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REPORT OF THE NEPHROPS WORKING GROUP

Aberdeen, 5 - 8 June 1984

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TABLE OF CONTENTS

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1. PARTICIPATION

The Nephrops Working Group met in Aberdeen from 5-8 June 1984. The following scientists attended the meeting :

N. Bailey	United Kingdom
D. Bennett	United Kingdom
A. Biseau	France
R. Briggs	United Kingdom
C. Chapman	United Kingdom
A. Charuau	France
G. Conan	Canada
A. Fernández	Spain
E. Gonzalez-Gurriaran	Spain
H. Hallbäck	Sweden
J.P. Hillis	Ireland
G. Howard	United Kingdom
J. Main	United Kingdom
J. Mason	United Kingdom
S. Munch-Petersen	Denmark
F. Redant (Chairman)	Belgium
G.I. Sangster	United Kingdom
S. Tveite	Norway

In addition the Working Group received written contributions from M. de Figueiredo (Portugal).

2. TERMS OF REFERENCE

At the Statutory Meeting in 1983 it was decided (C.Res.1983/2:21) that the Nephrops Working Group should meet in order to :

(i) update the available data on the biological features and the state of exploitation of the Nephrops stocks in areas IIIa, VIa, VIIa, VIIg-k and VIII;

(ii) review the results of experiments with selective trawls, with particular reference to the implication for :

(a) the exploitation of Nephrops in the above areas, and
(b) the conservation effect on roundfish species taken as a by-catch in the Nephrops fisheries

Since parts of this report may be relevant to the Fish Capture Committee and to ACFM (viz. the sections on selective trawls and management considerations) the Nephrops Working Group agreed to refer its report to these Committees.

3. BIOLOGICAL DATA

The last Nephrops Working Group Meeting extensively reviewed the biological features of Nephrops: stock size and biomass, natality, growth, consumption, activity rhythms and migrations, mortality. Since then additional information on several of these items have been collected. This information is summarized in the sections below. It is recommended that these sections be read together with the general comments in the corresponding sections of the previous Working Group Report (Anon., 1982a).

3.1 Stock Size and Biomass

3.1.1 Direct abundance estimates through larval surveys

A provisional estimate of the spawning stock biomass of Nephrops in the Western Irish Sea was made from larval surveys, carried out in 1982 jointly by the United Kingdom and Ireland (Nichols et al., 1983). Basic data used in this assessment were : the abundance and development rate of stage I larvae, estimates of the effective fecundity for female Nephrops and length and weight data for the spawning females. This gave a spawning stock biomass of between 5 250 and 8 080 tonnes. This estimate includes only females participating in the hatch (calculated at about 90% of the total mature female stock). No attempt has been made to include the biomass of males.

The inclusion of larval mortality rates (Nichols et al., in preparation) gave a revised spawning stock biomass of between 6 255 and 9 620 tonnes. The quality of the input parameters was discussed and it was concluded that it should be possible to obtain a more reliable estimate with improved data on the rate of larval development in relation to temperature, particularly at the lower temperatures found at the beginning of the larval season. Work is in hand (Bennett, pers. comm. and Hillis, pers. comm.) to provide better larval development data. There is also a need to improve data on effective fecundity, female maturity, sex ratio and length composition of the female stock (see section 3.2).

The biomass estimate obtained from these larval surveys has been used to set Nephrops recruitment in a steady-state model of the technical and biological interactions between Nephrops and cod in the Irish Sea (Brander and Bennett, in press) (See section 3.6.2).

3.1.2 Underwater surveys

Observations on Nephrops density, using a television camera, have recently been made in the sound of Jura and the Clyde (Bailey and Chapman, 1983). Table 1 shows estimates of Nephrops and burrow densities in the two areas. It should be noted that, as a measure of Nephrops abundance, burrow densities provide an upper limit since a proportion of the burrows can be expected to be empty in an exploited stock. Conversely, Nephrops densities provide a lower limit since not all Nephrops are present on the mud surface at the same time. Although absolute densities are not obtained, the technique provides useful limits for comparison with measures of abundance obtained by other methods and also when comparing different stocks.

3.2 Natality

3.2.1 Sex ratio

New data on the sex ratio in Nephrops catches and landings are available for the Scottish waters (Bailey and Chapman, unpubl. data), the Irish Sea (Hillis, unpubl. data and Briggs, unpubl. data), the Celtic Sea (Charuau, unpubl. data), West of Ireland, North and West Galicia (Fernández, unpubl. data) (Tables 2-12).

Strictly, of course, sex ratios should be calculated for animals of the same age, effectively meaning comparison of small females with males of a much larger size (see section 3.3). Judging by the shape of the length frequency distributions this would have the effect of increasing the sex ratio in favour of the females. On the other hand the use of fixed size groupings implies that at large sizes the female groupings contain quite a number of age classes while in a similar size group of males only one or two would be present.

As berried females are less available for capture than males, the exploitation rate on males would be expected to be higher than on females. This would depend upon the seasonality of the fishery in relation to the incubation period. Seasonal sex ratio data in the more southern areas such as the Irish Sea and the Celtic Sea support this conclusion, indicating that during the summer months, when females have hatched and are not yet berried, there appear to be more females than males. In the more northern areas (e.g. Northumberland, Skagerrak) the percentage of females is highest in winter and does not generally exceed 50%, associated presumably with less than annual breeding.

3.2.2 Sexual maturity, spawning, incubation and hatching

A summary of the present knowledge on ovary development in Nephrops has been given by Figueiredo (1982). A further stage R, which is the result of resorbtion of the oocytes in fully developed ovaries prior to spawning, is described and its implications when calculating the size at first maturity and the spawning stock are discussed.

Numerical data on the importance of ovary resorbtion were provided for the Nephrops population in Portuguese waters (Figueiredo, 1982). In these stocks ovary resorbtion appeared to be a common feature. The resorbtion ratio was higher towards the end of the spawning season and was inversely related to the size of the females.

Further information on the resorbtion phenomenon was given by Bailey and Chapman (unpubl. data). A study of ovary development in Nephrops from the Scottish West coast suggested that differentiation and maturation of oocytes in berried females lagged behind that of non-ovigerous females. In the summer months there was considerable overlap (particularly at large sizes of Nephrops) between females with recently spawned eggs and ovigerous females with eggs about to hatch. After hatching these females gave rise to the latest spawners or their ovaries were resorbed.

It is suggested that oviposition may accur annually for several years after maturity but that it occurs progressively later every year, until eventually the ovary is resorbed without spawning and reproduction is missed out. Whether it becomes biennieal from then on is not clear (Bailey and Chapman, pers. comm.) (see also section 3.3.2 for additional comments on this item).

Some data on the composition of the female Nephrops stock in the Irish Sea were presented (Hillis, unpubl. data). The proportion of mature females sharply increased in May/July, followed by an increase in the number of berried females in August/September (Figure 1). The proportion of ovigerous females in the samples however remained very low, due to the burrowing behaviour of the females in berried condition.

Additional data on the size at first maturity of female Nephrops were provided for the Sound of Jura and the Clyde (Bailey and Chapman, 1983), the Celtic Sea (Charuau and Morizur, unpubl. data), the Algarve and the Alentejo area (Figueiredo, 1982).

Female Nephrops in the Sound of Jura matured at a smaller size than those in the Clyde (50% maturity at 23 mm carapace length compared with 27 mm). Although the size differed between these two areas, reference to the growth data (see section 3.3.2) shows that maturity occurred at the same age (Bailey and Chapman, 1983).

The size at first maturity of Celtic Sea Nephrops was estimated from the numbers of berried females in the catches (Charuau and Morizur, unpubl. data). The mean size at first maturity was found to be 31 mm. This is likely to be an overestimate since part of the berried females disappear from the catchable stock when they hide in their burrows during the ovigerous period.

In the Algarve population the size at first maturity of female Nephrops increased from 22.2 mm in July to 29.0 mm in September/October, because of the progression of ovary resorbtion during the spawning period (see above). In the Alentejo population the size at first maturity in the beginning of the main spawning season was 31.1 mm (no data were available for the end of the spawning period) (Figueiredo, 1982).

3.2.3 Potential fecundity, loss of eggs and effective fecundity

The number of eggs in the ovaries of Celtic Sea Nephrops is related to the carapace length of the females by the relationship :

$$N_{eggs,\ ovary} = 0.196\ L_c^{2.576}$$

The average diameter of the eggs at incubation stage A varied according to the size of the females : it was minimal for small females and maximal for medium sized females. The loss rate of eggs would be higher in smaller females than in the larger ones. When computing the fecundity per recruit, it was suggested as more realistic to consider the first spawn as non-viable (Morizur and Rivoalen, 1982).

Updated estimates of the potential fecundity, loss of eggs and effective fecundity are also available for the Nephrops stocks of the Portuguese West coast (Figueiredo, Margo and Franco, 1982). The numbers of eggs in the ovary and in development stages A, B+C, D_i and D_f (resp. the initial and the final phase of stage D) in relation to the carapace length are given by

$$N_{eggs,\ ovary} = 0.3234\ L_c^{2.5045}$$

$$N_{eggs,\ stage\ A} = 0.0563\ L_c^{2.8924}$$

$$N_{eggs,\ stage\ B+C} = 0.1947\ L_c^{2.4586}$$

$$N_{eggs,\ stage\ D_i} = 0.0434\ L_c^{2.8206}$$

$$N_{eggs,\ stage\ D_f} = 0.0647\ L_c^{2.6215}$$

The total loss of eggs during incubation was calculated to be 68%. This corresponds to a loss rate of about 10% per month (Figueiredo, Margo and Franco, 1982).

The progressive loss of eggs during developemnt is well documented (see e.g. Anon., 1982a) but the underlying causes are poorly understood. Predation was suggested by Morizur (1979). Egg loss could also occur when Nephrops escape from e.g. predators by swimming. This has recently been investigated by Newland (unpubl. data). The number of eggs lost during swimming was small, ranging from 0 to 20, but was positively correlated with the number of tail beats and with female size.

Recent observations on berried females in Loch Torridon (Scotland) showed that up to 35% of the females had very low egg counts even immediately after spawning (Bailey and Chapman, unpubl. data). This loss may be caused by failure of the eggs to adhere to the pleopods during spawning.

3.2.4 Larval abundance

Continuous plankton records taken in the North-Western Irish Sea in the months March to June from 1971 to 1982 have been used to investigate annual and seasonal fluctuations in abundance of Nephrops larvae (Lindley, 1983). There was a decline in numbers from the period 1971-1974 to the end of the decade with evidence of a subsequent recovery. The mean seasonal maximum was in May. Stage I larvae were dominant in March and April; stage II larvae were most abundant in May and June.

3.3 Growth

3.3.1 Biometric relationships

New or updated length/weight relationships are available for the Nephrops populations from the Clyde, Sound of Jura, South Minch, North Minch, Moray Firth and Firth of Forth (Howard and Hall, 1983), the Celtic Sea (Charuau and Morizur, unpubl. data), North Galicia (Fariña, in press) and the Southern Portuguese coast (Arrobas, 1982) (Table 13).

As part of a study on seasonal changes in condition of Nephrops in Scottish waters length/weight relationships of intermoult animals (whole Nephrops and various component organs) were determined throughout the year (Bailey and Chapman, unpubl. data). Most tissues exhibited lowest weights and highest water contents in February/March and highest weights and lowest water contents in September/October. The testis did not show any seasonal cycle while the ovary increased in weight from October to the following August, prior to spawning.

Furthermore, biometric relationships, involving total length, carapace length, tail length, tail width, total weight and tail weight, have been established in view of market sampling programmes or minimum landing size regulations (Hillis and Earley, 1982a; Bennett, 1983; Briggs, 1983; Howard and Hall, 1983 and unpubl. data; Redant, unpubl. data).

3.3.2 Annual growth

New data on the growth of Nephrops have been collected in six areas around Scotland (Moray Firth, Firth of Forth, Loch Torridon, Loch Melfort, Clyde and Sound of Jura), by following the progression of modes in length frequency distributions, by examining moult increments of animals kept in aquaria or sea bed cages, by studying the moult frequency and by tagging (Chapman, 1982; Bailey and Chapman, 1983).

In immature males and females the growth increment was found to be proportional to pre-moult carapace length. After reaching sexual maturity however, there was a striking difference between males and females. While the relationship between increment and pre-moult size remained a direct one in males it changed to an inverse one in mature females (Chapman, 1982; Bailey and Chapman, 1983).

The numbers of moults per year in different size classes of Nephrops are given in the Table below. In small Nephrops (below 15 mm carapace length) moulting was too frequent to identify specific periods of moulting. Above 15 mm the number of moults could be determined up to a size when it was not clear whether all animals moulted each year (Bailey and Chapman, 1983).

Carapace length range (mm)	CLYDE		SOUND OF JURA	
	Males	Females	Males	Females
21-30	4	4	2	1-2[a]
31-40	2	1	1	1
41-50	1	1	1	?[c]
51-60	0-1[b]	0-1[b]	?[c]	-
> 60	0-1[b]	0-1[b]	?[c]	-

a : 2 moults up to maturation at 23 mm, 1 moult thereafter

b : moulting either once per year or once every 2 years or longer

c: too few in samples

The results of recent tagging experiments in Loch Torridon, together with earlier ones (Chapman, 1982) have given more information on moult frequency, particularly of larger Nephrops. The Table below gives the proportion of males and females in each 5 mm carapace length class which would be extpected to moult annually (Bailey and Chapman, unpubl. data).

Carapace length Size range (mm)	Males moult/year			Females moult/year	
	0	1	2	0	1
30 - 34			1		
35 - 39		0.500	0.500		1
40 - 44		0.920	0.080	0.158	0.842
45 - 49	0.043	0.936	0.021	0.361	0.639
50 - 54	0.056	0.944		0.250	0.750
55 - 59	0.348	0.652		0.333	0.667
60 - 64	0.571	0.429		1[a]	
65 - 69	1[a]				

a : from tag returns after two or more years; these sizes are likely to moult once every two or three years.

There was some evidence of geographical differences in growth increments especially in female Nephrops (viz. the Sound of Jura compared to the Clyde), and for variation in moult frequency between areas (viz. Loch Melfort compared to Loch Torridon and the Sound of Jura compared to the Clyde) (Chapmann, 1982; Bailey and Chapman, 1983).

Bailey and Chapman (1983) discuss the findings for the Clyde and the Sound of Jura in the light of the differences in population density and food availability (see sections 3.1.2 and 3.4), and conclude that further work on the growth of Nephrops in relation to available food supply would be worthwhile.

In an extensive review on the moulting process in Crustaceans (lobsters, shrimps, crabs, euphausiids, mysids, isopods and stomapods) Conan (1984) discusses the periodicity and phases of moults in relation to external factors, such as temperature and photoperiod. Photoperiod and, within reasonable ranges, temperature may be taken as seasonal signals on which the individual moult cycles of some Crustaceans become synchronized, rather than as determinant factors with direct incidence on the hormonal regulation of moulting. These signals may instigate the individuals to moult in environmental conditions suitable for growth and may allow moult and reproduction cycles to be phased adequately.

The differences in moult frequency of juveniles, males and females are discussed in relation to areal distribution, age at first maturity, spawning behaviour and periodicity. It appears that there are two types of moulting processes. The first one allows rapid growth with short intervals between moults and is present in - amongst others - juvenile Nephrops. The other type is revealed at the onset of maturity in many slow growing decapods and is seasonal. The neuro-hormonal processes which could be controlling these two types of moulting are reviewed (Conan, 1984).

It is suggested that alternate seasonal moult patterns within the geopgraphic distributions of e.g. Nephrops would also correspond to alternate reproductive patterns. A seasonal moult pattern of two moult periods per year for the males and one moult for the females, may correspond to a breeding cycle of one year. Alternatively, a seasonal moult pattern of one moult period per year for the males and one moult every two years for the females, may correspond to a breeding cycle of two years (Conan, 1984).

The factors that drive or trigger synchronisation of moulting events in Crustaceans are not well known. A few working hypotheses, such as the phasing on external environmental factors and the exchange of signals between individuals, e.g. through pheromones, are proposed (Conan, 1984).

3.3.3 Growth curves

Additional growth data, based on modal analysis of length distributions and tag-recapture studies, were collected for Nephrops in Icelandic waters (Eiriksson, 1982). Although distinct modes were not always easily recognised, an overall movement of the length distribution to the right could be seen. A growth curve of the von Bertalanffy type was calculated, with L_∞ = 80 mm (the size of the largest Nephrops caught on virgin grounds) and K = 0.101.

A first attempt has been made to fit von Bertalanffy equations to Nephrops growth data for the Sound of Jura and the Clyde (Bailey and Chapman, 1983). This provided a good fit to the growth data for males (L_∞ = 73.2 and K = 0.160 for the Clyde and L_∞ = 57.0 and K = 0.166 for the Sound of Jura) but was less

satisfactory for the female data (L_∞ = 54.9 and K = 0.156 for the Clyde and L_∞ = 40.7 and K = 0.228 for the Sound of Jura). The estimates of L_∞ for males were reasonably close to the maximum size taken in trawl catches, but the values of L_∞ predicted for females were well below the maximum size in the catches. The equations also gave unrealistic estimates of t_o. Further analysis of the data, using weight instead of length, did not greatly improve the values of L_∞ or the estimates of t_o.

Bennett (pers. comm.) reviewed the existing growth data on Irish Sea Nephrops and calculated von Bertalanffy growth curves for males (with L_∞ = 49.5 and K = 0.23) and females (with L_∞=33.0 and K = 0.41). These curves fitted better to the published data particularly for females, than the equations used in the last Nephrops assessment by the Irish Sea and Bristol Channel Working Group (Anon., 1983a).

Preliminary von Bertalanffy growth curves were calculated for Celtic Sea Nephrops, using length frequency distributions and moult frequency data. Charuau and Morizur, unpubl. data). However, due to the poor quality of the input parameters, the obtained growth constant were considered to be less reliable. Tagging experiments (6 000 Nephrops tagged) which were expected to provide better data on moult increment and frequency were started in 1982, but due to the low return rate (1% at present) these experiments will not be continued.

According to Bailey and Chapman (pers. communication)it seems probable that the von Bertalanffy growth curve is unsuitable for describing female growth and that it may be better to describe growth empirically in two phases separated by maturity. The empirical description would be a combination of moult increment information (obtained for all sizes of Nephrops from tagging and cage experiments) and moult frequency information.

3.3.4 Advances in tagging

Tags which survived ecdysis preferably many times are a most desirable tool for assessing growth and mortality. (see section 3.6). Recent tagging experiments using fine plastic streamers have been carried out in Scotland and France. The number of recaptures in some of these experiments have been poor, about 1 to 2% in Scottish and French experiments on the main Nephrops trawling grounds. However, recapture rates up to 20% have been obtained in small-scale experiments in Scottish creel fisheries. Irish marking of diver-caught Nephrops by cutting notches in the telson and/or uropods yielded poor results.

The development of a binary-coded magnetic wire tag appears to offer possibilities of greatly improved tagging results. Captive Nephrops tagged in the claw-base or leg have survived in good condition for four months in Ireland, but have not yet moulted. Two species of crabs have been tagged with magnetic wire tags with a good measure of success in North America (Bailey, pers. comm. and Montfranz, pers. comm.). The method has also been used to mark juvenile cultured lobsters released in the sea by MAFF at Conway.

Outstanding problems are :

(1) to indicate carapace length at tagging. This can probably be achieved by choosing different sites in the body to indicate different lengths,

(2) it may be necessary to restrict tagging to non-edible parts of Nephrops

(3) to return tagged Nephrops to the seabed without blinding or increased exposure to predators, and

(4) tag recovery.

3.4 Consumption

Food consumption rates of captive males and unberried females were determined at the Marine Laboratory, Aberdeen, at a range of temperatures (Bailey and Chapman, unpubl. data). The consumption rate varied considerably from day to day and through the moult cycle, with lowest food consumption immediately prior to and following ecdysis, and highest consumption rates in early pre-moult. Up to about 14°C consumption rates increased with increasing temperature; above this consumption rates fell. There was evidence of slightly higher consumption rates in females. A very high proportion of the food consumed (over 90%) was assimilated. Quantitative estimates of consumption rates in the field were not determined though assessment of stomach fullness showed that Clyde Nephrops had slightly fuller stomachs than Sound of Jura animals.

Information on the diet of Nephrops in the Clyde and Sound of Jura was obtained from stomach content analysis of animals caught in short (15 minutes) trawl hauls (Bailey, pers. comm.). Due to the extreme fragmentation of the food items by the gastric mill, quantitative estimates of the amounts of different foods could not be made. Instead, a percentage occurrence method was used. Results showed that in both areas Nephrops preyed on a wide range of organisms but that the diet composition was different in the two areas. The diets in fact reflected the abundance of the benthic organisms in the different areas as determined from grab samples. There was some evidence of seasonal changes in diet, again reflecting changes in abundance of various benthic prey organisms and also reflecting the movements of hypoplanktonic and hyperbenthic organisms over the grounds.

3.5 Activity Rhythms and Migrations

3.5.1 Activity rhythms

Diurnal variations in cpue and length composition of the catches were investigated in a summer concentrated Nephrops fishery in the Central North Sea (Redant and De Clerck, 1984). This study included a detailed analysis of log-book data of several commercial Nephrops trawlers and length-frequency data of Nephrops in individual hauls. Peak cpue values were observed immediately after dawn and before dusk. Significant changes in the length composition of the Nephrops caught with the time of the day could not be demonstrated.

3.5.2 Migrations

The results of large-scale tagging experiments on Nephrops in four areas around Scotland (Chapman, 1982; Bailey and Chapman, unpubl. data) confirmed that the movements of Nephrops are very localised. Discrete areas of mud with Nephrops populations, sometimes only a few hundred meters apart, may therefore be considered as separate stocklets, at least as far as the juvenile and adult population is concerned.

3.6 Mortality

3.6.1 Total mortality

Total mortalities in different Nephrops stocks (males only) were calculated from length distributions, using Beverton and Holt's method, and Ssentongo and Larkin's method (Morizur, 1982). Both methods are based on the analysis of size frequencies in the catch and require (1) an accurate knowledge of growth in the area fished and (2) the assumption that the size frequency in the catch accurately represents the size frequency in the population. Morizur, using available approximations for growth from the Irish Sea and the Bay of Biscay, extrapolated to quasi-unexploited stocks in Scottish, Icelandic and Faroese

waters and obtained estimates of natural mortality ranging from 0.10 to 0.40 (Table 14). Total mortalities for exploited stocks varied between 0.35 and 1.15 (Table 15). Real mortalities, however, differ from apparent mortalities as a consequence of the sex-dependent seasonal and the size and depth-dependent circadian behaviour in Nephrops.

Some preliminary estimates of total mortality have been made for the Nephrops stock in the Clyde (Bailey and Chapman, unpubl. data). Estimates for the males ranged from 0.62 to 0.99. For females, up to a size at which large numbers with resorbing ovaries occurred (see section 3.2.2) estimates ranged from 0.05 to 0.19. Estimates for the largest females were from 0.18 to 0.31. It was felt that the large differences in total mortality reflect the behaviour of berried females, which remain in their burrows most of the time and which, in doing so, are exposed to lower fishing mortality and presumably lower predation mortality as well.

The mortality of Celtic Sea Nephrops (males only) was estimated using Beverton and Holt's method and Jones' cohort analysis (Charuau and Morizur, unpubl. data). The estimates varied between 0.20 and 0.60 according to the method and the values of the input parameters used.

3.6.2 Predation mortality

Recently several contributions on the predation mortality of particularly Irish Sea Nephrops were published (Armstrong, 1980 and 1982; Fannon and Hillis, 1982; Boyd, 1983 and Symonds and Elson, 1983).

Armstrong (1980 and 1982) investigated the food and predator-prey relationships of several demersal fish species on a relatively small Nephrops ground off the west coast of the Isle of Man. Poor cod, pouting and cod could be regarded as a common feeding type, particularly during the first half year. During this period there was a gradual increase in the importance of Nephrops in the diets of successive size classes of this predator group. Poor cod fed mainly on 0-group Nephrops, pouting on 1-group Nephrops and cod on 2+ group Nephrops. In this relatively small area predation by the highly abundant poor cod was considered as a major contribution to the natural mortality of Nephrops. During the second half-year shrimp was the predominant food item eaten by poor cod and pouting, and the swimming crab was eaten in preference to Nephrops by cod.

Nephrops (especially the 2+ group) were also frequently recorded in the stomachs of lesser spotted dogfish and large thornback ray. The other fish species investigated (different rays, spurdog, long rough dab, whiting, Norway pout, pollack, saithe, hake and monk) did not or only occasionally prey on Nephrops (Armstrong, 1980).

A similar study, covering however a much wider area in the western Irish Sea is reported by Symonds and Elson (1983). The fish species dealt with were lesser spotted dogfish, spurdog, cod, whiting, saithe, hake, poor cod, Norway pout, pouting, grey gurnard and monk. Nephrops were found to be the dominant prey in cod. No Nephrops were recorded in cod smaller than 30 cm and the proportion of Nephrops in the food of cod increased with predator size. Other fish preyed on Nephrops to a much lesser extent, the most notable of these being pouting and lesser spotted dogfish. Cod consumed about 88% of the Nephrops eaten and this is - as far as the Irish Sea is concerned - the only predator which could exert a significant predation mortality on Nephrops.

Fannon and Hillis (1982) investigated the food of especially cod on the fishing grounds off Dublin. Nephrops made up 15.0% of its diet in the first quarter, increasing to 16.4 and 32.0% in the second and third quarter, and dropping to 0.6% in the fourth quarter. Larger cod concentrated on larger Nephrops, whereas the smaller predators, although they contained Nephrops at the same frequency, were consuming smaller individuals. Over 55% of the Nephrops in the cod stomachs had a carapace length below 25 mm.

The total amount of food consumed by cod in the year 1981 was estimated at nearly 20 200 tonnes, out of which 3 130 (about 16%) consisted of Nephrops. This figure is comparable to the commercial landings for Ireland for that year (viz. 3 185 tonnes), though the latter do not include discards, which may run at 30-40% of the weight of the landings (Fannon and Hillis, 1982).

Comparable results were obtained from a cod stomach sampling programme in the north-western Irish Sea by Boyd (1983). A high proportion of cod stomachs contained Nephrops, particularly in the second and third quarter, when nearly 40% of the stomach contents consisted of Nephrops. The Nephrops eaten ranged in size from 7 to 45 mm carapace length, with a mean size of around 21 mm. Both the mean carapace length and the numbers of Nephrops eaten increased with increasing cod size. The Nephrops preference index (i.e. the mean Nephrops tail weight/cod weight ratio) showed a clear trend, decreasing from 0.22 in 0-1 kg cod to 0.05 in 7+ kg cod.

A programme for studying the stomach contents of gadoids is in progress in France for all the fisheries in the Celtic Sea. Preliminary results were reported by Du Buit (1982).

Data on predation were used in a multispecies steady state model of the technical (by-catch) and biological (predation) interactions between Nephrops and cod in the Irish Sea (Brander, 1983; Brander and Bennett, in press). The model, which is age structured and incorporate growth, mortality, maturity, stock/recruitment relationship, selectivity, by-catch levels, discarding, unit value, and predation, was found to be robust to changes in the inputs for which most uncertainty exists, i.e. the cod stock/recruit relationship and the functional feeding relationship. Attention is focused on the need to improve the knowledge of the total consumption of Nephrops, the growth rate of Nephrops (see section 3.3) and the mortality due to causes other than predation.

The Working Group suggests that further studies on the predation by fishes on Nephrops take into account the sex of the Nephrops recorded in the stomach contents.

3.6.4 Mortality of discards

The survival rates of discarded Nephrops, caught under commercial conditions, were estimated during the spring of 1982 (Charuau, Morizur and Rivoalen, 1982a). The Nephrops were put in cages on the sea bed and the numbers of survivors were counted after 2-3 days. In the Bay of Biscay the survival rate was 31% and in the Celtic Sea 19%. Taking into account the experimental conditions, the differences in sorting time on board of the vessels and the influence of moulting and temperature, the average survival rate of discarded Nephrops in the Bay of Biscay was estimated at 30 to 40% and in the Celtic Sea at 20 to 50%.

Considerable progress has been made in studies by Shelton (unpubl. data) of the damaging effects of high light intensity on Nephrops eyes. The amount of damage depended on whether the eye was dark or light adapted. In the light adapted eye the masking pigment shields the rhabdomes to some extent but not

sufficiently to prevent rhabdome breakdown entirely. The following Table shows the percentage of retina damage by different exposure times to artificial light, according to the state of dark/light adaptation.

Exposure time (seconds)	Percentage retina damaged	
	light adapted	dark adapted
10	23	82
30	62	90
60	61	100
180	72	100
300	88	100
1 800	100	100

The influence of light induced eye damage on the survival of discarded Nephrops is not known. Tagging experiments are planned in Scottish waters to compare the survival and growth of Nephrops with and without eye damage. These experiments may show whether there is any recovery of vision with time.

3.6.4 Fishing induced mortality

The survival of Nephrops escaping from the cod-end of a "Bigouden" lobster trawl was studied in the Bay of Biscay (Morizur, Charuau and Rivoalen, 1982). The 45 mm cod-end was covered with a 14mm meshed net, in order to retain the Nephrops escaping from the cod-end. Soon after hauling the Nephrops from the cover were put into cages and returned to the sea bed. After an immersion time of 60-78 hours the average survival rate was about 70% The survival rate increased with increasing size of the Nephrops.

3.6.5 Comments on mortality estimates

The Working Group noted that the only estimates of mortality coefficients were of total mortality (see section 3.6.1). The observed predation and discarding mortalities (see sections 3.6.2 and 3.6.3), which probably contribute a significant part of total mortality, could not yet be combined to estimates of mortality coefficients.

The Working Group also noted that the observed relatively high survival rates of discards under experimental conditions (see section 3.6.3) probably are overestimates of the real survival rate of discards form the commercial fishery, where discards are merely thrown overbord and not lowered in cages. Furthermore, the observations on predation and discarding mortalities are likely to be interrelated, i.e. observations of high predation mortality from stomach analyses in an area could be caused by large amounts of discards in that area.

4. STATE OF EXPLOITATION

The state of exploitation of the Nephrops stocks was evaluated by analysing the trends in landings, cpue and mean size of Nephrops caught or landed.

Several Working Group members regretted that some major Nephrops stocks were not included in the Terms of Reference (e.g. Scottish east coast, central North Sea, west of Ireland, north and west Galicia, Portuguese waters). Therefore, the Working Group agreed to review all the major Nephrops stocks in Regions 2 and 3.

4.1 Kattegat and Skagerrak

The fishery is conducted mainly in the central and northern part of the Kattegat. Small catches are also taken in inshore waters along the Swedish and Norwegian Skagerrak coast. The fishery is somewaht seasonal with the peak during July-August. In addition small amounts of Nephrops are also taken as by-catch in the Pandalus fisheries in the Skagerrak. Table 16 shows the landings from the Kattegat and Skagerrak (Division IIIa) since 1974.

During the mid-seventies the bulk of the Danish Nephrops catches were taken in the central Kattegat in the area around the Island of Anholt, whereas most of the catches in 1981-83 were taken in the Northern part (northeast of Skagen). The decline in landings during 1976-1978 (Table 16) probably reflects the declining abundance of Nephrops in the central Kattegat which was heavily exploited during this period; the increase in landings since 1982 probably results from a shift of effort to fishing grounds in the Northern Kattegat.

The Norwegian landings of Nephrops have mainly been a by-catch from Pandalus trawlers. The construction of the trawl has changed to bigger and lighter ones in order to catch more shrimp and this has reduced the by-catches of Nephrops (Table 16). The by-catch was highest during the winter months when the shrimps are caught in shallower water. In 1983 however, a sudden increase was caused by a Nephrops directed trawl fishery, inspired by a successful trial creel fishery in the inner Skagerrak started in 1982 (Table 16). This shows that there may be possibilities for further increase in the Nephrops catches.

The Swedish catches in the Kattegat and Skagerrak have increased consistently since 1977 (Table 16). The main reason for this increase is the good market price for Nephrops which has resulted in several shrimp and whitefish trawlers changing to Nephrops fishing. The fishing fleet has also started to exploit new grounds which means that all Swedish offshore Nephrops grounds are now exploited to some extent. During 1983 an experimental fishery with creels started on inshore stocks and this fishery will expand during 1984-1985.

Cpue data on the Swedish Nephrops fishery have been collected since 1978, but in general the biological data on the Nephrops stock(s) in the Kattegat and Skagerrak are insufficient to support any stock assessment.

The high Danish catches in 1975 may reflect an increase in the catchability of Nephrops due to oxygen deficiency on the sea bottom, caused by the exceptionally warm and calm weather in July-August 1975 (Bagge and Munch-Petersen, 1979).

4.2 North Sea

The North Sea proper, (Divisions IVa, IVb and IVc, except the Scottish inshore waters, (see section 4.3) include several Nephrops grounds: the Botney Gut-Silver pit area, exploited almost exclusively by Belgian vessels, the Farne

Deeps, exploited exclusively by UK vessels and the Fladen Ground, where Nephrops is a by-catch of the Pandalus fishery.

4.2.1 Botney Gut - Silver Pit

The Nephrops stock in this area is fished by 10-15 Belgian trawlers, mainly landing at Zeebrugge. The fishery is Nephrops directed, although there is an important fish by-catch (mainly cod, whiting and plaice, with smaller quantities of dogfish, gurnard, turbot, dab, sole, lemon sole and monk). Details on this fishery are included in Redant and De Clerck (1984).

The Nephrops landings have risen rapidly from the mid-sixties to the mid-seventies, mainly as a consequence of increased fishing effort. Since then the landings stabilized at a level of between 450 and 600 tonnes per year (Table 17). Landings, total effort and cpue show remarkable seasonal variations, with maxima during summer and early autumn and minima during winter and early spring. Cpue values during the main Nephrops season exhibit some fluctuations from year to year but appear to be fairly stable over a longer period (1977-1983).

Data on the length composition of the landings are regularly being collected but the available time series is still too short to allow an evaluation of possible long-term trends. The stable landings and cpue values however suggest that the Nephrops stock in this area is not overexploited.

Very recently the UK Sea Fish Industry Authority showed interest in the exploitation of the Botney Gut - Silver Pit Nephrops stock (Anon., 1983c). This might result in an increase of the Nephrops directed effort in the area and the exploitation pressure on the stock.

4.2.2 Farne Deeps

The fishery in the Farne Deeps is prosecuted by English and Scottish vessels landing at ports in the north-east of England. There has been a dramatic increase in landings in 1982 and 1983 (Table 17), being twice the average of the last ten years. This increase probably reflects a switch of fishing effort into the unrestricted Nephrops fishery as fishing opportunities for other species are reduced by lower TAC's. There are data available on fishing effort but they need careful analysis to identify Nephrops directed trips. Sampling of the length composition of the landings has been done for a few years and are currently being examined to allow an appreciation of the state of exploitation.

The recent doubling of the landings must give some cause of concern. The fishing industry is beginning to question whether the existing regulations provide adequate protection to the stock. They are asking whether the minimum landing size (25 mm carapace length) is large enough, particularly in relation to existing market requirements.

4.3 Scottish Waters

The Nephrops stocks in the Scottish inshore waters (Moray Firth and Firth of Forth on the east coast (Divisions IVa and IVb); North Minch, South Minch and Clyde on the west coast (Division VIa) are exploited exclusively by vessels registered in the United Kingdom and Northern Ireland. The main Scottish ports having fleets of Nephrops trawlers are Eyemouth, Dunbar, Pittenween, Arbroath, Buckie, Lossimouth, Burghead, Stornoway, Lochinver, Mallaig, Oban, Tarbert, Campbeltown, Ayr and Girvan.

The Nephrops landings in Scotland (Table 18) increased dramatically during the sixties and early seventies, largely as a result of a considerable increase in fishing effort (Table 19). During the last few years annual landings have fluctuated around 11 - 12 000 tonnes.

In Scotland, vessels landing Nephrops are classified as "Nephrops trawlers" when this species accounts for 50% or more of the value of the landings. Nephrops trawlers now account for 80-90% of the landings. The fishery is mainly directed at Nephrops, though there is an important by-catch of fish (mixed whitefish such as cod, haddock, whiting and saithe, with smaller quantities of hake, plaice, monk and dogfish). The fishing effort of Nephrops trawlers is recorded in several ways related to fishing time (e.g. hours fishing, days absent from port, etc.).

Landings of Nephrops not accounted for by Nephrops trawlers are mostly taken by creel (5%) and light trawlers (5%). Further details on the Scottish Nephrops fisheries (vessel types, gear, creel fishery, fishing grounds, legislation, etc.) are given by Howard (1982).

In general the Scottish Nephrops fisheries are in a reasonably healthy state. There are occasional market problems when the landings exceed market demands. This can lead to market restrictions, especially on the quantities of small Nephrops tails bought for processing. Market preferences seem to have a greater influence on the minimum landing size than the legislation figure of 25 mm carapace length.

The relationships between landings and fishing effort since 1965 for each main area are shown in Figure 2.

In the North Minch, South Minch, Clyde and Moray Firth there is no evidence of overexploitation, but in the Firth of Forth there is evidence of a recent decline in the stock. This is shown more clearly in Figure 3. Fishing effort sharply increased up to 1975, which resulted in a decline in the landings/effort over the same period. The effort was reduced as larger vessels in the fleet moved to the west coast. The most recent figures show encouraging signs that the Nephrops stock in the Firth of Forth is recovering.

4.4. The Irish Sea

The Nephrops fishing grounds in the Irish Sea (Division VIIa) are in two distinct areas. The largest one is situated in the north-western part of the Irish Sea, between the Isle of Man and the Irish coast. This area is fished mainly by Irish, Northern Irish and Manx Nephrops trawlers, with a small amount of Scottish effort in the north and French effort in the offshore waters south-west of the Isle of Man. A smaller Nephrops ground is located in the north-eastern Irish Sea, off the Cumberland coast and is exploited mainly by English vessels, with a few visiting Northern Irish trawlers.

It seems unlikely that there are any movements of adults or larvae between these two areas. Therefore, they can be considered as two separate Nephrops management units (Anon., 1983a).

4.4.1 Irish Sea - east

The majority of the landings from the eastern Irish Sea are from ICES rectangle 37E6 and are landed at Fleetwood and Whitehaven. The landings in the last five years (1979 - 1983) have fluctuated within the range of 730 - 910 tonnes (Table 20).

Effort information is collected, but due to the mixed nature of the fisheries at certain times of the year it is not easy to identify Nephrops directed fishing trips. An attempt to do this is given in Figure 4. The catch per unit effort of Northern Irish vessels landing at Whitehaven shows a similar pattern to U.K. vessels landing at Fleetwood, although their cpue is somewhat higher. In recent years cpue has fluctuated about a relatively constant level. U.K vessels landing at Whitehaven show a somewhat different pattern (Figure 4), but the choice of >25% of the landed weight to identify Nephrops directed fishing limited the number of trips sampled to a rather low level.

Length composition data are now being collected, but a long continuous time series does not exist to allow an analysis for possible changes in the length composition of the landings. This limited evidence would suggest that the Nephrops stock in the eastern Irish Sea is not overexploited, with relatively constant catch and cpue.

4.4.2 Irish Sea - west

The western Irish Sea Nephrops grounds are fished mainly by Northern Ireland, the Republic of Ireland, Scotland, the Isle of Man and France. The main home ports of Nephrops trawlers operating in this area are Portagovie, Ardglass and Kilkeel in Northern Ireland, Clogerhead, Skerries and Howth in the Republic of Ireland, Ayre, Girvan, Campbeltown and Kirkcudbright in Scotland, Peel on the Isle of Man, and Lorient and Les Sables d'Olonne in France. Landings reported for Division VIIa for these countries are taken from the western grounds (Table 20).

In the last two years, landings of Northern Ireland and more especially the Republic of Ireland have increased. The Irish fishing season has been lengthening in recent years from the traditional summer and early autumn season to now include nearly the whole year, with the exception of the period around March, when a spawning concentration of cod attracts fishing effort (and may also result in reduced emergence of Nephrops).

While the landings have been increasing, the average size of Nephrops caught, and particularly those landed, has fallen. Sampling of the Northern Irish catches during 1968-1983 shows a decline in mean carapace length (Figure 5). Available data for the Republic of Ireland, 1980-1984 demonstrate falling mean length with both catch and landings, this being more marked with landings than with catch (Table 21). Northern Irish data show a reduction in the discarding rate, which has declined from 59% in 1980 to 43% in 1983 (by numbers), which could explain the lower mean carapace length in the landings (Briggs, 1983).

Catch per unit effort data were examined from two Northern Irish vessels which remained unchanged for several years and are known to fish consistently the same area. Landing data from the two vessels have been extracted for the peak months of July-August and expressed as kilogrammes per horsepower per hour for the period 1974-1982. Figure 6 shows that cpue increased for both vessels up to 1979-1980 and then plunged downward; an event which may be explained by an increase in the minimum mesh size permitted and marketing difficulties at that time.

Detailed examination of the catch composition data shows a wide range in mean length (see e.g. Figure 5), suggesting that the western Irish Sea stock is rather heterogeneous. Similarities in catch composition and sediment type between the western Irish Sea and the Sound of Jura (Scotland) suggest that the "high density-low growth" hypothesis of Bailey and Chapman (1983) may also apply to the western Irish Sea stock.

4.5 West of Ireland

The waters west of Ireland (Division VIIb, VIIc and the northern parts of Divisions VIIj and VIIk) include three major Nephrops grounds: Galway Bay, exclusively fished by Irish vessels, Aran, mainly fished by Irish vessels, with a few French ones, and the Porcupine Bank, mainly fished by French, Irish and Spanish vessels.

Only French and Spanish data on Nephrops landings from Aran and Porcupine Bank were available to the Working Group (Table 22). Irish data for VIIb,c do not specify area of capture, but in 1981 and subsequent years landings came predominantly from the Porcupine Bank (Table 22).

Since 1981 the Porcupine Bank is visited more and more frequently by French and Irish Nephrops directed trawlers, especially during spring and summer. Yields are very high, up to 900 kg per vessel per day (compared to 300 kg in the Celtic Sea), on depths between 300 and 500 metres.

The Spanish fishery in this area is a demersal fishery where the main species is hake. Nephrops is an important by-catch, together with megrim, monk and other species. Since the Spanish EEC agreement of September 1978 a licence system has been established for Spanish vessels operating in the area. The Spanish fleet is prohibited to fish east of 12°W, between 50°30' and 56°30'N and the percentage of Nephrops and Clupeiforms in their catches is limited to 5% by weight.

The introduction of a licencing system for Spanish vessels and the rise in French and Irish effort in the area, have together made for very great changes in the exploitation pattern in this area, making it very difficult to describe or analyse long-term trends in the landings.

The Spanish cpue data show a spectacular increase in the last five years (Table 23), i.e. subsequent to the restriction of the Spanish fleet to the fishing grounds west of 12°W. A possible explanation for this phenomenon could be that Nephrops are much more abundant in the area exploited at present (VIIc and VIIk) than in the area exploited prior to 1978 (VIIb, VIIc, VIIj and VIIk).

Figure 7 shows the seasonal fluctuations in the cpue of the Spanish fleet from 1976 to 1983. Maximum values occur in summer, minimum values in winter.

Comparison of the length composition of the Spanish Nephrops landings in 1977 (first year sampled) and 1983 reveals an increase of the average carapace length, both in males and in females (Figure 8). This could be a consequence of the shift of the fleet to other grounds (inhabited by Nephrops with a different length composition) and/or the increase of the mesh size to 80 mm.

As far as the Spanish data are concerned, there is no evidence that the Porcupine Nephrops stock is overexploited. It must be stressed that the Spanish effort decreased in the last five years and that the mesh size increased.

4.6 Celtic Sea

The Nephrops stocks in the Celtic Sea (Divisions VIIg, VIIh and the outermost eastern part of Division VIIj) are exploited mainly by French trawlers, operating from Audierne, Douarnenez, Saint-Guénolé, Le Guilvinec, Loctody, Concarneau, Lorient, Les Sables d'Olonne and La Rochelle (Charuau, 1981).

The French landings of Nephrops from the Celtic Sea (Table 24) have declined in the last four years (1980-1984) for the following reasons :

(a) the shift of part of the fleet towards the Porcupine Bank during spring and summer (see section 4.5);

(b) the change in target species from Nephrops to monk in the southern Celtic Sea and the Bay of Biscay due to a decline in the yield of Nephrops in the winter fishery.

According to French data the fisheries in the Celtic Sea can be divided into three sub-areas (Labadie, Baltimore and Galley in the north-west, Smalls in the north-east, Jones and Cockburn in the south). They each seem to correspond to separate biological entities, but owing to the frequent shifts of Nephrops fleet from one area to another, it is not possible to carry out regular biological samplings of the landings by area. The quantities caught in each sub-area by French trawlers are known from the fishermen's logbooks. In 1983 the partitioning of the catches over these three sub-areas was as follows :

Labadie, Baltimore, Galley	1 110 tonnes
Smalls	1 593 tonnes
Jones, Cockburn	343 tonnes

A limited number of English vessels is also fishing in the Celtic Sea. Smalls grounds are fished by up to four Nephrops trawlers from Newlyn. Another fishery is carried out by U.K. registered vessels, which were previously Spanish. These are trawling for fish,and Nephrops seems to be a small by-catch (Table 24).

The Irish fishery for Nephrops in Divisions VIIg-k (Table 24) has been traditionally confined to small inshore areas, notably Bantry Bay and Kenmare River in the south-west, with most landings at Castletownbere, but also including smaller areas fished from ports further east, such as Unionhall and Helvick. Since 1981 however, catches from the Smalls grounds landed in Dunmore East and Kilmore Quay have increased to actually exceed those from the inshore Nephrops grounds.

Recent Spanish landing statistics for Divisions VIIg-k, e.g. in Bulletin Statistique, refer to the area west of 12°W and not to the Celtic Sea proper. (see also section 4.5).

Detailed reviews of the Nephrops fleets and fisheries in the Celtic Sea are given by Charuau (1981), Charuau and Morizur (1981), Charuau, Morizur and Rivoalen (1982b) and in the Report of the Ad hoc Study Group on Population Assessments in Sub-areas VII and VIII (Anon., 1983b). The Celtic Sea Nephrops stocks have recently been evaluated by Charuau and Morizur (unpubl. report, 1982) and by the Irish Sea and Bristol Channel Working Group (Anon., 1983a).

4.7 Bay of Biscay

Nephrops are particularly abundant in the muddy areas, the so-called "vasières", of the Bay of Biscay (Divisions VIIIa and VIIIb), where they are exploited exclusively by French trawlers, mainly from Saint-Guénolé, Le Guilvinec, Lesconil, Loctudy, Concarneau, Saint-Nazaire and les Sables d'Olonne (Charuau, 1981).

Extensive reviews on the French Nephrops fishery in the Bay of Biscay can be found in Charuau (1981) and in the report of the Ad hoc Study Group on

Population Assessments in Sub-areas VII and VIII (Anon., 1983b).

In the northern part of the Bay of Biscay (north of 47°N) a Nephrops directed fishery is carried out the year round by about 300 vessels, operating during day time. Fishing trips ususally take only one day and the Nephrops are landed live. For socio-economic reasons the effort is limited to about 180 trips per vessel per year, with eight or nine hours of trawling per trip.

In the area south of 47°N Nephrops fishing is restricted to the spring and summer months. During autumn and winter the fleet is aiming at hake, sole and monk.

The irregularities in the quantities of Nephrops landed (daily as well as seasonal) sometimes cause a sales problem, but as a rule the market is well adapted to this particular situation. The minimum landing size is 80 mm total length, which is above the EEC legislation figure.

Although the Nephrops landings from the Bay of Biscay have been declining since 1974 (Table 25) there is no evidence of overexploitation.

In most harbours, particularly in the northern part of the Bay of Biscay, Nephrops are landed and sold daily. The Nephrops trawlers therefore tend to work in a relatively small area, within easy reach from their home port (i.e. within a distance of maximum 30 nautical miles). As a consequence, certain areas are heavily exploited, whereas others, often further offshore or in regions with rough grounds less accessible to trawling, are only feebly or even not at all exploited. The overall picture however shows no evidence that the Bay of Biscay Nephrops stock is overfished.

During the last 20 years the cpue of the French Nephrops fleet in the Bay of Biscay has shown considerable fluctuations (Table 26). The fluctuations are very difficult to explain. Three possible explanations can, however, be put forward :

(a) the introduction of new electronic navigation instruments;

(b) the modernisation of the vessels and the improvement of the fishing gear, and

(c) the discovery of new fishing grounds.

At present the cpue's seem to have reached a relative equilibrium and their fluctuations are mainly due to meteorological conditions and the movements of the vessels in their search for richer fishing grounds.

4.8 Spanish Coast

The geographic distribution of Nephrops off the north-western Spanish coast shows a marked discontinuity north of Cape Finisterre, such that two separate stocks can be distinguished: The north Galician stock and the west Galicien stock.

4.8.1 North Galicia

The north Galician Nephrops stock is situated in the outermost western part of Division VIIIc and is exploited exclusively by Spanish trawlers based in La Coruña.

A comprehensive description of the Nephrops fishery on the north Galician coast is given by Sarda and Fernandez (1981). Nephrops is one of the most important species in this demersal fishery, together with hake, blue whiting

and horse mackerel. Although Nephrops is only the seventh species in landed weight it is the second species with respect to economic value.

The Nephrops landings from 1975 to 1983 show a decreasing trend (Table 27) but this trend is not clear in the cpue data.

Table 28 gives the cpues of "bakas" (single trawlers) and "parejas" (pair trawlers) exploiting the north Galician Nephrops stock. Cpues were calculated using two different units of effort, days and horsepower days.

The cpues exhibit clear seasonal variations, with maximum values in summer and minimum values in winter (Figure 7).

There has been a considerable decrease in the overall fishing effort (number of days fishing), for the "bakas" as well as for the "parejas" (Table 28). In the case of the "bakas" it was due to a decline of the fleet, the older boats with a lower motor power having been removed from the fleet. This is reflected by an increase of the mean BHP of this vessel category. In the case of the "parejas" the decrease in effort is related to the growing interest of the fleet in blue whiting.

A comparison of the length frequency distributions of Nephrops landed in 1979 (first year sampled) and 1983 shows that the average carapace length decreased by five millimetres in males and four in females (Figure 9). This trend gives cause for concern, but the decline of the trawl fleet is a precautionary measure which can be expected to have a restoring effect on the stock.

4.8.2 West Galicia

The west Galician Nephrops stock extends from the Spanish-Portuguese border to Cape Finisterre (northern part of Division IXa) and is exploited by the fleets of Muros, Riveira and Marin.

The fishery on the west Galician Nephrops stock is similar to that on the northern stock (for details see Sarda and Fernández, 1981). The main species are also hake, Nephrops, blue whiting and horse mackerel. An important part of this Nephrops stock is in front of the "Rias Bajas" at depths between 80 and 150 m. This area is closed from 1 October to 31 March, to avoid trawling on the recruits of hake and other fish species.

The Nephrops landings from 1975 to 1983 do not show any clear trend, although a slight increase can be observed in the last three years (Table 27).

Fishing effort and cpue data are not available for this stock.

The length composition of the Nephrops landed in 1977 (first year sampled) and 1983 are given in Figure 10. They display a decrease in the average carapace length : about 3 millimetres in males compared to only one millimetre in females.

4.9 Portuguese Waters

The Portuguese waters (Division IXa) include two important and distinct Nephrops stocks: the Alentejo stock along the Portuguese south-west coast and the Algarve stock along the south coast. Smaller quantities of Nephrops are also caught off the Portuguese west coast between the Spanish-Portuguese border and Cabo da Roca (i.e. along the coast of the Provinces Minho, Douro and Beira Litoral). Nephrops are particularly abundant on the edge of the

continental shelf, at depths between 200 and 1 000 metres.

Prior to 1983 these stocks were exploited by Portuguese and Spanish vessels, mainly based at Cascais, Lisbon, Setubal Olhão, Portimão, Ayamonte, Isla Cristina and Huelva. The Spanish fisheries were interrupted from January 1983 onwards, depending on a Spanish-Portuguese agreement, except for the most eastern part of the Algarve stock (Gulf of Cadiz).

The fleets and fisheries in the Alentejo and Algarve areas have been reviewed by Sarda and Fernández (1981), Arrobas (1982) and the Spanish Portuguese Working Group on the Norway Lobster (Anon., 1982b). This Working Group also assessed the state of exploitation of the Nephrops stocks in these areas.

Details on landings, cpue and length composition of the Nephrops landed were available for Portugal only, (Figueiredo, pers. comm.) i.e. until 1982 for less than 10% of the Nephrops catches in the Portuguese waters (Table 29). This and the abrupt change in exploitation pattern since January 1983 make it very difficult to formulate precise conclusions on the state of exploitation of the Nephrops stocks in this area.

Tables 30 and 31 show the breakdown of the Portuguese landings by area, harbour and month, for 1981 and 1982. In these years no Portuguese trawlers were fishing directly for Nephrops. A few ones operating in the Alentejo area caught Nephrops as a by-catch of a finfish directed fishery. In the Algarve area a small number of vessels fished seasonally for Nephrops while their major effort was directed on Penaeus. Table 32 shows a similar breakdown of the Portuguese landings for 1983. The fishery from Vila Real is a new venture for the Portuguese Nephrops directed fishery. Three Vila Real trawlers have been fishing exclusively for Nephrops under the direction of Spanish masters engaged by Portuguese ship-owners. These vessels accounted for nearly half of the total landings in 1983. The Portuguese Nephrops landings are expected to increase significantly in 1984 (Figureido, pers. comm.).

Table 33 shows monthly landings/vessel of Spanish and Portuguese trawlers having operated north and south of Cabo da Roca in 1981 and 1982. The area north of Cabo da Roca includes the Nephrops stock off the coast of Minho, Douro and Beira Litoral; the area south of Cabo da Roca includes the Alentejo and Algarve stocks. Yields were highest during summer and early autumn. A similar feature is seen in Table 34, which shows monthly landings/vessel of Portuguese trawlers by area and home port for 1983. It should be noted that the landings/vessel at Vila Real are very similar to those of the Spanish fleet in 1981-1982 (Figueiredo, pers. comm.).

Trends in the length composition of Nephrops landed are shown in Tables 35 and 36. The mean length of both males and females landed from the Algarve stock considerably increased in 1983. This was because the trawlers from Vila Real exploited more distant and deeper fishing grounds inhabited by bigger Nephrops not previously exploited by Portuguese fishermen (Figueiredo, pers. comm.).

5. SELECTIVE TRAWLS

The Working Group reviewed and discussed the results of recent Scottish, Irish and French experiments with selective Nephrops trawls, with an upper "fish codend" and a lower "Nephrops codend" (Figure 11). The following sections contain short summaries of these experiments and some general comments, particularly on the conservation effect of selective trawls on roundfish taken as a by-catch in the Nephrops fisheries.

5.1 Scottish Experiments With Selective Trawls

A Boris 520 fish/prawn trawl was re-rigged with a separator panel which divided the net into two horizontal compartments with separate codends (Main and Sangster, 1982). The prime function being to separate haddock and whiting from Nephrops and groundfish (cod, flatfish and skate) during trawling. Diving scientists, using a towed underwater vehicle, observed, measured and when necessary adjusted the gear to obtain the most favourable arrangement during normal towing conditions. Catch figures of whitefish and Nephrops in both codends were examined using both 50 mm, 70 mm and 85 mm mesh separation panels set at different heights above the sea bed. Many dogfish were meshed in the 85 mm separator panel just in front of the codend. This caused problems and delays owing to the crew having to clear the fish from this inner panel prior to re-shooting the gear.

These experiments demonstrated one example of making use of the individual reactions of fish and Nephrops in order to develop a precise fishing technique in a specific fishery. The 70 mm separator panel set at 75 cm above the footrope of the modified Boris 520 fish/prawn trawl showed a good separation of the majority of the catches of haddock and whiting from the Nephrops and groundfish like cod, flatfish and skate (Table 37). Table 38 shows results using 50 mm and 85 mm panels. Table 39 shows pooled results from 1981-1983 with the separator panel set at 75 cm height. This gear is a useful and practical fishing arrangement in a Nephrops fishery where there is a large by-catch of undersized, unsaleable gadoid fish. It is however important to check the net by using divers, to ensure that the adjustment and the height of the panels are correct prior to fishing.

5.2 Irish Experiments on the Selectivity of Nephrops trawls

A selection experiment with an Irish Nephrops trawl covered with 52 small meshed covers in addition to that on the codend showed that the greatest escapement of Nephrops occurred from the undersides of the bases of the wings (Hillis and Earley, 1982b). Virtually no Nephrops escaped from the upper half of the net, very few from the lower half close to the selvedges, and relatively few from the centre of the lower half, leaving the zone where the net lifts from the seabed as it approaches the selvedge as the area of main escapement. From front to rear, the percentages of escapes from the different parts of the trawl were as follows :

Wings	32%
Wing-bases	42%
Belly	7%
Codend	18%

There was a progressive increase in the size of escapes from front to rear of the net. This clearly demonstrates the importance of the forward part of the trawl for selectivity as well as clearly showing why early workers like Cole and Simpson (1965) had difficulty in obtaining realistic selectivity curves.

To avoid pockets glutting and invalidating results, hauls were kept short (maximum 1 hour), so no experience of selectivity during sharp turns and no experience of escapement caused by necessity to swing the catch aboard in two or three lifts could be gained and possible effects of these situations remain unknown.

Experiments with a selective trawl with two codends, upper and lower, yielded 88% of Nephrops in the lower codend and 79% of whiting of age group 1 or older

in the upper codend (Table 40; Hillis, unpubl. data). Experiments with a diagonal panel of large mesh netting (Hillis, 1983) or an array of fore and aft cords (Hillis, unpubl. data) to deflect such strongly demersal fish such as cod and flatfish into the upper codend whilst letting Nephrops pass through into the lower one were only partially successful as they easily became blocked by debris (e.g. discarded plastic sheets) or by clinging action of edible crabs. Such devices did not seem to justify the extra complication involved in fitting them.

5.3 French Experiments with Selective Trawls

A "bigouden" trawl was modified for the purpose by the Scottish method (Main and Sangster, 1982) with a separator panel and two cod-ends. The separator panel and the codends were made of 50 mm mesh.

A preliminary cruise was conducted in the Bay of Biscay for accurately determining the lengths of the panel ropes and of the strop controlling the height of the panel. Separation of Nephrops and hake was good for a separator panel height of 80 cm which was adopted for all the following experiments. A uniform codend mesh size of 50 mm was also maintained for easy comparison between the two codends. As in the commercial fishery, the duration of each haul was three hours.

The experiment in the Bay of Biscay was carried out during the spring of 1984. The main by-catch species are hake, monk and sole. Problems arise with juvenile hake feeding during spring and summer in the Nephrops areas (see also section 6.2). Hake is never sought by Nephrops trawlers (its price is less than half of Nephrops) but it is unavoidable by-catch. The use of a selective trawl may prove to be a means of avoiding small hake. The first results (Table 41) are very encouraging, but a proportion of smaller hake is caught by the bottom codend. A study of their length frequency composition is now being undertaken.

The experiment in the Celtic Sea was made with the same trawl rigged in the same manner. The by-catch is more important and varied than in the Bay of Biscay (Table 41), and composed of larger individuals. Most species are often present in number in both codends and there is no evidence for that fishery that the selective trawl can be a solution to the by-catch problem.

5.4 General Conclusions On Selective Trawls

Traditional methods for solving by-catch problems are usually based upon mesh size regulations. Selective trawls with upper and lower codend and with a large mesh on the net top-side could offer an alternative fishing strategy.

The advantage of separator trawls are the conservation effect on fish stocks, ease of sorting the catch, high quality of fish caught, relative ease in lifting the gear aboard, and quicker discarding.

Problems due to incomplete separation with hake suggest that more research is required in order that the practical and economic feasibility of such trawls can be assessed. It was agreed that more quantitative data on catch compositions in relation to separator panel height are required. Comparative studies between trawls with separator panels and traditional low headline Nephrops trawls would also be of value.

6. MANAGEMENTS CONSIDERATIONS

6.1 Management Units For Nephrops Fisheries

Present ICES Divisions do not necessarily correspond to the boundaries of Nephrops stocks. Many fishing grounds are geographically located on the boundaries between ICES Divisions. Countries collecting and reporting Nephrops data to ICES tend to do so for each ICES Division rather than by actual fishing ground or stock. Such data can often be difficult to analyse.

Recent data (Bailey and Chapman, 1983) show that there can be wide differences in biological parameters, particularly in growth, even on a small geographical scale (see section 3.3). Records of tagging data also confirm that Nephrops have very limited movements and the exchange of benthic stages between stock(let)s is neglibile or nil (see section 3.5.2 and Anon., 1982a).

In many cases it might not be practical to manage a fishery sub-divided into very small management units, although these may be biologically meaningful. Nevertheless it would be useful to develop management strategies which take account of the existence of variability of biological characteristics on the fishing grounds, especially when the fishermen deliberately distribute their fishing effort to follow seasonal patterns of differential availability of Nephrops.

In most cases it is a yet not possible to differentiate actual unit stocks. However, it is felt that fishing areas do have some biological meaning and when information on stock boundaries is lacking the limits of fishing grounds can be used to define management units for reporting data and modelling.

The Working Group has identified such functional areas in Regions 2 and 3 and recommends that these should be used as statistical units for reporting data and for further stock assessment purposes. If the statistical data cannot be reported by such areas, they should at least be reported to the smallest statistical unit used by ICES - a statistical rectangle. A list of the management units is provided (see also Figure 12):

1. Swedish and Norwegian Skagerrak coast*
2. North and Central Kattegat
3. Botney Gut and Silver Pit
4. Farne Deeps
5. Fladen Ground
6. Firth of Forth
7. Moray Firth
8. Noup
9. North Minch*
10. South Minch*
11. Clyde*
12. Irish Sea east
13. Irish Sea west
14. Porcupine Bank
15. Aran
16. Northwest and west Ireland*
17. Southwest Ireland*
18. Northwest Labadie, Baltimore and Galley
19. Jones and Cockburn
20. Smalls
21. Bay of Biscay north of 47°N
22. Bay of Biscay south of 47°N
23. North Galicia
24. West Galicia
25. Minho, Douro and Beira Litoral
26. Alentejo
27. Algarve

*These functional units include complexes of small stocklets, often more or less isolated in deep sea lochs or fjords separated from the open sea by shallow rocky bottom sills.

6.2 Management Problems

An attempt was made to identify those stocks which might be overexploited or have management problems and therefore warrant priority attention. Details of trends in catch, cpue, size composition of catches and landings have been summarised (Table 42) and used to judge whether particular stocks are overexploited. Some fisheries also have conflicts for space, e.g. trawling versus fixed gear (creels), and conflicts of resources, e.g. finfish by-catches, which may be causing management difficulties.

Only one stock has clear evidence of overexploitation, the Firth of Forth stock, where the catch and cpue have declined in recent years. This stock is fished only by Scotland and further research is in hand. As a result of the reduction in the cpue, fishing effort has been directed to other areas and there are signs that the stock is now beginning to recover. The North Galician stock has also shown a decrease in catch and in average size of the landings. There is some reduction in fishing effort and this may allow the stock to recover. A similar situation has arisen in the north and central Kattegat where cpue has fallen in some areas and effort has been directed to new grounds, thus maintaining the overall catch.

Two other stocks are giving some cause for concern, namely the Farne Deeps stock and the western Irish Sea stock. In the last two years catches in both areas have increased, they have doubled in the Farne Deeps. This may well be the result of effort being switched from TAC restricted fisheries to the unrestricted Nephrops fishery. The data available from these fisheries are currently being examined. The size of Nephrops caught and landed in the western Irish Sea is declining; the decline in landed size is due to a reduction in the discarding of small Nephrops.

Overall, there does not seem to be any sign of recruitment overfishing in Nephrops stocks, but the data available for most Nephrops fisheries are not adequate to assess whether growth overfishing is occurring. There is a need to analyse more fully existing data for these fisheries, particularly those giving cause for concern at present.

Regular biological sampling is lacking in some fisheries and is inadequate in others. The biological problems associated with Crustacea make the task of assessing Nephrops stocks more difficult than for fish, but in many areas the basic data used for stock assessment are not being collected and this should be remedied.

One of the main management problems related to the exploitation of Nephrops is the effect of these fisheries on juvenile demersal fish species. This is the case for whiting in the western Irish Sea and for hake in the Celtic Sea (northwest Labadie, Baltimore, Galley, Jones, Cockburn and Smalls), the Bay of Biscay (northern and southern stocks) and west Galicia. In these areas there is an overlap between Nephrops grounds and finfish nurseries such that the discarding mortality of small whiting and hake can be expected to be considerable.

To facilitate any future management strategies aiming at a reduction of the mortality of juvenile whiting and hake, there is an urgent need to quantify the impact of the small meshed Nephrops fisheries on the recruiting year classes of these fish species. Therefore, the Working Group recommends that the impact of the Nephrops fisheries on whiting and hake recruitment should urgently be assessed.

The most appropriate place to consider whiting seems to be in the Irish Sea and Bristol Channel Working Group, whereas hake could be dealt with, either by the Hake Working Group, a joint meeting between the Hake and Nephrops Working Groups, or an ad hoc Study Group on Hake By-Catches.

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APPENDIX 1

RECOMMENDATIONS

The Nephrops Working Group recommends that :

1. The management units listed in section 6.1 should be used as statistical units for reporting data and for further assessment purposes (for details and comments see section 6.1);

2. The impact of the Nephrops fisheries on whiting and hake recruitment should urgently be assessed (for details and comments see section 6.2).

Table 1. Estimates of Nephrops, and burrow density in the Clyde and Sound of Jura, Scotland (Bailey and Chapman, 1983).

	Television Camera Observations					
	Area surveyed m^2	No. of burrows	Burrow density per m^2	Area surveyed m^2	No. of Nephrops	Nephrops density per m^2
Clyde	5 193	1 391	0.268	7 700	99	0.013
Jura	3 180	2 874	0.904	7 181	935	0.130
Ratio $\frac{\text{Jura}}{\text{Clyde}}$			3.37			10.0

Table 2. Sex ratio (% of females) by month and size class of trawl caught *Nephrops* in the Firth of Forth. Scottish landings, 1981-1983 (Chapman, unpubl. data).

Carapace length (mm)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Trawl-1981												
15-19							+			+		+
20-24	0.3						0.3	2.1	0.3	0.5	0.4	0.3
25-29	8.6						6.2	18.6	2.8	11.1	9.1	4.0
30-34	15.9						14.1	25.9	21.8	20.2	14.7	9.1
35-39	7.0						16.2	7.6	15.1	11.0	6.8	6.5
40-44	3.7						5.7	1.7	2.0	2.4	1.2	2.3
45-49	0.7						1.0	0.2	0.2	0.4	0.2	0.6
50-54	+						0.2	0.1		0.1	+	0.1
55-59	+						+	+		+		+
Trawl-1982												
15-19	+		0.3			+		0.6	0.4		0.1	
20-24	0.2		3.0			2.8		6.1	1.3	0.2	2.2	
25-29	2.9	4.3	10.9		2.5	10.1		20.2	14.4	3.6	6.9	
30-34	8.5	16.3	10.3		4.3	7.4		9.8	20.0	7.4	7.2	
35-39	7.1	9.0	5.0		2.3	3.7		3.9	6.8	6.0	2.9	
40-44	3.4	2.4	1.5		0.7	1.7		0.7	1.2	3.2	1.0	
45-49	0.3	0.3	0.2			0.1		+	0.2	1.5	0.2	
50-54		+	+			+				0.5	+	
55-59		+								0.1		
Trawl-1983												
15-19								0.1				
20-24	3.2	1.7	0.3	0.6	0.2	0.1	0.9	0.7		0.1	0.1	0.1
25-29	17.2	14.8	4.6	11.3	2.6	5.9	4.5	8.7		5.0	8.3	3.3
30-34	6.4	13.0	12.8	11.0	1.7	12.7	10.7	22.8		20.4	15.5	9.8
35-39	0.5	2.6	5.4	3.9	1.2	6.0	9.0	11.2		9.5	4.2	4.5
40-44	0.2	1.7	1.1	1.5	0.8	3.7	4.6	3.0		2.1	1.3	1.4
45-49	+	0.6	0.4	0.3	0.2	0.3	0.5	0.4		0.2	0.1	0.3
50-54	+	0.1	0.2	+		0.2	0.2	+		+	+	+
55-59		+	+			+		+				+

Table 3. Sex ratio (% of females) by month and size class of trawl caught Nephrops in the Moray Firth, Scottish landings, 1981-1983 (Chapman, unpubl. data).

Carapace length (mm)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Trawl-1981												
15-19						0.1						
20-24	1.4		0.9		0.2	0.9	1.2					
25-29	5.3		3.5		3.7	28.7	18.8					
30-34	11.7		7.7		4.6	7.4	24.1					
35-39	5.8		5.1		3.2	0.7	7.3					
40-44	0.2		1.4		0.7	0.1	0.7					
45-49			0.2				0.1					
Trawl-1982												
15-19			0.1	1.4				0.3				
20-24			5.6	11.4	0.1			9.5	0.8		1.2	
25-29			19.5	20.6	1.9			27.9	10.9		15.7	
30-34			16.8	9.8	6.3			33.6	25.3		13.4	
35-39			4.3	3.7	2.9			5.6	12.5		4.0	
40-44			0.7	0.2	0.2			0.8	3.8		1.3	
45-49			0.1					0.1	1.0		0.2	
50-54								+	0.1		0.1	
55-59									+		+	
60-64											+	
Trawl-1983												
15-19			0.6								1.6	+
20-24		1.1	5.3	3.3	1.5	5.0	4.0	1.3	0.5		16.7	2.1
25-29		15.5	13.8	8.8	9.7	19.7	21.7	12.3	6.9		19.8	8.6
30-34		21.8	5.8	5.9	12.7	22.5	24.5	20.8	17.8		7.8	5.8
35-39		8.5	3.6	1.9	8.8	5.0	8.2	9.0	15.3		1.7	1.3
40-44		1.6	0.5	0.9	1.7	1.8	2.2	1.6	3.6		0.2	0.3
45-49		0.1	+	1.3	0.1	0.4	0.3	0.2	1.1		+	+
50-54		+		0.3	+	0.1	0.1	+	+		+	
55-59						+	+	+			+	

Table 4. Sex ratio (% of females) by month and size class of trawl and creel caught Nephrops in the North Minch, Scottish landings, 1981-1983 (Chapman, unpubl. data)

Cerapace length (mm)	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
Trawl-1981												
15-19												
20-24		0.5		0.4			1.1	0.5	1.9			
25-29		11.0		2.2			6.4	6.7	11.7			
30-34		11.0		0.5	0.5		16.9	11.2	8.8			
35-39		0.8		0.1			9.9	4.5	1.2			
40-44							1.1	0.4	0.2			
45-49							+	+	+			
Creel-1981												
20-24												
25-29							0.2					
30-34							2.3					
35-39							4.8					
40-44							6.9					
45-49							6.1					
50-54							0.9					
55-59							+					
Trawl-1982												
15-19											0.1	0.1
20-24			0.7		0.2		3.8	4.0			3.3	4.6
25-29			4.1		10.3		27.9	29.7			12.5	5.0
30-34			3.4		7.5		18.5	33.8			3.9	1.4
35-39			0.6		2.5		1.8	8.8			0.9	+
40-44					0.3		0.2	0.7			0.1	
45-49					+		+	0.1			+	
50-54							+					
Creel-1982												
20-24												
25-29							0.4					
30-34					1.6		7.8					
35-39					13.5		21.0					
40-44					13.0		7.4					
45-49					1.4		0.9					
50-54							0.3					
Trawl-1983												
15-19			2.4					0.1		0.4	+	
20-24			14.5	5.5	10.0		2.7	10.2	1.8	6.4	3.4	0.5
25-29	0.3		11.3	16.6	24.3		33.2	29.8	18.0	20.9	18.1	11.3
30-34	0.1		2.9	6.2	8.6		31.3	13.5	19.4	5.8	4.0	3.9
35-39	0.8		0.1	1.6	0.4		3.6	0.9	3.1	1.3	0.6	0.6
40-44	1.4		0.1	0.2			0.2	0.1	1.5	0.1	+	0.2
45-49							+		+		+	
Creel-1983												
20-24												
25-29				0.5	0.4		0.4					
30-34		0.4		5.2	8.6		2.7					
35-39		1.4		12.8	17.3		12.2					
40-44		1.1		5.8	4.6		6.8					
45-49				1.1	0.4		1.2					
50-54				+								

Table 5. Sex ratio (% of females) by month and length class of trawl and creel caught Nephrops in the South Minch, Scottish landings, 1981-1983 (Chapman, unpubl. data).

Carapace length (mm)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Trawl-1981												
15-19					4.9						+	
20-24	0.8	1.2			27.6	0.6	0.9	4.7	1.4	6.2	3.5	10.3
25-29	6.0	4.4	2.7		15.2	4.8	18.5	14.7	19.2	17.9	13.0	13.2
30-34	4.5	2.3	5.3		4.9	16.2	20.7	9.4	10.6	7.5	5.7	1.6
35-39	0.8	1.4	3.5		1.9	6.0	9.8	2.7	1.5	1.4	1.2	+
40-44	0.1	0.8	0.7		0.2	0.4	1.5	0.1	0.5	0.3	0.1	
45-49		0.1	0.1				0.2		+	+	+	
50-54	+											
Creel-1981												
15-19											+	
20-24					0.1						0.3	0.1
25-29	0.4	0.4	0.4		1.4			2.0	0.1	0.4	1.3	1.0
30-34	1.2	9.5	8.3	1.2	10.9		3.0	11.7	3.7	6.4	5.7	4.6
35-39	9.8	11.7	7.1	7.4	13.4		17.5	13.7	15.4	11.5	9.1	7.4
40-44	8.4	3.7	1.2	2.8	6.7		7.2	1.1	6.2	9.4	8.0	5.5
45-49	2.0	1.0	0.1		1.2		0.9	0.1	2.2	3.4	2.1	2.6
50-54	0.5	0.1			+		+		0.7	1.0	0.6	
55-59		+							+	0.1		
Trawl-1982												
15-19	0.2							5.3		1.3	0.3	
20-24	1.1	2.7	4.1	1.6				20.7		10.3	4.7	8.9
25-29	4.6	5.7	10.9	10.7	1.9			10.8	1.3	6.0	8.4	20.9
30-34	0.9	0.8	3.8	1.3	5.8			1.8	10.6	3.5	2.3	1.3
35-39	0.4	0.1	1.2	+	4.0			0.5	7.1	0.5	1.6	+
40-44	+		+	+	4.7				1.3	0.1	0.7	+
45-49			+		2.4				+		0.1	
50-54					0.3							
Creel-1982												
20-24				0.1	0.2	0.1		0.1		0.3		+
25-29		0.6	0.8	0.9	4.3	4.7	0.3	4.3		6.4	2.6	0.2
30-34	1.7	8.9	4.6	7.5	19.0	18.9	13.3	21.9		24.4	16.5	5.4
35-39	4.4	6.4	10.8	19.2	23.9	13.0	21.8	24.3		14.8	9.9	17.4
40-44	2.5	0.8	2.4	8.5	10.6	4.6	6.2	2.5		2.4	1.9	8.0
45-49	0.1	0.1	0.5	1.2	1.0	0.6	0.7	0.3		0.1	0.2	1.2
50-54			+	0.1	0.1	0.1	+					0.2
55-59					+	+						
Trawl-1983												
15-19									1.2			
20-24	3.7		0.3	1.2				0.1	20.9	1.5		
25-29	13.2		2.5	14.5				10.6	18.9	15.0		
30-34	9.8		3.1	4.4				21.8	5.7	14.7		
35-39	0.3			+				0.4		0.5		
40-44	0.1							+		+		
Creel-1983												
25-29	0.1		0.6	1.0	2.0	1.0	3.1	0.3	2.3	0.1		1.3
30-34	4.9		4.9	7.4	20.5	15.3	26.0	16.4	17.5	12.1		7.6
35-39	14.7		7.0	7.9	18.8	21.8	18.9	27.5	26.6	27.6		8.4
40-44	3.5		1.3	2.8	4.8	6.8	4.1	8.9	5.4	13.6		1.3
45-49	0.5		0.1	0.5	0.2	0.4	0.3	0.6	0.9	2.3		0.3
50-54			+	+			+	+		+		

Table 6. Sex ratio (% of females) by month and length class of trawl caught Nephrops in the Clyde, Scottish landings, 1981-1983 (Chapman, unpubl. data).

Carapace length (mm)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Trawl-1981												
15-19						0.2			0.3		0.3	0.1
20-24			0.6		3.2	11.4	7.2		4.9	0.3	8.7	4.7
25-29			5.8		35.4	18.1	27.2		21.6	5.9	18.7	17.0
30-34			9.9		7.6	13.8	26.1		18.3	12.8	7.5	10.3
35-39			5.2		0.4	6.0	8.2		5.8	10.2	5.2	3.4
40-44			2.7		0.2	3.1	5.3		1.6	5.4	3.8	2.9
45-49			1.4		+	1.7	1.5		0.7	2.5	1.3	1.6
50-54			0.2		+	0.2	0.2		0.3	0.5	0.2	0.5
55-59			+		+				+	+	+	+
60-64											+	
Trawl-1982												
15-19			1.4			0.1	+		0.1		0.8	0.1
20-24	1.0		22.5	1.2	0.2	4.8	3.5		6.0		20.6	4.1
25-29	3.7		11.8	8.9	1.2	28.5	20.9		18.1		6.1	20.9
30-34	3.0		1.1	8.9	3.8	22.5	26.5		10.7		1.8	8.9
35-39	2.0		0.1	3.2	2.6	3.9	12.4		3.8		0.6	1.5
40-44	2.0		+	1.4	1.9	0.8	4.9		2.6		0.4	0.7
45-49	0.6			0.5	2.2	0.1	1.3		0.9		0.1	0.2
50-54	0.1			0.1	0.9	+	+		0.1		+	+
55-59	0.1			+	0.5	+	+		+		+	+
60-64					0.2				+			
Trawl-1983												
15-19	+											3.0
20-24	2.6	1.3	5.1	1.7	2.0		2.9	5.9	7.8	0.7	2.6	21.5
25-29	9.3	10.8	13.8	12.7	20.8		26.0	24.7	21.9	11.8	25.6	9.1
30-34	4.3	9.6	6.1	10.6	12.7		13.5	22.1	18.6	7.9	8.4	0.8
35-39	0.5	2.4	0.8	2.3	2.2		8.9	9.9	5.0	2.1	2.0	0.3
40-44	0.1	1.8	0.3	0.8	0.9		1.1	4.5	1.9	0.9	1.2	0.1
45-49	+	1.0	0.2	0.5	+			1.6	1.0	0.2	0.4	+
50-54	+	0.5	+	0.1	+			0.3	0.2	0.1	0.1	+
55-59	+	0.2	+	+				+	+	+		
60-64				+						+		

Table 7. Sex ratio (% of females) by month and length class of Nephrops in the Irish Sea, Northern Irish landings, 1983 (Briggs, unpubl. data)

Carapace length (mm)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
15-19	47.7	53.5	61.9	55.5	64.6	59.8	66.3	66.4	66.7	68.7	65.5	51.0
20-24	9.8	18.9	50.0	53.1	55.7	62.1	60.7	61.1	61.7	58.0	51.5	52.5
25-29	-	15.0	17.1	11.6	18.9	35.8	60.9	50.3	33.0	19.0	14.6	15.0
30-34	-	-	2.3	8.5	1.8	16.0	39.9	36.6	16.2	9.3	2.1	-
35-39	-	-	-	-	-	10.0	10.0	28.0	-	-	-	-
Monthly mean	39.4	33.6	37.0	43.8	50.7	60.5	60.7	56.6	51.0	45.5	38.1	40.2

Table 8. Sex ratio (% of females) by month of Nephrops in the Irish Sea, Irish commercial and research vessel catches, 1980-1984 (Hillis, unpubl. data).

Year	Month											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1980	-	34.1	-	-	-	-	49.8	50.5	47.0	-	-	-
1981	34.4	25.1	-	-	-	64.3	50.4	-	40.7	-	-	-
1982	26.4	-	-	38.9	-	-	-	-	-	-	43.6	-
1983	-	-	-	-	-	59.9	-	47.9	44.4	-	30.8	-
1984	32.0	43.7	43.1	...	...	...	...	...	...	...	...	...
Unweighted mean	30.9	34.3	43.1	38.9	-	62.1	50.1	49.2	44.0	-	37.2	-

Table 9. Sex ratio (% of females) by lenght class of Nephrops in the Celtic Sea, French landings, 1981-1983 (Charuau, unpubl. data)

Carapace length (mm)	1981	1982	1983
20-24	22.8	-	-
25-29	63.6	55.8	63.6
30-34	46.8	51.4	36.7
35-39	38.0	35.6	36.5
40-44	25.1	18.5	34.8
45-49	11.4	3.4	14.0
50-54	3.5	0.8	1.0
55-59	-	2.2	-

Table 10. Sex ratio (% of females) by size class of Nephrops in the Porcupine Bank area, Spanish landings, 1977, 1979-83 (Fernandez, unpubl. data).

Carapace length (mm)	1977	1979	1980	1981	1982	1983
20	37.5	69.2	47.0	49.0	49.0	64.7
25	35.5	34.7	45.0	39.1	44.2	45.2
30	17.6	7.9	17.4	23.8	31.2	26.4
35	4.5	2.2	9.2	8.8	15.6	12.6
40	0.6	0.2	4.6	5.3	6.7	4.4
45	0.1	0.5	2.3	5.4	3.8	1.7
50	0.2	0.1	1.5	1.6	1.5	0.5
55	0.4	0.0	1.7	2.2	0.8	1.5
60	0.0	0.0	0.0	0.0	0.0	0.0
65	0.0	0.0	0.0	0.0	9.5	0.0
70	-	0.0	0.0	0.0	0.0	-
Total	9.2	2.1	13.1	12.1	15.2	12.4

Table 11. Sex ratio (% of females) by length class of Nephrops off North Galicia, Spanish landings 1979-1983 (Fernandez, unpbl.data).

Carapace length (mm)	1979	1980	1981	1982	1983
20	14.0	64.8	30.1	64.3	67.7
25	45.7	52.0	45.1	52.8	53.4
30	46.1	48.8	39.9	52.1	45.8
35	22.3	44.1	26.9	42.6	38.6
40	16.6	25.4	29.8	34.8	21.8
45	18.1	22.7	23.2	30.5	22.9
50	13.3	15.5	15.4	37.9	8.6
55	6.0	9.4	3.9	30.9	28.1
60	0.0	0.0	7.2	15.0	0.0
65	0.0	0.0	2.0	0.0	0.0
70	0.0	0.0	0.0	0.0	0.0
75	0.0	-	0.0	0.0	0.0
80	-	-	0.0	0.0	0.0
Total	26.5	43.3	31.8	45.2	43.6

Table 12 Sex ratio (% of females) by length class of *Nephrops* off West Galicia. Spanish landings 1977-78 and 1980-83 (Fernandez, unpubl. data).

Carapace length (mm)	1977	1978	1980	1981	1982	1983
15	29.9	53.1	-	-	-	61.2
20	38.8	41.8	33.0	27.6	5.5	55.9
25	58.0	44.1	56.6	2.4	21.5	52.8
30	61.9	55.6	26.1	3.0	28.4	42.8
35	43.1	39.0	33.8	1.0	21.2	31.8
40	14.7	32.0	35.0	2.1	24.7	32.1
45	10.0	23.1	24.8	7.1	21.3	30.0
50	4.8	12.0	26.2	23.0	25.8	26.2
55	0.6	15.6	26.1	3.3	9.9	14.7
60	0.0	3.2	24.7	4.2	1.4	1.5
65	0.0	0.4	7.3	3.5	1.4	0.0
70	0.0	0.0	4.6	0.0	0.8	6.7
75	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	-	0.0	0.0
Total	40.9	40.8	26.8	2.6	22.7	40.3

Table 13 Length/weight relationships of Nephrops in different geographical areas

Area	Length/weight relationship[a]	Reference
Firth of Forth	♂ $W = 0.000203\ L_c^{3.34}$	Howard and Hall, 1983
	♀ $W = 0.000313\ L_c^{3.18}$	
Moray Firth	♂ $W = 0.000503\ L_c^{3.08}$	Howard and Hall, 1983
	♀ $W = 0.000476\ L_c^{3.03}$	
North Minch	♂ $W = 0.000105\ L_c^{3.51}$	Howard and Hall, 1983
	♀ $W = 0.001010\ L_c^{2.85}$	
South Minch	♂ $W = 0.000363\ L_c^{3.18}$	Howard and Hall, 1983
	♀ $W = 0.000885\ L_c^{2.91}$	
Sound of Jura	♂ $W = 0.000154\ L_c^{3.41}$	Howard and Hall, 1983
	♀ $W = 0.000847\ L_c^{2.90}$	
Clyde	♂ $W = 0.000451\ L_c^{3.11}$	Howard and Hall, 1983
	♀ $W = 0.000839\ L_c^{2.91}$	
Celtic Sea	mostly ♂ $W = 0.00024\ L_c^{3.8}$ (live weight)	Charuau and Morizur unpublished data
	mostly ♂ $W = 0.000095\ L_c^{3.55}$ (iced weight)	
North Galicia	♂ + ♀ $W = 0.000428\ L_c^{3.158}$	Fariña, in press
Algarve	♂ $W = 0.000205\ L_c^{3.318}$	Arrobas, 1982
	♀ $W = 0.006787\ L_c^{2.943}$	

(a) W = total weight (grammes)
L_c = carapace length (mm)

Table 14 Total mortalities of quasi-unexploited Nephrops stocks, according to Beverton and Holt's method (Z_1) and Ssentongo and Larkin's method (Z_2) (Morizur, 1982).

Area and period	Source of data	Reference length(a)	Class(a) interval	K	L_∞		Truncation point		Z_1	Z_2
					L_t	L_c	L_t	L_c		
Moray Firth, Firth of Clyde, 1906-1907	Mc Intosh (1980)	L_t	1	0.1	22.5	70	14.5 17.5		0.23 0.26	0.28 0.31
North Shields, 1911-1912	Storrow (1912)	L_t	1	0.1	22.5	70	16.5 17.5		0.33 0.36	0.38 0.41
Firth of Clyde, 1927	Thomas (1954)	L_t	1	0.1	22.5	70	9.5 13.5 16.5		0.25 0.21 0.18	0.30 0.25 0.23
Inner Minch, 1959 1960	Thomas (1965)	L_c L_c	5 5	0.1 0.1		70 70		49.5 49.5	0.18 0.14	0.22 0.18
East of Shetland, 1960	Thomas (1965)	L_c	5	0.1		70 60		49.5 49.5	0.32 0.12	0.37 0.16
Faroe, 1937 and 1939	Andersen (1962)	L_t	1	0.1	25.2	80	16.0 18.0 20.0		0.29 0.29 0.29	0.34 0.34 0.34
Eldeyjarbank, 1959	Sigurdsson (1959)	L_t	1	0.11	25.2 24.0	80 75	18.5 18.5		0.26 0.20	0.31 0.24
Krisuvikurbjarg, 1959	Sigurdsson (1959)	L_t	1	0.11	25.2 24.0	80 75	17.5 17.5		0.27 0.21	0.32 0.26
Vestmann Islands, 1959	Sigurdsson (1959)	L_t	1	0.11	25.2 24.0	80 75	17.5 17.5		0.32 0.25	0.36 0.30

(a) L_t = total length (cm) , L_c = carapace length (mm)

Table 15 Total mortalities of exploited Nephrops stocks, according to Beverton and Holt's method (Z_1) and Ssentongo and Larkin's method (Z_2) (Morizur, 1982).

Area and period	Source of data	Reference length[a]	Class[a] interval	K	L_∞		Truncation point		Z_1	Z_2
					L_t	L_c	L_t	L_o		
Celtic Sea, Labadie, 1961	Cole (1965)	L_c	1	0.105		76.31		42.5	0.51	0.56
				0.09		80		42.5	0.49	0.54
Celtic Sea, Labadie, 1978	Charuau (unpubl.)	L_c	1	0.105		76.31		49.5	0.65	0.66
								52.5	0.69	0.74
				0.09		80		49.5	0.64	0.69
								52.5	0.70	0.74
Bay of Biscay, Lesconil, 1971-1978	Charuau (unpubl.)	L_o	1	0.105		76.31		29.5	1.08	1.13
								34.5	1.02	1.07
								39.5	0.95	1.00
Bay of Biscay, 1975-1978	Esperandieu (1980)	L_c	1	0.105		76.31		40	0.65	0.71
								43	0.66	0.71
Firth of Forth, 1967-1973	Jones (1979)	L_c	5	0.1		70		39.5	0.37	0.42
Iceland, Area 146, 1970	Eiriksson (1979)	L_c	2	0.1		80		56	0.53	0.58
				0.1		75		56	0.40	0.45
Iceland, Area 154, 1973	Eiriksson (1979)	L_c	2	0.1		80		56	0.56	0.61
				0.1		75		56	0.42	0.47

(a) L_t = total length (cm) L_o = carapace length (mm)

Table 16 Total landings of Nephrops by Danish, Norwegian and Swedish vessels from the Kattegat and Skagerrak 1974-1983 (in tonnes).

Year	Denmark	Norway	Sweden
1974	1 730	36	575
1975	2 603	28	395
1976	1 637	31	250
1977	1 265	12	222
1978	1 451	14	345
1979	1 807	9	439
1980	2 205	18	488
1981	2 179	8	622
1982	2 726	8	648
1983	2 312*	47*	775*

*Preliminary

Table 17 Total landings of Nephrops by Belgian and UK vessels from the North Sea proper 1974-1983 (in tonnes).

YEAR	Belgium	England and Scotland
	Botney Gut + Silver Pit	Farne Deeps
1974	418	489
1975	433	583
1976	426	1 088
1977	454	1 447
1978	574	999
1979	299	757
1980	569	915
1981	526	1 006
1982	449*	2 443*
1983	633*	2 078*

* Preliminary

Table 18 Total landings of Nephrops by Scottish vessels from the Scottish waters 1965-1983 (in tonnes).

Year	Firth of Forth	Moray Firth	North Minch	South Minth	Clyde
1965	679	626	280	1 113	1 166
1966	1 559	837	310	843	1 077
1967	1 300	836	515	782	1 542
1968	963	699	416	1 224	1 737
1969	1 028	1 132	no data	1 716	1 875
1970	1 497	808	no data	1 811	1 790
1971	1 314	1 029	no data	1 803	1 769
1972	1 773	868	no data	2 267	2 565
1973	1 621	1 208	1 469	1 746	2 274
1974	1 452	1 299	1 607	1 216	1 508
1975	1 468	812	1 552	1 730	1 303
1976	1 877	1 806	1 348	2 132	1 440
1977	1 572	750	1 354	1 969	1 728
1978	1 309	1 273	2 091	2 105	1 923
1979	1 171	1 187	2 686	2 941	2 122
1980	1 063	814	1 727	1 561	2 184
1981	945	1 281	2 320	2 823	2 498
1982	1 138	1 004	2 323	2 690	2 373
1983	1 681	798	2 784	2 500	3 889

Table 19 Fishing effort of Scottish Nephrops vessels in the Scottish waters 1965-1983 (in 100's hours fishing).

Year	Firth of Forth	Moray Firth	North Minch	South Minch	Clyde
1965	203	329	113	337	519
1966	431	341	113	287	608
1967	480	282	202	347	777
1968	419	333	193	628	826
1969	432	517	no data	738	840
1970	457	330	no data	664	782
1971	466	346	no data	519	783
1972	593	307	no data	838	1 061
1973	591	455	452	849	1 179
1974	640	519	580	380	900
1975	782	324	466	659	888
1976	785	491	373	777	985
1977	645	218	371	599	964
1978	593	337	605	677	809
1979	572	442	870	1 039	989
1980	508	335	703	757	1 123
1981	426	435	787	1 005	1 327
1982	517	424	825	989	1 132
1983	607	204	645	754	1 499

Table 20 Total landings of Nephrops by French, Irish and UK vessels from the Irish Sea, 1974-1983 (in tonnes).

Year	EAST	W E S T				
	England and Wales	Northern Ireland	Ireland	Scotland	Isle of Man	France
1974	180	2 489	982	27	19	
1975	574	3 439	909	24	62	771
1976	645	3 217	1 614	45	108	267
1977	625	3 163	2 469	78	231	348
1978	963	4 147	2 921	130	252	440
1979	901	4 396	3 436	194	1 119	348
1980	731	2 544	1 709	125	273	153
1981	831	3 752	3 202	67	273	254
1982	869	4 488	4 394	90	370	156
1983	738	4 950	4 459	508	170	26

Table 21 Changes in mean carapace length in Irish Nephrops catches and landings, from available monthly samples, 1980-1984 (Hillis, unpubl. data)

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
				A. Mean length in catches, sexes combined								
1980	-	25.5	-	-	-	-	26.2	27.1	24.4	-	-	-
1981	25.2	26.8	-	-	-	28.1	26.3	-	-	-	24.5	-
1982	25.3	-	-	26.4	-	-	-	-	-	-	23.9	-
1983	-	-	-	-	-	26.2	-	-	23.7	-	26.4	-
1984	25.5	23.9	24.4	...	...	...	...	...	...	...	...	...
				B. Mean length in landings, sexes combined								
1980	-	-	-	-	-	-	-	32.2	29.8	-	-	-
1981	-	32.8	-	-	-	33.6	-	-	-	-	-	-
1982	31.2	-	-	29.5	-	29.9	28.4	-	-	-	26.0	-
1983	-	-	-	-	-	28.3	-	-	26.6	-	-	-
1984	29.3	26.9	31.1	...	...	...	...	...	...	...	...	...

Table 22 Total landings of Nephrops by French, Irish and Spanish vessels from West of Ireland, 1974-1983 (in tonnes)

Year	Aran	Porcupine Bank		Aran and Porcupine Bank
	France	France	Spain	Ireland
1974			1 894	
1975			2 262	
1976			1 387	
1977			1 545	
1978			174*	41
1979			225*	70
1980			238*	309
1981	387	53	331*	71
1982	396	356	397*	513
1983	210	590	299*	788

* With part of the fleet (see section 4.5)

Table 23 Effort and CPUE data of the Spanish fleet fishing on the Porcupine Bank Nephrops stock, 1967-1983 (Fernandez, unpubl. data).

Years	Fishing days	$\overline{BHP}$ (b)	KGS x F.days^{-1}	Kgs x F.days^{-1} x $\overline{BHP}^{-1}$ x 10^2
1967 (a)	11 760	514	43.20	8.40
1968 (a)	11 232	563	47.81	8.49
1969 (a)	12 804	589	41.86	7.10
1970 (a)	8 724	614	35.88	5.84
1971	25 560	623	56.50	9.07
1972	29 148	646	59.70	9.24
1973	27 768	652	76.90	11.79
1974	28 452	675	66.60	9.87
1975	31 704	723	71.30	9.87
1976	30 480	613	45.50	7.42
1977	27 048	724	57.10	7.89
1978 (c)	2 222.4	745	78.40	10.52
1979 (c)	2 176.8	723	103.60	14.33
1980 (c)	2 277.6	714	104.40	14.62
1981 (c)	1 941.6	736	170.70	23.20
1982 (c)	2 140.8	804	185.50	23.08
1983 (c)	1 897.2	803	157.40	19.60

(a) = with partial landings and effort data

(b) = $\overline{BHP} = \sum$ BHP vessel x trips/$\sum$ trips

(c) = with part of the fleet

Table 24 Total landings of Nephrops by French, English and Irish vessels from the Celtic Sea and adjacent inshore areas, 1974-83 (in tonnes).

Year	Bantry Bay, Kenmare River, etc.	Smalls			Jones, Cockburn Labadie. Galley, etc.	
	Ireland	England and Wales	France	Ireland	England and Wales	France
1974						4 199
1975						4 574
1976						4 748
1977						4 957
1978	473	+		22		4 056
1979	767	-		94		4 542
1980	463	17		56	2	3 519
1981	328	+		148	+	3 667
1982	260	26		134	+	3 227
1983	459	73		580	4	

Table 25 Total landings of Nephrops by French vessels from the Bay of Biscay, 1974-1983 (in tonnes)

Year	France
1974	7 100
1975	6 782
1976	6 313
1977	5 291
1978	4 716
1979	4 794
1980	6 107
1981	6 090
1982	
1983	

Table 26 CPUE data of French vessels (home-port Lesconil) fishing on the Bay of Biscay Nephrops stock, 1966-83 (Charuau, unpubl. data).

Year	CPUE kg/fishing day
1966	71.6
1967	54.8
1968	70.2
1969	88.8
1970	64.1
1971	63.6
1972	77.6
1973	105.4
1974	125.6
1975	121.5
1976	107.8
1977	93.4
1978	80.1
1979	91.7
1980	108.7
1981	114.0
1982	104.7
1983	113.6

Table 27 Total landings of Nephrops by Spanish vessels from the Spanish waters, 1974-1983 (in tonnes)

Year	North Galicia	West Galicia
1974		
1975	771	622
1976	598	603
1977	853	620
1978	730	575
1979	442	580
1980	559	599
1981	318	823
1982	431	736
1983	418	786

Table 28 Effort and CPUE data of the Spanish fleet fishing on the North Galicia Nephrops stock, 1975-1983 (Fernandez, unpubl. data).

"Baka" = single trawler ; "pareja" = pair trawler.

Year	Fishings days		$\overline{BHP}$		Kgs x F.days^{-1}		Kgs x F.days^{-1} x $\overline{BHP}^{-1}$ x 10^2	
	Bakas	Parejas	Bakas	Parejas	Bakas	Parejas	Bakas	Parejas
1975	8823	1450	454	890	82.8	8.0	18.2	0.90
1976	10159	1477	482	526	56.0	5.8	11.6	1.10
1977	9233	1645	490	794	88.4	6.7	18.0	0.84
1978	7561	2076	549	575	91.3	7.6	16.6	1.32
1979	7766	1631	510	842	60.2	3.3	11.8	0.39
1980	6942	690	529	902	76.4	2.2	14.4	0.24
1981	7147	490	522	530	44.4	0.1	8.5	0.02
1982	7698	470	556	820	56.0	0.1	10.1	0.01
1983	6343	720	541	849	65.8	1.3	12.2	0.15

Table 29 Total landings of Nephrops by Portuguese and Spanish vessels from the Portuguese waters, 1974-1983 (in tonnes)

Year	Minho, Douro, Beira Litoral and Alentejo		Algarve	
	Portugal	Spain	Portugal	Spain
1974	24	-	14	-
1975	20	137	14	1 510
1976	23	132	7	1 752
1977	12	95	3	1 764
1978	19	120	26	1 979
1979	36	96	66	1 532
1980	50	193	92	1 300
1981	36	270	86	1 033
1982		130		1 177
1983		0*		0*

* The Spanish fishery in these areas ceased from January 1983 onwards (see section 4.9.)

Table 30 Total landings of Nephrops by Portuguese vessels from the Portuguese waters, by port and month, 1981 (in kilogrammes).

Port/area	Total	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Porto	290	-	-	8	-	-	-	259	-	18	1	4	-
Aveiro	187	2	-	-	-	-	-	-	-	39	-	33	113
Figueira de Foz	107	-	-	24	23	-	-	60	-	-	-	-	-
Area total North of Cabo da Roca	584	2	-	32	23	-	-	319	-	57	1	37	113
Lisboa	1 121	44	35	40	226	392	270	24	22	33	34	2	-
Cascais	13 945	871	383	143	1 617	2 239	2 413	1 582	1 276	1 536	730	916	239
Setubal	20 373	1 447	258	958	5 609	4 790	4 540	2 125	41	90	448	67	-
Area total Alentejo	35 439	2 362	676	1 141	7 452	7 421	7 223	3 731	1 339	1 659	1 212	985	239
Portimão	9 600	-	-	-	309	1 301	1 246	1 800	1 626	1 146	654	699	819
Faro	1 596	-	-	736	-	-	728	-	132	-	-	-	-
Olhão	74 931	511	915	2 832	8 130	13 434	7 398	19 386	13 477	3 181	1 948	1 668	2 051
Area total Algarve	86 127	511	915	3 568	8 439	14 735	9 372	21 186	15 235	4 327	2 602	2 367	2 870

Table 31 Total landings of Nephrops by Portuguese vessels from the Portuguese waters, by port and month, 1982 (in kilogrammes).

PORT/AREA	TOTAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Porto	8	-	-	-	-	-	1	6	-	1	-	-	-
Aveiro	111	-	7	-	-	-	13	91	-	-	-	-	-
Figueira de Foz	139	-	-	-	12	-	10	117	-	-	-	-	-
AREA TOTAL North of Cabo da Roca	258	-	7	-	12	-	24	214	-	1	-	-	-
Lisboa	768	-	5	259	202	-	32	106	89	23	-	-	52
Cascais	1 215	76	-	267	242	-	80	259	74	214	-	-	3
Setubal	11 185	-	395	91	1 994	633	773	2 893	2 470	284	398	623	631
AREA TOTAL Alentejo	13 168	76	400	617	2 438	633	885	3 258	2 633	521	398	623	686
Portimão	6 474	362	211	378	853	861	729	638	745	500	953	166	78
Faro	656	-	-	-	-	-	656	-	-	-	-	-	-
Olhão	56 982	428	94	1 161	3 136	4 388	7 558	2 364	8 536	9 465	12 997	2 316	5 194
AREA TOTAL Algarve	64 764	790	305	1 539	3 989	5 249	8 943	3 002	9 281	9 965	13 950	2 482	5 269

Table 32 Total landings of Nephrops by Portuguese vessels from the Portuguese waters, by port and month, 1983 (in kilogrammes).

PORT/AREA	TOTAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Porto	470	-	9	-	-	110	-	9	137	130	20	6	49
Aveiro	273	-	-	-	-	259	9	5	-	-	-	-	-
Figuiera da Foz	-	-	-	-	-	-	-	-	-	-	-	-	-
AREA TOTAL North of Cabo da Roca	743	-	9	-	-	369	9	14	137	130	20	6	49
Lisboa	818	5	4	136	357	211	38	67	-	-	-	-	-
Cascais	3 266	-	-	-	78	106	804	163	662	487	693	240	33
Setubal	13 518	1 146	1 859	319	36	2 711*	2 449	2 666	480	843	423*	382	204
AREA TOTAL Alentejo**	17 602	1 151	1 863	455	471	3 028	3 291	2 896	1 142	1 330	1 116	622	237
Portimão	31 827	45	385	217	304	3 041	5 376	772	4 742	7 279	5 661	2 145	1 860
Olhão	74 224	1 542	1 226	3 313	5 748	22 051	8 010	6 933	4 731	7 788	7 666	3 706	1 510
Vila Real	120 347	-	-	5 287	8 028	19 960	18 800	17 917	13 125	15 220	8 320	7 494	6 196
AREA TOTAL Algarve***	226 398	1 587	1 611	8 817	14 080	45 052	32 186	25 622	22 598	30 287	21 647	13 345	9 566

* Estimated numbers

** The figures for the Alentejo area may include a few captures from the area North of Cabo da Roca

*** The figures for the Algarve area do include some captures from the Alentejo area

Table 33 CPUE data (kilogrammes/vessel) of the Portuguese and Spanish Fleets fishing on the Nephrops stocks in the Portuguese waters, by month, 1981-1982 (Figueiredo, pers. comm.)

Area	Fleet	Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
North of Cabo da Roca	Portugal	1981	Landings too small to allow calculation of CPUE data											
		1982												
	Spain	1981	387	155	267	248	105	1 782	1 064	359	554	362	163	195
		1982	242	520	566	237	857	1 464	1 032	1 101	713	772	771	515
Alentejo and Algarve	Portugal	1981	212	106	316	1 061	1 477	1 106	1 685	1 105	403	254	226	213
		1982	86	70	144	378	490	702	391	662	524	1 025	310	458
	Spain	1981	2 092	837	1 440	1 341	5 658	9 622	5 744	3 516	2 288	2 859	3 173	2 751
		1982	785	2 273	3 099	2 552	2 627	6 850	4 827	5 153	3 334	3 611	3 606	2 410

Table 34 CPUE data (kilogrammes/vessel) of the Portuguese fleet fishing on the Nephrops stocks in the Portuguese waters, by port and month, 1983 (Figueiredo, pers. comm.)

Area	Port	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
North of Cabo da Roca	Porto Aveiro Figueira da Foz	Landings too small to allow calculation of CPUE data											
Alentejo	Lisboa	-	-	10	25	15	3	5	-	-	-	-	-
	Cascais	-	-	-	11	15	115	23	95	70	99	34	5
	Setubal	382	620	106	12	904	816	889	160	281	141	127	68
Algarve	Portimão	15	128	72	101	753	1 344	129	790	1 212	943	306	266
	Olhão	171	136	368	639	2 450	890	693	473	708	697	337	137
	Vila Real	-	-	2 643	4 014	9 980	9 400	8 958	6 562	7 610	2 773	2 498	2 065

Table 35 Length frequency distribution of male Nephrops landed by Portuguese and Spanish Vessels from the Portuguese waters, 1980-1983 (Figueiredo, pers.comm.)

Carapace length (mm)	North of Cabo da Roca (Spanish data only)				Alentejo (Portuguese data only)				Algarve (Portuguese data only)			
	1980	1981	1982	1983	1980	1981	1982	1983	1980	1981	1982	1983
10-14	-	-	-	-	-	-	-	-	-	-	-	-
15-19	-	-	-	-	-	-	-	1	14		1	13
20-24	89	83	-	-	32	7	-	-	1 996	2 021	949	904
25-29	356	2 521	-	-	281	79	1	10	7 279	8 361	4 880	8 629
30-34	2 640	13 054	-	-	1 219	542	41	215	9 338	8 368	6 413	16 081
35-39	3 678	10 993	-	-	1 966	1 011	201	397	2 419	3 672	3 573	9 997
40-44	3 767	7 686	-	-	1 363	1 062	404	335	1 808	1 764	1 631	6 538
45-49	2 284	3 584	-	-	762	519	126	55	520	709	608	3 558
50-54	1 958	1 566	-	-	531	328	82	96	96	240	152	1 981
55-59	1 918	1 306	-	-	278	98	32	55	10	13	22	478
60-64	1 424	962	-	-	110	39	21	40	0	0	2	42
65-69	1 275	1 008	-	-	81	23	24	12	-	-	-	1
70-74	1 246	1 189	-	-	40	19	29	2	-	-	-	-
75-79	741	667	-	-	16	5	11	1	-	-	-	-
80-84	89	-	-	-	3	1	6	-	-	-	-	-
85-89	-	-	-	-	0	-	0	-	-	-	-	-
Total	21 465	44 619	-	-	6 682	3 733	978	1 219	23 480	25 148	18 231	48 242
Mean Carapace length	48.79	40.97	-	-	41.38	41.88	45.58	41.63	31.80	32.09	33.21	36.02

Table 36 Length frequency distribution of female Nephrops landed by Portuguese and Spanish Vessels from the Portuguese waters, 1980-1983 (Figueiredo, pers. comm.)

Carapace length (mm)	North of Cabo da Roca (Spanish data only)				Alentejo (Portuguese data only)				Algarve (Portuguese data only)			
	1980	1981	1982	1983	1980	1981	1982	1983	1980	1981	1982	1983
10-14	-	-	-	-	-	-	-	-	-	-	-	3
15-19	-	-	-	-	-	-	-	-	-	-	6	21
20-24	58	9	-	-	18	6	-	2	1 767	2 466	1 109	1 373
25-29	86	113	-	-	240	136	11	10	7 431	10 382	5 543	14 829
30-34	432	416	-	-	1 290	1 031	89	211	3 198	8 569	3 867	18 599
35-39	720	771	-	-	1 254	1 601	321	432	1 255	1 731	924	8 434
40-44	1 094	720	-	-	730	1 084	405	419	453	197	113	1 886
45-49	864	380	-	-	245	298	78	95	71	22	7	238
50-54	403	122	-	-	102	93	11	34	5	3	0	87
55-59	173	37	-	-	27	16	2	4	1	-	0	32
60-64	144	1	-	-	6	12	3	0	-	-	-	2
65-69	115	41	-	-	8	0	-	-	-	-	-	2
70-74	58	27	-	-	4	-	-	-	-	-	-	-
75-79	29	14	-	-	-	-	-	-	-	-	-	-
80-84	-	-	-	-	-	-	-	-	-	-	-	-
85-89	-	-	-	-	-	-	-	-	-	-	-	-
Total	4 176	2 651	-	-	3 924	4 277	920	1 207	14 181	23 370	11 569	45 506
Mean Carapace length	44.67	41.04	-	-	37.39	38.39	40.25	39.53	29.48	29.69	29.64	32.04

Table 37 Catches of Nephrops and fish in Scottish experiments with a selective trawl with upper and lower codends. Boris 520 Dual Purpose Fish/Prawn trawl, 70 mm separator panel set at 75 cm above groundlines. Results from eight daytime trawl hauls (Main and Sangster, unpubl. data).

	Top Codend				Bottom Codend				Total catch of each species (numbers)
	All sizes		Undersized		All sizes		Undersized		
	% of total catch	(numbers) (N_t)	% of N_t	(numbers)	% of total catch	(numbers) (N_b)	% of N_b	(numbers)	
Haddock	89.1	(147)	9.8	(13)	10.9	(18)	72.2	(13)	165
Whiting	54.5	(144)	92.4	(133)	45.5	(120)	100	(120)	264
Cod	0	(-)	-		100	(10)	-		10
Herring	68.7	(268)	98.9	(265)	31.3	(122)	100	(122)	390
Hake	40.0	(308)	100	(308)	60.0	(462)	100	(462)	770
Pout	5.7	(4)	-		94.3	(66)	-		70
Angler	0	(-)	-		100	(36)	-		36
Spotted Dogfish	0	(-)	-		100	(19)	-		19
Spotted Dogfish	9.1	(1)	-		90.9	(10)	-		11
Gurnard	0	(-)	-		100	(162)	-		162
Flatfish	0	(-)	-		100	(843)	73.7	(621)	843
Nephrops	0.4	(61)	19.7	(12)	99.6	(15 664)	8.7	(1 361)	15 725

Table 38 Catches of Nephrops in Scottish experiments with a selective trawl. Boris 520 Dual Purpose Fish/ Prawn Trawl. Nephrops catches with 85 and 50 mm separator panel mesh size, set at different heights above the groundlines (Main and Sangster, unpubl. data).

Height above groundlines	Separator panel mesh size	Nephrops catch in top codend	Nephrops catch in bottom codend
Panel set at 150 cm (7 hauls)	85 mm	0	6 350
Panel set at 100 cm (6 hauls)		0	4 456
Panel set at 90 cm (6 hauls)		0	5 507
Panel set at 75 cm (29 hauls)	50 mm	61	94 645
Panel set at 60 cm (6 hauls)		56	13 992

Table 39 Catches of Nephrops and fish in Scottish experiments with a selective trawl, with the separator panel set at 75 cm above the ground-lines. Pooled results from 1981-1983 (Main and Sangster, unpubl.data)

Species	% in top codend	% in bottom codend	Total Catch
Haddock	87.6	12.4	5 126
Whiting	84.5	15.5	26 559
Cod	4.0	96.0	220
Skate	0	100.0	87
Flatfish	0.8	99.2	2 273
Angler	0.5	99.5	187
Nephrops	0.06	99.94	94 706

Table 40 Catches of Nephrops and WHITING in Irish experiments with a selective trawl with upper and lower codends, summer 1983 (Hillis, unpubl. data).

Haul	Duration (hours)	NEPHROPS				WHITING			
		Kg in upper codend	Kg in lower codend	Total Catch	% in lower codend	Kg in upper codend	Kg in lower codend	Total Catch	% in upper codend
1	1.00	0.8	2.2	3.0	74.6	6.6	2.3	8.9	74.4
2	3.00	27.1	221.4	248.5	89.1	51.1	19.0	70.1	72.9
3	3.00	23.2	187.1	210.3	89.0	119.9	16.3	136.2	88.0
4	1.05	2.2	52.0	54.2	95.9	4.8	4.5	9.3	51.3
5	3.00	27.5	390.9	418.4	93.4	104.3	27.6	131.9	79.1
6	3.00	75.6	247.1	322.7	76.6	260.7	45.4	286.1	91.1
7	1.00	10.6	27.5	38.1	72.2	10.1	8.2	18.3	55.3
8	3.00	29.1	327.0	356.1	91.8	54.0	36.8	90.8	59.5
TOTAL	18.05	196.1	1 455.2	1 651.3	88.1	611.5	160.1	771.6	79.3

Table 41 Catches of Nephrops and fish in French experiments with a selective trawl with upper and lower codends, Bay of Biscay and Celtic Sea, spring 1984 (Charuau, unpubl.data).

	Nephrops	Cod	Whiting	Haddock	Saithe	Hake	Ling	Megrim	Monk	Cats	Dogfishes	Rays	Various fishes
						A. Bay of Biscay, 16 hauls							
Kg in upper codend	17.1	-	-	-	-	156.7	-	-	20.8	-	-	-	84.3
Kg in lower codend	227.1	-	-	-	-	17.2	-	-	154.0	-	-	-	179.1
Total Catch	244.2	-	-	-	-	173.9	-	-	174.8	-	-	-	263.4
% in upper codend	7.2	-	-	-	-	90.1	-	-	11.9	-	-	-	32.0
						B. Celtic Sea, 28 hauls							
Kg in upper codend	79.7	208.5	11.5	20.0	154.3	229.0	34.9	45.9	20.0	0	42.6	0	85.4
Kg in lower codend	828.7	435.5	0	0	74.5	168.0	130.3	199.5	134.7	125.0	10.0	50.0	52.2
Total catch	908.4	644.0	11.5	20.0	228.8	397.0	165.2	245.4	154.7	125.0	52.6	50.0	137.6
% in upper codend	20.3	32.4	100.0	100.0	67.4	57.7	21.1	18.7	12.9	0	81.0	0	62.1

Table 42. Trends in landings, cpue, mean size of Nephrops caught and landed, and management problems of the main Nephrops stocks in Regions 2 and 3.

Stock [a]	Trend in landings	Trend in cpue [b]	Trend in size of Nephrops caught [b]	Trend in size of Nephrops landed [b]	Evidence of over-exploitation	Changes in discarding practices	By-catch problem	Conflicts for space	Countries involved	Section
1	+++	NYA	?	?	No	No	No	Maybe Trawl-creel	Norway-Sweden	4.1
2	F	NYA	?	?	?	No	No	No	Denmark-Sweden	4.1
3	F	C	?	NYA	No	?	No	No	Belgium	4.2
4	+++	NYA	?	NYA	?	?	Maybe	No	England-Scotland	4.2
5	?	?	?	?	?	?	?	?	Denmark-Scotland	4.2
6	---	---	?	NYA	Yes	?	No	No	Scotland	4.3
7	F	F	?	NYA	No	?	No	No	Scotland	4.3
8									Scotland	4.3
9	+++	C	?	NYA	No	?	No	Yes Trawl-creel	Scotland	4.3
10	+++	C	?	NYA	No	?	No	Yes Trawl-creel	Scotland	4.3
11	+++	C	?	NYA	No	?	No	No	Scotland	4.3
12	F	F	?	?	No	?	Maybe	No	England-N Ireland	4.4
13	F+	NYA	---	---	?	Yes	Whiting	No	Ireland-N Ireland	4.4
14	?	?	?	NYA	No	?	No	No	France - Ireland Spain	4.5
15	?	?	?	?	?	?	?	?	France - Ireland	4.5
16	?	?	?	?	?	?	?	?	Ireland	4.5
17	F-	?	?	?	?	?	?	?	Ireland	4.6
18	F-	C	?	NYA	No	No	Hake-Megrim	No	France - Ireland	4.6
19	F-	C	?	NYA	No	No	Hake	No	France	4.6
20	NYA	C	?	NYA	No	No	Hake-Megrim	No	England- France Ireland	4.6
21	F-	C	?	?	No	No	Hake	No	France	4.7
22	F-	C	?	?	No	No	Hake-Sole	No	France	4.7
23	---	---	---	---	Some	No	No	No	Spain	4.8
24	+++	?	---	---	No	No	No	Hake-nursery	Spain	4.8
25	+++	?	?	?	No	No	No	Hake-gill net	Portugal	4.9
26									Portugal	4.9
27									Portugal	4.9

a) Stock numbers correspond to the numbers in section 6.1 and Figure 12.

b) Major trends in last five years:
+++: strongly increasing
F+: fluctuating, but with an increasing trend
F : fluctuating
F-: fluctuating, but with a decreasing trend
---: strongly decreasing
C : fairly constant
NYA: data available but not yet analysed

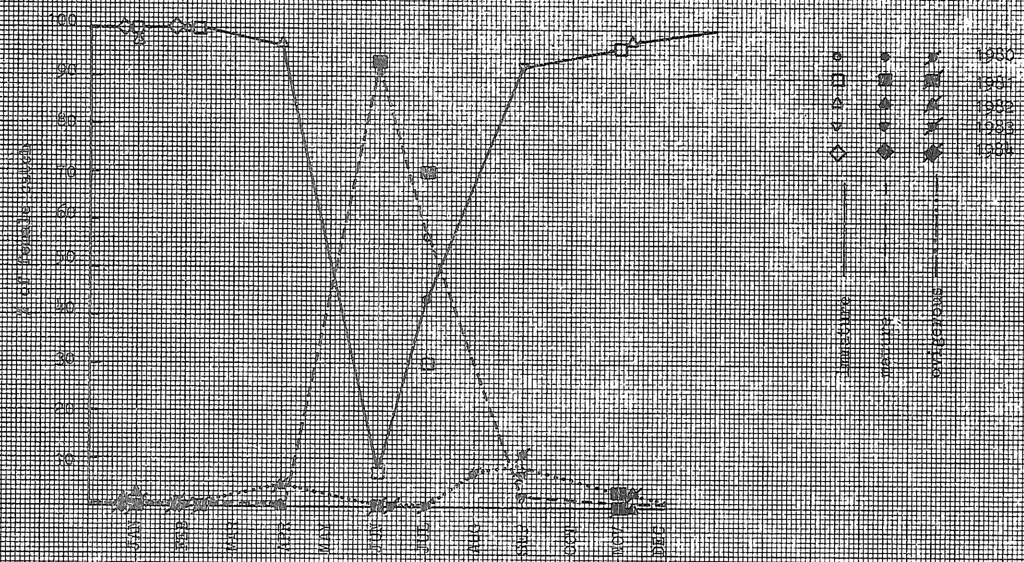

Figure 1. Composition of the female Nephrops stock in the Irish Sea, data from commercial catches, 1980–1984 (Hillis, unpubl. data).

Figure 2. Scottish Nephrops landings and fishing effort by area, 1965-1983.

Lines fitted between origin and bivariate mean, (·) data prior to 1977, (x) data after 1977 (Chapman, unpubl. data)

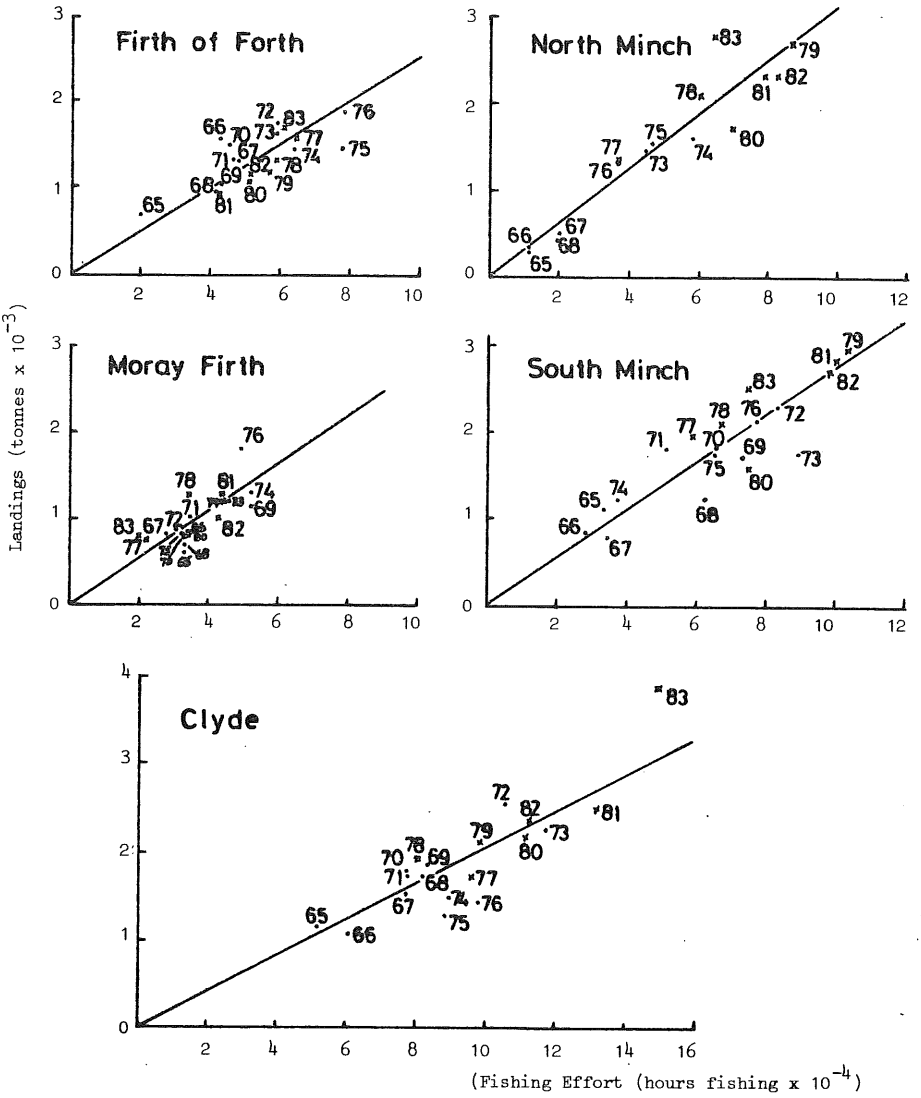

Figure 2. Nephrops-directed fishing effort and landings per unit effort in the Firth of Forth (Scottish East coast), 1965-1985 (Chapman, unpubl. data).

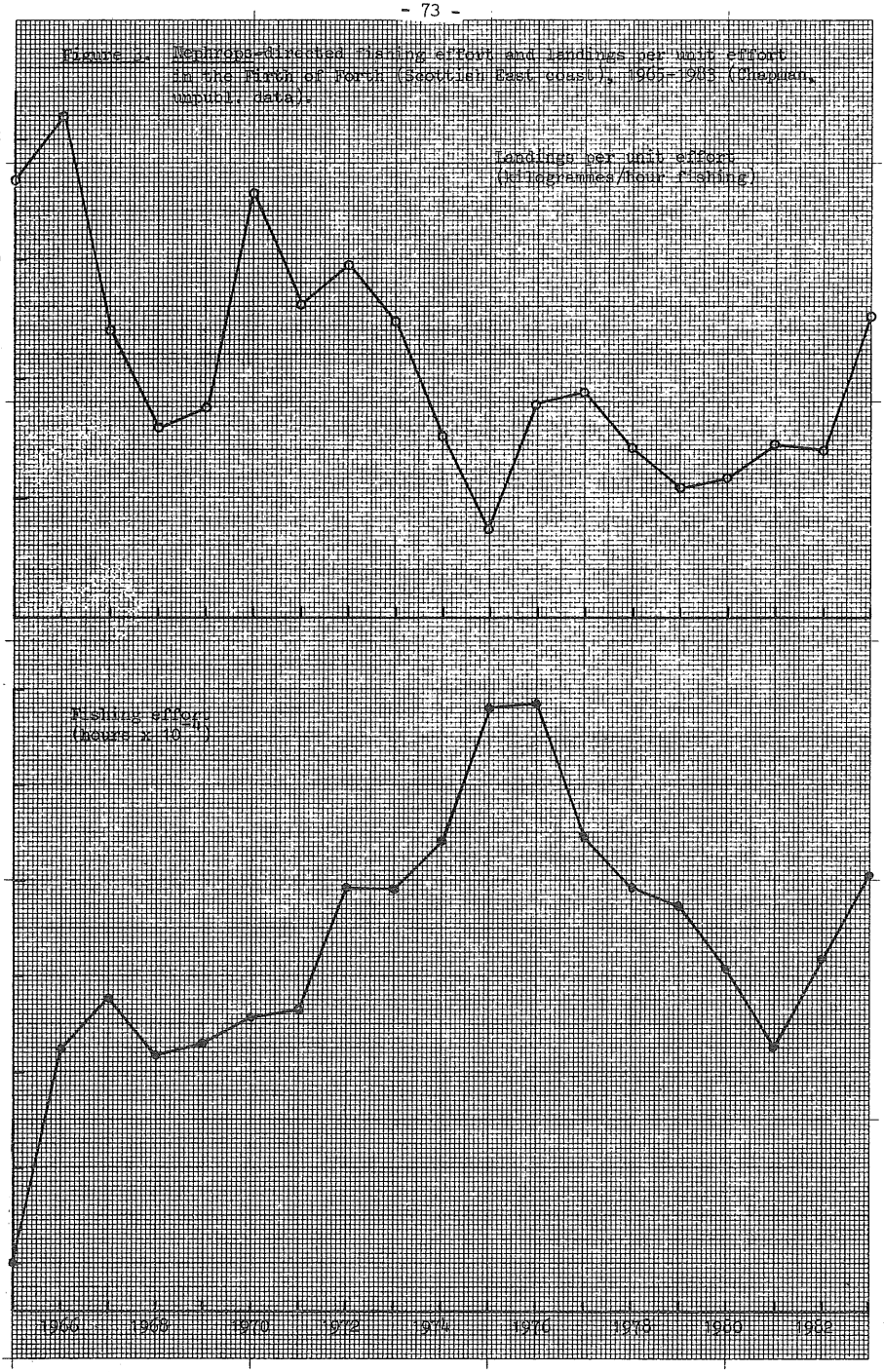

Figure 4. *Nephrops* catch per unit effort from Northern Irish vessesl landing at Whitehaven (a), UK vessels where *Nephrops* exceeds 25% of landed weight, landing at Whitehaven (b), and at Fleetwood (c), 1973-1982 (Bennett, unpubl data).

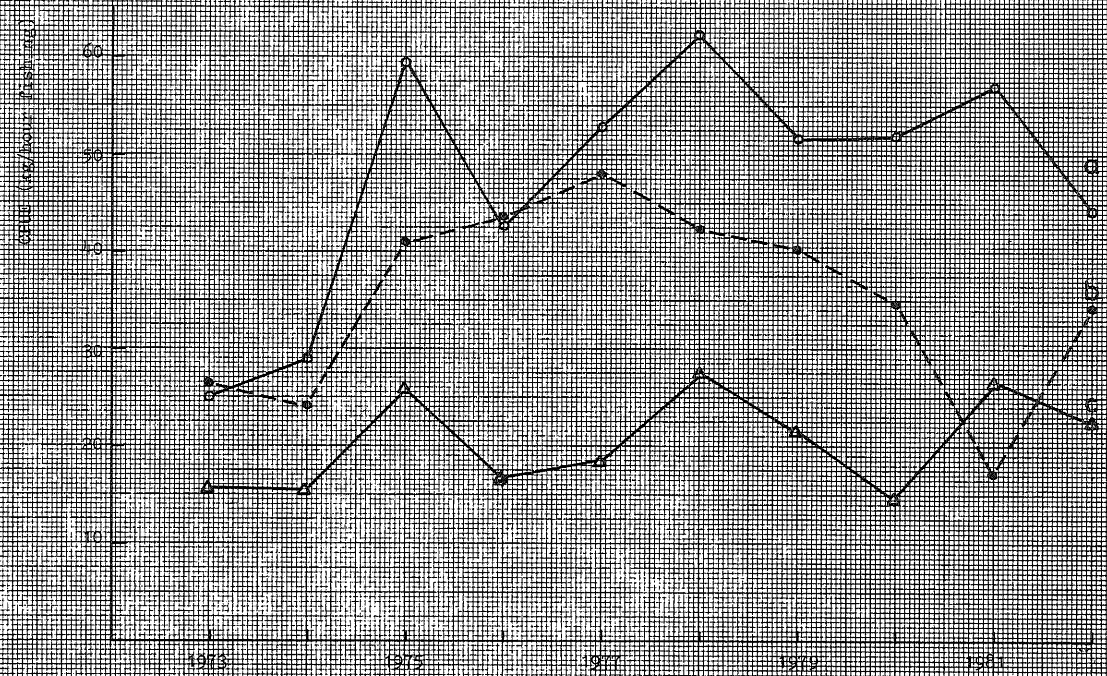

Figure 5. Regression of mean carapace length in total Northern Irish Nephrops catch against year, 1968-1983.

The fitted line y = 40.2-1.99 x (r = 0.546) is based upon 337 tows, from each of which around 200 Nephrops were measured.

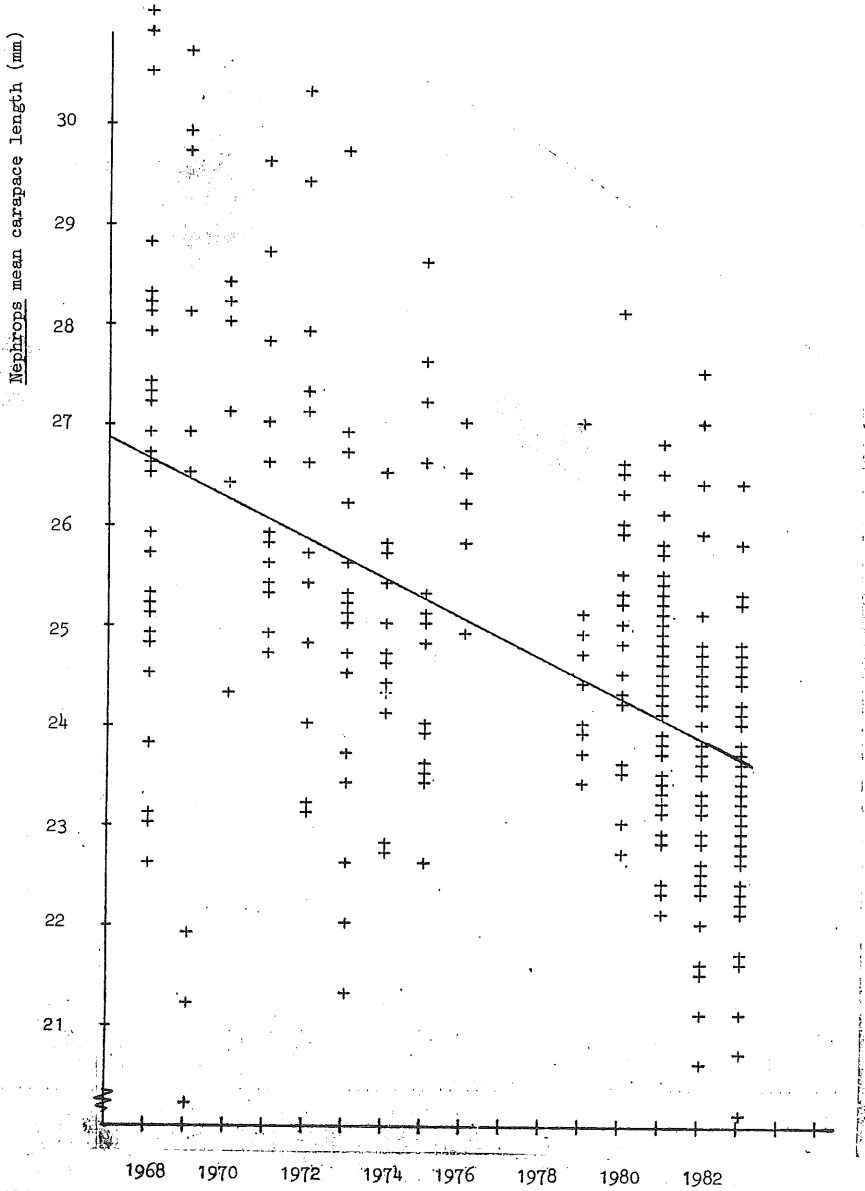

Figure 6. Catch per unit effort of Northern Irish Nephrops trawlers operating in the Western Irish Sea, 1974-1982 (Briggs, unpubl. data).

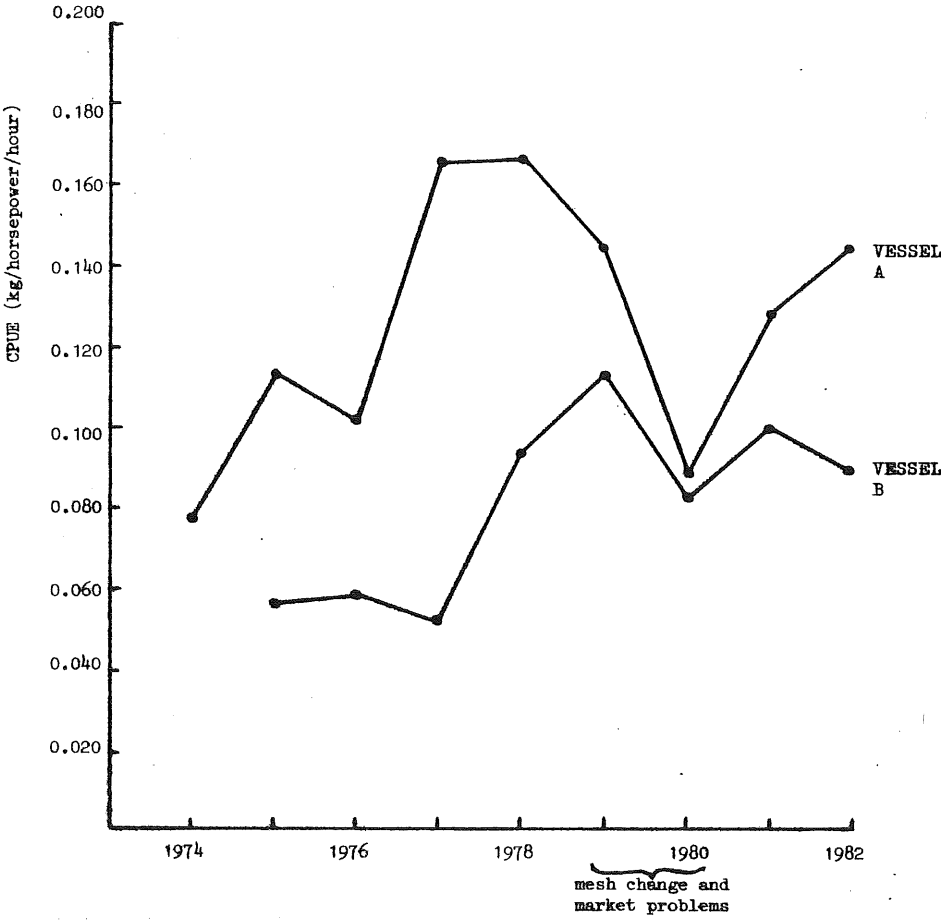

Figure 7. Seasonal variations in CPUE of the Spanish fleet fishing on the Porcupine Bank and North Galicia *Nephrops* stocks, 1976-1983 (Fernandez, unpubl. data).

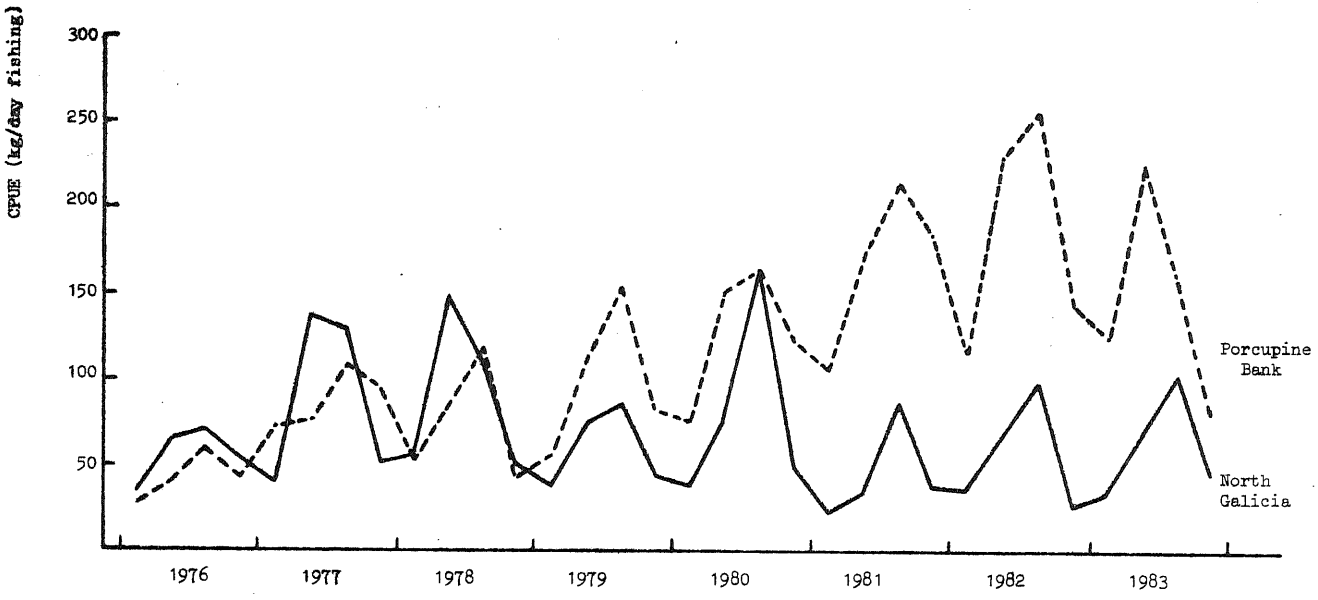

Figure 8. Length composition of Nephrops landed by Spanish vessels from the Porcupine Bank, 1977 and 1983 (Fernandez, unpubl. data).

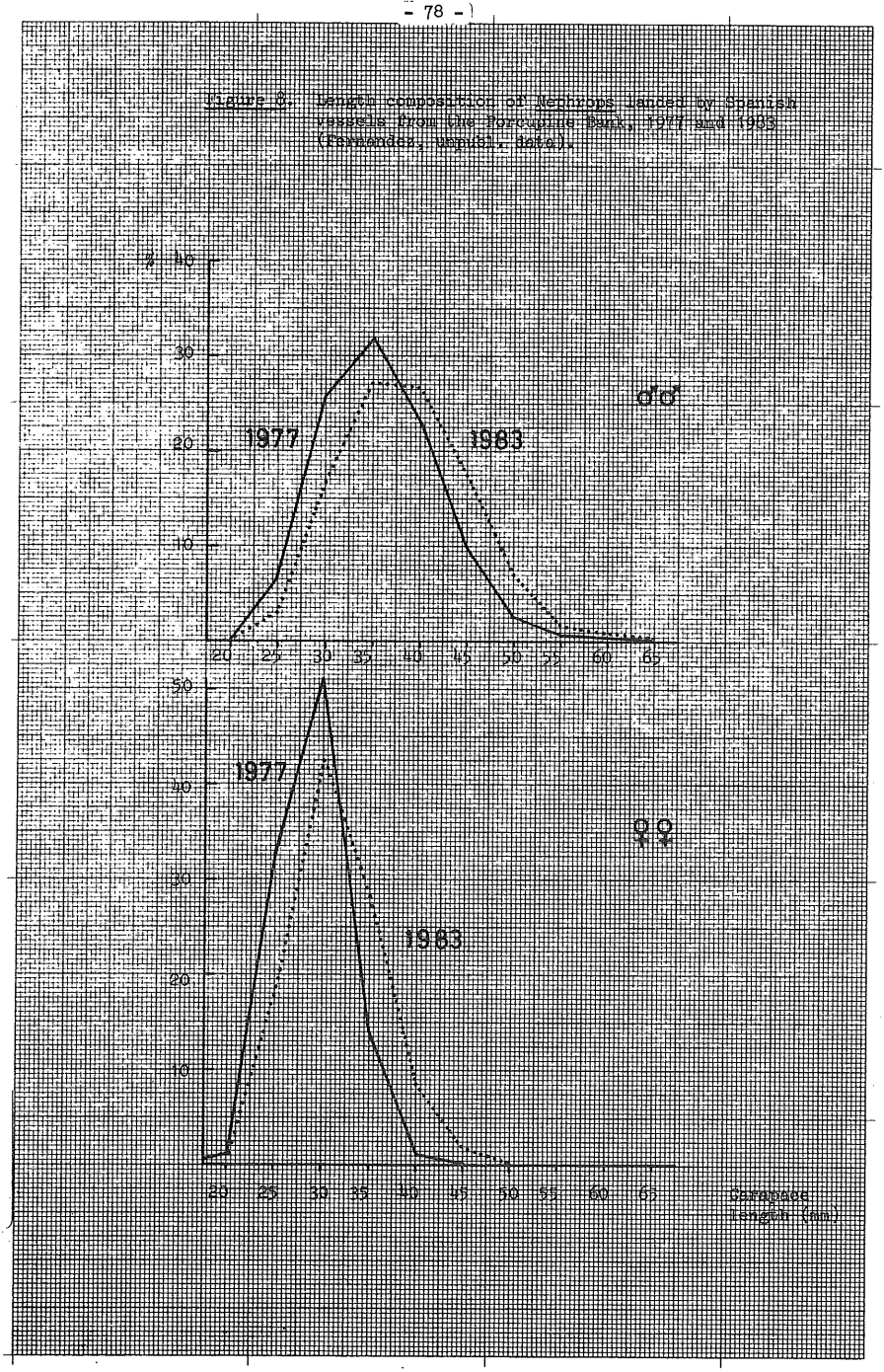

Figure 9. Length composition of Nephrops landed by Spanish vessels from the North Catalan Stock, 1979 and 1983 (Fernandez, unpubl. data).

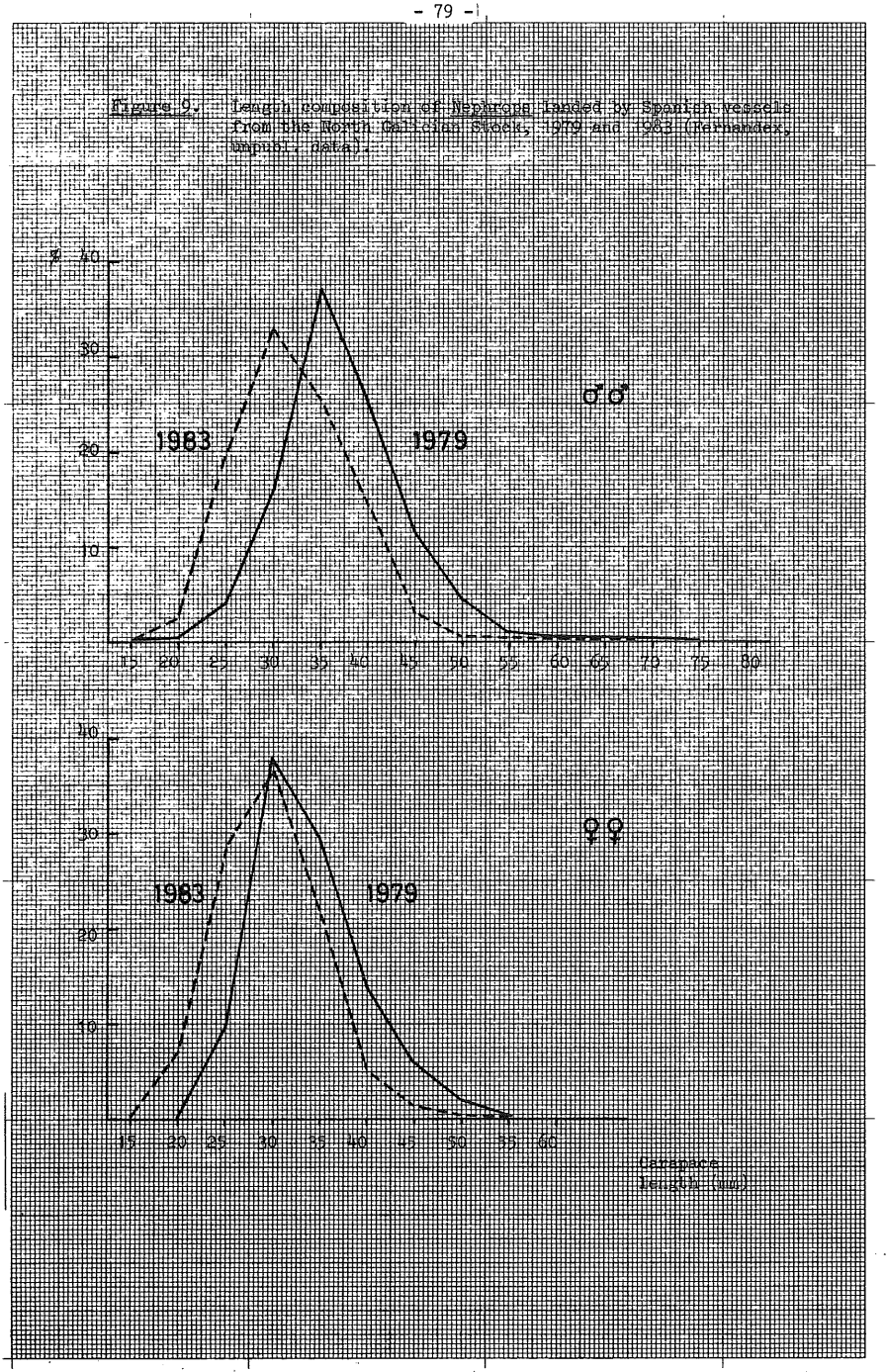

Figure 10. Length composition of Nephrops landed by Spanish vessels from the West Galician stock, 1977 and 1983 (Fernandez, unpubl. data).

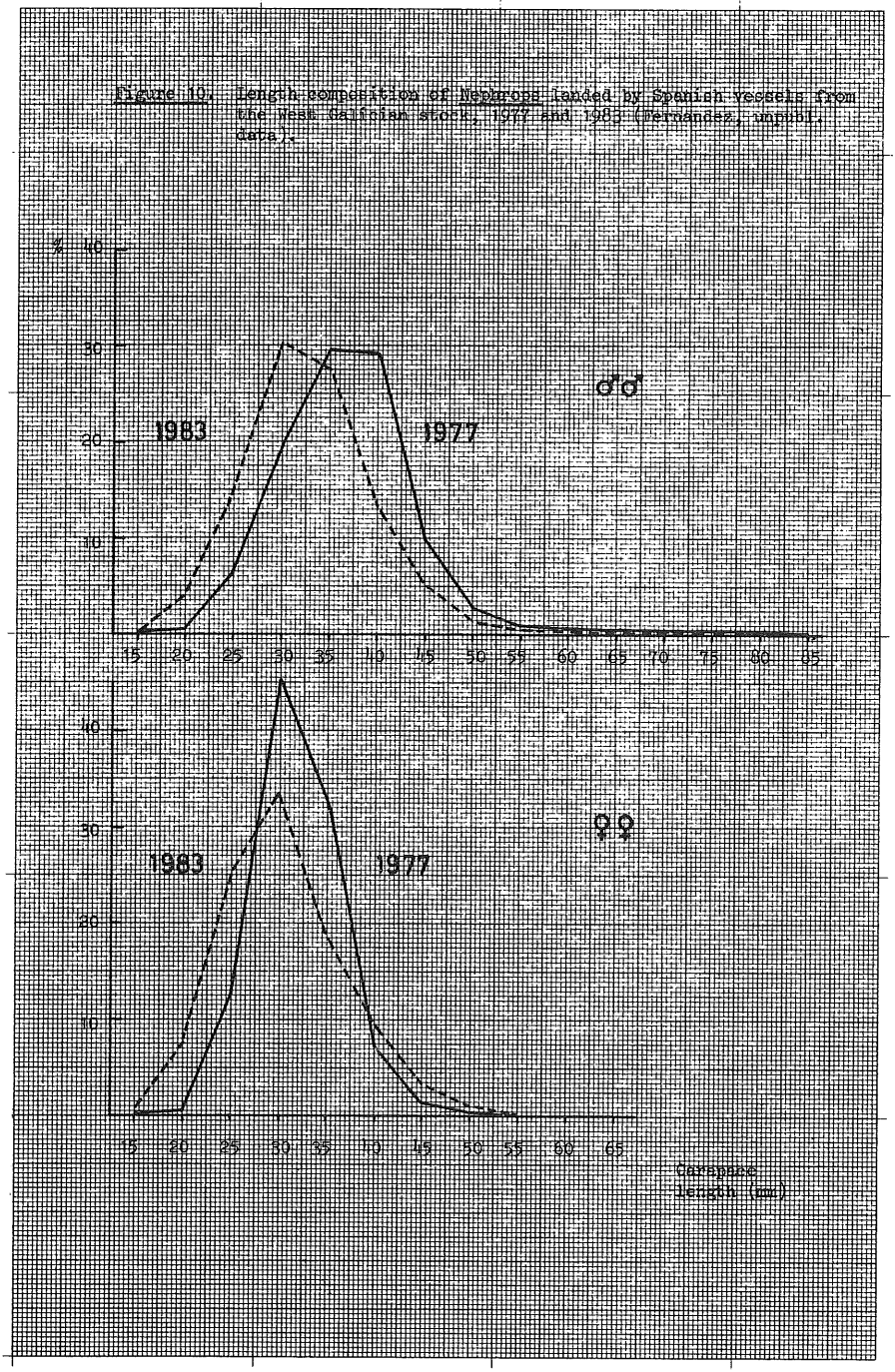

Figure 11. Sketch of a Scottish Boris 520 Dual Purpose Fish/Prawn trawl with separator panel and two codends (from Main and Sangster, 1982).

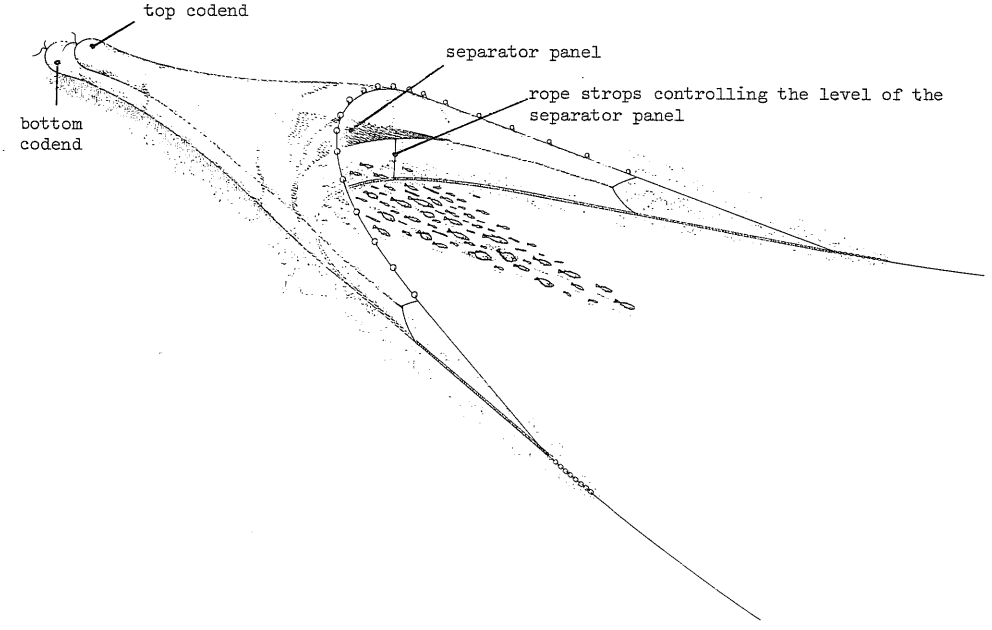

Figure 12. Nephrops management units in Regions 2 and 3.
Numbers correspond to the numbers in Section 6.1. and Table 42.