Changes in Chela Heights and Carapace Lengths in Male and Female Golden King Crabs *Lithodes aequispinus* after Molting in the Laboratory

A. J. Paul and J. M. Paul

Reprinted from the
Alaska Fishery Research Bulletin
Vol. 6 No. 2, Winter 1999

The Alaska Fishery Research Bulletin can found on the World Wide Web
at URL: http://www.state.ak.us/adfg/geninfo/pubs/afrb/afrbhome.htm .

Alaska Fishery Research Bulletin 6(2):70–77. 2000.

Changes in Chela Heights and Carapace Lengths in Male and Female Golden King Crabs *Lithodes aequispinus* after Molting in the Laboratory

A. J. Paul and J. M. Paul

ABSTRACT: Golden king crabs *Lithodes aequispinus* from Prince William Sound, Alaska were measured for changes in carapace length (CL) and chela height (CH) after they molted in the laboratory. The predicted increase in CL for males (95 to 155 mm) was expressed by the equation: New CL (mm) = Initial CL (0.91) + 21.90 (r^2 = 0.97). The postmolt CH (Y) was linearly related to premolt values (X) by the equation: $Y = 0.90X + 6.79$ (r^2 = 0.85). Increases in CL and CH for males averaged 10% (SD = 3) and 12% (SD = 10), respectively. After molting CH/CL increased in 42%, decreased in 41%, and stayed the same in the remaining 17% of the 58 males. The predicted increase in CL for females (104 to 157 mm) was expressed by the equation: New CL (mm) = Initial CL (0.97) + 10.21 (r^2 = 0.91). Increases in CL and CH averaged 5% (SD = 2) and 16% (SD = 18), respectively, for ovigerous females. Like males claw growth in millimeters in females was weakly dependent on initial CH. After molting CH/CL ratios increased in 48%, decreased in 14%, and stayed the same in 38% of 104 females.

INTRODUCTION

The golden king crab *Lithodes aequispinus* is an important commercial species in Alaska. There is considerable interest in understanding their growth processes so the species can be managed for a high economic return while protecting stocks. One goal of Alaska's crab management program is to allow males a chance to breed before they reach harvestable size, which in Prince William Sound is 178 mm carapace length (CL; Donaldson and Donaldson 1992). A change in the ratio of chela height (CH) to CL has been used to determine male maturity status (Jewett et al. 1985). However, the method was theoretical because the relative growth of CL and CH in golden king crabs was unknown when that report was prepared. In Alaska female golden king crabs are protected from harvest. Previously, no published information existed on growth or morphometric changes in females. This information is useful in qualitatively determining the number of egg clutches a female might produce. There was also no published information on growth per molt for male crabs in Prince William Sound. The objective of our study was to provide data on carapace and chela growth and allometry of prerecruit males and adult females.

METHODS

Golden king crabs were captured with pots on the west side of Prince William Sound, 11–14 November 1996, 1 May 1997, and 20 October 1998. Crabs were captured at depths of 108 to 152 m. They were held in 800–1,000-L seawater tanks at the Seward Marine Center Laboratory until the end of September 1999. During the study the water temperatures ranged from about 3.5° to 10°C (Figure 1). Data on the holding temperature are provided because temperature may affect growth rate (Fisher 1999). Salinity of the incoming water was 32–34 ppt. Crabs were fed to excess every third day and 3 food types were used. At one feeding they were given whole Pacific herring *Clupea pallasi*; at the next feeding they were given octopus *Octopus dofleini* or squid (species unknown), and then walleye pollock *Theragra chalcogramma* at the next feeding. Growth data are included for 58 males (CL 95 to 155 mm). Similar growth information was ac-

Authors: A. J. PAUL and J. M. PAUL are marine biologists with the University of Alaska Institute of Marine Science, Seward Marine Center Laboratory, P.O. Box 730, Seward, Alaska 99664. A. J. Paul's email: ffajp@aurora.uaf.edu.
Acknowledgments: Alaska Department of Fish and Game staff from Cordova and Homer collected specimens for this study. This is contribution 2624 from the Institute of Marine Science, University of Alaska Fairbanks.
Project Sponsorship: This study was funded jointly by the Alaska Sea Grant College Program under grant number NA46RG0104 project number R/06-36 and the Alaska Department of Fish and Game.

quired for 101 egg bearing females (CL 104 to 157 mm), and 3 females that became primiparous. No crabs molted twice.

For each crab premolt and postmolt CL and CH were recorded to the nearest millimeter 2 weeks after molting. The carapace was measured from the eye notch directly to its posterior edge. Chela height was measured across the widest portion of the largest claw. No attempt was made to characterize carapace condition.

A Mann-Whitney rank sum test was used to compare the premolt and postmolt CH/CL of both sexes. Growth and morphometric changes were plotted using linear regressions.

RESULTS

Changes in CL

Molting was observed at all months of the year in both sexes (Table 1). Following a molt the predicted increase in CL for crabs of both sexes was expressed by linear equations ($r^2 \geq 0.91$, $P<0.001$; Figures 2A, 2B). The average increase in CL for males was 10.2 mm (SD = 3.0), or 8.1% (SD = 3.0; Figure 3A). The average increase in CL for females was 6.6 mm (SD = 2.2), or 5.1% (SD = 1.8; Figure 3B). Three juvenile females (initial CL = 104, 107, and 120 mm) molted to the primiparous state (postmolt CL = 116, 117, and

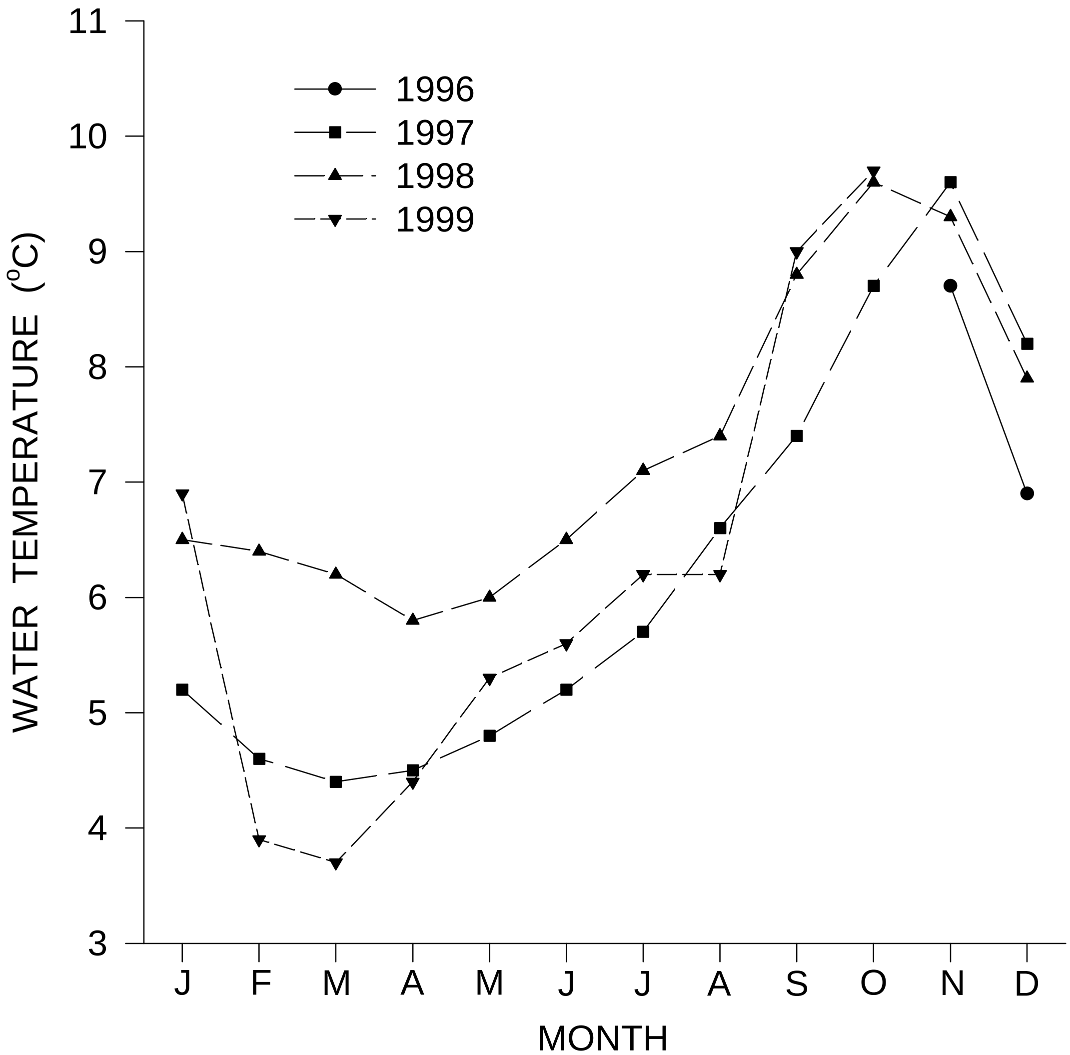

Figure 1. Laboratory water temperatures during the study.

Table 1. Time of molting for captive golden king crabs at the Seward Marine Center Laboratory.

Month	% Males Molting (n = 58)	% Females Molting (n = 104)
January	6	3
February	2	4
March	4	1
April	2	2
May	16	11
June	14	9
July	14	26
August	10	19
September	10	12
October	10	8
November	4	4
December	8	2

128 mm). Growth in CL was weakly dependent on initial measurements of that parameter in both sexes (Figures 3A, 3B).

Changes in CH

For males and females, the postmolt CH was correlated with the initial CH linearly ($r^2 = 0.85$, $P<0.0001$; Figures 2C, 2D). The average increase in CH for males was 3.6 mm (SD = 2.3) or 12.6% (SD = 9.7; Figure 3C). The average increase in CH for females was 0.82 mm (SD = 3.4) or 16.8% (SD = 18.1; Figure 3D). No clear relationship was found between initial CH and chela growth following a molt in either sex (Figures 3C, 3D).

Changes in CH/CL

In males CH and CL were related linearly, but the r^2 value was only 0.50, $P<0.0001$ (Figure 4A). The CH/CL increased with the molt in 42% of males, stayed the same in 17%, and decreased in 41% (Figure 5A). The premolt and postmolt CH/CL was also linear for females ($r^2 = 0.82$, $P<0.0001$; Figure 4B). The CH/CL increased with the molt in 48% of females, stayed the same in 38%, and decreased in 14% (Figure 5B). The Mann-Whitney rank sum tests indicated the differences in median values for CH/CL of premolt and postmolt males ($P = 0.0446$) and females ($P<0.0001$) were greater than would be expected by chance.

DISCUSSION

No other information on the growth rate of juveniles or female golden king crabs has been published. Growth in CL for male golden king crabs (126 to 170 mm) from southeastern Alaska averages 16 mm (range 7–21 mm; Koeneman and Buchanan 1985). A 16-mm average growth increment is higher than the 10.2 mm we observed for males from Prince William Sound, which is about 350 km to the north. The lower growth rate might be related to specific stock characteristics, or it might be an artifact of sample size. The difference may also be related to latitude. Somerton and Otto (1986) reported latitudinal, depth, and site-specific differences in growth rates for golden king crabs with smaller specimens in the northern portion of their range. They speculated that oceanographic conditions and food availability at different latitudes affected growth potential. Laboratory growth may have been affected by diet and temperature. The laboratory water from 75 m would have been warmer than that at 108–150 m where the crabs were captured. Additionally, 1998 was a very warm year (Figure 1). *Callinectes sapidus* mature at smaller sizes as temperature increases (Fisher 1999), but similar studies have not been done with golden king crabs. Only an in situ tagging study can determine how dependable our laboratory growth estimates are.

Ovigerous females in our collections were typically 120 to 150 mm CL (Figure 2B). Using the CL growth equation, a 120-mm female would require 5 molts to reach 150 mm and could produce one clutch with each molt (Figure 2B). Some females may undergo fewer molts because not all start producing eggs at 120 mm, or grow to ≥150 mm CL, and some mortality must occur.

We found no previous observations on chela growth in golden king crabs for comparison. In mature Gulf of Alaska red king crabs *Paralithodes camtschaticus*, male postmolt CH/CL increased in 28%, decreased in 25%, and remained the same in 47% of 64 captives (Paul and Paul 1995). Several females had similar or smaller CH after molting, and males generally had bigger ones. In some male anomurans the chelae are important secondary sexual characters and are used to fight for mates. Under these conditions large chelae are advantageous. Perhaps chela size does not play a similar role in golden king crab females, and that is why female CH growth at molting is minimal.

Size at maturity has been determined for golden king crab males from British Columbia, Canada (Jewett et al. 1985) and the eastern Bering Sea (Somerton and Otto 1986) using the techniques of Somerton and MacIntosh (1983), which assume CH changes with respect to CL at maturity. Males matured at about 114 mm CL in British Columbia and 132 mm CL in

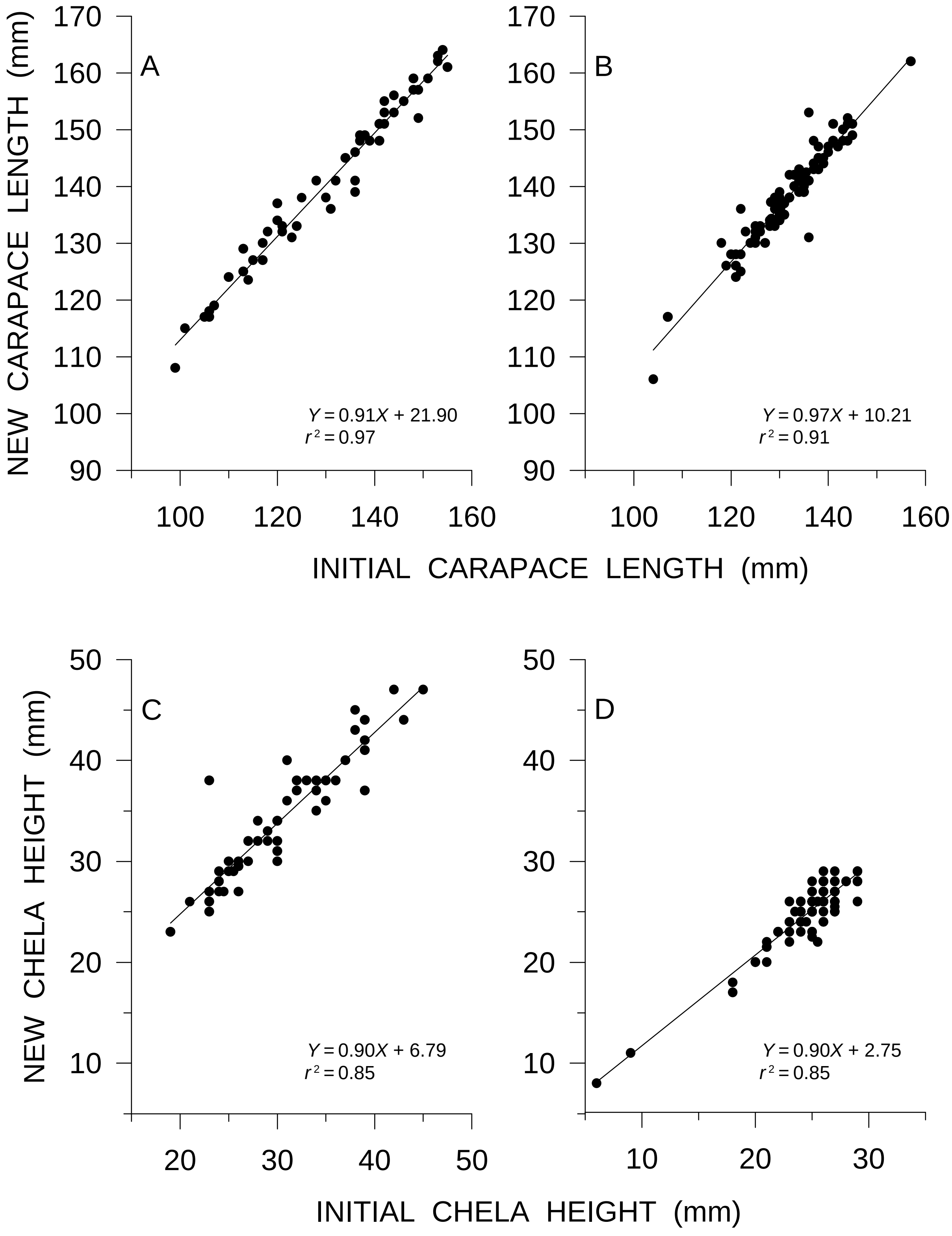

Figure 2. Changes in carapace length and chela height for male (A, C) and female (B, D) golden king crabs molting in the laboratory.

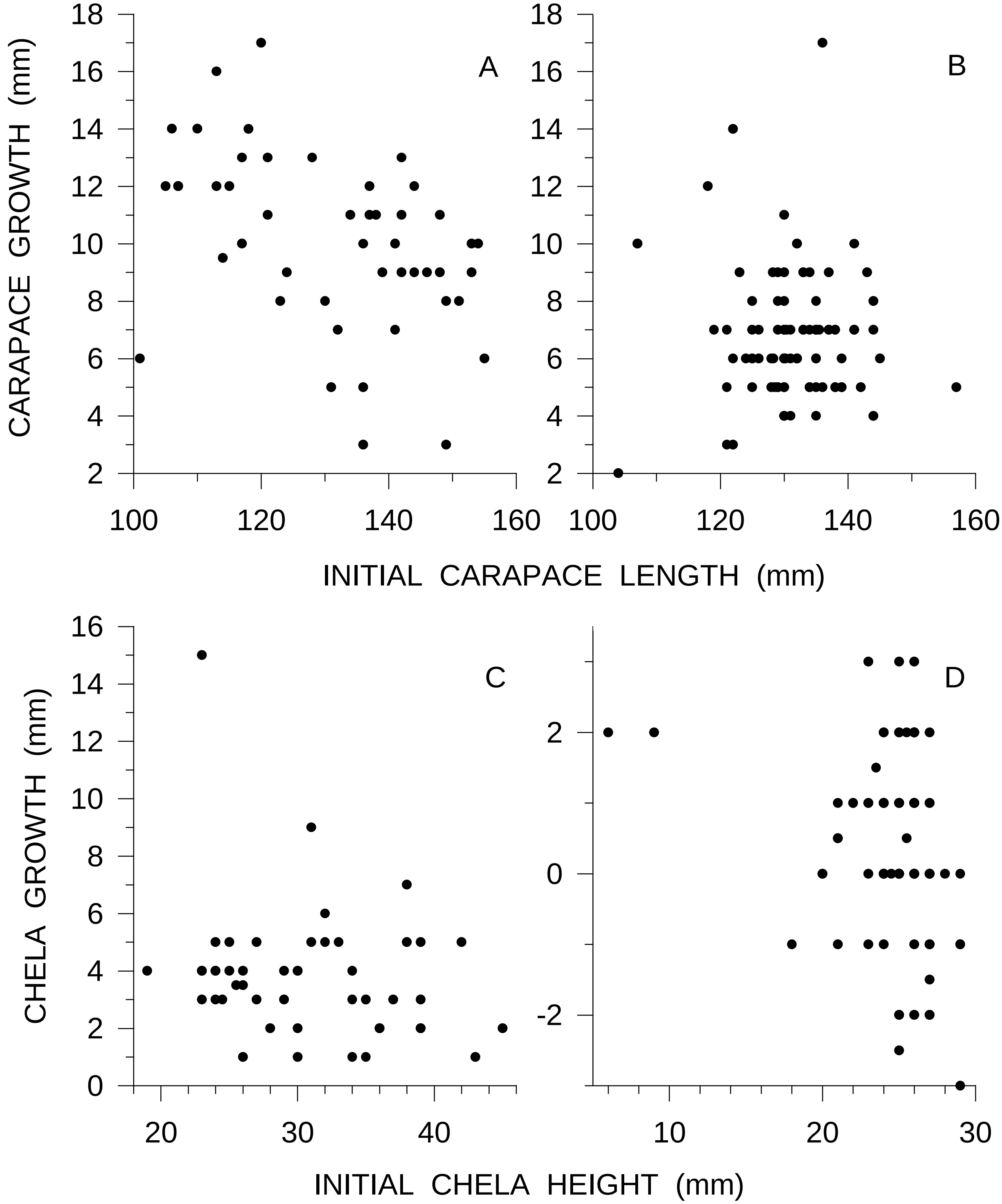

Figure 3. Growth (mm) in carapace length and chela height for male (A, C) and female (B, D) golden king crabs after molting in the laboratory.

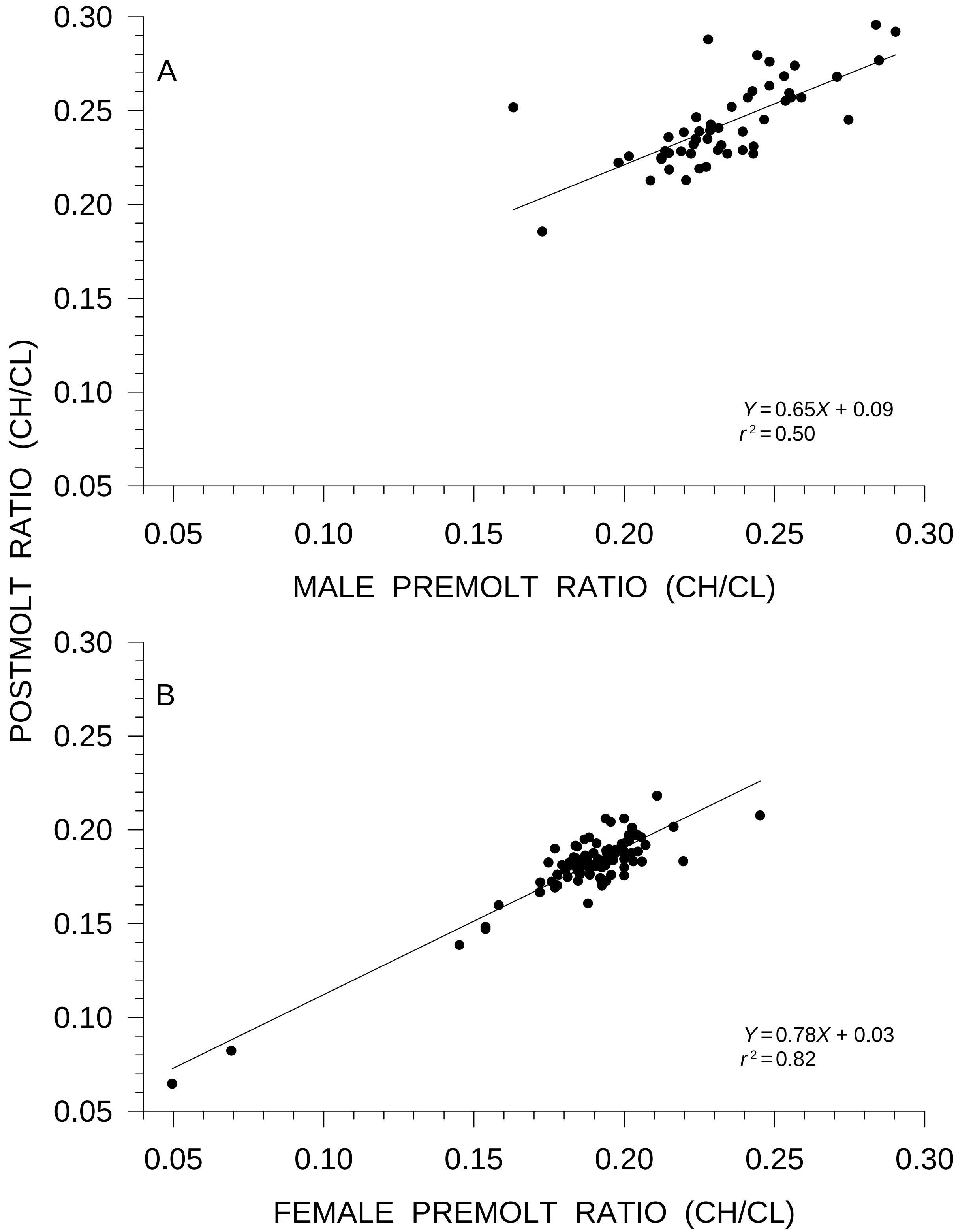

Figure 4. Changes in the ratio of chela height to carapace length (CH/CL) in male (A; *n* = 58) and female (B; *n* = 104) golden king crabs after molting in the laboratory.

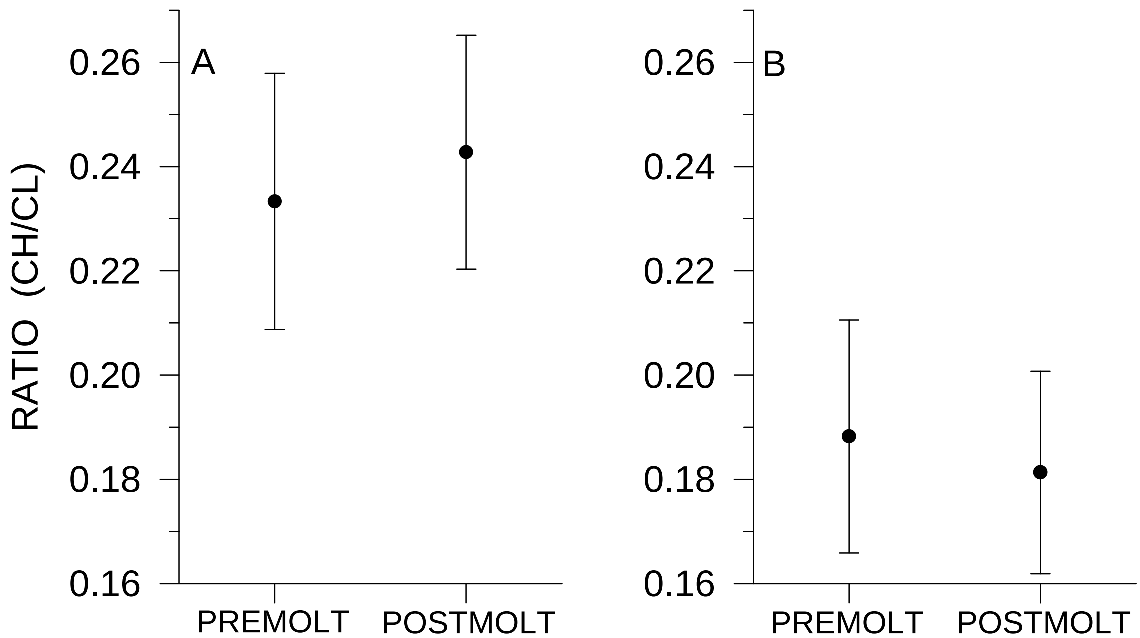

Figure 5. Premolt and postmolt measurements of the ratio of chela height to carapace length (CH/CL) in male (A) and female (B) golden king crabs after molting in the laboratory. Data are plotted as $\overline{x} \pm$SD.

the southern Bering Sea. These studies noted a strong differentiation in mature male CH morphology, but the inability to identify regenerating chelae caused large confidence intervals in the estimate for size at maturity. In our study some males probably had regenerating chelae. A comparison of the premolt CH/CL plots for males (Figure 6A) shows a few individuals with smaller CH than cohorts of the same CL. These discrepancies are not as apparent after the molt (Figure 6B). Our study clearly demonstrated that, in males 95 to 155 mm CL, the postmolt CH/CL may increase or decrease after a molt. The lack of predictability in shell growth patterns, and the possibility of regenerating chelae, should be considered when identifying male maturity using the relationship of CH to CL.

LITERATURE CITED

Donaldson, W. E., and W. K. Donaldson. 1992. A review of the history and justification for size limits in Alaskan king, Tanner, and snow crab fisheries. Alaska Department of Fish and Game, Division of Commercial Fisheries, Fishery Research Bulletin 92-02, Juneau.

Fisher, M. R. 1999. Effect of temperature and salinity on size at maturity of female blue crabs. Transactions of the American Fisheries Society 128(3):499–506.

Jewett, S. C., N. A. Sloan, and D. A. Somerton. 1985. Size at sexual maturity and fecundity of the fjord-dwelling golden king crab *Lithodes aequispina* Benedict from northern British Columbia. Journal of Crustacean Biology 5(3):377–385.

Koeneman, T. M., and D. V. Buchanan. 1985. Growth of the golden king crab, *Lithodes aequispina*, in southeast Alaskan waters. Pages 281–296 *in* Proceedings of the international king crab symposium. University of Alaska Fairbanks, Alaska Sea Grant Report 85-12.

Paul, A. J., and J. M. Paul. 1995. Changes in chela heights and carapace lengths in mature male red king crabs *Paralithodes camtschaticus* after molting in the laboratory. Alaska Fishery Research Bulletin 2(2):164–167.

Somerton, D. A., and R. A. MacIntosh. 1983. The size at sexual maturity of blue king crab, *Paralithodes platypus*, in Alaska. Fishery Bulletin 81(3):621– 628.

Somerton, D. A., and R. S. Otto. 1986. Distribution and reproductive biology of the golden king crab, *Lithodes aequispina*, in the eastern Bering Sea. Fishery Bulletin 84(3):571–584.

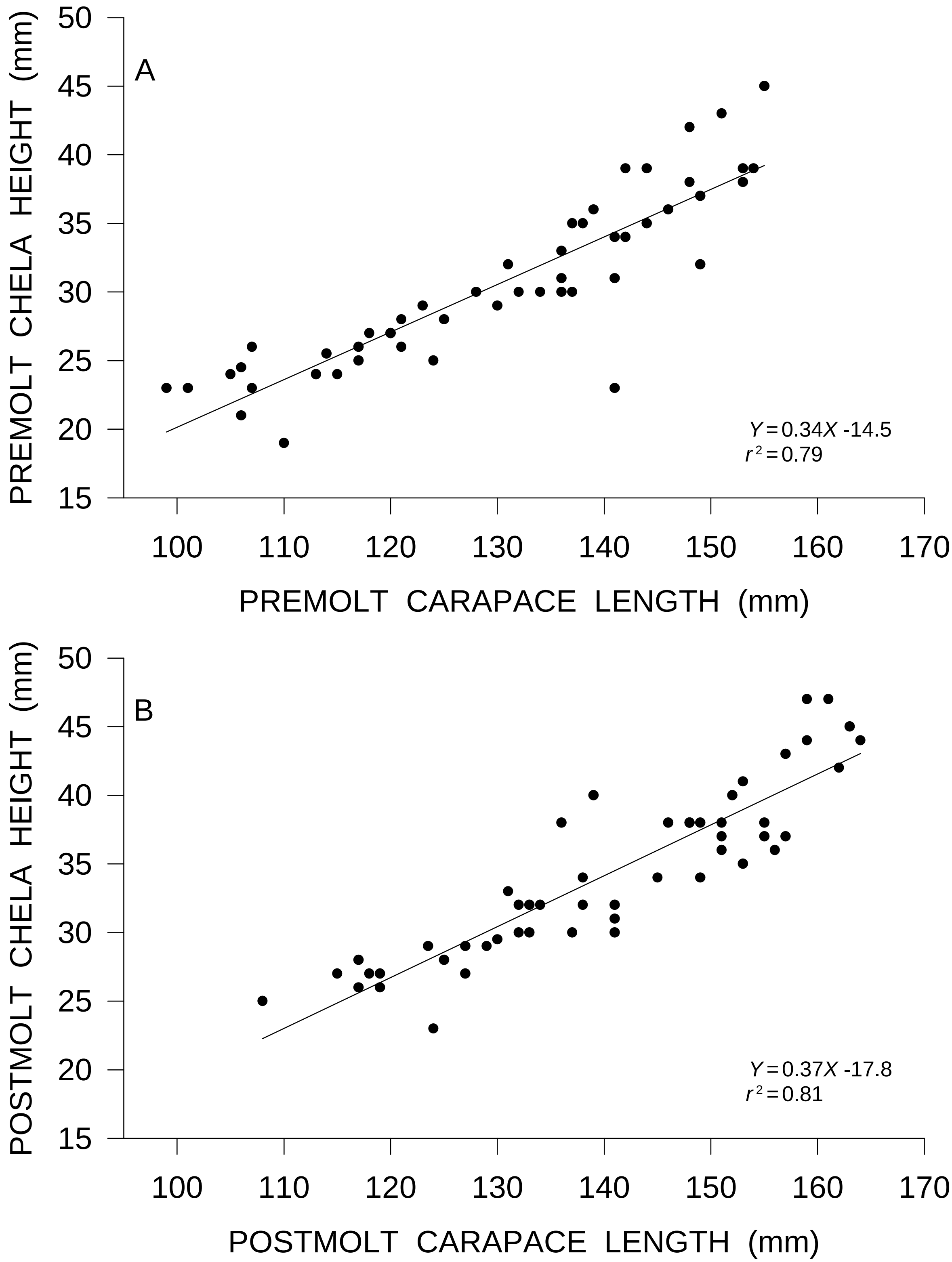

Figure 6. Carapace lengths and chela heights for male golden king crabs at capture (A) and after molting (B).