International Council for the
Exploration of the Sea

C.M.1990/Assess:16

PART 1

REPORT OF THE WORKING GROUP ON NEPHROPS STOCKS

Nantes, France, 21-28 March 1990

*General Secretary
ICES
Palægade 2-4
DK-1261 Copenhagen K
Denmark

TABLE OF CONTENTS

1. TERMS OF REFERENCE

The Working Group on Nephrops Stocks met in Nantes, France, from 21-28 March 1990 to :

(a) review recent progress in biological research and modelling on Nephrops stocks ;

(b) make analytical assessments of the Nephrops stocks in Division IIIa and Sub-area IV ;

(c) for as many stocks as possible, provide information on the state of exploitation and catch possibilities ;

(d) review and improve technical aspects of the existing assessments ;

(e) review the legal minimum landing size and mesh size in all Nephrops fisheries ;

(f) produce a report for ACMP at its 1990 session on the effects of hypoxia in particular, and other forms of pollution, on the relevant Nephrops stocks in Division IIIa based on a review to be produced by Ms. E. Nielsen and Dr. O. Bagge.

2. PARTICIPANTS

The following scientists attended the meeting of the Working Group :

Mr. N. BAILEY - Scotland.
Mr. D. BENNETT - England.
Mr. R. BRIGGS - Northern Ireland.
Mr. A. CHARUAU - France.
Ms. A.M. CARAMELO - Portugal.
Mr. H. EIRIKSSON - Iceland.
Mr. A.C. FARIÑA - Spain.
Mr. H. HALLBÄCK - Sweden.
Mr. J.P. HILLIS - Ireland (until 24 March).
Mr. T. MACER - England.
Mr. R. MILLER - Canada.
Mr. S. MUNCH PETERSEN - Denmark.
Mr. A. NICOLAJSEN - Faroe Islands.
Mr. J. PEREIRO - Spain.
Mr. F. REDANT (Chairman) - Belgium.
Ms. C. TALIDEC - France.
Mr. M. ULMESTRAND - Sweden.

In addition, written contributions were received from Mr. S. TVEITE, Norway.

3. RECENT PROGRESS IN BIOLOGICAL RESEARCH AND MODELLING

3.1. Growth

Several items of new work were reported to the Working Group, either completed or in progress. For the Irish Sea, research vessel data were used to derive new estimates of growth for male Nephrops (TULLY et al., 1989). Polymodal analysis of length frequency curves provided estimates of annual growth, which were used in a Ford-Walford plot to estimate K and $L\infty$.

For the Farn Deeps stock, preliminary results of work at the University of Newcastle (UK) were reported from a Petersen analysis of length modes from research vessel samples taken at fortnightly intervals. Three modes could be detected for males and females, and these, together with estimates of $L\infty$ from the largest animals in the landings, were used to estimate growth parameters.

New data for growth of Nephrops in Portuguese waters were obtained from tagging experiments (FIGUEIREDO, 1989). By the end of 1988 a total of 87 animals had been recaptured from 6 609 individuals released, and 35 of the recaptures had moulted. The average annual growth was 4.5 mm for males and 1.9 mm for females, in sizes ranging between 30 and 50 mm.

Work is in progress at the IFREMER laboratory at Lorient on ageing the carapace of Nephrops by measuring the natural radioactivity of thorium 228 and radium 228, a method which has been applied successfully on other crustaceans such as spider crabs and lobsters (LE FOLL et al., 1989). After moulting, marine decapods take up not only calcium from seawater for shell hardening but also radium, which follows the chemical behaviour of calcium. Initially there is no thorium in

the carapace but the radium 228 taken up by the animal decays to thorium 228.

The ratio 228 Th/228 Ra can be used as a chronometer to determine the age of the carapace, i.e. the time elapsed since the last moult. The method has been standardized on carapaces of known age from captive animals. Initial tests of the method have been encouraging : for example, the age estimated for a carapace 9 months old was between 9 months and 9.5 months.

Measurements on Nephrops ready to moult will be made in 1990, in order to establish a relationship between carapace length and duration of the intermoult for each sex, using animals caught in the Bay of Biscay. It will also be necessary to estimate the moult increment in relation to length and sex. This will be done next year by means of re-immersion in cages of Nephrops ready to moult.

3.2. Mortality

Estimates of total mortality from catch curves were correlated with fishing effort along a transect in the Irish Sea to derive an estimate of natural mortality of male Nephrops of 0.18 (TULLY et al., 1989). This value is somewhat lower than the value of 0.26 estimated by MORIZUR (1982). Average total mortality along the transect was estimated to be 0.99.

3.3. Selectivity

Some preliminary results of work in progress at the Marine Laboratory, Aberdeen were reported, involving the use of a twin-trawl to estimate whole trawl selectivity. One trawl had a 70 mm mesh and the other had 35 mm mesh throughout, and 12 valid hauls were completed. The method appears promising and

overcomes the problem of diurnal differences in Nephrops availability encountered in the alternate haul method, and the high cost of using two parallel towing vessels.

The mean selection factor for the 70 mm mesh was 0.42 and the selection range was 6.7 mm. The latter value is significantly smaller than those obtained from most of the previous selectivity experiments on Nephrops. More work is needed to confirm the results of the twin-trawl experiments.

4. MANAGEMENT UNITS

During its previous meetings (ICES, 1984 and 1989) the Working Group identified 30 so-called functional units for the assessment and management of Nephrops stocks (Table 4.1.).

This year the Working Group made an attempt to describe these functional units in terms of ICES statistical rectangles, for the calculation of unit-wise catch, landings and effort data. Charts of these groupings of statistical rectangles, together with the reference numbers of the corresponding management units, are presented in Figures 4.1. - 4.3.

Some Nephrops landings were reported to come from rectangles outside these groupings, but except for a few areas, where the boundaries of the present management units may need to be expanded to coincide with the actual stock boundaries (e.g. W of Scotland and in the Cantabrian Sea), these quantities are small as compared to those taken within the present groupings.

5. TRENDS IN LANDINGS, EFFORT, CPUE AND LPUE (1)

5.1. Iceland (Management Unit 1)

Landings reported by : Iceland

Iceland

Catches and landings have remained rather stable over the period 1980-87 (Table 5.1.). From 1987 onwards however the landings have fallen by almost a third, which is also reflected in a similar drop in LPUE from 1987 to 1989. This is considered to be the result of a weather induced reduction in catchability as well as falling stock abundance.

5.2. Faroe Islands (Management Unit 2)

Landings reported by : Faroes

Faroes

Since the start of the Nephrops fishery in 1947 the principal gear was the trawl, though creels were also used. Since 1980 only creels are allowed. The fishery has been regulated by setting constraints on the effort by limiting fishing days and numbers of trawlers or creels.

In the period of trawling, the landings varied between 2 and 96 tonnes/year, with an average of 35 tonnes. Fishing effort fluctuated between 28 and about 3 720 hours trawling, with an average of 1 142 hours. The highest and lowest values for

---

(1) Stock-wise summaries are given in Annex 1.

LPUE were 90.9 kg/hour trawling (in 1948) and 12.2 kg/hour trawling (in 1961), with an overall mean of 40.0 kg/hour.

Since trawling was prohibited in 1980 the fishing season has moved from the summer to the winter, and landings statistics are from then on given by fishing season (Table 5.2.). Over the seasons 1980/81-88/89 landings varied between 50 and 93 tonnes, with an average catch of 68 tonnes. Effort fluctuated between 784 000 and 1 697 000 creeldays, with an overall mean of 1 229 000 creeldays. The highest and lowest values for LPUE were 97 and 35 g/creelday (in 1986/87 and 1981/82 respectively), with an average of 60.5 g/creelday.

5.3. Skagerrak and Kattegat (Management Units 3 and 4)

Landings reported by : Denmark, Norway (Skagerrak only) and Sweden

Denmark

The Danish landings from the Skagerrak (Management Unit 3) and the Kattegat (Management Unit 4) over the period 1980-89 are shown in Tables 5.3. and 5.5.

In both areas the effort of the Danish Nephrops fishery has increased considerably, especially since 1984 when the majority of the vessels started using double instead of single trawls. Furthermore, since 1988 there has been a marked shift of effort from the southern Kattegat to the northern Kattegat and the Skagerrak, due to the dramatic changes in environmental conditions mentioned below. Thus, the overall trend since 1984 for the two areas is one of increasing effort in the Skagerrak and the northern Kattegat, while the Nephrops fishery in the southern Kattegat completely stopped in 1988.

According to logbook records most of the Danish Skagerrak catches are taken on the slopes north and north-west of Jutland. During the period 1980-84 a substantial increase in Danish landings from the Skagerrak took place (Table 5.3.). The peak in 1984 was followed by declining landings in 1985-88, but the figure for 1989 is the highest on record.

Danish effort data are available for the period 1987-89 only, and during this short time period the LPUEs (logbook records) seem to have been rather stable, viz. 84.1 kg/day in 1987, 84.3 kg/day in 1988 and 86.3 kg/day in 1989.

In the Kattegat, landings have declined since 1984 in spite of the above mentioned increase in effort, and the sharp drop in LPUE from 84.2 kg/day in 1987, to 63.8 kg/day in 1989 suggests a further decline of the stock. The Swedish effort data (see below) point into the same direction.

It is believed that the severe hypoxia conditions prevailing in the southern Kattegat in the past years (1987-89) are the main reason for the drastic changes in the Nephrops fishery. A preliminary report dealing with hypoxia in the Kattegat and its effect on various demersal fish and shellfish stocks was available to the Working Group (BAGGE et al., 1990), and further information on this topic can be found in this paper.

Sweden

Total Swedish landings of Nephrops from the Skagerrak and the Kattegat are shown in Tables 5.3. and 5.5. and in Figure 5.1.

As the stocks of cod and flatfish have been poor since the mid-1980s a great part of the Swedish trawling fleet has changed to Nephrops, not only during the main season (July-October) but more or less during the whole year. In the Skagerrak area the effort by Nephrops trawl thus increased

from about 40 000 hours trawling in 1980-81 to over 100 000 hours in 1988 and 1989 (Table 5.4.).

Also in the Skagerrak a creel fishery for Nephrops was introduced in 1984. In 1988-89 it accounted for about 10 % of the total Swedish Nephrops landings from the Skagerrak and the Kattegat.

The oxygen deficiency in the bottom water layers of the southern Kattegat during the past autumns has caused a shift of the fleet to the northern parts of the Kattegat. In spite of the fact that the fishing area has been badly reduced, total fishing effort with Nephrops trawl in the Kattegat has increased during the same period of time (Table 5.6.).

The introduction of modern electronic equipment and the shift from single trawls to more efficient twin-trawls, together with the increase in overall fishing effort and in effort per unit area, highly increased fishing pressure on the Nephrops stocks.

In the Skagerrak the Nephrops landings increased up to 1984 and are now quite stable (Table 5.3.). Effort has steadily increased over the period 1980-89, with CPUE and LPUE decreasing since 1984 (Table 5.4.).

In the Kattegat landings increased up to 1986 and have since decreased (Table 5.5.). Since 1985 effort has increased in the northern Kattegat, while there has been a considerable decrease in effort in the southern area because of the oxygen depletion problem. CPUE and LPUE have decreased since 1982, and the preliminary figures for 1989 are the lowest recorded during the 1980s (Table 5.6.).

5.4. Botney Gut and Silver Pit (Management Unit 5)

Landings reported by : Belgium, Denmark and UK

Belgium

The Nephrops stock in the Botney Gut and Silver Pit area is exploited mainly by Belgian trawlers, with smaller quantities (10 - 15 %) landed by Danish and UK vessels (Table 5.7.).

Annual landings by Belgian Nephrops trawlers were between 600 and 700 tonnes in 1983-85. They dropped below 400 tonnes in 1986, but have steadily increased since then (Table 5.8.).

Annual effort increased from about 40 - 45 000 hours fishing in the early 1980s to a peak value of 62 000 hours in 1985 ; then decreased by almost 15 % in 1986 and 1987, and increased again in most recent years to reach a level of nearly 65 000 hours in 1989 (Table 5.8.).

LPUEs remained above 10 kg/hour fishing until 1985, with a peak value of 16.3 kg in 1983, but sharply dropped to only 7.0 kg/hour fishing in 1986. Since then the LPUE has slightly recovered, to reach a value of 8.6 kg/hour fishing in 1989, despite the 20 % increase is overall fishing effort over the same period of time (Table 5.8.).

Detrended monthly LPUEs show that the amplitude of seasonal variation has been reducing over the past five years (Figure 5.2.), actually meaning that the peak values at the height of the fishing season (3rd and 4th quarter) were lower than in the early 1980s, and that the LPUEs during the period of lowest catch rates (1st quarter) have increased. There are some indications that the latter may be due to the combined effect of a succession of mild winters and an increase in the availability of females during the winter season, possibly as a

consequence of a reduction in the proportion of females spawning.

Denmark

See Section 5.6. for a description of the Danish Nephrops fisheries in the North Sea.

5.5. Farn Deeps (Management Unit 6)

Landings reported by : UK and Denmark

United Kingdom (England & Wales)

Because the main fishing season for Nephrops extends over the period October to March, the data for this stock are analyzed on the basis of each year commencing on July 1st.

Landings and fishing effort have both increased steadily over the past 10 years (Tables 5.9. and 5.10.). LPUEs increased sharply between 1980/81 and 1982/83 but subsequently the trend has been downward. Nevertheless, the current level of LPUE corresponds approximately to the average level observed over the past 25 years. Estimates of the actual catch rates (i.e. landings + discards) are available only for the past 5 seasons. There was a fall in CPUE in the first three seasons but it has increased again in the latest two seasons (Table 5.10.). Mean GRT has remained fairly constant over the period, and a fishing power correction to the CPUE and LPUE data based on mean GRT has little effect on the trends.

Denmark

See Section 5.6. for a description of the Danish Nephrops fisheries in the North Sea.

5.6. Fladen Ground (Management Unit 7)

Landings reported by : UK and Denmark

United Kingdom (Scotland)

Information on the Fladen Ground in presented for the first time.

Landings (all gears combined) have risen markedly in the last ten years, reaching a peak of over 1 700 tonnes in 1989 (Table 5.11.). Effort (data refer to Nephrops trawl only) has also increased (Table 5.12.), with a pronounced movement of fishing activity by Scottish vessels over the whole Fladen Ground in recent years. LPUEs show no obvious trend and it is noteworthy that LPUE is amongst the highest of all Scottish Nephrops fisheries (see Tables 5.12. and 5.16. - 5.21.).

Denmark

The Danish Nephrops landings from the North Sea have until the mid-1980s mainly been by-catches to the Pandalus fishery or the industrial fisheries with small meshed gear. Since then fisheries with Nephrops trawls have been conducted, especially on the Fladen Ground and in the eastern part of Division IVa. The Danish Nephrops catches from the Silver Pit (Management Unit 5) and the Farn Deeps (Management Unit 6) are by-catches still.

Table 5.13. gives the Danish Nephrops landings from the North Sea. According to logbook records for 1989 approximately 25 % of these landings were taken as by-catch, whereas in the Skagerrak and the Kattegat (Management Units 3 and 4) less than 10 % was by-catch.

5.7. Firth of Forth, Moray Firth, Noup, North Minch, South Minch and Clyde (Management Units 8-13)

Landings reported by : UK

United Kingdom (Scotland)

Updated overall landings from the Nephrops stocks in the Scottish waters by various gears are shown in Tables 5.14. (by gear, all management units combined) and 5.15. (by management unit, all gears combined).

Landings fell somewhat from the all time high in 1988 to about 18 000 tonnes in 1989, of which over 84 % were made by Nephrops trawl and over 6 % by creels. Landings by all gears for the stocks in Sub-area VI (i.e. North Minch, South Minch and Clyde) amounted to about 10 950 tonnes, considerably lower than the 16 000 tonnes TAC set for the area.

The effort and LPUE data presented refer to Nephrops trawlers only. Information on the Firth of Forth, Moray Firth, North Minch, South Minch and Clyde was discussed in the previous Working Group report (ICES, 1989). Data for the Noup are presented for the first time.

For the Firth of Forth (Management Unit 8) the update for 1989 indicates a fall in landings and effort with little change in LPUE (Table 5.16.).

For the Moray Firth (Management Unit 9) the data series presented differs somewhat from that in the 1989 Working Group's report (ICES, 1989). This is because the area corresponding to the Moray Firth has been redefined to include an additional statistical square (viz. 44E8, see Figure. 4.2.). For the new area, the trend in landings has been upward, reflecting recent increases in effort (Table 5.17.). LPUE has fluctuated without obvious trend.

Data are also presented for the Noup (Management Unit 10) but these are collected for only one statistical rectangle (viz. 47E6, see Figure 4.2.), and show marked fluctuations in landings and effort (Table 5.18.). LPUE shows no obvious trend, but values are probably unreliable in some years.

Updates for 1989 suggest that in the North Minch (Management Unit 11) landings and effort dropped, but LPUE was stable (Table 5.19.).

In the South Minch (Management Unit 12) landings and effort rose but again LPUE was relatively stable (Table 5.20.).

In the Clyde (Management Unit 13) landings dropped by over 25 % despite a maintenance of the 1988 effort levels (Table 5.21.) and consequently LPUE dropped to the lowest level in the data series presented (LPUE was at similarly low levels in the mid-1970s). LPUEs in the Clyde are the lowest of all Scottish stocks. It was pointed out last year (ICES, 1989) that the intensity of effort (effort per unit area) in the Clyde was approaching levels which it was considered led to "over-exploitation" in the Firth of Forth (ICES, 1988), and the reduced LPUE may be indicative of this.

It is important to emphasise that the unit of effort is hours fished, taking no account of changes in gear efficiency or engine power. It is likely that the generally steady LPUE figures, apparent in most Scottish stocks, are in reality downward. There has been widespread adoption of the twin and triple rigged trawls which are regarded to have higher efficiencies than conventional gears. From January 1990 these gears are being recorded separately such that it should be possible to comment on the magnitude of their effort.

5.8. Irish Sea East (Management Unit 14)

Landings reported by : UK and France

United Kingdom (England & Wales, Northern Ireland)

Landings by UK vessels in England from the eastern Irish Sea have fallen to 393 tonnes in 1989, the lowest for the period 1980-89 (Table 5.22.). Fishing effort by directed voyages (i.e. voyages where Nephrops accounts for > 25 % of the landings), which caught 77 % of the recorded landings, fell by 4 % to about 18 200 hours fished (Table 5.23.). Over half (53 %) of this directed effort comes from visiting Northern Irish registered vessels fishing from Whitehaven during the main Nephrops season.

The overall LPUE, based on the Nephrops directed voyages, has stabilised at 16.7 kg/hour trawling, within the range (9.5 to 21.7) of the lower levels of LPUE observed since 1986 (Figure 5.3.). The LPUE data for 1988, expressed as numbers/hour fished by sex, are now available (Figure 5.4.) and also show a levelling off of the LPUE.

France

The French Nephrops landings from the eastern Irish Sea are taken as a by-catch of the finfish fishery (Table 5.22.).

5.9. Irish Sea West (Management Unit 15)

Landings reported by : UK and Ireland

UK (Northern Ireland)

Total Nephrops landings by UK vessels into Northern Ireland during 1989 were about 5 550 tonnes (Table 5.25.). This was a

6 % increase on the 1988 landings and contributed for 69 % to the international landings from this management unit.

Analysis of discard data demonstrated that the catches have fluctuated over the past 8 years and do not show the upward trend apparent in the landings (Table 5.26.).

This is attributed to market driven changes in the discard rate : in recent years there has been a trend towards landing smaller Nephrops, encouraged by a reduction of the minimum landing size. Another change in market practice since the mid-1980s is the increasing trend towards landing whole Nephrops. In 1989 almost 18 % (977 tonnes) were landed whole.

Although showing fluctuations over the years, the limited data available suggest that LPUE (calculated from an effort index based on motor power and hours fished) is relatively stable (Table 5.25.).

Republic of Ireland

Irish landings over the years 1980-89 have fluctuated between 1 600 and 4 200 tonnes, with peaks of over 4 000 tonnes in 1982 and 1987, and troughs at 1 600 tonnes in 1980 and about 2 000 tonnes in 1985. Since 1987 there has been a sharp fall to under 2 500 tonnes in 1989 (Table 5.24.).

Catch and discard data are currently being collected from 1984 onwards. Catches show similar trends to landings, with a progressive fall in the percentage of Nephrops discarded.

5.10. Porcupine and Aran Islands (Management Units 16 and 17)

Landings reported by : Spain (Porcupine Bank only), France, Ireland and UK (Porcupine Bank only)

Spain

Landings by Spanish vessels over the period 1980-89 have fluctuated between 1 400 and 3 950 tonnes. After increasing up to 1982, when a maximum of over 3 900 tonnes was reached, landings declined to only 1 462 tonnes in 1986, and have since fluctuated around an average of about 1 500 tonnes, half the average for 1980-85 (Table 5.26.).

Fishing effort decreased considerably from 1980 to 1986, then slightly increased in 1987, and maintained this level until 1989 (Table 5.27.).

CPUE of Nephrops directed trawlers (there are no discards in this fishery) continuously decreased from 1982 to 1988, then remained about the same in 1989 (Table 5.27.).

France

Trends in landings, effort and LPUE over the past years were described in the 1989 Working Group's report (ICES, 1989), and are confirmed by the 1989 figures. These are the lowest for the whole time series, at about 30 % below the figures observed in the first years of exploitation (Tables 5.26. and 5.28.).

5.11. Republic of Ireland coast (Management Units 18 and 19)

Landings reported by : Ireland

Republic of Ireland

Landings from the NW and W Irish coast stocks (Management Unit 18) have fluctuated considerably between only 1 tonne in 1980 and 90 tonnes in 1984 (Table 5.29.).

Landings taken on the SW coast of Ireland (Management Unit 19) have strongly increased, especially since 1985 when a level of nearly 700 tonnes was reached. Since then landings have remained above 600 tonnes/year, except in 1986 when the figure dropped to 474 tonnes (Table 5.29.).

There are no effort, CPUE or LPUE data for these fisheries.

5.12. Celtic Sea (Management Units 20, 21 and 22)

Landings reported by : France and Ireland

France

French Nephrops landings from the Celtic Sea increased by about 350 tonnes in 1989 (Table 5.30.), whilst fishing effort declined from the higher levels of 1987 and 1988 to the level recorded in 1984-86 (Table 5.31.).

The LPUE for 1989 (viz. 272 kg/day) is close to the highest value observed in the reference period (viz. 282/kg day in 1985) (Table 5.31.).

Republic of Ireland

Landings taken by Irish trawlers have strongly fluctuated over the years, from only 30 - 90 tonnes in 1980-82, to a first peak of 510 tonnes in 1983, followed by a five years period of much smaller landings (170 - 330 tonnes/year) and a second peak of 540 tonnes in 1989 (Table 5.30.).

5.13. Bay of Biscay (Management Units 23 and 24)

Landings reported by : France

France

After an increase in landings from around 4 500 tonnes in 1984-86 to an all time high of 6 220 tonnes in 1988, the preliminary figure of about 5 200 tonnes for 1989 shows a clear decrease, to a value close to the mean for the reference period (Table 5.32.).

The LPUE, which peaked at 119 kg/day in 1988, decreased to 95 kg/day in 1989, some 5 % below the overall average of 102 kg/day for 1980-89 (Table 5.33.).

In recent years, the increases of the mesh size and the overall decrease in effort, which partly turned to finfish, led to a stabilization of the yield, in spite of the pessimistic exploitation pattern for the males (see Section 7.15.), which represent about 75 % of the total weight landed.

5.14. North Galicia (Management Unit 25)

Landings reported by : Spain

Spain

Landings decreased from 1977 to 1981, then fluctuated between 350 and 500 tonnes until 1988, and in 1989 fell to about 300 tonnes, i.e. almost 25 % below the average for the reference period 1980-89 (Table 5.34.).

Fishing effort declined from 1976 to 1980 and again from 1982 to 1987, but increased in 1988 and 1989, to a level nearly 35 % above that in 1987 (Table 5.35.).

The annual CPUE (there are no discards in this fishery) has fluctuated within a wide range of values, but shows no clear long-term trend. In most recent years however, CPUE dropped

from 15.4 kg/day * BHP * 100^{-2} in 1987, to only 10.1 kg/day * BHP * 100^{-2} in 1989 (Table 5.35.).

A more extensive description of the North Galician Nephrops fishery is given by FARIÑA (1989).

Catches of more than 100 tonnes/year are taken in the Cantabrian Sea (Table 5.34.). More information about the actual location of these Nephrops grounds would be necessary to identify the boundaries between this stock and the North Galician stock.

5.15. West Galicia (Management Unit 26)

Landings reported by : Spain

Spain

Nephrops landings from the West Galician stock have fluctuated over the past 15 years between 600 - 830 tonnes, without obvious trend (Table 5.36.).

CPUE data (there are no discards in this fishery) for the trawler fleets of Muros and Riveira, available since 1984, have fluctuated between 15 and 33.5 kg/day, again without obvious trend (Table 5.37.).

5.16. North Portugal (Management Unit 27)

Landings reported by : Portugal

Portugal

Portuguese landings from this stock have fluctuated between

13 and 97 tonnes (Table 5.38.). There are no effort, CPUE or LPUE data for this fishery.

5.17. SW and S Portugal (Management Units 28 and 29)

Landings reported by : Portugal

Portugal

Since January 1983 the Nephrops stocks in the Alentejo and Algarve area (SW and S Portugal) are exploited exclusively by Portuguese trawlers (see the 1989 Working Group's report for an historical account of this fishery).

Table 5.38. shows that the Portuguese landings rapidly rose from about 250 tonnes 1983 to nearly 1 500 tonnes in 1987. Since then they decreased sharply to only 350 tonnes in 1989, i.e. by nearly 75 % as compared to the figure for 1987 and by 65 % as compared to that for 1988.

In 1989 the fishery was conducted by about 32 vessels during the whole year, with a mean GRT of 93 tonnes and a mean motor power of 292 KW (Table 5.38.). From 1987 to 1989 the number of Nephrops trawlers decreased by 13 units.

5.18. Gulf of Cadiz (Management Unit 30)

Landings reported by : Spain

Spain

Only partial landings data (1985-87) are available for this fishery (Table 5.36.).

6. TRENDS IN MEAN SIZE (2)(3)

6.1. Iceland (Management Unit 1)

Iceland

The mean sizes of male and female Nephrops in the catches have remained fairly stable during 1980-89 (Table 6.1.). Although fishing mortality of the females is considered to be much lower, because of their greater burrowing behaviour as well as their smaller size, the mean sizes of both sexes show the same trend, presumably as a result of the concurring effects of recruitment and growth on both males and females.

In years of very high fishing effort however, such as in the mid- and late 1960s, the mean size of the males is seen to drop off more rapidly than that of the females (Figure 6.1.). Moreover, the difference in size between the two sexes is seen to be greater in Iceland than in most other Nephrops stocks. This may be partly due to the very slow growth in female Nephrops around Iceland, owing to their biennial spawning regime.

6.2. Faroe Islands (Management Unit 2)

Faroes

There has been no regular sampling for length measurements on

---

(2) Stock-wise summaries are given in Annex 1.

(3) Unless stated otherwise the mean sizes given refer to carapace lengths (CL).

this Nephrops stock. For the season 1989/90 the mean sizes of males and females in the landings were 50.3 mm and 43.9 mm respectively.

6.3. Skagerrak and Kattegat (Management Units 3 and 4)

Sweden

Catch samples taken in 1985, 1986 and 1989 from the Skagerrak and the Kattegat showed similar size compositions. The mean sizes were almost stable for both males and females, except for an unexploited part of the Skagerrak stock on which a creel fishery was introduced in 1984, and where the mean size of especially male Nephrops in the catches decreased.

6.4. Botney Gut and Silver Pit (Management Unit 5)

Belgium

Nephrops landed from the Botney Gut and Silver Pit by Belgian trawlers are auctioned in three market classes, viz. "small" (< 35 mm), "medium" (30-45 mm) and "large" (> 40 mm). "Small" Nephrops are only landed from the last hauls, the rest being discarded at sea. Due to this discarding practice it is impossible to calculate overall mean sizes by pooling the data for the three market categories. Instead they are given for the market classes "small" and "medium + large" separately (Figures 6.2. - 6.5.).

Over the past five years the mean sizes of both male and female "small" Nephrops have remained fairly stable, at a level between 30.0 and 33.0 mm (Figures 6.3. and 6.4.). Over the same time period the mean size of male "medium + large" Nephrops has increased from 37.0 - 40.0 mm to 39.5 - 43.0 mm,

whereas that of the females remained rather stable between 36.0 and 40.0 mm (Figures 6.5. and 6.6.).

There is no evidence of changes is discarding practice or market preference.

6.5. Farn Deeps (Management Unit 6)

United Kingdom (England & Wales)

As pointed out in last year's report (ICES, 1989), mean sizes for both males and females in the landings have declined over the past 10 seasons (Table 6.2.) and are now lower than those observed in the 1960s.

As far as the mean sizes in the catches (landings + discards) are concerned, the available data for the past five seasons show some slight evidence of a decline (Table 6.2.), and the recent values are significantly smaller than those observed in the 1960s.

The changes in mean sizes of the landings could be explained, at least to some extent, by changes in market requirements, in that more smaller Nephrops have been landed in recent years. The reduction in mean sizes of the catches may be due in part to increased levels of exploitation.

6.6. Fladen Ground (Management Unit 7)

United Kingdom (Scotland)

Mean sizes for the Fladen Ground are presented for the first time. There is no obvious trend in either male or female mean sizes (Table 6.3.).

6.7. Firth of Forth, Moray Firth, Noup, North Minch, South Minch and Clyde (Management Units 8-13)

United Kingdom (Scotland)

Mean sizes of male and female Nephrops landed from the Firth of Forth, Moray Firth, North Minch, South Minch and Clyde are given in Tables 6.4. - 6.8. Data were presented in the 1989 Working Group's report (ICES, 1989). New or updated figures for 1988 and 1989 are included.

The latest estimates of mean size suggest a decline in the Firth of Forth (Management Unit 8 - Table 6.4.), but these are still higher than the mean sizes recorded in the mid-1970s, when the stock was considered to be "overexploited" (ICES, 1988).

Trends in the Moray Firth data (Management Unit 9) are less obvious (Table 6.5.), and the current mean sizes are above those experienced in the 1970s.

No mean size data were available for the Noup (Management Unit 10).

In the North Minch (Management Unit 11), the recent figures suggest a decline in mean size of males, but female sizes remained stable at about 30 mm (Table 6.6.).

In the South Minch (Management Unit 12), the pattern of fluctuation without obvious trend continued in 1988 and 1989 (Table 6.7.).

In the Clyde (Management Unit 13), mean sizes continued to rise in 1988 and 1989, for both males and females (Table 6.8.). It is difficult to say whether this reflects a true increase in mean size in the stock or rather a change in the landing practices towards larger animals. It is unfortunate

that Scottish data are based on landings and not catches. Earlier (see Section 5.7.) it was argued that the reduced LPUE in the Clyde in recent years might be the result of a high exploitation rate. However, a change in landing practice towards larger, less numerous, but more valuable Nephrops, could also produce this result. Effort has remained fairly constant in recent years so that the examination of individual length compositions gives an idea of the landing rates at length. The landing rates of larger animals in the Clyde appear to have stayed the same over a number of years, but recently there has been a dramatic drop in the landing rates of small Nephrops. This could support the idea of a change in landing practice, with increased discarding of smaller Nephrops. Unfortunately accurate discard information was not available. The alternative explanation of reduced numbers of small Nephrops is that of a decline in recruitment in recent years.

A similar phenomenon relating to mean size and landing rates of Nephrops is seen in the Irish Sea East (see Section 6.8.). The observation also emphasises the need to collect discard information.

6.8. Irish Sea East (Management Unit 14)

United Kingdom (England & Wales)

Only three size composition samples of the landings were taken in 1989. This was insufficient to warrant raising, so there are no new mean size data for this stock, although the provisional data for 1988 have now been updated (Table 6.9.).

An increase in the mean sizes of both males and females in 1987 and 1988 was reported last year (ICES, 1989), together with a decrease in landings and LPUE, and a decrease in the proportion of females in the landings.

As noted in Section 5.8., the 1987-89 LPUE has stabilised, and the ratio of landed tails to whole Nephrops (on a whole weight equivalent basis) has remained at about 50 : 50. The limited 1989 size composition data tends to add weight to last year's hypothesis that the changes seen since 1986 in landings, LPUE, sex ratio, and mean size are the result of a market driven change in the fishermen's size selection, resulting in more small Nephrops, especially females, being discarded. However, with no direct observations on discards or catch, the alternative hypothesis of a recent decline in recruitment cannot entirely be rejected.

6.9. Irish Sea West (Management Unit 15)

United Kingdom (Northern Ireland)

The mean sizes of Nephrops in the catches show an overall increase since 1983, with a peak of 27.5 mm and 24.5 mm for males and females respectively in 1988 (Table 6.10.).

Republic of Ireland

Irish mean "size" data are available in the form of mean weights (sexes pooled) in catches, landings and discards for 1971 and from 1984 onwards (Table 6.11.).

Mean weights in the catches have generally increased since 1984, whilst those in the landings have decreased. This probably reflects a decline in the proportion of Nephrops discarded, which the falling mean weight of the discards up to 1987 appears to confirm.

The increase in mean weight of the discards in 1988 and 1989 is less easily explicable, but may be a reflection of an increase of the mesh size used in Nephrops trawls, following the change in EC legislation in 1986.

6.10. Porcupine Bank (Management Unit 16)

Spain

Mean sizes of males have fluctuated between 38 and 41 mm over the period 1980-89. For the females a small increase in mean size occurred during the past years, viz. from 33 - 35 mm in 1980-86, to 35 - 38.5 mm in 1987-89 (Table 6.12.).

6.11. Aran Islands (Management Unit 17)

No mean size data available.

6.12. Republic of Ireland coast (Management Units 18 and 19)

No mean size data available.

6.13. Celtic Sea (Management Units 20, 21 and 22)

France

The available time series (1984-89) of mean sizes in the landings shows fairly stable values around 38 - 39 mm for the males, and around 35 - 36 mm for the females (Table 6.13.). No mesh increase occurred during this period.

The mean size is clearly influenced by a discarding practice which is peculiar to this fishery, with the actual commercial minimum landing size (viz. 35 mm) being much larger than the legal minimum landing size (viz. 25 mm).

6.14. Bay of Biscay (Management Units 23 and 24)

France

Sampling of Nephrops from the Bay of Biscay mainly covers the northern part of the area (Management Unit 23). As reported last year (ICES, 1989), the management of this fishery is dominated by two regulations which have influenced the mean size of the Nephrops landed :

- successive increases in mesh size, to 45 mm in 1979 and to 50 mm in 1986, and

- a stable commercial minimum landing size (viz. 22.5 mm).

The recent increase in the mean size of male Nephrops landed, from 26 mm in 1985 to 29 mm in 1989, mainly reflects the consequences of the increase in mesh size from 45 to 50 mm in 1986 (Table 6.14.).

The mean size of the females on the other hand, hardly varied over the years, with an overall mean of 26.8 ± 0.5 mm (Table 6.14.). It should also be noted that the length range of females landed is very narrow (viz. 22 - 30 mm) as compared to most other Nephrops fisheries.

6.15. North Galicia (Management Unit 25)

Spain

The mean sizes of Nephrops caught and landed (there are no discards in this fishery) decreased from 1981 to 1983 for males, and to 1984 for females, but have increased again since 1986. This trend has continued in 1989, with a notable increment in mean size of both sexes (Table 6.15.).

6.16. West Galicia (Management Unit 26)

Spain

Mean size data for male and female Nephrops in the catches (there are no discards in this fishery) are available for 1981-83, 1985-86 and 1988-89. It is necessary to emphasize the sharp fall in mean size for both sexes in 1989 : from 35.0 and 32.9 mm in 1988, to 29.9 and 28.5 mm in 1989 for males and females respectively (Table 6.16.).

6.17. North Portugal (Management Unit 27)

No mean size data available.

6.18. SW and S Portugal (Management Units 28 and 29)

Portugal

Mean size data from the landings and from research cruises are available for the years 1983-89 and 1983-87 respectively (Table 6.17.).

Over these periods the mean sizes of both males and females were fairly stable, in both the landings and the research cruise samples.

6.19. Gulf of Cadiz (Management Unit 30)

No mean size data available.

7. STOCK AND MESH ASSESSMENTS, MANAGEMENT CONSIDERATIONS (4)

7.1. Introduction

The Working Group carried out yield per recruit and mesh assessments, using length cohort analysis (LCA) (JONES, 1984), for all management units for which adequate length composition data were available at the meeting, viz. :

- Iceland (Management Unit 1 - males only),
- Faroe Islands (Management Unit 2 - Y/R assessment only),
- Botney Gut and Silver Pit (Management Unit 5),
- Farn Deeps (Management Unit 6),
- Fladen Ground (Management Unit 7),
- Firth of Forth (Management Unit 8),
- Moray Firth (Management Unit 9),
- North Minch (Management Unit 11),
- South Minch (Management Unit 12),
- Clyde (Management Unit 13),
- Irish Sea East (Management Unit 14),
- Irish Sea West (Management Unit 15),
- Porcupine Bank (Management Unit 16),
- Celtic Sea (Management Units 20, 21 and 22 combined),
- Bay of Biscay (Management Units 23 and 24 combined),
- North Galicia (Management Unit 25),
- West Galicia (Management Unit 26), and
- SW and S Portugal (Management Units 28 and 29 combined).

Reference periods for the assessments were chosen to eliminate or at least to minimize the effect of changes in exploitation pattern, resulting from e.g. changes in effort, mesh size or discarding practice.

---

(4) Stock-wise summaries are given in Annex 1.

Last year's Working Group meeting extensively discussed the choice of growth parameters, terminal F, natural mortality and mesh selection parameters to be used in the LCAs. Since then little progress has been made in obtaining better estimates for these parameters, and therefore last year's comments on the uncertainties in the input parameters and their possible impact on the assessments remain valid (see ICES, 1989, Section 7, Annex 2 and Annex 3).

With respect to female growth, which is known - at least in a number of stocks - to change markedly after maturation, it should be emphasized that whenever possible and/or relevant different growth parameters were used for immature and mature females (see Table 7.1. and stock-wise sections).

Y/R assessments

Yield per recruit and biomass per recruit were calculated as relative changes in landings (after 1 year and long-term) and biomass (long-term) for relative changes in effort.

Input parameters are summarized in Table 7.1. and discussed in the stock-wise sections (see Sections 7.2. - 7.20.). Input length distributions for the numbers removed (i.e. landings plus dead discards), meaned across years are shown in Tables 7.2. - 7.20., together with LCA output values for delta T and annual F, for each length group. Mean annual Fs, averaged across the lower 75 % of the length range - to exclude the length groups affected by terminal F - are given in Table 7.21. Y/R and B/R against effort curves are shown in Figures 7.1. - 7.41.

Mesh assessments

Mesh assessments were done for most stocks, to estimate the short-term (i.e. after 1 year) and long-term effects of different mesh size increases. Mesh changes assessed varied

from one management unit to another, depending on the mesh size(s) currently used, and the legal minimum mesh sizes for Nephrops and finfish trawls (see Table 8.1. and stock-wise sections).

Input parameters are discussed in the stock-wise sections (see Sections 7.2. - 7.20.). Relative changes in Y/R and B/R at status quo effort are given in Tables 7.22. - 7.38. Relative changes in Y/R (long-term) against effort curves are shown in Figures 7.42. - 7.78. for various changes in mesh size.

Management considerations

Management recommendations (if relevant) and landings options are provided for each management unit in the stock-wise sections (see Sections 7.2. - 7.20.). The Working Group proposes the following landings options :

(1) The maximum landing within the time period corresponding to the reference period used in the LCA with an overriding minimum of 5 years.
(2) The mean + standard deviation over the same time period.
(3) The mean over the same time period.

The relationship between state of exploitation and landings options is discussed in Section 7.21.

7.2. Iceland (Management Unit 1)

LCA - Input parameters

Reference period : 1988-89

Annual catches of female Nephrops amounted to some 100 - 200 tonnes in 1988-89 (i.e. less than 10 % of the total). During

the Icelandic trawl season (May - August) females are mostly in a soft-shelled condition and hence discarded for that reason or because of their small size. Therefore the Y/R and mesh assessments were only done on males.

Input parameters for growth, terminal F, natural mortality, discard survival and mesh selection are given in Table 7.1.

LCA - Results (Table 7.2. ; Figure 7.1.)

Current mean F calculated over the whole size range from the LCA was 0.24, which equals well with the $F_{0.1}$ on the Y/R curve shown in the Icelandic "age" based assessment described in last year's Working Group report (ICES, 1989).

Increasing the effort by 50 % would give an increase of only ≈ 2 % in long-term landings, although landings after 1 year could increase by some 24 % (Figure 7.1.). It is therefore suggested that fishing effort should be kept at the recent years levels near $F_{0.1}$.

The stock biomass in the LCA assessment, however, indicates a somewhat smaller stock of male Nephrops than the figure given by the "age" based assessments for 1988 and 1989. The importance of the bad weather factor (see Section 5.1.) may therefore have been overestimated when determining terminal Fs in 1988, in which case the Fs would become higher and the estimate of stock biomass for 1988 as well as the prognosis for 1989 smaller. This would comply well with the drop in LPUE for those two years discussed in Section 5.1.

Mesh assessment (Table 7.22. ; Figure 7.42.)

Legal min. mesh size Nephrops : 80 mm
Legal min. mesh size finfish : 120 - 155 mm
Current Nephrops mesh size : 80 mm
Mesh increases assessed : from 80 to 90 mm

The results of an increase in mesh size from 80 to 90 mm, at status quo effort, do not indicate any changes in long-term landings (Table 7.22.).

7.3. Faroe Islands (Management Unit 2)

LCA - Input parameters

Reference period : season 1989/90

Biological and technical parameters were taken from results of Icelandic investigations (Table 7.1.).

LCA - Results (Table 7.3. ; Figures 7.2.-7.3.)

The results show that mean F is 0.11 for males and 0.18 for females (Table 7.21.), and that current F is far below F_{max} for both sexes. An increase in effort by 50 % will increase long-term landings by 19 % and 12 % for males and females respectively (Figures 7.2. and 7.3.). However, if effort was to increase to that level, LPUE would probably drop by about 21 % and 26 % for males and females respectively.

Mesh assessment

The Nephrops fishery around the Faroe Islands is a creel fishery (see Section 5.2.) and therefore no mesh assessment was made.

Management considerations

Landings options for the Faroe Islands stock are given in the text table on next page.

Landings options	(in tonnes/year)
Reference period	: seasons 1984/85-88/89
Maximum	: 91
Mean + sd	: 88
Mean	: 67.5

7.4. Skagerrak and Kattegat (Management Units 3 and 4)

LCA and Mesh assessment

No analytical assessments of these units are presented, since the basic length data were considered to be too sporadic. The same applies to growth parameters.

Management considerations

With respect to the Kattegat stock (Management Unit 4), the downward trend in the Danish and Swedish LPUE figures for the years 1987-89, together with the decrease in landings suggest a sharply declining stock in the northern Kattegat. This was to be expected as a result of the steep increase of particularly Danish effort over the last 5 years (see Section 5.3.).

The corresponding figures for the Skagerrak (Management Unit 3) show a similar trend in LPUE, although not as pronounced as that for the northern Kattegat (see Section 5.3.).

Although the basic data obviously still are too poor to base any reliable assessment on, the Working Group is of the opinion that the Nephrops stock, especially in the Kattegat, is in such a state that some regulatory measures are needed, e.g. by limiting the effort.

Landings options for the Skagerrak and the Kattegat stocks are given in the text table below.

Landings options (in tonnes/year)			
		Skagerrak	Kattegat
Reference period	:	1985-89	1985-89
Maximum	:	2 608	1 807
Mean + sd	:	2 548	1 811
Mean	:	2 321	1 577

7.5. Botney Gut and Silver Pit (Management Unit 5)

LCA - Input parameters

Reference period : 1986-89

Length compositions of the landings were calculated from Belgian market sample data, weighted by season and market category (see Section 6.4.) and raised to total landing by the whole fleet.

Length compositions of the discards were estimated from the quantities of "small" Nephrops landed per standard haul by the vessels actually landing small Nephrops, and raised to total effort by the whole fleet. This gives a minimum estimate of the numbers discarded, especially for the smaller size classes, since the left hand side of the distribution is truncated as a result of size selection by the fishermen.

The growth parameters for Central North Sea Nephrops were assumed to be similar to those for the Moray Firth stock (see Section 7.8.), which inhabits similar sediments and

which shows similar size compositions. Since the landings contain few females with a size below that at 50 % maturity (≈ 25 mm) only one set of growth parameters was used for the females, with values of K and $L\infty$ corresponding to the growth curves for matures.

Initial runs for the females with K = 0.06 and $L\infty$ = 60 mm gave highly unrealistic results for the numbers attaining the smallest length and the biomasses calculated by the LCA, as compared to the figures for the males. Therefore the final runs were made with a more conservative K of 0.08 for the females, whereas the other growth parameters were left unaltered. A similar adjustment of numbers attaining smallest length and of biomasses would have been obtained by changing the value of M.

LCA - Results (Table 7.4. ; Figures 7.4.-7.5.)

Mean Fs generated by the LCA were 0.18 for the males and 0.07 for the females (Table 7.21.). The results also show that current Fs for both males and females in the Botney Gut-Silver Pit stock are well below F_{max}. Due to the flat-topped shape of the curves the long-term gains in landings from an increase in effort are rather small (Figures 7.4. and 7.5.), especially for the males (only ≈ 5 %) which, on average, constitute about two-thirds of the landings. The underestimate of the numbers discarded however tends to underestimate Fs on the smaller length groups and therefore may have resulted in an optimistic assessment of the actual state of exploitation.

Mesh assessment (Table 7.23. ; Figures 7.43.-7.44.).

Legal min. mesh size Nephrops : 70 mm
Legal min. mesh size finfish : 90 mm
Current Nephrops mesh size : 70 mm
Mesh increases assessed : from 70 to 80 and 90 mm

Selection factors for whole trawl selectivity were assumed to be 0.4 for all mesh sizes, and selection ranges were assumed to increase from 13 mm for the 70 mm mesh, over 15 mm for the 80 mm mesh, to 17 mm for the 90 mm mesh.

With status quo effort any increase of the mesh size would result in moderate to substantial short-term losses for both males and females (Table 7.23.). The introduction of an 80 mm mesh would hardly effect long-term landings of the males, but would cause a long-term loss of nearly 6 % for the females. As a matter of fact only the long-term biomass would benefit from a larger mesh size.

Again it should be stressed that better estimates of the numbers discarded would have given more optimistic predictions of the long-term effects of a mesh size increase. Higher survival rates of the discards, on the contrary, would have given more pessimistic projections.

Management considerations

The results of the present assessment indicate that there is no urgent need for protective measures for the Botney Gut-Silver Pit stock.

However, the Working Group felt that a rapid and substantial increase of fishing effort, as a likely consequence of a diversion of effort from other TAC restricted Nephrops and/or finfish fisheries in the North Sea, should be avoided. Therefore, it seems advisable to limit the effort to a level corresponding to the maximum landings over the last five years.

Landings options for the Botney Gut - Silver Pit stock are given in the text table on next page.

Landings options	(in tonnes/year)
Reference period	: 1985-89
Maximum	: 768 (*)
Mean + sd	: 710 (*)
Mean	: 579 (*)

(*) based on landings figures for Belgium, raised by 1.15 to include landings by UK vessels and partly unknown (1985-87) landings by Danish vessels (see Section 5.4.)

7.6. Farn Deeps (Management Unit 6)

LCA - Input parameters

Reference period : seasons 1984/85 - 1988/89

The period chosen for averaging length composition data was from season 1984/85 to 1988/89, this being the period for which discard data are available.

Values for $L\infty$ were set to the maximum length observed in the landings over the same period. For males and immature females K was estimated from a Ford-Walford plot, using the same $L\infty$ values. Values for L_t and L_{t+1} were estimated from the modal lengths of age classes which could be identified from length compositions taken during research vessel surveys in 1989. For mature females, there is evidence from other stocks that growth is markedly slower (see e.g. ICES, 1989). Since data for mature females are lacking for the Farn Deeps stock at present, it was decided to use values estimated for mature females from the Clyde stock. A value of 24 mm was selected as the transition length, chosen by inspection of the length of females carrying eggs. These growth data should be treated

as preliminary, pending the results of further work currently in progress (see Section 3.1.).

Values of natural mortality of 0.3 (for males and immature females) and 0.2 (for mature females) were assumed, as was the discard survival rate of 0.25.

LCA - Results (Table 7.5. ; Figures 7.6.-7.7.)

Mean F was 0.52 for the males and 0.14 for the females (Table 7.21.). The Y/R curves indicate that current F for the males is 60 % above F_{max}, but that for females current F corresponds to F_{max}. For males, the LCA predicts gains in long-term landings and biomass of 32 % and 158 % respectively, for a reduction in effort to F_{max}. However, the absolute values of these predicted gains should be treated with caution, in view of the large extrapolation to F_{max}.

Although there is a considerable difference in the Y/R curves for the two sexes, it may be concluded that further increases in effort will not result in gains in long-term landings.

Mesh assessment (Table 7.24. ; Figures 7.45.-7.46.).

Legal min. mesh size Nephrops : 70 mm
Legal min. mesh size finfish : 90 mm
Current Nephrops mesh size : 70 mm
Mesh increases assessed : from 70 to 80 and 90 mm

The selection factor and selection range for the current mesh size of 70 mm were set at 0.4 and 13 mm respectively, based on inspection of selectivity data for other stocks (BENNETT, 1984 and BRIGGS, 1986). Assessments were made for increases in mesh size to 80 mm and 90 mm, and for these the selection range was increased to 15 mm and 17 mm respectively.

For males, the results indicate that, at the current level of effort, a mesh increase to 80 or 90 mm would result in long-term gains in landings of 21 % or 37 % respectively, with small losses after 1 year. For females, these mesh increases result in very little changes in long-term landings, but there is an increase in biomass of 20 % (for the 80 mm mesh) or 40 % (for the 90 mm mesh). However, losses after 1 year are more significant for the females : 15 % for an 80 mm mesh and 30 % for a 90 mm mesh.

In view of these results, and the high levels of discarding in this fishery, it may be concluded that a mesh increase would be beneficial, provided that the selectivity of the gear in use corresponds to that assumed in the assessment.

Management considerations

As pointed out in Section 5.5., the landings from this stock have been increasing in recent years and the maximum value of 3 100 tonnes refers to last year (1989), data for which are provisional. The Y/R analysis suggests that an appropriate management strategy would be to stabilise the fishery at its current level, and for this purpose the final 1989 landings value could be suggested.

Landings options	(in tonnes/year)
Reference period	: 1985-89
Maximum	: 3 100 (*)
Mean + sd	: 2 822 (*)
Mean	: 2 368 (*)

(*) data refer to calendar years and not to years commencing on July 1st, as used for the LCA

7.7. Fladen (Management Unit 7)

LCA - Input parameters

Reference period : 1980-89

The assessments were carried out using length compositions from Scottish data only, collected between 1980 and 1989. These come mostly from the south-west corner of the ground and may not be fully representative of the area as a whole. There were no discard data included.

Parameters for growth and length-weight relationship were mostly based on Scottish data collected in other areas (see Section 7.8.). For females two growth curves were used, with a separation at the length of 50 % maturity. Input natural mortality rates were 0.3 (for males and immature females), and 0.2 (for mature females). Input F was set at 0.3 for both sexes.

LCA - Results (Table 7.6. ; Figures 7.8.-7.9.)

Mean F for males was 0.27, amongst the lowest obtained for the Scottish stocks (Table 7.21.). In view of the relatively recent development of this fishery and the large area of ground covered this is perhaps not surprising. Biomass of males was estimated to be just over 2 000 tonnes. This is very low but, as already said in the previous paragraph, the assessment did not include discards. Mean F on females was at 0.18.

Figures 7.8. and 7.9. show, for males and females respectively, long-term changes in landings and biomass which could be expected from changes in fishing effort. For males a very flat long-term yield curve is evident, with current F close to F_{max}.

In females there is more evidence that current F is to the left of F_{max}, although increases in effort by as much as 50 % would improve long-term landings by only ≈ 5 %.

Reductions in effort would increase biomass of both males and females.

Mesh assessment (Table 7.25. ; Figures 7.47.-7.48.)

Legal min. mesh size Nephrops : 70 mm
Legal min. mesh size finfish : 90 mm
Current Nephrops mesh size : 70 mm
Mesh changes assessed : from 70 to 60, 80 and 90 mm

Mesh selectivity parameters obtained from Danish data (KIRKEGAARD et al., 1989) were used to investigate the effects of mesh changes on long-term landings.

For both males and females there is no evidence that increases in mesh size will improve long-term landings. In fact, at 90 mm, losses of 8 % and 25 % for males and females respectively, are predicted (Table 7.25.). It must be remembered that discards were not included in the assessments, and if substantial, would radically alter the results, pushing the yield curves to the left.

A reduction in mesh to 60 mm was also investigated but there was little evidence of a change in long-term landings and the predicted biomass change was clearly downward (Table 7.25.).

Management considerations

In view of the uncertainties in biological input parameters and the lack of discard data, it is felt that the assessment is somewhat unreliable. Moreover, fishing effort throughout the period has shown an increasing trend (see Section 5.6.).

An additional problem therefore is that the stock is probably not in a steady state.

Because of the many uncertainties in the assessment no clear guidance can be given. However, since the fishery is relatively recent and the fishing grounds of considerable size (judging by the extent of suitable substrate for Nephrops), it is felt that severe restrictions should not be applied on this fishery. A precautionary TAC slightly above the maximum landings figure seems to be the most appropriate option.

Landings options (in tonnes/year)	
Reference period	: 1980-89
Maximum	: 2 363 (*)
Mean + sd	: 1 762 (*)
Mean	: 1 102 (*)

(*) for earlier years (1980-84) no Danish landings figures are available, so the true figures could be higher

7.8. Firth of Forth, Moray Firth, Noup, North Minch, South Minch and Clyde (Management Units 8-13)

LCA - Input parameters

Reference period : 1980-89 (for all management units, except for the Noup, which was not assessed)

For each stock, separate assessments for males and females were carried out using length compositions collected by Scotland between 1980 and 1989. Extensive data were available on the landed length compositions but only limited information was available on discards. Accordingly, ogives of the propor-

tions discarded at length were applied to the average length distributions. These are likely to be underestimates and are truncated, so that there may well be discarding below the length of the smallest Nephrops in the length distribution.

Input parameters for growth were based on BAILEY and CHAPMAN (1983) and CHAPMAN (1982). Growth data were collected in only a few areas (Clyde, Jura and Torridon) so input parameters for other areas were based on observations of sediment distribution and also the general pattern in size compositions over a number of years. For females it was decided to adopt the approach used at the last Working Group meeting (ICES, 1989) of using different growth curves for immature animals (based on male growth) and for mature animals (based on moult increment data and the assumption of one moult per year). L_∞ values were lower for mature females than for the immatures and, more importantly, lower K values were also predicted. Input parameters for all stocks and for both sexes are given in Table 7.1.

Length-weight relationships were based on HOWARD and HALL (1983) using pooled slopes.

Input natural mortality for males and immature females was 0.3 (based on MORIZUR, 1982). For mature females it was decided to adopt a lower value (viz. 0.2) owing to their reduced emergence when carrying eggs. The choice of these values was in line with those used for other areas, but their applicability is uncertain and they were considered to be overestimates. Input F was 0.3 for all areas and for both sexes.

The proportion of discards surviving was set nominally at 0.25. This was based on observations made in cages placed on the seabed in the Nephrops habitat. Between 30 and 50 % of the Nephrops (DAFS, current work) were found to survive the trawling and handling process, but this figure was adjusted

downward because considerable discarding normally takes place away from the Nephrops grounds.

LCA - Results (Tables 7.7.-7.12. ; Figures 7.10.-7.22.).

Annualized mean F for the males was highest in the Firth of Forth stock (0.40), followed by - in descending order - the Clyde (0.38), South Minch (0.38), North Minch (0.29) and Moray Firth (0.27). The pattern throughout the stocks seems reasonable when compared with other indicators such as LPUE (see Section 5.7.).

At the last Working Group it was argued that the relatively high value of M used (0.3) produced a conservative estimate of the fishing mortality rate such that if F was still high, there were good grounds for some change in exploitation pattern. It has been pointed out that the assessments are dependent on input parameter values (ICES, 1989) and that M is influential. It was decided to apply a lower value of M (viz. 0.2) to the Scottish stock showing the lowest mean F, i.e. the Moray Firth, to investigate the effect on mean F.

Application of the lower value generated a mean F of 0.42 for the Moray Firth, an increase of nearly 60 %. Altering the Ms on the other Scottish stocks would also lead to increases in mean F. Since there are no strong reasons for choosing an M of 0.3 as opposed to the lower value, the implications of 0.3 being an overestimate must be remembered in the later predictions.

Mean F values on the females were considerably lower than on the males (Table 7.21.). Values ranged from 0.10 in the South Minch, down to $\approx$ 0.005 in the Moray Firth. In descending order of mean F the stocks were arranged as follows : South Minch, Clyde, Firth of Forth, North Minch and Moray Firth.

The values of F on the females were very low (as compared to

most other Nephrops stocks - Table 7.21.), and in order to check whether these results were at all sensible, some comparisons between males and females were made of the numbers attaining the smallest length, the average standing stock in numbers and the biomass (Table 7.12.). Although these figures are sometimes regarded as rather meaningless, comparison between sexes was considered to be worthwhile.

It is known that the sex ratio of juvenile Nephrops in at least some Scottish stocks is close to 1 : 1 (BAILEY, 1984). Thus the ratio of females to males attaining the smallest length ought to be close to 1 : 1 also. In some stocks (Firth of Forth, South Minch and Clyde), reasonable results were obtained, but for the Moray Firth and North Minch female numbers far exceeded the males (Table 7.12.).

In terms of overall biomass (calculated from the product of mean weight at length and the average numbers in the sea at length) ratios always favoured the females. This is not unexpected since low mortality rates during egg incubation could lead to the accumulation of more year classes in the stock than for males. Again, however, rather high, unbelievable ratios were obtained for the Moray Firth and the North Minch (Table 7.12.).

A third check related to the overall numbers in the stock (males and females combined) forming the standing stock. Estimates of stock size may be converted to densities if the area occupied by the fishery is known. For the Clyde, the Firth of Forth and the Moray Firth fisheries, overall areas comprising the Nephrops grounds were earlier estimated by reference to sediment charts (ICES, 1989). Computations using stock size and area, produced density estimates of 0.73 per m^2, 1.14 per m^2 and 6.3 per m^2 for the Clyde, Firth of Forth and Moray Firth respectively. Compared with estimates obtained by direct observation using underwater TV (BAILEY and CHAPMAN, 1983) the derived Clyde and Firth of Forth density

estimates are not unreasonable but the Moray Firth results are very high. Bearing in mind that the stock estimates are obtained from length distributions raised to Nephrops trawl and light trawl only, these densities are minimum estimates.

In view of the "inconsistencies" between assessments it was decided that, as for males, the effects of using different input parameters should be investigated for the "worst female case", i.e. the Moray Firth. Two additional runs were carried out, one in which the rather low K value of 0.06 on mature females was adjusted upwards to 0.1 (a figure used e.g. in the Irish Sea), and one where M was adjusted downward to 0.2 for immature females (as in the second male run) and to 0.1 for mature females.

In terms of mean F, much higher values were obtained in these runs (0.15 and 0.13 respectively), than in the original one (0.005). The text table below illustrates the effects on the estimates of numbers attaining the smallest length. Both the second and the third run drastically reduced the numbers of females and produced more sensible results. For brevity the biomasses and densities resulting from the new input parameters are not presented but these too were much more realistic.

Output from additional Moray Firth assessments, compared with first run

		Numbers attaining smallest length
Males	- 1st run	155 134
	- 2nd run	111 320
Females	- 1st run	2 878 398
	- 2nd run	164 111
	- 3rd run	131 399

Once more the results illustrate the sensitivity of the LCA method, and the difficulty of choosing which parameter to "adjust". The approach has of course assumed that only the female input parameters were responsible for the discrepancy between the sexes. Any errors in male input would also have produced anomalous results. Therefore the approach needs further investigation.

Prediction of the effects of changes in effort

Y/R and B/R curves for male Nephrops are shown in Figures 7.10. (Firth of Forth), 7.12. - 7.13. (Moray Firth), 7.17. (North Minch), 7.19. (South Minch) and 7.21. (Clyde).

For three of the stocks (viz. Firth of Forth, South Minch and Clyde) current F is above F_{max}. Long-term gains of < 5 % are predicted by reductions in effort of 30 %, together with short-term losses by the end of one year of about 15 %. The other two stocks (viz. Moray Firth and North Minch) exhibit flat-topped Y/R curves where current F is close to F_{max}, suggesting effort should be held constant.

It should be remembered that M at 0.3 is likely to be high and that it gives conservative estimates of long-term gains in landings with reductions in effort. Figure 7.13. shows the "worst case" Moray Firth yield curve with M at 0.2. Here current F is seen to be above F_{max} and there appears to be a considerable long-term benefit in reducing the effort ; a 15 % increase in long-term landings at a 50 % cut in effort. Bearing in mind that 0.2 is as plausible a value of M as 0.3 for all the Scottish stocks, the predicted long-term gains in landings could be above those quoted here. In addition, discards were probably underestimated and this too produced a flatter Y/R curve than would otherwise have been the case.

In all cases substantial gains in male stock biomass were predicted by reductions in effort.

The results for the males suggest that no further increases in effort be allowed on any of the five stocks (Management Units 8, 9, 11, 12 and 13).

Results for the females are shown in Figures 7.11. (Firth of Forth), 7.14. - 7.16. (Moray Firth), 7.18. (North Minch), 7.20. (South Minch) and 7.22. (Clyde).

Rather different results were obtained from those for the males. In all stocks current F was predicted to be to the left of F_{max}, and in most cases even the long-term gains in stock biomass were negligeable with reductions in effort.

In the previous paragraph on LCA results, reservations were expressed on the validity of the output because of the uncertainties in the choice of input parameters. Accordingly, predictions were also made for the "worst case" Moray Firth stock (where an almost straight line Y/R curve was found), using the inputs for the second and third run described above. Figures 7.15. and 7.16. illustrate the results and show that much flatter Y/R curves were produced, where current F is close to F_{max}, and where biomass increases more substantially with reduced effort.

On the one hand the low Fs for females are not surprising, especially in view of the long periods spent in the burrows during incubation, and flatter Y/R curves are probably to be expected. On the other hand it is felt that the predictions for females presented here, suggesting increased yield with increased effort, are rather too optimistic and result either from the application of inappropriate growth parameters, collected from other areas or from an incorrect choice of M. The results from the second and third run are probably more realistic.

It is also important to note that any increase in effort implied by the female predictions will result in increased

effort on the males too. For these however, the case for holding effort constant or even for reducing effort was much stronger. It is therefore recommended that a policy be adopted of first considering the more vulnerable component of the stock. In this case the male position would dictate that effort be held constant or be reduced.

Mesh Assessments (Tables 7.26.-7.30. ; Figures 7.49.-7.61.)

Legal min. mesh size Nephrops : 70 mm
Legal min. mesh size finfish : 90 mm
Current Nephrops mesh size : 70 mm
Mesh increases assessed : from 70 to 80 and 90 mm

Input parameters for the mesh assessment (selection factor and range) were based on the work summarised in BENNETT (1984) and BRIGGS (1986). These results were in broad agreement with earlier work by DAFS. For predicting the effects of increases in mesh size from 70 mm to 80 and 90 mm it was assumed that the selection range increased with the mesh size, viz. from 13 mm for the 70 mm mesh, over 15 mm for the 80 mm mesh, to 17 mm for the 90 mm mesh. This approach is conservative, tending to reduce the apparent benefits of increasing mesh sizes.

Figures 7.49. (Firth of Forth), 7.51. - 7.52. (Moray Firth), 7.56. (North Minch), 7.58. (South Minch) and 7.60. (Clyde) show the effects of various mesh size increases on the Y/R curve for males. Tables 7.26. - 7.30. show the predicted changes in short- and long-term landings and long-term biomass under status quo effort conditions.

The results suggest that, at status quo effort, increases in mesh to 80 and 90 mm would produce long-term increases in landings of $\approx$ 8 % and $\approx$ 13 % respectively, in the Firth of Forth, South Minch and Clyde. These increases are rather more substantial than the predicted effects of effort reduction

with no mesh change (see previous paragraph). The losses in landings after 1 year for the same changes would be ≈ 7 % and ≈ 17 %, while stock biomass would increase by around 27 % and 55 % (Tables 7.26., 7.29. and 7.30.).

For the Moray Firth (using M = 0.3) and the North Minch the case for a mesh change is less convincing. However, the use of M = 0.2 in the Moray Firth assessment totally changed the result (Table 7.27., Figures 7.51. and 7.52.) so that long-term landings were predicted to increase by 16 % and 26 % for meshes of 80 and 90 mm. Bearing in mind also that a conservative approach was taken by using a rather high selection range, as compared to the most recent estimates from twin-trawl selectivity experiments (see Section 3.3.), and remembering that discards were almost certainly underestimated, a mesh change throughout the Scottish stocks would appear to be beneficial for the males. Long-term benefits were predicted in moving to 90 mm, but this of course depends on whether the selectivity parameters used in the prediction match the selection properties of a 90 mm mesh. Unfortunately however, there were no recent Nephrops selectivity data for 90 mm nets available to the Working Group.

Results for the females are shown in Figures 7.50. (Firth of Forth), 7.53. - 7.55. (Moray Firth), 7.57. (North Minch), 7.59. (South Minch) and 7.61. (Clyde), and in Tables 7.26.-7.30.

In all cases, the results suggest long-term losses in female landings with increased mesh size. Again however, these results are based on uncertain inputs regarding K and M. In the Moray Firth, the use of alternative inputs in the second and third run suggests that the losses at status quo effort would then be negligible, although there would still be no gains (Table 7.27. and Figures 7.53. - 7.55.).

For the same reasons as offered in the discussion of the Y/R assessment it is recommended that the results for the males be taken as more indicative of the needs of the various fisheries.

Management considerations

The following text table summarises the landings options for the Scottish stocks assessed (Management Units 8, 9, 11, 12 and 13), together with landings options for the Noup and for the catches taken outside the present management units (see Sections 4. and 5.7.).

Landings options (in tonnes)

	Maximum	Mean + sd	Mean
Firth of Forth	2 528	2 259	1 754
Moray Firth	2 576	2 216	1 639
Noup	111	90	57
Other North Sea	363	247	145
North Minch	4 144	4 061	3 402
South Minch	4 415	4 157	3 608
Clyde	4 329	4 043	3 342
Other W of Scotland	638	496	346

In view of the comments on the Y/R curves for the males and the uncertainties regarding the input parameters for the females, it is recommended that no increases in effort be allowed in any of these areas. Since for the Firth of Forth, South Minch and Clyde, current F appeared to be past F_{max} (despite the choice of a high M), it is felt that the mean landings figure is the most realistic catch option in these stocks. For the Moray Firth and the North Minch, either the

mean + sd or the maximum are probably more appropriate, thus allowing some flexibility in the fishery.

7.9. Irish Sea East (Management Unit 14)

LCA - Input parameters

Reference period : 1985-88

During the reference period there has been a change in discarding practice (see Section 6.8.). If all discards die, there has been no real change in exploitation pattern, but with some discards surviving one would expect fishing mortality to have been reduced on smaller Nephrops.

Comparison of the size distributions before and after the change in discarding (Figure 7.23.) gives some indication of the extra discarding. This was used to provide an approximate estimate of the extra discarding for inclusion in the LCA. This procedure provides a reasonable estimate of discarding at sizes above ≈ 25 mm, where the extra discarding has taken place. It does, however, underestimate discarding at smaller sizes, where discarding already occurred prior to 1987.

Input parameters for growth, natural mortality, terminal F, discard survival and mesh selection are given in Table 7.1.

LCA - Results (Table 7.13. ; Figures 7.24.-7.25.)

Annualized mean F was at 0.21 for the males and at 0.15 for the females (Table 7.21.).

The Y/R curve for the males (Figure 7.24.) is flat-topped, with current effort just below F_{max}. There would be little to be gained in long-term landings from an increase in effort, and long-term biomass would be reduced. Quite large decreases

in effort would have little impact on long-term landings (e.g. only 12 % with a 50 % reduction in effort), but there would be significant increases in biomass (40 %) and LPUE. If more complete discard inputs were available the Y/R curve would be expected to be more dome shaped, and to have F_{max} further to the left than the one calculated here.

The female Y/R curve (Figure 7.25.) is also flat-topped and current effort is just above F_{max}. Since 1986 however, the landings have consisted predominantly of males (≈ 77 %), as the discarding practice changed (see Section 6.8.).

Mesh assessment (Table 7.31. ; Figures 7.62.-7.63.)

Legal min. mesh size Nephrops : 70 mm
Legal min. mesh size finfish : 70 mm
Current Nephrops mesh size : 70 mm
Mesh increases assessed : from 70 to 75, 80 and 85 mm

Small gains of 2 - 4 % in long-term landings were predicted for mesh increases from 70 mm to 75, 80 and 85 mm, for both males and females at current effort (Table 7.31.). These gains, however, are likely to be underestimated as the discard data are incomplete, particularly at the smaller sizes of Nephrops, where mesh selection changes would mainly occur.

Management considerations

The total international landings in the last three years (1987-89) have averaged 478 tonnes. This is some 40 % below the average of 807 tonnes for the years 1980-86. It appears (see Section 5.8. and 6.8.) that the lower recent English landings (91 % of the total) are the result of market driven changes in the discarding of Nephrops, the majority of which are above the 25 mm minimum landing size. With, say, 75 % of these discards dying, there has been little reduction in fishing mortality on the smaller Nephrops.

The Y/R analysis suggests that fishing effort should not be allowed to increase. A landings option based on the average figure for the most recent years would confine effort to current levels, as long as the discarding practice stayed the same. A return to the previous discard regime, with an increase in the landings of legal sized but smaller Nephrops, would increase LPUE, and compliance with a landings option based on the average of recent years would then result in a considerable decrease in effort, with minimal benefit to the stock.

Landings options (in tonnes/year)	
Reference period	: 1985-89
Maximum	: 757
Mean + sd	: 674
Mean	: 546

7.10. Irish Sea West (Management Unit 15)

LCA - Input parameters

Reference period : 1987-89

The data used were numbers caught and discarded by Ireland and Northern Ireland (raised to catches as described by BRIGGS, 1985), averaged over the years 1987-89. This period was selected as it was considered to represent a period of relatively steady state since the most recent increase in mesh size to 70 mm in 1986.

Input values for K and L_∞ for males and juvenile females were taken from new growth data obtained by fitting normal curves to polymodal length frequency distributions (TULLY et al.,

1989). Growth data for mature female Nephrops were from tagging results (HILLIS, 1979 and 1987). Female maturity was taken to occur at 24 mm knife edged (BRIGGS, 1988). Length-weight relationships were those of POPE and THOMAS (1955).

BRANDER and BENNETT (1986) estimated natural mortality in this area, due to cod predation alone, to be 0.2, with natural mortality from other sources elevating this value to 0.3. The work of TULLY et al. (1989), however, indicated a value of M = 0.18. The value of M = 0.3, used in last year's assessment for male Nephrops (ICES, 1989) was derived by "rounding up" from M = 0.26 (MORIZUR, 1982). In view of the difficulty in measuring natural mortality and the sensitivity of the LCA to this parameter a range of values (M = 0.2, 0.25 and 0.3) was used for male Nephrops. The female assessments were performed using a single value for M of 0.2. Discard survival, which is believed to be low in this fishery, was set at 0.10.

The mesh size in current use was taken as 68 mm, which represents a weighted mean of that thought to be used by Ireland (65 mm) and Northern Ireland (70 mm). The mesh selection factor of 0.4 was a recalculation from HILLIS and EARLEY (1982). The selection range was also obtained from this source. The same selection factor was used in the mesh assessments.

LCA - Results (Table 7.14. ; Figures 7.26.-7.29.).

Although results vary depending upon the input parameters chosen, it would appear that the males are being fished at a level of effort beyond F_{max}, and the females near to F_{max} (Figures 7.26. - 7.29.). Estimates of the extent by which the current exploitation rate exceeds F_{max} for males are very sensitive to the value used for natural mortality. At low natural mortality values (M = 0.2) a reduction in effort by 50 % would be required to achieve F_{max}, and would increase long-term landings by $\approx$ 20 %. With higher natural mortality

(M = 0.3) an estimated 20 % reduction in effort on males would suffice to reach F_{max}, but this would increase long-term landings by only ≈ 2 %.

Mesh assessment (Table 7.32. ; Figures 7.64.-7.66.)

Legal min. mesh size Nephrops : 70 mm
Legal min. mesh size finfish : 70 mm
Current Nephrops mesh size : 65 mm (Irl) and 70 mm (NI)
Mesh increases assessed : from 68 to 75, 80 and 85 mm

Short-term losses and long-term gains for male and female Nephrops predicted for a range of mesh size increases are shown in Table 7.32. Results for male Nephrops are given for a range of natural mortality values (M = 0.2, 0.25 and 0.3).

The results of the mesh assessments indicate negligible long-term gains in landings with mesh increase for the females and moderate to large gains for the males. The magnitude of these long-term gains is very sensitive to the value of M selected for the assessment. In view of the natural mortality value of 0.3, used for assessing neighboring management units (e.g. Irish Sea East and W of Scotland), it seems unlikely that the western Irish Sea Nephrops are subjected to a lower value.

Management considerations

Before considering an increase in minimum mesh size the current legal minimum mesh size (70 mm) should be strictly enforced. In addition effort should not be allowed to increase.

Landings options for the western Irish Sea stock are given in the text table on next page.

Landings options (in tonnes/year)			
Reference period	:	1985-89	
Maximum	:	9 199	
Mean + sd	:	9 161	9 041 (*)
Mean	:	8 085	8 523 (*)

(*) excluding (left) and including (right) the unusually low landings figure of 6 339 tonnes for 1985

7.11. Porcupine Bank (Management Unit 16)

LCA - Input parameters

Reference period : 1980-89

The assessments were made using length compositions from Spanish data only, collected over the period 1980-89.

Values of $L\infty$ (75 mm for the males and 60 mm for the females) were chosen to be larger than the maximum sizes measured from monthly catch samples. Natural mortality for both sexes was reduced from 0.3, used in last year's assessment (ICES, 1989) to 0.2, because predation was considered to be low in this area.

Selection parameters (SF = 0.58 and SR = 25 mm) were taken from ROBLES et al. (1985).

LCA - Results (Table 7.15. ; Figures 7.30.-7.31.)

Annualized mean F was 0.32 for both males and females (Table 7.21.).

The results of the Y/R assessment indicate that any increase in effort would give only moderate decreases in long-term landings for both sexes. For males any decrease in effort by as much as 50 % would increase long-term landings by only ≈ 7 % (Figure 7.30.). For females effort decreases down to 40 % below current F would result in almost no change in long-term landings (Figure 7.31.).

Mesh assessment (Table 7.33. ; Figures 7.67.-7.68.)

Legal min. mesh size Nephrops : 70 mm
Legal min. mesh size finfish : 80 mm
Current Nephrops mesh size : 74-80 mm (Sp) and 80 mm (Fr)
Mesh increases assessed : from 74 to 80 and 85 mm

If the mesh size was increased from 74 to 85 mm the long-term landings for males, at current effort, would increase by 7 %. At increased or decreased effort the long-term gains would be slightly larger or smaller respectively (Figure 7.67.). For females there would be little benefit from a mesh increase at any change in effort up to 30 % above or below current F. With a value for M of 0.3 instead of 0.2 the predicted benefits of a mesh increase would be even less. Therefore, any benefits from an increase in mesh size would be slight.

Management considerations

The results of the present assessments show that even substantial decreases in effort or increases in mesh size would produce only small long-term benefits in yield.

It should also be noted that over the last five years this fishery has become less attractive to French vessels, and that their effort seems to be continuously decreasing (see Section 5.10.). Therefore a landings option corresponding to the mean + sd could be recommended to maintain the current exploitation pattern (see text table on next page).

Landings options	(in tonnes/year)
Reference period	: 1985-89
Maximum	: 4 007 (*)
Mean + sd	: 3 494 (*)
Mean	: 2 689 (*)

(*) for earlier years (1985-88) no Irish landings figures are available, so the true figures are most likely 10 - 15 % higher (see Section 7.12. and Table 5.26.)

7.12. Aran Islands (Management Unit 17)

LCA and Mesh assessment

No Y/R or mesh assessment made.

Management considerations

Irish landings figures are common to the Porcupine Bank and the Aran Islands (see Section 5.10.), and therefore it is difficult to give realistic landings options for this management unit.

In 1989 the Irish landings were split for the first time into 872 tonnes (75 %) for the Aran Islands and 295 tonnes for the Porcupine Bank. Over the period 1980-89 the French landings from the Aran Islands stock have declined from 452 tonnes in 1980 to 14 tonnes in 1989. The best estimate of the landings option seems to be the mean + sd of the landings in the last five years, i.e. ≈ 1 330 tonnes (see text table on next page).

Landings options (in tonnes/year)	
Reference period	: 1985-89
Maximum	: 1 573
Mean + sd	: 1 328
Mean	: 960

(*) derived from annual figures calculated as 75 % of the Irish landings figure for Porcupine and Aran Islands combined, plus the French figure for the Aran Islands (see Table 5.26.)

7.13. Republic of Ireland coast (Management Units 18 and 19)

LCA and Mesh assessment

No Y/R or mesh assessment made.

Management considerations

Landings options for the Irish coast stocks are given in the text table below.

Landings options (in tonnes/year)			
		MU 18	MU 19
Reference period	:	1984-88	1984-88
Maximum	:	90	725
Mean + sd	:	63	709
Mean	:	28	576

7.14. Celtic Sea (Management Units 20, 21 and 22)

LCA - Input parameters

Reference period : 1987-89

Length compositions of the landings were calculated from French market sample data and raised to total landings by the whole fleet. Estimates of the numbers discarded were made by using results of a discard sampling survey, carried out at sea on commercial trawlers in 1985.

Growth parameters came from a length composition analysis, using Powell's method. Natural mortalities were calculated from MORIZUR (1982). The discard survival rate was calculated from the results of re-immersion experiments with sea cages.

LCA - Results (Table 7.16. ; Figures 7.32.-7.33.).

The estimated values of F are quite low, with a mean of 0.14 for males and 0.04 for females (Table 7.21.).

For males, the Y/R curve is flat-topped with current F below F_{max} (Figure 7.32.).

Within the range of effort changes investigated (from - 90 % to + 50 %) the female Y/R curve is almost asymptotic, and current F is far below F_{max} (Figure 7.33.).

It should be noted however, that discards are mostly females in this fishery. Therefore the estimates of the discards will have to be confirmed to obtain more reliable length composition data for the females.

Mesh assessment (Table 7.34. ; Figures 7.69.-7.70.)

Legal min. mesh size Nephrops : 70 mm

Legal min. mesh size finfish : 80 mm
Current Nephrops mesh size : 80 mm
Mesh increases assessed : from 80 to 85 and 90 mm

For males, no long-term gains in landings are likely to be obtained by increasing the mesh size, either with status quo effort, or with an increase in effort. For females, with status quo effort, increasing the mesh size to 85 or 90 mm would result in short-term (i.e. after 1 year) losses of 12 % and 24 %, and in long-term losses of 10 % and 21 % respectively. Only long-term biomass would benefit from a larger mesh size.

Management considerations

The male part of the stock (which represent about 85 % of the numbers landed) could sustain a slight increase in effort, but such an increase would have negative consequences on the demersal fisheries in the Celtic Sea as a whole. Therefore, the landings option proposed is the maximum landings figure in the last five years.

Landings options (in tonnes/year)	
Reference period	: 1985-89
Maximum	: 3 821
Mean + sd	: 3 788
Mean	: 3 357

7.15. Bay of Biscay (Management Units 23 and 24)

LCA - Input parameters

Reference period : 1987-89

Length compositions were averaged over the years 1987 to 1989, to minimize the effect of the most recent mesh change (from 45 to 50 mm) in 1986. Discards were estimated by means of a discard ogive, calculated in 1987 for the new mesh size.

Growth data were derived from CONAN and MORIZUR (1979), based on a modal analysis (using NORMSEP) of monthly size compositions, guided by the results from tagging experiments and the increments at moult in sea cages.

The value of M was calculated using the above parameters for growth (MORIZUR, 1982). He obtained a range of 0.3 to 0.6, the lowest value being used in the present assessment. Discard survival was calculated by GUEGUEN and CHARUAU (1975). This factor was established under rough operational conditions and the value used was the lowest of the range obtained (0.3 - 0.4).

Selectivity parameters were derived from French selectivity experiments (see summary of results in ICES, 1979). Mesh size and selection range (SR) are positively related according to the relationship $SR = 0.43 * L_{50}$.

LCA - Results (Table 7.17. ; Figures 7.34.-7.35.)

The male Y/R curve shows that current F is 40 % above F_{max}. The predicted effect of decreasing effort to F_{max} would be an increase of long-term biomass of 64 %. The gain in long-term landings, however, would be small (viz. ≈ 8 %). This confirms the diagnosis of the last year's assessment (ICES, 1989).

For females, current F is well below F_{max}. Only the length groups from 22 to 30 mm are submitted to a moderate fishing mortality. The catchability of females is very low throughout the year and their availability to the fishery is restricted to a period of approximately 4 months only. Mean F for the

females was 0.19, well below that for the males (viz. 0.37) (Table 7.21.).

Mesh assessment (Table 7.35. ; Figures 7.71.-7.72.)

Legal min. mesh size Nephrops : 55 mm (from April 1st, 1990)
Legal min. mesh size finfish : 65 mm
Current Nephrops mesh size : 50 mm (until April 1st, 1990)
Mesh increases assessed : from 50 to 55, 60 and 65 mm

The assessments were based on the situation in 1987-89, when 50 mm was the mesh size in use.

For the males, at status quo effort, an increase in mesh size would lead to the following gains in long-term landings : 9 % for 55 mm, 16 % for 60 mm, and 21 % for 65 mm (Table 7.35.).

For the females an increase in mesh size to 60 mm would lead to little change in long-term landings. A further increase to 65 mm would give a loss of ≈ 11 %. This contrasts with the gains predicted for the males.

Management considerations

With the implementation of a new mesh size of 55 mm in 1990, together with the option to use selective trawls, it would be the best to wait and see how the likely improvements in exploitation pattern affect the fishery in the next few years. There is also likely to be some reduction in effort as old Nephrops trawlers leave the fleet, and others switch effort onto new target species, such as rays, monk and megrim.

Bearing in mind that in recent years effort has remained rather steady and that the fluctuations in landings mainly reflect fluctuations in LPUE, it is recommended that the catch possibility be set at the maximum landings figure of the last five years (see text table on next page).

Landings options	(in tonnes/year)
Reference period	: 1985-89
Maximum	: 6 220
Mean + sd	: 5 936
Mean	: 5 181

7.16. North Galicia (Management Unit 25)

LCA - Input parameters

Reference period : 1984-89

$L\infty$ for the males was 80 mm, near the maximum size recorded in monthly catch samples. Female $L\infty$ was 65 mm. K was assumed to be 0.12 for males and 0.15 for females. Natural mortality was set at 0.2 for both sexes.

LCA - Results (Table 7.18. ; Figures 7.36.-7.37.)

Annualized mean F for males was 0.43 and for females 0.47 (Table 7.21.).

Current F is well above F_{max} for both males and females, but a change in effort of plus or minus 40 % would change long-term landings by only $\approx$ 5 %.

Mesh assessment (Table 7.36. ; Figures 7.73.-7.74.)

Legal min. mesh size Nephrops : 55 mm
Legal min. mesh size finfish : 65 mm
Current Nephrops mesh size : 40 mm
Mesh increases assessed : from 40 to 55, 60 and 65 mm

An increase in mesh size to 65 mm would increase long-term landings by 9 % for both sexes. Effects of smaller increases to 55 and 60 mm are given in Table 7.36.

Management considerations

The Y/R analysis shows that reductions in effort would produce small increases in yield, and that larger yields could be obtained by increasing the mesh size.

Catches coming from the Cantabrian Sea must be included in the catch possibilities, because they are taken in the same ICES Division (VIIIc) as those from the North Galician stock.

Landings options (in tonnes/year)

	North Galicia	Cantabrian Sea
Reference period :	1985-89	1985-89
Maximum :	439	151
Mean + sd :	412	145
Mean :	357	133

7.17. West Galicia (Management Unit 26)

LCA - Input parameters

Reference period : 1981-83, 1985-86 and 1988-89

The L_∞ for males was set near the maximum size obtained from monthly catch samples, viz. at 85 mm. L_∞ for the females was 70 mm. As for the North Galician stock K was assumed to be

0.12 for males and 0.15 for females, and natural mortality was set at 0.2 for both sexes.

LCA - Results (Table 7.19. ; Figures 7.38.-7.39.)

Mean F on males was 0.20, well below that on females, 0.38 (Table 7.21.).

Current F for males is just above F_{max}, while for females it is well above F_{max}. A change in effort of plus or minus 30 % on males does not affect long-term landings. Similar changes in effort on females would change long-term landings by plus or minus 7 %.

Mesh assessment (Table 7.37. ; Figures 7.75.-7.76.)

Legal min. mesh size Nephrops : 55 mm
Legal min. mesh size finfish : 65 mm
Current Nephrops mesh size : 40 mm
Mesh increases assessed : from 40 to 55, 60 and 65 mm

An increase in mesh size to 65 mm would increase long-term landings by 10 % for males and by 19 % for females. Effects of smaller mesh size increases to 55 and 60 mm are given in Table 7.37.).

Management considerations

Landings from this stock have fluctuated without particular trend over the past 15 years (see Section 5.15.). The Y/R analysis shows that reductions in effort would produce small increases in long-term landings for the females only. Larger gains could be obtained by increasing the mesh size.

Landings options for the West Galician stock are given in the text table on next page.

Landings options	(in tonnes/year)
Reference period	: 1985-89
Maximum	: 750
Mean + sd	: 717
Mean	: 669

7.18. North Portugal (Management Unit 27)

LCA and Mesh assessment

No Y/R or mesh assessment made.

Management considerations

Landings options for this stock are given in the text table below.

Landings options	(in tonnes/year)
Reference period	: 1985-89
Maximum	: 97
Mean + sd	: 76
Mean	: 43

7.19. SW and S Portugal (Management Units 28 and 29)

LCA - Input parameters

Reference period : 1984-89

Values of $L\infty$ were chosen to be greater than the largest sizes in the samples, viz. 70 and 65 mm for males and females respectively. Values of K were calculated from Ford-Walford plots, based on the chosen values of $L\infty$ and annual growth increments using Bhattacharya's method for all males and for females < 26 mm. Tagging experiments (FIGUEIREDO, 1989) provided the growth increments for females ≥ 26 mm (i.e. the size at 50 % maturity).

M was set at 0.2 (for all length groups of males and for females < 26 mm) and at 0.1 (for females ≥ 26 mm). The other input parameters are given in Table 7.1.

LCA - Results (Table 7.20. ; Figures 7.40.-7.41.)

Annualized mean F on males was 0.44 and on females 0.19 (Table 7.21.).

Current F was 50 - 60 % above F_{max} for males and 30 % above F_{max} for females. Decreasing effort to F_{max} would increase long-term landings and biomass for males by 15 % and 120-175 % respectively. For females a reduction in effort from current levels to F_{max} would hardly affect long-term landings but would increase long-term biomass by about 52 %.

Mesh assessment (Table 7.38. ; Figures 7.77.-7.78.)

Legal min. mesh size Nephrops : 55 mm
Legal min. mesh size finfish : 65 mm
Current Nephrops mesh size : 50 mm
Mesh increases assessed : from 50 to 55 and 65 mm

Figures 7.77. and 7.78. show the long-term effects of changes from the present mesh size to 55 mm and 65 mm. Increasing the present mesh to 55 mm and 65 mm at status quo effort predicts long-term gains in landings of 4 % and 12 % for males, and of 2 % and 6 % for females (Table 7.38.).

Management considerations

The Y/R assessment shows that for the Alentejo and Algarve stocks there is no advantage in allowing effort to rise any further, as this would decrease long-term landings and biomass. It is also recommended to increase the mesh size to 65 mm, as this would result in long-term gains in the landings.

Landings options	(in tonnes/year)
Reference period	: 1984-89
Maximum	: 1 482
Mean + sd	: 1 202
Mean	: 769

7.20. Gulf of Cadiz (Management Unit 30)

LCA and Mesh assessment

No Y/R or mesh assessment made

Management considerations

Landings options for the Gulf of Cadiz stock are given in the text table below.

Landings options	(in tonnes/year)
Reference period	: 1985-87
Maximum	: 302
Mean + sd	: 300
Mean	: 260

7.21. Proposed grouping of management units for TAC purposes

The present TAC areas (viz. Vb(EC)+VI, VII, VIIIa,b, VIIIc, VIIId,e and IX+X) were setup in 1986 for allocation purposes when Spain and Portugal joined the EEC. It was not intended that the TACs set should unduly restrict effort. In fact only in VIIIc have the landings been within 90 % of the TAC. In the other areas the TAC uptake has ranged between 0 and 85 %, averaging 65 % over the period 1986-88 (Table 7.39.).

This Working Group recognizes 30 management units, and ACFM's attention was drawn (ICES, 1989) to our recommendation that these units should be used (a) as statistical units for reporting data, (b) for further assessment purposes, and (c) for management purposes. The present TAC areas include groupings of several of these management units. Within some of these TAC areas the management units have quite different states of exploitation. STCF (October, 1989) recognized this problem in TAC areas like VII, where it considered that "an **overall TAC [...] is probably not the best management measure because it will impose unjustified catch limitations on those units which are presently in a healthy state and will not achieve the objective of decreasing fishing effort where it is needed**".

Both ACFM and STCF recommended the adjustment of most Nephrops TACs down to the landings levels in the last three years. Neither the advice on subdividing TAC areas or on reducing TACs to recent landings levels has been implemented for 1990.

The states of exploitation shown by the analytical assessments in this report fell into three groups :

(1) Those where current F was below F_{max},
(2) Those where current F was close to F_{max}, and
(3) Those where current F was above F_{max}.

To provide guidance on catch levels for controlling effort in relation to the state of exploitation the Working Group has calculated three landings options :

(1) The maximum landing within the time period corresponding to the reference period used in the LCA with an overriding minimum of 5 years.
(2) The mean + standard deviation over the same time period.
(3) The mean over the same time period.

The landings options (1)-(3) should be related to the states of exploitation (1)-(3) in the following way :

(a) Use of landings option (1) will leave some room for expansion of effort in a management unit where the assessment suggested current F was below F_{max}, assuming average levels of recruitment.
(b) Landings option (2) lies between the average and the maximum and would provide a conservative upper limit to effort expansion.
(c) Landings option (3) would hold effort at the average of the time period used, reducing effort if very recent landings have been above average. This option would equate with a state of exploitation where current F was above F_{max}.

These landings options are conservative in their impact upon fishing effort. The main reasons for choosing this approach were :

(a) There are several uncertainties in the parameter inputs to the LCA, and the results should be treated with caution because LCA is sensitive to small changes in some of the input parameters (see e.g. ICES, 1989, Annex 3).
(b) The Y/R curves in many units were quite different for males and females, one having flat-topped curves with current F near or above F_{max}, while the other had current

F below F_{max}. To protect the more vulnerable sex, usually the males, the Y/R curve which suggested that effort should be constrained was adopted for determining the overall state of exploitation.

(c) The stock-recruitment relationship is unknown, but even in fisheries where effort seems well above F_{max} there has been no evidence of a deleterious effect upon recruitment.

(d) The Working Group is concerned that the recent reductions in finfish TACs in some areas could result in a diversion of effort onto Nephrops, but does not see any need to severely reduce current effort or prevent some increase in effort in certain units in the short-term.

The choice of TAC areas presents some difficulties. It is probably unrealistic to expect a TAC management at the level of most of the individual management units recognized by the Working Group. However, the grouping of units within a TAC area which includes units with different states of exploitation may - in fisheries with different seasonal patterns of effort and landings - result in the uptake of the TAC (or quota) in one or more units before the others have started or completed their "traditional" fishery. Where units are fished by mainly or only one country, and the quota are allocated to that country, this problem would be minimized as long as the landings do not exceed the quota.

Taking account of (a) the evidence on stock identity, population structure and biology, (b) the trends in catches, landings, effort, CPUE, LPUE and mean size and (c) the assessments and the state of exploitation, the TAC area groupings shown in Table 7.40. are recommended.

8. LEGAL MINIMUM LANDING SIZE AND MESH SIZE

The Working Group accepts ACFM's recommendation that the minimum landing size (MLS) should be set at the 25 % selection length (L_{25}) of the legal mesh size. A table is given (Table 8.1.) with the legal minimum mesh sizes for Nephrops and finfish trawls, the Nephrops mesh sizes in use, the MLS and the L_{25} values, as calculated from the selection parameters used in the assessments (see Sections 7.2. - 7.20.).

It is recommended that in areas where there are major discrepancies between MLS and L_{25}, and especially where the MLS is well below the L_{25}, the MLS be adjusted to match the L_{25}.

If any mesh increase recommendations are implemented (see Sections 7.2. - 7.20.) then the MLS will need to be adjusted accordingly.

9. REFERENCES

BAGGE, O., NIELSEN, E., MELLERGAARD, S. and DALSGAARD, I. (1990) : Hypoxia and the demersal fish stocks in the Kattegat (IIIa) and Sub-division 22.
Working document submitted to the Nephrops Working Group, ICES (in press).

BAILEY, N. (1984) : Some aspects of reproduction in Nephrops.
ICES, Shellfish Comm., CM 1984/K : 33 (mimeo).

BAILEY, N. and CHAPMAN, C.J. (1983) : A comparison of density, length composition and growth of two Nephrops populations off the west coast of Scotland.
ICES, Shellfish Comm., CM 1983/K : 42 (mimeo).

BENNETT, D.B. (1984) : A review of Irish Sea Nephrops mesh selection.
ICES, Shellfish Comm., CM 1984/K : 5 (mimeo).

BRANDER, K. and BENNETT, D.B. (1986) : Interactions between Norway lobster (Nephrops norvegicus) and cod (Gadus morhua) and their fisheries in the Irish Sea.
In : Jamieson, G.S. and Bourne, N. (Eds.) : North Pacific Workshop on Stock Assessment and Management of Invertebrates, Special Publ. Fish. and Aquat. Sciences, 92, 269-281.

BRIGGS, R. (1985) : Catch composition in the Northern Ireland Nephrops fishery.
Fisheries Research, 3, 47-60.

BRIGGS, R. (1986) : A general review of mesh selection for Nephrops norvegicus.
Fisheries Research, 4, 59-73.

BRIGGS, R. (1988) : A preliminary analysis of maturity data for Northwest Irish Sea Nephrops.
ICES, Shellfish Comm., CM 1988/K : 21 (mimeo).

CHAPMAN, C. (1982) : Nephrops tagging experiments in Scottish waters 1977-79.
ICES, Shellfish Comm., CM 1982/K : 22 (mimeo).

FARIÑA, A.C. (1989) : The North Galician Nephrops fishery.
ICES, Shellfish Comm., CM 1989/K : 20 (mimeo).

CONAN, G. and MORIZUR, Y. (1979) : Long-term impact of a change in mesh size from 45-50 to 70 mm on yield in weight and fecundity per recruit for Norway lobster populations. Is there a simple solution to a complex problem : a simulation model.

ICES, Shellfish Comm., CM 1979/K : 43 (mimeo).

FIGUEIREDO, M.J. (1989) : Preliminary results of the tagging experiments on Nephrops norvegicus in Portuguese waters.
ICES, Shellfish Comm., CM 1989/K : 25 (mimeo).

GUEGUEN, J. and CHARUAU, A. (1975) : Essai de détermination du taux de survie des langoustines hors taille rejetées lors des opérations de pêche commerciale.
ICES, Shellfish and Benthos Comm., CM 1975/K : 12 (mimeo).

HILLIS, J.P. (1979) : Growth studies on the prawn Nephrops norvegicus.
Rapp. P.-V. Réun. Cons. int. Explor. Mer., 175, 170-175.

HILLIS, J.P. (1987) : A study of the catch composition in the Irish Nephrops fishery with special attention to growth and maturity.
ICES, Shellfish Comm., CM 1987/K : 22 (mimeo).

HILLIS, J.P. and EARLEY, J.J. (1982) : Selectivity in the Nephrops trawl.
ICES, Fish Capture Comm., CM 1982/B : 19 (mimeo).

HOWARD, F.G. and HALL, W.B. (1983) : Some observations on the biometrics of Nephrops norvegicus (L.) in Scottish waters.
ICES, Shellfish Comm., CM 1983/K : 36 (mimeo).

ICES (1979) : Report of the Working Group on Assessment of Nephrops stocks.
ICES, Shellfish Comm., CM 1979/K : 2 (mimeo).

ICES (1984) : Report of the Nephrops Working Group.
ICES, Shellfish Comm., CM 1984/K : 4 (mimeo).

ICES (1988) : Report of the Ad hoc Study Group on Nephrops.
ICES, Shellfish Comm., CM 1988/K : 29 (mimeo).

ICES (1989) : Report of the Working Group on Nephrops stocks.
ICES, CM 1989/Assess : 18 (mimeo).

JONES, R. (1984) : Assessing the effects of a change in exploitation pattern using length composition data.
FAO Fish. Tech. Paper, 256.

KIRKEGAARD, E., NIELSEN, N.A. and BAGGE, O. (1989) : Mesh selection of Nephrops in 60 and 70 mm Nephrops trawls.
ICES, Fish Capture Comm., CM 1989/B : 32 (mimeo).

LE FOLL, D., BRICHET, E., REYSS, J.L., LALOU, C. and LATROUITE, D. (1989) : Age determination of the spider crab Maja squinado and the European lobster Homarus gammarus by 228 Th/228 Ra chronology : possible extensions to other crustaceans.
Can. J. Fish. Aquat. Sci. 46 : 720-724.

MORIZUR, Y. (1982) : Estimation de la mortalité pour quelques stocks de la langoustine, Nephrops norvegicus (L).
Rapp. P.-V. Réun. Cons. int. Explor. Mer, 175 : 176-181.

POPE, H.J. and THOMAS, H.J. (1960) : Some biometric observations on Nephrops norvegicus (L.).
ICES, Shellfish Comm., CM 1960, paper no. 180 (mimeo).

ROBLES, R., PEREIRO, F.J. and FERNANDEZ, A. (1985) : Selectividad de los artes de arrestre en la pesqueria de Galicia : merluza, jurel, lirio, gallos y cigala.
Bol. Inst. Esp. Oceanogr., 2 (3), 77-88.

TULLY, O., HILLIS, J.P. and Mc MULLAN, D. (1989) : Fitting normal curves to polymodal length frequencies to assess growth in Nephrops.
ICES, Shellfish Comm., CM 1989/K : 32 (mimeo).