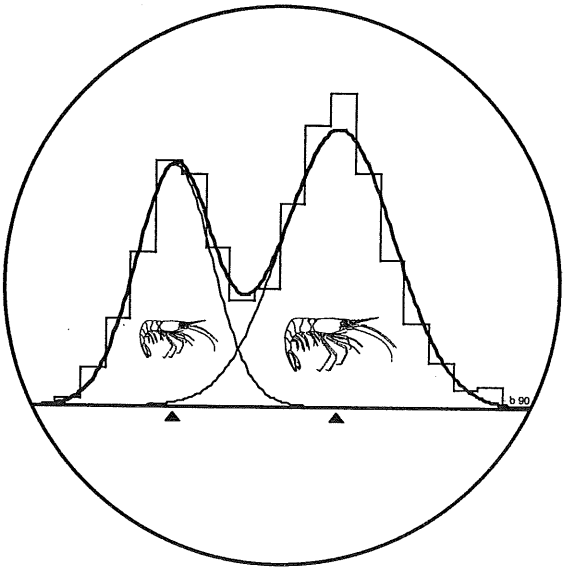
Fol. 41 Assess

INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA
CONSEIL INTERNATIONAL POUR L'EXPLORATION DE LA MER

C.M.1990 / Assess : 9

Report of The Working Group on the Assessment of *Pandalus* Stocks.



Copenhagen, 12-16 February 1990

1 INTRODUCTION

1.1 Participants

N. Bailey	UK (Scotland)
K. Lehmann	Denmark (Greenland)
S. Munch-Petersen (Chairman)	Denmark
E.M. Nilssen	Norway
B. Sjöstrand	Sweden
S. Tveite	Norway

1.2 Terms of Reference

The Working Group on the Assessment of Pandalus Stocks (Chairman: Mr S. Munch-Petersen) met at ICES Headquarters from 12-16 February 1990 (C.Res.1989/2:4:1) to:

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

2) evaluate the basis for treating Pandalus in the Norwegian Deeps and Division IIIa as separate stock units and, if appropriate, make an assessment for these units combined.

Two additional questions concerning mesh size and a proposed weekend fishing ban for Pandalus in Division IIIa were referred to the Working Group (see Section 6).

2 THE PANDALUS STOCKS WITHIN ICES SUB-AREAS III AND IV

2.1 Stock Identification

The Pandalus on Fladen Ground and in Farn Deeps are recognized as separate stocks and management units on basis of geographical separation and hydrographical considerations. However, the background for item 2 in the Terms of Reference has been the management problem concerning the Pandalus distributed continuously from the Norwegian Deeps in Division IVa into the Skagerrak (Division IIIa).

Samples of shrimps from the Norwegian Deeps and from the Skagerrak differ in their length frequency distributions (LFD) in that there is a higher proportion of small (young) shrimps in the samples from the Skagerrak. This feature has been remarkably constant over time; shrimps in the Norwegian Deeps are always larger. In the 1989 Working Group report (Anon., 1989a), this difference in observed LFDs was demonstrated by non-parametric tests.

Inspired by the Report of the Workshop on the Multivariate Analysis of Shellfish Stocks (Anon., 1989b), in which examples of multivariate analysis of LFDs from various crustacean stocks were given, the Working Group this year performed a Discriminant Function Analysis on Pandalus LFDs from the Fladen Ground, Norwegian Deeps and Skagerrak. The results (Annex 1) showed that the LFDs from the three areas were indeed different, and that the differ-

ence between Norwegian Deeps and Skagerrak LFDs was less pronounced than between either of these and those from the Fladen Ground (cf. Annex 1, Figure 1.)

The difference could be caused by different population dynamics (e.g., recruitment, growth, mortality) which would suggest that there are three different stocks.

Concerning the difference between the Skagerrak and the Norwegian Deeps, an alternative explanation to the observed difference could be that larvae and small shrimps drift from the Norwegian Deeps into Skagerrak and that adult shrimps migrate in the opposite direction. The instrument for transport of the juvenile shrimps exists in the Tampen current, which during a large part of the year moves sub-surface Altlantic water into the Skagerrak following the western and southern slope of the trench along west and south coasts of Norway (Cushing, 1982).

The Working Group believed it most probable that the observed differences in LFDs are an effect of larval drift and adult migration and that the shrimps in these two areas, therefore, should be regarded as one stock.

2.2 Management Units

Quite independent of the above-mentioned scientific questions on stock separation, the Working Group was forced this year to pool the data from these two areas because of misallocation of some of the Norwegian landings prior to 1988. The Norwegian Pandalus landings are divided between the Skagerrak (Division IIIa) and the Norwegian Deeps (Division IVa) according to ports of landing, and prior to 1988 landings to some fishing ports west of Division IIIa were reported as taken in Division IIIa. From 1988 onwards, this misallocation has been corrected. In 1988, the misreported landings were around 1,200 t. However, for the years prior to 1988 the landing figures have not been corrected and this may never be possible. This break in the data series renders it impossible to make separate standard assessments for these two areas at present. Thus, this year's Working Group report gives only an assessment of the two stocks combined.

Table 2.1 shows the landings of Pandalus from Divisions IIIa and IV as officially reported. The other tables of landings (Tables 3.1, 4.1, and 5.1) are Working Group estimates and refer to the stocks (management units) considered by the Working Group.

Figure 2.1 shows how the geographical distribution of the stocks is presently defined according to statistical squares. Squares adjacent to the main fishing grounds are also included even if only small catches are reported from them.

3 SKAGERRAK AND THE NORWEGIAN DEEPS (DIVISIONS IIIA AND IVA EAST)

3.1 The Fishery

3.1.1 Landings

As mentioned in Section 2 it was decided to treat the Pandalus catches from these two areas as a single assessment unit this year. Table 3.1 gives the landings since 1970 from these two areas combined. Landings confined to Skagerrak only (Division IIIa) are shown in Table 2.1. It is noted that there has been a decline of approximately 20% since the peak catches in 1987. This decline is reflected both in Danish and Norwegian catches.

3.1.2 Discards

Discarding is known to occur, but no data on the amounts were presented.

3.1.3 Effort

Data on effort and CPUE are given in Table 3.2 which shows annual as well as quarterly figures. Danish and Swedish data are available for the whole period considered. Norway supplied data for 1986-1988. These were regressed against the corresponding Swedish CPUE data (Table 3.2, footnote) to obtain estimates of Norwegian CPUE for the remaining quarters. The quarterly figures were summed to give yearly values.

Danish and Swedish effort increased from 1988 to 1989, while Norwegian effort (according to the estimates) seems to have decreased.

3.2 Assessment

3.2.1 Age distributions

National quarterly samples of length frequencies from Division IIIa and the Norwegian Deeps, respectively, were split into normal distributions. Each normal distribution, assumed to represent an age group, is described by mean length, standard deviation, and proportion of total sample size. The mean lengths of the age groups are given in Figure 3.1. A maximum of six age groups were identified.

The quarterly national catches (in tonnes) were converted to catch in numbers at age by applying the number of shrimps per kg in the samples and the age distributions. Quarterly national figures of catch in numbers at age were added to give the yearly data.

Norway supplied samples for most quarters from 1984 quarter 3 onwards from both main areas. Denmark started a sampling programme in 1987, and Sweden in 1989. Table 3.3 gives yearly catch in numbers from 1985 onwards.

3.2.2 Mean weight at age and maturity

Quarterly length/weight relationships based on Swedish 1989 data were presented and applied to the mean length-at-age values. The relations used were ($W = aL^b$):

Quarter	a	b
1	0.00250	2.658
2	0.00310	2.493
3	0.00314	2.526
4	0.00317	2.558

Resulting mean weights at age are given in Table 3.4.

The maturity ogive for shrimp varies from year to year. The proportion of females in the 2-group in the first quarter of the year is shown below:

1985	1986	1987	1988	1989
0.62	0.09	0.20	0.30	0.68

These proportions have been used for the 2-group. The 0- and 1-groups are considered immature, and the older ones fully mature.

3.2.3 Natural mortality

No new data were presented that enabled the Working Group to revise its estimates of natural mortality. The value 0.75 was used as in previous years.

3.2.4 VPA

Because of previous years' large degree of subjectivity in tuning the quarterly VPAs, it was decided this year to carry out the VPA on a yearly basis rendering it possible to apply the tuning module implemented at ICES.

National data on effort and catches in numbers at age were used as basis for the tuning procedure. The output from the tuning is presented in Table 3.5. Fleet 3 showed the smallest standard error for the logarithmic catchabilities (q) and was chosen to have terminal q estimated as the mean. The qs fluctuate without any pronounced trend; variance ratios of around 0.3 indicated a certain consistency among the estimates.

The fishing mortalities (Table 3.6) for age groups 1-3 vary between 0.36 and 0.49 during the five years of analyses.

The spawning stock biomass, calculated at the time of hatching (1 April) oscillates without any trend between 13,000 and 20,000 t (Table 3.7).

This assessment can, of course, not be directly compared with the ones for only Division IIIa, carried out in previous years. It indicates, however, a lower general level of exploitation (average 1985-1988 F = 0.42 vs. 0.6 in previous assessments) also for Division IIIa, and consequently a higher biomass estimate.

3.2.5 Recruitment

The abundance of 0-group shrimp observed during survey cruises in October has always been highest in the eastern part of Skagerrak (see text table below).

Number of 0-group shrimps per "swept area" in October

	1984	1985	1986	1987	1988	1989
North of Stavanger	5	-	-	-	44	78
Norwegian Coast - Division IVa	-	17	-	-	27	119
Egersund Bank	19	381	44	91	259	245
Western Skagerrak	30	36	2	7	238	2,112
Eastern Skagerrak	3,047	1,787	1,430	668	1,764	7,276
Total (0-group indices)	3,101	2,221	1,476	766	2,332	9,830

Similarly, at other times of the year 0-group shrimps are proportionally less abundant in the western areas. The explanation for this distribution could be that larvae from the western areas are transported eastwards by the Tampen current, cf. Section 2.1.

Figure 3.2 shows the temperature in 300 m depth at both sides of Skagerrak. For the few years available, there appears to be some covariation between temperature and recruitment. The index from the survey shown in the text table above is also highly correlated to the 1-group observed during the following year's cruise and also to the 1-group calculated by VPA (Figure 3.3).

3.2.6 Catch prediction

The input data for the prediction are shown in Table 3.8.

Both the 1988 and the 1989 year classes as 1-groups were estimated from the regression of VPA estimates of 1-group on 0-group indices (Figure 3.3). The 1988 year class, 9,747 million shrimps as 1-group, will become 3,853 million as 2-group in 1990 if a Z of 0.928 is applied. The 1989 year class is obviously very abundant and was estimated as 30,552 million 1-group.

The fishing pattern used is the 1985-1989 average, scaled to the 1989 level.

Mean weights and maturity are also applied as the 1985-1989 averages. Recruitment in 1990-1991 (16,232 million) is the 1985-1988 average from VPA.

The status quo catch in 1990 (unchanged fishing pattern and level of effort) is predicted to be 18,000 t (11,000 t in 1989) and a further increase to 23,000 t in 1991 (Table 3.9). The reason for these high estimates is the seemingly very abundant 1989 year class, which, according to this prediction, will constitute around 9,000 t (50%) of the 1990 catch and an even higher percentage of the 1991 catch.

The Working Group is of the opinion that this prediction probably is too optimistic. The unusually high 0-group index may be the result of the high temperature in 1989 influencing the behaviour of the juveniles. It should also be pointed out that the level of natural mortality is of great importance to the predicted catch level and is not estimated with great precision. There seems, however, no doubt that the 1989 year class is very abundant. This has already been confirmed by the very large amounts of small shrimps in catches, reported by fishermen.

An alternative prediction assuming average (1985-1988) 1-group abundance in 1990 gives a catch of 11,000 t in 1990 (same level as in 1989) increasing to 12,000 t in 1991 (tables not shown in the report).

4 FLADEN GROUND

4.1 The Fishery

Table 4.1 shows the landings from the Fladen Ground since 1970. The drastic reduction in catches from 1987 to 1988 was reversed during 1989. This development could indicate a quicker recovery of the stock than expected, after its presumed collapse in 1987-1988. Total landings increased from around 1,200 t in 1988 to about 3,000 t in 1989.

4.2 CPUE Data

The CPUE data are shown in Tables 4.2 and 4.3. Both the Danish and Scottish CPUE figures refer to shrimp trawler catches. The Danish data are logbook records (catch-per-day). Total effort (Table 4.3) has been calculated from CPUE and total (official) landings. In order to combine the Danish and Scottish effort, relative effort indices were made for each country, and a combined index calculated.

The quarterly effort figures reflect the seasonal variation in the fishery. In 1989, after the drop in both effort and CPUE in 1988, CPUE and effort again increased, approaching the levels before 1988.

4.3 Assessment

4.3.1 Age distribution of the catch

The basic data for estimating the quarterly age distribution of the 1989 catches are Scottish samples from landings in the first two quarters, and Norwegian survey data from the fourth quarter (Table 4.4). The age composition of both the Danish and Scottish catches was based on these scanty data from first, second, and fourth quarters, whereas the age composition of third quarter catches was taken as similar to that of 1988. This procedure may be criticized; it emphasizes the need to intensify the sampling of this fishery.

The splitting of the length distribution into age distribution was done by the Bhattacharya method, cf. Table 4.5 and Figure 4.1.

4.3.2 Mean weight at age

Mean weights at age in the catches (Table 4.6) were calculated by converting the mean lengths at age using the length/weight relationship (Anon., 1977):

$$w = 0.00264 \times CL^{2551}$$

4.3.3 Natural mortality

As in previous years, M was set at 1.0 annually (Anon., 1977) for the Fladen Ground stock.

4.3.4 Fishing mortality

Owing to difficulties experienced at previous working groups in estimating input F values, this year two methods were compared in order to investigate how sensitive stock estimates and fishing mortality rates were to the choices made.

Method a):

The somewhat subjective method adopted for the previous assessment (Anon., 1989a) was used: Input F values for the fourth quarter of the most recent year were chosen such that the estimated quarterly F values followed a similar pattern to the calculated effort index (Table 4.3). Input Fs on the oldest age were adopted from 1988 levels.

Method b):

For running the VPA, input F values were required for each age group in the most recent quarter and also for the oldest age group in each data year.

Input Fs at age were obtained by constructing catchability plots of F at age (using F values for 1987 and earlier derived at the 1989 Working Group) plotted against the index of effort. Where

catch data at age were present for the last quarter of 1989, then the plots were constructed for this quarter. In cases, however, where catch data were not available for the last quarter, the VPA effectively required input F values for an earlier quarter, i.e., the first one with catch data. In these circumstances, catchability plots were constructed for the appropriate quarter.

The regression equations (through the origin) relating F to effort index, were used together with the most recent estimate of the effort index, to derive the appropriate input F at age. The quarterly VPA was then run to generate Fs and numbers at age. A development on this procedure would be to use the new F values generated to 'retune' the VPA successively until stability was reached. This was not attempted on this occasion.

The Fs obtained from the VPA for age group 2 were taken as input Fs for the oldest age (3). In practice, the top right-hand triangle of the VPA was run to give the F value for the 2-year olds in the last quarter of the year previous to the current year. This was then 'downloaded' to the 3-year olds allowing the next diagonal of the VPA to be calculated, and so on.

4.3.5 Quarterly VPAs

Tuning method a

Fishing mortalities per quarter are shown in Table 4.7. Figures 4.2 and 4.3 show the level of agreement between the estimated average Fs (mean 1-3) and the combined effort index. Agreement appears, at first sight, reasonable although there are some differences for the most recent year. Annual Fs are shown in the text table below:

Age	1984	1985	1986	1987	1988	1989
0	+	-	+	+	+	-
1	0.052	0.113	0.084	0.095	0.015	0.227
2	0.671	0.460	0.746	1.446	0.116	1.141
3	0.915	1.420	0.374	1.347	0.175	0.256
$\bar{F}$(1-3)	0.546	0.664	0.401	0.963	0.102	0.541

Estimated stock sizes for the VPA from the method a) tuning are given in Table 4.8. Total stock size and spawning stock size refer to the 1 January and 1 April, respectively. The results confirm the observation made last year (Anon., 1989a) that total stock was low at the beginning of 1988, and they suggest a further decline to the lowest level ever at the beginning of 1989. On the other hand, the 1988 spawning stock which, on the basis of last year's assessment, was thought to have declined to the lowest level ever, is now estimated to have been higher than at any other time, and to have continued at a reasonable level into 1989.

Tuning method b

The results obtained using this method present a somewhat different picture. Fishing mortalities are shown in Table 4.9. It is noticeable that the "tuned" input F values in the fourth quarter were much lower than for method a). Figures 4.4 and 4.5 show the level of agreement between average F and the effort index. Again, reasonable agreement in the pattern was achieved with improvement in the most recent year. Rather poorer agreement was evident in the periods of high effort during 1985 and 1987. Annual Fs are shown in the text table below:

Age	1984	1985	1986	1987	1988	1989
0	+	-	+	+	+	-
1	0.070	0.123	0.082	0.113	0.040	0.063
2	0.746	0.690	0.864	1.417	0.144	0.847
3	0.927	2.098	0.757	2.412	0.168	0.331
$\bar{F}$(1-3)	0.881	0.970	0.568	1.314	0.108	0.414

Estimated stock sizes by the method b) tuning are given in Table 4.10. The results again confirm the reduction in total stock between 1987 and 1988 but suggest that stock size at the beginning of 1989 had recovered and risen to average levels. This finding is more consistent with the higher CPUEs recorded in 1989 for both the Scottish and Danish fleets (Table 4.3) which suggest an improvement in stock abundance during 1989 compared to the 1988 levels (see Section 4.1). Method b) tuning also indicated a general rise in spawning stock biomass in 1988 maintained in 1989.

4.3.6 Annual VPA

In view of the difficulties regarding tuning on quarters where effort is low and also the problem caused by an absence of catch data in the fourth quarter for some age groups, it was decided to also attempt an annual VPA, using the tuning module available at ICES Headquarters.

Combined catch-at-age data prior to 1989 were available only for Danish and Scottish landings combined. Therefore, combined catches at age (Table 4.11) and the combined index of effort for Danish and Scottish fleets (Table 4.3) were used as the basis for tuning. (In future, it should be possible to tune for each of these fleets separately.) Output from the tuning is shown in Table 4.12. Logarithmic catchabilities showed no pronounced trend and terminal q was estimated as the mean.

Annual fishing mortalities (Table 4.13) show a similar pattern to those estimated by the quarterly VPA (method b) but were generally somewhat lower, varying between 0.132 and 0.93.

Stock sizes are shown in Table 4.14 and are in general agreement with the results of the quarterly VPA, suggesting a low stock size in 1988 with some recovery since then. Spawning stock biomass (referring to the time of hatching) is relatively stable.

In view of the larger time series of data now available, annual VPA is a more realistic proposition although the marked seasonal fluctuations in the fishery and the fact that Fladen shrimps are so short-lived could still make annual assessments unreliable.

4.4 Management Considerations

Short-term predictions on the development of the Fladen Ground fishery have not been attempted at this stage because of

a) a lack of adequate recruitment information,

b) unpredictable variations in effort from year to year which makes selection of reference Fs very difficult.

All the VPAs presented above confirm the reduction in stock size in 1988, even if the SSB was underestimated in last year's VPA. However, both the development in the fishery in 1989 and this year's VPA estimates of stock size indicate that the stock already seems to be in the stage of recovery.

It may be that, due to the few age groups constituting the stock, a single year's (1988) reduction in effort has contributed significantly to the recovery of the stock in 1989.

The Working Group also wishes to point out that good recruitment indices would be essential for short-term prediction of a stock with such few age groups.

5 FARN DEEPS

During 1989, Pandalus borealis in the Farn Deeps (Division IVb) were fished by Scottish, English, and Danish boats. Catch data from all three countries have been available since 1986 and are shown in Table 5.1 (together with earlier data from England and Scotland). CPUE data from Scottish shrimp trawlers are also included.

Total landings from the Farn Deeps decreased in 1989 to 50% of the 1988 figure, largely because Danish landings fell dramatically. UK landings rose in 1989 owing to increased landings in England by English boats.

CPUE appeared to fall in 1989 but this was probably because Scottish shrimp trawl landings were only made in April and May, a period normally associated with lowest catch rates. Without catch rate data for the entire period of the shrimp fishery, it is difficult to comment on the significance of the observed trends.

Samples collected from commercial vessels in April and May suggested that the catch composition was rather different from that observed in 1987 and 1988. In 1989, over 75% of the catch was of shrimps of age 2 and older.

6 ADDITIONAL MANAGEMENT MEASURES IN THE PANDALUS FISHERY

At the consultations between Sweden, Norway, and the EEC on the regulation of fisheries in Division IIIa in 1990, the parties decided to submit to ICES the results of experimental fisheries, carried out by each party, with mesh sizes between 40 and 45 mm, to obtain advice on the appropriate mesh size in the shrimp fishery.-

It was also agreed at the consultations that Norway and Sweden should bring their proposal of introducing a weekend ban in the shrimp fishery to ICES for scientific evaluation.

These requests (in a letter dated 7 February 1990 from the National Fishery Board of Sweden) were referred to the Working Group for consideration.

6.1 Mesh Size Experiments

The Working Group received two special reports (unpublished) on experimental shrimp fishery in Skagerrak using trawls with different mesh size in the codend, one from Sweden and one from Denmark.

The results of both these experiments indicate no difference between the size composition of shrimps (Pandalus) in the trawls with 35 and 40 mm meshes in the codends. In both experiments the catches of small shrimp in the trawls with 45 mm meshes in the codend were smaller than those in the parallel hauls with 35 mm meshes. The differences were, however, mostly marginal. Norwegian selection experiments (Valdemarsen, 1988) show similar results.

It is the Working Group's opinion that increasing the mesh size in the codend from 35 mm to 45 mm will have only little effect on the Pandalus selection, the main reason being that the long tow time practised in the commercial fishery generally reduces the selection in the trawls drastically, at least when ordinary diamond shaped meshes are used.

The Working Group was informed (no report available) that Norwegian experiments both with square meshes and separation trawls have shown improved selection compared to standard gear.

6.2 Weekend Ban

The Working Group has no information to hand to quantify the effects of a weekend ban on the Pandalus stock.

If, however, such a ban leads to a reduction in fishing time that is not compensated for by bigger trawls or other ways of increasing fishing power, effort will be reduced.

Temporary halts in fishing activity may alter the catchability of shrimps by giving them more opportunities to reform aggregations (shoals). The Working Group has no information to evaluate this.

7 REFERENCES

Anon. 1977. Report of the Working Group on the Assessment of Pandalus Stocks. ICES, Doc. C.M.1977/K:10.

Anon. 1988. Report of the Working Group on the Assessment of Pandalus Stocks. ICES, Doc. C.M.1988/Assess:14.

Anon. 1989a. Report of the Working Group on the Assessment of Pandalus Stocks. ICES, Doc. C.M.1989/Assess:9.

Anon. 1989b. Report of the Working Group on the Multivariate Analysis of Shellfish Stocks. ICES, Doc. C.M.1989/K:5.

Cushing, D.H. 1982. Climate and Fisheries. Academic Press, 1982.

Valdemarsen, J.W. 1988. Size selectivity in shrimp trawls. Proc. World Symp. fish. gear, fish. vessel design. St. John's, Nov. 1988, pp.39-41.

Table 2.1 Nominal landings (tonnes) of Pandalus borealis in ICES Division IIIa and Sub-area IV as officially reported to ICES.

Year	Division IIIa				Sub-area IV					
	Denmark	Norway	Sweden	Total	Denmark	Norway	Sweden	UK(Engl)[1]	UK(Scotl)[2]	Total
1970	757	982	2,740[3]	4,479	3,460	1,107	...	14	100	4,681
1971	834	1,392	2,906[3]	5,132	3,572	1,265	...	-	438	5,275
1972	773	1,123	2,524[3]	4,420	2,448	1,216	...	692	187	4,543
1973	716	1,415	2,130[3]	4,261	196	931	...	1,021	163	2,311
1974	475	1,186	2,003[3]	3,664	337	767	..	50	432	1,586
1975	743	1,463	1,740	3,946	1,392	604	261	-	525	2,782
1976	865	2,541	2,212	2,212	5,618	1,051	136	186	2,006	5,240
1977	763	2,167	1,895	4,825	782	960	124	265	1,723	3,854
1978	757	1,841	1,529	4,127	1,592	692	78	98	2,044	4,504
1979	973	2,489	1,752	5,214	962	594	34	238	309	2,137
1980	1,679	3,498	2,121	7,298	1,273	1,140	38	203	406	3,060
1981	2,593	3,753	2,210	8,556	719	1,435	31	1	341	2,527
1982	2,920	3,877	1,421	8,218	1,069	1,545	92	-	354	3,060
1983	1,571	3,722	988	6,281	5,725	1,657	112	65	1,836	9,395
1984	1,717	3,509	933	6,159	4,638	1,274	120	277	25	6,334
1985	4,105	4,772	1,474	10,351	4,582	1,785	128	415	1,347	8,257
1986	4,686	4,811	1,357	10,854	3,896	1,681	157	458	358	6,550
1987	4,140	5,199	1,085	10,424	9,223	3,144	252	526	774	13,919
1988	2,278	3,048[4]	1,075	6,401	2,647	4,613[4]	220	489	109	8,078
1989[5]	2,451	3,149	1,303	6,903	3,223	3,262	129	181	573	7,368

[1] Includes other Pandalid shrimp.
[2] Includes small amounts of other Pandalid shrimp.
[3] Includes Sub-area IV.
[4] Working Group figure.
[5] Preliminary.

Table 3.1 *Pandalus borealis* landings from Divisions IIIa (Skagerrak) and IVa (eastern part) (Norwegian Deeps) ('000 tonnes) as estimated by the Working Group.

Year	Denmark	Norway	Sweden	Total
1970	1,102	1,729	2,742	5,573
1971	1,190	2,486	2,906	6,582
1972	1,017	2,477	2,524	6,018
1973	755	2,333	2,130	5,218
1974	530	1,809	2,003	4,342
1975	817	2,339	2,003	5,159
1976	1,204	3,348	2,529	7,081
1977	1,120	3,004	2,019	6,143
1978	1,459	2,440	1,609	5,508
1979	1,062	3,040	1,787	5,889
1980	1,678	4,562	2,159	8,399
1981	2,593	5,183	2,241	10,017
1982	3,766	5,042	1,450	10,258
1983	1,567	5,361	1,136	8,064
1984	1,747	4,783	1,022	7,552
1985	3,827	6,646	1,571	12,044
1986	4,834	6,490	1,463	12,787
1987	4,599	8,343	1,321	14,263
1988	3,068	7,661	1,278	12,007
1989	3,150	6,411	1,433	10,994

Table 3.2 Pandalus stocks in Division IIIa and Norwegian Deep combined. CPUE and estimates of effort indices by quarters.

Year	Quarter	Denmark			Sweden			Norway			Total catch
		C/f (kg/day)	C (t)	f (days)	C/f (kg/hr)	C (t)	f ($hrsx10^{-3}$)	C/f (kg/hr)	C (t)	f ($hrsx10^{-3}$)	
1984	1	418	336	724	21.4	183	8.6	27.9[1]	1,402	50.3[1]	1,921
	2	303	264	441	18.8	234	12.4	24.6[1]	1,053	42.8[1]	1,551
	3	569	800	994	34.8	393	11.3	44.6[1]	1,751	39.3[1]	2,944
	4	488	347	722	26.7	213	8.0	34.5[1]	577	16.7[1]	1,137
Total/Average		462	1,747	2,881	25.4	1,022	40.2	32.1[1]	4,783	149.1[1]	7,552
1985	1	409	410	819	28.2	208	7.4	36.4[1]	1,679	46.1[1]	2,297
	2	621	909	958	28.9	491	17.0	37.2[1]	2,051	55.1[1]	3,451
	3	833	1,482	855	33.5	484	14.5	43.0[1]	1,600	37.2[1]	3,566
	4	866	1,026	875	38.2	387	10.1	48.9[1]	1,316	26.9[1]	2,729
Total/Average		713	3,827	3,507	32.1	1,571	48.9	40.2[1]	6,646	165.3[1]	12,044
1986	1	633	914	1,165	34.2	282	8.3	41.7	1,661	39.8	2,857
	2	476	1,656	934	26.6	500	18.8	29.8	1,660	55.7	3,816
	3	625	1,464	1,220	30.9	383	12.4	40.2	1,664	41.4	3,511
	4	566	800	1,010	30.6	299	9.7	40.3	1,505	37.3	2,604
Total/Average		558	4,834	4,329	29.7	1,463	49.2	37.2	6,490	174.3	12,787
1987	1	491	1,069	996	29.0	328	11.3	42.0	2,687	64.0	4,084
	2	474	1,511	947	20.1	388	19.3	34.1	2,722	79.8	4,621
	3	539	1,051	1,195	22.1	312	14.1	29.1	1,336	45.9	2,699
	4	515	968	515	23.5	293	12.5	25.3	1,598	63.2	2,859
Total/Average		498	4,599	3,653	23.1	1,321	57.2	33.0	8,343	252.9	14,263
1988	1	484	1,111	968	25.8	296	11.5	41.4	2,675	64.6	4,082
	2	421	1,094	797	20.8	429	20.6	28.2	2,254	79.9	3,777
	3	405	502	405	22.1	268	12.1	25.3	1,623	64.2	2,393
	4	379	361	379	22.4	285	12.7	21.3	1,109	52.1	1,755
Total/Average		428	3,068	2,499	22.5	1,278	56.9	29.4	7,661	260.8	12,007
1989[2]	1	345	529	676	22.8	297	13.0	29.6[1]	1,707	57.7[1]	2,533
	2	417	1,037	680	21.1	461	21.9	27.5[1]	1,476	53.7[1]	2,974
	3	545	1,111	1,097	26.8	391	14.6	34.6[1]	2,071	59.9[1]	3,573
	4	376	473	734	21.7	284	13.1	28.3[1]	1,157	40.9[1]	1,914
Total/Average		434	3,150	3,187	22.9	1,433	62.6	30.2[1]	6,411	212.2[1]	10,994

[1] Estimated from CPUE (Norway) = CPUE (Sweden) * 1,248 + 1.18.
[2] Preliminary.

Table 3.3 VIRTUAL POPULATION ANALYSIS

Pandalus in Division IIIa and Norwegian Deeps (Division IVa East)

CATCH IN NUMBERS UNIT: millions

	1985	1986	1987	1988	1989
0	35	11	10	36	71
1	742	875	869	447	1124
2	1249	969	947	599	522
3	246	537	561	380	323
4	111	34	116	222	44
5+	0	2	12	0	0
TOTAL	2384	2428	2514	1684	2084

Table 3.4 VIRTUAL POPULATION ANALYSIS

Pandalus in Division IIIa and Norwegian Deep (Division IVa East)

MEAN WEIGHT AT AGE OF THE STOCK UNIT: gram

	1985	1986	1987	1988	1989
0	.710	.980	.700	.960	1.180
1	3.000	3.290	2.630	2.880	3.410
2	5.360	5.550	4.550	5.360	6.590
3	9.150	8.490	8.570	9.070	9.260
4	12.290	12.450	11.560	12.670	12.830
5+	16.250	16.100	14.160	.000	.000

Table 3.5

```
Module run at 15.13.27  06 MARCH 1990
DISAGGREGATED Qs
LOG TRANSFORMATION
Explanatory variate TIME
Fleet  1 ,DENMARK              , has terminal q estimated from trend
Fleet  2 ,NORWAY               , has terminal q estimated from trend
Fleet  3 ,SWEDEN               , has terminal q estimated as the mean
FLEETS COMBINED BY ** VARIANCE **
Terminal Fs estimated using Hybrid method
Regression weights
     , 1.000, 1.000, 1.000, 1.000, 1.000,
Oldest age F = 1.000*average of 2 younger ages. Fleets combined by variance of predictions
Fishing mortalities

  Age,    85,    86,    87,    88,    89,

    0,  .003,  .001,  .001,  .002,  .005,
    1,  .083,  .175,  .203,  .101,  .178,
    2,  .417,  .269,  .559,  .392,  .301,
    3,  .785,  .626,  .468,  .971,  .768,
    4,  .601,  .448,  .513,  .682,  .535,

Log catchability estimates

 Age  0
 Fleet,    85,    86,    87,    88,    89
-------,------,------,------,------,------
     1 ,-14.73,-16.29,-16.11,-20.64,-14.46
     2 ,-11.87,-12.59,-13.07,-11.81,-11.07
     3 ,-11.46,-12.91,-13.14,-11.54,-13.01

                                SUMMARY STATISTICS
Fleet , Pred.  , SE(q),Partial,Raised,   SLOPE    ,    SE     ,INTRCPT,  SE
      ,   q    ,      ,   F   ,   F   ,           ,   Slope   ,       ,Intrcpt
------,--------,------,-------,-------,-----------,-----------,-------,------
    1 ,-17.21  , 3.513, .0001 , .0003 , -.381E+00,  .878E+00,-15.306,  2.913
    2 ,-11.61  ,  .982, .0019 , .0030 ,  .238E+00,  .246E+00,-12.796,   .814
    3 ,-12.41  ,  .917, .0003 , .0093 ,  .000E+00,  .000E+00,-12.412,   .374
 Fbar     SIGMA(int.)     SIGMA(ext.)     SIGMA(overall)  Variance ratio
 .005        .658            .536            .658             .662

 Age  1
 Fleet,    85,    86,    87,    88,    89
-------,------,------,------,------,------
     1 ,-11.65,-11.06,-10.86,-12.50,-11.42
     2 , -8.32, -7.60, -7.71, -8.16, -7.44
     3 , -8.31, -7.84, -7.96, -8.11, -8.10

                                SUMMARY STATISTICS
Fleet , Pred.  , SE(q),Partial,Raised,   SLOPE    ,    SE     ,INTRCPT,  SE
      ,   q    ,      ,   F   ,   F   ,           ,   Slope   ,       ,Intrcpt
------,--------,------,-------,-------,-----------,-----------,-------,------
    1 ,-11.69  ,  .908, .0266 , .1351 , -.978E-01,  .227E+00,-11.203,   .753
    2 , -7.61  ,  .474, .1052 , .1511 ,  .119E+00,  .118E+00, -8.206,   .393
    3 , -8.06  ,  .196, .0197 , .1848 ,  .000E+00,  .000E+00, -8.064,   .080
 Fbar     SIGMA(int.)     SIGMA(ext.)     SIGMA(overall)  Variance ratio
 .178        .177          .625E-01          .177             .124

 Age  2
 Fleet,    85,    86,    87,    88,    89
-------,------,------,------,------,------
     1 ,-10.16,-10.67, -9.94, -9.45,-10.82
     2 , -6.60, -7.14, -6.63, -7.43, -7.04
     3 , -6.75, -7.38, -7.05, -7.31, -7.11

                                SUMMARY STATISTICS
Fleet , Pred.  , SE(q),Partial,Raised,   SLOPE    ,    SE     ,INTRCPT,  SE
      ,   q    ,      ,   F   ,   F   ,           ,   Slope   ,       ,Intrcpt
------,--------,------,-------,-------,-----------,-----------,-------,------
    1 ,-10.23  ,  .810, .1152 , .5441 , -.926E-02,  .203E+00,-10.181,   .672
    2 , -7.20  ,  .441, .1582 , .2556 , -.117E+00,  .110E+00, -6.619,   .366
    3 , -7.12  ,  .271, .0505 , .2986 ,  .000E+00,  .000E+00, -7.122,   .111
 Fbar     SIGMA(int.)     SIGMA(ext.)     SIGMA(overall)  Variance ratio
 .300        .222            .129            .222             .336

 Age  3
 Fleet,    85,    86,    87,    88,    89
-------,------,------,------,------,------
     1 , -9.92, -9.81,-10.15, -8.84,-10.16
     2 , -5.74, -6.32, -6.80, -6.25, -5.93
     3 , -6.41, -6.48, -7.22, -6.38, -6.65

                                SUMMARY STATISTICS
Fleet , Pred.  , SE(q),Partial,Raised,   SLOPE    ,    SE     ,INTRCPT,  SE
      ,   q    ,      ,   F   ,   F   ,           ,   Slope   ,       ,Intrcpt
------,--------,------,-------,-------,-----------,-----------,-------,------
    1 , -9.68  ,  .786, .1999 ,1.2433 , .495E-01,  .197E+00, -9.924,   .652
    2 , -6.27  ,  .587, .4019 , .5478 ,-.310E-01,  .147E+00, -6.114,   .487
    3 , -6.63  ,  .381, .0830 , .7853 ,  .000E+00,  .000E+00, -6.626,   .155
 Fbar     SIGMA(int.)     SIGMA(ext.)     SIGMA(overall)  Variance ratio
 .765        .296            .176            .296             .355
```

Table 3.6 VIRTUAL POPULATION ANALYSIS
PANDALUS IN DIVISION III-A AND NORWEGIAN DEEPS (DIVISION IV A East)

FISHING MORTALITY COEFFICIENT UNIT: Year-1 NATURAL MORTALITY COEFFICIENT = .75

	1985	1986	1987	1988	1989	1985-89
0	.003	.001	.001	.002	.005	.003
1	.083	.175	.203	.101	.178	.148
2	.417	.269	.559	.391	.300	.387
3	.785	.626	.468	.971	.765	.723
4	.601	.448	.513	.682	.535	.556
5+	.601	.448	.513	.682	.535	.556
(1- 3)U	.429	.357	.410	.488	.414	
(2- 3)U	.601	.448	.513	.681	.533	

Table 3.7 VIRTUAL POPULATION ANALYSIS
PANDALUS IN DIVISION III-A AND NORWEGIAN DEEPS (DIVISION IV A East)

STOCK SIZE IN NUMBERS UNIT: millions

BIOMASS TOTALS UNIT: tonnes

ALL VALUES, EXCEPT THOSE REFERRING TO THE SPAWNING STOCK ARE GIVEN FOR 1 JANUARY; THE SPAWNING STOCK DATA REFLECT THE STOCK SITUATION AT SPAWNING TIME, WHEREBY THE FOLLOWING VALUES ARE USED: PROPORTION OF ANNUAL F BEFORE SPAWNING: .200
PROPORTION OF ANNUAL M BEFORE SPAWNING: .250

	1985	1986	1987	1988	1989	1990	1985-88
0	16271	14098	13931	20627	20454	0	16232
1	13208	7662	6652	6574	9719	9614	8524
2	5073	5743	3038	2566	2807	3844	4105
3	612	1579	2073	821	819	982	1271
4	336	132	399	613	147	180	370
5+	1	6	40	0	0	41	12
TOTAL NO	35502	29221	26132	31201	33946		
SPS NO	3080	1665	2343	1594	2183		
TOT.BIOM	88118	86044	64006	67701	85250		
SPS BIOM	19874	13376	19330	13866	16623		

Table 3.8

List of input variables for the ICES prediction program.

PANDALUS IN SKAGERRAK (IIIA) AND NORWEGIAN DEEPS (IVA E)
The reference F is the mean F for the age group range from 1 to 3

The number of recruits per year is as follows:

Year	Recruitment
1990	16232.0
1991	16232.0
1992	16232.0

Proportion of F (fishing mortality) effective before spawning: .2000
Proportion of M (natural mortality) effective before spawning: .2500

Data are printed in the following units:

Number of fish:	millions
Weight by age group in the catch:	gram
Weight by age group in the stock:	gram
Stock biomass:	tonnes
Catch weight:	tonnes

age	stock size	fishing pattern	natural mortality	maturity ogive	weight in the catch	weight in the stock
0	16232.0	.00	.75	.00	.906	.906
1	30552.0	.15	.75	.00	3.040	3.040
2	3853.0	.38	.75	.38	5.482	5.482
3	908.0	.71	.75	1.00	8.900	8.900
4	178.0	.55	.75	1.00	12.360	12.360
5+	39.0	.55	.75	1.00	15.480	15.480

Table 3.9

Effects of different levels of fishing mortality on
catch, stock biomass and spawning stock biomass.

PANDALUS IN SKAGERRAK (IIIA) AND NORWEGIAN DEEPS (IVA E)

Year 1990					Year 1991					Year 1992	
fac-tor	ref. F	stock biomass	sp.stock biomass	catch	fac-tor	ref. F	stock biomass	sp.stock biomass	catch	stock biomass	sp.stock biomass
1.0	.41	140	14	18	.0	.00	121	34	0	119	57
					.1	.04		33	3	117	54
					.2	.08		33	5	114	52
					.4	.17		32	10	109	47
					.6	.25		32	15	104	42
					.8	.33		31	19	100	38
					1.0	.41		31	23	96	34
					1.2	.50		30	27	92	31
					1.4	.58		29	30	88	28
					1.6	.66		29	34	85	25
					1.8	.74		28	37	82	23
					2.0	.83		28	39	79	21

The data unit of the biomass and the catch is 1000 tonnes.
The spawning stock biomass is given for the time of spawning.
The spawning stock biomass for 1992 has been calculated with the same fishing mortality as for 1991.
The reference F is the mean F for the age group range from 1 to 3

Table 4.1 Landings (t) of Pandalus borealis from the Fladen Ground (Division IVa) as estimated by the Working Group.

Year	Denmark	Fed.Rep.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	1,552	-	-	1,937	3,489
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
1987	7,326	-	-	686	8,012
1988	1,077	-	-	84	1,161
1989	2,438	-	-	547	2,985

Table 4.2 Pandalus borealis CPUE 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	37
1985	1.21	86
1986	0.96	71
1987	1.24	81
1988	0.83	44
1989	0.99	65

[1] Denmark, 1972-1977: kg per hour.
1982-1988: tonnes per day.
[2] Scotland, kg per hour.

Table 4.3 Pandalus. Effort indices, Fladen Ground.

Year	Quarter	Denmark				UK (Scotland)				Combined index[2]
		CPUE (t/day)	Total catch	f	Index[1]	CPUE (kg/h)	Total catch	f	Index[1]	
1984	1	1.27	2,809	2,212	1.68	-	-	-	-	1.68
	2	0.75	1,407	1,876	1.43	37	25	676	0.21	1.41
	3	0.57	273	479	0.36	-	-	-	-	0.36
	4	0.56	63	113	0.09	-	-	-	-	0.09
1985	1	1.16	1,742	1,502	1.14	72	359	4,986	1.58	1.22
	2	1.24	1,617	1,304	0.99	88	770	8,750	2.78	1.57
	3	1.47	289	197	0.15	114	212	1,869	0.59	0.34
	4	0.04	0.1	3	0.002	-	-	-	-	0.002
1986	1	1.12	1,130	1,009	0.77	72	80	1,111	0.35	0.74
	2	0.89	833	936	0.71	68	150	2,206	0.70	0.71
	3	0.94	1,255	1,335	1.02	77	71	922	0.29	0.98
	4	0.71	200	282	0.21	-	-	-	-	0.21
1987	1	1.21	2,336	1,931	1.47	89	131	1,473	0.47	1.42
	2	1.20	2,643	2,203	1.68	79	509	6,443	2.05	1.72
	3	1.43	2,014	1,408	1.07	78	45	577	0.18	1.05
	4	0.89	333	374	0.28	-	-	-	-	0.28
1988	1	0.886	637	719	0.55	45.7	2	40	0.01	0.54
	2	0.775	366	434	0.33	43.5	76	1,744	0.55	0.37
	3	0.748	37	49	0.04	-	-	-	-	0.04
	4	0.466	37	79	0.06	-	-	-	-	0.06
1989	1	0.916	546	596	0.454	53	24	453	0.144	0.44
	2	0.924	1,088	1,177	0.896	57	302	5,298	1.683	1.067
	3	1.273	671	527	0.401	83	221	2,663	0.846	0.511
	4	0.732	133	182	0.138	-	-	-	-	0.138

[1] Relative to average effort in first-third quarters in 1985-1987.
[2] Weighted by total landings.

Table 4.4 Pandalus, Fladen Ground.
Catch in numbers (millions) by age and quarter.

Pandalus Fladen CATCH AT AGE IN NUMBERS (-1 REPRESENTS < HALF A UNIT)
UNITS = millions

	1984 1	2	3	4	1985 1	2	3	4	1986 1	2	3	4
0	0	0	0	1	0	0	0	0	0	0	0	1
1	71	183	42	16	18	260	76	0	17	87	203	52
2	319	234	41	3	366	434	75	0	196	181	198	11
3	227	46	13	0	163	30	2	0	77	22	61	0
4+	0	0	0	0	0	0	0	0	0	0	0	0

	1987 1	2	3	4	1988 1	2	3	4	1989 1	2	3	4
0	0	0	0	1	0	0	0	1	0	0	0	0
1	20	118	315	87	1	8	4	3	14	150	112	30
2	506	644	307	18	178	126	5	4	68	141	114	4
3	81	75	9	0	21	10	0	0	58	143	0	0
4+	0	0	0	0	0	0	0	0	0	0	0	0

Table 4.5 Pandalus, Fladen Ground, 1989.
Mean carapace lengths (mm) at age and proportions at age. Estimated using Bhattacharya method.

Year class	Age		Quarter			
			1	2	3[1]	4
1989	0	$\bar{x}$				
		prop.	-	-	-	-
1988	1	$\bar{x}$	11.71	12.45	15.96	16.96
		prop.	0.099	0.346	0.495	0.875
1987	2	$\bar{x}$	17.16	17.10	18.42	19.47
		prop.	0.483	0.324	0.505	0.125
1986	3	$\bar{x}$	19.42	19.43		
			0.418	0.330		

[1] From 1988 data.

Table 4.6 Pandalus, Fladen Ground.
Mean weight at age (g) by age and quarter.

Pandalus Fladen WEIGHT AT AGE (-1 REPRESENTS < 0.0005 UNIT)
UNITS = g

	1984 1	2	3	4	1985 1	2	3	4	1986 1	2	3	4
0	.000	.000	.000	.610	.000	.000	.000	.610	.000	.000	.000	.610
1	.850	1.240	1.770	2.320	1.200	1.870	1.770	2.320	1.000	1.450	1.770	2.320
2	3.380	3.070	3.660	4.100	2.970	3.170	3.660	4.100	3.210	3.190	3.660	4.100
3	5.720	5.200	5.680	6.880	4.150	5.000	5.680	6.880	5.060	5.120	5.680	6.880
4+	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

	1987 1	2	3	4	1988 1	2	3	4	1989 1	2	3	4
0	.000	.000	.000	.610	.000	.000	.000	1.110	.000	.000	.000	.000
1	.990	1.290	1.770	2.320	.660	1.280	3.090	3.600	1.400	1.640	3.090	3.610
2	3.280	3.340	3.660	4.100	3.040	3.050	4.460	5.100	3.720	3.690	4.460	5.140
3	5.380	5.170	5.680	6.880	5.100	5.000	5.680	6.880	5.100	5.110	6.880	6.880
4+	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

Table 4.7 Pandalus, Fladen Ground.
Fishing mortalities by age and quarter (Method a).

Pandalus Fladen F AT AGE (-1 REPRESENTS < 0.0005 UNIT)

	1984				1985				1986			
	1	2	3	4	1	2	3	4	1	2	3	4
0	.000	.000	.000	-1.000	.000	.000	.000	.000	.000	.000	.000	-1.000
1	.009	.030	.009	.004	.004	.078	.031	.000	.002	.016	.049	.017
2	.255	.318	.089	.009	.138	.255	.067	.000	.142	.200	.371	.033
3	.583	.232	.100	.000	.922	.448	.050	.000	.124	.050	.200	.000
4+	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
F 1- 3	.282	.193	.066	.004	.355	.260	.049	.000	.090	.089	.207	.016

	1987				1988				1989			
	1	2	3	4	1	2	3	4	1	2	3	4
0	.000	.000	.000	-1.000	.000	.000	.000	-1.000	.000	.000	.000	.000
1	.002	.016	.056	.021	.001	.006	.004	.004	.006	.091	.095	.035
2	.232	.552	.598	.064	.056	.054	.003	.003	.110	.370	.621	.040
3	.376	.771	.200	.000	.105	.070	.000	.000	.056	.200	.000	.000
4+	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
F 1- 3	.203	.446	.285	.028	.054	.043	.002	.002	.058	.220	.239	.025

Table 4.8 Pandalus, Fladen Ground.
Stock sizes in numbers (millions) by age and quarter. Total stock size and biomass (tonnes) shown for first quarter. Spawning stock size and biomass shown for second quarter. (Method a).

Pandalus Fladen STOCK AT AGE IN NUMBERS (-1 REPRESENTS < HALF A UNIT)
PROPORTION OF F (INTERVAL 2) BEFORE SPAWNING = .00 PROPORTION OF M (INTERVAL 2) BEFORE SPAWNING = .00
0-GROUP NOT ACCOUNTED FOR IN TOTAL NUMBER OR BIOMASS
UNITS = millions

	1984 1	2	3	4	1985 1	2	3	4	1986 1	2	3	4
0	0	0	0	6499	0	0	0	10424	0	0	0	14113
1	9157	7069	5344	4125	5060	3925	2828	2136	8118	6307	4836	3588
2	1596	963	546	389	3199	2170	1310	954	1663	1123	716	385
3	574	250	154	0	300	93	46	0	743	511	379	0
4+	0	0	0	0	0	0	0	0	0	0	0	0
TOT	11327				8559				10525			
SPN		731				1178				1073		
TBM	16460				16818				17218			
SSB		2777				3904				4409		

	1987 1	2	3	4	1988 1	2	3	4	1989 1	2	3	4
0	0	0	0	2596	0	0	0	3246	0	0	0	0
1	10990	8542	6548	4823	2021	1573	1218	945	2527	1956	1391	985
2	2748	1697	761	326	3680	2709	1999	1552	733	511	275	115
3	290	155	56	0	238	167	0	0	1206	888	0	0
4+	0	0	0	0	0	0	0	0	0	0	0	0
TOT	14028				5938				4466			
SPN		1004				1521				1144		
TBM	21455				13733				12414			
SSB		3636				4966				5481		

Table 4.9 Pandalus, Fladen Ground.
Fishing mortalities by age and quarter (Method b).

Pandalus Fladen F AT AGE (-1 REPRESENTS < 0.0005 UNIT)

	1984				1985				1986			
	1	2	3	4	1	2	3	4	1	2	3	4
0	.000	.000	.000	-1.000	.000	.000	.000	.000	.000	.000	.000	-1.000
1	.012	.040	.012	.006	.004	.085	.034	.000	.002	.016	.048	.016
2	.277	.357	.102	.010	.192	.387	.111	.000	.158	.227	.439	.040
3	.589	.236	.102	.000	1.194	.793	.111	.000	.222	.096	.439	.000
4+	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
F 1- 3	.293	.211	.072	.005	.463	.422	.085	.000	.127	.113	.309	.019

	1987				1988				1989			
	1	2	3	4	1	2	3	4	1	2	3	4
0	.000	.000	.000	-1.000	.000	.000	.000	-1.000	.000	.000	.000	.000
1	.002	.019	.067	.025	-1.000	.005	.003	.003	.002	.026	.026	.009
2	.230	.543	.582	.062	.069	.067	.004	.004	.091	.293	.434	.025
3	.489	1.341	.582	.000	.101	.067	.000	.000	.070	.261	.000	.000
4+	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
F 1- 3	.241	.634	.411	.029	.057	.046	.002	.002	.055	.193	.153	.011

Table 4.10 Pandalus, Fladen Ground.
Stock sizes in numbers (millions) by age and quarter. Total stock size and biomass (tonnes(shown for first quarter. Spawning stock size and biomass shown for second quarter (Method b).

Pandalus Fladen STOCK AT AGE IN NUMBERS (-1 REPRESENTS < HALF A UNIT)
PROPORTION OF F (INTERVAL 2) BEFORE SPAWNING = .00 PROPORTION OF M (INTERVAL 2) BEFORE SPAWNING = .00
0-GROUP NOT ACCOUNTED FOR IN TOTAL NUMBER OR BIOMASS
UNITS = millions

	1984				1985				1986			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0	0	0	5965	0	0	0	10513	0	0	0	11820
1	6877	5294	3962	3048	4645	3601	2576	1940	8188	6362	4878	3620
2	1480	874	476	335	2360	1517	803	559	1511	1004	624	313
3	569	246	151	0	258	61	21	0	435	272	192	0
4+	0	0	0	0	0	0	0	0	0	0	0	0
TOT	8927				7263				10134			
SPN		683				819				774		
TBM	14105				13654				15240			
SSB		2620				2709				2993		

	1987				1988				1989			
	1	2	3	4	1	2	3	4	1	2	3	4
0	0	0	0	3101	0	0	0	10854	0	0	0	0
1	9204	7151	5465	3979	2414	1879	1457	1131	8452	6570	4985	3784
2	2774	1717	777	338	3023	2198	1601	1242	878	624	363	183
3	234	112	23	0	247	174	0	0	964	700	0	0
4+	0	0	0	0	0	0	0	0	0	0	0	0
TOT	12212				5684				10294			
SPN		970				1273				1012		
TBM	19470				12044				20015			
SSB		3445				4222				4727		

Table 4.11 VIRTUAL POPULATION ANALYSIS.

PANDALUS IN FLADEN GROUND (IVA)

CATCH IN NUMBERS UNIT: millions

	1984	1985	1986	1987	1988	1989
1	312	354	359	540	16	306
2	597	875	586	1475	313	327
3	286	195	160	165	31	201
4+	0	0	0	0	0	0
TOTAL	1195	1424	1105	2180	360	834

Table 4.12

DISAGGREGATED Qs
LOG TRANSFORMATION
NO explanatory variate (Mean used)
Fleet 1 ,DKSCOT , has terminal q estimated as the mean
FLEETS COMBINED BY ** VARIANCE **

Regression weights
, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000,
Oldest age F = 1.000*average of 1 younger ages. Fleets combined by variance of predictions
Fishing mortalities

Age,	84,	85,	86,	87,	88,	89,
1,	.067,	.111,	.070,	.107,	.007,	.042,
2,	.456,	.699,	.700,	1.344,	.194,	.457,
3,	.456,	.699,	.700,	1.344,	.194,	.457,

Log catchability estimates

Age 1

Fleet,	84,	85,	86,	87,	88,	89
1 ,	-3.14,	-2.20,	-2.76,	-2.84,	-4.10,	-3.01

SUMMARY STATISTICS

Fleet ,	Pred. q ,	SE(q),	Partial F ,	Raised, F ,	SLOPE ,	SE Slope ,	INTRCPT,	SE Intrcpt
1 ,	-3.01 ,	.673,	.0420 ,	.0420,	.000E+00,	.000E+00,	-3.007,	.254

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.042	.673	0.000	.673	0.000

Age 2

Fleet,	84,	85,	86,	87,	88,	89
1 ,	-1.22,	-.36,	-.46,	-.31,	-.75,	-.62

SUMMARY STATISTICS

Fleet ,	Pred. q ,	SE(q),	Partial F ,	Raised, F ,	SLOPE ,	SE Slope ,	INTRCPT,	SE Intrcpt
1 ,	-.62 ,	.364,	.4569 ,	.4569,	.000E+00,	.000E+00,	-.621,	.138

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.457	.364	0.000	.364	0.000

Table 4.13 VIRTUAL POPULATION ANALYSIS.

PANDALUS IN FLADEN GROUND (IVA)

FISHING MORTALITY COEFFICIENT UNIT: Year-1 NATURAL MORTALITY COEFFICIENT = 1.00

	1984	1985	1986	1987	1988	1989	1984-88
1	.067	.111	.070	.107	.007	.042	.072
2	.456	.699	.700	1.343	.194	.457	.679
3	.456	.699	.700	1.344	.194	.457	.679
4+	.456	.699	.700	1.344	.194	.457	.679
(1- 3)U	.326	.503	.490	.931	.132	.319	

Table 4.14 VIRTUAL POPULATION ANALYSIS.

PANDALUS IN FLADEN GROUND (IVA)

STOCK SIZE IN NUMBERS UNIT: millions

BIOMASS TOTALS UNIT: tonnes

ALL VALUES, EXCEPT THOSE REFERRING TO THE SPAWNING STOCK ARE GIVEN FOR 1 JANUARY; THE SPAWNING STOCK DATA REFLECT THE STOCK SITUATION AT SPAWNING TIME, WHEREBY THE FOLLOWING VALUES ARE USED: PROPORTION OF ANNUAL F BEFORE SPAWNING: .330
PROPORTION OF ANNUAL M BEFORE SPAWNING: .250

	1984	1985	1986	1987	1988	1989	1990	1984-88
1	7563	5290	8301	8345	3720	11727	0	6644
2	2486	2602	1742	2846	2758	1359	4137	2487
3	1191	580	476	318	273	835	317	568
4+	0	0	0	0	0	0	195	0
TOTAL NO	11241	8472	10519	11509	6752	13922		
SPS NO	1631	1163	833	871	1207	1015		
TOT.BIOM	24516	20237	22800	25757	17810	37240		
SPS BIOM	7228	4056	3376	3260	4122	4672		

Table 5.1 Landings (t) of Pandalus borealis from Division IVb, the Farn Deeps as estimated by the Working Group.

Year	UK (England)	UK (Scotland)	Denmark	Total	CPUE kg/hr (Scotland)
1977	227	-	No data	-	-
1978	91	2	-	-	No data
1979	235	34	-	-	No data
1980	203	17	-	-	60
1981	1	-	-	-	-
1982	-	-	-	-	-
1983	65	-	-	-	-
1984	30	-	-	-	-
1985	2	6	-	-	70
1986	137	57	106	300	127
1987	212	86	92	390	101
1988	91	25	384	500	67
1989	168	8	72	248	44

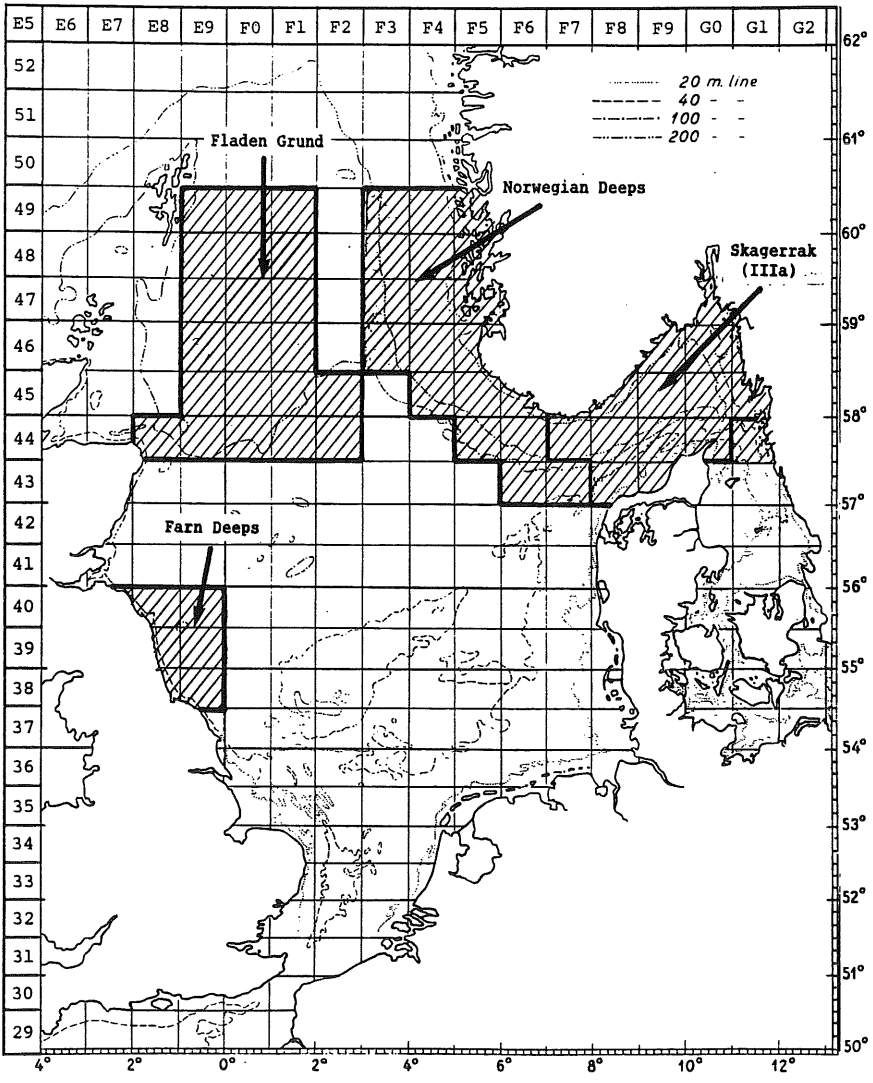


Figure 2.1 The management units of Pandalus in ICES Sub-area IV and Division IIIa as defined by statistical squares according to the Working Group.

Figure 3.1

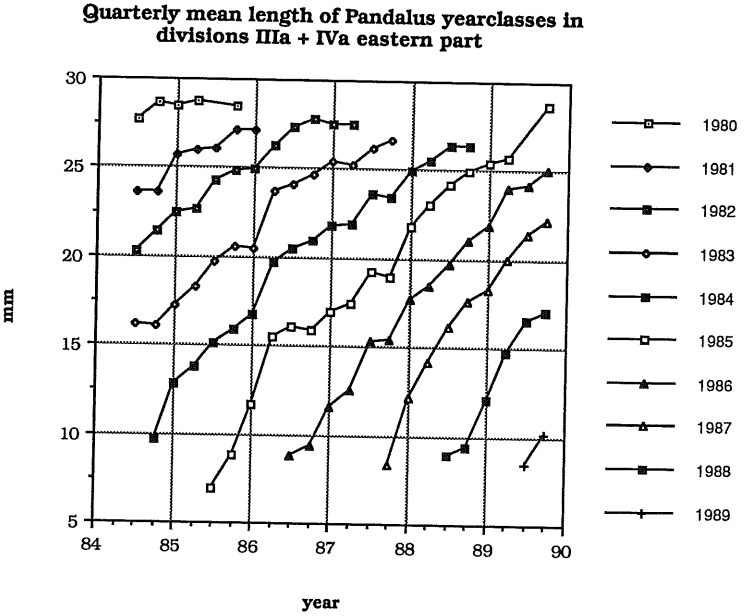

Quarterly mean length of Pandalus yearclasses in divisions IIIa + IVa eastern part
mm
30
25
20
15
10
5
84
85
86
87
88
89
90
year
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989

Figure 3.2

Temperatures at 300 m depth, 10 and 30 nautical miles south-east of Arendal, and index of O-group abundance from survey

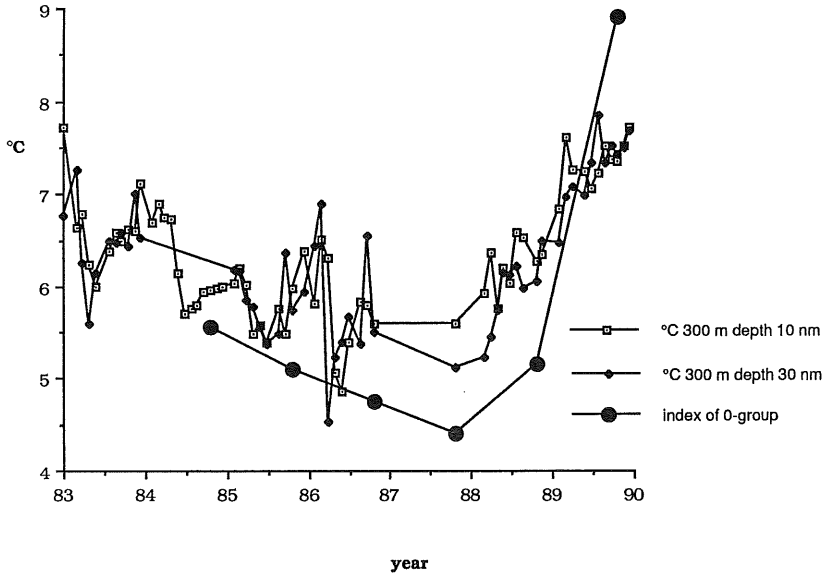
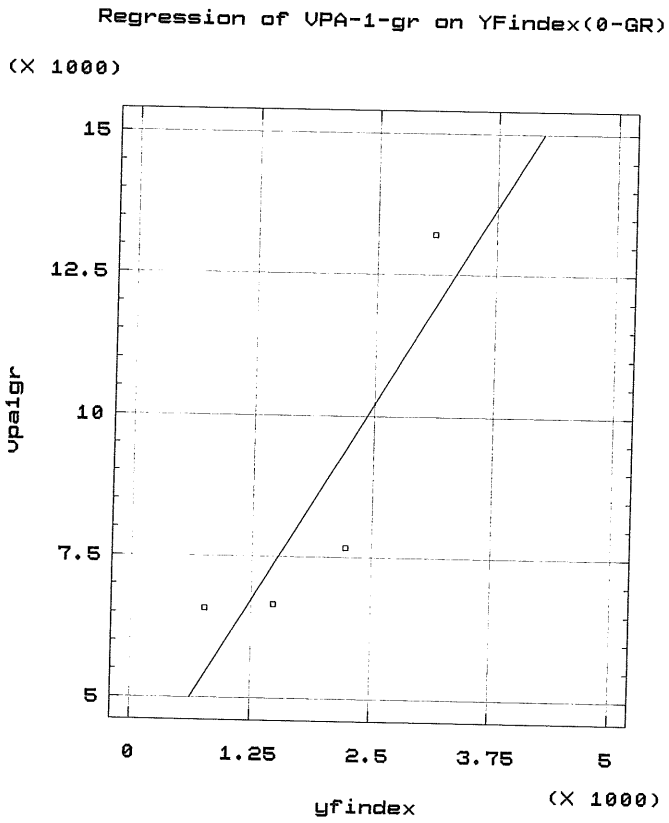


Figure 3.3 Regression of VPA estimates of 1-group on 0-group indices. (Year classes 1984-1987.)



Regression: $Y = 2.775 * X + 3277.3$

$r^2 = 0.7730$

Year class 1988 as 1-group: $9747 * 10^6$

Year class 1989 as 1-group: $30552 * 10^6$

Figure 4.1 Fladen Ground. (Mean length at age by quarter for estimated cohorts.)

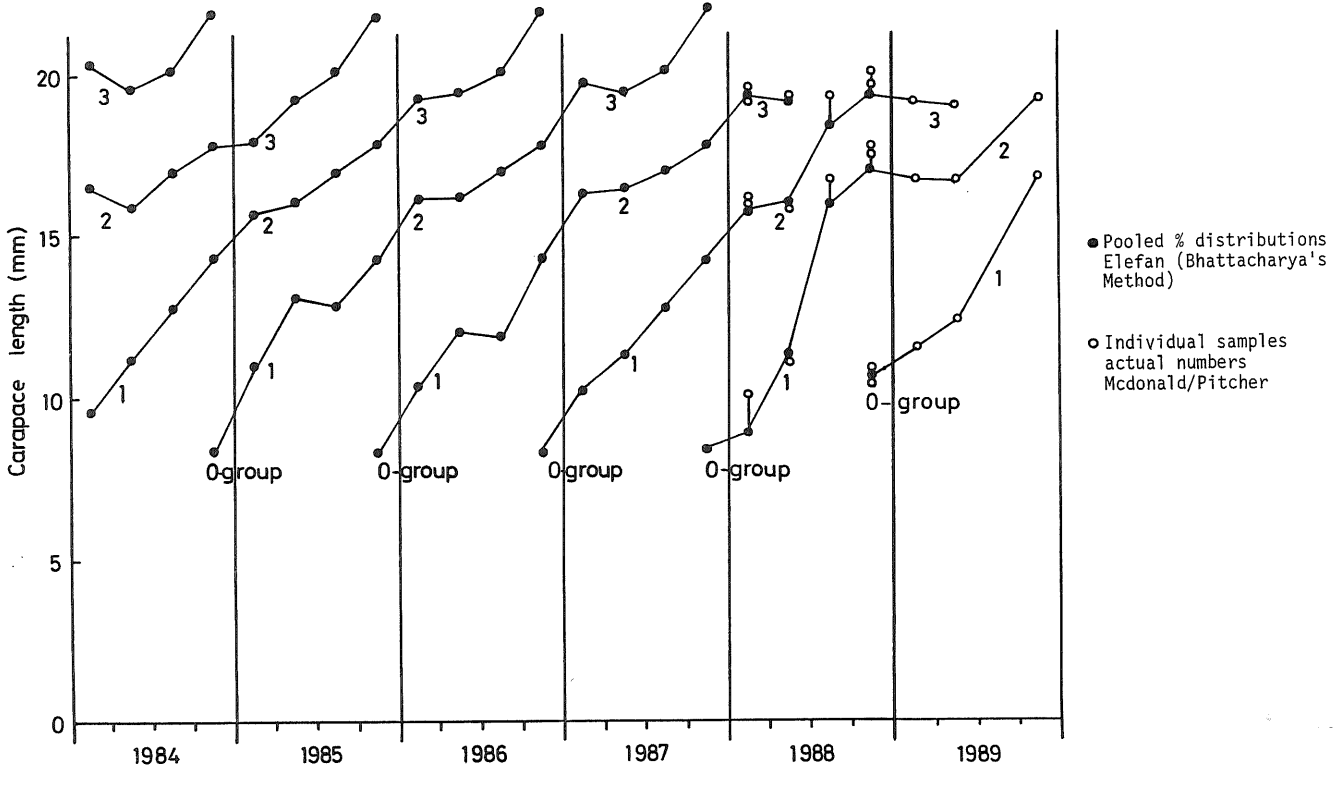


Figure 4.2 Fladen. Effort index and average F using method a) tuning.

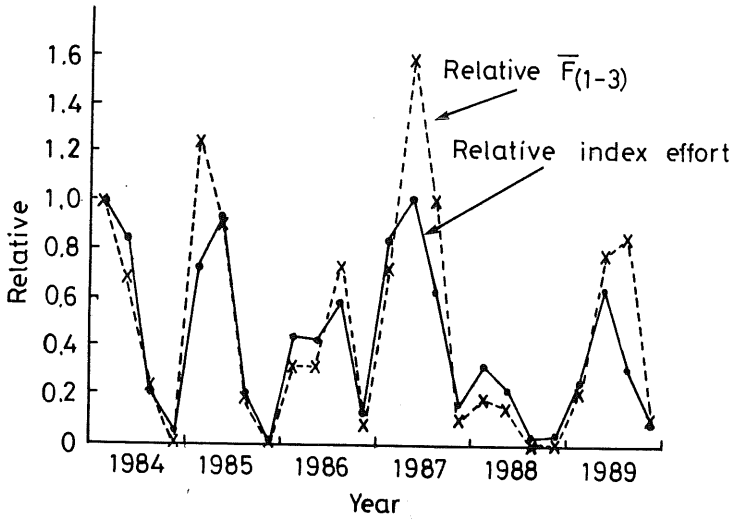


Figure 4.3 Fladen. Average F vs. effort index using method a) tuning.

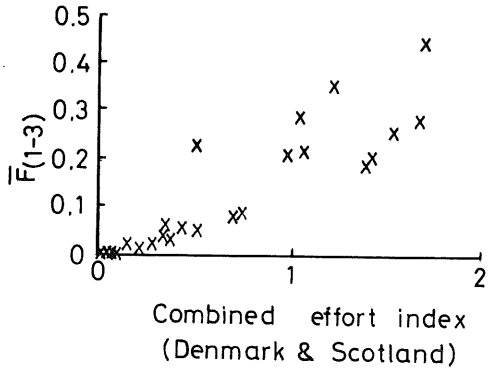


Figure 4.4 Fladen. Effort index and average F using method b) tuning.

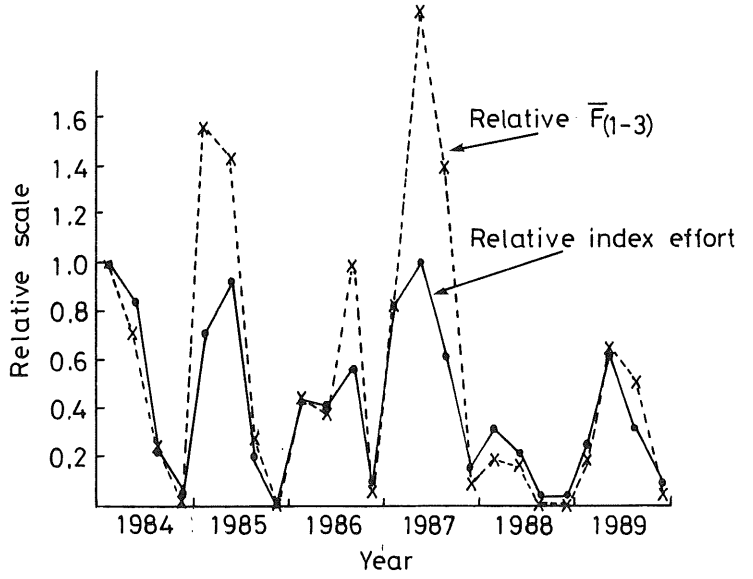
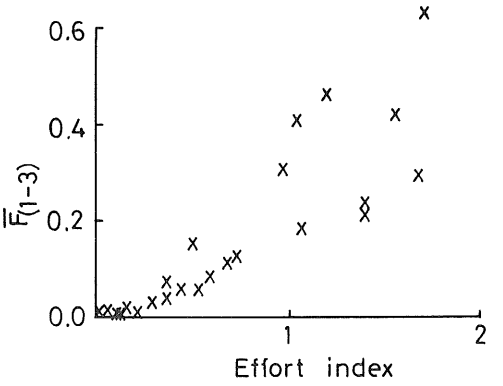


Figure 4.5 Fladen. Average F vs. effort index using method b) tuning.



ANNEX 1

A MULTIVARIATE EXERCISE ON SEPARATION OF PANDALUS "STOCKS"

Background

In the following, data on P. borealis in the North Sea - Skagerrak areas were considered. In these waters, well defined, geographically separated areas with Pandalus are found at the Farn Deeps and Fladen Ground, each of which are considered as unit stocks for assessment purposes. There is a continuous distribution of P. borealis from the Norwegian Deeps along the west coast of Norway to the Skagerrak, and in the ICES Pandalus Assessment Working Group there has been some discussion whether the populations living there should be considered as one or more stocks. There are some biological characteristics that indicate difference, e.g., growth rates, between shrimps from the Skagerrak and those in the Norwegian Deeps and, based on these differences, the Working Group has hitherto assumed two stocks in this area, even if the basis for this separation is somewhat tentative (Annon., 1989a).

Data

The data originally consisted of 1 mm length frequencies by sex (males, inter-sexes, and females), from 22 trawl hauls, grouped into three areas: Fladen Ground (10 hauls), Norwegian Deeps (5 hauls), and Skagerrak(7 hauls). The data were collected during a Danish two-week shrimp survey in November-December 1988.

Results

The original data were joined into 2 mm length groups (7 male, 4 inter-sex, and 7 female groups), and the numbers in each 2 mm length groups were logtransformed.

A Discriminant Function Analysis (DFA) was performed on the male and female length groups.

Discriminant analysis is useful when you have data that are a priori classified into two or more groups and you want to find one or more functions of quantitative measurements that will help you to discriminate among groups.

Text table: Discriminant Analysis For Area

Discriminant function	Eigenvalue	Relative percentage		Canonical correlation
1	280.6	97.5		0.998
2	7.2	2.5		0.937
Function derived	Wilks lambda	Chi-square	DF	P-value
0	0.00043	96.80	28	<0.001
1	0.12206	26.29	13	0.016

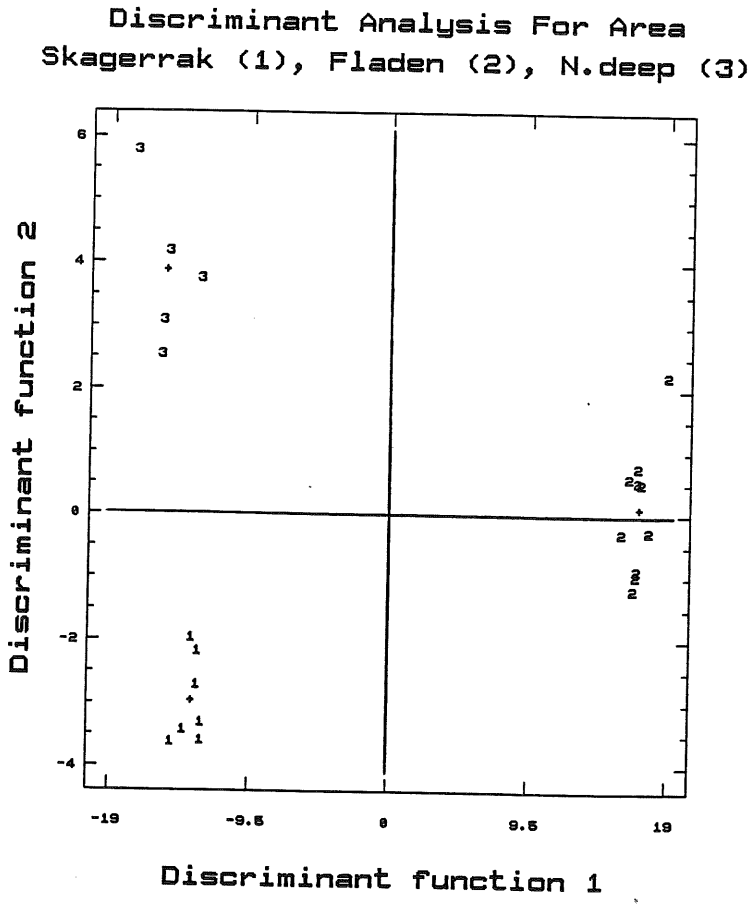
The text table shows the generation of the canonical discriminant functions. The aim is to obtain a small number of functions useful for discriminating among the three groups. In this case, both functions are significant, but function 1 is very good.

The DFA clearly indicated three groups of Pandalus, with the Fladen Ground shrimps most separated from the others "along" function 1 (Annex 1, Figure 1).

The separation between the Skagerrak and Norwegian Deep "along" function 2 is not so well pronounced.

Summary

These particular results should, naturally, not be taken as conclusive for stock separation purposes. This is especially so because the data are limited with respect to a given set of biological variables which need to be interpreted in a wider context. Furthermore, neither temporal factors nor fishing influence (e.g., differences in effort) were analyzed.



Annex 1, Figure 1 Discriminant function plot.
Discriminant analysis performed on male and female length frequencies.