Advisory Committee on Fishery Management

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PART 1

REPORT OF THE WORKING GROUP ON *NEPHROPS* STOCKS

Lowestoft, 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. TERMS OF REFERENCE

The Working Group on *Nephrops* Stocks met in Lowestoft, UK(England) from 2 to 9 March 1995 to act upon ICES Council Resolution 1994 2:6:18 which states that the Terms of Reference are to:

a) review and update available fishery, sampling, and biological data for *Nephrops* assessments, reporting in particular on any improvements in effort indices;

b) continue methodological development in *Nephrops* assessment taking note of progress made by the Study Group on Life Histories and Assessment Methods of *Nephrops* Stocks;

c) assess the status of those stocks of *Nephrops* in the ICES area where new methodology or new data justify a new assessment, revising catch options only where necessary;

d) evaluate the possibility of giving longer-term advice for *Nephrops* stocks and consider the effect on assessments and catch options of working at the different levels of the functional unit, management area and the current TAC zones.

e) in the light of recent studies on mesh selection in *Nephrops* trawls, update mesh assessments where appropriate.

2. PARTICIPANTS

The following scientists attended the meeting of the Working Group

M. Afonso Dias	UK, Scotland
N. Bailey	UK, Scotland
D. Bennett (Chairman)	UK, England
R. Briggs	UK, Northern Ireland
C. Brown	UK, England
A-M. Caramelo	Portugal
C. Chapman	UK, Scotland
C. Farina	Spain
P. Hillis	Ireland
A. Lawler	UK, England
P. Marchal	UK, England
F. Redant	Belgium
C. Talidec	France
S. Tveite	Norway
M. Ulmestrand	Sweden

3. INPUT DATA AND BIOLOGICAL PARAMETERS USED IN THE *NEPHROPS* ASSESSMENTS

3.1. Introduction

In recent years we have seen a gradual improvement in the coverage and reliability of *Nephrops* data collection in several countries. There are still some long lasting unresolved difficulties, even with the collection of landing statistics. With the advent of TAC management, and pressure from increasing fishing effort by fin-fish vessels switching to *Nephrops*, there are indications that the quality of landing statistics is now beginning to fall.

Substantial unrecorded landings are believed to have occurred during 1994. Revised landings figures, corrected for non-reported landings, were presented last year for one Functional Unit (FU 5). These resulted in pushing the landings figures up by some 20 % throughout the data series. It is recognised that non-reported landings may exist in several other Functional Units. Estimates of these unrecorded landings were unavailable in most cases, and so could not be incorporated into the assessments. The Working Group will monitor the situation carefully and consider the consequences at its next meeting.

The sampling of length distributions of landings, and particularly discards, had been improving. However, it is now clear that in many countries the resources available for *Nephrops* sampling are being reduced as public expenditure is being restricted. This action will degrade the quality of the inputs to the assessments and compromise the standing of the management advice offered by ACFM.

The Working Group was specifically asked in Term of Reference (a) to "review and update available fishery, sampling, and biological data for *Nephrops* assessments, reporting in particular on any improvements in effort indices". A sub-group of the Working Group addressed the issue of improvements to effort indices and reports in Section 3.2.1.

3.2. Fishery Data

Updated information on landings was provided by the participants for Units 3-31. Units 1 (Iceland) and 2 (Faroes) were not represented this year, but an update to landings was received from the Faroes. Landings for a number of stocks were slightly revised, to eliminate former errors in the data series, due to allocation problems.

Again the Working Group expressed its hope that all countries will continue to attempt collecting representative landing statistics. In some cases the landings are

not recorded by statistical rectangle, and this creates difficulties in defining Functional Units, and in allocating landings and effort to them. It should be clear that the use of incomplete landing statistics may have a bearing on the reliability of the analytical assessments. The apparent increase in under-reporting is of particular concern.

Effort data were updated for most stocks. For some the effort data series was revised, mainly as a result of improvements in the techniques to collect and/or calculate effort data. Where available, the effort for the last 10 years is given on both a quarterly and an annual basis, as agreed at last year's meeting of the Study Group (Anon., 1994a).

3.2.1. Scope for improving fishing effort data

A sub-group from the Working Group conducted a full discussion of the main issues. The general conclusion was that little progress had been made since the 1993 Working Group (Anon., 1993), where this topic was last dealt with in detail. Problems remain in apportioning effort in mixed fisheries, identifying target species, recording changes in gear efficiency and fishing power, formulating models relating gear/vessel parameters to effort and applying appropriate corrections.

Working Group members also felt that monitoring systems for collecting effort, gear and vessel data were deteriorating in many countries. Insufficient resources were being allocated to the task. It was perceived that monitoring and enforcement agencies were concentrating their resources on monitoring the landings, to meet the requirements of TAC management. It was noted that because of mis-reporting and under-reporting, even landings data were becoming unreliable. This also meant that the criteria used to identify *Nephrops* trawlers in some countries (see below) would fail and effort would not be correctly recorded. Even where effort monitoring was attempted, fisheries scientists were seldom consulted about changes in the recording system. There was a clear need, for example, for scientists using fishing effort data to have a say in the design of logbooks.

In the future, it was anticipated that more emphasis would be placed on management by direct effort control and this should lead to significant improvements in the recording of fishing effort and associated parameters. It would be necessary, for example, to acquire data on the relative catching power of different fleets and fishing units. Some studies along these lines were currently being undertaken in the UK with EU funding. This work involved a survey of all UK vessels fishing in ICES Division IVb, from which data on gear parameters, vessel size and power were used to classify 16 different fleets, including *Nephrops* trawlers. On the basis of this survey, one vessel was selected as being representative of each fleet and the fishing activities of these vessels are now being investigated in detail during extensive sea trials.

The criteria used by different countries to identify *Nephrops* 'directed' fishing effort varied widely. In Scotland, '*Nephrops* trawlers' were identified on a daily basis as those vessels for which *Nephrops* formed >50% of the value of the total catch. In England and Belgium, the criterion was >25% by weight. In Belgium, this threshold could lead to both otter and beam trawl data being grouped. In Spain, vessel classification was based on the *Nephrops*/hake ratio by value over the whole year and in, Portugal, classification was based around the possession of a crustacean fishing licence. The group felt there was scope for standardisation, at least between countries fishing the same stocks. It would then be possible to compare the effort and CPUE trends by different fleet units. It was suggested that real progress in monitoring fishing effort could be achieved if the position of vessels and their towing activities were tracked by remote sensing techniques. This could provide an objective means of measuring effort on particular *Nephrops* grounds, since their boundaries were generally well known with reasonable accuracy. It was encouraging that pilot schemes of this type were currently being evaluated in Belgium and Portugal.

Attempts to correct effort data were being undertaken in some FUs. Where multi-rig trawls were in use, their effort was now being recorded separately from single trawls in Sweden, Denmark and the UK, and data for the two types of gear are provided appropriately in the Report (e.g. Figure 5.2.1 ; Table 5.3.3). In Sweden, a linear relationship between twin (TT) and single trawl (ST) LPUE was derived ($TT = 1.684 * ST + 0.0946$) which is used to correct the LPUE data series. A potential problem in some FUs was that a range of mesh sizes were now used in *Nephrops* trawls. This was a particular problem in the UK, where the ban on use of multi-rig gear with 70mm mesh nets (except at Fladen) had led to 70 - 100mm meshes being used. Information on mesh size used by different vessels was not routinely recorded, making mesh assessments difficult (Section 6).

In most countries, information on fishing vessel size, tonnage (GRT) and power (HP) was recorded, though it was not always routinely accessible. Corrections for HP and/or GRT were, or could be, applied to LPUE data in some FUs (6, 11, 15, 16, 25, 31). In applying these corrections, a linear relationship between vessel power and effective fishing effort was assumed, though this was probably an over-simplification. More research on this topic was needed.

3.3. Length Composition Sampling

A summary table is provided for each Functional Unit, with details of the sampling levels for catches, landings and discards by quarter for the last year, and annually for the last 10 years.

For most stocks, sampling levels are assumed to be sufficiently high, with respect to both sampling frequency and sample size, to produce reliable annual length frequency distributions of the removals. For

many stocks, however, there is little statistical evidence that the reliability requirements are actually being achieved. The use of quarterly or even monthly CPUEs or LPUEs by sex to evaluate the state of exploitation (Anon., 1994a) make the quality requirements even tighter. There is still a need to carefully re-evaluate the ongoing sampling programmes, and to improve them where needed. Unfortunately cutbacks in resources seem to be degrading the length sampling programme at a time when, with increasing fishing pressure in many *Nephrops* fisheries, there is a need to improve the quality of the assessments.

3.4. Biological Input Parameters

It was noted by the ACFM reviewer that in the 1994 Working Group Report there were some inconsistencies between stocks in values adopted for those parameters which are poorly estimated. Inconsistencies in assumptions about natural mortality were discussed and it was found that the necessary changes had already been made, but Table 3.4.1 had not been updated - it has now.

Discussions of discard mortality rates were more involved. Previously most assessments included a value of 25% discard survival (based on limited survival experiments and assumptions about the proportions discarded on grounds inappropriate for *Nephrops*). Recent observations from the Farn Deeps (Evans *et al*, 1994) suggest that, in some areas at least, rather lower discard survival rates may pertain and it was suggested that a value of 10% survival might be more suitable. It was also pointed out that a 'conservative' approach could be adopted where zero discard survival was assumed. It was decided for the present to continue with the assumption of 25% survival, but for the Farn Deeps some additional assessments were made using lower values (see Section 5.6.1).

4. METHODS EMPLOYED IN THE ASSESSMENT OF *NEPHROPS*

Assessment methods employed by the *Nephrops* Working Group in recent years were reviewed and discussed by Sub-Groups. Shortfalls in some approaches were identified and new developments facilitating the assessment process were highlighted and implemented. The following review summarises the main discussion of the Sub-Groups and subsequent plenary sessions, and deals first with the most basic approaches moving on to methods of increasing complexity

4.1. Landings, effort, and mean size data

4.1.1. Examination of trends

Examination of trends in fisheries data remains an important element of *Nephrops* assessments, especially for stocks with few biological or sampling data. For a number of stocks, available information now extends over many years providing good historical perspective. It was suggested that in these circumstances more attention should be paid to the broad, overall trends rather than to small fluctuations (noise) in the most recent years.

Long-term trend plots have been routinely provided for landings, effort and LPUE data. This year mean size plots have been added to provide a combination figure summarising long-term trends. In some cases, however, the landings series provided relates to the effort and LPUE data series for vessels specifically targeting *Nephrops*. This subset of the overall landings varies in significance depending on the fishery in question. It would be helpful if ACFM could make clear whether a long-term plot of total international landings is also required.

4.1.2. Landings versus effort plots

Plots of landings versus effort were introduced (Anon., 1991) as a predictive tool which might provide guidance on appropriate landings for a given target effort level. For numerous stocks the relationship appeared to be linear and the correlation was good. At recent meetings, however, advice on catch options has remained unchanged when there has been little apparent change in the state of the stock. Consequently, recent plots of landings versus effort have not been used. It was decided to leave these figures out of the present and future reports unless there was a specific requirement.

For some stocks evidence had previously been presented to suggest a more 'dome shaped ' relationship between landings and effort. There has been discussion (Anon., 1994a and 1994b) of the use of surplus production models to predict optimum catch levels, although the general problem has been highlighted of assumptions about equilibrium in the fitting of such models by early methods. An attempt (Shanks *et al*, 1994) was made to use non-equilibrium methods on numerous Scottish stocks but, with the exception of the Firth of Forth, results were disappointing. The Skagerrak/Kattegat stock shows evidence of 'depletion', and similar methods may well prove successful when applied to this area. There was, unfortunately, insufficient time for this to be carried out.

4.1.3. Improving the estimates of CPUEs, LPUEs, and mean sizes

The CPUEs and LPUEs currently used by the Working Group are based on data collected during sea sampling programmes and official landings statistics, pooled over the full range of size classes in the catches or market categories in the landings. Similarly, the mean sizes of male and female *Nephrops* in catches and landings are calculated over the full range of size classes in the length frequency distributions of catch, discard and market samples.

Estimates of CPUE and mean sizes in the catches are sensitive to a number of factors, such as recruitment variability and year-to-year changes in the emergence of *Nephrops* or in the relative numbers of egg-bearing females, which strictly speaking may not be driven by exploitation. In addition, the estimates of the LPUEs and the mean sizes in the landings are sensitive to changes in discarding practice. Over the years, trends in CPUEs, LPUEs and mean sizes have been used by the Working Group as indicators of the state of exploitation of the *Nephrops* stocks, but quite often the interpretation of these trends was hampered by the variability caused by these factors.

In an attempt to reduce the background noise in the data, an alternative method of calculating the CPUEs, LPUEs and mean sizes was explored, using the data for the Botney Gut - Silver Pit as an example. The main aim of this alternative approach was to eliminate those size classes from the calculations which are most sensitive to variations in recruitment and/or discarding, and to retain only those which are likely to be most sensitive to changes in fishing pressure. In the exercise with the Botney Gut - Silver Pit data, the "truncation length" was set at 35 mm CL, which was found to be the critical size above which (a) almost no discarding is taking place, even when the catch rates are highest and the discarding rates most liberal (Redant and Polet, 1994), and (b) all females have reached sexual maturity (Redant, 1994).

CPUEs and LPUEs

Three series of monthly LPUE data were compared to evaluate the "tapering" effect of truncation on the estimates of the LPUEs :

a) the LPUEs (kg/hour trawling) derived from the landing statistics for all market categories combined, i.e. whole *Nephrops* ("small" (mostly < 30 mm CL), "medium" (mostly 30-45 mm CL) and "large" (mostly > 40 mm CL)), and *Nephrops* tails

b) the LPUEs (kg/hour trawling), also derived from the landing statistics, but only for the market categories "medium" and "large" *Nephrops*

c) the LPUEs (either kg or nos./hour trawling) for all size classes > 35 mm CL, derived from the length frequency (LF) data collected during the routine market sampling programme (for details see Section 5.5.1).

As can be seen from Figures 4.1.1 and 4.1.2, the LPUEs derived from the LF-data correspond very well with the LPUEs for "medium" plus "large" *Nephrops*, which are hardly affected by variations in recruitment or discarding practice. The LPUEs for all market categories combined, on the other hand, show much more background noise, and this can only be explained by the seasonal and year-to-year variations in recruitment and/or discarding practice, which particularly affect the landings of the market categories "small" and "tails".

Mean sizes

In this exercise, two data sets were compared, separately for males and females, with the mean sizes in the landings from individual vessels being calculated (a) over the full range of sizes, and (b) for all males or females > 35 mm CL.

The data with all size classes combined show high levels of variability, particularly in the females (Figures 4.1.3 and 4.1.5). The mean sizes of the females display a marked seasonal pattern, with very low values in the first and sometimes the second quarter, and much higher values in the third and the fourth quarter. This pattern is clearly connected with the reproductive cycle of the females. During summer and early autumn (i.e. between hatching and spawning) most females emerge from the burrows, and all female size classes are more or less equally available to trawling. During winter and early spring, however, most of the larger females are egg-bearing and hiding in their burrows, so that only the smallest females are available to trawling.

Compared with the mean sizes calculated over the full range of size classes, those for *Nephrops* > 35 mm CL show much lower variability, particularly since 1993 when the sample size was increased from 100 to 200 *Nephrops* per market category (Figures 4.1.4 and 4.1.6). The exclusion of the smallest size classes from the calculations resulted in an overall "compression" of the means within a much narrower range. In this particular exercise the "tapering" effect on the mean sizes of the males was relatively small (Figures 4.1.3 and 4.1.4), but in fisheries where the discarding practices vary widely from one vessel to another (as seems to be the case in e.g. the Farn Deeps), it could be expected to be more important.

Over all, the modified method to calculate the mean sizes of *Nephrops* in the landings yielded much less scattered data sets, with much lower coefficients of variation (0.027 and 0.023 for males and females respectively, as opposed to

0.038 and 0.068 for the means across the full size range). This clearly is an advantage, particularly since the long-term changes in mean size upon changes in fishing effort, as predicted by the LCA (see Figure 4.1.7 for an example), are relatively small at around 2 mm CL for increases or decreases in fishing effort of up to 50 %.

Conclusion

The exercise with the Botney Gut - Silver Pit data clearly shows that LPUEs and mean sizes derived from LF-data "truncated" at a critical length above which (a) discarding is insignificant and (b) all females are sexually mature, become almost insensitive to variations in recruitment, egg-bearing condition and discarding practice. The obvious conclusion being that they are much more reliable as indicators of the state of exploitation of the fully recruited size classes than the CPUEs, LPUEs or mean sizes calculated across all size classes (or market categories) in the catches or landings.

The Working Group thus identified two possible approaches for improving the interpretation of CPUE/LPUE and size composition information, (a) the estimation of catch rates by length class for the larger sizes in the distribution, and (b) the calculation of mean size for a size range above that affected by either discarding or recruitment. Presentation of such improved indices will be considered for a subsequent meeting.

4.2. Analytical assessments

4.2.1. Length-based assessments

The LBA3 program, which uses Jones' method to carry out length-based 'cohort analysis' (LCA) and to make predictions of the effects of exploitation pattern and effort changes, was briefly reviewed. There were no changes in the coding or new developments to this program which essentially provides assessments of the yield per recruit (Y/R) type.

Although ACFM do not require repeat assessments every year, there now appears to be a requirement to include, where available, a Y/R curve in the ACFM report for each stock. It was decided to carry out new assessments when there had been some change in the state of exploitation, a change in parameter values, or a revision of the length composition data. For stocks exhibiting no such changes a Y/R curve generated during an earlier meeting would be included. In all cases, the period covered by the assessment should have a stable effort and exploitation pattern.

There was a question raised about the suitability of the range of length classes included in the calculation of the summary Fbar value of the LCA. Previously, the lower 75% of the length range was used to avoid potential problems of inclusion of F values on the largest sizes close to L infinity. In order to also avoid likely problems at the smallest sizes, brought about by partial recruitment and uncertainties about discard practice, it was decided to adopt a new approach. Fbar was calculated over the interquartile range or 'middle 50% ' of the length range. It was hoped that this might also facilitate comparison of these Fbar values with ones generated during pseudo age-based assessments.

The issue of combining Y/R curves between sexes (and/or combining curves between Functional Units within a Management Area) was again discussed. While there may be some merits in this type of presentation for predictive purposes in determining the overall effects of movement away from the *status quo* position, the Group felt that on balance there would be a loss of information. The principal concern lies with the fact that the two sexes appear in most FUs to have rather different states of exploitation. Separate Y/R curves offer a way of identifying these differences, and it was considered to be extremely important to distinguish the state of the most vulnerable component, the males.

4.2.2. Deconvolution

The continuing work comparing VPAs made with 'age' data generated from maximum-likelihood methods (e.g. MIX) with those using age data from crude 'slicing' are reported below (Section 4.2.3). There was some discussion of whether other slicing methods could be tried. Comments were made on some preliminary work from Portugal comparing the Kimura and Chikuni (1987) method with the present *ad hoc* slicing approach described last year (Anon., 1994b). With $t_0 = 0$ the resultant age structure was similar regardless of method (except for age 1). With t_0 adjusted to a realistic value (i.e. to deliver a length of 24 mm CL at age 1.5 years which fits existing growth data for Portuguese waters) separable VPA results were different between the two slicing methods, while a Laurec- Shepherd tuned VPA gave similar results between the two. There will be further work on this subject. Although not ideal, the present slicing method appears to be able to detect broad trends in stock parameters and is considered useful (Anon 1994a).

The Working Group decided to continue using the existing L2AGE slicing program for the present. This program was modified prior to the Working Group to produce output files in a format suitable for use in the Lowestoft VPA package (version 3.1) (see below).

4.2.3. Comparison of MIX deconvolution and L2AGE slicing using SEP VPA

This Working Group, and the *Nephrops* Study Group (Anon., 1994a) have been exploring the use of the MIX software (MacDonald and Pitcher, 1979) to separate the western Irish Sea (FU 15) monthly length-frequency distributions into age groups for input to the VPA. The Working Group felt it would be worthwhile to make a comparison between the simple L2AGE slicing approach (Anon., 1994b) and a MIX deconvolution, using both "age" compositions as inputs to the separable VPA in the Lowestoft VPA v 3.1 suite (Darby and Flatman, 1994) and examining differences in resulting F at age values.

The Northern Ireland and Republic of Ireland male length composition data for total removals from 1989-1994 were sliced into nominal ages using the L2AGE program, as done at the 1994 meeting (Anon., 1994b). Total removals (landings + 90% of discards) represent the total estimated *Nephrops* taken from the stock by the fishery, assuming a discard mortality of 90%. In addition, the male data for the Republic of Ireland, 1989-1994, were aged by the MIX normal curve-fitting program, and this age-composition was raised to the total FU15 international catch by applying the age-compositions to the Northern Irish data.

Some problems inherent in the growth pattern of *Nephrops* are to be expected with the normal curve-fitting method. During periods of moulting the standard deviation of length at age might be expected to rise, as postmoult individuals of one age would be indistinguishable by length from premoult individuals a year or more older, depending on the moult frequency. However, as annual moulting will hopefully only have an effect during a fairly limited part of the year, and those with biennial or triennial moulting will only affect a very small part of the population, these effects were not seen as insuperable obstacles to the effective operation of the method.

Irish data for 1993 and 1994 were analysed with an assumption of constant sigma (standard deviation) of mean length values, while those for earlier years had been analysed solely with the objective of minimising CHI squared. There was insufficient time to apply the same approach to all years. This resulted in the earlier data tending to have the dominance of the largest cohort exaggerated, leading to increased F values and a reduced number of identified age-groups. The constant sigma constraint (unlike any other constraints on sigma offered by the program) made the analyses easier and quicker to run, and resulted in unconstrained mean length values corresponding closely to observed modal values or at the points where intuition suggested they should be. Hence, while age-groups 1 to 4 were normally present and identifiable every month from the 1989 to 1991 data, for the 1993-1994 data series age-group 5 was also normally visible.

Table 4.2.1 shows the values of F at age obtained by each method, and Tables 4.2.2 and 4.2.3 give the separable F residual outputs. There were several notable differences between the results of the two methods. In general, F values with MIX were higher than for the slicing approach. This was especially true for age groups 1 and 2 for all years, while for the older ages there was a smaller difference, particularly in the later years. Residuals were generally higher with MIX, an effect partly due to the use of slightly different methods when applying MIX to the last two years' data. The estimation of higher F values with MIX was obvious, especially with the numerically important age group 2, though less so for the years 1993-94 when the assumption of constant standard deviation of mean length-at-age.

The MIX approach is sensitive to the constraints which may or may not be applied during deconvolution. Unfortunately there was insufficient time to standardise the approach taken for all years of the data series. There is some scope for further investigation of this technique.

4.2.4. VPA

For those stocks with adequate data, and where VPA had apparently performed reasonably well in the past, this method of assessment was continued. The principal difference in approach at this meeting was the use of the Lowestoft VPA (version 3.1) suite (Darby and Flatman, 1994) which included a number of features which have not previously been exploited in the assessment of *Nephrops*. The previous VPA package used is essentially similar to the *ad hoc* tuning module in the Lowestoft package and most earlier assessments were of the Laurec-Shepherd type. This year it was also possible to make use of a separable model, and Extended Survivors Analysis (XSA). In addition, more extensive diagnostic and statistical output was available to make improved judgements about the performance of the VPA.

The Working Group had a presentation of the approach used by the Lowestoft package from its authors (Darby and Flatman, 1994). This provided considerable help to those members of the Working Group who were not familiar with the package. It is hoped that the members will build on this experience at home, so that the package can be routinely used at subsequent Working Group meetings.

4.3. Judging the Status of a Stock

As before it was decided that most attention should be paid to the male component of the stock since in most

cases this was perceived as the most vulnerable component and since most assessments of females suggested that F was generally low and the stock was not over exploited.

The full range of information was taken into account in making a judgement. For stocks where the VPA appeared to perform well this was used to give some idea of trends in the stock. In other cases the shape of the LCA Y/R curve was considered and trends in fishery data (such as CPUE) were also examined. There was no attempt to use as a basis for the judgement the same pieces of information for all stocks; each one was dealt with on the merits of the assessments applied.

4.4. Catch Predictions

At the 1993 Working Group meeting (Anon., 1993), three methods were used to make predictions of suitable catch options. The choice used for each FU depended on the quality of the assessments and the effort data available. These were

a) a short-term forecast along finfish lines using average recruitment values from the converged part of the VPA.

b) landings vs. effort plots where the correlation was particularly good.

c) mean landings for a suitable reference period.

The Working Group has taken note of ACFM's suggestion that, if the advice on the state of stock had not changed (as a result of new data or changes in input parameter values), then there was no reason to 'update' the catch option by the addition of new data points to the series. In practice there were few stocks for which major changes occurred.

Table 3.4.1 Input parameters used in assessments of male and female Nephrops. For some Functional Units, growth and natural mortality parameters are given for immature females (above) and mature females (below).

		MALES						FEMALES					
MA	Functional Unit	Grp Int.	Dis Surv.	K	L	M	a	b	K	L	TL	M	a	b
A	Iceland(1)	2	-	0.11	80	0.2	0.00113	2.867						
B	Faroes(2)	Data not available												
C	N Minch (11)	2	0.25	0.16	70	0.3	0.00028	3.24	0.16	70	25	0.3	0.00084	2.91
									0.06	60		0.2		
	S Minch (12)	2	0.25	0.16	68	0.3	0.00028	3.24	0.16	68	26	0.3	0.00089	2.91
									0.06	59		0.2		
	F Clyde (13)	2	0.25	0.16	73	0.3	0.00028	3.24	0.16	73	27	0.3	0.000845	2.91
									0.06	62		0.2		
D	None													
E	Skag/Katt(3,4)	2	0.25	0.16	75	0.3	0.00045	3.11	0.1	65		0.2	0.0011	2.85
F	Moray Firth (9)	2	0.25	0.165	62	0.3	0.00028	3.24	0.165	62	23	0.3	0.00074	2.91
									0.06	56		0.2		
	Noup (10)	No data available												
G	Fladen (7)	2	0.25	0.16	66	0.3	0.0003	3.25	0.16	66	25	0.3	0.00074	2.91
									0.1	56		0.2		
H	Botney Gut (5)	2	0.25	0.165	62	0.3	0.0003	3.24	0.16	62	27	0.3	0.00135	2.82
									0.08	60		0.2		
I	Farn Deeps (6)	2	0.25	0.16	66	0.3	0.00038	3.17	0.16	66	24	0.3	0.00091	2.89
									0.06	58		0.2		
	Firth Forth (8)	2	0.25	0.163	66	0.3	0.00028	3.24	0.163	66	25	0.3	0.00085	2.91
									0.065	58		0.2		
J	Irish Sea E (14)	2	0.25	0.16	60	0.3	0.00029	2.94	0.16	60	24	0.3		
									0.1	56		0.2	0.00029	2.92
	Irish Sea w (15)								0.16	60	24	0.3		
									0.1	56		0.2	0.00068	2.96
K	None													
L	Porc. Bank (16)	2	na	0.14	75	0.2	0.00009	3.55	0.16	60		0.2	0.00009	3.55
	Aran Grounds (17)	2	na	0.15	60	0.3	0.00032	3.21	0.15	60	24	0.3		
									0.1	50		0.2	0.00068	2.96
	Irish Coast (18,19)	No data available												
M	Celt. Sea (20-22)	2	0.25	0.17	68	0.3	0.00009	3.55	0.17	68	31	0.3		
									0.1	49		0.2	0.00009	3.55
N	Biscay (23,24)	2	0.3	0.14	76	0.3	0.00039	3.18	0.14	76	25	0.3		
									0.11	56		0.2	0.00081	2.97
O	N Galicia (25)	2	na	0.12	80	0.2	0.00043	3.16	0.16	70	24	0.2		
									0.08	60		0.2	0.00043	3.16
	Cantabrian (31)	5	na	0.15	90	0.2	0.00043	3.16	0.1	70		0.2	0.00043	3.16
P	None													
Q	W Galicia (26)	5	na	0.15	85	0.2	0.00043	3.16	0.15	85	24	0.2	0.00043	3.16
									0.1	70		0.2		
	N Portugal (27)	2	na	0.2	70	0.2	0.00028	3.22	0.2	70	26	0.2		
									0.068	65		0.1	0.00056	3.03
	SW S Port (28,29)	2	na	0.2	70	0.3	0.00028	3.22	0.2	70	30	0.3		
									0.065	65		0.2	0.00056	3.03
R	None													

na = Not applicable

TL=Transition Length

Table 4.2.1 Values of F obtained by use of the normal curve-fitting program, MIX and the slicing program, L2AGE for western Irish Sea (FU15) males.

1. MIX:-

	1989	1990	1991	1992	1993	1994	Mean	S. D.
1	0.1071	0.0078	0.0669	0.0232	0.0103	0.0233	0.0398	0.0393
2	0.5728	0.6483	0.6332	0.5538	0.5630	0.6386	0.6016	0.0428
3	1.2751	1.6193	1.1735	0.7641	0.8149	0.9000	1.0912	0.3284
4	1.2170	1.2541	1.0923	0.8490	1.0495	0.9186	1.0634	0.1600
5+	1.2170	1.2541	1.0923	0.8490	1.0495	0.9186	1.0634	0.1600
F bar 2-4	1.0216	1.1739	0.9663	0.7223	0.8091	0.8191		

2. Slicing

	1989	1990	1991	1992	1993	1994	Mean	S.D.
1	0.0040	0.0051	0.0030	0.0019	0.0065	0.0045	0.0042	0.0016
2	0.2132	0.2132	0.1911	0.2176	0.3355	0.2665	0.2395	0.0532
3	0.7230	0.6679	0.7789	0.9461	1.0252	0.9928	0.8557	0.1513
4	0.7643	0.7528	0.7055	0.6872	1.0043	1.1537	0.8446	0.1898
5+	0.7643	0.7528	0.7055	0.6872	1.0043	1.1537	0.8446	0.1898
Fbar 2-4	0.5668	0.5446	0.5585	0.6170	0.7883	0.8043		

Table 4.2.2

Title : 7a west nephrops male aged by mix

At 9/03/1995 15:10

Separable analysis
from 1989 to 1994 on ages 1 to 4
with Terminal F of 1.000 on age 3 and Terminal S of 1.000

Initial sum of squared residuals was 83.029 and
final sum of squared residuals is 5.497 after 54 iterations

Matrix of Residuals

Years	1989/90	1990/91	1991/92	1992/93	1993/94	TOT	WTS
1/ 2	1.404	-1.322	.708	.025	-.817	-.003	.239
2/ 3	-.360	-.113	-.048	.258	.262	-.002	1.000
3/ 4	.030	.468	-.134	-.291	-.074	-.002	.922
TOT	.003	.002	-.003	-.004	-.002	-.006	
WTS	1.000	1.000	1.000	1.000	1.000		

Fishing Mortalities (F)

	1989	1990	1991	1992	1993	1994
F-values	1.2755	1.3296	1.2763	.8670	.8866	1.0000

Selection-at-age (S)

	1	2	3	4
S-values	.0233	.5460	1.0000	1.0000

Run title : 7a west nephrops male aged by mix

At 9/03/1995 15:10

Traditional vpa Terminal populations from weighted Separable populations

Fishing mortality residuals

YEAR	1989	1990	1991	1992	1993	1994
AGE						
1	.0774	-.0232	.0371	.0030	-.0103	.0000
2	-.1236	-.0776	-.0636	.0804	.0790	.0926
3	-.0004	.2897	-.1028	-.1029	-.0716	-.1000
4	-.0585	-.0755	-.1840	-.0180	.1629	-.0814

Table 4.2.3

Title : 7a west nephrops male aged by slicing

At 9/03/1995 15:14

Separable analysis
from 1989 to 1994 on ages 1 to 4
with Terminal F of 1.000 on age 3 and Terminal S of 1.000

Initial sum of squared residuals was 145.230 and
final sum of squared residuals is 1.101 after 37 iterations

Matrix of Residuals

Years	1989/90	1990/91	1991/92	1992/93	1993/94	TOT	WTS
1/ 2	.060	.451	.017	-.712	.197	.013	.085
2/ 3	.036	-.025	-.050	.022	.025	.008	1.000
3/ 4	-.156	-.088	.330	.275	-.355	.007	.126
TOT	.021	.003	-.006	-.004	-.003	.028	
WTS	1.000	1.000	1.000	1.000	1.000		

Fishing Mortalities (F)

	1989	1990	1991	1992	1993	1994
F-values	.7784	.7008	.6852	.8466	1.2048	1.0000

Selection-at-age (S)

	1	2	3	4
S-values	.0045	.2736	1.0000	1.0000

Run title : 7a west nephrops male aged by slicing

At 9/03/1995 15:14

Traditional vpa Terminal populations from weighted Separable populations

Fishing mortality residuals

YEAR	1989	1990	1991	1992	1993	1994
AGE						
1	.0004	.0019	-.0001	-.0019	.0010	.0000
2	.0003	.0115	.0037	-.0140	.0058	-.0070
3	-.0554	-.0329	.0937	.0995	-.1796	-.0072
4	-.0141	.0520	.0203	-.1639	-.2005	.1537

Nephrops : Botney Gut - Silver Pit
Comparison of abundance indices
Kg/hour (› 35 mm) vs. LPUEs Fish-stats

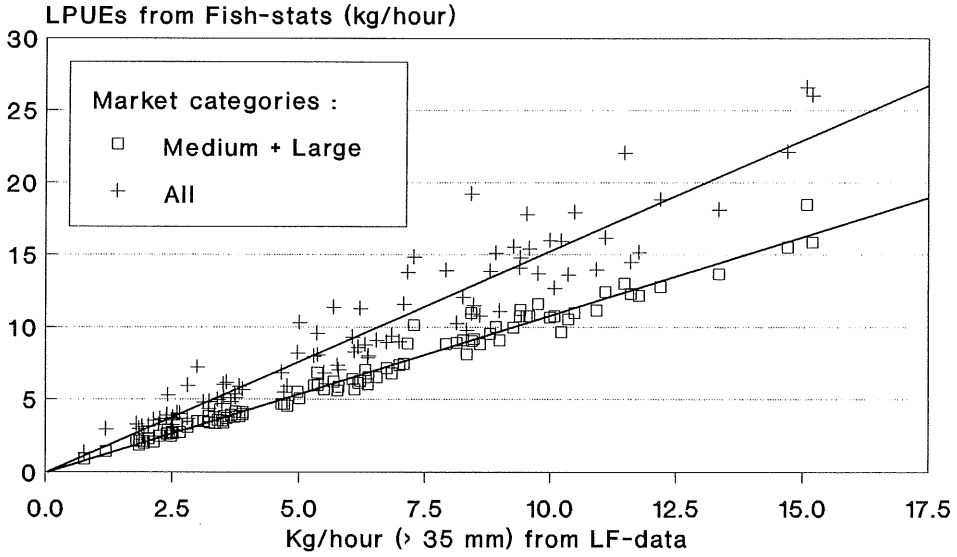


Figure 4.1.1

Nephrops : Botney Gut - Silver Pit
Comparison of abundance indices
Nos./hour (› 35 mm) vs. LPUEs Fish-stats

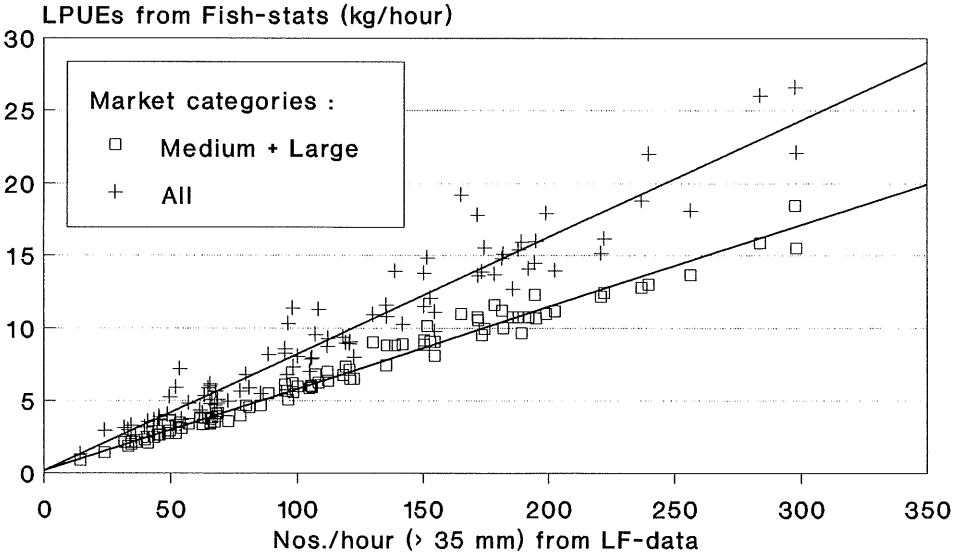


Figure 4.1.2

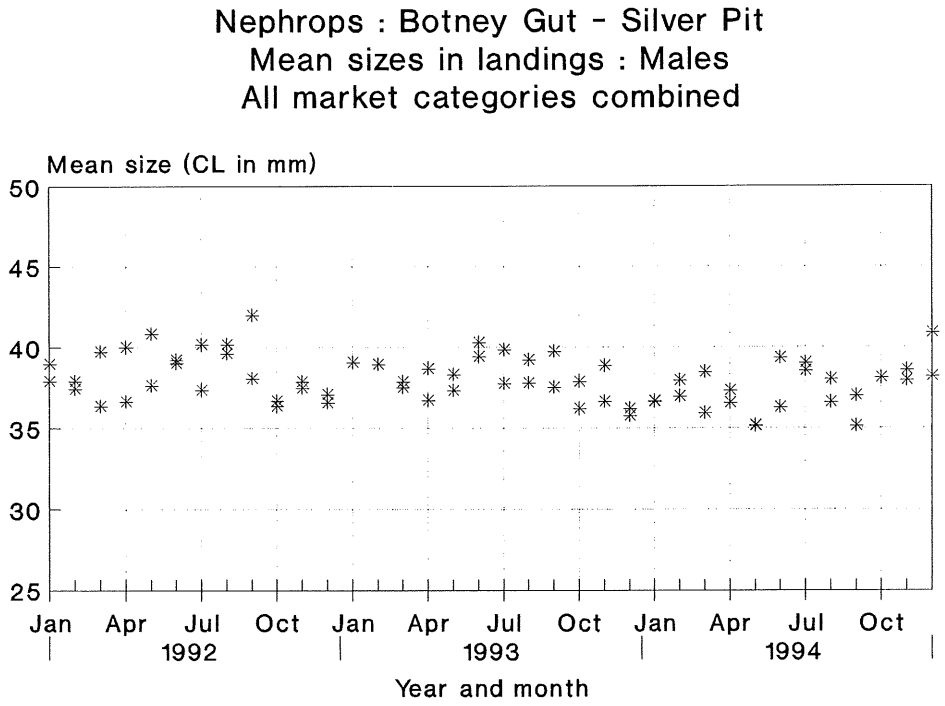


Figure 4.1.3

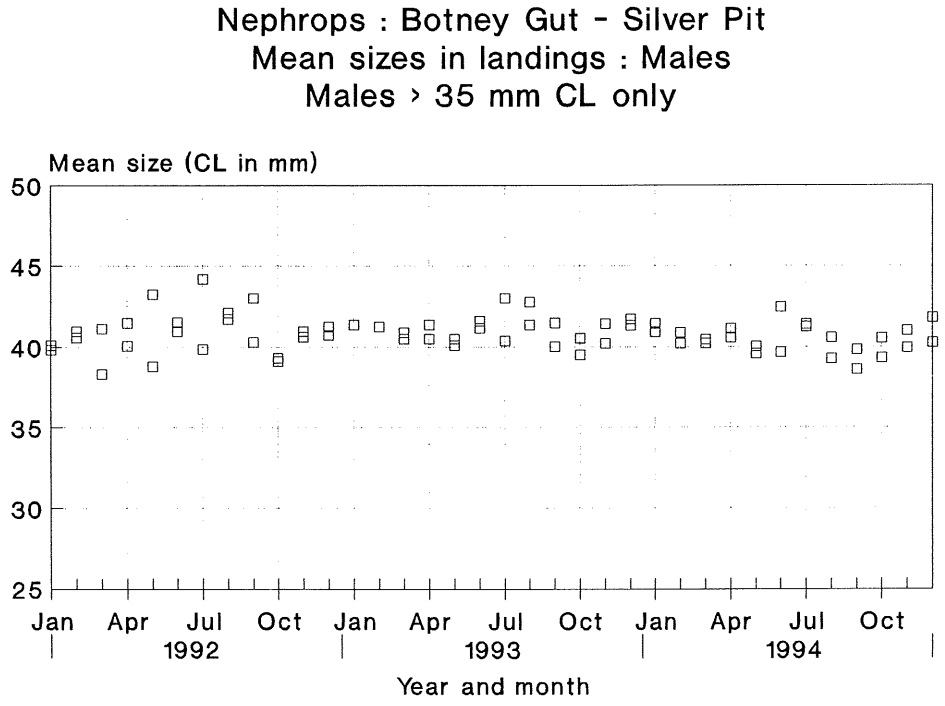


Figure 4.1.4

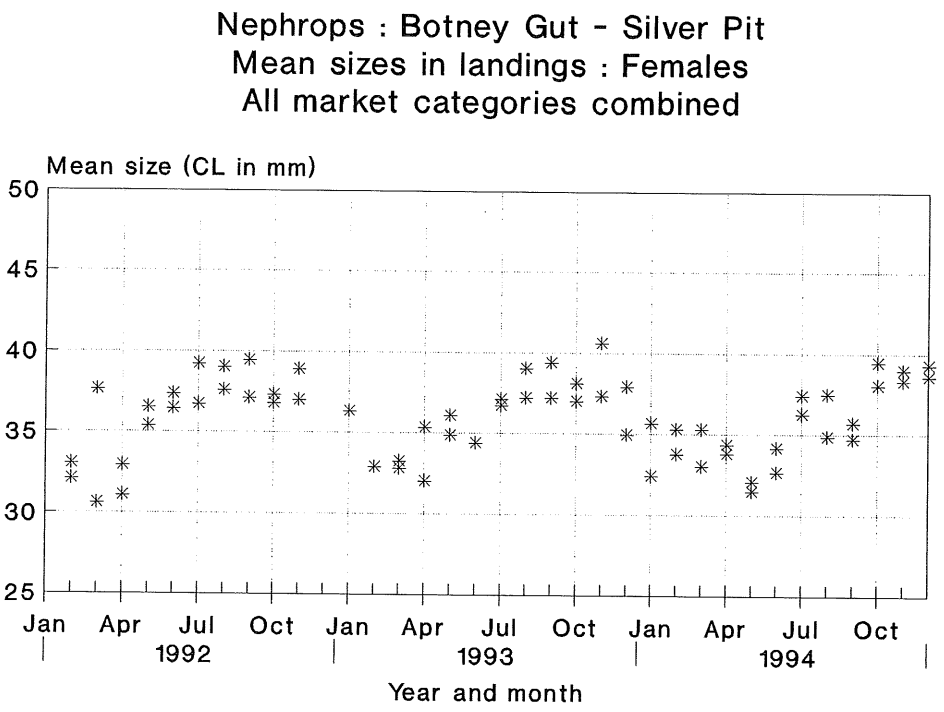


Figure 4.1.5

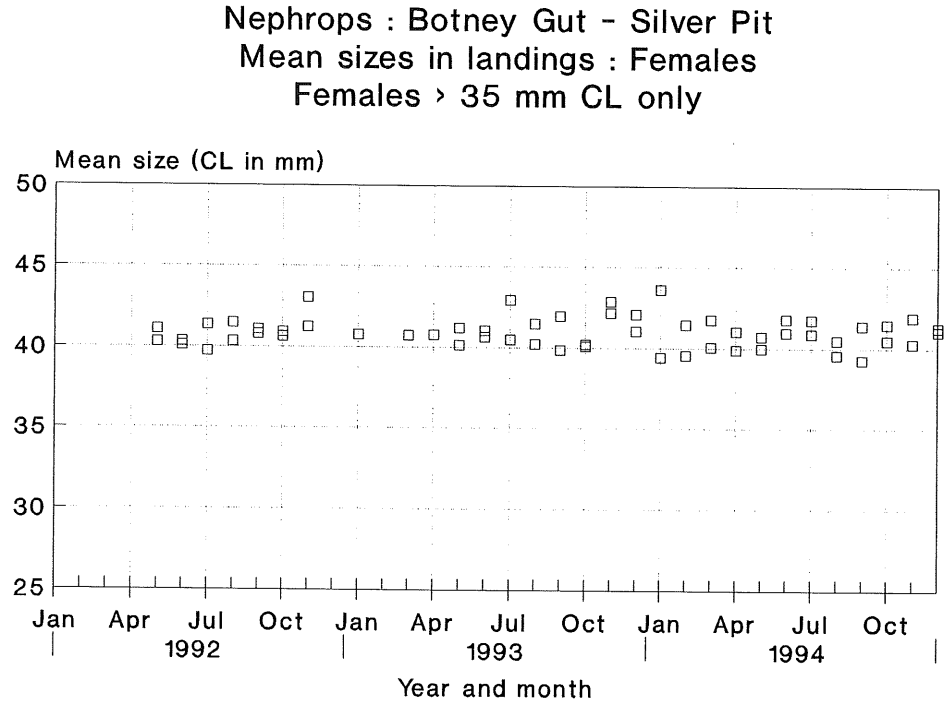


Figure 4.1.6

Nephrops : Firth of Forth
Changes in mean size predicted by LCA
Males

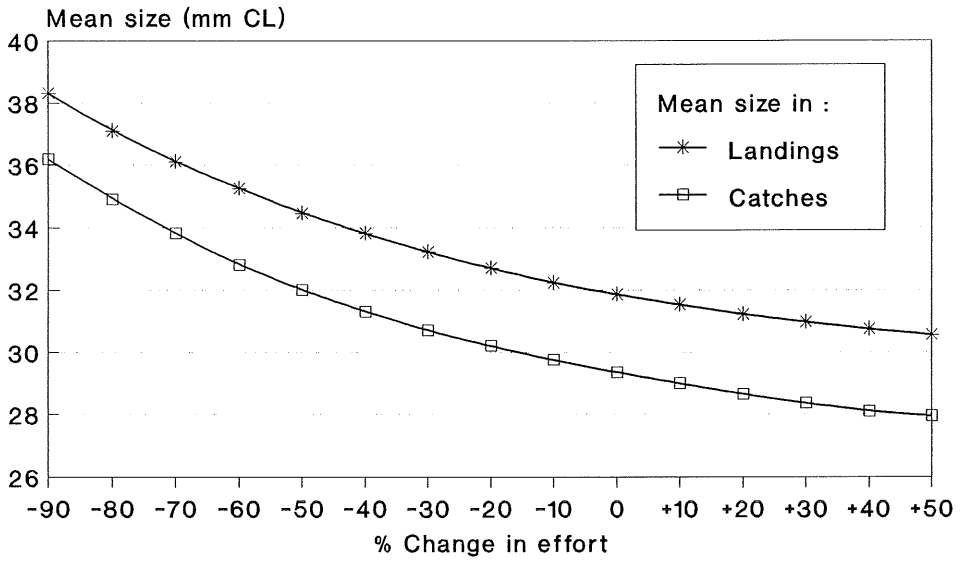


Figure 4.1.7

5. ASSESSMENTS AND MANAGEMENT POSSIBILITIES FOR *NEPHROPHS*

5.1. General Introductory Notes on *Nephrops* Stocks

5.1.1. Functional units, management and TAC areas

In response to Term of Reference (d) a general discussion on working at the Functional Unit (FU), Management Area (MA) and TAC levels is given in Section 7.2.

The Functional Units (FU) are defined by the groupings of rectangles given in Table 5.1.1 and illustrated in Figures 5.1.1, 5.1.2 and 5.1.3. There has been a small revision to FU 12, and there was some discussion of the FU definitions in the area of the Norwegian Deeps and southern Ireland.

Norwegian Deeps

Since 1987 the Norwegian *Nephrops* fishery has spread in a westerly direction. In the 1994 Working Group Report (Anon., 1994b) it was suggested that FU 3 (the Skagerrak area) and Management Area G should be revised. Some Norwegian log book data from statistical rectangles show the distribution of this new fishery, but the total Norwegian landings of 151 t cannot be separated into statistical rectangles.

Denmark reported landings of 303 t in 1994 from the Norwegian Deeps which is outside FUs 3 and 7 (Figure 5.1.4.). The distribution of this fishery indicates a continuous *Nephrops* population along the southern slope of the Norwegian Deeps and into the Skagerrak. Between Fladen and the Norwegian Deeps there might be a physical boundary which could not be revealed from the available log book data.

As the boundaries remain unclear, and there is no biological sampling from the fishery in the Norwegian Deeps, the Working Group recommends a meeting between involved countries to elucidate whether any new Functional Units and Management Areas should be defined. The meeting should be arranged prior to the next *Nephrops* Working Group meeting to consider the distribution of *Nephrops* landings in more detail, sea bed sediment data, and any other information relevant to the task. Any proposed changes should be circulated to Working Group members for consideration so that landings data could be revised before the next Working Group meeting in 1996.

Functional units 11-13

A proposal by Scotland to change the statistical rectangles comprising the South Minch (FU 12) was adopted by the Working Group. The effect of the change was to add two statistical rectangles, 41E2 and 43E2 to FU 12, reflecting their relatively high annual landings (over 230 t in recent years) and up to date information on the distribution of suitable sediments (Table 5.1.1 and Figure 5.1.5).

The system of data collection in Scotland now allows separation of landings and effort information from the Firth of Clyde and the Sound of Jura (East and West of the Kintyre Peninsular respectively) which together make up the Clyde Functional Unit (FU 13). Although these "split" data were used in the assessments, the definition of FU 13 was not changed. Also the overall Management Area C remains unchanged (Figure 5.1.2.).

Functional units 19-22

Attention was drawn again to the fact that Irish fisheries in FU 19 (ICES Division VIIj) were continuous with some of those in FU 20-22 (ICES Division VIIg) (Figure 5.1.2). However, with no Irish research taking place to monitor the stocks exploited by these fisheries, the FU descriptions remain unchanged.

Management Areas

The Management Areas (MA) have been described using, as far as possible, existing ICES Sub-area and Division boundaries. The main difficulty in keeping to this aim was in Divisions IVa (where a Working Group boundary was set up between MA F and MA G), IVb,c (where a Working Group boundary was set up between MA H and MA I) and VIIa/VIIg (where a Working Group boundary was set up between MA J and MA M). The Management Areas are described, together with the Functional Units they contain, in Table 5.1.2, and are shown in Figures 5.1.1, 5.1.2 and 5.1.3.

TAC Areas

The Working Group and ACFM have pointed out that TACs based on the present large areas defined by ICES boundaries are not satisfactory. They do not allow for the management of Functional Units in a way which takes account of the different levels of exploitation which may exist within such large groupings. The Working Group wishes to reiterate its view that *Nephrops* are more appropriately managed at a smaller scale and again recommends that the Management Areas described are adopted.

Specific examples of potential and actual problems inherent in the current system are:

(1) Sub-Area IV North Sea: There are four MAs defined within Sub-area IV, comprising six FUs. The TAC for the North Sea has now been allocated by

country. The fears expressed in last year's report (Anon., 1994b) were realised in 1994 when a switch of effort by fin-fish trawlers to catch *Nephrops* resulted in a rapid uptake of the TAC. The imminent exhaustion of the TAC led the UK fishing industry to sucessfully lobby for an increase in the Precautionary TAC to a level of 15,000 t, some 21% above that recommended by ACFM. The 1995 TAC has been set at 15,200 t.

The high uptake of the TAC took place on both the Fladen Ground (FU7) and the Farn Deeps (FU6), providing examples of the two difficulties global TACs can create for *Nephrops* :- (a) the possibility for an increase in effort on new grounds like the Fladen, before the traditional fisheries have had their opportunity to take their normal share, and (b) the risk that there is little to stop a large proportion of the North Sea fishing effort switching to one of the North Sea *Nephrops* FUs (e.g. Farn Deeps) where the advice is to limit effort at the present level. The large North Sea TAC area increases the risks of over exploitation in the already hard-pressed FUs.

(2) Sub-Area VII: In this area the TAC covers a large area and offers no opportunity to effectively manage each FU or even each MA according to their individual states of exploitation. The Irish Sea (MA J, FUs 14 and 15), for example, is considered to be fully exploited, and could easily be separated from the rest of Sub-area VII to ensure that the management aim of *status quo* effort is achievable.

5.1.2. Assessments

Some revisions to databases made it essential to reassess certain FUs. As ACFM included Y/R figures in their Report last year, the LCAs of many of the Functional Units were updated and the Y/R plots presented for use by ACFM. Table 5.1.3 summarises the types of assessment that were carried out for the different Functional Units and gives some idea of the general 'quality' of these assessments.

The assessments were conducted on males and females separately, and these frequently gave rather different results. The reasons for adopting this approach have been discussed before (Anon., 1991) and are based on the greater availability and probably vulnerability of males in many of the stocks, and the desirability to accommodate different growth and natural mortality rates for the two sexes.

For age-based assessments, in addition to the use of NEPASS (Anon., 1994b), the Lowestoft VPA package was used. Full details of tuning output and available diagnostics have been included in the Report.

5.1.3. Management considerations; provision of catch options

It seems unlikely at the present time that any of the *Nephrops* stocks under consideration are in imminent danger of collapse; they therefore lie outside the ACFM category of stocks in immediate danger of falling below MBAL. For six Functional Units 3, 4, 6, 8, 13, and 15 there is slightly more anxiety and a suggestion that the situation should be very carefully monitored. Most stocks where the state of exploitation is assessed on a yield per recruit basis appear to be fully exploited.

Concern remains, however, that there are considerable opportunities for effort transfer from the increasingly more restricted fin-fish fisheries. For most *Nephrops* Functional Units this would be detrimental; consequently most catch options recommended are of the *status quo* type with the aim of constraining effort. It is felt that the style of current ACFM advice, concentrating as it does primarily on stocks in immediate danger, does not give sufficient emphasis to proactive management of stocks where the current state of exploitation is regarded as about right. Some discussion of this would be welcomed.

In line with ACFM's directions, the Working Group has offered recommendations for most stocks which are based on a collective discussion made in the light of the quality of the input data, parameter values, and assessment results, and any special considerations relevant to the Functional Unit in question. In most cases where the *status quo* objective is recommended no attempt has been made to update the catch options presented previously (Anon., 1993), which were variously based on mean landings or calculated from various effort factors.

The Working Group is aware that managing *Nephrops* by the use of TACs and quotas may not be the most desirable method of controlling the levels of effort on *Nephrops*. A more satisfactory approach would be to attempt to control effort directly and the Group would urge that possibilities for this be investigated.

5.1.4. Section layout

The remainder of the stock assessment section (Section 5) has been organised to list Management Areas, and then Functional Units contained within each area, according to the order used by ACFM in its report. Tables and figures appear at the end of each Management Area section rather than grouped at the back of the report.

For each Functional Unit, there are sections covering input data (length compositions and input parameter values) and also comments on the quality of these data. As before, information on landings, effort, CPUE/LPUE

and mean size precedes a description of the length-based assessment (where appropriate). This is followed by sections on the age-based approach (where appropriate) for males and females. Where other methods have been adopted these are described. Some comments on the general quality of the assessment is then included and on the potential for making a prediction. Management considerations for the Functional Unit are then dealt with.

Summaries of the management considerations for the Management Area are then given together with tables which summarise the recent history of landings (by Functional Unit and by country).

TABLE 5.1.1 NEPHROPS FUNCTIONAL UNITS AND DESCRIPTIONS BY STATISTICAL RECTANGLES

No.	Name	ICES	Statistical rectangles
1	Iceland - South coast	Va	55-56 C6-DO; 55-56 D2-D4
2	Faroe Islands	Vb	55E3
3	Skagerrak	IIIa	47G0; 46F9-G1; 45F8-G1; 44F7-G0; 43F8-F9
4	North and Central Kattegat	IIIa	44G1; 42-43G0-G2; 41G1-G2
5	Botney Gut and Silver Pit	IVb,c	36-37 F1-F4; 35F2-F3
6	Farn deeps	IVb	38-40 E8-E9; 37E9
7	Fladen Ground	IVa	44-49 E9-F1; 45-46E8; 44-45F2
8	Firth of Forth	IVb	40-41E7; 41E6
9	Moray Firth	IVa	44-45 E6-E7; 44E8
10	Noup	IVa	47E6
11	North Minch	VIa	44-46 E3-E4
12	South Minch	VIa	41-43 E2-E4;
13	Clyde	VIa	39-40 E4-E5
14	Irish Sea East	VIIa	35-38E6; 38E5
15	Irish Sea West	VIIa	36E3; 35-37 E4-E5; 38E4
16	Porcupine Bank	VIIc,k	34D6-D8; 33D5-D8; 32D5-D6
17	Aran Grounds	VIIb	34-35 D9-E0
18	NW and W Ireland	VIIb	37D9-E1; 36D9
19	SW Ireland	VIIg,j	31-33 D9-E0
20	NW Labadie, Baltimore and Galley	VIIg,j	)
21	Jones and Cockburn	VIIg,h,j	)28-32E1-E2; 33E2; 31-33E3; 31E4
22	Smalls	VIIg	)
23	Bay of Biscay North	VIIIa	22-24 E6-E7; 23-24E5
24	Bay of Biscay South	VIIIb	20-21 E7-E8; 19E8
25	North Galicia	VIIIc	15E0-E1; 16E1
26	West Galicia	IXa	13-14 E0-E1
27	North Portugal (N Cape Espichel)	IXa	6-12E0; 9-12E1
28	SW Portugal (Alentejo)	IXa	3-5 E0-E1
29	S Portugal (Algarve)	IXa	2E0-E2
30	Gulf of Cadiz	IXa	2-3 E2-E3
31	Cantabrian Sea	VIIIc	16E4-E7

Table 5.1.2 Description of Management Areas together with their Nephrops Working Group labels and the Functional Units contained within them

Working Group Label	Management Area Description	Functional Units	
A	Va	1	Iceland
B	Vb (non EC)	2	Faroe Islands
C	VIa	11	North Minch
		12	South Minch
		13	Clyde
D	Vb (EC) + VIb		None
E	IIIa	3+4	Skagerrak and Kattegat
F	IVa: rect. 44-48 E6-E7 + 44E8	9	Moray Firth
		10	Noup
G	IVa: remainder	7	Fladen
H	IVb, c E of 1°E	5	Botney Gut
I	IVb,c W of 1°E	6	Farn Deeps
		8	Firth of Forth
J	VIIa: excluding rect. 33 E2-E5	14	Irish Sea East
		15	Irish Sea West
K	VIId,e		None
L	VIIb,c,j,k	16	Porcupine Bank
		17	Aran Grounds
		18+19	Irish coast
M	VIIf,g,h and VIIa 33E2-E5	20+21+22	Celtic Sea
N	VIIIa,b	23+24	Bay of Biscay
O	VIIIc	25	North Galicia
		31	Cantabrian Sea
P	VIIId,e		None
Q	IXa	26	West Galicia
		27	N Portugal
		28+29	S and SW Portugal
		30	Gulf of Cadiz
R	IXb + X		None

Table 5.1.3 Summary of Nephrops Assessments carried out by WG in 1995

Key to assessment types: LCA (length based), VPA ('age' based), 0ther (e.g. TV survey). Note letters in parenthesis indicate that assessment not repeated in 1994, earlier assessment referred to.
Key to quality: + = acceptable and used, ? = questionable, x = assessment did not perform well.

			Assessment Type			Quality		
MA	FU		LCA	VPA	Other	LCA	VPA	Other
A	1	Iceland	None					
B	2	Faroe Islands	None					
C	11	North Minch	LCA	-	-	+	-	-
	12	South Minch	LCA	-	-	+	-	-
	13	Clyde	LCA	VPA	-	+	+[1]	-
D	None							
E	3+4	Skagerrak/Kattegat	(LCA)	-	-	?	-	-
F	9	Moray Firth	LCA	VPA	O	+	+[1]	?
	10	Noup	-	-	O	-	-	?
G	7	Fladen	-	-	O	-	-	+
H	5	Botney Gut	(LCA)	-	-	?	-	-
I	6	Farn Deeps	LCA	VPA	-	+	+	-
	8	Firth of Forth	LCA	VPA	O	+	+	+
J	14	Irish Sea East	LCA	-	-	+	-	-
	15	Irish Sea West	LCA	VPA	-	+	?	-
K	None							
L	16	Porcupine Bank	(LCA)	-	-	?	-	-
	17	Aran Grounds	None					
	18+19	Irish coast	None					
M	20-22	Celtic Sea	LCA	VPA	-	+	+[1]	-
N	23+24	Bay of Biscay	LCA	VPA	-	+	?	-
O	25	North Galicia	LCA	VPA	-	?	?	-
	31	Cantabrian Sea	None					
P	None							
Q	26	West Galicia	(LCA)	-	-	?	-	-
	27	N Portugal	None					
	28+29	S&SW Portugal	LCA	VPA	-	?	?	-
	30	Gulf of Cadiz	None					
R	None							

[1]Serious doubts about the usefulness of the female assessment.

Figure 5.1.1.
Functional Units and Management Areas in IIIa and IV

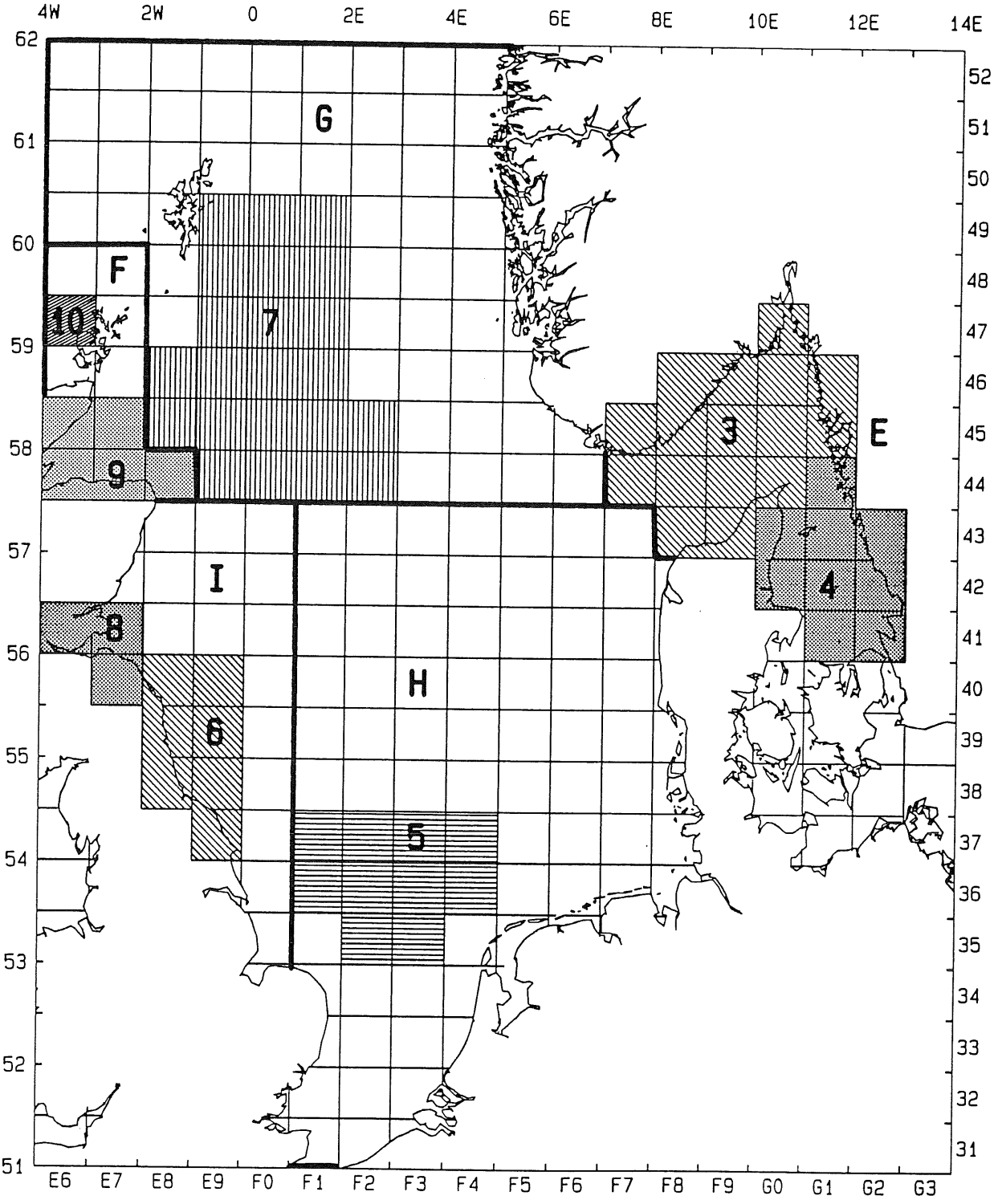


Figure 5.1.2.
Nephrops Functional Units and Management Areas in V, VI and VII

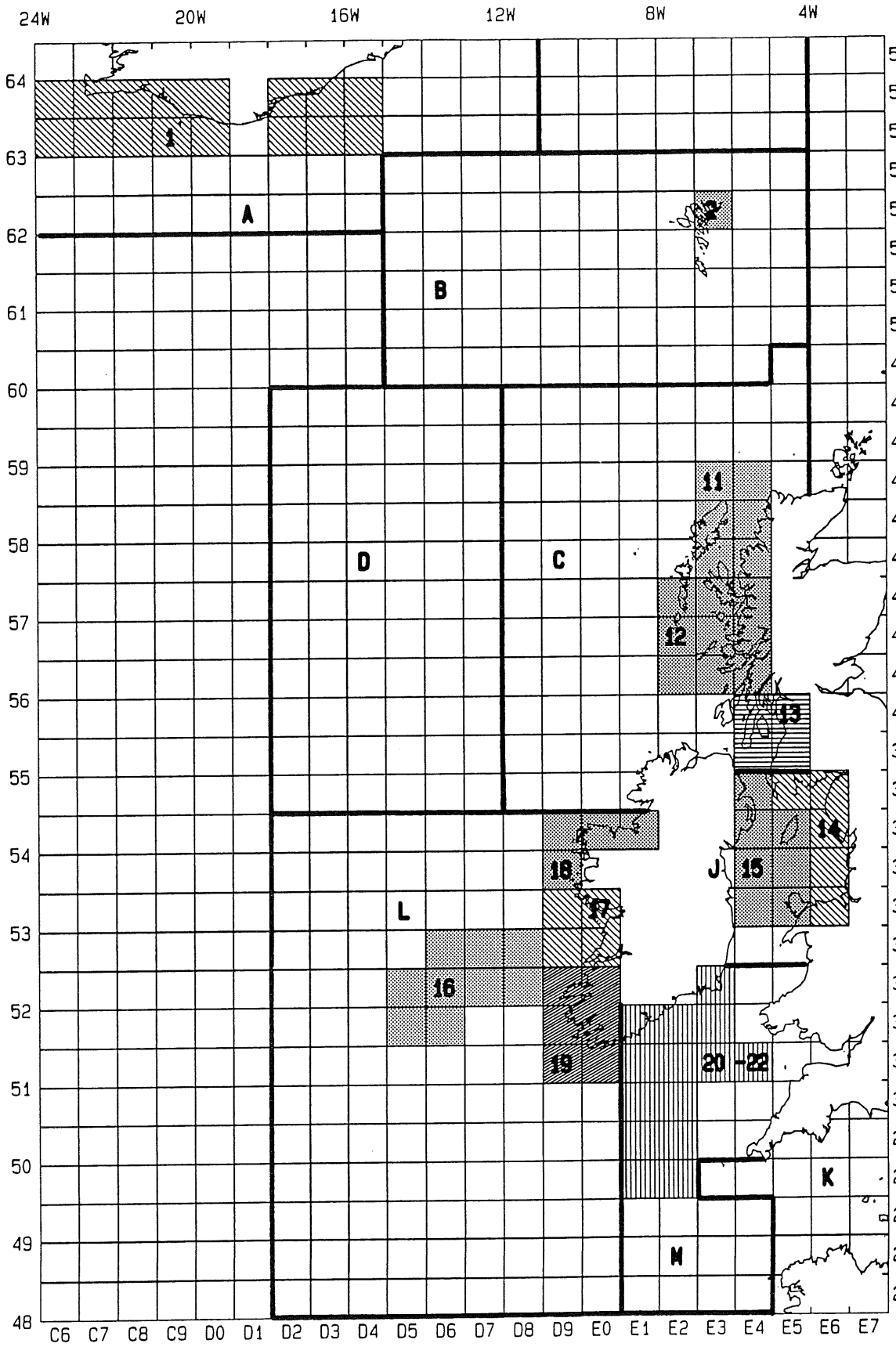


Figure 5.1.3.
Nephrops Functional Units and Management Areas in VIII to X

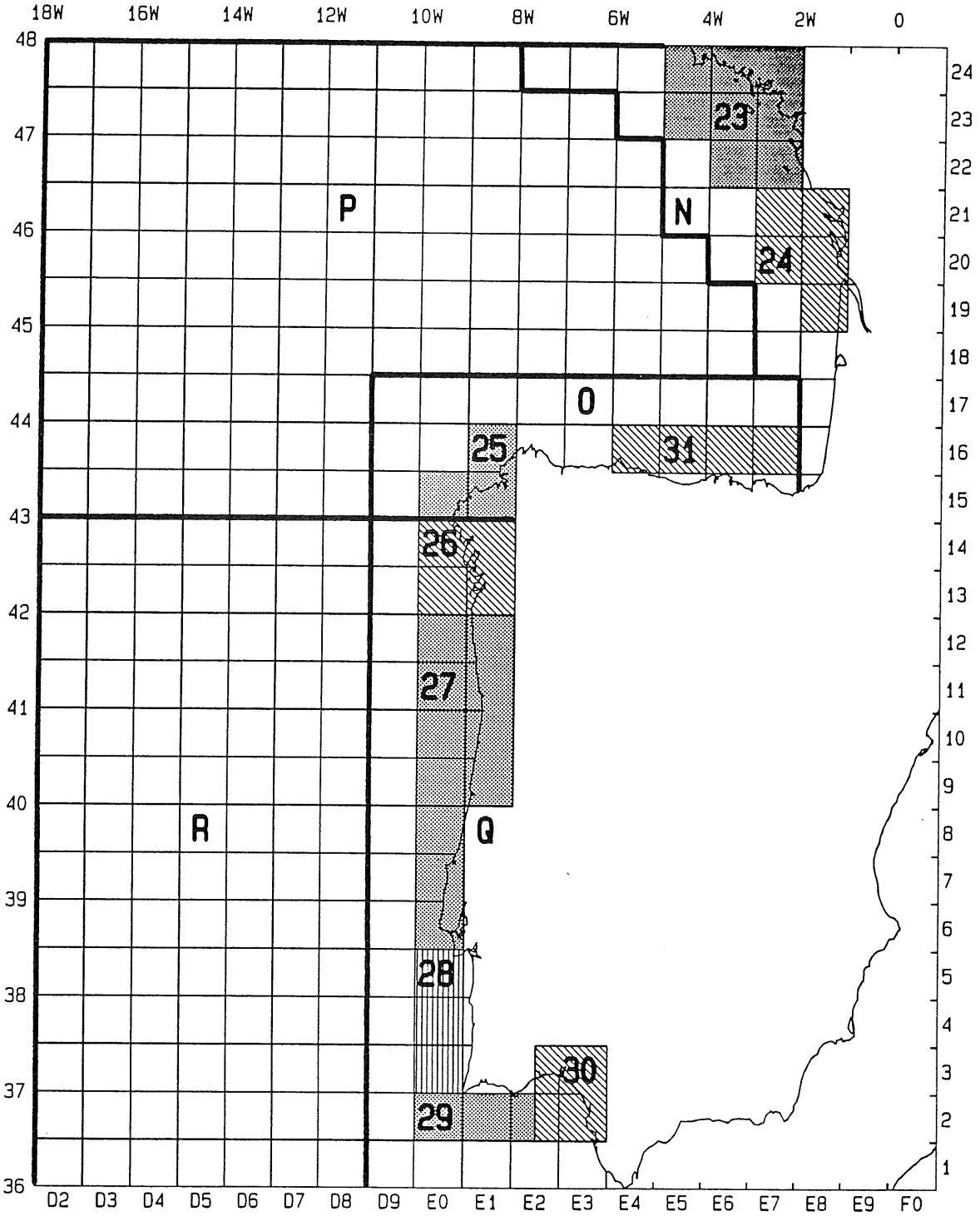


Figure 5.1.4.
N SEA NEPHROPS CATCHES FROM DANISH LOGBOOK DATA 1994

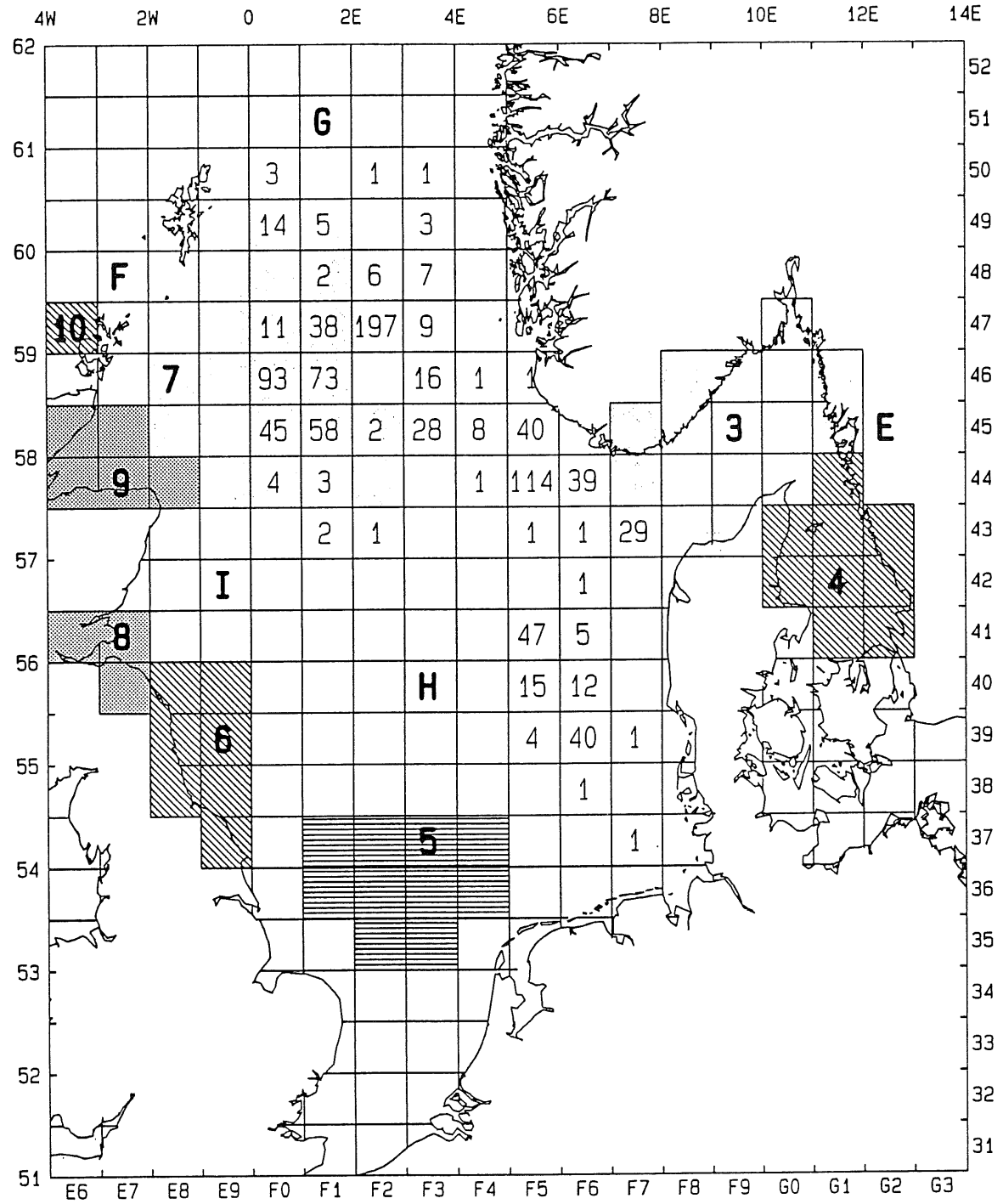
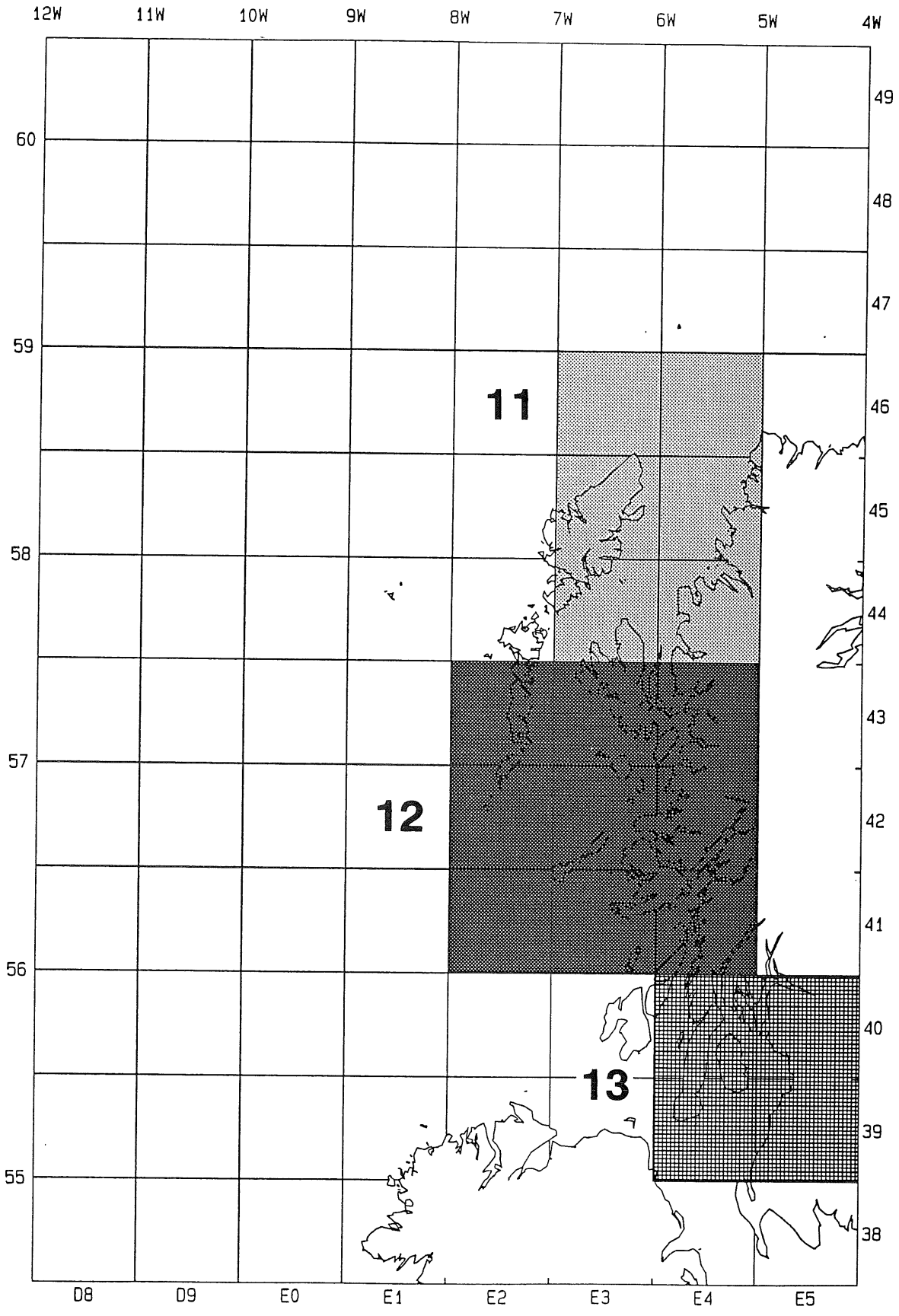


Figure 5.1.5. Management Area C: Fus 11-13



5.2. Division IIIa (Management Area E)

Functional Units **Skagerrak (3)**
Kattegat (4)

The statistical rectangles comprising this Management Area and its constituent Functional Units are shown in Figure 5.1.1.

5.2.1. Skagerrak (Functional Unit 3)

Landings

Denmark, Sweden and Norway exploit this FU (Table 5.2.1). Landings have fluctuated between 2933 and 1900 tonnes in the last 10 years. Total landings in 1994 decreased by about 370 tonnes compared to the landings in 1993. Denmark and Sweden dominate the *Nephrops* fishery in the Skagerrak (64% and 33% respectively of total 1994 landings), with Norway landing 66 tonnes (3%). The landings from the Swedish creel fishery decreased from 123 tonnes in 1993 to 90 tonnes in 1994, and have fluctuated without trend during the 9 years of creel landing data. When adequate data become available it would seem reasonable to assess this fishery separately. Long-term trends in total landings are given in Figure 5.2.1. Swedish effort and corresponding landings data are available from log books for 1978-94 and correspond well to the Swedish sale slips for both Skagerrak and Kattegat, indicating a high degree of reliability in the log book data.

Effort and LPUE

Table 5.2.2 gives the Swedish effort data for the Skagerrak since 1985. Effort data are available for the period 1978-1994 (Figure 5.2.1), and in the last five years they have been separated into single trawl and twin trawl data (Figure 5.2.2 and 5.2.3). The conversion of twin trawl LPUE to single trawl LPUE indicates that total Swedish trawling effort (expressed as single trawl units) in the Skagerrak has decreased by about 15% to 118,000 trawling hours since the maximum of 138,000 trawling hours in 1991 (Figure 5.2.1). The long-term trend in Swedish effort shows an increase of about 195% from the 40,000 trawling hours in 1982.

The total Danish effort in the Skagerrak (days trawling) has been estimated from log book data (Table 5.2.3, Figure 5.2.1), and is assumed to be exerted mainly by twin trawls for the whole period. It shows an increasing trend to a maximum in 1990, and has since decreased in 1994 to the lowest recorded. However, the estimates of total effort in recent years may be underestimated due to some misreporting in log book records. LPUE in both the Danish and Swedish Skagerrak fishery showed a decreasing trend until 1992, but have increased in the last two years (Figure 5.2.1).

5.2.2. Kattegat (Functional Unit 4)

Landings

From 1985 to 1994 the total landings have decreased by 52% from 1798 tonnes to 862 tonnes and are now the lowest during the recent ten year period (Table 5.2.4; long-term trends Figure 5.2.1). Denmark dominates the Kattegat *Nephrops* fishery accounting for 84% of total landings; the remaining 16% is landed by Sweden.

Effort and LPUE

Danish LPUE (kg/day) figures based on log book data are available for 1987-94 (Figure 5.2.1). The Danish LPUE in the Kattegat has increased in the last two years (Table 5.2.6). Total Danish effort has been estimated from these data. It appears that Danish effort in the Kattegat has decreased since 1989 and is now the lowest recorded during the 8 years of data. However, as mentioned above, the estimates of total effort may be underestimated due to some misreporting in log books. The Swedish standardised total effort has been relatively stable during the period 1978-90 (Table 5.2.5). Since 1990 there has been an increasing trend in effort, mainly due to a shift from single trawls to twin trawls (Figure 5.2.1). LPUE for the Swedish trawlers shows a markedly decreasing trend during the last ten years. The LPUE for the Skagerrak and Kattegat combined and Denmark and Sweden combined (with relative effort) also shows a decreasing trend (Figure 5.2.1).

5.2.3. Skagerrak and Kattegat combined (Functional Units 3+4)

Data and biological inputs

For the Skagerrak, length frequency data are available from Sweden for 1990-1994; from Denmark for 1991-1994 and from Norway for 1992 and 1994. For the Kattegat, length frequency data are available from Sweden for 1990-1992 and from Denmark for 1991-1994. During 1994 Sweden sampled 12 landings and 12 discards separately and Denmark and Norway sampled 3 and 2 catches respectively. As the samples of size distribution from each country do not cover each quarter of a year (Table 5.2.7), raising to the annual total size distribution might be biased. It would be desirable to increase the sampling intensity, particularly in Denmark, covering all quarters of the year, especially as separating catch rates by sex is necessary.

Total size distribution in the catch from Division IIIa (FU 3+4)

The proportions of landings from Division IIIa caught by Denmark, Sweden and Norway were 70%, 28% and 2% respectively. When raising each country's size compositions to total Division IIIa catch, the low

sampling frequency from the main country (Denmark) might give an incorrect estimation of total size distribution. If the estimated size distribution for 1994 is correct, the discarded proportion of total catch is 84% in numbers and 67% in weight. In 1993 75% in numbers (57% in weight) were undersized and discarded, which was an increase from 1992. Although there are uncertainties in the estimates, this underlines again the mismatch between the current minimum landing size (40 mm CL) and the mesh size in use (70 mm diamond mesh) which generates a high fishing mortality on undersized, discarded *Nephrops*.

Assessment of Skagerrak and Kattegat combined (Division IIIa (FU 3+4))

As the 1994 data were considered to be unreliable, no new assessments were carried out on this stock. The main purpose of the last year's LCA was to assess the changes in long-term Y/R with changes in gear selectivity.

Quality of input parameters for LCA

For last year's assessment the average length distribution of 1990-1993 was used. The growth parameters were borrowed from Division IVa stocks, and natural mortality was set to 0.3 for males and 0.2 for females (Table 5.2.7).

Length Cohort Analysis

The output from last year's LCA is given for males and females in Figure 5.2.4. The estimated mean F (interquartile length range) for males and females was 0.53 and 0.16 respectively. The LCA for males indicates an increase of about 20 % in long term yield if effort was reduced by 50 %, while the LCA for females indicate an increase of about 4 % in long term yield if effort was reduced by 30 % (Fig 5.2.4). These analyses indicate high fishing pressure, especially for the males, but also for the females. The uncertainty of the input parameters in the LCA for Division IIIa makes this analysis rather speculative.

Age-based assessment

No age-based assessment was carried out on this stock.

5.2.4. Summary for Division IIIa (Management Area E)

The landings for Division IIIa (Management Area E) are summarised by FU (Table 5.2.8) and country (Table 5.2.9).

Management considerations

The Working Group is of the opinion, as it was last year, that if a catch option is set for Division IIIa, it must be based on the observed trends in Swedish effort and LPUE, since the Swedish data are considered the most reliable and extend back to 1978. The observations suggest that the stock has declined.

As there were no new data to improve the assessment, the Working Group is of the opinion, as last year, that the LCA for both males and females are probably too uncertain to base management recommendations on. The results seem to be very sensitive to relatively small changes in the growth parameters, which themselves are not based on any growth investigations in Division IIIa, but have been taken from *Nephrops* stocks in Division IVa. The large amount of undersized *Nephrops* in the Division IIIa catches reflects the fact that the MLS does not correspond to the L_{25} of the current legal mesh size with standard diamond-shaped meshes. Therefore, more selective trawls could be an effective conservation measure. The effect on the stock size of decreasing the proportion of undersized *Nephrops* using more selective trawls, would depend on the survival rate of both discards and mesh-escapees. Therefore, the Working Group encourages further investigations on survival of mesh-escaped and discarded *Nephrops*.

On the basis of the observed increased Swedish effort, and with LPUE showing a decreasing trend, the Working Group recommends that if a TAC is to be set, it should not allow any further increase in total effort with the current mesh shape and size.

Table 5.2.1 Skagerrak (Functional Unit 3): Landings (tonnes) by country, 1985-94

Year	Denmark	Norway	Sweden		Total
			Trawl	Creel	
1985	1334	72	785**		2191
1986	1054	64	800	100	2018
1987	1385	80	865	110	2440
1988	1260	103	886	114	2349
1989	1795	61	643	65	2603
1990	1749	147	860	110	2865
1991	1639	194	949	151	2933
1992	1151	111	524	114	1900
1993	1485	100	577	123	2285
1994*	1224	66	531	90	1911

* provisional
** may include catches by creels

Table 5.2.2 Skagerrak (Functional Unit 3): Catches and landings (tonnes), effort ('000 hours, trawling), CPUE and LPUE (Kg/hour trawling), of Swedish Nephrops trawlers, 1985-94, single trawl. Twin trawl (1990-94) in parenthesis

Year	Catches	Landings	Effort	CPUE	LPUE
1985	?	642	66.0	?	9.7
1986	?	715	74.0	?	9.7
1987	?	775	91.3	?	8.5
1988	?	700	108.8	?	6.4
1989	?	555	97.1	?	5.7
1990	729(302)	490(203)	73.5(17.1)	9.9(17.7)	6.7(11.9)
1991	676(740)	401(439)	71.4(39.5)	9.5(18.7)	5.6(11.1)
1992	360(370)	231(238)	73.7(34.1)	4.9(10.9)	3.1(7.0)
1993	614(568)	279(258)	72.6(35.9)	8.4(15.8)	3.8(7.2)
1994*	441(444)	246(248)	60.1(34.1)	7.3(13.1)	4.1(7.3)

* provisional

Table 5.2.3 Skagerrak (Functional Unit 3): Effort (days trawling), LPUE (Kg/day trawling) of Danish Nephrops trawlers, 1987-94

Year	Effort	LPUE
1987	16591	84.1
1988	15569	81.6
1989	21642	82.4
1990	22812	76.3
1991	22162	73.3
1992	15328	75.6
1993	14074	104.8
1994	11182	109.9

Table 5.2.4 Kattegat (Functional Unit 4): Landings (tonnes) by country, 1985-94

Year	Denmark	Sweden	Total
1985	1609	189	1798
1986	1593	214	1807
1987	1454	151	1605
1988	1204	160	1364
1989	1222	91	1313
1990	1349	127	1476
1991	1185	130	1315
1992	901	111	1012
1993	765	159	924
1994*	720	142	862

* provisional

Table 5.2.5 Kattegat (Functional Unit 4): Catches and landings (tonnes), effort ('000 hours, trawling), CPUE and LPUE (Kg/hour trawling) of Swedish Nephrops trawlers, single 1984-93, Twin trawl (1990-94) in parenthesis

Year	Catches	Landings	Effort	CPUE	LPUE
1985	?	99	11.6	?	8.5
1986	?	137	16.2	?	8.5
1987	?	109	19.4	?	5.6
1988	?	100	16.8	?	6.0
1989	?	67	19.6	?	3.4
1990	114(25)	77(17)	14.2(1.9)	8.0(13.2)	5.4(9.1)
1991	66(93)	39(55)	10.3(8.8)	6.4(10.6)	3.7(6.2)
1992	44(101)	28(65)	11.6(14.2)	3.8(7.1)	2.4(4.6)
1993	128(187)	58(85)	14.9(17.8)	8.6(10.6)	3.9(4.8)
1994	95(138)	53(77)	16.2(14.2)	5.7(9.7)	3.2(5.4)

Table 5.2.6 Kattegat (Functional Unit 4) : Effort (days trawling), LPUE (Kg/day trawling) of Danish, Nephrops trawlers, 1987-94

Year	Effort	LPUE
1987	17520	84.2
1988	14276	86.7
1989	18858	65.2
1990	17164	78.7
1991	17182	68.6
1992	13434	65.9
1993	10195	74.9
1994	9405	77.2

Table 5.2.7 Data and Biological Inputs: Skagerrak and Kattegat

FU	3 and 4	MA	IIIa (Area E)

FLEET	Swedish	GEAR	Trawl

1994	NUMBER OF SAMPLES				Mean
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	No./sample
Catch					
Landings	1	2	3	6	599
Discards	1	2	3	6	1033

	NUMBER OF SAMPLES									
YEAR	94	93	92	91	90	89	88	87	86	85
Catch										
Landings	12	7	8	8	6					
Discards	12	7	8	8	6					

FLEET	Danish	GEAR	Trawl

1994	NUMBER OF SAMPLES				Mean
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	No./sample
Catch			1	2	1124
Landings					
Discards					

	NUMBER OF SAMPLES									
YEAR	94	93	92	91	90	89	88	87	86	85
Catch	3	5	1							
Landings		5	4							
Discards		5	4							

FLEET	Norwegian	GEAR	Trawl

1994	NUMBER OF SAMPLES				Mean
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	No./sample
Catch				2	142
Landings					
Discards					

INPUT PARAMETERS		
Parameter	Value	Source
Discard Survival	0.25	Borrowed from stocks in IVa
MALES		
Growth - K	0.16	"
Growth - L(inf)	75	"
Nat. Mort. - M	0.3	
Length/weight - a	0.00045	Swedish observations (unpub.)
Length/weight - b	3.11	
FEMALES		
Immature Growth	NA	All length groups assumed to be mature
K	NA	
L(inf)	NA	
Nat.Mort. - M	NA	
Size at Maturity	28	Swedish observations (unpublished)
Mature Growth		
K	0.1	Borrowed from stocks in IVa
L(inf)	65	"
Nat.Mort. - M	0.2	"
Length/weight - a	0.00108	Swedish observations(unpub.)
Length/weight - b	2.85	"

Table 5.2.8 Nephrops landings (tonnes) by Functional Unit plus other rectangles in Division IIIa (Management Area E)

Year	FU 3	FU 4	Other	Total
1985	2191	1798		3989
1986	2018	1807		3825
1987	2440	1605		4045
1988	2349	1364		3713
1989	2603	1313		3916
1990	2865	1476		4341
1991	2933	1315		4248
1992	1900	1012		2912
1993	2285	924		3209
1994	1911	862		2773

Table 5.2.9 Total Nephrops landings (tonnes) by country in Division IIIa (Management Area E)

Year	Denmark	Norway	Sweden	Total
1985	2943	72	974	3989
1986	2647	64	1114	3825
1987	2839	80	1126	4045
1988	2464	89	1160	3713
1989	3017	70	829	3916
1990	3098	146	1097	4341
1991	2824	194	1230	4248
1992	2052	111	749	2912
1993	2250	100	859	3209
1994	1944	66	763	2773

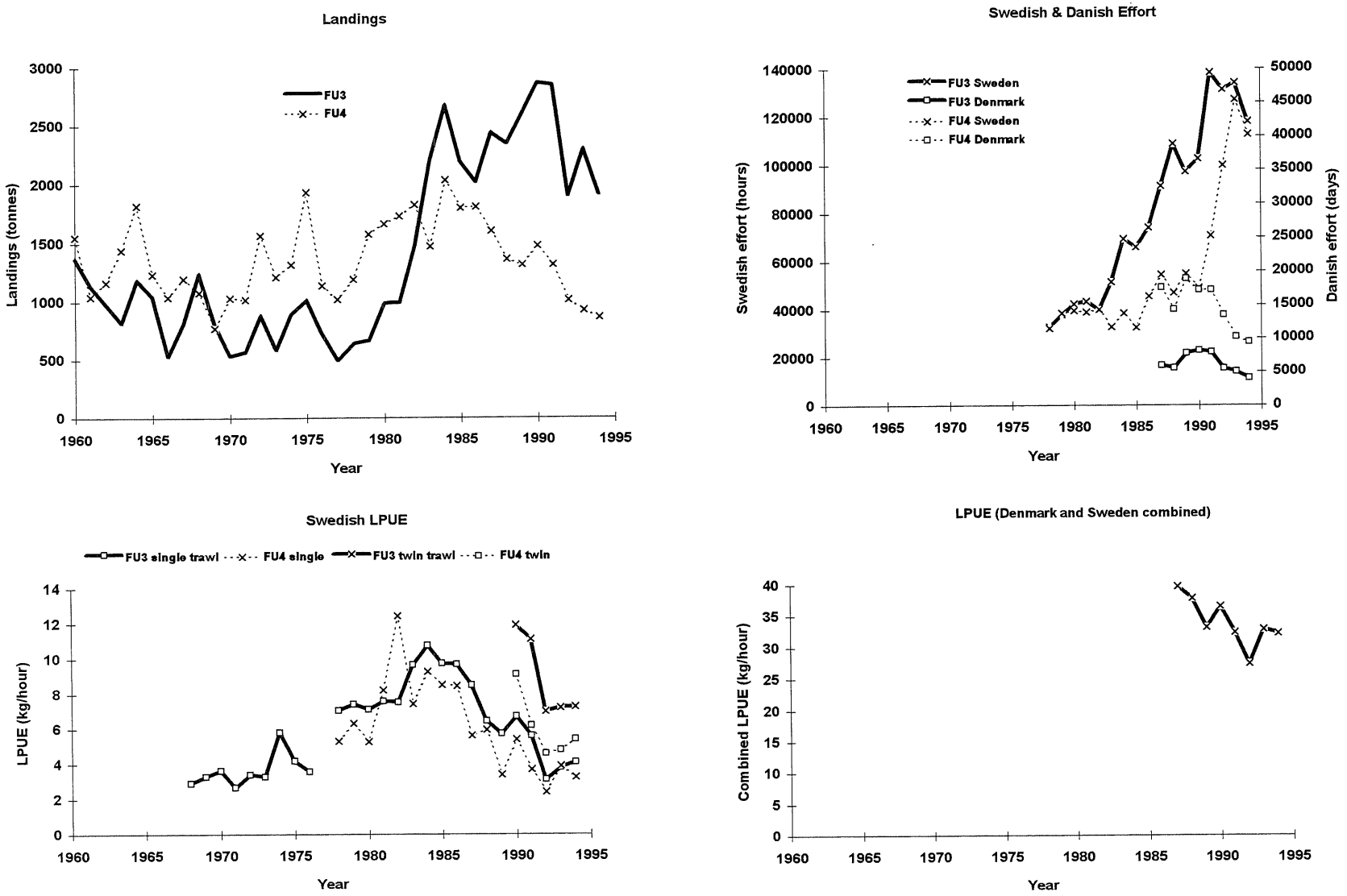


Figure 5.2.1 Skagerrak (FU3) and Kattegat (FU4): Long term trends in total landings (tonnes), Swedish (hours) and Danish (days) effort and LPUE, and combined LPUE

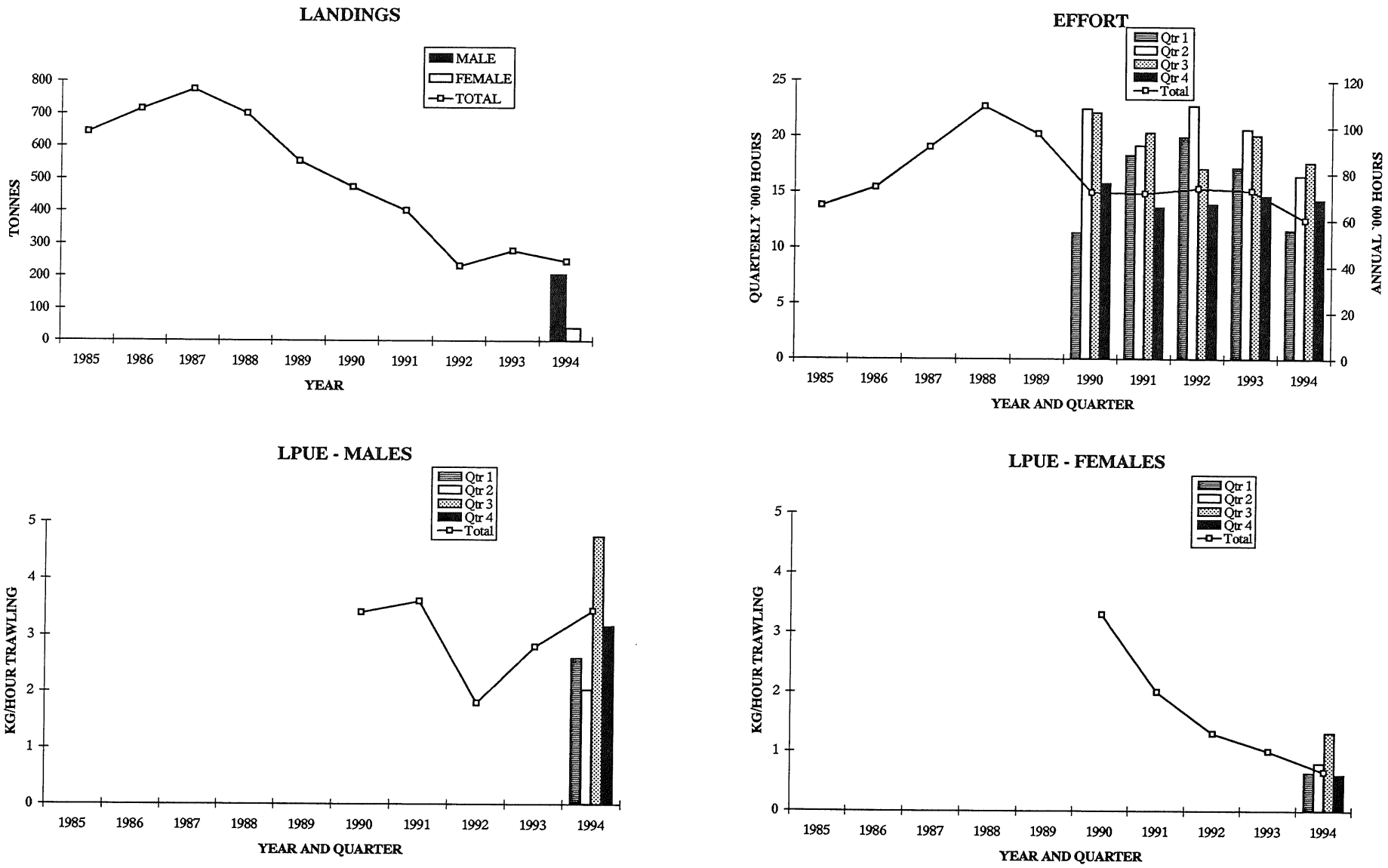


Figure 5.2.2. Skagerrak (functional unit 3) : trends in landings,effort and LPUE by quarter and sex from Swedish Nephrops Single trawlers.

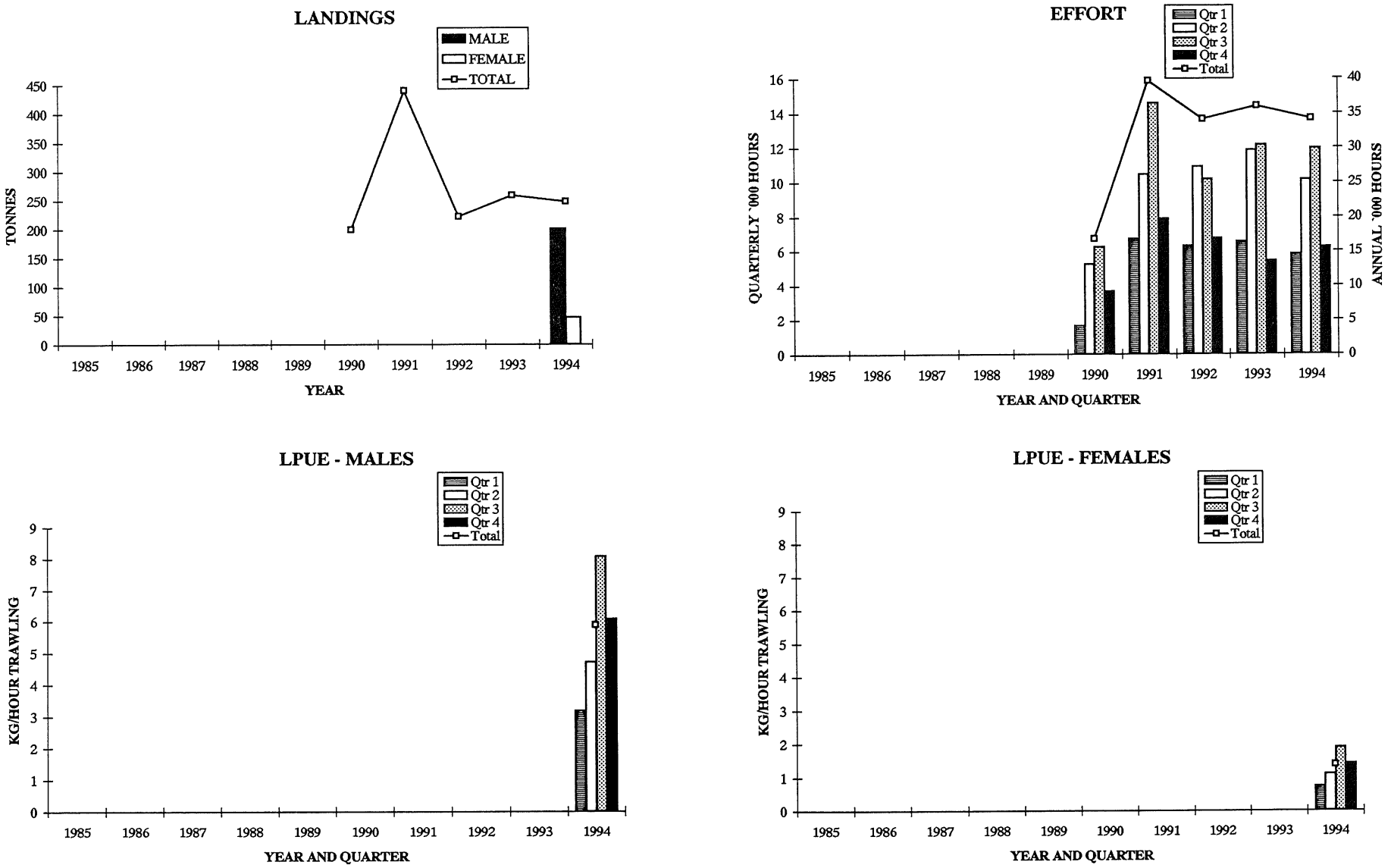
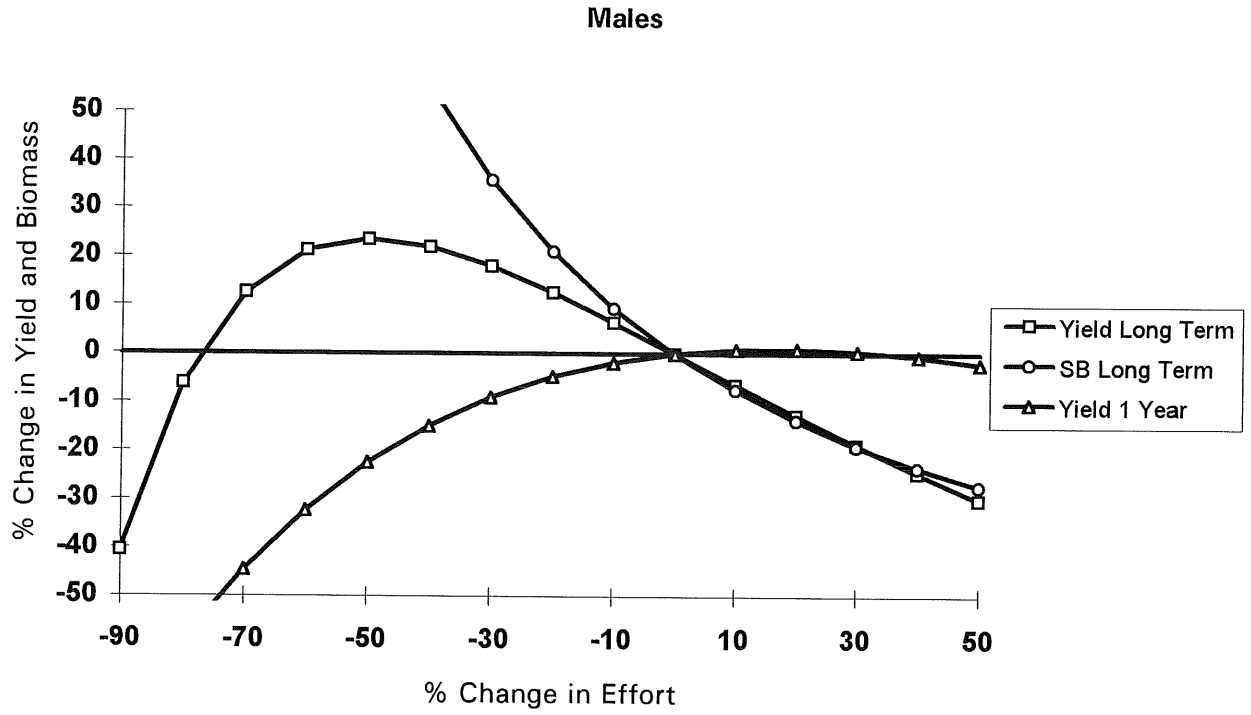


Figure 5.2.3. Skagerrak (functional unit 3) : trends in landings,effort and LPUE by quarter and sex from Swedish Nephrops twin trawlers.



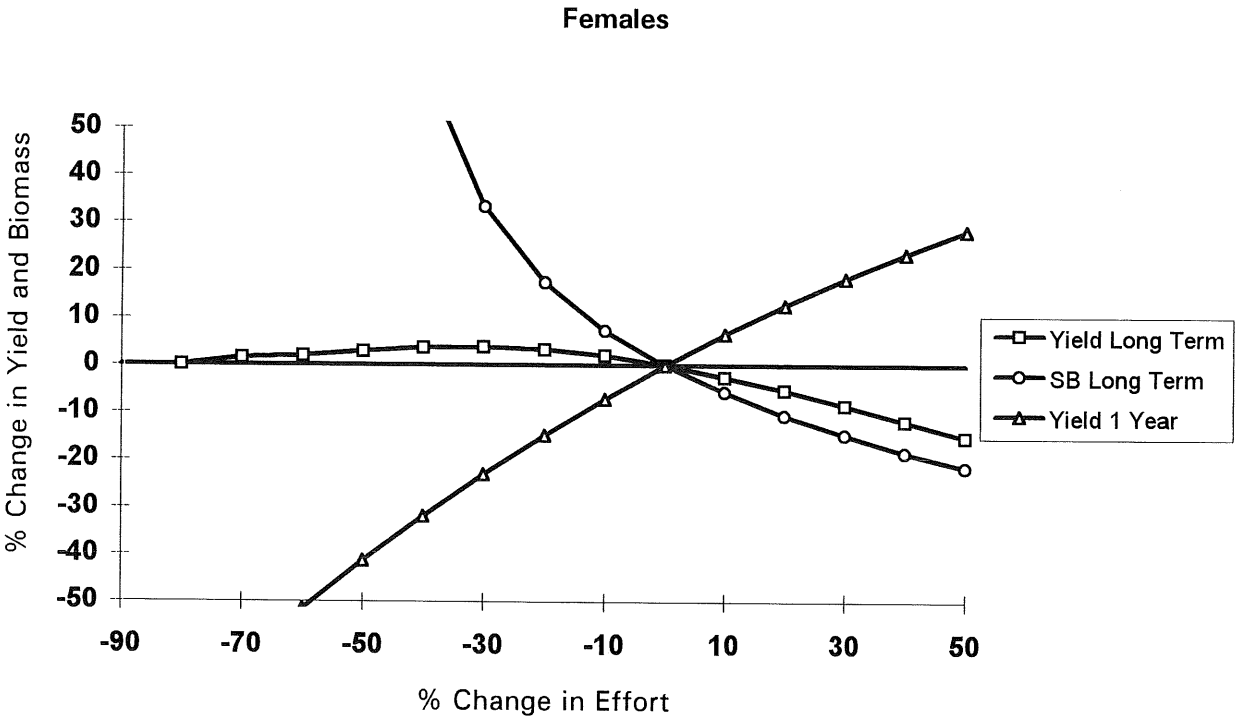


Figure 5.2.4 Skagerrak (FU3) and Kattegat (FU4): Percentage changes in long term landings and stock biomass, and short term landings following various changes in fishing effort. Males and females shown separately

5.3. Division Iva 44-48 E6-E7 + 44E8 (Management Area F)

Functional Units Moray Firth (9)
Noup (10)

The statistical rectangles comprising this Management Area and its constituent Functional Units are shown in Figure 5.1.1.

5.3.1. Moray Firth (Functional Unit 9)

Data and biological inputs

Adequate sampling of commercial trawl landings is usually achieved in this fishery. Details of sampling, on a quarterly basis, are given in Table 5.3.1. Discard sampling on board commercial fishing vessels was carried out during the 2nd, 3rd and 4th quarters of the year. The landing and discard samples were raised to fleet level and combined to estimate total removals assuming a discard survival of 25%. In the absence of reliable discard data before 1990, an average was estimated from the combined 1990-1993 data and this was applied retrospectively to estimate the removals in earlier years.

Input parameters were unchanged from previous years (Table 5.3.1).

Comments on the quality of inputs

In general this stock is well sampled, apart from the discards prior to 1990, and compared to some other Scottish grounds, there appears to be less biological variation in growth and other parameters (see Anon.,1993).

Landings, effort, LPUE, mean size

Landings data were reported for UK vessels only. Provisionally, total landings in 1994 were 1501 t, lower than at any time in the reference period, and well below the peak landings of 1989 (Table 5.3.2 and Figure 5.3.1). *Nephrops* trawlers accounted for 1163 t (77% of the 1994 total). In 1994, fishing effort by these vessels was slightly down on the previous year, and well below the high levels in the period 1987-1990 (Table 5.3.3 and Figure 5.3.1).

No detailed information is available concerning the accuracy of landings statistics. Some under-reporting of landings is likely to have occurred towards the end of 1994, resulting from the rapid take up of the UK quota.

In 1994, there was a decline in overall *Nephrops* trawl LPUE (Table 5.3.3), compared to previous years, though over the full time series LPUE has fluctuated without obvious trend (Figure 5.3.1). The recent decline may have partly arisen from a fall in effort using multi-rig trawls (Table 5.3.3). The use of multi-rig trawls has declined in this fishery following the UK national ban; they accounted for only 11% of hours fished in 1994 compared to 42% in 1993. The reduction in overall LPUE appears to be associated with a decline in male LPUE (Figure 5.3.2). In contrast, female LPUE has increased in recent years. These changes seem to reflect a different seasonal fishing pattern, with high fishing effort in the 3rd quarter and a relative reduction in fishing in the 4th quarter, resulting in a more balanced exploitation of the sexes in this FU, compared to other Scottish stocks.

The mean size of males and females has risen in recent years in both landings and catches (Table 5.3.4, Figure 5.3.1). Note that mean size data given here, and elsewhere in this Report for other FUs around Scotland, may differ slightly from the values given in previous Reports. This has arisen because of a major reorganisation of the Scottish *Nephrops* database to allow analysis at the Statistical Rectangle level. The trends in the data are not affected.

Assessments

Length-based assessment

In view of the revision of the length composition data, it was considered appropriate to update the LCA. The reference period chosen was 1991-94, during which fishing effort was reasonably stable (Figure 5.3.1). Input F values were the same as previously (0.05, 0.025 for males and females respectively). Output from the LCAs are given in Tables 5.3.5 and 5.3.6 for males and females respectively. For males, the LCA resulted in a fairly flat-topped Y/R curve, with current F above Fmax (Figure 5.3.3). In females, the Y/R relationship was curvi-linear (Figure 5.3.3), with current F well below Fmax. These results were essentially similar to those given in last year's Report. Annualised fishing mortalities (averaged across the inter-quartile length range) were 0.56 and 0.08 for males and females respectively.

Age-based assessment

A single fleet assessment was carried out using Scottish data from 1981-1994. The Lowestoft VPA program was used on nominal 'age' groups generated by slicing the length distributions. Tuning of the VPA was carried out using Scottish *Nephrops* trawl effort data, adjusted to total trawl effort. The sexes were assessed separately.

Males

The slicing procedure generated 9 nominal 'age' groups (9 = plus group). Catch numbers and mean weights at age are shown in Table 5.3.7. Weights at age were assumed to represent stock mean weights. Preliminary calculations showed SOP discrepancies were small in relation to landed weights, and since the analysis included a proportion of discards, no corrections were applied. Natural mortality and maturity parameters are also given in Table 5.3.7.

The fleet catchability residuals, arising from Laurec-Shepherd tuning are plotted in Figure 5.3.4. For young ages, there was no evidence of trends in the residuals but, for age 1, there were large fluctuations in the most recent years. The residuals for the older age groups showed strong year effects.

Tuning of the VPA was carried out using the XSA option (v.3.1). Tuning was performed over the whole 14 year period, over ages 1 - 8, with a tricubic time taper but without shrinkage. For the catchability analysis, catchability was dependent on stock size for ages < 3, with estimates shrunk to the population mean; catchability was independent of age for ages≥5. Survivor estimates were shrunk towards mean F. Tuning details and results are given in Table 5.3.8. The tuning converged after 18 iterations.

F at age and population numbers at age estimated by the VPA are given in Tables 5.3.9. Annual mean F values were calculated for ages 3-6 (Table 5.3.9) and are plotted with trawl effort data in Figure 5.3.5. The correlation coefficient between mean F and effort is significant (r^2=0.42, P<0.05), suggesting that the VPA has performed reasonably well.

Trends in the estimates of yield, mean F, TSB and recruitment are given in Table 5.3.9 and plotted in Figure 5.3.6. Landings of males increased during the 1980s, reaching a peak in 1989, and then declined. Mean F has fluctuated, with evidence of a rising trend; F was high in 1989. TSB and recruitment estimates reveal similar trends; apparently increasing during the mid 1980s and then declining (see also Figure 5.3.2).

Females

The slicing procedure gave 16 'nominal age' groups (16 = plus group). Catch numbers and mean weights at age data are given in Table 5.3.10. As for the males, mean catch weights at age were assumed to represent stock weights and no SOP corrections were applied. Different values of M were chosen for immature and mature females (Tables 5.3.10, and 5.3.1).

Fleet catchability residuals from Laurec-Shepherd are plotted in Figure 5.3.7. These show marked trends and year effects at most ages.

XSA tuning choices were the same as for males (Table 5.3.11). The tuning had not converged to the program criteria after 50 iterations (examination of the final year F values from the last two iterations suggests that convergence had occurred to 3 decimal places).

Estimates of F at age and population numbers at age from the VPA are given in Tables 5.3.12.. Fishing mortality estimates for females were extremely low, mostly less than 0.1. Annual mean F was calculated over age groups 3-13 (Table 5.3.12) and these values are plotted with trawl fishing effort in Figure 5.3.8. The relationship between mean F and effort is not significant (r^2=0.23), indicating that the VPA has again not performed well in the case of females (see Anon., 1994a).

Trends in yield, mean F, TSB and recruitment estimated by the VPA are shown in Figure 5.3.9. Female landings show a rising trend; mean F values are extremely low, much lower than for males. The estimates of TSB and recruitment show similar trends, both being relatively high in the late 1980s. Comparison between TSB and recruitment estimates for the two sexes (Tables 5.3.9 and 5.3.12) shows greater values in females (by a factor of 3) than in males. This is regarded as unrealistic.

Other aspects

Landings and fishing effort/area indices are shown in Figure 5.3.10. This suggests that both indices are quite low in comparison with some other Scottish stocks.

A combined TV camera and trawl survey of this stock was carried out by Scotland in 1993 and 1994. Results for the 1994 survey are given in Table 5.3.13. Estimates of the mean burrow density across different parts of the ground varied from 0.05 to 0.70/m^2. These estimates, raised to the total ground area (2195 km^2), gave an overall abundance estimate of 850 million burrows (95% confidence interval 640- 1060 million). From this abundance range, the equivalent stock biomass estimates were in the range 15,100 - 25,100 t (Table 5.3.14). This represents a large increase on the results from the 1993 survey.

As pointed out in the 1994 Report, comparisons between the TV estimates and those derived from analytical assessments are difficult in the case of this stock because the VPA results cannot be considered reliable for the females.

Comments on the quality of the assessments

The VPA appears to have performed reasonably well in males, but much less well in females, for which fishing mortalities were so low that the tuning failed to converge.

Management considerations

The LCA results on males (Figure 5.3.3) suggested that exploitation was marginally above optimum and, in any case, the Y/R curve is very flat-topped, offering little gain from a reduction in effort. Fishing effort is currently well below the high levels of 1987-1990 (Figure 5.3.1) and the VPA results suggest that fishing mortality on males has recently stabilised below the high value in 1989 (Figure 5.3.6). Other recent indices of stock condition, LPUE (Figure 5.3.1), landings/area and effort/area (Figure 5.3.10) suggest that the stock is in a healthy state. Maintenance of

fishing effort around the current level would be appropriate for this stock.

5.3.2. Noup (Functional Unit 10)

Data and biological inputs

No sampling of the landings has taken place in this small fishery to date, and biological parameters for the stock are largely unknown. However, a TV survey of the ground was conducted by Scotland in June 1994, providing estimates of burrow density and abundance of the stock.

Landings, effort, LPUE, mean size

Landings data were reported for UK vessels only. In 1994, landings from the Noup were 491 t, the highest landings ever recorded (Table 5.3.15). Most of the landings (63%) were taken by *Nephrops* trawlers. No details are available concerning under-reporting of landings (see Section 5.3.1).

Table 5.3.16 and Figure 5.3.11 show marked fluctuations in LPUE, with recent values relatively high compared to most other Scottish stocks. The use of multi-rig gear in 1994 declined to 8% of *Nephrops* trawl effort (Table 5.3.16). No mean size data are available.

Assessments

As noted previously, the absence of length composition data and biological information precludes stock assessments by analytical methods. The stock survey, based on TV camera tows at 10 stations, gave a mean density estimate of 0.63 burrows/m^2 (SD = 0.32). This density, raised to the total ground area (398.5 km^2), gave a mean stock abundance estimate of 250 million burrows (95% confidence interval 160 - 340). Since no trawl sampling was possible at the time of the TV survey, the mean weight of *Nephrops* in the Moray Firth trawl samples (24g) was used to provide preliminary stock biomass estimates in the range 4,000 - 8,000 t.

A measure of the relative fishing 'pressure' on the stock is provided by landings/area and effort/area indices. Using the high 1994 landings (Table 5.3.15) and equivalent effort gave indices of 1.23 t/km^2 and 0.033 '000h/km^2 respectively. As reported last year, these values are comparable to the indices for some other Scottish grounds, given in Figure 5.3.10.

Management considerations

In the absence of any analytical assessment, predictions about the state of the Noup stock can only be based on LPUE, landings/area trends and a preliminary TV survey. Comparisons with other Scottish stocks in terms of the landings and effort/area indices (Figure 5.3.10) suggests that current levels of fishing effort may be close to the optimum for this small Functional Unit. Maintenance of effort at this level would be acceptable.

5.3.3. Summary for Division IVa 44-48 E6-E7 + 44E8 (Management Area F)

The recent landings in FU 9 and 10 and from other ICES rectangles forming MA F are given in Tables 5.3.17 and 5.3.18. The Working Group again advised that maintenance of fishing effort at the current level in the Moray Firth (FU 9) should be the main management objective.

Table 5.3.1 Input data and parameters: Moray Firth

FU	9	MA	F
FLEET	UK Scotland	GEAR	Nephrops and Light trawl

1994	NUMBER OF SAMPLES				Mean
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	No./sample
Catch					
Landings	3	10	13	11	480
Discards	0	2	5	4	173

	NUMBER OF SAMPLES									
YEAR	94	93	92	91	90	89	88	87	86	85
Catch										
Landings	37	52	49	46	78	44	42	84	67	59
Discards	11	8	7	9	8					

INPUT PARAMETERS		
Parameter	Value	Source
Discard Survival	0.25	Gueguen and Charuau,1975; Anon.,1985
MALES		
Growth - K	0.165	Adapted from Bailey and Chapman, 1983
Growth - L(inf)	62	"
Nat. Mort. - M	0.3	Morizur, 1982
Length/weight - a	0.00028	Howard and Hall, 1983
Length/weight - b	3.24	"
FEMALES		
Immature Growth		
K	0.165	as for males
L(inf)	62	"
Nat.Mort. - M	0.3	"
Size at Maturity	23	Adapted from Bailey, 1984
Mature Growth		
K	0.06	as for males
L(inf)	56	"
Nat.Mort. - M	0.2	assumed *
Length/weight - a	0.00074	as for males
Length/weight - b	2.91	"

* based on Morizur, 1982 and assuming lower mature female rate

Table 5.3.2 Moray Firth (Functional Unit 9) : Landings (tonnes) by gear, all UK, 1985-94

Year	Nephrops	Other trawl	Total
1985	1908	173	2081
1986	1933	210	2143
1987	1723	268	1991
1988	1638	321	1959
1989	2102	474	2576
1990	1700	338	2038
1991	1284	233	1517
1992	1282	305	1587
1993	1505	302	1807
1994*	1163	338	1501

* provisional

Table 5.3.3 Moray Firth (Functional Unit 9) : Landings (tonnes), effort ('000 hours trawling), and LPUE (kg/hour trawling) of Scottish Nephrops trawlers, 1985-94. Figures in brackets left and right of the overall values are for single and multi-rig respectively

Year	Landings	Effort	LPUE
1985	1908	49.2	38.8
1986	1933	51.6	37.5
1987	1723	70.6	24.4
1988	1638	60.9	26.9
1989	2102	69.6	30.2
1990	1700	58.4	29.1
1991	(571) 1284 (713)	(25.1) 47.1 (22.0)	(22.7) 27.3 (32.5)
1992	(617) 1282 (651)	(24.8) 41.5 (16.1)	(24.8) 30.9 (40.4)
1993	(783) 1505 (722)	(28.1) 48.6 (20.6)	(27.9) 30.9 (35.1)
1994*	(1012)1163 (151)	(41.2) 46.5 (5.3)	(24.6) 25.0 (28.3)

* provisional

Table 5.3.4 Moray Firth (Functional Unit 9) : Mean sizes (CL mm) of male and female Nephrops in Scottish landings, 1985-94. Mean sizes in catches, 1990-95, given in parenthesis

Year	Males	Females
1985	31.2	29.8
1986	30.4	29.0
1987	31.5	29.6
1988	31.0	30.2
1989	32.6	30.4
1990	32.5 (30.8)	30.7 (29.6)
1991	31.9 (29.9)	29.3 (28.0)
1992	33.6 (31.7)	32.0 (29.8)
1993	34.6 (32.9)	32.4 (31.3)
1994	34.6 (32.4)	32.6 (31.5)

Table 5.3.5 Moray Firth (FU9): Males - LCA output

COHORT ANALYSIS
L INFINITY = 62.0000 K = .1650

COHORT ANALYSIS BY POPE'S APPROXIMATION

SIZE MM	REMOVALS	M	DT	FDT	F	Z	NO. ATTAINING	AVE. NO. IN SEA	BIOMASS kg
13.0	2.3	.3000	.2526	.0000	.0001	.3001	112201.4	27290.6	40066.9
15.0	7.7	.3000	.2635	.0001	.0003	.3003	104012.0	26355.3	59639.6
17.0	43.6	.3000	.2755	.0005	.0017	.3017	96097.6	25407.1	84208.5
19.0	259.5	.3000	.2887	.0031	.0106	.3106	88431.9	24415.3	113846.1
21.0	930.8	.3000	.3031	.0121	.0400	.3400	80847.8	23284.1	147852.2
23.0	2309.3	.3000	.3191	.0338	.1059	.4059	72931.3	21825.3	183722.8
25.0	4590.8	.3000	.3368	.0784	.2326	.5326	64073.0	19754.2	215521.4
27.0	5110.4	.3000	.3566	.1061	.2976	.5976	53550.9	17199.2	238571.6
29.0	5486.0	.3000	.3789	.1441	.3803	.6803	43273.6	14454.0	250715.3
31.0	5903.5	.3000	.4042	.2077	.5139	.8139	33440.9	11518.1	246255.9
33.0	5263.2	.3000	.4331	.2658	.6136	.9136	24065.9	8607.6	223971.1
35.0	4610.3	.3000	.4664	.3641	.7806	1.0806	16201.6	5935.9	185875.8
37.0	3018.3	.3000	.5053	.4045	.8004	1.1004	9787.3	3793.8	141545.1
39.0	1823.9	.3000	.5513	.4354	.7897	1.0897	5612.5	2326.1	102476.1
41.0	1018.3	.3000	.6066	.4500	.7419	1.0419	3077.7	1383.8	71404.7
43.0	582.8	.3000	.6741	.5011	.7434	1.0434	1635.9	791.9	47509.1
45.0	288.3	.3000	.7586	.5091	.6712	.9712	809.7	434.6	30112.9
47.0	120.8	.3000	.8673	.4385	.5056	.8056	387.6	241.9	19237.0
49.0	54.4	.3000	1.0124	.3983	.3934	.6934	192.7	140.2	12726.6
51.0	18.4	.3000	1.2162	.2629	.2162	.5162	95.5	86.3	8891.5
53.0	8.3	.3000	1.5231	.2289	.1503	.4503	51.0	56.2	6545.2
55.0	1.8	.3000	2.0392	.1000	.0491	.3491	25.7	37.5	4908.8
57.0	1.8	.3000			.0500	.3500	12.6	37.5	5499.9
				TOTAL BIOMASS INCLUDES LENGTHS ABOVE +GP				235451.3	2453381.0

Table 5.3.6 Moray Firth (FU9): Females - LCA output

COHORT ANALYSIS

LOWER CURVE LINF= 62.0000 K= .1650
UPPER CURVE LINF= 56.0000 K= .0600
TRANSITION LENGTH= 23.0000

COHORT ANALYSIS BY POPE'S APPROXIMATION

SIZE MM	REMOVALS	M	DT	FDT	F	Z	NO. ATTAINING	AVE. NO. IN SEA	BIOMASS kg
13.0	8.5	.3000	.2526	.0000	.0001	.3001	254809.8	61976.5	99107.0
15.0	26.8	.3000	.2635	.0001	.0004	.3004	236208.2	59851.0	141157.8
17.0	74.3	.3000	.2755	.0004	.0013	.3013	218226.1	57699.7	191717.3
19.0	394.7	.3000	.2887	.0021	.0071	.3071	200841.9	55478.5	250476.3
21.0	1023.7	.3000	.3031	.0058	.0193	.3193	183803.5	53098.9	316359.0
23.0	3269.4	.2000	.3191	.0204	.0641	.2641	166849.8	51053.1	391815.5
25.0	6021.6	.2000	1.1115	.0449	.0404	.2404	153368.9	149599.7	1449265.0
27.0	7308.8	.2000	1.1910	.0727	.0610	.2610	117410.0	120184.1	1444513.0
29.0	7896.9	.2000	1.2827	.1102	.0859	.2859	86036.5	92384.2	1357266.0
31.0	7453.1	.2000	1.3897	.1551	.1116	.3116	59622.5	67249.8	1192125.0
33.0	6270.7	.2000	1.5162	.2091	.1379	.3379	38668.6	45876.8	970156.3
35.0	3498.0	.2000	1.6681	.1965	.1178	.3178	23165.3	29992.1	749016.1
37.0	1938.6	.2000	1.8538	.1877	.1013	.3013	13633.5	19365.0	566020.9
39.0	832.4	.2000	2.0861	.1410	.0676	.2676	7799.4	12468.3	423101.6
41.0	359.4	.2000	2.3850	.1078	.0452	.2452	4463.2	8059.7	315224.3
43.0	144.9	.2000	2.7842	.0801	.0288	.2288	2486.9	5121.3	229333.9
45.0	66.2	.2000	3.3445	.0729	.0218	.2218	1315.4	3106.0	158298.3
47.0	38.6	.2000	4.1886	.0984	.0235	.2235	626.4	1703.8	98282.8
49.0	18.8	.2000	5.6079	.1440	.0257	.2257	245.7	781.5	50768.0
51.0	7.7	.2000		.	.0250	.2250	69.3	781.5	56905.9
				TOTAL BIOMASS INCLUDES LENGTHS ABOVE +GP				897394.4	10577930.0

Table 5.3.7 Moray Firth (FU9) Males - VPA input

Run title : Moray Firth Males 19INDEX FILE

At 8/03/1995 9:33

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE														
1	45	47	74	98	144	115	175	191	164	168	115	19	1	58
2	3546	3420	3639	6013	13188	14065	12940	12346	11451	7592	8173	4270	2344	2237
3	17402	8887	9187	16597	29494	35387	28350	29397	36603	18441	21889	18025	10350	6485
4	14517	7441	6958	11865	17088	16512	16767	17852	24356	16856	14799	17459	12799	6360
5	6270	4324	3273	5589	8248	5685	7540	6176	9869	7232	5554	9230	8254	4023
6	2676	2370	1607	2502	2953	2472	2573	2757	5412	2165	1635	2736	2873	1881
7	1044	951	649	898	862	862	1129	627	2211	473	442	779	854	721
8	421	436	355	386	333	304	757	242	1169	212	110	211	316	323
+gp	193	377	690	302	181	128	551	224	910	168	61	82	159	195
0 TOTA	46112	28251	26433	44250	72493	75529	70781	69810	92144	53306	52776	52811	37949	22281
TONSLA	1004	676	598	895	1341	1272	1344	1263	1938	1099	919	1127	966	561

Run title : Moray Firth Males 19INDEX FILE

At 8/03/1995 9:33

Table 2 Catch weights at age (kg)

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE														
1	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.003	0.003	0.003	0.002
2	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
3	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
4	0.024	0.024	0.024	0.024	0.024	0.023	0.024	0.023	0.023	0.024	0.024	0.024	0.024	0.024
5	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.034	0.034	0.034	0.035	0.035
6	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.048	0.047	0.047	0.047	0.047	0.047
7	0.061	0.061	0.061	0.061	0.061	0.061	0.062	0.061	0.061	0.061	0.06	0.061	0.061	0.061
8	0.072	0.072	0.073	0.072	0.072	0.071	0.073	0.073	0.073	0.073	0.072	0.072	0.071	0.072
+gp	0.087	0.097	0.106	0.098	0.092	0.091	0.094	0.096	0.098	0.095	0.092	0.088	0.092	0.091
0 SOPC	0.9322	0.9397	0.9142	0.9035	0.9248	0.916	0.9174	0.9396	0.932	0.9707	0.89	0.9251	0.9819	0.9743

Run title : Moray Firth Males 19INDEX FILE

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Table 4 Natural Mortality (M) at age

YEAR	All Years
AGE	
1	0.3
2	0.3
3	0.3
4	0.3
5	0.3
6	0.3
7	0.3
8	0.3
+gp	0.3

Run title : Moray Firth Males 19INDEX FILE

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Table 5 Proportion mature at age

YEAR	All Years
AGE	
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
+gp	1

Table 5.3.8 Moray Firth (FU9) Males - VPA Tuning information

Lowestoft VPA Version 3.1

8/03/1995 9:47

Extended Survivors Analysis

Moray Firth Males 19INDEX FILE

CPUE data from file c:\nepdat\mf\males\tuneff.dat

Catch data for 14 years. 1981 to 1994. Ages 1 to 9.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
FLEET 1	1981	1994	1	8	0	1

Time series weights :

Tapered time weighting applied
Power = 3 over 20 years

Catchability analysis :

Catchability dependent on stock size for ages < 3

Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 3

Catchability independent of age for ages >= 5

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 5 years or the 5 oldest ages.

S.E. of the mean to which the estimates are shrunk = .500

Minimum standard error for population
estimates derived from each fleet = .300

Prior weighting not applied

Tuning converged after 18 iterations

Regression weights

0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0	0	0.001
2	0.109	0.124	0.107	0.106	0.12	0.079	0.117	0.103	0.088	0.081
3	0.45	0.537	0.444	0.427	0.594	0.325	0.387	0.459	0.437	0.42
4	0.64	0.562	0.606	0.644	0.905	0.701	0.538	0.711	0.816	0.606
5	0.81	0.515	0.626	0.534	1.124	0.891	0.6	0.918	1.083	0.766
6	0.6	0.703	0.53	0.561	1.804	0.955	0.577	0.793	0.999	0.919
7	0.664	0.392	0.991	0.262	1.681	0.914	0.58	0.698	0.713	0.869
8	0.598	0.595	0.84	0.673	1.396	0.833	0.628	0.709	0.803	0.754

XSA population numbers (Thousands)

AGE / YEAR	1	2	3	4	5	6	7	8
1985	190000	149000	94500	42000	17300	7600	2060	861
1986	200000	140000	99000	44600	16400	5690	3090	787
1987	193000	148000	91900	42900	18800	7260	2090	1550
1988	159000	143000	98300	43700	17300	7460	3170	573
1989	156000	117000	95000	47500	17000	7530	3160	1810
1990	117000	116000	77200	38900	14200	4090	918	435
1991	68700	86300	79200	41300	14300	4330	1160	273
1992	43800	50800	56900	39900	17900	5810	1800	483
1993	44900	32400	34000	26700	14500	5280	1950	664
1994	90000	33300	22000	16300	8730	3630	1440	708

Estimated population abundance at 1st Jan 1995

0	66600	22700	10700	6570	3010	1070	448

Taper weighted geometric mean of the VPA populations:

115000	88000	65300	35400	14900	5640	2020	782

Standard error of the weighted Log(VPA populations) :

0.5674	0.5708	0.4795	0.3161	0.222	0.2571	0.4121	0.5838

Table 5.3.8 (cont)

Log catchability residuals.

Fleet : FLEET 1

Age	1981	1982	1983	1984
1	-0.02	-0.09	0.03	-0.03
2	-0.11	-0.04	0.05	0.14
3	0.5	0	0.12	0.35
4	0.49	0.26	0.15	0.38
5	0.2	0.37	0.28	0.3
6	0.07	0.41	0.47	0.67
7	-0.06	0.11	0.15	0.57
8	0.09	0.1	0.06	0.13

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	-0.09	-0.28	-0.21	0.08	-0.06	0.34	0.8	0.41	-1.17	0.16
2	0.21	0.27	-0.21	-0.11	-0.13	-0.35	0.26	0.23	-0.03	-0.14
3	0.14	0.25	-0.29	-0.22	-0.05	-0.45	-0.05	0.2	0.03	-0.04
4	0.06	-0.13	-0.41	-0.24	-0.06	-0.12	-0.15	0.21	0.22	-0.11
5	0.16	-0.35	-0.51	-0.56	0.02	-0.01	-0.17	0.32	0.36	-0.01
6	-0.14	-0.05	-0.68	-0.51	0.48	0.05	-0.21	0.18	0.28	0.17
7	-0.04	-0.62	-0.06	-1.26	0.41	0.01	-0.21	0.06	-0.05	0.12
8	-0.14	-0.21	-0.23	-0.33	0.23	-0.08	-0.13	0.07	0.07	-0.02

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	3	4	5	6	7	8
Mean Log	-4.9348	-4.5079	-4.3753	-4.3753	-4.3753	-4.3753
S.E(Log q	0.2433	0.2386	0.3243	0.3894	0.4653	0.1697

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
1	0.49	1.847	11.51	0.58	14	0.51	-11.36
2	0.97	0.261	6.59	0.89	14	0.22	-6.44

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	1.07	-0.394	4.51	0.78	14	0.27	-4.93
4	1.24	-0.813	3.08	0.55	14	0.3	-4.51
5	1.6	-0.813	1.24	0.16	14	0.53	-4.38
6	1.55	-0.745	1.95	0.17	14	0.61	-4.32
7	1.33	-0.71	3.41	0.33	14	0.62	-4.46
8	0.9	1.254	4.63	0.95	14	0.14	-4.41

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength

Year class = 1993

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N		Scaled Weights	Estimated F
FLEET 1	78258	0.529	0	0		1	0.335	0.001
P shrinka	88016	0.57					0.289	0.001
F shrinka	46645	0.5					0.376	0.001

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
66641	0.31	0.23	3	0.746	0.001

Age 2 Catchability dependent on age and year class strength

Year class = 1992

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N		Scaled Weights	Estimated F
FLEET 1	16852	0.275	0.376	1.37		2	0.593	0.108
P shrinka	65273	0.48					0.212	0.029
F shrinka	17952	0.5					0.195	0.102

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
22731	0.22	0.4	4	1.843	0.081

Table 5.3.8 (cont)

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 1991

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	10907	0.198	0.104	0.53	3	0.8	0.413
F shrinkag	9944	0.5				0.2	0.446

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
10708	0.19	0.08	4	0.427	0.42

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

Year class = 1990

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	7109	0.17	0.141	0.83	4	0.785	0.571
F shrinkag	4941	0.5				0.215	0.746

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
6575	0.17	0.14	5	0.801	0.606

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

Year class = 1989

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	3417	0.175	0.061	0.35	5	0.703	0.7
F shrinkag	2222	0.5				0.297	0.939

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
3006	0.19	0.11	6	0.592	0.766

Age 6 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1988

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	1245	0.204	0.084	0.41	6	0.575	0.833
F shrinkag	879	0.5				0.425	1.044

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
1074	0.24	0.11	7	0.451	0.919

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1987

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	496	0.23	0.084	0.37	7	0.515	0.812
F shrinkag	402	0.5				0.485	0.933

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
448	0.27	0.08	8	0.291	0.869

Age 8 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1986

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	240	0.209	0.028	0.13	8	0.666	0.769
F shrinkag	260	0.5				0.334	0.727

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
246	0.22	0.03	9	0.123	0.754

Table 5.3.9 Moray Firth (FU9) Males - VPA outputs

Run title : Moray Firth Males 19INDEX FILE

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Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	FBAR 92-94
AGE															
1	0.0004	0.0004	0.0005	0.0006	0.0009	0.0007	0.0011	0.0014	0.0012	0.0017	0.0019	0.0005	0	0.0008	0.0004
2	0.0573	0.0473	0.0404	0.0533	0.1086	0.1238	0.1073	0.106	0.1202	0.0793	0.1165	0.1027	0.0878	0.0813	0.0906
3	0.4825	0.2224	0.1933	0.2927	0.4505	0.5367	0.4439	0.4268	0.5935	0.3252	0.3871	0.4587	0.4368	0.4195	0.4383
4	0.7327	0.443	0.3056	0.4648	0.6399	0.5622	0.6057	0.6443	0.9047	0.7007	0.5384	0.7113	0.8161	0.6057	0.711
5	0.6271	0.57	0.402	0.4902	0.8102	0.5151	0.6257	0.5342	1.1242	0.8908	0.6005	0.9177	1.0833	0.7662	0.9224
6	0.5509	0.5887	0.4868	0.7145	0.6	0.7033	0.5303	0.5607	1.8037	0.9555	0.5772	0.7926	0.9986	0.919	0.9034
7	0.4826	0.4346	0.3517	0.6408	0.6642	0.3916	0.9911	0.2616	1.6808	0.9135	0.5804	0.6981	0.7126	0.869	0.7599
8	0.5597	0.4304	0.3207	0.4126	0.5977	0.5946	0.8399	0.6729	1.3958	0.8334	0.6277	0.7094	0.803	0.7545	0.7556
+gp	0.5597	0.4304	0.3207	0.4126	0.5977	0.5946	0.8399	0.6729	1.3958	0.8334	0.6277	0.7094	0.803	0.7545	
0 FBAR '3-6	0.5983	0.456	0.3469	0.4906	0.6252	0.5793	0.5514	0.5415	1.1065	0.718	0.5258	0.7201	0.8337	0.6776	

Run title : Moray Firth Males 19INDEX FILE

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Terminal Fs derived using XSA (With F shrinkage)

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	GMST 81-92	AMST 81-92
AGE																	
1	116077	144206	181674	201180	189646	199568	192679	158796	156454	116738	68743	43764	44929	90023	0	135682	147460
2	74005	85954	106790	134524	148954	140369	147745	142589	117475	115763	86337	50827	32405	33283	66641	107576	112611
3	52823	51772	60732	75980	94482	98996	91882	98315	95006	77171	79225	56925	33979	21989	22731	75672	77776
4	32473	24154	30705	37084	42002	44608	42881	43667	47531	38878	41298	39852	26658	16264	10708	38158	38761
5	15637	11562	11490	16758	17260	16408	18835	17336	16984	14249	14293	17857	14496	8732	6575	15543	15722
6	7339	6188	4844	5694	7604	5687	7262	7463	7527	4088	4332	5808	5284	3635	3006	6022	6153
7	3168	3134	2544	2206	2065	3092	2085	3166	3156	918	1165	1802	1948	1442	1074	2219	2375
8	1140	1448	1503	1326	861	787	1548	573	1806	435	273	483	664	708	448	876	1015
+gp	513	1234	2888	1024	460	326	1098	519	1354	336	150	183	326	418	392		
0 TO	303176	329652	403171	475775	503333	509842	506016	472424	447294	368577	295815	217501	160688	176493	111575		

Run title : Moray Firth Males 19INDEX FILE

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Table 16 Summary (without SOP correction)

Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 6
1981	116077	3671	3671	1004	0.2733	0.5983
1982	144206	3535	3535	676	0.1912	0.456
1983	181674	4187	4187	598	0.1427	0.3469
1984	201180	4818	4818	895	0.1858	0.4906
1985	189646	5283	5283	1341	0.2538	0.6252
1986	199568	5249	5249	1272	0.2424	0.5793
1987	192679	5422	5422	1344	0.2479	0.5514
1988	158796	5240	5240	1263	0.2411	0.5415
1989	156454	5245	5245	1938	0.3695	1.1065
1990	116738	3969	3969	1099	0.2768	0.718
1991	68743	3790	3790	919	0.2426	0.5258
1992	43764	3332	3332	1127	0.3381	0.7201
1993	44929	2461	2461	966	0.3925	0.8337
1994	90023	1798	1798	561	0.3119	0.6776
Arith. Mean	136034	4143	4143	1072	0.265	0.6265
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 5.3.10 Moray Firth (FU9) Females - VPA inputs

Run title : Moray Firth Females INDEX FILE

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Table 1 Catch numbers at age Numbers*10**-3

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE														
1	94	82	122	99	214	240	208	182	212	282	175	75	12	140
2	8070	6093	5186	5065	12576	17667	13399	11305	10523	9620	11566	4633	2813	3717
3	7531	4518	3198	3661	9150	14464	8970	7433	9240	9059	9197	4995	3970	3690
4	6709	5279	3093	3452	9262	11829	8028	7852	9772	10238	9247	4619	6029	4653
5	4634	4294	2824	2816	7328	8385	5671	6256	6669	7936	7484	4180	6872	6081
6	3139	3626	2501	2130	5527	5580	4426	4894	4574	6233	4904	3922	6848	7061
7	2153	3005	2204	1655	4218	3688	3550	3888	3130	4867	3054	3561	6414	7412
8	1514	2009	1806	1387	3182	2489	2577	2993	1922	3223	2032	2687	5108	6716
9	927	1364	1163	892	2093	1828	1718	2062	1232	2365	1211	1862	3355	4489
10	655	1061	868	665	1590	1521	1318	1628	919	1968	833	1471	2547	3445
11	323	473	605	455	1000	1065	737	951	799	1450	385	611	1647	1540
12	295	432	551	413	900	980	670	880	766	1330	355	557	1469	1367
13	161	226	280	204	401	556	339	529	603	737	202	292	587	516
14	151	215	264	193	377	527	324	500	583	704	192	279	556	488
15	41	91	86	63	111	210	156	173	354	338	83	131	211	178
+gp	118	296	361	221	347	734	822	809	1144	1321	304	504	489	593
0 TOTA	36514	33063	25111	23369	58276	71762	52914	52331	52439	61672	51222	34377	48926	52086
TONSLA	412	444	342	275	740	871	646	695	630	936	597	462	837	938

Run title : Moray Firth Females INDEX FILE

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Table 2 Catch weights at age (kg)

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE														
1	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
2	0.008	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008
3	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
5	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
6	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.017
7	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
8	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
9	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
10	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
11	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029
12	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
13	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
14	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
15	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
+gp	0.044	0.046	0.048	0.047	0.044	0.046	0.048	0.047	0.046	0.047	0.048	0.047	0.043	0.045
0 SOPC	0.858	0.9206	0.8903	0.8195	0.9083	0.9113	0.8839	0.9037	0.8386	0.9779	0.8945	0.8457	0.9688	0.9926

Run title : Moray Firth Females INDEX FILE

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Table 4 Natural Mortality (M) at age

YEAR	All Years
AGE	
1	0.3
2	0.3
3	0.2
4	0.2
5	0.2
6	0.2
7	0.2
8	0.2
9	0.2
10	0.2
11	0.2
12	0.2
13	0.2
14	0.2
15	0.2
+gp	0.2

Run title : Moray Firth Females INDEX FILE

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Table 5 Proportion mature at age

YEAR	1981
AGE	
1	0
2	0
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
11	1
12	1
13	1
14	1
15	1
+gp	1

Table 5.3.11 Moray Firth (FU9) Females - VPA tuning information

Lowestoft VPA Version 3.1

8/03/1995 11.51

Extended Survivors Analysis

Moray Firth Females INDEX FILE

CPUE data from file c:\nepdat\mf\females\tuneff.dat

Catch data for 14 years 1981 to 1994 Ages 1 to 16

Fleet	First year	Last year	First age	Last age	Alpha	Beta
FLEET 1	1981	1994	1	15	0	1

Time series weights :

Tapered time weighting applied
Power = 3 over 20 years

Catchability analysis :

Catchability dependent on stock size for ages < 3

Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 3

Catchability independent of age for ages >= 5

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 5 years or the 5 oldest ages.

S E of the mean to which the estimates are shrunk = 500

Minimum standard error for population
estimates derived from each fleet = 300

Prior weighting not applied

Tuning had not converged after 50 iterations

Total absolute residual between iterations
49 and 50 = 00324

Final year F values

Age	1	2	3	4	5	6	7	8	9	10
Iteration 4	0.0005	0 0311	0.047	0.0562	0.0636	0 0897	0.1136	0 1241	0 1105	0 1132
Iteration 5	0.0005	0 031	0.0469	0 0561	0 0634	0.0894	0.1133	0 1238	0 1102	0 1129

Age	11	12	13	14	15
Iteration 4	0.0764	0.096	0 0596	0 0782	0 0438
Iteration 5	0.0762	0 0957	0.0594	0.078	0 0436

Regression weights

0 751	0 82	0 877	0 921	0 954	0 976	0 99	0 997	1	1

Fishing mortalities

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.001	0.001	0.001	0 001	0.001	0.001	0 001	0.001	0	0 001
2	0.053	0.068	0.05	0.041	0 042	0.042	0.055	0 033	0 027	0.031
3	0.057	0.084	0.047	0.037	0 045	0.048	0.054	0.032	0.037	0.047
4	0.088	0.097	0.062	0.053	0.062	0.064	0.063	0.035	0.049	0.056
5	0.098	0.107	0.061	0.062	0.058	0.066	0.061	0 037	0.066	0.063
6	0.108	0.1	0.075	0.069	0 059	0.07	0.053	0 041	0.078	0.089
7	0.113	0.097	0.085	0.088	0.058	0.082	0 044	0.049	0.087	0.113
8	0.11	0.091	0.091	0.096	0.057	0.077	0.045	0 05	0.093	0.124
9	0.093	0.086	0.083	0.098	0.052	0.092	0.038	0.053	0.082	0.11
10	0.086	0.09	0.082	0.106	0 058	0.11	0.042	0.059	0.095	0.113
11	0.071	0.077	0.058	0.078	0.069	0.122	0.028	0 04	0.086	0.076
12	0.099	0.092	0.063	0.09	0.083	0.158	0.039	0.052	0 126	0.096
13	0.054	0.082	0.041	0.065	0.083	0.108	0.032	0.041	0.071	0.059
14	0.072	0.093	0.063	0.079	0.095	0 131	0.037	0.057	0 103	0.078
15	0.036	0.052	0.036	0.043	0 074	0 073	0 02	0.032	0 056	0 044

XSA population numbers (Thousands)

AGE / YEAR	1	2	3	4	5	6	7	8	9	10
1985	423000	281000	183000	122000	87100	59700	43500	33600	26100	21200
1986	434000	313000	198000	141000	91600	64700	43900	31800	24700	19400
1987	443000	321000	217000	149000	105000	67400	47900	32600	23800	18500
1988	406000	328000	226000	169000	114000	80900	51200	36000	24400	17900
1989	369000	300000	233000	179000	131000	88100	61800	38400	26800	18100
1990	341000	273000	213000	183000	137000	102000	68000	47800	29700	20800
1991	225000	252000	194000	167000	140000	105000	77500	51200	36200	22200
1992	167000	167000	177000	150000	128000	108000	81800	60700	40100	28500
1993	191000	123000	120000	140000	119000	101000	84900	63700	47300	31200
1994	297000	141000	89000	94300	109000	91200	76500	63700	47500	35700

Estimated population abundance at 1st Jan 1995

0	221000	102000	69700	73200	84200	68500	56100	46200	35000

Taper weighted geometric mean of the VPA populations :

309000	229000	168000	137000	107000	79900	59000	42700	30600	22000

Standard error of the weighted Log(VPA populations)

0.3324	0.3406	0 3074	0.2442	0 2353	0.2573	0.2749	0 2854	0 2709	0 2474

AGE / YEAR	11	12	13	14	15
1985	16200	10500	8420	5970	3450
1986	15900	12300	7800	6530	4550
1987	14500	12100	9210	5880	4870
1988	14000	11200	9290	7240	4520
1989	13200	10600	8410	7130	5470
1990	14000	10100	7970	6340	5310
1991	15200	10100	7040	5860	4550
1992	17400	12100	7970	5580	4620
1993	22000	13700	9430	6260	4320
1994	23200	16600	9880	7190	4620

Estimated population abundance at 1st Jan 1995

26200	17700	12400	7650	5460

Taper weighted geometric mean of the VPA populations :

15600	11200	7940	5790	4040

Standard error of the weighted Log(VPA populations)

0 2169	0 1997	0 1996	0 2412	0 3654

Table 5.3.11 (cont)

Log catchability residuals.

Fleet : FLEET 1

Age	1981	1982	1983	1984
1	0.18	0.17	0.39	0.05
2	0.57	0.45	0.43	0.09
3	0.8	0.53	0.31	0.17
4	0.67	0.72	0.39	0.19
5	0.46	0.68	0.53	0.27
6	0.29	0.76	0.66	0.31
7	0.21	0.78	0.78	0.32
8	0.27	0.67	0.8	0.39
9	0.01	0.7	0.63	0.16
10	0.03	0.67	0.77	0.14
11	-0.16	0.22	0.63	0.19
12	0.06	0.66	0.88	0.31
13	-0.07	0.31	0.74	-0.04
14	0.31	0.75	0.98	0.44
15	0.04	0.33	0.34	-0.39

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.03	0.03	-0.29	-0.22	-0.13	0.25	0.51	0.34	-1.01	0.05
2	0.22	0.34	-0.2	-0.27	-0.37	-0.19	0.23	-0.04	-0.24	-0.17
3	0.28	0.61	-0.33	-0.45	-0.42	-0.15	0.19	-0.26	-0.22	-0.02
4	0.46	0.49	-0.32	-0.36	-0.34	-0.12	0.1	-0.43	-0.21	-0.1
5	0.48	0.51	-0.4	-0.27	-0.5	-0.17	-0.03	-0.45	0.01	-0.06
6	0.58	0.44	-0.2	-0.17	-0.48	-0.11	-0.17	-0.34	0.17	0.28
7	0.63	0.42	-0.07	0.07	-0.5	0.05	-0.34	-0.16	0.29	0.52
8	0.61	0.34	0	0.17	-0.52	-0.01	-0.33	-0.14	0.35	0.61
9	0.43	0.28	-0.1	0.18	-0.6	0.16	-0.5	-0.09	0.22	0.49
10	0.36	0.34	-0.11	0.26	-0.5	0.34	-0.39	0.02	0.37	0.52
11	0.16	0.18	-0.46	-0.04	-0.32	0.44	-0.79	-0.38	0.28	0.12
12	0.5	0.36	-0.37	0.1	-0.14	0.7	-0.46	-0.1	0.66	0.35
13	-0.11	0.24	-0.79	-0.23	-0.14	0.32	-0.66	-0.33	0.08	-0.13
14	0.19	0.37	-0.38	-0.03	-0.01	0.51	-0.52	-0.02	0.46	0.15
15	-0.5	-0.2	-0.93	-0.64	-0.25	-0.07	-1.12	-0.6	-0.16	-0.43

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	3	4	5	6	7	8	9	10	11	12
Mean Log	-7.1339	-6.8772	-6.7954	-6.7954	-6.7954	-6.7954	-6.7954	-6.7954	-6.7954	-6.7954
S.E(Log q	0.3731	0.3763	0.3907	0.3907	0.4294	0.4368	0.3988	0.409	0.3986	0.4811

Age	13	14	15
Mean Log	-6.7954	-6.7954	-6.7954
S.E(Log q	0.4048	0.4405	0.5772

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
1	0.61	0.974	12.04	0.4	14	0.43	-11.67
2	0.8	0.707	8.24	0.58	14	0.3	-7.24

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	1.65	-1.056	3.93	0.22	14	0.61	-7.13
4	11.28	-2.249	-44.02	0.01	14	3.6	-6.88
5	-3.09	-4.043	26.38	0.09	14	0.77	-6.8
6	******	-2.844	605.91	0	14	38.2	-6.71
7	2.62	-1.459	-0.4	0.08	14	0.98	-6.64
8	1.23	-0.416	5.69	0.26	14	0.51	-6.62
9	1.02	-0.044	6.62	0.32	14	0.41	-6.69
10	0.76	0.655	7.43	0.45	14	0.29	-6.63
11	0.82	0.365	7.32	0.31	14	0.34	-6.82
12	1.01	-0.009	6.56	0.18	14	0.45	-6.58
13	2.82	-1.067	3.11	0.04	14	1.1	-6.89
14	2.94	-1.325	2.67	0.05	14	1.14	-6.62
15	2.03	-1.571	6.03	0.2	14	0.77	-7.19

Table 5.3.11 (cont)

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength

Year class = 1993

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N		Scaled Weights	Estimated F
FLEET 1	231469	0.446	0	0	1		0.285	0.001
P shrinka	228730	0.34					0.488	0.001
F shrinka	192129	0.5					0.227	0.001

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
220618	0.24	0.06	3	0.265	0.001

Age 2 Catchability dependent on age and year class strength

Year class = 1992

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	68555	0.298	0.369	1.24	2	0.428	0.046
P shrinka	168111	0.31				0.415	0.019
F shrinka	78928	0.5				0.157	0.04

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
101727	0.2	0.36	4	1.845	0.031

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 1991

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	68470	0.23	0.161	0.7	3	0.816	0.048
F shrinka	75552	0.5				0.184	0.043

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
69719	0.21	0.12	4	0.579	0.047

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

Year class = 1990

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	72905	0.191	0.142	0.74	4	0.861	0.056
F shrinka	74867	0.5				0.139	0.055

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
73175	0.18	0.11	5	0.64	0.056

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

Year class = 1989

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	83094	0.174	0.107	0.61	5	0.878	0.064
F shrinka	92838	0.5				0.122	0.058

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
84229	0.16	0.09	6	0.554	0.063

Table 5.3.11 (cont)

Age 6 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1988

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	65098	0.16	0.108	0.68	6	0.889	0.094
F shrinka	102697	0.5				0.111	0.06

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
68480	0.15	0.11	7	0.733	0.089

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1987

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	52246	0.152	0.129	0.85	7	0.892	0.121
F shrinka	100860	0.5				0.108	0.064

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
56076	0.15	0.14	8	0.958	0.113

Age 8 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1986

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	42730	0.145	0.124	0.86	8	0.896	0.133
F shrinka	91073	0.5				0.104	0.065

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
46244	0.14	0.14	9	0.998	0.124

Age 9 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1985

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	32845	0.14	0.108	0.77	9	0.902	0.117
F shrinka	62017	0.5				0.098	0.063

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
34962	0.14	0.12	10	0.866	0.11

Age 10 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1984

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	24951	0.137	0.111	0.82	10	0.905	0.118
F shrinka	41156	0.5				0.095	0.073

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
26168	0.13	0.11	11	0.844	0.113

Table 5.3.11 (cont)

Age 11 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1983

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	17487	0.132	0.098	0.74	11	0.91	0.077
F shrinka	19430	0.5				0.09	0.069

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
17654	0.13	0.09	12	0.696	0.076

Age 12 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1982

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	12305	0.131	0.1	0.77	12	0.909	0.096
F shrinka	12832	0.5				0.091	0.092

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
12352	0.13	0.09	13	0.719	0.096

Age 13 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1981

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	7750	0.13	0.106	0.82	13	0.909	0.058
F shrinka	6713	0.5				0.091	0.067

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
7650	0.13	0.1	14	0.773	0.059

Age 14 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1980

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	5513	0.13	0.111	0.86	14	0.91	0.077
F shrinka	4991	0.5				0.09	0.085

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
5465	0.13	0.1	15	0.811	0.078

Age 15 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1979

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	3914	0.134	0.113	0.85	14	0.904	0.04
F shrinka	1827	0.5				0.096	0.085

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
3637	0.13	0.12	15	0.935	0.044

Table 5.3.12 Moray Firth (FU9) Females - VPA outputs

Run title : Moray Firth Females INDEX FILE

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Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	FBAR 92-94
AGE															
1	0.0004	0.0003	0.0004	0.0003	0.0006	0.0006	0.0005	0.0005	0.0007	0.001	0.0009	0.0005	0.0001	0.0005	0.0004
2	0.0551	0.0373	0.0287	0.0236	0.0533	0.0678	0.0497	0.0409	0.0416	0.0418	0.0548	0.0328	0.0268	0.031	0.0302
3	0.0712	0.0416	0.0259	0.0268	0.0569	0.0844	0.0468	0.037	0.0448	0.048	0.0538	0.0317	0.0374	0.0469	0.0387
4	0.0808	0.0652	0.0361	0.0352	0.0875	0.097	0.0615	0.0526	0.0624	0.0639	0.0633	0.0345	0.0487	0.0561	0.0464
5	0.0713	0.0681	0.045	0.0418	0.0976	0.1066	0.0615	0.0623	0.0577	0.066	0.0608	0.0368	0.0659	0.0634	0.0554
6	0.06	0.0732	0.0514	0.0434	0.1079	0.1002	0.0753	0.0692	0.0591	0.0702	0.0529	0.0409	0.0779	0.0894	0.0694
7	0.0551	0.0751	0.058	0.0436	0.1134	0.0975	0.0855	0.0877	0.0576	0.0825	0.0445	0.0493	0.0871	0.1133	0.0832
8	0.0588	0.0668	0.0589	0.047	0.1105	0.0905	0.0914	0.0964	0.0569	0.0775	0.0448	0.0501	0.0928	0.1238	0.0889
9	0.0455	0.069	0.0501	0.0373	0.0929	0.0855	0.0832	0.0982	0.0522	0.0921	0.0377	0.0527	0.0817	0.1102	0.0815
10	0.0464	0.0673	0.0572	0.0365	0.0864	0.0904	0.0819	0.1059	0.0578	0.1105	0.0424	0.0587	0.0947	0.1129	0.0887
11	0.0384	0.0428	0.0497	0.0384	0.0708	0.0767	0.0577	0.0782	0.0693	0.1219	0.0283	0.0396	0.0862	0.0762	0.0673
12	0.0477	0.0661	0.0642	0.0434	0.0993	0.0918	0.0632	0.0905	0.0833	0.1578	0.0395	0.0521	0.1262	0.0957	0.0913
13	0.042	0.0468	0.0557	0.0305	0.0541	0.082	0.0415	0.065	0.0826	0.1078	0.0322	0.0413	0.0712	0.0594	0.0573
14	0.0613	0.0728	0.0708	0.0493	0.0724	0.0935	0.0627	0.0794	0.0947	0.131	0.0369	0.0567	0.1033	0.078	0.0793
15	0.0469	0.0476	0.0374	0.0214	0.0364	0.0524	0.0361	0.0433	0.0741	0.0729	0.0203	0.0318	0.0555	0.0436	0.0436
+gp	0.0469	0.0476	0.0374	0.0214	0.0364	0.0524	0.0361	0.0433	0.0741	0.0729	0.0203	0.0318	0.0555	0.0436	
0 FBAR	0.0561	0.062	0.0502	0.0385	0.0888	0.0912	0.0681	0.0766	0.0622	0.0907	0.0455	0.0443	0.0791	0.0861	

Run title : Moray Firth Females INDEX FILE

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Terminal Fs derived using XSA (With F shrinkage)

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	GMST 81-92	AMST 81-92
AGE																	
1	261312	287423	341280	379847	422658	433648	443111	405600	368767	340616	225353	166729	190758	297340	0	327343	339695
2	174919	193504	212858	252722	281312	312929	321048	328086	300320	273007	252091	166795	123452	141307	220618	249505	255799
3	121146	122637	138107	153225	182862	197577	216617	226306	233322	213425	193969	176799	119577	89034	101727	177083	181333
4	95500	92371	96318	110179	122137	141435	148675	169235	178558	182667	166541	150487	140231	94309	69719	133915	137842
5	74438	72119	70850	76060	87084	91617	105094	114461	131453	137350	140292	127985	119028	109357	73175	99126	102400
6	59546	56752	55160	55453	59725	64668	67423	80912	88052	101591	105272	108089	101003	91234	84229	72802	75220
7	44340	45912	43184	42899	43474	43897	47897	51196	61817	67952	77535	81752	84948	76498	68480	52804	54321
8	29276	34354	34870	33362	33625	31776	32603	36002	38398	47779	51231	60718	63711	63745	56076	37750	38666
9	23025	22600	26310	26915	26059	24651	23764	24361	26768	29698	36202	40106	47280	47540	46244	27118	27538
10	15972	18013	17269	20488	21229	19442	18528	17902	18080	20801	22175	28544	31152	35674	34962	19652	19870
11	9459	12484	13788	13353	16173	15943	14541	13977	13185	13971	15249	17402	22038	23200	26168	13979	14127
12	7004	7453	9793	10741	10521	12336	12089	11238	10583	10072	10126	12136	13694	16553	17654	10200	10341
13	4312	5467	5711	7519	8421	7800	9214	9291	8405	7972	7043	7970	9432	9883	12352	7259	7427
14	2800	3385	4271	4423	5972	6531	5883	7237	7128	6336	5860	5583	6261	7192	7650	5251	5451
15	984	2156	2577	3258	3447	4548	4870	4524	5473	5309	4550	4624	4319	4623	5465	3531	3860
+gp	2845	7019	10851	11477	10699	15843	25600	21063	17641	20699	16691	17781	9988	15341	15661		
0 TO	926878	983647	1083197	1201920	1335396	1424639	1496957	1521391	1507950	1479245	1330180	1173499	1086873	1122831	840180		

Run title : Moray Firth Females INDEX FILE

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Table 16 Summary (without SOP correction)

Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3-13
1981	261312	9767	7584	412	0.0543	0.0561
1982	287423	10281	8064	444	0.0551	0.062
1983	341280	11126	8612	342	0.0398	0.0502
1984	379847	12101	9192	275	0.0299	0.0385
1985	422658	13204	9967	740	0.0743	0.0888
1986	433648	14218	10727	871	0.0812	0.0912
1987	443111	15350	11773	646	0.0549	0.0681
1988	405600	15861	12347	695	0.0563	0.0766
1989	368767	16173	12965	630	0.0486	0.0622
1990	340616	16611	13678	936	0.0685	0.0907
1991	225353	16049	13608	597	0.0438	0.0455
1992	166729	15658	13823	462	0.0334	0.0443
1993	190758	14636	13076	837	0.064	0.0791
1994	297340	14448	12425	938	0.0755	0.0861
Arith. Mean	326032	13963	11274	630	0.0557	0.0671

Table 5.3.13 Results by stratum of the 1994 TV survey in the Moray Firth.

Stratum	Area strata (Km2)	Weight strata (%)	Sample size	Mean density (burr./m2)	Observed variance	Coeff. variation	Abundance (millions)	Variance strata	Contrib. to total var. (%)
P	690	31.4	10	0.703	0.1175	0.49	485	5600	54.6
Q	655	29.8	7	0.320	0.0589	0.76	210	3606	35.1
R	728	33.1	9	0.204	0.0178	0.65	148	1047	10.2
S	122	5.6	2	0.053	0.0013	0.68	6	9	0.1
TOTAL	2195	100.0	28.0				850	10262	100.0

Table 5.3.14 Results of the 1993-94 TV surveys in the Moray Firth.

YEAR	1993	1994
Mean density (burrows/m2)	0.19	0.39
Abundance (millions)	418	850
+/- 95% confidence limit	94	213
Biomass ('000 tonnes)	6.7 - 10.5	15.1 - 25.1

Table 5.3.15 Noup (Functional Unit 10) : Landings (tonnes) by gear, all UK, 1985-94

Year	Nephrops	Other trawl	Total
1985	2	20	22
1986	46	22	68
1987	12	32	44
1988	23	53	76
1989	24	61	85
1990	101	116	217
1991	110	86	196
1992	58	130	188
1993	200	176	376
1994*	308	183	491

* Provisional

Table 5.3.16 Noup (Functional Unit 10) : Landings (tonnes), effort ('000 hours trawling), and LPUE (kg/hour trawling) of Scottish Nephrops trawlers, 1985-94. Figures in brackets to the left and right of the overall values are for single and multi-rig trawls respectively

Year	Landings	Effort	LPUE
1985	1.5	<0.1	25.0
1986	45.7	0.7	62.6
1987	12.3	0.7	18.1
1988	23.3	1.0	34.3
1989	23.7	0.9	25.8
1990	101.0	2.9	34.6
1991	(23) 110.0 (87)	(0.9) 4.8 (3.9)	(25.3) 23.1 (22.6)
1992	(33) 58 (23)	(1.4) 1.9 (0.4)	(23.0) 30.0 (53.9)
1993	(152) 200 (48)	(3.6) 4.8 (1.2)	(42.0) 41.3 (39.0)
1994*	(273) 308 (35)	(7.6) 8.3 (0.7)	(36.0) 37.0 (46.6)

* provisional

Table 5.3.17 Nephrops landings (tonnes) by Functional Unit plus other rectangles in Management Area F (IVa 44-48 E6-E7 44E8)

Year	FU 9	FU 10	Other	Total
1985	2081	22	15	2118
1986	2143	68	44	2255
1987	1991	44	30	2065
1988	1959	76	45	2080
1989	2576	85	44	2705
1990	2038	217	69	2324
1991	1517	196	65	1778
1992	1587	188	43	1818
1993	1807	376	69	2252
1994	1501	491	137	2129

Table 5.3.18 Total Nephrops landings (tonnes) by country in Management Area F (IVa 44-48 E6 -E7 44E8)

Year	UK	Total
1985	2118	2118
1986	2255	2255
1987	2065	2065
1988	2080	2080
1989	2705	2705
1990	2324	2324
1991	1778	1778
1992	1818	1818
1993	2252	2252
1994	2129	2129

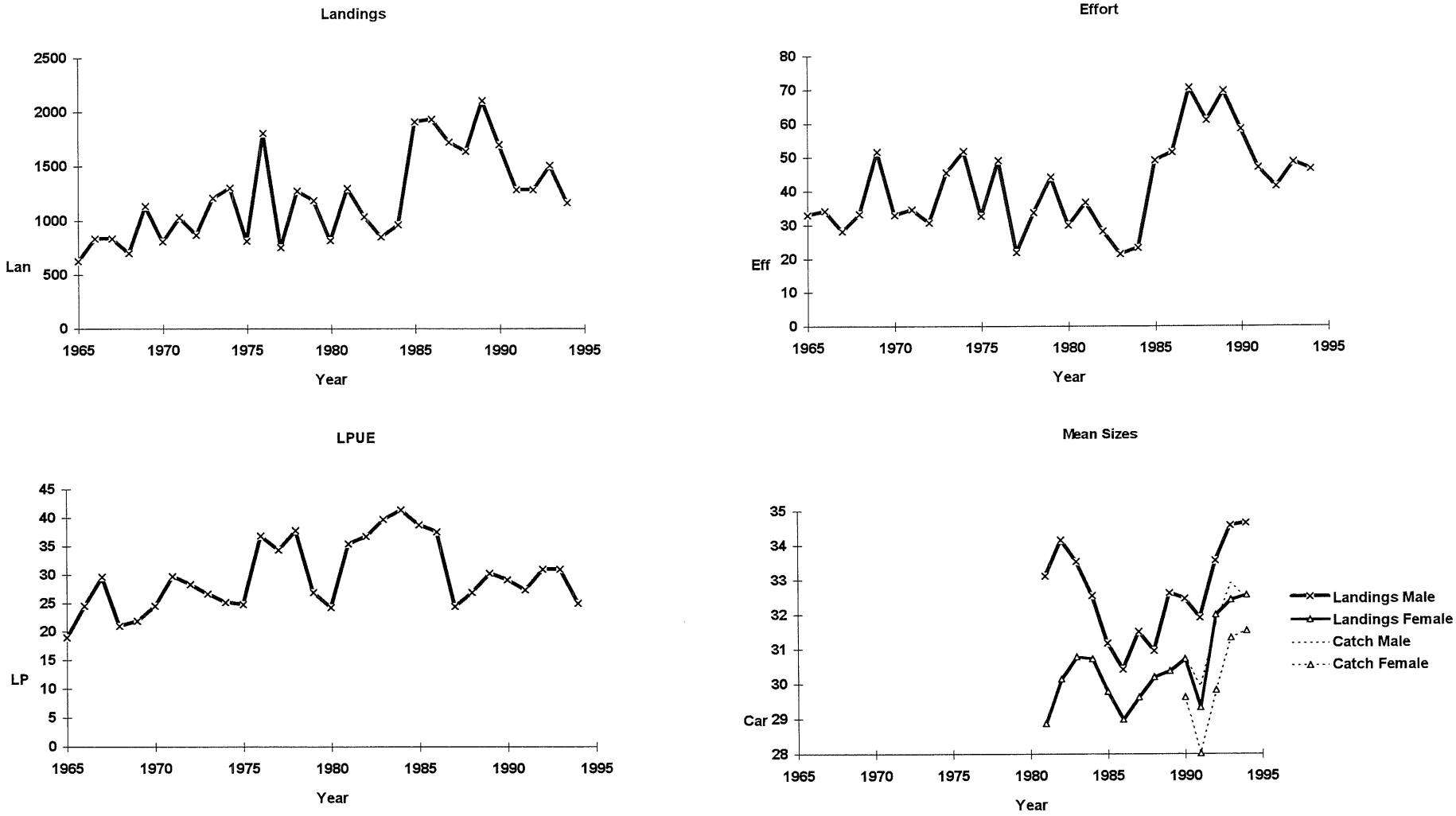


Figure 5.3.1 Moray Firth (FU9): Long term trends in Scottish Nephrops trawler landings (tonnes), effort ('000 hours), LPUE (kg/hour) and mean size (mm CL) in catch and landings.

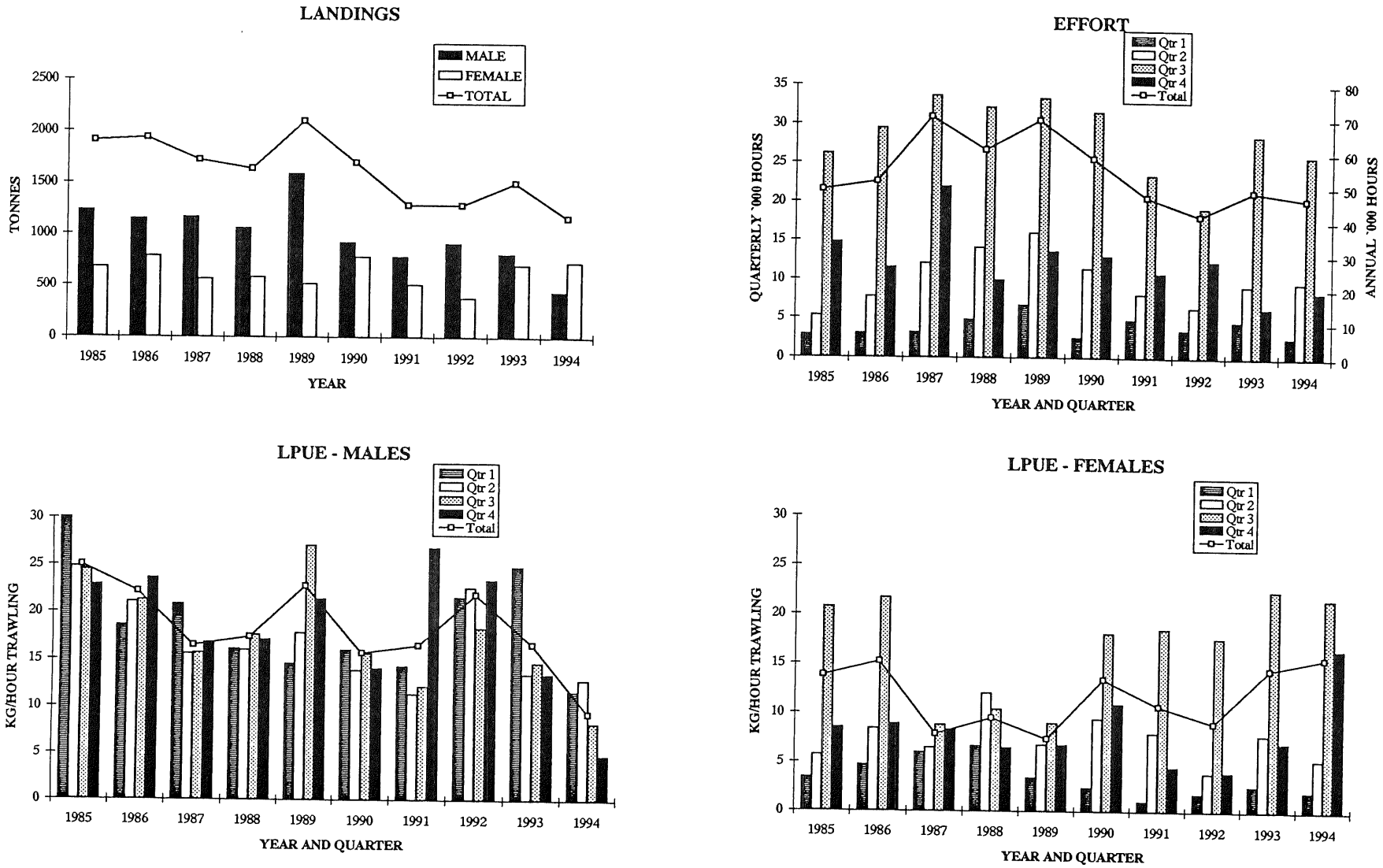
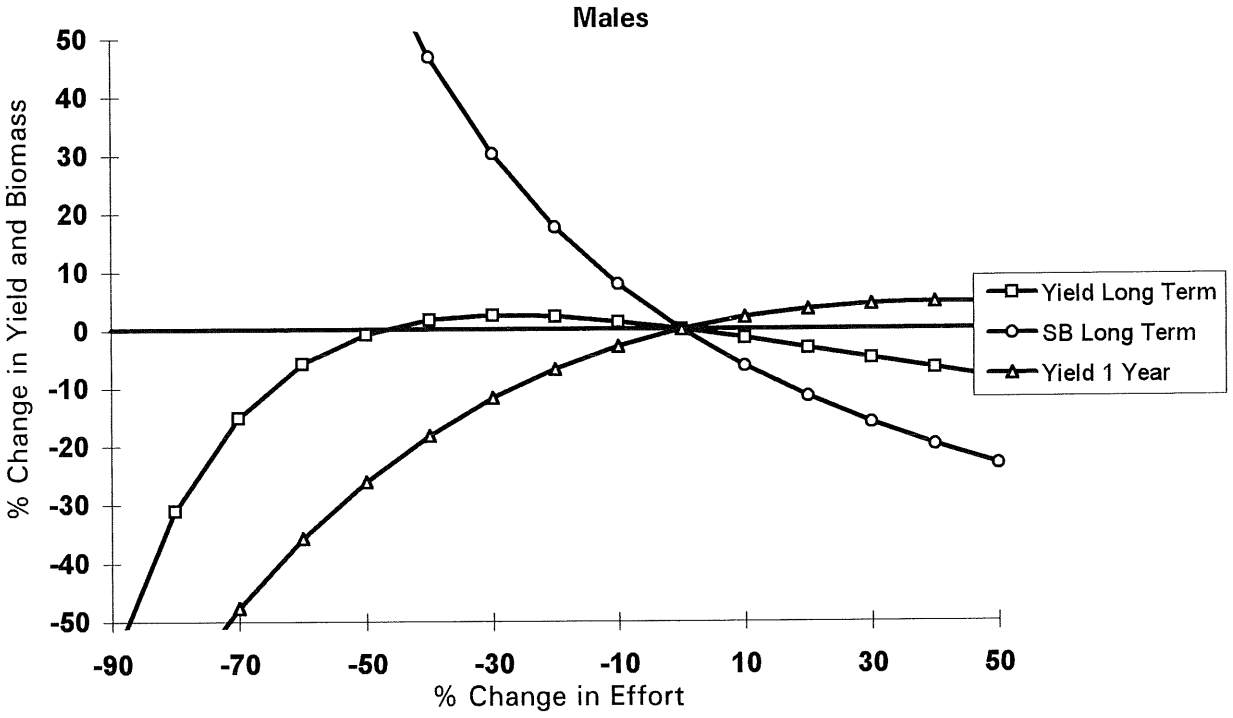


Figure 5.3.2. Moray Firth (functional unit 9) : trends in landings,effort and LPUE by quarter and sex from Scottish Nephrops trawlers.



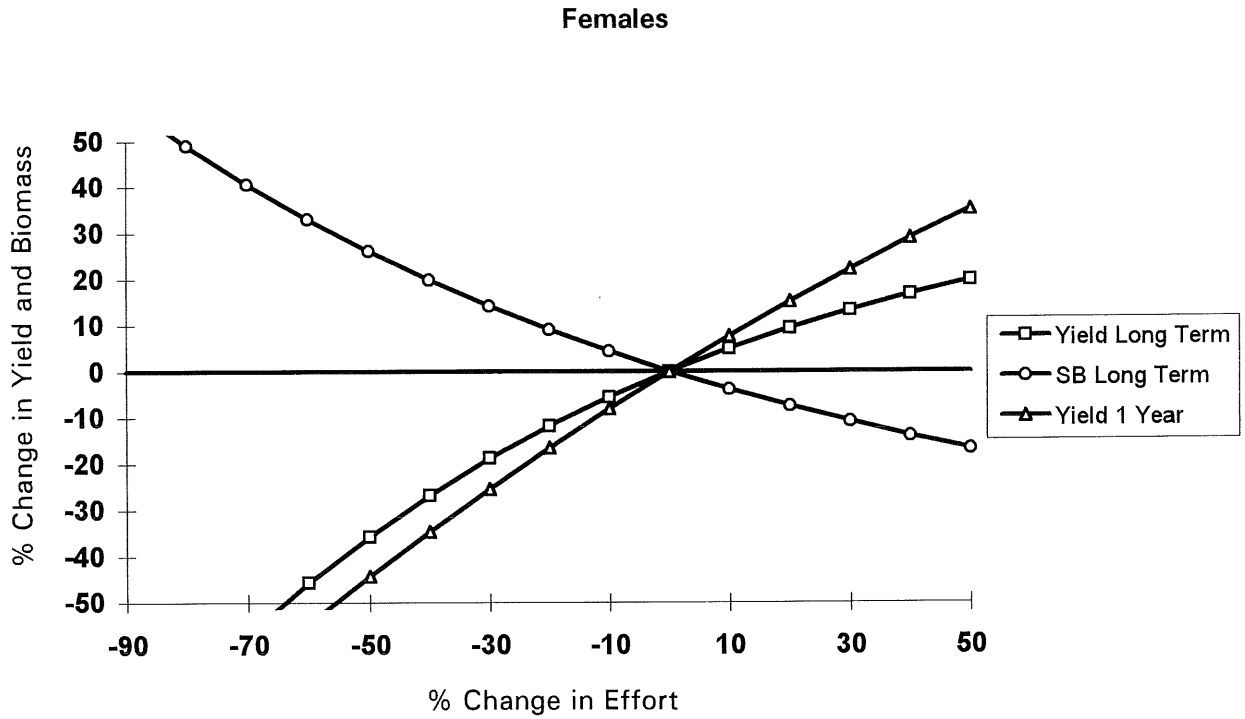


Figure 5.3.3 Moray Firth (FU9): Percentage changes in long term landings and stock biomass, and short term landings following various changes in fishing effort. Males and females shown separately.

Figure 5.3.4 Moray Firth (FU9) Males - Log Catchability Residuals (using Laurec-Shepherd)

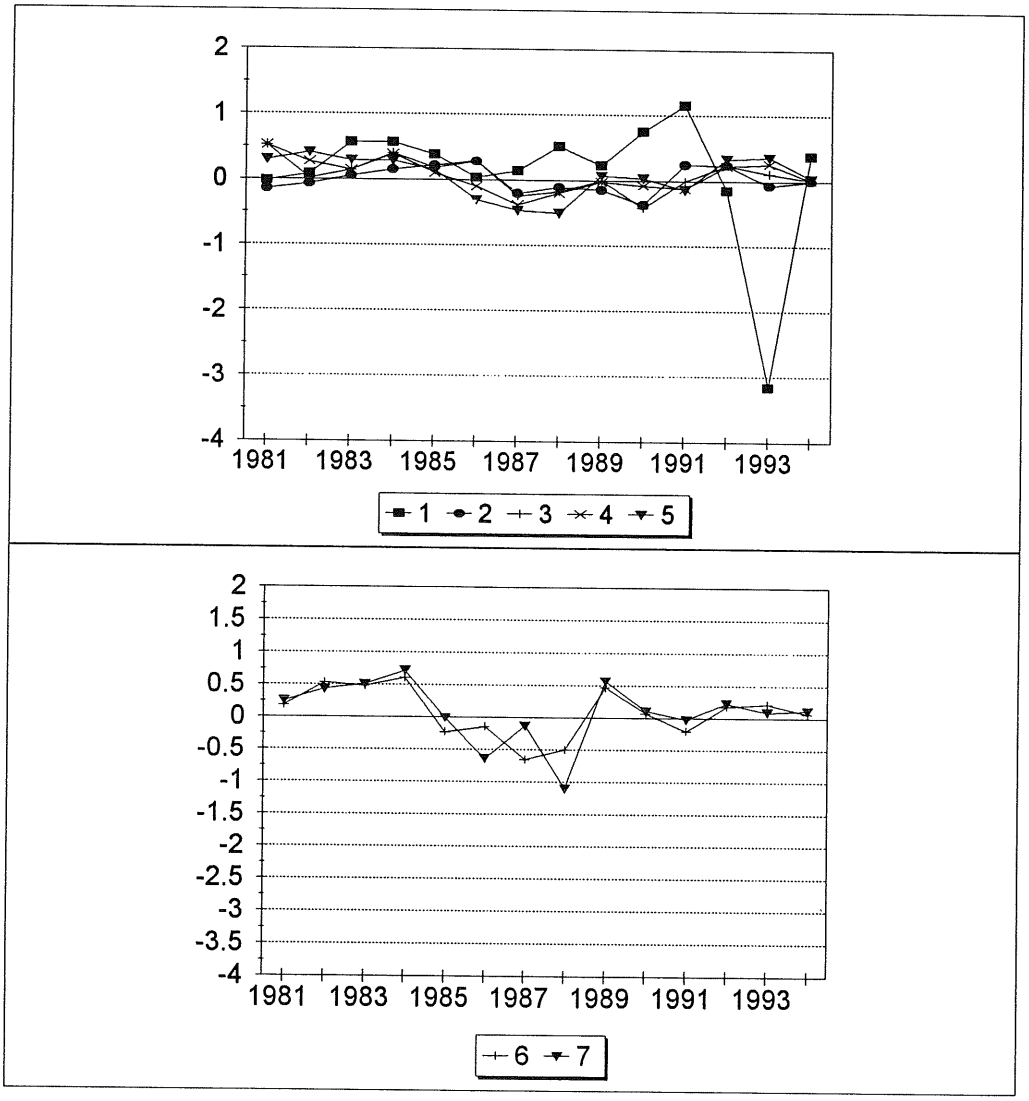
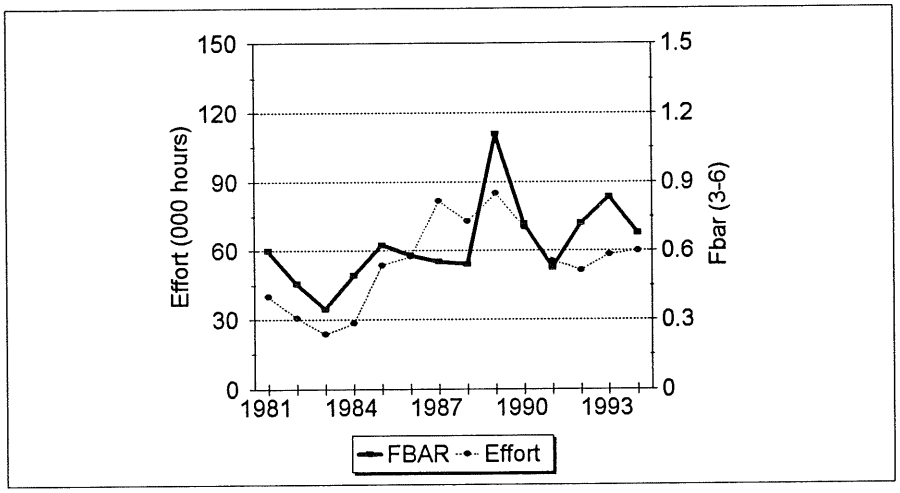


Figure 5.3.5 Moray Firth (FU9) Males - Fbar and effort and relationship between them



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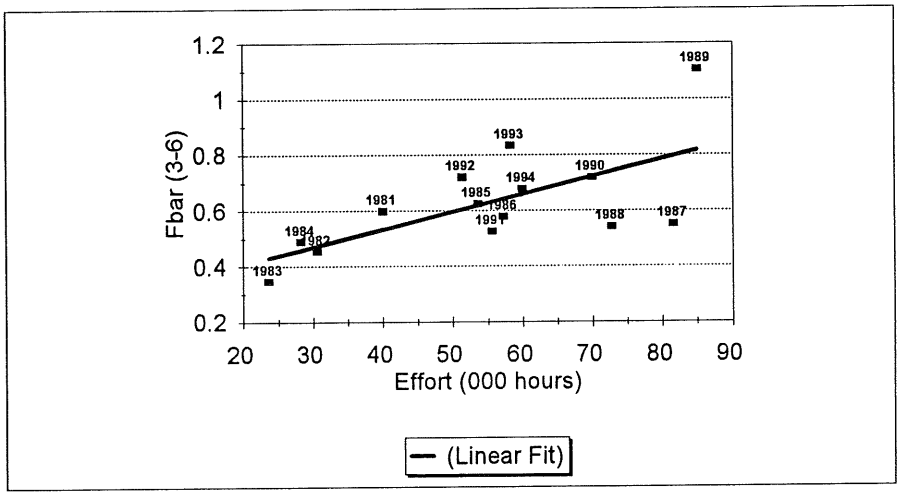
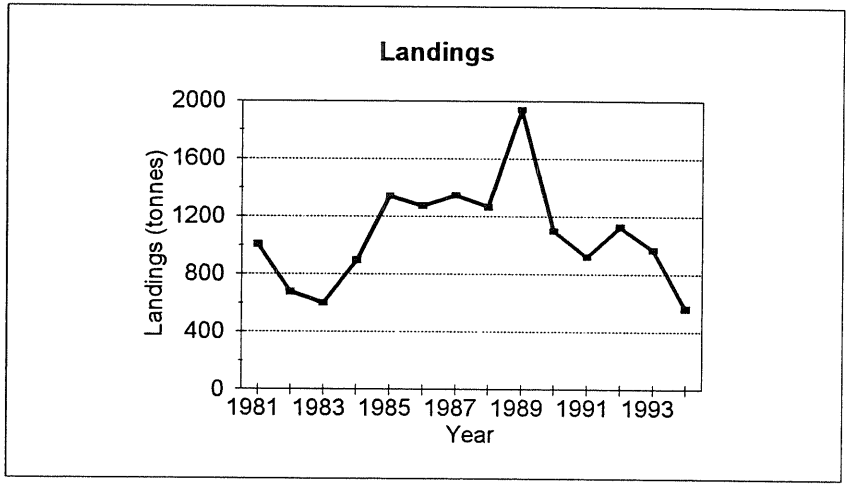
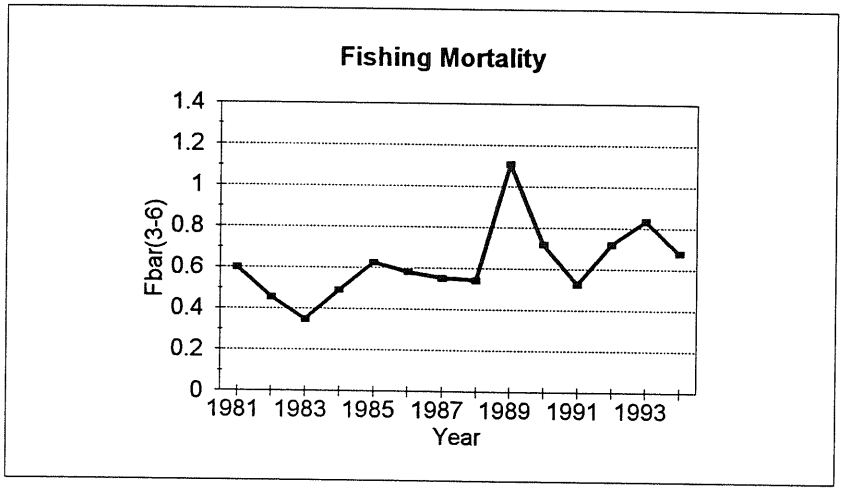
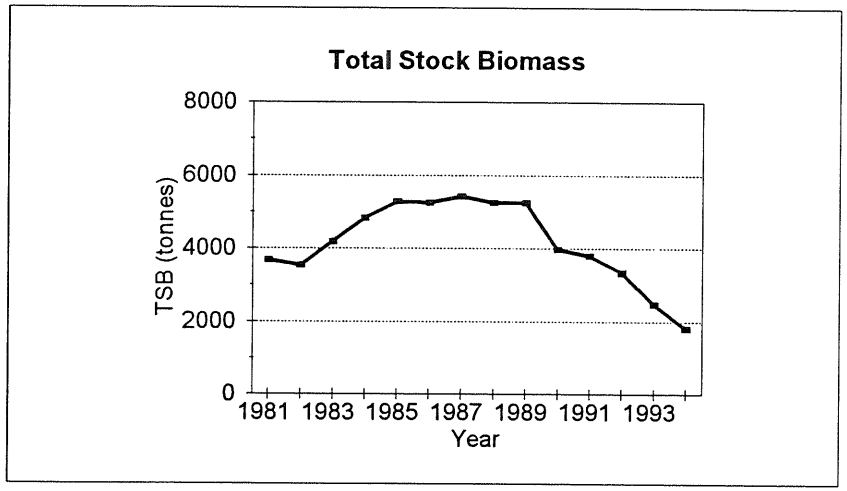


Figure 5.3.6 Moray Firth (FU9) Males - Trends in Landings, Fbar, Total Stock Biomass and ln Recruits from XSA







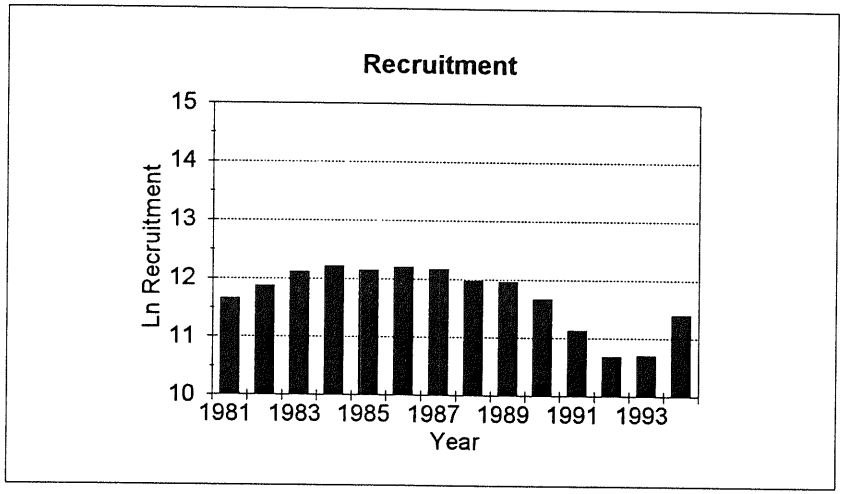


Figure 5.3.7 Moray Firth (FU9) Females - Log Catchability Residuals (using Laurec-Shepherd method)

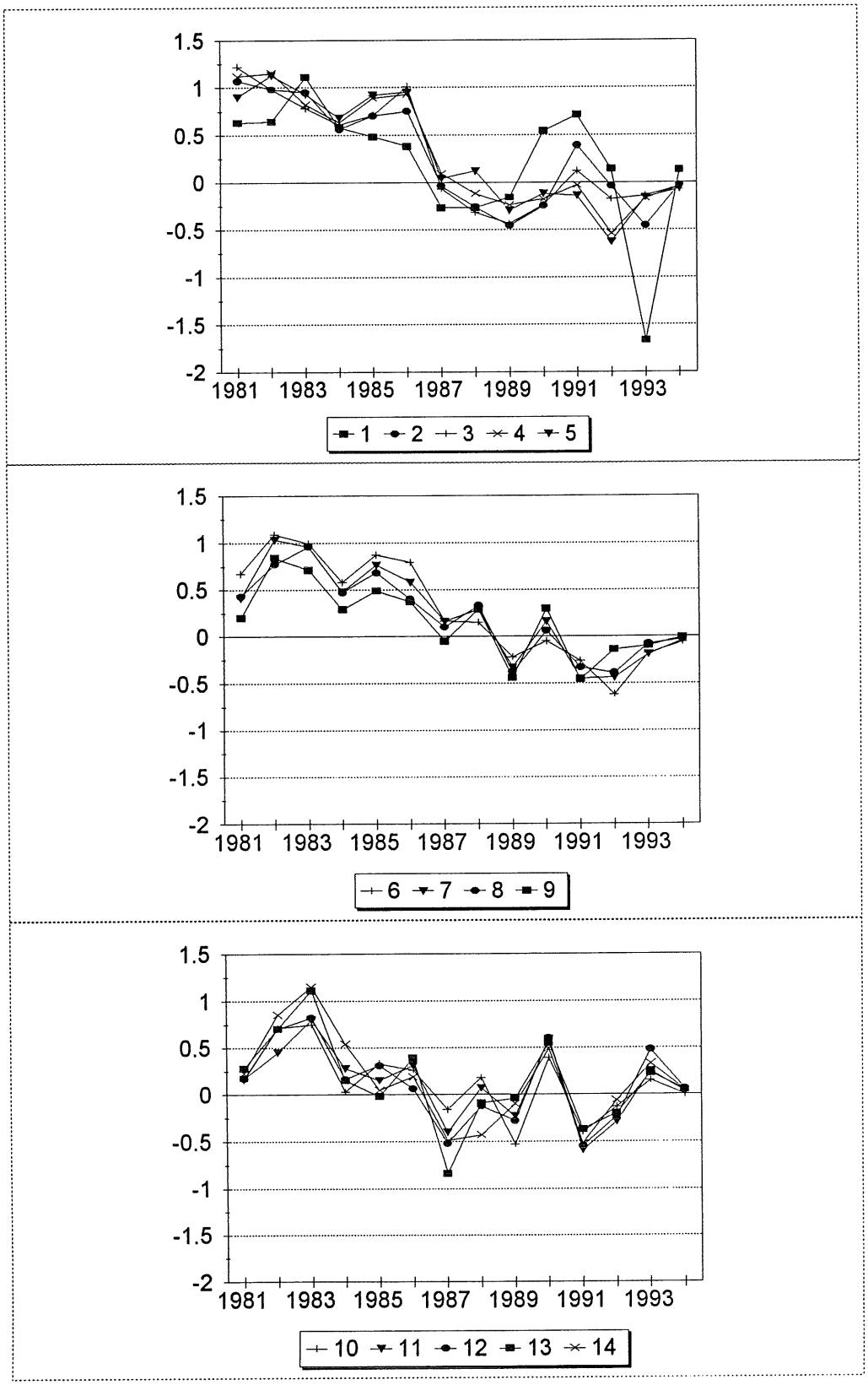
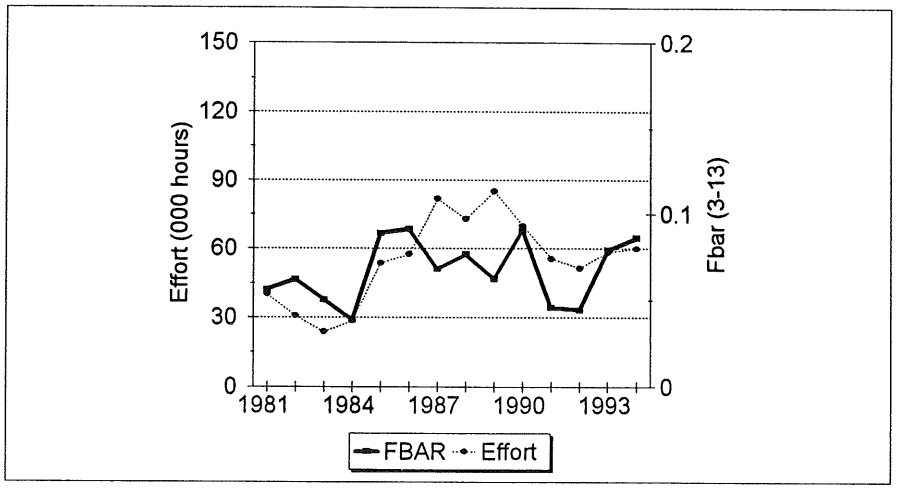


Figure 5.3.8 Moray Firth (FU9) Females - Fbar and Effort and relationship between them



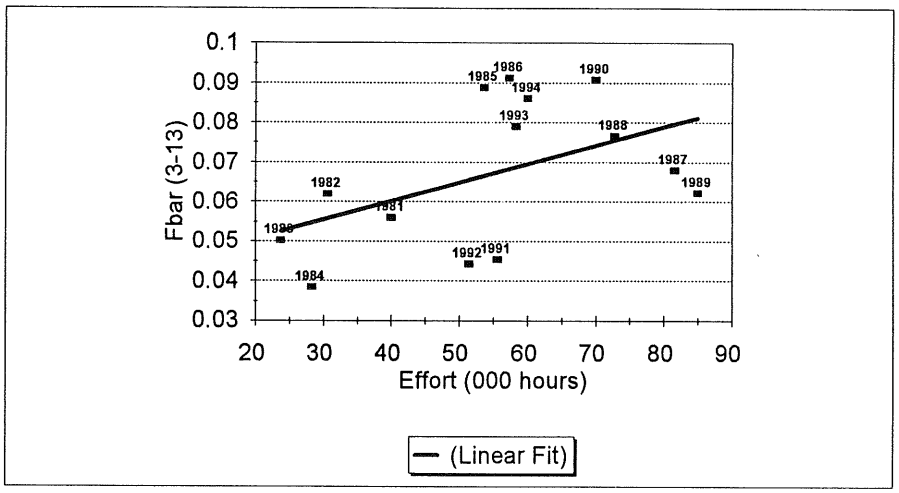
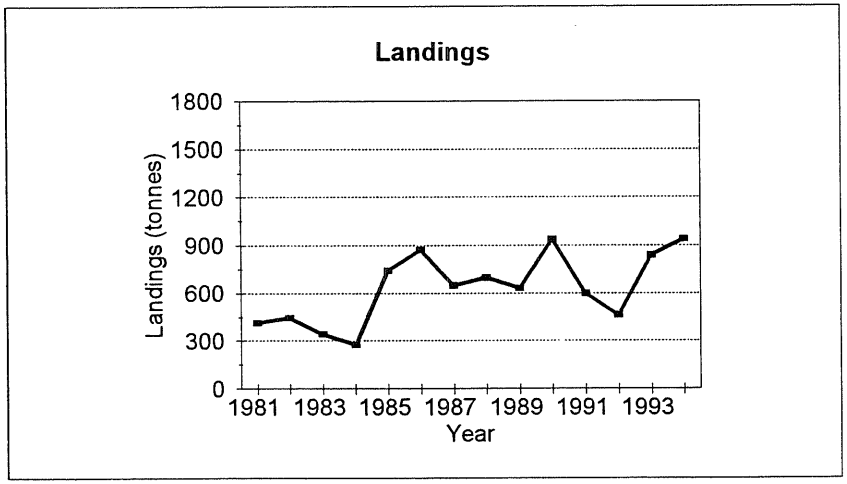
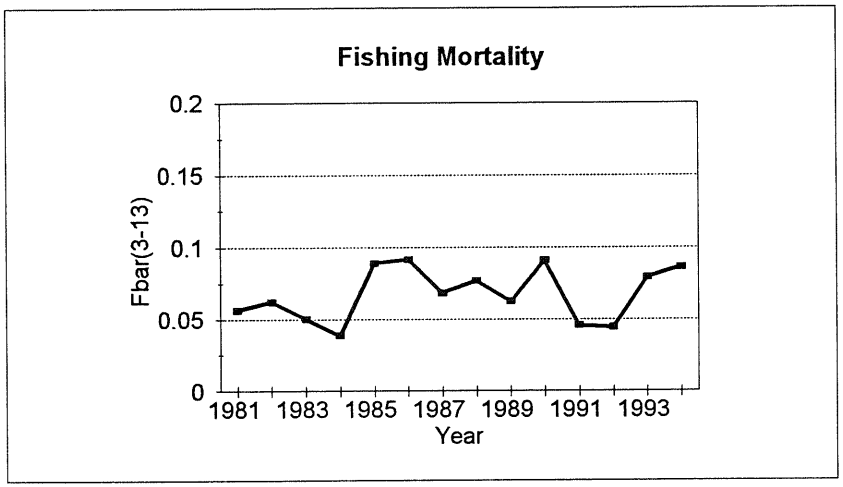
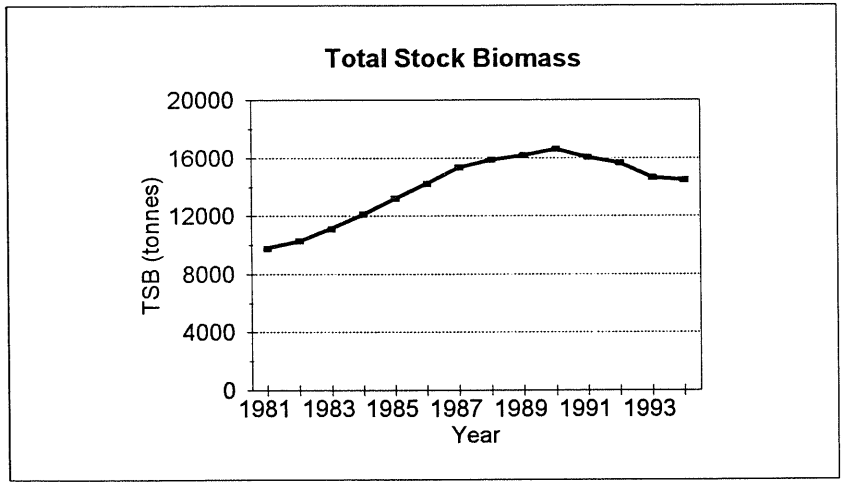
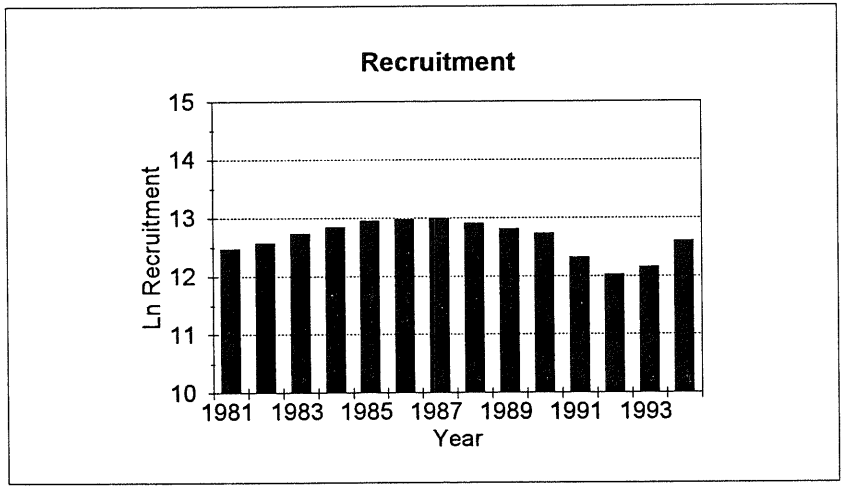


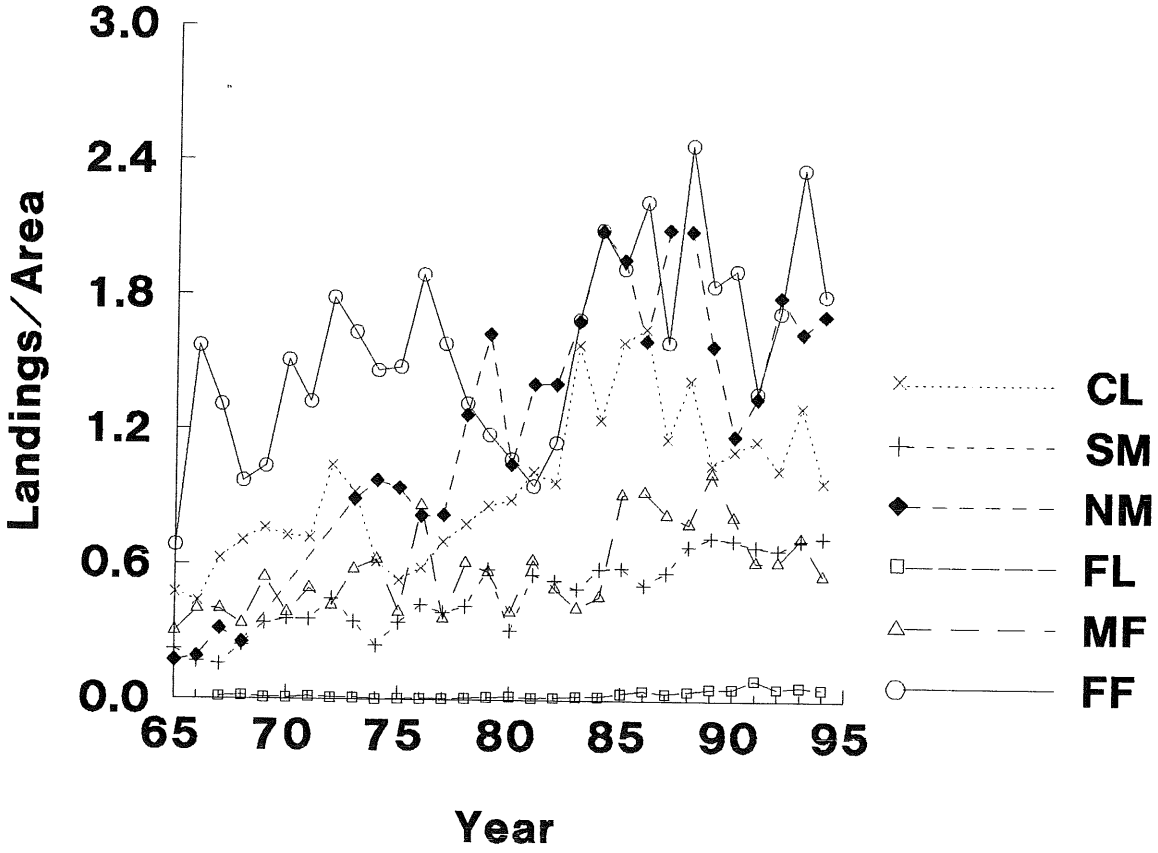
Figure 5.3.9 Moray Firth (FU9) Females - Trends in Landings, Fbar, Total Stock Biomass and Ln Recruits from XSA











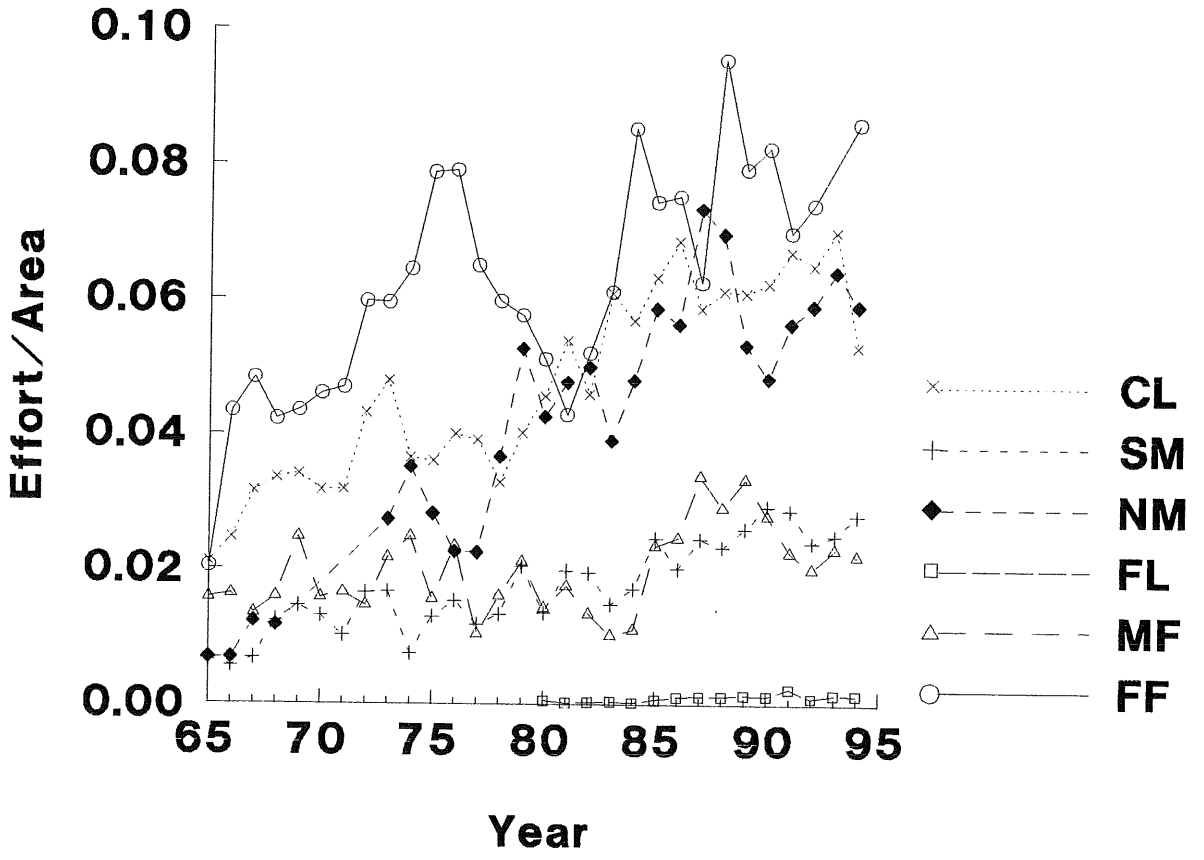
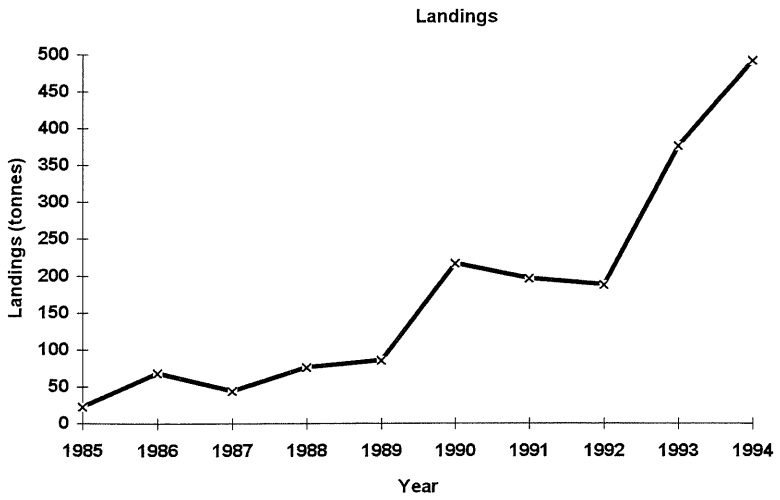
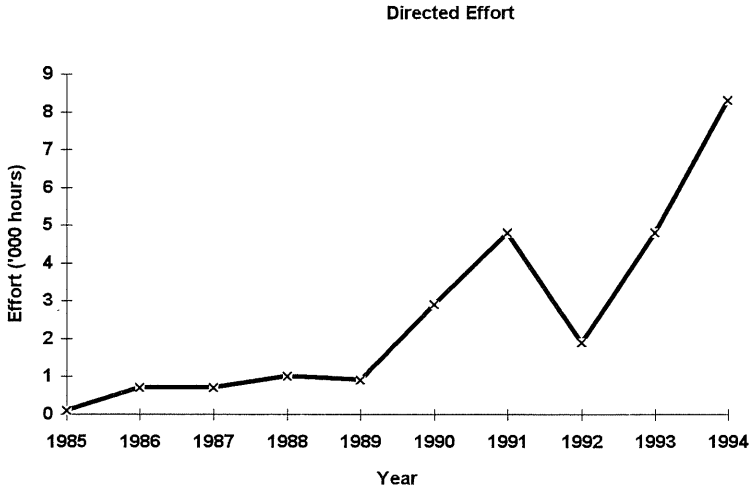


Figure 5.3.10 Nephrops trawl landings per unit area (t/km^2) and effort per unit area ('000h/km^2) on various Scottish grounds (CL = Clyde (FU13), SM = South Minch (FU12), NM = North Minch (FU 11), FL = Fladen (FU7), MF = Moray Firth (FU9), and FF = Firth of Forth (FU8)).





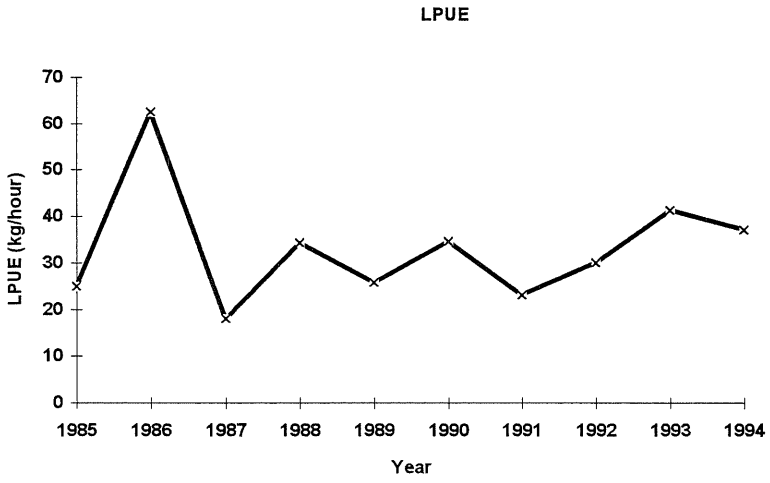


Figure 5.3.11 Noup (FU10): Longterm trends in UK landings (tonnes), effort by Scottish Nephrops trawlers ('000 hours), and LPUE (kg/hour).

5.4. Division IVa Remainder (Management Area G)

Functional Units Fladen (7)

The statistical squares comprising this Management Area and its constituent Functional Units are shown in Figure 5.1.1.

5.4.1. Fladen Ground (Functional Unit 7)

Data and biological inputs

In 1994, there was some improvement in sampling of the landings, with 14 boats being sampled (Table 5.4.1). As in previous years, it was not possible to sample the discards. Input parameters used in past analytical assessments are included in Table 5.4.1 for reference.

Comments on the quality of inputs

No analytical assessments were performed at this Working Group , although LCA and VPA assessments have been carried out on the stock in the past (Anon.,1991; 1992). Instead, another combined TV camera and trawl survey was carried out by Scotland in July 1994. This was the third such survey, using techniques described previously (Anon., 1993a; 1994a; Bailey et al., 1993).

Landings, effort, LPUE and mean size

Landings data were reported by Scotland, Denmark and Norway (Table 5.4.2). Provisional total landings in 1994 showed a marked increase on the previous year, reaching 4288 t, the highest ever recorded. The majority (3968 t) were landed in Scotland, and 314 t were recorded by Denmark (Table 5.4.2).

The extent of under-reporting is not accurately known (see Section 5.3.1).

Although UK *Nephrops* trawlers remain the main fleet component, accounting for 1747 t (44% of the 1994 UK total - Table 5.4.3), the increase in landings mainly reflected greater fishing effort by large UK multi-rig trawlers fishing for mixed demersal species. These now account for 33% of the UK landings, with large single-rig trawlers (targeting mixed demersal species) making up the balance (23%).

In 1994, there was a fall in LPUE by both single and multi-rig UK *Nephrops* trawlers (Table 5.4.3). The two classifications of multi-rig vessels (*Nephrops* and demersal trawlers) now account for 53% of UK fishing effort. The Fladen Ground is exempted from the UK legislation banning 70mm mesh multi-rig gears in other *Nephrops* fisheries.

In 1994, LPUE by Danish trawlers increased to 239.0 kg/day, the highest level recorded in the series (Table 5.4.4).

Long time series of landings, effort and LPUE for Scottish *Nephrops* trawlers, together with mean size data from Scottish sampling of the landings, are shown in Figure 5.4.1. The mean size of male *Nephrops* in trawl landings appears to have fallen in the early 1980s but has since been more stable (Table 5.4.5, Figure 5.4.1). The level of sampling was insufficient for a detailed analysis of seasonal trends split by sex.

Assessments

In previous Reports, the Working Group drew attention to the difficulties of sampling and assessing this widely distributed stock (Anon.,1992). Since 1992, as an alternative assessment method for this stock, an annual survey has been undertaken during a summer cruise of the SOAFD Research Vessel SCOTIA, using an underwater TV camera and otter trawl.

The surveys have confirmed the widespread distribution of *Nephrops* on the ground, with an estimated area of about 30000 km^2. Details of the 1994 survey are given in Table 5.4.6 and a summary of these results are compared to previous surveys in Table 5.4.7. 1994 estimates of mean *Nephrops* burrow density in different parts of the ground (strata) varied from 0.11 to 0.44/m^2 (Table 5.4.6) and these values were raised to the total mud sediment area for each strata and combined to provide an estimate of stock abundance. The 1994 survey gave a mean abundance estimate of about 8300 million *Nephrops* burrows (95% confidence interval 7200-9400).

An estimate of biomass is provided by the product of the strata abundance and a value for the mean weight of *Nephrops* derived from trawl sampling. This procedure gave a biomass estimate for the stock in the range 176-230 thousand tonnes (Table 5.4.7), and the comparison with earlier surveys suggests that the size of the stock may be increasing. Note that for the abundance estimates given in Table 5.4.7, no allowance has been made for the fact that a proportion of burrows will be unoccupied. In last years Report the abundance and biomass estimates were reduced by 10% to allow for empty burrows, but this procedure has not been followed this year because of uncertainty about the correct value to use.

Fishing pressure on the stock, in terms of the landings and effort/area indices, is currently very low in comparison with other Scottish stocks (Figure 5.3.10).

Comments on the quality of the assessment

Several factors which may affect the accuracy of the TV survey assessments are discussed in Anon. (1993; 1994a) and Bailey et al.(1993). Research is in hand to improve

calibration of the TV method and progress on this will be kept under review by the *Nephrops* Study Group. The biomass estimate is obviously dependent on the value for the mean weights of *Nephrops* in each stratum, derived from trawl sampling which may not be fully representative of the whole area.

Management considerations

The evidence from the TV surveys, the low estimates of fishing pressure compared to other stocks (Figure 5.3.10) and the relatively high values of LPUE suggests that the Fladen stock is currently under-exploited.

5.4.2. Summary for Division IVa remainder (Management Area G)

A decision on the revision of the ICES Statistical Rectangles making up 'other rectangles' in this MA was deferred, but will be considered prior to the next Working Group meeting (Section 5.1.1).

The recent landings in FU7 and other ICES rectangles forming MA G are given in Tables 5.4.8 and 5.4.9. In 1994, total landings for the MA reached 4844 t which is close to the ACFM recommended TAC. Although the stock seems capable of supporting a larger fishery, the Working Group again stressed the difficulties which can arise if the TAC for this MA is aggregated with those for other Management Areas in the North Sea. It is then virtually impossible to achieve a balance between expansion of the Fladen fishery and the need to curb effort increases on some of the inshore grounds (e.g. FUs 6 and 8). The aggregated TAC caused problems in 1994, when high landings, particularly at Fladen and in the Farn Deeps, led to rapid take up of the UK quota towards the end of the year. As a consequence, significant under-reporting of landings is believed to have occurred, and there was pressure on the EU to increase the Precautionary TAC. As a result, 2000 t were added to the 1994 TAC (raising it from 13000 to 15000 t). These difficulties can only be overcome by separate allocation and management of the TAC on the basis of the MAs defined by the Working Group.

Table 5.4.1 Input data and parameters: Fladen Ground

FU	7	MA	G
FLEET	UK Scotland	GEAR	Nephrops and Light trawl

1994	NUMBER OF SAMPLES				Mean
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	No./sample
Catch					
Landings	1	7	5	1	571
Discards					

	NUMBER OF SAMPLES									
YEAR	94	93	92	91	90	89	88	87	86	85
Catch										
Landings	14	6	4	12	9	11	3	4	5	2
Discards										

INPUT PARAMETERS		
Parameter	Value	Source
Discard Survival	0.25	Gueguen and Charuau,1975; Anon.,1985
MALES		
Growth - K	0.16	Adapted from Bailey and Chapman, 1983
Growth - L(inf)	66	"
Nat. Mort. - M	0.3	Morizur, 1982
Length/weight - a	0.0003	After Howard and Hall, 1983
Length/weight - b	3.25	"
FEMALES		
Immature Growth		
K	0.16	as for males
L(inf)	66	"
Nat.Mort. - M	0.3	"
Size at Maturity	25	Adapted from Bailey, 1984
Mature Growth		
K	0.1	as for males
L(inf)	56	"
Nat.Mort. - M	0.2	assumed *
Length/weight - a	0.00074	as for males
Length/weight - b	2.91	"

* based on Morizur, 1982 and assuming lower mature female rate

Table 5.4.2 Fladen (Functional Unit 7) : Landings (tonnes) by Country, 1985-94

Year	UK	Denmark	Belgium	Norway	Total
1985	1141	7	?	0	1148
1986	1493	50	0	0	1543
1987	1398	323	0	0	1721
1988	1493	81	0	0	1574
1989	2133	230	0	0	2363
1990	2302	290	2	0	2594
1991	3796	445	0	0	4241
1992	2953	327	3	0	3283
1993	3270	225	0	3	3498
1994*	3968	314	0	6	4288

* provisional

Table 5.4.3 Fladen (Functional Unit 7) : Landings (tonnes), effort ('000 hours trawling) and LPUE (kg/hour trawling) of Scottish Nephrops trawlers, 1985-94. Figures in brackets to the left and right of the overall values are for single and multi-rig trawls respectively

Year	Landings	Effort	LPUE
1985	1016	26.6	38.2
1986	1398	37.8	37.0
1987	1024	41.6	24.6
1988	1306	41.7	31.3
1989	1719	47.1	36.5
1990	1703	43.4	39.2
1991	(409) 3024 (2615)	(11.4) 78.5 (67.1)	(35.8) 38.5 (39.0)
1992	(340) 1794 (1448)	(9.4) 38.6 (28.9)	(36.6) 46.5 (50.0)
1993	(388) 2033 (1645)	(9.6) 49.9 (40.3)	(40.3) 40.7 (40.8)
1994*	(280) 1747 (1467)	(8.0) 47.5 (39.5)	(34.9) 36.7 (37.1)

* provisional

Table 5.4.4 Fladen (Functional Unit 7) : Effort (days trawling) and LPUE (kg/day trawling) of Danish Nephrops trawlers, 1988-94

Year	Effort	LPUE
1988	934	86.7
1989	1876	122.6
1990	3323	89.0
1991	3786	116.1
1992	2363	144.2
1993	1859	129.9
1994	1442	239.0

Table 5.4.5 Fladen (Functional Unit 7) : Mean sizes (CL mm) of male and female Nephrops in Scottish landings, 1985-94

Year	Males	Females
1985	35.2	31.6
1986	31.3	28.7
1987	31.5	29.5
1988	30.0	29.4
1989	33.6	31.5
1990	32.6	29.4
1991	34.2	31.9
1992	35.0	33.1
1993	32.1	29.7
1994	33.4	30.4

Table 5.4.6 Results by stratum of the 1994 TV survey in the Fladen Ground.

Stratum	Area strata (Km2)	Weight strata (%)	Sample size	Mean density (burr./m2)	Observed variance	Coeff. variation	Abundance (millions)	Variance strata	Contrib. to total var. (%)
A	2666	9.5	4	0.151	0.0078	0.59	403	13924	4.9
B	3075	10.9	7	0.175	0.0164	0.73	540	22163	7.7
C	4007	14.2	10	0.261	0.0200	0.54	1047	32067	11.2
D	3064	10.9	5	0.445	0.0363	0.43	1365	68087	23.7
E	3208	11.4	7	0.435	0.0161	0.29	1396	23688	8.3
F	2462	8.7	4	0.396	0.0211	0.37	975	32027	11.2
G	2559	9.1	8	0.331	0.0117	0.33	848	9544	3.3
H	2002	7.1	2	0.408	0.0044	0.16	818	8774	3.1
I	2864	10.2	8	0.238	0.0517	0.96	681	53001	18.5
J	2246	8.0	4	0.114	0.0188	1.20	256	23664	8.2
TOTAL	28152	100.0	59				8329	286939	100

Table 5.4.7 Results of the 1992-94 TV surveys in the Fladen Ground.

YEAR	1992	1993	1994
Mean density (burrows/m2)	0.17	0.21	0.30
Abundance (millions)	4942	6007	8329
+/- 95% confidence limit	508	768	1099
Biomass ('000 tonnes)	110 - 135	132 - 171	176 - 230

Table 5.4.8 Nephrops landings (tonnes) by Functional unit plus other rectangles in Management Area G (IVa Remainder)

Year	FU 7	Other*	Total
1985	1148	>34	1182
1986	1543	>17	1560
1987	1721	>14	1735
1988	1574	57	1631
1989	2363	75	2438
1990	2594	117	2711
1991	4241	242	4483
1992	3283	200	3483
1993	3498	359	3857
1994	4288	556	4844

* includes Norwegian and Danish landings from Norwegian Deeps (see section 5.1.1)

Table 5.4.9 Total Nephrops landings (tonnes) by country in Management Area G (IVa Remainder)

Year	UK	Denmark	Norway	Belgium	Total
1985	1182	?	0	?	1182
1986	1510	50	0	0	1560
1987	1411	323	1	0	1735
1988	1501	127	3	0	1631
1989	2154	275	9	0	2438
1990	2318	353	38	>2	2711
1991	3848	528	107	0	4483
1992	2998	369	113	3	3483
1993	3320	434	103	0	3857
1994	4086	601	157	0	4844

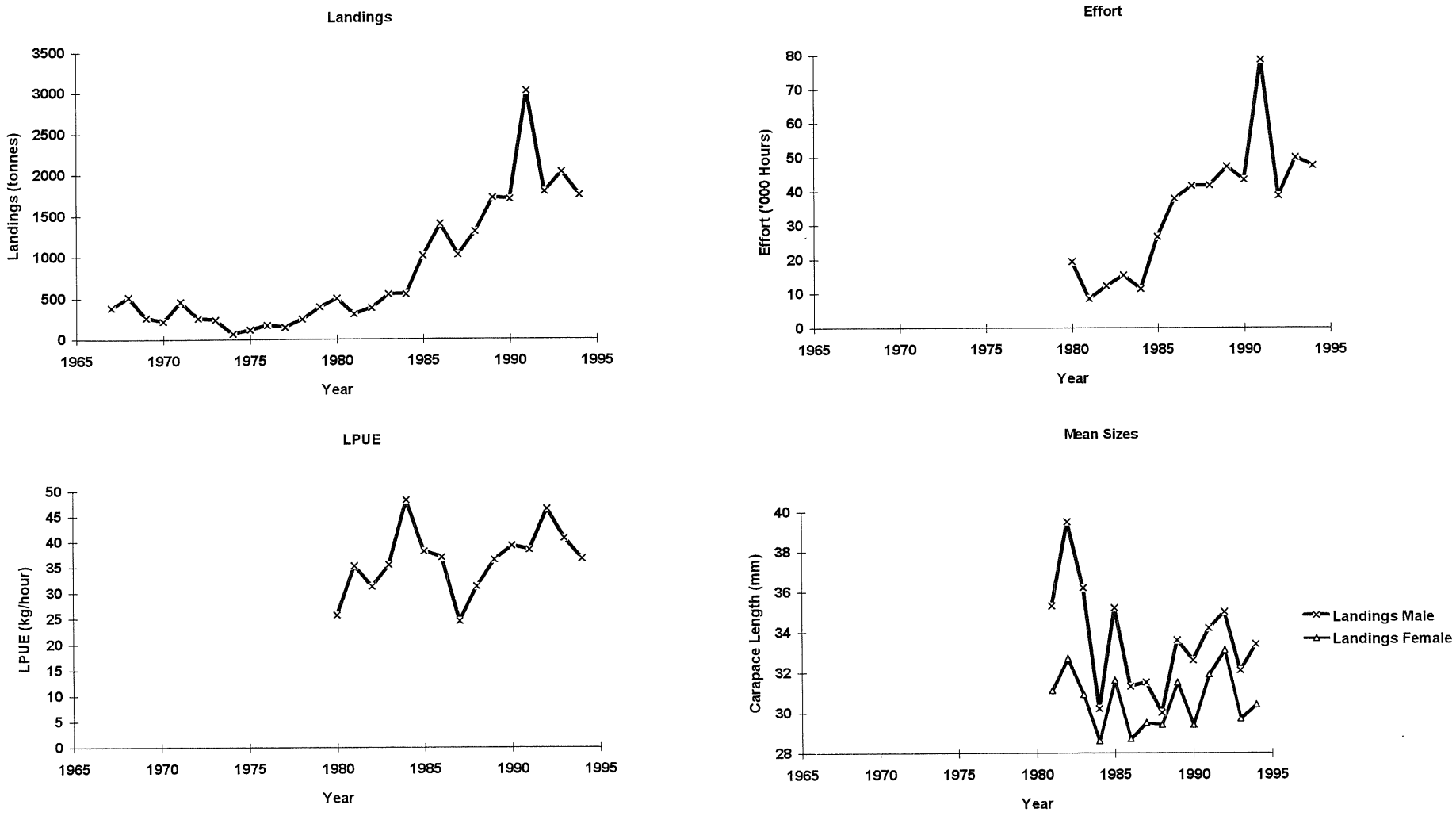


Figure 5.4.1 Fladen Ground (FU7): Long term trends in Scottish Nephrops trawler landings (tonnes), effort ('000 hours), LPUE (kg/hour) and mean size (mm CL) in the landings from Nephrops and "light trawl" trawlers.

5.5. Divisions IVb,c, east of 1° East (Management Area H)

Functional Units Botney Gut - Silver Pit (5)

The statistical rectangles comprising this Management Area and its constituent Functional Unit are shown in Figure 5.1.1.

5.5.1. Botney Gut - Silver Pit (Functional Unit 5)

Data and biological inputs

Landings and effort statistics were available for Belgium (landings and effort data by vessel class and gear type since 1981), Denmark (since 1988 for both landings and effort), and the UK (landings only). The Belgian landings data for 1994 were revised to include non-reported *Nephrops* landings, following the same procedure as in last year's revision of the data for 1986-93 (Anon., 1994b).

Length frequency data are collected from market samples of the landings by Belgian *Nephrops* directed trawlers only. A routine auction sampling programme has been in operation since 1986 (Table 5.5.1). As a rule two vessels are being sampled every month.

General comments on the quality of the data

The Belgian landings allocated to the Botney Gut - Silver Pit comprise small quantities of *Nephrops* (presumed to be less than 5 % in 1992 and 1993, and even less in 1994) taken east of 4° E, in an area which is known to yield valuable by-catches of sole. The current landings and effort recording system, however, does not distinguish between *Nephrops* taken on different grounds, especially when they were fished during the same voyage. Throughout the port sampling programme, special care was taken to omit vessels with "blended" catches coming from different grounds.

Effort data for the Belgian *Nephrops* trawlers are recorded by voyage, but precise information on their directedness towards *Nephrops* is lacking. Both during winter (when the *Nephrops* catches are generally poor) and during summer (when the shelf-life of *Nephrops* is relatively short, even when kept on ice), the vessels may direct part of their effort towards demersal fish on the higher grounds in the vicinity of the Botney Gut and the Silver Pit. As a consequence, the effort figures may be over-estimated as compared to the volume of the actual *Nephrops* landings, which, in turn, may result in an under-estimation of the LPUEs.

Landings, effort and LPUE

Total international landings from the Botney Gut - Silver Pit area rose from about 600 t in 1992 to just over 700 t in 1993, then dropped again by almost 30 % to 503 t in 1994 (Table 5.5.2). Most of the landings (usually > 85 %) were taken by Belgian trawlers. Over the past years, the landings by the Danish fleet dropped from 184 t in 1991 to zero in 1994.

Long-term effort and LPUE data series are available for the Belgian *Nephrops* directed trawlers only. Landings by these vessels steadily rose from about 450 t in 1986 to almost 700 t in 1990 and 1991 (Table 5.5.3 and Figure 5.5.1). In 1992, they dropped to 554 t, then went up again to 664 t in 1993. In 1994, they fell by about 30 % to 463 t.

Total effort increased from around 53,000 hours trawling in 1986-87 to peak at around 85,000 hours in 1991-92, then sharply fell to 37,000 hours in 1994 (a 55 % decrease in two years; Table 5.5.3 and Figure 5.5.1). The decrease in *Nephrops* directed fishing effort is an immediate consequence of the 1991-94 decommissioning scheme, set up to meet the EU targets on the overall reduction in fishing capacity. Within the framework of this scheme 45 Belgian trawlers (amongst which 15 used to fish for *Nephrops* during at least part of the year) were decommissioned. As a result, the number of *Nephrops* "specialist" trawlers (i.e. vessels targeting *Nephrops* during most of the year) went down from about 20 units in 1991-92 (the peak years in terms of *Nephrops* directed effort) to only 10 units at the end of 1994.

Danish effort continued to decline, with zero effort in 1994 (Table 5.5.4).

A break-down of the Belgian *Nephrops* landings by sex (Figure 5.5.1) shows that the male landings remained relatively stable at a level between 400 and 450 t from 1988 up to 1993, but decreased slightly to 367 t in 1994. The female landings, however, showed large fluctuations, which were mostly related to (a) the annual variations in catchability, as reflected by the quarterly LPUEs (Figure 5.5.1), and (b) changes in the seasonal distribution of fishing effort (Figure 5.5.1), which, particularly in 1992, led to much lower female catches than in the preceding years (see also Anon., 1993, 1994a).

Quarterly and annual LPUEs by sex were calculated for the size classes > 35 mm CL, to reduce the noise due to both seasonal and year-to-year changes in discarding and tailing. The annual LPUEs for the males went down from about 6.0 kg/hour trawling in 1987-88 to 2.9 kg in 1991, then gradually increased again to 5.9 kg in 1994 (Figure 5.5.1). Over the past 10 years, the annual LPUEs of the females have been fluctuating between 0.9 and 2.5 kg/hour trawling, mostly depending on their availability during the third quarter (Figure 5.5.1).

Mean sizes

Mean sizes of *Nephrops* landed are available for the Belgian fleet only. As for the LPUEs, the calculations were restricted to the size classes > 35 mm CL, to minimise the

background noise due to variations in discarding and recruitment. The figures thus obtained reflect more closely the changes in the length composition of the largest *Nephrops* (which are most vulnerable to over-exploitation), and therefore can be considered as being indicative of any long-term changes in fishing pressure.

The mean sizes of males and females separately are shown in Figures 5.5.2 and 5.5.3, where each symbol represents the landings of one vessel sampled. The mean sizes of the males appear to have slightly decreased during the most recent years, whereas those of the females remained almost constant throughout the time series.

Assessments

In view of the considerable decrease in fishing effort, which means that the fishery is far from being in a "steady state", the Working Group decided not to update last years LCA.

Under such circumstances, the use of an age-based assessment technique, allowing a tuning of the data for varying levels of fishing effort, would be a good alternative. The quality of the length composition data for the years prior to 1992, however, was considered to be too poor to guarantee a reasonably reliable output from the VPA. Sampling of the tails, which make up 25-35 % of the landings in weight (especially since 1989), was started in 1992 only. Since the length distribution of the tails differs markedly from that of the *Nephrops* landed whole (see Figures 5.5.4 and 5.5.5, as examples), the estimates of the removals-at-length for the smallest size classes in the landings taken prior to 1992 are underestimated. Currently, an attempt is being made to "back-calculate" these length compositions but, at the time of the Working Group meeting, these "revised" data series were not yet available.

Management considerations

Bearing in mind (a) that fishing effort by the Belgian *Nephrops* directed trawler fleet has decreased by over 50 % since 1992, (b) that the Danish *Nephrops* trawlers have (at least for the time being) ceased fishing in the Botney Gut - Silver Pit area, and (c) that the "discard-corrected" LPUEs of male *Nephrops* (which are generally considered to be the most vulnerable sex) have increased by almost 65 % since 1992, there seems to be very little reason for concern for this stock. Therefore, the Working Group recommends that the TAC be maintained at its current level.

5.5.2. Summary of Divisions IVb,c east of 1° East (Management Area H)

Landings from other rectangles within Management Area H but outside Functional Unit 5 (Botney Gut - Silver Pit) increased fivefold over the past years, from about 70 t in 1988 to about 350 t in 1994 (Table 5.5.5). Most of these landings were taken by Danish trawlers (Table 5.5.6), in an area comprising 6 statistical rectangles north of White Bank (see also Figure 5.1.4).

Since Management Area H comprises only one Functional Unit, the management advice given for this unit equally applies to the area as a whole, i.e. to maintain the 1996 TAC at its current level.

Table 5.5.1 Input Data and parameters: Botney Gut

FU	5	MA	H
FLEET	Belgium	GEAR	trawl (otter+Nephrops)

1994	NUMBER OF SAMPLES				Mean
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	No./sample
Catch					
Landings	6	6	6	6	600-800*
Discards					

* 200 per market category (small, medium, large and tails)

	NUMBER OF SAMPLES									
YEAR	94	93	92	91	90	89	88	87	86	85
Catch										
Landings	24	22	24	24	24	24	24	24	24	18
Discards										

INPUT PARAMETERS		
Parameter	value	Source
Discard Survival	0.25	Gueguen and Charuau, 1975
MALES		
Growth - K	0.165	Taken from Scottish stocks
Growth - L(inf)	62	"
Nat. Mort. - M	0.3	Morizur, 1982
Length/weight - a	0.0003	Redant (unpublished)
Length/weight - b	3.24	"
FEMALES		
Immature Growth		
K	0.165	Taken from Scottish stocks
L(inf)	62	"
Nat.Mort. - M	0.3	Morizur, 1982
Size at Maturity	27	Redant (1994)
Mature Growth		
K	0.08	as for immatures
L(inf)	60	"
Nat.Mort. - M	0.2	assumed (based on Morizur , 1982)
Length/weight - a	0.00135	Redant (unpublished)
Length/weight - b	2.82	"

Table 5.5.2 Botney Gut - Silver Pit (Functional Unit 5): Landings (tonnes) by country, 1985-94

Year	Belgium**	Denmark	UK	Total
1985	680	?	<1	>680
1986	447	?	4	>451
1987	507	?	6	>513
1988	580	59	4	>643
1989	672	90	1	763
1990	716	161	1	878
1991	707	184	2	893
1992	564	30	12	606
1993	682	20	4	706
1994*	494	0	9	503

* provisional
** Data for 1986-1994 revised to include non-reported landings

Table 5.5.3 Botney Gut - Silver Pit (Functional Unit 5): Landings (tonnes), effort ('000 hours trawling) and LPUE (kg/hour trawling) of Belgian Nephrops directed otter trawlers, 1985-94

Year	Landings**	Effort	LPUE
1985	669	62.2	10.8
1986	447	53.6	8.4
1987	507	52.3	9.7
1988	578	57.9	10.0
1989	669	63.6	10.5
1990	699	72.9	9.6
1991	676	85.3	7.9
1992	554	83.1	6.7
1993	664	59.6	11.2
1994	463	37.0	12.5

** Data for 1986-1994 revised to include non-reported landings

Table 5.5.4 Botney Gut-Silver Pit (Functional Unit 5): Effort (days trawling) and LPUE (kg/day trawling) of Danish Nephrops trawlers, 1988-94

Year	Effort	LPUE
1988		285.1
1989		200.2
1990	1770	208.0
1991	620	295.6
1992	146	159.4
1993	96	175.5
1994	0	-

Table 5.5.5 Nephrops landings (tonnes) by Functional Unit plus other rectangles in Management Area H (IVb and IVc east of 1 ° east)

Year	FU 5	Other	Total
1985	>680	>1	>681
1986	>451	>10	>461
1987	>513	>4	>517
1988	643	71	714
1989	763	127	890
1990	878	122	1000
1991	893	161	1054
1992	606	203	809
1993	706	246	952
1994	503	346	849

Table 5.5.6 Total Nephrops landings (tonnes) by country in Management Area H (IVb and IVc east of 1° east)

Year	Belgium*	Denmark	UK	Total
1985	680	?	1	>681
1986	457	?	4	>461
1987	511	?	6	>517
1988	587	122	5	714
1989	677	210	3	890
1990	730	266	4	1000
1991	734	315	5	1054
1992	583	208	18	809
1993	693	253	6	952
1994	515	313	21	849

* Data for 1986-1994 revised to include non-reported landings

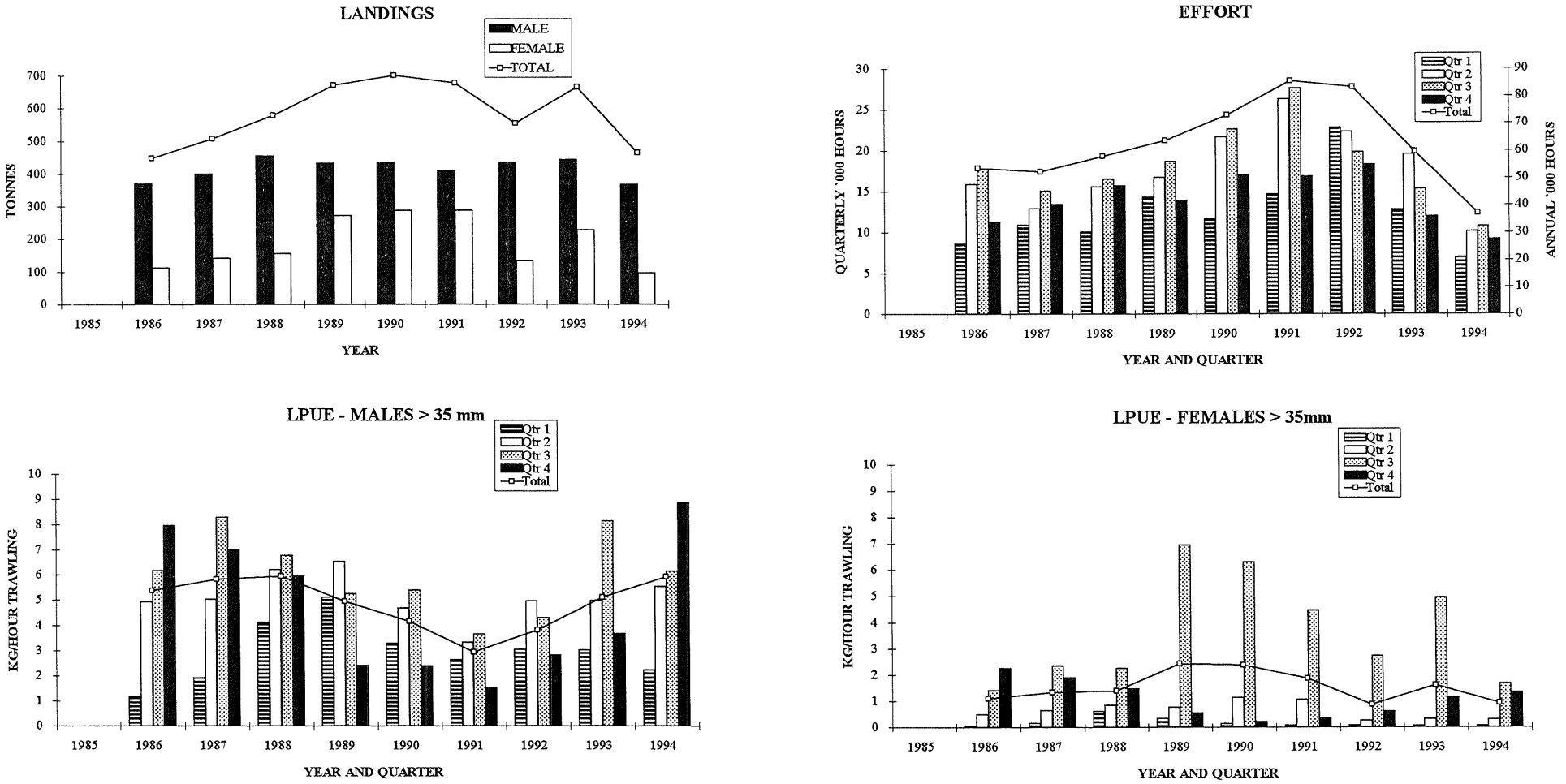


Figure 5.5.1. Botney Gut (Functional Unit 5) : trends in landings,effort and LPUE by quarter and sex from Belgian Nephrops trawlers.

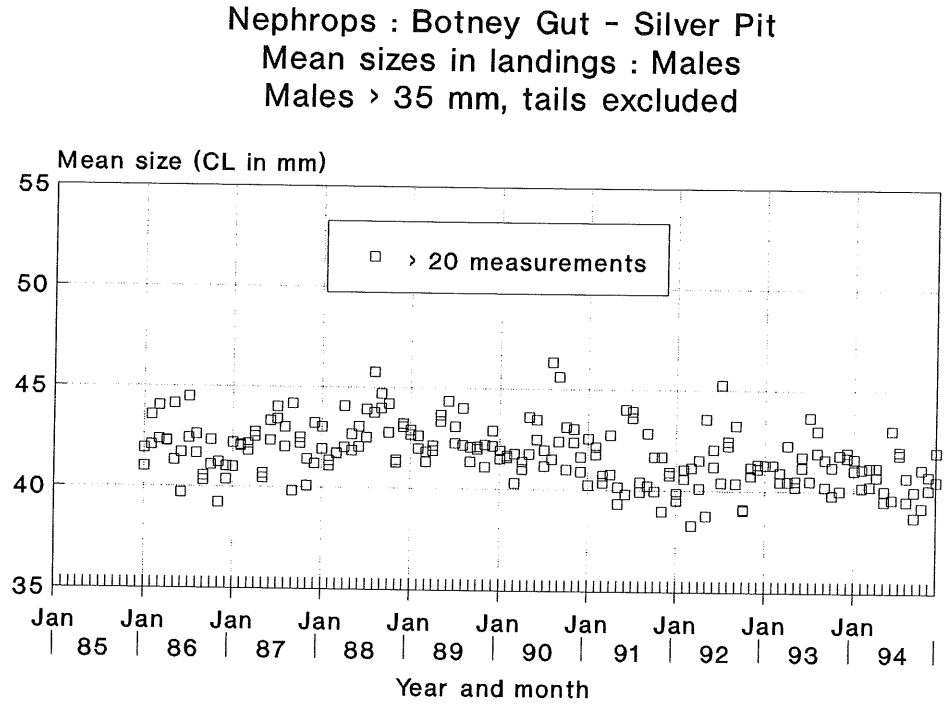


Figure 5.5.2

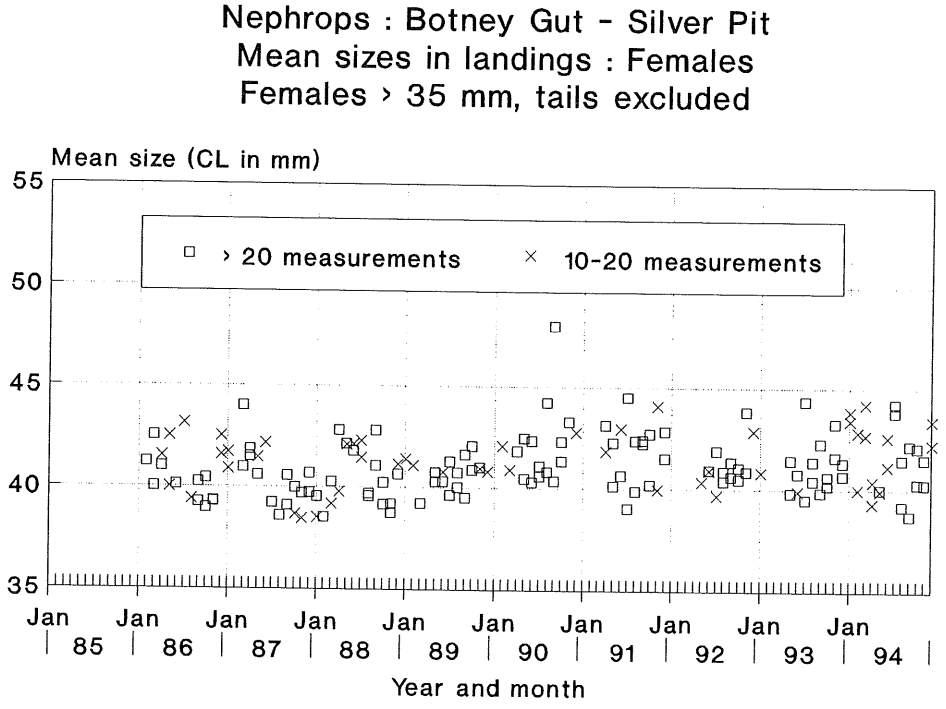


Figure 5.5.3

Nephrops : Botney Gut - Silver Pit
Length composition of landings
1994 : Males

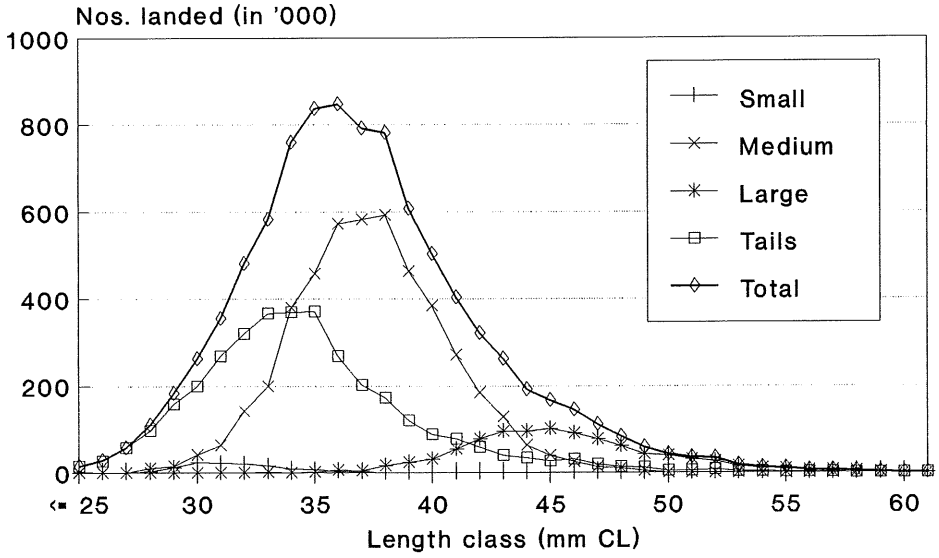


Figure 5.5.4

Nephrops : Botney Gut - Silver Pit
Length composition of landings
1994 : Females

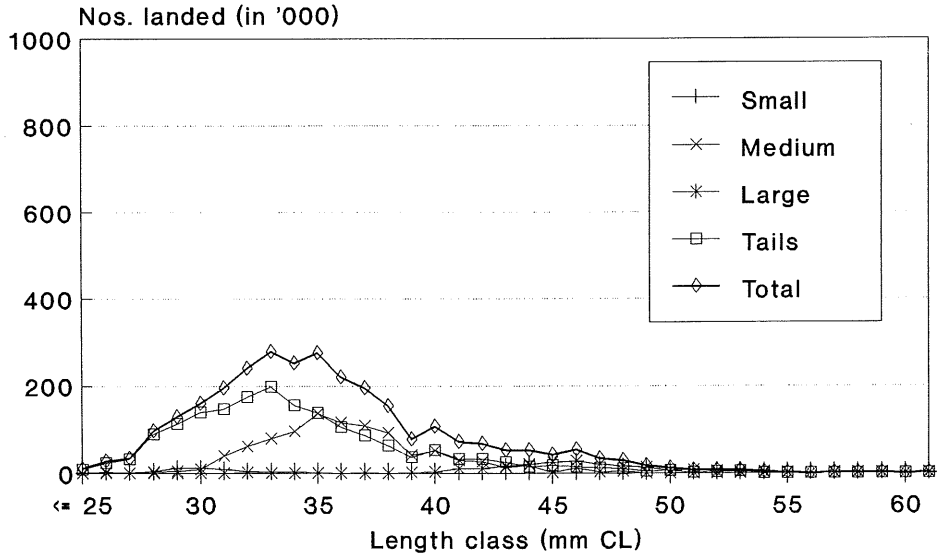


Figure 5.5.5

5.6. Division IVb,c West of 1° East (Management Area 1)

Functional Units **Farn Deeps (6)**
Firth of Forth (8)

The statistical squares comprising this Management Area and its constituent Functional Units are shown in Figure 5.1.1.

5.6.1. Farn Deeps (Functional Unit 6)

Data and Biological Inputs

Landings and effort statistics and length compositions of landings, catches, and discards were available for 1994. As with last year the database has been organised on an annual (calendar) basis to allow the possibility of calculating annual catch options using a short-term prediction approach.

The biological inputs for growth, maturity, length/weight relationships, and natural mortality were unchanged from those used last year (Table 5.6.1).

Comments on General Quality of Inputs

The quality of statistics collection was believed to be essentially similar to that in previous years, although there is some evidence of under-reporting in 1994. The length compositions were sampled at the most important ports in NE England on a monthly basis. In the last year 14 length samples of the landings were on average taken in each quarter (Table 5.6.1). In addition, 29 discard samples were taken at the main port of North Shields and Amble throughout the year, with the bulk of them covering the period of the main winter fishery.

Evans *et al* (1994) in a study of discarding in the Farn Deeps fishery, using data on the discarding practice of the fishermen, injury rates, and laboratory studies, deduced that a high proportion of discarded *Nephrops* were dead. They concluded that previous studies elsewhere seriously overestimated the probable discard survival rates in this particular fishery. The sensitivity of the LCA to a reduction in discard survival from the value of 0.25 used previously to 0.1 was examined (see later).

The other biological inputs (Table 5.6.1) are either directly based on observations in the Farn Deeps (length/weight, size at maturity), derived from other Functional Units (natural mortality), or determined from Farn Deeps data with reference to estimates from other Functional Units (growth).

Landings and Catches

Landings from this unit (Table 5.6.2, long-term trends Figure 5.6.1) are made mainly by UK vessels. The total landings in 1994 were 3676 t (provisional value), the highest in the series, and an increase of 21% on the landings of the previous year. It can be seen from Figure 5.6.2 that, except for 1990, the landings are predominately males, ranging from 50% (1990) to 76% (1993).

Effort

The fishing effort recorded for UK trawlers (Table 5.6.3, long-term trends Figure 5.6.1) had more than doubled between 1984 and a peak of 134,000 hours in 1989. The effort steadied at a slightly lower level of 115,000 hours in 1990-1991, then fell by 39% in 1992, the lowest since 1985. In 1993 the effort increased up to the 1990-1991 level of 112,000 hours, and in 1994 this has increased to 143,000 hours, the highest yet recorded. The highest effort is usually in quarter 4 (Figure 5.6.2), with quarter 1 being the next highest. Effort has usually been considerably lower in quarters 2 and 3, but a more even spread of effort was seen in 1993 and 1994.

CPUE/LPUE

CPUE data (Table 5.6.3, Figures 5.6.1 and 5.6.2) available from 1985 are mainly calculated from discard sampling during the principal winter fishing season (around October-March). In the last five years (1990-1994) CPUE has been fairly stable about a mean of 33 kg/h, some 29% below the average of 41 kg/h for the previous five years (1985-1989).

The LPUE (Table 5.6.3 and Figures 5.6.1 and 5.6.2) has fallen steadily from a peak of 32 kg/h in 1982 to 18 kg/h in 1991. The last three years (1992-94) have seen a recovery to 27 kg/h in 1993 and a similar figure (26 kg/h) in 1994. However, the rise in LPUE in 1992 and 1993 is believed to be due to a reduction in discarding. The slight fall in LPUE (26 kg/h) in 1994 has also been accompanied by a rise in discard rates. This is borne out by an increase in the mean size of both sexes from the landings in 1994, following a period of general decline (Table 5.6.4, Figure 5.6.1). The LPUE of females is usually considerably lower (annual average 1984-94 of 7 kg/h) than for males (14 kg/h) (Figure 5.6.2). In 1994 the LPUE of males decreased to 14 kg/h from last years highest of the series (21 kg/hr). The LPUE of the females increased to 8 kg/h, after a period (1991-93) of below average values.

Mean Size

The decline in the mean size of *Nephrops* in the landings up to 1993 has been reversed with a rise to 33.8 mm CL for males, and to 30.5 mm CL for females

(Table 5.6.4, Figure 5.6.1). As mentioned above, the recent decline in mean size was considered to be the result of less discarding and the consequent landing of more small *Nephrops*. However, in 1994 discarding is believed to have increased, resulting in an increase in the mean sizes in the landings.

Mean sizes in the catches have fluctuated within the range 26.5 to 31.2 mm CL, with mainly higher values for both males and females in the last 3 years (Table 5.6.4, Figure 5.6.1).

Assessments

Length-based assessment

In the first part of the available time series there was a rising trend in fishing effort. Over the period 1990-94 effort has fluctuated about this higher level without trends and this term was, therefore, chosen as the reference period. Following the publication of a study on discarding in the Farn deeps fishery (Evans *et al*, 1994) which suggested that the discard survival rate of 0.25 previously used by the Working Group , may be overoptimistic, the impact of the lowering of the discard survival rate to 0.1 was assessed. Other input parameters were the same as used previously (Table 5.6.1).

There were slightly higher F values at lower sizes with a discard survival of 0.1, but the Y/R and B/R curves (Figure 5.6.3) were similar for both values of discard survival. The results of the LCA, with the previous discard survival value of 0.25, are presented in Tables 5.6.5 (males) and 5.6.6 (females), with annualised mean F values, for the interquartile range of the length range, of 0.61 and 0.14 for males and females respectively.

The Y/R curve (Figure 5.6.3) for males showed that the recent F has been well to the right of Fmax, and predicts that reductions in effort by up to 40% could result in modest long-term increases in Y/R of up to 10%. By contrast, for the females current F is below Fmax (Figure 5.6.3).

Age-based assessment

The age-based assessment was re-worked with the addition of a further year's length data and a revision of the database for the years 1985-94. Other inputs were the same as last year (Tables 3.4.1 and 5.6.1). As over 99% of the landings are made by the UK fleet a single fleet assessment was done using the Lowestoft VPA suite.

VPA Tuning

The male and female catch-at-age data sets (Tables 5.6.7 and 5.6.8) were screened for outliers using Separable VPA. The residual matrix exhibited high residuals at the youngest and oldest ages but there were no extreme values. Chequered patterns, characteristic of changes in selection, were noted throughout the series. They indicated that the assumption of separability does not hold for the data sets from either sex.

XSA was used for the full assessment of both sexes separately. The time series of log catchability residuals at age derived from the XSA runs are presented in Figures 5.6.4 (males) and 5.6.5 (females). In general the series are noisy with the largest residuals for the youngest and oldest ages. Year effects are apparent, but there are no trends with time.

For the males, preliminary runs established that the catchabilities of ages 1 and 2 should be treated as being dependent on population size. Catchability was held independent of age for ages 9 and above. This allowed the catchability to decline over the older ages, a pattern consistent with prior knowledge. Initial runs established that average fishing mortality exhibited a sharp decline in 1992, the low values reduce the mean F for the last five years over the assessment and produced a reduction in final year estimates of terminal F when shrinkage was applied. F shrinkage was not used for the final assessment.

Table 5.6.9 presents the tuning diagnostic output for the male assessment. The catchability residual matrix indicates year effects and selection changes. The standard errors of the fleet catchabilities for the majority of ages are less than 35%. The standard errors of the terminal population in the final year are all less than 20%. Both sets of diagnostics indicate that although the catchability residuals exhibit patterns there appear to be no damaging effects on the quality of the assessment.

For the females, preliminary runs established that the catchabilities of ages 1 and 2 should be treated as being dependent on population size. Catchability was held independent of age for ages 13 and above. Initial runs established that, as for the males, the average fishing mortality exhibited a sharp decline in 1992. However, in contrast to the males, F was high in 1990. The effect of these outliers cancels each other and shrinkage to the mean F was applied in the final assessment.

Table 5.6.10 presents the tuning diagnostic output for the female assessment. The catchability residual matrix indicates year effects, especially in 1990, and selection changes. The standard errors of the fleet catchabilities have greater levels of noise than the male assessments but are still less than 35%. The standard errors of the terminal population in the final year are all less than 25%. As with the males, although the catchability residuals exhibit patterns there appear to be no damaging effects on the quality of the assessment.

The catchability residuals from both assessments show year effects and selection changes, it is possible that the latter may be induced by errors in the position at which slicing separates age groups. If the first age is incorrectly separated, then all older ages in that year will be influenced. The confounding of the effects of selection changes and slicing assumptions should be examined.

VPA output

Males

The estimate of Fbar(3-8) from the final run of the XSA (Table 5.6.11) correlated well with the fishing effort (Figure 5.6.6, $r^2 = 0.82$, $P < 0.05$) and followed quite closely the trends over the time period 1985-94.

The summary outputs (Table 5.6.11 Figure 5.6.7) from the XSA show that landings of males increased considerably in 1993 and 1994 to 2393 t, following a period when landings fluctuated around 1400 t. Fbar(3-8) rose fairly steadily from 1985 to 1991, dropped to 0.46 in 1992 and has risen again to the highest value (1.01) of the series in 1994. SSB has fluctuated around 8000 t, having increased from a low of 7299 t in 1990 to a high of 8719 t in 1993. Recruitment has fluctuated between 331 million and 185 million.

Females

The correlation of Fbar(3-12) with effort for females was not as good as that for males, but was significant (Table 5.6.12, Figure 5.6.8, $r^2 = 0.61$, $P < 0.05$). Landings of females, which are less than males (Table 5.6.12 and Figure 5.6.9), have followed a similar trend to the males, having increased rapidly in the last two years. Fbar(3-12) reached a peak in 1990, declined in 1992, but has increased again recently. SSB declined over the period 1986-91, but has increased again recently. Recruitment was reasonably constant over the period 1985-94 with mean of 265 million, except for 1992 when R = 488 million.

Comparison of males and females

The mean Fs on males were higher than those on females. This is consistent with the greater availability of males than females, and was also observed in the LCA, which gave lower values. Mean recruitment of males and females at nominal age 1 were very close (Tables 5.6.11 and 5.6.12).

General Comments on the Quality of the Assessment

Data collection and research efforts on this Functional Unit have been maintained at a high level for several years. The landings and effort statistics have been thought to be reasonably complete and reliable until recently. There are indications that there has been some under-reporting of landings, particularly in 1994. There has been an intensive length sampling programme since 1983, particularly for the landings. A reduction in sampling levels for the discards for 1990-92 has necessitated some adjustment to the mean seasonal values, but this is unlikely to have had any significant impact on the assessments. Some of the biological inputs are dependent upon estimates from other functional units. Given the highly domed shape of the male Y/R curve and the need for a 40% reduction in effort to achieve Fmax, together with the trends in F(bar), and TSB from the VPA, as well as the past decline in CPUE and mean size, only major changes to the biological inputs would be likely to change the perception of the state of exploitation and the appropriate management requirements.

Management Considerations

The VPA seems to be consistent this year with significant correlations between F(bar) and effort for both male and female *Nephrops*. The short-term trends in F(bar) TSB, SSB, and R (Figures 5.6.7 and 5.6.9) can be taken, together with the results of the recent LCAs and the LPUE/CPUE and mean size trends, to provide guidance on the state of exploitation of this functional unit.

The landings from the Farn Deeps fell from a peak of 3098 t in 1989 to 1463 t in 1992, but have since increased to 3676 t in 1994, the highest ever. Effort has increased back up to the higher levels of the 1988-1991 period, to a maximum of 143000 h in 1994. CPUE has remained reasonably stable in the last five years, while LPUE has increased, probably due to a decrease in discarding. The mean size of the catch remains close to the average of the time period (1985-1994), but the mean size of the landings has risen from last year's lowest of the series.

The LCA yield-per-recruit analysis shows that for males effort would need to be reduced by 40% to achieve Fmax, but for females current effort is below Fmax. The VPA has shown higher levels of F for males than for females, with an increasing trend in F(bar) for both males and females until 1990, a dip in 1992, followed by increases in 1993 and 1994, with that for males being the highest recorded (Fbar (3-8) = 1.0). The TSB estimates from the VPA had shown a recent recovery, but fell again for males in 1994, and can be expected to decline further if effort is maintained at its current level.

Overall these factors lead to the conclusion that the Farn Deeps is at least fully exploited. Concern has been expressed that there may have been signs that this Functional Unit could not sustain the high levels of effort seen in the late 1980s. Effort had fallen from the 1989 peak, particularly in 1992. In 1993 and 1994 effort

again increased and it is suggested that further effort increases in this fishery should be prevented, and the impact of the recent high levels of effort should be carefully monitored.

5.6.2. Firth of Forth (Functional Unit 8)

Data and Biological Inputs

Sampling of commercial trawl landings is carried out regularly at the Scottish ports of Pittenweem and Eyemouth. The level of sampling is summarised on a quarterly basis in Table 5.6.13. The trawl discards were sampled each quarter on board commercial fishing vessels (Table 5.6.13). The trawl landings and discard samples were raised to fleet level and combined to estimate total removals, as described for the Moray Firth.

All input parameters remained the same as in previous years (Table 5.6.13).

Comments on the Quality of Inputs

Adequate sampling of the landings is usually achieved in this fishery. The level of discard sampling is considered minimal, bearing in mind the high temporal variability in discard rates. It is hoped to increase the level of discard sampling in 1995. The uniform sedimentary environment probably means input parameters are better estimated for this stock than for some others in Scottish waters (Anon.,1993).

Landings, Effort, LPUE, Mean Size

Landings data were reported by UK vessels only. In 1994, reported landings were 1812 t, down about 550 t compared to the high landings of the previous year (Table 5.6.14). In the long-term data series, landings have fluctuated around 2000 t (Figure 5.6.10). 99% of the 1994 landings were made by Scottish *Nephrops* trawlers. The fall in landings reflected a decline in fishing effort and a small decrease in LPUE (Table 5.6.15). Following the UK ban, no multi-rig gear was used in this fishery in 1994. Recently, LPUE has remained fairly stable, though at a relatively low level in comparison to earlier years (Table 5.6.15; Figure 5.6.10).

Figure 5.6.11 shows landings, effort and LPUE data apportioned between the sexes. The male contribution to the annual landings is usually much greater than the female. Higher female contributions to the landings in some years (e.g. 1988-89) appear to relate to a change in fleet fishing pattern, with increased effort in the 3rd quarter and reduced effort in the 4th quarter.

The mean size of both sexes in trawl landings and catches suggest a declining trend (Table 5.6.16, Figure 5.6.10).

Assessments

Length-based assessment

Following revision of the length composition data, the LCA was carried out for the most recent 5-yr reference period, 1990-94. Input F choices were unchanged from previous analyses (0.1, 0.05 in males and females respectively). Outputs from the LCA are given in Tables 5.6.17 and 5.6.18. The long term Y/R curve for males was dome shaped suggesting current F was well above Fmax, while for females the Y/R curve was curvi-linear (Figure 5.6.12). Annualised fishing mortalities (averaged over the inter-quartile length range) were 0.87 and 0.16 for males and females respectively.

Age-based assessment

As in previous years, slicing of the length composition was carried out to generate nominal 'age' groups. The slicing package, L2AGE was adapted to generate files suitable for analysis by the Lowestoft VPA software. In some preliminary runs, a comparison was made between results from TUNE 1, the VPA program used previously, and from the Ad Hoc option, with Laurec-Shepherd tuning, available in the Lowestoft package. Given comparable inputs and tuning choices both methods gave the same results for Firth of Forth males. In view of its widespread use in other assessment Working Group s, the XSA tuning option was used for the main assessment. Single fleet assessments of males and females separately were carried out using Scottish data from 1981 -1994. Effort data were derived as for the Moray Firth.

Males

The slicing procedure generated 11 'nominal age' groups (11 = plus group). Catch numbers and mean weights at age are given in Table 5.6.19. Weights at age data were assumed to represent stock mean weights and, as for the Moray Firth, no corrections were applied. Values for natural mortality and maturity are also given in Table 5.6.19.

The fleet catchability residuals, arising from the Laurec-Shepherd (LS) method are plotted in Figure 5.6.13. The residuals seem reasonably trend-free, apart from the erratic fluctuations for nominal age 1 and evidence of 'year' effects in the older age groups (>5).

XSA (v.3.1) was used to tune the VPA. Tuning was performed over the whole 14 year period, over ages 1-10, with a tricubic time taper but without shrinkage. For the catchability analysis, catchability was dependent on stock size for ages < 3, with estimates shrunk to the population mean; catchability was independent of age for ages ≥ 6. Further details about the tuning and the tuning results are given in Table 5.6.20. The tuning converged after 23 iterations.

Estimates of fishing mortality and population numbers from the VPA are given in Table 5.6.21. Figure 5.6.14 shows a relatively good fit between mean F (over ages 3-8) and fishing effort trends and the correlation coefficient between them ($r^2 = 0.83$) is highly significant ($P < 0.001$).

Trends in VPA estimates of yield, mean F, TSB and recruitment are given in Table 5.6.21 and plotted in Figure 5.6.15. Male landings increased initially but since 1983 have fluctuated without trend. Mean F has fluctuated about a generally rising trend and is now higher than for any other Scottish stock. Both TSB and recruitment have been reasonably stable.

Females

The slicing procedure gave 16 'nominal age' groups (16 = plus group). Catch numbers and mean weights at age are presented in Table 5.6.22. As for males, weights at age data were assumed to represent stock weights and no SOP corrections were applied. Natural mortality and maturity values are also given in Table 5.6.22. For females M is assumed to decrease at the onset of sexual maturity (see also Table 5.6.13).

The fleet catchability residuals from the LS tuning are plotted in Figure 5.6.16. As for the males, the residuals for 'age' 1 were large and erratic. There were also marked year effects for most other ages.

Tuning details are given in Table 5.6.23. The catchability analysis was similar to males except that q was independent of age for ages ≥ 5. The tuning had not converged to the criteria set by the program after 70 iterations, though examination of the final year F values at age from the last two iterations suggested that convergence had occurred to 3 decimal places.

Estimates of fishing mortality and population numbers from the VPA are given in Tables 5.6.24. Fishing mortality estimates were much lower than for males. Plots showing fishing effort and mean F (over ages 3-13) trends and the degree of correlation between them are shown in Figure 5.6.17. The correlation is poorer than for males ($r^2 = 0.37$) but is still statistically significant ($P < 0.05$).

Trends in the VPA estimates of female yields, mean F, TSB and recruitment are given in Table 5.6.24 and plotted in Figure 5.6.18. Landings increased initially but since 1985 they have fluctuated without trend. Mean F has fluctuated at a low level, with relatively high values in 1988-90. TSB and recruitment have been relatively stable. Comparison between Tables 5.6.21 and 5.6.24 shows that annual estimates of TSB and recruitment are reasonably consistent between the sexes.

Other aspects

Landings and effort/area indices, shown in Figure 5.3.10, are currently very high; the latter index is higher in the Firth of Forth than for all other Scottish grounds.

TV camera and trawl surveys of the Firth of Forth grounds were conducted during cruises of RV Scotia in 1993 and 1994. Details of the 1994 survey results are given in Table 5.6.25. Estimates of mean burrow density across different strata varied from 0.41 to 0.73/m^2. Abundance and biomass estimates raised to the total ground area (915.3km^2) were about 530 million burrows (95% confidence interval 440-620) and the equivalent biomass estimate was in the range 7600 - 10800 t (Table 5.6.26). Comparison with the results of the 1993 survey (not corrected for unoccupied burrows) suggests a fall in the abundance and biomass of the stock between surveys.

Comments on the quality of the assessments

In general this stock is considered to provide reliable assessment results in comparison to other Scottish stocks. The VPA on sliced 'age' groups has been used for several years and it has invariably performed consistently well, particularly on males. The uniformity of the sedimentary environment, good sampling coverage (at least of the landings) and the even distribution of fishing effort, probably contributes to the quality of data used in the assessments. There was good agreement between the direct TV estimates of abundance and biomass given above and those derived from the VPA (abundance 480 million, biomass 10,000 t).

Management considerations

The available evidence suggests that the Firth of Forth stock could derive some long-term benefit from a reduction in fishing effort. The Y/R curve for males suggested that an effort reduction of 50% should generate an increase in long term yield of about 20%, though this would be offset to some extent by a reduction in the yield from females. Both the LCA and VPA suggest that fishing mortality on males is higher than on other stocks in Scottish waters. The VPA showed an increasing trend in F, particularly in males, though TSB and recruitment appeared to be reasonably stable.

5.6.3. Summary for Division IVb,c West of 1° East (Management Area I)

The recent *Nephrops* landings in Functional Units 6 and 8 and from other ICES rectangles forming MA I are given in Tables 5.6.27 and 5.6.28. The Working Group again recommended that the main management objective should be to prevent further increases in fishing effort in both Functional Units. This is unlikely to be achieved, however, without separating the TAC from other MAs in the North Sea (see Section 5.4).

Table 5.6.1 Input data and parameters: Farn Deeps

FU 6	MA I
FLEET UK	GEAR Trawl

1994	NUMBER OF SAMPLES				Mean
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	No./sample
Catch	8	3	7	11	724
Landings	25	15	8	7	188
Discards	8	3	7	11	446

	NUMBER OF SAMPLES									
YEAR**	94	93	92	91	90	89	88	87	86	85
Catch	29	23	10	10	26	31	37	36	8	15
Landings	55	66	40	48	74	70	44	49	70	52
Discards	29	23	10	10	26	31	37	36	8	15

INPUT PARAMETERS		
Parameter	Value	Source
Discard Survival	0.25	Anon, 1985
MALES		
Growth - K	0.16	Macer (unpublished) and comparison
Growth - L(inf)	66	with Scottish stocks
Nat. Mort. - M	0.3	Morizur, 1982
Length/weight - a	0.00038	Farn Deeps observations (Macer unpub.)
Length/weight - b	3.17	"
FEMALES		
Immature Growth		
K	0.16	as for males
L(inf)	66	"
Nat.Mort. - M	0.3	"
Size at Maturity	24mm	50% berried
Mature Growth		
K	0.06	as for males
L(inf)	58	"
Nat.Mort. - M	0.2	assumed (based on Morizur, 1982)
Length/weight - a	0.00091	as for males
Length/weight - b	2.89	"

Table 5.6.2 Farn Deeps (Functional Unit 6): Landings (tonnes) by country, 1985-94

Year	UK	Denmark	Belgium	Total
1985	2028	+	?	>2028
1986	2015	+	0	>2015
1987	2193	+	0	>2193
1988	2494	10	0	2504
1989	3098	1	0	3098
1990	2498	+	0	2498
1991	2061	1	1	2063
1992	1463	0	<1	1463
1993	3030	0	0	3030
1994	3675	1	0	3676

+ small unrecorded ? small unallocated by FU

Table 5.6.3 Farn Deeps (Functional Unit 6): Catches and landings (tonnes), effort ('000 hours trawling), CPUE and LPUE (kg/hr trawling), of UK Nephrops trawlers, 1985-94

Year	Catches	Landings	Effort	CPUE	LPUE
1985	4223	2012	89	48	23
1986	2800	1995	90	31	22
1987	4435	2177	98	45	22
1988	5531	2472	118	47	21
1989	4639	3076	134	35	23
1990	4096	2471	116	35	21
1991	3075	2020	115	27	18
1992	2287	1437	70	33	21
1993	3568	3011	112	32	27
1994	5163	3665	143	36	26

Table 5.6.4 Farn Deeps (Functional Unit 6): Mean sizes (CL mm) of male and female Nephrops in English catches and landings, 1985-94

Year	Catches		Landings	
	Males	Females	Males	Females
1985	29.6	28.0	34.9	33.3
1986	31.2	29.7	34.8	33.2
1987	28.1	26.5	34.8	32.8
1988	28.2	26.8	34.5	33.4
1989	28.5	27.7	31.9	31.4
1990	26.6	26.9	31.3	30.8
1991	28.4	26.6	33.0	32.6
1992	30.3	28.5	32.5	31.4
1993	29.6	27.0	30.6	28.0
1994	30.4	27.4	33.8	30.5

Table 5.6.5 Farne Deeps (FU6): Males - LCA output.

COHORT ANALYSIS

L INFINITY = 66.0000 K = .1600

COHORT ANALYSIS BY POPE'S APPROXIMATION

SIZE MM	REMOVALS	M	DT	FDT	F	Z	NO. ATTAINING	AVE. NO. IN SEA	BIOMASS kg
12.0	46.5	.3000	.2359	.0002	.0008	.3008	256990.0	58517.6	77498.5
14.0	136.5	.3000	.2451	.0006	.0024	.3024	239388.3	56558.8	117983.2
16.0	716.5	.3000	.2551	.0034	.0131	.3131	222284.1	54506.5	169180.0
18.0	2118.3	.3000	.2660	.0108	.0406	.3406	205215.4	52187.0	230582.0
20.0	5239.8	.3000	.2778	.0296	.1065	.4065	187440.4	49242.6	298953.3
22.0	8838.5	.3000	.2908	.0567	.1951	.4951	167425.2	45337.6	367414.3
24.0	11226.3	.3000	.3049	.0845	.2772	.5772	144979.0	40537.5	428079.4
26.0	10874.3	.3000	.3206	.0985	.3074	.6074	121580.4	35416.6	477520.1
28.0	13482.0	.3000	.3379	.1528	.4523	.7523	100068.3	29859.1	505117.8
30.0	12379.0	.3000	.3572	.1843	.5158	.8158	77605.4	24049.3	502775.1
32.0	11931.3	.3000	.3789	.2456	.6483	.9483	57985.3	18456.8	470582.1
34.0	8934.8	.3000	.4034	.2672	.6624	.9624	40482.8	13533.1	415917.8
36.0	7052.0	.3000	.4312	.3202	.7425	1.0425	27458.6	9536.7	349645.7
38.0	4855.5	.3000	.4632	.3526	.7613	1.0613	17516.4	6409.4	277736.7
40.0	3366.0	.3000	.5003	.4135	.8265	1.1265	10714.4	4097.6	208115.9
42.0	2086.3	.3000	.5438	.4639	.8530	1.1530	6098.5	2463.9	145566.7
44.0	951.0	.3000	.5957	.3845	.6455	.9455	3257.7	1483.7	101271.3
46.0	554.0	.3000	.6585	.4000	.6074	.9074	1854.9	919.5	72051.8
48.0	261.0	.3000	.7361	.3364	.4569	.7569	1020.5	575.9	51513.4
50.0	121.0	.3000	.8346	.2674	.3204	.6204	584.5	380.8	38672.2
52.0	75.0	.3000	.9634	.2861	.2970	.5970	348.3	255.2	29283.0
54.0	33.0	.3000	1.1395	.2229	.1956	.4956	196.0	170.6	22021.8
56.0	23.0	.3000	1.3946	.2937	.2106	.5106	111.4	111.1	16068.5
58.0	9.0	.3000	1.7980	.2429	.1351	.4351	54.7	68.2	10996.2
60.0	10.0	.3000			.2000	.5000	25.0	68.2	10996.2
							TOTALS	504811.5	5406539.0

NOTE: AVE. POP. & BIOMASS LARGEST LENGTH ASSUMED TO EQUAL THOSE OF PENULTIMATE LENGTH

Table 5.6.6 Farne Deeps (FU6): Females - LCA output.

COHORT ANALYSIS

LOWER CURVE LINF= 66.0000 K= .1600

UPPER CURVE LINF= 58.0000 K= .0600

TRANSITION LENGTH= 24.0000

COHORT ANALYSIS BY POPE'S APPROXIMATION

SIZE MM	REMOVALS	M	DT	FDT	F	Z	NO. ATTAINING	AVE. NO. IN SEA	BIOMASS kg
14.0	233.3	.3000	.2451	.0009	.0039	.3039	256117.5	60500.8	139335.2
16.0	557.5	.3000	.2551	.0024	.0096	.3096	237734.0	58321.3	192966.5
18.0	2262.8	.3000	.2660	.0108	.0405	.3405	219680.0	55866.1	255055.6
20.0	6328.8	.3000	.2778	.0334	.1203	.4203	200656.6	52615.0	320938.0
22.0	9789.8	.3000	.2908	.0590	.2029	.5029	178540.1	48294.1	383331.9
24.0	10261.3	.2000	.3049	.0710	.2330	.4330	154254.8	44065.1	445248.8
26.0	10447.0	.2000	1.0756	.0900	.0837	.2837	135175.2	125311.9	1582177.0
28.0	9708.0	.2000	1.1499	.1158	.1007	.3007	99628.8	96854.9	1503911.0
30.0	8765.3	.2000	1.2351	.1516	.1227	.3227	70506.8	71822.0	1352702.0
32.0	8162.5	.2000	1.3340	.2195	.1645	.3645	47327.4	49998.1	1128493.0
34.0	4898.5	.2000	1.4502	.2164	.1492	.3492	29101.2	33112.6	886159.6
36.0	3271.8	.2000	1.5885	.2468	.1553	.3553	17537.3	21287.7	669128.5
38.0	1594.0	.2000	1.7560	.2114	.1204	.3204	9972.8	13393.6	490299.4
40.0	1117.0	.2000	1.9631	.2734	.1393	.3393	5682.0	8143.3	344540.0
42.0	504.0	.2000	2.2255	.2430	.1092	.3092	2919.1	4696.8	228095.8
44.0	187.0	.2000	2.5692	.1801	.0701	.2701	1467.0	2717.8	150550.9
46.0	125.0	.2000	3.0387	.2628	.0865	.2865	732.9	1487.1	93426.6
48.0	35.0	.2000	3.7191	.1808	.0486	.2486	306.9	744.7	52786.1
50.0	18.0	.2000	4.7947	.2729	.0569	.2569	121.7	335.6	26706.9
52.0	3.0	.2000	6.7578	.1816	.0269	.2269	35.5	122.8	10920.2
54.0	1.0	.2000			.0300	.2300	7.7	122.8	10920.2
							TOTALS	749936.8	10278610.0

NOTE: AVE. POP. & BIOMASS LARGEST LENGTH ASSUMED TO EQUAL THOSE OF PENULTIMATE LENGTH

Table 5.6.7 Farne Deeps (FU6): Male - VPA input.

```
FU6 FARN DEEPS MALES CATCH NUMBERS THOUSANDS
1 2
1985 1994
1 11
1
     539.8   29995.1   54623.0   24694.4    8070.5    2792.8    1290.0     559.6     278.1     160.3     259.5
     542.6   13314.3   21068.7   14624.6    7555.1    2979.3    1455.9     703.5     352.4     170.0     247.6
    3972.3   46337.4   38785.2   19049.9    7807.8    3047.8    1400.5     610.4     312.1     174.0     283.5
    2775.9   59613.3   63185.1   21011.8    9127.1    3725.1    1677.7     719.6     376.4     204.6     273.3
    6157.6   38314.4   56954.9   24051.4    7621.6    2640.2    1111.5     383.1     140.8      52.6      48.0
    8386.8   57056.1   29786.4   15686.5    5050.6    2373.0    1051.2     398.0     227.7     103.3     143.4
    2476.7   33591.9   31156.1   18861.0    7281.8    2391.8     769.7     290.3     127.8      67.8     104.1
     341.3   10859.0   37569.9   20353.6    4473.7     993.8     418.9     117.8      38.1      23.7      20.0
    1267.0   15698.6   39254.9   30795.0   15821.8    3980.6     674.3     135.1      18.3      10.9       7.5
    2532.9   30492.8   41917.5   28217.8   14759.2    6086.0    1750.2     412.5     125.7      37.2      14.3

FU6 FARN DEEPS MALES CATCH WTS KGS
1 3
1985 1994
1 11
1
      .004      .010      .017      .029      .043      .058      .074      .090      .104      .117      .148
      .004      .009      .018      .029      .043      .059      .074      .090      .103      .117      .146
      .004      .009      .017      .029      .043      .059      .074      .090      .104      .118      .145
      .004      .010      .017      .029      .043      .058      .074      .090      .104      .117      .145
      .004      .010      .017      .029      .043      .059      .073      .089      .102      .117      .141
      .004      .009      .018      .029      .043      .059      .074      .090      .103      .117      .142
      .004      .009      .018      .029      .043      .058      .073      .089      .104      .117      .147
      .004      .010      .018      .029      .042      .058      .073      .088      .105      .117      .160
      .004      .010      .018      .030      .043      .057      .071      .087      .109      .112      .170
      .004      .010      .018      .030      .044      .058      .073      .089      .103      .113      .147

FU6 FARN DEEPS MALES STOCK WTS KGS
1 4
1985 1994
1 11
1
      .004      .010      .017      .029      .043      .058      .074      .090      .104      .117      .148
      .004      .009      .018      .029      .043      .059      .074      .090      .103      .117      .146
      .004      .009      .017      .029      .043      .059      .074      .090      .104      .118      .145
      .004      .010      .017      .029      .043      .058      .074      .090      .104      .117      .145
      .004      .010      .017      .029      .043      .059      .073      .089      .102      .117      .141
      .004      .009      .018      .029      .043      .059      .074      .090      .103      .117      .142
      .004      .009      .018      .029      .043      .058      .073      .089      .104      .117      .147
      .004      .010      .018      .029      .042      .058      .073      .088      .105      .117      .160
      .004      .010      .018      .030      .043      .057      .071      .087      .109      .112      .170
      .004      .010      .018      .030      .044      .058      .073      .089      .103      .113      .147

FU6 FARN DEEPS MALES NATURAL MORTALITY
1 5
1985 1994
1 11
2
 .300 .300 .300 .300 .300 .300 .300 .300 .300 .300 .300

FU6 FARN DEEPS MALES PROPORTION MATURE
1 6
1985 1994
1 11
2
      1.0       1.0       1.0       1.0       1.0       1.0       1.0       1.0       1.0       1.0       1.0

FU6 FARN DEEPS MALES PROP M BEFORE SPAWN
1 8
1985 1994
1 11
3
0


FU6 FARN DEEPS MALES PROP F BEFORE SP
1 7
1985 1994
1 11
3
0
```

Table 5.6.8 Farne Deeps (FU6): Females - VPA input.


```
FU6 FARN DEEPS FEMAL CATCH NUMBERS THOUSANDS
1 2
1985 1994
1 15
1
     892.8   24699.0   10131.7    8215.6    7210.6    5214.1    3714.0    2665.0    1739.4    1171.4     763.7     453.9     388.7     228.5     737.7
     369.4   12141.9    6404.3    6737.6    5753.2    4742.5    3769.5    3076.3    2453.9    1794.8    1321.7     758.4     639.8     435.1    1230.5
    6498.8   46682.6   14940.0   12804.3    8850.1    6389.0    4226.5    2849.5    2230.4    1508.8     990.9     668.9     601.1     294.0    1056.3
    4729.9   57058.5   14772.7    9735.4    7149.8    6715.2    5373.7    4306.5    3040.6    2212.7    1618.4     873.5     716.7     421.6    1480.6
    5184.9   37817.3   12698.2   10725.8    8369.1    7320.0    6015.9    4959.8    3551.1    2555.3    1840.5     952.1     765.1     400.3    1052.5
    7001.8   51632.9    9181.2    9395.5   10454.7   10277.9    7357.7    5324.1    4083.7    2689.7    1689.1     996.9     851.2     399.7    1015.9
    3495.5   30558.5    4289.8    3280.9    4614.1    4624.5    3564.1    2849.6    2526.3    1767.7    1223.2     798.1     708.6     331.3     712.8
     204.9    9885.5    4153.2    3418.7    2607.0    2974.3    1930.2    1212.2     873.1     599.2     402.6     320.0     302.6     159.3     310.1
    1356.9   14861.8    6405.5    6942.8    5758.1    3664.1    2876.7    2269.2    1360.4     846.9     478.4     359.2     334.2     140.8     433.0
    3116.7   45313.0   22291.3   17894.6   12050.5    9273.4    6356.5    4109.2    1455.5    1042.1     745.4     666.2     649.5     336.4     910.6

FU6 FARN DEEPS FEMAL CATCH WTS KGS
1 3
1985 1994
1 15
1
      .004      .010      .013      .016      .019      .022      .024      .027      .031      .033      .036      .040      .042      .046      .055
      .004      .009      .014      .016      .019      .022      .024      .027      .031      .033      .036      .040      .042      .047      .054
      .004      .009      .013      .016      .019      .022      .024      .027      .031      .033      .036      .040      .042      .046      .057
      .004      .009      .013      .016      .019      .022      .024      .027      .031      .033      .036      .040      .042      .046      .055
      .004      .009      .013      .016      .019      .022      .024      .027      .031      .033      .036      .040      .042      .046      .054
      .004      .008      .013      .016      .019      .022      .024      .027      .031      .033      .036      .040      .042      .046      .055
      .004      .008      .013      .016      .019      .022      .024      .027      .031      .033      .036      .040      .042      .046      .053
      .004      .009      .013      .016      .019      .022      .024      .027      .031      .033      .036      .040      .042      .046      .053
      .004      .009      .014      .016      .019      .022      .024      .027      .031      .033      .036      .040      .042      .046      .055
      .004      .010      .013      .016      .019      .022      .024      .027      .031      .033      .036      .041      .042      .046      .055

FU6 FARN DEEPS FEMAL STOCK WTS KGS
1 4
1985 1994
1 15
1
      .004      .010      .013      .016      .019      .022      .024      .027      .031      .033      .036      .040      .042      .046      .055
      .004      .009      .014      .016      .019      .022      .024      .027      .031      .033      .036      .040      .042      .047      .054
      .004      .009      .013      .016      .019      .022      .024      .027      .031      .033      .036      .040      .042      .046      .057
      .004      .009      .013      .016      .019      .022      .024      .027      .031      .033      .036      .040      .042      .046      .055
      .004      .009      .013      .016      .019      .022      .024      .027      .031      .033      .036      .040      .042      .046      .054
      .004      .008      .013      .016      .019      .022      .024      .027      .031      .033      .036      .040      .042      .046      .055
      .004      .008      .013      .016      .019      .022      .024      .027      .031      .033      .036      .040      .042      .046      .053
      .004      .009      .013      .016      .019      .022      .024      .027      .031      .033      .036      .040      .042      .046      .053
      .004      .009      .014      .016      .019      .022      .024      .027      .031      .033      .036      .040      .042      .046      .055
      .004      .010      .013      .016      .019      .022      .024      .027      .031      .033      .036      .041      .042      .046      .055
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Table 5.6.8 cont'd. Farne Deeps (FU6): Females - VPA input.

```
FU6 FARN DEEPS FEMAL NATURAL MORTALITY
 1 5
 1985 1994
 1 15
 2
  .300 .300 .200 .200 .200 .200 .200 .200 .200 .200 .200 .200 .200 .200 .200

FU6 FARN DEEPS FEMAL PROPORTION MATURE
 1 6
 1985 1994
 1 15
 2
        .0        .0       1.0       1.0       1.0       1.0       1.0       1.0       1.0       1.0       1.0
1.0       1.0       1.0       1.0

FU6 FARN DEEPS FEMAL PROP M BEFORE SPAWN
 1 8
 1985 1994
 1 15
 3
 0

FU6 FARN DEEPS FEMAL PROP F BEFORE SP
 1 7
 1985 1994
 1 15
 3
 0
```

Table 5.6.9 Farne Deeps (FU6): males - VPA tuning information

Lowestoft VPA Version 3.1

Extended Survivors Analysis

FU6 FARN DEEPS MALES INDEX FILE

CPUE data from file C:\DATA\NEPHROPS\NEPWG95\FU6\VPA\MALE\TUNEFF.DAT

Catch data for 10 years, 1985 to 1994. Ages 1 to 11.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
FLEET 1	1985	1994	1	10	0	1

Time series weights :

Tapered time weighting not applied

Catchability analysis :
Catchability dependent on stock size for ages < 3
Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 3
Catchability independent of age for ages >= 9

Terminal population estimation :

Final estimates not shrunk towards mean F

Minimum standard error for population
estimates derived from each fleet = .300

Prior weighting not applied

Tuning had not converged after 40 iterations

Total absolute residual between iterations
39 and 40 = .00388

Final year F values

Age	1	2	3	4	5	6	7	8	9	10
Iteration 39	0.0115	0.2194	0.8127	1.0054	0.9789	1.021	1.0959	1.1401	1.147	0.8899
Iteration 40	0.0115	0.2193	0.811	1.0042	0.9789	1.0212	1.0958	1.1402	1.1474	0.89

Regression weights

1	1	1	1	1	1	1	1	1	1

Fishing mortalities

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.003	0.002	0.015	0.014	0.022	0.031	0.013	0.002	0.006	0.012
2	0.259	0.103	0.264	0.369	0.298	0.323	0.185	0.078	0.143	0.219
3	0.738	0.329	0.559	0.81	0.859	0.452	0.33	0.367	0.503	0.811
4	0.73	0.502	0.645	0.793	1.024	0.705	0.67	0.423	0.675	1.004
5	0.605	0.586	0.636	0.883	0.898	0.705	1.027	0.365	0.803	0.979
6	0.497	0.535	0.569	0.849	0.807	0.945	1.062	0.401	0.752	1.021
7	0.423	0.602	0.596	0.844	0.773	1.099	1.168	0.593	0.601	1.096
8	0.389	0.491	0.631	0.834	0.525	0.829	1.371	0.611	0.434	1.14
9	0.403	0.519	0.478	1.315	0.421	0.808	0.821	0.735	0.195	1.147
10	0.496	0.526	0.603	0.781	0.722	0.732	0.694	0.383	0.544	0.89

XSA population numbers (Thousands)

	AGE									
YEAR	1	2	3	4	5	6	7	8	9	10
1985	2.13E+05	1.53E+05	1.22E+05	5.54E+04	2.06E+04	8.29E+03	4.34E+03	2.02E+03	9.75E+02	4.77E+02
1986	3.14E+05	1.58E+05	8.73E+04	4.30E+04	1.98E+04	8.35E+03	3.74E+03	2.11E+03	1.01E+03	4.83E+02
1987	3.07E+05	2.32E+05	1.05E+05	4.65E+04	1.93E+04	8.16E+03	3.62E+03	1.52E+03	9.55E+02	4.46E+02
1988	2.37E+05	2.24E+05	1.32E+05	4.46E+04	1.81E+04	7.57E+03	3.42E+03	1.48E+03	5.98E+02	4.39E+02
1989	3.31E+05	1.73E+05	1.15E+05	4.36E+04	1.49E+04	5.54E+03	2.40E+03	1.09E+03	4.76E+02	1.19E+02
1990	3.21E+05	2.40E+05	9.52E+04	3.60E+04	1.16E+04	4.51E+03	1.83E+03	8.20E+02	4.77E+02	2.31E+02
1991	2.30E+05	2.31E+05	1.29E+05	4.49E+04	1.32E+04	4.25E+03	1.30E+03	4.52E+02	2.65E+02	1.57E+02
1992	1.85E+05	1.68E+05	1.42E+05	6.86E+04	1.70E+04	3.50E+03	1.09E+03	2.99E+02	8.50E+01	8.65E+01
1993	2.44E+05	1.37E+05	1.15E+05	7.29E+04	3.33E+04	8.75E+03	1.73E+03	4.46E+02	1.20E+02	3.02E+01
1994	2.56E+05	1.80E+05	8.77E+04	5.17E+04	2.75E+04	1.11E+04	3.05E+03	7.05E+02	2.14E+02	7.33E+01

Estimated population abundance at 1st Jan 1995

0.00E+00	1.88E+05	1.07E+05	2.89E+04	1.41E+04	7.65E+03	2.95E+03	7.56E+02	1.67E+02	5.03E+01

Taper weighted geometric mean of the VPA populations:

2.59E+05	1.86E+05	1.12E+05	4.96E+04	1.86E+04	6.58E+03	2.41E+03	9.03E+02	3.86E+02	1.81E+02

Standard error of the weighted Log(VPA populations) :

0.1975	0.2039	0.1713	0.219	0.3172	0.3785	0.481	0.6812	0.8835	0.9617

Table 5.6.9 cont'd. Farne Deeps (FU6): males - VPA tuning information

Log catchability residuals.

Fleet : FLEET 1

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	-0.14	-0.53	0.1	0.19	0.07	0.24	0.19	-0.07	-0.07	0.02
2	0.31	-0.16	0.05	0.14	0.12	0.05	-0.19	-0.21	-0.03	-0.08
3	0.5	-0.33	0.11	0.29	0.23	-0.26	-0.57	0.03	-0.11	0.11
4	0.24	-0.15	0.01	0.02	0.16	-0.07	-0.12	-0.08	-0.07	0.07
5	0.02	-0.04	-0.04	0.09	0	-0.11	0.26	-0.26	0.06	0.01
6	-0.16	-0.11	-0.14	0.06	-0.1	0.2	0.31	-0.15	0.02	0.07
7	-0.36	-0.04	-0.13	0.02	-0.18	0.3	0.36	0.19	-0.25	0.1
8	-0.35	-0.14	0.02	0.1	-0.46	0.12	0.61	0.32	-0.47	0.23
9	-0.21	0.02	-0.14	0.66	-0.57	0.21	0.22	0.61	-1.16	0.35
10	0	0.04	0.09	0.15	-0.04	0.11	0.06	-0.03	-0.14	0.1

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

Age	3	4	5	6	7	8	9	10
Mean Log q	-5.3089	-5.061	-5.0263	-5.0409	-4.9978	-5.0971	-5.2066	-5.2066
S.E(Log q)	0.3208	0.1251	0.1343	0.1606	0.2384	0.3556	0.5531	0.0933

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
1	0.32	1.689	11.51	0.43	10	0.24	-9.47
2	0.49	1.759	9.28	0.6	10	0.18	-6.28

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	0.71	0.625	7.13	0.37	10	0.24	-5.31
4	0.97	0.13	5.21	0.76	10	0.13	-5.06
5	0.97	0.172	5.15	0.85	10	0.14	-5.03
6	1.12	-0.759	4.58	0.83	10	0.18	-5.04
7	1.44	-2.193	3.78	0.76	10	0.29	-5
8	1.29	-1.357	4.6	0.73	10	0.44	-5.1
9	0.99	0.029	5.21	0.72	10	0.58	-5.21
10	0.95	2.2	5.17	1	10	0.07	-5.17

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength

Year class = 1993

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	191819	0.3	0	0	1	0.314	0.011
P shrinkage mean	186054	0.2				0.686	0.012

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
187843	0.17	0.03	2	0.15	0.012

Age 2 Catchability dependent on age and year class strength

Year class = 1992

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	98915	0.212	0.005	0.02	2	0.343	0.235
P shrinkage mean	111561	0.17				0.657	0.211

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
107051	0.13	0.07	3	0.515	0.219

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 1991

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	28916	0.18	0.054	0.3	3	1	0.81

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
28916	0.18	0.05	3	0.302	0.811

Table 5.6.9 cont'd. Farne Deeps (FU6): males - VPA tuning information

Age 4 Catchability constant w.r.t. time and dependent on age
Year class = 1990

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	14061	0.16	0.085	0.53	4	1	1.003

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
14061	0.16	0.08	4	0.53	1.004

Age 5 Catchability constant w.r.t. time and dependent on age
Year class = 1989

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	7647	0.157	0.057	0.37	5	1	0.979

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
7647	0.16	0.06	5	0.366	0.979

Age 6 Catchability constant w.r.t. time and dependent on age
Year class = 1988

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	2948	0.159	0.077	0.48	6	1	1.021

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2948	0.16	0.08	6	0.483	1.021

Age 7 Catchability constant w.r.t. time and dependent on age
Year class = 1987

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	756	0.16	0.057	0.36	7	1	1.096

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
756	0.16	0.06	7	0.358	1.096

Age 8 Catchability constant w.r.t. time and dependent on age
Year class = 1986

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	167	0.173	0.083	0.48	8	1	1.14

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
167	0.17	0.08	8	0.481	1.14

Age 9 Catchability constant w.r.t. time and dependent on age
Year class = 1985

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	50	0.195	0.123	0.63	9	1	1.148

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
50	0.2	0.12	9	0.632	1.147

Age 10 Catchability constant w.r.t. time and age (fixed at the value for age) 9
Year class = 1984

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	22	0.198	0.15	0.76	10	1	0.89

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
22	0.2	0.15	10	0.759	0.89

Table 5.6.10 Farne Deeps (FU6): Females - VPA tuning information.

Lowestoft VPA Version 3.1
Extended Survivors Analysis

FU6 FARN DEEPS FEMALINDEX FILE

CPUE data from file c:\data\tuneff.dat

Catch data for 10 years. 1985 to 1994. Ages 1 to 15.

Fleet	First year	Last year	First age	Last age	Alpha	Beta	
FLEET 1		1985	1994	1	14	0	1

Time series weights :

Tapered time weighting applied
Power = 3 over 20 years

Catchability analysis :

Catchability dependent on stock size for ages < 3

Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 3

Catchability independent of age for ages >= 13

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 5 years or the 5 oldest ages.

S.E. of the mean to which the estimates are shrunk = .500

Minimum standard error for population

estimates derived from each fleet = .300

Prior weighting not applied

Tuning had not converged after 70 iterations

Total absolute residual between iterations

69 and 70 = .00059

Final year F values

Age	1	2	3	4	5	6	7	8	9	10
Iteration 69	0.0148	0.2893	0.1017	0.1938	0.2672	0.3838	0.4584	0.4032	0.268	0.3011
Iteration 70	0.0148	0.2892	0.1016	0.1937	0.2671	0.3837	0.4584	0.4032	0.268	0.3011

Age	11	12	13	14
Iteration 69	0.3249	0.3769	0.5642	0.4919
Iteration 70	0.3249	0.3769	0.5642	0.4919

Regression weights

	0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.005	0.002	0.031	0.029	0.027	0.035	0.014	0	0.006	0.015
2	0.194	0.1	0.364	0.458	0.388	0.453	0.236	0.057	0.049	0.289
3	0.11	0.074	0.181	0.196	0.181	0.16	0.063	0.048	0.05	0.102
4	0.116	0.099	0.208	0.172	0.214	0.198	0.079	0.066	0.105	0.194
5	0.142	0.111	0.182	0.171	0.22	0.333	0.141	0.083	0.15	0.267
6	0.152	0.13	0.173	0.205	0.266	0.461	0.24	0.127	0.16	0.384
7	0.146	0.157	0.164	0.216	0.286	0.469	0.285	0.149	0.174	0.458
8	0.156	0.173	0.17	0.251	0.318	0.442	0.332	0.147	0.262	0.403
9	0.163	0.21	0.183	0.277	0.339	0.472	0.389	0.16	0.245	0.268
10	0.169	0.252	0.193	0.278	0.397	0.468	0.384	0.148	0.23	0.301
11	0.17	0.293	0.215	0.327	0.394	0.5	0.403	0.14	0.169	0.325
12	0.171	0.255	0.236	0.298	0.325	0.385	0.469	0.172	0.178	0.377
13	0.206	0.388	0.33	0.429	0.465	0.544	0.524	0.324	0.275	0.564
14	0.253	0.374	0.31	0.408	0.454	0.475	0.421	0.21	0.245	0.492

Table 5.6.10 cont'd. Farne Deeps (FU6): Females - VPA tuning information.

XSA population numbers (Thousands)

	AGE									
YEAR	1	2	3	4	5	6	7	8	9	10
1985	2.01E+05	1.63E+05	1.08E+05	8.30E+04	6.04E+04	4.09E+04	3.03E+04	2.04E+04	1.28E+04	8.32E+03
1986	2.41E+05	1.48E+05	9.93E+04	7.92E+04	6.05E+04	4.29E+04	2.87E+04	2.14E+04	1.43E+04	8.90E+03
1987	2.51E+05	1.78E+05	9.95E+04	7.55E+04	5.88E+04	4.43E+04	3.08E+04	2.01E+04	1.48E+04	9.51E+03
1988	1.90E+05	1.80E+05	9.16E+04	6.80E+04	5.02E+04	4.01E+04	3.05E+04	2.14E+04	1.39E+04	1.01E+04
1989	2.28E+05	1.37E+05	8.46E+04	6.17E+04	4.68E+04	3.46E+04	2.68E+04	2.01E+04	1.36E+04	8.62E+03
1990	2.36E+05	1.65E+05	6.88E+04	5.78E+04	4.08E+04	3.08E+04	2.17E+04	1.65E+04	1.20E+04	7.95E+03
1991	2.82E+05	1.69E+05	7.75E+04	4.80E+04	3.88E+04	2.39E+04	1.59E+04	1.11E+04	8.66E+03	6.12E+03
1992	4.88E+05	2.06E+05	9.87E+04	5.95E+04	3.63E+04	2.76E+04	1.54E+04	9.78E+03	6.54E+03	4.81E+03
1993	2.85E+05	3.61E+05	1.44E+05	7.71E+04	4.56E+04	2.74E+04	1.99E+04	1.09E+04	6.91E+03	4.56E+03
1994	2.46E+05	2.10E+05	2.55E+05	1.12E+05	5.68E+04	3.22E+04	1.91E+04	1.37E+04	6.84E+03	4.43E+03

Estimated population abundance at 1st Jan 1995

0.00E+00	1.80E+05	1.16E+05	1.89E+05	7.58E+04	3.56E+04	1.79E+04	9.89E+03	7.49E+03	4.28E+03

Taper weighted geometric mean of the VPA populations:

2.59E+05	1.86E+05	1.05E+05	6.99E+04	4.81E+04	3.33E+04	2.28E+04	1.56E+04	1.03E+04	6.90E+03

Standard error of the weighted Log(VPA populations) :

0.2655	0.2775	0.3846	0.2435	0.1906	0.2137	0.2739	0.3164	0.344	0.326

	AGE			
YEAR	11	12	13	14
1985	5.39E+03	3.18E+03	2.31E+03	1.13E+03
1986	5.75E+03	3.72E+03	2.20E+03	1.54E+03
1987	5.66E+03	3.51E+03	2.36E+03	1.22E+03
1988	6.42E+03	3.74E+03	2.27E+03	1.39E+03
1989	6.24E+03	3.79E+03	2.27E+03	1.21E+03
1990	4.75E+03	3.45E+03	2.24E+03	1.17E+03
1991	4.08E+03	2.36E+03	1.92E+03	1.07E+03
1992	3.41E+03	2.23E+03	1.21E+03	9.30E+02
1993	3.39E+03	2.43E+03	1.54E+03	7.15E+02
1994	2.97E+03	2.34E+03	1.66E+03	9.57E+02

Estimated population abundance at 1st Jan 1995

2.68E+03	1.76E+03	1.32E+03	7.75E+02

Taper weighted geometric mean of the VPA populations:

4.58E+03	2.98E+03	1.93E+03	1.10E+03

Standard error of the weighted Log(VPA populations) :

0.2859	0.2273	0.23	0.2195

Log catchability residuals.

Fleet : FLEET 1

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.52	0.71	-0.48	0.01	-0.16	-0.38	-0.27	0.14	0.09	0
2	0.11	1.05	-0.64	-0.71	0.17	-0.54	0.12	0.69	0.19	-0.34
3	0.27	-0.14	0.67	0.55	0.37	0.37	-0.55	-0.34	-0.74	-0.28
4	0.05	-0.13	0.53	0.15	0.25	0.31	-0.61	-0.29	-0.28	0.09
5	0.02	-0.24	0.17	-0.09	0.05	0.6	-0.26	-0.29	-0.15	0.18
6	-0.14	-0.32	-0.12	-0.15	0.01	0.69	0.04	-0.1	-0.32	0.31
7	-0.27	-0.22	-0.26	-0.18	-0.01	0.62	0.12	-0.02	-0.32	0.4
8	-0.29	-0.21	-0.3	-0.11	0.02	0.48	0.2	-0.12	0	0.19
9	-0.27	-0.04	-0.26	-0.04	0.06	0.52	0.33	-0.06	-0.09	-0.24
10	-0.26	0.11	-0.24	-0.07	0.18	0.47	0.28	-0.17	-0.19	-0.16
11	-0.28	0.24	-0.15	0.07	0.15	0.52	0.31	-0.25	-0.51	-0.11
12	-0.27	0.1	-0.06	-0.02	-0.04	0.26	0.45	-0.04	-0.46	0.04
13	-0.45	0.16	-0.09	-0.02	-0.05	0.24	0.21	0.23	-0.39	0.08
14	-0.25	0.12	-0.15	-0.07	-0.07	0.11	-0.01	-0.21	-0.51	-0.06

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

Age	3	4	5	6	7	8	9	10	11	12
Mean Log q	-6.9746	-6.6996	-6.4686	-6.2341	-6.1484	-6.0661	-6.0413	-6.0053	-5.9853	-5.9837
S.E(Log q)	0.4963	0.3429	0.2777	0.3105	0.3169	0.2454	0.2594	0.2543	0.3193	0.2594

Age	13	14
Mean Log q	-5.6236	-5.6236
S.E(Log q)	0.2441	0.2196

Table 5.6.10 cont'd. Farne Deeps (FU6): Females - VPA tuning information.

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
1	-0.41	-2.796	13.73	0.35	10	0.39	-9.36
2	-1.09	-2.75	18.5	0.19	10	0.61	-6.3

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	2	-1.131	2.41	0.15	10	0.97	-6.97
4	0.69	0.931	8.1	0.55	10	0.24	-6.7
5	0.84	0.366	7.17	0.41	10	0.25	-6.47
6	1.58	-0.701	3.83	0.17	10	0.5	-6.23
7	1.98	-1.274	2.36	0.19	10	0.6	-6.15
8	1.36	-0.979	4.78	0.5	10	0.33	-6.07
9	0.95	0.195	6.21	0.66	10	0.26	-6.04
10	0.83	0.721	6.48	0.72	10	0.22	-6.01
11	0.69	1.193	6.75	0.67	10	0.21	-5.99
12	0.98	0.058	6.03	0.45	10	0.27	-5.98
13	1.17	-0.375	5.29	0.4	10	0.3	-5.62
14	0.61	3.221	6.23	0.9	10	0.08	-5.73

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength

Year class = 1993

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	179102	0.406	0	0	1	0.261	0.015
P shrinkage mean	186499	0.28				0.565	0.014
F shrinkage mean	160812	0.5				0.174	0.017

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
179842	0.21	0.04	3	0.184	0.015

1
Age 2 Catchability dependent on age and year class strength

Year class = 1992

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	112723	0.345	0.196	0.57	2	0.367	0.297
P shrinkage mean	105280	0.38				0.397	0.315
F shrinkage mean	144644	0.5				0.235	0.239

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
116327	0.23	0.1	4	0.438	0.289

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 1991

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	187925	0.312	0.149	0.48	3	0.692	0.102
F shrinkage mean	190291	0.5				0.308	0.101

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
188650	0.27	0.1	4	0.381	0.102

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

Year class = 1990

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	67953	0.228	0.234	1.03	4	0.79	0.214
F shrinkage mean	114184	0.5				0.21	0.133

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
75776	0.21	0.22	5	1.037	0.194

Table 5.6.10 cont'd. Farne Deeps (FU6): Females - VPA tuning information.

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

Year class = 1989

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	32881	0.184	0.123	0.67	5	0.834	0.286
F shrinkage mean	53278	0.5				0.166	0.186

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
35622	0.17	0.13	6	0.765	0.267

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

Year class = 1988

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	16379	0.163	0.127	0.78	6	0.843	0.414
F shrinkage mean	29264	0.5				0.157	0.252

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
17944	0.16	0.14	7	0.898	0.384

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

Year class = 1987

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	8895	0.148	0.15	1.01	7	0.852	0.499
F shrinkage mean	18249	0.5				0.148	0.274

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
9891	0.15	0.17	8	1.131	0.458

Age 8 Catchability constant w.r.t. time and dependent on age

Year class = 1986

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	7114	0.138	0.099	0.72	8	0.87	0.42
F shrinkage mean	10538	0.5				0.13	0.302

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
7488	0.14	0.1	9	0.733	0.403

Age 9 Catchability constant w.r.t. time and dependent on age

Year class = 1985

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	4411	0.134	0.098	0.73	9	0.881	0.261
F shrinkage mean	3454	0.5				0.119	0.323

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
4284	0.13	0.09	10	0.692	0.268

Age 10 Catchability constant w.r.t. time and dependent on age

Year class = 1984

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	2718	0.129	0.086	0.67	10	0.882	0.298
F shrinkage mean	2435	0.5				0.118	0.327

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2683	0.13	0.08	11	0.606	0.301

Table 5.6.10 cont'd. Farne Deeps (FU6): Females - VPA tuning information.

Age 11 Catchability constant w.r.t. time and dependent on age

Year class = 1983

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	1755	0.129	0.076	0.58	10	0.876	0.325
F shrinkage mean	1769	0.5				0.124	0.323

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1757	0.13	0.07	11	0.519	0.325

Age 12 Catchability constant w.r.t. time and dependent on age

Year class = 1982

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	1274	0.126	0.098	0.78	10	0.878	0.387
F shrinkage mean	1673	0.5				0.122	0.308

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1317	0.13	0.09	11	0.73	0.377

Age 13 Catchability constant w.r.t. time and dependent on age

Year class = 1981

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	732	0.125	0.099	0.79	10	0.859	0.589
F shrinkage mean	1096	0.5				0.141	0.429

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
775	0.13	0.1	11	0.774	0.564

Age 14 Catchability constant w.r.t. time and age (fixed at the value for age) 13

Year class = 1980

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	452	0.128	0.082	0.64	10	0.858	0.515
F shrinkage mean	681	0.5				0.142	0.369

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
479	0.13	0.09	11	0.669	0.492

Table 5.6.11 Farne Deeps (FU6): male - VPA outputs

Terminal Fs derived using XSA (Without F shrinkage)
Fishing mortality (F) at age

YEAR / AGE	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	FBAR 92-94
1	0.0029	0.002	0.0151	0.0137	0.0218	0.0308	0.0126	0.0021	0.006	0.0115	0.0066
2	0.2591	0.1034	0.2635	0.3695	0.2975	0.323	0.1853	0.0778	0.1434	0.2193	0.1468
3	0.7385	0.329	0.5589	0.8097	0.8591	0.452	0.33	0.3673	0.5026	0.811	0.5603
4	0.7295	0.5024	0.6454	0.7932	1.024	0.7053	0.6702	0.4227	0.6755	1.0042	0.7008
5	0.6053	0.5862	0.6356	0.883	0.898	0.7047	1.0271	0.3648	0.803	0.9789	0.7155
6	0.4966	0.5353	0.5694	0.8487	0.8068	0.9452	1.0617	0.4009	0.7522	1.0212	0.7248
7	0.4234	0.6024	0.5964	0.8441	0.773	1.0991	1.1676	0.5927	0.6009	1.0958	0.7631
8	0.3893	0.4912	0.6307	0.8338	0.5254	0.8293	1.3709	0.6115	0.434	1.1402	0.7286
9	0.4026	0.5185	0.4777	1.3153	0.4215	0.8085	0.8208	0.7353	0.1946	1.1474	0.6924
10	0.4956	0.5261	0.6031	0.7807	0.7219	0.7321	0.6936	0.3835	0.5437	0.89	0.6057
+gp	0.4956	0.5261	0.6031	0.7807	0.7219	0.7321	0.6936	0.3835	0.5437	0.89	
FBAR 3- 8	0.5638	0.5078	0.6061	0.8354	0.8144	0.7893	0.9379	0.46	0.628	1.0085	

Terminal Fs derived using XSA (Without F shrinkage)
Stock number at age (start of year) Numbers*10**-3

YEAR / AGE	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	GMST 85-92	AMST 85-92
1	213270	314316	307264	236732	331316	321163	230267	184733	244292	256458	0	261804	267383
2	152695	157530	232384	224208	172986	240145	230705	168454	136560	179886	187843	194204	197388
3	121537	87302	105241	132272	114788	95174	128795	141998	115447	87654	107051	114485	115888
4	55402	43022	46541	44582	43605	36015	44869	68598	72858	51739	28916	47023	47829
5	20650	19788	19284	18082	14942	11602	13179	17006	33300	27469	14061	16516	16817
6	8291	8351	8157	7566	5540	4509	4248	3496	8748	11051	7647	5957	6270
7	4342	3738	3622	3419	2399	1832	1298	1088	1734	3054	2948	2438	2717
8	2016	2106	1516	1478	1089	820	452	299	446	705	756	1018	1222
9	975	1012	955	598	476	477	265	85	120	214	167	481	605
10	477	483	446	439	119	231	157	86	30	73	50	253	305
+gp	759	692	714	573	106	314	237	72	20	27	31		
TOTAL	580413	638341	726125	669948	687366	712284	654473	585915	613556	618330	349471		

Summary (without SOP correction)

Terminal Fs derived using XSA (Without F shrinkage)

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 8
1985	213270	8194	8194	1468	0.2475	0.5638
1986	314316	7566	7566	1189	0.2663	0.5078
1987	307264	8430	8430	1428	0.2601	0.6061
1988	236732	8529	8529	1580	0.2936	0.8354
1989	331316	7590	7590	1791	0.4082	0.8144
1990	321163	7299	7299	1259	0.3423	0.7893
1991	230267	7646	7646	1335	0.2698	0.9379
1992	184733	8022	8022	1088	0.1824	0.46
1993	244292	8719	8719	2309	0.3475	0.628
1994	256458	8124	8124	2393	0.4525	1.0085
				recalculated after xsa by * ratio males by total landings		
Arith. Mean	263981	8012	8012	1583	0.307	0.7151
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 5.6.12 Farne Deeps (FU6): Females - VPA output.

Run title : FU6 FARN DEEPS FEMALINDEX FILE
Terminal Fs derived using XSA (With F shrinkage)
Fishing mortality (F) at age

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	FBAR 92-94
AGE											
1	0.0052	0.0018	0.0305	0.0293	0.0268	0.0351	0.0145	0.0005	0.0056	0.0148	0.007
2	0.1941	0.0999	0.3636	0.4578	0.3875	0.4535	0.2362	0.0573	0.049	0.2892	0.1318
3	0.1095	0.074	0.1814	0.1962	0.1814	0.1596	0.0632	0.0476	0.0503	0.1016	0.0665
4	0.1159	0.0987	0.2076	0.1724	0.2135	0.1981	0.0785	0.0656	0.1049	0.1937	0.1214
5	0.1416	0.111	0.1821	0.1713	0.2201	0.3332	0.1409	0.0826	0.1501	0.2671	0.1666
6	0.152	0.1303	0.1734	0.2046	0.266	0.4608	0.2403	0.1269	0.16	0.3837	0.2235
7	0.1456	0.1566	0.1643	0.2164	0.2857	0.4687	0.2849	0.1491	0.1741	0.4584	0.2605
8	0.1556	0.1727	0.1703	0.2513	0.3179	0.4422	0.3324	0.1473	0.2625	0.4032	0.271
9	0.1628	0.2099	0.1826	0.277	0.3393	0.4722	0.3891	0.1597	0.2452	0.268	0.2243
10	0.1691	0.2521	0.1928	0.2781	0.3969	0.468	0.3843	0.1483	0.2296	0.3011	0.2263
11	0.1702	0.2929	0.2148	0.3266	0.3942	0.4998	0.4027	0.1397	0.1694	0.3249	0.2113
12	0.1714	0.255	0.2362	0.2985	0.325	0.3852	0.4686	0.1725	0.1783	0.3769	0.2426
13	0.2057	0.3884	0.3302	0.4287	0.4653	0.5437	0.5242	0.3241	0.2746	0.5642	0.3877
14	0.2528	0.3744	0.3098	0.4082	0.4544	0.4749	0.4207	0.2097	0.2454	0.4919	0.3157
+gp	0.2528	0.3744	0.3098	0.4082	0.4544	0.4749	0.4207	0.2097	0.2454	0.4919	
0 FBAR 3-12		0.1494	0.1753	0.1906	0.2392	0.294	0.3888	0.2785	0.1239	0.1725	0.3079

Terminal Fs derived using XSA (With F shrinkage)

Stock number at age (start of year) Numbers*10**-3

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	GMST 85-92	AMST 85-92
AGE													
1	201397	240607	251172	190116	228125	235943	282380	488108	284546	246344	0	253709	264731
2	162677	148430	177928	180479	136771	164537	168764	206184	361423	209629	179842	167076	168221
3	107956	99255	99509	91632	84592	68773	77451	98722	144236	254957	116327	90108	90986
4	82996	79219	75469	67953	61655	57768	47999	59530	77069	112295	188650	65605	66574
5	60366	60517	58763	50203	46826	40774	38795	36329	45646	56816	75776	48173	49072
6	40858	42899	44342	40103	34633	30765	23923	27588	27385	32161	35622	34882	35639
7	30285	28734	30832	30523	26757	21732	15889	15402	19896	19106	17944	24172	25019
8	20443	21435	20115	21419	20128	16464	11135	9784	10864	13686	9891	16951	17615
9	12796	14326	14766	13890	13639	11991	8662	6538	6913	6841	7488	11688	12076
10	8321	8902	9509	10071	8621	7954	6123	4806	4563	4429	4284	7843	8038
11	5392	5753	5665	6420	6243	4746	4078	3413	3393	2969	2683	5111	5214
12	3185	3723	3514	3741	3792	3446	2357	2232	2430	2345	1757	3190	3249
13	2310	2197	2362	2272	2273	2243	1920	1208	1538	1665	1317	2058	2098
14	1130	1540	1220	1390	1211	1168	1066	930	715	957	775	1194	1207
+gp	3628	4320	4353	4841	3156	2941	2274	1802	2187	2565	1763		
TOTAL	743741	761859	799517	715054	678423	671246	692817	962576	992803	966765	644119		

Summary (without SOP correction)

Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	females FBAR 3-12
Age 1						
1985	201397	9830	7397	559	0.2742	0.1494
1986	240607	9809	7511	825	0.2683	0.1753
1987	251172	10002	7396	765	0.2965	0.1906
1988	190116	9380	6995	925	0.358	0.2392
1989	228125	8472	6329	1306	0.4895	0.294
1990	235943	7749	5489	1240	0.4551	0.3888
1991	282380	7162	4682	729	0.4406	0.2785
1992	488108	8737	4929	374	0.2968	0.1239
1993	284546	10686	6295	722	0.4813	0.1725
1994	246344	11624	8543	1284	0.4303	0.3079
Arith. Mean	264874	9345	6557	873	0.3791	0.232
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

landings recalculated after xsa by * ratio females by total landings

Table 5.6.13 Input data and parameters: Firth of Forth

FU	8	MA	I
FLEET	UK Scotland	GEAR	Nephrops and Light trawl

1994	NUMBER OF SAMPLES				Mean
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	No./sample
Catch					
Landings	21	13	19	20	390
Discards	4	4	4	4	256

	NUMBER OF SAMPLES									
YEAR	94	93	92	91	90	89	88	87	86	85
Catch										
Landings	73	52	69	62	71	44	37	67	61	89
Discards	16	11	12	6	7					

INPUT PARAMETERS		
Parameter	Value	Source
Discard Survival	0.25	Gueguen and Charuau,1975; Anon.,1985
MALES		
Growth - K	0.163	Adapted from Bailey and Chapman, 1983
Growth - L(inf)	66	"
Nat. Mort. - M	0.3	Morizur, 1982
Length/weight - a	0.00028	Howard and Hall, 1983
Length/weight - b	3.24	"
FEMALES		
Immature Growth		
K	0.163	as for males
L(inf)	66	"
Nat.Mort. - M	0.3	"
Size at Maturity	25	Adapted from Bailey, 1984
Mature Growth		
K	0.065	as for males
L(inf)	58	"
Nat.Mort. - M	0.2	assumed *
Length/weight - a	0.00085	as for males
Length/weight - b	2.91	"

* based on Morizur, 1982 and assuming lower mature female rate

Table 5.6.14 Firth of Forth (Functional Unit 8) : Landings (tonnes) by gear, all UK, 1985-94

Year	Nephrops	Other trawl	Total
1985	1908	61	1969
1986	2204	59	2263
1987	1582	92	1674
1988	2455	73	2528
1989	1833	52	1885
1990	1901	30	1931
1991	1359	43	1402
1992	1714	41	1755
1993	2349	20	2369
1994*	1790	22	1812

* provisional

Table 5.6.15 Firth of Forth (Functional Unit 8) : Landings (tonnes), effort ('000 hours trawling), and LPUE (kg/hour trawling) of Scottish Nephrops trawlers, 1985-94. Figures in brackets to the left and right of the overall values are for single and multi-rig trawls respectively

Year	Landings	Effort	LPUE
1985	1908	73.9	25.8
1986	2204	74.7	29.5
1987	1582	62.1	25.5
1988	2455	94.8	25.9
1989	1833	78.7	23.3
1990	1901	81.8	23.1
1991	(1231) 1359 (128)	(63.9) 69.4 (5.5)	(19.3) 19.6 (23.2)
1992	(1480) 1714 (198)	(63.3) 73.1 (8.5)	(23.4) 23.4 (23.3)
1993	(2340) 2349 (9)	(100.1) 100.2 (0.2)	(23.4) 23.4 (52.9)
1994*	(1790) 1790 (0)	(85.4) 85.4 (0)	(21.0) 21.0 (-)

* provisional

Table 5.6.16 Firth of Forth (Functional Unit 8) : Mean sizes (CL mm) of male and female Nephrops in Scottish landings, 1985-94. Mean sizes in catches , 1990-94, given in parenthesis

Year	Males	Females
1985	33.7	31.2
1986	31.9	30.4
1987	32.2	31.0
1988	31.1	30.6
1989	31.1	31.2
1990	31.4 (29.8)	30.4 (28.9)
1991	31.3 (30.1)	30.1 (28.5)
1992	32.0 (31.1)	29.7 (28.7)
1993	33.5 (31.3)	31.2 (29.2)
1994*	31.2 (26.6)	29.8 (25.6)

* provisional

Table 5.6.17 Firth of Forth (FU8): Males - LCA output

COHORT ANALYSIS

L INFINITY = 66.0000 K = .1630

COHORT ANALYSIS BY POPE'S APPROXIMATION

SIZE MM	REMOVALS	M	DT	FDT	F	Z	NO. ATTAINING	AVE. NO. IN SEA	BIOMASS kg
15.0	54.6	.3000	.2454	.0004	.0014	.3014	159556.9	37746.7	85116.6
17.0	658.9	.3000	.2557	.0046	.0181	.3181	148178.3	36383.8	120164.7
19.0	1276.7	.3000	.2668	.0098	.0366	.3366	136604.0	34854.6	161951.2
21.0	3882.8	.3000	.2789	.0330	.1182	.4182	124870.5	32873.4	208008.1
23.0	8139.4	.3000	.2922	.0796	.2725	.5725	111123.8	29899.6	250804.7
25.0	12425.2	.3000	.3068	.1490	.4855	.7855	94007.2	25630.1	278644.7
27.0	11393.9	.3000	.3230	.1766	.5468	.8468	73874.3	20874.5	288532.6
29.0	11363.7	.3000	.3409	.2393	.7019	1.0019	56197.4	16229.5	280520.3
31.0	9921.6	.3000	.3610	.3042	.8426	1.1426	39936.7	11813.3	251677.2
33.0	6803.1	.3000	.3836	.3182	.8296	1.1296	26439.1	8229.7	213385.1
35.0	5411.4	.3000	.4091	.4089	.9995	1.2995	17142.5	5440.1	169750.2
37.0	3294.4	.3000	.4384	.4297	.9801	1.2801	10073.1	3379.5	125643.0
39.0	1902.0	.3000	.4722	.4389	.9295	1.2295	5747.0	2058.5	90365.5
41.0	1248.1	.3000	.5115	.5431	1.0616	1.3616	3216.0	1184.9	60926.2
43.0	611.6	.3000	.5581	.5361	.9605	1.2605	1602.5	642.2	38393.3
45.0	370.4	.3000	.6140	.7177	1.1689	1.4689	793.0	320.8	22148.3
47.0	150.7	.3000	.6824	.7315	1.0720	1.3720	321.8	142.6	11299.3
49.0	55.2	.3000	.7679	.6751	.8791	1.1791	126.2	63.7	5765.7
51.0	20.2	.3000	.8779	.6008	.6843	.9843	51.0	30.0	3080.7
53.0	5.0	.3000	1.0249	.3163	.3087	.6087	21.5	16.4	1903.1
55.0	3.1	.3000	1.2311	.3910	.3176	.6176	11.5	9.9	1297.5
57.0	1.2	.3000	1.5418	.3295	.2137	.5137	5.4	5.7	839.5
59.0	.7	.3000	2.0642	.4959	.2402	.5402	2.4	3.0	495.8
61.0	.2	.3000			.1000	.4000	.8	3.0	551.3
				TOTAL BIOMASS INCLUDES LENGTHS ABOVE			+GP	267838.7	2671816.0

Table 5.6.18 Firth of Forth (FU8): Females - LCA output

COHORT ANALYSIS

LOWER CURVE LINF= 66.0000 K= .1630
UPPER CURVE LINF= 58.0000 K= .0650
TRANSITION LENGTH= 25.0000

COHORT ANALYSIS BY POPE'S APPROXIMATION

SIZE MM	REMOVALS	M	DT	FDT	F	Z	NO. ATTAINING	AVE. NO. IN SEA	BIOMASS kg
13.0	14.6	.3000	.2360	.0001	.0004	.3004	162784.6	37085.4	67970.4
15.0	93.1	.3000	.2454	.0006	.0026	.3026	151644.3	35869.8	96962.1
17.0	545.5	.3000	.2557	.0040	.0158	.3158	140790.2	34579.9	131689.2
19.0	1775.1	.3000	.2668	.0143	.0537	.3537	129870.5	33062.4	171086.2
21.0	4760.1	.3000	.2789	.0429	.1538	.4538	118176.1	30959.7	211412.6
23.0	8242.8	.3000	.2922	.0863	.2955	.5955	104125.3	27925.3	245638.0
25.0	10423.7	.2000	.3068	.1311	.4272	.6272	87497.1	24420.3	271148.0
27.0	9417.7	.2000	1.0260	.1562	.1522	.3522	72180.8	62154.2	856217.7
29.0	6957.9	.2000	1.0994	.1677	.1526	.3526	50290.5	45832.6	771757.3
31.0	4904.4	.2000	1.1840	.1764	.1490	.3490	34130.7	33101.9	672547.8
33.0	2983.8	.2000	1.2828	.1628	.1269	.3269	22577.4	23656.1	573363.8
35.0	2083.9	.2000	1.3996	.1761	.1258	.3258	14843.7	16682.8	477520.7
37.0	1315.3	.2000	1.5397	.1780	.1156	.3156	9407.9	11473.1	384355.5
39.0	608.7	.2000	1.7112	.1333	.0779	.2779	5786.8	7880.4	306496.2
41.0	426.5	.2000	1.9256	.1552	.0806	.2806	3596.7	5350.7	239854.2
43.0	220.8	.2000	2.2016	.1408	.0640	.2640	2095.3	3498.5	179561.6
45.0	141.9	.2000	2.5701	.1703	.0663	.2663	1171.9	2181.1	127401.8
47.0	69.9	.2000	3.0872	.1756	.0569	.2569	591.1	1260.0	83305.9
49.0	28.7	.2000	3.8664	.1719	.0445	.2445	267.5	669.0	49806.1
51.0	11.6	.2000	5.1765	.2074	.0401	.2401	103.9	308.0	25706.4
53.0	6.0	.2000			.0500	.2500	30.0	308.0	28690.5
					TOTAL BIOMASS INCLUDES LENGTHS ABOVE +GP			438567.1	6001182.0

Table 5.6.19 Firth of Forth (FU8) Males - VPA inputs

Run title : Firth Forth Males 19INDEX FILE

At 7/03/1995 19:16

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE														
1	183	491	320	960	547	550	422	1435	718	747	241	206	237	8428
2	6781	10475	11469	19293	14775	23072	18392	36393	23451	24131	16229	14920	23207	64696
3	10134	13144	18920	26017	24624	33062	25412	31770	27737	32235	23865	34424	31731	28565
4	7664	9049	12399	17531	13738	12046	10719	14922	9943	12229	9296	14933	18200	9431
5	3595	4153	5272	8088	5772	4464	3718	5648	3007	2908	2191	3873	7304	3169
6	1325	2032	2302	2931	2152	1428	1154	1836	795	737	542	728	2505	994
7	499	732	1055	953	722	435	431	685	320	244	141	168	748	347
8	160	243	466	249	189	124	128	164	66	46	36	29	117	70
9	69	118	216	75	72	44	47	66	48	12	11	6	29	23
10	30	36	89	30	32	22	13	24	13	4	2	2	8	5
+gp	35	38	77	54	21	24	16	18	10	6	4	2	8	2
0 TOTA	30475	40510	52585	76179	62643	75269	60453	92961	66109	73298	52558	69291	84094	115729
TONSLA	688	900	1267	1622	1500	1312	1091	1496	1033	1179	906	1319	1678	1067

Run title : Firth Forth Males 19INDEX FILE

At 7/03/1995 19:16

Table 2 Catch weights at age (kg)

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE														
1	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.004	0.004	0.004
2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.011	0.011	0.009
3	0.019	0.018	0.019	0.019	0.019	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
4	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.029	0.029	0.03	0.03	0.03
5	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.043	0.043	0.043	0.044	0.044
6	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.058	0.059	0.058	0.058	0.059	0.059
7	0.074	0.074	0.074	0.073	0.074	0.074	0.074	0.074	0.074	0.073	0.073	0.073	0.073	0.074
8	0.091	0.092	0.091	0.091	0.091	0.091	0.091	0.091	0.093	0.091	0.091	0.09	0.091	0.091
9	0.104	0.104	0.105	0.104	0.105	0.105	0.103	0.104	0.104	0.103	0.102	0.104	0.103	0.103
10	0.118	0.116	0.116	0.119	0.116	0.118	0.118	0.117	0.116	0.12	0.126	0.118	0.116	0.116
+gp	0.146	0.162	0.145	0.155	0.15	0.142	0.146	0.142	0.144	0.143	0.129	0.136	0.148	0.134
0 SOPC	0.8653	0.8859	0.9185	0.8733	1.0028	0.8611	0.8735	0.8203	0.8253	0.8595	0.9022	0.9054	0.8774	0.6482

Run title : Firth Forth Males 19INDEX FILE

At 7/03/1995 19:16

Table 4 Natural Mortality (M) at age

YEAR	All years
AGE	
1	0.3
2	0.3
3	0.3
4	0.3
5	0.3
6	0.3
7	0.3
8	0.3
9	0.3
10	0.3
+gp	0.3

Run title : Firth Forth Males 19INDEX FILE

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Table 5 Proportion mature at age

YEAR	All years
AGE	
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
+gp	1

Table 5.6.20 Firth of Forth (FU8) Males - VPA Tuning information

Lowestoft VPA Version 3.1

7/03/1995 22:27

Extended Survivors Analysis

Firth Forth Males 19INDEX FILE

CPUE data from file C:\NEPDAT\FF\MALES\TUNEFF.DAT

Catch data for 14 years. 1981 to 1994. Ages 1 to 11.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
FLEET 1	1981	1994	1	10	0	1

Time series weights :

Tapered time weighting applied
Power = 3 over 20 years

Catchability analysis :

Catchability dependent on stock size for ages < 3

Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 3

Catchability independent of age for ages >= 6

Terminal population estimation :

Final estimates not shrunk towards mean F

Minimum standard error for population
estimates derived from each fleet = .300

Prior weighting not applied

Tuning converged after 23 iterations

Regression weights

0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.004	0.005	0.003	0.01	0.005	0.005	0.002	0.002	0.001	0.061
2	0.165	0.276	0.228	0.411	0.255	0.256	0.162	0.189	0.269	0.611
3	0.616	0.784	0.641	0.912	0.741	0.774	0.494	0.701	0.906	0.72
4	0.858	0.826	0.735	1.247	0.992	1.06	0.607	0.775	1.293	0.894
5	1.011	0.906	0.766	1.478	1.124	1.106	0.609	0.635	1.485	0.971
6	1.113	0.875	0.723	1.457	1.032	1.161	0.712	0.472	1.488	0.987
7	1.144	0.815	0.846	1.895	1.491	1.374	0.834	0.569	1.814	1.023
8	1.033	0.684	0.691	1.15	1.337	1.103	0.873	0.441	1.275	1.041
9	0.906	0.829	0.708	1.182	1.922	1.218	1.119	0.389	1.371	1.126
10	0.93	0.905	0.769	1.237	0.969	0.931	0.795	0.824	1.556	1.104

XSA population numbers (Thousands)

AGE / YEAR	1	2	3	4	5	6	7	8	9	10
1985	150000	113000	62200	27700	10500	3720	1230	340	141	60.8
1986	142000	111000	70700	24900	8700	2840	907	290	89.7	42.2
1987	170000	105000	62400	23900	8070	2610	878	297	109	29
1988	165000	125000	61700	24300	8500	2780	937	279	110	39.6
1989	168000	121000	61600	18400	5180	1440	480	104	65.5	25.1
1990	171000	124000	69500	21700	5050	1250	379	80	20.3	7.1
1991	136000	126000	71100	23700	5580	1240	289	71	19.7	4.45
1992	154000	101000	79300	32200	9570	2250	450	93.1	22	4.76
1993	222000	114000	61900	29100	11000	3760	1040	189	44.4	11
1994	166000	164000	64700	18500	5930	1840	629	125	39	8.34

Estimated population abundance at 1st Jan 1995

0	115000	66100	23300	5620	1660	508	168	32.8	9.38

Taper weighted geometric mean of the VPA populations:

160000	116000	65700	25200	8190	2500	765	200	67	20.7

Standard error of the weighted Log(VPA populations) :

0.1318	0.1425	0.098	0.2032	0.3477	0.4962	0.5947	0.796	0.9496	1.1453

Table 5.6.20 (cont)

Log catchability residuals.

Fleet : FLEET 1

Age	1981	1982	1983	1984
1	1.89	-0.32	1.22	-0.95
2	0.02	-0.03	-0.05	0.02
3	-0.31	-0.44	-0.29	-0.2
4	-0.06	-0.22	-0.19	-0.06
5	-0.07	-0.12	-0.13	0.03
6	-0.11	0.04	0.11	0.08
7	-0.12	-0.06	0.36	0.17
8	-0.51	-0.25	0.49	-0.1
9	-0.02	-0.31	0.69	-0.34
10	0	0	0.22	-0.04

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.25	0.32	0.43	-1.82	-0.44	-0.5	2.44	2.87	2.95	-7.11
2	-0.1	0.09	0.12	0.06	-0.01	-0.04	-0.15	0.03	-0.03	0.07
3	-0.02	0.2	0.17	0.11	0.1	0.12	-0.18	0.12	0.07	0.01
4	0.04	-0.01	0.03	0.15	0.12	0.16	-0.24	-0.05	0.15	-0.05
5	0.12	0.01	0	0.24	0.16	0.12	-0.31	-0.32	0.21	-0.04
6	0.21	-0.03	-0.06	0.22	0.07	0.16	-0.17	-0.62	0.21	-0.03
7	0.24	-0.1	0.09	0.48	0.43	0.33	-0.01	-0.43	0.4	0
8	0.14	-0.28	-0.11	-0.01	0.33	0.11	0.03	-0.68	0.06	0.02
9	0.01	-0.09	-0.08	0.02	0.68	0.21	0.28	-0.81	0.13	0.1
10	0.03	0	0	0.06	0.01	-0.05	-0.06	-0.07	0.25	0.08

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	3	4	5	6	7	8	9	10
Mean Log	-4.8125	-4.5471	-4.4717	-4.4658	-4.4658	-4.4658	-4.4658	-4.4658
S.E(Log q	0.1827	0.1369	0.1888	0.2367	0.3103	0.3018	0.3981	0.1057

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
1	-2.75	-0.547	18.01	0	14	2.92	-9.8
2	0.35	3.63	9.61	0.77	14	0.08	-5.8

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	0.71	0.706	6.66	0.38	14	0.13	-4.81
4	1.22	-0.867	3.29	0.61	14	0.17	-4.55
5	1	-0.01	4.46	0.77	14	0.2	-4.47
6	0.9	0.702	4.79	0.85	14	0.22	-4.47
7	0.92	0.595	4.52	0.85	14	0.26	-4.33
8	1	0.039	4.51	0.88	14	0.31	-4.51
9	0.97	0.239	4.42	0.86	14	0.4	-4.43
10	0.98	0.869	4.4	0.99	14	0.1	-4.43

Table 5.6.20 (cont)

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength

Year class = 1993

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	94	3.818	0	0	1	0.001	4.357
P shrinka	116432	0.14				0.999	0.06

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
115353	0.14	7.12	2	49.972	0.061

Age 2 Catchability dependent on age and year class strength

Year class = 1992

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	72649	0.299	0.265	0.89	2	0.055	0.569
P shrinka	65709	0.1				0.945	0.614

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
66074	0.09	0.08	3	0.871	0.611

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 1991

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	23318	0.214	0.127	0.59	3	1	0.72

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
23318	0.21	0.13	3	0.592	0.72

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

Year class = 1990

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	5616	0.195	0.066	0.34	4	1	0.894

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
5616	0.19	0.07	4	0.338	0.894

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

Year class = 1989

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	1663	0.207	0.047	0.22	5	1	0.971

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
1663	0.21	0.05	5	0.225	0.971

Table 5.6.20 (cont)

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

Year class = 1988

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	508	0.215	0.044	0.2	6	1	0.987

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
508	0.22	0.04	6	0.203	0.987

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 6

Year class = 1987

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	168	0.219	0.058	0.27	7	1	1.023

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
168	0.22	0.06	7	0.266	1.023

Age 8 Catchability constant w.r.t. time and age (fixed at the value for age) 6

Year class = 1986

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	33	0.236	0.088	0.37	8	1	1.041

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
33	0.24	0.09	8	0.374	1.041

Age 9 Catchability constant w.r.t. time and age (fixed at the value for age) 6

Year class = 1985

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	9	0.23	0.064	0.28	9	1	1.126

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
9	0.23	0.06	9	0.279	1.126

Age 10 Catchability constant w.r.t. time and age (fixed at the value for age) 6

Year class = 1984

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	2	0.225	0.08	0.35	10	1	1.104

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
2	0.23	0.08	10	0.353	1.104

Table 5.6.21 Firth of Forth (FU8) Males - VPA outputs

Run title : Firth Forth Males 19INDEX FILE

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Terminal Fs derived using XSA (Without F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	FBAR 92-94
AGE															
1	0.0015	0.004	0.0026	0.0073	0.0042	0.0045	0.0029	0.0102	0.005	0.0051	0.0021	0.0016	0.0012	0.061	0.0213
2	0.0914	0.1233	0.1362	0.2366	0.1654	0.2765	0.2284	0.4113	0.255	0.2562	0.1622	0.1885	0.2692	0.6113	0.3563
3	0.2711	0.2882	0.3857	0.5923	0.6159	0.7836	0.6414	0.9118	0.7411	0.7745	0.4939	0.7014	0.9055	0.72	0.7756
4	0.4601	0.4705	0.5538	0.8883	0.8581	0.826	0.735	1.2473	0.9915	1.06	0.6074	0.7755	1.2929	0.8942	0.9875
5	0.4904	0.5576	0.6397	1.054	1.0106	0.9061	0.7657	1.4785	1.1236	1.106	0.6094	0.6348	1.4851	0.971	1.0303
6	0.4723	0.6595	0.8178	1.1153	1.1128	0.8754	0.7231	1.4573	1.0316	1.1605	0.7117	0.4719	1.4881	0.9873	0.9824
7	0.4674	0.5978	1.0625	1.2269	1.1439	0.8147	0.8457	1.8948	1.4913	1.3743	0.8339	0.5693	1.8143	1.0226	1.1354
8	0.3168	0.4957	1.2127	0.9254	1.0326	0.684	0.6908	1.1502	1.3369	1.1029	0.8726	0.4413	1.2753	1.0409	0.9192
9	0.5194	0.4632	1.4826	0.7252	0.9059	0.8286	0.7081	1.1819	1.9217	1.2175	1.1189	0.389	1.3714	1.1258	0.9621
10	0.5284	0.6391	0.9204	0.9848	0.9296	0.9047	0.7688	1.2374	0.9688	0.9305	0.7946	0.8242	1.5564	1.1044	1.1617
+gp	0.5284	0.6391	0.9204	0.9848	0.9296	0.9047	0.7688	1.2374	0.9688	0.9305	0.7946	0.8242	1.5564	1.1044	
0 FBAR 3-8	0.413	0.5116	0.7787	0.967	0.9623	0.815	0.7336	1.3566	1.1193	1.0964	0.6882	0.5991	1.3769	0.9393	

Run title : Firth Forth Males 19INDEX FILE

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Terminal Fs derived using XSA (Without F shrinkage)

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	GMST 81-92	AMST 81-92
AGE																	
1	141799	141789	143987	153129	150445	141916	169758	165041	168298	170881	136451	154462	222134	165502	0	152701	153163
2	90218	104890	104617	106392	112615	110982	104661	125396	121030	124061	125949	100878	114251	164357	115353	110450	110974
3	49587	60999	68688	67631	62211	70711	62359	61705	61572	69477	71137	79337	61891	64665	66074	65051	65451
4	24142	28013	33876	34601	27710	24893	23927	24324	18367	21740	23725	32159	29145	18538	23318	26034	26456
5	10776	11289	12964	14424	10545	8703	8074	8499	5177	5048	5579	9575	10970	5926	5616	8745	9221
6	4090	4889	4788	5066	3724	2843	2605	2781	1436	1247	1237	2247	3760	1841	1663	2748	3080
7	1553	1890	1873	1566	1230	907	878	937	480	379	289	450	1039	629	508	870	1036
8	685	721	770	479	340	290	297	279	104	80	71	93	189	125	168	257	351
9	199	370	325	170	141	90	109	110	65	20	20	22	44	39	33	92	137
10	85	88	172	55	61	42	29	40	25	7	4	5	11	8	9	31	51
+gp	98	92	146	97	39	45	33	28	17	11	8	3	12	3	3		
0 TO	323232	355027	372206	383611	369062	361423	372729	389141	376572	392951	364471	379231	443445	421633	212744		

Run title : Firth Forth Males 19INDEX FILE

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Table 16 Summary (without SOP correction)

Terminal Fs derived using XSA (Without F shrinkage)

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 8
1981	141799	4073	4073	688	0.1688	0.413
1982	141789	4609	4609	900	0.1954	0.5116
1983	143987	5080	5080	1267	0.2495	0.7787
1984	153129	5130	5130	1622	0.3162	0.967
1985	150445	4575	4575	1500	0.3279	0.9623
1986	141916	4362	4362	1312	0.3008	0.815
1987	169758	4186	4186	1091	0.2605	0.7336
1988	165041	4407	4407	1496	0.3394	1.3566
1989	168298	3911	3911	1033	0.264	1.1193
1990	170881	4135	4135	1179	0.2852	1.0964
1991	136451	4253	4253	906	0.2129	0.6882
1992	154462	4707	4707	1319	0.2803	0.5991
1993	222134	4939	4939	1678	0.3398	1.3769
1994	165502	4294	4294	1067	0.2485	0.9393
Arith. Mean	158971	4476	4476	1219	0.2707	0.8826
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 5.6.22 Firth of Forth (FU8) Females - VPA inputs

Run title : Firth Forth Females INDEX FILE

At 9/03/1995 14:25

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE														
1	243	359	406	669	439	562	436	1486	703	776	319	316	377	10225
2	5767	7500	9494	15442	12525	24284	14306	29857	21145	23005	17123	14068	18742	61561
3	2198	2362	3838	6084	5333	12267	6698	10560	8448	8426	5995	6894	8733	10812
4	1944	1595	3562	4936	4295	9611	5610	7443	6206	5682	4337	5146	6831	6932
5	1887	1709	3263	3977	3347	6526	4367	6036	4479	3985	3319	3014	5305	4502
6	1613	1313	2706	2534	2188	4042	2938	4708	3743	2830	1984	1521	2510	2786
7	1392	1053	1587	1731	1300	2470	1808	3169	2677	2061	1317	939	1908	2134
8	1146	884	1151	1239	869	1729	1265	2370	2190	1626	920	636	1536	1514
9	848	727	951	805	573	1240	899	1772	1885	1270	579	410	1206	806
10	560	582	596	446	323	657	418	1369	1147	671	337	243	501	420
11	468	512	492	360	254	513	310	1183	944	533	276	198	358	326
12	211	226	249	238	104	285	192	448	514	365	172	105	284	182
13	191	199	221	211	97	254	167	411	450	321	156	95	254	157
14	115	96	111	105	69	135	72	268	200	151	95	55	139	61
15	115	96	111	105	69	135	71	268	200	151	95	55	139	61
+gp	226	272	186	185	115	308	148	670	580	390	223	179	369	130
0 TOTA	18923	19485	28924	39066	31899	65019	39705	72019	55509	52242	37247	33872	49191	102607
TONSLA	317	293	455	512	469	951	580	1032	851	749	497	435	687	738

Run title : Firth Forth Females INDEX FILE

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Table 2 Catch weights at age (kg)

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE														
1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
2	0.01	0.01	0.01	0.01	0.01	0.011	0.011	0.01	0.01	0.011	0.01	0.011	0.011	0.009
3	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
4	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.017	0.018	0.017
5	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
6	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
7	0.028	0.028	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027
8	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
9	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
10	0.038	0.038	0.038	0.037	0.038	0.037	0.037	0.038	0.038	0.037	0.038	0.038	0.037	0.037
11	0.039	0.039	0.039	0.04	0.039	0.039	0.04	0.039	0.039	0.04	0.04	0.039	0.04	0.039
12	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
13	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
14	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052
15	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052
+gp	0.064	0.066	0.065	0.065	0.064	0.066	0.065	0.066	0.065	0.066	0.065	0.065	0.063	0.064
0 SOPC	0.8103	0.7732	0.8285	0.7664	0.8782	0.8451	0.8271	0.8161	0.8331	0.8285	0.8233	0.792	0.7917	0.5973

Run title : Firth Forth Females INDEX FILE

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Table 4 Natural Mortality (M) at age

YEAR	All Years
AGE	
1	0.3
2	0.3
3	0.2
4	0.2
5	0.2
6	0.2
7	0.2
8	0.2
9	0.2
10	0.2
11	0.2
12	0.2
13	0.2
14	0.2
15	0.2
+gp	0.2

Run title : Firth Forth Females INDEX FILE

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Table 5 Proportion mature at age

YEAR	All Years
AGE	
1	0
2	0
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
11	1
12	1
13	1
14	1
15	1
+gp	1

Table 5.6.23 Firth of Forth (FU8) Females - VPA Tuning information

Lowestoft VPA Version 3.1

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Extended Survivors Analysis

Firth Forth Females INDEX FILE

CPUE data from file C:\NEPDAT\FF\FEMALES\TUNEFF.DAT

Catch data for 14 years. 1981 to 1994. Ages 1 to 16.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
FLEET 1	1981	1994	1	15	0	1

Time series weights :

Tapered time weighting applied
Power = 3 over 20 years

Catchability analysis :

Catchability dependent on stock size for ages < 3

Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 3

Catchability independent of age for ages >= 5

Terminal population estimation :

Final estimates not shrunk towards mean F

Minimum standard error for population
estimates derived from each fleet = .300

Prior weighting not applied

Tuning had not converged after 70 iterations

Total absolute residual between iterations
69 and 70 = .00152

Final year F values

Age	1	2	3	4	5	6	7	8	9	10
Iteration 6	0.0888	0.6714	0.2007	0.2084	0.2133	0.2054	0.252	0.2743	0.23	0.1766
Iteration 7	0.0888	0.6712	0.2006	0.2083	0.2132	0.2053	0.2519	0.2741	0.2299	0.1765

Age	11	12	13	14	15
Iteration 6	0.1738	0.155	0.1942	0.1748	0.1883
Iteration 7	0.1737	0.1549	0.1941	0.1745	0.1882

Regression weights

0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.004	0.006	0.004	0.014	0.006	0.007	0.003	0.002	0.002	0.089
2	0.162	0.339	0.213	0.42	0.317	0.32	0.236	0.185	0.219	0.671
3	0.102	0.25	0.154	0.254	0.21	0.212	0.135	0.148	0.177	0.201
4	0.115	0.27	0.172	0.257	0.233	0.214	0.161	0.164	0.214	0.208
5	0.137	0.257	0.189	0.284	0.242	0.231	0.186	0.16	0.254	0.213
6	0.129	0.243	0.176	0.32	0.286	0.238	0.172	0.122	0.194	0.205
7	0.106	0.21	0.163	0.292	0.304	0.252	0.166	0.115	0.221	0.252
8	0.099	0.201	0.158	0.333	0.337	0.306	0.17	0.112	0.278	0.274
9	0.103	0.201	0.153	0.347	0.485	0.334	0.169	0.106	0.322	0.23
10	0.082	0.166	0.096	0.366	0.397	0.317	0.137	0.099	0.183	0.176
11	0.092	0.18	0.11	0.429	0.466	0.325	0.207	0.112	0.208	0.174
12	0.074	0.142	0.094	0.229	0.335	0.329	0.164	0.113	0.232	0.155
13	0.105	0.262	0.116	0.3	0.379	0.361	0.227	0.127	0.438	0.194
14	0.117	0.209	0.108	0.276	0.233	0.209	0.172	0.117	0.28	0.175
15	0.164	0.352	0.162	0.74	0.34	0.277	0.197	0.142	0.481	0.188

XSA population numbers (Thousands)

AGE / YEAR	1	2	3	4	5	6	7	8	9	10
1985	133000	97400	60700	43600	29000	20000	14200	10100	6440	4560
1986	118000	98100	61400	44800	31800	20700	14400	10500	7520	4760
1987	137000	86700	51700	39200	28000	20100	13300	9560	7020	5040
1988	124000	101000	51900	36300	27000	19000	13800	9240	6680	4930
1989	133000	90400	49200	33000	23000	16600	11300	8460	5420	3860
1990	129000	97700	48800	32600	21400	14800	10200	6820	4940	2730
1991	131000	94800	52500	32300	21600	13900	9530	6510	4110	2900
1992	150000	96500	55500	37600	22500	14700	9580	6610	4500	2840
1993	198000	111000	59400	39200	26100	15700	10600	7000	4840	3310
1994	140000	146000	65700	40700	25900	16600	10600	6980	4340	2870

Estimated population abundance at 1st Jan 1995

0	94800	55400	44100	27100	17100	11100	6740	4340	2820

Taper weighted geometric mean of the VPA populations:

136000	98800	55000	37600	25600	17200	11800	8080	5480	3650

Standard error of the weighted Log(VPA populations) :

0.1393	0.1526	0.1021	0.1073	0.1272	0.1436	0.158	0.1757	0.2027	0.232

Table 5.6.23 (cont)

AGE / YEAR	11	12	13	14	15
1985	3180	1610	1070	690	499
1986	3440	2380	1220	792	503
1987	3300	2350	1690	770	526
1988	3750	2420	1750	1230	566
1989	2800	2000	1580	1060	765
1990	2130	1440	1170	884	689
1991	1630	1260	848	667	587
1992	2070	1080	875	553	460
1993	2110	1510	792	631	403
1994	2260	1400	983	419	390

Estimated population abundance at 1st Jan 1995

1970	1560	983	663	288

Taper weighted geometric mean of the VPA populations:

2520	1660	1160	764	571

Standard error of the weighted Log(VPA populations) :

0.2485	0.2595	0.2705	0.3108	0.2816

Log catchability residuals.

Fleet : FLEET 1

Age	1981	1982	1983	1984
1	0.57	0.29	0.22	0.11
2	0.01	-0.05	-0.12	-0.14
3	-0.51	-0.7	-0.41	-0.37
4	-0.45	-0.87	-0.25	-0.29
5	-0.17	-0.6	-0.11	-0.25
6	0.01	-0.42	0.03	-0.36
7	0.19	-0.3	-0.05	-0.4
8	0.51	-0.12	-0.02	-0.28
9	0.54	0.25	0.16	-0.36
10	0.51	0.37	0.3	-0.58
11	0.73	0.65	0.49	-0.14
12	0.17	0.22	0.22	-0.16
13	0.35	0.28	0.46	0.13
14	0.02	-0.18	-0.08	-0.2
15	0	-0.03	0.16	-0.1

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.33	0.26	0.19	-0.36	0.01	-0.02	0.55	0.45	0.27	-2.1
2	-0.15	0.13	0.09	0.1	0.13	0.08	0.04	-0.08	-0.22	0.09
3	-0.39	0.49	0.17	0.27	0.27	0.25	-0.05	0	-0.12	0.16
4	-0.37	0.47	0.18	0.18	0.27	0.16	0.02	0	-0.04	0.1
5	-0.31	0.31	0.16	0.17	0.2	0.12	0.06	-0.14	0.03	0.01
6	-0.37	0.26	0.09	0.29	0.36	0.16	-0.02	-0.41	-0.24	-0.03
7	-0.56	0.11	0.01	0.2	0.43	0.21	-0.06	-0.47	-0.11	0.18
8	-0.63	0.07	-0.02	0.33	0.53	0.41	-0.03	-0.49	0.11	0.26
9	-0.59	0.07	-0.05	0.37	0.89	0.49	-0.04	-0.55	0.26	0.08
10	-0.83	-0.13	-0.51	0.42	0.69	0.44	-0.24	-0.61	-0.3	-0.18
11	-0.7	-0.04	-0.38	0.58	0.85	0.46	0.17	-0.5	-0.17	-0.19
12	-0.92	-0.28	-0.53	-0.04	0.52	0.48	-0.07	-0.48	-0.06	-0.31
13	-0.57	0.33	-0.33	0.23	0.64	0.57	0.28	-0.36	0.57	-0.08
14	-0.47	0.11	-0.39	0.14	0.16	0.03	-0.02	-0.45	0.12	-0.19
15	-0.13	0.62	0.01	1.12	0.54	0.31	0.12	-0.26	0.68	-0.11

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	3	4	5	6	7	8	9	10	11	12
Mean Log	-6.2298	-6.1264	-6.0157	-6.0157	-6.0157	-6.0157	-6.0157	-6.0157	-6.0157	-6.0157
S.E(Log q	0.3274	0.3075	0.222	0.2756	0.2989	0.3547	0.4391	0.4968	0.5011	0.4211

Age	13	14	15
Mean Log	-6.0157	-6.0157	-6.0157
S.E(Log q	0.4315	0.2514	0.4808

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
1	-0.78	-1.044	13.6	0.04	14	0.76	-9.53
2	0.38	2.401	9.32	0.61	14	0.13	-5.75

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	1.01	-0.009	6.19	0.09	14	0.35	-6.23
4	1.21	-0.183	5.22	0.08	14	0.39	-6.13
5	1.15	-0.229	5.4	0.2	14	0.27	-6.02
6	0.79	0.43	6.82	0.31	14	0.23	-6.05
7	1.16	-0.222	5.52	0.18	14	0.36	-6.05
8	1.42	-0.461	4.68	0.11	14	0.52	-5.97
9	1.07	-0.096	5.72	0.17	14	0.48	-5.91
10	1.15	-0.188	5.78	0.15	14	0.59	-6.09
11	0.9	0.176	6.12	0.24	14	0.46	-5.93
12	0.9	0.21	6.25	0.33	14	0.39	-6.12
13	0.9	0.235	5.97	0.37	14	0.37	-5.85
14	0.73	1.74	6.25	0.82	14	0.15	-6.11
15	0.97	0.058	5.8	0.33	14	0.42	-5.78

Table 5.6.23 (cont)

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength

Year class = 1993

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	11553	1.039	0	0	1	0.019	0.566
P shrinka	98824	0.15				0.981	0.085

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
94802	0.15	2.13	2	14.081	0.089

Age 2 Catchability dependent on age and year class strength

Year class = 1992

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	61889	0.282	0.057	0.2	2	0.063	0.618
P shrinka	54990	0.1				0.937	0.675

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
55399	0.1	0.08	3	0.838	0.671

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 1991

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	44066	0.219	0.154	0.71	3	1	0.201

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
44066	0.22	0.15	3	0.707	0.201

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

Year class = 1990

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	27099	0.182	0.085	0.47	4	1	0.208

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
27099	0.18	0.08	4	0.466	0.208

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

Year class = 1989

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	17147	0.158	0.012	0.08	5	1	0.213

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
17147	0.16	0.01	5	0.076	0.213

Table 5.6.23 (cont)

Age 6 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1988

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	11063	0.144	0.017	0.12	6	1	0.205

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
11063	0.14	0.02	6	0.119	0.205

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1987

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	6740	0.133	0.075	0.56	7	1	0.252

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
6740	0.13	0.07	7	0.563	0.252

Age 8 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1986

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	4345	0.129	0.091	0.7	8	1	0.274

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
4345	0.13	0.09	8	0.701	0.274

Age 9 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1985

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	2824	0.128	0.086	0.67	9	1	0.23

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
2824	0.13	0.09	9	0.672	0.23

Age 10 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1984

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	1971	0.131	0.083	0.63	10	1	0.176

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
1971	0.13	0.08	10	0.633	0.176

Table 5.6.23 (cont)

Age 11 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1983

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	1556	0.133	0.093	0.7	11	1	0.174

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
1556	0.13	0.09	11	0.701	0.174

Age 12 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1982

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	983	0.141	0.106	0.75	12	1	0.155

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
983	0.14	0.11	12	0.752	0.155

Age 13 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1981

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	663	0.145	0.088	0.6	13	1	0.194

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
663	0.15	0.09	13	0.605	0.194

Age 14 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1980

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	288	0.157	0.102	0.65	14	1	0.174

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
288	0.16	0.1	14	0.648	0.175

Age 15 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1979

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	265	0.147	0.074	0.5	14	1	0.188

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
265	0.15	0.07	14	0.503	0.188

Table 5.6.24 Firth of Forth (FU8) Females - VPA outputs

Run title : Firth Forth Females INDEX FILE

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Terminal Fs derived using XSA (Without F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	FBAR 92-94
AGE															
1	0.0026	0.0034	0.0035	0.0059	0.0038	0.0056	0.0037	0.0141	0.0062	0.007	0.0028	0.0025	0.0022	0.0888	0.0311
2	0.0939	0.1127	0.1277	0.1981	0.1618	0.3393	0.2127	0.4203	0.3172	0.3198	0.2355	0.1855	0.2194	0.6712	0.3587
3	0.0533	0.0531	0.0816	0.1189	0.1022	0.2495	0.1544	0.2545	0.2104	0.212	0.1348	0.1477	0.1773	0.2006	0.1752
4	0.0634	0.0498	0.106	0.1434	0.1153	0.2703	0.1723	0.2569	0.2332	0.2137	0.1607	0.164	0.2139	0.2083	0.1954
5	0.0937	0.0728	0.1364	0.1654	0.1366	0.2571	0.1891	0.2839	0.2424	0.2307	0.1863	0.1601	0.2542	0.2132	0.2092
6	0.1117	0.0872	0.1579	0.1493	0.1288	0.2433	0.1758	0.3203	0.2859	0.2379	0.1717	0.1217	0.1943	0.2053	0.1738
7	0.1338	0.099	0.1445	0.1436	0.1063	0.2102	0.163	0.2919	0.304	0.2518	0.1657	0.1146	0.2211	0.2519	0.1959
8	0.1841	0.1177	0.1495	0.1604	0.0994	0.2012	0.1582	0.3334	0.3371	0.3059	0.1697	0.1124	0.278	0.2741	0.2215
9	0.1904	0.1704	0.1794	0.1481	0.1035	0.2011	0.1526	0.347	0.4852	0.3339	0.1694	0.106	0.3223	0.2299	0.2194
10	0.1841	0.1935	0.2056	0.1193	0.0816	0.1656	0.0961	0.3664	0.3973	0.3168	0.1374	0.0993	0.1827	0.1765	0.1528
11	0.2306	0.2557	0.249	0.1846	0.0923	0.1802	0.1096	0.4293	0.4658	0.3246	0.2071	0.1117	0.2078	0.1737	0.1644
12	0.1313	0.1661	0.1903	0.1826	0.0744	0.1423	0.0944	0.229	0.335	0.3289	0.1635	0.1132	0.232	0.1549	0.1667
13	0.1572	0.1766	0.243	0.2437	0.1051	0.2616	0.1159	0.3003	0.3786	0.3614	0.2275	0.1274	0.4375	0.1941	0.253
14	0.1124	0.1106	0.1414	0.1746	0.1165	0.2094	0.1083	0.2756	0.2331	0.2094	0.1719	0.1167	0.2798	0.1745	0.1903
15	0.1107	0.1291	0.18	0.1925	0.1644	0.3524	0.1623	0.7397	0.3404	0.2769	0.197	0.1418	0.4807	0.1882	0.2702
+gp	0.1107	0.1291	0.18	0.1925	0.1644	0.3524	0.1623	0.7397	0.3404	0.2769	0.197	0.1418	0.4807	0.1882	
0 FBAR '3-13	0.1394	0.1311	0.1676	0.1599	0.1041	0.2166	0.1438	0.3103	0.3341	0.2834	0.1722	0.1253	0.2474	0.2075	

Run title : Firth Forth Females INDEX FILE

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Terminal Fs derived using XSA (Without F shrinkage)

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	GMST 81-92	AMST 81-92
AGE																	
1	110650	124607	135226	132285	132885	117731	136976	123720	132632	128875	130699	149561	197904	139852	0	129306	129654
2	74778	81762	92002	99829	97423	98067	86734	101099	90375	97651	94805	96549	110526	146287	94802	92254	92589
3	46758	50433	54115	59985	60663	61393	51748	51940	49198	48751	52541	55495	59418	65748	55399	53385	53585
4	34989	36294	39154	40833	43607	44842	39165	36307	32971	32636	32290	37592	39198	40745	44066	37351	37557
5	23308	26888	28272	28833	28965	31816	28017	26989	22991	21378	21579	22513	26122	25912	27099	25751	25962
6	16869	17375	20467	20195	20008	20686	20144	18986	16635	14771	13897	14665	15704	16586	17147	17723	17892
7	12280	12352	13038	14309	14242	14402	13279	13834	11284	10233	9533	9583	10630	10587	11063	12234	12364
8	7531	8794	9160	9238	10149	10484	9556	9237	8459	6817	6513	6613	6996	6977	6740	8440	8546
9	5405	5129	6401	6458	6443	7523	7019	6679	5418	4944	4110	4500	4838	4338	4345	5744	5836
10	3681	3658	3542	4380	4559	4756	5037	4933	3865	2731	2899	2841	3314	2870	2824	3824	3907
11	2509	2507	2468	2361	3183	3440	3300	3746	2800	2127	1629	2069	2106	2260	1971	2609	2678
12	1894	1631	1590	1575	1607	2376	2352	2421	1997	1439	1259	1084	1515	1401	1556	1718	1769
13	1452	1360	1131	1076	1075	1221	1687	1752	1577	1169	848	875	792	983	983	1236	1269
14	1200	1016	933	726	690	792	770	1230	1063	884	667	553	631	419	663	853	877
15	1215	878	745	663	499	503	526	566	765	689	587	460	403	390	288	649	675
+gp	2377	2471	1244	1160	834	1137	1088	1397	2205	1770	1372	1489	1058	832	829		
0 TO	346896	377155	409488	423908	426833	421168	407397	404838	384233	376864	375227	406441	481154	466187	269775		

Run title : Firth Forth Females INDEX FILE

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Table 16 Summary (without SOP correction)

Terminal Fs derived using XSA (Without F shrinkage)

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3-13
1981	110650	4948	3646	317	0.087	0.1394
1982	124607	5250	3810	293	0.0768	0.1311
1983	135226	5565	3968	455	0.1146	0.1676
1984	132285	5792	4133	512	0.1238	0.1599
1985	132885	5864	4226	469	0.111	0.1041
1986	117731	6135	4467	951	0.2128	0.2166
1987	136976	5716	4077	580	0.1424	0.1438
1988	123720	5671	4042	1032	0.2553	0.3103
1989	132632	5180	3613	851	0.2357	0.3341
1990	128875	4993	3274	749	0.2286	0.2834
1991	130699	4775	3174	497	0.1567	0.1722
1992	149561	5143	3333	435	0.1304	0.1253
1993	197904	5821	3616	687	0.1899	0.2474
1994	139852	5677	3662	738	0.2015	0.2075
Arith. Mean	135257	5466	3789	612	0.1619	0.1959
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 5.6.25 Results by stratum of the 1994 TV survey in the Firth of Forth.

Stratum	Area strata (Km2)	Weight strata (%)	Sample size	Mean density (burr./m2)	Observed variance	Coeff. variation	Abundance (millions)	Variance strata	Contrib. to total var. (%)
W	291	31.8	10	0.408	0.0875	0.73	119	740	37.3
X+	423	46.2	15	0.730	0.0839	0.40	309	1002	50.5
Y-	201	22.0	5	0.505	0.0300	0.34	102	243	12.2
TOTAL	915	100.0	30.0				529	1985	100.0

Table 5.6.26 Results of the 1993-94 TV surveys in the Firth of Forth.

YEAR	1993	1994
Mean density (burrows/m2)	0.72	0.58
Abundance (millions)	655	529
+/- 95% confidence limit	167	92
Biomass ('000 tonnes)	9.9 - 16.7	7.6 - 10.8

Table 5.6.27 Nephrops landings (tonnes) by Functional Unit plus other rectangles in Management Area I (IVb, c West of 1° East)

Year	FU 6	FU 8	Other	Total
1985	2028	1969	107	4104
1986	2015	2263	143	4421
1987	2193	1674	138	4005
1988	2504	2528	310	5342
1989	3098	1885	157	5140
1990	2498	1931	132	4561
1991	2063	1402	355	3820
1992	1463	1755	257	3475
1993	3030	2369	255	5654
1994	3676	1812	392	5880

Table 5.6.28 Total Nephrops Landings (tonnes) by country in Management Area I (IVb,c West of 1°East)

Year	UK	Denmark	Belgium	Total
1985	4104	+	?	4104
1986	4421	+	0	4421
1987	4005	+	0	4005
1988	5330	12	0	5342
1989	5138	2	0	5140
1990	4555	1	5	4561
1991	3815	1	4	3820
1992	3471	3	1	3475
1993	5654	0	1	5655
1994	5879	1	0	5880

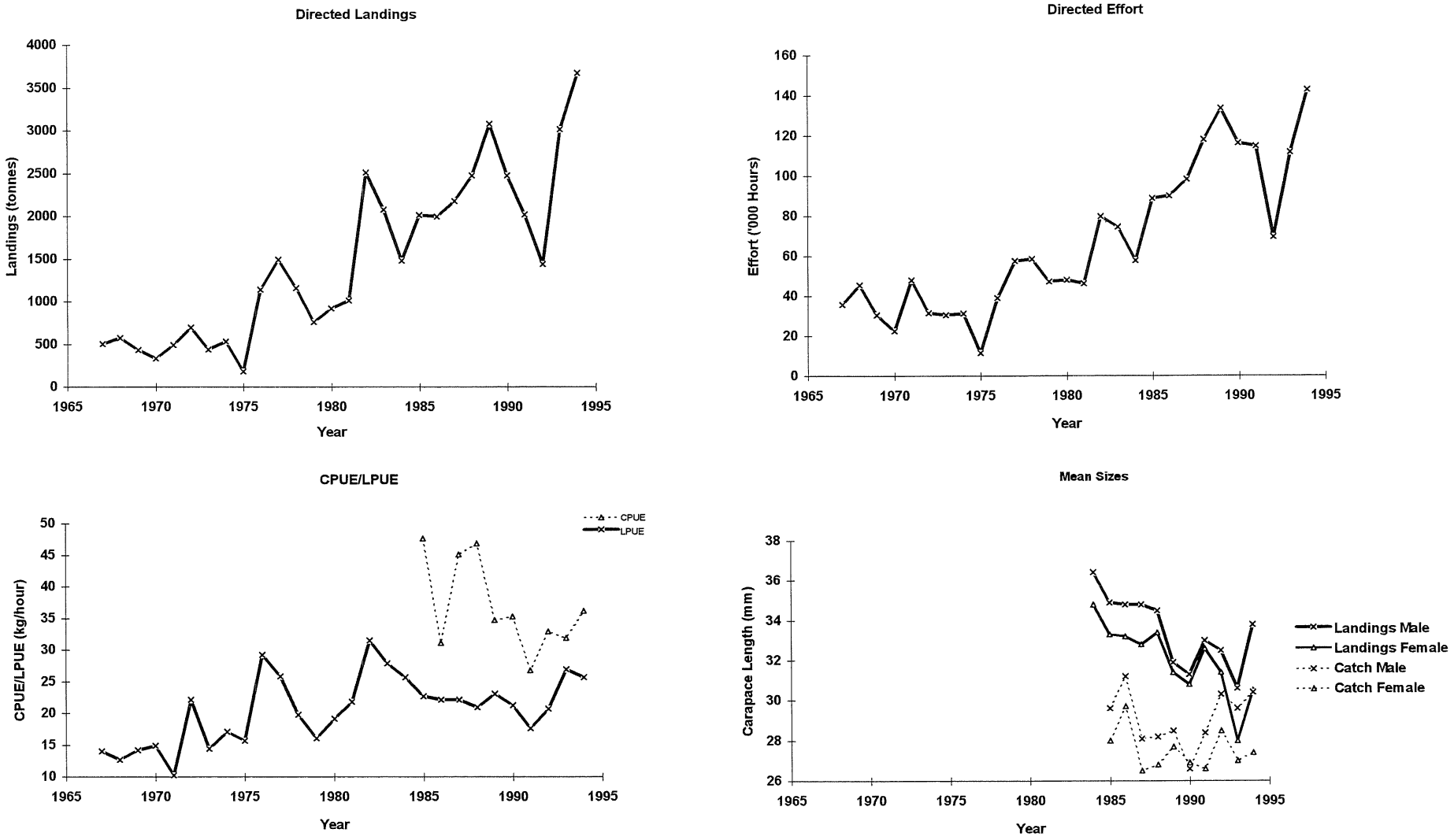


Figure 5.6.1 Farne Deeps (FU6): Long term trends in directed landings (tonnes), directed effort ('000 hours), CPUE (kg/hour), LPUE (kg/hour) and mean size (mm CL) in catch and landings.

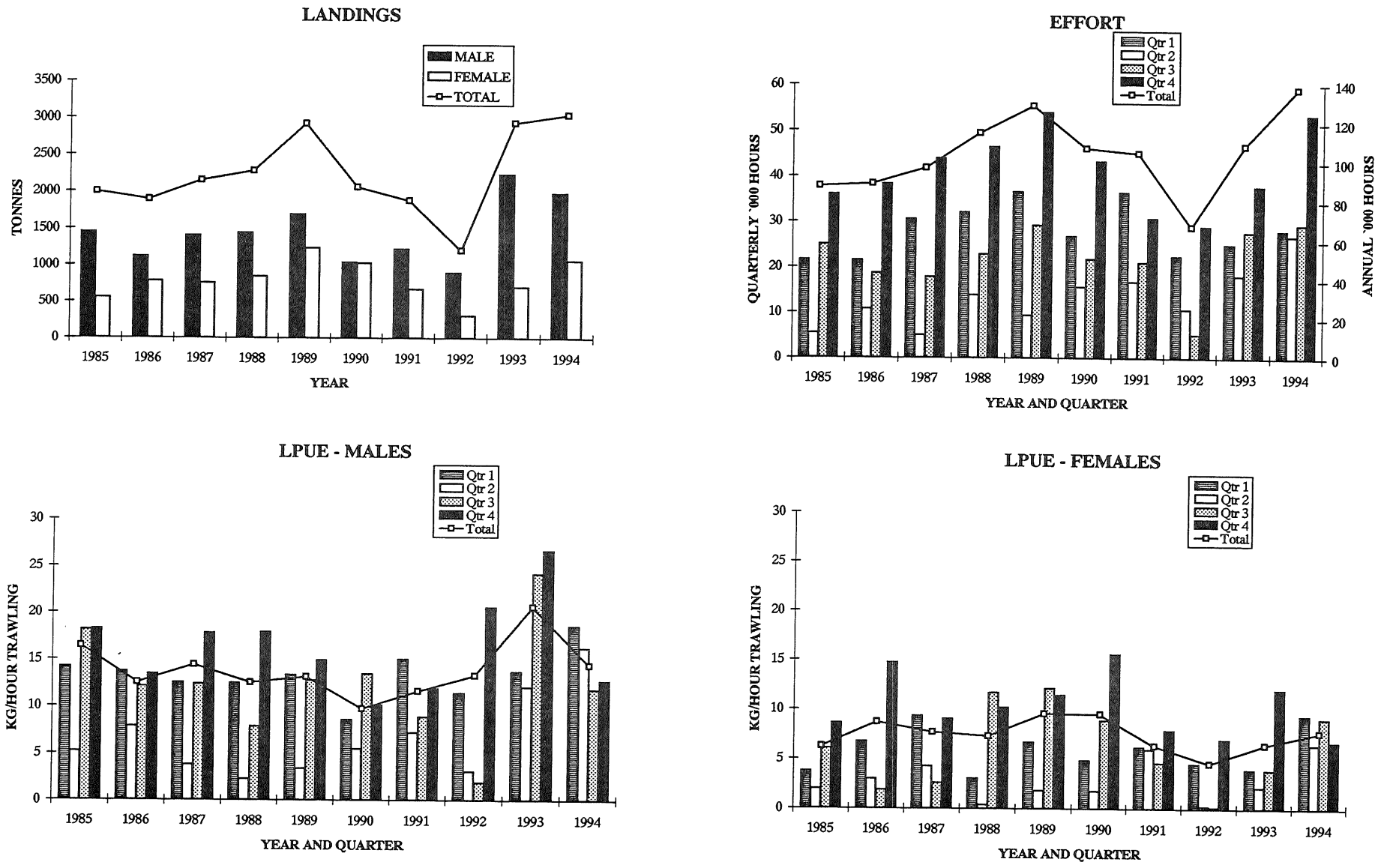
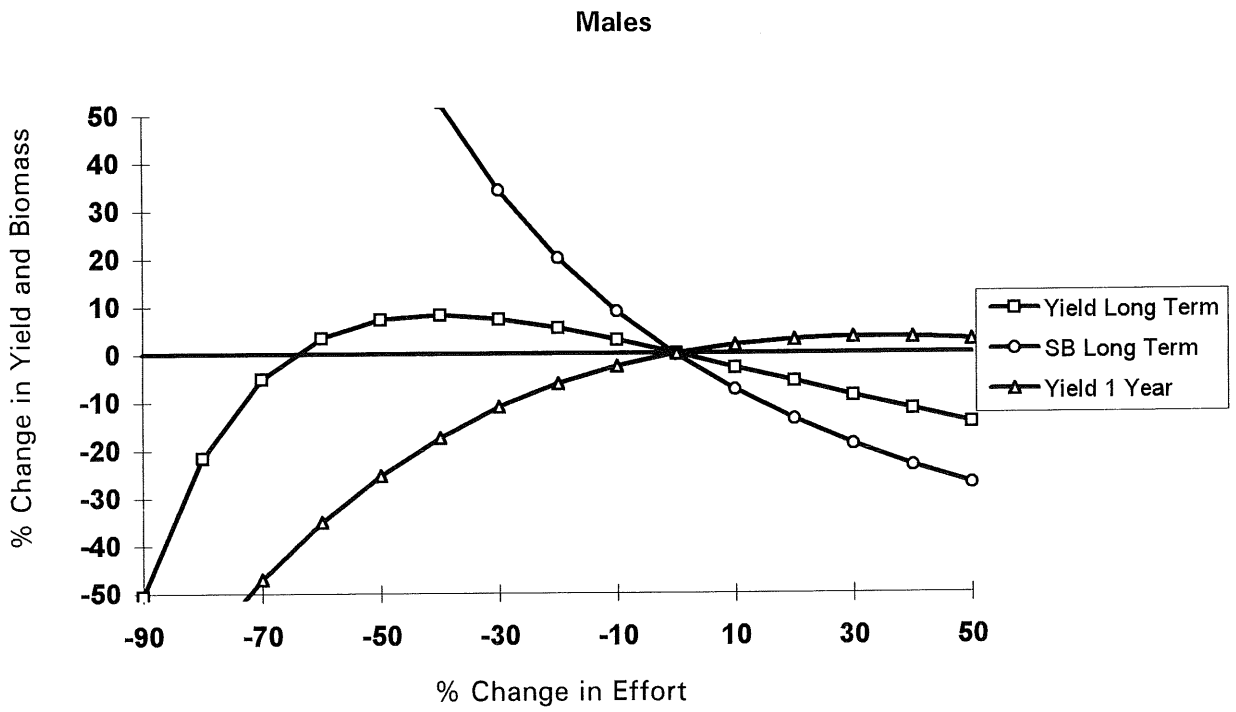


Figure 5.6.2. Farn Deeps (Functional Unit 6) : trends in landings,effort and LPUE by quarter and sex from English Nephrops trawlers.



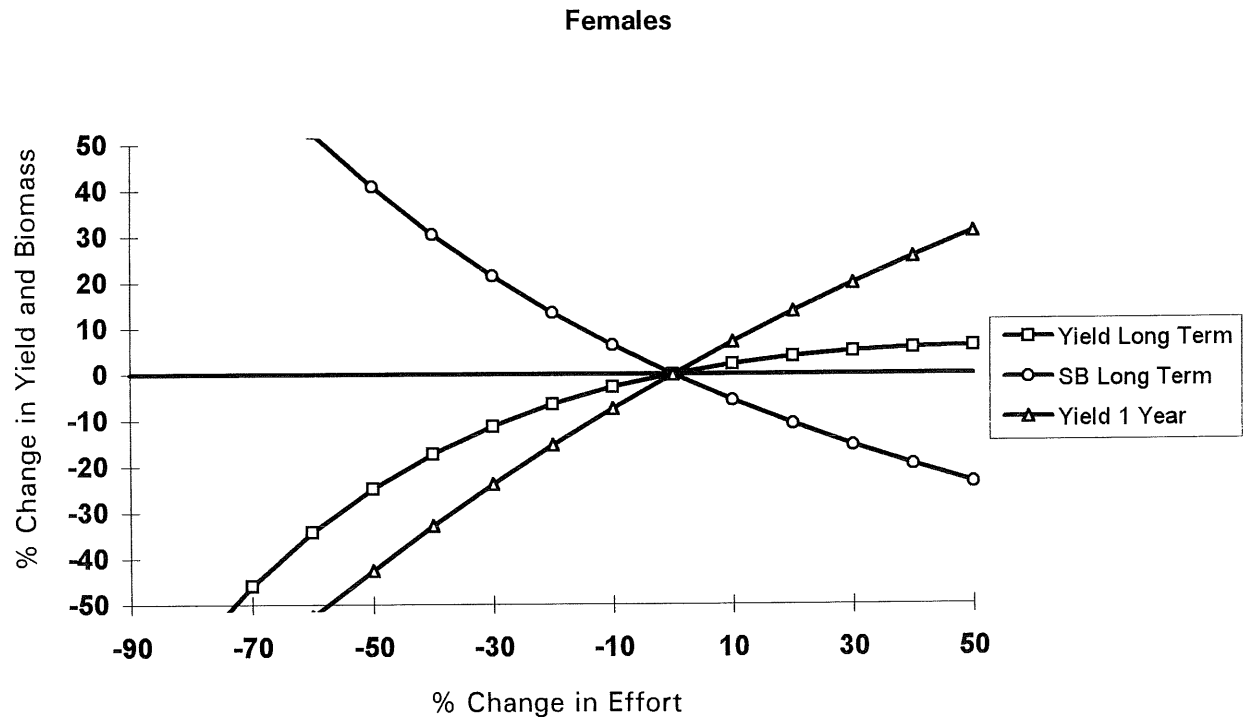


Figure 5.6.3 Farne Deeps (FU6): Percentage changes in long term landings and stock biomass, and short term landings following various changes in fishing effort. Males and females shown separately.

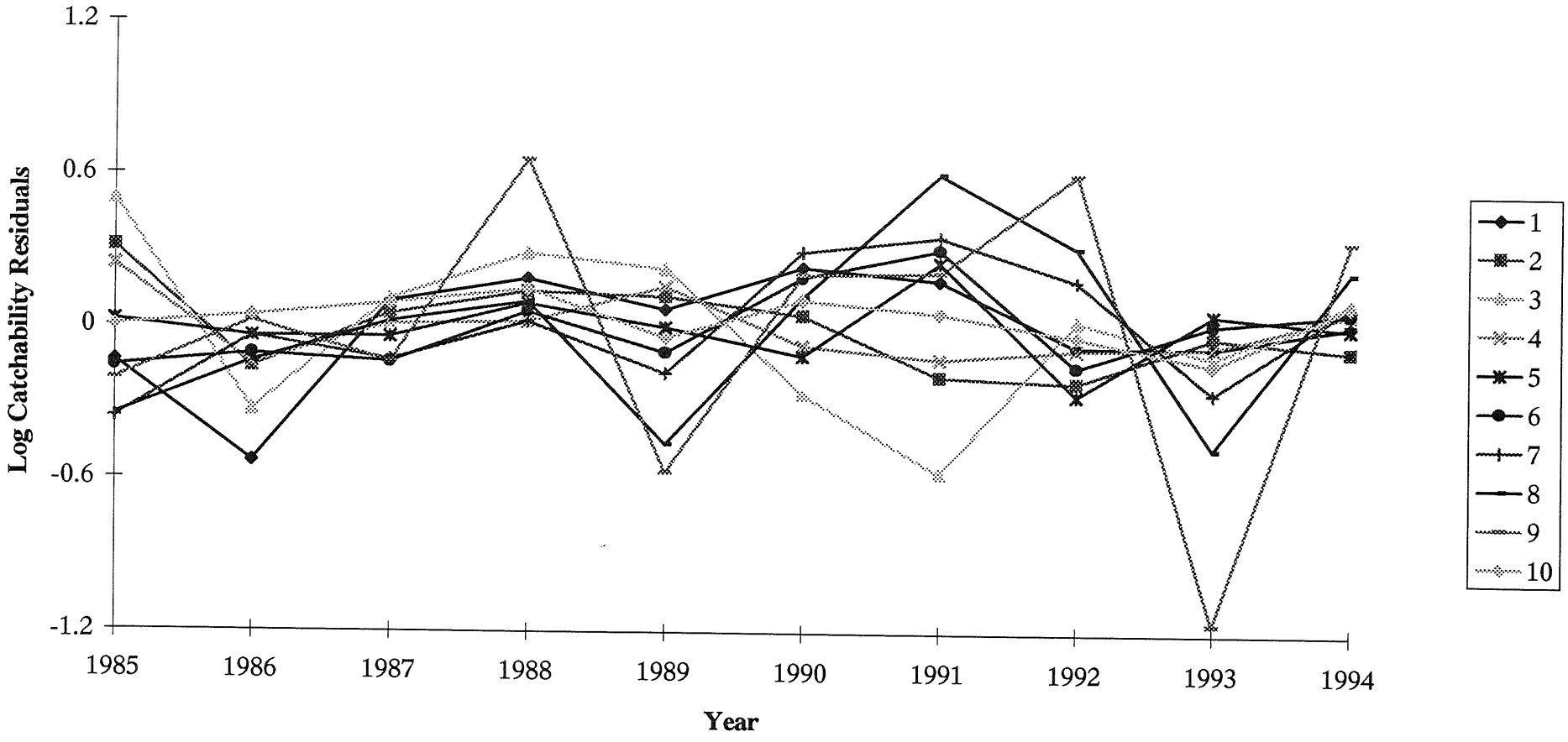


Figure 5.6.4 Farne Deeps (FU6): Males log catchability residuals from XSA

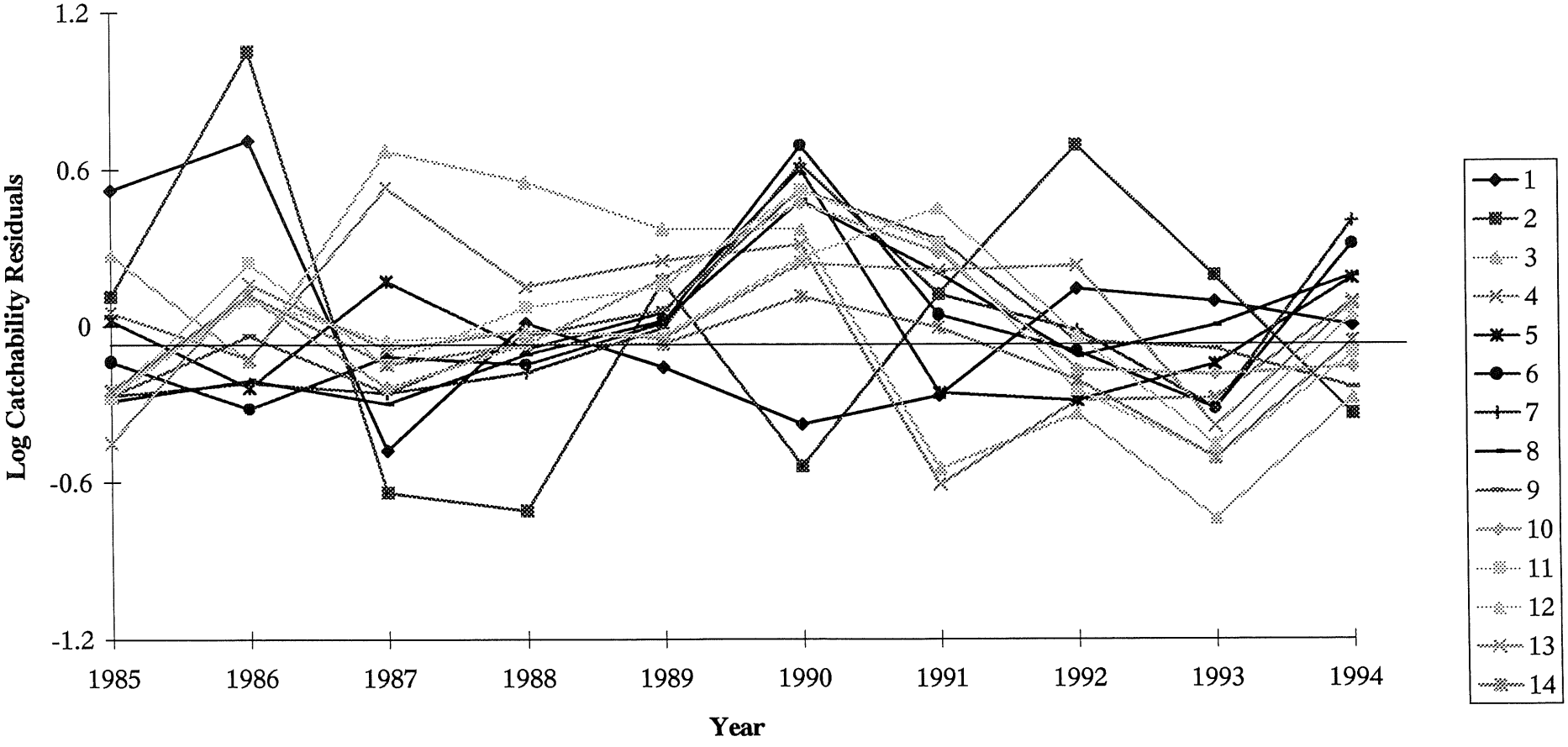
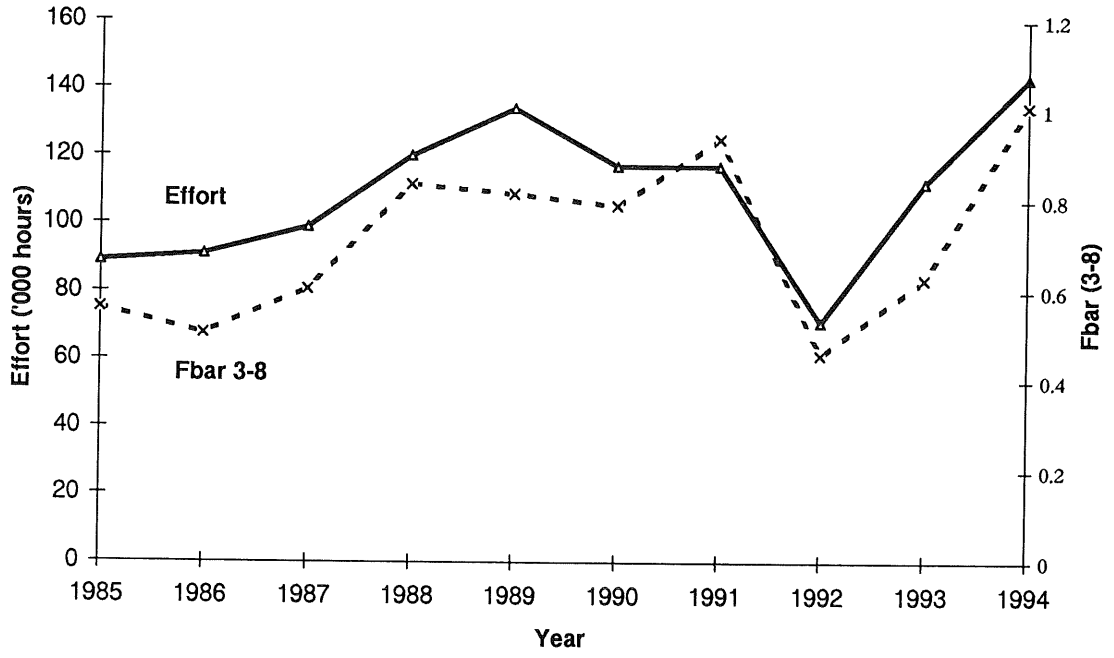


Figure 5.6.5 Farne Deeps (FU6): Females - log catchability residuals from XSA



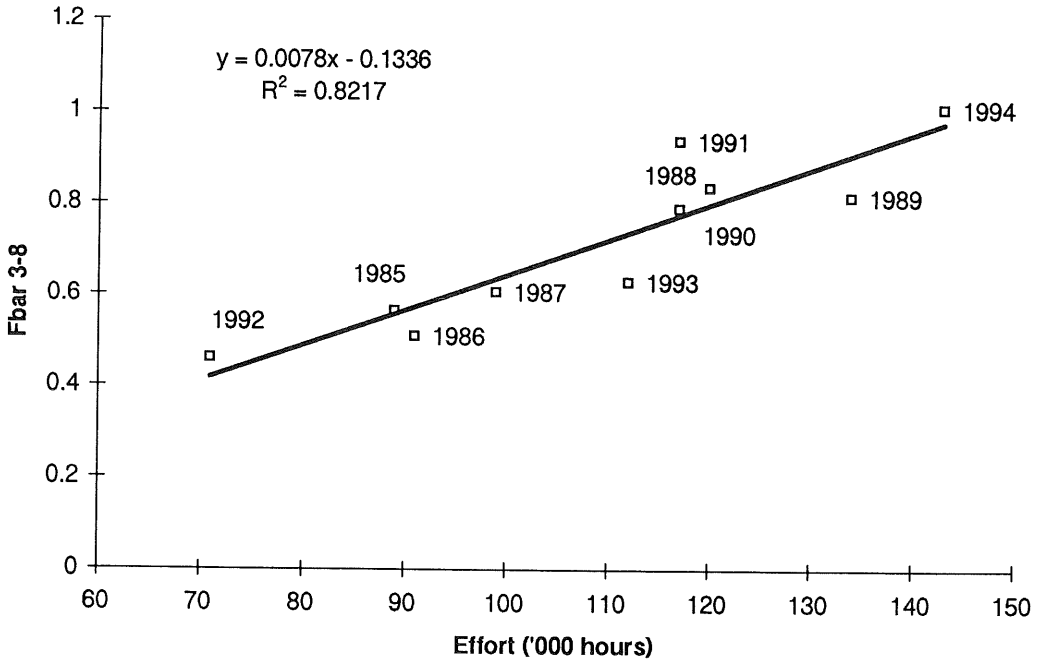


Figure 5.6.6 Farn Deeps (FU6): Males - plot of effort and Fbar from XSA, together with their regression.

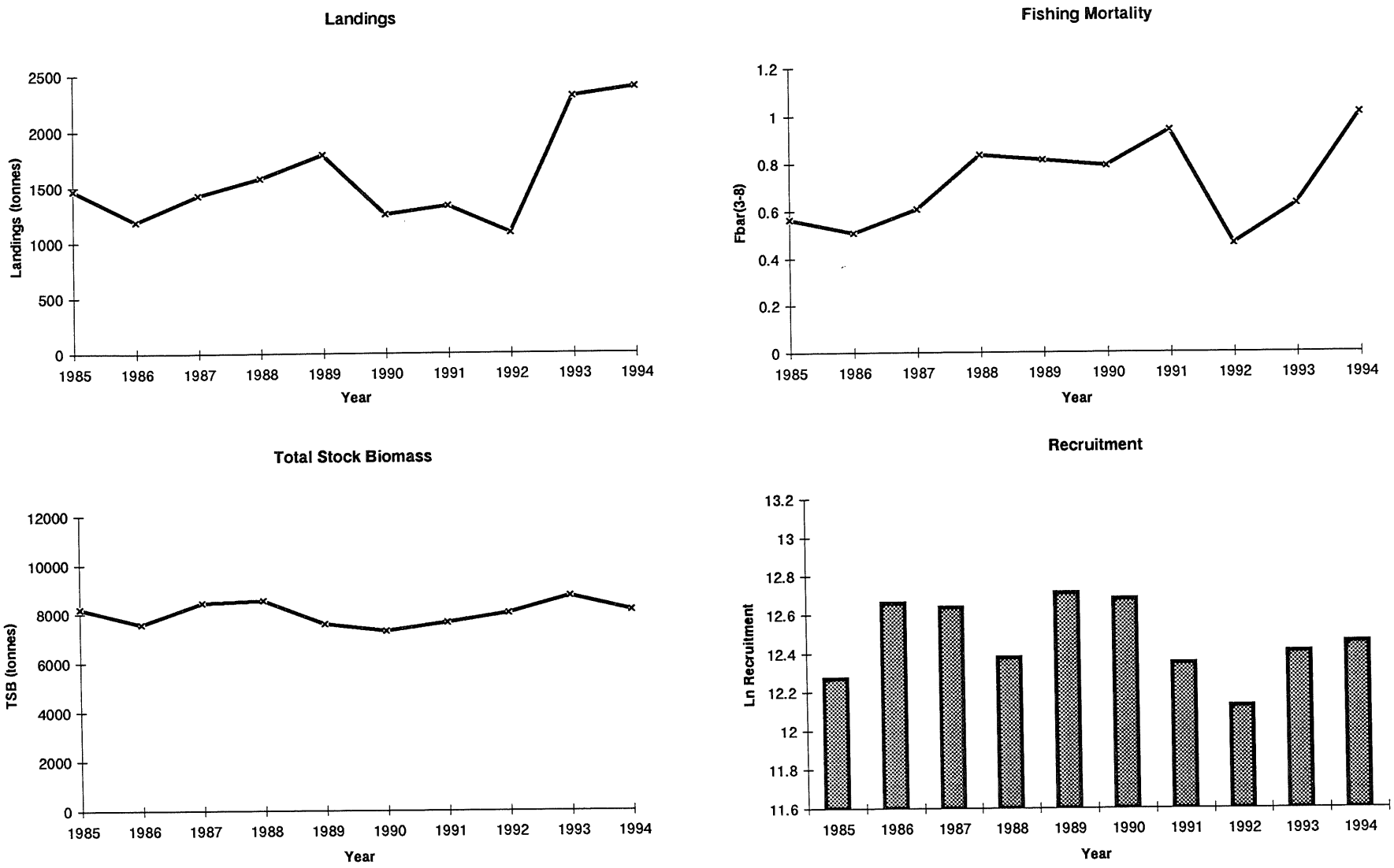
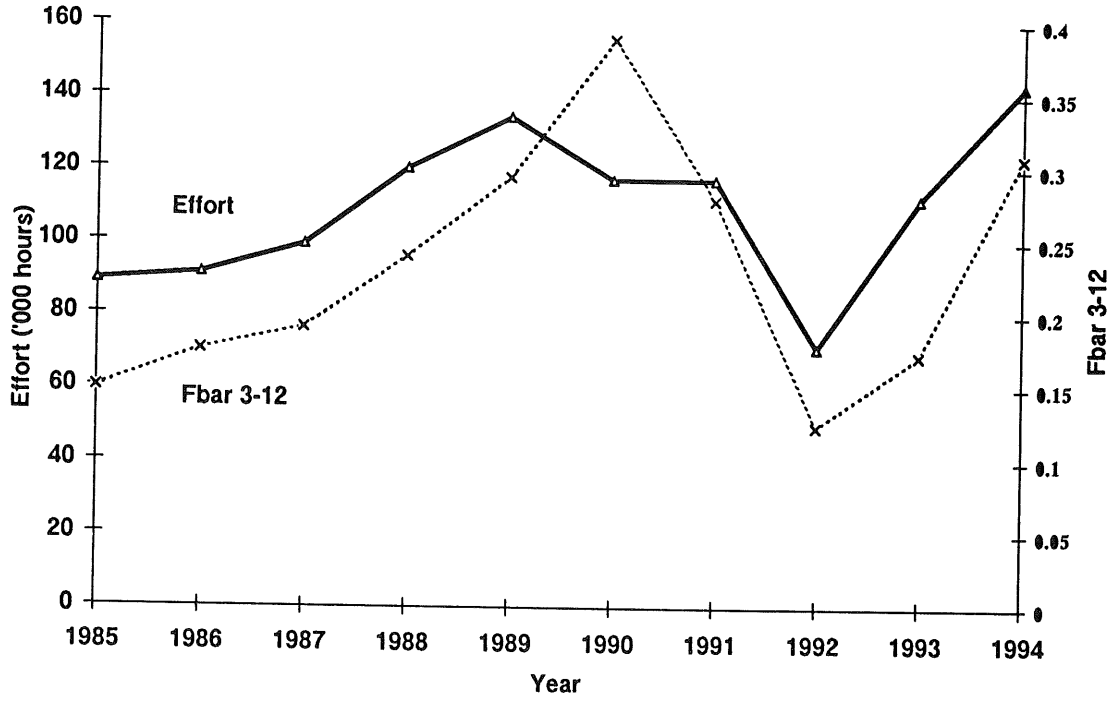


Figure 5.6.7 Farne Deeps (FU6): Males - trends in landings, fishing mortality, total stock biomass, and Ln recruitment from XSA.



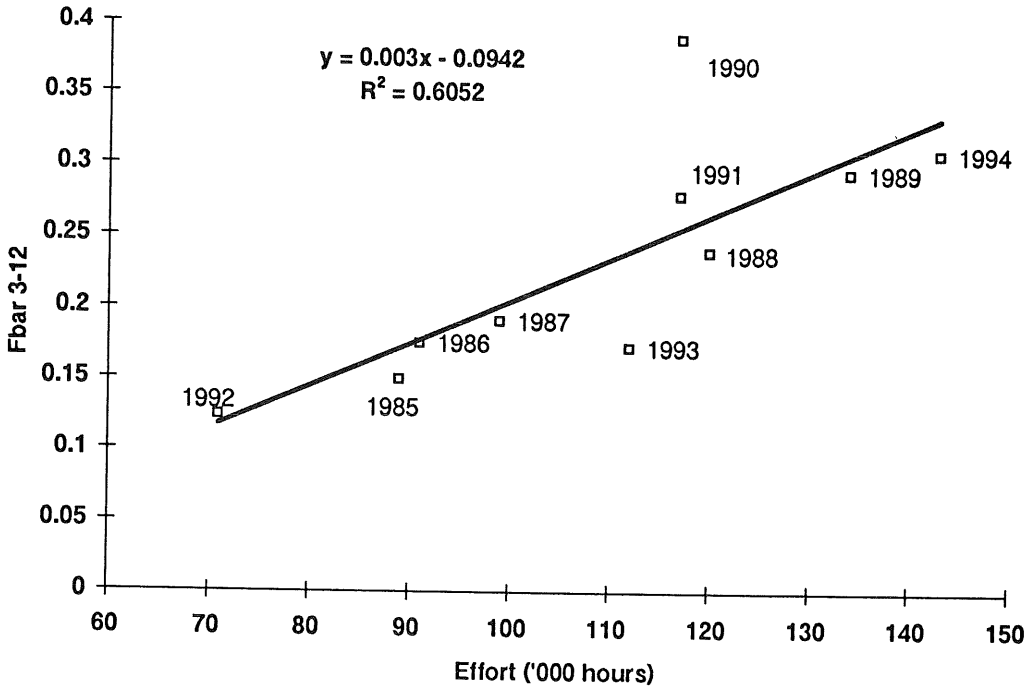
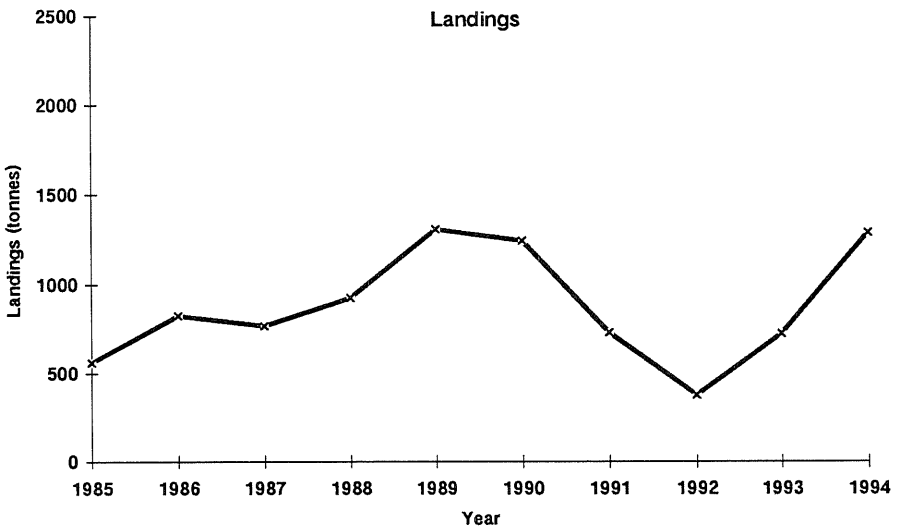
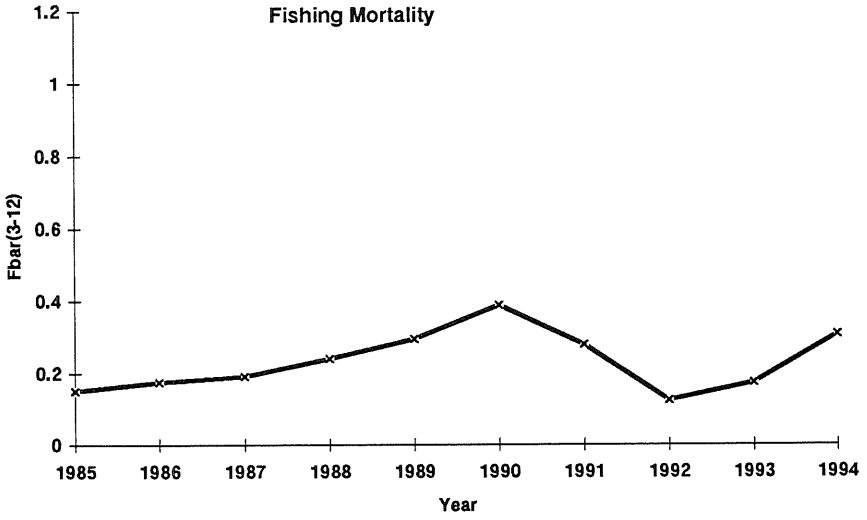
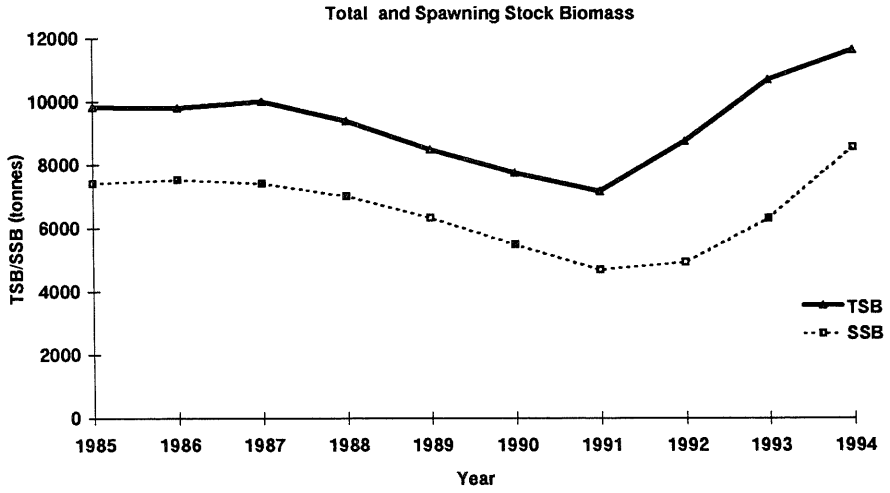


Figure 5.6.8 Farne Deeps (FU6): Females - plot of effort and Fbar from XSA, together with their regression.







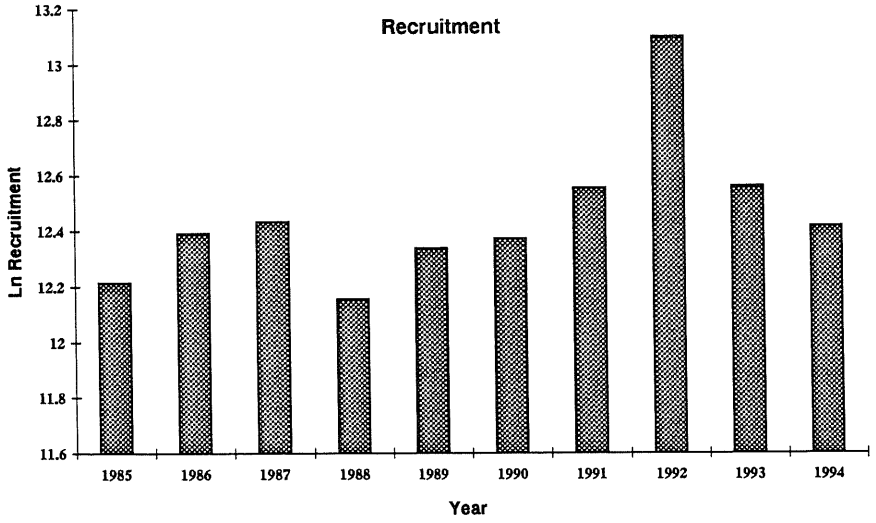


Figure 5.6.9 Farne Deeps (FU6): Females - trends in landings, fishing mortality, total and spawning stock biomass, and Ln recruitment from XSA.

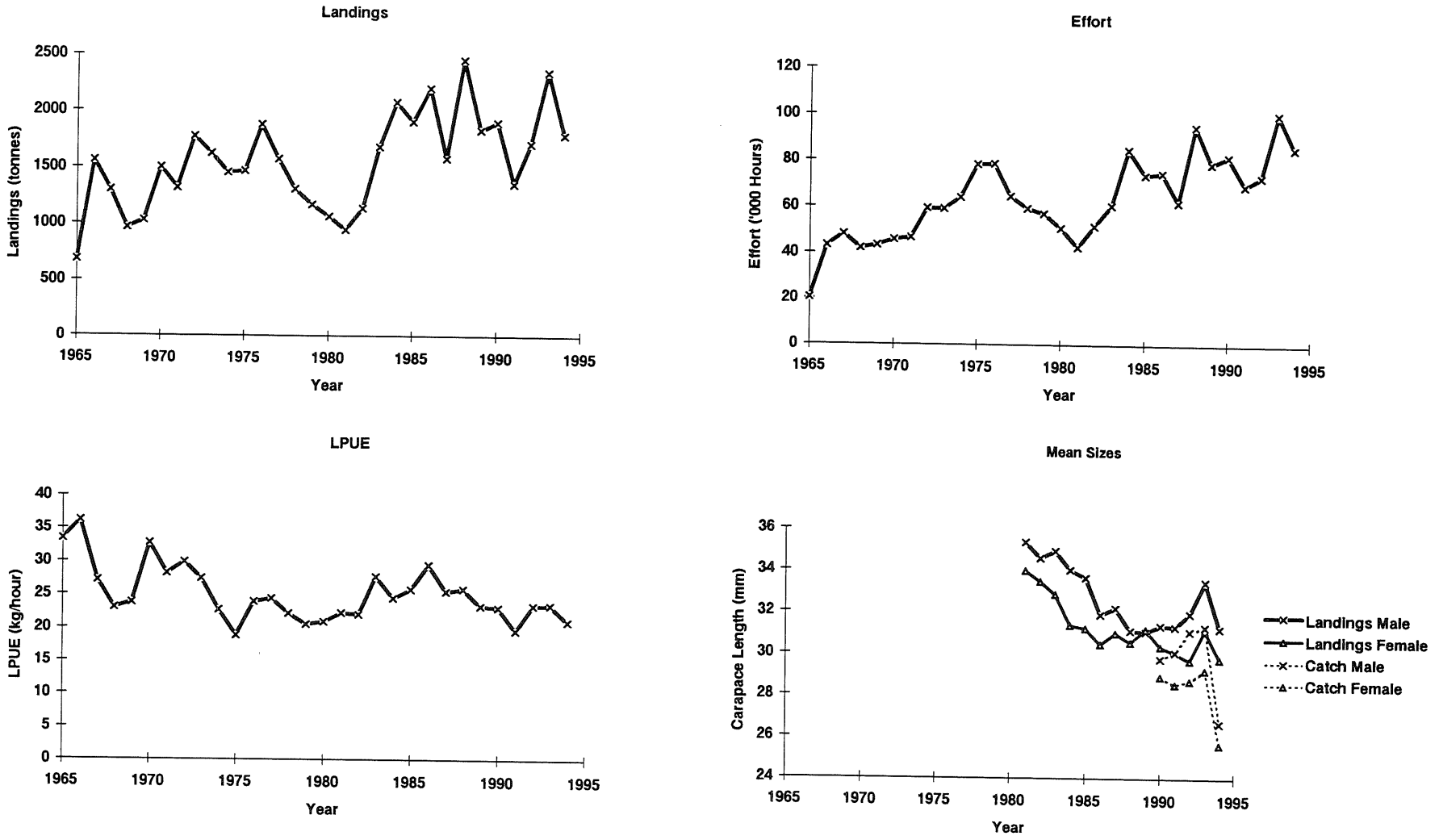


Figure 5.6.10 Firth of Forth (FU8): Long term trends in Scottish Nephrops trawler landings (tonnes), effort ('000 hours), LPUE (kg/hour) and mean size (mm CL) in catch and landings.

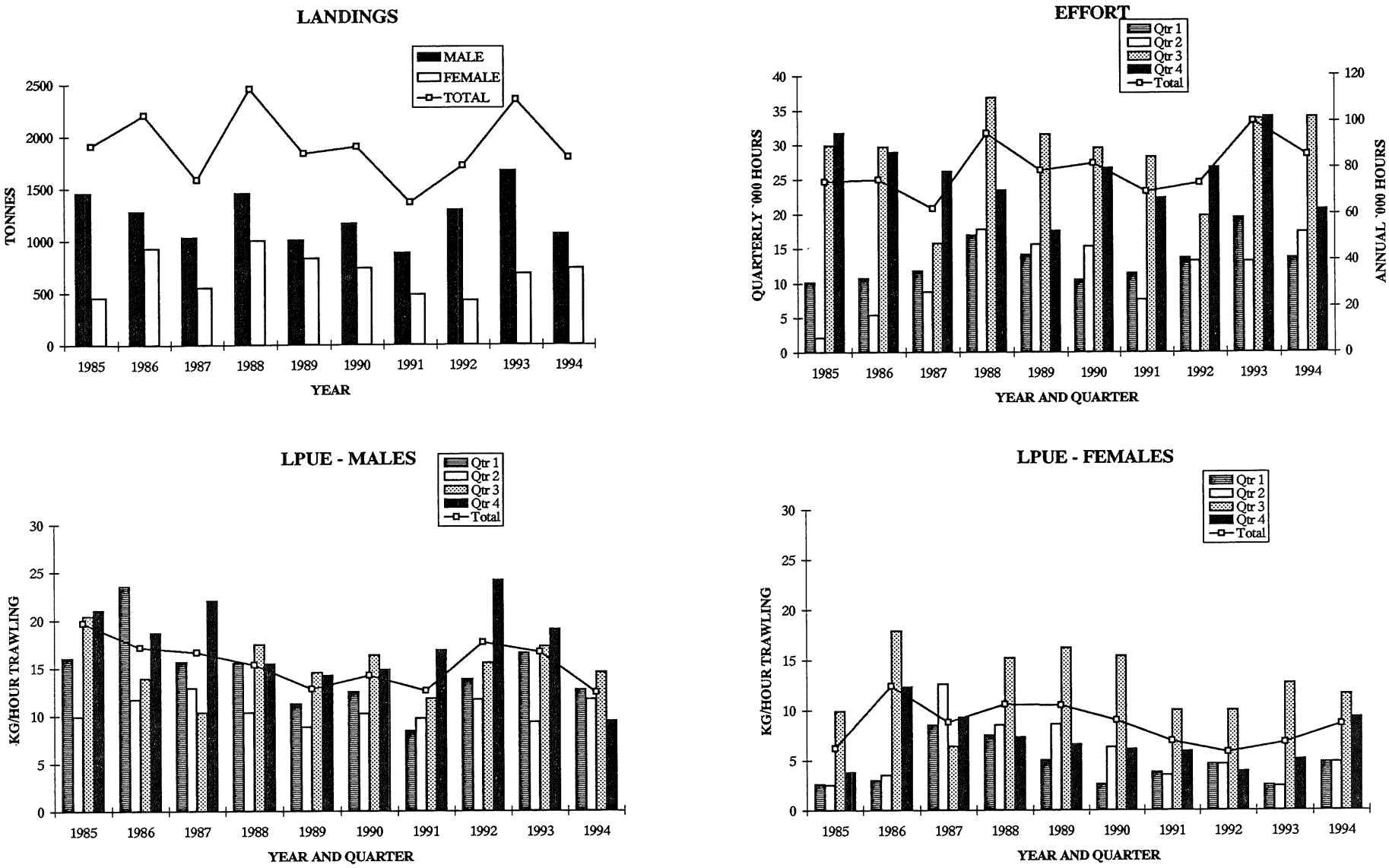


Figure 5.6.11. Firth of Forth (Functional Unit 8) : trends in landings,effort and LPUE by quarter and sex from Scottish Nephrops trawlers.

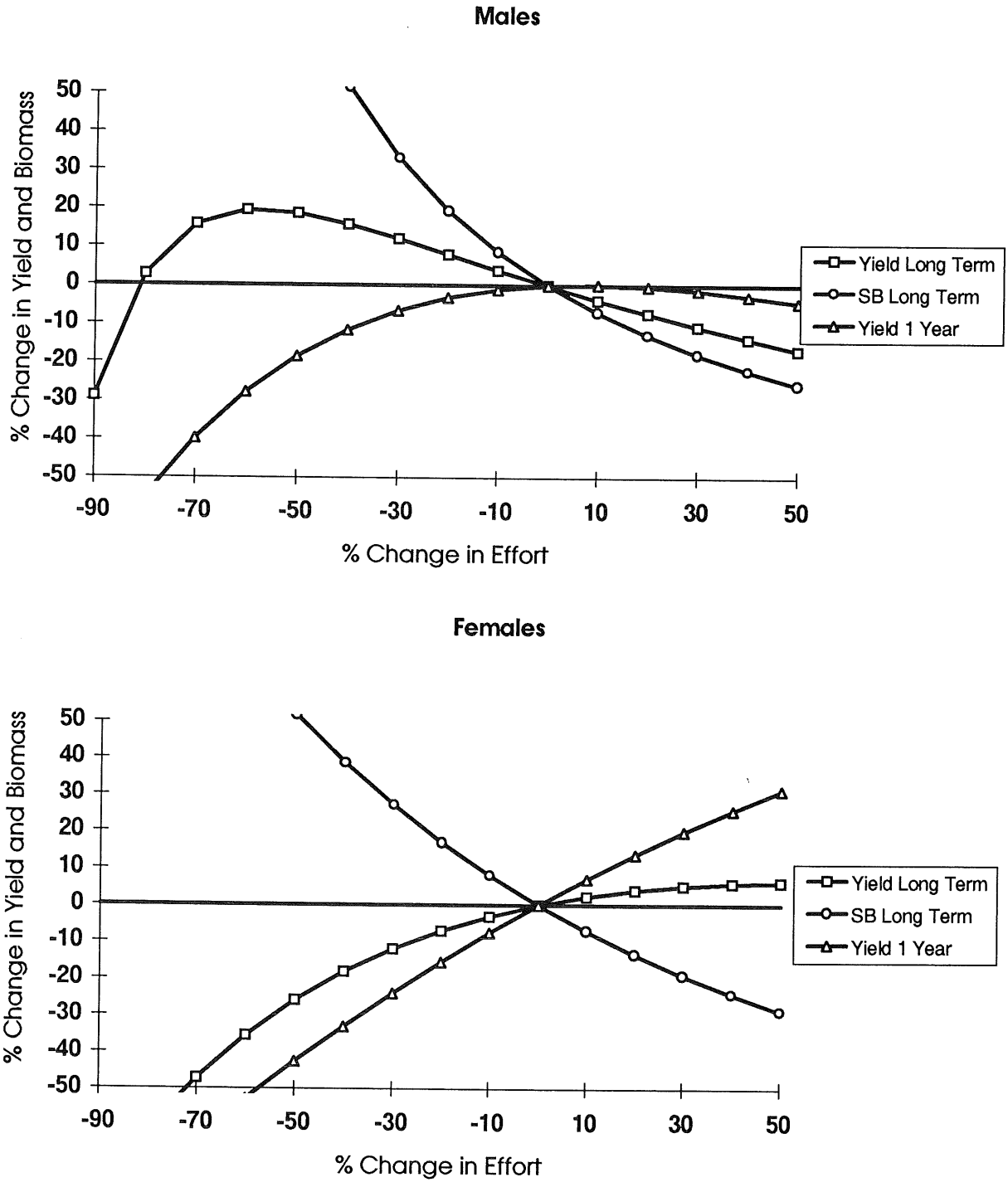


Figure 5.6.12 Firth of Forth (FU8): Percentage changes in long term landings and stock biomass, and short term landings following various changes in fishing effort. Males and females shown separately.

Figure 5.6.13 Firth of Forth (FU8) Males - Log Catchability Residuals (using Laurec-Shepherd method)

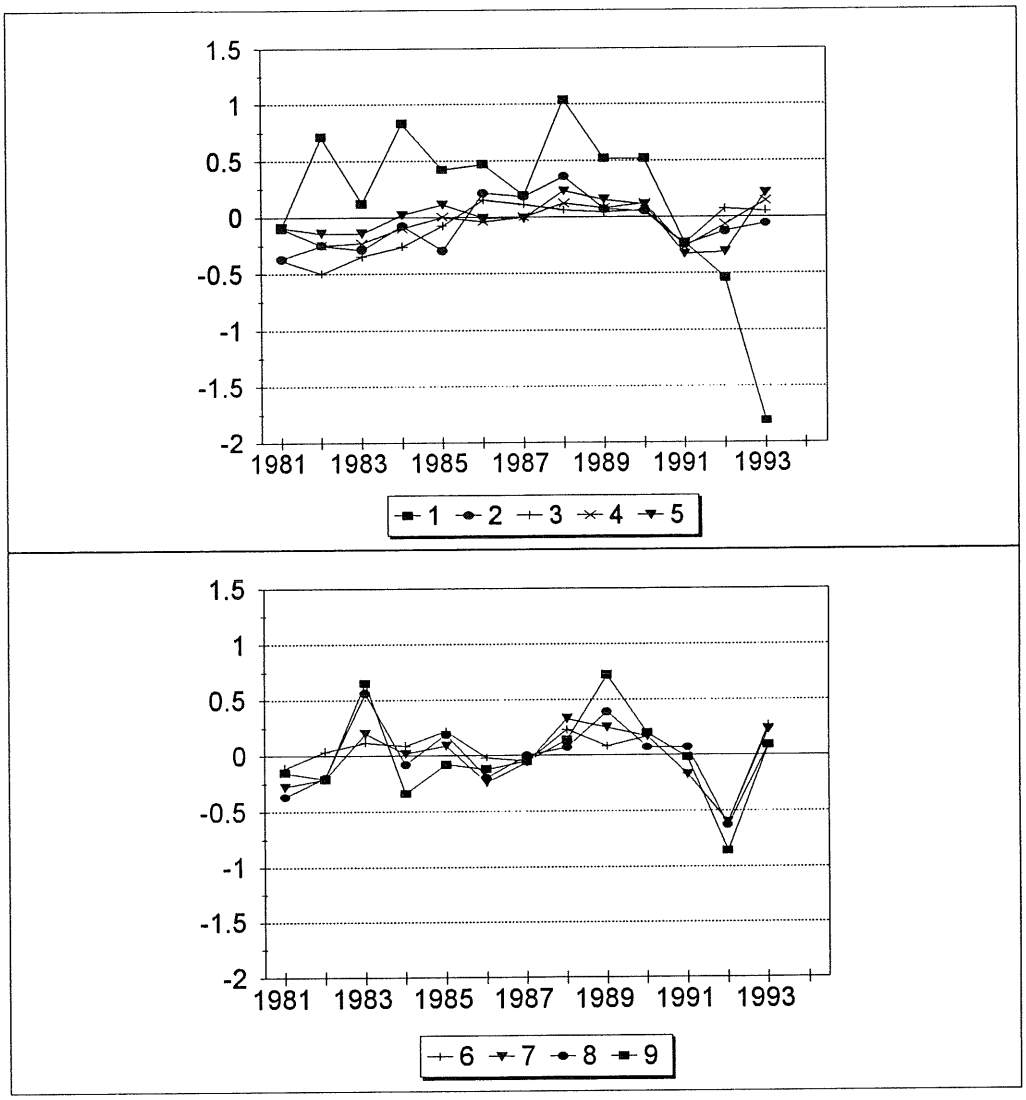
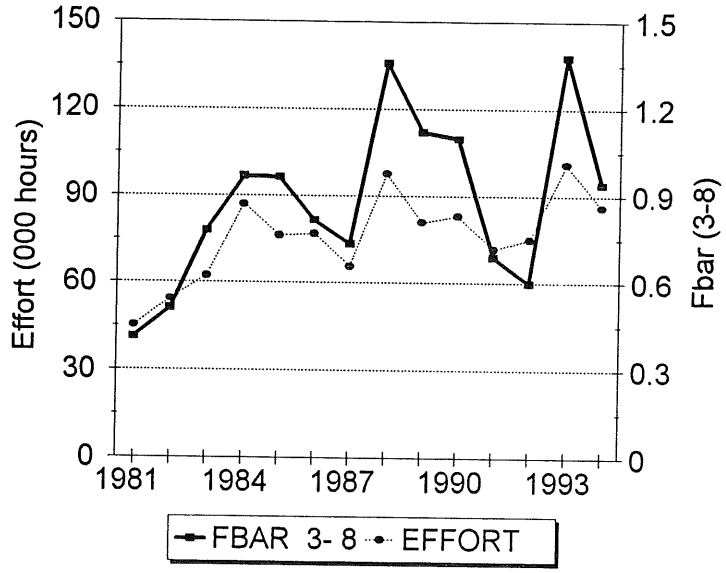


Figure 5.6.14 Firth of Forth (FU8) Males - Effort and FBar and relationship between them



r = 0.9098

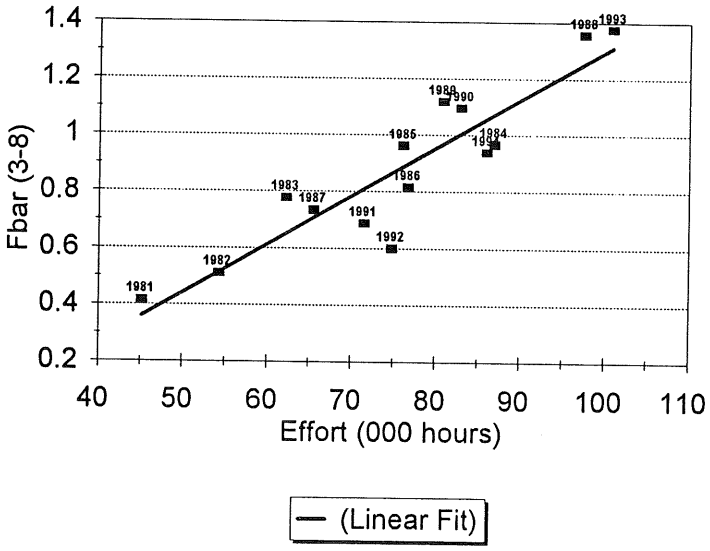
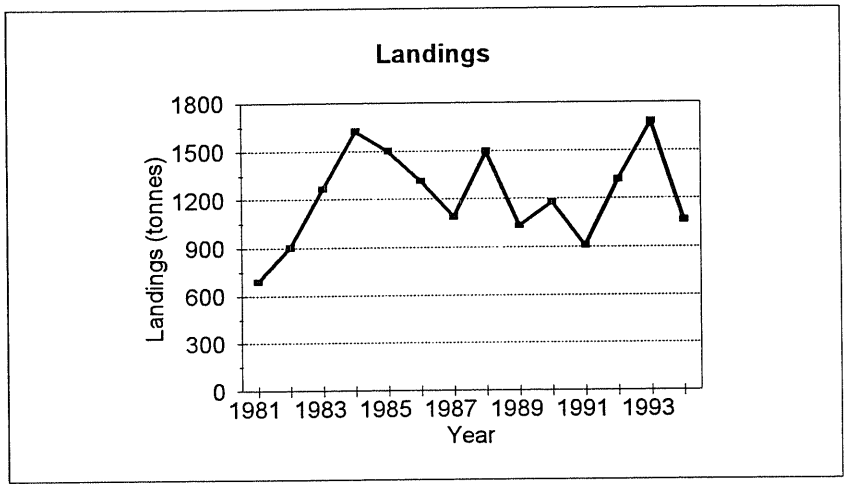
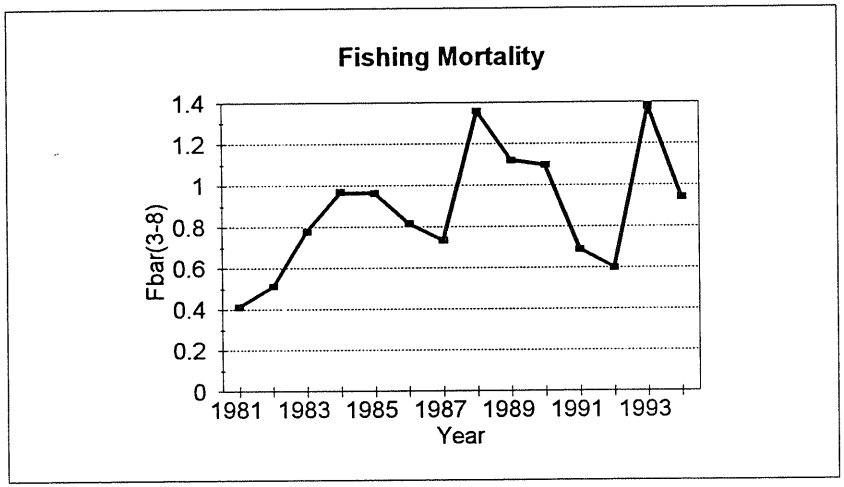
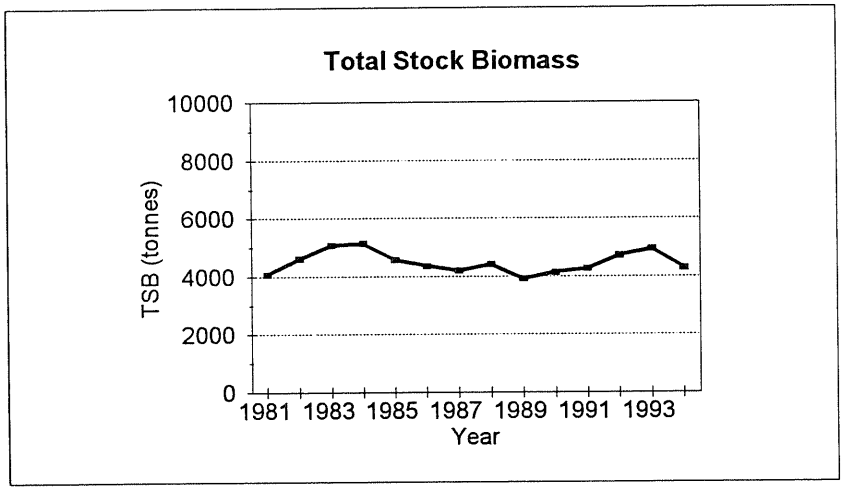


Figure 5.6.15 Firth of Forth (FU8) Males - Trends in Landings, Fbar, Total Stock Biomass and Ln recruits from XSA







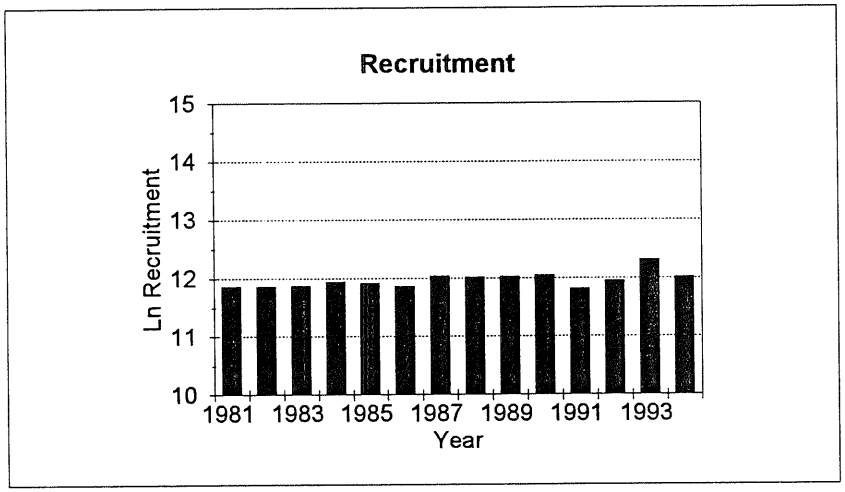


Figure 5.6.16 Firth of Forth (FU8) Females - Log Catchability Residuals (using Laurec-Shepherd method)

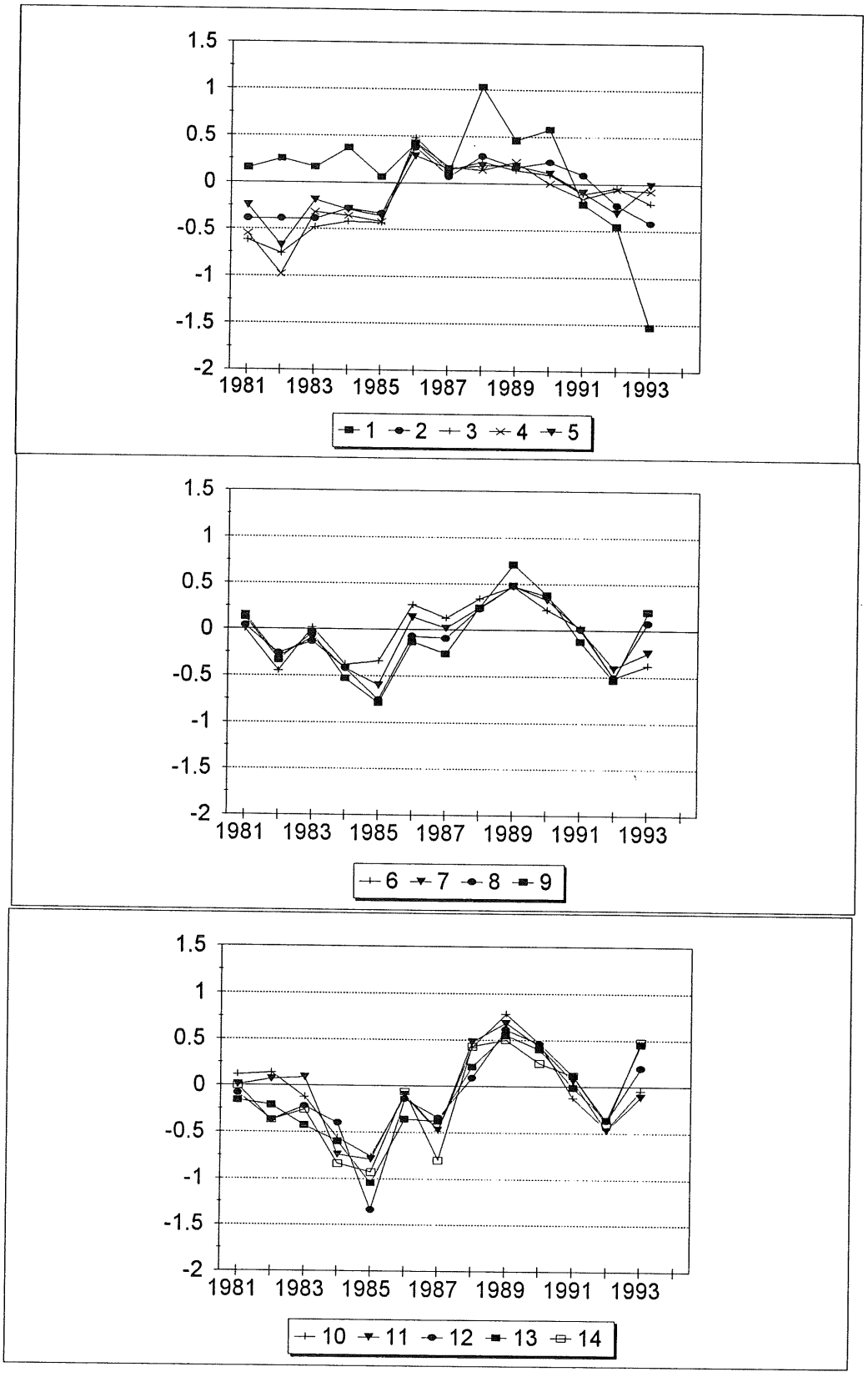
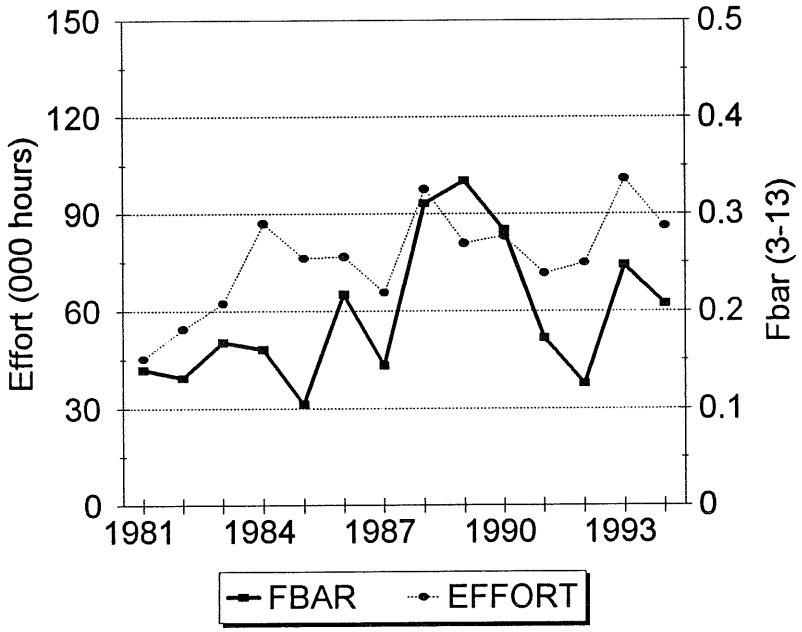


Figure 5.6.17 Firth of Forth (FU8) Females - Effort and Fbar and relationship between them



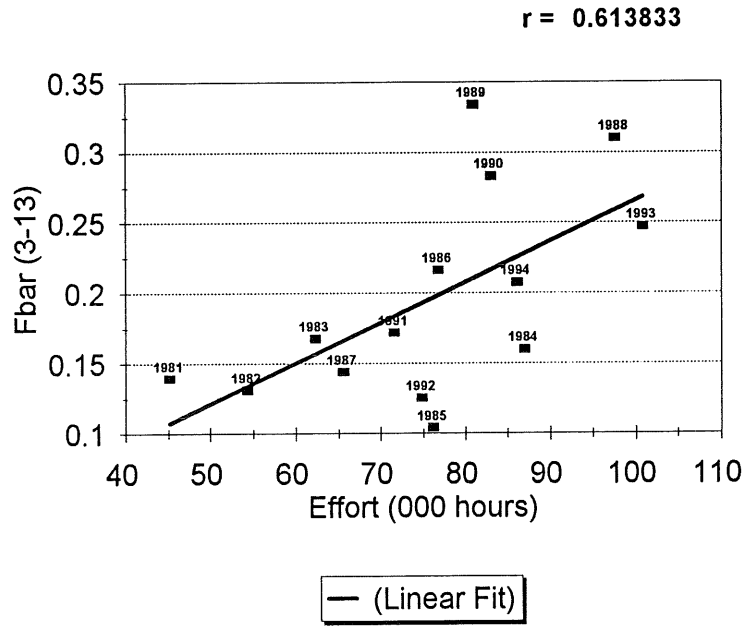
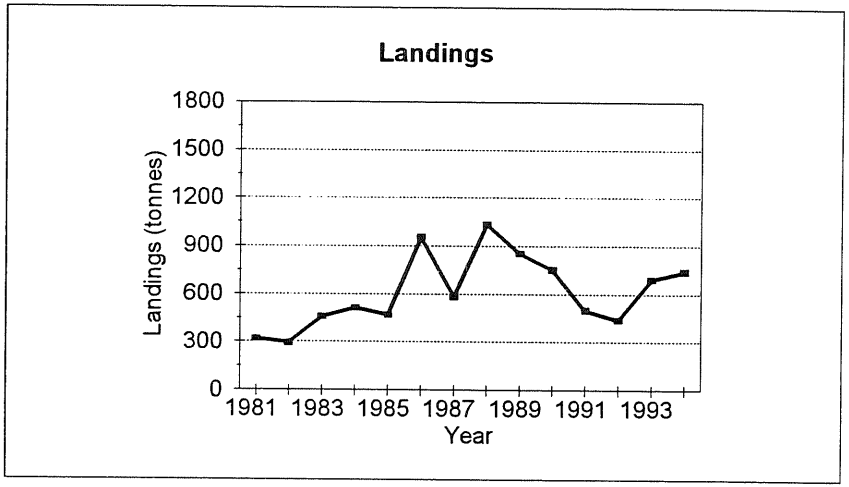
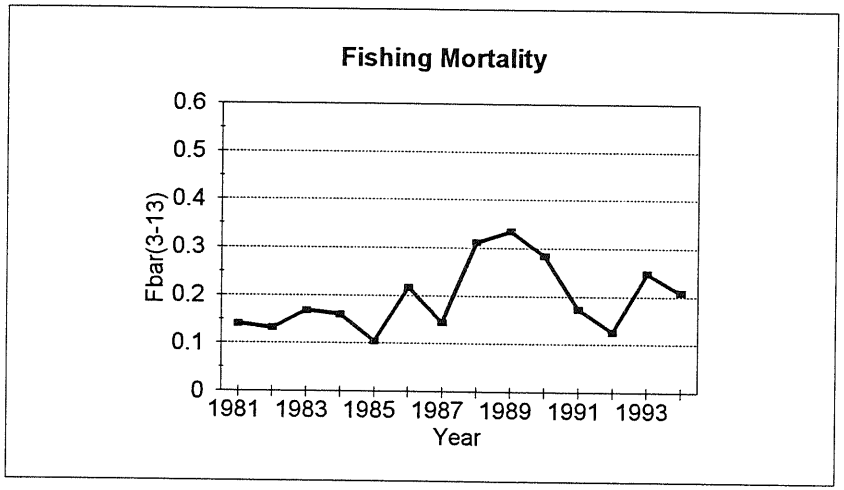
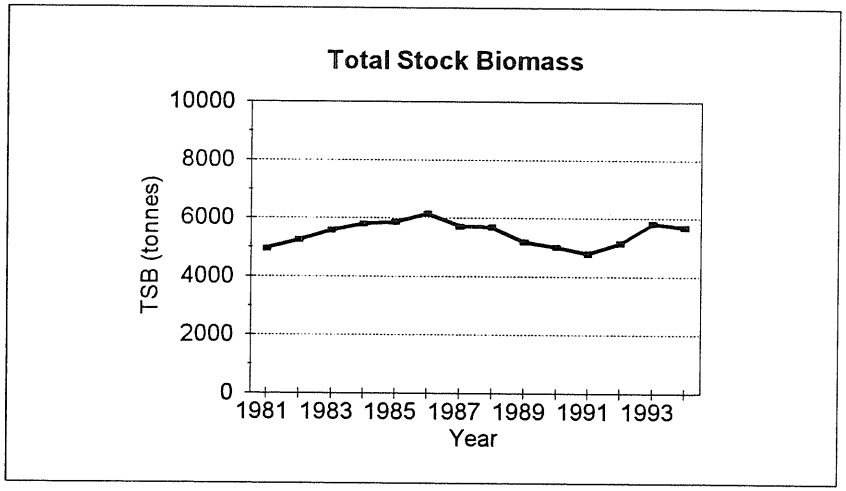
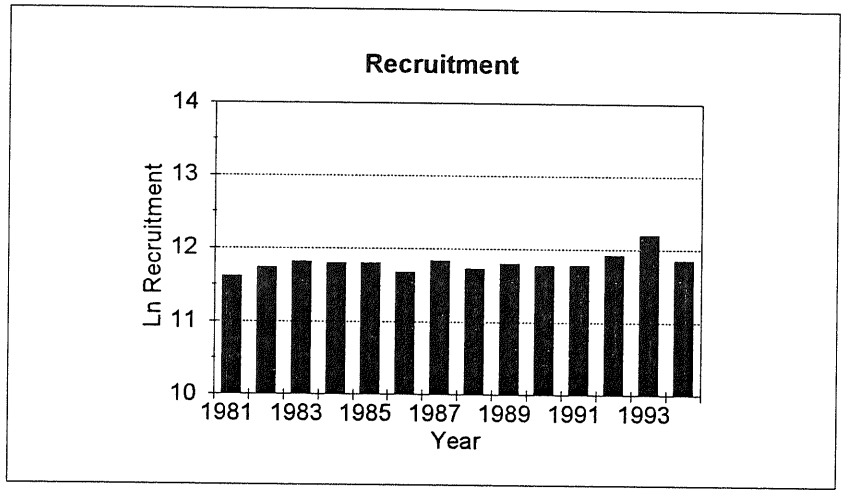


Figure 5.6.18 Firth of Forth (FU8) Females - Trends in Landings, Fbar, Total Stock Biomass and Ln Recruits from XSA









5.7. Division Va (Management Area A)

Functional Units - Iceland (1)

The statistical rectangles comprising this Management Area and its constituent Functional Units are shown in Figure 5.1.2.

5.7.1. Iceland (Functional Unit 1)

Information on fishery statistics is given in Tables 5.7.1 - 5.7.3. These figures have not been updated since 1992. No other information was presented for Iceland.

5.7.2. Summary of Division Va (Management Area A)

Managed by national TACs, further advice not given.

5.8. Division Vb (non EC) (Management area A)

Functional Units - Faroes (2)

The statistical rectangles comprising this Management Area and its constituent Functional Units are shown in Figure 5.1.2.

5.8.1. Fareoes (Functional Unit 2)

Information on landings, effort and LPUE of the Faroese creel fishery have been updated and revised using logbook data (Table 5.8.1). No other information on the Faroes *Nephrops* stock was provided.

5.8.2. Summary of Division Vb (non EC) (Management Area B)

Managed by National TACs, further advice not given.

5.9. Divisions Vb (EC) and VIb (Management Area D

Functional Units - none

5.9.1. Summary of Divisions Vb (EC) and VIb (Management Area D)

Zero TAC to prevent misreporting.

Table 5.7.1 Iceland (Functional Unit 1) : Catches and landings (tonnes), effort ('000 hours trawling), CPUE and LPUE (kg/hour trawling), of Icelandic Nephrops trawlers, TAC (tonnes), 1985-94

Year	Catches	Landings	Effort	CPUE	LPUE	TAC
1985	2628	2385	42.3	62.1	56.4	2300
1986	2882	2564	41.8	68.9	61.3	2500
1987	2980	2712	51.6	57.8	52.6	2700
1988	2496	2240	56.1	44.5	39.9	2600
1989	2100	1841	51.1	41.1	36	2100
1990	1939	1660	41.5	46.7	40	2100
1991	NA	2160	51.3	NA	42.1	2100
1992	NA	NA	NA	NA	NA	NA
1993	NA	NA	NA	NA	NA	NA
1994*	NA	NA	NA	NA	NA	NA

* provisional

Table 5.7.2 Iceland (Functional Unit 1) : Landings (tonnes), effort ('000 creel hauls) and LPUE (g/creel haul),1989-94

Year	Landings	Effort	LPUE
1989	25	113.1	221
1990	31	103	301
1991	10	NA	NA
1992	NA	NA	NA
1993	NA	NA	NA
1994*	NA	NA	NA

* provisional

Table 5.7.3 Iceland (Functional Unit 1) : Mean sizes (CL mm) of male and female Nephrops in catches, 1985-94

Year	Males	Females
1985	44.5	35.4
1986	43.7	35.6
1987	45.5	37.2
1988	44.7	36.5
1989	44.0	35.7
1990	41.6	35.6
1991	42.1	35.6
1992	NA	NA
1993	NA	NA
1994	NA	NA

Table 5.8.1 Faroes (Functional Unit 2) : Landings (tonnes), effort ('000 creeldays) and LPUE (g/creelday), 1985-94

Season	Landings	Effort	LPUE
1985/86	44	469	93
1986/87	80	512	156
1987/88	91	630	144
1988/89	74	628	117
1989/90	62	650	96
1990/91	56	624	90
1991/92	57	785	73
1992/93	63	889	71
1993/94	73	1162	63
1994/95	76		

5.10. Division VIa (Management Area C)

Functional Units North Minch 11
South Minch 12
Firth of Clyde 13

Details concerning the revision of boundaries in this Management Area are given in Section 5.1.1 (Figures 5.1.2 and 5.1.5).

5.10.1. North Minch (Functional Unit 11)

Data and biological inputs.

The length compositions of commercial landings were obtained by port sampling during most months of the year. The level of trawl sampling is summarised on a quarterly basis in Table 5.10.1. Sampling of the discards took place on board commercial trawlers during the 2nd, 3rd and 4th quarters. The trawl landing and discard samples were raised to fleet level. An average of discard data for the years 1990-93 was used to estimate the removals in earlier years.

Sampling of the creel landings was only achieved in four months of the year (in the 2nd, 3rd and 4th quarters (Table 5.10.1)).

The assessments were run using the same input parameters as last year (Table 5.10.1).

Comments on the quality of inputs

A reasonable level of port sampling is achieved for the trawl fishery but the sampling of discards has only been possible in the last 5 years. The choice of biological inputs is based on observations from other Scottish areas (see discussion in Anon., 1993).

Sampling of the creel fishery has been limited to a few samples in most years. A VPA assessment for the creel fishery was attempted in 1993 but has not been repeated because of the paucity of data.

Landings, effort, LPUE, mean size

Landings data were reported from UK vessels alone. In 1994, provisional total landings were 3477 t representing an increase of nearly 300 t on the previous year. *Nephrops* trawlers accounted for 81% of the landings; landings by creel were similar to the previous year, amounting to 12% of the total (Table 5.10.2).
No details are available concerning the accuracy of the landing figures in this fishery but under-reporting is probably minimal. In 1994, the Area VIa TAC was not taken and there were none of the under-reporting problems identified in 1993.

In 1994, there was a slight decline in fishing effort by *Nephrops* trawlers, compared to the previous year (Table 5.10.3), but the long-term data series shows that effort has been fairly stable in the last four years. In the long-term data series, *Nephrops* trawl LPUE appears to have been fairly stable since 1986 (Figure 5.10.1). Use of 70mm mesh multi-rig gear by *Nephrops* trawlers has now been eliminated in this fishery, following the UK National ban.

Figure 5.10.2 shows landings, effort and LPUE data apportioned between the sexes. In general, males make the largest contribution to the landings and LPUE, though in some years (e.g. 1989-90) the contributions from the two sexes were more equal. This appears to be associated with reduced fishing effort in the first quarter of the year.

Data on mean size of *Nephrops* in trawl landings and catches (from 1990) is given in Table 5.10.4 and included in the long-term time series plots in Figure 5.10.1. The mean size of both sexes in landings has fluctuated without obvious trend. Though the series is limited, mean size in catches suggests declining trends.

Assessments

Length-based assessment

In view of the database reorganisation, the LCA was carried out using length composition data for the most recent four year reference period (1991-94), during which effort appears to have been fairly stable (Figure 5.10.1). The same input F choices were used as previously (0.15, 0.03 for males and females respectively).

The LCA outputs for males and females are given in Tables 5.10.5 and 5.10.6 respectively. Fig. 5.10.3 shows that the long term Y/R curve for males was flat-topped, with current F above Fmax, while the relationship for females was curvi-linear, with current F well below Fmax. Annualised fishing mortalities (averaged across the inter-quartile length range) were 0.67 and 0.08 for males and females respectively.

Other aspects

The VPA assessments carried out at previous Working Group s (Anon.,1992; 1993) gave interpretational problems so this approach was not repeated this year.

Fishing intensity indices derived from estimates of ground area (see Anon., 1993) are shown in Figure 5.3.10. This suggests that landings/area and effort/area in the North Minch are currently high compared to some other Scottish stocks. These indices are over estimates, however, because some areas of muddy substrate are not taken into account.

Comments on the quality of the assessments

The LCA gave results which were similar to previous analyses (Anon., 1993). There was reasonable agreement between male and female population numbers in the recruiting size classes (Tables 5.10.5 and 5.10.6), suggesting some consistency between the two analyses.

Management considerations

The LCA results for males suggest this stock is over exploited, though the Y/R curve was fairly flat-topped. The potential yield gain in reducing effort to Fmax would be very small. The long-term trend plots (Figure 5.10.1) suggest that fishing effort has been reasonably stable in the last four years. The Working Group therefore suggested that the same advice as last year (Anon., 1994b) was still appropriate, namely that fishing effort should be maintained at the current level.

5.10.2. South Minch (Functional Unit 12)

Data and biological inputs

Sampling the length composition

The length compositions of commercial trawl landings were obtained by port sampling on a monthly basis. The level of sampling is summarised in Table 5.10.7. Discard sampling on board commercial trawlers took place in each quarter in 1994. Landing and discard samples were raised to trawl fleet level in the same way as for the N. Minch.

In 1994, only limited sampling of landings was achieved in the creel fishery (Table 5.10.7).

Input parameters

For analysis of the trawl fishery, all input parameters remained the same as previously (Table 5.10.7).

Comments on the quality of inputs

As for the North Minch, biological variability within the stock makes the choice of parameters difficult.

Landings, effort, LPUE, mean size

Landings data were reported from UK vessels alone. Note that revision of the boundaries of this FU (Section 5.1.1) has resulted in a series of higher landings (from 1979 onwards) compared to figures provided in previous Working Group Reports. In 1994, provisional total landings were 4319 t. Since 1988 the landings have regularly exceeded 4000 t per year (Table 5.10.8). 85% of the 1994 landings were by *Nephrops* trawl, 9% by creel and 6% by other trawl gear. The 1994 creel landings (389 tonnes) were lower than at any time in the last 10 years (Table 5.10.8). For comments on under-reporting see under N. Minch above.

Long-term plots of landings, effort and LPUE by *Nephrops* trawlers are given in Figure 5.10.4. Landings and effort have been fairly stable since 1988; LPUE has tended to fluctuate without obvious trend. In addition to the overall figures, a comparison between LPUE data of single- and multi-rig *Nephrops* trawlers in recent years is included in Table 5.10.9. The proportion of effort using multi-rig gear has continued to decline in this fishery following the UK ban.

Figure 5.10.5 shows that males contribute more than females to the landings and LPUE. The contribution of the females seems to be greater when fishing effort is relatively high during the 2nd and 3rd quarters of the year.

The mean size of males and females in trawl samples is given in Table 5.10.10 and plotted in Figure 5.10.4. The mean size in landings has fluctuated without obvious trend. A limited series of mean size data in trawl catches is available from 1990.

Assessments

Length-based assessment

With the revision of the FU boundary and the length composition database it was considered worthwhile to repeat the LCA. The most recent four year reference period (1991-94) was used. Input F choices were the same as in previous assessments (0.3, 0.25 for males and females respectively). Output results from the LCA are given in Tables 5.10.11 and 5.10.12 for males and females respectively. Fig. 5.10.6 suggests a very flat-topped Y/R curve for males, with current F above Fmax. The Y/R relationship for females was curvi-linear, with current F well below Fmax. Annualised fishing mortalities (averaged over the inter-quartile length range) were 0.57 and 0.14 for males and females respectively.

Other aspects

Since VPA assessments carried out at earlier Working Group s (Anon., 1992; 1993) gave inconclusive results this approach was not tried again this year.

Trends in landings/area and effort/area indices for the South Minch are shown in Figure 5.3.10. This suggests that recent fishing pressure on this stock is moderate in comparison to some other stocks in Scottish waters.

Comments on the quality of the assessments

As for the North Minch, the updated LCA gave consistent results in terms of male and female numbers in the recruiting size classes (Tables 5.10.11 and 5.10.12).

Management considerations

This year's LCA results broadly confirmed those given in earlier Reports (Anon., 1993; 1994). The Y/R curve for the males was very flat-topped with current F above Fmax. The potential long-term gains from an effort reduction would, however, be very small. Fishing effort appears to have stabilised since 1987 (Figure 5.10.4) and fishing pressure is not particularly high in comparison with other stocks when related to the area of muddy sediments available (Figure 5.3.10). The long-term data series shows that LPUE has fluctuated without obvious trend (Figure 5.10.4). The Working Group concluded that maintaining effort at current levels would be appropriate for this stock.

5.10.3. Firth of Clyde (Functional Unit 13)

Data and biological inputs

The length compositions of commercial landings were obtained by sampling at the main ports during most months of the year. The level of sampling is summarised on a quarterly basis in Table 5.10.13. Discard sampling was carried out on board commercial trawlers during each quarter of the year. The landings and discard samples were raised to fleet level, as described for the N. Minch. So far, nearly all sampling of landings and discards has been carried out in the Firth of Clyde fishery (east of Kintyre) and very little sampling has been done in the Sound of Jura (west of Kintyre). No sampling of the small creel fishery has been done.

The same input parameters were used as in previous years (Table 5.10.13).

Comments on the quality of inputs

As mentioned in last years Report, the ICES statistical squares covering this Functional Unit are divided by the Kintyre peninsular (Figure 5.1.5) and the former system for monitoring effort and landings produced aggregated data for both sides. In an attempt to improve the quality of the assessments, the Scottish data for the Clyde has recently been reanalysed in order to separate landings and effort information from the Firth of Clyde and the Sound of Jura (Section 5.1.1). This should enable the Firth of Clyde population to be assessed using a better choice of biological parameters than previously. Earlier research revealed large variability in *Nephrops* growth and other biological parameters between the two populations (Bailey and Chapman, 1983). Given adequate sampling in the future, separate assessments should also be possible for the Sound of Jura.

No account, in terms of input parameters, has yet been taken of the high prevalence of the parasitic dinoflagellate, *Hematodinium sp.* in Clyde *Nephrops* and elsewhere (Field et al., 1992; Anon., 1994a). The implications of this disease are being investigated by the University of Glasgow and a detailed report should be available shortly. A summary of the findings will be included in the next *Nephrops* Study Group Report.

Landings, effort, LPUE, mean size

Landings data were reported from UK vessels alone. Table 5.10.14 shows the overall annual landings for the FU and the results of partitioning the data by gear and by area. In 1994, overall landings were 2508 t, the lowest recorded since 1983 (Figure 5.10.7). 95% of the landings were made by *Nephrops* trawlers, 4% by other trawl methods and the creel landings were very small (Table 5.10.14). When split by area, Table 5.10.14 shows that the greater proportion of the landings are taken in the Firth of Clyde; only 21 % of the 1994 landings were taken from the Sound of Jura.

Landings, fishing effort and LPUE data attributed to *Nephrops* trawlers are given separately in Table 5.10.15 for the Firth of Clyde and Sound of Jura. LPUE in the Sound of Jura was consistently higher than in the Firth of Clyde, often by a factor of two. Also, multi-rig trawls contribute a high proportion of fishing effort in both parts of the FU. Taking the FU as a whole, Figure 5.10.7 shows large fluctuations in LPUE, with relatively low values in the last 6 years.

For comments on under-reporting of landings see North Minch Section above.

Figure 5.10.8 shows landings, effort and LPUE data apportioned between the sexes. These data refer to the Firth of Clyde only, and suggests that females contribute a fairly high proportion of the landings in some years (e.g. 1989-90 and 1994), though males generally have higher LPUEs. The recent decline in overall LPUE appears to follow a gradual fall in male LPUE (Figure 5.10.8).

The mean size of males and females in trawl landings and catches are given in Table 5.10.16, and plotted in Figure 5.10.7. Mean size in landings has fluctuated with no obvious trend (Figure 5.10.7). Mean size data in trawl catches are available from 1990.

Assessments

Length-based assessment

In view of the reorganisation of the database and its separation into two data sets, it was considered worthwhile to carry out both LCA and VPA assessments for one part of the FU, the Firth of Clyde. The four years, 1990-93, during which effort was reasonably stable (Figure 5.10.7), were used as the reference period. Input F choices were the same as used in previous assessments (0.2, 0.025 for males and females respectively). Output results for the LCA are given in Tables 5.10.17 and 5.10.18 for males and females respectively. The long-term Y/R curve for males was very flat-topped, with current F above Fmax (Figure 5.10.9). For

females the Y/R relationship was virtually linear (Figure 5.10.9). Annualised fishing mortalities (averaged across the inter-quartile length range) were 0.490 and 0.019 for males and females respectively.

Age-based assessment

A single fleet assessment was carried out Scottish trawl data, for the period 1981-94, using the Lowestoft VPA program, as described for the Moray Firth and the Firth of Forth (Sections 5.3.1 and 5.6.2).

Males

The slicing procedure gave 11 nominal 'age' groups (11 = plus group). Catch numbers and mean weights at age are given in Table 5.10.19 . Weights at age were assumed to be equivalent to stock weights and no SOP corrections were applied. Values chosen for natural mortality and maturity are also shown in Table 5.10.19.

The fleet catchability residuals from ad hoc Laurec-Shepherd tuning are shown in Figure 5.10.10. Large residuals were again found for age 1; between ages 2-5 the residuals were highly variable but with little indication of trend; for the older age groups the residual plots revealed strong year effects. XSA tuning was carried out over the whole 14 year period and ages 1-10, with a tricubic taper but without shrinkage. Tuning choices (Table 5.10.20) were the same as for the Moray Firth. Tuning converged after 17 iterations.

Estimates of fishing mortality and population numbers are given in Tables 5.10.21. Figure 5.10.11 shows a poor fit between fishing effort and mean F (averaged over ages 3-8) trends and the correlation coefficient between them was not statistically significant ($r^2 = 0.20$). Nevertheless, the value of r^2 represents a better result than previous assessments (e.g. Anon., 1993). It is also worth noting that the recording of effort in this fishery may be unreliable, particularly in recent years, since there was a deterioration over a number of years (e.g. Anon. 1991,1992, 1993 and 1994b) in the correlation between landings and effort.

Trends in yield, mean F, TSB and recruitment are given in Table 5.10.21 and plotted in Figure 5.10.12. Landings of males have fluctuated with evidence of a gradual decline over the time period; mean F has also fluctuated, with relatively high values in 1988-89 and evidence of a rising trend; TSB and recruitment appear to have declined in recent years.

Females

The slicing procedure generated 16 nominal 'age' groups (16 = +gp). Catch numbers and mean weights at age are given in Table 5.10.22. As for males, catch mean weights were assumed to be equivalent to stock weights and no SOP corrections were applied. Natural mortality and maturity input values are also given in Table 5.10.22. As for the other stocks M is assumed to decline in mature females (see also Table 5.10.13). Tuning choices were the same as for the males (Table 5.10.23). The tuning had not converged after 60 iterations.

Fleet catchability residuals from the LS tuning are plotted in Figure 5.10.13. These show evidence of trends at the younger ages and strong years effects for older age groups. VPA estimates of fishing mortality and population numbers at age are given in Tables 5.10.24. As found in other Scottish stocks, fishing mortality estimates for females are much lower than for males. The plots in Figure 5.10.14 indicate no relationship between estimates of annual mean F (averaged over ages 3-13) and trawl fishing effort (r^2 =.0.01). As mentioned above, the effort figures may be unreliable.

Trends in estimates of stock condition are given in Table 5.10.24 and plotted in Figure 5.10.15. Female landings have fluctuated without trend; mean F estimates appear to have been relatively stable around a low value of 0.1; TSB has also been relatively stable; recruitment has fluctuated, but to a lesser extent than in the males. Comparison between summaries for the two sexes (Tables 5.10.21 & 5.10.24) indicate some inconsistencies, in that the TSB estimates for females are roughly twice the male estimates and recruitment also appears to be about 50% higher in females. There must be considerable doubt about the reliability of the female estimates, in view of the poor convergence of the VPA.

Other aspects

On the basis of landings and effort per unit area of ground, the fishing pressure on the Clyde stock is moderately high (Figure 5.3.10).

Comments on the quality of the assessments

By separating off the Sound of Jura from the assessment for the Firth of Clyde it was hoped that the analyses would show some improvement on those reported previously (Anon., 1993). The fact that separation of LPUE data (Table 5.10.15) suggested large differences in stock biomass provided some justification for taking this step.

The large discrepancy between numbers of males and females in the recruiting size classes suggests the LCA results should be treated with caution, particularly in the case of females. Similarly the VPA results for the females are considered unreliable because of the low F values (less than the values chosen for M) and the fact that the XSA tuning did not converge. A major problem is that effort data used in the tuning may be unreliable, since it correlates poorly with *Nephrops* trawl landings (Figure 5.10.7, see also Anon., 1994b).

Management considerations

The LCA applied to Firth of Clyde produced similar results to the previous analysis for the whole FU (Anon.,1993a). For the males, the Y/R curve was very flat-topped with current F slightly to the right of Fmax, whereas the females appear to be only lightly exploited. Long-term trend plots (Figure 5.10.7) show that LPUE has fluctuated but is currently at a low level and the plots showing LPUE by sex (Figure 5.10.8) indicate that declines in the male component are primarily responsible. As pointed out in last years Report, these LPUE figures may not be reliable because of possible inaccuracies in the recording of fishing effort (Anon., 1994b). Taken at face value, the VPA results for the males suggest that fishing mortality is currently below the peak level of 1988-89. On the other hand stock biomass and recruitment of males have shown evidence of declines in more recent years and this will need to be carefully monitored.

The Working Group concluded that, for the present, maintaining fishing effort around current levels was acceptable for this stock.

5.10.4. Summary for Division VIa (Management Area C)

The recent landings in Functional Units 11, 12, 13 and other ICES rectangles forming MA C are in Tables 5.10.25 and by country in Table 5.10.26. For the Management Area as a whole it is suggested that fishing effort should be held at current levels.

Table 5.10.1 Input data and parameters: North Minch

FU	11	MA	C
FLEET	UK Scotland	GEAR	Nephrops and Light trawl

1994	NUMBER OF SAMPLES				Mean
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	No./sample
Catch					
Landings	8	9	20	18	525
Discards	0	3	6	4	296

	NUMBER OF SAMPLES									
YEAR	94	93	92	91	90	89	88	87	86	85
Catch										
Landings	55	39	47	57	53	42	43	33	37	34
Discards	13	11	13	14	13					

FLEET	UK Scotland	GEAR	Creel

1994	NUMBER OF SAMPLES				Mean
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	No./sample
Catch					
Landings	0	2	2	5	440
Discards					

	NUMBER OF SAMPLES									
YEAR	94	93	92	91	90	89	88	87	86	85
Catch										
Landings	9	9	4	4	10	4	5	2	3	4
Discards										

INPUT PARAMETERS	Trawl	
Parameter	Value	Source
Discard Survival	0.25	Gueguen and Charuau,1975; Anon.,1985
MALES		
Growth - K	0.16	Adapted from Bailey and Chapman, 1983
Growth - L(inf)	70	"
Nat. Mort. - M	0.3	Morizur, 1982
Length/weight - a	0.00028	Howard and Hall, 1983
Length/weight - b	3.24	"
FEMALES		
Immature Growth		
K	0.16	as for males
L(inf)	70	"
Nat.Mort. - M	0.3	"
Size at Maturity	26	Adapted from Bailey, 1984
Mature Growth		
K	0.06	as for males
L(inf)	60	"
Nat.Mort. - M	0.2	assumed *
Length/weight - a	0.000845	as for males
Length/weight - b	2.91	"

* based on Morizur, 1982 and assuming lower mature female rate

Note: For Creel assessment inputs see Clyde (Table 5.4.53)
except for discard survival which is assumed 100%

Table 5.10.2 North Minch (Functional Unit 11) : Landings (tonnes) by gear, all UK, 1985-94

Year	Nephrops	Other trawl	Creel	Total
1985	3236	117	708	4061
1986	2642	202	538	3382
1987	3458	144	482	4084
1988	3449	149	437	4035
1989	2603	112	490	3205
1990	1941	133	469	2543
1991	2221	130	438	2789
1992	2964	150	434	3548
1993	2699	85	408	3192
1994*	2828	234	415	3477

* provisional

Table 5.10.3 North Minch (Functional Unit 11) : Landings (tonnes), effort ('000 hours trawling) and LPUE (kg/hour trawling) of Scottish Nephrops trawlers, 1985-94. Figure in brackets left and right of overall values are for single and multi-rig trawls respectively

Year	Landings	Effort	LPUE
1985	3236	96.8	33.4
1986	2642	93.0	28.4
1987	3458	121.2	28.5
1988	3449	115.0	30.0
1989	2603	87.9	29.6
1990	1941	79.8	24.3
1991	(2116) 2221 (105)	(90.2) 93.1 (2.9)	(23.5) 23.9 (36.7)
1992	(2755) 2964 (167)	(93.2) 98.9 (3.7)	(29.6) 30.0 (45.6)
1993	(2657) 2699 (42)	(104.4) 105.4 (1.0)	(25.4) 25.6 (43.4)
1994*	(2828) 2828 (0)	(96.7) 96.7 (0)	(29.2) 29.2 (-)

* provisional

Table 5.10.4 North Minch (Functional Unit 11) : Mean sizes (CL mm) of male and female Nephrops in Scottish landings, 1985-94. Mean sizes in catches, 1990-94 given in parenthesis

Year	Males	Females
1985	30.9	28.0
1986	32.4	29.6
1987	32.9	31.2
1988	32.7	31.8
1989	32.3	31.6
1990	32.5 (31.8)	31.1 (30.4)
1991	34.2 (33.4)	31.4 (30.5)
1992	33.1 (32.4)	29.8 (29.4)
1993	32.5 (32.4)	29.3 (29.1)
1994	33.3 (30.7)	29.8 (27.8)

Table 5.10.5 North Minch (FU 11): Males - LCA output

COHORT ANALYSIS

L INFINITY = 70.0000 K = .1630

COHORT ANALYSIS BY POPE'S APPROXIMATION

SIZE MM	REMOVALS	M	DT	FDT	F	Z	NO. ATTAINING	AVE. NO. IN SEA	BIOMASS kg
15.0	.1	.3000	.2272	.0000	.0000	.3000	208114.9	45717.4	101632.9
17.0	60.3	.3000	.2360	.0003	.0014	.3014	194399.6	44282.9	144186.1
19.0	819.2	.3000	.2454	.0047	.0192	.3192	181054.4	42740.5	195785.9
21.0	2845.2	.3000	.2557	.0178	.0697	.3697	167412.8	40840.4	254767.6
23.0	6612.1	.3000	.2668	.0462	.1733	.4733	152314.5	38173.6	315683.7
25.0	9018.4	.3000	.2789	.0726	.2604	.5604	134246.5	34663.3	371525.3
27.0	11090.8	.3000	.2922	.1064	.3641	.6641	114821.9	30496.2	415567.4
29.0	12465.6	.3000	.3068	.1485	.4841	.7841	94570.1	25789.0	439452.3
31.0	12796.5	.3000	.3230	.1993	.6169	.9169	74349.2	20783.3	436520.3
33.0	11141.9	.3000	.3409	.2384	.6992	.9992	55292.1	15975.1	408356.6
35.0	10131.7	.3000	.3610	.3174	.8792	1.1792	39330.2	11562.6	355697.0
37.0	7211.1	.3000	.3836	.3528	.9197	1.2197	25695.8	7871.6	288512.2
39.0	4414.8	.3000	.4091	.3448	.8428	1.1428	16094.8	5260.0	227646.8
41.0	2844.0	.3000	.4384	.3584	.8175	1.1175	10083.7	3494.9	177160.7
43.0	1654.7	.3000	.4722	.3390	.7179	1.0179	6178.0	2316.0	136498.5
45.0	1055.4	.3000	.5115	.3542	.6925	.9925	3820.5	1532.5	104316.0
47.0	719.6	.3000	.5581	.4159	.7452	1.0452	2299.5	972.3	75970.6
49.0	421.7	.3000	.6140	.4468	.7276	1.0276	1283.2	584.3	52107.3
51.0	190.3	.3000	.6824	.3693	.5412	.8412	682.8	354.5	35896.0
53.0	98.6	.3000	.7679	.3392	.4418	.7418	384.6	225.1	25763.7
55.0	44.9	.3000	.8779	.2684	.3057	.6057	217.6	148.2	19073.8
57.0	22.0	.3000	1.0249	.2240	.2186	.5186	127.8	101.6	14660.2
59.0	7.0	.3000	1.2311	.1188	.0965	.3965	75.1	73.2	11783.2
61.0	15.8	.3000	1.5418	.5652	.3666	.6666	46.1	44.4	7954.2
63.0	5.5	.3000			.1500	.4500	16.5	44.4	8815.9
				TOTAL BIOMASS INCLUDES LENGTHS ABOVE +GP				374136.4	4644815.0

Table 5.10.6 North Minch (FU 11): Females - LCA output

COHORT ANALYSIS

LOWER CURVE LINF= 70.0000 K= .1600

UPPER CURVE LINF= 60.0000 K= .0600

TRANSITION LENGTH= 25.0000

COHORT ANALYSIS BY POPE'S APPROXIMATION

SIZE MM	REMOVALS	M	DT	FDT	F	Z	NO. ATTAINING	AVE. NO. IN SEA	BIOMASS kg
15.0	1.7	.3000	.2315	.0000	.0000	.3000	231340.3	51739.4	139529.8
17.0	107.7	.3000	.2404	.0005	.0022	.3022	215816.8	50045.7	190137.1
19.0	585.1	.3000	.2500	.0030	.0121	.3121	200695.4	48272.4	249202.8
21.0	3669.3	.3000	.2605	.0208	.0797	.3797	185628.4	46033.7	313604.8
23.0	8184.0	.3000	.2718	.0520	.1914	.4914	168147.5	42779.0	375407.2
25.0	10970.1	.2000	.2841	.0798	.2809	.4809	147124.6	39073.6	432825.8
27.0	10866.0	.2000	1.0420	.0987	.0947	.2947	128334.2	115142.5	1582423.0
29.0	8976.4	.2000	1.1115	.1123	.1011	.3011	94401.3	89176.9	1498070.0
31.0	6341.2	.2000	1.1910	.1118	.0938	.2938	67552.3	67883.8	1375972.0
33.0	5067.7	.2000	1.2827	.1290	.1006	.3006	47605.2	50669.1	1225191.0
35.0	3045.8	.2000	1.3897	.1144	.0823	.2823	32375.8	37215.6	1062729.0
37.0	1815.5	.2000	1.5162	.1016	.0670	.2670	21869.0	27267.0	911305.4
39.0	1133.6	.2000	1.6681	.0963	.0577	.2577	14588.5	19779.1	767464.8
41.0	585.8	.2000	1.8538	.0772	.0416	.2416	9490.8	14181.1	634194.4
43.0	273.6	.2000	2.0861	.0572	.0274	.2274	6064.0	10072.5	515750.8
45.0	180.9	.2000	2.3850	.0628	.0263	.2263	3773.4	6954.5	405275.9
47.0	96.1	.2000	2.7842	.0595	.0214	.2214	2199.4	4571.2	301510.7
49.0	52.0	.2000	3.3445	.0631	.0189	.2189	1187.5	2816.3	209187.5
51.0	43.2	.2000	4.1886	.1222	.0292	.2292	571.1	1537.8	128037.2
53.0	21.4	.2000	5.6079	.1881	.0335	.2335	218.7	683.7	63533.9
55.0	7.7	.2000			.0300	.2300	59.0	683.7	70626.4
				TOTAL BIOMASS INCLUDES LENGTHS ABOVE +GP				727946.4	12608420.0

Table 5.10.7 Input data and parameters: South Minch

FU	12	MA	C
FLEET	UK Scotland	GEAR	Nephrops and Light trawl

1994	NUMBER OF SAMPLES				Mean
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	No./sample
Catch					
Landings	14	20	14	14	536
Discards	3	7	4	6	163

	NUMBER OF SAMPLES									
YEAR	94	93	92	91	90	89	88	87	86	85
Catch										
Landings	62	72	49	66	56	40	46	61	69	52
Discards	20	15	15	8	13					

FLEET	UK Scotland	GEAR	Creel

1994	NUMBER OF SAMPLES				Mean
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	No./sample
Catch					
Landings	0	1	3	6	305
Discards					

	NUMBER OF SAMPLES									
YEAR	94	93	92	91	90	89	88	87	86	85
Catch										
Landings	10	25	8	10	14	5	5	21	18	30
Discards										

INPUT PARAMETERS	Trawl	
Parameter	Value	Source
Discard Survival	0.25	Gueguen and Charuau,1975; Anon.,1985
MALES		
Growth - K	0.161	Adapted from Bailey and Chapman, 1983
Growth - L(inf)	68	"
Nat. Mort. - M	0.3	Morizur, 1982
Length/weight - a	0.00028	Howard and Hall, 1983
Length/weight - b	3.24	"
FEMALES		
Immature Growth		
K	0.161	as for males
L(inf)	68	"
Nat.Mort. - M	0.3	"
Size at Maturity	26	Adapted from Bailey, 1984
Mature Growth		
K	0.06	as for males
L(inf)	59	"
Nat.Mort. - M	0.2	assumed *
Length/weight - a	0.00089	as for males
Length/weight - b	2.91	"

* based on Morizur, 1982 and assuming lower mature female rate

Table 5.10.8 South Minch (Functional Unit 12) : Landings (tonnes) by gear, all UK, 1985-94

Year	Nephrops	Other trawl	Creel	Total
1985	3096	424	488	4008
1986	2694	288	502	3484
1987	2927	418	546	3891
1988	3544	364	555	4463
1989	3846	338	561	4745
1990	3732	262	436	4430
1991	3597	341	503	4442
1992	3479	208	549	4237
1993	3608	197	649	4454
1994*	3669	261	389	4319

* provisional

Table 5.10.9 South Minch (Functional Unit 12) : Landings (tonnes), effort ('000 hours trawling) and LPUE (kg/hour trawling) of Scottish Nephrops trawlers, 1985-94. Figures in brackets left and right of the overall values are for single and multi-rig trawls respectively

Year	Landings	Effort	LPUE
1985	3096	130.3	23.8
1986	2694	105.8	25.5
1987	2927	126.3	23.2
1988	3544	120.9	29.3
1989	3846	138.3	27.8
1990	3732	153.5	24.3
1991	(3109) 3597 (488)	(134.6) 150.5 (15.8)	(23.1) 23.9 (30.8)
1992	(3092) 3479 (387)	(115.0) 127.3 (12.3)	(26.9) 27.3 (31.5)
1993	(3441) 3608 (167)	(122.5) 126.5 (4.0)	(28.1) 28.5 (41.5)
1994*	(3576) 3669 (93)	(138.9) 141.9 (3.0)	(25.7) 25.8 (31.3)

* provisional

Table 5.10.10 South Minch (Functional Unit 12) : Mean sizes (CL mm) of male and female Nephrops in Scottish landings, 1985-94. Mean sizes in catches, 1990-1993, given in parenthesis

Year	Males	Females
1985	32.4	29.2
1986	32.4	29.4
1987	32.0	28.9
1988	33.2	31.6
1989	33.1	30.4
1990	32.0 (30.4)	30.0 (28.3)
1991	33.1 (32.6)	29.0 (28.6)
1992	34.5 (33.0)	30.8 (29.4)
1993	33.2 (31.9)	29.3 (28.4)
1994	34.3 (33.2)	30.2 (28.8)

Table 5.10.11 South Minch (FU12): Males - LCA output

COHORT ANALYSIS

L INFINITY = 68.0000 K = .1610

COHORT ANALYSIS BY POPE'S APPROXIMATION

SIZE MM	REMOVALS	M	DT	FDT	F	Z	NO. ATTAINING	AVE. NO. IN SEA	BIOMASS kg
15.0	6.8	.3000	.2389	.0000	.0001	.3001	272119.8	62739.0	139973.0
17.0	66.3	.3000	.2485	.0003	.0011	.3011	253291.3	60641.1	198156.4
19.0	633.2	.3000	.2588	.0028	.0108	.3108	235032.6	58452.1	268717.1
21.0	2625.8	.3000	.2701	.0127	.0470	.3470	216863.6	55912.7	350040.0
23.0	5732.4	.3000	.2824	.0308	.1089	.4089	197463.1	52659.9	437041.6
25.0	8516.3	.3000	.2958	.0519	.1755	.4755	175929.8	48549.7	522225.6
27.0	11398.3	.3000	.3106	.0814	.2619	.5619	152842.5	43564.1	595770.6
29.0	14981.3	.3000	.3270	.1308	.3999	.6999	128363.7	37515.8	641571.3
31.0	16464.6	.3000	.3452	.1861	.5392	.8392	102105.6	30597.2	644949.9
33.0	14631.5	.3000	.3655	.2259	.6182	.9182	76428.1	23728.5	608723.0
35.0	13633.1	.3000	.3883	.3072	.7910	1.0910	54640.5	17296.4	533992.2
37.0	9397.9	.3000	.4142	.3279	.7916	1.0916	35770.1	11919.8	438455.3
39.0	6157.2	.3000	.4438	.3413	.7690	1.0690	22758.4	8042.8	349332.6
41.0	3834.6	.3000	.4780	.3438	.7192	1.0192	14160.5	5358.2	272585.3
43.0	2257.9	.3000	.5179	.3292	.6357	.9357	8699.4	3570.7	211200.0
45.0	1465.8	.3000	.5650	.3535	.6255	.9255	5358.4	2357.7	161059.9
47.0	834.4	.3000	.6216	.3402	.5473	.8473	3176.2	1534.9	120355.8
49.0	510.8	.3000	.6908	.3596	.5205	.8205	1875.7	989.1	88527.6
51.0	271.6	.3000	.7774	.3380	.4348	.7348	1064.1	630.2	64046.4
53.0	234.3	.3000	.8888	.5895	.6633	.9633	601.0	358.9	41219.5
55.0	73.1	.3000	1.0376	.4073	.3925	.6925	255.3	189.0	24415.2
57.0	34.9	.3000	1.2464	.4126	.3310	.6310	124.5	107.4	15548.0
59.0	14.9	.3000	1.5610	.4038	.2587	.5587	56.7	59.0	9538.6
61.0	6.1	.3000	2.0899	.4342	.2078	.5078	23.7	30.5	5483.5
63.0	4.1	.3000			.3000	.6000	8.2	30.5	6077.6
					TOTAL BIOMASS INCLUDES LENGTHS ABOVE +GP			526865.8	6755083.0

Table 5.10.12 South Minch (FU12): Females - LCA output

COHORT ANALYSIS

LOWER CURVE LINF= 68.0000 K= .1610

UPPER CURVE LINF= 59.0000 K= .0600

TRANSITION LENGTH= 26.0000

COHORT ANALYSIS BY POPE'S APPROXIMATION

SIZE MM	REMOVALS	M	DT	FDT	F	Z	NO. ATTAINING	AVE. NO. IN SEA	BIOMASS kg
13.0	2.2	.3000	.2301	.0000	.0000	.3000	241423.4	53670.5	103129.1
15.0	8.1	.3000	.2389	.0000	.0002	.3002	225320.1	51948.7	147223.5
17.0	110.9	.3000	.2485	.0005	.0022	.3022	209727.4	50204.5	200446.7
19.0	860.1	.3000	.2588	.0046	.0178	.3178	194555.1	48342.4	262264.2
21.0	3815.1	.3000	.2701	.0224	.0830	.3830	179192.0	45979.4	329174.8
23.0	8288.0	.3000	.2824	.0550	.1948	.4948	161581.5	42582.7	392700.5
25.0	12495.3	.3000	.2958	.0976	.3298	.6298	140513.0	37924.7	441477.0
27.0	14802.9	.2000	1.0756	.1524	.1417	.3417	116627.1	104979.7	1516171.0
29.0	13777.0	.2000	1.1499	.2124	.1847	.3847	80759.2	75043.6	1324799.0
31.0	9581.8	.2000	1.2351	.2344	.1898	.3898	51886.9	50865.1	1083476.0
33.0	5690.7	.2000	1.3340	.2267	.1699	.3699	32061.4	33759.1	857842.5
35.0	2875.5	.2000	1.4502	.1861	.1284	.3284	19573.2	22583.1	677698.1
37.0	1677.6	.2000	1.5885	.1764	.1111	.3111	12158.0	15239.2	535236.4
39.0	1147.0	.2000	1.7560	.2037	.1160	.3160	7417.6	9996.5	407622.1
41.0	512.7	.2000	1.9631	.1584	.0807	.2807	4258.6	6427.2	302058.1
43.0	217.4	.2000	2.2255	.1173	.0527	.2527	2454.5	4178.1	224822.3
45.0	69.4	.2000	2.5692	.0663	.0258	.2258	1398.7	2726.5	166975.2
47.0	28.3	.2000	3.0387	.0502	.0165	.2165	783.0	1743.4	120841.2
49.0	14.4	.2000	3.7191	.0529	.0142	.2142	405.5	1039.6	81152.0
51.0	1.3	.2000	4.7947	.0116	.0024	.2024	182.8	561.0	49084.2
53.0	3.4	.2000	6.7578	.1015	.0150	.2150	69.3	246.8	24102.7
55.0	1.8	.2000			.0250	.2250	16.2	246.8	26793.3
				TOTAL BIOMASS INCLUDES LENGTHS ABOVE +GP			660535.7		9301882.0

Table 5.10.13 Input data and parameters: Firth of Clyde

FU	13	MA	C
FLEET	UK Scotland	GEAR	Nephrops and Light Trawl

1994	NUMBER OF SAMPLES				Mean
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	No./sample
Catch					
Landings	11	7	20	11	606
Discards	2	4	6	6	226

	NUMBER OF SAMPLES									
YEAR	94	93	92	91	90	89	88	87	86	85
Catch										
Landings	49	37	57	76	53	44	42	51	30	55
Discards	18	19	13	18	13					

INPUT PARAMETERS		
Parameter	Value	Source
Discard Survival	0.25	Gueguen and Charuau,1975; Anon.,1985
MALES		
Growth - K	0.16	Bailey and Chapman, 1983
Growth - L(inf)	73	"
Nat. Mort. - M	0.3	Morizur, 1982
Length/weight - a	0.00028	Howard and Hall, 1983
Length/weight - b	3.24	"
FEMALES		
Immature Growth		
K	0.16	as for males
L(inf)	73	"
Nat.Mort. - M	0.3	"
Size at Maturity	27	Bailey, 1984
Mature Growth		
K	0.06	as for males
L(inf)	62	"
Nat.Mort. - M	0.2	assumed *
Length/weight - a	0.000845	as for males
Length/weight - b	2.91	"

* based on Morizur, 1982 and assuming lower mature female rate

Table 5.10.14 Clyde (Functional Unit 13) : Landings (tonnes) split by area into Firth of Clyde and Sound of Jura components (all gears);by gear type (both areas combined), and FU total 1985-94. Scottish data only.

Year	By Area		By gear type			Total
	F. of Clyde	S. of Jura	Nephrops	other trawl	Creel	
1985	3452	725	3818	294	64	4177
1986	3214	1115	3751	498	79	4329
1987	2404	601	2630	309	65	3005
1988	3307	154	3308	108	45	3461
1989	2579	217	2578	182	36	2796
1990	2559	319	2732	122	24	2878
1991	2631	384	2744	249	22	3015
1992	2332	395	2471	247	9	2727
1993	2738	577	3207	102	5	3315
1994*	1975	533	2388	94	26	2508

* provisional

Tables 5.10.15 Clyde (Functional Unit 13) : Landings (tonnes), effort ('000 hours trawling), and LPUE (kg/hour trawling) of Scottish Nephrops trawlers, 1985-94. Figures in brackets left and right of the overall values are for single and multi-rig trawls respectively. Data presented for the Firth of Clyde and Sound of Jura separately.

Firth of Clyde

Year	Landings	Effort	LPUE
1985	3154	131.6	24.0
1986	2745	141.5	19.4
1987	2126	126.8	16.8
1988	3190	141.6	22.5
1989	2394	144.3	16.6
1990	2435	142.8	17.0
1991	(1594) 2489 (895)	(113.5) 152.9 (39.4)	(14.0) 16.3 (22.7)
1992	(1317) 2091 (774)	(102.2) 144.6 (42.4)	(12.9) 14.5 (18.3)
1993	(1771) 2650 (879)	(113.7) 156.8 (43.1)	(15.6) 16.9 (20.4)
1994*	(1415) 1922 (507)	(87.8) 114.5 (26.6)	(16.1) 16.8 (19.0)

* provisional

Sound of Jura

Year	Landings	Effort	LPUE
1985	664	17.5	37.9
1986	1006	27.3	36.8
1987	504	17.5	28.7
1988	118	4.3	27.4
1989	184	5.7	32.2
1990	297	10.7	27.7
1991	(191) 355 (164)	(7.6) 13.1 (5.5)	(25.1) 27.2 (30.0)
1992	(210) 380 (169)	(8.7) 14.3 (5.5)	(24.1) 26.6 (30.6)
1993	(331) 557 (226)	(10.2) 15.2 (5.0)	(32.6) 36.7 (44.8)
1994*	(225) 466 (241)	(8.6) 15.4 (6.9)	(26.2) 30.2 (35.1)

* provisional

Table 5.10.16 Clyde (Functional Unit 13) : Mean sizes (CL mm) of male and female Nephrops in Scottish landings, 1985-94. Mean sizes in catches, 1990-94, given in parenthesis

Year	Males	Females
1985	30.3	28.1
1986	30.5	28.3
1987	31.6	30.2
1988	35.5	31.9
1989	36.8	34.2
1990	33.4 (30.0)	33.0 (29.1)
1991	31.5 (30.8)	30.5 (29.0)
1992	33.6 (33.0)	32.0 (31.4)
1993	36.3 (34.3)	34.3 (32.9)
1994	34.3 (30.7)	32.7 (30.2)

Table 5.10.17 Firth of Clyde (FU13): Male - LCA output

COHORT ANALYSIS
L INFINITY = 73.0000 K = .1600

COHORT ANALYSIS BY POPE'S APPROXIMATION

SIZE MM	REMOVALS	M	DT	FDT	F	Z	NO. ATTAINING	AVE. NO. IN SEA	BIOMASS kg
15.0	25.8	.3000	.2193	.0002	.0008	.3008	150386.3	31918.3	71211.0
17.0	315.7	.3000	.2273	.0023	.0102	.3102	140785.0	30898.0	100965.0
19.0	1017.5	.3000	.2359	.0081	.0342	.3342	131199.9	29758.7	136807.4
21.0	2817.4	.3000	.2451	.0244	.0995	.3995	121254.5	28313.9	177258.5
23.0	4708.9	.3000	.2551	.0455	.1784	.4784	109941.9	26405.9	219151.0
25.0	6422.1	.3000	.2660	.0712	.2675	.5675	97308.8	24024.9	258424.8
27.0	7018.5	.3000	.2778	.0915	.3294	.6294	83674.5	21327.8	291672.4
29.0	8619.5	.3000	.2908	.1372	.4717	.7717	70251.2	18296.2	312890.4
31.0	9238.2	.3000	.3049	.1891	.6201	.9201	56131.5	14925.1	314602.3
33.0	8023.9	.3000	.3206	.2214	.6905	.9905	42399.2	11645.8	298758.7
35.0	6523.8	.3000	.3379	.2515	.7442	1.0442	30864.3	8788.1	271315.3
37.0	4591.5	.3000	.3572	.2528	.7076	1.0076	21687.3	6506.5	239332.3
39.0	3228.5	.3000	.3789	.2560	.6756	.9756	15131.3	4793.0	208180.3
41.0	1994.6	.3000	.4034	.2265	.5615	.8615	10455.4	3562.6	181237.9
43.0	1386.7	.3000	.4312	.2235	.5183	.8183	7386.2	2683.7	158737.4
45.0	894.5	.3000	.4632	.2043	.4410	.7410	5190.1	2034.8	139000.9
47.0	537.1	.3000	.5003	.1711	.3419	.6419	3682.3	1575.6	123547.9
49.0	356.8	.3000	.5438	.1566	.2879	.5879	2670.9	1243.2	111263.2
51.0	253.5	.3000	.5957	.1542	.2588	.5588	1940.0	983.0	99894.7
53.0	159.6	.3000	.6585	.1355	.2057	.5057	1390.7	778.9	89452.1
55.0	115.9	.3000	.7361	.1391	.1889	.4889	996.8	616.2	79622.7
57.0	73.8	.3000	.8346	.1281	.1535	.4535	695.5	483.2	69954.2
59.0	44.5	.3000	.9634	.1142	.1186	.4186	476.3	377.7	61019.5
61.0	36.8	.3000	1.1395	.1476	.1295	.4295	318.3	286.8	51528.3
63.0	22.5	.3000	1.3946	.1534	.1100	.4100	195.1	207.2	41268.0
65.0	16.0	.3000	1.7980	.2110	.1174	.4174	110.1	139.3	30646.1
67.0	20.8	.3000			.2000	.5000	52.0	139.3	33758.4
				TOTAL BIOMASS INCLUDES LENGTHS ABOVE +GP				272992.3	4245666.0

Table 5.10.18 Firth of Clyde (FU13): Female - LCA output

COHORT ANALYSIS
LOWER CURVE LINF= 73.0000 K= .1600
UPPER CURVE LINF= 62.0000 K= .0600

TRANSITION LENGTH= 27.0000

COHORT ANALYSIS BY POPE'S APPROXIMATION

SIZE MM	REMOVALS	M	DT	FDT	F	Z	NO. ATTAINING	AVE. NO. IN SEA	BIOMASS kg
13.0	1.0	.3000	.2119	.0000	.0000	.3000	900130.9	184788.4	337881.2
15.0	14.8	.3000	.2193	.0000	.0001	.3001	844693.4	179294.0	483516.9
17.0	616.4	.3000	.2273	.0008	.0035	.3035	790890.4	173706.2	659956.1
19.0	1646.3	.3000	.2359	.0023	.0098	.3098	738162.1	167905.8	866802.1
21.0	3060.7	.3000	.2451	.0046	.0189	.3189	686143.7	161787.5	1102178.0
23.0	5288.2	.3000	.2551	.0087	.0341	.3341	634546.1	155188.4	1361855.0
25.0	6047.9	.3000	.2660	.0109	.0408	.3408	582699.8	148178.4	1641399.0
27.0	6374.2	.2000	.2778	.0124	.0446	.2446	532196.4	142944.5	1964510.0
29.0	7158.3	.2000	1.0420	.0161	.0155	.2155	497232.1	464077.1	7795965.0
31.0	6140.9	.2000	1.1115	.0174	.0157	.2157	397243.4	392606.7	7957946.0
33.0	4783.6	.2000	1.1910	.0174	.0146	.2146	312566.5	328495.3	7943094.0
35.0	3641.2	.2000	1.2827	.0172	.0134	.2134	242070.9	271622.9	7756459.0
37.0	2726.2	.2000	1.3897	.0172	.0124	.2124	184093.8	221540.1	7404221.0
39.0	1936.8	.2000	1.5162	.0166	.0109	.2109	137049.7	177842.0	6900584.0
41.0	1484.7	.2000	1.6681	.0178	.0107	.2107	99536.2	139997.5	6260841.0
43.0	920.0	.2000	1.8538	.0159	.0086	.2086	70044.4	107686.5	5513983.0
45.0	625.4	.2000	2.0861	.0163	.0078	.2078	47581.4	80541.0	4693524.0
47.0	413.6	.2000	2.3850	.0172	.0072	.2072	30842.9	58042.8	3828396.0
49.0	217.4	.2000	2.7842	.0154	.0055	.2055	18816.5	39893.0	2963166.0
51.0	162.1	.2000	3.3445	.0216	.0064	.2064	10617.5	25645.8	2135225.0
53.0	97.9	.2000	4.1886	.0284	.0068	.2068	5323.0	14915.9	1386028.0
55.0	55.8	.2000	5.6079	.0446	.0080	.2080	2238.9	7411.8	765608.4
57.0	77.5	.2000			.0250	.2250	697.5	7411.8	847920.2
				TOTAL BIOMASS INCLUDES LENGTHS ABOVE +GP			3666347.0		84442730.0

Table 5.10.19 Firth of Clyde (FU13) : Males VPA Input

Run title : Clyde Males 1995 INDEX FILE

At 8/03/1995 12:50

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE														
1	1763	2087	4173	6643	8703	6783	2526	2526	1970	5903	3333	744	311	3722
2	20128	21888	44288	37306	54394	51990	30594	21010	12427	26242	30782	17624	11660	18063
3	26984	26013	40661	26056	38572	31803	37171	28664	12797	26744	33802	26686	20216	12104
4	8550	8523	12260	8568	11121	11393	9344	16381	11489	9320	10997	12654	14596	8000
5	3167	2220	4380	2851	3129	3418	2157	7263	4424	2622	2339	4086	4898	2996
6	1106	865	1545	1065	1061	1496	688	2600	1862	957	679	1396	1583	1174
7	530	354	832	477	479	765	316	1269	965	396	302	464	693	530
8	179	172	384	282	227	288	111	549	549	212	165	133	298	224
9	62	103	220	155	114	151	51	265	311	121	69	65	170	135
10	28	60	136	114	57	63	24	157	163	67	25	38	72	55
+gp	40	87	198	265	58	49	50	184	230	134	97	66	98	46
0 TOTA	62536	62372	109077	83780	117913	108198	83032	80867	47187	72718	82589	63956	54594	47049
TONSLA	1385	1362	2211	1647	2112	1901	1535	2219	1472	1388	1717	1615	1618	1022

Run title : Clyde Males 1995 INDEX FILE

At 8/03/1995 12:50

Table 2 Catch weights at age (kg)

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE														
1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.005
2	0.012	0.012	0.012	0.011	0.011	0.011	0.012	0.012	0.011	0.011	0.012	0.012	0.012	0.01
3	0.022	0.022	0.022	0.022	0.022	0.021	0.022	0.023	0.023	0.022	0.022	0.023	0.023	0.023
4	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.038	0.038	0.037	0.037	0.037	0.038	0.038
5	0.057	0.056	0.057	0.056	0.056	0.056	0.056	0.056	0.057	0.057	0.056	0.057	0.056	0.056
6	0.076	0.077	0.076	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.076	0.076	0.077
7	0.098	0.098	0.099	0.098	0.098	0.098	0.098	0.099	0.099	0.098	0.099	0.097	0.098	0.097
8	0.12	0.12	0.121	0.121	0.12	0.121	0.119	0.121	0.12	0.121	0.119	0.119	0.121	0.121
9	0.136	0.139	0.139	0.138	0.138	0.138	0.14	0.138	0.139	0.139	0.139	0.14	0.138	0.138
10	0.159	0.159	0.159	0.16	0.159	0.159	0.159	0.16	0.159	0.159	0.158	0.159	0.159	0.158
+gp	0.194	0.202	0.2	0.207	0.207	0.197	0.202	0.193	0.203	0.206	0.211	0.218	0.2	0.193
0 SOPC	0.9117	0.9403	0.8885	0.9405	0.9304	0.8832	0.8614	0.9084	0.9495	0.8707	0.9519	0.9354	0.9438	0.8849

Run title : Clyde Males 1995 INDEX FILE

At 8/03/1995 12:50

Table 4 Natural Mortality (M) at age

YEAR	All Years
AGE	
1	0.3
2	0.3
3	0.3
4	0.3
5	0.3
6	0.3
7	0.3
8	0.3
9	0.3
10	0.3
+gp	0.3

Table 5 Proportion mature at age

YEAR	All Years
AGE	
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
+gp	1

Table 5.10.20 Firth of Clyde (FU13) Males - VPA Tuning Information

Lowestoft VPA Version 3.1

8/03/1995 12:51

Extended Survivors Analysis

Clyde Males 1995 INDEX FILE

CPUE data from file C:\NEPDAT\CL\MALES\TUNEFF.DAT

Catch data for 14 years. 1981 to 1994. Ages 1 to 11.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
FLEET 1	1981	1994	1	10	0	1

Time series weights :

Tapered time weighting applied
Power = 3 over 20 years

Catchability analysis :

Catchability dependent on stock size for ages < 3

Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 3

Catchability independent of age for ages >= 5

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 5 years or the 5 oldest ages.

S.E. of the mean to which the estimates are shrunk = .500

Minimum standard error for population
estimates derived from each fleet = .300

Prior weighting not applied

Tuning converged after 17 iterations

1

Regression weights

0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.042	0.047	0.026	0.021	0.012	0.039	0.033	0.011	0.003	0.024
2	0.478	0.422	0.344	0.347	0.15	0.255	0.325	0.269	0.261	0.259
3	0.808	0.66	0.706	0.734	0.416	0.633	0.703	0.597	0.652	0.541
4	0.667	0.685	0.464	0.943	0.881	0.709	0.673	0.725	0.925	0.675
5	0.442	0.5	0.29	0.965	0.847	0.572	0.43	0.657	0.813	0.547
6	0.32	0.444	0.194	0.792	0.825	0.493	0.315	0.566	0.665	0.521
7	0.339	0.457	0.174	0.76	0.928	0.459	0.316	0.417	0.714	0.555
8	0.493	0.397	0.121	0.588	1.094	0.603	0.397	0.251	0.595	0.606
9	0.46	0.841	0.123	0.532	0.95	0.895	0.456	0.301	0.676	0.688
10	0.491	0.571	0.337	0.792	0.874	0.616	0.503	0.553	0.737	0.553

1

XSA population numbers (Thousands)

AGE YEAR	1	2	3	4	5	6	7	8	9	10
1985	247000	166000	80800	26500	10200	4510	1930	679	359	171
1986	173000	176000	76400	26700	10100	4850	2430	1020	307	168
1987	115000	122000	85300	29300	9960	4540	2300	1140	508	98.2
1988	143000	83300	64100	31200	13600	5520	2770	1430	747	333
1989	185000	104000	43700	22800	9000	3850	1850	959	590	325
1990	181000	135000	66300	21300	6990	2860	1250	543	238	169
1991	121000	129000	77800	26100	7780	2920	1290	585	220	72
1992	80500	86700	68900	28500	9860	3750	1580	698	291	103
1993	125000	59000	49000	28100	10200	3790	1580	772	402	160
1994	182000	92000	33700	18900	8260	3360	1440	572	315	152

Estimated population abundance at 1st Jan 1995

0	132000	52600	14500	7140	3540	1480	614	231	117

Taper weighted geometric mean of the VPA populations:

156000	113000	62700	25200	9340	3850	1760	821	390	170

Standard error of the weighted Log(VPA populations) :

0.3201	0.3181	0.2824	0.151	0.1737	0.1932	0.2536	0.3096	0.3959	0.5202

Table 5.10.20 (cont)

Log catchability residuals.

Fleet : FLEET 1

Age	1981	1982	1983	1984
1	-0.29	-0.16	-0.07	0.07
2	-0.11	-0.04	0.23	0.04
3	0.14	0.28	0.39	0.05
4	0.04	0.08	0.11	-0.16
5	0.04	0.02	0.24	-0.16
6	-0.18	-0.26	0.18	-0.27
7	-0.43	-0.4	0.16	-0.08
8	-0.79	-0.72	0.09	0.01
9	-0.92	-0.55	-0.15	0.12
10	-0.24	-0.12	0.14	0.02

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.08	0.31	0.32	0.06	-0.34	0.2	0.31	0.04	-0.8	0.1
2	0.17	0.05	0.12	0.2	-0.46	-0.19	-0.06	-0.04	0.06	0.12
3	0.21	-0.02	0.17	0.11	-0.51	-0.06	-0.03	-0.19	-0.12	0.03
4	-0.07	-0.07	-0.33	0.27	0.14	-0.04	-0.16	-0.08	0.13	0.16
5	-0.26	-0.17	-0.58	0.5	0.32	-0.03	-0.39	0.04	0.22	0.17
6	-0.58	-0.28	-0.98	0.31	0.29	-0.18	-0.7	-0.11	0.02	0.12
7	-0.52	-0.26	-1.09	0.27	0.41	-0.25	-0.69	-0.41	0.1	0.19
8	-0.15	-0.4	-1.45	0.02	0.57	0.02	-0.47	-0.92	-0.08	0.27
9	-0.22	0.34	-1.44	-0.08	0.43	0.41	-0.33	-0.74	0.04	0.4
10	-0.15	-0.04	-0.43	0.31	0.35	0.04	-0.23	-0.13	0.13	0.18

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	3	4	5	6	7	8	9	10
Mean Log	-5.4277	-5.3374	-5.5545	-5.5545	-5.5545	-5.5545	-5.5545	-5.5545
S.E(Log q	0.2203	0.1684	0.3075	0.4372	0.4847	0.6154	0.5881	0.2304

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
1	0.45	1.64	10.58	0.49	14	0.35	-8.9
2	0.65	1.79	8.08	0.74	14	0.2	-6.2

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	0.73	1.644	6.94	0.8	14	0.15	-5.43
4	1.25	-0.56	4.14	0.35	14	0.22	-5.34
5	0.62	1.138	6.92	0.49	14	0.19	-5.55
6	0.84	0.279	6.13	0.25	14	0.35	-5.74
7	0.92	0.162	5.9	0.29	14	0.42	-5.76
8	1.49	-0.576	5.36	0.13	14	0.86	-5.81
9	1.22	-0.393	5.64	0.25	14	0.73	-5.7
10	0.75	3.614	5.45	0.96	14	0.12	-5.55
1							

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength

Year class = 1993

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	144953	0.365	0	0	1	0.345	0.022
P shrinka	112507	0.32				0.466	0.028
F shrinka	162187	0.5				0.189	0.02

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
131559	0.22	0.13	3	0.588	0.024

Table 5.10.20 (cont)

Age 2 Catchability dependent on age and year class strength

Year class = 1992

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	43992	0.247	0.429	1.74	2	0.434	0.303
P shrinka	62678	0.28				0.429	0.222
F shrinka	53694	0.5				0.137	0.254

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
52625	0.18	0.22	4	1.226	0.259

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 1991

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	15154	0.188	0.007	0.04	3	0.782	0.523
F shrinka	12432	0.5				0.218	0.609

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
14515	0.18	0.05	4	0.293	0.541

1
Age 4 Catchability constant w.r.t. time and dependent on age

Year class = 1990

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	7699	0.17	0.085	0.5	4	0.755	0.639
F shrinka	5669	0.5				0.245	0.795

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
7143	0.18	0.1	5	0.56	0.675

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

Year class = 1989

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	3907	0.182	0.063	0.35	5	0.737	0.507
F shrinka	2683	0.5				0.263	0.674

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
3539	0.19	0.1	6	0.526	0.547

1
Age 6 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1988

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	1581	0.193	0.069	0.36	6	0.678	0.494
F shrinka	1284	0.5				0.322	0.581

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
1479	0.21	0.07	7	0.341	0.521

Table 5.10.20 (cont)

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1987

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	629	0.202	0.066	0.33	7	0.639	0.545
F shrinkag	587	0.5				0.361	0.575

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
614	0.22	0.05	8	0.23	0.555

1

Age 8 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1986

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	227	0.211	0.1	0.47	8	0.569	0.614
F shrinkag	236	0.5				0.431	0.596

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
231	0.25	0.07	9	0.289	0.606

Age 9 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1985

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	113	0.226	0.132	0.58	9	0.541	0.709
F shrinkag	123	0.5				0.459	0.665

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
117	0.26	0.09	10	0.359	0.688

1

Age 10 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1984

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	67	0.214	0.11	0.51	10	0.705	0.538
F shrinkag	59	0.5				0.295	0.592

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
65	0.21	0.09	11	0.427	0.553

Table 5.10.21 Firth of Clyde (FU13) Males - VPA outputs

Run title : Clyde Males 1995 INDEX FILE

At 8/03/1995 12:52

Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	FBAR 92-94
AGE															
1	0.0114	0.0127	0.0233	0.0338	0.0418	0.0467	0.0258	0.0207	0.0124	0.0387	0.0326	0.0108	0.0029	0.0241	0.0126
2	0.2313	0.2134	0.4553	0.3345	0.4777	0.4219	0.3443	0.3466	0.1496	0.255	0.3252	0.2695	0.261	0.2588	0.2631
3	0.6814	0.6051	0.9072	0.6124	0.8083	0.6603	0.7062	0.7336	0.4163	0.6325	0.7034	0.5973	0.6517	0.541	0.5967
4	0.6719	0.5385	0.7529	0.5451	0.667	0.6853	0.4636	0.9428	0.8814	0.7086	0.6729	0.7252	0.9248	0.675	0.775
5	0.5418	0.4091	0.6831	0.4346	0.442	0.5	0.2898	0.9647	0.8471	0.5722	0.4298	0.6567	0.8129	0.5473	0.6723
6	0.4318	0.3081	0.6438	0.3879	0.3195	0.4441	0.1938	0.7917	0.8253	0.4932	0.3147	0.5665	0.6646	0.521	0.584
7	0.338	0.2661	0.6319	0.473	0.3391	0.4566	0.1736	0.7604	0.9278	0.459	0.3163	0.4169	0.7143	0.5554	0.5622
8	0.2346	0.1933	0.591	0.5163	0.4927	0.3968	0.1206	0.5883	1.0937	0.6035	0.3974	0.2509	0.595	0.6061	0.484
9	0.2053	0.2298	0.4602	0.5785	0.46	0.8413	0.1226	0.532	0.9501	0.8951	0.4556	0.3008	0.6765	0.6885	0.5552
10	0.4076	0.3521	0.6186	0.5232	0.4905	0.5709	0.3374	0.7923	0.8737	0.6164	0.5031	0.5532	0.7374	0.5531	0.6146
+gp	0.4076	0.3521	0.6186	0.5232	0.4905	0.5709	0.3374	0.7923	0.8737	0.6164	0.5031	0.5532	0.7374	0.5531	
0 FBAR '3-8	0.4832	0.3867	0.7016	0.4949	0.5114	0.5239	0.3246	0.7969	0.8319	0.5782	0.4724	0.5356	0.7272	0.5743	

Run title : Clyde Males 1995 INDEX FILE

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Terminal Fs derived using XSA (With F shrinkage)

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	GMST 81-92	AMST 81-92
AGE																	
1	180721	192335	210646	232324	247015	172591	115438	143203	185115	180755	120888	80476	124578	181910	0	164416	171792
2	113244	132364	140690	152458	166393	175502	122020	83345	103914	135441	128826	86687	58978	92022	131559	125321	128407
3	63451	66569	79218	66106	80834	76450	85268	64062	43660	66285	77751	68942	49050	33656	52625	68969	69883
4	20303	23781	26926	23689	26546	26685	29262	31175	22788	21329	26087	28506	28105	18937	14515	25395	25590
5	8797	7682	10282	9395	10175	10093	9963	13635	8996	6993	7780	9861	10226	8258	7143	9338	9471
6	3664	3791	3780	3847	4507	4845	4535	5524	3850	2857	2923	3750	3788	3360	3539	3924	3989
7	2146	1762	2064	1471	1934	2426	2302	2768	1854	1249	1292	1581	1577	1444	1479	1852	1904
8	993	1134	1001	813	679	1020	1138	1434	959	543	585	698	772	572	614	881	916
9	391	582	692	410	359	307	508	747	590	238	220	291	402	315	231	413	445
10	96	236	343	324	171	168	98	333	325	169	72	103	160	152	117	177	203
+gp	136	337	488	743	170	129	202	383	446	333	279	178	214	124	117		
0 TO	393942	430572	476128	491581	538781	470216	370735	346609	372496	416192	366702	281072	277849	340750	211939		

Run title : Clyde Males 1995 INDEX FILE

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Table 16 Summary (without SOP correction)

Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 8
1981	180721	5614	5614	1385	0.2467	0.4832
1982	192335	6112	6112	1362	0.2228	0.3867
1983	210646	6928	6928	2211	0.3191	0.7016
1984	232324	6497	6497	1647	0.2534	0.4949
1985	247015	7126	7126	2112	0.2963	0.5114
1986	172591	6780	6780	1901	0.2803	0.5239
1987	115438	6396	6396	1535	0.24	0.3246
1988	143203	6241	6241	2219	0.3556	0.7969
1989	185115	5271	5271	1472	0.2793	0.8319
1990	180755	5576	5576	1388	0.2489	0.5782
1991	120888	5785	5785	1717	0.2967	0.4724
1992	80476	5262	5262	1615	0.3069	0.5356
1993	124578	4883	4883	1618	0.3313	0.7272
1994	181910	4345	4345	1022	0.2351	0.5743
Arith. Mean	169142	5915	5915	1657	0.2795	0.5673
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 5.10.22 Firth of Clyde (FU13) Females - VPA input

Run title : Clyde Females 1995 INDEX FILE

At 8/03/1995 12:56

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE														
1	2640	3271	5274	8642	8662	8089	3041	3996	3079	9087	4360	637	305	3466
2	24435	16744	42448	51667	67957	50910	26538	26815	14886	28285	28911	13544	13128	21295
3	7007	5143	11342	8185	11509	7984	5841	8944	3967	7871	6605	5421	6590	4594
4	5599	4017	6828	5218	7353	5004	3812	7224	4235	5313	4985	4428	6978	4693
5	4438	2248	4011	2392	3924	3504	2647	5393	5558	4114	3204	2709	6039	4616
6	2568	1388	2974	944	2314	2341	1857	2871	4412	3878	1960	1895	4213	4081
7	1837	1067	2094	620	1517	1701	1262	2122	3642	3173	1613	1293	3200	3175
8	1404	882	1477	485	1043	1233	859	1750	2937	2512	1395	904	2482	2381
9	954	689	1027	268	712	676	580	1337	1808	1728	998	691	1693	1505
10	619	569	681	186	480	486	404	955	1256	1549	721	548	1229	961
11	463	511	521	148	371	395	322	774	997	1453	590	479	1010	708
12	341	346	399	98	207	211	246	464	626	670	376	305	634	437
13	313	321	371	89	191	194	231	423	583	621	355	292	589	403
14	171	192	229	44	111	105	153	209	363	367	245	227	360	230
15	165	182	219	42	107	101	149	202	348	353	237	220	349	221
+gp	364	298	621	205	398	307	572	921	1243	931	762	1121	1230	661
0 TOTA	53318	37867	80516	79232	106857	83242	48512	64398	49940	71904	57316	34713	50030	53425
TONSLA	875	605	1165	940	1373	1013	687	1078	1101	1160	912	708	1156	947
SOPCOF	89	89	85	90										

Run title : Clyde Females 1995 INDEX FILE

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Table 2 Catch weights at age (kg)

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE														
1	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.005	0.005	0.006	0.007	0.006
2	0.012	0.011	0.012	0.011	0.011	0.011	0.011	0.012	0.011	0.011	0.011	0.012	0.012	0.011
3	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
4	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.021	0.02	0.02	0.02	0.02	0.021
5	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
6	0.028	0.028	0.028	0.027	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028
7	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
8	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
9	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
10	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.043	0.042	0.042	0.042	0.042
11	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
12	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
13	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052
14	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058
15	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
+gp	0.071	0.073	0.077	0.08	0.079	0.076	0.082	0.079	0.083	0.077	0.078	0.084	0.079	0.077
0 SOPC	0.8896	0.891	0.8501	0.9049	0.9077	0.8379	0.8449	0.8645	0.9305	0.8484	0.9097	0.9333	0.9456	0.8711

Run title : Clyde Females 1995 INDEX FILE

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Table 4 Natural Mortality (M) at age

YEAR	All Years
AGE	
1	0.3
2	0.3
3	0.2
4	0.2
5	0.2
6	0.2
7	0.2
8	0.2
9	0.2
10	0.2
11	0.2
12	0.2
13	0.2
14	0.2
15	0.2
+gp	0.2

Run title : Clyde Females 1995 INDEX FILE

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Table 5 Proportion mature at age

YEAR	All Years
AGE	
1	0
2	0
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
11	1
12	1
13	1
14	1
15	1
+gp	1

Table 5.10.23 Firth of Clyde (FU13) Females - VPA Tuning information

Lowestoft VPA Version 3.1

8/03/1995 12:57

Extended Survivors Analysis

Clyde Females 1995 INDEX FILE

CPUE data from file C:\NEPDAT\CL\FEMALES\TUNEFF.DAT

Catch data for 14 years. 1981 to 1994. Ages 1 to 16.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
FLEET 1	1981	1994	1	15	0	1

Time series weights :

Tapered time weighting applied
Power = 3 over 20 years

Catchability analysis :

Catchability dependent on stock size for ages < 3

Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 3

Catchability independent of age for ages >= 5

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 5 years or the 5 oldest ages.

S.E. of the mean to which the estimates are shrunk = .500

Minimum standard error for population
estimates derived from each fleet = .300

Prior weighting not applied

Tuning had not converged after 60 iterations

Total absolute residual between iterations
59 and 60 = .00112

Final year F values

Age	1	2	3	4	5	6	7	8	9	10
Iteration 5	0.019	0.192	0.0738	0.082	0.0956	0.1193	0.1365	0.1511	0.1133	0.0891
Iteration 6	0.019	0.1919	0.0738	0.0819	0.0955	0.1192	0.1364	0.151	0.1132	0.089

Age	11	12	13	14	15
Iteration 5	0.095	0.0826	0.0949	0.076	0.096
Iteration 6	0.0949	0.0826	0.0949	0.0759	0.096

Regression weights

0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.039	0.045	0.019	0.025	0.016	0.046	0.028	0.005	0.002	0.019
2	0.481	0.374	0.229	0.255	0.134	0.225	0.224	0.125	0.147	0.192
3	0.144	0.098	0.069	0.118	0.057	0.102	0.079	0.062	0.087	0.074
4	0.122	0.086	0.062	0.114	0.075	0.1	0.087	0.069	0.107	0.082
5	0.091	0.079	0.06	0.117	0.121	0.098	0.081	0.062	0.128	0.096
6	0.071	0.072	0.054	0.085	0.132	0.116	0.062	0.063	0.13	0.119
7	0.066	0.068	0.05	0.081	0.148	0.133	0.065	0.052	0.143	0.136
8	0.062	0.07	0.045	0.091	0.155	0.145	0.079	0.047	0.135	0.151
9	0.056	0.052	0.043	0.091	0.129	0.128	0.078	0.051	0.116	0.113
10	0.053	0.049	0.04	0.092	0.116	0.155	0.072	0.056	0.121	0.089
11	0.065	0.056	0.042	0.099	0.131	0.19	0.081	0.063	0.14	0.095
12	0.058	0.047	0.045	0.078	0.109	0.122	0.069	0.055	0.11	0.083
13	0.077	0.071	0.067	0.102	0.134	0.15	0.087	0.07	0.143	0.095
14	0.069	0.056	0.073	0.08	0.119	0.117	0.081	0.074	0.115	0.076
15	0.09	0.083	0.104	0.131	0.185	0.163	0.103	0.097	0.156	0.096

XSA population numbers (Thousands)

AGE / YEAR	1	2	3	4	5	6	7	8	9	10
1985	266000	207000	94600	70600	50000	37300	26300	19200	14400	10300
1986	212000	190000	94600	67100	51200	37400	28400	20100	14800	11100
1987	191000	150000	86600	70200	50400	38700	28500	21700	15400	11500
1988	191000	139000	88500	73800	54000	38900	30000	22200	17000	12100
1989	223000	138000	79600	64400	53900	39400	29200	22700	16600	12700
1990	236000	163000	89600	61500	48900	39100	28200	20600	15900	11900
1991	186000	167000	96300	66200	45600	36300	28500	20200	14600	11500
1992	151000	134000	98900	72900	49700	34400	28000	21900	15300	11100
1993	192000	112000	87800	76100	55700	38300	26500	21700	17100	11900
1994	214000	142000	71400	66000	56000	40100	27500	18800	15500	12500

Estimated population abundance at 1st Jan 1995

0	155000	86700	54300	49800	41700	29200	19700	13200	11400

Taper weighted geometric mean of the VPA populations:

211000	153000	89300	67700	50200	36800	27100	19900	14600	10700

Standard error of the weighted Log(VPA populations) :

0.1728	0.1703	0.0978	0.0752	0.0838	0.082	0.0961	0.1354	0.1723	0.2118

Table 5.10.23 (cont)

AGE / YEAR	11	12	13	14	15
1985	6550	4060	2840	1830	1380
1986	7960	5020	3140	2150	1400
1987	8660	6160	3920	2390	1670
1988	9050	6800	4820	3000	1820
1989	9000	6710	5150	3570	2270
1990	9270	6470	4930	3690	2590
1991	8370	6280	4690	3470	2690
1992	8720	6320	4800	3520	2620
1993	8560	6710	4900	3660	2680
1994	8640	6090	4920	3480	2670

Estimated population abundance at 1st Jan 1995

9350	6440	4600	3670	2640

Taper weighted geometric mean of the VPA populations:

7670	5490	4050	2900	2120

Standard error of the weighted Log(VPA populations) :

0.2408	0.259	0.2729	0.2697	0.2569

Log catchability residuals.

Fleet : FLEET 1

Age	1981	1982	1983	1984
1	0.02	-0.06	-0.08	-0.07
2	0.06	0	0.03	0.06
3	0.23	0.09	0.54	0.23
4	0.3	0.2	0.34	0.1
5	0.39	-0.04	0.21	-0.35
6	0.2	-0.22	0.23	-0.92
7	0.28	-0.14	0.17	-1.02
8	0.45	0.1	0.16	-0.98
9	0.4	0.31	0.24	-1.23
10	0.35	0.46	0.3	-1.15
11	0.34	0.74	0.38	-0.91
12	0.21	0.62	0.53	-0.96
13	0.07	0.72	0.74	-0.63
14	-0.18	0.12	0.42	-1.04
15	0.13	0.43	0.24	-0.95

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	-0.01	0.2	0.11	0.14	-0.08	0.12	0.17	-0.06	-0.46	0.05
2	0.03	0	0.05	0.11	-0.11	-0.05	-0.09	-0.12	0.05	0.07
3	0.49	0.07	-0.15	0.28	-0.51	0.12	-0.22	-0.45	-0.14	0.03
4	0.29	-0.09	-0.3	0.22	-0.26	0.07	-0.16	-0.37	0.04	0.11
5	0.01	-0.16	-0.31	0.26	0.24	0.06	-0.21	-0.46	0.23	0.28
6	-0.23	-0.25	-0.4	-0.06	0.33	0.23	-0.48	-0.45	0.25	0.5
7	-0.3	-0.3	-0.48	-0.1	0.44	0.37	-0.43	-0.63	0.35	0.64
8	-0.37	-0.28	-0.6	0.01	0.48	0.45	-0.23	-0.75	0.29	0.74
9	-0.46	-0.58	-0.65	0.01	0.3	0.33	-0.24	-0.66	0.14	0.45
10	-0.52	-0.62	-0.72	0.02	0.19	0.52	-0.32	-0.56	0.18	0.21
11	-0.32	-0.49	-0.66	0.1	0.31	0.72	-0.2	-0.46	0.32	0.28
12	-0.43	-0.67	-0.59	-0.14	0.13	0.28	-0.37	-0.59	0.09	0.14
13	-0.15	-0.27	-0.19	0.12	0.34	0.49	-0.13	-0.35	0.34	0.28
14	-0.25	-0.51	-0.1	-0.12	0.22	0.24	-0.2	-0.29	0.13	0.05
15	0	-0.11	0.24	0.37	0.66	0.57	0.03	-0.01	0.43	0.29

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	3	4	5	6	7	8	9	10	11	12
Mean Log	-7.4075	-7.3764	-7.3967	-7.3967	-7.3967	-7.3967	-7.3967	-7.3967	-7.3967	-7.3967
S.E(Log q	0.3159	0.2323	0.2744	0.4125	0.4944	0.5262	0.5243	0.5239	0.5046	0.4823

Age	13	14	15
Mean Log	-7.3967	-7.3967	-7.3967
S.E(Log q	0.3958	0.3641	0.4306

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
1	0.23	2.272	11.53	0.48	14	0.19	-9
2	0.31	4.652	10.25	0.83	14	0.08	-6.48

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	0.86	0.153	7.96	0.11	14	0.29	-7.41
4	2.37	-0.584	2.24	0.02	14	0.57	-7.38
5	0.47	1.151	9.23	0.33	14	0.13	-7.4
6	0.32	1.475	9.54	0.33	14	0.12	-7.48
7	0.84	0.115	7.91	0.05	14	0.43	-7.47
8	1.98	-0.394	5.02	0.02	14	1.08	-7.43
9	1.04	-0.041	7.44	0.1	14	0.56	-7.52
10	1	0.003	7.54	0.15	14	0.53	-7.53
11	0.93	0.107	7.51	0.21	14	0.49	-7.4
12	1.03	-0.043	7.53	0.24	14	0.49	-7.56
13	0.76	0.712	7.56	0.48	14	0.3	-7.31
14	0.58	2.123	7.7	0.73	14	0.17	-7.5
15	0.58	1.693	7.4	0.64	14	0.2	-7.21

Table 5.10.23 (cont)

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength

Year class = 1993

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	163545	0.3	0	0	1	0.221	0.018
P shrinka	153129	0.17				0.698	0.019
F shrinka	152954	0.5				0.081	0.019

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
155356	0.14	0.04	3	0.29	0.019

Age 2 Catchability dependent on age and year class strength

Year class = 1992

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	71263	0.212	0.269	1.27	2	0.144	0.229
P shrinka	89308	0.1				0.824	0.187
F shrinka	97516	0.5				0.032	0.172

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
86686	0.09	0.14	4	1.552	0.192

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 1991

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	54773	0.179	0.034	0.19	3	0.868	0.073
F shrinka	51554	0.5				0.132	0.078

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
54337	0.17	0.03	4	0.17	0.074

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

Year class = 1990

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	50232	0.154	0.078	0.51	4	0.895	0.081
F shrinka	46144	0.5				0.105	0.088

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
49788	0.15	0.07	5	0.443	0.082

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

Year class = 1989

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	41805	0.139	0.123	0.88	5	0.908	0.095
F shrinka	40500	0.5				0.092	0.098

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
41683	0.13	0.1	6	0.779	0.096

Table 5.10.23 (cont)

Age 6 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1988

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	28658	0.133	0.127	0.95	6	0.907	0.121
F shrinka	34819	0.5				0.093	0.101

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
29180	0.13	0.11	7	0.872	0.119

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1987

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	19185	0.13	0.126	0.97	7	0.906	0.14
F shrinka	25038	0.5				0.094	0.109

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
19669	0.13	0.12	8	0.912	0.136

Age 8 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1986

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	12777	0.129	0.131	1.01	8	0.9	0.156
F shrinka	18109	0.5				0.1	0.112

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
13228	0.13	0.12	9	0.969	0.151

Age 9 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1985

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	11215	0.128	0.112	0.87	9	0.903	0.115
F shrinka	12847	0.5				0.097	0.101

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
11364	0.13	0.1	10	0.806	0.113

Age 10 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1984

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	9524	0.13	0.097	0.75	10	0.898	0.087
F shrinka	7908	0.5				0.102	0.104

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
9345	0.13	0.09	11	0.7	0.089

Table 5.10.23 (cont)

Age 11 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1983

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	6646	0.132	0.094	0.71	11	0.89	0.092
F shrinka	4968	0.5				0.11	0.121

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
6437	0.13	0.09	12	0.689	0.095

Age 12 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1982

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	4671	0.133	0.095	0.71	12	0.888	0.081
F shrinka	4051	0.5				0.112	0.093

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
4597	0.13	0.09	13	0.661	0.083

Age 13 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1981

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	3764	0.132	0.082	0.62	13	0.894	0.092
F shrinka	2936	0.5				0.106	0.117

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
3666	0.13	0.08	14	0.599	0.095

Age 14 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1980

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	2732	0.131	0.085	0.65	14	0.898	0.073
F shrinka	1946	0.5				0.102	0.102

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
2640	0.13	0.08	15	0.647	0.076

Age 15 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1979

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLEET 1	1969	0.134	0.093	0.69	14	0.895	0.097
F shrinka	2185	0.5				0.105	0.088

Weighted prediction :

Survivors at end of	Int s.e	Ext s.e	N	Var Ratio	F
1991	0.13	0.08	15	0.647	0.096

Table 5.10.24 Firth of Clyde (FU13) Females - VPA outputs

Run title : Clyde Females 1995 INDEX FILE

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Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	FBAR 92-94
AGE															
1	0.0154	0.0157	0.0239	0.0354	0.0386	0.0453	0.0187	0.0246	0.0161	0.0457	0.0276	0.0049	0.0019	0.019	0.0086
2	0.2171	0.1424	0.3245	0.3852	0.4815	0.3739	0.2295	0.2547	0.1336	0.2253	0.2244	0.1246	0.1469	0.1919	0.1545
3	0.1017	0.0678	0.1429	0.0997	0.1443	0.0979	0.0691	0.1184	0.0567	0.1021	0.0788	0.0625	0.0866	0.0738	0.0743
4	0.1125	0.0779	0.1207	0.0903	0.1222	0.0861	0.0619	0.1144	0.0755	0.1003	0.0868	0.0695	0.1069	0.0819	0.0861
5	0.1206	0.0602	0.104	0.0565	0.0908	0.0787	0.0598	0.1169	0.121	0.0976	0.0809	0.0621	0.1277	0.0955	0.0951
6	0.0991	0.0502	0.1056	0.032	0.0711	0.0717	0.0544	0.0852	0.1323	0.1161	0.0615	0.0628	0.1297	0.1192	0.1039
7	0.1078	0.0543	0.0997	0.0288	0.066	0.0685	0.0502	0.0813	0.1482	0.1326	0.0645	0.0525	0.1434	0.1364	0.1108
8	0.1277	0.0691	0.0991	0.0301	0.0618	0.0701	0.0447	0.0913	0.1546	0.1446	0.0792	0.0467	0.135	0.151	0.1109
9	0.1216	0.0851	0.1073	0.0234	0.0563	0.0518	0.0426	0.0909	0.1285	0.128	0.0785	0.0512	0.1159	0.1132	0.0934
10	0.1151	0.0989	0.1136	0.0254	0.0531	0.0495	0.0396	0.0916	0.1156	0.1549	0.0721	0.0563	0.1211	0.089	0.0888
11	0.1138	0.1312	0.1236	0.0324	0.0647	0.0564	0.042	0.0993	0.1305	0.1902	0.0811	0.0626	0.1398	0.0949	0.0991
12	0.1003	0.1167	0.1436	0.0306	0.058	0.0475	0.0451	0.0785	0.1089	0.1216	0.0685	0.0548	0.1103	0.0826	0.0825
13	0.0869	0.1293	0.1767	0.0428	0.0773	0.0706	0.0672	0.1018	0.1337	0.1499	0.0872	0.0696	0.1426	0.0949	0.1024
14	0.0682	0.0703	0.1283	0.0282	0.0694	0.0555	0.0735	0.0801	0.1195	0.1166	0.0813	0.0739	0.1149	0.0759	0.0882
15	0.0923	0.0964	0.1073	0.031	0.0898	0.0832	0.1035	0.1305	0.1855	0.1632	0.1027	0.0973	0.1558	0.096	0.1164
+gp	0.0923	0.0964	0.1073	0.031	0.0898	0.0832	0.1035	0.1305	0.1855	0.1632	0.1027	0.0973	0.1558	0.096	
0 FBAR	0.1098	0.0855	0.1215	0.0447	0.0787	0.0681	0.0524	0.0972	0.1187	0.1307	0.0763	0.0591	0.1235	0.1029	

Run title : Clyde Females 1995 INDEX FILE

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Terminal Fs derived using XSA (With F shrinkage)

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	GMST 81-92	AMST 81-92
AGE																	
1	200875	244044	259589	288944	265993	212355	190556	191273	223492	236149	186372	151417	191610	213651	0	217608	220922
2	145457	146539	177978	187769	206617	189598	150354	138550	138259	162917	167123	134315	111624	141686	155356	160577	162123
3	80113	86726	94147	95313	94632	94575	96639	88544	79561	89612	96347	98924	87845	71393	86686	91046	91261
4	58142	59251	66351	66818	70630	67065	70207	73836	64401	61549	66246	72906	76087	65959	54337	66274	66450
5	43179	42537	44875	48146	49985	51174	50380	54031	53916	48894	45585	49727	55684	55981	49788	48397	48536
6	30081	31336	32792	33112	37254	37373	38727	38853	39357	39114	36309	34423	38262	40126	41683	35587	35728
7	19861	22305	24400	24158	26255	28407	28480	30027	29212	28230	28514	27954	26469	27514	29180	26299	26484
8	12940	14599	17296	18082	19217	20123	21719	22176	22664	20622	20242	21887	21717	18775	19669	19046	19297
9	9205	9324	11154	12824	14366	14790	15359	17005	16572	15898	14611	15310	17101	15534	13228	13603	13868
10	6287	6673	7011	8203	10257	11118	11498	12051	12712	11932	11453	11060	11910	12469	11364	9744	10021
11	4755	4587	4949	5123	6548	7964	8663	9048	9003	9271	8368	8725	8559	8639	9345	6997	7250
12	3949	3474	3294	3581	4061	5025	6162	6801	6708	6469	6276	6317	6710	6094	6437	4990	5176
13	4156	2925	2531	2336	2843	3138	3923	4823	5148	4925	4690	4798	4896	4920	4597	3716	3853
14	2866	3119	2104	1737	1832	2155	2394	3003	3566	3687	3471	3519	3664	3476	3666	2698	2788
15	2065	2191	2381	1516	1382	1400	1669	1821	2270	2591	2686	2620	2676	2674	2640	1995	2049
+gp	4547	3571	6729	7424	5112	4242	6408	8288	8072	6803	8595	13307	9377	7956	7908		
0 TO	628478	683201	757582	805085	816986	750500	703137	700128	714912	748664	706888	657207	674189	696846	495884		

Run title : Clyde Females 1995 INDEX FILE

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Table 16 Summary (without SOP correction)

Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3-13
1981	200875	10074	7324	875	0.1195	0.1098
1982	244044	10572	7496	605	0.0807	0.0855
1983	259589	11993	8300	1165	0.1404	0.1215
1984	288944	12332	8533	940	0.1101	0.0447
1985	265993	12833	8964	1373	0.1532	0.0787
1986	212355	12500	9140	1013	0.1109	0.0681
1987	190556	12512	9715	687	0.0707	0.0524
1988	191273	12972	10162	1078	0.1061	0.0972
1989	223492	12845	9983	1101	0.1103	0.1187
1990	236149	12599	9626	1160	0.1205	0.1307
1991	186372	12437	9667	912	0.0943	0.0763
1992	151417	12930	10410	708	0.068	0.0591
1993	191610	12923	10242	1156	0.1129	0.1235
1994	213651	12455	9614	947	0.0985	0.1029
Arith. Mean	218309	12284	9227	980	0.1069	0.0907
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 5.10.25 Nephrops landings (tonnes) by Functional Unit plus other rectangles in Management Area C (Via). Data for FU12 and other rectangles reflect revisions of statistical squares making up the Management Area (see section 5.1.1)

Year	FU 11	FU 12	FU 13	Other	Total
1985	4061	4008	4184	111	12364
1986	3382	3484	4342	106	11314
1987	4084	3891	3008	260	11243
1988	4035	4463	3468	546	12512
1989	3205	4745	2812	235	10997
1990	2543	4430	2912	217	10102
1991	2789	4442	3038	298	10567
1992	3548	4237	2744	283	10812
1993	3192	4454	3343	376	11365
1994	3477	4319	2557	483	10836

Table 5.10.26 Total Nephrops landings (tonnes) by country in Management Area C (VIa)

Year	UK	Spain	Ireland	Total
1985	12364	0		12364
1986	11310	4		11314
1987	11243	?		11243
1988	12512	?		12512
1989	10990	7		10997
1990	10101	1		10102
1991	10515	19	33	10567
1992	10784	18	10	10812
1993	11358	+	7	11365
1994	10834	0	2	10836

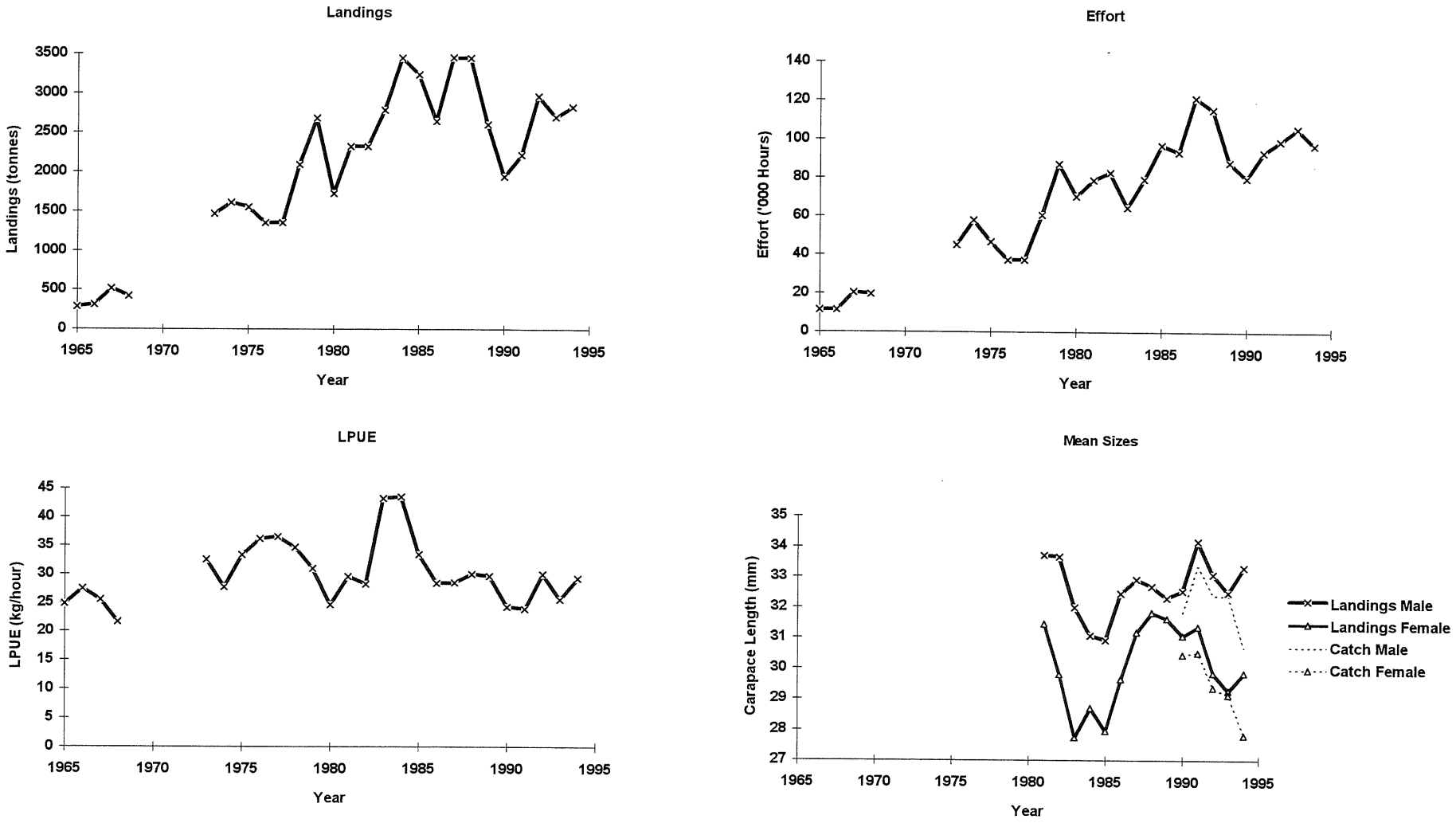


Figure 5.10.1 North Minch (FU11): Long term trends in Scottish Nephrops trawler landings (tonnes), effort ('000 hours), LPUE (kg/hour) and mean size (mm CL) in catch and landings.

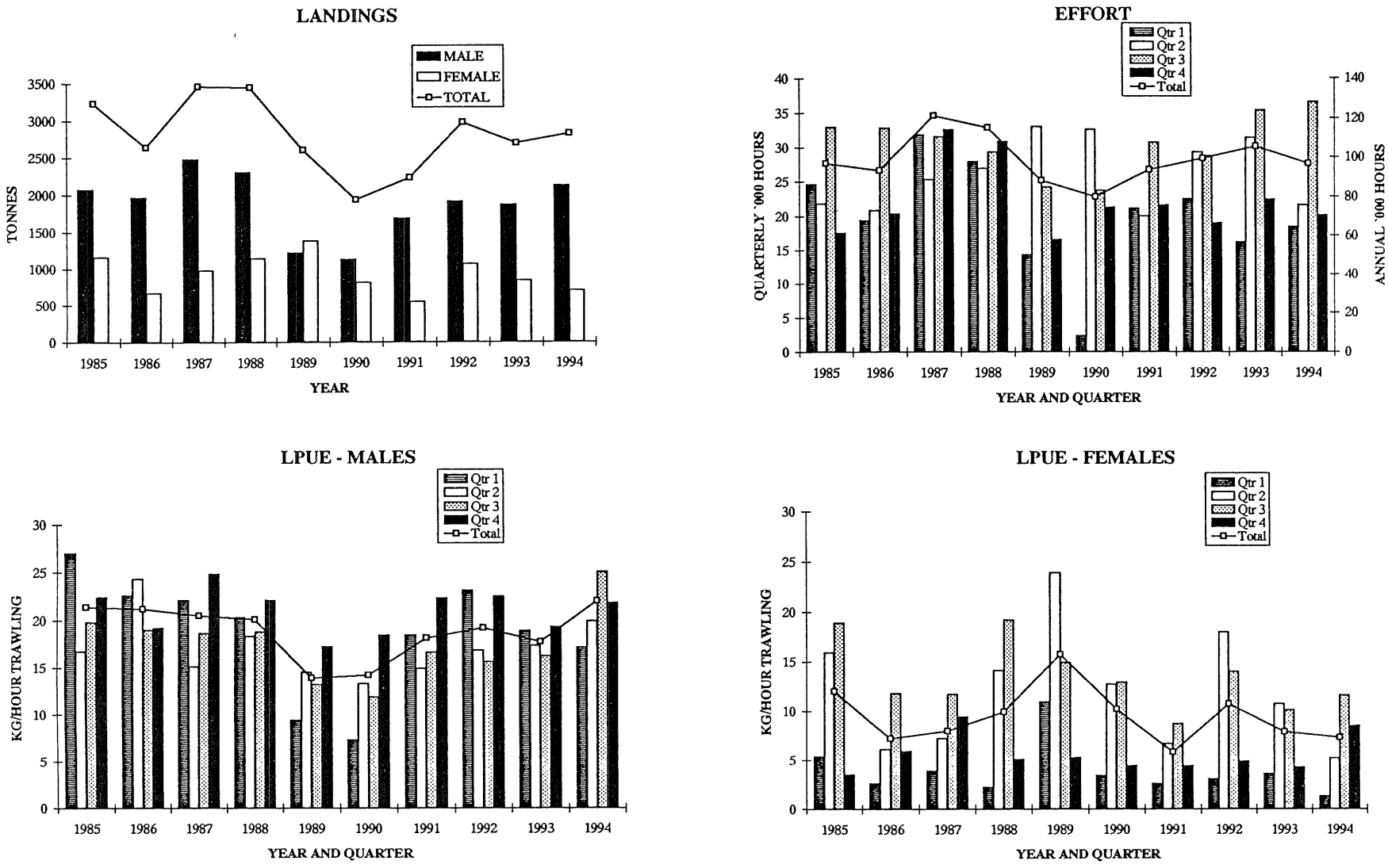
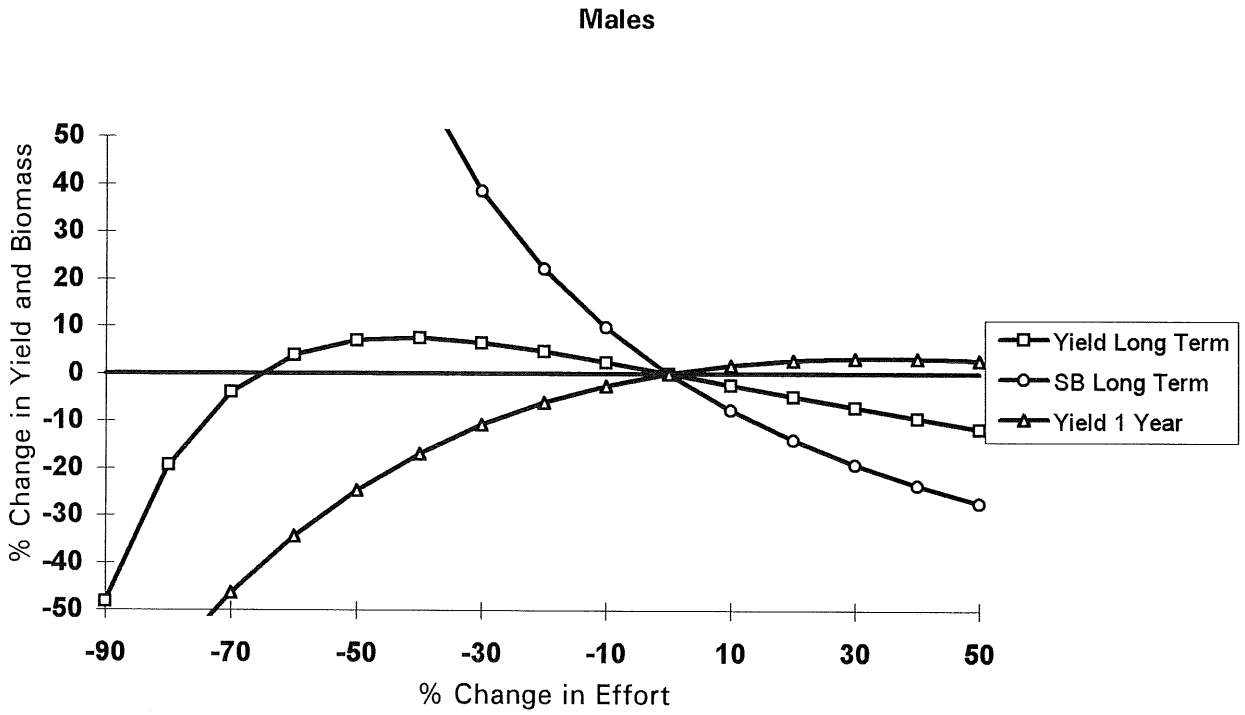


Figure 5.10.2. North Minch (functional unit 11) : trends in landings,effort and LPUE by quarter and sex from Scottish Nephrops trawlers.



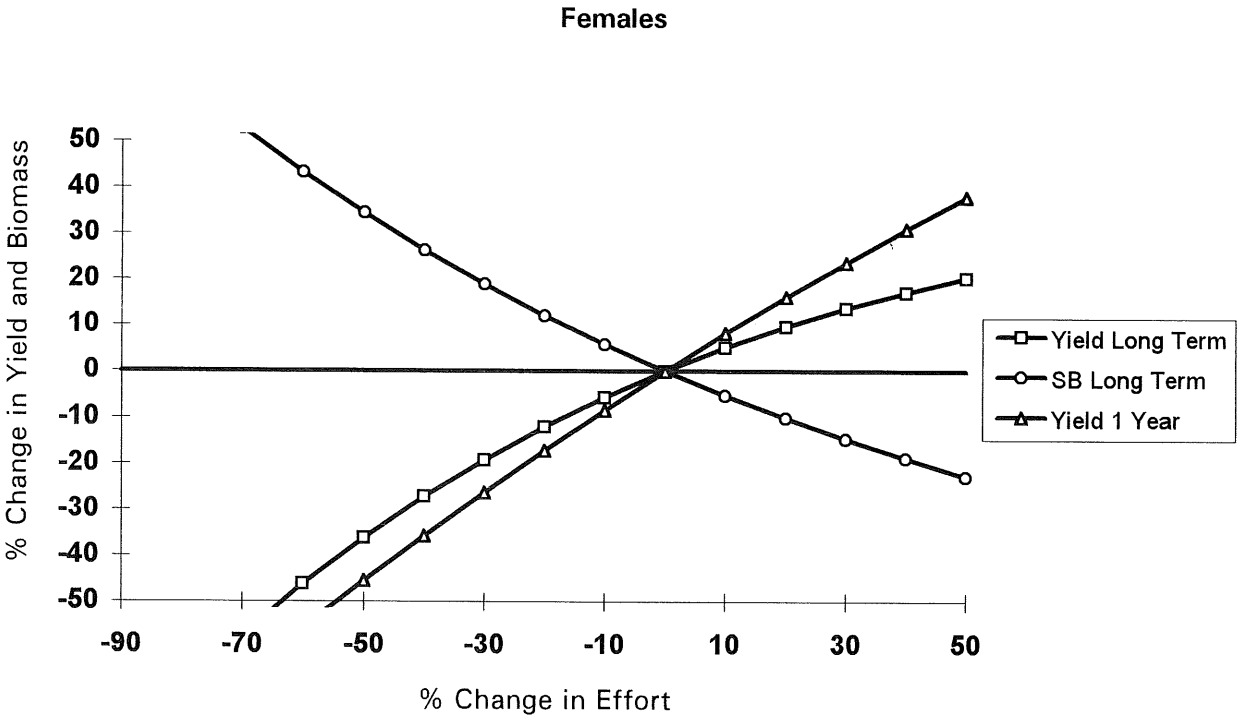


Figure 5.10.3 North Minch (FU11): Percentage changes in long term landings and stock biomass, and short term landings following various changes in fishing effort. Males and females shown separately.

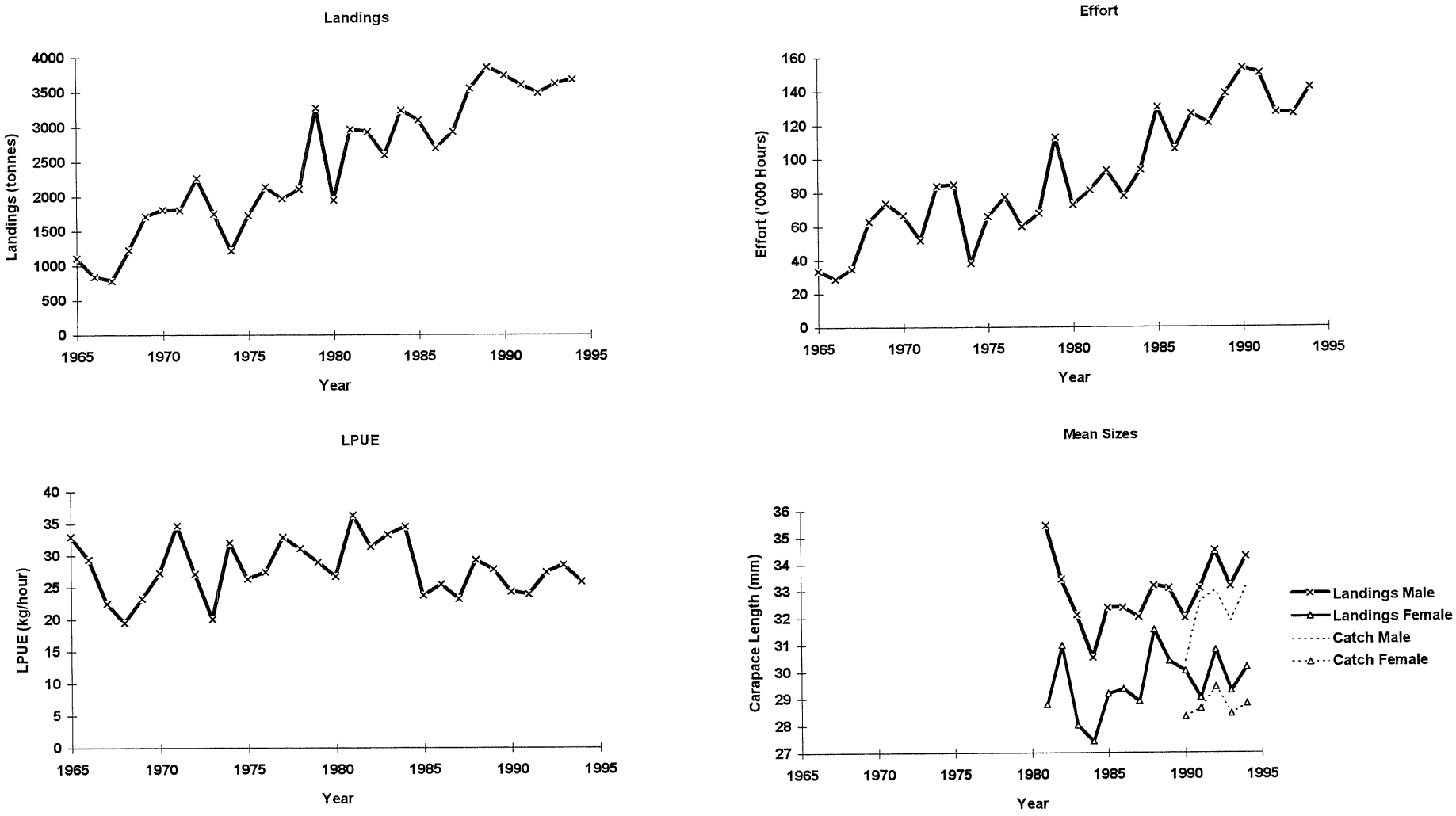
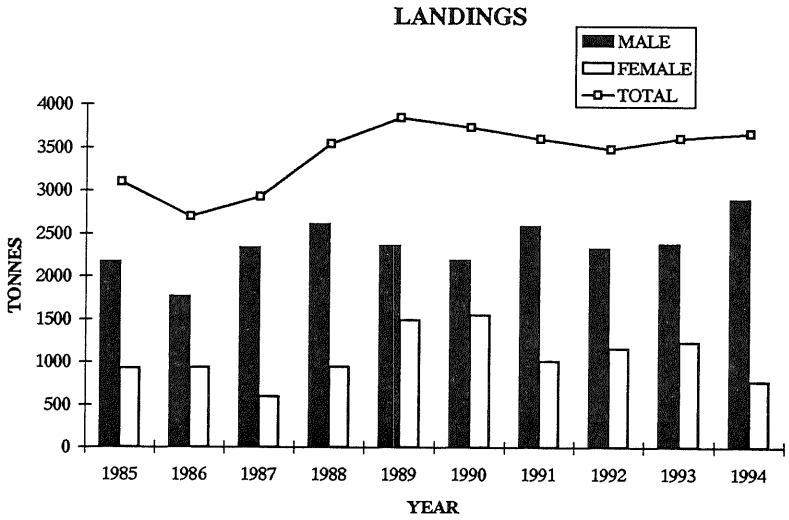
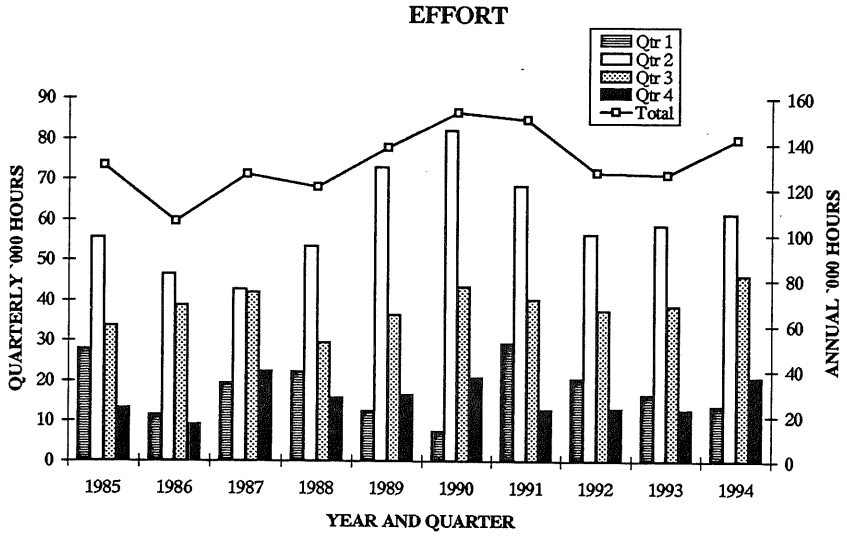
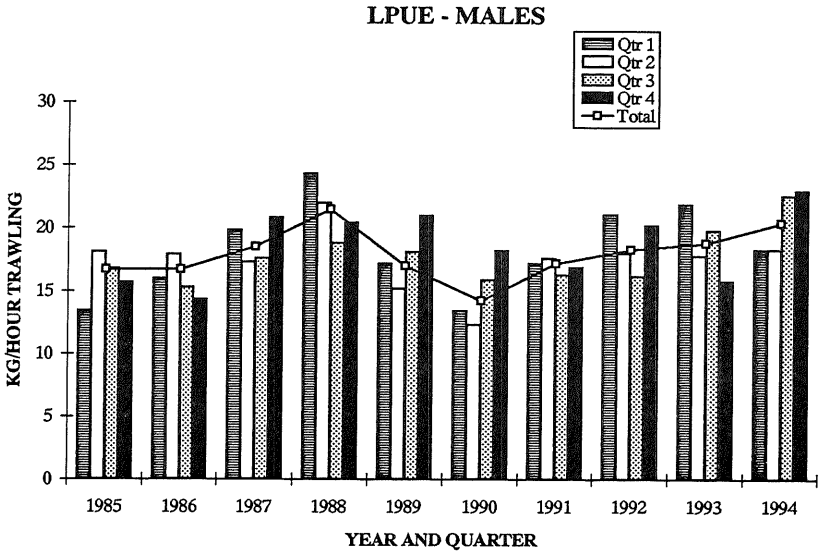


Figure 5.10.4 South Minch (FU12): Long term trends in Scottish Nephrops trawler landings (tonnes), effort ('000 hours), LPUE (kg/hour) and mean size (mm CL) in catch and landings.







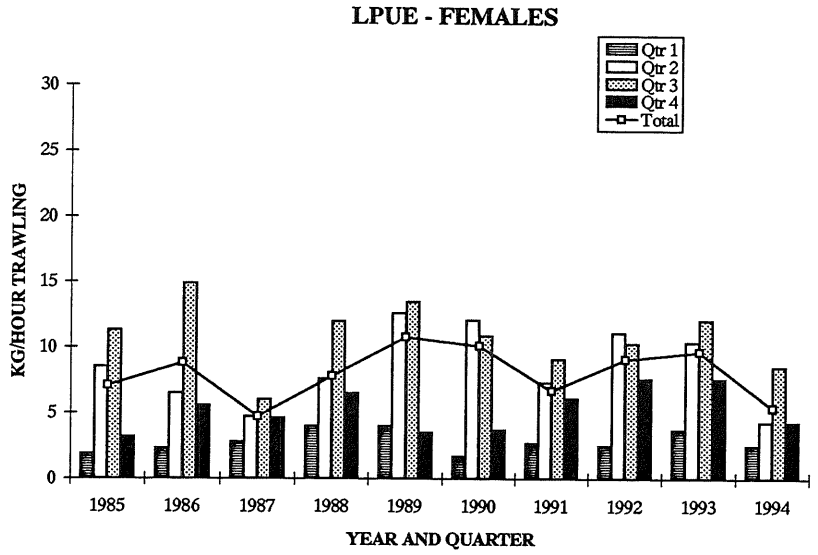
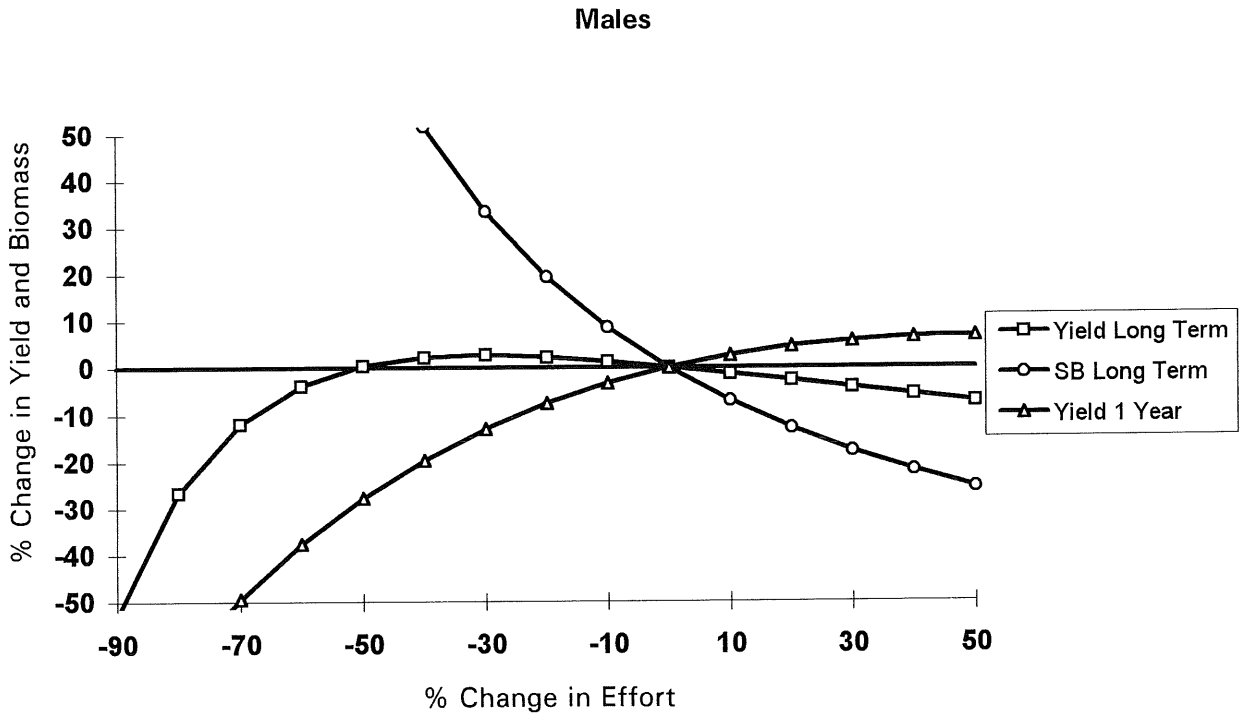


Figure 5.10.5. South Minch (functional unit 12) : trends in landings,effort and LPUE by quarter and sex from Scottish Nephrops trawlers.



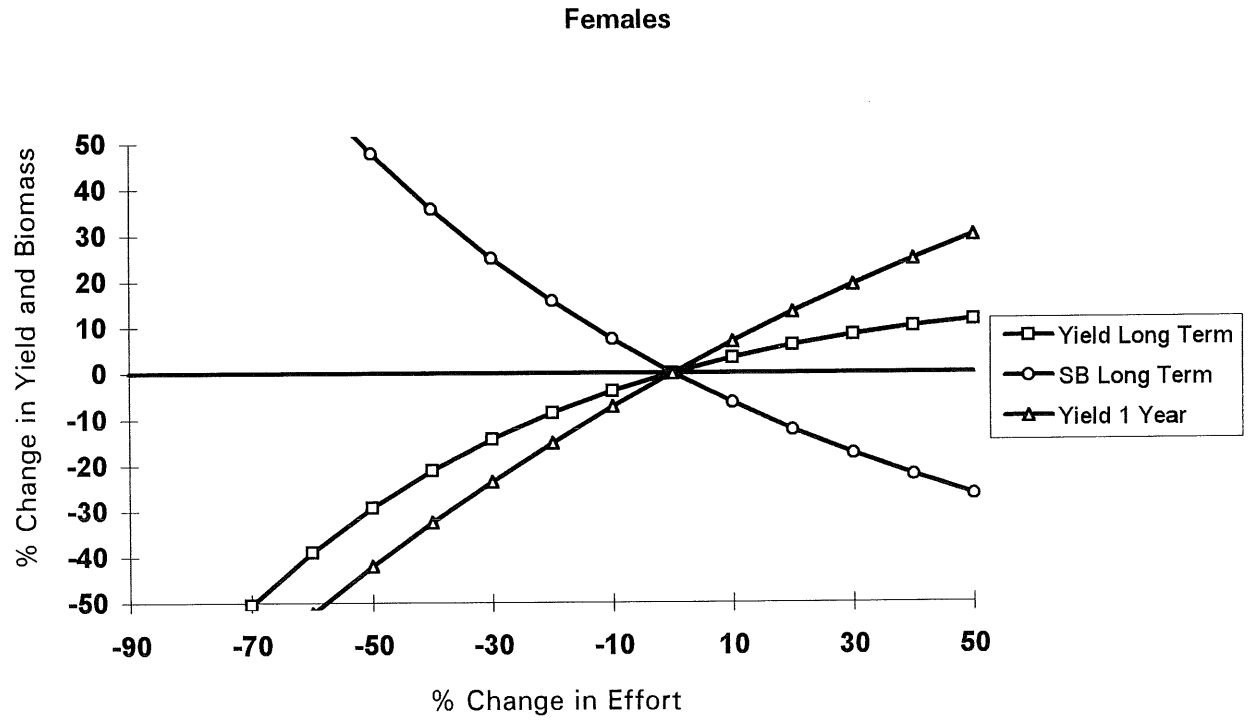


Figure 5.10.6 South Minch (FU12): Percentage changes in long term landings and stock biomass, and short term landings following various changes in fishing effort. Males and females shown separately.

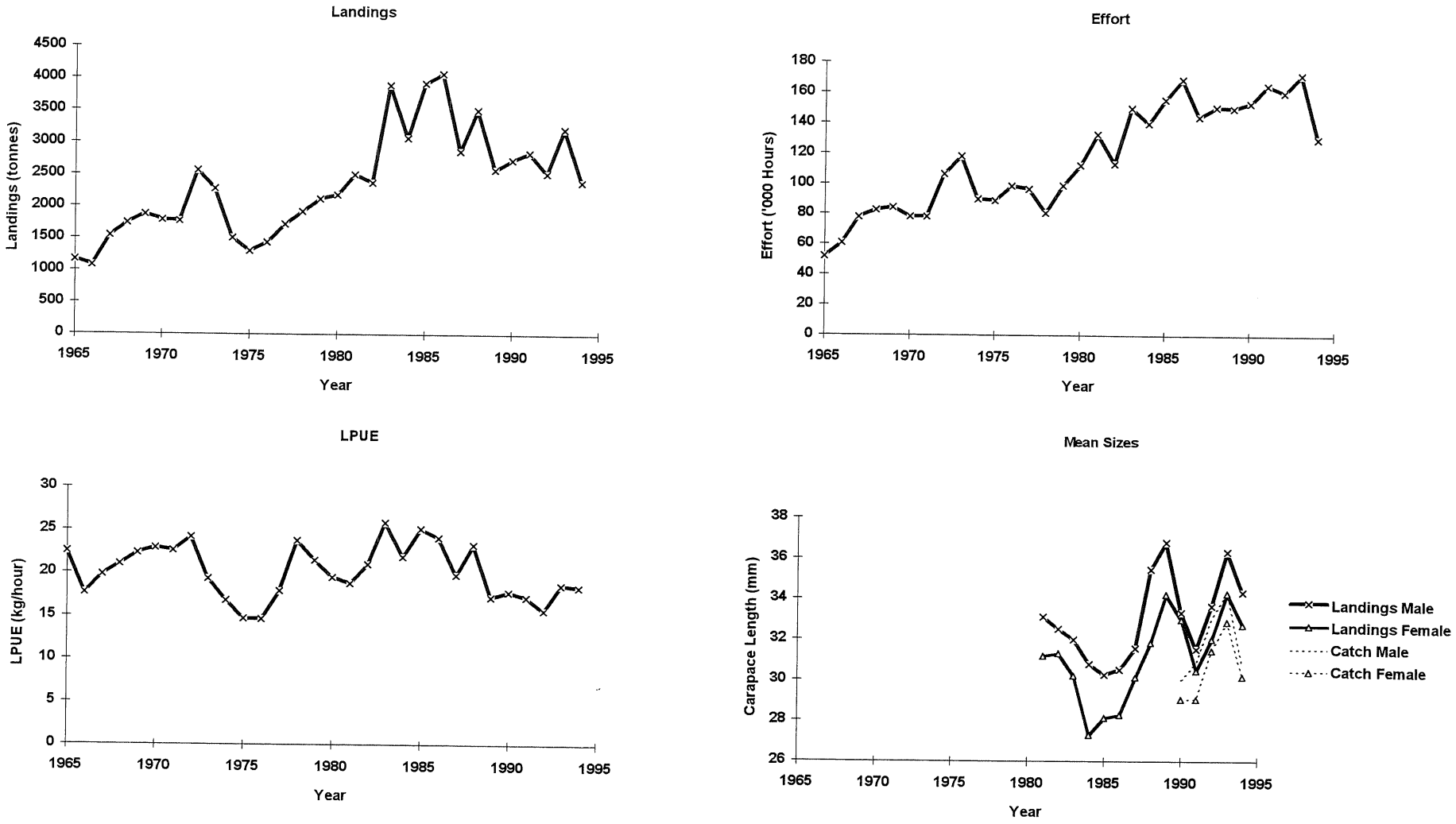


Figure 5.10.7 Firth of Clyde(FU13): Long term trends in Scottish Nephrops trawler landings (tonnes), effort ('000 hours), LPUE (kg/hour) and mean size (mm CL) in catch and landings.

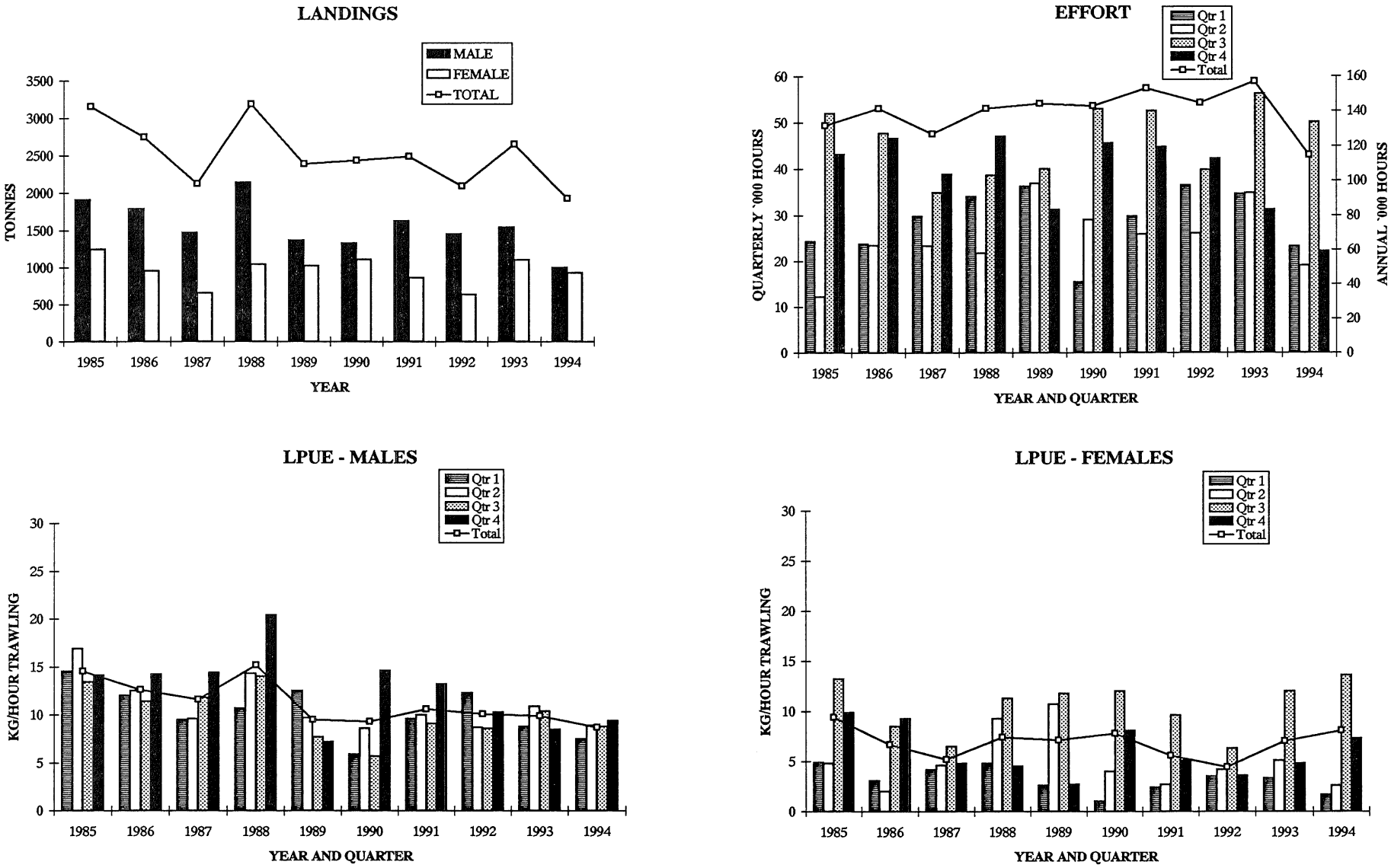


Figure 5.10.8. Clyde (functional unit 13) : trends in landings,effort and LPUE by quarter and sex from Scottish Nephrops trawlers.

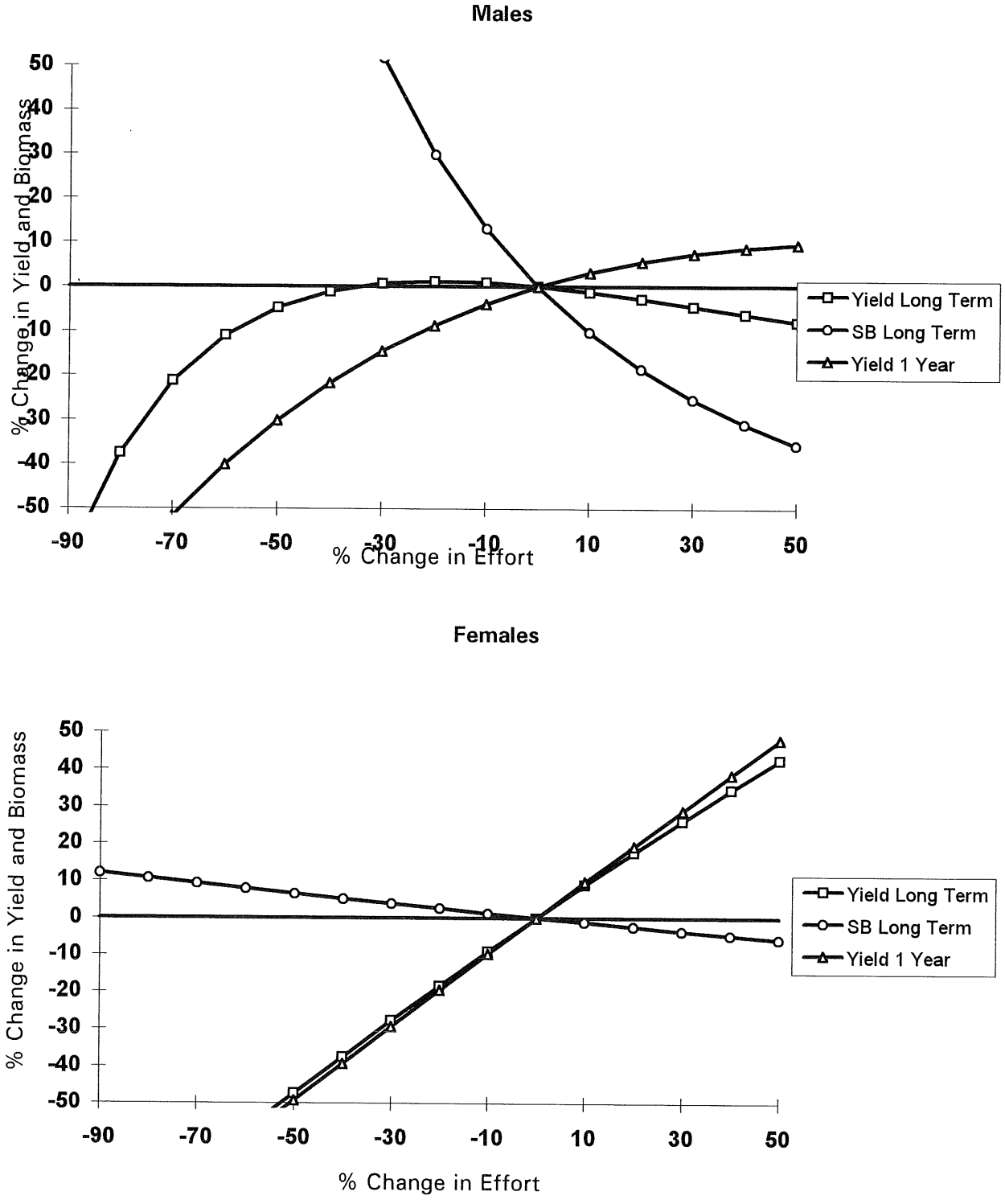


Figure 5.10.9 Firth of Clyde (FU13): Percentage changes in long term landings and stock biomass, and short term landings following various changes in fishing effort. Males and females shown separately.

Figure 5.10.10 Firth of Clyde (FU13) Males - Log Catchability Residuals (Laurec- Shepherd method)

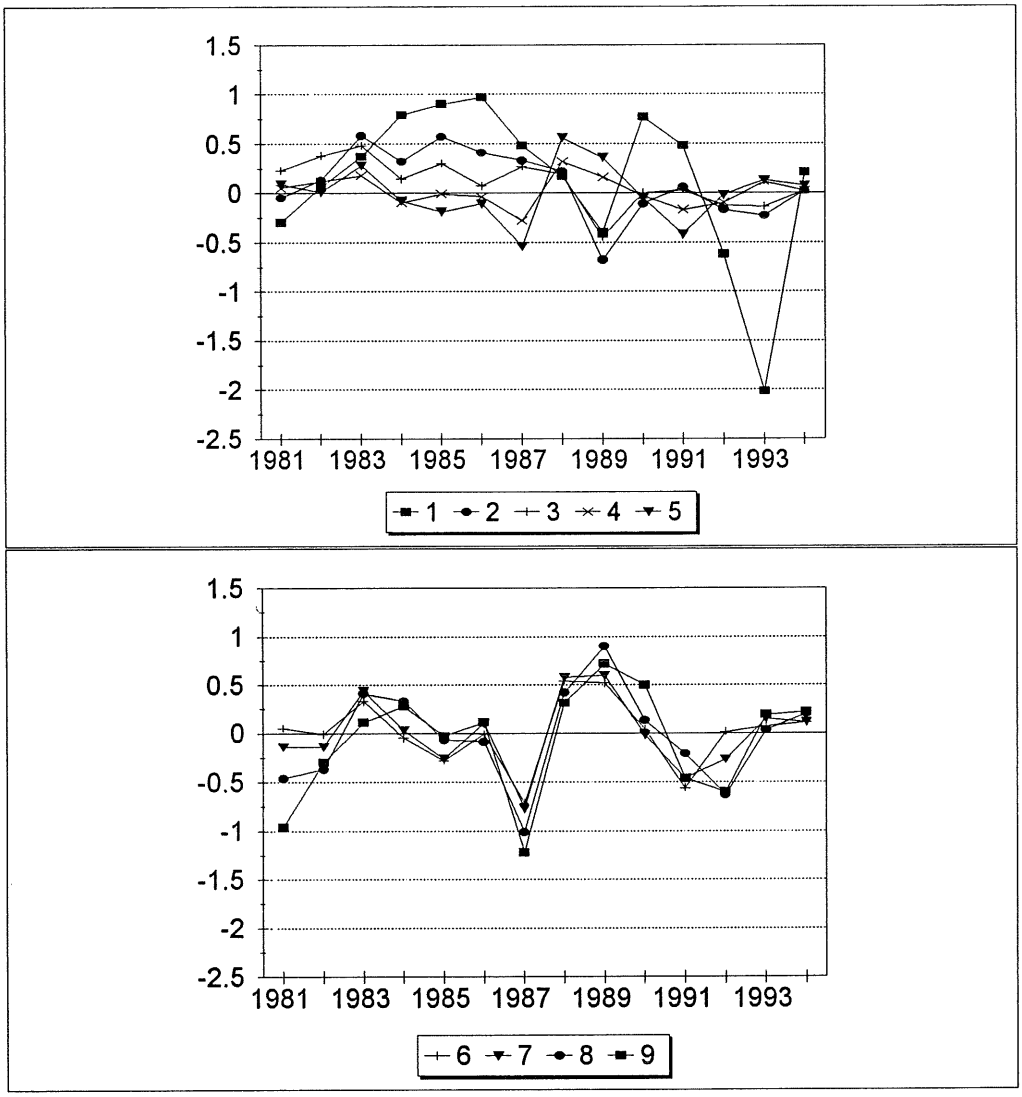
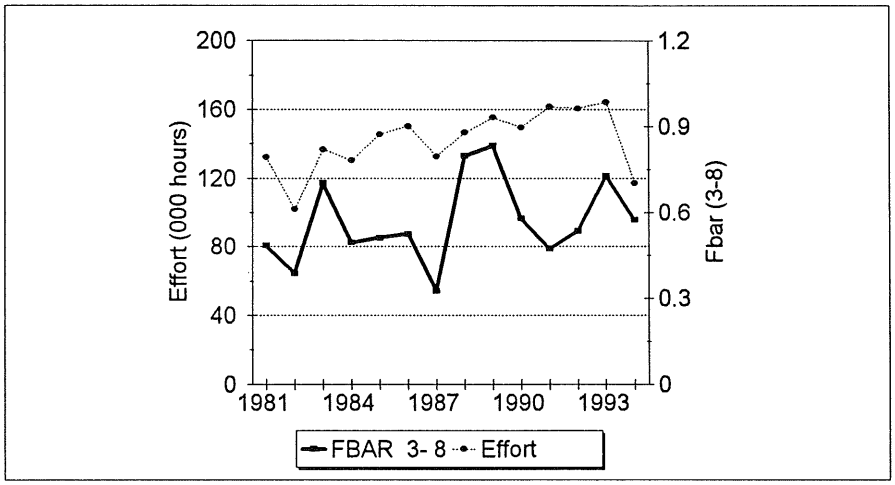


Figure 5.10.11 Firth of Clyde (FU13) Males - Fbar and Effort and relationship between them



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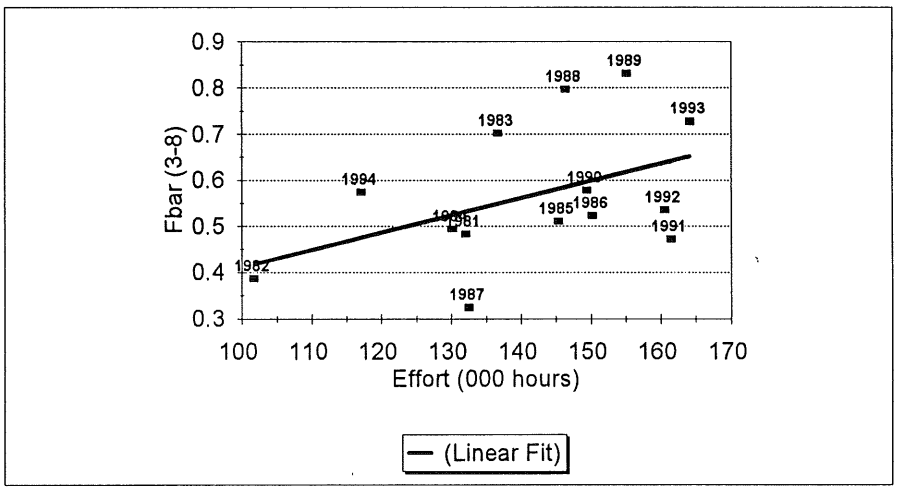
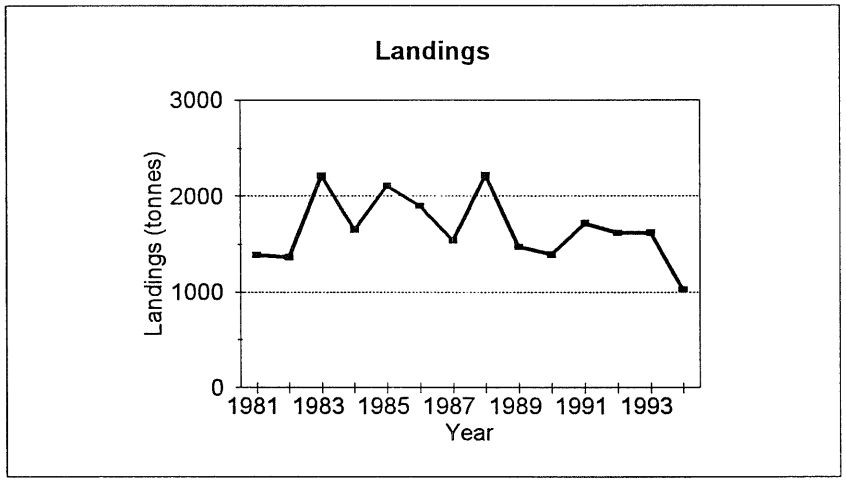
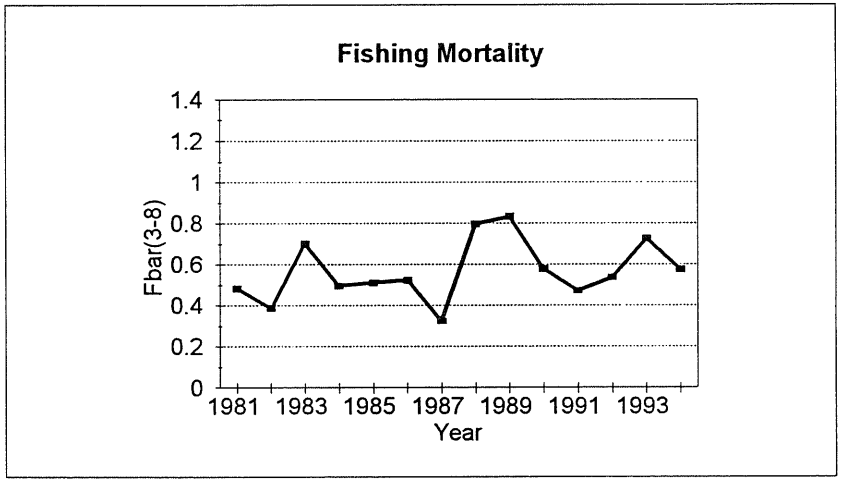
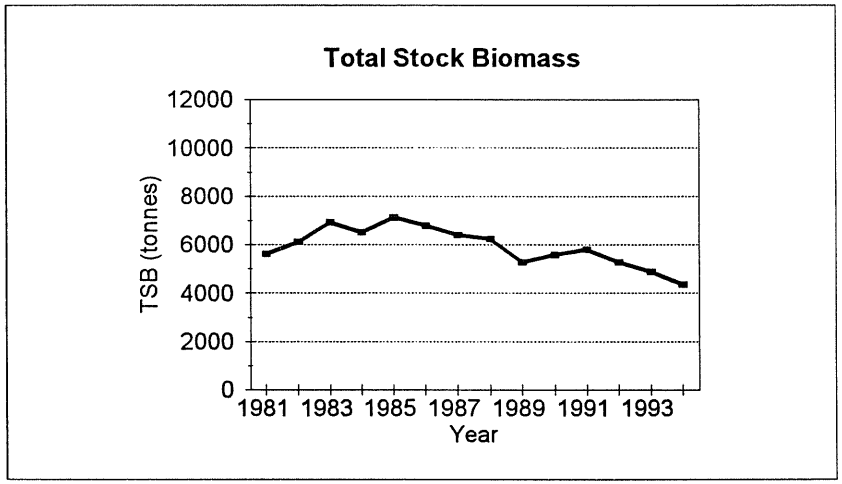


Figure 5.10.12 Firth of Clyde (FU13) Males - Trends in Landings, Fishing Mortality, Total Stock Biomass and Ln Recruits from XSA







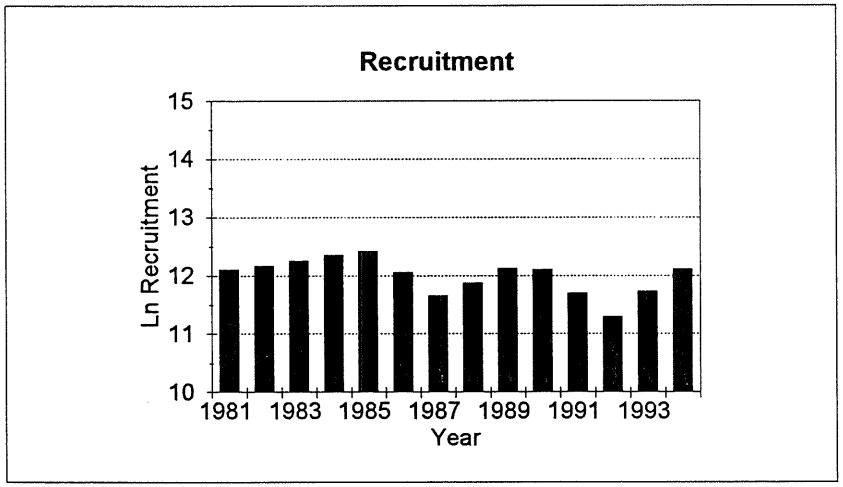


Figure 5.10.13 Firth of Clyde (FU13) Females - Log Catchability Residuals (Laurec-Shepherd method)

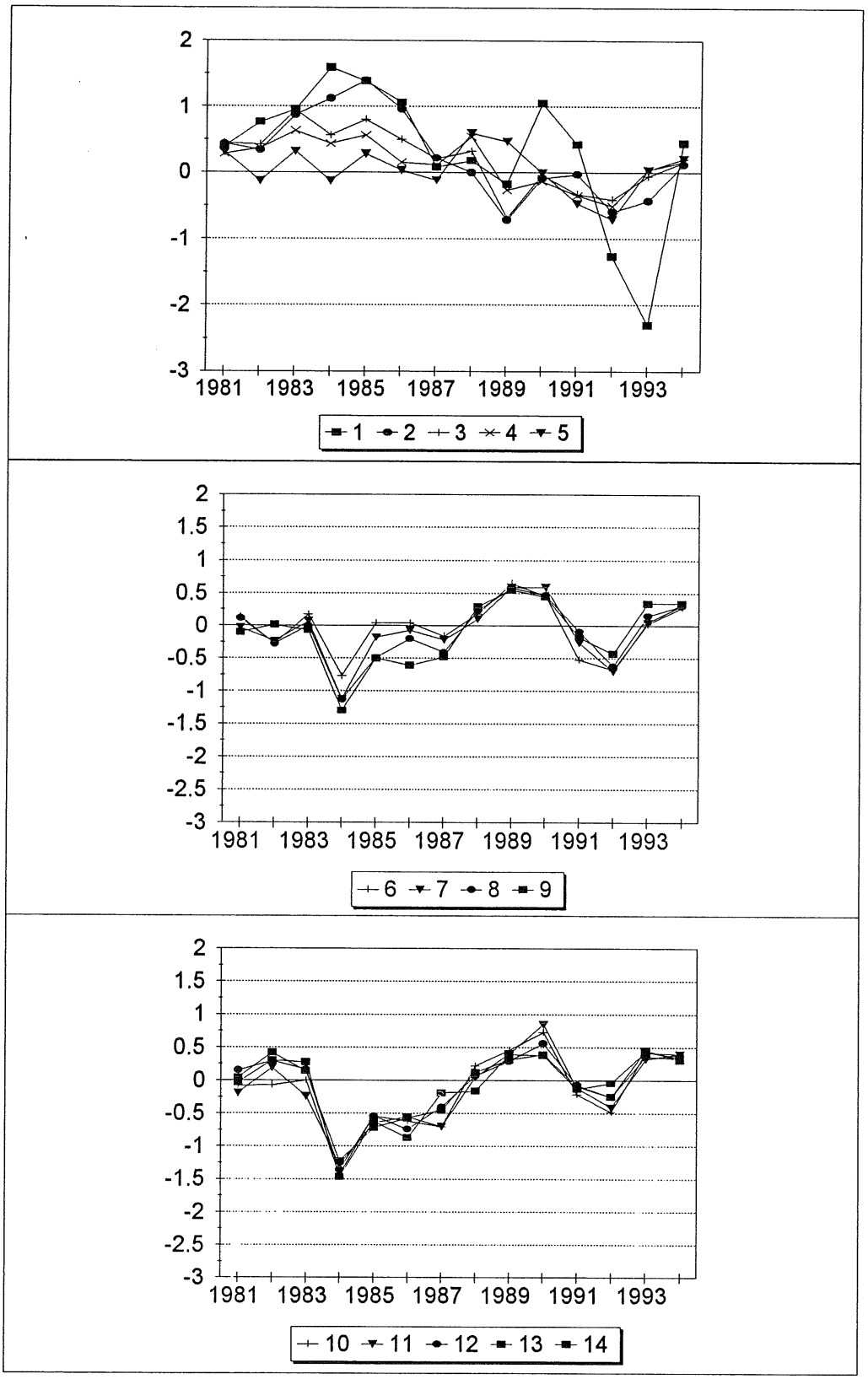
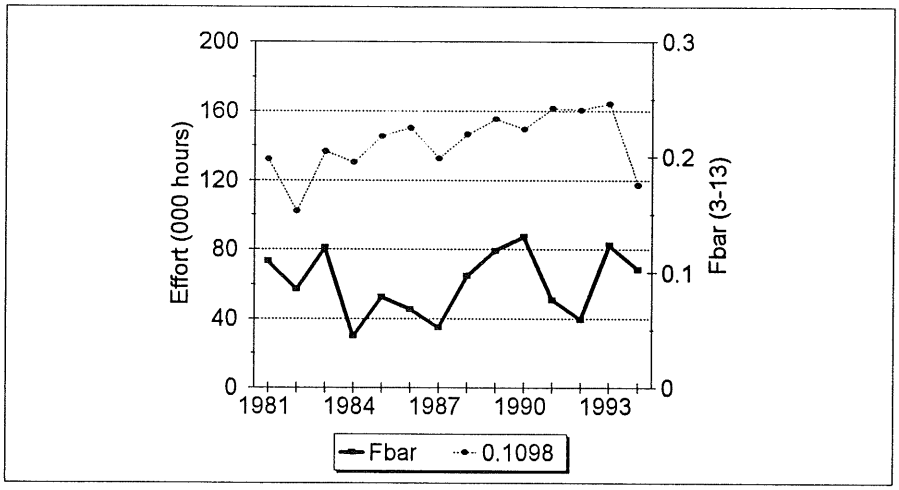


Figure 5.10.14 Firth of Clyde (FU13) Females - Fbar and Effort and relationship between them



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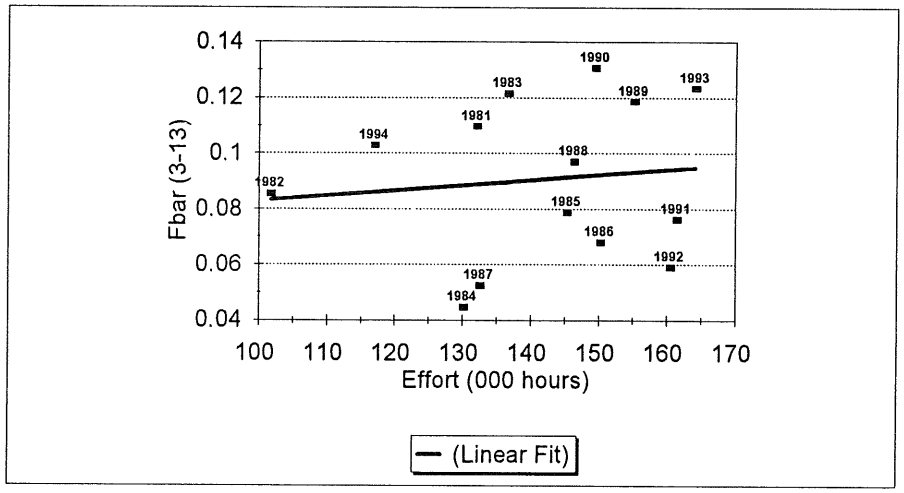

Figure 5.10.15 Firth of Clyde (FU13) Females - Trends in Landings, Fbar, Total Stock Biomass and Ln recruits from XSA