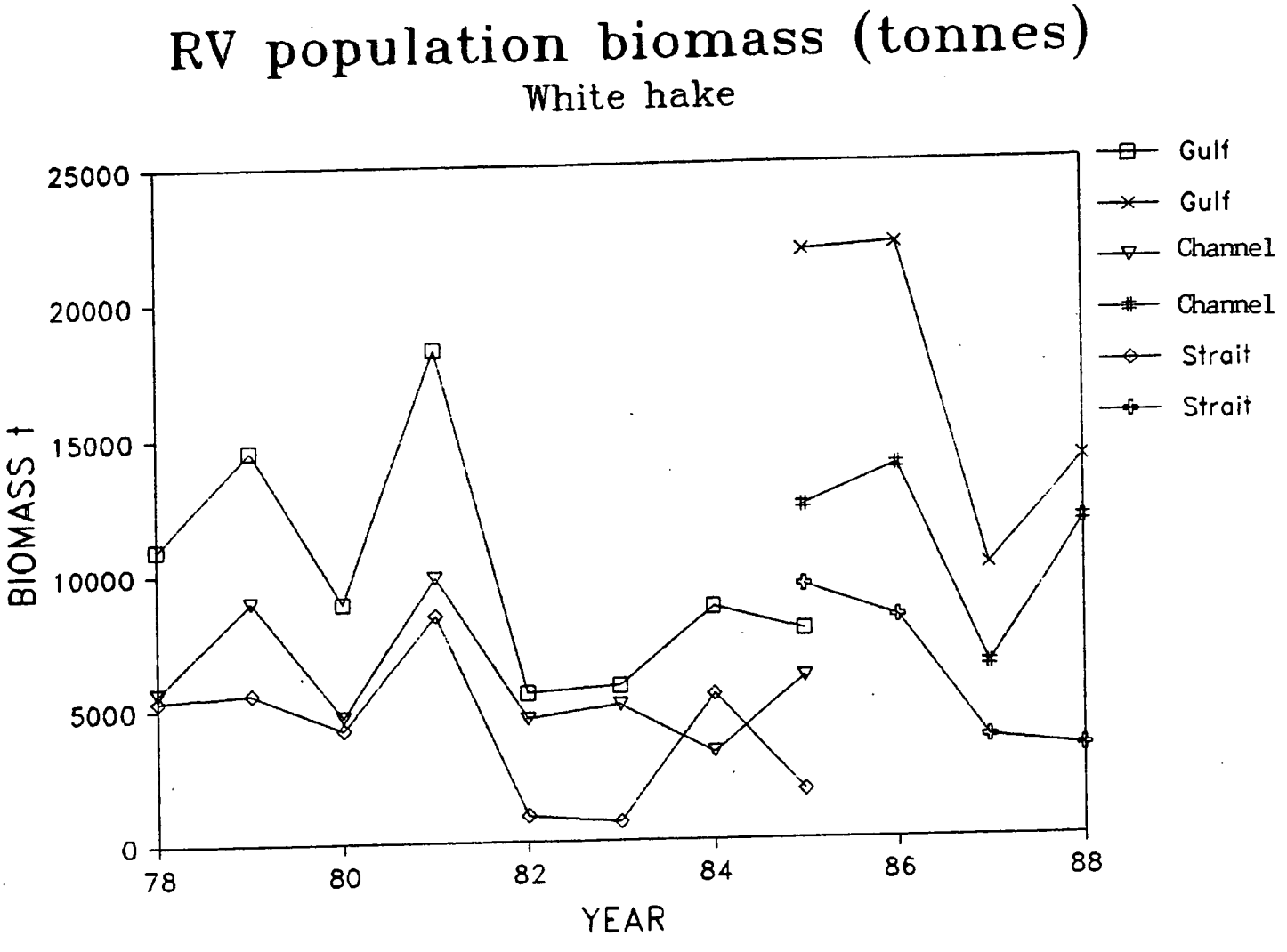


Figure 10. Population at age of NAFO division 4T white hake from the research vessel survey of the RV Lady Hammond (1985 to 1988).

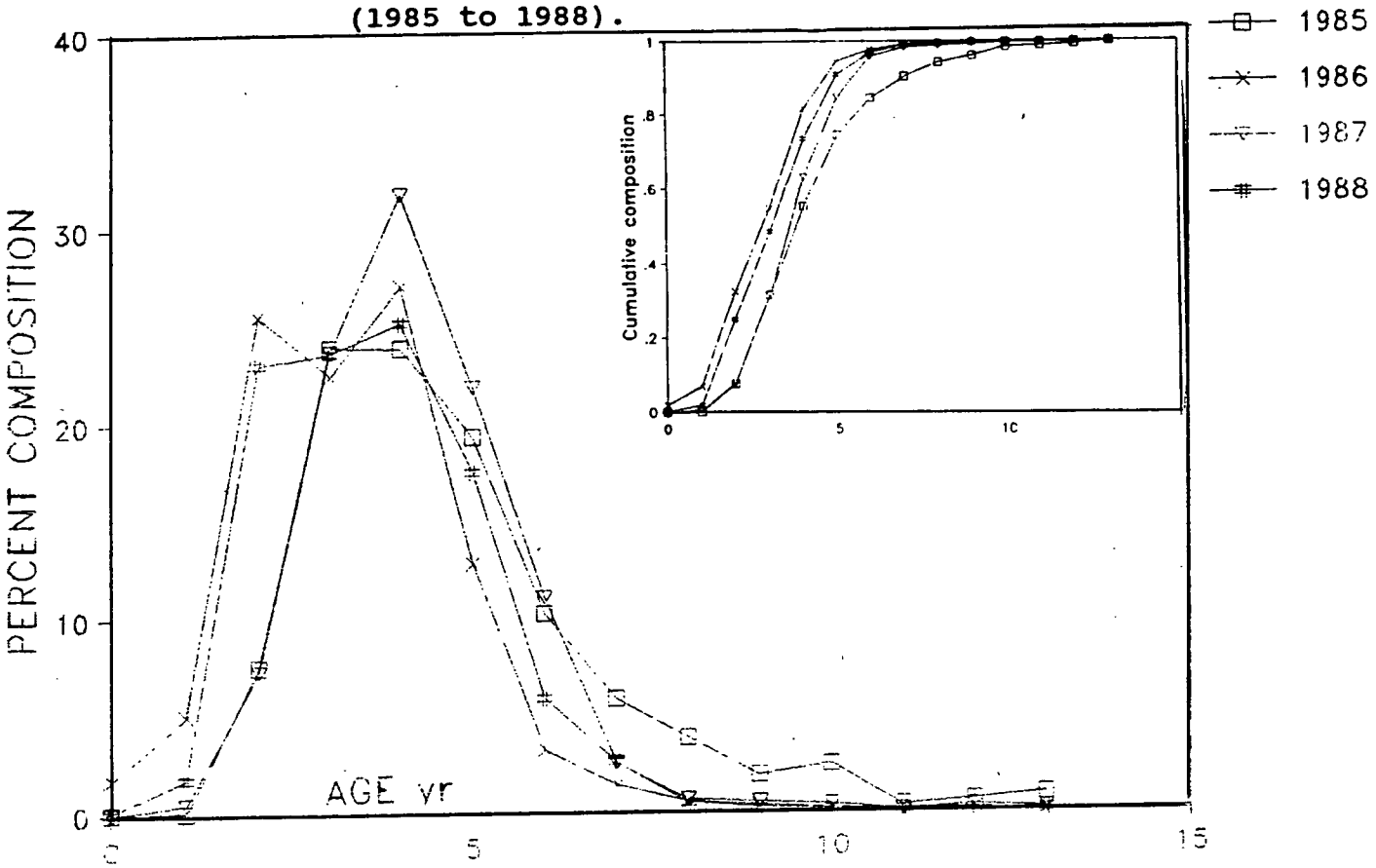


Figure 11. Length frequencies of NAFO division 4T white hake from the research vessel survey of the RV Lady Hammond (1985 to 1988).

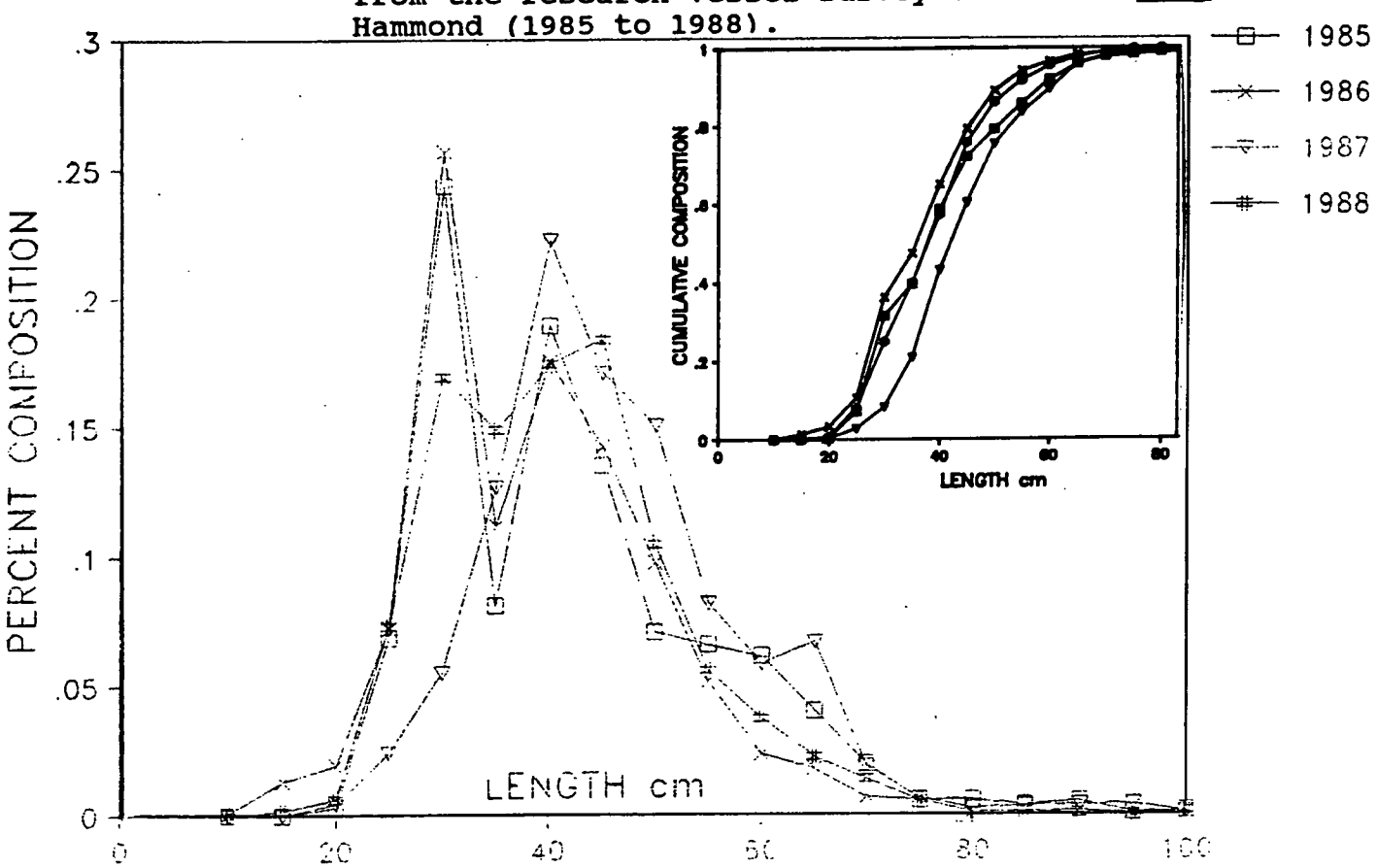


Figure 12. Weight at age of NAFO division 4T white hake from research vessel data for the selected 'hake' strata (1971 to 1988).

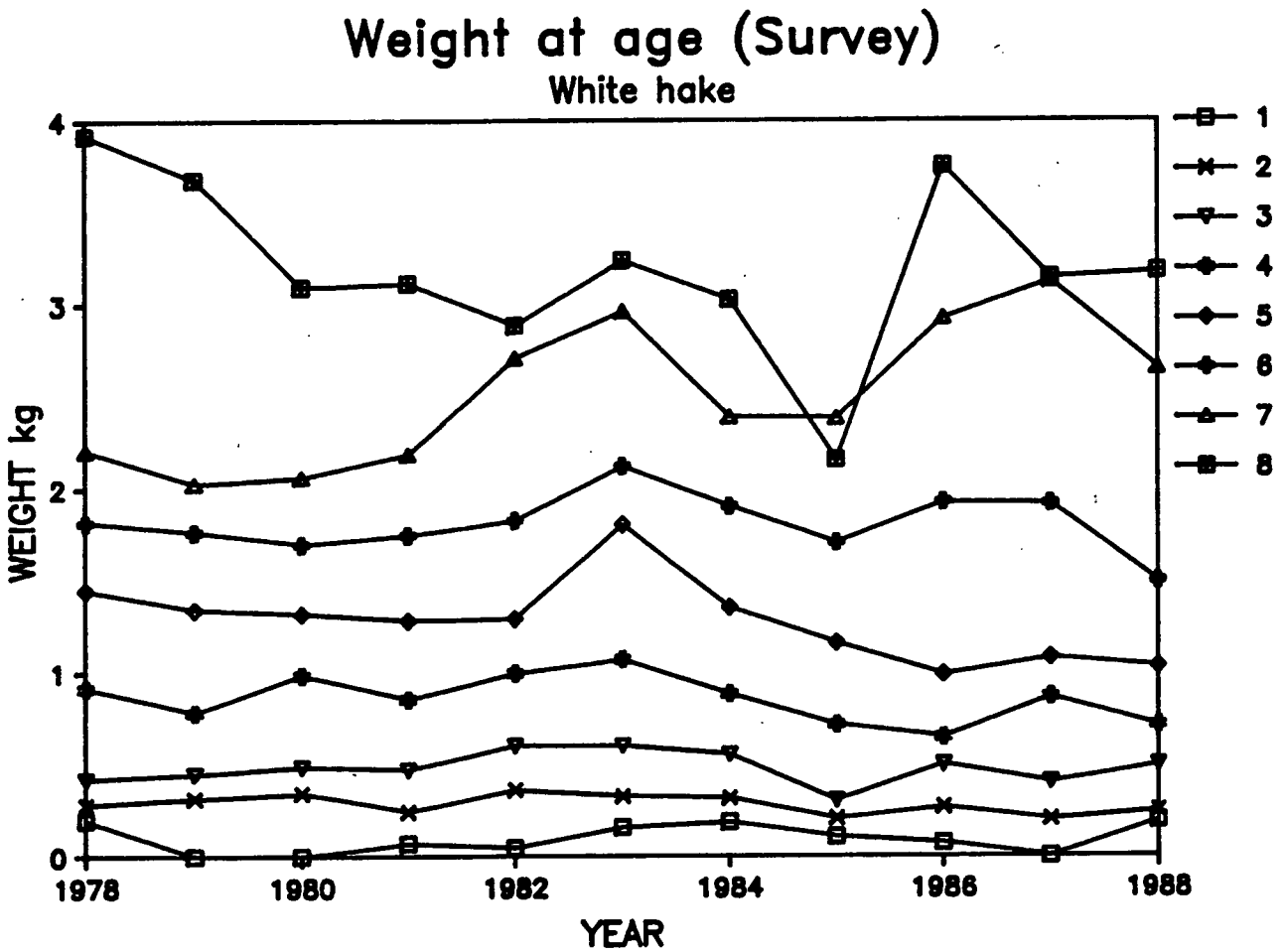
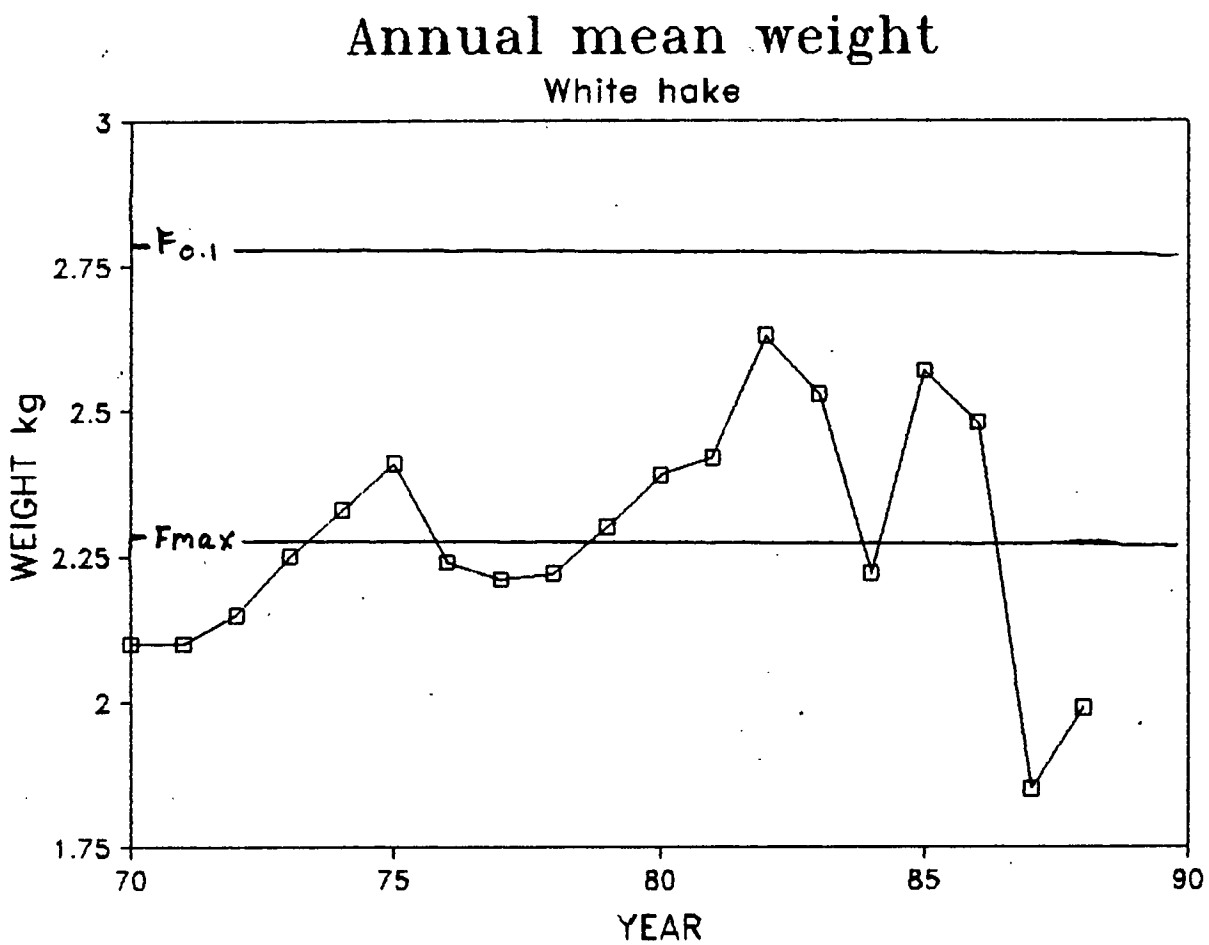


Figure 13. Annual mean weights for the NAFO division 4T white hake as compared to the mean weights estimated if fishing at Fo.1 and Fmax. (Fo.1 and Fmax taken from yield per recruit in this document.)



APPENDIX I.

Distribution of white hake (Urophycis tenuis) in the southern Gulf of St. Lawrence

Distribution of the catch (kg) of white hake estimated from surveys conducted in the southern Gulf of St. Lawrence (NAFO division 4T) from 1970 to 1988 are presented in Figure 1. The 1970 survey was incomplete and covered only the northern and western portions of NAFO division 4T. From 1970 until 1983 the surveys were conducted as stratified random surveys with the RV E.E. Prince, a stern trawler capable of only 12 hours of fishing per day (daylight only survey). The surveys from 1984 to 1987 were fixed station design and were conducted in 1984 and 1985 from the RV E.E. Prince and from 1985 to 1987 from the RV Lady Hammond (1985 was a comparative survey using both vessels). The fixed stations were selected based on sampling sites successfully fished in the random stratified surveys of 1981 to 1983. The RV Lady Hammond is capable of 24 hr fishing. The 1988 survey was a stratified random survey with day/night paired stations.

The distribution of white hake from the research surveys (particularly with the RV Lady Hammond) in the southern Gulf of St. Lawrence indicates increasing biomass with depth along the slope of the Laurentian Channel (200 to 300 m). This would imply the distribution may extend beyond the limits of our survey area into the Laurentian Channel at depths greater than 300 m. This is confirmed by a composite distribution map of the NAFO Division 4T portion of the surveys conducted by Quebec Region (Laberge, pers. comm.) during August and January (1984 to 1987) (Figure 2).

Landings of white hake in NAFO Divisions 4R and 4S are low, generally less than 100 tonnes per year. Dockside sampling by DFO staff indicates these fish are larger (generally all fish > 60cm) than those sampled from NAFO Division 4T (modal length between 50 and 60 cm). Surveys conducted by Quebec Region during August in NAFO Divisions 4R and 4S and the extreme northern portion of Division 4T (northern Gulf) indicate a different picture. The biomass estimates are in the same magnitude as those estimated from the southern Gulf surveys.

Year	Month	Survey (DFO region)	NAFO Division	Biomass tonnes
1987	August	Quebec	4R	6,300
1987	"	Quebec	4S	9,300
1987	"	Quebec	4T *	6,000
1987	September	Gulf	4T (Channel)	6,400
1987	"	Gulf	4T (Strait)	3,700
approximate total Gulf of St. Lawrence biomass				30,000

con't

Year	Month	Survey (DFO region)	NAFO Division	Biomass tonnes
1988	August	Quebec	4R	3,800
1988	"	Quebec	4S	5,400
1988	"	Quebec	4T *	6,700
1988	September	Gulf	4T (Channel)	11,700
1988	"	Gulf	4T (Strait)	3,300
approximate total Gulf of St. Lawrence biomass				27,000

* northern part of Division 4T (Laurentian Channel and slopes)

The length frequencies from the surveys of the northern Gulf indicate different mean lengths in the different divisions.

Sex	Survey (DFO-Region)	NAFO Division	Modal length cm	Population estimates (numbers)
Male	Quebec	4R	34 - 39	1.1 m
Male	Quebec	4S	45	1.2 m
Male	Quebec	4T	43 - 48	3.0 m
Male	Gulf	4T	40	4.8 m
Female	Quebec	4R	55+	1.8 m
Female	Quebec	4S	53	2.5 m
Female	Quebec	4T	45	4.1 m
Female	Gulf	4T	51	4.8 m

This suggests a possible movement of larger (especially female) hake from the southern Gulf northwards with fewer but larger fish occurring in more northerly areas. Females outnumber the smaller males in all divisions of the northern Gulf surveys. Seasonal surveys of the southeastern portion of Division 4T indicate both inshore (Strait) and offshore (Channel) components overwinter along the Laurentian Channel (Clay, 1989). If the assumption regarding movement of larger fish northwards is true, it would tend to force the calibration of the VPA to higher F's on the older age groups than would be due to commercial exploitation alone. It would also lead to an apparent size or age selective mortality.

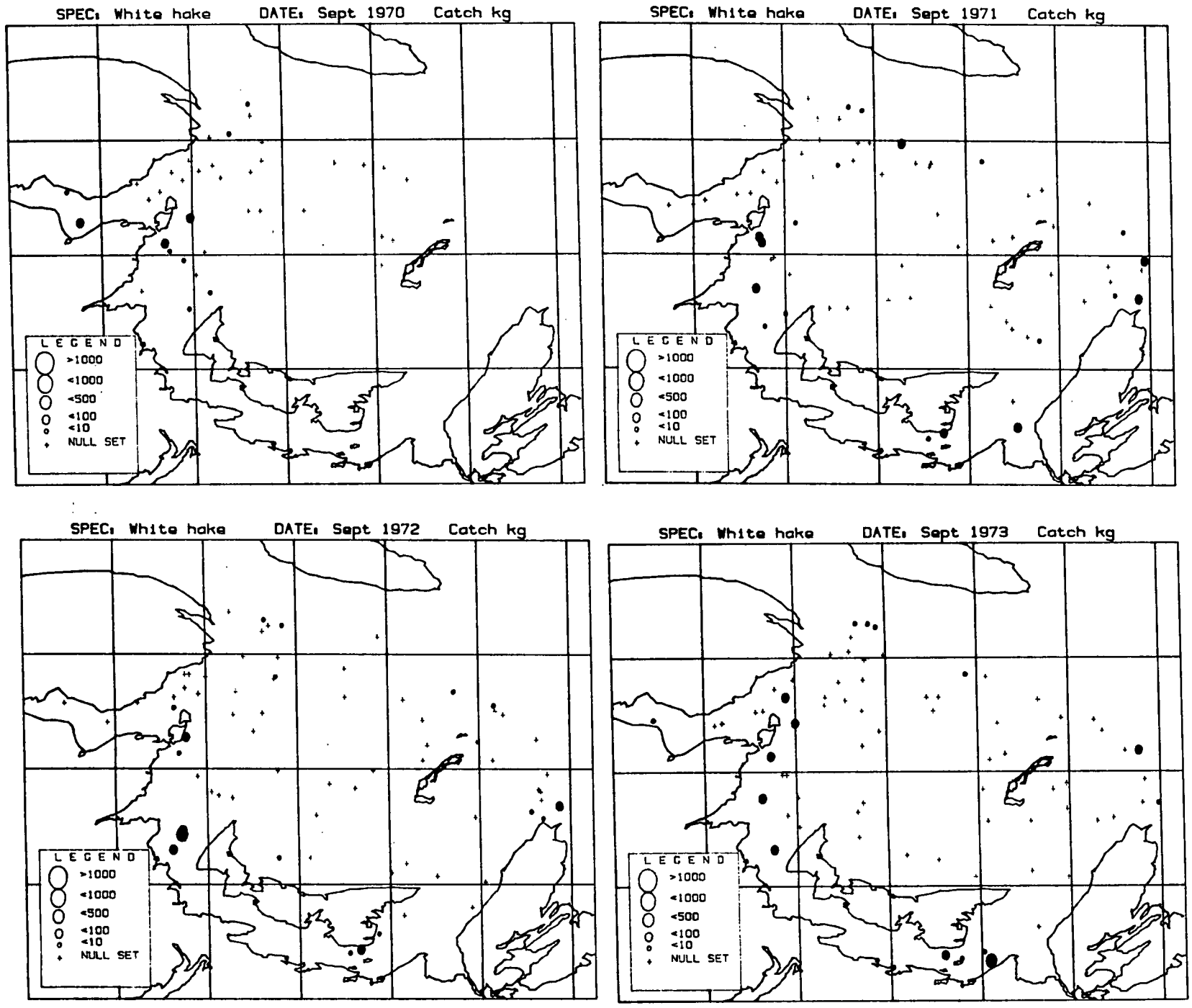
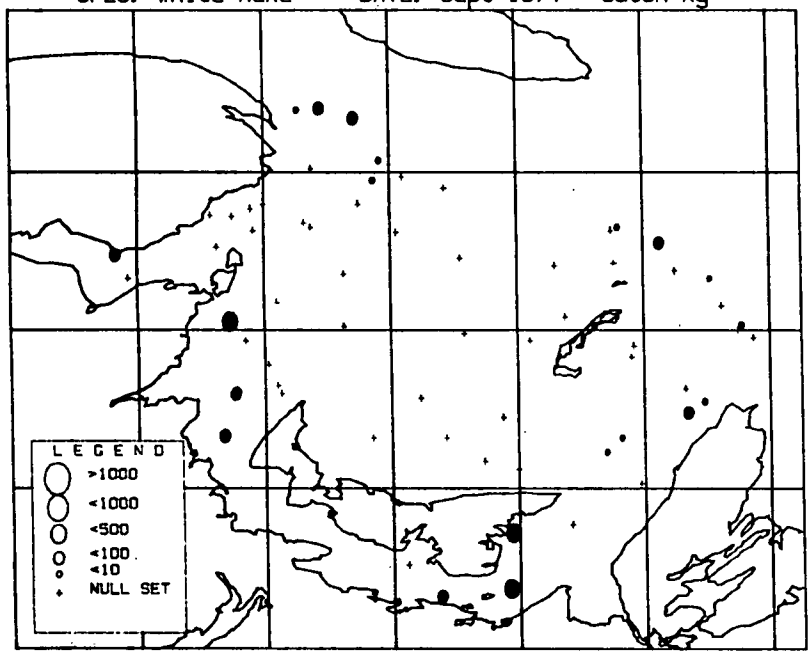
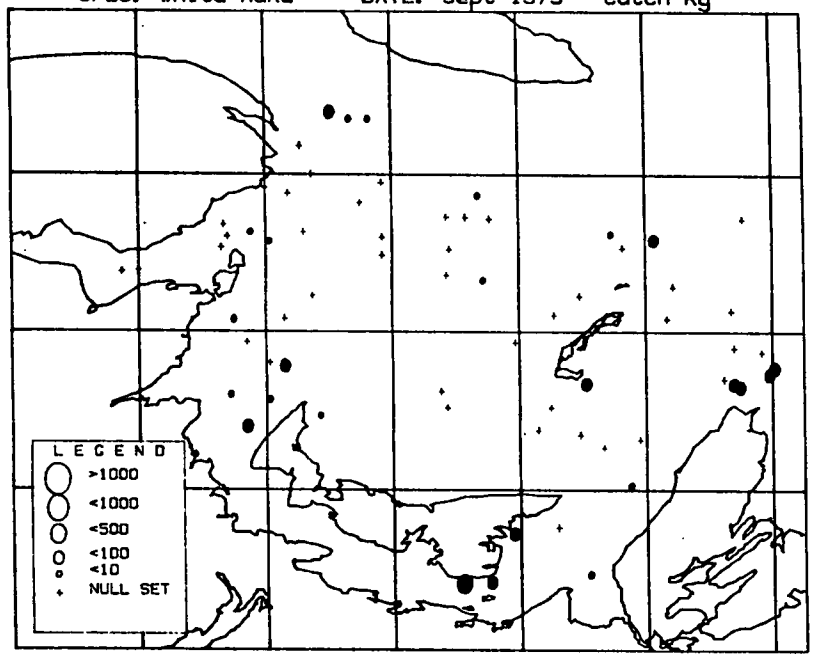


Figure 1. Distribution of white hake in catch weight per tow. Data are from the Gulf Region surveys of the southern Gulf in September.

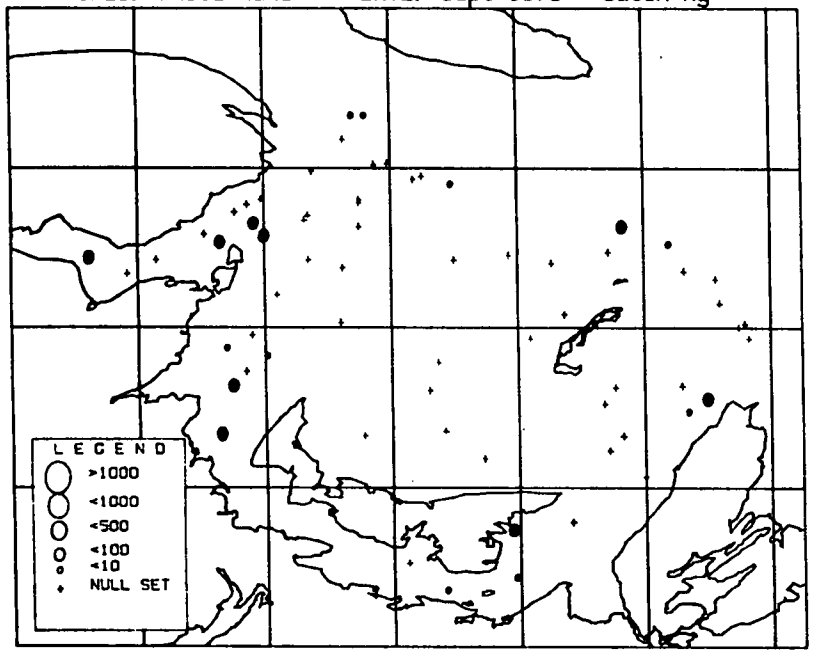
SPEC: White hake DATE: Sept 1974 Catch kg



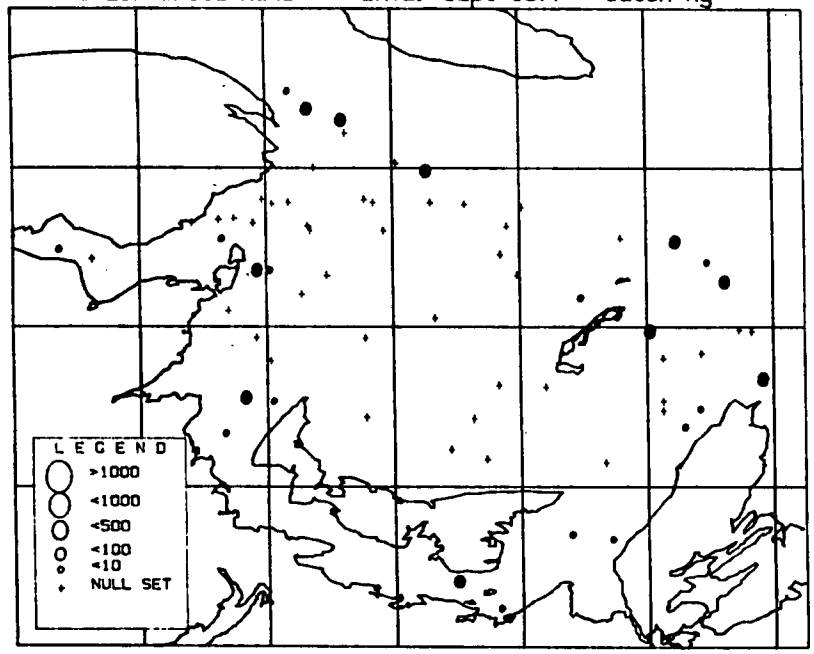
SPEC: White hake DATE: Sept 1975 Catch kg

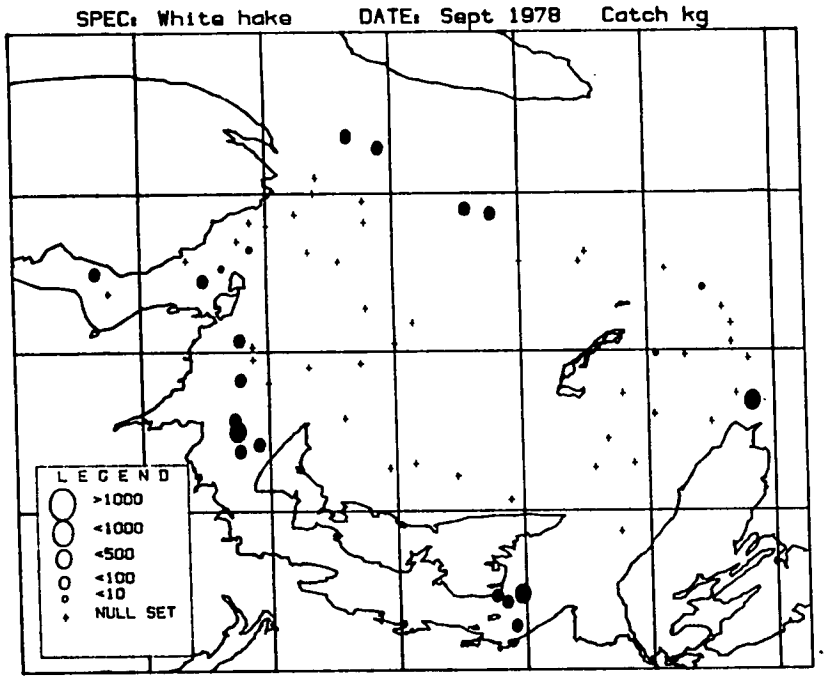


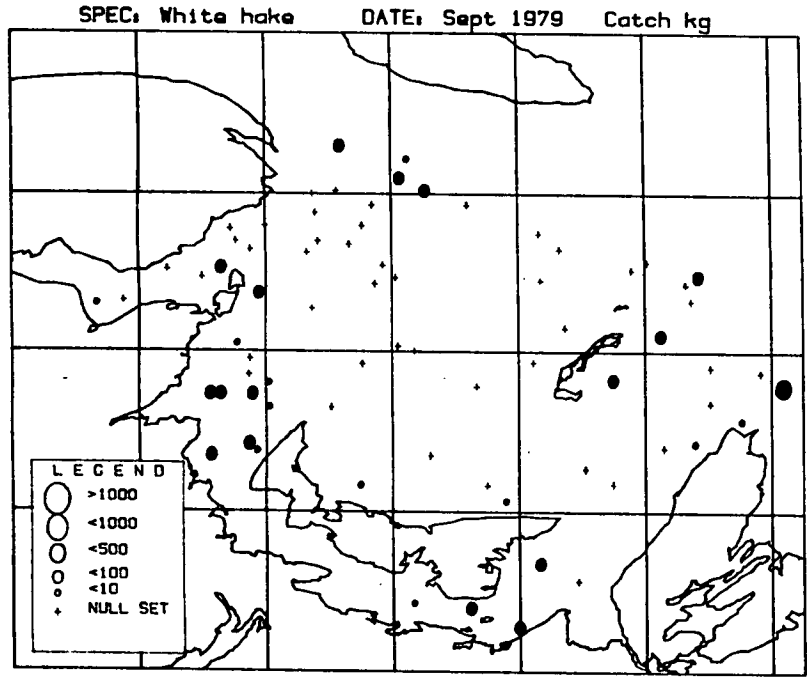
SPEC: White hake DATE: Sept 1976 Catch kg

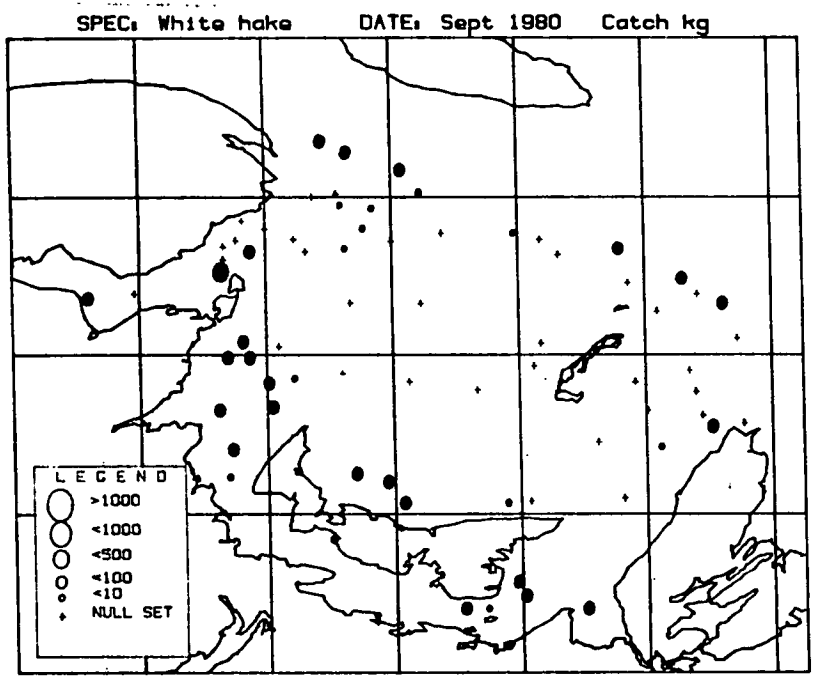


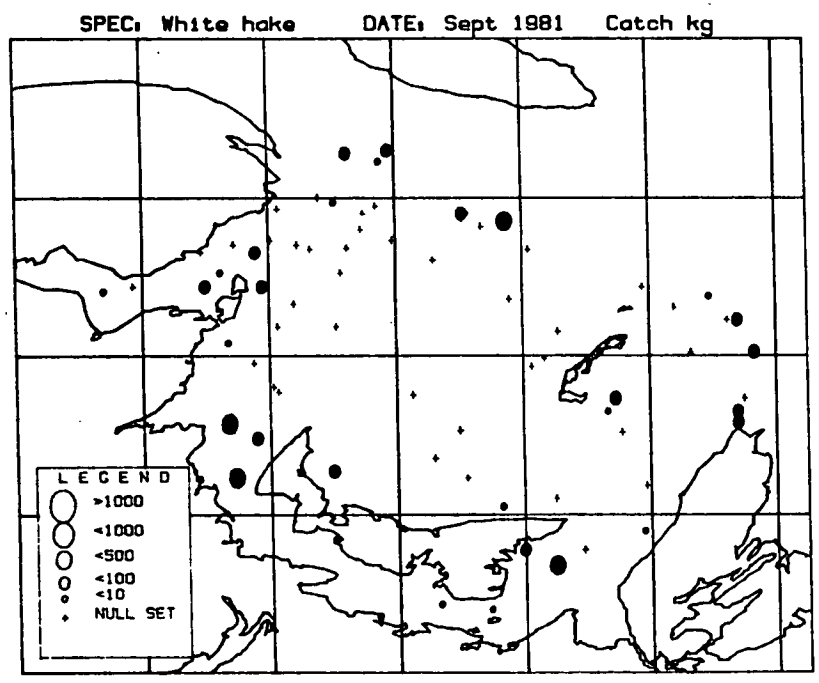
SPEC: White hake DATE: Sept 1977 Catch kg



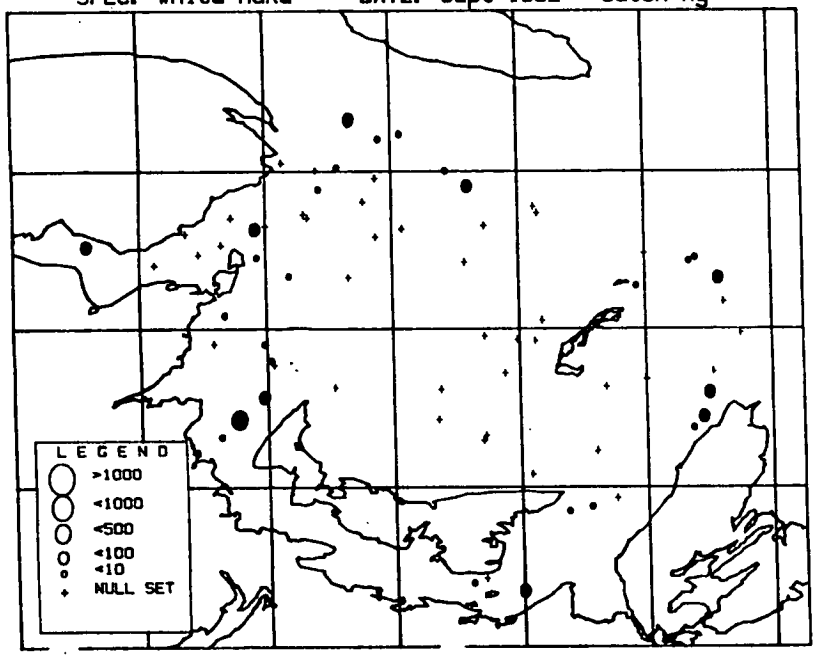

SPEC: White hake DATE: Sept 1978 Catch kg
LEGEND
>1000
<1000
<500
<100
<10
NULL SET


SPEC: White hake DATE: Sept 1979 Catch kg
LEGEND
>1000
<1000
<500
<100
<10
NULL SET

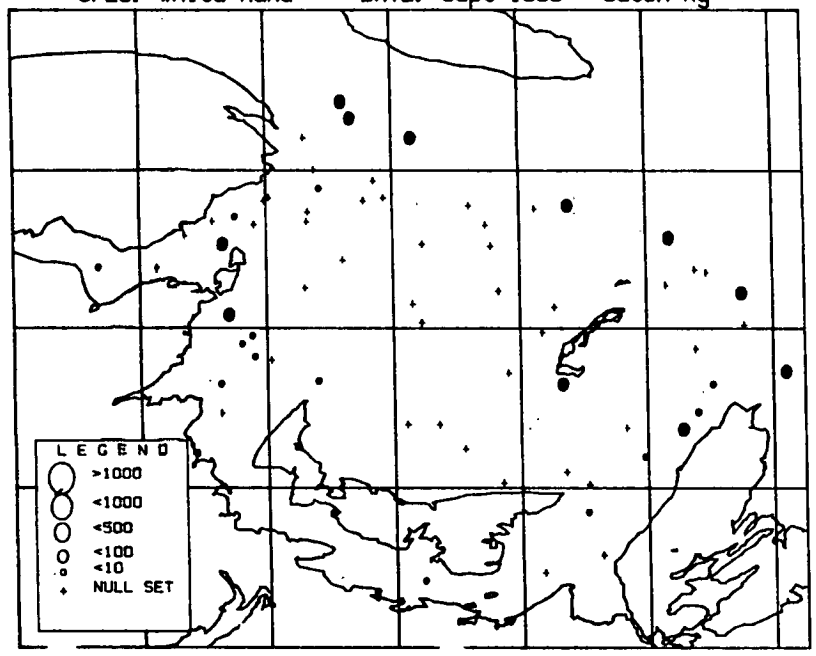

SPEC: White hake DATE: Sept 1980 Catch kg
LEGEND
>1000
<1000
<500
<100
<10
NULL SET


SPEC: White hake DATE: Sept 1981 Catch kg
LEGEND
>1000
<1000
<500
<100
<10
NULL SET

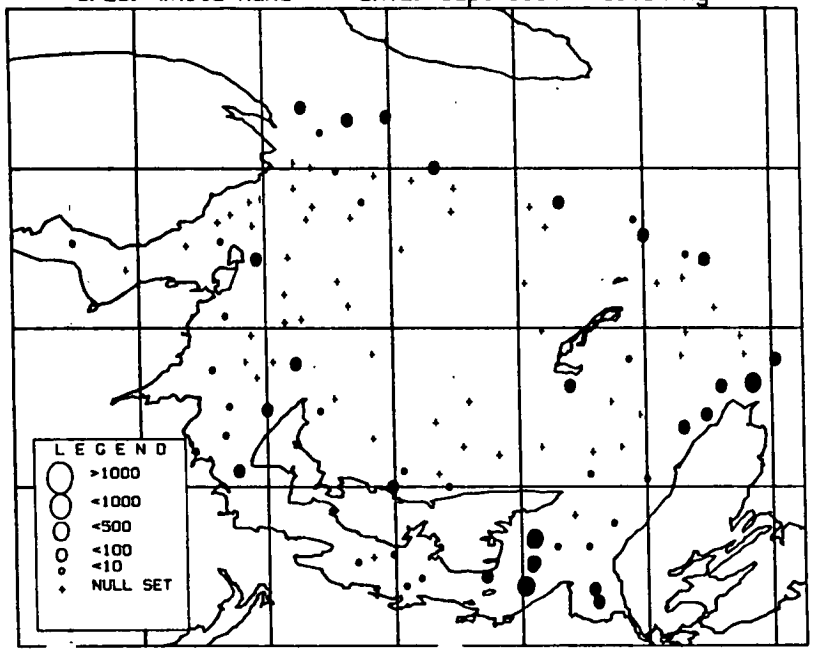
SPEC: White hake DATE: Sept 1982 Catch kg



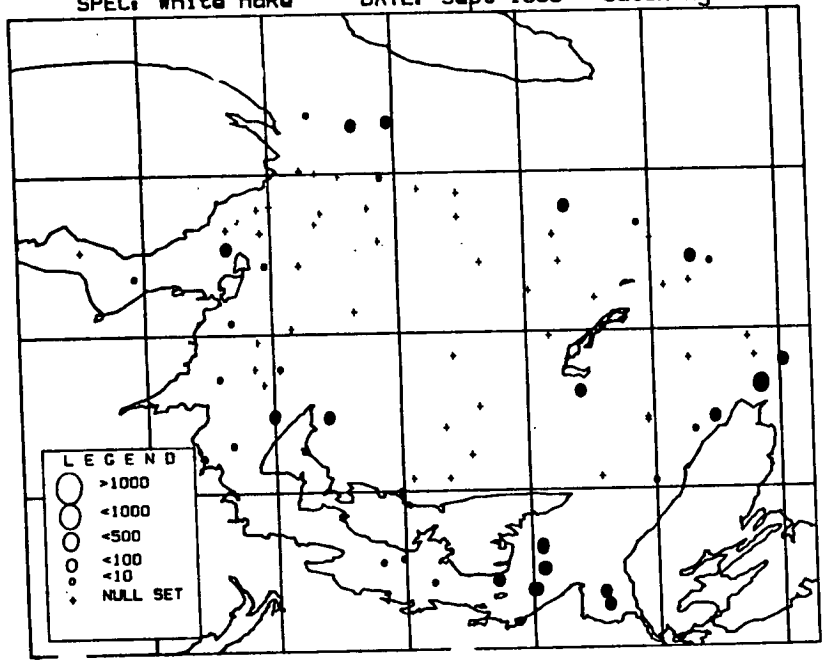
SPEC: White hake DATE: Sept 1983 Catch kg

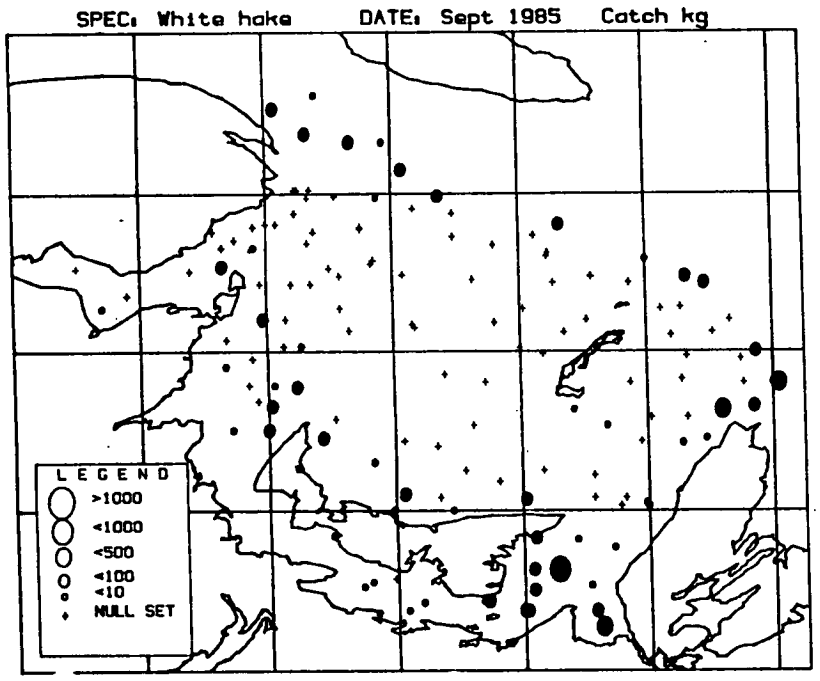


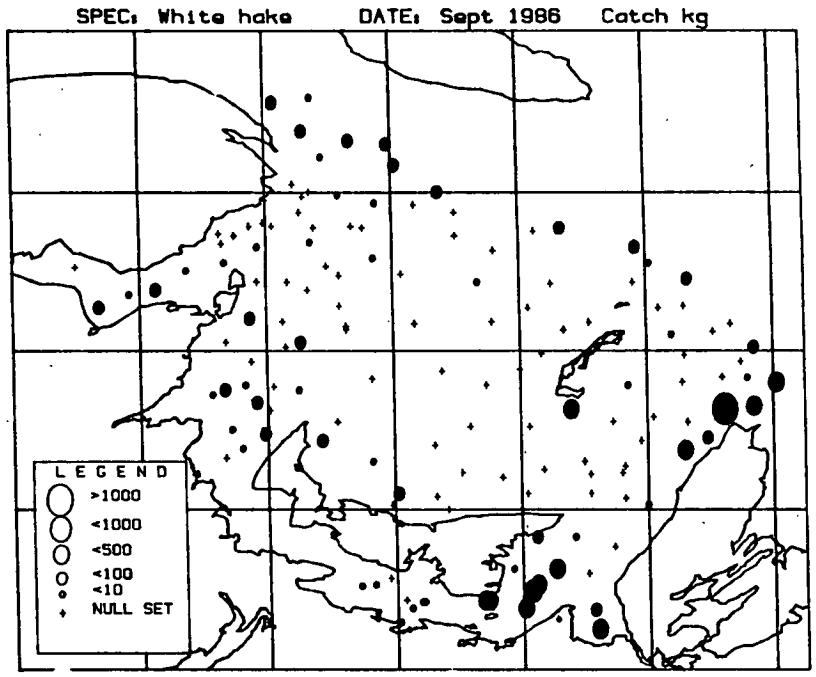
SPEC: White hake DATE: Sept 1984 Catch kg

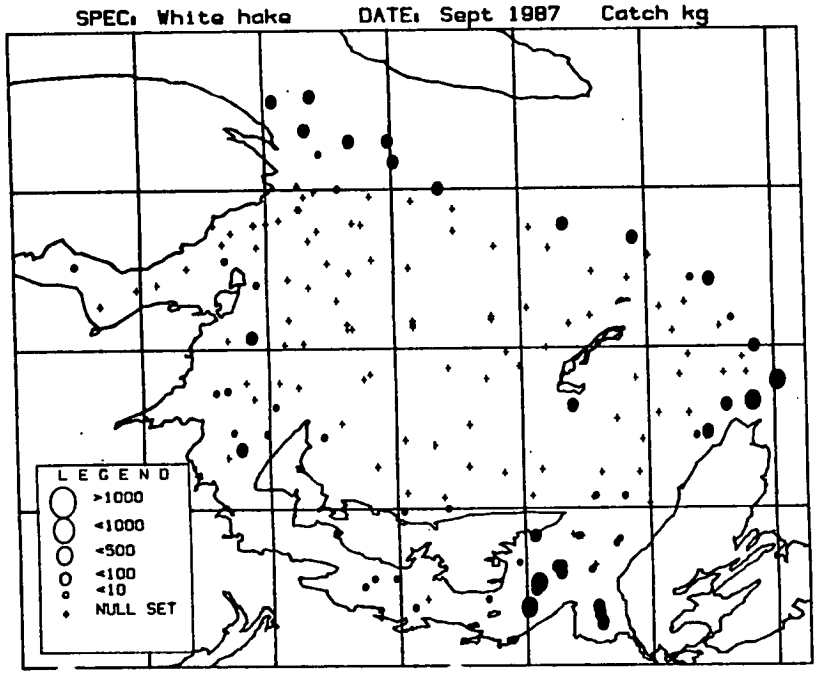


SPEC: White hake DATE: Sept 1985 Catch kg




SPEC: White hake DATE: Sept 1985 Catch kg
LEGEND
>1000
<1000
<500
<100
<10
NULL SET


SPEC: White hake DATE: Sept 1986 Catch kg
LEGEND
>1000
<1000
<500
<100
<10
NULL SET


SPEC: White hake DATE: Sept 1987 Catch kg
LEGEND
>1000
<1000
<500
<100
<10
NULL SET

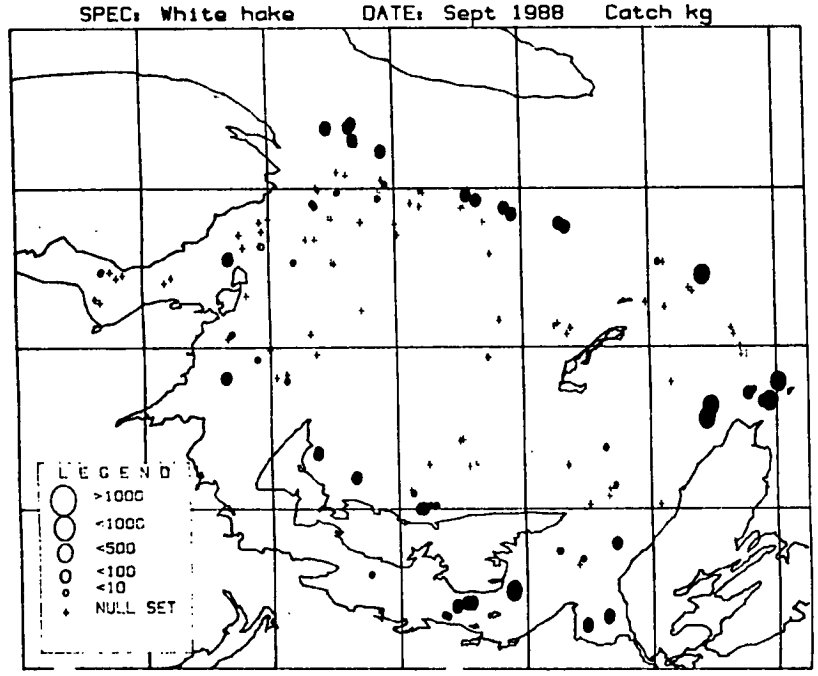

SPEC: White hake DATE: Sept 1988 Catch kg
LEGEND
>1000
<1000
<500
<100
<10
NULL SET

Figure 2. Distribution of white hake in catch weight per tow. Data are from the Quebec Region surveys and only include the portion of the surveys in NAFO Division 4T and are a composite of 1984 to 1987.

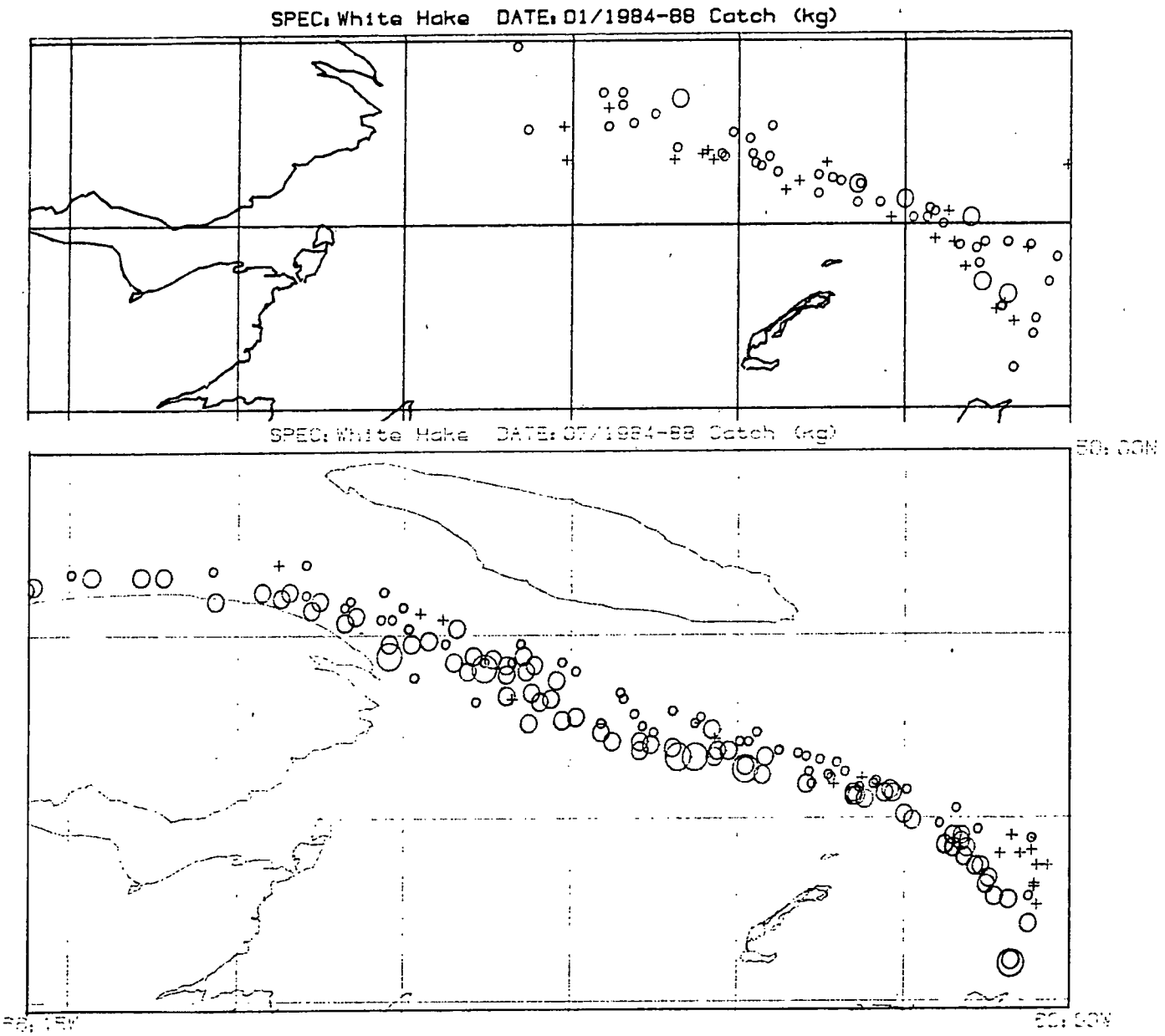


Table 1a. Population at age for white hake estimated from research vessel surveys in the southern Gulf of St. Lawrence (NAFO division 4T) (based on surveys of the entire area selected to comprise a 'single index').

Population at age (Survey) White hake

	random stratified surveys						
	RV E.E. Prince						
AGE	year						
	1978	1979	1980	1981	1982	1983	1984
0	0	0	0	0	0	0	20
1	109	0	25	91	31	234	19
2	4050	482	551	1284	337	1394	262
3	2826	3521	1889	3667	1180	1390	1330
4	4931	3515	3548	6631	1672	1452	2210
5	4223	3407	4466	6183	2318	858	2251
6	1853	2586	1715	4496	817	545	1107
7	602	997	830	1258	714	288	571
8	111	344	445	812	211	130	360
9	44	33	156	202	194	139	107
10	139	40	189	62	1	17	146
11	1	54	31	27	27	1	25
12	37	129	1	104	43	1	23
13	1	1	28	93	1	1	0
total	18927	15109	13874	24910	7546	6450	8431

	fixed station surveys			random stratified survey
	RV E.E. Prince	RV Lady Hammond		
AGE	year			
	1985	1986	1987	1988
0	0	56	0	0
1	190	90	0	8
2	147	450	35	303
3	1139	1749	181	1149
4	383	3632	527	2587
5	160	993	715	2516
6	107	264	83	556
7	88	199	113	139
8	138	135	33	30
9	121	44	0	13
10	71	2	0	38
11	23	70	0	0
12	0	5	0	0
13	0	65	0	0
total	2567	7754	1687	7339

Table 1b. Mean catch per tow for white hake estimated from research vessel surveys in the southern Gulf of St. Lawrence (NAFO division 4T) (based on surveys of the entire area selected to comprise a 'single index').

Mean catch per tow (Survey) White hake

AGE	random stratified surveys RV E.E. Prince year 1978	1979	1980	1981	1982	1983	1984
0	.00	.00	.00	.00	.00	.00	.01
1	.02	.00	.00	.00	.03	.04	.01
2	.69	.08	.09	.16	.05	.27	.14
3	.33	.45	.36	.29	.22	.23	.69
4	.55	.21	.46	.12	.46	.23	1.14
5	.63	.46	.72	.14	.34	.19	1.17
6	.28	.54	.30	.26	.37	.11	.57
7	.09	.23	.15	.22	.22	.06	.30
8	.01	.07	.08	.15	.12	.07	.19
9	.01	.01	.03	.07	.01	.07	.06
10	.02	.01	.07	.00	.03	.01	.08
11	.00	.02	.02	.01	.00	.00	.01
12	.02	.04	.01	.00	.00	.00	.01
13	.00	.00	.00	.04	.00	.00	.00
total	2.65	2.12	2.29	1.46	1.85	1.28	4.38

AGE	fixed station surveys RV E.E. Prince year 1985	RV Lady Hammond 1986	1987	random stratified survey 1988
0	.00	.03	.00	.00
1	.10	.05	.00	.00
2	.08	.23	.02	.15
3	.59	.91	.09	.58
4	.20	1.88	.27	1.30
5	.08	.51	.37	1.26
6	.06	.14	.04	.28
7	.05	.10	.06	.07
8	.07	.07	.02	.01
9	.06	.02	.00	.01
10	.04	.00	.00	.02
11	.01	.04	.00	.00
12	.00	.00	.00	.00
13	0	.03	.00	.00
total	1.34	4.01	.87	3.68

Table 1b. con't

Coefficient of variation of mean catch per tow for white hake estimated from research vessel surveys in the southern Gulf of St. Lawrence (NAFO division 4T) (based on surveys of the entire area selected to comprise a 'single index').

Coefficient of variation of mean catch per tow (Survey) White hake

	random stratified surveys						
	RV E.E. Prince						
AGE	year						
	1978	1979	1980	1981	1982	1983	1984
0							76.10
1	39.69				86.60	40.44	75.09
2	31.20	63.11	46.22	40.38	52.44	46.39	43.63
3	25.08	50.13	41.63	39.37	22.39	33.58	42.53
4	62.77	34.83	22.51	22.71	38.50	45.56	45.53
5	43.23	63.82	24.33	39.46	35.87	25.70	43.26
6	40.24	66.76	24.73	54.71	35.00	28.57	43.71
7	44.04	68.10	22.51	59.03	30.28	46.96	47.95
8	66.51	60.07	29.10	44.03	37.21	25.28	62.24
9	56.04	61.86	43.19	45.72	38.71	9.92	45.24
10	52.08	72.22	40.42	70.99	40.73	74.11	36.01
11		73.27	60.27	51.11			71.77
12	100.00	73.56	100.00	70.99			71.79
13				63.44			

	fixed station survey			random stratified survey
	RV E.E. Prince	RV Lady Hammond		
AGE	year			
	1985	1986	1987	1988
0		100.00		
1	99.65	82.43		44.37
2	75.89	47.25	98.22	40.83
3	72.26	50.83	37.18	59.92
4	35.94	69.57	32.90	47.23
5	30.27	51.27	36.67	25.51
6	26.86	67.26	29.80	20.31
7	43.93	36.95	65.92	76.32
8	52.24	23.92	100.00	100.00
9	82.53	20.99		65.79
10	48.44	100.00		65.55
11	100.00	93.50		
12		50.32		
13		100.00		

Table 1c. Weight at age (kg) of white hake from research vessel surveys in the southern Gulf of St.Lawrence (NAFO division 4T) (based on surveys of the entire area selected to comprise a 'single index').

Mean weight at age (Survey) White hake

AGE	random stratified surveys RV E.E. Prince year 1978	1979	1980	1981	1982	1983	1984
0							.156
1	.106	.152	.250	.075	.075	.114	.168
2	.207	.325	.349	.317	.302	.352	.387
3	.427	.527	.488	.574	.544	.685	.635
4	1.036	.860	.950	1.233	.976	1.126	.948
5	1.480	1.427	1.373	1.664	1.506	1.868	1.395
6	1.911	1.903	1.845	2.302	2.035	2.131	1.901
7	2.662	2.250	2.462	2.916	2.598	2.989	2.366
8	3.625	2.686	3.242	3.208	2.525	4.900	3.044
9	2.000	3.200	3.408	3.275	3.167	3.900	2.668
10	2.067	3.925	5.540	2.500	3.600	6.000	5.348
11	5.200	5.100	3.800	3.400	2.400	5.200	3.474
12	7.200	2.617	11.000	10.267	3.150	5.800	6.250
13	8.000	8.000	8.000	9.500	9.000	8.000	

AGE	fixed station survey RV E.E. Prince year 1985	RV Lady Hammond 1986	1987	random stratified survey 1988
0		.040		
1	.115	.072		.193
2	.129	.267	.201	.246
3	.208	.500	.403	.496
4	.697	.646	.866	.709
5	1.334	.988	1.079	1.029
6	1.990	1.925	1.916	1.492
7	2.959	2.925	3.126	2.652
8	3.269	3.751	3.144	3.177
9	2.851	3.648		6.141
10	3.138	2.017		8.017
11	3.016	7.798		
12		2.652		
13		9.194		

APPENDIX II.

Tables and output of SPA run with a terminal F of 0.65. (See text for details and input parameters.

POPULATION NUMBERS 7/ 7/89

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
3	4978	4449	3751	3761	4609	6619	9337	11533	11146	7663
4	4364	3998	3567	2989	3007	3729	5369	7571	9364	9054
5	2892	2936	2630	2350	1998	2236	2860	4127	5899	7347
6	1634	1651	1687	1482	1328	1294	1480	1952	2954	4308
7	884	929	950	946	800	820	750	912	1273	1928
8	379	390	422	417	369	375	332	354	476	732
9	184	182	191	198	171	180	154	154	168	236
10	86	84	80	81	66	70	60	66	67	83
11	31	33	31	26	22	25	20	24	28	32
12	12	15	15	14	10	11	13	12	15	20
13	4	4	5	5	4	4	3	3	3	5
3+	15450	14671	13327	12270	12384	15364	20378	26707	31394	31408
4+	10472	10222	9576	8509	7775	8744	11041	15175	20248	23745
5+	6108	6224	6010	5520	4768	5015	5672	7604	10884	14691
6+	3216	3288	3380	3170	2770	2779	2812	3477	4985	7343

	1980	1981	1982	1983	1984	1985	1986	1987	1988
3	5556	4887	3988	4225	5413	5614	3850	875	21
4	6193	4466	3942	3260	3408	4378	4523	3151	692
5	6989	4663	3272	3125	2554	2409	3393	3546	2169
6	5265	4796	2851	2187	2023	1379	1458	2350	1742
7	2653	2821	2159	1318	1086	886	618	764	1103
8	976	1104	1069	784	535	422	361	219	250
9	318	319	366	384	287	202	113	89	39
10	103	138	124	166	107	94	58	23	11
11	26	18	30	31	73	41	29	6	5
12	19	15	11	6	21	42	16	4	2
13	6	10	11	1	1	8	7	1	1
3+	28103	23236	17821	15487	15508	15475	14426	11028	6035
4+	22547	18349	13834	11262	10094	9860	10575	10153	6014
5+	16355	13882	9892	8002	6687	5482	6053	7002	5323
6+	9366	9220	6621	4877	4133	3074	2660	3456	3154

MEAN POPULATION BIOMASS (KG) 7/ 7/89

	1970	1971	1972	1973	1974	1975	1976
3	4693733	4191174	3523374	3538337	4361027	6271027	8844238
4	4838846	4386684	3916708	3304107	3495370	4398744	6339892
5	4124689	4199250	3729080	3336532	3018879	3413394	4428207
6	2830276	2875105	2903707	2508442	2389415	2261340	2659884
7	1670801	1777803	1791023	1696096	1552262	1494565	1459474
8	885407	918349	976120	909921	869383	819370	764473
9	455851	442070	456547	428419	404019	389312	371921
10	248887	238340	216230	202404	187883	180284	175062
11	129724	132347	126387	98256	91663	106114	92559
12	50478	63366	61032	55367	43362	39668	44748
13	25493	24509	31954	27314	24143	21110	16594
3+	19954186	19248997	17732162	16105195	16437407	19394928	25197053
4+	15260454	15057823	14208788	12566858	12076380	13123901	16352815
5+	10421607	10671138	10292081	9262751	8581010	8725156	10012922

YEAR	1977	1978	1979	1980	1981	1982	1983
3	10931530	10566704	7247054	5240680	4617329	3792299	4029813
4	8998538	11167352	10712702	7240842	5154518	4724135	3905027
5	6535281	9430009	11640696	10849267	6861049	5017208	4840673
6	3600404	5451883	7738921	8878310	7489963	4503750	3491048
7	1855913	2705818	3870560	4887851	4994344	3755133	2439944
8	822389	1127451	1637718	1937536	2203381	2204717	1586583
9	373093	429539	571139	768959	735402	903091	752966
10	200873	211474	220010	217995	316352	301418	504635
11	111714	139376	144069	117159	83561	86105	172528
12	43918	63772	81395	95771	90594	31010	24983
13	17135	19312	32679	39086	59218	69860	8103
3+	33490788	41312689	43896943	40273455	32605712	25388726	21756303
4+	22559259	30745985	36649889	35032775	27988382	21596427	17726490
5+	13560721	19578633	25937187	27791933	22833864	16872292	13821463

YEAR	1984	1985	1986	1987	1988
3	5072462	5301277	3464833	492701	5102
4	3714442	5371770	3897965	2158814	579187
5	3184116	3806536	4182880	3312106	2185383
6	3043432	2247067	2386505	3366993	2360225
7	1882334	1642722	1068333	1328013	2106253
8	1103495	809632	719727	395483	631931
9	610565	425533	250417	161884	143500
10	301506	254890	128220	67095	46458
11	255675	167582	80480	31454	26035
12	82727	121421	40973	19129	16697
13	7282	41940	24137	6341	8245
3+	19258036	20190371	16244470	11340014	8109015
4+	14185574	14889094	12779636	10847313	8103913
5+	10471133	9517323	8881671	8688499	7524726

CATCH BIOMASS (KG) 7/ 7/89

	1970	1971	1972	1973	1974	1975	1976	1977
3	90300	88200	95550	84000	51450	58800	85050	90300
4	950844	960245	850119	670157	335750	287402	400214	445876
5	1486674	1486674	1391661	1237032	707940	726570	806679	877473
6	1033752	1015616	1099495	1045087	673299	779848	754911	818387
7	1032091	1045926	1115101	1256218	866071	1051460	805197	835634
8	474768	474768	544005	629727	448392	563787	435204	448392
9	263958	274659	299628	385236	278226	353133	238989	235422
10	188286	192769	197252	224150	147939	188286	125524	130007
11	70200	81900	70200	76050	46800	46800	29250	29250
12	48300	55200	55200	62100	34500	48300	62100	55200
13	28479	28479	37972	37972	28479	28479	18986	18986
3+	5667652	5704436	5756183	5707729	3618846	4132865	3762104	3984927
4+	5577352	5616236	5660633	5623729	3567396	4074065	3677054	3894627
5+	4626508	4655991	4810514	4953572	3231646	3786663	3276840	3448751

YEAR	1978	1979	1980	1981	1982	1983	1984	1985
3	82950	94500	95550	69300	5250	60420	62400	86100
4	475422	631210	607036	573461	151759	172800	545670	294680
5	1078677	1551879	1915164	2002725	1017198	1136450	1324310	1149720
6	1235515	2203524	3765487	4479592	2575312	1747140	1905020	1355640
7	954615	1859424	3309332	3848897	3054768	1711290	1401640	1146480
8	567084	1038555	1780380	1991388	1816647	1277580	855950	903900
9	217587	360267	488679	549318	531483	808510	557740	447700
10	116558	210701	336225	421402	354157	316660	232670	248400
11	23400	46800	40950	23400	122850	33350	91800	119510
12	55200	75900	41400	6900	62100	33400	60100	196540
13	18986	37972	47465	75944	85437	10730	9030	61040
3+	4825994	8110732	12427668	14042327	9776961	7308330	7046330	6009710
4+	4743044	8016232	12332118	13973027	9771711	7247910	6983930	5923610
5+	4267622	7385022	11725082	13399566	9619952	7075110	6438260	5628930

YEAR	1986	1987	1988
3	993	17064	60
4	168954	375197	46306
5	699675	1691280	653429
6	1064338	1872514	1225783
7	894838	1217470	1362219
8	863265	602928	410755
9	350365	299320	93275
10	262965	94320	30197
11	151041	24309	16923
12	100142	17344	10853
13	46464	10407	10200
3+	4603040	6222153	3860000
4+	4602047	6205089	3859940
5+	4433093	5829892	3813634

MEAN WEIGHT (g) OF INDIVIDUALS IN CATCH 7/ 7/89

1970	1971	1972	1973	1974	1975	1976	1977
2096.80	2103.41	2151.04	2253.35	2331.73	2411.24	2240.68	2216.31

1978	1979	1980	1981	1982	1983	1984	1985
2218.85	2302.22	2390.86	2421.09	2626.80	2530.59	2224.22	2568.25

1986	1987	1988
2484.10	1846.34	2119.59

MEAN AGE OF INDIVIDUALS IN CATCH 7/ 7/89

1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
5.52	5.53	5.63	5.84	6.01	6.18	5.81	5.77	5.79	5.97	6.17	6.24

1982	1983	1984	1985	1986	1987	1988
6.65	6.49	6.03	6.26	6.34	5.63	6.10

WEIGHTS AT THE BEGINNING OF THE YEAR 7/ 7/89

	1970	1971	1972	1973	1974	1975	1976
3	928.42	928.42	928.42	928.42	928.42	928.42	928.42
4	1140.27	1187.50	1187.50	1187.50	1187.50	1187.50	1187.50
5	1688.86	1581.77	1581.77	1581.77	1581.77	1581.77	1581.77
6	2051.98	2055.10	2055.10	2055.10	2055.10	2055.10	2055.10
7	2534.86	2504.55	2504.55	2504.55	2504.55	2504.55	2504.55
8	3169.76	3020.40	3020.40	3020.40	3020.40	3020.40	3020.40
9	3181.78	3429.34	3429.34	3429.34	3429.34	3429.34	3429.34
10	3924.42	3998.86	3998.86	3998.86	3998.86	3998.86	3998.86
11	5386.53	5121.09	5121.09	5121.09	5121.09	5121.09	5121.09
12	5882.63	6353.35	6353.35	6353.35	6353.35	6353.35	6353.35
13	8093.31	8093.31	8093.31	8093.31	8093.31	8093.31	8093.31
14	.00	11134.76	11134.76	11134.76	11134.76	11134.76	11134.76

table con't next page

table con't from previous page

WEIGHTS AT THE BEGINNING OF THE YEAR 7/ 7/89

	1977	1978	1979	1980	1981	1982	1983
3	928.42	928.42	928.42	928.42	928.42	928.42	926.01
4	1187.50	1187.50	1187.50	1187.50	1187.50	1187.50	1190.59
5	1581.77	1581.77	1581.77	1581.77	1581.77	1581.77	1601.60
6	2055.10	2055.10	2055.10	2055.10	2055.10	2055.10	2033.68
7	2504.55	2504.55	2504.55	2504.55	2504.55	2504.55	2523.94
8	3020.40	3020.40	3020.40	3020.40	3020.40	3020.40	2980.28
9	3429.34	3429.34	3429.34	3429.34	3429.34	3429.34	3382.39
10	3998.86	3998.86	3998.86	3998.86	3998.86	3998.86	3988.59
11	5121.09	5121.09	5121.09	5121.09	5121.09	5121.09	5468.24
12	6353.35	6353.35	6353.35	6353.35	6353.35	6353.35	6989.10
13	8093.31	8093.31	8093.31	8093.31	8093.31	8093.31	8604.48
14	11134.76	11134.76	11134.76	11134.76	11134.76	11134.76	10473.28

	1984	1985	1986	1987	1988	1989
3	960.87	899.59	1091.88	1092.07	512.79	.00
4	1169.36	1202.33	1009.73	902.91	778.92	142.16
5	1501.50	1610.25	1430.90	1125.68	1025.12	1183.17
6	2054.53	1989.45	2113.34	1734.32	1574.64	1598.25
7	2439.18	2492.01	2566.37	2531.89	2403.93	2292.58
8	3012.69	3040.72	3226.62	3246.22	3289.19	3331.59
9	3366.20	3457.02	3911.62	3980.27	4550.20	4275.37
10	3902.99	4029.64	4549.89	5113.15	5069.39	6551.71
11	4524.53	5254.82	5496.20	6733.22	7045.28	7125.13
12	6331.41	5394.50	6707.64	7546.46	9354.81	10062.97
13	8683.35	7239.28	7006.92	8627.94	9381.94	12468.46
14	13259.05	11263.67	10851.90	6950.62	11544.06	8262.65

POPULATION BIOMASS AT BEGINNING OF YEAR 7/ 7/89

	1970	1971	1972	1973	1974	1975	1976
3	4621815	4130548	3482576	3491684	4278832	6145651	8668419
4	4976587	4747722	4235416	3549366	3570694	4428222	6375636
5	4884269	4643760	4159787	3717797	3160223	3537440	4523834
6	3353712	3393480	3466921	3046667	2729595	2658904	3041407
7	2240798	2325945	2378331	2368845	2004126	2054756	1879190
8	1202690	1178637	1275169	1259949	1115193	1132633	1003920
9	585369	623167	653351	678919	586246	618937	529116
10	338439	337568	319626	323585	263733	281106	238549
11	169129	169692	157642	134596	112099	125825	103721
12	72624	95068	92830	91882	63048	68336	82226
13	31988	31421	41492	39189	31217	29675	21092
3+	22477421	21677007	20263142	18702478	17915004	21081485	26467109

	1977	1978	1979	1980	1981	1982	1983
3	10707207	10347818	7114726	5157882	4537324	3702164	3912418
4	8990655	11120301	10751457	7353987	5303725	4680685	3881603
5	6527712	9330931	11621988	11054290	7375079	5175077	5005198
6	4010706	6071254	8852703	10819603	9855893	5859033	4447815
7	2284837	3188182	4829444	6644424	7064098	5407453	3325659
8	1068670	1438092	2212068	2949416	3333435	3227319	2335424
9	528140	575892	808414	1090636	1093845	1255076	1298053
10	265673	268272	331292	410726	551504	494789	663484
11	122108	145826	162096	133309	92105	152618	171076
12	76808	95459	125228	118980	95465	70705	40943
13	21408	22793	41895	51403	80538	92264	10583
3+	34603925	42604821	46851311	45784657	39383011	30117184	25092255

	1984	1985	1986	1987	1988
3	5201575	5050615	4204104	955154	10751
4	3984791	5263729	4566605	2845522	538784
5	3834405	3878750	4855066	3991361	2223075
6	4156815	2744217	3081317	4075790	2743235
7	2647894	2207466	1585399	1934929	2652265
8	1611742	1283472	1164481	710516	822821
9	965336	697131	442635	354431	177529
10	419059	379513	262323	116919	58172
11	329007	213518	159929	40880	32338
12	133670	224280	109364	27522	21470
13	10939	60515	47264	9997	11314
3+	23295233	22003205	20478489	15063022	9291755

DISTRIBUTION OF GROWTH OVER AGES (PER CENT) 7/ 7/89

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
3	24.3	22.1	20.3	22.4	27.2	32.5	34.9	32.2	25.4	16.7	13.5	14.9
4	33.4	26.7	26.1	24.3	25.4	26.6	29.2	31.0	31.4	28.8	21.7	19.3
5	17.3	24.6	24.0	23.6	20.5	19.3	18.9	20.7	24.3	28.8	30.2	24.3
6	12.1	12.3	13.6	13.0	12.1	9.5	8.5	8.6	10.6	14.4	18.7	20.0
7	6.4	7.5	8.3	8.8	7.7	6.3	4.6	4.3	5.1	7.0	10.2	13.2
8	1.5	2.8	3.3	3.6	3.2	2.6	1.8	1.4	1.6	2.3	3.3	4.6
9	2.3	1.3	1.4	1.4	1.4	1.1	.8	.6	.6	.7	1.1	1.3
10	1.5	1.3	1.3	1.4	1.2	1.0	.7	.6	.5	.5	.6	1.1
11	.5	.7	.7	.6	.5	.5	.3	.3	.3	.3	.3	.2
12	.4	.3	.3	.3	.2	.2	.2	.1	.1	.2	.2	.3
13	.4	.4	.6	.5	.5	.4	.2	.2	.2	.2	.3	.6

	1982	1983	1984	1985	1986	1987	1988
3	15.8	20.1	25.0	15.2	-44.6	-11.1	-.2
4	23.8	19.4	25.9	22.1	25.1	6.8	7.9
5	21.7	26.9	19.1	25.6	50.8	40.8	31.6
6	15.8	13.8	12.4	14.9	26.5	41.4	29.3
7	12.3	10.4	9.1	9.9	15.7	13.7	23.0
8	5.5	4.8	3.6	5.2	13.2	5.5	5.6
9	2.0	1.7	2.1	2.3	5.0	1.3	1.7
10	1.5	1.8	1.9	1.8	4.5	.9	.5
11	.5	.7	.8	1.1	2.3	.4	.3
12	.1	.2	.1	1.0	.6	.2	.2
13	.9	.2	.1	.8	.8	.2	.2

PRODUCTION 7/ 7/89

SOURCE	1970	1971	1972	1973	1974
RECRUITMENT BIOMASS	4621815	4130548	3482576	3491684	4278832
GROWTH	4746717	4675725	4273246	3879534	3944619
TOTAL PRODUCTION	9368532	8806273	7755822	7371218	8223451
LOSS THROUGH FISHING	5667652	5704436	5756183	5707729	3618846
SURPLUS PRODUCTION	5377695	4956474	4209389	4150179	4935970
NET PRODUCTION	-289957	-747962	-1546794	-1557550	1317124

SOURCE	1975	1976	1977	1978	1979
RECRUITMENT BIOMASS	6145651	8668419	10707207	10347818	7114726
GROWTH	4742647	6243402	8349135	10236025	10689493
TOTAL PRODUCTION	10888297	14911821	19056342	20583843	17804218
LOSS THROUGH FISHING	4132865	3762104	3984927	4825994	8110732
SURPLUS PRODUCTION	7009312	9872410	12358184	12321305	9024830
NET PRODUCTION	2876447	6110306	8373257	7495311	914098

table con't on next page

table con't from previous page

PRODUCTION 7/ 7/89

SOURCE	1980	1981	1982	1983	1984
RECRUITMENT BIOMASS	5157882	4537324	3702164	3912418	5201575
GROWTH	9571014	7635433	5963535	4666587	4560673
TOTAL PRODUCTION	14728896	12172757	9665700	8579004	9762248
LOSS THROUGH FISHING	12427668	14042327	9776961	7308330	7046330
SURPLUS PRODUCTION	6674205	5651615	4587954	4227744	5910641
NET PRODUCTION	-5753463	-8390712	-5189007	-3080586	-1135689

SOURCE	1985	1986	1987	1988
RECRUITMENT BIOMASS	5050615	4204104	955154	10751
GROWTH	4345479	1488987	2711244	3074430
TOTAL PRODUCTION	9396094	5693091	3666398	3085181
LOSS THROUGH FISHING	6009710	4603040	6222153	3860000
SURPLUS PRODUCTION	5358019	2444197	1398395	1463378
NET PRODUCTION	-651691	-2158843	-4823758	-2396622

PRODUCTION/BIOMASS RATIO 7/ 7/89

1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
.47	.46	.44	.46	.50	.56	.59	.57	.50	.41	.37	.37	.38	.39

1984	1985	1986	1987	1988
.51	.47	.35	.32	.38

FISHING MORTALITY 7/ 7/89

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	.019	.021	.027	.024	.012	.009	.010	.008	.008	.013	.018
4	.197	.219	.217	.203	.096	.065	.063	.050	.043	.059	.084
5	.360	.354	.373	.371	.235	.213	.182	.134	.114	.133	.177
6	.365	.353	.379	.417	.282	.345	.284	.227	.227	.285	.424
7	.618	.588	.623	.741	.558	.704	.552	.450	.353	.480	.677
8	.536	.517	.557	.692	.516	.688	.569	.545	.503	.634	.919
9	.579	.621	.656	.899	.689	.907	.643	.631	.507	.631	.636
10	.757	.809	.912	1.107	.787	1.044	.717	.647	.551	.958	1.542
11	.541	.619	.555	.774	.511	.441	.316	.262	.168	.325	.350
12	.957	.871	.904	1.122	.796	1.218	1.388	1.257	.866	.932	.432
13	.630	.680	.710	.950	.700	.900	.660	.620	.490	.680	.740
6+	.482	.471	.502	.604	.434	.556	.424	.348	.301	.392	.567

	1981	1982	1983	1984	1985	1986	1987	1988
3	.015	.001	.015	.012	.016	.000	.035	.012
4	.111	.032	.044	.147	.055	.043	.174	.080
5	.292	.203	.235	.416	.302	.167	.511	.299
6	.598	.572	.500	.626	.603	.446	.556	.519
7	.771	.813	.701	.745	.698	.838	.917	.647
8	.904	.824	.805	.776	1.116	1.199	1.525	.650
9	.747	.589	1.074	.913	1.052	1.399	1.849	.650
10	1.332	1.175	.628	.772	.975	2.051	1.406	.650
11	.280	1.427	.193	.359	.713	1.877	.773	.650
12	.076	2.003	1.337	.726	1.619	2.444	.907	.650
13	.820	.750	.870	.770	1.030	1.610	1.260	.650
6+	.702	.710	.652	.696	.758	.745	.737	.577

Appendix III.

Tables and output of projection run with an F of 0.30, approximating Fo.1. (See text for details and input parameters.

POPULATION NUMBERS 7/ 7/89

	1988	1989	1990	1991	1992	1993
3	5500	5500	5500	5500	5500	5500
4	692	4503	4479	4479	4479	4479
5	2169	523	3553	3534	3534	3534
6	1742	1317	373	2534	2520	2520
7	1103	849	848	240	1632	1624
8	250	473	515	515	146	992
9	39	107	287	313	313	89
10	11	17	65	174	190	190
11	5	5	10	39	106	115
12	2	2	3	6	24	64
13	1	1	1	2	4	14
3+	11514	13295	15634	17336	18447	19120
4+	6014	7795	10134	11836	12947	13620
5+	5323	3293	5656	7357	8468	9141
6+	3154	2770	2103	3823	4934	5607

POPULATION BIOMASS (KG) (AVERAGE) 7/ 7/89

	1988	1989	1990	1991	1992	1993
3	3148730	3140593	3140593	3140593	3140593	3140593
4	553445	3677770	3658126	3658126	3658126	3658126
5	2309448	600068	4078125	4056342	4056342	4056342
6	2552356	2188865	619873	4212726	4190225	4190225
7	2107246	1891916	1891193	535574	3639820	3620379
8	631762	1395770	1520659	1520077	430476	2925565
9	124148	397454	1066671	1162113	1161668	328977
10	45091	76550	297699	798952	870439	870106
11	23798	29706	61261	238241	639380	696590
12	13720	13701	20776	42845	166623	447175
13	4316	7282	8833	13394	27622	107423
3+	11514066	13419681	16363813	19378988	21981320	24041506
4+	8365335	10279087	13223219	16238394	18840726	20900912
5+	7811890	6601317	9565093	12580268	15182600	17242786
6+	5502441	6001249	5486968	8523925	11126257	13186444

CATCH BIOMASS (KG) 7/ 7/89

	1988	1989	1990	1991	1992	1993
3	140	16959	16959	16959	16959	16959
4	44248	135710	134985	134985	134985	134985
5	690525	82809	562781	559775	559775	559775
6	1325566	524671	148584	1009791	1004397	1004397
7	1362861	564737	564521	159869	1086486	1080683
8	410645	418731	456198	456023	129143	877670
9	80696	119236	320001	348634	348501	98693
10	29310	22965	89310	239686	261132	261032
11	15469	8912	18378	71472	191814	208977
12	8919	4111	6233	12854	49987	134153
13	9480	2185	2650	4018	8287	32227
3+	3977858	1901027	2320601	3014066	3791466	4409551
4+	3977719	1884067	2303641	2997107	3774507	4392592
5+	3933471	1748358	2168657	2862122	3639522	4257607
6+	3242945	1665548	1605875	2302347	3079747	3697832

MEAN WEIGHT (g) OF INDIVIDUALS IN CATCH 7/ 7/89

1988	1989	1990	1991	1992	1993
2184.3	2280.6	2169.1	2178.7	2305.1	2444.6

FISHING MORTALITY 7/ 7/89

	1988	1989	1990	1991	1992	1993
3	.000	.005	.005	.005	.005	.005
4	.080	.037	.037	.037	.037	.037
5	.299	.138	.138	.138	.138	.138
6	.519	.240	.240	.240	.240	.240
7	.647	.299	.299	.299	.299	.299
8	.650	.300	.300	.300	.300	.300
9	.650	.300	.300	.300	.300	.300
10	.650	.300	.300	.300	.300	.300
11	.650	.300	.300	.300	.300	.300
12	.650	.300	.300	.300	.300	.300
13	2.195	.300	.300	.300	.300	.300
3+	.219	.077	.083	.097	.109	.116

PRODUCTION 7/ 7/89

SOURCE	1988	1989	1990	1991	1992	1993
RECRUITMENT BIOMASS	2882910	2882910	2882910	2882910	2882910	2882910
GROWTH	4179497	4684456	5740874	6838876	7611725	8118473
TOTAL PRODUCTION	7062407	7567365	8623784	9721786	10494634	11001383
LOSS THROUGH FISHING	3977858	1901027	2320601	3014066	3791466	4409551
SURPLUS PRODUCTION	4759594	4883429	5351021	5845989	6098370	6193081
NET PRODUCTION	781736	2982403	3030420	2831922	2306904	1783530

PRODUCTION/BIOMASS RATIO 7/ 7/89

1988	1989	1990	1991	1992	1993
.61	.56	.53	.50	.48	.46

SUMMARY OF PROJECTIONS 7/ 7/89

YEAR	1988	1989	1990	1991
POPULATION NUMBERS	11514.47	13295.35	15634.41	17336.24
POPULATION BIOMASS	11514066.18	13419681.40	16363813.38	19378988.35
CATCH	3977858.16	1901026.59	2320600.65	3014066.32
F OR QUOTA	3977858.16	.30	.30	.30

YEAR	1992	1993
POPULATION NUMBERS	18446.98	19120.27
POPULATION BIOMASS	21981320.39	24041506.56
CATCH	3791466.40	4409551.42
F OR QUOTA	.30	.30

AGE GROUPS CONSIDERED:3+

Tables and output of projection run with an F of 0.60, approximating twice Fo.1 or about equal to the F of the last several years. (See text for details and input parameters.

POPULATION NUMBERS 7/ 7/89

	1988	1989	1990	1991	1992	1993
3	5500	5500	5500	5500	5500	5500
4	692	4503	4455	4455	4455	4455
5	2169	523	3424	3388	3388	3388
6	1742	1317	325	2127	2105	2105
7	1103	849	667	165	1078	1067
8	250	473	382	301	74	486
9	39	107	213	172	135	33
10	11	17	48	96	77	61
11	5	5	7	22	43	35
12	2	2	2	3	10	19
13	1	1	1	1	2	4
3+	11514	13295	15025	16228	16866	17152
4+	6014	7795	9525	10728	11366	11652
5+	5323	3293	5070	6274	6911	7198
6+	3154	2770	1646	2886	3524	3810

POPULATION BIOMASS (KG) (AVERAGE) 7/ 7/89

	1988	1989	1990	1991	1992	1993
3	3148730	3132418	3132418	3132418	3132418	3132418
4	553445	3613370	3574714	3574714	3574714	3574714
5	2309448	562679	3685494	3646066	3646066	3646066
6	2552356	1963345	484337	3172362	3138424	3138424
7	2107246	1655885	1302458	321303	2104504	2081990
8	631762	1220886	986861	776228	191487	1254226
9	124148	347655	691199	558707	439458	108410
10	45091	66959	192908	383535	310017	243848
11	23798	25984	39697	114367	227381	183796
12	13720	11985	13463	20567	59255	117811
13	4316	6369	5724	6430	9823	28301
3+	11514066	12607540	14109277	15706703	16833554	17510008
4+	8365335	9475122	10976859	12574284	13701135	14377589
5+	7811890	5861751	7402144	8999569	10126420	10802874
6+	5502441	5299072	3716650	5353503	6480354	7156808

CATCH BIOMASS (KG) 7/ 7/89

	1988	1989	1990	1991	1992	1993
3	140	33830	33830	33830	33830	33830
4	44248	266667	263814	263814	263814	263814
5	690525	155300	1017196	1006314	1006314	1006314
6	1325566	941228	232191	1520831	1504561	1504561
7	1362861	988564	777567	191818	1256389	1242948
8	410645	732532	592117	465737	114893	752536
9	80696	208593	414720	335225	263675	65046
10	29310	40175	115745	230121	186011	146309
11	15469	15591	23818	68620	136429	110278
12	8919	7191	8078	12341	35554	70687
13	9480	3822	3435	3858	5894	16981
3+	3977858	3393492	3482512	4132510	4807363	5213303
4+	3977719	3359662	3448682	4098679	4773533	5179473
5+	3933471	3092996	3184868	3834865	4509719	4915659
6+	3242945	2937696	2167672	2828551	3503405	3909345

MEAN WEIGHT (g) OF INDIVIDUALS IN CATCH 7/ 7/89

1988	1989	1990	1991	1992	1993
2184.3	2238.5	1989.2	1932.5	2001.6	2068.7

FISHING MORTALITY 7/ 7/89

	1988	1989	1990	1991	1992	1993
3	.000	.011	.011	.011	.011	.011
4	.080	.074	.074	.074	.074	.074
5	.299	.276	.276	.276	.276	.276
6	.519	.479	.479	.479	.479	.479
7	.647	.597	.597	.597	.597	.597
8	.650	.600	.600	.600	.600	.600
9	.650	.600	.600	.600	.600	.600
10	.650	.600	.600	.600	.600	.600
11	.650	.600	.600	.600	.600	.600
12	.650	.600	.600	.600	.600	.600
13	2.195	.600	.600	.600	.600	.600
3+	.219	.153	.152	.172	.189	.195

PRODUCTION 7/ 7/89

SOURCE	1988	1989	1990	1991	1992	1993
RECRUITMENT BIOMASS	2882910	2882910	2882910	2882910	2882910	2882910
GROWTH	4179497	4473737	5093834	5772673	6146839	6332299
TOTAL PRODUCTION	7062407	7356647	7976744	8655583	9029749	9215209
LOSS THROUGH FISHING	3977858	3393492	3482512	4132510	4807363	5213303
SURPLUS PRODUCTION	4759594	4835139	5154889	5514242	5663038	5713207
NET PRODUCTION	781736	1441646	1672377	1381732	855675	499904

PRODUCTION/BIOMASS RATIO 7/ 7/89

1988	1989	1990	1991	1992	1993
.61	.58	.57	.55	.54	.53

SUMMARY OF PROJECTIONS 7/ 7/89

YEAR	1988	1989	1990	1991
POPULATION NUMBERS	11514.47	13295.35	15024.82	16228.48
POPULATION BIOMASS	11514066.18	12607540.97	14109277.88	15706703.29
CATCH	3977858.16	3393492.47	3482512.10	4132509.51
F OR QUOTA	3977858.16	.60	.60	.60

YEAR	1992	1993
POPULATION NUMBERS	16866.11	17152.31
POPULATION BIOMASS	16833554.34	17510008.17
CATCH	4807363.46	5213303.29
F OR QUOTA	.60	.60

AGE GROUPS CONSIDERED:3+