Canadian Atlantic Fisheries Scientific Advisory Committee

Comité scientifique consultatif des pêches canadiennes dans l'Atlantique

CAFSAC Research Document 86/98

CSCPCA Document de recherche 86/98

An evaluation of the population dynamics of 4X haddock during 1962-85 with yield projected to 1987.

by

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Abstract

In this evaluation of the 4X haddock resource, a number of new technical innovations were introduced. First, sampling and survey data were available for the first half of 1986 and were used in the estimation, by cohort analysis, of the beginning of 1986 population size. Variance estimates were also calculated for both data sets, in the latter case these being derived from the delta distribution transformation. Comparison of the variance in the catch, and thus cohort analysis-derived population numbers, with the survey variance led to a calibration model employing the survey data as the dependent variable. In addition, a log transformation was used to homogenize the variance on both the y and x axis. The criterion for choice of the 1986 age-specific fishing mortalities was minimization of the cohort-specific standardized residuals around the age specific relationships. Based on residual distributions, the cohort analysis calibrated with a log model was considered superior to that tuned with a linear model.

The analytical results provide a 1986 fully recruited fishing mortality of 0.38, which is only slightly more optimistic than the previous assessment. Fishable biomass has been stable over the last three years but is expected to decline in the near future due to recent recruitment being weak to average. This has already been reflected in commercial catch rates. Given a 1986 TAC of 15,000 t, the $F_{0.1}$ catch in 1987 will be about 12,300 t, well below the long-term average of 20,000 t seen for this resource.

Résumé

Dans la présente évaluation des ressources en aiglefin en 4X, un certain nombre de nouvelles techniques ont été introduites. On a d'abord utilisé les données d'échantillonnage et d'enquête recueillies au cours des six premiers mois de 1986 pour déterminer, par analyse de cohorte, la taille de la population au début de 1986. Les variances des deux séries de données ont également été calculées; dans le dernier cas, les variances obtenues résultent d'une transformation de distribution delta. En comparant la variance relative aux captures, et de ce fait le nombre de poissons de la population calculé à partir de l'analyse de cohorte, avec la variance des données d'enquête, on obtient un modèle d'étalonnage utilisant les données de relevé comme variable dépendante. On a ensuite eu recours à une transformation logarithmique pour uniformiser la variance sur les axes y et x. Le critère de sélection des mortalités de 1986 dues à la pêche pour un âge donné a été la réduction de l'importance des résiduels normalisés résultant de l'analyse de cohorte et relatifs à l'âge. Compte tenu des distributions résiduelles, l'analyse de cohorte calibrée avec un modèle logarithmique s'est révélée supérieure à celle mise au point avec un modèle linéaire.

Selon les résultats d'analyse, la mortalité due à la pêche pour un recrutement total a été en 1986 de 0,38, ce qui est légèrement plus encourageant que les résultats de l'évaluation précédente. Le recrutement varie depuis quelque temps de moyen à faible et bien que la biomasse qui peut être pêchée ait été stable au cours des trois dernières années, il devrait néanmoins diminuer. Cette diminution a déjà commencé à se répercuter sur les taux de prises commerciales. Compte tenu d'un TPA de 15 000 t en 1986, la prise $F_{0.1}$ sera d'environ 12 300 t en 1987, ce qui est de beaucoup inférieur à la prise moyenne à long terme de 20 000 t en ce qui concerne cette ressource.

Introduction

Sequential Population Analysis (SPA) has been used to provide estimates of the size of the haddock population in NAFO Division 4X since 1974. These analyses have been tuned using groundfish survey data, both US and Canadian. Commercial catch rate indices have also been used, although their utility has been limited by problems in data quality. Since 1980 US survey coverage in NAFO Division 4X has been incomplete. Consequently, the Canadian summer bottom trawl data have been used almost exclusively to tune the SPA.

The survey data have been treated in various ways to account for the presence of sets with unusually large abundance. In particular, these sets have been either removed or a Winsoring technique been employed. Smith (pers. comm.) has stated that a transformation of the data that can account for unusually large sets is more appropriate. Pennington (1983) illustrated the use of the delta distribution in the treatment of large survey sets. This method was investigated in this assessment.

Tuning of the SPA has been effected using a variety of procedures. Initial efforts used geometric mean regressions between SPA abundance and survey index, generally aggregated across age groups. More recently, age by age tuning has been conducted, using as criteria, maximization of the correlation coefficient (r) and attainment of a zero origin. Mohn (1983) showed that examination of the residuals of the last point would provide a more appropriate criterion. Doubleday (1981) used a combination of age by age regressions and cohort by cohort residuals in his "survivor analysis" to effect tuning. In the 1984 assessment, in addition to the survivor analysis, tuning of the SPA was conducted through minimization of the last point's residual in SPA-RV (research survey) plots. This places a high degree of weight on the accuracy of the last point in the data series. Consequently, this and the 1985 assessment tuned the SPA by minimization of a cohort's standardized residuals.

This assessment presents a structured examination of the assumption underlying the statistical models used in tuning the SPA. A major component of this is examination of error distributions in the SPA and RV data sets.

The stock sizes for 1962-85 are given and yield projected to 1987, under $F_{0.1}$ conditions.

Trends in Reported Landings

Annual Trends

The long-term (1930-1983) average annual catch for 4X haddock is about 20,000 t. This level has rarely been maintained for long

periods. Prior to the mid-1960s, Canadian and US fishing vessels landed 15,000-20,000 t annually. In 1965-66, the Canadian offshore fleet expanded rapidly and displaced US fishing effort. As well, landings by the USSR substantially increased. A combination of high exploitation rates and declining recruitment caused a sharp stock decline which provoked the establishment of quotas and closed spawning areas in 1970 in an attempt to curb fishing effort (Figure 1).

The resource showed signs of recovery in the mid-1970s and yield steadily increased to reach a maximum of almost 31,000 t by 1981. During this recovery period, TACs were consistently overrun (Table 1). Indeed, there was at that time concern about the large levels of discarding and misreporting by species and area of landings. In 1982, the TAC was set high in anticipation of high stock abundance but during 1982-1984 the catch fell substantially short of the TAC, with the largest shortfall occurring in the last year. In 1984 and 1985, the large offshore trawlers decided to stay out of 4X, due to poor catch rates. In the fleet with vessels under 65' LOA, the fixed gear experienced considerable difficulty in meeting their allocation (Table 2). This was blamed on high by-catch of dogfish. The 1985 TAC was very restrictive and in the inshore sector caused overruns of allocations late in the year (Table 2). This prompted the establishment of seasonal allocations in 1986. It might be noted that in the spring of 1985 the tonnage class 2 and 3 dragger fleets fished Divisions 4VW much more extensively than in previous years due to the low quota and catch rates in Division 4X and the high catch rates in Division 4VW. In addition, about 2,000 t of haddock were reported from Division 5Ze by tonnage class 1 to 3 draggers in the third quarter of 1985. This is uncharacteristically high and is suspected to have been misreported Division 4X haddock. However, this could not be confirmed and consequently this catch was not included in this assessment.

Fishing in 1986 is far behind that of 1985 but ahead of that in 1982-84 (Table 2).

Canadian Fishery by Gear Type, Tonnage Class, and Unit Area

During the mid-1960s, activity by the large offshore trawler fleet represented the predominant amount of fishing effort directed on the resource. This fleet fished (and still does) primarily in unit areas 4Xp and 4Xn (Figure 2) during the beginning and end of the year. Since the recovery of the stock in the mid-1970s, the activities of the tonnage class one to three vessels have dramatically increased. This fleet now lands the majority of the catch. The small draggers fish in unit areas 4Xp and 4Xn in the spring and move into 4Xp and 4Xr during the summer and fall. The longliners on the other hand restrict their efforts to 4Xm, 4Xn, 4Xo, and 4Xp throughout the year. Expansion of longline fleet effort has not been as great as that of the dragger fleet (Table 3).

Catch by miscellaneous gears such as gillnets and traps has always been less than 2,500 t annually.

Age Composition of the Commercial Catch

Sampling Intensity

Since 1970, sampling for this resource has been generally good (Table 3). Prior to 1981 however, sampling was weighted heavily toward the offshore fleet and consequently sampling of inshore fleet catches was scanty. Since that time, sampling has been excellent with rates of one sample per 200-300 t landed being attained. Sampling was particularly good in 1985 and the first half of 1986.

Construction of 1962-85 Catch at age

Construction of the catch-at-age matrix prior to 1978 is discussed by O'Boyle (1981). No adjustment has been made for the USSR catches in the mid-1960s. The length frequency of these landings was assumed to be the same as that for Canada. This is probably an inappropriate assumption and efforts are presently underway to rectify this. However this should be kept in mind when analyzing the present data set for recruitment studies.

Construction of the 1978-84 catch at age is discussed by O'Boyle and Gregory (1985). The 1985 catch at age was constructed using the sampling stratum-sample availability table given in Table 4a. That for the first half of 1986 is given in Table 4b. This is in keeping with the practice followed since 1982.

For 1979-86, only Canadian sampling was used as no foreign sampling data were available. No correction for discarding and/or misreporting has been applied.

Trends in Age Composition

The 1985 observed age composition (Table 5a) was predicted quite well by O'Boyle and Gregory (1985). The catch of the 1981 and 1982 year-class was higher than expected, however (Table 6, Figure 3). The dominant feature of the 1985 fishery is the dependence on the 1980 year-class, which makes up almost half the weight of the entire catch (Table 5a). The 1981 year-class is dominant in the first half of the 1986 fishery (Table 5b).

The 1985 weights at age (Figure 4) compare favourably with those in 1984 but for ages 3-7 are slightly smaller than the average for the 1981-84 period, in keeping with the trend of declining weights at age shown by O'Boyle and Gregory (1985).

The average age of a fish in the catch is relatively young but stable since 1981 (Figure 5) while the average weight has exhibited a continuous decline since 1980.

Estimates of Variance in the Catch

The MFD age-length key system for extraction of commercial samples does not calculate variance estimates. Thus the system developed by the Gulf Region was used instead. This software generates an identical output to that of MFD but also incudes variance estimates assuming a simple multinomial model (Gavaris and Gavaris, 1983). There are indications that the simple multinomial assumption is incorrect (Smith and Maguire, 1983). Nevertheless, the Gulf software provides minimum variance estimates that can allow examination of overall patterns in precision.

The catch at age for 1980-85 was recalculated using the Gulf Region software to generate the variance and coefficient of variation (CV) estimates provided in Table 7a and 7b. CVs were highest for the youngest and oldest age groups while being relatively low for the middle age groups.

White (pers. comm.) has derived a formula which allows estimation of the variance in the integrated catch at age (Table 7 c, d, and e). This variance was used as an estimate of the variance in the population numbers at age generated by the sequential population analysis. Unlike the unintegrated variance, the CVs for the integrated catch decreases continuously with decreasing age. This is understandable as increasingly more information is accumulated along a cohort the longer its catch history.

Finally, age specific plots of the integrated catch variance versus the mean integrated catch (Figure 6) exhibit strong heteroscedasticity. This has significant implications for the tuning models to be discussed later.

Stock Abundance Trends

Commercial Catch Rates

Commercial catch rate indices were developed for various fleet sectors operating in 4X (Table 8). As was pointed out by O'Boyle et al. (1984), use of the multiplicative model (Gavaris, 1980) in the analysis of this data set, on an age-aggregated basis, was not considered appropriate.

Most indices exhibit declines in catch rates since the early 1980s, particularly during the first quarter (Figures 7-9). The most consistent trends are shown for otter trawlers, TC 2-3 (Figure 7). Catch rates for the tonnage class 4-5 otter trawlers also decreased

during 1980-85 in the first quarter but showed a dramatic increase in 1986. Examination of the raw data disclosed that only one trip (Cape John during 4 February-5 March) was present on the file. This boat had an exceptionally good trip which was not uncharacteristic when compared to those in recent previous years. For this reason, the 1986 data were not used in this time series.

Longline catch rates (Figure 9) show a continuous decline since the mid-late 1970s.

These trends were further examined after application of the sampling data. First the gear specific catch at age for the various gear sectors was calculated (Table 9). Then, the catch rates in Table 8 were split across the age groups recording the age structure (Table 10). The resulting age structured catch rate data clearly show (Figure 10) dramatic declines in catch rates since the late 1970s.

Groundfish Bottom Trawl Surveys

Standardized Canadian summer bottom trawl survey have been conducted in 4X since 1970. The vessel used during 1970-81 was the A.T. Cameron. In 1982 the Lady Hammond was used and in 1983 and 1984, the Alfred Needler was used. In the 1983 and 1984 assessments, discussion of conversion factors was extensive. In 1985, a conversion factor of 1.22 ATC = LH = AN was used. The SSS Subcommittee of CAFSAC met to decide the appropriate conversion factors and has recommended that the A.T. Cameron values be adjusted upward by a factor of 1.2 i.e. 1.2 ATC = LH = AN. This was done here.

Variability in the survey data is very high. For the last three years, some of this variation has been reduced by deletion of tows with exceptionally high catch rates. The justification of this is weak and ideally application of a transformation to the entire data set is required.

Pennington (1983) applied the delta distribution to sets of plankton and groundfish survey data with satisfactory results. Smith (pers. comm.) conducted an evaluation of this transformation and found it superior in performance to either the arithmetic mean or the log-normal transform as applied by O'Boyle and Gregory (1985) when the data followed a Gaussian distribution. The major problem is the small sample sizes which makes the variance calculation unreliable and thus also the re-transformed mean.

The arithmetic and delta parameters for the summer survey data are given in Tables 11 and 12. Based on recent CAFSAC recommendations, treatment of the data with the log-normal transform was not undertaken.

A comparison of the age compositions of the arithmetic and delta data sets (Table 13) revealed a great deal of similarity except for

three cells (1981, age 1 and 2; 1982, age 1). Investigation of the raw data in these cases uncovered exceptionally high variance in strata 80 and 90 which distorted the delta means (Table 12b).

The population abundance trends observed in the two data treatments are very similar. They exhibit peaks and valleys since 1970, generally indicating an increasing trend except perhaps for the last three years. When examined on an age-group basis, they indicate a continual increase in numbers of age 2-5 haddock since the mid-1970s. The abundance of age 6-9 haddock first increased between 1975 and 1977 and decrease subsequently. The abundance trends for the age 2-5 haddock are substantially different from those observed in the commercial catch rates at age during the same period (Figures 11 and 12).

The discrepancy between survey and commercial catch rates can be due to a number of factors. The survey data may be suspect due to vessel changes as well as areal and seasonal coverage problems. The commercial data are suspect due to misreporting and discarding problems as well as changes in trawl mesh size in recent years. It was considered that the survey data, although variable, is more reflective of trends in population abundance. It was thus used to calibrate the SPA.

Two recruitment indices were developed using the delta-transformed survey data set. These were calculated by first standardizing the age 1, 2, and 3 catch rate to the age specific 1970-86 average. Then age 1 and 2 estimates on a cohort by cohort basis were averaged. The same was done for ages 2 and 3. The indices (Figure 13, Table 14) show stable recruitment during 1967-77 with a dramatic increase pulse in 1979-80. It is this pulse that is supporting the current fishery.

Estimates of total mortality (Z) for the fully recruited age groups based on survey and commercial catch rate data (Figure 14, Table 15) show exceptionally high Z's in recent years. If natural mortality is taken as 0.2, fishing mortalities in excess of 0.8 are indicated by these three data sets.

The variance structure of the survey data is comparable to that of the catch data, showing the same strong heterogeneity (Figure 15). A degree of the heterogeneity in the data can be gained from examination of the relationships between the variance in the survey and catch data (Figure 16). The ratios $\frac{S^2_{survey}}{S^2_{catch}}$ are given in Table 16a. It is evident that treatment of the data set to compensate for these trends is required.

Finally, the degree of variability in the survey and catch data is quite different. Table 16b shows the ratio of the coefficients of variation between the survey and catch data. The former is many times

more variable than the latter. From this it can be concluded, that when using Ordinary Least Squares Regression (OLS), the survey data should be regressed on the SPA estimates rather than the other way around.

Sequential Population Analysis

Survivor Analysis

A survivor analysis (Doubleday, 1981) was conducted on the 1970-85 survey (delta transformed) data set. The results (Table 17) indicated fully recruited fishing mortalities in 1985 in the range of 0.3-1.06.

The SPA Tuning Models

The underlying relationship in the SPA calibration process is that the observed catch rate is some function of population density, $\overline{D}$, or

$$U = q'\overline{D} = q'\overline{N}/A = q\overline{N}$$

Typically, U, the catch rate is either a survey or commercial index and $\overline{N}$ is the mid year estimate from the SPA. A, the area, is assumed to be constant, and here considered part of q. The catchability, q, is the constant of proportionality between the index and the abundance.

In fitting this model to a set of data, it has often been observed, through examination of residual patterns, that the zero intercept assumption is inappropriate. The biological reasons for this are unclear but could be due to inappropriate stock assumptions in the construction of the catch at age. For this reason, an extra parameter, C, is generally added to allow for a non-zero intercept. It must be emphasized that this is a modification to the above theoretical relationship dictated by data constraints.

The above model also makes a number of assumptions regarding the error structure in the data. A more complete model would be

$$U_i = C + q\,(\overline{N}_i + \delta_i) + \varepsilon_i,\ i = 1, 2 \ldots n$$

where U_i is the observed catch rate
C is the intercept
q is q'/A
$\overline{N}_i$ is the mean population abundance
δ_i is measurement error in N_i
ε_i is measurement error in U_i
n is the number of observations

This model is fit to a set of U_i and $\overline{N}_i$ data using some parameterization algorithm, generally least squares. Use of this particular method requires the following assumptions (Draper and Smith, 1966):

1. The ratio, λ, of the variances in U_i and N_i be infinitely large. In other words, the errors about the line exist in the Y direction only.

2. The error, ε_i, is a Gaussian random variable with mean zero and variance ^{2} (unknown) or

$$E(\varepsilon_i) = 0, \; V(\varepsilon_i) = \sigma^2$$

3. ε_i and ε_j are uncorrelated, $(i \neq j)$, so that

$$\text{cor}\,(\varepsilon_i, \varepsilon_j) = 0$$

The large errors in the data sets make if difficult to resolve the C and B coefficients. Consequently most applications have fixed B at 1 (i.e. accepted a linear relationship between U and $\overline{N}$) and allowed C, the intercept, to vary. This is done in the following tuning exercise.

Regarding the first assumption, past calibration work has generally regressed the SPA estimate, $\overline{N}$, as a function of the index, U, under the assumption that λ is 0 (all errors in the index). A comparison of the coefficients of variation in the survey and catch-at-age data (Table 16b) shows that the survey data is more variable than the catch at age. Consequently, a model regressing U on $\overline{N}$ is more appropriate. There are maximum likelihood estimators available that use the lambda ratio to calculate the equation constants but these, as does ordinary least squares, require that the error, ε and δ, be normal and homogeneous (assumption 4). The strong trends between the variance and the mean for both the survey and catch-at-age data suggest that this is not the case. This problem can be rectified through either a weighted (by variance) least squares or use of a suitable transformation. The latter approach, using the log transform, was investigated here.

Assumption 3 calls for independence in the errors of the observations. This is reasonable if one assumes that sampling or measurement error is the main source of variation in the x and y variables. However, if the model is wrong, then this assumption will be violated. Given the level of variation existant in the data sets, it is expected that violation of assumption 3 is not a problem.

Thus the two models examined in this assessment are

1. $U_i = C + q\overline{N}_i + \varepsilon_i$ (linear model)

2. $\ln U_i = \ln(C + q\overline{N}_i) + \varepsilon_i$ (log model)

The index U_i is the survey catch rate at age and $\overline{N}_i$ is the mid year population numbers from the SPA.

The difference between the two models is the transformation to handle the error structure. The effect of the transformation will be

investigated through examination of outliers and heteroscedasticity in residual (diagnostic) plots.

Finally, as stated above, least squares is used to fit the models. Model 1 was fit using OLS while model 2 was fit using nonlinear least squares. The algorithm used is the method of linearization (Draper and Smith, 1966) based on the Newton-Raphson technique.

The SPA Calibration

The procedure followed was the same for models 1 and 2 except that in the former, the residuals were standardized by the S_U, which is the estimated standard error of U at a given $\overline{N}$. No standardization of the residuals was done for model 2, because variance is stabilized by use of the ln transformation. In addition, the models were fit only to the 1970-82 data set as the 1983-86 SPA data is strongly influenced by analysis input conditions. In the case of 1986, the SPA software was modified to handle semi-annual catch-at-age data. Thus the 1986 fishing mortality was expressed as an annual rate based on the data for the first half of the year.

Calibration commenced with the age 8 relationship and was conducted sequentially back through ages 7 to 2. The criterion for choice of the 1986 fishing mortality at a given age was minimization of that particular cohort's residuals around the various age-specific regression lines. This procedure differs from that of O'Boyle and Gregory (1985) in that they examined not only cohort specific residuals but also those along an age-specific relationship.

The age 12 and 13+ fishing mortality was calculated as

$$F = \frac{\sum_{i=1}^{13+} c_i}{\sum_{i=1}^{13+} \overline{N}_i \cdot PR_i}$$

where PR_i, the partial recruitment in year i is calculated by dividing the mean F for ages 7 to 10 into the age 1 to 13+ F_i on a year by year basis.

Model 1 vs Model 2 Tuning

A comparison of the regression diagnostic plots for the two models (Figures 17-24) showed that in general both models fit the data well. However, the treatment with the log transform appears to be superior. The log transformation reduces significantly the trends in variance with

the predicted y and observed x seen in the results of the linear model. As well, outliers are less prominent in the diagnostic plots for the model 2 fit. For this reason, the calibration using model 2 was accepted for the purposes of stock assessment.

Results of Cohort Analysis using Model 2 Tuning

Diagnostic information of the cohort analysis tuned using model 2 is given in Tables 18-19 and Figures 20-24.

The intercepts of the age specific relationships were very close to the origin. However, their significance could not be tested with the existing software.

The fit of the SPA to the aggregated by ages 2-5 survey data was reasonably good (Figure 25). The fit to the ages 6-8 population is less satisfactory, due to an underestimation of abundance by the SPA during 1977-81. The reason for this discrepancy is unknown but could be due to the high rates of misreporting and discarding of catch reported to have occurred during this period.

The SPA results were also compared to the age-specific 1st quarter catch rate information (Table 10) for TC 2-3 draggers and TC 4-5 trawlers. The fishable biomass from the SPA was calculated as:

$$FB_{2-5} = \sum_{i=2}^{5} \overline{N}_i \, \overline{W}_i \, PR_i$$

$$FB_{6-8} = \sum_{i=6}^{8} \overline{N}_i \, \overline{W}_i \, PR_i$$

where $\overline{N}$ is the mean population numbers from the SPA during the 1st quarter, $\overline{W}_i$ are the mean annual fishery weights at age (Table 5a) and PR_i is the gear specific partial recruitment vector calculated as per O'Boyle and Gregory (1985) and illustrated in Figure 26a. The results of this calculation compare favourably to a direct commercial catch rate-survey comparison (Figure 26b) and confirm the presence of dome-shaped partial recruitment in 4X haddock bottom trawl fisheries.

As described by O'Boyle and Gregory (1985), the survey-tuned SPA results indicate that the fleets are not catching the biomass that is predicted to be there, particularly since 1983 (Figure 27-28). A number of reasons for this were hypothesized in the previous assessment. Nothing more can be added here to these comments.

Assuming that the SPA tuning with the survey data is providing an analysis which correctly describes the population fluctuations, it can

be seen that the fully recruited fishing mortality in the first half of 1986, expressed on an annual basis, is 0.38 at age 5. The fishing mortalities on ages 6 and older are estimated to be 0.3 (except for age 7 where it is 0.23), substantially lower than the value calculated from total mortality estimates (0.588) for the 1981-86 survey data.

Age 1+ biomass declined from 1964 to 1971, increased thereafter until 1978-79 and has slightly declined since then.

Fishing mortality followed an increasing trend from 1967 to very high levels in 1984 and has declined since. This is consistent with the observation that the fleets have recently cut back their fishing effort in 4X and have moved eastward.

Final Cohort Analysis

The analysis shows a strong 1982 year-class (74 x 10^6 fish), contrary to the estimate of 49 x 10^6 fish provided by O'Boyle and Gregory (1985). The projected 1987 catch is critically dependent on the estimate of this year-class. Thus, it was decided to take the conservative route of setting the size of the 1982 year-class equal to that of 1980, around 50 x 10^6 fish, for projection purposes. Although the survey age 1+2 indices for these year-classes are quite different, those for ages 2+3 are not, thus supporting this decision.

The cohort analysis with this adjustment for the 1982 year-class is given in Table 20 while a comparison of this analysis age one estimates with those presented previously is given in Table 21. The estimate of the 1980 year-class is lower while those for 1981-1983 are higher than those provided by O'Boyle and Gregory (1985).

An estimate of the 1985 year-class at age one was obtained by comparing the 1970-85 age one SPA numbers with the 1969-84 year-class age 1+2 survey indices (Table 14). First the SPA numbers were regressed on the survey data, assuming zero intercept, to provide an estimate of the slope, B. This value, 48701, was multiplied by the 1986 survey estimate of 0.384 to provide a 1985 year-class size estimate of 18,701.

From this it can be seen that the recruitment to the stock in recent years has been below average to weak.

Prognosis

Catch projections to 1987 were conducted using the input data given in Table 22. The beginning of year population numbers are those for 1986. The catch at age is not strictly speaking an input but rather the output assuming that the 1986 TAC of 15,000 t is caught. This was derived using the 1985 weights at age and partial recruitment as given in Table 22. The latter is compared with previous estimates (Table 23).

They compare favourably with those of O'Boyle and Gregory (1985), the main difference being the presence of a dome in the current data set. For projection purposes, recruitment was considered full for ages 5, 6, and 7. Note that the 1986 partial recruitment estimates could not be used as they only apply to the first half of the year.

The results (Table 24) show that a 15,000 t TAC in 1986 will result in a fully recruited fishing mortality of 0.39, in excess of the $F_{0.1}$ value of 0.25. Yield at $F_{0.1}$ in 1987 should be about 12,300 t. This estimate is critically dependent upon the estimate of the 1982 year-class which makes up 42% of the weight of the yield in that year. It is evident that current yield from this resource is well below the long term value of 20,000 t due to recent poor recruitment.

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Table 1. Reported nominal catch (t round) of haddock from NAFO Division 4X (excluding unit area 4Xs) by country. The numbers in brackets represent the number of commercial samples in that year.

Year	CANADA (MQ)	CANADA (NFLD)	USA	USSR	SPAIN	OTHER	TOTAL	TAC
1968	27277 (48)	-	2858	335	116	36	30622	-
1969	27413 (55)	-	1707	-	473	19	29612	-
1970	15560 (26)	-	1639	2	370	12	17583	18000
1971	16067 (29)	-	656	97	347	1	17168	18000
1972	12391 (36)	-	411	10	470	1	13283	9000
1973	12536 (30)	-	268	14	134	6	12958	9000
1974	12246 (25)	-	662	35	97	-	13040	-
1975	15991 (56)	-	2109	39	7	2	18148	15000
1976	16294 (45)	-	972	-	95	5	17366	15000
1977	19561 (79)	-	1649	2	-	12	21224	15000
1978	25300 (62)	114	1135	2	-	27	26578	21500
1979	24287 (49)	268	69	3	-	15	24642	26000
1980	28215 (56)	71	256	38	-	37	28617	28000
1981	30156 (82)	117	465	-	-	15	30753	27850
1982	23216 (92)	28	853	-	-	4	24101	32000
1983	24446 (119)	44	492	17	-	7	25006	32000
1984	19455 (97)	23	205	-	-	-	19683	32000
1985	15018 (86)	-	24	-	-	1	15043	15000
1986[1]	7264 (32)	-	12[2]	-	-	-	7276	15000

Long-term averages:

A. 1930-60 = 16854 t
B. 1961-83 = 24217 t
C. 1930-83 = 20127 t

[1] 1 January-30 June 1986
[2] NAFO Circular Letter 86/51

Table 2. Recent Canadian fishery allocations and the respective reported catch (t) of 4X haddock. Information from Atlantic Quota Reports[1]

YEAR	REPORT DATA	FLEET	FINAL ALLOCATION	REPORTED[2] CATCH	%	CLOSURE DATES
1976		All vessels	13300	15715	118	
1977		All vessels	13400	20220	151	
1978		All vessels	21500	25518	119	
1979		<125'	17500	17949	103	
		>125'	8500	6471	76	
		Total	26000	24420		
1980		<125'	22500	23585	105	
		>125'	5500	5095	93	
		Total	28000	28680		
1981	31/12	<125'	22350	25102	112	24/10-31/12
		>125'	5500	5380	98	02/05-31/12
		Total	27850	30482		
1982	31/12	FG. <65'	8850	8168 (5146)	92	
		MG. <65'	15000	12909 (8162)	86	
		FG. 65-100'	100	124 (119)	124	23/05-31/12
		MG. 65-100'	1000	567 (451)	57	
		MG. >100'	7050	2829 (2179)	40	
		Total	32000	24597		
1983	31/12	FG. <65'	9050	9179 (4918)	101	
		MG. <65'	15000	12991 (9057)	87	
		FG. 65-100'	100	108 (171)	108	12/04-31/12
		MG. 65-100'	800	177 (185)	22	
		MG. >100'	7050	2438 (2171)	35	
		Total	32000	24893		
1984	31/12	FG. <65'	8850	6958 (4397)	79	
		MG. <65'	15000	12359 (8463)	82	
		FG. 65-100'	100	3 (2)	3	
		MG. 65-100'	1000	44 (33)	4	
		MG. >100'	7050	648 (468)	9	
		Total	32000	20012		
1985	31/12	FG. <65'	4000	4496 (2486)	112	16/11-31/12
		MG. <65'	10000	10214 (7457)	102	13/08-31/12
		FG. 65-100'	100	1 (1)	1	
		MG. 65-100'	100	61 (46)	61	
		MG. >100'	800	541 (543)	68	
		Total	15000	15313		
1986	20/08	FG. <65'	5000	2631	53	
		MG. <65' 1/1-30/4	2700			13/03
		1/5-31/8	4000			18/07
		1/9-31/12	2300	5694	63	
		FG. 65-100'	100	0	0	
		MG. 65-100'	100	110	110	15/02
		MG. >100'	800	177	22	
		Total	15000	8612		

[1] Numbers in brackets indicate reported catch by late August of that year.

[2] These figures are based on hail information and thus are unofficial and not comparable to those in Table 1.

Table 3. Reported nominal catch (t round) of haddock from NAFO Division 4X (excluding unit area 4Xs) landed in the Maritimes split by tonnage class and gear type. The numbers in brackets represent the mean weight landed per age/size sample collected.

	TONNAGE CLASS						
	1-3			4-5			
YEAR	OT	LL	MISC	OT	LL	MISC	TOTAL
1970	4894 (979)	2754	1295	6500 (295)	113	3	15559
1971	4289 (715)	3019 (1006)	954	7712 (454)	93	0	16067
1972	2741 (914)	3904 (558)	933 (933)	4750 (238)	63	0	12391
1973	1822 (304)	5714 (635)	701	4228 (302)	70	0	12535
1974	3949 (790)	6106 (611)	509 (509)	1623 (325)	56	0	12243
1975	6091 (338)	4917 (615)	548 (548)	4409 (457)	26	0	15991
1976	4348 (1087)	4591 (765)	1159 (580)	6144 (486)	46	6	16294
1977	6185 (1031)	3918 (490)	960	8345 (130)	117	35	19560
1978	9213 (9213)	5957 (596)	1947 (487)	8093 (169)	92	0	25302
1979	9870 (4935)	4292 (358)	1435 (718)	8634 (262)	56	0	24287
1980	13050 (1266)	5635 (331)	2403 (601)	7045 (310)	82	0	28215
1981	14769 (348)	6925 (266)	1915 (274)	6475 (950)	70	0	30156
1982	11614 (235)	6708 (335)	1889 (135)	2972 (309)	32	0	23216
1983	12315 (209)	7759 (210)	1821 (228)	2538 (181)	15	0	24446
1984	11744 (202)	6297 (203)	805 (805)	609 (87)	0	0	19455
1985	9727 (171)	4027 (168)	697	566 (113)	1	0	15018
1986[1]	4775 (133)	2116 (176)	206	167 (167)	0	0	7264

[1] 1 January-30 June 1986

Table 4a. Summary of commercial sampling for the 4X haddock fishery in 1985 - tons landed (no. of samples*).

Otter Trawlers

Quarter	m - p TC 1-3	m - p TC 4+	q - r TC 1-3	q - r TC 4+
1	2702 (12-8)	522 (5-5)	138 (1-1)	0
2	2391 (21-14)	21	1226 (6-5)	0
3	230 (1-1)	17	2212 (10-7)	13
4	89 (1-1)	17	738 (5-5)	0
Total	5412 (35-24)	577 (5-5)	4314 (22-18)	13

Longliners

Quarter	m - p TC 1-3	m - p TC 4+	q - r TC 1-3	q - r TC 4+
1	1925 (7-7)	1	11	0
2	345 (6-3)	0	46	0
3	822 (7-4)	0	59	0
4	815 (4-4)	0	3	0
Total	3907 (24-18)	1	119	0

Miscellaneous Gear

Quarter	m - p TC 1-3	m - p TC 4+	q - r TC 1-3	q - r TC 4+
1	12	0	0	0
2	105	0	29	0
3	455	0	52	0
4	41	0	4	0
Total	613	0	85	0

* - The first number represents the total number of samples collected and used in analysis and the second number represents the actual number of samples aged.

Table 4b. Summary of commercial sampling for the 4X haddock fishery in the first two quarters of 1986 - tons landed (no. of samples*).

Otter Trawlers

Quarter	m - p TC 1-3	m - p TC 4+	q - r TC 1-3	q - r TC 4+
1	2615 (17-9)	159 (1-1)	110 (1-1)	0
2	1154 (7-4)	20	896 (11-7)	0
Total	3769	179	1006	-

Longliners

Quarter	m - p TC 1-3	m - p TC 4+	q - r TC 1-3	q - r TC 4+
1	1845 (8-6)	0	3	0
2	250 (4-4)	0	18	0
Total	2095	-	21	-

Miscellaneous Gear

Quarter	m - p TC 1-3	m - p TC 4+	q - r TC 1-3	q - r TC 4+
1	115	0	0	0
2	81	0	10	0
Total	196	-	10	-

* - The first number represents the total number of samples collected and used in analysis and the second number represents the actual number of samples aged.

Table 5a. Landings Numbers (A), Weight (B), Percent by Number (C), and Percent by Weight (D) of NAFO Division 4X (excluding 4Xs) haddock.

A.

LANDINGS AT AGE (000S) OF HADDOCK CAUGHT IN UNIT AREAS 4XH-4XR, EXCLUDING DISCARDS

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	0	0	0	0	0	0	0	0	0	0	41	150	1	37	18	2	0	0	16	1	0	0	2	0
2	139	713	155	70	219	22	665	10	1055	788	22	3077	694	2175	1296	1285	75	81	161	1182	491	64	708	199
3	4524	2013	1272	3038	18341	515	297	2016	724	1617	3434	113	4653	4568	1644	3126	3354	1158	2445	2215	3639	3294	1108	1957
4	1415	7185	4286	1981	9796	20380	1164	1968	1502	788	1841	2247	309	5164	4261	2019	7014	6709	3008	6219	2474	5476	4680	2257
5	1778	3087	9337	3153	3167	9148	17448	1621	379	1422	509	1067	1779	485	3482	3193	2094	3881	5413	4199	4628	3733	3439	4539
6	1708	1649	3018	5409	2149	1039	4684	11243	524	404	645	527	509	1103	434	2881	2832	1070	3499	3195	1703	2232	2396	1497
7	1648	1415	1492	1973	3747	735	713	3220	4536	69	90	600	189	247	807	360	1040	1244	527	1163	1457	940	948	489
8	973	593	1370	1000	840	1052	518	455	1863	3316	57	322	269	172	154	389	137	263	623	357	340	395	340	144
9	645	478	612	745	409	187	672	249	133	1020	1166	259	186	62	71	107	107	57	169	323	183	187	110	53
10	232	152	416	288	424	102	190	194	96	163	512	614	269	32	95	72	26	68	34	97	94	119	77	20
11	205	113	297	203	88	90	131	172	175	181	26	55	552	165	39	23	9	11	21	14	45	69	36	8
12	64	59	168	114	62	23	65	94	27	146	193	13	24	229	103	8	6	1	3	23	16	25	20	1
13+	100	43	36	113	84	81	89	69	37	105	92	6	4	11	157	87	48	18	10	9	14	25	12	1

B.

MEAN WEIGHT (KG) AT AGE OF HADDOCK CAUGHT IN UNIT AREAS 4XH-4XR

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	0.290	0.290	0.290	0.290	0.290	0.290	0.290	0.290	0.290	0.290	0.290	0.270	0.180	0.230	0.230	0.280	0.290	0.290	0.160	0.230	0.000	0.000	0.250	0.000
2	0.560	0.500	0.500	0.360	0.310	0.320	0.370	0.560	0.570	0.500	0.450	0.510	0.460	0.520	0.520	0.460	0.440	0.510	0.522	0.593	0.493	0.394	0.527	0.562
3	0.750	0.780	0.750	0.650	0.670	0.620	0.620	0.750	0.900	0.960	0.900	0.750	0.820	0.820	0.810	0.710	0.870	0.870	0.882	0.887	0.907	0.758	0.785	0.791
4	1.150	1.050	1.000	1.000	0.850	0.850	0.900	0.880	1.050	1.250	1.350	1.250	1.100	1.200	1.190	1.220	1.330	1.330	1.326	1.260	1.294	1.141	1.069	1.043
5	1.400	1.450	1.300	1.200	1.230	1.050	1.100	1.150	1.160	1.400	1.600	1.800	1.700	1.550	1.600	1.720	1.850	1.840	1.777	1.721	1.653	1.714	1.411	1.378
6	1.600	1.700	1.700	1.560	1.500	1.450	1.300	1.350	1.430	1.500	1.750	2.000	2.300	2.250	2.100	2.200	2.330	2.360	2.355	2.219	2.130	2.146	1.932	1.924
7	2.200	1.850	1.950	1.950	1.800	1.800	1.700	1.600	1.650	1.750	1.900	2.200	2.500	2.850	2.950	2.940	2.700	2.830	2.906	2.654	2.577	2.607	2.287	2.442
8	2.120	2.350	2.040	2.200	2.180	2.050	2.050	2.000	1.950	1.950	2.100	2.300	2.600	3.000	3.500	3.300	3.390	3.300	3.278	3.134	2.947	2.869	2.683	2.896
9	1.900	2.250	2.500	2.300	2.500	2.360	2.300	2.450	2.300	2.300	2.300	2.500	2.800	3.200	3.600	3.570	3.770	4.030	3.811	3.608	3.470	3.108	3.054	3.321
10	2.400	2.200	2.400	2.630	2.500	2.700	2.520	2.500	2.820	2.650	2.800	2.700	2.950	3.450	3.800	3.770	4.170	4.150	4.332	3.688	4.033	3.550	3.431	3.218
11	2.860	2.700	2.420	2.500	2.750	2.700	3.000	2.700	2.800	3.250	3.000	3.300	3.200	3.500	4.100	3.690	4.030	4.960	4.200	4.546	3.946	3.630	3.841	4.063
12	2.700	3.200	3.000	2.700	2.600	2.890	2.900	3.300	2.850	3.000	3.700	3.400	3.800	3.700	4.000	3.940	3.620	6.000	4.963	4.823	4.033	3.790	4.114	4.300
13+	3.990	3.250	3.610	3.300	3.000	2.800	2.950	3.060	3.600	3.000	3.300	4.200	3.900	4.400	4.200	3.910	4.630	5.680	5.711	4.680	4.908	4.064	4.000	5.700

C.

PERCENT AGE COMPOSITION BY NUMBERS OF HADDOCK CAUGHT IN UNIT AREA 4XH-4XR

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	1.66	0.01	0.26	0.14	0.01	0.00	0.00	0.10	0.01	0.00	0.00	0.01	0.00
2	1.03	4.07	0.69	0.39	0.56	0.07	2.50	0.05	9.55	7.87	0.25	34.00	7.35	15.05	10.16	9.48	0.45	0.56	1.01	6.22	3.26	0.39	5.10	1.78
3	33.68	11.50	5.66	16.80	46.64	1.54	1.12	9.46	6.55	16.14	39.80	1.25	49.30	31.61	12.88	23.07	20.03	7.95	15.35	11.66	24.12	19.89	7.99	17.53
4	10.54	41.06	19.08	10.95	24.91	61.07	4.37	9.23	13.59	7.87	21.34	24.83	3.27	35.74	33.39	14.90	41.89	46.08	18.88	32.74	16.40	33.07	33.73	20.21
5	13.24	17.64	41.57	17.43	8.05	27.41	65.51	7.61	3.43	14.19	5.90	11.79	18.85	3.36	28.85	23.56	12.51	26.65	33.98	22.10	30.68	22.54	24.78	40.65
6	12.72	9.42	13.44	29.91	5.46	3.11	17.59	52.76	4.74	4.03	7.48	5.82	5.39	7.63	3.40	21.26	16.92	7.35	21.97	16.82	11.29	13.48	17.27	13.41
7	12.27	8.09	6.64	10.91	9.53	2.20	2.68	15.11	41.05	0.69	1.04	6.63	2.00	1.71	6.32	2.66	6.21	8.54	3.31	6.12	9.66	5.68	6.83	4.38
8	7.24	3.39	6.10	5.53	2.14	3.15	1.94	2.14	16.86	33.10	0.66	3.56	2.85	1.19	1.21	2.87	0.82	1.81	3.91	1.88	2.25	2.39	2.45	1.29
9	4.80	2.73	2.72	4.12	1.04	0.56	2.52	1.17	1.20	10.18	13.51	2.86	1.97	0.43	0.56	0.79	0.64	0.39	1.06	1.70	1.21	1.13	0.79	0.47
10	1.73	0.87	1.85	1.59	1.08	0.31	0.71	0.91	0.87	1.63	5.93	6.78	2.85	0.22	0.74	0.53	0.16	0.47	0.21	0.51	0.62	0.72	0.55	0.18
11	1.53	0.65	1.32	1.12	0.22	0.27	0.49	0.81	1.58	1.81	0.30	0.61	5.85	1.14	0.31	0.17	0.05	0.08	0.13	0.07	0.30	0.42	0.26	0.07
12	0.48	0.34	0.75	0.63	0.16	0.07	0.24	0.44	0.24	1.46	2.24	0.14	0.25	1.58	0.81	0.06	0.04	0.01	0.02	0.12	0.11	0.15	0.14	0.01
13+	0.74	0.25	0.16	0.62	0.21	0.24	0.33	0.32	0.33	1.05	1.07	0.07	0.04	0.08	1.23	0.64	0.29	0.12	0.06	0.05	0.09	0.15	0.09	0.01

D.

PERCENT AGE COMPOSITION BY WEIGHT OF HADDOCK CAUGHT IN UNIT AREAS 4XH-4XR

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.33	0.00	0.05	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2	0.41	1.56	0.24	0.10	0.17	0.02	0.77	0.02	3.66	2.43	0.08	12.97	2.45	6.53	3.61	2.88	0.12	0.17	0.29	2.28	1.00	0.10	1.90	0.74
3	17.91	6.89	2.97	7.62	31.42	0.95	0.58	5.32	3.97	9.56	23.70	0.70	29.28	21.63	7.14	10.80	10.88	4.08	7.54	6.39	13.69	9.99	4.42	10.29
4	8.59	33.08	13.32	7.65	21.29	51.72	3.28	6.09	9.61	6.07	19.06	23.22	2.61	35.78	27.19	11.98	34.79	36.12	13.94	25.47	13.28	25.00	25.43	15.65
5	13.14	19.63	37.73	14.60	9.96	28.68	60.16	6.56	2.68	12.26	6.24	15.88	23.21	4.34	31.59	26.72	14.45	28.91	33.61	23.49	31.74	25.60	24.66	41.58
6	14.42	12.29	15.95	32.57	8.24	4.50	19.09	53.38	4.57	3.73	8.65	8.71	8.99	14.33	4.89	30.83	24.61	10.22	28.80	23.05	15.05	19.17	23.53	19.15
7	19.13	11.48	9.04	14.85	17.24	3.95	3.80	18.12	45.60	0.74	1.31	10.91	3.63	4.06	12.76	5.15	10.47	14.25	5.35	10.03	15.58	9.81	11.02	7.94
8	10.89	6.11	8.69	8.49	4.68	6.44	3.33	3.20	22.13	39.83	0.92	6.12	5.37	2.98	2.89	6.24	1.73	3.51	7.14	3.64	4.16	4.53	4.64	2.77
9	6.47	4.72	4.76	6.61	2.61	1.32	4.84	2.15	1.86	14.45	20.56	5.35	4.00	1.15	1.37	1.86	1.50	0.93	2.25	3.79	2.63	2.33	1.71	1.17
10	2.94	1.47	3.10	2.92	2.71	6.82	1.50	1.71	1.65	2.66	10.99	13.71	6.09	0.64	1.94	1.32	0.40	1.14	0.51	1.16	1.57	1.69	1.34	0.43
11	3.09	1.34	2.23	1.96	0.42	0.73	1.23	1.63	2.99	3.62	0.60	1.50	13.56	3.33	0.86	0.41	0.14	0.22	0.31	0.21	0.74	1.00	0.70	0.22
12	0.91	0.83	1.57	1.19	0.41	0.20	0.59	1.09	0.47	2.70	5.48	0.37	0.70	4.89	2.21	0.15	0.08	0.02	0.05	0.36	0.27	0.38	0.42	0.03
13+	2.11	0.61	0.40	1.44	0.64	0.68	0.82	0.74	0.81	1.94	2.33	0.21	0.12	0.28	3.54	1.65	0.83	0.41	0.20	0.14	0.29	0.41	0.24	0.04

Table 5b. Landings numbers, weight, percent numbers, and percent weight at age of NAFO Division 4X (excluding 4Xs) haddock for the first half of 1986.

Age	Numbers x 10^{-3}	S^2	C.V.	Weight (kg)	% by Number	% by Weight
1	0	.000	0.000	0	0	0
2	4	.001	0.008	.410	0.07	0.02
3	153	319.476	0.117	.678	2.82	1.43
4	1600	7056.466	0.053	.949	29.53	20.92
5	2275	9839.278	0.044	1.264	41.98	39.63
6	1055	5400.825	0.070	1.771	19.47	25.75
7	192	708.198	0.139	2.410	3.54	6.38
8	79	195.169	0.177	2.742	1.46	2.99
9	28	48.520	0.249	3.439	0.52	1.33
10	18	27.154	0.290	3.583	0.33	0.89
11	9	25.057	0.556	3.037	0.17	0.38
12	4	10.524	0.811	3.110	0.07	0.17
13+	2	4.402	1.049	4.410	0.04	0.12

Table 6. Comparison of 1985 Projected Catch Numbers with that observed in the 1985 fishery.

Age	Observed No.	Observed %	Projected No.	Projected %
1	0	0	1	0.01
2	199	1.78	110	1.08
3	1957	17.53	1171	11.52
4	2257	20.21	1552	15.27
5	4539	40.65	4786	47.10
6	1497	13.41	1322	13.01
7	489	4.38	744	7.32
8	144	1.29	294	2.89
9	53	0.47	106	1.04
10	20	0.18	34	0.33
11	8	0.07	24	0.24
12	1	0.01	11	0.11
13+	1	0.01	7	0.07
No. (000's)	11165	100.00	10162	100.00
Catch (t)	15043		15043	

Table 7. Variance and coefficients of variation for catch (A and B) and integrated catch (C, D, and E) at age. Note that the integrated catch estimates are for the beginning of the year.

A. Estimate of Variance in Landings at age

	1980	1981	1982	1983	1984	1985
1	14	2	0	0	2	0
2	875	6194	1563	310	3503	1799
3	13778	17086	13852	17610	9077	10850
4	45135	34222	21668	31315	24679	16296
5	71556	32814	20781	24147	28286	15574
6	43629	19070	10508	16131	16076	6661
7	4382	6352	6952	6173	7327	1663
8	5144	1319	2292	2500	2055	447
9	829	890	842	829	323	88
10	91	289	257	452	257	52
11	61	19	166	261	58	7
12	6	37	80	76	37	1

B. Coefficients of Variation for Landings at age

	1980	1981	1982	1983	1984	1985
1	.234	1.414	.000	.000	.707	.000
2	.184	.067	.081	.275	.084	.213
3	.048	.059	.032	.040	.086	.053
4	.071	.030	.059	.032	.034	.057
5	.049	.043	.031	.042	.049	.027
6	.060	.043	.060	.057	.053	.055
7	.126	.069	.057	.084	.090	.083
8	.115	.102	.141	.127	.133	.147
9	.170	.092	.159	.154	.163	.177
10	.281	.175	.171	.179	.208	.361
11	.372	.311	.286	.234	.212	.331
12	.816	.264	.559	.349	.304	.000

C. Integrated Landings at Age

	1980	1981	1982	1983	1984	1985
1	31596	26683	6458	4182	271	0
2	22126	25854	21846	5288	3424	220
3	25986	17970	20098	17441	4271	2163
4	14689	19063	12708	13162	11299	2494
5	13823	9304	9981	8166	5821	3016
6	6587	6420	3818	3984	3308	1654
7	1697	2227	2365	1585	1242	540
8	1468	913	771	618	447	159
9	442	638	424	324	149	59
10	83	209	230	182	96	22
11	54	37	83	103	41	9
12	3	25	18	28	22	1

D. Variance of Integrated Landings at Age

	1980	1981	1982	1983	1984	1985
1	407181	245015	91322	35876	3280	0
2	301285	272930	164237	61215	24049	2197
3	249448	201241	177880	108811	40780	13252
4	181742	155930	120907	107895	58521	19904
5	153605	84872	76504	63306	46686	19022
6	76073	44380	30025	34268	22665	8136
7	12237	15273	14135	11523	9764	2031
8	9385	4615	5037	3783	2670	546
9	2299	2415	2014	1500	489	107
10	363	862	890	660	327	64
11	142	169	341	386	73	9
12	7	45	98	93	45	1

E. Coefficients of Variation of Integrated Landings at Age

	1980	1981	1982	1983	1984	1985
1	.020	.019	.047	.045	.211	.000
2	.025	.020	.019	.047	.045	.213
3	.019	.025	.021	.019	.047	.053
4	.029	.021	.027	.025	.021	.057
5	.028	.031	.028	.031	.037	.027
6	.042	.033	.045	.046	.046	.055
7	.065	.055	.050	.068	.080	.083
8	.068	.074	.092	.100	.116	.147
9	.108	.077	.106	.120	.149	.177
10	.230	.140	.130	.141	.188	.361
11	.220	.351	.221	.190	.207	.331
12	.816	.264	.559	.349	.304	.000

Table 8. Commercial catch rates (tons per unit effort) of 4X haddock for various fleet sectors. For otter trawlers the unit of effort is in hours fishing; for longliners, the unit of effort is in thousands of lines fished. QTR is the year quarter. Below the quarter is indicated the unit areas of capture (see Figure 2).

	OTB-2 (TC 2-3)			OTB-2 (TC 4-5)		LL (TC 2-3)		
Year	QTR1 / MNOP	QTR2 / MNOP	QTR3 / QR	QTR1 / MNOP	QTR2 / MNOP	QTR1 / MNOP	QTR2 / MNOP	QTR3 / MNOP
1968	.279	.362	.665	.531	.373	3.161	7.029	-
69	-	.273	.576	.635	.563	14.997	-	-
1970	.064	.374	.155	.332	.650	10.261	-	-
71	.190	.369	.078	.282	.380	11.424	11.970	8.022
72	.099	.286	.094	.308	.390	16.789	4.822	7.413
73	-	.308	.564	.290	.231	15.824	4.076	23.208
74	.257	.142	.092	.335	.315	15.783	10.305	7.099
75	-	.298	.221	.424	.411	13.865	12.424	6.430
76	.362	.204	.205	.433	.352	15.204	9.197	6.647
77	.509	.349	.299	.479	.451	15.782	9.041	14.355
78	.428	.690	.247	.551	.646	17.214	14.147	7.877
79	.522	.461	.210	.895	.491	17.819	9.683	8.088
1980	.559	.329	.217	.827	.236	13.665	10.974	9.609
81	.462	.442	.289	.880	.889	15.011	8.184	8.743
82	.351	.231	.253	.642	.477	13.485	8.780	7.990
83	.287	.265	.180	.605	.380	13.985	10.883	8.951
84	.256	.259	.182	.413	.493	15.343	11.131	7.197
85	.283	.266	.125	.474	.389	13.345	9.883	5.823
86	.226	.138	-	.923	-	10.923	5.503	-

Table 9. Landings at age of 4X haddock by gear sector in 1st and 3rd quarter.

A. LANDINGS AT AGE (000S) OF 4X HADDOCK REPORTED BY OTB, TC1-3 IN FIRST QUARTER

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2	0	0	0	0	0	0	1	0	0	0	4	0	0	2	0	0
3	29	32	23	0	5	2	9	43	171	33	34	103	65	62	13	76	17
4	57	16	18	2	1	7	56	58	336	337	150	791	143	393	298	254	575
5	20	17	6	1	10	0	50	145	84	175	345	627	456	428	369	1126	909
6	16	8	7	0	4	1	8	112	87	36	200	562	160	219	495	319	465
7	114	0	1	0	1	0	11	12	50	28	39	188	99	92	143	90	31
8	40	46	0	0	1	0	2	14	10	9	16	26	11	19	52	8	32
9	1	16	7	0	0	0	1	2	4	1	8	35	9	16	5	16	4
10	3	3	2	0	0	0	1	1	0	0	0	14	2	7	15	0	3
11	2	2	0	0	1	0	0	1	0	0	0	2	1	3	4	0	2
12	0	2	0	0	0	0	1	0	0	0	0	3	2	1	3	0	0
13+	1	1	0	0	0	0	1	2	0	0	0	2	0	0	0	0	0

B. LANDINGS AT AGE (000S) OF 4X HADDOCK REPORTED BY OTB, TC4-5 IN FIRST QUARTER

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	7	2	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0
3	109	503	603	12	65	73	117	256	363	157	87	123	67	184	0	34	1
4	214	244	474	976	15	157	746	349	713	1579	390	713	128	720	60	109	32
5	77	270	148	471	122	21	670	864	177	823	876	1119	488	393	70	200	51
6	61	127	171	201	49	25	104	668	185	171	508	382	175	211	52	45	26
7	430	0	31	172	11	6	140	69	106	130	100	223	172	44	32	13	2
8	150	714	12	27	17	2	21	85	21	42	41	24	30	16	7	2	2
9	5	244	221	51	5	2	18	11	9	3	20	9	6	6	2	2	0
10	13	42	48	116	4	0	13	9	0	2	1	6	8	5	2	0	0
11	6	34	8	5	18	1	4	6	0	1	0	0	0	3	0	0	0
12	1	30	12	2	2	1	7	2	0	0	0	0	0	0	0	0	0
13+	3	9	6	0	0	0	10	14	0	0	1	0	0	0	0	0	0

C. LANDINGS AT AGE (000S) OF 4X HADDOCK BY ALL GEARS IN FIRST QUARTER

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	13	3	0	0	5	37	2	4	0	0	0	11	1	1	2	0	0
3	210	685	986	13	260	550	209	420	979	240	160	364	294	540	27	197	38
4	414	333	773	1061	48	1035	1356	569	1910	2252	731	2241	559	2064	996	735	848
5	149	368	229	528	394	99	1226	1413	528	1213	1615	1648	1549	1230	1232	2151	1594
6	118	173	284	236	143	160	177	1121	582	267	910	1296	576	616	920	608	943
7	833	0	48	226	61	36	251	115	314	189	177	560	451	235	427	164	116
8	289	972	19	60	60	19	41	138	46	65	74	136	72	83	120	42	66
9	10	333	377	77	47	8	30	23	33	6	36	109	34	49	28	20	19
10	24	58	83	330	48	4	23	16	7	3	2	38	16	26	32	6	14
11	12	46	12	23	135	12	10	9	0	1	3	4	4	14	9	1	7
12	2	41	24	7	10	12	11	4	0	0	0	9	1	4	7	0	3
13+	83	37	10	3	2	1	20	23	7	3	3	7	1	5	1	0	1

D. LANDINGS AT AGE (000S) OF 4X HADDOCK REPORTED BY OTB, TC1-3 IN THIRD QTR (OR)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	18	0	0	25	0	0	5	4	0	0	0	0	0	0	2	0
2	620	1414	21	1527	1398	1161	473	841	6	12	29	660	281	8	460	167
3	137	300	838	0	1125	1199	289	570	340	323	365	681	1436	881	343	854
4	91	11	42	0	1	452	294	73	725	814	505	739	429	542	1221	621
5	20	10	8	0	10	2	180	53	179	61	530	339	497	256	382	386
6	12	0	8	0	2	3	17	22	141	151	356	235	89	222	171	61
7	155	0	0	0	0	0	11	5	29	96	74	51	67	55	64	15
8	48	31	0	0	0	0	0	0	8	0	47	35	9	19	7	5
9	4	5	10	0	0	0	0	0	3	3	21	25	10	13	8	1
10	3	0	10	0	0	0	0	0	1	0	5	10	1	16	8	0
11	12	0	0	0	11	0	0	1	0	0	4	0	4	15	3	0
12	1	2	0	0	0	0	1	0	0	0	0	0	0	7	0	0
13+	3	6	0	0	0	0	5	1	3	0	0	0	0	0	0	0

Table 10. Catch rate (no. per hour fished) at age for Canadian otter trawlers fishing 4X haddock in unit areas MNOP (A and B) and QR (C) in the 1st and 3rd quarters during 1970-86.

A.

CATCH RATES (NO PER HR) AT AGE FOR OTB, TC2-3 IN FIRST QUARTER

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.299	0.112	0.000	0.012	0.000	2.158	0.184	0.440	0.000	0.000	0.000	0.551	0.088	0.000	0.204	0.000	0.000
3	4.714	28.312	26.684	0.670	32.163	46.798	16.605	34.499	73.586	20.350	15.118	13.370	15.093	8.749	1.508	7.916	1.518
4	9.296	13.762	20.997	55.481	7.619	151.330	105.767	46.941	144.626	205.282	66.377	102.711	33.126	55.139	33.516	26.638	49.826
5	3.349	15.212	6.539	26.769	60.403	6.324	94.959	116.159	35.933	107.010	152.934	81.447	105.278	60.044	41.384	117.969	78.694
6	2.653	7.150	7.567	11.443	24.164	24.552	14.742	89.892	37.466	22.242	88.667	72.941	37.052	30.613	55.535	33.445	40.309
7	18.691	0.000	1.374	9.767	5.459	5.630	19.910	9.237	21.496	16.908	17.438	24.416	22.903	12.889	16.082	9.400	2.701
8	6.493	40.212	0.545	1.549	8.394	4.340	2.912	11.468	4.248	5.447	7.137	3.335	2.611	2.661	5.811	9.871	2.754
9	0.234	13.750	9.762	2.890	2.220	1.339	2.544	1.508	1.821	0.416	3.481	4.498	2.150	2.261	0.534	1.662	0.318
10	0.547	2.387	2.141	6.600	1.779	0.942	1.784	1.194	0.096	0.265	0.105	1.836	0.548	0.991	1.712	0.000	0.265
11	0.276	1.887	0.338	0.312	9.018	1.885	0.551	0.754	0.000	0.151	0.070	0.214	0.175	0.435	0.408	0.000	0.177
12	0.051	1.687	0.522	0.092	0.852	2.381	0.971	0.251	0.000	0.000	0.035	0.398	0.351	0.157	0.346	0.000	0.000
13+	0.112	0.525	0.276	0.000	0.000	0.273	1.443	1.822	0.032	0.189	0.211	0.275	0.000	0.000	0.000	0.000	0.000

B.

CATCH RATE (NO PER HR) AT AGE FOR OTB, TC4-5, IN FIRST QUARTER

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	1.551	0.167	0.000	0.019	0.000	0.219	0.220	0.414	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	24.452	42.022	83.017	1.092	41.925	92.110	19.862	32.466	94.862	34.892	22.365	32.965	25.639	52.812	0.063	30.903	6.201
4	48.225	20.426	65.325	90.390	9.931	198.732	126.511	44.174	186.189	351.968	98.200	191.714	48.891	207.065	84.775	100.212	203.493
5	17.375	22.579	20.342	43.613	78.735	26.975	113.584	109.313	46.259	183.475	226.255	300.737	187.085	113.130	97.859	184.748	321.391
6	13.765	10.612	23.542	18.643	31.498	31.325	17.634	84.594	48.233	38.135	131.176	102.597	67.122	60.773	73.678	41.578	164.626
7	96.959	0.000	4.274	15.912	7.116	8.078	23.815	8.693	27.673	28.990	25.798	59.924	66.052	12.782	44.547	12.279	11.033
8	33.685	59.684	1.695	2.523	10.942	2.632	3.483	10.792	5.469	9.339	10.559	6.425	11.400	4.503	9.458	1.530	11.249
9	1.212	20.408	30.370	4.708	2.894	2.230	3.044	1.419	2.344	0.713	5.149	2.514	2.346	1.638	2.522	1.903	1.298
10	2.835	3.544	6.661	10.753	2.319	0.512	2.134	1.124	0.123	0.454	0.156	1.537	3.045	1.410	2.365	0.000	1.082
11	1.430	2.801	1.051	0.508	11.755	1.206	0.659	0.710	0.000	0.259	0.104	0.000	0.000	0.819	0.000	0.000	0.721
12	0.267	2.505	1.624	0.151	1.110	1.279	1.161	0.237	0.000	0.000	0.052	0.000	0.000	0.000	0.000	0.000	0.000
13+	0.582	0.779	0.860	0.000	0.000	0.256	1.726	1.715	0.041	0.324	0.312	0.000	0.000	0.000	0.000	0.000	0.000

C.

CATCH RATE (NO PER HR) AT AGE FOR OTB, TC2-3 IN 3RD QUARTER

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	2.398	0.000	0.000	17.788	0.000	0.000	0.712	0.810	0.000	0.000	0.000	0.000	0.000	0.000	0.108	0.000
2	80.629	99.928	2.117	1066.828	75.344	111.066	62.838	166.661	0.678	1.104	1.918	49.442	19.667	0.492	23.876	9.405
3	17.767	21.211	84.942	0.000	60.638	114.731	38.374	112.997	38.228	29.777	23.782	51.001	100.627	56.111	33.392	48.179
4	11.830	0.805	4.254	0.000	0.082	43.203	39.018	14.545	81.591	75.048	32.916	55.367	30.024	34.511	63.422	35.071
5	2.559	0.730	0.798	0.000	0.522	0.216	23.871	10.434	20.115	5.654	34.506	25.407	34.787	16.304	19.819	21.798
6	1.550	0.000	0.807	0.000	0.096	0.270	2.202	4.423	15.869	13.933	23.201	17.631	6.226	14.141	8.884	3.440
7	20.194	0.013	0.000	0.000	0.000	0.000	1.508	0.997	3.277	8.831	4.845	3.846	4.665	3.509	3.332	0.821
8	6.200	2.214	0.000	0.000	0.027	0.000	0.000	0.000	0.952	0.000	3.053	2.620	0.632	1.230	0.370	0.262
9	0.468	0.327	1.054	0.000	0.000	0.000	0.000	0.000	0.323	0.296	1.350	1.850	0.672	0.816	0.416	0.060
10	0.439	0.013	0.978	0.000	0.000	0.000	0.000	0.000	0.065	0.000	0.303	0.728	0.099	1.023	0.432	0.000
11	1.594	0.013	0.000	0.000	0.604	0.000	0.000	0.280	0.000	0.000	0.290	0.000	0.277	0.945	0.154	0.000
12	0.146	0.138	0.000	0.000	0.000	0.000	0.169	0.000	0.000	0.000	0.000	0.000	0.000	0.414	0.000	0.000
13+	0.439	0.403	0.000	0.000	0.000	0.000	0.712	0.280	0.323	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 11.

A. CANADIAN SUMMER SURVEY - STRATIFIED AR, MEAN CATCH (NUMBERS) PER STANDARD TOW 17/ 9/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
0	0.000	0.000	0.000	0.000	0.000	0.000	0.069	0.012	0.012	0.523	0.029	0.678	0.271	0.349	0.310	0.000	0.121
1	5.899	0.118	5.900	4.449	11.533	6.970	6.371	6.303	6.571	1.678	21.864	41.014	13.062	6.858	4.730	6.637	3.867
2	4.733	11.116	0.262	12.362	23.725	3.744	6.530	33.303	5.275	13.293	6.943	28.791	28.715	4.538	23.612	6.779	8.809
3	1.404	4.716	3.258	0.395	32.536	4.876	4.217	38.456	9.552	9.718	15.326	6.878	12.815	14.449	12.503	24.828	10.013
4	2.597	2.061	1.350	2.435	1.022	7.952	4.228	11.133	2.820	10.319	8.036	8.772	4.687	5.828	17.865	19.104	17.079
5	1.118	2.926	0.885	1.174	4.410	0.427	7.610	11.314	1.244	4.881	12.741	3.155	6.654	3.558	5.591	11.710	10.304
6	2.639	1.384	0.904	0.388	0.993	1.945	0.574	6.538	2.432	1.937	4.354	3.469	2.614	2.351	3.207	3.089	2.833
7	5.787	2.087	0.613	0.559	0.546	0.531	0.658	0.767	1.083	3.040	1.683	1.157	2.504	0.962	1.569	0.952	0.618
8	0.795	5.210	0.899	0.414	0.581	0.422	0.119	1.024	0.029	1.145	1.312	0.250	0.338	0.322	0.562	0.095	0.258
9	0.337	0.759	1.239	0.267	0.359	0.176	0.024	0.139	0.000	0.248	0.657	0.464	0.166	0.292	0.448	0.000	0.069
10	0.279	0.093	0.043	0.395	0.277	0.110	0.037	0.112	0.000	0.033	0.245	0.232	0.060	0.209	0.080	0.040	0.017
11	0.085	0.045	0.006	0.007	0.350	0.301	0.000	0.010	0.034	0.000	0.043	0.142	0.038	0.090	0.033	0.000	0.017
12	0.029	0.061	0.005	0.000	0.000	0.269	0.242	0.070	0.042	0.000	0.000	0.036	0.000	0.069	0.031	0.030	0.000
13+	0.000	0.000	0.000	0.015	0.000	0.000	0.078	0.076	0.009	0.000	0.000	0.000	0.000	0.021	0.041	0.000	0.000
NK	0.000	0.000	0.000	0.000	0.000	0.000	0.032	0.008	0.093	0.045	0.050	0.005	0.000	0.049	0.000	0.034	0.078

B. CANADIAN SUMMER SURVEY - STRATIFIED AR, VARIANCE OF CATCH (NUMBERS) PER STANDARD TOW 17/ 9/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
0	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.062	0.001	0.215	0.071	0.055	0.016	0.000	0.003
1	2.213	0.003	6.800	6.661	43.246	7.914	2.507	3.306	5.082	0.798	197.087	567.615	26.343	5.087	4.723	2.913	0.225
2	1.943	8.016	0.017	18.957	68.293	1.190	1.826	145.719	3.394	2.462	8.684	159.086	66.925	2.648	128.399	1.796	5.964
3	0.109	2.058	0.865	0.014	103.353	2.012	0.337	571.267	5.354	0.544	34.920	11.160	11.735	19.349	20.705	65.860	6.822
4	0.584	0.486	0.068	0.335	0.076	4.723	0.465	45.794	0.455	5.486	6.252	2.531	1.130	1.050	37.346	76.995	14.160
5	0.200	1.006	0.022	0.066	1.372	0.019	1.371	25.827	0.130	1.924	14.898	0.218	1.841	0.322	2.021	15.721	3.355
6	1.136	0.236	0.022	0.008	0.095	0.327	0.005	6.546	0.577	0.242	1.530	0.264	0.204	0.122	0.403	0.257	0.405
7	3.667	0.624	0.010	0.017	0.026	0.032	0.007	0.054	0.078	0.597	0.149	0.050	0.260	0.021	0.092	0.038	0.046
8	0.084	3.065	0.024	0.013	0.029	0.019	0.000	0.135	0.000	0.078	0.054	0.004	0.009	0.004	0.010	0.001	0.008
9	0.016	0.068	0.046	0.008	0.011	0.005	0.000	0.001	0.000	0.012	0.018	0.017	0.003	0.005	0.009	0.000	0.002
10	0.017	0.003	0.000	0.016	0.007	0.004	0.000	0.001	0.000	0.000	0.003	0.012	0.001	0.003	0.001	0.000	0.000
11	0.001	0.000	0.000	0.000	0.005	0.011	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000
12	0.000	0.001	0.000	0.000	0.000	0.007	0.007	0.002	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
13+	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NK	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.002	0.002	0.000	0.000	0.001	0.000	0.001	0.004

C. CANADIAN SUMMER SURVEY - COEFFICIENTS OF VARIATION IN AR, MEAN CATCH (NUMBERS) PER STANDARD TOW 17/ 9/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
0	0.000	0.000	0.000	0.000	0.000	0.000	0.794	0.000	0.000	0.476	1.090	0.684	0.983	0.672	0.408	0.000	0.453
1	0.252	0.464	0.442	0.580	0.570	0.404	0.249	0.288	0.343	0.532	0.642	0.581	0.393	0.329	0.459	0.257	0.123
2	0.295	0.255	0.498	0.352	0.348	0.291	0.207	0.362	0.349	0.118	0.424	0.438	0.285	0.359	0.480	0.198	0.277
3	0.235	0.304	0.285	0.300	0.312	0.291	0.138	0.618	0.242	0.076	0.386	0.486	0.267	0.304	0.364	0.327	0.261
4	0.294	0.338	0.193	0.238	0.270	0.273	0.161	0.608	0.239	0.227	0.311	0.181	0.227	0.176	0.342	0.459	0.220
5	0.400	0.343	0.168	0.219	0.266	0.323	0.154	0.449	0.290	0.284	0.303	0.148	0.204	0.159	0.254	0.339	0.178
6	0.404	0.351	0.164	0.231	0.310	0.294	0.123	0.391	0.312	0.254	0.284	0.148	0.173	0.149	0.198	0.164	0.225
7	0.331	0.379	0.163	0.233	0.295	0.337	0.127	0.303	0.258	0.254	0.229	0.193	0.204	0.151	0.193	0.205	0.347
8	0.365	0.336	0.172	0.275	0.293	0.327	0.000	0.359	0.000	0.244	0.177	0.253	0.281	0.196	0.178	0.333	0.347
9	0.375	0.344	0.173	0.335	0.292	0.402	0.000	0.227	0.000	0.442	0.204	0.281	0.330	0.242	0.212	0.000	0.648
10	0.467	0.589	0.000	0.320	0.302	0.575	0.000	0.282	0.000	0.000	0.224	0.472	0.527	0.262	0.395	0.000	0.000
11	0.372	0.000	0.000	0.000	0.202	0.348	0.000	0.000	0.000	0.000	0.000	0.386	0.000	0.000	0.000	0.000	0.000
12	0.000	0.518	0.000	0.000	0.000	0.311	0.346	0.639	0.753	0.000	0.000	0.000	0.000	0.458	0.000	0.000	0.000
13+	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.416	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NK	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.680	0.994	0.894	0.000	0.000	0.645	0.000	0.930	0.811

Table 12.

A. CANADIAN SUMMER SURVEY - STRATIFIED DELTA MEAN CATCH (NUMBERS) PER STANDARD TOW 17/ 9/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
0	0.000	0.000	0.000	0.000	0.000	0.000	0.069	0.012	0.012	0.523	0.029	0.678	0.271	0.349	0.304	0.000	0.121
1	5.975	0.117	5.802	4.177	13.875	7.086	6.252	6.751	7.271	1.680	21.801	40.736	25.007	6.691	5.687	6.478	3.819
2	5.309	11.139	0.263	13.011	22.355	3.685	6.530	31.355	5.310	13.707	6.994	73.459	29.244	4.546	25.404	6.752	9.924
3	1.453	4.716	3.775	0.391	32.684	4.888	4.220	31.656	9.542	10.163	14.502	13.345	12.048	14.540	13.688	27.667	9.828
4	2.622	2.048	1.341	2.422	1.067	7.997	4.264	9.420	2.683	10.408	8.118	9.063	4.408	5.795	18.812	19.348	17.186
5	1.101	2.851	0.907	1.173	4.723	0.429	7.705	9.969	1.216	4.726	13.042	3.156	6.364	3.559	5.861	11.885	10.482
6	2.565	1.344	0.931	0.391	0.997	1.961	0.575	5.931	2.503	1.932	4.831	3.469	2.609	2.356	3.267	3.403	3.219
7	5.821	2.013	0.656	0.554	0.575	0.531	0.668	0.749	1.069	3.158	1.689	1.150	2.582	1.033	1.605	0.987	0.602
8	0.916	5.071	1.125	0.414	0.609	0.422	0.119	0.968	0.029	1.262	1.420	0.250	0.334	0.319	0.560	0.095	0.258
9	0.337	0.774	1.239	0.267	0.394	0.176	0.024	0.139	0.000	0.249	0.658	0.464	0.163	0.297	0.442	0.000	0.069
10	0.279	0.093	0.043	0.395	0.303	0.110	0.037	0.118	0.000	0.033	0.245	0.232	0.060	0.210	0.080	0.040	0.017
11	0.085	0.045	0.006	0.007	0.350	0.301	0.000	0.010	0.034	0.000	0.043	0.142	0.038	0.090	0.033	0.000	0.017
12	0.029	0.065	0.005	0.000	0.000	0.269	0.242	0.070	0.042	0.000	0.000	0.036	0.000	0.069	0.031	0.030	0.000
13+	0.000	0.000	0.000	0.015	0.000	0.000	0.078	0.076	0.009	0.000	0.000	0.000	0.000	0.021	0.041	0.000	0.000
NK	0.000	0.000	0.000	0.000	0.000	0.000	0.032	0.008	0.093	0.045	0.050	0.005	0.000	0.049	0.000	0.034	0.078

B. CANADIAN SUMMER SURVEY - STRATIFIED DELTA VARIANCE OF CATCH (NUMBERS) PER STANDARD TOW 17/ 9/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
0	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.062	0.001	0.215	0.071	0.055	0.014	0.000	0.003
1	2.572	0.003	6.560	4.880	80.541	8.887	2.317	7.565	8.446	0.800	196.731	594.692	314.654	4.609	8.413	2.634	0.194
2	4.300	8.245	0.018	30.277	40.378	1.142	2.380	111.277	4.049	38.207	8.673	4507.446	79.244	2.661	176.788	1.761	10.153
3	0.153	2.070	2.299	0.012	109.130	2.061	0.730	288.089	7.493	39.057	25.689	114.609	9.162	19.462	33.509	94.923	5.312
4	0.616	0.477	0.071	0.463	0.114	4.903	0.514	27.159	0.391	15.421	6.460	3.334	0.863	0.934	45.528	77.350	18.322
5	0.193	0.900	0.031	0.137	2.398	0.019	2.115	13.047	0.122	1.568	16.852	0.217	1.448	0.337	2.604	15.939	7.658
6	1.077	0.205	0.033	0.015	0.090	0.330	0.024	3.430	0.644	0.233	2.420	0.264	0.199	0.127	0.450	0.923	1.498
7	3.630	0.545	0.024	0.023	0.037	0.032	0.026	0.043	0.071	0.880	0.199	0.047	0.268	0.051	0.107	0.063	0.050
8	0.134	2.739	0.145	0.015	0.042	0.019	0.001	0.091	0.000	0.157	0.140	0.004	0.008	0.004	0.010	0.001	0.009
9	0.016	0.072	0.046	0.010	0.023	0.005	0.000	0.001	0.000	0.012	0.022	0.017	0.003	0.005	0.009	0.000	0.002
10	0.017	0.003	0.000	0.017	0.012	0.004	0.000	0.001	0.000	0.001	0.003	0.012	0.001	0.003	0.001	0.000	0.000
11	0.001	0.000	0.000	0.000	0.005	0.011	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000
12	0.000	0.001	0.000	0.000	0.000	0.007	0.008	0.002	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
13+	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NK	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.002	0.002	0.000	0.000	0.001	0.000	0.001	0.004

C. CANADIAN SUMMER SURVEY - COEFFICIENTS OF VARIATION IN DELTA MEAN CATCH (NUMBERS) PER STANDARD TOW 17/ 9/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
0	0.000	0.000	0.000	0.000	0.000	0.000	0.794	0.000	0.000	0.476	1.090	0.684	0.983	0.672	0.389	0.000	0.453
1	0.268	0.468	0.441	0.529	0.647	0.421	0.243	0.407	0.400	0.532	0.643	0.599	0.709	0.321	0.510	0.251	0.115
2	0.391	0.258	0.510	0.423	0.284	0.290	0.236	0.336	0.379	0.451	0.421	0.914	0.304	0.359	0.523	0.197	0.324
3	0.269	0.305	0.402	0.280	0.320	0.294	0.202	0.536	0.287	0.615	0.349	0.802	0.251	0.303	0.423	0.352	0.235
4	0.299	0.337	0.199	0.281	0.316	0.277	0.168	0.553	0.233	0.377	0.313	0.201	0.211	0.167	0.359	0.455	0.249
5	0.399	0.333	0.194	0.316	0.328	0.321	0.189	0.362	0.287	0.265	0.315	0.148	0.189	0.163	0.275	0.336	0.264
6	0.405	0.337	0.195	0.313	0.301	0.293	0.269	0.312	0.321	0.250	0.322	0.148	0.171	0.151	0.205	0.282	0.380
7	0.327	0.367	0.236	0.274	0.335	0.337	0.241	0.277	0.249	0.297	0.264	0.189	0.200	0.219	0.204	0.254	0.371
8	0.400	0.326	0.338	0.296	0.337	0.327	0.266	0.312	0.000	0.314	0.263	0.253	0.268	0.198	0.179	0.333	0.368
9	0.375	0.347	0.173	0.375	0.385	0.402	0.000	0.227	0.000	0.440	0.225	0.281	0.336	0.238	0.215	0.000	0.648
10	0.467	0.589	0.000	0.330	0.362	0.575	0.000	0.268	0.000	0.958	0.224	0.472	0.527	0.261	0.395	0.000	0.000
11	0.372	0.000	0.000	0.000	0.202	0.348	0.000	0.000	0.000	0.000	0.000	0.386	0.000	0.000	0.000	0.000	0.000
12	0.000	0.486	0.000	0.000	0.000	0.311	0.370	0.639	0.753	0.000	0.000	0.000	0.000	0.458	0.000	0.000	0.000
13+	0.000	0.000	0.000	0.000	0.000	0.000	0.405	0.416	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NK	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.680	0.994	0.894	0.000	0.000	0.645	0.000	0.930	0.811

Table 13.

A. PERCENT AGE COMPOSITION OF UNTRANSFORMED SURVEY DATA 17/ 9/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
0	0.000	0.000	0.000	0.000	0.000	0.000	0.224	0.011	0.041	1.116	0.040	0.713	0.377	0.874	0.439	0.000	0.224
1	22.952	0.386	38.401	19.462	15.109	25.142	20.692	5.758	22.507	3.581	29.835	43.153	18.161	17.169	6.701	9.055	7.150
2	18.415	36.355	1.705	54.077	31.081	13.505	21.209	30.423	18.068	28.367	9.474	30.293	39.924	11.361	33.453	9.249	16.288
3	5.463	15.424	21.205	1.728	42.624	17.588	13.696	35.314	32.717	20.738	20.913	7.237	17.817	36.172	17.714	33.873	18.514
4	10.104	6.741	8.787	10.652	1.339	28.684	13.732	10.170	9.659	22.021	10.966	9.230	6.517	14.590	25.311	26.063	31.579
5	4.350	9.570	5.760	5.136	5.777	1.540	24.717	10.336	4.261	10.416	17.386	3.320	9.251	8.907	7.921	15.976	19.052
6	10.268	4.526	5.884	1.697	1.301	7.016	1.864	5.973	8.330	4.134	5.941	3.650	3.634	5.886	4.544	4.214	5.238
7	22.516	6.826	3.990	2.445	0.715	1.915	2.137	0.701	3.709	6.487	2.297	1.217	3.481	2.408	2.223	1.299	1.143
8	3.093	17.040	5.851	1.811	0.761	1.522	0.387	0.935	0.099	2.443	1.790	0.263	0.470	0.806	0.796	0.130	0.477
9	1.311	2.482	8.064	1.168	0.470	0.635	0.078	0.127	0.000	0.529	0.897	0.488	0.231	0.731	0.635	0.000	0.128
10	1.086	0.304	0.280	1.728	0.363	0.397	0.120	0.102	0.000	0.070	0.334	0.244	0.083	0.523	0.113	0.055	0.031
11	0.331	0.147	0.039	0.031	0.459	1.086	0.000	0.009	0.116	0.000	0.059	0.149	0.053	0.225	0.047	0.000	0.031
12	0.113	0.200	0.033	0.000	0.000	0.970	0.786	0.064	0.144	0.000	0.000	0.038	0.000	0.173	0.044	0.041	0.000
13+	0.000	0.000	0.000	0.066	0.000	0.000	0.253	0.069	0.031	0.000	0.000	0.000	0.000	0.053	0.058	0.000	0.000
NK	0.000	0.000	0.000	0.000	0.000	0.000	0.104	0.007	0.319	0.096	0.068	0.005	0.000	0.123	0.000	0.046	0.144

B. PERCENT AGE COMPOSITION OF DELTA TRANSFORMED SURVEY DATA 17/ 9/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
0	0.000	0.000	0.000	0.000	0.000	0.000	0.224	0.012	0.040	1.092	0.039	0.464	0.326	0.874	0.401	0.000	0.218
1	22.554	0.386	36.051	17.991	17.804	25.439	20.289	6.943	24.389	3.508	29.693	27.866	30.083	16.759	7.501	8.444	6.879
2	20.040	36.792	1.634	56.041	28.685	13.229	21.191	32.248	17.811	28.624	9.526	50.251	35.179	11.387	33.508	8.801	17.695
3	5.485	15.577	23.462	1.684	41.939	17.548	13.695	32.557	32.006	21.223	19.752	9.129	14.493	36.419	18.054	36.063	17.702
4	9.897	6.764	8.332	10.432	1.369	28.709	13.837	9.688	8.999	21.735	11.057	6.200	5.303	14.515	24.813	25.219	30.955
5	4.156	9.417	5.636	5.052	6.060	1.540	25.004	10.253	4.079	9.869	17.763	2.159	7.656	8.914	7.731	15.492	18.880
6	9.682	4.439	5.785	1.684	1.279	7.040	1.866	6.100	8.396	4.035	6.580	2.373	3.139	5.901	4.309	4.436	5.798
7	21.973	6.649	4.076	2.386	0.738	1.906	2.168	0.770	3.586	6.595	2.300	0.787	3.106	2.587	2.117	1.287	1.084
8	3.458	16.749	6.990	1.783	0.781	1.515	0.386	0.996	0.097	2.635	1.934	0.171	0.402	0.799	0.739	0.124	0.465
9	1.272	2.556	7.699	1.150	0.506	0.632	0.078	0.143	0.000	0.520	0.896	0.317	0.196	0.744	0.583	0.000	0.124
10	1.053	0.307	0.267	1.701	0.389	0.395	0.120	0.121	0.000	0.069	0.334	0.159	0.072	0.526	0.106	0.052	0.031
11	0.321	0.149	0.037	0.030	0.449	1.081	0.000	0.010	0.114	0.000	0.059	0.097	0.046	0.225	0.044	0.000	0.031
12	0.109	0.215	0.031	0.000	0.000	0.966	0.785	0.072	0.141	0.000	0.000	0.025	0.000	0.173	0.041	0.039	0.000
13+	0.000	0.000	0.000	0.065	0.000	0.000	0.253	0.078	0.030	0.000	0.000	0.000	0.000	0.053	0.054	0.000	0.000
NK	0.000	0.000	0.000	0.000	0.000	0.000	0.104	0.008	0.312	0.094	0.068	0.003	0.000	0.123	0.000	0.044	0.140

C. PERCENT DIFFERENCE (AR-DELTA) BETWEEN THE TWO SURVEY TREATMENTS 17/ 9/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0
1	0.4	0.0	2.4	1.5	-2.7	-0.3	0.4	-1.2	-1.9	0.1	0.1	15.3	-11.9	0.4	-0.8	0.6	0.3
2	-1.6	-0.4	0.1	-2.0	2.4	0.3	0.0	-1.8	0.3	-0.3	-0.1	-20.0	4.7	0.0	-0.1	0.4	-1.4
3	0.0	-0.2	-2.3	0.0	0.7	0.0	0.0	2.8	0.7	-0.5	1.2	-1.9	3.3	-0.2	-0.3	-2.2	0.8
4	0.2	0.0	0.5	0.2	0.0	0.0	-0.1	0.5	0.7	0.3	-0.1	3.0	1.2	0.1	0.5	0.8	0.6
5	0.2	0.2	0.1	0.1	-0.3	0.0	-0.3	0.1	0.2	0.5	-0.4	1.2	1.6	0.0	0.2	0.5	0.2
6	0.6	0.1	0.1	0.0	0.0	0.0	0.0	-0.1	-0.1	0.1	-0.6	1.3	0.5	0.0	0.2	-0.2	-0.6
7	0.5	0.2	-0.1	0.1	0.0	0.0	0.0	-0.1	0.1	-0.1	0.0	0.4	0.4	-0.2	0.1	0.0	0.1
8	-0.4	0.3	-1.1	0.0	0.0	0.0	0.0	-0.1	0.0	-0.2	-0.1	0.1	0.1	0.0	0.1	0.0	0.0
9	0.0	-0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 14. Recruitment indices for 4X haddock calculated from summer groundfish survey data set.

Year-Class	Age 1 + 2 Index	Age 2 + 3 Index
1968	-	0.360
1969	0.652	0.506
1970	0.014	0.024
1971	0.703	1.740
1972	0.917	0.905
1973	0.813	0.288
1974	0.562	1.493
1975	1.305	1.379
1976	0.507	0.581
1977	0.799	1.023
1978	0.305	0.764
1979	3.417	2.812
1980	2.971	1.515
1981	1.400	0.700
1982	1.139	1.928
1983	0.499	0.613
1984	0.636	-
1985	0.384*	-

* Based on age one numbers per tow only.

Table 15. Estimates of total mortality, Z, for ages 5-8/6-9 derived from survey and commercial catch rate indices. QTR is the year quarter.

Year	Survey	OTB2 TC 2-3 QTR1	OTB2 TC 4-5 QTR1	OTB2 TC 2-3 QTR3
1970/71	0.123	-0.673	0.579	2.480
1971	1.049	1.179	0.439	0.463
1972	0.800	-0.470	0.177	-
1973	-0.017	0.208	0.431	-
1974	0.804	1.010	1.064	0.873
1975/76	0.880	0.018	0.364	-2.034
1976	0.152	0.167	0.407	1.627
1977	1.588	1.249	0.936	-0.253
1978	-0.315	0.790	0.503	0.556
1979	0.253	0.262	0.409	-0.133
1980/81	1.370	0.928	0.831	0.928
1981	0.344	1.035	1.162	1.401
1982	1.088	1.243	1.426	0.855
1983	0.213	0.309	0.384	0.995
1984	0.923	0.963	1.370	1.956
1985/86	1.373	1.255	-	-

Table 16. Ratio of survey/catch variance (A) and survey cv/catch cv (B).

A.

	1980	1981	1982	1983	1984	1985
1	0.0004832	0.0024272	0.0034455	0.0001285	0.0025649	0.0000000
2	0.0000288	0.0145130	0.0004825	0.0000435	0.0073512	0.0008015
3	0.0001030	0.0005695	0.0000515	0.0001789	0.0008217	0.0021629
4	0.0000355	0.0000214	0.0000071	0.0000087	0.0007780	0.0038862
5	0.0001097	0.0000026	0.0000189	0.0000053	0.0000558	0.0008379
6	0.0000318	0.0000059	0.0000066	0.0000037	0.0000199	0.0001174
7	0.0000163	0.0000031	0.0000190	0.0000044	0.0000110	0.0000310
8	0.0000142	0.0000009	0.0000016	0.0000011	0.0000037	0.0000018

B.

	1980	1981	1982	1983	1984	1985
1	32.168	31.508	15.092	7.130	2.417	0.251
2	16.843	45.697	16.021	7.635	11.631	0.923
3	18.395	32.089	11.964	15.969	8.998	6.644
4	10.796	9.594	7.805	6.671	17.080	7.975
5	11.241	4.761	6.753	5.262	7.441	12.441
6	7.667	4.488	3.800	3.238	4.464	3.133
7	4.063	3.428	4.010	3.215	2.548	3.064
8	3.875	3.419	2.911	1.983	1.539	2.264

Table 17. Survivor analysis of 4X haddock age 3-8 survey data, treated with delta transform.

INTEGRATED CATCH 86/09/17

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
3	3957	8596	12085	3130	22560	22025	10563	25929	28215	16673	22389	15233	16484	14241	3344	1029
4	5188	2553	3828	7346	2367	14610	14038	8760	18546	18465	11737	14319	10341	9324	8014	1187
5	1416	2924	1509	1834	4201	1574	7495	8140	3849	8680	9853	6317	6844	5625	3640	2387
6	445	504	1475	785	800	2149	873	3180	3942	1741	3771	4053	2554	2549	1858	787
7	3442	106	441	645	310	316	900	357	869	1416	714	1028	1249	910	675	257
8	780	1744	30	169	141	90	81	205	72	138	328	188	179	208	179	76

ITERATION 1 RMS=1.75232441
G/S CHANGE IN SURVIVORS=56.21260617

AGE	SURVIVORS	%
3	70046	2835.23
4	31482	2560.14
5	19109	1845.86
6	4249	1473.71
7	1173	1473.71
8	68	1473.71

FINAL ITERATION (15)

INTEGRATED SURVIVORS 86/09/17

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
3	554	342	1014	4	3056	3201	624	953	879	1698	205	2886	8556	31588	42496	77413
4	677	454	280	830	3	2502	2621	511	780	720	1370	168	2363	7005	25862	34793
5	334	555	371	229	680	3	2948	2146	418	639	589	1138	138	1934	5735	21174
6	2872	383	454	304	185	557	2	1677	1757	343	523	482	932	113	1584	4695
7	4416	2368	559	372	249	154	456	2	1373	1438	280	428	395	763	92	1297
8	370	3616	1939	458	304	204	126	373	2	1124	1178	230	351	323	625	75

POPULATION NUMBERS 86/09/17

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
3	4511	6938	13099	3134	25615	25226	11188	26882	29094	18391	22594	18119	25040	45828	45840	78442
4	5866	3007	4108	8177	2370	16512	16659	7491	17326	19184	13127	14487	12704	16329	33876	35980
5	2250	3479	1880	2063	4881	1577	9543	10286	4268	9319	10243	7455	6981	7560	9375	23561
6	3338	1486	1929	1069	988	2705	876	4857	5699	2083	4294	4535	3485	2661	3442	5483
7	10859	2474	1000	1016	559	472	1356	359	2242	2855	994	1456	1644	1673	767	1554
8	1350	5360	1969	627	446	294	207	578	74	1262	1505	417	529	531	803	151

ESTIMATED SURVIVORS 86/09/17

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
3	54	2255	0	0	23333	0	466	21241	0	4034	6232	9188	8775	16363	26269	70037
4	619	1073	0	0	148	2627	0	6966	0	3325	3676	3610	468	3342	29736	43737
5	306	1161	82	164	2242	0	3339	5094	0	21	7158	0	2434	572	5316	17667
6	2922	713	0	0	406	449	0	3370	0	670	2029	641	782	559	2189	3824
7	1592	2118	389	127	398	344	62	553	523	2397	1314	494	1892	453	1252	1083
8	335	5181	1472	399	684	481	85	1105	0	1557	1596	163	283	237	585	58

ESTIMATED VARIANCE OF SURVIVORS 86/09/17

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
3	1185131	12484835	8003855	85820	599660745	13412126	9996780	562532976	51110960	57980114	118056803	149138636	181342968	394019221	520938411	3075813765
4	4094047	2863775	1227834	4005256	777340	-43665278	12414134	60587613	4914996	73763355	44996645	59084323	17791876	51027973	602241726	1226413747
5	641800	4303475	435551	728485	11810294	97440	31431861	52617232	782874	11825302	90056114	5273498	21442981	10004573	40478583	240540536
6	3311034	909049	436203	76938	500241	1935281	166389	17702915	3152903	1878465	11745270	6056163	3425604	2793441	8013182	12564932
7	24644139	2947176	312987	223223	240466	205073	324542	408021	831139	7253418	2074807	961865	4848763	776103	1873564	1056989
8	910389	27901238	1373224	185967	402412	193224	15365	1016686	912	1728045	2187827	67814	121040	110412	340261	9792

WEIGHTED SURVIVORS 86/09/17

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
3	2	2	0	0	21	0	3	4	0	15	1	50	374	5229	18438	79037
4	14	15	0	0	0	32	0	7	0	5	17	1	19	506	4667	13040
5	12	28	0	0	38	0	56	39	0	0	8	0	1	47	1015	9258
6	446	30	0	0	11	46	0	100	0	21	19	11	48	2	222	2352
7	837	225	111	59	64	23	38	1	332	304	37	53	41	123	6	834
8	335	2430	783	191	175	96	75	216	0	476	672	140	242	227	362	58

Table 17. (Continued)

RMS=0.5909998286

ESTIMATED SURVIVORS FOR AGE 3 (WEIGHTED)

YEAR	SURVIVORS	VARIANCE	STANDARD ERROR	C.V.(%)	$\bar{N}$	F
1970	335	910389	954	285.23	2408	1.7737
1971	3269	13085870	3617	110.66	7613	0.6453
1972	1754	739171	855	48.73	2205	0.0289
1973	414	89043	298	72.10	858	0.5287
1974	275	103063	321	116.67	630	0.6281
1975	184	38729	197	106.79	413	0.6069
1976	114	13472	116	101.99	307	0.7915
1977	337	198379	445	132.07	836	0.7080
1978	1	887	30	2172.14	145	4.4578
1979	1017	527780	726	71.47	1531	0.2094
1980	1065	920618	959	90.09	1983	0.4218
1981	208	58294	241	116.31	641	0.9283
1982	317	103345	321	101.42	758	0.6721
1983	292	105569	325	111.14	787	0.7906
1984	565	210596	459	81.26	1062	0.4318
1985	68	9701	98	144.36	240	1.0557

ESTIMATED SURVIVORS FOR 1985 (WEIGHTED)

AGE	SURVIVORS	VARIANCE	STANDARD ERROR	C.V.(%)
3	70037	3075813765	55460	79.19
4	31478	365630967	19121	60.75
5	19155	125916713	11221	58.58
6	4247	7727796	2780	65.46
7	1173	814290	902	76.95
8	68	9701	98	144.36

FINAL ESTIMATION FOR K

AGE	K	LN(K)	VAR(LN(K))	STANDARD ERROR	D.F	$\bar{N}$	F
3	2634.87	7.7477	0.4042	0.1642	1	87696	0.0249
4	2059.75	7.7272	0.2410	0.1268	1	40932	0.0627
5	1845.48	7.4181	0.2048	0.1166	1	28385	0.1934
6	1473.10	7.0900	0.4103	0.1170	29	6830	0.2754
7	1473.10	7.0900	0.4103	0.1170	29	1969	0.3183
8	1473.10	7.0900	0.4103	0.1170	29	239	1.0560

RESIDUALS 86/09/17

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
3	-0.0909	0.6559	-0.2019	-1.0394	1.2857	-0.5991	0.0670	1.2055	-0.0728	0.4489	0.5986	0.7362	0.3104	-0.1060	-0.1666	-0.0001
4	0.1348	0.5360	-0.1797	-0.2768	0.1418	0.2149	-0.4228	1.1690	-0.7254	0.3284	0.4593	0.4709	-0.1186	-0.0960	0.3517	0.3195
5	-0.1018	0.4137	-0.1162	0.0480	0.5799	-0.6889	0.3988	0.5815	-0.6428	-0.0662	0.8544	-0.2468	0.5202	-0.1406	0.1430	-0.0716
6	0.1241	0.2866	-0.3413	-0.6188	0.3767	0.0656	-0.0332	0.5871	-0.4354	0.3119	0.5052	0.1193	0.0978	0.2655	0.3352	-0.0695
7	-0.2361	0.1811	-0.0345	-0.2175	0.4161	0.5051	-0.3207	1.1234	-0.3532	0.4883	0.9172	0.1516	0.8386	-0.0948	1.1257	-0.0665
8	-0.0004	0.3320	-0.1723	-0.0277	0.6993	0.7480	-0.1655	0.9036	-0.5434	0.3870	0.3291	-0.1250	-0.0732	-0.1223	0.0285	-0.0773

MEAN OF RESIDUALS=0.1551608862

STANDARD DEVIATION OF RESIDUALS=0.4629970076

OUTLIERS OF RESIDUALS 86/09/17

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
3	0.00	0.00	0.00	-1.34	1.29	0.00	0.00	1.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.17	-0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12	0.00	0.00	0.00	0.00	0.00	0.00	1.13	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Age 2

SUMMARY OF DATA FROM PLOT

CARRIER VARIABLE; POPULATION NOS
RESPONSE VARIABLE(S); SURVEY - θ;OBSERVED, +;PREDICTED

INDEX	CARRIER	θ	+	RANK
1970	1.017E4	5.309	3.6663	1972
1971	1.835E4	11.139	8.659	1970
1972	4.606E3	0.263	0.2645	1975
1973	3.345E4	13.011	17.8838	1985
1974	3.229E4	22.355	17.1741	1971
1975	1.046E4	3.685	7.5038	1986
1976	3.346E4	6.53	19.1139	1980
1977	3.790E4	31.355	20.6056	1978
1978	2.189E4	5.31	10.8211	1981
1979	2.953E4	13.707	15.4922	1983
1980	2.173E4	6.994	10.724	1979
1981	2.746E4	73.459	14.2229	1974
1982	3.553E4	29.244	19.1538	1973
1983	2.777E4	4.546	14.4148	1976
1984	5.430E4	25.404	30.6224	1982
1985	1.711E4	6.752	7.9023	1977
1986	2.023E4	9.824	9.8408	1984

Age 3

SUMMARY OF DATA FROM PLOT

CARRIER VARIABLE; POPULATION NOS
RESPONSE VARIABLE(S); SURVEY - θ;OBSERVED, +;PREDICTED

INDEX	CARRIER	θ	+	RANK
1970	4.506E3	1.453	1.0279	1973
1971	7.055E3	4.716	2.7823	1970
1972	1.287E4	3.776	6.7852	1971
1973	3.705E3	0.391	0.4771	1976
1974	2.371E4	32.684	14.2467	1972
1975	2.376E4	4.388	14.2768	1986
1976	1.176E4	4.22	6.0214	1981
1977	2.690E4	31.656	16.4389	1979
1978	2.879E4	9.542	17.7367	1982
1979	1.730E4	10.163	9.8327	1984
1980	2.289E4	14.502	13.6806	1980
1981	1.658E4	13.345	9.3366	1974
1982	2.010E4	12.048	11.7584	1975
1983	2.719E4	14.54	16.6387	1977
1984	2.215E4	13.688	13.1694	1983
1985	4.318E4	27.667	27.6421	1978
1986	1.378E4	9.828	7.4109	1985

Age 4

SUMMARY OF DATA FROM PLOT

CARRIER VARIABLE; POPULATION NOS
RESPONSE VARIABLE(S); SURVEY - θ;OBSERVED, +;PREDICTED

INDEX	CARRIER	θ	+	RANK
1970	5.735E3	2.622	2.615	1974
1971	2.985E3	2.048	1.457	1971
1972	4.130E3	1.341	1.94	1972
1973	8.024E3	2.422	3.579	1970
1974	2.829E3	1.067	1.392	1977
1975	1.480E4	7.997	6.432	1973
1976	1.539E4	4.264	6.602	1982
1977	7.907E3	9.42	3.53	1983
1978	1.691E4	2.683	7.323	1980
1979	1.858E4	10.408	8.024	1981
1980	1.210E4	8.118	5.296	1975
1981	1.433E4	9.063	6.232	1976
1982	1.139E4	4.408	4.998	1985
1983	1.199E4	5.795	5.248	1978
1984	1.847E4	18.812	7.976	1984
1985	1.652E4	19.348	7.156	1979
1986	3.304E4	17.186	14.113	1986

Age 5

SUMMARY OF DATA FROM PLOT

CARRIER VARIABLE; POPULATION NOS
RESPONSE VARIABLE(S); SURVEY - θ;OBSERVED, +;PREDICTED

INDEX	CARRIER	θ	+	RANK
1970	2.075E3	1.101	0.9026	1972
1971	3.335E3	2.851	2.0755	1975
1972	1.870E3	0.907	0.7116	1970
1973	2.111E3	1.173	0.9357	1973
1974	4.742E3	4.723	3.386	1971
1975	1.935E3	0.429	0.7722	1978
1976	8.139E3	7.705	6.5496	1974
1977	9.246E3	9.969	7.5812	1984
1978	4.533E3	1.216	3.1916	1983
1979	9.127E3	4.726	7.4705	1981
1980	9.632E3	13.042	7.9406	1982
1981	6.313E3	3.156	4.8493	1976
1982	6.756E3	6.364	5.2622	1979
1983	6.230E3	3.559	4.7723	1977
1984	5.858E3	5.861	4.4255	1980
1985	1.082E4	11.885	9.0462	1986
1986	1.047E4	10.482	8.7235	1985

Age 6

SUMMARY OF DATA FROM PLOT

CARRIER VARIABLE; POPULATION NOS
RESPONSE VARIABLE(S); SURVEY - θ;OBSERVED, +;PREDICTED

INDEX	CARRIER	θ	+	RANK
1970	2610	2.565	2.2547	1973
1971	1334	1.344	0.905	1974
1972	1859	0.931	1.4608	1976
1973	1041	0.391	0.5948	1971
1974	1061	0.997	0.6165	1972
1975	2613	1.961	2.2579	1984
1976	1161	0.575	0.7224	1979
1977	3607	5.931	3.3097	1983
1978	4753	2.503	4.5218	1970
1979	2357	1.932	1.9873	1975
1980	3930	4.831	3.6513	1985
1981	4076	3.469	3.8063	1982
1982	2748	2.609	2.4006	1977
1983	2608	2.356	2.2527	1980
1984	2306	3.267	1.9335	1981
1985	2742	3.403	2.3945	1978
1986	6191	3.219	6.0434	1986

Age 7

SUMMARY OF DATA FROM PLOT

CARRIER VARIABLE; POPULATION NOS
RESPONSE VARIABLE(S); SURVEY - θ;OBSERVED, +;PREDICTED

INDEX	CARRIER	θ	+	RANK
1970	1.195E4	5.821	9.5442	1975
1971	1.898E3	2.013	1.6403	1974
1972	8.931E2	0.656	0.8499	1977
1973	9.339E2	0.554	0.882	1984
1974	5.609E2	0.575	0.5887	1985
1975	5.480E2	0.531	0.5785	1972
1976	1.269E3	0.668	1.1452	1973
1977	5.825E2	0.749	0.6056	1983
1978	1.386E3	1.069	1.2377	1980
1979	2.192E3	3.158	1.8717	1976
1980	1.250E3	1.689	1.1305	1982
1981	1.391E3	1.15	1.2418	1978
1982	1.366E3	2.582	1.2218	1981
1983	1.091E3	1.033	1.0056	1986
1984	8.056E2	1.605	0.7811	1971
1985	8.686E2	0.987	0.8306	1979
1986	1.532E3	0.602	1.3522	1970

Age 8

SUMMARY OF DATA FROM PLOT

CARRIER VARIABLE; POPULATION NOS
RESPONSE VARIABLE(S); SURVEY - θ;OBSERVED, +;PREDICTED

INDEX	CARRIER	θ	+	RANK
1970	3019.1	0.916	2.98	1976
1971	6225	5.071	6.3039	1978
1972	1497.3	1.125	1.4022	1975
1973	509.5	0.414	0.3781	1985
1974	401.1	0.609	0.2657	1984
1975	289.8	0.422	0.1504	1974
1976	271	0.119	0.131	1983
1977	530.5	0.768	0.4	1986
1978	274.9	0.029	0.1349	1973
1979	641.5	1.262	0.5151	1977
1980	997.5	1.42	0.8841	1982
1981	626.6	0.25	0.4996	1981
1982	563.5	0.334	0.4341	1979
1983	430.3	0.319	0.2961	1980
1984	381.7	0.56	0.2456	1972
1985	296.5	0.095	0.1574	1970
1986	463.6	0.258	0.3306	1971

Table 18. Carrier (SPA population numbers) and Response (survey no. per tow -- observed and predicted) variables for model 2 (log) tuning of cohort analysis.

(A)

RESIDUALS FROM MODEL 1 (LINEAR) 19/ 9/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	0.035	0.014	0.015	0.570	0.036	0.318	0.981	0.182	0.479	0.371	0.383	2.849	0.107	1.044	0.675	0.188	0.020
3	0.077	0.211	0.459	0.032	1.873	1.368	0.297	1.409	1.250	0.137	0.166	0.314	0.240	0.674	0.687	0.450	0.169
4	0.209	0.039	0.420	0.590	0.336	0.408	0.925	1.829	1.621	0.683	0.822	0.835	0.363	0.026	3.183	3.092	0.739
5	0.197	0.354	0.214	0.212	0.492	0.039	0.070	0.524	1.077	1.794	1.696	1.114	0.180	0.877	0.219	0.099	1.439
6	0.170	0.231	0.589	0.319	0.170	0.364	0.270	2.182	1.623	0.161	0.939	0.331	0.085	0.012	1.060	0.505	2.241
7	0.263	0.589	0.637	0.799	0.543	0.594	0.850	0.322	0.379	1.961	0.542	0.273	1.680	0.248	0.695	0.175	1.252
8	2.230	0.706	0.115	0.135	0.328	0.143	0.349	0.786	0.507	1.156	1.000	0.558	0.338	0.202	0.268	0.421	0.346

(B)

RESIDUALS FORM MODEL 2 (LOG) 19/ 9/86

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
2	0.370	0.252	0.006	0.318	0.264	0.711	1.074	0.420	0.712	0.122	0.427	1.642	0.423	1.154	0.187	0.157	0.002
3	0.346	0.528	0.586	0.199	0.830	1.072	0.355	0.655	0.620	0.033	0.058	0.357	0.024	0.135	0.039	0.001	0.282
4	0.003	0.340	0.369	0.391	0.266	0.218	0.449	0.982	1.004	0.260	0.427	0.374	0.126	0.099	0.858	0.995	0.197
5	0.199	0.317	0.243	0.226	0.333	0.588	0.162	0.274	0.965	0.458	0.496	0.430	0.190	0.293	0.281	0.273	0.184
6	0.129	0.395	0.450	0.420	0.481	0.141	0.228	0.583	0.591	0.028	0.280	0.093	0.083	0.045	0.525	0.351	0.630
7	0.494	0.205	0.259	0.465	0.023	0.086	0.539	0.212	0.147	0.523	0.401	0.077	0.748	0.027	0.720	0.172	0.809
8	1.180	0.218	0.220	0.091	0.829	1.032	0.096	0.884	1.537	0.896	0.474	0.692	0.262	0.074	0.824	0.505	0.248

Table 19. Absolute (A) and Log (B) residuals from the model 1 and model 2 fit of RV to SPA data respectively.

Table 20. Cohort analysis tuned using survey data (delta transformed) fit with model two (log) and adjusted for the size of the 1982 year class.

POPULATION NUMBERS (000S)

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	24986	91666	201011	16142	10075	17382	8063	14465	25305	6232	47321	44220	23732	48793	52060	29598	39921	29439	37886	48291	37529	50202	23232	27384	0
2	32401	20457	75050	164574	13216	8248	14231	6601	11843	20718	5103	38706	36068	19429	39915	42607	24231	32685	24103	31004	39537	30726	41102	19019	22420
3	59711	26402	16104	61306	134678	10622	6733	11049	5396	8742	16249	4158	28906	28902	13939	31507	33721	19770	26687	19588	24314	31926	25098	33011	15391
4	19226	44793	19795	12034	47444	93670	8231	5244	7222	3763	5694	10197	3302	19456	19530	9925	22967	24573	15139	19637	14033	16614	23158	19546	25256
5	11566	14461	30173	12329	8060	29980	58250	5686	2513	4554	2367	2996	6315	2424	11256	12134	6299	12457	14048	9673	10450	9251	8648	14725	13961
6	9567	7861	9046	16255	7241	3733	16268	31903	3188	1714	2442	1476	1487	3561	1546	5884	7045	3262	6688	6604	4120	4368	4196	3968	7949
7	4687	6288	4944	4676	8414	3984	2116	9081	15947	2136	1038	1416	733	757	1917	873	2211	3206	1703	2309	2516	1832	1557	1267	1894
8	3144	2347	3867	2698	2043	3498	2597	1088	4521	8952	1687	768	616	429	397	839	389	869	1499	917	838	742	650	417	595
9	1895	1694	1385	1927	1304	912	1912	1657	479	2016	4329	1329	338	261	196	185	335	194	474	664	428	379	256	224	211
10	1049	968	954	580	903	697	578	958	1132	272	728	2489	854	108	158	96	55	178	108	235	251	185	141	105	136
11	536	649	655	405	214	356	479	301	608	840	75	132	1482	456	60	43	13	21	84	57	104	121	44	46	68
12	202	253	429	268	148	96	210	273	91	340	524	38	59	714	224	14	14	3	8	50	34	45	36	3	30
13	316	184	92	265	200	337	288	201	125	244	250	17	10	34	341	148	116	52	25	19	30	45	22	3	15
	169288	218023	363505	293456	233940	173516	119955	88507	78369	60522	87805	107944	103902	125324	141538	133852	137318	126710	128450	139048	134185	146434	128132	119719	87927

FISHING MORTALITY 13/ 1/87

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.004	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.005	0.039	0.002	0.000	0.018	0.003	0.053	0.002	0.164	0.043	0.005	0.092	0.021	0.132	0.037	0.034	0.003	0.003	0.007	0.043	0.014	0.002	0.019	0.012	0.000
3	0.087	0.088	0.091	0.056	0.163	0.055	0.050	0.225	0.161	0.229	0.266	0.030	0.196	0.192	0.140	0.116	0.116	0.067	0.107	0.134	0.181	0.121	0.050	0.068	0.021
4	0.085	0.195	0.274	0.201	0.259	0.275	0.170	0.536	0.261	0.263	0.442	0.279	0.109	0.347	0.276	0.255	0.412	0.359	0.248	0.431	0.217	0.453	0.253	0.137	0.138
5	0.186	0.269	0.419	0.332	0.570	0.411	0.402	0.378	0.182	0.423	0.271	0.500	0.373	0.250	0.449	0.344	0.458	0.422	0.555	0.653	0.672	0.591	0.579	0.417	0.375
6	0.220	0.264	0.460	0.458	0.398	0.368	0.383	0.493	0.200	0.302	0.345	0.501	0.475	0.419	0.372	0.779	0.587	0.450	0.863	0.765	0.610	0.832	0.997	0.539	0.300
7	0.492	0.286	0.406	0.628	0.678	0.228	0.466	0.497	0.377	0.036	0.101	0.632	0.335	0.447	0.626	0.609	0.734	0.560	0.419	0.813	1.022	0.837	1.118	0.556	0.225
8	0.419	0.328	0.497	0.527	0.606	0.404	0.249	0.621	0.608	0.527	0.038	0.622	0.659	0.585	0.561	0.718	0.493	0.407	0.615	0.562	0.595	0.888	0.864	0.481	0.300
9	0.472	0.374	0.670	0.557	0.426	0.257	0.492	0.182	0.367	0.819	0.353	0.243	0.938	0.304	0.512	1.017	0.435	0.392	0.502	0.772	0.640	0.789	0.667	0.303	0.300
10	0.280	0.191	0.657	0.796	0.731	0.176	0.452	0.253	0.098	1.089	1.504	0.318	0.428	0.396	1.097	1.765	0.741	0.550	0.430	0.610	0.534	1.243	0.927	0.237	0.300
11	0.550	0.214	0.695	0.808	0.605	0.328	0.360	0.997	0.382	0.272	0.484	0.614	0.530	0.511	1.281	0.891	1.344	0.839	0.324	0.315	0.646	1.002	2.420	0.215	0.300
12	0.426	0.296	0.558	0.626	0.613	0.306	0.414	0.472	0.394	0.633	0.516	0.473	0.592	0.433	0.697	1.021	0.603	0.480	0.567	0.702	0.713	0.932	0.916	0.422	0.300
13	0.426	0.296	0.558	0.626	0.613	0.306	0.414	0.472	0.394	0.633	0.516	0.473	0.592	0.433	0.697	1.021	0.603	0.480	0.567	0.702	0.713	0.932	0.916	0.422	0.300

AGE	c	q	R	Residuals: Age Specific	Residuals: Cohort Specific
2	-2.54929	0.00061	0.45379	7.20083	0.00000
3	-2.07274	0.00069	0.70406	3.98641	0.10443
4	0.20037	0.00042	0.72709	5.23040	0.64583
5	-1.03047	0.00093	0.90235	2.68866	2.35618
6	-0.50636	0.00106	0.65562	2.43715	1.40475
7	0.14754	0.00079	0.88119	3.13951	3.56351
8	-0.15005	0.00104	0.91480	8.97813	0.77841

Table 21. Comparison of numbers (000's) at age 1 generated by CAFSAC assessments since 1977.

Assessment	F_t	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
O'Boyle unpublished assessment #1 1977	0.28	30810	7007	60391	49293	28861	33393	-	-	-	-	-	-	-	-	-	-
O'Boyle unpublished assessment #2 1978	0.33	20810	7007	60231	35308	14606	26889	44755	-	-	-	-	-	-	-	-	-
Res. Doc. 78/19	0.3	33077	10775	75014	56364	34737	43539	83036	29423	-	-	-	-	-	-	-	-
Res. Doc. 80/2	0.325	26436	7169	50301	53352	28948	56167	73480	41293	50339	-	-	-	-	-	-	-
Res. Doc. 81/24	0.300	25436	6504	48605	47176	26207	50577	81785	41959	76120	45299	100000	-	-	-	-	-
Res. Doc. 82/53	0.400	25524	6146	47857	46326	24960	54146	62978	38975	61878	31820	97036	91945	-	-	-	-
Res. Doc. 83/73	0.300	25452	6605	47994	45115	25379	51390	63675	37615	68601	35501	115809	93681	32367	-	-	-
Res. Doc. 83/73	0.400	25372	6457	47684	44602	24567	50130	59385	33466	56954	28185	87988	75471	30736	-	-	-
Res. Doc. 84/100	0.65	25297	6307	47457	44500	24198	49041	52623	30238	41299	28012	37950	39444	24481	20000	-	-
Res. Doc. 85/109	0.60	25306	6292	47423	44360	24044	49054	52098	30164	41818	33882	39844	58478	28652	48570	12031	-
Present Document	0.30	25305	6232	47321	44220	23732	48793	52060	29598	39921	29439	37886	48291	37529	50202	23232	27384

Table 22. 1986 population conditions used for projection purposes.

Age	Beg. of Year Numbers at Age $x10^{-3}$	Catch Numbers at Age $x10^{-3}$	Weights at Age kg	Partial Recruitment
1	18701	1	0.250	0.0001
2	22420	172	0.562	0.022
3	15391	644	0.791	0.122
4	25256	2116	1.043	0.250
5	13961	4090	1.378	1.000
6	7949	2329	1.924	1.000
7	1894	555	2.442	1.000
8	595	154	2.896	0.865
9	211	37	3.321	0.545
10	136	19	3.218	0.426
11	68	9	4.063	0.387
12	30	7	4.300	0.759
13+	15	3	5.700	0.759

M = 0.2

$F_{0.1}$ = 0.25

Age one recruitment = 30 x 10^6 (geometric mean of 1962-85)

Table 23. Comparison of partial recruitment estimates calculated in 1985 with that provided in O'Boyle et al. (1983), O'Boyle et al. (1984), and O'Boyle and Gregory (1985).

Age	1985 Estimates	1984 Estimates	1983 Estimates	SPA (1971-83)
1	0.0001	0.000	0.000	0.000
2	0.022	0.033	0.007	0.039
3	0.122	0.110	0.238	0.250
4	0.25	0.330	0.672	0.559
5	0.75	0.850	1.000	0.830
6	0.97	1.000	1.000	1.000
7	1.000	1.000	1.000	0.923
8	0.865	1.000	1.000	1.015
9	0.545	1.000	1.000	1.114
10	0.426	1.000	1.000	1.322
11	0.387	1.000	1.000	1.074
12	0.759	1.000	1.000	1.000
13+	0.759	1.000	1.000	1.000

Table 24. Catch projection results using input data given in Table 22.

Year	Beg. of Year 1+ Population Biomass t	Mid-Year 1+ Fishable Biomass t	Annual 1+ Catch Biomass t	Fully Recruited Fishing Mortality
1986	98302	49836	15000	0.387
1987	99968	60505	12304	0.250

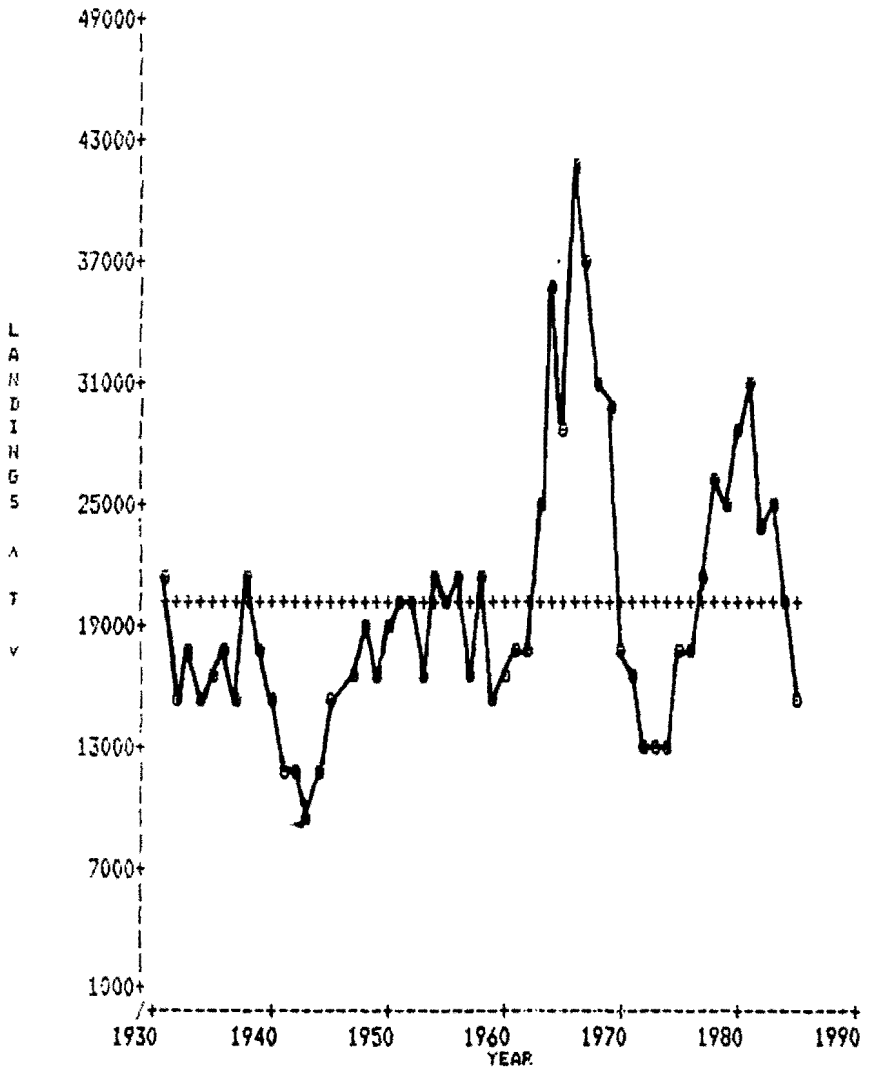


Figure 1. Long-term trends in 4X haddock landings. Mean level for 1930-83 indicated by +.

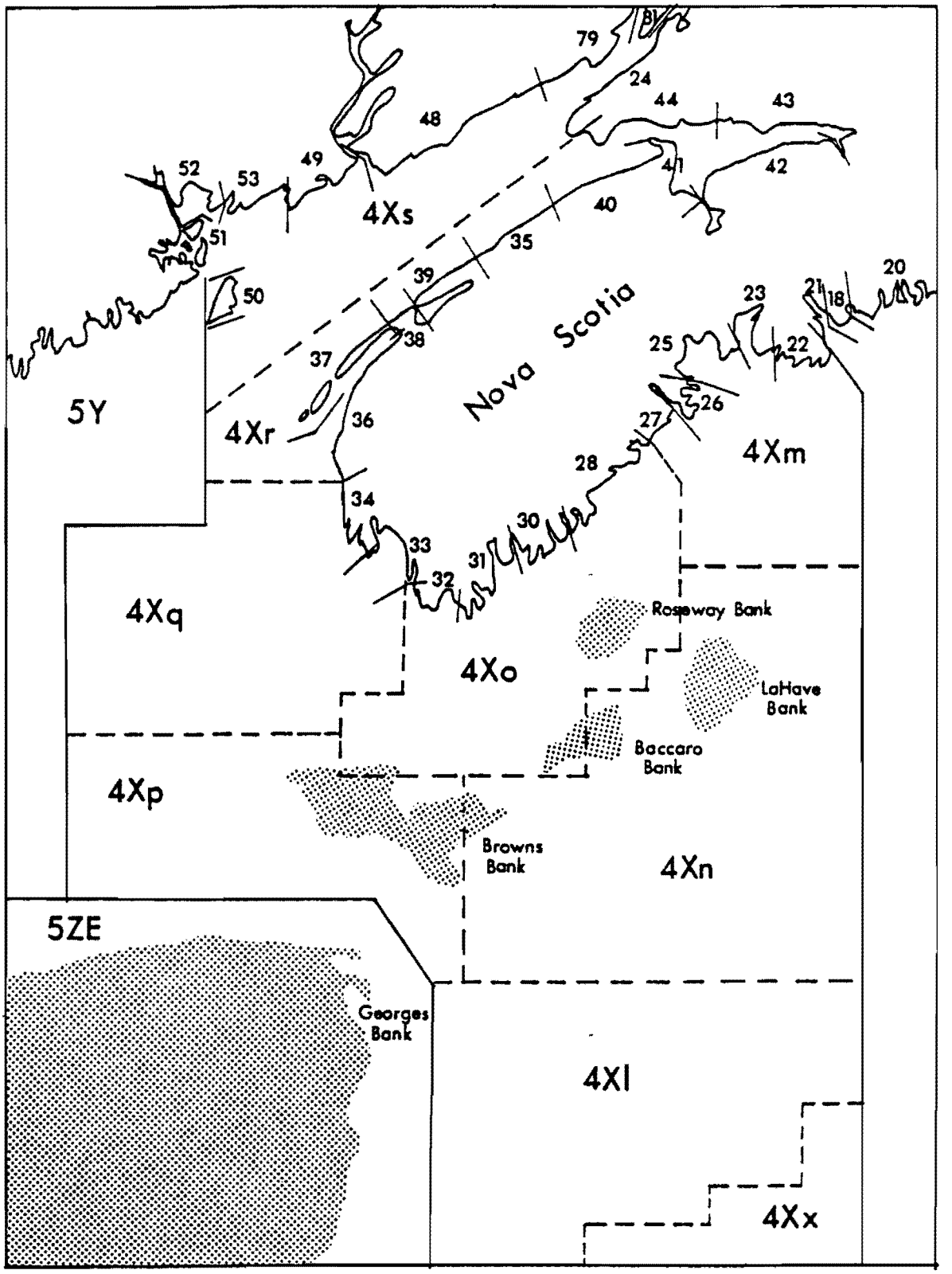
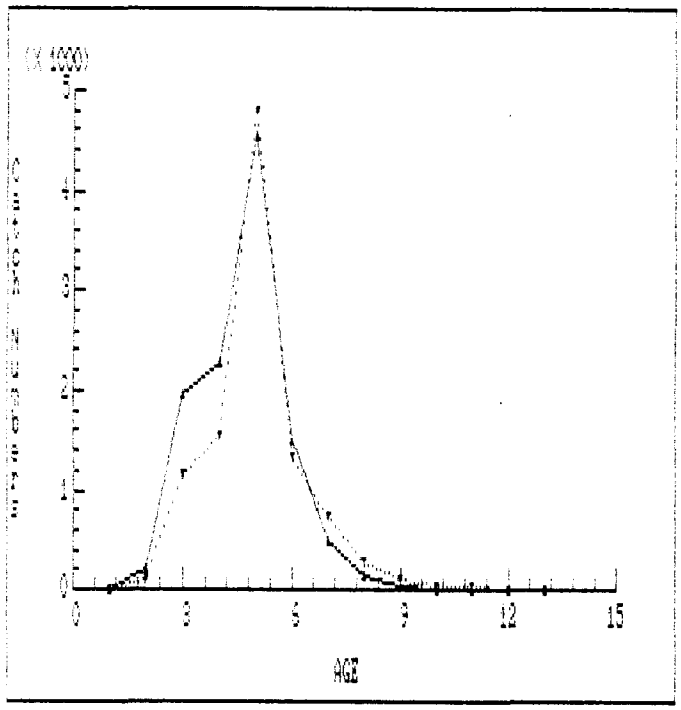


Figure 2. Canadian fisheries statistical unit areas in NAFO Division 4X.

A.



B.

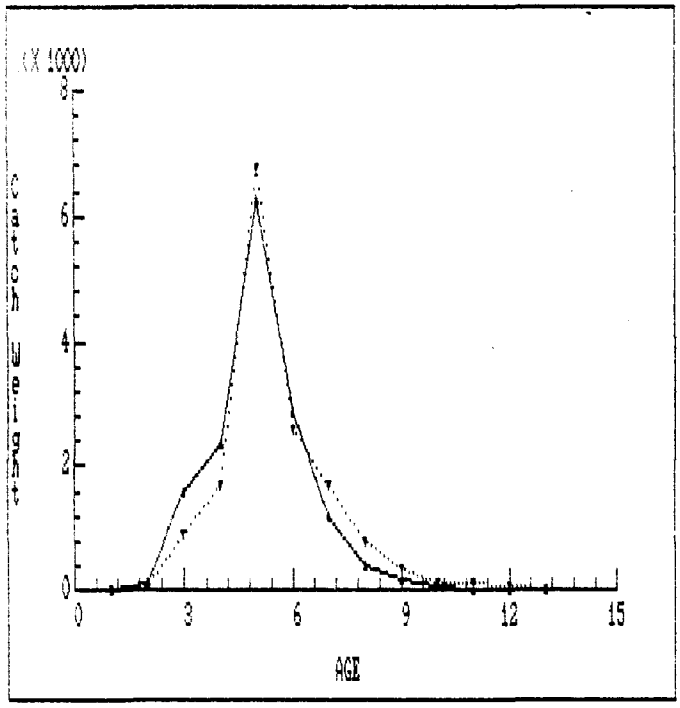
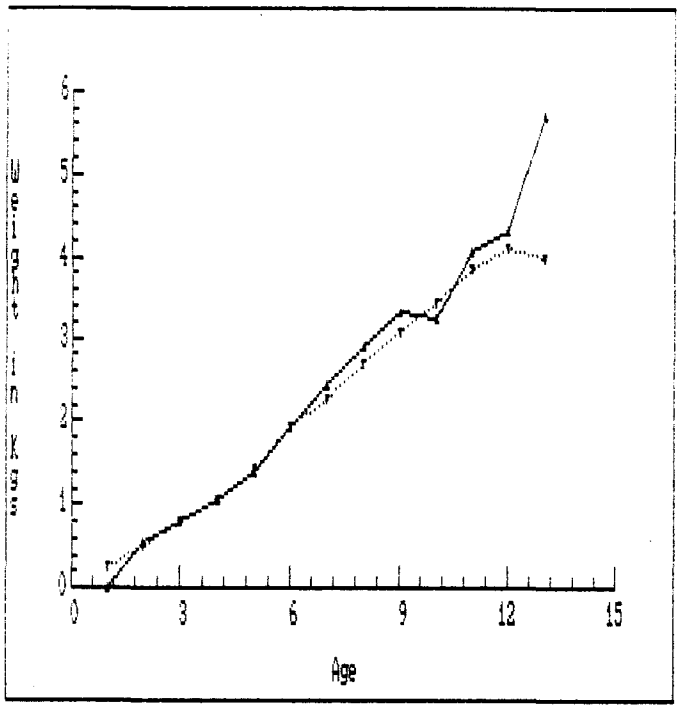


Figure 3. Catch numbers (000's) numbers and weights (t) at age for 4X haddock.

A. Comparison of observed 1985 catch at age (—) with that projected, using 15043 t in 1985, by O'Boyle and Gregory, 1985 (---).

B. Comparison of observed 1985 catch weight at age (—) with that projected, using 15043 t in 1985, by O'Boyle and Gregory, 1985 (---).

A.



B.

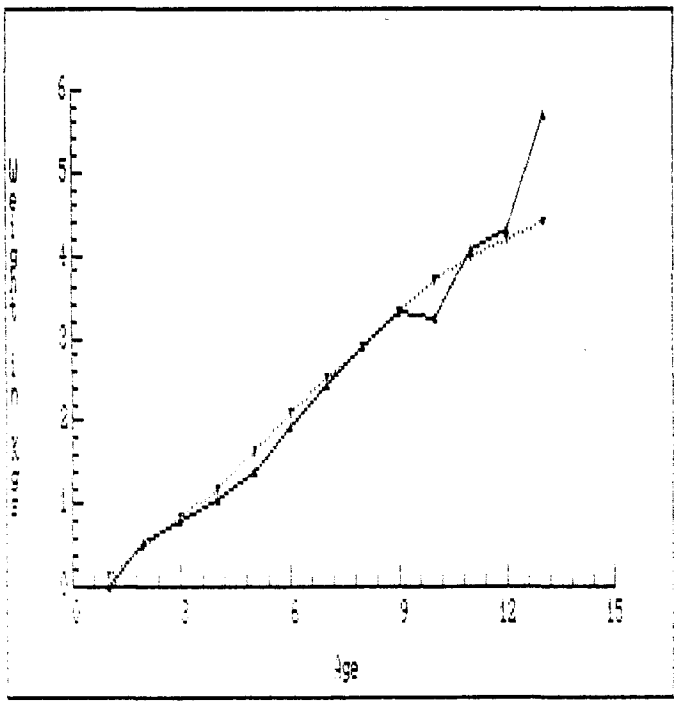
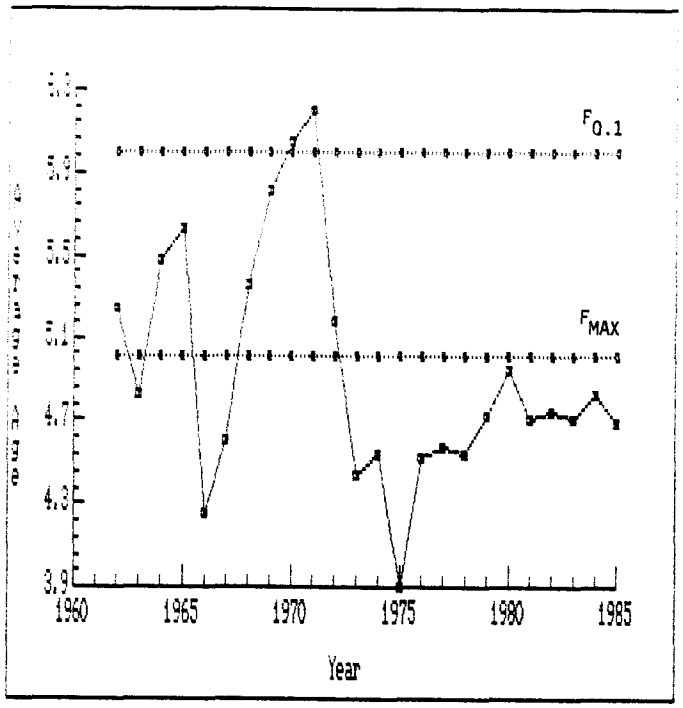


Figure 4. Weight at age (kg) of haddock in commercial catch samples in NAFO Division 4X, 1981-1985.

A. Weights at age for 1984 (---) and 1985 (—).
B. Weights at age for 1985 (—) and mean weights at age for 1981-1984 (---).

A.



B.

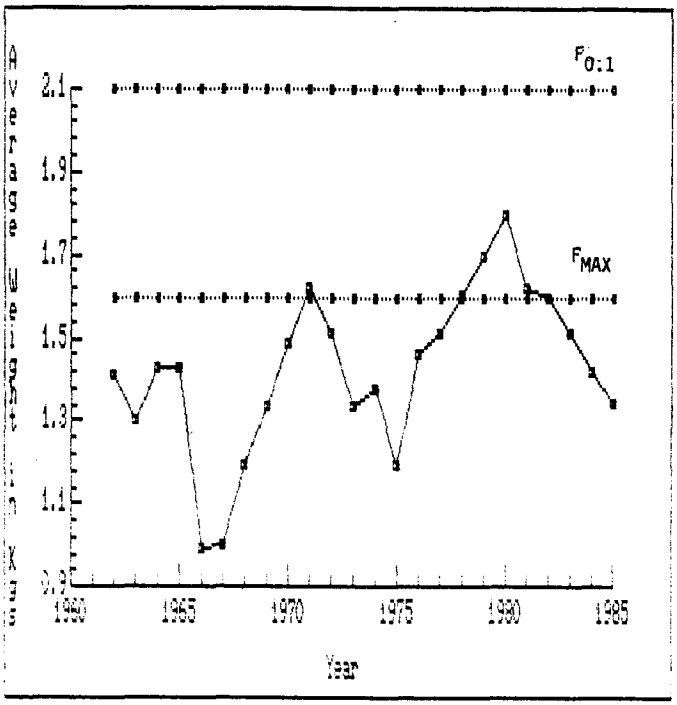


Figure 5. Age-size characteristics of landings of 4X haddock.

A. Average age of 4X haddock in landings.
B. Average weight (kg) of 4X haddock in landings.

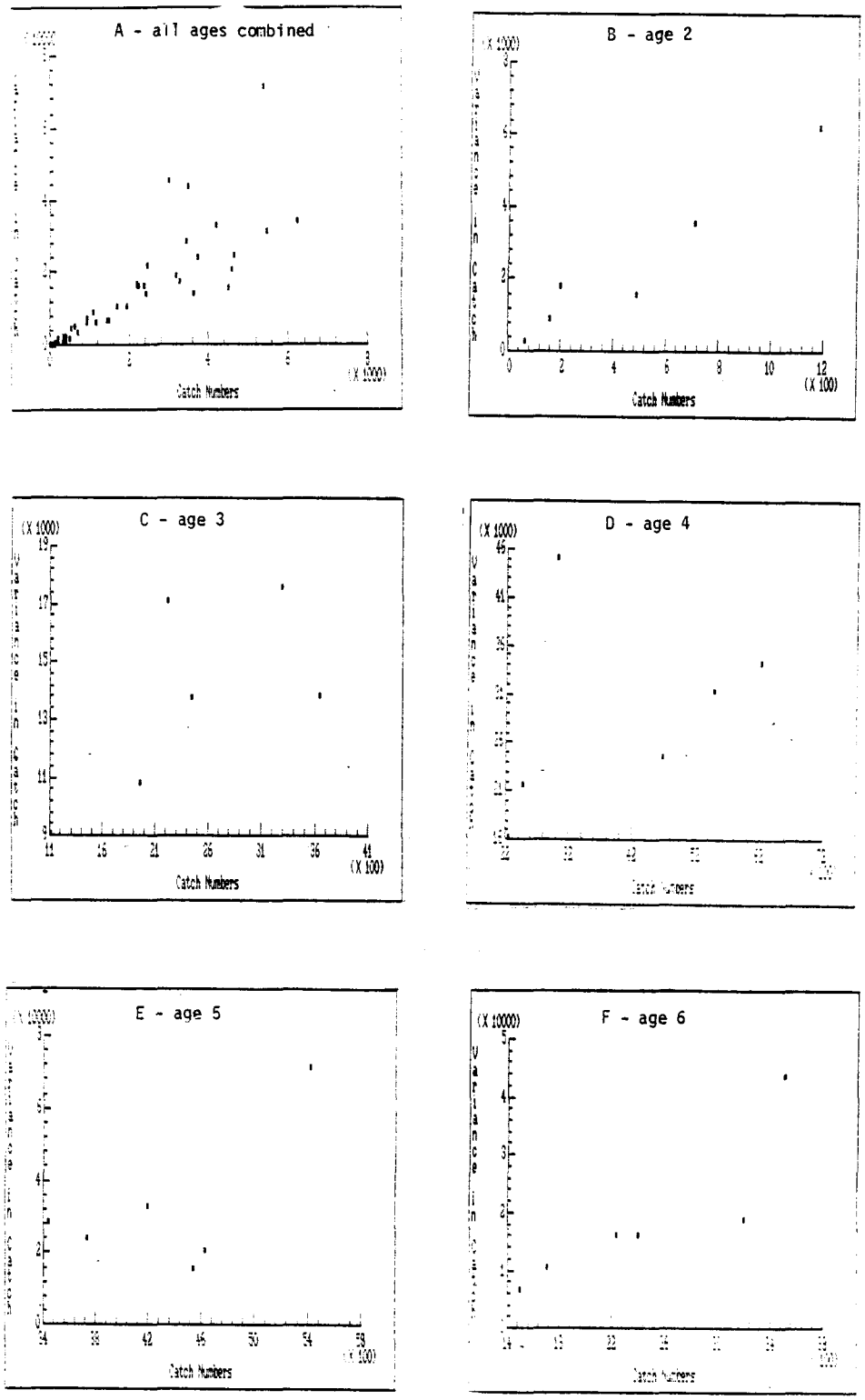
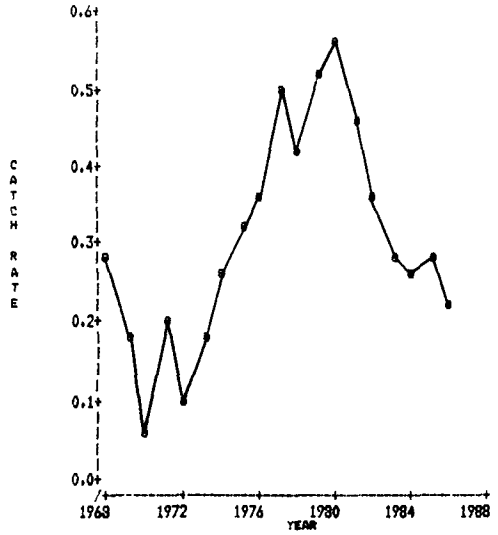
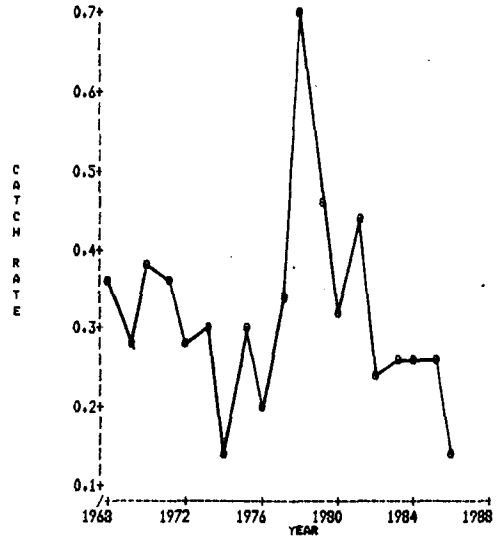


Figure 6. Relationships between variance and mean integrated catch at age for all age groups combined (A) and individually for ages 2 to 6 (B through F) during 1980-85.

A.



B.



C.

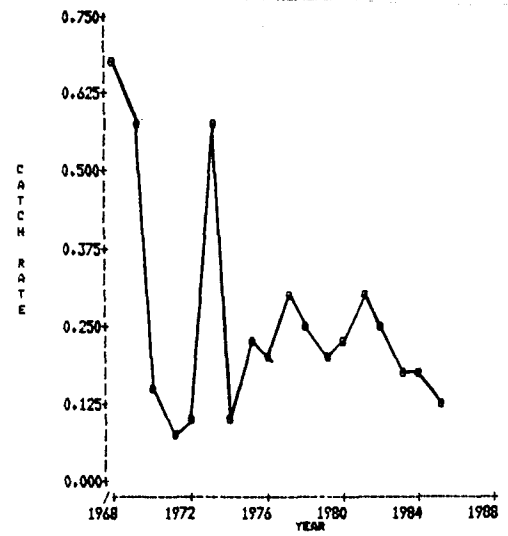
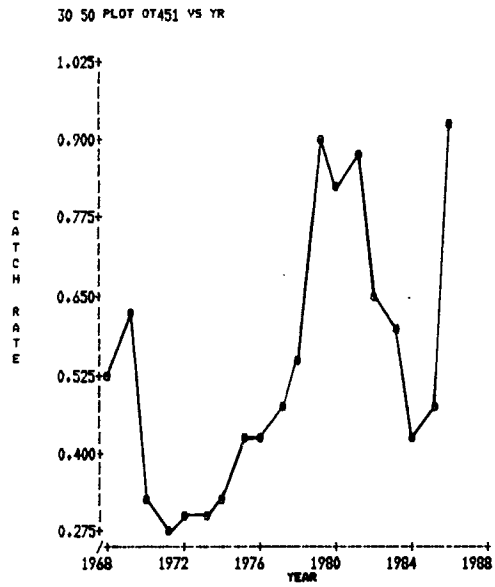


Figure 7. Trends in catch rates (t per hour fished) of haddock by otter trawlers, TC 2-3, fishing in 1st quarter, 4X MNOP (A), 2nd quarter, 4X MNOP (B), and third quarter, 4X QR (C).

A.



B.

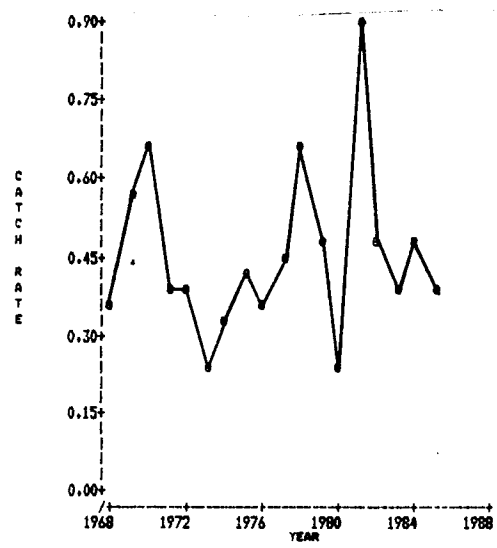
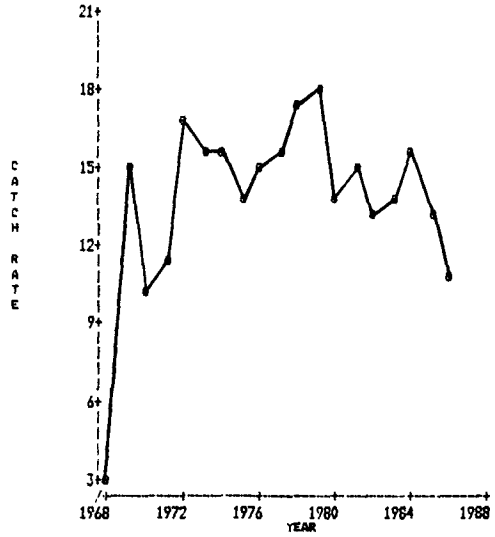
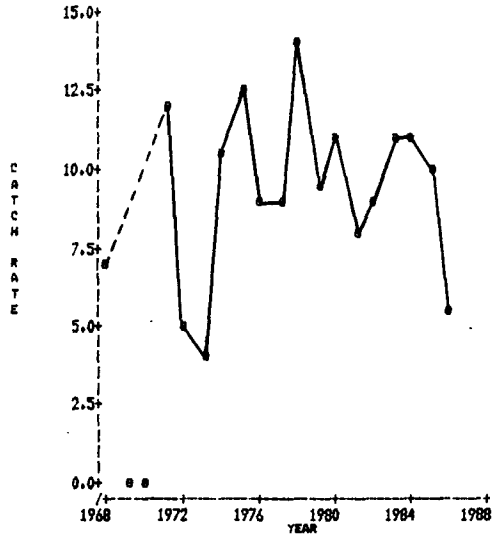


Figure 8. Trends in catch rates (t per hour fished) of haddock by otter trawlers, TC 4-5, fishing in 1st quarter, 4X MNOP (A) and 2nd quarter, 4X MNOP (B).

A.



B.



C.

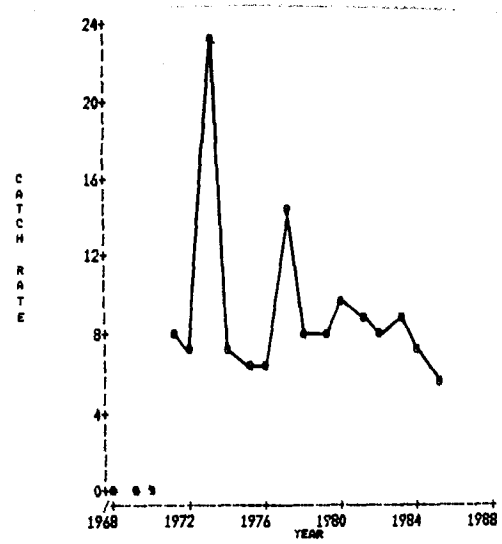


Figure 9. Trends in catch rates (t per thousands of lines fished) of haddock by longliners, TC 2-3, fishing in 4X MNOP during 1st (A), 2nd (B) and 3rd (C) quarters.

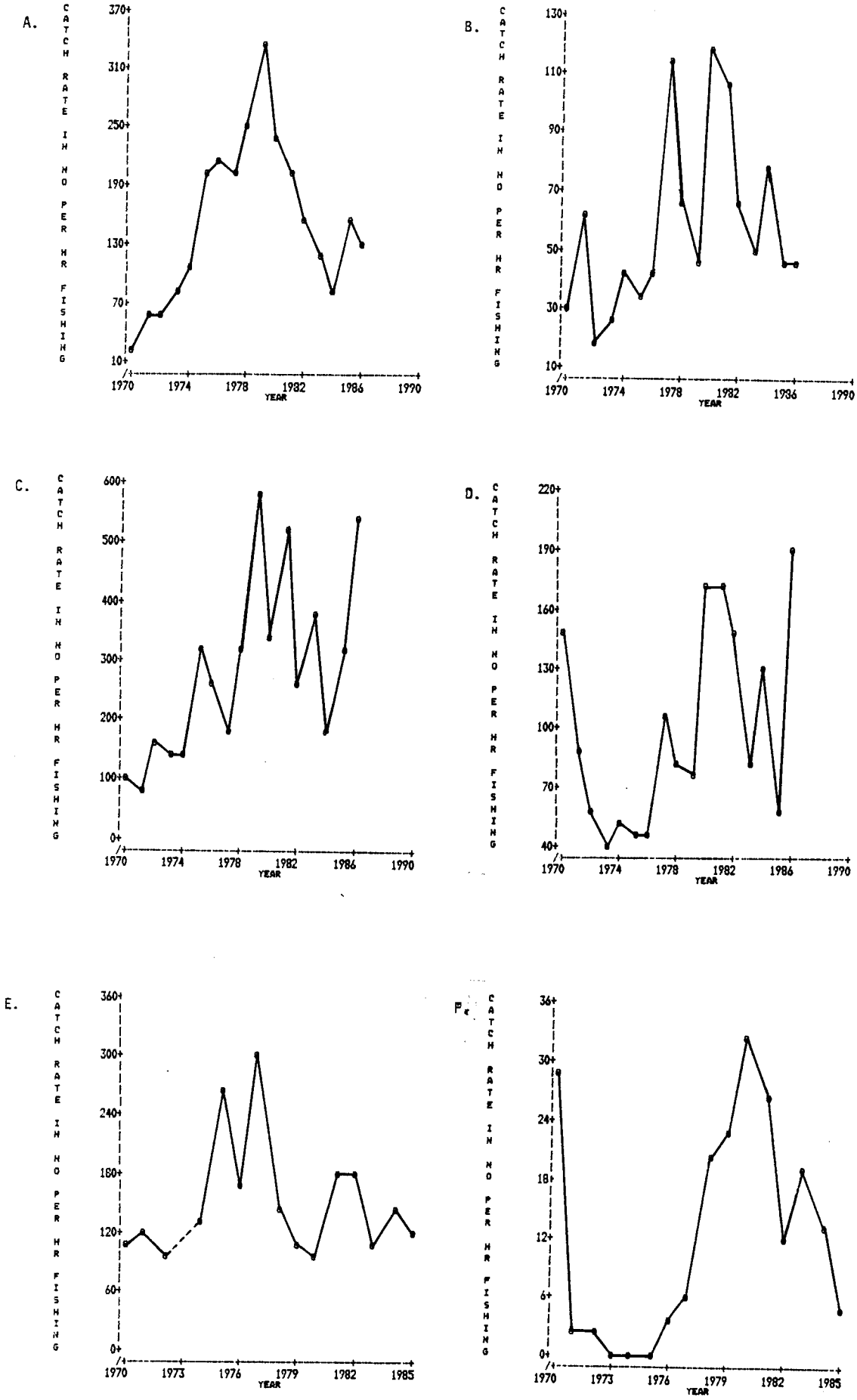
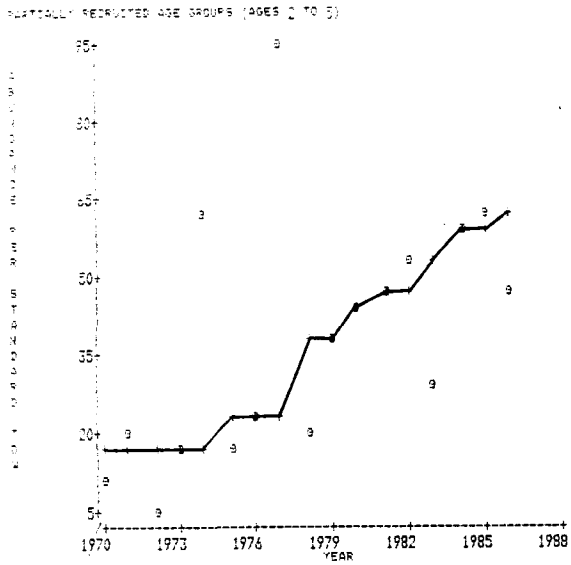


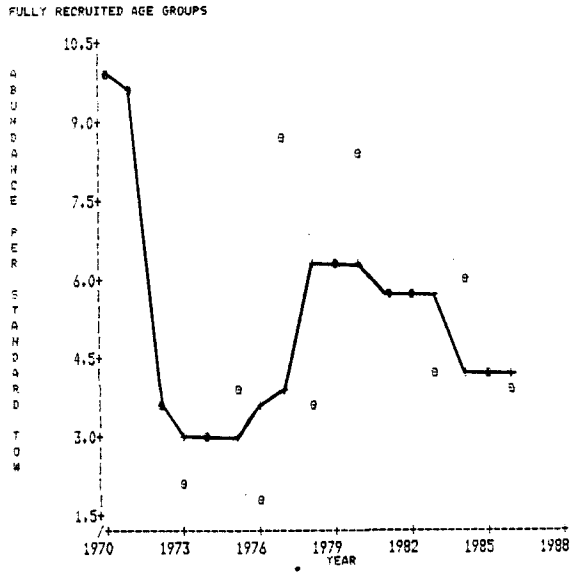
Figure 10. Trends in catch rates (no per hour fished) of haddock for ages 2-5 (A,C,E,) and age 6-9 (B,D,F,) by otter trawlers.

A-B: TC 2-3, 1st quarter, 4X MNOP.
C-D: TC 4-5, 1st quarter, 4X MNOP.
E-F: TC 2-3, 3rd quarter, 4X QR.

A.



B.



C.

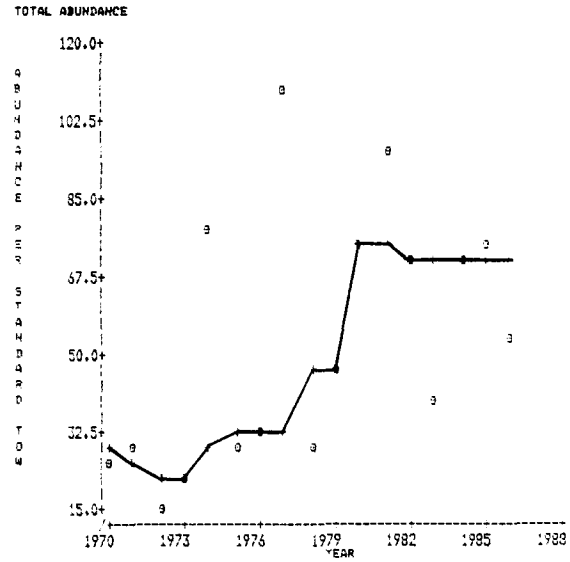
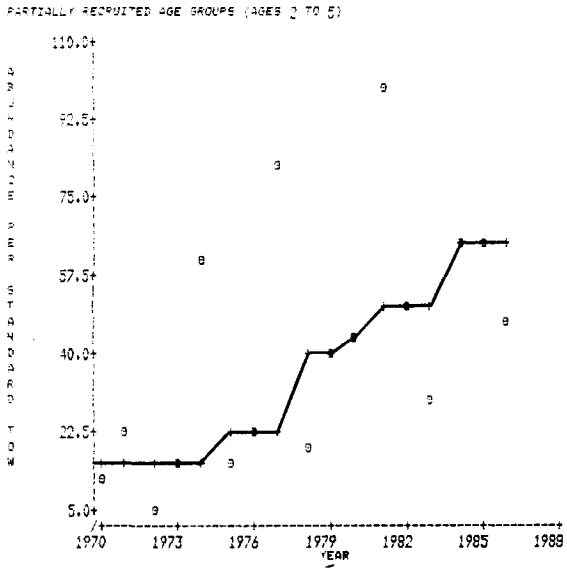
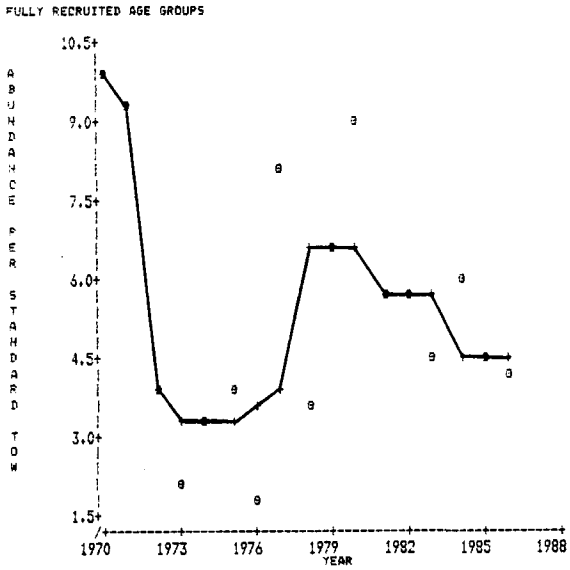


Figure 11 . Survey arithmetic mean catch rates (#/tow) of haddock from 4X during 1979-86.

A.



B.



C.

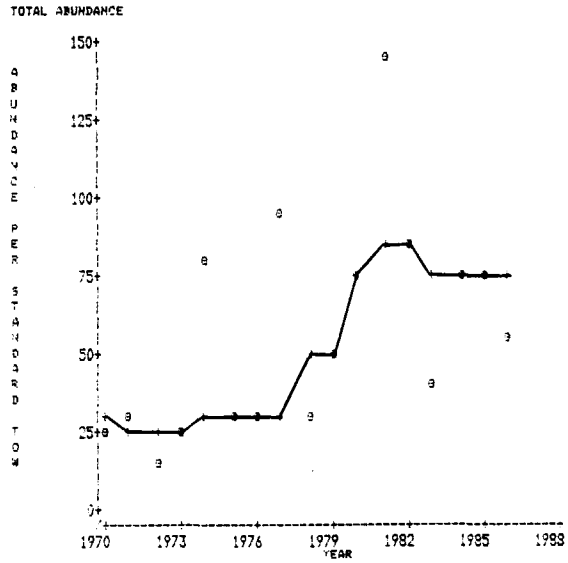


Figure 12. Survey delta transformed catch rates (#/tow) of haddock from 4X during 1970-86.

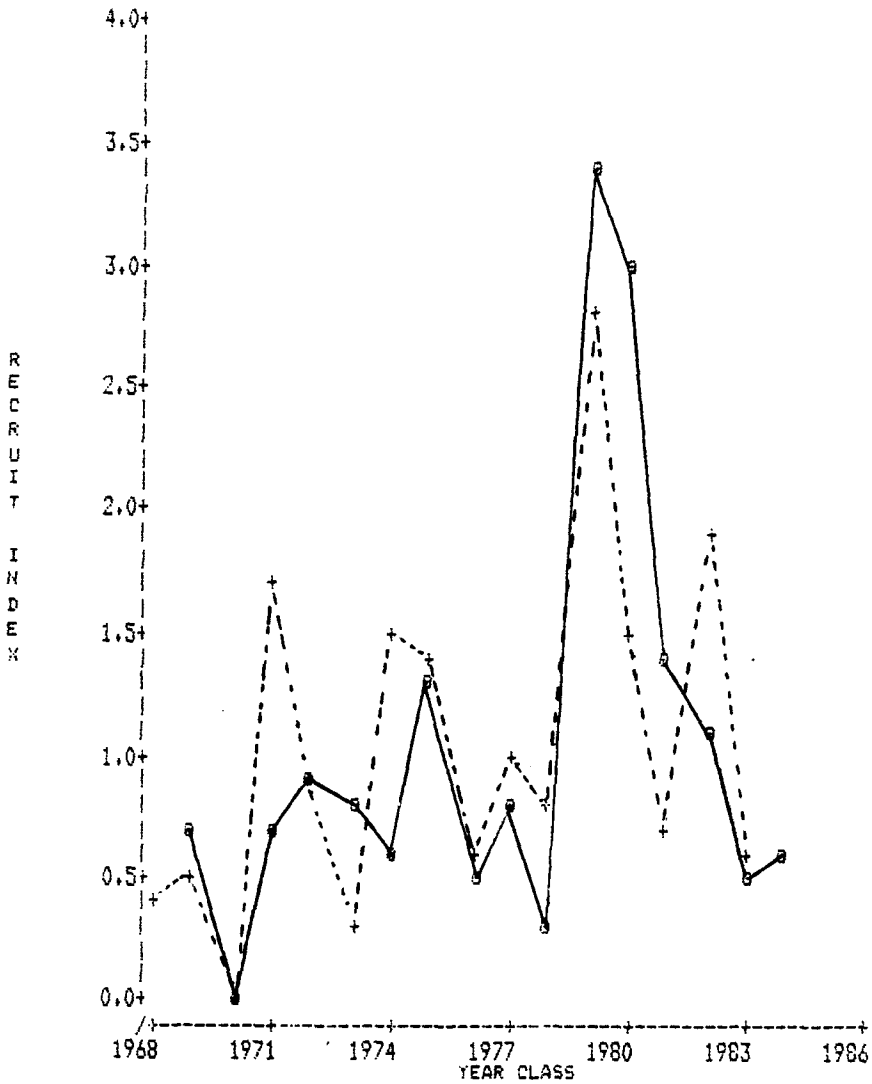
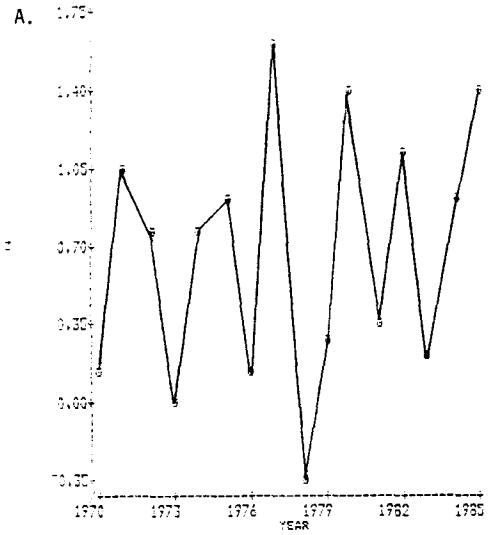
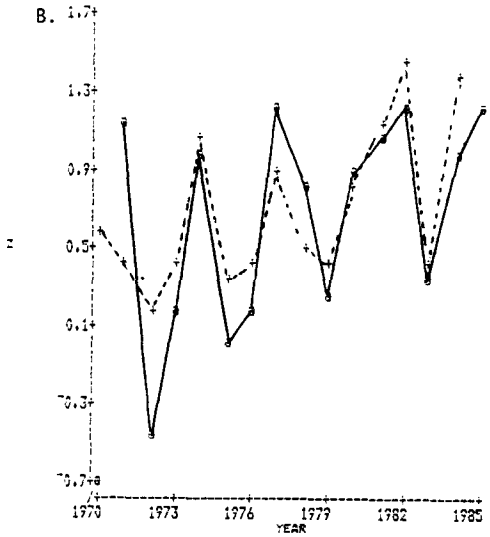


Figure 13. Trend in age 1 + 2 (——) and age 2 + 3 (---) recruitment indices derived from survey data set.





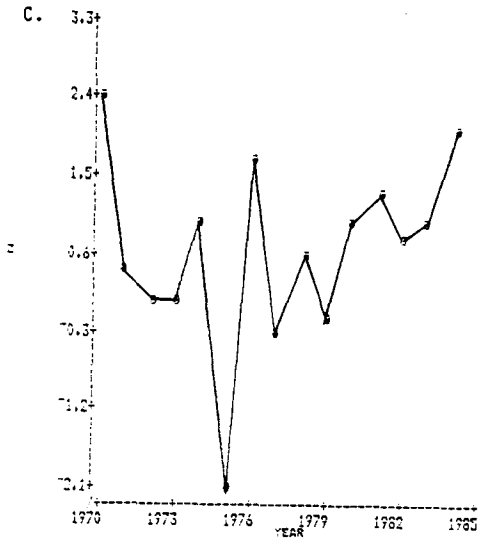


Figure 14. Estimates of total mortality (Z) for the fully recruited age groups (5-8/6-9) in surveys (A), OTB2, TC 2-3 QTR1 (B,---), OTB2, TC 4-5 (B, ——), and OTB2, TC 2-3 QTR3 (C).

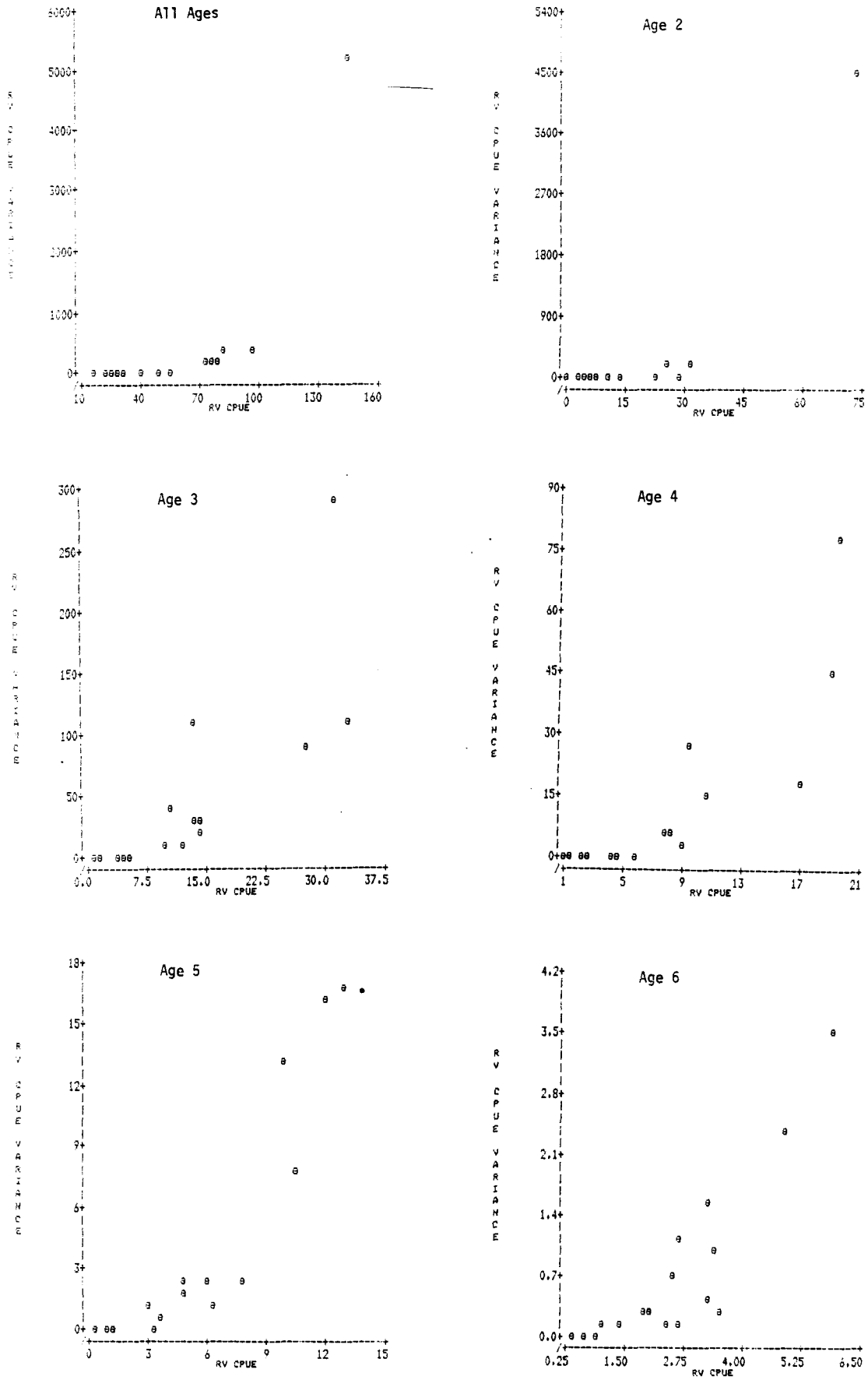


Figure 15. Relationship between variance in survey mean numbers per tow (delta transformed) and survey mean numbers per tow for 4X haddock during 1970-86.

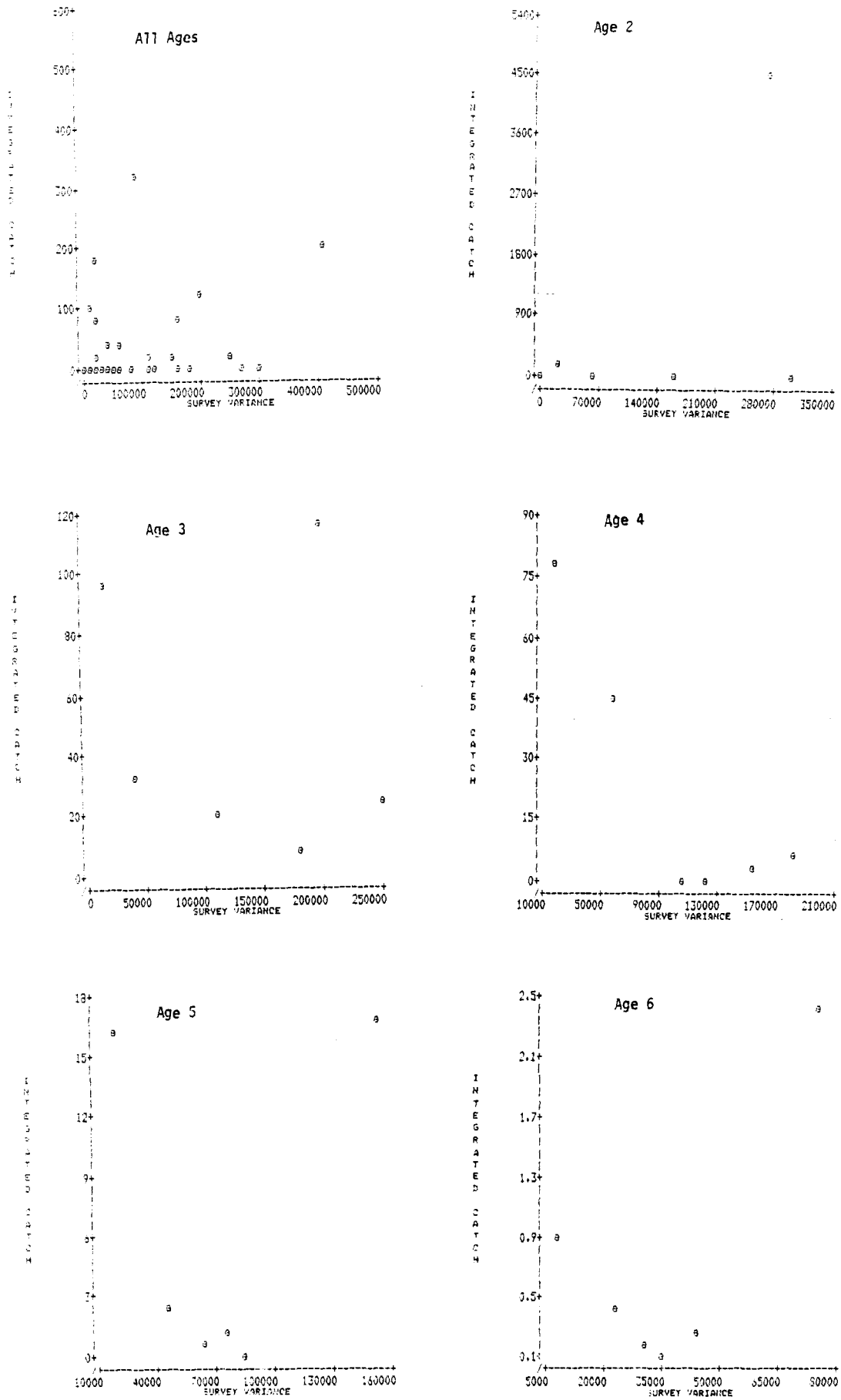


Figure 16. Relationships between integrated catch variance and survey variance for 4X haddock of different ages.

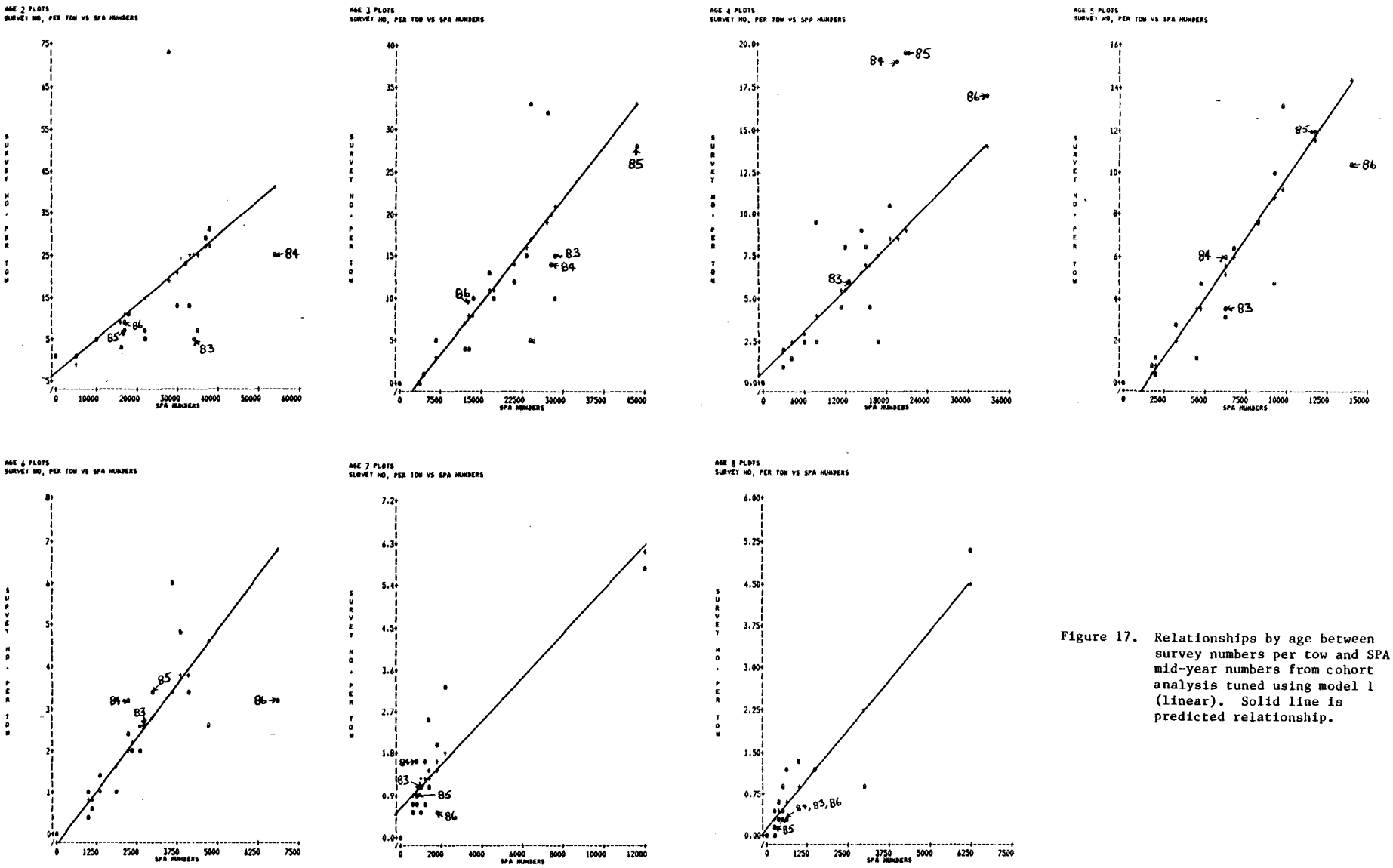


Figure 17. Relationships by age between survey numbers per tow and SPA mid-year numbers from cohort analysis tuned using model 1 (linear). Solid line is predicted relationship.

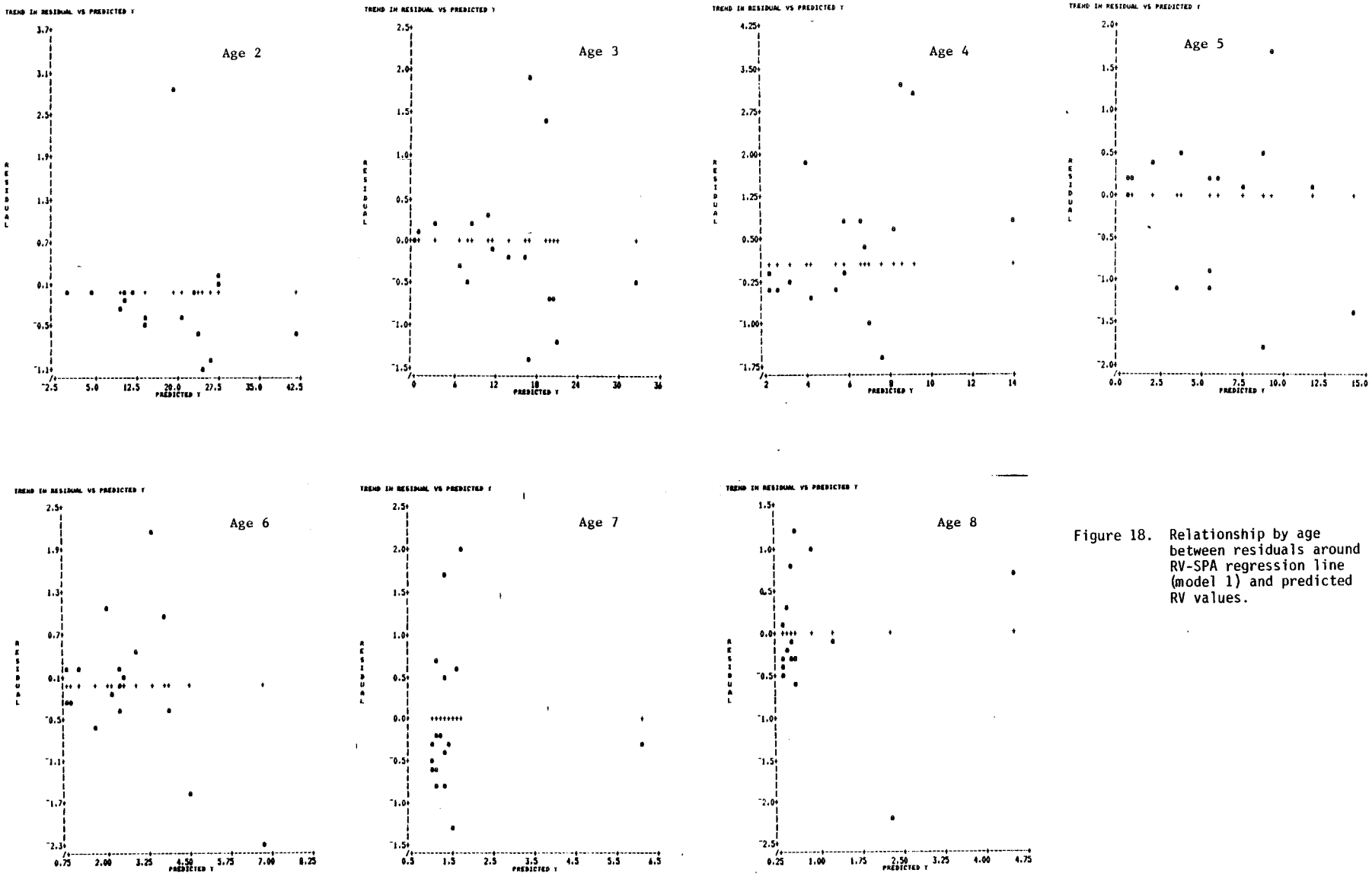


Figure 18. Relationship by age between residuals around RV-SPA regression line (model 1) and predicted RV values.

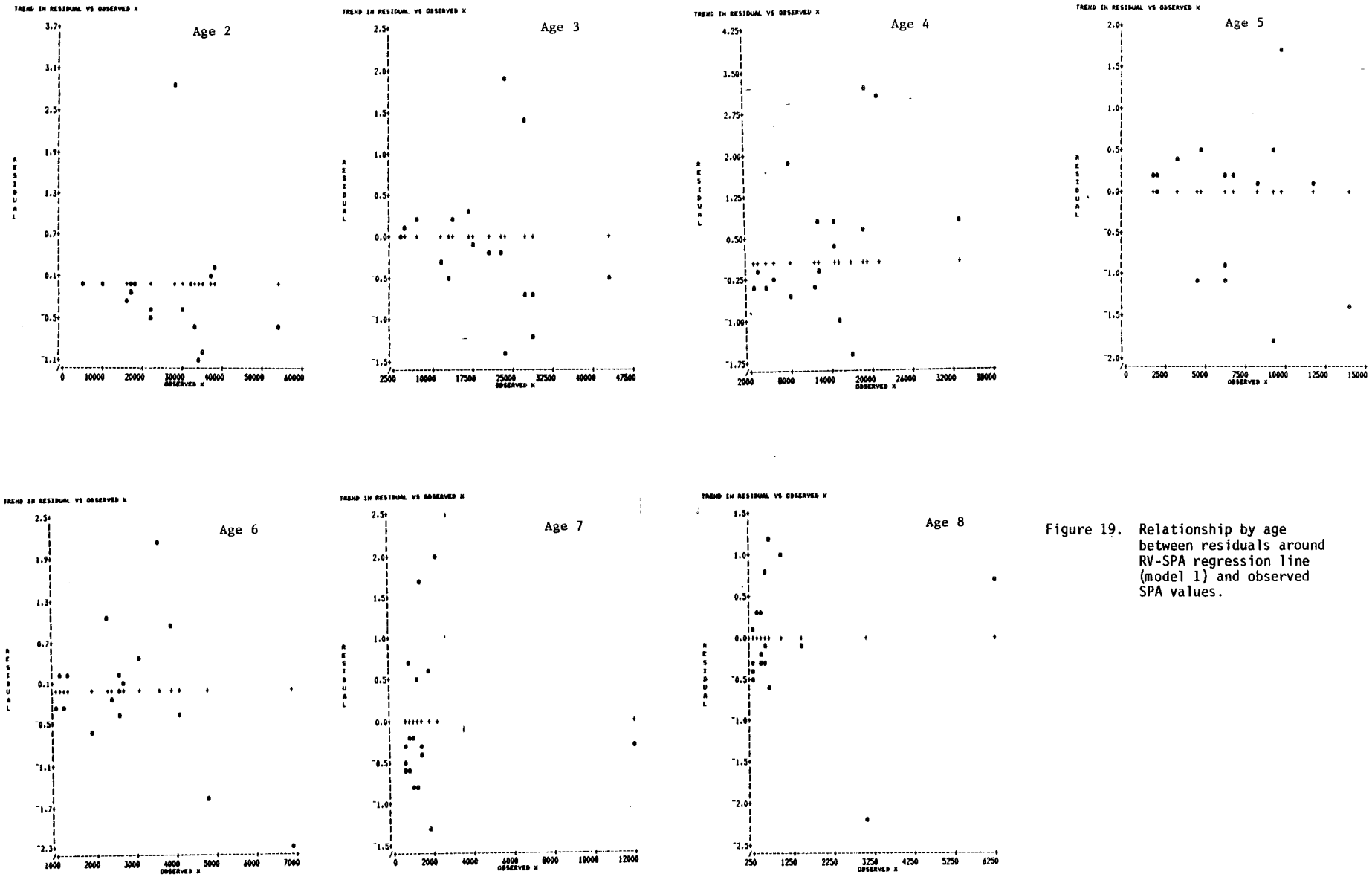


Figure 19. Relationship by age between residuals around RV-SPA regression line (model 1) and observed SPA values.

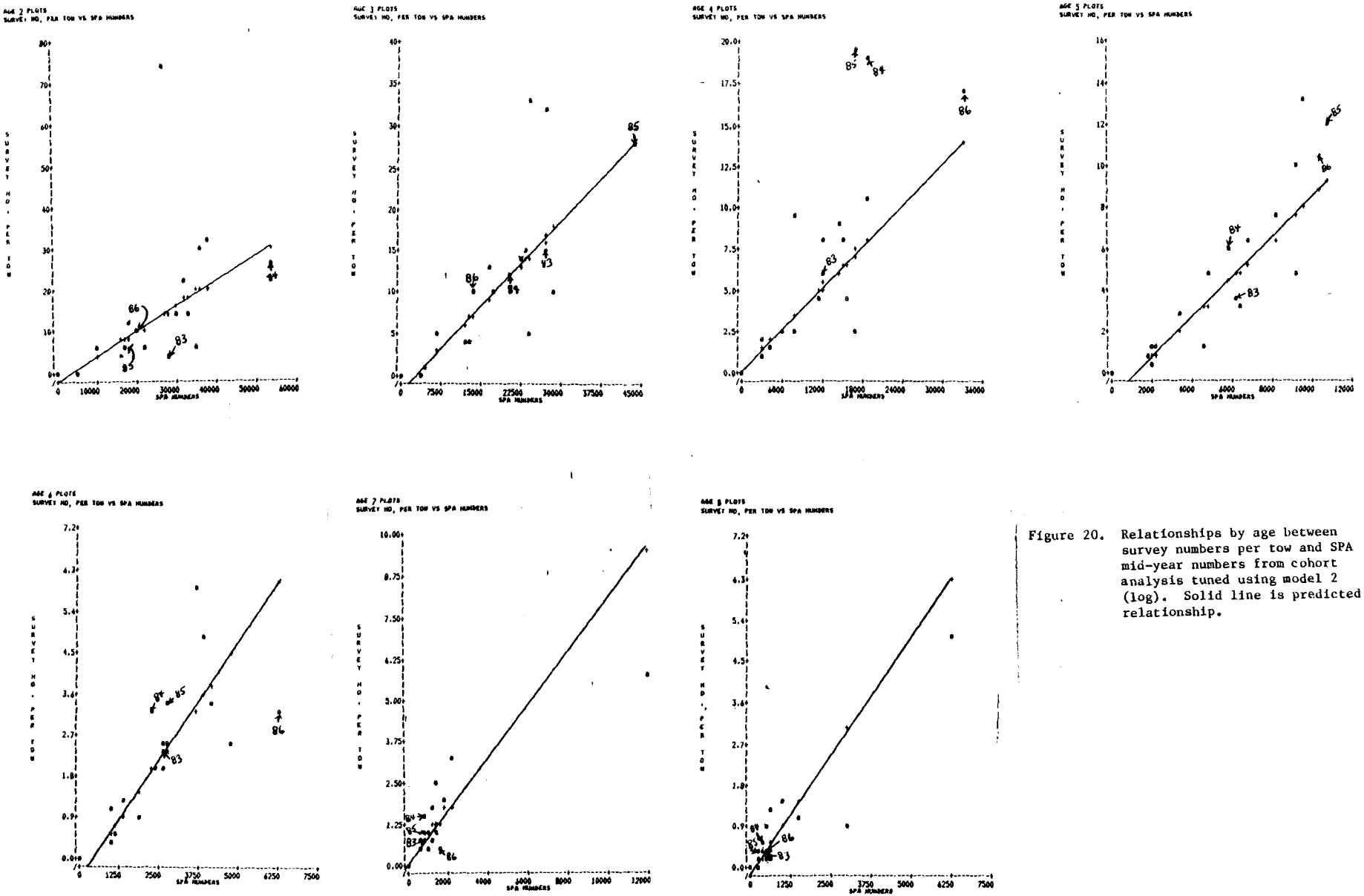


Figure 20. Relationships by age between survey numbers per tow and SPA mid-year numbers from cohort analysis tuned using model 2 (log). Solid line is predicted relationship.

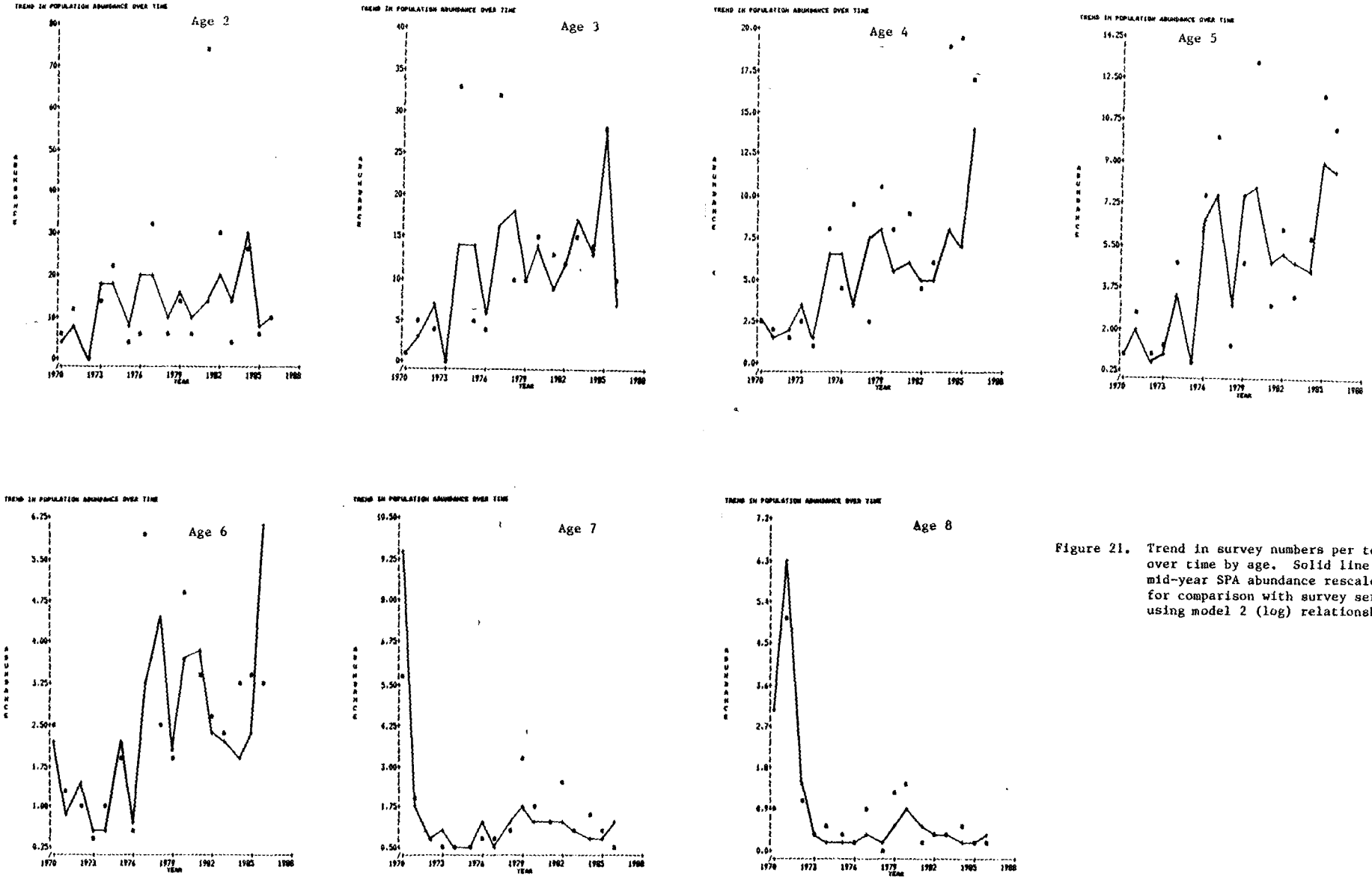


Figure 21. Trend in survey numbers per tow over time by age. Solid line is mid-year SPA abundance rescaled for comparison with survey series using model 2 (log) relationship.

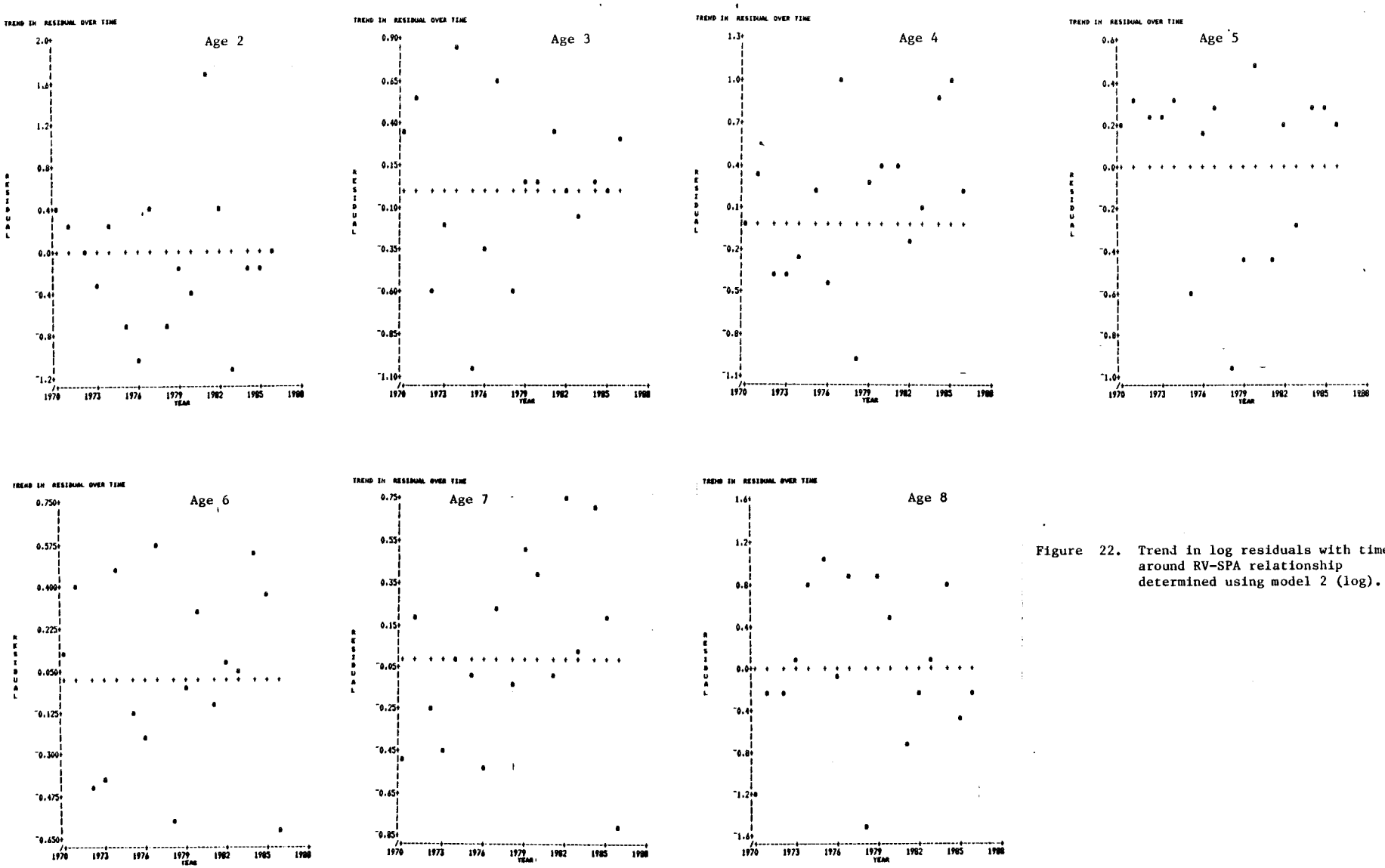


Figure 22. Trend in log residuals with time around RV-SPA relationship determined using model 2 (log).

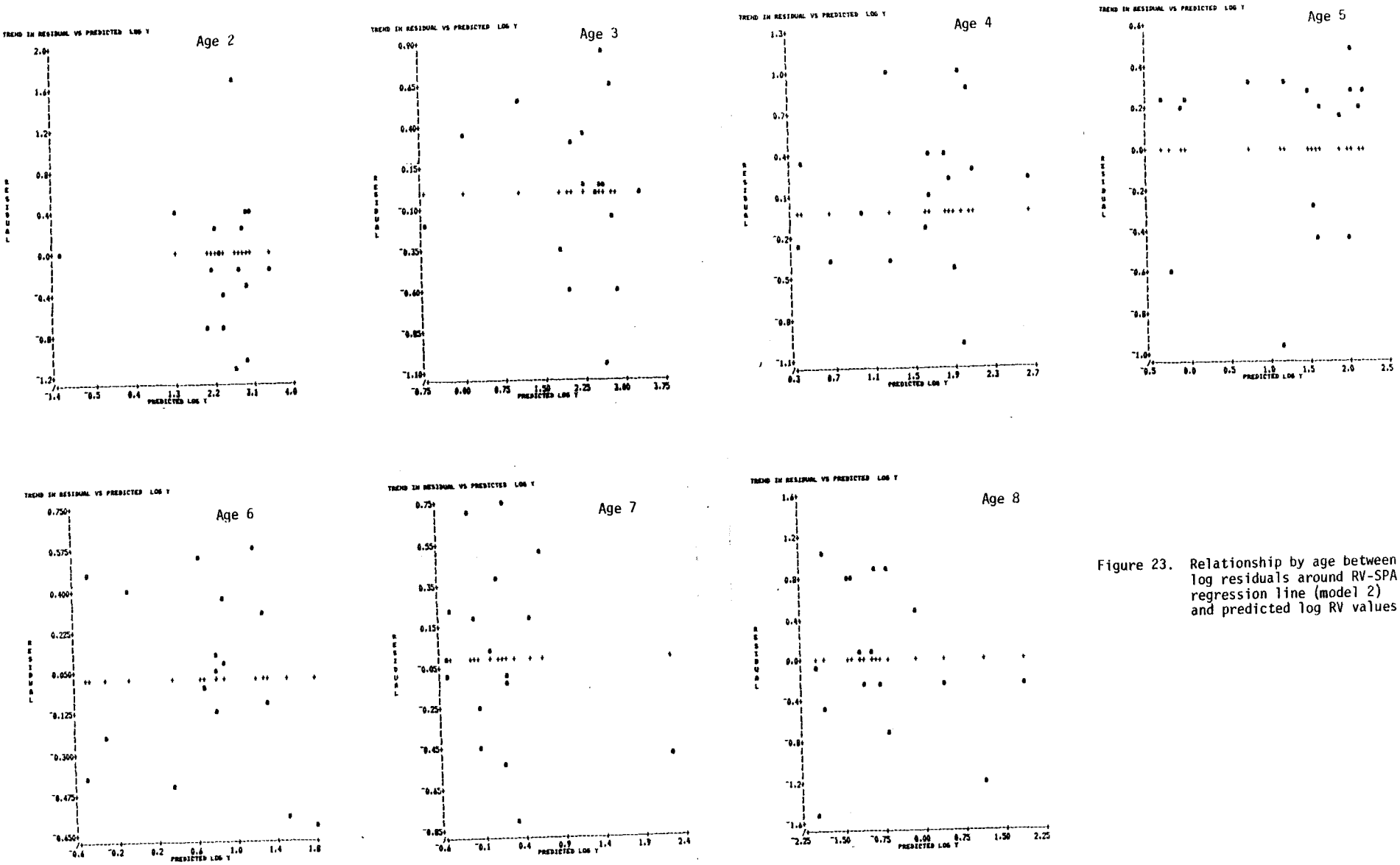


Figure 23. Relationship by age between log residuals around RV-SPA regression line (model 2) and predicted log RV values.

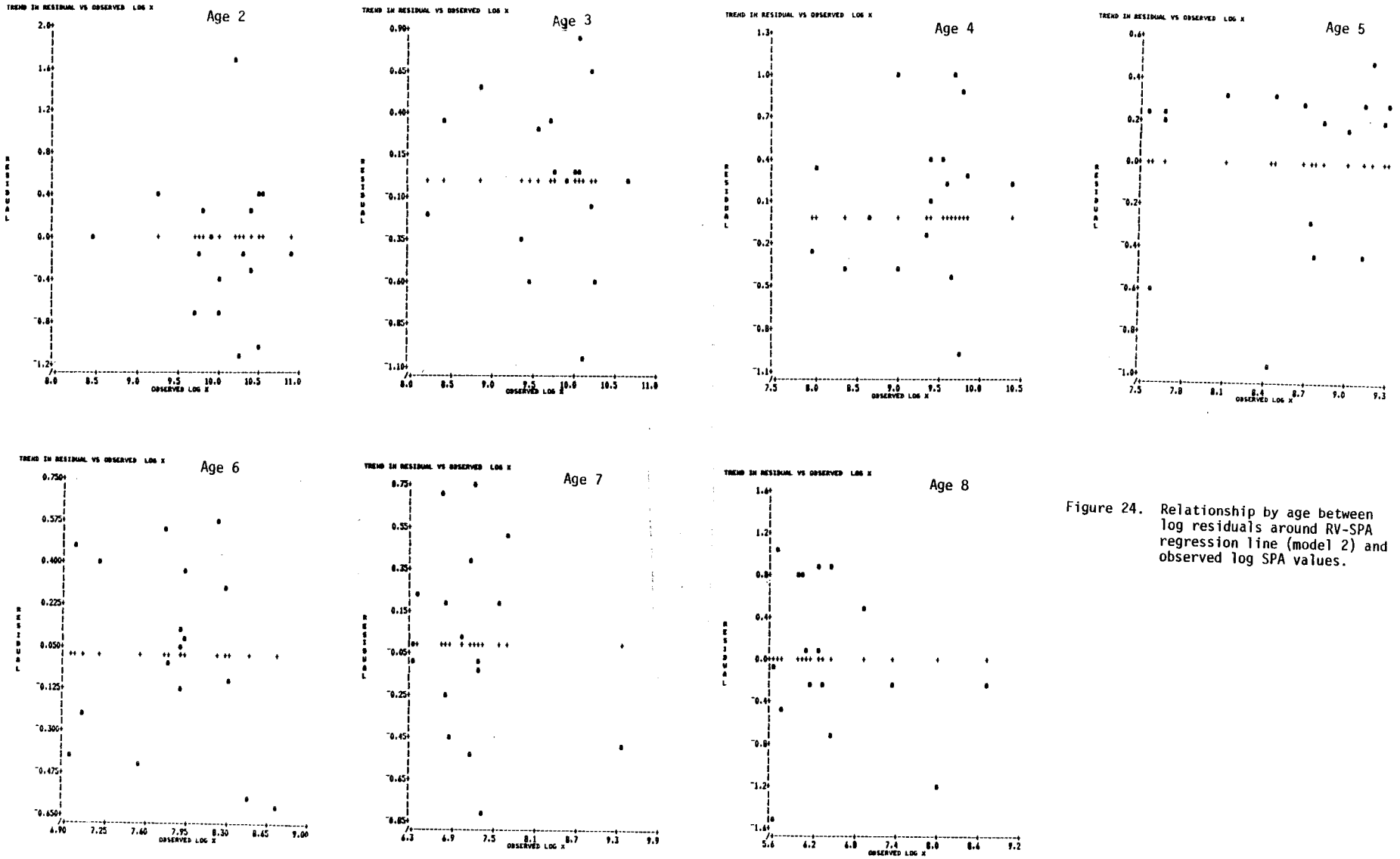
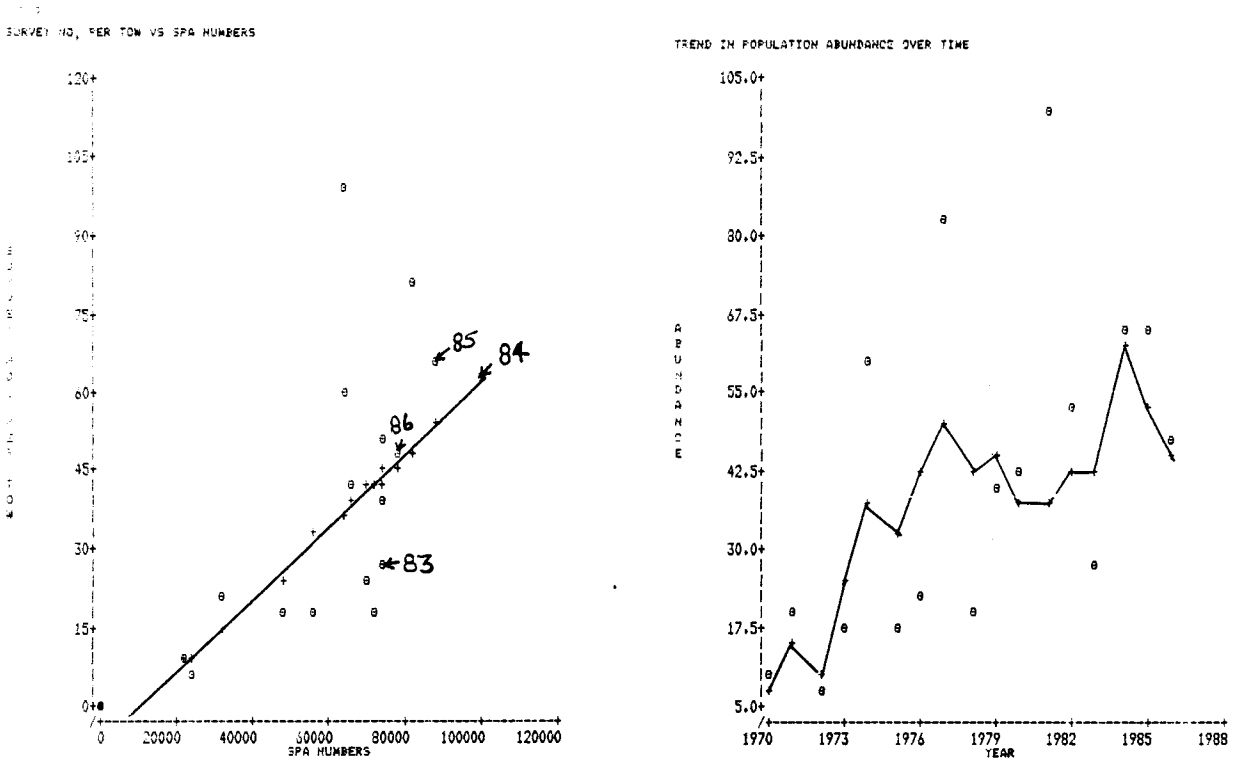


Figure 24. Relationship by age between log residuals around RV-SPA regression line (model 2) and observed log SPA values.

Ages 2 - 5



Ages 6 - 8

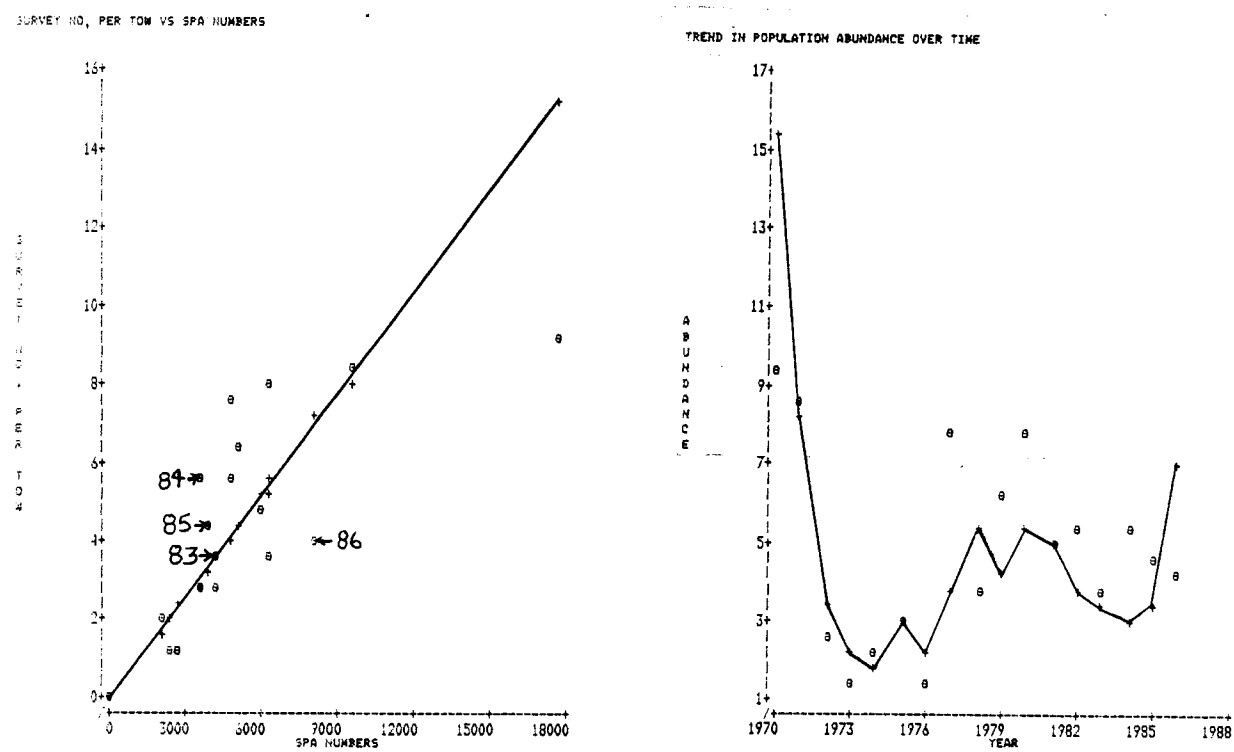


Figure 25. Trends in ages 2-5 and 6-8 abundance calculated by cohort analysis tuned using model 2 (log). Solid line is SPA mid-year numbers rescaled for comparison with survey series.

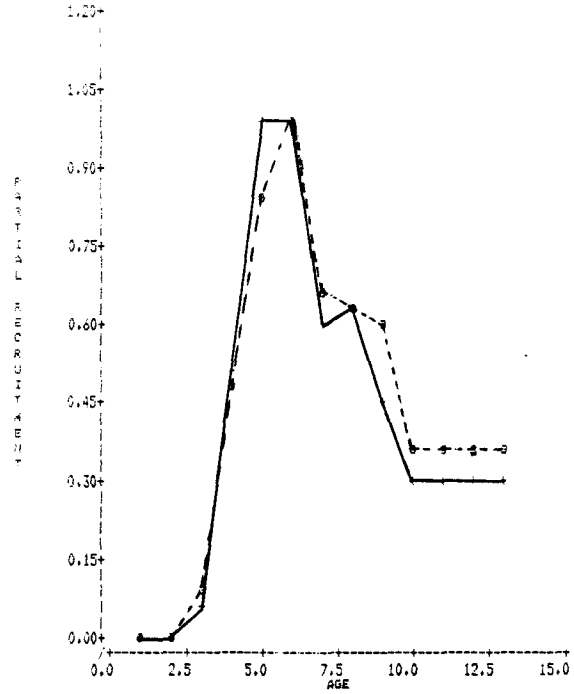


Figure 26a. Partial recruitment patterns of 4X haddock to otter trawlers, TC 2-3 (---) and TC 4-5 (——) in first quarter of year, as derived from results of cohort analysis.

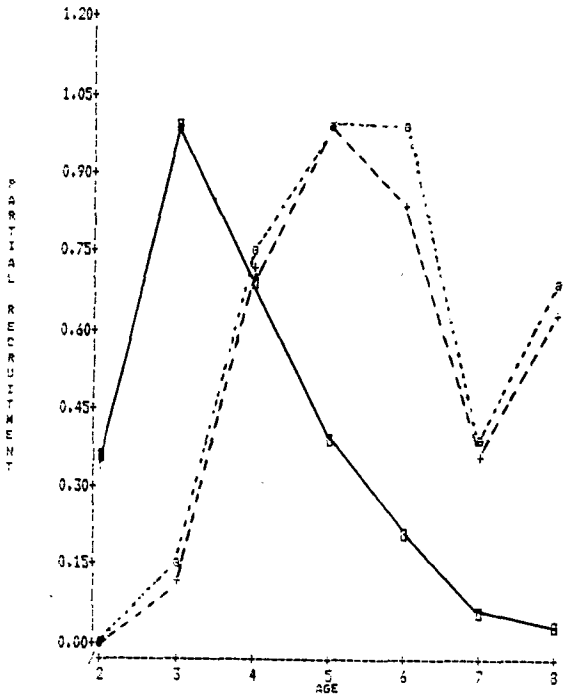
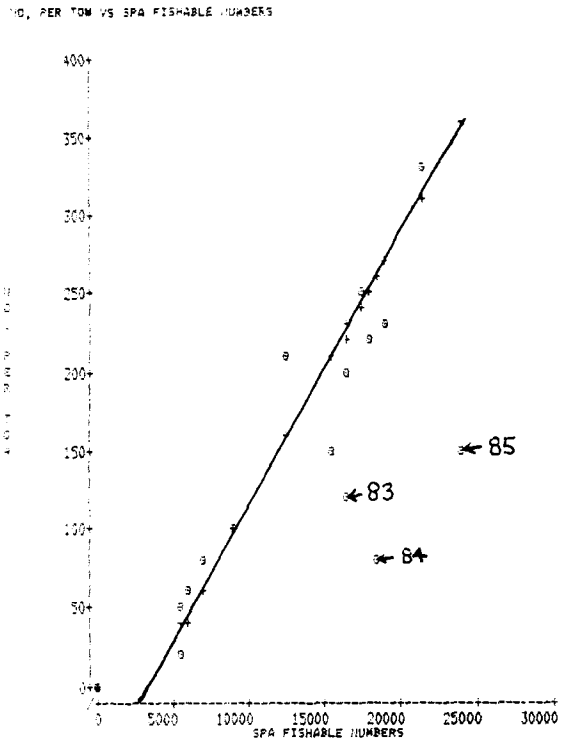
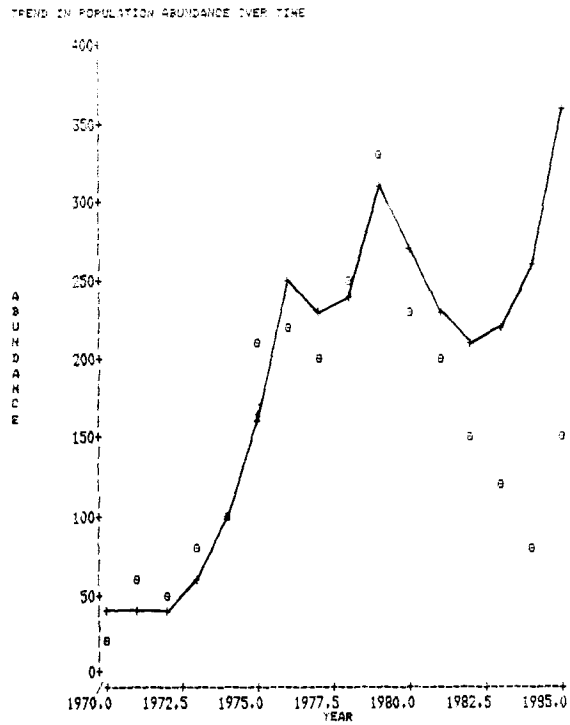


Figure 26b. Partial recruitment patterns calculated by decomposing the U/RV matrix into age and year effects in a multiplicative model.

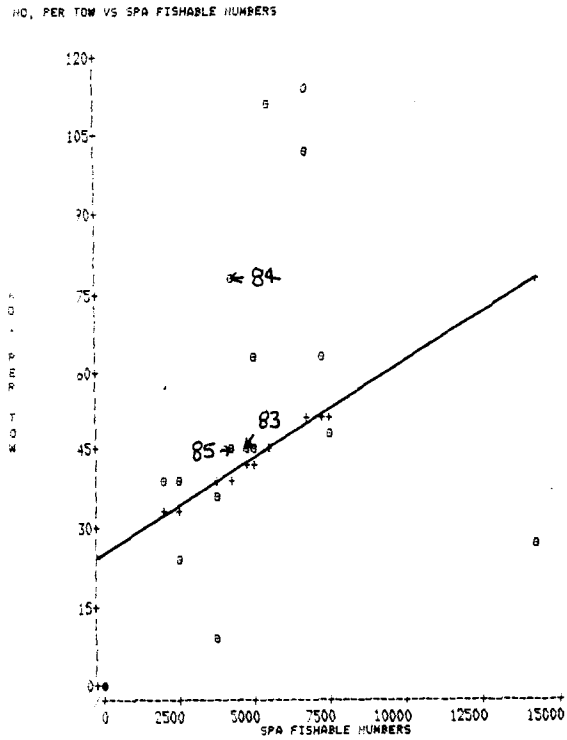
—— OTB2, TC2-3, QTR3
... OTB2, TC2-3, QTR1
--- OTB2, TC4-5, QTR1

Ages 2-5





Ages 6-8



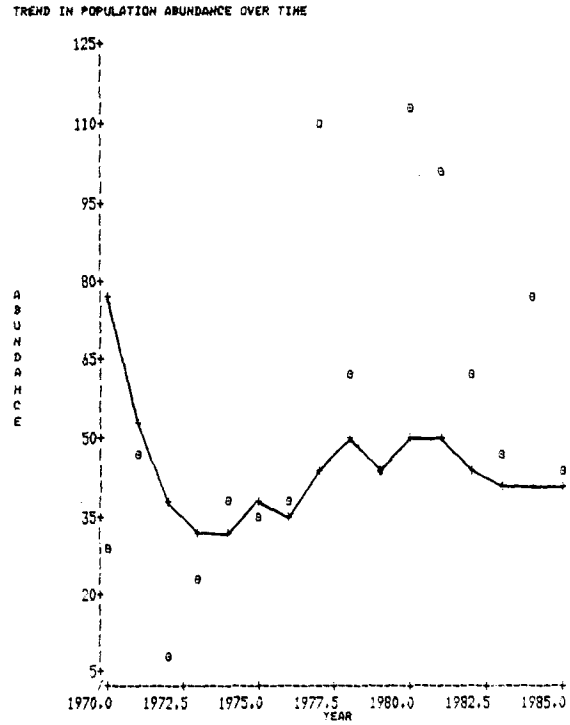
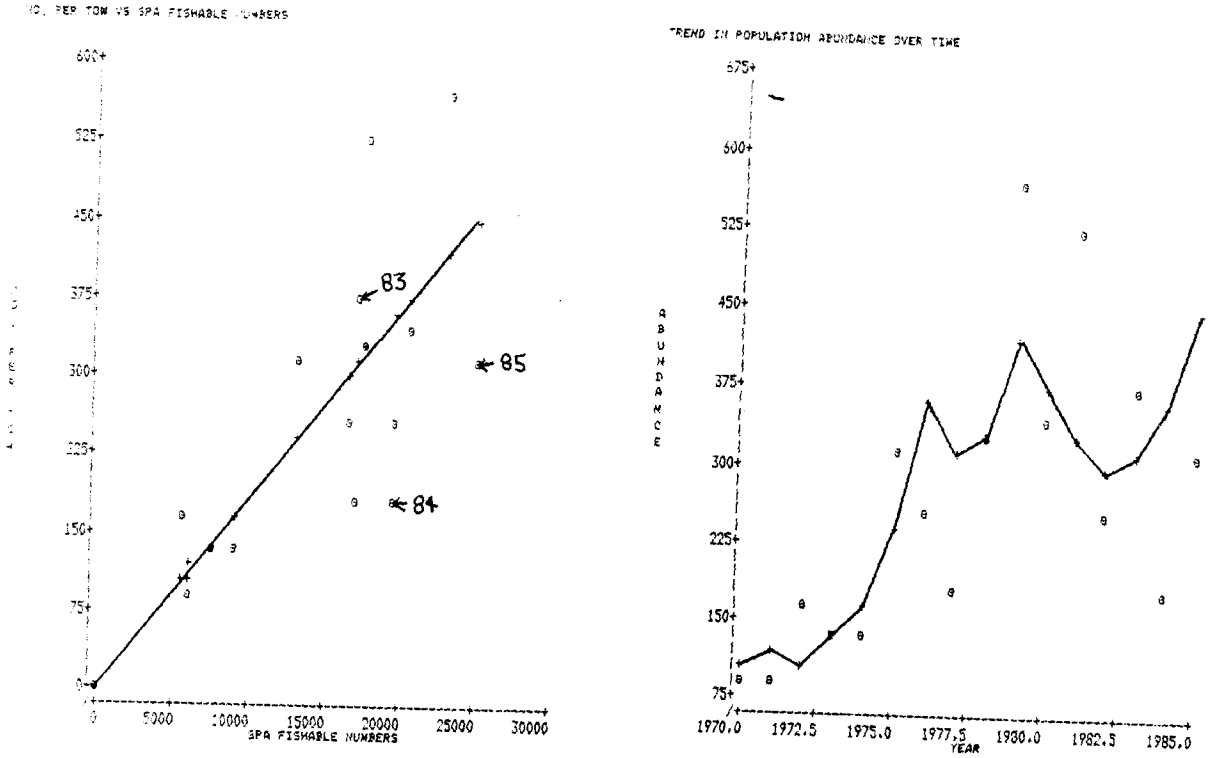


Figure 27. Trends in ages 2-5 and 6-8 abundance calculated by cohort analysis tuned using model 2 (log). Solid line is SPA 1st quarter numbers rescaled for comparison with OTB2, TC 2-3, Quarter 1 catch rates in numbers per tow.

Ages 2-5



Ages 6-8

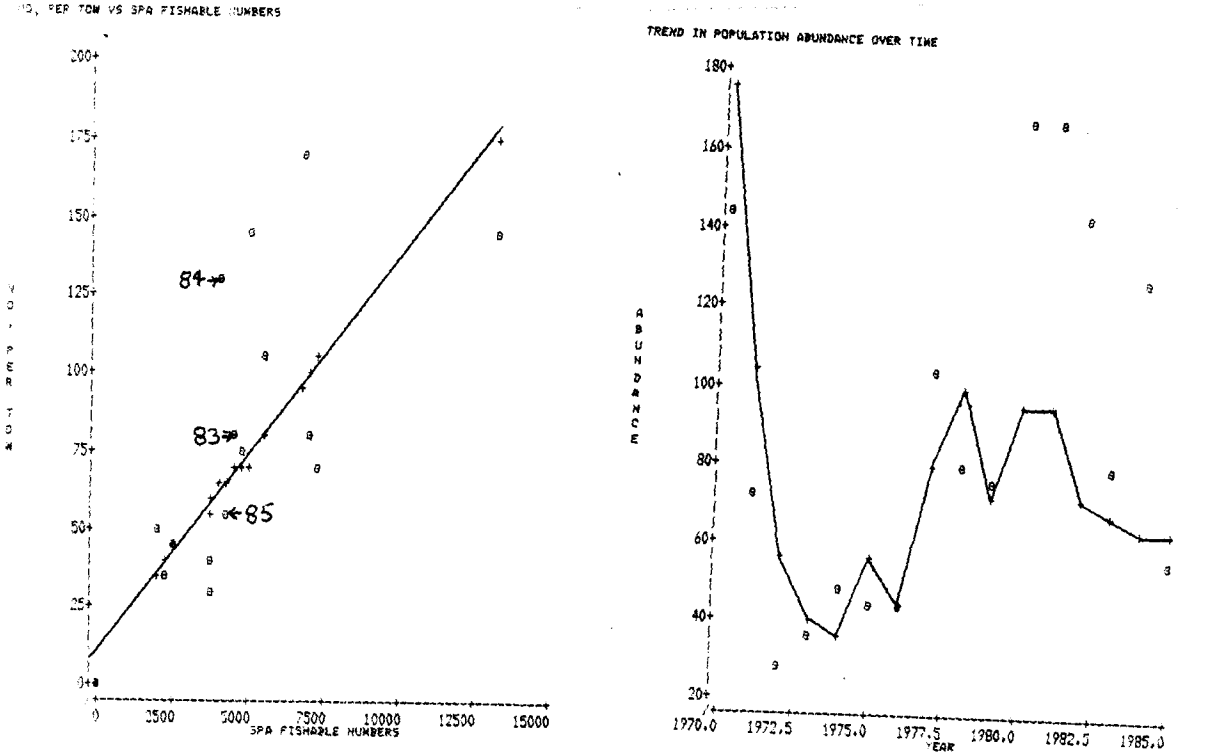


Figure 28. Trends in ages 2-5 and 6-8 abundance calculated by cohort analysis tuned using model 2 (log). Solid line is SPA 1st quarter numbers rescaled for comparison with OTB2, TC 4-5, Quarter 1 catch rate in numbers per tow.