Advisory Committee on Fisheries Management

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REPORT OF THE

STUDY GROUP ON THE ASSESSMENT OF OTHER FISH AND SHELLFISH SPECIES

Aberdeen, United Kingdom
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International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

Palægade 2–4 DK-1261 Copenhagen K Denmark

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1 INTRODUCTION

1.1 Participants

J. Addison	United Kingdom
M. Basson	United Kingdom
D. Beanlands	Canada
R. Cook	United Kingdom
M.R. Dunn	United Kingdom
P. Large	United Kingdom
R. Mohn (Chair)	Canada
Y. Morizur	France
S. Reeves	United Kingdom
D. Sampson	USA

1.2 ToR 1998

"A Study Group on the Assessment of Other Fish and Shellfish Species will be established [SGASSO], (Chairman: Dr R. Mohn, Canada) and will meet in ICES, Headquarters from 17–21 August, 1998 (to be confirmed) to:

a) Compile available information on the abundance, distribution and exploitation (catches or landings) by ICES Division of commercial fish and shellfish species not currently assessed within ICES;

b) evaluate trends in the populations of these species over time and, wherever possible, their state of exploitation;

c) consider the possibility of carrying out assessments of the stocks and fisheries considered by this group and developing advice consistent with the precautionary approach;

d) provide information on quantities of discards by gear type for the stocks and fisheries considered by this group using the format proposed by the Working Group of Ecosystem Effects of Fishing Activities with a view to establishing a time series.

1.3 Selected extracts from 1997 Study Group report (ICES, 1998a)

The 1997 meeting of the Study Group produced a wide range of recommendations. They have been abridged and renumbered from the Study Group Report.

1. The Study Group is dealing with a wide range and number of species, stocks and fisheries. Even if there are only limited data, simple assessments may take longer than more complex ones, since data need to be prepared from scratch, and it is important to apply a range of different methods to the data.

2. More countries need to be represented at the Study Group to give a complete overview of the problem, and contribute information on the relevant stocks.

3. It is essential that the membership is able to provide both biological and modelling/methodological expertise.

4. The Study Group identified the importance of collating life history details as well as biological input parameters for modelling. This work is a pre-requisite to any assessment work.

5. The Study Group will be unable to identify the scale of the problem and set priorities, unless basic information and data are available. These data/information need to be computerised.

6. For many species data are non-existent or sparse. A simplified approach to both assessment and management will be required.

7. Priorities need to be assessed against an objective set of criteria to identify which species/stocks/fisheries the Study Group should concentrate on.

8. Options for additional funding should be considered, to ensure that the basic information, which would allow prioritising, and the actual data, which would allow assessment, are obtained.

9. Members should be encouraged to provide basic information and data prior to, or at, the Study Group's next meeting.

2 METHODS

2.1 Data Base

2.1.1 Objectives

A prototype data base was developed and described in last year's Study Group report. It was not updated intersessionally and it was expressed that it would be desirable to refine the objectives for this data base before more time was spent on its development. The Study Group concluded that there were two primary objectives for this data base; as a consolidated reference tool and a tool for drawing analogies among stocks.

Maintenance and development of the data base pose a considerable problem. Without someone who has the obligation and time to dedicate to this project, it is unlikely to progress.

The utility of the data base would improve if it were widely available. It is currently in MSExcel and thus easily used and distributed via e-mail. Perhaps a website would further enhance its availability. If the data base were built up to a useful level it would be a means of participation without travel. The current data base contains very little numerical fishery data (e.g., catch data, survey indices, etc.). Technically, it would not be difficult to build links to such data, but again the question is who would do this.

Objective 1. Consolidated reference tool

The first use of the SGASSO data base would be as a reference utility to compare the pertinent information on unassessed stocks. This information is needed to set priorities for analysis or other attention and, secondly, to identify critical gaps in information and hence prioritise research. It was noted that priorities for SGASSO assessment could be set from other criteria; for example, economic or political importance. This data base may help in explaining why certain stocks were not assessed while similar ones were.

Objective 2. Stock analog tool

Objective 1 could be fulfilled if the data base contained only unassessed and SGASSO assessed stocks. But the data base would be more powerful if assessed stocks were added. The principal advantage would be the ability to infer stock characteristics of unassessed stocks from assessed ones; the unassessed stock is assumed to be an analog of assessed.

Although the expansion to include assessed stocks is desirable, it remains a problem as to who will do it.

2.1.2 Revised format

As a result of the discussions on refining the objectives, the format of last year's database was updated. The attempt was to simplify the data input, whilst focusing in more detail on the objectives. Table 2.1 shows the new format.

The principle changes are an expansion of the fields describing species characteristics, for example *habit, reproduction* and *dominant depth preference*. There has also been a simplification of the fields describing data availability. Maintaining these fields is useful for reference and to identify the gaps in information, even though it is a gross simplification. More detail would require more complex and numerous data fields to be completed, which was felt to be undesirable. Finally, there are now fields for basic stock assessment results where available (e.g., Fpa, Bpa), which have direct use in stock analogy.

One potential requirement of the database is to identify economically important and biologically vulnerable species. A subjective measure of economic importance was previously included as it allows some consideration of local importance, but it has been removed, as total landings revenue alone should be adequate for the objectives of the Study

Group. Biological vulnerability was also previously measured subjectively, however the new fields describing the life cycle and exploitation patterns (e.g., size at first capture vs. size at first maturity) should be able to define this in a more objective manner.

2.2 Survey Biomass

Last year's Study Group suggests that North Sea research survey series would be a good resource to give insight to many unassessed species. The object was to correct survey catch rates for the efficiency of the survey gear, and if possible the availability of the various species to the survey, yielding biomass estimates. These estimates could be compared to reported catches and exploitation also estimated in a quick and simple manner. Unfortunately, the expertise was not available at this meeting to pursue this suggestion. Information has been summarised from Sparholt (1990) to demonstrate the potential utility of this approach.

Using data from the International Bottom Trawl Survey (IBTS) and the English Groundfish Survey (EGFS) abundance indices were calculated in units of kgs/hr for all species recorded in the surveys. For those species for which there are standard assessments that give estimates of total stock biomass, "availabilities" were calculated as the ratio of the total biomass estimate to the survey CPUE value. The "standard" species include cod, haddock, whiting, saithe, Norway pout, herring, sprat, sandeel, mackerel, plaice and sole. These availabilities were then used to scale the survey CPUEs for the other species to estimates of total biomass. Although there were differences between the estimates obtained from the two surveys, both data sets suggest that the eleven standard species account for between 65–70% of the total North Sea fish biomass. The remaining biomass comprises a very large number of other species but only represents about 30–35% of the total. At face value this would suggest that there is little scope for diversion of effort from the main species to other fish. Furthermore, of the "other fish", many are unlikely to be economical to exploit by virtue of their rarity, size or marketability.

Sparholt's study was based on the data available in the mid 1980s. It would be worthwhile updating his analysis now that more survey and assessment data have accumulated. It is also desirable to try to obtain more information on benthic organisms not adequately sampled by trawl survey gear. This is likely to be relevant for shellfish resources which are not well represented in trawl survey catches.

2.3 Stock Synthesis

The Stock Synthesis program is widely used to develop stock assessments for U.S. Pacific Coast groundfish stocks (Methot, 1990; Pacific Fishery Management Council, 1996). This program, which elaborates on the methods of Fournier and Archibald (1982) and Deriso et al. (1985), uses time series of catch biomass and age or size composition, coupled with auxiliary information such as survey indices of stock biomass, to derive maximum likelihood estimates of numerical stock abundance, stock biomass, and related parameters. Stock Synthesis is a very powerful tool for examining fisheries data and offers considerable flexibility in the types of data that it can accommodate. It differs from traditional catch at age methods, such as Virtual Population Analysis, in that it does not require one to input a complete catch at age data matrix and it does not assume that the catch at age data are an exact accounting of removals by the fishery. Fortran source code, Win95 executable program files, and documentation for Stock Synthesis can be downloaded from http://www.refm.noaa.gov/modeling.htm.

The Stock Synthesis program uses standard deterministic equations to simulate the dynamics of an age-structured population. Exponential decay in the number of fish for a given year class is determined by a natural mortality coefficient, age-specific selectivity coefficients, and year-specific fishing mortality coefficients. A standard Baranov catch equation is used to determine the catch at age in numbers of fish, which is coupled with average weight at age to determine catch at age in weight. Stock Synthesis allows the user to either fix or estimate the various parameters that define the population structure and dynamics. Estimated parameters are maximum likelihood estimates and satisfy a total likelihood function that is the weighted sum of individual likelihood components, with a separate component for each type of observed data (e.g., fishery age or size composition data, fishery catch per unit effort, survey age or size composition data, survey biomass index values). One can include likelihood components that tend to constrain the estimates of annual recruitment to conform to a spawner recruit relationship with lognormal random process error. Age and size composition data are usually assumed to be consistent with multinomial random observations. Survey biomass indices and catch per unit effort data are usually assumed to be consistent with lognormal random observations. The program can be configured to account for variable or biased observations of age. As it is typically configured the Stock Synthesis Program assumes that the data for catch biomass are measured with perfect accuracy and it adjusts the estimated fishing mortality coefficients so that each annual estimate of total catch biomass equals the observed total catch biomass.

3 PRECAUTIONARY APPROACH

As fishing effort is directed from TAC stocks to lesser studied ones, there is a need for a precautionary approach for resources about which little is known. Because of limited distribution or specific biological characteristics some these stocks could be particularly vulnerable. This concern was expressed in the Report of the Study Group on the Precautionary Approach to Fisheries Management (ICES CM 1997/Assess:7) as "In a precautionary approach, the advice should be more cautious in these cases (stocks with inadequate data to assess their status...), and include mechanisms to increase the knowledge."

The Study Group had copies of the recent reports of two Study Groups, a draft of the 1998 Report of the Study Group on the Precautionary Approach to Fisheries Management (SGPAFM) and the Report of the Study Group on the Biology and Assessment of Deep-Sea Fisheries Resources (ICES, 1998b) both of which met in February, 1998. A synthesis of these reports yields the following suggestions:

$F_{lim} = F_{30\%}$ (The F that provides 30% of the virgin SSB/R)
$F_{pa} = M$ or $0.5 * F_{lim}$
$B_{lim} = B_{30\%}$ (The B that is 30% of the virgin or maximum observed B - possibly after smoothing of time series)
$B_{pa} = B_{50\%}$ (The B that is 50% of the virgin or maximum observed B)

Also, precautionary fishing mortality rates were extracted from the SGPAFM Draft Report to be used for comparison to flatfish and monkfish reviewed by this Study Group.

Species	**Area**	F_{pa}
Plaice	North Sea	0.30
	IIIa	0.68
	VIId	0.40
	VIIa	0.44
	VIIe	0.52
	VIIf,g	0.40
Sole	North Sea	0.45
	VIIe	0.20
	VIIf,g	0.32
	Biscay	0.40
	IIIa	0.38
Megrim (whiffiagonis)	VIIb,c,e-k	0.27
Southern Megrim (whiff.)		0.34
Southern Megrim (boscii)		0.32
Flounder	24–25	0.42

The above set of 15 values of F_{pa} for a range of flatfish stocks have the following summary statistics:

min	Q1	med	mean	Q3	max
0.20	0.32	0.40	0.39	0.43	0.68

The age ranges involved in the F's were not specified, but these could be picked up from the ICES Working Group Reports.

The only other relevant species for which F_{pa} values were defined by SGPAFM is Anglerfish (*piscatorius* and *budegassa*):

L. piscatorius	VIIb-k,VIIIab	0.36
L. budegassa		0.12

The NAFO 4X monkfish reviewed below is more similar to *L. piscatorius* than *budegassa*, although it matures younger suggesting that an F_{pa} of 0.36 is still likely to be conservative.

4 RESULTS

4.1 Assessment studies

The following assessments were done in the context of exploration within the Study Group. Although, they are the best possible estimates given the time and personnel available, they would all benefit from further analysis, data and reflection.

4.1.1 Lemon sole *Microstomus kitt* (North Sea)

Introduction

Lemon sole, *Microstomus kitt*, have recently been included in a mixed flatfish TAC in the North Sea, although hitherto they have not been subject to catch restrictions. The analysis presented here is based on work by Criado (1994).

Lemon sole are taken in mixed demersal fisheries around the British Isles and in the North sea. International landings are relatively small, around 12,000 t per year, when compared to commercially exploited flatfish species such as plaice, *Pleuronectes platessa*. Despite the small volume of the landings, lemon sole commands a high price which makes it a potentially valuable resource. There are six main countries which currently land lemon sole, namely, Scotland, England (& Wales), France, Belgium and Denmark. However, the majority of landings are by UK vessels.

The main concentrations of lemon sole are off the east coast of Scotland in the Northern North Sea (Rae, 1965) although moderate concentrations extend south along the English east coast and northwest around to the West of Scotland (Figure 4.1.1.1). For assessment purposes, lemon sole from the North Sea (IV) and the West of Scotland (VIa) were considered as a unit stock because there is no reason to believe that there are either physical or biological barriers over these areas of its distribution.

Catch at age and effort data

Catch at age data from commercial Scottish landings are available from the FRS Marine Laboratory, Aberdeen for the period 1976 to 1992. Effort data are available for five Scottish fleets: trawl, light trawl, pair trawl, *nephrops* trawl and seine net. International landings from official sources were obtained for Belgium, Denmark, France, Germany, Ireland, Netherlands and England & Wales. Scottish catch at age data were raised to the total international catch. The catch at age data are given in Table 4.1.1.1. There was no information on discards.

Natural Mortality, Maturity, Weight at age

The values for natural mortality were assumed to be similar to those of plaice (ICES, 1995) and thus estimated at 0.1 for all ages. Rae (1965) provided biological information to estimate the values of maturity at age (Table 4.1.1.2). The two latter values were estimated to be 0.5. Weights at age in the catch were available from commercial Scottish fleets and these were used also for stock weights (Table 4.1.1.3).

Catch at age analysis

XSA (Darby & Flatman, 1994) with standard defaults was used to obtain estimates of fishing mortality and stock numbers (Tables 4.1.1.4, 4.1.1.5). All five series of commercial fleet effort data were used in the calibration. In general the correlation between the commercial CPUE data and the XSA estimated stock numbers was poor (Table 4.1.1.6), particularly for the youngest ages. The highest correlations were associated with the light trawl data and these data contributed most to the estimated survivors (Table 4.1.1.7). The log catchability residuals are plotted in Fig. 4.1.1.2. These are large, especially for the oldest and youngest ages but show no strong trends.

Stock trends

Figure 4.1.1.3 and Table 4.1.1.8 show historical trends in catch, fishing mortality, recruitment and spawning stock biomass as estimated from XSA. Typically the catch has been in the range 5000–7000 t with fishing mortality fluctuating around 0.4. Fishing mortality in the period 1989–1992 is higher and may indicate a substantial increase in exploitation. However, these estimates are most sensitive to the calibration data and need to be treated with care given the comparatively poor performance of the tuning data. These values are also heavily influenced by the shrinkage used in the analysis which will tend to result in F values in 1992 close to the long term mean. Both spawning stock biomass and recruitment show no long term trend. SSB has remained close to 25000 t over the period of observation. Recruitment appears to show a strong annual autocorrelation.

Equilibrium analysis

A standard Thompson-Bell yield per recruit analysis was performed using estimates of fishing mortality and weights at age for the period 1990–1992 (Table 4.1.1.9). The results are given in Figure 4.1.1.4. The curve is flat topped with F_{max} poorly defined at a value of 0.44. Analysis of the stock-recruit data gives an estimate of F_{med} of 0.65.

An age structured production model was used to investigate likely yield and SSB equilibria under differing rates of exploitation. A Shepherd curve including a first order autocorrelation was fitted to the SSB-recruitment data derived from XSA (Table 4.1.1.10). This curve was then used to estimate equilibrium SSB and yield (Figure 4.1.1.5). Clearly, given the limited number of observations and the high autocorrelation between successive year classes, the stock-recruitment relationship is very poorly defined and the expected equilibrium values need to be treated with a degree of scepticism. At face value they suggest MSY in the region of F = 0.75 corresponding to a yield of 6,900 t. The annual observations plotted on the equilibrium graphs are consistent with the model predictions suggesting that the fishery has not operated far from equilibrium conditions.

Precautionary reference points

Following the recipe adopted by the Study Group on the Precautionary Approach to Fisheries Management (ICES, 1998 c) it is suggested that F_{med} be used as a value for F_{pa}. This is because the stock-recruit data appear to lie on the right hand descending limb of a stock-recruit relationship and F_{med} will have a high probability of being below F_{crash}. For similar reasons B_{pa} can be chosen as B_{loss} = 18000 t. Fishing at F_{med} would be expected to result in an equilibrium SSB of approximately 24000 t.

Present stock status

The available data provide estimates of stock stock size and fishing mortality up to 1992 only. The collection of age structured data was discontinued after that date. The assessment suggests that fishing mortality was increasing in the early 1990s and was close to or above F_{pa}. It is quite likely that the stock is now being fished beyond the precautionary reference points.

Modified DeLury

Indices of abundance in terms of biomass and numbers were constructed from the XSA files (which have effort and indices by age) for the five Scottish fleets. Plots of the overall indices show quite different signals from the five fleets (Figure 4.1.1.6 a,b). Indices of recruitment were constructed from the effort and catch in numbers at age 4 (the youngest age in the CPUE data, Figure 4.1.1.6 c). This allows us to fit production-type models to the data, as well as, a modified DeLury model.

Modified DeLury models were fitted to each of the fleet-indices separately, with an assumed natural mortality of 0.1. In most cases, the fits were very poor, and the estimates of population size were highly unrealistic. For the pair trawl fleet, the fit was good, but the population size was again unrealistically large. Only for the trawl fleet was the fit good and the population size realistic (results below). Both fleets that gave good fits had effort levels varying over a wide range, one increasing, the other decreasing (Figure 4.1.1.7). This change in effort could affect the indices of abundance.

The fit and diagnostics for the trawl fleet are shown in Figure 4.1.1.8. Results from the trawl fleet indices suggest that the population increased from 1975 to 1983, and then decreased again. The estimate of population numbers (Table 4.1.1.11) in the first year is surprisingly low, and may not be particularly reliable. The exploitation rates (catch numbers over population numbers) show an increase from around 0.08 in 1986 to 0.26 in 1992.

Population numbers were converted to population biomass by using the ratios between landings and total catch numbers in each year as nominal mean weights. The biomass is estimated at around 25,000 t in 1992. Figure 4.1.1.9 shows the biomass estimates and landings.

The catches used in the above assessments included all age classes. Given that the recruitment indices are for age 4, it may be more appropriate to use only catches from age 4 and older. Results from such an assessment were essentially identical to the results shown above.

Confidence intervals for the three parameters (population size in the first year, N1; catchability coefficient for the adult index, q; coefficient for the recruit index, lambda) are very wide. For example, for N1 the 95% CI is [43, 1.6e5] (Figure 4.1.1.10).

Production models

The best fits were identified with either the Scottish nephrops trawl or Scottish heavy trawl abundance indices and the Fox model, with an initial proportion between 0.3 and 0.7, and a time lag of 4 years. Figures 4.1.1.11- 4.1.1.13 show results for an initial proportion of 0.3. As the time lag was decreased the quality of the fit decreased, and the model increasingly failed to capture the inter-annual changes in CPUE (i.e., the fitted model became more linear through time). The fits were relatively insensitive to the error model chosen, but the best fit was given with the gamma error model. Other combinations of production model, initial proportion, abundance index and time lag failed to give adequate fits to the data (R^2 generally less than 0.4, or linear or fluctuating fits to the data).

The time lag suggests that recruitment occurs at around five years of age, which may be reasonable for this relatively slow growing species. However, this implies that population growth is dominated by recruitment rather than the growth of already recruited cohorts, which seems unreasonable for a species that probably has an extended age structure. Also, the predicted trends in biomass varied when using the different abundance indices, although the maximum biomass predicted by each was similar (approximately 22,000 t).

The quality of the available commercial catch-effort data as abundance indices for lemon sole must therefore be questioned, particularly the assumptions of constant catchability across time, and discrete stock status.

4.1.2 Monkfish *Lophius americanus* (NAFO 4X)

Introduction

Monkfish (*Lophius americanus*) is a benthic fish occurring in the Northwest Atlantic from the northern Gulf of Saint Lawrence, southward to Cape Hatteras, North Carolina. They are tolerant of a large range of temperatures, but seem to be most abundant between 3 and 11° C depending on the season and latitude. Their stock structure is unknown, but USA survey distributions suggest northern and southern components with the shallow waters of central George's as a boundary zone. Canadian survey distributions, do not indicate a discontinuity between the 4X, 4W, and 5Z areas. Spawning appears to take place in Canadian waters during the summer months, thus suggesting some degree of independence between the various components.

The Fishery

The importance of monkfish as a Canadian commercial species has increased dramatically since the early 1990's due to the emergence of a number of new market categories for whole fish and livers. Prior to this, catches were given as "crew share" and sold only for tails. They were not under quota management.

Since 1978, monkfish have been almost exclusively a bycatch fishery of groundfish and scalloping ventures with the highest landings being reported by the scallop fleet fishing in 4VW (Western Bank) during 1986 and 1987 and George's Bank (5Zc) between 1989 and 1991. Landings in both 4VW and 5Zc have declined since that time but have increased in 4X. Since 1993 the small mobile gear fleet have been directing for monkfish in this area resulting in an increase in landings from just over 300 t in 1991, to over 1100 t in 1994.

The fishery is essentially a directed bycatch fishery being prosecuted almost exclusively in one small area to the west of Brown's Bank. Another smaller area on the northeast edge of Brown's Bank appears to be the only other area where fishing takes place. For the vessels directing for monkfish in 4X, landings indicate that fall markets are usually higher while for the fleet as a whole, monkfish landings are spread throughout the year with some concentration in the spring and fall months.

Concerned about possible increased exploitation in Canadian waters, a 20 percent bycatch limit of monkfish was imposed on the fleet targeting this species until such time as the feasibility of allowing various other management options, could be assessed. A cooperative science/industry study was therefore established to provide information on monkfish population biology that will hopefully help in the development of a rational plan for the exploitation of monkfish on the Scotian Shelf and George's Bank.

Data

Survey data from the Canadian Scotian Shelf Summer Research Vessel series from 1970 provide information on distribution, abundance and biomass. However, monkfish do not seem particularly available to this survey with mean numbers per tow below 1. However, in 4X, they do show an increasing trend from 1990 to a series high in 1995. The 1996 and 1997 survey mean numbers have declined somewhat. Mean weight per tow exhibited a similar but less pronounced trend, but without a series high in 1995, possibly indicating improved recruitment.

Landings data are complete from 1964. However, the large catches in the early 1970's are attributed to Russian vessels and are not considered reliable.

Modified DeLury Analysis

A modified DeLury model (DeLury with a recruitment index) was applied to the 4X monkfish data. Indices of numbers of recruits and numbers of adults were obtained from survey length-frequencies in terms of numbers per tow. Length-slicing was used to separate recruits and adults. Natural mortality was assumed to be 0.2. Average individual weight in the catch was not available to convert total catch in weight to total catch in numbers. When a constant weight was assumed, the model fit was extremely poor, and parameter estimates highly unrealistic (extremely high population size).

A nominal weight in each year was calculated from the survey indices in terms of weight per tow and numbers per tow, and used to obtain total catch numbers. The nominal weights show a strong general decline, particularly since 1979 (Figure 4.1.2.1). The modified DeLury applied to these data, does give a reasonable fit in the sense that estimated population numbers are realistic, and residuals are acceptable (though large in some cases).

Two runs were performed, the first including the whole data series, the second only starting from 1977, because of doubts about the total catches in earlier years. The fits and diagnostics for the two runs are given in Figures 4.1.2.2 and 4.1.2.3. Confidence intervals on parameters are very wide, as also suggested by the large scatter of residuals. Figure 4.1.2.4 shows estimates of total mortality (z) for these two DeLury runs, and the two length-based methods. The run which includes the whole data series give estimates of total mortality that are consistent with estimates from the length-based analyses (which are independent from the DeLury analyses).

Both DeLury runs show a decline in population abundance since the 1970's, but the details and actual levels are quite different depending on whether all the data are included or not (Table 4.1.2.1 and Figure 4.1.2.5). The truncated series

(1977 onward) suggests very high population abundance (129,000 t) in 1977 with a rapid decline to only 12% of that in 1997. The full data series implies a much lower population abundance in 1977 (20,000 t) and a decline to 24% of that in 1997.

Stock synthesis

The length-based version of the Stock Synthesis program was used to analyse the monkfish data from NAFO statistical area 4X. The following data were put into the program: annual landings data (1970–97); annual length composition data from the commercial fishery (1995–96); annual length composition data from the DFO research trawl survey (1970–97); and annual estimates of stock biomass derived from the DFO research trawl survey. No age composition data were available for the fishery or survey, but DFO data on size at age were used to partially specify the growth curve. The program was configured to conform with the following assumptions. The natural mortality coefficient was fixed at 0.25/yr for both sexes and all age classes and years. The selectivity coefficients were generated from simple asymptotic logistic curves based on length, one curve for the fishery and one for the survey, with each curve defined by two estimated parameters. Size selection did not differ by sex. The landings data were assumed to be exact, with the fishery producing no appreciable amounts of discarding. The annual length composition data were assumed to be from simple random samples of 100 fish and the annual survey estimates of biomass were all assumed to be similarly variable, with a 10% coefficient of variation. The stock at the start of 1970 was assumed to be in equilibrium with a low historical level of catch (28 t/yr). The estimated annual recruitment values were not constrained to conform to any underlying stock and recruitment relationship.

In the length-based version of Stock Synthesis the simulated age distributions are transformed to length distributions based on von Bertalanffy growth curves with random error. The length distributions are then filtered by length-selection curves to generate expected length compositions corresponding to the observed fishery and survey length compositions. The analysis of the monkfish data assumed that males and females grew according to the same growth curve, such that length at age 7 years was 66.3 cm (derived from 42 fish determined to be age 7 based on vertebral sections). Length for a given age was assumed to be normally distributed with coefficients of variation in length at age of 18% at age 1 and 10% at age 15, and values at intermediate ages determined by linear interpolation. To convert length to weight and thus derive expected catch biomass values, the program related weight (gm) to length (cm) according to the assumed power function Weight = 0.0487 Length $^{2.805}$ (derived from 217 observations of length and weight). To convert total biomass to spawning biomass the program assumed a logistic relationship between proportion mature and length, such that 50% maturity for females occurred at 23.2 cm and the logistic slope coefficient was 0.143 per cm (derived from 376 observations of length and maturity stage).

Two Stock Synthesis analyses were completed during the Study Group meeting. In both analyses the Synthesis program estimated the virgin (unexploited and equilibrium) number of recruits, the numbers of annual recruits (1970–97), the fishery and survey selectivity curve parameters, and the von Bertalanffy growth coefficient (k). In the first analysis it was assumed that male and female length at age 2 years was 32.2 cm. This resulted in a total log-likelihood value of -2216.0 and an estimated ending stock biomass of 33,397 t. In the second analysis ("Run 2") the program was configured to estimate the length at age 2, but the configuration was otherwise the same as in the first analysis. In Run 2 the total log-likelihood value was -1894.0, the estimated ending stock biomass was 32,182 t, and the length at age 2 was estimated to be 25.6 cm. The large difference between the log-likelihood values (332 log-likelihood units given one degree of freedom) indicates the great importance of the growth parameters in determining the fit to the observed length composition data, but the small difference in estimated ending biomass (1215 t) suggests that the estimates of stock biomass are relatively robust to the assumed growth parameters.

The two analyses differed very little with regard to the fit to the survey biomass data or the estimates of stock biomass available to the fishery, rates of exploitation, or spawning stock biomass. There were slight differences in the estimates of annual recruitment, but both analyses estimated that there were relatively low levels of recruitment from the mid 1970s through 1989, with large levels of recruitment subsequently. The estimated stock reconstruction suggested that this monkfish stock is currently being exploited at a much higher level than in the past, but the annual catches are small compared to the overall stock size; hence the exploitation rate is low. The stock biomass estimated by Synthesis relative to the survey estimates of stock biomass implies that the survey trawl only captures about 7% of the fully vulnerable sizes of monkfish in its path.

Using the Run 2 configuration, in which there were two estimated growth parameters, three sets of sensitivity analyses were completed. In the first set, to confirm that the Synthesis program had found the global maximum likelihood, the program was re-run using starting parameter values that were uniformly randomly distributed over ranges of 50–150% of the final parameter values estimated from Run 2. The total log-likelihood surface appeared to be very flat with respect to the estimates of ending biomass (Figure 4.1.2.6, upper panel) but the log-likelihood value from Run 2 was within 0.01% of the apparent global maximum. In two of the 50 random replicate trials the program stopped its iterative search at what appeared to be a local maximum. In the second set of sensitivity analyses the parameter that determines the level of virgin recruitment was fixed at a series of values and the Synthesis program was re-run to derive new estimates for the unconstrained parameters. The total log-likelihood surface was extremely flat and did not have a well-defined maximum; the input data were consistent with a wide range of values for ending biomass (Figure 4.1.2.6, middle panel). Comparison of the individual likelihood components (fishery length composition, survey biomass index, and survey length composition) indicated inconsistencies among the input data sources. For example, low values of the virgin recruitment multiplier provided better fits to the fishery length data but worse fits to the survey biomass index. In the third set of sensitivity analyses the natural mortality coefficient was fixed at a series of values and the program was re-run to derive new estimates for the unconstrained parameters (including the virgin recruitment multiplier). Low values for the rate of natural mortality produced lower estimates of ending stock biomass, and vice versa (Figure 4.1.2.6, lower panel). In the vicinity of the natural mortality coefficient assumed in Run 2 (0.25 /yr) the total log-likelihood surface had a fairly well-defined maximum with respect to the natural mortality coefficient, but the individual likelihood components indicated inconsistencies among the input data sources.

4.1.3 Edible crab (*Cancer pagurus*) in The Channel

Some preliminary assessments for the edible crab *(Cancer pagurus)* stock in the Channel (La Manche) were carried out on some new data which was not available at last year's Study Group. This stock is assumed to cover areas VIId, e and h, the southern section of VIIf, and the northern section of VIIIa. Mature females are known to migrate in a westerly direction from area VII, but males show no directional movements. The stock is fished by vessels from England, France and the Channel Islands, with a series of different metiers exploiting different components of the stock. Catchability is known to be influenced by gear type, physiological factors such as moult and reproductive cycle, temperature, and behavioural factors such as intra- and inter-specific interactions around pots. Males and females are marketed differently, and there are different minimum sizes across areas, and in Area VIIe in the UK, between sexes.

Landings

We took a time series of landings (best estimates provided by scientists) for France (all areas combined) and UK (Area VII only) from 1985 to 1994. These data are only preliminary estimates of total landings from this stock as they do not include landings from the Channel Islands.

CPUE data from France

A time series of crab CPUE and fishing effort is available from 1986 to 1996 in the French potter fleet from Morlaix (Latrouite and Noel, 1998). The catch of this fleet represents between 20 and 39% of the total French catch according to years. CPUE by the observed fleet was computed for Area VIIe which represents more than 50% of the landings of that fleet. The effort is expressed in numbers of pots hauled and CPUE is expressed in crab weight per 1000 pots hauled.

The number of vessels in the Morlaix fleet increased from 1986 to 1990 but has been constant since 1991. The numbers of pots hauled in the observed fleet is roughly constant during the available time series.

Production modelling with CPUE from French fleet

The French CPUE data in Area VIIe was used to fit a Schaefer production model under non-equilibrium conditions. An estimate of the current biomass as a proportion of the virgin biomass (initial proportion) is required for fitting the model. For this stock, which was exploited prior to the available time series, the initial proportion is thought to be approximately 0.3–0.5. (Analysis of historical size distribution data would provide estimates of fishing mortality and current biomass levels in relation to virgin biomass).

In initial model fits, the time lag was set to 0. Least-squares provided the best fit to this data set compared to Log or Gamma transformations for an initial proportion of 0.5 (Table 4.1.3.1), and similar results were obtained for all values of the initial proportion. An example of the fitted model with least squares error structure and initial proportion of 0.5 is given in Figure 4.1.3.1. The associated confidence intervals for the estimated parameters (calculated from bootstrapping) are shown in Figure 4.1.3.2. Varying the initial proportion (IP), the best fit is obtained for the lowest IP value (0.05), although there was little difference in the goodness-of-fit for all values of IP (Table 4.1.3.2). The estimate of r appeared insensitive to the value of IP, but K increased as the initial proportion declined. Confidence limits for the estimates of K, q, r (and hence MSY) were extremely wide (Table 4.1.3.3).

Estimates of the parameters in the model were insensitive to variations in the time lag from 0 to 5 years when IP was set at 0.5 (Table 4.1.3.4), but these parameter estimates were more sensitive to assumptions about the time lag when IP was set at 0.2 (Table 4.1.3.5). In both cases we obtained the best fit for a time lag of 2 years, but the fit for an initial proportion of 0.2 gave very different parameter estimates to other time lags, and a relatively much higher value of r-squared. It is not clear why the fitting procedure should produce such values.

The conclusion that we draw from this series of fitted models is that the lack of sensitivity of parameter estimates, and the lack of variation in the goodness-of-fit for these models, reflects the relatively small variation in landings and CPUE observed over the time series. Therefore we conclude that, although the fits appear to be relatively good, they are not particularly informative.

Analysis of size distribution data

Size distribution by sex was available for UK vessels for crabs in Areas VIId and VIIe, with the latter being split into inshore and offshore vessels. Some size distribution information was also available for large mesh nets in the French fishery in Area VIIe. It was decided therefore that during the time available at this Study Group, it would not be possible to produce a single estimate of fishing mortality for this stock. However at last year's Study Group a preliminary estimate of fishing mortality of approximately 0.8 was made from catch curve analysis.

This estimate of F for this stock seems surprisingly high, when one considers that there has been only a small decline in CPUE over the 10 year time period for which we have data. The stock production model estimates biomass to be approximately 90,000 t at the end of the time series, and with a total catch of 15,000 t, this corresponds to an F of approximately 0.16, substantially less than that estimated from size distribution data.

Future requirements for assessment of this stock.

There are a number of improvements to the data set that are needed before we can complete a realistic assessment of this stock. Firstly we need to collate more accurate landings for this stock, in particular to include Channel Islands data. There are size distribution data for all years for which catch data is available and so could be included in any detailed analysis, although care will need to be taken to consider how to aggregate data across metiers. Estimates of fishing mortality from size distribution data must inevitably require good information on growth rates in the stock, which is currently lacking.

Postscript: South Wales CPUE

A good accurate time series of catch and effort data for the South Wales crab fishery from 1980 to 1997 was also investigated, but no reasonable conclusions could be drawn. Firstly, the residuals showed very clear trends with data from 1980–1985 differing considerably from data for 1986 onwards. This may well have been caused by changes in catchability in the fishery, possibly due to changes in gear efficiency around that time. Secondly, model fits based on data from 1986–1997 only, were inconclusive primarily because there was such little contrast in the data, with catch increasing linearly with effort over the time period.

4.2 Case studies. *Raya*

General

Ray species in the North Sea have quite discrete distributions (Walker, 1998). The starry ray (*R. radiata*) is abundant offshore in the central North Sea, whereas the cuckoo ray (*R. naevus*) occurs mainly in northern British coastal waters. Thornback rays (*R. clavata*) are found primarily in the coastal waters around the Thames estuary and spotted rays (*R. montagui*) off the east coast of Britain and around the Wash. North Sea rays have traditionally been landed for human consumption. All species have a commercial value, except for the starry ray, which is landed incidentally in Danish industrial fisheries. Although North sea rays are mainly caught as a bycatch, there is a limited long-line fishery for rays off the British coast and in the past directed fisheries have been prosecuted off the European continental coast (Walker, 1996). Landings started declining in the North Sea in the early 1920s and again in the mid-1950s, following a period of recovery during the World War II, but have remained stable during the past 15–20 years (Walker, 1998).

Assessment data and methods

Formal assessment data were not available to the Study Group and consequently data were obtained from a variety of sources. The landings data used were those officially reported to ICES for the years 1974 to 1993 (Table 4.2.1). These data are for all species combined (rays are not generally landed by species on commercial fish markets), and to allow analysis by species these data were disaggregated according to the species proportions observed each year in catches taken during the International Bottom Trawl Survey of the North Sea. Modified DeLury constant recruitment and Schaefer production models were fitted to the derived landings data for each species and CPUE indices published for the aforementioned survey. In the absence of mean weight data, the DeLury analyses were carried out assuming a constant mean weight for all species and years. Natural mortality was assumed to be 0.15 for all species and years.

Results

The results from both Delury and Schaefer for each of the four species analysed (not presented) were very unreliable, reflecting a poor fit for a range of model assumptions and error models. The main reason for this was frequently a lack of contrast in CPUE.

4.3 Data extractions

Dab, Witch and Flounder in the North Sea

The flatfish species Common Dab (*Limanda limanda*), Witch (*Glyptocephalus cynoglossus*) and Flounder (*Platicthys flesus*) are bycatch species in the demersal fisheries of the North Sea, and as such catches of these species are now limited by the recently introduced mixed flatfish TAC. Catch data were compiled for these species with a view to performing assessments. Within the time available it was not possible to assemble complete sets of data, but the data compiled are presented here as a first step towards possible future assessments. Other existing data which would also be of use in assessments are also discussed.

Estimates of human consumption landings of these species have been obtained from official landings statistics. These are incomplete for some recent years with some nations, notably the Netherlands, not reporting catches at a species level for all years. Estimates of discards for some Danish and Scottish fleets have been taken from Jensen *et al* (1993). These estimates are only available for a limited year range and do not cover the whole national fleet in either case. However, for both nations, the fleets sampled represent a high proportion of the vessels within the national fleets and are regarded here as estimates of total discards for these nations. Some of these species are taken as bycatch in Danish and Norwegian industrial fisheries. Estimates of these bycatches are taken from the Report of the Working Group on the Assessment of Demersal Stocks in the North sea and Skagerrak (ICES, 1998d)

Survey indices of abundance were drawn from Heesen & Daan (1996) or Heesen (1996). They summarise data from IBTS surveys for 1970–1993. As such these survey indices represent survey catch rates in numbers rather than a biomass index; i.e., they do not incorporate information on the size composition of the survey catches.

The data compiled here reflect the data that were readily available at short notice. Other data are available which could also be used in assessment. In particular, data from only one survey series are presented here, when it is likely that other survey series, particularly beam-trawl surveys, would provide useful information. More recent information on discards and size composition of the discards, should be available from existing discard sampling schemes. Species composition of industrial bycatches is sampled routinely, with the results being presented in the Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak.

4.3.1 Common Dab

Catch trends

Long-term trends in landings of Common Dab are given in Figure 4.3.1.1. Since 1903 landings have varied between 1.5 and 11.8,000 t, with a mean of close to 6,000 t. Reported landings since 1988 are given by nation in Table 4.3.1.1. No reported landings of Dab are available for the Netherlands since 1989. However the North Sea Demersal WG (ICES, 1998d) note that there has been a recent increase in Dutch landings of Dab, with around 10,000 t being landed in 1996 (ICES, 1998d, Figure 9.1.2). Hence the total of reported landings is a substantial under-estimate of the actual landings in recent years.

Estimates of discards are available for some years for Scottish and Danish fleets in Jensen *et al* (1993). These are given in Table 4.3.1.2. Estimates of the industrial bycatch of Dab are also given in Table 4.3.1.2. Discarding is substantial, with the limited sampling indicating mean discard rates (discard wt/total catch wt) of around 85% for Scottish vessels and 69% for Danish vessels. Substantial quantities are also taken in the industrial fisheries. Given the extent of discarding and of industrial bycatch, the official landings are clearly not an adequate reflection of the actual catch in this case.

Research vessel survey data

IBTS indices taken from Heesen & Daan (1996) are given in Figure 4.3.1.2. There is some indication of an increase in catch-rate since the mid 1980s.

Other data sources

Figure 9.1.2 in the Report of the North Sea Demersal WG (ICES, 1998d) gives an indication of the recent increase in Dutch landings of Common Dab.

4.3.2 Witch

Catch trends

Long-term trends in landings of Witch are given in Figure 4.3.2.1. Since 1903 Landings have varied between 100 t and 3200 t, with a mean of 1600 t. Recent landings have been above the long-term average, following an increase in about 1982. This may reflect the movement of fishing effort into more offshore areas during this period. Reported landings since 1988 are given by nation in Table 4.3.2.1.

Estimates of discards are available for some years for Scottish and Danish fleets in Jensen *et al* (1993). These are given in Table 4.3.2.2. Estimates of the industrial bycatch of Witch are also given in Table 4.3.2.2. The level of discarding appears to be relatively small, with the limited sampling indicating mean discard rates (discard wt/total catch wt) of around 14% for Scottish vessels and 4% for Danish vessels. The quantities taken as bycatch in the industrial fisheries are also generally small.

Research vessel survey data

IBTS indices taken from Heesen (1996) are given in Figure 4.3.2.2. These show some relatively high catch rates in recent years, but the numbers of fish caught during the survey are generally low.

4.3.3 Flounder

Catch trends

Long-term trends in landings of Flounder are given in Figure 4.3.3.1. Since 1903 Landings have varied between 750 t and 5500 t, with a mean of 2200 t. Reported landings since 1988 are given by nation in Table 4.3.3.1.

Estimates of discards are available for some years for Scottish and Danish fleets in Jensen *et al* (1993). These are given in Table 4.3.3.2. the level of discarding appears to be relatively small, with the limited sampling indicating mean discard rates (discard wt/total catch wt) of around 5% for Danish vessels and 65% for Scottish vessels. Although the Scottish discard rate is high, Scottish landings are small so the amount discarded is small. This species is not listed as a bycatch species in ICES CM I998/Assess:7 so bycatches are presumably negligible.

Research vessel survey data

IBTS indices taken from Heesen (1996) are given in Figure 4.3.3.2. These fluctuate without any clear trend, and the numbers of fish caught during the survey are generally low.

5 RECOMMENDATIONS

This is the third, and final, year of the SGASSO mandate. It was felt to be important to consider our experience and suggest ways to improve either a continuation of the Study Group or another group to carry out similar functions. The Study Group demonstrated that it could carry out assessments, but was not as successful as it could have been. The most important element for a the success of SGASSO, or a SGASSO-like group, is the clear definition of objectives. The ToR were too broad to allow a focus of resources or to attract wider participation; prospective participants did not know what we were going to do. It is **recommended** that ICES consult its clients for a specific set of objectives before the Study Group is re-convened. These objectives should include the areas and species to be considered, and the purpose to which the analysis is directed (the question asked). It is probable that the question asked would be one of two sorts. The first is what is the ability of the resource (ecosystem) to support effort directed towards unassessed stocks, either new effort or effort from traditional fisheries. The second question would be the need for assessments of specific stocks - perhaps on an area or species basis.

Discussion led to three potentially useful scenarios for future meetings, which are predicated by the client's objectives. It should be noted that all of these are within the current ToR. If the prime objective is to estimate the ability of the resource to absorb redirected effort from traditional fisheries, an analysis focusing on survey data and catchabilites would be indicated. Such a meeting would require personnel conversant with and having access to the relevant survey data bases, catch statistics and biology of the species under consideration. The analysis would probably be an approach similar to that of Sparholt (1990) but extended to include catch, and possibly catch rate, information. Completion of this analysis would be feasible at a single meeting.

If TACs are required, two separate meetings would be best. In the two Study Group meetings to date, most of the time was spent on data preparation, then on matching methods to data, and finally a little time was available to discuss the individual assessments. The problem of methods specific for data poor situations was also addressed, but not given much time. The Study Group felt that two meetings would be necessary with slightly different personnel. The first would assess methods for data poor situations and would require analytical skills. Both simulated and fishery data would be needed to conduct these trials. The second would take place conceivably a year later and apply these methods to pre-specified stocks. It is important that the data be extracted before the meeting, or less desirable, considerable time be added to the meeting for data extraction. We reiterate that priorities on stocks/areas/species be in place to focus the Study Group.

Recommendations:

1. Another meeting of the SGASSO should NOT be held until a clearer mandate is established. Such clarification should include objectives, and priorities for species or areas.

2. If specific TAC's are required a SGASSO (or an other group) meeting should be held to assess methods for data sparse situations. This meeting would require intersessional preparation, particularly for the production of simulated and fishery test data sets and definition of criteria.

3. Establish mechanisms for communication with other groups - for example, Deep Sea, Elasmobranchs, Crangon and Crab groups. SGASSO could be used to focus on one of these groups at a time as a training function.

4. Obtaining additional funding for travel or support should be considered. A contract to fill the data base is desirable. Someone has to collect and enter the species data and it would be best for a single person to review published reports and contact individual laboratories. Little progress is likely without establishing personal responsibility for the data base. The preliminary version of the database (currently in EXCEL) is working and easily migrated to other formats.

5. Study Group Membership should contain both biological and methods/modelling expertise; although, the composition might change for specific meetings.

6. Stock co-ordinators should be appointed to assure intersessional progress.

6 REFERENCES

Criado, A. 1994. The state of the Lemon sole (Microstomus kitt) fisheries in the North Sea. Unpublished MSc thesis, University of Aberdeen, UK

Darby, C.D. and Flatman, S. 1994. Virtual Population Analysis: version 3.1 (windows/Dos) user guide. MAFF Information Technology Series No. 1. Directorate of Fisheries Research, Lowestoft, 85pp.

Deriso, R.B., T.J. Quinn II, and P.R. Neal. 1985. Catch-age analysis with auxiliary information. Can. J. Fish. Aquat. Sci. 42:815–824.

Fournier, D. and C.P. Archibald. 1982. A general theory for analyzing catch at age data. Can. J. Fish. Aquat. Sci. 39:1195–1207.

Latrouite, D. and P.Noel,. 1998. Les crabiers du quartier de Morlaix, flottille, activite et production de 1985 a 1996. Rapport provisoire Ifremer/drv/rh/brest

Heesen, H J L (1996) Time-series data for a selection of forty fish species caught during the International Bottom Trawl Survey. *ICES J. Mar. Sci.*, 53, 1079–1084.

Heesen, H J L & Daan, N (1996) Long-term trends in ten non-target North sea fish species. *ICES J. Mar. Sci.*, 53, 1063–1078.

ICES. 1995. Report of the Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak. ICES CM 1995/Assess:8.

ICES. 1998d. Report of the Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak. ICES CM 1998/Assess:7.

ICES. 1997. Report of the Study Group on the Precautionary Approach to Fisheries Management. ICES CM 1997/Assess:7.

ICES. 1998a. Report of the Study Group on the Assessment of other Fish and Shellfish Species. ICES CM 1998/Assess:8.

ICES. 1998b. Report of the Study Group on the Biology and Assessment of Deep-Sea Fisheries Resources. ICES CM 1998/ACFM:12.

ICES. 1998 c. Report of the Study Group on the Precautionary Approach to Fisheries Management. ICES CM 1998/ACFM:10. Ref. D

Jensen, H., Emslie, D.C. and Coull, K.A, (1993) Discards of fish species of no or very little economic interest. Report of EC study contract no. 92/3508.

Methot, R.D. 1990. Synthesis model: an adaptable framework for analysis of diverse stock assessment data. Int. N. Pac. Fish. Comm. Bull. 50:259–277.

Pacific Fishery Management Council. 1996. Status of the Pacific Coast groundfish fishery through 1996 and recommended acceptable biological catches for 1997. Pacific Fishery Management Council, Portland, OR.

Rae, B.B. (1965). The Lemon sole. Fishing News Books Ltd. London.

Sparholt, Henrik. 1990. An estimate of the total biomass of fish in the North Sea. J. Cons. int. Mer, 46: 200–210.

Walker, P. 1998. Draft Thesis: University of Amsterdam. Fleeting images: Dynamics of North Sea ray populations. 147pp.

Walker, P., and Heessen, H.J.L. 1996. Long-term changes in ray populations in the North Sea. ICES Journal of Marine Science, 53: 1085–1093.

Table 2.1. A summary of the data fields and type of data required in the SGASSO stock database.

FIELD NAME	EXPLANATION
Latin name of species	names if > 1 species
Area	ICES areas
Nation	
Institute; Contact	Institute and individual providing this information
Type of animal	M = Mollusc, Ce = Cephalopod, F = Roundfish, FL = Flatfish, E = Elasmobranch, C = Crustacean, O = Other fish
Habit	B = Benthic, D = Demersal, P = Pelagic
Reproduction	S = Semelparous, I = Iteroparous
Dominant depth preference	E = Estuarine, I = Inshore (0–60 m), S = Shelf and shelfedge (60–400 m), D = Deepwater (> 400 m)
Estimated number of stocks in area	
Fecundity	Approximate egg numbers
Mean (typical) values for the following data fields, by sex where available	
Expected life span (years)	Ideally for an unexploited stock
M (if known)	
Growth rate K	
Terminal size (or Linf)	
Size at first maturity (cm)	Median value if available
Life cycle comments	e.g., hermaphrodite; parental care
For the Species, Nation and Area specific above:	
Main catching gears	
Size at first capture (cm)	If discard data not available, smallest size landed. Median value if available.
Landings trend	I = Increasing, N = No trend, D = Decreasing
Effort trend	I = Increasing, N = No trend, D = Decreasing
Mean value of annual landings (with reference years)	Estimated mean annual value over the reference period cited (including units, e.g., £,$ etc.). Ideally for the period 1988–98.
Potential exploitation level	Potential for increased exploitation in the future (H = High, M = Medium, L = Low)
Indications of data availability and quality	
Total landings statistics	(Y/N with data quality: *Poor **Medium ***Good)
Commercial catch-effort series	(Y/N with data quality: *Poor **Medium ***Good)
Length frequency samples	(Y/N with data quality: *Poor **Medium ***Good)
Age frequency samples	(Y/N with data quality: *Poor **Medium ***Good)
Survey Abundance Index	(Y/N with data quality: *Poor **Medium ***Good)
Discard data	(Y/N with data quality: *Poor **Medium ***Good)
Data from prior assessments	
Prior Assessment Methods	e.g., XSA, Schaefer, Delury etc.
Fpa	
Bpa	
Stock status	Any additional comments on the stock status

TABLE 4.1.1.1. Lemon sole, North Sea
International catch at age ('000), Total , 1976 to 1992.

Age	1976	1977	1978	1979	1980	1981	1982
2	19	18	32	2	0	89	6
3	1447	1117	773	1004	216	1208	1287
4	3152	5136	3799	4227	4294	3514	3860
5	3982	5016	6255	4198	4557	4784	4321
6	2187	3008	3694	5073	3241	1962	2683
7	1317	1479	1425	3329	2832	1149	2087
8	1144	739	573	1451	1735	1286	1205
9	856	592	276	492	1163	921	983
10+	1425	838	199	634	819	863	1259

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
2	0	0	0	0	0	0	0	2	0	0
3	87	2	13	109	158	4	0	133	355	108
4	1710	434	863	1131	2287	305	269	2170	3811	3065
5	6915	2470	3825	3685	5106	2166	3008	6291	8633	7149
6	7302	5072	5838	4693	5066	5509	4999	5754	5842	5658
7	4179	6014	4926	3624	3259	5494	4353	3307	2099	2485
8	1727	2745	2734	1745	1406	3079	3830	1824	539	905
9	927	955	885	608	496	1550	2028	402	212	326
10+	437	440	284	152	226	889	1471	299	42	74

TABLE 4.1.1.2. Lemon sole, North Sea

Natural Mortality and proportion mature

Age	Nat Mor	Mat.
2	.100	.000
3	.100	.400
4	.100	.750
5	.100	1.000
6	.100	1.000
7	.100	1.000
8	.100	1.000
9	.100	1.000
10+	.100	1.000

TABLE 4.1.1.3 Lemon sole, North Sea
International mean weight at age (kg), Total catch, 1976 to 1992.

Age	1976	1977	1978	1979	1980	1981	1982
2	.168	.182	.170	.247	.000	.203	.169
3	.254	.231	.252	.233	.208	.258	.256
4	.287	.282	.313	.267	.252	.308	.265
5	.283	.311	.326	.312	.283	.333	.309
6	.296	.346	.360	.333	.335	.351	.351
7	.315	.351	.413	.362	.372	.335	.379
8	.351	.377	.423	.386	.394	.394	.414
9	.349	.419	.464	.460	.425	.401	.481
10+	.421	.508	.446	.434	.510	.427	.556

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
2	.000	.000	.000	.000	.000	.000	.000	.119	.000	.000
3	.238	.122	.189	.188	.206	.217	.000	.187	.177	.180
4	.234	.217	.206	.216	.215	.196	.224	.235	.232	.241
5	.272	.250	.250	.266	.257	.239	.264	.282	.295	.286
6	.311	.312	.286	.309	.296	.270	.289	.329	.361	.340
7	.368	.351	.337	.344	.345	.298	.312	.365	.405	.380
8	.434	.408	.395	.402	.399	.350	.333	.387	.471	.433
9	.503	.494	.499	.456	.473	.386	.363	.487	.518	.472
10+	.616	.640	.632	.725	.668	.453	.407	.546	.648	.690

TABLE 4.1.1.4. Lemon sole, North Sea
International F at age, Total , 1976 to 1992.

Age	1976	1977	1978	1979	1980	1981	1982
2	.001	.001	.001	.000	.000	.003	.000
3	.045	.051	.033	.034	.006	.037	.048
4	.138	.201	.221	.229	.181	.115	.141
5	.306	.302	.355	.360	.367	.279	.181
6	.438	.354	.338	.482	.461	.237	.223
7	.545	.529	.252	.511	.482	.260	.378
8	.496	.597	.355	.389	.485	.372	.423
9	.449	.458	.411	.517	.548	.456	.478
10+	.449	.458	.411	.517	.548	.456	.478

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
2	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
3	.003	.000	.001	.006	.009	.000	.000	.004	.008	.004
4	.075	.018	.034	.051	.143	.019	.013	.087	.131	.077
5	.358	.133	.189	.179	.301	.175	.240	.425	.511	.341
6	.463	.429	.463	.330	.354	.541	.672	.852	.785	.659
7	.561	.768	.857	.517	.357	.713	.987	1.204	.781	.821
8	.544	.790	.870	.756	.343	.594	1.614	1.513	.545	.829
9	.594	.584	.560	.417	.439	.689	.893	.627	.606	.662
10+	.594	.584	.560	.417	.439	.689	.893	.627	.606	.662

TABLE 4.1.1.5. Lemon sole, North Sea
Tuned Stock Numbers at age (10**-3), 1976 to 1993, (numbers in 1993 are VPA survivors)

Age	1976	1977	1978	1979	1980	1981	1982	1983
2	25918	27384	34579	41787	38963	32012	32268	32966
3	34341	23433	24762	31258	37808	35255	28881	29192
4	25692	29697	20141	21670	27328	34005	30751	24908
5	15895	20249	21985	14611	15586	20644	27426	24153
6	6480	10594	13550	13943	9228	9769	14129	20706
7	3294	3783	6725	8747	7791	5267	6973	10232
8	3075	1728	2016	4729	4748	4355	3673	4325
9	2487	1695	861	1280	2899	2646	2718	2177
10+	4121	2390	619	1643	2032	2470	3465	1021

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
2	29378	22166	20580	26129	33426	40136	53665	31438	31923	0
3	29829	26582	20057	18621	23643	30245	36316	48556	28446	28885
4	26331	26989	24040	18045	16699	21389	27367	32734	43598	25636
5	20911	23412	23600	20677	14152	14820	19097	22698	25994	36533
6	15276	16572	17546	17849	13853	10745	10548	11296	12326	16720
7	11789	8998	9442	11412	11332	7294	4967	4071	4664	5771
8	5283	4947	3456	5096	7226	5027	2459	1349	1687	1857
9	2270	2169	1875	1468	3273	3610	906	490	708	666
10+	1039	694	468	667	1867	2597	671	97	161	405

Table 4.1.1.6. Regressions between commercial CPUE and numbers at age from XSA.

Scottish Trawl

Age,	Slope ,	t-value ,	Intercept,	RSquare,	No Pts,	Reg s.e,	Mean Q
4,	.64,	.249,	15.81,	.04,	17,	1.30,	-19.04,
5,	.41,	1.086,	12.82,	.25,	17,	.39,	-17.06,
6,	.69,	.686,	14.04,	.33,	17,	.37,	-16.07,
7,	1.06,	-.126,	15.78,	.32,	17,	.59,	-15.41,
8,	1.07,	-.185,	15.52,	.40,	17,	.66,	-15.02,
9,	.64,	3.340,	12.36,	.90,	17,	.23,	-15.11,

Scottish Seine

Age,	Slope ,	t-value ,	Intercept,	RSquare,	No Pts,	Reg s.e,	Mean Q
4,	.38,	1.424,	13.04,	.35,	17,	.38,	-17.65,
5,	.88,	.148,	15.39,	.14,	17,	.57,	-16.12,
6,	32.86,	-1.406,	208.79,	.00,	17,	18.73,	-15.57,
7,	2.29,	-1.244,	23.59,	.09,	17,	1.34,	-15.33,
8,	1.16,	-.388,	16.31,	.38,	17,	.68,	-15.22,
9,	1.18,	-.885,	16.78,	.70,	17,	.43,	-15.35,

Scottish Light Trawl

Age,	Slope ,	t-value ,	Intercept,	RSquare,	No Pts,	Reg s.e,	Mean Q
4,	.79,	.218,	16.04,	.10,	17,	.86,	-17.63,
5,	1.02,	-.037,	16.38,	.23,	17,	.41,	-16.24,
6,	1.15,	-.357,	16.62,	.37,	17,	.34,	-15.71,
7,	.86,	.536,	14.50,	.59,	17,	.34,	-15.42,
8,	.98,	.061,	15.34,	.55,	17,	.49,	-15.47,
9,	.79,	2.264,	13.95,	.92,	17,	.19,	-15.66,

Scottish Nephrops Trawl

Age,	Slope ,	t-value ,	Intercept,	RSquare,	No Pts,	Reg s.e,	Mean Q
4,	.70,	.300,	16.82,	.09,	17,	.89,	-19.70,
5,	8.83,	-1.288,	84.43,	.00,	17,	4.34,	-18.36,
6,	1.55,	-.736,	22.53,	.15,	17,	.62,	-17.91,
7,	.76,	.873,	15.57,	.56,	17,	.36,	-17.74,

Scottish Pair Trawl

Age,	Slope ,	t-value ,	Intercept,	RSquare,	No Pts,	Reg s.e,	Mean Q
4,	.30,	2.413,	12.50,	.54,	17,	.26,	-18.03,
5,	.57,	.807,	13.62,	.26,	17,	.38,	-16.45,
6,	1.81,	-.428,	20.85,	.03,	17,	1.56,	-15.78,
7,	1.56,	-.506,	19.23,	.07,	17,	1.44,	-15.52,
8,	1.35,	-.458,	17.89,	.14,	17,	1.31,	-15.36,
9,	1.49,	-.875,	19.63,	.24,	17,	1.18,	-15.62,

Table 4.1.1.7. Lemon sole, Terminal year survivor and F summaries :

Age 2 Catchability dependent on age and year class strength

Year class = 1990

Fleet, Estimated ,		Estimated, Survivors,	Int, s.e,	Ext, s.e,	Var, Ratio,	N, ,	Scaled, Weights,	Estimated F
SCOTRL	,	1.,	.000,	.000,	.00,	0,	.000,	.000
SCOSEI	,	1.,	.000,	.000,	.00,	0,	.000,	.000
SCOLTR	,	1.,	.000,	.000,	.00,	0,	.000,	.000
SCONTR	,	1.,	.000,	.000,	.00,	0,	.000,	.000
SCOPTR	,	1.,	.000,	.000,	.00,	0,	.000,	.000
P shrinkage mean	,	28885.,	.26,,,,				1.000,	.000
F shrinkage mean	,	0.,	.50,,,,				.000,	.000

Weighted prediction :

Survivors, at end of year,	Int, s.e,	Ext, s.e,	N, ,	Var, Ratio,	F
28885.,	.26,	.00,	1,	.000,	.000

Age 3 Catchability dependent on age and year class strength

Year class = 1989

Fleet, Estimated ,		Estimated, Survivors,	Int, s.e,	Ext, s.e,	Var, Ratio,	N, ,	Scaled, Weights,	Estimated F
SCOTRL	,	1.,	.000,	.000,	.00,	0,	.000,	.000
SCOSEI	,	1.,	.000,	.000,	.00,	0,	.000,	.000
SCOLTR	,	1.,	.000,	.000,	.00,	0,	.000,	.000
SCONTR	,	1.,	.000,	.000,	.00,	0,	.000,	.000
SCOPTR	,	1.,	.000,	.000,	.00,	0,	.000,	.000
P shrinkage mean	,	25865.,	.27,,,,				.778,	.004
F shrinkage mean	,	24852.,	.50,,,,				.222,	.004

Weighted prediction :

Survivors, at end of year,	Int, s.e,	Ext, s.e,	N, ,	Var, Ratio,	F
25636.,	.24,	10.15,	2,	43.102,	.004

Age 4 Catchability constant w.r.t. time and dependent on age

Year class = 1988

Fleet, Estimated ,		Estimated, Survivors,	Int, s.e,	Ext, s.e,	Var, Ratio,	N, ,	Scaled, Weights,	Estimated F
SCOTRL	,	5684.,	2.027,	.000,	.00,	1,	.032,	.414
SCOSEI	,	49693.,	1.084,	.000,	.00,	1,	.110,	.057
SCOLTR	,	22749.,	1.092,	.000,	.00,	1,	.109,	.121
SCONTR	,	46971.,	1.271,	.000,	.00,	1,	.080,	.060
SCOPTR	,	69299.,	1.083,	.000,	.00,	1,	.110,	.041
F shrinkage mean	,	35588.,	.50,,,,				.559,	.079

Weighted prediction :

Survivors, at end of year,	Int, s.e,	Ext, s.e,	N, ,	Var, Ratio,	F
36533.,	.37,	.20,	6,	.538,	.077

Table 4.1.1.7 cont.

Age 5 Catchability constant w.r.t. time and dependent on age

Year class = 1987

Fleet, Estimated		Estimated,	Int,	Ext,	Var,	N,	Scaled,	
,		Survivors,	s.e,	s.e,	Ratio,	,	Weights,	F
SCOTRL	,	7247.,	.904,	.597,	.66,	2,	.050,	.662
SCOSEI	,	33160.,	.550,	.224,	.41,	2,	.134,	.187
SCOLTR	,	12073.,	.375,	.191,	.51,	2,	.292,	.447
SCONTR	,	15167.,	.487,	.265,	.54,	2,	.173,	.370
SCOPTR	,	26366.,	.585,	.338,	.58,	2,	.118,	.229
F shrinkage mean	,	17319.,	.50,,,,				.234,	.331

Weighted prediction :

Survivors, at end of year,	Int, s.e,	Ext, s.e,	N, ,	Var, Ratio,	F
16720.,	.21,	.15,	11,	.693,	.341

Age 6 Catchability constant w.r.t. time and dependent on age

Year class = 1986

Fleet, Estimated		Estimated,	Int,	Ext,	Var,	N,	Scaled,	
,		Survivors,	s.e,	s.e,	Ratio,	,	Weights,	F
SCOTRL	,	3681.,	.478,	.274,	.57,	3,	.094,	.901
SCOSEI	,	11924.,	.425,	.111,	.[illegible]6,	3,	.105,	.373
SCOLTR	,	4948.,	.241,	.152,	.63,	3,	.354,	.736
SCONTR	,	4665.,	.321,	.229,	.72,	3,	.198,	.767
SCOPTR	,	12847.,	.501,	.165,	.33,	3,	.071,	.350
F shrinkage mean	,	5960.,	.50,,,,				.179,	.643

Weighted prediction :

Survivors, at end of year,	Int, s.e,	Ext, s.e,	N, ,	Var, Ratio,	F
5771.,	.16,	.11,	16,	.728,	.659

Age 7 Catchability constant w.r.t. time and dependent on age

Year class = 1985

Fleet, Estimated		Estimated,	Int,	Ext,	Var,	N,	Scaled,	
,		Survivors,	s.e,	s.e,	Ratio,	,	Weights,	F
SCOTRL	,	1268.,	.393,	.316,	.80,	4,	.118,	1.052
SCOSEI	,	3102.,	.389,	.266,	.68,	4,	.110,	.566
SCOLTR	,	1632.,	.226,	.190,	.84,	4,	.312,	.895
SCONTR	,	1772.,	.295,	.158,	.54,	4,	.188,	.848
SCOPTR	,	3247.,	.493,	.529,	1.07,	4,	.061,	.547
F shrinkage mean	,	1886.,	.50,,,,				.211,	.812

Weighted prediction :

Survivors, at end of year,	Int, s.e,	Ext, s.e,	N, ,	Var, Ratio,	F
1857.,	.16,	.11,	21,	.690,	.821

Table 4.1.1.7 cont.

Age 8 Catchability constant w.r.t. time and age (fixed at the value for age) 7

Year class = 1984

Fleet, Estimated		Estimated, Survivors,	Int, s.e,	Ext, s.e,	Var, Ratio,	N, ,	Scaled, Weights,	F
SCOTRL	,	625.,	.395,	.245,	.62,	5,	.109,	.866
SCOSEI	,	967.,	.377,	.210,	.56,	5,	.131,	.637
SCOLTR	,	618.,	.240,	.120,	.50,	5,	.269,	.872
SCONTR	,	626.,	.302,	.126,	.42,	5,	.188,	.865
SCOPTR	,	1115.,	.521,	.324,	.62,	5,	.060,	.572
F shrinkage mean	,	564.,	.50,,,,				.243,	.927

Weighted prediction :

Survivors, at end of year,	Int, s.e,	Ext, s.e,	N, ,	Var, Ratio,	F
666.,	.17,	.08,	26,	.465,	.829

Age 9 Catchability constant w.r.t. time and age (fixed at the value for age) 7

Year class = 1983

Fleet, Estimated		Estimated, Survivors,	Int, s.e,	Ext, s.e,	Var, Ratio,	N, ,	Scaled, Weights,	F
SCOTRL	,	362.,	.394,	.185,	.47,	6,	.118,	.619
SCOSEI	,	297.,	.298,	.131,	.44,	6,	.235,	.715
SCOLTR	,	282.,	.250,	.104,	.41,	6,	.282,	.743
SCONTR	,	264.,	.339,	.209,	.62,	6,	.110,	.777
SCOPTR	,	580.,	.529,	.184,	.35,	6,	.064,	.428
F shrinkage mean	,	425.,	.50,,,,				.191,	.548

Weighted prediction :

Survivors, at end of year,	Int, s.e,	Ext, s.e,	N, ,	Var, Ratio,	F
330.,	.15,	.07,	31,	.448,	.662

TABLE 4.1.1.8. Lemon sole, North Sea

Mean fishing mortality, biomass and recruitment, 1976 - 1992.

Year	Mean F Ages 5 to 8	Stock Biomass (tonnes) Total	Spawning	Recruits Age 2 Yclass	Thousand
1976	.446	31585	20154	1974	25918
1977	.446	32638	22313	1975	27384
1978	.325	34774	23575	1976	34579
1979	.435	38885	22747	1977	41787
1980	.449	29290	22850	1978	38963
1981	.287	41967	27393	1979	32012
1982	.301	41827	29900	1980	32268
1983	.482	33152	27526	1981	32966
1984	.530	27427	23815	1982	29378
1985	.595	27683	23279	1983	22166
1986	.446	26494	22934	1984	20580
1987	.339	25423	22152	1985	26129
1988	.506	23542	19645	1986	33426
1989	.878	18127	16929	1987	40136
1990	.999	32036	19967	1988	53665
1991	.655	29563	22508	1989	31438
1992	.663	30201	24502	1990	31923
Min.	.287	18127	16929	Min.	20580
Mean	.516	30860	23070	Gmean	31795
Max.	.999	41967	29900	Max.	53665

Min, max and geo. mean recruitment calculated over years 1976 to 1990
(Arithmetic mean recruitment 1976 - 1990 = 32757)
Biomass totals calculated at start of year.

TABLE 4.1.1.9. Lemon sole, Input for equilibrium calculations

Age	F and mean Wt at age used: Scaled Mean F 1990 - 1992	Mean Wt. at age (kg) 1990 - 1992 Stock	Catch
2	.000	.040	.040
3	.004	.181	.181
4	.084	.236	.236
5	.365	.288	.288
6	.657	.343	.343
7	.802	.383	.383
8	.826	.430	.430
9	.542	.492	.492
10	.542	.628	.628

Table 4.1.1.10. Result from fitting a Shepherd curve to lemon sole stock-recruit data. r is the autocorrelation parameter.

Coefficient of determination =, .3420

	Parameter,	s.d.
a	2.1895,	2.2520,
b	28.7010,	19.3638,
c	3.0589,	5.5651,
r	0.5731,	0.2998,

Table 4.1.1.11 Population estimates of Lemon Sole from the Scottish trawl fleet indices of abundance used with the modified DeLury method.

Year	Landings (t)	Catch (no's)	Population (no's)	catch/pop. (exploitation)	Biomass (t)
1976	4787	15528	21866	0.71	6741
1977	5657	17943	75661	0.24	23854
1978	5815	17026	107860	0.16	36837
1979	6541	20410	144146	0.14	46195
1980	6290	18855	174229	0.11	58126
1981	5561	15775	178082	0.09	62784
1982	6227	17691	254473	0.07	89565
1983	7681	23286	261416	0.09	86227
1984	6440	18131	224086	0.08	79591
1985	6045	19368	187213	0.10	58429
1986	5004	15745	188931	0.08	60042
1987	5464	18004	189833	0.09	57613
1988	5831	18997	175013	0.11	53720
1989	6410	19958	141442	0.14	45428
1990	6630	20182	109102	0.18	35843
1991	7065	21532	87349	0.25	28659
1992	6524	19770	75785	0.26	25008

Table 4.1.2.1

Year	Catch (t)	Catch nos (nos)	Nominal weight	All data Biomass	77+data Biomass	All data DeLury Z	77+data DeLury Z	Cat.curve Z	Jones Z
1970	0	0.00	7.92	20486		0.00			
1971	134	40.34	3.32	10296		0.01			
1972	21	9.50	2.21	8575		0.00		0.12	0.22
1973	1300	419.58	3.10	10011		0.13		0.23	0.29
1974	1350	286.79	4.71	22496		0.06		0.22	0.48
1975	2104	394.74	5.33	23383		0.09		0.23	0.43
1976	17	3.11	5.47	19748		0.00		0.15	0.40
1977	521	96.35	5.41	20559	128913	0.03	0.00	0.12	0.39
1978	125	24.84	5.03	15864	99231	0.01	0.00	0.01	0.38
1979	78	11.39	6.85	25737	129176	0.00	0.00	-0.08	0.28
1980	97	28.89	3.36	10981	53375	0.01	0.00	-0.02	0.27
1981	135	31.08	4.34	11798	57060	0.01	0.00	0.07	0.25
1982	169	60.80	2.78	6279	30223	0.03	0.01	0.06	0.26
1983	288	56.05	5.14	9546	46200	0.03	0.01	0.21	0.30
1984	352	102.46	3.44	7091	29772	0.05	0.01	0.18	0.34
1985	369	166.65	2.21	3678	15828	0.10	0.02	0.14	0.34
1986	540	129.47	4.17	8020	30580	0.07	0.02	0.02	0.36
1987	396	90.32	4.38	10948	36213	0.04	0.01	0.07	0.37
1988	290	108.75	2.67	5576	18589	0.05	0.02	0.02	0.34
1989	231	69.30	3.33	5590	19183	0.04	0.01	0.02	0.31
1990	407	491.21	0.83	1472	4733	0.28	0.09	0.24	0.37
1991	342	155.76	2.20	3575	12392	0.10	0.03	0.42	0.40
1992	463	395.48	1.17	1470	5416	0.31	0.09	0.45	0.40
1993	553	329.94	1.68	1979	7700	0.28	0.07	0.56	0.52
1994	1159	1745.84	0.66	1566	4860	0.74	0.24	0.57	0.54
1995	932	822.35	1.13	1258	6967	0.74	0.13	0.68	0.61
1996	1067	835.40	1.28	2752	11279	0.39	0.09		
1997	1187	995.16	1.19	4870	16093	0.24	0.07		

Table 4.1.3.1 CrabVIIe; Schaefer model - initial proportion of 0.5, time lag of 0; output parameters for different error structures

error struct.	K (x10^5)	q	r	R^2
Least-squares	2.082	0.01528	0.2357	0.674
Log	2.706	0.01159	0.1741	0.660
Gamma	2.020	0.01578	0.244	0.670

Table 4.1.3.2 CrabVIIe; Schaefer model - least squares; time lag = 0; output parameters versus initial proportion input

initial prop.	K (x10^5)	q	r	R^2
0.05	11.42	0.0280	0.268	0.688
0.1	6.046	0.0264	0.264	0.686
0.2	3.409	0.0234	0.257	0.684
0.3	2.586	0.0206	0.249	0.681
0.4	2.231	0.0179	0.242	0.677
0.5	2.082	0.0153	0.236	0.674
0.6	2.067	0.0128	0.229	0.670
0.7	2.170	0.0104	0.222	0.666
0.8	2.416	0.0082	0.214	0.662
0.9	2.900	0.0061	0.206	0.658
1.0	3.891	0.0045	0.198	0.654

Table 4.1.3.3 Crab VIIe; Schaefer model - least squares; time lag = 0; Confidence interval of output parameters for initial proportion of 0.5.

parameter	fitted	CI (95%)
K	208,247	88,050 - 1,906,770
q	0.0153	0.0016 - 0.0383
r	0.236	0 - 0.612
MSY	12,271	0 - 13,496

Table 4.1.3.4 CrabVIIe; Schaefer model - least squares; intitial prop. = 0.5; output parameters versus time lag input

time lag.	K (x10^5)	q	r	R^2
0	2.082	0.0153	0.236	0.674
1	2.074	0.0153	0.236	0.674
2	2.033	0.0157	0.241	0.675
3	2.061	0.0155	0.236	0.675
4	2.141	0.0149	0.226	0.673
5	2.225	0.0143	0.216	0.672

Table 4.1.3.5 CrabVIIe; Schaefer model - least squares; intitial prop. = 0.2; output parameters versus time lag input

time lag.	K (x10^5)	q	r	R^2
0	3.409	0.0234	0.257	0.684
1	2.738	0.0294	0.322	0.688
2	0.740	0.1179	1.291	0.785
3	2.269	0.0360	0.382	0.697
4	3.376	0.0238	0.244	0.688
5	4.206	0.0190	0.188	0.681

Table 4.2.1 North Sea rays: Landings data used for case studies (see text)

	R. montagui	R. clavata	R. naevus	R. radiata
1974	331.9	0.0	2765.4	1382.7
1975	0.0	0.0	444.9	3731.1
1976	361.5	0.0	1841.2	2530.3
1977	182.9	0.0	857.4	3772.7
1978	217.8	0.0	1701.5	3062.7
1979	16.1	0.0	342.0	5069.0
1980	132.2	1101.6	396.6	3304.7
1981	0.0	594.2	757.6	5348.1
1982	1140.7	520.9	546.9	2031.4
1983	162.4	2387.6	573.0	2101.1
1984	246.7	959.5	205.6	3824.2
1985	390.7	892.0	682.3	3211.0
1986	87.5	607.6	300.8	3208.1
1987	46.3	734.5	93.6	4230.6
1988	121.0	537.7	635.1	3387.3
1989	112.3	513.3	294.4	3079.9
1990	72.8	505.7	303.4	2518.1
1991	160.9	2550.0	70.3	618.8
1992	49.1	58.5	333.4	3158.9
1993	59.1	157.6	239.3	3344.1

Table 4.3.1.1

Landings (t) of Common Dab from the North Sea, 1988-1997
By nation, as officially reported to ICES

Year	BEL	DEN	ENG	FAR	FRA	GER	NED	SCO	SWE	Total
1988	697	1324	221		349	72	3404	1000		7067
1989	443	1280	170		223	117	2521	1062		5816
1990	416	1103	216		214	162		586	4	2701
1991	491	1160	343		258	290		906		3448
1992	464	699	300		217	218		749		2647
1993	548	1016	439		235	493		578		3309
1994	397	1307	682		133	626		716		3861
1995	410	1306	1226	1	155			767		3865
1996	527	1484	1195		177	718		733		4834
1997 *	507	1399	1235					1049		4190

* Provisional

Table 4.3.1.2

Common Dab, North Sea
Available estimates of discards and industrial bycatch

	Discards (t)		Industrial b
	DEN	SCO	DEN+NOR
1984			149
1985			187
1986		6737	3209
1987		5429	4632
1988		6452	3781
1989		4659	7743
1990	3873	6075	4706
1991	1752	3631	5578
1992		3927	3986
1993			4871
1994			528
1995			1028
1996			1065
1997			

Table 4.3.2.1

Landings (t) of Witch from the North Sea, 1988-1997
By nation, as officially reported to ICES

Year	DEN	ENG	FAR	FRA	GER	NED	NOR	SCO	SWE	Total
1988	447	191		13	6	9	9	1402	3	2080
1989	452	172		14	5	10	15	1649	4	2321
1990	532	132		20	3	4	40	1627	6	2364
1991	512	139		9	3	2	75	1588	12	2340
1992	460	118		13	5	7	46	1273	5	1927
1993	383	115		14	3	13	52	1140	3	1723
1994	458	127	1	2	5	14	56	1258	3	1924
1995	384	129	4		9	7	14	1322	2	1871
1996	434	100			7		14	1331	2	1888
1997 *	488	110				1		1370		1969

* Provisional

Table 4.3.2.2

Witch, North Sea
Available estimates of discards and industrial bycatch

	Discards (t)		Industrial b
	DEN	SCO	DEN+NOR
1984			241
1985			236
1986		250	132
1987		482	341
1988		311	44
1989	16	305	255
1990	20	361	251
1991	26	121	1439
1992		176	195
1993			246
1994			40
1995			0
1996			97
1997			

Table 4.3.3.1

Landings (t) of Flounder from the North Sea, 1988-1997
By nation, as officially reported to ICES

Year	BEL	DEN	ENG	FRA	GER	NED	SCO	Total
1988	160	509	66	44	105	682	32	1598
1989	200	632	63	28	95	916	17	1951
1990	153	467	38	69	147		7	881
1991	260	377	50	51	902		19	1659
1992	152	492	54	35	521		22	1276
1993	194	1812	111	47	356		25	2545
1994	196	642	226	57	921		21	2063
1995	301	628	220	103	843		30	2125
1996	262	1439	166	68	43		27	2005
1997 *	110	988	114				43	1255

* Provisional

Table 4.3.3.2

Flounder, North Sea
Available estimates of discards.

	Discards (t)	
	DEN	SCO
1984		
1985		
1986		18
1987		388
1988		109
1989	21	0
1990	29	291
1991	30	44
1992		91
1993		
1994		
1995		
1996		
1997		

Figure 4.1.1.1. Main distribution of lemon sole, after Rae (1965).

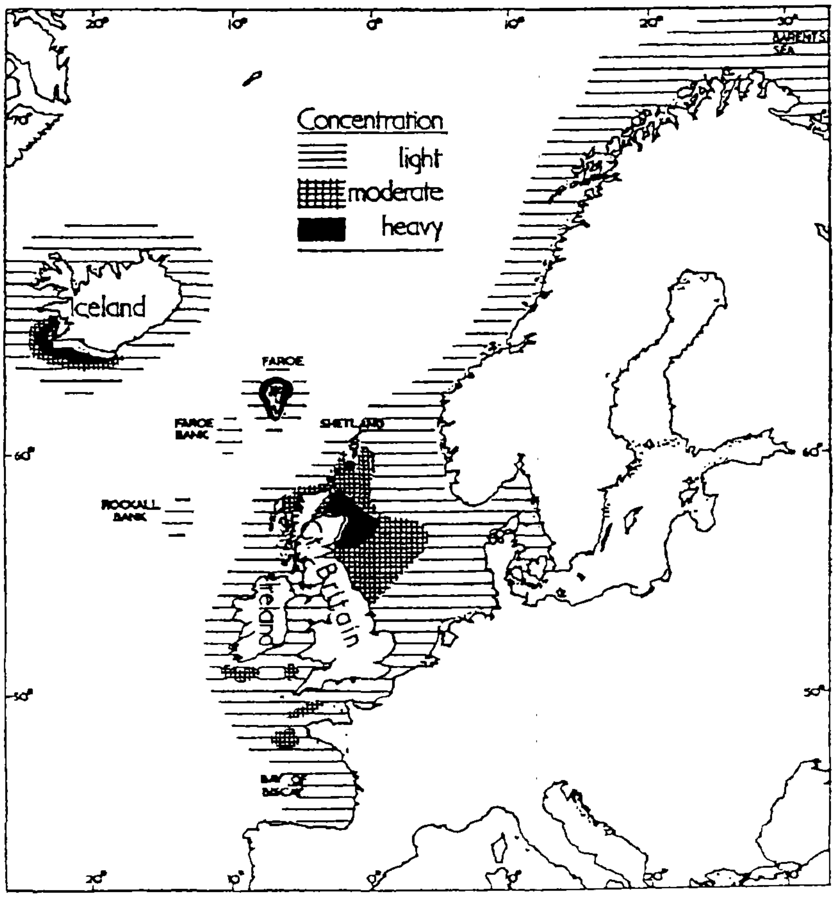


Figure 4.1.1.2. Lemon sole. Log catchability residuals.

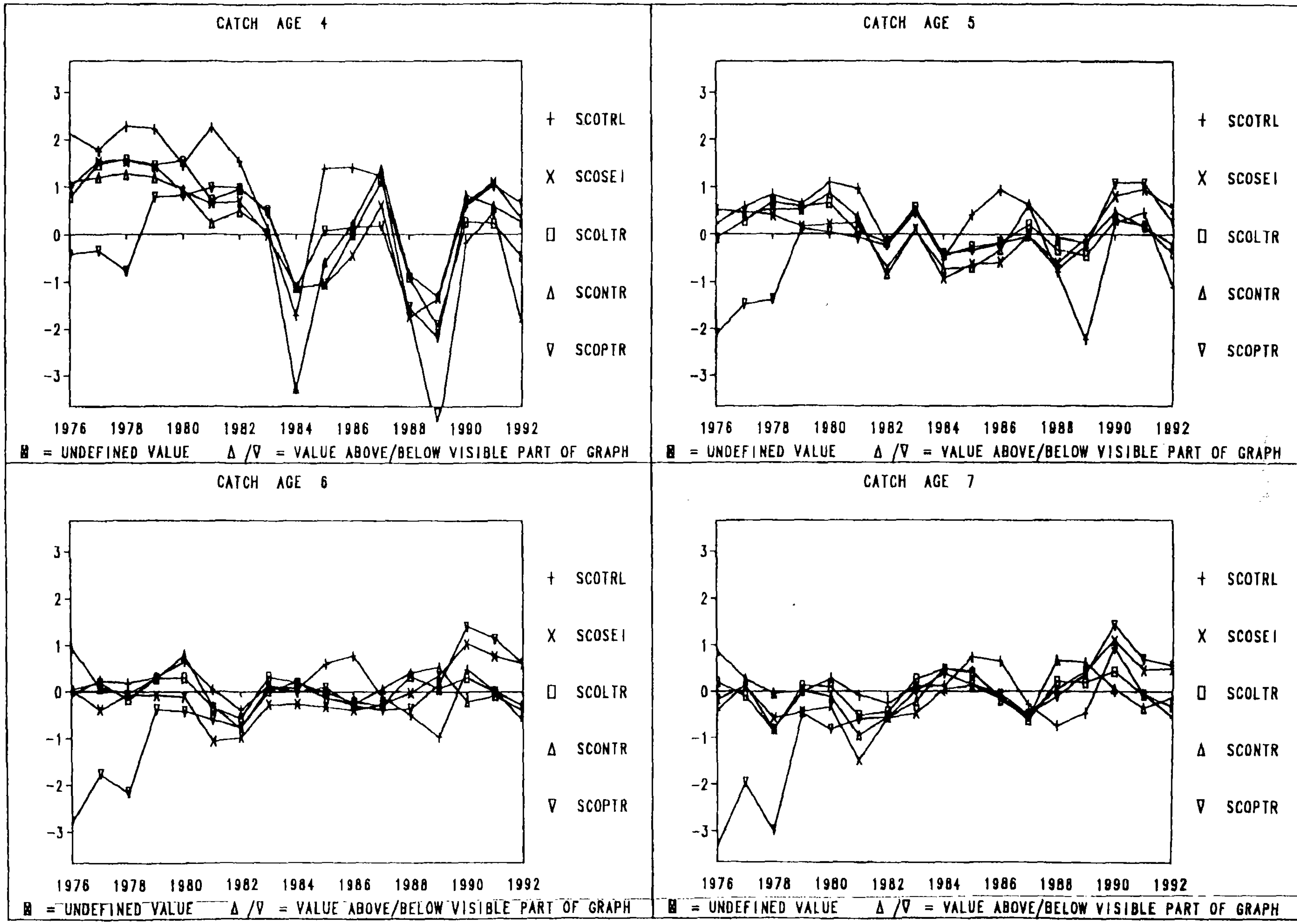


Fig. 4.1.1.2. cont.

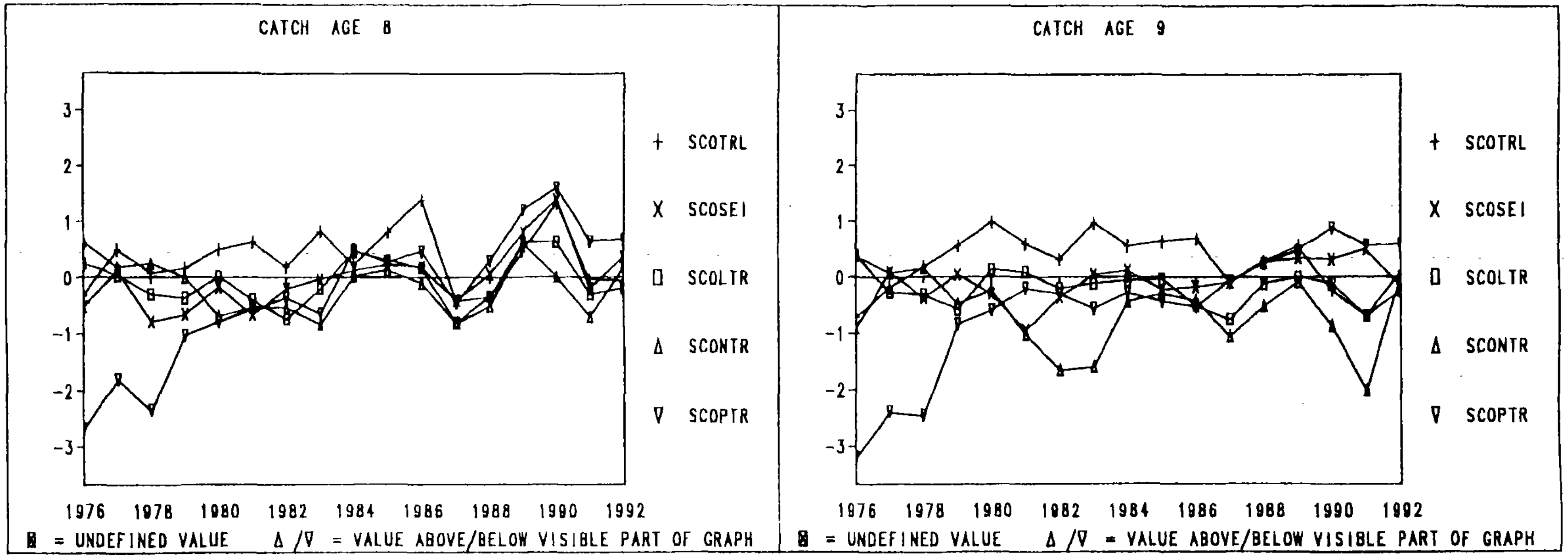


Fig. 4.1.1.3. Lemon sole. Stock trends estimated from XSA.

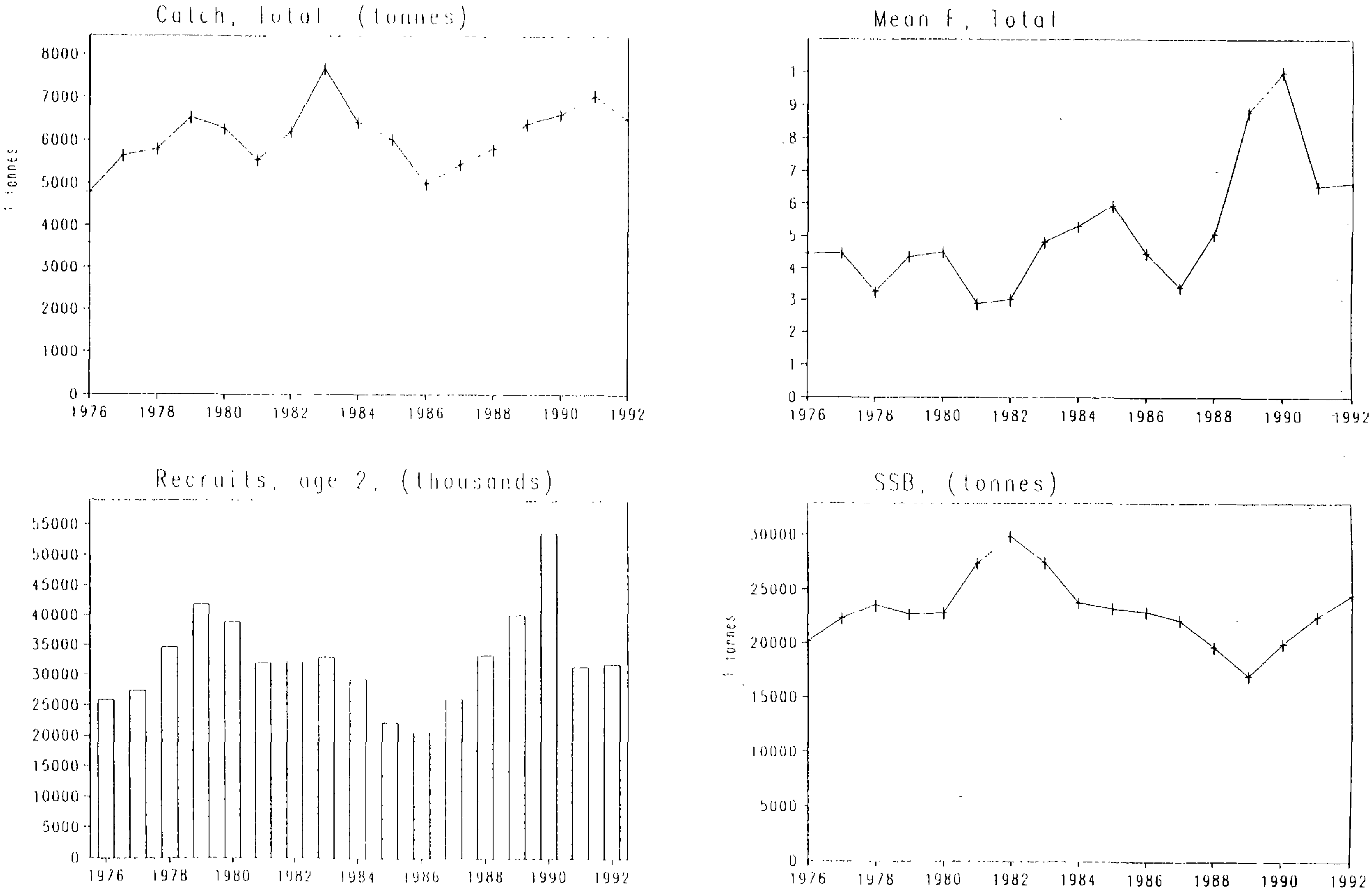


Fig. 4.1.1.4. Lemon sole. Yield per recruit.

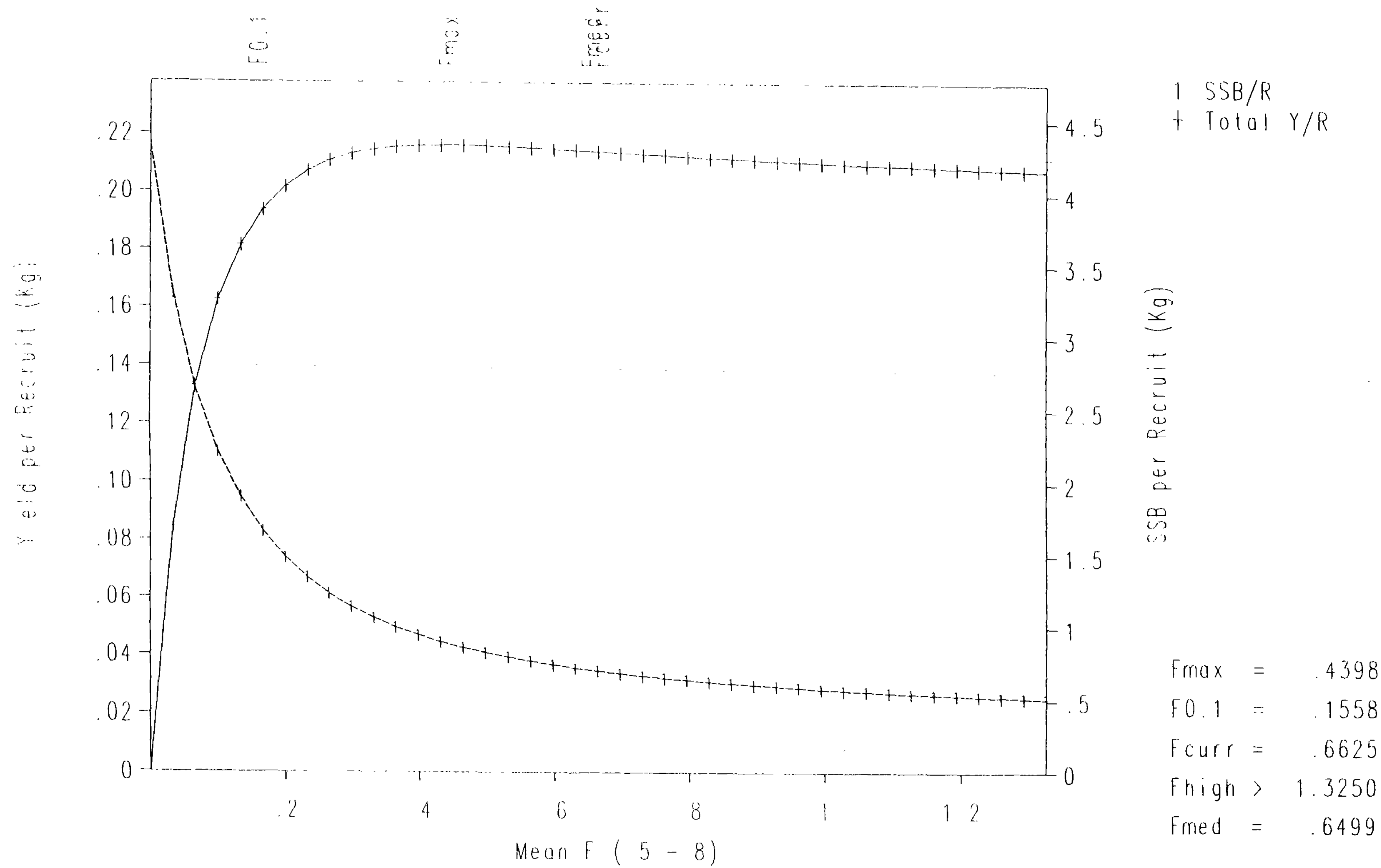


Fig. 4.1.1.5. Lemon sole. Equilibrium analysis.

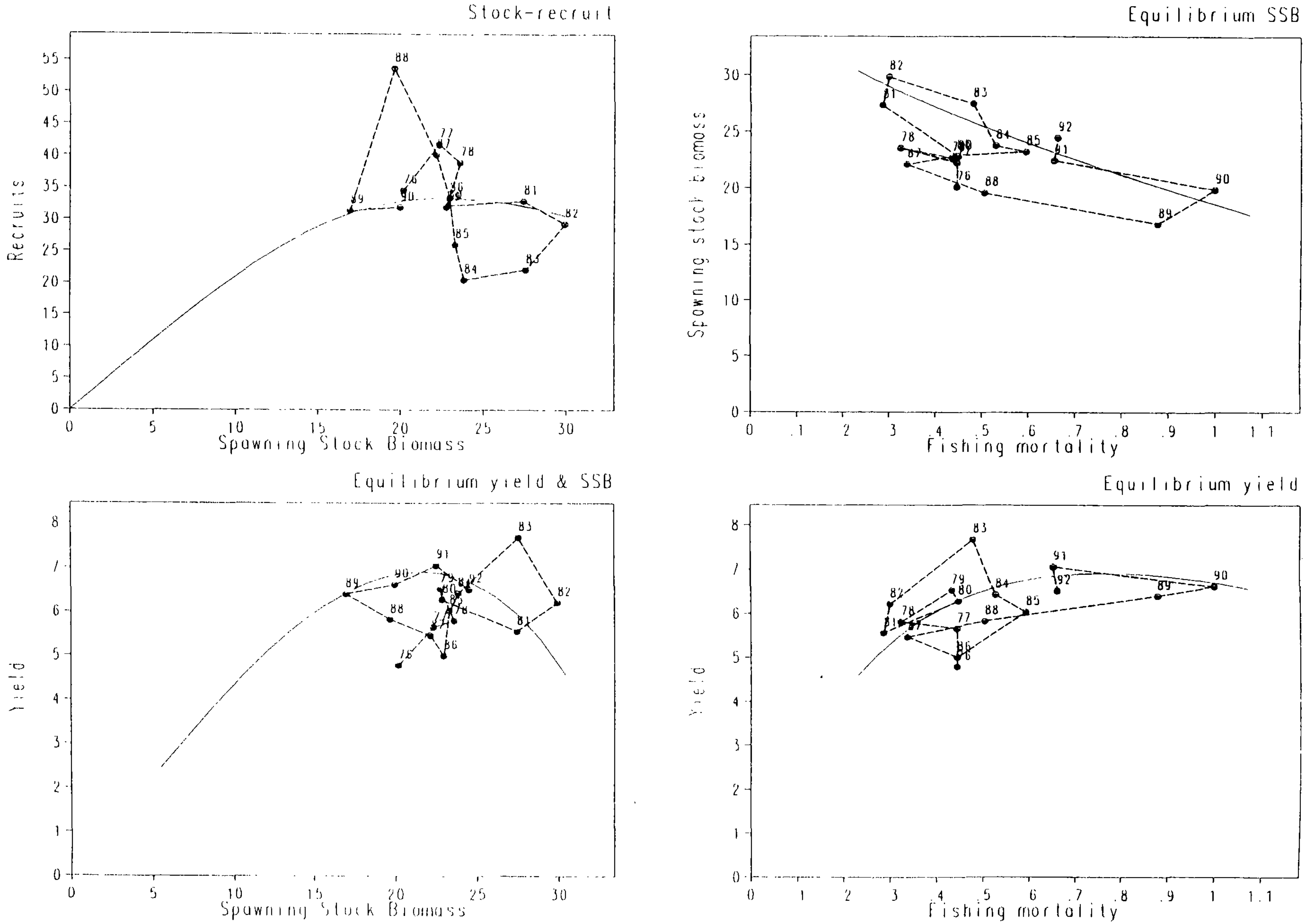


Figure 4.1.1.6 (a)

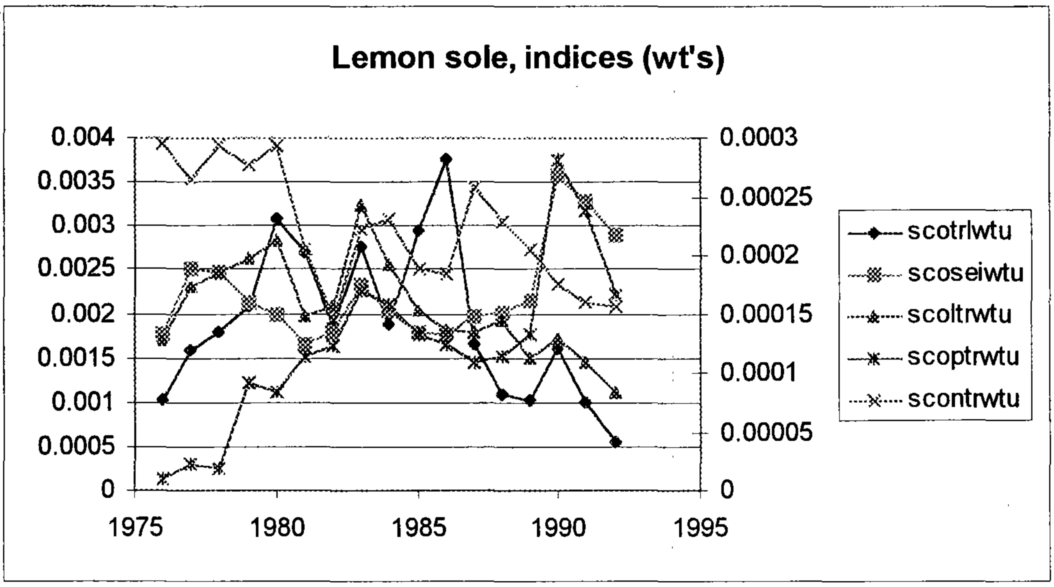


Figure 4.1.1.6 (b)

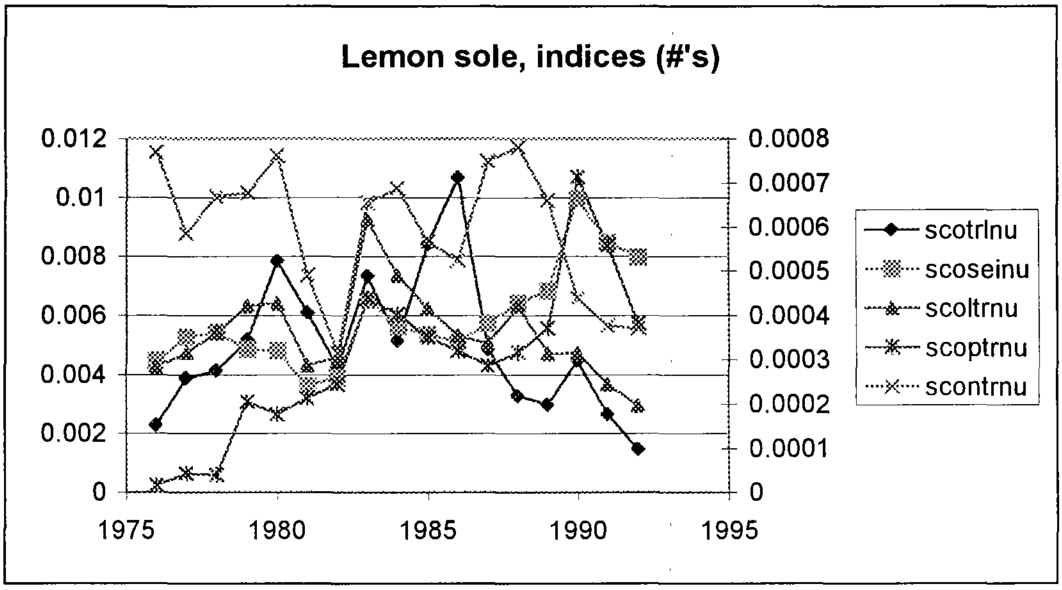


Figure 4.1.1.6 (c)

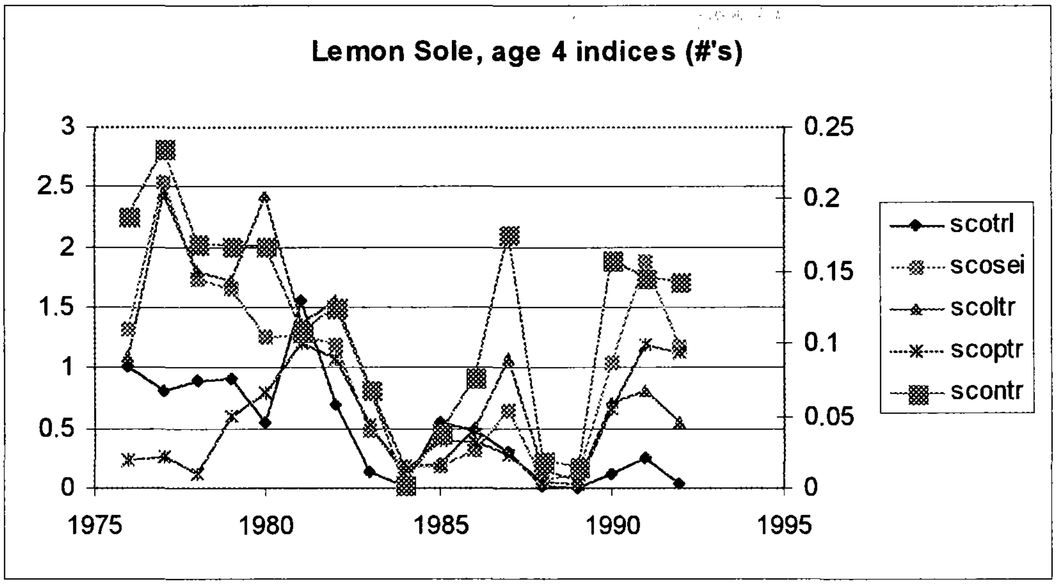


Figure 4.1.1.7

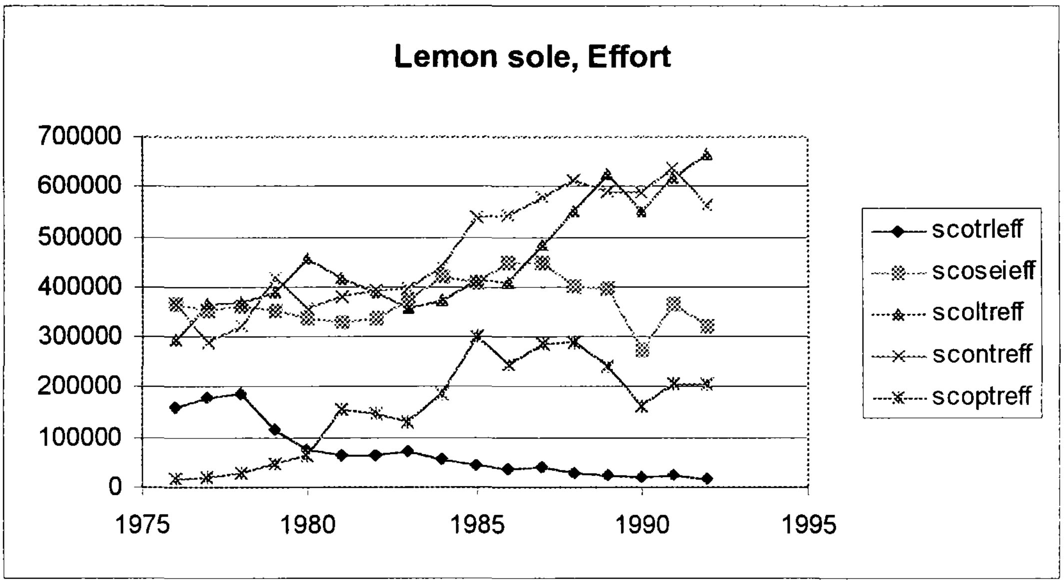


Figure 4.1.1.8

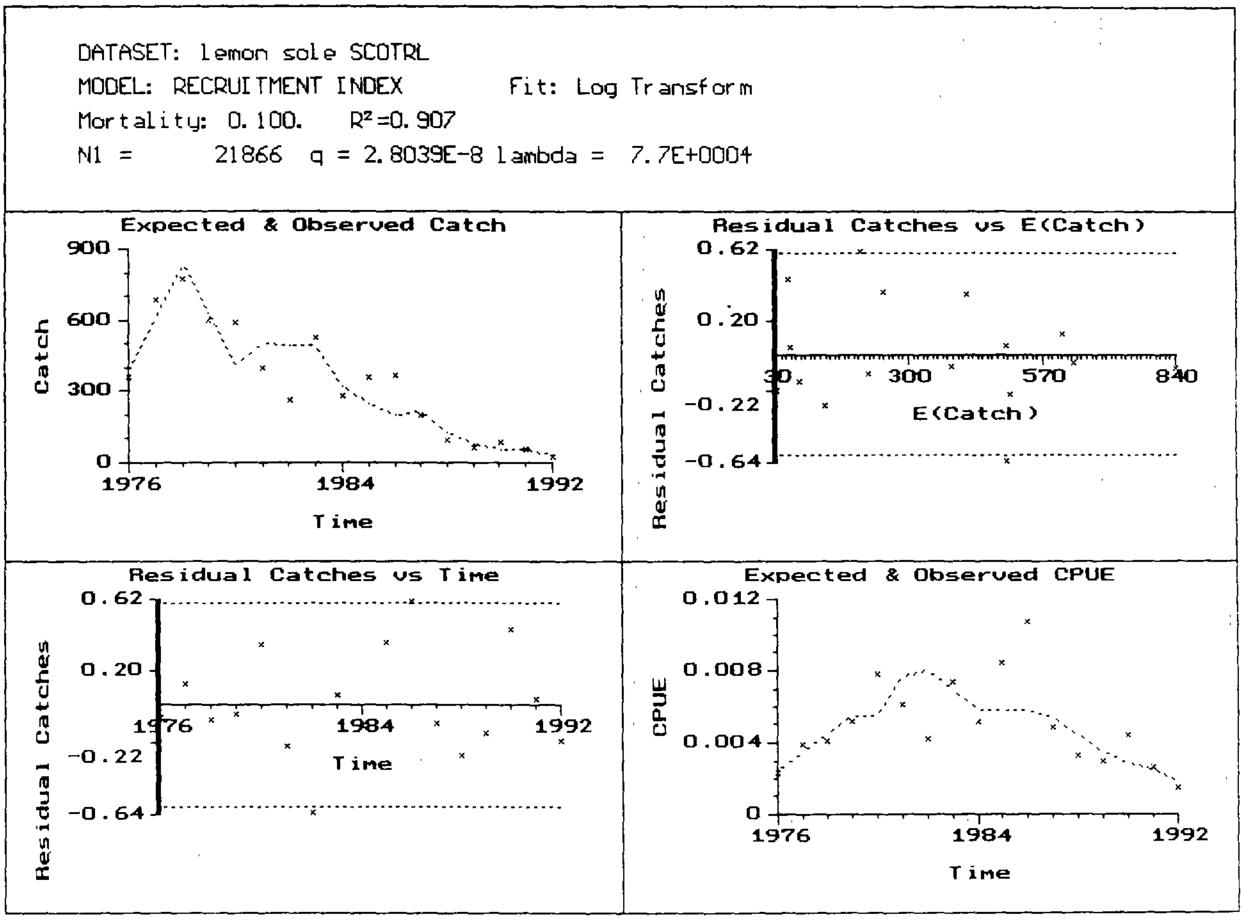

DATASET: lemon sole SCOTRL
MODEL: RECRUITMENT INDEX
Fit: Log Transform
Mortality: 0.100. R²=0.907
N1 = 21866 q = 2.8039E-8 lambda = 7.7E+0004
Expected & Observed Catch
Catch
Time
Residual Catches vs E(Catch)
Residual Catches
E(Catch)
Residual Catches vs Time
Residual Catches
Time
Expected & Observed CPUE
CPUE
Time

Figure 4.1.1.9

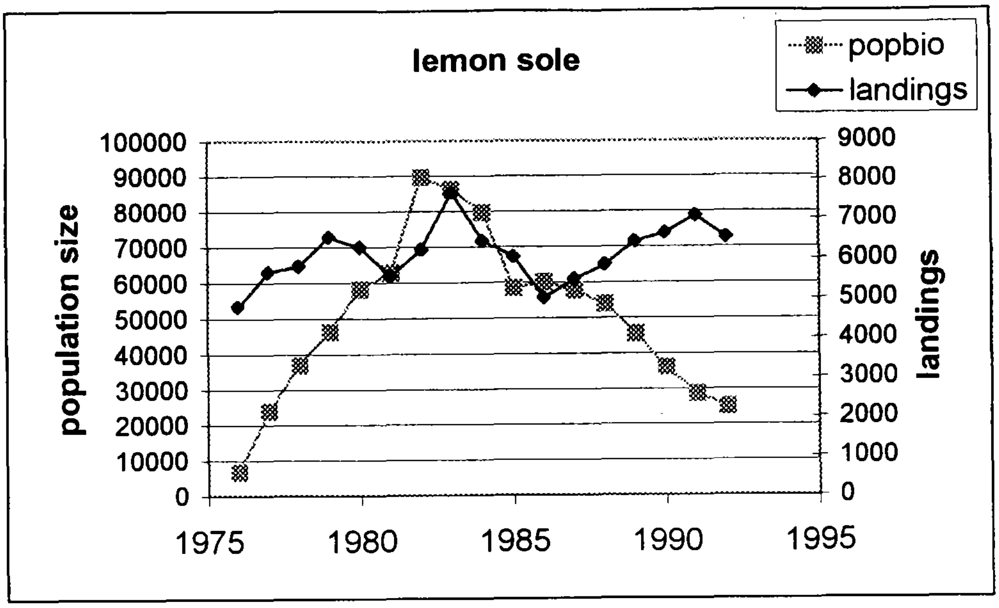


Figure 4.1.1.10

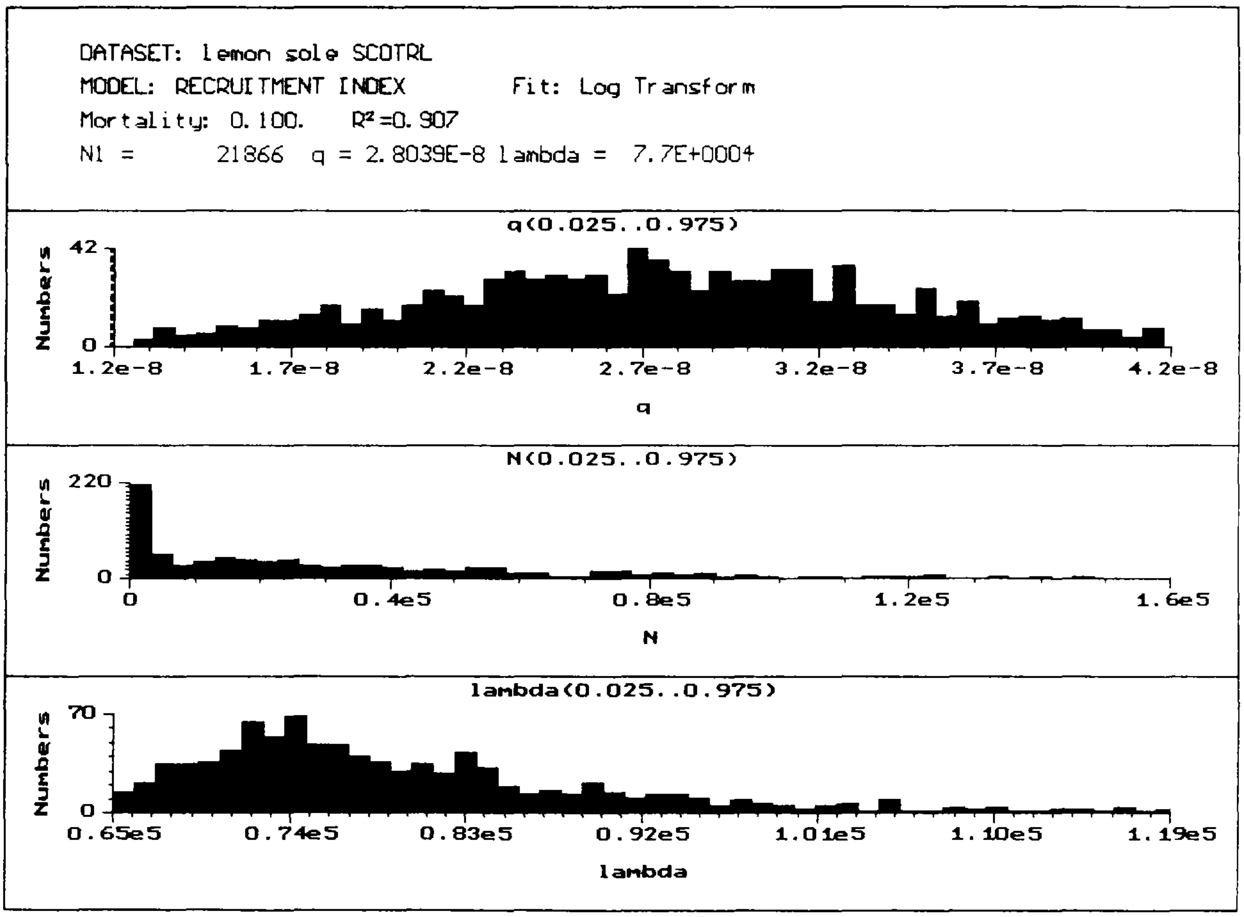


Figure 4.1.1.11

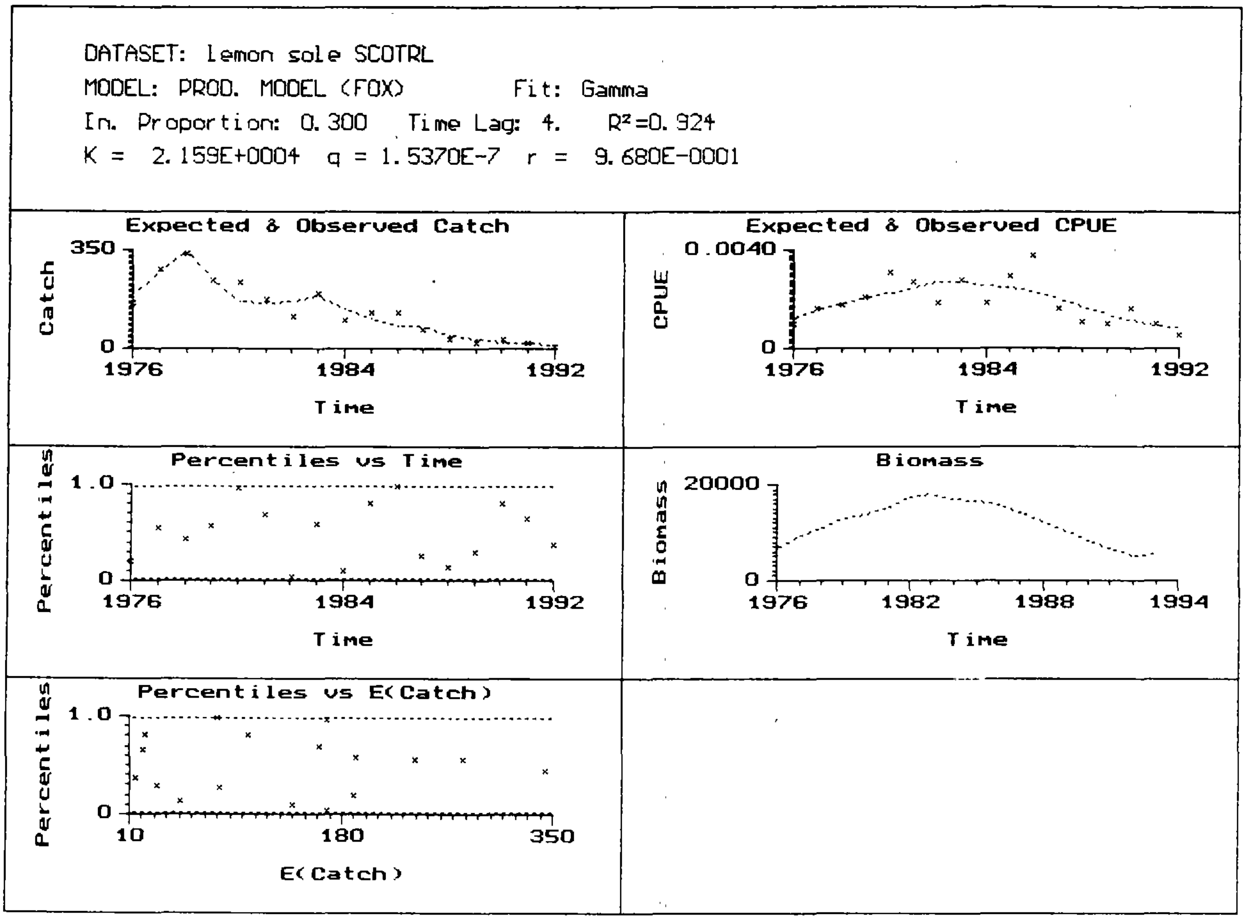


Figure 4.1.1.12

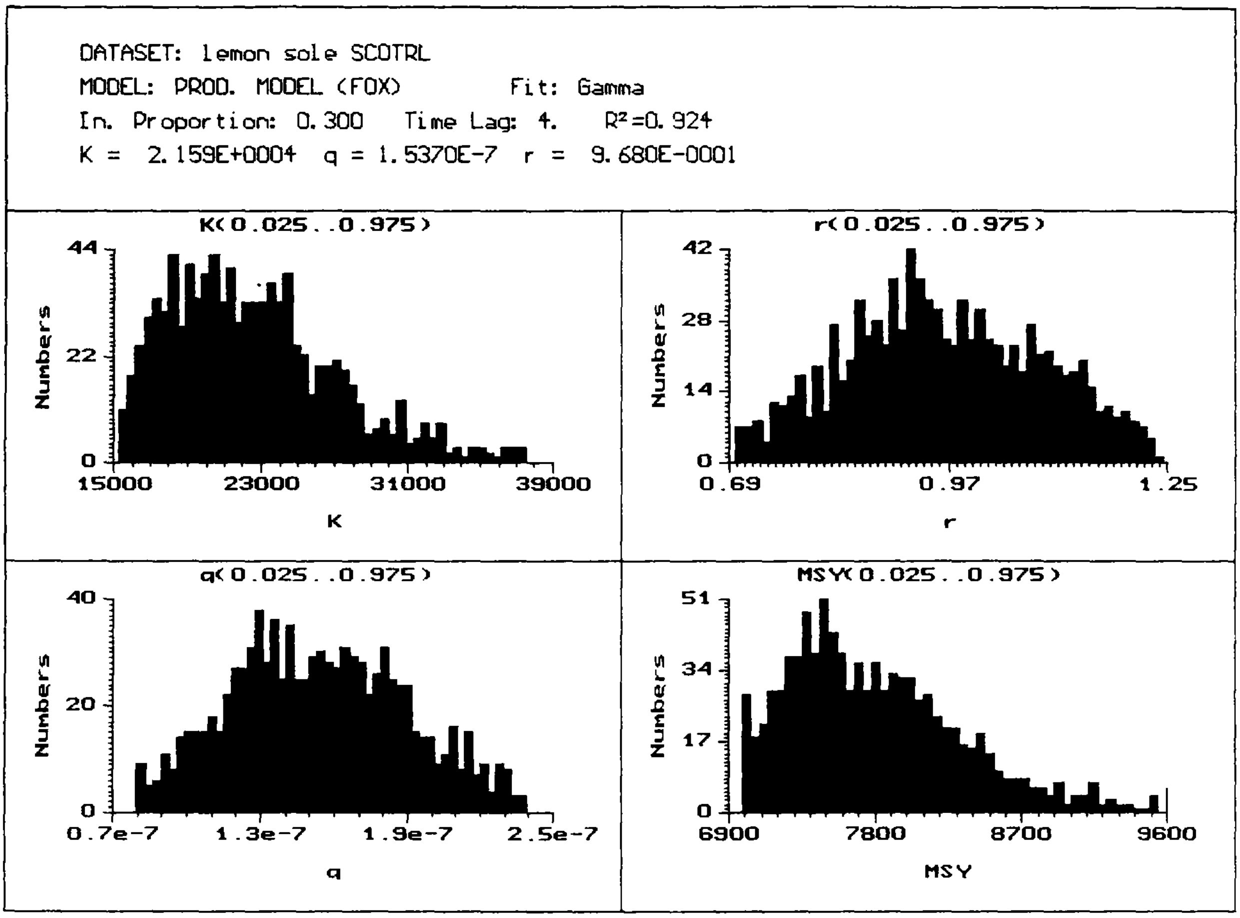


Figure 4.1.1.13 Estimates of lemon sole fishing mortality (catch/biomass) for the North Sea, from Fox models fitted with either heavy trawl or nephrops trawl data.

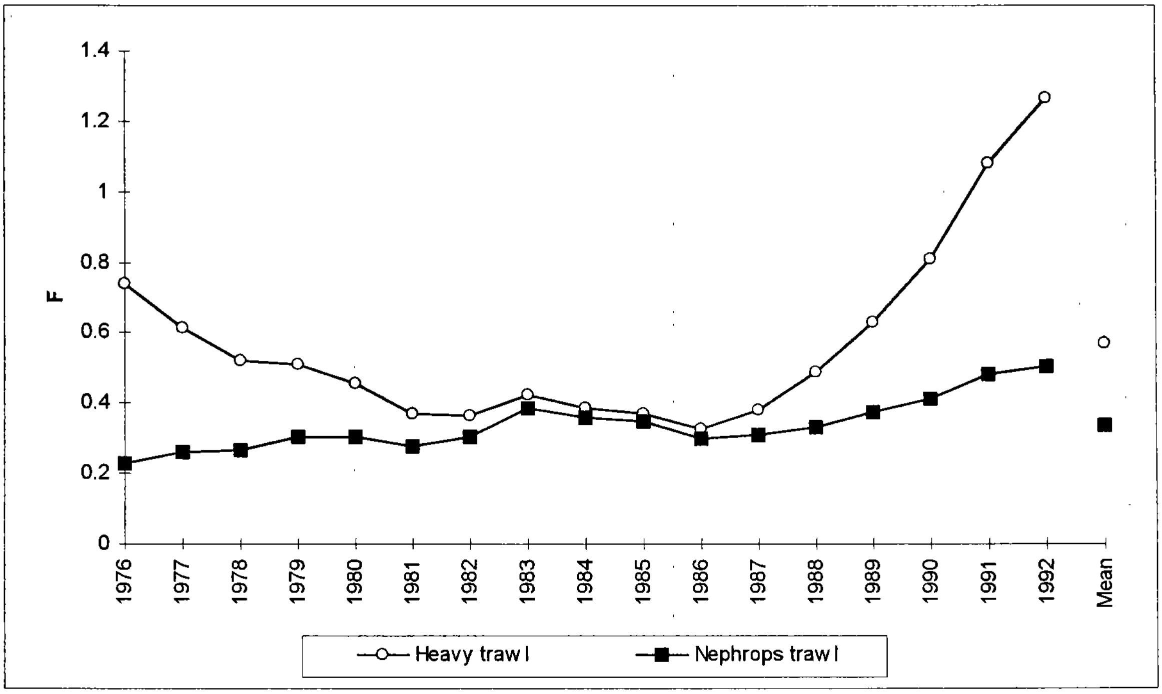


Figure 4.1.2.1

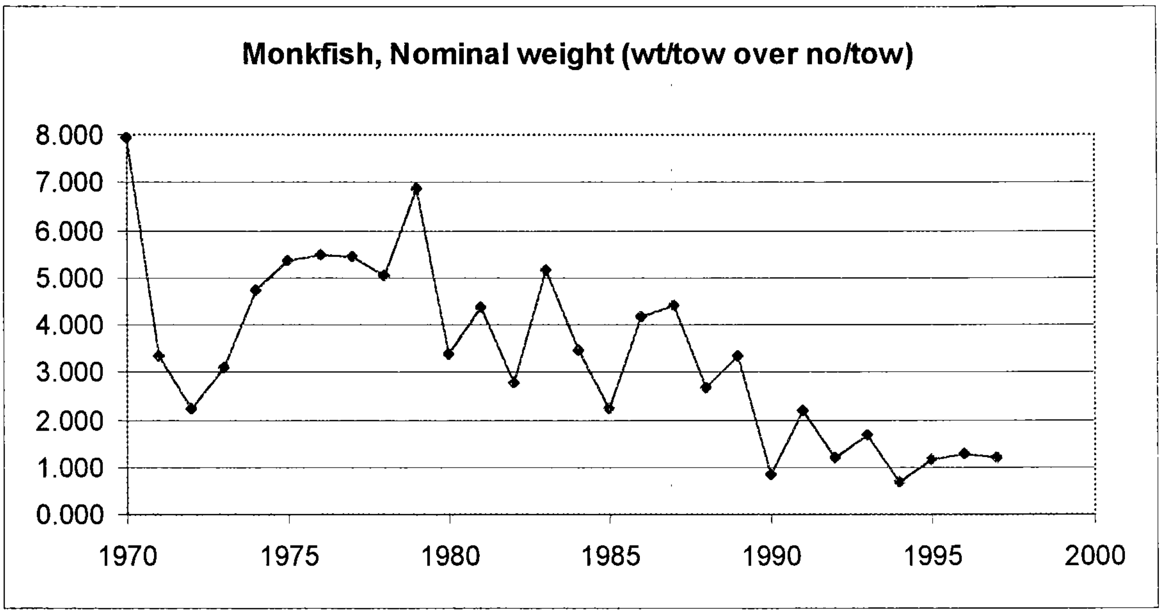


Figure 4.1.2.2

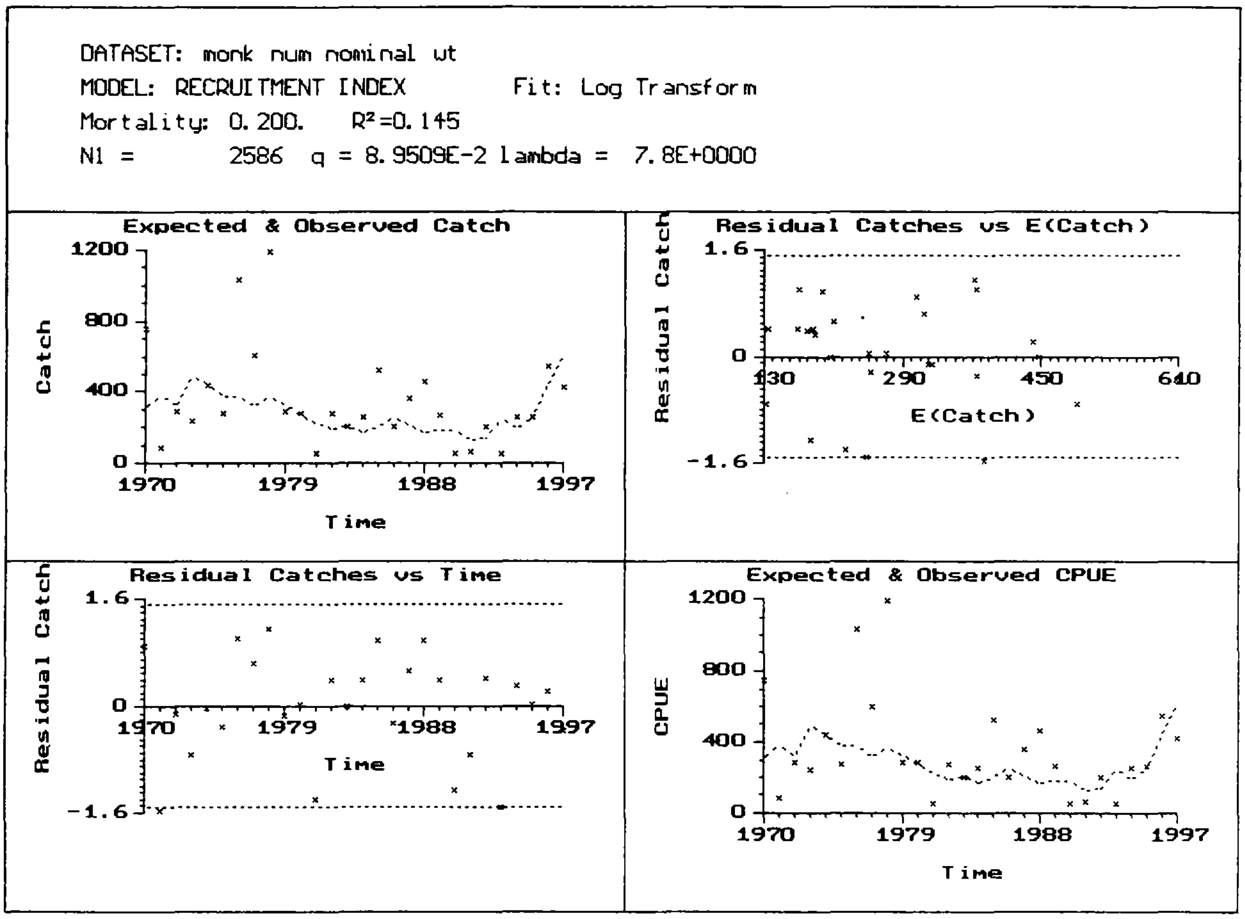
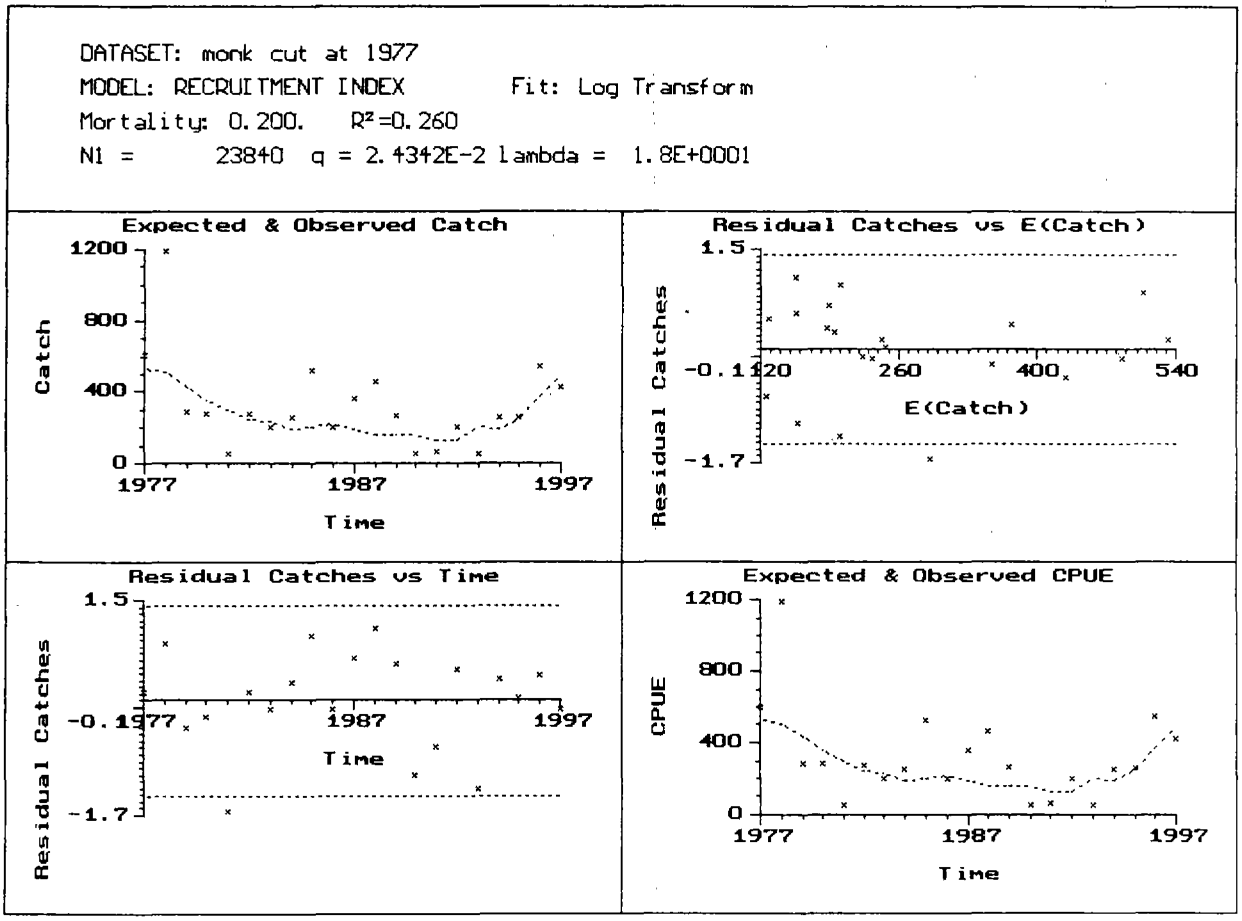

DATASET: monk num nominal wt
MODEL: RECRUITMENT INDEX
Fit: Log Transform
Mortality: 0.200.
R²=0.145
N1 = 2586
q = 8.9509E-2
lambda = 7.8E+0000
Expected & Observed Catch
Catch
1200
800
400
0
1970
1979
1988
1997
Time
Residual Catches vs E(Catch)
Residual Catch
1.6
0
-1.6
130
290
450
610
E(Catch)
Residual Catches vs Time
Residual Catch
1.6
0
-1.6
1970
1979
1988
1997
Time
Expected & Observed CPUE
CPUE
1200
800
400
0
1970
1979
1988
1997
Time

Figure 4.1.2.3



 O:\Acfm\Wgreps\Sgasso\Reports\1999\Rep.Doc

Figure 4.1.2.4

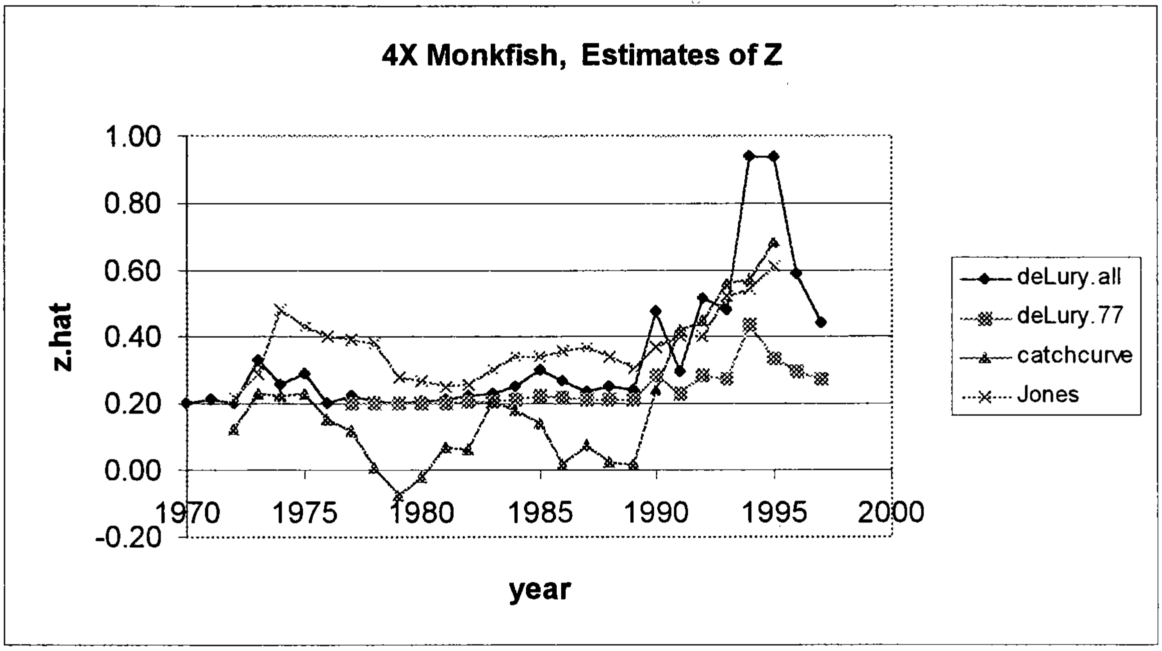


Figure 4.1.2.5

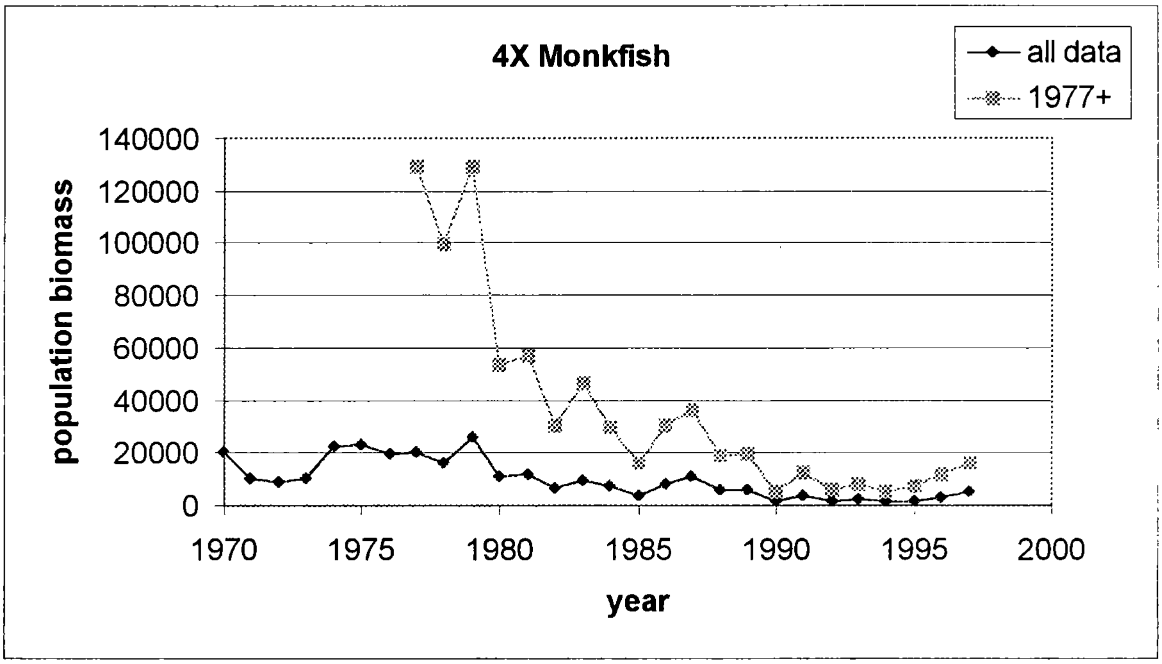
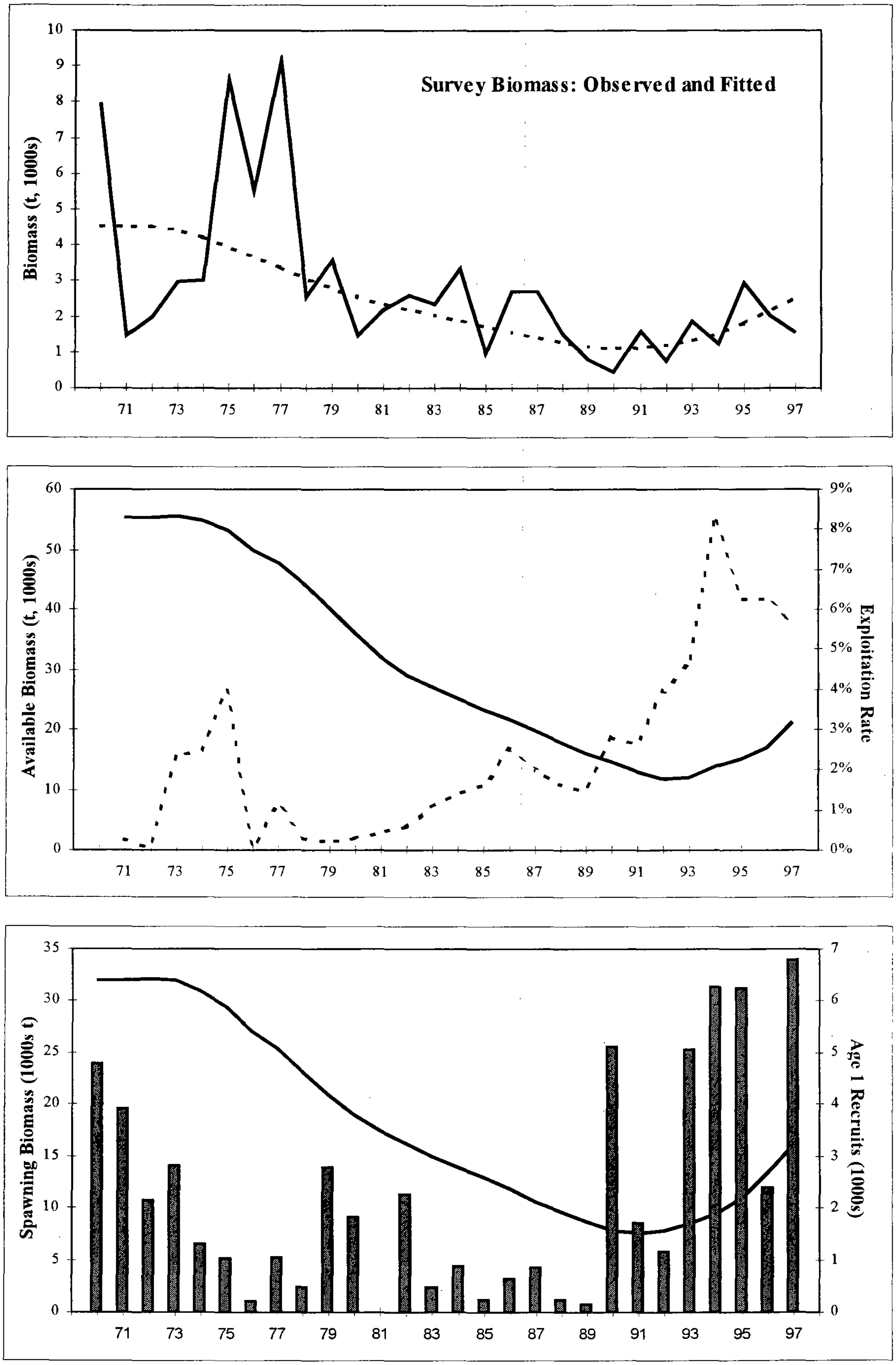


Figure 4.1.2.6



Survey Biomass: Observed and Fitted
Biomass (t, 1000s)
0
1
2
3
4
5
6
7
8
9
10
71
73
75
77
79
81
83
85
87
89
91
93
95
97
Available Biomass (t, 1000s)
0
10
20
30
40
50
60
0%
1%
2%
3%
4%
5%
6%
7%
8%
9%
Exploitation Rate
Spawning Biomass (1000s t)
0
5
10
15
20
25
30
35
Age 1 Recruits (1000s)
0
1
2
3
4
5
6
7

Figure 4.1.3.1

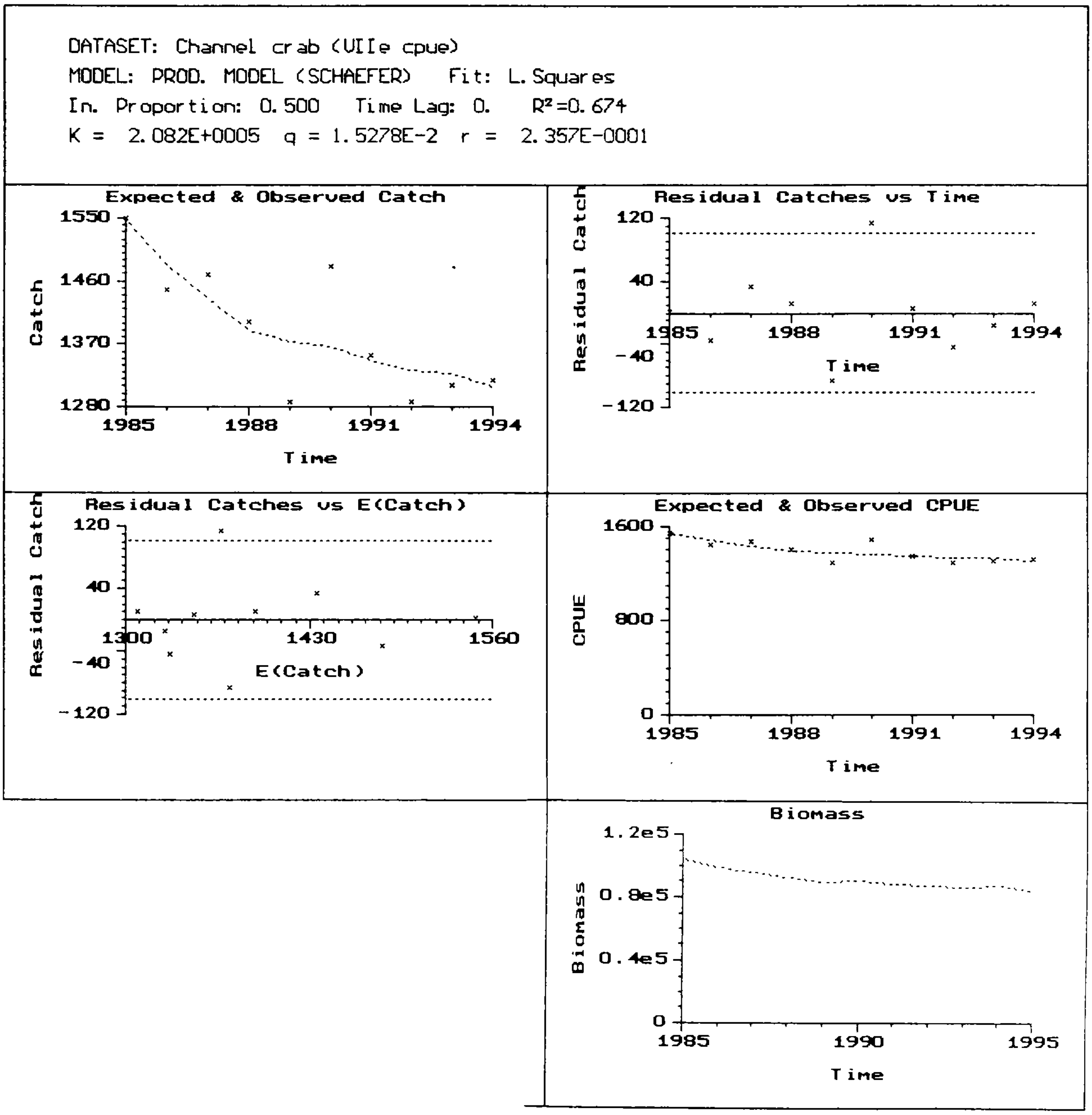
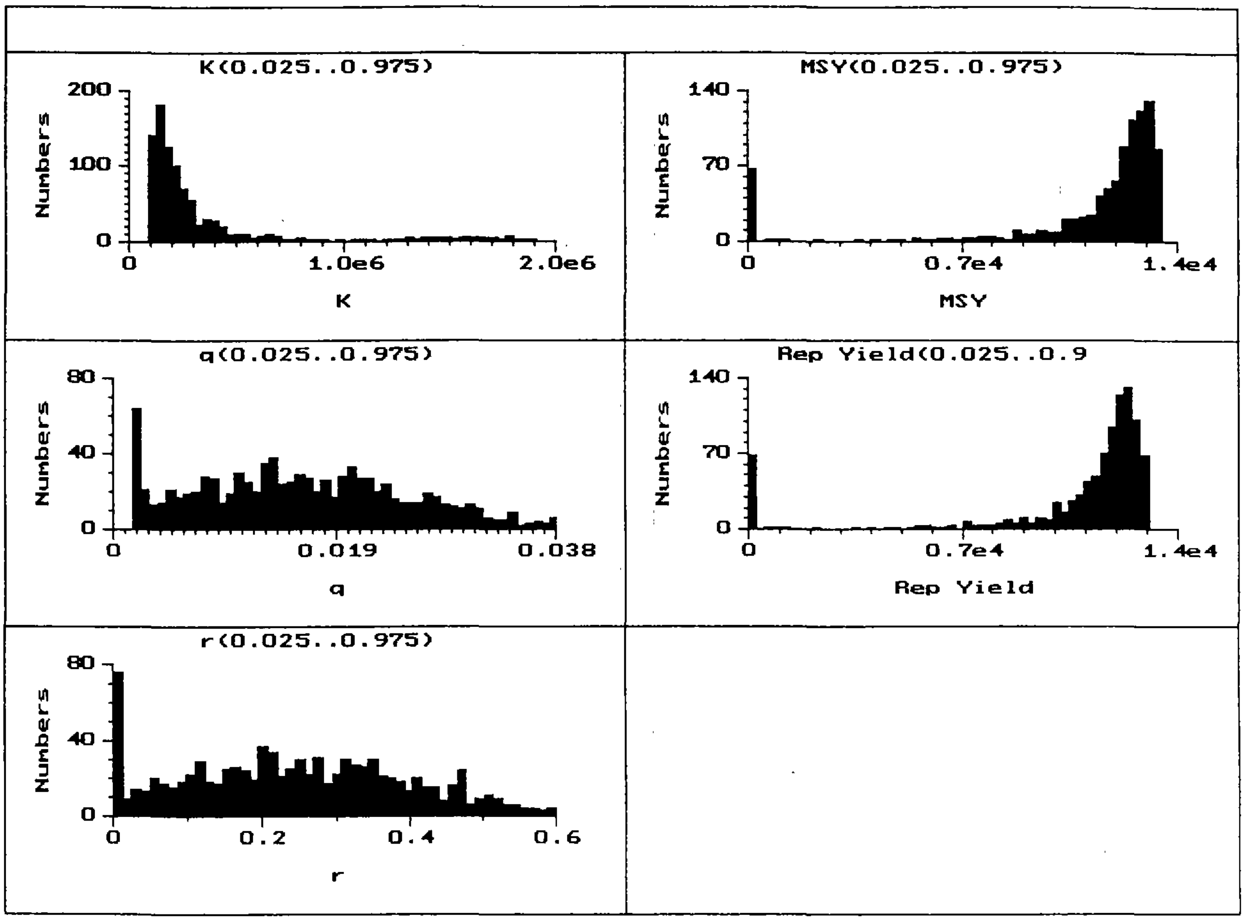

DATASET: Channel crab (VIIe cpue)
MODEL: PROD. MODEL (SCHAEFER) Fit: L.Squares
In. Proportion: 0.500 Time Lag: 0. R²=0.674
K = 2.082E+0005 q = 1.5278E-2 r = 2.357E-0001
Expected & Observed Catch
Catch
1550
1460
1370
1280
1985
1988
1991
1994
Time
Residual Catches vs Time
Residual Catch
120
40
-40
-120
1985
1988
1991
1994
Time
Residual Catches vs E(Catch)
Residual Catch
120
40
-40
-120
1300
1430
1560
E(Catch)
Expected & Observed CPUE
CPUE
1600
800
0
1985
1988
1991
1994
Time
Biomass
Biomass
1.2e5
0.8e5
0.4e5
0
1985
1990
1995
Time

Figure 4.1.3.2



K(0.025..0.975)
200
100
0
Numbers
0
1.0e6
2.0e6
K
MSY(0.025..0.975)
140
70
0
Numbers
0
0.7e4
1.4e4
MSY
q(0.025..0.975)
80
40
0
Numbers
0
0.019
0.038
q
Rep Yield(0.025..0.9
140
70
0
Numbers
0
0.7e4
1.4e4
Rep Yield
r(0.025..0.975)
80
40
0
Numbers
0
0.2
0.4
0.6
r

Figure 4.3.1.1

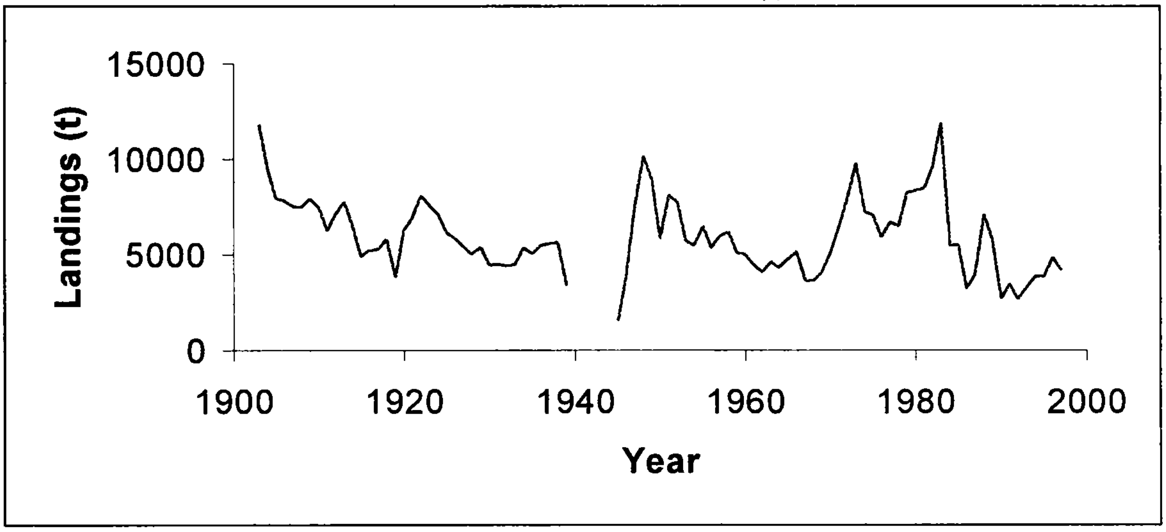


Figure 4.3.1.2

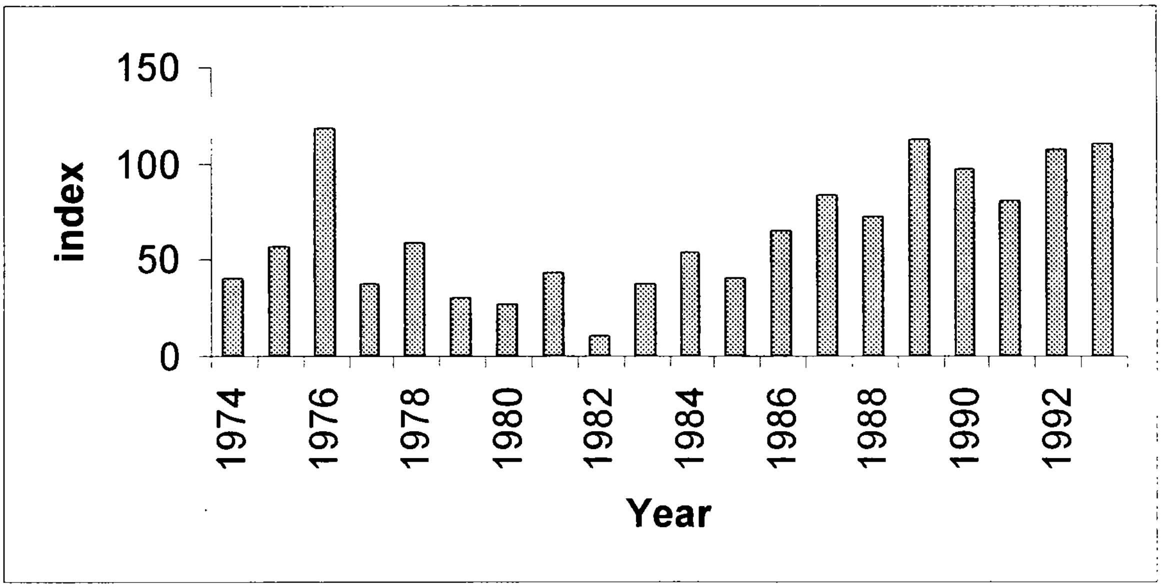


Figure 4.3.2.1

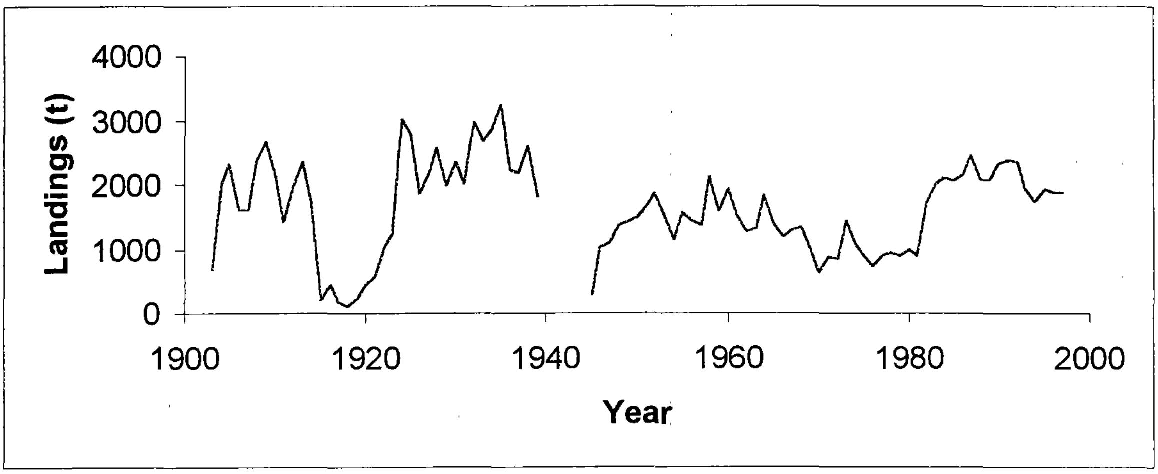


Figure 4.3.2.2

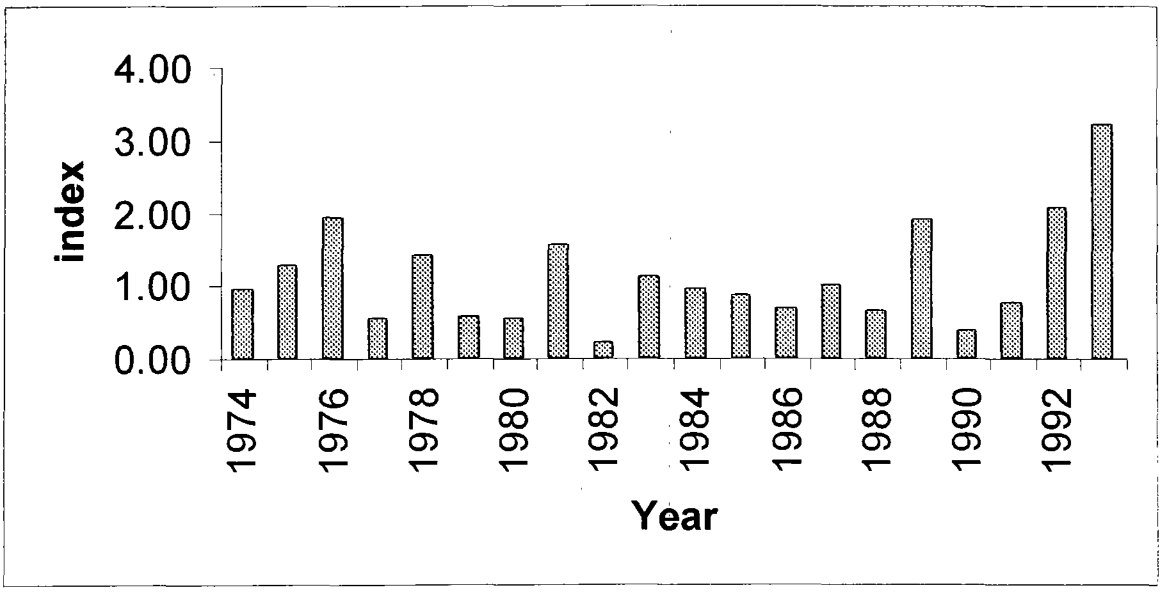


Figure 4.3.3.1

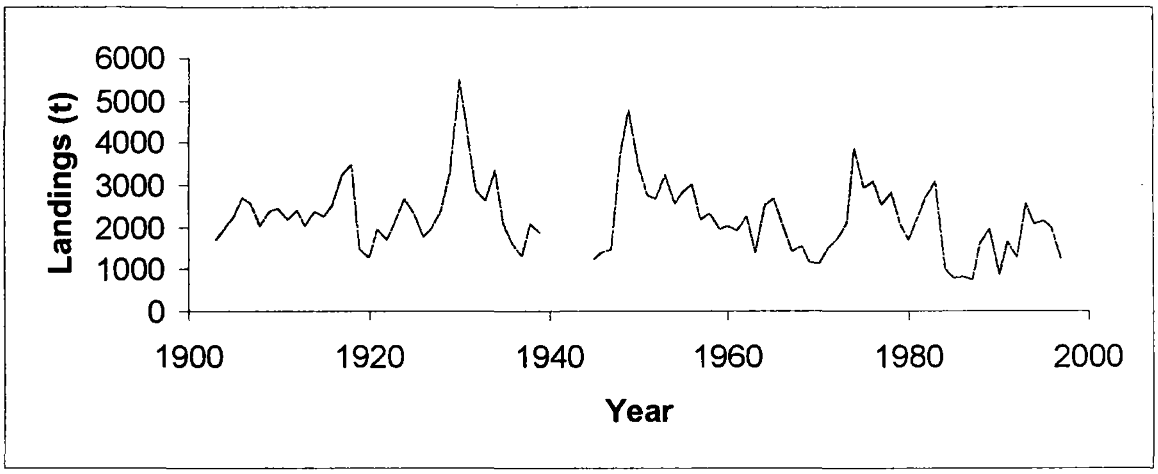
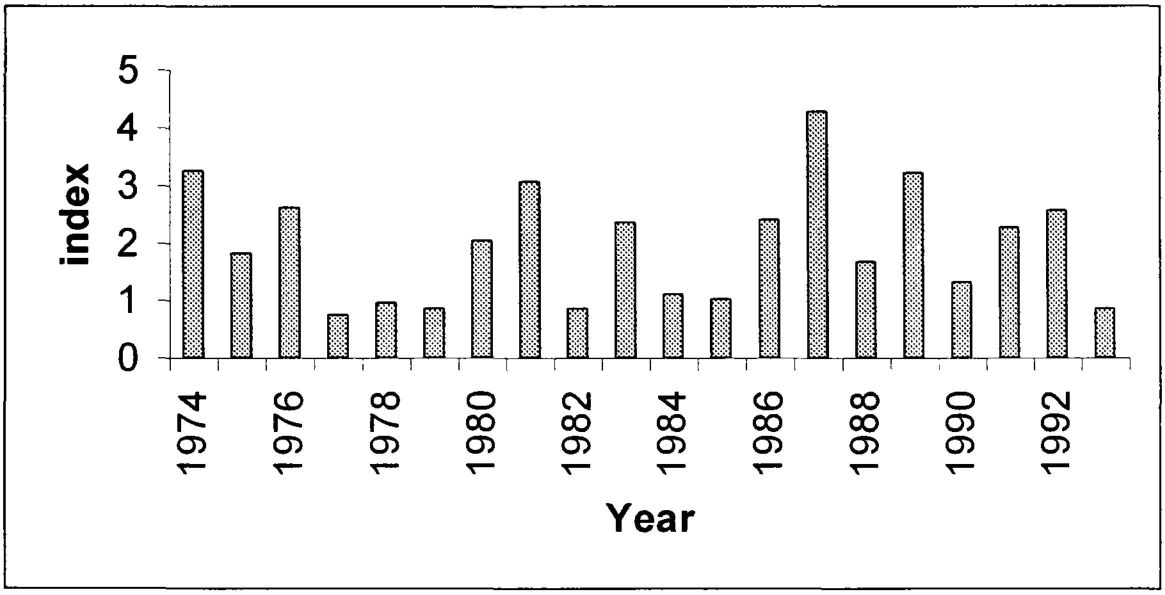


Figure 4.3.3.2



Appendix 1

E-mail addresses of participants:

Name	Address	E-mail
J. Addison (Julian)	CEFAS, Lowestoft	j.t.addison@cefas.co.uk
M. Basson (Marinelle)	CEFAS, Lowestoft	m.basson@cefas.co.uk
D. Beanlands (Diane)	DFO, Canada	beanlandsd@mar.dfo-mpo.gc.ca
R. Cook (Robin)	FRS Marine Lab, Aberdeen	cookrm @marlab.ac.uk
M. Dunn (Mathew)	CEMARE, Portsmouth U.	m.r.dunn@cefas.co.uk
P. Large (Philip)	CEFAS, Lowestoft	p.a.large@cefas.co.uk
R. Mohn (Bob)	DFO, Canada	mohnr@mar.dfo-mpo.gc.ca
Y. Morizur (Yvon)	Ifremer, Brest	yvon.morizur@ifremer.fr
S. Reeves (Stuart)	FRS Marine Lab, Aberdeen	s.reeves@ marlab.ac.uk
D. Sampson (David)	Oregon State Univ.	David.Sampson@hmsc.orst.edu

Appendix 2

SGASSO Stock Summary Sheet

Stock ID: Rogue Wolf Eel

Status: Underexploited

Data:

Fishery: 12 years C and E
Research: 3 surveys 1996–98
Other: M and K from independent studies

Abundance:

Method	Measure	Estimate	CV	Prior	Comment
best					

Exploitation

Method	Measure	Estimate	CV	Prior	Comment
best					

Target

Method	Measure	Estimate	CV	Prior	Comment