COOPERATIVE RESEARCH REPORT

No. 83

ICES CRUSTACEAN WORKING GROUPS' REPORTS 1977

https://doi.org/10.17895/ices.pub.7707

ISBN 978-87-7482-568-5

ISSN 2707-7144

International Council for the Exploration of the Sea
Charlottenlund Slot, DK-2920 Charlottenlund
Denmark

December, 1978

TABLE OF CONTENTS

Page

REPORT OF THE WORKING GROUP ON ASSESSMENT OF NEPHROPS STOCKS

Aberdeen, 28 February - 4 March 1977

List of Contents (ctd)

REPORT OF THE WORKING GROUP ON ASSESSMENT OF PANDALUS STOCKS

Conwy, N. Wales, 24-26 May 1977

REPORTS OF THE WORKING GROUP ON HOMARUS STOCKS

Nantes, 24-27 April 1975 and Bergen, 3-6 May 1977

List of Contents (ctd)

-o-o-o-

REPORT OF THE WORKING GROUP ON ASSESSMENT OF NEPHROPS STOCKS

Aberdeen, 28 February - 4 March 1977

1. PARTICIPANTS

The Nephrops Working Group met in Aberdeen from 28 February - 4 March 1977, with the following participants:

Dr O Bagge	Denmark
Mr C J Chapman	United Kingdom
M A Charuau	France
Dr E Edwards	United Kingdom
Mr H Eiríksson	Iceland
M A Fernández-García	Spain
Mr H Hallbäck	Sweden
Dr J P Hillis	Ireland
Mr R Jones (Chairman)	United Kingdom
Mr P J Warren	United Kingdom.

2. OBJECTIVES

The objectives (C.Res.1976/2:36) were:

1. To review and collate data obtained since the last meeting in 1975.
2. To offer advice on the implications to the Nephrops fishery and its by-catches of a change in the mesh size of nets.
3. Also, as a result of a request from NEAFC, the Group was asked to provide information on the distribution, biology and state of exploitation of Nephrops stocks with reference to 200-mile zones.

3. SUMMARY

3.1 Review of Data

Landings, effort and catch per unit effort data were updated to 1976. These and other data are tabulated in Tables 1-3.3.

3.2 Mesh assessments

Estimates were made of the immediate and long-term effects on the catch per recruit of changes in mesh size, using length composition and such growth and selectivity data as were available to the Group.

An increase in mesh size would lead to a short-term loss in catch. It was noted that such losses would primarily consist of smaller individuals of sizes that would normally be discarded. Table 14 shows estimates of the immediate losses in catch. These are likely to be overestimates of the immediate losses in landings.

Estimates of long-term effects were of a very approximate nature (Table 15) due to uncertainties about growth, selectivity and natural mortality. Nevertheless it was noted that in NEAFC Region 2, an increase in mesh size to the size of mesh used for NEAFC Recommendation 4 species, was not likely to decrease, and in many instances, should increase catches per recruit. Such increases should also decrease the proportion of the smaller and less valuable individuals in the catch.

For Iceland, it was thought that the mesh size used for NEAFC Recommendation 4 species would be much too large for Nephrops. An increase in mesh size from 80 to 90 mm should improve the yield per recruit if M = 0.1, but not if M = 0.2.

3.3 State of Stocks with Reference to 200-mile Fisheries Zones

Nephrops is a demersal species that lives on the sea bottom, spending most of its time in a mud burrow. The distribution is in discrete stocks with little or any migration of individuals beyond individual stock boundaries. Within the EEC zone there are discrete fisheries in Sub-areas IV, VI, VII and VIII and Division IIIa.

In Division IIIa, the grounds fished by Denmark and Sweden meet close to the border between Swedish and Danish waters (Figure 2). Evidence suggests that the Danish fishery may extend to a very small extent into Swedish waters. It seems likely that the Swedish fishery extends into Danish waters.

Outside the EEC zone there are stocks in the Norwegian zone (Divisions IVa and IIIa), at Iceland (Division Va), off the Portuguese coast (Division IXa) and off the north and southwest coasts of Spain (Divisions IXa and VIIIc). Each of these stocks is within the national waters of one of these countries and does not extend into any other national fishery zone.

Little is known about the state of exploitation of the *Nephrops* stocks. The assessments showed that for the large individuals of both sexes, in all stocks, values of F/Z were mostly in the range of 0.6 - 0.8.

4. RECOMMENDATION

The Group recommended that to improve the reliability of the assessments, further data should be collected on:

1. Length compositions of the landings and catches for the various fisheries.
2. Estimates of the growth rate for different fisheries.
3. Selectivity data, with particular reference to the escape of *Nephrops* from different parts of the net, under commercial conditions.
4. Discards, with particular reference
   a) to survival
   b) to the proportions discarded in each length group.
5. By-catches, with particular reference to length compositions and quantities caught. It was thought that this information could be of value to other Working Groups and might be incorporated in their assessments.

5. REVIEW OF FISHERIES

5.1 Denmark

The main fishing area is in Division IIIa (Figure 2) although a small part of the catch comes from Divisions IVa and b. Before 1950, the Danish yield was about 600 tons. Since 1953 landings have fluctuated between one and two thousand tons without discernible trend (Table 1.1).

Within Division IIIa, more than half of the Danish landings come from the Kattegat (Table 1.2).

The main landing ports are Gilleleje, Grenå, Anholt, Læsø, Frederikshavn, and Skagen.

The catch comes mainly from a Nephrops-directed trawl fishery, the mesh size in the cod end being 35 mm (stretched). A small part of the catch comes from the Pandalus fishery in the Skagerrak and the North Sea.

Most of the vessels are about 50 feet and less in size with engines of 75-250 hp.

5.2 Sweden

The Swedish fishery is in Division IIIa, near the Swedish coast (Figure 2). The number of boats fishing Nephrops in 1976 was about 45. The trawlers are mostly 15-20 m in size with engines between 150-250 bhp. Most Nephrops are caught during July-November in 2 main areas, one off Lysekil and the other near and to the south of Gothenburg. A very small part of the Nephrops landings comes from the Pandalus fishery.

5.3 United Kingdom

5.3.1 Scotland

Scottish vessels fish for Nephrops off the east (Divisions IVa,IVb) and west coasts (Division VIa) of Scotland and on the Fladen Ground in the North Sea (Figure 1).

The main fishery is undertaken by Nephrops trawlers of 12-20 m with engines generally of 60-250 hp. There is also a creel fishery for Nephrops on the west coast by smaller vessels. The landings have risen steadily (Table 1.1) to 11 000 tonnes in 1976. The creel fishery accounted for about 5% of the total landings. Catch per unit effort (Table 3.1) has remained fairly steady. High recent catch rates at some ports probably result from exploitation of new grounds further offshore.

5.3.2 England, Wales and N.Ireland

Landings of Nephrops come from two fishing areas, one in the North Sea (Division IVb) and the other in the Irish Sea (Division VIIa). (Figure 1.) The North Sea stock is centred around the Farn Deeps off the northeast coast and appears to be discrete. The main ports of landing are Seahouses, Amble, Blyth, North Shields and Hartlepool. Total annual landings in metric tonnes for these five ports (1970-76) are tabulated below:

1970	1971	1972	1973	1974	1975	1976
425	727	1 045	663	489	582	1 123

Daily landings at the major port of North Shields for the years 1974-76 are presented in Figures 5-7 and demonstrate the short and medium term fluctuations in availability within the fishery.

Daily catches per unit effort (kg/boat day) for North Shields, 1976, are also presented in Table 3.3.

In the Irish Sea, landings are made at Whitehaven and Fleetwood, on the English coast, and at Portavogie, Kilkeel, and Ardglass in Northern Ireland.

5.4 Ireland

The main fishery takes place in the Irish Sea (Division VIIa) chiefly at the ports of Skerries and Clogherhead, where it is mainly *Nephrops*-directed (Figure 1). There is also a smaller fishery in Divisions VIIg-k, mainly at Castletownbere, and scattered irregular landings from Divisions VIIb,c and VIa.

5.5 France

Half of the French landings come from the Bay of Biscay, whilst the other half come from the Celtic Sea and the Irish Sea. Vessels are of three classes:

- In Sub-area VIII, "artisan" trawlers (25-50 GRT, 18-20 m long, 150-300 bhp) fish exclusively for *Nephrops* all the year round.
- In Divisions VIIa,b,f,g "artisan" trawlers (50-90 GRT, 21 m long, 300-450 bhp) fish chiefly for *Nephrops*.
- In Divisions VIIb,g,h "semi-industrial" trawlers fish for white fish, but *Nephrops* is also an important part of the catch.

Recently, in spite of an increase in fishing effort in all areas, catches have tended to stabilize (average for 1974-76 was 12 000 tonnes).

5.6 Spain

In the north-east Atlantic there are two important Spanish fisheries for *Nephrops*. One is on the Continental Shelf off the northwest of Spain and the other is to the west of Ireland.

The fishery off the northwest of Spain is situated to the west of Division VIIIc and to the north of Division IXa. The fishery is operated by about 220 industrial trawlers with 380 bhp power. This fishery is primarily directed at hake. These are mainly young individuals and the principal by-catch consists of *Nephrops*, *Micromesistius poutassou*, and *Trachurus trachurus*.

Off the west of Ireland the *Nephrops* is taken as a by-catch in a fishery for hake, megrim, and angler fish. These are fished by about 280 industrial trawlers, with a mean horse power of 705 bhp.

Nephrops is also taken as the principal species in an area from 52-53°N and 12-14°W fished by a group of 25-30 trawlers with a mean horse power of 450 bhp. These take about 50% of the Spanish catch.

5.7 Iceland

The *Nephrops* fishery is a summer one (May-August) and a special *Nephrops* trawl with a minimum legal mesh size of 80 mm is used (Figure 3). Landings are shown in Tables 1.1 and 1.2. Table 2.1 gives fishing effort data, and Table 3.1 summarises landings per unit effort.

6. MESH SIZES IN USE

Details of mesh sizes in use in the various fisheries, are given in Table 7.

Cod-end mesh sizes range from 35 mm for Denmark and Norway and around 40 mm for Ireland to 80 mm for Iceland.

Mesh sizes for *Nephrops* fisheries are not regulated by international agreement, but national regulations exist for some countries.

For the United Kingdom, mesh sizes are restricted to 70 mm, except in the Irish Sea, where mesh sizes of up to 50 mm are permitted for vessels fishing for whiting.

At Iceland, there is a minimum cod-end mesh size for Nephrops vessels of 80 mm.

Spanish vessels that fish for Nephrops south of latitude 48°N use cod-end mesh sizes of about 40 mm. Vessels fishing for Nephrops off the west of Ireland use 60 mm.

For Sweden, vessels fishing for Nephrops generally have cod-end mesh sizes of 70 mm. In addition, in three specified areas inside territorial limits, trawling with a mesh size of 60-65 mm is permitted.

7. MINIMUM LANDING SIZES

For some countries, the minimum size of Nephrops that may be landed is regulated. Details for those countries that impose restrictions are given in Table 7.

For Denmark, the minimum legal landing size is 130 mm total length, or 72 mm tail length if only tails are landed. For Norway and Sweden the minimum landing size is 130 mm total length, and for the Faroe Islands, where there is a trap fishery, the minimum landing size is 150 mm total length.

In the United Kingdom there is no regulation controlling the minimum size for Nephrops landed for sale, but on the northeast coast of England a voluntary agreement exists to limit landed size to approximately 30 mm carapace length (equivalent to 100 mm total length). This agreement is implemented on the market using a count per pound of Nephrops graded at sea. Figure 8 shows the relationship between count per pound and carapace length.

In Spain, the minimum legal landing size is 120 mm measured from the posterior margin of the orbit to the end of the last segment (i.e., to the beginning of the telson). This is equivalent to 152.5 mm total length or 45.5 mm carapace length.

At Iceland there is a minimum legal landing size of 70 mm tail length, or 10 g tail weight.

8. SELECTIVITY DATA

Estimates of the selection factor range from approximately 0.3 - 0.5. A value of 0.3 can be obtained from data in Garrod (1976). Values ranging from 0.39 - 0.50 were obtained by Charuau depending on duration of haul (see below).

Duration of Haul	Selection Factor	
30 mins	0.39	covered cod-end method
60 mins	0.42	
150 mins (duration of commercial hauls)	0.50	both covered cod-end and alternate hauls

Work in the northwest Irish Sea by Cole and Simpson (1965), and Hillis (unpubl. data) showed that substantial numbers of Nephrops escape through various parts of the trawl other than the cod-end.

For Iceland, data provided by Eiríksson suggested a selection factor of 0.4.

In January 1976 a comparison of 70 mm and 50 mm Nephrops/whitefish trawls made of the same mesh size throughout was undertaken in the Farn Deeps fishery, northeast England. Six 1-hour hauls were completed, working each trawl on alternate days. The results are summarised as length/frequency distributions in Figures 9A and 9B. Using a 70 mm unimesh trawl, the mean carapace length of all Nephrops was 29.6 mm (both sexes, n = 1 621) and 58% of the catch was below the agreed minimum landing size of 30 mm carapace length. Using a 50 mm unimesh trawl, the mean carapace length was 28.8 mm (both sexes, n = 1 949) and 63% of the catch was below 30 mm carapace length.

Similar results were obtained by Pope and Thomas (1975).

A comparison of Nephrops trawls with 60 mm and 40 mm cod-ends was undertaken in September 1976 in the northern part of the Bay of Biscay. The duration of hauls was uniformly 2½ hours (15 hauls with each gear). The following results were obtained:

Numbers of Nephrops 1)	Mesh size	
	40 mm	60 mm
Undersized	4 979	1 940
Commercial size:		
Small (22-29 mm)	3 927	1 620
Big	803	478
Weight of Nephrops 2)		
Undersized	28.3	11.1
Commercial size:		
Small	43.4	18.1
Big	18.9	11.8

1) Numbers per 10 hours fishing.
2) Kg per 10 hours fishing.

The immediate losses were 52% in weight.

9. GROWTH

Growth has been investigated:

a. in the aquarium by direct observation, and

b. in the field by tagging and from observations on the rate of progression of prominent length modes.

In the Bay of Biscay, studies of the intermoult cycle by means of a microscopic examination of the setae on the pleopods (according to Drach's method) suggest two moult periods, one in spring and one in late summer. Mature females begin moulting in January, and the individuals that moult in spring are always more numerous. (Charuau, unpubl. data.)

Observations on the intermoult increments of individuals maintained in large containers in the sea are recorded in Table 9.
Irish data on Nephrops growth are presented in Table 8. Further data are published in papers by Thomas (1965), Farmer (1973), Conan (1975), Charuau (1975) and Hillis (1977).

10. BY-CATCHES (Tables 6.1 - 6.9)

In many Nephrops fisheries, there is a by-catch of other species. in other instances Nephrops is taken as a by-catch in a fishery for other species.

In Division IIIa, Danish and Swedish vessels take various gadoid and flatfish species as by-catches. For Danish vessels, sole is frequently the principal species taken in November-February. For Swedish vessels, the most important species in the by-catches are cod, whiting, pollack and plaice.

In the Irish Sea, considerable numbers of young whiting are taken by United Kingdom and Irish vessels along with Nephrops at certain times of the year. The mixed fishery by French "semi-industrial" trawlers is mainly directed at demersal species, principally whiting, cod and hake.

In the Celtic Sea, fishing for demersal species by French vessels (chiefly for hake and whiting) is important.

Off the west of Ireland, Nephrops is taken as a by-catch in the fishery by Spain for hake, megrim and angler fish (Table 6.4).

In the northern part of the Bay of Biscay, the French artisan fishery is primarily directed at Nephrops. Many young hake are caught, and a large proportion of these are rejected (40-95 percent in number). (Table 6.8.) This fishery is near the 12-mile limit in depths of 90-110 m. 59.2 percent of landings (in weight) consist of Nephrops 22-29 mm (carapace length).

The Group recognised that in certain instances (e.g., whiting in the Irish Sea and hake in the Bay of Biscay) substantial numbers of young fish were destroyed by fisheries using small mesh nets. It was agreed that further data on by-catches should be collected and made available for other Working Groups to take into account in their assessments.

11. DISCARDING

Discarding is normal practice in most Nephrops fisheries, either because of the capture of individuals too small to be of much value, or to comply with a minimum landing regulation where one exists.

Experiments by Charuau in the Bay of Biscay in June 1975 have shown that only 31 percent of undersized Nephrops exposed on the deck for 30 minutes subsequently survived for 3 days in a cage on the bottom. For individuals exposed on deck for 60 minutes, only 25% subsequently survived.

Some data on the percentages discarded at various lengths are given in Tables 12.1-12.3.

Table 5.3 shows the length compositions of the discarded and the landed components of the Irish catches. This shows the relatively large numbers discarded.

12. MESH ASSESSMENTS

Mesh assessments were made to take account of both the immediate and the long-term effects of changes in mesh size.

Fishing effort was assumed to be constant throughout.

12.1 Data Used

12.1.1 Length compositions

The length compositions used in the assessments are shown in Tables 5.5 and 5.6. Males and females were treated separately. Each of the distributions was chosen so as to be representative of the length composition of *Nephrops* in the catch before discarding had taken place.

Seasonal length compositions of the catch in the Irish Sea (Div.VIIa) are shown in Table 5.3. These show the effect of the strong, but brief influx of adult females in mid-summer.

12.1.2 Selectivity data

Since estimates of the selection factor are variable, and this could influence results significantly, the assessments were done using values of 0.3 and 0.5. A value of 0.03 was used for the slope of the selection curve at the 50% release lengths (based on data in Garrod, 1976).

12.1.3 Growth and mortality parameters

Using the limited data available on growth increments and frequencies of moult interval, estimates were made of annual growth increments.

Tables 11.1 and 11.2 summarise the annual increments estimated from the various sources of data that were available. Using these, it was possible to determine values of the Bertalanffy parameter K corresponding to any chosen value of L_∞. The formula used for doing this and the values obtained for each fishery are shown in Tables 11.1 and 11.2

Many of the values obtained for the different fisheries do not necessarily differ significantly. However, since each fishery can be treated separately and since there was no basis for preferring one set of estimates to another, it was agreed that rather than attempt to standardise the values obtained, the assessments would be done using the particular values obtained for each fishery individually.

12.1.4 Natural mortality

No estimates were available of natural mortality. For the Irish Sea, Z is believed to be about 1.0 (Anon., 1976). For Denmark and Sweden in the Kattegat, values of M = 0.05 and 0.1 were adopted for females. For other sexes and areas, assessments were done using M = 0.1 and M = 0.2.

Differences between the values reflect the uncertainty about the correct values to use.

12.1.5 Rate of exploitation (F/Z)

Preliminary analyses of the length compositions gave values of F/Z for the larger individuals of about 0.7 - 0.8 for most stocks. For the final assessments the value of F/Z for the largest individuals was taken as 0.7.

12.1.6 Weight/length relationship

Various relationships between carapace length and body weight were used. These were:

$$W = 0.00078L^{2.936}$$
$$W = 0.00045L^{3.15}$$
$$W = 0.00055L^{3.0}$$

where L = carapace length in mm,
and W = total body weight in g.

The differences between these relationships are not large enough to affect the assessments significantly.

12.2 Methods of Assessment

Immediate effects were calculated using the length composition and selectivity data. The results are shown in Table 14. The long-term effects of changes in mesh size were calculated using the method described by Jones (1977).

The values summarised below were obtained by averaging results for males and females assuming a 50:50 sex ratio.

12.3 Immediate Losses (Table 14)

For Denmark an increase from 35 to 50 mm should lead to losses of 1-6% whilst an increase to 70 mm should lead to losses of 5-24%.

For Sweden an increase in mesh size from 60 to 70 mm should give an immediate loss of 2-12%.

For Spain in Division IXa, an increase in mesh size from 40 to 60 mm should lead to immediate losses of 4-19%. In Divisions VIIc,k an increase from 60 to 80 mm should lead to losses of 7-33% (based on males only). The exact value depends on the selection factor adopted.

For NE England an increase from 70 to 80 mm should lead to an immediate loss of 8-33%.

For Ireland and Northern Ireland in Division VIIa an increase in mesh size to 70 mm should lead to losses of about 12-50%.

For Scotland in the Firth of Forth an increase in mesh size from 70 to 80 mm should lead to losses of 6-27%.

For Iceland an increase in mesh size from 80 to 90 mm should lead to losses of 3-21% (based on males only).

For France in Division VIIIa an increase from 39 to 60 mm should lead to immediate losses of 14-44%.

In each instance the range of values depends on the selection factor used. Estimates based on a selection factor of 0.5 are all larger than estimates based on a factor of 0.3.

In all fisheries, the immediate losses would consist of the smallest individuals of sizes that would in any event probably be discarded. As far as landings are concerned therefore, the immediate losses would be smaller than those shown in Table 14.

12.4 Long-term Changes

Table 15 shows estimates of the long-term effects of a change in mesh size on the catch per recruit. Estimates are given for each sex separately.

12.4.1 Effects on the catches per recruit (Table 15)

For Denmark an increase in mesh size from 35 to 70 mm should lead to long-term gains of 2-12% for one combination of values of M. (0.05 for females and 0.1 for males.) For larger values of M (0.1 for females and 0.2 for males) the long-term gains would be zero. It was noted that when a selection factor of 0.3 was adopted, the immediate loss, even for an increase in mesh size to 70 mm, was so small, that little long-term change could be expected.

For Sweden an increase in mesh size from 60 to 70 mm should, to a first approximation, have very little effect on the catch per recruit.

For Spain in Division IXa, an increase in mesh size from 40 to 60 mm should lead to long-term gains of 2-15%. In Divisions VIIc,k an increase in mesh size from 60 to 80 mm should lead to long-term gains of 2-20% (based on males only).

For the NE England fishery an increase in mesh size of 70 to 80 mm should lead to a long-term gain of 1-18%.

For Ireland, an increase in mesh size to 70 mm should lead to long-term gains of 4-55%.

For Northern Ireland, an increase in mesh size to 70 mm should lead to long-term gains of 0-51%.

For Iceland, an increase in mesh size to 90 mm should lead to long-term gains of 0-9% (based on males only).

For France, an increase in mesh size of 39 to 60 mm should lead to long-term gains of 5-35%.

For Scotland, increases in mesh size of up to 20 mm should lead to a long-term increase in the yield per recruit provided M is no greater than 0.2 (Jones, 1977).

12.4.2 Effect on the size composition of the catch

In general, the net effect of an increase in mesh size should be to reduce the proportion of the smaller, and less valuable individuals, and to increase the proportion of larger and more valuable individuals.

12.5 Limitations of the Assessments

The Group recognised that the mesh assessments made in this report are necessarily provisional due to unavoidable limitations in the data or lack of essential information.

For some fisheries the length composition was based on only one year's data and for this reason might have been influenced by the presence of either particularly strong or particularly weak year classes.

Estimates of growth rate were regarded as provisional, and for some stocks had to be based on data collected in other areas.

Selectivity experiments have led to rather variable estimates of the selection factor. Also there is some uncertainty about the escapement of *Nephrops* from parts of the net other than the cod-end.

No data were available for estimating M, and values had to be assumed.

It was also noted that the long-term effects related to catches per recruit rather than actual catches.

12.6 Conclusions

It was noted that the assessments were of a very approximate nature. Nevertheless the Group noted that:

1. Except for Iceland, an increase in mesh size to the size of mesh used for NEAFC Recommendation 4 species should not significantly decrease, and in many instances should increase the catch per recruit. In the case of Iceland, it was thought that the mesh size used for NEAFC Recommendation 4 species would be much too large for Nephrops. An increase in mesh size from 80 to 90 mm should improve the yield per recruit if M = 0.1 but not if M = 0.2.
2. Because of the discarding of many of the smallest individuals caught, an increase in mesh size should benefit landings more than catches.

It was concluded therefore that the minimum mesh sizes applicable to NEAFC Recommendation 4 species should be applied to Nephrops in NEAFC Region 2.

13. DISTRIBUTION AND STATE OF EXPLOITATION WITH REFERENCE TO 200-MILE FISHERY ZONES

13.1 Distribution of Stocks

The distribution of the main fisheries is shown in Figures 1-3.

Nephrops is a demersal species that spends most of its time in a mud burrow. The stocks are of limited extent, and except for the stocks exploited by Denmark and Sweden in Kattegat, are widely separated from one another.

According to the available information on the distribution of the Danish fishery in the Kattegat in 1975, about 160 tons of Nephrops was caught on the Swedish side of the midwater line. It must be stressed, however, that the sampling was not specially designed to give information on the distribution of the fishery as only one harbour was covered in the southern part of the Kattegat and the catches are referred to quarter-rectangles. The dividing line crosses several of these.

With the possible exception of the stocks exploited by Denmark and Sweden in the Kattegat, none of these stocks extends from any exclusive fishery zone into any other exclusive fishery zone.

13.2 State of Exploitation

Little is known about the state of exploitation of the Nephrops stocks. The assessments showed that for the large individuals of both sexes in all stocks, values of F/Z were mostly in the range of 0.6 - 0.8.

14. SPAWNING TIMES AND AREAS

The spawning season varies broadly with temperature, getting later as mean annual sea temperature falls. After hatching, Nephrops larvae are pelagic for about 3-6 weeks. During this period, larval drift appears to be negligible, and the larvae remain in the vicinity of the areas in which they are spawned.

Divisions IVa,b,c and VIa

Spawning generally occurs in late summer, the eggs being carried by the female until they hatch in the following spring. Spawning takes place on the fishing grounds, there being no specific spawning areas.

Sub-area VII

Spawning is in August-September in Division VIIa, but probably slightly earlier in Divisions VIIg-k and VIIb,c. Spawning takes place in depths of 20-100 m off the Isle of Man. In Divisions VIIg-k and VIIb,c it is presumed to be fairly close to the Irish coast. Distribution of planktonic larvae during April-June in Division VIIa off the Irish coast has been described by Hillis (1974).

Sub-area VIII

Spawning in the Bay of Biscay occurs in June-July.

Division IIIa

Spawning in Division IIIa is from August to October. Spawning takes place in the eastern part of the Kattegat, northwards from the northern entrance of the Sound in depths of 30-80 m. There is also spawning east and southeast of Skagen and Frederikshavn in depths of 40-70 m, and off the Danish Skagerrak coast in depths of 50 to 150 m.

Division Va (Iceland)

There is a two-year breeding cycle (Eiríksson, 1970) with a peak of spawning in May-June and a peak of hatching in May-July. Spawning and hatching areas are thought to be essentially the same as the area of distribution.

15. SEX RATIO AND BREEDING CYCLE

Berried female Nephrops largely disappear from the catch and consequently the sex ratio varies seasonally according to the phase of the breeding cycle in different areas. Table 13 shows the seasonal variations in sex ratio (expressed as females per 100 males) and proportion of ovigerous females in the catches from several areas. The time of peak spawning and hatching tends to occur later in the year in more northerly grounds and this is reflected in the sex ratio. Overall sex ratios may be influenced by the size of mesh used, a large mesh depressing the proportion of females.

Nephrops spawn annually in some areas (Portugal, Irish Sea, Scotland). In other areas the occurrence of non-berried females in catches during the main spawning period indicates a longer breeding cycle (for example 2 years in Iceland waters).

REFERENCES

Anon., 1976. Report of the Working Group on Nephrops stocks. Charlottenlund, 21-23 Jan.1975. ICES Coop.Res.Rep., No.55, pp.42.

Charuau, A. 1975. Croissance de la langoustine sur les fonds du Sud-Bretagne. ICES, Doc. C.M.1975/K:11 (miméo.).

Cole, H.A. and Simpson, A.C. 1965. Selection of trawl nets in the Nephrops fishery. Rapp.p.-v. Cons.int.Explor.Mer, 156:203-205.

Conan, G. 1975. Périodicité des mues, croissance et cycle biologique de Nephrops norvegicus (L.) dans le Golfe de Gascogne. C.R.Acad.Sci., Paris 6 281 (3-XI-75), Série D-1349.

Eiríksson, H. 1970. On the breeding cycle and fecundity of the Norway lobster at southwest Iceland. ICES, Doc. C.M.1970/K:6, pp.4 (mimeo.).

Farmer, A.S. 1973. Age and growth in Nephrops norvegicus (Decapoda: Nephropsidae). Mar.Biol., 23:315-325.

Farmer, A.S. 1974. Relative growth in Nephrops norvegicus (L.) (Decapoda: Nephropsidae). J.nat.Hist., 8:605-620.

Fernández, Garcia A. 1976. Data on the Norway lobster populations of Galicia (North-West Spain). ICES, Doc. C.M.1976/K:29 (mimeo.).

Fernández, Garcia C. et al. 1976. a) Primer estudio de la pesqueria demersal de grand sole y oeste de Irlanda para la flota española. Bol.Inst.Ocean, No.213.

Figueiredo, M.J. and Barraca, I.F. 1963. Contribuição para o conhecimento da pesca e da biologia do lagostim (Nephrops norvegicus (L.)) na costa portuguesa. Notas e Estudos, Inst.Biol.Marit.Lisb., No.28:1-44.

Garrod, D.J. 1976. Mesh selection of Nephrops.Fisheries Research Technical Rep., No.26, pp.9.

Hillis, J.P. 1977. Growth studies in the prawn, Nephrops norvegicus. Spec.Meeting on Population Assessment of Shellfish Stocks, 29.9-1.10 1976. Doc. No.59. (To be published in ICES Rapp.p.-v.Réun. Cons. int.Explor.Mer, Vol.175.)

Hillis, J.P. 1974. Field observations on larvae of the Dublin Bay prawn Nephrops norvegicus (L.) in the western Irish Sea. Irish.Fish. Invest. Ser.B., No.13.

Jensen, Aa. J.C. 1965. Nephrops in the Skagerrak and Kattegat (length, growth, tagging experiments and changes in stock and fishery yield). Rapp.p.-v.Réun.Cons.perm.Int.Explor.Mer, 156:150-154.

Jones, R. 1977. A preliminary assessment of the Firth of Forth stock of Nephrops. Spec.Meeting on Population Assessment of Shellfish Stocks. Doc. No.24. (To be published in Rapp.p.-v. Réun.Cons.int.Explor. Mer, Vol.175.)

Pope, J.A. and Thomas, H.J. 1975. A comparison of the catch of Nephrops by trawls of 50 mm and 70 mm mesh size. ICES, Doc.C.M.1975/K:8 (mimeo.).

Storrow, B. 1912. The prawn (Norway lobster, Nephrops norvegicus) and the prawn fishery of North Shields. Dove Mar.Lab., N.S., 1:10-31.

Storrow, B. 1913. The prawn (Norway lobster, Nephrops norvegicus) and the prawn fishery of North Shields. Dove Mar.Lab., N.S., 2:9-12.

Symonds, D.J. 1972. The fishery for Norway lobster, Nephrops norvegicus (L.), off the north-east coast of England. Fish.Invest.Lond., Ser.2, 27(3):1-35.

Thomas, H.J. 1965. The growth of Norway lobsters in aquaria. Rapp.p.-v. Réun. Cons.perm-Int.Explor.Mer, 156:209-216.

Watson, P.S. 1973. The Northern Ireland fishery for the Norway lobster, Nephrops norvegicus (L.) 1962-1972. Dept.Agr. N.Ireland, Fish.Res. Leaflet, No.6, 17 pp.

Watson, P.S. 1975. Studies on Nephrops norvegicus (L.) and the fishery off Northern Ireland (unpubl. typescript).

ANNEX I

CONVERSION FROM CARAPACE LENGTH TO TOTAL LENGTH

In biological investigations involving *Nephrops*, carapace length is usually employed as the measure of individual size. For other purposes, i.e., the enforcement of minimum landing sizes (where they apply) *Nephrops* sizes are quoted as total length. In order to provide a conversion between these two measures of length the following table has been constructed from Symonds' biometric relationships in "The fishery for the Norway lobster, *Nephrops norvegicus* (L.) off the northeast coast of England".

Symonds' equations for calculating total length (L) from carapace length (C) for both sexes are respectively:-

Males $L = 3.02C + 10.70$

Females $L = 3.10C + 8.35$

Carapace length (mm)	Total length (mm) Males	Total length (mm) Females
10	41	39
15	56	55
20	71	70
25	86	86
30	101	101
35	116	117
40	132	132
45	147	148
50	162	163
55	177	179
60	192	194
65	207	210

ANNEX 2

NOTES ON THE PREPARATION OF LENGTH COMPOSITIONS FOR THE NORTHERN IRELAND DATA (1971-74)

1. **Analysis of Sex, Length Compositions**

Length compositions were available for Irish Sea catches by N.Ireland trawlers in two papers by Watson (1973; 1975; see p.13) (Table 1).

Table 1

Year	Months											
	J	F	M	A	M	J	J	A	S	O	N	D
1971	✓		✓						✓		✓	
1972	✓			✓			✓		✓	✓	✓	
1973	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓
1974		✓	✓			✓						✓
No. of compositions	5		5		3		3		3		5	

Combined in 2 month periods gave 3-5 length compositions per period. The percentage of males and females in each 5 mm length group were tabulated for each sample and then averaged over each 2 month period. These data are shown in Table 2 below.

Table 2. Average percentage of *Nephrops* by sex and length group in 2 month periods (1971-74).

No. of samples	J/F 5		M/A 5		M/J 3		J/A 3		S/O 3		N/D 5	
Length	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
15-19	5.4	6.7	3.5	8.0	2.3	3.5	2.8	4.7	2.5	4.6	7.6	5.8
20-24	18.4	20.7	19.6	18.3	14.9	24.2	11.7	20.1	21.7	23.0	20.0	17.8
25-29	25.3	7.3	21.0	6.3	16.2	21.2	13.6	26.4	23.2	7.3	31.3	4.9
30-34	9.4	0.3	11.8	0.7	7.6	5.4	5.7	11.0	10.6	1.8	11.6	0.7
35-39	3.5	0.1	6.5	0.3	2.8	0.5	1.4	1.4	3.6	0.3	3.9	0.04
40-44	1.7	0	2.9	0	1.1	0	0.8	0.1	0.8	0	1.0	0
45-49	0.8	0	0.9	0	0.3	0	0.1	0	0.4	0	0.06	0
50-54	0.06	0	0.1	0	0.07	0	0	0	0.1	0	0.07	0

These figures were used in the computation.

The average weight of *Nephrops* in each 5 mm group was estimated from carapace length to total weight data for the Irish Sea population given by Farmer (1974) (Table 3).

Table 3

Length (mm) range	15/19	20/24	25/29	30/34	35/39	40/44	45/49	50/54
Average wt (kg)	0.0029	0.0068	0.0134	0.0236	0.0382	0.0582	0.0846	0.1184

The product of average weight and the numbers given in Table 2 gave the relative weights of males and females for each 2 month period (Table 4).

Table 4

Relative weight of males and females in each 2 month period

	J/F	M/A	M/J	J/A	S/O	N/D
Males	1010	1209	710	513	946	1073
Females	270	261	606	824	322	222
Total	1280	1470	1316	1337	1268	1295
% males	79	82	54	38	75	83

These data were used to estimate the total catch weight of males and females for each 2 month period.

2. Analysis of Landings

The annual landings from the Irish Sea by N Ireland *Nephrops* trawlers between 1971-74 are given in Table 5.

Table 5

Year	Landings (t)
1971	2 190
1972	2 998
1973	2 733
1974	2 490
Average	2 603

Seasonal variation in landings was assumed to follow the trend given by Watson (1973, Figure 3) for the years 1968-72 (Table 6).

Table 6

Month	Landings (tonnes)	Bi-monthly landing (tonnes)	%
J F	127.5 131.3	259	12
M A	135.0 225.0	360	16.7
M J	217.5 232.5	450	20.9
J A	210.0 337.5	548	25.4
S O	198.8 127.5	326	15.1
N D	138.8 75.0	214	9.9
Total	2 157	2 157	

The % landings in each 2 month period were applied to the average annual landings in 1971-74 (2 603 tonnes). The average landings were converted to bi-monthly catches using discard data by length from Hillis (pers. comm.) converted to weight using the average weights given in Table 3. This gave the proportion of the catch by weight discarded at sea for each 2 month period (Table 7). Each bi-monthly catch was divided between the sexes using the data of Table 4.

Table 7

	J/F	M/A	M/J	J/A	O/S	N/D	Total
Average landings 1971-74 (tonnes)	312	435	544	661	393	258	2 603
% discarded (by weight)	34	28	34	31	35	35	
Average male + female catch 1971-74(tonnes)	473	604	824	958	605	397	3 861
Average catch ♂	374	495	445	364	454	330	2 462
Average catch ♀	99	109	379	594	151	67	1 399

-o-o-o-

Table 1.1. Annual landings of *Nephrops* in the ICES Area 1954-1975 (metric tons, whole body weight).

Country	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974*)	1975*)
Belgium	456	441	374	649	831	970	788	895	668	766	789	536	705	477	456	468	479	378	299	392	444	451
Denmark	521	1 014	1 470	1 638	1 678	1 530	2 236	1 452	1 666	1 752	2 243	1 744	1 152	1 495	1 737	1 176	1 244	1 233	2 096	1 339	1 734	2 613
Faroe Islands	3	2	2	51	91	96	73	35	39	78	54	49	43	36	23	23	-	38	31	43	31	44
France	4 928	5 136	5 574	7 440	6 604	7 213	8 188	8 410	8 244	8 706	9 644	7 783	7 325	7 703	8 310	11 227	10 022	9 025	9 581	12 098	12 549	12 828
Germany, Fed.Rep.	57	75	75	58	94	97	117	110	91	109	145	57	26	65	65	29	6	3	2	3	1	12
Iceland	-	-	-	-	728	1 404	2 081	1 490	2 662	5 550	3 487	3 706	3 465	2 731	2 489	3 512	4 026	4 657	4 321	2 791	1 983	2 357
Ireland	52	209	206	340	599	736	397	715	840	1 491	1 016	801	1 251	878	1 493	1 372	2 019	1 775	1 823	2 150	1 380	1 055
Netherlands	+	+	+	+	+	+	20	11	4	11	-	-	-	-	-	-	-	-	-	-	29	29
Norway	19	121	72	189	88	66	69	58	50	15	102	161	36	15	84	74	18	52	29	37	38	28
Portugal	74	112	53	29	64	97	85	77	68	71	170	214	205	321	246	261	210	120	72	72	38	34
Spain	1 667	1 963	1 716	1 742	1 701	1 749	1 697	2 192	1 626	1 710	2 468	3 065	3 576	4 109	4 047	4 237	3 234	3 231	3 759	4 530[1]	4 022	5 331
Sweden	584	651	722	834	679	654	716	691	511	560	782	550	436	554	613	431	335	373	468	452	575	395
England/Wales	252	279	220	277	395	326	431	770	325	297	356	396	1 064	768	983	859	612	1 044	948	814	669	1 157
N. Ireland[2]	125	298	400	450	634	563	371	695	562	997	962	698	1 045	1 522	1 436	1 997	2 107	2 190	2 998	2 732	1 887	2 579
Scotland	575	1 084	1 058	1 374	1 144	2 163	1 969	2 920	3 482	3 708	4 940	5 244	6 344	6 687	7 203	8 189	8 179	9 029	10 780	9 780	8 319	8 223
All countries	9 313	11 385	11 942	15 071	15 330	17 664	19 238	20 521	20 838	25 821	27 158	25 004	26 673	27 361	29 185	33 855	32 491	33 148	37 207	37 233		

*) Provisional. 1) Spanish data from 1973-1976 revised. 2) The N. Ireland landings have been multiplied by 3/4 because incorrect conversion factor from tail - to total weight was used by all years before 1976.

Table 1.2. Annual catch of Nephrops (in metric tons) by country and by fishing areas 1960-1976.

Year	Va Belgium	Va Iceland	Va Others	Va Total	Vb1 Faroe Isl.	IIa Total	IIIa Denmark (Skagerak)	IIIa Denmark (Kattegat)	IIIa Germany, FR	IIIa Norway	IIIa Sweden	IIIa Total	IIIb,c Total
1960	451	2 081	+	2 532	73	-	1 095	1 133	115	68	716	3 127	1
1961	322	1 490	+	1 812	35	-	828	618	110	57	691	2 304	-
1962	154	2 662	-	2 816	39	-	783	678	88	-	511	2 260	1
1963	510	5 550	2	6 062	79e)	-	605	1 141	109	12	560	2 427	1
1964	586	3 487	-	4 073	54	-	812	1 416	138	102	782	3 250	1
1965	409	3 706	-	4 115	49	-	736	996	57	142	550	2 481	+
1966	546	3 465	-	4 011	43	-	316	824	22	17	436	1 615	+
1967	208	2 731	-	2 939	36	1f)	509	949	60	15	554	2 087	1
1968	157	2 489	-	2 646	23	-	873	838	-	83	613	2 407	-
1969	188	3 512	1	3 701	23	-	590	561	23	74	431	1 679	5h)
1970	119	4 026	-	4 145	-	-	321	910	6	18	335	1 590	-
1971	155	4 657	-	4 812	38	30i)	333	881	2	18	373	1 607	-
1972	82	4 321	178j)	4 581	31	-	675	1 410	1	24	468	2 578	-
1973	5	2 791	-	2 796	43	-	272	1 064	2	28	452	1 818	-
1974p)	6	1 983			31		573	1 156	1	35			
1975p)		2 357			44		846	1 756	9	26			
1976p)		2 781					576	1 062					

Year	IVa Belgium	IVa Denmark	IVa France a)	IVa Germany, FR	IVa Norway b)	IVa Scotland	IVa Total	IVb Belgium	IVb Denmark c)	IVb Germany, FR	IVb Netherlands	IVb England/Wales	IVb Scotland	IVb Total	IVc Belgium	IVc Others	IVc Total	VIa France	VIa Ireland	VIa Scotland	VIa Others	VIa Total
1960	5	..	-	2	1	539	567d)	121	7	..	..	270	498	896	32	..	32	178	2	931	1	1 112
1961	8	..	89	-	1	765	863	372	6	-	11	582	590	1 561	75	1	76	147	11	1 554	-	1 712
1962	2	..	24	3	-	899	928	390	5	-	4	175	632	1 206	62	..	62	149	1	1 950	2	2 102
1963	8	..	24	+	3	932	967	151	5	+	7	198	685	1 046	39	4	43	105	-	2 087	3	2 195
1964	21	..	12	1	+	1 387	1 421	107	14	4	-	234	907	1 266	17	-	17	367	32	2 645	3	3 047
1965	2	..	2	-	19	1 029	1 052	86	13	-	-	293	1 052	1 444	10	-	10	367	1	3 147	-	3 515
1966	4	..	9	-	19	1 432	1 464	112	12	4	-	828	1 964	2 920	22	1	23	-	5	2 945	-	2 950
1967	1	..	5	-	+	1 386	1 392	242	36	5	-	699	1 451	2 433	23	..	23	315	2	3 849	+	4 166
1968	2	..	-	+	1	1 496	1 499	249	26	65	-	894	1 135	2 374g)	46	..	46	315	11	4 571	-	4 897
1969	+	..	-	1	-	1 575	1 576	230	25	-	-	688	1 113	2 056	45	-	45	224	6	5 494	-	5 724
1970	3	..	-	-	-	1 092	1 095	330	12	-	-	419	1 654	2 415	19	-	19	-	-	5 431	-	5 431
1971	2	..	-	-	4	1 638	1 644	215	19	1	-	702	1 412	2 349	5	-	5	200	-	5 972	+	6 172
1972	1	..	-	-	5	1 304	1 310	213	11	1	-	827	1 904	2 956	3	-	3	108	-	7 556	-	7 664
1973	+	..	-	-	9	1 566	1 575	358	3	1	-	446	1 754	2 562	29	-	29	-	2	6 422	-	6 424
1974p)		4			3	1 557		404	-		28	489	1 595		31	5		-	1	5 140		
1975p)		3			2	985		424	5	3	23	583	1 552		26			215	21	5 662		
1976p)		5				2 083							2 187					26	12	6 676		

a)France 1960-66 IVa includes IVb,c. b)Norway IVa includes IVb,c. c)Denmark IVb includes IVa. d)1960 total includes Netherlands 20 tons. e)Faroes 78, Scotland 1.
f)France. g)1968 total includes France 5 tons. h)Denmark +, Germany, FR 5. i)Norway 30. j)France 178.

Year	VIIa Belgium k)	VIIa France k)	VIIa Ireland	VIIa England/Wales	VIIa N. Ireland q)	VIIa Scotland	VIIa Total k)	VIIb,c France	VIIb,c Spain	VIIb,c Ireland	VIIb,c Total	VIId,e France	VIId,e Others	VIId,e Total
1960	178	133	392	-	371	1	1 075	191	-	3	218l)	-	3	3
1961	11	139	688	179	695	11	1 723	151	-	3	154	2	9	11
1962	3	140	649	67	562	1	1 422	171	-	2	173	4	-	4
1963	1	449	1 059	24	997	1	2 531	588	-	2	590	-	3	3
1964	29	652	539	34	962	1	2 217	493	-	80	573	-	2	2
1965	8	489	557	35	698	16	1 803	514	-	80	594	24	1	25
1966	1	...n)	886	193	1 045	3	2 128	...n)	-	87	87	-	-	-
1967	2	1 122	731	49	1 522	1	3 427	441	-	49	490	-	-	-
1968	+	981	906	72	1 436	1	3 396	441	-	17	458	5	-	5
1969	3	762	941	161	1 997	6	3 870	609	-	3	612	26	+	26
1970	7	547	1 258	192	2 107	2	4 113	256	750	18	1 024	64	+	64
1971	1	305	1 415	342	2 190	7	4 260	500	722	1	1 223	20	-	20
1972	-	7	1 626	121	2 998	16	4 768	-	869	46	915	55	-	55
1973	-	-	1 862	368	2 732	38	5 000	811	1 576	35	2 422	297	+	297
1974p)	-	-	982	180	1 887	27		900	947	67	1 914	300		
1975p)		771	907	574	2 579	24		477	1 131	9	1 617	2		
1976p)		375	1 812					638	639	30	1 361	3		

Year	VIIf Belgium k)	VIIf France k)	VIIf Others	VIIf Total	VIIg-k Belgium	VIIg-k France	VIIg-k Ireland	VIIg-k Spain	VIIg-k England/Wales	VIIg-k Total	VIII France	VIII Spain	VIII Total	IX Portugal	IX Spain	IX Total	X Portugal	Unknown Total m)	Total All Areas
1960	...	...	-	...	-	4 085	-	-	134	4 219	3 524	577	4 101	84	1 120	1 204	1	77	19 238
1961	...	...	-	...	106	4 258	13	-	-	4 377	3 607	744	4 351	73	1 448	1 521	4	17	20 521
1962	8	...	1	9	47	4 708	188	-	82	5 025	3 042	768	3 810	62	858	920	6	56	20 839
1963	14	...	-	14	37	3 500	430	-	75	4 042	4 040	1 053	5 093	67	657	724	4	-	25 821
1964	4	...	-	4	22	3 522	365	-	88	3 997	4 596	1 278	5 874	166	1 190	1 356	4	2	27 158
1965	+	...	6	6	20	2 946	163	-	62	3 191	3 441	1 721	5 162	210	1 344	1 554	4	-	25 005
1966	1	...n)	-	1	19	3 549n)	273	-	42	3 793	3 857	2 038	5 895	201	1 538	1 739	4	-	26 673
1967	-	84	-	84	1	2 488	96	-	20	2 605	3 245	2 574	5 819	317	1 535	1 852	4	2	27 361
1968	-	55	-	55	2	2 649	559	-	17	3 227	3 859	2 814	6 673	242	1 233	1 475	4	-	29 185
1969	+	10	-	10	2	4 786	422	-	10	5 220	4 810	2 734	7 544	257	1 503	1 760	4	-	33 855
1970	+	2	-	2	1	3 699	743	750	1	5 194	5 454	15	5 469	207	1 733	1 940	3	-	32 504
1971	-	10	-	10	-	4 000	359	722	-	5 081	3 990	50	4 040	120	1 781	1 901	..o)	-	33 192
1972	+	190	-	190	-	3 518	151	869	-	4 538	5 525	51	5 576	72	1 962	2 034	..o)	-	37 199
1973	+	21	-	21	-	3 929	251	1 576	-	5 756	7 040	32	7 072	72	2 363	2 435	..o)	-	38 250
1974p)	1	50			2	4 199	330	947	-	5 478	7 100	56	7 156	38	2 071	2 109			
1975p)		5			1	4 574	118	1 131	-	5 824	6 782	64	6 846	34	3 005	3 039			
1976p)		2			-	4 316	258	693	-	5 267	5 477	59	5 536	-	3 085	3 085			

k) Dots (...) in VIIf signify that the catches have been included in VIIa. l) 1960 total includes England/Wales 24 tons. m) 1962 France 6; Norway 50; figures for other years refer to France. n) France 1966 VIIg-k includes VIIa, VIIb,c, VIIf. o) Details not available. p) Provisional data only. q) The N. Ireland landings have been multiplied by 3/4 an incorrect conversion factor from tail - to total weight was used for all years before 1975.

Table 1.3 Scotland.
Nephrops: landings (tonnes) by districts.

	Eyemouth	Leith	Anstruther	Total
1954	59.8	11.8	156.0	227.6
1955	43.9	329.5	430.0	803.5
1956	39.2	306.8	317.3	663.3
1957	54.6	446.7	481.4	982.8
1958	21.5	421.7	241.6	684.8
1959	40.5	405.0	383.8	829.4
1960	43.9	227.5	227.0	498.5
1961	74.6	290.8	223.0	588.4
1962	94.9	232.9	303.2	630.9
1963	41.3	280.2	362.9	684.3
1964	67.7	518.9	318.3	904.8
1965	147.3	419.4	478.9	1 045.6
1966	286.9	668.3	947.8	1 902.9
1967	216.9	687.6	443.7	1 348.2
1968	237.3	510.9	299.4	1 047.6
1969	165.4	576.5	348.8	1 090.7
1970	252.2	759.3	601.3	1 612.8
1971	212.5	680.0	464.1	1 356.7
1972	455.5	776.4	637.7	1 869.6
1973	296.5	710.6	689.5	1 696.6
1974	223.1	683.1	600.4	1 506.6
1975	232.7	683.2	577.4	1 493.3
1976	391.6	931.9	728.0	2 051.5

Table 1.4 France. Breakdown of landings by port and area for 1976 (in tonnes).

Port \ Area	North of 48°N								South of 48°N	
	VI a	VII a	VII b	VII e	VII f	VII g	VII h	VII j	VIII a	VIII b
DOUARNENEZ	12.7	37.3	18.6			457.7	353.9	5.8		
SAINT GUENOLE		1.53	116.45			1 654.88	3.06		174.52	
LE GUILVINEC						217.16	21.53		1 057.96	
LESCONIL									945.63	
LOCTUDY			3.69	1.01	0.92	659.30	32.15		936.28	
CONCARNEAU	13.69		21.82	0.68	0.17	8.77	15.41	0.5	582.80	
LORIENT		195.51	34.68	0.84	0.68	299.08	446.32		962.63	
SAINT NAZAIRE									461.00	
LES SABLES D'OLONNE		53.0	243.0			37.0			332.54	
LA ROCHELLE		88.08	199.39			94.66	14.61		5.82	18.29
TOTAL	26.39	375.42	637.63	2.53	1.77	3 428 55	886.98	6.3	5 459.18	18.29

Table 2.1. Fishing effort 1960-1976.

Year	Scotland		England (NE)	Northern Ireland		Ireland	France		Denmark	Sweden	Faroe Isl.	Iceland	Spain VII,b.c.j.k			
	Hours fishing			Hours fishing		Hours fishing x BHP x 10^{-2} Skerries May - October	Total power (50 GRT) x BHP x 10^{-3}	Lesconil days fishing x BHP x 10^{-2}	Gilleleje (October) hours fishing	Hours fishing	Hours fishing	Hours fishing	All vessels[1)]		Nephrops trawlers[2)]	
	Anstruther	Buckie	Hours fishing	Total	< 50mm mesh								Fishing days	BHP	Fishing days	BHP
1960	-			-	-						3 721	25 223				
1961	-			-	-	7 380	91.3				2 876	-				
1962	-	28 290	9 487	-	14 533	6 651	94.9				1 633	34 756				
1963	7 268	24 685	6 465	-	31 336	7 326	103.9				2 538	63 356				
1964	7 102	41 869	7 309	-	22 688	6 336	108.6		716			52 753				
1965	9 090	-	9 994	37 479	11 982	6 120	116.6		291.5			57 816				
1966	22 027	-	18 490	54 511	21 803	6 831	124.6	10 941	1 341			56 342				
1967	18 155	26 031	22 380	75 395	9 720	8 145	119.5	9 296	803.5			65 492				
1968	14 493	29 046	22 195	91 791	32 341	8 973	121.1	9 958	2 223.5	14 793		84 373				
1969	14 589	28 115	23 165	106 433	48 740	9 909	130.6	10 912	822.5	12 711		90 502				
1970	19 001	17 528	12 653	99 162	43 908		144.4	11 259	IIIa Jan-Dec	11 883		100 125	21 420	598		
1971	18 199	19 470	22 522	95 259	47 106		148.9	12 049		11 332		96 219	25 212	621		
1972	22 096	18 307	18 641	119 082	78 094		159.3	11 011		11 700		114 615	28 932	645	3 360	463
1973	30 817	26 791	16 436	126 360	81 684		170.9	12 774	272 154	10 354		89 169	27 348	651	3 912	388
1974	-	-		110 700	69 300*)		180.6	12 558	213 951	11 733		50 458	27 744	661	3 756	386
1975	30 312	8 123		125 700	85 812		195.3	14 541	341 176	11 292		61 220	31 212	712	5 736	480
1976	32 069	28 178		147 738	89 104		211.4	13 760	296 036	7 123		76 796	29 880	728	1 428	360

*) Raised from January - October value.

1) 1 fishing day = 15 hours' fishing.

2) Divisions VIIc, k only.

Table 3.1. Landings per unit of effort (catch in kg per hour fishing unless otherwise stated)

Year	Scotland Anstruther	Scotland Buckie	England (NE)	Northern Ireland All methods	Northern Ireland mesh <50mm	Ireland Skerries	France Lesconil VIII	France Lorient VIIb	France Lorient VIIg	Denmark Gilleleje (October)	Faroe Islands	Iceland	Spain (VIIb,c,j,k) All vessels	Spain (VIIb,c,j,k) Nephrops trawlers	Denmark IIIa Jan-Dec	Sweden
1960				-	-						19.6	82.5				
1961				-	-	43.61					12.2					
1962		16.8	13.5*)	-	23	39.28					23.2	76.6				
1963	27.2	21.1	21.8	-	30	71.98					30.5	87.6				
1964	25.4	16.3	22.5	-	31	27.17				11.0		66.1				
1965	36.6	-	22.6	19	31	36.62				7.7		64.1				
1966	37.6	-	24.1	19	33	55.86	51.5			4.5		61.5				
1967	24.4	27.4	17.0	20	31	30.34	39.4			8.0		41.7				
1968	20.3	18.8	21.0	16	24	37.44	50.1			7.2		29.5				7.9
1969	23.9	17.8	17.5	19	27	47.45	62.7			10.1		38.8				6.6
1970	31.5	22.9	18.6	21	28		45.5					40.2	70			6.3
1971	25.4	29.0	15.7	23	24		44.7	128.44	75.60			48.4	57			6.5
1972	29.0	27.9	21.4	26	29		53.1	36.45	84.24			37.7	60	148		6.5
1973	22.4	29.5	14.0	22	25		70.3	79.50	47.54			31.3	78	220	4.92	7.2
1974	15.5	16.4		17	20*)		80.0	123.36	51.65			39.3	68	175	8.10	10.2
1975	19.0	40.8		20	23		77.35	128.65	46.46			38.5	72	179	7.65	10.6
1976	22.7	41.4		22	37		68.7					36.2	46	179	5.55	7.9

*) Based on January - October.

France: kg per day. Adjusted to standard 100 bhp vessel

Spain: kg/fishing day = kg/~18 hours fishing

Table 3.2 Spain Catch per unit effort. Kg/fishing day, monthly values for 1974.

Month	J	F	M	A	M	J	J	A	S	O	N	D
Divs. IXa - VIIc 1)	40	70	76	67	89	108	92	75	47	51	66	70
Divs. VIIb,c,j,k 1)	29	33	33	38	83	96	187	150	50	33	33	50
Divs. VIIc,k 2)	138	155	154	177	230	324	326	177	92	139	189	157

1) All vessels.

2) Nephrops trawlers.

Data obtained in La Coruña 1974

Table 3.3 United Kingdom (England).
Nephrops landings per unit effort in kg/boat day.
Port of North Shields, northeast coast of England.
January to December 1976.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1			171	87	58		51		153	416	239	218
2			82	197			70		107	344	153	209
3			57	138	77		51				287	216
4			79		70			77		485	294	183
5			94	336	61			204		435	257	
6			68	193	87		64	153	77	336	150	340
7				238	71		111	153	75			
8				176	51		102		72	255	140	251
9	94	151	128	197			96	51	85	238	115	222
10	125	106	127	196	82		128	51			128	167
11		109	194		58			71		252	179	240
12	162	98	177	181	51		189	82			194	
13	97	97	86	96			128	68		136	231	295
14	51			90			117	122	51	231		293
15	51			51			102				279	197
16	77	90					163	51			176	155
17	106	77					82	89			129	143
18						51		64	124	371	232	
19	141		61				102	102			249	
20		82	102	119			179	51	231	431	191	
21		122		126		51	102	102	186	327		
22				172		51			139	111	221	102
23		204		121		51	51	109	153	128		102
24	51	281	230	72			51	134	295			
25		193	228					82	284	102		
26		194	311	68				102		69	68	
27	51	239	185	51			51	85		132	132	
28	91	197				51	77		286	122		
29	57		204	51		51			357	158	216	
30			132	68		82	51		486		283	
31			128					102				

These data illustrate the variability of seasonal and daily catch rates

Table 4. Mean carapace lengths, Males, 1958 - 74 (mm).

Year	UK (Scotland)				Ireland	Iceland	Denmark
	FF	MF	NM	FC	Skerries, summer (Median)		
1958	-	-	-	-	29.9	-	
1959	-	-	-	-	30.2	-	
1960	47	38	44	37	26.2	51.2	
1961	40	-	-	-	29.8	52.4	
1962	38	32	40	34	30.4	46.6	
1963	36	32	37	30	-	49.2	
1964	36	29	36	30	27.6	50.9	
1965	39	35	37	35	-	50.4	
1966	36	-	-	-	28.7	46.5	
1967	34	29	39	34	28.8	44.1	
1968	33	-	-	-	25.3	44.2	
1969	34	-	49	33	26.8	42.5	
1970	31	32	43	35	28.3	43.0	
1971	35	34	-	39	27.2	44.7	45.1
1972	32	31	34	34	25.9	43.0	43.8
1973	31	27	33	34	25.3	42.3	44.8
1974	30	28	38	31	-	44.8	42.4
1975	32	30	32	35	-	42.5	41.5
1976	31	31	-	32	24.3	43.0	40.1

FF = Firth of Forth

MF = Moray Firth

NM = North Minch

FC = Firth of Clyde

Table 5.1 Denmark.
Length compositions of *Nephrops* caught (numbers per sample)
Div. IIIa 1971-76 (based on sampling from July-December)

A. MALES

Carapace length (mm)	1971	1972	1973	1974	1975	1976
10 - 15						
15 - 20					3	
20 - 25	3		1	3	24	13
25 - 30	8	17	5	36	130	113
30 - 35	23	28	28	172	476	384
35 - 40	77	27	74	521	571	574
40 - 45	119	64	32	659	541	659
45 - 50	120	84	46	337	571	375
50 - 55	103	47	35	209	351	184
55 - 60	48	27	34	103	134	58
60 - 65	9	5	20	51	45	13
65 - 70			3	6	12	
70 - 75			1			
75 - 80			1			
Total no	510	295	280	2098	2858	2373
wt sampled (kg)	37.7	18.0	21.7	98.9	169.5	110.8

B. FEMALES

Carapace length (mm)	1971	1972	1973	1974	1975	1976
10 - 15				1		
15 - 20		1		1	2	4
20 - 25	4	16	1	1	23	56
25 - 30	4	30	0	27	138	178
30 - 35	28	55	19	93	505	408
35 - 40	69	44	11	130	438	549
40 - 45	75	25	16	132	415	389
45 - 50	57	6	8	108	247	309
50 - 55	21	2	13	36	67	140
55 - 60	2		7	9	11	28
60 - 65			4	1	1	2
65 - 70			3			
70 - 75						
75 - 80						
Total No	260	179	82	548	1847	2062
wt sampled (kg)	10.7	7.5	5.0	24.2	87.2	70.1

Table 5.2 France.
Length composition of *Nephrops* caught (Lesconil).

Carapace length (mm)	MALES					FEMALES				
	1972	1973	1974	1975	1976	1972	1973	1974	1975	1976
10-14	136	308	416	284	125	264	628	463	309	180
15-19	2 340	7 731	5 881	6 392	7 029	2 472	8 628	6 184	7 519	7 636
20-24	11 430	23 607	19 222	23 245	23 395	11 517	24 224	21 662	25 890	22 468
25-29	13 682	18 050	14 703	19 915	18 584	14 428	14 823	11 251	16 245	15 829
30-34	7 898	6 412	5 984	7 263	6 757	4 670	2 378	3 556	1 572	2 900
35-39	4 022	2 064	2 048	1 867	1 966	1 237	267	851	173	297
40-44	1 250	483	624	433	607	282	29	113	22	33
45-49	372	139	85	103	145	2		5	2	2
50-54	82	29	42	30	38					
55-59	26			5	2					

France.
Percentage composition of *Nephrops* catch (by weight) at Lesconil.

Carapace length (mm)	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
22-29	57.50	56.0	61.2	56.5	57.0	61.0	61.2	61.7	63.2	56.5
≥ 30	42.50	44.0	38.8	43.5	43.0	39.0	38.8	38.3	36.8	43.5

Table 5.3 Ireland.
Length distributions in Irish (east) fishery, with totals (numbers and weights) caught and landed. (Based on 1970-71 length frequency distributions.)

	Carapace length (mm)	% landed/ catch	Oct/Nov/Dec/ Jan/Feb/Mar		Apr/May		June/July		Aug/Sep		Total	
			N_c	N_l	N_c	N_l	N_c	N_l	N_c	N_l	N_c	N_l
MALES	15 - 19	0	1 498	-	599	-	275	-	1 024	-	3 396	-
	20 - 24	12	7 517	902	4 072	489	3 162	379	5 040	605	19 791	2 375
	25 - 29	60	10 296	6 178	5 486	3 292	4 710	2 826	7 536	4 522	28 028	16 817
	30 - 34	100	4 819	4 819	2 883	2 883	1 681	1 681	3 544	3 544	12 927	12 927
	35 - 39	100	1 832	1 832	1 170	1 170	446	446	759	759	4 207	4 207
	40 - 44	100	695	695	187	187	152	152	150	150	1 184	1 184
	45 - 49	100	171	171	66	66	38	38	46	46	321	321
	Total Numbers ('000)		26 828	14 597	14 464	8 087	10 463	5 522	18 099	9 626	69 854	37 831
	Total Weight (metric tonnes)		438.6	325.6	236.2	176.3	158.2	109.8	270.7	191.3	1 103.7	803.0
FEMALES	15 - 19	0	1 922	-	459	-	323	-	1 381	-	4 085	-
	20 - 24	12	8 853	1 062	5 795	695	5 365	644	3 388	1 007	28 401	3 408
	25 - 29	60	3 537	2 122	3 520	2 112	8 156	4 894	9 435	5 661	24 648	14 789
	30 - 34	100	117	117	300	300	3 105	3 105	2 531	2 531	6 053	6 053
	35 - 39	100	27	27	37	37	788	788	403	403	1 255	1 255
	40 - 44	100	-	-	9	9	161	161	115	115	285	285
	45 - 49	100	9	9	-	-	9	9	-	-	18	18
	Total Numbers ('000)		14 465	3 337	10 120	3 153	17 908	9 601	22 253	9 717	64 745	25 808
	Total Weight (metric tonnes)		122.1	39.4	98.5	40.8	240.2	161.2	259.4	150.4	720.2	391.8
SEXES COMBINED	Total Numbers ('000)		41 293	17 934	24 584	11 240	28 371	15 123	40 352	19 343	134 599	63 639
	Total Weight (metric tonnes)		560.7	365.0	334.7	217.1	398.4	271.0	530.1	341.7	1 823.9	1 194.8

N_c = number caught; N_l = number landed

Table 5.4 Numbers (thousands) of *Nephrops* caught annually at Anstruther. Mean for the period 1967-74. (Anon.,1976).

Carapace length (mm)	Males	Females
10-14	1	2
15-19	163	155
20-24	1 391	1 512
25-29	4 120	3 660
30-34	4 729	4 027
35-39	3 040	2 593
40-44	1 650	963
45-49	827	164
50-54	312	6
55-59	94	0.3
60-64	10	-
65-69	3	-
Total	16 340	13 082
	29 422	

Table 5.5 Length compositions used in the assessments (Nos. per mille).

MALES

Carapace length (mm)	Denmark[3] IIIa	Sweden[2] IIIa	Spain[5] IXa	France[4] VIIIa	Spain[6] VII c,k	Northern Ireland	Ireland[9]	NE England[1]	Scotland[8]	Iceland[7]
10-15				5						
15-20	1		3	120		65	71	7	10	1
20-25	5	6	128	395	1	307	386	120	85	10
25-30	37	27	177	316	68	365	332	377	252	56
30-35	132	157	187	117	248	161	153	262	289	153
35-40	219	181	192	35	312	60	42	142	186	227
40-45	247	228	183	10	240	24	13	63	101	206
45-50	182	201	81	2	95	7	2	20	51	157
50-55	110	99	29	1	28	11		8	19	108
55-60	48	71	12		6			1	6	56
60-65	17	27	4		2				1	22
65-70	1	4	3							4
70-75			1							

Table 5.6 Length compositions used in the assessments (Nos. per mille).

FEMALES

Carapace length (mm)	Denmark[3] IIIa	Sweden[2] IIIa	Spain[5] IXa	France[4] VIIIa	Northern Ireland	Ireland[9]	NE England[1]	Scotland[8]
10-15	1			8				
15-20	1		2	153	115	102	18	12
20-25	17	11	123	481	457	464	264	116
25-30	73	115	163	296	319	339	490	280
30-35	218	252	176	53	96	82	151	307
35-40	253	180	242	8	12	10	66	198
40-45	216	205	234	1	1	2	9	74
45-50	151	134	50				2	13
50-55	56	77	7					
55-60	12	20	3					
60-65	1	6						
65-70	1							

1) Jan.1976 (Totals from 6 one-hour hauls with 70 mm unimesh trawl)
2) Autumn 1976. 3) For period 1971-76 (Jul-Dec only). 4) Mean for 1973-76.
5) Based on samples taken in 1974-76. 6) Jan-Feb 1977. 7) Mean for period 1969-75.
8) Mean for period 1967-74 at port of Anstruther. 9) 1976-77 data.

Table 6.1 By-catch data Denmark. Landings (kg per 100 kg *Nephrops*) from Division IIIa.

	1973	1974	1975	1976
Pandalus	2.0	1.6	3.5	2.5
Plaice	16.9	7.3	8.8	29.6
Dab	2.4	0.5	1.1	3.2
Sole	6.7	3.1	2.7	4.9
Cod	45.3	12.2	19.9	35.7
Haddock	2.2	0.4	2.1	4.5
Whiting	3.3	0.4	0.5	5.2
Norway pout	20.1	-	-	-
Blue whiting	6.7	-	1.6	-
Unspecified	442.2	414.8	307.8	265.6
Total By-catch	457.8	440.3	348.0	351.2
Total *Nephrops* (tonnes)	1 339	1 733	2 610	1 643
Total By-catch (tonnes)	7 335	7 630	9 083	5 770

Table 6.2 By-catch data France. Landings (kg per 100 kg *Nephrops*) from Sub-area VII 1975 (Artisan *Nephrops* trawlers landing at Rochelle and Lorient).

Species composition	La Rochelle			Lorient			
	VIIa	VIIb	VIIg	VIIa	VIIb	VIIg	VIIh
Cod	29.05	2.64	21.39	81.24	6.67	53.66	3.73
Haddock			0.2	8.57	14.91	17.89	12.03
Saithe	1.45		7.54	13.73	1.26	10.56	2.07
Ling			0.62	6.16	4.76	9.65	4.16
Whiting	35.24		31.17	164.26	1.51	108.33	2.84
Hake	6.8	1.32	8.19	19.13	4.76	30.15	9.89
Monk	8.97	9.25	13.39	22.50	8.98	40.85	18.33
Megrim	1.76		5.71	4.05	11.35	26.24	26.45
Plaice	2.65		0.90	10.92	0.33	14.13	0.61
Sole	4.29		4.23	8.0	0.52	10.16	0.85
Total	90.21	13.21	93.34	338.55	55.05	321.62	80.96
Total landings in tonnes:							
Nephrops	15.83	3.78	95.84	165.81	36.28	283.90	231.52
By-catch	19.70	2.25	137.88	917.75	33.49	1493.20	334.21

Table 6.3 By-catch data. France. Monthly landings by *Nephrops* trawlers (kg per 10 hrs fishing) in 1976 at Lesconil.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dogfish	4.8	3.1	3.9	2.1	1.3	1.9	2.6	2.1	4.5	4.3	5.2	3.5
Skate	9.9	6.7	15.13	1.4	2.4	2.0	1.6	2.0	8.9	5.2	4.4	13.0
M. merluccius	43.9	29.3	16.9	29.09	42.6	45.9	40.8	34.7	26.5	36.5	46.9	62.0
Trisopterus luscus	12.0	9.3	9.5	6.6	7.0	6.3	7.7	6.5	5.2	14.7	9.8	14.0
P. pollachius	4.9	6.5	3.5	2.8	3.6	3.7	3.9	3.2	0.9	1.4	2.7	2.0
Molva molva	4.3	2.8	3.1	2.4	3.0	2.4	2.6	2.3	2.9	2.3	4.2	4.0
Pagellus bogaraveo	2.2	0	0	0	11.8	3.3	5.5	6.3	1.1	3.0	2.9	0
Solea vulgaris	4.0	8.3	2.3	2.5	1.7	1.3	1.0	1.5	3.3	5.7	1.8	8.5
Lophius	30.0	26.8	27.5	13.1	18.1	14.2	12.7	14.1	36.2	32.5	25.8	39.2
Cephalopods	10.6	6.4	5.0	3.0	3.0	2.5	2.3	1.4	2.3	3.0	13.1	15.1
Nephrops	116.5	110.2	127.3	183.0	166.0	157.6	133.4	90.3	61.9	84.2	166.1	147.9
Total *Nephrops* (tonnes)	47.7	49.7	77.5	129.6	114.5	132.3	114.8	72.6	35.1	29.3	85.0	57.5

Table 6.4 By-catch data. Spain.
Monthly landings (metric tonnes) of *Nephrops* and principal fish species from the Spanish demersal fishery in Divisions VIIb,c,j,k in 1974.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hake (*Merluccius merluccius*)	1 233	1 374	1 533	1 518	1 453	1 202	853	850	949	994	1 076	1 248
Megrim (*Lepidorhombus* sp.)	518	664	1 303	1 257	1 079	1 331	1 242	1 079	976	1 005	916	753
Angler (*Lophius* sp.)	450	511	720	824	824	839	749	748	673	644	601	493
(*Nephrops*)	68	77	77	89	194	225	437	351	117	77	77	117

Table 6.5 By-catch data. Scotland: landings from 4 areas, 1970-1975 1).

Year	Total *Nephrops* (100 kg)	Total by-catch (100 kg)	Cod	Haddock	Whiting	Saithe	Hake	Monk	Plaice	Others*	Total
Firth of Forth											
1970	15964	8895	11.56	17.01	23.31	-	-	0.19	2.48	1.17	55.72
1971	13619	7350	28.88	8.97	11.15	0.12	-	0.15	2.65	2.15	53.97
1972	18374	5921	15.53	9.11	3.34	0.13	-	0.12	2.10	1.90	32.23
1973	16799	5967	14.04	9.56	7.30	0.11	+	0.44	2.44	1.63	35.52
1974	14519	4806	14.99	3.91	9.26	0.07	-	1.52	1.27	2.08	33.10
1975	14681	5580	17.51	4.24	11.21	0.33	-	2.35	0.77	1.60	38.01
Moray Firth											
1970	8374	4610	5.64	28.15	9.90	0.32	1.36	1.71	2.91	5.06	55.05
1971	10669	5630	13.70	18.74	6.18	0.37	0.66	3.05	2.87	7.20	52.77
1972	10029	2582	7.40	6.96	1.72	0.37	0.46	2.22	0.92	5.70	25.75
1973	12523	3327	6.45	8.43	1.20	0.72	0.26	2.30	1.37	5.84	26.57
1974	12982	4305	8.08	8.60	3.60	0.12	0.15	4.34	2.16	6.11	33.16
1975	8122	3505	5.07	6.40	5.63	0.17	0.17	11.60	3.84	10.27	43.15
South Minch											
1970	17925	21775	15.54	37.47	18.79	0.59	4.44	17.51	0.54	26.60	121.48
1971	18539	19292	13.10	18.08	24.76	0.45	3.20	17.65	0.66	26.16	104.06
1972	23795	24102	15.82	8.94	23.82	2.11	4.52	18.37	1.04	26.67	101.29
1973	17223	19952	16.91	5.81	24.29	7.62	8.36	21.61	0.71	30.54	115.85
1974	11139	8280	12.06	1.80	16.58	2.41	3.54	14.21	0.71	23.02	74.33
1975	10173	7691	8.29	1.82	26.71	1.58	6.13	11.32	1.14	18.61	75.60
Clyde											
1970	19072	19759	14.96	2.46	6.01	48.42	12.71	2.85	1.42	14.77	103.60
1971	18338	21162	24.19	2.13	5.36	56.11	11.47	3.23	1.62	11.29	115.40
1972	26600	34766	20.47	2.97	10.00	67.02	12.71	3.96	1.10	12.47	130.70
1973	23533	30259	21.33	2.71	0.01	73.95	14.73	3.54	1.44	10.87	128.58
1974	15086	35300	38.88	2.68	10.15	135.04	21.02	5.50	2.71	18.01	233.99
1975	13036	27785	38.17	1.62	+	114.75	27.46	5.88	2.18	23.08	213.14

* Including skate, dogfish, witch, L sole, Megrim

1) Landings by species expressed as kg per 100kg of *Nephrops*

Table 6.6 By-catch data (*Nephrops*). Sweden.
Effort (trawling hours), landings and catch/effort (kg/hour) from Leran, Sörgrundet and St Pölsan - Falkenberg during 1968-76.

Year	COD			WHITING			HAKE		
	Effort	Landings	kg/hour	Effort	Landings	kg/hour	Effort	Landings	kg/hour
1968	14 790	183 390	12.40	14 758	18 300	1.24	14 839	9 942	0.67
1969	12 704	146 599	11.54	12 678	15 848	1.25	12 731	17 060	1.34
1970	11 886	179 482	15.10	11 891	16 529	1.39	23 040	32 026	1.39
1971	11 323	141 768	12.52	11 291	12 081	1.07	11 332	11 899	1.05
1972	11 704	143 963	12.30	11 710	20 376	1.74	11 681	30 722	2.63
1973	10 349	153 275	14.81	10 352	20 186	1.95	10 336	26 668	2.58
1974	11 737	139 321	11.87	9 838	16 626	1.69	11 761	19 876	1.69
1975	11 184	138 460	12.38	11 180	22 248	1.99	11 170	28 930	2.59
1976	7 122	95 642	13.43	7 113	18 777	2.64	7 116	30 883	4.34

Table 6.7 By-catch data (*Nephrops*). Sweden.
Effort (trawling hours), landings and catch/effort (kg/hour) from Leran, Sörgrundet and St Pölsan - Falkenberg during 1968-76.

Year	POLLACK			PLAICE		
	Effort	Landings	kg/hour	Effort	Landings	kg/hour
1968	14 780	49 069	3.32	14 756	23 904	1.62
1969	12 701	81 035	6.38	12 716	26 068	2.05
1970	11 896	56 505	4.75	11 910	21 438	1.80
1971	11 338	57 370	5.06	11 327	24 807	2.19
1972	11 700	65 755	5.62	11 721	21 333	1.82
1973	10 346	49 247	4.76	10 356	16 259	1.57
1974	11 729	64 977	5.54	11 722	17 348	1.48
1975	11 172	46 476	4.16	11 183	18 564	1.66
1976	7 116	42 766	6.01	7 134	17 693	2.48

Table 6.8 By-catch data. France.
Number per 10 hours' fishing of hake taken by Artisan trawlers from Lorient working 47°30'N-3°30'W.

Length (cm)	Feb 73	Mar	May	Jul	Aug	Jan 74	Mar	Jul	Sep	Oct	Nov
A. DISCARDS[1]											
4 - 6											
7 - 9					98			77			
10 - 12		12	7		94	7	44	19	164	40	
13 - 15	3	340	642	11	2	18	250	1	1 547	595	66
16 - 18	41	570	2 211	16	18	25	371	22	1 606	1 316	847
19 - 21	78	450	940	7	48	6	167	76	166	739	1 459
22 - 24	6	156	52		8		29	21		46	339
25 - 27					4		15				
28 - 30							4				
B. LANDINGS											
16 - 18					2			9			
19 - 21	46	5	7	29	17	3	25	61	4	42	47
22 - 24	211	141	64	92	136	11	119	105		61	191
25 - 27	185	114	49	60	98	9	62	66	29	12	69
28 - 30	77	57	26	35	53	8	18	64	44	37	7
31 - 33	19	19	14	5	36	4		32	33	44	11
34 - 36	4	17	6	9	27	2	19	16	24	24	14
37 - 39	3	2	7		9	7		5	11	11	5
40 - 42		2	4		4	2		1		1	6
43 - 45	2	2	1		2	2		1		1	4
46 - 48			1	4	2	2		1	2		3
49 - 51			1		1		4				3
52 - 54				8	2	2		1	1	1	2
55 - 57			1		1	7			1		1
58+			2	3	5	10		1	3		7

1) Based on samples taken at sea.

Table 6.9 By-catch data. Spain.
Size compositions of hake.

Division	IXa - VIIc (west)	VIIb,c,j,k
Length (cm)	Numbers (millions)[1)]	Number (millions) [2)]
5 - 9	5.57	
10 - 14	104.30	.03
15 - 19	189.59	1.44
20 - 24	53.75	5.18
25 - 29	14.84	7.62
30 - 34	7.64	8.20
35 - 39	2.69	6.62
40 - 44	1.75	4.26
45 - 49	1.14	2.65
50 - 54	.70	1.25
55 - 59	.68	.67
60 - 64	.78	.42
65 - 69	.68	.23
70 - 74	.29	.22
75 - 79	.10	.12
80 - 84	.04	.10
85 - 89	.04	.05
90	.03	.03
Total number (millions)	383.25	39.10
Weight (tonnes)	22 822	14 500
Mesh size in use	40	60

1) Total numbers caught including an estimate of the undersized fish (based on samples taken just before landing).

2) Total number landed.

Hake is the most important species in the by-catch.

Data obtained from the ports of La Coruña and Vigo (1973-74-75-76).

Table 7. Mesh sizes in use, and minimum landing sizes.

Country	Cod end mesh size (mm)	Minimum landing size[2] (mm)
Denmark	35	130[5]
Faroe Islands	Trap fishery	150
France	40 (south 48°N) 60 (north 48°N)	80
Iceland	80	70[4]
Ireland	ca. 40[6]	None
Norway	35[1]	130
Spain	40 (south 48°N) 60 (north 48°N)	120[3]
Sweden	60-70	130
UK (Engl. & Wales)	70	100[7]
UK (Scotland)	70	None
UK (N.Ireland)	50[8]	None

1) From Anon., 1976.
2) Total length unless otherwise stated.
3) From orbit to beginning of telson (equivalent to 152.5 mm total length).
4) Tail length.
5) Equivalent to a tail length of 72 mm.
6) Mesh size in rest of trawl, 45 - 60 mm.
7) Voluntary agreement for English NE coast only.
8) Cod end is 40 mm, but 50 mm was considered more appropriate for the assessments because of the larger meshes (up to 70 mm) in other parts of the trawl.

Table 8. Growth data estimated from available Irish material (Hillis, unpubl. data).
P = Petersen's method; L = laboratory observations; M = marking results.

Age group (July)	MALE			FEMALE		
	Carapace length (mm)	Annual increment (mm)	Data source	Carapace length (mm)	Annual increment (mm)	Data source
0	4	10	L, P	4	10	L, P
1	14	7	P, L	14	7	P, L
2	21	5	P	21	4	P
3	26	4.5	P	25	1.5	P
4	30.5	4	P	26.5	1.5	M
5	34.5		P	28		M

Table 9. France. Moult increments of Nephrops[1]. Carapace lengths (mm).

MALE		FEMALE	
Length before moult	Length after moult	Length before moult	Length after moult
21.4	23.6	24.9	27.4
22.0	25.4	26.2	28.3
25.8	28.5	26.8	28.5
26.0	28.7	29.1	30.8
26.3	29.1		
26.9	30.2		
28.0	31.3		

1) Based on observations on individuals maintained in large containers in the sea.

Table 10. Percentage of *Nephrops* about to moult[1)] (Sub-area VIII).

Year and month	Males	Females
1974		
Oct	14.44	7.68
Nov	7.28	2.57
Dec	5.73	7.60
1975		
Jan	9.61	11.54
Feb	12.34	11.66
Mar	25.51	12.84
Apr	27.97	17.35
May	15.59	12.08
Jun	10.68	5.79
Jul	12.14	4.54
Aug	19.46	11.20
Sep	26.58	15.02
Oct	7.81	4.32
Nov	5.97	2.41
Dec	13.34	11.67
1976		
Jan	11.46	22.21
Feb	12.12	18.31
Mar	20.45	15.02
Apr	21.26	9.40
May	24.90	9.32
Jun	19.43	5.71
Jul	8.05	1.56
Aug	24.47	13.58
Sep	23.98	16.59
Oct	5.89	3.35

1) Based on unpublished data by Charuau.

Table 11.1 Growth increments and values for L∞, K and M/K used in the assessments.

A. MALES

	L_t	L_{t+1}	L∞	K[1]	M/K[2]
NE England	20	25	70 80	0.11 0.088	0.9 1.1
	42	44.7	70 80	0.1 0.074	1.0 1.4
Scotland[4]	20	25	70	0.11	0.95
France[5] VIIIa	26	31.5	70 80	0.13 0.10	0.75 0.93
	39	42	70 80	0.11 0.075	0.98 1.32
Denmark[6] and Sweden IIIa	20	26	70 80	0.13 0.10	0.77 1.00
	42	46	70 80	0.15 0.11	0.67 0.90
NW Spain[3] and W Ireland	27.2	33.8	85 90 100 115	0.12 0.11 0.10 0.08	0.83 0.91 1.00 1.25
Irish Sea[7][8] (N.Ireland and Ireland)	30 30 30	34 34 34	60 70 80	0.14 0.11 0.08	0.71 0.91 1.25
Iceland[4]	20 42	25 46	80 80	0.088 0.11	1.1 0.9

1) Calculated from $K = \ln[(L_\infty - L_t)/(L_\infty - L_{t+1})]$.
2) Values of M/K for M = 0.1.
3) Increment based on Conan (1975).
4) Growth increment based on Thomas (1965).
5) Growth increments based on data of Charuau.
6) Growth increments based on Jensen (1965).
7) Growth increments from Farmer (1973).
8) Growth increments based on data of Hillis (Table 8).

Table 11.2 Growth increments and values for L_∞, K and M/K used in the assessments.

B. FEMALES

	L_t	L_{t+1}	L_∞	K[1)]	M/K[2)]
NE England	22	25	70 80	0.065 0.053	1.5 1.9
	29	30.7	70 80	0.04 0.03	2.3 2.9
Scotland[4)]	22	25	70	0.065	1.54
France[5)] VIIIa	25	27.5	70 80	0.057 0.046	1.7 2.14
	29	30.7	70 80	0.04 0.03	2.3 2.9
Denmark[6)] and Sweden IIIa	22	24	60 70	0.06 0.04	1.66 2.5
	42	45	60 70	0.18 0.11	0.56 0.88
NW Spain[3)] and W Ireland	26	31	70 80	0.12 0.10	0.83 1.0
Irish Sea[7)8)] (N.Ireland)	20 20 20	23 23 23	50 60 70	0.11 0.08 0.06	0.91 1.25 1.67

1) Calculated from $K = \ln [(L_\infty - L_t)/(L_\infty - L_{t+1})]$

2) Values of M/K for M = 0.1.

3) Increments based on Conan (1975).

4) Growth increment based on Thomas (1965).

5) Growth increments based on data of Charuau.

6) Growth increments based on Jensen (1965).

7) Growth increments from Farmer (1973).

8) Growth increments based on data of Hillis (Table 8).

Table 12.1 France.
Percentages of *Nephrops* discarded at various lengths in Div.VIIIa.

Carapace length (mm)	% rejected
17	100
18	100
19	99
20	92
21	74
22	46
23	21
24	5
25	2
26	1

Table 12.2 Scotland.
Percentages of *Nephrops* discarded at various lengths based on Anstruther samples taken Jan-Aug 1966 (from Anon., 1976).

Carapace length (mm)	% rejected
22	100
23	100
24	99
25	99
26	96
27	94
28	88
29	79
30	65
31	51
32	39
33	18
34	8
35	5
36	2
37	1

Table 12.3 Sweden.
Discards of *Nephrops* in weight and % from the areas of Leran, Sörgrund and St Pölsan - Falkenberg during 1968-76.

Year	Total catch	kg discarded	% disc.
1968	117 306	20 131	17.16
1969	84 146	12 435	14.78
1970	74 388	11 318	15.21
1971	73 656	7 371	10.01
1972	75 932	6 241	8.22
1973	75 068	7 300	9.73
1974	119 908	19 873	16.57
1975	107 513	18 322	17.04
1976	56 126	8 674	15.45
1968-76	784 042	111 666	14.24

Table 13. Geographical variation in the annual cycle of the sex ratio and percentage of females ovigerous.

Country	Sub-area/ Division	Details of ratio	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
A FEMALES PER 100 MALES														
Iceland	Va	Total F/100M	45	63	43	16	10	13	29	29	45	44	70	110
Sweden	III	Total F/100M	50	40	76	86	-	59	-	40	54	92	79	34
England NE (Storrow, 1912, 1913)	IVb	Total F/100M	26	88	75	74	29	6	9	18	25	72	76	98
England NE (Symonds, 1972)	IVb	Total F/100M	52	61	54	134	22	17	15	17	39	57	75	70
Scotland (Thomas & Figueiredo, 1965)	IVa, b VIa	Total F/100M	-	-	14	-	26	76	66	88	84	68	18	31
Northern Ireland	VIIa	Total F/100M	71	53	55	67	97	137	220	75	79	75	58	46
Ireland	VIIa	Imm. F/100M	33	29	38	47	32	56	39	80	60	49	54	60
		Mat. F/100M	0	0	1	16	43	178	122	36	44	15	2	+
		Total F/100M	33	29	39	63	75	234	161	117	104	64	56	61
France (Charuau, 1975)	VIII	Total F/100M	90	100	115	118	102	102	83	84	79	63	49	70
Portugal (Figueiredo & Barraca 1963)	IX		16	27	32	11	30	45	56	49	39	35	23	43
OVIGEROUS FEMALES PER 100 FEMALES														
Iceland	Va	Tot Ov F/100F	0.1	0.9	0.0	2.2	15.6	21.8	3.9	1.9	1.2	0.8	0.4	0.0
England NE (Storrow, 1912, 1913)	IVb	Old egg F/100F	0.0	0.0	0.0	0.0	4.2	(7.1)	0.0	1.0	3.6	0.0	0.0	0.0
		New egg F/100F	0.0	0.0	0.0	0.0	1.2	(0.0)	7.3	16.2	57.2	13.4	7.7	0.6
England NE (Symonds, 1972(	IVb	Total Ov F/100F	0.0	0.2	1.0	0.3	3.1	0.0	0.0	2.9	4.0	3.7	1.5	0.0
Scotland (Thomas & Figueiredo, 1965)	IVa, b, VIa	Total Ov F/100F	-	-	2.0	-	1.3	1.0	1.1	6.7	18.7	5.9	6.6	2.4
Northern Ireland	VIIa	Total Ov F/100F	0.5	0.4	1.0	0.3	3.1	0.0	0.0	2.9	4.0	3.7	1.5	0.0
Ireland	VIIa	Old egg F/100 Mat F	*	*	(0.0)	0.0	3.6	1.0	0.0	0.1	0.0	0.0	(0.0)	(0.0)
		New egg F/100 Mat F	*	*	(0.0)	0.0	0.0	0.0	0.6	6.1	51.5	41.1	(55.6)	(80.0)
		Total F/100F	0.0	0.0	0.0	0.0	2.0	0.7	0.4	4.6	18.4	10.4	1.3	0.8
Portugal	IX	Total F/100F	78.9		8.6		0.0		- -	-	- -	-	61.8	

M = Male; F = Female; Imm = Immature (non breeding); Mat = Mature; Ov = Ovigerous; Old egg = Bearing eggs extruded in the previous calendar year; New egg = Bearing eggs extruded in the current calendar year;
* = Mature females absent; - = No sample. Brackets denote ratio values based on denominator sample N of under 50.

Table 14. Immediate losses.

	Current mesh (mm)	New mesh (mm)	Sex	SF	% loss
Denmark IIIa	35	50	♂	0.3	1
				0.5	5
			♀	0.3	2
				0.5	8
		70	♂	0.3	4
				0.5	20
			♀	0.3	6
				0.5	27
Sweden IIIa	60	70	♂	0.3	2
				0.5	10
			♀	0.3	3
				0.5	13
Spain IXa	40	60	♂	0.3	4
				0.5	17
			♀	0.3	5
				0.5	20
France VIIIa	39	50	♂	0.3	6
				0.5	21
			♀	0.3	7
				0.5	25
		60	♂	0.3	13
				0.5	41
			♀	0.3	16
				0.5	48
Spain VIIc,k	60	80	♂	0.3	7
				0.5	33
NE England	70	80	♂	0.3	7
				0.5	29
			♀	0.3	10
				0.5	36
Iceland	80	90	♂	0.3	3
				0.5	21
N.Ireland VIIa	50 1)	70	♂	0.3	12
				0.5	40
			♀	0.3	18
				0.5	50
Ireland VIIa	50 1)	70	♂	0.3	14
				0.5	43
			♀	0.3	17
				0.5	49
Scotland IVa	70	80	♂	0.3	6
				0.5	25
			♀	0.3	7
				0.5	29

1) Mesh size intermediate in size between mesh sizes in cod end and in other parts of the trawl.

Table 15. Long-term changes in the catch per recruit.

New mesh (mm)	M	Sex	SF	% change
DENMARK IIIa				
50	0.05	♀	0.3	+1
			0.5	+3
	0.1	♂	0.3	+0.4
			0.5	+2
		♀	0.3	0
			0.5	0
	0.2	♂	0.3	0
			0.5	0
70	0.05	♀	0.3	+3
			0.5	+13
	0.1	♂	0.3	+2
			0.5	+10
		♀	0.3	0
			0.5	0
	0.2	♂	0.3	0
			0.5	0
SWEDEN IIIa				
70	0.05	♀	0.3	0
			0.5	+5
	0.1	♂	0.3	-0.4
			0.5	+4
		♀	0.3	-2
			0.5	0
	0.2	♂	0.3	-2
			0.5	-1
SPAIN IXa				
60	0.1	♂	0.3	+4
			0.5	+16
		♀	0.3	+4
			0.5	+13
	0.2	♂	0.3	+2
			0.5	+9
		♀	0.3	+2
			0.5	+6
FRANCE VIIIa				
50	0.1	♂	0.3	+5
			0.5	+19
		♀	0.3	+4
			0.5	+13
	0.2	♂	0.3	+4
			0.5	+14
		♀	0.3	+1
			0.5	+3

continued on page 48

Table 15 (ctd)

New mesh (mm)	M	Sex	SF	% change
	FRANCE, VIIIa (ctd)			
60	0.1	♂	0.3	+11
			0.5	+43
		♀	0.3	+8
			0.5	+28
	0.2	♂	0.3	+8
			0.5	+27
		♀	0.3	+2
			0.5	+5
	SPAIN VIIc,k			
80	0.1	♂	0.3	+4
			0.5	+20
	0.2	♂	0.3	+2
			0.5	+11
	NE ENGLAND (IV)			
80	0.1	♂	0.3	+4
			0.5	+21
		♀	0.3	+2
			0.5	+16
	0.2	♂	0.3	+2
			0.5	+10
		♀	0.3	-1
			0.5	0
	ICELAND (Va)			
90	0.1	♂	0.3	+2
			0.5	+9
	0.2	♂	0.3	0
			0.5	0
	N.IRELAND (VIIa)			
70	0.1	♂	0.3	+1
			0.5	+70
		♀	0.3	+7
			0.5	+32
	0.2	♂	0.3	-2
			0.5	+43
		♀	0.3	+2
			0.5	+8
	IRELAND (VIIa)			
70	0.1	♂	0.3	+8
			0.5	+64
		♀	0.3	+9
			0.5	+47
	0.2	♂	0.3	+4
			0.5	+40
		♀	0.3	+5
			0.5	+18

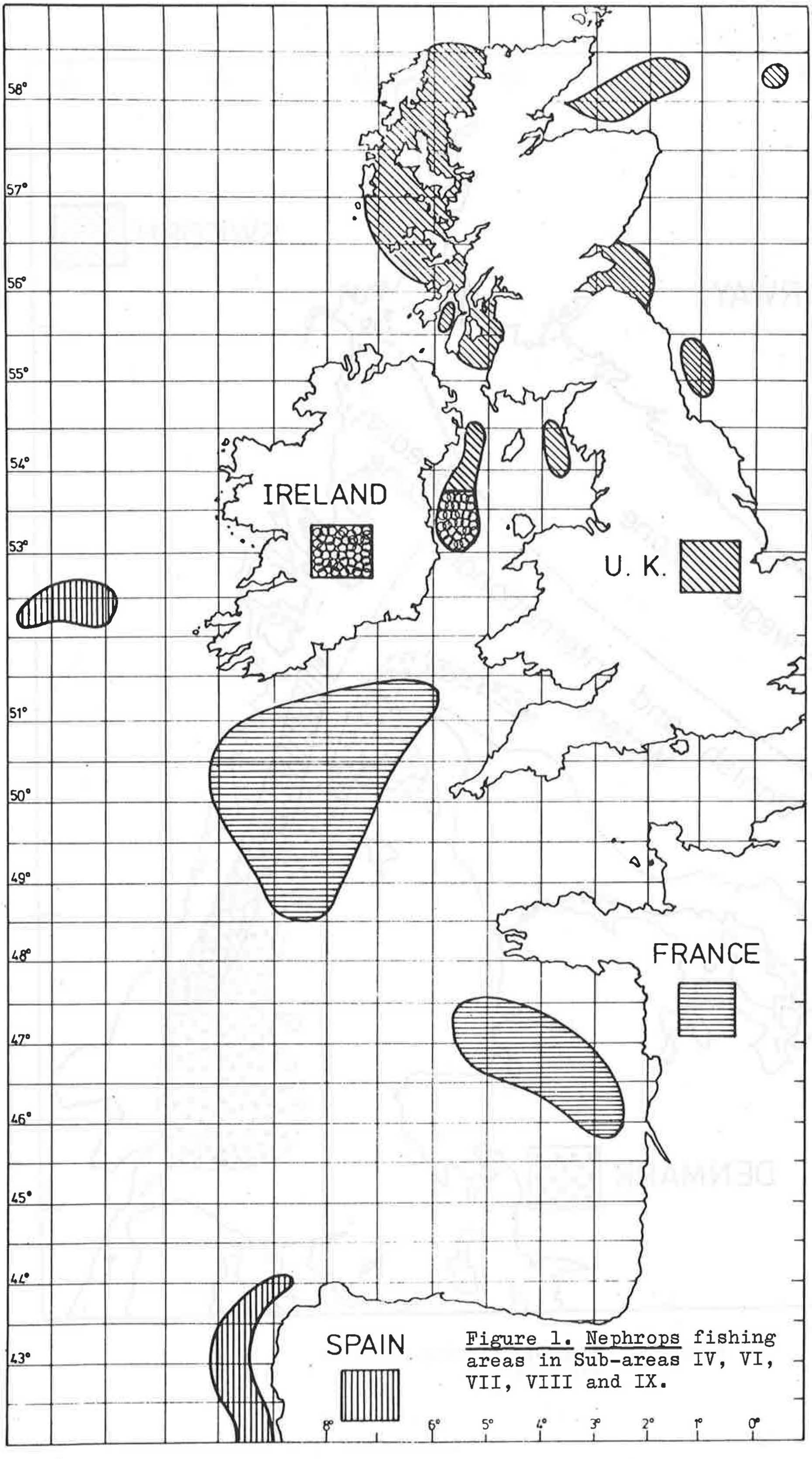


Figure 1. *Nephrops* fishing areas in Sub-areas IV, VI, VII, VIII and IX.

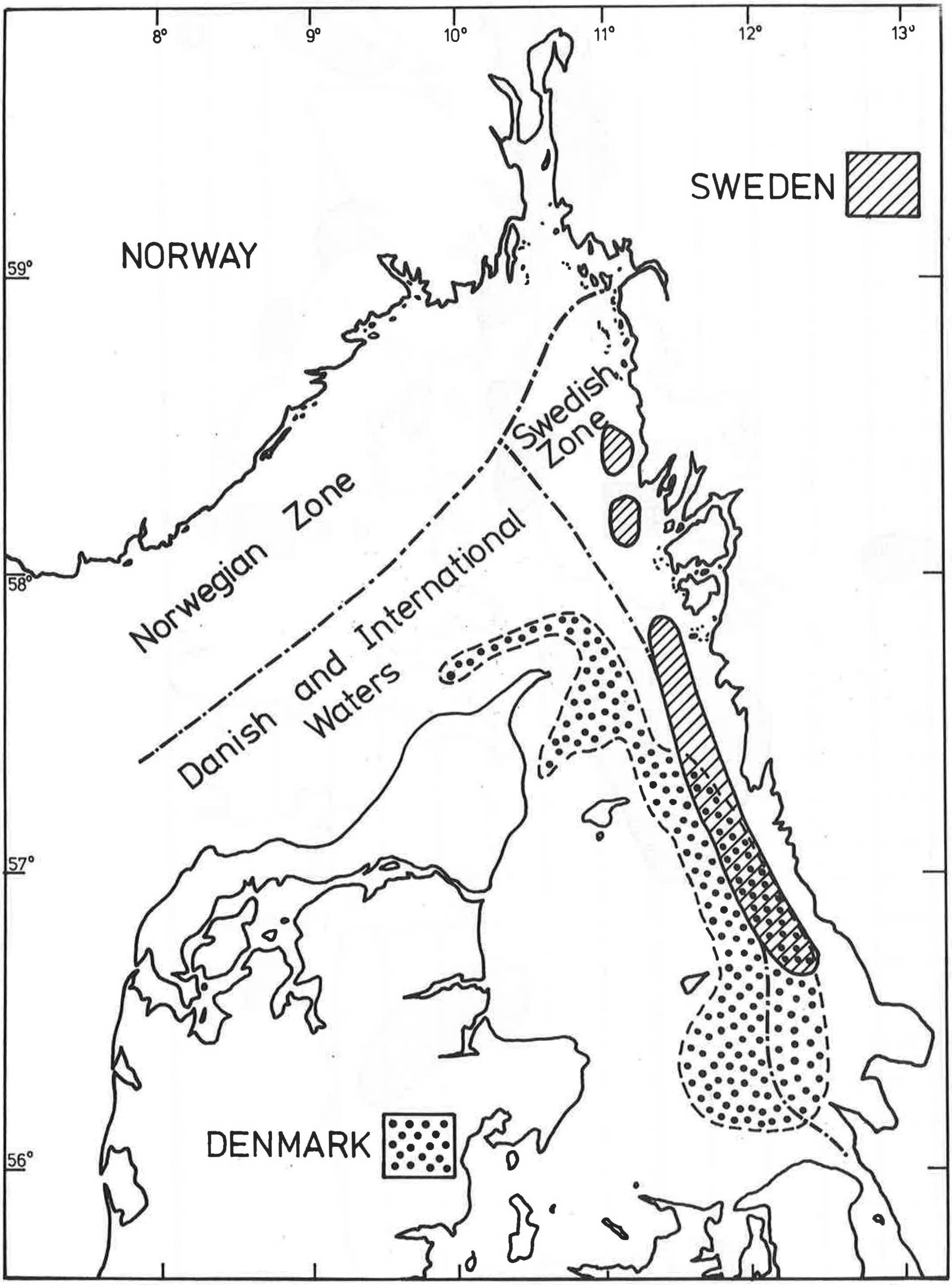
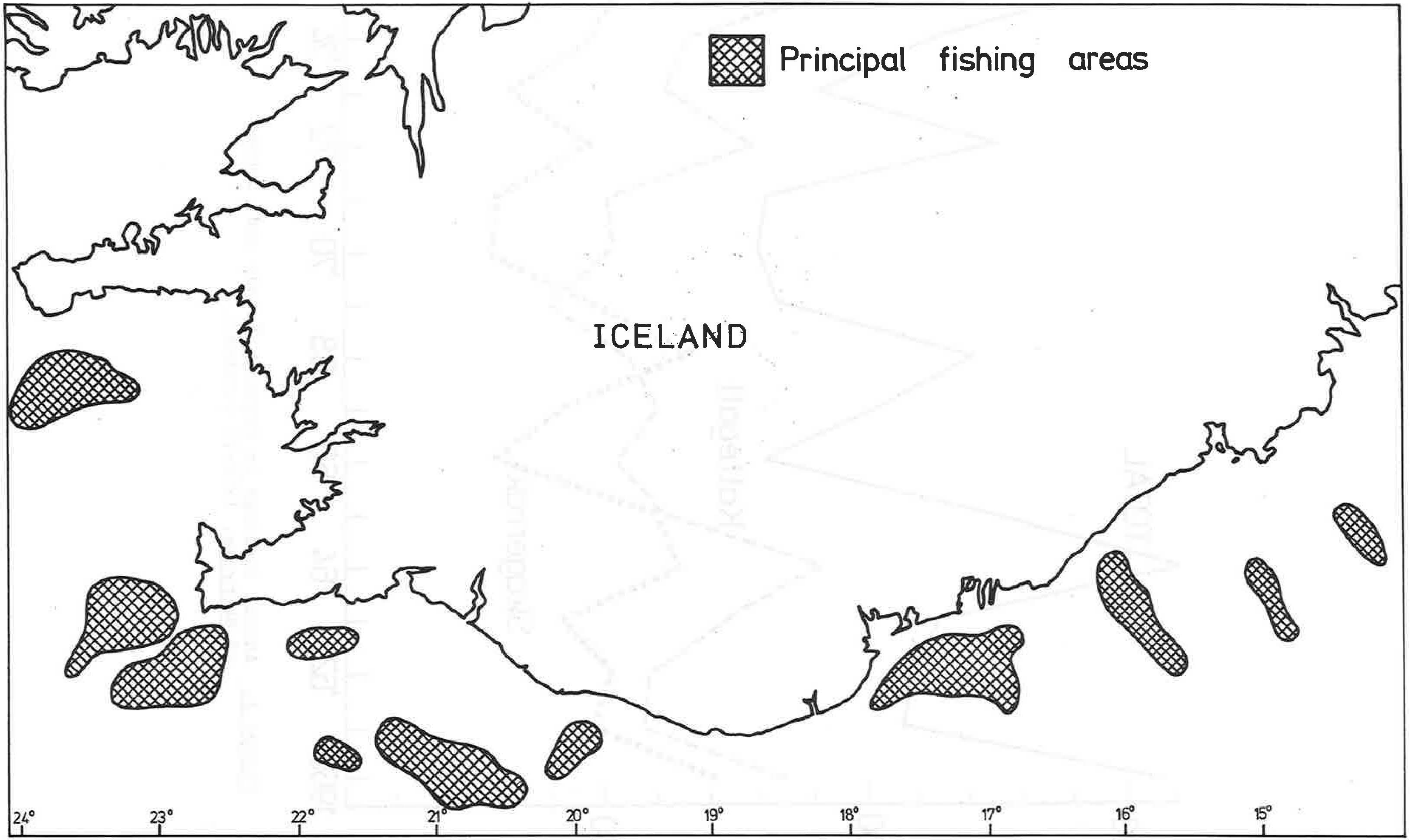


Figure 2. Nephrops fishing areas in Sub-area III.



<u>Figure 3.</u> Principal *Nephrops* fishing areas at Iceland.

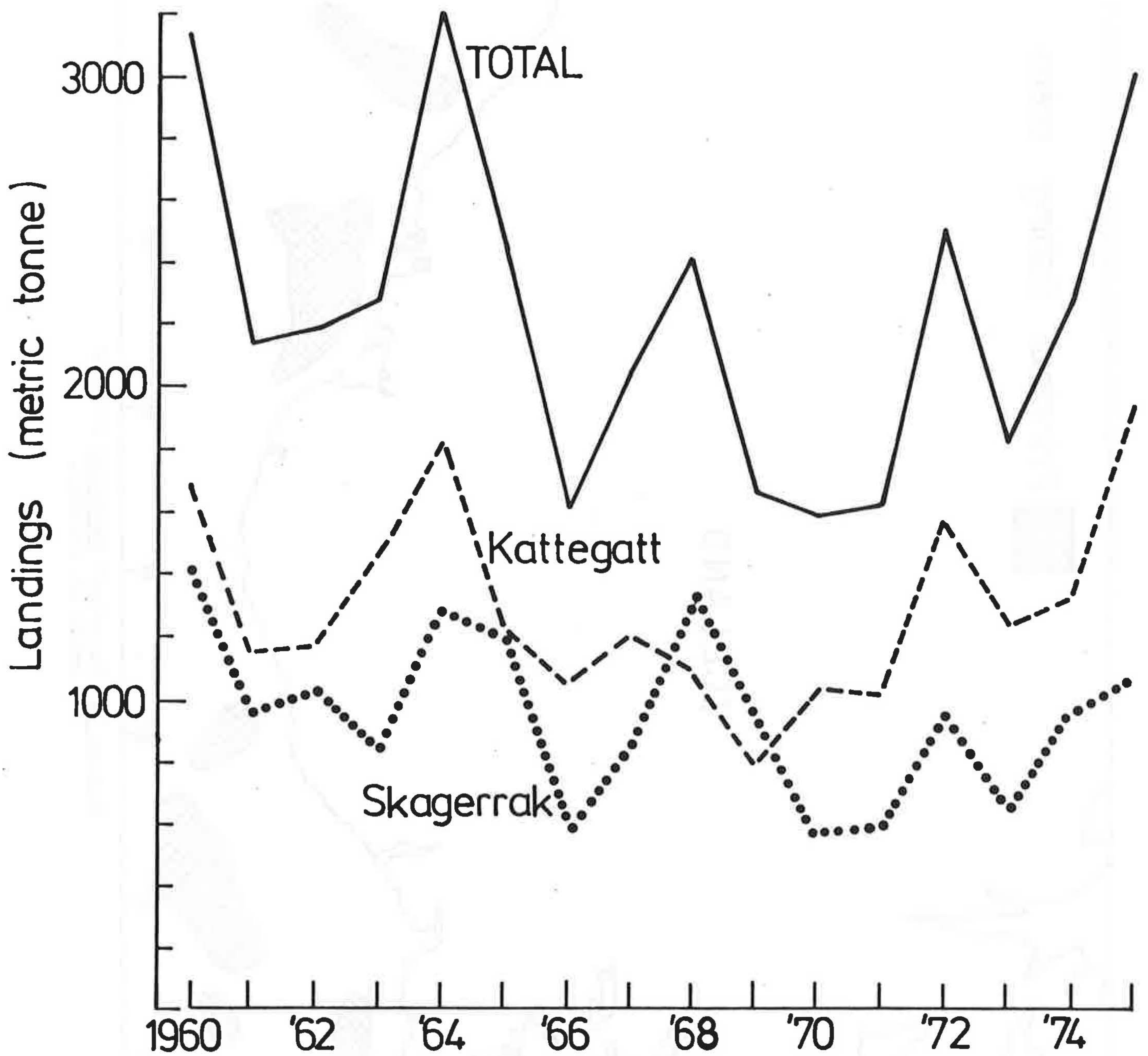


Figure 4. Annual landings in Denmark, Norway and Sweden of *Nephrops*, 1960-75 (tonnes).

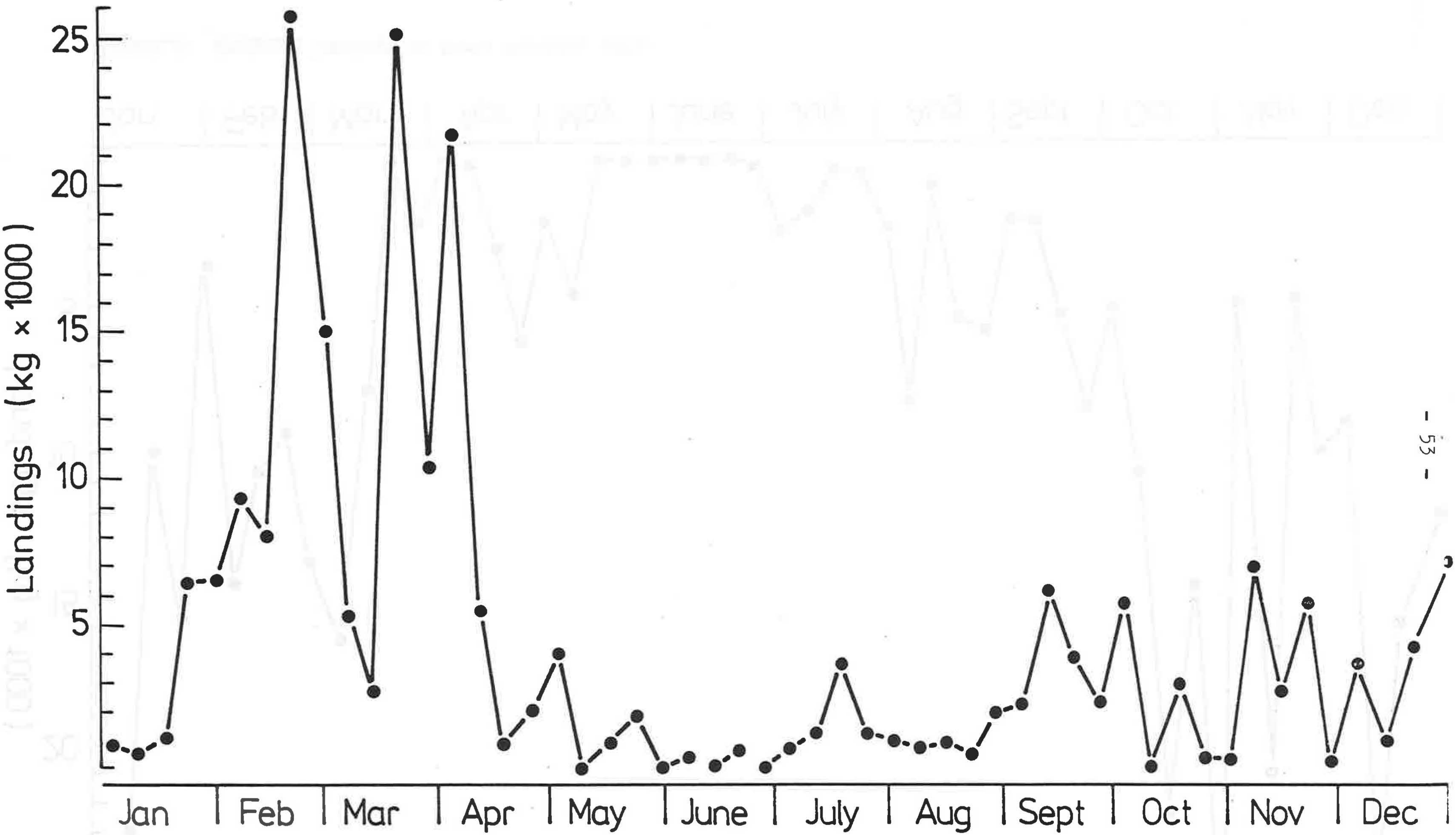


Figure 5. *Nephrops* landings at North Shields, 1974.

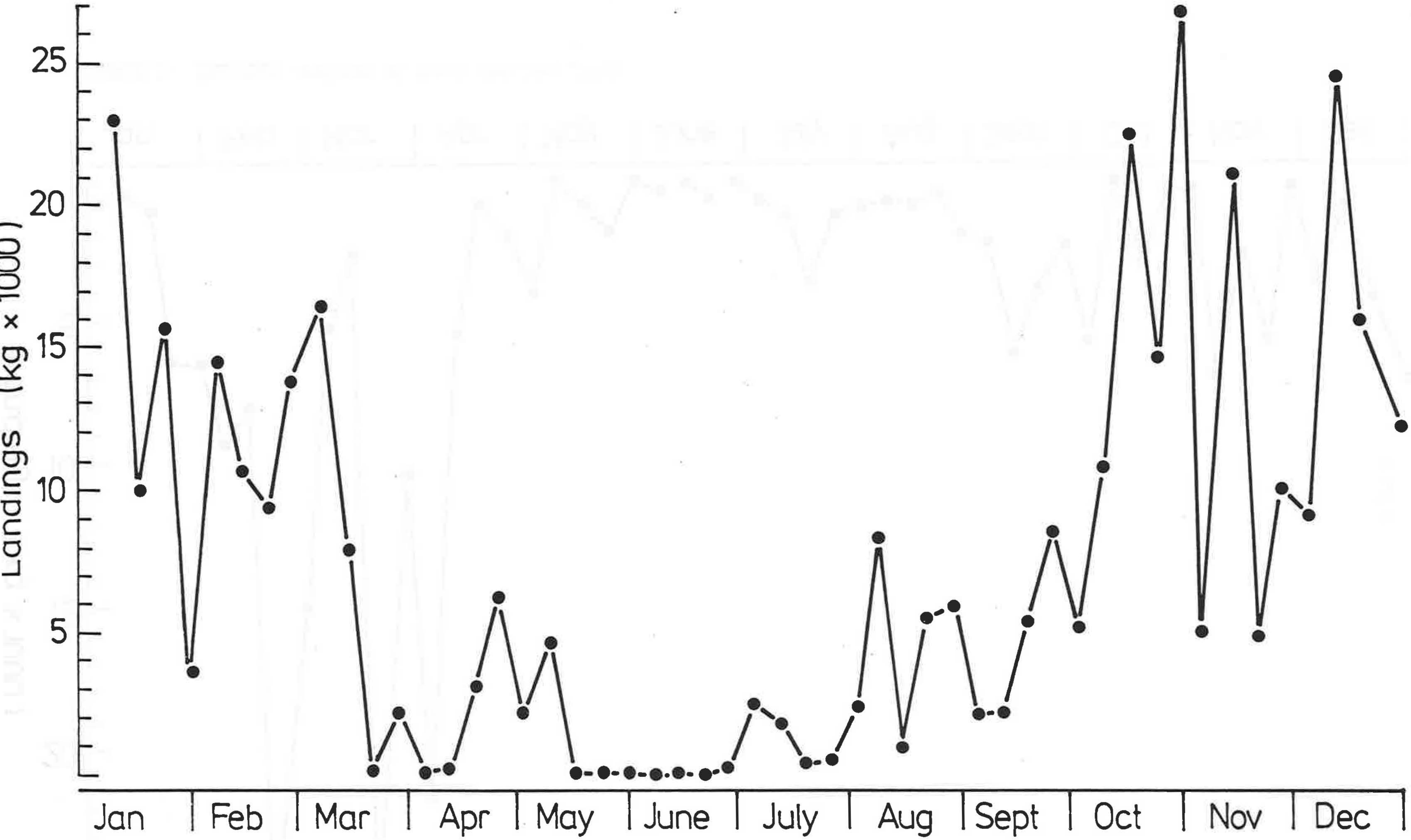
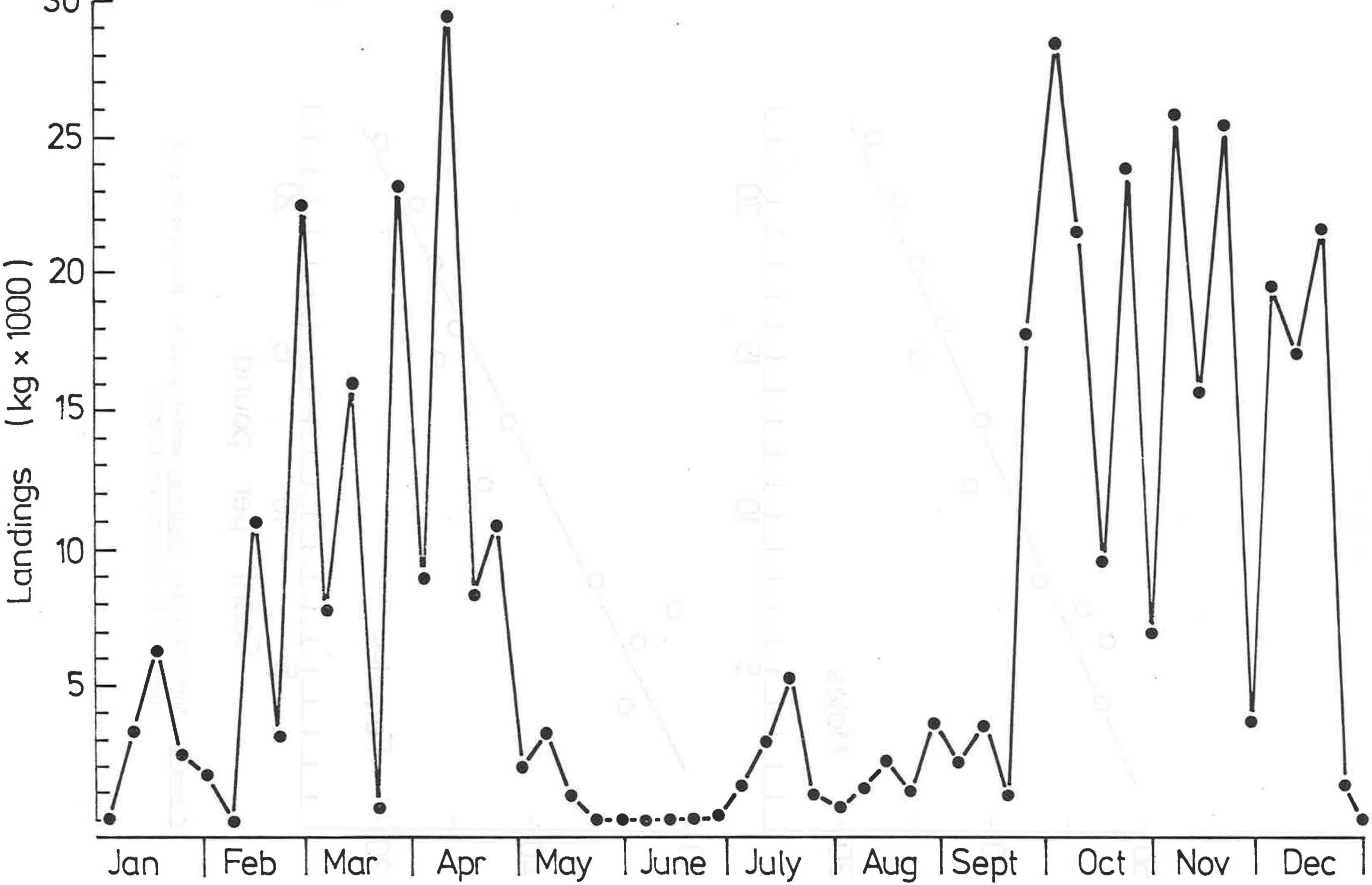


Figure 6. Nephrops landings at North Shields, 1975.



<u>Figure 7</u>. <u>Nephrops</u> landings at North Shields, 1976.

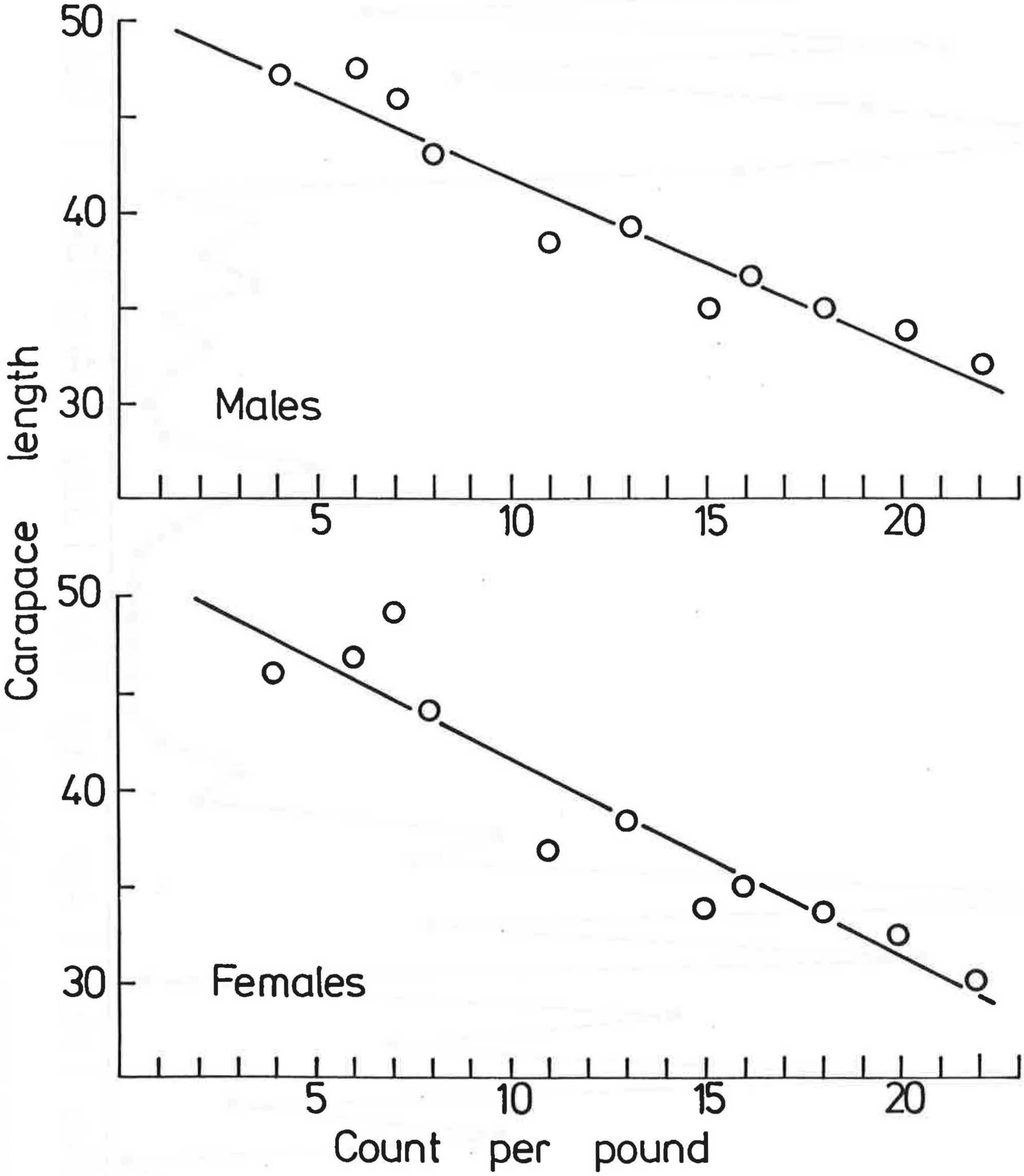


Figure 8. North Shields. *Nephrops* market grades. Relationship of count per lb to carapace length.

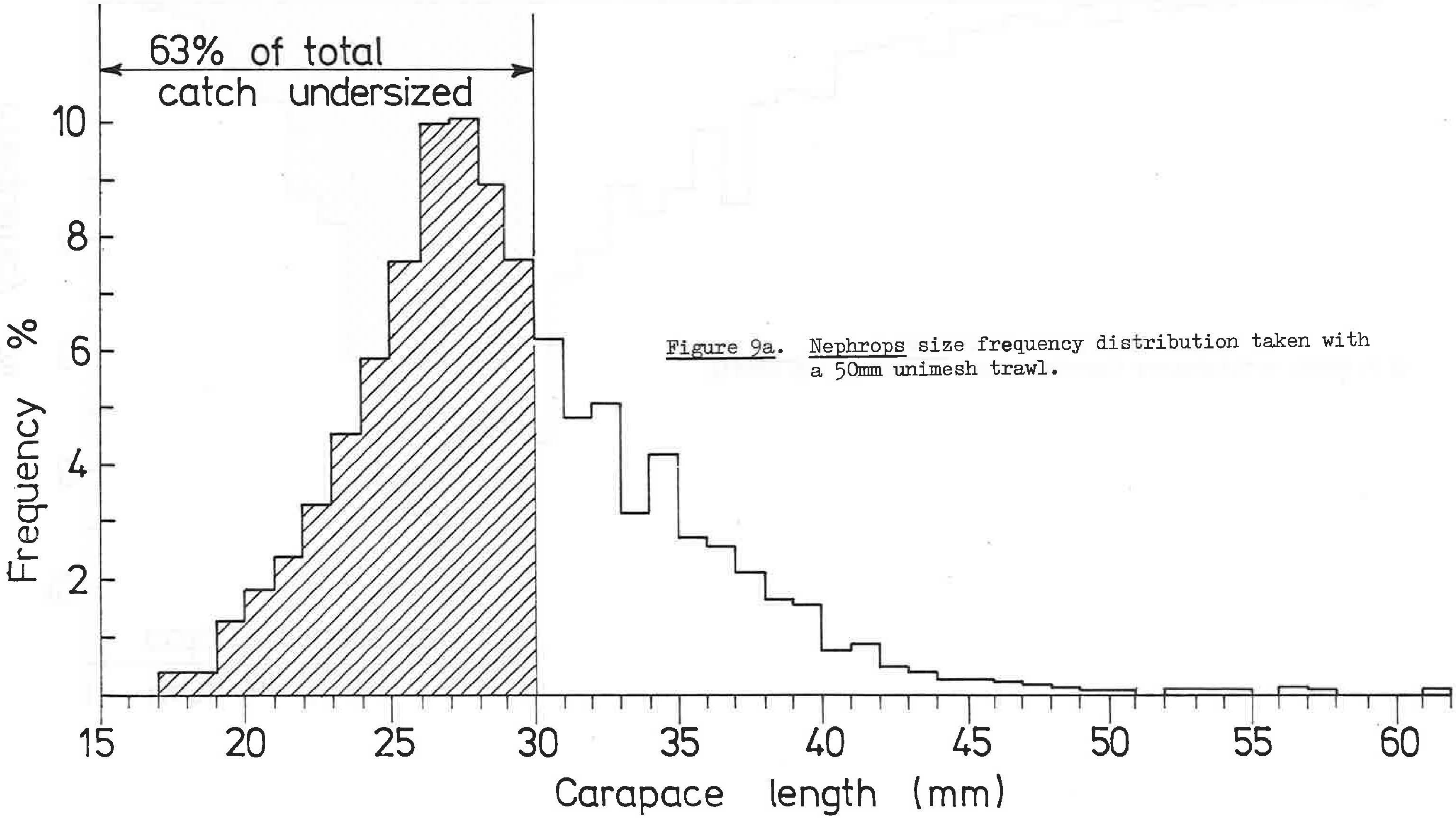


Figure 9a. Nephrops size frequency distribution taken with a 50mm unimesh trawl.

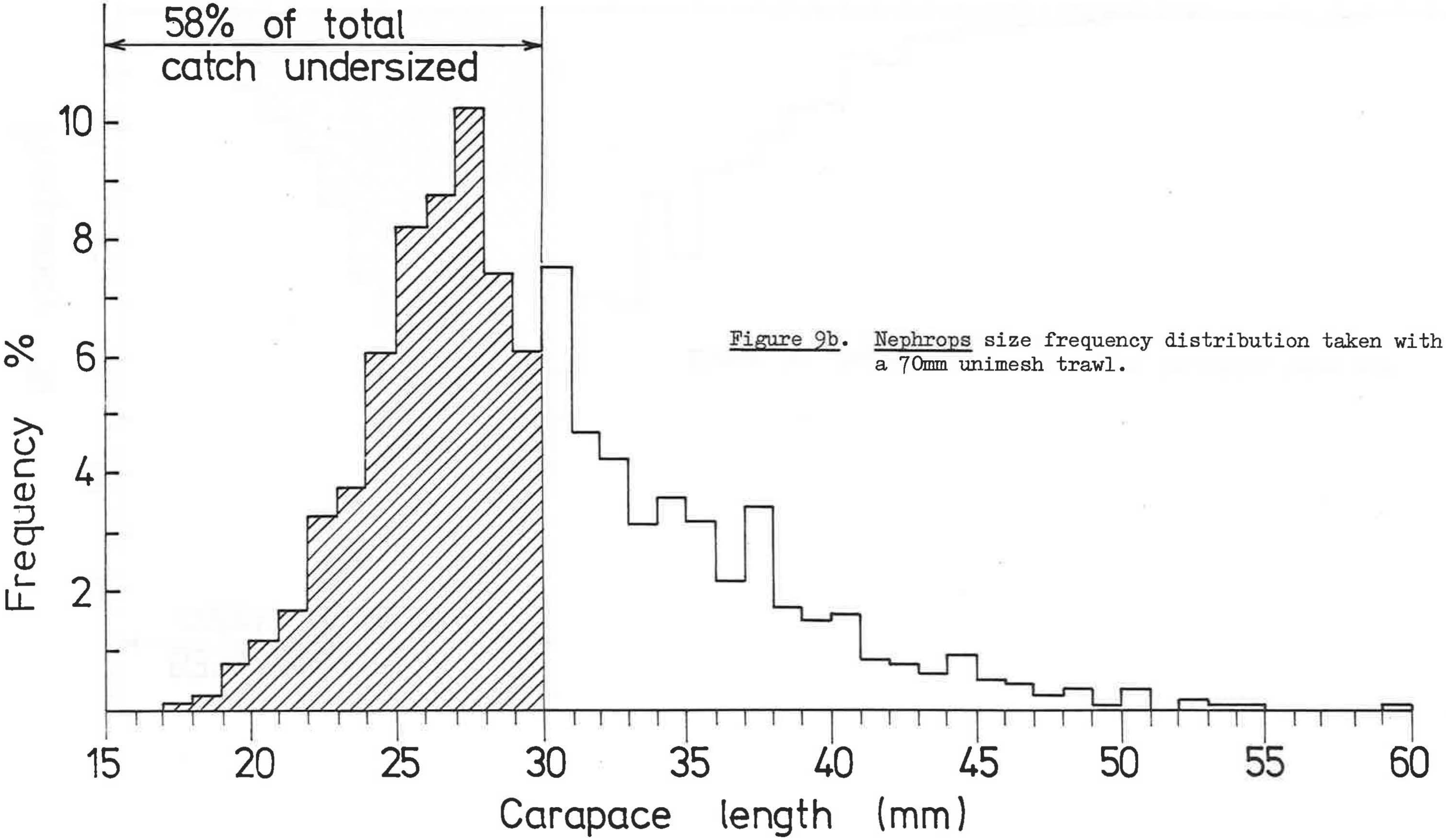


Figure 9b. Nephrops size frequency distribution taken with a 70mm unimesh trawl.

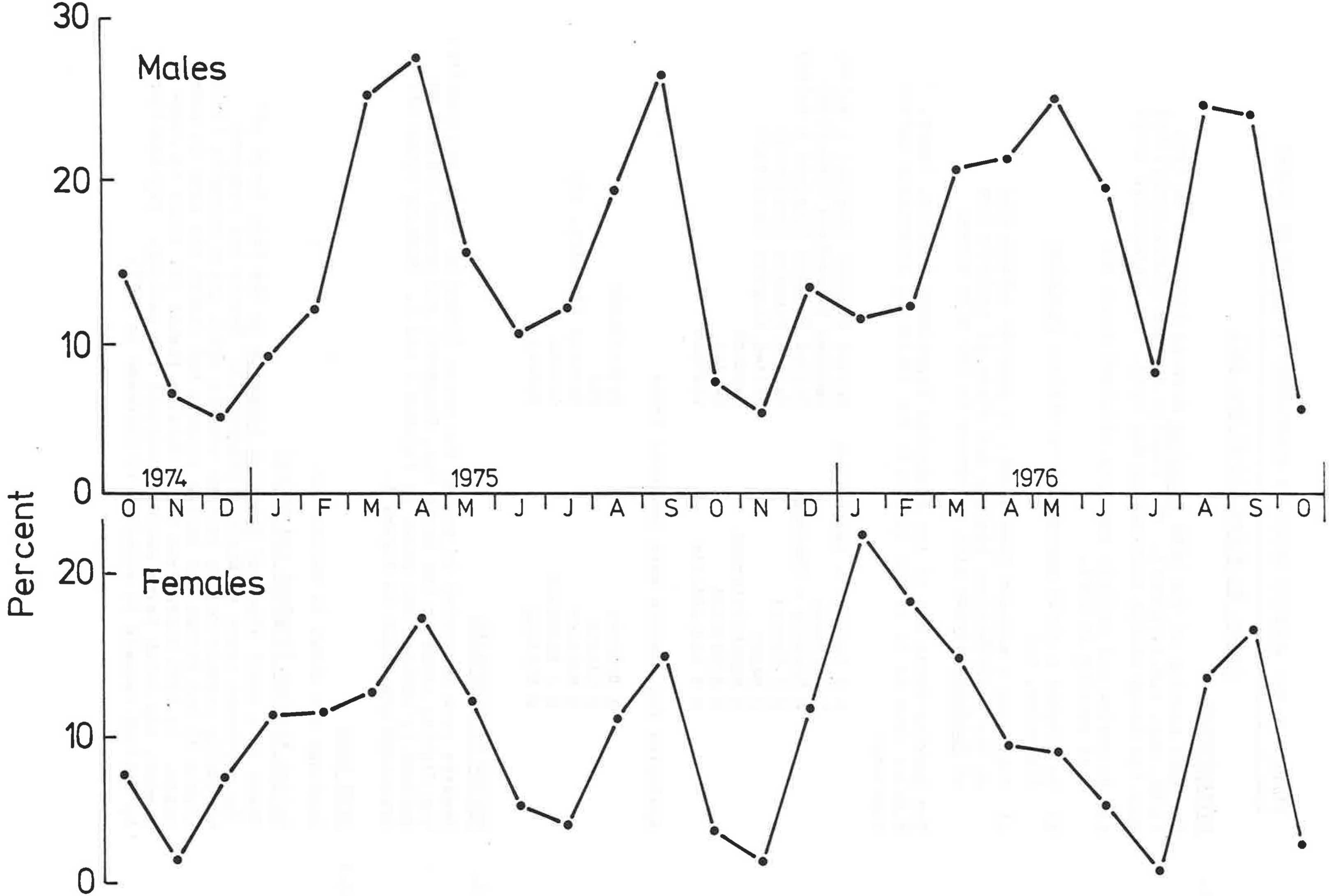


Figure 10. Percentage of Nephrops about to moult.

REPORT OF THE WORKING GROUP ON ASSESSMENT OF *PANDALUS* STOCKS

Conwy, N. Wales, 24-26 May 1977

1. INTRODUCTION

The last meeting of the ICES *Pandalus* Working Group was in 1973 (ICES, Doc. C.M.1973/K:2). The Council decided (C.Res.1976/2:35) that the Group should meet during May 1977. The objectives were:

a) to review and collate any data obtained since the last meeting in 1973,

b) to attempt a yield assessment on various *Pandalus* fisheries, and

c) following a request from NEAFC, to provide information on the distribution, biology and state of exploitation of *Pandalus* stocks with reference to 200 mile zones.

The Working Group met at the Fisheries Experiment Station, Conwy, N.Wales from 24 to 26 May 1977 with the following scientists participating:

D B Bennett - Rapporteur	United Kingdom (England & Wales)
D Carlsson	Denmark (Greenland Fisheries)
E Edwards - Chairman	United Kingdom (England & Wales)
F G Howard	United Kingdom (Scotland)
J Mason	United Kingdom (Scotland)
S Munch-Petersen	Denmark
B Sjöstrand	Sweden
S U Skúladóttir	Iceland

Apologies for absence were received from:

R Boddeke	Netherlands
S Clarke	USA
R Meixner	Germany (Fed.Rep. of)
E J Sandeman	Canada
Ø Ulltang	Norway.

2. REVIEW OF FISHERIES

Members were requested to review the areas fished by their own country. The fishing areas in the North Sea, Skagerrak and around Iceland as defined by members are shown in Figures 1 and 2. Fishing areas off Greenland are shown in Figure 3.

2.1 ICES Area

Landings are shown in Tables 1-4.

United Kingdom (England and Wales)

There is a small stock of *Pandalus borealis* in the Farn Deeps off the northeast coast of England (Figure 1). Stocks had remained virtually unexploited by British vessels until quite recently (1970) (Table 1) but German and Danish vessels had fished the area in some years. In 1976 boats from North Shields fished the stock in June-August, the catch being sent to Scotland for peeling. Exploitation by British vessels is expected to increase in 1977.

United Kingdom (Scotland)

The main fishing ground is Fladen (Figure 1) where catches have increased greatly since fishing started in 1970 (Tables 1-3). Up to 36 vessels worked these grounds in 1976, and fishing occurred during nine months of the year. Landings of Pandalus at Scottish ports increased from just over 100 tonnes in 1970 to almost 2 000 tonnes in 1976 (Table 3). The fishery is continuing to expand and landings are increasing. Catch per unit of effort has increased (Table 5) as the efficiency of Scottish shrimp fishermen improved and also possibly due to increases in shrimp abundance. The catch is processed and 12 peeling machines have now been established at ports on the east coast of Scotland.

Denmark

Since the mid-1960s, apart from the years 1973-74, Fladen (Figure 1) has been the main fishing ground. Following the sudden drop in 1973 the Danish catches from Fladen have slowly increased (Table 3). Catch per unit of effort by Danish boats in the area has fluctuated in recent years (Table 5). Catches from the Skagerrak (Figure 1) have been reasonably stable during the last seven years (Table 4).

Sweden

Most of the Swedish catch is taken in the Skagerrak (Table 4), and a variable proportion from the northern North Sea (Norwegian Deeps) (Figure 1). Fishing effort has been reduced but catch per unit of effort, which fell from 1970 to 1973 increased (Table 5). Data on c.p.u.e. are available from selected boats, but from 1977 onwards it is obligatory for Swedish fishermen to record catches, fishing effort and area.

Iceland

The fishery for Pandalus borealis is buoyant (Table 1); new stocks have been located both offshore and inshore (Figure 2) and the c.p.u.e. is high in some areas. The fishery is well managed by means of a quota system based on changes in c.p.u.e. which is closely monitored. Quotas relate to total annual catches but are modified on a weekly basis for the benefit of processors.

2.2 ICNAF Area

Greenland

Fisheries exist close inshore and in deeper water offshore (Figure 3, Table 6). In general, the inshore stocks are heavily exploited but the offshore fishery is expanding rapidly with catch rates of up to 15 tonnes/hour recorded. The offshore grounds are also exploited by vessels from Faroe, Denmark, Norway, USSR, Spain, France and Japan. The effort from Greenland is increasing. The offshore fishery is regulated by ICNAF with a TAC of 36 000 tonnes for 1977.

3. DISTRIBUTION AND STATE OF EXPLOITATION WITH REFERENCE TO 200 MILE FISHERY ZONES

3.1 Distribution of Stocks

The distribution of the main fisheries for Pandalus borealis is shown in Figures 1-3. Pandalus is a demersal species which forms discrete stocks. There is no evidence that juveniles or adults migrate between stocks although there is evidence of movement within stocks and larval dispersal could occur over a wide area. With the exception of the offshore Greenland stock, most stocks are of limited extent geographically, determined by the nature of the bottom deposit. Except for the Skagerrak population, which is fished by Norway, Sweden and Denmark, most stocks are within the 200 mile zones of individual countries. For example, in the North Sea both the Farn Deep and Fladen stocks lie within the United Kingdom 200 mile fishery zone. Icelandic stocks are also within this country's own zone. In the Greenland fishery, a small proportion of the catch is taken from Canadian waters but the remainder comes from Greenland's 200 mile zone.

3.2 State of Exploitation

Little is known about the state of exploitation of *Pandalus* stocks - the assessment completed by the Working Group suggests that fishing mortality varies for different fisheries but was mostly in the range F = 0.7 - 1.0, although less than this at Iceland (Arnafjördur) (Table 10).

3.3 It should be recorded that observations by the Department of Agriculture and Fisheries for Scotland suggested that stocks of *Dichelopandalus bonnieri* exist off the Scottish west coast which are not at present exploited.

4. MESH SIZES IN USE

Pandalus borealis is included in the species listed under NEAFC Recommendation 2, which permits the use of cod end meshes of less than 50 mm, but not smaller than 16 mm. There are national regulations existing in some countries. Details of mesh sizes in use in the various countries are given below:

United Kingdom:	minimum of 16 mm cod end [Under the Fishing Nets (NE Atlantic) Order 1977], cod ends usually 25-28 mm
Denmark:	no regulations, cod ends usually 25-28 mm
Sweden:	no regulations, cod ends usually 35 mm
Iceland:	national regulations stipulate a 35 mm cod end. It has been proposed to increase this to 38 mm in 1979
Greenland:	offshore fishery 40 mm cod end enforced by ICNAF. Inshore - no regulation.

5. MINIMUM LANDING SIZE

Only Iceland regulates the size of *Pandalus borealis* landed for commercial use, and has a minimum standard of 300 shrimps per kg. Greenland has a minimum landing weight of 2g but this is based on a market requirement and is not a national regulation.

6. BIOLOGY

6.1 Reproduction

Sex reversal in most shrimps seems to occur in all areas considered, except Greenland, at 16-17 mm carapace length. In Greenland it occurs at a larger size of 20-25 mm carapace length.

Data were presented to estimate size and age at maturity for females (Table 9). The following criteria have been used to describe maturity - first berried, 50%, and 100% berried. The more northern stocks mature at a large size and considerably greater age. Data on the fecundity of the species were limited: Allen (1959) reported that in the Farn Deep (NE England) the number of eggs carried varied between 300 and 1 500. Hjort and Ruud (1938) and Horsted and Smidt (1956) working in Greenland waters reported much higher counts, up to 3 860 eggs per shrimp. It appears that females in northern waters are more fecund than in the North Sea. The eggs are spawned in August to November and are carried until the following spring.

6.2 Migrations

The Group agreed that no data were available to suggest any definite migration patterns between the main Pandalus stocks. After hatching the larvae are pelagic for about 3-4 months, little is known about larval drift but it could form a source of recruitment to other stocks. There is evidence, based on limited tagging studies and observation by fishermen that local movements occur within stocks. Reference was made to the vertical distribution of Pandalus in relation to light intensity (Barr, 1970).

6.3 Predation

Cod is a main predator on Pandalus, followed in the central North Sea by the hagfish. Other recorded predators include Greenland halibut, hake, seals and, to a small extent, haddock. Predation pressure on Pandalus borealis is considered to be considerable, resulting in quite high levels of mortality, particularly on Fladen and in the Skagerrak.

7. YIELD ASSESSMENT

Yield assessments were carried out on the Fladen, Skagerrak and Iceland (Arnafjördur) P. borealis stocks using the Beverton and Holt (1959) dynamic pool yield model.

7.1 Input Parameters

Growth - The constants (K, W_∞ and t_o) of the von Bertalanffy (1938) growth equation (Table 7) necessary for the Beverton and Holt yield equation, were obtained by analysis of size composition data. Poly-modal size-frequency distributions were analysed either by Cassie's (1954) or Bhattacharya's (1967) techniques (Fladen and Skagerrak) or Skúladóttir's (1976) deviation method (Iceland) to identify the modes which were assumed to be year classes; the differences in length between modes being the annual growth rate. There were some very noticable differences between the growth constants for the three P. borealis stocks considered. The rate of growth (K) in the Skagerrak, and more so in Iceland, was lower than for the Fladen stock. Conversely W_∞ was low (W_∞ = 10.5g, L_∞ = 27.2 mm carapace length) for the Fladen and higher for Iceland (W_∞ = 18.3g, L_∞ = 31.0 mm) and the Skagerrak (W_∞ = 22.0g, L_∞ = 34.5 mm). The number of year classes is similarly related with only 4 present in the Fladen stock and up to 10 in Iceland. Thus, in more northern and colder waters, although the growth rate is reduced, it appears that the survival rate is greater.

The following length/weight relationships were used where necessary:

(CL = carapace length)

Fladen: Wt (g) = 0.00264. $CL^{2.551}$ (mm)

Skagerrak: Wt (g) = 0.00207. $CL^{2.618}$ (mm)

Iceland: Wt (g) = 0.00519. $CL^{3.05}$ (mm)

Maximum age (t_λ) and age at recruitment (t_r) - the last observed mode of the polymodal size frequencies was taken to be the maximum age for the Fladen and Skagerrak stocks. As no migrations are known to occur, it was assumed that the stock is fully recruited to the potentially fishable stock from age zero.

Natural mortality (M) - considerable attention was given to the estimation of natural mortality. Size composition data from a stock of P. borealis off southwest Iceland have been examined by the deviation method and an estimate of natural mortality of M = 0.5 obtained from the "catch curve" produced. The values of M chosen for the assessment of the Arnafjördur Icelandic stock were 0.3 and 0.2 as less large cod are present there than off southwest Iceland.However, a higher natural mortality was believed to be more appropriate for the Fladen and Skagerrak stocks. No direct estimate of M was possible. The Skagerrak stock, and particularly the Fladen stock have fewer year classes present than the Icelandic stocks and the growth rate is higher, with a higher K and larger W_∞ (Table 7). This suggests that M is higher in these two stocks. Values of M = 0.5 and 1.0 were chosen for the assessment.

Selectivity - data from selectivity experiments conducted by Denmark, Iceland, Norway, Scotland and Sweden were collated and a selection factor of 0.436 ± 0.016 calculated by linear regression through the origin (Figure 4). This selection factor was used for all the stocks considered in the assessment.

Fishing mortality (F) and mean selection age (t_c) - to analyse the relationship between F, t_c and yield-per-recruit, a range of values from F = 0.2 to 2.0 and t_c = 0.5 to 3.5, 5.5 or 6.0 (Fladen, Skagerrak and Iceland, respectively) were used in the assessment.

7.2 Yield Assessment Results and Conclusions

The maximum yield in weight-per-recruit ($(Y_W/R)_{max}$) is very sensitive to the level of natural mortality (M). An increase in M from 0.5 to 1.0 resulted in a 61% drop in $(Y_W/R)_{max}$ for the Fladen and a 68% drop for the Skagerrak (Table 8, Figures 5 and 6). The $(t_c)_{max}$ was reduced from 2.0 to 1.0 for the Fladen and 2.5 to 1.0 for the Skagerrak when M was increased from 0.5 to 1.0 (Table 8).

Lower values of M were used for the assessment of the Icelandic stock. An increase in M from 0.2 to 0.3 resulted in a 40% drop in $(Y_W/R)_{max}$, with $(t_c)_{max}$ dropping from 5.5 to 4.0 years (Table 8, Figure 7).

The $(Y_W/R)_{max}$ occurred at an $(F)_{max}$ of 2.0 for all three stocks assessed (Table 8, Figures 5-7). In fact, the true $(F)_{max}$ was probably greater than 2.0, the maximum F input used.

With such high estimated natural mortalities, particularly for the Fladen and Skagerrak stocks of P. borealis, maximum yields were obtained with a high fishing mortality and low mean selection age - the ideal conditions for recruitment failure! The high natural mortality rates used result in flat-topped Y_W/R curves (Figure 8) in which, above fairly low levels of fishing mortality, further increases in F produce only small gains in Y_W/R. For example, for the Fladen when M = 0.5, an increase in F from 1.0 to 2.0 at a t_c of 2.0 would result in an increase of only 15% in Y_W/R from 915 to 1 056g/1 000 recruits. For the

Skagerrak when M = 0.5, an increase in F from 1.0 to 2.0 at a t_c of 2.5 would result in an increase of only 6% in Y_W/R from 894 to 949g/1 000 recruits.

Although the estimated natural mortality for the Arnafjördur, Iceland stock is lower (0.2-0.3) than for the Fladen and Skagerrak, the lower growth rate of P. borealis in the colder Icelandic waters also produces a flat-topped yield curve (Figure 8). Thus, when M = 0.2, an increase in F from 1.0 to 2.0 at a t_c of 5.5 results in an increase of only 3% in Y_W/R from 1 929 to 1 978g/1 000 recruits. There would seem to be little advantage in having a level of fishing mortality above 1.0.

The mean selection ages $(t_c)_{max}$ at maximum yield per recruit $(Y_W/R)_{max}$ were low for the Fladen and Skagerrak P. borealis stocks (Table 8), being 2.0 and 2.5 years, respectively when M = 0.5, and 1.0 years for both stocks when M = 1.0. For Iceland $(t_c)_{max}$ was 5.5 with M = 0.2 and 4.0 when M = 0.3, both being considerably higher than for the other two stocks - a consequence of the lower natural mortality.

Comparison of these $(t_c)_{max}$ values (Table 8) with age at maturity for females data (Table 9) shows that for the Fladen and Skagerrak stocks the $(t_c)_{max}$ for M = 0.5 is at about the age of 50% berried, while the $(t_c)_{max}$ for M = 1.0 is below the age when berried females are first recorded. For the Icelandic stock the $(t_c)_{max}$ values at M = 0.2 and 0.3 correspond to the age at 100% berried and 50% berried, respectively (Table 9).

Nothing is known about the stock/recruitment relationship for P. borealis, but it is clearly undesirable to fish the Fladen and Skagerrak stocks at the $(t_c)_{max}$ when M = 1.0, or even to have a high rate of exploitation at the $(t_c)_{max}$ if M = 0.5. The Icelandic stock could probably be fished at the $(t_c)_{max}$ values without the likelihood of recruitment overfishing as long as the fishing mortality was not excessive.

8. MANAGEMENT PROPOSALS

The yield assessment carried out suffers from a lack of certain reliable estimates of input parameters - particularly natural mortality. However, utilisation of the assessment results, together with known data on age at maturity, in a comparison with the present estimated mean selection age and fishing mortality suggests certain management actions.

8.1 Fladen

The present mesh size used by both the Danish and Scottish fishermen exploiting this stock is 25 mm (Table 10). This is equivalent to a t_c of 0.7 yr (11.0 mm carapace length), and age well below the age at first maturity for females (Table 9) and below the $(t_c)_{max}$ even if M is as high as 1.0 (Table 8). This is clearly an undesirable situation, particularly in relation to future recruitment.

It is proposed (Table 10) that the mesh size for both Denmark and Scotland (or any other country) fishing on the Fladen be increased to 35 mm. This is equivalent to a t_c of 1.5 yr (15.4 mm carapace length).

The present level of fishing mortality is believed to be about F = 1.0. This level of F should not be allowed to increase.

8.2 Skagerrak

The Danish fishery in the Skagerrak uses a mesh size of 25 mm (as on the Fladen), while the Swedish fishery uses a mesh of 35 mm (Table 10).

These sizes are equivalent to a t_c of 1.0 yr (11.0 mm carapace length) and 1.7 yr (15.0 mm carapace length) respectively, ages well below or at about the age at first maturity for females (Table 9). They are below the $(t_c)_{max}$ when M = 0.5 and above or equal to the $(t_c)_{max}$ at M = 1.0 (Table 8). Again, this is an undesirable situation.

It is proposed (Table 10) that the mesh size for both Denmark and Sweden (or any other country) fishing in the Skagerrak be increased to 45 mm. This is equivalent to a t_c of 3 yr (20 mm carapace length).

The present level of fishing mortality is believed to be about F = 0.7. This level of F should not be allowed to increase.

8.3 Iceland

The Icelandic authorities have already made management proposals which have been accepted. These recommendations are repeated here, together with the assessment results to allow comparison with the more southern stocks considered.

The present mesh size in use in Arnafjördur, Iceland is 35 mm (Table 10). This size is equivalent to a t_c of 2.6 yr (15.4 mm carapace length), at an age below the age at first maturity for females (Table 9) and well below the $(t_c)_{max}$, even if M = 0.3 (Table 8).

It has been proposed to increase by 1979 the mesh size in use on the Icelandic fishery to 38 mm. This is equivalent to a t_c of 3 yr (16.7 mm carapace length).

The present level of fishing mortality is F = 0.3, as a result of quota management in recent years. It has been proposed that F should be allowed to increase to F = 0.4 - 0.5.

9. EFFECTS OF PROPOSED CHANGES IN MESH SIZE

9.1 Yield

If the mean selection age and fishing mortality were selected to maximise yield per recruit (Table 8) recruitment failure would be expected. For this reason, although little is known of the stock/recruitment relationship, the proposed mean selection age and fishing mortalities have been chosen to ensure adequate recruitment. This could result in losses in yield per recruit, particularly if natural mortality is high. The increase in mesh size to 45 mm in the Skagerrak could result in a 50% drop in yield per recruit. However, the over-riding necessity to conserve the breeding stock and ensure adequate recruitment justifies this loss in yield per recruit. It is expected, of course, that the total yield from the fisheries will increase as a result of these management measures.

9.2 By-catch

Considerable quantities of fin-fish by-catches result from the *Pandalus* fisheries. The Scottish fishery on Fladen lands a by-catch of normal commercial sized cod, Norway pout, haddock, monk and dogfish (Table 11). The proportion of by-catch landed varies from 19% to 59% of the total landed catch by weight and from 12% to 28% by value (Table 12). The proposed increase in mesh size from 25 mm to 35 mm on the Fladen is not expected to affect the composition or proportion of landed by-catch from Scottish vessels.

The Danish fishery for *Pandalus* both at Fladen and in the Skagerrak lands a by-catch, mainly of Norway pout, for reduction to fish meal.

This by-catch can be nearly 10 times the weight of the Pandalus landed, but only 3-37% by value, and has become less important in recent years (Table 12). The increases in mesh size proposed, to 35 mm for the Fladen and 45 mm for the Skagerrak, would undoubtedly reduce the by-catch, particularly of Norway pout. It has not been possible to assess these losses, but the loss in value is likely to be small and the expected increase in Pandalus landings resulting from the mesh increases will more than compensate for these losses.

In Iceland shrimp fisheries are stopped in an area when the number of young gadoids caught exceeds that which is considered desirable at the time. This depends upon certain conditions, such as, the year class strength of the gadoids.

The beneficial effect on fin-fish fisheries from a reduction in the by-catch from Pandalus fisheries could not be assessed by the Working Group. It was noted that recent Norwegian trials on selective trawls were encouraging (Thomassen and Ulltang, 1975).

10. RECOMMENDATIONS FOR FUTURE RESEARCH

Although the Working Group was able to carry out a yield assessment for three of the stocks in the ICES area and put forward management proposals, there is plenty of scope for future research.

The major assessment input requiring study is natural mortality, followed closely by age determination and growth rates. There is a need to consider more carefully stock identity and to consider the origin of recruitment, particularly in relation to larval distribution. Although data on selectivity were presented to the meeting, there is a need for further studies, particularly of selection in parts of the trawl, other than the cod end. Further studies on reproduction, such as identifying first time spawners, would be useful. The management proposals have raised a number of questions in relation to the fin-fish by-catch. There is scope for the Working Group to consider this aspect of assessment more fully at a later date and to improve on the quality of the assessment.

REFERENCES

Allen, J A, 1959. On the biology of Pandalus borealis Krøyer with reference to a population off the Northumberland coast. J.mar.biol. Ass. U.K, 38(1):189-220.

Barr, L, 1970. Diel vertical migration of Pandalus borealis in Kachemak Bay, Alaska. J.Fish.Res.Bd Can., 27(4):669-676.

Bertalanffy, von L, 1938. A quantitative theory of organic growth. Hum.Biol., 10(2):181-213.

Beverton, R J H and S J Holt, 1957. On the dynamics of exploited fish populations. Fish.Invest., Lond. Ser.2, 19: 533 pp.

Bhattacharya, C G, 1967. A simple method of resolution of a distribution into Gaussian components. Biometrics, 23:115-135.

Cassie, R M, 1954. Some uses of probability paper in the analysis of size frequency distributions. Aust. J.mar.Freshw.Res., 5(3):513-522.

Hjort, J and J T Ruud, 1938. Deepsea prawn fisheries and their problems. Hvalrådets Skr., Norsk.Vidensk.-Akad., Oslo, No.17:144 pp.

Horsted, S Å and E Smidt, 1956. The deepsea prawn (Pandalus borealis) in Greenland waters. Medd. Dansk.Fisk.Havunders., N.S.1 (II):1-118.

Thomassen, T and Ø Ulltang, 1975. Report from mesh selection experiments on Pandalus borealis in Norwegian waters. ICES, Doc. C.M.1975/K:51 (mimeo.).

Skúladóttir, U, 1976. Comparing several methods of assessing the maximum sustainable yield of Pandalus borealis in Arnafjördur. ICES Spec. Meeting on Popul.Assess. of Shellfish Stocks, Paper No.30:13 pp. (to be published in Rapp.Proc.-verb., Cons.int.Explor.Mer, Volume 175).

Table 1. Pandalus borealis landings (tonnes) from the ICES area.
Source: Bulletin Statistique and pers.comm.

Year	Denmark	Germany (Fed.Rep.)	Iceland	Norway	Sweden	England	Scotland	Spain	Total
1960	2 580	-	1 336	9 616	4 039	-	-	-	17 571
1961	3 174	-	1 375	10 036	4 462	-	-	-	19 047
1962	4 448	-	700	10 816	5 725	-	-	-	21 689
1963	4 735	-	678	11 658	5 161	-	-	71	22 273
1964	3 602	-	572	11 017	4 654	-	-	-	19 815
1965	5 074	-	901	10 434	3 867	-	-	-	20 276
1966	4 697	68	1 790	7 406	1 788	-	-	-	15 749
1967	4 791	23	1 508	8 355	1 930	-	-	-	16 607
1968	5 175	41	2 451	7 201	2 025	-	-	-	16 893
1969	5 434	0	3 276	6 353	1 822	-	-	-	16 885
1970	4 217	-	4 510	7 597	2 742	14	104	-	19 184
1971	4 432	33	6 326	7 773	2 906	-	436	-	21 906
1972	3 221	-	5 291	9 111	2 524		187	1 941	22 275
1973	912		7 286	9 267	2 130	1 424	163	-	21 182
1974	812		6 058		2 003	40	434		
1975	2 135		4 525		2 003	0	525		
1976*	2 666		6 256		2 529	140	1 940		

* Preliminary.

Table 2. Pandalus borealis landings (tonnes) from ICES SUB-area IV (North Sea). Source: Bulletin Statistique and pers.comm.

Year	Denmark	Germany (Fed.Rep.)	Norway	England	Scotland	Sweden	Total
1970	3 460	-	1 107	14	104	915	5 600
1971	3 572	33	1 265	-	436	1 358	6 664
1972	2 448	-	1 216	-	187	1 150	5 001
1973	196	-	931	1 424	163	936	2 226
1974	337			40	434	520	
1975	1 392			0	525	252	
1976*	1 801			140	1 940	177	

* Preliminary

Table 3. Estimated Pandalus borealis landings (tonnes) from the Fladen ground.

Year	Denmark	Germany (Fed.Rep.)	Norway	U.K. (Scotland)	Sweden	Total
1970	3 115	-		104		
1971	3 216	33		436		
1972	2 204	-		187		
1973	157	-		163		
1974	282			434		
1975	1 308			525		
1976*	1 522			1 940		

* Preliminary

Table 4. Pandalus borealis landings (tonnes) from ICES Division IIIa (Skaggerak-Kattegat). Source: Bulletin Statistique and pers.comm.

Year	Denmark	Norway	Sweden	Total
1970	757	982	1 827	3 566
1971	834	1 392	1 548	3 774
1972	773	1 123	1 374	3 270
1973	716	1 415	1 194	3 325
1974	475		1 483	
1975	743		1 751	
1976*	865		2 352	

* Preliminary

Table 5. Reported *Pandalus borealis* catch (kg) per hour from Danish and Scottish vessels fishing Fladen, and Danish and Swedish vessels fishing the Skagerrak and Norwegian Channel.

Year	Fladen		Skagerrak and Norwegian Channel	
	Danish boats	Scottish boats	Danish boats	Swedish boats
1970	-	31	-	17
1971	-	68	-	18
1972	117	69	14	15
1973	45	87	9	14
1974	122	124	23	17
1975	187	128	31	20
1976	105	115	38	26

Table 6. Annual landings (tonnes) of *Pandalus borealis* by all nations fishing at West Greenland (ICNAF Sub area 1) 1970-76 (including Greenland inshore catches).

Countries	1970	1971	1972	1973	1974	1975	1976*
Greenland	8 429	8 941	7 368	8 135	10 244	9 893	9 771
Denmark	-	-	-	196	308	1 142	2 717
Faroe	130	496	755	1 371	2 023	5 300	11 179
Norway	-	-	1 409	2 940	5 917	8 678	11 658
Spain	-	-	-	-	-	6 948	6 932
USSR	-	-	-	-	-	6 033	6 468
France	-	-	-	-	-	-	802
Japan	-	-	-	-	-	-	146
Total	8 559	9 437	9 532	12 642	18 492	37 994	49 673

*Preliminary

Table 7. Input parameters for the Beverton and Holt (1959) simple yield per recruit equation for the Fladen, Skagerrak and Iceland (Arnafjördur) *Pandalus borealis* stocks.

(CL = carapace length)

Input	Fladen	Skagerrak	Iceland
K	0.41	0.24	0.16
W_∞ (g)	10.5	22.0	18.3
(L_∞: mm CL)	(27.2)	(34.5)	(31.0)
t_o (yr)	-0.57	-0.64	-1.70
t_λ (yr)	4	6	10
t_r (yr)	0	0	0
R	1 000	1 000	1 000
M	0.5/1.0	0.5/1.0	0.2/0.3
F_{min}	0.2	0.2	0.2
F_{max}	2.0	2.0	2.0
F_{inc}	0.2	0.2	0.2
$t_{c_{min}}$ (yr)	0.5	0.5	0.5
$t_{c_{max}}$ (yr)	3.5	5.5	6.0
$t_{c_{inc}}$ (yr)	0.5	0.5	0.5

Table 8. Summary of the results of the yield assessment for the Fladen, Skagerrak and Iceland *Pandalus borealis* stocks.

	Fladen		Skagerrak		Iceland	
M	0.5	1.0	0.5	1.0	0.2	0.3
$(Y_W/R)_{max}$	1056	412	949	299	1978	1193
$(F)_{max}$	2.0	2.0	2.0	2.0	2.0	2.0
$(t_c)_{max}$	2.0	1.0	2.5	1.0	5.5	4.0

Table 9. Size (mm - carapace length) and age (yr) when *Pandalus borealis* are first berried (= ovigerous), 50% berried and 100% berried.

Stock	1st berried		50% berried		100% berried	
	CL (mm)	Age (yr)	CL (mm)	Age (yr)	CL (mm)	Age (yr)
Fladen	15	1.4	17	1.8	19	2.4
Skagerrak	15	1.7	18	2.4	21	3.3
Iceland (Arnafjördur)	16	2.8	19	4.2	22	6.0

Table 10. Comparison of the present mesh sizes in use and the estimated level of fishing mortality, with the proposed management recommendations for the Fladen, Skagerrak and Iceland (Arnafjördur) fisheries for *Pandalus borealis*.

	Fladen	Skagerrak		Iceland
	Danish and Scottish fisheries	Danish fishery	Swedish fishery	
Present mesh size (mm, stretched)	25	25	35	35
Present mean selection size (carapace length - mm)	11.0	11.0	15.0	15.4
Present mean selection age (years)	0.7	1.0	1.7	2.6
Proposed mesh size	35	45	45	38
Proposed mean selection size	15.4	20.0	20.0	16.7
Proposed mean selection age	1.5	3	3	3
Present fishing mortality (F)	1.0	0.7	0.7	0.3
Proposed fishing mortality (F)	Leave same	Leave same	Leave same	0.4-0.5

Table 11. Composition of the landings of Pandalus and by-catch (metric tonnes) in the Scottish fishery on the Fladen Ground 1970-76.

	1970	1971	1972	1973	1974	1975	1976
Pandalus catch	104	436	187	163	434	525	1940
Value (p.st.)	20186	82190	32588	43131	150561	180469	770071
Total by-catch	149.54	286.35	110.94	75.98	103.80	146.16	526.39
Value (p.st.)	7993	20010	12207	11718	21744	24217	147565
Nephrops	0.05	15.86	3.56	1.40	13.62	1.14	51.48
Squid	-	-	-	-	-	-	4.82
Cod	50.84	87.62	67.69	42.61	57.74	69.80	207.13
Haddock	41.81	35.10	14.12	3.47	2.95	5.52	15.12
Whiting	6.06	11.96	7.33	1.09	1.92	4.15	15.86
Saithe	0.72	1.48	3.70	1.02	4.43	8.84	19.59
Hake	0.17	0.37	0.08	0.06	0.04	0.05	0.98
Lythe (Pollack)	-	-	-	-	-	0.01	-
Ling	1.70	3.63	1.95	4.51	1.16	4.58	12.27
Catfish	1.31	2.23	1.67	1.61	2.56	2.10	3.74
Monk	5.17	9.94	4.28	4.88	13.10	27.23	101.68
Plaice	0.13	0.18	0.25	0.10	0.03	-	0.16
Lemon Sole	0.23	0.14	0.16	0.20	0.02	-	0.43
Witch	2.00	2.08	1.67	1.80	0.82	0.94	2.75
Dab	-	-	-	0.12	0.03	0.11	0.20
Halibut	0.65	0.95	0.42	0.05	0.13	0.18	0.54
Megrim	0.20	0.14	0.23	-	0.15	0.37	0.56
Turbot	0.02	0.16	0.06	0.03	0.10	0.03	0.08
Skate	0.44	1.00	0.43	0.51	0.29	0.87	1.07
Dogfish	0.64	9.37	2.85	3.59	4.51	14.27	20.78
Herring	-	0.12	0.36	-	-	-	-
Mackerel	-	-	-	-	-	0.04	-
Norway Pout	37.39	103.00	-	8.92	-	5.93	66.44
Brill	-	-	-	-	-	-	0.01
Unspecified	-	1.02	0.13	-	-	-	-
Roes	-	-	-	0.01	-	-	-

Table 12. Comparison of Pandalus and by-catch weight (tonnes) and values from the Scottish and Danish fisheries on the Fladen.

	1970	1971	1972	1973	1974	1975	1976
Scottish landings							
Pandalus (t)	104	436	187	163	434	525	1 940
Value (p.st. '000)	20	82	33	43	151	180	770
By-catch (t)	150	286	111	78	104	146	526
Value (p.st. '000)	8	20	12	11	22	24	148
By-catch as % of total value	28.4	19.6	27.3	21.4	12.6	11.8	16.1
Danish landings*							
Pandalus (t)	-	-	2 204	157	282	1 309	1 522
Value ('000 D.Kr.)	-	-	11 990	1 226	2 262	8 417	11 916
By-catch (t)	-	-	27 100	1 161	801	685	841
Value ('000 D.Kr.)	-	-	7 050	685	462	231	614
By-catch as % of total value	-	-	37	36	17	3	5

* Estimated from the landings in the ports of Skagen, Hirtshals and Hanstholm.

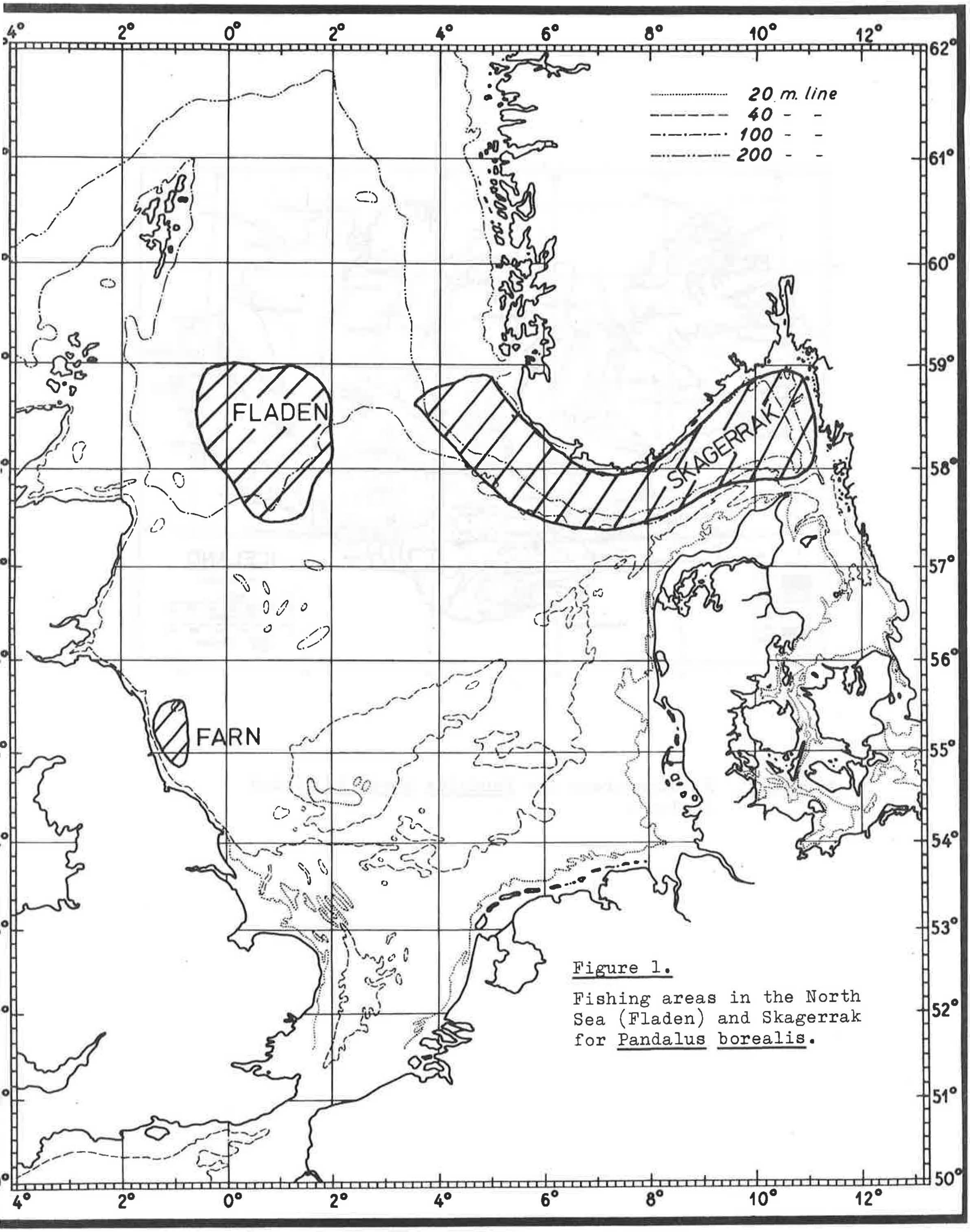


Figure 1.

Fishing areas in the North Sea (Fladen) and Skagerrak for Pandalus borealis.

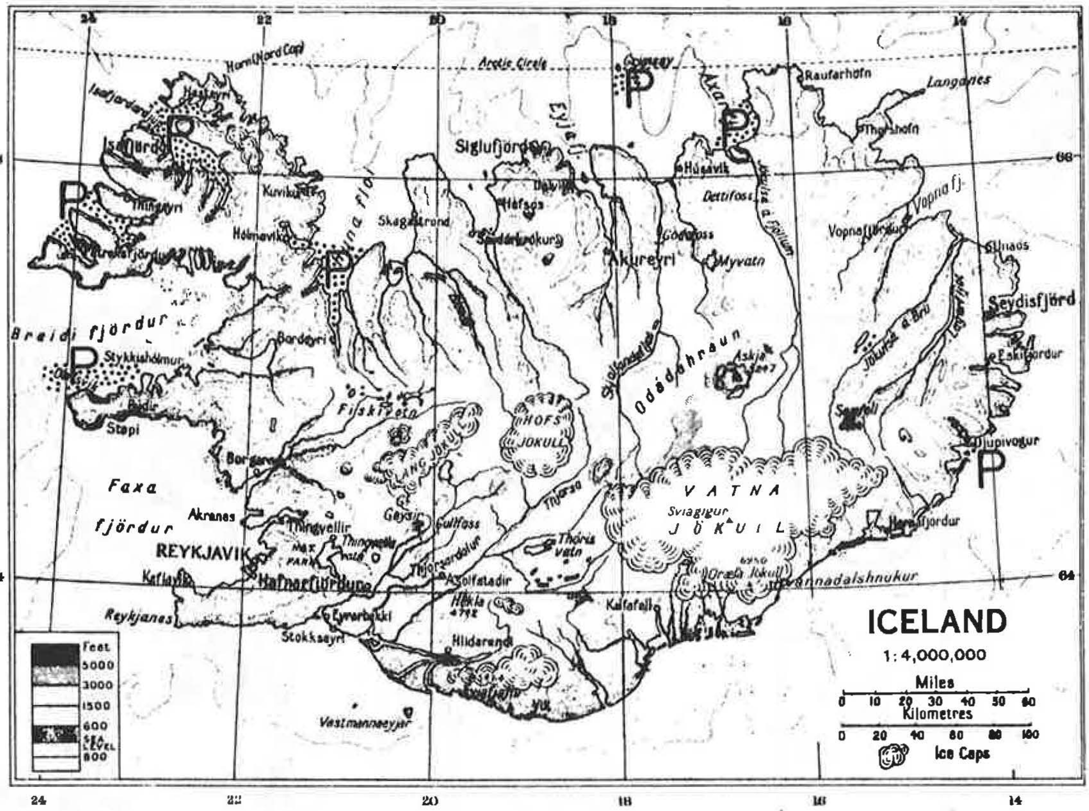


Figure 2. Fishing areas for Pandalus borealis around Iceland.

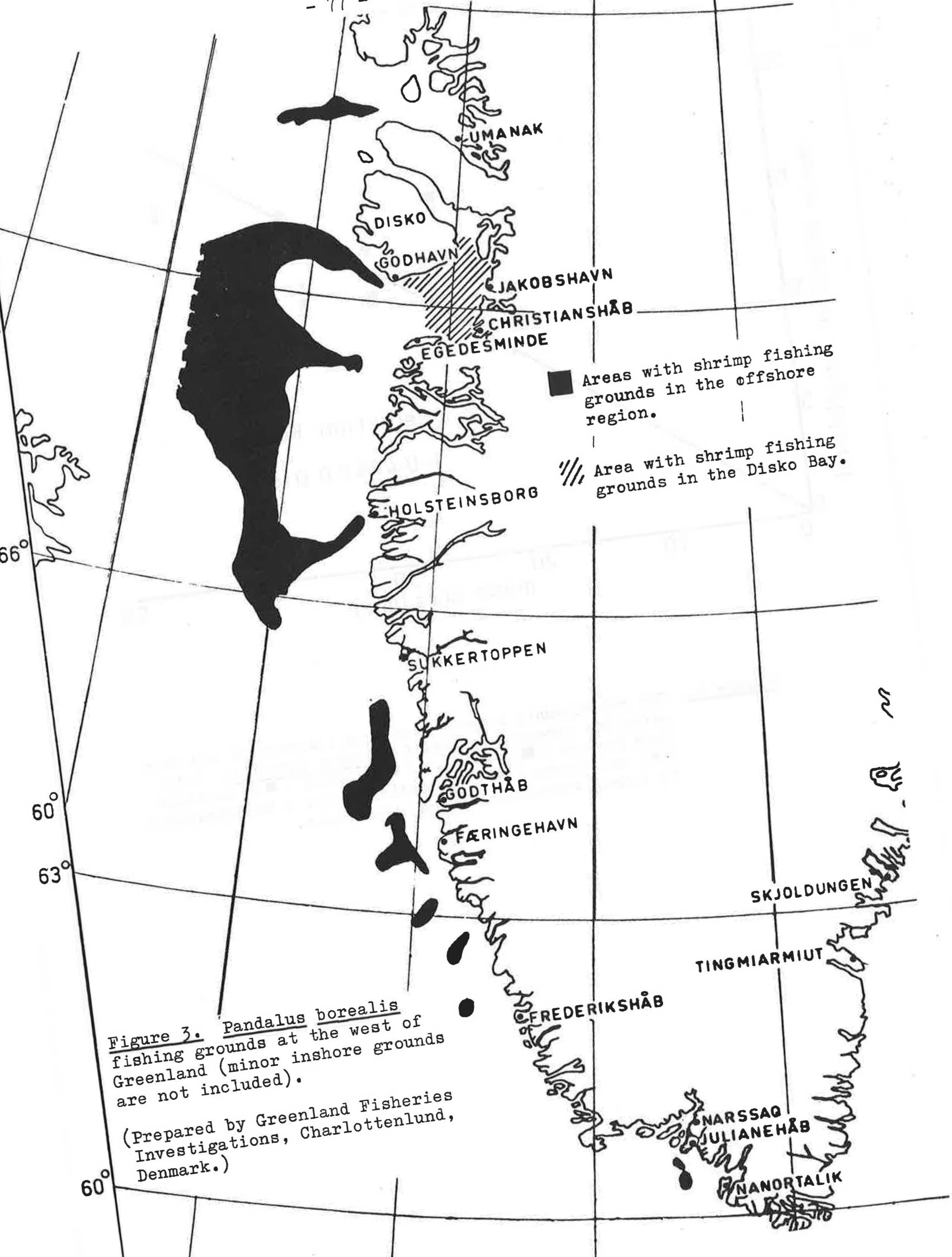


Figure 3. Pandalus borealis fishing grounds at the west of Greenland (minor inshore grounds are not included).

(Prepared by Greenland Fisheries Investigations, Charlottenlund, Denmark.)

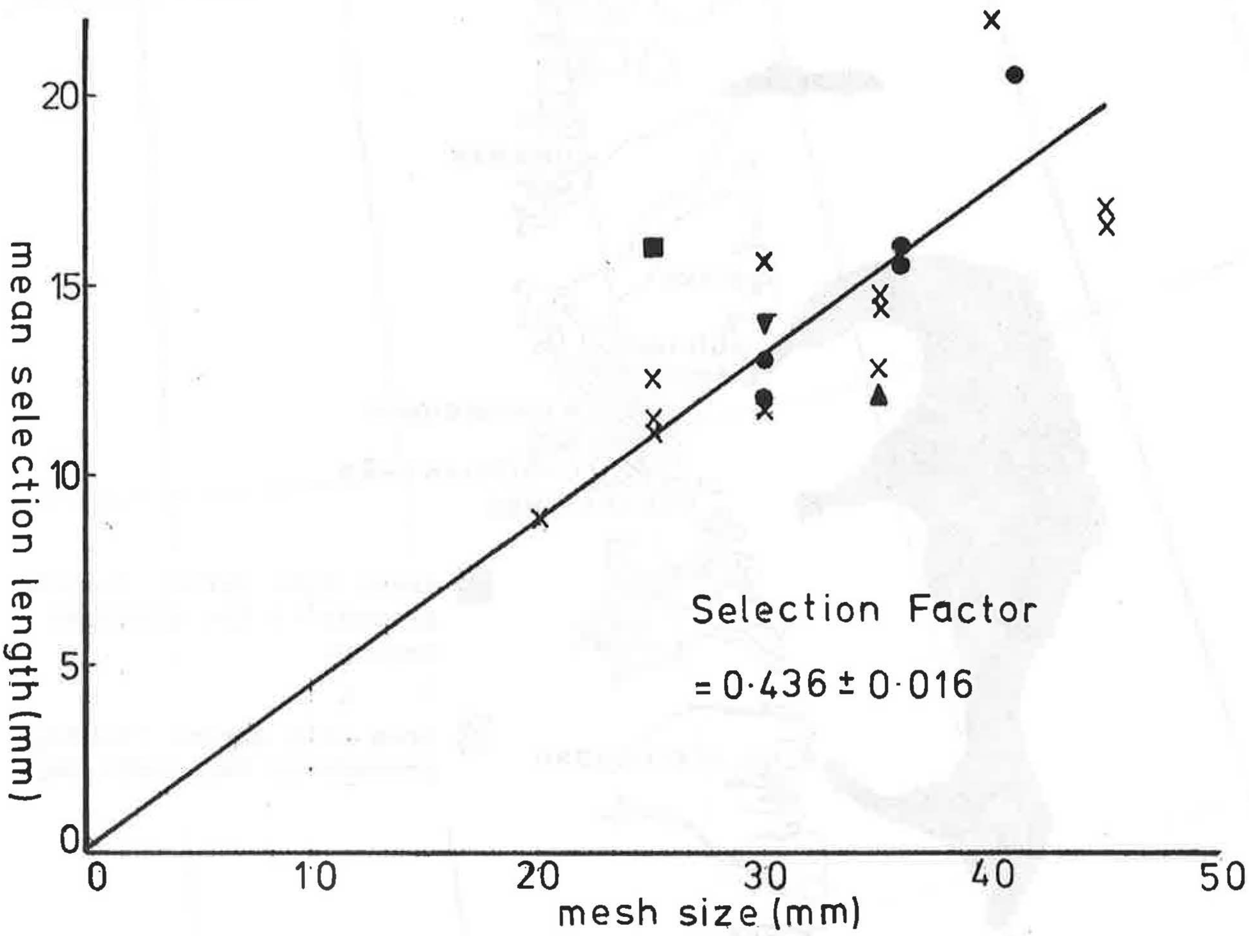
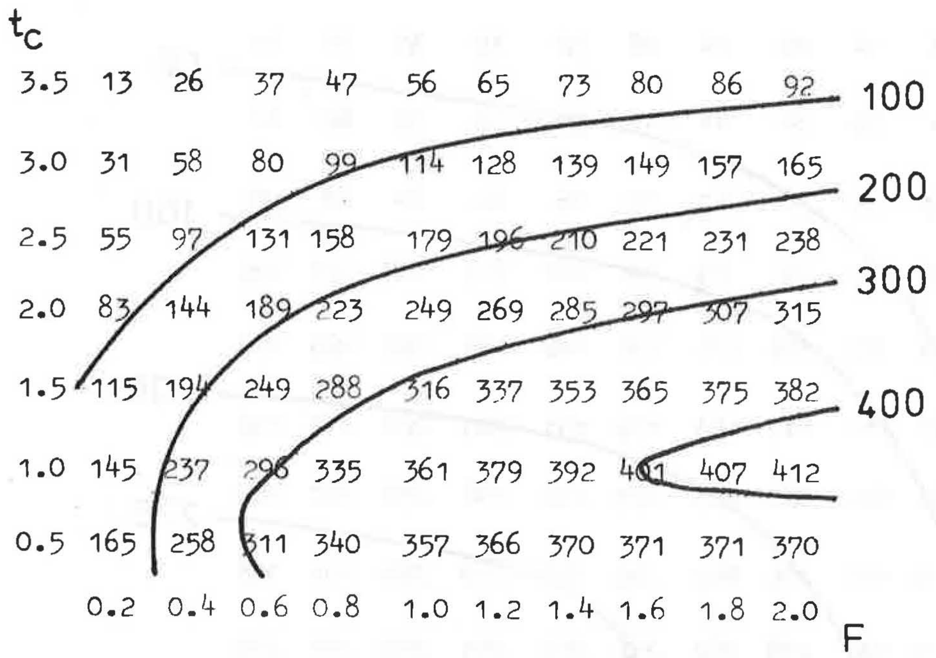


Figure 4. The relationship between mesh size (stretched) and mean selection carapace length of Pandalus borealis. Data from Denmark (■), Iceland (▼), Norway (●), Scotland (✕) and Sweden (▲). Selection factor ± SE calculated by linear regression through the origin.



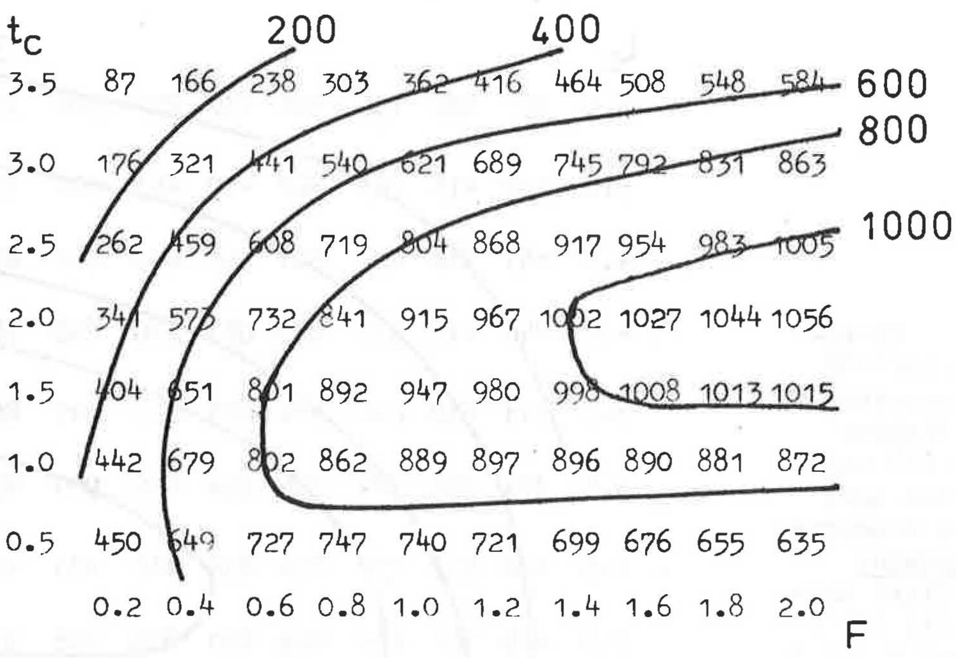
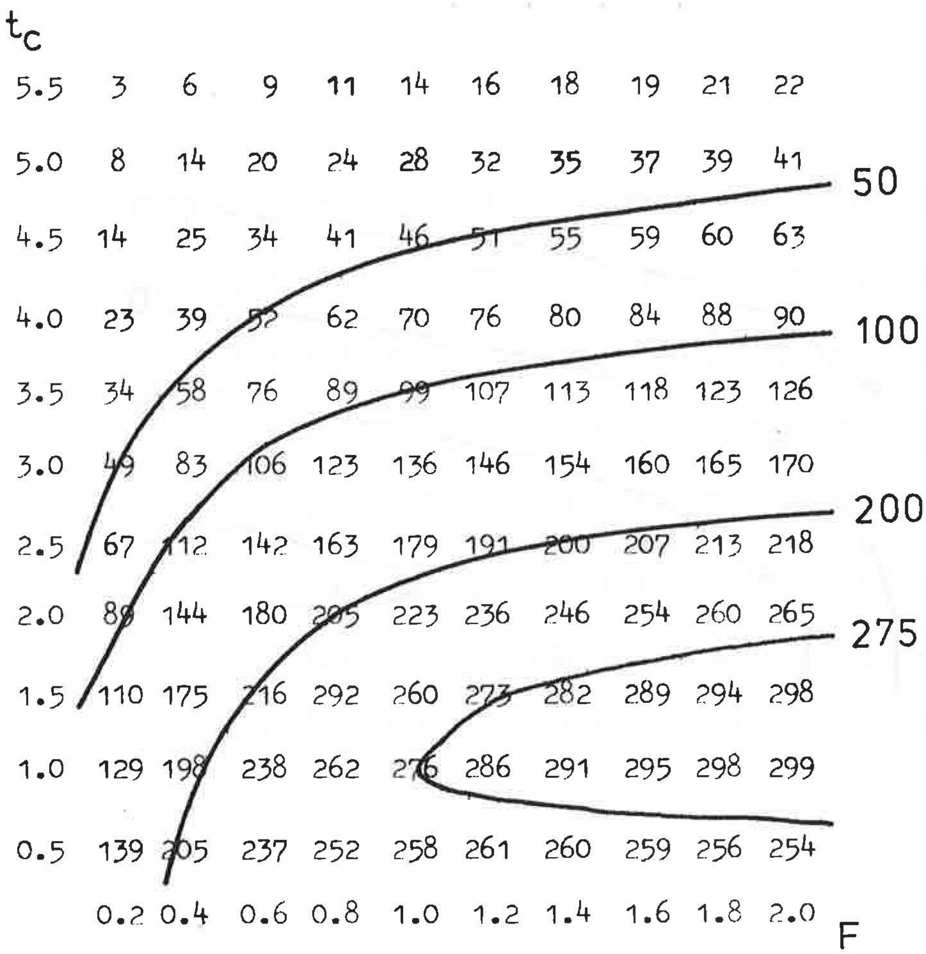


Figure 5. Yield-per-recruit (g/1000 recruits) isopleths for a range of fishing mortalities (F) and mean selection ages (t_c) for the Fladen stock of *Pandalus borealis* : (top) natural mortality (M) = 1.0; (bottom) M = 0.5.



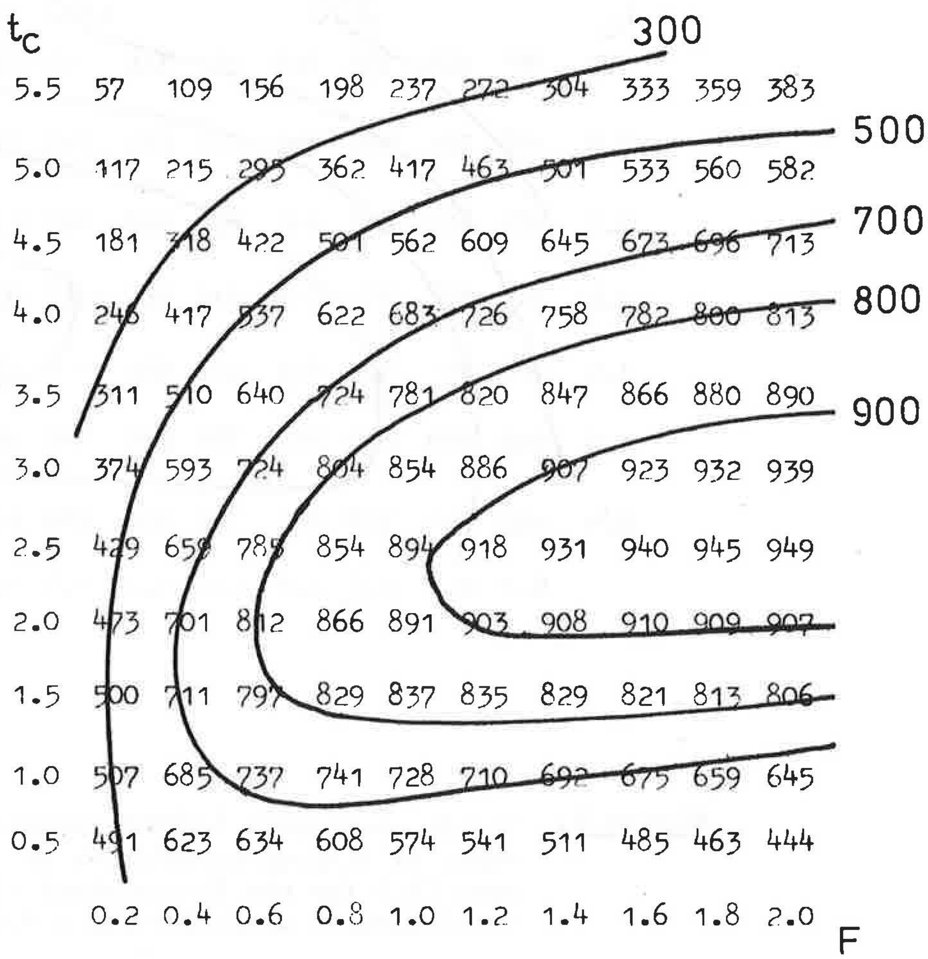
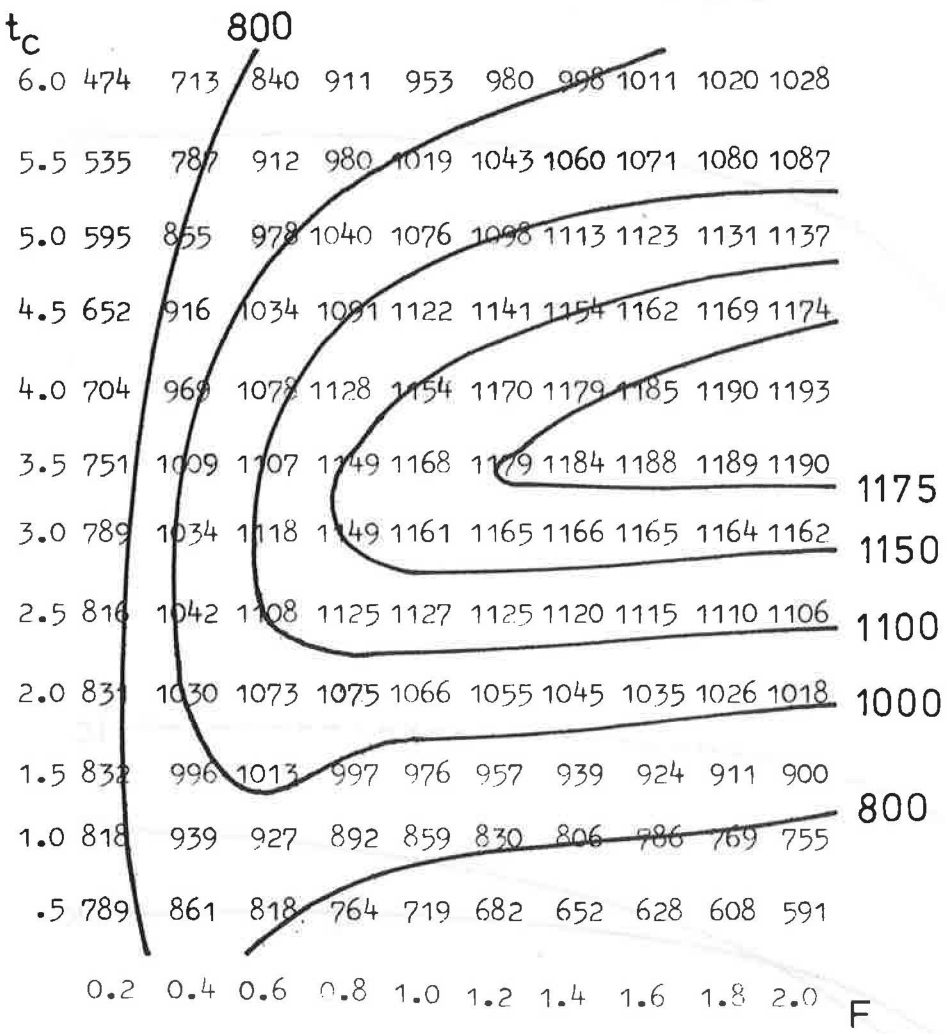
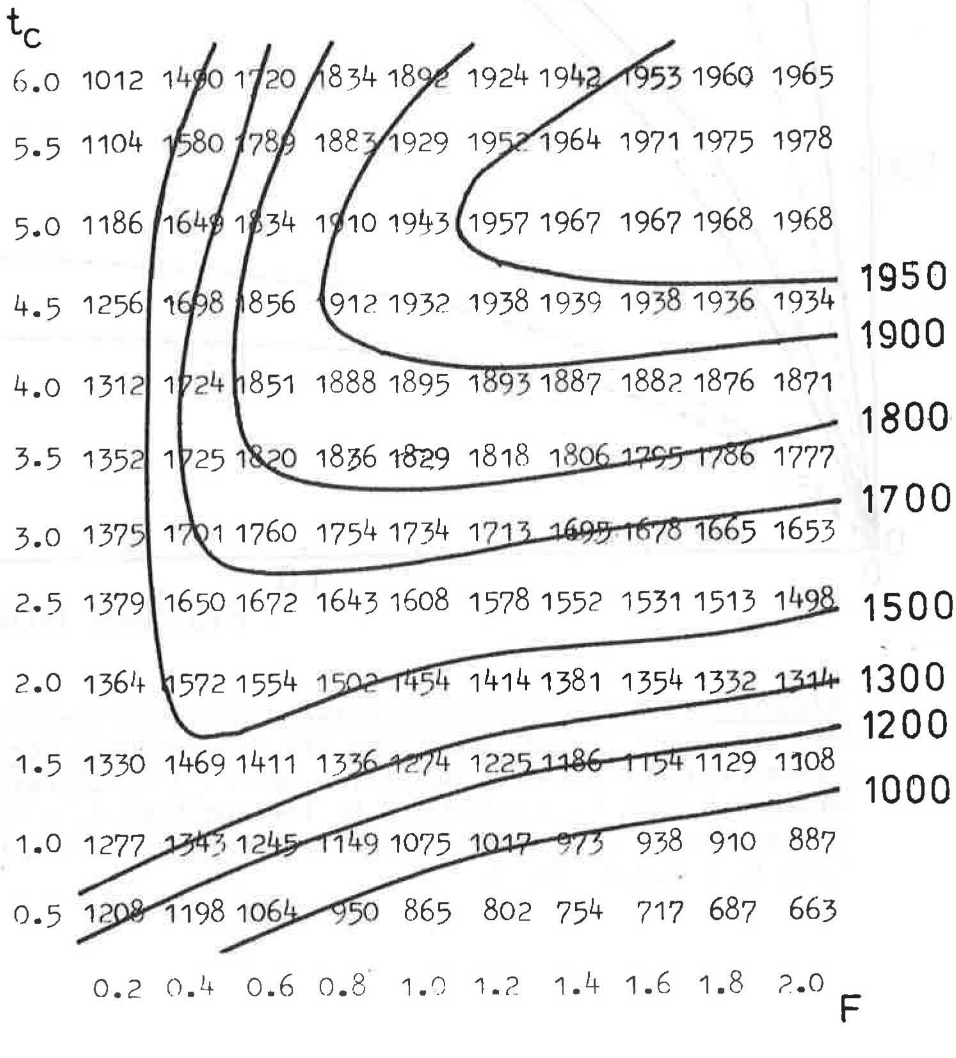


Figure 6. Yield-per-recruit (g/1000 recruits) isopleths for a range of fishing mortalities (F) and mean selection ages (t_c) for the Skagerrak stock of *Pandalus borealis* : (top) natural mortality (M) = 1.0; (bottom) M = 0.5.



t_c	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
6.0	474	713	840	911	953	980	998	1011	1020	1028
5.5	535	787	912	980	1019	1043	1060	1071	1080	1087
5.0	595	855	978	1040	1076	1098	1113	1123	1131	1137
4.5	652	916	1034	1091	1122	1141	1154	1162	1169	1174
4.0	704	969	1078	1128	1154	1170	1179	1185	1190	1193
3.5	751	1009	1107	1149	1168	1179	1184	1188	1189	1190
3.0	789	1034	1118	1149	1161	1165	1166	1165	1164	1162
2.5	816	1042	1108	1125	1127	1125	1120	1115	1110	1106
2.0	831	1030	1073	1075	1066	1055	1045	1035	1026	1018
1.5	832	996	1013	997	976	957	939	924	911	900
1.0	818	939	927	892	859	830	806	786	769	755
.5	789	861	818	764	719	682	652	628	608	591
	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0 F



t_c	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
6.0	1012	1490	1720	1834	1892	1924	1942	1953	1960	1965
5.5	1104	1580	1789	1883	1929	1952	1964	1971	1975	1978
5.0	1186	1649	1834	1910	1943	1957	1967	1967	1968	1968
4.5	1256	1698	1856	1912	1932	1938	1939	1938	1936	1934
4.0	1312	1724	1851	1888	1895	1893	1887	1882	1876	1871
3.5	1352	1725	1820	1836	1829	1818	1806	1795	1786	1777
3.0	1375	1701	1760	1754	1734	1713	1695	1678	1665	1653
2.5	1379	1650	1672	1643	1608	1578	1552	1531	1513	1498
2.0	1364	1572	1554	1502	1454	1414	1381	1354	1332	1314
1.5	1330	1469	1411	1336	1274	1225	1186	1154	1129	1108
1.0	1277	1343	1245	1149	1075	1017	973	938	910	887
0.5	1208	1198	1064	950	865	802	754	717	687	663
	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0 F

Figure 7. Yield-per-recruit (g/1000 recruits) isopleths for a range of fishing mortalities (F) and mean selection ages (t_c) for the Iceland (Arnarfjördur) stock of *Pandalus borealis* : (top) natural mortality (M) = 0.3; (bottom) M = 0.2.

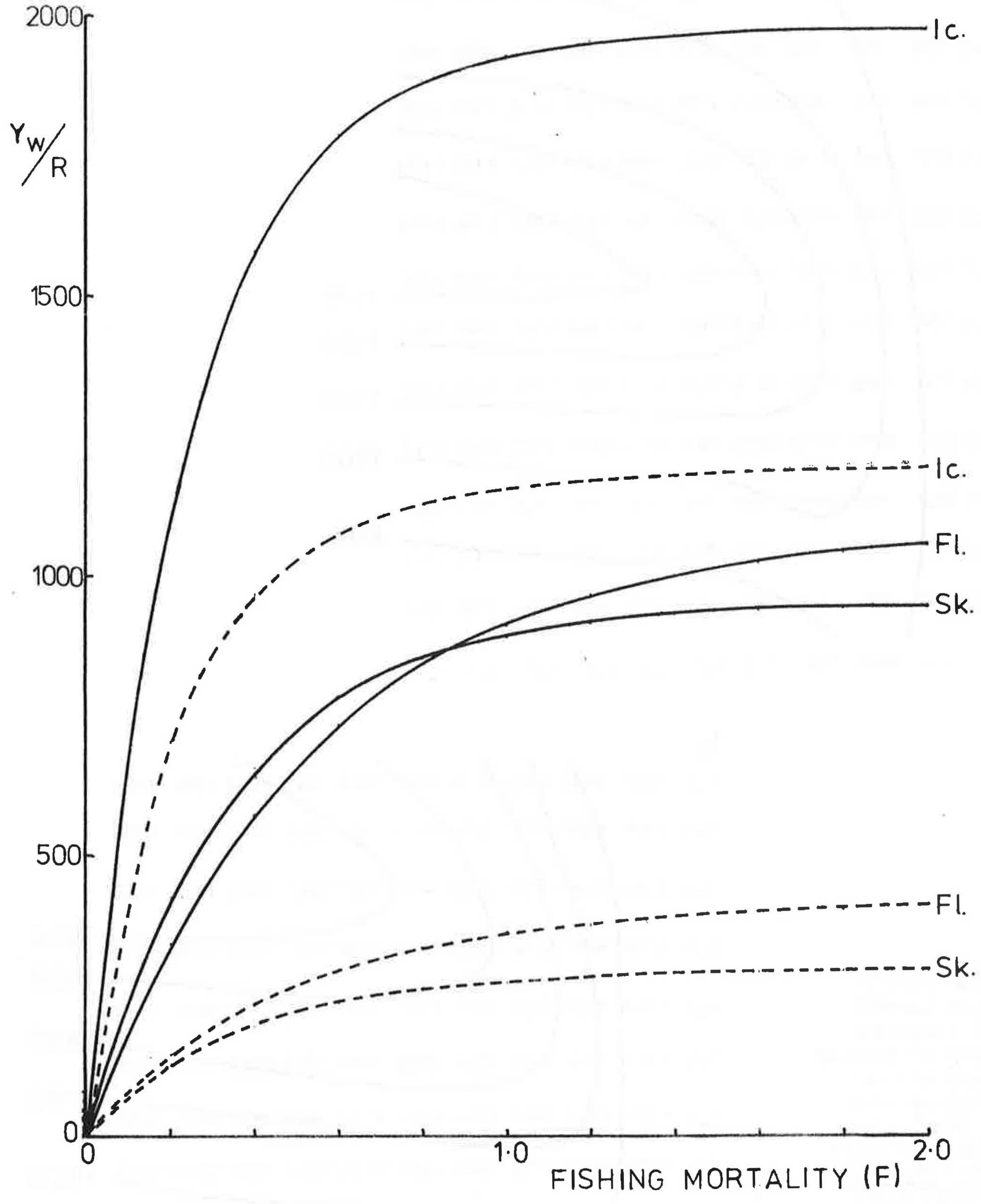


Figure 8. The relationship between yield-per-recruit (Y_W/R = g/1000 recruits) and fishing mortality (F) for Pandalus borealis: i) continuous lines; Fladen (Fl), mean selection age (t_c) = 2.0, natural mortality (M) = 0.5; Skagerrak (Sk), t_c = 2.5, M = 0.5; Iceland (Ic), t_c = 5.5, M = 0.2: ii) dotted lines; Fladen (Fl), t_c = 1.0, M = 1.0; Skagerrak (Sk), t_c = 1.0, M = 1.0; Iceland (Ic), t_c = 4.0, M = 0. 3.

REPORTS OF THE WORKING GROUP ON HOMARUS STOCKS

Nantes, 24-27 April 1975 and Bergen, 3-6 May 1977

FOREWORD BY THE CHAIRMAN

The two reports of meetings of the Homarus Working Group held in Nantes, France, in 1975 and in Bergen. Norway, in 1977, have been combined into one document. Thus it has been possible to present a uniform account of the state of lobster stocks on both sides of the Atlantic.

In presenting the reports to ICES, I wish to take the opportunity to emphasise certain matters concerned with it. Firstly, I wish to place on record my thanks to all members of the Working Group, who by their contribution made possible the production of a highly significant appraisal of an important commercially valuable invertebrate animal, in a manner hitherto unavailable to scientists. Secondly, I wish to thank Mr K Gundersen of Norway who so ably deputised for me in Bergen, when I was prevented from being present. Finally, I wish to pay a special tribute to Dr D Bennett, who has acted as Rapporteur throughout the life of the Working Group, to date. Without his work, help and cooperation, the reports could not have been presented so capably and incorporate such substantive material.

F.A. Gibson

---

1. INTRODUCTION

The first meeting of the ICES Working Group on Homarus stocks met in Nantes, France, during 24-27 April 1975. Council Resolution 1974/2:10 from the 1974 Statutory Meeting of ICES asked the Working Group to evaluate the state of the lobster (Homarus sp.) stocks, the various methods of conservation, the potential for hatching and rearing, and to put forward proposals for future research. The following scientists participated:

J Audouin	France	K Gundersen	Norway
D B Bennett (Rapporteur)	U.K.	J T Hughes	USA
		G De Kergariou	France
J D Castell	Canada	J Y Le Gall	France
G Conan	France	M Leglise	France
B I Dybern	Sweden	J Mason	U.K.
G P Ennis	Canada	H Quiroga	Spain
J M de Figueiredo	Portugal	D G Wilder	Canada
F A Gibson (Chairman)	Ireland		

Their report, Doc. C.M.1975/K:38, was well received by the Shellfish and Benthos Committee. In the following year the Committee recommended (Council Resolution 1976/2:37) that the Working Group should reconvene to consider and report on the significant progress in lobster research and development made since 1975. The Group met in Bergen, Norway, during 3-6 May with the following participants:

V C Anthony	USA	G P Ennis	Canada
J Audouin	France	K Gundersen (Acting Chairman)	Norway
D B Bennett (Rapporteur)	U.K.	H Hallbäck	Sweden
K M Bhatnagar	Ireland	J Mason	U.K.
J F Caddy	Canada	S Tveite	Norway

The report, Doc. C.M.1977/K:11, recommended that fishing mortality should be significantly reduced and the minimum landing size increased to improve yields and ensure adequate breeding stocks. Failing such action recruitment failure in several Homarus fisheries could be expected and other stocks would continue to decline. Member countries were informed of these findings and the Advisory Committee on Fishery Management was requested to consider the management aspects arising from the report of the Working Group (C.Res.1977/4:21).

2. STATE OF THE LOBSTER STOCKS

2.1 Europe

The total recorded catch of the European lobster (Homarus gammarus) is about 1 900 tonnes (1973), about 6% of the catch of the American lobster. Lobster catches (Table 1) have continued to decline in the traditional fisheries of Sweden, W Norway, E Scotland and Wales. In England and France catches have been maintained at recent levels, which are below average. Catch per unit effort (c.p.u.e.) is low and falling in many areas. Fishermen are attempting to compensate for falls in c.p.u.e. by increasing the number of traps fished. Catches and c.p.u.e. have increased in the inner Skagerrak, in Norway, Ireland and W Scotland, the latter partly as a result of French, English and Channel Island vessels fishing previously unexploited stocks. Part-time fishermen continue to increase in many areas. In Sweden it is estimated that only 40% of the total catch is landed by full-time fishermen. The value per kg of lobsters has increased considerably in all fisheries.

The overall catch is being maintained in some countries by the development of socalled "offshore fisheries", fishing previously unexploited stocks. However, these stocks, which when first fished have a high c.p.u.e. and initially support a high fishing intensity, are quite quickly fished down to a c.p.u.e. which is uneconomic for the larger boats fishing these "offshore" grounds. Thus fishing effort on the offshore English Channel grounds was, within 4-5 years of their discovery, switched to the west coast of Scotland.

2.2 North America

Landings of the American lobster (Homarus americanus) in recent years by Canada and the United States have been valued in excess of $ 80 million, making this fishery one of the most valuable in the Northwest Atlantic. The USA currently (1975-76) lands about 13 000 tonnes annually (Table 2a). About 20% of the catch now comes from the offshore fishery. There has been a slow decline in landings and c.p.u.e. while the fishing effort (number of traps) has more than doubled. Stocks appear to be fully utilised.

Landings in the Canadian fishery (Table 2b) over the last decade have fluctuated from year to year with a slight downward trend, to the present level of 16 000 - 17 000 tonnes per annum. Within the overall landing figures, trends have been evident from area to area along the Canadian Atlantic coast. While Newfoundland and Quebec landings have increased over the last 3 years, there have been declines in Maritimes inshore catches. These declines have not been totally offset by an offshore trap fishery from South Nova Scotia to the Gulf of Maine, which began in 1972, and has made an increasing contribution to Maritime landings up to a plateau of 500-600 tonnes over the last few years. Other events in the fishery which have followed from the high fishing intensity in most areas, have been a limitation on numbers of traps per boat and numbers of licences in the fishery in the late 1960s; more recently, buy-back schemes are being introduced in some areas, as a first attempt to reduce existing effort levels. Another significant event has been the increasing use of large traps with wider entrance holes to exploit the small proportion of the population growing through the size range that can enter the 4-5 inch (10-13 cm) diameter entrance rings of the conventional inshore traps. Taken together with the generally low size limits (below the size at first female maturity in most areas), and the high exploitation rates, this development may have disturbing implications for future recruitment to the stocks.

2.3 Relationship between Inshore and Offshore Stocks

Soon after the development of the offshore fishery in N America the question of the relationship between inshore and offshore stocks was raised. In USA about 10 000 sphyrion tagged lobsters were released on the offshore grounds and although 1 000 were returned most were recaptured on the offshore areas. The possibility of recruitment from the offshore to the inshore stocks by larval drift was examined and in general the water currents appeared to be offshore. However, as further grounds are fished nearer to the inshore fishery this problem is likely to become more significant.

It was interesting to note that when the "offshore" fishery in the English Channel developed the stock was composed of about 50% large (average carapace length 120 mm) females, of which up to 80% were berried. It is quite likely, bearing in mind the relatively small distance from the shore (65 km) that larvae produced from this offshore stock contribute to the recruitment inshore. However, when the c.p.u.e. falls to say 45 kg/boat/day many boats leave the offshore fishery and the stock, although reduced in abundance, is left to recover and to still produce larvae.

3. RESEARCH AND DEVELOPMENT 1975 - 1976

3.1 Europe

England and Wales

Monitoring of population structure and catch and effort trends have continued in all the major fisheries. To estimate growth and mortality rates and migrations a tagging programme commenced in 1976 on the E and NE coasts of England. Biological studies have included work on larval recruitment, juvenile ecology and moult staging.

France

Studies have continued on the size composition and catch rates of lobster stocks resulting from the prohibition of fishing and release of juvenile lobsters into sanctuary areas. Comparisons are being made in the laboratory on the growth rates of *H. gammarus* and *H. americanus* and hybrids.

Ireland

Monitoring of size frequencies and catch and effort (boat-trap census) has continued with comparisons of the carapace length/total length ratio on the Atlantic and Irish Sea coasts. Branded lobsters were released in 1974. Only small movements of recaptures were recorded. Exploratory fishing in 72-126 m, 80 km offshore proved unsuccessful.

Norway

Catch/effort and size composition data collected over a number of years have been analysed for a yield assessment. Tagged lobsters continue to be returned.

Scotland and Sweden

Monitoring of catch, effort and population structure continued.

3.2 North America

Canada

Research effort is at present expanding. Size frequency, moult stages and fishing effort are sampled at key ports. Historical data are being prepared for analysis. The need for increased size limits is being considered. Escape gap studies have been completed on crabs (Cancer irroratus) and lobsters. Tagging studies to estimate growth, mortality rates, movements, standing stock, recruitment etc. are continuing in a number of areas. First estimates of population parameters suggest that in addition to yield/recruit considerations, present fishing strategy may be adversely affecting recruitment potential. Tagging studies in Canadian waters have so far shown few movements > 10 miles although there appear to be seasonal vertical movements in some areas which may also result in horizontal displacements on a seasonal basis.

United States

A State-Federal Scientific Committee, consisting of scientists from 11 coastal states (Maine to North Carolina) and the National Marine Fisheries Service (NMFS), has been established to organise and conduct the necessary research to allow the formulation of lobster management plans. Every lobster-producing state has now initiated or intensified its own lobster R & D. The Lobster Scientific Committee has conducted a preliminary assessment of lobster growth and mortality to determine levels of yield per recruit for various levels of minimum sizes and fishing mortality, and to identify research priorities.

4. RECENT OR IMMINENT CHANGES IN MANAGEMENT STRATEGY

4.1 Europe

England, Wales and Scotland in 1976 introduced carapace length for the measurement of minimum landing size at 80 mm, equivalent to the previous total length measurement of 9 inches (229 mm). France, Norway and Sweden still use total length. Sweden has recently extended the summer closed season in an attempt to reduce the fishing activity of part-time fishermen, and to protect moulting lobsters. Ireland is in the process of introducing a licensing system for lobster boats, sellers and buyers, designed to control fishing effort, particularly of part-time fishermen.

4.2 North America

Efforts to develop a unified management programme in the United States resulted in the establishment of a Policy Committee, composed of state fishery administrators and the Regional Director of NMFS, which provides overall programme guidance and facilitates implementation of decisions through existing legal and institutional channels. It is intended to increase the present size limits of 3 1/16 in (78 mm), 3 1/8 in (79 mm) and 3 3/16 in (81 mm) to a uniform 3½ in (89 mm) in the United States. Escape gaps are being introduced in various states.

Canada hopes to increase the size limits in some areas over the next few years. In an attempt to reduce fishing effort a licence buy-back scheme is being introduced. A closed season may be introduced for the offshore fishery. The management strategy favours full-time fishermen.

5. EVALUATION OF CONSERVATION METHODS

5.1 Minimum Size

5.1.a Method of measurement

The Group recommends that for both legal and scientific purposes carapace length shall be used. This should be measured in millimetres from the back of either eye socket to the dorsal mid-point of the posterior margin of the carapace. For scientific work the measurement should be taken to the nearest millimetre or 1/10 millimetre below.

The Group also recommends that particularly for commercial and enforcement purposes uniformity of minimum legal sizes between countries is desirable.

5.1.b Can a lobster fishery be managed by minimum size alone?

In the light of the experience of several countries and the present state of the lobster stocks it was felt that effective management of a lobster fishery could not be achieved by minimum size regulations alone. However, the control of the minimum size does have an important role in lobster management. The appropriate size should be selected in relation to size at first maturity (5.3.a) and in terms of yield assessment (5.1.c); the utilisation of escape gaps is recommended (5.1.d).

5.1.c Yield assessment and optimum minimum size

If the maximum sustainable yield is the objective of lobster fishery management then there are two direct fishery management controls: i) size or age at first capture, and ii) level of fishing effort (see 5.2). Selection of the appropriate size at first capture and level of fishing effort should ideally be made using some yield assessment model. Most such models require certain basic parameters, in particular recruitment, growth and mortality rates. Information on recruitment is very limited and this is usually overcome by using yield per recruit theory. This still leaves the problems of quantifying growth and mortality rates.

A considerable amount of moult increment data are available but data on moult frequency under natural conditions are lacking to enable the determination of annual growth rates. Work is continuing in several countries to try to determine external morphological changes or internal physiological changes, e.g. serum protein or calcium levels, which may be correlated with the moult cycle and hence determine the moult frequency of lobsters at various sizes.

Determination of exploitation rates is possible over short periods outside the moulting season using non-persistant tagging methods. If longer-term estimates of mortality rates and of movements are to be made it is necessary to develop a persistent tag, or at least quantify tag losses. Although the sphyrion tag is reasonably successful doubts were expressed concerning its persistence and the problem of infections caused by the anchor. Further development and testing of the Gundersen toggle tag and of branding was thought to be worthwhile. Where hatchery-reared juveniles are being released the use of natural tags, e.g. odd colours, should be considered (see 5.3.d).

It was thought preferable to have uniformity of minimum sizes within and between countries. As far as was known, growth and natural mortality rates do not vary appreciably from area to area within most countries, but may vary from country to country. Fishing mortality rates vary considerably both within and between countries and, therefore, to achieve the maximum sustainable yield different minimum sizes may be required. However, the international enforcement problems and market size requirements should be carefully considered when changes in minimum sizes are proposed.

5.1.d Escape gaps

The Group felt that the use of escape gaps has considerable conservation value. There is evidence to suggest that there is mortality, particularly by predation, of undersized lobsters returned to the sea after sorting on the fishing boats. Effective escape gaps would reduce the numbers of undersized lobsters brought to the surface and should reduce losses due to predation when returned. The temptation for fishermen to land undersized lobsters would also be reduced. If minimum sizes are increased in the future, the effectiveness and value of escape gaps increase.

There are certain problems in enforcing the use of escape gaps but if the principle of their use and the advantage of less sorting of the catch, less pot materials, less ballast and less damage to pots from wave action can be "sold" to fishermen, the enforcement problems would be reduced. It would be useful to establish more clearly the relationship between the size, shape, number and position of escape gaps and the size composition of the pot catch, and therefore the size composition of those released.

Escape hatches with bio-degradable fastenings are being tested in USA to prevent "ghost-fishing" by pots lost at sea. It was felt that "ghost-fishing" was not a significant problem in Europe.

5.2 Control of Fishing Effort

5.2.a Methods of control

Licensing can be used to achieve four aims:

(i) control of the level of fishing effort by restricting the number of licences available.

(ii) control of the fishing effort of part-time fishermen.

(iii) suspension or withdrawal of licence is the best deterrent to enforce other regulations, e.g. minimum size.

(iv) to collect catch and effort information.

The majority of the Group felt that if one or more of these aims features in their fisheries management policy then licensing is recommended as a means of achieving these aims.

Number of traps per boat. This method of control of effort may be necessary in association with licensing. Although the number of boats or fishermen may be controlled by restricted entry and licensing, unless trap limits are imposed the licensed fishermen can still increase their fishing effort by increasing the number of pots fished.

In Canada the limits on the number of traps allowed were initially set too high, and some fishermen increased their number of pots to meet the limit imposed. However, some Canadian fishermen are now asking for the limit to be lowered! There are many enforcement problems associated with limiting the number of traps fished. This is to some extent overcome by identifying traps with coded markings, which enables enforcement officers to identify unmarked and therefore prohibited fishing gear.

Closed seasons have very little value in directly controlling fishing effort, unless coupled with other effort controls, e.g. trap number limits. They have certain advantages in marketing, e.g. the Canadian open season coincides with a period of low catches in the USA, and therefore enables exports to the USA when their own supplies are limited.

Where a mixed fishery for lobsters and crab exists, as in most of Europe, closed seasons for lobsters alone are very difficult to enforce.

Closed seasons during certain times of the year can be used to restrict the activities of part-time fishermen. Sweden has a summer closed season, primarily for biological reasons, but now considered valuable for stopping leisure fishing for lobsters.

In many areas natural closed seasons occur as the result of bad weather, cold water temperatures making lobsters inactive or moulting reducing catchability.

Closed areas can be used to provide a reservoir breeding stock (see 5.3.c) or as a means of reducing fishing effort on the whole stock. A fishery could be divided into areas which were closed for a few years on a rotational basis. This may be easier to enforce than trying to ensure that the trap limits are not exceeded.

Quotas were thought to be the most useful when applied to international fisheries where it is necessary to apportion a total allowable catch between nations. In a national fishery the imposition of a quota would tend to create a short period of intense fishing at the beginning of a season which would quickly catch the quota. It would also be difficult to know when the quota had been reached. In most countries the lobster catch is inadequately recorded.

Control of other fishing methods. Canada, France, Ireland, Spain and Sweden prohibit the catching of lobsters by divers. In Canada lobsters can only be caught by traps, i.e. no otter trawl in the offshore fishery, unlike USA where half the offshore landings are trawl-caught. Many part-time fishermen are divers and if it is thought necessary to control part-time fishing effort then control of diving for lobsters is appropriate.

5.2.b Determination of appropriate level of effort

Decisions on the appropriate level of effort for a fishery depend on whether the criteria used take account solely of biological yields or whether socio-economic factors are also considered.

Selection of the appropriate level of effort to achieve the maximum yield should ideally (as for the minimum size) be made using some yield assessment model. This need not be a complex mathematical model. Determination of the appropriate level of exploitation would enable the level of fishing effort to be controlled to achieve the required exploitation rate. There are many lobster fisheries where it is believed a reduction in fishing effort would result in increased catch rates and therefore increase the economic efficiency of the industry. Social considerations must play a part in decision making when controlling fishing effort, particularly where local communities are dependent upon fishing for employment.

If the data on growth and mortality are not available for yield assessment models it may be necessary to make decisions on controlling effort (and/or minimum size) which may only be judged in the light of future catches. The collection of adequate catch and effort information is therefore essential to observe the effects of fishery management changes. Even where sufficient data exist for a population model, it is necessary to prove the model by observing catch and effort data.

5.3 Improvement of Recruitment

5.3.a Minimum size in relation to size at maturity

It would appear quite logical that, particularly where the rate of exploitation is high, the minimum size should be set above the size at maturity. This would ensure that breeding females, and males, are available in the stock. As male lobsters are able to mate with more than one female, the stock of mature males need not be as large as that of the females. However, no information is available on the stock/recruitment relationship and it is thus impossible to decide how large a stock of breeding females is required for adequate annual recruitment.

In certain parts of Canada although there are few mature females in the stock and fishing intensity is high, catches have remained relatively stable.

The Group felt that although the stock/recruitment relationship is not known it could be assumed that good recruitment is more likely from a larger breeding stock and therefore the minimum size should be set above the size at maturity.

5.3.b Protection of ovigerous females

The question of whether ovigerous females should be landed depends again on the unknown stock/recruitment relationship. Observations in Canada over a 16 year period failed to show any clear relationship between larval abundance and subsequent lobster catches. At the present time Canada, USA and Spain prohibit the landing of ovigerous females. In many countries it would be difficult to enforce such a prohibition without tests to determine whether a lobster has been "scrubbed". The Group felt that it is necessary to ensure that the breeding stock is of a sufficient size to ensure adequate larval production and recruitment to the fishable stock. It is not possible to determine quantitatively the size of the breeding stock required. The necessity and advisability of having a regulation prohibiting the landing of ovigerous females depends upon the present relationship between the minimum size and size at maturity, the rate of exploitation, the origin of larval recruitment to the stock and the feasibility of adequately enforcing the regulation.

An alternative approach to prohibiting the landing of ovigerous females is to buy ovigerous females from fishermen and release them back into the fishery, in preference into closed sanctuary areas as in France. This would reduce the enforcement problems. It is necessary to attempt to monitor future catches and determine the value of this action. This is being done in France but the sanctuaries have not been in operation for a sufficient time to observe an increase in the fishable stock.

5.3.c Closed areas to conserve a breeding stock

A simpler approach is to close off areas of the fishery to allow a large unfished breeding stock to build up. If larval drift occurs to other areas or juveniles disperse this would increase recruitment to the fishable stock. There would be enforcement problems because the closed areas would have a potentially high catch per unit effort which would encourage fishermen to fish inside the closed areas.

5.3.d Release of juveniles into the fishery or sanctuaries

The objective of releasing juveniles into the fishery or sanctuaries rather than protecting ovigerous females is to attempt to overcome the high mortality between the hatching of eggs and the settling of juveniles onto the sea bed. A hatchery is necessary to provide the young lobsters for release. This conservation approach is practised in France and USA. In France the juveniles are released into closed sanctuary areas, whereas in USA releases are into the open fishery.

Again there are many problems in trying to evaluate the usefulness of this approach. It has not been possible to demonstrate an increase in commercial landings as a result of releasing juveniles. Work is progressing in USA and France to develop genetic tagging, using for example rare coloured sports, to enable estimation of the proportion of juveniles released which survive to enter the fishable stock.

Observations by divers in Canada showed almost 100% mortality by predation within 10 minutes after releasing 5th to 7th stage juveniles onto the sea bed. It is essential to ensure that juveniles released into the sea have readily accessible cover or that visual predation is avoided by, say, releasing at night.

5.4 Habitat Improvement

5.4.a Artificial reefs

The Group felt that the main problem with artificial reefs is cost effectiveness. In those areas where fishing intensity is high and stock abundance is low the availability of suitable habitat niches would not appear to be a limiting factor. There is some suggestion that where the lobster population is reduced the crab population may increase and provide competition for any future increase in the lobster stock either by natural or man-made recruitment.

There may be some value in establishing artificial reefs in areas where the habitat is not suitable for lobsters, perhaps in association with warm water from power stations. Present costings do not make such ventures economically viable.

5.4.b Control of the effects of other fishing methods

The issue of competition between say trawlers and potters for suitable fishing grounds does not come under this heading. However, there is some evidence that heavy beam trawls and various dredges, e.g. Irish moss raking in Canada, could either cause direct damage to lobsters or destroy the habitat required by lobsters. This did not appear to be a significant problem in any of the countries represented.

5.4.c Pollution control

The Group recognised that relatively little information appeared to be available on the effects of various pollutants on adult, juvenile and larval lobsters. It was felt that the larvae are likely to be more sensitive to pollutants than adults. Although it has not been possible to demonstrate any significant mortality due to pollution the Group felt that more toxicological work, particularly with the larvae, would enable a closer assessment of the possible effects of pollutants on lobster stocks.

6. THE POTENTIAL FOR HATCHING AND REARING

The potential uses of lobster hatching and rearing are twofold: 1) to produce artificially reared lobsters for direct human consumption or 2) to provide juveniles for release into the natural fishery or sanctuary areas to aid recruitment to the natural stock.The value of the latter approach has been discussed in Section 5.3.d. Both uses require the same hatchery techniques, but rearing-on techniques need only be developed to artificially produce marketable lobsters. The necessary hatchery techniques appear to be available to produce *Homarus americanus* or *Homarus gammarus* at a size suitable for release into the sea. As it is difficult to evaluate the release of juveniles into the sea it is difficult to make an economic assessment of hatchery techniques used for this purpose.

Considerable interest has been shown for many years in the potential for rearing lobsters to a marketable size. Research work is being carried out in several countries by both government research establishments and private industry on both species of *Homarus*. As with all commercial projects the ultimate aim to make a profit will decide whether lobster rearing is a viable proposition.

Present research is concentrating upon the biological and technological problems of hatching and rearing. Attention is being focused upon optimal environmental conditions, particularly temperature, nutritional studies and formulation of artificial diets, disease problems and genetics and selective breeding. The future potential of rearing obviously depends upon the cost-effectiveness of the hatching and rearing techniques being developed.

The present research into hatching and rearing is producing a lot of interesting biological information on lobster life histories, growth, feeding, diseases etc., which will be of value in the management of the natural fisheries.

Visit to the Ile d'Yeu lobster hatchery

At the kind invitation of M Audouin (ISTPM, France) the members of the 1975 Group visited the lobster hatchery on the Ile d'Yeu. The objective of this hatchery is to produce 6th or 7th stage juvenile lobsters for release into sanctuary areas around the French coast. In 1974 a total of 150 000 6th or 7th stage lobsters were released.

The techniques used were relatively simple but successful. Ovigerous females were brought by fishermen between June and October, allowed to hatch and the larvae transferred to large outside tanks. The lobster larvae were fed on Artemia larvae or the larvae of Maia squinado hatched in adjacent tanks. After about 14 days, and with a survival rate of between 50-80%, the 3rd or 4th stage larvae were transferred to individual compartments in tanks inside the hatchery building. After about 1½ months, being fed on frozen adult Artemia, the 6th or 7th stage juveniles are released into the sanctuary areas. During the Group's visit several thousand juvenile lobsters of about 30 mm total length were held in the hatchery. These juveniles had been held since September last year and were to be released into the sanctuaries this summer.

The Group wishes to record its appreciation of the hospitality offered by M Audouin and his colleagues, and the authorities on the Ile d'Yeu.

7. GROWTH AND MORTALITY RATES

Discontinuous growth (made up of two components, moult increment and moult frequency), the apparent lack of ageing structures, the difficulty of distinguishing the modes of a size frequency distribution which might indicate year classes or moult classes, and the need for special tagging techniques which ensure that tags are not lost at ecdysis are the inherent problems associated with the estimation of annual growth rates of large decapod Crustacea, such as Homarus. The von Bertalanffy growth equation has been extensively used to describe the growth of fin-fish. While this equation is not ideally suited to the discontinuous growth pattern of lobsters it is a useful approximation which allows the use of the Beverton and Holt dynamic pool model for yield per recruit assessment. This is especially so when lobsters are moulting once each year over the size range considered for an assessment.

Analysis of polymodal size frequency has provided some estimates of annual growth. The use of tagging data has provided good estimates of moult increments which have been coupled with sparse data on moult frequency. Von Bertalanffy's growth equations from a number of Homarus stocks were examined (Table 3, Figure 1). It is readily apparent that there is considerable variation in the growth curves (Figure 1) with the slowest growth from Norway females (H. gammarus) and the fastest from southern New England, USA (H. americanus). K values ranged from 0.10 for the Norway females to 0.39 for Newfoundland males. There was also a wide range in L_∞ from 105 mm CL for Newfoundland males to 267 mm CL for Maine, USA lobsters. Much of this variability in growth rates is due to variable moult frequencies - the parameter which is the most difficult to estimate accurately!

Fishing mortality (F) rates from various sources have been calculated from tag return data and/or size composition data. The values obtained (Table 3) range from F = >0.67 (last available estimate of 0.67 in 1971) for the American offshore fishery to F = 2.30 in the Maine fishery. Generally, F values exceed 1.0 and are frequently as high as 2.0.

There are no direct estimates of natural mortality (M) and the best available estimates range from M = 0.1 to 0.25 with a general consensus from the Working Group that such a slow-growing long-lived animal has few predators and that therefore natural mortality can be expected to be low - say M = <0.1.

8. YIELD ASSESSMENT

At the present time it is obvious that some of the estimates for the parameter inputs for a yield assessment are not wholly reliable. However, the examination of the available data for a range of stocks from both Europe and North America does enable a preliminary assessment to be made utilising a range of probable values for growth, fishing and natural mortality rates. The choice of a suitable yield model is not critical at this stage. For convenience, the Beverton and Holt (1959) dynamic pool model was chosen. This model incorporates the von Bertalanffy growth equation, which as already discussed may not be an ideal description of the discontinuous growth of lobsters. (A yield per recruit analysis using a discontinuous growth curve was briefly examined at the meeting and found to give similar results to those obtained by the Working Group.) Isometric growth is also assumed by the model and although male lobsters show allometric growth of the chelae this model is a suitable approximation. The dynamic pool model also assumes constant mortality rates for various ages: this assumption may not be valid but the available data on mortality rates are not comprehensive enough to reject this assumption. Despite these reservations, the Group felt that useful management advice could be obtained from a yield per recruit assessment using this dynamic pool model with the parameter inputs at present available.

Three stocks were chosen for yield per recruit assessment incorporating a range of K values from 0.10 to 0.39 (Table 4). Two values of M were chosen M = 0.1, thought to be the more realistic value, and M = 0.3 to observe the effect of incorporating a higher M value. Fishing mortality (F) ranged from 0.1 to 1.5 and age at first capture - assuming knife-edged selection - from 4 to 15 years (Table 4).

8.1 Yield per Recruit Results

Newfoundland males

The maximum yield in weight per recruit $(Y_W/R)_{max}$ of 552 kg/1 000 when M = 0.1 occurs at a high fishing mortality (F_{max} = 1.5) and an age (size) at first capture $(t_c)_{max}$ of 7 yr (96 mm CL) (Table 5, Figure 2). If M = 0.3 the $(Y_W/R)_{max}$ is reduced to 372 kg/1 000 at an $(F)_{max}$ of 1.5 and a $(t_c)_{max}$ of 4 yr (Table 5, Figure 2). Although the $(Y_W/R)_{max}$ occurs at quite high values of $(F)_{max}$ the low growth rates produce flat-topped yield per recruit curves in which, above fairly low levels of fishing mortality, further increases in F produce only small gains in yield per recruit. For example, if M = 0.1 and t_c = 7 yr, the Y_W/R at F = 0.5 is 519 kg/1 000, only 6% less than the Y_W/R at $(F)_{max}$ = 1.5, at F = 0.3 the Y_W/R is only 13% less than at $(F)_{max}$.

Norway males

If M = 0.1 the $(Y_W/R)_{max}$ of 564 kg/1 000 occurs at $(F)_{max}$ = 1.5 and $(t_c)_{max}$ of 9 yr (106 mm CL) (Table 5, Figure 3). The $(Y_W/R)_{max}$ is reduced to 277 kg/1 000 at $(F)_{max}$ = 1.5 and $(t_c)_{max}$ = 5 yr if M = 0.3. As with the Newfoundland males, the yield per recruit curves are flat-topped. A reduction from $(F)_{max}$ = 1.5 to F = 0.3 at t_c = 9 and M = 0.1 results in only a 9% loss in Y_W/R. If M = 0.3 at t_c = 5 the loss is 20%.

Norway females

Although the growth rate is low (K = 0.1, Table 4). the W_∞ is higher (2 448 kg) than for the other two assessments. This results in quite high $(t_c)_{max}$ values when M = 0.1, the $(Y_W/R)_{max}$ of 371 kg/1 000 occurs at $(F)_{max}$ = 1.5 and $(t_c)_{max}$ = 14 yr (Table 5, Figure 4). Of course if M is higher (M = 0.3) $(t_c)_{max}$ is reduced to 7 yr, although $(F)_{max}$ remains high at 1.5. As with the other assessments a considerable reduction in F has little effect on Y_W/R values. For example, if M = 0.1 and t_c = 14 a reduction from $(F)_{max}$ = 1.5 to F = 0.3 results in only a 19% drop in Y_W/R to 300 kg/1 000.

9. MANAGEMENT RECOMMENDATIONS

9.1 Yield Per Recruit

The three assessments carried out have been used to show general conclusions regarding the relationships between Y_W/R and M, F and t_c. The model is obviously sensitive to M, the parameter which in most cases is estimated roughly. However, the general consensus is that M is low and probably less than 0.1. It is probably safe, therefore, to consider the assessments utilising M = 0.1 as closer to reality than those with M = 0.3. Although the $(F)_{max}$ values were quite high ~1.5, it is clear that a considerable reduction in F would result in relatively small losses in Y_W/R. This would of course increase the economic efficiency of a fishery as c.p.u.e. would be expected to increase (see 9.2 also). The present calculated or estimated values of F (Table 3) generally exceed F = 1.0. These yield per recruit assessments clearly show that F values of the order of 0.3 - 0.5 would be more suitable.

The present l_c values in most fisheries are around 80 mm CL, although in one area in Canada, the southern Gulf of St Lawrence, the l_c is as low as 64 mm CL. If M = 0.1 the $(l_c)_{max}$ values at $(F)_{max}$ range from 96 to 117 mm CL (t_c = 7 to 14 yr). At the suggested level of F ~0.5 the l_c values range from 91 to 108 mm CL (t_c = 6 to 12 yr) - still well above the present size (age) at first capture. An increase in l_c would increase the yield per recruit from all these fisheries.

The conclusion from these preliminary assessments is clear - the present levels of fishing mortality are too high and the size (age) at first capture too low.

9.2 Recruitment

Little is known about the behaviour and ecology of larval and juvenile lobsters. The source of recruitment to many fisheries is not known and little is known of the stock/recruitment relationship. Despite these unknowns, it is clear that with the present situation where exploitation rates are high and the size (age) at first capture is often below the size (age) at first maturity, many of the lobster stocks on both sides of the Atlantic are heading for recruitment failure. The proposed reduction in fishing mortality and increases in size (age) at first capture would alleviate this situation. The reduced catch rates in recent years indicate a reduction in stock abundance. Although the stock/recruitment relationship is unknown, at some low level of spawning stock an increase in stock size (resulting from a reduction in F and increase in l_c) will certainly increase recruitment.

9.3 Summary of Management Recommendations

To improve yield per recruit and to ensure an adequate breeding stock it is essential in most European and North American Homarus stocks to reduce fishing mortality significantly from the present level in excess of F = 1.0 to an optimum level within the range F = 0.3 - 0.5.

At the same time the present size (age) at first capture (minimum landing size) is too low and should be raised, at least above the size (age) at first maturity for each stock.

If these management recommendations are not implemented in the near future recruitment failure in several Homarus fisheries can be expected and other stocks will continue to decline.

For obvious reasons, the considerable reductions in fishing mortality proposed and the immediate losses in catches resulting from increases in minimum landing sizes will be difficult to accept in socio-economic terms. The changes proposed will inevitably have to take place in measured steps. It is thus essential that the first steps in the right direction for the future management policy of Homarus stocks to be taken immediately. Further delay only makes the inevitable proposed action more difficult to implement.

10. PROPOSALS FOR FUTURE RESEARCH

10.1 Catch-Effort Statistics and Stock Relationships

10.1.a Improvement of the collection of catch and effort statistics is essential for both future research work and for adequate fishery management.

10.1.b Declines in the catches from traditional fishing areas have been observed. The available catch-effort data should be examined to attempt to determine the cause(s) of the observed declines in catches.

10.1.c To aid the interpretation of catch-effort data the effects of environmental conditions, e.g. climatic changes, on catchability should be examined.

10.1.d With the development of offshore fisheries it is now essential to understand the relationships between inshore and offshore stocks. Particular attention should be paid to possible movements of lobsters between inshore and offshore areas, and to the possible role of offshore lobsters as reservoir breeding stocks.

10.2 Sampling and Escape Gaps

10.2.a Most observations on lobster stocks are made using commercial traps as the sampling method. More information on the selectivity of this sampling gear would aid the interpretation of population structure data.

10.2.b Studies under natural conditions of the intraspecific and inter-specific behavioural interactions to baited traps would facilitate the interpretation of catch, effort and catch composition data.

10.2.c As the Group felt that the use of escape gaps has considerable conservation value it would be useful to establish more clearly the relationship between the size, shape and number and position of escape gaps and the size composition of the pot catch.

10.3 Recruitment

10.3.a Any research to elucidate the stock/recruitment relationships would be most useful.

10.3.b Failing any direct information on the stock/recruitment it was thought worthwhile to try to evaluate the possibility of improving recruitment by releasing hatchery reared young lobsters and/or providing sanctuaries to conserve a breeding stock. Carefully controlled experiments with adequate monitoring would be essential. The development of genetically tagged lobsters, e.g., rare coloured sports, would help to assess the value of releasing hatchery reared young lobsters into the fishery.

10.3.c Particular attention should be paid to the possible predation losses of both hatchery reared juveniles released into the sea and undersized lobsters returned to the sea during fishing operations.

10.3.d Information is lacking on all aspects of the ecology of lobsters between the egg stage and the smallest pre-recruit lobsters caught in traps at a size of about 50 mm carapace length.

10.4 Growth, Mortality, Migrations, and Tagging

10.4.a The development of a persistent tagging method is an essential requirement to enable estimation of growth and mortality rates and observe migrations. Further development of the branding and Gundersen toggle-tagging techniques should be encouraged.

10.4.b A considerable amount of moult increment data are available for both species of *Homarus*, but data on moulting frequency in the wild are very sparse. As annual growth is an essential parameter for all population models it is necessary to determine moulting frequency and hence obtain estimates of annual growth.

10.4.c Similarly mortality rates, both natural and fishing, are essential to population models. The development of persistent tagging technique should encourage the estimation of mortality rates.

10.5 Rearing

The demand for lobsters at present exceeds the supply. There is probably a potential market for an alternative to the present live market, e.g., frozen small tails. Continued research into the biological and technological problems of hatching and rearing should be encouraged. Although economics will decide whether rearing is a viable proposition, a considerable amount of biological information, of value to the understanding of the natural stocks, will result from this research.

10.6 Pollution

Research into the acute and chronic toxicological effects of various common pollutants on lobsters, particularly larvae, would enable a better assessment of the possible effects of pollution on lobster stocks.

10.7 Yield Assessment and Research Priorities

The 1975 Group found it extremely difficult to agree on the priority that should be given to the various proposals for future research. It is essential to halt the decline in traditional lobster stocks and to provide adequate scientific advice for management of these important fisheries. The ability of the various countries represented to carry out these research proposals obviously depends upon their own resources and research priorities. As the decline in lobster stocks is common to most European countries and to North America it was felt that a cooperative research approach would be beneficial.

Although the preliminary assessments made by the 1977 Working Group used data which in many cases should be improved, clear management recommendations have been justifiably produced. Future research must concentrate on improving the parameter inputs for a yield assessment together with the additional information on the biology, particularly reproduction and recruitment, necessary to evaluate yield assessments and make valid management conclusions.

The Group felt that a considerable amount of data, both published and unpublished, existed which should be collated in such a way as to benefit those whose task it is to manage the *Homarus* stocks. In particular it was felt that a review of the growth data available and a consideration of the modelling of growth in homarids were essential. There is an obvious need to re-examine data and make better estimates of mortality parameters. Data on size and age at maturity together with information on recruitment are necessary, particularly in the light of the likelihood of recruitment failure in a number of stocks. The assessments in this report can only be regarded as preliminary. The Group believes that many of the necessary data are available for more accurate assessments to be made of many stocks other than those considered here.

REFERENCES

Bertalanffy, von L, 1938. A quantitative theory of organic growth. Hum. Biol., 10(2):181-213.

Beverton, R J H and S J Holt, 1957. On the dynamics of exploited fish populations. Fishery Invest., Lond., Ser.2, 19:533 pp.

Table 1. European lobster landings (tonnes).
Source: Bulletin Statistique - ICES.

Year	Denmark	E & W	France	Ireland	Norway	Scotland	Spain	Sweden	All European countries
1950	216	352*	304	170	969	784	19	215	3 074
1951	157	346	368	139	862	643	29	252	2 833
1952	186	331	449	164	712	635	32	210	2 751
1953	145	403	485	200	848	635	37	216	3 006
1954	124	450	499	189	648	597	34	188	2 765
1955	108	506	497	253	632	662	34	167	2 889
1956	101	492	537	308	708	688	32	178	3 074
1957	74	528	568	270	655	728	53	148	3 059
1958	75	495	625	300	714	704	68	164	3 174
1959	72	489	401	347	684	819	57	160	4 159
1960	85	465	497	267	787	890	37	168	3 226
1961	76	565	509	180	681	991	26	147	3 211
1962	67	469	437	167	551	898	24	120	2 767
1963	71	480	318	153	498	805	5	105	2 470
1964	50	477	388	217	353	793	23	92	2 443
1965	35	398	426	205	350	643	20	86	2 194
1966	30	420	446	278	248	586	20	78	2 325
1967	30	387	422	279	239	567	161	64	2 411
1968	24	371	361	287	276	616	99	66	2 358
1969	25	383	340	298	218	568	17	66	1 954
1970	22	491	324	277	202	602	47	71	2 108
1971	15	451	310	285	133	678	20	50	1 952
1972	16	429	373	221	161	585	16	43	1 893
1973	13	457	420	258	150	545	13	42	1 898
1974	11	377	400*	253	139	600	12	38	1 830*
1975	14	342	400*	332	128	503	-	43	1 762*
1976	12	348	400*	370	116	531	-	33	1 810*
Averages 1950-59	126	439	573	234	743	690	40	190	3 078
Averages 1960-69	49	442	414	233	420	736	43	99	2 536
Averages 1970-76	15	414	357*	285	147	578	22*	46*	1 893*

* Approximate or estimated as available.

Table 2a. Lobster landings (tonnes) from the United States inshore and offshore (traps and trawls) fisheries for 1965-76.

Year	Inshore traps	Offshore traps	Offshore trawls	Other*	Total
1965	11 218	0	2 481	20	13 719
1966	11 609	0	1 776	15	13 400
1967	10 068	0	2 048	15	12 131
1968	12 253	0	2 490	25	14 768
1969	12 165	52	3 086	22	15 325
1970	11 604	666	3 199	23	15 492
1971	11 308	1 480	2 477	16	15 281
1972	10 626	2 890	1 093	17	14 626
1973	10 518	1 945	671	16	13 150
1974	10 398	1 749	940	-	13 087
1975	10 476	1 939	726	-	13 141
1976	11 708	1 914	598	-	14 220

* Includes scuba diving and fish pots.

Table 2b. Lobster landings (tonnes) in Canada.

Year	Maritimes			P.Q.	Nfld.	Canada
	Inshore	Offshore (trap)	Total			
1965	15 193	-	15 193	1 494	1 695	18 382
1966	13 584	-	13 584	1 773	1 580	16 937
1967	12 926	-	12 926	1 501	1 414	15 841
1968	13 842	-	13 842	1 274	1 808	16 924
1969	15 406	-	15 406	1 083	1 730	18 219
1970	13 937	-	13 937	1 195	1 463	16 595
1971	14 720	100	14 820	1 108	1 381	17 309
1972	12 471	334	12 805	1 009	1 237	15 051
1973	13 422	481	13 903	981	1 263	16 147
1974	11 496	410	11 906	1 005	1 326	14 237
1975	14 040	547	14 587	1 204	1 697	17 488
1976	11 669	636	12 305	1 247	2 229	15 781

Table 3. Calculated or estimated von Bertalanffy growth constants, fishing and natural mortality, minimum landing size and size at maturity for a number of H. gammarus and H. americanus stocks.

Country	Sex	K	L_∞ (mm)	W_∞ (kg)	t_o	F	M	Present l_c (mm)	Size at: 1st maturity	50% maturity
H. gammarus										
England	♂	0.12	196	6.55		1.17	0.25	80		
	♀	0.17	160	2.59		1.17	0.25	80	77	85+
Ireland	♂	0.121	174		0.34	0.8	0.06	83	76-83	
Norway	♂	0.20	129	1.65	(0.34)	1.5	<0.1	78		
	♀	0.10	157	2.45	(0.34)	1.5	<0.1	78		
H. americanus										
Canada (Nfld.)	♂	0.390	105	0.99	0.796	1.77	0.11	81		
	♀	0.240	112	1.06	0.689	1.77	0.11	81	67	75
USA: Maine	⚥	0.048	267	12.2	-0.772	2.30	0.1-0.2	81	83	
S New England	♂	0.115	253	11.2	-0.140	>0.67	0.1-0.2	81		

Table 4. Input parameters for the Beverton and Holt (1959) yield per recruit equation for the Newfoundland male, and Norway male and female *Homarus* stocks.

Input	Newfoundland ♂	Norway ♂	Norway ♀
K	0.39	0.20	0.10
W_∞ (kg)	0.992	1.654	2.448
(L_∞ mm CL)	(105)	(129)	(157)
t_o (yr)	0.8	0.34	0.34
t_λ (yr)	20	20	20
t_r (yr)	4	4	4
R	1000	1000	1000
M	0.1/0.3	0.1/0.3	0.1/0.3
F_{min}	0.1	0.1	0.1
F_{max}	1.5	1.5	1.5
F_{inc}	0.1	0.1	0.1
t_c min(yr)	4	4	4
t_c max(yr)	15	15	15
t_c inc (yr)	1	1	1

Table 5. Calculated age (size) at first capture $(t_c)_{max}$ ($(l_c)_{max}$) giving maximum yield $(Y_W/R)_{max}$ for selected values of M and F, and fishing mortality $(F)_{max}$ giving $(Y_W/R)_{max}$ for selected values of M and t_c (l_c) for three *Homarus* stocks.

Country	Sex	M	F	$(t_c)_{max}$	$(l_c)_{max}$	$(Y_W/R)_{max}$	t_c	l_c	$(F)_{max}$	$(Y_W/R)_{max}$
			0.2	5	85	458	4	75	0.4	480
Newfoundland	♂	0.1	0.5	6	91	529	5	84	0.6	520
			1.5	7	96	552	6	91	>1.0	545
			0.2	4	75	>240	4	75	>1.4	>372
Newfoundland	♂	0.3	0.5	4	75	>333	5	85	>1.5	>365
			1.5	4	75	>372	6	91	>1.5	>322
			0.2	7	93	481	5	78	0.3	469
Norway	♂	0.1	0.5	8	101	547	6	87	0.4	505
			1.5	9	106	564	7	93	0.6	533
			0.2	4	60	>201	5	78	>1.5	>277
Norway	♂	0.3	0.5	4	60	253	6	87	>1.5	>272
			1.5	<5	<78	277	7	93	>1.5	>249
			0.2	10	97	306	7	76	0.3	290
Norway	♀	0.1	0.5	12	108	359	10	97	0.5	346
			1.5	14	117	371	12	108	1.0	366
			0.2	5	58	87	7	76	>1.5	>113
Norway	♀	0.3	0.5	6	68	106	10	97	>1.5	> 88
			1.5	7	76	113	12	108	>1.5	> 65

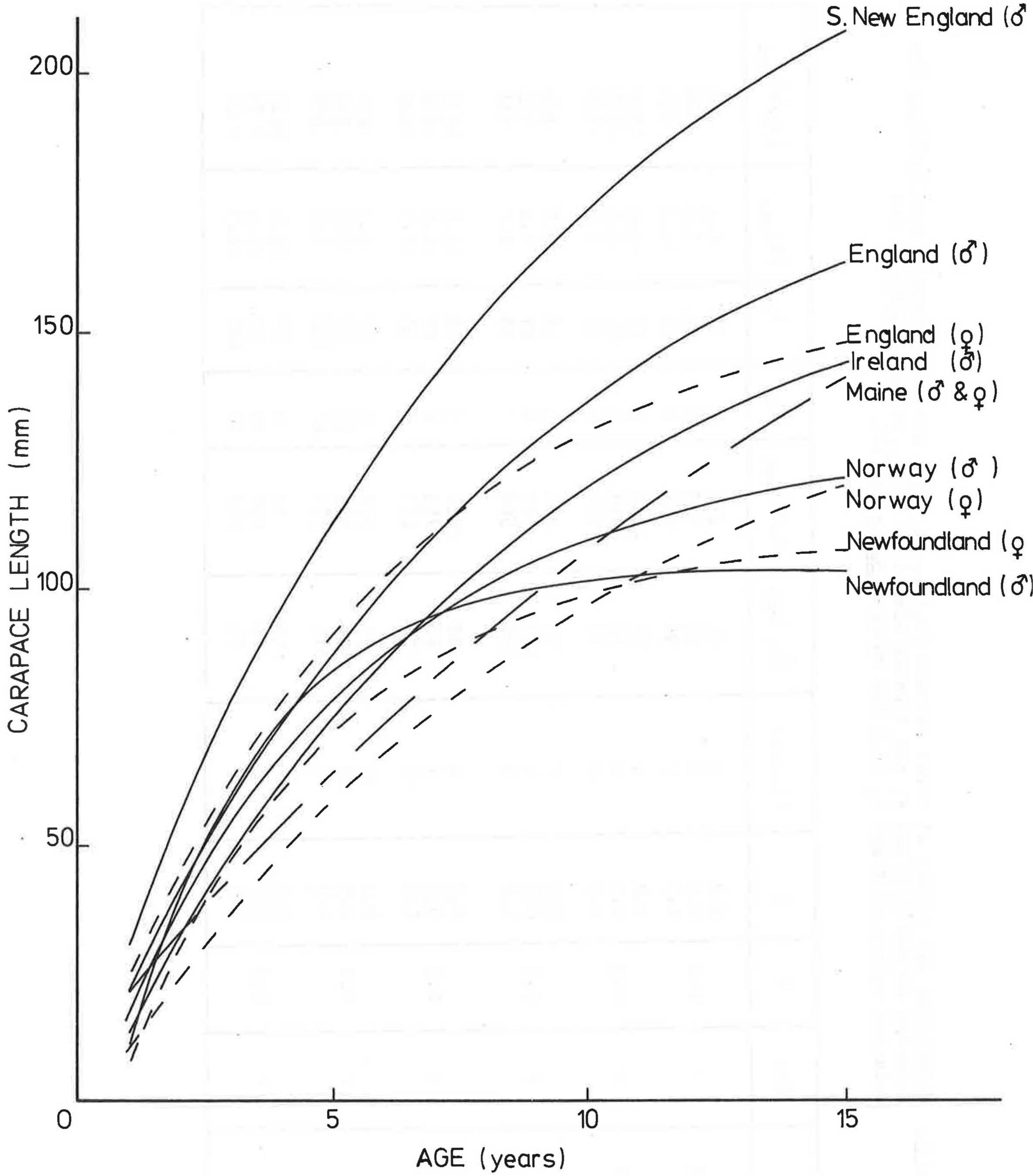
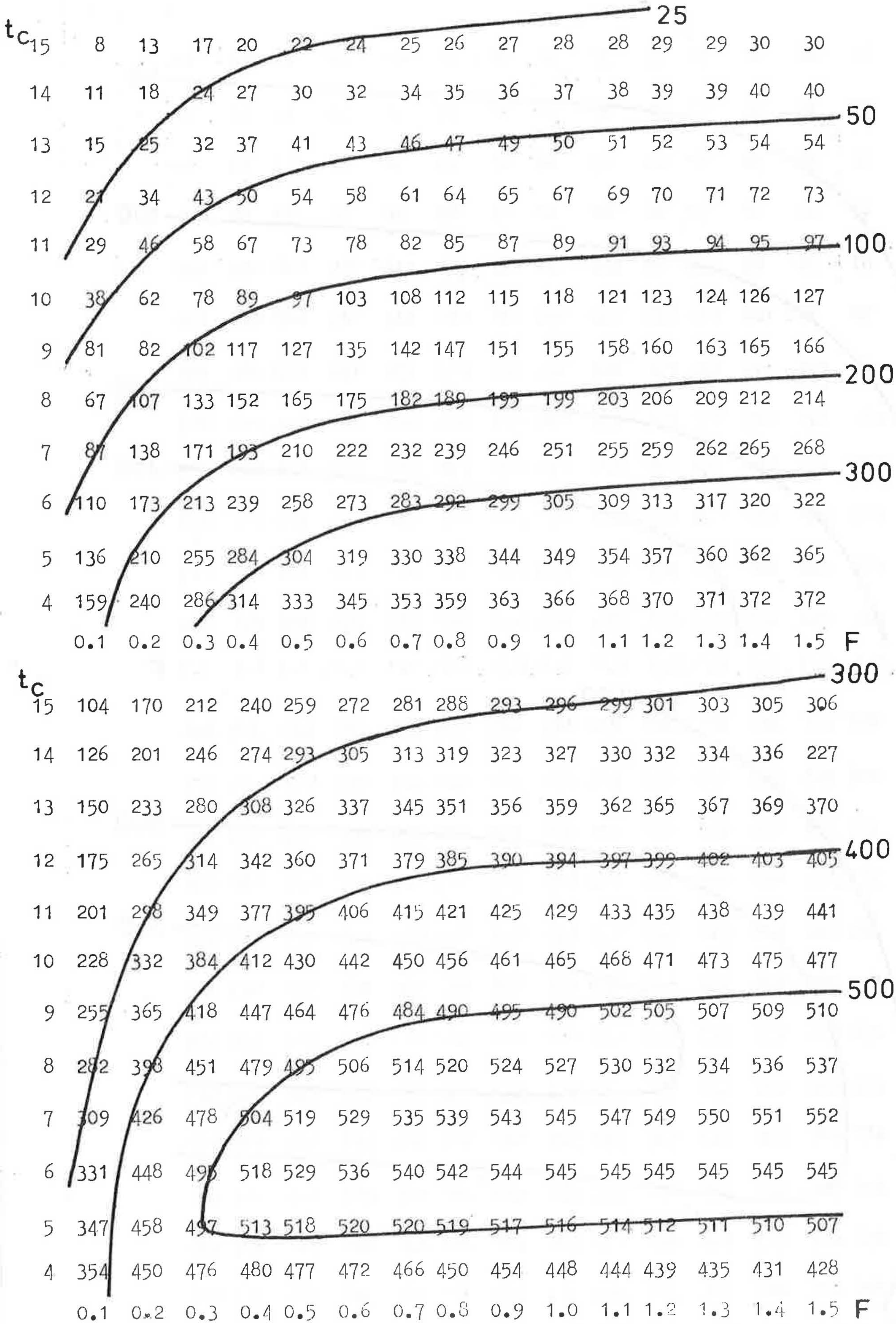


Figure 1. Lobster growth curves (von Bertalanffy) for various stocks of *H. gammarus* and *H. americanus.*



t_c															
15	8	13	17	20	22	24	25	26	27	28	28	29	29	30	30
14	11	18	24	27	30	32	34	35	36	37	38	39	39	40	40
13	15	25	32	37	41	43	46	47	49	50	51	52	53	54	54
12	21	34	43	50	54	58	61	64	65	67	69	70	71	72	73
11	29	46	58	67	73	78	82	85	87	89	91	93	94	95	97
10	38	62	78	89	97	103	108	112	115	118	121	123	124	126	127
9	81	82	102	117	127	135	142	147	151	155	158	160	163	165	166
8	67	107	133	152	165	175	182	189	195	199	203	206	209	212	214
7	87	138	171	193	210	222	232	239	246	251	255	259	262	265	268
6	110	173	213	239	258	273	283	292	299	305	309	313	317	320	322
5	136	210	255	284	304	319	330	338	344	349	354	357	360	362	365
4	159	240	286	314	333	345	353	359	363	366	368	370	371	372	372
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5 F

t_c															
15	104	170	212	240	259	272	281	288	293	296	299	301	303	305	306
14	126	201	246	274	293	305	313	319	323	327	330	332	334	336	227
13	150	233	280	308	326	337	345	351	356	359	362	365	367	369	370
12	175	265	314	342	360	371	379	385	390	394	397	399	402	403	405
11	201	298	349	377	395	406	415	421	425	429	433	435	438	439	441
10	228	332	384	412	430	442	450	456	461	465	468	471	473	475	477
9	255	365	418	447	464	476	484	490	495	490	502	505	507	509	510
8	282	398	451	479	495	506	514	520	524	527	530	532	534	536	537
7	309	426	478	504	519	529	535	539	543	545	547	549	550	551	552
6	331	448	495	518	529	536	540	542	544	545	545	545	545	545	545
5	347	458	497	513	518	520	520	519	517	516	514	512	511	510	507
4	354	450	476	480	477	472	466	450	454	448	444	439	435	431	428
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5 F

Figure 2. Yield-per-recruit (kg/1000) isopleths for a range of fishing mortalities (F) and age at first capture (t_c) for Newfoundland, Canada, male *H. americanus*: (top) natural mortality (M) = 0.3, (bottom) M = 0.1.

t_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5
15	12	20	26	30	33	35	37	38	40	41	41	42	43	43	44
14	16	27	34	40	43	46	49	50	52	53	54	55	56	57	57
13	22	36	45	52	57	60	63	66	67	69	70	72	73	73	74
12	29	47	59	68	73	78	82	84	87	89	90	92	93	94	95
11	38	61	76	87	94	99	104	107	110	113	115	116	118	119	120
10	49	78	97	109	118	125	130	135	138	141	143	145	147	149	150
9	63	98	121	136	146	154	161	165	169	173	175	178	180	181	183
8	78	121	147	165	177	186	193	198	203	206	209	212	214	216	217
7	95	145	175	195	208	218	225	231	235	238	241	244	246	248	249
6	112	169	202	222	235	245	251	257	260	263	266	268	269	271	272
5	128	189	222	241	253	260	266	269	272	273	275	276	276	277	277
4	140	201	230	245	253	257	259	260	260	260	259	258	258	257	256

t_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5
15	156	254	317	358	384	402	414	423	429	434	438	440	443	445	446
14	187	296	360	399	423	439	449	457	462	466	469	472	474	476	477
13	218	335	399	436	458	472	481	488	492	496	499	501	503	505	506
12	248	371	435	469	489	502	510	515	519	523	525	527	529	530	532
11	277	405	466	498	516	526	533	538	541	544	546	548	549	551	552
10	305	434	492	520	536	544	550	554	556	558	560	561	562	563	563
9	330	458	511	535	547	553	557	559	561	562	563	563	563	564	564
8	350	474	520	539	547	550	552	552	552	552	552	551	550	550	549
7	366	481	518	530	533	533	531	529	527	525	523	521	520	518	517
6	375	476	502	505	502	497	492	487	482	478	475	472	469	466	464
5	375	458	469	463	452	442	432	424	417	411	406	401	397	393	390
4	365	426	420	402	384	368	354	343	333	325	318	312	306	301	297

Figure 3. Yield-per-recruit (kg/1000) isopleths for a range of fishing mortalities (F) and age at first capture (t_c) for Norwegian male *H. gammarus*: (top) natural mortality (M) = 0.3, (bottom) M = 0.1.

t_c															
15	10	17	22	25	28	30	31	32	33	34	34	35	35	36	36
14	14	22	28	32	35	37	39	40	41	42	42	43	43	44	44
13	18	28	35	40	43	46	47	49	50	51	52	52	53	54	54
12	22	35	43	49	53	55	57	59	60	61	62	63	64	64	65
11	28	43	53	59	63	66	68	70	72	73	74	75	75	76	77
10	34	52	62	69	74	77	80	82	83	85	86	86	87	88	88
9	40	61	73	80	85	88	91	93	94	96	97	98	98	99	99
8	47	70	82	90	95	98	101	103	104	105	106	107	107	109	108
7	53	78	91	98	103	106	108	109	110	111	112	112	112	113	113
6	59	84	96	103	106	108	110	111	111	111	112	112	112	112	112
5	63	87	98	102	104	105	105	105	105	105	104	104	103	103	103
4	65	86	94	96	95	94	93	92	91	90	88	87	87	86	85
F	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5

t_c															
15	138	223	275	308	329	342	350	356	359	362	363	364	365	366	366
14	160	248	300	329	346	355	361	365	367	368	369	370	370	371	371
13	180	272	319	343	356	362	366	268	367	370	370	370	370	370	370
12	198	288	330	350	359	363	365	365	366	366	366	365	365	365	365
11	212	300	336	350	356	357	358	357	356	356	355	354	354	353	353
10	224	306	334	344	346	345	344	342	341	339	338	337	336	335	334
9	231	305	327	330	329	326	323	320	318	316	314	312	311	309	308
8	235	299	312	310	306	300	296	292	288	285	283	281	279	277	276
7	234	286	290	284	275	268	262	256	252	248	245	243	240	238	236
6	230	268	263	251	239	230	222	216	210	206	202	199	197	194	192
5	221	244	230	213	199	187	178	171	165	161	157	153	150	148	146
4	209	216	194	173	156	143	134	126	120	115	111	107	105	102	100
F	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5

Figure 4. Yield-per-recruit (kg/1000) isopleths for a range of fishing mortalities (F) and age at first capture (t_c) for Norwegian female *H. gammarus*: (top) natural mortality (M) = 0.3, (bottom) M = 0.1.