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Growth curves for Newfoundland lobsters from data on molt increment and proportion molting

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INTRODUCTION

A prerequisite to yield pre recruit assessment in a fish stock is knowledge of growth rate. In decapod crustacea, where the age of individual animals cannot be determined, there are a number of approaches to the estimation of growth rates. One of these is to combine molt increment and proportion motling data to produce a growth curve for the size range for which these data are available. This approach is being used to study growth rates in a number of Newfoundland lobster populations to provide a basis for yield per recruit assessments. This paper describes the methods used and provides the results obtained from one set of data.

METHODS AND MATERIALS

Data

In northern Placentia Bay, Newfoundland, 477 lobsters were tagged, June 15 - August 26, 1970 and another 387 were tagged June 30 - July 9, 1975. The "sphyrion" tag (Scarratt and Elson, 1965; Ennis, 1972) was used and lobsters ranged in size from 35 to 125 mm carapace length at tagging. Lobsters were tagged as soon as they were removed from the traps and released immediately afterwards in the area of capture so that air exposure was minimal. Recaptures up to June 1976 are included here. To determine the proportion of lobsters molting, 935 lobsters caught in traps in the fall of 1975 after molting had virtually ceased for the year were carefully examined for coloration, shell hardness and epifauna (Ennis, 1977) to determine whether each had molted during the preceding molting period. Samples were also obtained in the same area over the same period by scuba diving to determine if there was any bias with respect to shell condition in the trap-caught samples.

Data analysis

Growth per molt. For tagged lobsters that were known to have molted only once before recapture, growth per molt was analyzed by means of arithmetic least squares regression of premolt carapace length against postmolt carapace length (the so-called Hiatt growth equation). Comparisons of slopes and intercepts for two different years (1970 and 1975 taggings) were made by covariance analysis. Mauchline (1976) argues that the points on a Hiatt growth diagram are fitted better by a hyperbola than a straight line. The premolt-postmolt carapace lengths given in this paper did not fit a hyperbola, possibly because the premolt size ranges considered (50-94 mm for males and 56-106 mm for females) were too restrictive.

Proportion molting. The premolt carapace length of those lobsters in the fall, trap-caught sample that were classified as new-shelled (i.e. molted during the preceding molting period) was calculated to the nearest mm using the premolt-postmolt regression equation. These data plus numbers at the same carapace length that did not molt gave estimates of the proportion molting at each mm size. A graph of proportion molting against carapace length suggested a sigmoid relationship so the data were subjected to probit analysis.

Comparison of diver- and trap-caught samples.

An analysis of variance was used to compare the proportions of new-shelled lobsters in diver-caught and trap-caught samples.

RESULTS

Growth per molt

Arithmetic least squares regression of postmolt carapace length on premolt carapace length for males in 1970 and in 1975 and for females in the same years gave correlation coefficients >.97. Analysis of covariance showed no significant difference between slopes ($P = .61$) or intercepts ($P = .81$) between years for females; for males slopes were different at the 5% level ($P = .04$). This difference was considered unimportant, however, and data for 1970 and 1975 were combined. The resulting equations were $Y = 1.1837X - 2.3484$ for males and $Y = 1.0076X + 8.8779$ for females. These lines (Fig. 1) were significantly different ($P < .001$) in slope.

Proportion molting

The number that molted and total number examined at each carapace length (> 60 mm) for the fall 1975 sampling were subjected to probit analysis. The resulting equations were $Y = 19.348 - 0.164X$ for males and $Y = 13.693 - .103X$ for females. The probit (Y) was transformed to proportion molting (Fig. 2) by reference to the appropriate table (Finney, 1962, p. 264).

Chi-square for goodness of fit was insignificant for males ($P > .9$) but was highly significant ($P < .001$) for females. However, as explained by Finney (1962), a significant X^2 does not necessarily mean an unacceptable fit since data giving proportions near 1 or 0 (of which there were more for the females) can contribute disproportionately to the total X^2 value.

Comparsion of diver- and trap-caught samples

The proportion of new-shelled lobsters in diver-caught and trap-caught samples were compared by analysis of variance for a variety of size ranges and for each sex separately (Table 1). For the size range 61-105 mm, which included all the data, there was a greater proportion of new-shelled lobsters in the male diver-caught sample than in the male trap-caught sample but for females there was no difference between diver- and trap-caught samples. There was no difference between diver- and trap-caught samples for either males or females over the 76-90 mm size range which included most of the data or over the size ranges containing only commercial size lobsters (i.e. 81-90 mm, 81-105 mm). Differences existed in size ranges which included smaller lobsters (Table 1). In all these cases there was a greater proportion of new-shelled lobsters in the diver-caught samples.

Annual growth determined from growth per molt and proportion molting

Analysis of size frequency distributions (not reported here) for samples of lobsters collected by diving and ranging in carapace length from 6-80 mm indicated that a mean carapace length of 61 mm would be attained one year earlier in males than in females. Taking 61 mm and separating them by 1 year on the graph (Fig. 3), annual growth beyond 61 mm was estimated by multiplying the difference between a premolt length and its calculated postmolt length by the calculated proportion molting for that premolt length. The results (Fig. 3) indicate that males attain appreciably larger mean sizes at age but the difference becomes smaller beyond age 10.

DISCUSSION

Year to year variations in growth rate of lobsters in a particular area may be determined by comparing the combination of growth pre molt and proportion molting data. Where is has been possible to compare growth per molt data for two different years in the same area there was no significant difference, so a single tagging project in a particular area should provide the necessary growth per molt data. Annual variation in growth rate therefore would be caused by variation in proportion molting. This could be monitored by annual shell condition sampling following the molting period. Samples caught by trap during the fall appear to be acceptable for this purpose. If it is assumed that divers sample new- and old-shelled lobsters randomly, then traps appear to under sample new-shelled lobsters at the smaller sizes

(61-70 mm). Sampling error by divers may be the case of higher proportions of new-shelled lobsters at smaller sizes in diver-caught samples. Recognition of old-shelled lobsters at smaller sizes requires more careful examination than for larger lobsters. It seems likely that the extra care required to determine shell condition of smaller lobsters underwater because of reduced visibility was not taken and many old-shelled lobsters were recorded as new-shelled. In Newfoundland waters where the molting period is relatively short and well defined (late July to early September) and where lobsters, at least as small as 60 mm carapace length, molt no more than once annually, the determination of proportions molting by shell condition sampling is relatively straightforward and reliable. It is suggested that estimates of growth rates from data on molt increment and proportions molting, as obtained by the methods described in this paper, would be sufficiently accurate to be used in yield per recruit assessments.

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Table 1. Proportions of new-shelled lobsters in diver-caught and trap-caught samples compared by analysis of variance.

	Carapace length (mm) size ranges							
Sample	61-105	76-90	61-80	66-80	71-80	76-80	81-90	81-105
Male diver	.9421	.9444	.9571	.9643	.9773	.9688	.9250	.9216
Male trap	.8639*	.8755	.7951**	.7934**	.7934*	.7619*	.8951	.8720
Female diver	.8079	.7527	.8170	.7886	.7475	.7193	.7955	.7800
Female trap	.7838	.7646	.6420**	.6352**	.6306*	.6131	.8450	.8558

* $0.05 \geq P > 0.01$
** $P \leq 0.01$

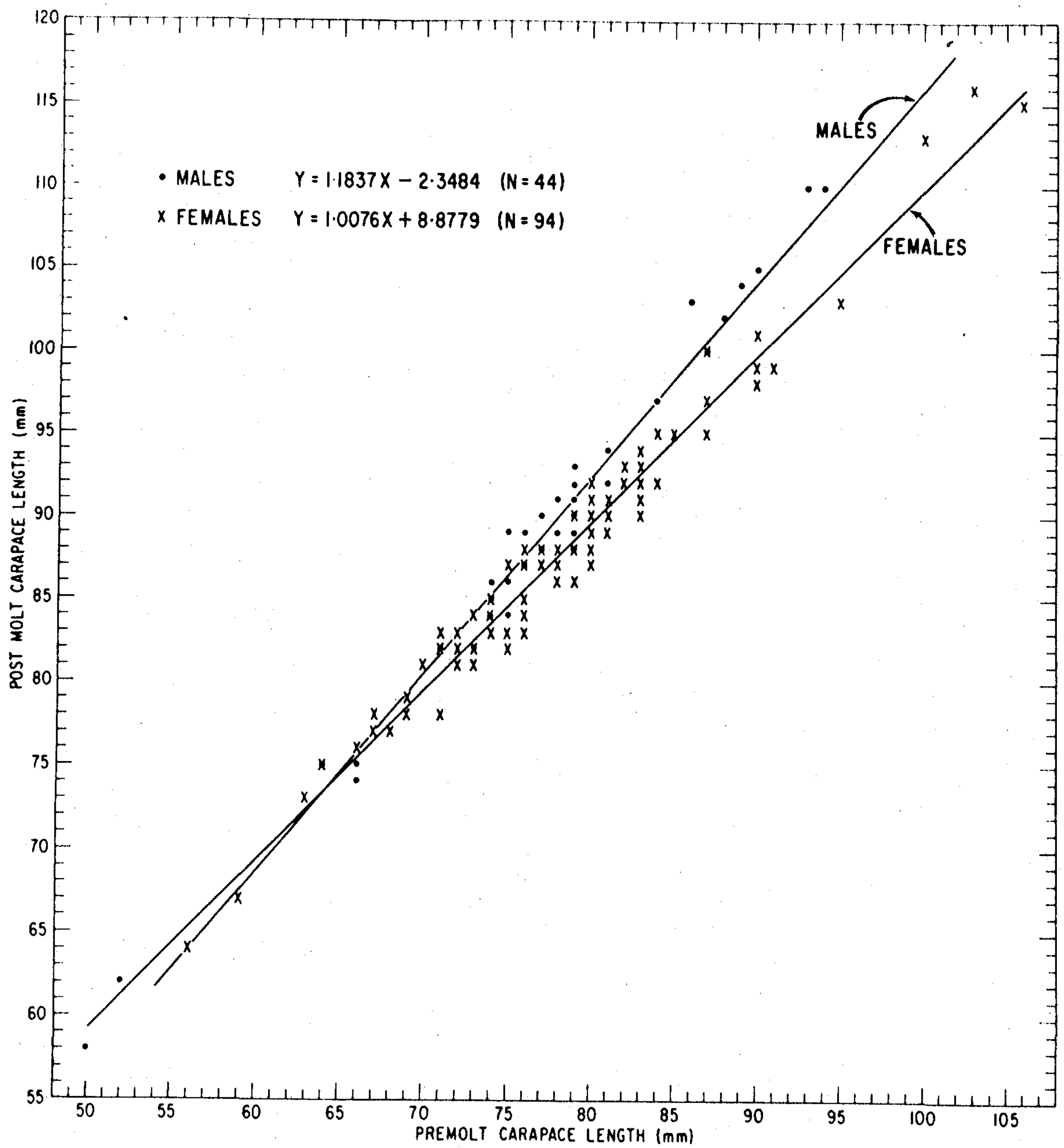

Fig. 1. Premolt-postmolt regression lines for sphyrion tagged lobsters at Arnold's Cove, Newfoundland.

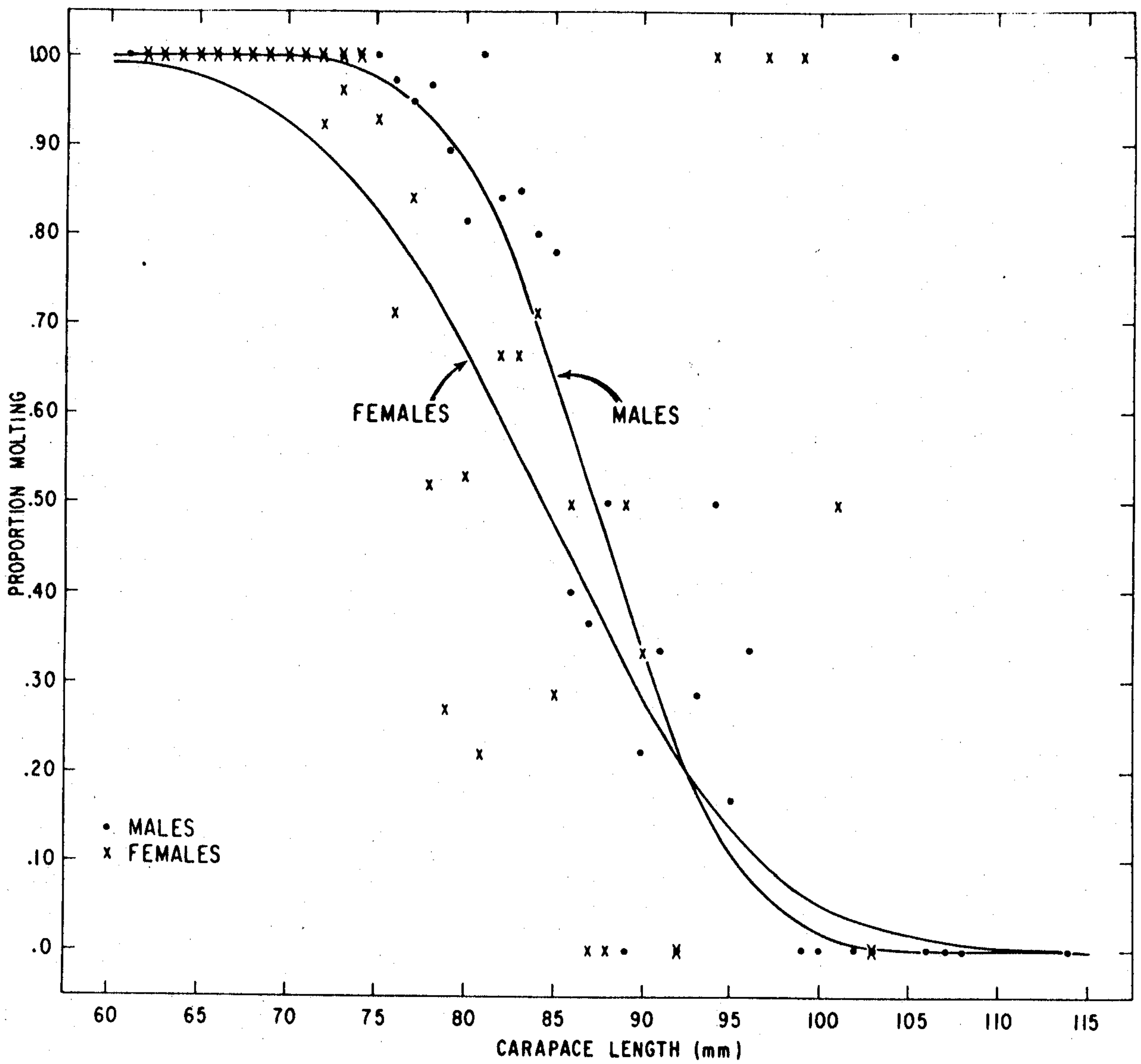

Fig. 2. Proportions molting based on shell condition sampling following the molting period. The data were subjected to probit analysis and probits were transformed to proportions by reference to the appropriate table.

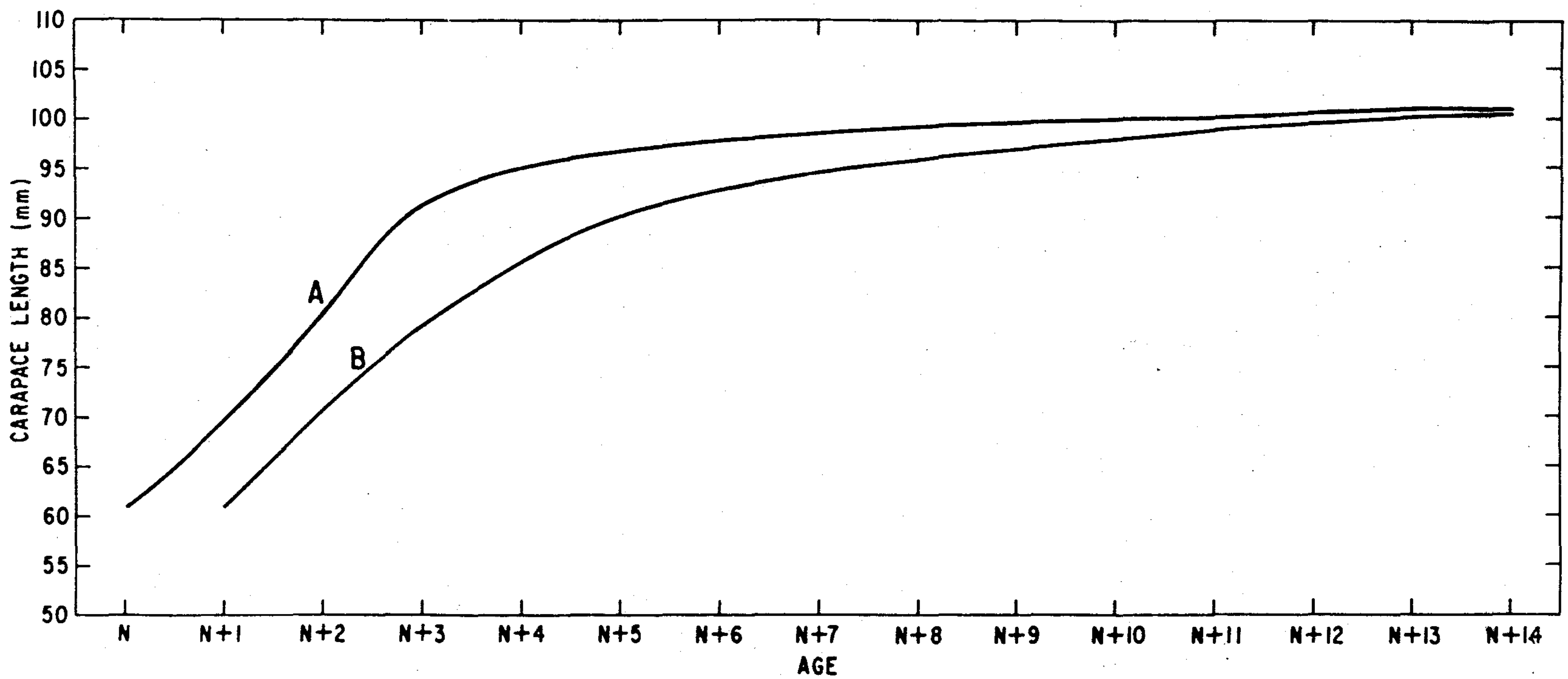

Fig. 3. Growth curves based on the combination of growth per molt and proportion molting data (A - males, B - females).