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Faroese investigations of the prawn fisheries at Greenland and an attempt to estimate total mortality on the oldest age-groups

by

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Introduction

Catch and effort data for the first 3 quarters of 1976 are at hand now. Later this year the Faroese fisheries laboratory placed an observer, Skipper Pall Olsen, on board on the Faroese prawn trawler "HVITANES." Mr. Olsen undertook a rather extensive sampling on board allowing the catch of "HVITANES" to be split into length frequencies and numbers.

These length data have been used as the basis of an attempt to estimate growth parameters and total mortality in the Greenland prawn stock.

Materials and Methods

Catch and effort data have been collected and treated as described in Res.Doc. 76/VI/15 (Hoydal 1976).

Only length samples taken randomly from the catch before the sorting of the prawns have been used and the length referred to is the lateral length of the carapace as used by Horsted and Smidt (1956).

The material has been split into seven groups based on time and area of fishery. For the first group no samples could be used.

The groups are defined as follows, following the coding of statistical rectangles used by Greenland Fisheries investigations:

	Place	Time
Area 1	JF 21 JB 20	1 to 4 April 1976
Area 2	JA 23	5 to 8 April 1976
3	HP 26	9 to 10 April 1976
4	JD 19	11 to 20 April 1976
5	KA 10	21 to 26 April 1976
6	JZ 8 KA 10	27 April to 9 May 1976

Area	Place	Time
7	KJ 7	15 May to 2 June
	KF 7	
	KE 8	
	KB 11	

The grouping in ovigerous, nonovigerous and indeterminate is not taken into consideration in this paper.

Results

Weighted averages of catch effort data for different areas for the first nine months of 1976 compared to 1974 and 1975 data are given in Table 1.

The results for 1975 and 1976 are practically identical. From 1974 to 1975 there is a large increase in CPU in the northern areas, but the most likely explanation for this is the introduction of larger and more efficient vessels.

The length frequencies are given in Tables 2 - 8 and plotted for some areas in Fig. 1 to 5.

Estimating L_∞,K and Total Mortality, Z

It has been shown by Mr. W.P. Andersen, Danish Fisheries Investigations, that by rearranging some of the equations in the Beverton/Holt model it should be possible to estimate L_∞, K and N_* and mortality from length compositions directly. Unfortunately, the method and its application is not published by Mr. Andersen, but a short review of method is given in Appendix I by this author, who of course has all responsibility of eventual errors and misinterpretation of the method. The author has had severe doubts about the possibility of using this method on prawns. But on the other hand it is thought to be interesting to present what came out of it.

In Table 9 estimated values of Z and corresponding estimated growth parameters and age composition are given.

It seems that one has to assume high total mortalities to get reasonable age compositions.

Comparison with the Findings of other Authors

Thomassen (1975) has estimated growth parameters and total mortality by splitting length frequencies into yearclasses and then calculate L_∞, K, T_0 and Z in the usual way for a local stock in Balsrood Fjord.

It is interesting to note that he finds a very high Z on the oldest age groups and growth parameters, much like the ones found by the author through a quite different method. Comparing the outcome of the run with Z = 1.5 with the findings of Thomassen gives these results:

Thomassen	This Document
Z = 1.81	Z = 1.5
K = .43	K = .498
L_∞ = 27.2	L_∞ = 38.3

REFERENCES

HOYDAL, Kjartan. An Assessment of the Deep Sea Shrimp (Pandalus Borealis) ICNAF Res.Doc. 76/VI/15

HORSTED, SV.A.A. & Erik Smidt: The Deep Sea Prawn (Pandalus Borealis) in Green Land Waters, Medd. Danm. Fisk. Havvndersøgelser N.S. I,11

THOMASSEN, Thore: Growth Recruitment and Mortality of Pandalus Borealis (Krøyer) in Bals Fjord, Nortern Norway

Table 1. Catch per unit effort (kilo/hour trawling) of deep sea prawn, 1974 to 1976 Faroese vessels

Area/Year	1974	1975	1976
1 B	.272	.721	.712
1 C	.264	.368	.310
1 D	.269	.263 (1 D + 1 E)	.265 (1 D + 1 E)
1 E	.176		

Table 2. Length frequency deep sea prawns, Faroese trawler HVITANES, 1976

AREA NO 2

CATCH WEIGHT 13020 KG — WEIGTH OF SAMPLES 0.[illegible] KG

CARAPACE mm	OVIGEROUS 1000'	NON OVIGEROUS 1000'	INDETERMIN. 1000'	TOTAL 1000'
13	0	0	12	12
14	0	0	12	12
15	0	0	12	12
16	0	0	61	61
17	0	0	49	49
18	0	0	49	49
19	0	0	74	74
20	0	0	61	61
21	0	0	159	159
22	0	0	123	123
23	0	0	172	172
24	0	0	74	74
25	0	0	49	49
26	0	0	98	98
27	0	0	86	86
28	0	0	221	221
29	0	0	61	61
30	0	0	61	61
31	0	0	37	37
32	0	0	37	37
33	0	0	12	12
TOTAL	0	0	1521	1521

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Table 3. Length frequency deep sea prawns, Faroese trawler HVITANES, 1976

AREA NO 3

CATCH WEIGHT 4050 KG		WEIGTH OF SAMPLES 0.68 KG		
CARAPACE mm	OVIGEROUS 1000'	NON OVIGEROUS 1000'	INDETERMIN. 1000'	TOTAL 1000'
17	0	0	6	6
19	0	0	12	12
20	0	0	31	31
21	0	0	37	37
22	0	0	37	37
23	0	0	56	56
24	0	0	25	25
25	0	0	6	6
26	0	0	37	37
27	0	0	31	31
28	0	0	31	31
29	0	0	19	19
30	0	0	25	25
31	0	0	25	25
32	0	0	19	19
33	0	0	25	25
TOTAL	0	0	423	423

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Table 4. Length frequency deep sea prawns, Faroese trawler HVITANES, 1976

AREA NO 4

CATCH WEIGHT 21035 KG		WEIGTH OF SAMPLES 2.845 KG		
CARAPACE mm	OVIGEROUS 1000'	NON OVIGEROUS 1000'	INDETERMIN. 1000'	TOTAL 1000'
17	0	32	0	32
18	0	14	0	14
19	0	18	0	18
20	0	78	0	78
21	0	110	0	110
22	0	119	0	119
23	0	206	0	206
24	0	220	0	220
25	0	335	0	335
26	0	389	0	389
27	32	244	0	275
28	51	180	0	231
29	186	74	0	260
30	205	0	0	205
31	333	0	0	333
32	196	0	0	196
33	51	0	0	51
34	7	0	0	7
TOTAL	1060	2020	0	3080

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Table 5. Length frequency deep sea prawns, Faroese trawler HVITANES, 1976

AREA NO 5

CATCH WEIGHT 40045 KG CARAPACE mm	 OVIGEROUS 1000'	WEIGTH OF SAMPLES 4.955 KG NON OVIGEROUS 1000'	 INDETERMIN. 1000'	 TOTAL 1000'
15	0	11	0	11
16	0	11	0	11
18	0	29	0	29
19	0	149	0	149
20	0	57	0	57
21	0	174	0	174
22	0	597	0	597
23	0	773	0	773
24	0	1182	0	1182
25	0	1112	0	1112
26	3	690	0	693
27	59	63	0	122
28	353	715	0	1068
29	790	208	0	998
30	943	15	0	958
31	566	3	0	569
32	156	0	0	156
33	7	84	0	91
34	43	0	0	43
TOTAL	2920	5874	0	8794

Table 6. Length frequency deep sea prawns, Faroese trawler HVITANES, 1976

AREA NO 6

CATCH WEIGHT 100725 KG LENGTH mm	 OVIGEROUS 1000'	WEIGHT OF SAMPLES 18.35 KG NON OVIGEROUS 1000'	 INDETERMIN 1000'	 TOTAL 1000'
18	0	34	0	34
19	0	76	0	76
20	0	381	0	381
21	0	637	0	637
22	0	1449	0	1449
23	0	2398	0	2398
24	0	2270	0	2270
25	0	3423	0	3423
26	53	2461	0	2513
27	708	1930	0	2638
28	1881	1886	0	3767
29	3293	1251	0	4544
30	3217	1070	0	4286
31	1745	344	0	2090
32	937	[illegible]	0	956
33	362	33	0	395
34	49	0	0	49
TOTAL	12245	19661	0	31906

Table 7. Length frequency deep sea prawns, Faroese trawler HVITANES, 1976

AREA NO 7

CATCH WEIGHT 154675 KG CARAPACE mm	OVIGEROUS 1000′	WEIGTH OF SAMPLES 17.615 KG NON OVIGEROUS 1000′	INDETERMIN. 1000′	TOTAL 1000′
15	0	8	0	8
16	0	50	0	50
17	0	69	75	144
18	0	88	108	197
19	0	113	121	234
20	0	68	145	213
21	0	96	287	383
22	0	270	516	786
23	0	372	556	928
24	0	422	641	1063
25	0	338	722	1060
26	17	275	779	1071
27	51	266	1397	1714
28	152	230	2600	2983
29	186	141	3170	3498
30	203	97	2623	2923
31	118	27	1592	1737
32	68	19	910	997
33	51	2	346	399
34	0	0	99	99
TOTAL	8461	2949	16690	20485

Table 8. Length frequency deep sea prawns, Faroese trawler HVITANES, 1976, All Areas.

ALL AREAS

CATCH WEIGHT 443120 KG LENGTH mm	OVIGEROUS 1000′	WEIGHT OF SAMPLES 47 KG NON OVIGEROUS 1000′	INDETERMIN 1000′	TOTAL 1000′
13	0	0	19	19
14	0	0	19	19
15	0	19	19	38
16	0	61	93	154
17	0	102	159	261
18	0	166	183	349
19	0	372	252	624
20	0	587	284	871
21	0	1035	585	1620
22	0	2513	759	3272
23	0	3844	901	4745
24	0	4247	790	5037
25	0	5349	806	6156
26	73	3931	984	4987
27	857	2508	1574	4940
28	2475	3131	2982	8588
29	4549	1704	3291	9544
30	4694	1182	2753	8629
31	2854	374	1685	4912
32	1384	37	994	2415
33	472	134	402	1007
34	107	0	99	206
TOTAL	17464	31295	19633	68392

Table 9. Estimates of L_∞ and K and age for different values of Z, T_0=0

	Z=1.5 K=.498 L =35.3	Z=1.4 K=.432 L =35.3	Z=1.2 K=.399 L =35.3	Z=1.0 K=.332 L =35.3	Z=0.6 K=.199 L =35.3
Carapace Length(mm)	Age	Age	Age	Age	Age
29.5	3.6	4.2	4.5	5.4	9.1
30.5	4.0	4.6	5.0	6.0	10.0
31.5	4.5	5.2	5.6	6.7	11.2
32.5	5.1	5.9	6.4	7.6	12.7
33.5	6.1	6.9	7.5	9.0	14.9
34.5	7.6	8.8	9.6	11.4	19.0

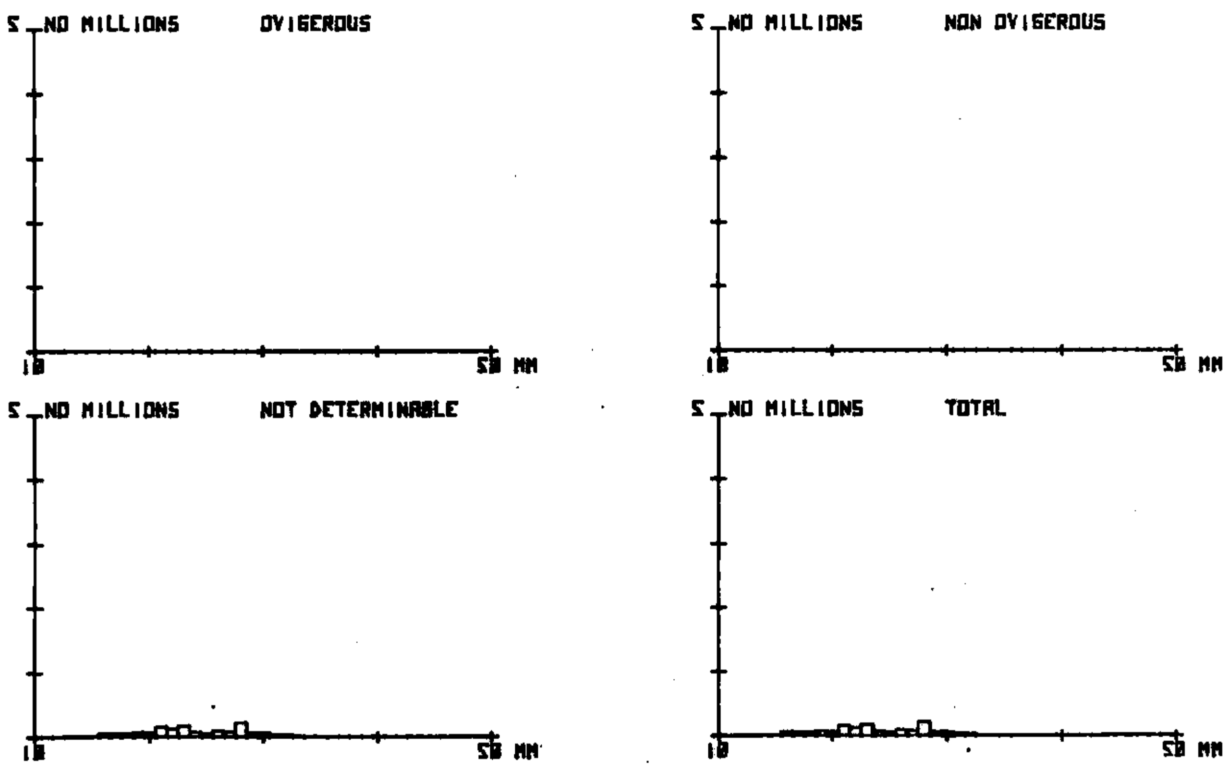

Fig. 1. Length frequency deep sea prawns Hvitanes, 1976, Area 2.

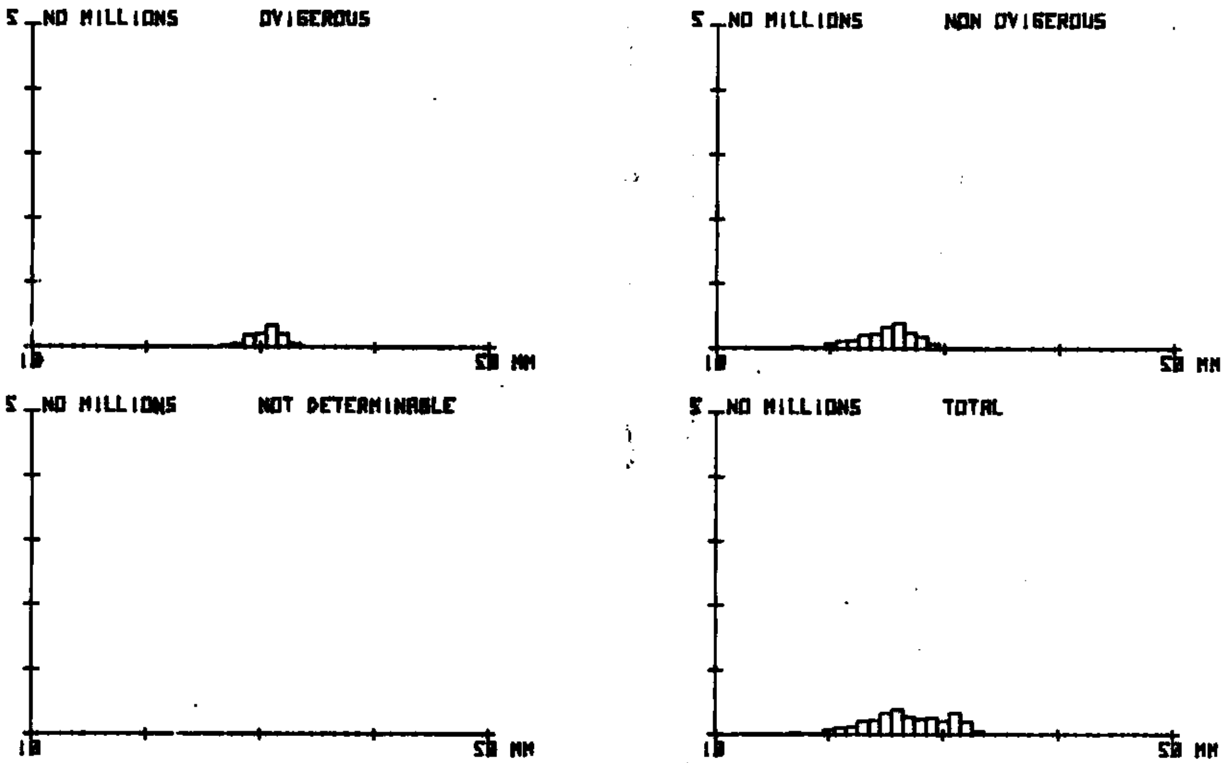

Fig. 2. Length frequency deep sea prawns Hvitanes, 1976, Area 4.

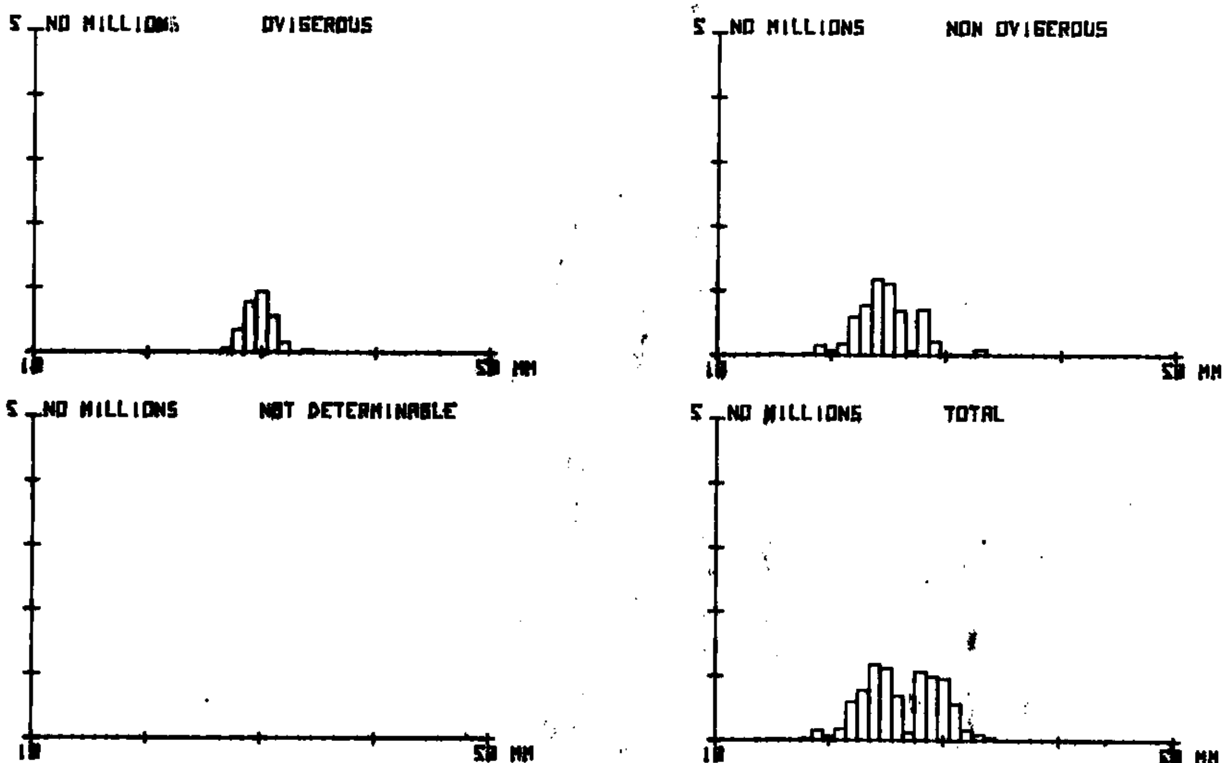

Fig. 3. Length frequency deep sea prawns Hvitanes, 1976, Area 5.

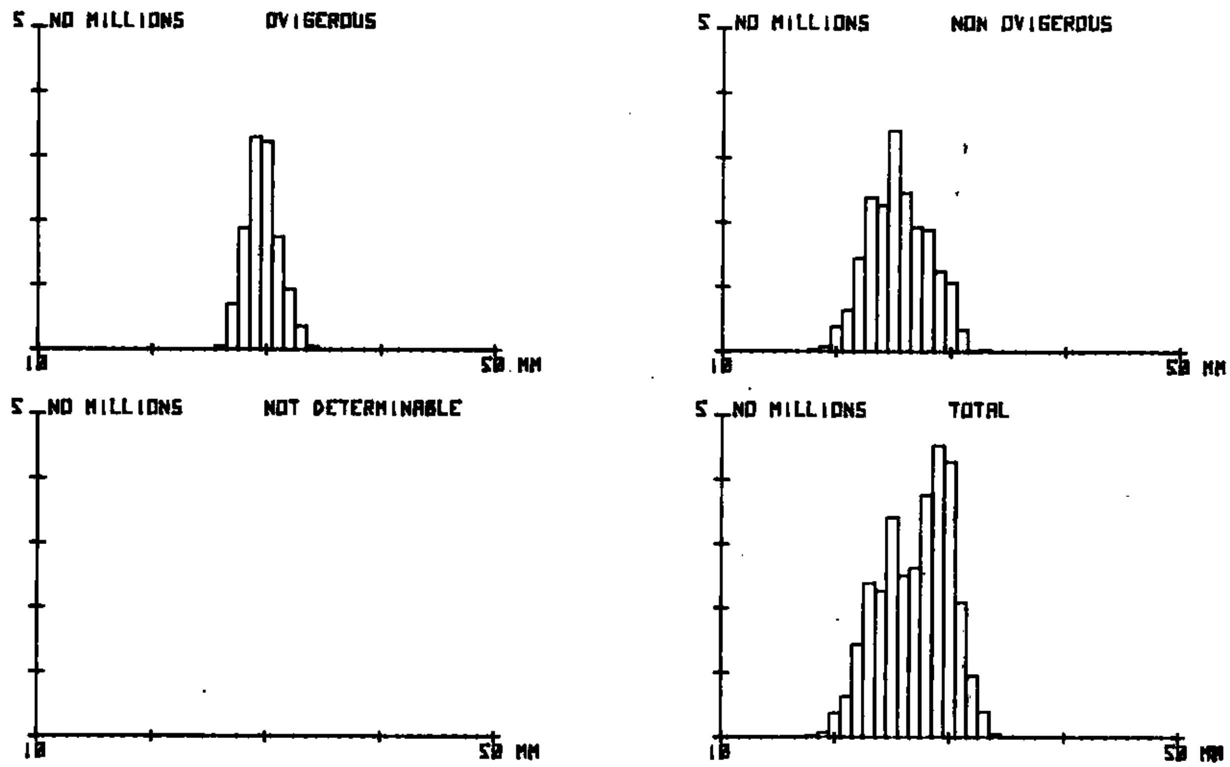

Fig. 4. Length frequency deep sea prawns Hvitanes, 1976, Area 6.

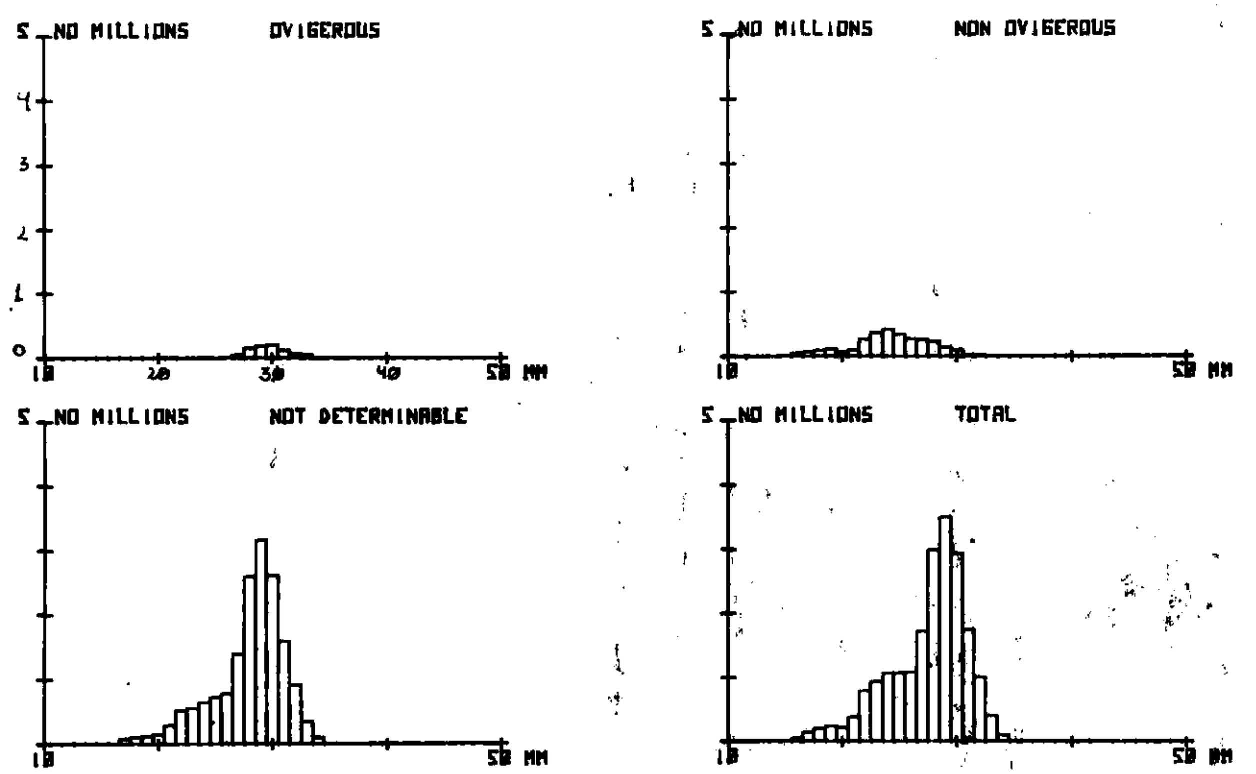

Fig. 5. Length frequencies deep sea prawns Hvitanes, 1976, Area 7.

APPENDIX I

Estimating L_∞, K and N_0 from length composition

The rearrangement of the equations are according to Mr. K.P. Andersen as follows:

The two equations in question are the growth equation

1) $$l = L_\infty (1 - e^{-K(t-t_0)})$$

and a form of the equation giving yields in numbers

2) $$dY = N_0 e^{-(F+M)(t-t_0)} dt$$

The first equation is rearranged in the following way

1a $$t = t_0 - \frac{1}{K} \log \left(1 - \frac{l}{L_\infty}\right)$$

1b $$dt = \left(K L_\infty \left(1 - \frac{l}{L_\infty}\right)\right)^{-1} dl$$

Equation (1b) is inserted into equation (2), giving

2a $$dY = N_0 \frac{F+M}{K} \log \left(1 - \frac{l}{L_\infty}\right) \left(K L_\infty \left(1 - \frac{l}{L_\infty}\right)\right)^{-1} dl$$

reducing to

2b $$dY = \frac{N_0 dl}{K L_\infty} \left(1 - \frac{l}{L_\infty}\right)^{\frac{F+M-K}{K}}$$

3) $$\log dY = \log \frac{N_0 dl}{K L_\infty} + \frac{F+M-K}{K} \log \left(1 - \frac{l}{L_\infty}\right)$$

shortening the notation it can be written as

4) $$\log dY = A + B \log (1 - Cl)$$

It can then be seen that

$$L_\infty = 1/C$$

$$K = \frac{F+M}{B+1}$$

$$N_0 = \frac{(F+M) e^{A + (F+M) t_0}}{(B+1) C dl}$$

<u>The Estimation Procedure</u>

The method was originally invented as a check procedure for length compositions brought to mesh assessments. The method checked if the length data were consistent with the growth and mortality data acquired with other methods.

In these original cases the basic data were total catches. The stock in question split on lengths groups in numbers. In order to prevent influence of very bad or very abundant year classes an average length composition was calculated averaging for several years.

In the actual case with the prawns the material has to be understood as an index of the numbers in each length category and the estimation of N , of course, only corresponds to the catch used in this analysis (See Table 8) .

The crucial point is to find a section of the length frequency curve where numbers in the length groups decrease with increasing length.

If this is not found the method breaks down and the sections have to include at least 4 to 5 length groups to give any chance to make the estimation.

The estimation is done by a computor program by Mr. Andersen in the actual case run on a Hewlett Packard 9830 A model.

The procedure contains the following steps:

The appropriate length groups and start guesses of A, B, and C.

The program then solves 3 equations:

$$X_1 = \log(1 - C\ell_i)$$

$$X_2 = B\ell_i / (1 - C\ell_i) \qquad \text{for each length group}$$

$$Y_1 = N_{\ell_i} - A - B \log(1 - C\ell_i)$$

and the outcome is through iteration used to find better and better estimates of A,B,C. When the estimates are satisfactory the program then calculates L_∞, K, N_0 for a range of Z and calculates age curve of length frequency corresponding to the estimates . An example of the output is given in the following table.

```
510 DATA 8,1.57,0.0285
520 DATA 29.5,9544,30.5,8629,31.5,4912,32.5,2415,33.5,1007,34.5,205
```

RAKJUVEIDA HJA HVITANES 1976
EST [illegible], NO AND K .LENGTH FREQUENCIES ALL AREAS
TO 0

Z-1-5

N(0)	7241971.361
K	0.498
L8	35.303

LENGTH	OBS.NOS.	EST.NOS.	DIFF.	AGE
29.5	9544	10904.124	1360.124	3.625
30.5	8629	7453.927	-1175.073	4.004
31.5	4912	4660.871	-251.129	4.473
32.5	2415	2523.232	108.232	5.086
33.5	1007	1038.749	31.749	5.971
34.5	206	204.098	-1.902	7.596

F 1 M 0.3 TO 0

N(0)	6276375.180
K	0.432
L8	35.303

LENGTH	OBS.NOS.	EST.NOS.	DIFF.	AGE
29.5	9544	10904.124	1360.124	4.182
30.5	8629	7453.927	-1175.073	4.620
31.5	4912	4660.871	-251.129	5.161
32.5	2415	2523.232	108.232	5.808
33.5	1007	1038.749	31.749	6.890
34.5	206	204.098	-1.902	8.764