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DO LENGTH-AT-AGE VARY WITH DEPTH?

The Northern Shrimp (*Pandalus borealis*) in Davis Strait (NAFO division 1B).

by

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INTRODUCTION

The northern shrimp populations offshore Westgreenland represent a valuable economical resource. They have therefore been subject to numerous investigations in order to provide the best advice on the optimum exploitation. As most models used in population analysis and assessment are age structured, knowledge on the age structure in the shrimp populations is required. Direct age determination of shrimp is however impossible because all hard structures , which would normally be used , are shed with each molt. Age determination has therefore often been attempted by separation of size groups from length frequency distributions.

Frechette and Dupouy (1979) have indicated a slight increase in average size with depth for a given shrimp age group in the Davis Strait. Simard & Savard (1990) have, however, reported disappointing results from attempts to reduce the variability by pooling length-frequency distributions on a regional basis or on depth intervals. The aim of the present paper is to further investigate whether the average size of a single age group varies significantly between shallow and deep water in the Davis Strait.

MATERIALS AND METHODS

Samples of northern shrimp from Davis Strait collected during research surveys conducted by the Greenland Fisheries Research Institute in July and August 1988, 1989 and 1990 were used. A Skjervoy 3300 trawl with 44 mm mesh-size in the codend was used and trawling time was held close to 60 minutes (Carlsson & Kanneworff, 1991). The survey is considered to give a minimum estimate of the shrimp population greater than 15 mm CL (Degel et al., 1991). Random samples were taken from the trawl catches. The shrimps were separated according to the stage of their sexual development. The oblique carapace length (CL) was measured to the nearest 0.1 mm, and then combined in 0.5 mm interval for data analysis.

Only samples from NAFO division 1B were used in the analysis, as this area generally has had the highest effort in the offshore shrimp fishery at Westgreenland, and therefore traditionally has been chosen as a frame of reference (ICNAF 1976 & 1977). Any potential geographic differences in mean lengths were also attempted minimized by only working with samples from NAFO division 1B. Only juveniles and males were included. As earlier works have shown that the interpretation of a length-frequency distribution without considering the sexual stages is difficult (Frechette & Parsons, 1983). Samples of less than 10 individuals were discarded, which left 140 samples from 1988, 122 from 1989 and 108 from 1990. These samples were weighted by the cpue for juveniles-males calculated as: cpue juveniles-males = ((juvenile-male sampleweight / total sampleweight) * total cpue). The juvenile-male sampleweight was calculated using the length-weight relationship for juvenile-males of P.borealis: $W = .00087 * L^{2.869}$ (D. Carlsson pers. comm.) to convert the lengths of the juveniles and males to weights. The weighted length-frequency distributions were then pooled in 50 meters intervals, 50-100 meter, 101-150 meter etc, giving a total of nine length-frequency distributions from 1988, eight from 1989 and eight from 1990, as there were no samples from depthstratum 551-600 meter in 1989 and 1990.

The weighted length-frequency distributions were separated into different size groups by using the Modal class Progression Analysis (MPA) program from the ELEFAN-system (Gayanilo et al., 1988). The program MPA separates the length-frequency distributions into normal components using the Bhattacharya method (P. Sparre et al., 1989). The origin - year and the depth stratum - of the length-frequency distributions was concealed, until an age was assigned to each size group, based on data from Savard et al. (1989). Finally the mean lengths by age groups were plotted by depth stratum, fig. 2.

RESULTS AND DISCUSSION.

A length-frequency distributions can be separated into size-groups using a number of different methods (e.g. Bhattacharya 1967, Shepherd 1987, Pauly & David 1981). The assumption underlying all of them is that age groups can be differentiated using the length-frequency information. None of these methods represent entirely objective ways of separating length-frequency distributions.

Two methods were considered: A Least SQuare (LSQ) fit based on the Non LINear regression analysis (NLIN) from the SAS-program (SAS Institute Inc., 1988), and the Modal class Progression Analysis (MPA) from the ELEFAN-system. In the LSQ case it was assumed that the length frequency distributions could be separated into normally distributed components, assuming 2 or 3 components. The LSQ technique was not successful, as at best 2/3 of the distributions could be fitted satisfactory to the models. In the MPA the number of components were only restricted downward, insisting that the length-frequency distributions should be separated into at least two components. Further to assure consistency in the analysis it was decided that the estimated mean length of each size-group should be separated by approximately 2 mm equivalent to the mean annually growth of P. borealis (Savard et al., 1989). Being aware of MPA's subjectivity the data sets were tested for a large number of alternative solutions before the best fit was selected. The model gave satisfactory fits in 23 out of 25 cases.

Fig. 1. shows the mean length of all samples per 50 meters depth interval plotted against the depth for all three years 1988, 1989 and 1990. Increased mean length at greater depth is seen for all three years.

The data from all three years were then combined. Fig. 2. shows the relationship between mean length and depth for three successive age groups. Only the agegroups determined as 4, 5 and 6 years are presented. These three age groups were assumed not to be influenced by selectivity. Linear regression analysis for the three age groups showed highly significant positive slopes ($p<0.002$). The estimated slopes for all three agegroups are close to be identical (Table 1), each agegroup is separated by approximately 2 mm. A single age group shows an approximate 1.5 mm difference in meanlength between 200 meters and 500 meters depth. Assuming that P. borealis grows approximately 2 mm per year (Savard et al., 1989) this would mean that the age could be misinterpreted by +/- 1 year, if the data from 200-500 m are pooled without considering the sampling depths.

CONCLUSION

A significant length at age variation was found. It is therefore concluded that it would be advisable to apply depth stratification whenever age-at-length keys for shrimps are to be constructed and used, as such a relationship could affect the assessment of the P. borealis when based on the VPA. Further, applying age-at-length keys to other strata than to those they represent could imply misallocation to catch-at-age by as much as one year.

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Table 1: Intercepts, slopes and standard errors (std. error) of the linear regression analysis for the three agegroups presented. The carapace length (intercept) is in mm.

Age	4	5	6
Intercept	16.63	19.10	21.20
Std error	0.46	0.43	0.51
Slope	0.0057	0.0058	0.0055
Std error	0.0012	0.0011	0.0013

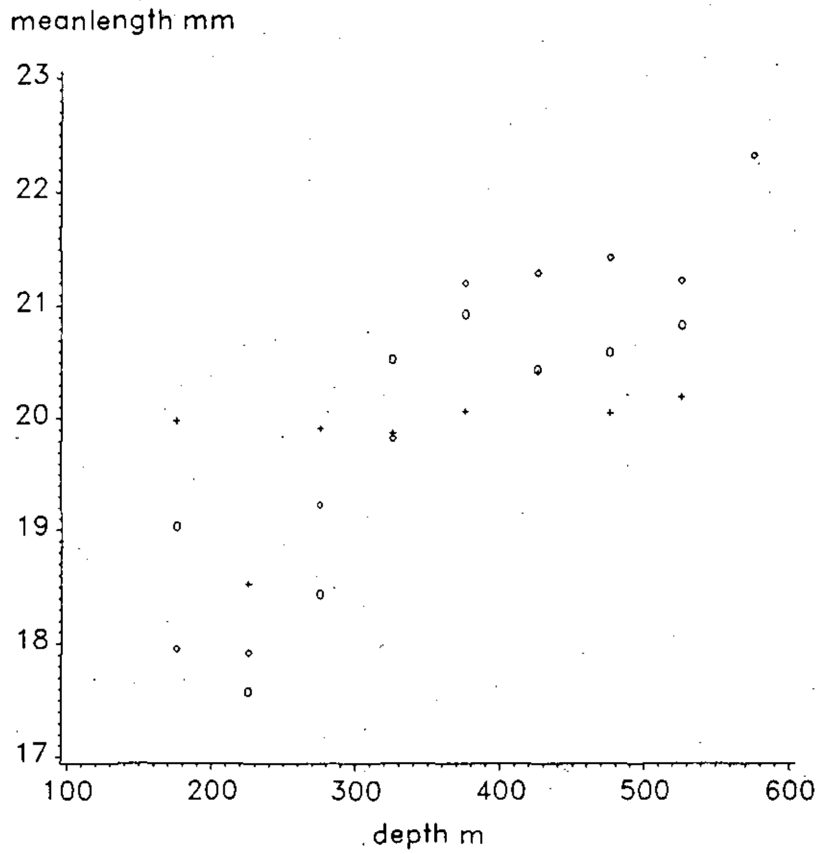

Figure 1: The meanlength of all samples (millimeter) per 50 meters depth intervals for 1988 (diamond), 1989 (circle) anf 1990 (plus)

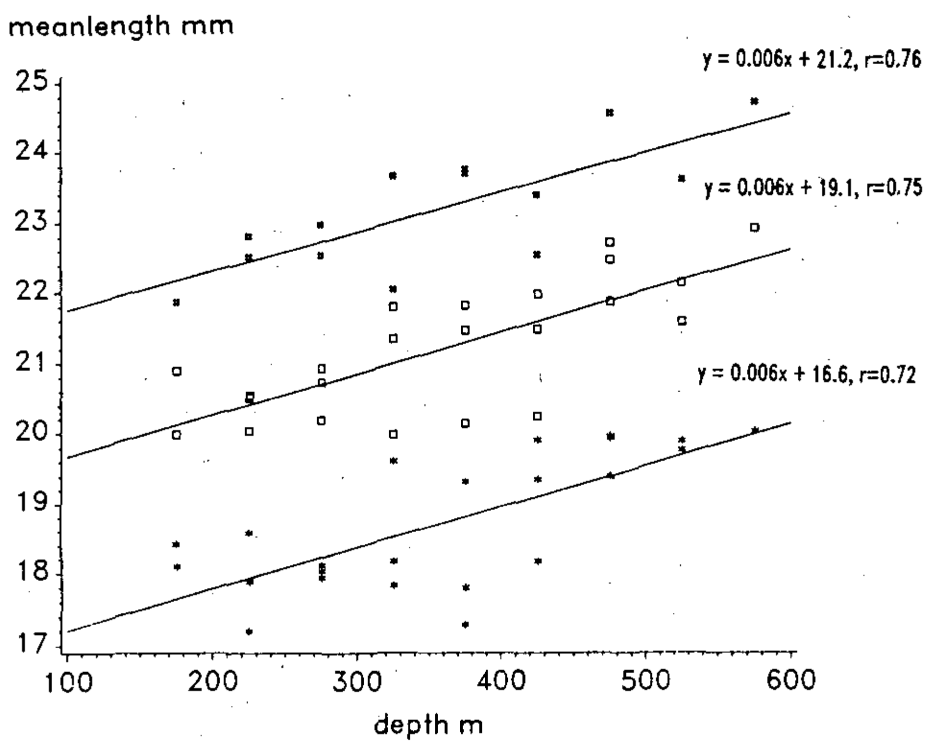

Figure 2: The meanlength (milimeter) by agegroup by depth (meter).
Star = agegroup 4, square = agegroup 5, hash = agegroup 6.