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REPORT OF THE WORKING GROUP ON ASSESSMENT OF PANDALUS STOCKS

Lysekil, Sweden, 24-26 April 1979

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SUMMARY

- 1) The Pandalus fisheries were reviewed with particular reference to recent catch, effort and cpue data (Section 2), the current regulations and common practice (Section 3), and recent by-catch data (Section 4).
- 2) Recent and current research programmes were discussed (Section 5).
- 3) Regulatory measures were considered (Section 6). The 1977 assessment (ICES, 1978. Coop. Res. Rep. No 83) provides the basis for the following recommendations:-

Fladen: the mesh size should be increased to 35mm

Skagerrak: the mesh size should be increased to 45mm

These increases in mesh size will increase the size at first capture above the size at first maturity to protect the breeding stock. Fin-fish by-catches will also be reduced.
- 4) A stock assessment sub-group has been formed to report to the next meeting of the Working Group in 1980.

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1. INTRODUCTION

The last meeting of the ICES Pandalus Working Group was held in 1977 at Conwy, N. Wales when a full report was produced (ICES, 1978. Coop. Res. Rep. No 83).

At the 66th Statutory Meeting in 1978 the Council decided (C. Res. 1978/2:34) that the Group should meet at Lysekil, Sweden for 3 days in April 1979 to advise on regulatory measures for Pandalus stocks.

The following participated:

D.B. Bennett - Rapporteur	United Kingdom (England and Wales)
D. Carlsson	Denmark (Greenland Fisheries)
B.I. Dybern	Sweden
E. Edwards - Chairman	United Kingdom (England and Wales)
H. Hallbäck	Sweden
J. Mason	United Kingdom (Scotland)
S. Munch-Petersen	Denmark
E.J. Sandeman	Canada
B. Sjostrand	Sweden
P. Øynes	Norway

2. REVIEW OF FISHERIES

2.1 ICES Area

Denmark

The Danish landings from the Skagerrak-Kattegat area (Division IIIa) in 1977 and 1978 were approximately the same as in previous years (Table 4).

The landings from the North Sea (Division IVa) were still much lower than in the late 1960s, with large fluctuations (Table 2) due to the fluctuations in the catches from Fladen Ground (Table 3)

Cpue changed little in 1977 (Table 5). No data are available for 1978.

Norway

The coastal and fjord fisheries for Pandalus in Norway have been stabilised at about the same level for many years. From 1969 vessels started fishing at Spitsbergen and in the Barents Sea. Fishing effort has increased each year with catches rising from about 5 000 t in 1970 to reach 18.000 t in 1978.

The total Norwegian landings of Pandalus in the ICES area in 1978 was 20 928 t (Table 1). Most of this, 17 958 t, was taken in the Barents sea. Almost all the catch was taken from very limited areas of sea bed near the boundary between ICES Sub-area I and Division II a. About 1 000 t of the Norwegian landings were from Soviet waters near Novaya Zemlya. There was no fishing in the Spitsbergen and Jan Mayen areas (II b and XIV) in 1978.

Sweden

Most of the Swedish catch is taken in the Skagerrak (Table 4) and a small proportion from south west Norway (Table 2). During 1977 and 1978 the landings (Table 4) and cpue (Table 5) both decreased, but the shrimp fishery is still Sweden's second largest marine fishery in terms of economic value. It has been suggested that the number of shrimp trawlers should be increased, but with the decline in landings in the last two years any increase in the fleet should first be carefully considered. The number of boats fishing mainly for shrimps is at present (1979) about 75, with a total of about 250 men.

United Kingdom (England and Wales)

There is a small fishery in the Farn Deep's off northeast England (Division IV b) which is exploited sporadically. In 1977 up to 12 boats caught 265 t (Table 2). Fishing occurred from April to August with the majority being caught in June and July. Landings at 98t were considerably less in 1978.

United Kingdom (Scotland)

Fladen (Division IVa) has continued to be the main fishing ground and landings after a slight fall in 1977 to 1 704 t, rose in 1978 to 2 027 t (Table 3). After reaching a peak of 128 kg/h in 1975, cpue has since fluctuated round a slightly lower level (Table 5). A little fishing took place in 1977 and 1978 in the Farn Deep. Landings were 21 t (cpue 110 kg/h) in 1977, but fell to only 2 t (cpue 45 kg/h) in 1978.

Landings of Dichelopandalus bonnieri taken on the west coast (Division VI a) were small, 0.8 t in 1977 and 1.2 t in 1978.

2.2 ICNAF Area

Canada

The stocks in ICNAF Subareas 2, 3 and 4 (Table 6) are now exploited only by Canadian vessels.

The fishery off Labrador (Subarea 2) is a recent one, with catches being negligible till 1975-76, when excellent catches were reported by one or two Canadian and Norwegian vessels. Following landings of 2 618 t in 1977 a precautionary quota of 6 100 t was introduced for 1978 and landings in the year reached only 3 260 t (preliminary figure).

Though a few shrimp grounds are known to exist off Newfoundland in Subarea 3, catch rates have generally been too low to encourage commercial enterprises and landings have been negligible.

The main fishery in Subarea 4 has taken place in the Gulf of St. Lawrence, where shrimp concentrations occur in three main locations and statistics have been collected for each of these separately. Current landings are of the order of 5 000 t. Several small local concentrations of shrimps have been found in the Bay of Fundy and Nova Scotia Shelf areas of Subarea 4. They have yielded catches for only one or two years before becoming depleted.

Greenland (ICNAF Subarea 1 + Division OA)

In the inshore shrimp fisheries catches (Table 7) and effort have been stable for the last ten years. The offshore fishery takes place mainly in ICNAF Subarea 1, with only a minor part of the catch taken in Division OA. In 1977 the fishery in Subarea 1, was regulated for the first time with a TAC of 36 000 t (including discards). For 1978 a TAC was set for both Subareas 1 and O, totalling 40 000 t, of which only about 28 000 t (preliminary figure) have been fished. In 1977 and 1978 catch rates in the offshore fishery have declined, and the scientific advice for the 1979 quota is a reduction of ~~1/3~~ to 1/5 compared with the 1978 quota of 40 000 t. The final 1979 TAC has not been settled at present (April 1979).

3. REVIEW OF CURRENT REGULATIONS AND COMMON PRACTICE

3.1 ICES Area

NEAFC Recommendation 2 permits the use of cod-end meshes of less than 50 mm, but not smaller than 16 mm, when fishing for Pandalus.

Denmark

No regulations but cod-ends are now usually 30-35 mm.

Norway

Norway has several national regulations which are generally aimed at management of fishermen and fish by-catches rather than shrimps. Off northern Norway and in the Barents Sea the mesh size is 35 mm. In the Skagerrak and off S. Norway a 30 mm mesh is permitted. Vessels over 50 t must be licensed to catch shrimps and the issuing of new licences has been suspended. Towing time in inshore waters is limited to 3 h and to avoid long lines trawling is permitted only between 0600 and 1800 hr. To protect juvenile fish and spawning cod many fjords are closed, although viable shrimp fishing would be possible. From 1 November to 1 April in northern Norway spawning cod are protected by forbidding trawling in depths less than 220 m. Bobbins are not permitted inside the 12 mile limit to keep nets off the stony ground, thus reducing the fish catch.

Sweden

No national regulations, but cod-ends are usually about 30 mm. The West-coast fishermen's organisation has obligatory regulations:

2 man crew, maximum landing allowed 390 kg/week

3 man crew, maximum landing allowed 550 kg/week

4 or more crew, maximum landing allowed 730 kg/week

These restrictions are for boiled shrimps with a maximum count of 160/kg.

There are no limits for uncooked shrimps, with a maximum count of 275/kg.

Fishing is permitted for only 3 days per week and local arrangements close the fisheries for a 3 week holiday.

United Kingdom

Cod-ends are usually 25-35 mm.

3.2 ICNAF Area

Canada

There is a natural closed season in most years owing to winter ice. There are no mesh regulations; 38-44 is used.

In the Gulf of St. Lawrence two areas have limited entry licensing. In the recently developed fishery off the Labrador coast a precautionary TAC of 4 500 t was set in 1977 and licences made available to allow 12 trawlers to fish these stocks. For 1979 the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) has advised a small reduction in TAC, as well as recommending no discards be allowed and that bearing the cost of trained biological observers be considered a condition of the licence.

Greenland

Inshore there are no regulations, although fishermen have voluntarily agreed to limit fishing effort. The mesh size is about 40 mm.

Offshore management is by TAC and an ICNAF mesh size of 40 mm. The first TAC of 36 000 t was set in 1977 for ICNAF Subarea 1. This TAC was based upon fishable biomass estimates obtained by the swept area method using both commercial and research vessel trawl catch rates. A small quota was set in one area in case the offshore stock was the source of recruitment to Disko Bay. In 1978 no further data were available and the TAC was left at 36 000 t plus 4 000 t for a new area. For 1979 it has been noted that cpue has declined and a photographic survey also indicated a lower fishable biomass. A reduction in the TAC of 20-33% has been suggested for 1979.

4. BY-CATCH

4.1 ICES Area

Pandalus borealis is included in the species listed under NEAFC Recommendation 2, which permits use of cod-ends meshes of less than 50 mm, but not smaller than 16 mm. This often results in considerable quantities of fin-fish by-catches being taken in Pandalus fisheries. The Working Group discussed this problem in some detail, including measures aimed at reducing the loss of young of Recommendation 4 species (see section 6).

Denmark

Tables (8 and 9) show the most important species, which are landed as by-catch from the Pandalus fishery in the Kattegat-Skagerrak area and the Fladen Ground. In both areas Norway pout forms the major part. The figures are based on sampling in the harbours of Skagen, Hirtshals and Hanstholm, and cover about 25% of the total shrimp landings.

The Norway pout, blue whiting and the category "unspecified" are landed for industrial purposes. The category "unspecified" is used when the catch is very mixed, and includes Norway pout and blue whiting as well as undersized or unsuitable specimens of protected species.

On the basis of these figures the estimated yearly landings of cod, for human consumption from this fishery are less than 100 t. Those of haddock and whiting are less than 10 t. The total yearly landings by shrimp-trawl of fish for industrial purposes have declined since 1972, and in the last years have been less than 1 000 t.

Norway (Strom and Øynes 1971; Rasmussen & Øynes, 1974)

The by-catch problem has been studied for more than 10 years and a number of regulations have been introduced to protect the young of species important for human consumption. The problem varies from place to place. In the fjords of southern Norway and in all grounds deeper than 350 m there is virtually no by-catch of protected species. In the fjords of northern Norway and in the coastal waters off Troms and Finnmark cod and redfish are abundant in catches and consequently trawling for shrimps is forbidden in most fjords in Finnmark. Further north in the Barents Sea small redfish and capelin form the bulk of the by-catch, and in Arctic waters polar cod are commonly caught. If the by-catch on a particular ground becomes too large the boats move to other grounds. Studies of the by-catch problems have been intensified during the past 3 years.

Sweden

The by-catch consists mainly of fish species, and to a very small extent of other crustaceans, especially Nephrops. For the shrimp trawlers the by-catch is generally less important than the shrimps and much of it, including both unprotected species and undersized specimens of protected species is discarded (Table 10). Of the landed by-catch the greater part goes for industrial purposes (mainly as food for animals like minks). Most important among the species landed for human consumption are cod, witch and pollack.

United Kingdom (England) (Farn Deep Fishery)

The bycatch from the Farn Deep fishery for Pandalus is by weight mainly cod, whiting, haddock and Nephrops (Table 11). The value of the by-catch was 33% of the total landings in 1977 and 43% in 1978. There was no information about discards.

United Kingdom (Scotland) (Fladen fishery)

The proportion of the total catch which is discarded varies seasonally, being lowest in the early spring and highest in the summer (Howard, 1978). The predominant species discarded is Trisopterus esmarkii, which accounts for up to 96% by number of the discards. This species is seldom landed by Scottish boats for industrial purposes.

The by-catch landed for human consumption was 791 t in 1977 and 627 t in 1978, which included small quantities of Nephrops and squid. These were 46% and 31% respectively of the weights of shrimps landed. The most important species were cod, monk-fish, haddock, saithe and ling (Table 12).

4.2 ICNAF Area

Canada

ICNAF Subarea 2.

Catches of shrimp in this area have characteristically been quite clean with only small bycatches (about 8% of total catch) of either commercial sized or small fish. By-catches are not considered a problem though attempts will be made in 1979 to better quantify this.

Subarea 4.

In the Gulf of St. Lawrence the by-catch of commercial sized fish (for human consumption) gives rise to an important part of the fishermen's income. Indeed,

economic studies of the fishery of the northeast Gulf have shown that even with the by-catch many of the vessels are operating under marginal or sub-marginal economics (Fisher, 1977a, 1977b). Of major concern has been the very large numbers of young redfish which occur in the catches in years following the settlement of a good year-class, and substantial efforts have been devoted to the solution of this problem. These have included: (i) development of sorting trawls (Brothers and Way, 1977; Fontaine and Pilote, 1977). (ii) development of mid-water trawls (Tobey, 1977; Tobey and Rycroft, 1978). (iii) assessment of the impact of the by-catch of small redfish on the redfish stocks of the area (Parsons, 1978).

While the development of improved fishing gear and methods has met with some success, preliminary assessments of the by-catch of small redfish in the northeastern part of the Gulf, indicated that in 1976 no more than 3.5% of the estimated redfish biomass (expressed in numbers) was removed, and that no year-class was subjected to removals greater than a median 2.5% (Parsons, 1978).

Greenland

In the inshore shrimp fishery by-catch levels are at present not considered to have any significant effect on the commercial fish stocks in the area. These by-catches include small catches of redfish, Greenland halibut, American plaice, cod, wolf-fishes and eelpouts. In the Disko Bay fishery the by-catch of Greenland halibut is of some importance as dog-food; otherwise the by-catch is discarded.

Offshore the by-catch is of the same species as taken inshore, redfish being by far the most dominant species followed by Greenland halibut. By-catch levels vary considerably, not only by area and time of the year, but also by time of day. Logbook data from a restricted number of Greenland trawlers indicate a by-catch in weight roughly corresponding to about half of the shrimp catch. From October 1977 to September 1978 the by-catch corresponding to a shrimp catch of 5 500 tonnes amounted to approximately 2 600 tonnes redfish and 45 tonnes of other fin-fish.

The effects on the redfish stocks of this by-catch of redfish in the Pandalus fishery is being considered by ICNAF.

5. RECENT RESEARCH

5.1 ICES Area

Denmark

Sampling for cpue in the harbours where Pandalus is landed has been continued. Special interest is given to the by-catch in the Pandalus fishery.

Apart from these investigations no special Pandalus research has been carried out in the recent years, one of the reasons being the lack of a research vessel.

Norway

From 1950 to 1970 few shrimp investigations were done, but in 1970 exploratory fishing was started to find and chart new Pandalus grounds in the Barents Sea for the increasing Norwegian trawler fleet. During these investigations the problem of by-catch, especially cod and redfish, came to light. Experiments with separating trawls designed to retain shrimps while allowing fish to escape have been inconclusive.

Since 1976 investigations on board Norwegian trawlers fishing west of Greenland have been aimed at making biomass assessments. Similar investigations were started in 1978 in the Barents Sea.

In 1979 investigations will include hiring a small shrimp trawler for 8 weeks to carry out trawl surveys off Troms and Finnmark. A larger trawler (37 m long) is being hired to provide material for biomass assessments in the Barents Sea. The research vessel "Michael Sars" will carry out shrimp studies in the Jan Mayen area during 3 weeks in September 1979.

The larval life of Pandalus is being studied using material from different areas of the Barents Sea. Temperature tolerance of adults and larvae is being investigated.

Sweden

Trawl surveys are performed once or twice a year, covering Divisions IIIa and the eastern part of IVa. Information on horizontal and vertical distribution, size composition and sex ratios are obtained. Information is collected from selected shrimp trawlers representing 10-15% of the Swedish shrimp fishery about their daily catches, discarded fish etc.

United Kingdom (England and Wales - Farn Deep)

During years when a fishery by English vessels develops data are collected on total catch, cpue, catch composition and by-catch.

United Kingdom (Scotland)

Collection of catch-composition, total catch, cpue and by-catch data are continuing. Biological studies include the influence of environmental factors on the distribution and movements of shrimps.

5.2 ICNAF Area

Canada

Subarea 0 and 1

Research in this area has been restricted to exploratory surveys carried out in 1978. (Jones & Parsons, 1978; Veitch, Parsons and Duthie, 1978). No extensive stocks were found outside those already known.

Subarea 2

Research vessel cruises have been used to estimate minimum trawlable biomass using the swept area method and a precautionary TAC was calculated for two areas (Sandeman, 1978a; Parsons, Tucker and Veitch, 1979). Commercial catches are

sampled, but to date only a superficial examination of size frequencies has been undertaken and no real attempt has yet been made to obtain age distributions or growth rates.

Subarea 3

There are no commercial fisheries in this subarea at present. Exploratory fishing took place during which biological data has been collected.

Subarea 4

Research has been conducted on four relatively discrete stocks of shrimps. Catches have been sampled and research vessel surveys have provided estimates of minimum trawl-able biomass. In some areas TAC estimates have been obtained (Sandeman, 1978b).

In the Seven Islands area, west of Anticosti the biomass estimates were used to derive a first estimate of natural mortality rate (M) and MSY using Gulland's approximate relationship $MSY = 0.5 M B_0$, where B_0 = virgin biomass (Fréchette, pers.com.). Age distributions were derived using the Hasselblad technique (Hasselblad, 1966) and the computer program NORMSEP (Abramson, 1971). Use of Baranov's catch equation and the age distributions in successive years has allowed an estimate of the instantaneous natural mortality rate (M) of 0.7 for fully recruited year classes (Fréchette + Labonté, 1979). Of particular interest is the preliminary use of weight frequency distributions for the age analysis, which allow the right hand mode of the length frequency to be dissected into two separate modes (Fréchette & Labonté, 1979).

Research has also been conducted on selectivity, diurnal variations and various aspects of reproductive and feeding biology of the stock as well as selective shrimp trawls.

Greenland

Since 1975 catch and effort data has been collected by log-books from all Greenland trawlers > 300 GRT, and a similar system will soon be introduced for all vessels > 80 GRT. Information on fishing locality and effort in hours is now being collected from all shrimp vessels at landing.

In 1976 a random stratified trawl survey was conducted in ICNAF Division 1B to estimate shrimp biomass. Since then only a small number of trawl stations have been visited regularly by research vessels. Bottom photography surveys for biomass estimates have been conducted every year since 1976 and will be continued in the offshore area.

Scientific observers are regularly joining commercial shrimp trawlers; in 1978 observers participated in an exploratory survey in ICNAF Division 1A and OB by a commercial trawler.

Shrimp samples are regularly taken from commercial and research catches for analysis of catch composition, year-class strength and recruitment. Recently a sampling program to analyse diurnal variation in catch composition caused by diurnal migrations of the shrimp has been started.

Data on the sea current system at West Greenland has been obtained from an offshore oil drilling program and will, together with data on larval distributions, be used for analysis of larval drift and recruitment.

6. REGULATORY MEASURES

The Group discussed the management of Pandalus fisheries by mesh regulations, closed seasons, closed areas (nursery grounds), control of fishing effort and TACs. Experience from ICNAF indicates that regulating mesh sizes alone would be

insufficient to sustain catch levels in a heavily exploited stock and that some control of catches or effort would be required. The present management techniques in the Canadian and Greenland areas includes TACs, but not minimum mesh sizes because large meshes of > 40 mm are already voluntarily used by commercial fishermen.

With regard to European stocks there have been no major improvements in data inputs so that the assessment carried out at the 1977 meeting of the Pandalus Working Group (ICES, 1978. Coop. Res. Rep. No 83) is still the best available. Although the Beverton and Holt dynamic pool model used in that assessment may not be an ideal model it did enable the 1977 Working Group to suggest certain management actions. There was some discussion at this 1979 meeting of the need to control fishing effort. The cpue data available (Table 5) does not suggest that catch rates are falling appreciably. The Group considered that TACs could not be calculated at present. To prepare the ground for another assessment in the future the Working Group has set up a Stock Assessment Sub-Group (see section 7).

The prime objective of management of the Pandalus stocks in the ICES area must be to increase the mesh size and so increase the size at first capture above the size at first maturity to protect the breeding stock. The 1977 assessment (ICES, 1978. Coop. Res. Rep. No 83) provides the basis for the regulatory measures recommended.

6.1 Fladen

It is recommended that the mesh size be increased to 35 mm on the Fladen ground (Table 13). This is equivalent to a t_c of 1.5 yr (15.4 mm CL). The present mesh of 25 mm is equivalent to a t_c of 0.7 yr (11.0 mm CL), an age well below the age at first maturity for females (1.4 yr (15 mm CL)) and below the $(t_c)_{max}$ (Table 14).

An increase to 35 mm would conserve the breeding stock and, although there may be some loss in yield-per-recruit, the total yield will increase.

The Scottish fishery on Fladen lands a by-catch of normal commercial sized cod, Norway pout, haddock, monk and dogfish for human consumption (Table 12). The proposed increase in mesh to 35 mm is not expected to affect the composition or proportion of landed by-catch from Scottish vessels.

The Danish fishery at Fladen lands a by-catch, mainly of Norway pout, for reduction to fish meal (Table 8). This by-catch would be reduced by an increase in mesh size to 35 mm but the loss in value would be small and compensated by increased Pandalus landings.

6.2 Skagerrak

The Danish fishery in the Skagerrak uses a mesh size of as low as 25 mm, while the Swedish fishery uses a mesh of 35 mm. It is recommended that the mesh size for the Skagerrak be increased to 45 mm. This is equivalent to a t_c of 3 yr (20 mm CL) (Table 13). This increase in mesh to 45 mm 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 will increase.

An increase in mesh size to 45 mm in the Skagerrak will reduce the fish by-catch (Tables 9 and 10). 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.

7. FUTURE RESEARCH AND MEETINGS

7.1 Stock identity

Stock identity is important, particularly the possible relationship between the North Sea fishery and that in the Skagerrak. Larval studies are lacking but it is likely that samples are already available from fish larval studies.

7.2 Predation

It is known that cod and other fish species are important predators on Pandalus. Wherever possible during shrimp studies at sea stomach contents of associated fish and mammal species should be examined. Investigations of the dependence of Pandalus stocks on, for example, cod stocks should be encouraged.

7.3 Diurnal vertical migrations

No work on diurnal migrations has been done in Europe. It may be possible to use detailed cpue data eg from fishermen's log-books, to determine variations in catch rates with time. Experimental work may be possible on the shallower Fladen grounds.

7.4 Stock surveys

Photographic surveys have been found to complement the biomass estimates obtained by the swept area method (Horsted, 1978; Kanneworff, in press). Such photographic surveys should be encouraged. As well as stratifying sample stations by depth, temperature and bottom type should also be considered. Work off the Labrador coast shows concentration of Pandalus in waters of $\sim 4^{\circ}\text{C}$.

7.5 Yield assessment parameter inputs

There has been little or no progress to improve estimates of natural mortality, age determination or growth rates, as recommended in the 1977 report.

Age determination is essential and identification of first time spawners would help to sort out age groups.

7.6 Recruitment estimates

The Group suggests that international cooperation is required to assess recruitment levels by young shrimp surveys.

7.7 Assessment techniques

Management in the ICNAF areas has been by means of TACs. Such action has been stimulated by declines in catches and even complete collapses of fisheries. While in Europe the fisheries do not show any marked overall declines there is considerable pressure to increase the fishing effort eg Barents Sea. While the Group has emphasised the need to implement its proposals to increase mesh sizes, it recognizes that control of fishing effort may be necessary in the near or immediate future.

The Group also considers that because of the importance of predator-prey relationships a multi-species assessment approach could be more appropriate in the future.

It was not possible at this meeting to fully discuss and plan future assessments. To ensure the minimum delay in preparing the Working Group for its future needs a sub group on stock assessment was set up. This sub-group shall review the stock assessment methods available and their appropriateness to Pandalus stocks, and then prepare a plan for an assessment in the near future. Any lack of data required should be communicated to members of the Working Group immediately.

The sub-group should be

D B Bennett, Convenor

S Munch-Peterson

E J Sandeman

B Sjöstrand

and they should work by correspondence, but meet once if necessary, to prepare a draft report for circulation to the members of the Pandalus Working Group and presentation at the next meeting of the Working Group.

7.8 Future Pandalus Working Group Meetings

With the setting up of the stock assessment sub-group the Working Group should be prepared to meet for 4 days in the spring of 1980 to improve on its previous assessments with particular consideration of the need for fishing effort controls and TACs.

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Table 1. Pandalus borealis landings (tonnes) from the ICES area

Source: Bulletin Statistique and pers. comm.

	Denmark	Germany (F.R.)	Iceland	Norway	Sweden	England	Scotland	Others	Total
1960	2580	-	1336	9616	4039	-	-	-	17571
1961	3174	-	1375	10036	4462	-	-	-	19047
1962	4448	-	700	10816	5725	-	-	-	21689
1963	4735	-	678	11658	5161	-	-	71	22273
1964	3602	-	572	11017	4654	-	-	-	19815
1965	5074	-	901	10434	3867	-	-	-	20276
1966	4697	68	1790	7406	1788	-	-	-	15749
1967	4791	23	1508	8355	1930	-	-	-	16607
1968	5175	41	2451	7201	2025	-	-	-	16893
1969	5434	0	3276	6353	1822	-	-	-	16885
1970	4217	-	4510	7597	2742	14	104	-	19184
1971	4432	33	6326	7773	2906	-	436	-	21906
1972	3221	-	5291	9111	2524		187	1941	22275
1973	912		7286	9267	2130	1424	163	8	21190
1974	812		6516	9961	2003	50	432	1093	20867
1975	2135	2	4941	10264	2003	0	525	-	19870
1976*	2726		6256	13630	2529	140	1950		27231
1977*	1545	1	7149	20642	2019	265	1725	4854	38200
1978*	1885			20928	1608	98	2029		

* Preliminary

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

	Denmark	Germany (F.R.)	Norway	England	Scotland	Sweden	Total
1970	3460	-	1107	14	104	915	5600
1971	3572	33	1265	-	436	1358	6664
1972	2448	-	1216	-	187	1150	5001
1973	196	-	931	1424	163	936	2226
1974	337			40	434	520	
1975	1392		147	0	525	252	2316
1976*	1861		676	140	1950	177	4804
1977*	782		589	265	1725	113	3474
1978*	1128		956	98	2029	79	4290

* Preliminary

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

	Denmark	Germany (F.R.)	Norway	U K (Scotland)	Sweden	Total
1970	3115	-		104		
1971	3216	33		436		
1972	2204	-		187		
1973	157	-		163		
1974	282			434		
1975	1308			525		
1976*	1522			1950		
1977*	425			1704		
1978*	890 ⁺			2027		

* Preliminary

⁺ Rough Estimate

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

	Denmark	Norway	Sweden	Total
1970	757	982	1827	3566
1971	834	1392	1548	3774
1972	773	1123	1374	3270
1973	716	1415	1194	3325
1974	475		1483	
1975	743	1576	1751	4070
1976*	865	2858	2352	6075
1977*	763	1728	1906	4397
1978*	757	1343	1529	3629

* 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.

	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
1977	105	76	27	23
1978		81		20

* Collected from selected vessels

Table 6 Catches (tonnes) of shrimps (Pandalus borealis) from the Gulf of St Lawrence and Labrador (ICNAF Subareas 2, 3 and 4).

	Gulf of St. Lawrence	Labrador
1965	11	-
66	96	-
67	278	-
68	272	-
69	273	-
70	572	-
71	1 084	-
72	665	-
73	1 793	-
74	3 317	-
75	4 528	+ *
76	4 645	+ *
77	4 974	2 618
78		3 260

Data from Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC), Invertebrates and Marine Plants Subcommittee Report 78/7 and CAFSAC Research Document.

* Small catches were obtained by Norwegian and/or Canadian vessels but details are not known.

Table 7 Annual landings (tonnes) of Pandalus borealis by all nations fishing at West Greenland 1970-1978 (ICNAF Subarea 1, a small proportion from ICNAF Subarea 0 division OA).

	1970	1971	1972	1973	1974	1975	1976	1977	1978*
Greenland, inshore	8 264	8 741	7 342	7 950	10 064	8 700	7 300	7 800	7 500
" offshore	165	200	150	185	180	1 089	2 478	7 136	6 406
Faroes	130	496	755	1 371	2 023	5 300	11 179	12 851	8 151
Denmark	-	-	-	196	308	1 172	2 717	5 910	3 462
Norway	-	-	1 409	2 940	5 917	8 678	11 723	7 503	8 860
Canada	-	-	-	-	-	-	-	-	215
France	-	-	-	-	-	-	803	934	643
USSR	-	-	-	-	3 517	6 033	6 468	-	-
Spain	-	-	-	-	-	6 948	7 252	-	-
FRG	-	-	-	-	-	-	-	31	-
Japan	-	-	-	-	-	-	146	-	-
Total offshore	295	696	2 314	4 692	11 945	29 190	42 766	34 365	27 737
Total Subareas 1 + 0	8 559	9 437	9 656	12 642	22 009	37 890	50 066	42 165	35 237

* Preliminary

Table 8 Percentage species composition (by weight) in Danish shrimp trawl landings from Fladen Ground.

<u>Species</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
<u>Pandalus</u>	7.52	10.64	26.05	65.66	64.40	67.31
<u>Nephrops</u>	-	0.03	0.30	0.02	0.07	0.01
Cod	} 25.46	4.35	0.40	0.44	4.12	5.50
Haddock		1.25	0.03	0.09	0.22	0.80
Whiting		0.66	0.03	0.24	0.06	0.33
Norway Pout	35.96	54.47	27.32	-	26.20	23.93
Unspecified	31.06	28.59	45.87	33.55	4.92	2.14

Table 9 Percentage species composition (by weight) in Danish shrimp trawl landings from Skagerrak.

<u>Species</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
<u>Pandalus</u>	5.06	12.19	18.06	21.61	48.94	41.56
<u>Nephrops</u>	-	1.77	1.88	2.12	4.50	3.19
Cod	} 25.49	3.24	2.91	1.06	2.29	2.28
Haddock		0.40	0.07	0.06	0.24	0.32
Whiting		0.25	0.02	0.03	0.96	0.86
Norway Pout	29.80	11.30	0.19	-	34.05	5.40
Blue Whiting	-	1.30	13.20	0.33	-	38.29
Unspecified	39.00	69.54	63.67	74.78	9.03	8.10

Table 10 Catch rates (kg/h) of Pandalus and bycatch during 1975 from Swedish vessels in the Skagerrak fishery.

SPECIES ETC	FOR HUMAN CONSUMPTION	FOR INDUSTRIAL PURPOSE	DISCARDED
Boiled shrimps	10.11		
Raw shrimps	8.26		
Small shrimps			1.43
Cod	1.47		
Haddock	0.07	0.01	
Whiting	0.02	0.01	
Hake	0.09	0.002	
Pollack	0.19		
Ling	0.35		
Poor cod		0.17	
Norway pout		1.07	
Poutassou		2.22	
Rockling		0.003	
<u>Lycodes vahlii</u>		0.01	
Witch	1.04		
Plaice	0.03		
Halibut	0.03		
Lemon sole	0.01		
Turbot	0.001		
Brill	0.001		
Long rough dab		0.05	
Herring	0.01	0.12	
Sprat	0.01	0.07	
Lumpfish	0.001	0.02	
Monk	0.18		
Saithe	0.001		
Eel	0.001		
Catfish	0.001	0.003	
Tusk	0.001		
Argentine		1.32	
<u>Coryphaenoides rupestris</u>		0.65	
Rabbit fish		0.05	
Red fish		0.01	
<u>Lumpenus lumpretaeformis</u>		0.003	
Dogfish	0.10	0.04	
Rays and skates		0.15	
Other shrimps		0.03	
<u>Nephrops</u>	0.23		
Not specified	0.002	0.07	
TOTAL	3.83	6.09	15.30

Table 11. Catch composition from Pandalus fishing in the Farn Deep, England

	1977			1978		
	Value (£)	Tonnes	Kg/hr	Value (£)	Tonnes	Kg/hr
<u>Pandalus</u>	129624	229.78	60.64	54141	91.79	69.9
<u>Nephrops</u>	14339	13.26	3.50	9829	7.14	5.4
Cod	27023	58.36	15.40	17292	40.61	30.9
Haddock	6819	20.85	5.50	1878	4.68	3.6
Lemon Sole	3537	6.08	1.60	2776	4.51	3.4
Plaice	930	3.47	0.92	1403	4.39	3.3
Skates and rays	35	0.38	0.10	28	0.24	0.2
Whiting	4475	19.25	5.08	4947	23.78	18.1
Witches	196	0.86	0.23	72	0.21	0.2
Monks and anglers	211	0.61	0.16	286	0.67	0.5
Turbot	5	0.01	< 0.01	63	0.06	0.1
Halibut				22	0.02	< 0.1
Spurdogs	2535	9.07	2.39	119	0.58	0.4
Dabs	6	0.05	0.01	9	0.05	< 0.1
Gurnard	18	0.41	0.11			
Mixed Demersal	2063	7.92	2.09	1262	4.00	3.0
Herring	78	0.29	0.08	34	0.05	< 0.1
Mackerel	189	0.97	0.26			
TOTAL CATCH	192083	384.88	101.58	94161	182.78	139.1
BYCATCH	62459	155.10	40.93	40020	90.99	69.3

Table 12 Composition of by-catch landings (tonnes) from the Scottish Pandalus fishery on the Fladen ground.

	1977	1978
<u>Pandalus</u>	1704	2027
Total by-catch	791	627
<u>Nephrops</u>	8.42	7.49
Squid	3.30	3.10
Cod	298.98	277.88
Haddock	150.06	49.92
Whiting	19.09	30.22
Saithe	61.16	29.36
Hake	0.33	0.37
Lythe	0.10	0.12
Ling	25.83	27.08
Catfish	8.06	8.95
Monk	160.70	120.87
Plaice	1.42	0.68
Lemon sole	1.10	1.81
Witch	5.52	12.19
Dab	0.72	1.08
Halibut	0.83	0.86
Megrim	0.59	1.50
Turbot	0.13	0.73
Skate	1.87	2.86
Dogfish	40.13	38.64
Mackerel	0.77	0.27
Brill	+	-
Dover sole	0.05	-
Roes	-	0.03

Table 13 Comparison of the present mesh sizes in use and the estimated level of fishing mortality, with the proposed management recommendations for the Fladen and Skagerrak fisheries for Pandalus borealis, (taken from Table 10 of the 1977 Report.)

	Fladen		Skagerrak	
	Danish and Scottish fisheries		Danish fishery	Swedish fishery
Present mesh size (mm, stretched)	25		25	35
Present mean selection size (carapace length - mm)	11.0		11.0	15.0
Present mean selection age (years)	0.7		1.0	1.7

Proposed mesh size	35		45	45
Proposed mean selection size	15.4		20.0	20.0
Proposed mean selection age	1.5		3	3

Present estimated fishing mortality (F)	~1.0		~0.7	~0.7

Table 14 Summary of the results of the yield assessment for the Fladen and Skagerrak stocks. (Taken from Table 8 of the 1977 Report.)

	Fladen		Skagerrak	
	M	0.5	1.0	0.5
$(Y_w/R)_{\max}$	1056	412	949	299
$(F)_{\max}$	2.0	2.0	2.0	2.0
$(t_c)_{\max}$	2.0	1.0	2.5	1.0