THE ALASKA SNOW CRAB, *Chionoecetes bairdi*:

SIZE AND GROWTH

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ABSTRACT

Size frequency distributions of snow crabs from Prince William Sound show consistent modes at 8 to 9 mm, 12 mm, 17 to 19 mm, 23 to 27 mm, 37 to 40 mm, and 54 to 60 mm. Above 60 mm modes become less distinct.

Growth per molt was determined for crabs held in pens and tagged crabs molting in nature. An inflection point was found in the pre-molt width (X) *vs* post-molt width (Y) relationship for males at a pre-molt width of 87 mm. For males < 87 mm, $Y = 1.19(X)+4.17$; for males $\geq$ 87 mm, $Y = 1.07(X)+16.32$. Growth for crabs missing 1 to 3 legs and tagged crabs was not significantly different than the relationships above. For juvenile females $Y = 1.17(X)+4.80$ and in females molting to maturity $Y = 0.96(X)+17.59$.

The 87 mm inflection point in the male regression indicates the size preceding the molt to maturity. An 87 mm male will grow to 109 mm at one molt. The ovary begins to mature in females at an average size of 68 mm, one growth increment prior to the size at 50% maturity (85 mm). An 85 mm female will grow to 99 mm. Female *C. bairdi* undergo a terminal molt at maturity. The average size of adult females is very similar to that predicted from size at maturity and growth data.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

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The International Pacific Halibut Commission provided space for an observer aboard their charter vessel operating in the Kodiak and northern Gulf of Alaska areas.

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The snow crab, *Chionoecetes bairdi*, became an acknowledged Alaskan commercial fishery resource in 1967 when 118,000 lbs were harvested (Brown, 1971). By 1974, the catch had increased to 64 million lbs making this species the second most valuable shellfish resource (13 million dollars) to Alaska's fishermen (Alaska Dept. Fish Game, 1974). The present snow crab fishery exists in southeastern Alaska, Prince William Sound, the Gulf of Alaska, Alaska Peninsula, Aleutian Islands, and Southern Bering Sea. In these areas the animals are usually found in greatest abundance on the continental shelf and/or upper slope (50-150 fm).

Snow crab growth studies were initiated by the Alaska Department of Fish and Game (ADF&G) in Kodiak in 1974 (Donaldson, 1974). Inquiries were further expanded in late 1974 and 1975 through co-operation between shellfish scientists in ADF&G and the Alaska Sea Grant Program, University of Alaska. Research was directed toward the problems of incremental growth, molting frequency, age, and morphological characteristics of maturation for *C. bairdi* in Alaskan waters. Field research was performed in Kodiak because of the accessability of the resource and the presence of ADF&G personnel and equipment.

Studying the growth of *C. bairdi* is complicated by two factors. The majority of the population is found in waters 50 fathoms and deeper, not accessable by small boats or to SCUBA divers. As with all crustaceans, *C. bairdi* contains no growth ring forming hard parts. Therefore, growth studies must be conducted by recovering tagged crabs, observing growth per molt of crabs held in captivity, and analysing size frequency distributions.

Growth of *C. opilio* has been extensively studied in Japan (Ito, 1970; Kon *et al.*, 1968; Sinoda, 1968) and Canada (Watson, 1969). These investigations indicate the limits of usefulness of the various types of data and provide a range of growth rates which might be expected in *C. bairdi*.

MATERIALS AND METHODS

I. Size-Frequency Distributions

All size-frequency distributions are plotted using carapace width recorded to the nearest millimeter.

Crab samples were collected trawling, potfishing, and examining the stomachs of Pacific cod. Trawling was conducted in Prince William Sound in 1971, 1972, and 1973 using a 16-foot try-net with 0.75-inch netting in the cod end. In 1973 and 1975 samples were collected in the Northern Gulf of Alaska between Montague Is. and Cape St. Elias and near Kodiak Is. during an International Pacific Halibut Commission trawl survey using a 94-foot otter trawl with a 3.5-inch mesh cod end. Size-frequency of adult male crabs was determined by subsampling the commercial fishery around Kodiak Island during 1974. Snow crabs less than 40 mm carapace width were collected from cod *(Gadus macrocephalus)* stomachs sampled in the vicinity of Kodiak Island in July 1975.

II. Incremental Growth

Growth associated with a single ecdysis (molt) was determined for snow crabs (both sexes) collected in the pre-molt condition by SCUBA divers during the winter and spring of 1974 and 1975. Collections were made in Womens Bay and the surrounding Chiniak Bay in water depths to 75 ft

(Fig. 1). Crabs were immediately placed in underwater enclosures of either 0.25 m^3 or 0.67 m^3. The animals were not fed during captivity. Crabs not molting within one week were released. Crabs which were missing limbs previous to molting were also allowed to molt.

To minimize disturbance of the animals growth was determined by measuring the cast exoskeleton and the new-shell crab 24 hours after molting. Size measurements were taken at the widest point of the branchial region of the carapace. The greatest diameter of the propodus of the right chela was routinely measured. All sizes were recorded to the nearest millimeter using a steel vernier caliper.

Incremental growth was also determined for a limited number of crabs which had been measured, tagged and then released to the environment by National Marine Fisheries Service (NMFS) in October, 1973, and ADF&G, in July 1973 and 1974. Specimens were recovered by ADF&G scientists in the commercial fishery tag collection program and by research fishing. These crabs were marked using a "spaghetti"-type dart anchored in the thoracic muscles adjacent to the fourth walking leg; the tag is supposed to remain with the crab through a molt. Documentation of molting, and any subsequent growth were then determined by measuring the returned crab and comparing its size with information recorded prior to release.

Incremental growth was plotted by the Hiatt (1948) method with pre-molt carapace width as the independent variable and post-molt carapace width the dependent variable. Hiatt plots were tested for presence of inflection by the technique described by Mr. Dave Somerton, NMFS (personal communication, 1975). Male incremental growth data were first divided into two size groups by arbitrarily selecting a cutoff point at 80 mm carapace width. Least squares regression lines were fitted to each

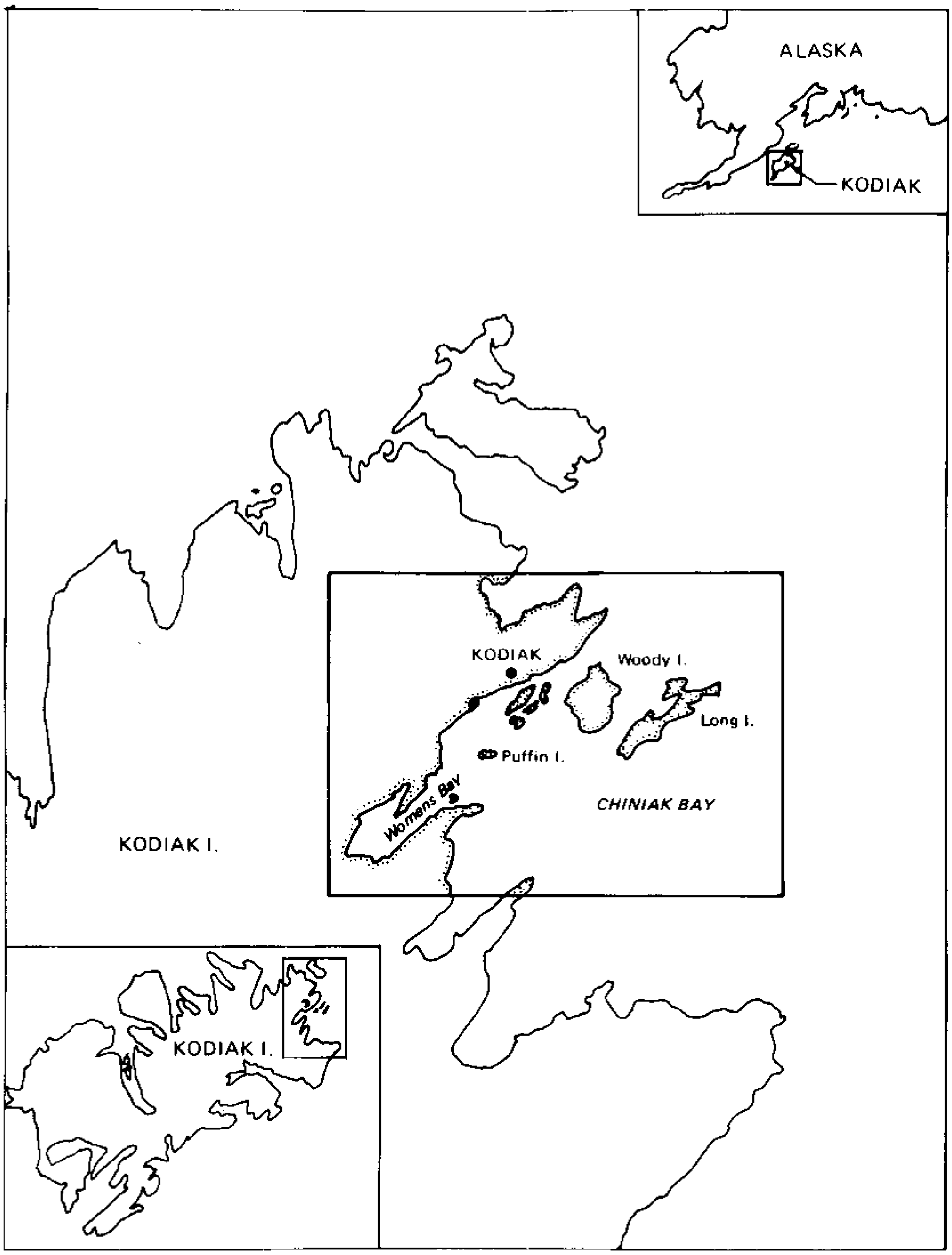

Figure 1. Chiniak Bay, Kodiak Island, Alaska; the collection site for snow crabs used in the incremental growth studies.

group, and residual sums-of-squares computed. The cutoff point was then increased by a millimeter and new regressions and sums-of-squares computed.

The process was continued with cutoff values ranging up to 108 mm. The size providing two lines with the lowest pooled residual sum-of-squares was considered the division between juvenile and adult growth. An F-test was used to determine if the pooled residual sum-of-squares was significantly less ($\alpha = 0.05$) in the two line model than by fitting a single line to all the data. Females molting to maturity were easily distinguished by changes in abdomen width and structure of the pleopods.

III. Size at Maturity

Determination of size at maturity was made for females by regressing carapace width against percent of mature females (Watson, 1969; Hilsinger, 1975). The size at which the ovary begins to mature (Hilsinger, 1975) was determined by a similar regression technique using the percentage of juvenile females with orange ovary as the dependent variable.

RESULTS

I. Size Frequency

Animals hatched at discrete times of the year are often reconizable on size frequency distributions since individuals of the same age with similar growth rates will tend to cluster around some average size, (Tyler and Cargo, 1963; Tesch, 1968). Size-frequency distributions for juvenile snow crabs collected in Prince William Sound, the Northern Gulf of Alaska and Kodiak Is. all exhibit such modal groupings (Figs. 2, 3, 4, 5, 6).

Prince William Sound crabs were taken during January, April, May, June, July, and August. In January dominant modes appear at 10 mm, 27 mm, and 37 mm carapace width, in April one group appears at 12 mm. From May through July the dominate mode was at 19 mm, while in August groups occurred at 12 mm, 19 mm, 27 mm, and 38 mm (Fig. 2). In the Northern Gulf of Alaska in July, modes appeared at 40 mm and 54 mm (Fig. 3). Snow crabs from Pacific cod stomachs (*Gadus macrocephalus*) collected on the IPHC trawl and ADF&G crab charter vessels exhibit similar modes at 9 mm, 12 mm, 17 mm, and 23 mm (Fig. 4, 5). In all samples where juvenile males and females were separated the modes appear at the same size for both sexes.

Size distributions for the crabs collected in the IPHC trawl survey exhibit a mode at 58 mm for males (Fig. 6B) and 60 mm for females (Fig. 6A). Above that size, juvenile females group around 83 mm while the males blend into one large size class ranging between 65 mm and 110 mm, the larger animals approaching the size at maturity reported by Brown and Powell, (1972). With the sexes combined, modes appear at 60 mm and 81 mm.

For all juveniles regardless of area and season, size classes appear with some consistency at 8 to 9 mm, 12 mm, 17 to 19 mm, 23 to 27 mm, 37 to 40 mm, and 54 to 60 mm. Above 60 mm no distinct grouping are apparent for males while females sometimes cluster at 83 mm. Adult females in this study averaged 94 mm (Fig. 6) while adult males from the Kodiak commercial fishery averaged 151 mm (Fig. 7.).

II. Incremental Growth

The growth at a single molt for the various groups was analysed by Hiatt's (1948) method for the following groups of crabs: 1) all males missing no legs previous to molting in holding pens, 2) males from group 1

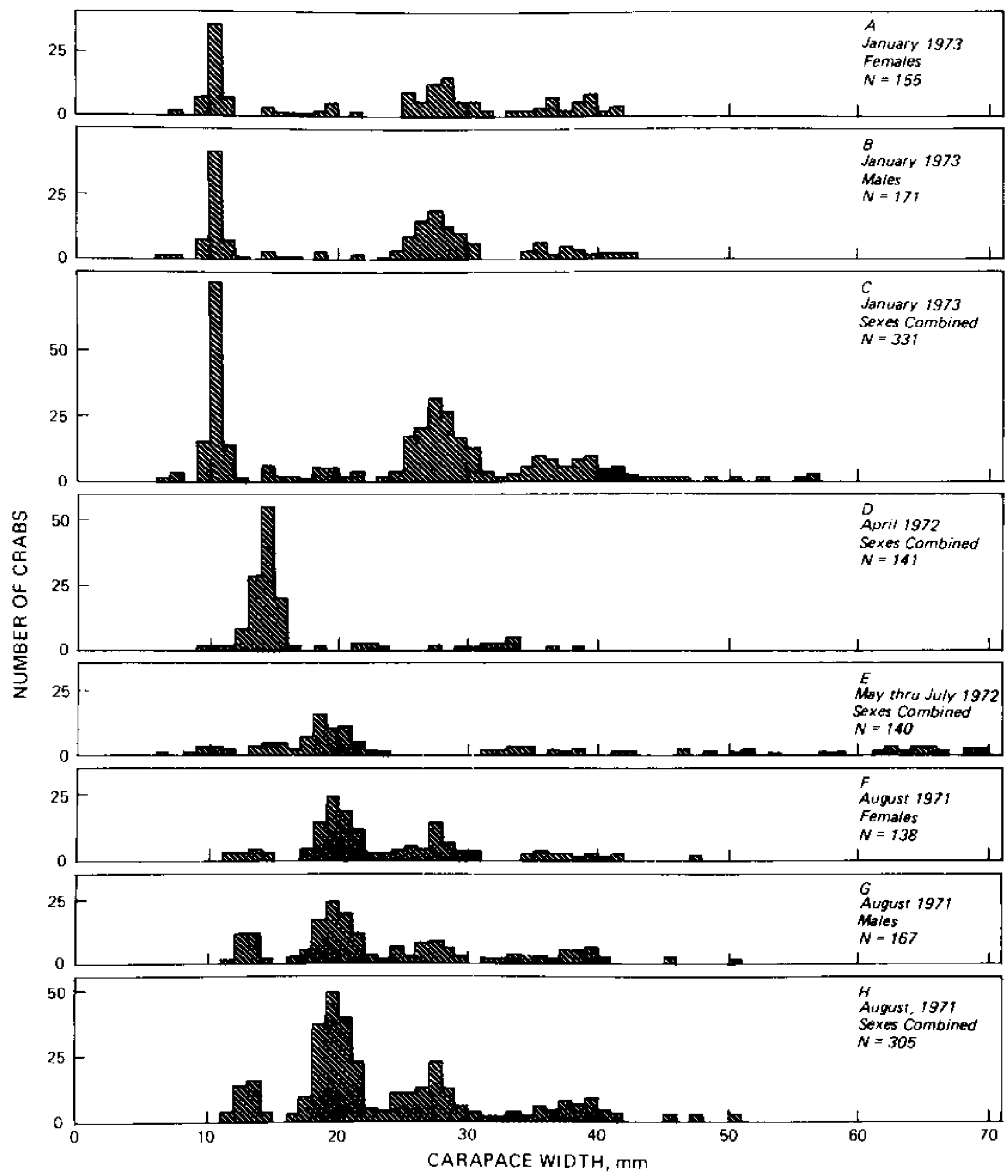

Figure 2. Size frequency distributions of snow crabs from Prince William Sound; 1971-1973; Sea Grant trawl survey.

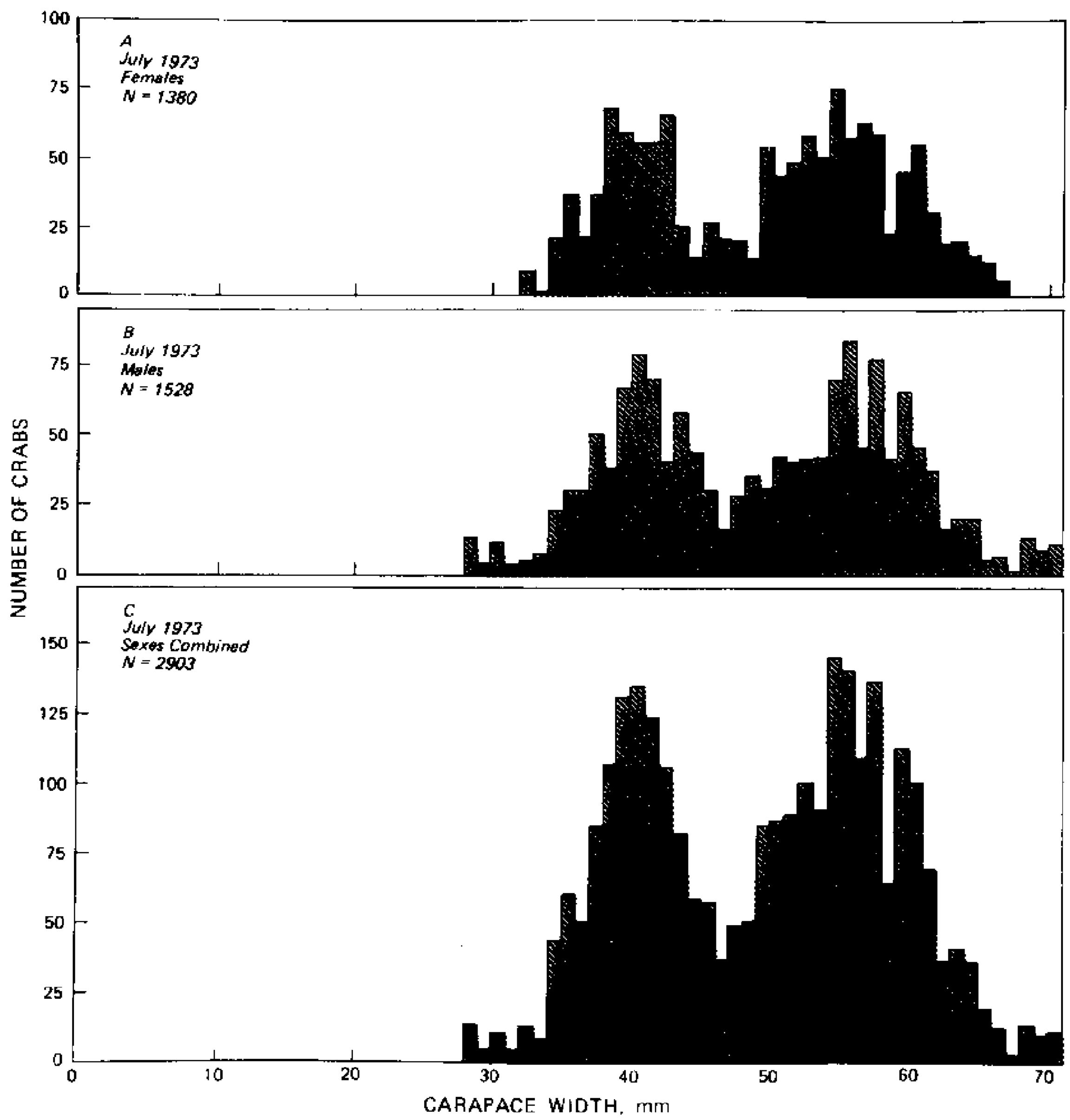

Figure 3. Size frequency distributions of snow crabs from the Northern Gulf of Alaska; August 1973; IPHC trawl survey.

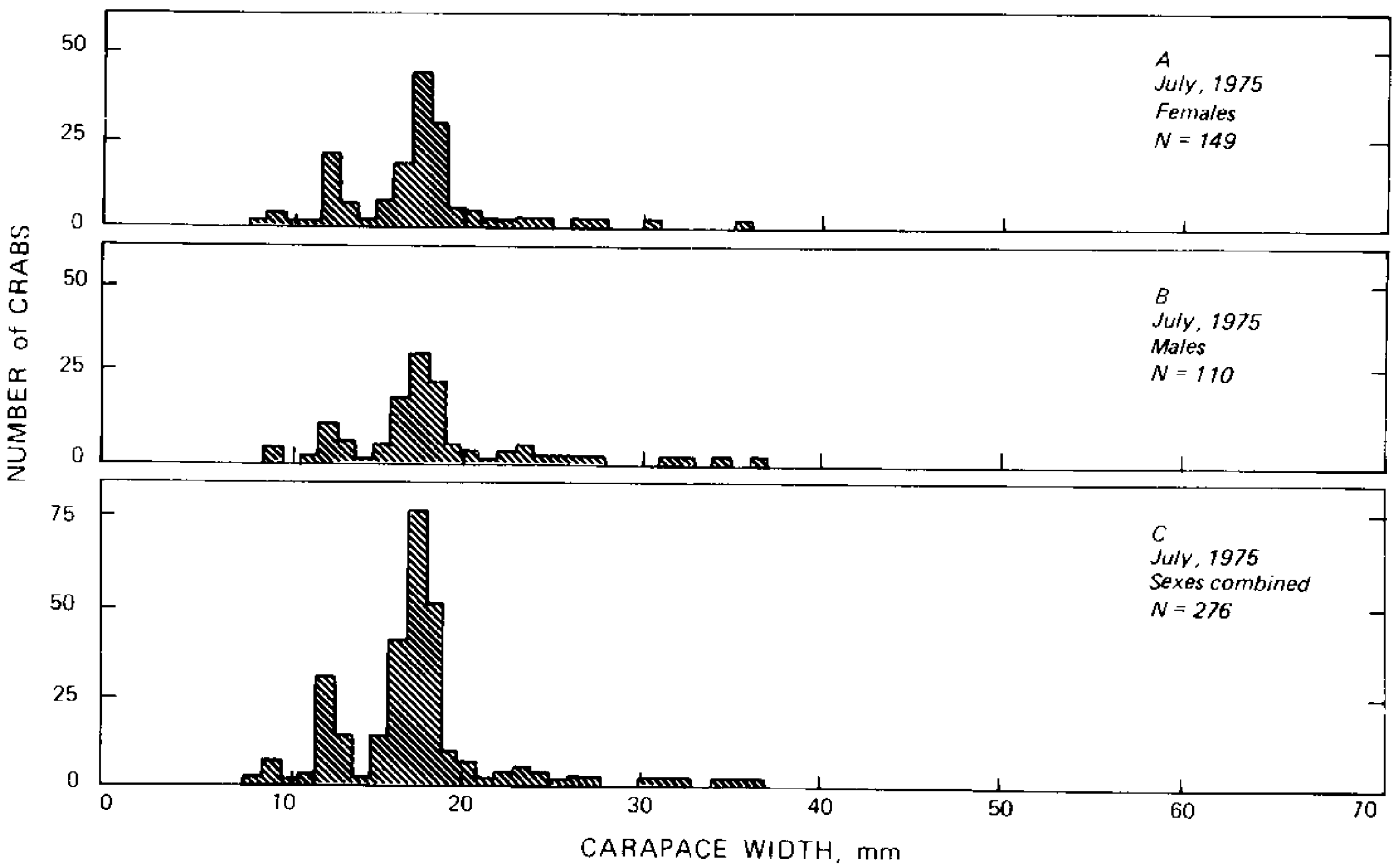

Figure 4. Size frequency distribution of snow crabs in Pacific cod (*Gadus macrocephalus*) stomachs from Kodiak Is.; July 1975; IPHC trawl study.

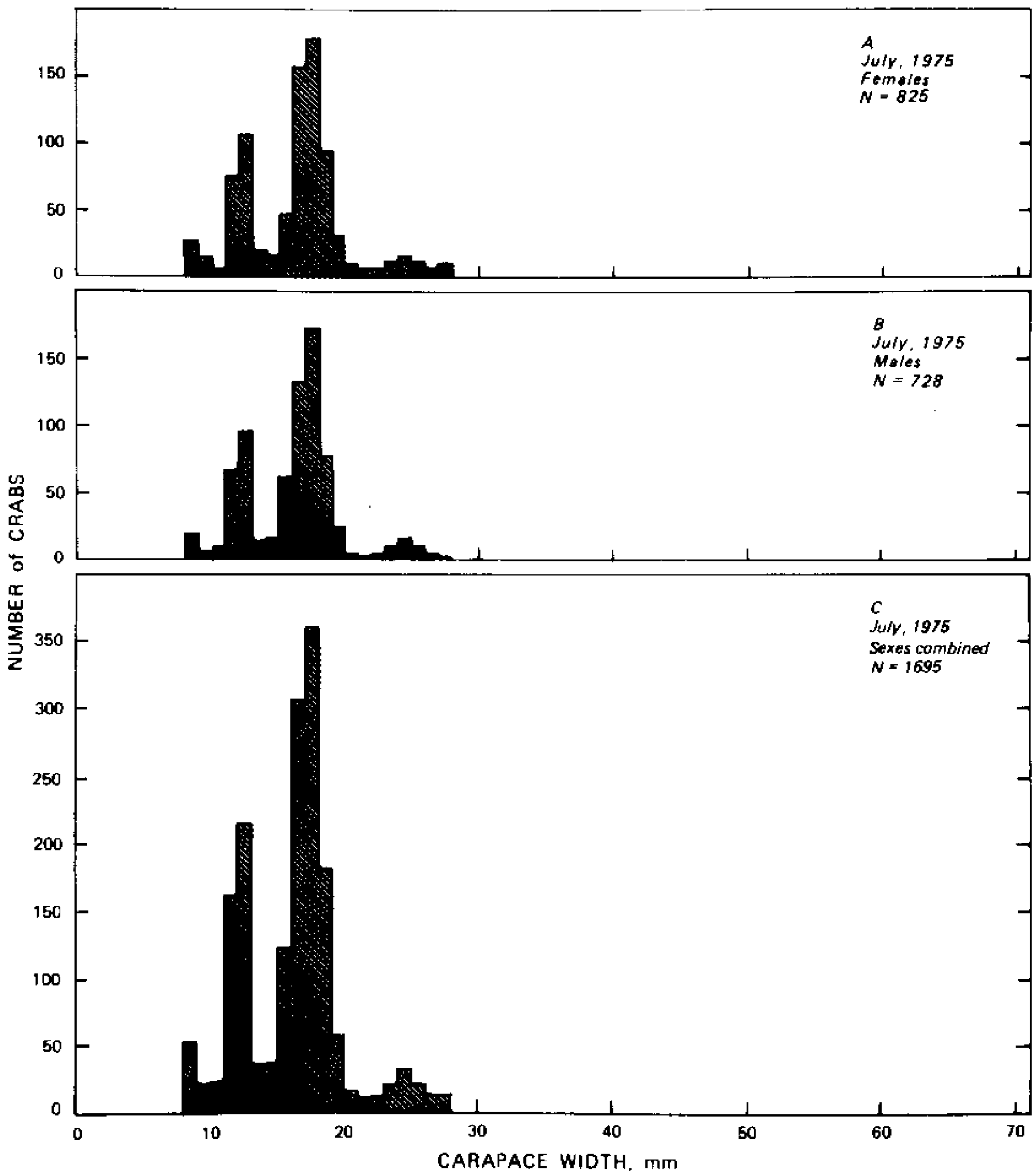

Figure 5. Size frequency distribution of snow crabs in Pacific cod (*Gadus macrocephalus*) stomachs from Kodiak Is.; July 1975, ADF&G pot survey.

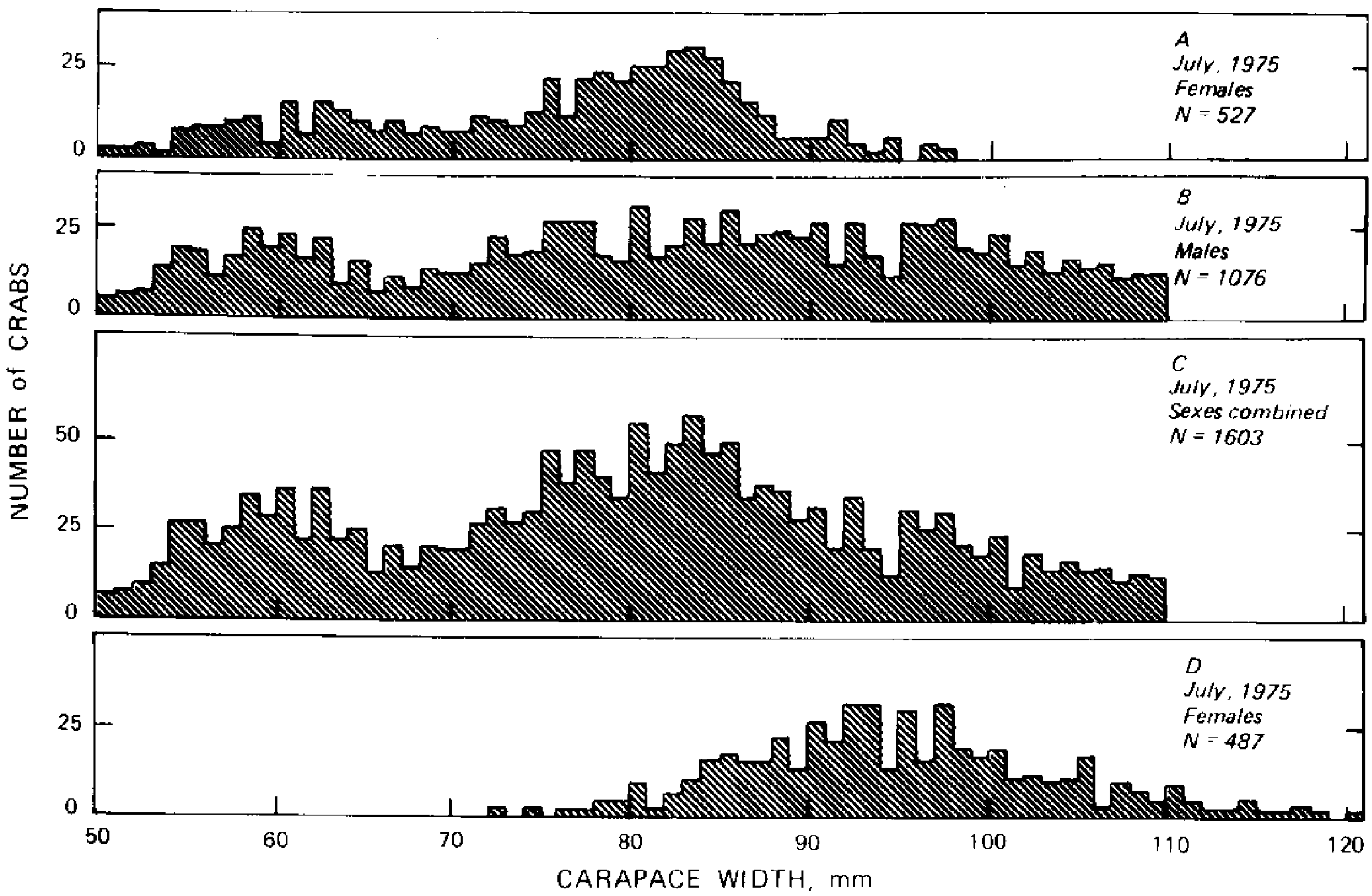

Figure 6. Size frequency distributions of juvenile and adult female snow crabs from Kodiak Is.; July, 1975; IPHC trawl survey.

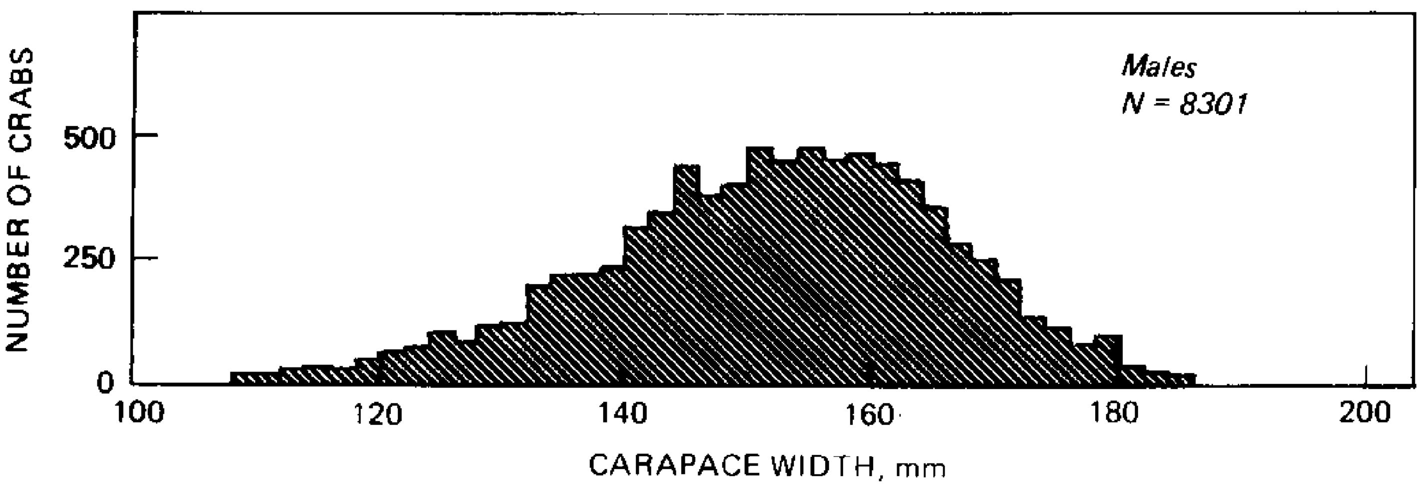

Figure 7. Size frequency distribution of male snow crabs from Kodiak Is., 1974; commercial fishery.

larger than or equal to 87 mm, 3) males from group 1 smaller than 87 mm, 4) males missing 1 to 3 legs while molting in holding pens, 5) tagged males molting in nature, 6) juvenile females molting in holding pens, 7) females molting to maturity in holding pens, 8) males less than 87 mm plus juvenile females (groups 2, 6, and 9) tagged males plus males greater than or equal to 87 mm (Table 1).

Groups 2 and 3 were created when a significant inflection point was found in the Hiatt plot for group 1 at a pre-molt carapace width of 87 mm. The pooled residual sum-of-squares of two lines fit to groupings above and below this size was significantly less ($F = 9.97$ *vs* critical $F_{.025} = 3.78$) than for a single line fitting all observations. The regressions for males and females are plotted separately (Figs. 8, 9) to show the distribution of the data points about these lines.

Covariance analyses were performed testing groups 3, 4, 5, 6, and 7 against group 2 as a control using Dunnett's "q'" statistic (Zar, 1974), (Table 2). The regression lines for tagged males and males missing 1 to 3 legs were not significantly different from males $\geq$ 87 mm carapace width ($\alpha = .05$). Males less than 87 mm carapace width, and both female groups were significantly different from the control. Newmann-Keuls' "q" statistic (Zar, 1974) was used to test equality of regression parameters for juvenile females against both females molting to maturity and males less than 87 mm carapace width (Table 3). No significant differences could be found in either comparison.

The average growth per molt for males (Table 4) increases absolutely with size up to the 130–139 mm carapace width. In contrast the percentage growth remains nearly constant in the juvenile animals and decreases with increasing size in the larger crabs. Juvenile females average a 27 percent

Table 1. Least-squares regressions relating pre-molt carapace width (X) to post-molt carapace width (Y); the correlation coefficient, r, included

Group	N	Regression Equation	r
1-Males missing no limbs	163	Y = 1.14 (X) + 9.17	.97
2-Adult males ($X \geq 87$ mm)	138	Y = 1.07 (X) + 16.32	.98
3-Juvenile males ($X < 87$ mm)	25	Y = 1.19 (X) + 4.17	.98
4-Males missing limbs	11	Y = 1.07 (X) + 15.43	.99
5-Tagged males	23	Y = 1.09 (X) + 12.48	.95
6-Juvenile females	5	Y = 1.17 (X) + 4.80	.99
7-Females molting to maturity	37	Y = 0.96 (X) + 17.59	.93
8-Juveniles - sexes combined	30	Y = 1.19 (X) + 4.03	.99
9-Tagged males plus holding pen adults	161	Y = 1.06 (X) + 17.11	.98

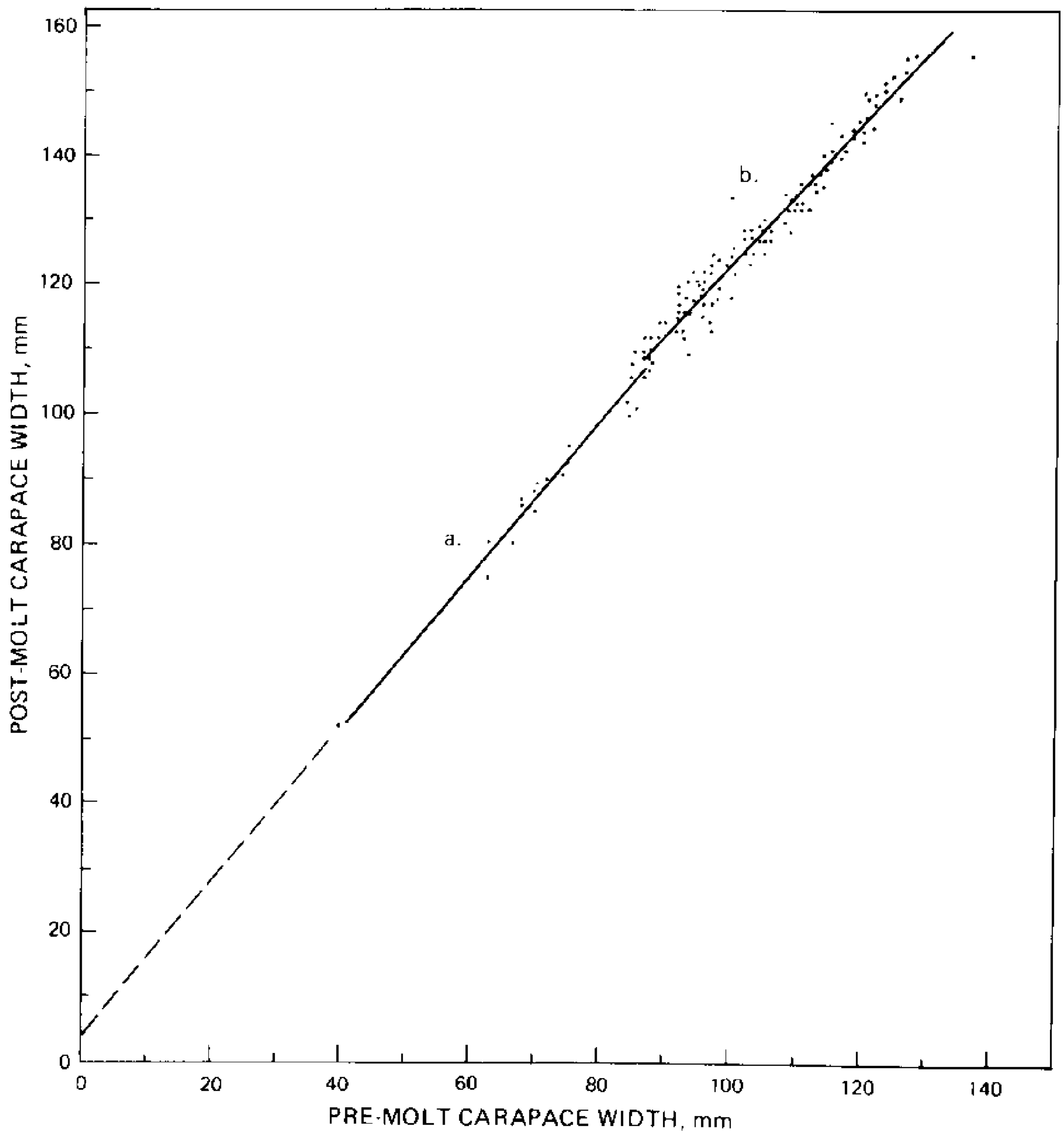

Figure 8. The relationship between pre-molt and post-molt carapace width for male snow crabs held in pens during molting. A least squares progression is plotted for: (a) crabs smaller than 87 mm; and (b) crabs 87 mm and larger.

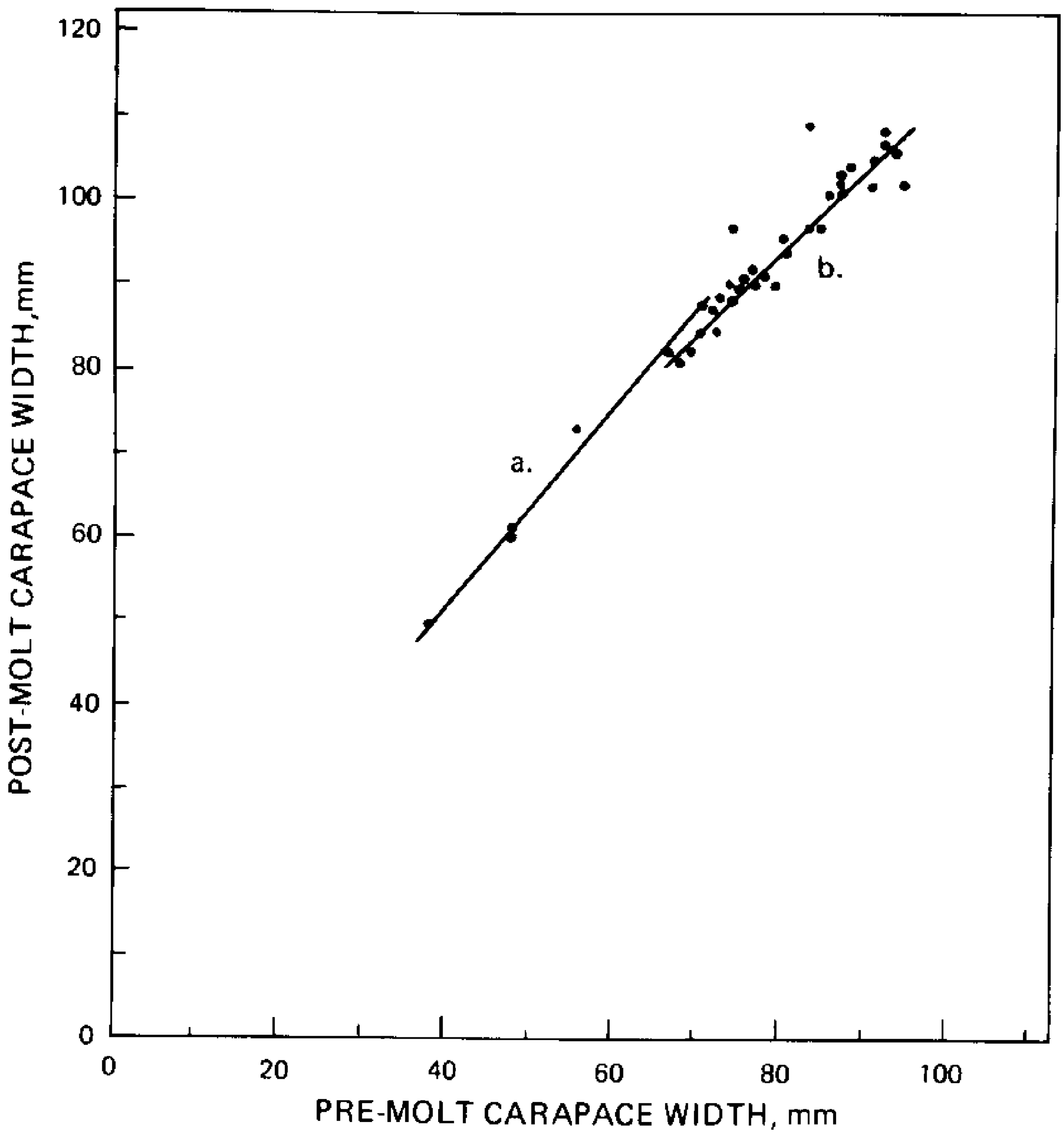

Figure 9. The relationship between pre-molt and post-molt carapace width for females: (a) remaining immature after the molt; and (b) molting to maturity.

Table 2. Covariance analyses testing equality of least squares regression parameters (slope and intercept) against a control group (adult males held in pens); Dunnett's "q".

test group	"q" slope	"q" intercept	DF	critical "q" $\alpha = .05$
Males less than 87 mm	4.72	3.88	159	1.96
Males missing 1 to 3 limbs	0.00	0.78	145	1.96
Tagged males	0.72	1.14	157	1.96
Juvenile females	3.98	10.91	139	1.96
Females molting to maturity	3.81	3.70	171	1.96

Table 3. Covariance analyses testing equality of least squares regression parameters, between selected test groups; Newman-Keuls "q".

test group	"q" slope	"q" intercept	DF	critical "q" $\alpha = .05$
Juvenile females against juvenile males	2.50	0.16	26	2.91
Juvenile females against females molting to maturity	2.21	0.02	38	2.86

Table 4. Average incremental growth for males larger than 40 mm carapace width molting in holding pens; 95% confidence limits included

Size group, mm	N	carapace width, mm		growth, mm	
		$\overline{X}_{pre}$	$\overline{Y}_{post}$	$\overline{Y-X}$	$\overline{Y-X}_{\%}$
40–49	1	40	52	12	33
50–59	0	--	--	--	--
60–69	7	65.86±2.23	81.86±3.96	16.00±2.40	24.26±3.33
70–79	8	73.13±2.29	91.12±2.98	18.00±1.42	24.41±2.25
80–86	9	84.00±1.64	103.88±2.70	19.88±2.47	23.70±3.02
87–89	11	87.81±1.67	110.09±1.74	22.27±1.65	25.35±1.87
90–99	40	94.92±0.73	117.98±1.13	22.95±0.99	24.18±1.07
100–109	33	104.51±0.99	127.55±1.17	23.03±0.72	22.05±0.74
110–119	35	113.74±0.81	138.03±1.26	24.43±0.72	21.48±0.60
120–129	19	122.84±1.28	148.63±1.89	25.79±1.13	20.99±0.90
130–139	1	137	156	19	14

size increase while those molting to maturity showed growth per molt ranging from 21 percent for 60 to 69 mm carapace width animals down to 14 percent for 90 to 99 mm carapace width animals (Table 5).

Two male crabs missing five legs, carapace width 71 mm and 72 mm, molted and grew 12.67 percent and 9.72 percent respectively. Size increase for males, 70 to 79 mm without limb loss averaged 24 percent.

III. Size at Maturity

Regressing carapace width against percentage of mature females (Fig. 10) yields the least squares regression equation, $Y = 4.33(X)-319.25$. Fifty percent maturity occurs at 85 mm carapace width. A similar regression plotting carapace width against the percentage of juveniles with orange ovaries has an equation of $Y = 3.97(X)-220.69$, and the size at which 50 percent of the females exhibit an orange ovary is 68 mm.

Brown and Powell (1972) suggest the size at maturity for males, based on chela size and reproductive tract weight is, 110 mm and 113 mm respectively. On occasion females in this study were found to produce fertile egg clutches when mated with males as small as 90 mm. The average size of males in mating pairs was 109 mm. Our incremental growth regression predicts a crab of 87 mm will molt to 109 mm carapace width.

DISCUSSION

I. Size-Frequency Distributions

Size-frequencies have been used to define age classes and instars (Kanno, 1975; Kon *et al.*, 1968; Ito, 1970). In crustaceans, where growth in size occurs only after molting, it is quite often unclear whether size-classes

Table 5. Average incremental growth for females molting to maturity in holding pens; 95% confidence limits included.

Size group, mm	N	carapace width, mm $\bar{X}_{pre}$	$\bar{Y}_{post}$	growth, mm $\overline{Y-X}$	$\overline{Y-X}_{\%}$
60-69	4	68.00±2.26	82.25±2.00	14.25±3.98	21.02±6.65
70-79	15	75.00±1.33	89.53±1.78	14.53±1.50	19.40±2.08
80-89	11	84.00±1.74	99.91±2.61	15.91±2.03	18.96±2.47
90-99	7	92.14±0.98	105.29±2.25	13.14±2.59	14.27±2.86

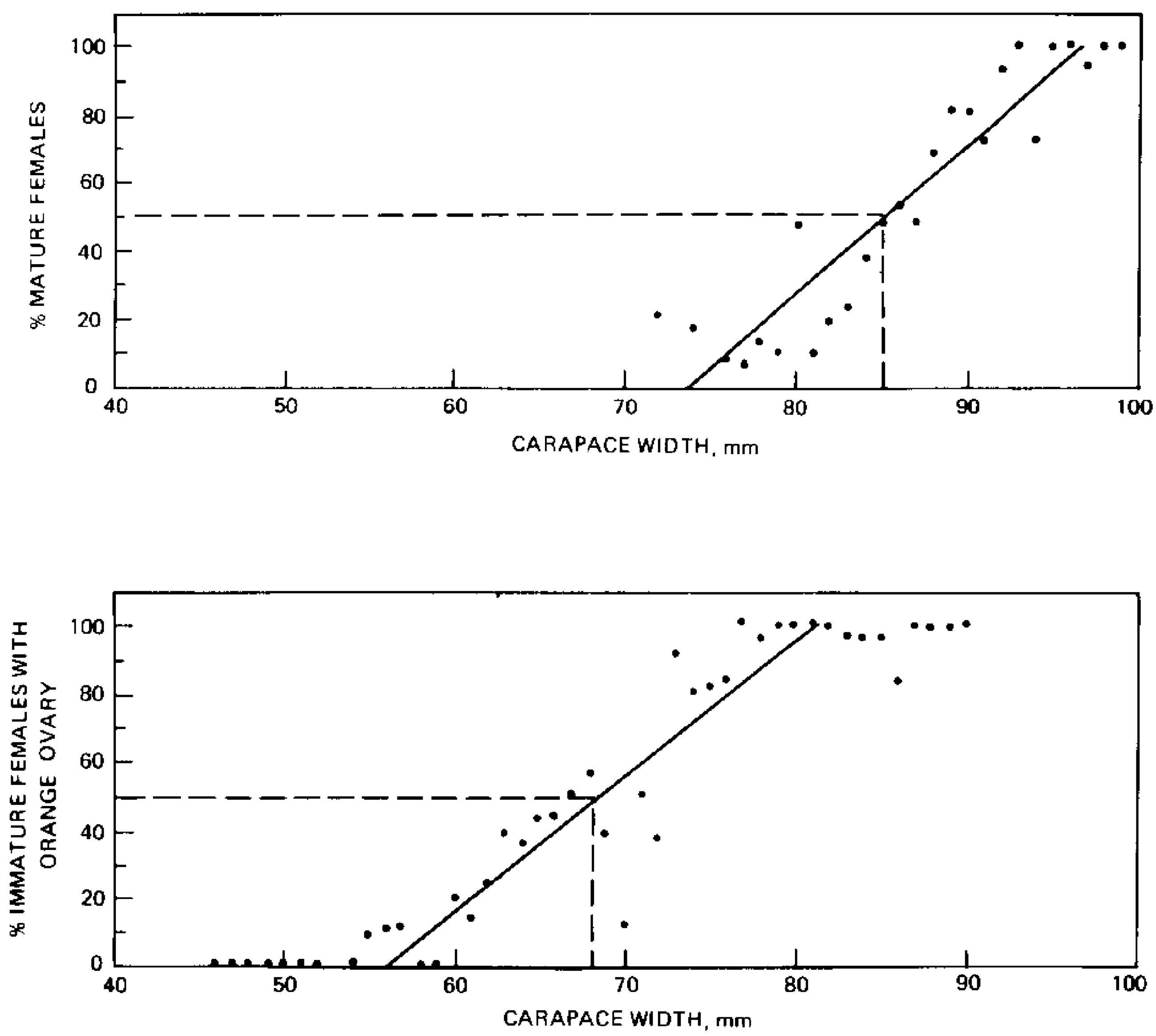

Figure 10. The relationship between size and maturity, and size and the development of the ovary (orange) in immature female snow crabs.

represent annual age groups or simply sequential instars in cases where the animals molt several times a year.

Size-frequency distributions reported in this study are subject to several sources of error. Trawl caught samples always reflect size selectivity related to mesh size. Prince William Sound studies utilized a trawl lined with 1/4-inch mesh netting, which retained crabs as small as 8 mm. The IPHC trawl with 3 1/2-inch mesh failed to capture crabs smaller than 28 mm. As a result, the variations in the position of modes in samples from the different nets reflect differential size selectivity as well as actual differences between areas and years. Size distributions of crabs collected from cod stomachs are subject to feeding selectivity and, to behavioral and spatial differences related to the size of the prey. While these factors introduce a bias of unknown magnitude, remarkable similarities are apparent in the distributions of sizes from different areas and seasons suggesting the problem of selectivity was probably a minor one. There is no way at present to interpret the small differences (a few millimeters) observed between the recurrent modal classes, other than to suppose that real differences do exist between localities and years.

II. Incremental Growth

Plots of growth per molt have been used (Hiatt, 1948; Kurata, 1960; Hepper, 1972) to develop a series of general growth relationships of the form $L_{n+1} = a+b(L_n)$ where L_n is the size of an animal and L_{n+1} the size following the molt. These equations should be linear within any one life history phase (larval, juvenile, or adult), with inflection points expected at the sizes of the first post larval animal and sexual maturity (Kurata, 1960). These inflection points may be used to divide the animals life history into discrete growth phases as a function of size.

To find the inflection point relating size and sexual maturity for males, two lines were fitted to the observations such that these two lines had the lowest pooled residual sum of squares of any possible combination of lines. The improvement of fit by these two lines over a single line is demonstrated statistically. By this criteron males 86 mm and less in width are considered the juveniles while those 87 mm and greater are grouped as adults. This size apparently defines the average size of males preceding their molt to maturity. In females the molt to maturity is obvious due to the morphological changes which occur, and finding an inflection point is not necessary in order to separate adults and juveniles.

Juvenile females and all males fall into Kurata's (1960) classification of progressive geometric growth where the growth increment increases with increasing size of the individuals. Adult males increase in size at a slower rate than juveniles. Adult females fall into the classification of retrogressive geometric growth where the growth increment decreases with increasing size. This happens during the terminal molt when growth is apparently reduced in favor of the production of reproductive products.

Juveniles of both sexes grow at the same rate. The Hiatt (1948) graphs for either cannot be distinguished statistically (Table 3) and the modes in size frequency for both sexes appear at the same positions for a given sample (Fig. 4, 5, and 6). Thus juvenile growth per molt can be defined by using the Hiatt method and combining males and females.

Snow crab growth is apparently not affected by moderate limb loss (three or fewer) or field tagging. However, growth was significantly reduced for the two individuals missing five limbs, presumably in response to the energy demand for leg regeneration. Similar observations have been noted for *Cancer pagurus* (Bennet, 1973) where severe limb loss (2 chelae or six legs) causes growth reduction by 25 percent.

III. Size at Maturity

Ovaries begin to mature in females at an average carapace width of 65 mm, or one molt prior to the mean size before molting to maturity at 85 mm. Based on our observed incremental growth relationship, a female at 85 mm will become 99 mm after molting to maturity. This prediction is very similar to the 94 mm average size of females from the IPHC trawl charter in 1975 and 100 mm average size on the ADF&G 1975 Charter, (Donaldson 1975).

The male size at maturity, 110 mm based on chela morphology and 113 mm related to reproductive tract measurements (Brown and Powell, 1972) occurs at one growth increment above the 87 mm inflection obtained in this study. This result substantiates the applicability of the Hiatt method as applied to defining separate growth phases in decapoda. Males attending females molting to maturity averaged 109 mm. Perhaps only in this inshore environment is the mating male population comprised of recently mature animals.

SUMMARY

This report describes the results of initial co-operative studies of snow crab (*Chionoecetes bairdi*) size and growth conducted jointly by ADF&G shellfish biologists and fishery scientists working through the University of Alaska's Sea Grant Program. The findings stress incremental growth related to sex, size, and state of maturity, and also depict the distributions

of sizes for juveniles and adults in samples taken from populations in the Northern Gulf of Alaska. The thrust of the continuing effort is the eventual development of a growth and age model for this commercial species in Alaskan waters.

Several size classes appear with consistancy in populations of *C. bairdi* from the Gulf of Alaska area. Since spawning is apparently seasonal, these size classes probably represent annual cohorts. However, until some notions of molting frequency are available (particularly for adults), there is no reliable way of relating size and age.

Incremental growth is remarkably constant and linear for *C. bairdi* within life history stages related to stages of maturity. As juveniles, both males and females exhibit increasing absolute growth with size. Following the molt to maturity, growth per molt continues to increase slightly for males, while for females undergoing the terminal ecdysis, the absolute growth is significantly less than would be predicted based on juvenile increases. Moderate limb loss and tagging does not appear to affect growth.

Our conclusions concerning growth are based on a relatively small sample size and as such must be viewed accordingly. Also, since the majority of the animals examined were collected (SCUBA) at the fringe of the natural populations preferred depth range, the data may not be applicable to all snow crabs. This report is the first critical analysis of growth data for Alaskan snow crabs. As such it warrants distribution as a technical report divorced of any further interpretation.

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APPENDIX I

Growth per molt; males larger than 86 mm carapace width (held in pens).

Date	Carapace Width		Growth		Claw Diameter	
	X	Y	$(Y-X)_A$	$(Y-X)_\%$	C_{pre}	C_{post}
5/ 4/74	88	112	24	27.27	13	18
5/19/74	87	110	23	26.43	12	16
5/26/74	88	107	19	21.59	13	17
12/17/74	89	114	25	28.08	13	18
12/17/74	87	112	25	28.73	12	18
1/ 6/75	88	110	22	25.00	12	16
1/ 9/75	87	112	25	28.73	11	21
1/15/75	89	112	23	25.84	12	19
1/15/75	88	107	19	21.59	13	15
1/24/75	87	106	19	21.83	13	18
1/25/75	88	109	21	23.86	12	21
1/31/74	93	116	23	24.73	--	--
5/13/74	94	116	22	23.40	12	19
5/11/74	96	115	19	19.79	14	18
5/19/74	94	109	15	15.95	15	19
5/20/74	98	119	21	21.42	15	25
5/20/74	90	114	24	26.66	11	18
5/20/74	92	115	23	25.00	14	19
6/ 2/74	94	116	22	23.40	14	17
6/ 9/74	93	113	20	21.50	14	18
12/16/74	94	121	27	28.72	13	20
12/16/74	98	117	19	19.38	15	25
12/16/74	97	113	16	16.49	14	21
12/20/74	92	117	25	27.17	13	22
12/21/74	93	116	19	20.43	13	19
12/24/74	92	118	26	28.26	13	18
12/24/74	92	116	24	26.08	12	18
12/27/74	97	123	26	26.80	14	19
12/28/74	96	117	21	21.87	14	23

APPENDIX I (Continued)

Date	Carapace Width		Growth		Claw Diameter	
	X	Y	$(Y-X)_A$	$(Y-X)_\%$	C_{pre}	C_{post}
12/28/74	97	117	20	20.61	15	26
1/ 4/75	96	119	23	23.95	14	24
1/ 6/75	92	117	25	27.17	13	17
1/ 7/75	98	124	26	26.53	14	19
1/ 8/75	93	112	19	20.43	13	17
1/13/75	97	124	27	27.83	15	19
1/13/75	96	118	22	22.91	14	23
1/15/75	93	118	25	26.88	13	18
1/17/75	99	123	24	24.24	15	28
1/19/75	97	123	26	26.80	14	19
1/19/75	92	113	21	22.82	13	22
1/19/75	97	122	25	25.77	15	25
1/21/75	96	119	23	23.95	14	26
1/21/75	97	114	17	17.52	14	18
1/24/75	92	119	27	29.34	14	20
1/24/75	95	120	25	26.31	13	18
1/25/75	95	121	26	27.36	14	19
2/ 2/75	96	121	25	26.04	14	19
2/ 3/75	94	119	25	26.59	14	20
3/ 4/75	99	124	25	25.25	15	21
3/22/75	94	122	28	29.28	13	19
2/13/74	101	122	21	20.79	15	25
4/30/74	100	118	18	18.00	15	22
12/11/74	103	128	25	24.27	16	24
12/16/74	109	128	19	17.43	17	26
12/16/74	102	125	23	22.54	16	25
12/22/74	108	134	26	24.07	17	28
12/24/74	103	123	20	19.41	15	26
12/30/74	104	127	23	22.11	--	--
1/ 1/75	103	127	24	23.30	16	27
1/ 1/75	106	129	23	21.69	16	28

APPENDIX I (Continued)

Date	Carapace Width X	Carapace Width Y	Growth $(Y-X)_A$	Growth $(Y-X)_{\%}$	Claw Diameter C_{pre}	Claw Diameter C_{post}
1/ 3/75	104	129	25	24.03	16	28
1/ 4/75	103	126	23	22.33	15	25
1/ 6/75	105	128	23	21.90	17	30
1/ 7/75	102	128	26	25.49	15	21
1/10/75	100	124	24	24.00	15	27
1/10/75	105	127	22	20.95	16	26
1/11/75	105	130	25	23.80	16	28
1/11/75	106	126	20	18.86	15	25
1/13/75	106	128	22	20.75	17	23
1/13/75	108	129	21	19.44	17	30
1/15/75	103	125	22	21.35	16	26
1/15/75	102	127	25	24.50	16	28
1/19/75	105	125	20	19.04	15	27
1/19/75	100	125	25	25.00	15	20
1/21/75	105	130	25	23.80	16	26
1/21/75	106	128	22	20.75	17	28
1/25/75	108	133	25	23.14	17	30
1/29/75	109	132	23	21.10	17	31
2/ 7/75	102	125	23	22.54	18	31
2/11/75	100	126	26	26.00	15	20
2/11/75	109	132	23	21.10	17	26
2/26/75	108	133	25	23.14	18	28
3/16/74	115	139	23	20.00	16	28
12/24/74	113	136	23	20.35	17	30
1/15/75	119	145	26	21.84	19	27
1/22/75	112	137	25	22.32	17	29
1/29/75	117	140	23	19.65	19	31
1/28/75	115	139	29	25.21	18	31
1/28/75	112	132	20	17.85	17	26
1/28/75	114	136	22	19.29	17	27

APPENDIX I (Continued)

Date	Carapace Width X	Carapace Width Y	Growth $(Y-X)_A$	Growth $(Y-X)_\%$	Claw Diameter C_{pre}	Claw Diameter C_{post}
1/31/75	117	143	26	22.22	19	35
2/ 1/75	111	133	22	19.82	17	27
2/ 3/75	114	137	23	20.17	18	30
2/ 4/75	111	136	25	22.52	17	28
2/ 5/75	113	137	24	21.23	18	29
2/ 5/75	112	136	24	21.43	17	32
2/ 6/75	114	140	26	22.80	18	30
2/ 6/75	117	143	26	22.22	19	34
2/ 6/75	115	141	26	22.61	17	31
2/ 6/75	111	136	25	22.52	18	32
2/ 6/75	111	136	25	22.52	18	32
2/ 7/75	110	133	23	20.90	17	19
2/ 9/75	115	139	24	20.87	18	31
2/ 9/75	116	140	24	20.69	18	28
2/10/75	115	140	25	21.74	19	31
2/10/75	118	144	26	22.03	20	34
2/10/75	118	143	25	21.18	19	33
2/10/75	115	145	30	26.08	19	34
2/10/75	113	135	23	20.35	19	33
2/10/75	114	138	24	21.05	18	31
2/11/75	111	132	21	18.92	17	28
2/11/75	110	134	24	21.82	18	29
2/11/75	115	145	30	26.08	17	31
2/14/75	113	137	24	21.23	18	33
2/15/75	111	135	24	21.62	17	30
2/26/75	111	134	23	20.72	17	29
3/ 9/75	113	135	22	19.46	17	32
2/15/74	122	144	22	18.03	21	33
2/15/74	125	149	24	19.20	21	33
3/17/74	126	148	22	17.48	21	33

APPENDIX I (Continued)

Date	Carapace Width X	Y	Growth $(Y-X)_\Lambda$	$(Y-X)_\%$	Claw Diameter C_{pre}	C_{post}
4/26/74	128	156	28	21.87	22	38
1/28/75	127	153	26	20.47	20	34
2/ 1/75	120	145	25	20.83	18	33
2/ 2/75	121	146	25	20.66	19	34
2/ 3/75	122	149	27	22.13	20	30
2/ 4/75	122	148	26	21.31	19	30
2/ 5/75	124	152	28	22.58	20	36
2/ 9/75	123	150	27	21.95	19	31
2/ 9/75	123	151	28	22.76	20	35
2/10/75	120	142	22	18.33	19	30
2/10/75	120	149	29	24.16	20	34
2/11/75	121	146	25	20.66	20	31
2/14/75	127	155	28	22.04	19	33
2/15/75	122	150	28	22.95	20	35
2/21/75	121	148	27	22.31	20	32
2/20/75	120	143	23	19.17	--	--
4/24/74	137	156	19	13.86	--	--

APPENDIX II

Growth per molt; males smaller than 87 mm (held in pens).

Date	Carapace Width		Growth		Claw Diameter	
	X	Y	$(Y-X)_A$	$(Y-X)_{\%}$	C_{pre}	C_{post}
3/25/75	40	52	12	30.00	5	7
5/20/74	63	80	17	26.98	8	10
6/ 1/74	68	86	18	26.47	10	13
6/ 1/74	68	87	19	27.94	9	12
6/ 1/74	68	85	17	25.00	9	13
6/ 1/74	64	80	16	25.00	8	10
1/13/75	67	80	13	19.40	9	11
5/13/75	63	75	12	19.04	9	10
2/18/74	70	88	18	25.71	--	--
3/10/74	77	95	18	23.37	11	14
5/19/74	71	89	18	25.35	10	13
6/ 1/74	76	95	19	25.00	10	14
6/ 1/74	70	85	15	19.73	10	11
6/ 8/74	74	91	17	22.97	11	13
12/13/74	72	93	21	29.16	9	14
1/13/75	75	93	18	24.00	9	13
2/13/74	86	101	15	17.44	12	18
6/ 4/74	84	102	18	21.42	13	15
6/ 9/74	80	101	21	26.25	12	15
12/16/74	81	102	21	25.92	12	16
12/21/74	84	105	21	25.00	12	15
1/ 4/75	86	110	24	27.90	12	18
1/19/75	85	106	21	24.70	12	16
1/28/75	85	108	23	27.05	12	16
5/ 3/75	85	100	15	17.64	13	18

APPENDIX III

Growth per molt; recaptured tagged males.

Date tagged	Date recovered	Carapace Width X	Carapace Width Y	Growth $(Y-X)_A$	Growth $(Y-X)_\%$
11/ 8/72	11/17/73	110	134	24	21.81
10/30/72	12/22/73	118	143	25	21.18
11/ /72	11/15/74	119	147	28	23.52
11/ 6/72	5/ 2/72	125	143	18	14.40
10/31/72	11/ 9/73	126	149	23	18.25
11/10/72	11/13/73	128	150	22	17.18
11/ /72	11/16/74	129	152	23	17.82
11/ 8/72	11/ 9/73	132	157	25	18.93
11/13/72	5/23/75	132	158	26	19.69
11/10/72	7/24/73	133	154	21	15.78
11/ /72	1/15/74	133	156	23	17.29
11/ /72	2/21/74	133	158	25	18.79
11/ /72	12/ 6/73	136	158	22	16.17
11/ /72	--	137	156	19	13.86
11/ 5/72	12/18/73	137	165	28	20.43
11/ 5/72	5/16/75	137	168	31	22.62
11/12/72	5/16/75	139	170	31	22.30
11/ /72	1/18/74	141	169	28	19.85
11/11/72	11/10/73	143	172	29	20.27
11/ 7/72	5/16/75	145	166	21	14.48
11/11/72	4/27/75	146	174	28	19.17
11/ /72	1/15/74	146	168	22	15.06
11/ 6/72	3/18/74	148	177	29	19.59

APPENDIX IV

Growth per molt; males missing (A) 1-3 legs, (B) 5 legs.

	Carapace Width		Growth	
Date	X	Y	$(Y-X)_A$	$(Y-X)_\%$
A. 2/19/75	82	101	19	23.17
12/19/74	93	119	26	27.17
12/17/74	93	114	21	22.58
1/ 7/75	109	132	23	21.10
2/ 9/75	110	133	23	20.90
2/ 9/75	112	135	23	20.53
2/ 9/75	114	142	28	24.56
2/ 9/75	114	138	24	21.05
4/ 6/75	118	138	20	16.95
2/13/75	172	148	26	21.31
2/19/75	127	150	23	23.17
B. 2/ 5/75	72	79	7	9.72
2/ 7/75	71	80	9	12.67

APPENDIX V

Growth per molt; females molting to maturity
(held in pens).

Date	Carapace Width X	Carapace Width Y	Growth $(Y-X)_A$	Growth $(Y-X)_\%$	Carapace width of attending male
5/26/74	68	81	13	19.12	-
5/26/74	69	82	13	18.84	-
1/ 5/75	66	84	18	27.27	-
2/ 3/75	69	82	13	18.84	90
2/ 4/74	74	97	23	31.00	108
2/13/74	74	90	16	21.62	109
2/18/74	76	91	15	19.73	109
5/ 4/74	72	84	12	16.66	114
5/18/74	72	87	15	20.83	110
5/26/74	77	90	13	16.88	123
5/26/74	71	84	13	18.31	120
6/ 4/74	75	89	14	18.66	104
1/ 4/75	77	92	15	19.48	113
1/10/75	74	90	16	21.62	-
2/ 7/75	73	88	15	20.54	104
2/10/75	77	92	15	19.48	107
2/26/75	74	88	14	18.41	79
5/10/75	76	90	14	18.42	96
6/ 4/75	78	91	13	16.66	93
2/ 8/74	84	97	13	15.47	107
2/20/74	87	103	16	18.39	110
2/18/74	88	104	16	18.18	106
2/28/74	83	109	26	31.32	126
2/ 5/75	87	101	14	16.09	114
2/10/75	80	95	15	18.75	116
3/19/75	86	102	16	18.60	127
3/18/75	83	97	14	16.85	127

Date	Carapace Width		Growth		Carapace width of attending male
	X	Y	$(Y-X)_A$	$(Y-X)_\%$	
4/11/75	80	94	14	17.50	106
4/28/75	86	101	15	17.44	112
6/ 8/75	80	96	16	20.00	104
2/ 8/74	94	102	8	8.51	-
2/ 8/74	91	105	14	15.38	-
3/ 4/74	91	102	11	12.09	122
5/ 1/74	93	106	13	13.98	106
4/ 9/75	92	107	15	16.30	119
4/15/75	92	108	16	17.39	109
6/ 9/75	92	107	15	16.30	102

APPENDIX VI

Growth per molt; juvenile females (held in pens).

Date	Carapace Width		Growth	
	X	Y	$(Y-X)_A$	$(Y-X)_\%$
4/28/74	38	49	11	28.94
5/18/74	48	61	13	27.08
4/ 7/75	48	60	12	25.00
3/23/74	56	73	17	30.35
12/11/74	71	87	16	22.53