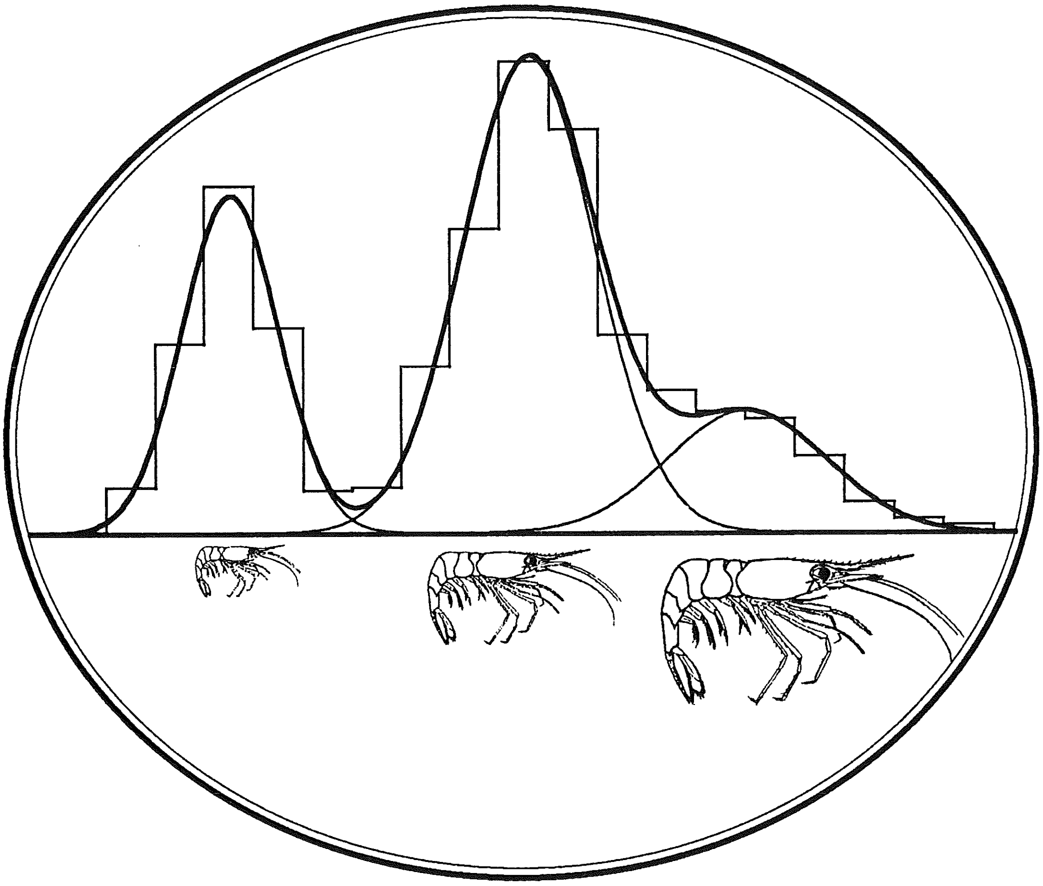
INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA
CONSEIL INTERNATIONAL POUR L'EXPLORATION DE LA MER

C.M.1991 / Assess : 8

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



Copenhagen, 11-14 February 1991

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1 INTRODUCTION

1.1 Participants

S. Munch-Petersen (Chairman)	Denmark
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, Denmark) met at ICES Headquarters from 11-14 February 1991 (C.Res. 1990/2:5:1) to assess the status of stocks of Pandalus borealis in the North Sea, Skagerrak, and Kattegat.

In addition, the Working Group was requested to comment on an ACFM proposal for "Re-arrangement of ICES Assessment Working Groups".

It was regretted that more members were not able to attend this year's Working Group meeting.

2 THE PANDALUS STOCKS WITHIN ICES SUB-AREA IV AND DIVISION IIIa

In last year's Working Group report (Anon., 1990), a detailed overview of the various stocks and the problems connected with identification of some of them was given. The Working Group this year again assumed three management units (Figure 2.1):

1. Skagerrak and Norwegian Deeps combined
2. Fladen Ground
3. Farn Deeps

Nominal landings for Division IIIa and Sub-area IV are shown in Table 2.1.

3 SKAGERRAK AND THE NORWEGIAN DEEPS

3.1 Fisheries

3.1.1 Landings

Landings from the Skagerrak (Division IIIa) and Sub-area IV are shown separately in Table 2.1. Table 3.1 gives the landings since 1970 from the Skagerrak and Norwegian Deeps combined. The decline in the total catch in these areas continued in 1990; the 1990 catch was around 10,000 t compared to more than 14,000 t in 1987.

3.1.2 Discards

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

3.1.3 Effort

Quarterly and annual figures for catch and effort are given in Table 3.2. The Danish and Norwegian total effort values have been estimated from CPUE data based on log-book records covering approximately 90% of the Danish and 30% of the Norwegian total catches. Danish and Swedish data are available for the whole period considered, whereas Norway provided data for 1986 onwards.

All countries showed reductions in effort between 1989 and 1990, Denmark by 43%, Norway by 25%, and Sweden by 12%.

3.2 Assessment

3.2.1 Age distributions

National quarterly samples of length frequencies from Division IIIa and the Norwegian Deeps 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 was 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 together with the age distributions. Quarterly national figures of catch in numbers at age were aggregated to provide the yearly data (Table 3.3).

3.2.2 Mean weight at age

The 1990 figures for mean weight at age were calculated in two ways:

1) As in previous years by applying quarterly length/weight relationships based on Swedish data, and

2) by applying the average weights of shrimps for each mm group on the length frequencies of each year class estimated by splitting the total length composition.

As seen from Table 3.4, there are very small differences for the Swedish data (using the same shrimps for both methods) but up to 15% differences when using the Swedish data on Norwegian samples.

The relations between length (L) and weight (W) calculated for 1990 were ($W = aL^b$):

	Quarter	a	b
Skagerrak	1	0,00162	2,687
	2	0,00651	2,254
	3	0,00366	2,438
	4	0,00200	2,656
Norwegian Deeps	1	0,00356	2,457
	2	0,00833	2,183

For the last two quarters, mean weights by mm groups from the Skagerrak were applied to Norwegian samples from the Norwegian Deeps. The resulting mean weights at age are given in Table 3.5.

The maturity ogive for shrimp varies from year to year. It is estimated as the proportion of intersexes and females in the 2-group in the first quarter of the year, and is as follows:

1985	1986	1987	1988	1989	1990
0.62	0.09	0.20	0.30	0.68	0.73

The 0- and 1-groups are assumed to be immature, and the 3- and older groups 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 for all ages as in previous years.

3.2.4 VPA

The level of fishing mortality in 1990 was estimated by tuning with national effort data. For all three fleets the terminal catchability (q) was estimated as the mean since no trend was obvious (Figure 3.2). F for the oldest non-plus age group (age 4) was set to the mean of age groups 2 and 3. Input for the tuning is given in Table 3.6 and the results are shown in Table 3.7. The standard error of q was below 0.45 in 9 out of 11 cases and below 0.68 in all cases.

The resulting values of mean F (Table 3.8) show a decrease in 1990 of about 40%, compared with a drop in total (relative) effort of about 30%. Table 3.9 shows estimated stock sizes which indicate increases in stock size during the last two years.

3.2.5 Recruitment

The abundance indices of young shrimps obtained by the Norwegian survey in October are given in Table 3.10. A description of the survey and the method used to derive the indices is given in the Annex to this report. It is in the shallower parts of the area covered, mainly in the eastern Skagerrak, that young shrimps are caught.

The 1989 year class was estimated as 2-group from the regression of 1-group survey values on VPA 2-group. A log-log regression was used and gave an estimate of 4.0×10^9 shrimps at age 2 (Figure 3.3). This is somewhat (17%) above the 1985-1989 average and rather close to the number estimated from the tuned VPA (4.6×10^9), but much smaller than previous estimates based on the numbers of 0-group.

The very high value for the 1989 year class as 0-group, obtained in the 1989 survey has thus not influenced the estimate. This data point could by chance be an outlier. Other possible causes are - as pointed out in the ACFM report from November 1990 - that the high water temperature has affected the shrimp growth and the catchability. The change in gear configuration in the 1989 survey (replacing bobbins by rock hoppers) as well as the shift from 1 hour hauls to 1/2 hour hauls may also have had an influence (see Annex).

Year class 1990 was estimated as 1-group to be 15.5×10^9 shrimps from the regression of 0-group survey values against VPA 1-group (Figure 3.4). This estimate is about twice the 1985-1989 average. If temperature and/or gear effects are responsible for the aberration of the 0-group index in 1989, these same factors are likely to have also influenced the 1990 0-group index, which should consequently be treated with caution.

3.2.6 Catch prediction

Input data for the prediction are shown in Table 3.11. The fishing pattern used is the 1985-1989 average scaled to the 1990 level. Mean weights are the averages for the period 1985-90, and recruitment in 1992 and 1993 is the average for the period 1985-89.

The *status quo* catches are predicted to be 13,000 t in 1991 and 15,000 t in 1992 (Table 3.12). The 1990 year class contributes about 4,000 t in 1991 and 7,600 t in 1992.

Taking the uncertainties of the size of the 1990 year class into account, the Working Group suggests that the final advice be postponed to November 1991, when a new estimate of the 1990 year class will be available.

4 THE FLADEN GROUND

4.1 The Fishery

Table 4.1 shows the landings from the Fladen Ground since 1972. Total catches in 1990 declined by approximately 32% compared to 1989. It is noted that, as in 1988 when catches were also low, the bulk of the catch consisted of age group 2 (Table 4.5) with the older age groups constituting only a minor fraction of the catch. Both the Danish and the Scottish fisheries stopped in the third quarter.

4.2 Effort Data

Total effort, both for the Danish and Scottish fisheries, has been estimated from CPUE data for shrimp trawlers. Table 4.2 shows the annual figures estimated from annual CPUE figures, whereas Table 4.3 shows quarterly figures. The quarterly figures reflect the large seasonal fluctuations in the fishery, especially in recent years.

In order to combine the Danish and Scottish effort, relative effort indices were determined for each country and combined indices calculated (Tables 4.2 and 4.3).

4.3 Assessment

4.3.1 Age distribution of catches

The age composition of the catch has been estimated using the Bhattacharya method from length compositions derived from sampling. Samples from the Danish fishery were available for the first and second quarters, and Scottish samples were available for the second and third quarters. No fishery took place in the fourth quarter.

The results of the splitting of the length distributions into age components are shown in Table 4.4 and Figure 4.1, and the resultant catch-at-age data are shown in Table 4.5.

4.3.2 Mean weight at age

Mean weights at age in the 1990 catches (Table 4.6) were calculated on the basis of figures for mean weights by length groups from the Danish length samples, i.e., using the estimated normally-distributed length groups within each age group. The mean weights by length group for the second quarter were also applied to the Scottish samples from the third quarter.

The SOP of total catches in 1990 fits the nominal landings closely. The maturity ogive used is shown below and is based on the observed numbers of berried females in samples from the first quarter in 1989 and 1990 (Danish and Scottish samples). The proportion mature at age 2 is about 60%:

Age	Proportion mature
0	0.0
1	0.0
2	0.6
3	1.0
4+	1.0

4.3.3 Natural mortality

As in previous years, M was set to 1.0 (Anon., 1977) for the Fladen Ground stock. In the near future figures for predation mortality on Pandalus may be provided by the ICES Multispecies Working Group, in which case the M-values may be changed.

4.3.4 VPA

In view of the difficulties regarding tuning of the quarterly VPAs described in last year's report (Anon., 1990) and because of lack of time and manpower this year, it was decided to apply only the annual VPA using the tuning module available at ICES Headquarters.

However, application of disaggregated effort data in the tuning is still not possible, since separate catch-at-age data for Denmark and Scotland are not available prior to 1989. Therefore, combined catches at age (Table 4.5) and the combined index of effort for Danish and Scottish fleets (Table 4.2) were used for tuning. (In future, it should be possible to tune for each of these fleets separately.) Output from the tuning is shown in Table 4.7. Logarithmic catchabilities showed no pronounced trends and terminal q was estimated as the mean.

Table 4.8 shows the estimated fishing mortalities, which, except in 1984, follow the trend of the effort figures (Figure 4.2).

Since 1987, the catch and effort as well as the estimated Fs and stock sizes (Table 4.9) have followed the same fluctuating pattern from year to year. This pattern may be interpreted as reflecting a situation where effort increases in the shrimp fishery when it is considered profitable, until it again becomes less profitable due to removal of most shrimps of marketable size. Fishing pressure is then reduced until the next batch of recruits has attained market size and is then considered worth fishing. If this is so, then shrimp catches from the Fladen Ground would be expected to increase in 1991 due to the good recruitment estimated for 1989.

4.4 Management Options

Short-term predictions for the shrimp fisheries on the Fladen Ground have not been attempted because of the lack of adequate recruitment data.

As stated in previous Working Group reports, the Working Group wishes to point out that good recruitment data are essential if any reliable forecasts are to be made for this stock because it consists of very few age groups.

5 FARN DEEPS

In 1990, Pandalus in the Farn Deeps (Division IVb) were fished almost solely by English vessels (Table 5.1). The Scottish and Danish catches were negligible, and total landings in 1990 were less than 30% of the peak landings of 1988.

No effort data were available for 1990.

6 ACFM PROPOSAL FOR RE-ARRANGEMENT OF ICES ASSESSMENT WORKING GROUPS

All assessment working groups have been requested to comment on the "Proposal for Re-Arrangement of ICES Assessment Working Groups" formulated by ACFM.

The proposal for the Working Group on the Assessment of Pandalus Stocks is that it ultimately be incorporated in a Sub-area IV and Division IIIa Demersal Working Group covering all important demersal species in this area. However, ACFM expresses the opinion that, because of the different assessment methods, the Working Group on the Assessment of Pandalus Stocks should for the time being be kept as a separate species-orientated Working Group.

The Working Group's comments are as follows:

1) The assessment methods used in the Pandalus Working Group are basically the same as those used in the demersal fish assessment working groups, i.e., age-based VPA combined with survey data and short-term predictions. The main difference is that the estimated age composition of the catch is derived by splitting length distributions into age components (instead of age determination from otoliths).

2) Since 1984 the stocks included in the terms of reference for the Pandalus Assessment Working Group have been only those in Sub-area IV and Division IIIa, and active members have been from countries having an interest in those stocks.

On the basis of 1) and 2), the Working Group found no strong arguments for maintaining the Working Group on the Assessment of Pandalus Stocks as a separate species-orientated Working Group. However, the Working Group was of the opinion that the number of participants attending meetings of the proposed Sub-area IV and Division IIIa Demersal Assessment Working Group would have to be very large and this could create organizational problems.

The present Working Group on the Assessmernt of Pandalus Stocks is also of the opinion that if or when the Working Group is dissolved, another, preferably methodological, working group or study group dealing with shrimps should be established to function as a forum for shrimp-orientated scientists within the ICES area. Such a working group or study group would not necessarily have to meet every year.

In connection with the proposal above, ACFM also asks whether annual assessment updates are necessary.

The view of the Pandalus Working Group is that assessments of Pandalus stocks in general are valid only for rather short time periods because of the short life span of this species, and particularly for the Pandalus stock on the Fladen Ground. Therefore, any regular assessment-based management of Pandalus stocks would require at least annual stock assessments (or updates).

7 REFERENCES

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

Anon. 1990. Report of the Working Group on the Assessment of Pandalus Stocks. ICES, Doc. C.M.1990/Assess:9.

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	5,618	1,861	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	2,527	3,156	1,309	6,987	3,298	3,223	122	353	590	7,607[5]
1990[6]	2,309	3,006	1,345	6,660	2,046	3,102	138	279	365	5,930

[1] Includes other Pandalid shrimp.
[2] Includes small amounts of other Pandalid shrimp.
[3] Includes Sub-area IV.
[4] Working Group figure.
[5] Includes 21 t by the Netherlands.
[6] Preliminary.

Table 3.1 Pandalus borealis landings from Divisions IIIa (Skagerrak) and IVa (eastern part) (Norwegian Deeps) 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
1990	2,479	6,108	1,540	10,127

Table 3.2.

Pandalus borealis in Div. IIIa and IVa E

Year	Quarter	Denmark Catch (t)	Denmark Effort (days)	Norway Catch (t)	Norway Effort (Khrs)	Sweden Catch (t)	Sweden Effort (Khrs)	Total catch (t)
1984	1	336	826	1402		183	8,6	1921
	2	264	899	1053	No data	234	12,4	1551
	3	800	1410	1751		393	11,3	2944
	4	347	734	577		213	8,0	1137
Total		1747	3869	4783		1023	40,3	7553
1985	1	410	1002	1679		208	7,4	2297
	2	909	1455	2051	No data	491	17,0	3451
	3	1482	1748	1600		484	14,5	3566
	4	1026	1189	1316		387	10,1	2729
Total		3827	5394	6646		1570	49,0	12043
1986	1	914	1451	1661	39,9	282	8,3	2857
	2	1656	3483	1661	56,3	500	18,8	3817
	3	1464	2343	1657	42,7	383	12,4	3504
	4	800	1424	1496	37,5	299	9,7	2595
Total		4834	8701	6475	176,4	1464	49,2	12773
1987	1	1069	2192	2687	65,2	328	11,3	4084
	2	1511	3188	2721	80,1	389	19,3	4621
	3	1051	1952	1336	49,0	312	14,1	2699
	4	968	1880	1595	63,9	293	12,4	2856
Total		4599	9212	8339	258,2	1322	57,1	14260
1988	1	1111	2296	2675	64,6	296	11,5	4082
	2	1094	2616	2254	79,9	429	20,6	3777
	3	502	1240	1623	64,2	268	12,1	2393
	4	361	953	1109	52,1	285	12,7	1755
Total		3068	7105	7661	260,8	1278	56,9	12007
1989	1	529	1545	1705	58,9	297	13,0	2531
	2	1037	2634	1482	71,0	461	21,9	2980
	3	1111	2039	2074	80,7	391	14,6	3576
	4	473	1260	1157	63,3	261	13,3	1891
Total		3150	7478	6418	274,0	1409	62,8	10977
1990	1	373,1	650	1357	36,8	346	10,2	2076
	2	649,7	1554	1770	80,4	333	17,1	2753
	3	884,6	1161	1618	55,5	509	14,9	3011
	4	571,7	871	1363	33,9	354	13,3	2289
Total		2479	4236	6108	206,6	1541	55,5	10128

Table 3.3 VIRTUAL POPULATION ANALYSIS.

PANDALUS in Divisions IIIa and IVa East.

CATCH IN NUMBERS UNIT: millions

	1985	1986	1987	1988	1989	1990
1	742	875	869	447	1124	1291
2	1249	969	947	599	522	931
3	246	537	561	380	323	124
4	111	34	116	222	44	32
5+	0	2	12	0	0	3
TOTAL	2348	2418	2505	1648	2013	2380

Table 3.4 A. Differences (in %) between mean weights at age calculated from 1) length/weight relation applied to mean length at age and 2) length-weight relation applied to the length frequency of estimated age components. Swedish samples.

	Age					
Quarter	0	1	2	3	4	5
1 Q		-0.32	0.59	1.09	0.75	
2 Q		0.63	0.58	0.50		
3 Q		0.77	0.26	0.59		
4 Q		0.82	0.59	0.75	-0.25	

B. Differences (in %) between mean weights at age calculated from 1) Swedish length-weight relation applied to mean length at age and 2) mean weights by length group in estimated age components. Norwegian samples.

	Age					
Quarter	0	1	2	3	4	5
1 Q		15.06	12.51	5.95	4.15	-2.78
2 Q		-4.32	4.07	1.13		
3 Q		-0.37	4.30	-1.95		
4 Q	9.28	0.51	1.65	2.05	-9.16	

Table 3.5 VIRTUAL POPULATION ANALYSIS.

PANDALUS in Divisions IIIa and IVa East.

MEAN WEIGHT AT AGE OF THE STOCK UNIT: gram

	1985	1986	1987	1988	1989	1990
1	3.000	3.290	2.630	2.880	3.410	2.990
2	5.360	5.550	4.550	5.360	6.590	5.330
3	9.150	8.490	8.570	9.070	9.260	8.250
4	12.290	12.450	11.560	12.670	12.830	10.380
5+	16.250	16.100	14.160	.000	.000	13.700

Table 3.6

```
PANDALUS IIIA-IVA TUNING
103
DENMARK
85,90
1,1
1,5
5394,274,405,54,16,0
8701,342,362,203,11,.2
9212,300.5,297.7,171.5,35.6,3.2
7105,41.8,305.8,144.6,45.2,0
7478,221.7,110.5,51.9,10.7,0
4236,447.8,247.6,10.6,0,0
NORWAY
86,90
1,1
1,5
176.4,435.9,496.8,268.4,18.6,1.2
258.2,483.6,565.1,339,70.6,7.5
260.8,329.1,235.5,197.7,155.4,0
274.2,783.1,323,236.8,26.1,0
206.6,752,548,79.4,29.5,2.6
SWEDEN
85,90
1,1
1,5
49.0,107.5,170.9,25.2,8.4,0.01
49.2,97.3,110.5,65.0,4.0,0.18
57.1,85.1,84.0,50.2,10.0,0.9
56.9,75.6,57.9,37.8,21.6,0.11
62.8,119.8,88.3,34.1,7.5,0.00
55.5,90.9,135.4,33.2,2.6,0.2
```

Table 3.7

Module run at 18.45.00 25 MARCH 1991
DISAGGREGATED Qs
LOG TRANSFORMATION
NO explanatory variate (Mean used)
Fleet 1 ,DENMARK , has terminal q estimated as the mean
Fleet 2 ,NORWAY , has terminal q estimated as the mean
Fleet 3 ,SWEDEN , 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 2 younger ages. Fleets combined by variance of predictions
Fishing mortalities

Age,	85,	86,	87,	88,	89,	90,
1,	.087,	.186,	.225,	.176,	.160,	.172,
2,	.430,	.287,	.608,	.451,	.621,	.356,
3,	.809,	.658,	.514,	1.165,	.994,	.567,
4,	.620,	.473,	.561,	.808,	.808,	.462,

Log catchability estimates

Age 1

Fleet,	85,	86,	87,	88,	89,	90
1	-12.03	-11.69	-11.68	-12.98	-12.38	-11.17
2		-7.55	-7.63	-7.61	-7.81	-7.63
3	-8.26	-7.78	-7.86	-7.56	-8.21	-8.43

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-11.99	.680	.0264	.0760	.000E+00	.000E+00	-11.988	.257
2	-7.65	.106	.0987	.1694	.000E+00	.000E+00	-7.647	.043
3	-8.02	.362	.0183	.2602	.000E+00	.000E+00	-8.016	.137

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.172	.101	.118	.118	1.387

Age 2

Fleet,	85,	86,	87,	88,	89,	90
1	-10.56	-11.30	-10.78	-10.34	-10.95	-10.71
2		-7.09	-6.57	-7.29	-6.57	-6.89
3	-6.72	-7.31	-6.97	-7.17	-6.39	-6.98

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-10.77	.358	.0887	.3336	.000E+00	.000E+00	-10.774	.135
2	-6.88	.350	.2119	.3600	.000E+00	.000E+00	-6.882	.143
3	-6.92	.355	.0546	.3753	.000E+00	.000E+00	-6.925	.134

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.356	.205	.343E-01	.205	.028

Age 3

Fleet,	85,	86,	87,	88,	89,	90
1	-10.32	-10.46	-10.98	-9.68	-10.75	-11.37
2		-6.28	-6.72	-6.06	-5.93	-6.34
3	-6.38	-6.43	-7.12	-6.20	-6.39	-5.90

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-10.59	.631	.1061	1.2360	.000E+00	.000E+00	-10.595	.238
2	-6.27	.332	.3917	.6093	.000E+00	.000E+00	-6.268	.136
3	-6.40	.437	.0920	.3421	.000E+00	.000E+00	-6.403	.165

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.566	.244	.294	.294	1.456

Table 3.8 VIRTUAL POPULATION ANALYSIS.

PANDALUS in Divisions IIIa and IVa East.

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

	1985	1986	1987	1988	1989	1990	1985-89
1	.087	.186	.225	.176	.160	.172	.167
2	.430	.287	.608	.451	.620	.356	.479
3	.809	.658	.514	1.165	.994	.566	.828
4	.620	.473	.561	.808	.808	.462	.654
5+	.620	.473	.561	.808	.808	.462	.654
(1- 3)U	.442	.377	.449	.597	.591	.365	
(2- 3)U	.620	.473	.561	.808	.807	.461	

Table 3.9 VIRTUAL POPULATION ANALYSIS.

PANDALUS in Divisions IIIa and IVa 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	1991	1985-89
1	12526	7260	6047	3899	10734	11487	0	8093
2	4948	5421	2848	2281	1545	4323	4569	3409
3	600	1520	1921	733	686	392	1430	1092
4	329	126	372	543	108	120	105	295
5+	1	6	37	0	0	10	39	9
TOTAL NO	18403	14333	11226	7456	13073	16333		
SPS NO	2998	1586	2158	1383	1312	2825		
TOT.BIOM	73641	68544	50154	36978	54524	62013		
SPS BIOM	19347	12756	17794	11993	10366	16432		

Table 3.10 Indices of 0- and 1-group shrimp from Norwegian Trawl Surveys in October. VPA values and regression equations.

Year-class	0-gr (IIIA)	1-gr(IIIA)	VPA 1-gr	VPA 2-gr
1983		7023		4948
1984	3077	20902	12526	5421
1985	1823	6914	7260	2848
1986	1432	6088	6047	2281
1987	675	2541	3899	1545
1988	2002	8714	10734	4323
1989	*? 9388*	*10743*	-	**4000**
1990	*4052*		**15574**	

Ln(VPA 2-gr)= 2,6588+0.6072 ln(1-gr index)

Ln(VPA 1-gr)=3,0161+0,79900 ln(0-gr index)

Table 3.11

List of input variables for the ICES prediction program.

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

The number of recruits per year is as follows:

Year	Recruitment
1991	15608.0
1992	8093.0
1993	8093.0

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
1	15608.0	.12	.75	.00	3.033	3.033
2	3849.0	.36	.75	.73	5.457	5.457
3	1430.0	.62	.75	1.00	8.798	8.798
4	105.0	.49	.75	1.00	12.030	12.030
5+	39.0	.49	.75	1.00	15.052	15.052

Table 3.12

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

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

Year 1991					Year 1992					Year 1993	
factor	ref. F	stock biomass	sp.stock biomass	catch	factor	ref. F	stock biomass	sp.stock biomass	catch	stock biomass	sp.stock biomass
1.0	.37	83	22	13	.0	.00	76	35	0	83	43
					.1	.04		35	2	81	42
					.2	.07		34	3	79	40
					.4	.15		34	7	76	37
					.6	.22		33	10	73	34
					.8	.29		33	12	70	31
					1.0	.37		32	15	68	29
					1.2	.44		31	17	65	26
					1.4	.51		31	20	63	24
					1.6	.58		30	22	61	23
					1.8	.66		30	24	59	21
					2.0	.73		29	25	57	19

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 1993 has been calculated with the same fishing mortality as for 1992.
The reference F is the mean F (non-weighted) 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	Sweden	Norway	UK (Scotland)	Total
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	-	2	84	1,163
1989	2,438	-	25	547	3,010
1990	1,681	4	3	365	2,053

Table 4.2 *Pandalus borealis*, Fladen Ground. Reported CPUE (shrimp trawlers), and estimated total effort.

Year	Denmark			UK (Scotland)			
	CPUE (t per day)	Total effort (Days)	Index[1]	CPUE (kg per hour)	Total effort (hours)	Index[1]	Combined index[2]
1982	0.96	295	0.10	74	4757	0.31	0.22
1983	1.18	4855	1.61	89	20528	1.32	1.54
1984	0.97	4694	1.56	37	676	0.04	1.55
1985	1.21	3016	1.00	86	15593	1.00	1.00
1986	0.96	3558	1.18	71	4239	0.28	1.11
1987	1.24	5908	1.96	81	8469	0.54	1.84
1988	0.83	1298	0.43	44	1909	0.12	0.41
1989	0.99	2463	0.82	65	8415	0.54	0.77
1990	1.28	1313	0.44	106	3443	0.22	0.40

[1] Relative to 1985.
[2] Weighted by total landings.

Table 4.3 Pandalus. Quarterly CPUE and effort indices, Fladen Ground.

Year	Quarter	Denmark CPUE (t/day)	Denmark Total catch	Denmark f	Denmark Index[1]	UK (Scotland) CPUE (kg/h)	UK (Scotland) Total catch	UK (Scotland) f	UK (Scotland) Index[1]	Combined index[2]
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
1990	1	1.59	201	126	0.10	-	-	-	-	0.10
	2	1.26	1,436	1,132	0.86	104.6	350	3,345	1.06	0.90
	3	0.52	44	84	0.06	151.0	148	148	0.31	0.25
	4	-	-	-	-	-	-	-	-	-

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

Table 4.4 Pandalus, Fladen Ground, 1990.
Mean carapace lengths (mm) at age and proportions at age. Estimated by the Bhattacharya method.

Year class	Age		Quarter 1 DK-samples	Quarter 2 DK-samples	Quarter 2 UK-samples	Quarter 3 UK samples
1990	0	$\bar{x}$	-	-	-	-
		prop.				
1989	1	$\bar{x}$	-	12.58	12.32	17.08
		prop.		0.13	0.05	0.91
1988	2	$\bar{x}$	17.57	16.24	17.72	21.01
		prop.	0.83	0.83	0.92	0.09
1987	3	$\bar{x}$	20.45	19.35	20.13	-
		prop.	0.17	0.04	0.03	-

Table 4.5

Pandalus in Fladen Ground (IVa)

CATCH IN NUMBERS UNIT: millions

	1984	1985	1986	1987	1988	1989	1990
1	312	354	359	540	16	306	43
2	597	875	586	1475	313	327	480
3	286	195	160	165	31	201	23
4+	0	0	0	0	0	0	0
TOTAL	1195	1424	1105	2180	360	834	546

Table 4.6

Pandalus in Fladen Ground (IVa)
CATEGORY: TOTAL

MEAN WEIGHT AT AGE IN THE CATCH UNIT: gram

	1984	1985	1986	1987	1988	1989	1990
1	1.276	1.816	1.735	1.726	2.125	2.350	1.770
2	3.280	3.129	3.372	3.396	3.089	3.982	3.860
3	5.633	4.292	5.306	5.303	5.064	5.109	5.830
4+	.000	.000	.000	.000	.000	.000	.000

Table 4.7 PANDALUS at the Fladen Ground. Tuning results.

Module run at 20.01.08 25 MARCH 1991
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, 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,	90,
1,	.069,	.116,	.077,	.145,	.010,	.054,	.024,
2,	.464,	.721,	.743,	1.581,	.278,	.774,	.265,
3,	.464,	.721,	.743,	1.581,	.278,	.774,	.265,

Log catchability estimates

Age 1

Fleet,	84,	85,	86,	87,	88,	89,	90
1 ,	-3.12,	-2.16,	-2.67,	-2.55,	-3.69,	-2.66,	-2.81

SUMMARY STATISTICS

Fleet ,	Pred. q ,	SE(q),	Partial F ,	Raised F ,	SLOPE ,	SE Slope ,	INTRCPT,	SE Intrcpt
1 ,	-2.81 ,	.517,	.0242 ,	.0242,	.000E+00,	.000E+00,	-2.807,	.183

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.024	.517	0.000	.517	0.000

Age 2

Fleet,	84,	85,	86,	87,	88,	89,	90
1 ,	-1.21,	-.33,	-.40,	-.16,	-.39,	.01,	-.41

SUMMARY STATISTICS

Fleet ,	Pred. q ,	SE(q),	Partial F ,	Raised F ,	SLOPE ,	SE Slope ,	INTRCPT,	SE Intrcpt
1 ,	-.41 ,	.409,	.2649 ,	.2649,	.000E+00,	.000E+00,	-.412,	.145

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.265	.409	0.000	.409	0.000

Table 4.8 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	1990	1985-89
1	.069	.116	.077	.145	.010	.054	.024	.080
2	.464	.721	.743	1.581	.278	.774	.265	.820
3	.464	.721	.743	1.581	.278	.774	.265	.820
4+	.464	.721	.743	1.581	.278	.774	.265	.820
(1- 3)U	.332	.519	.521	1.102	.189	.534	.185	

Table 4.9 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	1991
1	7404	5083	7646	6258	2478	9162	2844	0
2	2450	2543	1666	2605	1992	902	3193	1021
3	1174	567	455	291	197	555	153	901
4+	0	0	0	0	0	0	0	43
TOTAL NO	11028	8193	9767	9155	4667	10619	6190	
SPS NO	1767	1285	886	857	989	661	1476	
TOT.BIOM	24096	19621	21297	21194	12417	27957	18251	
SPS BIOM	7641	4424	3525	3168	3332	3009	5914	

Table 5.1 Landings (t) of *Pandalus borealis* from Division IVb, the Farne 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
1990	144	+	1	145	No data

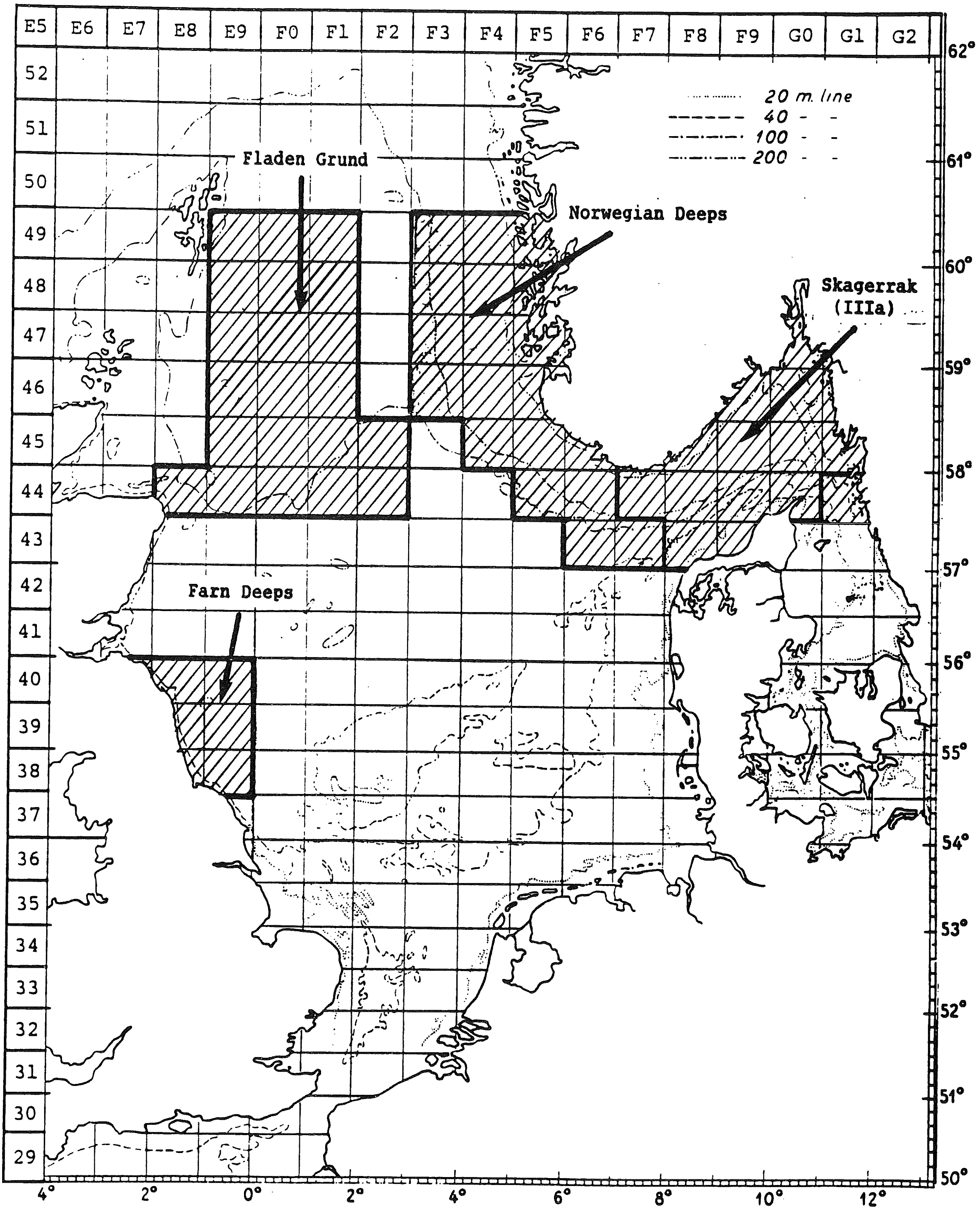


Figure 2.1 The management units of Pandalus in ICES Sub-area IV and Division IIIa as defined by statistical squares according to the Working Group.

Quarterly mean lengths of Panalus area IIIa and IVa east

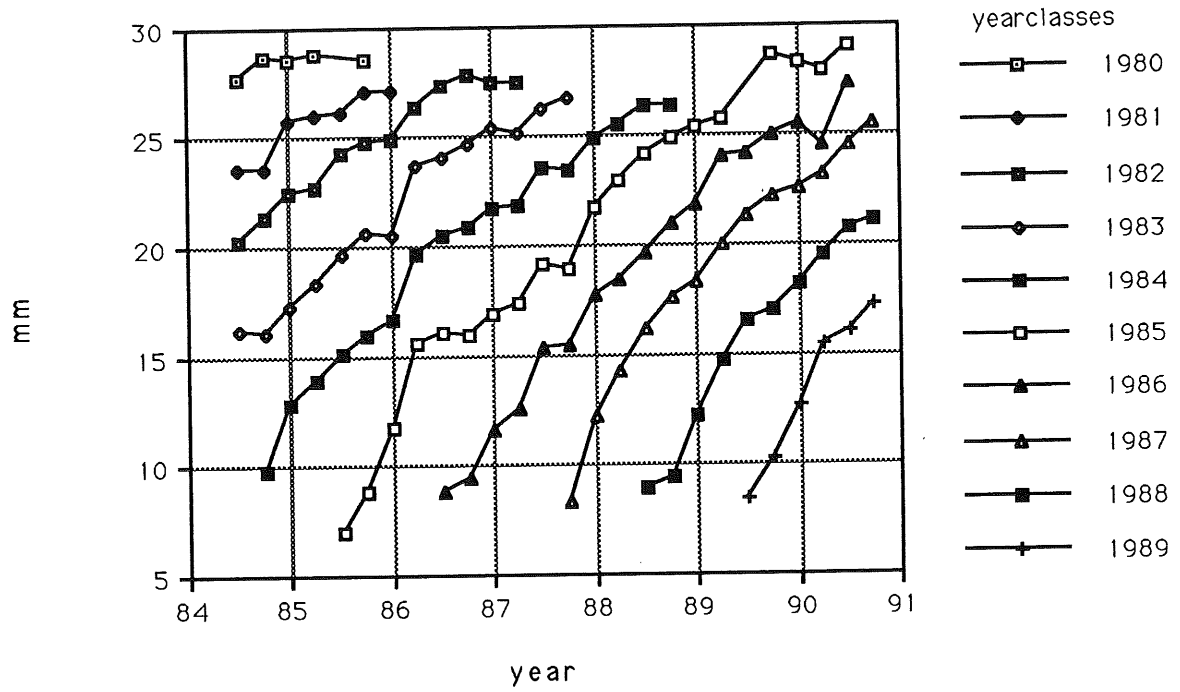


Figure 3.1

Figure 3.2
Log catchability. Pandalus IIIa+IVaE.

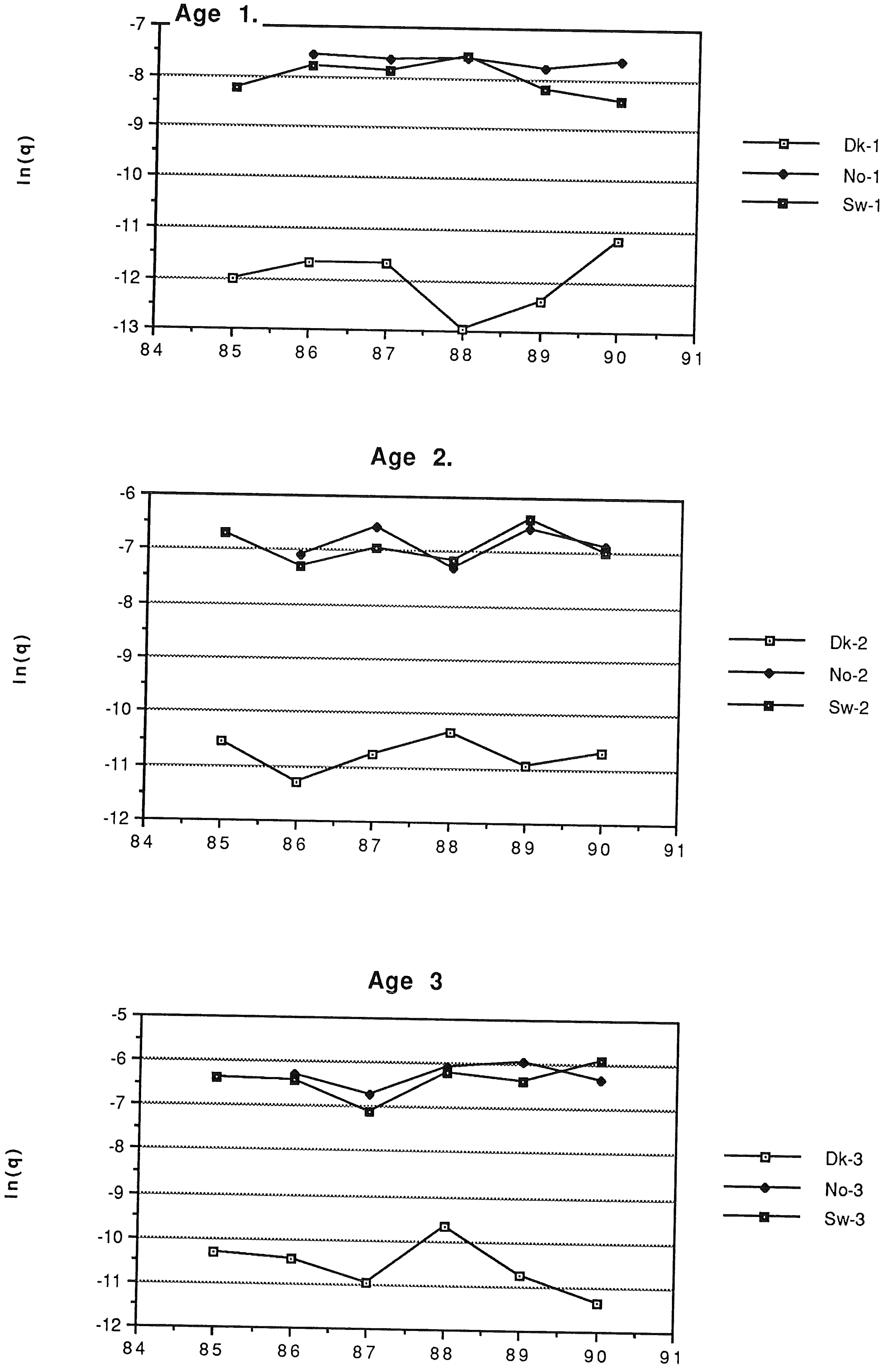


Figure 3.3
Pandalus. 1-gr indices (IIIa) and VPA 2-gr. Regression of log-values.

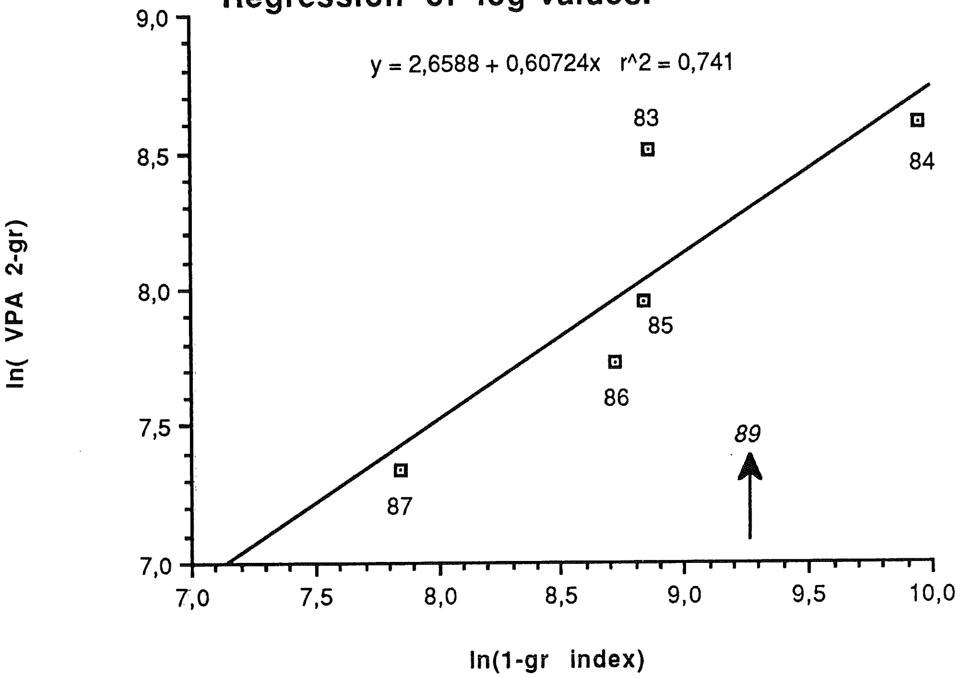


Figure 3.4.
Pandalus. 0-gr indices (IIIa) and VPA 1-gr. Regression of log-values.

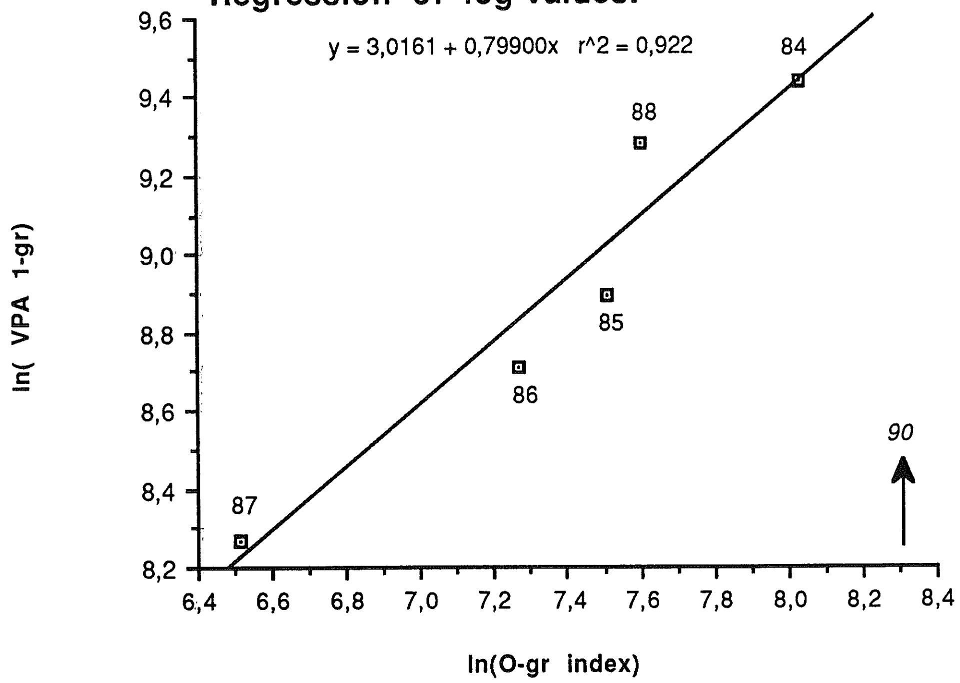
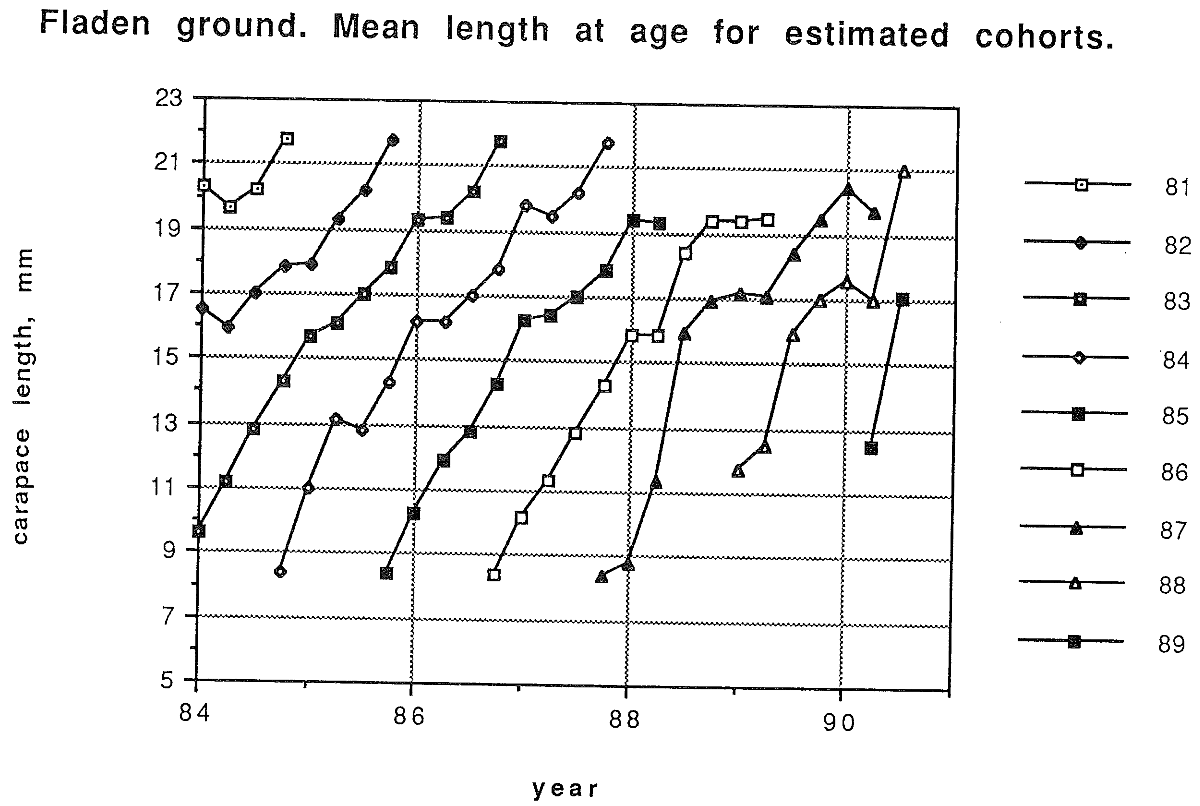
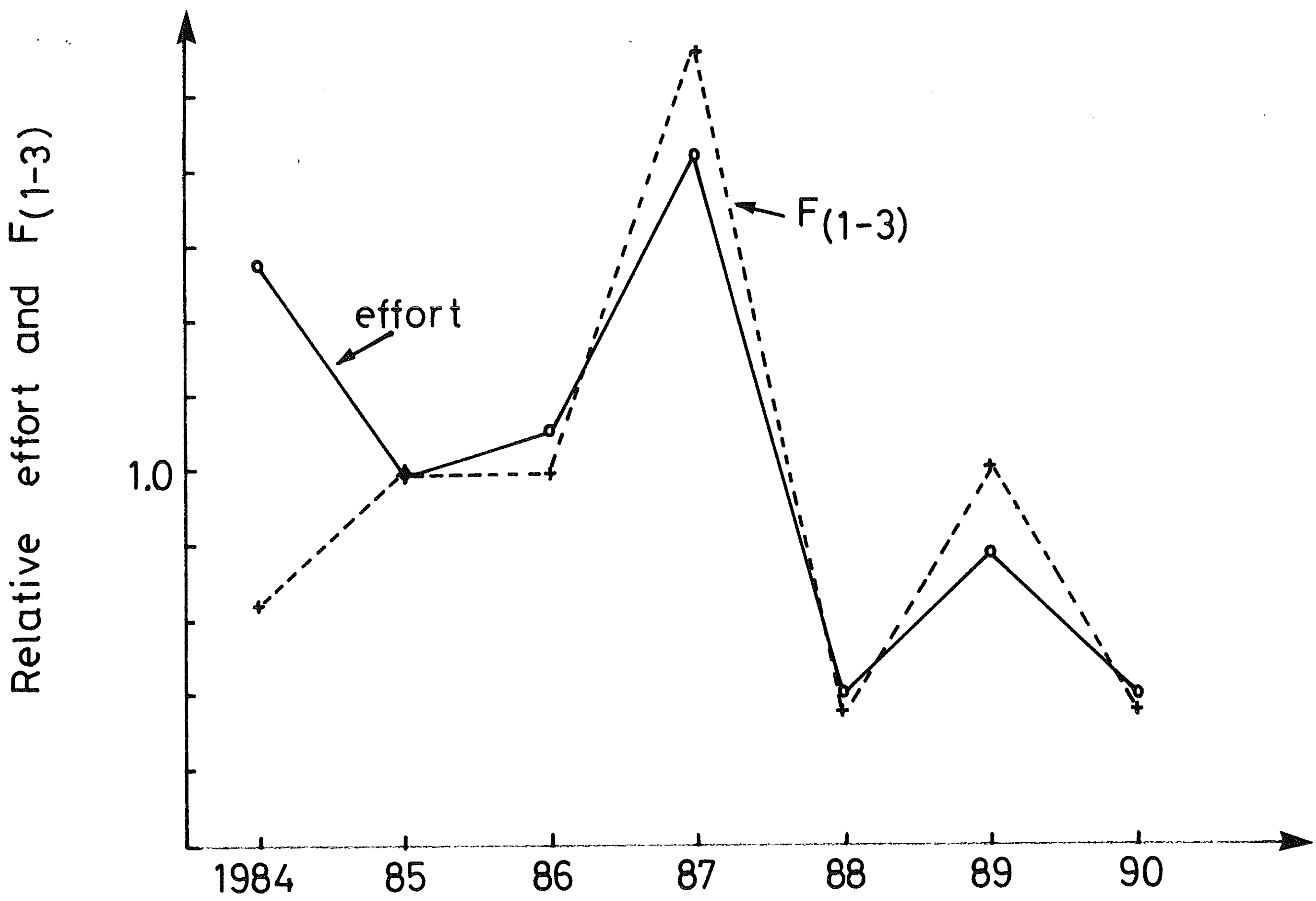


Figure 4.1


Fladen ground. Mean length at age for estimated cohorts.
carapace length, mm
23
21
19
17
15
13
11
9
7
5
84
86
88
90
year
81
82
83
84
85
86
87
88
89



<u>Figure 4.2</u> Fladen Ground. Effort indices and estimated $F_{(1-3)}$.

ANNEX: ABUNDANCE INDICES FROM THE NORWEGIAN TRAWL SURVEYS

The basis for the 0-group and 1-group indices referred to in Section 3.2.5 and shown in Table 3.10 consists of the data from the Norwegian trawl surveys covering the Skagerrak and the Norwegian Deeps (Annex Figure 1). A short description of the methods and estimation procedures involved in obtaining the indices is presented here.

The R/V "Michael Sars" has been used from 1984 onwards for annual shrimp surveys in the Skagerrak and the Norwegian Deeps. Cruises have taken place for 2-3 weeks in October-November.

The survey area is divided into 16 strata (Annex Figure 1) which are grouped according to depth as follows:

Stratum 1, 3, 5, 8, 11 and 14: 100-200 m

Stratum 2, 4, 6, 9, 12 and 15: 200-300 m

Stratum 7, 10, 13 and 16: 300-500 m

The surveys are based on fixed trawl stations, which have been spread as evenly as possible over all strata. The depth at most of the trawl stations lies between 100 and 450 m. In the southern and eastern part of the Norwegian Deeps it is possible to trawl almost everywhere. Along the Norwegian coast, however, the areas suitable for trawling are restricted.

The gear used is the Campelen 1800 trawl, which is the standard trawl of the Norwegian research vessels. Rubber bobbins were used until 1989, when these were changed to a rockhopper gear. When used in the shrimp surveys, the trawl is provided with a 6 mm mesh lining net in the cod-end. The duration of the hauls was one hour before 1989, but in 1989 and 1990 half-hour hauls were used. The average measure of the wing-spread at a tow speed of 3 knots (used for calculating swept area) is 11.7 m (Teigsmark and Øynes, 1983). A one hour haul, therefore, covers 0.019 sq. nm.

For each stratum the average number of shrimps caught per hour is calculated. This figure is then divided by the "swept area" (0.019) and multiplied by the area of the stratum in order to obtain a figure for the total number of shrimps per stratum. Samples of 250-300 shrimps per haul are the basis for estimation of average length frequencies by stratum. These length distributions are then split into age groups by the Bhattacharya method. For each age group, the number of shrimps available to the trawl in each stratum is calculated. These figures must be considered as indices, since a great proportion of the shrimps is pelagic and not available to the bottom trawl. This is especially the case for the 0-groups.

The 0-group index is of particular importance for prediction purposes. For the year classes 1984-1988 there seems to be good correlation between 0-group indices, 1-group indices and 1-group VPA estimates. However, the high 1989 0-group index fell somewhat outside these relationships (Section 3.2.5). One possible explanation is that due to high temperatures during the hatching and larval periods, the growth-rate was higher than average and thus a greater proportion of the 0-groups were distributed near the bottom than the other years.

However, part of the explanation for the high index-value for the 1989 year class may be the change from one-hour hauls to half-hour hauls in 1989. Because 0-group shrimps are found higher above the bottom, a larger proportion of the shrimps in the half-hour hauls should be 0-groups due to a greater fraction of total tow time being spent in setting and hauling the trawl.

REFERENCE

Teigsmark, G. and Øynes, P. 1983. Norwegian investigations on the deep sea shrimp (Pandalus borealis) in the Barents Sea in April-May 1983 and in the Spitsbergen area in July 1983. ICES Doc. C.M. 1983/K:46.

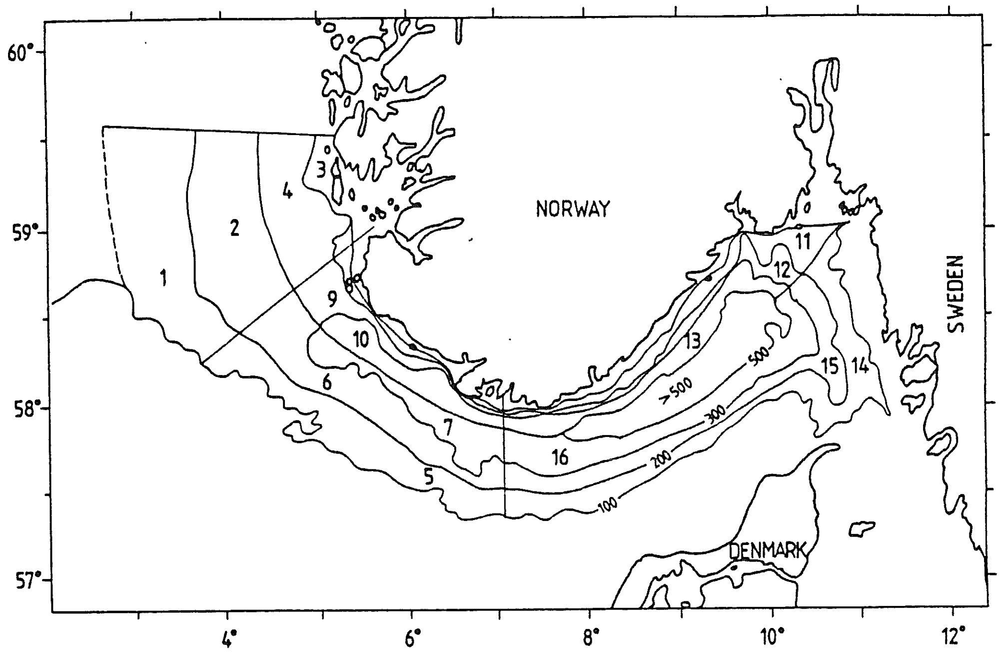


Figure 1 Norwegian Deeps in the North Sea and Skagerrak, 1 to 16: strata used for swept area calculations.