International Council for the Exploration of the Sea

C.M. 1977/K:38
Shellfish and Benthos Committee

COMPARISONS OF GROWTH, FECUNDITY AND MORTALITY BETWEEN TWO POPULATIONS OF PANDALUS BOREALIS IN NORTHERN NORWAY [x]

by

Thore Thomassen [xx]
Institute of Fisheries
University of Tromsø
N-9001 TROMSØ, Norway

ABSTRACT

A comparison of growth, fecundity and mortality between the populations of *Pandalus borealis*, living in Balsfjord and in Grøtsund, revealed a much higher growth rate in the Grøtsund population. This results in sex change one year earlier in the Grøtsund population, and that the females of this population compose the three and four year old prawns. The regressions between egg number and carapace length are totally different in these two populations. The Balsfjord prawns produce more eggs at any given length than the ones from Grøtsund, and throughout life the egg production per individual is 30% higher in Balsfjord than in Grøtsund according to the mean lengths of the avigerous yearclasses in 1977. Comparison of the mortality in these two populations shows that the instantaneous rate of total mortality, Z, was nearly constant from birth to four year of age in the Balsfjord population. In the Grøtsund population, however, the mortality was about twenty times higher the first year compared to the rest of the life.

[x] This study was supported in part by a grant from the Norwegian Fisheries Council, Proj.no. 401.04.

[xx] Present address: Nordland Regional College, Fisheries Division, P.O.Box 309, N-8001 BODØ, Norway

INTRODUCTION

The fjord project at the University of Tromsø, which is investigating the productivity of a North-Norwegian fjord, takes place in Balsfjord. The population study of Pandalus borealis within this project revealed a low growth rate, high mortality rate, and thereby that the maternal generation consists of four year-old prawns only (THOMASSEN, 1976). This is probably caused by the nearly arctic hydrographic conditions in Balsfjord. The temperature throughout the year varies only between 2 and 3°C.

By comparing the growth, fecundity and mortality rates of this prawn population with one living under normal coastal temperatures, one hopes to understand by which parameter(s) a prawn population reacts in order to compensate for slower growth and a delayed sex change. These reactions could be shown by a lower mortality rate, higher fecundity, or a combination of these two, in order to keep the population in equilibrium. This is under the assumption that food is not a limiting factor for growth.

MATERIALS AND METHODS

The two localities studied are Balsfjord and Grøtsund, both approximately ten nautical miles from Tromsø (Fig. 1). While Balsfjord is a rather closed locality with a sill at the entrance, Grøtsund is in open contact with the coastal current. Both localities have about 190 meters bottom depth.

Sampling was carried out by a small prawn trawl of 30 mm internal mesh size, and 10 mm in the cod end.

The catches were counted, sexed and measured (carapace length) to nearest mm below.

The von Bertalanffy growth parameters L_{∞} , K and t_0 were calculated according to RICKER (1975). When the length frequency distributions of yearclasses overlapped, means and standard deviations were estimated by the probability paper method described by HARDING, 1949.

Fecundity was measured by counting all eggs from about ninety individuals, sampeled randomly from each locality.

Linear regressions to the number of eggs per individual on carapace length, and 95% confidence limits to these regression estimates were calculated by a computer program at the Program Library, Institute of Fisheries, University of Tromsø.

The instantaneous rate of total mortality (Z) was estimated by comparing the relative strengths of the different yearclasses present in the samples. This parameter was also estimated for the prawns' first year of life, before they recruit to the prawn field. This was done by calculating how many one year old prawns would give one hundred first time females following the general formula:

$$N_1 = \frac{N_{1+n}}{\exp - nZ'}$$

where: N_1 = number at one year of age

N_{1+n} = number at first time females (here 100) at age 1+n

Z' = estimated Z from age 1 to age n+1.

The ratio between N_1 and the number of eggs (N_o) produced by 100 females in their complete whole lives, gives the instantaneous total mortality rate in the first year of life according to the formula:

$$\log_e \left(\frac{N_1}{N_o} \right) = Z$$

RESULTS

Growth

From Table 1, which gives the mean carapace length ($\bar{L}$) and the standard deviations (Sd) of the yearclasses present in A: Balsfjord and B: Grøtsund, the parameters L_∞, K. and t_o were found to be:

Equation	Locality	Years fitted	L_∞	K	t_o
I	Balsfjord	1 - 4	28.4	0.40	0
II	Grøtsund	1 - 2.5	56	0.16	-0.6
III	"	2.5 - 4	28	0.65	0.6

Fig. 2, A and B, gives the theoretical growth curves for Balsfjord and Grøtsund. While the Balsfjord data seem to easily fit a von Bertalanffy growth curve according to equation I, the solution for the Grøtsund data seem to be two curves, one describing the growth in the pre-ovigerous phase, and one for the female phase. The reason for this is the considerable difference in growth rate, which can be seen from the estimated values of K in II and III. The stippled line in Fig. 2B indicates the junction between these two growth curves.

A comparison of the growth curves between Balsfjord and Grøtsund prawn populations shows that in the first year of life the Grøtsund population gains about 30% in length. Consequently the Grøtsund prawn population functions as females at the age of three years, and that the matural stock consists of both three and four year-old prawns; while in Balsfjord this part of the population is composed of four year-old prawns only.

Fecundity

Fig. 3 shows the regression between egg numbers and carapace lengths in A: the Balsfjord population and B: that of Grøtsund. The 95% confidence limits and the slope of the regression lines reveal that these regressions are totally different.

The total number of eggs produced per female throughout life is about 30% higher in the Balsfjord population compared to the Grøtsund one. This magnitude is arrived at by reading off the number of eggs the mean length of maternal yearclass will produce. For the Balsfjord population in 1977, for which carapace length was estimated to be 22.7 mm, this means 1300 eggs. Because the Grøtsund maternal stock consists of two yearclasses,one must add the number of eggs produced by the three year-old prawns to the number of eggs produced by the percentage surviving to four years of age. In 1977 these figures should be: mean carapace lengths for the three and the four year-olds, 21.5 mm and 24.7 mm respectively. Then the corresponding egg numbers should be 770 plus 17% of 1300 eggs, which would give nearly 1000 eggs.

Mortality.

The instantaneous rates of total mortality, $\bar{Z}$, from one year of age and onwards, given in tables 5 and 6, are considerably higher in Balsfjord than in Grøtsund. The estimated values for the first year of age, however, demonstrate the opposite (Fig. 4).

DISCUSSION

The difference in growth rate of the prawn populations investigated, results in sex change one year earlier in Grøtsund compared to Balsfjord. Therefore the maternal generation in Grøtsund is composed of two yearclasses, while only one in Balsfjord. However, the fecundity is higher in the Balsfjord population. While the mortality rate is nearly constant throughout the whole life in the Balsfjord population, the one of Grøtsund shows a very high mortality the first year of life, assuming a steady state in the population.

The mortality the first year is probably best estimated in Balsfjord, because of the topografic conditions of this locality. In Grøtsund

the current system will probably have a much greater effect on the pelagic prawn larvae and tend to drift them away.
If the estimated mortality of the first year in Balsfjord is the most correct one, and that value goes for Grøtsund too, it means that the surpluss of the Grøtsund production drifts away.

When the egg samples were taken it was observed that number of dead eggs were higher in Grøtsund than in Balsfjord. While dead eggs were observed at about one per thousand in the Balsfjord material, this figure was probably five to ten times greater in the samples from Grøtsund.
This can indicate a higher egg and larval mortality in the Grøtsund population compared to the one of Balsfjord, as estimated.

REFERENCES

HARDING, J.P. 1949. The use of probability paper for graphical analysis of polymodal frequency distributions. J.Mar. Biol. Ass. U.K. 28 (1): 141-153.

RICKER, W.E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Bull.Fish.Res.Bd.Can. 191: 1-382.

THOMASSEN, T. 1976. Growth, recruitment and mortality of *Pandalus borealis* (Krøyer), in Balsfjord Northern Norway. Coun. Meet.int.Coun.Explor.Sea, 1976 (K 31): 1-10, 6 Tables (Mimeo).

Table 1 Pandalus borealis. Mean lengths (mm carapace), L, and standard deviations (Sd) of the yearclasses present in
A: Balsfjord from September 1976 to June 1977, and
B: Grøtsund from February 1976 to June 1977

	Date of sampling	Year class 1976 L	1976 Sd	1975 L	1975 Sd	1974 L	1974 Sd	1973 L	1973 Sd	1972 L	1972 Sd
A:	1976 Sep. 17			12.9	0.8	17.9	1.0	21.4	1.6		
	Nov. 24	7.0	0	14.7	0.8	18.8	0.9	21.9	1.7		
	1977 Feb. 16	8.0	0	15.3	0.9	19.1	0.8	22.7	1.2		
	Jun. 1	10.4	0.8	16.9	1.1	20.9	0.9	24.0	0		
B:	1976 Feb. 6			10.7	0.6	17.4	1.0	21.1	1.1*	25.5	1.5*
	Apr. 22			12.7	1.1	19.2	1.2				
	Aug. 13			15.3	1.0	21.2	0.9				
	1977 Feb. 14	9.8	0.7	16.5	0.9	21.5	1.3*	24.7	1.4*		
	May. 31	12.4	0.9	19.0	1.2						

*: Estimated by probability-paper

Table 2 Pandalus borealis. Mean number of eggs per length group (0.5 mm carapace) and standard deviations from Balsfjord in February 1977

1: Mean of length group	18.25	18.75	19.25	19.75	20.25	20.75	21.25	21.75	22.25
2: Mean no. of eggs	707			788	1066	919	1140	994	1335
3: Standard deviation				245		437	304	160	337
4: No. of indiv. examined	1			3	1	2	4	6	8

1:	22.75	23.25	23.75	24.25	24.75	25.25	25.75
2:	1244	1360	1350	1604	1489	1618	1640
3:	271	346	267	190	105		30
4:	21	21	9	7	6	1	2

Table 3 <u>Pandalus borealis</u>. Mean number of eggs per length group (0.5 mm carapace) and standard deviations from Grøtsund in February 1977

1: Mean of length group	18.25	18.75	19.25	19.75	20.25	20.75	21.25	21.75	22.25	22.75
2: Mean no. of eggs	406		460	723	322	965	655	825	867	958
3: Standard deviation			30				233	167	225	212
4: No. of indiv. examined	1		3	1	1	1	3	11	20	10
1:	23.25	23.75	24.25	24.75	25.25	25.75	26.25	26.75	27.25	27.75
2:	927	1327	1261	1236	1481	1895	916	1276	3083	422
3:	395	144	654	511	351	371		625		
4:	9	3	8	3	6	4	1	2	1	1

Table 4 Pandalus borealis. Yearclass frequency distributions (per cent) in A: Balsfjord from September 1976 to June 1977, and B: Grøtsund from February 1976 to June 1977

Locality	Year	Month	1976	1975	1974	1973	1972
A	1976	Sep.	+	85	13	2	
		Nov.	1	91	7	1	
	1977	Feb.	4	78	15	3	
		June	69	29	2	+	
B	1976	Feb.		51	42	6	1
		Apr.		79	15	6	+
		Aug.		85	10	5	
	1977	Feb.	36	44	8	2	
		June	51	37	11	1	

Table 5 <u>Pandalus borealis</u>. Estimates of instantaneous rate of total mortality (Z) in Balsfjord by comparing the strength of the yearclasses given in Table 4 A

		Z between successive yearclasses				
Year	Month	75/76	74/75	73/74	$\bar{Z}$	Sd
1976	Sep.		1.9	1.9	1.9	
	Nov.		2.6	1.9	2.25	
1977	Feb.		1.6	1.6	1.6	
	June	0.9	2.7		1.8	
					1.88	0.27

Table 6 Pandalus borealis. Estimates of instantaneous rate of total mortality (Z) in Grøtsund, by comparing the strength of the yearclasses given in Table 4 B

		Z between successive yearclasses					
Year	Month	75/76	74/75	73/74	72/73	$\bar{Z}$	Sd
1976	Feb		0.2	1.9	1.8	1.3	
	Apr.		1.7	0.9		1.3	
	Aug.		2.1	0.7		1.4	
1977	Feb.		1.7	1.4		1.55	
	June	0.3	1.2	2.4		1.3	
						1.37	0.10

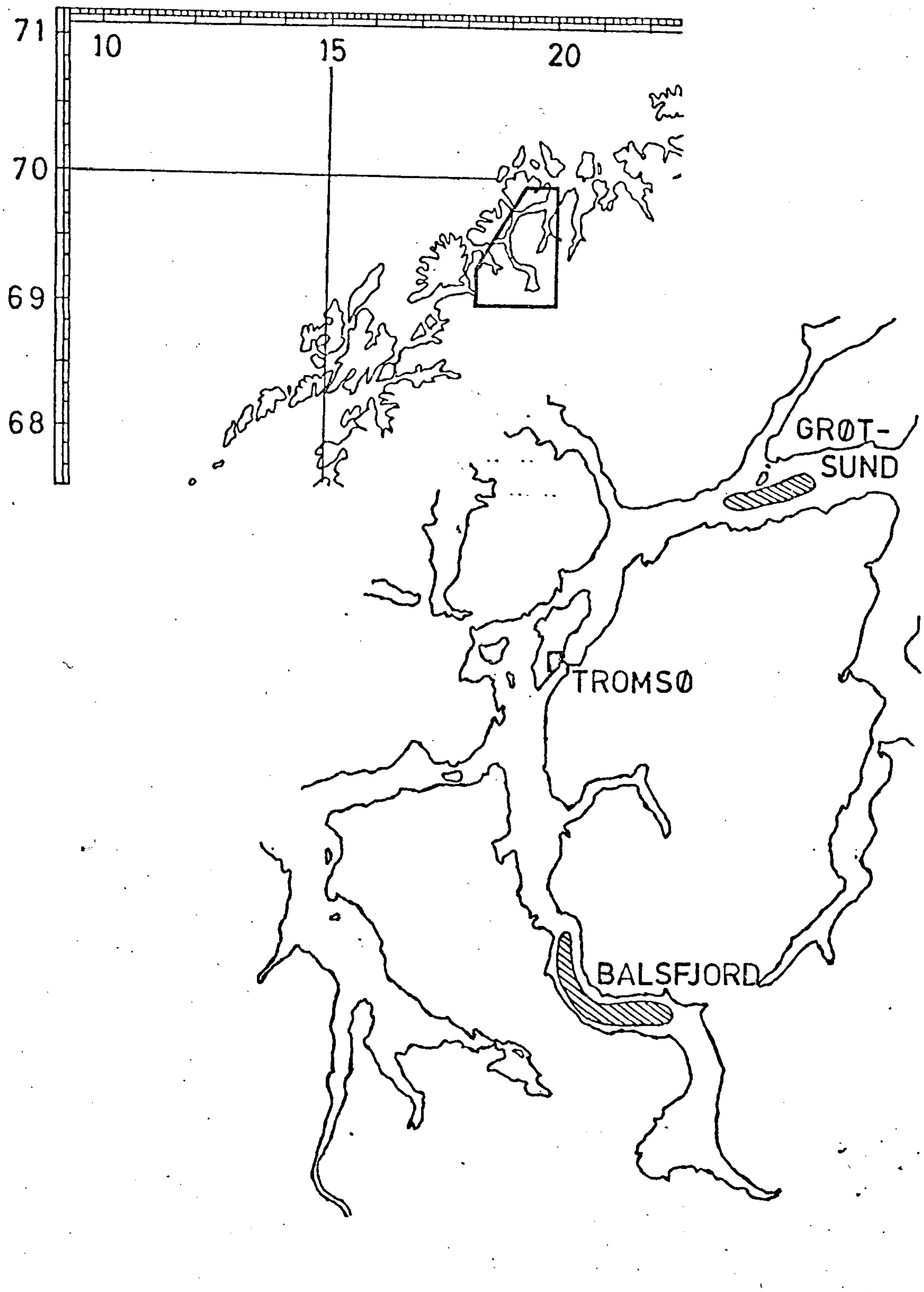

Fig. 1. Location map.

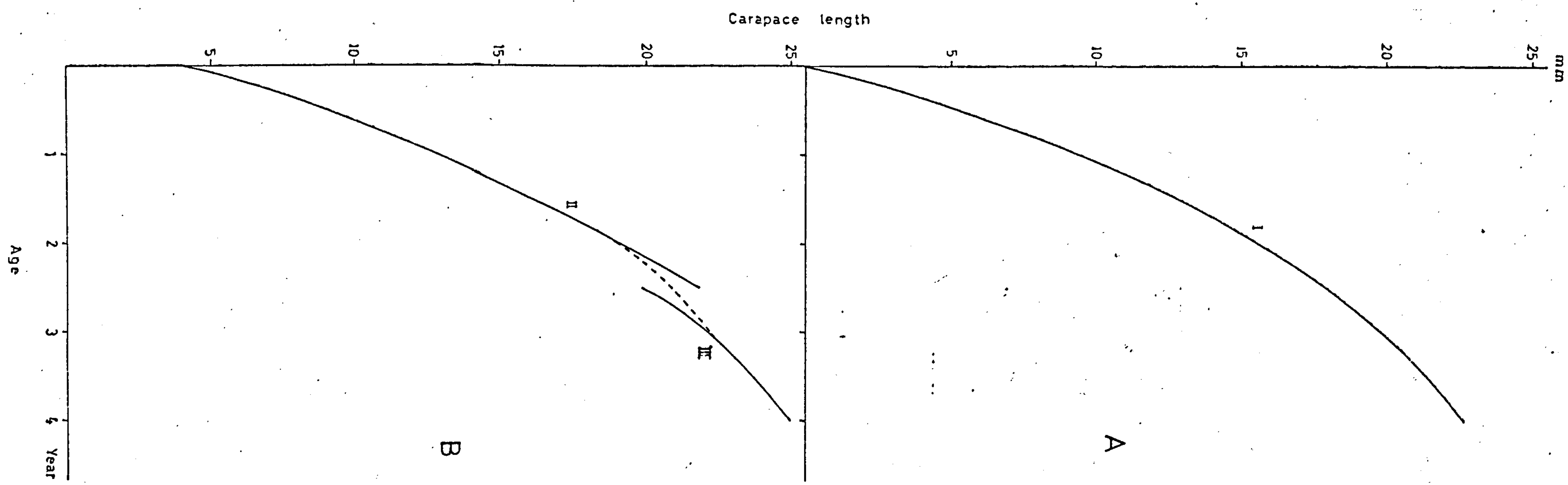

Fig. 2. Theoretical growth curves for <u>Pandalus borealis</u> from A:Balsfjord given by I: $l_t = 28{,}4\ [1 - \exp - 0.40t]$, and B:Grøtsund given by II: $l_t = 56\ [1 - \exp - 0{,}16(t+0.6)]$ and III : $l_t = 28\ [1 - \exp - 0.65(t-0.6)]$. Stippled line indicate junction between lines II and III.

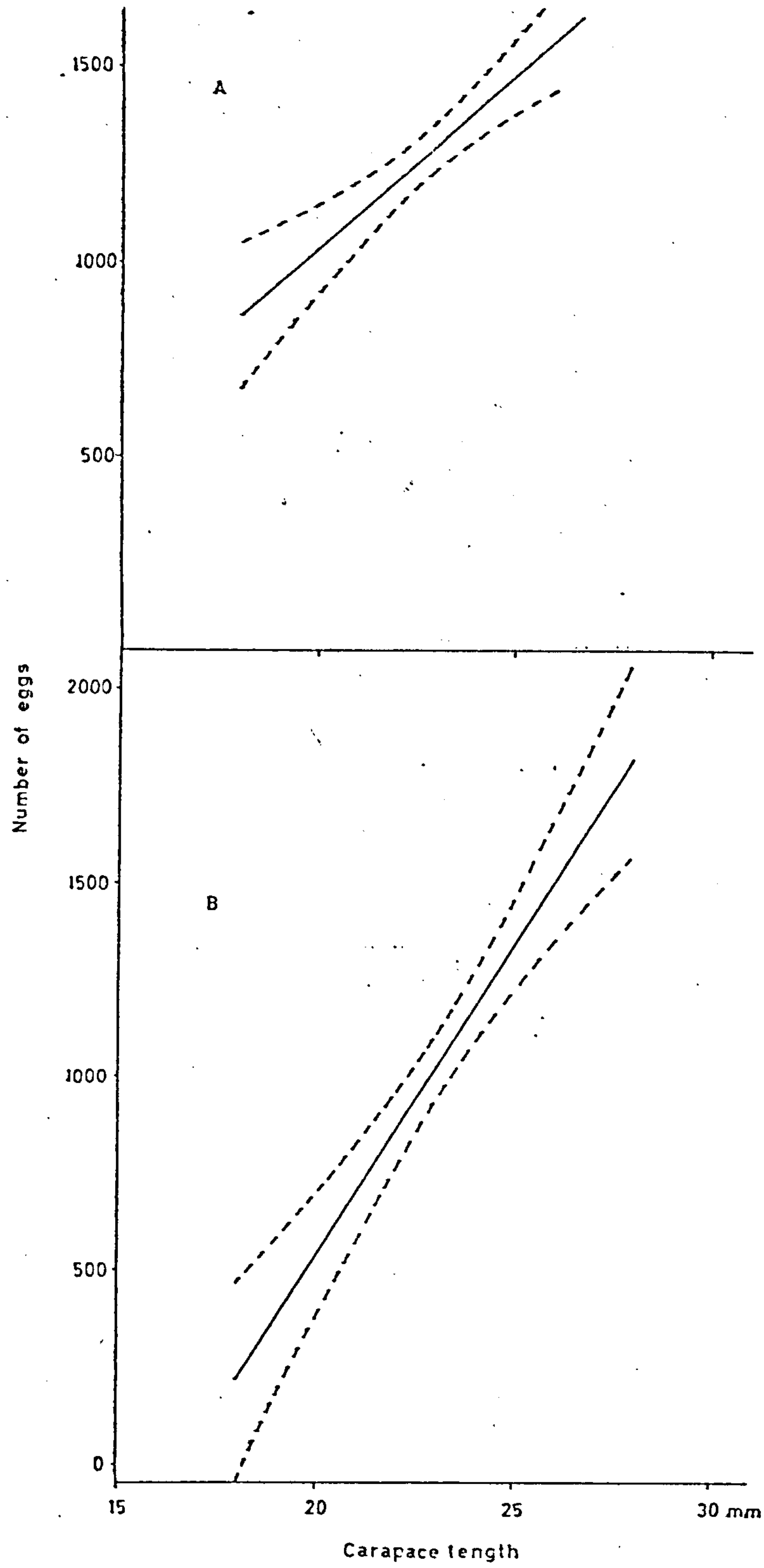

Fig. 3. Linear regression lines and 95% confidence limits between carapace lengths and egg numbers in <u>Pandaleus borealis</u> from A:Balsfjord and B:Grøtsund.

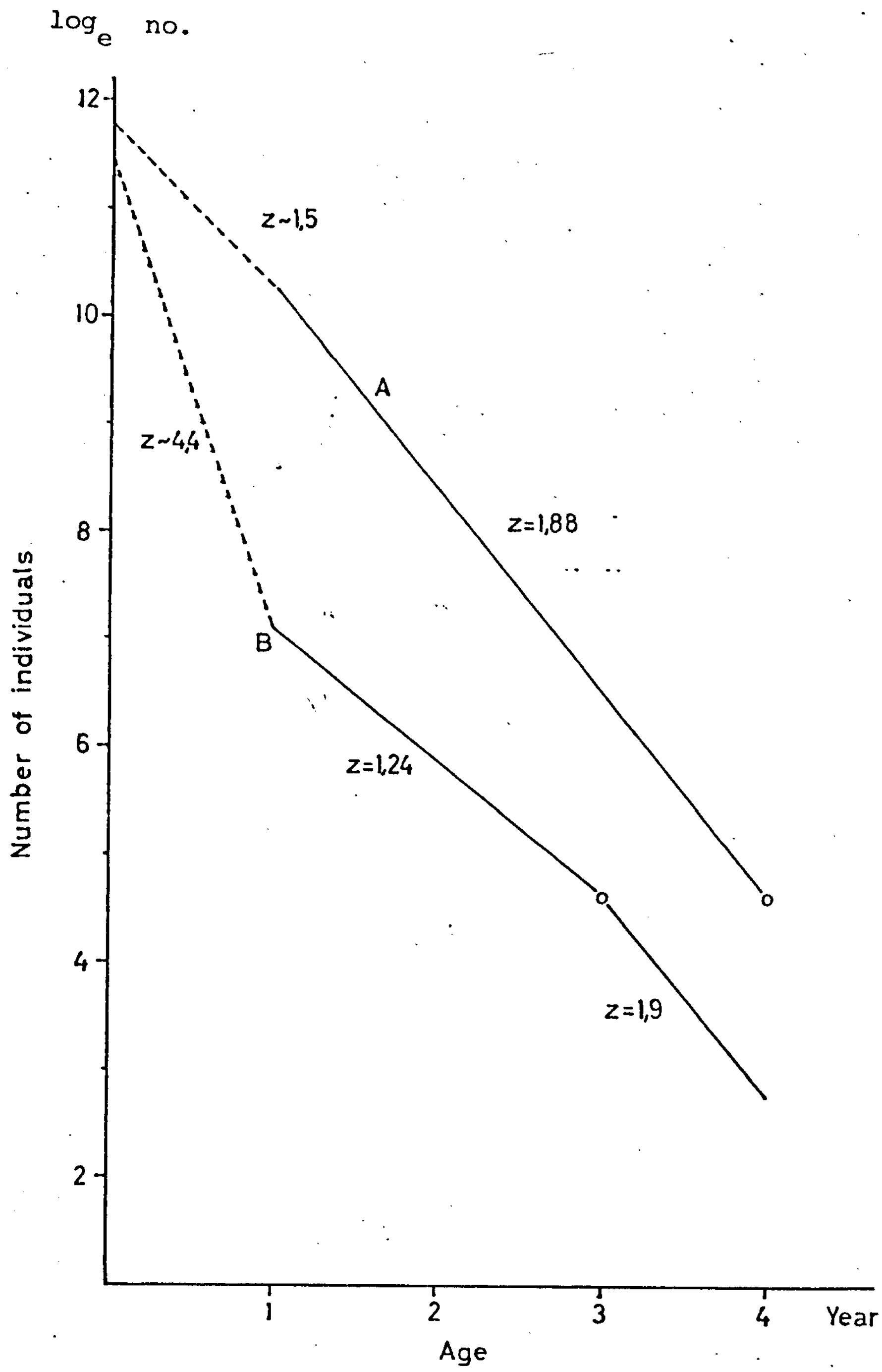

Fig. 4. Back-calculations showing the relationships of number *Pandalus borealis* with time i starting at ° with 100 first time spawning females, at A:Balsfjord and B:Grøtsund.
Solid line: Z from table 5.
Stippled line: estimated Z in the first year of life.