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

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TABLE OF CONTENTS

1 INTRODUCTION

1.1 Participation

B. Bergström	Sweden
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S. Tveite	Norway

1.2 Terms of Reference

The Working Group on the Assessment of Pandalus Stocks (Chairman: Mr B. Sjöstrand) met at ICES Headquarters from 10-13 February 1987 (C.Res.1986/2:5:2) to:

a) assess the status of the stocks of Pandalus borealis in the North Sea, Skagerrak, and Kattegat;

b) update data on by-catch in the Pandalus fisheries in the areas by species and countries.

2 PANDALUS STOCKS AND FISHERIES

In the North Sea and Division IIIa, three separate shrimp fisheries can be distinguished:

- Skagerrak/Kattegat/the eastern part of Division IVa along the Norwegian Deeps,
- Fladen ground in Division IVa,
- Farn Deeps in Division IVb.

The shrimp on Fladen and in Farn Deeps are treated as separate stocks.

Data from Norwegian surveys suggest that the majority of shrimp in the Norwegian Deeps are functional males for two breeding seasons, whereas the majority of shrimp in the Skagerrak function as males only once. A small proportion of early maturing, primary females are also found in the Skagerrak. The mean weight at age differs in the two areas indicating a difference in growth rate. Shrimp from the Skagerrak generally have a higher mean weight at age.

These differences in biological characteristics of Pandalus between the two areas would suggest that the populations should be considered as separate stocks in Division IIIa and in the eastern parts of Division IVa.

3 DIVISION IIIa

3.1 The Fishery

3.1.1 Landings

Total landings for the period 1970-1986 are given in Table 3.1 and in Figure 3.1 in which catches during 1951-1969 are also included as given in Bulletin Statistique. They show a substantial increase during the last two years, reaching 10,000 t. Both Danish and Norwegian landings increased in 1985 and 1986, whereas the Swedish landings remained steady.

3.1.2 Discards

Juvenile shrimp (carapace length less than approximately 15 mm) in the Norwegian and Swedish shrimp fisheries are discarded at sea during the sorting of the catches. Estimates of the amounts discarded in the Swedish fishery during 1970-1982 varied between 3% and 11% (in weight) of the total shrimp catch. No quantitative information is available for later years.

3.1.3 Effort data

Effort and CPUE data based on logbook records were available from Denmark, Norway, and Sweden. Tables 3.2 and 3.3. show the recorded effort data for 1982-1986 from Danish and Swedish vessels. The Norwegian effort data, which only cover two vessels, were considered too scanty to be included in the estimates of total effort. Instead, the Swedish CPUE data were assumed to be representative of the Norwegian shrimp fishery.

In order to obtain overall effort indices, the recorded effort data were transformed into relative effort indices in the following way:

Total Danish effort (days) was calculated from CPUE figures and Danish landings; the Swedish and Norwegian effort was similarly calculated from Swedish CPUE figures. Total relative effort indices (relative to 1982) were obtained by averaging (weighted by the landings) the national effort indices (Table 3.2).

The total indices show an increase of 30% from 1982 to 1986, stemming from a three-fold increase in Danish effort between 1983 and 1986.

Table 3.3. shows the effort indices for 1984-1986 split into quarters.

3.2 Assessment

3.2.1 Age distributions

Norway supplied data from monthly sampling from two commercial shrimp trawlers operating in the inner and the central Skagerrak, covering the period May 1984 to December 1986.

The ageing was done by splitting length frequency distributions into normal distributions (MacDonald and Pitcher, 1979) and taking into account sex ratio and reproductive stages (Rasmussen, 1953). The monthly age distributions were averaged quarterly.

The Group decided to use these age distributions as the basis for a first VPA. The short period covered by sampling and the marked seasonality of the fishery made it appropriate to use a quarterly period as the time unit. The total landings in numbers at age are given in Table 3.4.

3.2.2 Mean weight at age

The Norwegian samples provided mean carapace length (CL) at age. These were converted into weight by the relation

$$W = 0.00264CL^{2.551} \quad \text{(Anon., 1977)}$$

and used as mean weights both in the catch and in the stock (Table 3.5).

3.2.3 Natural mortality

In its 1977 report, the Working Group discussed the level of M. An estimate of M = 0.5 was given for an Icelandic stock, but it was decided that the level of M in Division IIIa and on the Fladen Ground should be higher.

No new data were presented at this meeting. Values of 0.75 for Division IIIa and 1.0 for the Fladen Ground were chosen.

3.2.4 Fishing mortality

The calculated quarterly indices of total effort were used for tuning the VPA. The input F for the youngest age group in the fourth quarter of 1986 was taken as the mean of the fourth quarter values in 1984 and 1985.

3.2.5 VPA results

The fishing mortalities per quarter are given in Table 3.6. The mean $F_{(1-3)}$, the relative F values, and the relative effort indices are given in the same table. For the first quarter of 1984, for which data were lacking, the same $F_{(1-3)}$ was assumed as in the second quarter, judging from the effort indices in Table 3.3. Yearly fishing mortalities were also calculated by summing over

quarters for the different age groups. These yearly figures are given below:

Age	1984 Quarters 2-4	1984 Quarters 1-4	1985	1986
0	0.01	-	0.01	0.02
1	0.18	-	0.26	0.26
2	0.34	-	0.68	0.84
3	0.28	-	1.04	1.26
4	-	-	0.21	0.46
$F_{(1-3)u}$	0.27	0.39	0.66	0.79
Effort index	-	0.94	1.10	1.31

This assessment indicates a declining stock size (see Table 3.7) from about 25,000 t in the last quarters of 1984 and 1985 to about 15,000 t at the end of 1986.

The stock estimates made from the Norwegian trawl surveys in the fourth quarters of 1984, 1985, and 1986 (Smedstad and Tveite, 1985) were 5,100, 12,500, and 5,900 t, respectively.

3.2.6 Recruitment

Swedish data on discarding rate of small shrimp in May-June during 1970-1983 were taken as indices of historical recruitment (see Table 3.8). These indices of 1-year-old shrimp vary in a similar way as the total landings (lagged 1 year), indicating that the 2-year-old shrimp make up the bulk of the catches (Figure 3.1). The geometric mean of the index for the period 1970-1983 is 1.33 kg/hr.

This index series was compared with the relative year-class strengths estimated by the VPA and with the estimates of the 1984-1986 year classes from the Norwegian trawl surveys:

Year class	Relative year-class strength from VPA (by age) 0	1	2	3	Average	Swedish recruit index at age 1 (kg/hr)	Changed base = VPA x 1.80	Norwegian trawl survey estimate	Changed base = Norw. x 1.12
1986	0.02 (0.13)	-	-	-	0.01	-	-	0.44	0.49
1985	0.80 (0.53)	0.53	-	-	0.53	-	0.95	0.47	0.53
1984	1.00 (0.66)	0.66	0.58	-	0.62	-	1.12	1.00	1.12
1983	-	1.00	1.00	1.00	1.00	-	1.80	-	-
1982	-	-	0.30	0.38	0.34	0.58	0.61	-	-
1981	-	-	-	0.31	0.31	0.59	0.56	-	-

The impression from the table above is that recruitment, except in 1983, has been below average. The 1986 year class appears, from the very scanty pieces of information available, also to be well below average.

3.2.7 Management considerations

The present level of shrimp catch is very high. It has reached the same level as in the early 1960s (Figure 3.1). The experience from that period is that after a few years of increasing catches, the fishery suffered from low catch rates and a total annual catch of around 3,000-4,000 t. It seems likely that overfishing played a role in these fluctuations.

The assessment given is based on a limited amount of age data from a short period of time and, consequently, has to be regarded as tentative. The actual level of stock size is not known with any precision since the value of natural mortality is uncertain. The Working Group was, therefore, not able to calculate any TAC based on this assessment. It will, however, point to the risk of a stock decline connected with present high catch levels and with the apparently low recruitment during the last few years.

Any reduction in the fishing effort would lead to a reduced variability in the total catch level.

The present pattern of exploitation is such that catches are dominated by shrimp that have not completed their first spawning as females.

The shrimp spawn as males in the autumn when they are 1 1/2 years old. One year later, most of them have changed sex and spawn as females. Their spawning is not, however, completed until next spring (age 3) when they shed their eggs-larvae hitherto carried under their body.

The proportion of pre-spawner (<3 years) shrimp in the landings is around 90%; their dominance in the catches is even greater owing to the discarding practice.

The legal minimum mesh size is at present 30 mm in the Danish and Swedish shrimp fisheries and 35 mm in the Norwegian fishery. An agreement was reached during the 1986 negotiations between the three parties to increase the minimum mesh size to 35 mm at 1 January 1989 in all shrimp fisheries.

4 DIVISION IVa - THE NORWEGIAN DEEPS

4.1 The Fishery

Data on total landings are given in Table 3.1 and show a decline from almost 3,000 t in the beginning of the 1970s to less than 1,000 t in 1978 and 1980. Thereafter, the total landings increased and reached 2,600 t in 1986.

4.2 Catch and Effort

Data on CPUE were provided from Danish and Swedish logbook records. In Norway, the logbook system is not full operational. The Working Group decided to use Swedish data in its calculations of the combined Swedish and Norwegian effort. Since Danish and Swedish figures are given in different units, relative indices were calculated with 1982 as the reference year (Table 4.1).

Danish and Swedish CPUE values show a similar pattern, the lowest values occurring in 1984 (Table 4.1). The calculated effort indices show an increase of almost 60% from 1982 to 1985. The preliminary index for 1986, however, is slightly lower than in the previous year.

4.3 Surveys in 1984-1986

Three Norwegian trawl surveys were made during October-November in the years 1984-1986 (Smedstad and Tveite, 1985).

In each year sampled, at least five year classes were present. Compared to the Skagerrak situation, the frequency of older shrimp in the Norwegian Deeps is higher, indicating a lower mortality rate (Table 4.2).

Mean weight at age is constantly lower than in the Skagerrak, indicating a slower growth rate.

4.4 Management Considerations

The data presented for this stock were not sufficient for an assessment.

As shown in Table 4.1, there has been a substantial increase in the total fishing effort exerted on this stock during 1982 to 1986. The CPUE has varied by a factor of 2 in the same period.

A decrease in total effort would probably give more stable catch rates than at present. The Working Group was, however, not able to calculate the appropriate effort level.

5 FLADEN GROUND

5.1 The Fishery

The bulk of the catches are made by vessels from Denmark and Scotland; a small proportion is sometimes made by Norwegian boats. Shrimp catches by both Danish and Scottish vessels are retained intact, with no sorting and no discarding. The shrimp are landed fresh.

5.2 Catch and Catch-Per-Unit-Effort Data

Data on landings from Danish and Scottish vessels are presented for the period 1982-1986 (Table 5.1). Danish landings for 1982

and 1983 have been revised; previously recorded data included some catches from Division IIIa.

Catch-per-unit-effort data for the same period are also shown (Table 5.2).

A drop in total landings from Fladen was recorded in 1982, followed in 1983 by a substantial increase; CPUE increased also. Subsequently, catches have fallen and have remained lower.

Scottish landings during this period have fluctuated considerably, at least in part, because of marketing difficulties. CPUE data are presented as kg/day (Denmark) and kg/hr (Scotland). Considerable variation is apparent in the Scottish data, but only minor fluctuations are indicated by the Danish data. This probably reflects the greater market vagaries in Scotland affecting the fishing effort of the Scottish boats.

5.3 Recruitment

An estimate of recruitment was made using the length frequency data available from the Scottish fishery for the period 1982-1986. A division between juveniles (1+) and older shrimp was made as described in Anon. (1984). Because of a change in the provision of effort data, it was not possible to provide an index of juveniles caught per hour fishing.

The large proportion of juveniles in the catches indicates a strong dependence on the recruiting year class. The mean carapace length (MCL) of samples from the Fladen fishery is consistently lower than that found in samples from Division IIIa and the Norwegian Deeps. The MCL of Fladen samples was 16.25 mm.

Year	Total catch split into adults and juveniles			
	Weight (tonnes)		Number (millions)	
	Juveniles	Adults	Juveniles	Adults
1982	136	499	80.1	139.9
1983	1,619	5,945	953.1	1,665.1
1984	908	3,683	587.0	903.5
1985	1,222	3,767	618.6	1,207.5
1986	796	2,923	467.1	816.0

5.4 Management Considerations

From the length frequency distributions of samples obtained from the Scottish fishery, the total weights landed in each size group were estimated using the length/weight relationship $W = 0.00264 CL^{2.551}$. The total number landed from Fladen in each size category were then estimated for the years 1982-1986. These numbers were used as the basis for preliminary length cohort analyses. Three runs were made: two on the 1984 length composition using different terminal Fs for the largest length (F = 1.0 or 2.0) and

one on the 1985 length distribution (F = 2.0) (Table 5.3). The results indicate that the fishing mortality on younger shrimp (<17 mm CL) is moderate but that larger shrimp are fished at very high levels of F.

It is obvious that the shrimp fisheries on Fladen Ground, to a very large extent, are depending on the recruiting year classes and, therefore, both catches and catch rates are highly variable over time.

More stable catches or catch rates could be obtained by a decrease in effort and/or an increase in mesh size.

6 FARN DEEPS

6.1 The Fishery

The Farn Deeps, Division IVb, were regularly fished by vessels from England and Scotland during the period 1977-1980. Landings were made in both countries, but the bulk of the catches from all vessels were landed in England. Landings in England only were then recorded up to 1984, but in 1985 and 1986, landings of Pandalus were again made in both countries.

The landings for the period 1977-1986 are detailed in Table 6.1, together with CPUE data (kg/hr) from Scottish vessels.

Landings of human consumption by-catch species from this area are low; Scottish landings in 1985 and 1986 were 11.1 and 6.0 t, respectively.

7 BY-CATCH

The by-catch in the shrimp fishery in general consists of relatively small quantities of a variety of fish species landed for human consumption and larger quantities of fish which either are discarded or landed for fish meal.

The species composition of the by-catch in the Fladen Ground fishery differs from that in the Norwegian Deep and Skagerrak fisheries.

Tables 7.1-7.15 give the by-catch data submitted by Denmark, Norway, Sweden, and UK (Scotland). The Danish data are taken from logbook records and it is likely that discards or fish landed for meal have sometimes been omitted from these records. The Norwegian data are from direct samples of the catch. The Swedish data are logbook records. The Scottish data are taken from the official statistics provided by the Fisheries Inspectorate.

8 DATA DEFICIENCES AND FUTURE RESEARCH

The gaps in the provided data sets which consequently ought to be followed by increased national sampling/research efforts are:

- data on effort and CPUE from the Norwegian fisheries,

- sampling of the Danish and Swedish catches for length/age composition,

- recruitment data for all stocks/areas.

The Working Group recommends that coordinated trawl surveys be conducted in Sub-area IV and Division IIIa in order to obtain abundance indices of the recruiting young shrimp. Such surveys could be done in April-May for the 1-year-old shrimp, but should, if possible, be performed in the autumn in order to get indices for the same year class at an age of 1/2 year.

The Working Group also recommends that the material collected during the Stomach Sampling Programme in the North Sea should be investigated in order to find out if it could be suitable as a basis for an improved estimation of natural mortality of shrimp.

9 REFERENCES

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Table 3.1 Pandalus borealis landings from Divisions IIIa and IVa eastern part ('000 tonnes).

Year	Skagerrak, Kattegat				Division IVa Norwegian Deep			
	Denmark[1]	Norway	Sweden	Total	Denmark[1]	Norway	Sweden	Total
1970	757	982	1,827	3,566	345	747	915	2,007
1971	834	1,392	1,548	3,774	356	1,094	1,358	2,808
1972	773	1,123	1,374	3,270	244	1,354	1,150	2,748
1973	716	1,415	1,194	3,325	39	918	936	1,893
1974	475	1,186	1,483	3,144	55	623	520	1,198
1975	733	1,576	1,751	4,060	84	763	252	1,099
1976	865	2,541	2,352	5,758	339	807	177	1,323
1977	763	2,257	1,906	4,926	357	747	113	1,217
1978	757	1,925	1,529	4,211	702	515	80	1,297
1979	973	2,612	1,752	5,337	89	428	35	552
1980	1,678	3,666	2,121	7,465	-	896	38	934
1981	2,593	3,943	2,210	8,746	-	1,240	31	1,271
1982	2,623	3,693	1,359	7,675	1,083	1,349	91	2,523
1983	1,325	3,723	1,037	6,085	242	1,638	99	1,979
1984	1,641	3,509	933	6,083	159	1,245	120	1,524
1985	3,677	4,772	1,474	9,923	340	1,841	130	2,311
1986[2]	4,102	4,524	1,306	9,932	764	1,649	157	2,570

[1] 1982-1986 total Danish catch distributed on areas according to log-book data.

[2] Preliminary.

Table 3.2 Pandalus Division IIIa. CPUE and estimates of effort indices, 1982-1986.

Year	Denmark				Sweden				Norway			Total relative effort index[1]
	C/f (kg/day)	C (tonnes)	f (days)	Relative effort	C/f (kg/hr)	C (tonnes)	f (hrs)	Relative effort	C (tonnes)	f (hrs)	Relative effort	
1982	561	2,623	4,677	1.00	28.8	1,359	47,187	1.00	3,693	128,229	1.00	1.00
1983	535	1,325	2,476	0.53	23.9	1,037	43,389	0.92	3,723	155,774	1.21	1.01
1984	474	1,641	3,462	0.74	25.3	933	36,877	0.78	3,509	138,696	1.08	0.94
1985	726	3,677	5,068	1.08	32.1	1,474	45,919	0.97	4,772	148,660	1.16	1.10
1986	571	4,102	7,185	1.54	29.3	1,306	44,588	0.94	4,524	154,403	1.20	1.31

[1] Weighted by landings.

Table 3.3 Pandalus Division IIIa. CPUE and estimates of effort indices by quarters.

Year	Quarter	Denmark				Norway and Sweden				Total relative effort index[1]
		C/f (kg/day)	C (tonnes)	f (days)	Relative effort	C/f (kg/hr)	C (tonnes)	f (hrs)	Relative effort	
1984	1	444	283	637	1.00	19.8	1,188	60,000	1.00	1.00
	2	311	253	813.5	1.28	17.8	959	53,876	0.90	0.98
	3	574	775	1,350.2	2.12	35.3	1,667	47,224	0.79	1.21
	4	502	330	657.4	1.03	27.2	619	22,757	0.38	0.61
1985	1	409	330	806.8	1.27	27.6	1,359	49,239	0.82	0.
	2	628	889	1,415.6	2.22	28.8	1,884	65,417	1.09	1.45
	3	855	1,443	1,687.7	2.65	33.7	1,596	47,359	0.79	1.67
	4	875	1,015	1,160.0	1.62	37.8	1,320	34,921	0.58	1.12
1986	1	645	823	1,276.0	2.00	35.1	1,416	40,342	0.67	1.16
	2	484	1,266	2,615.7	4.10	25.7	1,663	64,708	1.08	2.38
	3	630	1,287	2,042.9	3.21	30.9	1,595	51,618	0.86	1.91
	4	580	726	1,251.7	1.96	30.2	1,173	38,841	0.65	1.15

[1] Weighted by landings.

Table 3.4 Pandalus in Division IIIa. Catches in numbers (millions) by quarter year and age.

Age		1984			1985				1986			
Year	Quarter	2	3	4	1	2	3	4	1	2	3	4
0	1	-	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	11.2	-	-	-	1.8	-
	4	-	-	67.5	-	-	-	33.6	-	-	-	1.0
1	1	-	-	-	103.6	-	-	-	45.8	-	-	-
	2	182.4	-	-	-	192.0	-	-	-	99.6	-	-
	3	-	601.3	-	-	-	287.5	-	-	-	331.7	-
	4	-	-	159.5	-	-	-	287.1	-	-	-	202.9
2	1	-	-	-	244.7	-	-	-	275.6	-	-	-
	2	95.0	-	-	-	391.3	-	-	-	229.2	-	-
	3	-	52.1	-	-	-	338.1	-	-	-	234.5	-
	4	-	-	43.6	-	-	-	210.4	-	-	-	140.3
3	1	-	-	-	67.0	-	-	-	153.0	-	-	-
	2	26.2	-	-	-	78.0	-	-	-	242.1	-	-
	3	-	6.6	-	-	-	21.0	-	-	-	55.9	-
	4	-	-	3.6	-	-	-	2.6	-	-	-	13.0
4	1	-	-	-	5.5	-	-	-	8.2	-	-	-
	2	-	-	-	-	6.0	-	-	-	6.4	-	-
	3	-	-	-	-	-	-	-	-	-	1.8	-
	4	-	-	-	-	-	-	-	-	-	-	-
Total		303.6	660.0	274.2	420.8	667.3	657.8	524.7	482.7	577.3	625.7	357.2

Table 3.5 Pandalus in Division IIIa. Mean weight at age of the catch (g) by quarter year and age.

Age		1984			1985				1986			
Year	Quarter	2	3	4	1	2	3	4	1	2	3	4
0	1	-	-	-	-	-	-	-	-	-	-	-
	2	1.00	-	-	-	-	-	-	-	-	-	-
	3	-	1.00	-	-	-	0.36	-	-	-	0.62	-
	4	-	-	1.01	-	-	-	0.89	-	-	-	0.72
1	1	-	-	-	1.46	-	-	-	1.17	-	-	
	2	2.47	-	-	-	1.87	-	-	-	2.01	-	-
	3	-	3.37	-	-	-	2.97	-	-	-	2.64	-
	4	-	-	3.11	-	-	-	3.32	-	-	-	3.27
2	1	-	-	-	3.80	-	-	-	3.74	-	-	-
	2	5.50	-	-	-	4.39	-	-	-	4.15	-	-
	3	-	6.70	-	-	-	5.86	-	-	-	6.23	-
	4	-	-	7.86	-	-	-	6.31	-	-	-	7.43
3	1	-	-	-	7.90	-	-	-	6.94	-	-	-
	2	9.14	-	-	-	8.03	-	-	-	7.01	-	-
	3	-	10.03	-	-	-	9.43	-	-	-	8.67	-
	4	-	-	11.72	-	-	-	11.72	-	-	-	11.28
4	1	-	-	-	12.06	-	-	-	11.28	-	-	-
	2	12.00	-	-	-	12.17	-	-	-	10.96	-	-
	3	-	12.00	-	-	-	12.00	-	-	-	11.83	-
	4	-	-	12.00	-	-	-	12.00	-	-	-	12.00

Table 3.6 Pandalus in Division IIIa. Fishing mortality per quarter year and age (M = 0.19 per quarter year and age).

Age		1984			1985				1986			
Year	Quarter	2	3	4	1	2	3	4	1	2	3	4
0	1	-	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	0.002	-	-	-	0.011	-
	4	-	-	0.010	-	-	-	0.006	-	-	-	0.008
1	1	-	-	-	0.019	-	-	-	0.010	-	-	-
	2	0.027	-	-	-	0.044	-	-	-	0.028	-	-
	3	-	0.117	-	-	-	0.085	-	-	-	0.121	-
	4	-	-	0.041	-	-	-	0.109	-	-	-	0.100
2	1	-	-	-	0.080	-	-	-	0.148	-	-	-
	2	0.135	-	-	-	0.174	-	-	-	0.174	-	-
	3	-	0.101	-	-	-	0.221	-	-	-	0.267	-
	4	-	-	0.113	-	-	-	0.206	-	-	-	0.250
3	1	-	-	-	0.250	-	-	-	0.223	-	-	-
	2	0.182	-	-	-	0.506	-	-	-	0.644	-	-
	3	-	0.063	-	-	-	0.243	-	-	-	0.292	-
	4	-	-	0.043	-	-	-	0.042	-	-	-	0.100
4	1	-	-	-	0.085	-	-	-	0.178	-	-	-
	2	-	-	-	-	0.125	-	-	-	0.201	-	-
	3	-	-	-	-	-	-	-	-	-	0.080	-
	4	-	-	-	-	-	-	-	-	-	-	-
$F_{(1-3)u}$		0.115	0.094	0.066	0.108	0.241	0.183	0.119	0.140	0.282	0.227	0.150
Relative F (to second quarter 1984)		1.00	0.82	0.57	0.94	2.10	1.59	1.03	1.22	2.45	1.97	1.30
Relative effort index		1.00	1.23	0.62	0.92	1.48	1.70	1.14	1.18	2.42	1.95	1.17

Table 3.7 Pandalus in Division IIIa. Stock size in numbers (millions) by quarter year and age. Biomass totals in tonnes. All values are given for first of each quarter.

Age		1984			1985				1986				1987
Year	Quarter	2	3	4	1	2	3	4	1	2	3	4	1
0	1	-	-	-	10,299	-	-	-	257	-	-	-	-
	2	10,687	-	-	-	8,534	-	-	-	213	-	-	-
	3	-	8,856	-	-	-	7,071	-	-	-	176	-	-
	4	-	-	7,338	-	-	-	5,849	-	-	-	145	-
1	1	-	-	-	6,019	-	-	-	4,816	-	-	-	119
	2	7,400	-	-	-	4,893	-	-	-	3,949	-	-	
	3	-	5,966	-	-	-	3,880	-	-	-	3,182	-	
	4	-	-	4,398	-	-	-	2,954	-	-	-	2,336	-
2	1	-	-	-	3,500	-	-	-	2,196	-	-	-	1,751
	2	825	-	-	-	2,678	-	-	-	1,569	-	-	-
	3	-	597	-	-	-	1,864	-	-	-	1,093	-	-
	4	-	-	447	-	-	-	1,238	-	-	-	693	-
3	1	-	-	-	331	-	-	-	835	-	-	-	447
	2	172	-	-	-	214	-	-	-	554	-	-	-
	3	-	119	-	-	-	107	-	-	-	241	-	-
	4	-	-	93	-	-	-	69	-	-	-	149	-
4	1	-	-	-	73	-	-	-	55	-	-	-	112
	2	-	-	-	-	56	-	-	-	38	-	-	-
	3	-	-	-	-	-	-	-	-	-	26	-	-
	4	-	-	-	-	-	-	-	-	-	-	-	-
Total no.		19,084	15,538	12,276	20,222	16,375	12,922	10,111	8,159	6,323	4,718	3,322	
Spawning stock no.		172	567	428	405	270	1,505	998	891	592	1,086	669	
Total biom.		35,075	34,155	25,691	25,588	23,302	26,000	23,641	20,267	18,751	17,712	14,573	
SSB		1,574	4,193	3,723	3,502	2,397	9,199	6,674	6,420	4,300	7,501	5,543	

Table 3.8 Discarding rate of juvenile shrimp in May-June in the Swedish shrimp fishery.

Year	kg/hr
1970	2.3
1971	1.2
1972	0.8
1973	1.0
1974	1.0
1975	1.6
1976	1.8
1977	1.0
1978	2.5
1979	1.9
1980	4.1
1981	1.3
1982	0.6
1983	0.6

Table 4.1 Catch per unit effort of the Danish (kg/day) and Swedish (kg/hr) fisheries and calculated effort indices for the Norwegian Deeps within Division IVa.

Year	Denmark				Sweden				Norway			Total relative effort
	CPUE (kg/day)	Catch (tonnes)	Effort (days)	Relative effort	CPUE (kg/hr)	Catch (tonnes)	Effort (hrs)	Relative effort	Catch (tonnes)	Effort (hrs)	Relative effort	
1982	471	1,083	2,299	1.00	42.2	91	2,156	1.00	1,349	31,967	1.00	1.00
1983	470	242	515	0.22	34.5	99	2,870	1.33	1,638	47,478	1.88	1.32
1984	279	159	570	0.25	24.7	120	4,858	2.25	1,245	50,405	1.58	1.49
1985	465	340	731	0.32	30.1	130	4,319	2.00	1,841	61,163	1.91	1.68
1986[1]	486	764	1,572	0.68	34.0[2]	157	4,618	2.14	1,649	48,500	1.52	1.31

[1] Preliminary.

[2] No fishing in the third quarter.

Table 4.2 Age distributions and mean weight at age (g) in Skagerrak and the Norwegian Deep from three surveys, 1984-1986.

Year	Year class													
	1986		1985		1984		1983		1982		1981		1980	
	%	$\bar{w}$	%	$\bar{w}$	%	$\bar{w}$	%	$\bar{w}$	%	$\bar{w}$	%	$\bar{w}$	%	$\bar{w}$
						Division IIIa								
1984	-	-	-	-	26.0	0.80	55.7	3.42	14.8	6.83	3.0	10.0	0.5	14.00
1985	-	-	6.1	0.70	70.5	3.47	21.6	6.96	1.8	11.66	-	-	-	-
1986	11.5	0.90	55.8	3.37	29.2	6.70	3.6	10.50	-	-	-	-	-	-
						Division IVa, eastern part								
1984	-	-	-	-	2.0	0.70	57.5	2.90	20.9	5.60	17.7	9.00	1.8	11.90
1985	-	-	0.4	0.55	37.6	2.91	26.2	5.70	27.2	8.90	8.6	11.70	-	-
1986	0.5	0.80	27.6	2.91	46.9	5.5	21.7	9.50	3.3	12.30	-	-	-	-

Table 5.1 Landings (tonnes) of Pandalus borealis from Division IVa, the Fladen Ground.

Year	Denmark	Federal Republic of Germany	Norway	UK (Scotland)	Total
1970	3,115	-	-	103	3,218
1971	3,216	33	-	439	3,688
1972	2,204	-	-	187	2,391
1973	157	-	-	163	320
1974	282	-	-	434	716
1975	1,308	-	-	525	1,833
1976	1,522	-	-	1,937	3,459
1977	425	-	112	1,692	2,229
1978	890	-	81	2,027	2,998
1979	565	-	44	268	877
1980	1,122	-	76	377	1,575
1981	685	-	1	347	1,033
1982	283	-	-	352	635
1983	5,729	-	8	1,827	7,564
1984	4,553	-	13	25	4,591
1985	3,649	-	-	1,341	4,990
1986	3,416	-	-	301	3,717

Table 5.2 *Pandalus borealis* CPUE figures from the Fladen Ground.

Year	Denmark[1]	UK (Scotland)[2]
1970	-	31
1971	-	66
1972	117	69
1973	45	87
1974	122	124
1975	187	128
1976	105	115
1977	105	76
1978	-	81
1979	-	51
1980	-	44
1981	-	45
1982	0.96	74
1983	1.18	89
1984	0.97	-
1985	1.21	-
1986	0.96	-

[1] Denmark, 1972-1977: kg per hour.
1982-1986: tonnes per day.

[2] Scotland, kg per hour.

Table 5.3 VPA on length groups, catches from Fladen. Annual fishing mortalities at length.

Carapace length (mm)	Annual F		
	1984A	1984B	1985
8	0.0022	0.0022	-
9	0.0118	0.0118	0.0015
10	0.0658	0.0656	0.0040
11	0.1992	0.1986	0.0219
12	0.2448	0.2441	0.0925
13	0.1321	0.1317	0.3037
14	0.0734	0.0732	0.3635
15	0.2522	0.2514	0.5623
16	0.6156	0.6134	1.1615
17	0.9307	0.9269	1.9742
18	0.6652	0.6618	1.8056
19	0.5633	0.5598	1.2612
20	0.8182	0.8119	1.1762
21	1.2533	1.2390	1.3614
22	1.4884	1.4562	0.6069
23	2.0649	1.9431	1.4804
24	2.0000	1.0000	2.0000

Input values

$M = 1.0$

$L_\infty = 27.2$

$K = 0.41$

$W = 0.00264L^{2.551}$

Table 6.1 Landings (t) of Pandalus borealis from Division IVb, the Farn Deep.

Year	England	Scotland	CPUE kg/hr (Scotland)
1977	227.1	-	
1978	90.9	2.3	no data
1979	235.0	34.3	no data
1980	203.3	17.3	60
1981	0.9	-	-
1982	-	-	-
1983	64.8	-	-
1984	30.7	-	-
1985	2.2	5.6	70
1986	137.3	57.2	127

Table 7.1 Species composition (% by weight) in the Pandalus fishery in 1984 by Denmark in Division IIIa.

Species	Quarter			
	1	2	3	4
Pandalus	41.9	33.2	50.8	33.2
By-catch				
A. Human cons.				
Cod	2.4	3.7	2.4	1.3
Haddock	1.4	1.2	0.1	-
Hake	0.2	3.9	0.7	0.9
Ling	-	0.1	0.1	0.1
Saithe	-	-	0.1	-
Whiting	0.1	-	3.3	-
Monk	0.4	0.4	-	-
Witch	2.4	0.8	0.3	0.1
Nephrops	1.7	1.5	1.7	0.8
Others	0.2	0.2	0.1	0.5
B. Industrial				
Blue whiting	38.3	42.1	28.2	31.1
Norway pout	-	-	1.2	13.5
Others	11.1	12.5	11.2	18.3

Table 7.2 Species composition (% by weight) in the Pandalus fishery in 1985 by Denmark in Division IIIa.

Species	Quarter			
	1	2	3	4
Pandalus	44.2	37.3	60.4	43.7
By-catch				
A. Human cons.				
Cod	2.3	2.1	0.9	1.1
Haddokk	3.2	0.1	-	-
Hake	0.1	0.4	0.2	0.3
Ling	0.1	-	-	-
Saithe	0.3	0.1	-	-
Whiting	0.4	-	-	-
Monk	1.0	0.2	-	-
Witch	0.8	0.7	0.3	0.3
Nephrops	2.6	0.5	0.5	0.1
Others	0.2	0.6	0.3	0.8
B. Industrial				
Blue whiting	5.6	49.1	28.7	44.2
Norway pout	1.0	1.2	-	-
Others	37.6	7.7	8.6	9.5

Table 7.3 Species composition (% by weight) in the Pandalus fishery in 1986 by Denmark in Division IIIa.

Species	Quarter			
	1	2	3	4
Pandalus	63.0	59.1	59.7	53.9
By-catch				
A. Human cons.				
Cod	3.3	3.5	2.1	1.6
Haddock	1.0	0.2	-	-
Hake	0.1	2.7	0.3	1.9
Ling	-	-	-	-
Saithe	0.3	0.1	0.1	-
Whiting	0.4	0.1	-	-
Monk	0.8	1.6	0.1	0.1
Witch	1.6	0.9	0.3	0.5
Nephrops	1.2	1.7	0.6	0.6
Others	0.1	0.1	0.2	0.5
B. Industrial				
Blue whiting	17.2	18.3	23.4	28.2
Norway pout	0.7	0.1	-	0.3
Others	10.3	11.3	13.2	12.3

Table 7.4 Species composition (% by weight) in the Pandalus fishery in Division IIIa (Skagerrak) by Sweden.

Species	1983	1984	1985
Pandalus	56.9	52.5	72.9
By-catch			
Cod	5.2	6.1	4.1
Haddock	1.6	3.6	1.0
Hake	0.4	0.3	0.2
Ling	0.2	0.1	0.1
Saithe	+	+	0.3
Whiting	1.7	1.2	0.2
Monk	0.1	0.1	+
Witch	1.7	2.2	1.2
Blue whiting	27.0	27.8	13.0
Nephrops	0.5	0.8	1.3
Others	4.8	5.2	5.7
Total (tonnes)	1,684	1,716	1,944

Table 7.5 Species composition (% by weight) in the Pandalus fishery in 1985 by Denmark in Division IVa (Norwegian Deep).

Species	Quarter			
	1	2	3	4
Pandalus	55.5	19.8	64.5	34.3
By-catch				
A. Human cons.				
Cod	4.5	2.5	4.8	2.7
Haddock	3.1	0.4	-	-
Hake	0.4	2.9	3.5	6.4
Ling	0.1	-	1.7	-
Saithe	-	-	0.4	2.4
Whiting	0.2	-	-	-
Monk	1.0	1.2	1.5	-
Witch	2.5	-	-	-
Nephrops	16.5	4.0	10.8	12.4
Others	-	-	-	-
B. Industrial				
Blue whiting	-	46.0	-	13.9
Norway pout	-	-	-	-
Others	15.8	23.1	12.8	27.8

Table 7.6 Species composition (% by weight in the Pandalus fishery in 1984 by Norway in Division IVa (Norwegian Deep).

Species	Quarter			
	1	2	3	4
Pandalus	41.8	36.3	34.5	24.7
By-catch				
A. Human cons.				
Cod	2.3	1.4	1.6	0.6
Haddock	0.5	-	-	-
Hake	0.2	0.9	0.1	0.1
Ling	0.3	1.0	1.4	0.8
Saithe	0.1	0.1	0.1	0.1
Whiting	0.9	-	-	-
Monk	0.4	0.8	0.3	0.1
Witch	0.1	0.4	0.1	0.1
Nephrops	0.1	-	-	-
Others	1.4	1.0	0.5	4.8
B. Industrial				
Blue whiting	21.6	39.9	34.4	42.9
Norway pout	6.4	0.8	8.5	16.5
Others	23.9	17.5	18.5	9.5

Table 7.7 Species composition (% by weight) in the Pandalus fishery in 1985 by Denmark in Division IVa (Norwegian Deep).

Species	Quarter			
	1	2	3	4
Pandalus	52.4	41.8	80.7	57.8
By-catch				
A. Human cons.				
Cod	3.6	3.0	1.7	4.6
Haddock	0.9	0.1	-	-
Hake	0.4	2.9	0.8	15.0
Ling	0.3	0.4	0.4	-
Saithe	2.0	0.5	0.3	-
Whiting	1.9	-	-	-
Monk	3.7	4.6	1.4	4.3
Witch	0.7	1.5	1.0	1.2
Nephrops	4.6	1.1	3.4	7.1
Others	0.7	1.5	-	1.2
B. Industrial				
Blue whiting	-	37.5	-	-
Norway pout	12.9	-	-	-
Others	15.5	5.0	10.2	8.8

Table 7.8 Species composition (% by weight) in the Pandalus fishery in 1985 by Norway in Division IVa (Norwegian Deep).

Species	Quarter			
	1	2	3	4
Pandalus	40.3	40.6	39.4	35.0
By-catch				
A. Human cons.				
Cod	2.3	1.0	1.7	1.2
Haddock	0.1	-	-	-
Hake	0.2	1.0	-	0.6
Ling	1.0	0.2	1.0	0.5
Saithe	2.3	0.1	0.4	0.1
Whiting	2.2	-	-	-
Monk	0.5	0.3	0.1	0.1
Witch	0.1	0.2	-	0.1
Nephrops	0.1	-	-	0.3
Others	1.2	0.9	0.8	1.4
B. Industrial				
Blue whiting	17.0	44.0	17.5	31.1
Norway pout	22.0	0.1	0.1	5.8
Others	10.1	11.5	39.0	23.7

Table 7.9 Species composition (% by weight) in the Pandalus fishery in 1986 by Denmark in Division IVa (Norwegian Deep).

Species	Quarter			
	1	2	3	4
Pandalus	63.8	43.1	79.2	67.1
By-catch				
A. Human cons.				
Cod	8.9	3.7	4.5	3.3
Haddock	2.2	0.1	-	0.1
Hake	1.3	6.7	1.0	9.9
Ling	0.1	0.7	0.8	0.5
Saithe	1.6	0.3	0.4	1.2
Whiting	1.8	-	-	-
Monk	11.6	7.8	1.4	3.3
Witch	1.3	0.8	0.2	0.4
Nephrops	4.4	2.5	3.9	7.3
Others	0.1	0.7	0.2	0.2
B. Industrial				
Blue whiting	0.5	27.7	0.6	0.7
Norway pout	-	-	-	0.2
Others	6.1	6.7	7.8	5.3

Table 7.10 Species composition (% by weight) in the Pandalus fishery in 1986 by Norway in Division IVa (Norwegian Deep).

Species	Quarter			
	1	2	3	4
Pandalus	39.1		36.3	33.3
By-catch				
A. Human cons.				
Cod	2.7		2.2	1.2
Haddock	0.1		-	-
Hake	0.1	No	0.1	0.3
Ling	1.0	data	0.8	0.6
Saithe	1.4		0.1	0.6
Whiting	-		-	-
Monk	0.1		0.2	0.1
Witch	0.1		0.1	0.1
Nephrops	0.5		0.2	-
Others	0.1		1.3	2.0
B. Industrial				
Blue whiting	8.4		28.2	28.4
Norway pout	23.9		10.2	14.4
Others	22.9		20.4	19.0

Table 7.11 Species composition (% by weight) in the Pandalus fishery in 1984 by Denmark in Division IVa (Fladen Ground).

Species	Quarter			
	1	2	3	4
Pandalus	80.2	76.2	29.8	46.4
By-catch				
A. Human cons.				
Cod	4.2	3.4	2.6	3.4
Haddock	2.2	1.0	0.8	0.6
Hake	-	-	-	0.2
Ling	0.3	0.3	0.2	-
Saithe	-	0.2	0.7	-
Whiting	1.2	0.5	0.6	1.2
Monk	0.5	0.9	-	-
Witch	-	-	-	-
Nephrops	0.7	2.2	0.6	4.8
Others	-	-	-	-
B. Industrial				
Blue whiting	-	-	-	-
Norway pout	0.9	0.6	57.5	35.8
Others	9.8	14.7	7.1	7.6

Table 7.12 Species composition (% by weight) in the Pandalus fishery in 1985 by Denmark in Division IVa (Fladen Ground).

Species	Quarter			
	1	2	3	4
Pandalus	81.7	86.1	85.3	
By-catch				
A. Human cons.				
Cod	2.7	2.5	4.2	
Haddock	1.0	0.7	1.8	
Hake	-	-	-	
Ling	0.3	0.1	0.2	No
Saithe	0.1	0.1	0.3	data
Whiting	0.7	0.2	0.1	
Monk	0.8	2.7	1.3	
Witch	-	-	-	
Nephrops	2.2	0.8	0.1	
Others	0.7	0.3	-	
B. Industrial				
Blue whiting	-	-	-	
Norway pout	1.9	-	-	
Others	8.0	6.5	6.6	

Table 7.13 Species composition (% by weight)) in the Pandalus fishery in 1986 by Denmark in Division IV (Fladen Ground).

Species	Quarter			
	1	2	3	4
Pandalus	76.8	75.4	77.9	74.2
By-catch				
A. Human cons.				
Cod	6.3	6.5	6.5	7.3
Haddock	2.3	1.0	4.9	9.6
Hake	-	-	-	-
Ling	0.4	0.2	0.1	-
Saithe	-	0.2	0.4	0.3
Whiting	0.4	0.3	0.4	0.9
Monk	4.6	5.4	1.3	0.4
Witch	-	-	-	-
Nephrops	1.1	2.4	2.8	3.3
Others	-	0.4	0.1	-
B. Industrial				
Blue whiting	-	-	-	-
Norway pout	-	-	-	-
Others	8.1	8.0	5.6	4.0

Table 7.14 Landings (tonnes) of shrimp and by-catch in the Scottish shrimp fishery at Fladen, 1976-1981.

Species	1976	1977	1978	1979	1980	1981
Shrimp	1,936.92	1,692.03	2,027.28	268.12	377.10	346.58
Total by-catch	525.49	791.07	627.01	137.78	260.38	171.65
Nephrops	51.48	8.42	7.49	4.39	5.09	11.75
Squids	4.82	3.30	3.10	-	-	-
Cod	207.13	298.98	277.88	40.62	90.17	57.39
Haddock	15.12	150.06	49.92	11.42	19.74	15.32
Whiting	15.86	19.09	30.22	36.43	46.20	7.85
Saithe	19.59	61.16	29.36	2.45	6.21	1.90
Hake	9.96	0.33	0.37	0.13	1.14	0.47
Lythe	-	0.10	0.12	-	-	0.28
Ling	12.27	25.83	27.08	5.65	13.59	12.25
Catfish	3.74	8.06	8.95	1.69	3.65	2.87
Monk	101.68	160.70	120.87	26.57	51.03	50.88
Plaice	0.15	1.42	0.68	0.79	0.45	0.18
Lemon sole	0.41	1.10	1.81	1.00	2.87	0.85
Witch	2.61	5.52	12.19	3.31	3.98	4.88
Dab	0.20	0.72	1.08	0.33	0.16	1.77
Halibut	0.51	0.83	0.86	0.20	0.42	0.30
Megrim	0.59	0.59	1.50	0.08	0.36	0.21
Turbot	0.04	0.13	0.73	0.11	0.22	0.11
Skate	1.06	1.87	2.86	0.46	1.18	0.53
Dogfish	20.78	40.13	38.64	2.28	6.75	1.88
Herring	-	-	-	-	-	-
Mackerel	-	0.77	0.27	-	-	-
Norway pout	66.44	-	-	-	-	-
Unspecified	0.05	0.05	-	-	0.01	0.02
Roes	-	-	0.03	0.01	0.64	0.01
Total demersal and pelagic fish	469.19	779.35	616.42	133.39	249.90	159.90

Table 7.15 Landings by shrimp trawl (t) of Pandalus and human consumption by-catch from Scottish vessels at Fladen, 1982-1986.

Species	1982		1983		1984		1985		1986	
	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%
Shrimp	352.2	75.9	1,788.8	75.8	23.62	74.5	1,332.9	76.5	285.0	71.8
Total by-catch	111.9	24.1	570.8	24.2	8.1	25.5	408.6	23.5	111.9	28.2
Nephrops	6.3	1.4	36.1	1.5	0.4	1.3	11.3	0.7	3.1	0.8
Squid	-	-	4.0	0.2	-	-	-	-	-	-
Cod	47.5	10.2	226.5	9.6	4.2	13.2	140.3	8.0	36.9	9.3
Haddock	12.9	2.8	115.2	4.9	0.5	1.6	38.8	2.2	27.1	6
Whiting	3.8	0.8	27.8	1.2	0.2	0.6	47.8	2.7	3.7	0.9
Saithe	0.9	0.2	6.6	0.3	0.2	0.6	11.6	0.7	1.6	0.4
Ling	6.0	1.3	28.4	1.2	0.7	2.2	16.4	0.9	3.9	1.0
Monk	23.2	5.0	80.9	3.4	1.0	3.2	81.6	4.7	26.4	6.7
Witch	2.7	0.6	15.3	0.7	0.2	0.6	12.6	0.7	3.0	0.8
Dogfish	1.2	0.3	8.4	0.4	0.1	0.3	30.5	1.8	1.5	0.4
Unspecified	7.3	1.6	21.6	0.9	0.6	1.9	17.7	1.0	4.7	1.2
Total demersal and pelagic fish	105.6	22.8	530.7	22.5	7.7	24.3	397.3	22.8	108.8	27.4

Figure 2.1 Total landings in Division IIIa, and discarding rate (kg/hr) in the SW fishery in May-June. Source: 1951-1969 Bull.Stat.s 1970-1985 ICES reports.