Advisory Committee on Fishery Management

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Report of the Working Group on *Nephrops* Stocks

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Part 2

Not to be quoted without prior consultation with the General Secretary

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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5.12. Management Area J

ICES description **VIIa North of 53° N**

Functional Units **Irish Sea East (FU 14)**
Irish Sea West (FU 15)

The statistical rectangles comprised in this Management Area and its constituent Functional Units are shown in Figure 5.1.2.

5.12.1. Irish Sea East (FU 14)

Description of the fisheries

UK - England, Wales, Northern Ireland

Since 1996, between 70-80 vessels (mainly side-trawlers) have consistently been fishing the eastern Irish Sea for *Nephrops*. Around 30 of these vessels, between 9 and 22 m in length, have their home ports in Whitehaven, Maryport and Fleetwood, England. The rest of the fleet is made up of generally larger vessels from Kilkeel, Northern Ireland, with a few boats visiting from Belgium and Scotland. 70 % of the landings from this fishery are to Whitehaven and 25 % to Maryport. Nearly half of the Northern Irish and a few of the English vessels use twin-rigged gear. This gear has an 80 mm mesh in the codend and is limited to vessels with higher engine power. Vessels operating single *Nephrops* otter trawls, use 70-80 mm mesh in the codend.

Vessels spend 1-3 days at sea if the catch is iced. Around 6 vessels in the fleet are refrigerated and can stay out for 4-5 days. The English and Northern Irish vessels generally fish dawn, midday and dusk tows of between 4 and 5 hours each.

The minimum landing size for *Nephrops* in the Irish Sea is 20 mm CL, so little of what is caught is discarded. Any discarding will be based on size and quality. The landings are generally sorted into three categories: two categories of good-quality whole *Nephrops* and one category of tails. The tailing is done at sea and includes the poorer quality and smaller *Nephrops*, and can include some undersized animals. The fishery is market driven and, at present, there appears to be market pressure to land whole and live *Nephrops*, the market price being around £ 18 per stone for tails (1 stone = 14 pounds = 6.4 kg), and £ 16 per stone for whole *Nephrops*. *Nephrops* are generally landed straight to merchants, who move them on to processors, but some categories may be auctioned at Fleetwood. There is very little evidence of 'black' landings.

During the main season (April-September), the vessels will target *Nephrops* depending on catch rates, weather and tides. Plaice and whiting make up the majority of the by-landings, but cannot compete in value on these grounds. In other months, most vessels switch to other species. A few join the winter *Nephrops* fishery in the Farn Deeps.

There has been little change in the fishery in the last 10 years. Twin-rigs were introduced in 1993-94. At first, the number of vessels adopting this gear increased, but in the last three years it has remained stable. The Northern Irish fleet was reduced by around one fifth in 1996-97 through decommissioning.

Trends in landings, effort, LPUE and mean size

Table	5.12.1.	Landings by country, 1989-98
Table	5.12.2.	Effort and LPUEs UK fleet, 1989-98
Table	5.12.3.	Mean sizes of Nephrops in catches and landings, UK data, 1989-98
Figure	5.12.1.	Long-term trends in landings, effort, LPUE and mean size, UK data
Figure	5.12.2.	Landings by sex + Quarterly plots of effort and LPUEs by sex, 1989-98
Figure	5.12.3.	Quarterly plots of LPUEs for selected size groups, 1989-98
Figure	5.12.14.	Fishing intensity indices

Landings and effort

The international landings of 586 t in 1997 were the highest since 1993 (Figure 5.12.1.), while in 1998 landings fell to 364 t, the lowest landings for this FU since 1974 and some 33 % below the 1989-98 average of 547 t. Most of these landings were made into England, with a high proportion (60 % of the directed landings and 45 % of the total landings) being made by visiting Northern Irish vessels. In 1998, landings were made from March to June, and the fishery virtually stopped in June and July. Landings and effort returned to expected levels in September. Since 1994, the sex ratio of the landings has changed from a ratio close to 1:1 to a ratio of 3:1 dominated by males (Figure 5.12.2.).

The 1998, directed fishing effort (13.9 10^3 hours trawling) was the lowest of the past 10 years. It accounted for 86 % of the total landings into England, and was 25 % below the 1989-98 mean of 18.5 10^3 hours trawling (Figure 5.12.1.).

The quarterly effort plots show a decline in effort in the 3rd quarter since 1996. In 1998, directed effort in the 3rd quarter (2.1 10^3 hours trawling) was 73 % below the 1989-98 mean of 7.7 10^3 hours trawling. This decline was accompanied by an increase in effort in the 1st and 2nd quarter and in the preceding 4th quarter.

LPUE

The LPUE series are based on a combination of directed *Nephrops* voyages by English and Welsh vessels landing to Fleetwood and Whitehaven, where the weight of *Nephrops* landed is more than 25 % of the total landing, and all trips by visiting Northern Irish vessels which target *Nephrops*. Although landings to Maryport have substantially exceeded landings into Fleetwood in recent years, current definitions of 'directed' stand for this WG, for continuity of the LPUE series.

LPUE, based on *Nephrops*-directed voyages, has fluctuated between 17 and 26 kg/hour trawling in the last 10 years, a level well below that achieved in the period 1976-86 (Figure 5.12.1.). Since 1986, the annual LPUE has fluctuated around an upward trend, despite a slight decline in directed landings and effort.

The highest male LPUEs are usually in the 1st, 2nd and 3rd quarter, while females have the highest LPUEs in the 3rd quarter, between hatching and spawning (Figure 5.12.2.). The LPUE trends show an increase for males and a decline for females.

The quarterly LPUE figures were truncated to show the LPUEs for *Nephrops* above and below 35 mm CL (Figure 5.12.3.). Most discards are smaller than 35 mm CL. General trends of increase are apparent in both sets of male LPUEs. The LPUEs for the smaller females seem to be relatively stable, fluctuating around an average of 3.7 kg/hour trawling. The trend for the larger females shows a steady decline, indicating that the decline in overall female LPUE could be driven by the larger females. The decline in the LPUE of larger females is consistent with the reduction in effort in the 3rd quarter and the increase in effort in the winter/spring period from 1995/96 to 1997/98. The mean size of females in the 3rd quarter is consistently higher than in other quarters (see below). This would also explain the change in the sex ratio highlighted earlier.

Mean size

Since 1996, the mean sizes of males and females in the landings have declined to 32.6 and 28.7 mm CL respectively (Figure 5.12.1.). The same trends are observed in the mean sizes estimated for the catches and the discards. This decline is consistent with the reduction in landings and effort in quarter 3, when the mean size of females is larger (see above). There appears to be a slight decline in quarterly mean size for both sexes, but this could be an effect of a change in effort distribution, a change in discarding practices or good recruitment.

Data and biological inputs for analytical assessments

Table 5.12.4. Sampling data and input parameters

Landings, effort statistics and length compositions of landings were available for 1997-98.

General comments on quality of data and inputs

The quality of statistics collection was believed to be similar to previous years. Since *Nephrops* is a TAC species, the UK Fisheries Inspectorate attempts to census the landings and effort of all vessels landing in the UK. There is no evidence to suggest that fishermen do mis-report their landings.

Only 8 and 9 samples of the landings were taken in 1997 and 1998 respectively. There was no discard sampling, so discards for 1997-98 were estimated using 1994 discard data, by means of the same method that was used to estimate the 1995-96 discards in the previous assessment (ICES, 1997a).

Discard mortality, natural mortality, length-weight relationships, and size at 50 % maturity are based on Irish Sea biological studies. Growth inputs are based on values estimated for the western Irish Sea, with some adjustment (referring to comparable Scottish stocks) to take account of the larger size distribution of *Nephrops* in the eastern Irish Sea.

Length based assessments (LCA)

The five years' reference period of 1994-98 was chosen because of the drop in LPUE in 1998 and the relative stability in the fishery in the previous four years. The LCA was updated with the 1997-98 landings and estimated discard data. Owing to the uncertainty over the fate of the discards in the Irish Sea East *Nephrops* fishery (see Section 4.3.), the discard survival rate was set to zero. This is the 'worst case scenario' and was considered to be the safest course of action.

Compared with the previous assessment (ICES, 1997a), the addition of the 1997-98 data has made only small changes in the Y/R curves. The male long-term Y/R curve is very flat topped, with current F near F_{max}, an improvement on the results from the previous assessment (ICES, 1997a). The females long-term Y/R curve is also flat topped with current F below F_{max}. Annualised mean F values for the inter-quartile length range were 0.44 for males and 0.17 for females.

Age based assessments (VPA)

The time series of length compositions of the landings is relatively short and there is a gap with no LF-data for 1989 and 1990. There has been no discard sampling data since 1994. The data were considered to be inadequate for an annual age-based assessment.

Comments on quality of assessments

Sampling in 1997 and 1998 was poorer than in previous years, even though samples of landings were available for each quarter of the year in 1998. The data series is still fragmented, with discard data only collected for the period 1991-94. The quality of some of the biological data is dependent upon inputs from other functional units.

As the long-term Y/R curves are flat-topped, Y/R is rather insensitive to relatively large changes in fishing effort. Nevertheless, the LCA is considered to provide an acceptable guide on the overall state of exploitation of this FU, since only major changes to the length data or biological inputs would be likely to change the perception of the state of exploitation and influence the choice of appropriate management measures.

More adequate sampling of landings and discards is needed in this area to provide a longer and better data series for assessment.

Management considerations

The LCA results show that current exploitation is close to F_{max} for males and below F_{max} for females. The trends in LPUE and mean size are consistent with a change in distribution of effort. There has been higher effort exerted on the smaller sizes in the population. The WG recommends that effort should not be increased above the present level and that the fishery should be closely monitored.

5.12.2. Irish Sea West (FU 15)

Description of the fisheries

Northern Ireland

In 1991, the Northern Ireland *Nephrops* fleet operating in the Irish Sea consisted of 230 trawlers of over 10 m length and with an engine power of 200-500 hp. The vessels used single net otter trawls of low headline height (< 1.5 m) and the same mesh size throughout. The minimum mesh size was increased to 70 mm in the mid-80s, and has remained at this size ever since. Recent studies have confirmed that 70 mm is the most appropriate minimum size for *Nephrops* in the Irish Sea (BRIGGS, *et al.,* 1999). The mesh size regulation is underpinned by a minimum landing size of 20 mm CL.

Vessels normally do 1-2 day trips during which 4-7 tows of 4-5 hours each are made. Over the seven year period from 1992 to 1998, there were 6 decommissioning rounds in Northern Ireland. These removed 56 vessels from the fleet traditionally associated with *Nephrops* fishing, leaving a fleet of 174 vessels at the end of December 1998. This marked an important effort reduction in the Irish Sea which has been offset, to some extent, by an increasing trend in the use of twin-trawls for *Nephrops* fishing, particularly since 1993. There are now up to 40 vessels working twin-trawls for *Nephrops* for part of the year, and semi-pelagic gear in a whitefish directed fishery for the rest of the time. Twin-trawl vessels tend to be larger and have higher engine power (400 hp and above) than those using single trawls.

Landings are into the three traditional Northern Ireland ports of Kilkeel, Ardglass and Portavogie. Historically, *Nephrops* were landed into Northern Ireland as tails only and sold to supply the lucrative 'scampi' industry for consumption at home and abroad The scampi industry requires a sustained supply of small *Nephrops*, which are homogenised and coated in breadcrumbs to produce the popular product. In the last 10-15 years, however, the trend has been towards landing whole large *Nephrops* for the export market. In 1997 and 1998, 27 % and 31 % of the *Nephrops* were landed whole.

In addition to the valuable *Nephrops* fishery, which represents about 50 % of the combined value of all the Northern Ireland sea fisheries, there is an important by-catch component for a range of species, with haddock, whiting and cod ranking as the most important. In an attempt to remedy the discard problem with juvenile whiting, legislation has been introduced stipulating that square mesh escape panels must be inserted in the top sheet of *Nephrops* trawls for use in the Irish Sea (BRIGGS, 1992).

Republic of Ireland

FU 15 contains the largest *Nephrops* fishery in the Republic of Ireland. There are 90-100 boats based there, the smaller ones being mostly side trawlers and the larger ones stern trawlers. Engine power ranges from 110-450 kW.

60-80 boats use twin-rigged trawls. The minimum mesh size in use is 80 mm, except when square meshed panels are used, in which case 70 mm is allowed. Few boats however, favour the latter option.

The main landing ports are Howth, Clogherhead, Skerries and Balbriggan. A small proportion of the landings into Howth, however, originates from FUs 20-22, more particularly from the Smalls grounds.

Trip duration is 1-5 days, depending on the size of the vessel. The twin-rig boats, which are on average the largest, make 3-4 tows of about 5 hours each during a 3-5 day trip. Single-rigged boats, which are generally smaller, make 4 hour tows during 1-3 day trips.

The average size of *Nephrops* in FU 15 being very small, comparatively high proportions are discarded – in 1997 and 1998, 30 % and 33 % respectively by number, and 18 % and 20 % respectively by weight. This fishery was traditionally notorious for the high numbers of immature whiting discarded, but this has not been a major problem in recent years due to the relatively large size of mesh used to fish for *Nephrops*. The large *Nephrops* are landed whole and the small ones usually in the form of tails, both categories fresh and iced, and are sold in these categories.

Most of the larger boats move freely between the *Nephrops* and whitefish fisheries, the latter fishing for cod, whiting, plaice, and in recent years, increasing amounts of haddock, hake and monkfish. Most smaller boats target *Nephrops* permanently, due to their lacking the power to fish effectively for whitefish. Boats fishing primarily for *Nephrops*, take important by-catches of whiting, cod and other demersals; when they are targeting whitefish, *Nephrops* can be an important by-catch species, particularly if fishing is taking place on *Nephrops* grounds (grounds with suitable sediment for *Nephrops*, which occupy a large part of the western Irish Sea). There is also an inter-port difference, with Clogherhead, Skerries and Balbriggan being *Nephrops* specialist ports, while the Howth based fleet pursues much more a mixed fishery.

The most notable change in the fishery over the last 10 years is the progressive move from single to twin-rigging. The fishery had poor years in the early 90s but had two good years in 1997 and 1998, possibly due to decreased overall effort as a result of decommissioning.

Trends in landings, effort, CPUE, LPUE and mean size

Table	5.12.7.	Landings by country, 1989-98
Table	5.12.8.	Catches, landings, effort, CPUEs and LPUEs Northern Irish fleet, 1989-98
Table	5.12.9.	Mean sizes of Nephrops in catches, landings and discards, Northern Irish data, 1989-98
Table	5.12.10.	Mean sizes of Nephrops in catches, landings and discards, Rep. of Ireland data, 1989-98
Figure	5.12.5.	Long-term trends in landings, effort, CPUE, LPUE and mean size, various data
Figure	5.12.6.	Landings by sex + Quarterly plots of effort and LPUEs by sex, 1989-98
Figure	5.12.14.	Fishing intensity indices

Landings, effort, CPUE and LPUE

Total international *Nephrops* landings from FU 15 in 1997 and 1998 were 9923 t and 9058 t respectively, which are the highest over the reference period (1989-98). Landings by UK vessels into Northern Ireland were 6598 t and 6026 t for the two years, which was about two thirds of the international landings in these years. Northern Ireland landings represented over 95 % of the total UK landings from this FU in both years. Republic of Ireland landings recovered from the low 1996 value of 1611 t (revised figure) to 3318 t in 1997, and a provisional 3007 t in 1998.

Effort data for the Northern Ireland fleet show a downward trend since 1991 (Figure 5.12.5.). This drop is mainly due to the decommissioning of Northern Ireland vessels described above. Another factor affecting effort in the Irish Sea is the change to twin-trawl gear. Some of these twin-trawl vessels do occasional voyages to grounds outside the Irish Sea, e.g. in the Celtic Sea (FUs 20-22). Although there are no effort data for the Republic of Ireland, it is likely that fluctuations in landings in recent years reflect changes in effort.

CPUEs and LPUEs for the Northern Ireland fleet, show an increasing trend, with the 1997 and 1998 values being the highest over the reference period. It is possible that this recent increase may be inflated due to the greater efficiency of the twin-trawl vessels. It was not possible to reliably disaggregate the single and twin-trawl CPUE data, but it is hoped that this might be achieved for a future meeting.

A more detailed analysis of effort data and CPUEs by sex is shown in Figure 5.12.6. Analysis of quarterly Northern Ireland effort data showed effort to be high during the summer months when female *Nephrops* are most available for capture. Annual CPUEs are therefore only comparable if the seasonal distribution of effort is constant, as discussed in the *Nephrops* Study Group Report (ICES, 1994b).

Mean size

The mean sizes of *Nephrops* in the catches (= landings plus discards) of both the Northern Ireland and the Republic of Ireland fisheries have fluctuated without obvious trend since the beginning of the time series in the mid-80s (Figure 5.12.5.).

Data and biological inputs for analytical assessments

Table 5.12.11. Sampling data and input parameters

As in 1997, the data used for the assessment of FU 15 were numbers of *Nephrops* landed, caught and discarded in samples taken by Northern Ireland and the Republic of Ireland. These data were raised to total numbers, using the international landed tonnage.

Trial analytical assessments were performed for male *Nephrops*, using new growth parameters generated from survey data by means of the Multifan deconvolution programme, as detailed in the text table below.

Parameter	'Traditional' value	Multifan value
Growth K	0.16	0.24
Growth Linf	60 mm CL	50.3 mm CL

Apart from this trial assessment, there were no changes to the biological input parameters compared with the previous assessments (see e.g. ICES, 1997a).

Northern Ireland sample data

The LFDs of *Nephrops* landed as tails for the scampi market were obtained by sampling the discarded heads from samples taken at sea on commercial vessels. Details of sampling and raising procedures are described in the 1996 *Nephrops* Study Group Report (ICES, 1996b).

Republic of Ireland sample data

Nephrops samples continued to be collected in four or five parts: unsorted catch, undersized whole discards, discarded 'heads' of *Nephrops* landed as tails, whole 'jumbo' (large) *Nephrops*, and occasionally (when they were not being tailed) small whole *Nephrops*. Since it is difficult to ascertain from the landings statistics what proportion of the *Nephrops* landed whole are small, the discarding ogive from samples of whole discards and heads was used to divide the sample of unsorted catch into discarded and landed portions. LFDs were obtained for males, and for immature, maturing, and mature non-ovigerous and ovigerous females.

General comments on quality of data and inputs

Although effort data were available for Northern Ireland vessels, there is continued concern that a move to the more efficient twin-trawl gear by some vessels may have caused artificial inflation of the CPUE values (see above). Sampling of catches, landings and discards by Northern Ireland was sustained during 1997 and 1998 as in earlier years.

For the Republic of Ireland, the quality of landings statistics is believed to be similar to those presented in 1997. Landings are now available by statistical rectangle, which allows landings into the same port from different fishing areas to be distinguished. The procedure used for calculating the weight in a FU, is obtained by summing the weight of *Nephrops* landings, including tail weights (x 3) for all rectangles in the FU. The official weight of *Nephrops* landings reported from port returns (Declarations Total) is then divided by the operations total to obtain a correction factor which is applied to the FU total to make the sum of all rectangles in the ICES Division equal to its Declarations Total.

Discard mortality, natural mortality, size at maturity and growth parameters are based on Irish Sea biological studies, while length/weight relationships are derived from Scottish data (Table 5.12.11.). Recent studies (BRIGGS, unpublished) confirm that these relationships are appropriate for Irish Sea stocks.

Length based assessments (LCA)

Table	5.12.12.	Output table LCA males, with mean F - with 'traditional' growth parameters
Table	5.12.13.	Output table LCA males, with mean F - with Multifan generated growth parameters
Table	5.12.14.	Output table LCA females, with mean F
Figure	5.12.7.	Changes in Y/R and B/R upon changes in F, males and females separately - with 'traditional' growth parameters
Figure	5.12.8.	Changes in Y/R and B/R upon changes in F, males only - with Multifan generated growth parameters

A length based assessment was performed on combined LFDs (= Northern Ireland plus Republic of Ireland data) of males and females, averaged over the period 1996-98. This was considered to be a period of steady state.

The Y/R curves for males and females are similar to those generated by earlier assessments, and are relatively flat-topped with current F above F_{max} for both sexes (Figure 5.12.7.). Mean F, averaged across the inter-quartile length range was 0.64 for males and 0.55 for females (Tables 5.12.12. and 5.12.14.).

The results from the trial LCA on male *Nephrops*, using new growth parameters generated by Multifan slicing of survey data, did not strongly conflict with those from the LCA with the 'traditional' input parameters. The new growth parameters gave a mean F of 0.45 (Table 5.12.13.) and suggested that the current level of effort is at F_{max} (Figure 5.12.8.).

Age based assessments (VPA)

The size composition data from Northern Ireland and the Republic of Ireland fisheries were combined and raised to provide an 'international' *Nephrops* size composition. Total removals were calculated as landings plus 90 % of discards, assuming a discard mortality of 90 % (also see Section 4.3.). Total removals were sliced into nominal 'ages', using the L2AGE program.

The Northern Ireland CPUE data were used to tune the VPA, performed on the age compositions of males and females separately. Both male and female VPA were run on 7 age classes and a plus group.
As with the length based assessments, a trial assessment was performed on male *Nephrops*, using the new growth parameters generated by Multifan.

Males

Table	5.12.15.	Output XSA males: Fs-at-age - with 'traditional' growth parameters
Table	5.12.16.	Output XSA males: Fs-at-age - with Multifan generated growth parameters
Table	5.12.18.	Output XSA males: Long-term trends in landings, Fbar, TSB, recruitment - with 'traditional' growth parameters
Table	5.12.19	Output XSA males: Long-term trends in landings, Fbar, TSB, recruitment - with Multifan generated growth parameters
Figure	5.12.9.	Output XSA males: Log catchability residuals - with 'traditional' growth parameters
Figure	5.12.11.	Output XSA males: Long-term trends in landings, Fbar, TSB, recruitment - with 'traditional' growth parameters
Figure	5.12.13.	Output XSA males: Plots of Fbar vs. effort - with 'traditional' growth parameters

The log catchability residuals did not show particular trends (Figure 5.12.9.). The outstanding residual for age 1 in 1998 is considered to be due to an anomaly in the sample data.

Stock biomass has increased in the early 90s but seems to be fairly stable now (Figure 5.12.11.). Recruitment has fluctuated considerably over the reference period (albeit without obvious trend), with the highest values in the early and mid-90s. F_{bar} on the males is generally high, fluctuating between 0.60 and 1.20, with an average of 0.88 (1986-98). Although F_{bar} has slightly increased in 1997 and 1998, the values are still far below the peak values observed in the late 80s and early 90s.

The correlation between F_{bar} and fishing effort is not significant ($r = 0.23$; $p > 0.05$) (Figure 5.12.13.).

The trial assessment using the new growth parameters generated by Multifan sliced the length composition into 6 nominal 'ages' and a plus group, and gave lower estimates of F_{bar} (see Tables 5.12.18. and 5.12.19.). Biomass and recruitment estimates too were generally slightly lower, but followed similar trends to those given by the XSA using the 'traditional' growth parameters.

Females

Table	5.12.17.	Output XSA males: Fs-at-age
Table	5.12.20.	Output XSA males: Long-term trends in landings, Fbar, TSB and recruitment
Figure	5.12.10.	Output XSA males: Log catchability residuals
Figure	5.12.12.	Output XSA males: Long-term trends in landings, Fbar, TSB and recruitment
Figure	5.12.13.	Output XSA males: Plots of Fbar vs. effort

As with the males, the log catchability residuals showed no marked age or year effects.

Total female stock biomass has been remarkably stable and recruitment has fluctuated without obvious trend over the time series. F_{bar} is lower than for the males, fluctuating between 0.45 and 0.95, and averaging 0.74 (1986-98).

The correlation between F_{bar} and fishing effort is not significant ($r = 0.34$; $p > 0.05$).

Fishery independent methods - Back-calculation of spawning stock biomass

A Northern Ireland co-ordinated study used estimates of larval production to back-calculate the spawning stock biomass of Irish Sea *Nephrops* (see Section 7 for further details). The estimate of female SSB for the western Irish Sea was 6375 t (CV = 0.18) and was similar to the estimates from the WG's assessments based on commercial catch data (ANON., 1999). This suggests that the WG's estimates of female fishing mortality for FU 15 may not be seriously in error.

Comments on quality of assessments

The correlations between F_{bar} and fishing effort were poor for both males and females. A better understanding of effort and refinement of the Northern Ireland effort data by disaggregating single and twin-trawl data, should improve the tuning of the VPA, although it is likely that some of the effort by the more efficient and generally larger vessels is outside the Irish Sea.

There is reasonable agreement between male and female population numbers in the recruiting age classes, suggesting some consistency between the two analyses. Stock biomass estimates from the LCA and the VPA were 12.7 10^3 t and 18.7 10^3 t respectively for the males, and 8.0 10^3 t and 12.2 10^3 t for the females. The male assessments with the Multifan generated growth parameters, estimated stock biomass at 17.4 10^3 t (LCA) and 18.1 10^3 t (VPA) (all figures are means for 1996-98).

The estimates of mean F indicate higher values for males than females, though the VPA gave consistently higher values for both sexes than the LCA.

Management considerations

The LCA gave relatively flat-topped Y/R curves for both sexes and suggests that the current level of F is 30-40 % beyond F_{max} for both males females. However, a reduction of effort to F_{max} would produce large short term losses in yield (> 20 %), with only small long-term gains (< 10 %). Moreover, it is likely that the large predicted increase in stock biomass associated with an effort reduction, would have a negative density effect on growth and reproduction of *Nephrops*.

Although the Northern Ireland effort data were not corrected for the increase in the number of twin-trawl vessels, the considerable reduction in fleet size due to decommissioning suggests that overall effort may have been reduced.

The WG recommends *status quo* management advice for FU 15, even though the methods used indicate relatively high levels of fishing mortality. Sustained catches, stable recruitment and the evidence of an effort reduction provided the basis for this advice. The improved picture demonstrated by the trial assessment on male *Nephrops* using new growth parameters reinforces this advice.

In view of the uncertainties in the assessment, and the increasing use of twin-trawl rigs, it is important that the situation should continue to be closely monitored.

5.12.3. Summary of Management Area J

Table 5.12.21. Landings by FU and from Other rectangles, 1989-98
Table 5.12.22. Landings by country, 1989-98

As the overall advice for both the Irish Sea East (FU 14) and the Irish Sea West (FU 15) is to prevent an effort increase, a TAC of 9400 t is recommended for MA J for the years 2000 and 2001.

Table 5.12.1. - Irish Sea East (FU 14): Landings (tonnes) by country, 1989-98.

Year	Belgium	Rep. of Ireland	Isle of Man	UK	Total
1989	0	7	0	431	438
1990	0	14	0	630	644
1991	1	19	0	840	859
1992	1	11	0	484	495
1993	0	35	0	583	618
1994	0	29	9	476	514
1995	2	22	3	477	504
1996	1	3	2	445	452
1997	1	2	0	582	586
1998 *	1	1	0	362	364
* provisional na = not available					

Table 5.12.2. - Irish Sea East (FU 14): Effort ('000 hours trawling) and LPUE (kg/hour trawling) of *Nephrops* directed voyages by UK trawlers, 1989-98.

Year	Effort	LPUE
1989	18.5	16.6
1990	17.8	24.4
1991	20.0	26.3
1992	18.6	19.8
1993	23.8	18.2
1994	17.8	21.7
1995	21.1	18.6
1996	17.2	22.1
1997	16.7	25.2
1998 *	13.9	19.4
* provisional na = not available		

Table 5.12.3. - Irish Sea East (FU 14): Mean sizes (mm CL) of male and female *Nephrops* from UK vessels landing in England and Wales, 1989-98.

Year	Catch		Landings		Discards	
	Males	Females	Males	Females	Males	Females
1989	na	na	na	na	na	na
1990	na	na	na	na	na	na
1991	30.0	29.5	32.1	33.5	26.9	26.6
1992	30.1	30.5	32.2	32.8	26.9	26.0
1993	31.6	30.6	35.0	34.6	26.7	26.5
1994	33.2	32.3	33.9	32.9	28.2	28.1
1995	32.1 **	31.6 **	32.6	32.1	27.5 **	27.3 **
1996	33.5 **	32.0 **	34.1	32.6	28.2 **	28.1 **
1997	33.4 **	30.7 **	34.1	31.3	27.7 **	27.5 **
1998 *	32.2 **	28.5 **	32.6	28.7	27.4 **	26.8 **

* provisional na = not available

** estimated by raising 1994 discard samples to the landed weights of the raised quarterly length distributions

Table 5.12.4. - Irish Sea East (FU 14): Input data and parameters.

FU	**14**	**MA**	**J**
FLEET	**UK England & Wales**	**GEAR**	**Trawl**

	1998					**1997**				
	Number of samples				Mean no. per sample	Number of samples				Mean no. per sample
	Qtr 1	Qtr 2	Qtr 3	Qtr 4		Qtr 1	Qtr 2	Qtr 3	Qtr 4	
Catch	0	0	0	0		0	0	0	0	
Landings	0	5	3	0	139	2	2	4	1	146
Discards	0	0	0	0		0	0	0	0	

	Number of samples									
Year	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989
Catch	0	0	2	0	34	9	12	11	0	0
Landings	8	9	12	13	11	20	27	13	3	3
Discards	0	0	0	0	34	9	12	11	0	0

INPUT PARAMETERS		
Parameter	Value	Source
Discard Survival	0	
MALES		
Growth - K	0.160	Irish Sea West data ; Bailey and Chapman, 1983
Growth - L(inf)	60	"
Natural mortality - M	0.3	Brander and Bennett, 1986, 1989
Length/weight - a	0.00022	Hossein et al, 1987
Length/weight - b	3.348	"
FEMALES		
Immature Growth		
Growth - K	0.160	Irish Sea West data ; Bailey and Chapman, 1983
Growth - L(inf)	60	"
Natural mortality - M	0.3	Brander and Bennett, 1986, 1989
Size at maturity	24	Briggs, 1988
Mature Growth		
Growth - K	0.100	Irish Sea West data ; Bailey and Chapman, 1983
Growth - L(inf)	56	"
Natural mortality - M	0.2	Brander and Bennett, 1986, 1989
Length/weight - a	0.00114	Hossein et al, 1987
Length/weight - b	2.820	"

Table 5.12.5. - Irish Sea East (FU 14): LCA output males.

Reference period	1994-98		
Linf (mm CL)	60.0	K	0.160

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
18	11	0.3	0.305	0.000	0.001	0.301	31643	9219	38179
20	40	0.3	0.321	0.002	0.005	0.305	28867	8817	51045
22	250	0.3	0.338	0.010	0.030	0.330	26182	8372	65729
24	645	0.3	0.357	0.030	0.083	0.383	23420	7820	81167
26	1372	0.3	0.379	0.074	0.195	0.495	20429	7059	94795
28	1811	0.3	0.403	0.121	0.299	0.599	16938	6070	103547
30	1553	0.3	0.431	0.133	0.308	0.608	13303	5046	107612
32	1484	0.3	0.463	0.169	0.365	0.665	10233	4080	107266
34	1647	0.3	0.500	0.269	0.538	0.838	7521	3073	98406
36	1200	0.3	0.544	0.306	0.562	0.862	4945	2147	82803
38	774	0.3	0.596	0.319	0.536	0.836	3095	1452	66794
40	493	0.3	0.659	0.341	0.518	0.818	1881	957	52071
42	252	0.3	0.736	0.296	0.403	0.703	1097	631	40229
44	170	0.3	0.835	0.349	0.418	0.718	654	411	30506
46	143	0.3	0.963	0.615	0.638	0.938	359	228	19578
48	65	0.3	1.140	0.754	0.662	0.962	146	101	9948
50	24	0.3	1.395	0.943	0.676	0.976	49	37	4184
52	4	0.3	1.798	0.531	0.295	0.595	13	14	1767
54	3	0.3			0.500	0.800	4	0	0
					Totals, including lengths above + group			65532	1055623

Mean F, calculated across inter-quartile range	0.439

Table 5.12.6. - Irish Sea East (FU 14): LCA output females.

Reference period	1994-98		
Linf immatures (mm CL)	60.0	K immatures	0.160
Linf matures (mm CL)	56.0	K matures	0.100
Transition length (mm CL)	24.0		

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
18	3	0.3	0.305	0.000	0.000	0.300	32132	9363	42893
20	49	0.3	0.321	0.002	0.006	0.306	29321	8954	54393
22	344	0.3	0.338	0.014	0.041	0.341	26585	8486	66622
24	910	0.2	0.357	0.041	0.114	0.314	23695	8008	79530
26	1579	0.2	0.690	0.083	0.121	0.321	21183	13112	161775
28	2210	0.2	0.741	0.151	0.204	0.404	16980	10875	164134
30	2002	0.2	0.800	0.189	0.236	0.436	12589	8505	154917
32	1307	0.2	0.870	0.175	0.201	0.401	8878	6521	141671
34	1103	0.2	0.953	0.215	0.226	0.426	6262	4905	125811
36	746	0.2	1.054	0.222	0.210	0.410	4173	3569	107074
38	368	0.2	1.178	0.166	0.141	0.341	2708	2627	91429
40	236	0.2	1.335	0.161	0.121	0.321	1813	1969	78910
42	126	0.2	1.542	0.133	0.086	0.286	1182	1473	67501
44	122	0.2	1.823	0.213	0.117	0.317	760	1053	54850
46	74	0.2	2.231	0.246	0.110	0.310	427	687	40461
48	42	0.2	2.877	0.301	0.105	0.305	214	409	27097
50	40	0.2			0.160	0.360	89	0	0
					Totals, including lengths above + group			90517	1459068

Mean F, calculated across inter-quartile range	0.172

Table 5.12.7. - Irish Sea West (FU 15): Landings (tonnes) by country, 1989-98.

Year	France	Rep. of Ireland	Isle of Man	UK	Total
1989	19	2477	8	5580	8084
1990	8	2710	25	5535	8278
1991	12	3371	61	6024	9468
1992	6	2370	14	5112	7502
1993	8	2715	32	5356	8111
1994	17	1768	7	5836	7628
1995	7	3247	20	5543	8817
1996	2	1611	8	5683	7304
1997	0	3318	7	6598	9923
1998 *	0	3007	25	6026	9058

* provisional na = not available

Table 5.12.8. - Irish Sea West (FU 15): Catches and landings (tonnes), effort ('000 hours trawling), CPUE and LPUE (kg/hour trawling) of Northern Ireland *Nephrops* trawlers, 1989-98.

Year	Catches	Landings	Effort	CPUE	LPUE
1989	5945	5517	191.4	32.2	28.8
1990	5679	5505	189.9	29.9	29.0
1991	6132	5925	200.6	30.6	29.5
1992	5692	5058	194.1	29.3	26.1
1993	6085	5295	184.1	33.1	28.8
1994	6599	5480	185.9	35.5	31.1
1995	6240	5401	167.8	37.2	32.2
1996	6312	5600	165.4	38.2	33.9
1997	7215	6546	179.0	40.3	36.6
1998 *	6692	5921	174.0	38.5	34.0

* provisional na = not available

Table 5.12.9. - Irish Sea West (FU 15): Mean sizes (mm CL) of male and female *Nephrops* in Northern Ireland catches, landings and discards, 1989-98.

Year	Catches		Landings		Discards	
	Males	Females	Males	Females	Males	Females
1989	26.6	24.9	27.4	25.9	20.8	20.5
1990	26.9	24.5	27.4	25.0	20.5	19.6
1991	26.7	23.6	27.3	24.2	20.8	19.8
1992	27.4	25.7	28.4	27.1	22.5	22.4
1993	25.9	24.2	27.1	25.6	21.3	21.0
1994	26.2	24.3	27.2	25.6	21.1	20.9
1995	27.7	24.9	29.0	26.0	22.0	21.6
1996	28.5	25.9	29.9	27.0	22.3	22.0
1997	26.1	24.3	27.2	25.7	19.9	20.1
1998 *	27.5	25.0	28.7	26.4	21.6	21.6

* provisional na = not available

Table 5.12.10. - Irish Sea West (FU 15): Mean sizes (mm CL) of male and female *Nephrops* in Republic of Ireland catches, landings and discards, 1989-98.

Year	Catches		Landings		Discards	
	Males	Females	Males	Females	Males	Females
1989	26.6 **		27.9 **		23.8 **	
1990	26.4 **		27.3 **		22.9 **	
1991	26.1 **		27.2 **		23.0 **	
1992	26.5 **		27.7 **		22.9 **	
1993	25.8 **		27.3 **		22.2 **	
1994	25.4	23.8	26.9	25.1	21.1	21.1
1995	25.8	24.2	27.5	26.0	21.3	21.1
1996	26.8	24.7	28.5	26.2	22.7	22.5
1997	26.8	26.1	28.3	27.7	na	na
1998 *	26.3	25.2	28.4	27.6	na	na

* provisional na = not available

** males and females combined

Table 5.12.11. - Irish Sea West (FU 15): Input data and parameters.

FU	15	MA	J
FLEET	UK Northern Ireland	GEAR	Trawl

	1998					1997				
	Number of samples				Mean no. per sample	Number of samples				Mean no. per sample
	Qtr 1	Qtr 2	Qtr 3	Qtr 4		Qtr 1	Qtr 2	Qtr 3	Qtr 4	
Catch	20	14	10	4	159	6	10	10	14	162
Landings	20	14	10	4	113	6	10	10	14	130
Discards	20	14	10	4	37	6	10	10	14	34

	Number of samples									
Year	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989
Catch	48	40	43	32	28	52	35	59	57	68
Landings	48	40	43	32	28	52	35	59	57	68
Discards	48	40	43	32	28	52	35	59	57	68

FU	15	MA	J
FLEET	Rep. of Ireland	GEAR	Trawl

	1998					1997				
	Number of samples				Mean no. per sample	Number of samples				Mean no. per sample
	Qtr 1	Qtr 2	Qtr 3	Qtr 4		Qtr 1	Qtr 2	Qtr 3	Qtr 4	
Catch	5	3	6	2	537	2	5	9	3	604
Landings	5	3	6	2	519	2	5	8	3	607
Discards	5	3	6	2	179	2	5	8	3	226

	Number of samples									
Year	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989
Catch	16	19	19	21	37	27	31	30	33	41
Landings	16	18	21	21	36	24	30	29	35	38
Discards	16	18	19	21	36	26	31	27	34	35

INPUT PARAMETERS		
Parameter	Value	Source
Discard Survival	0.10	ICES, 1991a
MALES		
Growth - K	0.160	Hillis, 1979 ; ICES, 1991a
Growth - L(inf)	60	"
Natural mortality - M	0.3	Brander and Bennett, 1986, 1989
Length/weight - a	0.00032	after Pope and Thomas, 1955 (data for Scottish stocks)
Length/weight - b	3.210	"
FEMALES		
Immature Growth		
Growth - K	0.160	Hillis, 1979 ; ICES, 1991a
Growth - L(inf)	60	"
Natural mortality - M	0.3	Brander and Bennett, 1986, 1989
Size at maturity	24	Briggs, 1988
Mature Growth		
Growth - K	0.100	Hillis, 1979 ; ICES, 1991a
Growth - L(inf)	56	"
Natural mortality - M	0.2	Brander and Bennett, 1986, 1989
Length/weight - a	0.00068	after Pope and Thomas, 1955 (data for Scottish stocks)
Length/weight - b	2.960	"

Table 5.12.12. - Irish Sea West (FU 15): LCA output males - using 'traditional' growth parameters.

Reference period	1996-98		
Linf (mm CL)	60.0	K	0.160

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
10	34	0.3	0.126	0.000	0.000	0.300	1041279	129018	78310
11	41	0.3	0.129	0.000	0.000	0.300	1002539	126730	103008
12	20	0.3	0.132	0.000	0.000	0.300	964479	124436	132184
13	262	0.3	0.134	0.000	0.002	0.302	927128	122122	166080
14	713	0.3	0.137	0.001	0.006	0.306	890230	119755	204850
15	1336	0.3	0.141	0.002	0.011	0.311	853590	117307	248565
16	2876	0.3	0.144	0.004	0.025	0.325	817062	114700	297054
17	4616	0.3	0.147	0.006	0.041	0.341	779776	111848	349889
18	7813	0.3	0.151	0.011	0.072	0.372	741605	108622	406153
19	11031	0.3	0.154	0.016	0.105	0.405	701204	104902	464456
20	12857	0.3	0.158	0.020	0.128	0.428	658701	100783	523920
21	18132	0.3	0.162	0.031	0.189	0.489	615607	96080	581981
22	26539	0.3	0.167	0.049	0.294	0.594	568647	90238	632477
23	32292	0.3	0.171	0.067	0.388	0.688	515029	83196	670473
24	36638	0.3	0.176	0.086	0.487	0.787	457766	75263	693353
25	36743	0.3	0.181	0.100	0.549	0.849	398531	66922	700990
26	37510	0.3	0.187	0.120	0.642	0.942	341691	58465	692885
27	35874	0.3	0.192	0.138	0.717	1.017	286615	50066	668272
28	31588	0.3	0.198	0.149	0.749	1.049	235692	42223	632042
29	27022	0.3	0.205	0.157	0.768	1.068	191410	35232	589134
30	22460	0.3	0.212	0.163	0.771	1.071	153793	29153	542540
31	18554	0.3	0.219	0.170	0.776	1.076	122564	23945	494248
32	16059	0.3	0.227	0.188	0.829	1.129	96806	19408	442877
33	13379	0.3	0.236	0.205	0.868	1.168	74904	15444	388422
34	9919	0.3	0.245	0.200	0.814	1.114	56872	12199	337198
35	7363	0.3	0.255	0.195	0.762	1.062	43280	9672	293027
36	5006	0.3	0.266	0.172	0.646	0.946	33004	7762	257076
37	4970	0.3	0.278	0.226	0.812	1.112	25662	6134	221568
38	3338	0.3	0.291	0.205	0.704	1.004	18843	4752	186774
39	2583	0.3	0.305	0.213	0.700	1.000	14074	3699	157884
40	2215	0.3	0.321	0.254	0.791	1.091	10376	2807	129814
41	1229	0.3	0.338	0.195	0.576	0.876	7314	2139	106996
42	1023	0.3	0.357	0.221	0.619	0.919	5440	1657	89444

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Table 5.12.12. - (continued).

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
43	775	0.3	0.379	0.235	0.620	0.920	3918	1254	72918
44	520	0.3	0.403	0.223	0.553	0.853	2765	944	59056
45	487	0.3	0.431	0.308	0.714	1.014	1961	685	46018
46	389	0.3	0.463	0.400	0.863	1.163	1266	453	32674
47	233	0.3	0.500	0.415	0.830	1.130	739	282	21785
48	199	0.3	0.544	0.722	1.328	1.628	420	152	12496
49	60	0.3	0.596	0.476	0.799	1.099	173	76	6668
50	45	0.3			0.300	0.600	90	0	0
					Totals, including lengths above + group			2020523	12735559

Mean F, calculated across inter-quartile range	0.637

Table 5.12.13. - Irish Sea West (FU 15): LCA output males - using Multifan generated growth parameters.

Reference period	1996-98		
Linf (mm CL)	50.3	K	0.239

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
10	34	0.3	0.105	0.000	0.000	0.300	1032581	106863	64863
11	41	0.3	0.108	0.000	0.000	0.300	1000488	106167	86294
12	20	0.3	0.111	0.000	0.000	0.300	968596	105459	112025
13	262	0.3	0.114	0.000	0.003	0.303	936939	104724	142418
14	713	0.3	0.117	0.001	0.007	0.307	905260	103934	177786
15	1336	0.3	0.120	0.002	0.013	0.313	873367	103063	218383
16	2876	0.3	0.124	0.004	0.028	0.328	841112	102042	264273
17	4616	0.3	0.128	0.006	0.046	0.346	807624	100792	315303
18	7813	0.3	0.132	0.010	0.079	0.379	772769	99193	370898
19	11031	0.3	0.136	0.015	0.114	0.414	735197	97129	430042
20	12857	0.3	0.140	0.019	0.136	0.436	695026	94669	492138
21	18132	0.3	0.145	0.029	0.198	0.498	653767	91635	555058
22	26539	0.3	0.151	0.046	0.303	0.603	608141	87506	613328
23	32292	0.3	0.156	0.061	0.393	0.693	555344	82185	662324
24	36638	0.3	0.162	0.078	0.483	0.783	498386	75914	699354
25	36743	0.3	0.169	0.090	0.532	0.832	438959	69105	723853
26	37510	0.3	0.176	0.106	0.605	0.905	381467	62007	734867
27	35874	0.3	0.184	0.120	0.655	0.955	325333	54770	731053
28	31588	0.3	0.192	0.127	0.661	0.961	273003	47859	716421
29	27022	0.3	0.201	0.131	0.651	0.951	227034	41577	695231
30	22460	0.3	0.211	0.132	0.624	0.924	187518	36003	670021
31	18554	0.3	0.223	0.133	0.597	0.897	154237	31125	642452
32	16059	0.3	0.235	0.141	0.601	0.901	126329	26769	610841
33	13379	0.3	0.249	0.146	0.586	0.886	102222	22851	574716
34	9919	0.3	0.265	0.135	0.508	0.808	81972	19548	540328
35	7363	0.3	0.283	0.123	0.436	0.736	66178	16896	511877
36	5006	0.3	0.303	0.103	0.338	0.638	53737	14819	490840
37	4970	0.3	0.327	0.125	0.384	0.684	44280	12977	468781
38	3338	0.3	0.355	0.105	0.295	0.595	35410	11325	445179
39	2583	0.3	0.388	0.100	0.259	0.559	28669	9993	426517
40	2215	0.3	0.427	0.108	0.253	0.553	23085	8787	406346
41	1229	0.3	0.476	0.075	0.158	0.458	18230	7797	389928
42	1023	0.3	0.537	0.079	0.146	0.446	14660	7002	377992

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Table 5.12.13. - (continued).

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
43	775	0.3	0.616	0.077	0.124	0.424	11535	6257	363942
44	520	0.3	0.723	0.068	0.093	0.393	8881	5590	349762
45	487	0.3	0.875	0.087	0.099	0.399	6682	4934	331575
46	389	0.3	1.108	0.103	0.093	0.393	4712	4232	304970
47	233	0.3	1.511	0.101	0.067	0.367	3051	3538	272985
48	199	0.3	2.387	0.177	0.074	0.374	1753	2768	228299
49	60	0.3	6.135	0.236	0.038	0.338	718	1855	163348
50	45	0.3			0.300	0.600	90	0	0
					Totals, including lengths above + group			1991659	17376610

Mean F, calculated across inter-quartile range	0.452

Table 5.12.14. - Irish Sea West (FU 15): LCA output females.

Reference period	1996-98		
Linf immatures (mm CL)	60.0	K immatures	0.160
Linf matures (mm CL)	56.0	K matures	0.100
Transition length (mm CL)	24.0		

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
10	48	0.3	0.126	0.000	0.001	0.301	760437	94219	67510
11	67	0.3	0.129	0.000	0.001	0.301	732123	92544	86801
12	64	0.3	0.132	0.000	0.001	0.301	704293	90864	109083
13	141	0.3	0.134	0.000	0.002	0.302	676970	89174	134443
14	788	0.3	0.137	0.001	0.009	0.309	650076	87431	162864
15	1645	0.3	0.141	0.003	0.019	0.319	623059	85579	194204
16	2527	0.3	0.144	0.004	0.030	0.330	595740	83600	228279
17	5152	0.3	0.147	0.009	0.063	0.363	568133	81360	264431
18	9449	0.3	0.151	0.018	0.120	0.420	538572	78601	301136
19	11633	0.3	0.154	0.024	0.154	0.454	505541	75347	337346
20	17191	0.3	0.158	0.038	0.241	0.541	471302	71477	371078
21	22483	0.3	0.162	0.055	0.337	0.637	432664	66732	398895
22	25923	0.3	0.167	0.071	0.423	0.723	390155	61263	418952
23	35499	0.3	0.171	0.111	0.650	0.950	345843	54658	425130
24	39177	0.3	0.176	0.147	0.836	1.136	293926	46905	412721
25	37848	0.2	0.328	0.177	0.541	0.741	240649	70055	693913
26	32527	0.2	0.339	0.196	0.579	0.779	188746	56234	624189
27	27689	0.2	0.351	0.221	0.628	0.828	144930	44133	546640
28	25233	0.2	0.364	0.276	0.760	0.960	108373	33269	458020
29	17716	0.2	0.377	0.275	0.730	0.930	76439	24331	370976
30	12957	0.2	0.392	0.288	0.735	0.935	53821	17672	297390
31	8231	0.2	0.408	0.261	0.640	0.840	37302	12892	238686
32	6021	0.2	0.426	0.271	0.637	0.837	26477	9481	192544
33	5281	0.2	0.445	0.353	0.795	0.995	18546	6662	148003
34	2507	0.2	0.465	0.249	0.535	0.735	11917	4695	113793
35	2235	0.2	0.488	0.325	0.666	0.866	8466	3369	88857
36	1623	0.2	0.513	0.368	0.717	0.917	5550	2271	65017
37	482	0.2	0.541	0.159	0.294	0.494	3467	1645	51025
38	414	0.2	0.572	0.181	0.316	0.516	2654	1314	44061
39	375	0.2	0.606	0.225	0.371	0.571	1977	1013	36645

Continued on next page

Table 5.12.14. - (continued).

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
40	404	0.2	0.645	0.368	0.571	0.771	1398	711	27699
41	261	0.2	0.690	0.399	0.578	0.778	850	454	19008
42	70	0.2	0.741	0.163	0.220	0.420	497	317	14223
43	172	0.2	0.800	0.717	0.896	1.096	364	194	9340
44	17	0.2	0.870	0.131	0.150	0.350	152	114	5849
45	51	0.2	0.953	0.698	0.732	0.932	112	71	3878
46	9	0.2	1.054	0.246	0.233	0.433	46	39	2279
47	9	0.2	1.178	0.427	0.363	0.563	29	25	1565
48	9	0.2			0.300	0.500	15	0	0
					Totals, including lengths above + group			1450712	7966469

Mean F, calculated across inter-quartile range	0.552

Table 5.12.15. - Irish Sea West (FU 15): VPA Fs-at-age males - using 'traditional' growth parameters.

Age	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.014	0.025	0.007	0.012	0.016	0.014	0.006	0.014	0.009	0.011	0.005	0.019	0.002
2	0.353	0.442	0.232	0.295	0.275	0.404	0.254	0.342	0.261	0.213	0.144	0.248	0.152
3	0.859	1.044	0.862	0.856	0.830	1.001	0.835	0.771	0.613	0.728	0.517	0.732	0.736
4	0.851	1.020	1.193	0.979	1.098	1.199	1.074	0.935	0.670	0.772	0.702	0.851	0.906
5	0.748	1.194	1.067	1.003	0.913	1.162	0.958	0.842	0.707	0.700	0.663	0.841	0.849
6	0.782	0.823	1.421	1.051	0.976	0.714	1.003	0.679	0.811	0.835	0.715	0.793	0.828
7	0.732	0.876	0.892	0.828	0.840	0.920	0.929	0.782	0.785	0.748	0.681	0.826	0.805
+ grp	0.732	0.876	0.892	0.828	0.840	0.920	0.929	0.782	0.785	0.748	0.681	0.826	0.805

Table 5.12.16. - Irish Sea West (FU 15): VPA Fs-at-age males - using Multifan generated growth parameters.

Age	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.030	0.050	0.019	0.027	0.032	0.033	0.013	0.033	0.022	0.025	0.011	0.038	0.004
2	0.542	0.676	0.400	0.473	0.436	0.617	0.419	0.519	0.397	0.354	0.240	0.381	0.301
3	0.907	1.094	1.027	0.940	0.959	1.116	0.958	0.827	0.662	0.817	0.592	0.806	0.823
4	0.718	0.943	1.144	0.952	1.015	1.091	0.951	0.799	0.592	0.670	0.707	0.799	0.824
5	0.657	0.843	0.851	0.772	0.913	0.925	0.926	0.715	0.588	0.604	0.597	0.688	0.720
6	0.595	0.708	0.653	0.661	0.706	0.766	0.705	0.644	0.607	0.641	0.615	0.688	0.647
+ grp	0.595	0.708	0.653	0.661	0.706	0.766	0.705	0.644	0.607	0.641	0.615	0.688	0.647

Table 5.12.17. - Irish Sea West (FU 15): VPA Fs-at-age females.

Age	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.012	0.019	0.011	0.010	0.009	0.017	0.011	0.011	0.007	0.006	0.005	0.020	0.005
2	0.350	0.433	0.337	0.386	0.341	0.448	0.278	0.432	0.354	0.277	0.229	0.388	0.301
3	0.701	0.785	0.647	0.730	0.719	0.632	0.607	0.739	0.619	0.618	0.469	0.612	0.653
4	0.814	0.787	0.780	0.883	0.895	0.653	1.034	1.037	0.674	0.705	0.514	0.786	0.805
5	0.696	0.760	0.752	0.906	0.802	0.657	1.085	0.942	0.748	0.670	0.462	0.773	0.777
6	0.772	0.724	0.683	0.860	0.725	0.600	1.003	0.673	1.088	0.502	0.598	0.669	0.756
7	0.663	0.685	0.644	0.766	0.728	0.712	0.875	0.762	0.759	0.592	0.639	0.743	0.771
+ grp	0.663	0.685	0.644	0.766	0.728	0.712	0.875	0.762	0.759	0.592	0.639	0.743	0.771

Table 5.12.18. - Irish Sea West (FU 15): VPA output males - using 'traditional' growth parameters.

Year	Recruits Age 1	Total Biomass	TSB	Landings	Yield/SSB	Fbar 3-5
	'000	tonnes	tonnes	tonnes		
1986	880405	15591	15591	5653	0.363	0.819
1987	824937	15024	15024	6466	0.430	1.086
1988	909581	13689	13689	4711	0.344	1.040
1989	938253	13976	13976	4545	0.325	0.946
1990	843749	13424	13424	4810	0.358	0.947
1991	855587	14337	14337	5566	0.388	1.121
1992	1040028	12788	12788	4287	0.335	0.956
1993	1100848	15052	15052	4591	0.305	0.849
1994	970768	16142	16142	4435	0.275	0.663
1995	1078497	18059	18059	5431	0.301	0.733
1996	989929	18552	18552	4832	0.261	0.627
1997	769866	19348	19348	6844	0.354	0.808
1998	814019	18293	18293	6231	0.341	0.830
Average 96-98						0.755

Table 5.12.19. - Irish Sea West (FU 15): VPA output males - using Multifan generated growth parameters.

Year	Recruits Age 1	Total Biomass	TSB	Landings	Yield/SSB	Fbar 1-6
	'000	tonnes	tonnes	tonnes		
1986	863637	15471	15471	5653	0.365	0.575
1987	731316	14577	14577	6466	0.444	0.719
1988	850394	13001	13001	4711	0.362	0.682
1989	852939	12803	12803	4545	0.355	0.637
1990	827715	13143	13143	4810	0.366	0.677
1991	777143	13152	13152	5566	0.423	0.758
1992	920401	12702	12702	4287	0.338	0.662
1993	1022703	13820	13820	4591	0.332	0.589
1994	920935	15055	15055	4435	0.295	0.478
1995	962509	16582	16582	5431	0.328	0.518
1996	995885	17669	17669	4832	0.274	0.460
1997	721017	18816	18816	6844	0.364	0.567
1998	752763	17838	17838	6231	0.349	0.553
Average 96-98						0.527

Table 5.12.20. - Irish Sea West (FU 15): VPA output females.

Year	Recruits Age 1	Total Biomass	TSB	Landings	Yield/SSB	Fbar 3-5
	'000	tonnes	tonnes	tonnes		
1986	810920	12941	6773	4151	0.613	0.737
1987	684331	12295	6553	4320	0.659	0.777
1988	747445	11361	6202	3558	0.574	0.726
1989	821434	11399	5726	3778	0.660	0.840
1990	862223	10764	5291	3517	0.665	0.805
1991	734979	11839	5756	3704	0.644	0.647
1992	858991	11122	6239	3799	0.609	0.909
1993	921076	12257	5837	4143	0.710	0.906
1994	821413	12169	5537	3532	0.638	0.680
1995	672041	12109	6540	3552	0.543	0.664
1996	681464	12042	7084	3036	0.429	0.482
1997	768381	12776	7512	4293	0.572	0.724
1998	723611	11845	6375	3743	0.587	0.745
Average 96-98						0.650

Table 5.12.21. - Management Area J (VIIa, North of 53° N): Total *Nephrops* landings (tonnes) by Functional Unit plus other rectangles, 1989-98.

Year	FU 14	FU 15	Total
1989	438	8084	***8522***
1990	644	8278	***8922***
1991	859	9468	***10327***
1992	495	7502	***7997***
1993	618	8111	***8729***
1994	514	7628	***8142***
1995	504	8817	***9321***
1996	452	7304	***7756***
1997	586	9923	***10509***
1998 *	364	9058	***9422***

* provisional na = not available

Table 5.12.22. - Management Area J (VIIa, North of 53° N): Total *Nephrops* landings (tonnes) by country, 1989-98.

Year	Belgium	France	Rep. of Ireland	Isle of Man	UK	Total
1989	0	19	2484	8	6011	***8522***
1990	0	8	2724	25	6165	***8922***
1991	1	12	3390	62	6864	***10327***
1992	1	6	2381	14	5596	***7997***
1993	0	8	2750	32	5939	***8729***
1994	0	17	1797	16	6312	***8142***
1995	2	7	3269	23	6020	***9321***
1996	1	2	1614	10	6127	***7756***
1997	1	0	3320	7	7180	***10509***
1998 *	1	0	3008	25	6388	***9422***

* provisional na = not available

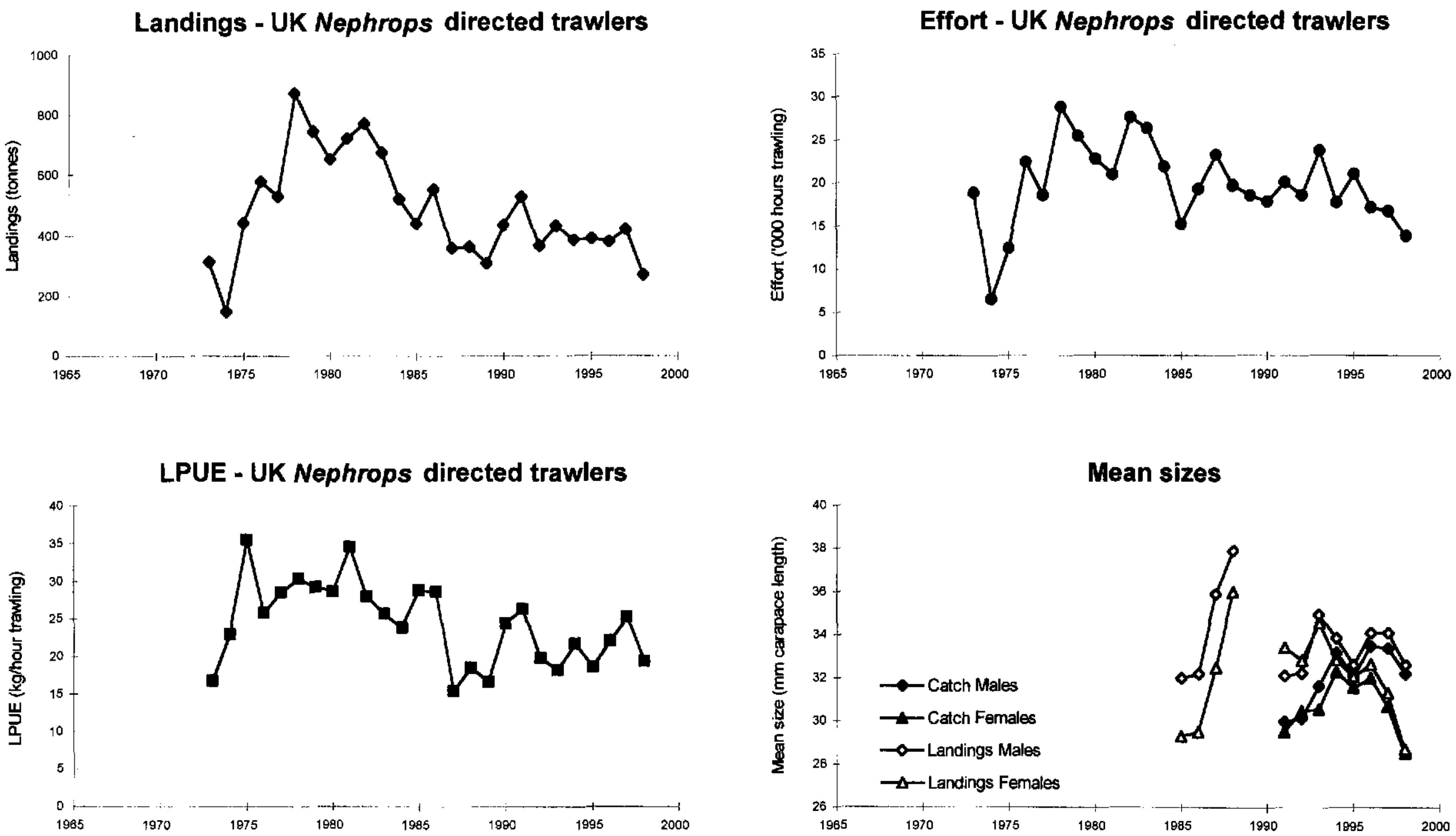


Figure 5.12.1. - Irish Sea East (FU 14): Long-term trends in landings, effort, LPUEs and mean sizes of *Nephrops* in catches and landings.

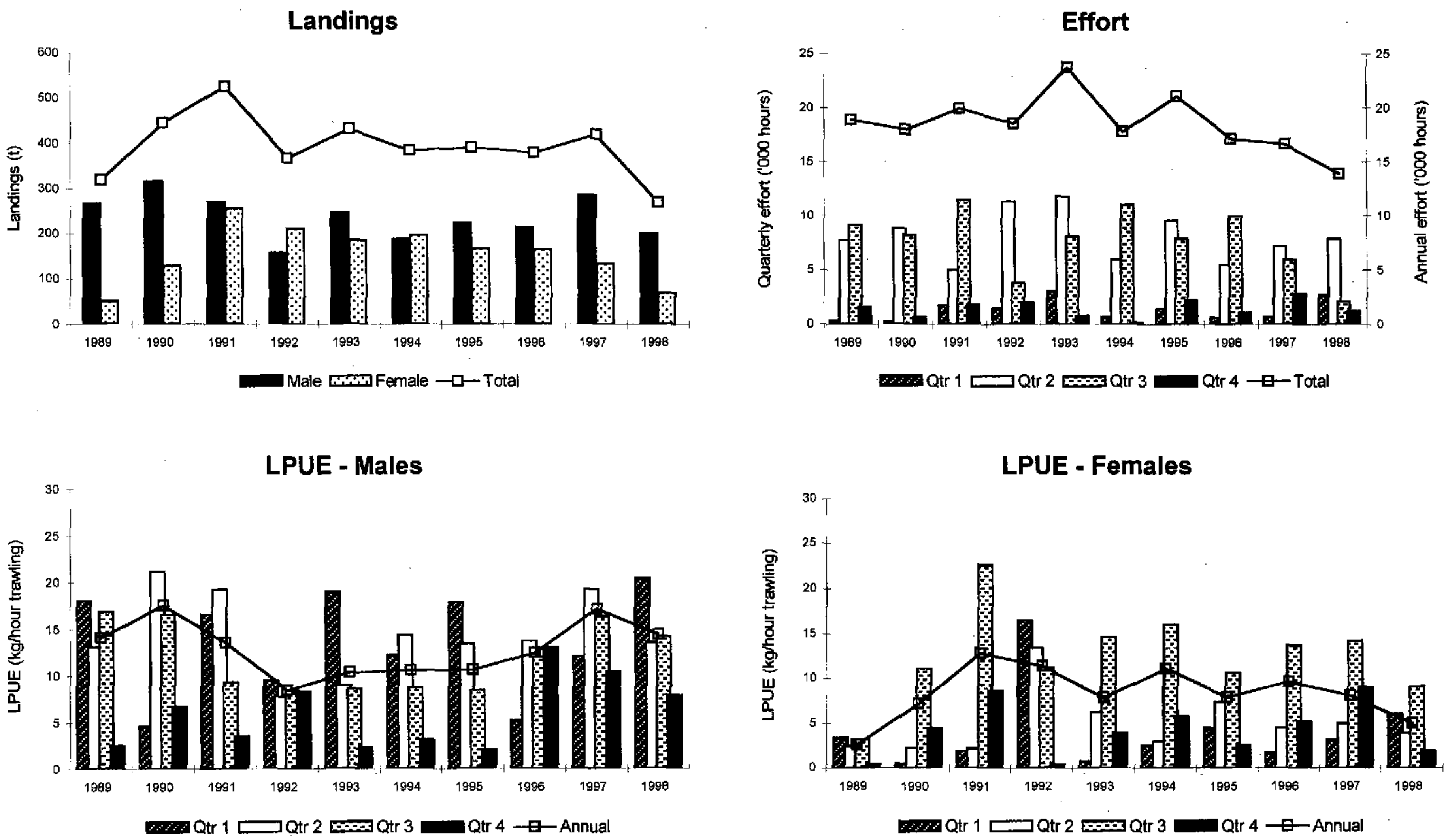


Figure 5.12.2. - Irish Sea East (FU 14): Landings, effort and LPUEs by quarter and sex from English *Nephrops* directed trawlers.

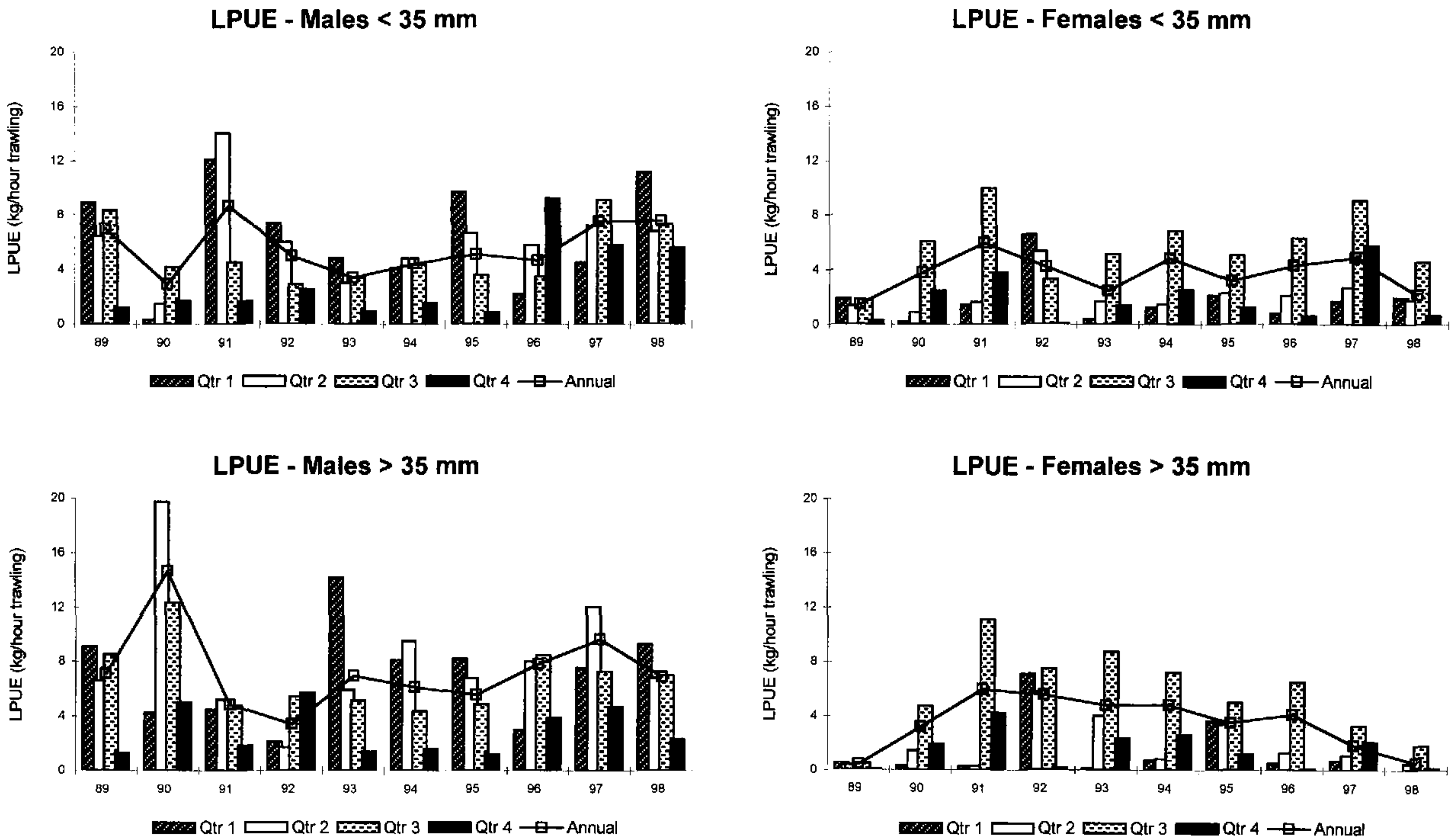
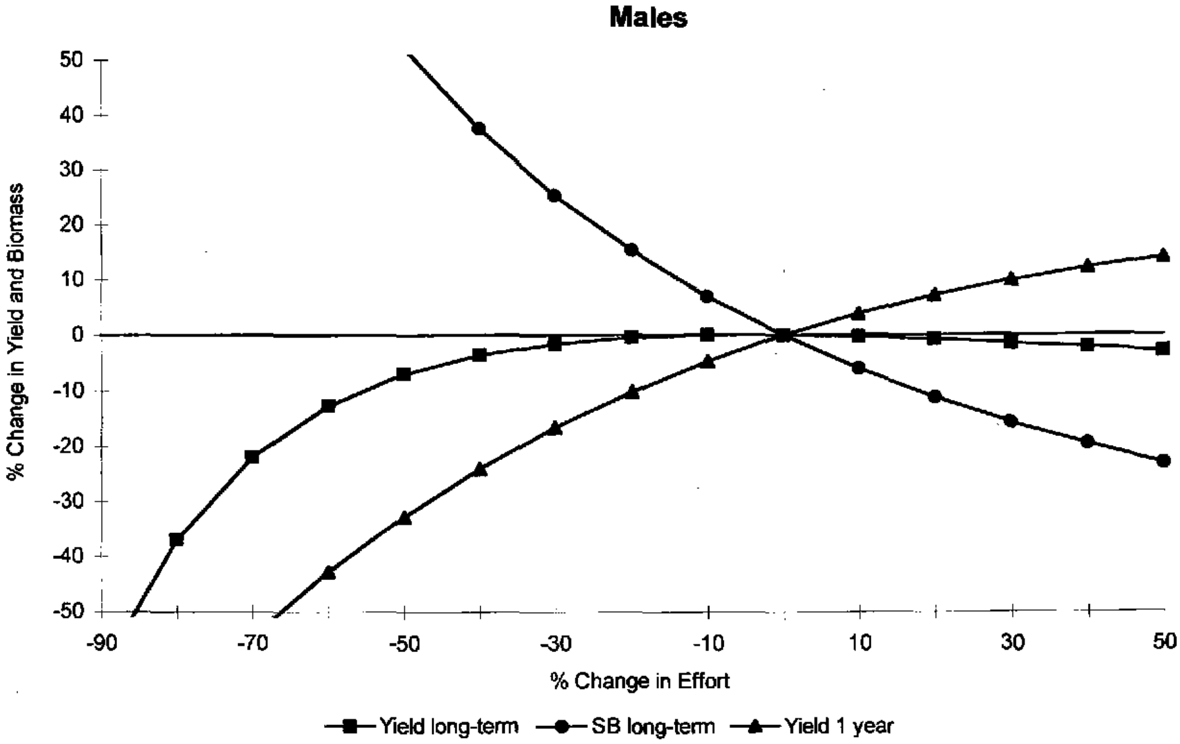


Figure 5.12.3. - Irish Sea East (FU 14): LPUEs by sex and quarter, for selected size groups.



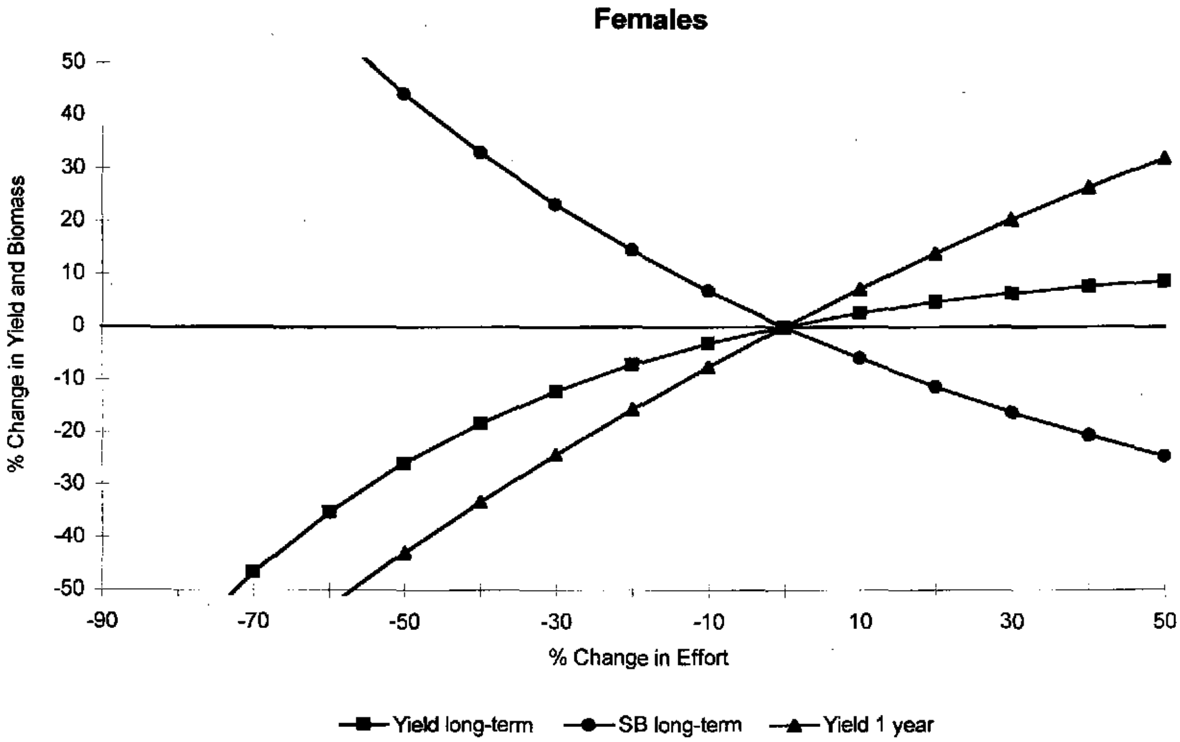


Figure 5.12.4. - Irish Sea East (FU 14): Output LCA: Relative changes in short term yield (ie after 1 year), long term yield and long term biomass upon relative changes in effort. Males and females shown separately.

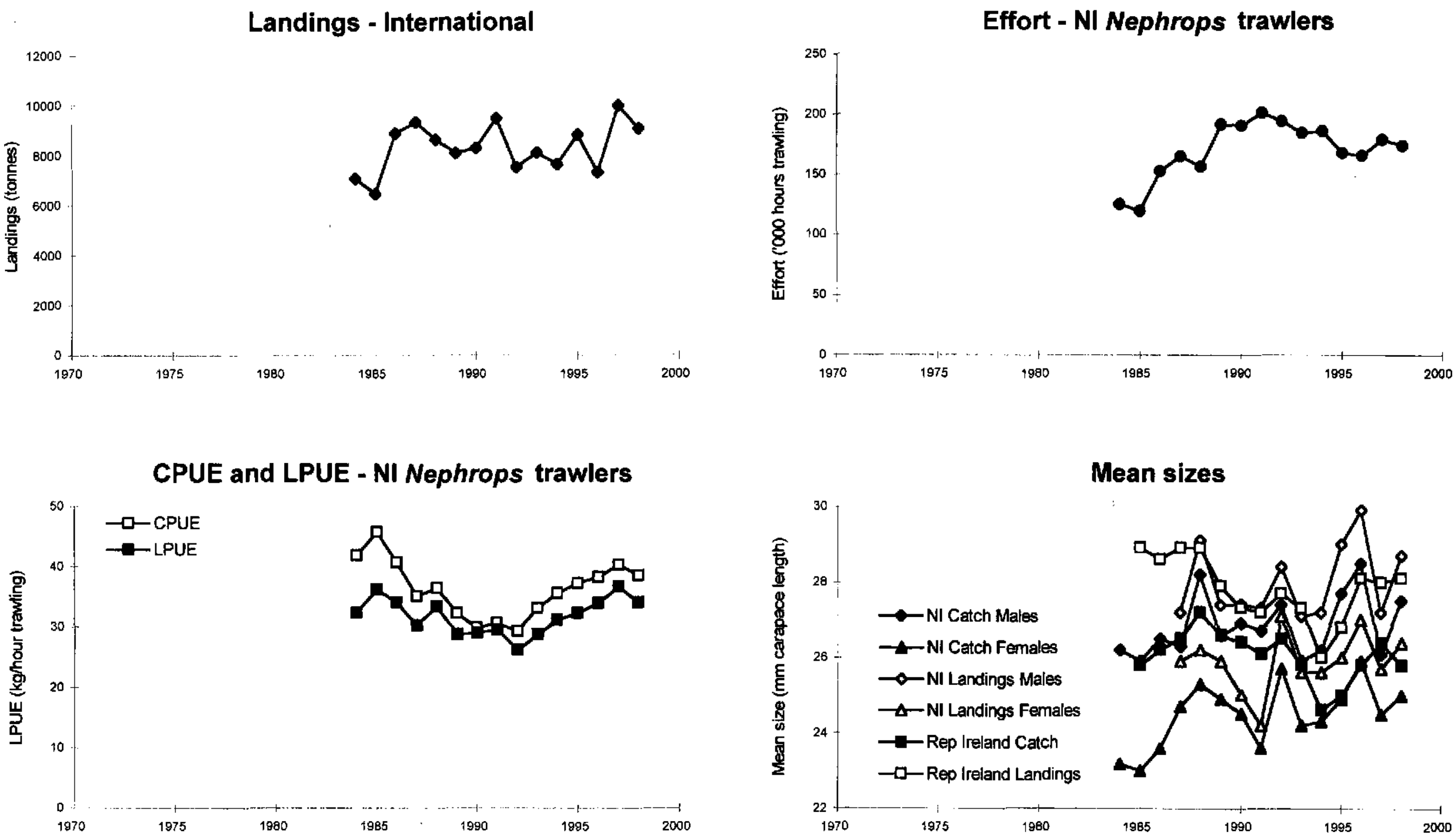


Figure 5.12.5. - Irish Sea West (FU 15): Long-term trends in landings, effort, CPUEs, LPUEs and mean sizes of *Nephrops* in catches and landings.

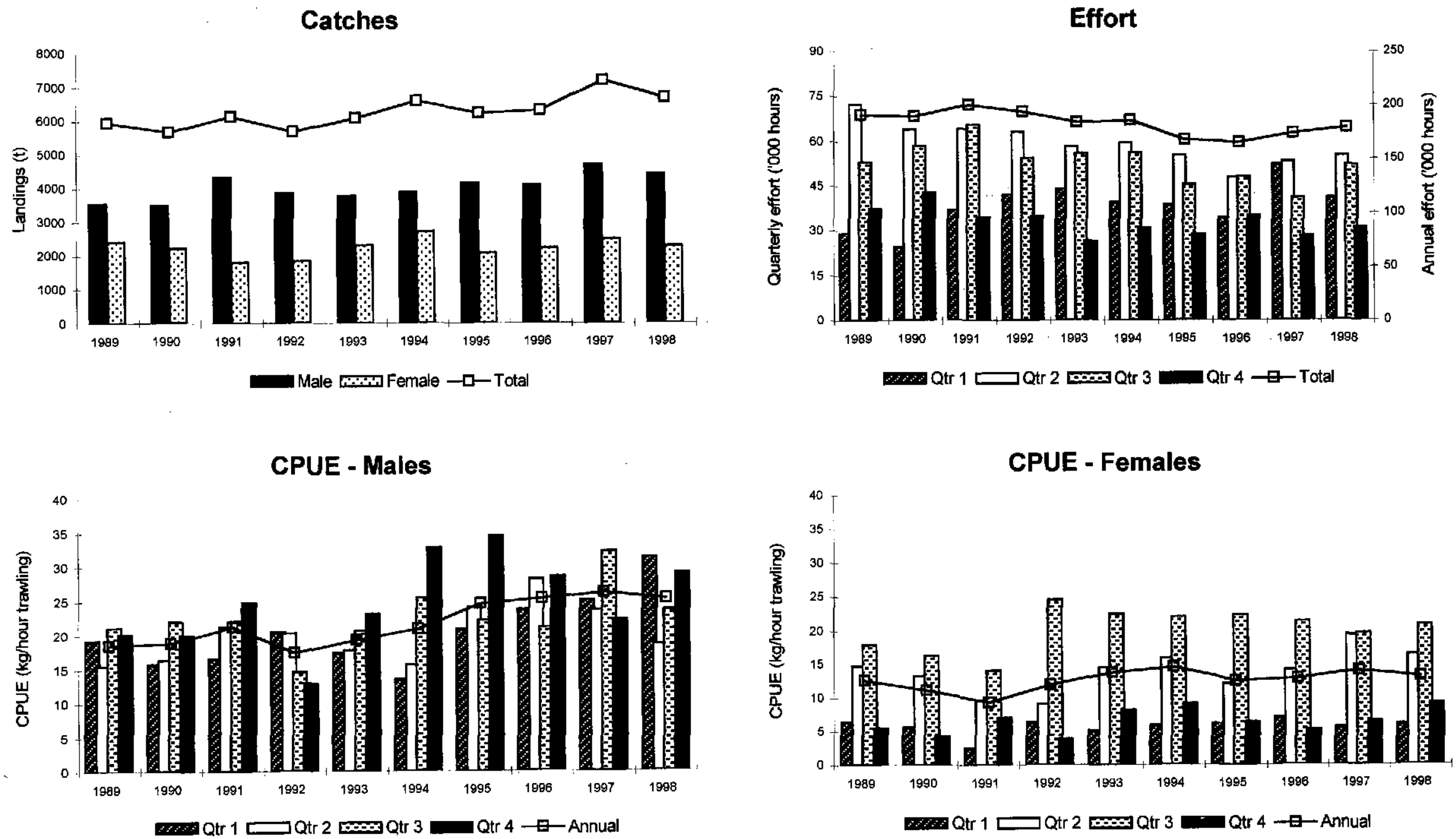
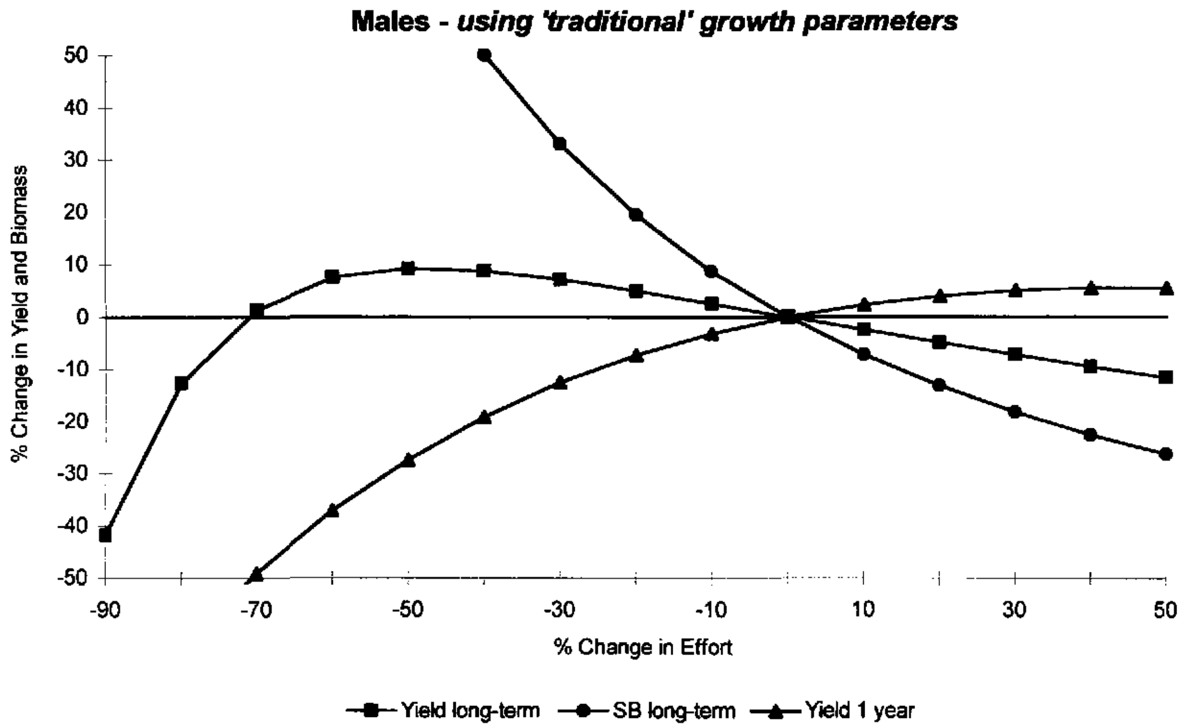


Figure 5.12.6. - Irish Sea West (FU 15): Catches, effort and CPUEs by quarter and sex from Northern Ireland *Nephrops* trawlers.



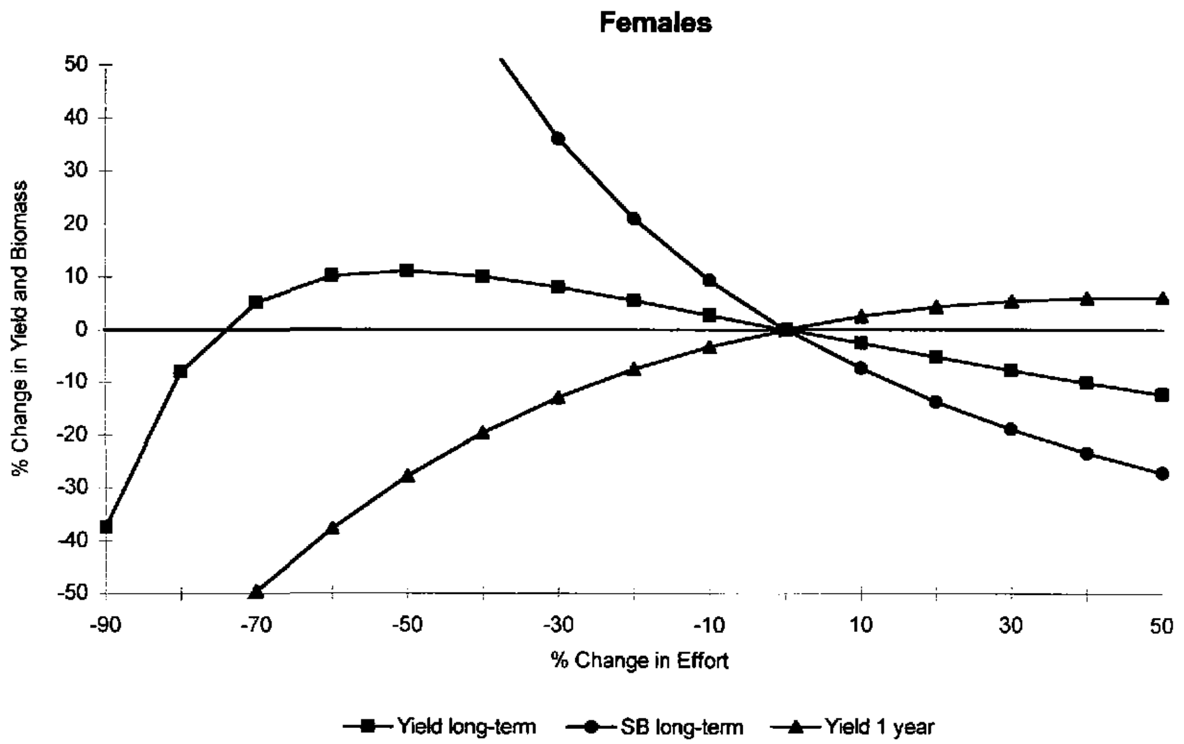


Figure 5.12.7. - Irish Sea West (FU 15): Output LCA: Relative changes in short-term yield (ie after 1 year), long-term yield and long-term biomass upon relative changes in effort. Males and females shown separately.

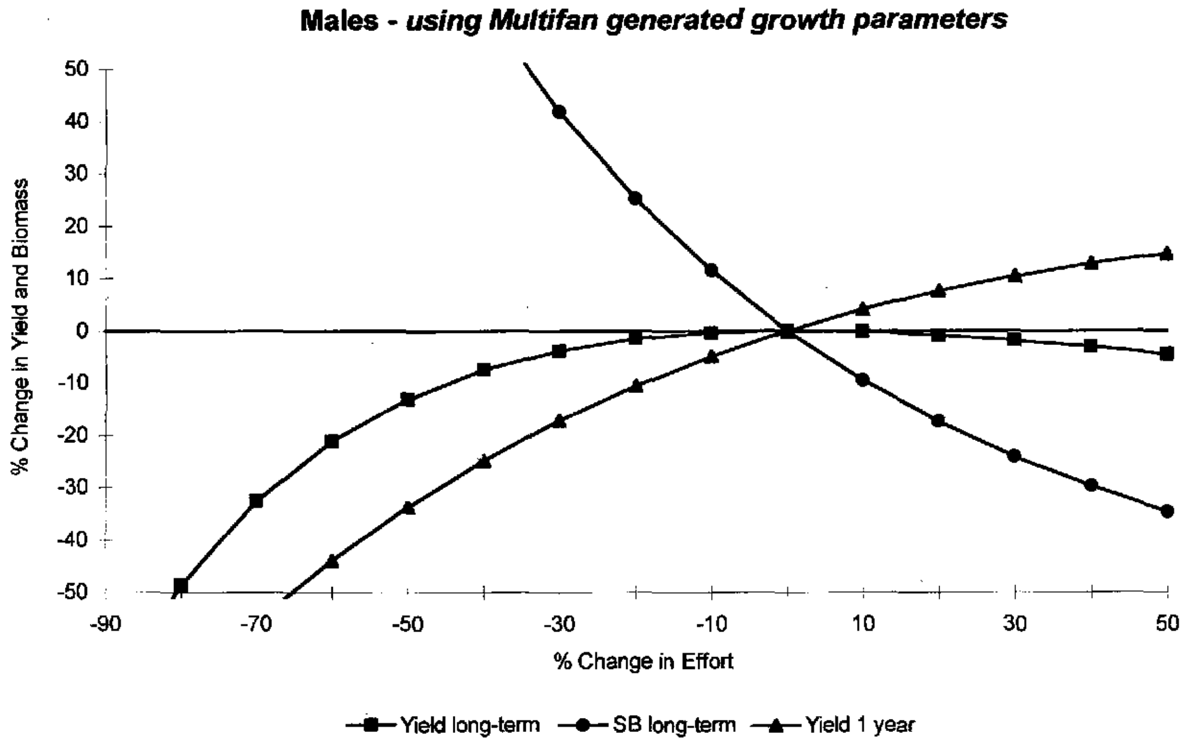


Figure 5.12.8. - Irish Sea West (FU 15): Output LCA: Relative changes in short-term yield (ie after 1 year), long-term yield and long-term biomass upon relative changes in effort. LCA run with growth parameters estimated by Multifan analysis of LFDs.

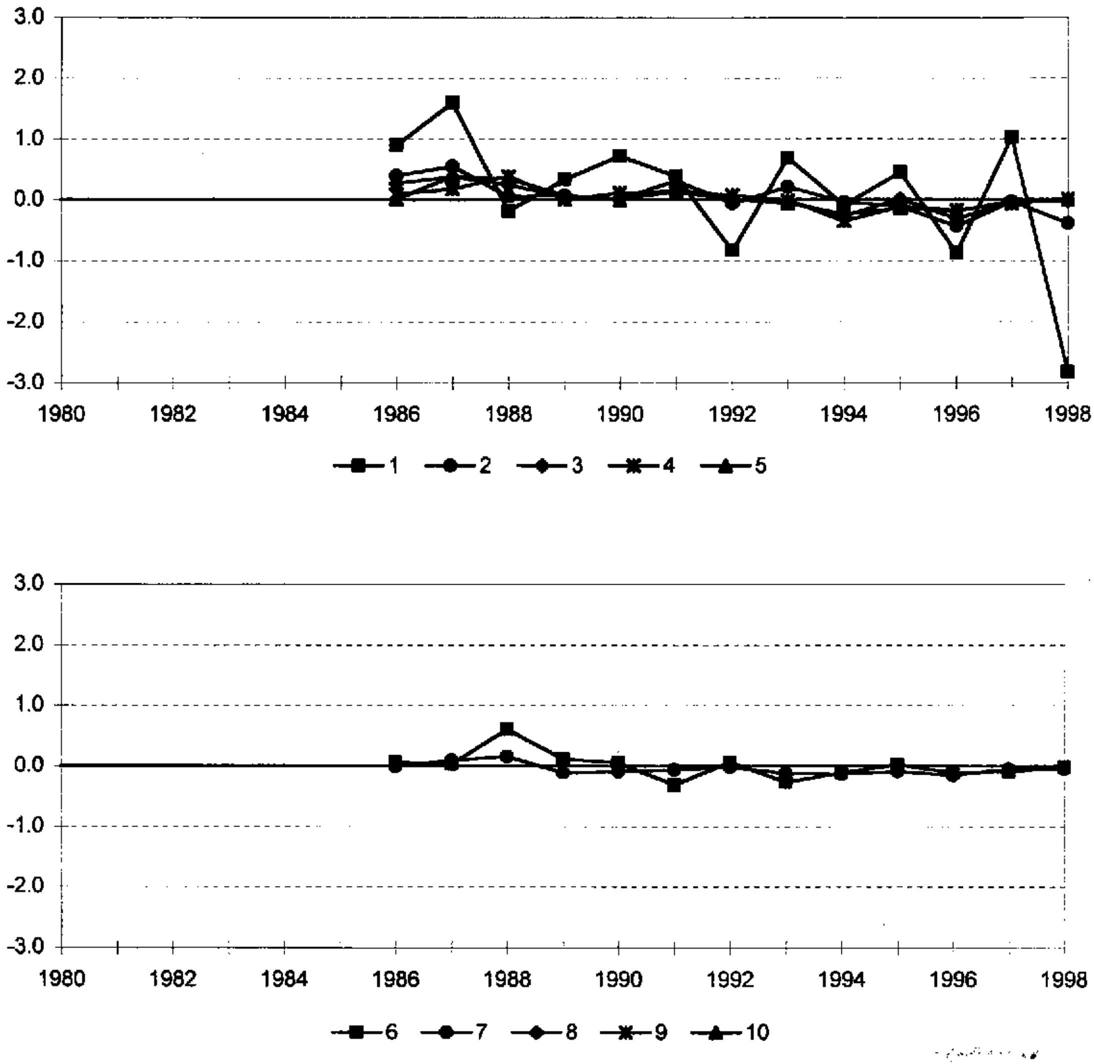
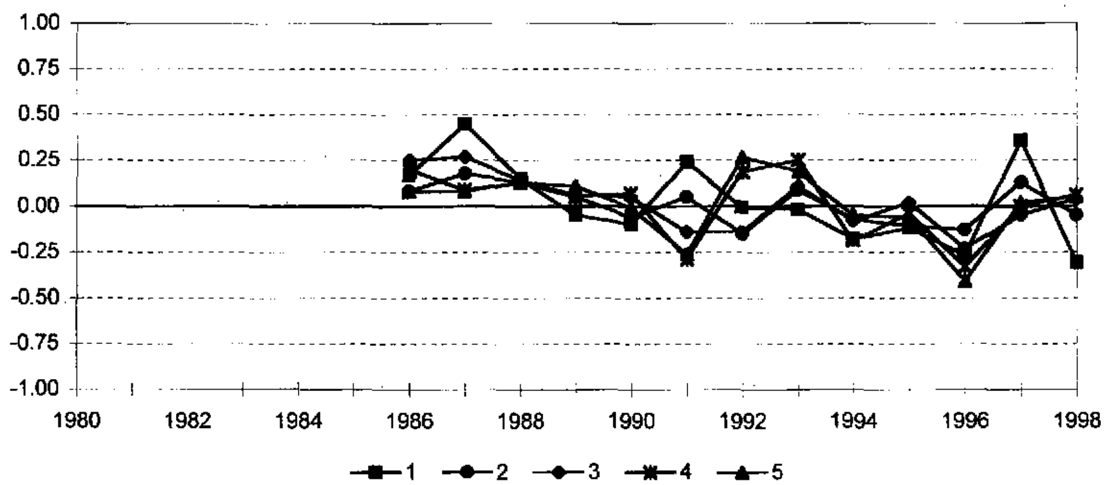


Figure 5.12.9. - Irish Sea West (FU 15): Output VPA males: Log catchability residuals.



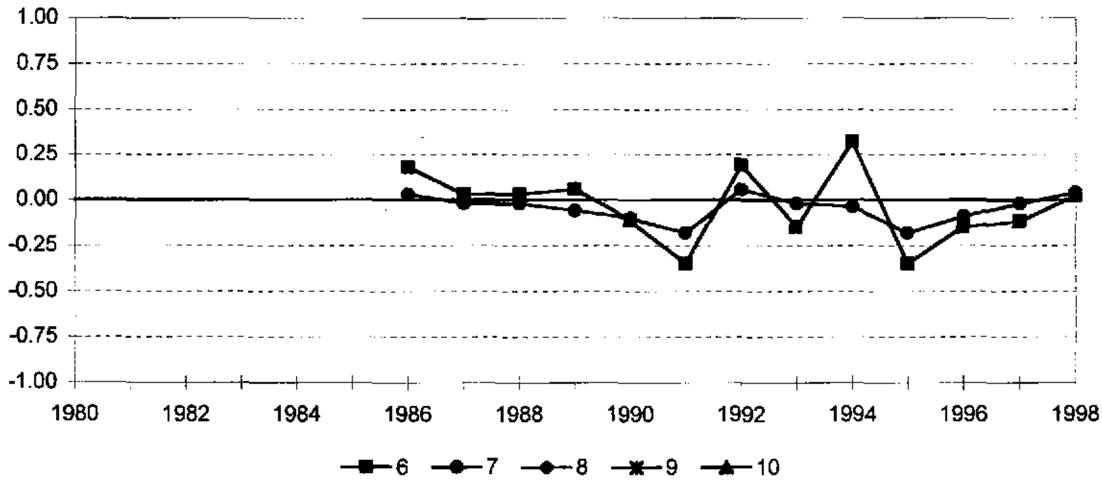


Figure 5.12.10. - Irish Sea West (FU 15): Output VPA females: Log catchability residuals.

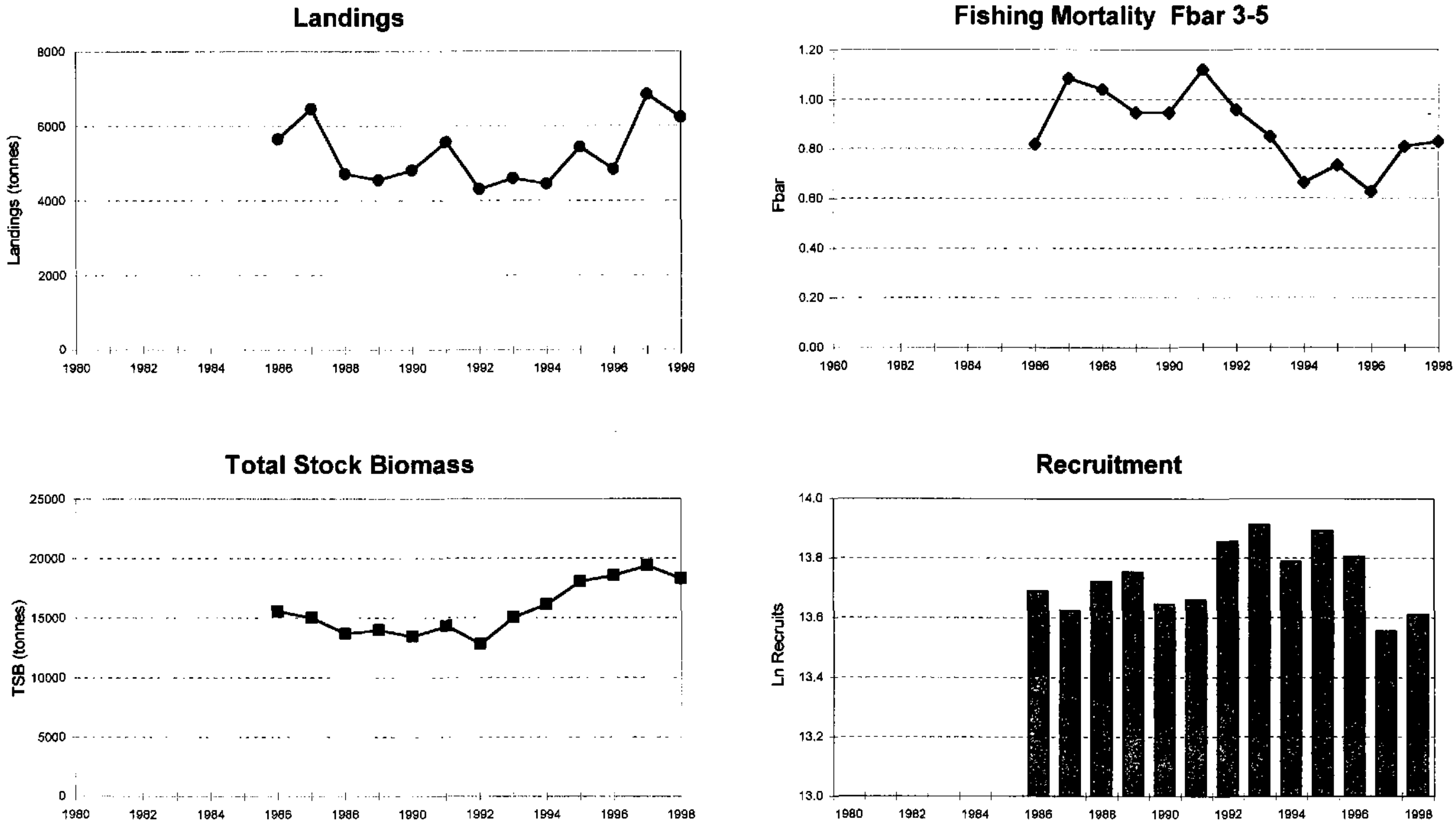


Figure 5.12.11. - Irish Sea West (FU 15): Output VPA males: Trends in Landings, Fbar, TSB and Recruitment.

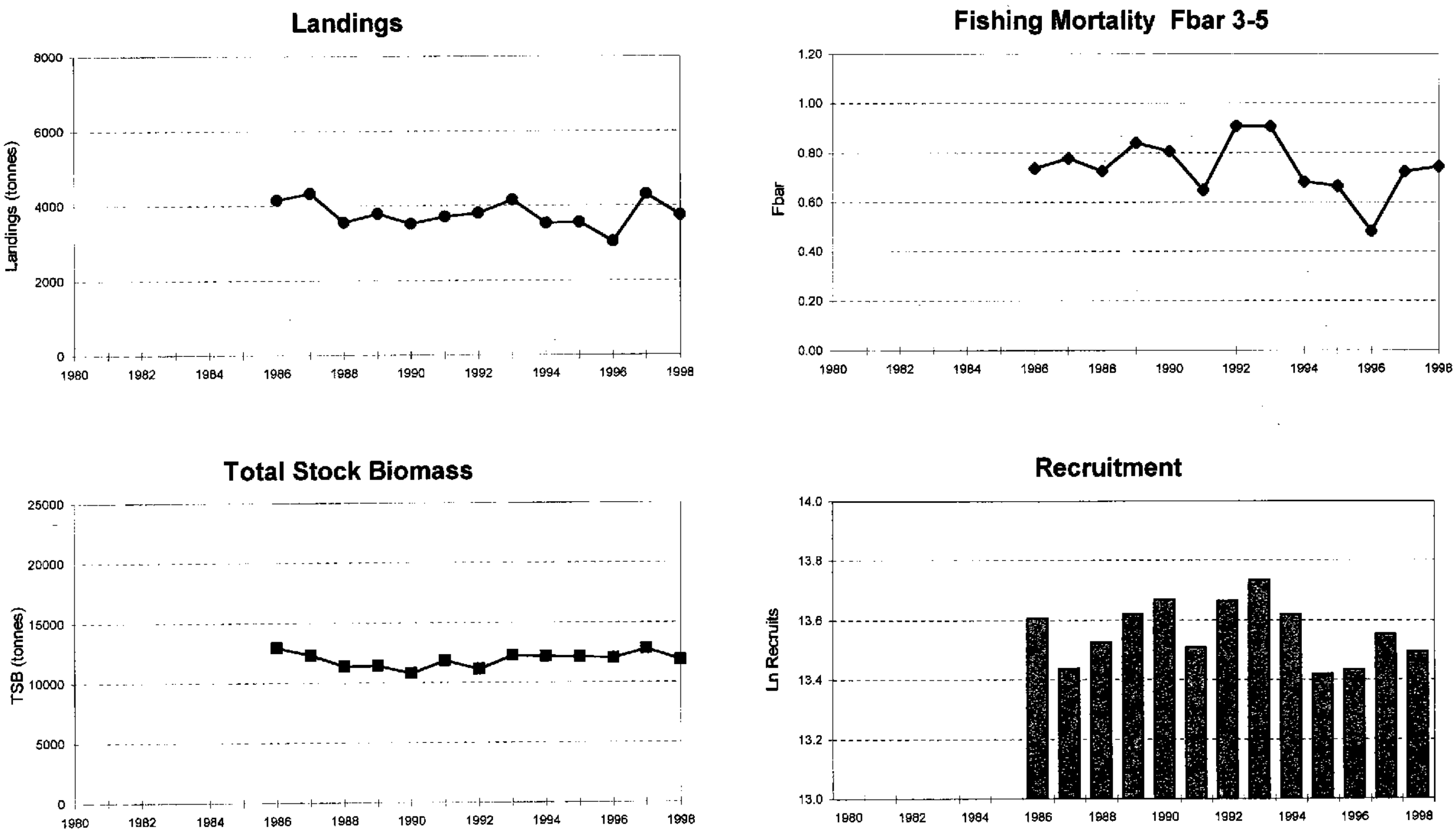


Figure 5.12.12. - Irish Sea West (FU 15): Output VPA females: Trends in Landings, Fbar, TSB and Recruitment.

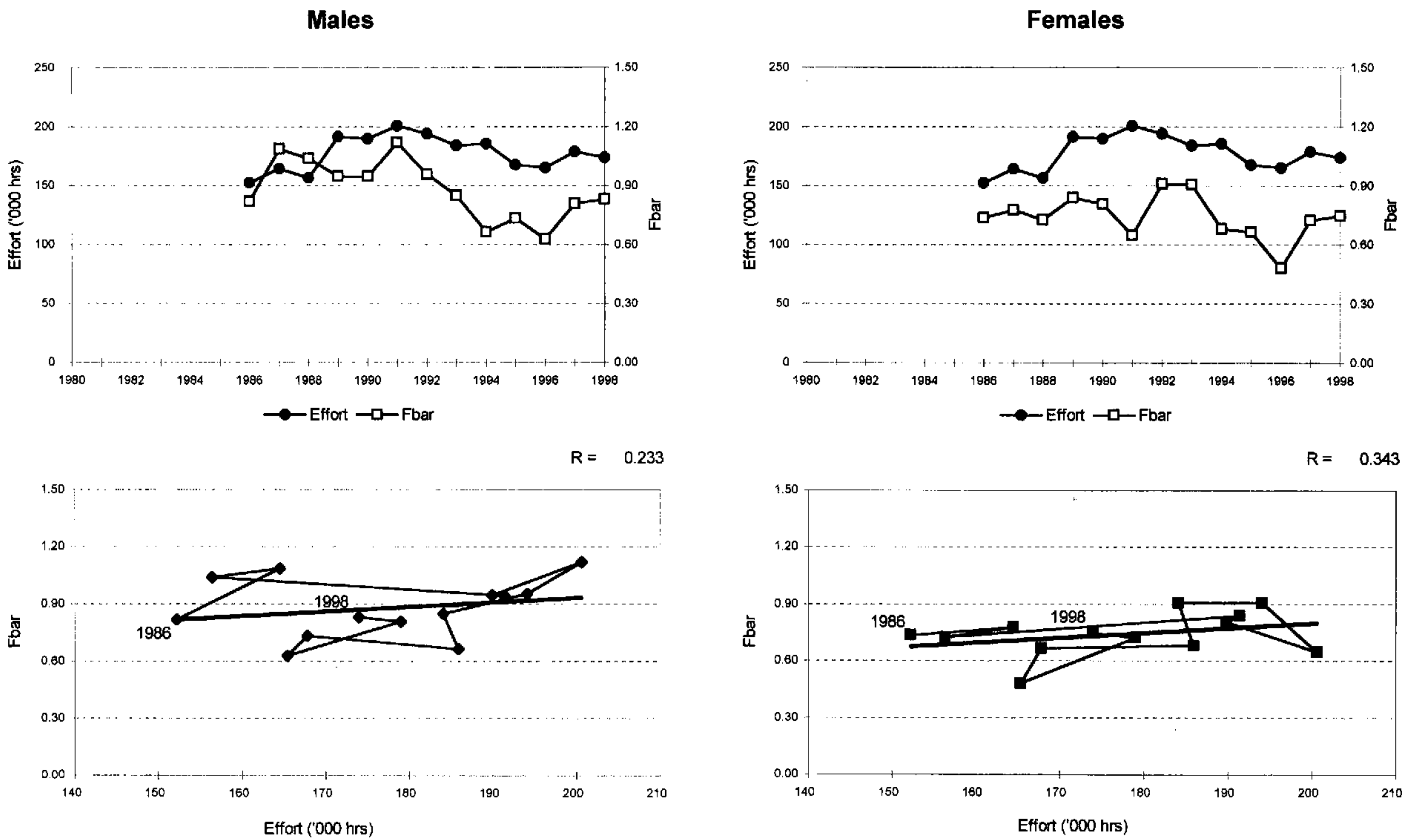
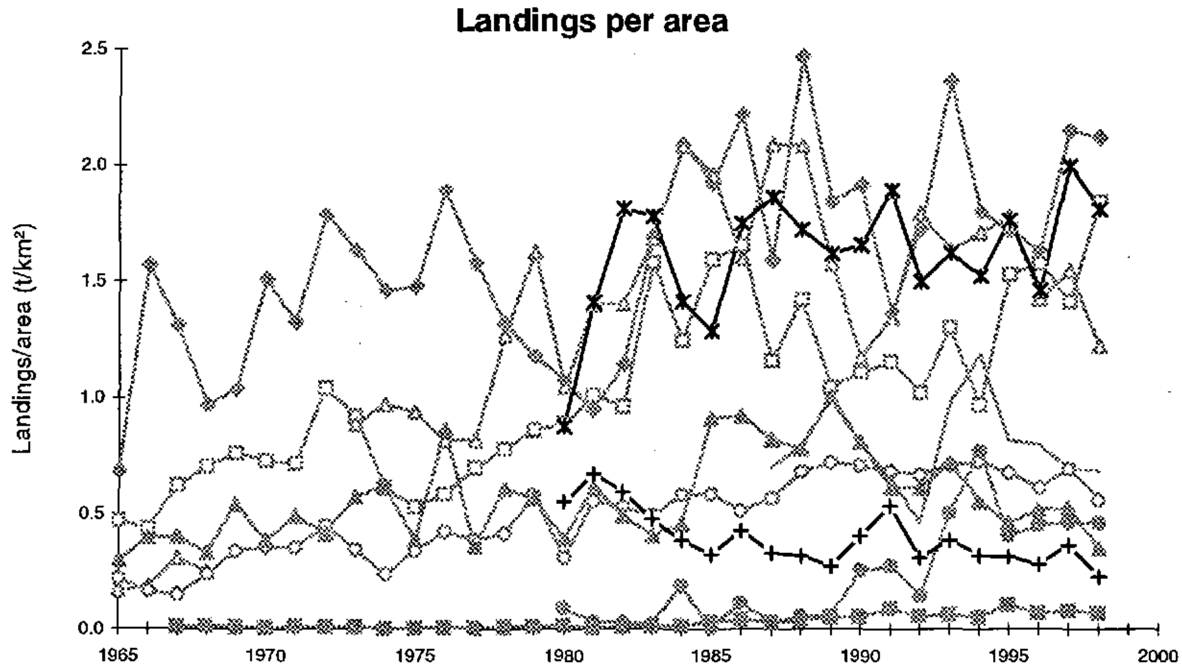


Figure 5.12.13. - Irish Sea West (FU 15): Effort and Fbar, and relationship between them, for males and females.



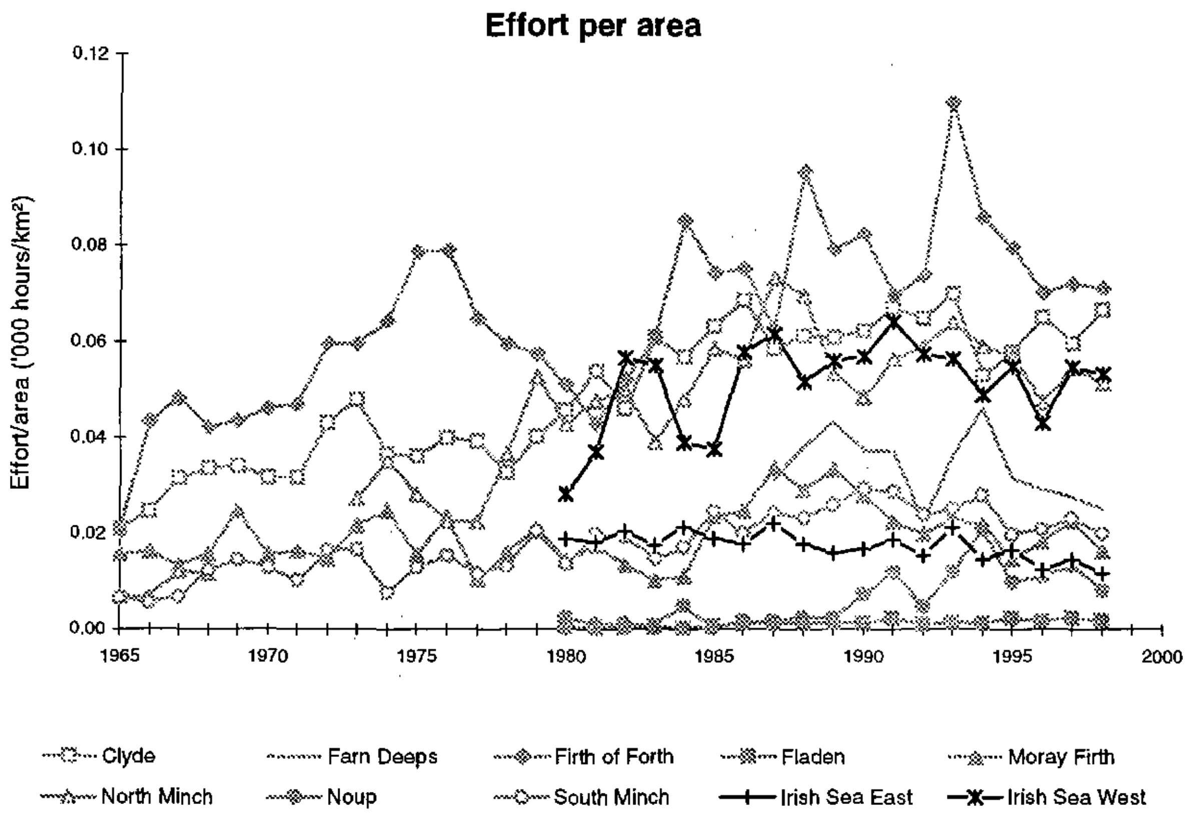


Figure 5.12.14. - *Nephrops* trawl landings per unit area (t/km²) and trawl effort per unit area ('000 hours trawling/km²) on various grounds.
Data relevant to this section of the report are shown in black.

5.13. Management Area K

ICES description **VIId,e**

Functional Units **none**

The statistical rectangles comprised in this Management Area are shown in Figure 5.1.2.

5.13.1. Summary for Management Area K

Zero TAC to prevent mis-reporting.

5.14. Management Area L

ICES description	**VIIb,c,j,k**
Functional Units	**Porcupine Bank (FU 16)** **Aran Grounds (FU 17)** **Ireland NW coast (FU 18)** **Ireland SW and SE coast (FU 19)**

The statistical rectangles comprised in this Management Area and its constituent Functional Units are shown in Figure 5.1.2.

5.14.1. Porcupine Bank (FU 16)

Description of the fisheries

France

French boats fishing on the Porcupine bank are part of the Celtic Sea fleet (about 20 of them) which is described in Section 5.15.1. The *Nephrops* fishery on the Porcupine Bank is strictly seasonal, from May to September. The technical features described for the Celtic Sea fleet equally apply to the vessels operating in FU 16.

Nephrops represents about two thirds of the landings by weight taken by French boats, and the by-catch species is anglerfish (with 19 % of the landings by weight). In value, *Nephrops* is worth 82 % of the revenues and anglerfish 12 %.

French trawlers started fishing in the area in the 80s. After several years of good catches, the catch rates fell and the vessels shifted to other grounds for some years. The past 3-4 years however, the interest for this fishery has increased again.

Spain

The Spanish fishery in the Porcupine area is a typical multi-species fishery, targeting different demersal species, amongst which *Nephrops*. The fleet, which consists of about 35 vessels, is composed of side-trawlers and is part of the so-called '300 fleet' in the Adhesion Treaty of Spain to the EEC in 1986.

Within the Porcupine fleet, two components can be distinguished: one consisting of vessels fishing with finfish trawls (average engine power 980 hp), and the other fishing with *Nephrops* trawls (average engine power 680 hp). The average duration of their trips is 15 days, of which 10-12 are actual fishing days. The major landing port is La Coruña.

The target species for the finfish directed fleet are hake, megrim and anglerfish, with *Nephrops* as a valued by-catch. Vessels fishing with *Nephrops* trawls are much more directed towards *Nephrops* (especially in spring and summer), and fish is a by-catch. Since 1994, vessels are defined as '*Nephrops* trawlers' when the weight ratio of *Nephrops*/hake in their landings exceeds 1 for all voyages (prior to 1994, the ratio was calculated for the annual landings).

Discarding of *Nephrops* is negligible in this fishery, representing about 1 % of the landings by weight (PEREZ *et al.*, 1996).

Trends in landings, effort, CPUE/LPUE and mean sizes

Table	5.14.1.	Landings by country, 1989-98
Table	5.14.2.	Effort and LPUEs Spanish and French fleets, 1989-98
Table	5.14.3.	Mean sizes of *Nephrops* in landings, Spanish data, 1989-98
Table	5.14.4.	Mean sizes of *Nephrops* in catches, Rep. of Ireland data, 1994-98
Figure	5.14.1.	Long-term trends in landings, effort, CPUE, LPUE and mean size, various data

Data on landings, effort, CPUE, LPUE and mean size, showing sufficient detail to allow the kind of comprehensive trend analysis that is made for most other *Nephrops* stocks, are available for the Spanish fleet only.

Landings and effort

Landings by the Spanish fleet continue on the decreasing trend (which started in the mid-80s) with 473 t in 1997 and 405 t in 1998 (Figure 5.14.1.). This is less than half the landings in the early 90s. The overall decrease in fleet size and fishing effort is largely responsible for the drop in landings.

Total Spanish fishing effort, like the landings, continues to decrease (Figure 5.14.1.). Average fishing effort in 1997-98 was at < 40 % of the effort in 1990. The decrease in effort is related to the cut in size of the Spanish fleet. This was brought about in two phases. Firstly in the 80s, when a considerable number of Spanish vessels were registered in other countries, where their landings are reported (so-called joint venture vessels). Secondly, in more recent years, as a result of the decommissioning of older units.

CPUE

The overall CPUE (all gears combined) of the Spanish trawler fleet has fluctuated without obvious trend between 10.8 and 16.2 kg/day * bhp/100 throughout the reference period (Figure 5.14.1.). The CPUEs of the *Nephrops* trawlers have fluctuated between 35 and 55 kg/day * bhp/100 up to 1994, but since then they show a slight decreasing trend (Table 5.14.2.). A similar trend is seen in the CPUEs of the finfish trawlers. Separate CPUEs for the two components of the fleet are not available for 1998.

Mean size

The mean sizes of *Nephrops* in Spanish landings from the Porcupine Bank have been quite stable over the period 1989-98, with values between 39 and 42 mm CL for the males, and between 34 and 37 mm CL for the females (Figure 5.14.1.).

The mean sizes of *Nephrops* in the landings of Vigo-based trawlers from 'other' rectangles (i.e. outside FU 16 but within MA L) for the period 1989-98 are given in Table 5.14.3. These mean sizes have decreased in 1997-98 for both sexes, although they still are above the lowest values in the time series, recorded in 1990.

Data and biological inputs for analytical assessments

| Table 5.14.5. Sampling data and input parameters

Length compositions of the landings by the Spanish, Irish and French fleets were available for 1997-98.

General comments on quality of data and inputs

As the length frequency data used in the LCA were based on the landings by Spain, Ireland and France (together accounting for > 90 % of the landings), they are probably more reliable than the ones used in the previous assessment (ICES, 1993a), which was restricted to data for Spain and Ireland.

Length based assessments (LCA)

| Table 5.14.6. Output table LCA males, with mean F
| Table 5.14.7. Output table LCA females, with mean F
| Figure 5.14.2. Changes in Y/R and B/R upon changes in F, for males and females separately

The long-term Y/R curve for males showed F_{max} to be 40 % below current F, but the predicted gains in yield upon a reduction in effort from current F to F_{max} are small (about 5 %). For females, the Y/R curve is flat-topped, with current F close to F_{max}. Bearing in mind that the catch consists for about 80 % of males, the stock as a whole (i.e. both sexes combined) would therefore appear to be slightly over-exploited, with current F in the region of 20-30 % above F_{max}.

Mean F, calculated across the inter-quartile length range, was 0.43 for males and 0.34 for females (Tables 5.14.6. and 5.14.7.)

Comments on quality of assessments

The length-based assessment was the first since 1993 (ICES, 1993a). As such, it represents a useful update of the pre-existing material. However, more intensive sampling could improve its quality.

This analyses suffer from a lack of (survey) data, which could reveal reasons for the rather different nature of the Spanish and Irish length frequency distributions (the Spanish having a higher mean length). This fishery poses difficulties, due to its extreme remoteness and great depth at which it takes place, thus making surveys expensive and time-consuming.

Management considerations

In view of the relatively stable condition of this fishery, a conservative approach seems to be appropriate, and the advice is that F should not be permitted to increase.

5.14.2. Aran Grounds (FU 17)

Description of the fisheries

Republic of Ireland

In 1996-98, over 99 % of the landings from this FU were made by the Republic of Ireland fleet, based mainly at Rossaveel, Co. Galway. The grounds lie immediately west and to some extent south-west of the Aran Islands, at the mouth of Galway Bay, where some of the fishermen have their homes.

In contrast to the Porcupine Bank, which is also fished by boats based at Rossaveel, the fishery on the Aran Grounds operates during all the year, weather permitting. 24-30 boats operate this fishery, of which six use twin-rigs, the rest being traditional side trawlers. Typical engine power is from 180 to 550 BHP, and the minimum mesh size in use is 80 mm. Fishing trips usually last for two days.

The situation regarding discarding is uncertain, but it seems probable that the percentages of *Nephrops* discarded are low. The main change currently taking place in the fishery is an increase in the proportion of twin-rigging boats. The fishery seems to be economically stable.

Trends in landings, effort, CPUE/LPUE and mean sizes

Table 5.14.8. Landings by country, 1989-98
Table 5.14.9. Mean sizes of Nephrops in catches and landings, Rep. of Ireland data, 1997-98

Landings

Over 99 % of the landings from this fishery in 1996-98 were made by the Republic of Ireland fleet, with negligible amounts reported by France and the UK The recent trend in international landings has been generally upwards. A short-term drop from 933 t in 1995 to 506 t in 1996 has been followed by increases to 813 t in 1997 and 1427 t in 1998. There are no effort, CPUE or LPUE data available for this fishery.

Mean size

As discards have not been sampled, comments are restricted to the landings. Mean size for the males was 31.6 and 31.1 mm CL in 1997 and 1998 respectively, and for females it was 32.0 and 31.5 mm CL. So far, however, the data series is too short to provide useful information on the state of the stock.

Data and biological inputs for analytical assessments

Table 5.14.10. Sampling data and input parameters

Length frequency data of the landings were collected in both 1997 and 1998, but seasonal coverage was incomplete. The growth parameters were taken from FUs 15 and 16, and the length-weight relationship from POPE and THOMAS (1955). Natural mortality was assumed in line with other stocks.

General comments on quality of data and inputs

As only two years' data were available, and sampling coverage was less complete than had been hoped for (in each year only three quarters were covered), the quality of the input data is probably only reasonable. The findings of the assessment should therefore be treated with caution. It is not considered probable however, that more complete coverage would have resulted in much change in the analytical assessments.

Length based assessments (LCA)

Table 5.14.11. Output table LCA males, with mean F
Table 5.14.12. Output table LCA females, with mean F
Figure 5.14.3. Changes in Y/R and B/R upon changes in F, for males and females separately

A length cohort analysis was carried out on Republic of Ireland data for 1997-98, using Pope's approximation. Input parameters, as discussed above, were taken from other fisheries, mainly the western Irish Sea.

The Y/R curves for both sexes were found to be flat-topped. Yield levels for Fs 40 % below current F to 20 % above were calculated to lie within plus or minus 1 % of the current yield. For females, current F was well below F_{max}, which occurred at F > 50 % above the current level. Fishing mortalities averaged over the inter-quartile length range were 0.83 for males and 0.30 for females. This is a larger than usual inter-sex difference in F values, and is associated with the relatively large mean size of females relative to males, which implies a higher survival rate amongst the females.

Comments on quality of assessments

The quality of the assessments is limited by the quality of the inputs. The apparently satisfactory state of exploitation of the stock is based on a slender base of evidence, which should improve with further sampling.

Management considerations

From the limited assessment presented here, the stock would appear to be in good condition. For the time being however, and pending further evidence on the state of exploitation of this stock, it would not be prudent to let effort increase.

5.14.3. Irish coast stocks (FUs 18-19)

Trends in landings, effort, LPUE and mean size

Table 5.14.13. Landings by country, 1989-98

For the time being, information on these FUs is limited to landings data, which are summarised in Table 5.14.13.

Landings are reported by the Republic of Ireland (FUs 18 and 19), France (FU 19) and the UK (FUs 18 and 19). Landings by the Republic of Ireland have fluctuated considerably throughout the time series, with high figures in the early 90s (between 570 t and 860 t, for the two FUs combined), much lower figures in the mid-90s (between 170 t and 370 t), and a provisional 672 t for 1998. Over the same period of time, the landings by the French fleet have decreased, from over 200 t in the early 90s to around 90 t in 1997 and 1998.

Management considerations

In the absence of further information, the WG did not feel to be in a position to express clear views on the state of exploitation of these stocks.

5.14.4. Summary for Management Area L

Table 5.14.14. Landings by FU and from Other rectangles, 1989-98
Table 5.14.15. Landings by country, 1989-98

In view of the results of the assessment for the Porcupine Bank (FU 16) (which suggests that a reduction of F to F_{max} for the males would result in very small gains in Y/R only) and for the Aran Grounds (FU 17) (which suggests that F for the males is close to F_{max}), there seems to be no reason to revise the advice given in the past. Therefore, the WG recommends to keep the TAC at the current level of 4000 t for the next two years.

Table 5.14.1. - Porcupine Bank (FU 16): Landings (tonnes) by country, 1989-98.

Year	France	Rep. of Ireland	Spain	UK	Total
1989	324	350	1417	17	2108
1990	336	169	1349	29	1883
1991	348	170	1021	74	1613
1992	665	311	822	170	1968
1993	799	206	752	69	1826
1994	1088	512	809	73	2482
1995	1234	1009	579	111	2933
1996	1069	823	471	141	2504
1997	1028	375	473	164	2040
1998 *	730	497	405	148	1780
* provisional na = not available					

Table 5.14.2. - Porcupine Bank (FU 16): Total effort (all gears combined) and CPUE (kg/day * BHP/100) for the Spanish fleet. Effort (hours trawling) and LPUE (kg/hour trawling) of French *Nephrops* trawlers from St Guénolé. All figures for 1989-98.

Year	Spanish fleet				French fleet	
	Effort	CPUE	CPUE	CPUE	Effort	LPUE
	All gears	*Nephrops* trawl	Finfish trawl	All gears		
1989	104825	45.1	10.8	13.5	16126	21.5
1990	96299	35.5	11.5	14.0	19100	19.9
1991	85220	33.4	8.9	12.0	23830	16.1
1992	58516	40.2	11.0	14.0	34989	19.0
1993	50007	39.9	9.9	15.1	42386	21.1
1994	49997	45.6	11.1	16.2	42400	27.6
1995	47686	54.1	8.5	12.1	46970	28.9
1996	43509	37.1	8.1	10.8	41983	25.5
1997	37367	32.8	6.8	12.7	42522	24.3
1998 *	36846	na	na	11.0	na	na
* provisional na = not available						

Table 5.14.3. - Porcupine Bank (FU 16): Mean sizes (mm CL) of male and female *Nephrops* in Spanish landings, 1989-98.

Year	Landings		Landings **	
	Males	Females	Males	Females
1989	40.5	36.5	37.4	30.9
1990	41.0	36.8	31.6	26.3
1991	39.4	34.5	37.1	34.7
1992	39.1	34.2	36.7	31.5
1993	41.7	36.1	39.1	35.9
1994	40.7	36.6	40.8	39.3
1995	41.4	36.6	38.0	36.0
1996	41.6	35.0	40.1	37.9
1997	40.0	34.9	34.1	32.4
1998 *	41.2	34.7	34.1	31.1

* provisional na = not available

** *Nephrops* caught in 'other' rectangles of VIIb,c,j,k and measured as landings in home port of Vigo

Table 5.14.4. - Porcupine Bank (FU 16): Mean sizes (mm CL) of male and female *Nephrops* in Rep. of Ireland catches, 1994-98.

Year	Catches	
	Males	Females
1994	na	na
1995	na	na
1996	na	na
1997	34.5	32.1
1998 *	36.6	34.0

* provisional na = not available

Table 5.14.5. - Porcupine Bank (FU 16): Input data and parameters.

FU	16	MA	L
FLEET	Spain	GEAR	Trawl

	1998					1997				
	Number of samples				Mean no. per sample	Number of samples				Mean no. per sample
	Qtr 1	Qtr 2	Qtr 3	Qtr 4		Qtr 1	Qtr 2	Qtr 3	Qtr 4	
Catch	0	0	0	0		0	0	0	0	
Landings	15	15	15	15	261	15	15	15	15	220
Discards	0	0	0	0		0	0	0	0	

	Number of samples									
Year	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989
Catch	0	0	0	0	0	0	0	0	0	0
Landings	60	60	56	59	36	37	36	36	36	35
Discards	0	0	0	0	0	0	0	0	0	0

FU	16	MA	L
FLEET	Rep. of Ireland	GEAR	Trawl

	1998					1997				
	Number of samples				Mean no. per sample	Number of samples				Mean no. per sample
	Qtr 1	Qtr 2	Qtr 3	Qtr 4		Qtr 1	Qtr 2	Qtr 3	Qtr 4	
Catch	0	0	0	0		0	0	0	0	
Landings	0	5	2	0	695	0	6	1	0	765
Discards	0	0	0	0		0	0	0	0	

	Number of samples									
Year	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989
Catch	0	0	0	0	0	0	0	0	0	0
Landings	7	7	4	8	0	0	10	16	35	0
Discards	0	0	0	0	0	0	0	0	0	0

FU	16	MA	L
FLEET	France	GEAR	Trawl

	1998					1997				
	Number of samples				Mean no. per sample	Number of samples				Mean no. per sample
	Qtr 1	Qtr 2	Qtr 3	Qtr 4		Qtr 1	Qtr 2	Qtr 3	Qtr 4	
Catch	0	0	0	0		0	0	0	0	
Landings	0	1	2	0	203	0	1	2	0	203
Discards	0	0	0	0		0	0	0	0	

	Number of samples									
Year	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989
Catch	0	0	0	0	0	0	0	0	0	0
Landings	3	3	8	0	0	0	0	0	0	0
Discards	0	0	0	0	0	0	0	0	0	0

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Table 5.14.5. - (continued).

INPUT PARAMETERS		
Parameter	Value	Source
Discard Survival	---	not applicable - discards considered negligible (< 1 %)
MALES		
Growth - K	0.140	based on values in other areas (ICES, 1991a)
Growth - L(inf)	75	based on maximum sizes observed in samples
Natural mortality - M	0.2	ICES, 1990a (estimated)
Length/weight - a	0.00009	based on Celtic Sea (FUs 20-22) data
Length/weight - b	3.550	"
FEMALES		
Immature Growth		
Growth - K	—	not applicable - few below CL 50 % maturity
Growth - L(inf)	—	"
Natural mortality - M	—	"
Size at maturity	24	Spanish observations from sampling (unpublished)
Mature Growth		
Growth - K	0.100	based on values in other areas (ICES, 1991a)
Growth - L(inf)	60	based on maximum sizes observed in samples
Natural mortality - M	0.2	ICES, 1990a (estimated)
Length/weight - a	0.00009	based on Celtic Sea (FUs 20-22) data
Length/weight - b	3.550	"

Table 5.14.6. - Porcupine Bank (FU 16): LCA output males.

Reference period			
Linf (mm CL)	75.0	K	0.140

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
21	8	0.2	0.134	0.000	0.001	0.201	110303	14532	70262
22	23	0.2	0.136	0.000	0.002	0.202	107389	14413	81890
23	19	0.2	0.139	0.000	0.001	0.201	104483	14292	94757
24	88	0.2	0.141	0.001	0.006	0.206	101606	14164	108887
25	234	0.2	0.144	0.002	0.017	0.217	98685	14020	124228
26	226	0.2	0.147	0.002	0.016	0.216	95647	13865	140826
27	566	0.2	0.150	0.006	0.041	0.241	92648	13683	158506
28	661	0.2	0.154	0.008	0.049	0.249	89346	13466	177079
29	1567	0.2	0.157	0.019	0.119	0.319	85991	13168	195711
30	1427	0.2	0.161	0.018	0.111	0.311	81791	12806	214254
31	2375	0.2	0.164	0.032	0.192	0.392	77802	12374	232133
32	2056	0.2	0.168	0.029	0.173	0.373	72952	11885	249131
33	3094	0.2	0.172	0.047	0.273	0.473	68519	11326	264387
34	3689	0.2	0.176	0.061	0.347	0.547	63159	10619	275156
35	3498	0.2	0.181	0.064	0.355	0.555	57346	9868	282987
36	3829	0.2	0.186	0.078	0.421	0.621	51875	9091	287732
37	3630	0.2	0.191	0.083	0.438	0.638	46228	8292	288874
38	2639	0.2	0.196	0.068	0.347	0.547	40939	7598	290618
39	3860	0.2	0.201	0.113	0.563	0.763	36781	6861	287449
40	2687	0.2	0.207	0.091	0.439	0.639	31549	6119	280124
41	2470	0.2	0.213	0.096	0.449	0.649	27638	5504	274778
42	2358	0.2	0.220	0.106	0.480	0.680	24067	4914	266945
43	1888	0.2	0.227	0.098	0.431	0.631	20726	4379	258399
44	1921	0.2	0.234	0.116	0.495	0.695	17962	3883	248336
45	1987	0.2	0.242	0.143	0.591	0.791	15265	3364	232840
46	1223	0.2	0.251	0.105	0.418	0.618	12605	2927	218839
47	1018	0.2	0.260	0.102	0.392	0.592	10797	2600	209624
48	862	0.2	0.270	0.101	0.373	0.573	9259	2313	200799
49	1210	0.2	0.280	0.170	0.608	0.808	7934	1989	185667
50	667	0.2	0.292	0.115	0.394	0.594	6326	1694	169744
51	698	0.2	0.304	0.145	0.478	0.678	5321	1462	157048
52	494	0.2	0.318	0.125	0.394	0.594	4330	1253	144130
53	558	0.2	0.332	0.175	0.527	0.727	3586	1058	130187

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Table 5.14.6. - (continued).

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
54	466	0.2	0.349	0.188	0.539	0.739	2816	865	113655
55	280	0.2	0.366	0.143	0.390	0.590	2177	717	100493
56	299	0.2	0.386	0.195	0.504	0.704	1754	593	88511
57	275	0.2	0.408	0.241	0.590	0.790	1336	466	74071
58	119	0.2	0.433	0.137	0.317	0.517	968	375	63414
59	210	0.2	0.461	0.333	0.723	0.923	774	290	52101
60	104	0.2	0.493	0.243	0.493	0.693	506	211	40163
61	75	0.2	0.529	0.248	0.468	0.668	359	160	32312
62	70	0.2	0.572	0.346	0.606	0.806	252	116	24685
63	44	0.2	0.622	0.347	0.558	0.758	159	79	17824
64	27	0.2	0.681	0.342	0.502	0.702	99	54	12844
65	44	0.2			0.500	0.700	62	54	12844
					Totals, including lengths above + group			273759	7435244

Mean F, calculated across inter-quartile range	0.431

Table 5.14.7. - Porcupine Bank (FU 16): LCA output females.

Reference period				
Linf immatures (mm CL)	na	K immatures	na	na = not applicable (very few animals below size at 50 % maturity)
Linf matures (mm CL)	60.0	K matures	0.100	
Transition length (mm CL)	24.0			

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
21	90	0.2	0.260	0.001	0.006	0.206	63769	16130	77988
22	114	0.2	0.267	0.002	0.007	0.207	60453	15684	89116
23	202	0.2	0.274	0.004	0.013	0.213	57202	15224	100938
24	216	0.2	0.282	0.004	0.015	0.215	53955	14749	113385
25	228	0.2	0.290	0.005	0.016	0.216	50790	14271	126451
26	579	0.2	0.299	0.013	0.042	0.242	47707	13739	139551
27	1107	0.2	0.308	0.026	0.085	0.285	44380	13075	151471
28	1180	0.2	0.318	0.030	0.096	0.296	40658	12321	162023
29	1930	0.2	0.328	0.055	0.169	0.369	37013	11431	169906
30	714	0.2	0.339	0.023	0.067	0.267	32797	10630	177844
31	1968	0.2	0.351	0.070	0.201	0.401	29957	9807	183978
32	2036	0.2	0.364	0.085	0.233	0.433	26027	8759	183599
33	2441	0.2	0.377	0.121	0.320	0.520	22240	7621	177886
34	1482	0.2	0.392	0.088	0.225	0.425	18275	6603	171086
35	2250	0.2	0.408	0.164	0.402	0.602	15472	5600	160598
36	1717	0.2	0.426	0.160	0.376	0.576	12102	4568	144578
37	2180	0.2	0.445	0.275	0.618	0.818	9471	3530	122979
38	1461	0.2	0.465	0.264	0.567	0.767	6585	2577	98553
39	1127	0.2	0.488	0.296	0.606	0.806	4609	1859	77893
40	738	0.2	0.513	0.286	0.558	0.758	3110	1322	60511
41	348	0.2	0.541	0.191	0.353	0.553	2108	985	49177
42	236	0.2	0.572	0.174	0.304	0.504	1563	776	42168
43	240	0.2	0.606	0.245	0.403	0.603	1172	595	35101
44	235	0.2	0.645	0.367	0.568	0.768	813	414	26452
45	78	0.2	0.690	0.184	0.267	0.467	495	292	20206
46	61	0.2	0.741	0.202	0.272	0.472	359	224	16767
47	90	0.2	0.800	0.483	0.603	0.803	253	149	12034
48	42	0.2	0.870	0.419	0.481	0.681	133	87	7575
49	27	0.2	0.953	0.512	0.537	0.737	74	50	4696
50	26	0.2			0.500	0.700	36	50	4696
					Totals, including lengths above + group			193122	2909203

Mean F, calculated across inter-quartile range	0.344

Table 5.14.8. - Aran Grounds (FU 17): Landings (tonnes) by country, 1989-98.

Year	France	Rep. of Ireland	UK	Total
1989	14	814	0	828
1990	27	317	1	345
1991	30	489	0	519
1992	11	399	2	412
1993	11	361	0	372
1994	18	707	4	729
1995	91	841	1	933
1996	2	500	4	506
1997	2	811	0	813
1998 *	2	1425	0	1427
* provisional na = not available				

Table 5.14.9. - Aran Grounds (FU 17): Mean sizes (mm CL) of male and female *Nephrops* in Rep. of Ireland catches, 1994-98.

Year	**Catches**	
	Males	Females
1994	na	na
1995	na	na
1996	na	na
1997	31.6	32.0
1998 *	31.1	31.5
* provisional na = not available		

Table 5.14.10. - Aran Grounds (FU 17) : Input data and parameters.

FU	**17**	**MA**	**L**
FLEET	**Rep. of Ireland**	**GEAR**	**Trawl**

	1998					**1997**				
	Number of samples				Mean no. per sample	Number of samples				Mean no. per sample
	Qtr 1	Qtr 2	Qtr 3	Qtr 4		Qtr 1	Qtr 2	Qtr 3	Qtr 4	
Catch	0	0	0	0		0	0	0	0	
Landings	5	5	0	2	660	0	7	1	3	851
Discards	0	0	0	0		0	0	0	0	

	Number of samples									
Year	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989
Catch	0	0	0	0	0	0	0	0	0	0
Landings	12	11	3	13	0	0	0	20	24	0
Discards	0	0	0	0	0	0	0	0	0	0

INPUT PARAMETERS		
Parameter	Value	Source
Discard Survival	—	not applicable - discards neglibible
MALES		
Growth - K	0.150	based on FUs 15 and 16
Growth - L(inf)	60	based on FU 15
Natural mortality - M	0.3	assumed, in line with other stocks
Length/weight - a	0.00032	based on Scottish data (Pope and Thomas, 1955)
Length/weight - b	3.210	"
FEMALES		
Immature Growth		
Growth - K	0.150	based on FUs 15 and 16
Growth - L(inf)	60	based on FU 15
Natural mortality - M	0.3	assumed, in line with other stocks
Size at maturity	24	
Mature Growth		
Growth - K	0.100	based on FUs 15 and 16
Growth - L(inf)	50	based on FU 15
Natural mortality - M	0.2	assumed, in line with other stocks
Length/weight - a	0.00068	based on Scottish data (Pope and Thomas, 1955)
Length/weight - b	2.960	"

Table 5.14.11. - Aran Grounds (FU 17): LCA output males.

Reference period	1997-98		
Linf (mm CL)	60.0	K	0.150

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
20	4	0.3	0.169	0.000	0.000	0.300	107193	17642	91712
21	102	0.3	0.173	0.001	0.006	0.306	101896	17186	104101
22	374	0.3	0.178	0.004	0.022	0.322	96639	16698	117037
23	327	0.3	0.183	0.004	0.020	0.320	91255	16191	130479
24	580	0.3	0.188	0.007	0.037	0.337	86071	15664	144300
25	1369	0.3	0.193	0.018	0.091	0.391	80792	15038	157516
26	2110	0.3	0.199	0.029	0.148	0.448	74911	14264	169042
27	4403	0.3	0.205	0.069	0.334	0.634	68521	13181	175933
28	5699	0.3	0.212	0.103	0.486	0.786	60162	11731	175601
29	6090	0.3	0.219	0.132	0.603	0.903	50940	10105	168971
30	5960	0.3	0.226	0.160	0.706	1.006	41813	8453	157311
31	5356	0.3	0.234	0.182	0.779	1.079	33310	6887	142157
32	4866	0.3	0.243	0.217	0.895	1.195	25881	5448	124318
33	4095	0.3	0.252	0.248	0.985	1.285	19374	4165	104749
34	3013	0.3	0.262	0.253	0.967	1.267	14022	3121	86258
35	2361	0.3	0.272	0.280	1.029	1.329	10067	2299	69644
36	1653	0.3	0.284	0.282	0.995	1.295	7011	1665	55135
37	1047	0.3	0.296	0.256	0.862	1.162	4855	1217	43965
38	660	0.3	0.310	0.224	0.724	1.024	3440	914	35935
39	685	0.3	0.325	0.339	1.041	1.341	2505	660	28180
40	374	0.3	0.342	0.279	0.815	1.115	1619	460	21294
41	248	0.3	0.360	0.270	0.749	1.049	1106	332	16604
42	207	0.3	0.381	0.341	0.896	1.196	758	232	12521
43	121	0.3	0.404	0.311	0.770	1.070	481	158	9170
44	78	0.3	0.430	0.311	0.722	1.022	312	109	6791
45	71	0.3	0.460	0.476	1.035	1.335	201	69	4640
46	37	0.3	0.494	0.457	0.924	1.224	109	40	2904
47	20	0.3	0.534	0.454	0.851	1.151	59	24	1827
48	12	0.3	0.580	0.523	0.902	1.202	32	13	1107
49	8	0.3			0.300	0.600	16	0	0
					Totals, including lengths above + group			183963	2359202

Mean F, calculated across inter-quartile range	0.831

Table 5.14.12. - Aran Grounds (FU 17): LCA output females.

Reference period	1997-98		
Linf immatures (mm CL)	60.0	K immatures	0.150
Linf matures (mm CL)	50.0	K matures	0.100
Transition length (mm CL)	24.0		

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
20	73	0.3	0.169	0.000	0.003	0.303	177916	29276	151989
21	74	0.3	0.173	0.000	0.003	0.303	169060	28522	170495
22	242	0.3	0.178	0.002	0.009	0.309	160430	27754	189799
23	1323	0.3	0.183	0.009	0.049	0.349	151861	26873	209017
24	1908	0.3	0.188	0.014	0.074	0.374	142476	25840	227372
25	516	0.2	0.408	0.004	0.010	0.210	132816	51960	514678
26	3571	0.2	0.426	0.031	0.073	0.273	121908	48983	543708
27	4430	0.2	0.445	0.044	0.098	0.298	108538	45187	559691
28	5825	0.2	0.465	0.066	0.143	0.343	95068	40881	562826
29	7345	0.2	0.488	0.100	0.205	0.405	81062	35888	547188
30	1425	0.2	0.513	0.023	0.045	0.245	66530	32073	539723
31	7067	0.2	0.541	0.136	0.251	0.451	58690	28156	521293
32	7178	0.2	0.572	0.181	0.316	0.516	45979	22759	462213
33	6748	0.2	0.606	0.235	0.388	0.588	34233	17459	387856
34	2125	0.2	0.645	0.099	0.154	0.354	23973	13832	335231
35	5244	0.2	0.690	0.349	0.506	0.706	19078	10421	274842
36	3815	0.2	0.741	0.431	0.582	0.782	11725	6594	188823
37	2487	0.2	0.800	0.528	0.660	0.860	6567	3800	117877
38	1062	0.2	0.870	0.433	0.497	0.697	3300	2153	72190
39	307	0.2	0.953	0.208	0.218	0.418	1799	1414	51170
40	497	0.2	1.054	0.611	0.580	0.780	1208	868	33807
41	244	0.2	1.178	0.727	0.618	0.818	531	402	16817
42	90	0.2	1.335	0.708	0.530	0.730	203	173	7771
43	15	0.2	1.542	0.260	0.169	0.369	77	90	4329
44	26	0.2			0.300	0.500	43	0	0
					Totals, including lengths above + group			501359	6690704

Mean F, calculated across inter-quartile range	0.301

Table 5.14.13. - Rep. of Ireland coast (FUs 18 and 19): Landings (tonnes) by country, 1989-98.

Year	FU 18			FU 19			
	Rep. of Ireland	UK	Total	France	Rep. of Ireland	UK	Total
1989	11	1	11	245	652 **	2	898
1990	5	0	5	181	569 **	4	754
1991	0	1	0	212	860 **	5	1077
1992	1	0	1	233	640 **	15	888
1993	9	1	10	229	672 **	4	904
1994	124	2	126	216	153 **	21	390
1995	23	2	25	175	218 **	12	405
1996	50	1	51	145	318	7	470
1997	16	0	16	93	161	7	261
1998 *	58	0	58	87	614	2	703

* provisional na = not available

** exclusive of landings from rectangles which were previously in FUs 20-22, and which are now in FU 19

Table 5.14.14. - Management Area L (VIIb,c,j,k): Total *Nephrops* landings (tonnes) by Functional Unit plus other rectangles, 1989-98.

Year	FU 16	FU 17	FU 18	FU 19	Other	Total
1989	2108	828	11	898	143	***3988***
1990	1883	345	5	754	114	***3101***
1991	1613	519	0	1077	196	***3405***
1992	1968	412	1	888	454	***3723***
1993	1826	372	10	904	486	***3598***
1994	2482	729	126	390	599	***4326***
1995	2933	933	25	405	694	***4990***
1996	2504	506	51	470	606	***4137***
1997	2040	813	16	261	550	***3680***
1998 *	1780	1427	58	703	588	***4556***
* provisional na = not available						

Table 5.14.15. - Management Area L (VIIb,c,j,k): Total *Nephrops* landings (tonnes) by country, 1989-98.

Year	France	Rep. of Ireland	Spain	UK	Total
1989	583	1827	1505	73	***3988***
1990	544	1060	1436	59	***3101***
1991	590	1519	1152	144	***3405***
1992	909	1351	1139	325	***3723***
1993	1039	1310	1075	175	***3598***
1994	1322	1716	1069	218	***4326***
1995	1500	2446	767	275	***4990***
1996	1216	1729	875	317	***4137***
1997	1123	1667	554	334	***3680***
1998 *	819	2810	570	357	***4556***
* provisional na = not available					

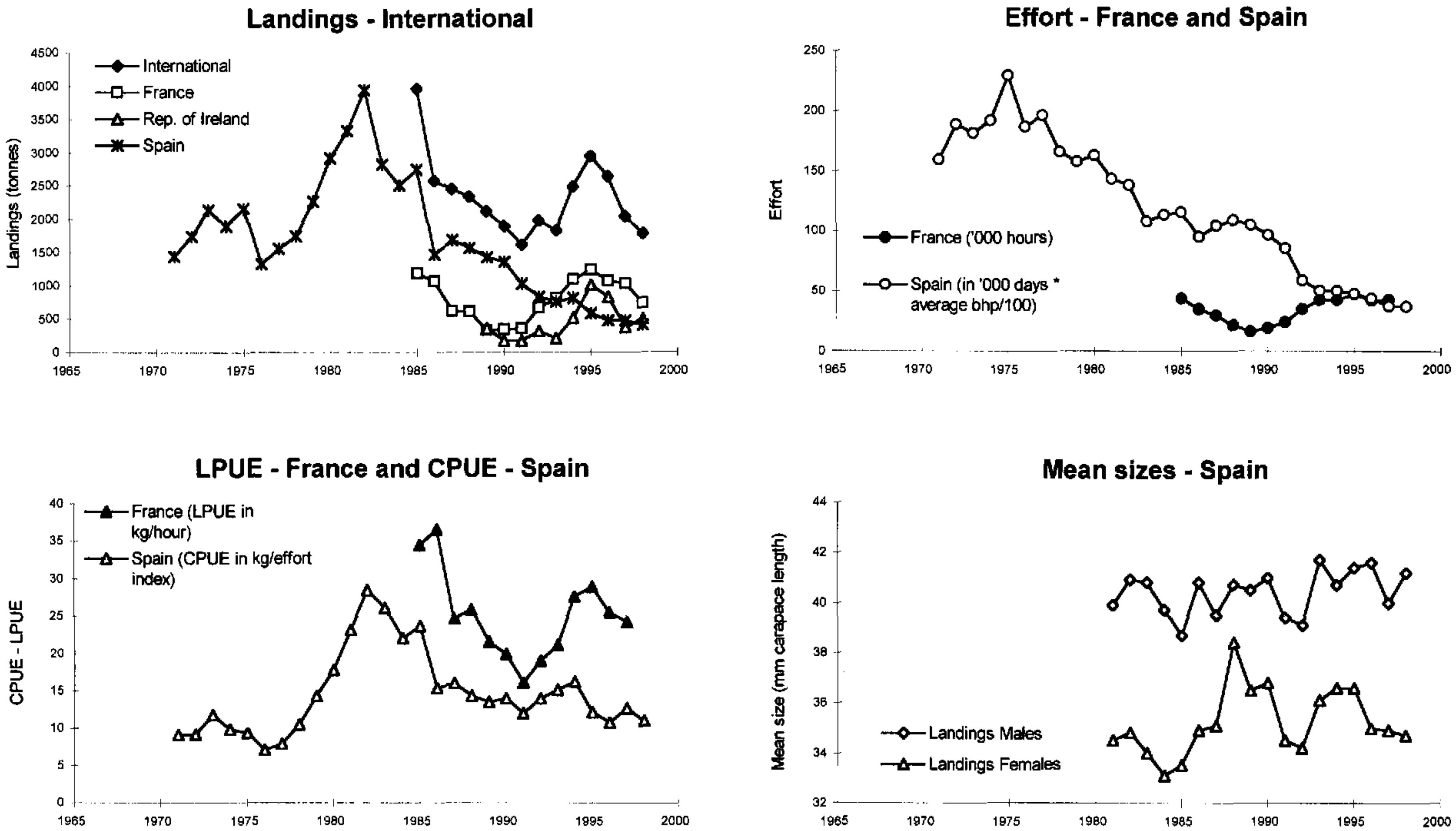
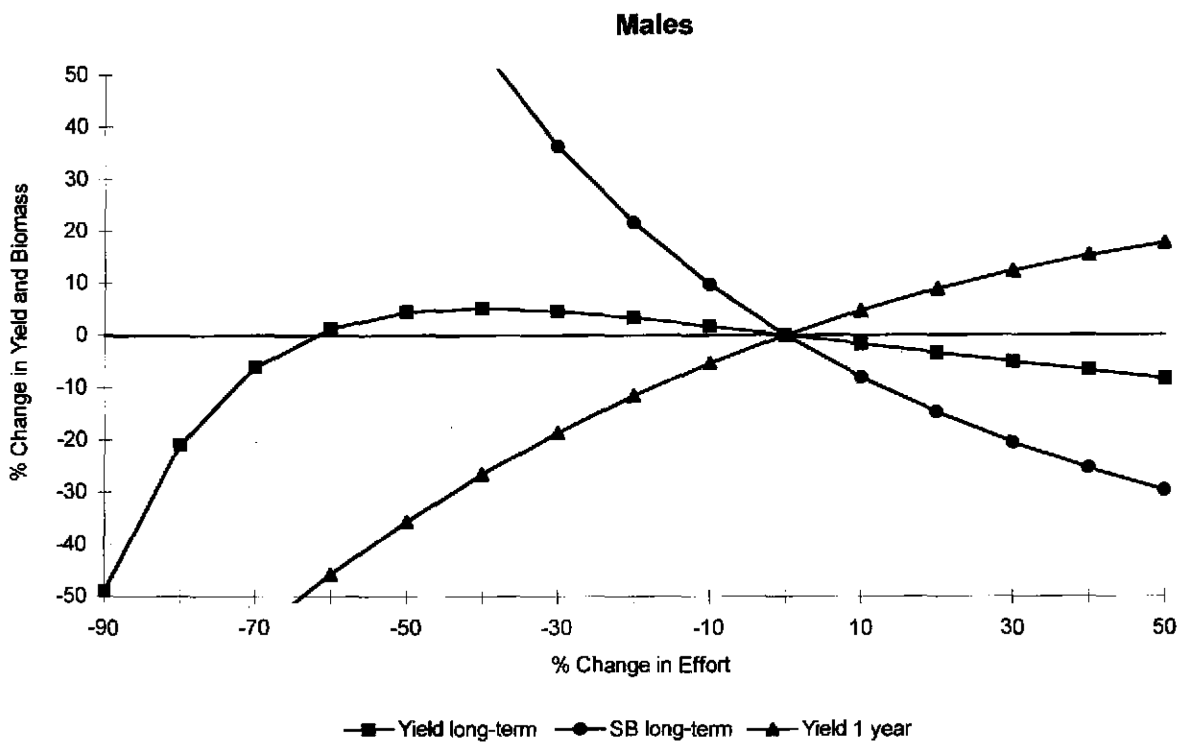


Figure 5.14.1. - Porcupine Bank (FU 16): Long-term trends in landings, effort, CPUEs, LPUEs and mean sizes of *Nephrops* in landings.



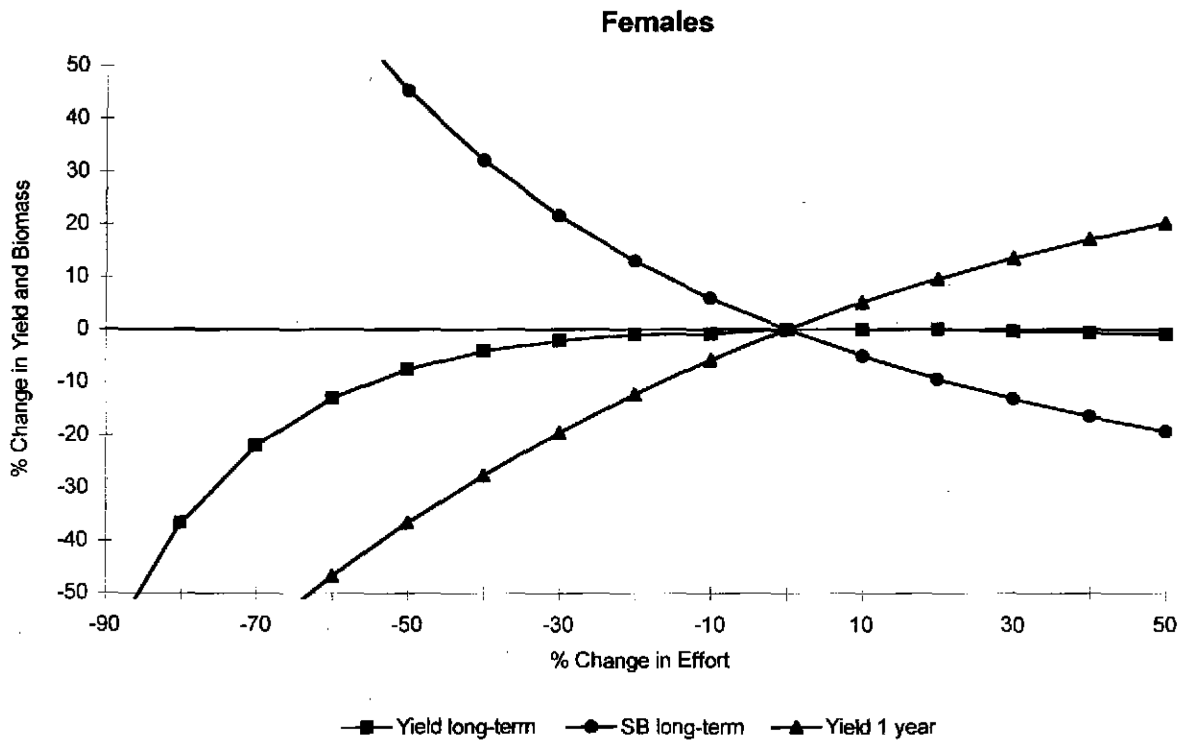
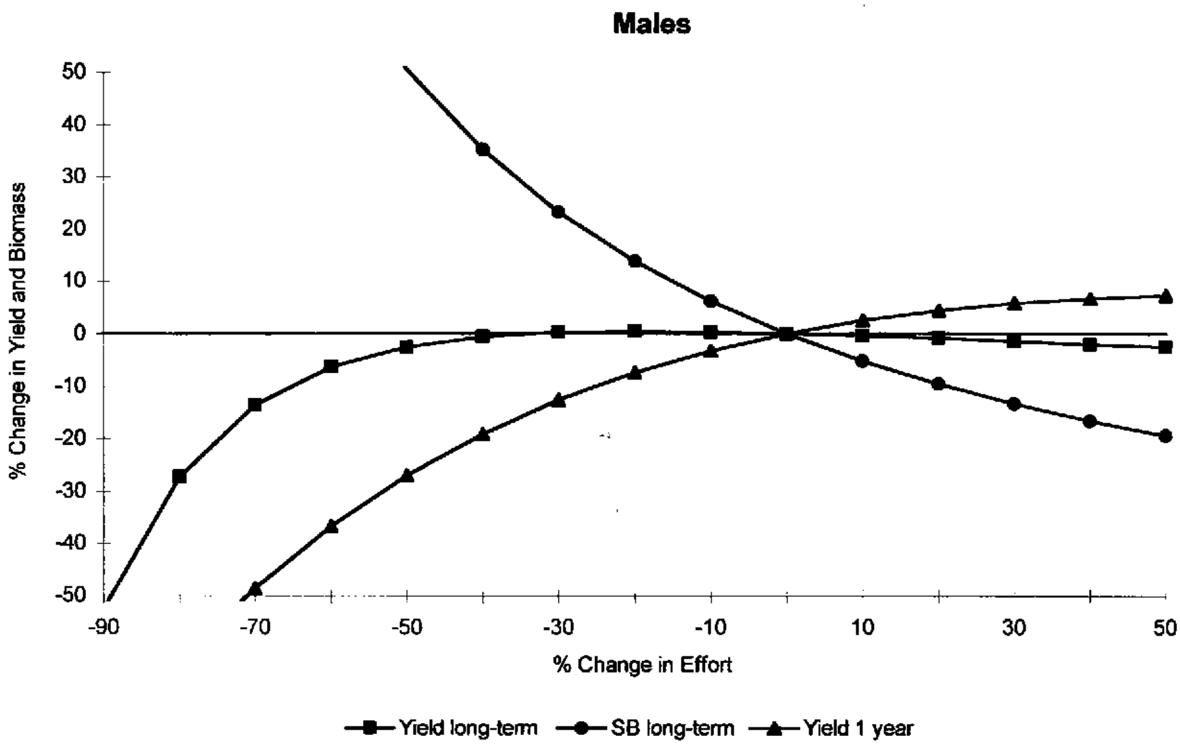


Figure 5.14.2. - Porcupine Bank (FU 16): Output LCA: Relative changes in short-term yield (ie after 1 year), long-term yield and long-term biomass upon relative changes in effort. Males and females shown separately.



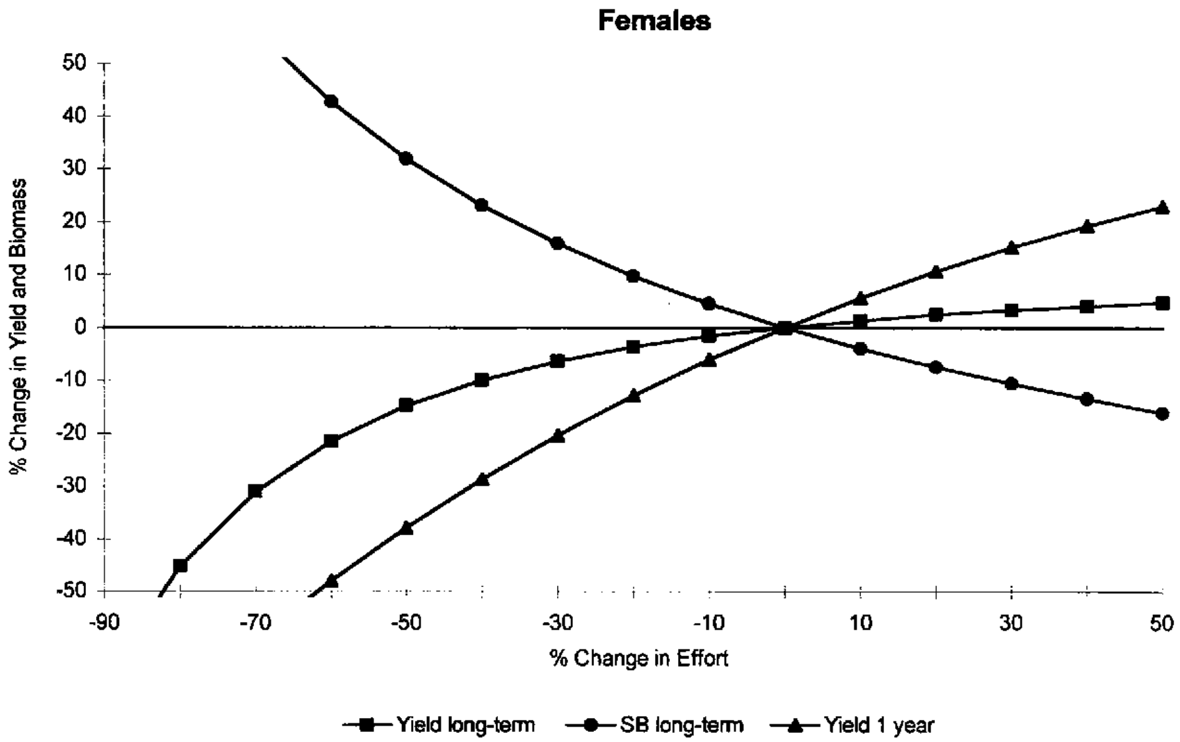


Figure 5.14.3. - Aran Grounds (FU 17): Output LCA: Relative changes in short-term yield (ie after 1 year), long-term yield and long-term biomass upon relative changes in effort. Males and females shown separately.

5.15. Management Area M

ICES description **VIIf,g,h excluding rectangles 31E1 32E1-E2, plus VIIa South of 53° N**

Functional Units **Celtic Sea (FUs 20-22)**

The statistical rectangles comprised in this Management Area and its constituent Functional Units are shown in Figure 5.1.2.

5.15.1. Celtic Sea (FUs 20-22)

Description of the fisheries

France

About 90 vessels are involved in the Celtic Sea fishery. They are all stern trawlers and their major technical characteristics are as follows:

	Engine power (kW)	Length over all (m)
Mean	260	20
Range	155-387	15-24

About 20 of these vessels go to the Porcupine bank (FU 16) from May to September.

The boats fish with 80 mm codend mesh sizes, to avoid problems with the minimum percentage of *Nephrops* that is required to fish with a 70 mm mesh size. The 80 mm mesh size also allows them to switch to finfish, when *Nephrops* catch rates are low (during the night for example, or during periods of bad weather). There have been some changes in gear in recent years, with rockhoppers being set on trawls and with a few boats beginning to use twin-trawls.

The major landing ports are located in the southern part of Brittanny, viz. Douarnenez, Loctudy, Saint Guénolé, Concarneau and Lorient.

The average duration of the fishing trips is 14 days. Given a 24 hours' journey to reach the *Nephrops* grounds, this leaves 12 effective fishing days on average per voyage. The boats make 5-6 hauls per day, of 3-5 hours each.

Discarding is substantial in this fishery. French fishermen's organisations have set a minimum landing size of 35 mm CL, which is far above the EU legal minimum landing size of 25 mm CL. Since trips are rather long and small *Nephrops* do not preserve very well on ice, they are discarded.

Nephrops are landed iced, and are sorted in two market categories (viz. 'small' and 'large') according to their size.

About 75 % of the fleet targets other species when *Nephrops* catch rates are low, during winter and periods of bad weather, but when they do, they use the same trawl and fish in the same area. Even when primarily targeted towards *Nephrops*, the boats also search for other species – otherwise their activities would not be profitable. *Nephrops* represents about 30 % (by weight) of the landings. Major by-catch species are cod (15 % of the total landings by weight), anglerfish (14 %), whiting (10 %) and megrim (8 %). The vessels also catch haddock, ling and hake, but is much lower proportions. In financial terms, *Nephrops* represents 53 % of the revenues, anglerfish 14 %, cod 9 %, megrim 6 % and whiting 4 %.

There is no problem of 'black' landings in this fishery, since catch quota are never reached. Quantities landed are all recorded in the auctions and are precisely known.

The number of boats in the Celtic Sea *Nephrops* fishery has decreased over the past 5 years, in compliance with the EU decommissioning programmes, and boats have been sold to other ports or other countries after a period of unfavourable market conditions due to low market prices in 1993 and 1994. As for now, the economic situation of the fleet seems to have recovered from this crisis.

UK

Each year, about 20 UK vessels land *Nephrops* from FUs 20-22. About half of these appear to target *Nephrops* and account for 80 % of the UK annual *Nephrops* landings from the area. Approximately two thirds of the *Nephrops* directed vessels land to Kilkeel and Portavogie in Northern Ireland.

Nearly all vessels are side trawlers (17-24 m in length), using twin *Nephrops* gear with an 80 mm mesh codend. The remainder are 18-34 m in length, use otter trawls with 75-90 mm meshes in the codend, and land to Plymouth, Milford Haven or Whitehaven.

The UK fleet in FUs 20-22 specifically targets *Nephrops* in May and June. Vessels landing to Northern Ireland spend 3-6 days at sea, whilst the others tend to make shorter trips of 2-3 days. Whiting, cod, anglerfish and megrim make up a large proportion of the by-landings for this fleet. Outside the main *Nephrops* season, effort is diverted to other species and possibly other areas.

Trends in landings, effort, LPUE and mean sizes

Table	5.15.1.	Landings by country, 1989-98
Table	5.15.2.	Effort and LPUEs French fleet, 1989-98
Table	5.15.3.	Mean sizes of *Nephrops* in catches and landings, French data, 1989-98
Figure	5.15.1.	Long-term trends in landings, effort, LPUE and mean size, French data
Figure	5.15.2.	Landings by sex + Quarterly plots of effort and LPUEs by sex, 1989-98

Landings and effort

Landings are reported by France, the Republic of Ireland and the UK. From 1989 to 1993, the French landings represented at least 80 % of the international *Nephrops* landings from the Celtic Sea, but the proportion has fallen to 70 % since then.

The French landings for 1998 are partial, and may represent only 75 % of the actual ones, because the statistics were still incomplete at the time of the WG meeting. Abstraction made of the 1998 figure, the French landings have been fluctuating without obvious trend between 2400 t and 3600 t (Figure 5.15.1.).

Irish landings rose from an average level of around 700 t in 1989-93, to 1415 t in 1994 and 2014 t in 1995 (Figure 5.15.1.). They fell back to 1067 t in 1996, then rose to 1663 t in 1998, though this is a preliminary figure. The higher levels of the last five years compared to previous years, may in part be due to more precise reporting.

Total landings from the Celtic Sea FUs have steadily increased from 2800 t in 1986 to about 5700 t in 1995, then decreased again to 3600 t in 1997 (Figure 5.15.1.). The sharp increase in total landings, which occurred between 1991 and 1995, was almost entirely due to a steady increase in the Irish landings.

Total French *Nephrops* directed effort decreased slightly from 1985 to 1988, then steadily increased until 1993, but has been falling off again since 1994 (Figure 5.15.1.). There are no effort data for 1998, because of the delay in the processing of the fishery statistics in France. Quarterly effort reaches a peak during the 2nd and the 3rd quarter, when the availability of *Nephrops* is highest (Figure 5.15.2.). There are no effort data for the Irish trawlers operating in the Celtic Sea.

LPUE

The LPUEs of the French *Nephrops* fleet have decreased from 15 kg/hour in 1988-89 to about 10 kg/hour in 1991, then increased to 13 kg/hour in 1995, and slightly decreased again to 11 kg/hour in 1997.

The LPUEs of the males show a similar trend, with peak values in 1989-90, a drop in 1991 and an increase since then (Figure 5.15.2.). The LPUEs of the females are very low compared to the males. Landings of females are generally small, because of their slower growth rate and the large commercial minimum landing size (35 mm CL).

Mean size

Mean sizes in the catches have been stable from 1987 to 1996, but increased in 1997 and 1998 for both males and females (Figure 5.15.1.). The figures for these years were obtained from a new discard sampling programme conducted in 1997 (details given below), whereas the figures for the previous years were derived from a discard sampling programme conducted in 1991. Mean sizes in the landings have remained fairly stable since the beginning of the 90s.

Data and biological inputs for analytical assessments

Table 5.15.4. Sampling data and input parameters

Length composition data of the French landings are available since 1987, but discard data are available for 1991 and 1997 only. The numbers discarded at length for 1987-96 were derived from the 1991 data, by means of the ratios between the numbers discarded at length and the total numbers landed (all sizes combined).

The biological parameters used in the assessments remained unchanged from those in the previous assessments (see e.g. ICES, 1997a).

General comments on quality of data and inputs

Because of the delay in the processing of the French landings and effort statistics for 1998, only partial data were available at the time of the meeting. Therefore, it was decided to exclude 1998 from the assessments.

French fishing effort is well documented for the Celtic Sea since the EU logbook is compulsory for all vessels fishing in the area. *Nephrops* directed fishing effort by the French trawler fleet is calculated from voyages for which > 10 % of the total value consists of *Nephrops* (or > 10 % of the total weight landed, when the value was not recorded). Fishing hours of these trips are then summed, to obtain an overall estimate of the effort directed towards *Nephrops*.

Length composition data of the landings are collected every month in the main home ports of the French *Nephrops* trawlers operating in the Celtic Sea. Discards, however, can not be sampled every year because of insufficient technical and financial resources. Applying discard length compositions from years during which a sampling programme was performed, to years for which there are no discard sampling data, may cause problems of consistency between the different data sets. Both males and females discarded in 1997 appeared to be larger than those discarded in 1991, and to be much less numerous (Figure 5.15.3.). These apparent differences may be caused by the difficulties in setting up a random sampling protocol, which ideally should have smoothed the overall level of variability between discard samples from the different grounds in the Celtic Sea.

In the absence of an Irish sampling programme in the area, the length compositions for the Irish fleet were derived from French data. Since the legal (EU) minimum landing size for *Nephrops* applied in the Republic of Ireland (25 mm CL) is much smaller than the minimum size acceptable to the French market (35 mm CL), the use of the French discard data under-estimates the Irish removals-at-length, especially for the size classes at or just above the legal minimum landing size.

Length-based assessments (LCA)

Table 5.15.5. Output table LCA males, with mean F
Table 5.15.6. Output table LCA females, with mean F
Figure 5.15.4. Changes in Y/R and B/R upon changes in F, for males and females separately

The reference period for the LCA was 1995-97. Average length compositions of the landings and discards were calculated over this period. The equilibrium condition is not met, since there have been changes in landings, effort and LPUEs.

The results of the Y/R analysis are very similar to those of the previous assessment, which was run over the 1991-96 reference period (ICES, 1997a). The male Y/R curve is flat-topped and maximum landings (+ 9 %) are expected to occur with a reduction in fishing mortality of 40 % from current F to F_{max}. For females, a predicted long-term gain of 22 % is expected upon a decrease of 40 % in fishing mortality from current F to F_{max}. The results for the females must be treated with caution, as only few are landed and large proportions of the females are being discarded. Therefore, the assessment of the female stock is strongly affected by the length composition of the discards, with all the problems this entails with regards to the quality of the discard data. Mean F calculated across the inter-quartile range is 0.41 for the males and 0.45 for the females (Tables 5.15.5. and 5.15.6.).

Age-based assessments (VPA)

The length distributions (reference period 1987-97) were split into 7 nominal 'age' groups (7 being a plus group) for both males and females, using the L2AGE slicing program. The VPA assessments were performed using the XSA option of the Lowestoft VPA package.

Males

Table	5.15.7.	Output XSA males: Fs-at-age
Table	5.15.9.	Output XSA males: Long-term trends in landings, Fbar, TSB and recruitment
Figure	5.15.5.	Output XSA males: Log catchability residuals
Figure	5.15.7.	Output XSA males: Long-term trends in landings, Fbar, TSB and recruitment
Figure	5.15.9.	Output XSA males: Plots of Fbar vs. effort

The VPA for the males was based on the following options:

- Catchability of all ages independent of population size.
- 'q- plateau' at ages 5 and older (default).
- Shrinkage to the mean with SE = 0.5.
- Tricubic tapered time weighting over 11 years.
- The 3 oldest ages kept for the mean.

The log-catchability residuals (as given by the XSA tuning) show some years effects for 1987-89 and 1996, and a slight decreasing trend in the earlier years of the time series.

Total biomass slightly increased until 1994, then decreased again 14.8 10^3 t in 1997, which is below the long-term average of 19.2 10^3 t (Figure 5.15.7.). Recruitment remained quite stable at around 450 10^6 from 1987 to 1995, then suddenly dropped to 28 10^6 in 1997. F_{bar} was fairly stable over the reference period, fluctuating between 0.39 and 0.54, with an average of 0.47, which is close to the value given by LCA (0.41).

The regression of F_{bar} on effort is not significant (r = 0.56) (Figure 5.15.9.).

The decrease in both biomass and recruitment in the last two years is clearly due to the differences in the estimates of the discards. Since discards were fewer and larger in 1997 than in the previous years (see above), this had a direct impact on the estimates of the recruits. The slicing program changed the age group numbers in 1997, and assigned most of the discards to 'age' 2, instead of 'age' 1, as was the case in the previous assessments (ICES, 1997a).

Females

Table	5.15.8.	Output XSA females: Fs-at-age
Table	5.15.10.	Output XSA females: Long-term trends in landings, Fbar, TSB and recruitment
Figure	5.15.6.	Output XSA females: Log catchability residuals
Figure	5.15.8.	Output XSA females: Long-term trends in landings, Fbar, TSB and recruitment
Figure	5.15.9.	Output XSA females: Plots of Fbar vs. effort

The VPA for the females was based on the following options:

- Catchability of all ages independent of population size.
- 'q- plateau' at ages 5 and older (default).
- Shrinkage to the mean with SE = 0.8.
- Tricubic tapered time weighting over 11 years.
- The 3 oldest ages kept for the mean.

The log-catchability residuals show no year effects, and they are low for all ages, except for ages 1-3 in the two first years of the time series.

Total biomass has been stable around 5 10^3 t until 1996, then decreased to 3.7 10^3 t, well below the long-term average of 5.1 10^3 t (Figure 5.15.8.). Recruitment has remained quite stable at around 160 10^6 from 1987 to 1995, then dropped to 11 10^6 in 1997. F_{bar} increased from 0.34 in 1987 to 0.43 in 1989. Since then it has remained fairly stable at around 0.45. The average value of 0.43 is close to the one obtained from the LCA (0.45).

The regression of F_{bar} on effort is not significant (r = 0.48) (Figure 5.15.9.).

As for males, the decrease in biomass and recruitment in the last two years of the time series is related to the differences in the discard estimates (see above). Both the fact that there were less discards in 1997 and that they were larger than in the years before, had a direct consequence on the estimates of the recruits. Again, the slicing program changed the age group numbers in 1997, by putting most of discards in 'age' 2, instead of 'age' 1, which resulted in lower estimates of the recruits than in the previous assessments (ICES, 1997a).

Comparison between males and females

The sex ratios in the recruits, as given by the VPA, vary between 0.66 and 0.75, with a mean of 0.71. This apparent imbalance is a consequence of the difficulties in deriving female discard estimates from the data (see above). With the exception of age 1, which is very poorly exploited, fishing mortalities – and hence catchability – for the younger ages are higher for the females than for the males (0.56 vs. 0.23 for age 2).

Comments on quality of the assessments

The Celtic Sea comprises three FUs which ideally should be dealt with separately. Since boats can fish in several FUs during the same voyage, it is impossible however to sample the catches by FU. This makes the assessments less reliable.

The growth parameters and the discard length compositions are the other sources of uncertainty in these assessments. New discard data available this year created a problem in the age based assessment, and particularly in the estimates of the numbers recruiting to the stock in 1997.

Management considerations

The LCA suggests that current F is above F_{max} for both sexes, but the Y/R curves are fairly flat-topped, especially for the males. Abstraction made for 1997 (because of the uncertainty on the numbers discarded, and the impact this has on the assessments), both recruitment and total biomass seem to be fairly stable.

For the time being, there is no reason to revise the *status quo* advice in terms of effort and/or catches, and the TAC can be kept at the previously recommended level.

5.15.2. Summary for Management Area M

Table 5.15.11. Landings by FU and from Other rectangles, 1989-98
Table 5.15.12. Landings by country, 1989-98

Landings from 'Other rectangles' within MA M but outside FUs 20-22 are small compared to those taken within the FUs. The management considerations for the FUs can thus be extended to the MA as a whole, and *status quo* effort and/or catches can be recommended, i.e. a TAC of 3800 t for 2000-2001.

Table 5.15.1. - Celtic Sea (FUs 20-22): Landings (tonnes) by country, 1989-98.

Year	Belgium	France	Rep. of Ireland	UK	Total
1989	0	2838	784	14	3636
1990	0	3581	528	14	4123
1991	3	2440	644	13	3100
1992	0	3182	750	84	4016
1993	0	3586	770	47	4403
1994	2	3442	1415	42	4901
1995	2	3628	2014	99	5743
1996	2	3117	1067	64	4250
1997	4	2426	1117	67	3614
1998 *	1	1727	1663	48	3439

* provisional na = not available

Table 5.15.2. - Celtic Sea (FUs 20-22): Effort (days fishing) and LPUE (kg/day fishing) of French trawlers, home port St Guénolé; estimated total effort ('000 hours trawling) and LPUE (kg/hour trawling). All figures for 1989-98.

Year	Effort	LPUE	Estimated effort	Estimated LPUE
	days	kg/day	'000 hrs	kg/hr
1989	4953	240	210	15
1990	5460	230	280	13
1991	5075	181	264	10
1992	5142	220	319	11
1993	5085	207	333	11
1994	4654	224	299	12
1995	5300	211	303	13
1996	na	na	271	12
1997	na	na	247	11
1998 *	na	na	na	na

* provisional na = not available

Table 5.15.3. - Celtic Sea (FUs 20-22): Mean sizes (mm CL) of male and female *Nephrops* in French catches and landings, 1989-98.

Year	Catches		Landings	
	Males	Females	Males	Females
1989	33.2	29.4	38.9	36.0
1990	33.8	29.7	39.7	35.4
1991	32.7	29.1	38.7	34.6
1992	32.8	29.0	38.1	35.3
1993	34.0	29.3	40.5	37.0
1994	33.0	29.3	40.2	37.6
1995	33.7	29.4	40.4	36.6
1996	33.6	29.1	40.0	37.2
1997	36.6	30.7	40.4	37.9
1998 *	36.6	30.6	40.6	37.0

* provisional na = not available

Table 5.15.4. - Celtic Sea (FUs 20-22): Input data and parameters.

FU	20-22	MA	M
FLEET	France	GEAR	Trawl

	1998					1997				
	Number of samples				Mean no. per sample	Number of samples				Mean no. per sample
	Qtr 1	Qtr 2	Qtr 3	Qtr 4		Qtr 1	Qtr 2	Qtr 3	Qtr 4	
Catch	0	0	0	0		0	0	0	0	
Landings	4	8	4	6	198	6	5	8	6	202
Discards	0	0	0	0		48	49	14	18	100

	Number of samples									
Year	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989
Catch	0	0	0	0	0	23	68	45	37	38
Landings	22	25	26	21	27	23	68	35	37	38
Discards	0	129	0	0	0	0	0	10	0	0

FU	20-22	MA	M
FLEET	Rep. of Ireland	GEAR	Trawl

	1998					1997				
	Number of samples				Mean no. per sample	Number of samples				Mean no. per sample
	Qtr 1	Qtr 2	Qtr 3	Qtr 4		Qtr 1	Qtr 2	Qtr 3	Qtr 4	
Catch	0	0	0	0		0	0	0	0	
Landings	1	0	2	2	374	0	2	6	3	333
Discards	0	0	0	0		0	0	0	0	

	Number of samples									
Year	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989
Catch	0	0	0	0	0	0	0	0	0	0
Landings	5	11	3	2	0	0	0	0	0	0
Discards	0	0	0	0	0	0	0	0	0	0

INPUT PARAMETERS		
Parameter	Value	Source
Discard Survival	0.25	Gueguen and Charuau, 1975
MALES		
Growth - K	0.170	chosen for consistency with other stocks
Growth - L(inf)	68	French observations (Powell's method, 1979)
Natural mortality - M	0.3	Morizur, 1982
Length/weight - a	0.00009	Charuau and Morizur,1982
Length/weight - b	3.550	"
FEMALES		
Immature Growth		
Growth - K	0.170	chosen for consistency with other stocks
Growth - L(inf)	68	French observations (Powell's method, 1979)
Natural mortality - M	0.3	Morizur, 1982
Size at maturity	31	Morizur, 1982
Mature Growth		
Growth - K	0.100	chosen for consistency with other stocks
Growth - L(inf)	49	French observations (Powell's method, 1979)
Natural mortality - M	0.2	based on Morizur, 1982 ; assuming lower rate for mature females
Length/weight - a	0.00009	Charuau and Morizur,1982
Length/weight - b	3.550	"

Table 5.15.5. - Celtic Sea (FUs 20-22): LCA output males.

Reference period	1995-97		
Linf (mm CL)	68.0	K	0.170

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
17	68	0.3	0.117	0.000	0.002	0.302	392278	44902	110350
18	21	0.3	0.119	0.000	0.001	0.301	378740	44215	132359
19	347	0.3	0.121	0.001	0.008	0.308	365454	43508	157007
20	627	0.3	0.124	0.002	0.015	0.315	352055	42761	184289
21	741	0.3	0.127	0.002	0.018	0.318	338600	41986	214282
22	1019	0.3	0.129	0.003	0.025	0.325	325263	41182	246990
23	2075	0.3	0.132	0.007	0.052	0.352	311890	40286	281951
24	3515	0.3	0.135	0.012	0.090	0.390	297729	39220	318254
25	5544	0.3	0.138	0.020	0.146	0.446	282447	37912	354583
26	6286	0.3	0.142	0.025	0.173	0.473	265529	36406	390314
27	8420	0.3	0.145	0.035	0.243	0.543	248321	34684	424109
28	8152	0.3	0.149	0.037	0.248	0.548	229494	32820	455572
29	7816	0.3	0.153	0.039	0.252	0.552	211495	30990	486196
30	9018	0.3	0.157	0.049	0.310	0.610	194380	29079	513529
31	7391	0.3	0.161	0.044	0.272	0.572	176636	27196	538556
32	7945	0.3	0.166	0.052	0.313	0.613	161084	25382	561616
33	6789	0.3	0.171	0.049	0.288	0.588	145522	23611	581766
34	5724	0.3	0.176	0.046	0.260	0.560	131648	22018	602215
35	7250	0.3	0.181	0.065	0.356	0.656	119317	20364	616454
36	6203	0.3	0.187	0.062	0.333	0.633	105954	18664	623536
37	7504	0.3	0.193	0.086	0.444	0.744	94150	16917	622106
38	7940	0.3	0.199	0.106	0.530	0.830	81567	14991	605267
39	6396	0.3	0.206	0.100	0.486	0.786	69124	13171	582468
40	7105	0.3	0.214	0.133	0.623	0.923	58773	11409	551373
41	4906	0.3	0.222	0.111	0.500	0.800	48239	9812	517049
42	5307	0.3	0.231	0.146	0.634	0.934	40385	8382	480674
43	4110	0.3	0.240	0.140	0.584	0.884	32558	7044	438711
44	3401	0.3	0.250	0.144	0.575	0.875	26330	5920	399667
45	2919	0.3	0.262	0.155	0.593	0.893	21150	4932	360344
46	1959	0.3	0.274	0.130	0.475	0.775	16748	4130	325908
47	1740	0.3	0.287	0.144	0.502	0.802	13548	3473	295623
48	1403	0.3	0.302	0.147	0.486	0.786	10764	2891	264975
49	990	0.3	0.318	0.130	0.410	0.710	8491	2417	238188

Continued on next page

Table 5.15.5. - (continued).

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
50	1100	0.3	0.336	0.187	0.557	0.857	6775	1979	209357
51	752	0.3	0.357	0.170	0.476	0.776	5079	1582	179443
52	742	0.3	0.380	0.228	0.600	0.900	3851	1238	150367
53	577	0.3	0.406	0.254	0.625	0.925	2736	926	120211
54	410	0.3	0.436	0.265	0.608	0.908	1880	677	93836
55	791	0.3			0.500	0.800	1265	677	100093
					Totals, including lengths above + group			789755	14329588

Mean F, calculated across inter-quartile range	0.413

Table 5.15.6. - Celtic Sea (FUs 20-22): LCA output females.

Reference period	1995-97		
Linf immatures (mm CL)	68.0	K immatures	0.170
Linf matures (mm CL)	49.0	K matures	0.100
Transition length (mm CL)	31.0		

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
16	93	0.3	0.114	0.001	0.005	0.305	175065	19653	39193
17	133	0.3	0.117	0.001	0.007	0.307	169076	19347	47547
18	133	0.3	0.119	0.001	0.007	0.307	163139	19038	56991
19	236	0.3	0.121	0.002	0.013	0.313	157295	18721	67558
20	522	0.3	0.124	0.004	0.028	0.328	151443	18379	79208
21	807	0.3	0.127	0.006	0.045	0.345	145407	18000	91863
22	1306	0.3	0.129	0.010	0.074	0.374	139200	17568	105366
23	3135	0.3	0.132	0.024	0.185	0.485	132624	16982	118852
24	4156	0.3	0.135	0.035	0.257	0.557	124394	16205	131493
25	5572	0.3	0.138	0.051	0.365	0.665	115376	15257	142691
26	5284	0.3	0.142	0.053	0.372	0.672	105225	14228	152541
27	7853	0.3	0.145	0.088	0.603	0.903	95672	13023	159250
28	7743	0.3	0.149	0.099	0.666	0.966	83909	11640	161569
29	6988	0.3	0.153	0.104	0.678	0.978	72671	10314	161817
30	8880	0.3	0.157	0.157	1.001	1.301	62585	8881	156838
31	6516	0.2	0.161	0.139	0.862	1.062	51034	7560	149701
32	6201	0.2	0.606	0.166	0.274	0.474	43004	22657	501320
33	4787	0.2	0.645	0.172	0.267	0.467	32257	17973	442854
34	2632	0.2	0.690	0.126	0.182	0.382	23862	14471	395805
35	2111	0.2	0.741	0.132	0.179	0.379	18330	11845	358551
36	1620	0.2	0.800	0.136	0.169	0.369	13845	9594	320527
37	1566	0.2	0.870	0.181	0.208	0.408	10302	7544	277417
38	1423	0.2	0.953	0.244	0.256	0.456	7221	5581	225319
39	717	0.2	1.054	0.187	0.177	0.377	4674	4064	179699
40	1885	0.2			0.300	0.500	3141	4064	196377
					Totals, including lengths above + group			342587	4720349

Mean F, calculated across inter-quartile range	0.445

Table 5.15.7. - Celtic Sea (FUs 20-22): VPA Fs-at-age males.

Age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.017	0.012	0.011	0.012	0.014	0.011	0.017	0.015	0.030	0.016	Not included in assessment
2	0.298	0.236	0.177	0.175	0.252	0.192	0.252	0.234	0.279	0.174	
3	0.509	0.431	0.404	0.323	0.433	0.307	0.353	0.308	0.391	0.314	
4	0.325	0.499	0.563	0.386	0.524	0.513	0.489	0.474	0.616	0.477	
5	0.328	0.447	0.597	0.490	0.468	0.701	0.572	0.654	0.627	0.586	
6	0.381	0.454	0.520	0.437	0.538	0.622	0.544	0.570	0.563	0.534	
+ grp	0.381	0.454	0.520	0.437	0.538	0.622	0.544	0.570	0.563	0.534	

Table 5.15.8. - Celtic Sea (FUs 20-22): VPA Fs-at-age females.

Age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.029	0.026	0.027	0.022	0.029	0.022	0.029	0.027	0.044	0.017	Not included in assessment
2	0.532	0.515	0.490	0.471	0.558	0.523	0.549	0.543	0.614	0.521	
3	0.330	0.340	0.354	0.322	0.342	0.361	0.327	0.358	0.353	0.432	
4	0.385	0.470	0.500	0.481	0.439	0.447	0.420	0.483	0.436	0.490	
5	0.400	0.476	0.568	0.640	0.569	0.461	0.492	0.510	0.528	0.537	
6	0.450	0.546	0.576	0.677	0.828	0.669	0.697	0.635	0.629	0.458	
+ grp	0.450	0.546	0.576	0.677	0.828	0.669	0.697	0.635	0.629	0.458	

Table 5.15.9. - Celtic Sea (FUs 20-22): VPA output males.

Year	Recruits Age 1	Total Biomass	TSB	Landings	Yield/SSB	Fbar 3-5
	'000	tonnes	tonnes	tonnes		
1987	397519	18049	18049	2743	0.152	0.458
1988	380701	17899	17899	2587	0.145	0.387
1989	446576	19181	19181	3438	0.179	0.459
1990	480341	19714	19714	3889	0.197	0.521
1991	432765	19416	19416	2930	0.151	0.400
1992	451985	20607	20607	4051	0.197	0.475
1993	454301	21150	21150	3813	0.180	0.507
1994	415135	21383	21383	4002	0.187	0.471
1995	369165	20718	20718	4203	0.203	0.479
1996	205333	18847	18847	4317	0.229	0.545
1997	28234	14799	14799	3528	0.238	0.459
1998						
Average 96-98						0.502

Table 5.15.10. - Celtic Sea (FUs 20-22): VPA output females.

Year	Recruits Age 1	Total Biomass	TSB	Landings	Yield/SSB	Fbar 3-5
	'000	tonnes	tonnes	tonnes		
1987	176808	5658	3512	392	0.112	0.336
1988	167281	5488	3239	324	0.100	0.372
1989	160416	5505	3378	429	0.127	0.429
1990	163086	5216	3290	501	0.152	0.474
1991	169914	4789	2645	365	0.138	0.481
1992	164838	4912	2733	352	0.129	0.450
1993	177482	5109	2917	345	0.118	0.423
1994	171129	5610	3339	608	0.182	0.413
1995	158422	5383	3236	461	0.142	0.450
1996	103693	4755	2980	340	0.114	0.439
1997	11038	3728	2779	178	0.064	0.486
1998						
Average 96-98						0.463

Table 5.15.11. - Management Area M (VIIf,g,h, excl. rect. 31E1 32E1-E2 + VIIa, South of 53° N): Total *Nephrops* landings (tonnes) by Functional Unit plus other rectangles, 1989-98.

Year	FUs 20-22	Other	Total
1989	3636	210	***3846***
1990	4123	263	***4386***
1991	3100	178	***3278***
1992	4016	236	***4252***
1993	4403	275	***4678***
1994	4901	287	***5188***
1995	5743	305	***6048***
1996	4250	281	***4531***
1997	3614	248	***3862***
1998 *	3439	108	***3547***
* provisional na = not available			

Table 5.15.12. - Management Area M (VIIf,g,h, excl. rect. 31E1 32E1-E2 + VIIa, South of 53° N): Total *Nephrops* landings (tonnes) by country, 1989-98.

Year	Belgium	France	Rep. of Ireland	UK	Total
1989	0	3044	784	18	***3846***
1990	0	3841	528	17	***4386***
1991	3	2617	644	14	***3278***
1992	0	3413	750	89	***4252***
1993	0	3846	770	62	***4678***
1994	2	3692	1426	68	***5188***
1995	2	3891	2031	124	***6048***
1996	2	3328	1115	86	***4531***
1997	4	2614	1149	95	***3862***
1998 *	1	1769	1714	63	***3547***
* provisional na = not available					

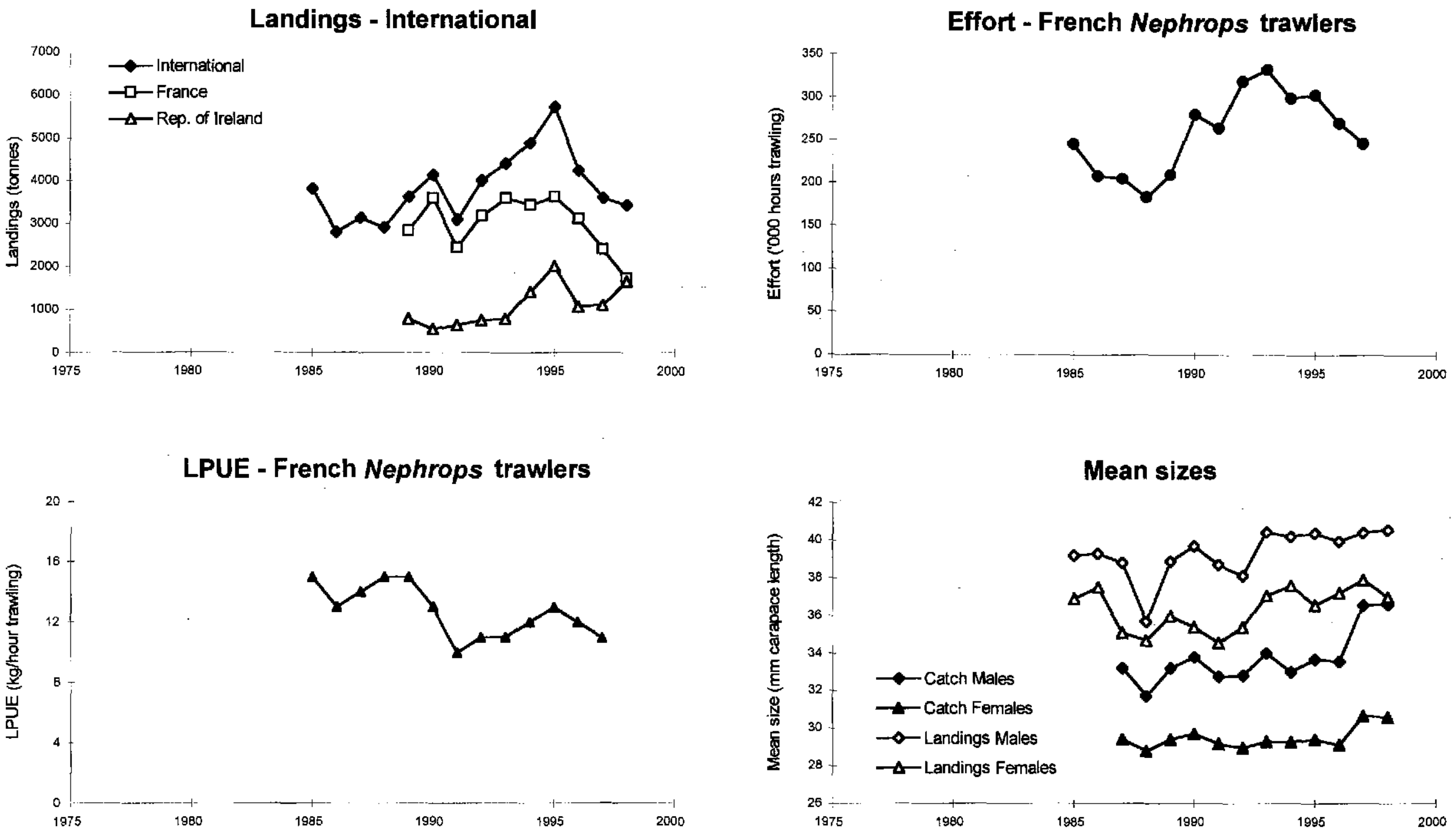


Figure 5.15.1. - Celtic Sea (FUs 20-22): Long-term trends in landings, effort, LPUEs and mean sizes of *Nephrops* in catches and landings.

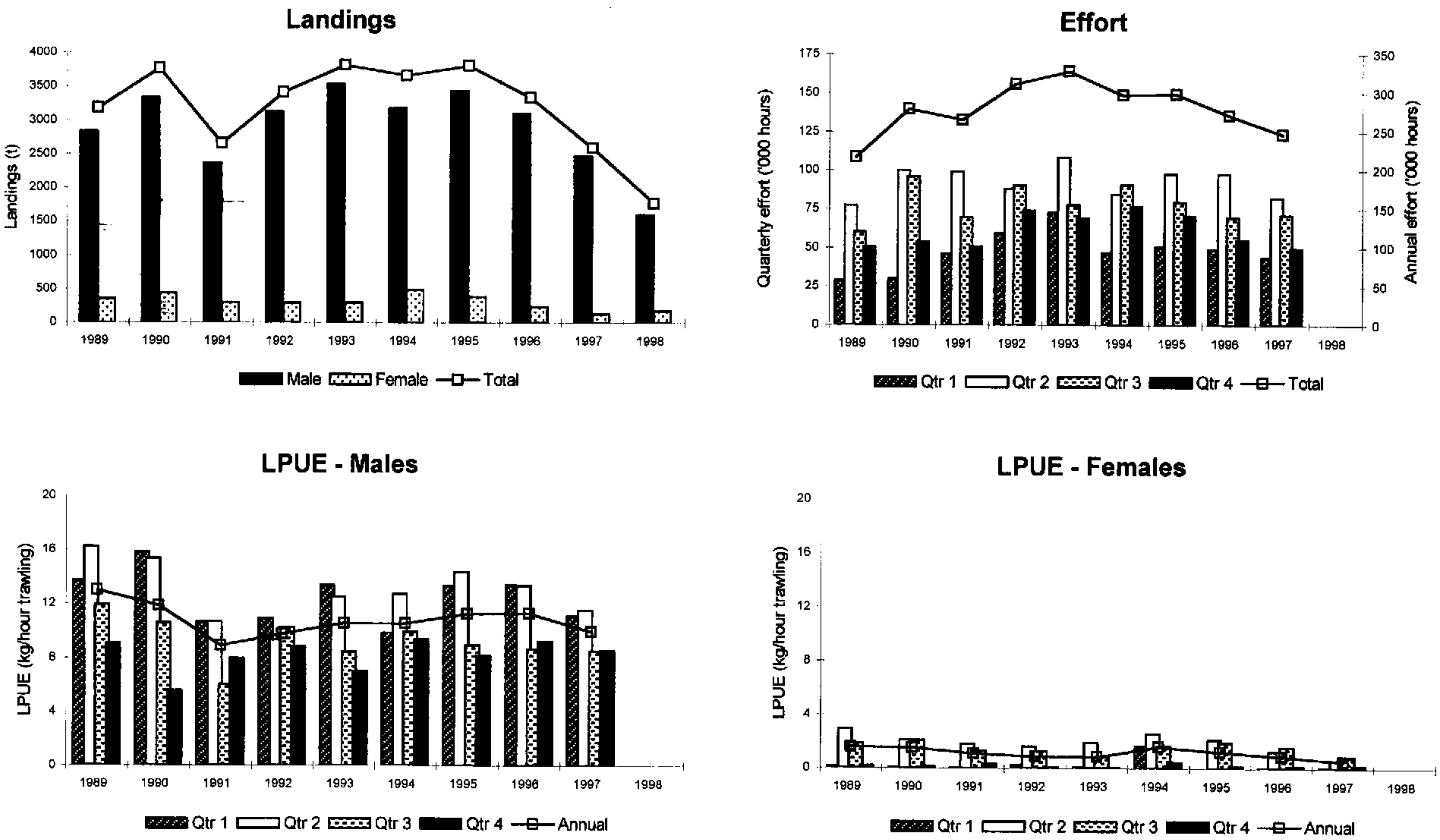
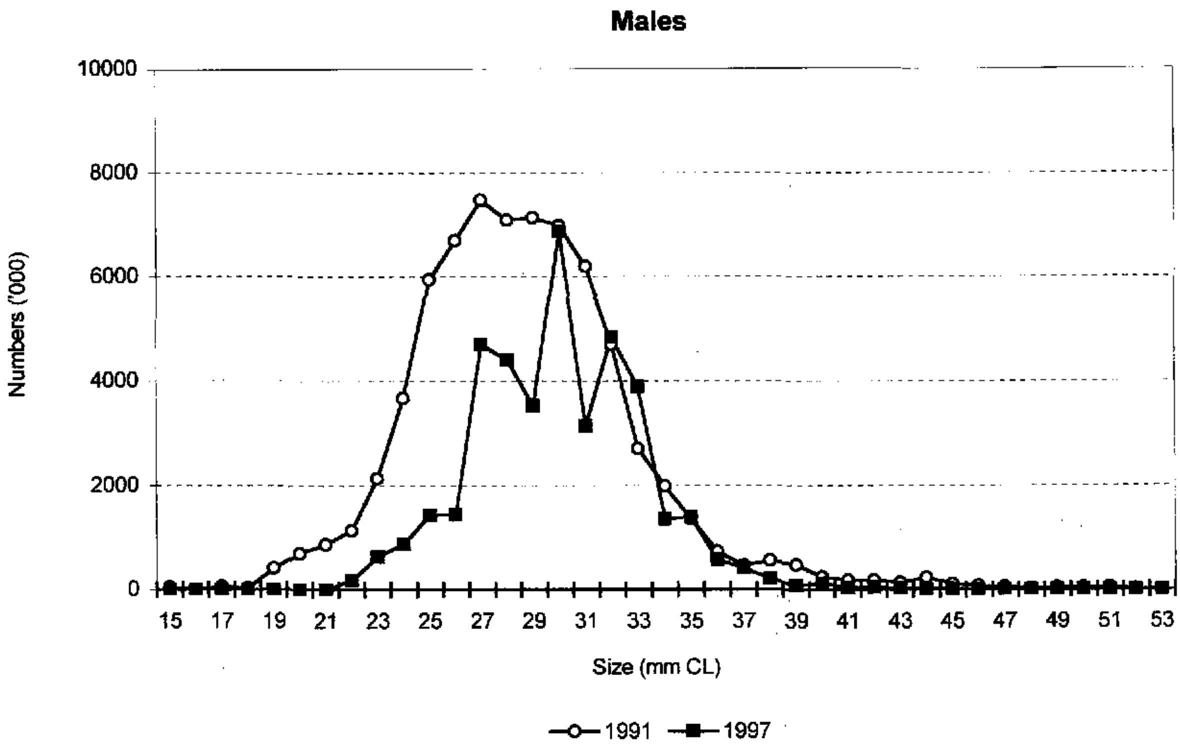


Figure 5.15.2. - Celtic Sea (FUs 20-22): Landings, effort and LPUEs by quarter and sex from French *Nephrops* trawlers.



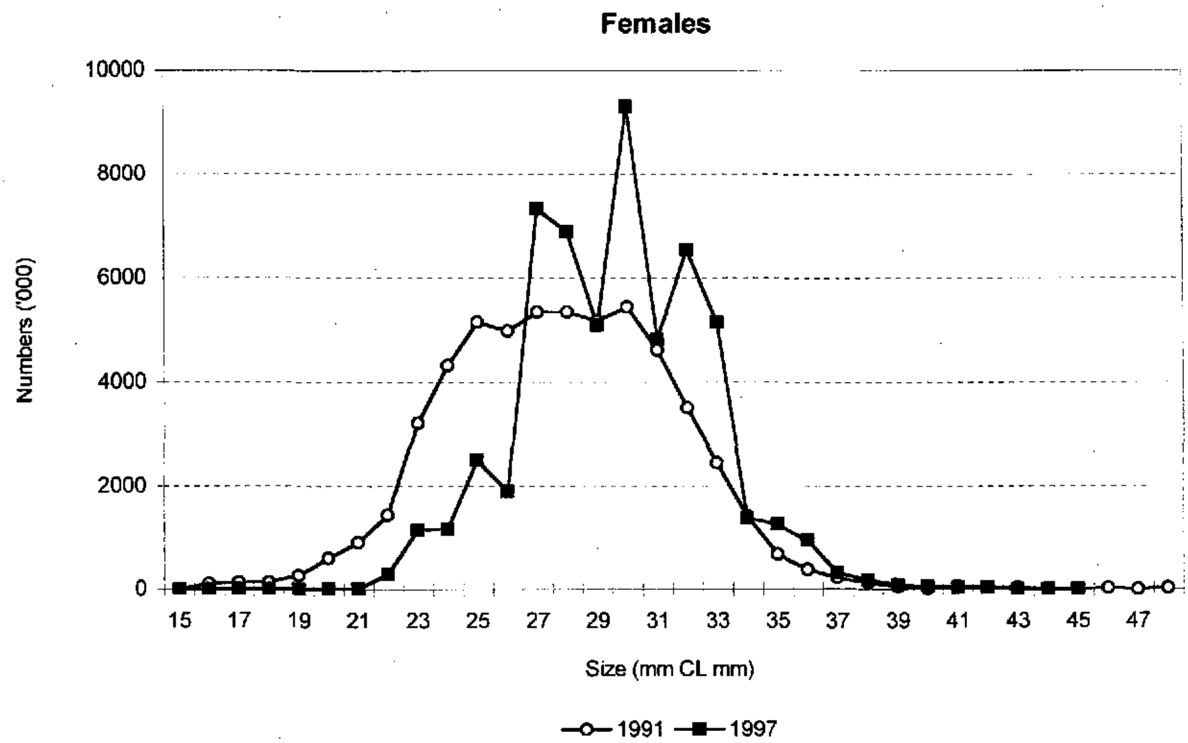
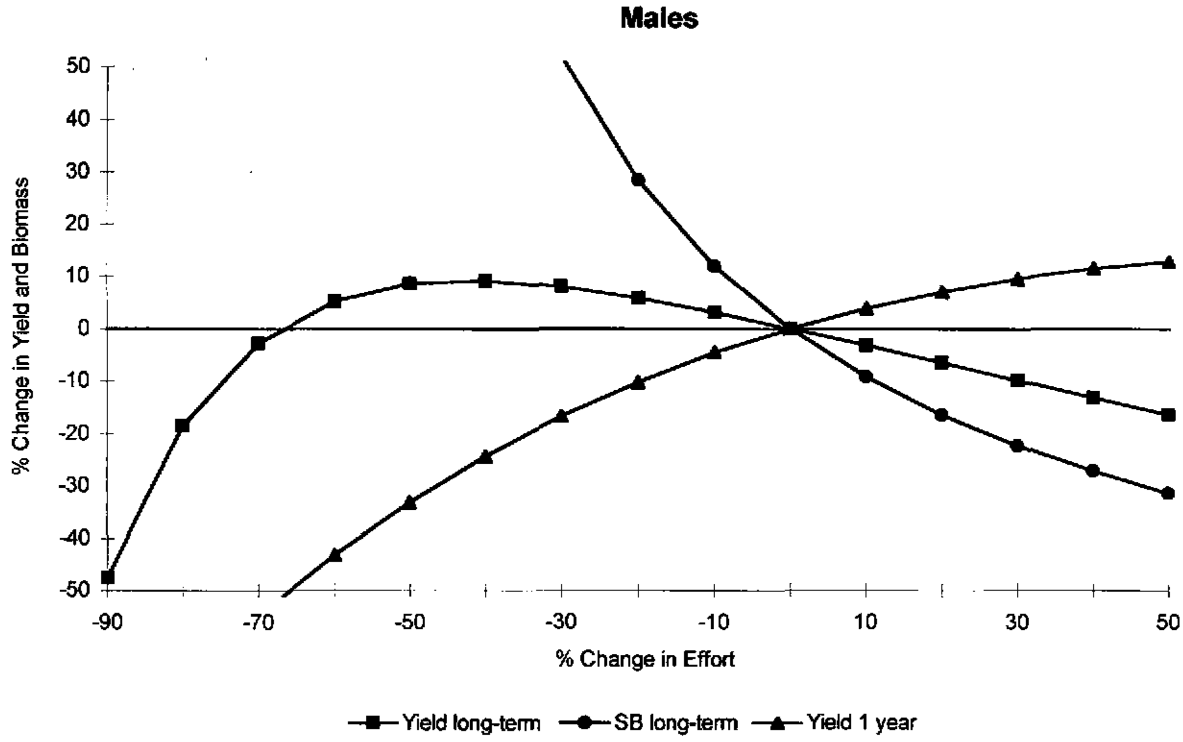


Figure 5.15.3. - Celtic Sea (FUs 20-22): LFDs of male and female *Nephrops* discards in 1991 and 1997 discard sampling programmes.



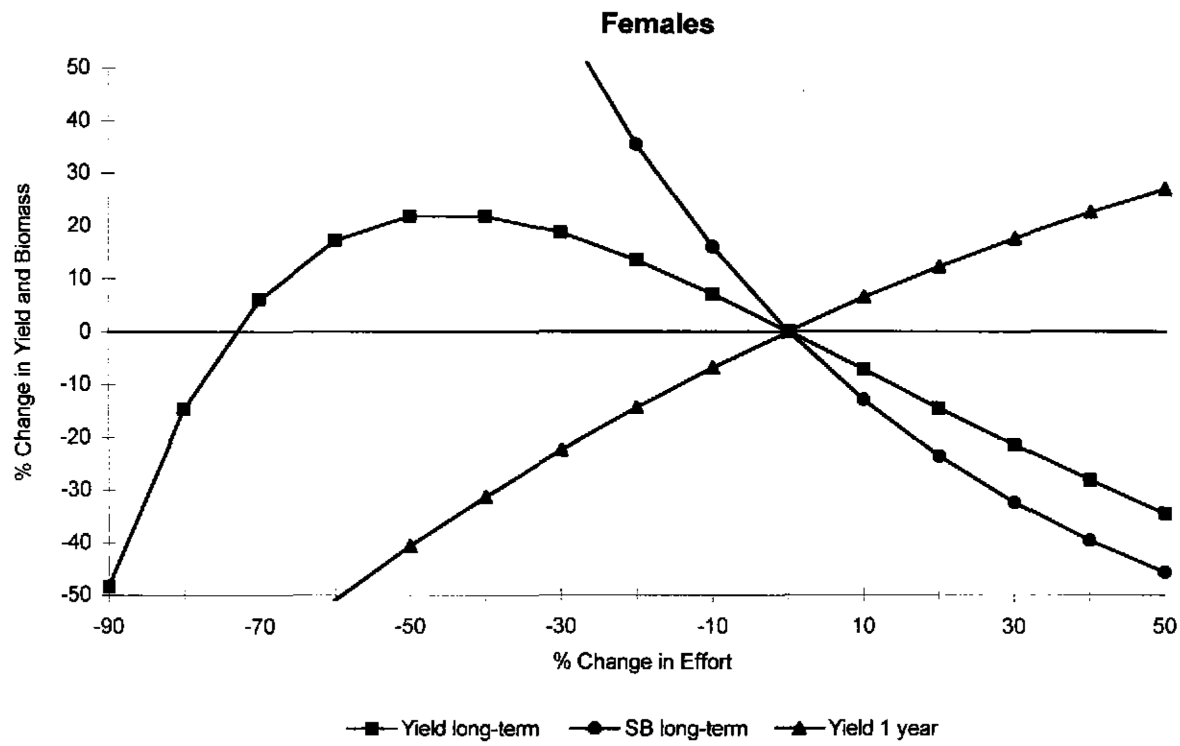
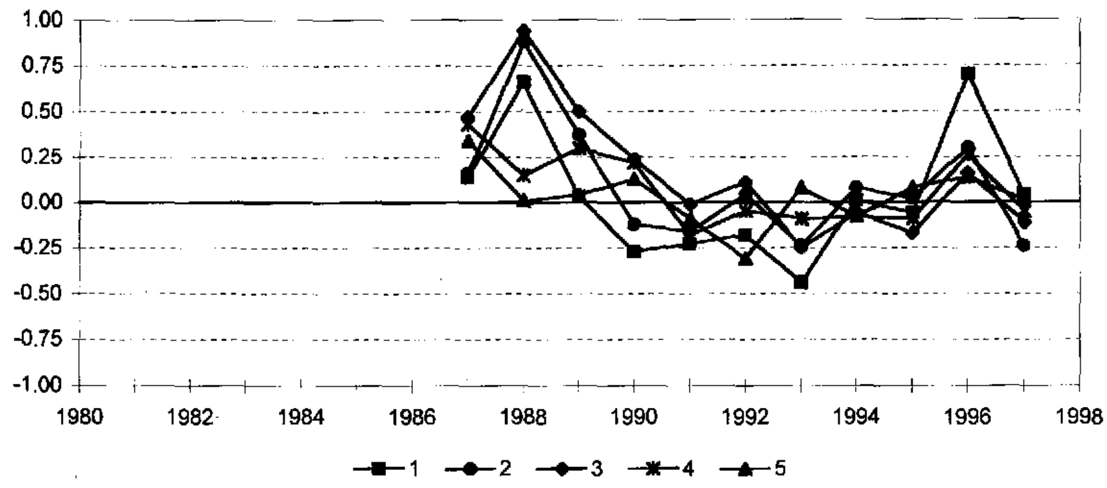


Figure 5.15.4. - Celtic Sea (FUs 20-22): Output LCA: Relative changes in short-term yield (ie after 1 year), long-term yield and long-term biomass upon relative changes in effort. Males and females shown separately.



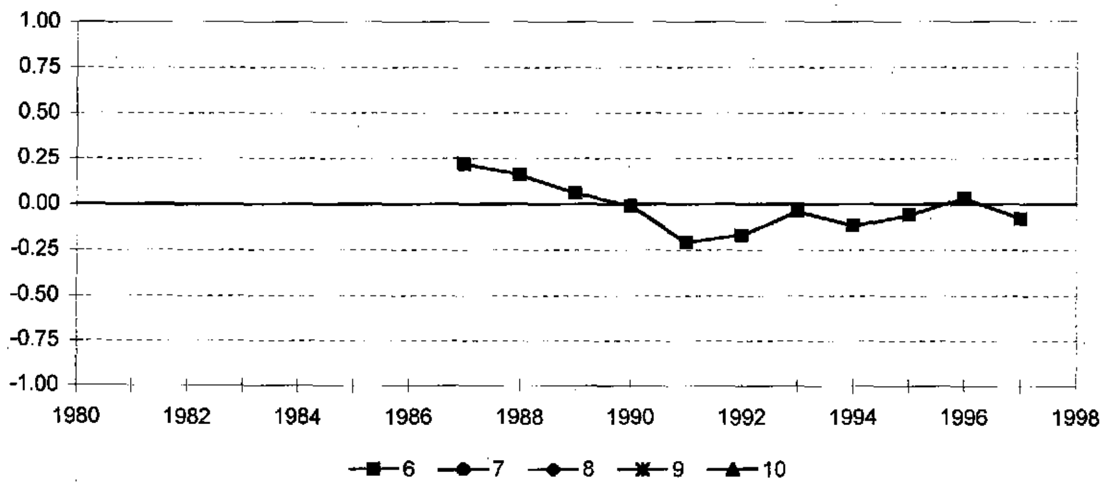
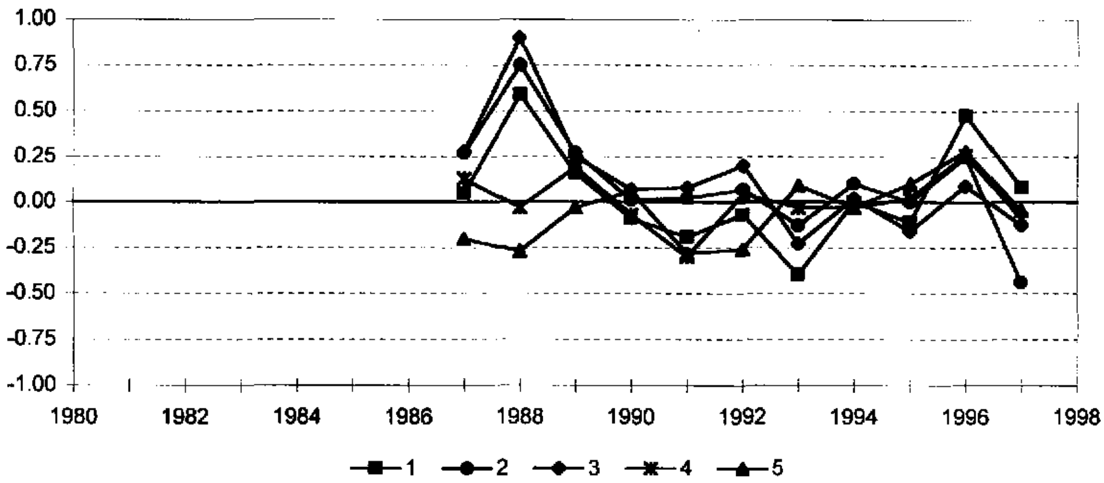


Figure 5.15.5. - Celtic Sea (FUs 20-22): Output VPA males: Log catchability residuals.



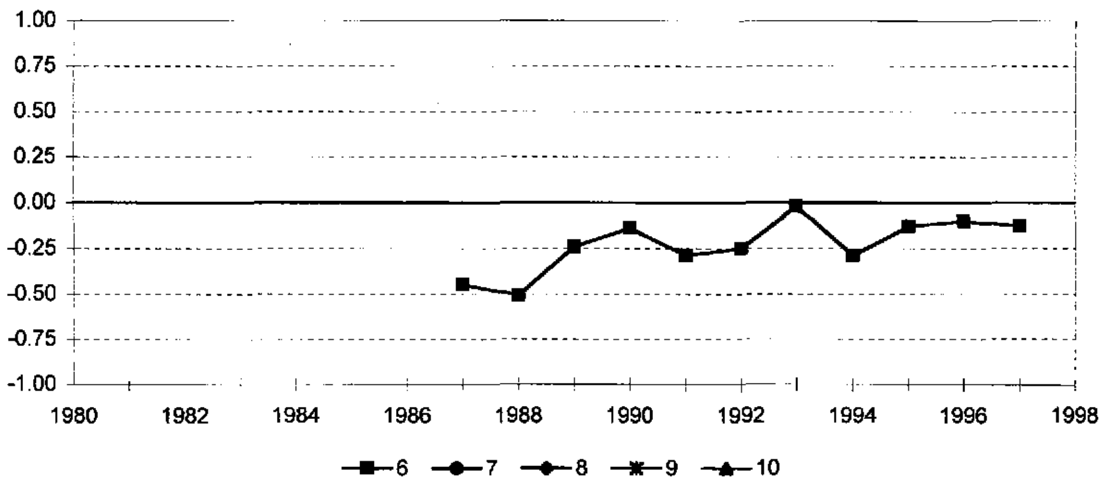


Figure 5.15.6. - Celtic Sea (FUs 20-22): Output VPA females: Log catchability residuals.

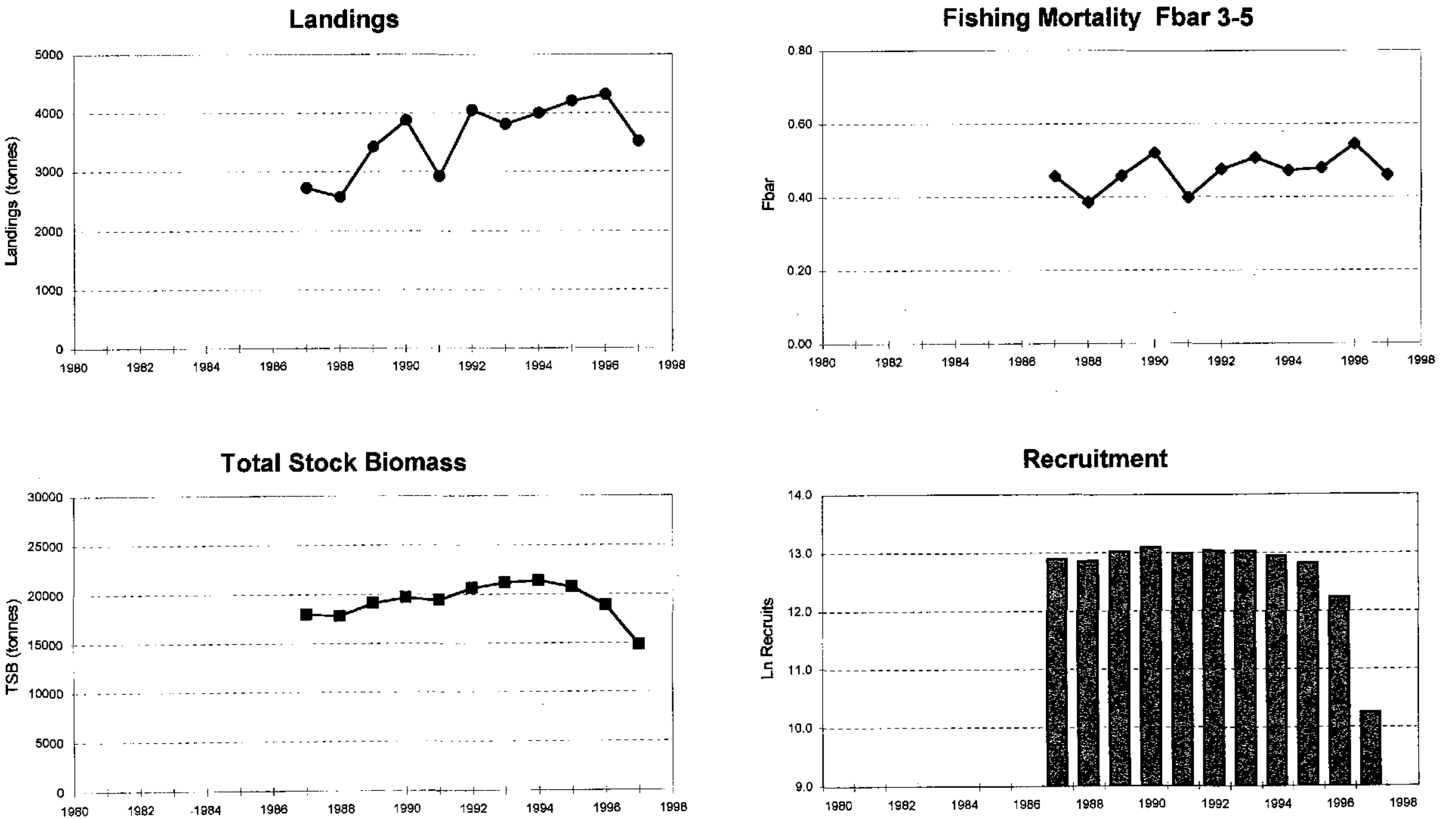


Figure 5.15.7. - Celtic Sea (FUs 20-22): Output VPA males: Trends in Landings, Fbar, TSB and Recruitment.

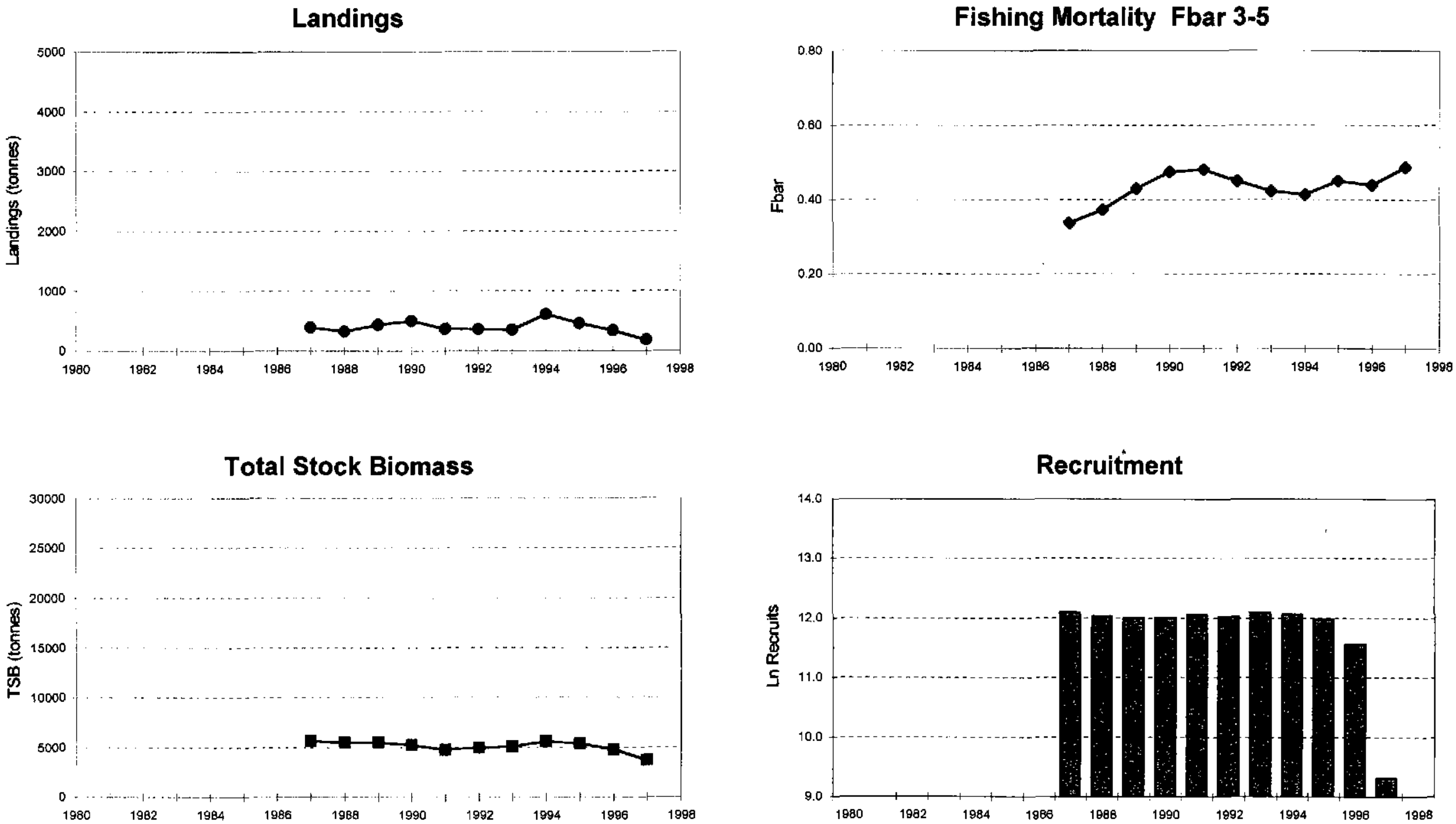


Figure 5.15.8. - Celtic Sea (FUs 20-22): Output VPA females: Trends in Landings, Fbar, TSB and Recruitment.

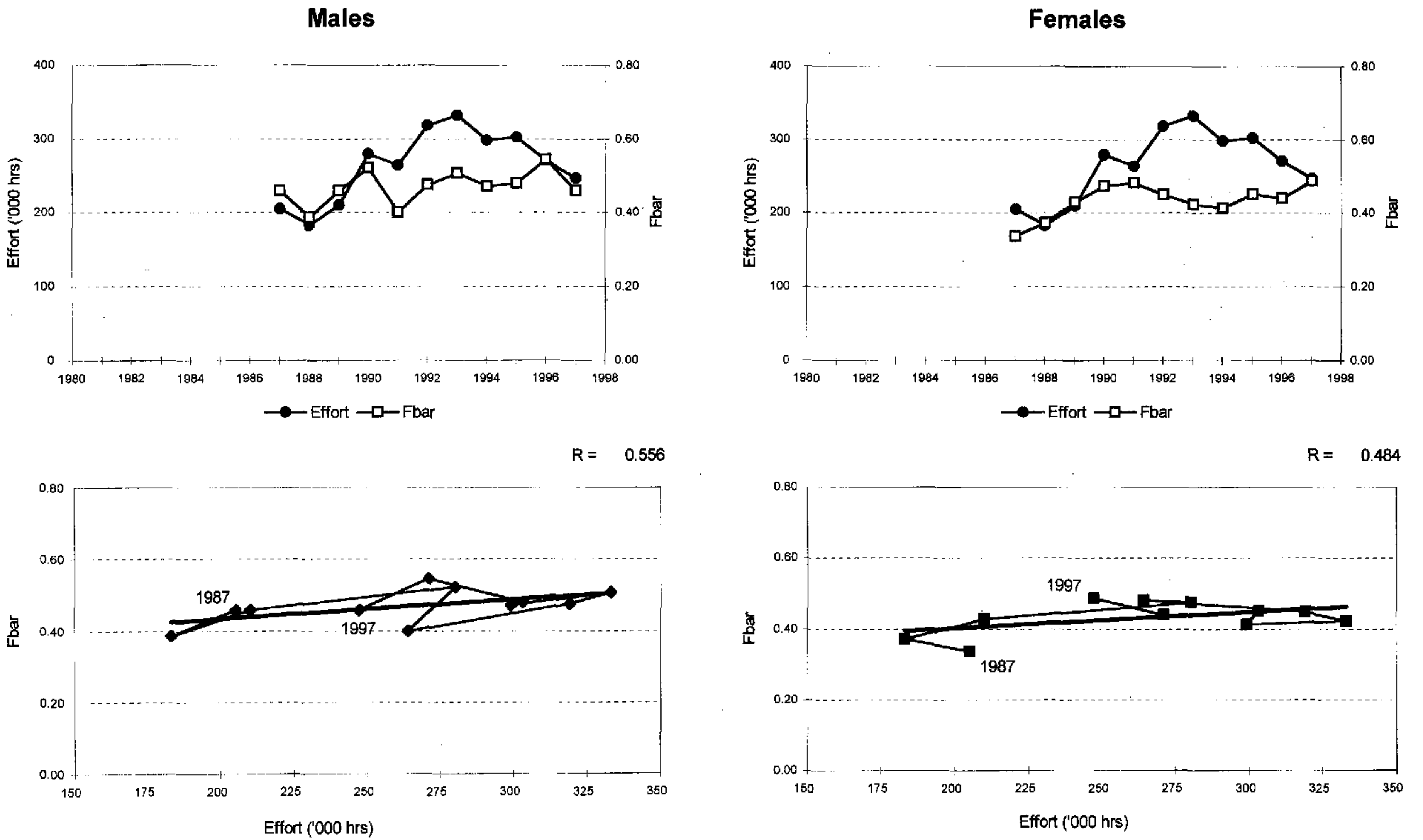


Figure 5.15.9. - Celtic Sea (FUs 20-22): Effort and Fbar, and relationship between them, for males and females.

5.16. Management Area N

ICES description **VIIIa,b**

Functional Units **Bay of Biscay North (FU 23)**
Bay of Biscay South (FU 24)

The statistical rectangles comprised in this Management Area and its constituent Functional Units are shown in Figure 5.1.3.

5.16.1. Bay of Biscay (FUs 23-24)

Description of the fisheries

France

About 170 boats are involved in the Bay of Biscay *Nephrops* fishery. All vessels are stern trawlers with the following main characteristics:

	Engine power (kW)	Length over all (m)
Mean	149	13.6
Range	54-244	8-20

The current codend mesh size for *Nephrops* in FUs 23 and 24 is 55 mm, which is smaller than the mesh size for finfish (65 mm). The exemption for using a 55 mm mesh is conditional upon compliance with a minimum share of 70 % (by weight) of *Nephrops* in the catches, and a maximum of 30 % (also by weight) of species protected by a minimum landing size. There have been some changes in gear in recent years, with rockhoppers being set on trawls and with an increasing number of boats adopting twin-trawls.

The major landing ports are located on the French Atlantic coast, from the southern part of Brittanny to Charente Maritime (south of the Loire river): Loctudy, Saint Guénolé, Le Guilvinec, Lesconil, Concarneau, Lorient, Le Croisic, Les Sables d'Olonne, La Rochelle, and La Cotinière on Oléron Island. Roughly 75 % of the boats participating in the Bay of Biscay *Nephrops* fishery are from the four first ports.

The duration of the trips varies from 1 to 4 days. The boats make 4-5 hauls per day, of 3-5 hours each.

Discarding is substantial in this fishery. To maintain price levels, fishermen's organisations have set a minimum landing size of 25 mm CL, which is above the EU legal minimum landing size of 20 mm CL.

Vessels making day-trips land their *Nephrops* alive. Those making longer trips land the *Nephrops* from the last haul(s) alive and the others iced. Some boats are equipped with the so-called 'Sycocrus system' which keeps the *Nephrops* in a lethargic state, in a cold mist of sea water. Once landed, they become lively again and can be sold like the live ones. In the northern ports, *Nephrops* are sorted in two market categories (viz. 'small' and 'large') but in most of the southern ports all size classes are landed mixed.

About half of the fleet targets other species when *Nephrops* catch rates are low, during winter and during periods of bad weather. About 25 % of the boats fish for *Nephrops* during the summer months only, when prices are good thanks to the afflux of tourists who spend the summer holidays on the Atlantic coast.

Even when targeting *Nephrops,* the boats also search for other species because their trips would not be profitable on *Nephrops* only. On average, *Nephrops* represents about 37 % by weight of the landings. Other major species in the landings are hake (17 % by weight) and anglerfish (9 %), together with smaller quantities of cuttlefish, sole (when using specific ground gear), bass and anchovy (when using pelagic gear). *Nephrops* accounts for 60 % of the revenues to the fishermen, hake 11 % and anglerfish 8 %.

The *Nephrops* grounds in the northern part of the Bay of Biscay are a hake nursery, and *Nephrops* are caught together with large quantities of small hake. In an attempt to remedy this problem, a selective trawl has been designed to let young hake escape. Because of the persisting illegal market for undersized hake, however, there is very little interest for this gear, despite the EU-regulation which allows the use of a smaller mesh size (viz. 50 mm) when selective gears are operated.

There is no problem of 'black' landings of *Nephrops* in this fishery, since catch quota are never reached. As in the Celtic Sea fishery, the landings are precisely known because they are recorded in the auctions.

The number of *Nephrops* directed vessels has decreased over the past 5 years, as a consequence of the EU decommissioning programmes. Low market prices in 1993 and 1994 badly affected the economic situation of the fishery, and many boats were sold to other ports or other countries. As for now, the economic situation has improved again and the fleet seems to have recovered from the crisis. Nevertheless, fishermen worry about the state of the *Nephrops* stock, and there is a clear willingness to restrict fishing effort, e.g. by ceasing the fishery during the weekends (as has been the case in the northern ports some 10 years ago).

Trends in landings, effort, LPUE and mean size

Table	5.16.1.	Landings by country, 1989-98
Table	5.16.2.	Effort and LPUEs French fleet, 1989-98
Table	5.16.3.	LPUEs of single and twin rig trawls, French fleet, 1995-98
Table	5.16.4.	Mean sizes of *Nephrops* in catches and landings, French data, 1989-98
Figure	5.16.1.	Long-term trends in landings, effort, LPUE and mean size, French data
Figure	5.16.2.	Landings by sex + Quarterly plots of effort and LPUEs by sex, 1989-98

Landings and effort

Nearly all the landings from FU 23-24 are taken by French trawlers. A few landings are reported by Spain from rectangles outside the FUs, but inside the MA. Landings from FUs 23-24 have fluctuated between 4500 t and 5700 t up to 1995, but since then they show a clear decreasing trend (Figure 5.16.1.). The 1998 landings figure is partial (because fisheries statistics were still incomplete at the time of the WG meeting), and may represent only 75 % of the actual figure. In 1997, landings fell to 3600 t (an almost 15 % drop compared to 1996) – the lowest figure in the time series.

Generally, more males are landed than females (Figure 5.16.2.), but this difference was less pronounced in the last two years.

The estimated total *Nephrops* directed effort has been fairly stable over the period 1988-93 (Figure 5.16.1.). The apparent increase from 1985 to 1988 can be attributed to improvements in the recording system. Effort dropped in 1994 for the Bay of Biscay as a whole, as well as for the *Nephrops* fleet of Lesconil, which is taken as a reference in terms of trends. For this fleet, effort has been close to 5000 days/year from 1989 to 1993 (Table 5.16.2.). Since then, it has decreased to 3206 days in 1998, which is the lowest figure in the series. This could be explained by a change in fishing practices, with a tendency to direct effort to finfish in the season of low *Nephrops* availability, and by a decrease in the number of fishing vessels, following the decommissioning scheme implemented by the EU.

Because of the recent changes in fishing gears, the number of hours trawling 'as such' is becoming less and less appropriate to quantify effort. Over the past years, the number of boats using twin-trawls has increased, together with that using rockhoppers on single trawls. Gear efficiency has gone up, but its effect on fishing effort as a whole is difficult to quantify, since twin-trawling is not always recorded in the fisheries statistics. An inquiry is in progress to build a time series on gear characteristics. This should allow to present effort and LPUE data for single and twin rigs separately. The data available so far (1995-97) are shown in Table 5.16.3.

LPUE

The LPUEs of the *Nephrops* fleet are fairly stable, fluctuating around a long-term average of 8.0 kg/hour (Figure 5.16.1.). From 1989 till 1993, the LPUEs for the reference port of Lesconil showed no particular trend, with values fluctuating between 84 and 101 kg/day (Table 5.16.2.). In 1994 however, the LPUEs dropped well below the long-term mean. Since then, they slightly increased to 97 kg/day in 1996, but decreased again to 82 kg/hour in 1997 and 81 kg/day in 1998 – the lowest figures in the time series. The LPUEs for both males and females are usually highest in the 2nd and 3rd quarter (Figure 5.16.2.).

Mean size

Until 1990, the mean sizes of particularly male *Nephrops* in the landings have almost steadily increased (Figure 5.16.1.). Despite an increase in mesh size from 50 to 55 mm in 1990, the mean sizes remained stable until 1996, then decreased again in 1997 and 1998, particularly for the males.

Mean sizes in the catches are available since 1991. Mean sizes of the males have fluctuated without obvious trend till 1996, then decreased in 1997 and 1998 (Figure 5.16.2.). Those of the females shown a slight but steady increase since the beginning of the time series. With respect to these figures, it should be noticed that the means for 1997-98 were derived from a discard sampling programme conducted in 1998 (details given below), whereas those for the earlier years were derived from a discard sampling programme conducted in 1991.

Data and biological inputs for analytical assessments

| Table 5.16.5. Sampling data and input parameters

Length compositions of the French landings have been sampled since 1984. Discard data are available for 1987, 1991 and 1998 only, and the numbers discarded at length for the other years were derived from these in the following way:

- The estimates for 1984-90 from the data collected during the 1987 discard sampling programme.
- Those for 1992-96 from the 1991 sampling programme.
- Those for 1997-98 from the 1998 sampling programme.

Up to 1987, all size distributions were recorded with a plus group set at 50 mm CL.

All biological parameters used in this year's assessments (growth parameters, length-weight relationships, natural mortality rates, discard survival rates, etc.) were the same as the ones used in previous assessments.

General comments on quality of data and inputs

Length frequency data of the landings are available on a monthly basis. Discards however, could not be sampled every year because of insufficient technical and financial resources. Applying discard length compositions from 'sampled' years to 'unsampled' years bears the risk of inconsistency between the different data sets:

- Males discarded in 1998 were of almost the same length range as those discarded in 1991, but they were much more numerous.
- Females discarded in 1998 were generally larger than those discarded in 1991 (a change caused by the market-driven increase in minimum landing size, which only affected the females because of the differences in growth between males and females), and they were also more numerous.

Estimates of the *Nephrops* directed effort are based on information on the landings composition and the numbers of hours fished per voyage. Voyages are considered to be *Nephrops* directed when > 10 % of their revenue is accounted for by *Nephrops* (or > 10 % of the weight landed, if the revenue was not recorded). Since most of the vessels involved in this fishery are not required to submit EU logbooks, the number of hours trawling per voyage was obtained from inquiries amongst the fishermen. The figures thus obtained however, should be considered as rough estimates.

Because of a serious delay in the processing of the landings and effort statistics for 1998, only partial data were available at the time of the meeting. Therefore, it was decided to exclude the year 1998 from the assessments.

Length based assessments (LCA)

The reference period over which the LCA was run was 1995-97. Average length compositions of landings and discards were derived from market samples and estimates of the discards, derived from the 1991 and 1998 discard sampling programmes. The equilibrium condition is not met, since there have been changes in effort during the reference period.

Yield per recruit assessment

Table 5.16.6. Output table LCA males, with mean F
Table 5.16.7. Output table LCA females, with mean F
Figure 5.16.4. Changes in Y/R and B/R upon changes in F, for males and females separately

The results of the Y/R assessments are similar to those of the previous assessments, performed on the data for 1991-96 (ICES, 1997a). For the males, maximum landings per recruit (+ 24 %) would be obtained by reducing F by 60 %. For the females, the long-term Y/R curve is flat-topped, with current F at 30 % above F_{max}, but the predicted long-term gain upon a reduction of F to F_{max} would be very small (4 %).

Mean F, calculated across the inter-quartile range, is 0.77 for the males and 0.48 for the females.

Mesh assessments

Figure 5.16.5. Long-term changes in Y/R upon different changes in mesh size

In order to investigate possible management options, several mesh size changes were simulated, using the gear selection parameters given by the Working Group on Fishery Units in Sub-Areas VII and VIII (ICES, 1991d).

The long-term Y/R upon increases in mesh size from the current 55 mm to 70 and 80 mm are shown in Figure 5.16.5. For males, it is clear that growth overfishing could be substantially reduced by increasing the mesh size, since F_{max} could be attained by a relatively small reduction in fishing mortality of 20 % only, provided that the mesh size is increased to 80 mm. The corresponding long-term gains in landings would be substantial, viz. + 40 %. Short-term losses (- 30 % for the males) must be kept in mind, even though gains are expected to appear after a relatively short period of three years. Long-term stock biomass is expected to be about twice the current level. The long-term gains in female landings upon mesh increases to 70 or 80 mm would be about 10 %, i.e. less than for males. As for the males however, there would be considerable long-term increases in stock biomass.

Age based assessments (VPA)

The length distributions (1984-97) were split into 6 nominal 'age' groups (plus-group at 7) for the males, and 9 'age' groups (plus-group at 10) for the females, using the L2AGE slicing program . The VPA assessments were performed using the XSA option of the Lowestoft VPA package.

Males

Table	5.16.8.	Output XSA males: Fs-at-age
Table	5.16.10.	Output XSA males: Long-term trends in landings, Fbar, TSB and recruitment
Figure	5.16.6.	Output XSA males: Log catchability residuals
Figure	5.16.8.	Output XSA males: Long-term trends in landings, Fbar, TSB and recruitment
Figure	5.16.10.	Output XSA males: Plots of Fbar vs. effort

The VPA for the males was run with the following options:

- Catchability of all ages independent of population size.
- 'q- plateau' at ages 5 and older (default).
- Shrinkage to the mean with SE = 0.8.
- Tricubic tapered time weighting over 11 years.
- The 3 oldest ages kept for the mean.

The log-catchability residuals show no particular trend or year effects, except in 1990 and 1991. The residuals are low for all years and ages, except for age 1. This might be due to the slicing of the length compositions into 'age' groups, but this would need to be examined in further detail before conclusions can be drawn.

Total biomass increased to 13.8 10^3 t in 1987, then decreased to 8.7 10^3 t in 1994, the lowest value in the time series and 37 % below the peak level of 1987 (Figure 5.16.8.). Since then, it has increased again to 9.3 10^3 t in 1997. Recruitment shows a similar trend, with a peak of 633 10^6 in 1987, and a drop to 323 10^6 in 1994 (- 49 %). Since then, recruitment has recovered to 637 10^6 in 1997, the highest value so far. The apparent increase in recruitment the last three years is most likely to be attributed to the differences in the basic data sets used to estimate the discards (see above). Since there were more discards in the 1998 discard sampling programme (the results of which were used to estimate the numbers discarded in 1997) than in the earlier sampling programmes (the results of which were used to estimate the numbers discarded in the years prior to 1997) (see above), this also had an 'inflating' effect on the estimate of the recruits in 1997.

F_{bar} has increased since 1986 (0.62) to a peak in 1996 (1.26) (Figure 5.16.8.). The average F_{bar} across the reference period is 0.87. The regression of F_{bar} on effort is not significant (r = 0.16) (Figure 5.16.10.).

Females

Table	5.16.9.	Output XSA females: Fs-at-age
Table	5.16.11.	Output XSA females: Long-term trends in landings, Fbar, TSB and recruitment
Figure	5.16.7.	Output XSA females: Log catchability residuals
Figure	5.16.9.	Output XSA females: Long-term trends in landings, Fbar, TSB and recruitment
Figure	5.16.10.	Output XSA females: Plots of Fbar vs. effort

The female run of the VPA was based on the following options:

- Catchability of all ages independent of population size.
- 'q- plateau' at ages 7 and older (default).

- Shrinkage to the mean with SE = 0.5.
- Tricubic tapered time weighting over 11 years.
- The 5 oldest ages kept for the mean (default).

As for the males, the log-catchability residuals show no particular trend or year effects, except for 1991.

Female SSB has been slightly increasing over the reference period, while total biomass has remained fairly stable with an increase in the most recent years (Figure 5.16.9.). The estimates of recruitment show a decreasing trend since the beginning of the time series: from 428 10^6 in 1984 to 236 10^6 in 1996 (- 45 %). As for males, the influence of the changes in discard estimates is predominant, but the effect works in the opposite direction compared to the females. The likely under-estimation of the male discards for the years prior to 1997 has lead to an under-estimation of the recruitment levels in the beginning of the time series, and an apparent increase in recruitment levels in the most recent years. The fact however, that the females in the 1998 discard survey were larger than in the earlier surveys, affected the estimates of the numbers discarded by age group, through assigning most of discards to nominal 'age' 2 instead of 'age' 1, and this has resulted in apparently opposite trends in male and female recruitment.

F_{bar} has fluctuated around 0.5, with peaks at 0.66 in 1986, and 0.69 in 1993. Recent levels of F_{bar} are below the long-term average of 0.51. The regression of F_{bar} on effort shows a significant relationship ($r = 0.60$; $p < 0.05$), even though the slope of the regression line is rather weak (Figure 5.16.10.).

Comparison of males and females

The sex ratios in the recruitment estimates given by the VPA vary between 0.53 to 0.73, with a mean of 0.59. With the exception of nominal 'age' group 1, which is very poorly exploited, fishing mortalities for the younger ages are higher for females than for males (0.40 vs. 0.30 for nominal 'age' 2).

Comments on quality of assessments

The growth parameters used are one of the main sources of uncertainty in the assessments. Other sources of uncertainty are related to the estimates of fishing effort and the annual length compositions of the discards. New discard estimates clearly caused some problems in the age based assessment. Given its impact on the outcome of age based assessments, the question on the most appropriate way of deriving discard LFDs for years in which no discard data were collected, should be given priority attention.

It should be noted that some problems with SOP remained. These are mostly related to errors in the landings data due to non- or mis-reporting. Fishing effort should also be investigated, since the number of hours fished 'as such' may not be an accurate estimate of the actual levels of fishing intensity, particularly when there has been a shift towards more efficient gears (twin-rigs, rockhoppers, etc.).

Management considerations

Fishing mortalities were found to be notably higher for males and almost the same for females compared to the previous assessments (ICES, 1997a). The new discard data gave less pessimistic results than last time for male recruitment, but a drop in recruitment is still seen in females.

The decreasing trends in TSB (abstraction made of the apparent increase in the last two years) show that there is immediate reason for concern about this fishery. The length based assessments give clear evidence of a growth overfishing problem with males, and lead to the conclusion that fishing mortality should be reduced by increasing the mesh size. In is worth noticing that a mesh size increase from 55 to 80 mm will be implemented in 2000 (as part of the new technical measures that will be issued by the EU), and that the authorisation for using smaller mesh sizes when fishing for *Nephrops* will be abolished. Even then however, it should be borne in mind that net gear efficiency is increasing, with more and more boats changing to twin-trawls. Eventually, this could offset the expected long-term benefits from the upcoming mesh size increase.

5.16.2. Summary for Management Area N

Table 5.16.12. Landings by FU and from Other rectangles, 1989-98
Table 5.16.13. Landings by country, 1989-98

Nephrops landings from other rectangles within MA N but outside FUs 23 and 24 are almost negligible. Therefore, the management advice given for these FUs can be extended to the MA as a whole, i.e. an increase in mesh size from 55 to 80 mm, which will be the case in the year 2000 anyway.

Table 5.16.1. - Bay of Biscay (FUs 23-24): Landings (tonnes) by country, 1989-98.

Year	Belgium	France		Total
	FUs 23-24	FU 23	FU 24	
1989	0	4600	630	5230
1990	1	4603	358	4962
1991	1	4352	401	4753
1992	0	5123	558	5681
1993	0	4404	512	4916
1994	1	3687	368	4056
1995	0	4060	379	4439
1996	0	4205	88	4293
1997	2	3451	147	3600
1998 *	2	2167	5	2174

* provisional na = not available

Table 5.16.2. - Bay of Biscay (FUs 23-24): Effort (days fishing) and LPUE (kg/day fishing) of French trawlers, home port Lesconil; estimated total effort ('000 hours trawling) and LPUE (kg/hour trawling). All figures for 1989-98.

Year	Effort	LPUE	Estimated effort	Estimated LPUE
	days	kg/day	'000 hrs	kg/hr
1989	5449	95	713	7.4
1990	4929	87	676	7.4
1991	4588	84	675	6.7
1992	4998	101	761	7.5
1993	5156	89	720	6.8
1994	4463	76	508	8.1
1995	4057	87	527	8.4
1996	3943	97	428	9.6
1997	3360	82	359	8.3
1998 *	3206	81	na	na

* provisional na = not available

Table 5.16.3. - Bay of Biscay (FUs 23-24): LPUEs (kg/hour fishing) of single and twin rig trawlers, 1995-98.

Year	LPUE single rigs	LPUE twin rigs
	kg/hr	kg/hr
1995	7.6	8.7
1996	7.8	11.0
1997	6.8	8.7
1998 *	na	na

* provisional na = not available

Table 5.16.4. - Bay of Biscay (FUs 23-24): Mean sizes (mm CL) of male and female *Nephrops* in French catches and landings, 1989-98.

Year	Catches		Landings	
	Males	Females	Males	Females
1989	na	na	29.2	26.8
1990	na	na	31.2	27.9
1991	27.7	25.4	31.0	28.4
1992	27.2	25.3	30.5	28.3
1993	26.9	25.3	30.0	28.5
1994	27.7	25.5	31.0	28.7
1995	27.9	25.8	31.0	28.8
1996	28.0	26.1	31.4	29.4
1997	21.0	26.6	29.5	28.8
1998 *	26.9	26.4	29.3	28.6

* provisional na = not available

Table 5.16.5. - Bay of Biscay (FUs 23-24): Input data and parameters.

FU	23 & 24	MA	N
FLEET	France	GEAR	Trawl

	1998					1997				
	Number of samples				Mean no. per sample	Number of samples				Mean no. per sample
	Qtr 1	Qtr 2	Qtr 3	Qtr 4		Qtr 1	Qtr 2	Qtr 3	Qtr 4	
Catch	82	81	83	78	na	0	0	0	0	
Landings	64	63	65	60	53	64	67	41	55	57
Discards	18	18	18	18	100	0	0	0	0	

	Number of samples									
Year	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989
Catch	324	0	0	0	0	0	0	0	0	0
Landings	252	227	206	174	167	184	190	227	208	346
Discards	72	0	0	0	0	0	0	42	0	0

INPUT PARAMETERS		
Parameter	Value	Source
Discard Survival	0.30	Gueguen and Charuau, 1975
MALES		
Growth - K	0.140	after Conan and Morizur, 1979 ; plus unpublished data
Growth - L(inf)	76	"
Natural mortality - M	0.3	Morizur, 1982
Length/weight - a	0.00039	Conan, 1978
Length/weight - b	3.180	"
FEMALES		
Immature Growth		
Growth - K	0.140	after Conan and Morizur, 1979 ; plus unpublished data
Growth - L(inf)	76	"
Natural mortality - M	0.3	Morizur, 1982
Size at maturity	25	Morizur, 1982
Mature Growth		
Growth - K	0.110	after Conan and Morizur, 1979 ; plus unpublished data
Growth - L(inf)	56	"
Natural mortality - M	0.2	based on Morizur, 1982 ; assuming lower rate for mature females
Length/weight - a	0.00081	Conan, 1978
Length/weight - b	2.970	"

Table 5.16.6. - Bay of Biscay (FUs 23-24): LCA output males.

Reference period	1995-97		
Linf (mm CL)	76.0	K	0.140

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
13	64	0.3	0.114	0.000	0.002	0.302	319355	35876	54996
14	84	0.3	0.116	0.000	0.002	0.302	308529	35213	67750
15	411	0.3	0.118	0.001	0.012	0.312	297880	34530	82133
16	667	0.3	0.120	0.002	0.020	0.320	287111	33815	98123
17	1108	0.3	0.122	0.004	0.034	0.334	276299	33059	115669
18	2665	0.3	0.124	0.010	0.083	0.383	265273	32183	134368
19	2764	0.3	0.126	0.011	0.089	0.389	252954	31207	154038
20	6817	0.3	0.129	0.029	0.228	0.528	240828	29967	173412
21	5712	0.3	0.131	0.026	0.200	0.500	225020	28547	192209
22	10094	0.3	0.134	0.050	0.375	0.675	210743	26906	209344
23	8618	0.3	0.136	0.047	0.344	0.644	192575	25087	224134
24	9861	0.3	0.139	0.059	0.424	0.724	176428	23283	237491
25	15401	0.3	0.141	0.104	0.734	1.034	159580	21000	243260
26	12797	0.3	0.144	0.100	0.691	0.991	137872	18539	242703
27	13176	0.3	0.147	0.120	0.812	1.112	119508	16236	239116
28	11252	0.3	0.150	0.120	0.801	1.101	101455	14061	232002
29	10146	0.3	0.154	0.129	0.838	1.138	85978	12118	223112
30	12141	0.3	0.157	0.189	1.204	1.504	72191	10095	206656
31	7366	0.3	0.161	0.142	0.884	1.184	57011	8334	189041
32	7939	0.3	0.164	0.190	1.154	1.454	47141	6886	172521
33	4872	0.3	0.168	0.145	0.860	1.160	37129	5670	156417
34	4227	0.3	0.172	0.153	0.889	1.189	30553	4756	144056
35	3671	0.3	0.176	0.164	0.931	1.231	24897	3947	130943
36	2472	0.3	0.181	0.136	0.749	1.049	20038	3301	119607
37	2542	0.3	0.186	0.172	0.925	1.225	16575	2751	108629
38	1861	0.3	0.191	0.157	0.822	1.122	13205	2265	97238
39	1131	0.3	0.196	0.116	0.591	0.891	10663	1915	89210
40	1340	0.3	0.201	0.168	0.833	1.133	8957	1612	81290
41	800	0.3	0.207	0.123	0.594	0.894	7131	1348	73477
42	912	0.3	0.213	0.173	0.811	1.111	5927	1125	66157
43	575	0.3	0.220	0.136	0.618	0.918	4676	931	58929
44	479	0.3	0.227	0.139	0.613	0.913	3822	783	53282
45	393	0.3	0.234	0.140	0.600	0.900	3108	656	47931

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Table 5.16.6. - (continued).

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
46	282	0.3	0.242	0.123	0.509	0.809	2517	554	43323
47	264	0.3	0.251	0.142	0.567	0.867	2069	466	39042
48	263	0.3	0.260	0.179	0.690	0.990	1665	381	34129
49	144	0.3	0.270	0.123	0.458	0.758	1288	314	29975
50	149	0.3	0.280	0.160	0.571	0.871	1050	261	26552
51	112	0.3	0.292	0.154	0.528	0.828	823	213	23076
52	86	0.3	0.304	0.149	0.491	0.791	646	175	20100
53	65	0.3	0.318	0.144	0.453	0.753	508	144	17538
54	48	0.3	0.332	0.134	0.403	0.703	400	119	15368
55	41	0.3	0.349	0.147	0.421	0.721	317	98	13406
56	35	0.3	0.366	0.162	0.441	0.741	246	79	11491
57	44	0.3	0.386	0.286	0.741	1.041	188	60	9178
58	45	0.3	0.408	0.485	1.188	1.488	126	38	6240
59	17	0.3	0.433	0.317	0.732	1.032	68	24	4094
60	15	0.3	0.461	0.443	0.960	1.260	44	15	2765
61	15	0.3			0.500	0.800	25	15	2913
					Totals, including lengths above + group			510954	5018432

Mean F, calculated across inter-quartile range	0.767

Table 5.16.7. - Bay of Biscay (FUs 23-24): LCA output females.

Reference period	1995-97		
Linf immatures (mm CL)	76.0	K immatures	0.140
Linf matures (mm CL)	56.0	K matures	0.110
Transition length (mm CL)	25.0		

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
11	82	0.3	0.111	0.000	0.002	0.302	379919	41378	47373
12	26	0.3	0.113	0.000	0.001	0.301	367424	40640	59602
13	33	0.3	0.114	0.000	0.001	0.301	355206	39906	73555
14	228	0.3	0.116	0.001	0.006	0.306	343201	39162	89251
15	600	0.3	0.118	0.002	0.016	0.316	331225	38387	106648
16	732	0.3	0.120	0.002	0.020	0.320	319108	37584	125723
17	1476	0.3	0.122	0.005	0.040	0.340	307101	36730	146328
18	2626	0.3	0.124	0.009	0.073	0.373	294606	35762	168039
19	3820	0.3	0.126	0.014	0.110	0.410	281252	34651	190373
20	5721	0.3	0.129	0.022	0.172	0.472	267036	33346	212541
21	5458	0.3	0.131	0.022	0.171	0.471	251311	31942	234528
22	8797	0.3	0.134	0.039	0.290	0.590	236269	30335	254924
23	9695	0.3	0.136	0.046	0.341	0.641	218370	28453	272069
24	12539	0.3	0.139	0.066	0.477	0.777	200137	26316	284796
25	17529	0.2	0.141	0.104	0.737	0.937	179699	23806	290135
26	18100	0.2	0.308	0.126	0.410	0.610	157403	44227	604239
27	19003	0.2	0.319	0.163	0.511	0.711	130444	37232	567827
28	14636	0.2	0.331	0.157	0.476	0.676	103975	30807	522427
29	14033	0.2	0.343	0.192	0.559	0.759	83162	25118	471896
30	14065	0.2	0.357	0.258	0.724	0.924	64087	19469	403828
31	8816	0.2	0.371	0.221	0.596	0.796	46105	14814	338174
32	7962	0.2	0.387	0.276	0.713	0.913	34312	11183	280121
33	4255	0.2	0.404	0.203	0.503	0.703	24097	8477	232339
34	3522	0.2	0.423	0.226	0.535	0.735	18140	6594	197207
35	2787	0.2	0.444	0.247	0.558	0.758	13293	5007	163027
36	1688	0.2	0.466	0.206	0.442	0.642	9498	3828	135338
37	1275	0.2	0.492	0.211	0.429	0.629	7041	2977	114057
38	708	0.2	0.520	0.156	0.300	0.500	5168	2365	97986
39	535	0.2	0.551	0.153	0.277	0.477	3986	1932	86363
40	538	0.2	0.587	0.206	0.351	0.551	3064	1536	73970

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Table 5.16.7. - (continued).

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
41	271	0.2	0.627	0.140	0.222	0.422	2218	1222	63266
42	257	0.2	0.674	0.176	0.261	0.461	1702	986	54758
43	158	0.2	0.728	0.146	0.201	0.401	1247	787	46871
44	76	0.2	0.791	0.092	0.117	0.317	932	652	41528
45	435	0.2			0.300	0.500	725	652	44362
					Totals, including lengths above + group			738262	7095466

Mean F, calculated across inter-quartile range	0.483

Table 5.16.8. - Bay of Biscay (FUs 23-24): VPA Fs-at-age males.

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.023	0.024	0.016	0.027	0.044	0.035	0.015	0.012	0.019	0.020	0.014	0.011	0.009	0.009	Not included in assessment
2	0.470	0.522	0.311	0.508	0.673	0.585	0.368	0.337	0.425	0.451	0.320	0.348	0.251	0.286	
3	0.827	0.754	0.595	0.797	0.898	0.658	0.638	0.776	0.957	0.899	0.853	1.003	0.941	0.779	
4	1.015	0.667	0.670	0.769	0.915	0.701	0.943	0.850	1.106	0.889	0.973	1.095	1.489	0.696	
5	0.793	0.806	0.591	0.818	0.818	0.625	0.929	0.932	1.140	1.009	0.751	1.095	1.336	0.697	
6	0.893	0.754	0.627	0.815	0.942	0.835	1.028	1.063	1.241	1.140	0.909	1.038	0.881	0.589	
+ grp	0.893	0.754	0.627	0.815	0.942	0.835	1.028	1.063	1.241	1.140	0.909	1.038	0.881	0.589	

Table 5.16.9. - Bay of Biscay (FUs 23-24): VPA Fs-at-age females.

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.111	0.116	0.114	0.073	0.065	0.086	0.094	0.042	0.058	0.062	0.039	0.034	0.030	0.032	Not included in assessment
2	1.128	1.143	1.044	0.844	1.025	0.890	0.682	0.509	0.738	0.617	0.452	0.426	0.345	0.427	
3	0.679	0.594	0.740	0.539	0.672	0.535	0.454	0.547	0.799	0.558	0.474	0.447	0.342	0.448	
4	0.720	0.591	0.838	0.427	0.579	0.420	0.521	0.537	0.633	0.701	0.463	0.531	0.519	0.466	
5	0.655	0.508	0.733	0.322	0.439	0.463	0.565	0.503	0.544	0.727	0.421	0.460	0.492	0.359	
6	0.535	0.495	0.513	0.245	0.354	0.465	0.483	0.368	0.407	0.731	0.420	0.390	0.524	0.319	
7	0.498	0.576	0.482	0.259	0.398	0.543	0.504	0.425	0.408	0.735	0.370	0.300	0.453	0.290	
8	0.412	0.647	0.556	0.344	0.408	0.590	0.558	0.489	0.491	0.671	0.560	0.351	0.427	0.301	
9	0.569	0.568	0.630	0.324	0.453	0.518	0.522	0.490	0.549	0.681	0.420	0.349	0.397	0.280	
+ grp	0.569	0.568	0.630	0.324	0.453	0.518	0.522	0.490	0.549	0.681	0.420	0.349	0.397	0.280	

Table 5.16.10. - Bay of Biscay (FUs 23-24): VPA output males.

Year	Recruits Age 1	Total Biomass	TSB	Landings	Yield/SSB	Fbar 3-8
	'000	tonnes	tonnes	tonnes		
1984	491379	9047	9047	3160	0.349	0.878
1985	519195	9843	9843	3249	0.330	0.742
1986	633804	11029	11029	2956	0.268	0.619
1987	633029	13778	13778	4900	0.356	0.795
1988	466875	13303	13303	5474	0.412	0.877
1989	389319	11254	11254	4141	0.368	0.661
1990	424341	10686	10686	3890	0.364	0.837
1991	445436	10535	10535	3710	0.352	0.852
1992	384283	10505	10505	4232	0.403	1.068
1993	345182	9221	9221	3614	0.392	0.932
1994	323286	8661	8661	3095	0.357	0.859
1995	368971	8748	8748	3390	0.388	1.064
1996	468737	8753	8753	3032	0.346	1.255
1997	637211	9321	9321	1999	0.215	0.724
1998						
Average 96-98						0.990

Table 5.16.11. - Bay of Biscay (FUs 23-24): VPA output females.

Year	Recruits Age 1	Total Biomass	TSB	Landings	Yield/SSB	Fbar 3-13
	'000	tonnes	tonnes	tonnes		
1984	428162	7861	3088	3013	0.976	0.618
1985	377022	7334	2894	2762	0.954	0.553
1986	344450	6793	2831	2671	0.943	0.661
1987	333952	6348	2628	1913	0.728	0.358
1988	342232	6796	3015	2400	0.796	0.488
1989	307372	6643	2967	2243	0.756	0.485
1990	301052	6382	2997	1965	0.656	0.505
1991	291832	6474	3277	1895	0.578	0.476
1992	309518	6956	3645	2558	0.702	0.558
1993	262717	6357	3143	2287	0.728	0.690
1994	276561	6266	3330	1696	0.509	0.430
1995	288426	6679	3555	1808	0.509	0.426
1996	325540	7312	3945	1789	0.454	0.466
1997	236719	7988	4466	1598	0.358	0.376
1998						
Average 96-98						0.421

Table 5.16.12. - Management Area N (VIIIa,b): Total *Nephrops* landings (tonnes) by Functional Unit plus other rectangles, 1989-98.

Year	FU 23	FU 24	Other	Total
1989	4600	630	142	***5372***
1990	4603	358	88	***5049***
1991	4352	401	55	***4808***
1992	5123	558	47	***5728***
1993	4404	512	49	***4965***
1994	3687	368	27	***4082***
1995	4060	379	14	***4453***
1996	4205	88	15	***4308***
1997	3451	147	43	***3641***
1998 *	2167	5	42	***2214***
* provisional na = not available				

Table 5.16.13. - Management Area N (VIIIa,b): Total *Nephrops* landings (tonnes) by country, 1989-98.

Year	Belgium	France	Spain	Total
1989	0	5295	77	***5372***
1990	1	4961	87	***5049***
1991	1	4753	55	***4808***
1992	0	5681	47	***5728***
1993	0	4916	49	***4965***
1994	1	4055	27	***4082***
1995	0	4439	14	***4453***
1996	0	4293	15	***4308***
1997	2	3598	41	***3641***
1998 *	2	2172	40	***2214***
* provisional na = not available				

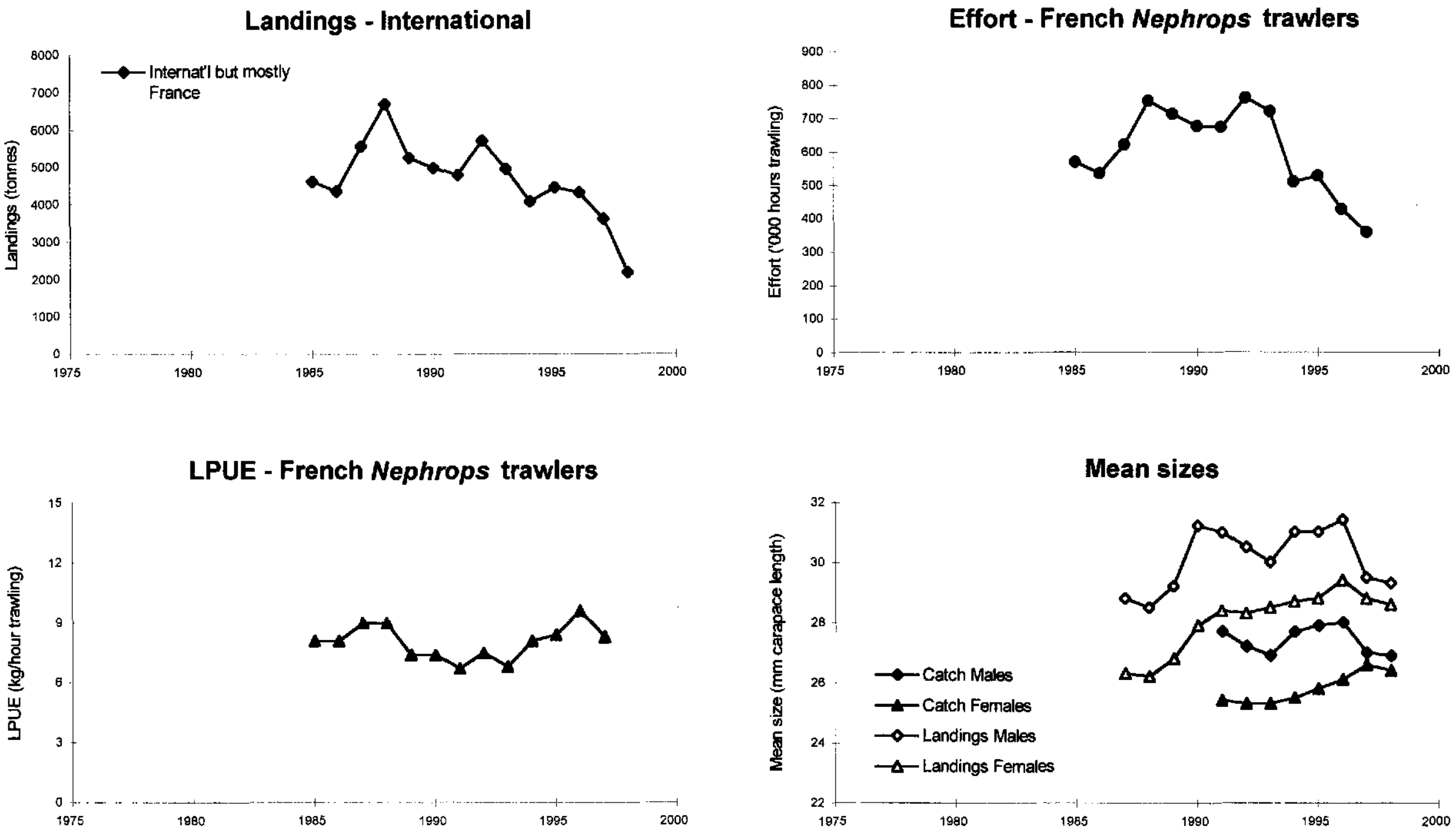


Figure 5.16.1. - Bay of Biscay (FUs 23-24): Long-term trends in landings, effort, LPUEs and mean sizes of *Nephrops* in catches and landings.

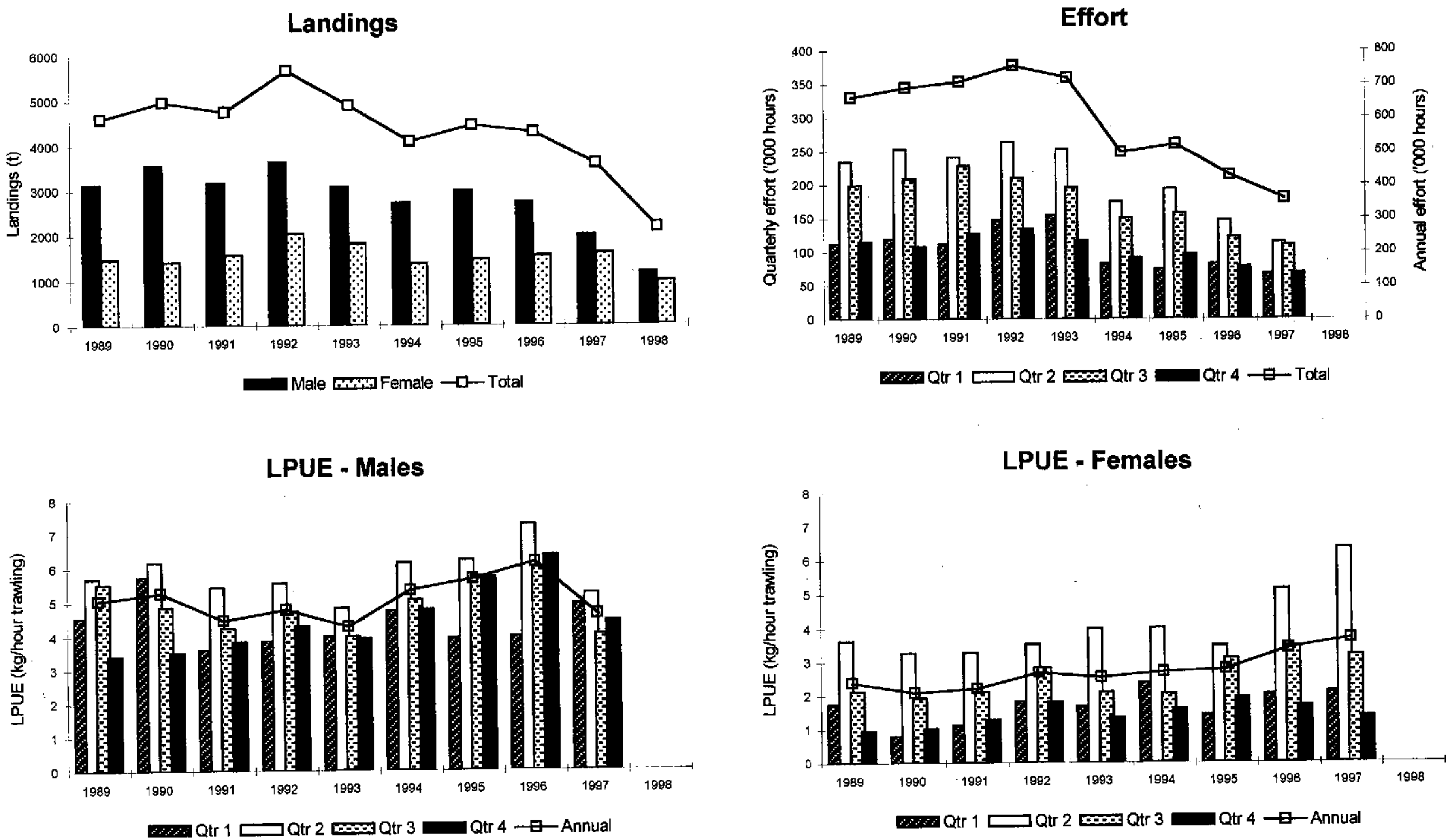
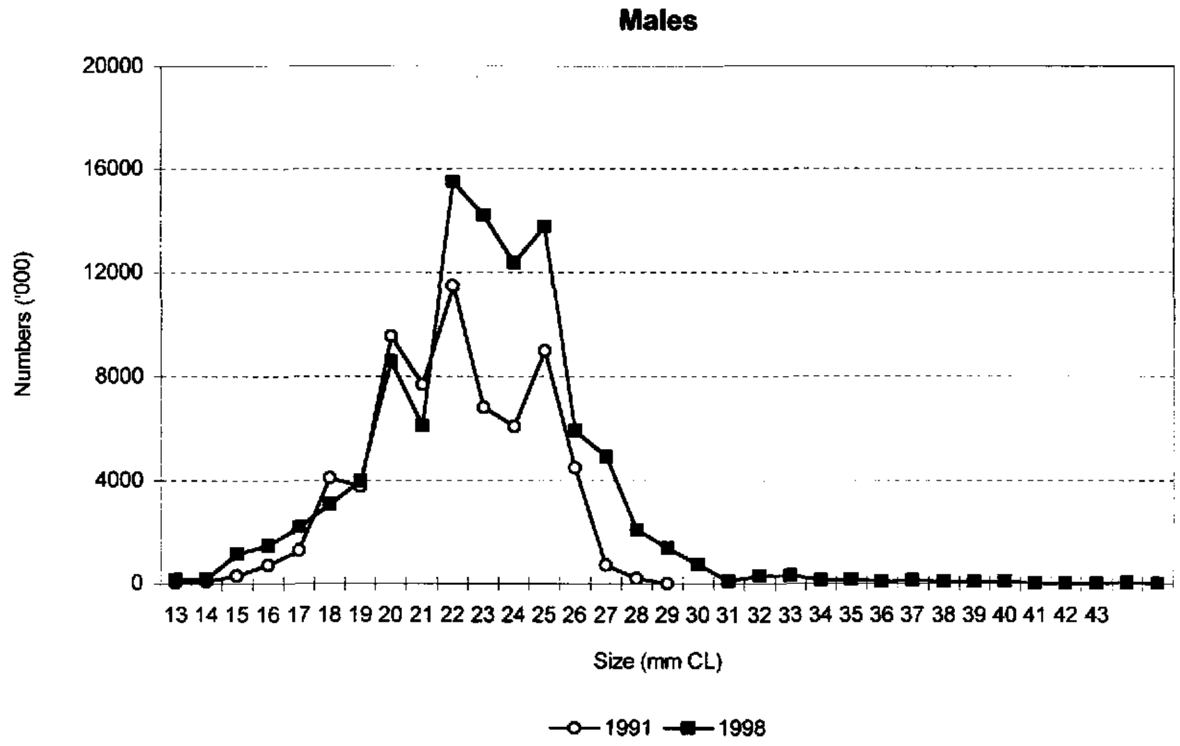


Figure 5.16.2. - Bay of Biscay (FUs 23-24): Landings, effort and LPUEs by quarter and sex from French *Nephrops* trawlers.



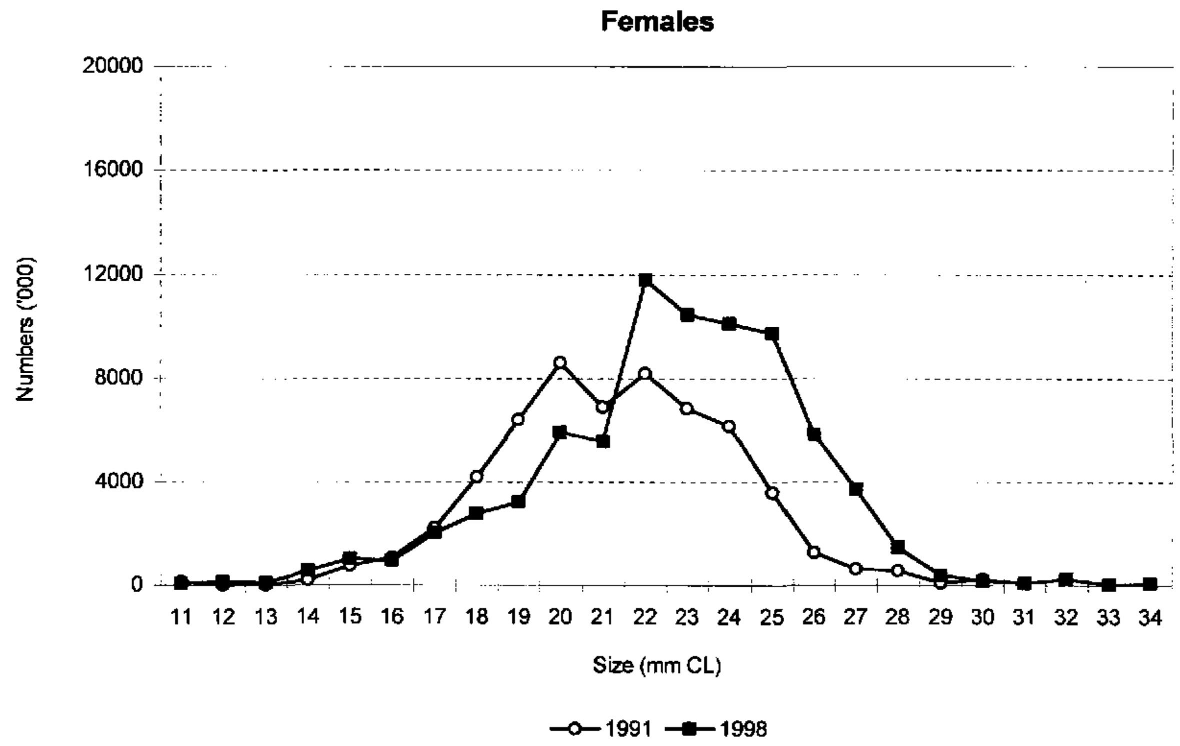
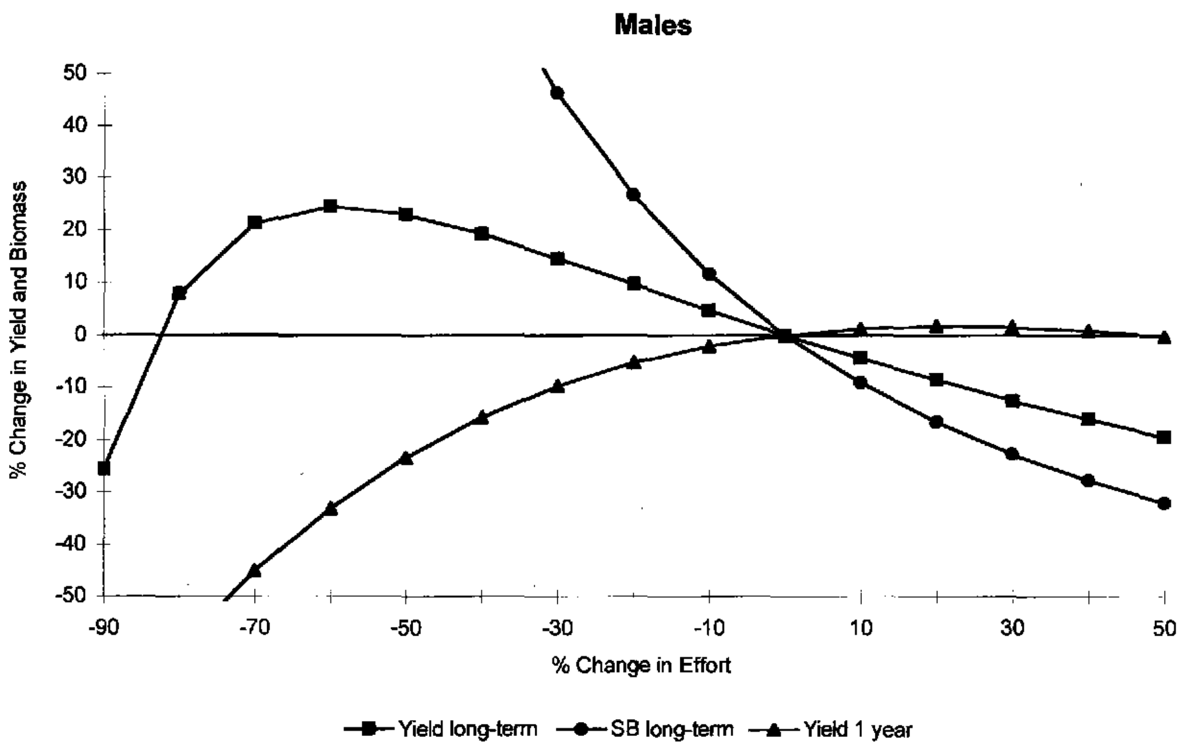


Figure 5.16.3. - Bay of Biscay (FUs 23-24): LFDs of male and female *Nephrops* discards in 1991 and 1998 discard sampling programmes.



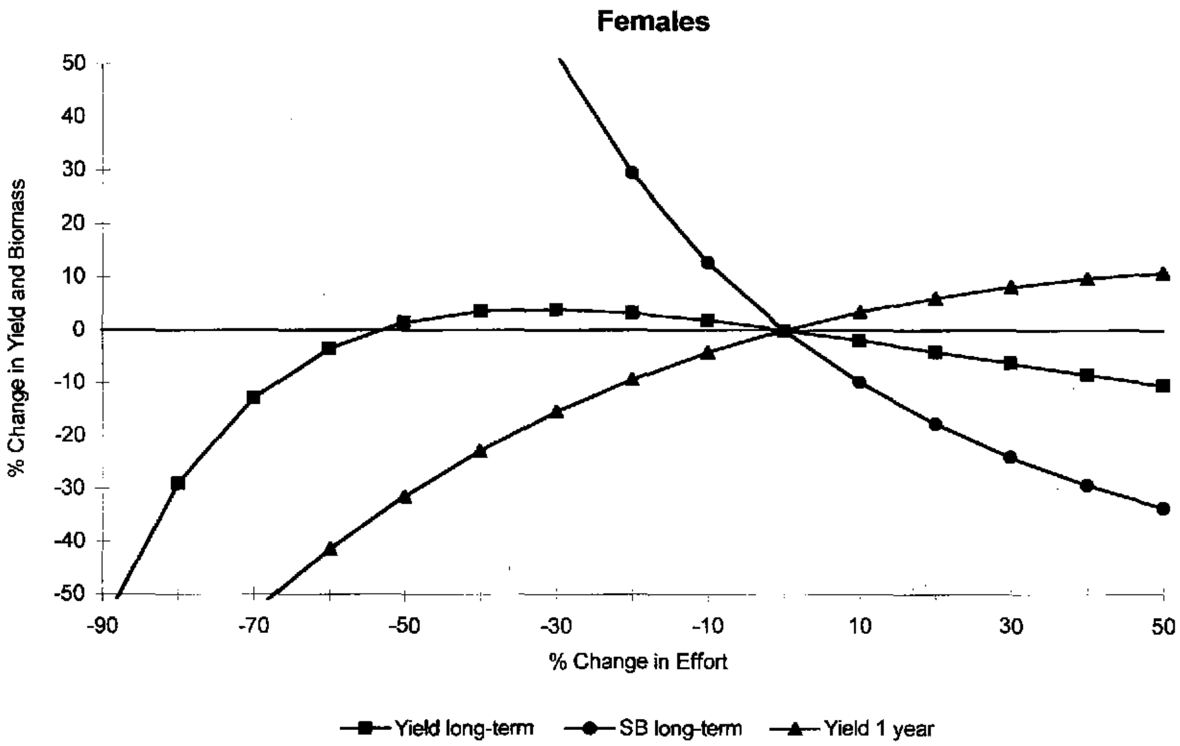


Figure 5.16.4. - Bay of Biscay (FUs 23-24): Output LCA: Relative changes in short-term yield (ie after 1 year), long-term yield and long-term biomass upon relative changes in effort. Males and females shown separately.

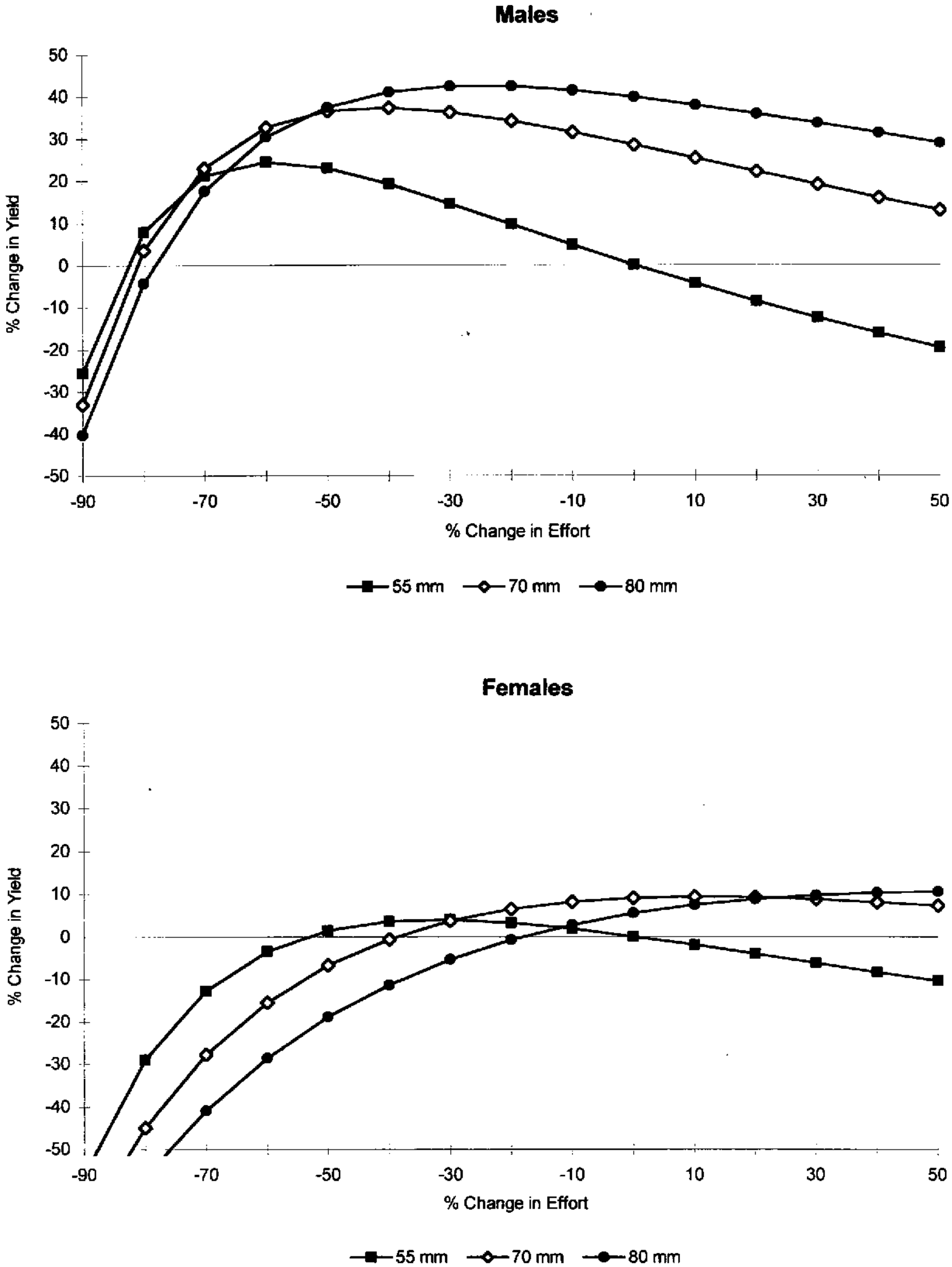
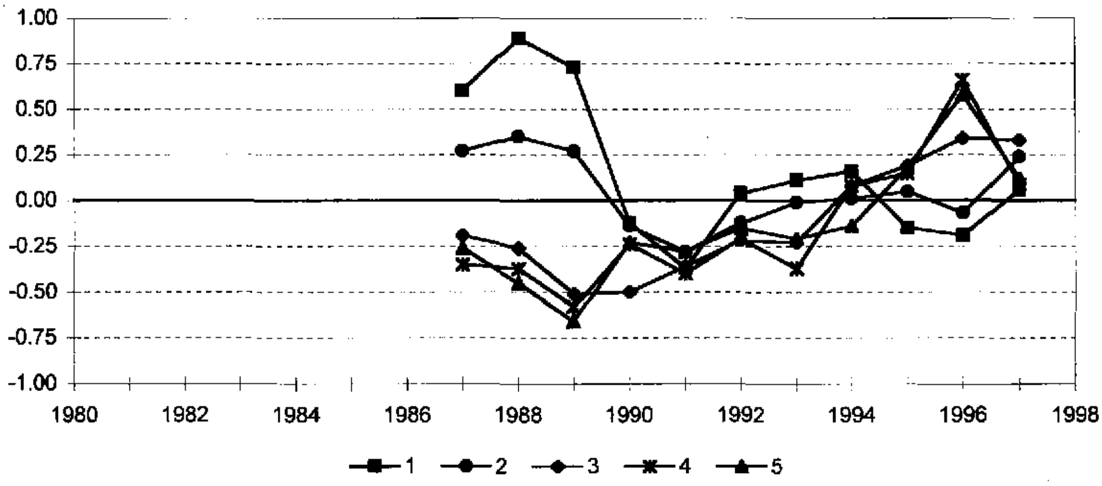


Figure 5.16.5. - Bay of Biscay (FUs 23-24): Output LCA mesh assessment: Relative changes in long-term yield upon relative changes in effort, for different mesh sizes.
Males and females shown separately.



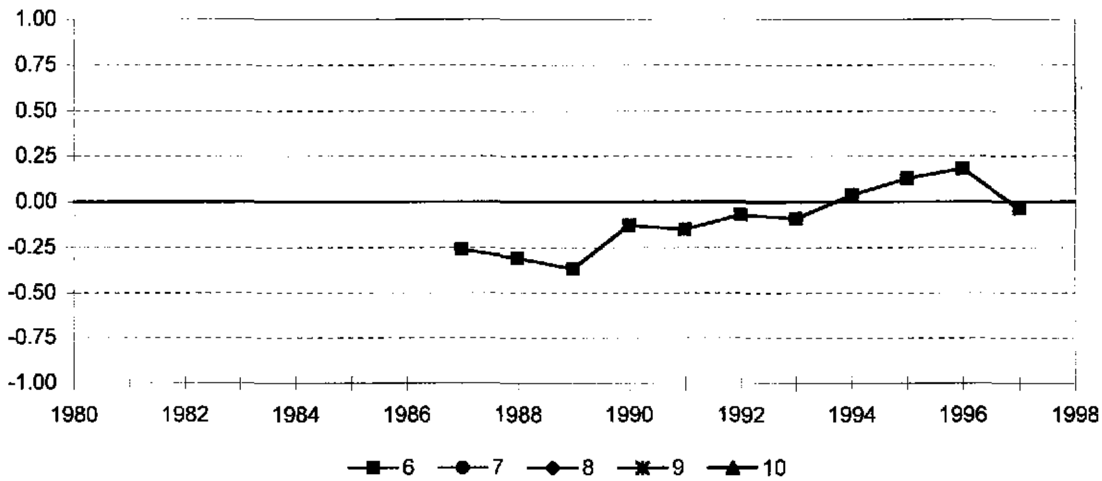
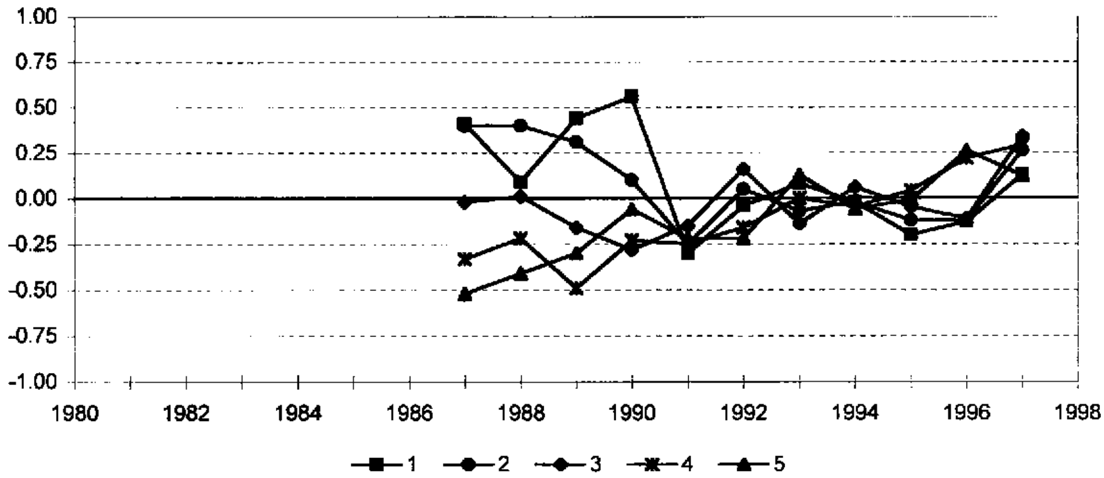


Figure 5.16.6. - Bay of Biscay (FUs 23-24): Output VPA males: Log catchability residuals.



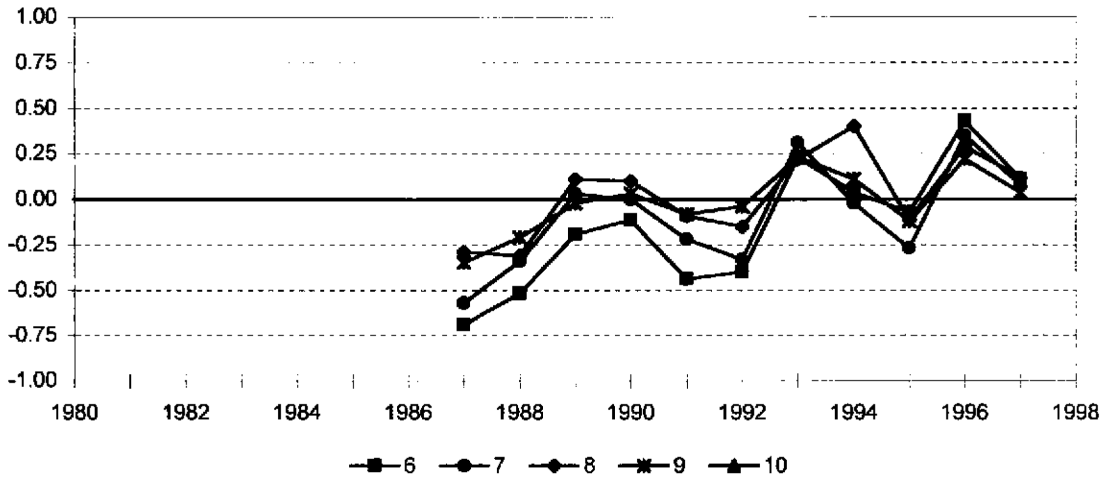


Figure 5.16.7. - Bay of Biscay (FUs 23-24): Output VPA females: Log catchability residuals.

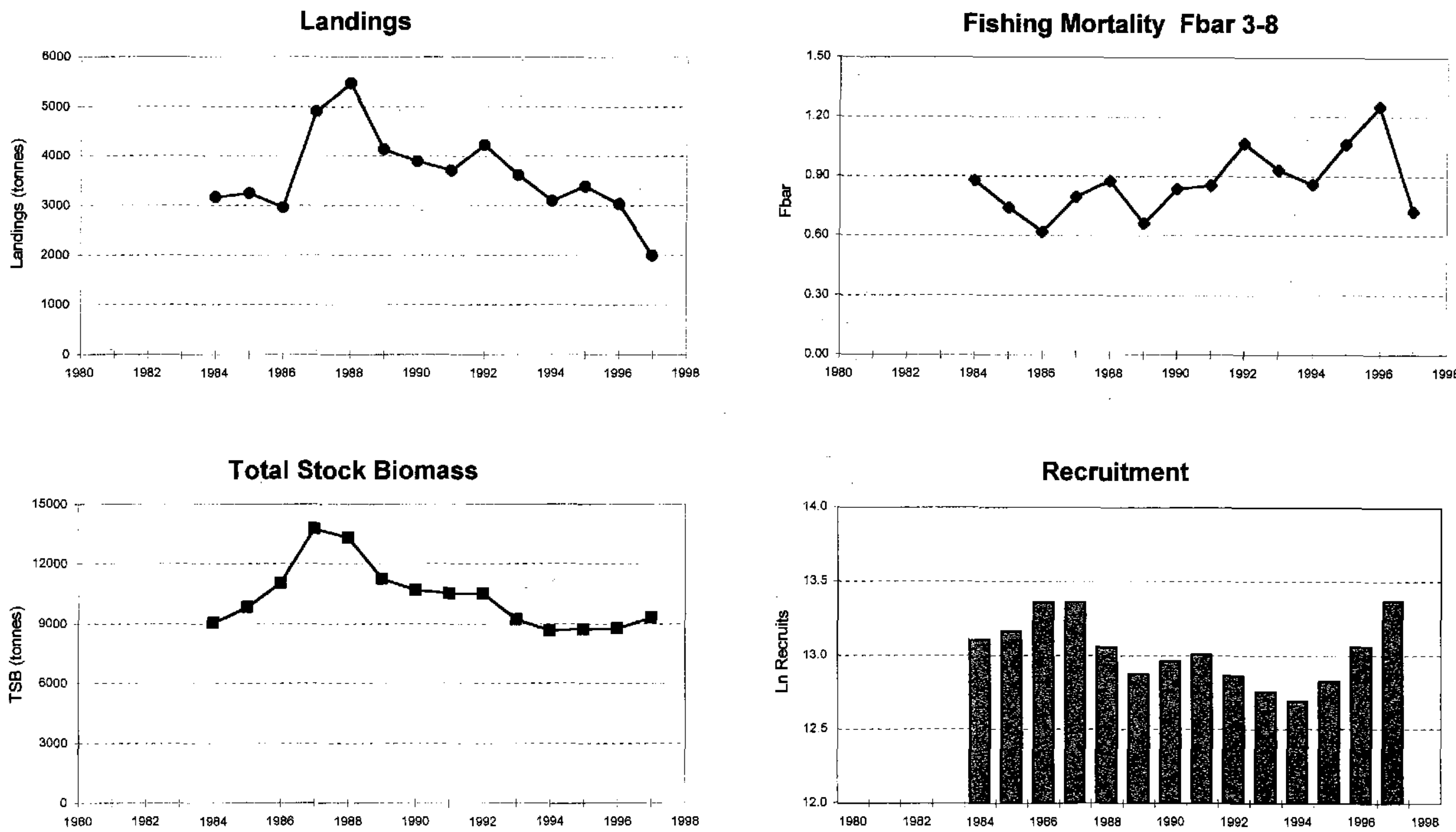


Figure 5.16.8. - Bay of Biscay (FUs 23-24): Output VPA males: Trends in Landings, Fbar, TSB and Recruitment.

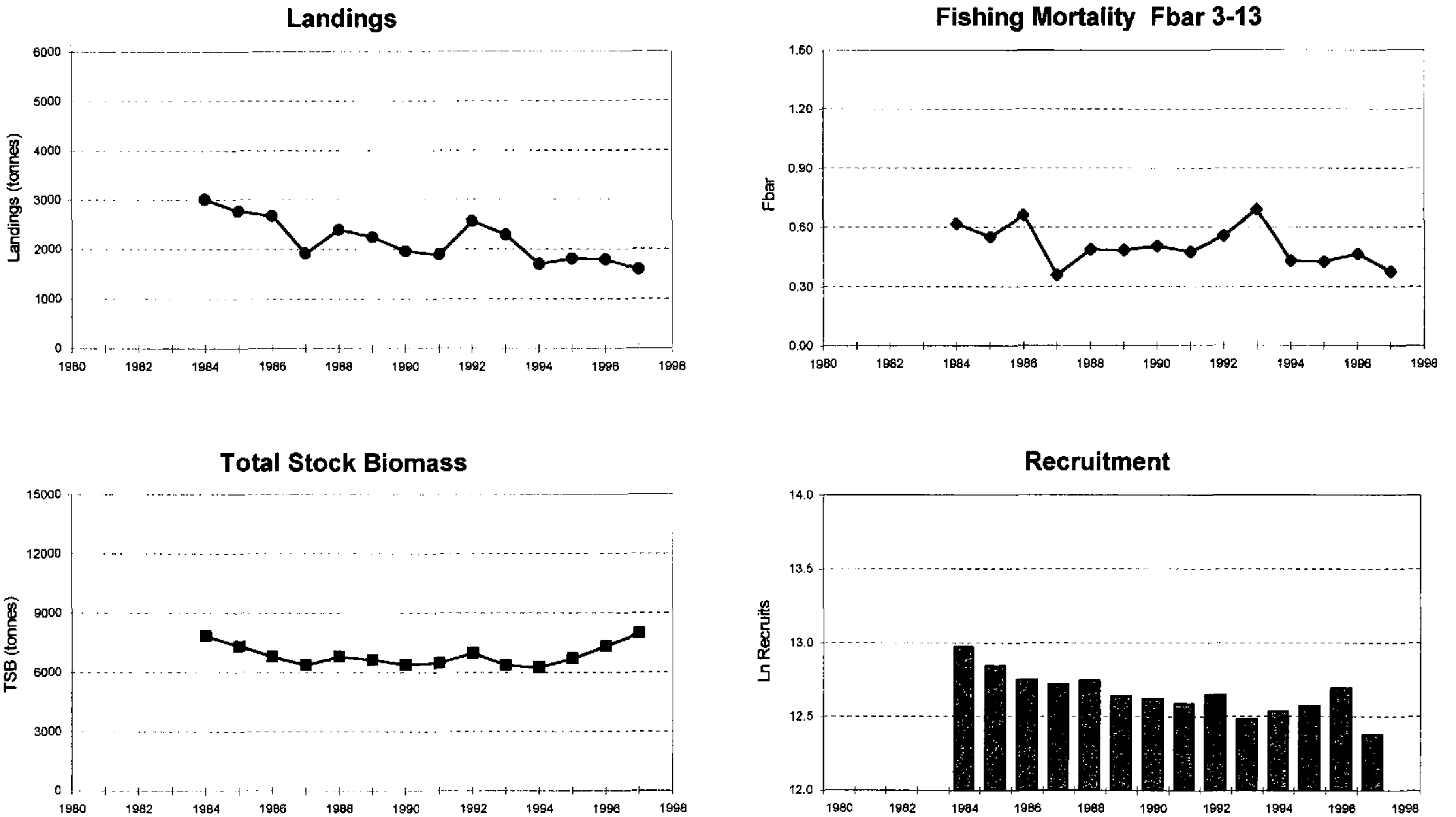


Figure 5.16.9. - Bay of Biscay (FUs 23-24): Output VPA females: Trends in Landings, Fbar, TSB and Recruitment.

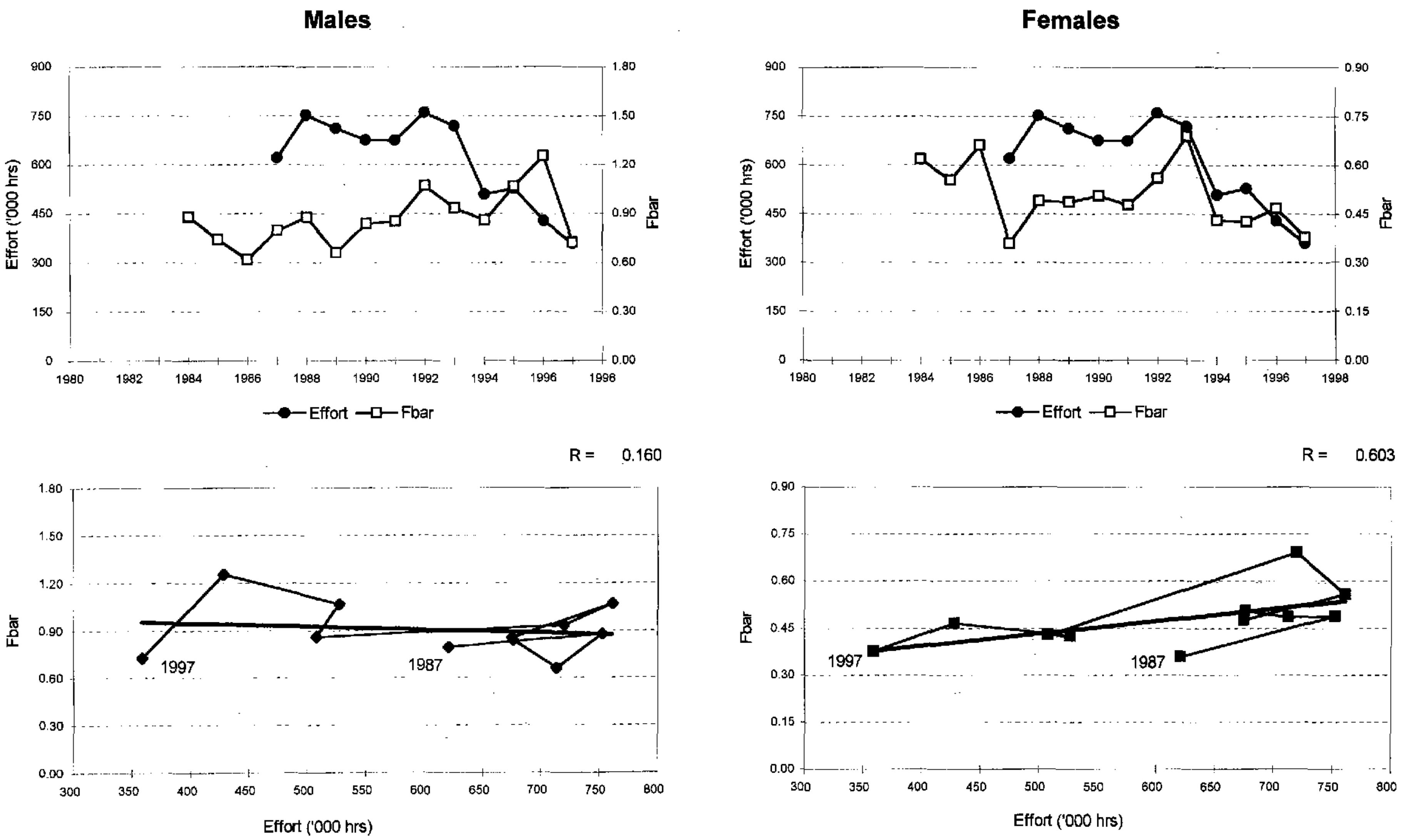


Figure 5.16.10. - Bay of Biscay (FUs 23-24): Effort and Fbar, and relationship between them, for males and females.

5.17. Management Area O

ICES description **VIIIc**

Functional Units **North Galicia (FU 25)**
Cantabrian Sea (FU 31)

The statistical rectangles comprised in this Management Area and its constituent Functional Units are shown in Figure 5.1.3.

5.17.1. North Galicia (FU 25)

Description of the fisheries

Spain

The fishing grounds comprised in this FU are located on the shelf and the upper slope off NW Spain, at depths between 100 and 600 m.

The fleet involved in the bottom trawl fishery off North Galicia is composed by two types of vessels: single and pair trawlers. The differences between the two are related to both gears and target species. Single trawlers fish for a variety of species (hake, blue whiting, horse mackerel, mackerel, megrim, anglerfish, *Nephrops*, cephalopods, etc.), while pair trawlers are primarily directed towards blue whiting and hake. Up to the early 90s, hake was the main target species of the trawlers. Nowadays, hake represents only about 5 % of the landings by weight, and horse mackerel and blue whiting have become the main species (each accounting for about 30 % of the landings). *Nephrops* represents only 2 % of the landings by single trawlers, with the highest yields in the 2nd and 3rd quarter. In economic terms however, *Nephrops* ranks third, after hake and anglerfish.

A census of the trawl fleet operating in the bottom fishery gave 44 vessels. The mean age of the vessels is 25 years. Others characteristics are (averages for all vessels combined): 26 m length over all, 516 hp and 164 GRT. The duration of the fishing trips varies between 1 and 3 days (depending on the location of the fishing grounds), and tows are of 3-8 hours duration. The major landing port is La Coruña. *Nephrops* are graded on board in market categories, and landed fresh. There are no *Nephrops* discards in this fishery.

Trends in landings, effort, CPUE and mean size

Table	5.17.1.	Landings by country, 1989-98
Table	5.17.2.	Effort and CPUEs Spanish fleet, 1989-98
Table	5.17.3.	Mean sizes of *Nephrops* in catches, Spanish data, 1989-98
Table	5.17.4.	*Nephrops* abundance indices from trawl surveys, 1989-98
Figure	5.17.1.	Long-term trends in landings, effort, CPUE and mean size, Spanish data
Figure	5.17.2.	Landings by sex + Quarterly plots of effort and CPUEs by sex, 1989-98

Landings and effort

Landings were reported by Spain only. The long-term series of the landings (Figure 5.17.1.) shows peak values in 1975 and 1977; a period with fairly stable landings, fluctuating around 425 t (1979-92); and one with much lower figures, between 210 t and 280 t (1993-97). In 1998, the landings dropped to 103 t. Since the traditional source of information on the landings (viz. the record sheets of the sales by trip in La Coruña harbour) was not available for 1998, the landings figure for this year was estimated from the landings that were sampled, and therefore it should be regarded as highly provisional. Overall, the trend in the landings since the early 80s has been downward.

Fishing effort data are available for the La Coruña trawler fleet, except for 1998. Effort has been quite stable since the mid-80s, fluctuating around 5300 days fishing, after a marked decrease from 1976 to 1987 (Figure 5.17.1.).

CPUE

CPUEs (*Nephrops* discards are negligible in this fishery, < 1 % by weight) have largely fluctuated – albeit without obvious trend – between 6.7 and 13.5 kg/day* BHP/100 over the past 10 years (Figure 5.17.1.). The lack of fishing effort data in 1998 prevented the calculation of the corresponding CPUE.

Fishing effort is almost evenly distributed over all quarters (Figure 5.17.2.). Both male and female CPUEs by quarter have become less variable in recent years, as opposed to the earlier years in the data series, when the CPUEs were usually highest in the 2nd and 3rd, and sometimes the 4th quarter.

Table 5.17.4. gives the abundance indices of *Nephrops* off North Galicia, derived from bottom trawl surveys carried out in autumn to estimate hake recruitment and to collect information on the relative abundance of demersal species. In general, these results show a higher degree of variability between years than the commercial CPUEs.

Mean size

The long-term data series of mean sizes in the landings show no particular trends (Figure 5.17.1.). Over the past 10 years, mean sizes have fluctuated within a range of 34.5-41.0 mm CL for the males and 33.0-39.5 mm CL for the females, with all-time peaks in 1989 and 1990 for males and females respectively (Table 5.17.3.).

Data and biological inputs for analytical assessments

Table 5.17.5. Sampling data and input parameters

Except for a new size at maturity for females (viz. 28 instead of 24 mm CL - ICES, 1998b), all input parameters were the same at the ones used in the 1997 LCA.

General comments on quality of data and inputs

The quality of the landings data collected in 1997 was believed to be similar to that in previous years. The landing figure for 1998 is uncertain (see above). Effort data for the trawlers fishing for both *Nephrops* and demersal fish, and landing in La Coruña, cover about 80 % of the total fishing effort in this FU. Effort data for these vessels are recorded by voyage, but precise information on their range of activities or their directedness towards *Nephrops* is lacking. Vessels may target horse mackerel for part of the year, or a variety of demersal species. The consequence being that strictly *Nephrops* directed effort may be over-estimated.

Length based assessments (LCA)

Table	5.17.6.	Output table LCA males, with mean F
Table	5.17.7.	Output table LCA females, with mean F
Figure	5.17.3.	Changes in Y/R and B/R upon changes in F, for males and females separately

The LCA was updated, using length composition data for the years 1995-97. This period was considered to meet the steady state requirement, since effort remained almost constant (Figure 5.17.1.). Input F choices were 0.2 and 0.05 for males and females respectively

The long-term Y/R curve for males is flat-topped, with current F above F_{max}, but only very small benefits in yield (+ 2 %) would be obtained by reducing effort from current F to F_{max}. For females, the Y/R was curvi-linear, with current F far below F_{max}. Annualised fishing mortalities (averaged across the inter-quartile length range) were 0.62 for males and 0.11 for females.

Comments on quality of assessments

The landings are sampled at an acceptable level, and landings and effort statistics are thought to have been reliable until 1997.

The LCA gives results which are similar to the previous analysis (ICES, 1997a), and provides and acceptable guide on the state of exploitation of this FU.

Management considerations

The results of the LCA and the trends in landings and CPUE suggest that the stock in this FU has stabilised, albeit at a relatively low level. Previous runs of LCA (ICES, 1997a) and VPA (ICES, 1995a) suggested that a reduction in effort would be recommendable for this FU. However, in view of the characteristics of this typically mixed fishery, where most of the effort is directed towards demersal fish, and where *Nephrops* plays a relatively small role as a target species, it can be expected that the management measures for the main target species (hake and blue whiting) will continue to define the levels of exploitation of *Nephrops*. The use of a 65 mm mesh size by most of the trawlers – as a consequence of a change in exploitation scheme of part of the fleet, in response to the seasonal patterns in species availability and market conditions – suggests that it is advisable to maintain the TAC at its current level.

5.17.2. Cantabrian Sea (FU 31)

Description of the fisheries

Spain

The *Nephrops* grounds in this FU are located in the eastern Cantabrian Sea (where the highest *Nephrops* densities are found at less than 100 m depth), and in the central Cantabrian Sea (at depths over 200 m, on the tops of submarine canyons).

The characteristics of the bottom trawl fishery in the Cantabrian Sea are similar to those of the North Galicia fishery (see Section 5.17.1.) with respect to types of vessels involved, gears used and species caught. 35 trawlers, averaging 24 m length over all, 447 hp, 139 GRT and 19 years old are operating this fishery.

Nephrops represents less than 1 % of the landings by weight. The most profitable species in this fishery are anglerfish (accounting for 12 % of the landings), hake and megrim (with 7 % each). Santander, Avilés and Ondarroa are the major landing ports.

Trends in landings, effort, CPUE and mean size

Table	5.17.8.	Landings by country, 1989-98
Table	5.17.9.	Effort and CPUEs Spanish fleet, 1989-98
Table	5.17.10.	Mean sizes of *Nephrops* in catches, Spanish data, 1989-98
Table	5.17.11.	*Nephrops* abundance indices from trawl surveys, 1989-98
Figure	5.17.4.	Long-term trends in landings, effort, CPUE and mean size, Spanish data

Landings and effort

Landings data are available for the years 1983-98. Although the total landings have been largely fluctuating, they show an overall downward trend after the peak of 172 t in 1990 (Figure 5.17.4). The 1998 figure of 65 t is the lowest in the time series. Since 1991, small landings by creels (< 10 t per year) have been reported.

Effort data for the trawlers of Avilés (corresponding to approximately 30 % of the total landings) are available for the period 1983-98. Fishing effort by this fleet shows an almost uninterrupted downward trend since the beginning of the time series (Figure 5.17.4.).

CPUE

CPUEs (discards are negligible in this fishery) are available for the trawlers of Avilés for the period 1983-98. After having increased up to 6.9 kg/day * bhp/100 between 1985 and 1990, the CPUEs fell to around 3.3 kg/day * bhp/100 in the years 1991-96 (Figure 5.17.4.). Since then, they have slightly increased again.

Table 5.17.11. shows the abundance indices of *Nephrops* on the Cantabrian shelf, derived from bottom trawl surveys carried out in autumn to estimate hake recruitment and to collect abundance indices for demersal species. The low densities of *Nephrops* for the Cantabrian shelf as a whole are due to the fact that the spatial distribution of *Nephrops* is restricted to two relatively small grounds (viz. off Cape Peñas and Basque Country) within the much larger area that was surveyed.

Mean size

Mean size data are available for 1988-98 (Figure 5.17.4.). Up to 1992, the mean sizes of the males have been quite stable (at around 41.5 mm CL), after which they rapidly increased to 46.6 mm CL in 1994. Similarly, the mean sizes of females were fairly stable at around 38.0 mm CL up to 1993, then they increased to 42.0 mm CL in the mid-90s. Since 1994-95, the mean sizes of both males and females have stabilised at these high levels.

Data and biological inputs for analytical assessments

Table 5.17.12. Sampling data and input parameters

Length composition samples of the landings by trawlers in Avilés and Santander are available for 1997 and 1998. There were no changes in input parameters compared to the ones used in the 1997 assessment.

General comments on quality of data and inputs

A reasonable level of sampling is achieved for this fishery. The biological input parameters are partly based on sampling observations and partly borrowed from adjacent FUs (e.g. North Galicia). It should be borne in mind however, that there are two distinct *Nephrops* grounds in the area (see above), and that information on the degree of biological variability between them is lacking.

Length based assessments (LCA)

Figure 5.17.5. Changes in Y/R and B/R upon changes in F, for males and females separately (taken from ICES, 1997a)

The addition of the size frequency data for 1997 and 1998 to the reference period used in the previous LCA (ICES, 1997a) did not alter the average length compositions. Therefore, and because the other inputs remained unchanged too, the WG saw no reason to repeat the length based assessment.

Following the results of the previous LCA (ICES, 1997a), the long-term Y/R curves for males and females are flat-topped. For males, current F is above F_{max}, but only small gains (3 %) would be obtained from a reduction in effort to the level of F_{max}. For females, current F is close to F_{max}. Annualised mean F, calculated across the inter-quartile range of the length distributions, was 0.46 for the males and 0.31 for the females (ICES, 1997a).

Comments on quality of assessments

The assessments are believed to be of the same overall quality as the ones made in 1997 (ICES, 1997a).

Management considerations

The results of the 1997 LCA for the Cantabrian Sea suggest that small benefit could be obtained from a reduction in fishing effort from current F to F_{max}. The characteristics of the trawl fishery in the Cantabrian Sea however, where *Nephrops* accounts for less than 2 % of the landings, precludes advice exclusively based on the level of exploitation of *Nephrops*.

Given the restricted area of the *Nephrops* grounds in the Cantabrian Sea, more precise information on fishing effort by statistical rectangle is required to give proper advice.

5.17.3. Summary for Management Area O

Table 5.17.13. Landings by FU and from Other rectangles, 1989-98
Table 5.17.14. Landings by country, 1989-98

Despite the multi-specific nature of the fisheries in this MA (which implies that the management measures for other species will continue to define the levels of exploitation of *Nephrops*) and the adoption of a 65 mm mesh size by many trawlers (which meant a *de facto* increase in the mesh size of gears used to catch *Nephrops*), *Nephrops* directed fishing effort should not be allowed to increase, and the TAC should be set accordingly.

Table 5.17.1. - North Galicia (FU 25): Landings (tonnes) by country, 1989-98.

Year	Spain	Total
1989	376	376
1990	285	285
1991	453	453
1992	428	428
1993	274	274
1994	245	245
1995	273	273
1996	209	209
1997	219	219
1998 *	103	103
* provisional na = not available		

Table 5.17.2. - North Galicia (FU 25): Effort (days fishing) and CPUE (kg/day * BHP/100) of Spanish "bacas", home port La Coruña, 1989-98.

Year	Effort	CPUE
1989	5753	10.1
1990	5710	6.7
1991	5135	12.4
1992	5127	13.5
1993	5829	9.2
1994	5216	9.3
1995	5538	8.4
1996	4911	7.6
1997	4850	7.9
1998 *	na	na
* provisional na = not available		

Table 5.17.3. - North Galicia (FU 25): Mean sizes (mm CL) of male and female *Nephrops* in Spanish catches, 1989-98.

Year	**Catches**	
	Males	Females
1989	40.9	38.7
1990	37.5	39.4
1991	34.8	33.3
1992	37.1	34.9
1993	37.4	36.0
1994	36.6	34.7
1995	37.1	35.8
1996	37.0	34.7
1997	36.5	35.1
1998 *	39.4	37.5
* provisional na = not available		

Table 5.17.4. - North Galicia (FU 25): Mean stratified catches (MSC) and standard errors (SE) of *Nephrops* in bottom trawl surveys off North Galicia, 1989-98.

Year	**Kg / 30 min haul**		**Nos. / 30 min haul**	
	MSC	SE	MSC	SE
1989	0.08	0.02	2.2	0.8
1990	0.23	0.06	8.0	2.1
1991	1.31	0.47	51.5	16.2
1992	0.45	0.13	12.8	3.4
1993	0.25	0.06	7.6	2.2
1994	0.15	0.06	4.4	1.9
1995	0.43	0.09	15.0	3.3
1996	0.30	0.08	11.1	3.3
1997	0.06	0.01	1.4	0.3
1998 *	0.06	0.02	1.5	0.5

* provisional na = not available

Table 5.17.5. - North Galicia (FU 25): Input data and parameters.

FU	**25**	**MA**	**O**
FLEET	**Spain**	**GEAR**	**Trawl**

	1998					**1997**				
	Number of samples				Mean no. per sample	Number of samples				Mean no. per sample
	Qtr 1	Qtr 2	Qtr 3	Qtr 4		Qtr 1	Qtr 2	Qtr 3	Qtr 4	
Catch	0	0	0	0		0	0	0	0	
Landings	17	18	18	17	86	18	18	18	18	93
Discards	0	0	0	0		0	0	0	0	

	Number of samples									
Year	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989
Catch	0	0	0	0	0	0	0	0	0	0
Landings	70	72	68	101	99	73	73	73	70	52
Discards	0	0	0	0	0	0	0	0	0	0

INPUT PARAMETERS		
Parameter	Value	Source
Discard Survival	—	not applicable - few discards (< 1%)
MALES		
Growth - K	0.160	ICES, 1994a
Growth - L(inf)	70	"
Natural mortality - M	0.2	"
Length/weight - a	0.00043	Fariña, 1984
Length/weight - b	3.160	"
FEMALES		
Immature Growth		
Growth - K	0.160	ICES, 1994a
Growth - L(inf)	70	"
Natural mortality - M	0.2	"
Size at maturity	28	Fariña, unpublished
Mature Growth		
Growth - K	0.080	ICES, 1994a
Growth - L(inf)	60	"
Natural mortality - M	0.2	assumed after Morizur, 1982
Length/weight - a	0.00043	Fariña, 1984
Length/weight - b	3.160	"

Table 5.17.6. - North Galicia (FU 25): LCA output males.

Reference period	1995-97		
Linf (mm CL)	70.0	K	0.160

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
22	3	0.2	0.266	0.001	0.002	0.202	5708	1478	12773
24	27	0.2	0.278	0.005	0.019	0.219	5410	1458	16397
26	67	0.2	0.291	0.014	0.047	0.247	5091	1428	20483
28	173	0.2	0.305	0.038	0.126	0.326	4738	1375	24722
30	346	0.2	0.321	0.087	0.271	0.471	4290	1277	28327
32	426	0.2	0.338	0.127	0.376	0.576	3689	1133	30626
34	578	0.2	0.357	0.219	0.614	0.814	3036	941	30648
36	460	0.2	0.379	0.236	0.623	0.823	2270	739	28684
38	417	0.2	0.403	0.302	0.749	0.949	1662	557	25538
40	343	0.2	0.431	0.378	0.877	1.077	1134	391	20996
42	227	0.2	0.463	0.404	0.873	1.073	713	260	16232
44	140	0.2	0.500	0.413	0.825	1.025	434	170	12226
46	75	0.2	0.544	0.362	0.666	0.866	260	113	9308
48	34	0.2	0.596	0.251	0.421	0.621	162	81	7611
50	22	0.2	0.659	0.235	0.356	0.556	112	62	6605
52	10	0.2	0.736	0.149	0.202	0.402	78	50	5976
54	6	0.2	0.835	0.120	0.143	0.343	58	42	5690
56	2	0.2	0.963	0.052	0.054	0.254	43	37	5634
58	3	0.2	1.140	0.104	0.091	0.291	34	33	5581
60	2	0.2	1.395	0.099	0.071	0.271	24	28	5331
62	2	0.2	1.798	0.153	0.085	0.285	17	24	4901
64	5	0.2			0.200	0.400	10	24	5409
					Totals, including lengths above + group			11699	329696

Mean F, calculated across inter-quartile range	0.621

Table 5.17.7. - North Galicia (FU 25): LCA output females.

Reference period	1995-97			
Linf immatures (mm CL)	na	K immatures	na	na = not applicable (very few animals below size at 50 % maturity)
Linf matures (mm CL)	70.0	K matures	0.160	
Transition length (mm CL)	28.0			

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
20	1	0.2	0.255	0.000	0.000	0.200	9736	2422	15696
22	10	0.2	0.266	0.001	0.004	0.204	9251	2395	20695
24	35	0.2	0.278	0.004	0.015	0.215	8762	2363	26573
26	79	0.2	0.291	0.010	0.034	0.234	8254	2320	33273
28	19	0.2	0.305	0.003	0.008	0.208	7711	2278	40951
30	370	0.2	0.862	0.057	0.066	0.266	7237	5576	123737
32	449	0.2	0.926	0.089	0.096	0.296	5752	4659	125972
34	540	0.2	1.001	0.146	0.146	0.346	4371	3696	120359
36	365	0.2	1.088	0.141	0.129	0.329	3091	2826	109702
38	273	0.2	1.191	0.153	0.128	0.328	2161	2131	97690
40	197	0.2	1.317	0.166	0.126	0.326	1462	1566	84047
42	127	0.2	1.472	0.167	0.113	0.313	952	1123	70067
44	48	0.2	1.669	0.099	0.059	0.259	600	814	58609
46	29	0.2	1.927	0.094	0.049	0.249	390	596	49302
48	14	0.2	2.279	0.075	0.033	0.233	241	427	40239
50	7	0.2	2.789	0.066	0.024	0.224	142	295	31513
52	3	0.2	3.596	0.057	0.016	0.216	76	190	22983
54	7	0.2			0.050	0.250	35	190	25837
					Totals, including lengths above + group			35867	1097245

Mean F, calculated across inter-quartile range	0.108

Table 5.17.8. - Cantabrian Sea (FU 31): Landings (tonnes) by country, 1989-98.

Year	Spain		Total
	Trawl	Trap	
1989	139	0	139
1990	172	0	172
1991	105	4	109
1992	92	2	94
1993	85	6	91
1994	146	2	148
1995	90	4	94
1996	120	9	129
1997	97	1	98
1998 *	65	3	68
* provisional na = not available			

Table 5.17.9. - Cantabrian Sea (FU 31): Effort (days fishing) and CPUE (kg/day * BHP/100) of Spanish trawlers, home port Avilés, 1989-98.

Year	Effort	CPUE
1989	1611	5.3
1990	2013	6.9
1991	1798	3.6
1992	1118	3.2
1993	1074	3.0
1994	1414	3.4
1995	1548	3.0
1996	1169	3.8
1997	1314	5.0
1998 *	1031	4.5
* provisional na = not available		

Table 5.17.10. - Cantabrian Sea (FU 31): Mean sizes (mm CL) of male and female *Nephrops* in Spanish catches, 1989-98.

Year	**Catches**	
	Males	Females
1989	42.3	39.2
1990	42.0	37.4
1991	40.9	37.1
1992	41.6	39.3
1993	45.2	39.6
1994	46.6	42.0
1995	44.6	41.5
1996	45.6	41.8
1997	43.2	40.5
1998 *	46.2	41.5
* provisional na = not available		

Table 5.17.11. - Cantabrian Sea (FU 31): Mean stratified catches (MSC) and standard errors (SE) of *Nephrops* in bottom trawl surveys in the Cantabrian Sea, 1989-98.

Year	**Kg / 30 min haul**		**Nos. / 30 min haul**	
	MSC	SE	MSC	SE
1989	0.05	0.02	1.4	0.8
1990	0.12	0.04	3.1	1.3
1991	0.10	0.05	2.5	1.2
1992	0.15	0.06	2.2	0.8
1993	0.13	0.04	2.9	1.0
1994	0.13	0.06	2.6	1.1
1995	0.08	0.03	1.2	0.5
1996	0.12	0.05	2.0	0.9
1997	0.05	0.02	0.8	0.3
1998 *	0.05	0.02	1.2	0.6

* provisional na = not available

Table 5.17.12. - Cantabrian Sea (FU 31): Input data and parameters.

FU	**31**	**MA**	**O**
FLEET	**Spain**	**GEAR**	**Trawl**

	1998					**1997**				
	Number of samples				Mean no. per sample	Number of samples				Mean no. per sample
	Qtr 1	Qtr 2	Qtr 3	Qtr 4		Qtr 1	Qtr 2	Qtr 3	Qtr 4	
Catch	0	0	0	0		0	0	0	0	
Landings	8	8	8	9	91	6	9	9	8	115
Discards	0	0	0	0		0	0	0	0	

	Number of samples									
Year	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989
Catch	0	0	0	0	0	0	0	0	0	0
Landings	33	32	28	22	30	29	29	24	35	38
Discards	0	0	0	0	0	0	0	0	0	0

INPUT PARAMETERS		
Parameter	Value	Source
Discard Survival	---	not applicable - few discards
MALES		
Growth - K	0.150	based on other stocks (ICES, 1991a)
Growth - L(inf)	90	based on maximum sizes observed in samples
Natural mortality - M	0.2	assumed the same as for FU 25
Length/weight - a	0.00043	"
Length/weight - b	3.160	"
FEMALES		
Immature Growth		
Growth - K	---	not applicable - few below CL 50 % maturity
Growth - L(inf)	---	"
Natural mortality - M	---	"
Size at maturity	---	"
Mature Growth		
Growth - K	0.100	based on other stocks (ICES, 1991a)
Growth - L(inf)	70	based on maximum sizes observed in samples
Natural mortality - M	0.2	assumed the same as for FU 25
Length/weight - a	0.00043	"
Length/weight - b	3.160	"

Table 5.17.13. - Management Area O (VIIIc): Total *Nephrops* landings (tonnes) by Functional Unit plus other rectangles, 1989-98.

Year	FU 25	FU 31	Other	Total
1989	376	139	0	***515***
1990	285	172	0	***457***
1991	453	109	0	***562***
1992	428	94	0	***522***
1993	274	91	0	***365***
1994	245	148	0	***393***
1995	273	94	0	***367***
1996	209	129	0	***338***
1997	219	98	0	***317***
1998 *	103	68	0	***171***
* provisional na = not available				

Table 5.17.14. - Management Area O (VIIIc): Total *Nephrops* landings (tonnes) by country, 1989-98.

Year	Spain	Total
1989	515	***515***
1990	457	***457***
1991	562	***562***
1992	522	***522***
1993	365	***365***
1994	393	***393***
1995	367	***367***
1996	338	***338***
1997	317	***317***
1998 *	171	***171***
* provisional na = not available		

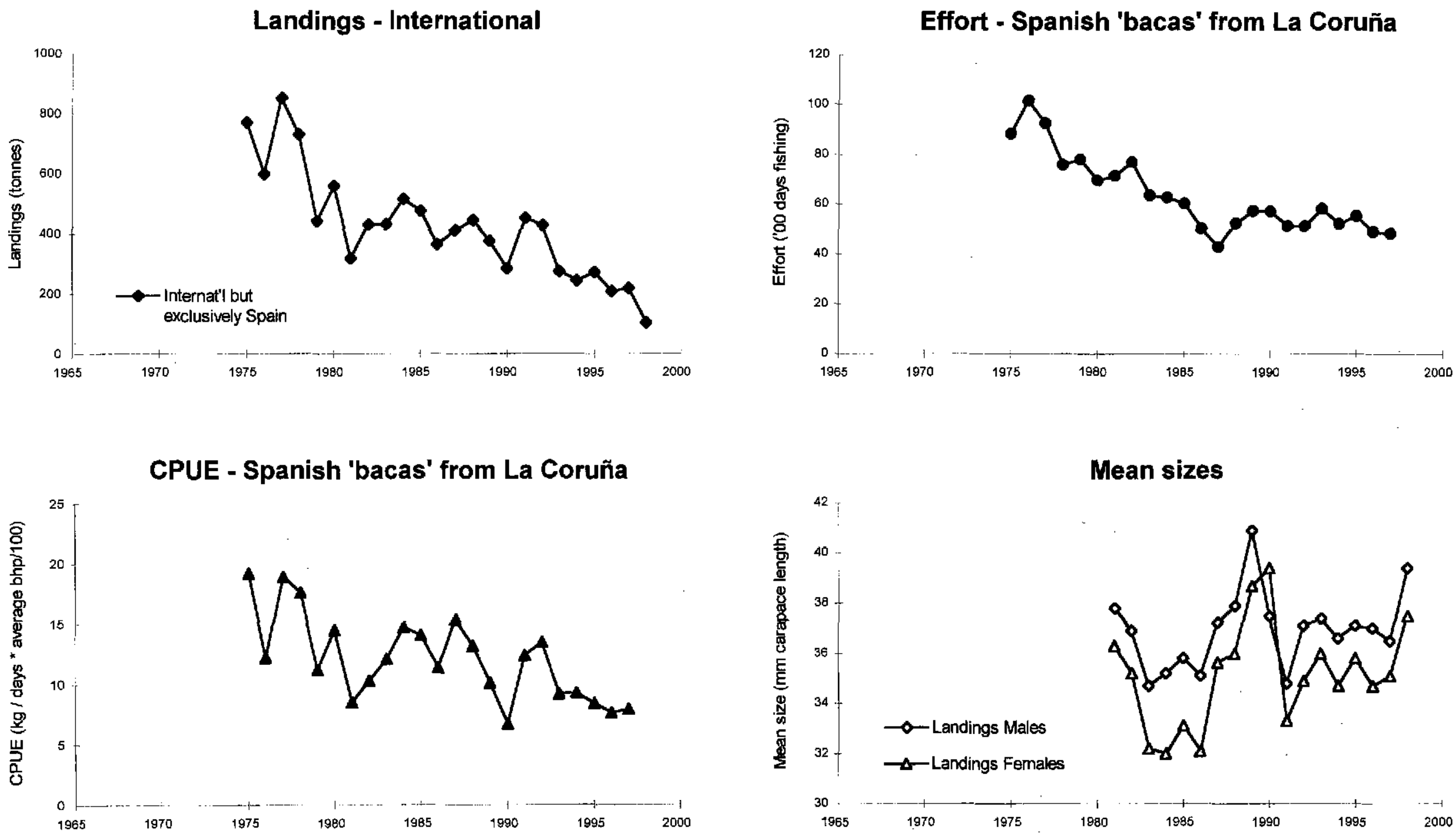


Figure 5.17.1. - North Galicia (FU 25): Long-term trends in landings, effort (La Coruña trawler fleet), CPUEs and mean sizes of *Nephrops* in landings.

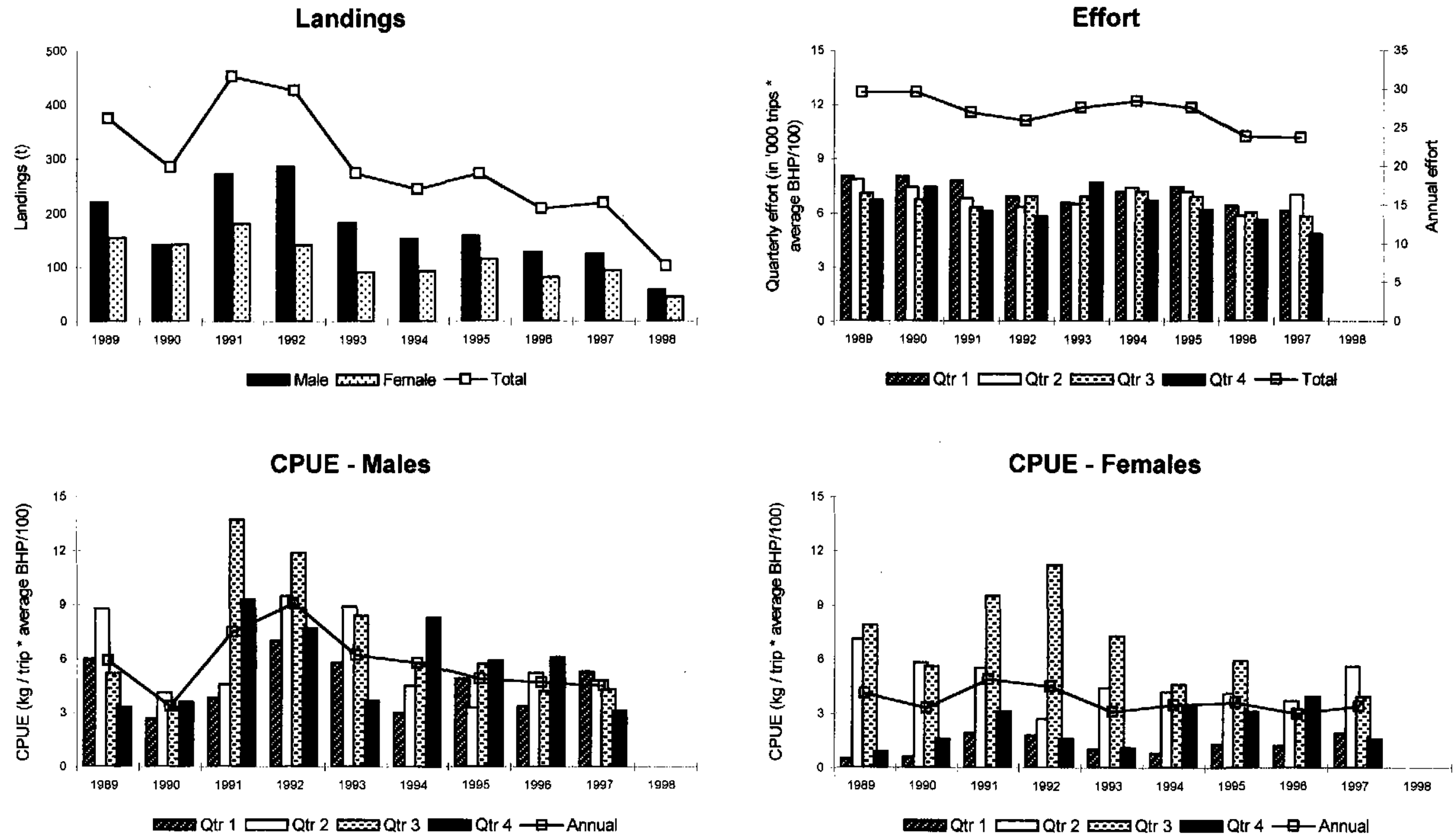
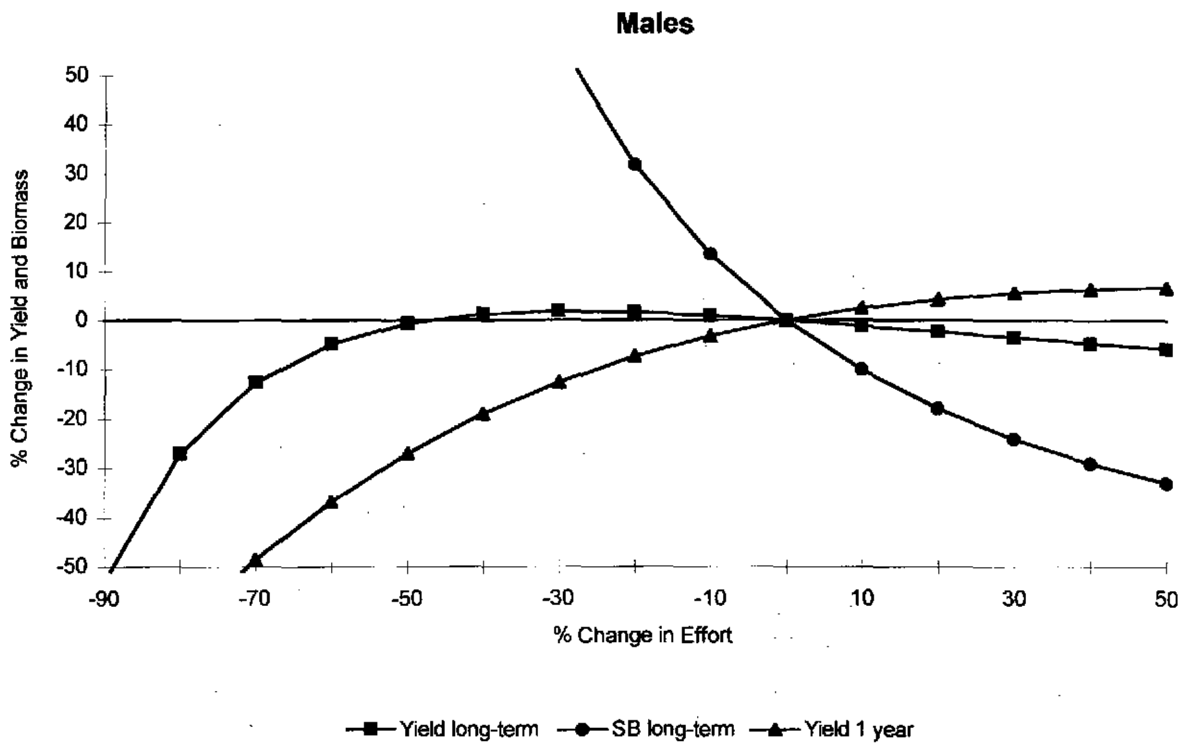


Figure 5.17.2. - North Galicia (FU 25): Landings, effort and CPUEs by quarter and sex from Spanish *Nephrops* trawlers.



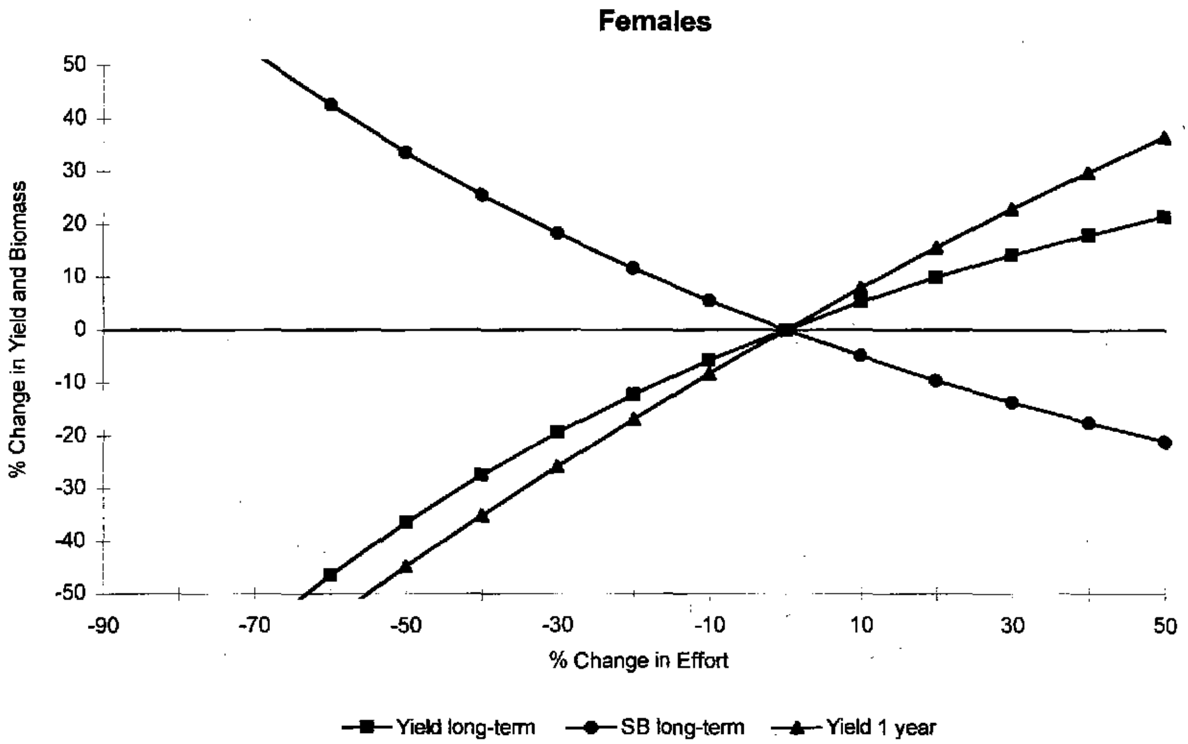


Figure 5.17.3. - North Galicia (FU 25): Output LCA: Relative changes in short-term yield (ie after 1 year), long-term yield and long-term biomass upon relative changes in effort. Males and females shown separately.

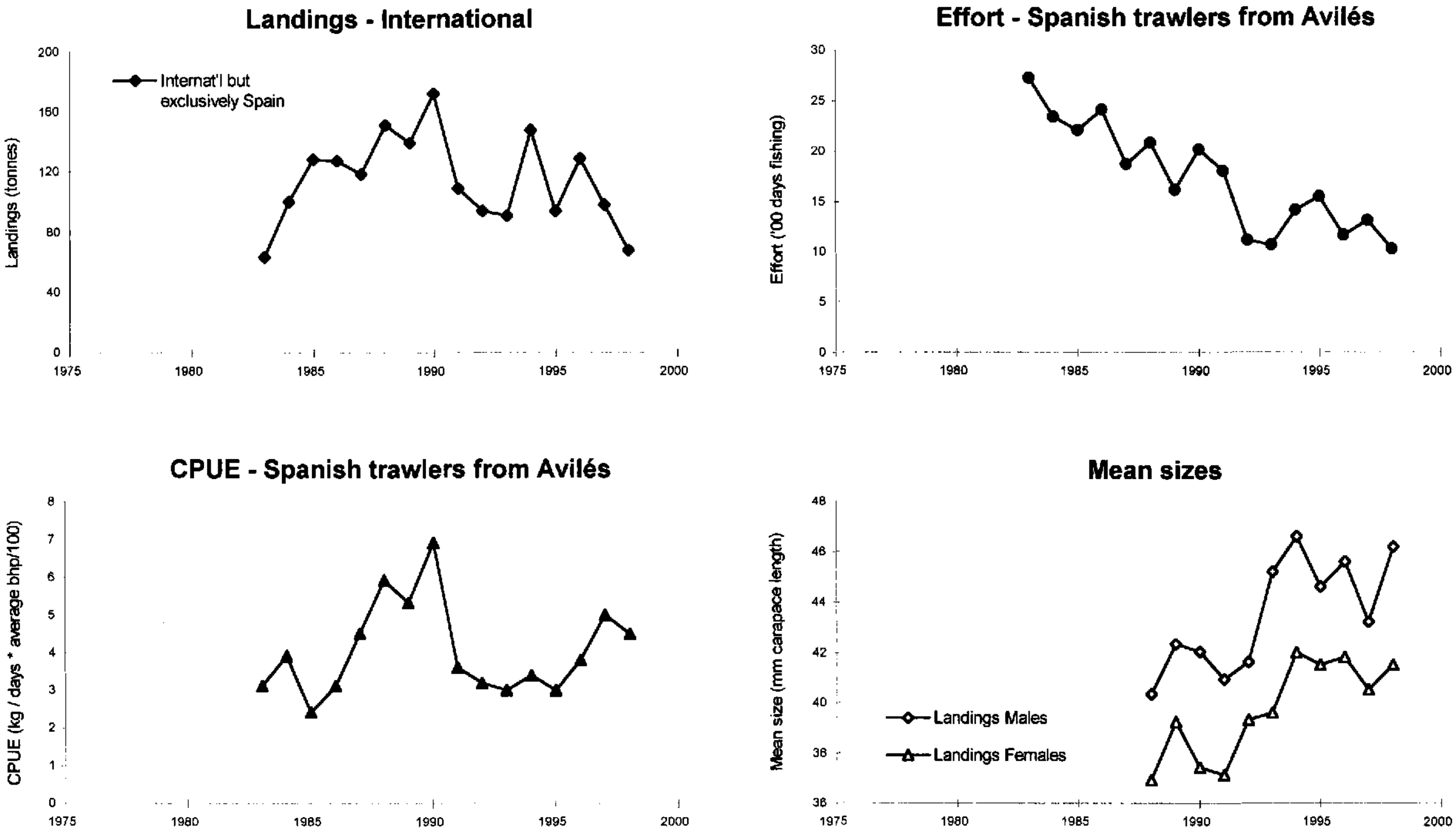
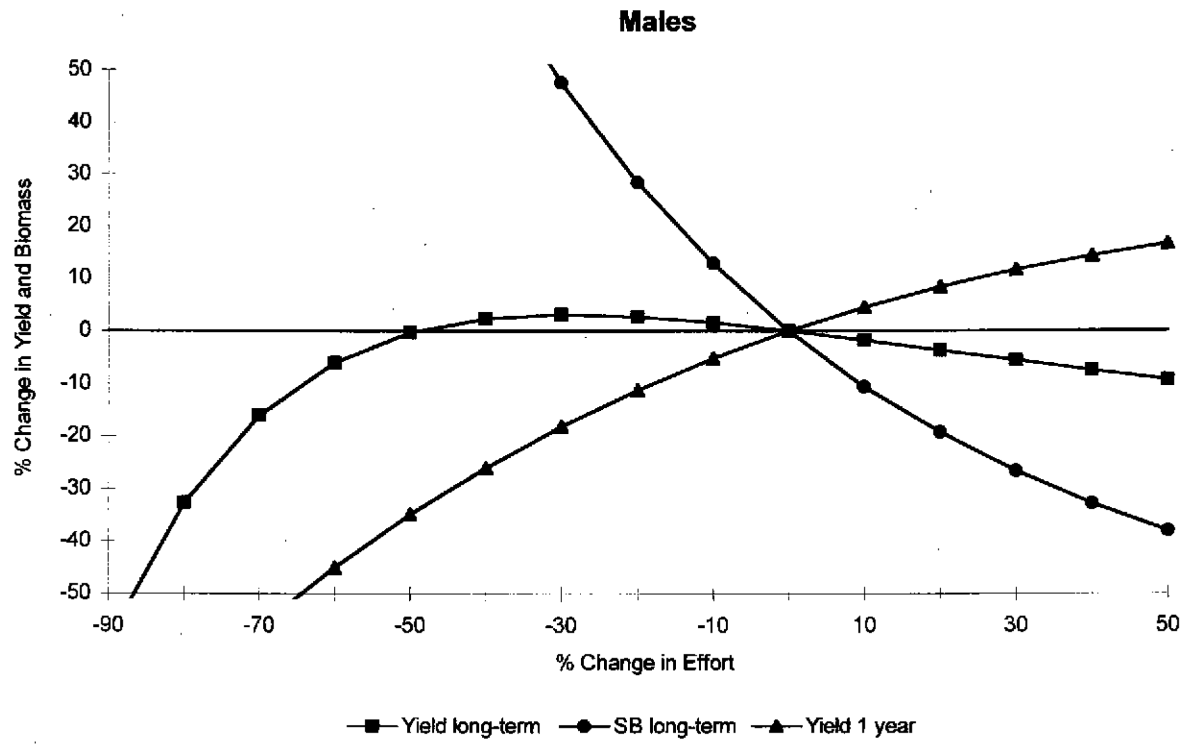


Figure 5.17.4. - Cantabrian Sea (FU 31): Long-term trends in landings, effort, CPUEs and mean sizes of *Nephrops* in landings.



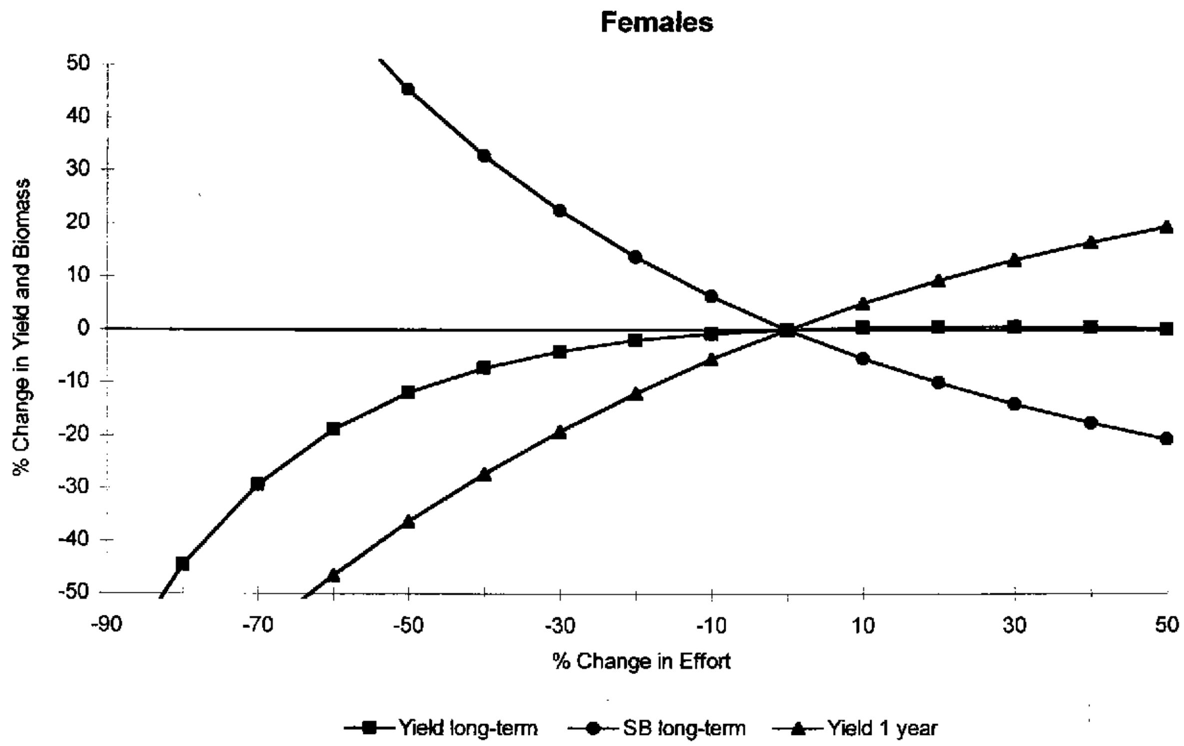


Figure 5.17.5. - Cantabrian Sea (FU 31): Output LCA: Relative changes in short-term yield (ie after 1 year), long-term yield and long-term biomass upon relative changes in effort. Males and females shown separately. Taken from 1997 *Nephrops* Working Group Report.

5.18. Management Area P

ICES description **VIIId,e**

Functional Units **none**

The statistical rectangles comprised in this Management Area are shown in Figure 5.1.3.

5.18.1. Summary for Management Area P

Zero TAC to prevent mis-reporting.

5.19. Management Area Q

ICES description	**Division IXa**
Functional Units	**West Galicia (FU 26)** **North Portugal (FU 27)** **South-West Portugal - Alentejo (FU 28)** **South Portugal - Algarve (FU 29)** **Gulf of Cadiz (FU 30)**

The statistical rectangles comprised in this Management Area and its constituent Functional Units are shown in Figure 5.1.3.

5.19.1. West Galicia (FU 26) and North Portugal (FU 27)

Description of the fisheries

Spain

The fishing grounds off West Galicia are a continuation of the grounds off North Galicia (FU 25 - see Section 5.17.1.), and the fisheries in the two areas are similar in terms of type of exploitation and species composition of the landings.

About 100 trawlers from the ports of Vigo, Marín, Riveira and Muros are involved in the West Galicia fishery. The characteristics of these vessels are similar to those of the North Galician trawlers, exception made for the Muros fleet, which has the oldest and smallest boats (with 387 hp and 127 GRT on average). Trawlers from Muros always make trips of 1 day duration, while part of the Vigo and Marín fleets spend 3 days per trip. These vessels also fish off North Portugal, which explains the longer duration of their voyages.

Fishing for *Nephrops* is restricted to part of the year only, and overall, *Nephrops* represents less than 2 % of the trawl landings from the area.

Portugal

In FU 27, *Nephrops* is found in patches on the continental slope, at depths of 300-700 m. In some areas, the bottom is irregular and trawling is difficult. There is also a narrow trawlable area in the North, where fishing occurs in shallow waters (FIGUEIREDO and VIRIATO, 1989). The trawlers mainly target demersal fish, and *Nephrops* is an important by-catch species. The catches are landed in Matosinhos, Nazaré and Peniche.

Trends in landings, effort, CPUE and mean sizes

Table	5.19.1.	FUs 26 and 27 - Landings by country, 1989-98
Table	5.19.2.	FU 26 - CPUEs Spanish fleet, 1989-98
Table	5.19.3.	FU 26 - Mean sizes of *Nephrops* in landings, Spanish data, 1989-98

Landings and effort statistics are reported by Spain and Portugal. *Nephrops* is a valuable by-catch in the fisheries from these FUs, where hake, blue whiting and horse mackerel are the most important species by weight.

Landings, effort and CPUE - Spain - FUs 26 and 27

Landings by Spain are mostly from FU 26, together with smaller quantities taken from FU 27. In the older data (see Table 5.19.1.), no distinction is made between the two FUs, therefore they are being discussed together.

Despite the slight increase in landings from FU 26 in 1996-97, the overall tendency since 1981 is a decreasing one (Figure 5.19.1.). Long-term trends in effort, available for four landing harbours (Figure 5.19.1.), indicate that effort has been fluctuating without obvious trend since 1986.

CPUE data (discards are considered negligible in this fishery, representing < 1 % of the catches) are available for the fleets of Muros and Riveira (since 1980), Marín (since 1990) and Vigo (since 1994) (Figure 5.19.1.). The figures for Marín and Vigo are much higher than for the other ports, due to the fact that the vessels from these ports (which fish on the more offshore grounds) usually stay out for three days per trip, as opposed to the one day trips for the vessels from Muros and Riveira (which exclusively fish the grounds close to the West Galician coast).

Table 5.19.4. gives the abundance indices of *Nephrops* off West Galicia, derived from data collected during bottom trawl surveys carried out in autumn. Although the main objective of these surveys is the estimation of hake recruitment, they are also believed to give a reliable picture of the long-term changes in *Nephrops* abundance. Catch rates have been on the decrease since 1993.

Landings, effort and CPUE - Portugal - FU 27

Table 5.19.1. and Figure 5.19.2. show the estimated total landings for the years 1985-91, the official landing figures for 1992-98, and a breakdown of the landings by gear type (trawl and creel). Total Portuguese landings from FU 27 have decreased since 1989, to a level of merely 6-8 t in 1997-98.

Fishing effort and CPUE (there are no discards in this fishery) for the trawl fishery are available for the period 1985-91, and are based on data obtained from log-books and ship-owner associations. CPUEs have been fluctuating with a suggestion of an upward trend (Figure 5.19.2.), but the data series is too short to draw definite conclusions.

Mean size - Spanish data - Mostly FU 26

The mean sizes of both males and females in the landings have fluctuated without obvious trend until 1988, then dropped to very low values in 1990 (Figure 5.19.1.). Subsequently, they increased again, and between 1991 and 1996 they remained reasonably stable. In last two years, the mean size shows a slight increase for both males and females.

Mean size - Portuguese data - FU 27

Mean size data for males and females, derived from port samples and from demersal research surveys, are available for 1985-98 (Table 5.19.6.; Figure 5.19.2.). Bearing in mind however, that these mean sizes are based on very small numbers of measurements, and that the research surveys were carried out with a different codend mesh size than the one used in the commercial fishery, it is not possible to draw definite conclusions from these data. Overall however, it looks as if the mean sizes have fluctuated without trend.

It is also worth noticing that the mean sizes in the landings are generally higher in the northern (FU 27) than in the southernmost areas of Portugal (FUs 28 and 29) (also see Table 5.19.11. and Figure 5.19.3.).

Data and biological inputs for analytical assessments

Table 5.19.7. Sampling data and input parameters

Landings length compositions for FU 26, additional to the existing time series, were available for 1997-98. Biological input parameters unchanged to those used in the previous assessments (ICES, 1997a).

Length compositions of the landings from FU 27 for the period 1985-98 were estimated from samples collected from one Portuguese harbour, viz. Matosinhos. In 1997 and 1998, only 8 and 3 samples were collected. There are no stock-specific biological parameters available for this FU.

General comments on quality of data and inputs

The quality of the Spanish landings and effort statistics collected in 1997-98 is believed to be similar to that in previous years. Part of the fleet (viz. the vessels based in Marín and Vigo) fishes on grounds located off North Portugal, in FU 27. These catches are landed in Spain but length compositions are not differentiated by FU. The length compositions of the Portuguese landings are based on a very small number of samples, which did not cover all months.

Length based assessments (LCA)

Taking into account (a) the characteristics of the fisheries in these two FUs, which are not specifically targeting *Nephrops*, and (b) that no new input parameters were available for either of these FUs, the WG concluded that there was no need for repeating the assessment performed in 1997, and that the management considerations formulated in the 1997 WG Report (ICES, 1997a) could be re-iterated.

Management considerations

Bearing in mind the multi-specific nature of the fisheries in the area, it can be expected that the level of exploitation and the pattern of the finfish fisheries will continue to define the exploitation level on *Nephrops*.

5.19.2. South-West and South Portugal (FUs 28-29)

Description of the fisheries

Portugal

The Portuguese fleet fishing for *Nephrops* in FUs 28 and 29 comprises two components, viz. trawlers targeting demersal fish, and trawlers targeting crustaceans. The demersal fish fleet operates year-round along the entire coast of Portugal. Data on the average fish catch composition of this fleet show that in recent years horse mackerel and hake were the most valuable species, with 39 % and 3 % of the total catch in weight. *Nephrops* is an important by-catch species to this fleet.

The crustacean trawler fleet fishes mainly off the south-west (FU 28) and south coast (FU 29) of Portugal, in deep waters (200-750 m). The fishery started in 1983 with 35 vessels, but since 1996, the number of trawlers has dropped to 25. The crustacean trawlers are smaller than the demersal trawlers, part of them being former sardine purse seiners converted into trawlers. The vessels range from 20-35 m in size, and from 350-700 hp in engine power. They are not specifically targeting *Nephrops*, but licensed for the crustacean fishery in general. The gear used is a shrimp trawl with a codend mesh size of 55 mm. Until fairly recently, the most important species in this fishery was *Nephrops*, but in the last three years it has been the shrimp *Parapenaeus longirostris* that has ranked first in terms of weight landed.

The main fishing ports are Portimão, Olhão and Vila Real de St António. For many years now, the average fishing regime of the Portuguese crustacean fleet has consisted of around 17 days at sea per month, one fishing day per trip, and 3 hauls of 3-4 hours each per day. The catches are sorted in three size categories and are landed on ice. There are a few freezer trawlers that make longer trips, coming to port just to land their catches.

Trends in landings, effort, CPUE and mean size

Table	5.19.8.	Landings by country, 1989-98
Table	5.19.9.	Effort and CPUEs Portuguese fleet, 1989-98
Table	5.19.11.	Mean sizes of *Nephrops* in landings and surveys, Portuguese data, 1989-98
Figure	5.19.3.	Long-term trends in landings, effort, CPUE and mean size, Portuguese data
Figure	5.19.4.	Landings by sex + Halfyearly plots of effort and CPUEs by sex, 1989-98

Landings, effort and CPUE

In 1989-92, the estimated landings from FUs 28 and 29 have fluctuated around an average of about 480 t per year (Figure 5.19.3.). Since then, the landings have fallen, and in 1996-98 the annual average was only 143 t. Males predominated the landings composition in the years 1989-93, but since 1996 the sex-ratio has been close to 1:1 (Figure 5.19.4.).

Estimated total fishing effort, calculated from the logbooks provided by the crustacean fleet, has fluctuated since 1988 without obvious long-term trend (Figure 5.19.3.).

The CPUEs show a declining trend throughout the 10-years period of 1989-98 (Figure 5.19.3.). This seems to be mostly the result of a decrease in male CPUE (Figure 5.19.4.), as catches are mainly composed of males. The CPUEs for females were more or less stable, with a peak in 1995. The highest CPUEs normally occur during the first half of the year (Figure 5.19.4.).

Mean size

Mean length data for males and females in landings and in research survey catches are available for 1984-98. The mean size of both male and female *Nephrops* in the landings has remained fairly stable (Figure 5.19.4.). The fluctuations in the mean sizes for both males and females in the survey samples, particularly in the last years, may be due to differences in the codend mesh sizes used.

Data and biological inputs for analytical assessments

Table 5.19.12. Sampling data and input parameters

Length distributions of the Portuguese trawl landings are obtained from sampling once or twice a month at the homeports of the fleets. The sampling data are raised to the total landings by market category, vessel and month. It was assumed that there are no discards. Effort data were estimated from logbooks provided by the crustacean fleet.

Input parameters to the assessments were the same as those used in previous years. For the females, two growth curves were used, with the transition length set at 30 mm CL.

General comments on quality of data and inputs

In 1995-98, only one harbour was sampled for *Nephrops* and the sampling frequency was lower than in 1993-94. The low sampling frequency and the relatively small size of the samples may be a source of error and may have artificially increased the level of variation in the estimated length compositions of the landings.

It was assumed that this fishery has no discards. Sampling on board the crustacean vessels should provide an estimate of the discards to be included in future assessments. The quality of the logbook data must be improved in order to produce a more reliable estimate of effort.

Length based assessments (LCA)

Table 5.19.13. Output table LCA males, with mean F
Table 5.19.14. Output table LCA females, with mean F
Figure 5.19.5. Changes in Y/R and B/R upon changes in F, for males and females separately

An LCA assessment was carried out for males and females separately over the reference period 1996-98, during which the stock was considered to be in a steady state.

The long-term Y/R curves for males and females are both flat-topped (Figure 5.19.5.), with current F at F_{max} for males, but below F_{max} for females, which is in line with the results of the previous assessments (see e.g. ICES, 1997a).

Mean F, calculated across the inter-quartile length range, was 0.49 for males and 0.23 for females. These values are lower than the ones obtained from the 1993-96 LCA assessment performed in 1997 (viz. 0.97 for males and 0.45 for females) (ICES, 1997a). This can be explained by a slight decrease in the average effort in the two periods and by the differences in the length composition of the catches (see above).

No new mesh assessments were made. The recommendation derived from the 1997 assessment (ICES, 1997a), viz. to increase the mesh size to 70 or 80 mm, is still valid.

Age based assessments (VPA)

A VPA analysis was carried out on both males and females, using the Portuguese data for 1984-98.

Males

Table 5.19.15. Output XSA males: Fs-at-age
Table 5.19.17. Output XSA males: Long-term trends in landings, Fbar, TSB and recruitment
Figure 5.19.6. Output XSA males: Log catchability residuals
Figure 5.19.8. Output XSA males: Long-term trends in landings, Fbar, TSB and recruitment
Figure 5.19.10. Output XSA males: Plots of Fbar vs. effort

The slicing procedure generated 9 nominal 'age' groups (the last one being a plus-group). After checking for trends in catchability, with the Laurec-Shepherd tuning method, XSA was adopted for the final analysis. Crustacean directed effort data were used for tuning.

Initial trial runs showed that the catchability of the first age group should be considered dependent on stock size. Different shrinkage weights (0.3, 0.5 and 0.8) for mean F were tried, and a value of 0.3 was adopted for the final analysis. Log catchability residuals are generally small, and whilst there are some year effects there are no overall trends over time (Figure 5.19.6.).

Stock biomass and recruitment have sharply decreased since 1991 and 1992 respectively, stabilising at a very low level in the period 1996-98 (Figure 5.19.8.). Conversely, F_{bar} (average 0.66) decreased from 1992 to 1997, then increased again in 1998. F_{bar} shows a very poor correlation with effort (r = 0.40) (Figure 5.19.10.).

Females

Table	5.19.16.	Output XSA females: Fs-at-age
Table	5.19.18.	Output XSA females: Long-term trends in landings, Fbar, TSB and recruitment
Figure	5.19.7.	Output XSA females: Log catchability residuals
Figure	5.19.9.	Output XSA females: Long-term trends in landings, Fbar, TSB and recruitment
Figure	5.19.10.	Output XSA females: Plots of Fbar vs. effort

The slicing procedure generated 11 nominal 'age' groups (the last one being a plus-group). Tuning was carried out along the same lines as for males, with XSA adopted for the final analysis. The crustacean directed effort data were used for tuning. As for males, a shrinkage weight of 0.3 was adopted for the final analysis, and catchability was assumed to depend on stock size for the first age group.

Log catchability residuals are generally small, and whilst there are some year effects, there are no overall trends over time (Figure 5.19.7.).

Stock biomass and recruitment have decreased between 1992 and 1995. Since then, they have stabilised at a low level (Figure 5.19.9.). F_{bar} values have been fairly stable, fluctuating around an average of 0.29, with the exception of 1995. F_{bar} shows a very poor correspondence with effort ($r < 0.01$) (Figure 5.19.10.).

Fishery independent methods -Trawl surveys

Table	5.19.10.	CPUEs in demersal trawl surveys, Portuguese data, 1990-98

Several crustacean directed trawl surveys were carried out in FUs 28 and 29 between May and August of the years 1990-98. Table 5.19.10. shows the average *Nephrops* CPUEs (in kg/hour trawling), which can be used as an overall index of abundance. The figures confirm the declining trend in stock biomass.

Comments on quality of the assessments

As already stated in previous WG Reports (see e.g. ICES, 1997a), the growth parameters and the value of M are the main sources of uncertainty in the assessment. Other sources of uncertainty are related to the unreported landings and the estimation of the discards.

Management considerations

The results from both the LCA and the VPA point to the same conclusions and confirm the concerns expressed in the previous WG Report (ICES, 1997a). Stock biomass and recruitment continue to be at a very low level, and fishing pressure is very high, affecting mostly the male component of the stock. Therefore, the WG recommends a significant reduction in overall fishing pressure on FUs 28 and 29. As already suggested in the 1997 WG Report (ICES, 1997a), different types of management action could contribute for the recovery of the stock: a substantial decrease in fishing effort, an mesh size increase, or the establishment of an extensive closed area.

5.19.3. Gulf of Cádiz (Functional Unit 30)

Trends in landings, effort, CPUE/LPUE and mean sizes

Table 5.19.8. Landings by country, 1989-98

Only landings data are available for this FU. After having fluctuated between 139 t and 302 t in 1987-91, the landings decreased to 49 t in 1996, the lowest value in the time series. No landings data were available for 1997, but in 1998 the landings increased again to 89 t.

Data and biological inputs for analytical assessments

Stock-specific biological data or length compositions are not available for this FU, and no assessments were carried out.

Management considerations

Due to lack of information, no specific advice could be given for this FU.

5.19.4. Summary for Management Area Q

Table 5.19.19. Landings by FU and from Other rectangles, 1989-98
Table 5.19.20. Landings by country, 1989-98

This MA includes five FUs. Two of them (FUs 28-29) urgently require management action since the current management approach is not preventing a fall in biomass and recruitment. Alternative measures are required in order to reduce fishing pressure and to enable the recovery of the stocks.

The WG recommends that fishing mortality and therefore the TAC for MA Q be reduced to a level of 500 t. However, it should be noticed that a single TAC, set for the entire area, will not result in a sufficient reduction in fishing mortality in the critical FUs 28 and 29.

Table 5.19.1. - West Galicia (FU 26) and North Portugal (FU 27): Landings (tonnes) by country, 1989-98.

Year	FU 26	FU 27			FUs 26-27 combined
	Spain	Spain	Portugal		All countries
		Trawl	Trawl	Creel	all gears
1989	620 **	na	66	22	708
1990	401 **	na	31	17	449
1991	549 **	na	40	14	603
1992	584 **	na	37	15	636
1993	472 **	na	36	14	522
1994	426 **	na	14	8	448
1995	501 **	na	9	1	511
1996	264	50	17	0	331
1997	359	68	6	0	433
1998 *	295	42	8	0	345

* provisional na = not available

** including landings from North Portugal (FU 27)

Table 5.19.2. - West Galicia (FU 26): CPUE (kg/trip) for Spanish trawlers, home ports of Muros, Riveira, Marin and Vigo, 1989-98.

Year	CPUE (kg/trip)			
	Muros	Riveira	Marin	Vigo
1989	16.4	27.4	na	na
1990	14.5	20.6	103.3	na
1991	26.4	29.6	117.5	na
1992	28.9	26.5	113.0	na
1993	17.3	22.4	105.4	na
1994	17.8	21.5	113.9	na
1995	17.2	22.0	93.3	15.6
1996	17.5	17.6	49.5	51.6
1997	19.7	15.2	66.3	80.6
1998 *	16.3	8.2	66.0	84.2

* provisional na = not available

Table 5.19.3. - West Galicia (FU 26): Mean sizes (mm CL) of male and female *Nephrops* in Spanish landings, 1989-98.

Year	Landings	
	Males	Females
1989	29.9	28.5
1990	26.0	24.8
1991	31.7	30.4
1992	36.4	33.3
1993	32.4	33.3
1994	36.0	34.4
1995	33.4	32.2
1996	32.1	31.4
1997	36.7	35.6
1998 *	38.4	37.8
* provisional na = not available		

Table 5.19.4. - West Galicia (FU 26): Mean stratified catches (MSC) and standard errors (SE) of *Nephrops* in bottom trawl surveys off West Galicia, 1989-98.

Year	Kg / 30 min haul		Nos. / 30 min haul	
	MSC	SE	MSC	SE
1989	0.43	0.12	20.0	5.2
1990	0.55	0.21	20.8	7.4
1991	0.67	0.33	25.4	12.3
1992	0.38	0.16	15.2	5.9
1993	0.12	0.10	4.8	3.9
1994	0.06	0.02	1.5	0.6
1995	0.28	0.16	10.5	6.6
1996	0.08	0.05	4.2	2.5
1997	0.05	0.02	1.1	0.3
1998 *	0.13	0.09	1.8	1.2
* provisional na = not available				

Table 5.19.5. - North Portugal (FU 27): Effort (estimated hours trawling) and CPUE (tonnes/boat and kg/hour) of Portuguese trawlers, 1989-98.

Year	No. of trawlers	CPUE t/boat	Estimated hours	CPUE kg/hour
1989	7	9.4	9400	7.0
1990	9	3.5	8970	3.5
1991	8	5.0	7499	5.3
1992	8	4.6	na	na
1993	5	7.2	na	na
1994	3	4.7	na	na
1995	4	2.7	na	na
1996	5	4.8	na	na
1997	4	na	na	na
1998 *	4	na	na	na

* provisional na = not available

Table 5.19.6. - North Portugal (FU 27): Mean sizes (mm CL) of male and female *Nephrops* in Portuguese landings and research trawl surveys, 1989-98.

Year	Landings		Research surveys	
	Males	Females	Males	Females
1989	40.8	40.7	No survey	
1990	39.6	39.1	42.2	40.0
1991	34.4	34.2	38.7	33.2
1992	35.0	35.4	40.9	35.6
1993	37.9	38.0	39.0	37.8
1994	35.1	32.9	No survey	
1995	40.3	40.5	No survey	
1996	38.3	38.7	No survey	
1997	37.1	34.6	No survey	
1998 *	40.3	38.6	No survey	

* provisional na = not available

Table 5.19.7. - West Galicia and North Portugal (FUs 26-27): Input data and parameters.

FU	26	MA	Q
FLEET	Spain	GEAR	Trawl

	1998					1997				
	Number of samples				Mean no. per sample	Number of samples				Mean no. per sample
	Qtr 1	Qtr 2	Qtr 3	Qtr 4		Qtr 1	Qtr 2	Qtr 3	Qtr 4	
Catch	0	0	0	0		0	0	0	0	
Landings	17	18	18	11	155	16	18	17	10	189
Discards	0	0	0	0		0	0	0	0	

	Number of samples									
Year	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989
Catch	0	0	0	0	0	0	0	0	0	0
Landings	64	61	53	47	33	29	26	35	38	29
Discards	0	0	0	0	0	0	0	0	0	0

FU	27	MA	Q
FLEET	Portugal	GEAR	Trawl

	1998					1997				
	Number of samples				Mean no. per sample	Number of samples				Mean no. per sample
	Qtr 1	Qtr 2	Qtr 3	Qtr 4		Qtr 1	Qtr 2	Qtr 3	Qtr 4	
Catch	0	0	0	0		0	0	0	0	
Landings	1	0	2	0	132	2	5	6	0	108
Discards	0	0	0	0		0	0	0	0	

	Number of samples									
Year	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989
Catch	0	0	0	0	0	0	0	0	0	0
Landings	3	8	18	5	17	12	5	3	7	18
Discards	0	0	0	0	0	0	0	0	0	0

INPUT PARAMETERS		
Parameter	Value	Source
Discard Survival	—	not applicable - few discards
MALES		
Growth - K	0.150	based on Fernandez et al., 1986
Growth - L(inf)	85	Fernandez et al., 1986
Natural mortality - M	0.2	"
Length/weight - a	0.00043	Fariña, 1984
Length/weight - b	3.160	"
FEMALES		
Immature Growth		
Growth - K	0.150	based on Fernandez et al., 1986
Growth - L(inf)	85	Fernandez et al., 1986
Natural mortality - M	0.2	"
Size at maturity	26	Fariña, unpublished
Mature Growth		
Growth - K	0.100	ICES, 1991a
Growth - L(inf)	65	"
Natural mortality - M	0.2	"
Length/weight - a	0.00043	Fariña, 1984
Length/weight - b	3.160	"

Table 5.19.8. - South-West and South Portugal (FUs 28-29) and Gulf of Cadiz (FU 30): Landings (tonnes) by country, 1989-98.

Year	FUs 28-29					FU 30
	Portugal			Spain	Total	Spain
	Trawl	Creel	Total	Trawl	All gears	All gears
1989	463	6	469	0	469	174
1990	520	4	524	0	524	220
1991	473	5	478	0	478	226
1992	469	1	470	na	>470	243
1993	376	1	377	na	>377	160
1994	237	0	237	na	>237	107
1995	272	1	273	na	>273	132
1996	131	1	132	na	>132	49
1997	134	2	136	na	>136	na
1998 *	159	2	161	na	>161	89

* provisional na = not available

Table 5.19.9. - South-West and South Portugal (FUs 28-29): Effort (estimated days trawling) and CPUE (tonnes/boat and kg/day) of Portuguese trawlers, 1989-98.

Year	No. of trawlers	CPUE	Estimated effort	CPUE
		t/boat	'00 days	kg/day
1989	34	13.6	39.5	119
1990	37	9.8	57.8	90
1991	39	12.1	49.8	96
1992	39	12.1	60.3	78
1993	33	11.4	50.8	74
1994	31	10.3	42.3	56
1995	30	6.4	49.6	55
1996	25	5.3	34.7	38
1997	25	5.4	24.9	54
1998 *	25	6.3	46.6	34

* provisional na = not available

Table 5.19.10. - South-West and South Portugal (FUs 28-29): *Nephrops* CPUEs (kg/hour) in demersal trawl surveys, 1990-98.

Month and year of survey	CPUE
	kg/hour
August 90	2.9
August 91	4.0
June 92	5.3
August 92	4.7
May 94	2.3
August 94	2.3
June 97	1.7
June 98	1.3

Table 5.19.11. - South-West and South Portugal (FUs 28-29): Mean sizes (mm CL) of male and female *Nephrops* in Portuguese landings and research trawl surveys, 1989-98.

Year	Landings		Research surveys	
	Males	Females	Males	Females
1989	37.4	33.5	33.6	29.9
1990	37.5	33.6	34.1	39.4
1991	36.6	31.9	37.5	31.7
1992	36.6	33.0	37.8	33.6
1993	36.7	33.9	39.5	34.1
1994	37.2	33.5	42.5	35.7
1995	39.3	37.0	42.0	33.7
1996	36.9	36.6	37.5	23.7
1997	35.9	32.8	42.8	42.0
1998 *	36.8	34.5	39.5	36.7

* provisional na = not available

Table 5.19.12. - South-West and South Portugal (FUs 28-29): Input data and parameters.

FU	28 & 29	MA	Q
FLEET	Portugal	GEAR	Trawl

	1998					1997				
	Number of samples				Mean no. per sample	Number of samples				Mean no. per sample
	Qtr 1	Qtr 2	Qtr 3	Qtr 4		Qtr 1	Qtr 2	Qtr 3	Qtr 4	
Catch	0	0	0	0		0	0	0	0	
Landings	8	20	8	7	167	4	4	9	4	135
Discards	0	0	0	0		0	0	0	0	

	Number of samples									
Year	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989
Catch	0	0	0	0	0	0	0	0	0	0
Landings	43	21	39	30	108	60	38	23	31	38
Discards	0	0	0	0	0	0	0	0	0	0

INPUT PARAMETERS		
Parameter	Value	Source
Discard Survival	0	
MALES		
Growth - K	0.200	Portuguese data (Bhattacharya method) ; tagging (ICES, 1990a)
Growth - L(inf)	70	"
Natural mortality - M	0.3	Figueiredo, 1989
Length/weight - a	0.00028	Figueiredo (pers comm., 1986)
Length/weight - b	3.220	"
FEMALES		
Immature Growth		
Growth - K	0.200	Portuguese data (Bhattacharya method) ; tagging (ICES, 1990a)
Growth - L(inf)	70	"
Natural mortality - M	0.3	Figueiredo, 1989
Size at maturity	30	ICES, 1994a
Mature Growth		
Growth - K	0.065	Portuguese data (Bhattacharya method) ; tagging (ICES, 1990a)
Growth - L(inf)	65	"
Natural mortality - M	0.2	Figueiredo, 1989
Length/weight - a	0.00056	Figueiredo (pers comm., 1986)
Length/weight - b	3.030	"

Table 5.19.13. - South-West and South Portugal (FUs 28-29): LCA output males.

Reference period	1996-98		
Linf (mm CL)	70.0	K	0.200

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
22	5	0.3	0.213	0.001	0.005	0.305	4437	914	6208
24	26	0.3	0.222	0.007	0.029	0.329	4158	891	7916
26	113	0.3	0.233	0.031	0.133	0.433	3865	855	9732
28	130	0.3	0.244	0.039	0.162	0.462	3495	806	11550
30	241	0.3	0.257	0.084	0.327	0.627	3123	740	13136
32	326	0.3	0.270	0.137	0.506	0.806	2659	646	14027
34	371	0.3	0.286	0.200	0.698	0.998	2139	532	13957
36	295	0.3	0.303	0.213	0.704	1.004	1608	420	13190
38	137	0.3	0.323	0.129	0.400	0.700	1186	343	12741
40	139	0.3	0.345	0.168	0.487	0.787	946	286	12490
42	127	0.3	0.371	0.205	0.553	0.853	722	229	11671
44	72	0.3	0.400	0.157	0.392	0.692	526	184	10838
46	61	0.3	0.435	0.179	0.410	0.710	399	149	10119
48	28	0.3	0.477	0.108	0.226	0.526	293	123	9568
50	24	0.3	0.527	0.121	0.230	0.530	228	105	9237
52	26	0.3	0.589	0.177	0.300	0.600	172	86	8536
54	22	0.3	0.668	0.221	0.332	0.632	121	66	7416
56	14	0.3	0.771	0.227	0.294	0.594	79	49	6195
58	25	0.3			0.300	0.600	50	49	6195
					Totals, including lengths above + group			7473	194725

Mean F, calculated across inter-quartile range	0.486

Table 5.19.14. - South-West and South Portugal (FUs 28-29): LCA output females.

Reference period	1996-98		
Linf immatures (mm CL)	70.0	K immatures	0.200
Linf matures (mm CL)	65.0	K matures	0.650
Transition length (mm CL)	30.0		

Size (mm CL)	Removals ('000)	M	DT (years)	F*DT	F	Z	Nos. attaining aver. size ('000)	Average nos. in the sea ('000)	Average biomass (kg)
22	7	0.3	0.213	0.001	0.006	0.306	5753	1185	8873
24	35	0.3	0.222	0.007	0.030	0.330	5391	1155	11134
26	139	0.3	0.233	0.029	0.125	0.425	5010	1110	13501
28	224	0.3	0.244	0.053	0.216	0.516	4538	1040	15718
30	368	0.3	0.257	0.100	0.392	0.692	4002	940	17392
32	469	0.2	0.962	0.167	0.174	0.374	3351	2707	60511
34	410	0.2	1.026	0.216	0.211	0.411	2339	1958	52308
36	336	0.2	1.099	0.281	0.255	0.455	1535	1327	41958
38	133	0.2	1.184	0.175	0.148	0.348	930	903	33475
40	129	0.2	1.283	0.272	0.212	0.412	616	614	26493
42	93	0.2	1.400	0.347	0.248	0.448	363	378	18827
44	81	0.2	1.540	0.671	0.436	0.636	194	191	10898
46	32	0.2	1.711	0.723	0.422	0.622	73	77	5008
48	17	0.2			0.420	0.620	25	77	5008
					Totals, including lengths above + group			13662	321103

Mean F, calculated across inter-quartile range	0.232

Table 5.19.15. - South-West and South Portugal (FUs 28-29): VPA Fs-at-age males.

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.156	0.243	0.135	0.267	0.156	0.185	0.285	0.133	0.355	0.330	0.214	0.021	0.105	0.145	0.138
2	0.456	0.545	0.607	0.463	0.471	0.279	0.801	0.266	0.765	1.120	0.555	0.595	0.620	0.737	0.685
3	0.588	0.535	0.780	0.549	0.445	0.556	1.255	0.360	0.758	0.845	0.854	1.176	0.543	0.410	0.793
4	0.497	0.659	1.039	0.745	0.387	1.104	1.122	0.636	1.234	0.718	1.115	0.708	0.443	0.285	0.671
5	0.425	0.921	0.535	0.482	0.447	0.793	0.717	0.657	1.112	0.578	0.591	0.335	0.388	0.125	0.454
6	0.679	1.135	0.549	0.532	0.498	0.884	0.455	0.592	1.013	0.959	0.644	0.111	0.324	0.555	0.527
7	0.543	1.262	0.295	0.539	0.331	1.007	1.222	0.387	0.339	0.364	2.430	0.106	0.136	0.704	0.742
8	0.554	0.918	0.649	0.577	0.426	0.885	0.963	0.526	0.907	0.704	1.146	0.473	0.381	0.481	0.651
+ grp	0.554	0.918	0.649	0.577	0.426	0.885	0.963	0.526	0.907	0.704	1.146	0.473	0.381	0.481	0.651

Table 5.19.16. - South-West and South Portugal (FUs 28-29): VPA Fs-at-age females.

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.260	0.329	0.232	0.614	0.320	0.282	0.297	0.403	0.370	0.413	0.336	0.079	0.070	0.236	0.185
2	0.174	0.198	0.198	0.273	0.255	0.140	0.293	0.269	0.256	0.284	0.246	0.251	0.131	0.307	0.207
3	0.262	0.225	0.274	0.302	0.383	0.271	0.375	0.184	0.239	0.205	0.181	0.532	0.234	0.307	0.257
4	0.365	0.249	0.244	0.273	0.347	0.304	0.261	0.138	0.237	0.180	0.190	0.813	0.291	0.276	0.349
5	0.541	0.350	0.336	0.236	0.285	0.388	0.298	0.152	0.338	0.139	0.166	0.670	0.419	0.155	0.267
6	0.350	0.303	0.276	0.196	0.308	0.238	0.563	0.223	0.292	0.251	0.134	0.567	0.261	0.097	0.238
7	0.142	0.222	0.264	0.189	0.230	0.325	0.315	0.242	0.247	0.291	0.226	0.866	0.302	0.104	0.353
8	0.245	0.081	0.258	0.243	0.128	0.380	0.517	0.289	0.305	0.324	0.189	0.516	0.413	0.050	0.311
9	0.288	0.133	0.133	0.829	0.197	0.514	0.385	0.133	0.253	0.457	0.275	0.533	0.731	0.130	0.457
10	0.315	0.219	0.255	0.340	0.231	0.333	0.393	0.235	0.325	0.315	0.219	0.545	0.352	0.120	0.312
+ grp	0.315	0.219	0.255	0.340	0.231	0.333	0.393	0.235	0.325	0.315	0.219	0.545	0.352	0.120	0.312

Table 5.19.17. - South-West and South Portugal (FUs 28-29): VPA output males.

Year	Recruits Age 1	Total Biomass	TSB	Landings	Yield/SSB	Fbar 3-6
	'000	tonnes	tonnes	tonnes		
1984	16549	998	524	292	0.558	0.547
1985	15036	981	487	353	0.725	0.813
1986	15941	893	427	315	0.738	0.726
1987	20121	900	395	277	0.702	0.577
1988	16274	949	459	249	0.543	0.444
1989	15932	976	509	318	0.625	0.834
1990	11029	731	354	350	0.988	0.887
1991	10262	1402	744	344	0.463	0.561
1992	12065	692	323	305	0.946	1.029
1993	7960	522	241	232	0.963	0.775
1994	4601	355	176	139	0.789	0.801
1995	3040	278	147	98	0.666	0.582
1996	4034	237	125	64	0.511	0.425
1997	4416	264	134	73	0.546	0.343
1998	4456	258	121	87	0.719	0.611
Average 96-98						0.460

Table 5.19.18. - South-West and South Portugal (FUs 28-29): VPA output females.

Year	Recruits Age 1	Total Biomass	TSB	Landings	Yield/SSB	Fbar 3-8
	'000	tonnes	tonnes	tonnes		
1984	12913	786	460	169	0.368	0.318
1985	13336	781	453	156	0.345	0.238
1986	12192	771	459	150	0.326	0.275
1987	16257	867	496	232	0.468	0.240
1988	11708	741	438	171	0.391	0.280
1989	11993	705	426	151	0.355	0.318
1990	10582	689	398	174	0.437	0.388
1991	12250	675	397	134	0.337	0.205
1992	12829	725	423	165	0.390	0.276
1993	9712	675	409	145	0.355	0.232
1994	5321	557	384	97	0.253	0.181
1995	3640	490	320	174	0.544	0.661
1996	4798	350	222	67	0.302	0.320
1997	5339	351	209	62	0.297	0.165
1998	5211	355	215	72	0.335	0.296
Average 96-98						0.260

Table 5.19.19. - Management Area Q (IXa): Total *Nephrops* landings (tonnes) by Functional Unit plus other rectangles, 1989-98.

Year	FU 26	FU 27	FUs 28-29	FU 30	Other	Total
1989	620 **	88	469	174	0	***1351***
1990	401 **	48	524	220	0	***1193***
1991	549 **	54	478	226	0	***1307***
1992	584 **	52	> 470	243	0	***> 1349***
1993	472 **	50	> 377	160	0	***> 1059***
1994	426 **	22	> 237	107	0	***> 792***
1995	501 **	10	> 273	132	0	***> 916***
1996	264	67	> 132	49	0	***> 512***
1997	359	74	> 136	na	0	***> 570***
1998 *	295	50	> 161	89	0	***> 595***
* provisional na = not available						
** including landings from North Portugal (FU 27)						

Table 5.19.20. - Management Area Q (IXa): Total *Nephrops* landings (tonnes) by country, 1989-98.

Year	Portugal	Spain	Total
1989	557	794	***1351***
1990	572	621	***1193***
1991	533	774	***1307***
1992	522	> 827	***> 1349***
1993	427	> 632	***> 1059***
1994	259	> 533	***> 792***
1995	283	> 633	***> 916***
1996	149	> 363	***> 512***
1997	143	> 427	***> 570***
1998 *	169	> 426	***> 595***
* provisional na = not available			

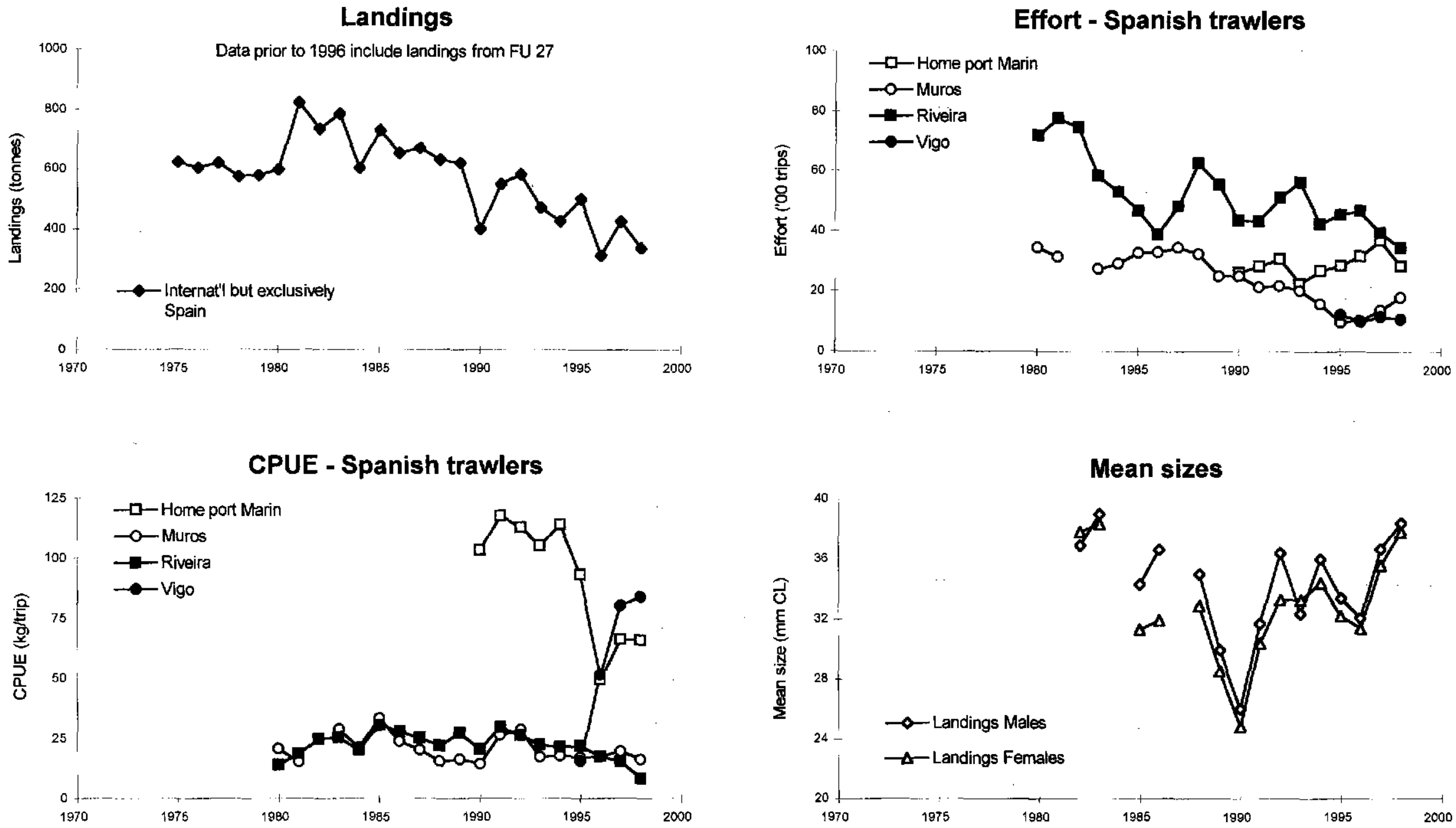


Figure 5.19.1. - West Galicia (FU 26): Long-term trends in landings, effort, CPUEs and mean sizes of *Nephrops* in landings.

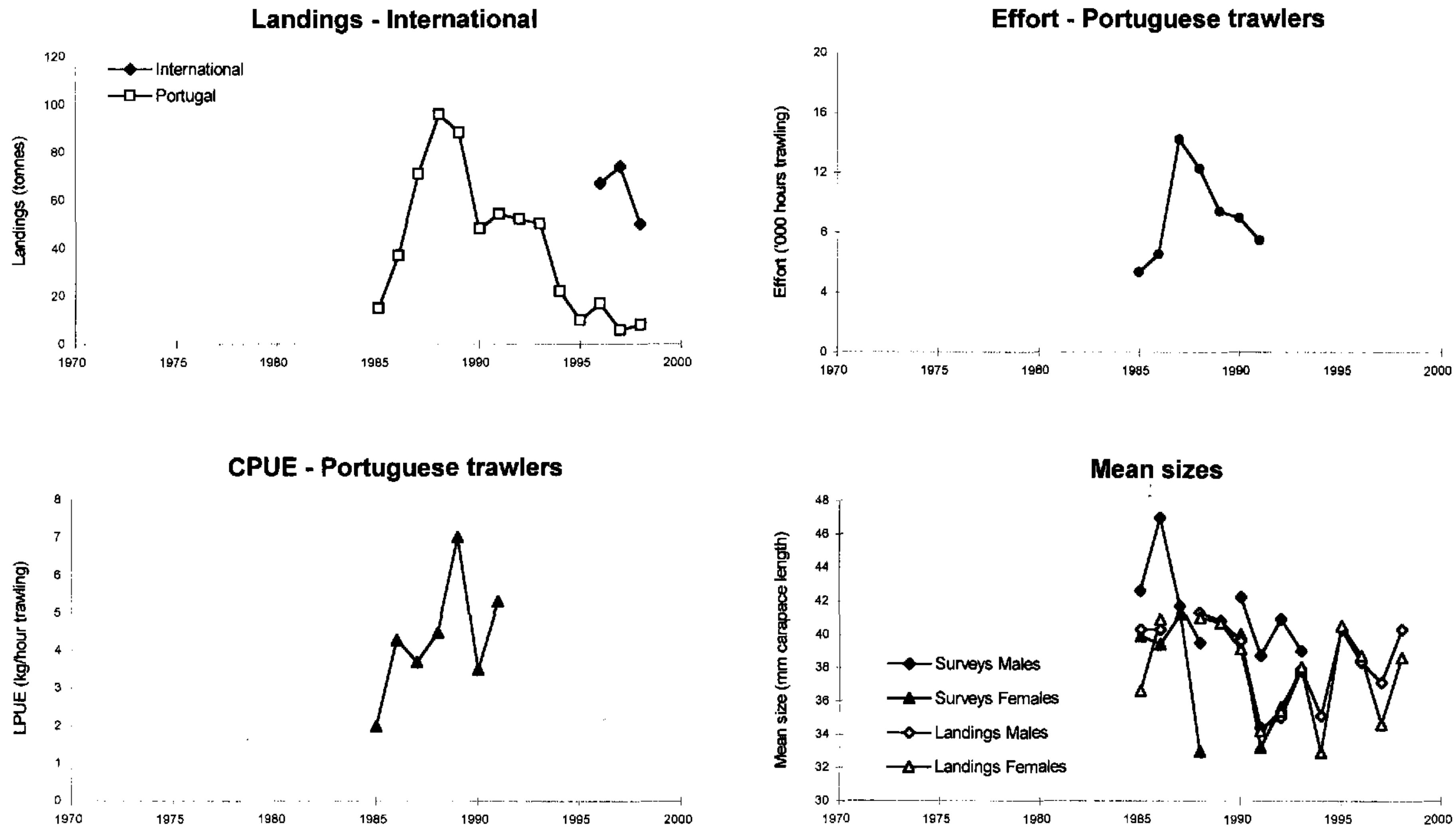


Figure 5.19.2. - North Portugal (FU 27): Long-term trends in landings, effort, CPUEs and mean sizes of *Nephrops* in surveys and landings.

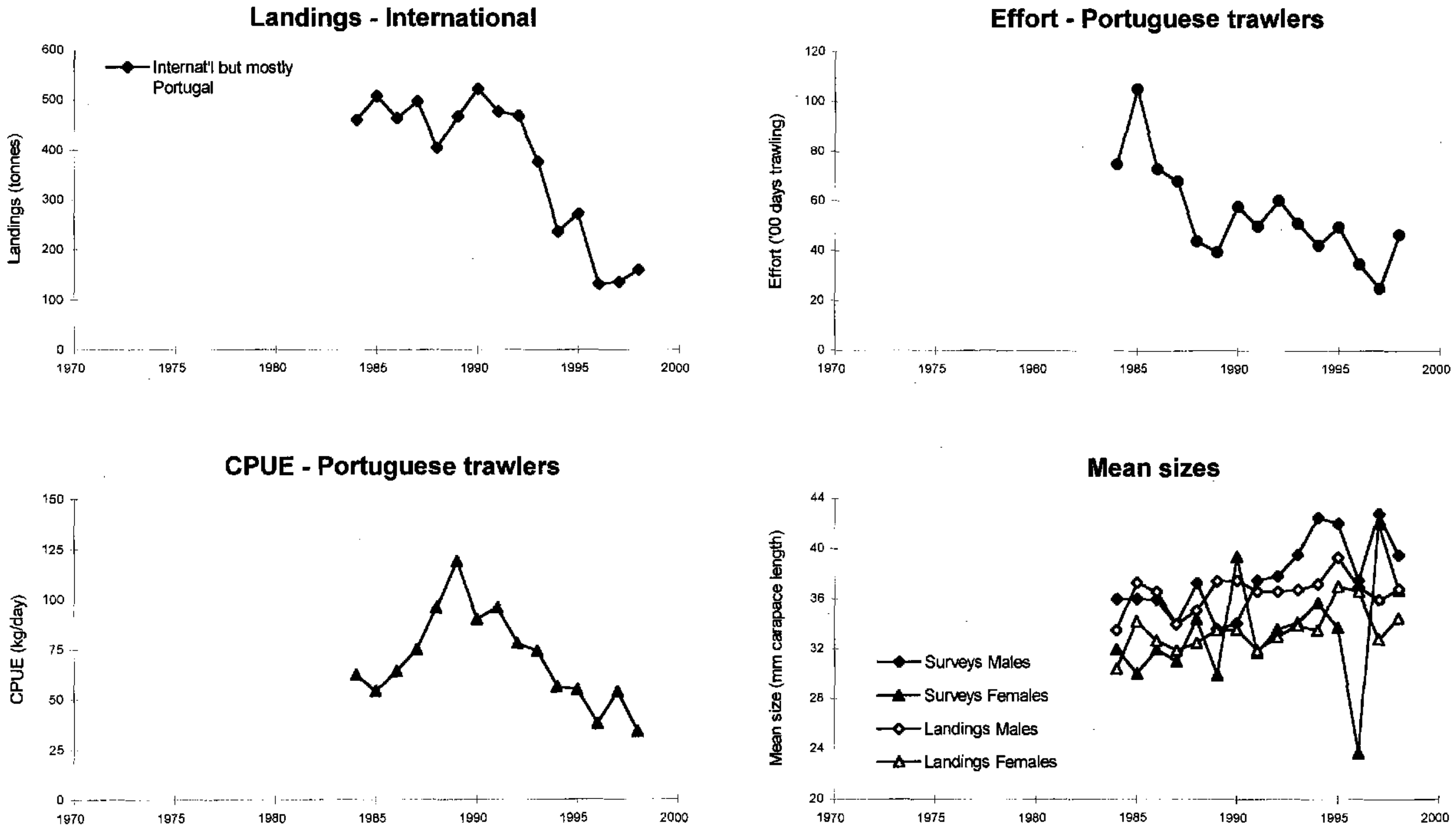


Figure 5.19.3. - SW and S Portugal (FUs 28-29): Long-term trends in landings, effort, CPUEs and mean sizes of *Nephrops* in surveys and landings.

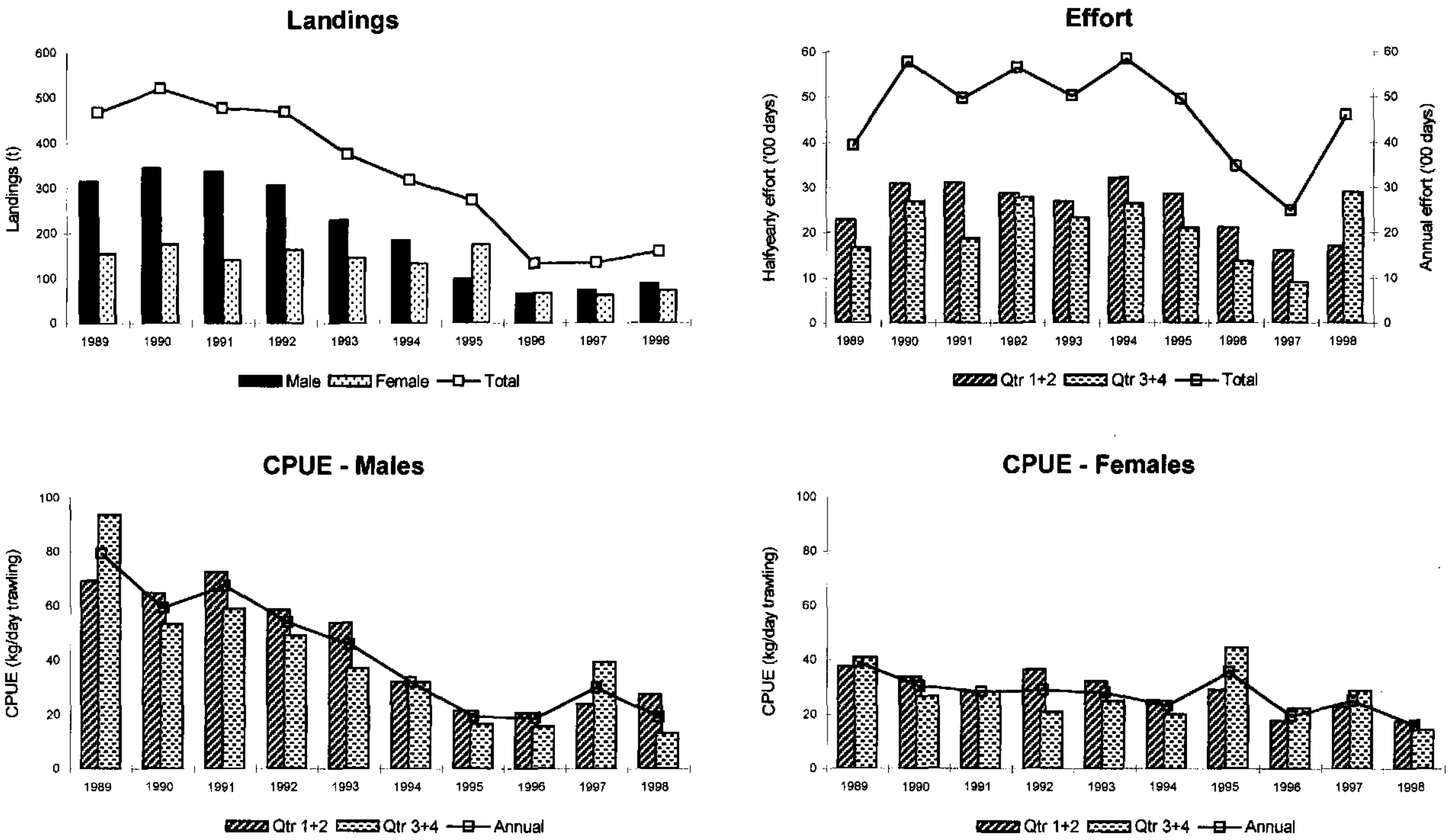


Figure 5.19.4. - SW and S Portugal (FUs 28-29): Landings, effort and CPUEs by quarter and sex from Portuguese *Nephrops* trawlers.

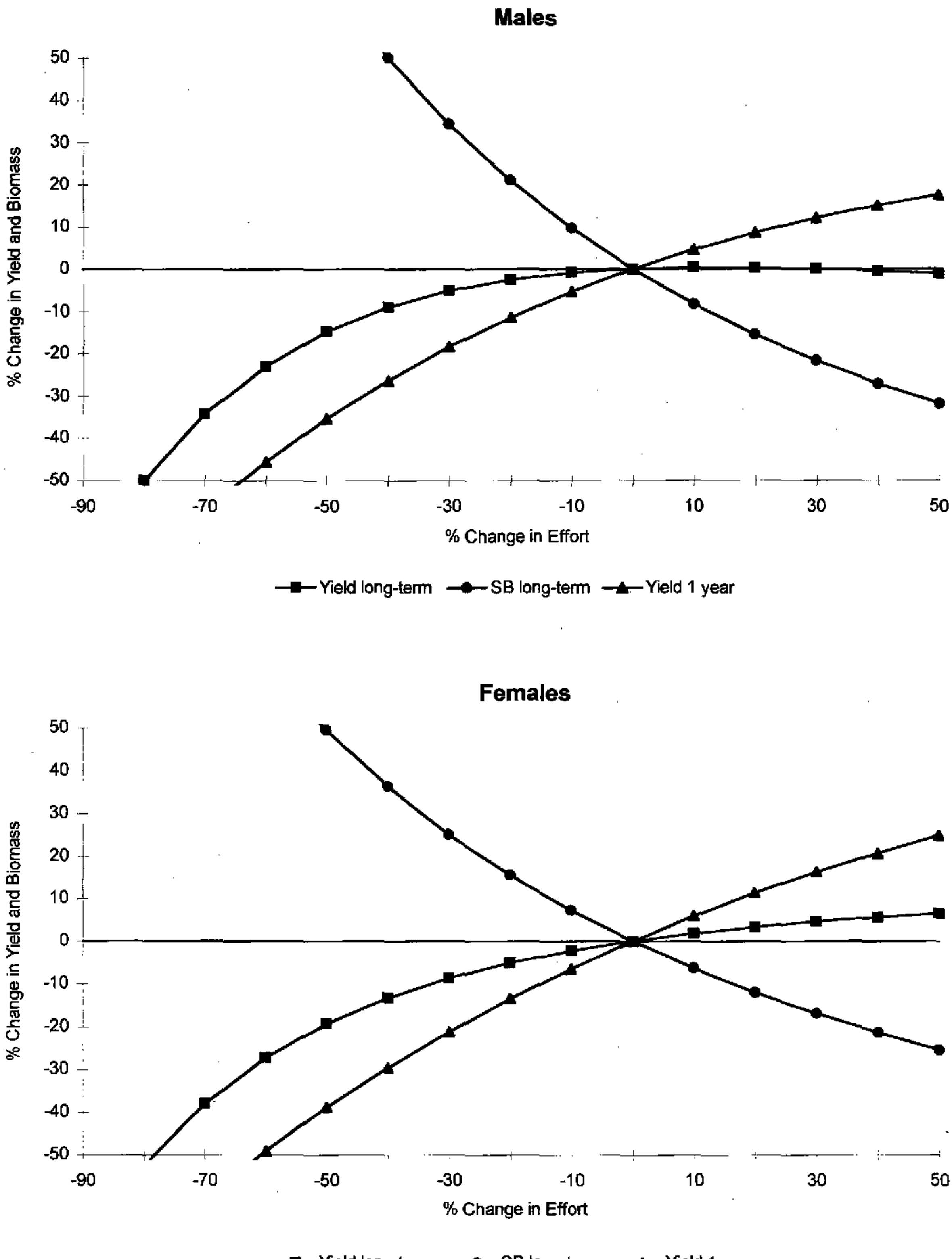
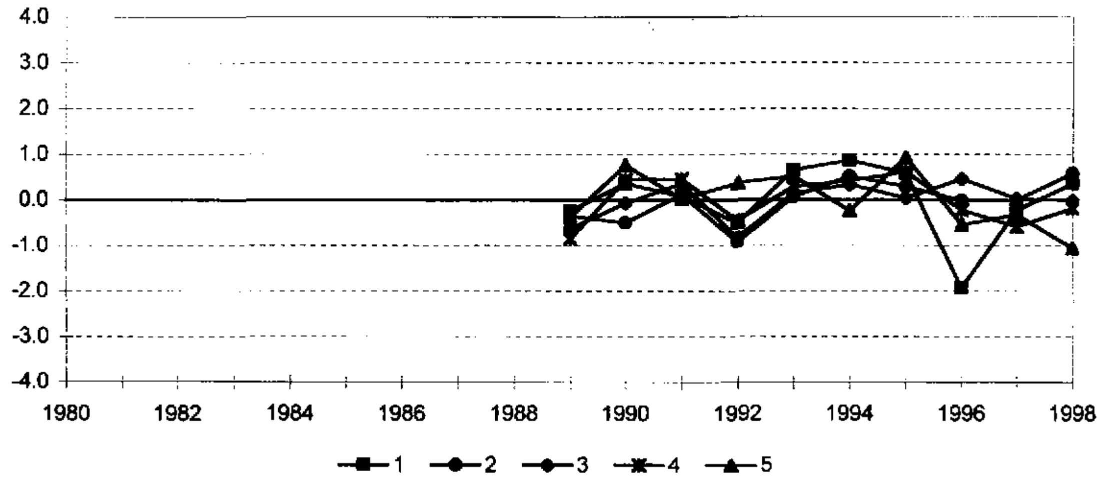


Figure 5.19.5. - SW and S Portugal (FUs 28-29): Output LCA: Relative changes in short-term yield (ie after 1 year), long-term yield and long-term biomass upon relative changes in effort. Males and females shown separately.



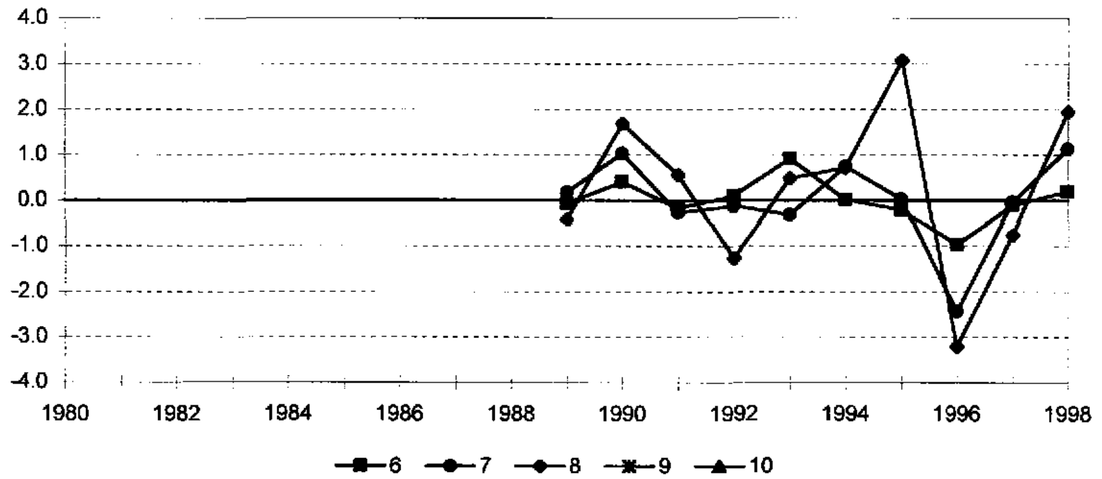
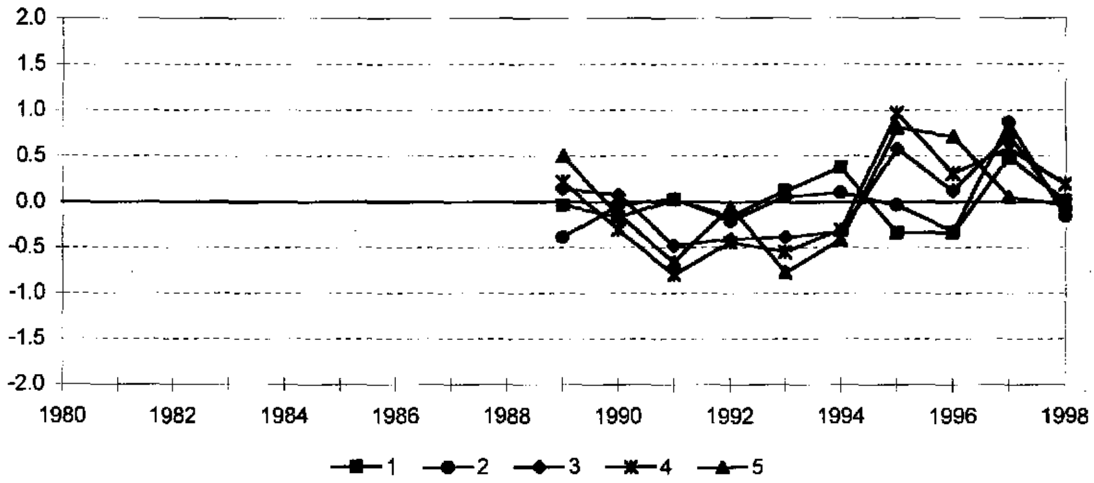


Figure 5.19.6. - SW and S Portugal (FUs 28-29): Output VPA males: Log catchability residuals.



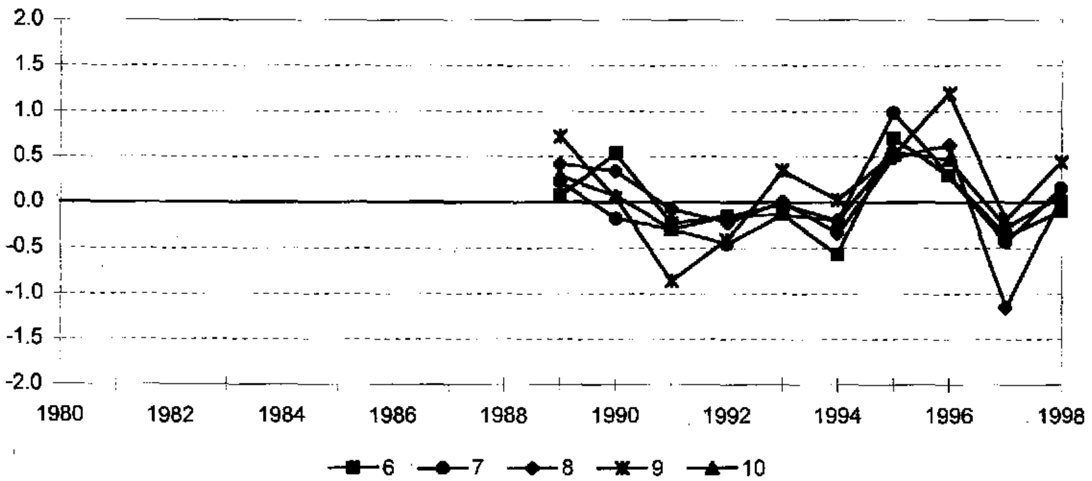


Figure 5.19.7. - SW and S Portugal (FUs 28-29): Output VPA females: Log catchability residuals.

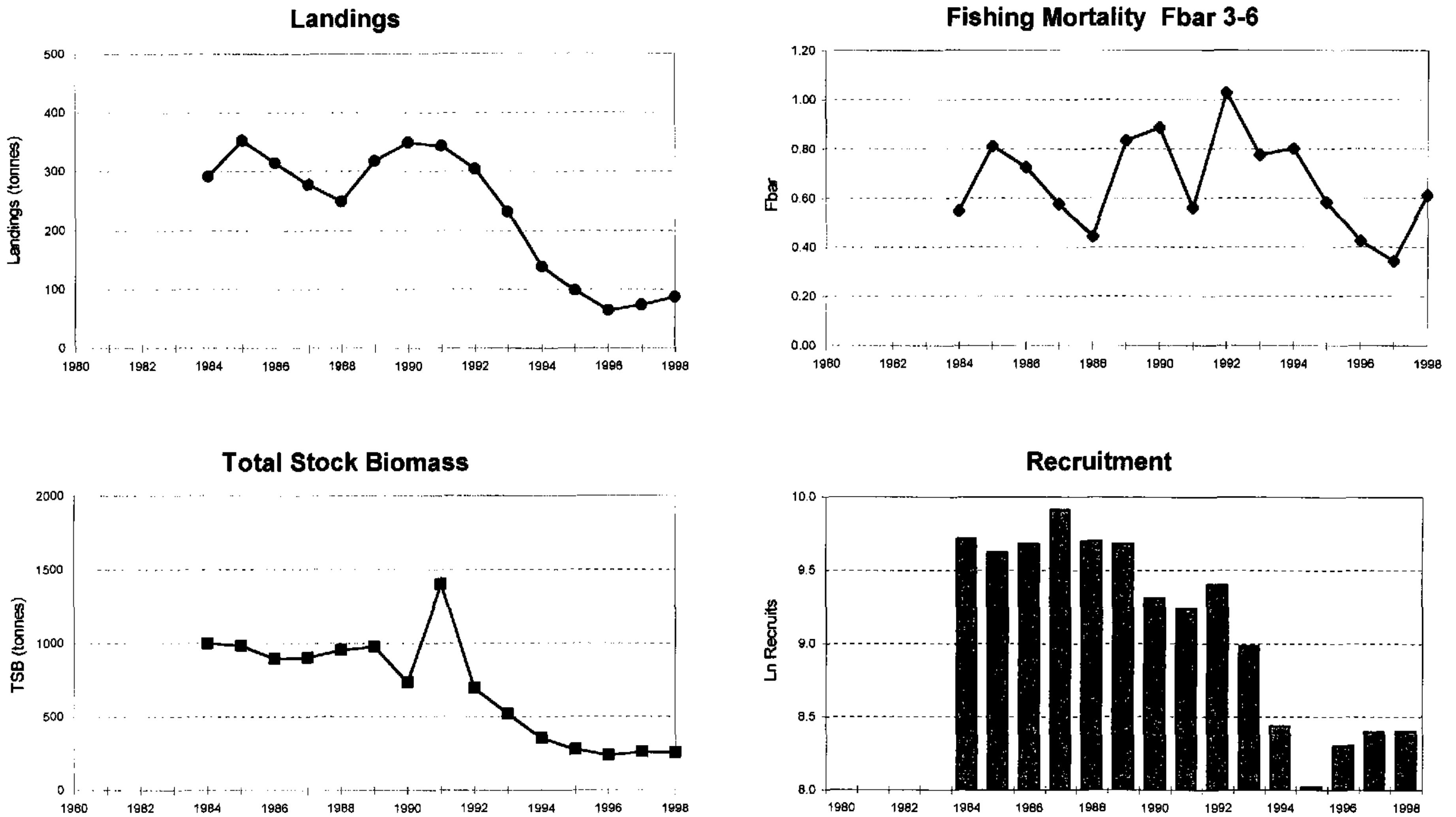


Figure 5.19.8. - SW and S Portugal (FUs 28-29): Output VPA males: Trends in Landings, Fbar, TSB and Recruitment.

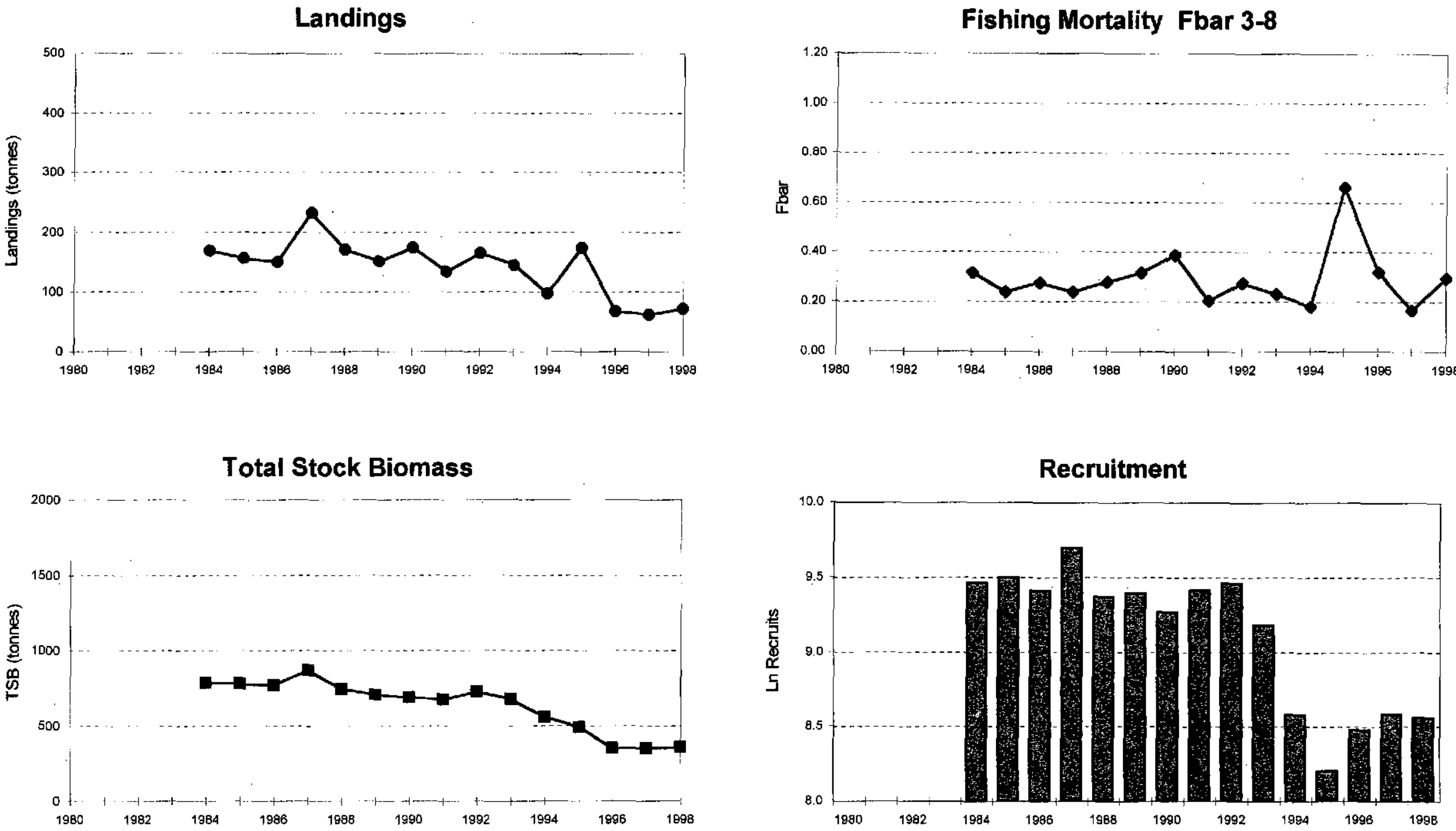


Figure 5.19.9. - SW and S Portugal (FUs 28-29): Output VPA females: Trends in Landings, Fbar, TSB and Recruitment.

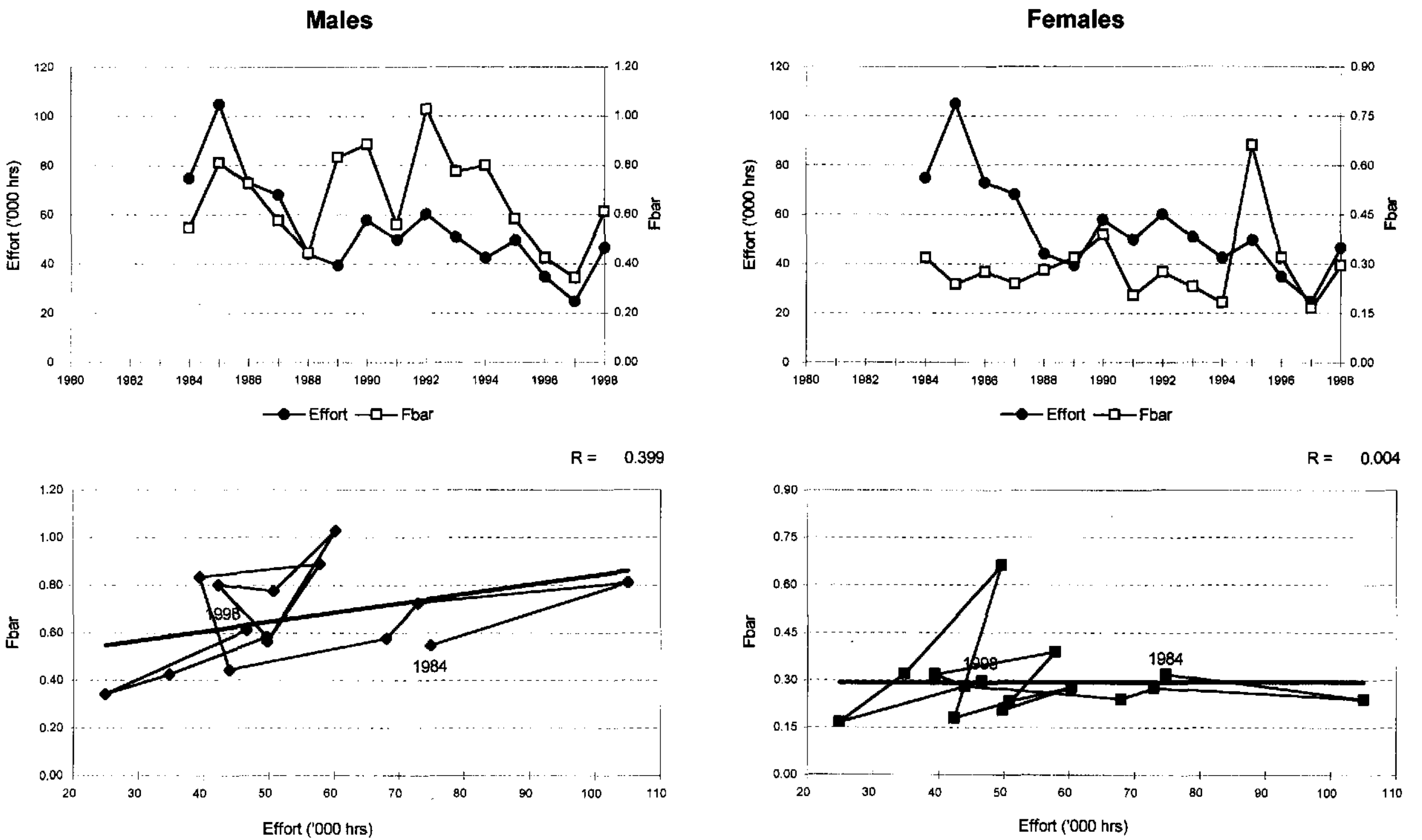


Figure 5.19.10. - SW and S Portugal (FUs 28-29): Effort and Fbar, and relationship between them, for males and females.

5.20. Management Area R

ICES description **IXb and X**

Functional Units **none**

The statistical rectangles comprised in this Management Area are shown in Figure 5.1.3.

5.20.1. Summary for Management Area P

Zero TAC to prevent mis-reporting.

6. Correspondence between state of exploitation indices and outcome of analytical assessments

The range of types of data available for the assessment of *Nephrops* stocks varies considerably. For some stocks, sufficient data are available to reliably run age based assessments, while others only have enough to run LCA confidently, and for some there is insufficient data to run any analytical assessments. Previously, it has been very difficult to provide advice for some stocks where no assessment is carried out. By examining the correspondence between certain indices and the outcome of analytical assessments for those stocks where they performed well, it may be possible to identify useful measures of the states of stocks for which no assessments can be carried out. Given the short time available at the WG, it was felt appropriate to examine a few indices for a limited number of stocks, with a view to examining the topic further within the *Nephrops* Study Group.

Methodology

Biomass, F_{bar} and recruitment data for the male stocks from the Farn Deeps (FU 6), Firth of Forth (FU 8), Moray Firth (FU 9), North Minch (FU 11) and Firth of Clyde (FU 13) were collated from the XSA assessments included in this Report. Only male stocks were examined in this preliminary analysis, since analytical assessments are generally considered to perform better for this sex in *Nephrops* (ICES, 1997a). Trends in these data were compared to CPUE and mean size data (above and below 35 mm CL, the size limit above which discarding becomes unimportant) and TV survey abundance estimates. The general state of exploitation of the stock was also estimated from the ratio of F_{bar} to F_{max} from the LCA.

Results

Example plots of the trends for two of the stocks (Firth of Clyde and Moray Firth) are shown in Figures 6.1. and 6.2.

In the Firth of Clyde (Figure 6.1.), the CPUEs for *Nephrops* < 35 mm CL have shown a considerable increase since the early 1990s, while the CPUEs of larger individuals have remained stable. Years in which the CPUE of the small individuals peaked (1995 and 1998) coincide with years in which the mean size of this group of individuals is low, suggesting they may indicate influxes of large numbers of small individuals (recruits) to the fishery. Burrow abundance from TV surveys has increased by a similar order of magnitude to that of the < 35 mm CL CPUE data (only 1995-98 data are available), confirming the increase in abundance, and suggesting that TV estimates may be heavily influenced by recruiting age classes. XSA estimates of biomass and recruitment also increased, but this is to be expected since they are not independent of the CPUE data.

For the Moray Firth (Figure 6.2.), the CPUEs for individuals < 35 mm CL increased sharply in 1995, but have decreased since then. As with the Clyde data, the increase in CPUE coincided with a drop in mean size, suggesting a large influx of recruits. The CPUEs for larger individuals remained stable, but the TV abundance estimates appear to have declined since the mid 1990s, suggesting that the change in abundance of individuals may be due to a reduction in the numbers of smaller animals. Unfortunately, no survey was carried out in 1995 which, from the CPUE data, appears to have been a very good year for recruitment.

Output F values are compared with the trends in CPUE, TV abundance and biomass in the text table below. While F_{bar} values from XSA and LCA are in general agreement, the degree of growth overfishing (F_{bar}/F_{max}) bears little relationship with the trends in recruitment and biomass. The most heavily exploited stocks (Firth of Forth and Firth of Clyde) are showing stable or increasing biomass and CPUE of smaller individuals, while the least exploited (Moray Firth) is showing declines.

Stock	F_{bar} (*)	F_{bar} (**)	F_{bar}/F_{max} (**)	Trends (last 5 years)		
				CPUE < 35 mm	TV	Biomass
Farn Deeps	0.52	0.55	1.61	stable	down	stable
Firth of Forth	0.89	0.82	2.27	stable	down	stable
Moray Firth	0.56	0.53	1.17	down	down	down
North Minch	0.68	0.62	1.54	down	fluctuating	down
South Minch	0.61	0.51	1.23	stable	fluctuating	down
Firth of Clyde	0.79	0.66	1.82	up	up	up

(*) from XSA (1998)
(**) from LCA of length distribution averaged over 3 to 5 years.

Conclusions

While CPUE data for larger individuals appear stable for the two stocks examined in detail, the data for the individuals < 35 mm CL appears quite variable, and given the concomitant changes in mean size, may reflect recruitment fluctuation. This preliminary analysis has only looked at animals above and below 35 mm CL, but future work could also examine narrower size ranges. Recruitment in *Nephrops* has previously been assumed to be quite stable (see e.g. ICES, 1997a), but these data (together with other data sets presented in Section 5.) suggest that this may not be the case. The use of CPUE data for small individuals may prove to be a useful index of recruitment where age based assessments are not possible, but since most of the smallest individuals are not landed, such an approach requires adequate discard sampling.

Given that the younger animals are numerically dominant in a population, it is not surprising that TV estimates of abundance are heavily influenced by these young age classes. It is possible, therefore, that TV survey data may be used as a recruitment index, particularly if it proves possible to count burrows in size ranges. Ideally for such a use, however, a continuous series of TV surveys is required.

Examination of length based Y/R curves (averaged over recent years, as is currently the practice in the WG) does not appear to identify problems of falling recruitment and biomass, and it would appear that the assumption of constant recruitment may be the reason for this. The WG has used this technique for a number of years, and for some stocks it is the only assessment method that can be applied. Its lack of sensitivity to reductions in biomass and recruitment, however, reduces its usefulness, and again highlights the need for other indices such as CPUE data.

It is felt that this exercise was worthwhile, and it is suggested that detailed examination of the correspondence between various indices be carried out for as many stocks as possible at the next meeting of the *Nephrops* Study Group.

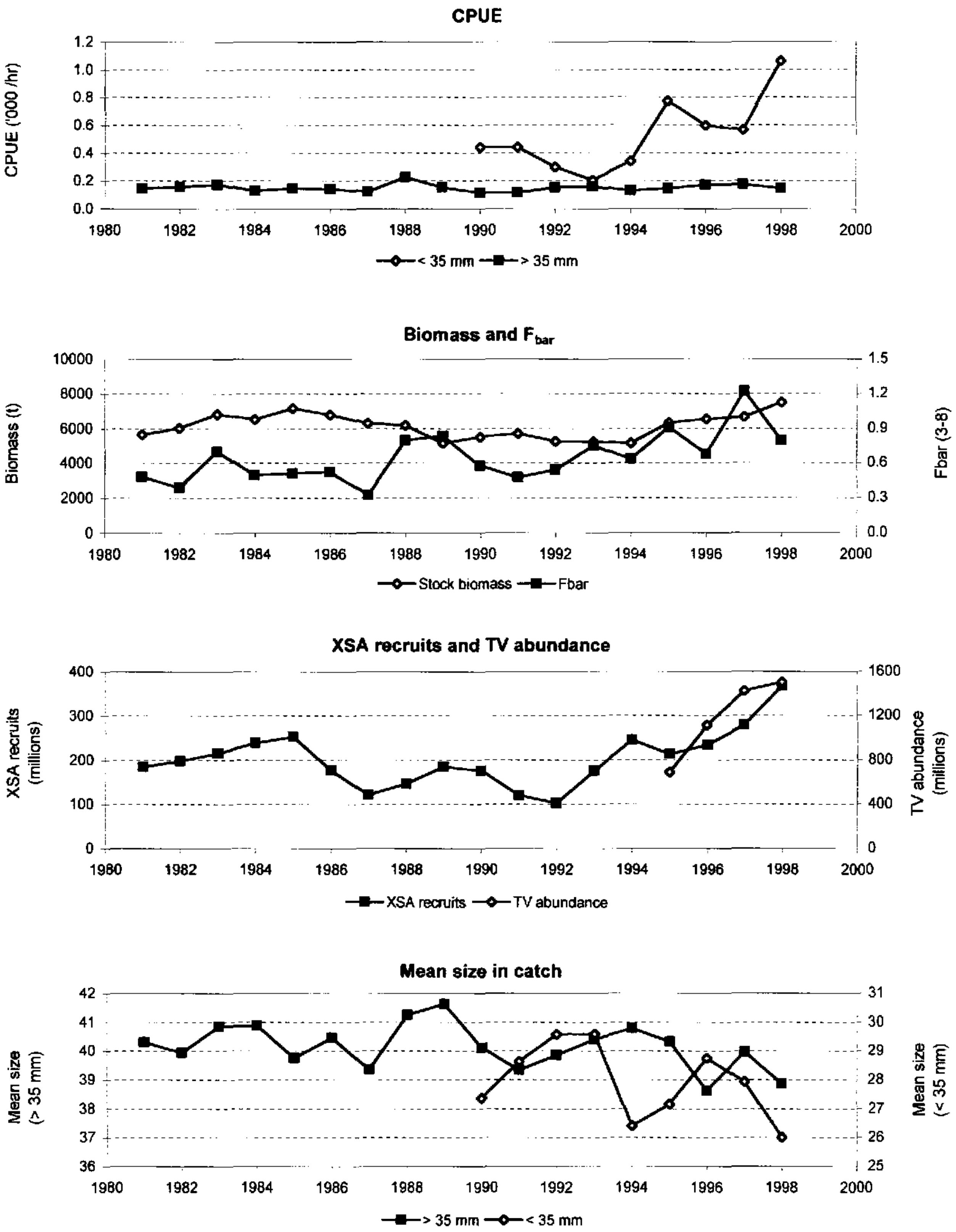


Figure 6.1. - Firth of Clyde (FU 13): Correspondence between indices of state of exploitation and output from analytical assessments.

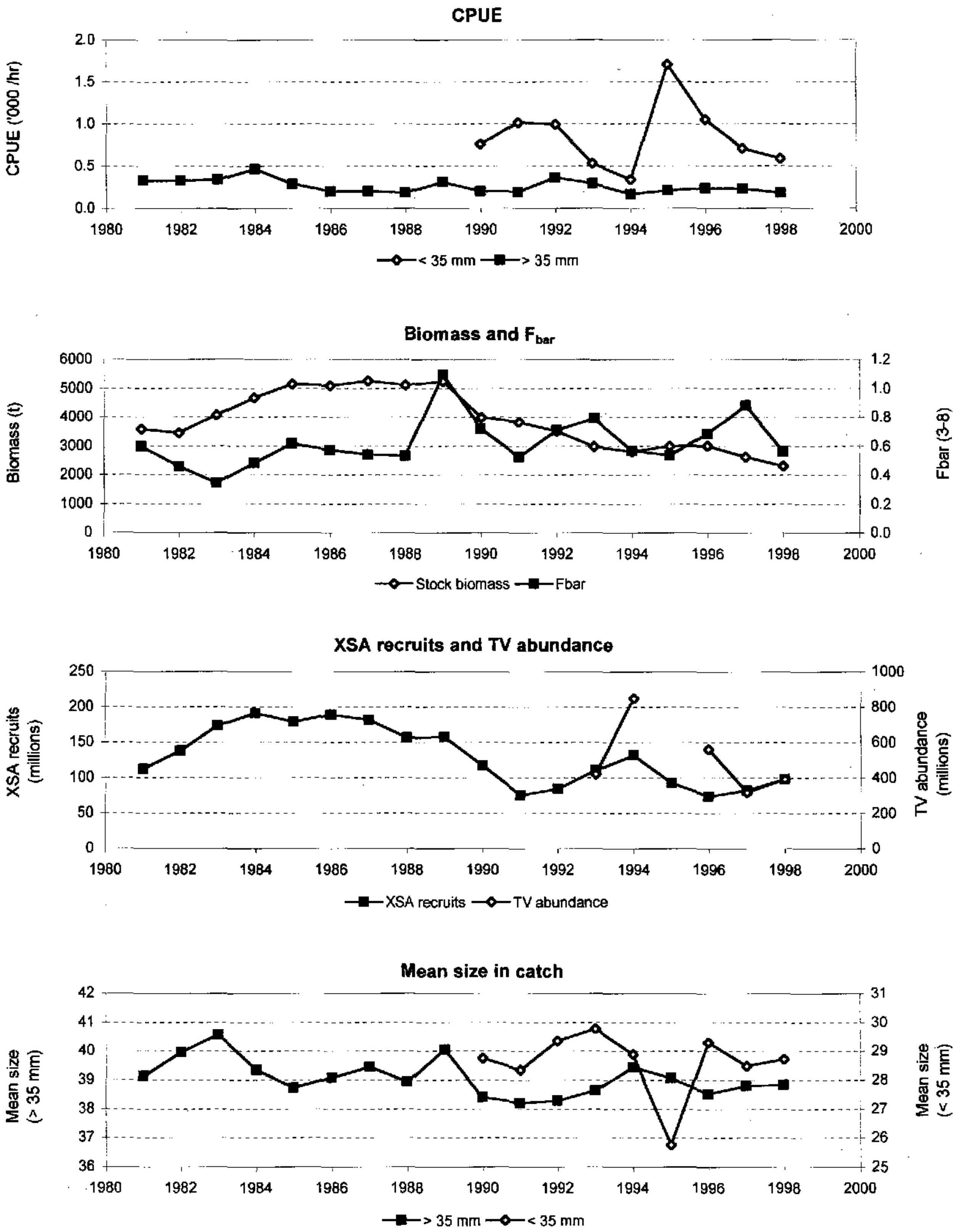


Figure 6.2. - Moray Firth (FU 9): Correspondence between indices of state of exploitation and output from analytical assessments.

7. Comparison between analytical assessments and fishery independent data

The comparison between analytical assessments and fishery independent data was included in the terms of reference of the WG (see Section 1.), so that progress made by the *Nephrops* Study Group (ICES, 1998b) on the use of fishery independent methods could be continued.

Discussions during a subgroup meeting revealed that WG members collecting and contributing fishery independent data were largely the same as reported by the Study Group (ICES, 1998b). Trawl survey abundance data are collected in Ireland, Portugal and Spain, although these were not available at the WG. There are plans in Portugal to make comparisons between trawl survey abundance indices and estimates of abundance derived from VPA, and similar attempts could be made using Irish data, although it was pointed out that this would not be straightforward. Recent vessel changes, methodological adjustments and skipper issues confound the trawl survey data series, making comparison with VPA estimates difficult. In addition to these operational factors, it continues to be recognised that the interpretation of trawl survey data is made difficult by the variable emergence behaviour of *Nephrops*.

Two other types of fishery independent data are also currently collected. In Northern Ireland, annual larval production estimates have been used to back-calculate adult biomass. A preliminary report of this work was presented at last year's Study Group (ICES, 1998b) and a short summary of the final results is provided below. A more detailed résumé of the findings will be included in the 1999 'by correspondence' Report of the *Nephrops* Study Group. Underwater TV surveys are routinely conducted in Scotland and England, and unworked data are available from Northern Ireland. Some indications of the trends in abundance are provided below, together with some further Scottish analysis incorporating TV abundance data into the Integrated Catch Analysis (ICA) assessment approach.

7.1. Biomass estimates from annual larval production

A recently completed EU-funded project (ANON., 1999), co-ordinated by the Department of Agriculture (Northern Ireland), in collaboration with Port Erin Marine Laboratory (Isle of Man), CEFAS (Lowestoft) and the Marine Institute (Dublin), used estimates of larval production to back-calculate spawning stock biomass of Irish Sea *Nephrops* (FUs 14 and 15).

The annual production of stage I and II *Nephrops* larvae was estimated from a series of ichthyoplankton surveys in 1995. Abundance estimates in each survey were converted to daily production estimates, using relationships between temperature and stage duration obtained from experiments on larvae hatched in the laboratory. Larval mortality was estimated from the decline in annual production between stage I and stage II, allowing numbers to be extrapolated to time of hatching. Fecundity and larval development were studied by establishing a hatchery capable of holding more than 200 adult female *Nephrops in vitro.* Animals collected by trawl and creel were maintained in individual containers over the 9 month incubation period, to examine fecundity and hatching success. An important observation made during these studies was the extrusion of eggs in captivity, which provided an estimate of mean potential fecundity of 104.3 eggs per gram female body weight (SE = 2.7). Egg loss during capture and incubation were investigated in both the field and the laboratory. Mean realised fecundity at hatching was estimated to be 67.6 eggs per gram female body weight (SE = 4.3), by subtracting estimates of egg loss during incubation from potential fecundity.

Historical data from Northern Ireland, England and the Republic of Ireland were collated to estimate *Nephrops* sex ratios. Investigation of the seasonal variations in emergence of male and female *Nephrops* indicated that the most reliable period to study mature female abundance from trawl-based sampling is the summer months. A mean sex ratio (number of mature females over the number of mature females plus all males) of 0.53 (SE = 0.026) was derived from Northern Ireland and Republic of Ireland data. As maturity in males cannot be reliably determined through macroscopic examination, this form of sex ratio was adopted to provide estimates of male biomass for comparison with the estimates from analytical assessments (LCA and VPA).

Female SSB was estimated to be 6375 t (CV = 0.18) for the Western Irish Sea and 444 t (CV = 0.27) for the Eastern Irish Sea. Maturity ogives, derived from the proportions of females with developing ovaries or carrying eggs, were used to calculate the SSB from population numbers estimated during the assessments performed by the ICES *Nephrops* Working Group. The SSB estimates for females from the annual larval production method were of a similar order to those from the traditional analytical assessments based on commercial catch data, and indicate that the ICES estimates of fishing mortality may not be seriously in error.

Additional information on the results of this study can be found in a Working Paper presented to the 1999 Study Group on Life Histories of *Nephrops* (BRIGGS, 1999, in ICES, 1999b).

7.2. Trends in overall abundance estimated from underwater TV surveys

English studies

Since 1996, there have been five underwater TV surveys of the Farn Deeps *Nephrops* grounds (FU 6), and two in the Eastern Irish Sea (FU 14) (Table 7.1.). Pre- and post-harvest surveys were carried out to provide recruitment indices from the between harvest period and depletion indices from the harvest period. Confidence in the abundance estimates will improve with further analyses of the results.

Abundance estimates were calculated using all the 'clear' TV tows in each survey. The lower abundance estimate calculated from the Farn Deeps spring survey in 1998 may be explained in part by sampling differences. Some TV tows, showing high densities in earlier surveys, were unusable in 1998 because of poor visibility. If stations cannot be repeated from one survey to the next, the comparability between surveys may be affected, especially if this is the case for stations displaying extremes in observed densities. The degree to which this affects overall abundance estimates and survey comparability remains to be investigated.

To calculate biomass, some reference to individual mean size for the population has to be made. So far, all calculations have been made using the average size of trawl caught *Nephrops* which does not account for that part of the population which is too small to be caught. The TV survey counts, however, include many holes whose occupants fall into this latter category. Computing the size of *Nephrops* from the size of the holes may be one way round this problem, but again this requires further investigation.

Scottish studies

Underwater TV surveys of various Scottish *Nephrops* stocks have been conducted since 1992. Table 7.1. summarises the data available, and provides estimates of mean burrow density across each ground as a whole.

A notable feature of these values is that the range of observed densities varies considerably between grounds. In the Firth of Forth (FU 8) and the Firth of Clyde (FU 13), densities are generally high (0.33-0.72 per m^2), whereas in the Moray Firth (FU 9) and the Fladen Ground (FU 7) overall densities are lower (0.13-0.39 per m^2). The situation in the Fladen Ground is an interesting one. By virtue of its very large area, this ground has by far the largest overall abundance, but on a local basis densities are not particularly high. It is noteworthy that values are not dissimilar to the Moray Firth, a stock showing signs of difficulty. It will be important to obtain information on the dynamics of the Fladen Ground stock in addition to point estimates of abundance from TV surveys, so as to better understand its resilience to increasing fishing pressure. So far, recommended increases in catch opportunities have been modest (in relative terms) (Table 5.1.6.), and it is suggested that this approach should be continued without allowing too rapid an expansion of the fisheries.

Figure 7.2. shows the trends in overall abundance (in 10^6 animals), together with the estimated confidence intervals for each stock. In several cases, there is reasonable correspondence between the trends in the TV survey data and the VPA estimates of stock biomass. In particular the recent marked increases in stock size in the Clyde are well demonstrated by both methods (see also Section 5.11.3.). Clearly, a longer time series of TV data will benefit the evaluation of this approach, as would an analysis to subdivide the estimates of burrow number into various size categories. Since all the TV material is recorded on video, the opportunity is there to carry out retrospective analysis of earlier surveys – this would be especially valuable.

7.3. Incorporation of TV abundance estimates in Integrated Catch Analysis

Further work on the incorporation of underwater TV data into Integrated Catch Analysis (ICA) (PATTERSON and MELVIN, 1996) was carried out. Preliminary work on this method was presented at the 1998 *Nephrops* Study Group (ICES, 1998b).

During the 1999 WG meeting, ICA was used to incorporate TV survey data into the assessments for the Firth of Forth (FU 8) and the Moray Firth (FU 9) stocks. Assessments were carried out with tuning on two age-structured indices:

- using the total abundance estimates from the fishery independent assessments as an index of total stock number (age 1+), and
- using CPUE data from the commercial fishery as an index for each age,

with a linear relationship between both indices and stock size.

Both indices were given equal weighting, but for the CPUE series ages 1 and 2 were down-weighted (weights of 0.05 and 0.30 respectively) since they are not fully recruited to the fishery. While the TV estimates of stock numbers do not provide sex specific estimates, as long as sex ratios remain constant, total stock numbers will be related to the numbers of each sex in a linear way. Biomass estimates are also available from fishery independent surveys, but these are subject to possible additional errors through application of inappropriate mean weight values to the abundance data (ICES, 1997a). Also, since they are derived from the abundance estimates, they are not independent from the former. Effort data are not used in the ICA assessment method, so the use of CPUE data is therefore not inappropriate. Assessments were carried out using ICA Version 1.3. The number of years for the separable constraint was set to the maximum over which the exploitation pattern has remained relatively stable. Assessments were only carried out for males.

Examination of the diagnostic plots and statistical output suggests that the model fits were acceptable. Skewness and kurtosis test statistics were small, showing that the residuals for the separable model and each index were not skewed, and that the assumption of log-normally distributed errors was justified. Marginal totals for the separable analysis residuals were close to zero, indicating that the tuning indices were not forcing the model away from the separable pattern, with respect to either ages or years.

Summary plots for the Firth of Forth ICA assessment are shown in Figure 7.3.; similar plots for the XSA assessment in Figure 7.4. ICA stock biomass levels were very similar to those of the XSA. In the most recent years, F_{bar} from the XSA was stable, while the ICA showed an increasing trend in F_{bar}. Recruitment levels were similar for both assessments, but while the XSA suggested relatively stable levels after a peak recruitment in 1993, ICA suggested higher levels of recruitment in both 1994 and 1997.

Summary plots for the Moray Firth ICA assessment are shown in Figure 7.5.; similar plots for the XSA assessment in Figure 7.6. Estimated male stock biomass in the early and mid-90s was very similar to that from the XSA assessment, but estimates for the earlier years were greater, suggesting a greater decline than the XSA assessment. ICA also suggested a sharp increase in F_{bar} in 1995-97, while the XSA suggested more stable levels. ICA recruitment estimates were generally higher than those given by the XSA, and showed a decline in the early 90s (as did the XSA), and a sharp drop in 1997.

Over the time period for which TV abundance estimates were available, the ICA assessments of both stocks showed differences in F_{bar} and recruitment from the XSA results. ICA showed an increase in F_{bar}, while the XSA assessments suggested a more stable exploitation pattern. However, for both stocks the TV abundance estimates have declined over this period of time. Recruitment estimates from the ICA appeared more variable than from the XSA.

ICA carries out age structured stock assessments, using abundance and/or biomass indices for tuning. The assessments were similar to those produced using XSA, but also allowed inclusion of the TV survey abundance data. At present, the time series of fishery independent data is relatively short compared to the fishery dependent data, so it is difficult to appreciate the full potential of the technique. There is no reason, however, to conclude that the technique is inappropriate for *Nephrops*.

While only TV survey data have been used to date for *Nephrops* assessments using ICA, a range of other indices could equally be applied. For stocks where there is concern over the accuracy of commercial effort data for use as a tuning index, ICA offers an approach in which research trawl survey indices could be used. It was also suggested at the WG that female assessments could be carried out, tuned on estimates of male recruits from the XSA. This may help constrain the female assessments to more realistic stock sizes.

Using ICA as described above incorporates more of the available data than other assessment techniques, and thus provides a useful tool for stocks where extra abundance indices are available. Survey data are available for a number of stocks, and application of ICA would allow these data to be incorporated into the assessments, potentially improving the ways in which assessments match observed changes in populations.

7.4. Conclusions

Results from larval studies and TV observations have produced encouraging results. The relatively close correspondence between biomass estimates back-calculated from larval numbers and VPA estimates of biomass is a good sign, and suggests that application of this technique is worthwhile in areas where larval sampling is fairly straightforward. The technique requires a lot of ship and laboratory analysis time, but could be very useful if applied periodically to confirm biomass results obtained from the analysis of fishery data.

Although the correspondence between biomass estimates from TV and VPA is not quite so close, the trends in the two data series frequently show good similarities, suggesting that the former could be exploited to improve analytical assessments. As more years are added to the time series of TV observations, it will be easier to evaluate the extent to which TV results are helpful. Further modifications incorporating estimation of different size categories of *Nephrops*, will also help. Meanwhile, it is felt that the efforts to incorporate these data into assessment methods should be pursued.

The WG also felt that collaborative studies between the various laboratories utilising under-water TV methods would be mutually beneficial for improving consistency and reducing variability in the estimation procedure.

Table 7.1. - Mean *Nephrops* burrow densities (number per m^2) calculated for each of the grounds surveyed in Scottish waters, 1992-98, and in English waters, 1996-98.								
Year	North Minch	South Minch	Firth of Clyde	Moray Firth	Firth of Forth	Fladen Ground	Farn Deeps	Irish Sea E
1992	ns	ns	ns	ns	ns	0.18		
1993	ns	ns	ns	0.19	0.72	0.21		
1994	0.38	ns	ns	0.39	0.58	0.30		
1995	ns	0.3	0.33	ns	ns	0.24		
1996	0.25	0.38	0.54	0.26	0.48	ns	0.83	0.35
1996 (*)							ns	ns
1997	ns	0.28	0.68	0.14	ns	0.13	0.59	ns
1997 (*)							0.61	ns
1998	0.41	0.38	0.72	0.18	0.38	0.18	0.25	ns
1998 (*)							0.44	0.12
* = autumn survey conducted during English studies ns = no survey made								

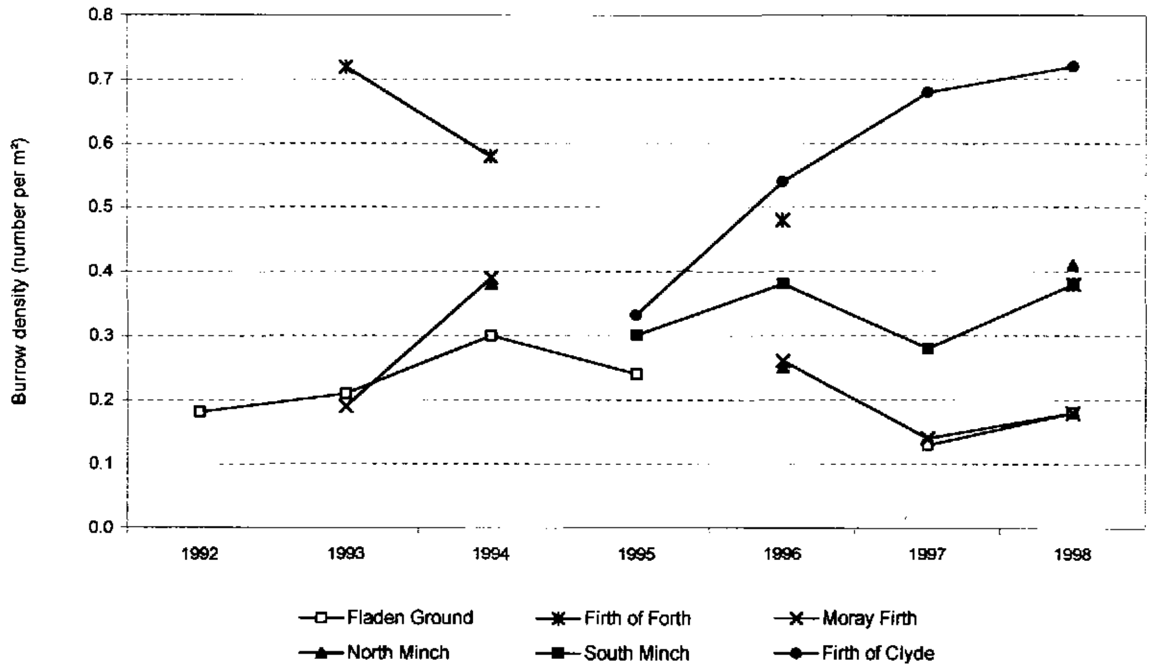


Figure 7.1. - Trends in mean burrow densities on Scottish *Nephrops* grounds, 1992-98.

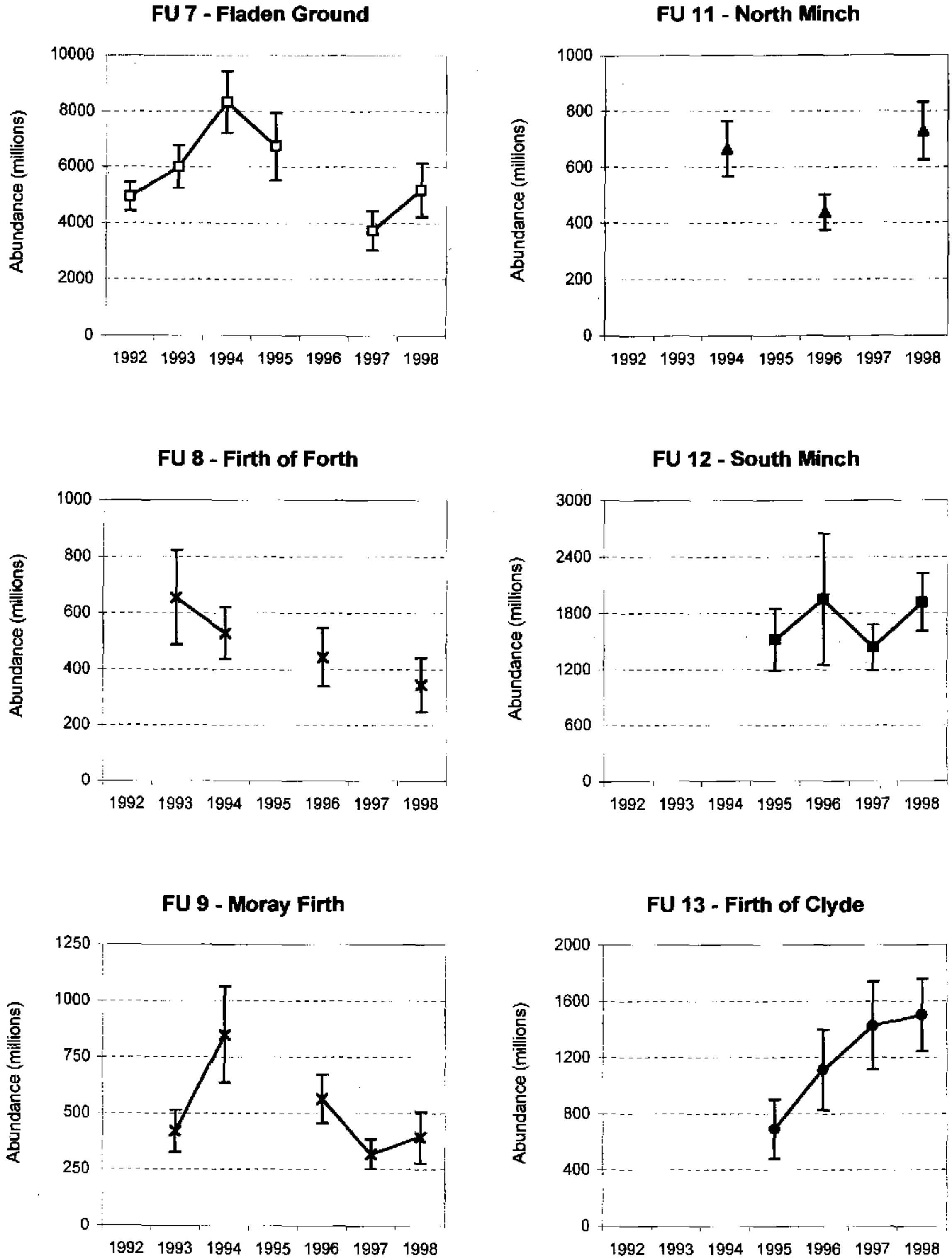


Figure 7.2. - Trends in abundance (in millions) of *Nephrops* in various Scottish stocks, estimated from underwater TV surveys, 1992-98. Vertical bars indicate 95 % confidence intervals.

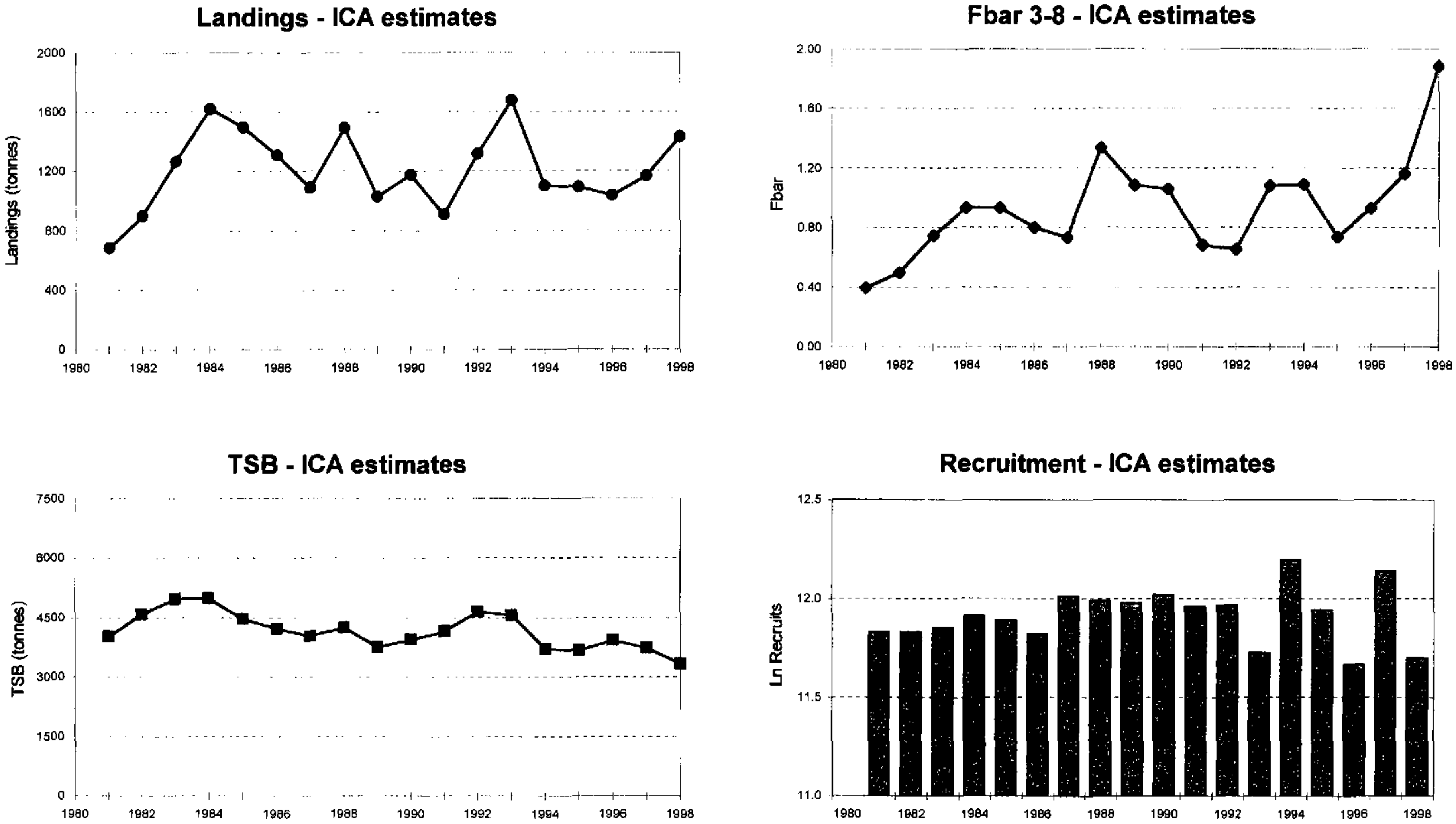


Figure 7.3. - Firth of Forth (FU 8): Output ICA males: Trends in Landings, Fbar, TSB and Recruitment.

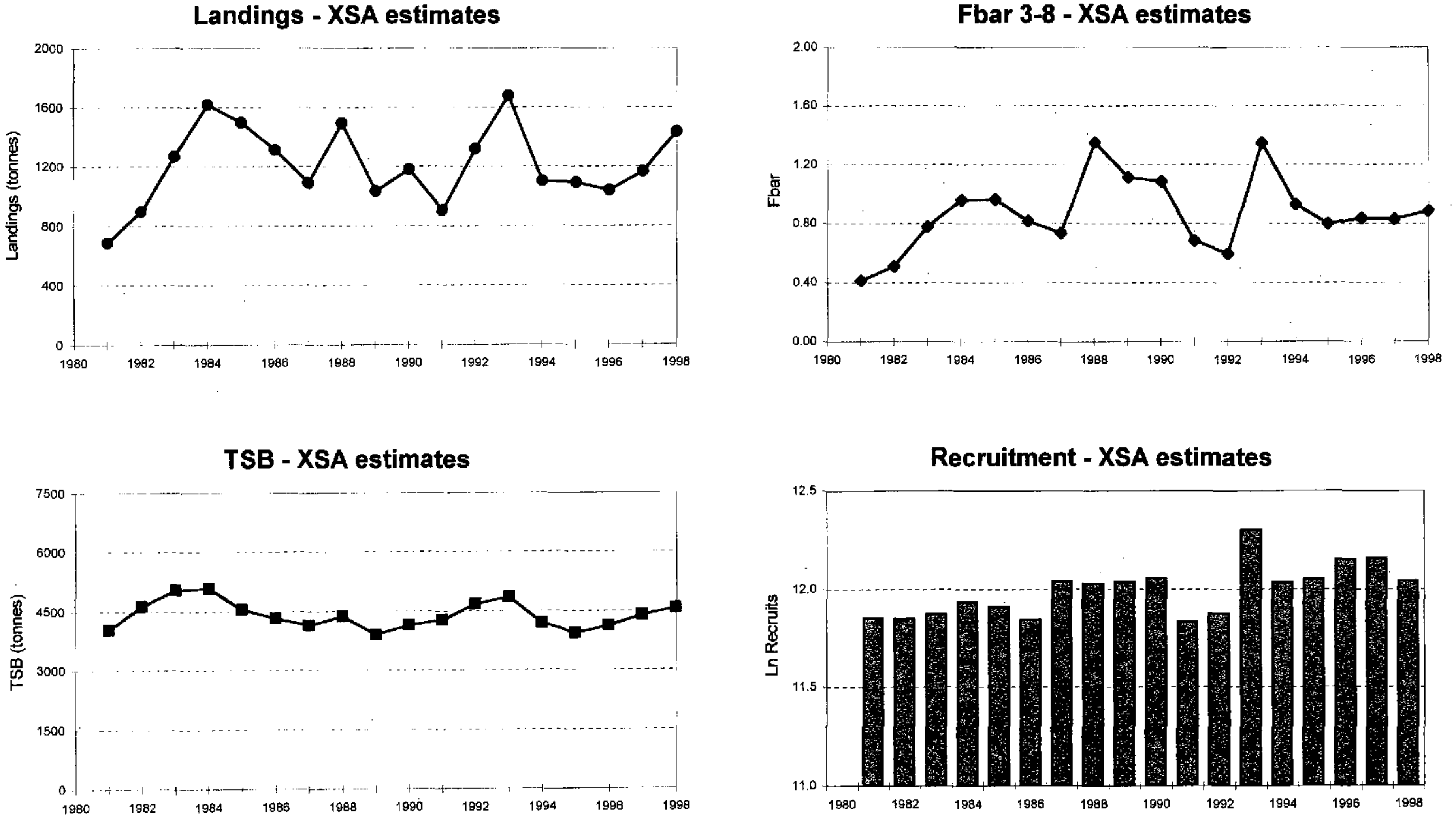


Figure 7.4. - Firth of Forth (FU 8): Output XSA males: Trends in Landings, Fbar, TSB and Recruitment.

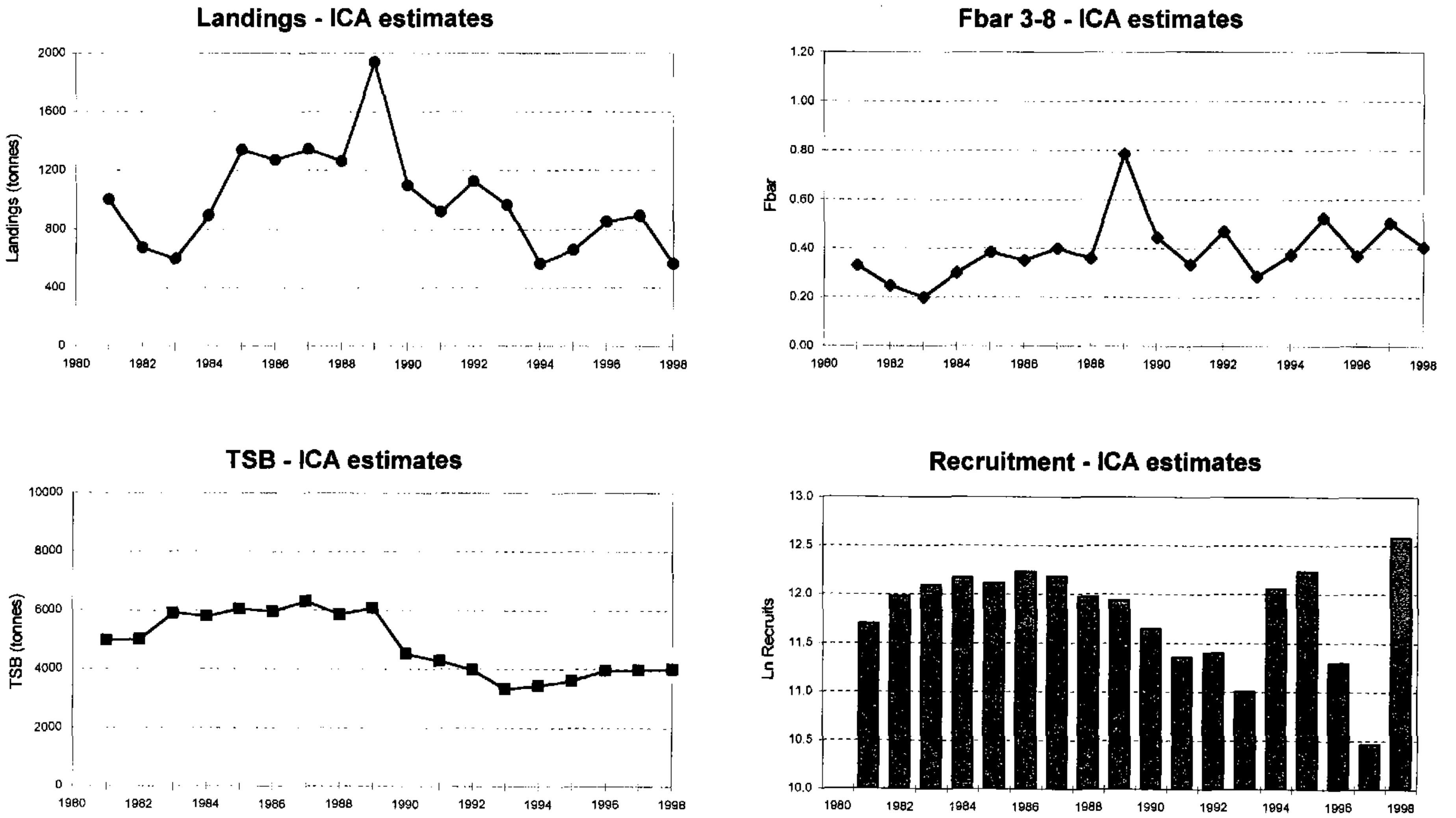


Figure 7.5. - Moray Firth (FU 9): Output ICA males: Trends in Landings, Fbar, TSB and Recruitment.

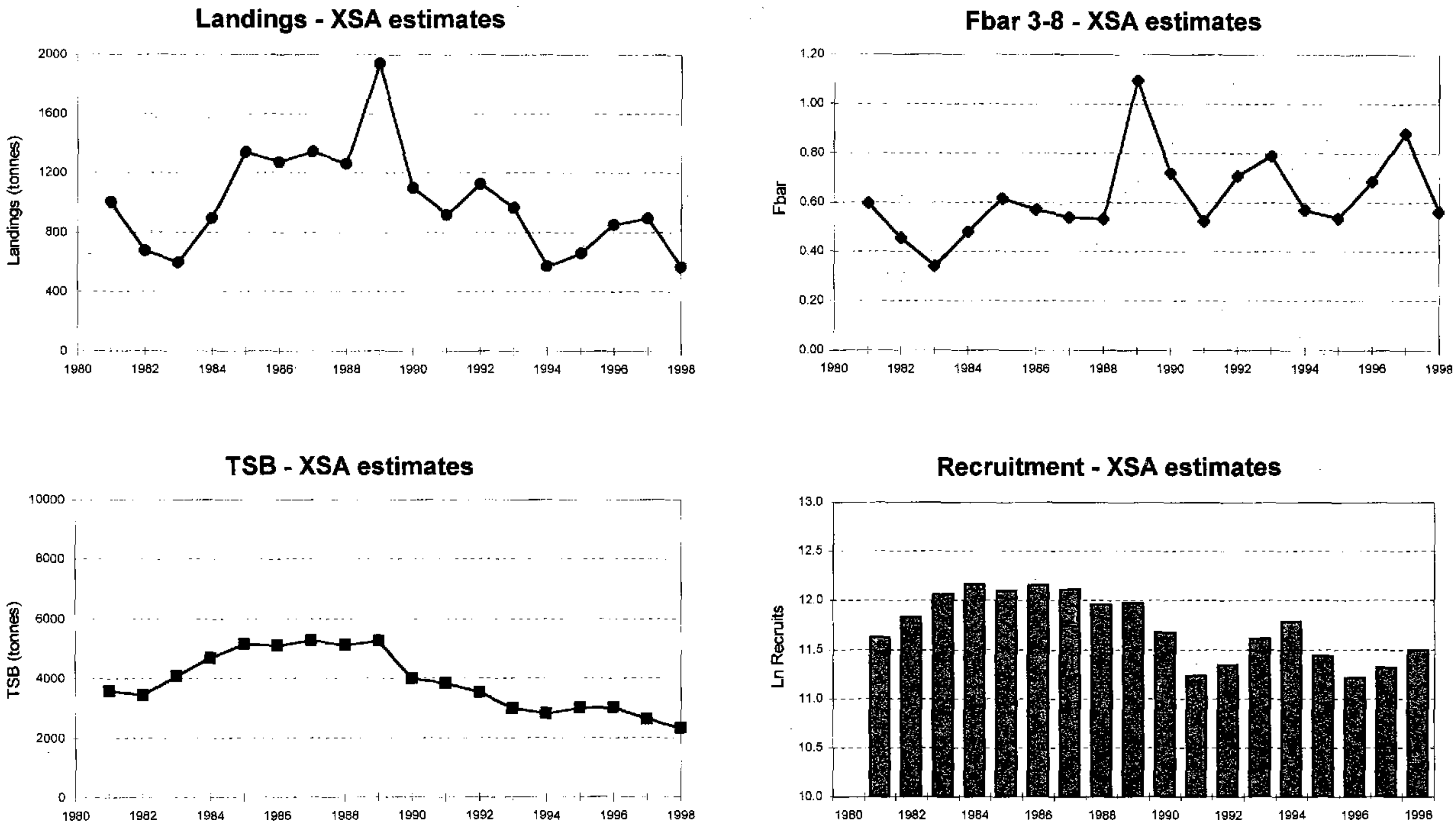


Figure 7.6. - Moray Firth (FU 9): Output XSA males: Trends in Landings, Fbar, TSB and Recruitment.

8. Biological reference points

The *Nephrops* Working Group has not previously used biological reference points (BRPs) as explicit targets or limits. The 1997 *Nephrops* Working Group (ICES, 1997a) and the 1998 *Nephrops* Study Group (ICES, 1998b) evaluated various types of BRPs for use with *Nephrops* stocks. These fell into three groups:

(1) BRPs calculated from analytical stock assessments (length-based LCA and age-based XSA), as commonly used by ICES for finfish stocks.

(2) *Nephrops*-specific BRPs, relating to biological characteristics and non-analytical stock indicators.

(3) Targets for optimum harvest levels, based on economic considerations.

The WG took the view that it remains inadvisable to accept current estimates of BRP values as a basis for managing *Nephrops* stocks. There are serious concerns about the application of current analytical assessment models to *Nephrops*, and their use in estimating BRPs. Particular concern was expressed about early detection of recruitment problems. *Nephrops*-specific BRPs may be possible in the future, such as a minimum male to female sex ratio for successful reproduction. However, no new information was available to the WG to allow further discussion of this topic in terms of either methods of measurement or setting appropriate BRP values for such criteria.

Accordingly, the following sections focus on identifying areas for development. BRPs arising from analytical assessments are re-assessed, concentrating on the identification of the critical features on which the estimated BRP values depend, rather than on the values themselves. Some further possible sources of information for *Nephrops*-specific BRPs are considered. Finally, the relevance of economic factors to fisheries management is briefly reviewed.

8.1. Biological reference points from age-based analytical assessments

The results of previous examination of BRPs for *Nephrops*, estimated from age-based assessment (XSA) outputs, have been inconclusive (ICES, 1997a, 1998b). Calculated BRP values appeared to have some value in interpreting the state of exploitation of individual stocks, but no useful generalisations could be drawn about the likelihood of growth or recruitment overfishing at any given level of fishing mortality. One reason for this difficulty may be that there are facets of *Nephrops* population biology which make this approach inappropriate. For example, there could be stabilising mechanisms which constrain variation in recruitment and spawning stock levels, such that no sign of recruitment overfishing will be apparent until the point of stock collapse.

Before we can draw this conclusion, however, we need to carefully examine the quality of the assessments on which the BRP estimates are based. How good are the age-based assessment models applied to *Nephrops* ? In some stocks at least, correspondence of XSA results with both fishery-dependent and independent stock indicators gives encouraging signs that trends in stock size, recruitment and fishing mortality are reflected qualitatively. However, since

BRP calculations depend directly and quantitatively on XSA outputs, we must be certain that the assessment models are appropriate, correctly applied and based on reliable catch data.

A full consideration of the validity of assessment models and quality of results obtained for *Nephrops* is beyond the scope of this document. Instead, we focus on the narrower question of how estimated BRP values are supported by the assessment results. During the 1998 *Nephrops* Study Group, yield and recruitment BRPs were estimated using XSA outputs from the 1997 WG. Here, we update these estimates, using the XSA outputs from the present WG (see Section 5. for details). Two modifications of methods employed at the 1998 *Nephrops* Study Group were adopted:

(1) The values of F-at-age were averaged over the last three years of the assessment (1996-98 for most FUs, 1995-97 for FUs 20-22 and FUs 23-24), rather than using the values from the single last year.

(2) The estimates of recruitment and spawning stock biomasses (SSB) for the most recent two years were omitted from consideration of the stock-recruitment relationships.

These modifications were designed to stabilise the estimates, reducing dependence on the most recent years, for which the assessments may not be well determined.

Two types of BRP were estimated, viz. yield and recruitment BRPs.

8.1.1. Yield BRPs

Yield BRPs were estimated from a yield per recruit (Y/R) analysis based on the vector of average F-at-age: F_{max} is the level of fishing mortality at which Y/R is maximised and $F_{0.1}$ is the level (lower than F_{max}) at which the slope of the Y/R curve is reduced to 10 % of its value at the origin (zero effort). Both relate to the avoidance of growth overfishing, i.e. they relate to the trade-off between gains in yield from exploiting the stock at an older average age (and hence at a larger size) and losses to natural mortality.

Y/R plots based on vectors of average F-at-age from XSA are mostly similar to those derived from length-based analyses (see Section 5. for further details). Y/R curves for *Nephrops* are mostly flat-topped, with current F at or above F_{max} for males, and below F_{max} for females in most stocks (Figure 8.1.).

Overall, the concurrence of the age- and length-based assessment results suggests that the age-based assessments are an adequate basis from which to draw conclusions about BRPs based on the Y/R curve. Therefore, the WG suggests that it is not necessary to conduct a separate length-based assessment as a basis for drawing conclusions about Y/R in those stocks for which the age-based assessment is considered to perform adequately.

F_{max} and $F_{0.1}$ are below F_{med} in every case (Tables 8.1. and 8.2.). This is to be expected, since growth overfishing sets in at a lower level of exploitation than recruitment overfishing. Management recommendations based on yield are perhaps beyond the remit of this WG, and cannot be divorced from social and economic considerations (see below, Section 8.3.). However, management that eliminates growth overfishing automatically avoids recruitment overfishing. This is not to say that it would be desirable to manage *Nephrops* stocks solely on the basis of a Y/R curve. There are considerable dangers in doing so. In most stocks, males are moderately overexploited in terms of Y/R, but the gains in Y/R upon a reduction of F to F_{max} are relatively modest. Thus, whilst growth overfishing certainly occurs, it is not perceived as a serious problem.

However, a recruitment decline would, in the short-term, give rise to a more favourable perception of the relative position of current F with respect to F_{max}. This is because the average age/size of individuals in the catch would increase, and, in the case of a length-based analysis, a shift of the LFD towards the larger size groups would cause a downwards bias in the estimation of F. The shape of the Y/R curve yields no information about recruitment overfishing, and the position of current F with respect to F_{max} or $F_{0.1}$ provides no clue about vulnerability to stock collapse.

Leaving apart the likelihood of recruitment overfishing, and supposing for the moment that the focus of management was to maximise yield, there would still be considerable grounds for caution in using BRPs based on a Y/R curve. Firstly, F_{max} is most often very imprecisely located, since the Y/R curves are usually very flat-topped. More important, however, is the implicit assumption that recruitment is independent of stock biomass. Despite the apparent stability of recruitment and SSB in most stocks (see Section 5. for further details), wide variations in SSB appear to be accompanied by similar variations in recruitment. Setting aside the difficulty in reconciling this stock-recruitment pattern with historical stock and fishery trends (see below), this implies that the shape of the yield curve will be very different from the Y/R curve. Changes in exploitation will be accompanied by changes in SSB, which in turn cause changes in recruitment. Changing the denominator of Y/R has the effect of exaggerating the relative changes in yield compared with Y/R. A yield curve will resemble a Y/R curve only if density-dependence perfectly compensates for changes in egg production, concomitant to changes in SSB. In general, a yield curve will be more highly domed than a Y/R curve, and the level of exploitation at which yield is maximised, F_{MSY}, will be lower than F_{max}. Thus, the relative gains to be expected from reducing F will be greater than is apparent from the Y/R curves, but the corresponding reductions in F will also be greater.

8.1.2. Recruitment BRPs

Recruitment BRPs were estimated from spawning stock biomass per recruit (SSB/R) analysis, based on the vector of average F-at-age, and the estimates of actual recruitment and SSB from the XSA. F_{med} is the level of exploitation at which, on average, the stock will replace itself. This is determined from the median of 'observed' recruitment to SSB ratios, related to a given level of F through the SSB/R curve. F_{low} and F_{high}, the levels of exploitation at which replacement of the stock is respectively almost certain and highly unlikely, are similarly found from the 10th and 90th percentiles of the distribution of observed recruitment to SSB ratios. All calculations were performed using the FISHLAB add-in to Excel (see ICES, 1998b for full details).

XSA estimates of *Nephrops* SSB and, particularly, recruitment tend not to be very variable within stocks (Figure 8.2.). This has two consequences for recruitment BRPs.

Firstly, the differences between F_{med}, F_{low} and F_{high} are small for any individual stock (Tables 8.1. and 8.2.; Figure 8.3.). This cannot be taken to mean that stock replacement is highly sensitive to small changes in exploitation level – it simply implies that we have no knowledge of how the stock would behave outside the narrow observed range of recruitment and SSB figures.

Secondly, F_{med} bears a strong resemblance to F_{bar}, the average exploitation level (Table 8.1.). Expressed as F-multipliers, the values of F_{med} cluster strongly around 1 (Table 8.2.; Figure 8.4.). Similarly, this cannot be taken to mean that the current level of exploitation is close to a desirable level for stock replacement in any given FU – it is simply a consequence of the narrow range of variation in observed recruitment and SSB.

There is a circularity in the argument that since the current level of F appears to give recruitment to SSB ratios that are fairly typical of the observed series, therefore the current level is the desirable level. Actual values of F_{med} differ widely between stocks, whereas, even accounting for biological differences, the ability to sustain a given level of exploitation is unlikely to be so variable.

A second feature of the stock-recruitment plots is that, in those stocks showing a relatively wide range of variation in (male) recruitment and SSB (e.g. FU 9 and FUs 28-29), a almost linear dependence of recruitment on SSB is apparent (Figure 8.3.). Thus, the ratio of recruitment to SSB is relatively invariant, the consequence being that recruitment and SSB variation have little impact on the estimated BRP values. Stock-recruitment relationships of this nature imply that density-dependent effects on recruitment are unimportant at current stock levels, and that the stock has little capacity to compensate for the effects of exploitation. The usual interpretation thereof for a finfish stock would be that the stock is located near the origin of a stock-recruitment curve, and thus that it is close to collapse (e.g. GABRIEL *et al.*, 1989). This clearly does not apply to *Nephrops*, as evidenced by stable stock sizes and recruitment levels and the long history of apparently sustainable exploitation seen in many stocks. Further research is needed into the nature of stock-recruitment relationships in *Nephrops* and into the possibility of biases and artefacts introduced by the stock assessment methods. Nevertheless we can conclude that, with the information currently available, this approach to estimate BRPs for *Nephrops* stocks does not reliably indicate vulnerability to recruitment overfishing.

Although it is too early to conclude that the XSA assessment method as such is a source of problems in estimating BRPs, one likely inadequacy can be highlighted. So far the WG has performed separate stock assessments for males and females, the main reason for this being that sexual differences in burrow emergence behaviour result in different patterns of mortality. Ovigerous females tend to remain in their burrows during the winter brooding period, and this makes them less vulnerable to both fishing gear and predation. Thus, lower estimates of fishing mortality and higher estimates of stock numbers would be expected for females. However, since recruitment to the fishable stock occurs before sexual maturity (i.e. before sexual differences in emergence behaviour result in differing mortality patterns), male and female stock assessments should resemble each other in one important respect – recruitment estimates. Assuming that the sex ratio in the larval stage is 1:1 and that, prior to sexual maturity, natural mortality is the same for males and females, equal numbers of males and females would be expected to recruit to the fishable stock in any one year. Figure 8.2. shows recruitment patterns estimated from XSA compared between males and females for each stock. In some cases, recruitment trends are similar between males and females in terms of both patterns and absolute levels (e.g. FU 6, FU 8, FUs 28-29). This implies that the assessment models performed equally well for both sexes. Some other stocks show good correspondence of trends, but very different levels of male and female recruitment (e.g. FU 5, FU 9). This implies that the models were successful in capturing trends, but introduced some systematic biases in the estimates of the numbers recruiting. Some stocks show very little correspondence between sexes in either trend or level (e.g. FUs 20-22, FUs 23-24), implying either that the assessment model is inappropriate, or that the catch-at-age data are unreliable for one or both sexes.

Adequate female stock assessment is an essential pre-requisite for the estimation of BRPs for recruitment overfishing. Assuming that reproductive success is not limited by a low ratio of males to females in the stock, recruitment depends most strongly on female SSB. Male biomass will have some role to play in determining density-dependent compensatory mechanisms, but at low stock levels (where density-independent processes dominate), female egg production (and thus SSB) will be the dominant influence on recruitment. Hence, BRPs are probably best estimated using female stock and recruitment data, and used as F-multipliers to find the appropriate levels of exploitation on males. Unfortunately, inadequacies of assessment are most likely to occur in females. Lower vulnerability of mature females to fishing gear (see above) means that much lower catches of females are taken from most stocks. This has the repercussion that natural mortality and its variation between years assumes a greater importance in determining stock numbers and patterns of overall mortality. Furthermore, differences in emergence behaviour between years, caused by variation in breeding success and environmental factors, may be expected to cause differences in female catchability.

Clearly, there is some scope for considering which recruitment and which SSB estimates are appropriate and how they should be combined for constructing stock-recruitment plots for *Nephrops*. However, this should not distract from the need for new assessment models which are both parsimonious and realistic for *Nephrops*, accounting for the essential features of population and fisheries biology.

SHEPHERD (1982) shows how Y/R, SSB/R and stock-recruitment models can be linked to give sustainable yield curves for a stock, and also to predict equilibrium SSB at different exploitation levels. This approach has been applied to lobster, *Homarus gammarus*, stock assessments by BANNISTER and ADDISON (1986), and ADDISON and BANNISTER (1998). The WG suggests that this approach be considered for future *Nephrops* assessments.

8.1.3. Summary and recommendations for further work

Formal BRPs based on analytical assessments can still not be recommended as a basis for sound management of *Nephrops* stocks. Current estimates of BRPs for recruitment overfishing appear to have very little power to assess stock vulnerability at any given effort level, and tend to converge strongly towards current estimates of exploitation levels. Stock assessment and management by reference to Y/R curves offer particular dangers of not detecting recruitment overfishing and of misleading conclusions about fishery yield and growth overfishing.

Two areas for future development are identified. Firstly, new assessment models are needed that account for the essential features of *Nephrops* biology. Amongst others, these models should not treat male and female catches as if they were derived from separate and independent stocks. Secondly, further research is needed into the nature of stock-recruitment relationships in *Nephrops*. XSA estimates suggest that *Nephrops* are unusual in that SSB and recruitment are relatively stable and linearly related. We need to establish whether these features are a biological reality or artefacts of the assessment techniques used, and to explore the consequences for stock management. Developments in these two areas should improve our understanding of appropriate targets and limits for stock management, and provide a sound basis for estimating BRPs.

8.2. Other sources of information for BRPs and related methodological topics

8.2.1. Effort and landings per area

The area of suitable muddy substrate is now known for a number of *Nephrops* stocks. Fishing effort and landings per unit area are indicators of fishing intensity on a stock. Time series of these indices are shown in e.g. Figure 5.3.11. Stocks with the highest effort and landings per unit area (e.g. Firth of Forth, FU 8; North Minch, FU 11; Firth of Clyde, FU 13; and Irish Sea West, FU 15) are those generally agreed to be the most heavily exploited, while stocks with the lowest values (e.g. Fladen Ground, FU 7; and Irish Sea East, FU 14) are recognised as being lightly exploited.

Clearly, there is a potential to use these indices – possibly in conjunction with other stock indicators – to construct BRPs, and to assess the potential of newly exploited grounds. A detailed examination of this topic is beyond the scope of the WG, but could be a subject for a future *Nephrops* Study Group meeting.

8.2.2. Indices of female maturity

Female *Nephrops* differ from males in that, for most of the year, they may very easily be distinguished from mature members of their sex by gonad colour. In populations in which virtually all non-senile females breed every year, distinction of immature from mature (breeding) females is immediately possible by noting the colour of the ovaries seen through the dorsal surface of the animal.

The simple practice adopted in Irish research has been to classify females as:

(1) Immature (dorsal appearance not differing from that of a male of similar size);

(2) Intermediate in colour between (1) and (3);

(3) Breeding females with fully developed dark green ovaries; and

(4) Ovigerous (carrying eggs under the abdomen).

The adult female's ovaries start developing about May, go through the intermediate stage through most of June, and are fully developed in July. They remain in this state until oviposition (the extrusion of the eggs) in late August or September. Some weeks after oviposition, the females retreat into their burrows and remain there for the rest of the incubation period until hatching in late April or early May, during which period they are extremely rare in trawl catches.

Non-breeding immature females can be distinguished from breeding adults by ovary colour (or absence of attached eggs) at most times of the year. The problem period is from late April to early June, when adult females have recently hatched eggs and are indistinguishable from the non-breeding ones by ovary colour. At this time of the year, mature females may be distinguished by abdomen width, which increases at maturity. This is, however, a more cumbersome criterion to apply in the field. The easily visible difference between immature and mature females forms a valuable tool for examining year-class strength in early life. The ratios of immature females to mature females (or to any other population component) could be a useful indicator in the monitoring of BRPs for recruitment.

There are several areas however, which require caution in applying ratios of immature females to other categories of *Nephrops*. Firstly, these ages are frequently incompletely recruited to the catching gears in use. Secondly, their distribution tends to be more patchy than that of adults, and on certain grounds they may be or appear to be completely absent.

The importance of avoiding May data has already been stressed. It should also be noted that from June to August (when breeding adult females are most abundant in the catches), the immatures are undergoing an active moulting phase, and hence that the ability to distinguish immature age-groups from each other by size modes is much reduced. From about October to March, there is much less moulting, and immature length-frequency distributions very often show clear modes, allowing accurate estimation of the numbers per age-group. The advantages of observations made at this season are somewhat offset by the absence of breeding adult females from the catches, but the extra clarity of the modes of immature females should more than compensate for the above-mentioned disadvantages.

The information presented here has nearly all been obtained from the western Irish Sea and care should be taken when applying it elsewhere. It should, however, be advantageously applicable in areas where *Nephrops* have a strongly marked seasonal rhythm, and where virtually all adult females are breeding annually. Problems may occur where numbers of adult females with undeveloped ovaries are present for all or most of the year (as is the case in more northerly waters, where breeding in the older age groups becomes biennial), and in stocks where immature females simply cannot be fished with standard gears (though presumably they could be surveyed using fine mesh trawls).

8.3. Economic considerations in relation to growth overfishing

Growth overfishing fails to maximise returns from a fishery. It involves catching too many fish or shellfish before they have lived long enough to have achieved the optimal amount of money-making growth, and catching them too expensively. Current F is above F_{max} in many *Nephrops* stocks. Gains to be expected from reducing F to a point at or close to F_{max} are of three types:

(1) Gains in catch weight, as growth in individual weight offsets losses to natural mortality.

(2) Gains in catch value, as medium and large individuals have a higher unit value than small individuals.

(3) Assuming a positive relationship of cost of fishing with the value of F, it follows that reducing F saves costs. However, the gains could be mitigated to a so far unknown

extent by density-dependence in *Nephrops* growth as the stock recovers in response to remedial management.

Assuming a linear relationship between variable (operating) costs of fishing and F, it follows that a reduction of F to a value close to, but usually below F_{max}, could allow many *Nephrops* fisheries to be operated with catches of males somewhat above and females somewhat below their present level, but overall with considerably reduced costs. Whilst this is not primarily a biological issue, it is highly relevant to the management of fisheries.

Research on, and consideration of these factors may well make effort reduction – which should be gradual and progressive if unacceptable initial losses are to be avoided – a much more attractive prospect than has hitherto been the case in the majority of fisheries that have to be managed.

Table 8.1. - BRPs for fishing mortality estimated from XSA results.

Functional Unit		F_{bar}	SSB/R based			Y/R based	
			F_{high}	F_{med}	F_{low}	F_{max}	$F_{0.1}$
FU 5 - Botney Gut	males	*0.270*	*0.423*	*0.385*	*0.161*	*0.803*	*0.254*
	females	*0.177*	*0.196*	*0.174*	*0.119*	*1.795*	*0.190*
FU 6 - Farn Deeps	males	0.526	0.954	0.530	0.424	0.385	0.190
	females	0.181	0.303	0.209	0.163	4.429	0.134
FU 8 - Firth of Forth	males	0.852	1.007	0.714	0.527	0.416	0.206
	females	0.249	0.279	0.180	0.152	0.702	0.180
FU 9 - Moray Firth	males	0.709	0.899	0.557	0.317	0.508	0.238
	females	*0.107*	*0.166*	*0.136*	*0.055*	*1.167*	*0.207*
FU 11 - North Minch	males	0.766	1.105	0.928	0.593	0.491	0.233
	females	0.187	0.620	0.377	0.251	0.627	0.181
FU 12 - South Minch	males	*0.721*	*0.963*	*0.759*	*0.531*	*0.488*	*0.220*
	females	*0.210*	*0.590*	*0.478*	*0.382*	*0.667*	*0.190*
FU 13 - Firth of Clyde	males	0.899	0.847	0.731	0.369	0.360	0.199
	females	*0.088*	*0.148*	*0.110*	*0.079*	*0.400*	*0.153*
FU 15 - Irish Sea West	males	*0.755*	*1.800*	*1.136*	*0.932*	*0.453*	*0.230*
	females	*0.650*	*0.890*	*0.750*	*0.592*	*0.387*	*0.177*
FUs 20-22 - Celtic Sea	males	*0.494*	*0.590*	*0.529*	*0.422*	*0.408*	*0.220*
	females	*0.459*	*0.406*	*0.343*	*0.326*	*0.532*	*0.181*
FUs 23-24 - Bay of Biscay	males	*1.015*	*2.905*	*1.436*	*1.064*	*0.507*	*0.275*
	females	*0.423*	*0.792*	*0.669*	*0.576*	*0.347*	*0.178*
FUs 28-29 - SW & S Portugal	males	*0.460*	*0.563*	*0.490*	*0.350*	*0.423*	*0.206*
	females	*0.260*	*0.259*	*0.212*	*0.058*	*1.733*	*0.307*

Figures in italics are from assessments that are considered being of questionable quality.

Table 8.2. - BRPs for fishing mortality estimated from XSA results, scaled relative to F_{bar}.

Functional Unit		SSB/R based			Y/R based	
		F_{high}	F_{med}	F_{low}	F_{max}	$F_{0.1}$
FU 5 - Botney Gut	males	*1.569*	*1.426*	*0.598*	*2.976*	*0.942*
	females	*1.107*	*0.981*	*0.671*	*10.143*	*1.074*
FU 6 - Farn Deeps	males	1.815	1.008	0.807	0.733	0.361
	females	1.669	1.151	0.901	24.413	0.741
FU 8 - Firth of Forth	males	1.182	0.838	0.619	0.489	0.242
	females	1.118	0.723	0.610	2.816	0.724
FU 9 - Moray Firth	males	1.268	0.786	0.447	0.716	0.336
	females	*1.563*	*1.273*	*0.516*	*10.960*	*1.944*
FU 11 - North Minch	males	1.442	1.211	0.774	0.641	0.304
	females	3.323	2.021	1.348	3.361	0.971
FU 12 - South Minch	males	*1.335*	*1.053*	*0.736*	*0.678*	*0.305*
	females	*2.815*	*2.279*	*1.820*	*3.183*	*0.906*
FU 13 - Firth of Clyde	males	0.942	0.814	0.410	0.400	0.221
	females	*1.683*	*1.260*	*0.899*	*4.565*	*1.749*
FU 15 - Irish Sea West	males	*2.384*	*1.504*	*1.234*	*0.600*	*0.304*
	females	*1.369*	*1.154*	*0.910*	*0.595*	*0.273*
FUs 20-22 - Celtic Sea	males	*1.195*	*1.070*	*0.855*	*0.826*	*0.444*
	females	*0.886*	*0.749*	*0.712*	*1.160*	*0.395*
FUs 23-24 - Bay of Biscay	males	*2.863*	*1.415*	*1.049*	*0.500*	*0.271*
	females	*1.873*	*1.583*	*1.363*	*0.822*	*0.422*
FUs 28-29 - SW & S Portugal	males	*1.223*	*1.065*	*0.760*	*0.919*	*0.448*
	females	*0.995*	*0.815*	*0.222*	*6.666*	*1.183*

Figures in italics are from assessments that are considered being of questionable quality.

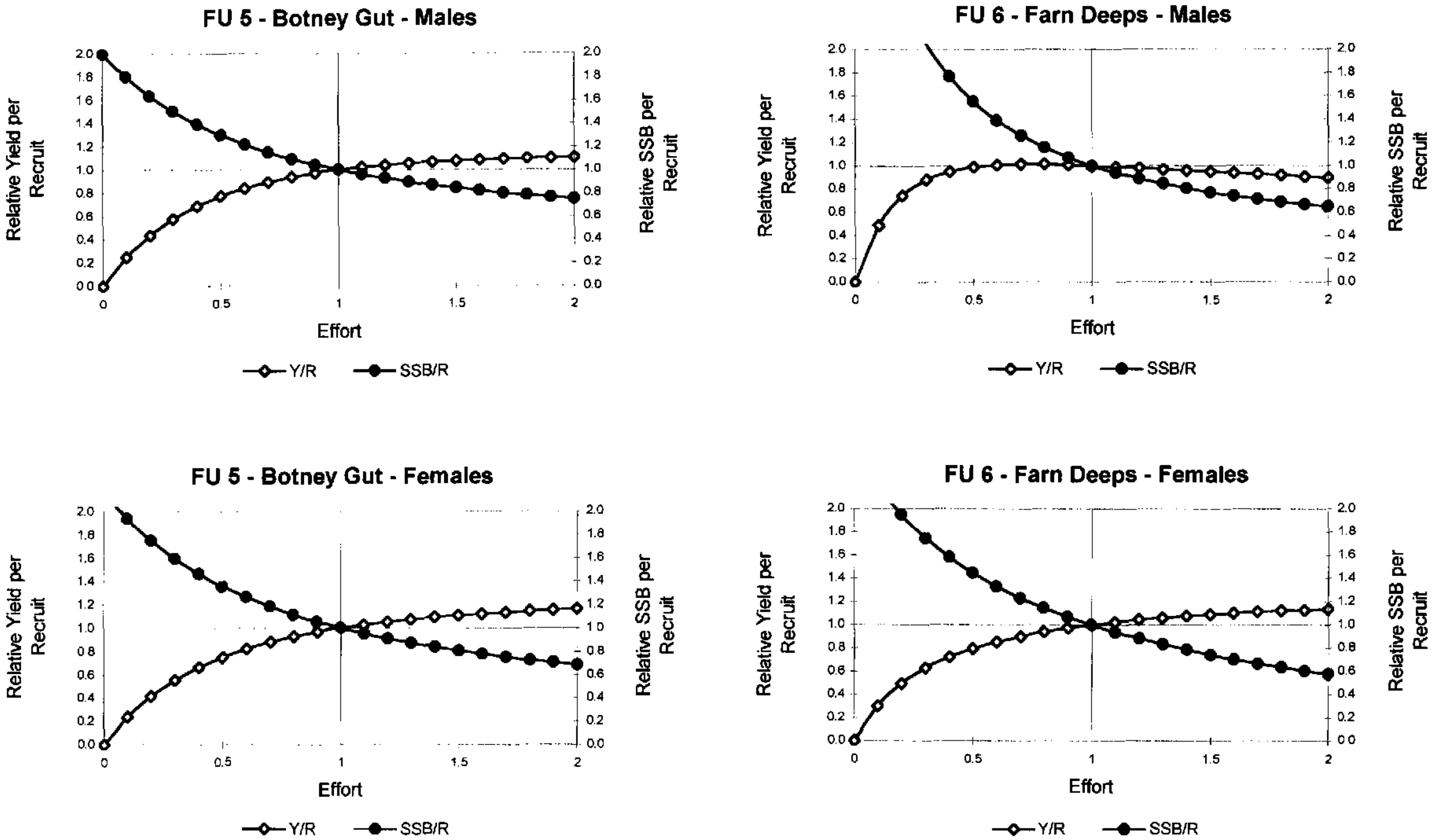


Figure 8.1. (a) - Yield per recruit and spawning stock biomass per recruit plots based on XSA results.

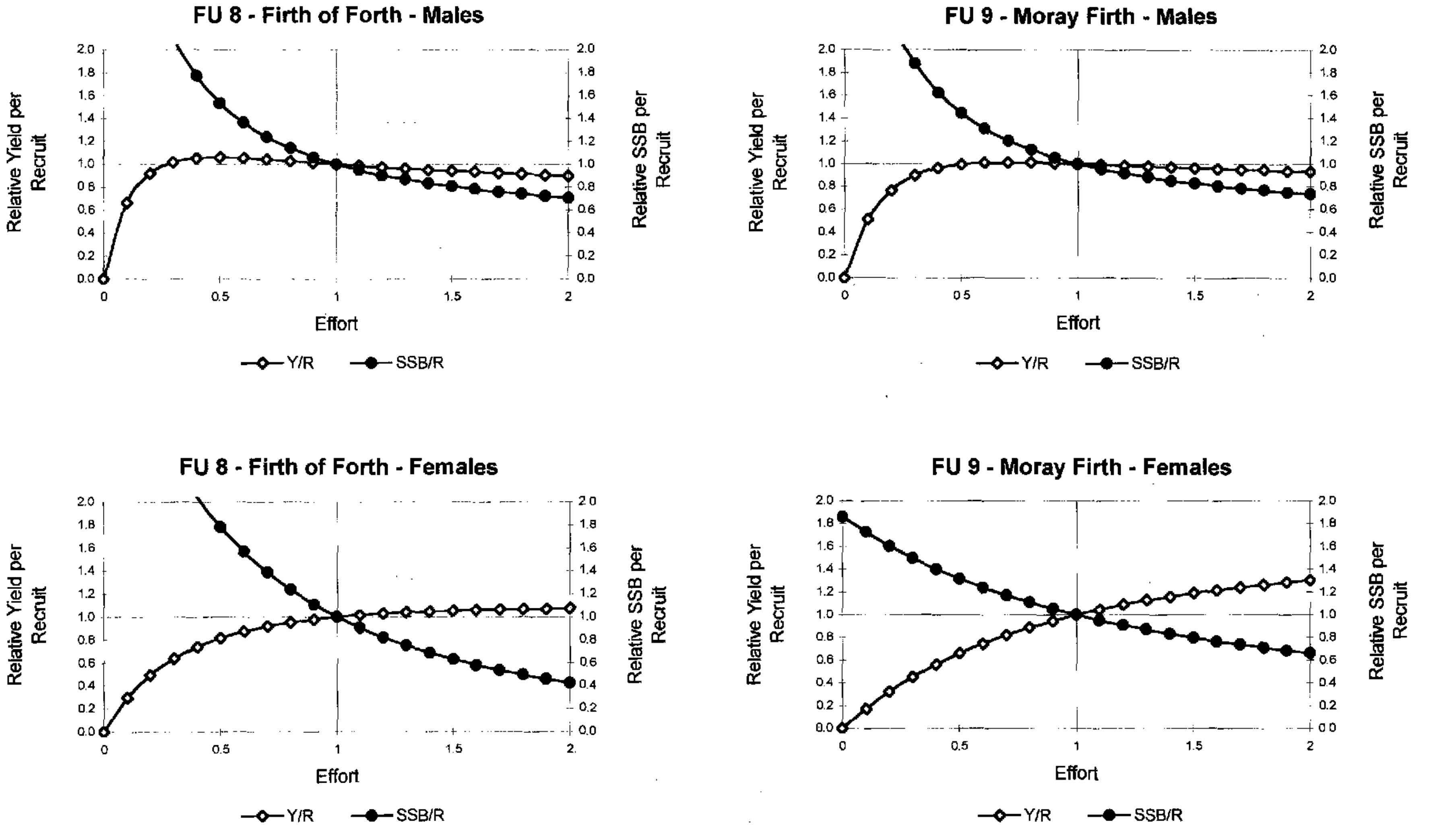


Figure 8.1. (b) - Yield per recruit and spawning stock biomass per recruit plots based on XSA results.

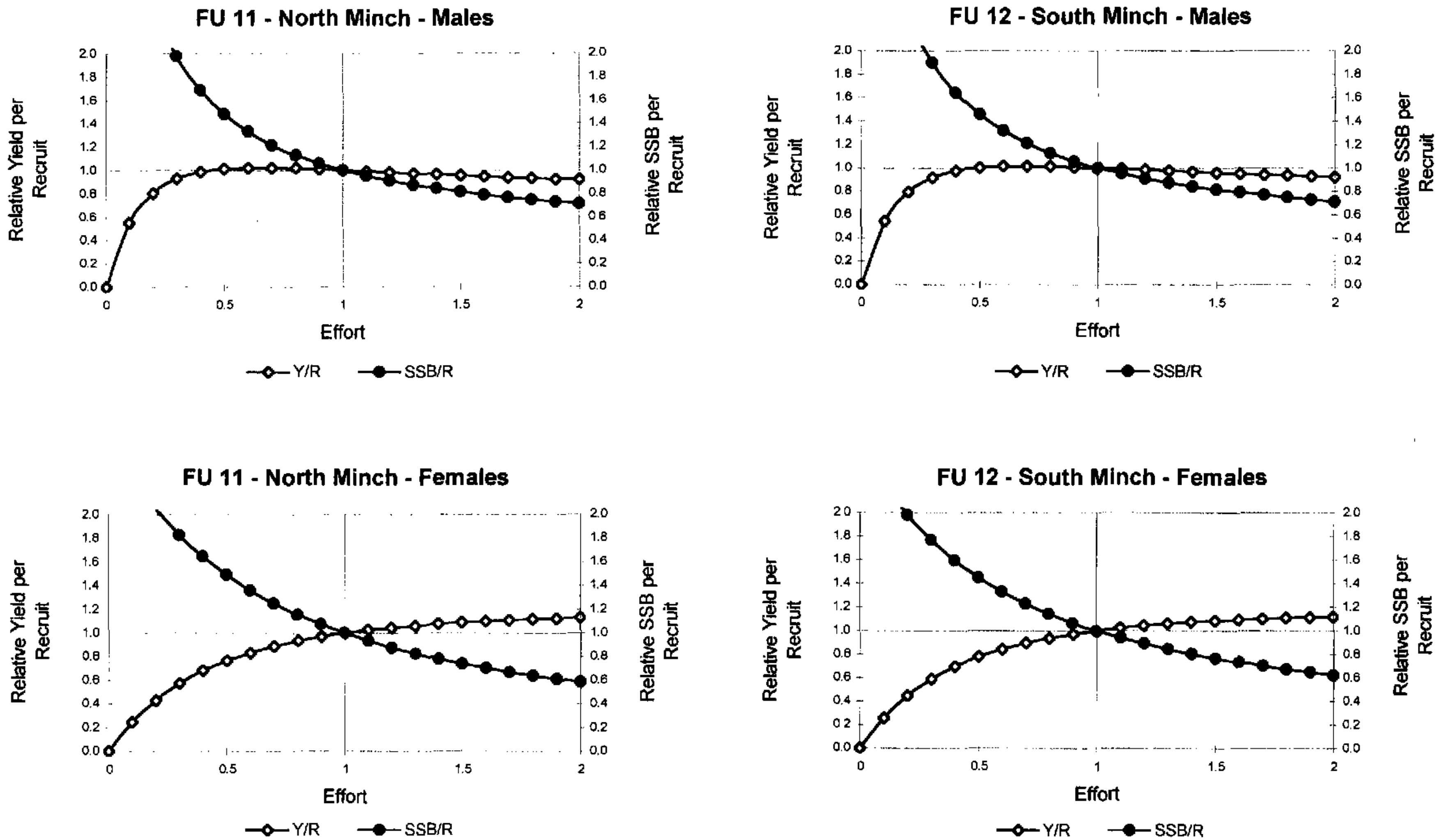


Figure 8.1. (c) - Yield per recruit and spawning stock biomass per recruit plots based on XSA results.

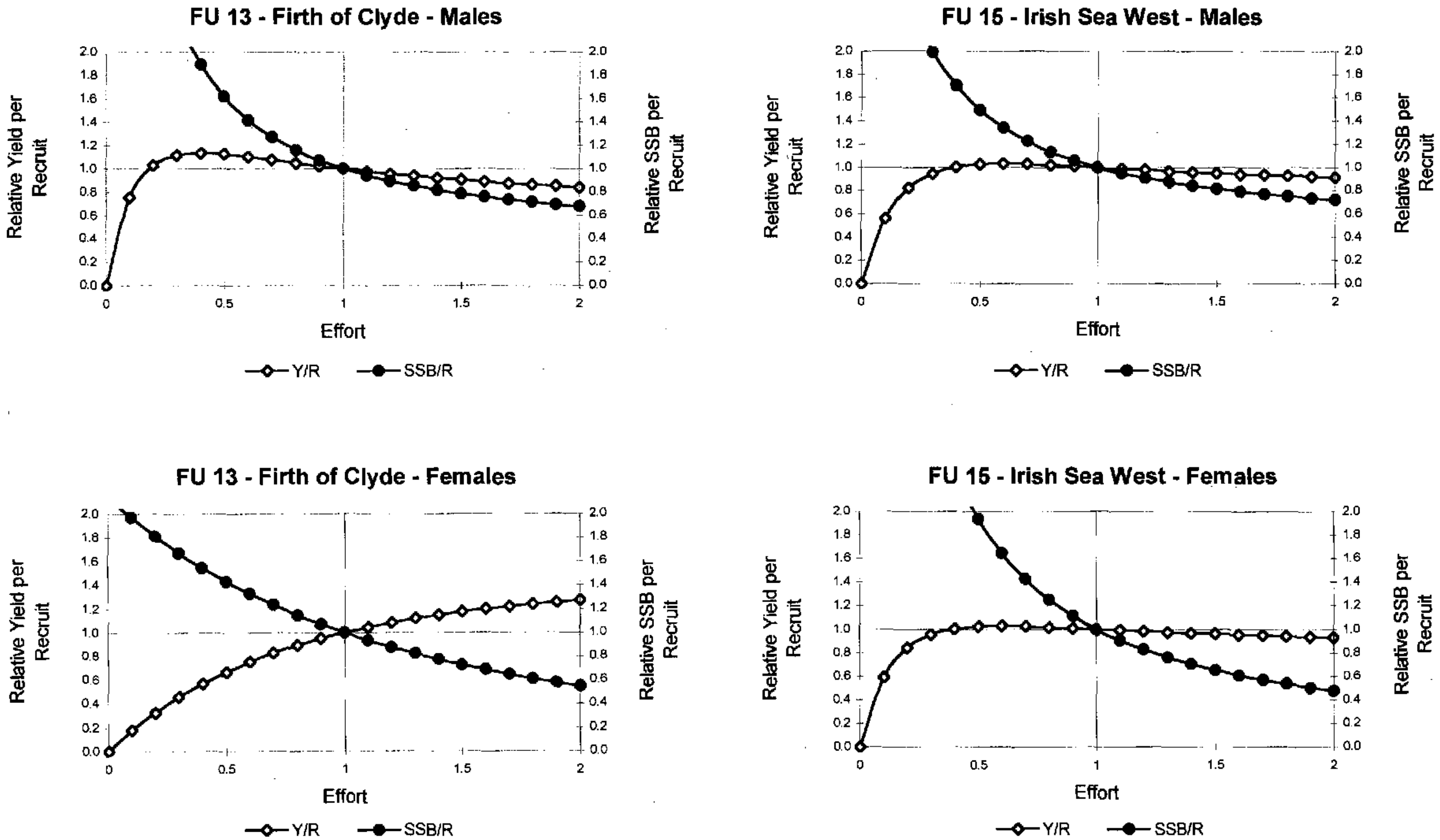


Figure 8.1. (d) - Yield per recruit and spawning stock biomass per recruit plots based on XSA results.

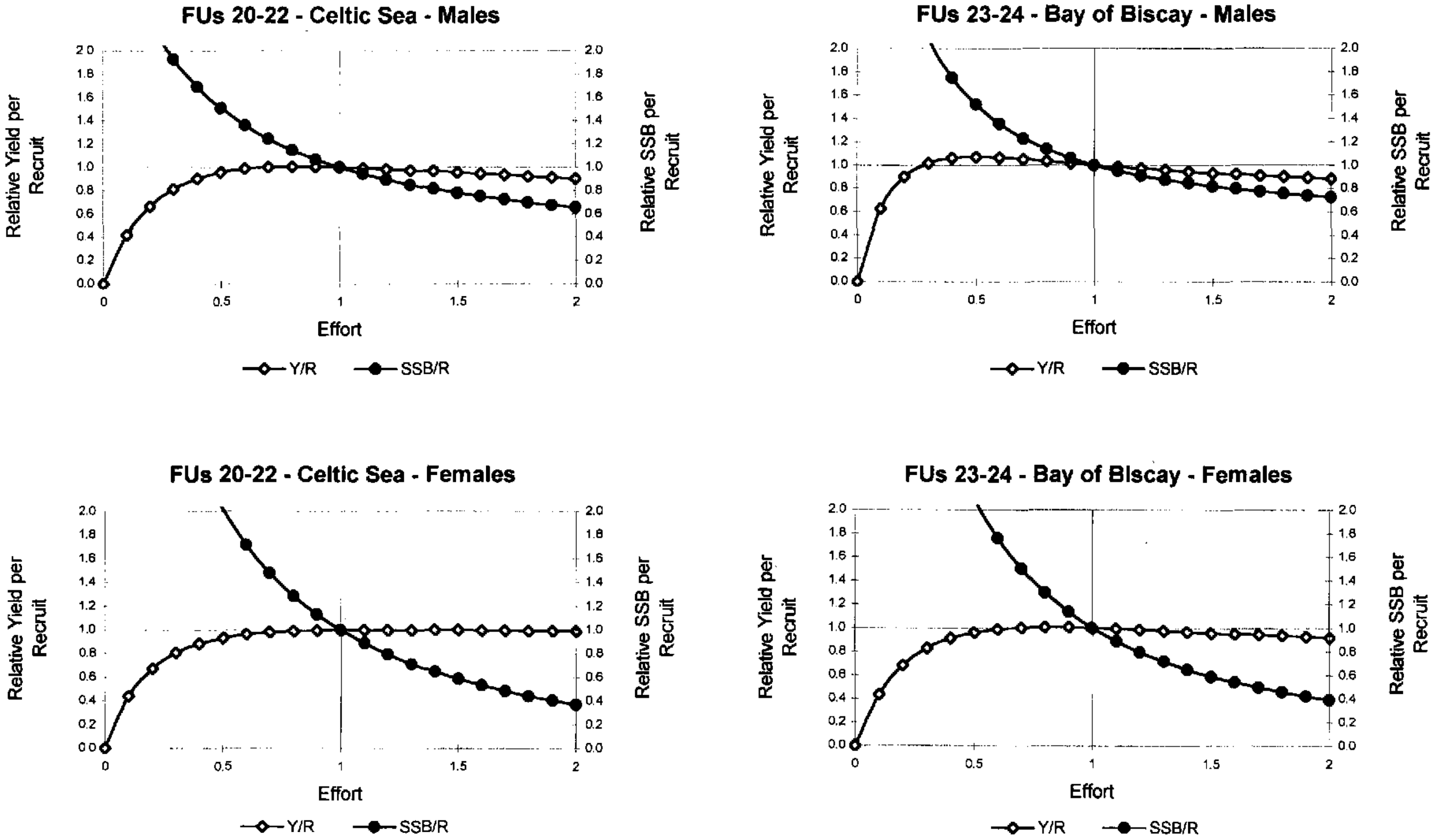
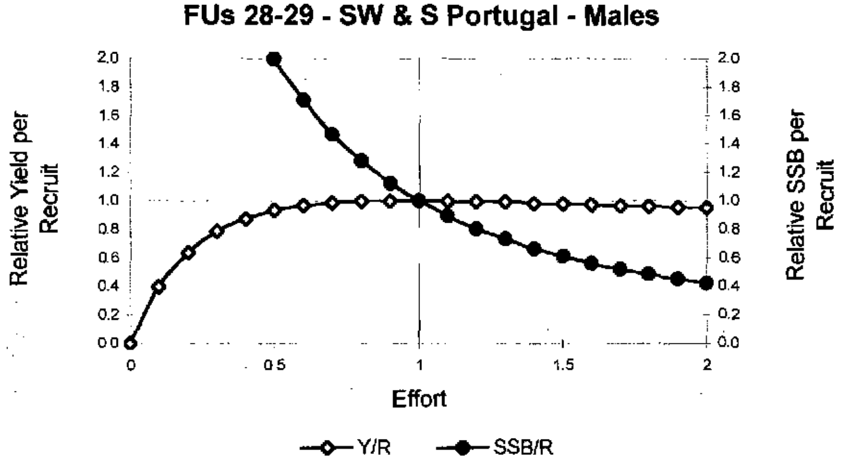


Figure 8.1. (e) - Yield per recruit and spawning stock biomass per recruit plots based on XSA results.



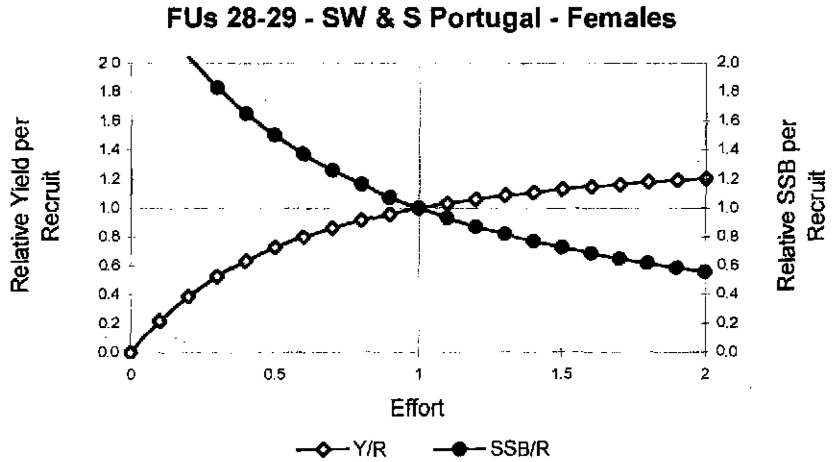


Figure 8.1. (f) - Yield per recruit and spawning stock biomass per recruit plots based on XSA results.

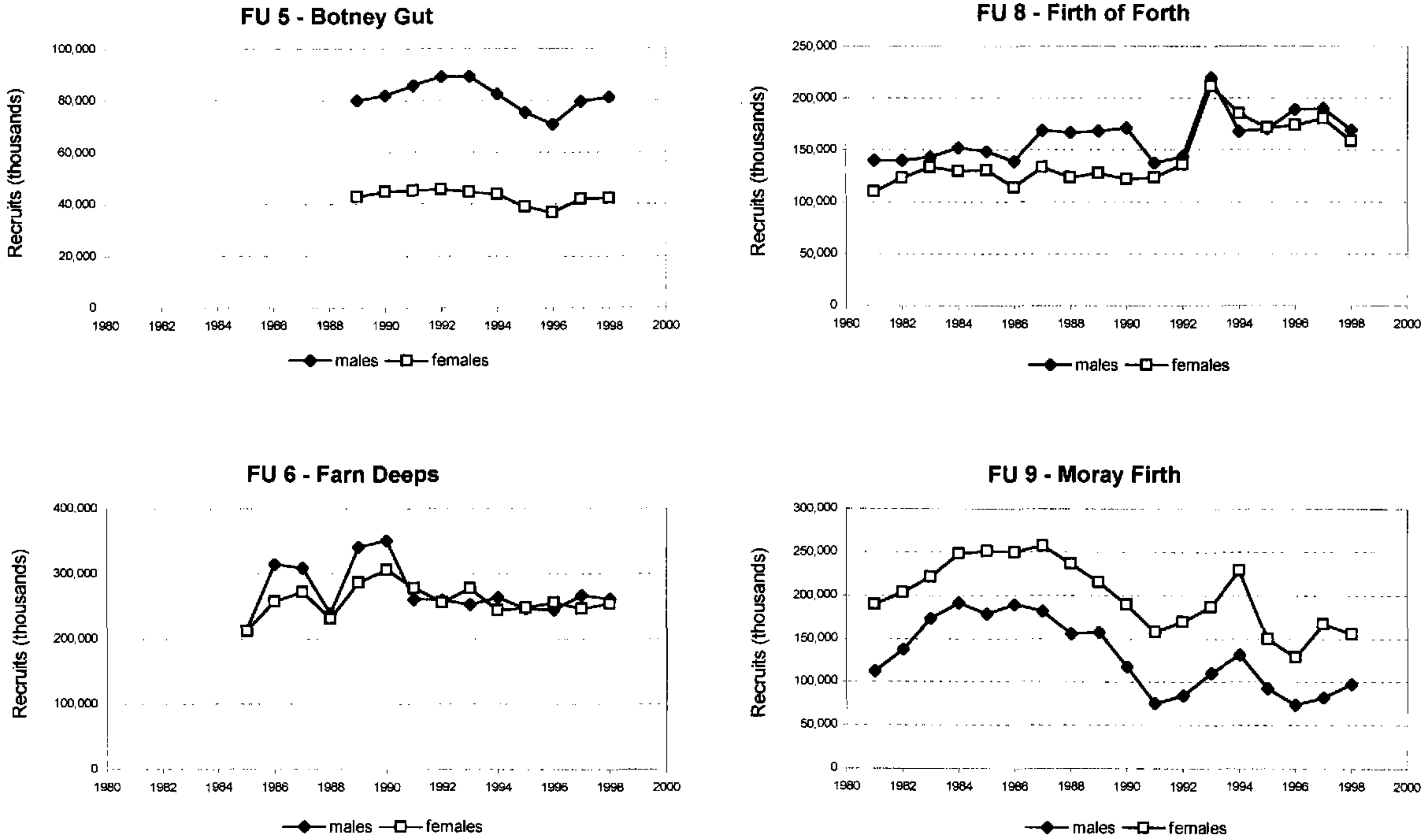


Figure 8.2. (a) - Trends in recruitment estimated from XSA.

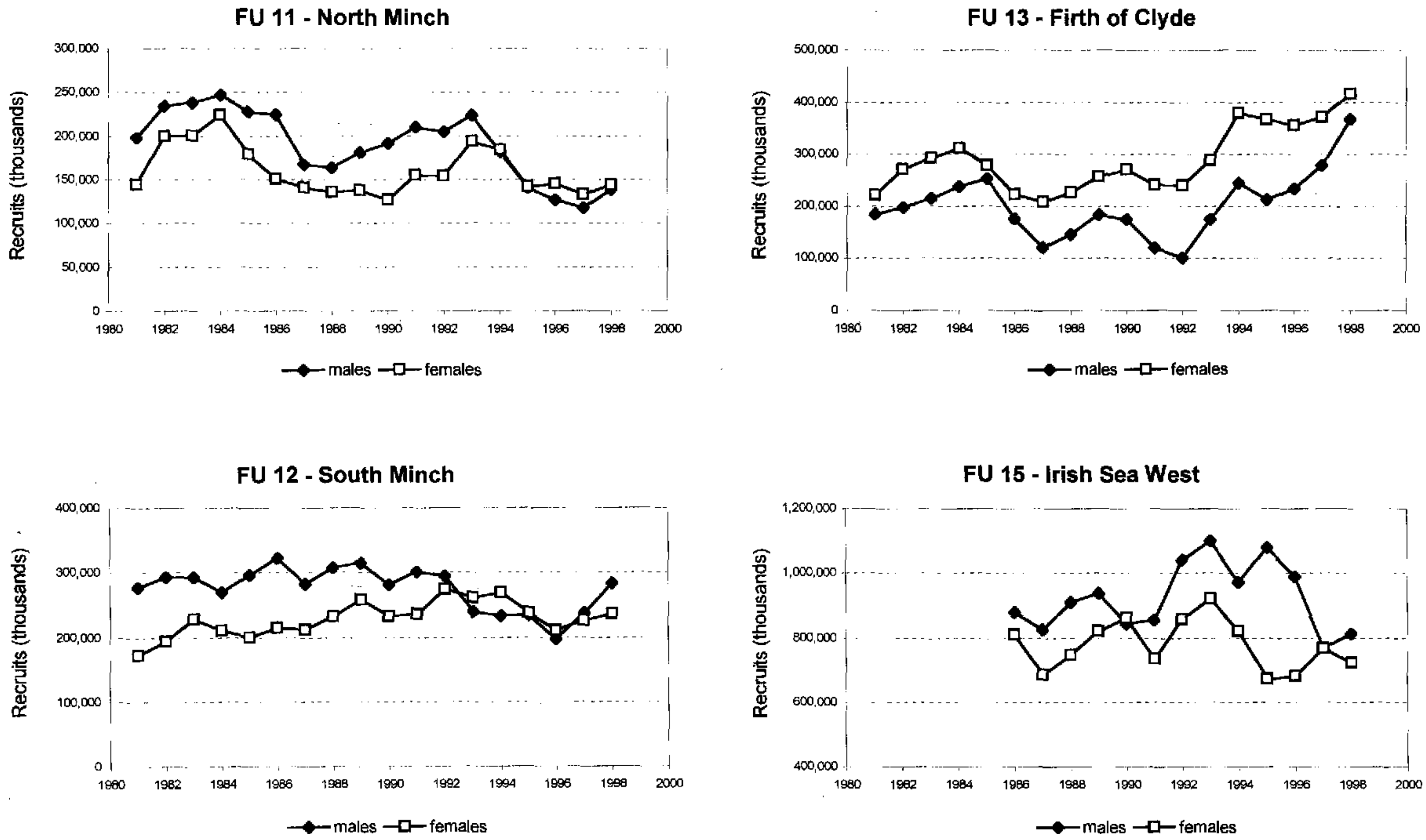


Figure 8.2. (b) - Trends in recruitment estimated from XSA.

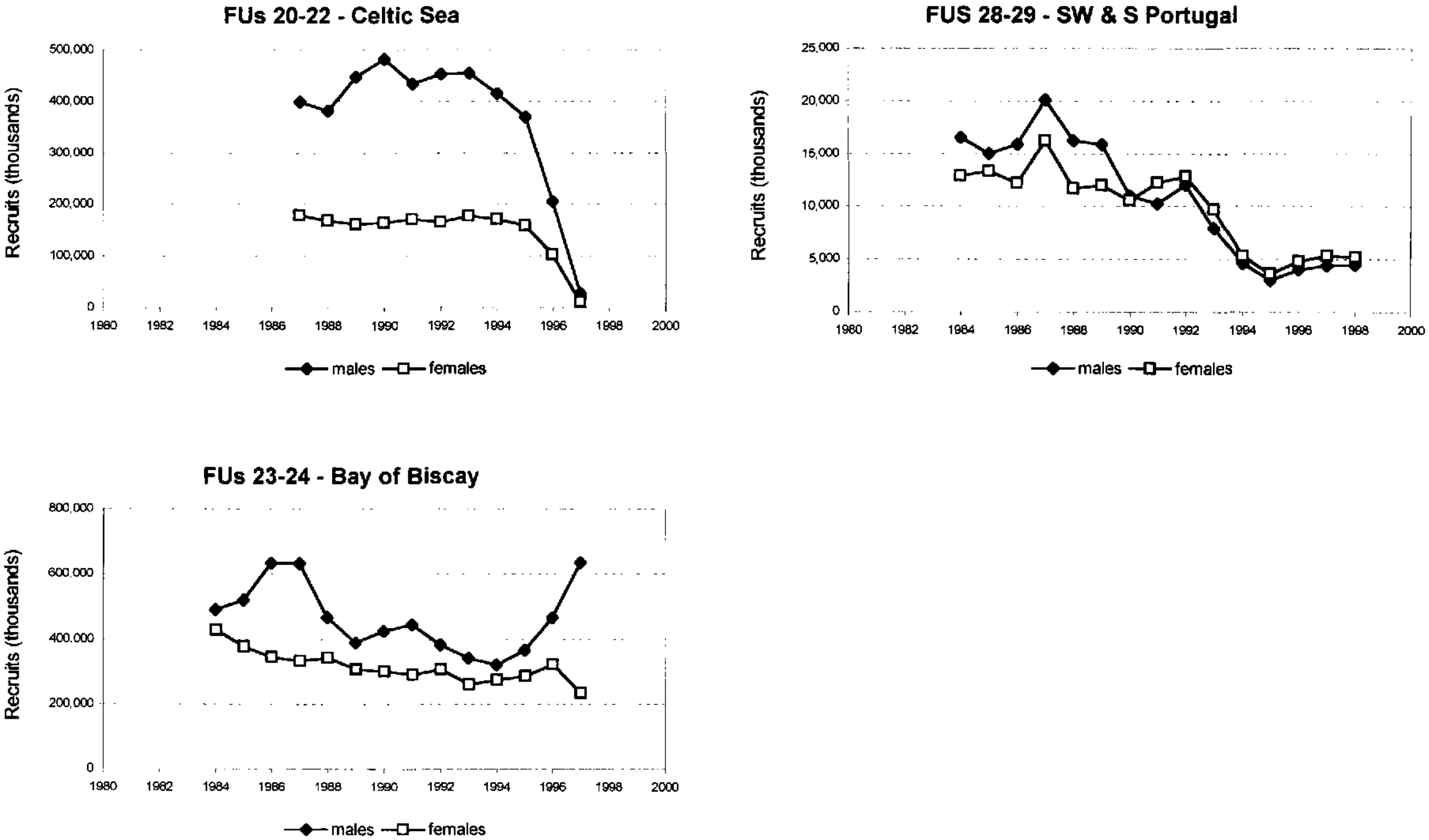


Figure 8.2. (c) - Trends in recruitment estimated from XSA.

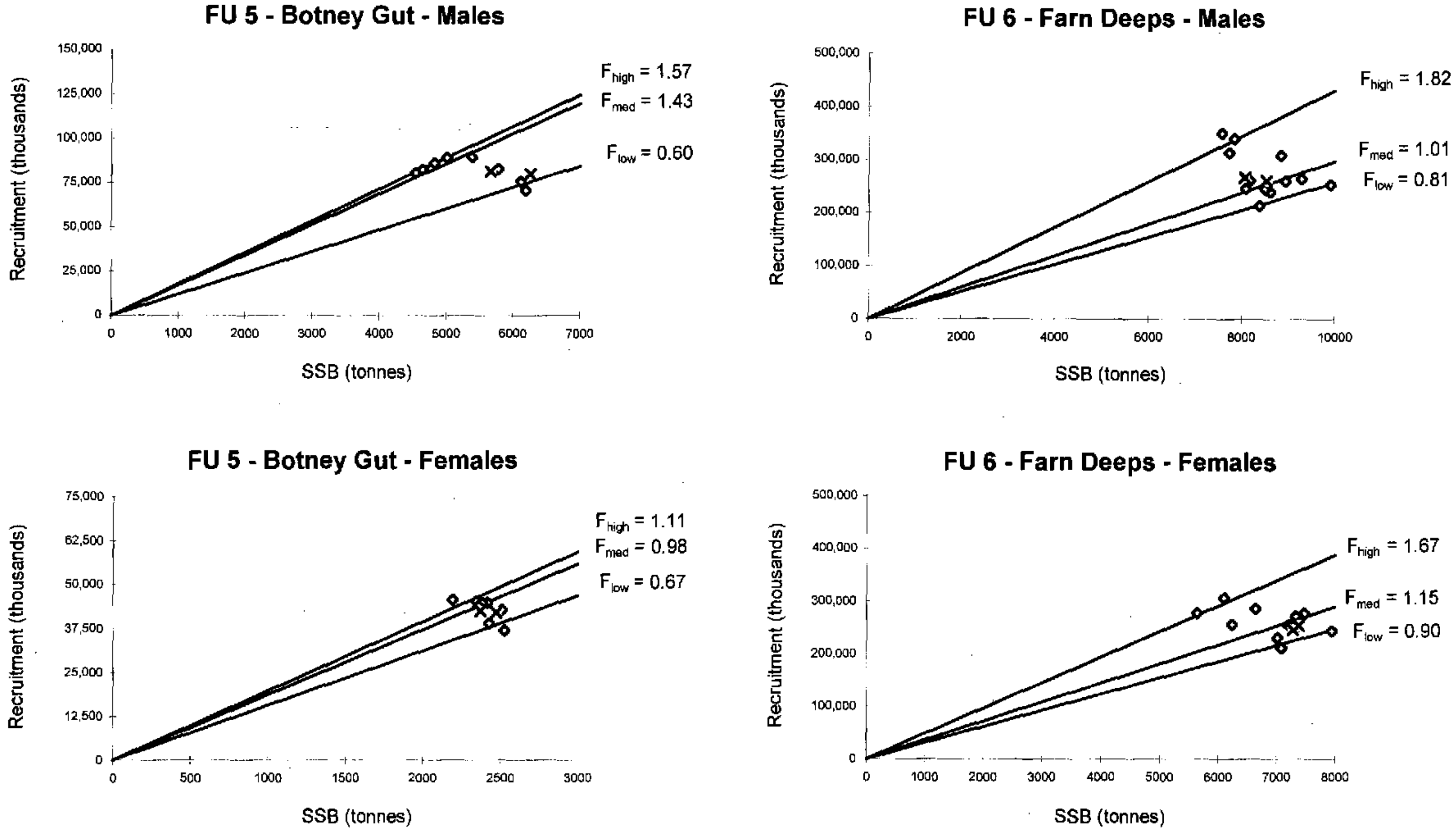


Figure 8.3. (a) - Stock-recruitment plots and associated BRPs.
Lines represent ratios of recruitment to SSB corresponding to the BRP estimates.
SSB and recruitment estimates for the last two years (marked as x) were excluded from estimation of BRPs.

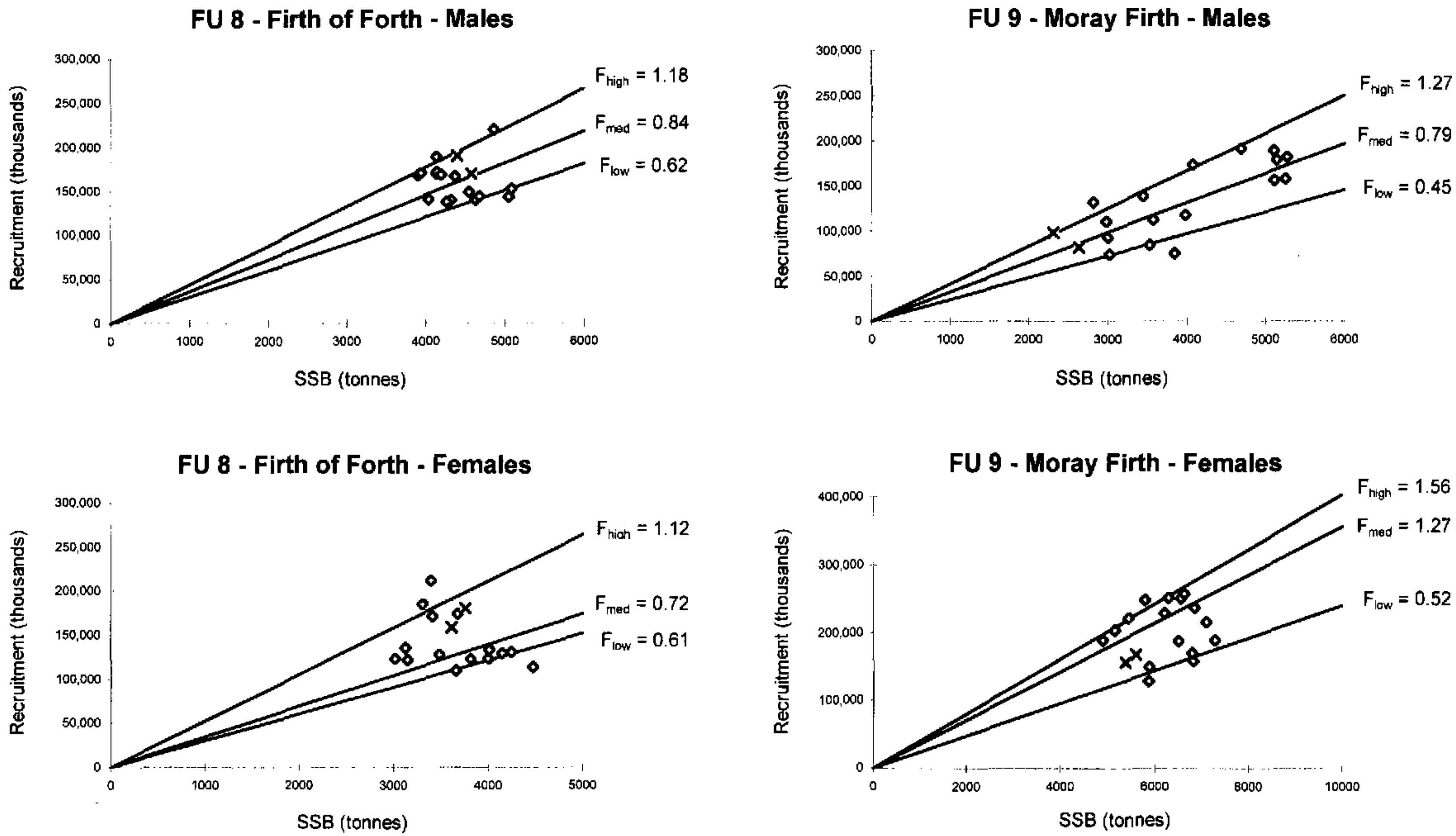


Figure 8.3. (b) - Stock-recruitment plots and associated BRPs.
Lines represent ratios of recruitment to SSB corresponding to the BRP estimates.
SSB and recruitment estimates for the last two years (marked as x) were excluded from estimation of BRPs.

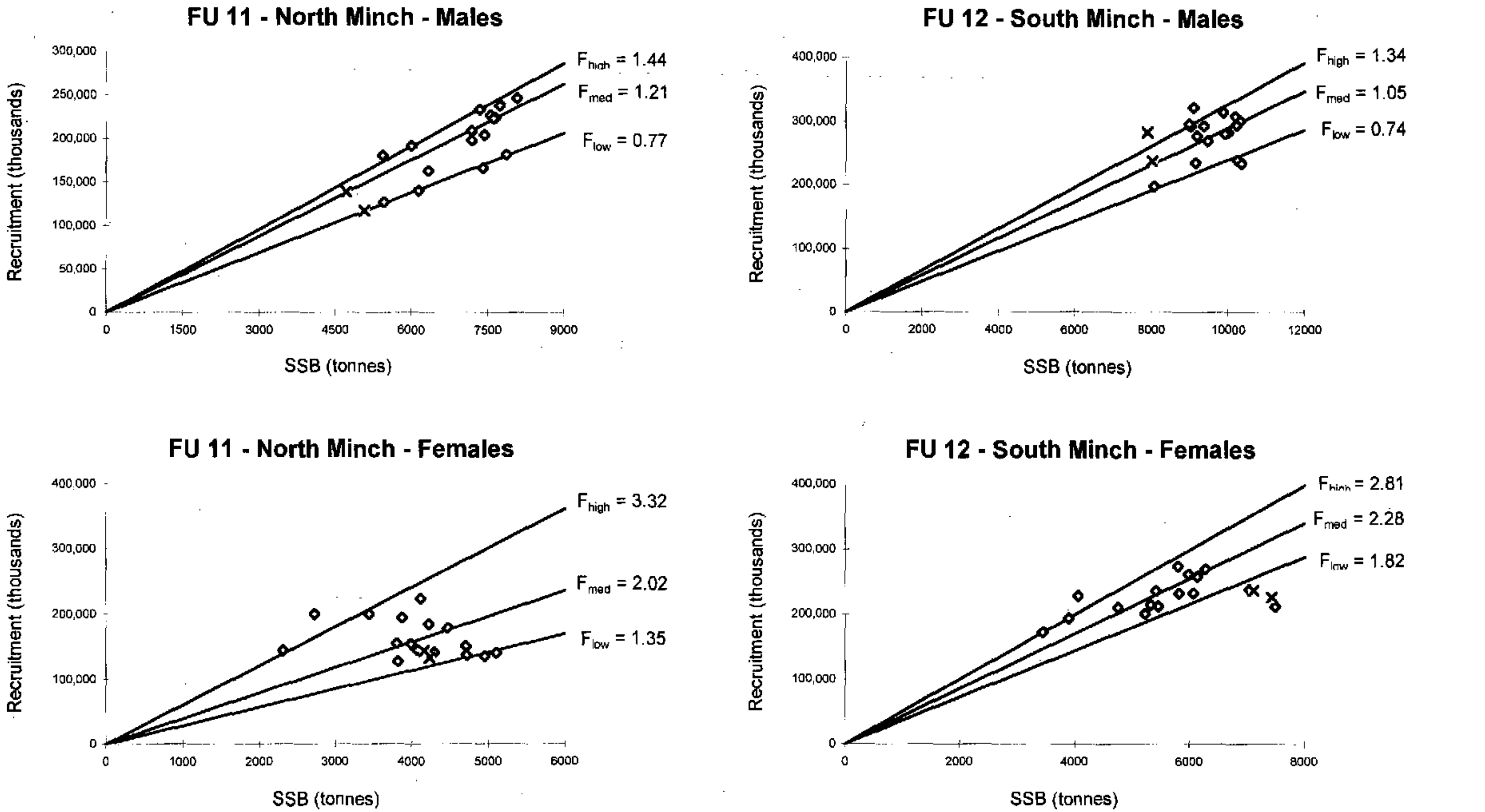


Figure 8.3. (c) - Stock-recruitment plots and associated BRPs.
Lines represent ratios of recruitment to SSB corresponding to the BRP estimates.
SSB and recruitment estimates for the last two years (marked as x) were excluded from estimation of BRPs.

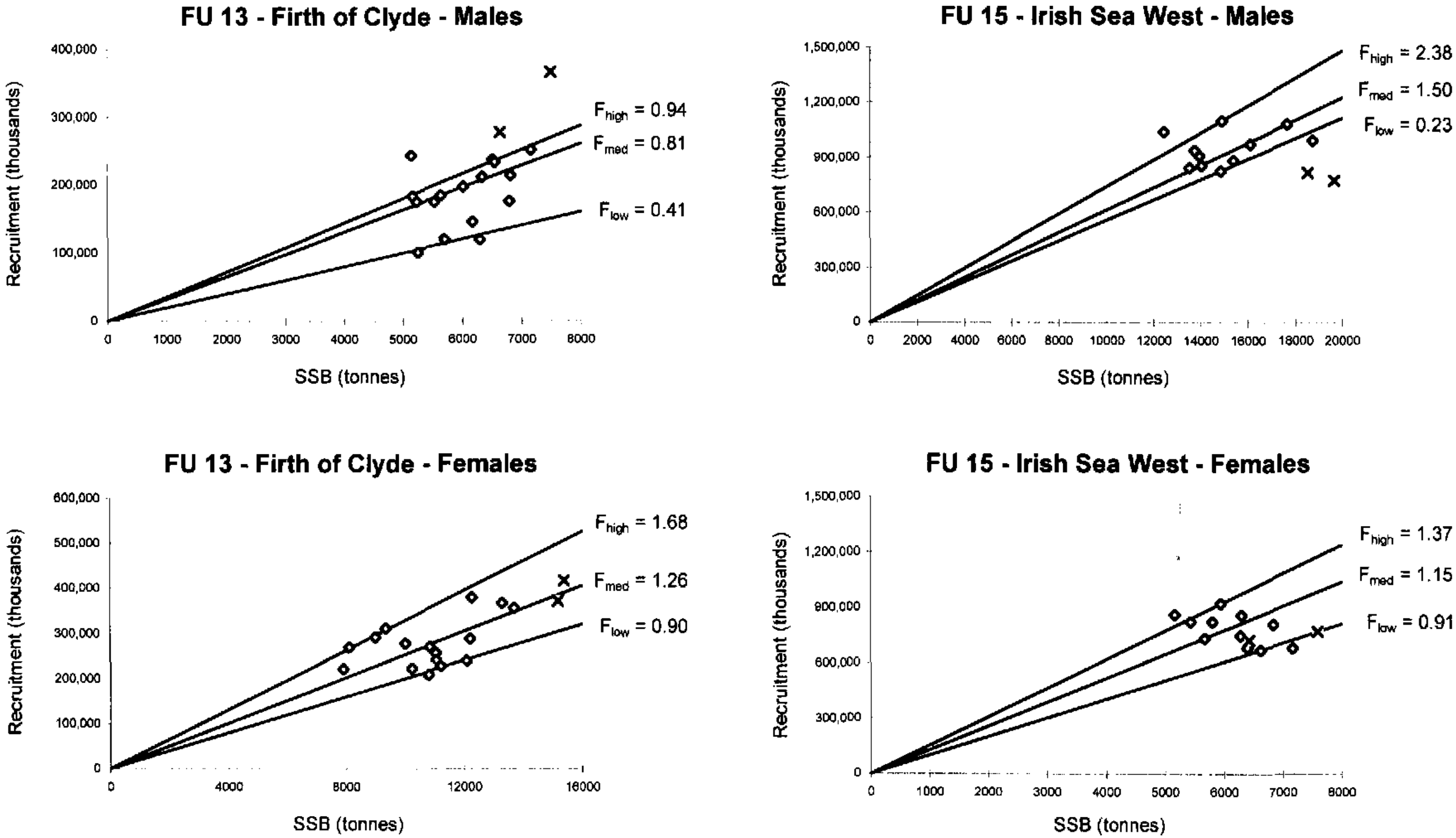


Figure 8.3. (d) - Stock-recruitment plots and associated BRPs.
Lines represent ratios of recruitment to SSB corresponding to the BRP estimates.
SSB and recruitment estimates for the last two years (marked as x) were excluded from estimation of BRPs.

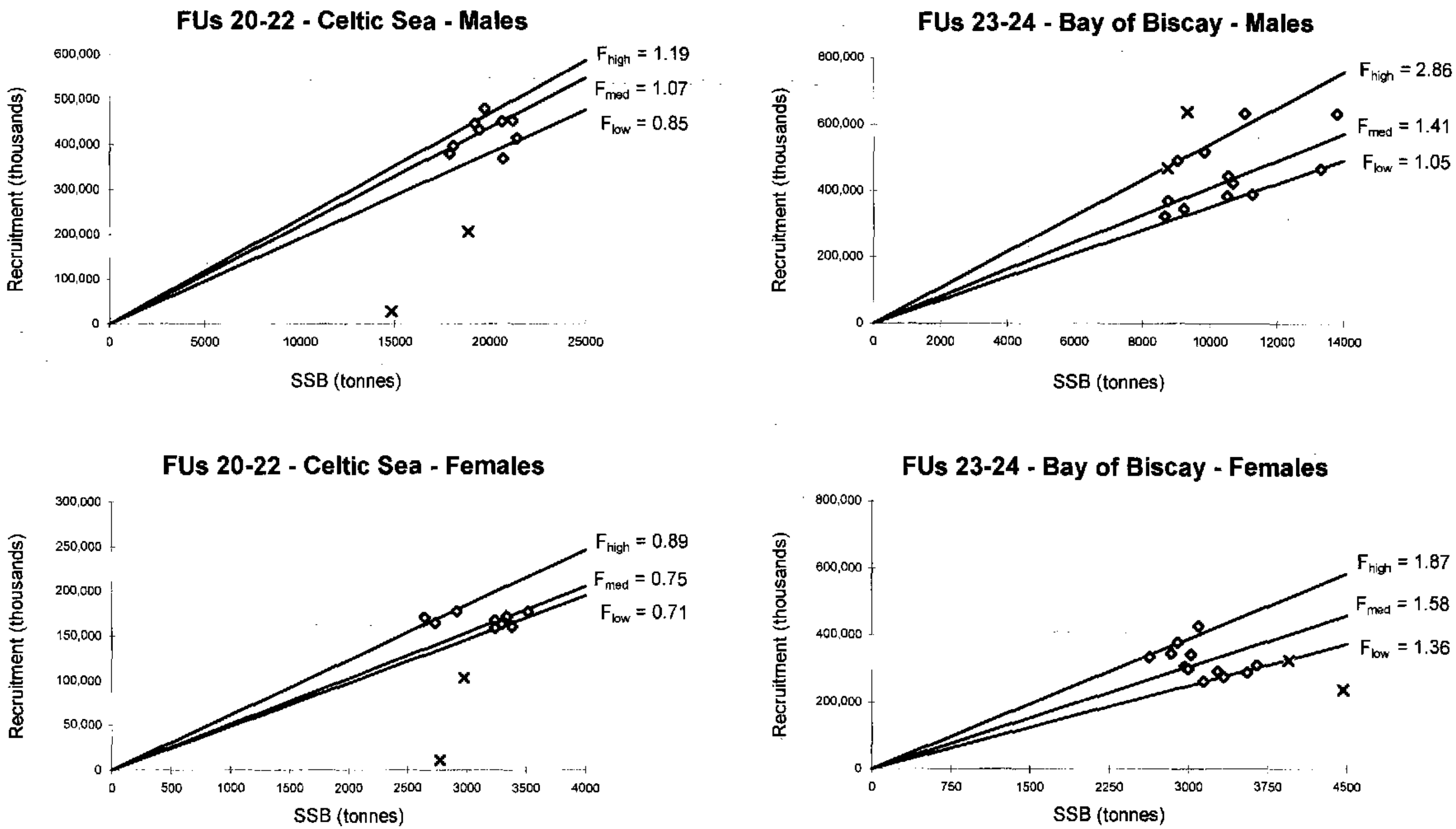
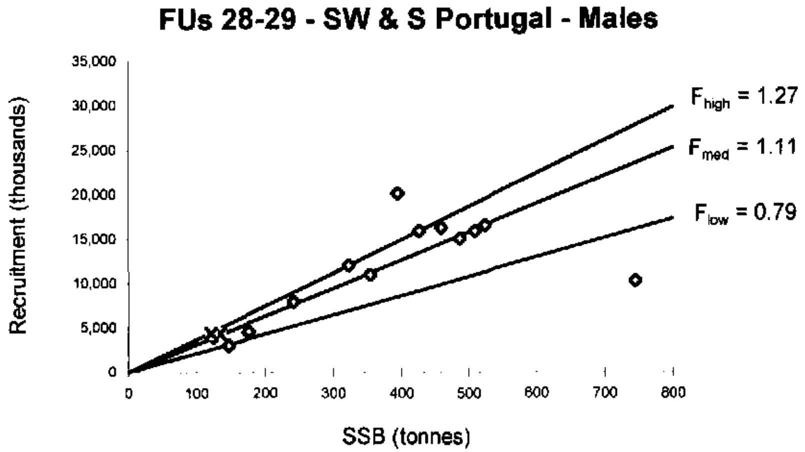


Figure 8.3. (e) - Stock-recruitment plots and associated BRPs.
Lines represent ratios of recruitment to SSB corresponding to the BRP estimates.
SSB and recruitment estimates for the last two years (marked as x) were excluded from estimation of BRPs.



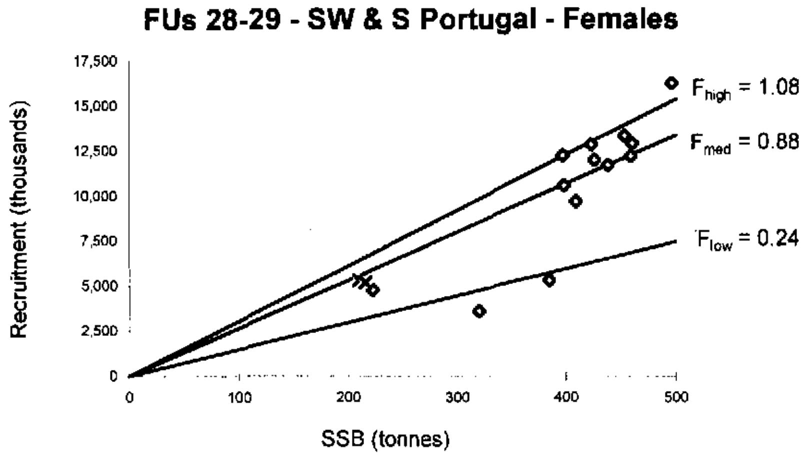


Figure 8.3. (f) - Stock-recruitment plots and associated BRPs.
Lines represent ratios of recruitment to SSB corresponding to the BRP estimates.
SSB and recruitment estimates for the last two years (marked as x) were excluded from estimation of BRPs.

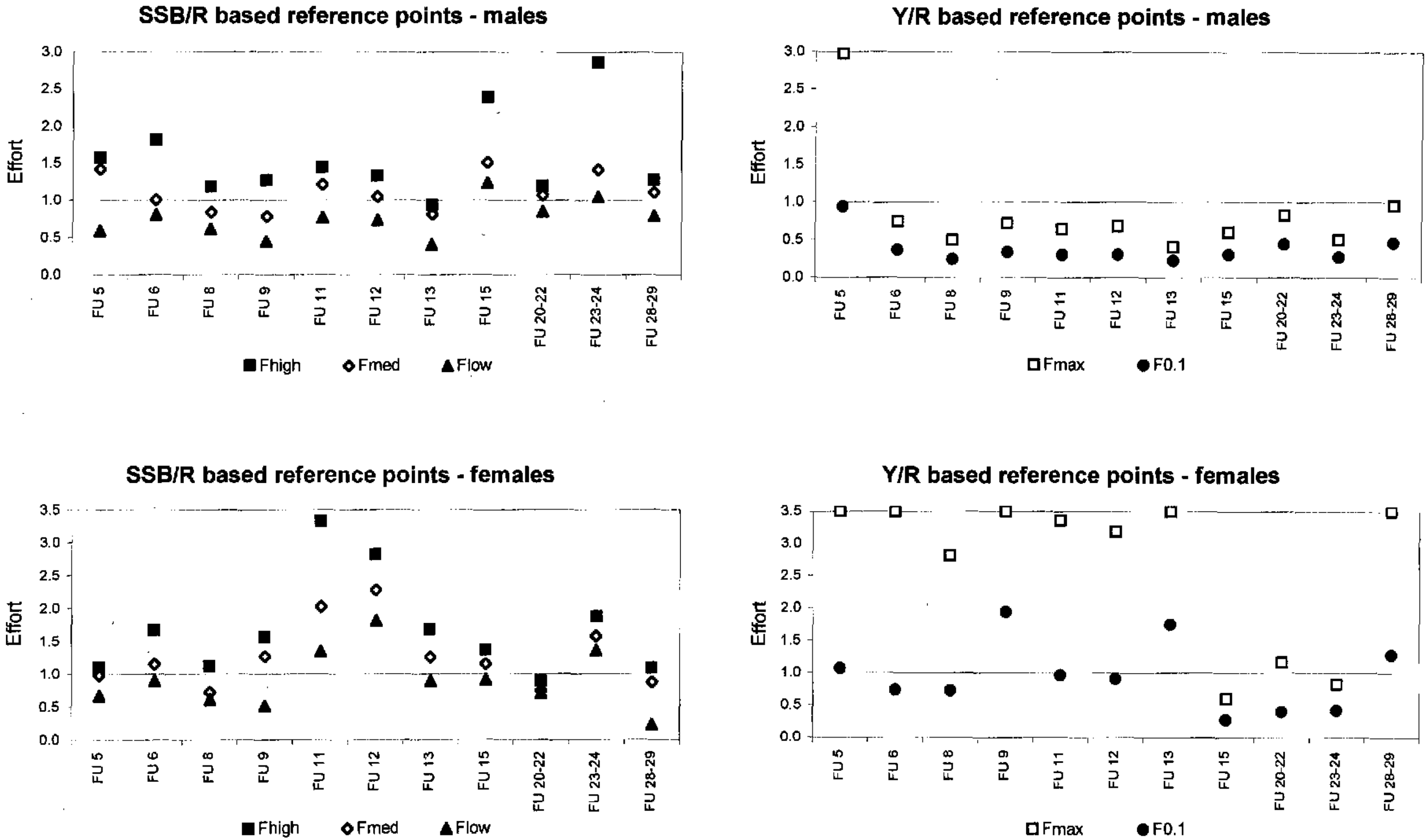


Figure 8.4. - BRPs for fishing mortality estimated from XSA results, shown in relation to current effort level.

9. Discards

The *Nephrops* Working Group was asked to update information on quantities of discards by gear type and area for the stocks of *Nephrops* and fisheries considered by this group (OSPAR Resolution 1997/5:3) (see Section 1.).

A summary of the availability of discard sampling data on the *Nephrops* fisheries is given in Table 9.1. This identifies the availability of *Nephrops*, commercial fish, non-commercial fish and benthos discard data, by *Nephrops* Management Area and/or Functional Unit (FU). In nearly all cases, the benthos is not recorded. Only in Scotland, Spain and Portugal are the non-commercial discards sampled. In Scotland, the fish discards are collected specifically for the ICES area-based fish assessment Working Groups, and are aggregated to match fish stock assessment areas. These data are available from the Northern Shelf, Southern Shelf and North Sea Demersal Working Groups, and from the various Pelagic Working Groups.

9.1. *Nephrops* discards

The WG updated the information on the quantities of *Nephrops* landed and discarded, using the inputs to the length cohort assessments (LCA). Length frequency distributions of the landings and the discards and of the total catches (= landings + discards), averaged over the reference period of the LCA (anything between the past 2-5 years) are given by FU, for males and females separately (Figures 9.1. to 9.15.). FUs are arranged in numerical order, and not by ICES Division and Management Area, as is the case in Section 5. Some FUs are missing from this overview, either because the data base was insufficient to run an LCA, or because the WG decided not to repeat the assessments performed at it's 1997 meeting.

Details of the *Nephrops* sampling procedures used by different countries are given in the 1996 Report of the *Nephrops* Study Group (ICES, 1996b), and updated information on the sampling levels in 1997-98 in Sections 5.2.-5.20. (see paragraphs 'Data and biological inputs for analytical assessments' and tables 'Input data and parameters'). Current sampling programmes mainly target *Nephrops* directed vessels. While *Nephrops* landings are nearly always adequately sampled, discards have to be sampled at sea, and this has resourcing implications which limit the frequency of sampling. For many stocks, the discards have to be estimated from data collected in a limited number of years, which are then extrapolated to the years with no discard samples. This bears the risk of levelling off year-to-year variations in the discards due to e.g. variations in recruitment or changes in discarding practices (which are often related to the availability of *Nephrops* on the grounds, the composition of the catches or market conditions).

The numbers discarded at length, shown in Figures 9.1. to 9.15., are the numbers actually discarded (dead or alive), and not the numbers removed from the population as a consequence of discarding. The removals-at-length (= landings + dead discards) can also be found in Sections 5.2.-5.20. (see tables 'LCA output males' and 'LCA output females', 2nd column, which gives the removals-at-length, averaged over the reference period of the LCA).

Additional information on the composition of the *Nephrops* discards can be found in several FU sections. The amounts of juvenile *Nephrops* discarded, and their size distributions, can be seen as an index of recruitment, and this information has been used for a number of FUs in the non-analytical assessments of the state of the stocks. (see e.g. FUs 3-4; Section 5.2.). For some stocks, comparative information is included on the length distributions of the discards in different years (see e.g. FUs 20-22; Section 5.15. and FUs 23-24; Section 5.16.).

9.2. Fish discards

Due to time constraints, the WG was unable to review the existing information on the discards of fish (and invertebrates) in the *Nephrops* fisheries.

Attention can be drawn however, to the results of a recently completed, EU-funded study on the fish discards in a large number of mostly demersal fisheries around Europe (COTTER *et al.*, 1999), amongst which several *Nephrops* directed and mixed *Nephrops*-whitefish fisheries:

- The Danish *Nephrops* fisheries in the Skagerrak and the North Sea (PRINCE, 1999).
- The Scottish *Nephrops* fisheries in the North Sea and West of Scotland (REEVES, 1999).
- The English *Nephrops* fisheries in the Southern North Sea (COTTER *et al.*, 1999).
- The Northern Ireland *Nephrops* fisheries in the Irish Sea (ARMSTRONG *et al.*, 1999).
- The Irish *Nephrops* fisheries (WHEATLEY and CONNOLLY, 1999).
- The French *Nephrops* and mixed *Nephrops*-whitefish fisheries in the Celtic Sea and the Northern Bay of Biscay (PERONNET, 1999).
- The Spanish mixed *Nephrops*-whitefish fisheries off Galicia (PEREZ, *et al.*, 1999 and TRUJILLO, *et al.*, 1999).

It should be remembered that the exploitation pattern generated on fish by *Nephrops* trawls is quite different from that generated by finfish gears. The *Nephrops* mesh size permitted is considerably smaller than that permitted for fish. In Regions 1 and 2, the *Nephrops* mesh size is 70 mm, while the fish mesh size ranges from 80 to 100 mm. In Region 3, the current *Nephrops* mesh size is 55 mm (though selective trawls with smaller mesh sizes are permitted), and the fish mesh size is 65 mm. These smaller mesh sizes are only permitted if certain catch composition conditions are met. EC Council Regulation 3094/86 specifies that a minimum of 30 % by weight in the retained catch must be *Nephrops*, and that the proportion of 'protected species' must not exceed 60 %. In the UK, national technical measures specify that square mesh panels of a mesh size of 80 mm (75 mm in Sub-area VII) must be fitted to *Nephrops* trawls. Square mesh panels allow small fish, particularly whiting and haddock, to escape before reaching the codend, and significantly reduce the quantities of small fish which have to be discarded.

With respect to the minimum mesh size for *Nephrops* trawls in Region 3, it is worth mentioning that the new technical measures issued by the EC, and coming into force in the year 2000, include an increase of the minimum mesh size from 55 to 70 or 80 mm (depending on the operational conditions and the gears used). This undoubtedly will have an effect on the volume and the composition of the catches, and hence of the discards, of the *Nephrops* trawlers operating in the area.

9.3. Research on discard reducing devices

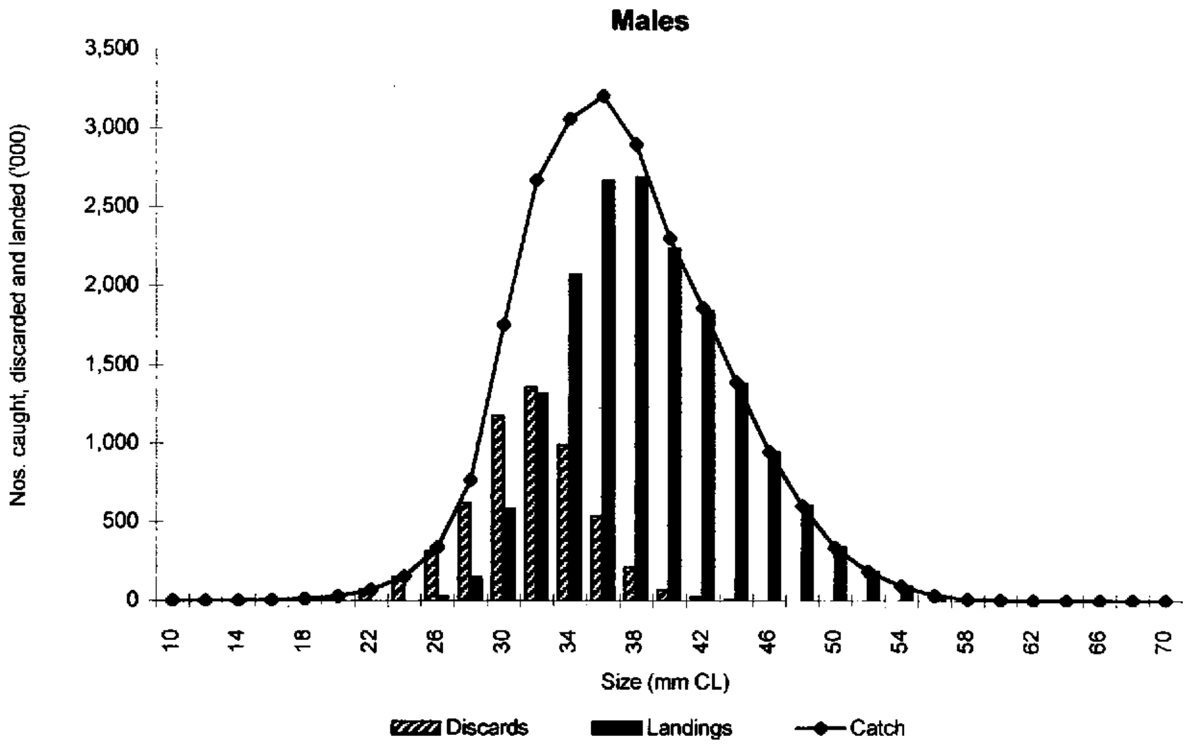
It is also worth reminding that in several countries, research is being done on the possibilities of improving the species- and size-selective properties of *Nephrops* trawls and of reducing the unwanted by-catches in the *Nephrops* fisheries. An example of this is the recently started, EU-funded project Netrasel, which aims at the development and optimisation of species- and size-selective grids for the *Nephrops* fisheries in, primarily, the North Sea and the Scottish waters.

Regular updates on the progress made in this field can be found in the biennial Reports of the *Nephrops* Study Group.

Table 9.1. - Discard data available for the *Nephrops* fisheries.

MA	Functional Unit	*Nephrops*	Commercial fish	Non-commercial Fish	Benthos
A	Iceland (FU 1)				
B	Faeroe Islands (FU 2)				
C	North Minch (FU 11)	Y	Y (*)	Y	N
	South Minch (FU 12)	Y	Y (*)	Y	N
	Clyde (FU 13)	Y	Y (*)	Y	N
D	None				
E	Skagerrak and Kattegat (FUs 3-4)	% of total catch	% of total catch	% of total catch	% of total catch
F	Moray Firth (FU 9)	Y	Y (*)	Y	N
	Noup (FU 10)	N	Y (*)	Y	N
G	Fladen (FU 7)	N	Y (*)	Y	N
H	Botney Gut (FU 5)	1993 only	1993 only	N	N
	Off Horn Reef (FU 33)	N	N	N	N
I	Farn Deeps (FU 6)	Y	Y (Gadoids)	N	N
	Firth of Forth (FU 8)	Y	Y (*)	Y	N
J	Irish Sea East (FU 14)	Y	Y	N	N
	Irish Sea West (FU 15)	N. Ireland Since 1986	N. Ireland Since 1996	N. Ireland Since 1996	N. Ireland Since 1996
		Rep. Ireland Weights and LFDs	Rep. Ireland Weights	Rep. Ireland Weights	Rep. Ireland Main species
K	None				
L	Porcupine Bank (FU 16)	1994 only (**)	1995 only (**)	1996 only (**)	1997 only (**)
	Aran Grounds (FU 17)	N	N	N	N
	Irish coast (FUs 18-19)	N	N	N	N
M	Celtic Sea (FUs 20-22)	1985, 91, 97	1985, 91, 97	N	N
N	Bay of Biscay (FUs 23-24)	1985, 91, 98	1985, 91, 98	N	N
O	North Galicia (FU 25)	1994 only (**)	1994 only (**)	1994 only (**)	1994 only (**)
	Cantabrian Sea (FU 31)	1994 only (**)	1994 only (**)	1994 only (**)	1994 only (**)
P	None				
Q	West Galicia (FU 26)	1994 only (**)	1994 only (**)	1994 only (**)	1994 only (**)
	North Portugal (FU 27)	N	Y	Y	N
	South West and South Portugal (FUs 28-29)	N	Y	Y	N
	Gulf of Cadiz (FU 30)	N	N	N	N
R	None				
S	Norwegian Deep (FU 32)	Y	Y	Y	N

(*) Data aggregated by SOAEFD stock monitoring section in a different way to the Nephrops FUs.
(**) Finfish trawls in Sub-areas VIIc,h,j,k. Based on onboard samplings by observers.
(***) Trawls in Sub-areas VIIIc and IXa. Based on onboard samplings by observers.



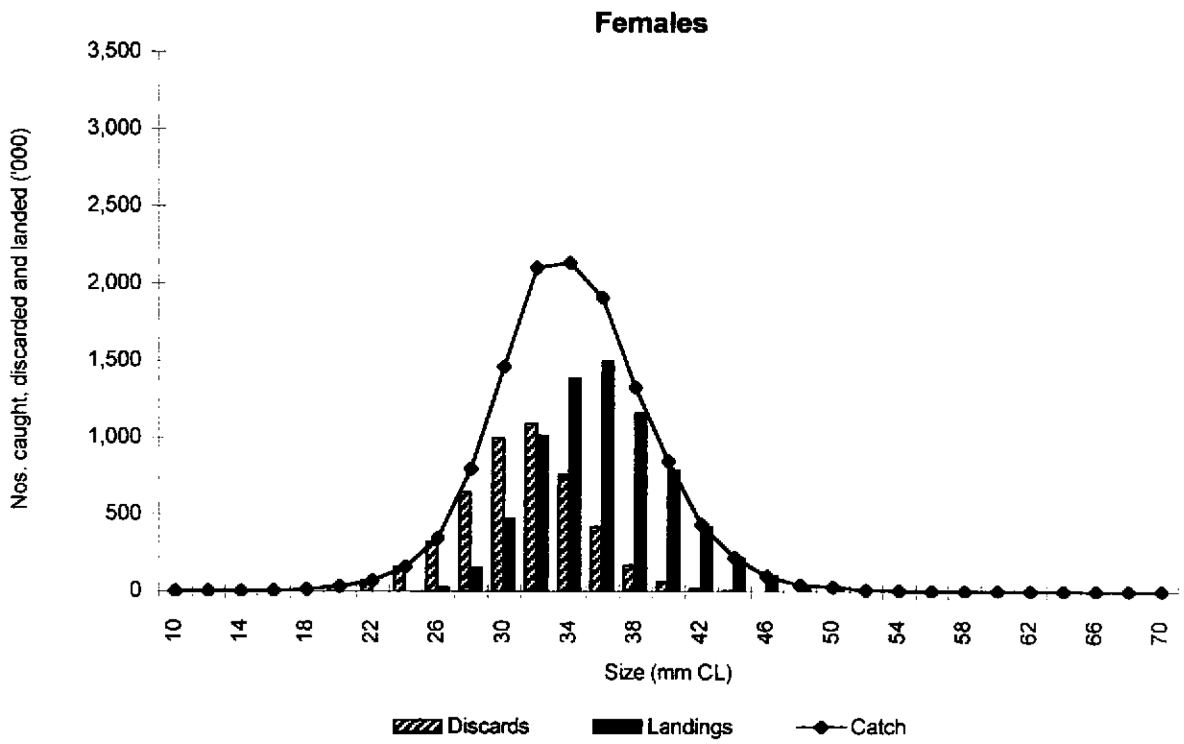
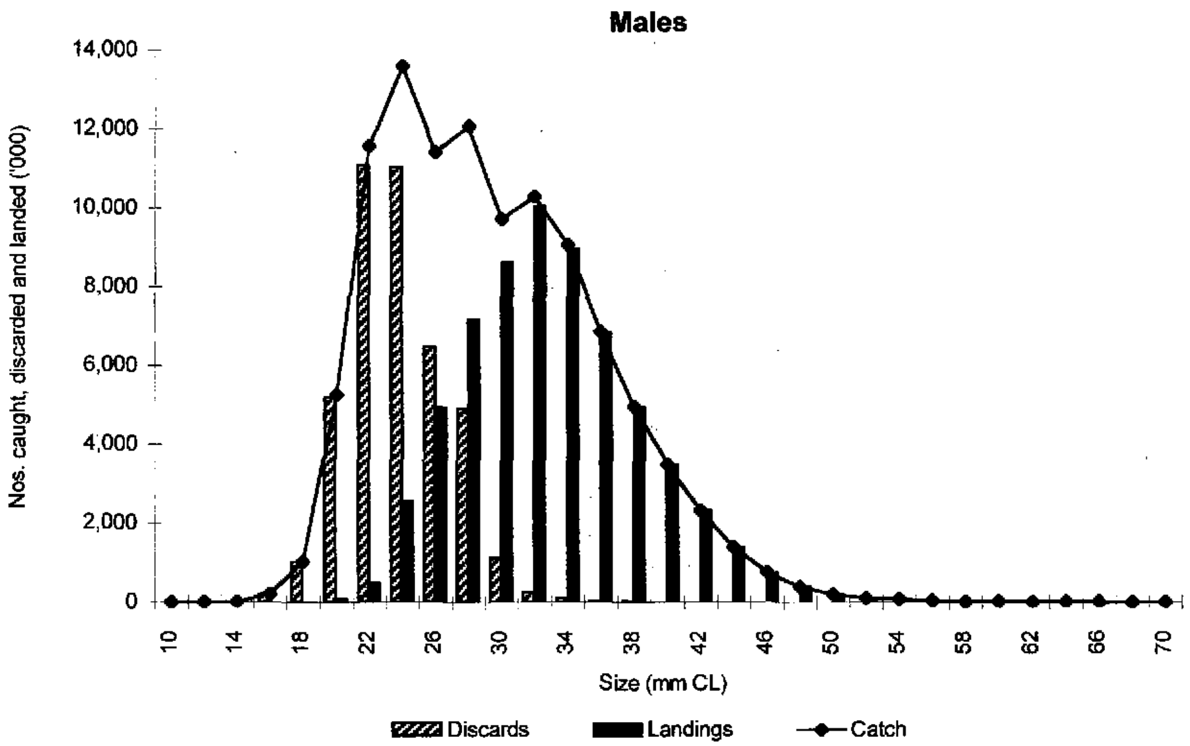


Figure 9.1. - Botney Gut - Silver Pit (FU 5): Length frequency distributions (in '000) of *Nephrops* caught, discarded and landed. Averages for the period 1996-98. Males and females shown separately.



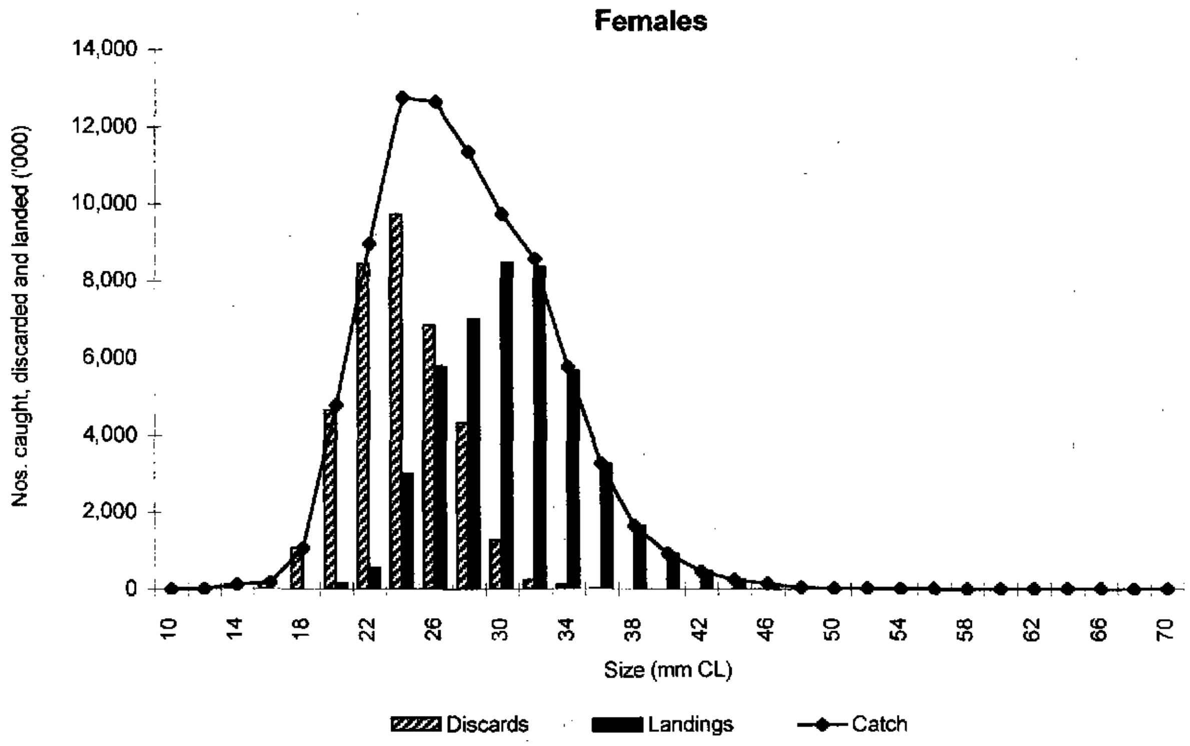
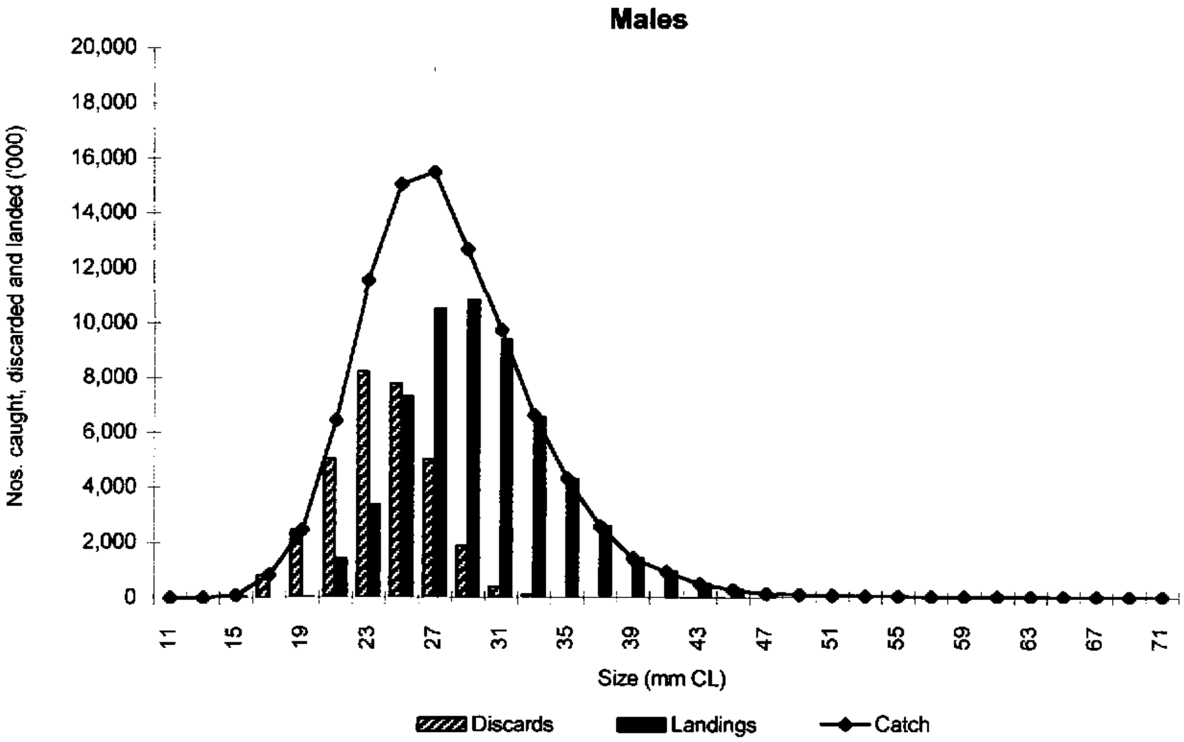


Figure 9.2. - Farn Deeps (FU 6): Length frequency distributions (in '000) of *Nephrops* caught, discarded and landed. Averages for the period 1994-98.
Males and females shown separately.



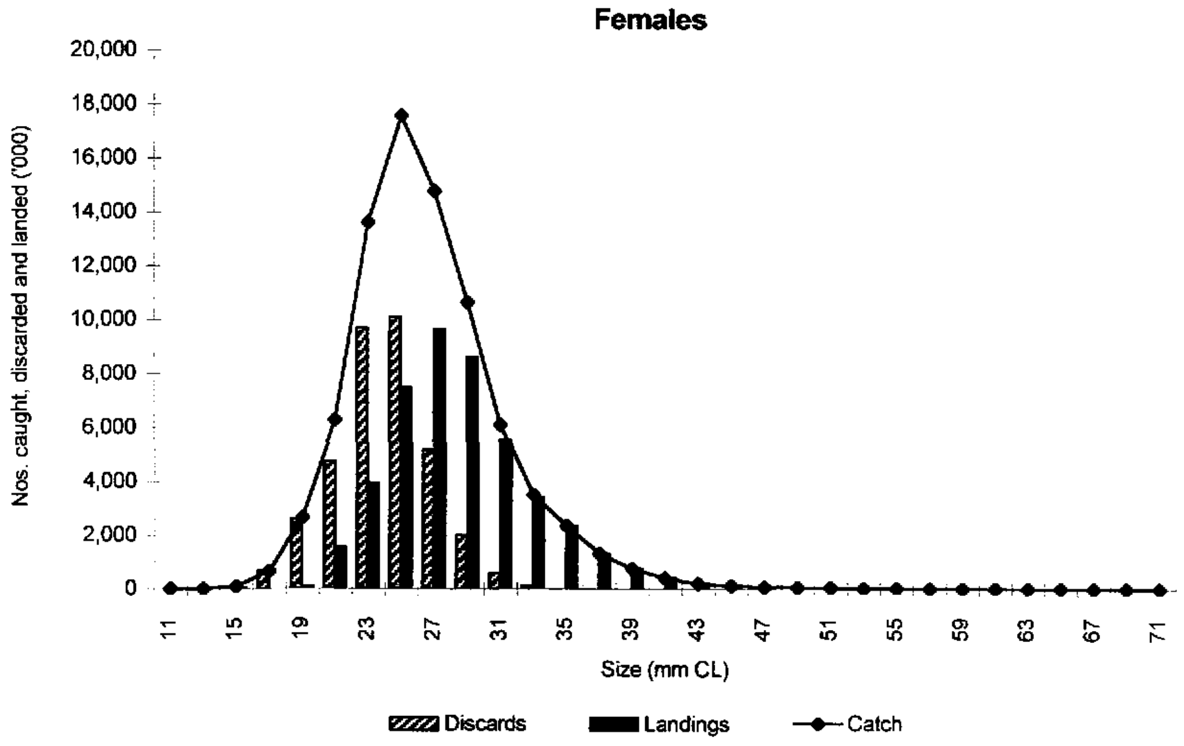
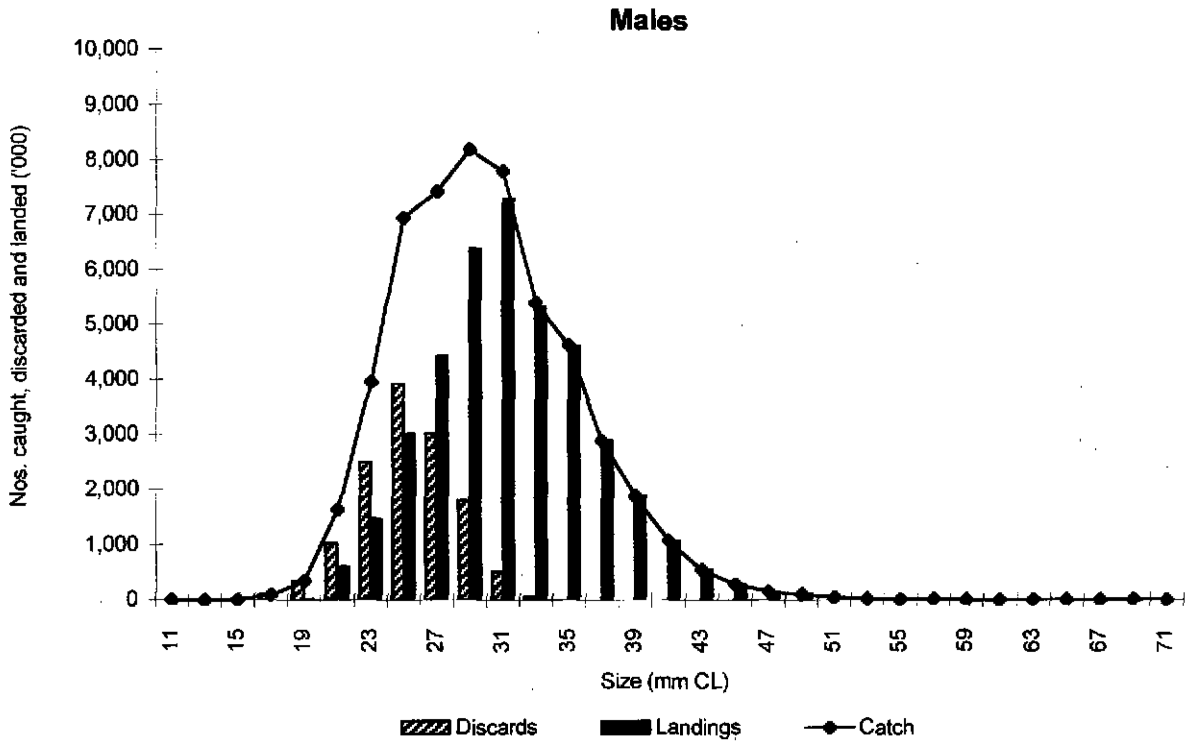


Figure 9.3. - Firth of Forth (FU 8): Length frequency distributions (in '000) of *Nephrops* caught, discarded and landed. Averages for the period 1996-98.
Males and females shown separately.



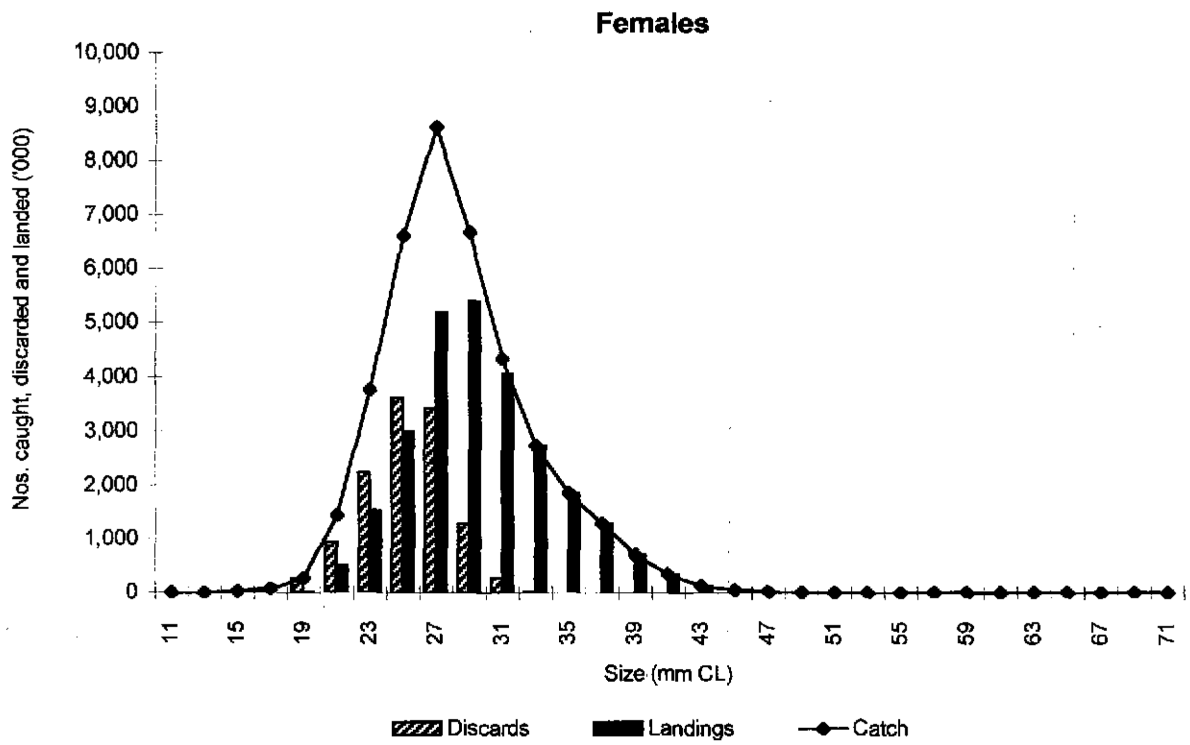
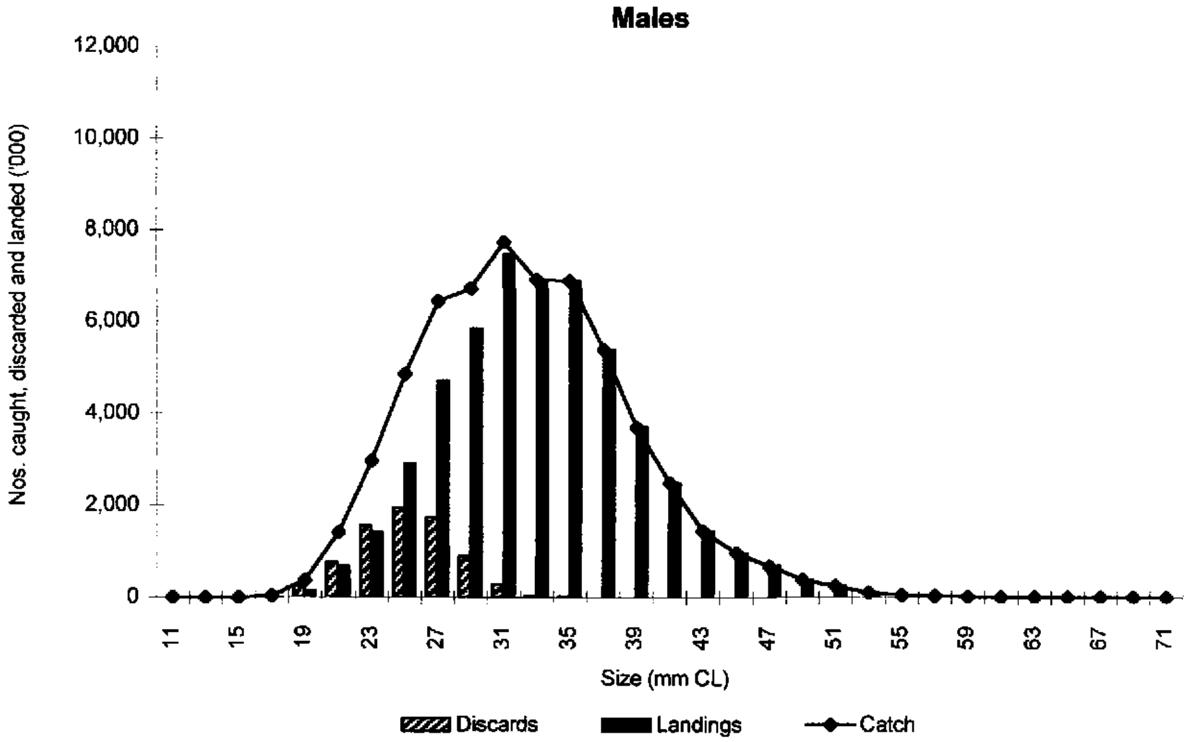


Figure 9.4. - Moray Firth (FU 9): Length frequency distributions (in '000) of *Nephrops* caught, discarded and landed. Averages for the period 1996-98.
Males and females shown separately.



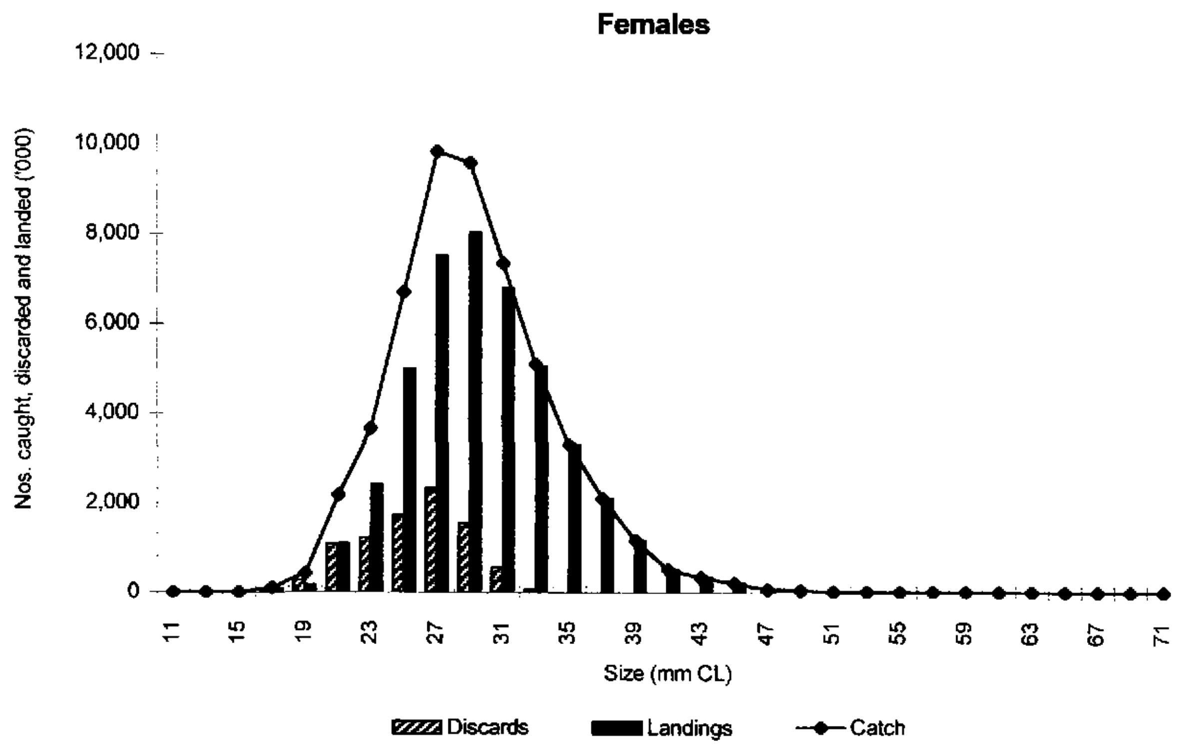
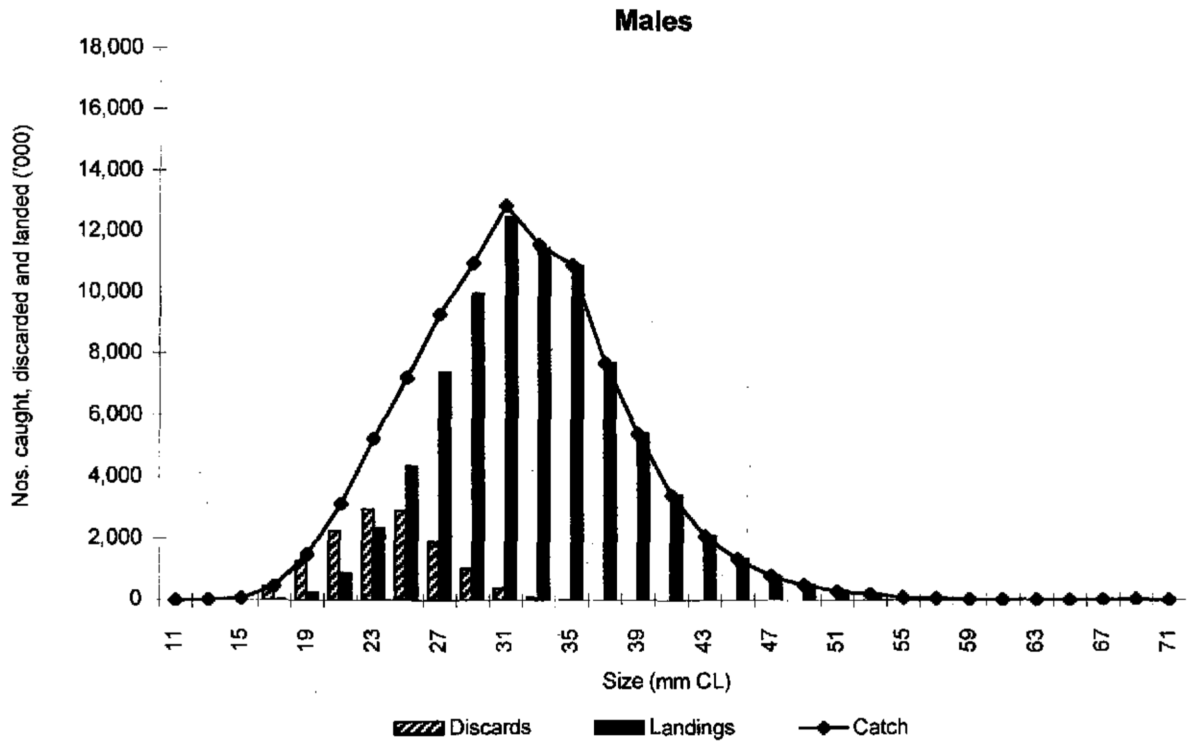


Figure 9.5. - North Minch (FU 11): Length frequency distributions (in '000) of *Nephrops* caught, discarded and landed. Averages for the period 1996-98.
Males and females shown separately.



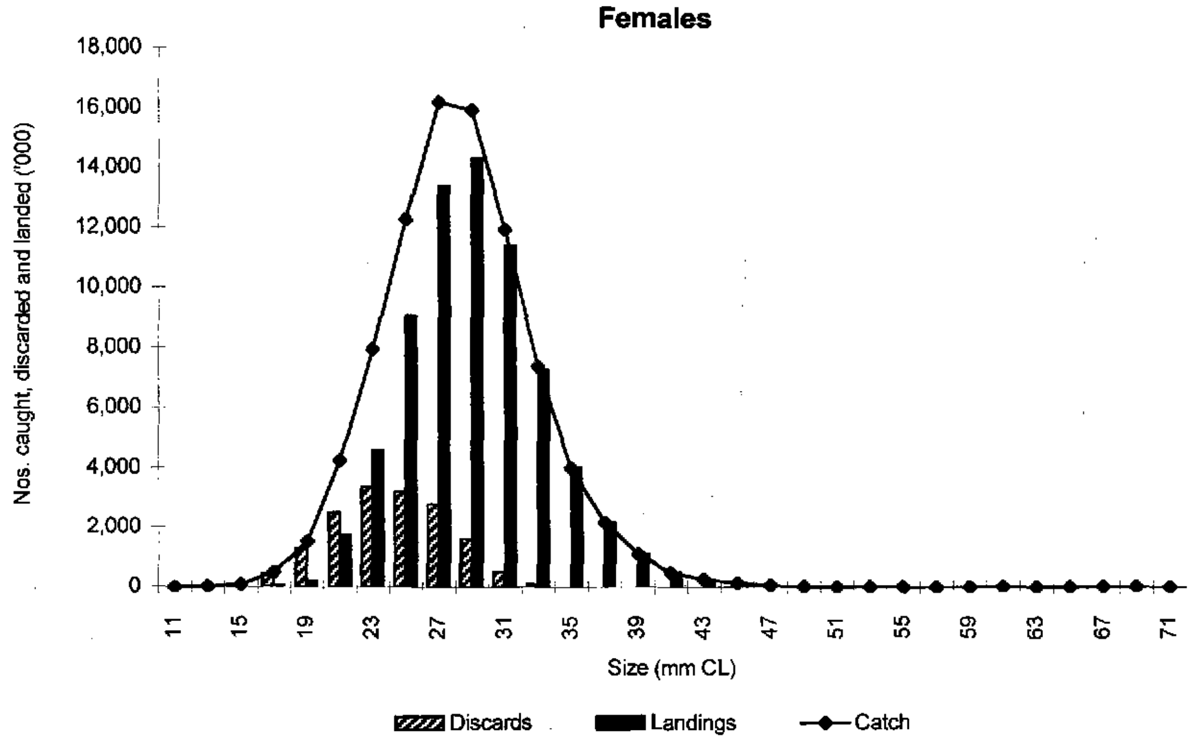
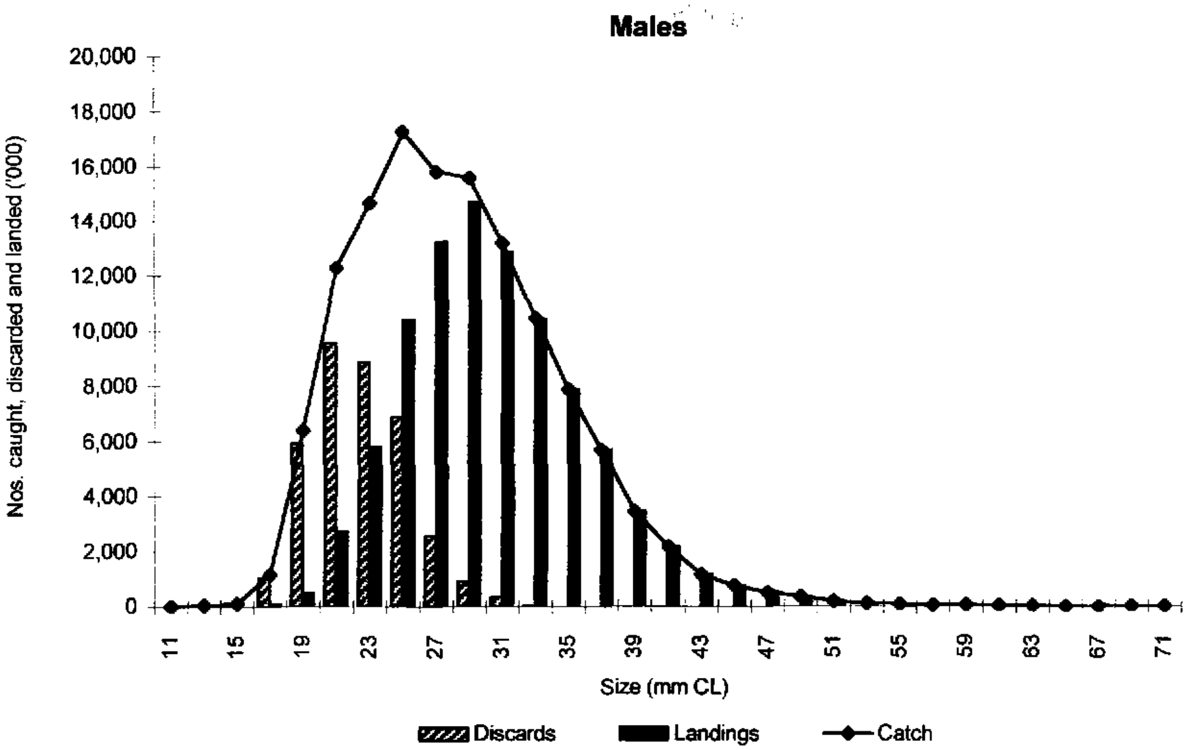


Figure 9.6. - South Minch (FU 12): Length frequency distributions (in '000) of *Nephrops* caught, discarded and landed. Averages for the period 1995-98.
Males and females shown separately.



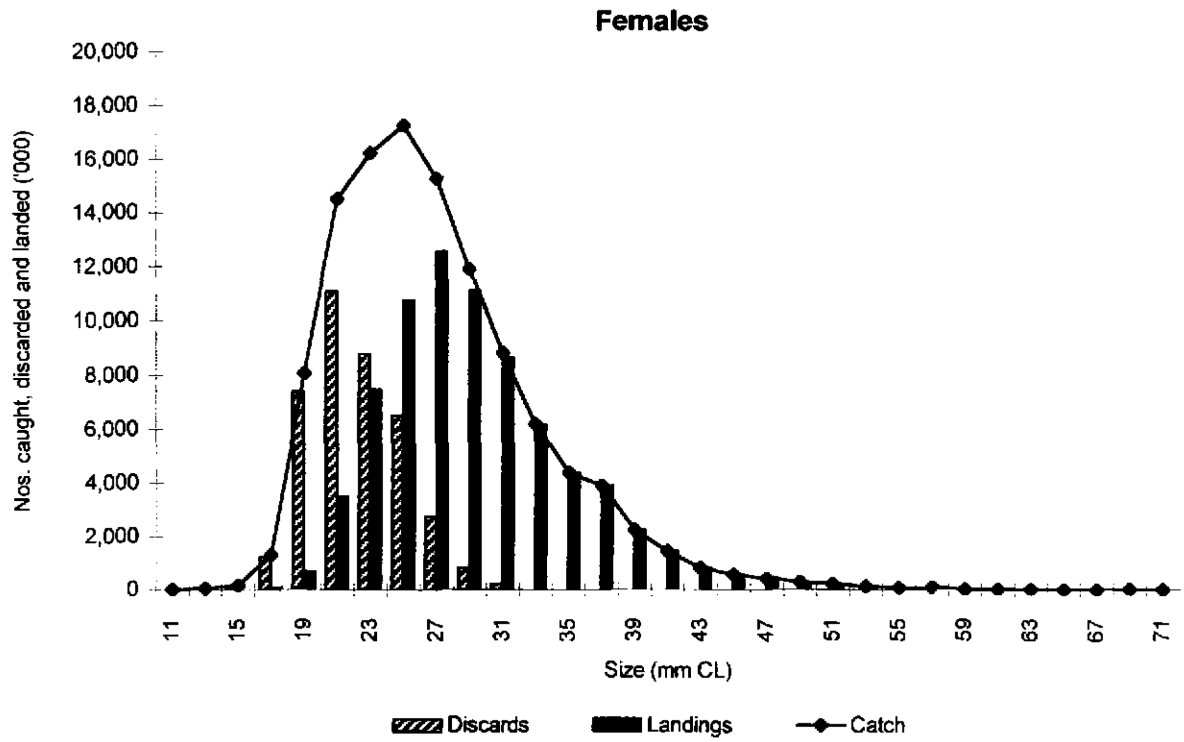
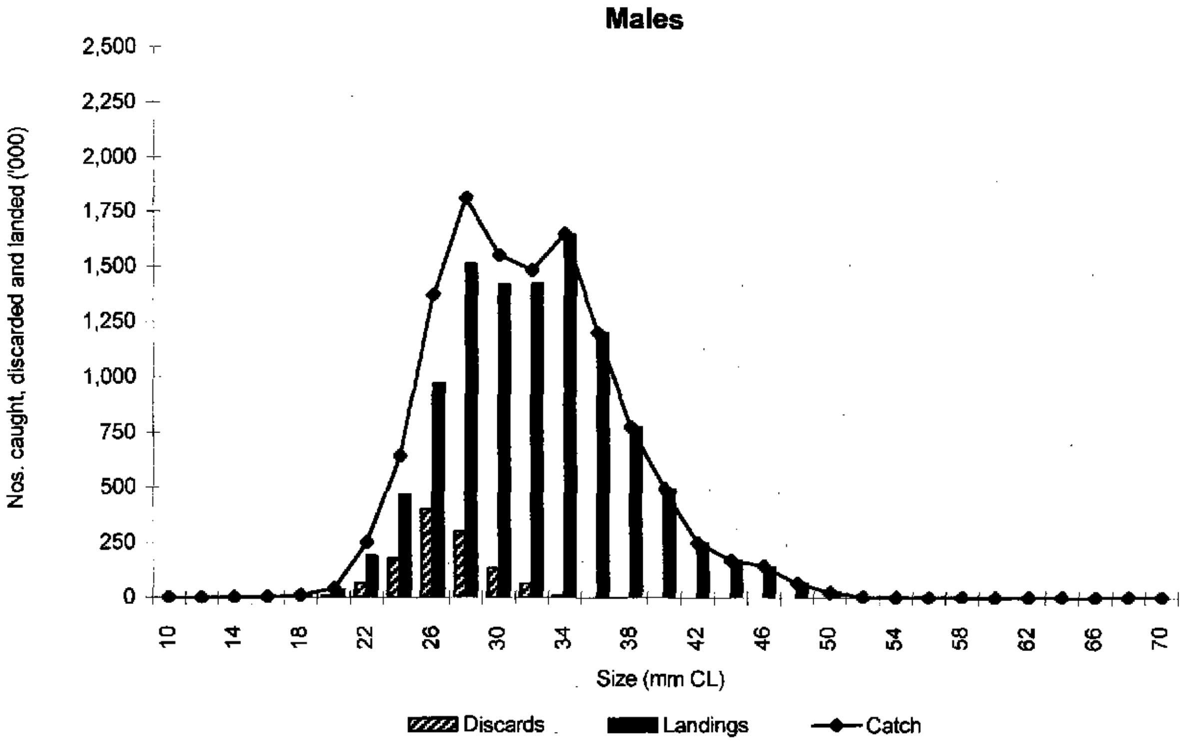


Figure 9.7. - Firth of Clyde (FU 13): Length frequency distributions (in '000) of *Nephrops* caught, discarded and landed. Averages for the period 1996-98.
Males and females shown separately.



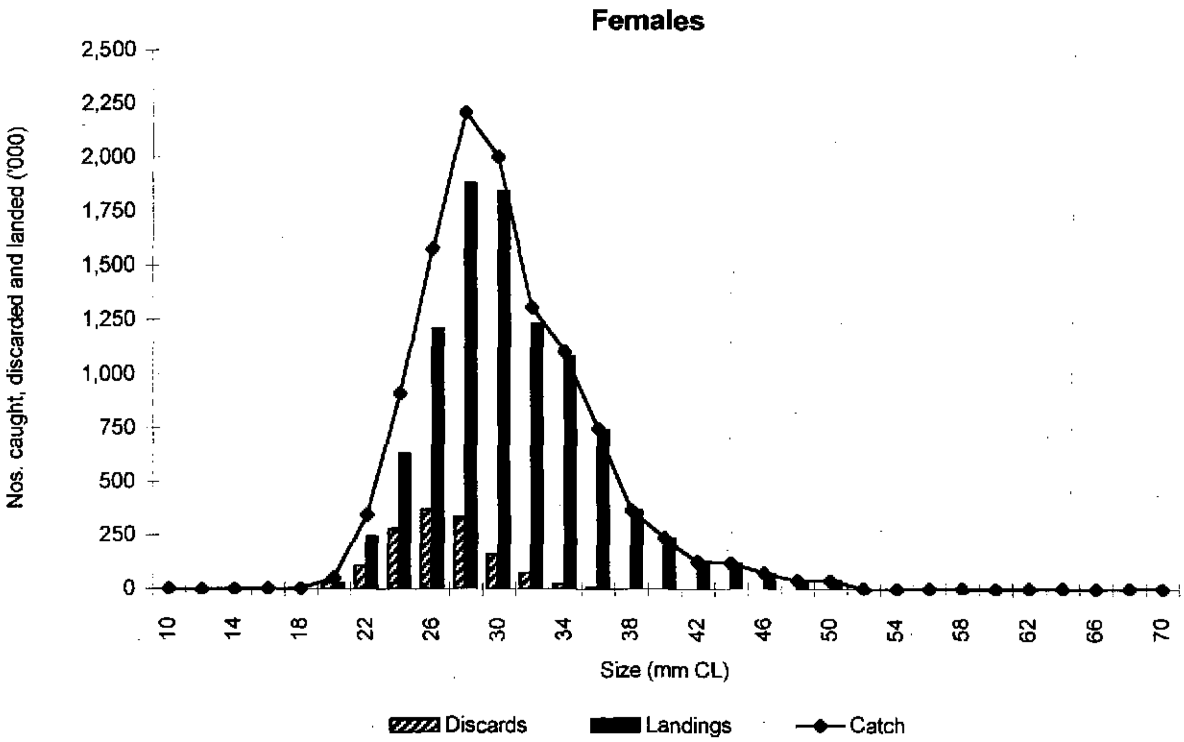
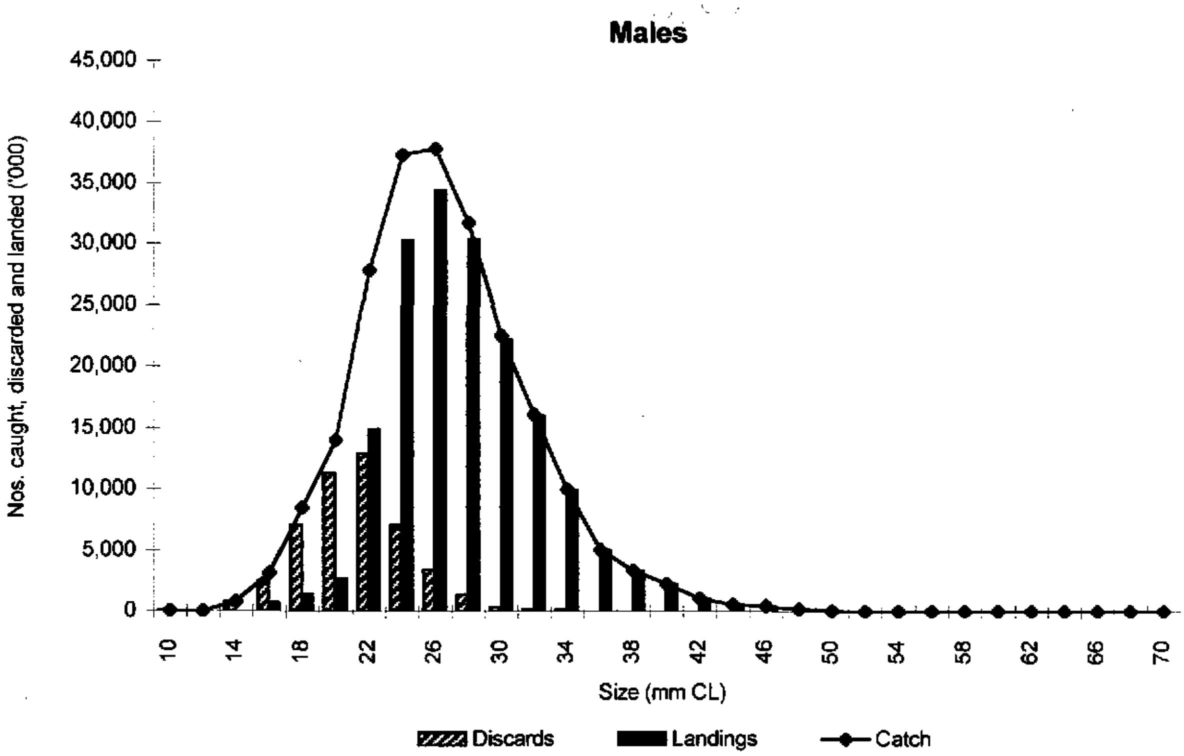


Figure 9.8. - Irish Sea East (FU 14): Length frequency distributions (in '000) of *Nephrops* caught, discarded and landed. Averages for the period 1994-98.
Males and females shown separately.



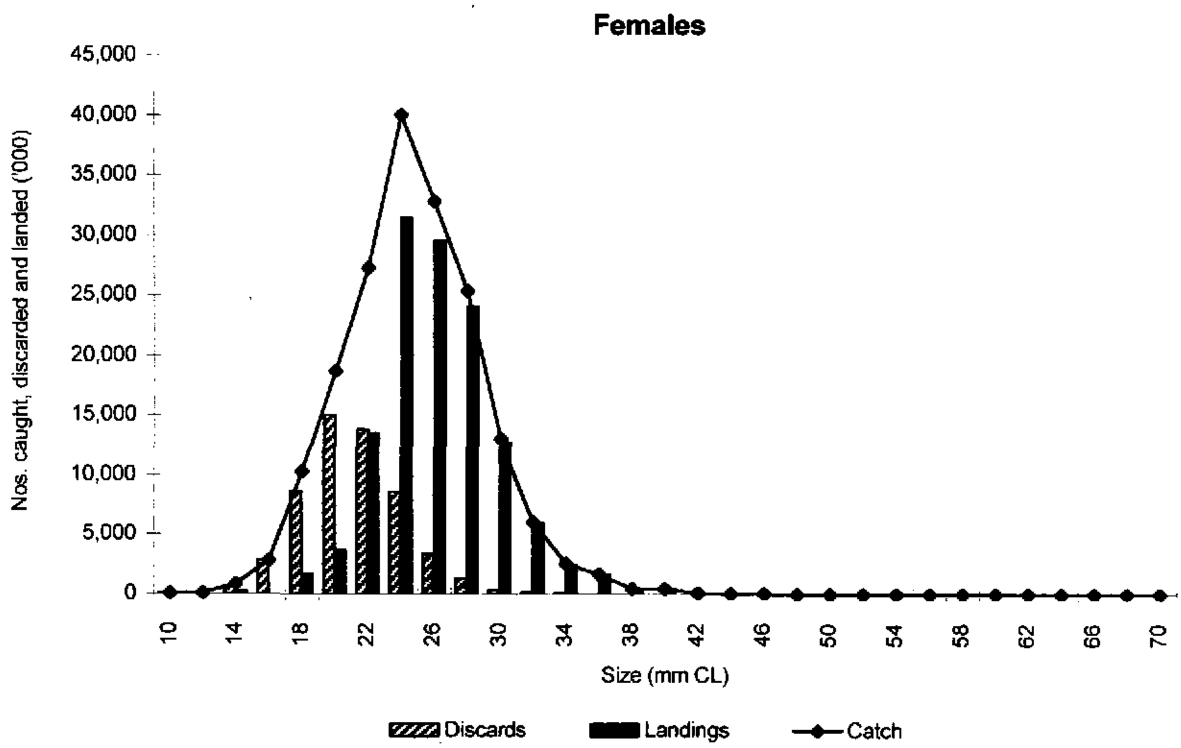
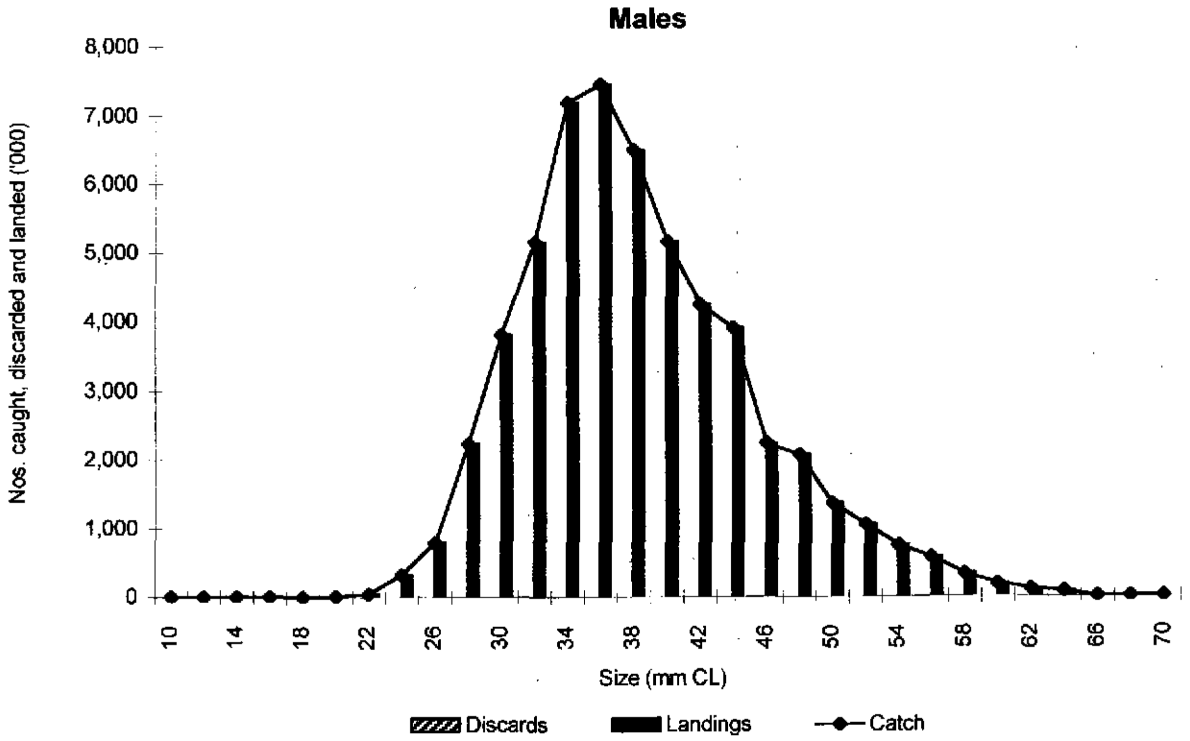


Figure 9.9. - Irish Sea West (FU 15): Length frequency distributions (in '000) of *Nephrops* caught, discarded and landed. Averages for the period 1996-98.
Males and females shown separately.



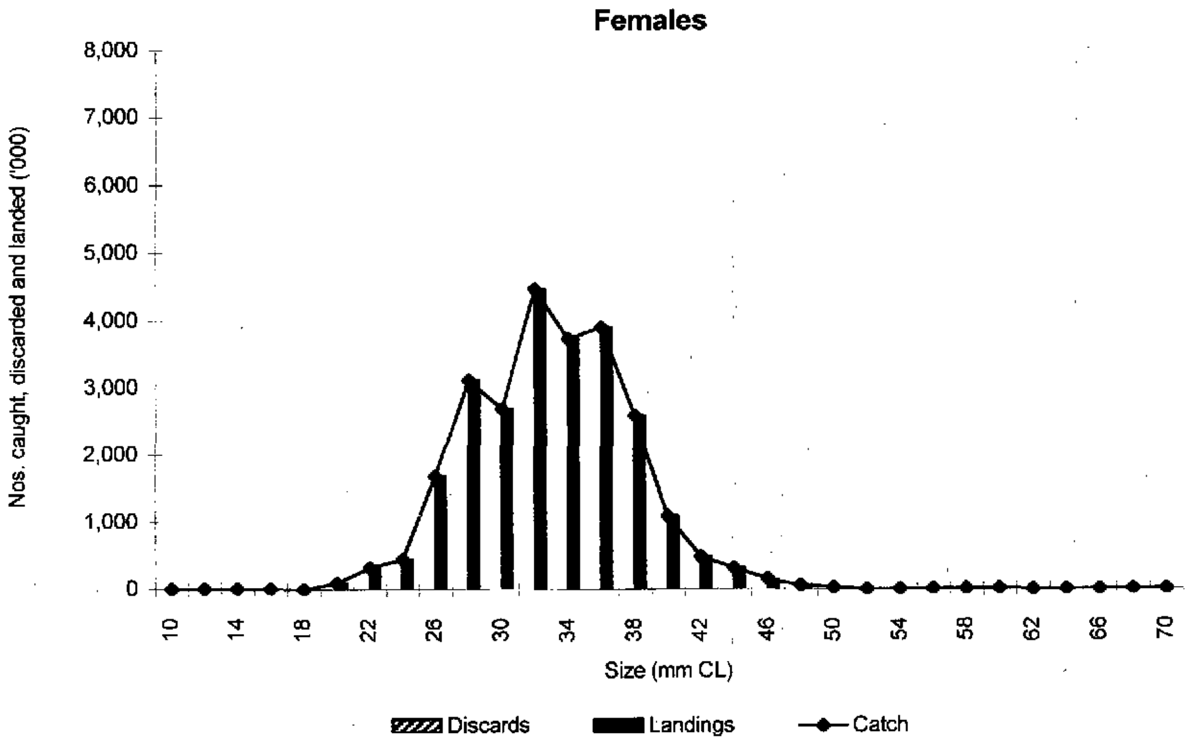
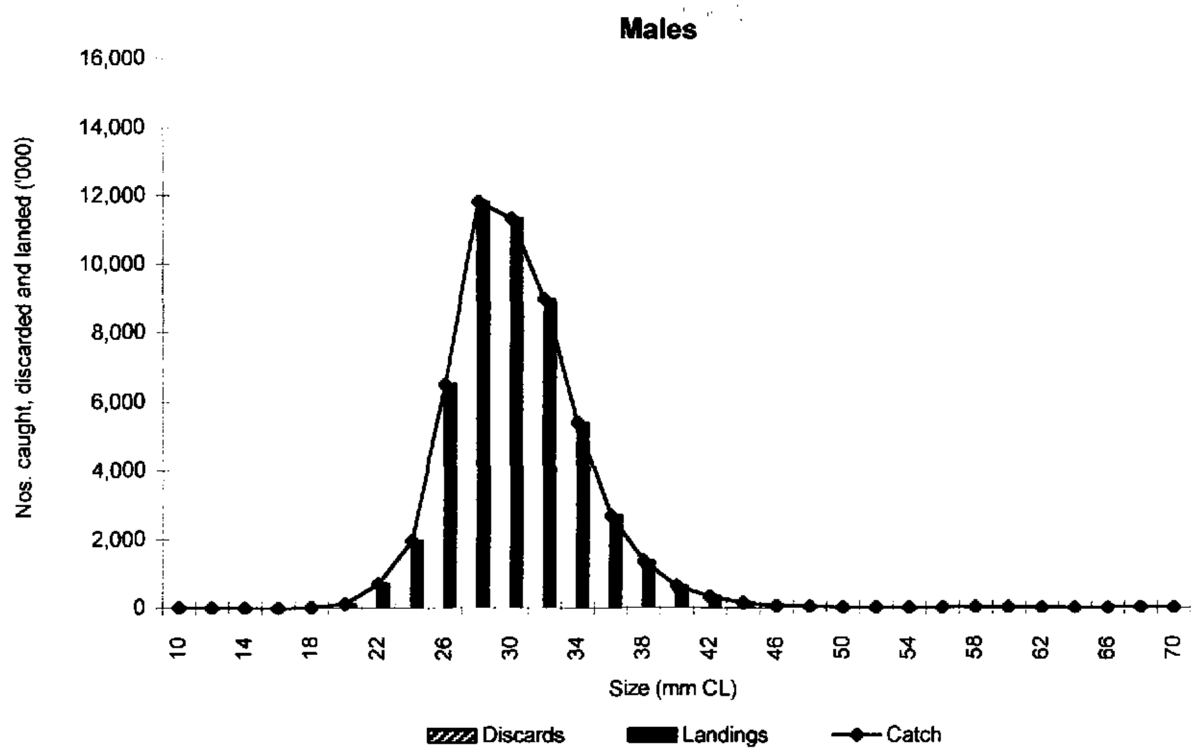


Figure 9.10. - Porcupine Bank (FU 16): Length frequency distributions (in '000) of *Nephrops* caught, discarded and landed. Males and females shown separately.
Note: Discards are virtually non-existent in this fishery. No estimate of discards made.



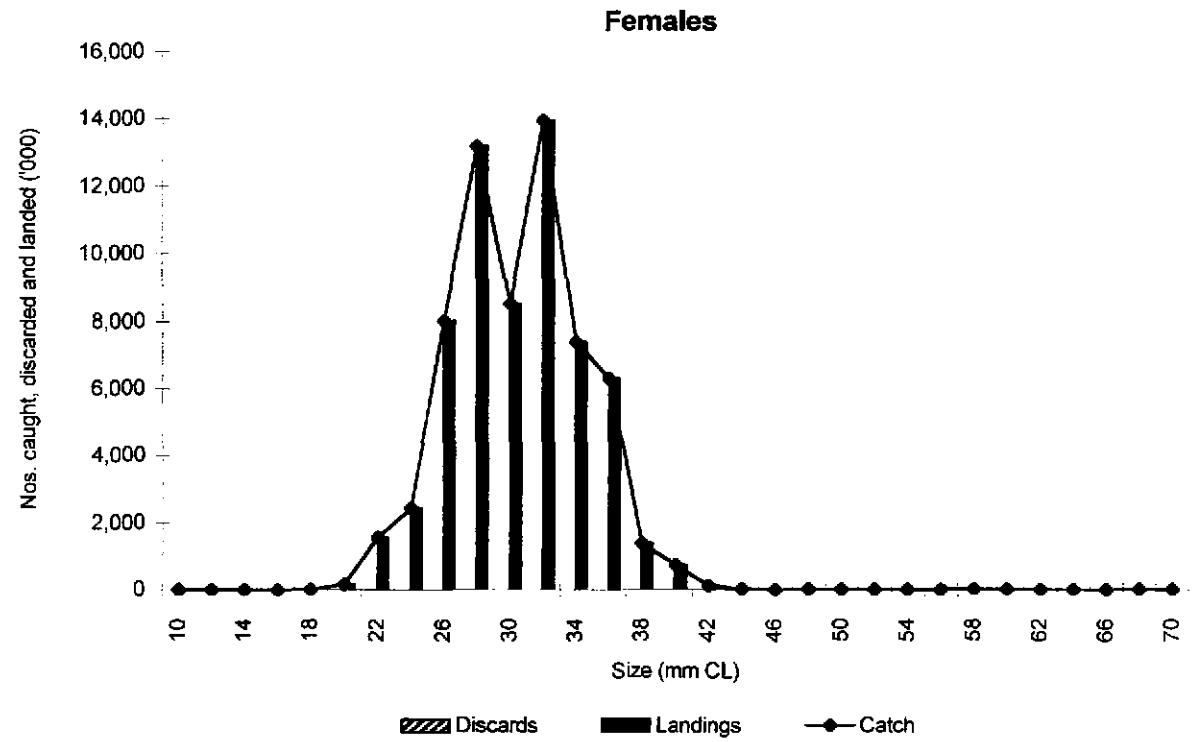
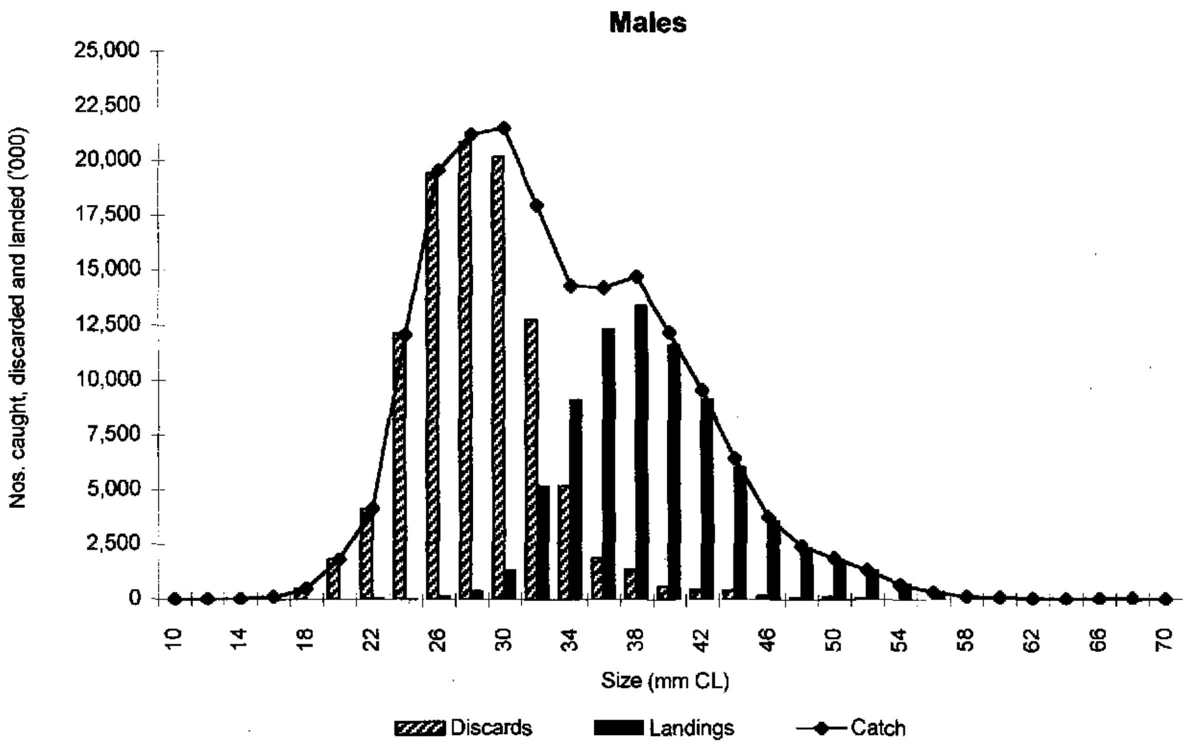


Figure 9.11. - Aran Grounds (FU 17): Length frequency distributions (in '000) of *Nephrops* caught, discarded and landed. Averages for the period 1997-98. Males and females shown separately. Note: Discards are virtually non-existent in this fishery. No estimate of discards made.



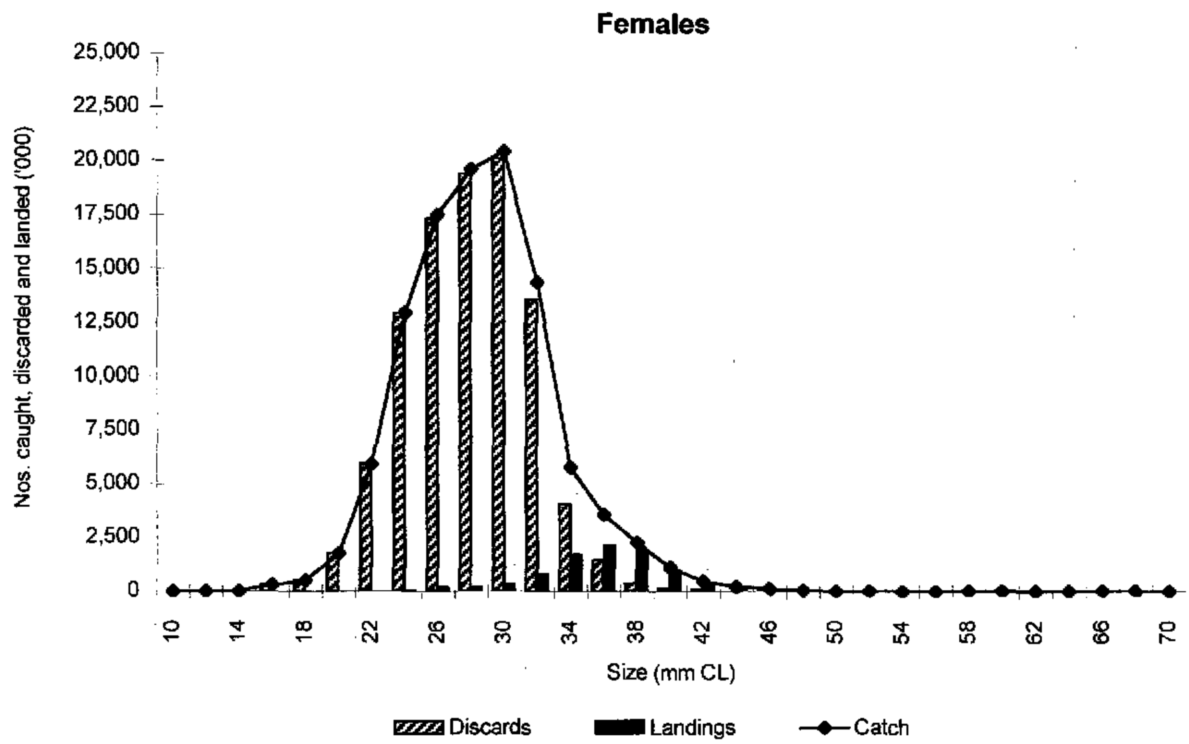
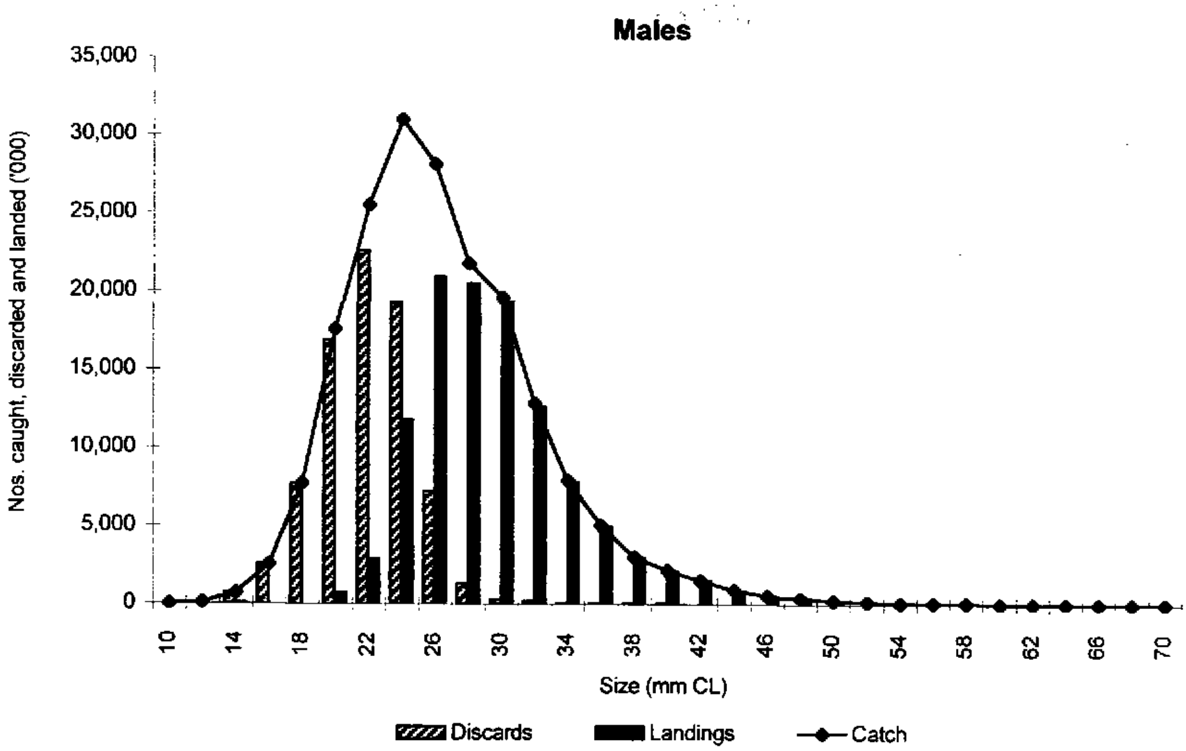


Figure 9.12. - Celtic Sea (FU 20-22): Length frequency distributions (in '000) of *Nephrops* caught, discarded and landed. Averages for the period 1995-97.
Males and females shown separately.



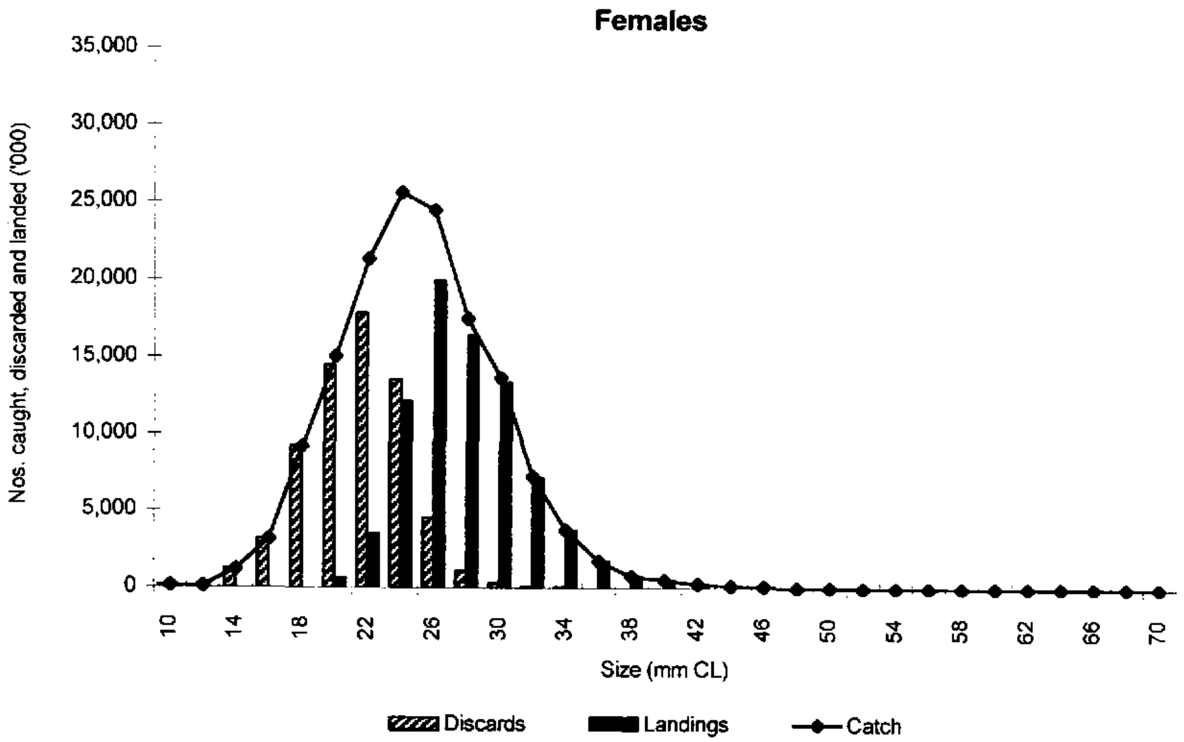


Figure 9.13. - Bay of Biscay (FU 23-24): Length frequency distributions (in '000) of *Nephrops* caught, discarded and landed. Averages for the period 1995-97.
Males and females shown separately.

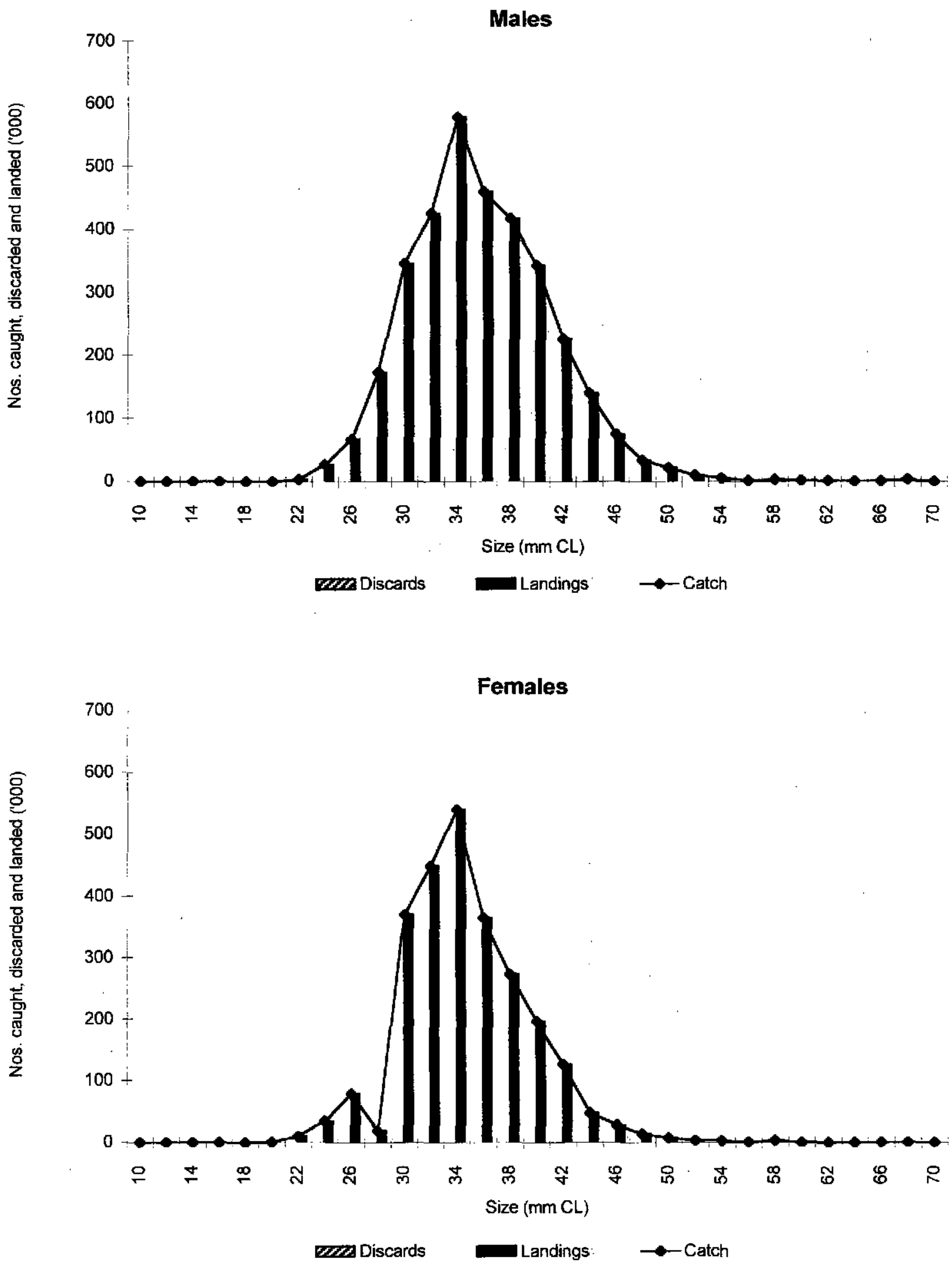
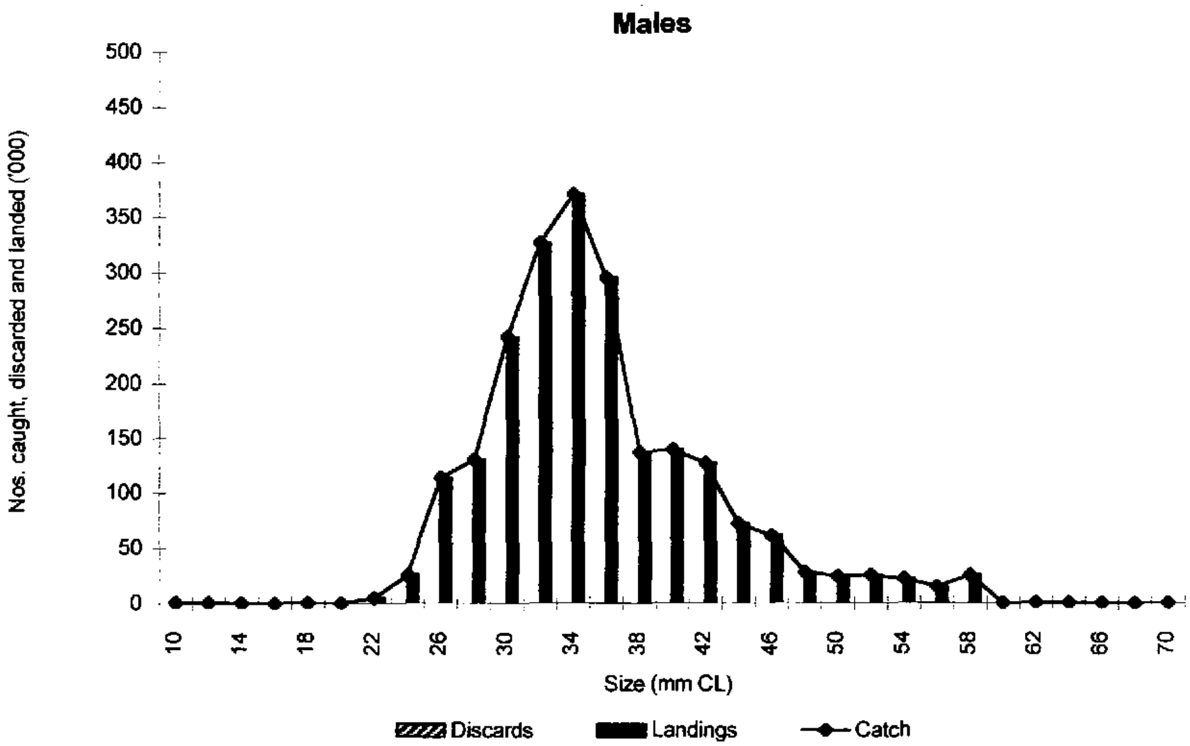


Figure 9.14. - North Galicia (FU 25): Length frequency distributions (in '000) of *Nephrops* caught, discarded and landed. Averages for the period 1995-97. Males and females shown separately. Note: Discards are virtually non-existent in this fishery. No estimate of discards made.



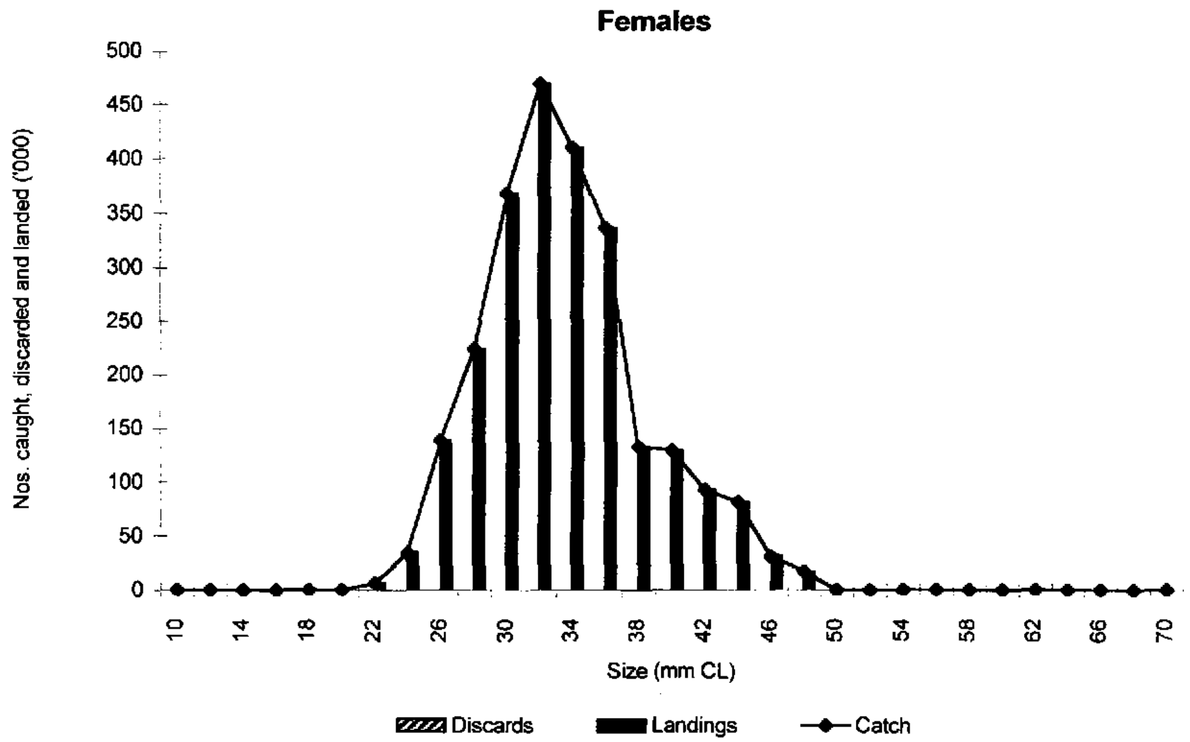


Figure 9.15. - SW and S Portugal (FUs 28-29): Length frequency distributions (in '000) of *Nephrops* caught, discarded and landed. Averages for 1996-98. Males and females shown separately. Note: Discards are virtually non-existent in this fishery. No estimate of discards made.

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Acronyms and abbreviations

ACFM	Advisory Committee on Fishery Management
B/R	Biomass per recruit
BRP	Biological reference point
CFP	Common Fisheries Policy
CL	Carapace length
CPUE	Catch per unit effort
CV	Coefficient of variation
EC	European Commission
EU	European Union
F	Fishing mortality
FU	Functional Unit
ICA	Integrated catch analysis
ICES	International Council for the Exploration of the Sea
K	Growth constant from Von Bertalanffy's growth equation
LCA	Length cohort analysis
LFD	Length frequency distribution
L_{inf}	$L_{infinity}$ from Von Bertalanffy's growth equation
LPUE	Landings per unit effort
M	Natural mortality
MA	Management Area
SE	Standard error
SOP	Sum of products
SSB	Spawning stock biomass
SSB/R	Spawning stock biomass per recruit
TAC	Total allowable catch
TSB	Total stock biomass
VPA	Virtual population analysis
WG	*Nephrops* Working Group
XSA	Extended survivor analysis
Y/R	Yield per recruit
Z	Total mortality