ICES COOPERATIVE RESEARCH REPORT

RAPPORT DES RECHERCHES COLLECTIVES

NO. 199

REPORT OF THE WORKING GROUP ON METHODS OF FISH STOCK ASSESSMENTS

St. John's, Newfoundland, Canada
20-27 June 1991

https://doi.org/10.17895/ices.pub.7979

ISBN 978-87-7482-680-4

ISSN 2707-7144

International Council for the Exploration of the Sea
Palægade 2-4, DK-1261 Copenhagen K
DENMARK

August 1995

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Vladimir Babayan	USSR
Frans van Beek	Netherlands
Ghislain Chouinard	Canada
Ramon Conser	USA
Robin Cook	UK (Scotland)
Yuri Efimov	USSR
Paul Fanning	Canada
Steve Flatman	UK (England)
Wendy Gabriel	USA
Pierre Gagnon	Canada
Dave Gray	Canada
Gudmundur Gudmundsson	Iceland
John Hoenig	Canada
Tore Jakobsen	Norway
Zinovy Kizner	USSR
Andras Kristiansen	Faroe Islands
Phil Kunzlik	UK (Scotland)
Bob Mohn	Canada
Ram Myers	Canada
Gloria Nielsen	Canada
Dominique Pelletier	France
Michael Prager	USA
Victor Restrepo	USA
Denis Rivard	Canada
John Shepherd	UK (England)
Bengt Sjöstrand	Sweden
Dankert Skagen	Iceland
Gunnar Stefánsson (Chairman)	Iceland
Reidar Toresen	Norway
Bernhard Vaske	Federal Republic of Germany
Jon Helge Volstad	Norway

1.2 Terms of Reference

It was decided at the Statutory Meeting in Copenhagen in 1990 (C. Res. 1990/2:5:24) that the Working Group on Methods of Fish Stock Assessments (Chairman: Dr G. Stefánsson) would meet in St. John's, Newfoundland from 20-27 June 1991 to:

a) consider the effects of management measures on the interpretation of fishing effort data and, in particular, advise how best to cope with considerable changes in catchability in assessments using effort and CPUE data;

b) advise on the accuracy of prognoses derived from assessments based upon effort and CPUE data and corresponding to the classical management options (the evaluation should use simulated and real data sets);

c) advise on the validation or otherwise of the hypotheses upon which stock estimation techniques are based (use of diagnostics, etc.);

d) advise on the appropriateness of using length cohort analysis for *Nephrops* stocks given the non-smooth growth of this species;

e) advise on the feasibility of extending time series on stock and recruitment for selected fish stocks to earlier years using cruder methods than virtual population analysis.

1.3 Working Papers

Working papers were available on some of the topics. These are listed in Appendix A.

1.4 Notation

The Working Group adhered as far as possible to the standard notation used previously, expanded as necessary. An updated version is given in Appendix B.

2 EFFECTS OF MANAGEMENT MEASURES

2.1 Introduction

Item a) of the terms of reference refers to the question of how various closures can affect stock assessments through catchability changes or otherwise. Such closures include closures of areas or limitations of the time periods when fishing is permitted.

It is quite obvious that if only aggregate measures of effort or CPUE are available, then resulting catchability estimates can be quite badly biased. For example if CPUE values have been calculated in aggregate form before the closure of an area with high catch per unit of effort, then the closure of this area may lead to a severe underestimate in the CPUE estimates after the closure takes effect. Similar concerns apply to temporal closures.

2.2 Remedial Measures

The group discussed the potential methods for handling this question, and came to the conclusion that it is absolutely essential to use disaggregated data for the computations of CPUE indices. Only in this case do possibilities exist for the elimination of the bias.

Two approaches were considered promising. Firstly, it is quite feasible to use disaggregated data in a GLM (multiplicative) model where the areas/seasons are factors. This sort of analysis has been carried out, e.g. in Anon. (1993a), and such an analysis eliminates the areal/seasonal effects from the index in question if the model is correct (see caveat below). The second approach is to use disaggregated indices as different fleets for tuning purposes. This approach should also allow for correction of the effect of a closure of an area or a season, e.g. by eliminating the corresponding indices from the analysis.

2.3 Case Study

2.3.1 Introduction

The Northeast Arctic cod was used as an example to illustrate the effect of removing one or more fleets from the CPUE series or aggregating fleets, in the Laurec Shepherd tuning.

CPUE data were available for five commercial trawler fleets, which account for approximately 1/2 - 2/3 of the total catch. These fleets are:

- Norwegian trawlers in Subarea I
- Norwegian trawlers in Division IIa
- Norwegian trawlers in Division IIb
- USSR trawlers in Subarea I
- USSR trawlers in Division IIb

Young cod are most abundant in Subarea I, while adult cod dominate in Division IIa. The catches in Division IIb by these fleets have been variable, and in some years close to zero.

The effect of removing or aggregating fleets was studied in terms of the terminal Fs in retrospective VPAs, which were compared to the F-values for the same years obtained in the most recent (1989) VPA. The actual mean Fs and residuals for ages 3-5 and ages 5-10 are shown in Tables 2.1-2.2 and Figures 2.1-2.2. For comparison, the Fs estimated by the latest Working Group (using different tuning data) are also included in the tables.

2.3.2 Fleet aggregation

The three Norwegian fleets were aggregated into one and the two USSR fleets into another. The resulting Fs did not deviate much from those obtained with all fleets disaggregated. The estimation of the Fs was slightly improved in most years for the ages 3-5, but not for the ages 5-10.

2.3.3 Omission of fleets

In general, omission of either the Subarea I fleets or the Division IIa fleet led to more variable estimates of the terminal Fs. In some single years, the discrepancy between the assessments using different tuning series was quite dramatic. The only case where a more systematic trend could be seen was in the Fs at ages 3-5 when the Sub-area I fleets were omitted. This led to a reduction in F_{3-5} except for the extremely high values in 1978 and 1979 (omitted from the residual plots).

2.3.4 Comments

One should be aware that using CPUE data in the assessment of this stock is problematical. There is reason to believe that the CPUE for these fleets are poorly correlated to the actual stock numbers. There has also been an increasing trend in the catchabilities. The contributions from each fleet to the final terminal Fs are frequently inconsistent. Therefore, the effect of omitting a fleet largely depends on its impact on the estimated catchabilities.

2.4 Caveats

Regardless of the method used, some potential biases remain. The full effects of closures may well be much more complex than intended, since the effort may completely move to another area or season. The effect of moving all the effort of a fleet into another area is not at all clear, since this may for example lead to a new learning process, which will again lead to catchability changes. Such catchability changes correspond to complex interactions in the GLM model which are not easily modelled or accounted for in any analyses. Extended comments on these problems have been made by this Working Group earlier (Anon., 1993a).

3 ACCURACY OF PROGNOSES

3.1 Introduction

Recent investigations by Canadian scientists (Sinclair *et al.*, 1990) have shown that retrospective analysis of the assessments made using current methodology sometimes indicates significant biases in both fishing mortality and population abundance estimates. In such analyses on real data sets, the most recent assessment has to be used as the best estimate of the truth.

Such biases, if present, may cause troublesome errors in the advice to managers, and need to be taken seriously. It was therefore decided to make a similar retrospective analysis of the accuracy of the assessments made by ICES working groups a high priority for the meeting. Prior to the meeting, a number of members undertook to carry out such analyses using standard *ad hoc* (Laurec-Shepherd) VPA tuning methods on stocks with which they were familiar. The stocks examined were:

- North Sea roundfish
- North Sea flatfish
- Irish Sea stocks
- Northeast Arctic cod

Furthermore, it is not yet known whether the problems are due to special features of the data or to the specific methods of analysis used. It was therefore decided at the meeting to carry out analyses of selected eastern and western Atlantic stocks using the methods current in both areas, and also to use the Time Series (TSER) and Extended Survivors (XSA) methods of analysis which were available at the meeting. The stocks were chosen to include a stock in each area for which a problem had been identified (4VsW cod and Division VIIe sole) as well as several for which no problems have been noted or for which the problems were considered to be less severe. The full list of retrospective analyses (each of which involves between 10 and 20 assessments) carried out at or before the meeting is given in Table 3.75.

The ICES Advisory Committee on Fishery Management (ACFM) is invited to note that the total number of assessments carried out at the meeting was about 400, which is believed to be some sort of record.[1]

Two approaches were adopted to allow a comprehensible presentation of the results obtained. Firstly, extensive plots were prepared of both fishing mortality and population numbers for age groups identified as newly recruited, partially recruited, and fully recruited in each case. These plots are referred to in the relevant sections below: the format is essentially identical to that of Sinclair *et al.* (1990). Secondly, where significant errors in previous assessments were identified by the analysis, the diagnostics provided by the methods were examined to see if any warning was provided.

A second approach to the retrospective analysis described above, which relies on simulating what a working group would have got using current methodology several or many years ago, is to analyze the results they actually obtained and compare these with the current estimates for that time. This historical approach is essentially just an extension of that implied by the standard ICES Quality Control diagrams extended over a long period. The results of this analysis are described in Section 3.2.6.

The Working Group did not attempt to make further comparison of estimates of catch (as opposed to those of fishing mortality and population number) since this would have required substantial extra programming effort. The precision of catch forecasts has, however, been studied by Sun and Shepherd (in prep.), using simulation methods. They confirmed that there is a substantial cancellation of errors in making catch forecasts and that the standard error of a catch forecast is around a half to a third of the standard error of estimates of average F and stock biomass (which are similar) for realistic levels of noise in the data. These results apply only to that part of the catch composed of age groups already observed in the fishery: the error due to imprecision of recruitment estimates is additional. For the methods tested (*ad hoc* tuning, XSA, and an integrated statistical method similar to CAGEAN), the standard errors of the catch forecast are of the order of 10%, when those of average F and SSB are about 20% or 30%. Pope (1983) and Pope and Gray (1983) have analyzed the contribution of recruitment and variability of weight-at-age to the total error, and these contributions may be similar or larger than those discussed above.

3.2 Results using ICES Methods

3.2.1 Background

Basic trials were performed before and during the meeting, using ICES methods. The analyses and results are ordered by assessment working group.

It must be noted that the retrospective assessments need not bear much resemblance to the actual assessments undertaken by the working groups in the corresponding years. Further, even the final assessments indicated in the retrospective analyses will not correspond exactly to the most recent assessments undertaken by the working

[1]Editors note: It follows from this that the assessments were all run in "automatic mode". It is quite possible that careful analysis might give better results for any single stock and method.

groups. There are several reasons for this, but the major ones are:

* changes in assessment methodology through time mean that earlier assessment techniques used by working groups do not correspond to those used today;

* recruitment estimation is not included in the retrospective analyses since this is normally done outside the tuning modules;

* specific deliberations by working groups to evaluate the quality of their data and adjust assessments accordingly cannot be analytically described in general (e.g. elimination of early years, poor fleet data etc);

* in some instances only long time series were used retrospectively, which excluded some surveys;

* age ranges chosen by assessment working groups may well differ from the ones used here.

The plots are given six to each page (Figures 3.1-3.37), where one column contains retrospective stock estimates and the other retrospective fishing mortalities. The three rows of plots correspond to the recruits, the partially recruited and the fully recruited parts of the populations. However, for the fishing mortalities the fully recruited portion only refers to the part of the age range where the mortalities are reasonably stable, so the oldest ages are omitted.

Each line in each plot corresponds to the assessment ending in the year indicated (t). Each assessment contains several years, y, from a base year to the assessment year, t. For comparison, stock estimates at the beginning of each terminal year are compared with the reference stock size from the final run (based on the last available data year, T). Fishing mortalities also refer to the last data year. **Note that the y-axes in the plots are not consistent between methods**. This must be borne in mind when comparing results from different methods.

The tables come in pairs for stock size and fishing mortality respectively (Tables 3.1-3.74).

For the stock estimates and current year F values, the deviations

$$100 \ln \frac{F(a,t,t)}{F(a,t,T)}$$

and

$$100 \ln \frac{N(a,t,t)}{N(a,t,T)}$$

are computed.

Each cell in the age columns contains the number of times a deviance of that magnitude was obtained between current and final estimates. Thus each column contains a histogram. The column labelled "AU" simply contains the sum of the previous ones.

The last three columns contain the sums of the previous ones, over the corresponding age groups, to indicate the effects within the recruiting, partially recruited and fully recruited age groups.

The last two lines simply refer to the average and standard deviation of the log-ratio. The average in this case is a measure of bias.

The line labelled $|p|>50$ indicates the frequency of "large" errors, i.e. how often errors of over 50% occur. It should be noted that a downwards error of 50%, as measured here, means that the measured ratio of the terminal F in a year to the final F for that year is about 61%, whereas an upwards error of 50% corresponds to 165%.

In the tables and figures the short-hand notation LS is used for the Laurec-Shepherd method and L2 for the Laurec-Shepherd method incorporating shrinkage (see section 3.4). The name ADAPT is in some places shortened to AD. TSER or TS is used for either of the two Time Series methods, but if further clarification is needed, TSER1 denotes the Time Series method without a CPUE or survey series, whereas TSER2 denotes the version which utilizes such a series. Finally, XS or XSA is used for the Extended Survivors Analysis and X2 denotes the shrinkage version of XSA.

3.2.2 North Sea cod, haddock and whiting

Data for these stocks were provided by the Chairman of the Roundfish Assessment Working Group and conformed to those used at its most recent meeting with the exception that an estimated discard component was included in the cod catch at age data for the youngest ages. The inclusion of discards in the North Sea cod data files has not been discussed by the Roundfish Working Group and their validity is not yet established. In consequence, the VPA results for the youngest ages of North Sea cod should be viewed cautiously.

Laurec-Shepherd tuning was undertaken assuming a 15 year tuning range prior to the most recent data year. For cod, this permitted retrospective assessments to be made assuming each of the years 1981-1989 to be the most recent data year with VPAs extending back to 1963. For haddock and whiting, the years 1977-1989 were treated as the most recent data year with VPAs extending back to 1960 in each case. Fleet catch and effort data used to tune the cod VPAs were: Scottish seine, trawl and light trawl and English trawl and seine. Haddock and whiting catch and effort data were provided by the three Scottish fleets only. Other fleet data, including survey data, which are normally used by the Roundfish Working Groups, were not included in these analyses because catch and effort data were not consistently available for them over all the tuning ranges.

Results are shown in Figure 3.1 for cod, Figure 3.34 for haddock and Figure 3.35 for whiting. The Roundfish Working Group routinely replaces VPA estimates for the youngest ages with calibrated survey index values of population size. Comments on the results shown here are therefore limited to partially and fully recruited ages only.

For the partially recruited ages it appears that fishing mortality rates are prone to underestimation for cod and overestimation for haddock. No systematic error is apparent for whiting although the values are rather poorly estimated. For the fully recruited ages, systematic underestimation of fishing mortality appears to be present in both cod and whiting stocks but not haddock. Indeed, haddock demonstrate an intriguing picture with massive underestimation of terminal F in the earliest retrospectives but rather less tendency to behave poorly in the more recent retrospectives. There is no immediately obvious explanation for this. It is recommended that the Working Group investigate this matter.

3.2.3 North Sea flatfish

North Sea plaice

Retrospective analyses were carried out with LS and XSA methods for North Sea plaice. The results are plotted in Figures 3.22–3.23. The stock numbers in the plots are, as in all other cases, those in the last data year (not survivors).

Recruits and partially-recruited age groups are in general poorly estimated. The Working Groups usually replace them by estimates including independent information from surveys. Fishing mortality in partially-recruited ages seems to be consistently overestimated in the first year only (converges in one year) by both LS and XSA. Stock numbers from these age groups are consequently underestimated in the first year.

First estimates of F in fully-recruited age groups are over- or underestimated with no systematic trend by LS. However, the first XSA values are always overestimates. The fishing mortality converges over more years.

Both LS and XSA tuning methods give similar and comparable results. First estimates of fishing mortality on the partly-recruited age groups are too large by both methods. Consequently stock numbers of these age groups are underestimated as compared to the final estimates. However, on the fully-recruited age groups only the XSA results seem biased. Also the level of fishing mortality on the oldest age groups estimated by the XSA is higher compared to the LS. This is probably due to the effect of the number of age groups available for convergence from the terminal F on the oldest age groups. The LS was run with 15 age groups, the XSA with 10.

Division VIIe sole

Retrospective analyses were carried out using all four methods: XSA, LS, ADAPT and TSER. The methods employed are described in Section 3.3.1 and in working papers R1, S1 and S2.

All methods identified problems with the full data set: the plots (Figures 3.8-3.11) show large one-sided residuals and poor retrospective convergence. Two of the methods (LS and XSA) have consistently overestimated fully-recruited fishing mortalities, the other two methods gave consistent underestimates retrospectively.

Examination of the diagnostic output reveals possible catchability trends, which may explain the results found here. It should be noted that the current Working Group practice is to shorten the time-series for tuning, thus reducing the problem.

3.2.4 Irish Sea plaice

Plots show no major problems in fully-recruited Fs, good retrospective convergence and a two-sided error distribution. The largest discrepancy came from the oldest retrospective assessments, where the tuning series were shortest at five points.

3.2.5 Northeast Arctic cod

The most recent assessments of Northeast Arctic cod have been based primarily on survey indices. The survey series is too short to base a retrospective analysis of tuning methods on, but CPUE data from trawl are available back to 1972 and the Laurec-Shepherd tuning method was used on these data with final assessment year ranging from 1978 to 1989. No downweighting of older data was used in the runs.

Except for a couple of years, the results (Tables 3.71–3.72, Figure 3.36) show severe underestimation of fishing mortality, in a third of the cases by more than 50%. An examination of the CPUE values compared to the stock numbers from the most recent VPA indicates a considerable increase in catchability over the period, which is probably the main reason for the underestimation of fishing mortality. The increase in catchability is likely to have been linked with the severe restrictions that were put on the trawl fisheries during this period, causing the trawlers to concentrate their fishing effort on the best fishing grounds, but other factors, both biological and technical, are probably also involved.

The analysis shows that the Laurec-Shepherd tuning method can give severe underestimates of fishing mortality when catchability is increasing. It should be noted, however, that there is a lot of noise in the data which may have contributed to the poor results. Considering the size of the error, it is recommended that the Arctic Fisheries Working Group should consider this problem in detail.

3.2.6 Evaluation of historical assessments

The occurrence of a possible bias in the first estimates of fishing mortality, biomass and recruitment as assessed by Working Groups was investigated. The first estimates were compared, for a number of stocks, with the most recent estimate (obtained in 1990 or 1991). Average fishing mortalities and SSB were taken from the VPA, while the recruitments are those assumed in the prediction.

During the periods covered, different assessment methods have been used by the different Working Groups. More sophisticated (tuning) methods have been introduced in recent years with the intention of improving the assessments. Consequently, the procedures followed by Working Groups have also changed in recent years.

The results of the comparisons are shown in Figures 3.38–3.46 and are very variable for different stocks. The example stocks show that first estimates of fishing mortality can be consistently under- or overestimated every year. Consequently, in those cases SSBs are over- or underestimates. In other stocks the first estimates appear to be underestimates one year and overestimates the next with no trends. However, there are also stocks which show reasonable agreement between the first and the converged estimates. Some assessments show improvement in recent years.

First recruitment estimates generally show the largest variation. In almost all situations the VPA cannot give a reliable estimate of recruitment, so Working Groups usually depend on independent information on recruiting year classes. When this information is not available, average recruitment must commonly be assumed. However, when information is available from recruitment surveys, the quality of the surveys and the type of analysis of the data contribute to the reliability of the estimate.

The most intriguing phenomenon, however, is the consistent under- or overestimation of the fishing mortalities for some stocks in the most recent years. Examples are the Northeast Arctic cod and haddock, and the Faroe saithe.

An historical analysis, as shown here, is easy to carry out and might give some guidance to Working Groups when they have to make choices in cases where different assessment methods give contradictory results (low F, high F). It is therefore recommended that Working Groups carry out such an analysis routinely for every stock.

3.3 Comparisons across Methods

3.3.1 Choice of methods

The cross-comparison involved four methods and seven species. The four methods correspond to assessment methodology currently used for eastern and western Atlantic stocks (Laurec-Shepherd or LS and ADAPT, respectively), and two proposed procedures (Extended Survivors Analysis or XSA and Time Series Analysis or TSER).

3.3.2 Choice of stocks

Selection of stocks for analysis by several methods was done by choosing two stocks from each of the eastern and western Atlantic. These stocks were chosen so that one from each region was known to have given problems in assessments and one was thought to be relatively well-behaved.

This led to the inclusion of North Sea cod (eastern, well-behaved), Western Channel (Division VIIe) sole (eastern, troublesome), 4TVn cod (western, well-behaved) and 4VsW cod (western, troublesome).

In addition, the North Sea plaice and Southern New England yellowtail flounder were taken as examples.

3.3.3 Retrospective Analysis using the Laurec-Shepherd Method

The retrospective tests of the Laurec-Shepherd method were carried out using the implementation in the Lowestoft VPA package. The standard defaults were used, with fishing mortality on the oldest age set at the average over the next three or five younger age groups. No time-taper downweighting was used, and the entire range of years for which five or more years of data were available was used for tuning, except for North Sea Cod where a sliding 15 year window was used. The age range was the same as that normally used by the relevant Working Group.

The analysis was carried out for all the five standard stocks, and also for North Sea plaice, SNE yellowtail flounder, Northeast Arctic cod, Irish Sea sole, cod and whiting, Western English Channel (Division VIIe) plaice, Celtic Sea sole, plaice, cod, and whiting, along with North Sea haddock and whiting.

No problems were encountered with the analysis, which took about 30 minutes per stock.

3.3.4 Retrospective Analysis using ADAPT

A description of the ADAPT method and the history of its development is provided as Appendix F. This method is best thought of as a framework rather than a precisely defined algorithm with a fixed set of input data and output results. Consequently, the details concerning its application to the various stocks considered during this meeting are provided within the sections describing each stock.

3.3.5 Retrospective Analysis using Extended Survivors Analysis

As a further check on the model dependence of bias in assessment results, the data for some stocks used for the comparative tests were also analysed using the Extended Survivors method (XSA). This is described by Shepherd in Working Paper S2.

The analysis was carried out for the five main stocks, and also for North Sea plaice and SNE yellowtail flounder.

For North Sea cod the number of years in the analysis was restricted to 15 for consistency with the other analyses of these data. The age range analysed was truncated to 13 years where necessary, simply to ensure that the output tables were neatly formatted. Otherwise the standard default choices were used, i.e. :

- Tricubic downweighting of old data, over 20 years;
- Catchability independent of abundance (linear relationship between CPUE and abundance) for all ages, i.e. no special treatment of recruits;
- Catchability independent of age for all indices above age 5 (age 8 in the case of 4TVn cod).

No other choices are necessary for this method. No problems were encountered with the analyses, which took about 30 minutes per stock (386 + 387 PC).

3.3.6 Retrospective Analysis using the Time Series Method

This method is based on the usual relationships between catches, stocks and fishing mortality rates and the natural mortality rate is supposed to be known. A detailed description of the method was presented by Gudmundsson (1987).

The estimated model of logF(a,y) is a multivariate ARIMA model. However, standard time series programs cannot be applied for the estimation because of the non-linear relationship between logF(a,y) and the observed catches. The program used is specially developed for the purpose of stock estimation and must not be confused with general purpose time series packages.

The fishing mortality rates are represented by a random walk model,

$$\log F(a,y) = \log F(a,y-1) + e(a,y).$$

The residuals, e(a,y), are stationary but not independent. Their properties are determined by four parameters. Stocks and fishing mortality rates are regarded as unobserved time series and calculated from the observed catch at age values by means of a linear approximation to the Kalman filter.

The calculations start in the first year and six parameters are used to provide initial values, including recruitment to the youngest age. The given relationships and Time Series model are used to predict next year's stocks, fishing mortality rates and catches at age. The catches are compared to the observed values and the Kalman filter updates the predicted stocks and fishing mortality rates in accordance with the catch prediction errors. This process is repeated for each year and the updated values of the stocks and fishing mortality rates have used all information in the data about these values in the last year. Final estimates of the earlier values are obtained by a backward procedure from the last year so that the information in both past and future observations is used. Measurement errors of the catch at age data are taken into account so that the estimated values do not fit the observed values exactly.

Although a random walk model is very flexible, it imposes sufficient constraints on the fishing mortality rates to ensure that the last years' values can be estimated without introducing any effort or catch per unit effort data. However, it is also possible to include a set of auxiliary data. As we do not use them for "tuning" in the sense of VPA, we can afford to model catchability of a fleet or research vessel as random walk and thus investigate whether it appears to be changing. The diagnostics applied with this method are described in Section 3.2.1.

The present programs were written for a Vax with VMS, but have been compiled without changes on UNIX machines. They must be compiled with the NAG routines. A description of the application of the programs is presented by Gudmundsson (1991b).

At the meeting retrospective analysis was performed with the Time Series Method on five stocks: North Sea cod, Western Channel (Division VIIe) sole, Irish Sea plaice, 4TVn cod and 4VsW cod. The analysis was carried out for all stocks with only catch at age data (TSER1). Western Channel sole was also analysed with CPUE from the UK inshore fleet, 4TVn cod with September research vessel survey CPUE and 4VsW cod was also analysed with CPUE from the July research vessel survey (TSER2).

The annual variations in catchability estimated for the survey of 4VsW cod were exceptionally high and included both transitory variations and changes modelled by random walk. There appeared also to be annual variations in catchability of the random walk type in the survey for 4TVn cod, but of more moderate magnitude. It is noticeable that in these estimates, where variations in catchability are allowed for, there was no indication that stock estimates from the retrospective runs were higher than the estimates obtained from the longest series.

The method has facilities to adjust for outliers and changes in variance with age or years. The diagnostics indicating such problems are therefore always acceptable in runs that are actually used. In the longest run with 4TVn cod, "correlation within cohorts" for the total catch at age residuals was 0.35. This is rather high, but as the "correlation within years" was only 0.11 it is not very alarming. No other uncomfortably high correlations appeared in the longest runs on any of the five stocks analyzed at the meeting.

3.3.7 Comparisons of results by stock

Comparisons in the following are given by stock, since most conclusions are similar across the methods considered.

Most of the analyses are based on both tables and plots. All tables and plots are grouped together by species for clarity, although they are referenced in different places in the text. Explanations of the tables are given in Section 3.2.1. Some sample interpretations of results are given in the following.

Division VIIe sole

Examination of the F ratio tables for the four methods reveals that the Time Series Method had the lowest "large error" index (14%), followed by the Laurec-Shepherd (31%), XSA (52%) and ADAPT (64%). Both LS and XSA methods gave a wide spread of positive F ratios, whereas the ADAPT method produced mainly high negative ratios. The TSER method was only marginally negative. The majority of these effects came from fully-recruited age groups.

Irish Sea plaice

The TSER method was not run on this stock, but all three remaining methods produced similar results according to the F ratio table. "Large error" index values were: ADAPT 14%, XSA 14% and LS 4%, with no significant biases in either direction. This stock is regarded as reasonably well-sampled, with commercial data used for tuning.

4T-Vn (J-A) cod

For this stock, retrospective analyses were conducted will all four methods (ADAPT/XSA; LS and TSER). All four methods indicated retrospective problems. Three of the four methods (ADAPT, XSA, LS) tended to underestimate F when compared to the reference year while the TSER method generally overestimated F. For ADAPT, the retrospective patterns appeared mostly for fully-recruited ages while for LS and XSA, the patterns were more prominent in the partially-recruited age groups. For the TSER method, the patterns appeared in partially and fully-recruited age groups.

The systematic error in population sizes was the largest for ADAPT in the fully-recruited ages (45). The proportion of large errors ($|p| > 50$) was highest for this method In the LS method and XSA, it was largest for the recruits. The measure of error for the TSER method was relatively low (<10).

The residuals diagnostics of the ADAPT and XSA analyses for the most recent year both indicated an increasing trend in catchability with negative zbar values in the early years and positive values in the recent years. For the survey index and the OTB CPUE index, a year effect was apparent for 1981.

4VsW cod

Plotted results for 4VsW cod indicated that all methods except TSER consistently mis-estimated stock size in the years of assessment, particularly for fully-recruited ages. The most recent assessment with the TSER method indicates Fs slightly lower than estimated in the terminal year. The other three methods all indicate the reverse retrospective pattern, with Fs in a given year apparently increasing as additional years are added to the analysis. The recruitment retrospectives (methods LS and XSA only) are more variable than partially- or fully-recruited ages and indicate both over- and under-estimates of recruitment numbers. The tables of retrospective ratios (based on Fs) show a severe underestimation.

Yellowtail flounder

Retrospective analyses for the Southern New England yellowtail flounder stock were conducted using ADAPT, LS and XSA. For all three methods, research survey indices of abundance were calibrated to the VPA population size. These survey indices tend to be highly variable, especially for the younger ages. Full recruitment was taken to occur at age 3. Comparison of the results will focus mainly on the F estimates for the fully-recruited ages (full F).

All of the methods exhibited good retrospective convergence; and little or no bias was evident in the retrospective estimates of full F (especially when compared with the apparent bias noted in other stocks examined by the Working Group). ADAPT showed no bias in the full F while the LS and XSA showed a moderate positive bias (i.e. a tendency to overestimate F).

All methods were sensitive to apparent year effects in the surveys, especially when these effects occurred in or near the terminal year. The proportion of large errors ($|p|>50$) was highest for LS (45), intermediate for ADAPT (36) and lowest for XSA (17).

Generally the LS results exhibited higher variability and some bias; ADAPT was variable but unbiased; and XSA was less variable but positively biased. However, in comparison with other stocks examined by the Working Group, the degree of bias was always moderate and the variability was not large.

3.4 Shrinkage

The results obtained using the TSER method at the Reykjavik workshop (Anon. 1993b) and at this meeting, as well as the results of Sun and Shepherd (in prep) using the much more primitive un-tuned conventional and separable VPA, show that methods which involve some sort of restraint on the variation of fishing mortality can perform well. It seems possible that including the recent level of F in the estimation procedure in addition to the estimates based on CPUE/survey data, as in the TSER2 method, could assist in reducing variance at the expense of a little bias (towards the recent mean) in the results. Obviously the restraint on F should be as weak as possible, as in the TSER method, to minimise the bias and allow detection of changes in F to the maximum extent possible.

This possibility looks particularly attractive because, in several cases where problems have been identified by retrospective testing, the problem is manifested as excessive predictions of changes of F, rather than vice versa. Also, of the six possible cases (increasing, constant, or decreasing F, with possible under or overestimation of F in each case), including shrinkage towards the mean is likely to be helpful or benign in four cases.

Shrinkage is a well established technique in statistical prediction (see e.g. Copas, 1983) and is already a standard part of the usual procedure for recruitment estimation within ICES (Shepherd, MS 1991). In the present context it amounts to treating only the symptoms of a disease, whilst research is underway in search of a cure.

The TSER2 procedure is computationally demanding and at present can handle only one set of CPUE indices, which is not enough for routine assessments. Some of the more adventurous members of the Working Group therefore decided to implement shrinkage towards the recent mean F into those procedures where this was technically easy, i.e. *ad hoc* (LS) tuned VPA and XSA. In both cases it can be done by simply including the mean F (or the survivors based on mean F) as an additional estimate in a weighted mean, with some appropriate weight. The arithmetic mean F over the last five years was used in both cases, with a CV of 0.2 for LS and 0.3 for XSA (with which the terminal Fs are less rigidly fixed by the algorithm).

The time period and these CVs are just guesstimates, and have not been optimised in any way.

The methods incorporating shrinkage were applied to two problem datasets, the Division VIIe sole and North-east Arctic cod (LS only for the latter). The results are illustrated in Figures 3.12, 3.13 and 3.37 and the diagnostics are given in Tables 3.23–3.26 and 3.73–3.74. It is clear that the shrinkage has reduced the systematic overestimation of the increasing trend of F in Division VIIe sole considerably in both cases, but some bias seems to have been introduced.

3.5 Retrospective Analysis - Conclusions

The Working Group concluded that retrospective patterns similar to those found by Sinclair *et al.*(1990) for several stocks of the northwest Atlantic are also found for many stocks assessed by ICES using different tuning methods. The problem is not specific to a particular tuning method but seems, from the results obtained here, to be universal. This is not surprising as most tuning methods depend upon similar underlying assumptions (e.g. with respect to calibration coefficients, the equations linking catch-at-age and abundance-at-age, natural mortality, etc.) and use all available data in a similar manner (e.g. indices-at-age, catch-at-age).

It also appears that retrospective patterns are stock specific, being absent on certain stock or very strong in others, regardless of the method used. This is consistent with the observations of Sinclair *et al.* (1990) who concluded that the retrospective patterns could be the result of certain patterns of misreporting, a trend in catchability in the tuning indices, a mis-specification of natural mortality, or a mis-specification of partial recruitment for the oldest ages in the stock. As a given combination of factors will affect the data in a particular way, all methods using these data are likely to be affected in a similar way.

The Working Group notes that retrospective analyses do not provide insight about the degree of departure from the "true" underlying population but simply reflect the degree of consistency between years when the same calibration technique is used.

The Working Group recommends:

- that retrospective analysis be applied on a routine basis each year at the assessment meetings to evaluate the degree of consistency between years;

- that diagnostics such as the ones described in this report be applied each year with particular attention being paid to;

    - high CVs in parameter estimates
    - year effects and age effects
    - trends in time series of residuals
    - correlation between parameter estimates (ADAPT)

If the application of diagnostics leads to the identification of specific problems, corrective measures should be taken to eliminate the problem(s).

The Working Group noted that over-parametrization of assessment models may lead to excessive variance and bias because of sensitivity to minor features of the data. This may be avoided by using both more restrictive models, and by taking account of the recent past in deriving solutions.

Possible corrective measures are:

- elimination of "bad" data (shorten CPUE series, drop poorly sampled age groups, drop or down-weight unreliable indices);

- restructure the model (particularly applicable for ADAPT using more restrictive assumptions).

In certain circumstances it may be possible to reduce retrospective errors by utilising shrinkage towards recent mean F values, pending full investigation of the causes. This does not, however, guarantee that the results will be closer to the truth and is likely to reduce the ability to detect sudden changes in fishing mortality.

In the longer term, the following areas need to be addressed:

- develop a better understanding of the factors leading to retrospective patterns (e.g. migrations, fishing patterns, varying catchability of the indices (particularly gear effects), standardization of effort data, etc.;

- improve the existing indices (multiplicative modelling) or develop new indices (e.g. index fishermen, observer data, new research vessel surveys);

- assess, through simulations, where the retrospective estimates lie with respect to the underlying true population when various factors are the likely causes of a retrospective deviation;

- evaluate remedies, i.e. various ways to account for the retrospective patterns observed (e.g. use of time series methods or, in this context, the development of operational multifleet implementations of time series methods should be encouraged).

4 ASSESSMENT DIAGNOSTICS

4.1 Introduction

Previous Working Group reports have drawn attention to the need for Working Group members to pay careful attention to the diagnostic output provided by various assessment techniques.

At this meeting it was decided to carry out a comparative study of the usefulness of those diagnostic measures which are available and which have been recommended for practical use. These include :

* coefficients of variation of key parameters;

* tables of residuals;

* indicators of year effects in survey/CPUE data;

* variance ratios indicating discrepancies between indices;

* correlations among parameters;

* means, variances and correlations among residuals.

The first three of these are available in some form for all the methods considered. The fourth is at present only available for *ad hoc* tuned VPA, whilst the fifth is at present provided only by ADAPT and TSER and the sixth only by TSER.

Recent experience in the ICES area has shown that year effects can have a very serious effect on assessments, since they cause spurious increases and decreases of fishing mortality to be observed, and these were therefore singled out for particular attention. Two new diagnostic parameters were defined for this purpose, based on the mean standardised residual (mean over ages for each index in each year), and on the proportion of residuals having the same sign.

A program provided by G. Gudmundsson was also used to examine the structure of the residuals for each method, and a simplified "contour" visualisation of the residual table was constructed.

4.2 Output from Methods

4.2.1 Laurec-Shepherd analysis

The diagnostic output from the LS procedure is described in detail in an earlier report from the Working Group (Anon., 1993a, Appendix B).

Retrospective analysis for Southern New England yellowtail flounder indicated a small tendency towards overestimation of F in terminal years. Overall, however, the results can be characterized by high interannual variations in terminal F relative to the baseline. This may be attributed to variability in the research vessel survey indices used for tuning.

In an explanatory analysis, diagnostic statistics from retrospective runs were compared with differences between terminal year and baseline F values to evaluate the sensitivity of terminal year diagnostics to potential irregularities in terminal F estimates. Four standard diagnostic statistics were inspected: sigma (internal), sigma (external), sigma (overall), and the variance ratio. These statistics were compared (by age) with the absolute difference between raw retrospective and baseline F values. Linear regression models were fitted using the absolute difference in F as a response variable and sigma (internal), sigma (external), sigma (overall) as single regressor effects.

Significant effects (alpha = 0.05) were observed in only one age-index combination (age 1 and sigma (internal)) and R-squared values were generally low (10 out of 15 were less than 0.10). Although a linear relationship between the variance ratio and deviations in F would not be expected, alternative functional relationships are not suggested by the observed scatter of observations (Figure 4.1).

Existing summary diagnostics do not appear to provide a reliable warning of potential errors in estimation of terminal F for this stock. Development of diagnostics incorporating more information contained in matrices of log q and residuals of q may be beneficial (although in this case, cursory inspection of residual matrices revealed no simple predictor within). Extension of this evaluation to a wider range of stocks may provide respective working groups with additional information on the confidence they may place in the performance of these diagnostics. The Working Group suggests that this type of analysis should be carried out for other stocks, particularly in conjunction with retrospective analyses.

4.2.2 Output and diagnostics from ADAPT

An example of the output and diagnostics provided by the APL implementation of the adaptive framework (ADAPT) is presented in Table 4.1 and Figure 4.4. Typically, the diagnostics of interest are the standard error of the parameter estimates, the correlation matrix of the parameters, as well as the residuals by fleet/index, by age and by year. Plots of residuals are also provided.

Standard errors of the estimates are often expressed as the ratio "standard error/parameter estimate" expressed in %. Typically, these percentages (loosely called coefficients of variation - CVs) are the lowest for the intermediate ages and increase for the younger and the older ages. In the best cases, they range from 15-35% for the intermediate ages. CVs higher than 45-50% generally lead to a revision of the formulation of the calibration model as such high values indicate that the parameter estimates are not well determined. For instance, it is not uncommon to use this criterion to evaluate which range of ages should be considered in the calibration. Similarly, the calibration will be rejected if all parameters have ratios (CVs) higher than 45-50%. The above diagnostics are rules-of-thumb and may vary depending on the data used in actual assessments.

The correlation matrix of parameter estimates is generally used at an early phase of the formulation of the calibration model under ADAPT as a crude indication of our ability to obtain independent parameter estimates in view of the information content of the data. It is thus most useful as a diagnostic the first time the ADAPT framework is applied on a given stock. Large negative or positive correlations between parameter estimates (say >0.6 or <-0.6) throughout the matrix indicate that too many parameters are being estimated for the given indices. Highly correlated parameters would not necessarily be an issue if the model (and its inherent parameters) was used simply to provide a predictive description of the dependent variable (as is the case, for instance, in many growth models). However, because the stock abundance estimates (which often represent less than half of the parameters that are estimated) are used directly to provide stock and catch projections, highly correlated parameters must be avoided (and particularly so here because correlations could be high between the abundance estimates and the calibration coefficients which are not used in the projections). It is thus desirable to have final formulations of the calibration that exhibit low correlation between parameter estimates and, in practice, values of the order of those presented in Table 4.1 are achievable for many stocks. In practice, values between -0.2 and 0.2 for most entries in the correlation matrix and some, but few, values between -0.6 and -0.2 or 0.2 and 0.6 seem and represent a "comfort zone".

For cases in which the correlation matrix is neither good enough to accept, nor bad enough to reject the calibration, it can still provide information either to revise the model formulation or to increase the amount of data (in years or indices). It is frequently an indication that the data series is too short.

The residuals are provided for each index, by age and by year. Residuals are inspected for evidence of outliers or of patterns that might be indicative of lack of fit. Their inspection often reveals the presence of year-effects (all residuals having the same sign or tendency for a given year) or age-effects. Age-effects that are found on the youngest or oldest ages can be eliminated by dropping these age-groups from the analysis. However, it is generally not possible to eliminate year-effects without making a number of additional assumptions as these are the result of the indices used for the calibration. The presence of temporal trends or strong patterns in the residuals for a specific index will often lead to the exclusion of that index from the formulation or, at a minimum, to the investigation of the sensitivity of final results to that index.

The retrospective analysis for Southern New England yellowtail flounder (SNE YTF) did not indicate any significant bias when using the ADAPT method (see Section 3.3.2). However, appreciable variability was evident in the results due mainly to the high variability in the research survey indices used for tuning. ADAPT retrospective runs were examined to ascertain whether the diagnostics provided would have indicated a problem for the assessment years when anomalous F estimates were obtained.

The following ADAPT diagnostics were compiled for each assessment year in the retrospective analysis (1977-89):

- mse from the fitted model;
- coefficients of variation (CV) on the population size estimates at the end of the terminal year;
- number of standardized residuals greater than 1.5 (in absolute value) in the most recent 3-year period
- percent of standardized residuals greater that 1.5 (in absolute value) over all years in the assessment

These diagnostics were compared with the absolute value of the log F ratio for fully-recruited ages (discussed in Section 3.2.1). An exploratory multiple linear regression model was fitted using the log F ratio as the dependent variable and the above diagnostics as the independent variables. The final three retrospective runs (terminal years 1987-89) were not used in the regression to avoid problems with lack of convergence of the base run (terminal year 1990).

The only diagnostic found to be significant was the CV on the age 4 population size at the end of the terminal year. This population size estimate is instrumental in the back-calculation of the F on fully-recruited ages in the terminal year. However, the model does not fit well (r^2=0.28; Figure 4.2) and does not exhibit good predictive power in identifying outliers in the estimated full F for the terminal year (Figure 4.3).

Although this exploratory analysis for yellowtail flounder did not identify ADAPT residuals useful for real time outlier identification, the Working Group felt that such examination of as many model diagnostics as practicable should be a part of all retrospective analyses. This process may help to develop better diagnostics when carried out over a broader range of stocks.

4.2.3 Output and diagnostics from Extended Survivors Analysis

The output provided by XSA (Table 4.2) is still in a preliminary format, and is missing some desirable labelling of rows and columns, etc. All the results are printed in "ages across" format, i.e. the transpose of the usual VPA tabulations. The estimates of survivors are printed as a separate row at the foot of the tabulation of population numbers.

The logarithms of the reciprocal catchability estimates are printed (0.00 indicates no data) as the first of two rows for each fleet. The log standard deviations (approximate fractional CVs) of each are given in the second row immediately following the reciprocal catchabilities themselves. These are most important numbers as they indicate the quality and utility of the CPUE/survey data for each age group of each index series. Values less than 0.3 are good, between 0.3 and 0.5 moderate, above 0.5 poor, and above 1.0 useless (or even positively misleading). For 4TVn cod the CVs for the commercial fleet are good or acceptable for ages 5-10, but poor for ages greater than 10. For the research survey the CVs are good or acceptable for ages 3-8, but poor above that.

The log unstandardised residuals of the estimates of population number from each fleet (relative to VPA) are also printed by the XSA program. Large residuals and gross year effects can be identified by eye in these tables, but the improved presentation developed at the meeting makes this task much easier (see below). The standard output at 27 June 1991 did not supply estimates of the standard error of the survivors estimates, or the variance ratio indicator of consistency among estimates, which is regrettable.

4.2.4 Output and diagnostics from the Time Series Method

The parameters of the Time Series Method are estimated from the likelihood function of catch prediction errors. The covariance matrix of the estimated parameters is obtained from the Hessian matrix, but these parameters are very different from those estimated in other methods applied at this meeting and will not be described further.

The programs also carry out various diagnostics on the standardized catch prediction errors. These can be applied to any comparable two-dimensional table of residuals, although the application of the results would depend somewhat on the premises of the respective method and which facilities it provided for eliminating the defects that might be discovered. (See Gudmundsson, 1991b, for a description of the application with the Time Series programs.) A program which supplies these diagnostics was provided at the meeting. An example of the diagnostic output is given in Table 4.3. Other (terse) outputs with various statistics are also given by the program, but not shown.

Skewness and kurtosis are test statistics for normality, based on the third and fourth moments respectively, and should have a standard normal distribution. Moderate departures from normality are usually fairly harmless, but values higher than 3 usually indicate outliers which could exert too great an influence on the results in least squares estimation or related techniques.

Variances are calculated for each age and year.

If we call the residuals e(a,y), "correlation within cohorts" represents the correlation coefficient between e(a,y) and e(a+1,y+1), "correlation within ages" represents the correlation between e(a,y) and e(a+1,y) and "correlation within years" represents the correlation between e(a,y) and e(a,y+1).

Serial correlation has been used extensively in Time Series Analysis to detect misspecification. High correlations within years or cohorts would presumably indicate misspecification in most methods of catch at age analysis, but correlation within ages could be normal. If the residuals were all independent, the distribution of the correlations should be normal with variance 1/(number of residuals). The expected value is either zero or -1/(number of years). But if the correlation within ages is not zero the variance is higher.

Although high serial correlations are strong indicators of misspecification, the reverse, unfortunately, does not hold. Models can be badly misspecified without producing significant correlation of residuals (Gudmundsson, 1991c).

4.3 Analysis of Residuals

The spreadsheet RENA.WK1 was written to produce some standard diagnostic outputs from residuals generated from the various assessment models. The spreadsheet accepts as input a data file of residuals for a fleet with an estimate of the standard deviation of the residuals by age. An example input file and details of the format are shown in Appendix G.

RENA first standardizes the residuals by dividing each age column by the standard deviation estimate for that age. If residuals have already been normalized, the deviations should be entered as a row of 1s. If there is only one overall estimate for all ages a row of values all equal to this constant should be entered.

RENA then calculates the mean residual for each year and 'zbar' where:

zbar = sqrt(n)*mean

This measure should be approximately N(0,1). The mean and standard deviation of 'zbar' for all ages is also shown. These values can be compared to 0 and 1 as general diagnostics.

Next RENA prints the sign of the residuals. Positive values are assigned 1 and negatives 0. For each of the years the proportion of positive residuals 'p+' is calculated along with 'z+' where:

z+ = sqrt(n)*(2(p+)-1)

Again the measure should be approximately N(0,1). The mean and standard deviation across all ages is also produced.

Lastly RENA produces and indicator plot that visually highlights the large residuals. RENA replaces each residual by a symbol as follows:

symbol	value range
N	largest negative

P	largest positive
=	value < -1.5
-	value < -0.5
*	value > 1.5
+	value > 0.5
blank	between -0.5 and 0.5

After making these calculations RENA produces three files. The analyses described above are saved in a text file with extension .OUT. The same information is also saved in a spreadsheet file with a .WK1 extension that can be used for further analysis. The third file is another text file with extension .GGA that can be fed into the analysis program RESANAL.EXE that is described below.

RENA.WK1 was written in Quattro Pro but should be compatible with any spreadsheet that can interpret Lotus 2.01 macro files. Appendix E gives examples of the inputs and outputs for RENA.WK1 and RESANAL. EXE. RESANAL is written in FORTRAN and compiled using the Microsoft FORTRAN compiler Version 5.0. It will use a math co-processor if available but can be run without one.

4.4 Diagnostics of Chosen Stocks

4.4.1 4TVn cod

The residual analysis statistics for 4TVn Cod show large year effects (>2.0) in 1971, 1972, 1973, 1976 and 1981 based on the mean standardised residual (Zbar), and in 1971, 1973, 1974, 1975, 1981, 1984, 1986 and 1990 based on z+ (>1.4) for the commercial fleet. The variance and correlation statistics show rather high variance for the younger ages and for some years, and a rather high serial correlation especially within ages (consistent with year effects).

For the research survey there appear to be significant year effects in 14 out of 20 years (based on Zbar > 2.0), and in 16 out of 20 years (based on Z+ > 1.4). Several of the Zbar values are very large (> 4.0).

The Mohn plots show a lot of patterning (similar residuals together) in both cases, confirm the strong year effects (rows of similar symbols), and show mostly negative residuals in earlier years, and positive ones in later years, suggesting increasing catchability (or some similar effect) for both indices.

4.4.2 North Sea cod

The XSA retrospective analysis plots for North Sea cod (Figures 3.1-3.3) suggest that the 1984 analysis underestimated terminal Fs on the fully-recruited ages particularly poorly. In consequence it was decided that the 1984 assessment diagnostics should be investigated to see whether they gave any clues to this at the time of the assessment. There was some suggestion that this may prove difficult as the frequency tables ("large error plots") of poor retrospective results for this stock and method showed zero frequencies of 50% over or underestimation for all terminal F values.

In the time available it was possible only superficially to investigate this stock and method. Therefore it was decided that the tabulations of sign and magnitude of residuals by year and age ("Mohn plots") would be inspected for each of the five fleets contributing to the analysis, firstly for the 1984 retrospective and then for the 1989 retrospective. It was hoped that this may suggest a particularly strong year effect in 1984 which would have been apparent at that time also.

In summary, the 1989 retrospective suggested that fleets 3 and 5 indicated a possible year effect in 1984, fleets 2 and 4 were ambiguous whilst fleet 1 gave no indication of a year effect. For the 1984 retrospective, fleets 4 and 5 suggested a 1984 year effect, if anything, but not convincingly so (the residuals were also of opposite sign to those apparent from the 1989 retrospective). It appears that such a superficial investigation of diagnostics could not have picked up the poor underestimation of fully-recruited terminal Fs in 1984. It was possible, however, to pick out some cohort effects from these residual tabulations but time did not permit further examination of them.

It remains to be seen whether an extensive investigation of the diagnostics would have made the F underestimation in 1984 more apparent at the time.

5 LENGTH-BASED METHODS

5.1 Introduction

To address item d) in the terms of reference (which originated as a question raised by the Working Group on *Nephrops* stocks), an investigation of length-based methods as applied to *Nephrops* was carried out. Traditionally, the most commonly used techniques are Jones' (1979) length-based VPA or cohort slicing. Jones' method converts a length frequency distribution into ages by essentially inverting the von Bertalanffy growth equation to yield an age for each size. The resulting approximate catch-at-age is then analyzed with the catch equation and exponential survivorship. This method requires the restrictive assumption that the stock is in equilibrium over the period of investigation. The other common method, which is known as cohort slicing, also uses the von Bertalanffy equation to convert length distributions into age distributions (Eiriksson, 1979). However, in contrast to Jones' approach, this is done on a year by year basis. The resulting catch-at-age matrix is then analysed with conventional age-based methods, for example Laurec-Shepherd VPA or a model using the ADAPT estimation environment.

Three presentations were made which described various approaches. The first (Kunzlik WP D29) introduced a method known as CASA (Catch at Size Analysis, Sullivan *et al.*, 1990). This method assumes a von Bertalanffy growth pattern and distributions of growth from length l and time t to time t+1. A gamma distribution was chosen by the authors but others could be used. The growth parameters may be estimated or supplied by the user. Recruitment also occurs over a distribution of sizes. Separable fishing mortality, the product of a function of length and of time, is assumed. The selectivity was modeled as a logistic function. Once the model is specified, the parameters are fitted with a non-linear least squares algorithm. The example presented did not use effort or survey data but the method may in theory be extended to include them.

The second presentation (Gudmundsson, WP L1) described an adaptation of an age-based time series analysis (Gudmundsson, 1987). The underlying growth and mortality models are similar to those in CASA. The length-based model does not convert the data into ages but directly estimates population parameters for length classes by fitting a growth function. The output is F and numbers by length class instead of length distributions. The method fits parameters using a maximum likelihood method.

The third presentation reviewed a method (Mohn and Savard, 1989) in which the population variables were described as functions of both age and length. It required a growth function which is described in terms of the distribution of lengths-at-age which are used to construct annual age-length keys from the catch and abundance data. The model assumes a trial age distribution which was used to construct initial age-length keys to convert the catches-at-length to ages. The catch-at-age was then used to estimate numbers-at-age via VPA equations. In the next iteration these numbers-at-age are used to refine the annual age-length keys etc. This method estimates numbers-at-age and numbers-at-length over time. The three dimensional N array is projected either onto the lengthtime margin to compare it with abundance data (in the current version either length-disaggregated CPUE or survey data) by fitting qs, or onto the more familiar age-time margin for inspection. The parameters are fitted using non-linear least squares within the ADAPT framework.

5.2 Comparison of Methods

Five analytical methods (two versions of cohort slicing, Mohn's and Gudmundsson's methods and CASA) were applied to three *Nephrops* stocks (southeast Iceland, Firth of Forth and Clyde). The Firth of Forth data are considered to be well behaved while the Clyde data are difficult to assess. Technical considerations made it impossible to test all methods on all stocks. Biomass, average F and recruitment estimates were obtained as a basis for comparison. All methods required an estimate of the natural mortality. A value for natural mortality of 0.2 was assumed for the southeast Iceland stock and of 0.3 for the Scottish stocks. The *ad hoc* method which is applied to cohort-sliced data tunes F to effort by fitting a quadratic to the correlation coefficient over a range of trial terminal Fs.

Figures 5.1-5.3 show the results for the southeast Iceland data and four methods of analysis: cohort slicing using the Laurec-Shepherd tuning procedure for the VPA (curves labelled with CoS.LS), cohort slicing and *ad hoc* VPA tuning (CoS.adh), Mohn's method (ADAPT) and Gudmundsson's Time Series Analysis (TimeAn). All four methods showed similar biomass trends. The F series also showed similar trends but the Fs from TimeAn were somewhat lower in magnitude. The recruitment series are similar in the early portion of the data but the ADAPT results diverge considerably from the other two in the more recent years. This is to some degree the result of the ADAPT model which, in order to minimize the number of parameters in the model, did not estimate the younger ages. The time series model did not produce a recruitment series that was comparable to the other methods. The degree of correspondence among these results is somewhat surprising. CoSadh and ADAPT results were obtained from a linear growth model which was derived from an inspection of the catch at length data while the other two used von Bertalanffy growth (supplied by the *Nephrops* Working Group).

Figure 5.4 shows the regressions of F on effort for the four methods. The effort information was used differently by all four methods. The cohort slicing *ad hoc* method used aggregated effort and average F and had the best regression fit. The cohort slicing Laurec-Shepherd disaggregated the effort over the age classes to estimate qs at age. The ADAPT model disaggregated catch rate over length distributions. The time series method (TimeAn) can estimate fishing mortality rates without any effort or CPUE data. As the author felt that the present effort measurements were fairly inappropriate for the catch at length data the effort was not used at all in the time series estimations reported here. It is thus not surprising that there is less agreement between the effort and fishing mortality rates for time series than the other methods.

The Firth of Forth data were analysed with the Laurec-Shepherd and *ad hoc* cohort slicing methods, Mohn's method and CASA (Figures 5.5-5.8). The biomass time series are fairly similar for the first three of these methods while the CASA biomass has a more negative time trend than the others. The average Fs show similar patterns with the first three being roughly parallel from year to year and CASA deviating from the others. The CASA recruit estimates vary much more from year to year than the others and, as was seen in the southeast Iceland data, the ADAPT recruitment estimates for the most recent years are more variable than the cohort slicing estimates. The regressions of F and effort are much higher than for the southeast Iceland data but show the same ranking. The CASA method does not use effort data in the analysis. The Firth of Forth effort and F series were detrended to remove time effects. The residuals still had significant correlation coefficients (Table 5.1).

The Clyde data represent a difficult data set (Figures 5.9-5.12). Instead of an F vs. effort r^2 in the order of 0.8 as in the Firth of Forth data, these data have r^2 in the order of 0.1. The Clyde data were analysed using the same four methods as for the Firth of Forth. The three methods which perform similarly in the Firth data, the two time slicings and the ADAPT, are not as tightly grouped here. The *ad hoc* time slice biomass series shows an increase between the final two years while the other two methods show a decline. The F series from the Laurec-Shepherd cohort-sliced data diverges from the other two. The recruitment indices show surprisingly consistent results. The CASA results are again quite divergent from the other three methods. The regression between F and effort is quite poor for all four methods and is slightly negative for CASA.

5.3 Discussion

All methods incorporate some growth model to relate size to survivorship and catch rates. In CASA, time series and cohort slicing - Laurec-Shepherd, von Bertalanffy growth models were used. In Mohn's method and the cohort slicing *ad hoc* methods, von Bertalanffy was used except for the southeast Iceland stock which had linear growth. None of the methods was constrained to a particular model. The fact that *Nephrops* grows by moults rather than continuously does not affect any of these methods. The cohort slicing methods only require a mean size-at-age. Gudmundsson's time series method and CASA are parameterized for a mean size-at-age and length class respectively and dispersion. Mohn's method requires distributions of sizes for each age. Hence, none of these methods require von Bertalanffy or even continuous growth. However, the cohort slicing methods would be expected to perform poorly if the moult frequency were so slow that a number of cohorts were in a single size category. This situation would be analogous to having to cope with a number of plus groups in each year in an age-based analysis. Such a situation is not a factor for *Nephrops* stocks but would be for American lobsters. Because they more closely incorporate age in their methodology, the cohort slicing and the ADAPT methods would be expected to work better when there are some visible modes in the catch size histograms.

It was observed that one of the deficiencies of Jones' method is that it cannot estimate the current fishing mortality, except over a range of years, and compare it to a target level. One method that might give an indication of the degree of exploitation relative to a target level would be to use Jones' method to get a selectivity pattern. From the selectivity and growth and natural mortality estimates an augmented yield per recruit analysis may be performed. The augmentation is the addition of mean size as a function of length (Figure 5.13). If recruitment and fishing practices were relatively stable, the mean size in the stock could be compared to the mean size at the target F as an index of exploitation.

The above length-based population analyses are not meant to be assessments of the various stocks. They were done under considerable time constraints and are intended only to give a basis for comparison. The various authors felt that given time they could have tuned their analyses for better performance. An example is the diagnostics supplied by the pattern of the length-time residuals from Mohn's method for the Clyde *Nephrops* stock shown in Table 5.2. It shows a strong positive band at 31 mm which suggests that the growth model is mis-specified. Also, the review of these methods only included those which had practitioners at the Working Group. Many others exist, for example a host of modal analysis programs which may be used to estimate catch at age from length distributions.

Future research into length-based analysis would benefit from a generalized growth model which could generate simulated data for testing. Such a model should include the ability to simulate growth in moults and growth as a function of size and age. The removals from the stock could have a selectivity which is a function of size, age or size and age. Perhaps growth mediated by density dependence and/or an exogenous signal should also be considered. Furthermore, actual catch-at-length data where catch-at-age data are also available would be valuable for research on this topic.

There are some practical considerations concerning length-based analysis which the Working Group observed. The two cohort slicing programs and Mohn's formulation produce similar estimates on all stocks and fitted the tuning data similarly. This agreement demonstrates that they work in roughly the same way and is not a demonstration that they found 'true' values. They were weakest in predicting recruitment in the recent years, but this is a weakness shared by many age-based methods. The consistency, and the fact that they have been used for a number of years, suggests that they are ready to be applied to fisheries data. These three methods produce output in ages and use age-based models which would be familiar to most potential users. The cohort slicing - Laurec-Shepherd version is in FORTRAN on MS-DOS machines and is therefore quite transportable. The other cohort slicing method and Mohn's method are written in APL on a Macintosh which limits there universality. CASA and Gudmundsson's method are more purely length-based analyses and many users would not be well acquainted with their internal models. They are both written in FORTRAN and should be fairly portable but will require more use to develop a familiarity with them.

6 EXTENDING TIME SERIES

Item e) in the terms of reference seeks advice on the feasibility of extending time series of stock and recruitment using cruder methods than VPA. There are two possible ways in which this may be interpreted. Firstly, given a particular time series starting in year T there may be a way of extracting information in the data on recruitment prior to year T. Secondly, there may be a number of distinct time series collected by various sampling methods (e.g. commercial CPUE or research vessel CPUE) which cover differing time periods. In order to obtain a continuous time series, these have to be set on the same scale. Both of these interpretations are briefly considered below. The methods used are not necessarily the best and they are presented for illustration only.

6.1 Extending a Recruitment Series with a Single Data Set

A data set containing age-structured data starting in year T with a age groups contains some information on recruitment in years T-a+1 due to the presence of year classes in the data at older ages. By making assumptions about the survival of the older fish, it is possible to back calculate the abundance of these year classes at the age of recruitment. The most obvious assumption to make is that of a steady state. Given this assumption, a variety of methods can be envisaged to back calculate the recruitment values. It can be done with conventional VPA, for example, by taking average Fs at age and using them to run the populations back. A similar procedure could be done with separable VPA. A simpler alternative is the multiplicative catch model of Shepherd and Nicholson (1986, 1991) which is perhaps most appropriately used on CPUE data. It has the advantage of being able to cope with a year effect caused by changes in the sampling efficiency of survey vessel(s). This technique was used by Cook (1989) to extend a four year data series to give a seven year recruitment series for Rockall haddock.

6.2 Extending Multiple Time Series for North Sea Haddock

Where several time series exist the problem of rescaling the data will depend on the degree to which the series overlap. It need not be a major problem to estimate appropriate calibration values. Difficulties will arise where the extent of any overlap is small or absent. By way of illustration an attempt has been made at this meeting to extend the time series for North Sea haddock recruitment and spawning stock as far back as possible using research vessel indices given by Jones and Hislop (1978) and VPA (Anon., 1991). The research vessel data extend back to 1926 for ages 1 to 5 and overlap with the VPA for the period 1960-1973. A break occurred during the war for the years 1940-1945 and no survey was carried out in 1959. Three different research vessels were used during the period. This data set therefore illustrates many of the problems in extending a time series. The approach adopted here has been to fit the Shepherd-Nicholson model to three blocks of the research vessel series, i.e 1926-1939, 1946-1960 and 1960-1969. The block 1960-1969 has been used to estimate calibration regressions with VPA so that the other two data blocks can be rescaled. The reason for using the model is to try to correct for different survey vessels and to fill in missing years where possible (e.g. 1959). The data set has been divided into three blocks to try to overcome the assumption in the model that the fishery has been in a steady state over all years in the analysis.

Calibrations for log recruitment and spawning stock biomass are given in Figures 6.1 and 6.2. These are for the period 1960 to 1969. The VPA values, maturity ogive and weights at age used to estimate SSB are taken from Anon. (1991). The fitted regressions have then been used to rescale the fitted populations at age from the multiplicative model as applied to the earlier data blocks. The extended time series in VPA units and including the VPA years are shown in Figures 6.3 and 6.4. The dotted lines mark the post-war to pre-VPA data block. It can be seen that, in the case of recruitment, it has been possible to estimate some of the recruiting year classes (at age 1) during the war when there were no surveys. Similarly, values for 1959 and 1922-1925 have been estimated when surveys were absent.

A stock recruitment plot is shown in Figure 6.5

6.3 Discussion

There are some important considerations which need to be mentioned. The analysis above assumes that in the surveys all age groups in the spawning stock have equal catchability. This is approximately true for haddock where most fish mature at age 2 and are also fully recruited to the sampling gear. It may not always be the case, however. In such situations estimates of total mortality at age obtained from VPA, say, could be applied to the recruitment values to estimate indices of abundance at age. SSB could be then calculated. This technique could be applied to a long time series consisting of recruitment values only and hence generate an age-structured population where SSB could be calculated. The procedure could also be applied to estimate the SSB for at least some of the war years and hence close the gap in the series in Figure 6.4. However, no reliable estimates of mortality rates exist for this period.

In analysing the survey data in separate blocks, there is a danger that the each block might require different calibration lines. This problem has not been properly addressed here and requires further investigation. One way round the problem would be to divide the survey series into overlapping blocks and calculate a series of appropriate calibration lines.

It could be argued that the approach adopted here is unnecessarily elaborate and that much the same result could be achieved by simply calibrating the survey data directly with the VPA. This undoubtedly needs to be investigated. In pursuing the line of analysis reported here it has been assumed that by fitting a model, some of the noise in the data will have been removed, and this may well be true for some data sets. Some care is needed in balancing the fairly restrictive assumptions in the multiplicative model against the desirability of removing noise from the raw observations.

7 OTHER TOPICS

In addition to the terms of reference, some further topics of relevance were discussed by the group. These items were introduced by some members and conclusions are given in Appendices C, D and E.

8 CONCLUSIONS AND RECOMMENDATIONS

The Working Group recommends:

- that retrospective analysis be applied on a routine basis each year at the assessment meetings to evaluate the degree of consistency between years;

- that assessment working groups routinely undertake an analysis of historical assessments and that final estimates from assessments be stored at ICES headquarters as the basis for such analyses.

- that diagnostics such as the ones described in this report be applied each year with particular attention being paid to:
  - high CVs in parameter estimates
  - year effects and age effects
  - trends in time series of residuals
  - correlation between parameter estimates (ADAPT);

- that the problems involved in using CPUE data from commercial trawlers in the assessment of Northeast Arctic cod be considered carefully by the Arctic Fisheries Working Group.

- that the North Sea Roundfish Working Group (or its successor) investigate the possible reasons for the underestimation of terminal F in retrospective analyses based on earlier years but apparently not in later years;

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Table 2.1

NORTH-EAST ARCTIC COD MEAN FISHING MORTALITY AGE 3-5

YEAR	1990 WG	LATEST VPA	RETROSPECTIVE VPA				RESIDUALS			
		ALL FL. DISAGG	ALL AL. DISAGG	EXCL SUB-A. I	EXCL DIV. IIa	FLEETS COMB.	ALL AL. DISAGG	EXCL SUB-A. I	EXCL DIV. IIa	FLEETS COMB.
1978	0.346	0.346	0.290	1.167	0.294	0.266	-0.056		-0.052	-0.080
1979	0.202	0.202	0.355	1.765	0.373	0.185	0.153		0.171	-0.017
1980	0.172	0.172	0.150	0.185	0.150	0.125	-0.022	0.013	-0.022	-0.047
1981	0.117	0.117	0.203	0.325	0.210	0.233	0.086	0.208	0.093	0.116
1982	0.187	0.187	0.114	0.043	0.116	0.150	-0.073	-0.144	-0.071	-0.037
1983	0.175	0.172	0.111	0.026	0.122	0.127	-0.061	-0.146	-0.050	-0.045
1984	0.144	0.137	0.058	0.023	0.062	0.101	-0.079	-0.114	-0.075	-0.036
1985	0.184	0.170	0.062	0.056	0.064	0.099	-0.108	-0.114	-0.106	-0.071
1986	0.225	0.214	0.109	0.043	0.176	0.129	-0.105	-0.171	-0.038	-0.085
1987	0.243	0.234	0.142	0.065	0.159	0.157	-0.092	-0.169	-0.075	-0.077
1988	0.207	0.205	0.126	0.074	0.131	0.171	-0.079	-0.131	-0.074	-0.034
1989	0.150	0.165	0.165	0.101	0.176	0.237	0.000	-0.064	0.011	0.072

Table 2.2

NORTH-EAST ARCTIC COD MEAN FISHING MORTALITY AGES 5-10

	1990 WG	LATEST VPA	RETROSPECTIVE				RESIDUALS			
		ALL FL. DISAGG	ALL AL. DISAGG	EXCL SUB-A. I	EXCL DIV. IIa	FLEETS COMB.	ALL AL. DISAGG	EXCL SUB-A. I	EXCL DIV. IIa	FLEETS COMB.
1978	0.925	0.930	0.565	0.719	0.529	0.473	-0.365	-0.211	-0.401	-0.457
1979	0.714	0.717	0.624	0.850	0.635	0.567	-0.093	0.133	-0.082	-0.150
1980	0.715	0.718	0.366	0.390	0.318	0.396	-0.352	-0.328	-0.400	-0.322
1981	0.824	0.814	0.556	0.596	0.622	0.669	-0.258	-0.218	-0.192	-0.145
1982	0.741	0.740	0.318	0.313	0.295	0.379	-0.422	-0.427	-0.445	-0.361
1983	0.736	0.736	0.326	0.512	0.386	0.341	-0.410	-0.224	-0.350	-0.395
1984	0.886	0.884	0.501	0.499	0.973	0.412	-0.383	-0.385	0.089	-0.472
1985	0.793	0.778	0.332	0.405	0.292	0.281	-0.446	-0.373	-0.486	-0.497
1986	0.907	0.866	0.462	0.530	0.292	0.445	-0.404	-0.336	-0.574	-0.421
1987	0.969	0.848	0.835	0.493	1.482	1.255	-0.013	-0.355	0.634	0.407
1988	0.883	0.655	0.864	0.940	1.053	0.698	0.209	0.285	0.398	0.043
1989	0.666	0.377	0.377	0.415	0.454	0.399	0.000	0.038	0.077	0.022

Table 3.1. Frequencies of deviations in retrospective analyses of NSCOD

METHOD=LS

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	All	Age groups: Recruits	Age groups: Partial recruits	Age groups: Fully recruited
F ratio												
70 < p	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	1	0	1	0	0	1
30 < p <= 50	0	0	1	1	0	2	0	0	4	0	0	4
10 < p <= 30	0	2	1	0	1	0	1	0	5	0	2	3
-10 < p <= 10	0	3	2	3	4	4	5	1	22	0	3	19
-30 < p <= -10	1	3	2	4	3	1	1	2	17	1	3	13
-50 < p <= -30	0	0	3	1	1	2	1	1	9	0	0	9
-70 < p <= -50	0	1	0	0	0	0	0	2	3	0	1	2
p <= -70	0	0	0	0	0	0	0	3	3	0	0	3
|p| > 50	0	1	0	0	0	0	1	5	7	0	1	6
|p| < 50	1	8	9	9	9	9	8	4	57	1	8	48
Total	1	9	9	9	9	9	9	9	64	1	9	54
Mean	-16	-9	-13	-9	-8	-2	4	-48	-12	-16	-9	-13
Std.	0	22	24	23	16	28	26	27	28	0	22	29

Table 3.2. Frequencies of deviations in retrospective analyses of NSCOD

METHOD=LS

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	All	Age groups: Recruits	Age groups: Partial recruits	Age groups: Fully recruited	Age groups: Others
N ratio															
70 < p	0	0	0	0	0	0	0	0	2	0	2	0	0	0	2
50 < p <= 70	1	0	0	0	0	0	0	3	1	0	5	1	0	3	1
30 < p <= 50	1	1	0	0	0	0	0	3	0	1	6	1	1	3	1
10 < p <= 30	2	2	5	4	3	3	2	2	3	3	29	2	2	19	6
-10 < p <= 10	3	5	3	4	6	4	5	1	3	4	38	3	5	23	7
-30 < p <= -10	0	1	1	1	0	2	1	0	0	1	7	0	1	5	1
-50 < p <= -30	1	0	0	0	0	0	1	0	0	0	2	1	0	1	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
p <= -70	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0
|p| > 50	2	0	0	0	0	0	0	3	3	0	8	2	0	3	3
|p| < 50	7	9	9	9	9	9	9	6	6	9	82	7	9	51	15
Total	9	9	9	9	9	9	9	9	9	9	90	9	9	54	18
Mean	1	6	8	7	6	2	-2	35	34	8	10	1	6	9	21
Std.	43	14	15	15	11	19	16	21	35	15	25	43	14	20	29

Table 3.3. Frequencies of deviations in retrospective analyses of NSCOD

METHOD=XS

	Age 1	2	3	4	5	6	7	8	All	Age groups: Recruits	Partial recruits	Fully recruited
F ratio												
70 < p	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	0	1	0	1	0	0	0	0	2	0	1	1
10 < p <= 30	0	0	1	0	0	2	2	1	6	0	0	6
-10 < p <= 10	0	4	2	3	3	3	5	3	23	0	4	19
-30 < p <= -10	1	3	4	4	5	4	2	4	27	1	3	23
-50 < p <= -30	0	1	2	1	1	0	0	1	6	0	1	5
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	0	0	0	0	0	0	0	0	0	0	0	0
|p| < 50	1	9	9	9	9	9	9	9	64	1	9	54
Total	1	9	9	9	9	9	9	9	64	1	9	54
Mean	-13	-8	-14	-13	-12	-4	1	-12	-9	-13	-8	-9
Std.	0	21	22	23	14	16	16	16	18	0	21	18

Table 3.4. Frequencies of deviations in retrospective analyses of NSCOD

METHOD=XS

	Age 1	2	3	4	5	6	7	8	9	All	Age groups: Recruits	Partial recruits	Fully recruited	Others
N ratio														
70 < p	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	2	0	0	1	0	0	0	0	0	3	2	0	1	0
10 < p <= 30	1	2	4	4	5	3	2	5	5	31	1	2	23	5
-10 < p <= 10	4	6	4	3	4	5	6	3	4	39	4	6	25	4
-30 < p <= -10	0	1	1	1	0	1	1	1	0	6	0	1	5	0
-50 < p <= -30	1	0	0	0	0	0	0	0	0	1	1	0	0	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0	0	0	0
p <= -70	1	0	0	0	0	0	0	0	0	1	1	0	0	0
|p| > 50	1	0	0	0	0	0	0	0	0	1	1	0	0	0
|p| < 50	8	9	9	9	9	9	9	9	9	80	8	9	54	9
Total	9	9	9	9	9	9	9	9	9	81	9	9	54	9
Mean	-3	5	9	10	8	3	0	10	11	6	-3	5	7	11
Std.	36	12	14	14	10	11	11	12	9	16	36	12	12	9

Table 3.5. Frequencies of deviations in retrospective analyses of NSCOD

METHOD=TS

	Age								All	Age groups		
	1	2	3	4	5	6	7	8		Recruits	Partial recruits	Fully recruited
F ratio												
70 < p	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	0	0	0	0	0	0	0	0	0	0	0	0
10 < p <= 30	2	1	1	1	0	0	0	0	5	2	1	2
-10 < p <= 10	4	6	5	3	4	4	4	5	35	4	6	25
-30 < p <= -10	1	0	1	3	3	3	3	2	16	1	0	15
-50 < p <= -30	0	0	0	0	0	0	0	0	0	0	0	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	0	0	0	0	0	0	0	0	0	0	0	0
|p| < 50	7	7	7	7	7	7	7	7	56	7	7	42
Total	7	7	7	7	7	7	7	7	56	7	7	42
Mean	2	-1	-2	-8	-7	-8	-7	-6	-5	2	-1	-6
Std.	17	8	12	11	6	8	7	6	10	17	8	8

Table 3.6. Frequencies of deviations in retrospective analyses of NSCOD

METHOD=TS

	Age								All	Age groups		
	1	2	3	4	5	6	7	8		Recruits	Partial recruits	Fully recruited
N ratio												
70 < p	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	0	0	0	1	0	0	0	0	1	0	0	1
10 < p <= 30	0	1	1	2	3	3	3	2	15	0	1	14
-10 < p <= 10	0	5	5	4	4	4	4	5	31	0	5	26
-30 < p <= -10	0	1	1	0	0	0	0	0	2	0	1	1
-50 < p <= -30	0	0	0	0	0	0	0	0	0	0	0	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	0	0	0	0	0	0	0	0	0	0	0	0
|p| < 50	0	7	7	7	7	7	7	7	49	0	7	42
Total	0	7	7	7	7	7	7	7	49	0	7	42
Mean	0	-0	2	10	9	8	8	7	6	0	-0	7
Std.	0	12	11	14	10	8	8	6	10	0	12	10

Table 3.7. Frequencies of deviations in retrospective analyses of ISPLAICE

METHOD=LS

	Age							All	Age groups		
	2	3	4	5	6	7	8		Recruits	Partial recruits	Fully recruited
F ratio											
70 < p	1	0	0	0	0	0	0	1	1	0	0
50 < p <= 70	0	0	0	1	0	2	0	3	0	0	3
30 < p <= 50	0	1	1	0	0	1	1	4	0	1	3
10 < p <= 30	1	4	2	3	3	3	3	19	1	4	14
-10 < p <= 10	4	4	4	4	3	1	4	24	4	4	16
-30 < p <= -10	4	2	2	1	2	1	1	13	4	2	7
-50 < p <= -30	1	1	1	2	2	1	2	10	1	1	8
-70 < p <= -50	1	0	2	0	1	2	0	6	1	0	5
p <= -70	0	0	0	1	1	1	1	4	0	0	4
|p| > 50	2	0	2	2	2	5	1	14	2	0	12
|p| < 50	10	12	10	10	10	7	11	70	10	12	48
Total	12	12	12	12	12	12	12	84	12	12	60
Mean	-5	0	-8	-7	-18	-5	-10	-7	-5	0	-10
Std.	43	25	35	35	41	46	35	37	43	25	38

Table 3.8. Frequencies of deviations in retrospective analyses of ISPLAICE

METHOD=LS

	Age							All	Age groups		
	2	3	4	5	6	7	8		Recruits	Partial recruits	Fully recruited
N ratio											
70 < p	0	0	0	0	1	0	1	2	0	0	2
50 < p <= 70	1	0	1	1	0	2	0	5	1	0	4
30 < p <= 50	1	1	1	2	2	2	2	11	1	1	9
10 < p <= 30	3	2	3	0	3	1	1	13	3	2	8
-10 < p <= 10	5	5	4	6	3	2	4	29	5	5	19
-30 < p <= -10	1	3	3	2	3	3	4	19	1	3	15
-50 < p <= -30	0	1	0	1	0	1	0	3	0	1	2
-70 < p <= -50	0	0	0	0	0	1	0	1	0	0	1
p <= -70	1	0	0	0	0	0	0	1	1	0	0
|p| > 50	2	0	1	1	1	3	1	9	2	0	7
|p| < 50	10	12	11	11	11	9	11	75	10	12	53
Total	12	12	12	12	12	12	12	84	12	12	60
Mean	5	-0	7	6	15	5	9	7	5	-0	8
Std.	40	19	25	27	35	39	31	31	40	19	31

Table 3.9. Frequencies of deviations in retrospective analyses of ISPLAICE with the

METHOD=AD

	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	All	Age groups: Recruits	Age groups: Partial recruits	Age groups: Fully recruited
F ratio											
70 < p	1	0	0	0	0	0	0	1	1	0	0
50 < p <= 70	0	1	0	1	0	0	0	2	0	1	1
30 < p <= 50	0	1	1	0	0	0	0	2	0	1	1
10 < p <= 30	2	0	3	1	0	3	2	11	2	0	9
-10 < p <= 10	1	6	2	4	6	4	4	27	1	6	20
-30 < p <= -10	4	0	1	2	4	2	4	17	4	0	13
-50 < p <= -30	1	1	2	1	0	0	0	5	1	1	3
-70 < p <= -50	1	1	1	1	0	1	0	5	1	1	3
p <= -70	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	2	2	1	2	0	1	0	8	2	2	4
|p| < 50	8	8	9	8	10	9	10	62	8	8	46
Total	10	10	10	10	10	10	10	70	10	10	50
Mean	-2	-0	-4	-7	-9	-4	-6	-5	-2	-0	-6
Std.	46	32	35	31	14	24	13	29	46	32	24

Table 3.10. Frequencies of deviations in retrospective analyses of ISPLAICE with the

METHOD=AD

	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	All	Age groups: Recruits	Age groups: Partial recruits	Age groups: Fully recruited	Age groups: Others
N ratio													
70 < p	0	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	1	0	0	0	0	0	0	0	1	1	0	0	0
30 < p <= 50	1	2	1	1	0	1	0	0	6	1	2	3	0
10 < p <= 30	3	0	3	3	4	2	4	4	23	3	0	16	4
-10 < p <= 10	2	6	2	4	6	4	5	5	34	2	6	21	5
-30 < p <= -10	2	0	3	1	0	3	1	1	11	2	0	8	1
-50 < p <= -30	0	2	1	1	0	0	0	0	4	0	2	2	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0	0	0
p <= -70	1	0	0	0	0	0	0	0	1	1	0	0	0
|p| > 50	2	0	0	0	0	0	0	0	2	2	0	0	0
|p| < 50	8	10	10	10	10	10	10	10	78	8	10	50	10
Total	10	10	10	10	10	10	10	10	80	10	10	50	10
Mean	1	0	3	6	6	2	5	5	4	1	0	5	5
Std.	42	24	25	23	11	19	11	11	22	42	24	18	11

Table 3.11. Frequencies of deviations in retrospective analyses of ISPLAICE

METHOD=XS

	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	All	Age groups: Recruits	Age groups: Partial recruits	Age groups: Fully recruited
F ratio											
70 < p	1	1	0	1	0	0	0	3	1	1	1
50 < p <= 70	0	0	1	0	0	0	0	1	0	0	1
30 < p <= 50	1	1	1	1	2	0	0	6	1	1	4
10 < p <= 30	2	2	3	1	1	5	4	18	2	2	14
-10 < p <= 10	1	4	1	2	4	3	5	20	1	4	15
-30 < p <= -10	3	0	1	3	2	2	1	12	3	0	9
-50 < p <= -30	0	0	2	1	1	0	0	4	0	0	4
-70 < p <= -50	1	2	1	1	0	0	0	5	1	2	2
p <= -70	1	0	0	0	0	0	0	1	1	0	0
|p| > 50	3	3	2	2	0	0	0	10	3	3	4
|p| < 50	7	7	8	8	10	10	10	60	7	7	46
Total	10	10	10	10	10	10	10	70	10	10	50
Mean	-1	5	1	-3	1	8	2	2	-1	5	2
Std.	50	41	37	40	22	17	13	33	50	41	27

Table 3.12. Frequencies of deviations in retrospective analyses of ISPLAICE

METHOD=XS

	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	All	Age groups: Recruits	Age groups: Partial recruits	Age groups: Fully recruited
N ratio											
70 < p	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	1	0	0	0	0	0	0	1	1	0	0
30 < p <= 50	1	2	2	2	0	0	0	7	1	2	4
10 < p <= 30	3	0	2	2	3	1	1	12	3	0	9
-10 < p <= 10	1	4	1	4	5	5	6	26	1	4	21
-30 < p <= -10	2	2	4	1	2	4	3	18	2	2	14
-50 < p <= -30	1	1	1	1	0	0	0	4	1	1	2
-70 < p <= -50	0	1	0	0	0	0	0	1	0	1	0
p <= -70	1	0	0	0	0	0	0	1	1	0	0
|p| > 50	2	1	0	0	0	0	0	3	2	1	0
|p| < 50	8	9	10	10	10	10	10	67	8	9	50
Total	10	10	10	10	10	10	10	70	10	10	50
Mean	1	-2	1	4	-0	-6	-1	-1	1	-2	-0
Std.	46	28	24	27	15	12	9	25	46	28	18

Table 3.13. Frequencies of deviations in retrospective analyses of ISPLAICE

METHOD=TS

	Age								Age groups		
	2	3	4	5	6	7	8	All	Recruits	Partial recruits	Fully recruited
F ratio											
70 < p	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	0	0	0	0	0	0	0	0	0	0	0
10 < p <= 30	2	2	2	3	1	1	1	12	2	2	8
-10 < p <= 10	4	3	4	2	3	4	5	25	4	3	18
-30 < p <= -10	0	1	0	1	2	1	0	5	0	1	4
-50 < p <= -30	0	0	0	0	0	0	0	0	0	0	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	0	0	0	0	0	0	0	0	0	0	0
|p| < 50	6	6	6	6	6	6	6	42	6	6	30
Total	6	6	6	6	6	6	6	42	6	6	30
Mean	9	5	10	7	-0	-1	3	5	9	5	4
Std.	10	12	11	17	12	10	8	11	10	12	12

Table 3.14. Frequencies of deviations in retrospective analyses of ISPLAICE

METHOD=TS

	Age									Age groups			
	2	3	4	5	6	7	8	9	All	Recruits	Partial recruits	Fully recruited	Others
N ratio													
70 < p	0	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	0	0	0	0	0	0	0	0	0	0	0	0	0
10 < p <= 30	0	0	0	1	2	1	1	1	6	0	0	5	1
-10 < p <= 10	2	5	4	2	3	5	3	4	28	2	5	17	4
-30 < p <= -10	4	1	2	3	1	0	2	1	14	4	1	8	1
-50 < p <= -30	0	0	0	0	0	0	0	0	0	0	0	0	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	0	0	0	0	0	0	0	0	0	0	0	0	0
|p| < 50	6	6	6	6	6	6	6	6	48	6	6	30	6
Total	6	6	6	6	6	6	6	6	48	6	6	30	6
Mean	-10	-4	-8	-6	-1	2	-0	-2	-4	-10	-4	-3	-2
Std.	9	10	11	16	13	9	10	9	11	9	10	12	9

Table 3.15. Frequencies of deviations in retrospective analyses of 7ESOLE

METHOD=LS

	Age							All	Age groups		
	2	3	4	5	6	7	8		Recruits	Partial recruits	Fully recruited
F ratio											
70 < p	1	3	1	1	2	3	3	14	1	3	10
50 < p <= 70	0	0	1	3	3	3	2	12	0	0	12
30 < p <= 50	1	5	3	2	1	0	1	13	1	5	7
10 < p <= 30	1	1	3	2	3	3	2	15	1	1	13
-10 < p <= 10	2	3	3	4	1	3	4	20	2	3	15
-30 < p <= -10	1	1	2	1	2	1	0	8	1	1	6
-50 < p <= -30	1	0	0	0	1	0	1	3	1	0	2
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	1	3	2	4	5	6	5	26	1	3	22
|p| < 50	6	10	11	9	8	7	8	59	6	10	43
Total	7	13	13	13	13	13	13	85	7	13	65
Mean	21	37	25	28	33	38	32	31	21	37	31
Std.	67	38	31	30	48	40	37	40	67	38	37

Table 3.16. Frequencies of deviations in retrospective analyses of 7ESOLE

METHOD=LS

	Age								All	Age groups			
	2	3	4	5	6	7	8	9		Recruits	Partial recruits	Fully recruited	Others
N ratio													
70 < p	0	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	1	0	0	0	0	0	0	0	1	1	0	0	0
10 < p <= 30	2	1	2	1	3	1	1	0	11	2	1	8	0
-10 < p <= 10	2	3	3	4	1	4	4	4	25	2	3	16	4
-30 < p <= -10	1	1	3	3	3	2	2	4	19	1	1	13	4
-50 < p <= -30	2	5	3	3	4	0	2	1	20	2	5	12	1
-70 < p <= -50	1	1	1	1	0	4	2	2	12	1	1	8	2
p <= -70	4	2	1	1	2	2	2	2	16	4	2	8	2
|p| > 50	5	3	2	2	2	6	4	4	28	5	3	16	4
|p| < 50	8	10	11	11	11	7	9	9	76	8	10	49	9
Total	13	13	13	13	13	13	13	13	104	13	13	65	13
Mean	-39	-31	-21	-24	-28	-32	-27	-28	-29	-39	-31	-26	-28
Std.	60	32	26	26	40	34	32	30	36	60	32	31	30

Table 3.17. Frequencies of deviations in retrospective analyses of 7ESOLE

METHOD=AD

	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	All	Age groups: Recruits	Age groups: Partial recruits	Age groups: Fully recruited
F ratio											
70 < p	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	0	0	0	0	0	0	0	0	0	0	0
10 < p <= 30	0	0	0	0	0	0	0	0	0	0	0
-10 < p <= 10	0	1	2	2	1	1	1	8	0	1	7
-30 < p <= -10	0	2	1	1	1	1	0	6	0	2	4
-50 < p <= -30	0	1	0	0	1	1	1	4	0	1	3
-70 < p <= -50	1	1	1	0	0	0	0	3	1	1	1
p <= -70	0	3	4	5	5	5	6	28	0	3	25
|p| > 50	1	4	5	5	5	5	6	31	1	4	26
|p| < 50	0	4	3	3	3	3	2	18	0	4	14
Total	1	8	8	8	8	8	8	49	1	8	40
Mean	-62	-51	-70	-83	-100	-111	-114	-88	-62	-51	-96
Std.	0	39	60	72	72	76	69	66	0	39	69

Table 3.18. Frequencies of deviations in retrospective analyses of 7ESOLE

METHOD=AD

	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	All	Age groups: Recruits	Age groups: Partial recruits	Age groups: Fully recruited	Age groups: Others
N ratio														
70 < p	2	2	4	5	5	5	6	5	5	39	2	2	25	10
50 < p <= 70	1	1	0	0	0	0	0	1	1	4	1	1	0	2
30 < p <= 50	1	1	1	0	1	1	0	0	0	5	1	1	3	0
10 < p <= 30	0	3	1	1	1	1	1	1	1	10	0	3	5	2
-10 < p <= 10	3	1	2	2	1	1	1	1	1	13	3	1	7	2
-30 < p <= -10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-50 < p <= -30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-70 < p <= -50	1	0	0	0	0	0	0	0	0	1	1	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	4	3	4	5	5	5	6	6	6	44	4	3	25	12
|p| < 50	4	5	4	3	3	3	2	2	2	28	4	5	15	4
Total	8	8	8	8	8	8	8	8	8	72	8	8	40	16
Mean	33	48	63	76	92	102	107	100	100	80	33	48	88	100
Std.	58	37	55	66	66	70	65	62	62	63	58	37	63	60

Table 3.19. Frequencies of deviations in retrospective analyses of 7ESOLE

METHOD=XS

	Age							All	Age groups		
	2	3	4	5	6	7	8		Recruits	Partial recruits	Fully recruited
F ratio											
70 < p	5	2	2	2	2	4	6	23	5	2	16
50 < p <= 70	1	4	4	3	5	4	3	24	1	4	19
30 < p <= 50	1	3	3	3	2	1	1	14	1	3	10
10 < p <= 30	1	1	1	1	1	2	1	8	1	1	6
-10 < p <= 10	2	2	3	4	3	2	2	18	2	2	14
-30 < p <= -10	2	1	0	0	0	0	0	3	2	1	0
-50 < p <= -30	1	0	0	0	0	0	0	1	1	0	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	6	6	6	5	7	8	9	47	6	6	35
|p| < 50	7	7	7	8	6	5	4	44	7	7	30
Total	13	13	13	13	13	13	13	91	13	13	65
Mean	45	41	40	38	46	54	62	47	45	41	48
Std.	66	35	30	28	32	35	40	39	66	35	34

Table 3.20. Frequencies of deviations in retrospective analyses of 7ESOLE

METHOD=XS

	Age									All	Age groups			
	2	3	4	5	6	7	8	9	10		Recruits	Partial recruits	Fully recruited	Others
N ratio														
70 < p	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	1	0	0	0	0	0	0	0	0	1	1	0	0	0
10 < p <= 30	2	1	0	0	0	0	0	0	0	3	2	1	0	0
-10 < p <= 10	2	2	4	4	3	2	2	2	1	22	2	2	15	3
-30 < p <= -10	1	3	2	1	2	2	2	1	1	15	1	3	9	2
-50 < p <= -30	1	4	3	4	3	3	2	1	1	22	1	4	15	2
-70 < p <= -50	2	1	4	4	3	3	5	6	5	33	2	1	19	11
p <= -70	4	2	0	0	2	3	2	3	5	21	4	2	7	8
|p| > 50	6	3	4	4	5	6	7	9	10	54	6	3	26	19
|p| < 50	7	10	9	9	8	7	6	4	3	63	7	10	39	7
Total	13	13	13	13	13	13	13	13	13	117	13	13	65	26
Mean	-43	-35	-32	-32	-38	-44	-50	-59	-60	-44	-43	-35	-39	-59
Std.	63	29	24	24	28	30	35	43	31	36	63	29	29	37

Table 3.21. Frequencies of deviations in retrospective analyses of 7ESOLE

METHOD=TS

	Age							All	Age groups		
	2	3	4	5	6	7	8		Recruits	Partial recruits	Fully recruited
F ratio											
70 < p	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	0	0	0	0	0	0	0	0	0	0	0
10 < p <= 30	0	0	0	0	0	1	1	2	0	0	2
-10 < p <= 10	4	4	4	4	4	3	3	26	4	4	18
-30 < p <= -10	2	2	2	1	1	0	0	8	2	2	4
-50 < p <= -30	0	0	0	1	1	2	2	6	0	0	6
-70 < p <= -50	1	1	1	1	1	1	1	7	1	1	5
p <= -70	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	1	1	1	1	1	1	1	7	1	1	5
|p| < 50	6	6	6	6	6	6	6	42	6	6	30
Total	7	7	7	7	7	7	7	49	7	7	35
Mean	-14	-12	-12	-15	-17	-18	-18	-15	-14	-12	-16
Std.	21	20	20	24	26	28	29	23	21	20	24

Table 3.22. Frequencies of deviations in retrospective analyses of 7ESOLE

METHOD=TS

	Age								All	Age groups			
	2	3	4	5	6	7	8	9		Recruits	Partial recruits	Fully recruited	Others
N ratio													
70 < p	0	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	1	1	1	1	1	5	0	0	4	1
30 < p <= 50	1	1	1	0	1	1	2	2	9	1	1	5	2
10 < p <= 30	2	2	2	2	1	1	1	0	11	2	2	7	0
-10 < p <= 10	4	4	4	4	4	3	2	3	28	4	4	17	3
-30 < p <= -10	0	0	0	0	0	1	1	1	3	0	0	2	1
-50 < p <= -30	0	0	0	0	0	0	0	0	0	0	0	0	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	0	0	0	1	1	1	1	1	5	0	0	4	1
|p| < 50	7	7	7	6	6	6	6	6	51	7	7	31	6
Total	7	7	7	7	7	7	7	7	56	7	7	35	7
Mean	11	11	11	13	15	17	18	18	14	11	11	15	18
Std.	18	18	18	21	23	26	28	28	21	18	18	22	28

Table 3.23. Frequencies of deviations in retrospective analyses of 7ESOLE

METHOD=L2

	Age								Age groups		
	2	3	4	5	6	7	8	All	Recruits	Partial recruits	Fully recruited
F ratio											
70 < p	0	1	0	0	1	1	2	5	0	1	4
50 < p <= 70	0	1	0	2	1	0	0	4	0	1	3
30 < p <= 50	0	0	3	0	1	1	0	5	0	0	5
10 < p <= 30	1	2	1	2	2	2	1	11	1	2	8
-10 < p <= 10	2	7	4	4	1	4	5	27	2	7	18
-30 < p <= -10	2	1	3	3	3	2	3	17	2	1	14
-50 < p <= -30	1	1	2	1	2	1	1	9	1	1	7
-70 < p <= -50	0	0	0	1	1	2	1	5	0	0	5
p <= -70	1	0	0	0	1	0	0	2	1	0	1
|p| > 50	1	2	0	3	4	3	3	16	1	2	13
|p| < 50	6	11	13	10	9	10	10	69	6	11	52
Total	7	13	13	13	13	13	13	85	7	13	65
Mean	-20	9	0	3	-4	-1	1	-0	-20	9	-0
Std.	31	31	29	35	45	44	41	37	31	31	38

Table 3.24. Frequencies of deviations in retrospective analyses of 7ESOLE

METHOD=L2

	Age									Age groups			
	2	3	4	5	6	7	8	9	All	Recruits	Partial recruits	Fully recruited	Others
N ratio													
70 < p	0	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	2	0	0	0	1	2	0	0	5	2	0	3	0
30 < p <= 50	2	1	2	1	2	0	2	1	11	2	1	7	1
10 < p <= 30	2	1	2	4	4	3	3	3	22	2	1	16	3
-10 < p <= 10	3	7	5	4	1	4	6	5	35	3	7	20	5
-30 < p <= -10	1	2	2	2	2	2	0	2	13	1	2	8	2
-50 < p <= -30	1	0	2	0	1	1	0	1	6	1	0	4	1
-70 < p <= -50	2	2	0	2	2	0	1	1	10	2	2	5	1
p <= -70	0	0	0	0	0	1	1	0	2	0	0	2	0
|p| > 50	4	2	0	2	3	3	2	1	17	4	2	10	1
|p| < 50	9	11	13	11	10	10	11	12	87	9	11	55	12
Total	13	13	13	13	13	13	13	13	104	13	13	65	13
Mean	7	-8	-0	-3	3	1	-1	-0	-0	7	-8	-0	-0
Std.	42	27	25	30	39	38	36	29	33	42	27	33	29

Table 3.25. Frequencies of deviations in retrospective analyses of 7ESOLE

METHOD=X2

	Age								Age groups		
	2	3	4	5	6	7	8	All	Recruits	Partial recruits	Fully recruited
F ratio											
70 < p	2	0	0	0	1	1	2	6	2	0	4
50 < p <= 70	1	2	0	1	0	1	0	5	1	2	2
30 < p <= 50	2	2	3	1	2	2	4	16	2	2	12
10 < p <= 30	0	3	5	6	5	6	3	28	0	3	25
-10 < p <= 10	2	5	4	3	4	1	2	21	2	5	14
-30 < p <= -10	2	1	1	2	0	0	0	6	2	1	3
-50 < p <= -30	3	0	0	0	1	1	1	6	3	0	3
-70 < p <= -50	1	0	0	0	0	1	1	3	1	0	2
p <= -70	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	4	2	0	1	1	3	3	14	4	2	8
|p| < 50	9	11	13	12	12	10	10	77	9	11	57
Total	13	13	13	13	13	13	13	91	13	13	65
Mean	5	17	15	14	16	19	22	16	5	17	17
Std.	45	26	17	21	30	40	39	32	45	26	30

Table 3.26. Frequencies of deviations in retrospective analyses of 7ESOLE

METHOD=X2

	Age										Age groups			
	2	3	4	5	6	7	8	9	10	All	Recruits	Partial recruits	Fully recruited	Others
N ratio														
70 < p	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	1	1	0	1	3	0	0	2	1
30 < p <= 50	4	0	0	0	1	0	1	0	0	6	4	0	2	0
10 < p <= 30	2	0	1	2	0	1	0	2	1	9	2	0	4	3
-10 < p <= 10	2	6	4	4	4	2	3	4	4	33	2	6	17	8
-30 < p <= -10	0	4	7	5	5	7	3	3	2	36	0	4	27	5
-50 < p <= -30	3	1	1	2	2	1	3	0	3	16	3	1	9	3
-70 < p <= -50	1	2	0	0	0	0	1	2	0	6	1	2	1	2
p <= -70	1	0	0	0	1	1	1	2	2	8	1	0	3	4
|p| > 50	2	2	0	0	1	2	3	4	3	17	2	2	6	7
|p| < 50	11	11	13	13	12	11	10	9	10	100	11	11	59	19
Total	13	13	13	13	13	13	13	13	13	117	13	13	65	26
Mean	-5	-15	-13	-12	-14	-16	-19	-24	-16	-15	-5	-15	-15	-20
Std.	44	23	15	18	26	36	35	43	38	32	44	23	27	40

Table 3.27. Frequencies of deviations in retrospective analyses of 4TVNCOD

METHOD=LS

	Age											Age groups		
	3	4	5	6	7	8	9	10	11	12	All	Recruits	Partial recruits	Fully recruited
F ratio														
70 < p	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	0	0	0	0	0	0	0	0	0	2	2	0	0	2
10 < p <= 30	0	0	0	1	0	0	0	1	4	6	12	0	1	11
-10 < p <= 10	4	5	5	2	2	3	4	2	5	3	35	4	14	17
-30 < p <= -10	2	4	4	6	6	5	3	4	2	0	36	2	20	14
-50 < p <= -30	1	0	2	2	3	3	3	2	0	0	16	1	7	8
-70 < p <= -50	3	1	0	0	0	0	1	1	0	0	6	3	1	2
p <= -70	1	1	0	0	0	0	0	1	0	0	3	1	1	1
|p| > 50	4	2	0	0	0	0	1	2	0	0	9	4	2	3
|p| < 50	7	9	11	11	11	11	10	9	11	11	101	7	42	52
Total	11	11	11	11	11	11	11	11	11	11	110	11	44	55
Mean	-35	-23	-13	-17	-21	-22	-22	-25	5	18	-16	-35	-19	-9
Std.	35	26	14	15	14	16	23	26	15	11	25	35	18	25

Table 3.28. Frequencies of deviations in retrospective analyses of 4TVNCOD

METHOD=LS

	Age														Age groups			
	3	4	5	6	7	8	9	10	11	12	13	14	15	All	Recruits	Partial recruits	Fully recruited	Others
N ratio																		
70 < p	1	1	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0
50 < p <= 70	3	1	0	0	0	0	0	1	0	0	0	0	0	5	3	1	1	0
30 < p <= 50	1	0	1	1	3	3	4	2	0	0	0	0	0	15	1	5	9	0
10 < p <= 30	2	4	4	6	5	5	3	4	2	0	1	2	0	38	2	19	14	3
-10 < p <= 10	4	5	6	3	3	3	4	4	5	5	10	6	10	68	4	17	21	26
-30 < p <= -10	0	0	0	1	0	0	0	0	4	6	0	3	1	15	0	1	10	4
-50 < p <= -30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	4	2	0	0	0	0	0	1	0	0	0	0	0	7	4	2	1	0
|p| < 50	7	9	11	11	11	11	11	10	11	11	11	11	11	136	7	42	54	33
Total	11	11	11	11	11	11	11	11	11	11	11	11	11	143	11	44	55	33
Mean	34	23	12	15	18	18	18	19	-3	-11	3	-1	0	11	34	17	8	1
Std.	34	26	13	13	12	13	19	20	11	7	5	9	5	20	34	17	19	7

Table 3.29. Frequencies of deviations in retrospective analyses of 4TVNCOD

METHOD=AD

	Age 3	4	5	6	7	8	9	10	11	12	All	Age groups: Recruits	Partial recruits	Fully recruited
F ratio														
70 < p	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	1	0	0	0	0	0	0	0	1	0	1	0
30 < p <= 50	0	1	0	0	0	0	0	0	0	0	1	0	1	0
10 < p <= 30	0	1	1	1	1	1	0	0	0	0	5	0	4	1
-10 < p <= 10	0	1	4	5	5	1	1	2	1	1	21	0	15	6
-30 < p <= -10	0	3	1	1	1	5	2	0	1	1	15	0	6	9
-50 < p <= -30	1	1	1	1	1	1	3	1	1	0	11	1	4	6
-70 < p <= -50	0	0	0	0	0	0	1	3	1	1	6	0	0	6
p <= -70	0	1	0	0	0	0	1	2	4	5	13	0	1	12
|p| > 50	0	1	1	0	0	0	2	5	5	6	20	0	2	18
|p| < 50	1	7	7	8	8	8	6	3	3	2	53	1	30	22
Total	1	8	8	8	8	8	8	8	8	8	73	1	32	40
Mean	-39	-15	2	-4	-8	-14	-35	-49	-65	-76	-29	-39	-6	-48
Std.	0	36	26	16	16	22	22	30	40	48	39	0	25	39

Table 3.30. Frequencies of deviations in retrospective analyses of 4TVNCOD

METHOD=AD

	Age 3	4	5	6	7	8	9	10	11	12	13	14	15	16	All	Age groups: Recruits	Partial recruits	Fully recruited	Others
N ratio																			
70 < p	0	1	0	0	0	0	0	0	2	3	2	0	0	0	8	0	1	5	2
50 < p <= 70	1	0	0	0	0	0	1	3	2	2	1	2	2	2	16	1	0	8	7
30 < p <= 50	2	1	1	0	1	1	2	3	2	1	0	0	4	4	22	2	3	9	8
10 < p <= 30	1	3	1	2	1	5	5	0	1	1	1	1	2	1	25	1	7	12	5
-10 < p <= 10	1	1	4	6	5	2	1	2	1	1	2	1	1	1	29	1	16	7	5
-30 < p <= -10	1	1	1	1	2	1	0	1	1	0	1	2	0	0	12	1	5	3	3
-50 < p <= -30	1	2	1	0	0	0	0	0	0	1	1	1	0	0	7	1	3	1	2
-70 < p <= -50	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	1	2	0	1	4	0	0	0	4
|p| > 50	2	1	1	0	0	0	1	3	4	5	4	4	2	3	30	2	2	13	13
|p| < 50	6	8	8	9	9	9	8	6	5	4	5	5	7	6	95	6	34	32	23
Total	8	9	9	9	9	9	9	9	9	9	9	9	9	9	125	8	36	45	36
Mean	4	9	-6	2	3	9	28	33	46	52	12	-13	34	23	17	4	2	34	14
Std.	43	38	26	14	15	19	17	28	40	50	70	56	19	46	41	43	25	35	52

Table 3.31. Frequencies of deviations in retrospective analyses of 4TVNCOD

METHOD=XS

	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	All	Age groups: Recruits	Age groups: Partial recruits	Age groups: Fully recruited
F ratio														
70 < p	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	0	0	0	0	0	0	0	0	0	1	1	0	0	1
10 < p <= 30	0	2	1	1	1	0	0	0	0	0	5	0	5	0
-10 < p <= 10	0	2	3	4	3	4	3	2	1	2	24	0	12	12
-30 < p <= -10	0	3	3	3	4	4	2	3	4	2	28	0	13	15
-50 < p <= -30	0	1	1	1	1	1	4	4	3	4	20	0	4	16
-70 < p <= -50	0	0	1	0	0	0	0	0	1	0	2	0	1	1
p <= -70	1	1	0	0	0	0	0	0	0	0	2	1	1	0
|p| > 50	1	1	1	0	0	0	0	0	1	0	4	1	2	1
|p| < 50	0	8	8	9	9	9	9	9	8	9	78	0	34	44
Total	1	9	9	9	9	9	9	9	9	9	82	1	36	45
Mean	-110	-19	-15	-13	-10	-17	-20	-27	-26	-23	-20	-110	-14	-22
Std.	0	35	21	18	17	16	16	17	18	26	23	0	23	19

Table 3.32. Frequencies of deviations in retrospective analyses of 4TVNCOD

METHOD=XS

	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	All	Age groups: Recruits	Age groups: Partial recruits	Age groups: Fully recruited	Age groups: Others
N ratio																
70 < p	0	1	0	0	0	0	0	0	0	0	1	2	0	1	0	1
50 < p <= 70	2	0	0	0	0	0	0	0	0	0	2	4	2	0	0	2
30 < p <= 50	2	1	1	1	1	1	2	2	3	3	2	19	2	4	11	2
10 < p <= 30	1	3	4	2	3	4	4	5	4	3	1	34	1	12	20	1
-10 < p <= 10	1	2	3	5	4	5	3	3	2	2	3	33	1	14	15	3
-30 < p <= -10	1	2	1	2	2	0	1	0	1	2	1	13	1	7	4	1
-50 < p <= -30	2	1	1	0	0	0	0	0	0	0	0	4	2	2	0	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	2	1	0	0	0	0	0	0	0	0	3	6	2	1	0	3
|p| < 50	7	9	10	10	10	10	10	10	10	10	7	103	7	39	50	7
Total	9	10	10	10	10	10	10	10	10	10	10	109	9	40	50	10
Mean	14	13	10	10	6	12	13	19	18	12	30	14	14	9	15	30
Std.	41	37	24	17	16	15	16	15	20	25	32	24	41	24	18	32

Table 3.33. Frequencies of deviations in retrospective analyses of 4TVNCOD

METHOD=TS

	Age									All	Age groups		
	3	4	5	6	7	8	9	10	11		Recruits	Partial recruits	Fully recruited
F ratio													
70 < p	0	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	0	0	0	0	0	0	0	0	0	0	0	0	0
10 < p <= 30	0	2	2	1	1	2	1	2	2	13	0	6	7
-10 < p <= 10	0	2	3	4	4	3	4	3	3	26	0	13	13
-30 < p <= -10	0	1	0	0	0	0	0	0	0	1	0	1	0
-50 < p <= -30	0	0	0	0	0	0	0	0	0	0	0	0	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	0	0	0	0	0	0	0	0	0	0	0	0	0
|p| < 50	0	5	5	5	5	5	5	5	5	40	0	20	20
Total	0	5	5	5	5	5	5	5	5	40	0	20	20
Mean	0	4	4	6	6	3	2	3	3	4	0	5	3
Std.	0	13	12	5	6	9	8	8	9	8	0	9	8

Table 3.34. Frequencies of deviations in retrospective analyses of 4TVNCOD

METHOD=TS

	Age									All	Age groups		
	3	4	5	6	7	8	9	10	11		Recruits	Partial recruits	Fully recruited
N ratio													
70 < p	0	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	0	0	0	0	0	0	0	0	0	0	0	0	0
10 < p <= 30	0	0	0	0	0	0	0	0	1	1	0	0	1
-10 < p <= 10	0	2	3	3	4	4	4	5	2	27	0	12	15
-30 < p <= -10	0	3	2	2	1	1	1	0	2	12	0	8	4
-50 < p <= -30	0	0	0	0	0	0	0	0	0	0	0	0	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	0	0	0	0	0	0	0	0	0	0	0	0	0
|p| < 50	0	5	5	5	5	5	5	5	5	40	0	20	20
Total	0	5	5	5	5	5	5	5	5	40	0	20	20
Mean	0	-9	-3	-5	-6	-4	-2	-2	-3	-4	0	-6	-3
Std.	0	10	8	6	4	7	7	6	11	7	0	7	8

Table 3.35. Frequencies of deviations in retrospective analyses of 4VSWCOD

METHOD=LS

	Age							All	Age groups		
	3	4	5	6	7	8	9		Recruits	Partial recruits	Fully recruited
F ratio											
70 < p	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	1	0	1	0	0	1
30 < p <= 50	0	0	0	0	0	0	0	0	0	0	0
10 < p <= 30	1	0	0	0	0	0	2	3	1	0	2
-10 < p <= 10	1	1	2	1	3	3	1	12	1	4	7
-30 < p <= -10	2	0	1	0	1	1	1	6	2	1	3
-50 < p <= -30	3	3	0	5	3	3	1	18	3	8	7
-70 < p <= -50	0	3	3	3	1	1	0	11	0	9	2
p <= -70	2	3	4	1	2	1	5	18	2	8	8
|p| > 50	2	6	7	4	3	3	5	30	2	17	11
|p| < 50	7	4	3	6	7	7	5	39	7	13	19
Total	9	10	10	10	10	10	10	69	9	30	30
Mean	-62	-63	-52	-45	-40	-26	-45	-47	-62	-53	-37
Std.	86	36	32	21	36	50	48	47	86	30	44

Table 3.36. Frequencies of deviations in retrospective analyses of 4VSWCOD

METHOD=LS

	Age									All	Age groups			
	3	4	5	6	7	8	9	10	11		Recruits	Partial recruits	Fully recruited	Others
N ratio														
70 < p	3	3	1	0	2	1	3	1	1	15	3	4	6	2
50 < p <= 70	0	3	5	3	1	1	3	2	0	18	0	11	5	2
30 < p <= 50	4	4	2	4	3	1	0	0	4	22	4	10	4	4
10 < p <= 30	3	1	2	4	3	4	3	3	1	24	3	7	10	4
-10 < p <= 10	1	1	2	1	3	4	1	3	3	19	1	4	8	6
-30 < p <= -10	1	0	0	0	0	0	2	0	1	4	1	0	2	1
-50 < p <= -30	0	0	0	0	0	1	0	3	0	4	0	0	1	3
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	3	6	6	3	3	2	6	3	1	33	3	15	11	4
|p| < 50	9	6	6	9	9	10	6	9	9	73	9	21	25	18
Total	12	12	12	12	12	12	12	12	10	106	12	36	36	22
Mean	58	55	43	38	35	25	40	13	24	37	58	46	33	18
Std.	75	33	27	20	29	39	38	41	33	41	75	27	35	37

Table 3.37. Frequencies of deviations in retrospective analyses of 4VSWCOD

METHOD=AD

	Age							All	Age groups		
	3	4	5	6	7	8	9		Recruits	Partial recruits	Fully recruited
F ratio											
70 < p	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	0	0	0	0	0	0	0	0	0	0	0
10 < p <= 30	0	0	0	0	0	0	0	0	0	0	0
-10 < p <= 10	1	1	1	1	1	1	1	7	1	3	3
-30 < p <= -10	2	1	0	0	0	2	0	5	2	1	2
-50 < p <= -30	1	2	1	2	1	0	0	7	1	5	1
-70 < p <= -50	1	1	2	1	1	1	2	9	1	4	4
p <= -70	3	3	4	4	5	4	5	28	3	11	14
|p| > 50	4	4	6	5	6	5	7	37	4	15	18
|p| < 50	4	4	2	3	2	3	1	19	4	9	6
Total	8	8	8	8	8	8	8	56	8	24	24
Mean	-71	-73	-76	-72	-71	-61	-83	-73	-71	-74	-72
Std.	66	58	48	48	38	44	43	48	66	49	41

Table 3.38. Frequencies of deviations in retrospective analyses of 4VSWCOD

METHOD=AD

	Age													All	Age groups			
	3	4	5	6	7	8	9	10	11	12	13	14	15		Recruits	Partial recruits	Fully recruited	Others
N ratio																		
70 < p	3	3	4	3	4	4	5	4	3	5	2	0	2	42	3	10	13	16
50 < p <= 70	0	1	1	1	1	1	1	1	3	0	2	0	1	13	0	3	3	7
30 < p <= 50	2	2	2	3	1	0	1	1	0	1	2	0	0	15	2	7	2	4
10 < p <= 30	2	1	0	0	1	1	0	0	1	1	0	2	1	10	2	1	2	5
-10 < p <= 10	1	1	1	1	1	2	1	2	1	1	1	3	3	19	1	3	4	11
-30 < p <= -10	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1
-50 < p <= -30	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	0	2	1	3	0	0	0	3
|p| > 50	3	4	5	4	5	5	6	5	6	5	4	2	4	58	3	13	16	26
|p| < 50	5	4	3	4	3	3	2	3	2	3	4	6	4	46	5	11	8	22
Total	8	8	8	8	8	8	8	8	8	8	8	8	8	104	8	24	24	48
Mean	63	71	70	63	61	52	69	60	63	62	43	-18	25	53	63	68	61	39
Std.	67	56	46	43	33	37	35	41	38	36	41	48	63	49	67	47	35	52

Table 3.39. Frequencies of deviations in retrospective analyses of 4VSWCOD

METHOD=XS

	Age								Age groups		
	3	4	5	6	7	8	9	All	Recruits	Partial recruits	Fully recruited
F ratio											
70 < p	2	1	1	0	0	0	0	4	2	2	0
50 < p <= 70	0	1	0	0	0	0	0	1	0	1	0
30 < p <= 50	0	1	1	1	0	1	1	5	0	3	2
10 < p <= 30	0	0	1	0	1	0	0	2	0	1	1
-10 < p <= 10	2	1	1	4	3	2	2	15	2	6	7
-30 < p <= -10	3	2	0	1	1	1	1	9	3	3	3
-50 < p <= -30	0	1	3	0	1	3	4	12	0	4	8
-70 < p <= -50	2	1	1	3	2	1	2	12	2	5	5
p <= -70	2	3	3	2	3	3	1	17	2	8	7
|p| > 50	6	6	5	5	5	4	3	34	6	16	12
|p| < 50	5	5	6	6	6	7	8	43	5	17	21
Total	11	11	11	11	11	11	11	77	11	33	33
Mean	-29	-28	-33	-38	-41	-40	-32	-34	-29	-33	-38
Std.	82	75	65	49	47	40	32	56	82	62	39

Table 3.40. Frequencies of deviations in retrospective analyses of 4VSWCOD

METHOD=XS

	Age										Age groups			
	3	4	5	6	7	8	9	10	11	All	Recruits	Partial recruits	Fully recruited	Others
N ratio														
70 < p	2	3	2	2	2	2	0	1	1	15	2	7	4	2
50 < p <= 70	2	0	2	2	1	2	1	1	4	15	2	4	4	5
30 < p <= 50	0	2	2	1	3	1	4	2	1	16	0	5	8	3
10 < p <= 30	2	2	1	1	1	3	3	2	2	17	2	4	7	4
-10 < p <= 10	3	1	1	4	3	2	2	3	3	22	3	6	7	6
-30 < p <= -10	0	1	1	1	1	1	1	2	0	8	0	3	3	2
-50 < p <= -30	0	0	1	0	0	0	0	0	0	1	0	1	0	0
-70 < p <= -50	0	1	1	0	0	0	0	0	0	2	0	2	0	0
p <= -70	2	1	0	0	0	0	0	0	0	3	2	1	0	0
|p| > 50	6	5	5	4	3	4	1	2	5	35	6	14	8	7
|p| < 50	5	6	6	7	8	7	10	9	6	64	5	19	25	15
Total	11	11	11	11	11	11	11	11	11	99	11	33	33	22
Mean	26	28	31	33	34	33	25	18	37	29	26	31	31	28
Std.	81	71	57	43	39	32	24	33	29	47	81	56	32	32

Table 3.41. Frequencies of deviations in retrospective analyses of 4VSWCOD

METHOD=TS

	Age								Age groups		
	3	4	5	6	7	8	9	All	Recruits	Partial recruits	Fully recruited
F ratio											
70 < p	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	0	0	0	0	0	0	0	0	0	0	0
10 < p <= 30	0	1	1	2	2	2	2	10	0	4	6
-10 < p <= 10	0	4	5	5	5	5	5	29	0	14	15
-30 < p <= -10	0	2	1	0	0	0	0	3	0	3	0
-50 < p <= -30	0	0	0	0	0	0	0	0	0	0	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	0	0	0	0	0	0	0	0	0	0	0
|p| < 50	0	7	7	7	7	7	7	42	0	21	21
Total	0	7	7	7	7	7	7	42	0	21	21
Mean	0	-5	-0	3	6	6	5	3	0	-1	6
Std.	0	13	12	10	8	8	10	10	0	11	8

Table 3.42. Frequencies of deviations in retrospective analyses of 4VSWCOD

METHOD=TS

	Age								Age groups		
	3	4	5	6	7	8	9	All	Recruits	Partial recruits	Fully recruited
N ratio											
70 < p	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	0	0	0	0	0	0	0	0	0	0	0
10 < p <= 30	0	2	1	0	0	0	0	3	0	3	0
-10 < p <= 10	0	4	5	6	5	5	5	30	0	15	15
-30 < p <= -10	0	1	1	1	2	2	2	9	0	3	6
-50 < p <= -30	0	0	0	0	0	0	0	0	0	0	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	0	0	0	0	0	0	0	0	0	0	0
|p| < 50	0	7	7	7	7	7	7	42	0	21	21
Total	0	7	7	7	7	7	7	42	0	21	21
Mean	0	6	0	-2	-5	-6	-7	-2	0	1	-6
Std.	0	11	11	8	7	7	7	9	0	10	7

Table 3.43. Frequencies of deviations in retrospective analyses of NSPLAICE

METHOD=LS

	Age 1	2	3	4	5	6	7	8	9	10	All	Age groups: Recruits	Partial recruits	Fully recruited
F ratio														
70 < p	1	1	0	0	0	0	0	0	0	0	2	1	1	0
50 < p <= 70	0	2	0	1	0	0	0	0	0	0	3	0	2	1
30 < p <= 50	0	1	2	0	2	1	1	1	1	0	9	0	1	8
10 < p <= 30	0	0	2	0	0	2	2	2	0	3	11	0	0	11
-10 < p <= 10	1	3	3	4	3	2	2	2	3	1	24	1	3	20
-30 < p <= -10	0	0	0	2	0	1	1	1	1	0	6	0	0	6
-50 < p <= -30	2	0	0	0	2	1	1	0	1	2	9	2	0	7
-70 < p <= -50	0	0	0	0	0	0	0	1	1	1	3	0	0	3
p <= -70	1	0	0	0	0	0	0	0	0	0	1	1	0	0
|p| > 50	2	3	0	1	0	0	0	1	1	1	9	2	3	4
|p| < 50	3	4	7	6	7	7	7	6	6	6	59	3	4	52
Total	5	7	7	7	7	7	7	7	7	7	68	5	7	56
Mean	47	36	16	1	1	2	1	-3	-9	-11	7	47	36	-0
Std.	220	35	17	23	29	24	27	35	34	36	62	220	35	28

Table 3.44. Frequencies of deviations in retrospective analyses of NSPLAICE

METHOD=LS

	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	All	Age groups: Recruits	Partial recruits	Fully recruited	Others
N ratio																				
70 < p	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	1	0	0	1
50 < p <= 70	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	3	0	0	1	2
30 < p <= 50	2	0	0	0	0	1	1	0	2	3	2	1	1	3	3	19	2	0	7	10
10 < p <= 30	0	0	0	2	2	0	1	1	1	0	0	1	1	0	0	9	0	0	7	2
-10 < p <= 10	1	3	3	4	3	4	3	2	3	1	1	2	2	2	2	36	1	3	23	9
-30 < p <= -10	0	0	3	0	1	2	2	2	0	3	3	2	0	1	1	20	0	0	13	7
-50 < p <= -30	0	3	1	1	1	0	0	1	1	0	0	0	1	1	1	11	0	3	5	3
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1
p <= -70	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0
|p| > 50	2	1	0	0	0	0	0	1	0	0	1	1	2	0	0	8	2	1	1	4
|p| < 50	3	6	7	7	7	7	7	6	7	7	6	6	5	7	7	95	3	6	55	31
Total	5	7	7	7	7	7	7	7	7	7	7	7	7	7	7	103	5	7	56	35
Mean	-51	-33	-12	-1	-1	-2	-1	2	7	9	8	17	5	9	9	-1	-51	-33	0	9
Std.	220	33	12	17	21	18	20	27	27	29	33	41	44	32	32	53	220	33	21	35

Table 3.45. Frequencies of deviations in retrospective analyses of NSPLAICE

METHOD=XS

	Age										Age groups		
	1	2	3	4	5	6	7	8	9	All	Recruits	Partial recruits	Fully recruited
F ratio													
70 < p	0	0	0	0	1	1	0	0	0	2	0	0	2
50 < p <= 70	0	1	1	1	0	0	1	1	0	5	0	1	4
30 < p <= 50	0	1	0	0	0	1	1	2	0	5	0	1	4
10 < p <= 30	0	3	2	1	3	3	3	2	4	21	0	3	18
-10 < p <= 10	1	2	4	4	1	2	2	2	3	21	1	2	18
-30 < p <= -10	0	0	0	1	2	0	0	0	0	3	0	0	3
-50 < p <= -30	0	0	0	0	0	0	0	0	0	0	0	0	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	0	1	1	1	1	1	1	1	0	7	0	1	6
|p| < 50	1	6	6	6	6	6	6	6	7	50	1	6	43
Total	1	7	7	7	7	7	7	7	7	57	1	7	49
Mean	0	23	17	9	14	25	26	25	12	19	0	23	18
Std.	0	24	20	27	32	30	25	17	11	23	0	24	23

Table 3.46. Frequencies of deviations in retrospective analyses of NSPLAICE

METHOD=XS

	Age										Age groups		
	1	2	3	4	5	6	7	8	9	All	Recruits	Partial recruits	Fully recruited
N ratio													
70 < p	1	0	0	0	0	0	0	0	0	1	1	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	2	0	0	0	0	0	0	0	0	2	2	0	0
10 < p <= 30	0	0	0	1	2	0	0	0	0	3	0	0	3
-10 < p <= 10	1	2	4	5	1	2	2	2	5	24	1	2	21
-30 < p <= -10	0	4	2	0	3	4	3	4	2	22	0	4	18
-50 < p <= -30	0	0	1	1	0	1	2	1	0	6	0	0	6
-70 < p <= -50	0	1	0	0	1	0	0	0	0	2	0	1	1
p <= -70	3	0	0	0	0	0	0	0	0	3	3	0	0
|p| > 50	4	1	0	0	1	0	0	0	0	6	4	1	1
|p| < 50	3	6	7	7	6	7	7	7	7	57	3	6	48
Total	7	7	7	7	7	7	7	7	7	63	7	7	49
Mean	-75	-21	-13	-6	-10	-16	-18	-17	-8	-20	-75	-21	-12
Std.	184	23	13	19	22	17	16	13	8	62	184	23	16

Table 3.47. Frequencies of deviations in retrospective analyses of SNEYTF

METHOD=LS

	Age					All	Age groups		
	1	2	3	4	5		Recruits	Partial recruits	Fully recruited
F ratio									
70 < p	1	2	2	2	4	11	1	2	8
50 < p <= 70	0	3	1	1	2	7	0	3	4
30 < p <= 50	0	2	0	3	3	8	0	2	6
10 < p <= 30	0	0	2	0	0	2	0	0	2
-10 < p <= 10	0	3	3	1	2	9	0	3	6
-30 < p <= -10	0	0	4	2	0	6	0	0	6
-50 < p <= -30	0	2	0	3	0	5	0	2	3
-70 < p <= -50	0	1	2	1	2	6	0	1	5
p <= -70	0	0	0	1	1	2	0	0	2
|p| > 50	1	6	5	5	9	26	1	6	19
|p| < 50	0	7	9	9	5	30	0	7	23
Total	1	13	14	14	14	56	1	13	42
Mean	114	30	4	2	27	17	114	30	11
Std.	0	61	44	58	85	64	0	61	64

Table 3.48. Frequencies of deviations in retrospective analyses of SNEYTF

METHOD=LS

	Age						All	Age groups			
	1	2	3	4	5	6		Recruits	Partial recruits	Fully recruited	Others
N ratio											
70 < p	1	0	0	0	1	0	2	1	0	1	0
50 < p <= 70	1	0	0	1	0	1	3	1	0	1	1
30 < p <= 50	0	1	2	1	1	1	6	0	1	4	1
10 < p <= 30	2	2	3	5	1	1	14	2	2	9	1
-10 < p <= 10	2	4	5	2	2	3	18	2	4	9	3
-30 < p <= -10	1	3	2	4	7	7	24	1	3	13	7
-50 < p <= -30	0	2	2	0	2	1	7	0	2	4	1
-70 < p <= -50	1	1	0	1	0	0	3	1	1	1	0
p <= -70	5	1	0	0	0	0	6	5	1	0	0
|p| > 50	8	2	0	2	1	1	14	8	2	3	1
|p| < 50	5	12	14	12	13	13	69	5	12	39	13
Total	13	14	14	14	14	14	83	13	14	42	14
Mean	-25	-17	1	3	-4	-4	-7	-25	-17	0	-4
Std.	73	39	22	30	34	28	41	73	39	29	28

Table 3.49. Frequencies of deviations in retrospective analyses of SNEYTF

METHOD=ADAPT

	Age 1	Age 2	Age 3	Age 4	Age 5	All	Age groups: Recruits	Age groups: Partial recruits	Age groups: Fully recruited
F ratio									
70 < p	1	2	1	2	2	8	1	2	5
50 < p <= 70	0	1	1	1	1	4	0	1	3
30 < p <= 50	0	1	4	2	1	8	0	1	7
10 < p <= 30	0	2	2	2	1	7	0	2	5
-10 < p <= 10	0	6	2	2	4	14	0	6	8
-30 < p <= -10	0	1	3	1	0	5	0	1	4
-50 < p <= -30	0	0	0	1	2	3	0	0	3
-70 < p <= -50	0	1	1	1	1	4	0	1	3
p <= -70	0	0	0	2	2	4	0	0	4
|p| > 50	1	4	3	6	6	20	1	4	15
|p| < 50	0	10	11	8	8	37	0	10	27
Total	1	14	14	14	14	57	1	14	42
Mean	104	18	18	-2	-9	8	104	18	2
Std.	0	46	45	64	73	59	0	46	61

Table 3.50. Frequencies of deviations in retrospective analyses of SNEYTF

METHOD=ADAPT

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	All	Age groups: Recruits	Age groups: Partial recruits	Age groups: Fully recruited	Age groups: Others
N ratio												
70 < p	2	0	0	1	1	0	0	4	2	0	2	0
50 < p <= 70	2	0	0	1	1	0	0	4	2	0	2	0
30 < p <= 50	0	1	1	1	1	2	2	8	0	1	3	4
10 < p <= 30	1	0	3	2	2	2	1	11	1	0	7	3
-10 < p <= 10	3	7	4	3	5	5	4	31	3	7	12	9
-30 < p <= -10	0	2	5	5	3	4	4	23	0	2	13	8
-50 < p <= -30	1	2	1	1	1	1	1	8	1	2	3	2
-70 < p <= -50	1	2	0	0	0	0	0	3	1	2	0	0
p <= -70	4	0	0	0	0	0	0	4	4	0	0	0
|p| > 50	9	2	0	2	2	0	0	15	9	2	4	0
|p| < 50	5	12	14	12	12	14	12	81	5	12	38	26
Total	14	14	14	14	14	14	12	96	14	14	42	26
Mean	-13	-12	-6	5	7	1	-2	-3	-13	-12	2	-0
Std.	72	28	21	34	36	22	22	38	72	28	31	22

Table 3.51. Frequencies of deviations in retrospective analyses of SNEYTF

METHOD=XS

	Age 1	Age 2	Age 3	Age 4	Age 5	All	Age groups: Recruits	Age groups: Partial recruits	Age groups: Fully recruited
F ratio									
70 < p	1	2	0	1	0	4	1	2	1
50 < p <= 70	0	2	1	2	3	8	0	2	6
30 < p <= 50	0	3	5	2	0	10	0	3	7
10 < p <= 30	0	0	2	1	4	7	0	0	7
-10 < p <= 10	0	5	3	5	6	19	0	5	14
-30 < p <= -10	0	1	2	2	0	5	0	1	4
-50 < p <= -30	0	1	1	1	1	4	0	1	3
-70 < p <= -50	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0
|p| > 50	1	4	1	3	3	12	1	4	7
|p| < 50	0	10	13	11	11	45	0	10	35
Total	1	14	14	14	14	57	1	14	42
Mean	104	28	16	15	16	20	104	28	16
Std.	0	41	29	33	27	34	0	41	29

Table 3.52. Frequencies of deviations in retrospective analyses of SNEYTF

METHOD=XS

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	All	Age groups: Recruits	Age groups: Partial recruits	Age groups: Fully recruited	Age groups: Others
N ratio											
70 < p	1	0	0	0	0	0	1	1	0	0	0
50 < p <= 70	3	0	0	0	0	0	3	3	0	0	0
30 < p <= 50	0	0	0	1	0	0	1	0	0	1	0
10 < p <= 30	1	1	2	1	1	1	7	1	1	4	1
-10 < p <= 10	3	6	6	7	8	5	35	3	6	21	5
-30 < p <= -10	0	2	5	4	3	6	20	0	2	12	6
-50 < p <= -30	1	3	1	1	2	2	10	1	3	4	2
-70 < p <= -50	1	1	0	0	0	0	2	1	1	0	0
p <= -70	4	1	0	0	0	0	5	4	1	0	0
|p| > 50	9	2	0	0	0	0	11	9	2	0	0
|p| < 50	5	12	14	14	14	14	73	5	12	42	14
Total	14	14	14	14	14	14	84	14	14	42	14
Mean	-14	-20	-7	-6	-8	-13	-11	-14	-20	-7	-13
Std.	71	28	16	18	14	18	33	71	28	16	18

Table 3.53. Frequencies of deviations in retrospective analyses of ISCOD

METHOD=LS

	Age						All	Age groups	
	1	2	3	4	5	6		Recruits	Fully recruited
F ratio									
70 < p	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	1	0	0	1	0	1
30 < p <= 50	0	0	1	1	1	1	4	0	4
10 < p <= 30	0	2	1	1	2	2	8	0	8
-10 < p <= 10	0	2	3	3	2	2	12	0	12
-30 < p <= -10	0	1	1	0	1	1	4	0	4
-50 < p <= -30	1	1	0	0	0	0	2	1	1
-70 < p <= -50	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0
|p| > 50	0	0	0	1	0	0	1	0	1
|p| < 50	1	6	6	5	6	6	30	1	29
Total	1	6	6	6	6	6	31	1	30
Mean	-33	-3	7	19	12	13	8	-33	10
Std.	0	21	20	23	23	20	22	0	21

Table 3.54. Frequencies of deviations in retrospective analyses of ISCOD

METHOD=LS

	Age						All	Age groups	
	1	2	3	4	5	6		Recruits	Fully recruited
N ratio									
70 < p	0	0	0	0	0	0	0	0	0
50 < p <= 70	2	0	0	0	0	0	2	2	0
30 < p <= 50	0	0	0	0	0	0	0	0	0
10 < p <= 30	1	1	0	0	1	0	3	1	2
-10 < p <= 10	2	4	5	3	3	4	21	2	19
-30 < p <= -10	1	1	1	3	2	2	10	1	9
-50 < p <= -30	0	0	0	0	0	0	0	0	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0
|p| > 50	2	0	0	0	0	0	2	2	0
|p| < 50	4	6	6	6	6	6	34	4	30
Total	6	6	6	6	6	6	36	6	30
Mean	20	2	-4	-11	-7	-8	-1	20	-5
Std.	36	14	11	13	13	12	20	36	13

Table 3.55. Frequencies of deviations in retrospective analyses of ISWHIT

METHOD=LS

	Age							All	Age groups		
	0	1	2	3	4	5	6		Recruits	Partial recruits	Fully recruited
F ratio											
70 < p	0	1	0	0	0	1	1	3	0	1	2
50 < p <= 70	0	0	0	1	0	0	0	1	0	0	1
30 < p <= 50	0	0	2	1	2	0	1	6	0	0	6
10 < p <= 30	0	1	1	0	1	2	1	6	0	1	5
-10 < p <= 10	1	3	1	2	2	3	1	13	1	3	9
-30 < p <= -10	0	1	0	1	1	0	1	4	0	1	3
-50 < p <= -30	0	0	1	1	0	0	1	3	0	0	3
-70 < p <= -50	0	0	1	0	0	0	0	1	0	0	1
p <= -70	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	0	1	1	1	0	1	1	5	0	1	4
|p| < 50	1	5	5	5	6	5	5	32	1	5	26
Total	1	6	6	6	6	6	6	37	1	6	30
Mean	0	22	0	8	14	19	24	14	0	22	13
Std.	0	50	42	36	25	30	60	39	0	50	38

Table 3.56. Frequencies of deviations in retrospective analyses of ISWHIT

METHOD=LS

	Age								All	Age groups			
	0	1	2	3	4	5	6	7		Recruits	Partial recruits	Fully recruited	Others
N ratio													
70 < p	0	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	0	0	1	0	0	0	0	0	1	0	0	1	0
10 < p <= 30	0	0	1	1	1	0	1	0	4	0	0	4	0
-10 < p <= 10	6	4	1	3	2	4	3	4	27	6	4	13	4
-30 < p <= -10	0	1	3	1	3	1	1	1	11	0	1	9	1
-50 < p <= -30	0	0	0	1	0	1	0	1	3	0	0	2	1
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	1	0	0	0	0	1	0	2	0	1	1	0
|p| > 50	0	1	0	0	0	0	1	0	2	0	1	1	0
|p| < 50	6	5	6	6	6	6	5	6	46	6	5	29	6
Total	6	6	6	6	6	6	6	6	48	6	6	30	6
Mean	-0	-14	1	-3	-7	-11	-12	-10	-7	-0	-14	-6	-10
Std.	0	31	27	18	12	17	33	14	21	0	31	22	14

Table 3.57. Frequencies of deviations in retrospective analyses of 7EPLAICE

METHOD=LS

	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	All	Age groups: Recruits	Partial recruits	Fully recruited
F ratio											
70 < p	0	0	0	0	0	0	1	1	0	0	1
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	2	0	0	0	0	0	0	2	2	0	0
10 < p <= 30	0	0	2	1	1	0	2	6	0	0	6
-10 < p <= 10	3	4	1	1	2	4	3	18	3	4	11
-30 < p <= -10	0	3	1	2	3	0	1	10	0	3	7
-50 < p <= -30	2	1	2	1	1	3	0	10	2	1	7
-70 < p <= -50	3	1	1	1	0	0	0	6	3	1	2
p <= -70	0	1	3	4	3	3	3	17	0	1	16
|p| > 50	3	2	4	5	3	3	4	24	3	2	19
|p| < 50	7	8	6	5	7	7	6	46	7	8	31
Total	10	10	10	10	10	10	10	70	10	10	50
Mean	-18	-22	-42	-43	-40	-45	-29	-34	-18	-22	-40
Std.	41	26	44	43	53	55	78	50	41	26	54

Table 3.58. Frequencies of deviations in retrospective analyses of 7EPLAICE

METHOD=LS

	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	All	Age groups: Recruits	Partial recruits	Fully recruited	Others
N ratio													
70 < p	0	0	3	1	3	3	3	2	15	0	0	13	2
50 < p <= 70	3	1	0	3	0	0	0	2	9	3	1	3	2
30 < p <= 50	2	2	2	1	0	3	0	1	11	2	2	6	1
10 < p <= 30	0	3	2	2	4	0	0	0	11	0	3	8	0
-10 < p <= 10	3	4	1	2	2	4	4	5	25	3	4	13	5
-30 < p <= -10	0	0	2	1	1	0	2	0	6	0	0	6	0
-50 < p <= -30	2	0	0	0	0	0	0	0	2	2	0	0	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	1	0	1	0	0	1	0
|p| > 50	3	1	3	4	3	3	4	4	25	3	1	17	4
|p| < 50	7	9	7	6	7	7	6	6	55	7	9	33	6
Total	10	10	10	10	10	10	10	10	80	10	10	50	10
Mean	17	18	34	35	33	38	24	36	29	17	18	33	36
Std.	38	21	36	36	43	48	66	47	43	38	21	46	47

Table 3.59. Frequencies of deviations in retrospective analyses of 7f,gPLAICE

METHOD=LS

	Age								Age groups		
	2	3	4	5	6	7	8	All	Recruits	Partial recruits	Fully recruited
F ratio											
70 < p	2	0	2	1	1	2	3	11	2	0	9
50 < p <= 70	0	3	0	2	2	1	0	8	0	3	5
30 < p <= 50	0	1	1	1	0	0	1	4	0	1	3
10 < p <= 30	0	2	3	2	1	2	0	10	0	2	8
-10 < p <= 10	3	1	1	1	2	2	2	12	3	1	8
-30 < p <= -10	0	2	1	1	1	2	2	9	0	2	7
-50 < p <= -30	1	0	0	0	1	0	0	2	1	0	1
-70 < p <= -50	0	0	1	1	1	0	1	4	0	0	4
p <= -70	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	2	3	3	4	4	3	4	23	2	3	18
|p| < 50	4	6	6	5	5	6	5	37	4	6	27
Total	6	9	9	9	9	9	9	60	6	9	45
Mean	23	23	25	22	13	30	23	23	23	23	23
Std.	53	31	50	43	52	52	59	47	53	31	50

Table 3.60. Frequencies of deviations in retrospective analyses of 7f,gPLAICE

METHOD=LS

	Age									Age groups			
	2	3	4	5	6	7	8	9	All	Recruits	Partial recruits	Fully recruited	Others
N ratio													
70 < p	0	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	1	1	0	1	0	3	0	0	3	0
30 < p <= 50	1	0	1	0	1	0	0	0	3	1	0	2	0
10 < p <= 30	0	2	1	1	1	2	1	1	9	0	2	6	1
-10 < p <= 10	4	3	1	1	3	3	3	2	20	4	3	11	2
-30 < p <= -10	0	0	4	2	0	1	1	3	11	0	0	8	3
-50 < p <= -30	1	4	0	4	1	0	0	3	13	1	4	5	3
-70 < p <= -50	2	0	2	0	1	1	0	0	6	2	0	4	0
p <= -70	1	0	0	0	1	2	3	0	7	1	0	6	0
|p| > 50	3	0	2	1	3	3	4	0	16	3	0	13	0
|p| < 50	6	9	7	8	6	6	5	9	56	6	9	32	9
Total	9	9	9	9	9	9	9	9	72	9	9	45	9
Mean	-27	-17	-15	-13	-10	-25	-20	-15	-18	-27	-17	-16	-15
Std.	41	24	34	32	42	43	51	22	36	41	24	39	22

Table 3.61. Frequencies of deviations in retrospective analyses of 7f,gSOLE

METHOD=LS

	Age							All	Age groups		
	2	3	4	5	6	7	8		Recruits	Partial recruits	Fully recruited
F ratio											
70 < p	0	0	0	1	0	2	0	3	0	0	3
50 < p <= 70	1	1	1	0	1	0	2	6	1	1	4
30 < p <= 50	0	2	1	0	1	1	3	8	0	2	6
10 < p <= 30	0	3	3	3	3	2	2	16	0	3	13
-10 < p <= 10	0	3	4	4	4	3	2	20	0	3	17
-30 < p <= -10	0	2	3	4	2	1	0	12	0	2	10
-50 < p <= -30	0	2	2	1	2	1	2	10	0	2	8
-70 < p <= -50	0	1	0	2	0	2	1	6	0	1	5
p <= -70	0	1	1	0	2	3	3	10	0	1	9
|p| > 50	1	3	2	3	3	7	6	25	1	3	21
|p| < 50	0	12	13	12	12	8	9	66	0	12	54
Total	1	15	15	15	15	15	15	91	1	15	75
Mean	64	-2	-5	-5	-8	-15	-14	-7	64	-2	-9
Std.	0	40	36	39	39	67	66	49	0	40	50

Table 3.62. Frequencies of deviations in retrospective analyses of 7f,gSOLE

METHOD=LS

	Age								All	Age groups			
	2	3	4	5	6	7	8	9		Recruits	Partial recruits	Fully recruited	Others
N ratio													
70 < p	2	0	1	0	2	3	3	2	13	2	0	9	2
50 < p <= 70	2	2	0	2	0	2	0	3	11	2	2	4	3
30 < p <= 50	0	2	2	1	2	1	3	0	11	0	2	9	0
10 < p <= 30	2	2	2	4	2	1	0	1	14	2	2	9	1
-10 < p <= 10	5	3	6	4	5	3	2	3	31	5	3	20	3
-30 < p <= -10	0	3	3	3	2	3	2	4	20	0	3	13	4
-50 < p <= -30	2	2	0	0	1	0	3	1	9	2	2	4	1
-70 < p <= -50	1	1	1	0	1	0	2	1	7	1	1	4	1
p <= -70	1	0	0	1	0	2	0	0	4	1	0	3	0
|p| > 50	6	3	2	3	3	7	5	6	35	6	3	20	6
|p| < 50	9	12	13	12	12	8	10	9	85	9	12	55	9
Total	15	15	15	15	15	15	15	15	120	15	15	75	15
Mean	-2	2	4	5	7	13	13	14	7	-2	2	8	14
Std.	72	35	32	35	35	61	58	45	48	72	35	45	45

Table 3.63. Frequencies of deviations in retrospective analyses of CSCOD

METHOD=LS

	Age							Age groups	
	1	2	3	4	5	6	All	Recruits	Fully recruited
F ratio									
70 < p	0	0	0	2	2	1	5	0	5
50 < p <= 70	0	0	2	1	0	2	5	0	5
30 < p <= 50	0	4	0	0	1	0	5	0	5
10 < p <= 30	0	0	2	0	1	0	3	0	3
-10 < p <= 10	0	6	1	2	5	2	16	0	16
-30 < p <= -10	0	3	3	4	0	4	14	0	14
-50 < p <= -30	0	2	5	1	3	4	15	0	15
-70 < p <= -50	0	0	0	2	3	1	6	0	6
p <= -70	1	0	2	3	0	1	7	1	6
|p| > 50	1	0	4	8	5	5	23	1	22
|p| < 50	0	15	11	7	10	10	53	0	53
Total	1	15	15	15	15	15	76	1	75
Mean	-231	2	-14	-13	-2	-12	-11	-231	-8
Std.	0	29	44	78	51	53	58	0	53

Table 3.64. Frequencies of deviations in retrospective analyses of CSCOD

METHOD=LS

	Age							Age groups	
	1	2	3	4	5	6	All	Recruits	Fully recruited
N ratio									
70 < p	7	0	0	1	0	0	8	7	1
50 < p <= 70	3	0	1	1	0	1	6	3	3
30 < p <= 50	0	1	3	4	5	5	18	0	18
10 < p <= 30	1	3	5	4	1	2	16	1	15
-10 < p <= 10	3	7	2	2	5	4	23	3	20
-30 < p <= -10	0	2	2	0	2	0	6	0	6
-50 < p <= -30	0	2	0	0	0	1	3	0	3
-70 < p <= -50	0	0	2	1	0	1	4	0	4
p <= -70	1	0	0	2	2	1	6	1	5
|p| > 50	11	0	3	5	2	3	24	11	13
|p| < 50	4	15	12	10	13	12	66	4	62
Total	15	15	15	15	15	15	90	15	75
Mean	63	-2	10	7	1	8	14	63	5
Std.	80	21	33	60	39	41	53	80	40

Table 3.65. Frequencies of deviations in retrospective analyses of CSWHIT

METHOD=LS

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	All	Recruits	Partial recruits	Fully recruited
F ratio										
70 < p	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	1	1	0	0	0	0	2	1	1	0
10 < p <= 30	0	0	0	0	1	0	1	0	0	1
-10 < p <= 10	0	2	3	2	2	3	12	0	2	10
-30 < p <= -10	0	1	1	2	1	1	6	0	1	5
-50 < p <= -30	0	0	0	0	0	0	0	0	0	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0
|p| > 50	0	0	0	0	0	0	0	0	0	0
|p| < 50	1	4	4	4	4	4	21	1	4	16
Total	1	4	4	4	4	4	21	1	4	16
Mean	33	9	-6	-11	-0	-5	-1	33	9	-6
Std.	0	24	15	13	11	12	17	0	24	12

Table 3.66. Frequencies of deviations in retrospective analyses of CSWHIT

METHOD=LS

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	All	Recruits	Partial recruits	Fully recruited
N ratio										
70 < p	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	0	0	0	0	0	0	0	0	0	0
10 < p <= 30	0	0	1	1	0	1	3	0	0	3
-10 < p <= 10	1	3	3	3	4	3	17	1	3	13
-30 < p <= -10	1	0	0	0	0	0	1	1	0	0
-50 < p <= -30	2	1	0	0	0	0	3	2	1	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0
|p| > 50	0	0	0	0	0	0	0	0	0	0
|p| < 50	4	4	4	4	4	4	24	4	4	16
Total	4	4	4	4	4	4	24	4	4	16
Mean	-24	-7	3	5	0	3	-3	-24	-7	3
Std.	18	18	8	6	5	5	14	18	18	6

Table 3.67. Frequencies of deviations in retrospective analyses of NSHADD

METHOD=LS

	Age							All	Age groups		
	0	1	2	3	4	5	6		Recruits	Partial recruits	Fully recruited
F ratio											
70 < p	0	3	0	0	0	0	1	4	0	3	1
50 < p <= 70	0	1	0	0	0	1	0	2	0	1	1
30 < p <= 50	0	3	0	1	0	0	1	5	0	3	2
10 < p <= 30	0	1	3	0	2	2	1	9	0	1	8
-10 < p <= 10	0	2	3	4	3	3	2	17	0	2	15
-30 < p <= -10	0	1	2	3	2	1	1	10	0	1	9
-50 < p <= -30	0	0	1	3	2	0	2	8	0	0	8
-70 < p <= -50	0	1	2	0	2	4	2	11	0	1	10
p <= -70	1	1	2	2	2	2	3	13	1	1	11
|p| > 50	1	6	4	2	4	7	6	30	1	6	23
|p| < 50	0	7	9	11	9	6	7	49	0	7	42
Total	1	13	13	13	13	13	13	79	1	13	65
Mean	-182	18	-24	-20	-30	-28	-27	-21	-182	18	-26
Std.	0	66	36	34	38	48	53	52	0	66	41

Table 3.68. Frequencies of deviations in retrospective analyses of NSHADD

METHOD=LS

	Age											All	Age groups			
	0	1	2	3	4	5	6	7	8	9	10		Recruits	Partial recruits	Fully recruited	Others
N ratio																
70 < p	4	1	0	0	1	0	1	2	2	4	1	16	4	1	2	9
50 < p <= 70	0	1	2	1	1	2	2	2	2	3	2	18	0	1	8	9
30 < p <= 50	1	0	3	1	2	4	3	1	0	0	2	17	1	0	13	3
10 < p <= 30	1	1	2	4	2	1	2	3	2	1	0	19	1	1	11	6
-10 < p <= 10	2	2	4	6	6	4	2	4	5	3	4	42	2	2	22	16
-30 < p <= -10	0	1	2	1	1	1	2	1	1	0	0	10	0	1	7	2
-50 < p <= -30	0	3	0	0	0	1	0	0	1	0	0	5	0	3	1	1
-70 < p <= -50	1	2	0	0	0	0	1	0	0	1	0	5	1	2	1	1
p <= -70	4	2	0	0	0	0	0	0	0	0	0	6	4	2	0	0
|p| > 50	9	6	2	1	2	2	4	4	4	8	3	45	9	6	11	19
|p| < 50	4	7	11	12	11	11	9	9	9	4	6	93	4	7	54	28
Total	13	13	13	13	13	13	13	13	13	12	9	138	13	13	65	47
Mean	13	-16	17	14	20	19	19	30	21	54	37	20	13	-16	18	35
Std.	110	61	26	21	25	32	37	36	41	64	40	52	110	61	28	47

Table 3.69. Frequencies of deviations in retrospective analyses of NSWHIT

METHOD=LS

	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	All	Age groups: Recruits	Partial recruits	Fully recruited
F ratio													
70 < p	0	3	0	0	0	0	0	2	1	6	0	3	3
50 < p <= 70	0	0	3	0	0	0	1	0	0	4	0	3	1
30 < p <= 50	0	2	1	0	0	2	0	0	0	5	0	3	2
10 < p <= 30	0	1	0	3	2	0	2	0	1	9	0	4	5
-10 < p <= 10	0	3	4	3	2	1	2	2	2	19	0	10	9
-30 < p <= -10	1	0	2	1	4	3	0	1	1	13	1	3	9
-50 < p <= -30	0	0	2	6	0	1	1	2	2	14	0	8	6
-70 < p <= -50	0	2	1	0	4	2	2	5	4	20	0	3	17
p <= -70	0	2	0	0	1	4	5	1	1	14	0	2	12
|p| > 50	0	7	4	0	5	6	8	8	6	44	0	11	33
|p| < 50	1	6	9	13	8	7	5	5	6	60	1	28	31
Total	1	13	13	13	13	13	13	13	12	104	1	39	64
Mean	-13	5	-1	-15	-27	-37	-43	-12	-25	-19	-13	-4	-29
Std.	0	86	40	30	34	49	59	86	47	58	0	57	57

Table 3.70. Frequencies of deviations in retrospective analyses of NSWHIT

METHOD=LS

	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	All	Age groups: Recruits	Partial recruits	Fully recruited
N ratio													
70 < p	4	2	0	0	0	1	1	0	0	8	4	2	2
50 < p <= 70	0	1	1	0	1	3	4	1	2	13	0	2	11
30 < p <= 50	1	1	2	4	4	3	2	4	4	25	1	7	17
10 < p <= 30	2	0	2	3	2	1	1	3	1	15	2	5	8
-10 < p <= 10	1	3	4	3	5	3	3	3	5	30	1	10	19
-30 < p <= -10	0	2	0	3	1	2	2	0	1	11	0	5	6
-50 < p <= -30	0	1	4	0	0	0	0	0	0	5	0	5	0
-70 < p <= -50	1	1	0	0	0	0	0	1	0	3	1	1	1
p <= -70	4	2	0	0	0	0	0	1	0	7	4	2	1
|p| > 50	9	6	1	0	1	4	5	3	2	31	9	7	15
|p| < 50	4	7	12	13	12	9	8	10	11	86	4	32	50
Total	13	13	13	13	13	13	13	13	13	117	13	39	65
Mean	-7	1	1	12	20	27	31	10	21	13	-7	5	22
Std.	137	70	33	22	24	32	39	44	23	58	137	45	33

Table 3.71. Frequencies of deviations in retrospective analyses of NEACOD

METHOD=LS

	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	All	Age groups: Recruits	Partial recruits	Fully recruited
F ratio														
70 < p	0	0	0	0	0	1	2	0	0	0	3	0	0	3
50 < p <= 70	0	1	1	0	0	0	0	0	0	0	2	0	2	0
30 < p <= 50	0	0	1	0	0	0	0	0	0	0	1	0	1	0
10 < p <= 30	0	2	0	1	0	0	0	0	2	2	7	0	3	4
-10 < p <= 10	0	2	1	1	1	1	2	2	9	3	22	0	4	18
-30 < p <= -10	1	0	1	2	1	0	1	2	1	7	16	1	3	12
-50 < p <= -30	0	1	4	1	2	4	1	2	0	0	15	0	6	9
-70 < p <= -50	0	2	0	3	3	1	4	2	0	0	15	0	5	10
p <= -70	0	4	4	4	5	5	2	4	0	0	28	0	12	16
|p| > 50	0	7	5	7	8	7	8	6	0	0	48	0	19	29
|p| < 50	1	5	7	5	4	5	4	6	12	12	61	1	17	43
Total	1	12	12	12	12	12	12	12	12	12	109	1	36	72
Mean	-15	-32	-34	-46	-63	-58	-25	-48	-1	-6	-34	-15	-37	-33
Std.	0	52	51	38	33	59	67	37	7	16	47	0	46	48

Table 3.72. Frequencies of deviations in retrospective analyses of NEACOD

METHOD=LS

	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	All	Age groups: Recruits	Partial recruits	Fully recruited	Others
N ratio																	
70 < p	4	4	2	2	2	3	2	1	0	0	0	0	20	4	8	8	0
50 < p <= 70	0	2	2	2	4	2	0	3	0	0	0	0	15	0	6	9	0
30 < p <= 50	0	1	2	3	3	2	4	2	0	0	1	0	18	0	6	11	1
10 < p <= 30	2	0	3	2	2	3	2	3	0	2	5	6	30	2	5	12	11
-10 < p <= 10	2	2	1	2	1	1	2	3	12	8	4	6	44	2	5	27	10
-30 < p <= -10	0	2	0	1	0	0	0	0	0	2	1	0	6	0	3	2	1
-50 < p <= -30	1	0	1	0	0	0	1	0	0	0	1	0	4	1	1	1	1
-70 < p <= -50	0	1	1	0	0	1	0	0	0	0	0	0	3	0	2	1	0
p <= -70	3	0	0	0	0	0	1	0	0	0	0	0	4	3	0	1	0
|p| > 50	7	7	5	4	6	6	3	4	0	0	0	0	42	7	16	19	0
|p| < 50	5	5	7	8	6	6	9	8	12	12	12	12	102	5	20	53	24
Total	12	12	12	12	12	12	12	12	12	12	12	12	144	12	36	72	24
Mean	15	30	30	37	47	42	19	34	0	3	8	12	23	15	33	24	10
Std.	89	49	44	31	25	43	43	28	5	10	23	10	41	89	41	34	18

Table 3.73. Frequencies of deviations in retrospective analyses of NEACOD

METHOD=L2

	Age									All	Age groups		
	3	4	5	6	7	8	9	10	11		Recruits	Partial recruits	Fully recruited
F ratio													
70 < p	0	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	0	0	0	0	0	0	0	0	0	0	0	0	0
30 < p <= 50	0	0	0	0	0	0	0	0	0	0	0	0	0
10 < p <= 30	1	0	0	0	0	1	0	1	0	3	1	0	2
-10 < p <= 10	0	1	1	1	1	2	5	1	2	14	0	3	11
-30 < p <= -10	0	1	0	1	2	2	1	3	3	13	0	2	11
-50 < p <= -30	0	3	2	2	2	1	0	1	1	12	0	7	5
-70 < p <= -50	0	1	3	2	1	0	0	0	0	7	0	6	1
p <= -70	0	0	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	0	1	3	2	1	0	0	0	0	7	0	6	1
|p| < 50	1	5	3	4	5	6	6	6	6	42	1	12	29
Total	1	6	6	6	6	6	6	6	6	49	1	18	30
Mean	20	-36	-43	-37	-31	-13	-0	-17	-18	-23	20	-38	-16
Std.	0	21	23	24	19	19	10	19	12	23	0	21	18

Table 3.74. Frequencies of deviations in retrospective analyses of NEACOD

METHOD=L2

	Age									All	Age groups		
	3	4	5	6	7	8	9	10	11		Recruits	Partial recruits	Fully recruited
N ratio													
70 < p	0	0	0	0	0	0	0	0	0	0	0	0	0
50 < p <= 70	2	1	2	0	0	0	0	0	0	5	2	3	0
30 < p <= 50	0	3	2	4	1	0	0	0	0	10	0	9	1
10 < p <= 30	1	1	1	1	4	3	1	4	3	19	1	3	15
-10 < p <= 10	2	1	1	1	1	3	5	2	3	19	2	3	14
-30 < p <= -10	1	0	0	0	0	0	0	0	0	1	1	0	0
-50 < p <= -30	0	0	0	0	0	0	0	0	0	0	0	0	0
-70 < p <= -50	0	0	0	0	0	0	0	0	0	0	0	0	0
p <= -70	0	0	0	0	0	0	0	0	0	0	0	0	0
|p| > 50	2	1	2	0	0	0	0	0	0	5	2	3	0
|p| < 50	4	5	4	6	6	6	6	6	6	49	4	15	30
Total	6	6	6	6	6	6	6	6	6	54	6	18	30
Mean	18	33	36	27	20	8	0	9	11	18	18	32	10
Std.	36	19	20	17	13	11	6	11	7	20	36	18	11

Table 3.75 Summary table of series (|p|>50) retrospective ratios of fully-recruited F in the final year to F in the reference year (longest series). Patterns for other age groups may differ from these. Also given are the full age range, the recruiting age, the partially and fully recruited age groups and the "calibration" age range which is the age range used for computing average Fs.

STOCK	METHOD LS	ADAPT	XSA	TSER	L2	X2	AGE RANGE	REC	PART	FUL REC	CAL RNG	COMMENT
N. Sea Cod	11 V	F	0 N	0 N			1-10	1	2	3	3- 8	
Ir. Sea Pl.	17 N	11 V	14 V	0 P			2-9+	2	3	4	4- 8	
VIIe Sole	31 P	63 N	52 P	14 N	19 V	12 N	2-10+	2	3	4	4- 8	Poor retrospective convergence. Low Fs; possible q trends
4TVn Cod	5 N	27 N	2 N	0 P			3-16	3	4-7	8	8-12	
4VsW Cod	37 N	75 N	36 N	0 P			3-15	3	4-6	7	7- 9	
N. Sea Pl.	7 N		12 P				1-15	1	2	3	3-10	
SNE Y'tail	45 P	36 V	17 V				1-7+	1	2	3	3- 5	Highly variable survey indices
Ir. Sea Cod	3 V						1-7+	1	-	2	2- 6	Short series
Ir. Sea Whg	13 V						0-8+	0	1	2	2- 6	Short series
VIIe Pl.	34 N						2-10+	2	3	4	4- 8	Poor retrosp. convergence. Bias
VIIfg Pl.	38 P						2-10+	2	3	4	4- 8	Poor retrospective convergence.
VIIfg Sole	27 V						2-10+	2	3	4	4- 8	Very poor retrosp. convergence
VIIfg Cod	29 N						1-7+	1	-	2	2- 6	
VIIfg Whg	0 V						1-7+	1	2	3	3- 6	Short series
N. Sea Had	35 N						0-10	0	1	2	2- 6	
N. Sea Whg	52 N						0-10	0	1-3	4	4- 8	
NE Arct Cod	40 N				3 N		3-14	3	4-6	7	7-12	

% frequency where log residual ratio of F is greater than 0.5

P: majority positive N: majority negative
V: variable pattern F: method could not be applied successfully

Table 4.1(a)

Sample output of diagnostics for ADAPT
Southern Gulf of St. Lawrence (4T-Vn (J-A)) COD

Population numbers at the beginning of the year

POPULATION NUMBERS (000S) 26/ 6/91

	71	72	73	74	75	76	77	78	79
3	88303	34345	46385	52872	42096	118469	166615	161455	113965
4	39088	72291	25245	36767	40816	33057	96573	135919	131702
5	31052	30156	39143	14436	25596	25472	23934	76030	102365
6	30930	19015	13991	19084	7499	14839	12775	15872	52632
7	18559	17164	9649	6712	7115	3890	6211	7867	8957
8	5912	9996	7337	4599	2793	2897	1744	3559	4098
9	3221	2781	5047	3531	2142	1117	1342	1061	1950
10	1624	1528	1445	2500	1351	754	511	835	654
11	487	869	773	695	1111	390	378	255	466
12	548	282	391	336	328	302	198	197	115
13	144	136	128	232	99	133	121	112	96
14	288	52	67	44	113	33	68	45	52
15	387	130	30	13	12	26	15	46	33
16	159	104	63	37	117	31	18	18	20
3+	220702	188848	149693	141858	131191	201411	310502	403272	417104

	80	81	82	83	84	85	86	87	88
3	113741	91260	190457	249154	136091	135550	116211	103809	108245
4	93178	92839	74630	155576	203960	111399	110830	95024	84928
5	103341	74461	72606	59835	126404	165904	89871	87683	76996
6	69756	71036	54379	50594	43532	99963	126859	66671	65596
7	33178	44306	41111	37020	30870	29271	66763	84200	45411
8	4265	18531	24636	22929	20059	17287	16592	46152	52606
9	1844	2339	9719	13621	12237	10328	8747	10183	31727
10	841	877	1131	5725	6567	5438	4902	4669	6513
11	272	399	327	526	2445	2779	2438	2004	2448
12	158	111	155	140	335	1160	1423	1026	1035
13	36	108	33	57	78	135	635	473	492
14	49	15	15	22	33	17	91	378	263
15	29	33	11	10	12	21	8	57	208
16	68	9	7	5	21	13	8	50	35
3+	420757	396324	469217	595213	582645	579265	545377	502382	476504

	89	90
3	114720	163085
4	88535	93874
5	68150	71249
6	58840	51192
7	43820	38631
8	29605	27426
9	32542	18615
10	20305	20860
11	3862	12300
12	1178	2365
13	446	629
14	230	231
15	171	145
16	69	131
3+	462475	500734

cont'd.

Table 4.(b) - Fishing Mortality

4TvN COD TUNING MAY 1991

FISHING MORTALITY 26/ 6/91

	71	72	73	74	75	76	77	78	79	80	81
3	.000	.108	.032	.059	.042	.004	.004	.004	.001	.003	.001
4	.059	.413	.359	.162	.271	.123	.039	.084	.043	.024	.046
5	.290	.568	.518	.455	.345	.490	.211	.168	.184	.175	.114
6	.389	.478	.535	.787	.456	.671	.285	.372	.261	.254	.347
7	.419	.650	.541	.677	.699	.602	.357	.452	.542	.382	.387
8	.554	.483	.531	.564	.717	.570	.297	.402	.598	.401	.445
9	.545	.454	.502	.761	.843	.582	.274	.284	.641	.543	.527
10	.426	.482	.533	.612	1.041	.491	.493	.384	.677	.545	.786
11	.346	.599	.633	.550	1.102	.481	.450	.598	.882	.701	.746
12	1.196	.592	.321	1.017	.704	.718	.368	.517	.954	.184	1.021
13	.817	.509	.867	.519	.890	.469	.777	.570	.476	.668	1.787
14	.596	.351	1.434	1.061	1.282	.621	.197	.130	.385	.199	.157
15	.555	.490	.511	.698	.943	.554	.354	.373	.695	.539	.626
16	.555	.490	.511	.698	.943	.554	.354	.373	.695	.539	.626

	82	83	84	85	86	87	88	89	90
3	.002	.000	.000	.001	.001	.001	.001	.001	.003
4	.021	.008	.007	.015	.034	.010	.020	.017	.031
5	.161	.118	.035	.068	.099	.090	.069	.086	.113
6	.185	.294	.197	.204	.210	.184	.203	.221	.241
7	.384	.413	.380	.368	.169	.270	.228	.269	.343
8	.393	.428	.464	.481	.288	.175	.280	.264	.362
9	.329	.530	.611	.545	.428	.247	.246	.245	.303
10	.566	.651	.660	.602	.694	.446	.323	.301	.273
11	.652	.249	.546	.469	.665	.461	.531	.290	.252
12	.796	.381	.708	.402	.902	.535	.643	.428	.260
13	.186	.342	1.331	.198	.319	.386	.560	.458	.278
14	.163	.429	.265	.612	.263	.396	.231	.262	.278
15	.369	.556	.620	.542	.574	.339	.285	.271	.278
16	.369	.556	.620	.542	.574	.339	.285	.271	.278

cont'd.

Table 4.1(c) - Residuals for Research vessel index
(Obs (ln $RV_{i,t}$) - Pred(ln $RV_{i,t}$))

4TvN COD TUNING MAY 1991

4TVn

RESIDUALS FOR RV INDEX 26/ 6/91

	71	72	73	74	75	76	77	78	79	80
3	-.892	-.175	.184	.156	-.535	.453	-.630	-.174	.123	.501
4	-.268	-.134	-.158	-.185	-.343	.010	-.655	-.294	.334	.003
5	-.176	-.286	-.271	-.239	-.258	-.114	-.329	-.480	-.061	.308
6	-.495	-.219	-.128	-.225	-.137	-.446	-.422	-.095	-.379	-.096
7	-.419	-.370	-.095	-.101	-.238	-.480	-.209	.098	.260	-.276
8	-.603	-.518	-.131	-.172	.292	-.536	.157	-.234	.174	-.022
9	-1.558	-.818	-.120	.354	-.010	-.025	.213	.081	.370	.320
10	-1.021	-.727	-.335	-.473	.082	-.014	.675	.382	-.034	.001

	81	82	83	84	85	86	87	88	89	90
3	.200	-.702	-.004	-.435	.358	.654	.123	.665	.130	.000
4	.883	.071	-.104	-.450	.410	.600	-.330	.762	-.026	-.127
5	.707	.092	.047	.007	.386	.588	-.129	.542	.016	-.349
6	.760	.720	-.124	.063	.971	.256	-.171	.352	.212	-.398
7	.398	.489	.134	-.118	.887	.428	-.027	.065	-.031	-.396
8	.677	.245	.233	.415	.549	.556	-.482	.134	-.108	-.626
9	.903	.069	.202	.216	.890	-.197	-.325	.218	-.096	-.687
10	.963	-.033	.512	-.137	.682	.707	.075	-.179	-.218	-.906

SUM OF RV RESIDUALS : 4.887497244E-4 MEAN RESIDUAL : 3.054685777E-6

Table 4.1(d) - Residuals for CPUE index
(Obs(ln $CPUE_{i,t}$) - Pred(ln $CPUE_{i,t}$))

RESIDUALS FROM CPUE INDEX 26/ 6/91

	71	72	73	74	75	76	77	78	79	80
5	.081	.787	.760	.539	.331	.918	.712	.102	.108	-.105
6	-.226	-.024	.138	.498	-.038	.646	.314	.336	-.316	-.241
7	-.504	.071	-.154	.045	.088	.176	.070	.265	.088	-.061
8	-.471	-.303	-.216	-.260	-.024	.112	-.394	.123	.088	-.015
9	-.353	-.866	-.537	.115	.191	.082	-.601	-.380	-.153	.408
10	-.949	-.801	-.953	-.465	.164	-.319	-.050	-.278	-.421	.207
11	-.664	-1.352	-.382	-.382	.400	-.174	.242	-.121	-.718	-.122
12	.113	-.964	-1.282	-.123	-.665	-.295	.073	-.462	.290	-.708

	81	82	83	84	85	86	87	88	89	90
5	-.634	-.077	-.425	-1.370	-.650	-.232	.028	-.418	-.221	-.234
6	.071	-.506	.007	-.337	-.167	-.052	.016	.057	-.062	-.114
7	-.081	-.040	.231	.099	.085	-.411	.300	-.174	-.117	.024
8	-.062	.010	.362	.471	.409	.182	-.237	.113	-.044	.157
9	-.182	-.164	.597	.712	.558	.561	-.011	.110	-.123	.037
10	-.136	.627	.765	.731	.546	.957	.493	.097	-.055	-.160
11	.128	.896	-.473	.501	.294	.960	.539	.884	-.313	-.144
12	-.414	1.003	.307	.375	.186	1.417	.244	.902	.204	-.202

SUM OF CPUE RESIDUALS : 4.903936195E-4 MEAN RESIDUAL : 3.064960122E-6

cont'd.

Table 4.1(e) - Estimates of the parameters, standard errors and C.V.s
Parameters 1-10 - Population estimates for ages 3-12
" 11-18 - Catchabilities for RV for ages 3 to 10
" 19-26 - Catchabilities for CPUE for ages 5 to 12

4TvN COD TUNING MAY 1991

4TVn

ESTIMATED PARAMETERS AND STANDARD eRRORS
APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

ORTHOGONALITY OFFSET......... 0.027639
MEAN SQUARE RESIDUALS 0.218363

PARAMETER	AGE	ESTIMATE	STD. ERR.	C.V.
NUMBERS				
	3	163366	78268	0.479
	4	94079	31589	0.336
	5	71502	16621	0.232
	6	51483	9862	0.192
	7	38917	6941	0.178
	8	27637	4905	0.177
	9	18740	3309	0.177
	10	20990	3774	0.180
	11	12372	2514	0.203
	12	2379	565	0.238
INDEX 1: RV SURVEY				
	3	1.98E-004	2.20E-005	0.111
	4	3.04E-004	3.28E-005	0.108
	5	3.94E-004	4.20E-005	0.107
	6	4.55E-004	4.84E-005	0.106
	7	4.55E-004	4.84E-005	0.106
	8	4.63E-004	4.92E-005	0.106
	9	4.13E-004	4.40E-005	0.107
	10	5.19E-004	5.55E-005	0.107
INDEX 2: OTB CPUE AT AGE				
	5	1.82E-004	1.94E-005	0.107
	6	3.41E-004	3.62E-005	0.106
	7	4.28E-004	4.54E-005	0.106
	8	4.09E-004	4.35E-005	0.106
	9	3.79E-004	4.02E-005	0.106
	10	4.21E-004	4.49E-005	0.107
	11	3.55E-004	3.79E-005	0.107
	12	3.85E-004	4.11E-005	0.107

cont'd.

Table 4.1(f) - Parameter correlation matrix

Parameter Correlation Matrix 26/ 6/91

	1	2	3	4	5	6	7	8	9	10
1	1.000	.039	.029	.023	.019	.015	.013	.011	.011	.008
2	.039	1.000	.040	.032	.026	.021	.018	.015	.016	.011
3	.029	.040	1.000	.045	.036	.029	.026	.021	.022	.015
4	.023	.032	.045	1.000	.046	.037	.033	.027	.028	.019
5	.019	.026	.036	.046	1.000	.047	.040	.034	.034	.025
6	.015	.021	.029	.037	.047	1.000	.050	.042	.041	.031
7	.013	.018	.026	.033	.040	.050	1.000	.031	.042	.049
8	.011	.015	.021	.027	.034	.042	.031	1.000	.054	.065
9	.011	.016	.022	.028	.034	.041	.042	.054	1.000	.071
10	.008	.011	.015	.019	.025	.031	.049	.065	.071	1.000
11	-.231	-.171	-.125	-.100	-.082	-.065	-.057	-.047	-.050	-.033
12	-.015	-.171	-.124	-.099	-.080	-.064	-.056	-.047	-.049	-.033
13	-.009	-.012	-.130	-.102	-.082	-.067	-.059	-.048	-.050	-.034
14	-.007	-.009	-.013	-.119	-.094	-.076	-.066	-.055	-.056	-.039
15	-.006	-.008	-.011	-.014	-.121	-.093	-.080	-.068	-.066	-.051
16	-.005	-.006	-.009	-.012	-.014	-.123	-.099	-.086	-.078	-.065
17	-.004	-.006	-.008	-.010	-.012	-.015	-.127	-.108	-.096	-.082
18	-.004	-.005	-.007	-.009	-.011	-.014	-.034	-.144	-.129	-.107
19	-.009	-.012	-.126	-.100	-.080	-.065	-.057	-.047	-.049	-.034
20	-.006	-.009	-.012	-.113	-.089	-.072	-.063	-.052	-.053	-.038
21	-.005	-.007	-.010	-.013	-.112	-.087	-.075	-.063	-.063	-.047
22	-.004	-.006	-.008	-.011	-.013	-.113	-.093	-.080	-.074	-.061
23	-.004	-.005	-.007	-.009	-.012	-.014	-.118	-.101	-.090	-.077
24	-.003	-.005	-.007	-.008	-.010	-.013	-.031	-.134	-.119	-.099
25	-.003	-.005	-.007	-.008	-.011	-.013	-.044	-.058	-.159	-.129
26	-.003	-.005	-.007	-.009	-.011	-.013	-.065	-.088	-.084	-.168

	11	12	13	14	15	16	17	18	19	20
1	-.231	-.015	-.009	-.007	-.006	-.005	-.004	-.004	-.009	-.006
2	-.171	-.171	-.012	-.009	-.008	-.006	-.006	-.005	-.012	-.009
3	-.125	-.124	-.130	-.013	-.011	-.009	-.008	-.007	-.126	-.012
4	-.100	-.099	-.102	-.119	-.014	-.012	-.010	-.009	-.100	-.113
5	-.082	-.080	-.082	-.094	-.121	-.014	-.012	-.011	-.080	-.089
6	-.065	-.064	-.067	-.076	-.093	-.123	-.015	-.014	-.065	-.072
7	-.057	-.056	-.059	-.066	-.080	-.099	-.127	-.034	-.057	-.063
8	-.047	-.047	-.048	-.055	-.068	-.086	-.108	-.144	-.047	-.052
9	-.050	-.049	-.050	-.056	-.066	-.078	-.096	-.129	-.049	-.053
10	-.033	-.033	-.034	-.039	-.051	-.065	-.082	-.107	-.034	-.038
11	1.000	.063	.039	.029	.024	.020	.017	.016	.038	.028
12	.063	1.000	.039	.029	.024	.020	.017	.016	.038	.027
13	.039	.039	1.000	.030	.024	.021	.018	.016	.039	.028
14	.029	.029	.030	1.000	.028	.024	.020	.019	.029	.032
15	.024	.024	.024	.028	1.000	.029	.024	.023	.024	.026
16	.020	.020	.021	.024	.029	1.000	.030	.028	.020	.022
17	.017	.017	.018	.020	.024	.030	1.000	.035	.017	.019
19	.038	.038	.039	.029	.024	.020	.017	.016	1.000	.028
20	.028	.027	.028	.032	.026	.022	.019	.018	.028	1.000
21	.023	.022	.023	.026	.032	.027	.023	.021	.022	.025
22	.019	.019	.019	.022	.027	.034	.029	.026	.019	.021
23	.016	.016	.017	.019	.023	.028	.036	.033	.016	.018
24	.015	.015	.015	.017	.021	.026	.032	.041	.015	.016
25	.015	.015	.015	.017	.021	.026	.032	.038	.015	.016
26	.015	.015	.015	.017	.021	.027	.034	.038	.015	.017

	21	22	23	24	25	26
1	-.005	-.004	-.004	-.003	-.003	-.003
2	-.007	-.006	-.005	-.005	-.005	-.005
3	-.010	-.008	-.007	-.007	-.007	-.007
4	-.013	-.011	-.009	-.008	-.008	-.009
5	-.112	-.013	-.012	-.010	-.011	-.011
6	-.087	-.113	-.014	-.013	-.013	-.013
7	-.075	-.093	-.118	-.031	-.044	-.065
8	-.063	-.080	-.101	-.134	-.058	-.088
9	-.063	-.074	-.090	-.119	-.159	-.084
10	-.047	-.061	-.077	-.099	-.129	-.168
11	.023	.019	.016	.015	.015	.015
12	.022	.019	.016	.015	.015	.015
13	.023	.019	.017	.015	.015	.015
14	.026	.022	.019	.017	.017	.017
15	.032	.027	.023	.021	.021	.021
16	.027	.034	.028	.026	.026	.027
17	.023	.029	.036	.032	.032	.034
18	.021	.026	.033	.041	.038	.038
19	.022	.019	.016	.015	.015	.015
20	.025	.021	.018	.016	.016	.017
21	1.000	.025	.022	.020	.020	.020
22	.025	1.000	.027	.024	.024	.025
23	.022	.027	1.000	.030	.030	.032
24	.020	.024	.030	1.000	.035	.035
25	.020	.024	.030	.035	1.000	.037
26	.020	.025	.032	.035	.037	1.000

Table 4.2. Extended Survivors Analysis: Output and diagnostics for 4TVn cod.

```
Extended Survivors Analysis
data from files :
c4tcn90x.dat
4TVn (J-A) COD CATCH AT AGE  AGES 3- 16+ AND YEARS 1971-90 (XSA)
c4ttu90x.dat
4T-Vn (J-A) COD Tuning data XSA version

data for    2 surveys over   20 years

age range from     3 to    14
ages lower than     3 treated as recruits
catchability independent of age for ages >=     8
regression type = c
tapered time weighting applied
power =     3 over  20 years
prior weighting not applied
final estimates not shrunk towards mean
estimates with s.e.'s greater than that of mean included
minimum s.e. for any survey taken as        0.30
minimum of    5 points used for regression
```

VPA fishing mortality

0.000	0.059	0.293	0.391	0.424	0.584	0.567	0.529	0.431	1.405	0.644
0.109	0.414	0.569	0.486	0.656	0.493	0.496	0.514	0.893	0.873	0.759
0.032	0.362	0.520	0.536	0.555	0.540	0.519	0.619	0.712	0.660	16.363
0.058	0.161	0.460	0.791	0.680	0.590	0.785	0.647	0.724	1.385	17.630
0.042	0.269	0.343	0.465	0.707	0.724	0.926	1.129	1.276	1.316	6.776
0.004	0.124	0.484	0.664	0.622	0.583	0.594	0.592	0.573	1.072	8.799
0.004	0.039	0.212	0.280	0.350	0.313	0.284	0.511	0.619	0.486	4.564
0.004	0.081	0.167	0.376	0.441	0.391	0.303	0.403	0.635	0.936	0.947
0.001	0.041	0.178	0.260	0.550	0.573	0.613	0.758	0.973	1.100	2.022
0.003	0.023	0.169	0.244	0.380	0.410	0.503	0.505	0.893	0.217	0.946
0.001	0.045	0.106	0.331	0.366	0.441	0.547	0.681	0.646	2.405	10.447
0.003	0.022	0.156	0.170	0.360	0.362	0.324	0.604	0.497	0.598	3.269
0.000	0.009	0.123	0.283	0.370	0.389	0.467	0.635	0.275	0.250	0.216
0.000	0.007	0.039	0.207	0.361	0.393	0.522	0.531	0.523	0.838	0.600
0.001	0.016	0.074	0.236	0.392	0.444	0.420	0.459	0.330	0.375	0.260
0.001	0.036	0.111	0.232	0.203	0.315	0.378	0.447	0.420	0.491	0.290
0.001	0.011	0.096	0.210	0.307	0.217	0.278	0.371	0.233	0.260	0.149
0.001	0.021	0.072	0.218	0.269	0.333	0.325	0.379	0.400	0.239	0.198
0.001	0.018	0.090	0.232	0.293	0.329	0.308	0.443	0.365	0.280	0.116
0.004	0.036	0.121	0.256	0.369	0.413	0.414	0.376	0.439	0.358	0.160

VPA population numbers

8.82E+04	3.90E+04	3.08E+04	3.08E+04	1.84E+04	5.69E+03	3.13E+03	1.37E+03	4.07E+02	5.07E+02	1.70E+02
3.41E+04	7.22E+04	3.01E+04	1.88E+04	1.71E+04	9.85E+03	2.60E+03	1.45E+03	6.62E+02	2.16E+02	1.02E+02
4.66E+04	2.51E+04	3.91E+04	1.40E+04	9.47E+03	7.25E+03	4.92E+03	1.29E+03	7.12E+02	2.22E+02	7.40E+01
5.32E+04	3.69E+04	1.43E+04	1.90E+04	6.69E+03	4.45E+03	3.46E+03	2.40E+03	5.71E+02	2.86E+02	9.39E+01
4.19E+04	4.11E+04	2.57E+04	7.39E+03	7.06E+03	2.77E+03	2.02E+03	1.29E+03	1.03E+03	2.27E+02	5.86E+01
1.19E+05	3.29E+04	2.57E+04	1.50E+04	3.80E+03	2.85E+03	1.10E+03	6.56E+02	3.42E+02	2.35E+02	4.97E+01
1.71E+05	9.69E+04	2.38E+04	1.30E+04	6.30E+03	1.67E+03	1.30E+03	4.97E+02	2.97E+02	1.58E+02	6.59E+01
1.67E+05	1.40E+05	7.63E+04	1.58E+04	8.03E+03	3.64E+03	1.00E+03	8.02E+02	2.44E+02	1.31E+02	7.95E+01
1.22E+05	1.36E+05	1.05E+05	5.29E+04	8.86E+03	4.23E+03	2.01E+03	6.05E+02	4.39E+02	1.06E+02	4.20E+01
1.17E+05	9.95E+04	1.07E+05	7.23E+04	3.34E+04	4.19E+03	1.95E+03	8.92E+02	2.32E+02	1.36E+02	2.89E+01
8.79E+04	9.53E+04	7.96E+04	7.38E+04	4.64E+04	1.87E+04	2.27E+03	9.67E+02	4.41E+02	7.77E+01	8.95E+01
1.68E+05	7.19E+04	7.46E+04	5.86E+04	4.34E+04	2.63E+04	9.84E+03	1.08E+03	4.01E+02	1.89E+02	5.74E+00
2.29E+05	1.37E+05	5.76E+04	5.23E+04	4.05E+04	2.48E+04	1.50E+04	5.83E+03	4.82E+02	2.00E+02	8.52E+01
1.22E+05	1.88E+05	1.11E+05	4.17E+04	3.22E+04	2.29E+04	1.38E+04	7.70E+03	2.53E+03	3.00E+02	1.27E+02
1.28E+05	1.00E+05	1.53E+05	8.76E+04	2.78E+04	1.84E+04	1.26E+04	6.68E+03	3.70E+03	1.23E+03	1.06E+02
1.12E+05	1.05E+05	8.06E+04	1.16E+05	5.67E+04	1.54E+04	9.66E+03	6.80E+03	3.46E+03	2.18E+03	6.90E+02
9.96E+04	9.14E+04	8.29E+04	5.91E+04	7.54E+04	3.79E+04	9.17E+03	5.42E+03	3.56E+03	1.86E+03	1.09E+03
1.02E+05	8.15E+04	7.40E+04	6.17E+04	3.92E+04	4.54E+04	2.49E+04	5.69E+03	3.06E+03	2.31E+03	1.18E+03
9.93E+04	8.35E+04	6.53E+04	5.64E+04	4.06E+04	2.45E+04	2.66E+04	1.48E+04	3.19E+03	1.68E+03	1.49E+03
1.39E+05	8.13E+04	6.72E+04	4.89E+04	3.66E+04	2.48E+04	1.45E+04	1.60E+04	7.76E+03	1.81E+03	1.04E+03
0.00E+00	1.14E+05	6.42E+04	4.88E+04	3.10E+04	2.08E+04	1.35E+04	7.85E+03	9.04E+03	4.12E+03	1.05E+03

Continued

Table 4.2 Continued

log reciprocal catchability

fleet = 1

0.00	0.00	8.84	8.02	7.72	7.68	7.68	7.68	7.68	7.68	0.00
0.00	0.00	0.35	0.20	0.13	0.14	0.27	0.39	0.50	0.59	0.00

fleet = 2

8.37	7.95	7.69	7.53	7.55	7.54	7.54	7.54	0.00	0.00	0.00
0.31	0.34	0.27	0.35	0.29	0.27	0.40	0.50	0.00	0.00	0.00

log population residuals for each fleet

fleet = 1

0.00	0.00	0.31	-0.19	-0.54	-0.56	-0.54	-0.84	-0.72	0.01	0.00
0.00	0.00	0.99	0.01	0.02	-0.42	-1.00	-0.85	-1.26	-0.78	0.00
0.00	0.00	0.97	0.16	-0.19	-0.34	-0.73	-0.92	-0.56	-0.77	0.00
0.00	0.00	0.76	0.50	-0.02	-0.36	-0.09	-0.53	-0.39	-0.07	0.00
0.00	0.00	0.54	0.00	0.03	-0.17	0.04	0.09	0.21	-0.27	0.00
0.00	0.00	1.11	0.65	0.15	-0.01	-0.12	-0.25	-0.28	-0.11	0.00
0.00	0.00	0.94	0.33	0.00	-0.48	-0.77	-0.13	0.27	0.16	0.00
0.00	0.00	0.32	0.37	0.19	-0.04	-0.52	-0.34	-0.35	-0.09	0.00
0.00	0.00	0.30	-0.29	0.04	-0.10	-0.43	-0.43	-0.93	0.19	0.00
0.00	0.00	0.08	-0.25	-0.12	-0.13	0.11	0.01	-0.19	-0.72	0.00
0.00	0.00	-0.48	0.05	-0.18	-0.21	-0.37	-0.41	-0.32	0.16	0.00
0.00	0.00	0.11	-0.55	-0.15	-0.21	-0.39	0.57	0.33	0.50	0.00
0.00	0.00	-0.16	0.00	0.07	0.13	0.25	0.62	-0.65	-0.30	0.00
0.00	0.00	-1.02	-0.25	0.00	0.17	0.33	0.39	0.17	0.32	0.00
0.00	0.00	-0.34	0.01	0.10	0.19	0.08	0.16	-0.34	-0.08	0.00
0.00	0.00	0.11	0.08	-0.27	0.14	0.22	0.40	0.21	0.58	0.00
0.00	0.00	0.31	0.18	0.38	-0.15	-0.10	0.20	-0.42	-0.68	0.00
0.00	0.00	-0.15	0.16	-0.05	0.15	0.18	0.15	0.32	-0.29	0.00
0.00	0.00	0.05	0.02	-0.07	0.04	-0.10	0.23	-0.36	-0.42	0.00
0.00	0.00	0.05	-0.03	0.04	0.15	0.13	0.05	0.13	-0.08	0.00

fleet = 2

-1.05	-0.41	-0.31	-0.66	-0.55	-0.68	-1.76	-0.80	0.00	0.00	0.00
-0.33	-0.28	-0.43	-0.37	-0.51	-0.63	-0.97	-0.67	0.00	0.00	0.00
0.02	-0.29	-0.42	-0.29	-0.21	-0.25	-0.33	-0.18	0.00	0.00	0.00
-0.01	-0.33	-0.38	-0.39	-0.24	-0.26	0.14	-0.43	0.00	0.00	0.00
-0.69	-0.50	-0.41	-0.28	-0.37	0.17	-0.14	0.17	0.00	0.00	0.00
0.29	-0.13	-0.28	-0.63	-0.59	-0.65	-0.25	0.18	0.00	0.00	0.00
-0.81	-0.80	-0.47	-0.61	-0.38	0.07	0.00	0.69	0.00	0.00	0.00
-0.36	-0.47	-0.63	-0.25	-0.08	-0.40	-0.10	0.42	0.00	0.00	0.00
-0.10	0.16	-0.24	-0.55	0.13	-0.01	0.07	0.08	0.00	0.00	0.00
0.32	-0.21	0.12	-0.31	-0.43	-0.13	-0.02	-0.11	0.00	0.00	0.00
0.08	0.71	0.49	0.54	0.19	0.53	0.69	0.77	0.00	0.00	0.00
-0.73	-0.04	-0.09	0.47	0.27	0.02	-0.20	0.02	0.00	0.00	0.00
-0.08	-0.12	-0.06	-0.33	-0.13	-0.01	-0.19	0.46	0.00	0.00	0.00
-0.49	-0.51	-0.01	-0.06	-0.32	0.09	-0.22	-0.41	0.00	0.00	0.00
0.25	0.37	0.32	0.96	0.81	0.32	0.34	0.35	0.00	0.00	0.00
0.54	0.51	0.56	0.19	0.47	0.52	-0.58	0.17	0.00	0.00	0.00
0.01	-0.44	-0.22	-0.20	-0.04	-0.39	-0.45	-0.15	0.00	0.00	0.00
0.56	0.66	0.43	0.26	0.10	0.19	0.27	-0.02	0.00	0.00	0.00
0.12	-0.11	-0.09	0.09	-0.08	-0.01	-0.10	0.19	0.00	0.00	0.00
0.00	-0.12	-0.43	-0.51	-0.47	-0.62	-0.60	-0.59	0.00	0.00	0.00

able 4.3. Time Series Analysis: Diagnostic output for 4TVn cod.

STANDARDIZED CATCH PREDICTION ERRORS

4	0.00	1.33	-0.72	-1.55	-0.58	-1.55	-1.50	-1.14	-0.74	1.15	-1.42	-0.63	-0.69	0.70
5	0.00	-0.26	-0.51	-0.78	-1.15	-0.52	-0.78	-1.75	0.95	0.54	-0.28	-0.74	-0.65	0.83
6	0.00	0.68	0.39	-0.55	0.04	-0.98	0.82	-0.63	0.82	2.02	-0.45	0.10	0.16	0.10
7	0.00	1.33	0.73	0.92	-0.08	-0.92	-0.07	-0.11	-0.04	-0.64	1.26	-0.34	-0.05	0.31
8	0.00	1.03	1.34	-1.12	1.45	-0.02	-0.75	-0.44	0.13	-1.39	-0.77	1.19	0.00	0.20
9	0.00	-0.06	1.86	-0.48	0.15	0.09	0.85	-0.16	-0.42	-0.29	-1.05	1.49	0.09	0.34
10	0.00	0.88	1.98	-0.35	0.25	-0.20	2.09	0.71	-0.82	-0.39	-0.02	0.26	2.01	0.57
11	0.00	-0.09	2.67	0.12	0.09	-0.98	-1.63	0.43	-0.68	-1.05	-1.53	0.24	-0.39	0.96

SELECTIVITY
0.196 0.269 0.266 0.265 0.264 0.000 0.000 0.000
SKEWNESS AND KURTOSIS
2.024 -0.240
VARIANCE AT AGE

1.2478 0.7037 0.6129 0.4782 0.8430 0.6272 1.1591 1.2334
VARIANCE AT YEAR

0.7409 2.2216 0.7226 0.4816 0.6850 1.4800 0.7098 0.4346 1.1732 0.9889
VARIANCE AT YEAR

0.6041 0.6421 0.3369
CORRELATION WITHIN COHORTS 0.35

CORRELATION WITHIN AGES AND YEARS 0.34 0.11

STANDARDIZED PREDICTION ERRORS OF CPUE

4	0.00	-0.75	0.94	-0.41	1.25	-1.77	0.09	0.20	0.63	0.04	-1.93	0.75	-1.31	-0.55
5	0.00	-0.75	0.10	0.40	1.48	-1.84	-0.49	0.57	1.65	0.40	-1.90	1.20	-1.41	-0.81
6	0.00	-0.04	0.36	0.26	1.61	0.78	-0.55	0.07	2.31	0.94	-1.42	1.13	-0.34	-0.72
7	0.00	0.45	0.52	0.39	1.32	-0.78	-0.33	-0.34	1.82	1.19	-0.55	0.65	-0.72	-0.73
8	0.00	-0.63	0.13	-0.18	1.90	-0.49	-0.37	0.24	0.58	-0.27	-1.41	1.18	-0.45	-0.81

SKEWNESS AND KURTOSIS
0.555 -0.812
VARIANCE AT AGE

1.1017 1.3973 1.1147 0.7844 0.7685
VARIANCE AT YEAR

0.4903 0.7071 0.2607 2.4390 1.7379 0.4570 0.2503 2.5092 0.7431 2.5258
VARIANCE AT YEAR

1.1427 1.0370 0.6002
CORRELATION WITHIN COHORTS -0.05

CORRELATION WITHIN AGES AND YEARS 0.67 -0.15

Table 5.1

Residuals from regressions vs time. Firth of forth.

Simple Regression X_1: resid-eff Y_1: resid-F.LS

DF:	R:	R-squared:	Adj. R-squared:	Std. Error:
9	.739	.546	.489	.104

Analysis of Variance Table

Source	DF:	Sum Squares:	Mean Square:	F-test:
REGRESSION	1	.103	.103	9.612
RESIDUAL	8	.086	.011	p = .0147
TOTAL	9	.189		

Residual Information Table

SS[e(i)-e(i-1)]:	e ≥ 0:	e < 0:	DW test:
.145	4	6	1.685

Simple Regression X_1: resid-eff Y_1: resid-F.LS

Beta Coefficient Table

Parameter:	Value:	Std. Err.:	Std. Value:	t-Value:	Probability:
INTERCEPT	-4.6864E-18				
SLOPE	.01	3.186E-3	.739	3.1	.0147

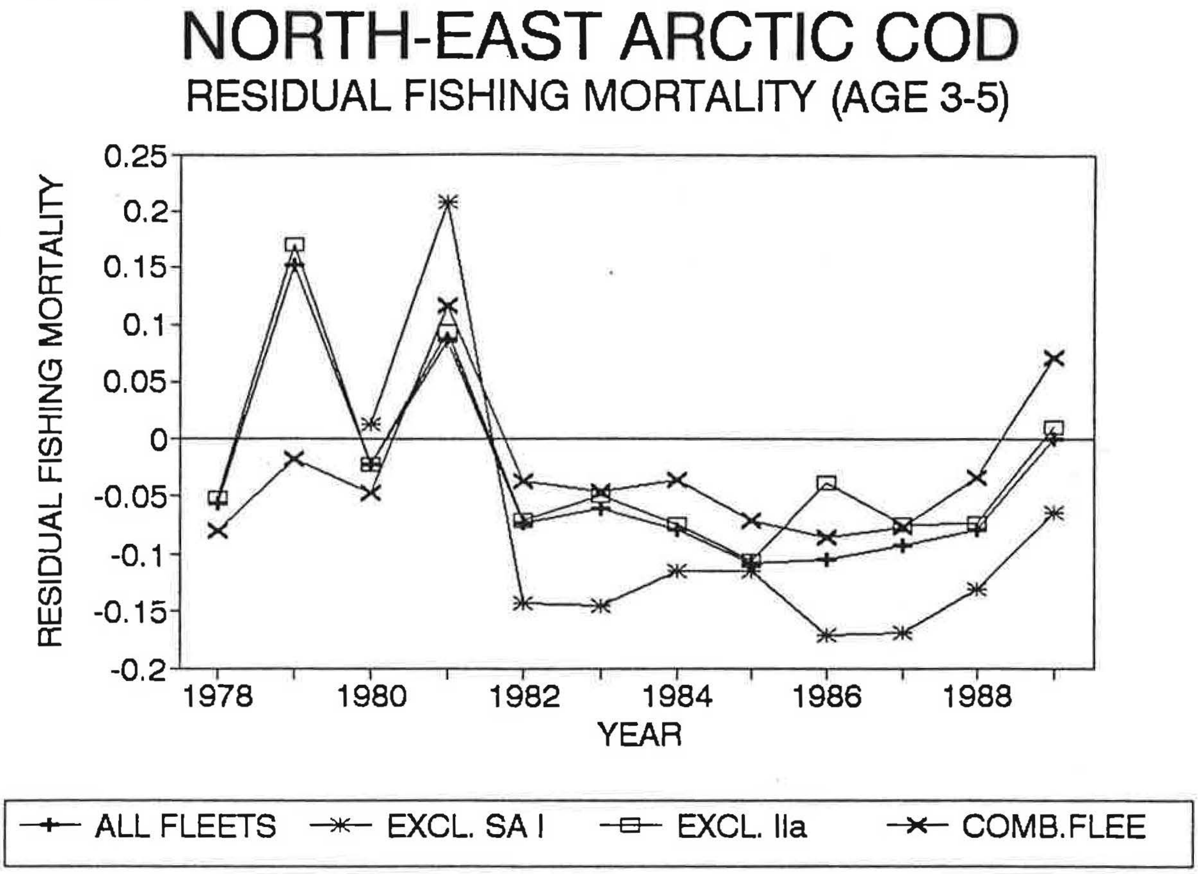
Confidence Intervals Table

Parameter:	95% Lower:	95% Upper:	90% Lower:	90% Upper:
MEAN (X,Y)	-.076	.076	-.061	.061
SLOPE	2.530E-3	.017	3.952E-3	.016

Table 5.2 Residual table from Clyde *Nephrops* length-based analysis. The plus minus signs represent one positive and negative standard deviation from the mean. The asterisk and equal signs denote two standard deviations. Note the band of asterisks at 31 mm which suggests that there is a size effect not accuonted for by the growth model. A diagonal pattern would indicate an improperly estimated year class and vertical bands would reflect a year effect.

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Length										
17	.	.	.	+	.	.	.	.	.	.
19	-	.	.	*	.	.	.	.	-	.
21	=	-	-	*	.	.	-	-	=	.
23	=	+	-	*	+	+	.	-	=	.
25	+	*	*	*	*	*	*	.	-	.
27	-	.	.	.	-	.	-	-	=	=
29	+	.	+	.	.	-	-	-	=	=
31	*	*	*	*	*	*	*	*	+	*
33	.	+	+	.	.	-	.	-	.	+
35	=	-	-	-	-	-	-	-	.	.
37	+	.	+	.	.	.	.	+	.	.
39	.	-	.	.	.	.	.	+	.	.
41	.	.	.	.	.	.	.	+	.	.
43	.	.	.	.	.	.	.	.	.	.
45	.	.	.	.	.	.	.	.	.	.
47	.	.	.	.	.	.	.	.	.	.
49	.	.	.	.	.	.	.	.	.	.
51	.	.	.	.	.	.	.	.	.	.
53	.	.	.	.	.	.	.	.	.	.
55	.	.	.	.	.	.	.	.	.	.
57	.	.	.	.	.	.	.	.	.	.
59	.	.	.	.	.	.	.	.	.	.
61	.	.	.	.	.	.	.	.	.	.
63	.	.	.	.	.	.	.	.	.	.
65	.	.	.	.	.	.	.	.	.	.
67	.	.	.	.	.	.	.	.	.	.

Figure 2.1


NORTH-EAST ARCTIC COD
RESIDUAL FISHING MORTALITY (AGE 3-5)
RESIDUAL FISHING MORTALITY
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
1978
1980
1982
1984
1986
1988
YEAR
ALL FLEETS
EXCL. SA I
EXCL. IIa
COMB.FLEE

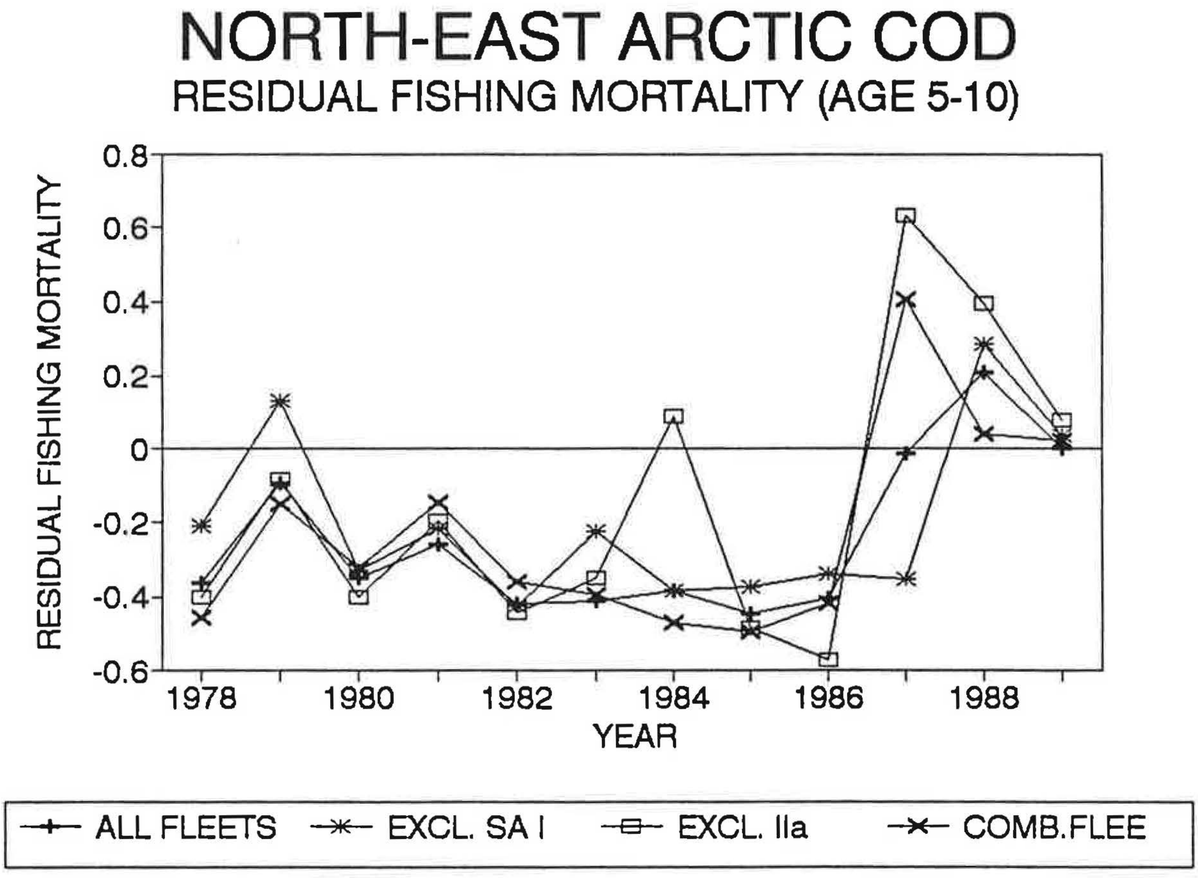
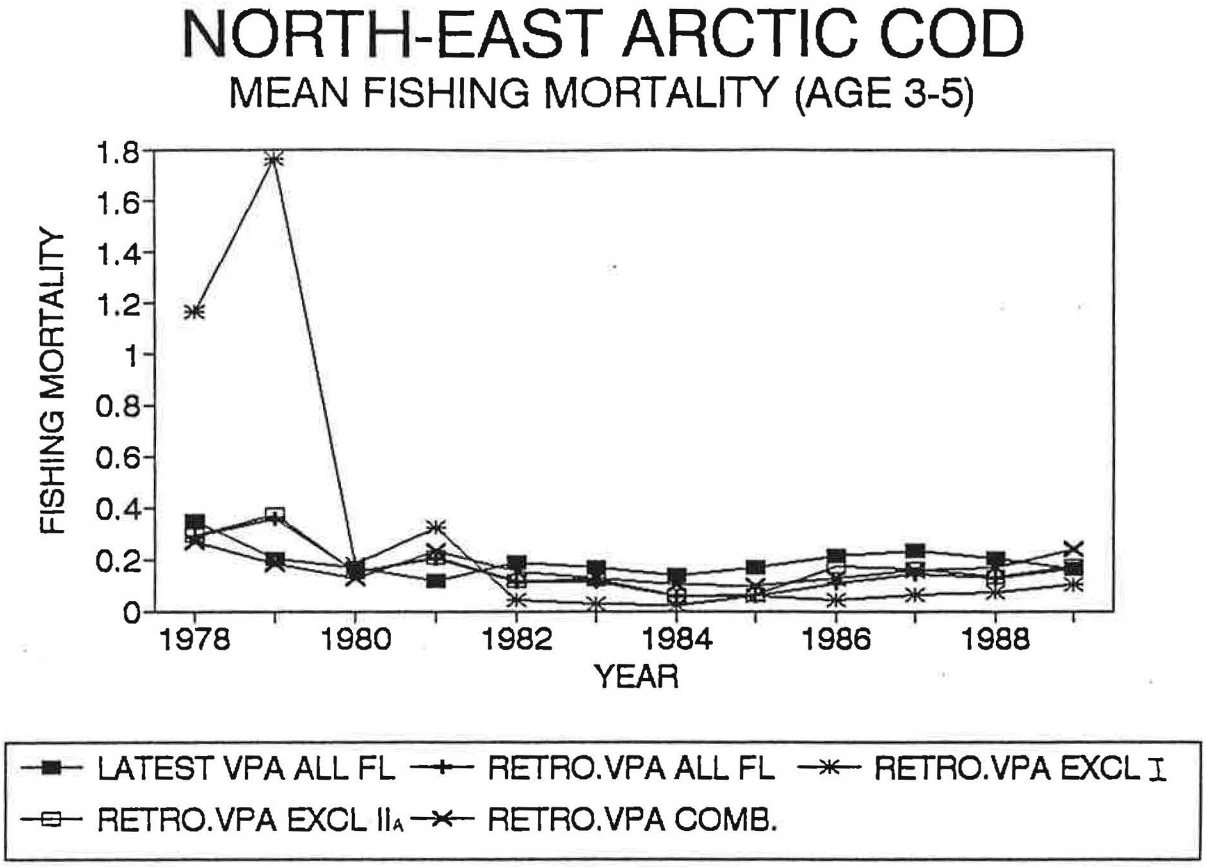

NORTH-EAST ARCTIC COD
RESIDUAL FISHING MORTALITY (AGE 5-10)
RESIDUAL FISHING MORTALITY
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
1978
1980
1982
1984
1986
1988
YEAR
ALL FLEETS
EXCL. SA I
EXCL. IIa
COMB.FLEE

Figure 2.2


NORTH-EAST ARCTIC COD
MEAN FISHING MORTALITY (AGE 3-5)
FISHING MORTALITY
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1978
1980
1982
1984
1986
1988
YEAR
LATEST VPA ALL FL
RETRO.VPA ALL FL
RETRO.VPA EXCL I
RETRO.VPA EXCL IIA
RETRO.VPA COMB.

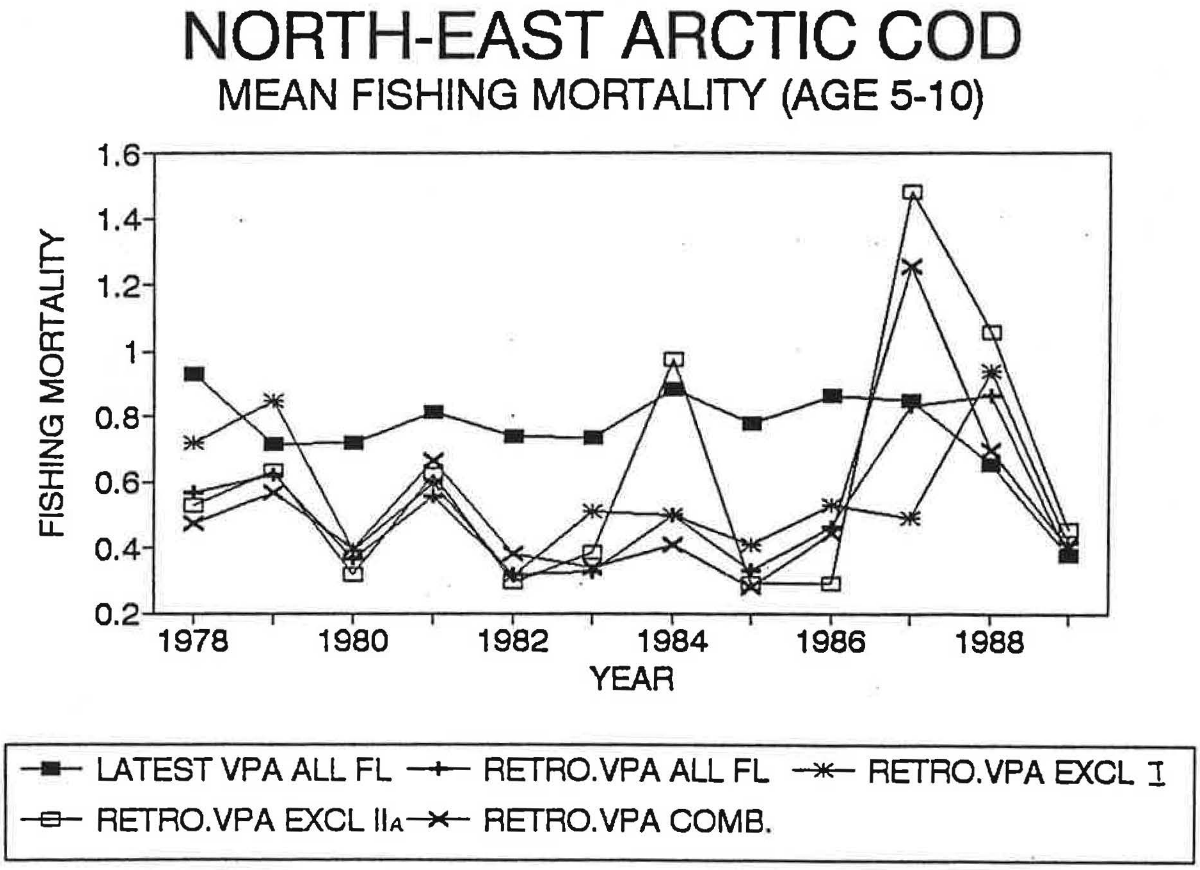

NORTH-EAST ARCTIC COD
MEAN FISHING MORTALITY (AGE 5-10)
FISHING MORTALITY
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
1978
1980
1982
1984
1986
1988
YEAR
LATEST VPA ALL FL
RETRO.VPA ALL FL
RETRO.VPA EXCL I
RETRO.VPA EXCL IIA
RETRO.VPA COMB.

Figure 3.1

Figure 3.1. Retrospective analysis
Stock: North Sea Cod
Procedure: Laurec – Shepherd

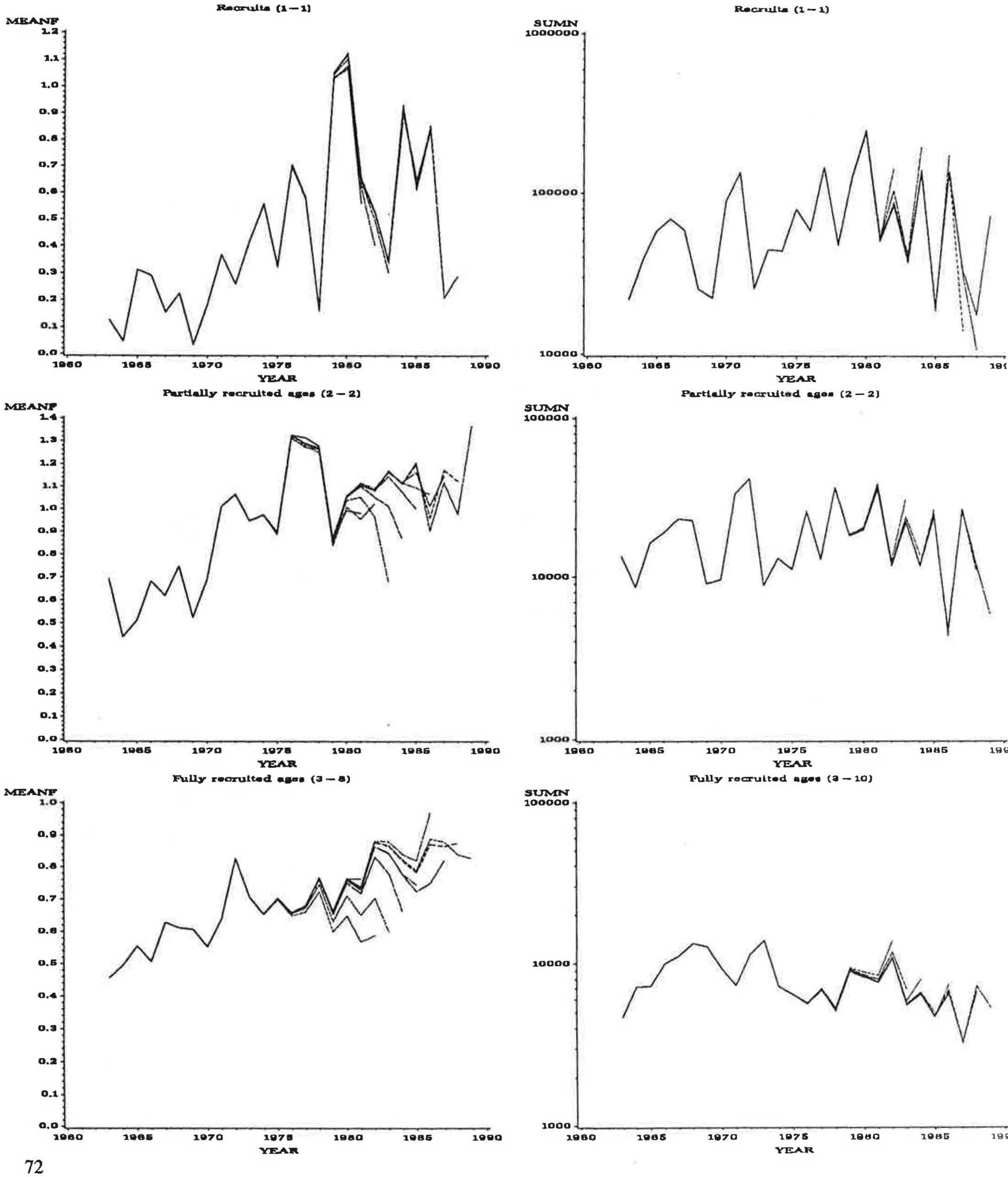


Figure 3.2

Retrospective analysis

Stock: North Sea Cod

Procedure: Extended Survivors Analysis

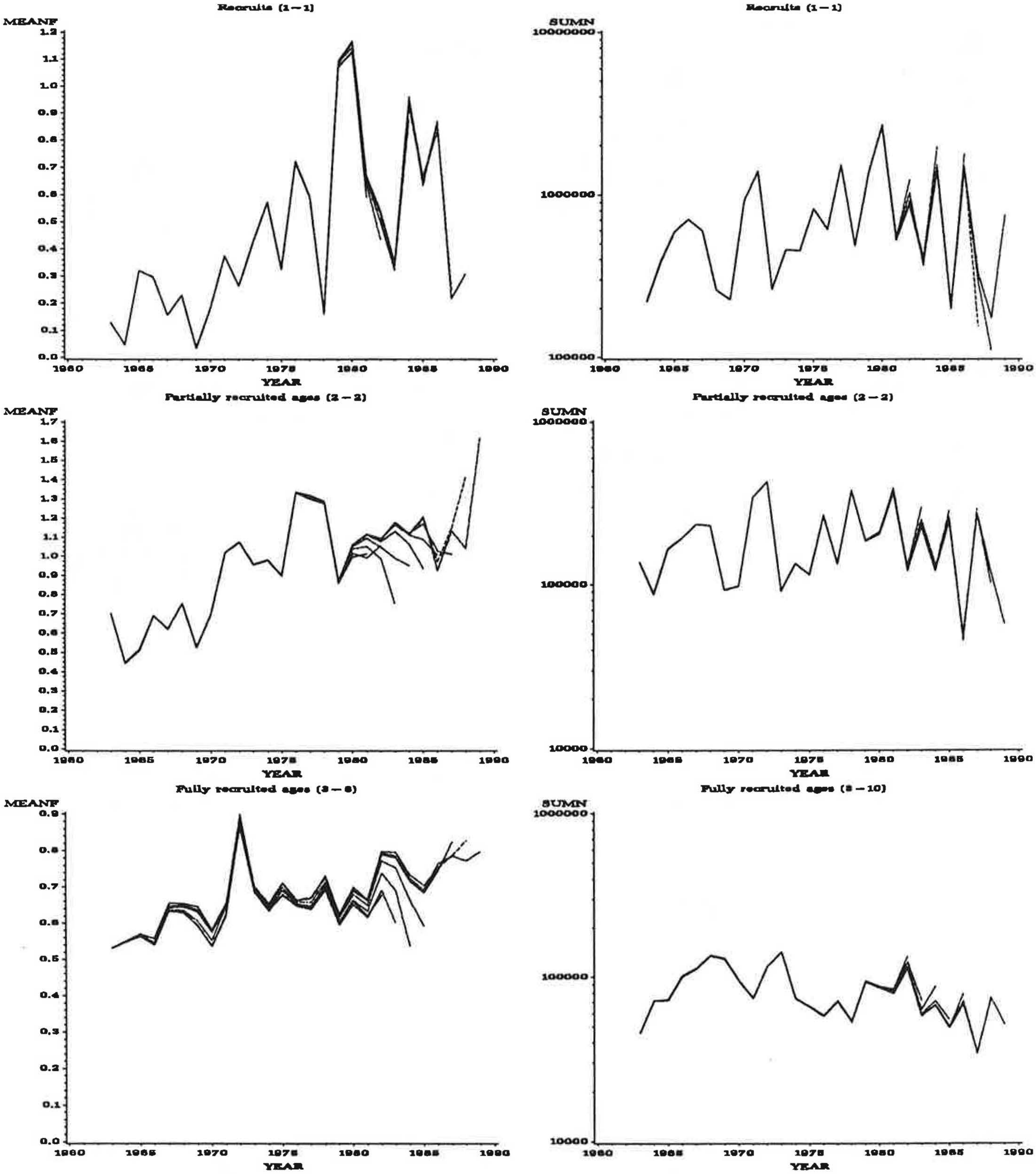


Figure 3.3

Stock: North Sea Cod

Procedure: Time Series Analysis

Retrospective analysis

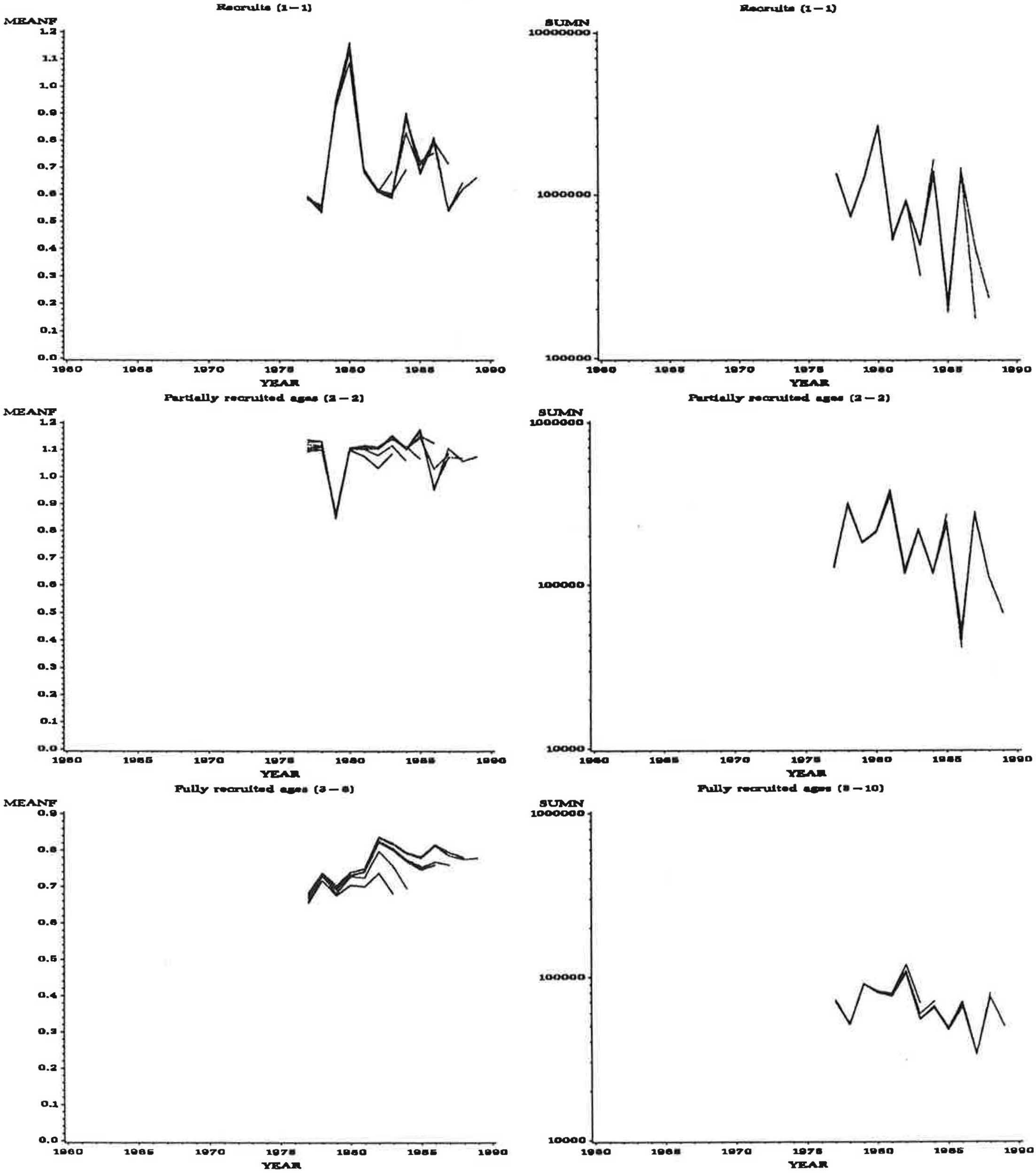


Figure 3.4

Stock: Irish Sea (VIIa) Plaice

Procedure: Laurec – Shepherd

Retrospective analysis

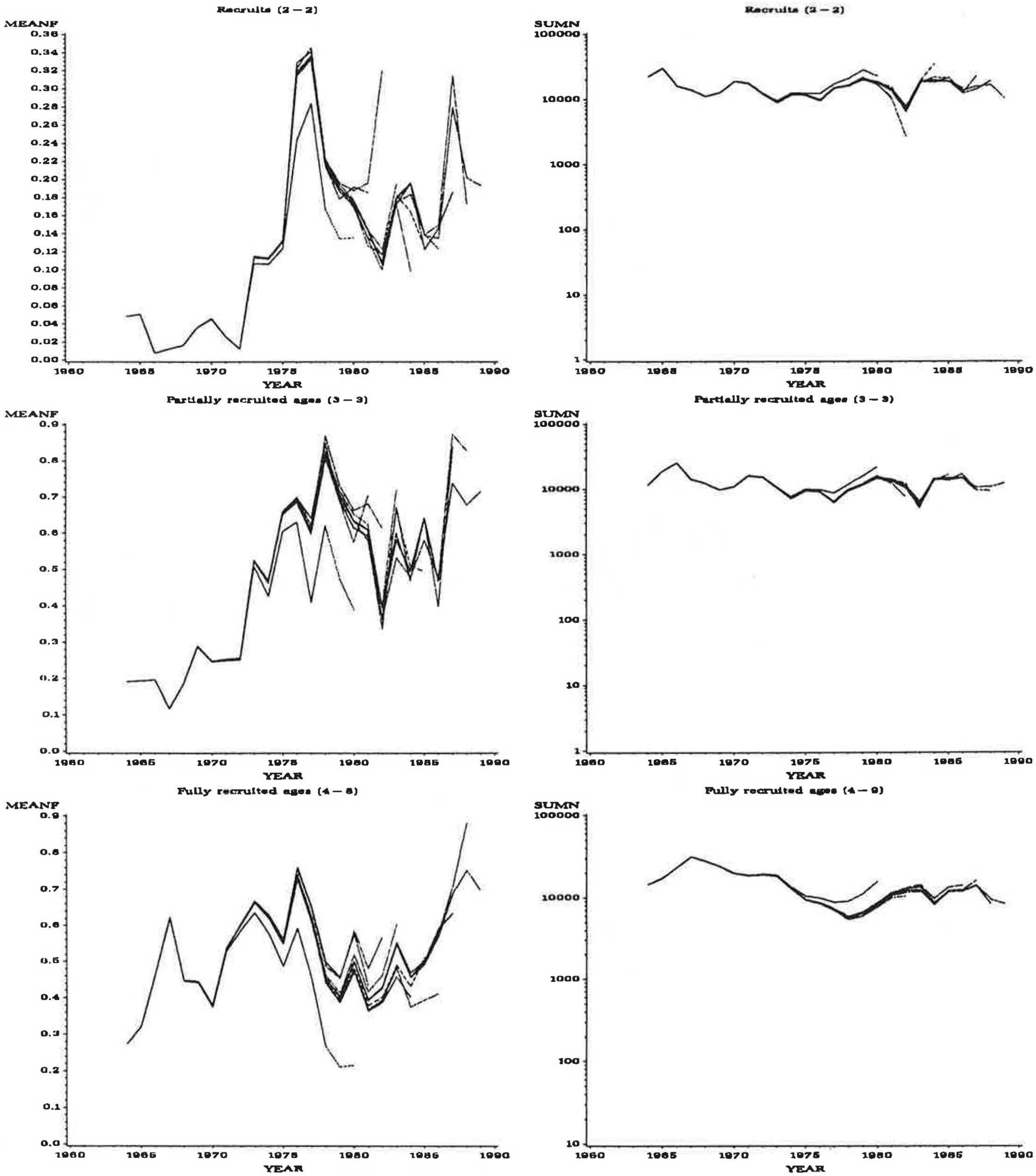


Figure 3.5

	Retrospective analysis
Stock:	Irish Sea (VIIa) Plaice
Procedure:	ADAPT

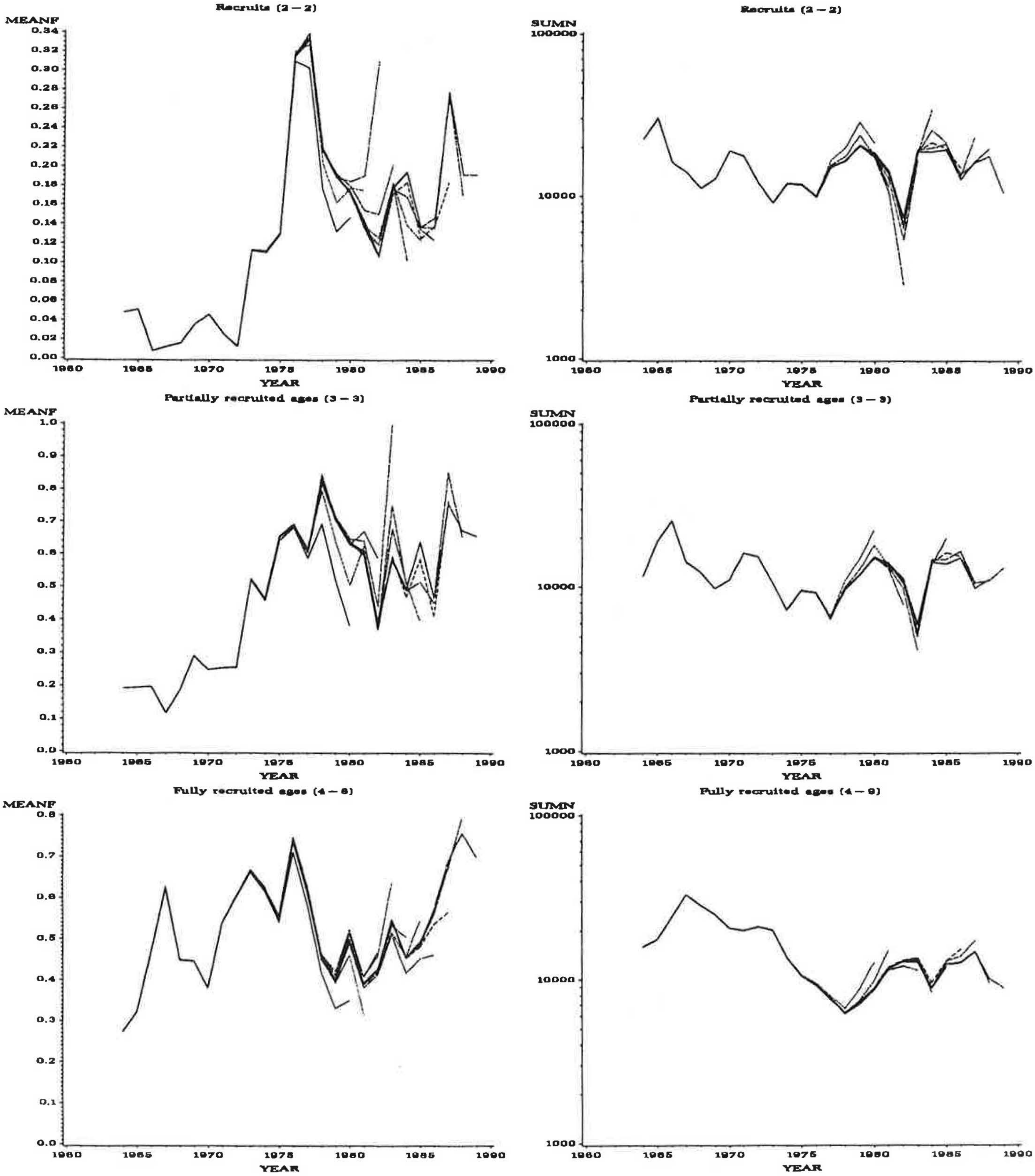


Figure 3.6

Stock: Irish Sea (VIIa) Plaice
Procedure: Extended Survivors Analysis

Retrospective analysis

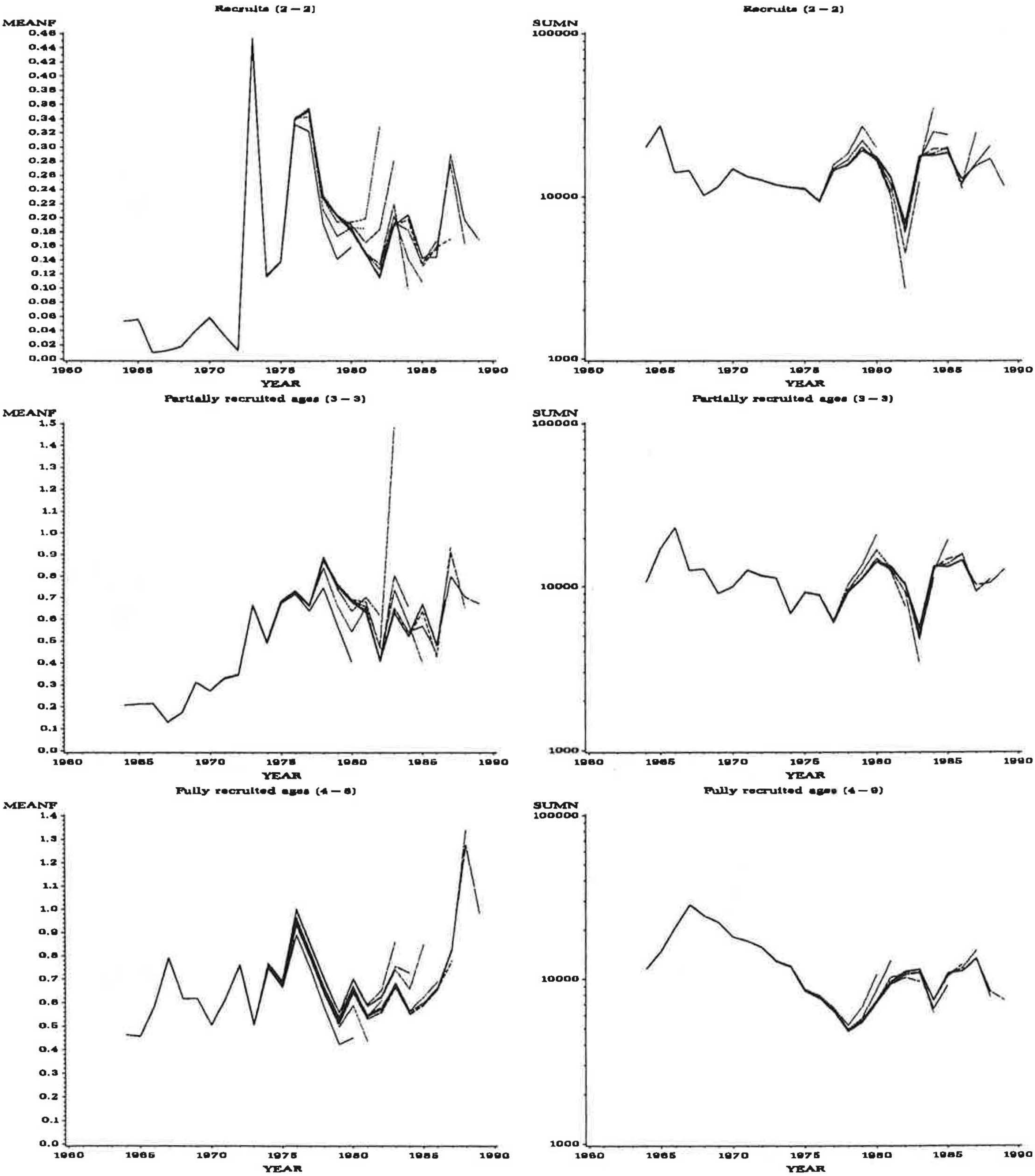


Figure 3.7

Stock: Irish Sea (VIIa) Plaice

Procedure: Time Series Analysis

Retrospective analysis

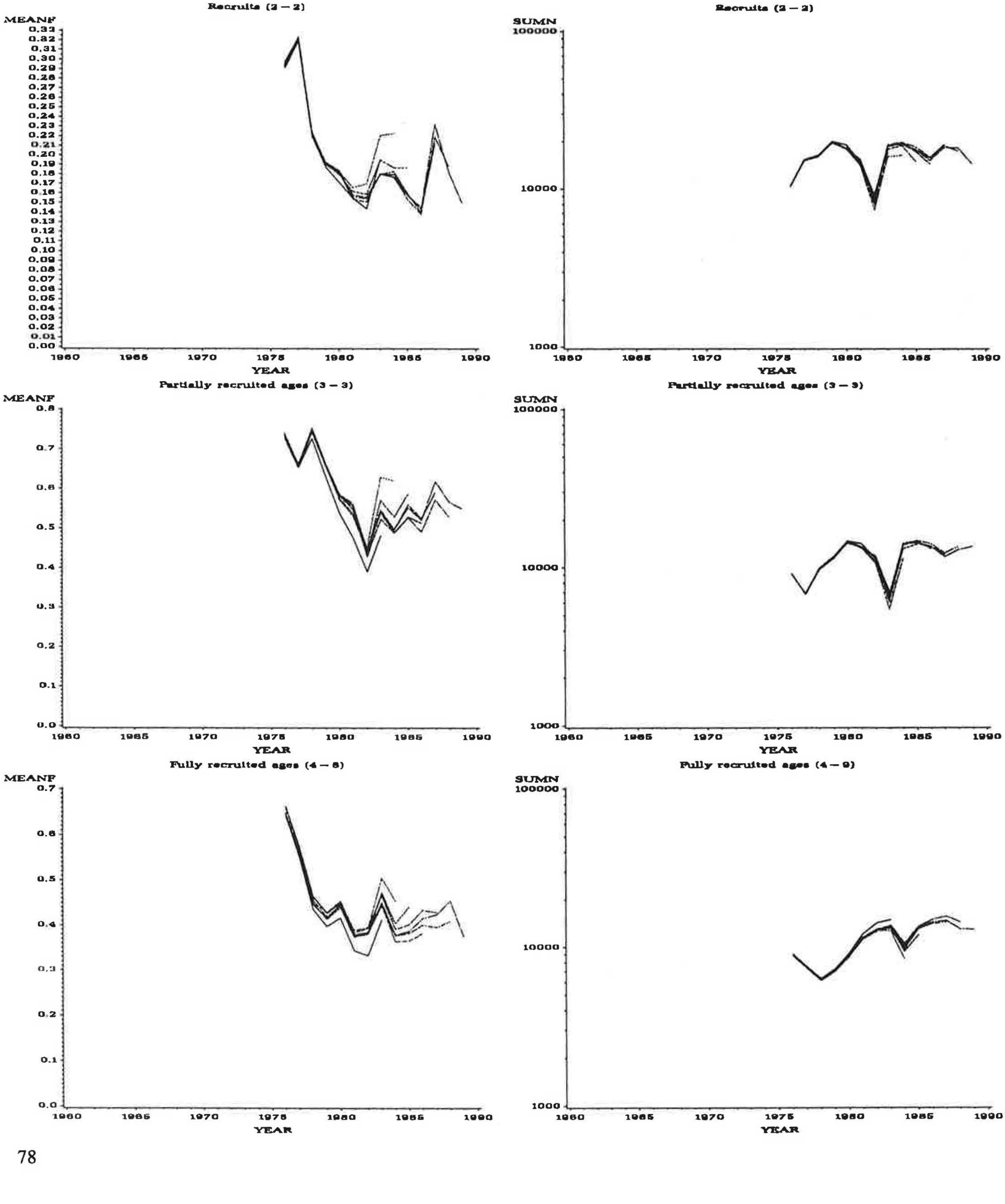


Figure 3.8

Stock: Western English Channel (VIIe) Sole

Procedure: Laurec – Shepherd

Retrospective analysis

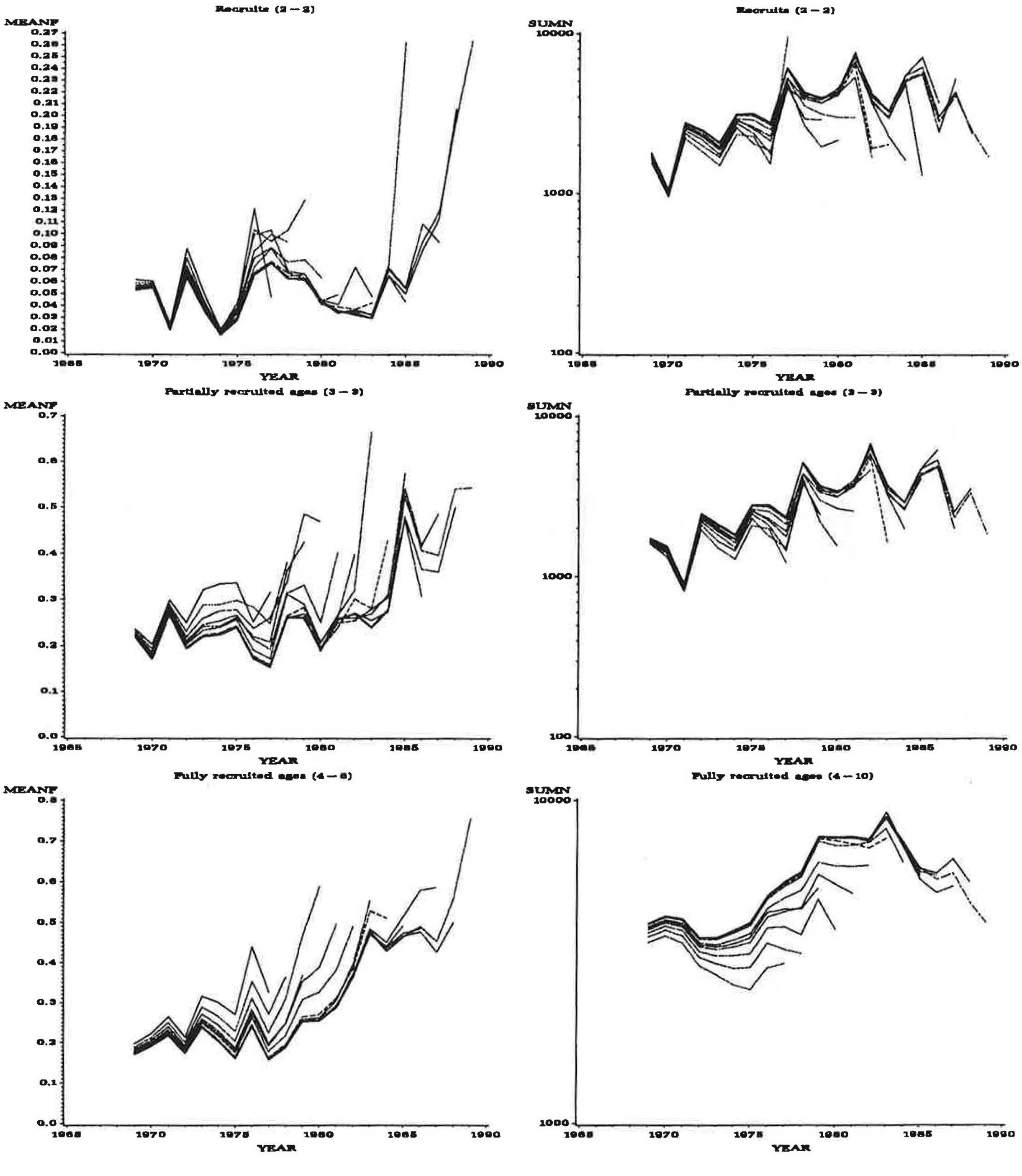


Figure 3.9

Stock: Western English Channel (VIIe) Sole

Procedure: ADAPT

Retrospective analysis

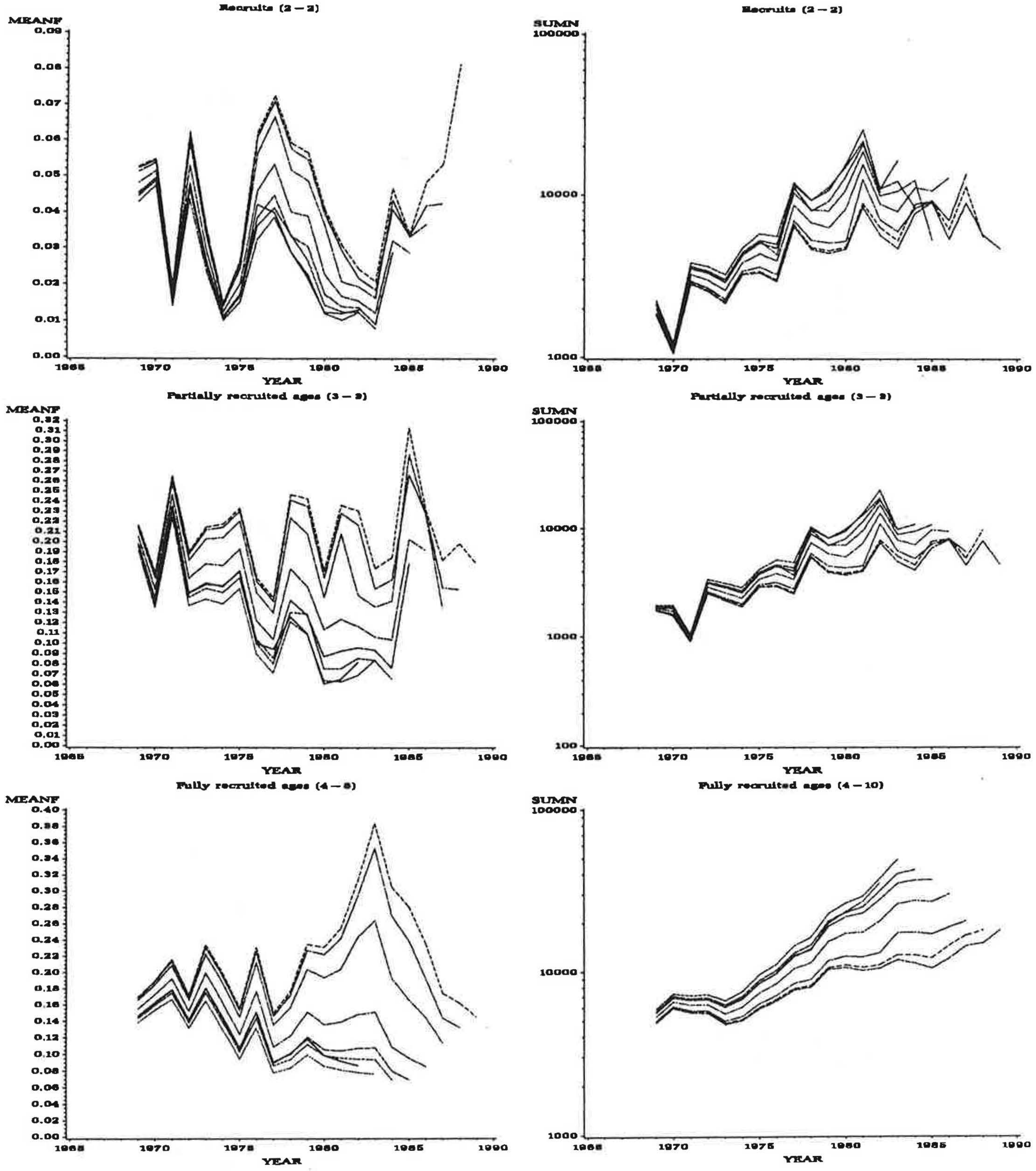


Figure 3.10

Stock: Western English Channel (VIIe) Sole

Procedure: Extended Survivors Analysis

Retrospective analysis

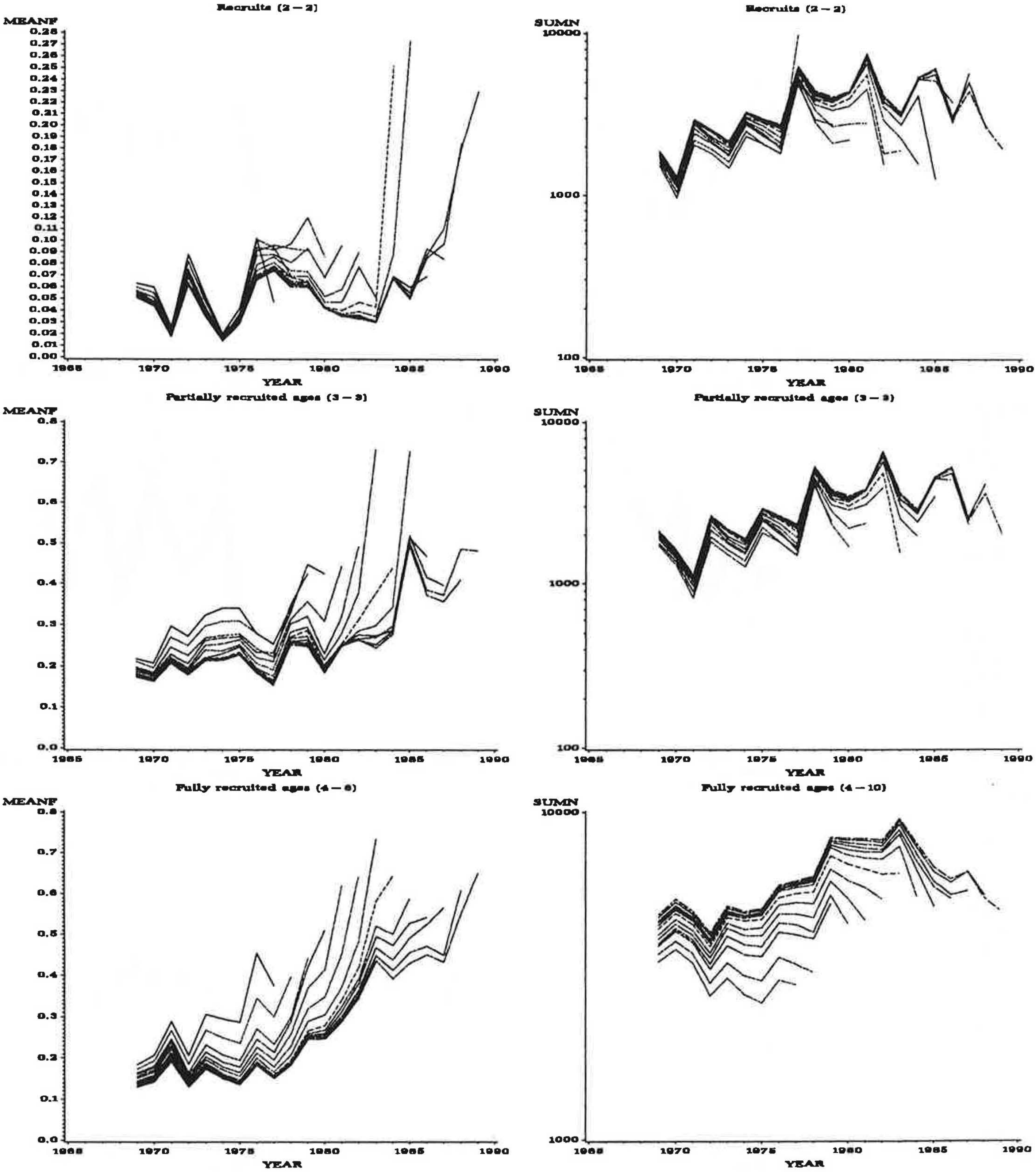


Figure 3.11 Retrospective analysis

Stock: Western English Channel (VIIe) Sole

Procedure: Time Series Analysis

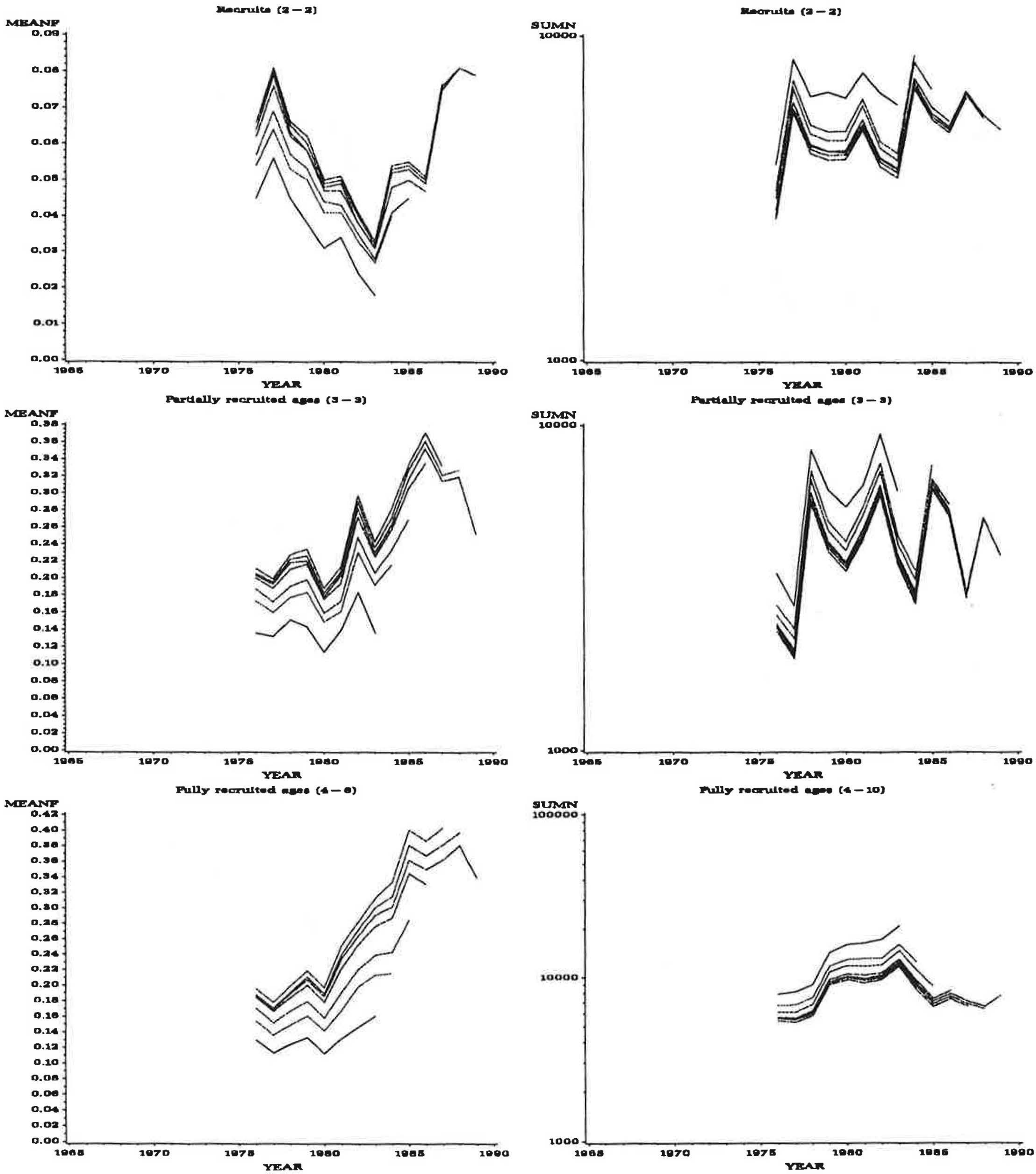


Figure 3.12

Stock: Retrospective analysis Western English Channel (VIIe) Sole

Procedure: Laurec – Shepherd with shrinkage

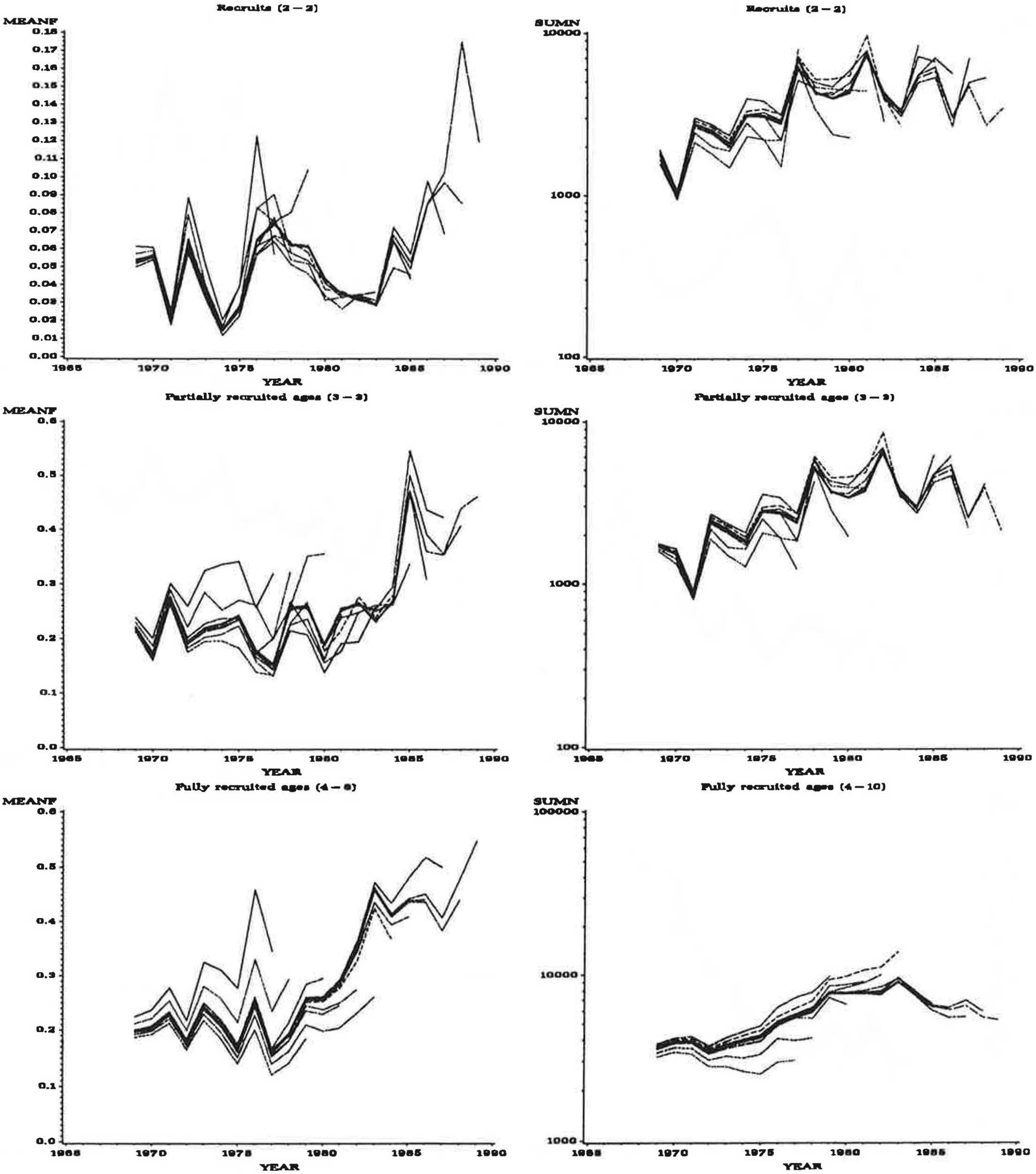


Figure 3.13

Retrospective analysis

Stock: Western English Channel (VIIe) Sole

Procedure: Extended Survivors Analysis with shrinkage

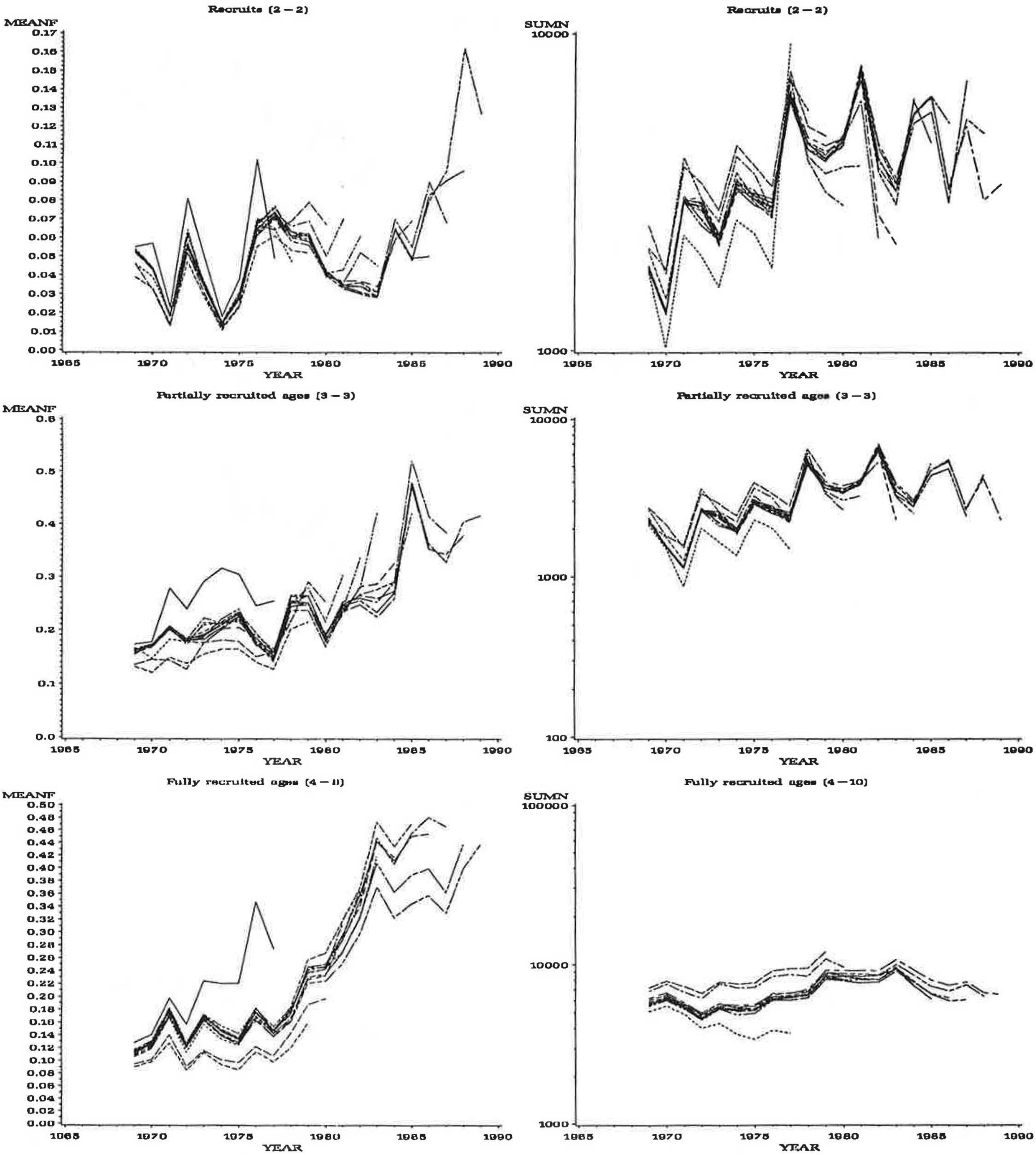


Figure 3.14

Retrospective analysis

Stock: 4TVn Cod

Procedure: Laurec – Shepherd

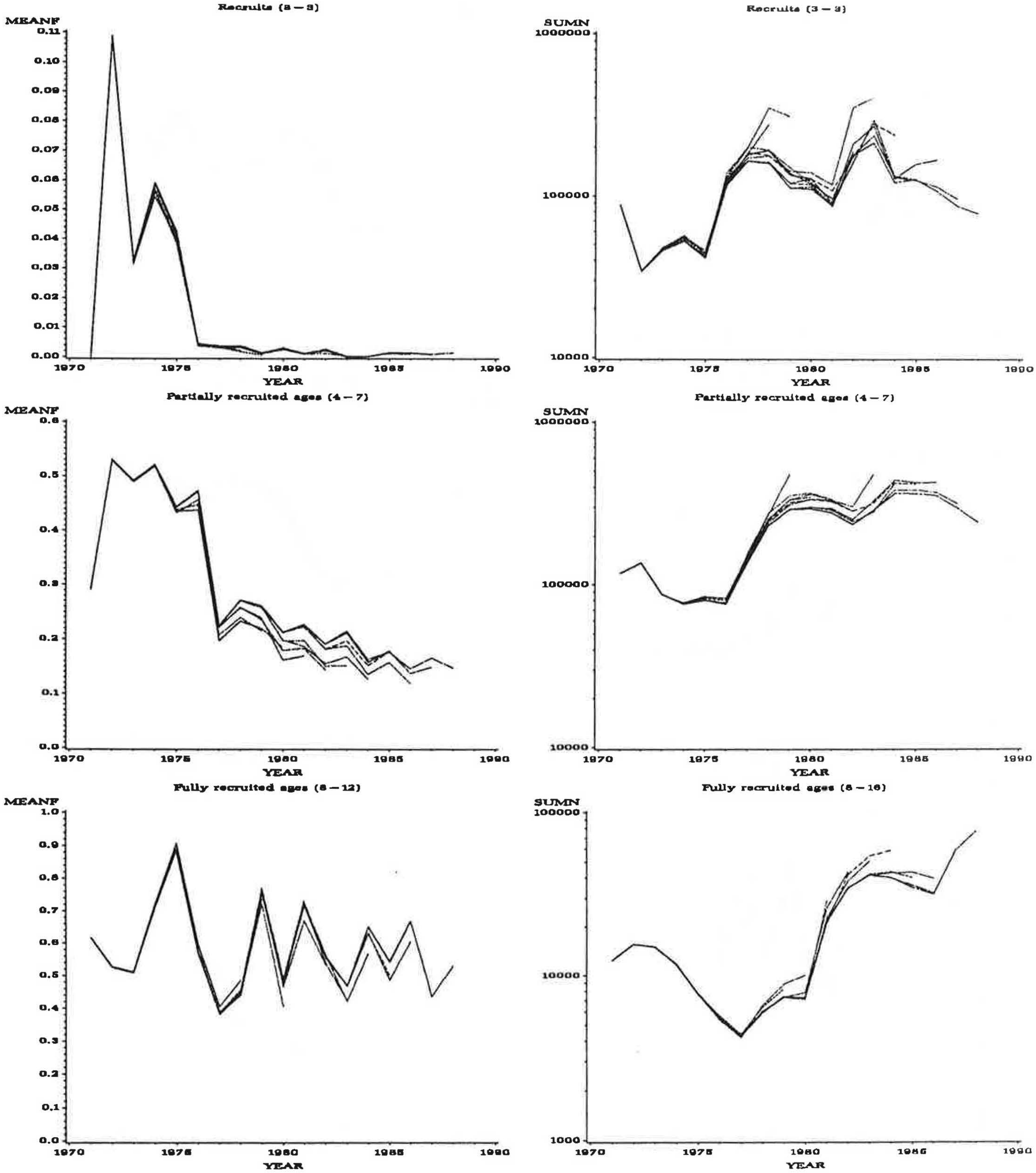


Figure 3.15

Retrospective analysis

Stock: 4TVn Cod

Procedure: ADAPT

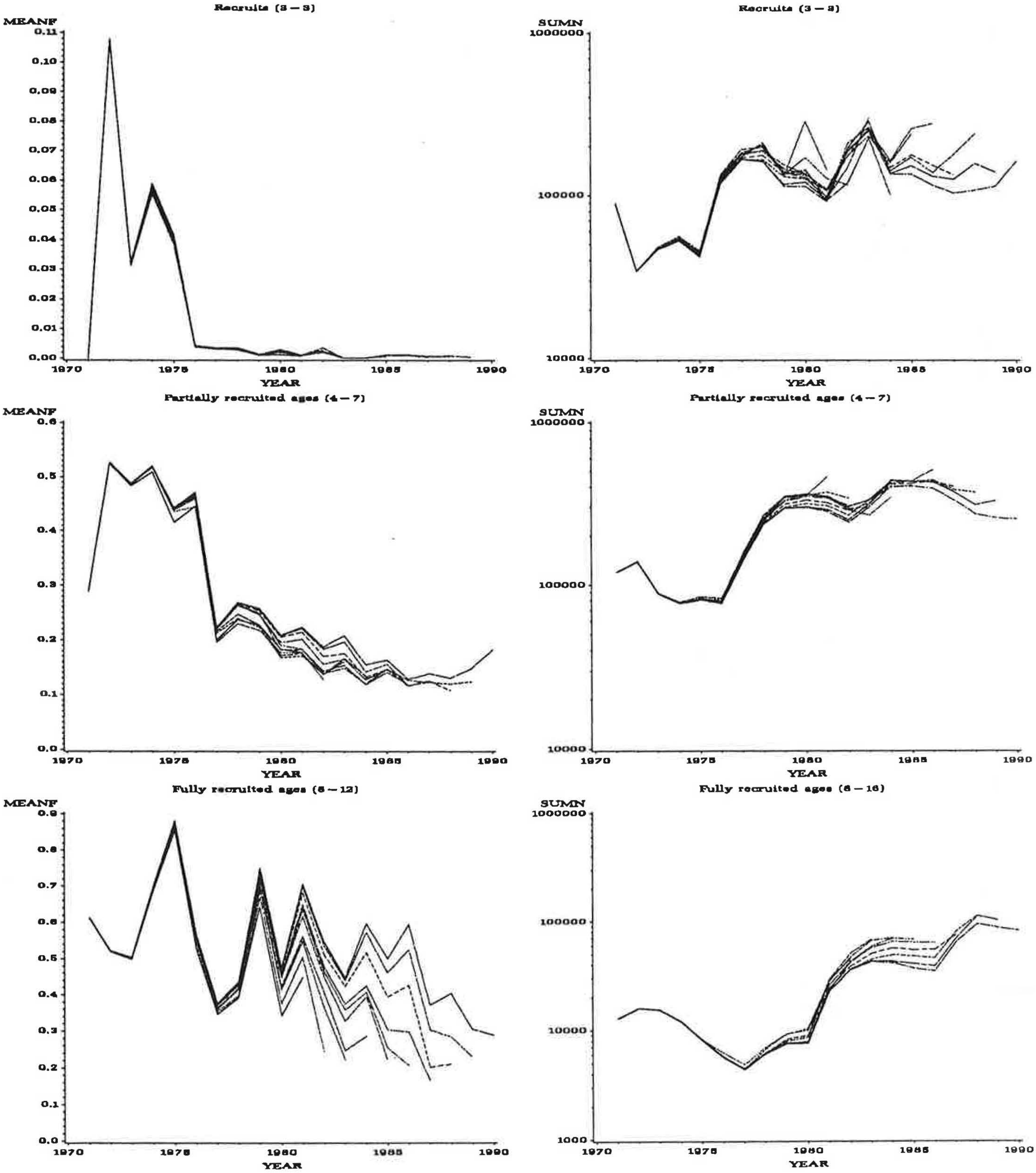


Figure 3.16

Retrospective analysis

Stock: 4TVn Cod

Procedure: Extended Survivors Analysis

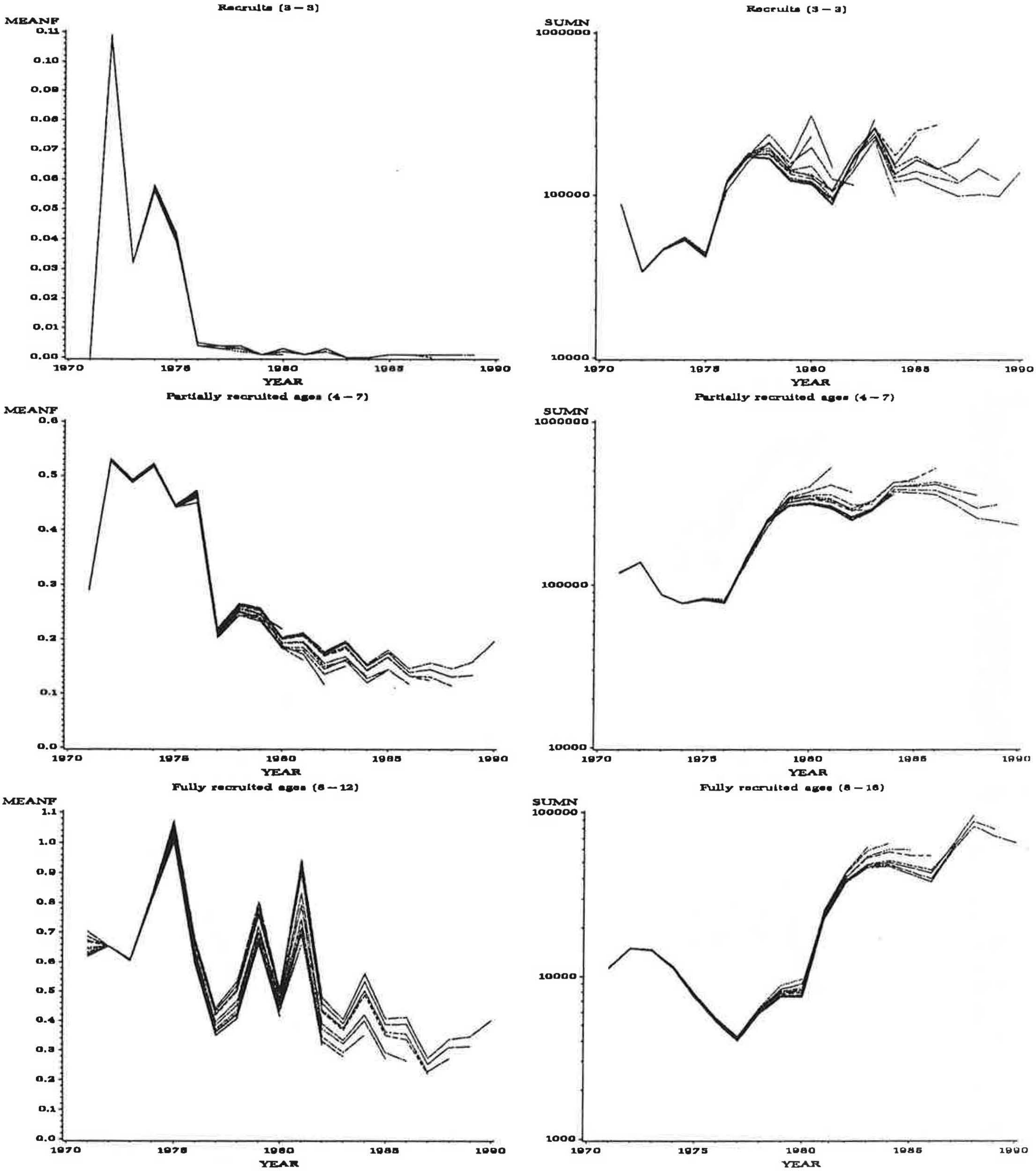


Figure 3.17

Stock: 4TVn Cod

Procedure: Retrospective analysis, Time Series Analysis

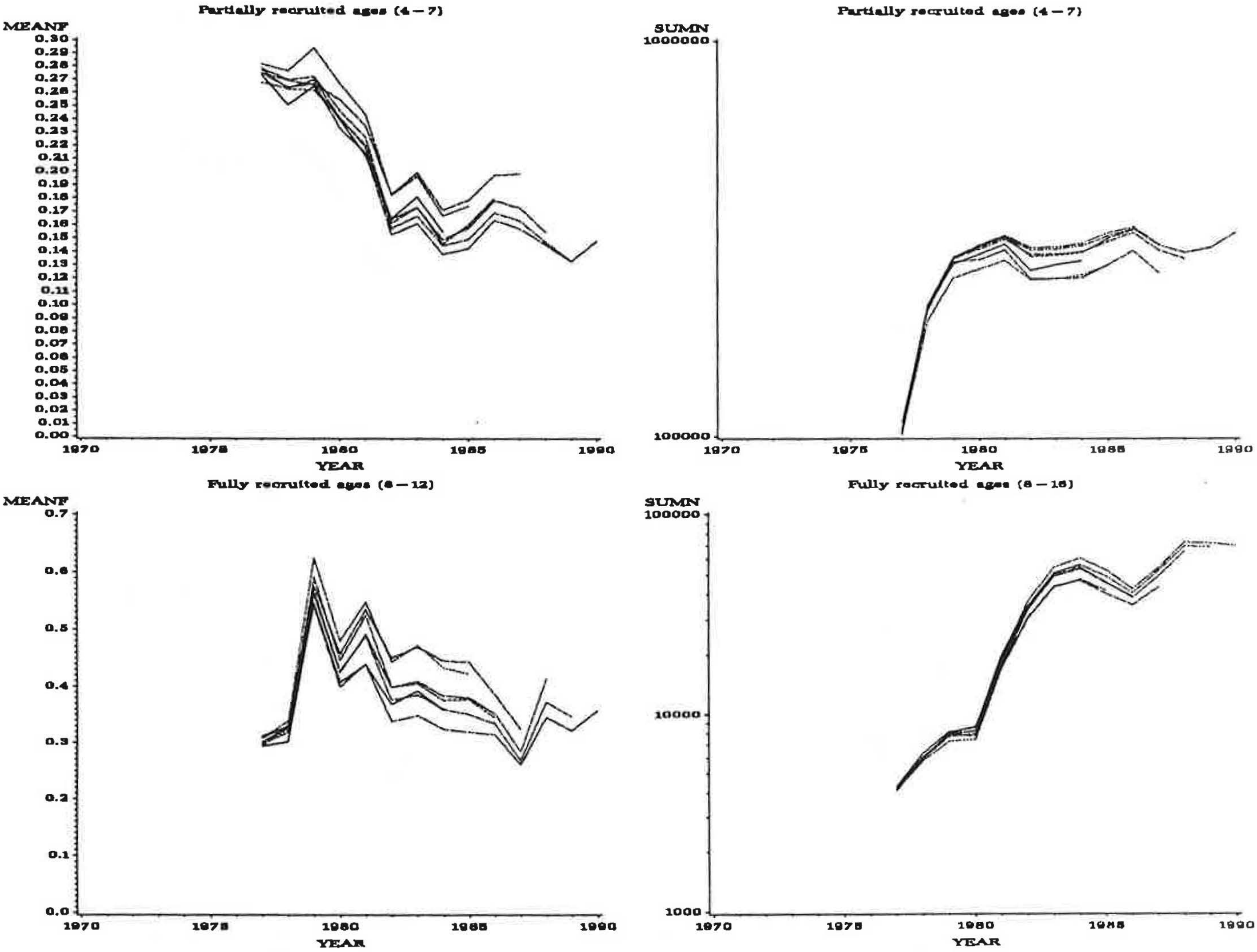


Figure 3.18

Stock: Retrospective analysis 4VsW Cod

Procedure: Laurec – Shepherd

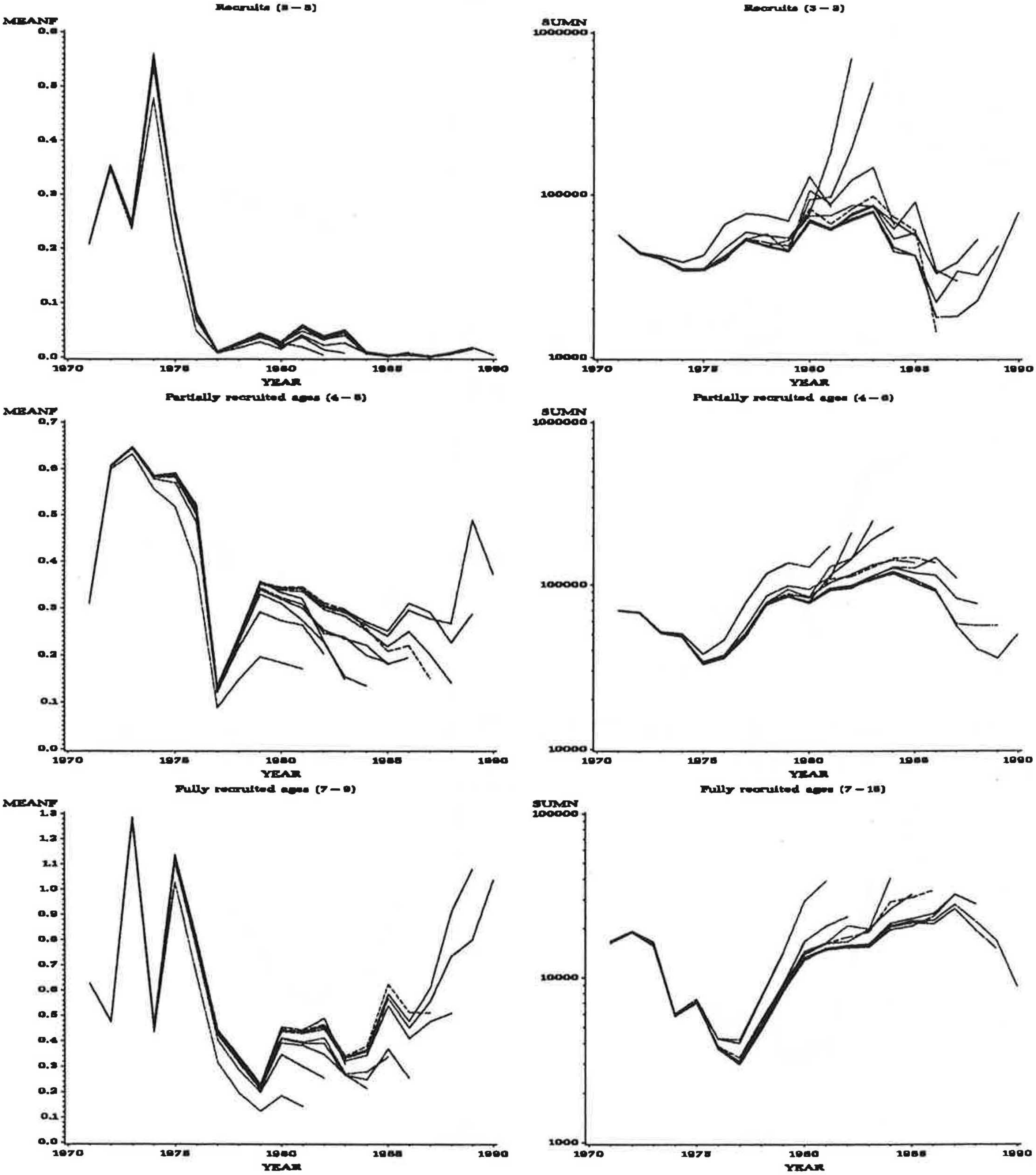


Figure 3.19

Stock: Retrospective analysis 4VsW Cod

Procedure: ADAPT

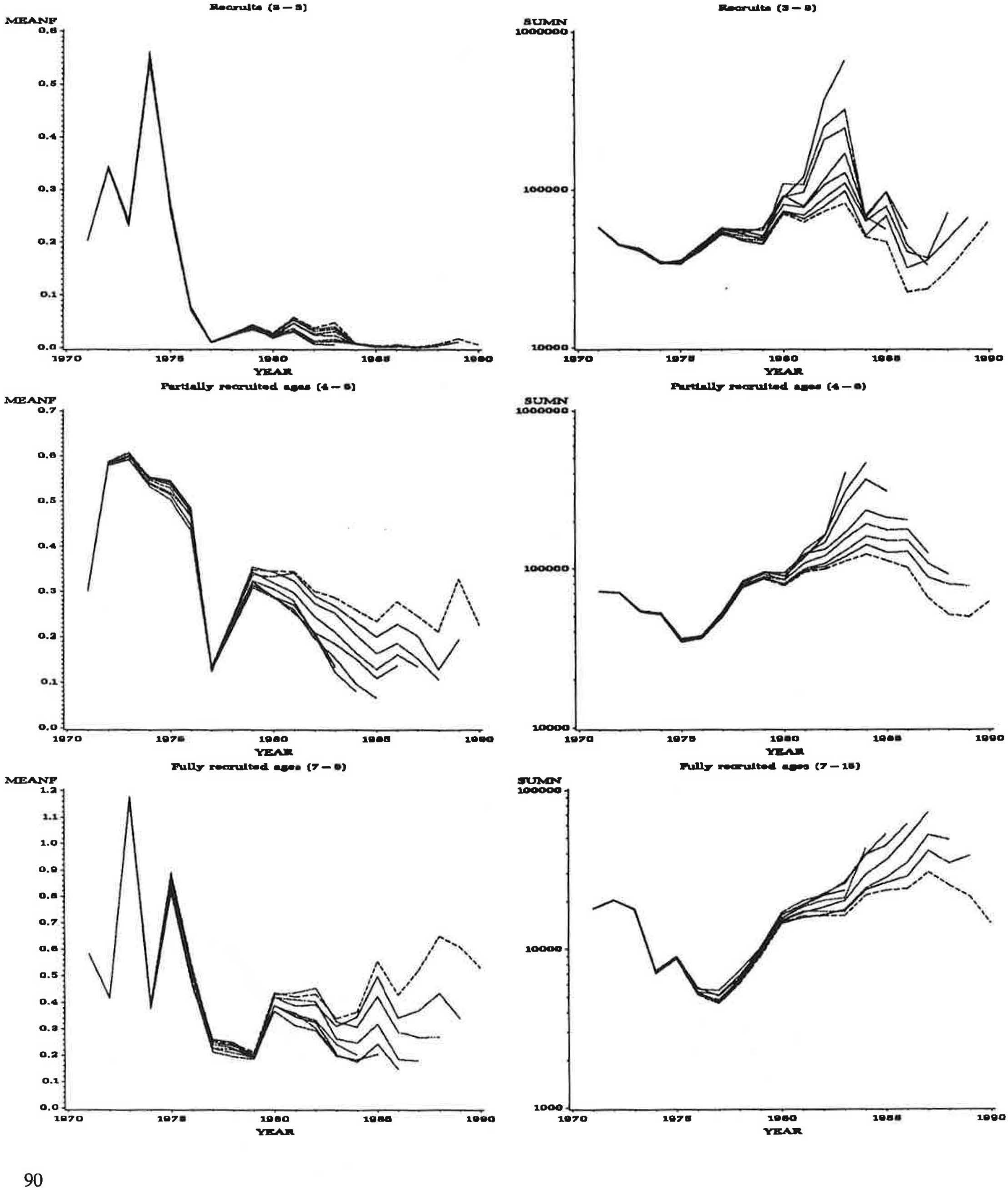


Figure 3.20
Stock:
Procedure:

Retrospective analysis
4VsW Cod
Extended Survivors Analysis

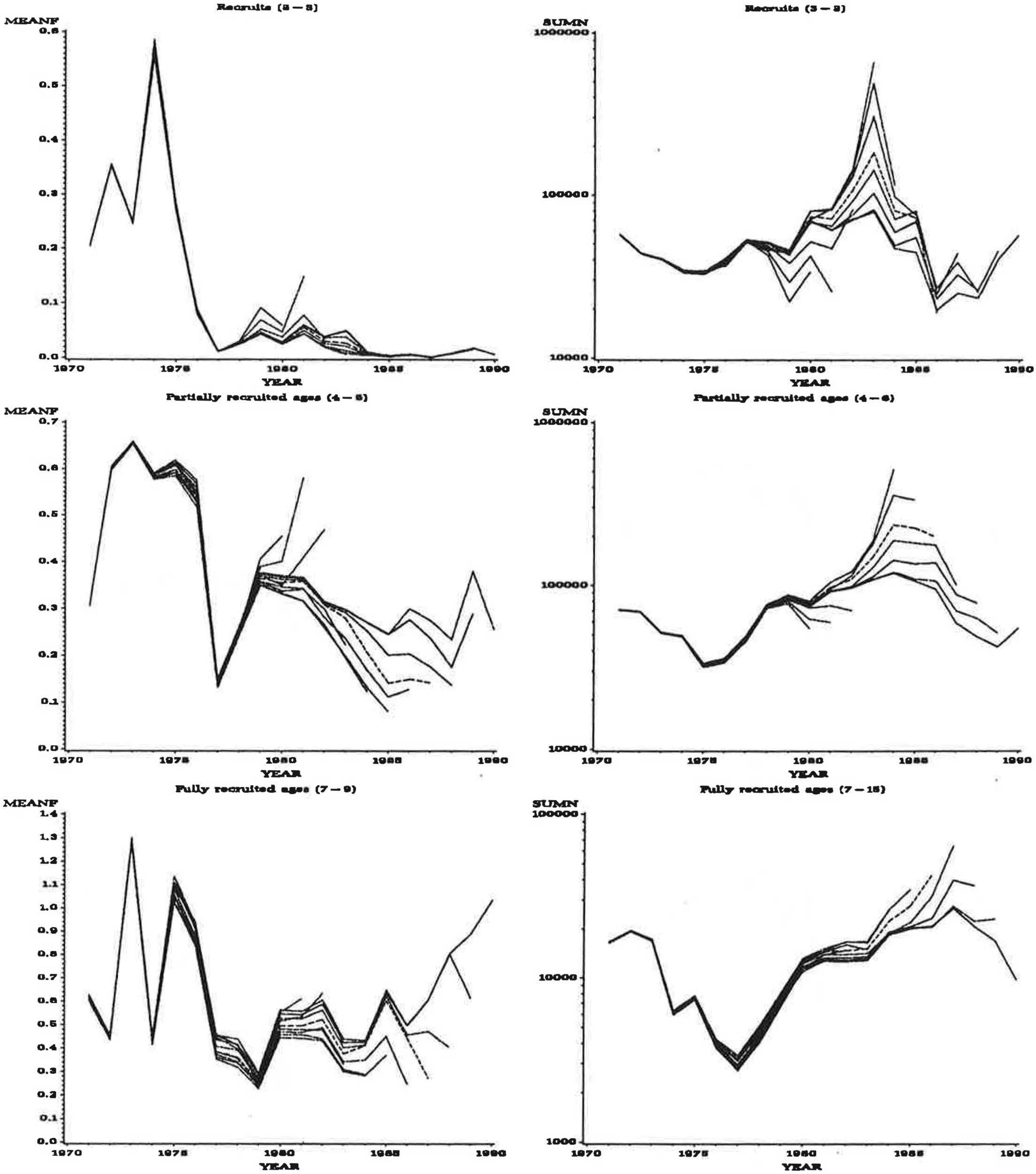


Figure 3.21

Stock: Retrospective analysis
Procedure: 4VsW Cod
Time Series Analysis

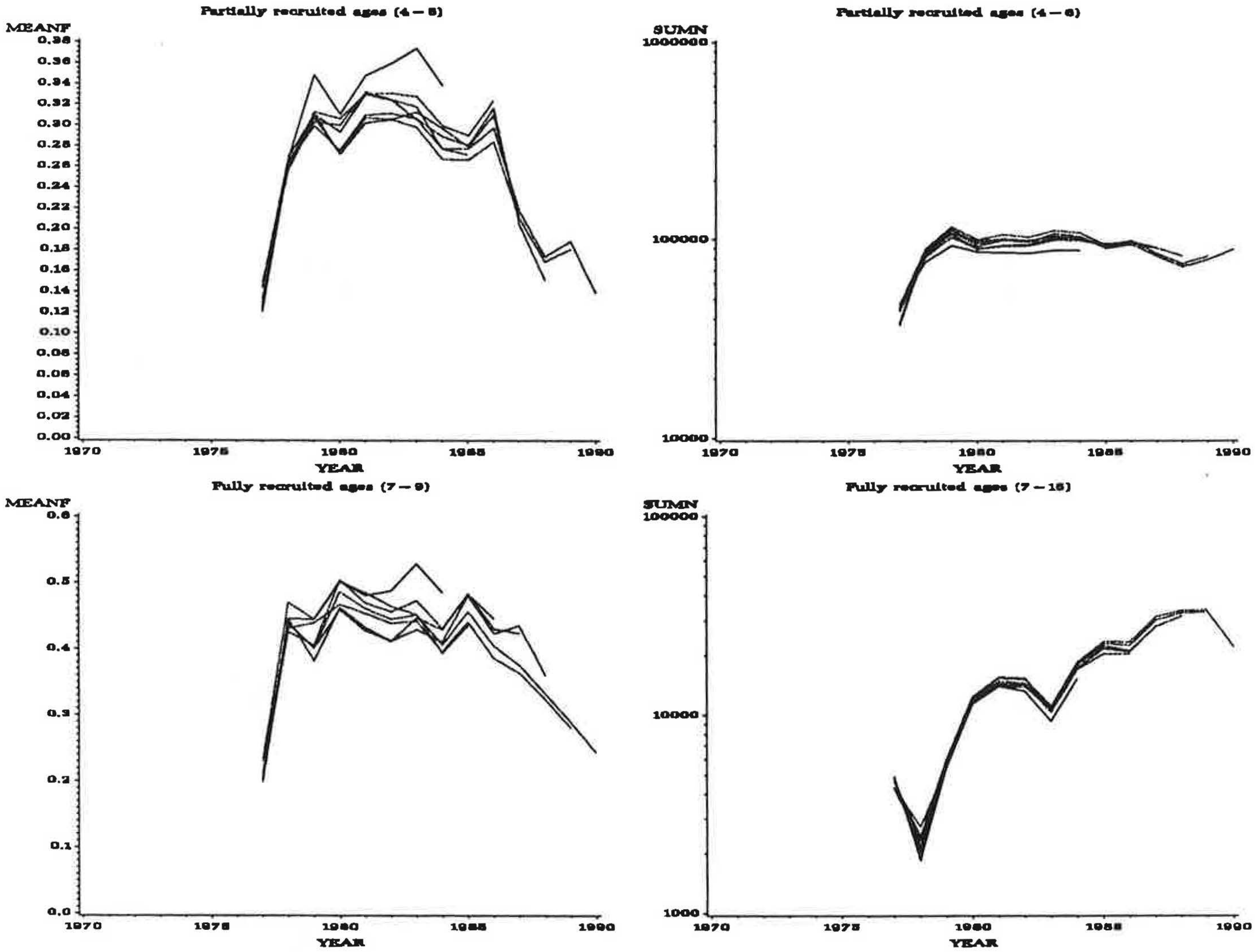


Figure 3.22

Retrospective analysis

Stock: North Sea Plaice

Procedure: Laurec – Shepherd

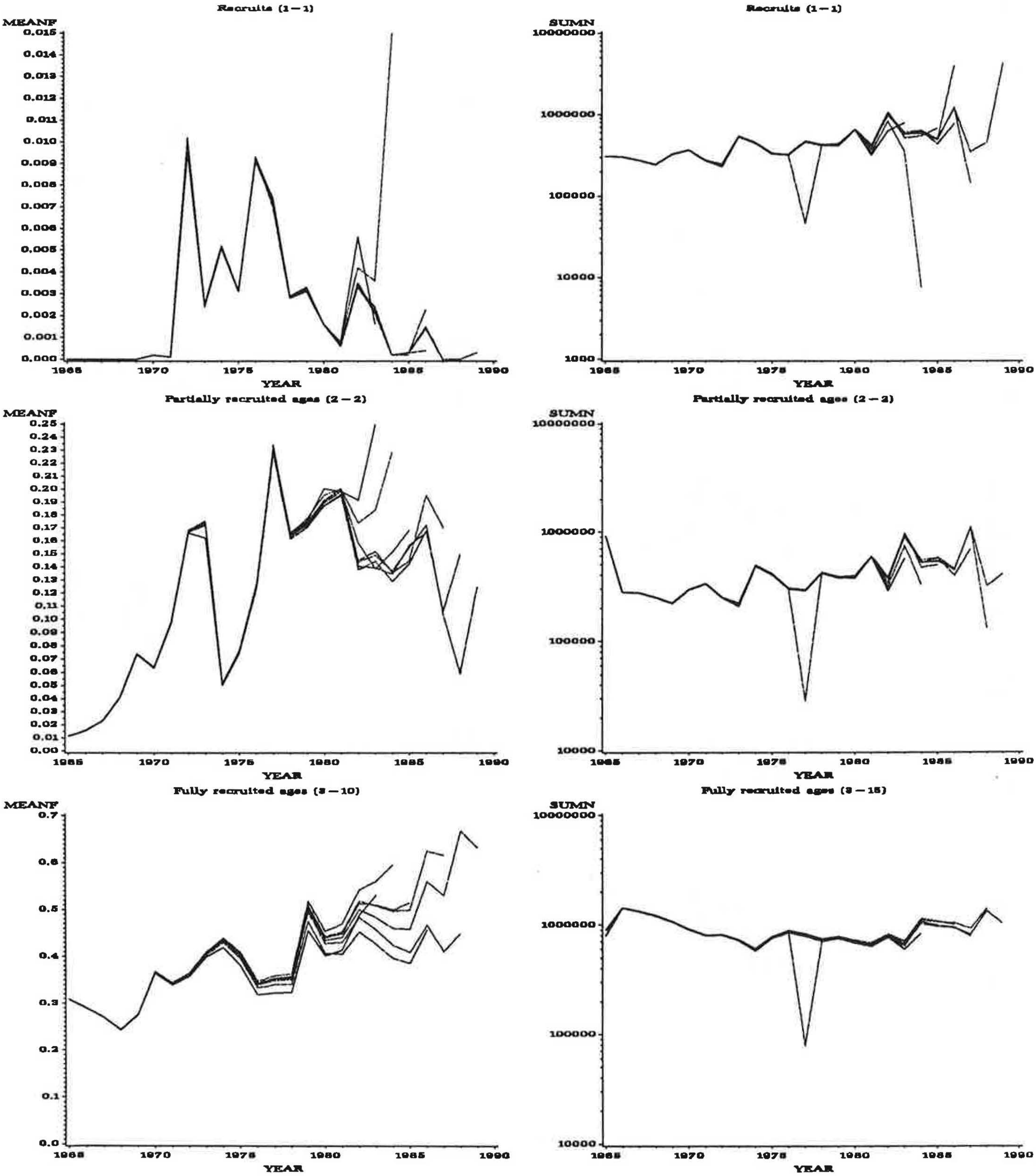


Figure 3.23

Stock: Retrospective analysis
North Sea Plaice
Procedure: Extended Survivors Analysis

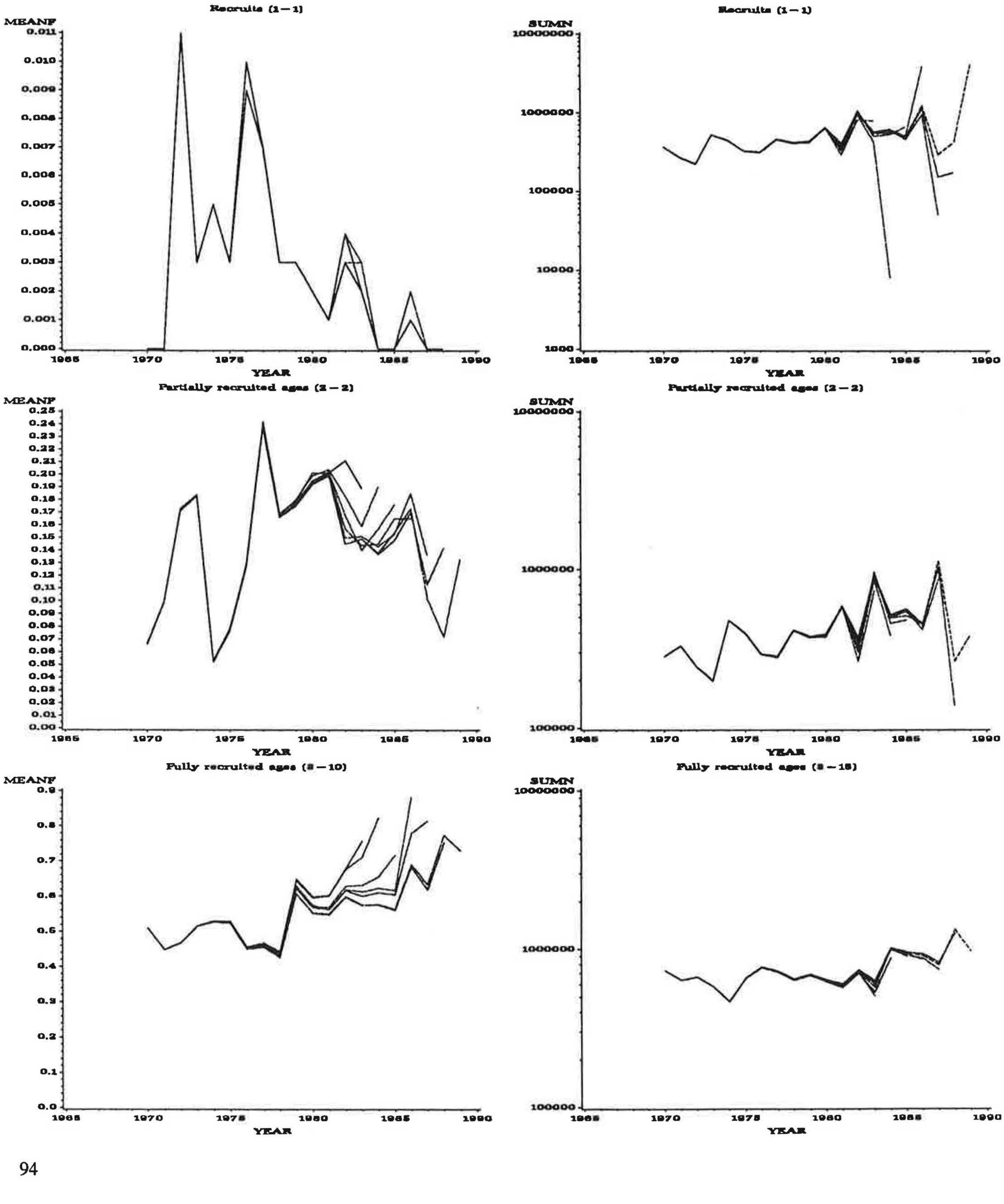


Figure 3.24

Stock: Retrospective analysis
SNE yellowtail Flounder
Procedure: Laurec – Shepherd

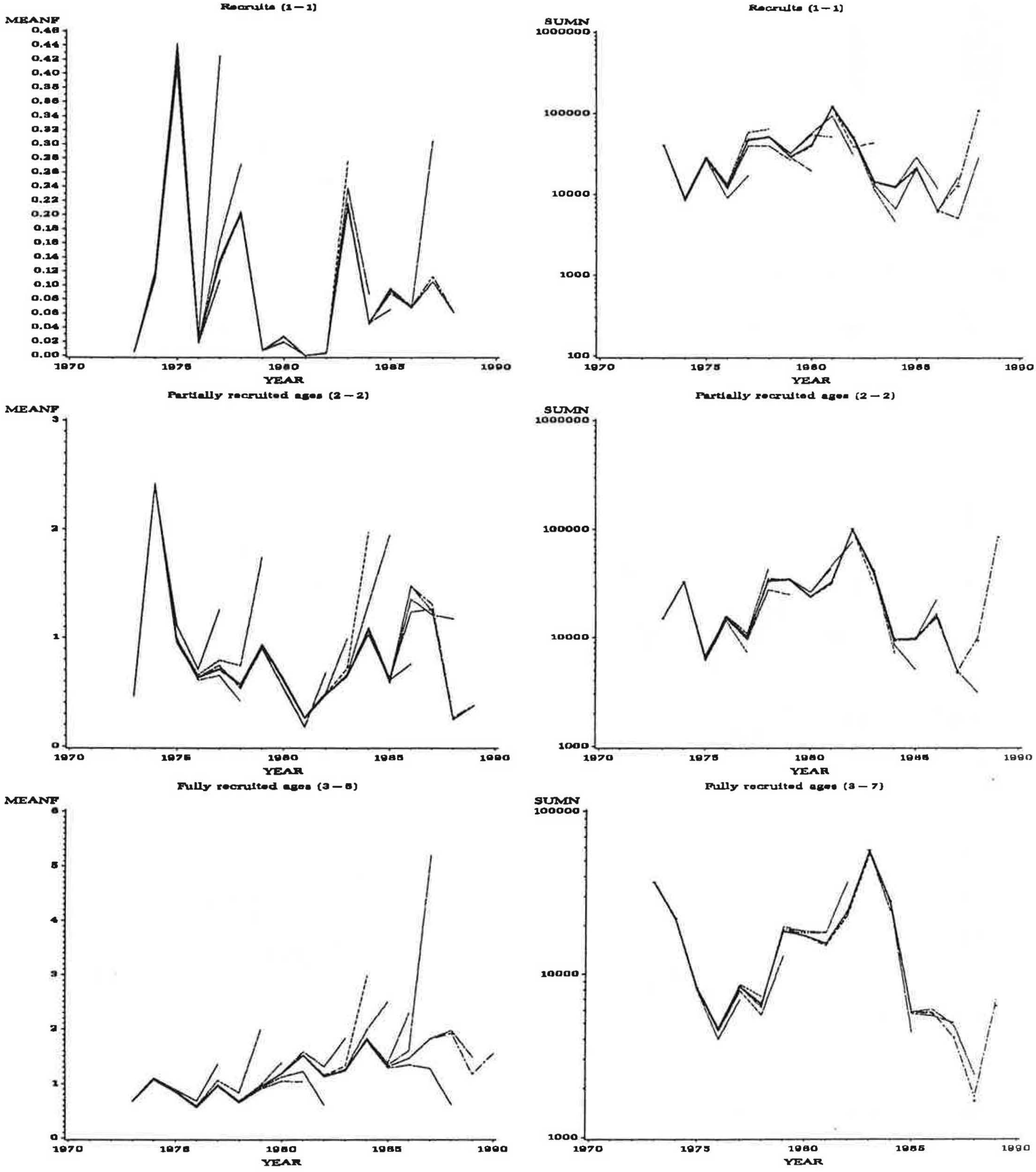


Figure 3.25

Stock: Retrospective analysis
SNE yellowtail Flounder
Procedure: ADAPT

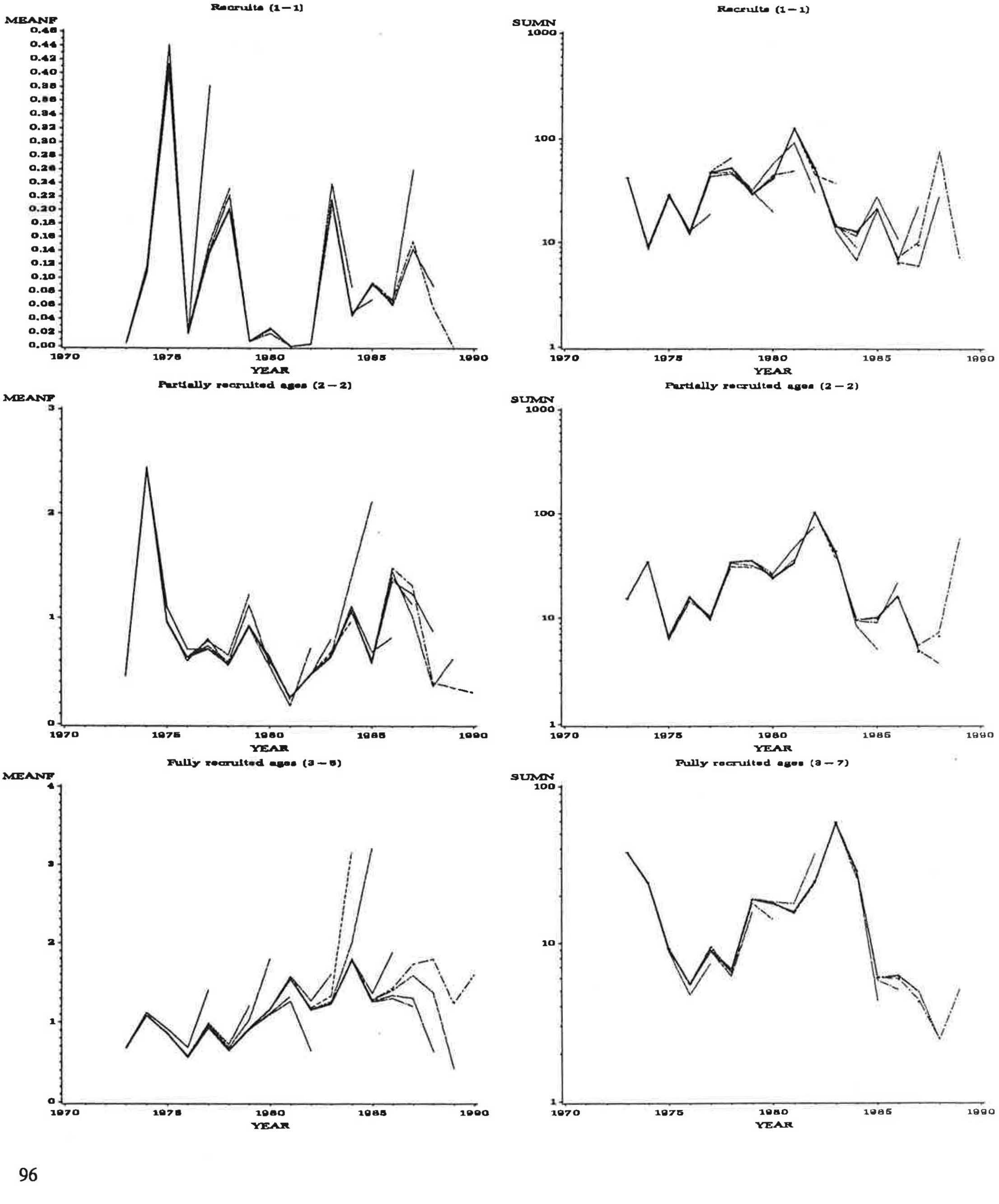


Figure 3.26

Stock: SNE yellowtail Flounder
Procedure: Extended Survivors Analysis

Retrospective analysis

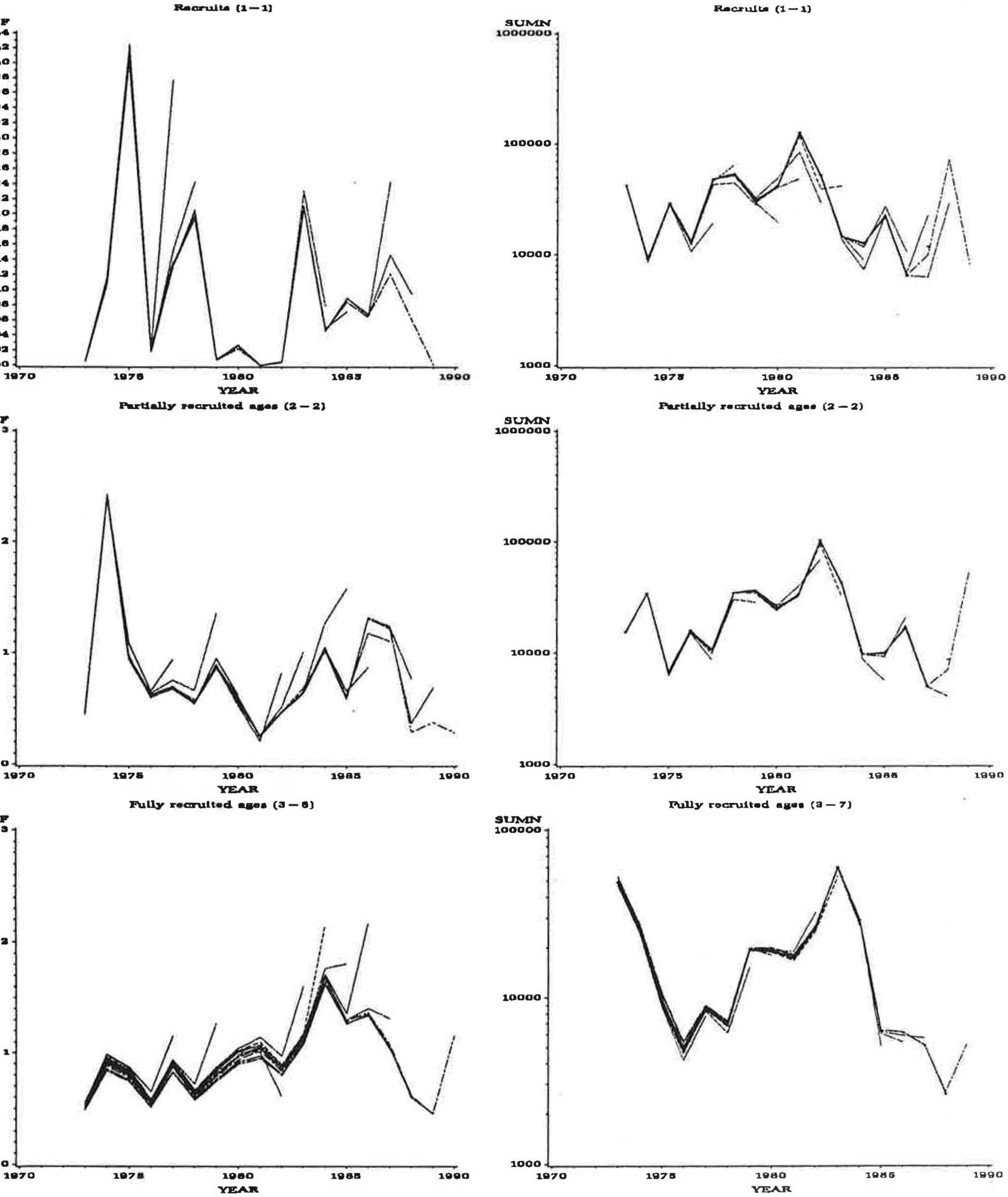


Figure 3.27

Stock: Irish Sea (VIIa) Cod
Procedure: Laurec – Shepherd

Retrospective analysis

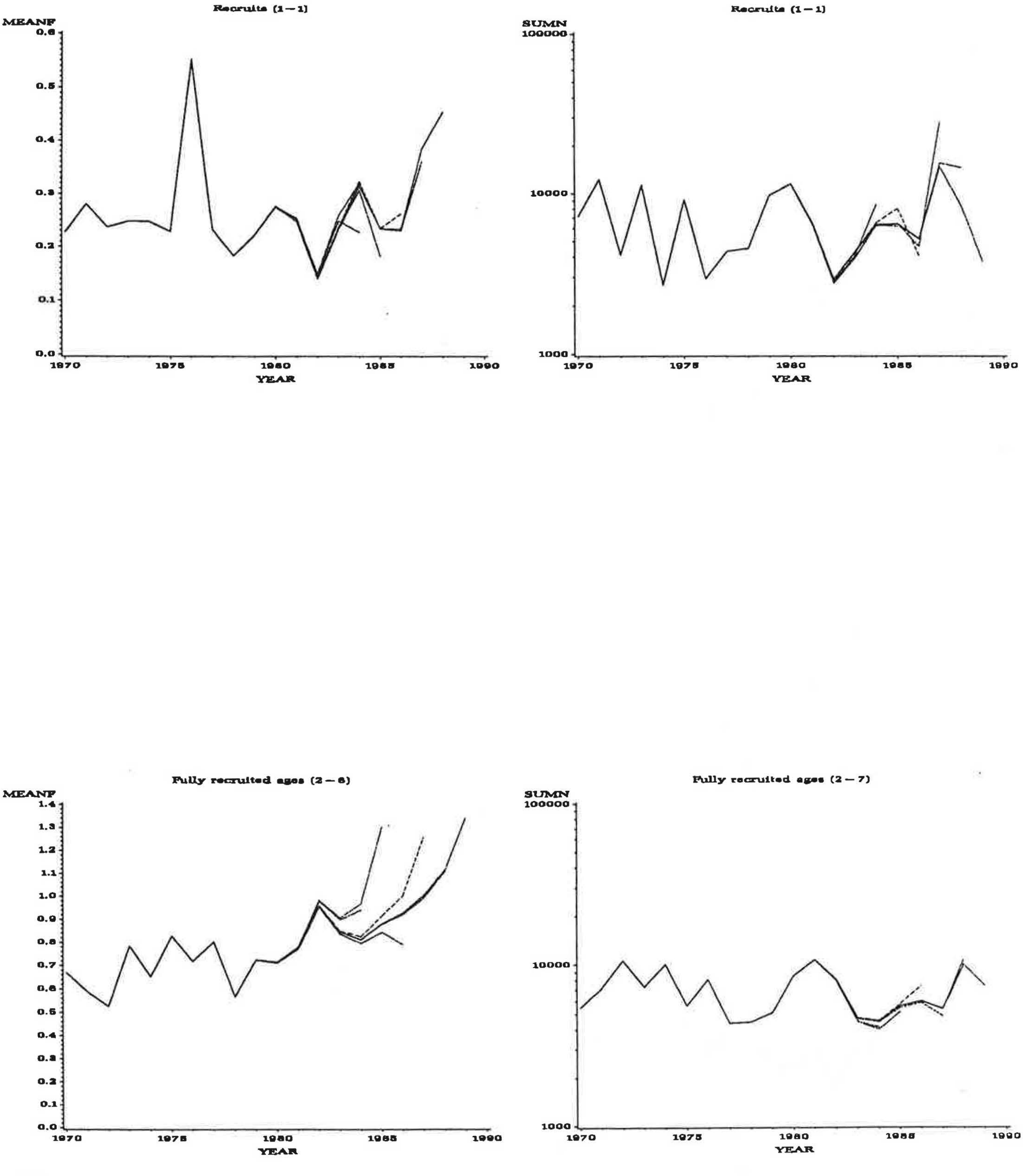


Figure 3.28 Retrospective analysis

Stock: Irish Sea (VIIa) Whiting

Procedure: Laurec – Shepherd

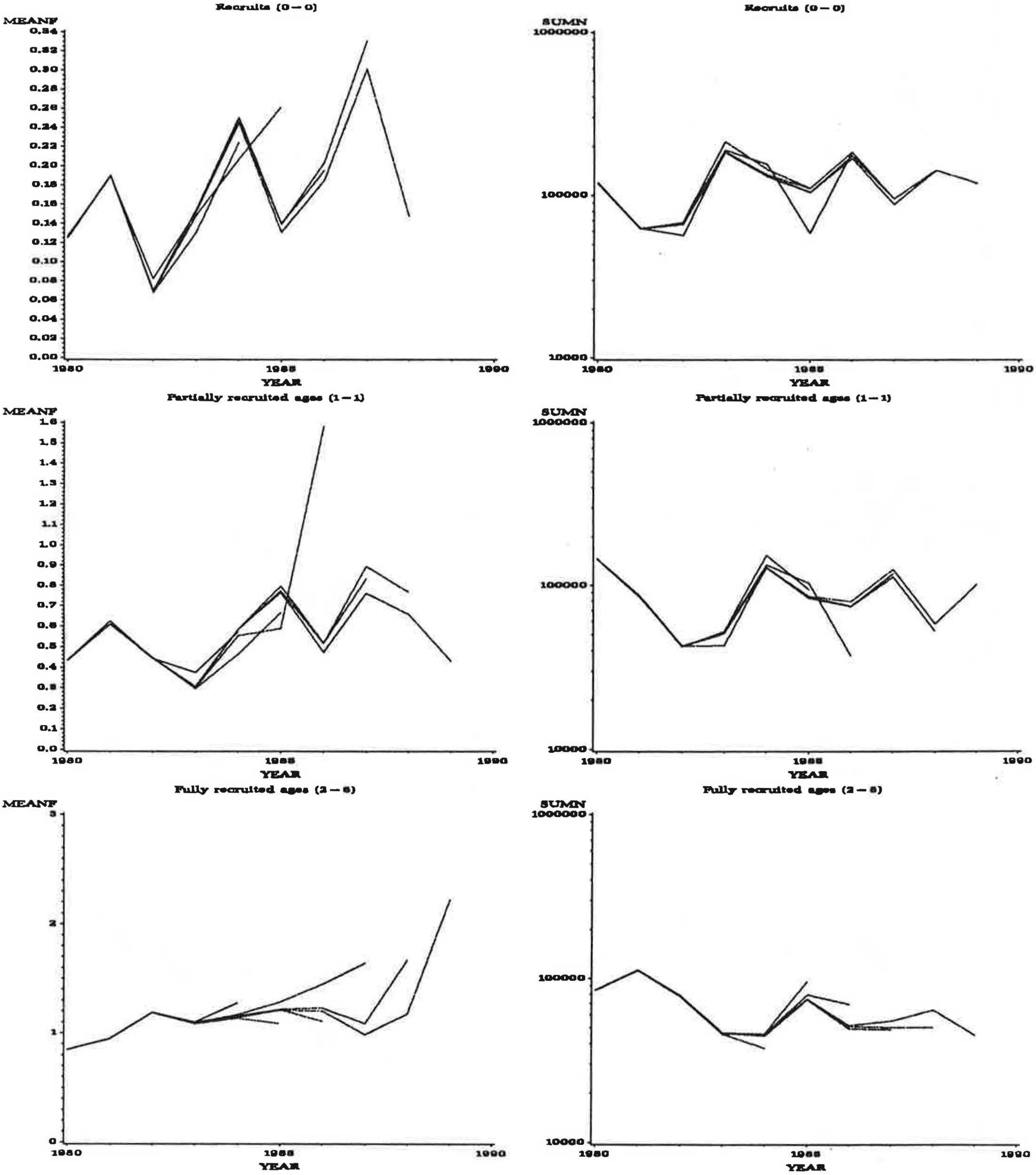


Figure 3.29

Stock: Retrospective analysis
Western English Channel (VIIe) Plaice
Procedure: Laurec – Shepherd

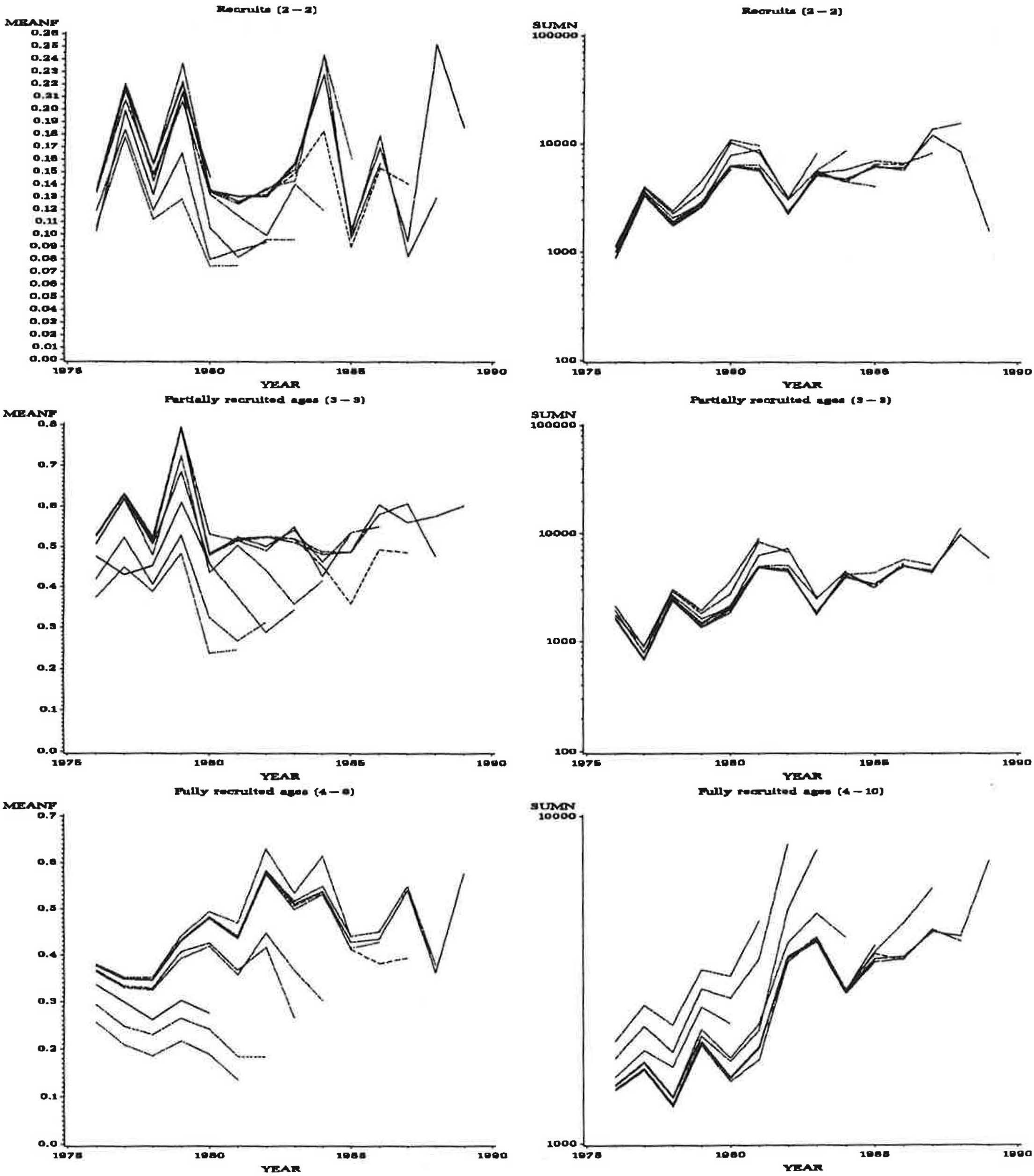


Figure 3.30

Stock: Retrospective analysis
Celtic Sea (VIIf+g) Plaice

Procedure: Laurec – Shepherd

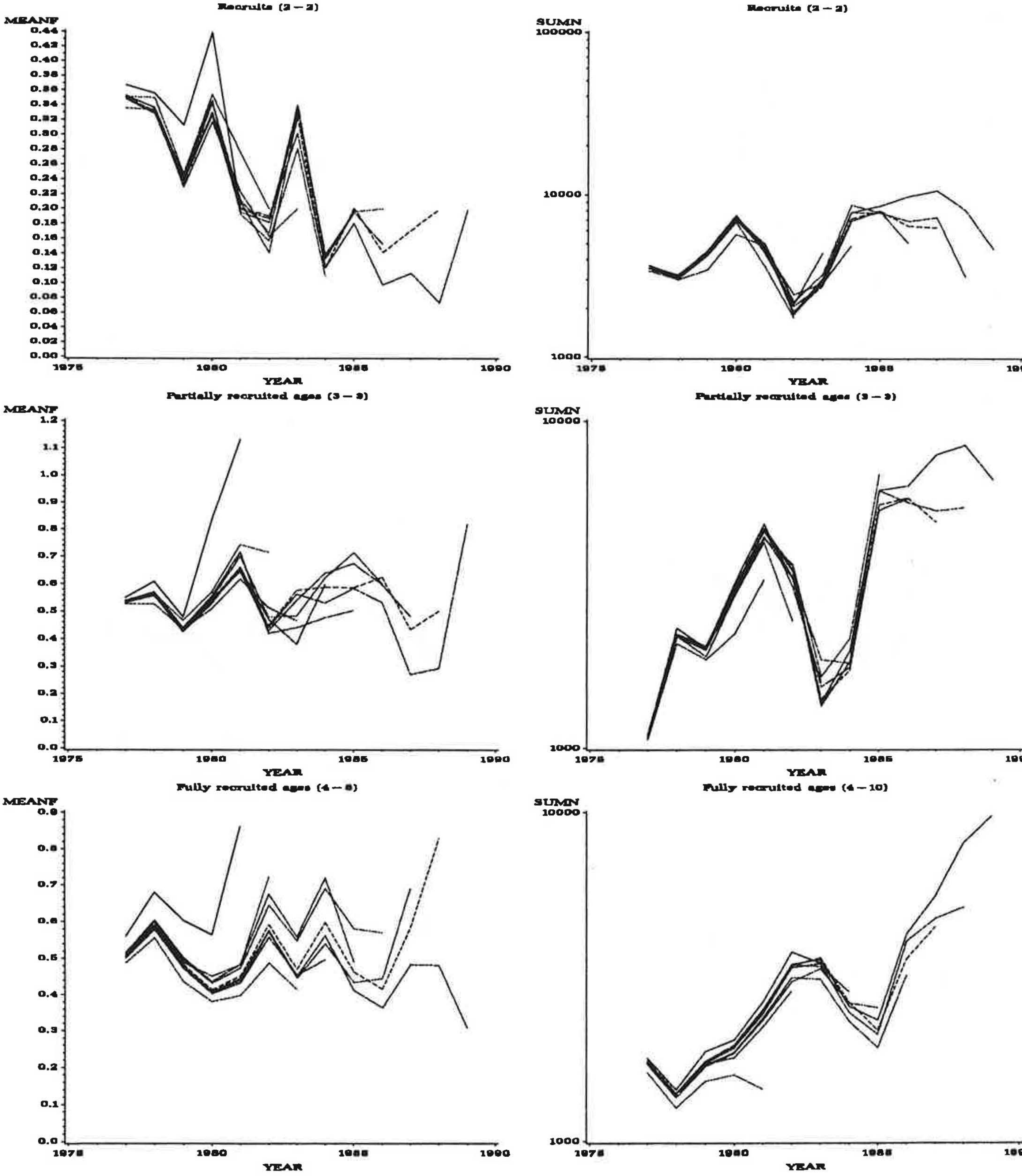


Figure 3.31

Retrospective analysis

Stock: Celtic Sea (VIIf+g) Sole

Procedure: Laurec – Shepherd

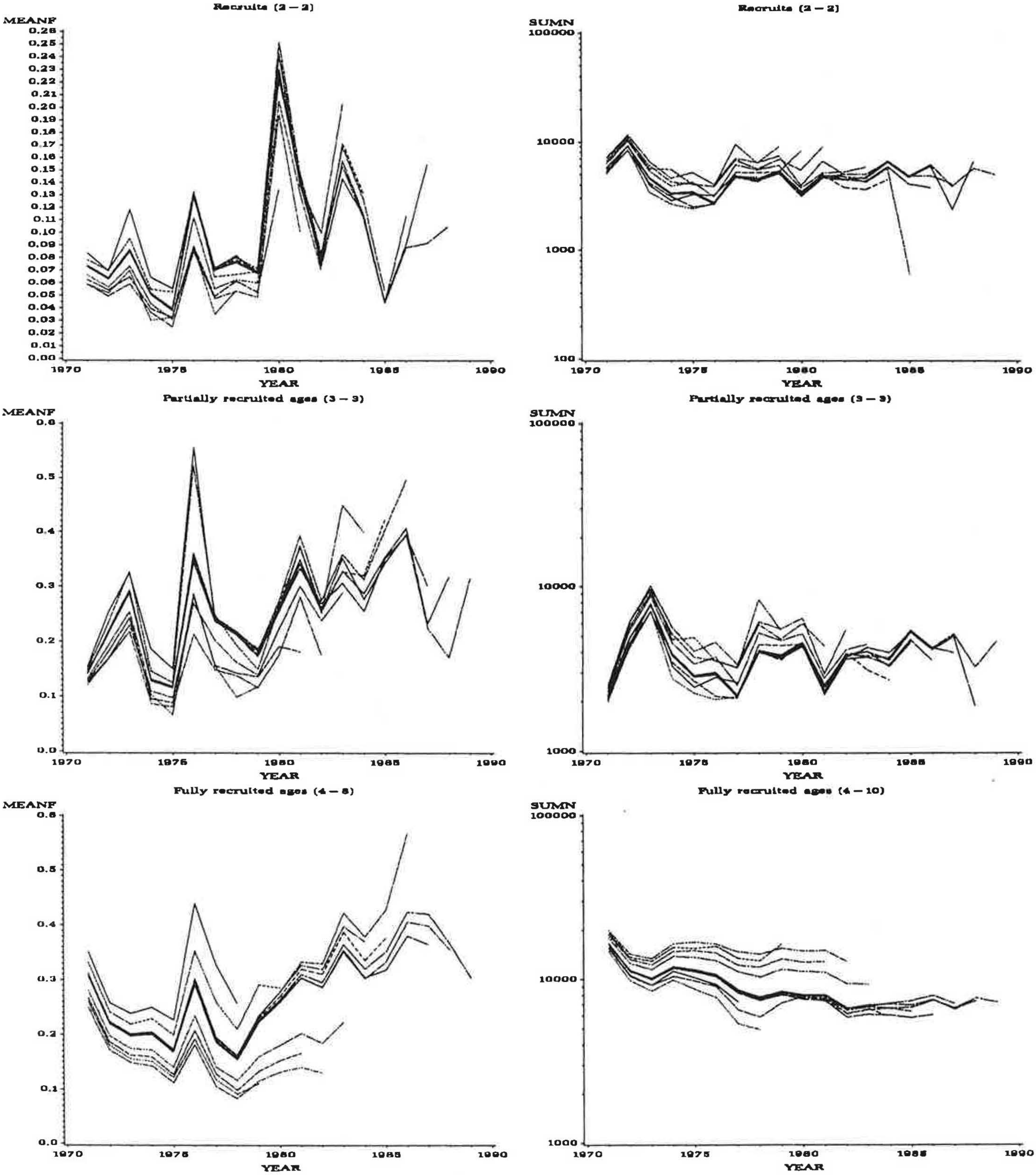
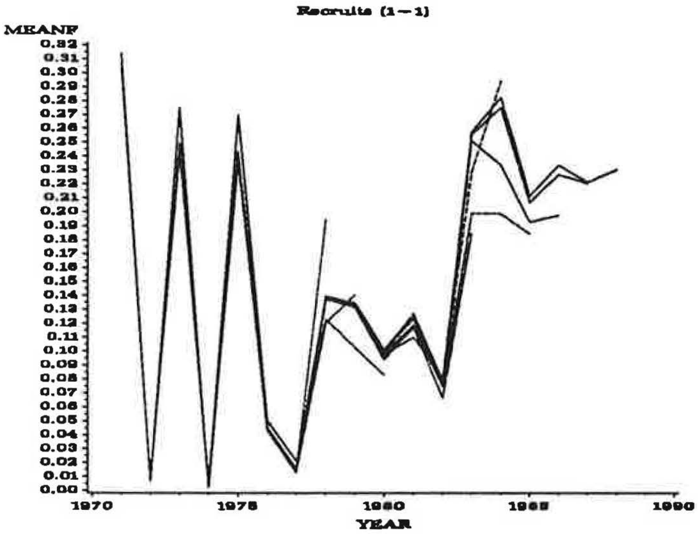


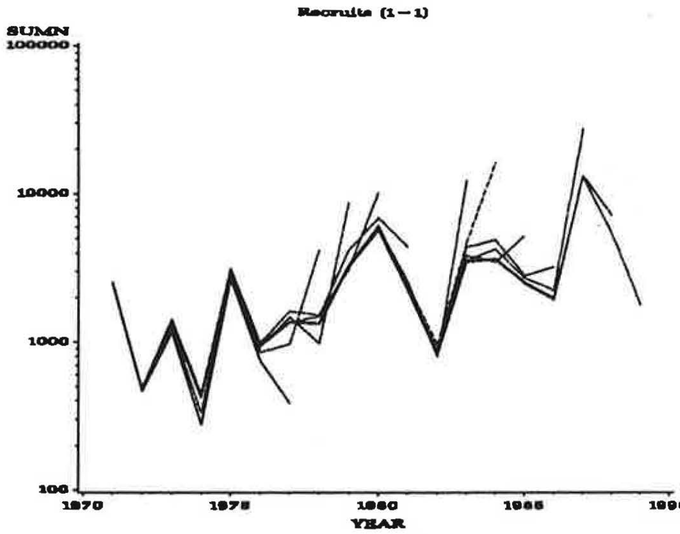
Figure 3.32

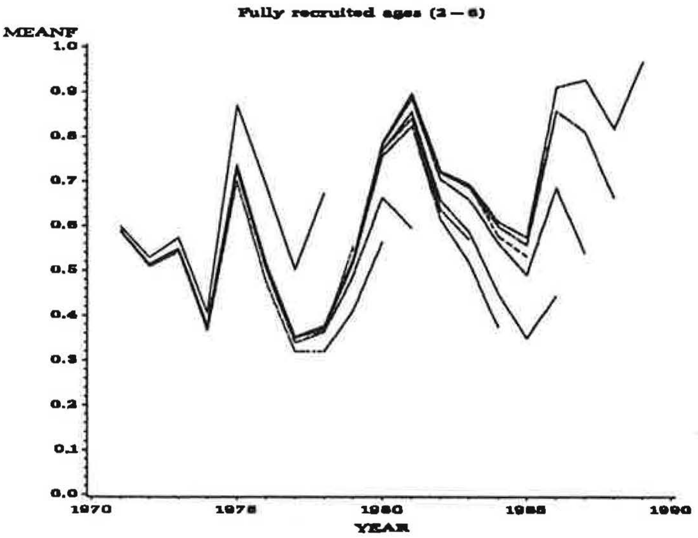
Stock: Celtic Sea (VIIf + g) Cod

Procedure: Laurec – Shepherd

Retrospective analysis







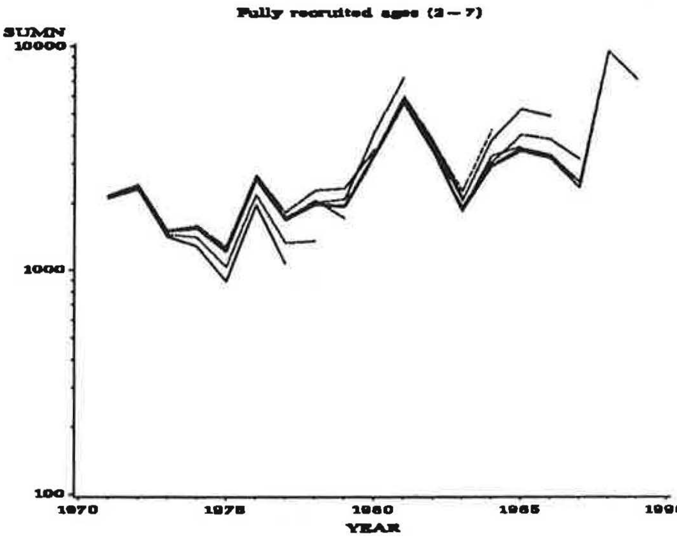


Figure 3.33 Retrospective analysis

Stock: Celtic Sea (VIIf+g) Whiting

Procedure: Laurec – Shepherd

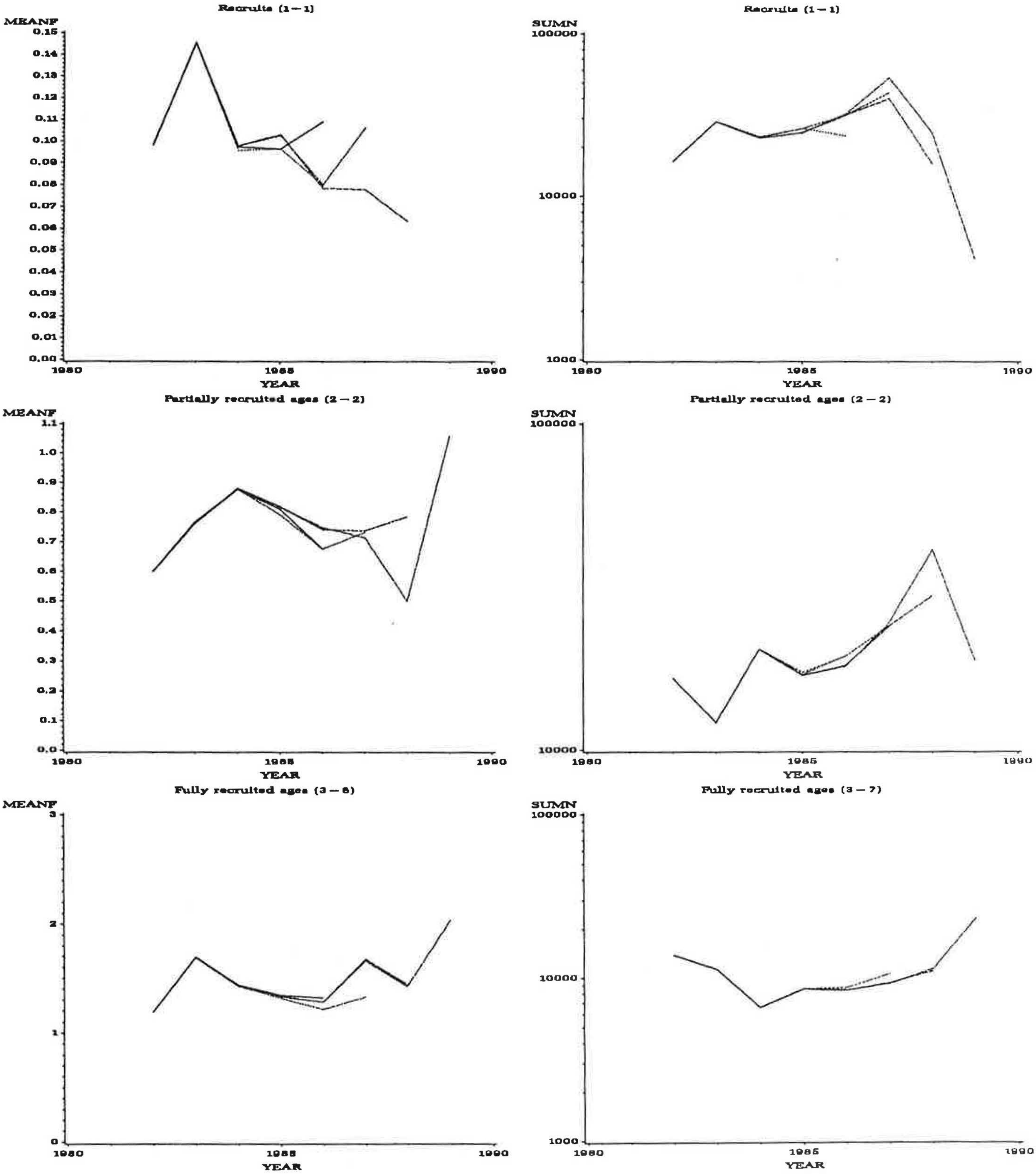


Figure 3.34

Stock:	Retrospective analysis
	North Sea Haddock
Procedure:	Laurec – Shepherd

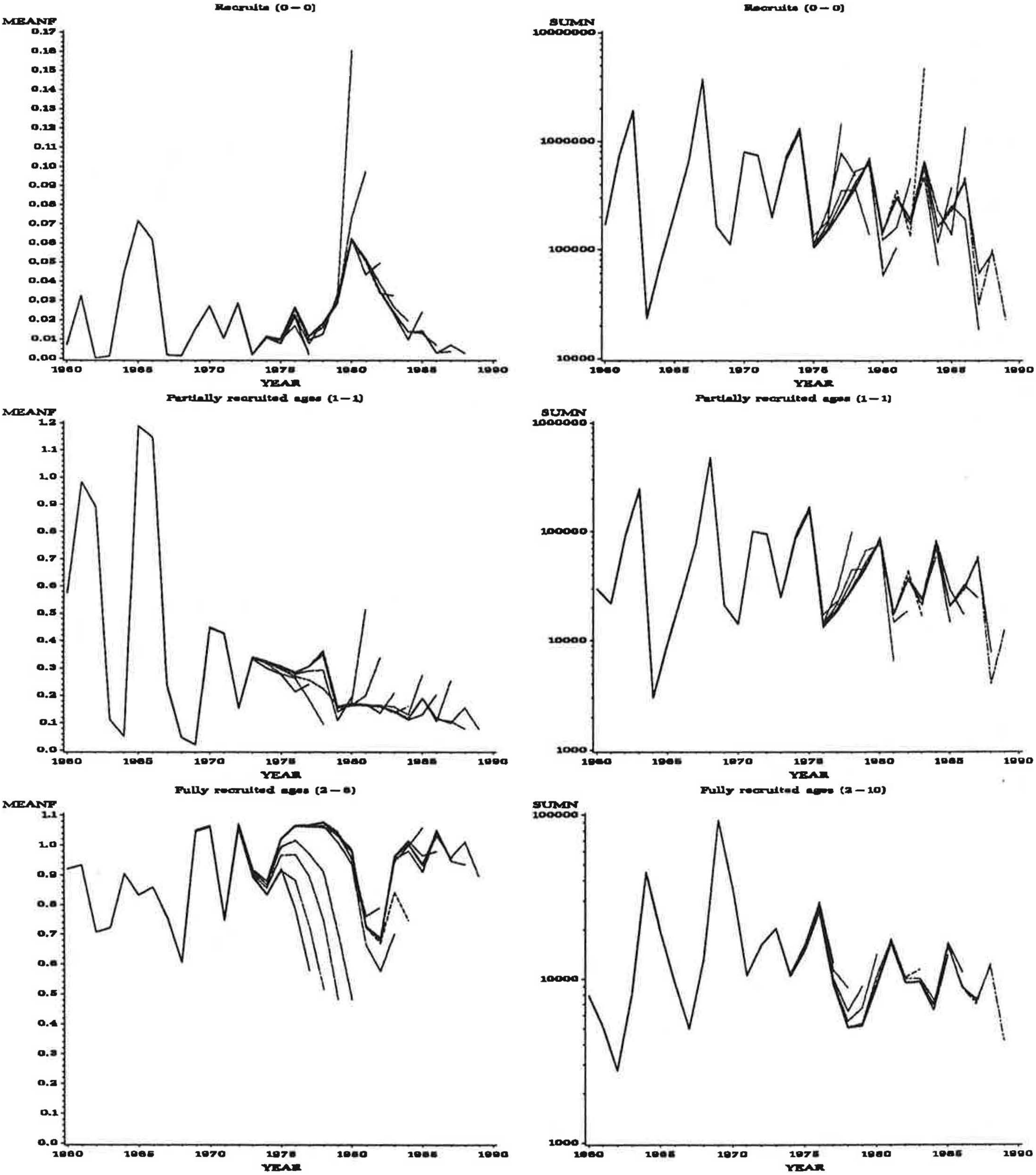


Figure 3.35 Retrospective analysis

Stock: North Sea Whiting

Procedure: Laurec – Shepherd

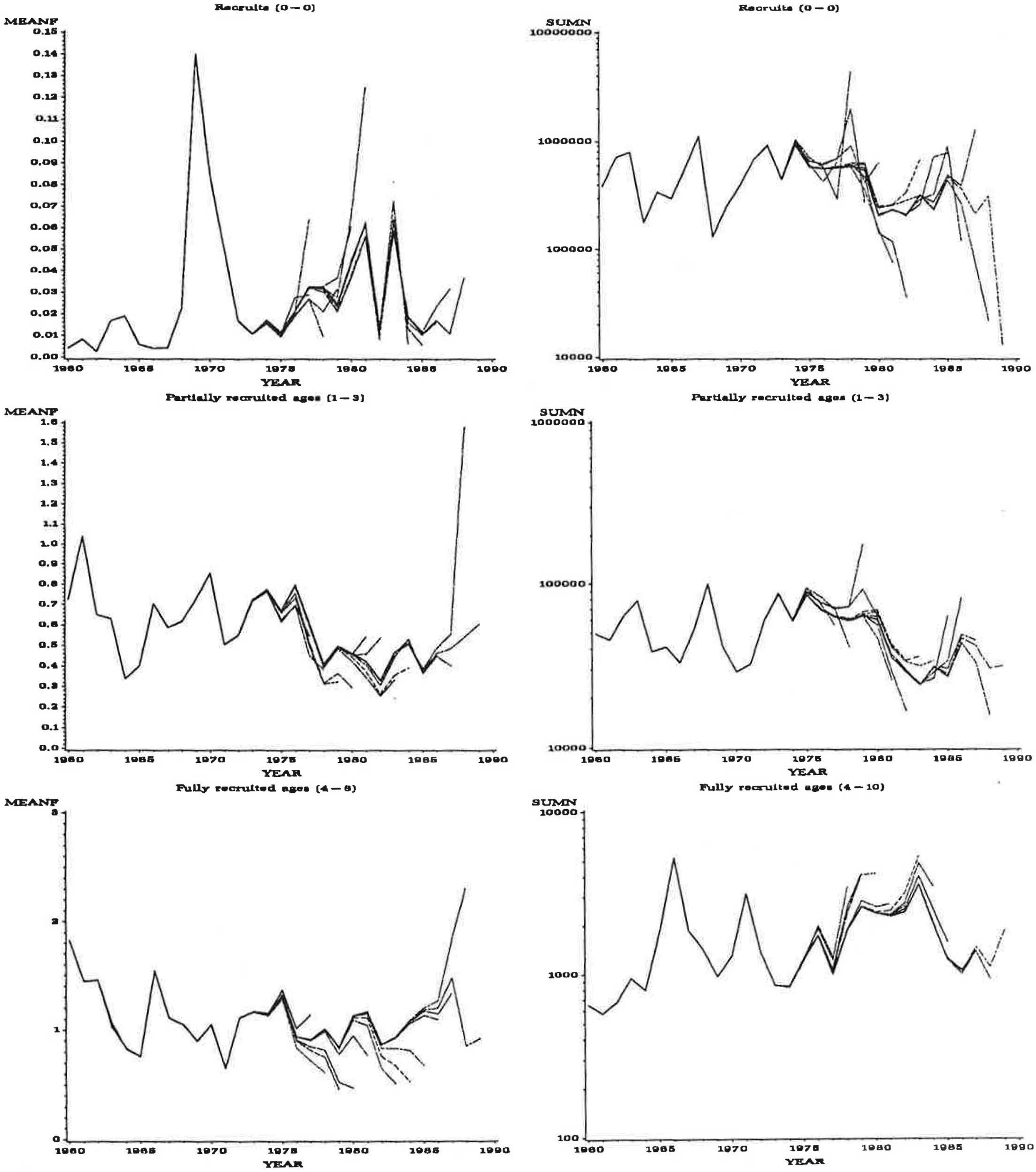


Figure 3.36

Retrospective analysis

Stock: North East Arctic Cod

Procedure: Laurec – Shepherd

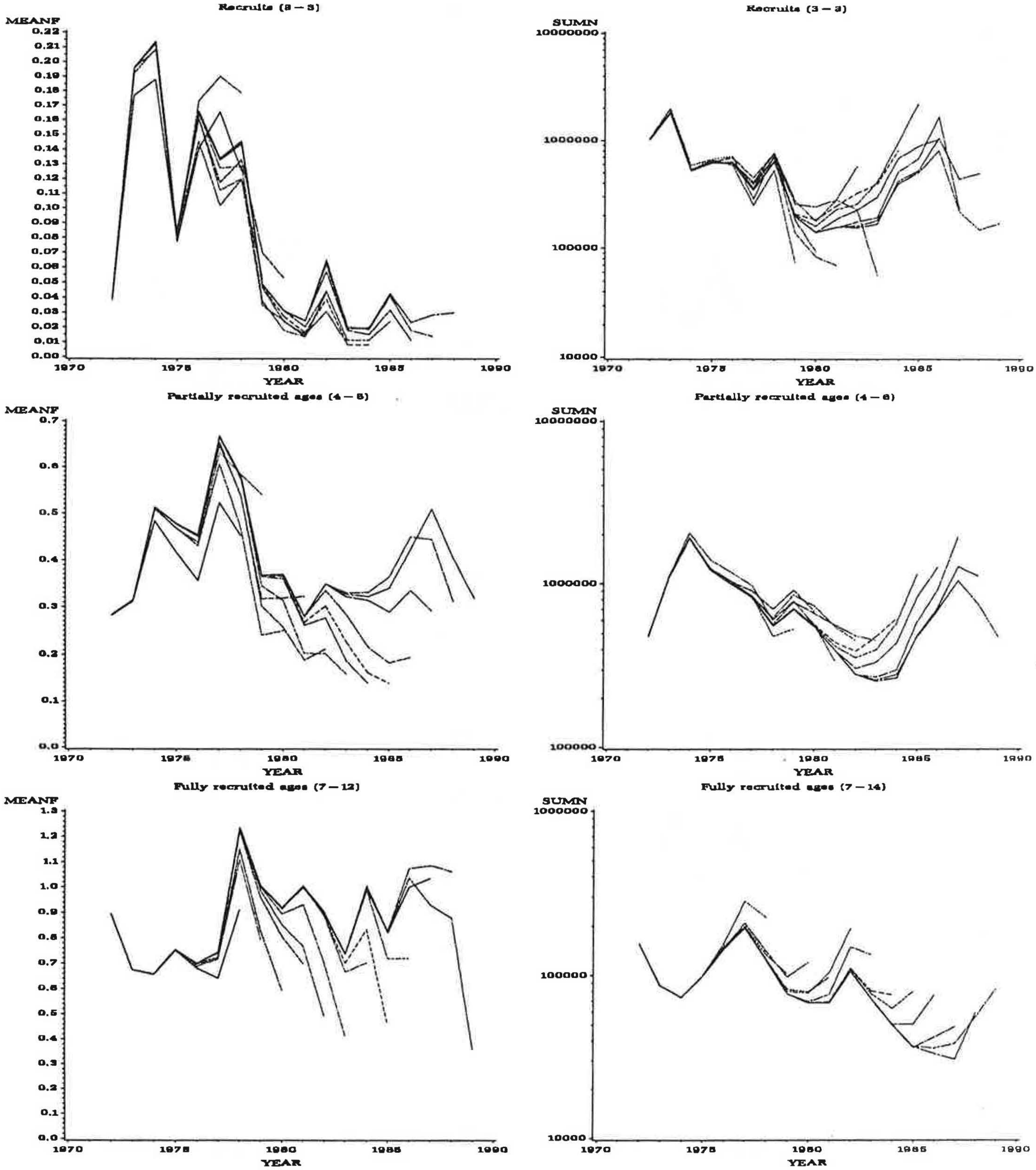


Figure 3.37

	Retrospective analysis
Stock:	North East Arctic Cod
Procedure:	Laurec–Shepherd with shrinkage

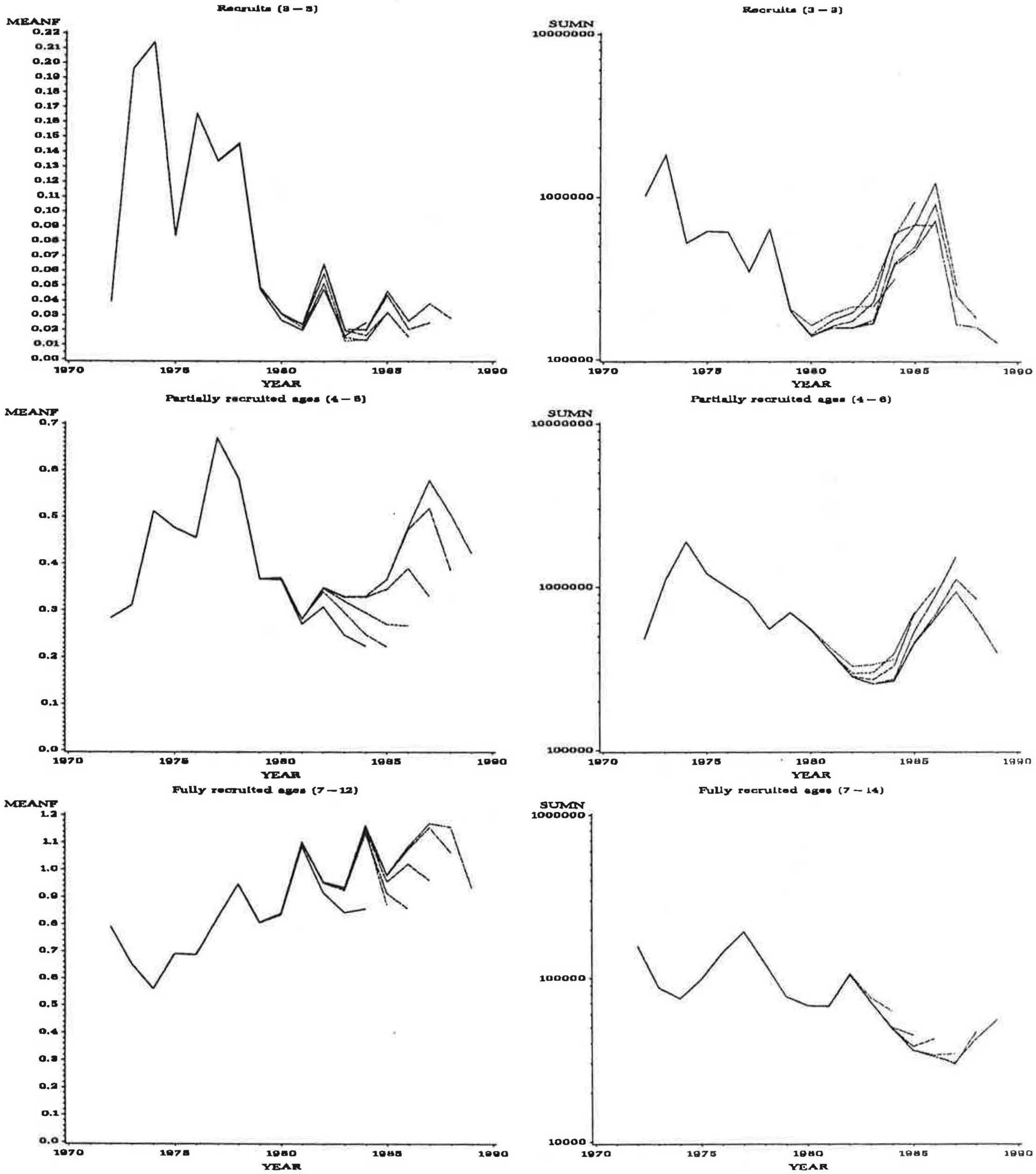


Figure 3.38

HISTORICAL ANALYSIS   FAROE PLATEAU COD

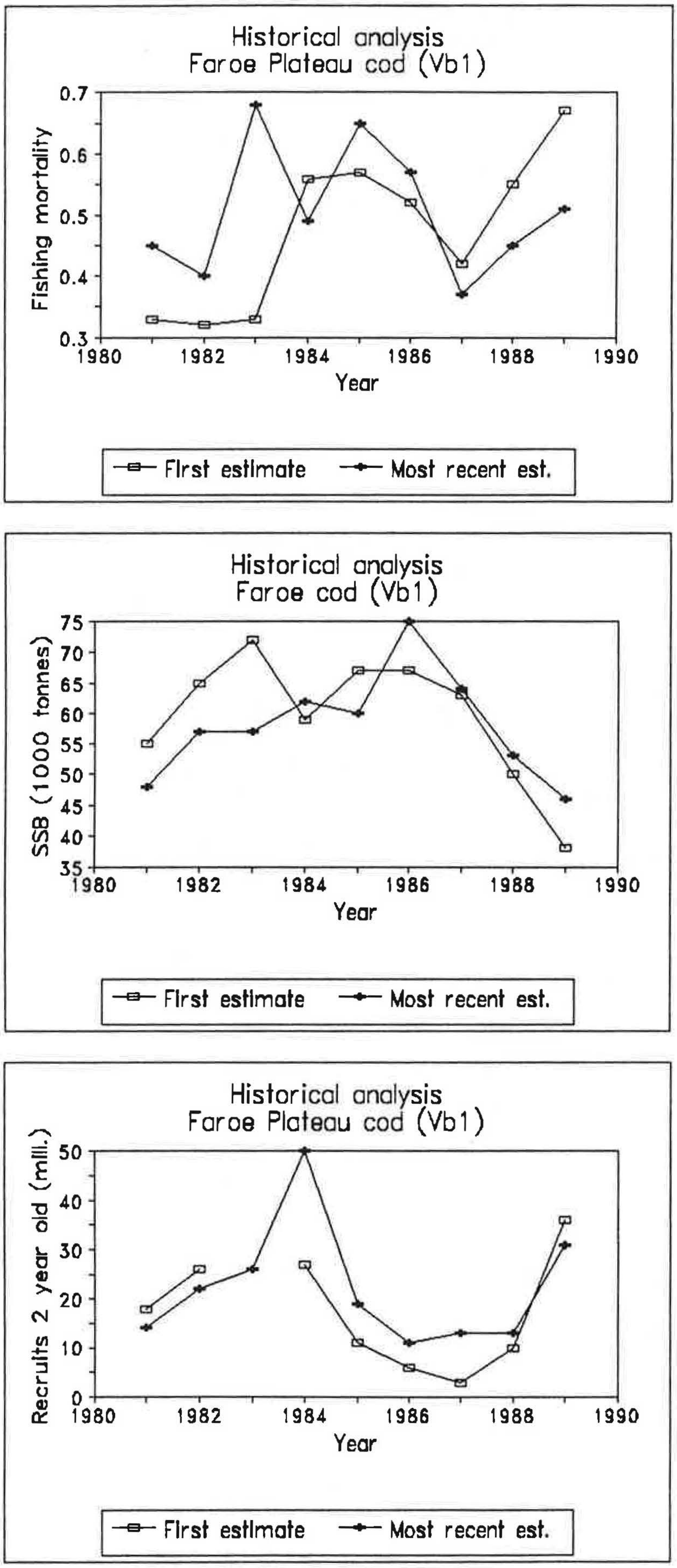
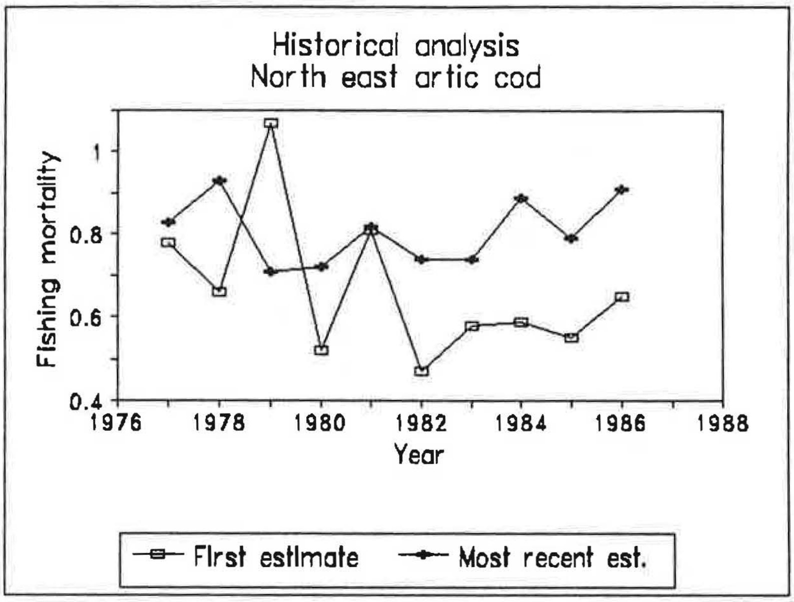
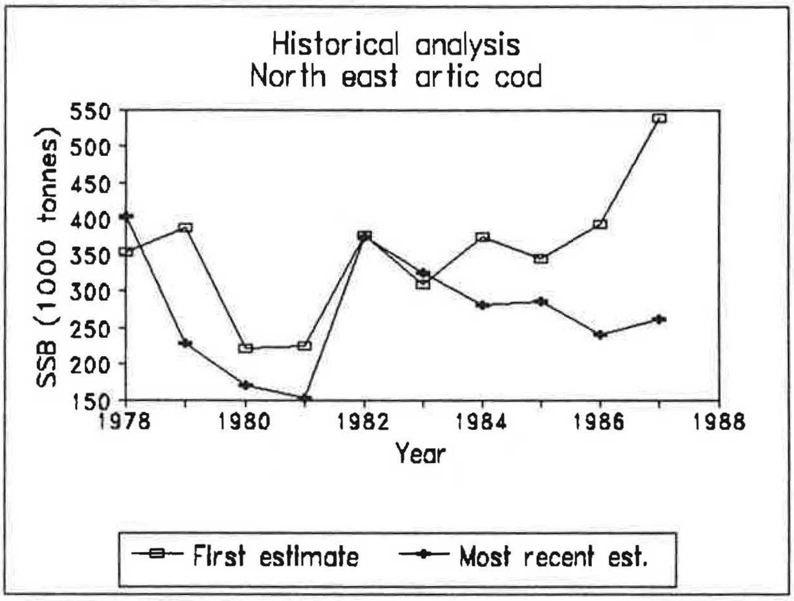


Figure 3.39

HISTORICAL ANALYSIS NORTH EAST ARTIC COD





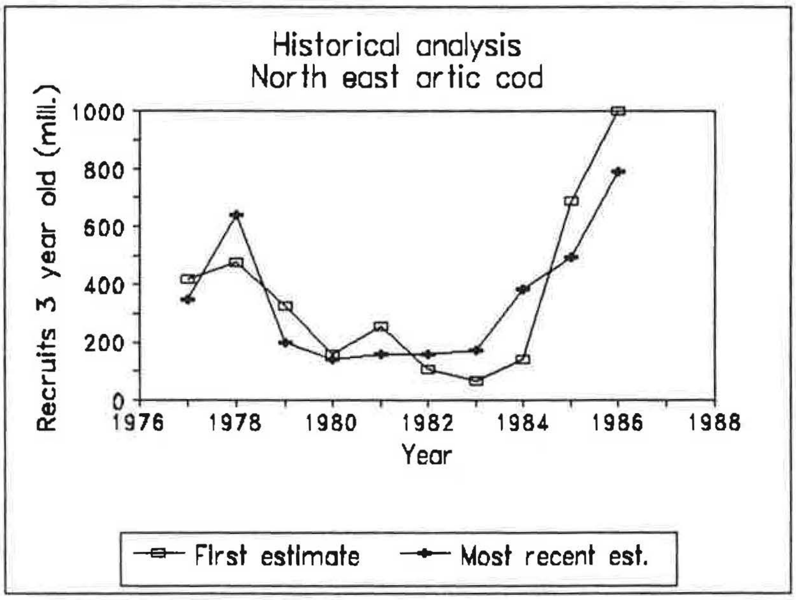
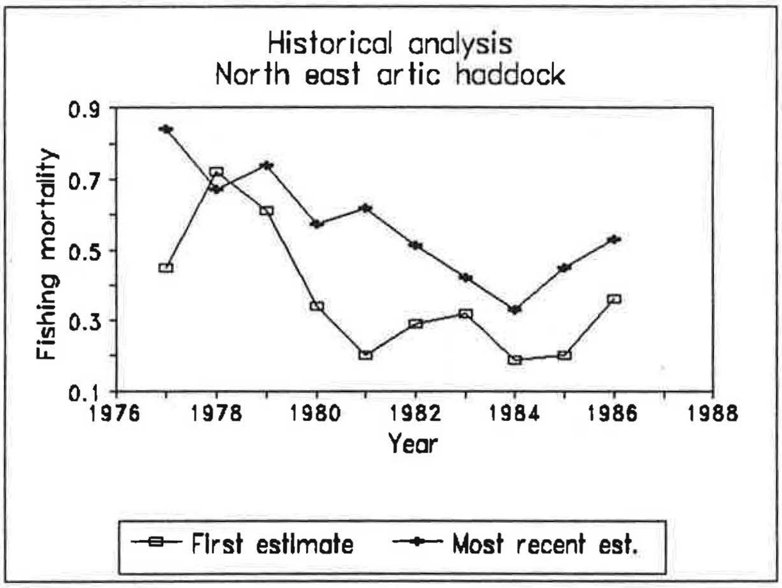
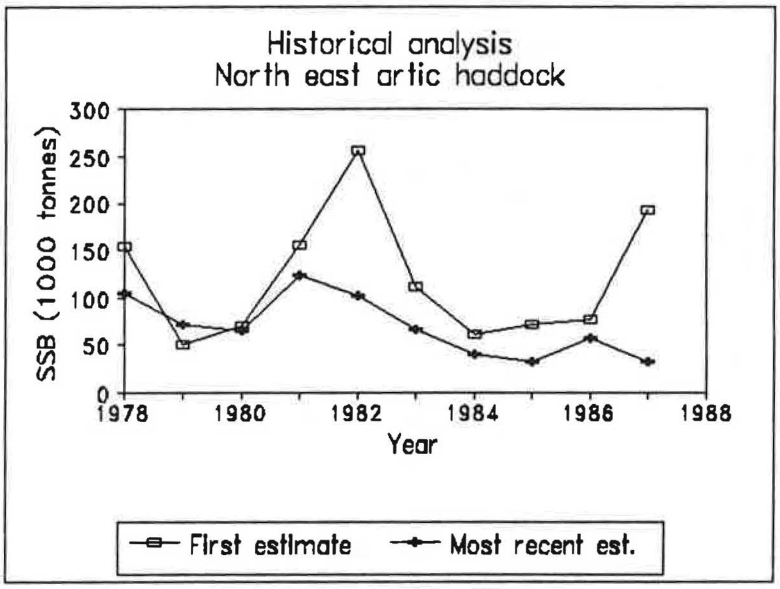


Figure 3.40

HISTORICAL ANALYSIS NORTH EAST ARTIC HADDOCK





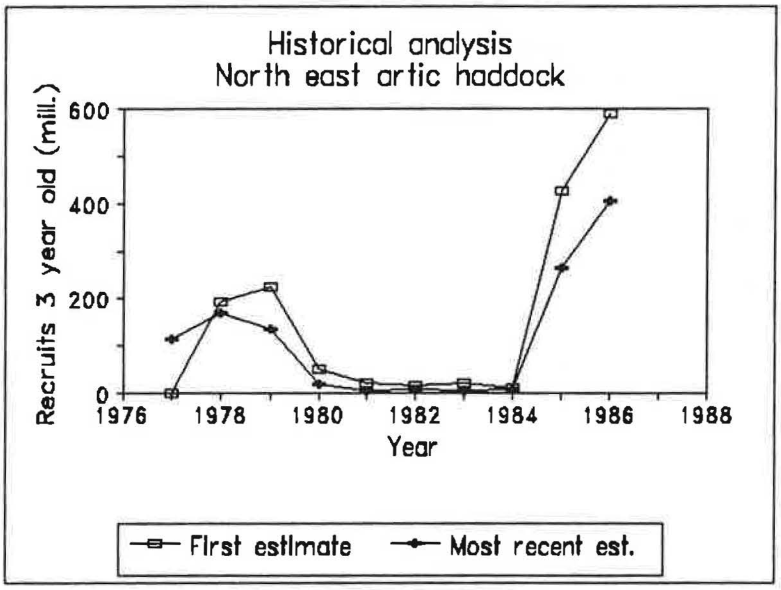
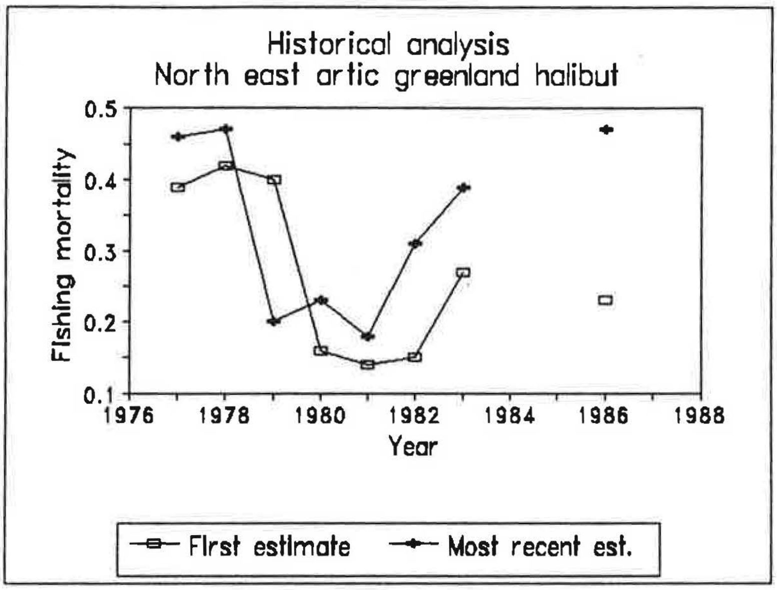
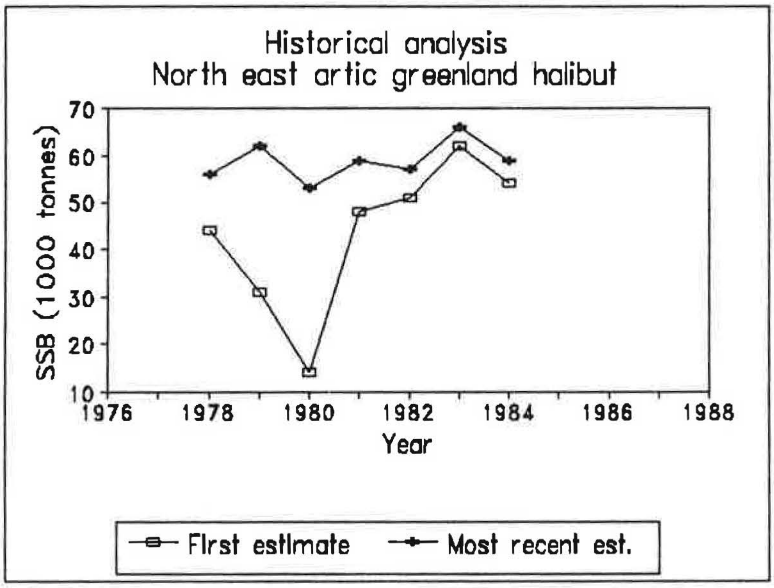


Figure 3.41

HISTORICAL ANALYSIS NORTH EAST ARTIC GREENLAND HALIBUT





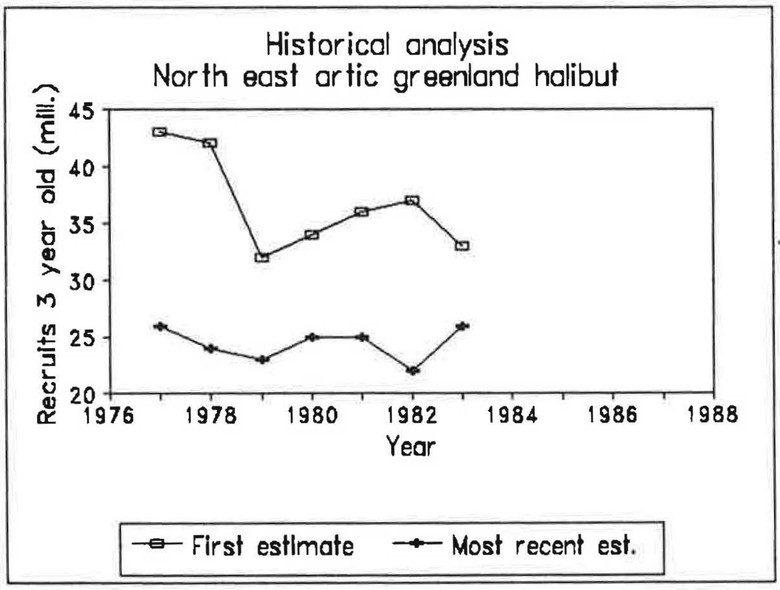
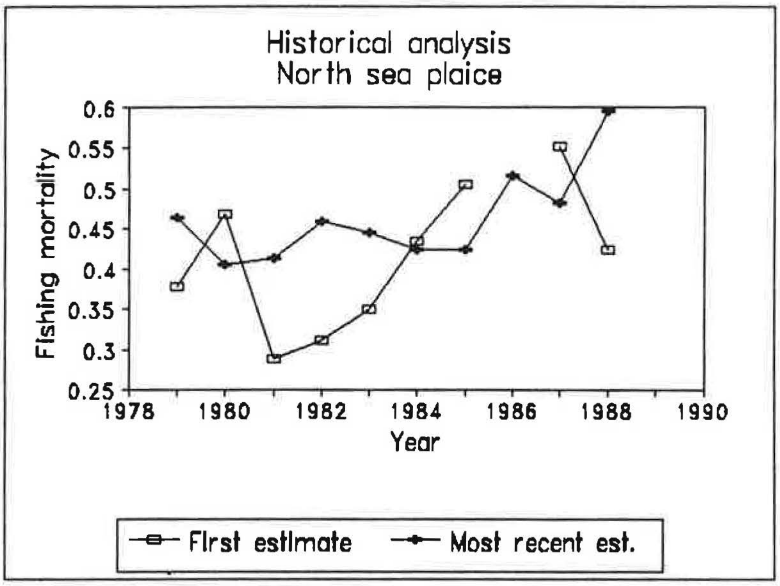
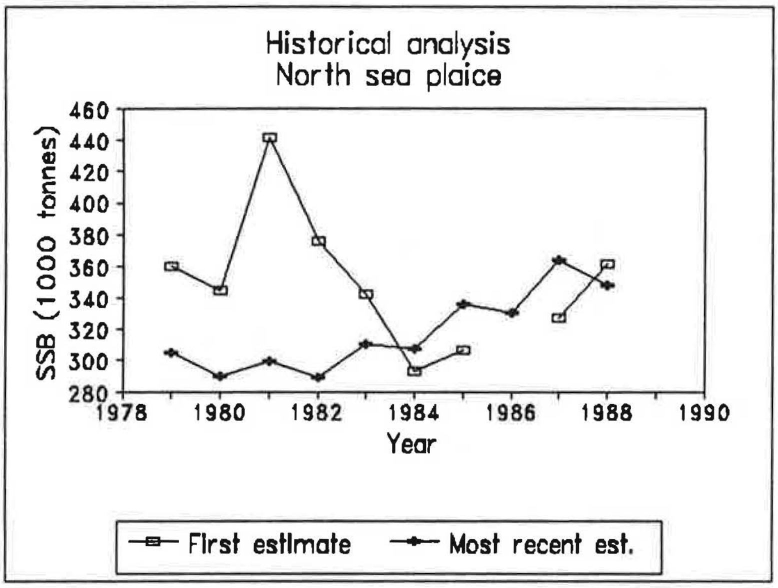


Figure 3.42

HISTORICAL ANALYSIS NORTH SEA PLAICE





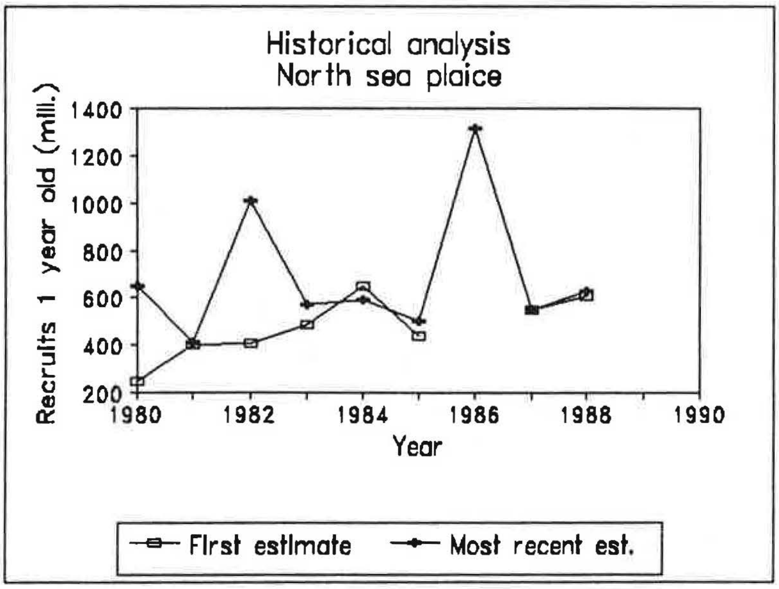


Figure 3.43
HISTORICAL ANALYSIS NORTH EAST ARTIC REDFISH (S.mentella)

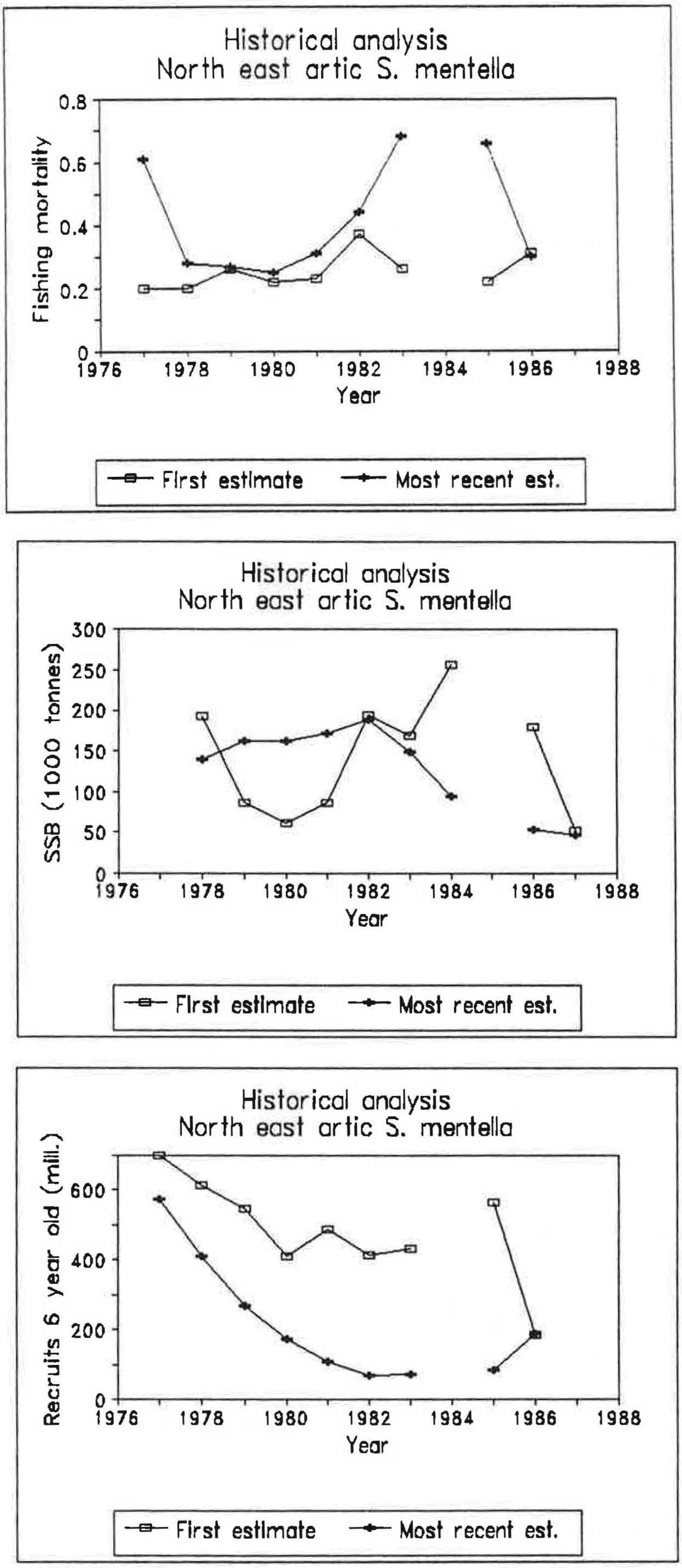
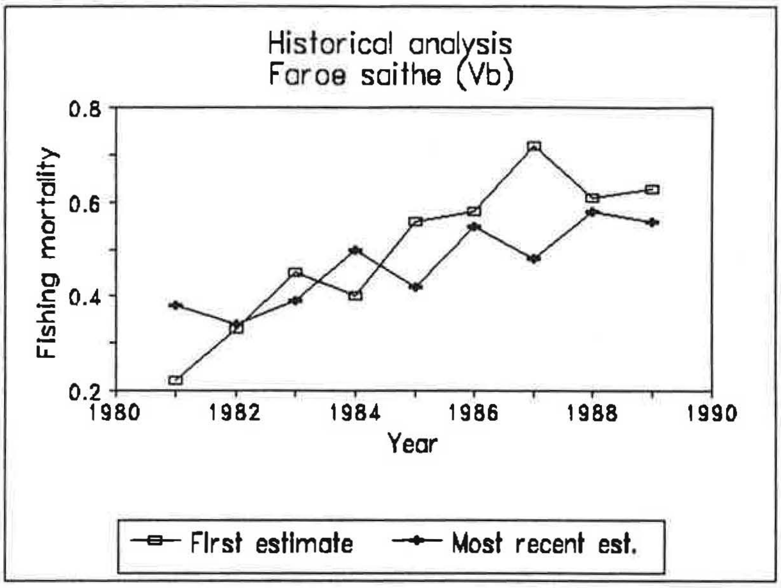
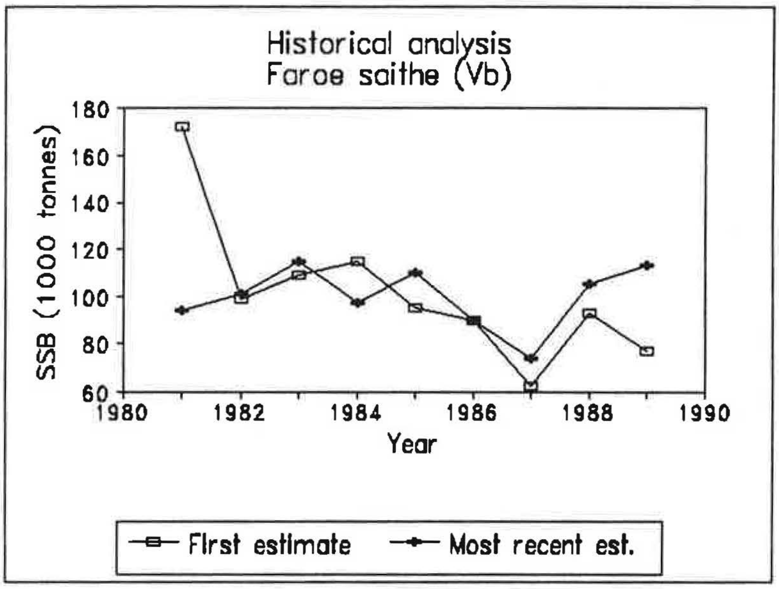


Figure 3.44
HISTORICAL ANALYSIS FAROE SAITHE





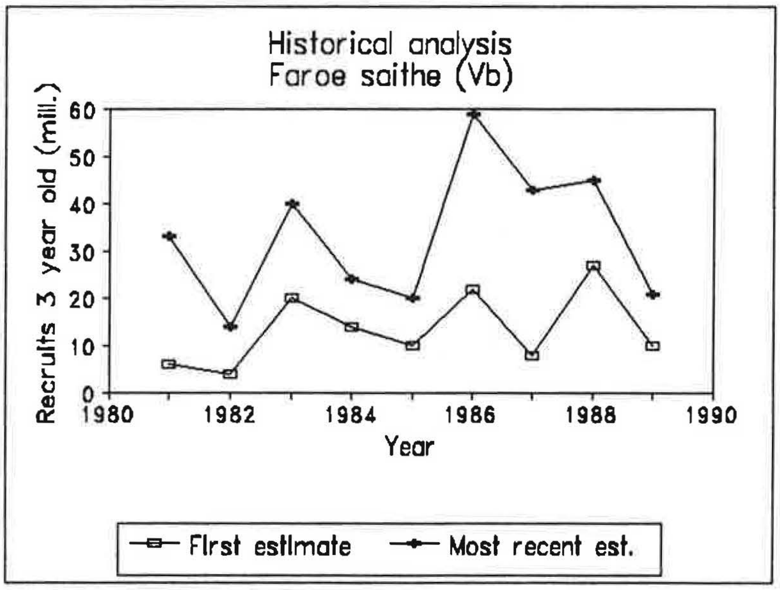


Figure 3.45

HISTORICAL ANALYSIS NORTH EAST ARTIC SAITHE

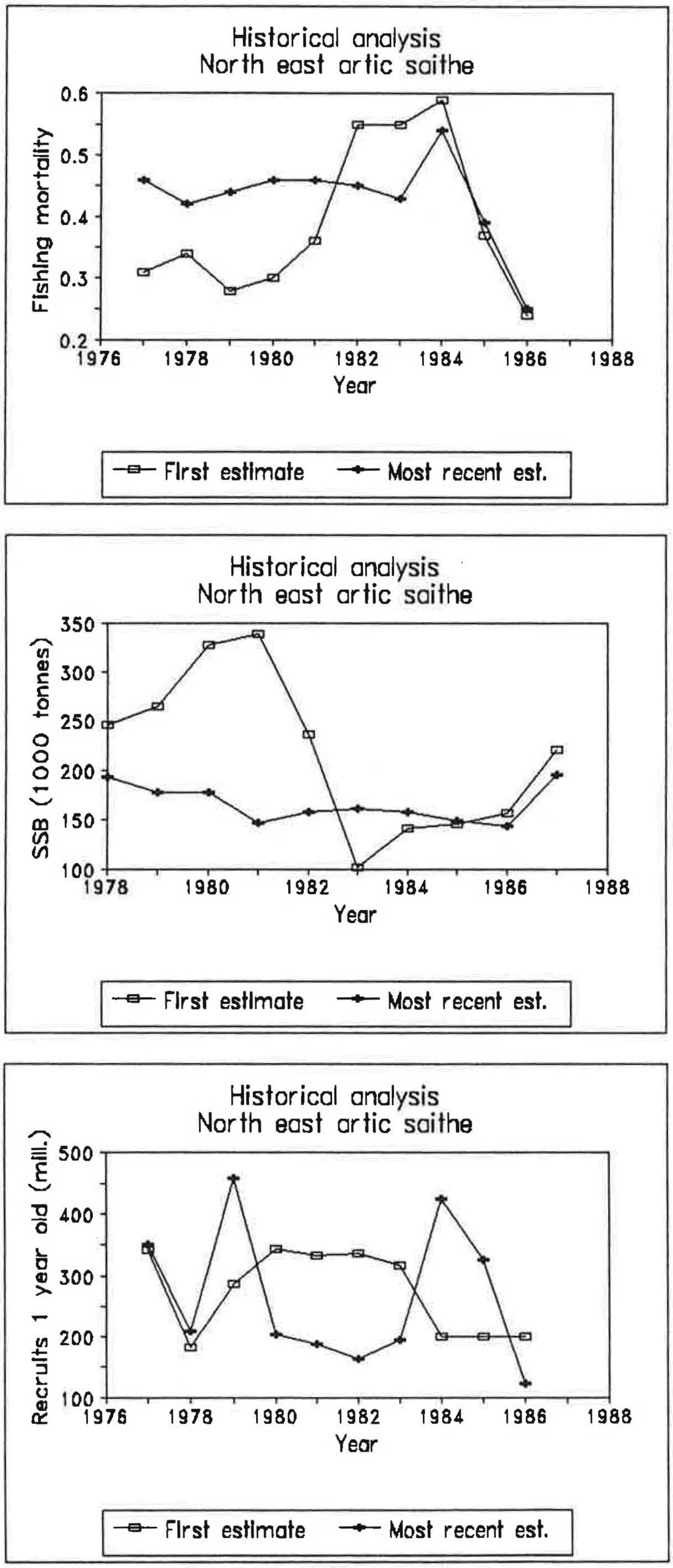


Figure 3.46

HISTORICAL ANALYSIS   NORTH SEA SOLE

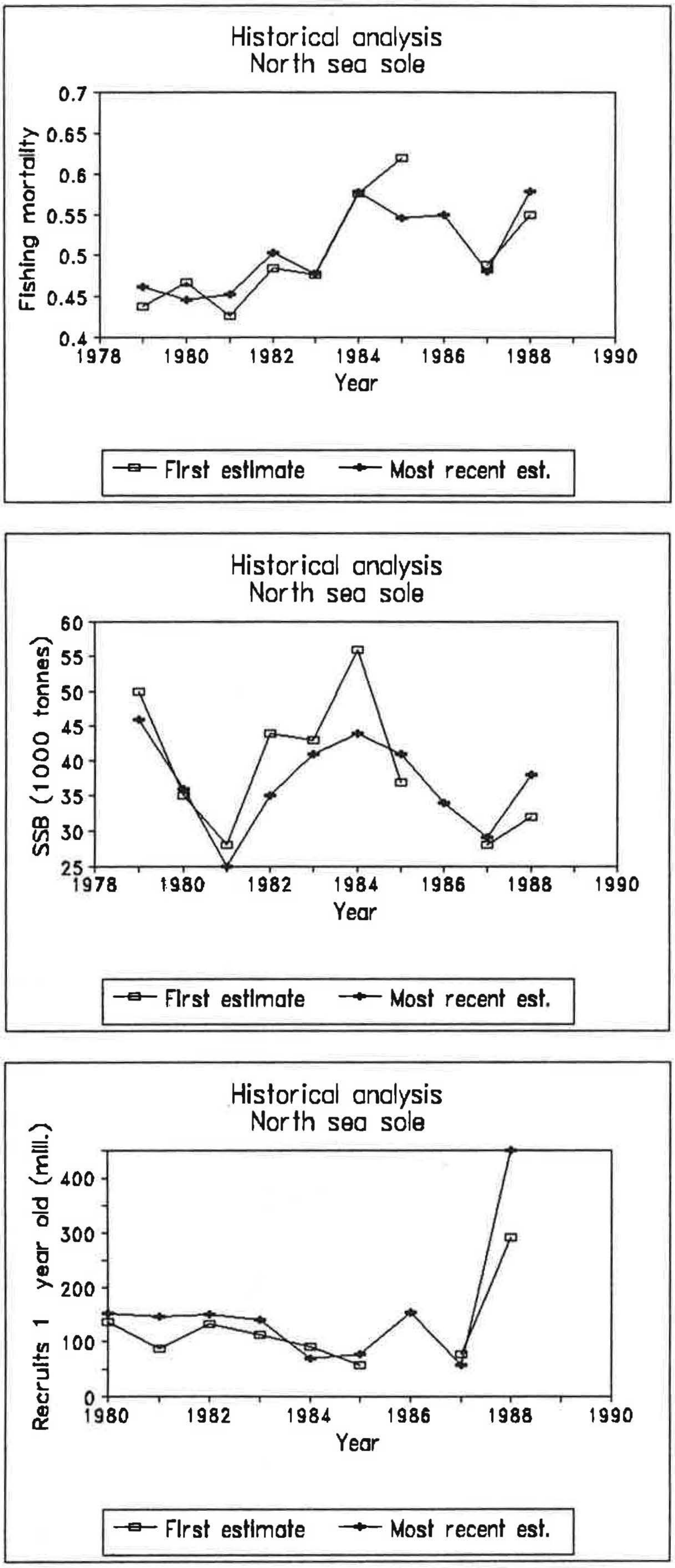


Figure 4.1 Comparison of deviations in terminal year F from baseline F (as absolute raw difference between F values) and variance ratios from terminal year, by age, Southern New England yellowtail flounder.

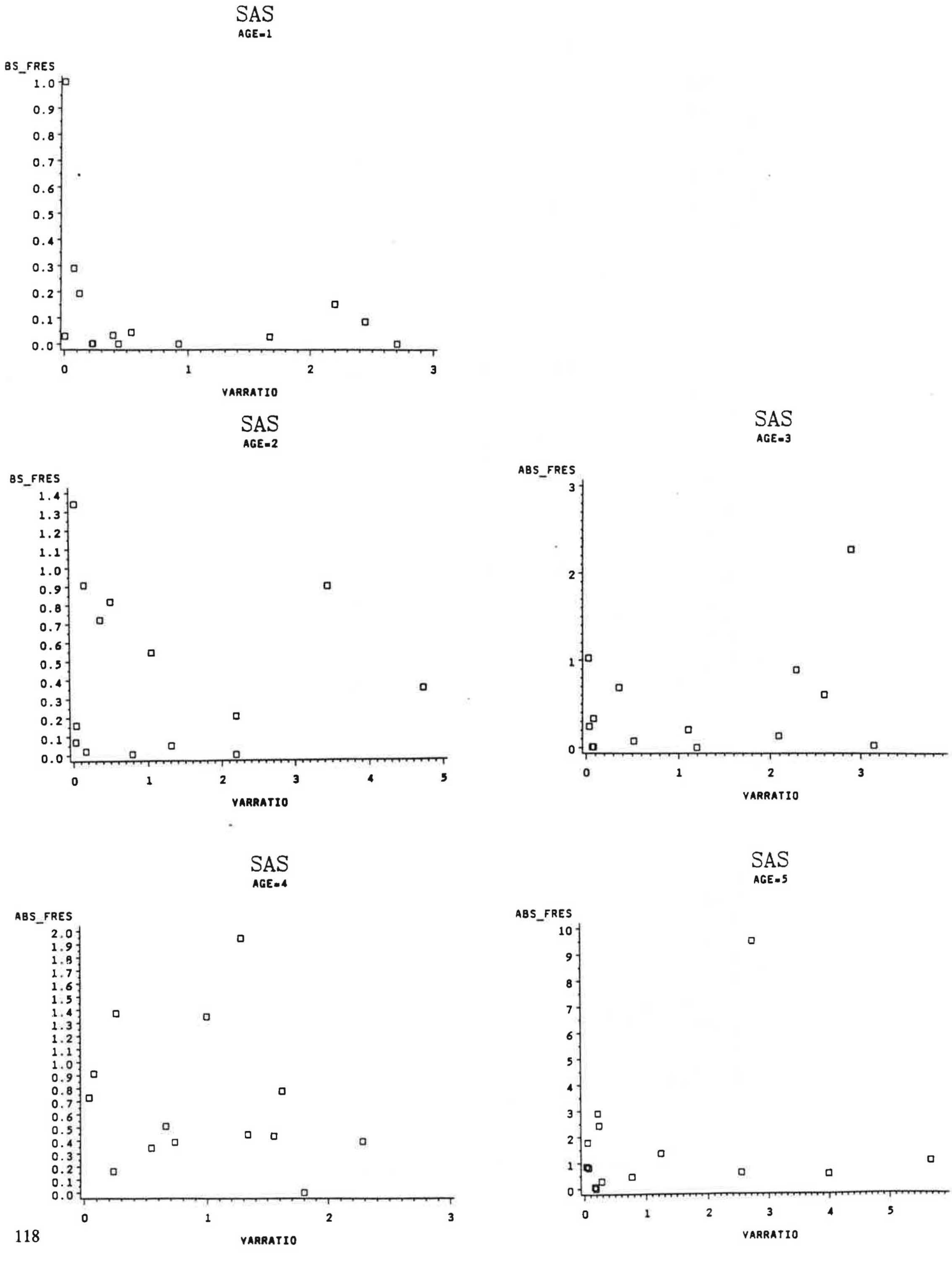


Figure 4.2

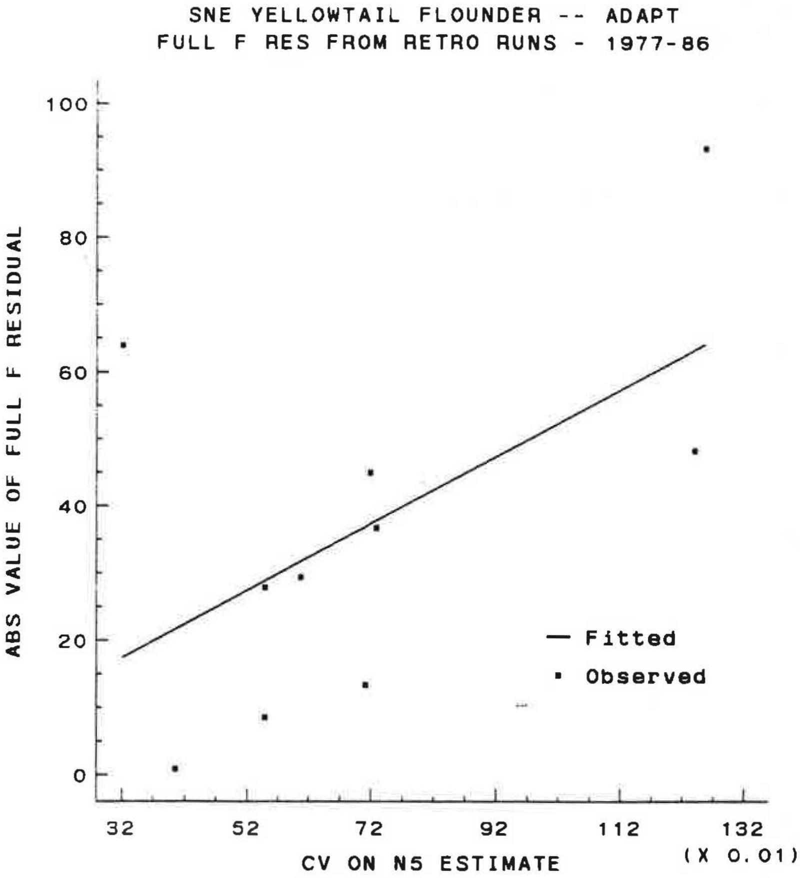


Figure 4.3

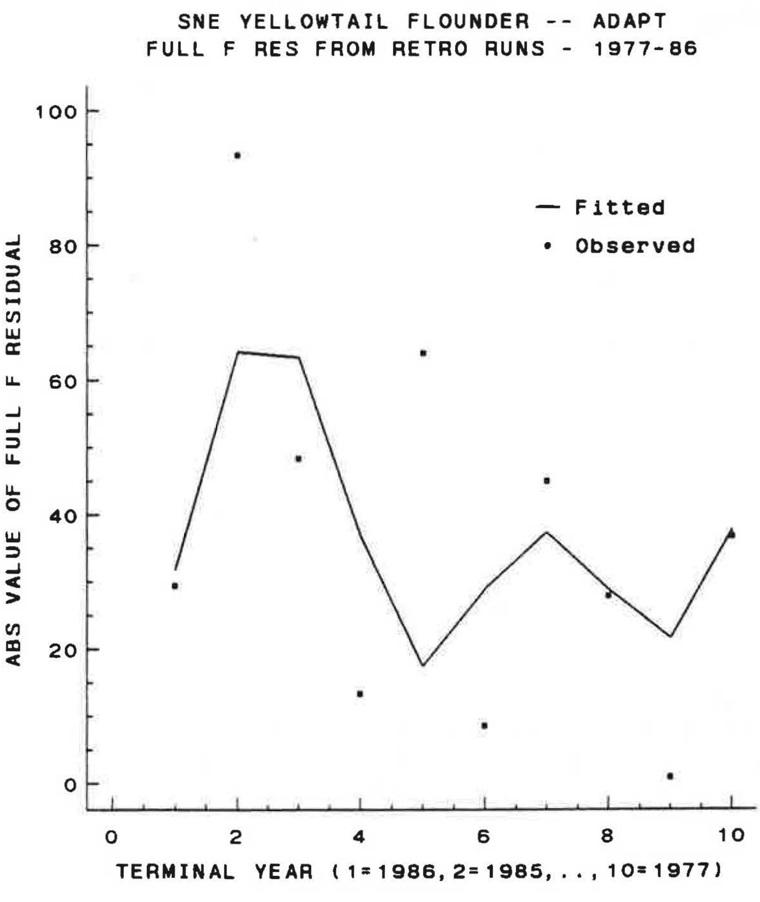


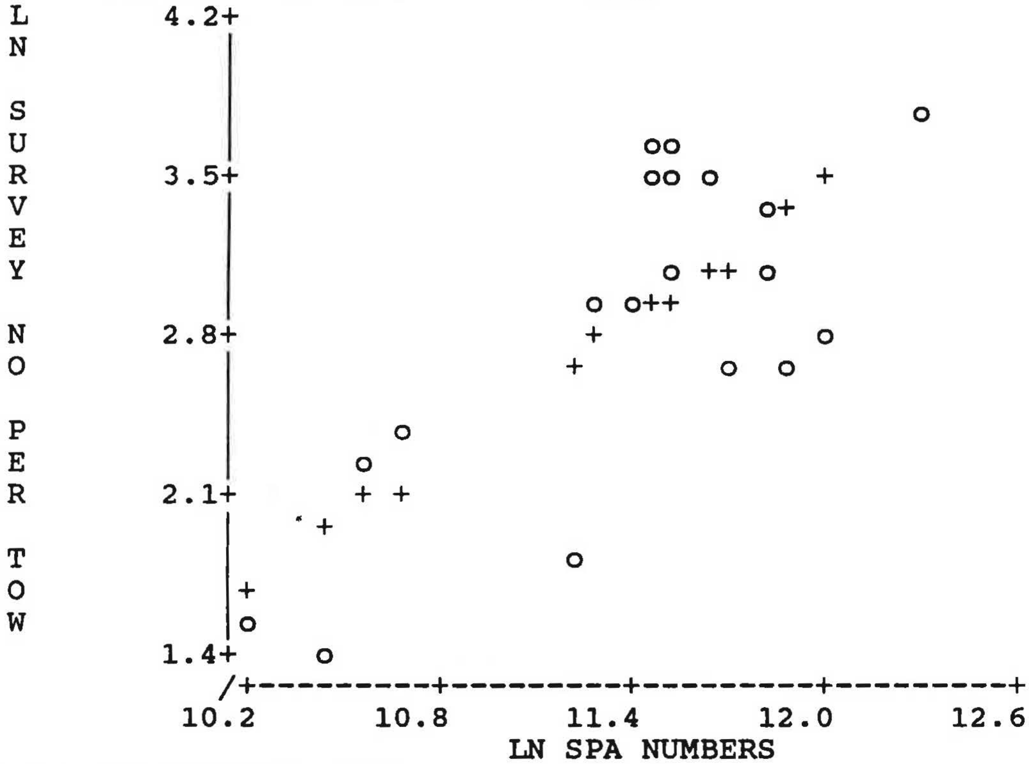
Figure 4.4 - Sample plots for age 3 only (plots are available for all ages estimated)

4TvN COD TUNING MAY 1991

4TVn

AGE 3 PLOTS

LN SURVEY NO. PER TOW VS LN SPA NUMBERS



TREND IN LN RESIDUAL OVER TIME

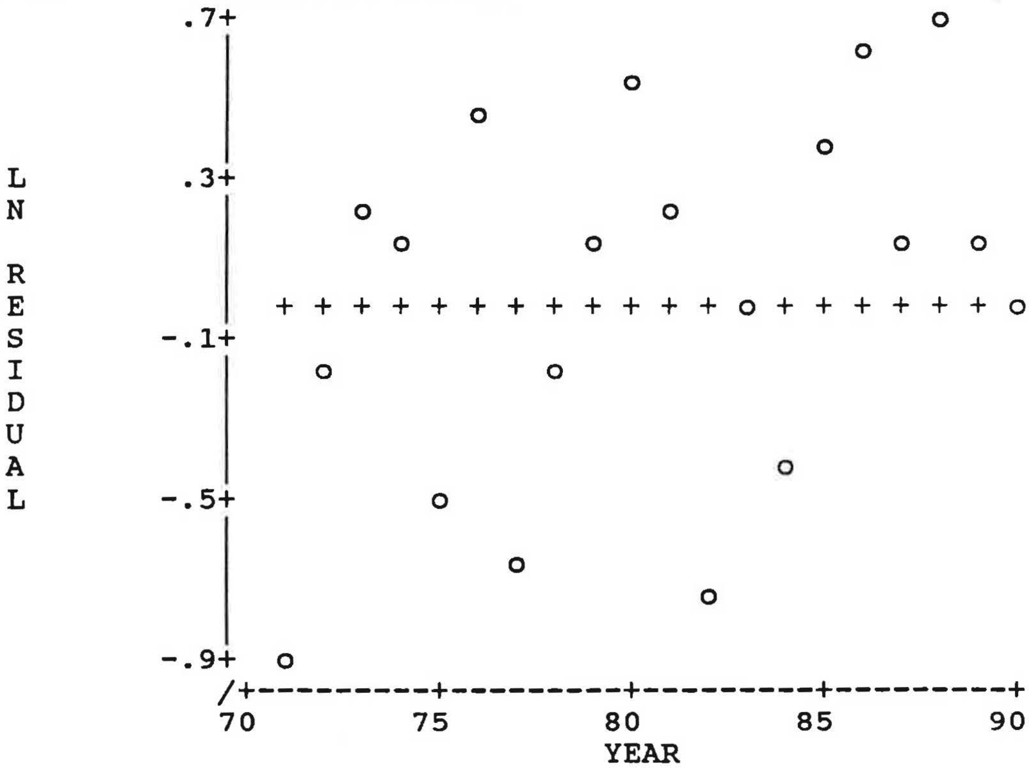
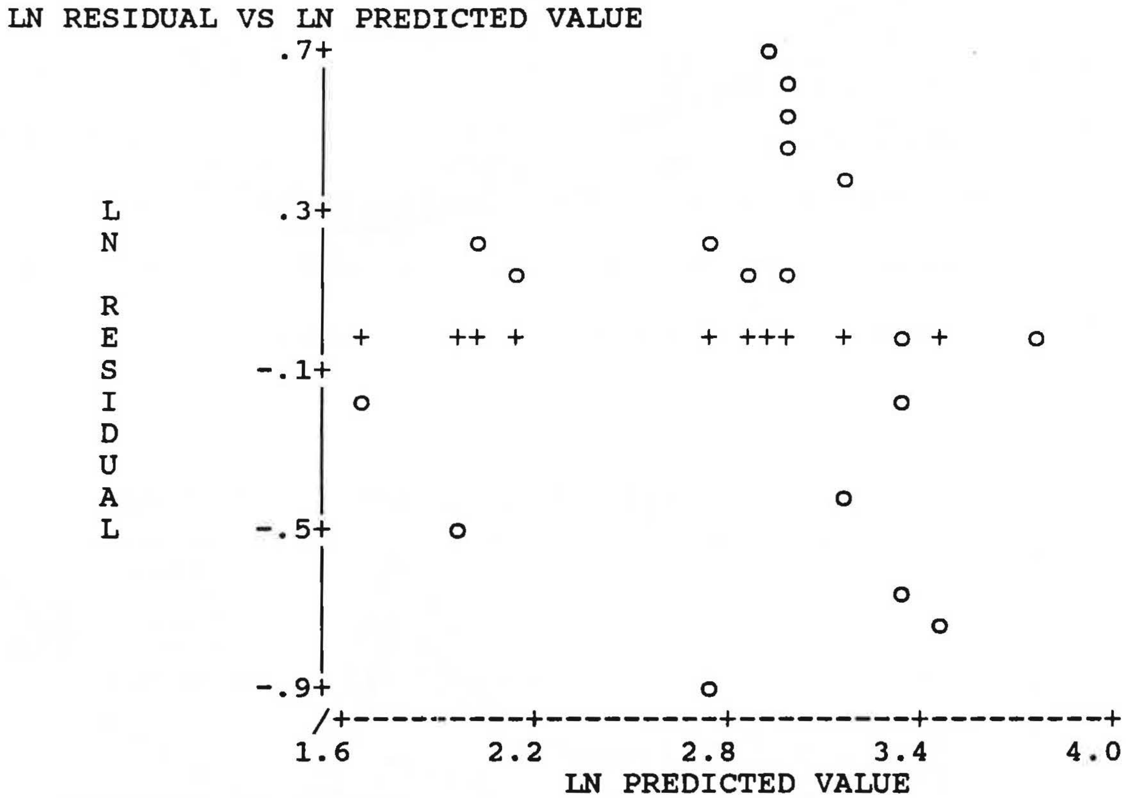


Figure 4.4 Continued



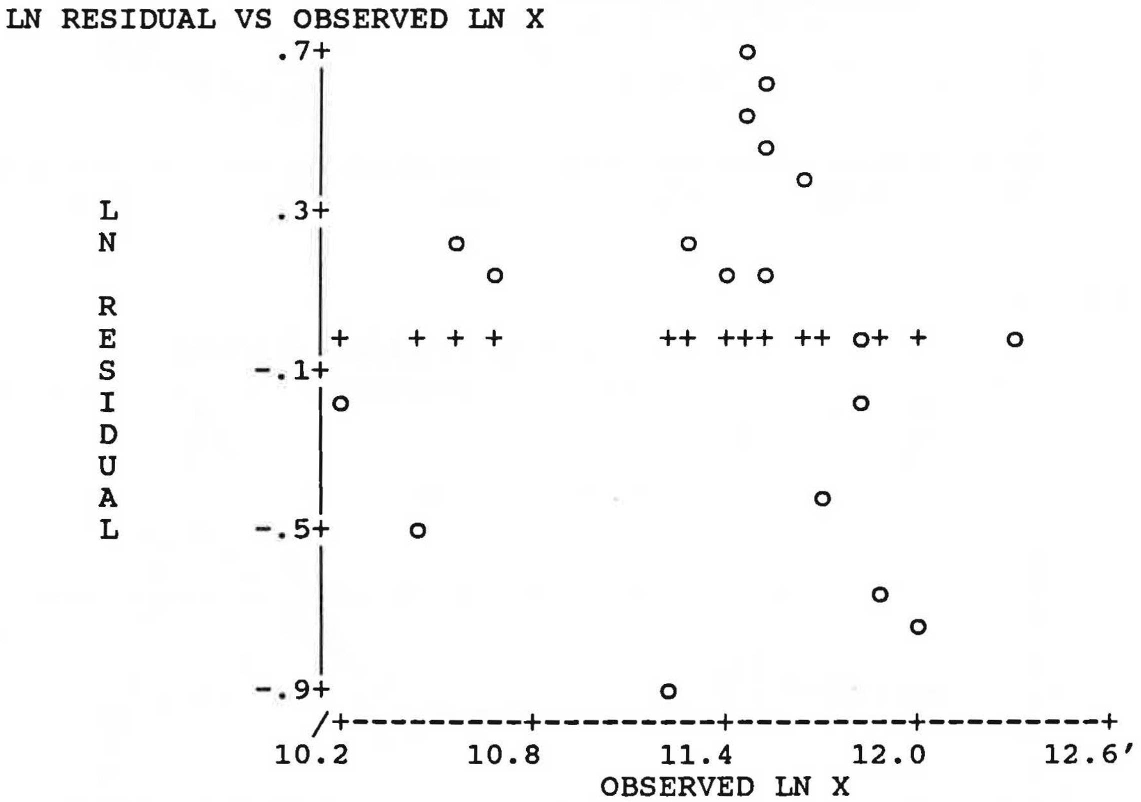


Figure 5.1

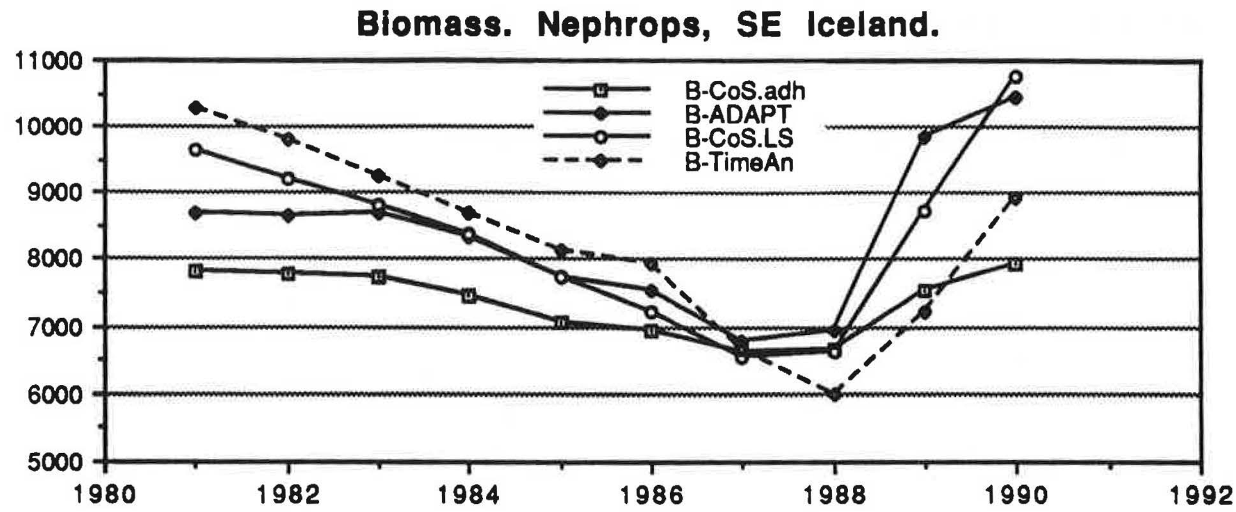


Figure 5.2

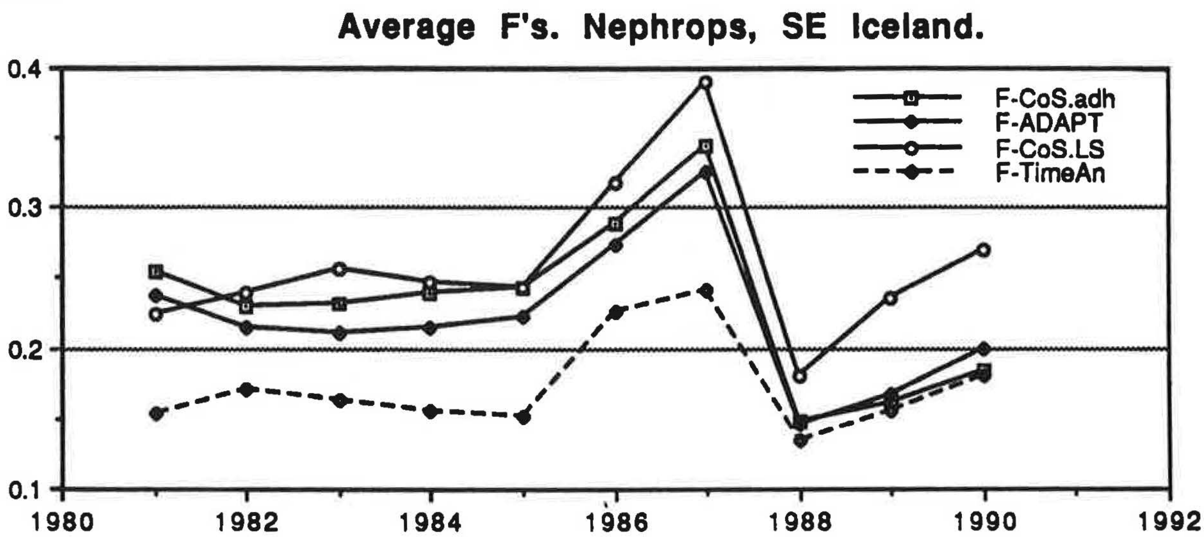


Figure 5.3

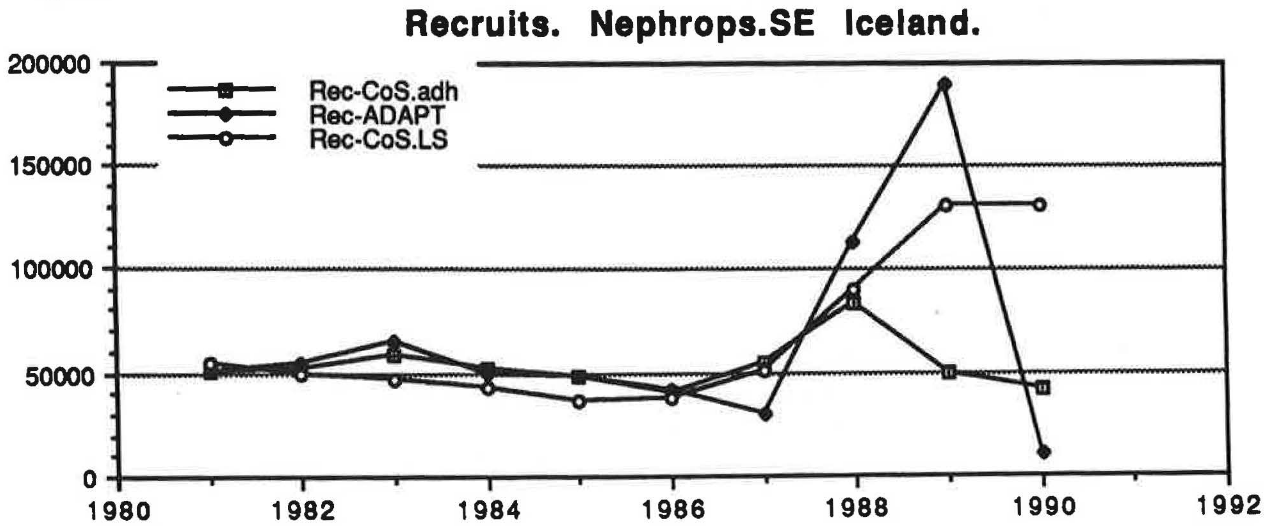


Figure 5.4

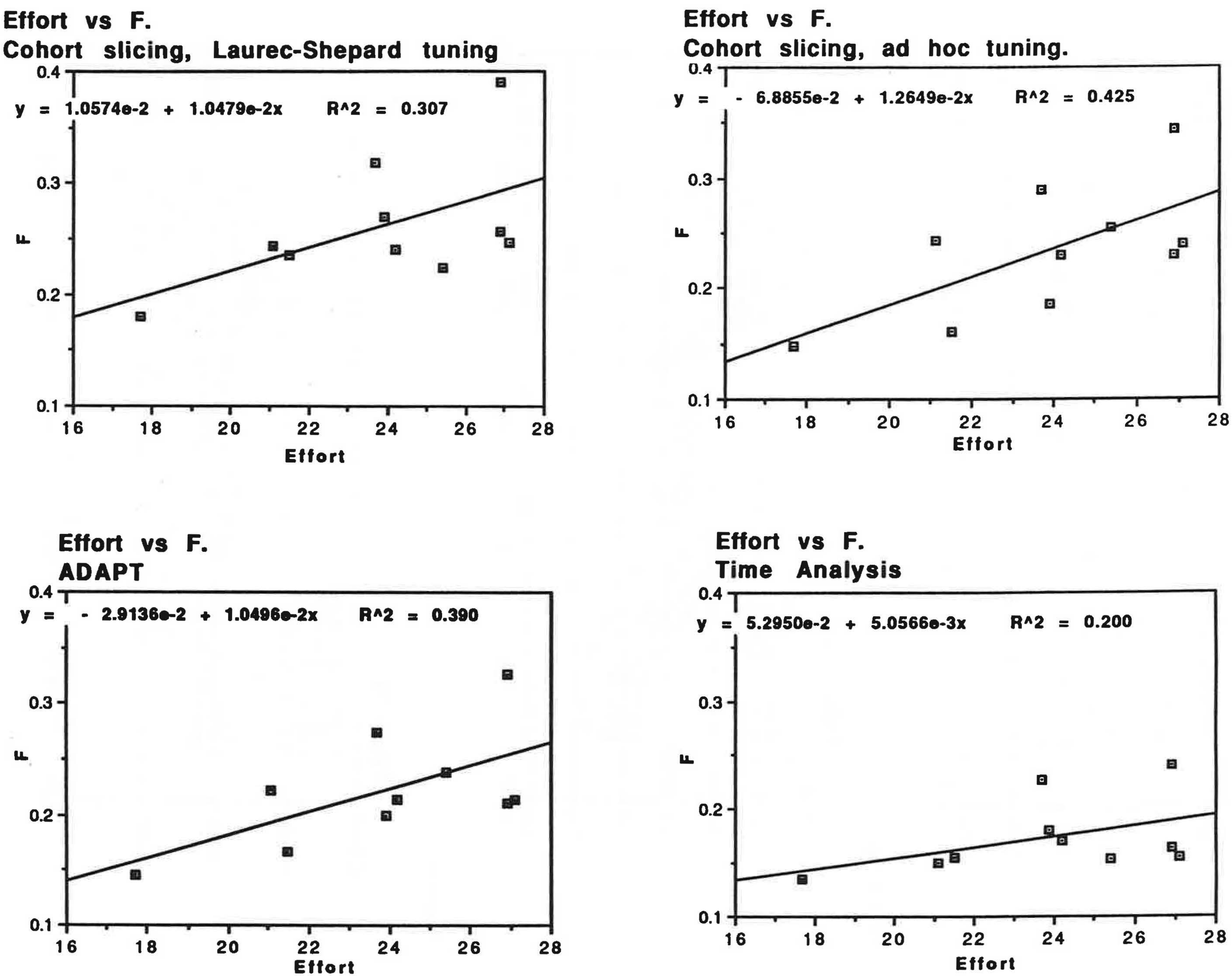

Effort vs F.
Cohort slicing, Laurec-Shepard tuning
y = 1.0574e-2 + 1.0479e-2x R^2 = 0.307
F
Effort
Effort vs F.
Cohort slicing, ad hoc tuning.
y = - 6.8855e-2 + 1.2649e-2x R^2 = 0.425
F
Effort
Effort vs F.
ADAPT
y = - 2.9136e-2 + 1.0496e-2x R^2 = 0.390
F
Effort
Effort vs F.
Time Analysis
y = 5.2950e-2 + 5.0566e-3x R^2 = 0.200
F
Effort

Figure 5.5

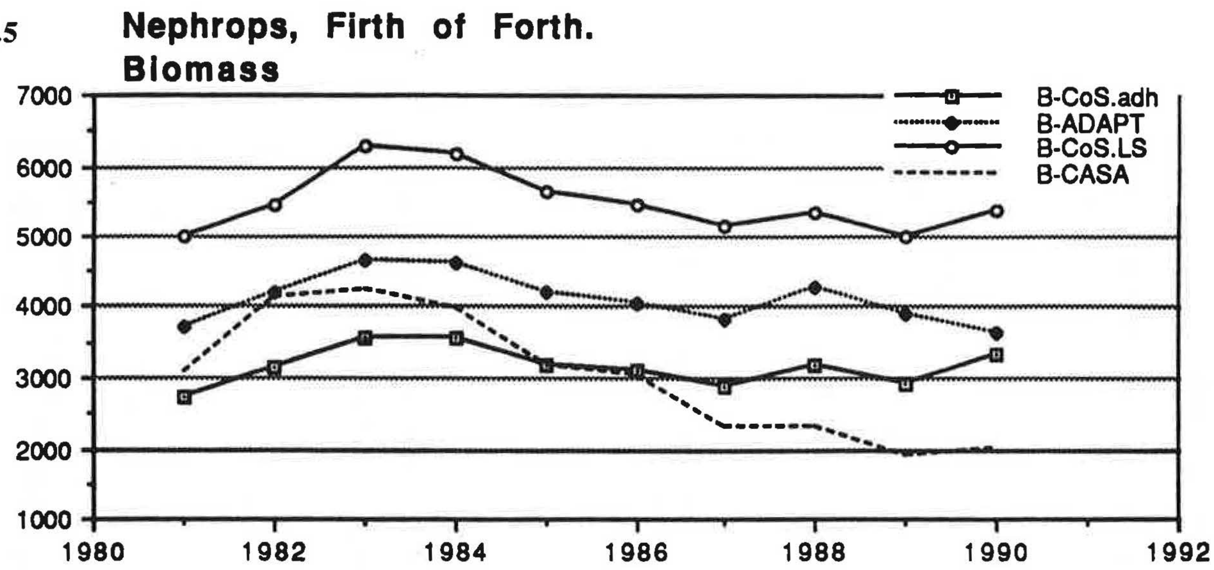


Figure 5.6

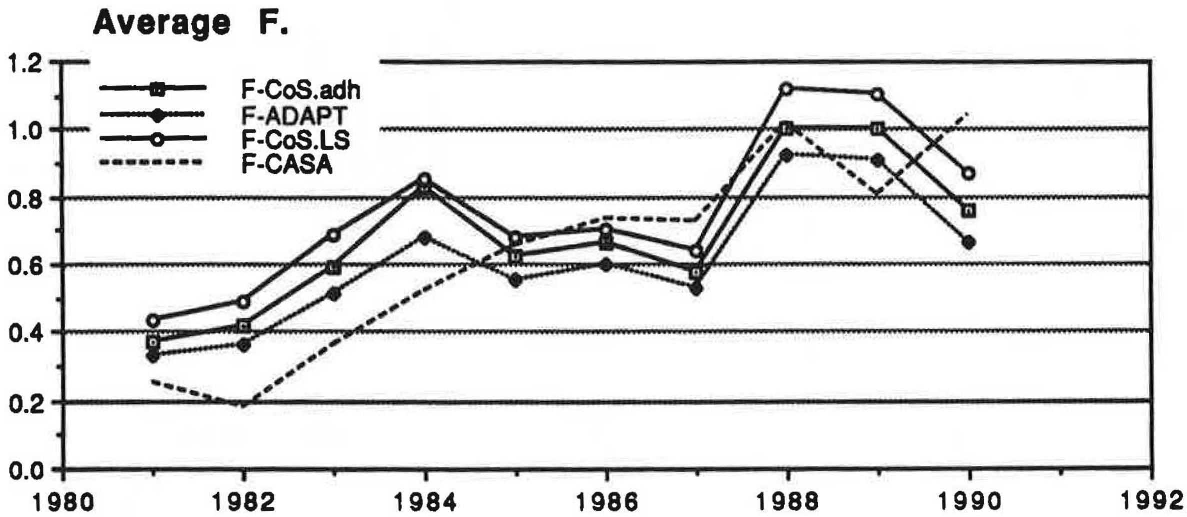


Figure 5.7

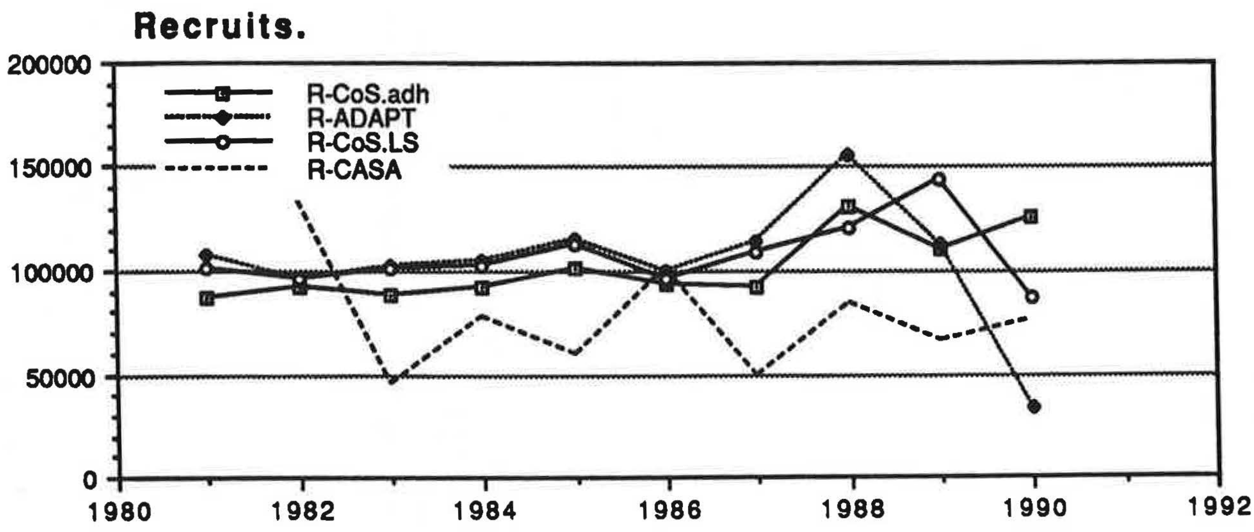
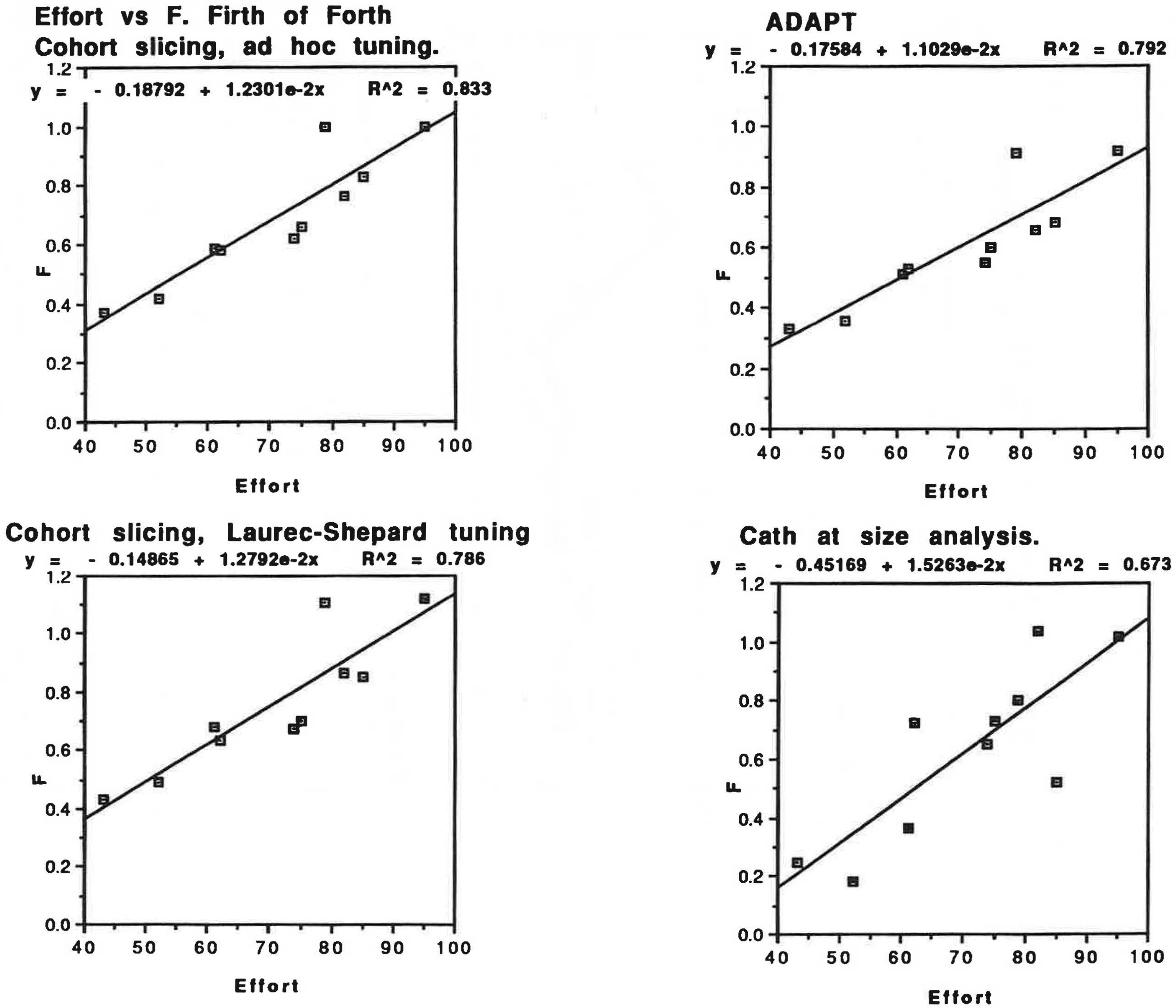


Figure 5.8



Effort vs F. Firth of Forth
Cohort slicing, ad hoc tuning.
y = - 0.18792 + 1.2301e-2x R^2 = 0.833
F
Effort
ADAPT
y = - 0.17584 + 1.1029e-2x R^2 = 0.792
F
Effort
Cohort slicing, Laurec-Shepard tuning
y = - 0.14865 + 1.2792e-2x R^2 = 0.786
F
Effort
Cath at size analysis.
y = - 0.45169 + 1.5263e-2x R^2 = 0.673
F
Effort

Figure 5.9

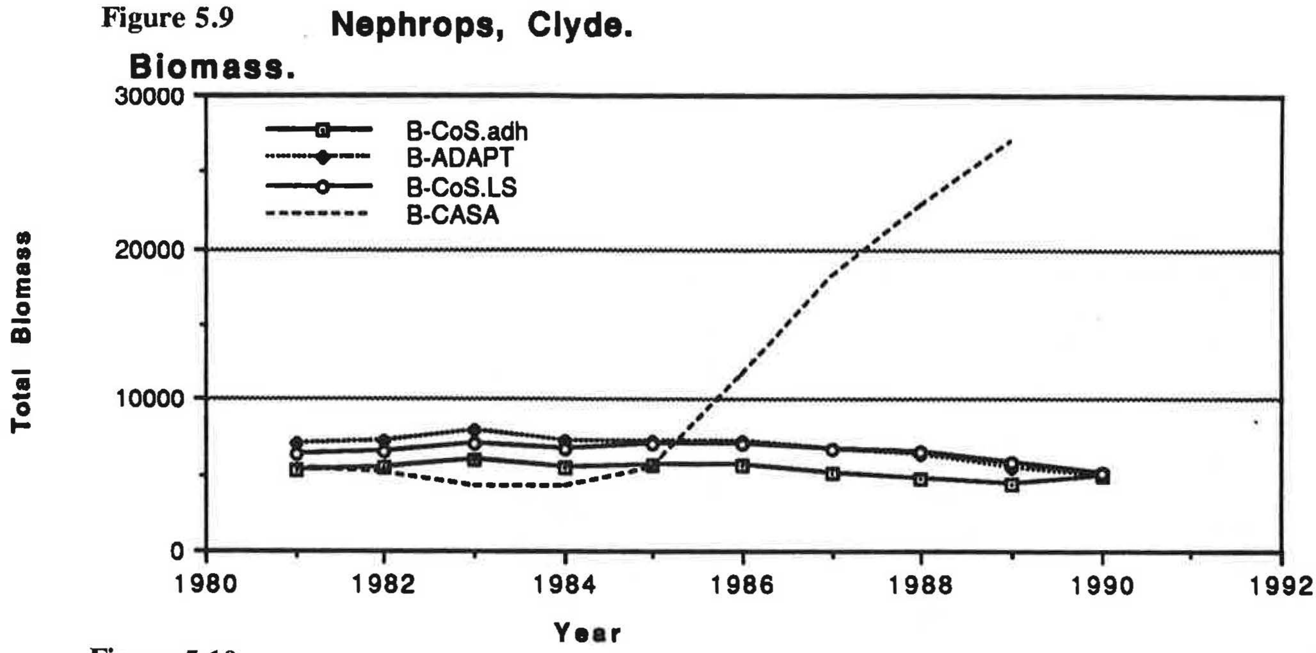


Figure 5.10

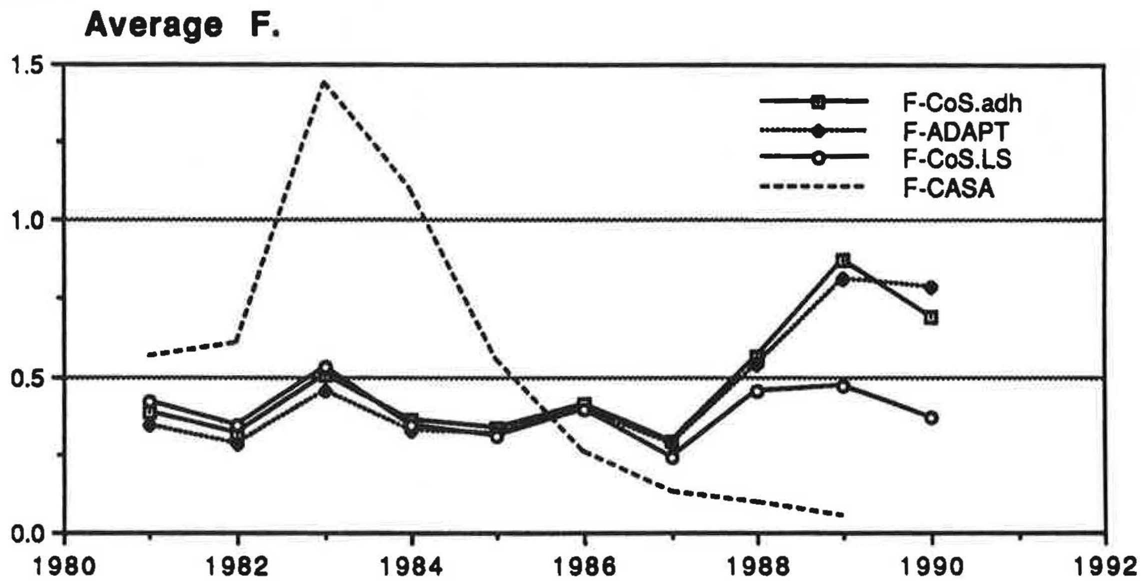


Figure 5.11

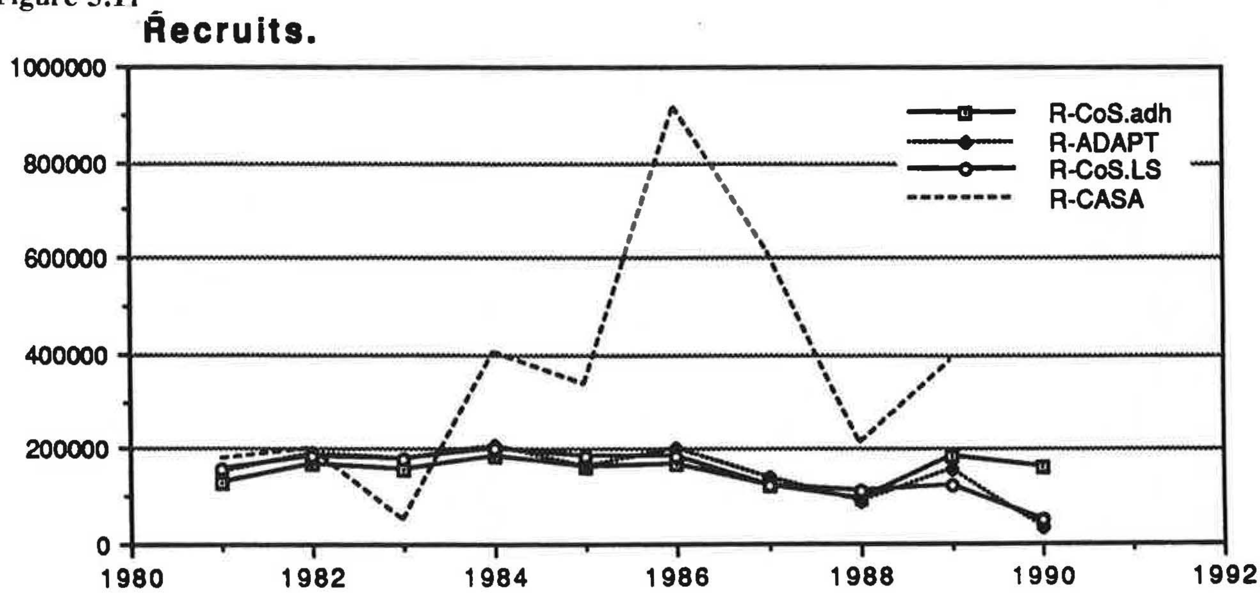
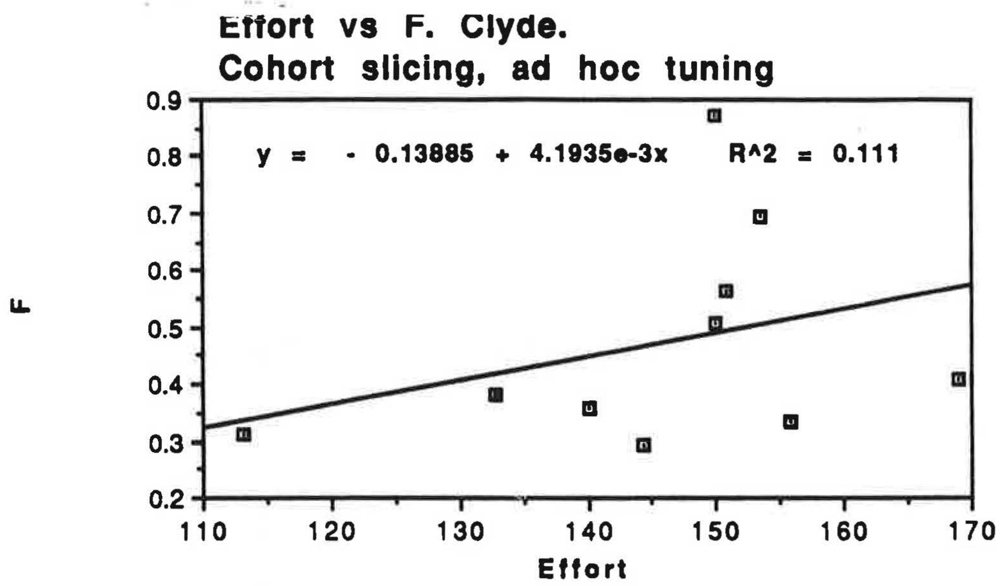
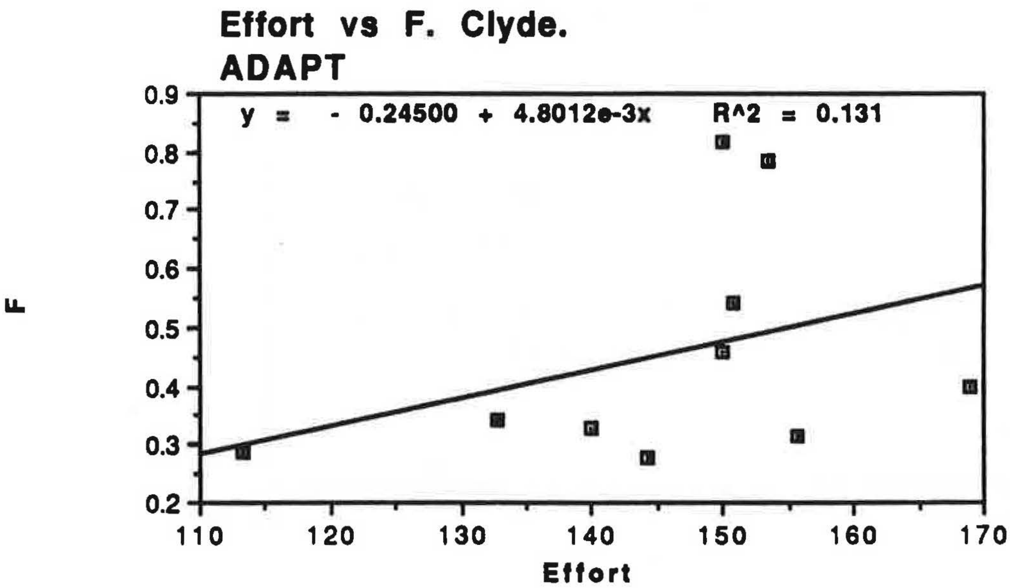


Figure 5.12


Effort vs F. Clyde.
Cohort slicing, ad hoc tuning
y = - 0.13885 + 4.1935e-3x R^2 = 0.111
F
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
110
120
130
140
150
160
170
Effort


Effort vs F. Clyde.
ADAPT
y = - 0.24500 + 4.8012e-3x R^2 = 0.131
F
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
110
120
130
140
150
160
170
Effort

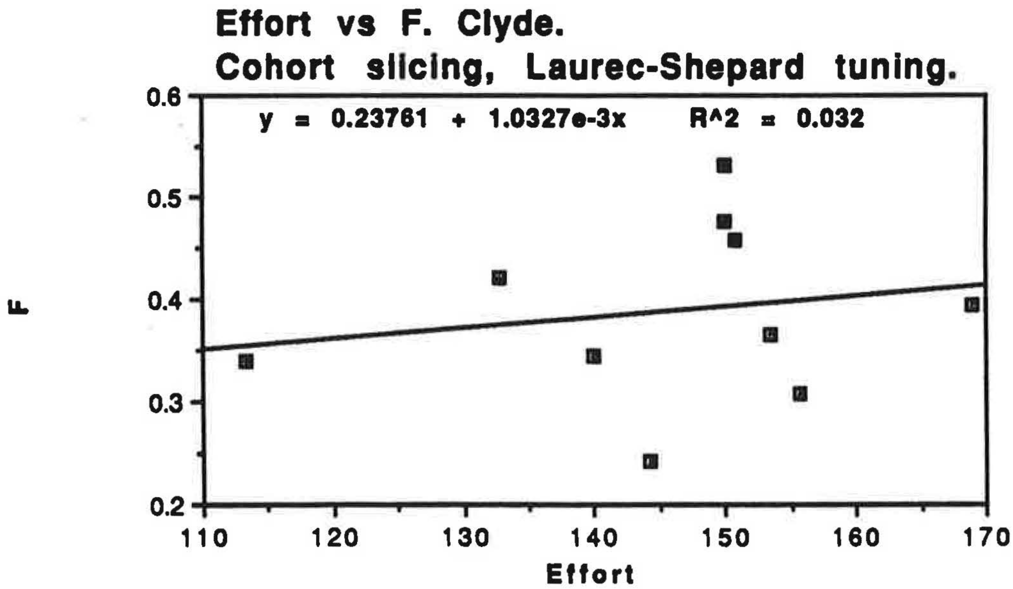
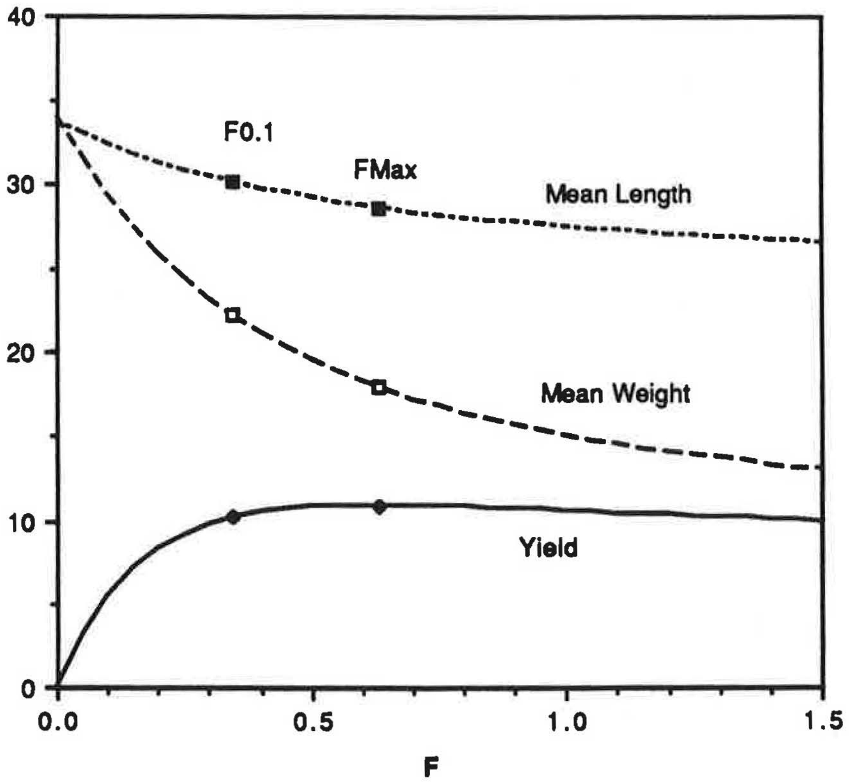

Effort vs F. Clyde.
Cohort slicing, Laurec-Shepard tuning.
y = 0.23761 + 1.0327e-3x R^2 = 0.032
F
0.6
0.5
0.4
0.3
0.2
110
120
130
140
150
160
170
Effort

Figure 5.13 **Yield per recruit for Firth of Forth**



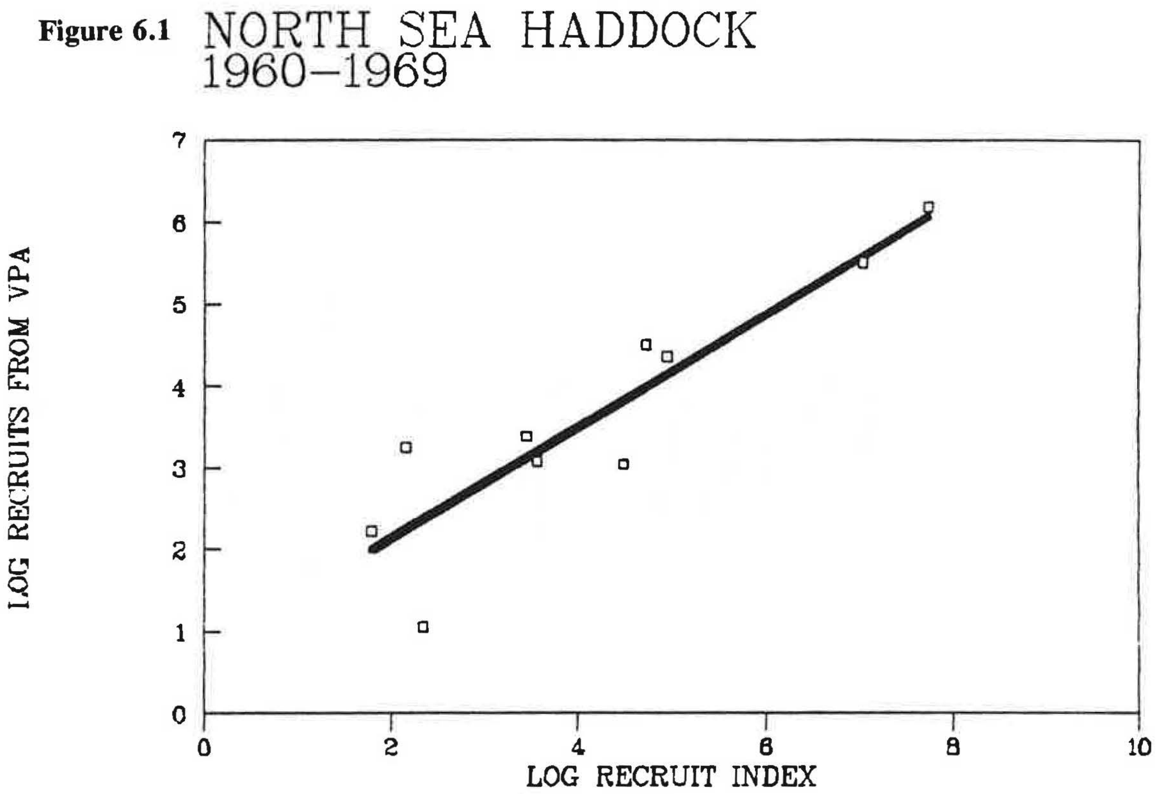


Figure 6.1

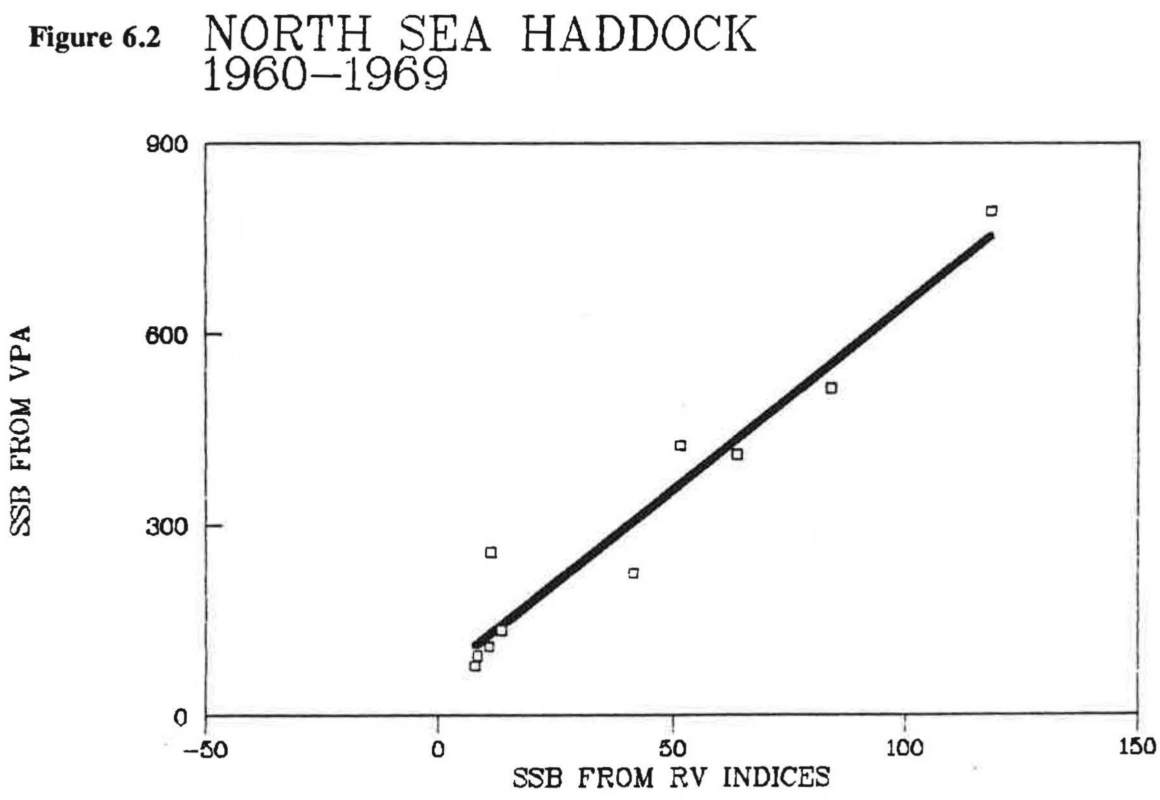


Figure 6.2

Figure 6.3

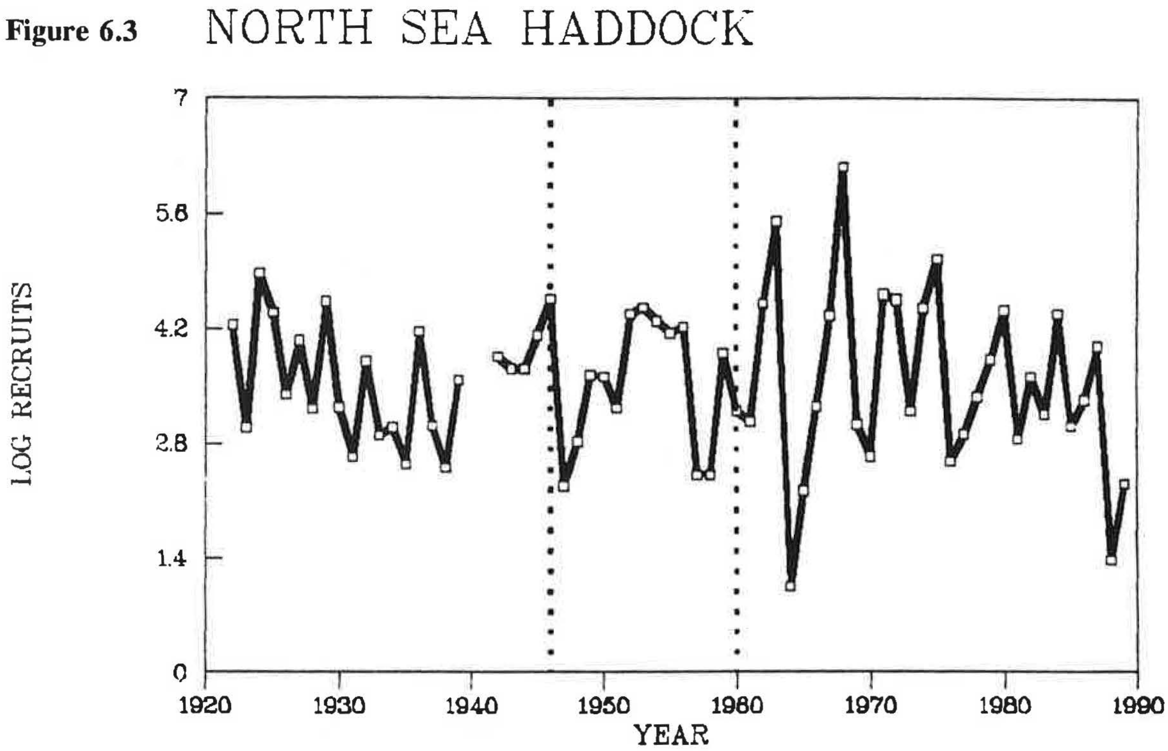


Figure 6.4

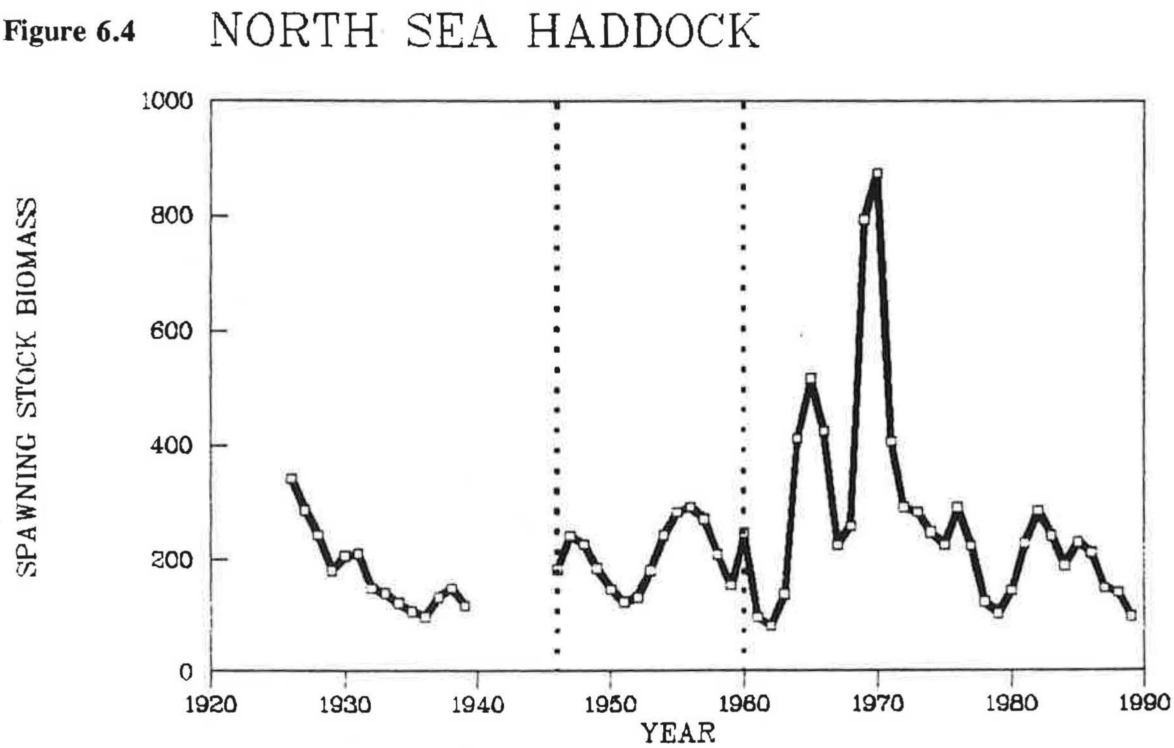
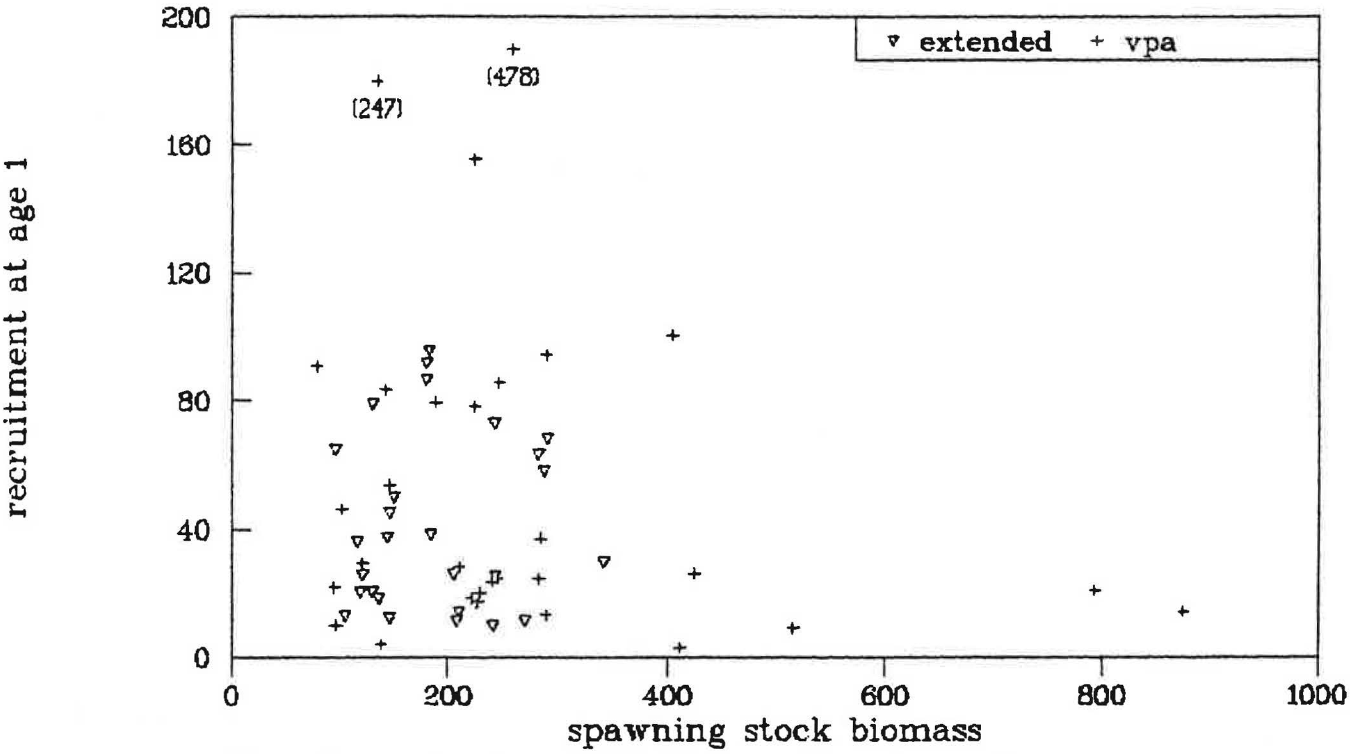


Figure 6.5 NORTH SEA HADDOCK



Numbers in brackets are offscale values

APPENDIX A: WORKING PAPERS AND RELEVANT DOCUMENTS AVAILABLE TO THE MEETING

Retrospective analysis and related topics (R)

R1: Flatman, S. Retrospective VPA results for ten ICES Stocks

R2: Gudmundsson, G. Trend in effort measurement errors or catchability.

Stock estimation (S)

S1: Gudmundsson, G. Application of programs for time series estimation of stocks and fishing mortality rates.

S2: Shepherd, J. G. Extended survivors analysis: An improved method for the analysis of catch-at-age data & catch-per-unit-effort data.

Length based analysis (L)

L1: Gudmundsson, G. Analysis of catch at length data.

L2: Mesnil, B. 1991. Comments on length cohort analysis.

Related documents (D)

D1-2: Anon., 1984. Report of the Working Group on use Effort Data in Assessments and of the Working Group on Methods of Fish Stock Assessments. ICES Coop. Res Rep No. 129.

D3: Anon., 1985. Report of the Working Group on Methods of Fish Stock Assessments. ICES Coop. Res Rep No. 133.

D4: Anon., 1988. Report of the Working Group on Methods of Fish Stock Assessments. ICES Coop. Res Rep No. 157.

D5: Anon., 1987. Report of the Working Group on Methods of Fish Stock Assessments. ICES C.M. 1987/Assess: 24. 107pp mimeo.

D6: Anon., 1988. Report of the Workshop on Methods of Fish Stock Assessments. ICES C.M. 1988/Assess: 26. 117pp mimeo.

D7: Anon., 1990. Report of the Working Group on Methods of Fish Stock Assessments. ICES C.M. 1990/Assess: 15. 95pp mimeo.

D8: ACFM proposal for changing working groups.

D9: Gavaris, S. 1987. Description of ADAPT. From Anon. 1988.

D10: Brander, K. (1987). How well do working groups predict catches ? J. Conseil, 43: 245-252.

D11: Cook, R. M., Kunzlik, P. A. and Fryer, R. J. (1990). On the quality of North Sea Cod Stock Forecasts. NAFO Sci. Council Meeting, Sept. 1990.

D12: Cook, R. M. Assessing a fish stock with limited data: An example from Rockall haddock. Ices C.M. 1989/G:4.

D13: Francis, R. I. C. C. (1990). Risk analysis in fishery management. NAFO Sci. Council Meeting, Sept. 1990.

D14: Hoenig, J. M. et al. A practical approach to risk and cost analysis of fishery management options, with applications to northern cod.

D15: Jones, R. 1974. Assessing the long term effects of changes in fishing effort and mesh size from length composition data. ICES C.M. 1974/F:33.

D16: Jones, R. 1976. A preliminary assessment of the Firth of Forth stock of Nephrops. ICES Special meeting on population assessments of shellfish stocks, No. 24.

D17: Jones, R. 1990. Length-cohort analysis: The importance of choosing the correct growth parameters.

D18: Pelletier, D. and Laurec, A. (1990). Toward more efficient adaptive TAC policies with error-prone data. NAFO Sci. Council Meeting, Sept. 1990.

D19: Restrepo, V. R., Powers, J. E., Turner, S. C. and Hoenig, J. M. Using simulation so quantify uncertainty in sequential population analysis and derived statistics, with application to the North Atlantic swordfish fishery. (mimeo)

D20: Shepherd. Report of special session on management under uncertainties related to biology and assessments, with case studies on some North Atlantic fisheries. NAFO Sci. Council Meeting, Sept. 1990.

D21: Sinclair, A., Gascon, D., O'Boyle, R., Rivard, D. and Gavaris, S. (1990). Consistency of some Northwest Atlantic groundfish stock assessments. NAFO Sci. Council Meeting, Sept. 1990.

D22: Shepherd, J. G. and Nicholson, M. D. Multiplicative analysis of catch-at-age data, and its application to catch forecasts. J. Cons. int. Explor. Mer. 47, 284-294.

D23: Mohn, R. K. Risk analysis of 4VsW cod. CAFSAC Working Paper 91/102

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APPENDIX B: NOTATION

NOTE: This standard (and largely mnemonic) notation is followed so far as possible, but not slavishly. Other usages and variations may be defined in the text. Array elements are denoted by means of either indices or suffices, whichever is more convenient. The same character may be used as both an index or a variable, if no confusion is likely.

Suffices and Indices

y	indicates	year
f	"	fleet
a	"	age
t	"	last (terminal) year
g	"	oldest (greatest) age group
l	"	length
k	"	year class
$	"	summation over all possible values of index (usually fleets)
#	"	summation over fleets having effort data
@	"	an average (usually over years)
*	"	a reference value

Quantities (all may have as many, and whatever, suffices are appropriate).

C(y,f,a)	Catch in numbers (including discards)
E(y,f)	Fishing effort
F(y,f,a)	Fishing mortality
F_s (y,f)	Separable estimate of overall fishing mortality
q	Catchability coefficient (as in F=qE)
Y	Yield in weight
W	Weight of an individual fish in the catch
W_s	Weight of an individual fish in the (spawning) stock
B	Biomass
P	Population number (also fishing power)
E	Fishing effort
U	Yield or landings per unit of effort
C_w	Catch in weight of fish (including discards)
N	Stock in numbers of fish
F	Instantaneous fishing mortality rate
M	Instantaneous natural mortality rate
Z	Instantaneous total mortality rate
S	Selection coefficient defined as the relative fishing mortality (over age)
R	Recruitment
f	Relative F (e.g., F/F*)
y	Relative yield (e.g., Y/Y*)
d	Fraction discarded
b	Fraction retained (b=1-d)
h	Hang-over factor
G	Instantaneous growth rate (in weight)
L	Landings in numbers (excludes discards)
l	Length
l_∞	Von Bertalanffy asymptotic length
K	Von Bertalanffy "growth rate"
r	Recruit index
MSY	Maximum sustainable yield
F_{msy}	Fishing mortality associated with MSY
E_{msy}	Fishing effort associated with MSY
B_{max}	Pristine stock biomass
m	Shape parameter for various surplus production models

APPENDIX C: SEPARABLE VPA - FURTHER ADVICE TO WORKING GROUPS

Need to Use Separable VPA

Separable VPA is a useful technique when no data are available for tuning the VPA (in which case it is less sensitive to errors than "tuning" using average Fs), or when the CPUE and/or survey data available are very noisy (cv's exceeding 0.5, say). In the latter case a separable VPA run guided in a general way by the overall trend of fishing mortality revealed by the noisy tuning results should be less sensitive to errors in both catch and CPUE data for the final year.

Its use in these cases is however optional, and a matter for judgement by the working group. When there is plenty of good quality CPUE/survey data available (at least one index with cv's of no more than 0.3 on the most important age groups, say) there is no particular advantage in using separable VPA after tuning, and therefore no need to do so. It may of course still be useful for exploring exploitation patterns for the stock, and thereby guiding the choice of F on the oldest age in any VPA.

Final Year Fishing Mortalities in Separable VPA and Catch Forecasts

There is sometimes some confusion over the final year fishing mortality estimates generated by separable VPA, and the best values to use for a catch forecast. This arises because separable VPA, like most other modern methods including *ad hoc* tuning methods, estimates final year populations in some overall average (and therefore hopefully robust) manner, and allows any sampling errors in the catch-at-age data to be reflected in the final year F values, which are therefore "noisy".

For a catch forecast it is important that stable estimates of both survivors and fishing mortality be used. The noisy final year Fs are not suitable for this purpose, since one would not expect the particular errors observed in the final year to be perpetuated in the future. This can normally best be achieved by using estimates of survivors, if available, directly, together with Fs obtained by averaging over the last few years (3 to 5 years, say) scaled up or down to reflect any changes in overall fishing effort and mortality if necessary. Alternatively, the F values may be obtained from Separable VPA by multiplying the selection values by an appropriate value of overall F. When a mesh change is being implemented it may of course be necessary to adjust the F values on the youngest ages to allow for this.

The values of survivors (i.e. the population numbers at the end of the final data year) required are supplied directly by the Lowestoft VPA package (final column of Table 10) for both Tuned and Separable VPA, and also by methods such as ADAPT and Extended Survivors Analysis (XSA). The ICES VPA package also provides the survivors in the table of stock numbers (shown as numbers at the beginning of the year following the last data year). The values used as stock numbers for the prediction must be taken from the final VPA in which the terminal Fs are the "noisy" values generated by separable VPA (using the recommended "terminal populations" option) or *ad hoc* tuning. This is necessary so that the final year initial populations will, when combined with the observed catches in the final year, correctly reproduce the survivors. The final year Fs in the VPA thus differ from the Fs used for the forecast, because the former are treated as being affected by sampling errors which are regarded as ephemeral.

When the survivors estimated by VPA are discarded in favour of separate estimates of recruitment, it is neither necessary nor desirable to make any adjustment to the F values in either the VPA or the forecast, since the need to make the replacement must mean that either the catch value or the F estimate (or both) are considered to be unreliable, and it is therefore better to use the recruit estimate and the average F value for the forecast, since these are presumably more reliable.

Selecting the reference age for unit selection

The results of Separable VPA are not affected by the choice of reference age for unit selection in any fundamental way, but there may be confusing side effects of unwise choices which are best avoided.

The reference age should not be chosen too low (in the partially recruited range) because this leads to most of the selection values becoming greater than one, and may interact with an inappropriate choice of terminal selection to produce domed selection patterns for no sound reason (see below). It should not be chosen too high, (ie anywhere near the maximum of the age range) since this makes the procedure liable to crash. The ideal choice is the first age at and above which the selection pattern may be regarded as fully recruited and flat. When there are high F values in the middle of the age range, it is a matter of taste whether to choose the reference age so as to normalise on the maximum values (ie. have 1.0 at the maximum) or to normalise on the flat part of the range so that some intermediate values exceed 1.0.

The terminal selection value must be chosen in the light of the above choice. Using 1.0 without thought may lead to

* a kick up on the oldest ages if one has normalised to an intermediate maximum F value

* low values on the oldest ages (and therefore a domed pattern) if one has normalised to F on a partially recruited age group

Both these undesirable side effects may be avoided by either

* making the "ideal choice referred to above, and using 1.0 for the terminal selection

* using a terminal selection value other than 1.0 to produce a "terminally flat" exploitation pattern, or any other shape considered appropriate.

NB. Please remember that Separable VPA does NOT determine the shape of the exploitation pattern on the oldest ages, it simply allows one to generate analyses consistent with what is believed to be appropriate, for whatever reason (including blind faith).

Selection of F values for Catch Forecasts

A further point of doubt may be whether it is better to use F values obtained from averages of VPA estimates for recent years, or from the separable exploitation pattern and an estimate of overall F. In normal circumstances there should be no appreciable difference between these, and one may use whichever is more convenient. The average Fs should be preferred if there is any suspicion of recent changes in the exploitation pattern and the separable model has been fitted using non-zero weights over many more ages than are used in the average. The averages may however be more sensitive to noise in the VPA, and if this is a problem the separable estimates are preferable. The basic rule is to use whatever estimates are believed to best represent F for the period of the forecast, and least affected by noise in the data.

APPENDIX D: TUNING SEASONAL VPAS

There is in principle no great difficulty in constructing seasonal VPA's which are tuned using CPUE/survey data, although software to do so is not generally available either at ICES or elsewhere. There are a number of technical details and difficulties which need to be taken into account, however, and some of these are discussed below.

Length of seasons

A VPA may be constructed with any length of season (not just quarterly), by a simple adaptation of the usual VPA or cohort analysis algorithms. The main difficulty is proper housekeeping of the time and age indices, which are no longer in one-to-one correspondence. Whilst it would be possible to overcome this by holding data in arrays indexed by yearclasses and time, rather than age and time, this would make the internal data structures incompatible with the usual ones, and almost certainly lead to confusion and error, so this is not recommended. It seems on balance preferable to keep season as a subdivision of time, indexed separately. This has the further advantage that it also makes it easy to analyse the data for seasonal effects (eg. season becomes an extra factor in a statistical analysis) as discussed below.

For IFAP it is suggested that one should allow for up to 12 seasons(ie. months) if this can be done without difficulty. The number of seasons should in any case be kept as a parameter, to allow easy recompilation for more detailed analyses if and when these become necessary. Pope's cohort analysis algorithm is particularly easily adapted to seasonal calculations, and may be the method of choice.

Zeroes in the data

Seasonal catch and CPUE data is particularly likely to suffer from zeroes in both the body of the data and in the youngest and oldest age groups. These need to be handled differently, depending on whether they occur in the total catch matrix or in a CPUE series.

Zeroes in the youngest age groups or the body of the catch-at-age data may be treated as such whatever algorithm is used, although they must be explicitly trapped when iterative ("exact") VPA algorithms are used, to avoid overflow or underflow errors. For cohort analysis they are not a problem and will lead correctly to a zero F estimate. Zeroes in the oldest age groups are a tricky problem for methods which initialise each cohort with an estimate of terminal fishing mortality, but not for those which start with a terminal population, and these should therefore be preferred in this context.

Zeroes in CPUE data which are associated with zero effort should be treated as missing, ie. given zero weight in the analysis, and a method which permits this is therefore required. Those associated with finite effort should be treated as small numbers and replaced by the smallest number distinguishable from zero : one third of the smallest non-zero number in the data is usually a satisfactory choice. They should also be given low weight since they are usually measured with low precision. For the oldest age groups it is probably preferable to treat zeroes as missing values anyway, since they may represent observations of arbitrarily small numbers.

Synchronisation of the tuning calculations

For seasonal analysis it is almost certainly necessary to make sure that the comparison of indices and VPA estimates are made at the correct time of year, especially if the fishery is highly seasonal but variable in timing. This may be done either by interpolating the VPA population estimates within seasons to the appropriate time, or by correcting the indices to the beginning of the appropriate season. The latter method is used by XSA for annual data , is mathematically equivalent so long as there is no need for absolute (unbiased) estimates of catchability, is computationally slightly less hassle, and indubitably adequate and probably the best option. In either case one is almost forced to assume that the fishery takes place uniformly within the season : if this is known to be incorrect then one could and should use a shorter seasonal period.

Reproducibility of Seasonal Patterns

The methods above do not require any assumption concerning reproducibility of the seasonal pattern from year to year, but this may be a feature of some datasets. Some existing methods estimate the exploitation pattern in the last time period by averaging over earlier F values. If there is a strong seasonal signal it may be preferable to average over the same season in previous years. On the other hand, if the seasonal pattern is weak an average over the immediately preceding periods may give a better estimate of the latest pattern of terminal fishing mortality.

Conclusions

On balance it seems probable that a method based on cohort analysis, allowing weighting of CPUE/survey indices, and based on terminal population rather than terminal F estimation is likely to be best suited for this application. It is therefore suggested that IFAP should use a method similar to XSA (which has all these features) for this purpose and should be relatively easy to adapt for the purpose.

APPENDIX E: SOME COMMENTS ON THE COMPUTATION OF AVERAGE F ACROSS AGE GROUPS

Before any attempt is made to compute average indices of fishing mortality, the purpose of the computation must be made quite clear. Annual indices of overall fishing mortality are mostly made either to examine their relationship to fishing effort or to measure the effect of fishing on the stock of interest. These two purposes are quite different and require different approaches.

It has been noted on several occasions (Shepherd, 1983, Anon., 1984) that population weighted mean Fs should not be used for the purpose of tuning VPA's or correlating with effort, and this is especially true if the averaging is across age groups which are not fully recruited to the fishery. Thus, for the purpose of obtaining a measure of fishing intensity, it must be emphasized that although alternate measures exist, a simple arithmetic average across age groups is to be preferred, since this is a simple measure, which will not cause the problems inherent in using population weighted averages for this purpose. The these problems primarily arise when variable recruitment coincides with the use of population weighted averages taken over non-flat portions of the fishing pattern.

For the purpose of estimating the effect that fishing has on the stock, however, somewhat different considerations must be taken into account. The primary interest here is a measure of the reduction in stock size, as inflicted by fishing. Thus it may be argued that the primary interest lies in the reduction of the number of fish in a certain age range during a year, measured on a scale similar to the usual fishing mortalities. Such a measure can be based on the reduction e.g. between the number of fish in the 5+ group in a year (y) and in the 6+ group in the following year. Assuming that there is equal interest in age groups a and older and that the natural mortality, M, is fixed on these age groups, a natural measure (Paloheimo, 1961) can be written as:

$$(1) \quad \ln \frac{\Sigma N_{a,y}}{\Sigma N_{a+1,y+1}} - M$$

Since this equation tends to give results quite similar to an average F, weighted by population numbers, the latter has often been used, particularly since it is available as direct output from packages, e.g. the ICES assessment programs.

In this context it must be noted that it is not at all obvious that this is the "best" measure if the fishing mortalities are subject to random variability. However, the intuitive appeal of the basic formula (1) does suggest that it should be made available as a standard option in the output from the new ICES assessment package.

For some of the stocks where emphasis has been placed on population weighted fishing mortalities, the real interest may in fact lie in the effect of fishing on the spawning stock. In this case, (1) is not entirely appropriate, but a slightly different formula should be used, which describes the spawning population in year y and its reduction during that year. In a given age group, a, the numbers of that age group in the spawning stock in year y are p(a,y)N(a,y), where p(a,y) denotes the proportion mature. During the year, these reduce to p(a,y)N(a+1,y+1). Assuming again that a constant natural mortality applies to all age groups in the spawning stock, the natural measure of overall the effect on the stock of fishing becomes

$$(2) \quad \ln \frac{\Sigma P_{a,y} N_{a,y}}{\Sigma P_{a,y} N_{a+1,y+1}} - M$$

Note that the uses of the same p(a,y) in both the numerator and the denominator are deliberate.

We therefore recommend that equations (1) and (2) be made available in ICES software for the purpose of obtaining a single measure of the effect of fishing, whereas a simple arithmetic mean should be used to obtain a fishing mortality measure related to effort.

Equation (1) should <u>only</u> be applied to age groups which are of equal interest, which can be assumed to have a constant natural mortality and which correspond to a flat portion of the selection pattern, whereas the arithmetic average should be taken over age groups prominent in the catches.

APPENDIX F: ADAPT - A DESCRIPTION OF THE METHOD AND ITS HISTORY

ADAPT is an age-structured, adaptable framework for estimating historical stock sizes of an exploited population. It is not a rigidly defined model in the mathematical sense, but rather a flexible set of modular tools designed to integrate all available data that may contain useful information on population size.

The statistical basis of the ADAPTive approach is to minimize the discrepancy between observations of state variables and their predicted values. The observed state variables are usually (but are not limited to) age-specific indices of population size, e.g. from commercial catch-effort data, research surveys, mark-recapture experiments, etc. The predicted values are a function of a vector of estimated population size (age-specific) and catchability parameters; and standard population dynamics equations (usually Gulland's (1965) VPA). Nonlinear least squares objective functions are generally employed to minimize the discrepancies.

The appellation ADAPT was introduced by Gavaris (1988). However, the foundation of the method was developed over the preceding decade under an umbrella of research generally referred to as VPA tuning. Although not generally recognized, Parks (1976) was the first to tune a VPA using auxiliary data and a least squares objective function. He tuned VPA back-calculated fishing mortality rates (Fs) to Fs derived independently from tagging experiments. Gray (1977) suggested a least squares approach to estimate mortality rates (both F and M) using a commercial catch-per-unit- effort (cpue) index of abundance as auxiliary data.

Doubleday (1981) used age-specific research survey indices of abundance as auxiliary data to estimate survivors in the terminal year for each cohort. This appears to have been the first attempt to utilize multiple indices of abundance in a least squares tuning procedure.

Parrack (1986) expanded upon Doubleday's work by integrating indices of abundance from widely diverse sources into the least squares objective function. His formulation allowed indices from commercial fisheries, research surveys, larval surveys, etc. Indices could be either age-specific or represent an age group; and could be expressed in either population number or biomass. Indices were related to population size either linearly or through a power function. Variance estimates were made assuming linearity at the optimal solution. He also recognized that not all indices are of equal value in measuring population abundance. Some indices will always be inherently more variable than others, and some may be biased. He introduced detailed examination of residuals and correlation statistics as an acceptance/rejection filter that each index needed to pass through in order to be used in the final tuning. The tuning procedure described by Parrack (1986) is the kernel of the method today known as ADAPT, both in terms of the objective function employed and in terms of the underlying philosophy.

Gavaris' (1988) ADAPTive framework generalized Parrack's procedure in several ways.

(1) The adaptive aspects of the method were greatly enhanced through the use of a modular model structure and implementation in the APL programming language. This made it possible to modify the objective function significantly, as needed to rectify problems, even during the course of an assessment working group meeting.

(2) A Marquardt algorithm (Bard 1974) was used for optimization of the least squares objective function. This allowed the simultaneous estimation of age-specific population sizes in the terminal year and catchabilities (Parrack estimated only the full F in the terminal year and relied on an input partial recruitment vector to complete the terminal year F vector). Additionally, the use of numerical derivatives in the Marquardt algorithm greatly enhanced the adaptive philosophy by making objective function modifications easy to implement.

(3) The more complete statistical model allowed for improved diagnostics. In addition to residual analysis, availability of the full variance-covariance matrix (assuming linearization at the optimal solution) provided variance estimates of all parameters, correlation among parameter estimates, and in general a better sense of which parameters were estimable from the available information.

The integration of many diverse sources of information focused attention on objective procedures to account for differences in the quality of information. Collie (1988) suggested that all indices of abundance should be included in the least squares objective function rather than employing Parrack's acceptance/rejection criteria. He recommended weighting the indices by the inverse of their variances. Vaughan · al. (1989) used Monte Carlo simulation to investigate the effect of weighting on the Fs estimated for bluefin tuna. They found that F estimates were unbiased only when the indices were weighted. Conser and Powers (1990) developed a more general weighting procedure that allowed for two-way effects, i.e. index and year. Gavaris and Van Eeckhaute (1991) employed a similar weighting procedure using an analysis of variance approach. Gassuikov (1990) suggested an alternative approach to weighting in ADAPT using the moving check procedure of Vapnik (1982).

Other areas of current research on the ADAPTive method include

(1) balancing the number of parameters estimated with the need to impose some model structure, e.g. the assumption of a partial recruitment pattern (Conser and Powers 1990; Restrepo and Powers 1991)

(2) procedures for incorporating all components of variance into the ADAPT variance estimates of stock size and fishing mortality (Restrepo et al. 1991)

It is noteworthy that all of the above cited work (with the exception of Gray 1977 and Gassuikov 1990) was developed in conjunction with assessment working groups associated with either the International Commission for the Conservation of Atlantic Tunas (ICCAT) or the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC). This development environment has been influential in shaping the flexibility and the pragmatic nature of ADAPT. It differs from the Doubleday-Deriso catch-at-age models (Doubleday 1976; Deriso et al. 1985; Kimura 1989), developed over a similar period, in several ways. Although both employ least squares objective functions and tune to auxiliary data,

(a) ADAPT does not assume separability (of fishing mortality and selectivity)
(b) ADAPT is more parsimonious in the number of parameters estimated
(c) ADAPT's philosophy requires careful attention to diagnostics (e.g. residuals, correlations, etc).

This coupled with its flexibility (including objective function modifications), encourages iterative re-runs of the model and re-thinking some assumptions until all major problems are rectified.

ADAPT has been used for assessment of a wide variety of fish stocks in several different assessment arenas, e.g. ICCAT, CAFSAC, NAFO. A small sample of the extent of these applications is provided for interested readers: ICCAT (Conser 1989; Nelson et al.1990), CAFSAC (O'Boyle et al. 1988; Chouinard and Sinclair 1988); NAFO (Baird and Bishop 1989); also see SEFC (1989); and many others.

APPENDIX G: NOTES ON RENA.WK1.

RENA is a spreadsheet that contains 1 macro that will take an input file of residuals for 1 fleet and produce 3 output files: a text file giving diagnostics on mean residuals by year, the proportion of positive residuals per year and an indicator plot of large residuals; a spreadsheet file with the same data as the text file for further analysis; a second text file that can be used as input to Gudmundur Gudmundsson's analysis.

The input final HAS to have an extension of .DAT.

If the file is XXX.DAT, the output files will be:

XXX.OUT - text output file
XXX.WK1 - spreadsheet
XXX.GGA - input to Gudmundur's program.

The ---.DAT file MUST have the following format: (see attached examples)

Line 1: Title information.
Line 2: Blank.
Line 3: Title for standard errors for residuals.
Line 4: Standard error for residuals, 1 for each age. (Enter row of 1's if residuals already standardized.)
Line 5: Title for residuals
Line 6: List of ages
Line 7... Year and list of residuals, 1 for each age, works best if format consistent between lines
1 line per year

Before you run this the first time, make an extra copy. It was programmed quickly and may not be robust!

How to run:

1. Load the RENA.WK1 speadsheet.
2. Enter ALT/L.
3. When asked enter the input file name. DO NOT ENTER ".DAT".
4. Wait!!

If you have problems:

1. Check your input file format.
2. Delete any of the new ----.OUT, ----.WK1, and ----.GGA files that were produced before you rerun.

Running Gudmundur's analysis:

1. The program is RESANAL.EXE.
2. The program prints to the screen but output can be piped. Input file name follows the program name as in:

```
RESANAL XXX.GGA              - output to screen
RESANAL XXX.GGA > XXX.TXT    - output to a file
```

EXAMPLE INPUT FILE XXX.DAT

7E SOLE, EXTENDED, FLEET 1: UK INSHORE GRAY

STANDARD ERRORS OF ESTIMATES

0.47	0.20	0.19	0.13	0.40	0.60	0.66	0.83	1.00	1.21	1.27	1.36

RESIDUALS

	2	3	4	5	6	7	8	9	10	11	12	13
1973	0.26	0.44	0.50	0.25	0.08	0.31	-0.82	0.20	-1.02	-1.59	-0.04	-0.01
1974	-0.43	0.61	0.14	0.19	0.29	0.18	-0.33	0.12	-0.29	-0.25	-0.05	-0.14
1975	0.21	0.49	-0.23	0.19	-0.48	-0.82	-0.24	-0.98	-0.45	-0.55	-0.59	0.42
1976	1.07	0.43	0.64	0.31	0.16	-0.24	0.30	0.42	0.13	-0.46	-0.30	0.51
1977	1.12	0.17	0.37	0.15	-0.16	-0.43	-0.29	-1.10	-0.42	-0.33	-0.15	0.01
1978	0.63	0.37	0.08	-0.05	-0.09	-0.21	-0.38	-0.31	0.11	-0.42	-0.66	0.19
1979	0.35	0.09	-0.05	-0.06	-0.10	-0.17	-0.11	-0.14	-0.03	-0.22	-0.46	0.44
1980	0.09	-0.22	-0.39	0.03	-0.97	-0.46	-0.43	-0.67	-0.85	0.27	0.21	-0.34
1981	-0.31	0.01	-0.04	-0.08	-0.42	-0.39	-0.36	-0.69	-0.56	-0.72	-0.30	-0.33
1982	-0.47	-0.03	0.19	0.10	-0.31	-0.74	-0.28	-0.13	-0.42	-0.16	-0.64	-0.32
1983	-0.33	-0.33	0.04	0.22	-0.37	-0.22	-0.02	0.00	0.17	-1.45	-0.64	1.31
1984	0.10	-0.25	-0.05	-0.08	0.00	-0.39	-0.40	-0.36	-0.78	-0.78	0.18	0.95
1985	-1.28	0.03	0.17	-0.09	0.04	-0.42	-0.44	0.04	-0.20	0.28	-0.33	-0.47
1986	0.05	0.19	0.09	-0.05	-0.28	-0.20	-0.35	-1.14	-1.22	-0.31	-0.75	-0.32
1987	0.18	-0.18	-0.10	-0.12	-0.94	-0.93	-0.22	-0.88	-0.29	-1.03	-0.27	0.32
1988	0.13	-0.12	-0.22	0.12	0.30	-0.13	0.03	-0.44	-1.02	-1.48	0.09	0.74
1989	0.14	-0.01	-0.21	-0.26	-0.32	-0.92	-0.07	0.18	-0.77	0.55	0.15	0.10

EXAMPLE TEXT OUTPUT XXX.OUT

7E SOLE, EXTENDED, FLEET 1: UK INSHORE GRAY

STANDARD ERRORS OF ESTIMATES

0.47	0.2	0.19	0.13	0.4	0.6	0.66	0.83	1	1.21	1.27	1.36

RESIDUALS

	2	3	4	5	6	7	8	9	10	11	12	13
1973	0.26	0.44	0.5	0.25	0.08	0.31	-0.82	0.2	-1.02	-1.59	-0.04	-0.01
1974	-0.43	0.61	0.14	0.19	0.29	0.18	-0.33	0.12	-0.29	-0.25	-0.05	-0.14
1975	0.21	0.49	-0.23	0.19	-0.48	-0.82	-0.24	-0.98	-0.45	-0.55	-0.59	0.42
1976	1.07	0.43	0.64	0.31	0.16	-0.24	0.3	0.42	0.13	-0.46	-0.3	0.51
1977	1.12	0.17	0.37	0.15	-0.16	-0.43	-0.29	-1.1	-0.42	-0.33	-0.15	0.01
1978	0.63	0.37	0.08	-0.05	-0.09	-0.21	-0.38	-0.31	0.11	-0.42	-0.66	0.19
1979	0.35	0.09	-0.05	-0.06	-0.1	-0.17	-0.11	-0.14	-0.03	-0.22	-0.46	0.44
1980	0.09	-0.22	-0.39	0.03	-0.97	-0.46	-0.43	-0.67	-0.85	0.27	0.21	-0.34
1981	-0.31	0.01	-0.04	-0.08	-0.42	-0.39	-0.36	-0.69	-0.56	-0.72	-0.3	-0.33
1982	-0.47	-0.03	0.19	0.1	-0.31	-0.74	-0.28	-0.13	-0.42	-0.16	-0.64	-0.32
1983	-0.33	-0.33	0.04	0.22	-0.37	-0.22	-0.02	0	0.17	-1.45	-0.64	1.31
1984	0.1	-0.25	-0.05	-0.08	0	-0.39	-0.4	-0.36	-0.78	-0.78	0.18	0.95
1985	-1.28	0.03	0.17	-0.09	0.04	-0.42	-0.44	0.04	-0.2	0.28	-0.33	-0.47
1986	0.05	0.19	0.09	-0.05	-0.28	-0.2	-0.35	-1.14	-1.22	-0.31	-0.75	-0.32
1987	0.18	-0.18	-0.1	-0.12	-0.94	-0.93	-0.22	-0.88	-0.29	-1.03	-0.27	0.32
1988	0.13	-0.12	-0.22	0.12	0.3	-0.13	0.03	-0.44	-1.02	-1.48	0.09	0.74
1989	0.14	-0.01	-0.21	-0.26	-0.32	-0.92	-0.07	0.18	-0.77	0.55	0.15	0.1

STANDARDIZED RESIDUALS

	2	3	4	5	6	7	8	9	10	11	12	13	mean	n	zbar	
1973	0.55	2.20	2.63	1.92	0.20	0.52	-1.24	0.24	-1.02	-1.31	-0.03	-0.01	0.39	12	1.34	
1974	-0.91	3.05	0.74	1.46	0.72	0.30	-0.50	0.14	-0.29	-0.21	-0.04	-0.10	0.36	12	1.26	
1975	0.45	2.45	-1.21	1.46	-1.20	-1.37	-0.36	-1.18	-0.45	-0.45	-0.46	0.31	-0.17	12	-0.58	
1976	2.28	2.15	3.37	2.38	0.40	-0.40	0.45	0.51	0.13	-0.38	-0.24	0.38	0.92	12	3.18	
1977	2.38	0.85	1.95	1.15	-0.40	-0.72	-0.44	-1.33	-0.42	-0.27	-0.12	0.01	0.22	12	0.76	
1978	1.34	1.85	0.42	-0.38	-0.23	-0.35	-0.58	-0.37	0.11	-0.35	-0.52	0.14	0.09	12	0.31	
1979	0.74	0.45	-0.26	-0.46	-0.25	-0.28	-0.17	-0.17	-0.03	-0.18	-0.36	0.32	-0.05	12	-0.19	
1980	0.19	-1.10	-2.05	0.23	-2.43	-0.77	-0.65	-0.81	-0.85	0.22	0.17	-0.25	-0.67	12	-2.34	
1981	-0.66	0.05	-0.21	-0.62	-1.05	-0.65	-0.55	-0.83	-0.56	-0.60	-0.24	-0.24	-0.51	12	-1.77	
1982	-1.00	-0.15	1.00	0.77	-0.78	-1.23	-0.42	-0.16	-0.42	-0.13	-0.50	-0.24	-0.27	12	-0.94	
1983	-0.70	-1.65	0.21	1.69	-0.93	-0.37	-0.03	0.00	0.17	-1.20	-0.50	0.96	-0.20	12	-0.68	
1984	0.21	-1.25	-0.26	-0.62	0.00	-0.65	-0.61	-0.43	-0.78	-0.64	0.14	0.70	-0.35	12	-1.21	
1985	-2.72	0.15	0.89	-0.69	0.10	-0.70	-0.67	0.05	-0.20	0.23	-0.26	-0.35	-0.35	12	-1.20	
1986	0.11	0.95	0.47	-0.38	-0.70	-0.33	-0.53	-1.37	-1.22	-0.26	-0.59	-0.24	-0.34	12	-1.18	mean
1987	0.38	-0.90	-0.53	-0.92	-2.35	-1.55	-0.33	-1.06	-0.29	-0.85	-0.21	0.24	-0.70	12	-2.42	-0.457
1988	0.28	-0.60	-1.16	0.92	0.75	-0.22	0.05	-0.53	-1.02	-1.22	0.07	0.54	-0.18	12	-0.62	s.d.
1989	0.30	-0.05	-1.11	-2.00	-0.80	-1.53	-0.11	0.22	-0.77	0.45	0.12	0.07	-0.43	12	-1.50	1.4096

SIGN OF RESIDUALS

	2	3	4	5	6	7	8	9	10	11	12	13	n+	n	p+	z+	
1973	1	1	1	1	1	1	0	1	0	0	0	0	7	12	0.58	0.58	
1974	0	1	1	1	1	1	0	1	0	0	0	0	6	12	0.50	0.00	
1975	1	1	0	1	0	0	0	0	0	0	0	1	4	12	0.33	-1.15	
1976	1	1	1	1	1	0	1	1	1	0	0	1	9	12	0.75	1.73	
1977	1	1	1	1	0	0	0	0	0	0	0	1	5	12	0.42	-0.58	
1978	1	1	1	0	0	0	0	0	1	0	0	1	5	12	0.42	-0.58	
1979	1	1	0	0	0	0	0	0	0	0	0	1	3	12	0.25	-1.73	
1980	1	0	0	1	0	0	0	0	0	1	1	0	4	12	0.33	-1.15	
1981	0	1	0	0	0	0	0	0	0	0	0	0	1	12	0.08	-2.89	
1982	0	0	1	1	0	0	0	0	0	0	0	0	2	12	0.17	-2.31	
1983	0	0	1	1	0	0	0	1	1	0	0	1	5	12	0.42	-0.58	
1984	1	0	0	0	1	0	0	0	0	0	1	1	4	12	0.33	-1.15	
1985	0	1	1	0	1	0	0	1	0	1	0	0	5	12	0.42	-0.58	
1986	1	1	1	0	0	0	0	0	0	0	0	0	3	12	0.25	-1.73	mean
1987	1	0	0	0	0	0	0	0	0	0	0	1	2	12	0.17	-2.31	-0.88
1988	1	0	0	1	1	0	1	0	0	0	1	1	6	12	0.50	0.00	s.d.
1989	1	0	0	0	0	0	0	1	0	1	1	1	5	12	0.42	-0.58	1.104

INDICATOR PLOT: '='<-1.5, '-'<-0.5,
'*'>1.5, '+'>0.5
'N' MOST NEG., 'P' MOST PO

STANDARDIZED RESIDUALS

	2	3	4	5	6	7	8	9	10	11	12	13
1973	+	*	*	*		+	-		-	-		
1974	-	*	+	+	+							
1975		*	-	+	-	-		-				
1976	*	*	P	*				+				
1977	*	+	*	+		-		-				
1978	+	*					-				-	
1979	+											
1980		-	=		=	-	-	-	-			
1981	-			-	-	-	-	-	-	-		
1982	-		+	+	-	-					-	
1983	-	=		*	-					-	-	+
1984		-		-		-	-		-	-		+
1985	N		+	-		-	-					
1986		+			-		-	-	-		-	
1987		-	-	-	=	=		-		-		
1988		-	-	+	+			-	-	-		+
1989			-	=	-	=			-			

EXAMPLE OUTPUT FROM RESANAL.EXE

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DEVA   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00
DEVT   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00
DEVT   1.00   1.00   1.00
 1      .361  -1.099    .261  2.091   2.191   1.151    .551    .001   -.849  -1.189   -.889    .021  -2.909   -.079

  .191    .091    .111
 2     1.703   2.553   1.953  1.653    .353   1.353   -.047  -1.597   -.447   -.647  -2.147  -1.747   -.347    .453

-1.397  -1.097   -.547
 3     2.342    .452  -1.498  3.082   1.662    .132   -.548  -2.338   -.498    .712   -.078   -.548    .602    .182

 -.818  -1.448  -1.398
 4     1.572   1.112   1.112  2.032    .802   -.728   -.808   -.118   -.968    .422   1.342   -.968  -1.038   -.728

-1.268    .572  -2.348
 5      .726   1.246   -.674   .926    .126    .296    .276  -1.904   -.524   -.254   -.404    .526    .626   -.174

-1.824   1.276   -.274
 6     1.126    .906   -.764   .206   -.114    .256    .326   -.164   -.044   -.624    .236   -.044   -.094    .276

 -.944    .386   -.924
 7     -.846   -.106    .034   .844   -.046   -.186    .224   -.256   -.156   -.026    .364   -.216   -.276   -.136

  .064    .444    .284
 8      .656    .556   -.764   .926   -.914    .046    .246   -.394   -.414    .256    .416   -.014    .466   -.954

 -.644   -.114    .636
 9     -.555    .175    .015   .595    .045    .575    .435   -.385   -.095    .045    .635   -.315    .265   -.755

  .175   -.555   -.305
10     -.889    .211   -.029   .041    .151    .071    .241    .641   -.179    .291   -.779   -.219    .651    .161

 -.429   -.799    .871
11      .180    .170   -.250  -.030    .090   -.310   -.150    .380   -.030   -.290   -.290    .350   -.050   -.380

  .000    .280    .330
12     -.142   -.232    .178   .248   -.122    .008    .188   -.382   -.372   -.372    .828    .568   -.482   -.372

  .108    .408   -.062



  SKEWNESS AND KURTOSIS
   .896   5.236
 VARIANCE AT AGE

   1.3917   1.9137   1.8915   1.4013    .7899    .3150    .1279    .3296    .1734    .2433
 VARIANCE AT AGE

    .0601    .1295
 VARIANCE AT YEAR

   1.2569   1.0018    .7566   1.9686    .7703    .3603    .1547   1.0624    .2298    .2790
 VARIANCE AT YEAR

    .7928    .4340    .9540    .2239    .7604    .5679    .8462
 CORRELATION WITHIN COHORTS       .14

CORRELATION WITHIN AGES AND YEARS     .38     .28
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Appendix H: Summary of Reports of ICES Working Group on the Methods of Fish Stock Assessment (and associated meetings).

Summary of topics

Topic	1981	1983	1984	1985	1987	1988	1989	1991
1. Application of separable VPA	-	M	r	-	-	-	-	m
2. Simpler methods of assessment	-	-	M	M	i	-	-	i
3. Measures of overall fishing mortality	-	-	-	-	-	-	-	-
4. Use of CPUE and effort data in assessments	M	M	r	r	M	M	m	i
5. Need for two-sex assessment	-	-	-	-	-	-	-	-
6. Computation and use of yield per recruit	-	M	m	i	-	-	-	
7. Inclusion of discards in assessments	-	-	-	-	-	-	-	-
8. Methods for estimation of recruitment	-	-	M	r	M	-	-	-
9. Density dependence growth, mortality, etc.)	-	-	-	-	-	-	-	-
10. Linear regression in assessments	-	-	M	-	m	-	-	-
11. Effect of age-dependent natural mortality	-	-	-	M	-	-	-	-
12. Stock-production models	-	-	-	-	M	-	-	-
13. Utilization of research survey data	-	-	-	-	M	M	m	i
14. Use of less reliable fishery statistics	-	-	-	-	m	-	i	i
15. Construction of survey and CPUE indices from disaggregated data	-	-	-	-	-	-	M	i
16. Implications of timing of WG meetings	-	-	-	-	-	-	m	-
17. Testing of age-balanced methods of analysis	-	-	-	-	-	M	m	M
18. Effects of management measures on CPUE	-	-	-	-	-	-	-	m
19. Evaluation and development of diagnostics	-	-	-	-	-	-	-	M
20. Application of length-based methods	-	-	-	-	-	-	-	m
21. Extension of time series of stock and recruitment	-	-	-	-	-	-		
22. Problems with weight-at-age	-	-	-	-	-	-	-	-

M: Major topic; m = minor topic; r = reprise;
i: incidentally considered

Dates, locations and reports of previous meetings of the ICES Working Group on the Methods of Fish Stock Assessment (and associated meetings).

Date	Place	Title	Citation
1981	Copenhagen	Rep. ICES WG on Use of Effort Data in Assessments	Coop Res Rep No. 129 (1984)
1983	Copenhagen	Rep. ICES WG on Methods of Fish Stock Assessment	Coop Res Rep No. 129 (1984)
1984	Copenhagen	Rep. ICES WG on Methods of Fish Stock Assessment	Coop Res Rep No. 133 (1985)
1985	Copenhagen	Rep. ICES WG on Methods of Fish Stock Assessment	Coop Res Rep No. 157 (1988)
1987	Copenhagen	Rep. ICES WG on Methods of Fish Stock Assessment	Coop Res Rep No. 191 (1993)
1988	Reykjavik	Rep. ICES Workshop on Methods of Fish Stock Assessment	Coop Res Rep No. 191 (1993)
1989	Nantes	Rep. ICES WG on Methods of Fish Stock Assessment	Coop Res Rep No. 191 (1993)
1991	St. John's	Rep. ICES WG on Methods of Stock Assessment	CM 1991/Assess 24 and Coop Res Rep. No. 199 (1995)