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GROWTH OF KING CRABS IN THE VICINITY OF KODIAK ISLAND, ALASKA

By:

Guy C. Powell
Division of Commercial Fisheries
Research Section
Kodiak, Alaska

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STATE OF ALASKA
[redacted] GOVERNOR
WALTER J. HICKEL
DEPARTMENT OF FISH AND GAME
WALTER KIRKNESS - COMMISSIONER
SUBPORT BUILDING, JUNEAU

ABSTRACT

Carapace length increments of juveniles and adult crabs of both sexes, Paralithodes camtschatica (Tilesius) were determined from a long range study conducted from 1954 to 1961. Small premolt crabs captured from the natural environment molted in cages while large crabs were tagged and studied upon subsequent recapture. Juveniles increased at a rate of 24 percent per molt in carapace length and attained a length of 100 millimeters at the completion of their fifth year at which time they attained puberty. Average increase per molt for adult females and males respectively was 4 and 20 millimeters. Adult females molted annually. Males molted annually until attaining a length of 143 millimeters at 7 or 8 years of age. At this size a small proportion of male crabs molted biennially. As size increased biennial molting became more prevalent and triennial and quadrennial molting began, consequently size of older crabs overlaps. For example, a 158 millimeter crab could have been 8 or 9 years old and a 175 millimeter crab 9, 10 or 11 years old. Anexuviant or "skip molt" crabs, those that do not molt annually, had exoskeletons that appeared old or very old. The study indicates that most male crabs attain a length of at least 169 millimeters by the age of 10 and molt once biennially during this time.

Note: Final project report for period June 14, 1957 to December 1961, but including data collected previous to contract, starting December 1954. This investigation was conducted with Federal-Aid provided by the Saltonstall-Kennedy Act under Contract Number 14-19-008-9382.

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GROWTH OF KING CRABS IN THE VICINITY OF KODIAK ISLAND, ALASKA

by

Guy C. Powell, Fishery Biologist
Division of Commercial Fisheries
Research Section
Kodiak, Alaska

INTRODUCTION

Management of a fishery to produce maximum sustained yield requires an understanding of many aspects of the life history of the species involved. Particularly important is knowledge of the relationship between size and age, that is, growth rates during the normal life span of the animal. This generalization applies to the management of the fishery for Alaskan king crab, Paralithodes camtschatica.

The objective of this report is to present an overall picture of the early growth data taken from the numerous studies conducted from 1954 to 1961 in the Kodiak Island area. Primary objectives were to determine relationships among molting, growth, size, and age of the king crab from the post larval stage to adulthood.

Two general methods were used: (1) Individual small crabs up to 80 mm. in carapace length were maintained in holding cages through one or more molts, whereby size changes were determined, and (2) large crabs were captured with commercial fishing gear, measured, tagged, and released. Recaptured crabs were measured, and the intervening molting and size changes were determined.

REVIEW OF LITERATURE AND BACKGROUND HISTORY

Crab stocks on the west coast of Russian Kamchatka were in a serious state of over-fishing in 1933 according to Marukawa (1933). Moiseev (1956) relates that the southwestern Kamchatka crab fishery which was organized in 1916 was exhausted only seven years later due to over-fishing. He further states that crab stocks near the southwestern coasts of Sakhalin required conservation to prevent serious depletion.

American stocks of king crabs have not been seriously depleted. The commercial catch of king crab in Alaska by American fishermen was sporadic prior to 1953 and never totaled more than four million round pounds. Information on biological parameters are needed in scientific management in order to determine the restrictive protection necessary to insure maximum catch. In most cases rational exploitation based on scientific findings makes it possible to achieve high sustained yields. Conversely, unrestricted harvest without scientific management may be injurious to a resource. This situation has occurred too often in the past. During 1953-1963 American production increased from 5 million round pounds to 72 million. History of the early industry is presented by Huizer (Alaska Fisheries Board and Alaska Department of Fisheries. Annual Report. Report Number 6, Juneau, Alaska, 1954).

The king crab research program developed simultaneously with the expanding fishery. Knowledge of the biology of Alaskan king crabs was non-existent until September 1940 at which time the first United States expedition began. Although the main objectives of the expedition were aimed towards initiating an American king crab industry, a mathematical study of the relative growth of the various body parts of king crab was made (Wallace, Pertuit, and Hvatum, 1949). World War II interrupted this program and for thirteen years no further work was done.

In 1954 two studies of king crab growth were initiated simultaneously. The Bureau of Commercial Fisheries Biological Laboratory in Seattle, Washington (then Pacific Salmon Investigations) started a program in the Bering Sea (Weber and Miyahara, 1962) while the Alaska Department of Fish and Game (then Alaska Department of Fisheries) began studying the stocks in the vicinity of Kodiak Island. This report summarizes all Kodiak Island king crab growth data collected from 1954 to 1961.

In 1957 two additional studies were started in different Alaskan localities. One in Kachemak Bay of Cook Inlet, Alaska (Bright, Durham and Knudsen, 1960), and the other in the vicinity of the Shumagin Islands of the Alaska Peninsula (Hayes and Montgomery, 1963).

American researchers were handicapped by the lack of available foreign king crab data. Much of the problem stemmed from language barriers and lack of translated material.

Weber and Miyahara (1962), in a review of the king crab growth literature state: "Most of the studies were made by Japanese scientists and depend upon one or combinations of three basic types of data: growth increment per molt and frequency of molt; size frequency distributions from 1 year which shows modes that are indicative of year classes; and size

frequency distribution data taken in successive years to observe the progression of weak or dominant year groups through the years." They further state, "that wide differences in growth rates are indicated, though the difference may in part be due to geographic separation, it appears that there may be some errors in interpretation." Therefore, it seemed important to carefully study the growth rates of king crabs in Alaskan areas separately, such as in the Bering Sea and around Kodiak Island.

Prelude to present study

During the present investigation growth of large crabs of both sexes was determined exclusively by tag and recapture methods because of the superiority of this method. A permanent tag was developed that would be retained throughout successive molts. Analysis of size frequency modes was avoided because of the limitations pointed out by MacKay and Weymouth (1935). They state that attempting to determine the age of a long-lived animal by this method may be seriously limited in that modes may be obliterated by overlapping of successive year groups.

Two shortcomings of a tag and recapture program are, (1) dependence upon the selective commercial fishery for recoveries, and (2) the task of determining the effects of tagging on growth. Neither of these limitations is believed serious enough to prevent obtaining accurate estimates of growth.

King crabs like all arthropods periodically molt their exoskeletons to increase in size. The periodic shedding of the outer protective covering is termed ecdysis. Growth occurs immediately after molting and before the flexible new exoskeleton hardens. A discussion of growth; therefore, is logically divided into length increase per molt and molt frequency sections.

Marmot Bay of Kodiak Island was the principal location in which tagged crabs were released, prior to 1958, primarily because considerable commercial fishing was being conducted within this bay. Commercial harvest increased appreciably in other bays in 1958, therefore Chiniak Bay was selected as a more ideal study area for the remainder of the investigation.

Early studies of 1954-1957 were handicapped by lack of control over tagging vessels. Most of the crabs which were used for tagging were donated by the industry to help reduce operational costs of the research program. Females, sublegal males (below 140 mm. length) and anexuviant males which hand't molted for two or more years were received in this way. An undesirable feature of tagging these crabs is they are avoided by commercial fishermen. Also undesirable is that crabs were tagged and released in small numbers within numerous bays making the possibility of substantial future recoveries

quite unlikely. Beginning in June 1958 the character of tagging programs was changed to emphasize marking only male crabs with subsequent release in large numbers in one locality. Specimens were obtained by a commercial fishing boat under State charter agreement. Boats were required to be equipped with divided holding tanks. Crabs were captured with pots, placed in one section of the tank and brought into the protection of the Kodiak harbor, where under suitable working conditions, they were tagged and transferred to the empty section until release. All tagged individuals were retained a maximum of one day before release.

In 1957 the investigation received additional assistance of federal funds made available through a United States Department of the Interior, Saltonstall-Kennedy contract. By late 1959 the growth study had gained full impetus with the tag and recovery program improving in quantity and quality as a result of previous experience.

This report emphasizes the growth of those crabs recaptured during 1960 and 1961 from the Chiniak Bay 1959 release because of the superiority of these data. Data from other tagging programs, 1954-1959 are presented separately.

A total of 8,862 (7,673 males and 1,189 females) king crabs were tagged and released in the four major bays of Kodiak Island from December 1954 through September 1959 (Figure 1). As of July 23, 1960, 1,501 (1,364 males and 137 females) were recaptured (Table 1). Of these, 645 were again returned to the ocean resulting in 106 additional recoveries. All instances of crabs released and recaptured more than one time are excluded from the tag and recovery data to avoid confusion. Only initial tagging and first recapture is recorded and analyzed. Of the 1,501 recoveries 835 were from the Chiniak Bay 1959 tagging.

Nine hundred of the recaptured tagged crabs (815 males and 85 females) showed increases in length. The other 601 provided no growth data because they were caught prior to ecdysis or because recovery measurements were lacking.

The smallest crab tagged and released was 63 mm. long; however, captive crabs as small as 30 mm. have been tagged successfully. Tagging and recapture was not a practical method for studying length increase per molt for small crabs because handling crabs of this size is difficult and time consuming, and returns are small since commercial fishing gear is selective for large crabs only.

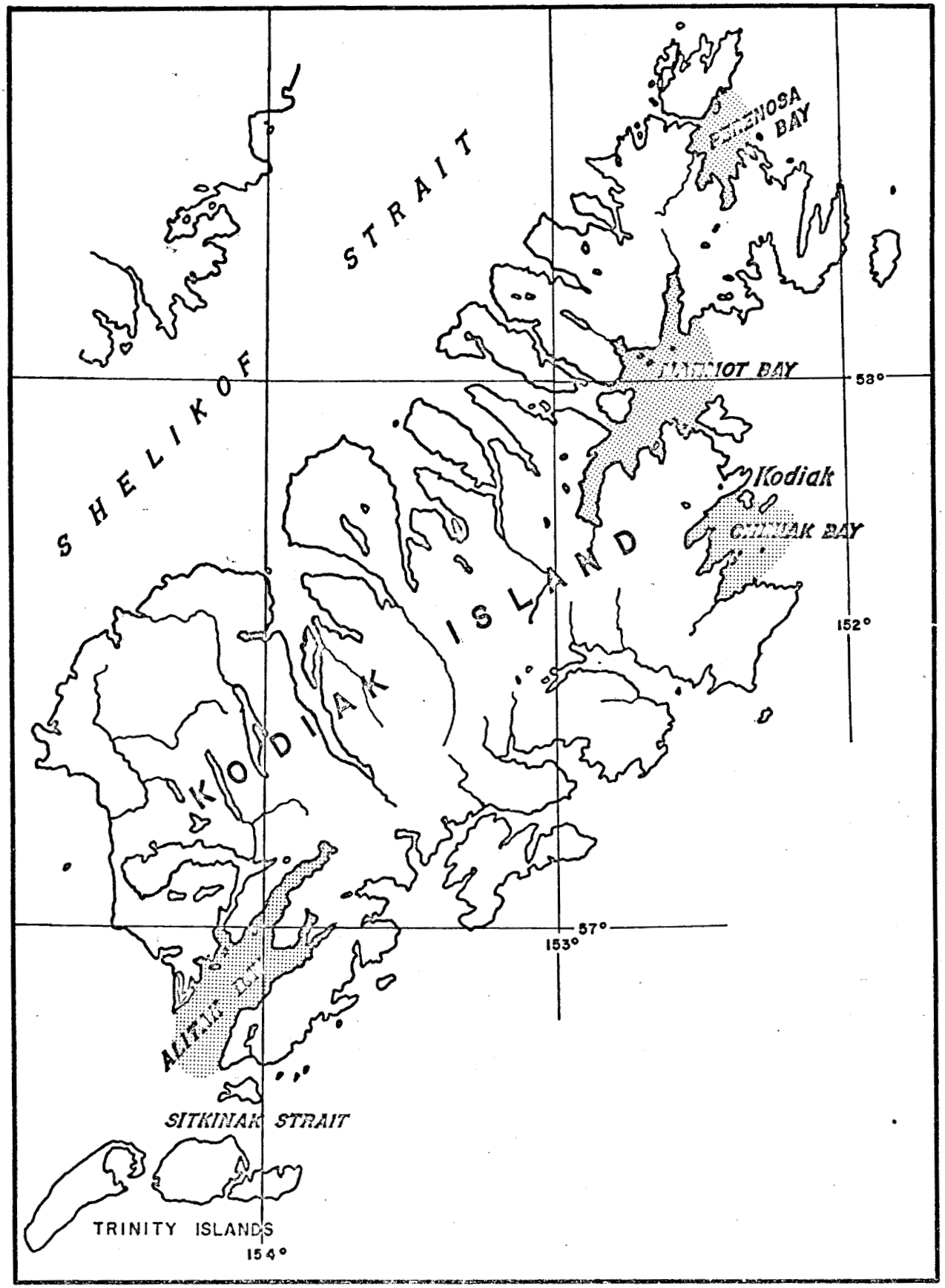

Figure 1. Four major fishing areas where crabs were tagged and released, Kodiak Island 1954-1959.

Table 1. Number of tagged king crabs released from 1954-1959 in the Kodiak Island area and number recaptured up to July 23, 1960, showing those contributing growth data, measurement accuracy data, and tags only (recoveries from Chiniak Bay 1959 are included up to November 30, 1961).

YEAR	BAY RELEASED AND MONTH	TOTAL RELEASED		TOTAL RECAPTURED		MALE			FEMALE			TOTAL
		Male	Female	Male	Female	Growth	Accuracy	Tag Only	Growth	Accuracy	Tag Only	
1955	Marmot (January)	25	474	16	104	12	0	4	74	0	30	120
1955	Marmot (October-November)	178	289	26	18	17	2	7	6	8	4	44
1956	Marmot (July)	0	2	0	1	0	0	0	0	1	0	1
1957	Marmot (November)	318	0	56	0	44	0	12	0	0	0	56
1959	Marmot (September)	648	0	23	0	2 1/	16	5	0	0	0	23
	TOTAL	1,169	765	121	123							
1954	Chiniak (December)	106	26	3	1	2	0	1	1	0	0	4
1955	Chiniak (January)	0	10	0	0	0	0	0	0	0	0	0
1956	Chiniak (March)	17	0	0	0	0	0	0	0	0	0	0
1957	Chiniak (October)	53	0	5	0	3	1	1	0	0	0	5
1958	Chiniak (May-June)	2,469	1	306	1	33	248	25	1	0	0	307
1959	Chiniak (September)	3,271	0	835	0	670 2/	143	22	0	0	0	835
	TOTAL	5,913	37	1,149	2							
1956	Alitak (September)	201	0	43	0	18	2	23	0	0	0	43
1956	Alitak (April)	56	143	5	1	0	2	3	1	0	0	6
1957	Alitak (February)	29	163	2	1	1	0	1	1	0	0	3
1958	Alitak (January)	105	0	16	0	5	6	5	0	0	0	16
	TOTAL	391	306	66	2							
1956	Perenosa (March)	81	2	2	0	2	0	0	0	0	0	2
1956	Perenosa (July)	119	79	26	10	6	1	19	1	1	8	36
	TOTAL	200	81	28	10							
	GRAND TOTALS	7,673	1,189	1,364	137	815	421	128	85	10	42	
		8,862		1,501		1,364			137			1,501
						1,501						

1/ One crab molted after recapture and is omitted from growth analysis.

2/ Twenty-six crabs possessed regenerating legs and so were omitted from the growth analysis.

METHODS

Measurements

Carapace length and width -- The only linear measurements taken of king crab are carapace length and width. Length measurements are less subject to error by compressing the carapace because the exoskeleton is much more rigid in this dimension. All references to crab size throughout this text are to carapace length expressed in mm. The length is the distance from the posterior margin of the right eye orbit of the carapace to the center of the posterior carapace margin (Figure 2). The width is the distance between lateral margins taken across the middle of the back and between the spines.

A 25 cm stainless-steel vernier caliper graduated in mm is used to measure crabs larger than 60 mm carapace length. Small crabs are measured with a 12 cm caliper also graduated in mm. Lengths are used exclusively in discussing the results presented in this report. Widths serve only as a check on measurement accuracy.

Body weight -- Small crabs were weighed with a Welch triple beam balance to the nearest one-tenth gram. Larger crabs were weighed with a general laboratory and animal balance which is accurate to the nearest 3 gms. Crabs were blotted and wrapped in cloth bathroom towels to remove excess moisture before weighing. During tagging crabs are measured before being released but not weighed because of the difficulty involved while working among the adverse conditions associated with tagging aboard a small boat. Useful weight estimates can be computed from carapace length however.

Shell Age Determination

Exoskeletal age is the basis for determining molt frequency. The same system utilized by Weber and Miyahara (1962) was used during the present study. The classification of shell types includes "new", "old" and "very old". During any given year, beginning with the period immediately after the molt, shell appearance progresses gradually from the class "new" to the class "old". If molting does not occur at the end of the first year, shell age progresses from "old" to "very old" during the second year. Again if molting does not occur, the crab becomes a triennial molter and shell age increases even more. Fishermen refer to these crabs as "graveyards."

Ventral coxal surfaces of the walking legs progressively become browner as a result of abrasive action from contact with the ocean bottom. There is variation among large and small crabs because the later molt more frequently preventing "old" shells from developing, and because ventral surfaces of small crabs evidentally do not experience as much abrasive action with the bottom.

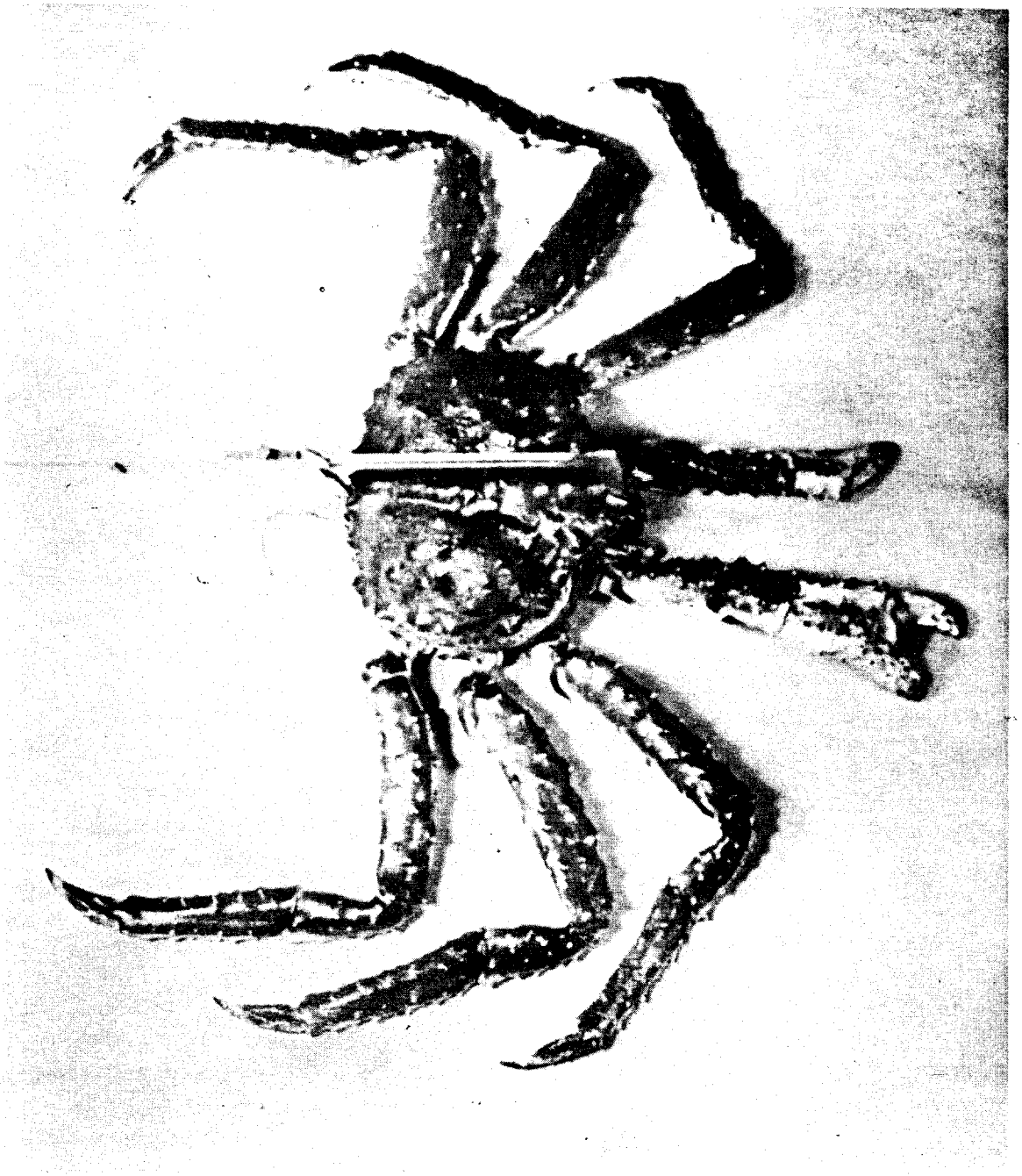

Figure 2. Standard method of measuring the carapace length of king crabs larger than 60 mm using a 12-inch vernier caliper.

A nine month-old shell of a small crab appears much newer than a similar aged shell of a large crab. Other indices which aid in determining the age of exoskeletons are: abundance of fouling organisms, barnacle size groups, and appearances of the surface of the meri.

Holding Small Crabs Captive

Growth of juvenile crabs too small for tagging was studied by placing late premolt specimens in aquaria, wire covered cages, or sunken pens until they molted and size increase could be recorded. Small premolt crabs (as large as 80 mm) are dark purple and during collecting trips are easily selected from among postmolt crabs by skin diving biologists. This method was successful for small crabs but not for larger ones which molt less frequently and are less available to divers.

Crabs larger than 80 mm appear to stunt in cages while small crabs do not, perhaps because they were held longer periods of time prior to molting. The few crabs less than 80 millimeters that were held captive the maximum of 40 days and which had regenerating appendages, produced increases similar to those held briefly and without injuries so they were included in the growth analysis in order to enlarge sample size. Most of the juveniles molted within 1 to 7 days after capture.

Facilities for holding post larval crabs (3-20 mm) were standard glass aquaria with a capacity of 30 gallons. Ocean water was oxygenated and circulated with piston pumps.

Weighted, wire-covered, wooden frame cages were used for holding crabs 20 to 80 mm in carapace length, having as their most desirable feature, the capability of being lowered to the bottom and raised to the surface when desired. A rotating boom mounted centrally on a floating raft together with a block and four, provided the mechanical advantage necessary for one man to easily lift the boxes to the surface (Figure 3).

Sunken bottomless pens provided a holding facility for crabs 50 to 80 mm and more closely simulated the natural environment than cages (Figure 4). Dimensions of the pens, constructed of one inch steel rod and sewed with stainless steel web for siding and top, were 10 by 10 by 3 feet. Two large doors in the top provided easy access to the interior. The use of pens was made possible through the use of SCUBA gear, including neoprene rubber wet suits for year-round diving (Figure 5). Use of SCUBA as an aid to king crab research is described (Anonymous, 1960).

Tagging Procedure

Marking king crabs is accomplished by guiding a curved steel needle,

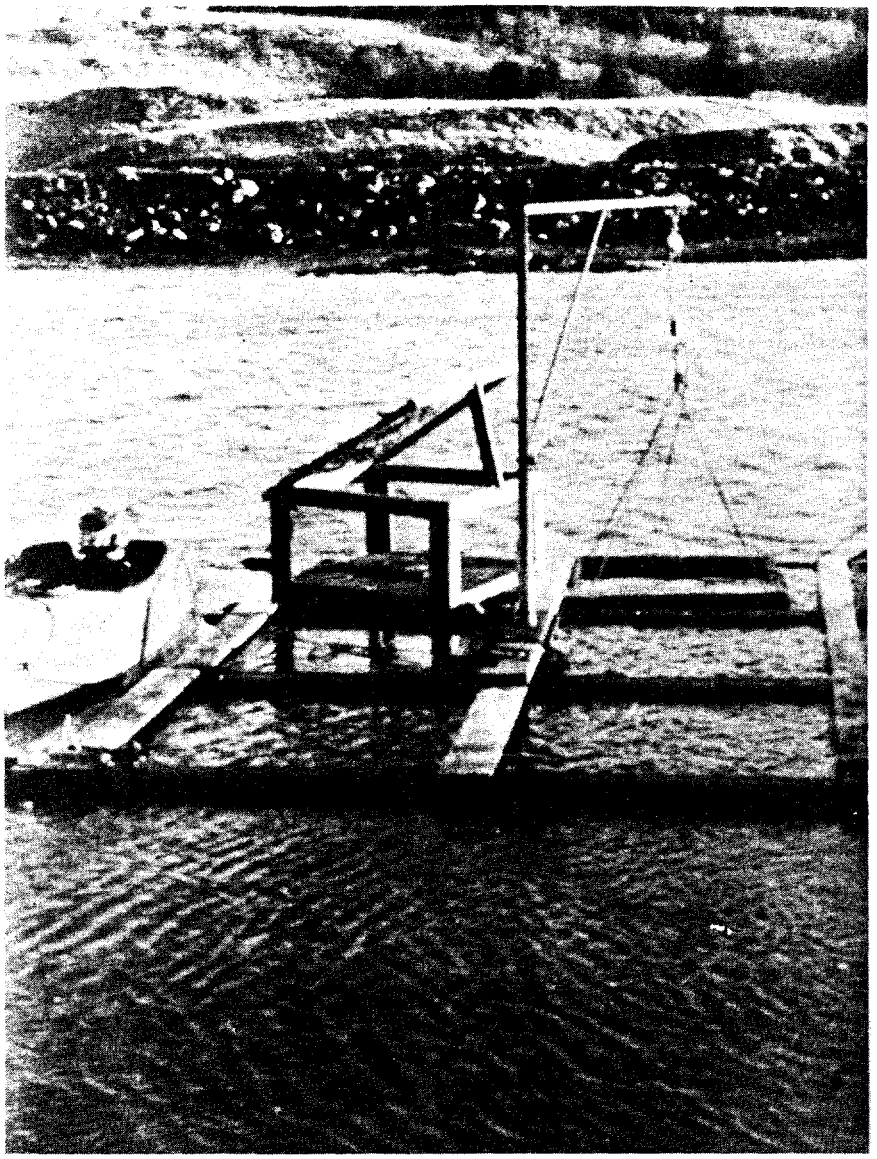

Figure 3. Weighted wooden holding cage illustrating method for lowering and raising.

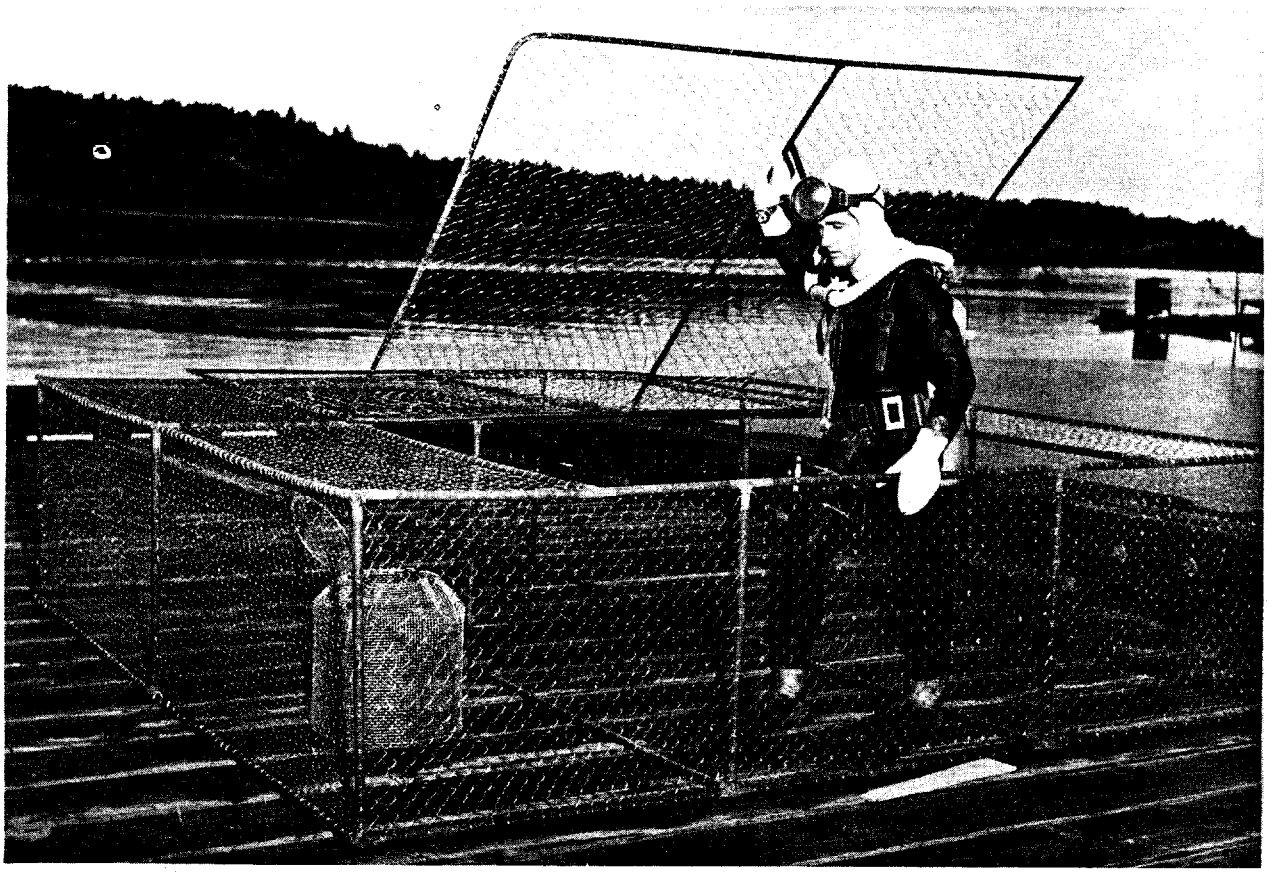

Figure 4. Bottomless pen attended by SCUBA diving biologist.

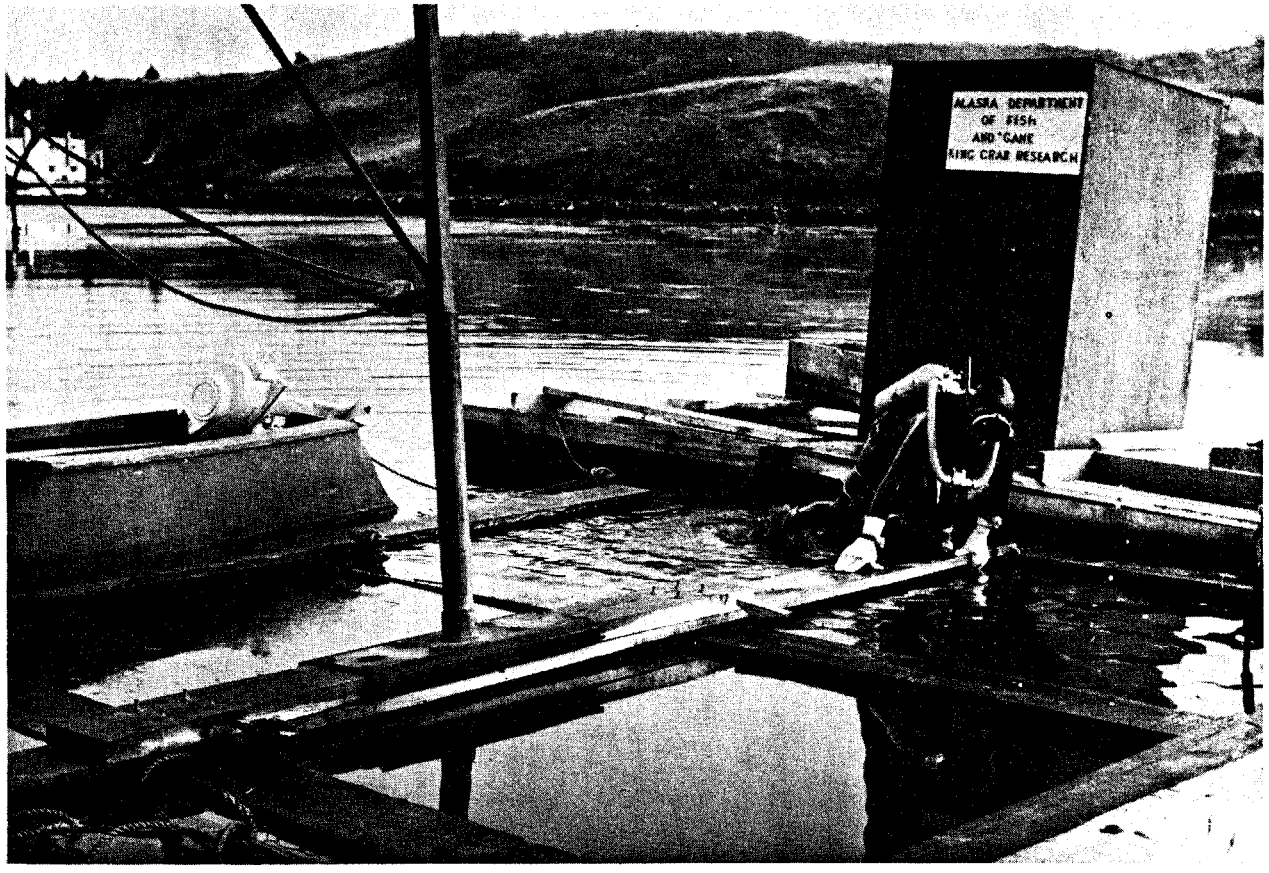

Figure 5. Foating raft facilities with boom for lowering and raising holding cages utilized in conjunction with year-round diving.

with hollow plastic tubing attached, through the muscular isthmus. The isthmus is located between the posterior ventral portion of the cephalothorax and the abdomen (Figure 6). The needle is removed from the plastic upon completion of insertion and the ends of the tube are tied to prevent the tag from slipping free.

Tagging procedures are described by Hayes (1961) and in the Alaska Department of Fisheries annual report (1954).

King crabs are marked with permanent loop tags capable of being retained throughout successive molts. The maximum time a tagged crab has been at large before recapture is six years (Powell, 1965). Retention is successful because the arthrodial membrane covering the isthmus undergoes dissolution prior to molting, thereby freeing the tag and allowing the soft crab to withdraw from the old shell while the tag remains attached.

SIZE AT SEXUAL MATURITY

Sexual maturity of female king crabs is easily determined by the presence or absence of externally developing eggs. Determining maturity of male king crabs, however, is a difficult task because there is no obvious external change.

One possible method for determining the sexual maturity of male crabs is the use of measurements of various body parts. Wallace, Pertuit, and Hvatum (1949), and Kurata (1961) have observed changes occurring in the relative growth of body parts at the size when males were expected to become mature; however, the data is not refined for practical use.

At present the only known method for determining sexual maturity of male crabs is histological examination of the cells lining the reproductive tract. Wallace, Pertuit, and Hvatum (1949) state that it is known that actively secreting cells become hypertrophied and examination of these cells for relative degree of proliferation and hypertrophy during the mating season may be indicative of mature specimens. Using this system, and with an incomplete series of specimens, they found the smallest mature male to be 100 mm in length and the largest immature to be 84. These lengths closely parallel those at which females attain sexual maturity and it seems probable that both sexes may become mature at the same time.

Marukawa (1933) referring to size at sexual maturity, states that biological minimum size of crabs from the west coast of Kamchatka and the vicinity of Nemuro is attained when the carapace reaches a width of 90-100 mm (these measurements correspond to carapace length measurements of 80-90 mm.). In

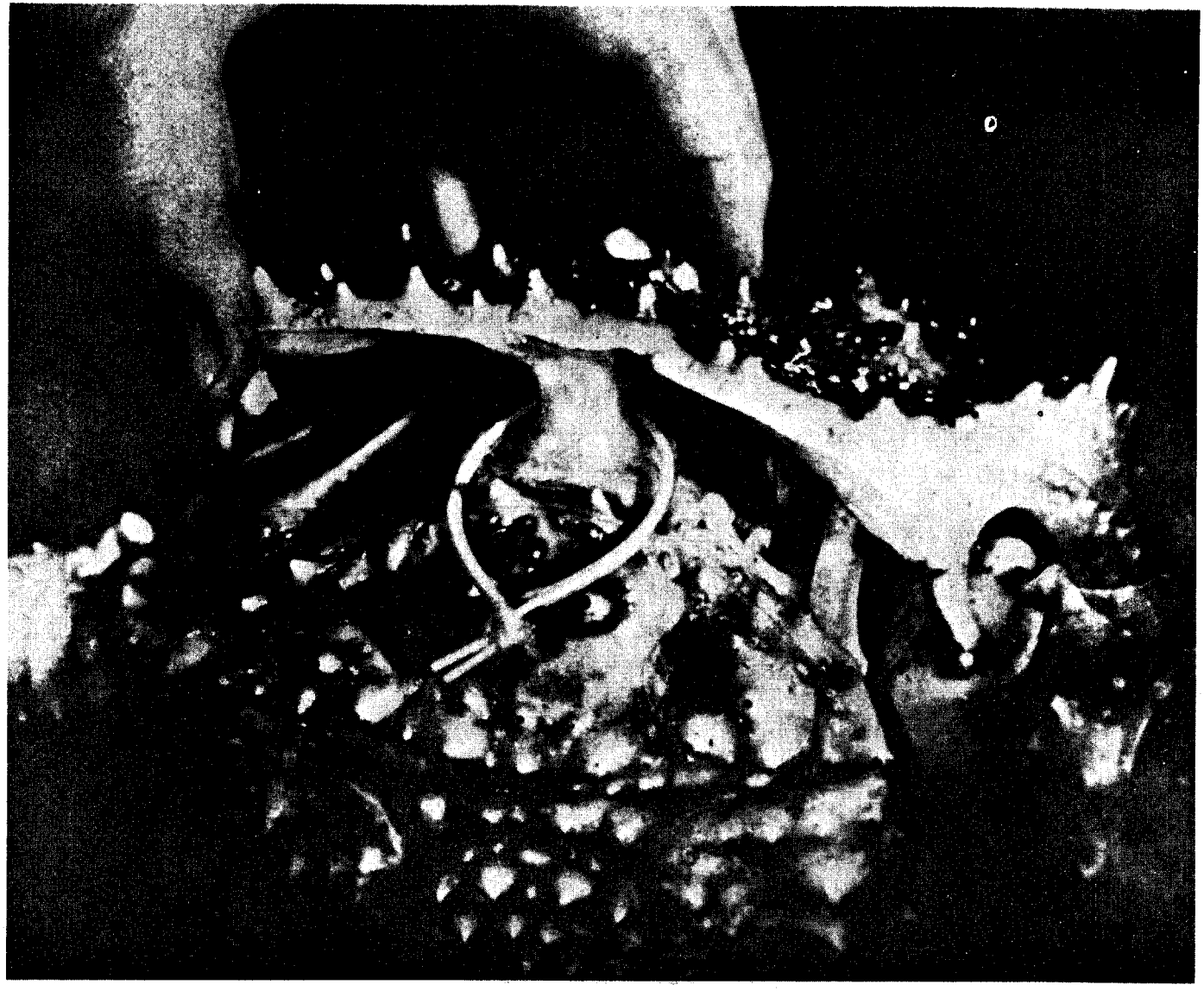

Figure 6. Posterior view of king crab showing white plastic tube threaded through the isthmus.

addition he says the biological minimum size is larger for crabs from the Nemuro region. Unfortunately he does not describe the techniques he used.

Wallace, Pertuit, and Hvatum (1949) relate that, "southeastern Bering Sea females become ovigerous at lengths ranging from 86 to 102 mm, while in the Pacific Ocean this state is reached at lengths ranging between 93 and 112 mm." More recent data from the Pacific Ocean is compatible. The smallest ovigerous females among 3,468 individuals examined in 1958 in Chiniak Bay was 95 mm long (Powell, 1958). Most were ovigerous at 113 mm; only 4 larger than 120 mm were barren.

MAXIMUM SIZE

The maximum size attained by king crabs varies throughout their range, becoming greater for those stocks to the east, from Japanese waters to those off Kodiak Island, Alaska. The maximum length (in millimeters) of males and females is 168 and 150 respectively for crabs from Japanese waters (Marukawa, 1933), 197 and 170 for those from the Bering Sea (M.M. Wallace, C.J. Pertuit, and A.H. Hvatum, 1949), and 227 and 195 for those around Kodiak Island. The maximum lengths stated for male and female crabs from Japanese waters are approximate because they had to be converted from width measurements (Marukawa, 1933, 200 and 160 mm respectively).

CRAB WEIGHT

The logarithmic graph showing the relationship between carapace length and total weight for male and female crabs from Chiniak Bay July 1960, is best represented by a straight line; however, the slope of the line for females declines at the approximate length of 110 mm and continues below that of males (Figure 7). Wallace, Pertuit, and Hvatum (1949) show a similar relationship among Bering Sea crabs. Only those crabs which molted in the spring of 1960 were used in the Chiniak Bay sample. Those covered with fouling organisms and with missing or regenerating legs were excluded. Strong evidence that the decline is attributed to attainment of female maturity is the presence of incubating eggs among all females this size. Simultaneous with maturity is a decline in female growth per molt.

The length-weight relationship may vary among seasons as a result of increasing meat yield following ecdysis. Preliminary studies show that yield of cooked meat is lowest just before and after the April molt, followed by a rapid increase the next three months (Powell and Nickerson, 1965). By mid-July meat yield is high enough to resume commercial exploitation. Increase

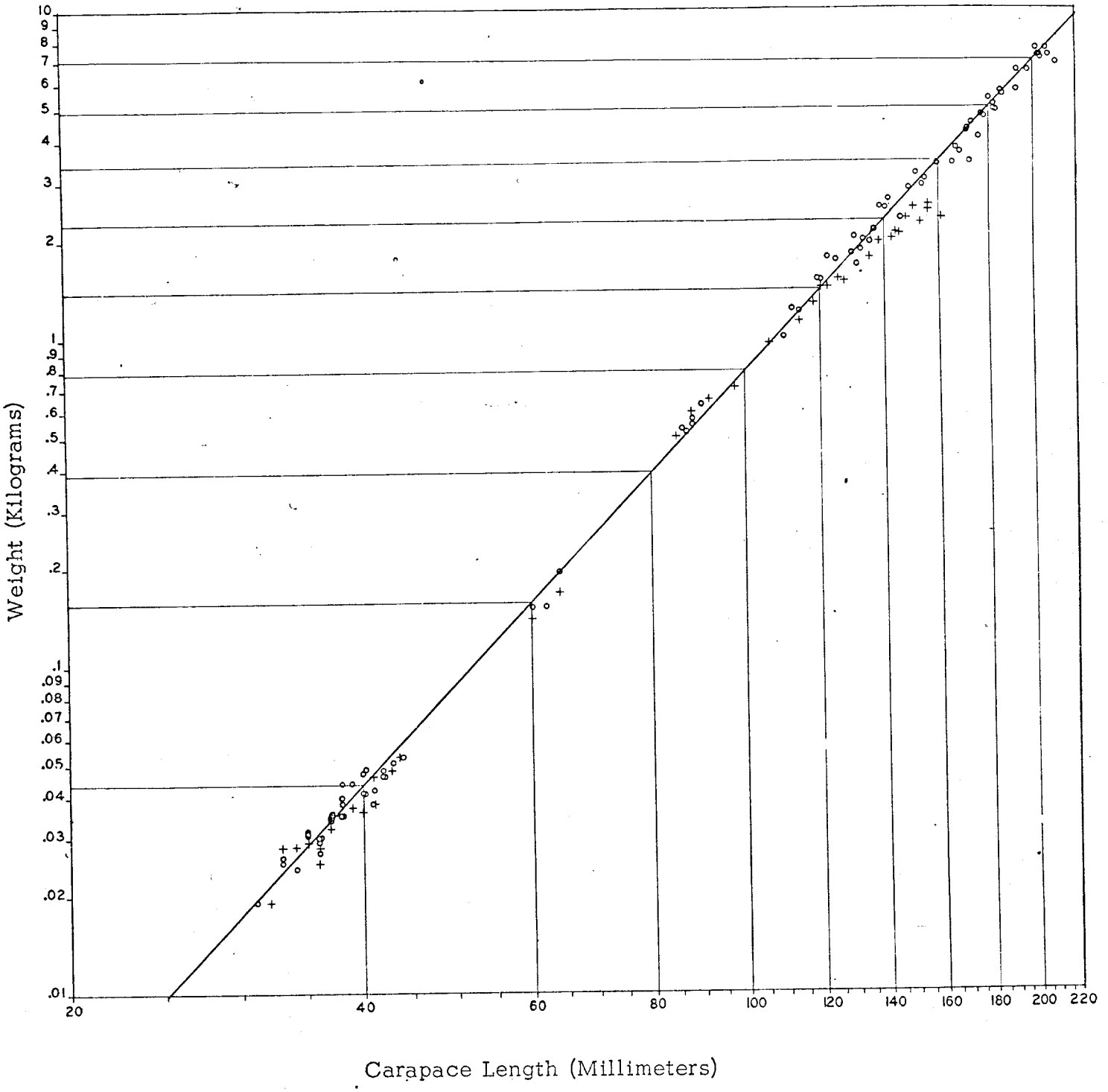

Figure 7. Logarithmic graph of king crab carapace-length crab-weight relationship for Chiniak Bay, July 1960 (Males 0; Females +).

after this time is small and gradual. Comparison of meat yield from annual and biennial molters of similar size revealed slightly greater quantities among the anexuviants but not enough to encourage harvest exclusively of old shell crabs. Maximum annual production would be attained by harvesting crabs at their critical size before anexuviation occurred.

Both male and female crabs attain a weight of approximately 1.4 kg at the age of 6 years when carapace length is approximately 118 mm. Weight increases of male crabs are considerable with each molt after the sixth year. By the time a male is 203 mm in length it will weigh approximately 7.1 kg and may be from 11 to 14 years of age, depending upon molt frequency. If molting is annual, maximum length and weight (227 mm and 11 kg) could be attained at age 13.

GROWTH

Two facts are important in understanding growth of king crabs. Growth occurs immediately after molting, and molt frequency decreases with age. Since juveniles molt more than annually, young adults annually, and old adults less than annually, it seemed appropriate to discuss growth accordingly in three separate sections.

Data are presented in terms of carapace length as (1) percent increase per molt for juveniles, (2) as increase per molt for young adults, and (3) average annual increase for old adults. Growth of juveniles will be discussed first.

Juveniles

A total of 159 juvenile male and female crabs ranging from 10 to 69 mm in length molted in captivity and steadily increased in carapace length at a rate of 24 and 23 percent per molt respectively (Figure 8 and Table 2). Growth of individual females is presented in Appendix Table 1, that of males in Appendix Table 2.

Six crabs, 70 to 80 mm, averaged an increase of 21 percent with each molt. Five grew while held in cages, the sixth grew in the natural environment and was the smallest tagged crab recaptured. Growth was similar in both instances.

Rate of increase per molt for 21 crabs 81 to 100 mm in carapace length (size prior to or immediately after attaining sexual maturity) declined to 18 percent and was derived entirely from male tag recoveries (Table 3). Five

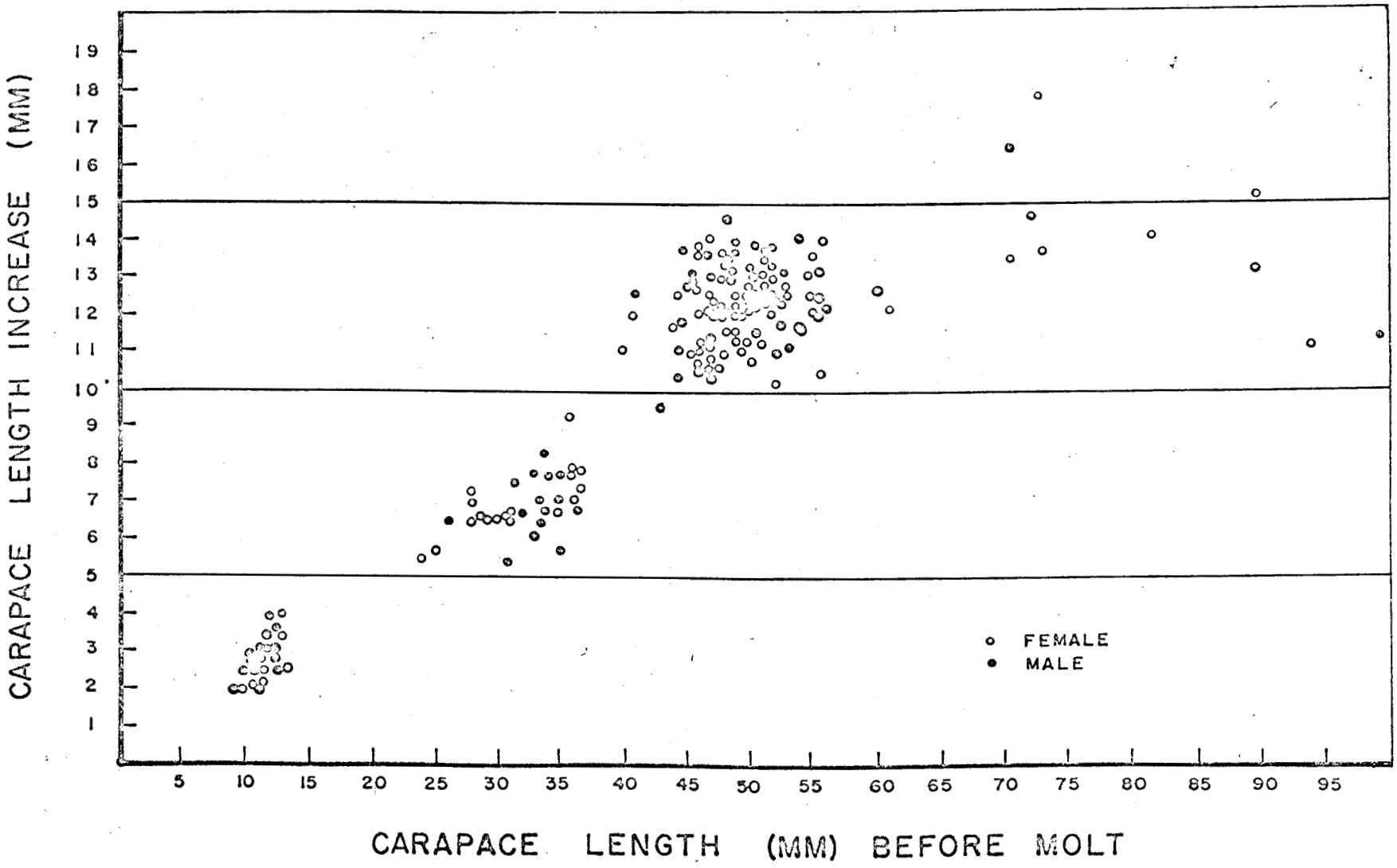

Figure 8. Carapace length increase per molt for juvenile male and female crabs from Chiniak Bay, 1959 molting in holding cages and aquaria.

Table 2. Average increase (carapace length)per molt by size groups for 169 juvenile king crabs of both sexes which molted in cages, Chiniak Bay, 1960. 1/

	Carapace length before molt	Males	Average rate of increase	Females	Average rate of increase	Total crabs
	mm.	Number	Percent	Number	Percent	Number
	10-20	16	24	7	21	23
	21-40	16	21	17	22	33
	41-69	49	25	54	24	103
Sub-total and average for sub-total		81	24	78	23	159
	70-80	2	21	3	21	5
	81-100	1	11	4	15	5
Total		84	-	85	-	169

1/ Growth of the 5 largest crabs, 81-100 mm is omitted from analysis because retardation is indicated when compared with growth of tag recoveries.

Table 3. Growth per molt for the 21 smallest juvenile male tag recoveries (81 to 100 mm at release) which were free one year, Chiniak Bay, 1959 tagging program. 1/ 2/

Tag recoveries	Carapace length at release	Average length increase	Range of length increases	Average length increase
Number	mm	mm	mm	Percent
2	86	14.5	14-15	16.9
2	87	17.0	16-18	19.5
1	90	16.0	16	17.8
2	93	17.5	17-18	18.8
2	94	18.0	18	18.0
3	95	19.0	19	19.0
3	96	18.7	16-21	19.5
2	97	17.5	16-19	18.0
1	98	19.0	19	19.0
3	99	17.7	17-19	17.9
Total 21 and averages	94	17.6	-	18.0

1/ One recaptured tagged crab from Chiniak Bay 1959 is omitted from this table. It was released at a carapace length of 76 mm and grew 21 percent.

2/ The 12 recoveries smaller than 101 mm from tagging programs other than Chiniak 1959 were excluded from this table because of greater inaccuracy in earlier data (Appendix Table 5).

crabs, 81-100 mm, molted in cages but their lower growth was omitted from final analysis because of possible retardation. The one male and four females averaged 14 percent increase per molt (Table 2).

It is interesting to note that the only female crab marked as a juvenile (98 mm) was recaptured as an adult measuring 122 mm (tag #704 Appendix Table 3). This female was free two molt season's and is believed to have molted once as a juvenile and once as an adult. Since the average increase for small adult females is approximately 6.2 mm and this particular female grew 25 mm, the increase as a juvenile was 18.8 or 19 percent which compares quite favorably with the average of 18 percent for the males in this size grouping.

Adults

Growth rates of adults, generally considered those larger than 100 mm in length, were determined exclusively by tagging. Preliminary attempts to rear adult crabs gave spurious results. Size frequency distributions of commercial catches were not attempted because of the cogent criticisms by MacKay and Weymouth (1935) as mentioned in the introduction.

Females - - A total of 1,189 female crabs were tagged from 1954 to 1957. By July 23, 1960, 137 had been recaptured (Table 1). The average length increase per molt for the 73 crabs free one year decreased with size and ranged from 6.2 to 2.8 mm for crabs 110 to 169 mm in carapace length before molt (Table 4). The average annual increase per molt for 85 crabs free from 1 to 6 years ranged from 3.8 to 4.8 mm (Table 5). Actual increases for these crabs are plotted in Figure 9 and are presented in Appendix Table 3. The salient feature is that adult female crabs grow an average of approximately 4.4 mm in carapace length annually.

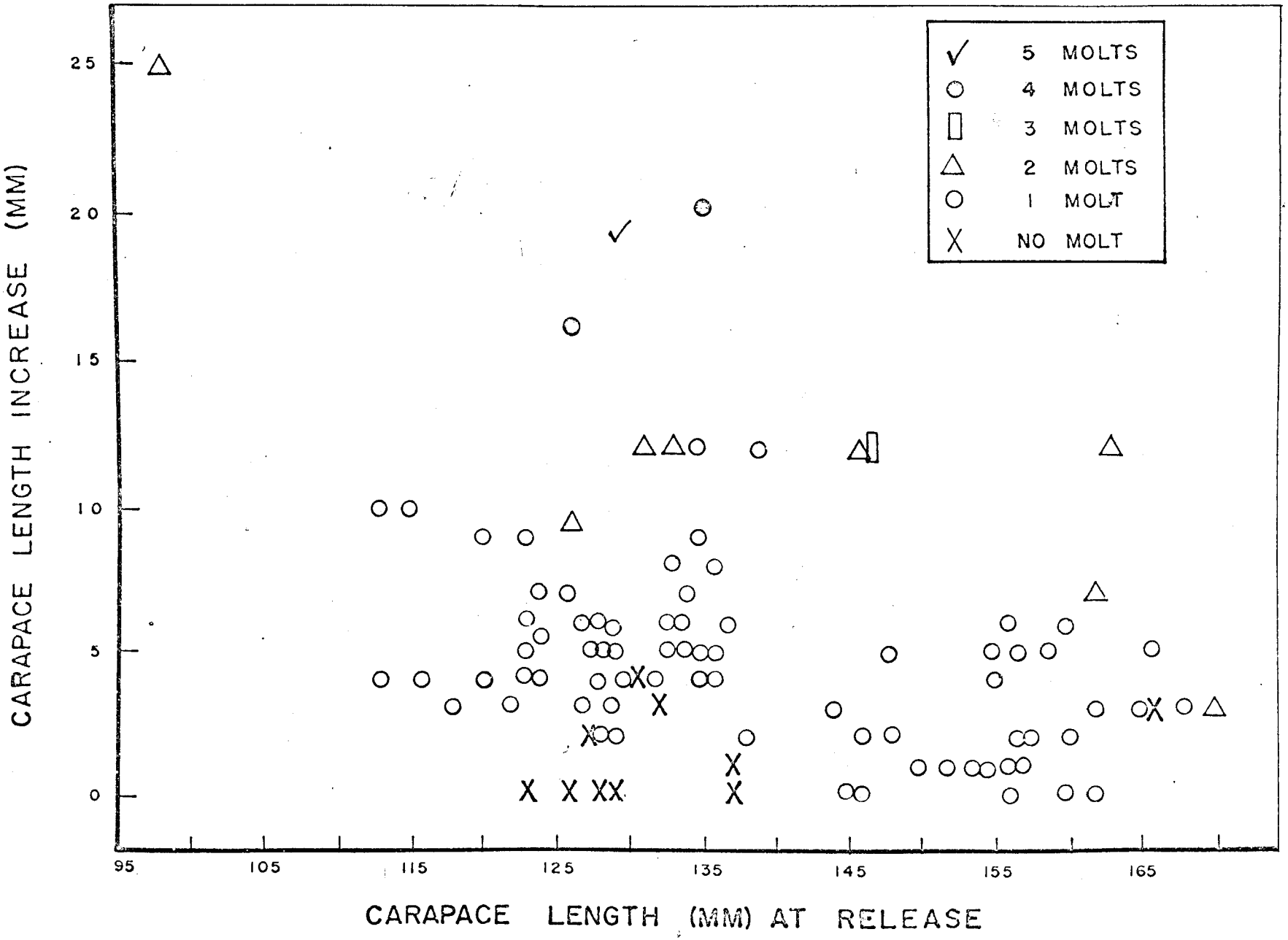

Figure 9. Carapace length increase for 85 large female crabs free one to five years and an indication of measurement accuracy for ten crabs captured before molting.

Table 4. Average increase by size groups for 73 adult female tag recoveries molting one time. 1/

Size group, carapace length	Female recoveries		Average length increase per molt
mm	Number		mm
110-119	5		6.2
120-129	23		5.1
130-139	17		5.9
140-149	6		2.0
150-159	14		2.5
160-169	8		2.8
Total	73	Average for total	4.4

1/ Five crabs 145 mm or larger molted but did not increase in length; these crabs are included in the averages (Appendix Table 3).

Table 5. Average annual increase (length per molt) of 85 female tag recoveries larger than 105 mm carapace length at release and free 1-6 years.

Tag recoveries		Duration of freedom		Average annual increase per molt
Number		Years		mm
73		1		4.4
7 1/		2		4.8
1		3		4.0
2		4		4.5
1		5		3.8
1 2/		6		4.3
Total 85	Range	1-6	Average for total	4.4

1/ Female tag number 704 is omitted because it molted once as an immature and once as an adult (Appendix Table 3).

2/ This tagged crab was captured after the July 23, 1960 closing date for returns but is included in this table for its value attributed to prolonged freedom. The data is not used in the final analysis.

Males -- Adult males experience considerably greater growth increments after molting than do females. A total of 7,673 male crabs were tagged and released during the 6 year period 1954 to 1959 in Marmot, Chiniak, Alitak and Perenosa Bay (Table 1). Length frequency distributions of releases and recoveries from the four major tagging studies, Chiniak Bay 1958 and 1959, and Marmot Bay 1957 and 1959, are presented in Table 6.

Only the Chiniak Bay 1959 investigation yielded enough recoveries for separate growth analysis. Recoveries from other programs were inadequate either because of limited releases, high tag loss due to poor quality plastic, limited commercial fishing, or a combination of these factors. In addition, the growth of the Chiniak Bay 1959 recoveries is discussed separately because the data contained fewer variables. Improvements included (1) tagging of male crabs only, (2) tagging only new-shell crabs, (3) releasing crabs in one bay rather than in many bays, (4) conducting tagging operations within two week period rather than throughout a prolonged period, (5) having only one measurer and one tagger, (6) marking many crabs of various sizes, and (7) availability of more accurate measuring instruments. Figure 10 illustrates the greater measurement accuracy which resulted with improved calipers.

By November 30, 1961, 835 of the 3,271 crabs released in Chiniak Bay in 1959 had been recovered (Appendix Table 4). Recoveries by 12 month intervals following release totaled 451, 318 and 65 respectively. One hundred forty-three recoveries provided an index for measurement accuracy, since they were captured before molting, i.e. length at release could be compared to length at recapture. Growth data was obtained from 670 crabs captured after molting, and 22 were tag only recaptures yielding no growth data (Table 1).

Of the 670 recoveries which were useful in growth determinations, 360 were free one molt season and 284 two molt seasons. Twenty-six possessed regenerating appendages and so were excluded from analysis because injuries on adults appears to retard growth.

Average carapace length increase per molt of the 359 male king crabs free one year was 19.7 mm. The one anexuviant crab which did not grow is excluded from analysis. Recoveries were grouped into 13 size classes of 5 mm each. The range, mean and 95 percent confidence limits of the length increases for each group are plotted in Figure 11. Analysis of variance tests showed significant differences in growth increments between size groups. The salient feature of these data is that the growth increment becomes larger with increasing size from 16.0 mm for crabs 74 to 91 mm in carapace length to 20.6 for crabs 122 to 126 mm. Growth increments remain similar for those crabs from 127 to 151 mm. Increments of crabs larger than 151 were calculated from the growth of crabs molting annually during two years of freedom and were found to decline to approximately 16 to 17 mm per molt.

Table 6. Length distribution of the 6,706 tagged crabs released, and 722 subsequent recoveries that contributed to growth and molting data, four major tagging programs, recoveries up to July 23, 1960. 1/

Carapace length at release	Number of king crabs in each tagging program							
	Chiniak Bay 1959		Marmot Bay 1959		Chiniak Bay 1958		Marmot Bay 1957	
	Releases	Recoveries	Releases	Recoveries 2/	Releases	Recoveries	Releases	Recoveries
Mm.	No.	No.	No.	No.	No.	No.	No.	No.
Sub legal-sized crabs								
60-79	106	3	49	0	306	1	5	0
80-91	323	22	208	0	481	8	26	4
92-96	288	21	134	0	257	3	33	2
97-101	285	40	82	1	186	3	72	12
102-106	354	60	56	0	92	2	42	9
107-111	404	77	38	0	53	0	32	4
112-116	403	86	20	0	62	3	37	2
117-121	312	79	17	0	70	3	30	2
122-126	212	60	13	0	57	3	10	2
127-131	195	61	10	0	86	1	14	2
132-136	188	66	6	0	113	1	10	4
137-141	112	48	4	0	133	2	7	1
Legal-sized crabs								
142-146	60	13	4	0	162	3	0	0
147-151	26	8	0	0	122	0	0	0
152-156	1	0	2	0	91	0	0	0
157-161	2	0	1	0	56	0	0	0
162-166	0	0	2	0	41	0	0	0
167-171	0	0	0	0	37	0	0	0
172-176	0	0	1	0	17	0	0	0
177-181	0	0	1	0	22	0	0	0
182-186	0	0	0	0	13	0	0	0
187-191	0	0	0	0	8	0	0	0
192-196	0	0	0	0	3	0	0	0
197-201	0	0	0	0	1	0	0	0
	3271	644	648	1	2469	33	318	44

1/ Recoveries from Chiniak Bay 1959 are included up to November 30, 1961.
2/ Twenty-six injured recoveries are omitted.

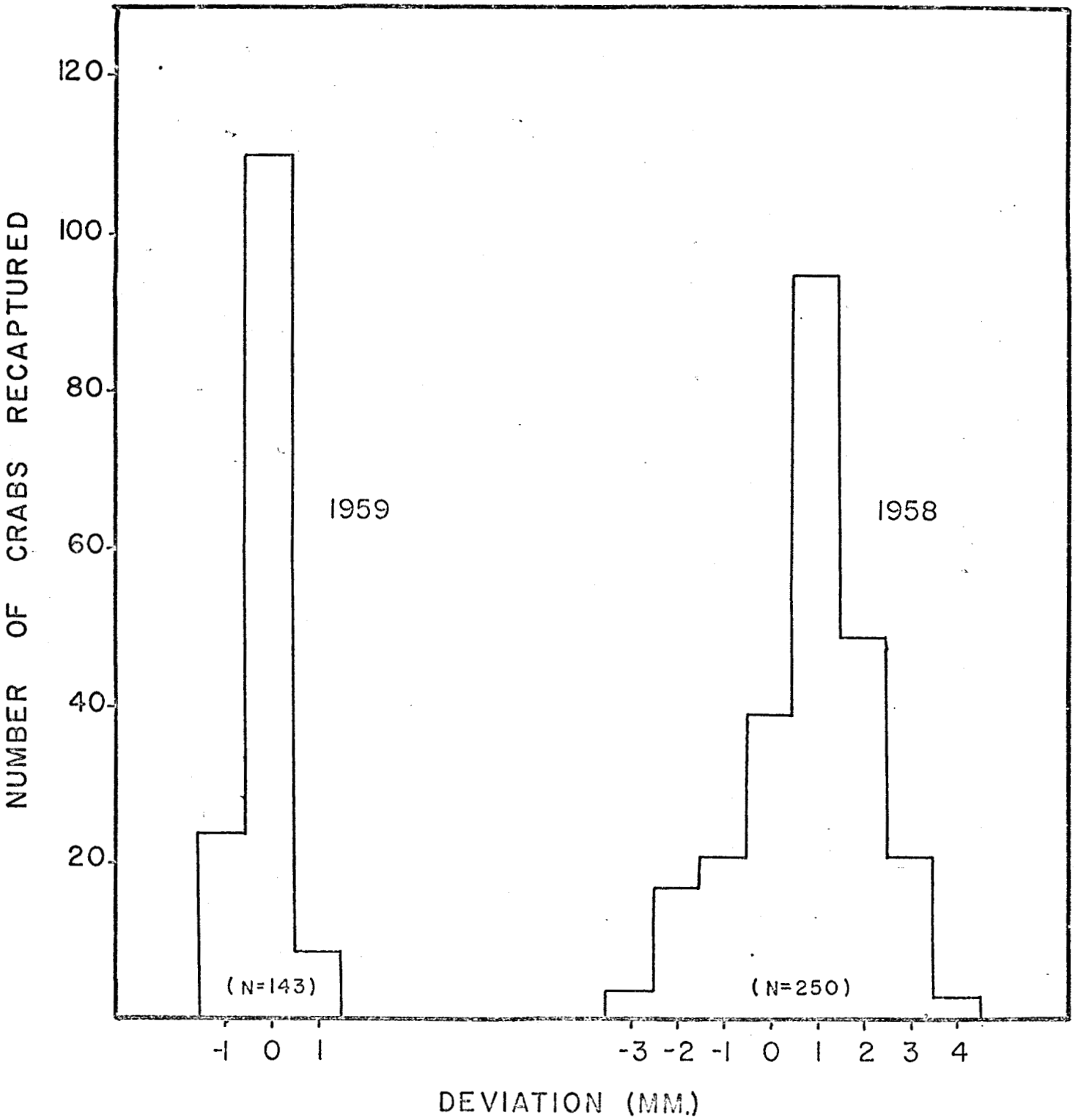

Figure 10. Deviation between length measurements taken at release and again at recapture for non-molting crabs tagged during 1958 and 1959, illustrating that improved measuring techniques had been achieved.

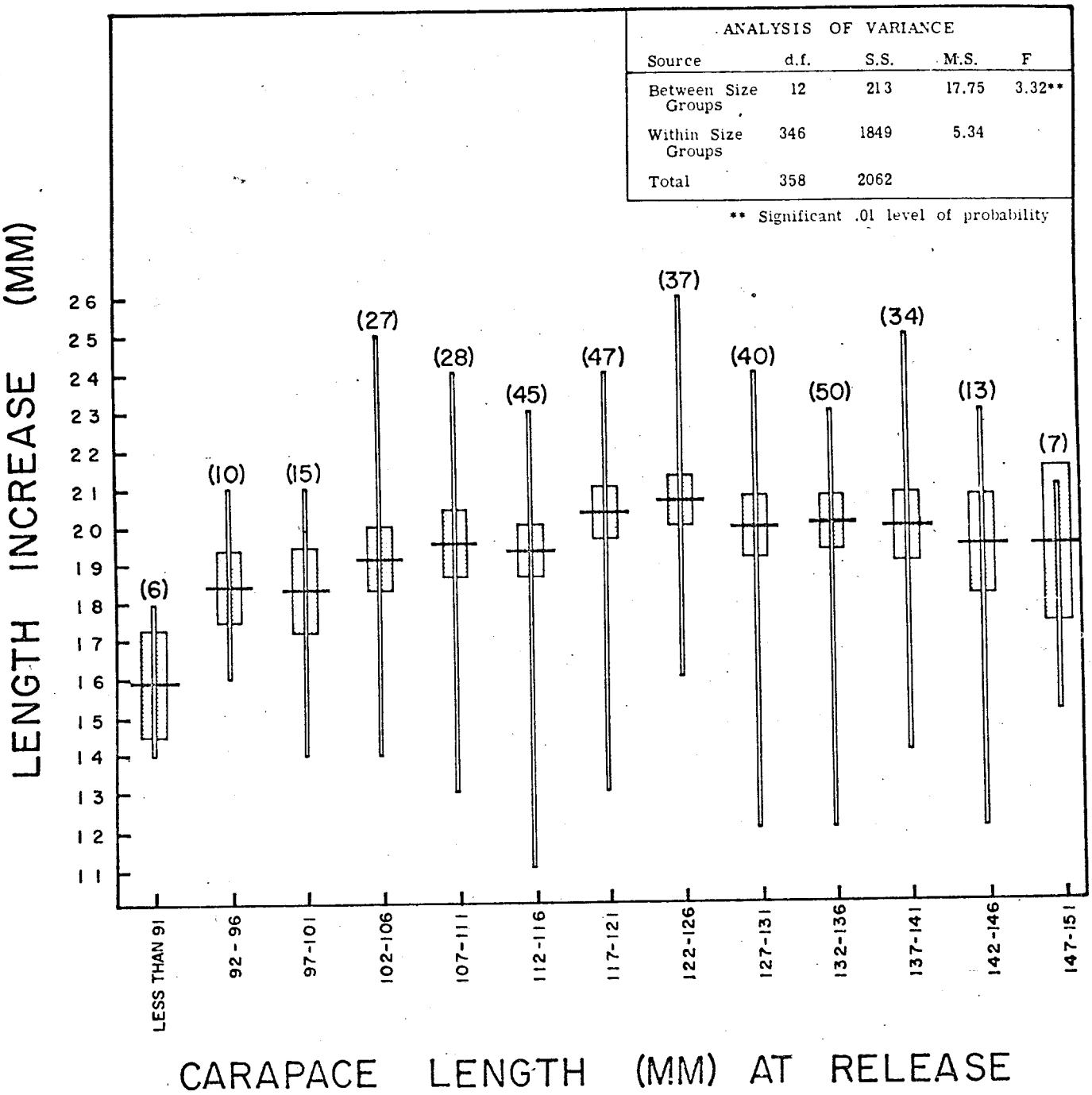

Figure 11. Average increase in carapace length for 359 king crabs recaptured after one molt, Chiniak Bay 1959, presented for size groups at release. Sample size is in parenthesis (.95 confidence limits).

Average length increase for each molt of the 284 male king crabs free two years before capture was 17 mm. The range, mean, and 95 percent confidence intervals of length increase during two years of freedom for each size group are plotted in Figure 12. These features merit comment. First, for crabs in most size groups free two years, increases in carapace length were quite similar. Second, the higher ranges but not means for the first three size groups suggests a few but not many of these crabs molted three times rather than two. Finally, the lower means for the last three size groups indicate that numerous crabs molted once. Visual examination of the exoskeletons of the 25 crabs which molted once revealed that growth occurred the first year free. Time of molting was evident because each crab was recaptured with a very old shell. A comparison of the growth of crabs for one and two years is tabulated in Table 7. Length increases for all crabs recovered from the 1959 tagging at Chiniak are plotted in Figure 13. Steplike growth and increasing spread in size among crabs molting twice are clearly revealed here.

In addition to the 1959 Chiniak data discussed above, recoveries of male crabs tagged in other years at Chiniak and at other localities furnish some information on crab growth. A total of 4,402 crabs, excluding those from Chiniak 1959, were released in four principal bays around Kodiak Island and 529 subsequent recoveries were made by July 23, 1960 (Appendix Table 5). Of these recoveries 142 provide growth data. Crabs free 1, 2, 3, and 4 years respectively numbered 70, 59, 11 and 2.

Average length increase with each molt for those free 1 through 4 years in that order was 16.7, 17.2, 17.7, and 15.5 mm (Table 8). Growth differences are essentially the same. Increases during the entire time at large are plotted in Figure 14.

Inadequate quantitative growth data exists for crabs larger than 150 mm. The largest crab to grow after one year at large increased 17 mm in carapace length, from 146 at release to 163 at recovery. Some knowledge of growth of larger crabs was obtained from recoveries of smaller crabs free two or more years. For example a crab released at 132 mm was recovered at 194 mm and had averaged 15.5 mm annually for the four years it was at freedom. The largest of 6 crabs which molted annually during 3 years of freedom increased 58 mm, from a carapace length of 126 to 184 mm, averaging 19.5 mm each year.

MOLT FREQUENCY

King crabs periodically exuviate or shed their exoskeletons with consequent enlargement of the newly formed integument. Time interval between molts progressively increases from a minimum of approximately three weeks for early post larval juveniles to a maximum of four years for adult males. Molt frequency

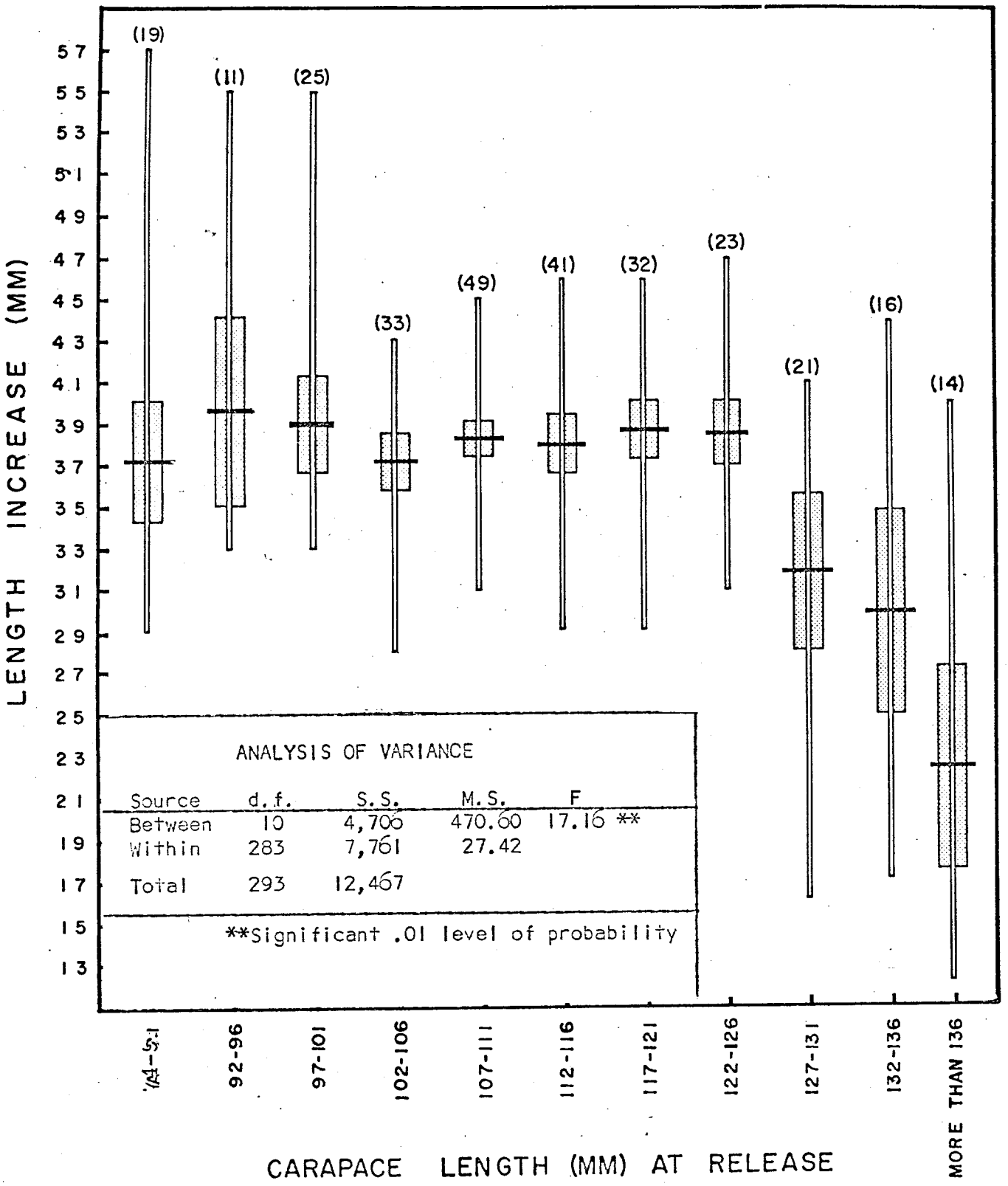

Figure 12. Average increase in carapace length of 284 king crabs recaptured after 2 years, Chiniak Bay 1959, presented for size groups at release. Sample size is in parenthesis (.95 confidence limits).

Table 7. Growth of recaptured tagged crabs free one and two years, Chiniak Bay releases, 1959.

Length when released	Free One Year		Free Two Years							Average annual increase
		Average increase per molt		Crabs Molting			Average increase per molt for crabs molting			
	Recoveries		Recoveries	Once	Twice	3 Times	Once	Twice	3 Times	
Mm.	Number	Mm.	Number	Numbers			Millimeters			Mm.
72-76	1	16.0	1	0	1	0	-	17.5	-	17.5
77-81	0	-	1	0	1	0	-	18.5	-	18.5
82-86	2	14.5	4	0	4	0	-	17.0	-	17.0
87-91	3	16.7	13	0	12	1	-	18.2	19.0	19.0
92-96	10	18.4	11	0	10	1	-	19.1	18.3	19.8
97-101	15	18.3	25	0	23	2	-	18.9	17.7	19.5
102-106	27	19.1	33	0	33	0	-	18.6	-	18.6
107-111	28	19.5	49	0	49	0	-	19.2	-	19.2
112-116	45	19.3	41	0	41	0	-	19.0	-	19.0
117-121	47	20.3	32	0	32	0	-	19.4	-	19.4
122-126	37	20.6	23	0	23	0	-	19.3	-	19.3
127-131	40	19.9	21	7	14	0	20.7	18.7	-	15.9
132-136	50	20.0	16	7	9	0	20.4	18.6	-	15.0
137-141 1/	34	19.9	10	7	3	0	18.6	18.5	-	12.1
142-146	13	19.4	3	3	0	0	17.7	-	-	17.7
147-151	7 2/	19.4	1	1	0	0	20.0	-	-	20.0
Total	359		284	25	255	4				

1/ The average annual increase of crabs larger than 136 at release is combined on Figure 12 because only 11 of the crabs which were free two years molted twice.

2/ The only anexuviant among the first year recoveries was one released at 148; it is excluded.

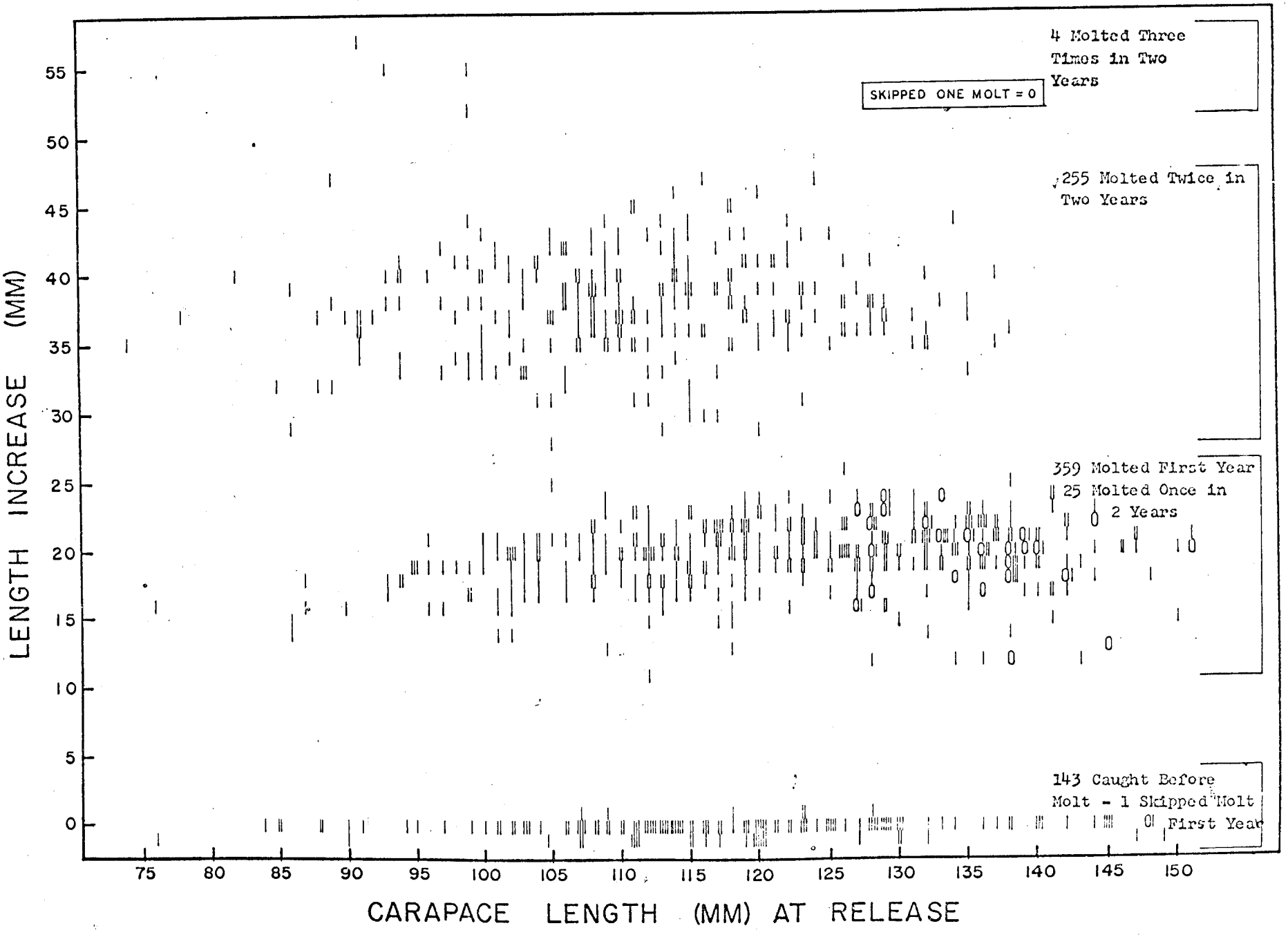

Figure 13. Increase in carapace length of 787 tagged crabs recaptured during two years following release, Chiniak Bay 1959, (26 recoveries excluded because of regenerating appendages).

Table 8. Average length increase per molt and average annual length increase of 142 male crab recoveries free from 1-4 years, all tagging programs except Chiniak Bay, 1959.[1/]

Totals and averages	Years free				Summation of four years
	1 year	2 years	3 years	4 years	
Total number of recoveries	70	59	11	2	142
Number of crabs molting each year free	66	51	6	1	124
Number of crabs molting more than once annually	0	3	0	0	3
Number of crabs skipping one molt	4	5	5	1	15
Average length increase per molt	16.7	17.2	17.7	15.5	17.0
Average annual length increase	15.7	16.9	15.9	14.1	16.2

1/ Three recoveries showing growth were excluded as being unreliable (Appendix Table 5).

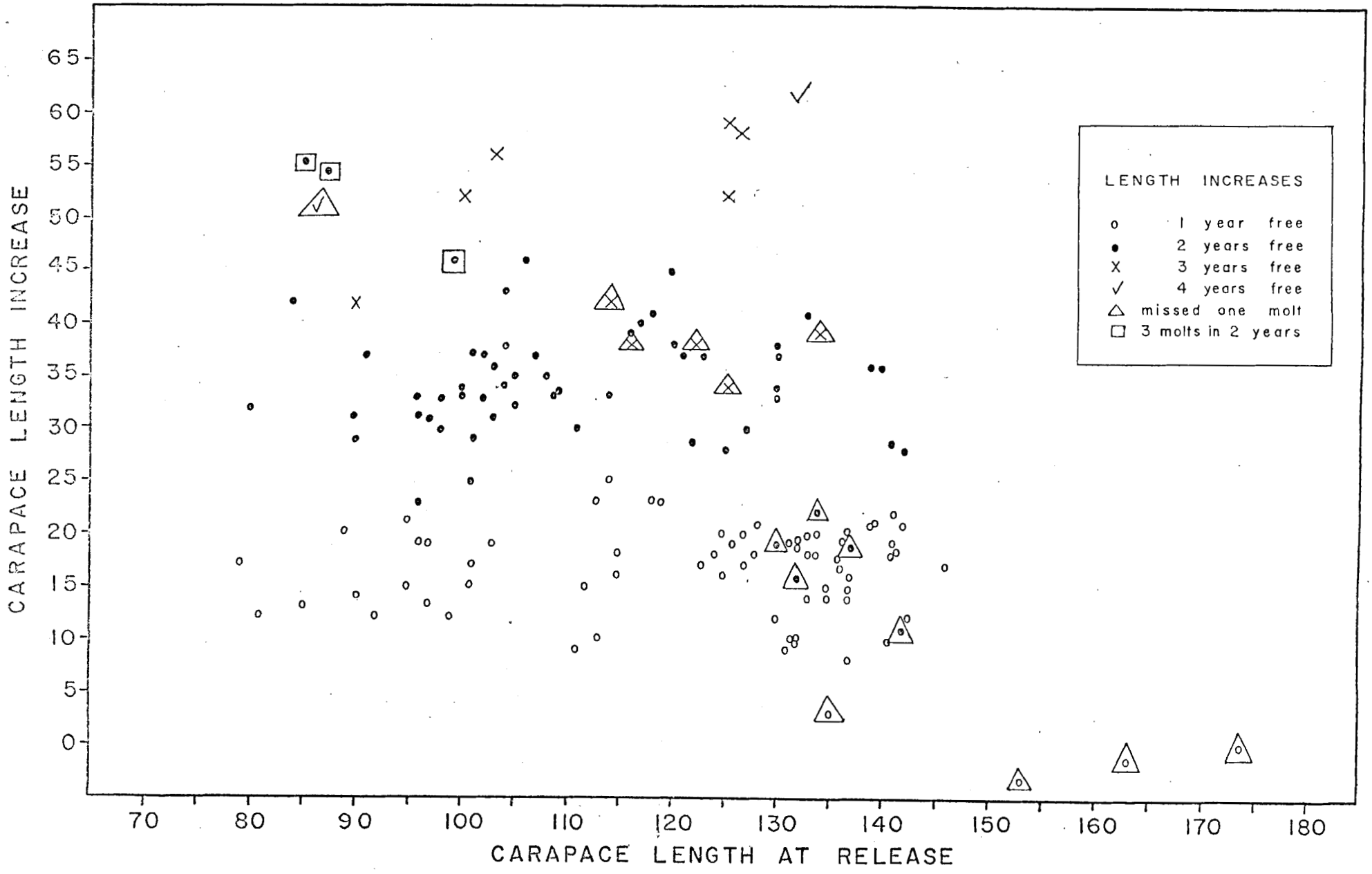

Figure 14. Increase in carapace length (mm) of 142 male king crabs recaptured 1-4 years after release in the various bays: Alitak, Chiniak, Marmot and Perenosa, 1954-1959 excluding only the [illegible] tag rec[illegible]

for juveniles of both sexes is similar. After attaining sexual maturity in the fourth or fifth year, young adults molt annually. Molting of adult females is correlated with reproduction, consequently ecdysis occurs annually throughout adulthood just prior to each year's breeding. Ecdysis of male crabs apparently is a function of growth independent of reproduction. Adult males molt annually through the seventh year after which time increased proportions of each successive age class molt biennially, triennially or even quadrennially. Crabs which molt less than annually are termed anexuviants.

Molt frequency during the first four years could not be obtained directly so was computed for each age class using length and rate of growth. Length frequency modes for each age class at the end of the annual growing period were obtained through the use of skin diving gear. Molt frequency was subsequently calculated by using the growth rate of 24 percent per molt, which was obtained during the length increase studies.

Molt frequencies of crabs larger than 80 mm were obtained exclusively through tagging and recapture programs. In order to determine the number of times a recaptured crab molted the following criteria were examined: number of molt seasons at large, growth in length, appearance of exoskeleton at recapture, and the correlation between total increase and known growth per molt. Molt frequency determinations are accurate because contrasting appearances exist between exoskeletons of crabs which grow and those which do not, and because molting adult crabs all exuviate during the same time period (late winter-early spring season).

Juvenile crabs molt many times throughout the first year and several times the second. The intermolt interval gradually increases until molting becomes annual during the early spring of the fourth or fifth year. Eight two year old crabs kept in cages for twelve months in 1959 (average initial length 38 mm) molted during June, July, August, October, February, and March with maximum activity during July and February. SCUBA divers have observed similar molting periods of small crabs in the natural environment. Holding crabs in captivity for extended periods of time to determine molt frequency was considered a poor method because of the difficulty in duplicating conditions of the natural environment. In spite of this, the 8 crabs which were kept in cages for 12 months in 1959 each molted two times, complimenting data obtained from calculations.

Seventy-nine percent or 241 of the 306 smallest male tag recoveries (71 -109 mm in carapace length at release from all tagging programs) were captured after the molting season and had increased in size (Table 9). Analysis of these recoveries revealed that molting occurs primarily during January, February, and March for crabs this size with limited ecdysis during November, and December (Appendix Tables 6 and 7). The frequency distribution of length at release for these 306 recoveries appears in Table 10. The 226 recoveries which were from the Chiniak September 1959 tagging showed that each of the 189 recoveries cap-

Table 9. Length frequency distribution of the 306 smallest male tag recoveries 71-109 mm in length showing number of crabs which molted and grew within three size groups.

Carapace length at release	Crabs increasing in size						
	Chiniak Bay 1959		Other tagging programs		Total		
	no	yes	no	yes	no	yes	sum
Mm.	No.	No.	No.	No.	No.	No.	No.
71-76	2	2	1	0	3	2	5
77-94	8	37	7	13	15	50	65
95-109	27	150	20	39	47	189	236
Sub total	37	189	28	52	65	241	306
Total	226		80		306		

Table 10. Length frequency distribution of the 306 smallest male tag recoveries 71-109 mm in length at release by tagging program.

Carapace length range	Tagging Program: Chiniak Bay 1959	Marmot Bay 1957	Marmot Bay 1959	Chiniak Bay 1958	Perenosa Bay 1956	Alitak Bay 1956	Chiniak Bay 1954	Total
Mm.	Number of Recoveries							
71-76	4	0	1	0	0	0	0	5
77-81	1	1	0	2	0	0	0	4
82-86	9	0	1	3	0	0	0	13
87-91	21	3	0	8	0	0	0	32
92-96	22	2	3	6	0	0	0	33
97-101	45	12	2	11	1	0	0	71
102-106	69	9	2	5	0	1	1	87
107-109	55	3	1	1	1	0	0	61
TOTALS	226	30	10	36	2	1	1	306

tured after December 1959 had molted, and each of the 117 captured after December 1960, 19 or more months later, had again molted (Table 11). Recoveries during January, February, and March are scarce but those of April, May, and June are numerous and reveal that molting occurs prior to April. Large adults molt during April and May; consequently commercial fishing declines markedly at that time.

Juvenile king crabs too small for tagging increase in carapace length at a rate of 24 percent with each molt. Successive sizes after each ecdysis were computed starting with the smallest crab of 2.5 mm. Length frequencies were used in conjunction with these computations and revealed that juveniles of both sexes molt 7 to 8 times the first year, 4 to 5 times the second, 2 or 3 the third, and 1 or 2 times the fourth year attaining a length of 84 mm after 16 or 17 molts.

Recoveries of small tagged crabs indicate some biannual molting among the larger juveniles. The smallest crab tagged and subsequently recaptured was released at a length of 71 mm. A total of 117 small crabs (71-109 mm in carapace length at release) were recaptured after having grown. These crabs were liberated in Chiniak Bay in 1959 and were free from 19-27 months before capture. This freedom interval encompasses two spring molting seasons when considering annually molting crabs. Four of these 117 crabs, or 3 percent, molted biannually. In addition to these 4 crabs, 2 other or 17 percent of 12 tagged in Chiniak Bay in 1958 molted biannually (Tables 12, 13 and Appendix Table 7).

The author does not know during what month these biannually molting crabs grew and since they were not soft when they were recaptured it seems most likely that they molted biannually during their first year of freedom when they were still small and when their intermolt period would more likely be less than a year.

The six biannually molting crabs were considered to have molted three times rather than two because two increments of 27 mm each is inconsistent with known growth whereas an average of 18 mm for three molts is compatible (Table 13). For convenience, annual molting is considered as beginning at a carapace length of 80 mm, since proportionally few crabs 71-109 mm molted biannually. Increased tagging is necessary before a more definite value can be obtained.

No dependable field method to predict ecdysis is known; therefore, it is presently impossible to determine if tagged old-shelled crabs recaptured during the molting season are in the premolt stage of ecdysis and would have molted if they weren't captured.

Male tag recoveries captured before June which did not grow were

Table 11. An indication of the molting season and molting frequency provided by observing when growth appears for the 226 smallest tag recoveries 71-109 mm in length at release from Chiniak Bay, September 1959 (recoveries up to November 31, 1961).

Recovery Date		Number spring molting seasons free	Number of molts: None	One	Two	Three	Total
			Number of Crabs				
Mo.	Year	No.	No.	No.	No.	No.	No.
Sept.	1959	0	9	0	0	0	9
October	1959	0	20	0	0	0	20
Nov.	1959	0	1	0	0	0	1
Dec.	1959	0	7	0	0	0	7
January	1960	0	0	1	0	0	1
Apr-June	1960	1	0	21	0	0	21
July-Aug.	1960	1	0	41	0	0	41
Sept.-Dec.	1960	1	0	9	0	0	9
March	1961	1	0	0	2	0	2
April	1961	2	0	0	5	0	5
May-June	1961	2	0	0	20	2	22
July-Aug.	1961	2	0	0	75	1	76
Sept.	1961	2	0	0	9	1	10
Oct-Nov.	1961	2	0	0	2	0	2
TOTALS			37	72	113	4	226

Table 12. Length distribution of the 226 smallest tag recoveries from Chiniak Bay 1959 showing opportunities to molt by three time intervals.

Size range (carapace length)	Duration of freedom before capture: 1 to 4 months (Sept.-Dec. 1955)	5 to 16 months (Jan.-Dec. 1960)	19 to 27 months (March-Nov. 1961)			Biannual molters	Total
	Number of times molted						
Mm.	None	One	Two	Three	Total	Percent	No.
71-76	2	1	1	0	1	0	4
77-81	0	0	1	0	1	0	1
82-86	3	2	4	0	4	0	9
87-91	5	3	12	1	13	7.7	21
92-96	1	10	10	1	11	9.1	22
97-101	5	15	23	2	25	8.0	45
102-106	9	27	33	0	33	0	69
107-109	12	14	29	0	29	0	55
TOTALS	37	72	113	4	117	3.4 1/	226

1/ 3.4 percent (4 of 117) molted more than annually.

Table 13. Size increases for the six tag recoveries which molted at a greater than annual rate.

Release area and data	Recovery date		Release length	Release width	Recovery length	Recovery width	Size increase 1/ length	Size increase 1/ width
	Month	Year	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.
Chiniak Bay June 1958	July	1960	85	93	140	162	55	69
	July	1960	87	97	143	166	56	69
Chiniak Bay September 1959	June	1961	93	103	148	170	55	67
	June	1961	99	108	154	177	55	69
	August	1961	91	100	148	172	57	72
	Sept.	1961	99	112	150	174	51	62
Averages			92	102	147	170	54	68
			Growth if only two molts occurred				27	34
			Growth if three molts occurred				18	23

1/ Length increase per molt data for crabs this size is approximately 18 mm, see Table 3 and Figure 11.

considered not to have had the opportunity and would molt later whereas, those captured during June or after were recorded as anexuviants. Most of the few recoveries of April and May had grown; therefore, the magnitude of possible error is slight.

The discussion of molt-frequency for adult males consists primarily of tag recovery data from the Chiniak Bay 1959 tagging program, and excludes data from earlier programs because greater variability exists among the data collected during the formative years of the study. The Chiniak Bay study to the present time does not provide molt-frequency data for adult anexuviant males with "very old shells," but only for "old-shell" males. Frequency of molt is believed to differ significantly between annual molters and biennial and triennial molters.

The proportions of the various sized old-shell, adult males which do not molt annually was determined by tabulating tag recoveries according to the size at which they had the opportunity to molt. Since adult males are considered to have one opportunity to molt each year, those free one year have one opportunity, those free two years two opportunities, and so on. This tabulation provided analysis of 400 opportunities to molt for 375 different old-shell crabs from 127 to 171 mm in length (Table 14). Some crabs had the opportunity to molt two times. The size at which the second molt occurred for those that molted twice was calculated by using known growth of crabs which were free one year. Each of the 25 crabs which were free 2 years, and which anexuviated one time (none anexuviated two times) failed to molt the second year, documents by the facts that they all showed growth attributed to one molt and were all recaptured with old shells rather than new shells. No tag recoveries revealed triennial or quadrennial molting.

Tag recovery data from the Chiniak Bay 1959 program revealed that all adult crabs smaller than 143 mm in length molted at least annually. Crabs of a size 127-142 mm had 315 opportunities for ecdysis and molting occurred at each opportunity. Crabs 143-149 mm had 45 opportunities to molt; 91 percent molted while the remaining 9 percent anexuviated. In contrast 51 percent of the crabs 150-159 mm molted while 49 percent anexuviated. Crabs this size had 35 opportunities for molting. None of the 5 tagged crabs larger than 159 mm molted. They each anexuviated and each were free one growing season.

Anexuviation can begin at a carapace length smaller than 143 mm but proportionally the incidence is small. Size at which anexuviation begins is believed dependent upon the health of the individual crab and health of the population. Tag return data from Marmot Bay 1956, for example, showed that the smallest tagged male crab to molt biennially was 135 mm in carapace length. Since that time, expanding commercial harvest is considered to have improved the population health of crabs in Marmot Bay with the result that few small males now become anexuviants.

Table 14. Occurrence of molting of adult male king crab tag recoveries having a total of 400 opportunities to molt during their freedom (Chiniak Bay September 1959 release of new shells, recoveries up to November 30, 1961).

Carapace length before molting 1/	Opportunities to molt: Tag recoveries which molted	Opportunities to molt: Tag recoveries that did not molt	Proportion of crabs: Molting	Proportion of crabs: Skipping	Carapace length before molting 1/	Opportunities to molt: Tag recoveries which molted	Opportunities to molt: Tag recoveries that did not molt	Proportion of crabs: Molting	Proportion of crabs: Skipping
MM	Number	Number	%	%	MM	Number	Number	%	%
127	21	0	100	0	146	4	0	100	0
128	39	0	100	0	147	8	0	100	0
129	26	0	100	0	148	7	2	78	22
130	16	0	100	0	149	4	0	100	0
131	21	0	100	0	150	2	3	40	60
132	27	0	100	0	151	2	0	100	0
133	9	0	100	0	152	4	2	67	33
134	20	0	100	0	153	4	2	67	33
135	28	0	100	0	154	0	2	0	100
136	18	0	100	0	155	3	0	100	0
137	23	0	100	0	156	0	3	0	100
138	18	0	100	0	157	0	2	0	100
139	5	0	100	0	158	3	2	60	40
140	13	0	100	0	159	0	1	0	100
141	12	0	100	0	160	0	3	0	100
142	19	0	100	0	161	0	0	0	0
143	2	1	67	33	162	0	0	0	0
144	10	0	100	0	166	0	1	0	100
145	6	1	86	14	171	0	1	0	100
					TOTALS	374	26		

1/ Used table 7 for those crabs molting twice in two years.

Triennial molting is believed to first occur among crabs 160 mm or larger and quadriennial molting with somewhat larger crabs. Supporting data consisted of visual observations of exoskeletal appearance of the commercial catch and from tag recoveries which had all molted either annually or biennially. Only a few large crabs have been tagged (they are from releases other than Chiniak 1959). Two of these crabs had the opportunity to become triennial molters but instead molted biennially. In addition, of 51 annual molting old-shelled tagged crabs ranging from 150 to 171 mm in length before the molting season, 21 or 41 percent molted and attained length of from 170 to 194 mm. Sixty percent anexuviated and remained the same length. It appears likely that if biennial molting begins at approximately 143 then triennial and quadrennial molting occurs at a larger size.

The number of times a crab anexuviates in a lifetime is not known due to insufficient molting data for larger crabs; however, a useful estimate is possible from existing facts. For example it is known that quadrennial molting almost always represents terminal anecdysis and triennial molting often does. Biennial molting exists among predominantly younger crabs growing every other year. Incidence of anexuviation during the life of a king crab therefore must logically vary from about zero to seven. Since biennial molting is most common, an estimate for the average frequency of anexuviation for crabs in the Kodiak area is four.

The molting sequence for the average crab in the Kodiak area may be similar to the following example. Anexuviation occurs for the first time when an eight year old crab molts biennially at a carapace length of 158. The following year the crab molts and grows to a size of 173 mm followed again the next year by biennial molting. During the next season the crab exuviates to a size of 190 mm and then enters a triennial terminal anecdysis. The preceding example infers old age mortality increases at the approximate size of 190 mm. The flow diagram (Figure 15) will clarify the complex molting sequence; quadrennial molting has been omitted to conserve space especially since it appears to occur relatively infrequently.

AGE ESTIMATES

Age analysis of king crabs starts with hatching of the egg, the peak of which occurs in mid-April. During the 12 weeks following hatching young crabs exist as free swimming planktonic larvae before assuming an adult appearance and a bottom existence (Marukawa, 1933). By mid-July in the Kodiak area tiny king crabs 2.5 mm in carapace length are found beneath rocks and among fauna and flora of the littoral area.

The age of small crabs was estimated from length frequency modes of crabs captured by divers and from growth per molt data of crabs held in cages.

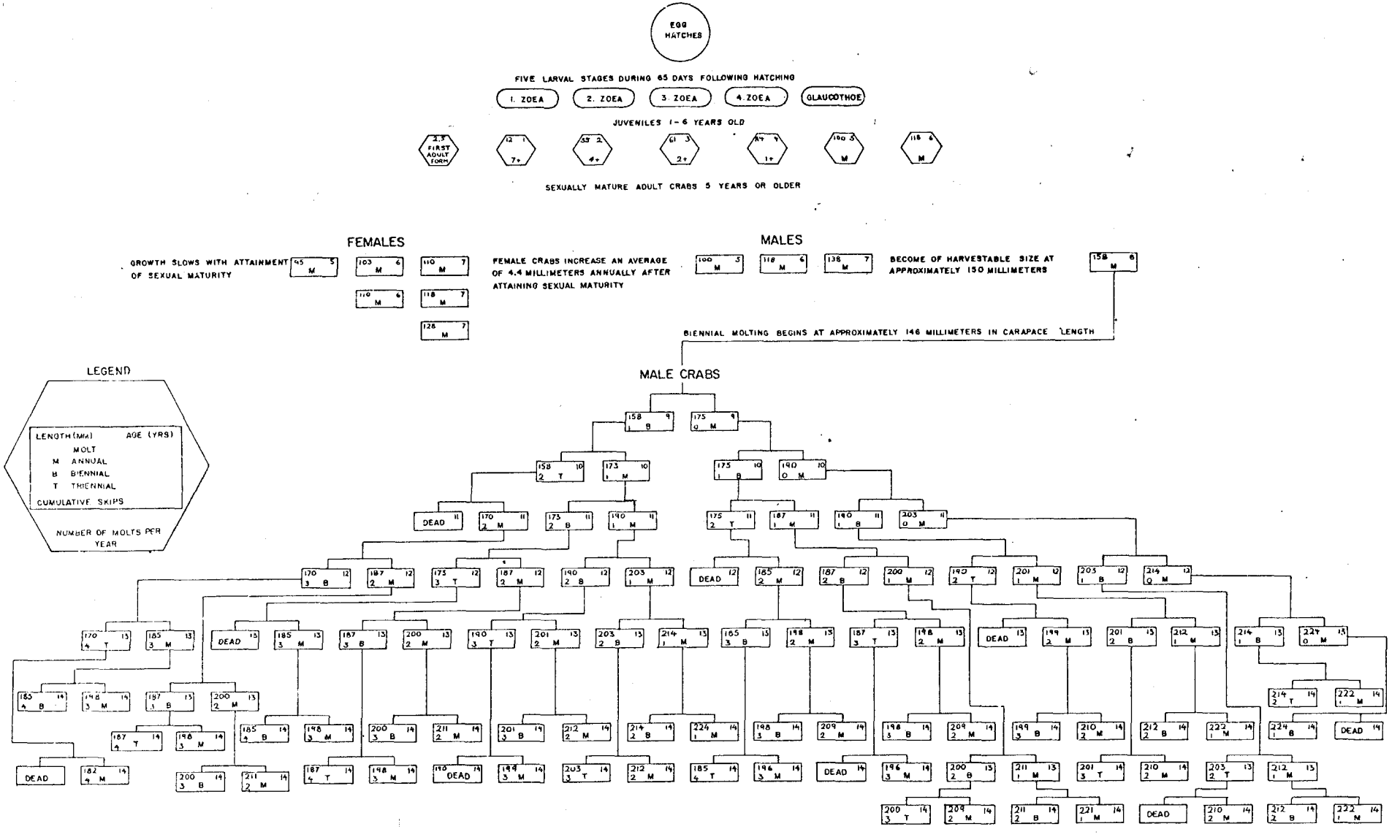

Figure 15. Flow diagram of the age-size relationships of king crabs.

Estimating age for larger crabs was accomplished by merely adding the known annual increments learned from tagging.

The accuracy of aging small crabs by frequency modes is believed to decrease as size increases as a result of the overlapping of age class lengths and probably becomes inaccurate after about four years. The majority of the crabs tagged ranged in length from 74 to 151 mm. Smaller crabs were not marked because methods had not been developed. Furthermore, development in tagging small crabs has been inhibited due to the difficulty of obtaining subsequent recoveries of small crabs from the selective commercial fishery. Larger crabs were not marked because they were not available during the tagging operation.

Age data for 1 to 4 year old juveniles consists of 1,368 measurements obtained during 5 intermittent collecting trips from May 1959 to April 1962 (Table 15). These data are by no means conclusive, but do provide a useful index for the age of young crabs. Both sexes have a similar growth rate until sexual maturity is attained. Results are comparable to those of Weber and Miyahara (1962) who also utilized diving as a tool in their study of juvenile crabs. Their investigation of juveniles was conducted at Unalaska Bay, 500 miles west of Kodiak Island.

Small crabs less than one year old and 6 to 10 mm in carapace length have been collected during the months of February and March approximately nine months after hatching, but due to the limited number of crab involved no further mention is warranted. Sample size of crabs 1 to 4 years old, however, is greater and deserved discussion.

The 65 crabs collected May 9, 1959 averaged 14.5 mm and were estimated to be 1 year, 3 weeks old because smaller crabs were absent, and the present year's larval crop had not yet developed into the bottom dwelling form (Table 15). Average length of these one year olds was gradually increasing as evidenced by numerous crabs in the molt and premolt stages of the molt cycle. By February it was assumed these crabs would be approximately 1 year 10 months old and have attained a length of about 30 mm, comparable to the size of the crabs obtained in the sample of February 1961.

Six hundred forty-nine 2 year olds were captured during two collecting trips. On May 18, 1960 a juvenile aggregate of 526 crabs, commonly known as a "pod", was captured by skin divers. The average length of these crabs was 36.6 mm and their age was estimated at 2 years 4 months (Table 15). A sample of premolt crabs from this group, averaging 34 mm, was retained in cages for 9 days. By May 27 all had molted and the new average length was 41 mm.

Crabs 2 years 7 months old attain an average length of approximately 49 mm by December, such as the sample of 123 crabs captured December 24,

Table 15. Carapace length frequencies of 1,368 small king crabs of both sexes captured at various times from Chiniak Bay.

Capture date			Total crabs both sexes	Length range	Average length			Estimated age 1/	
					males	females	both		
Mo.	Day	Year	No.	mm.	mm.	mm.	mm.	Yrs.	Wks.
May	9	1959	65	10-20	14.4	14.6	14.5	1	3
Feb.	12	1961	100	23-40	30.3	30.7	30.5	1	44
Feb.	19	1961	260	25-37	----	----	30.1	1	45
May	18	1960	526	26-46	36.6	36.7	36.6	2	4
Dec.	24	1959	123	40-56	49.3	49.2	49.3	2	37
April	25	1962	185	49-73	61.2	60.7	60.9	3	1
April	25	1962	131	74-98	84.6	83.7	84.2	4	1
Total			1,368						

1/ Assessing age begins April 15 when peak egg hatching is completed.

1959. These crabs were placed in wire cages for two months. By February 25, 1960, they had molted and attained an average length of 61.7 mm, a size similar to that of the crabs captured April 25, 1962. By relying upon these data a length of 61 mm is used to describe the size of crabs at the completion of their third year.

The number of three and four year old crabs studied for age determination totaled 185 and 131 respectively and were collected by divers from a concentration of approximately one-half million crabs on April 25, 1962. Two size groups were apparent and the 316 crabs measured were believed to adequately represent the relative size of these groups. No individual from either group were molting or preparing to molt, indicating a decreased rate of molt frequency among larger juveniles.

The above data indicated that crabs of both sexes attain carapace lengths of 12, 35, 61, and 84 mm respectively at 1 to 4 years of age (Table 16). The findings of Weber and Miyahara (1962) are compatible. They concluded that crabs sampled in May were in their second year at a carapace width of 11 to 12 mm and were in their third year at a carapace width of 37 mm. Near the end of the third year crabs were estimated to be 45 mm or larger. Methods of measuring small crabs differed between the two studies. Weber and Miyahara used widths while lengths were used during this study. The differences between the length and width of small crabs rarely exceeds 2 mm and hence was not considered a serious error.

Age estimates of crabs older than 4 years were derived from length increases of recaptured tagged crabs free various periods of time. Estimates for crabs older than four years are predominantly for males because only 85 tag recoveries provide female growth, and tagging of females occurred only during the formative years of the study. It was apparent from growth of females, however, that once maturity was attained (approximately 100 mm) molting became annual and length increments declined. Average annual growth for adult females was 4 mm; approximately 5 mm for those 110-139 mm and 2 mm for those 140-169 mm. Data for males is provided primarily by the 670 recoveries from Chiniak Bay 1959 releases.

In order to simplify age estimates of 5 year old crabs, the assumption was made that all males larger than 80 mm molt annually. As a result, five year old crabs are 100 mm in length. An error exists in this assumption because 3.4 percent of the 117 recoveries, ranging from 71-109 mm when released in Chiniak Bay in 1959, were found to molt biannually rather than annually (Table 12). This error is believed to be of small magnitude.

Six, seven, and eight year old crabs molt annually and attain estimated average lengths of 118 mm, 138 mm, and 158 mm respectively. The actual increases are presented in the preceding chapter on growth. An error exists in

Table 16. Estimated age-size relationships of male king crabs.

Carapace length before molt	Molt sequence	Rate of carapace length increase	Growth increment per molt	Average carapace length and cumulative age		Annual increment	Average number of molts for each year
MM	No.	%	MM	MM	Year	MM	No.
2.5	1	24.0	.6				
3.1	2	24.0	.7				
3.8	3	24.0	.9				
4.8	4	24.0	1.1				
5.9	5	24.0	1.4				
7.3	6	24.0	1.8				
9.1	7	24.0	2.2				
11.3	8	24.0	2.7				
14.0	9	24.0	3.4	12	1	9.5	7 +
17.3	10	24.0	4.1				
21.5	11	24.0	5.2				
26.6	12	24.0	6.4				
33.0	13	24.0	7.9	35	2	23.0	4 +
41.0	14	24.0	9.8				
50.8	15	24.0	12.2				
63.0	16	24.0	15.1	61	3	26.0	2 +
78.0	17	21.0	16.4	84	4	23.0	1 +
94.0	18	19.5	18.4	100	5	15.8	1
113.0	19	17.1	19.3	118	6	18.3	1
132.0	20	15.2	20.0	138	7	20.3	1
152.0	21	11.2	17.0	158	8	19.9	1
Biennial molting begins			15.0				
169.0	22	10.1	17.0	158	9	none	<1 *
Biennial molt			15.0	175	9	17.0	<1
Triennial molt			12.0	175	10	none	<1
186.0	23	7.0	13.0	175	11	none	<1
Biennial molt			11.0	190	10	15.0	<1
Triennial molt			9.0	190	11	none	<1
199.0	24	5.5	11.0	190	12	none	<1
Biennial molt			9.0	203	11	13.0	<1
Triennial molt			7.0	203	12	none	<1

* <1 Supporting data for growth of large crabs is lacking.

the estimate for eight year olds because some crabs anexuviate before attaining a length of 158 mm. The error is considered to be small enough, since only 14 percent of the 146 recaptured tagged crabs 138-158 anexuviated, that the estimate is useful (Table 14).

The age-size relationship of crabs 8 years old and older becomes complicated by the extended periods of anecdysis or non-molting of larger males. In addition, a significant decline in growth per molt may also occur among biennial and triennial molters, further complicating analysis. Since the proportion of anexuviant crabs increases with size, varies among area, and involves numerous biological and physiological factors, the age-size relationship of any particular crab is related to the length when anexuviation begins and the frequency of molt thereafter.

Exceptional maximum growth is obtained by crabs which molt annually throughout life. Annually molting crabs, 9, 10, 11, 12, and 13 years of age were estimated to attain lengths of 175, 190, 203, 214, and 224 mm respectively (Figure 15 and Table 16). Annually molting crabs represent the minority. The best example of such growth is provided by the recaptured tagged crab which was free 4 years and grew 62 mm from a length of 132 and 194 mm (Appendix Table 5). This growth was greater than the average for crabs in the Kodiak area.

The majority of crabs anexuviate for the first time at a size anywhere from 143-175 mm in length rather than continuing to molt annually. In exceptional cases of minimum growth where crabs might anexuviate at the smallest observed length of 143 mm and continue to anexuviate frequently, the near maximum length of 224 mm may not be attained until 18 years of age rather than 13. The majority of crabs in the Kodiak Island area do not attain the maximum size to which crabs grow and they also do not commonly produce growth in the extremes, but rather anexuviate and molt biennially before molting triennially; therefore average age is probably 13 and 14 years. The numerous possibilities of age-size relationships is presented in the flow diagram (Figure 15).

SUMMARY

A portion of the Japanese and Russian king crab stocks have been over-exploited. Growth studies of Alaskan stocks are necessary to insure that American stocks do not also become excessively utilized. A review of the developing American fishery and early research on growth is presented.

Growth of juvenile crabs was determined by studying modes in the natural environment and also length increases of crabs held in cages. Growth of adults was determined from tag and recapture studies.

Tagging of king crabs began in 1954 and by 1959 8,862 crabs had been marked and released. By 1961, 1,501 tagged crabs had been recovered by the commercial fishery. The bulk of the growth data for adult males has been derived from tag recoveries from the Chiniak Bay tagging program of 1959. Tagging operations prior to 1959 provided growth data for adult males and in addition for females, but the earlier programs were less accurate and were smaller in scope as a result of lack of experience.

Juveniles of both sexes attain sexual maturity at the approximate carapace length of 100 mm during the fifth year. The rate of length increase during the first four years remained constant at approximately 24 percent with each molt, thereafter rate of growth gradually declined.

Growth of adult males was significantly greater than growth of adult females. Adult females molted annually and averaged 4 mm per molt. The greatest recorded female carapace length was 195 mm.

Adult males molted annually through the eighth year and averaged 20 mm per molt, after which time increasing proportions molted biennially. No tagged males molted triennially or quadrennially but the presence of a few of these crabs in the commercial catch indicates that some crabs do molt less frequently. The largest male recorded was 227 mm in carapace length and weighed 11 kg. Maximum length could be attained at age 13 if molting is annual throughout adulthood. If molting is less frequent, age is correspondingly greater, perhaps 18 years but more probably 14 years.

Estimated length of 5 to 8 year old crabs is 100, 118, 138, and 158 mm respectively.

Male crabs attained critical size or reached peak growth at approximately 147 mm in carapace length when about 7 years of age.

Growth of crabs from different geographical areas and from areas of varying degrees of fishing intensity did not appear to differ widely in terms of growth per molt but did appear to differ in frequency of molt. Commercial cropping of males is believed to have resulted in an elevation in the size at which biennial, triennial and quadrennial molting commences, and a lowering of the relative degree of anexuviation.

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APPENDIX

Appendix Table 1. Carapace length-increase-per-molt of 85 captive juvenile female king crabs from Chiniak Bay, 1960.

(carapace length in mm.)

Before Molt	After Molt	Increase
10.0	12.0	2.0
11.0	13.0	2.0
11.0	13.0	2.0
11.5	14.0	2.5
12.0	15.0	3.0
13.0	16.5	3.5
13.5	16.0	2.5
24.0	29.5	5.5
25.2	31.0	5.8
28.0	35.3	7.3
28.5	35.0	6.5
28.5	35.0	6.5
30.0	36.5	6.5
30.0	36.5	6.5
30.8	37.5	6.7
31.0	37.5	6.5
31.0	37.8	6.8
35.2	42.0	6.8
36.0	43.0	7.0
36.0	43.8	7.8
36.0	45.3	9.3
36.2	44.0	7.8
36.5	43.8	7.3
36.5	44.3	7.8
40.3	51.3	11.0
41.0	53.3	12.3
44.5	56.3	11.8
44.5	57.0	12.5
46.0	57.0	11.0
46.0	57.0	11.0
46.0	58.0	12.0
46.3	57.0	10.7
46.3	60.0	13.7
46.3	60.0	13.7
46.7	58.0	11.3
46.7	59.3	12.6
47.0	61.0	14.0
47.5	58.0	10.5
47.5	58.0	10.5
47.5	60.0	12.5
47.5	60.0	12.5
47.7	58.5	10.8
48.3	59.5	11.2
48.3	60.5	12.2
48.3	60.5	12.2
48.3	61.3	13.0

Appendix Table 1 (Continued)

Before Molt	After Molt	Increase
48.3	61.3	13.0
48.3	62.0	13.7
49.0	60.5	11.5
49.0	60.5	11.5
49.0	61.3	12.3
49.0	61.3	12.3
49.0	61.5	12.5
49.5	60.7	11.2
49.5	61.3	11.8
50.0	60.7	10.7
50.0	61.3	11.3
50.0	62.3	12.3
50.0	62.7	12.7
50.0	63.5	13.5
51.0	62.3	11.3
51.0	63.5	12.5
51.0	63.7	12.7
51.3	64.7	13.4
51.5	64.5	13.0
51.7	63.5	11.8
52.0	65.0	13.0
52.5	62.7	10.2
52.7	65.0	12.3
53.3	65.7	12.4
53.3	66.0	12.7
54.7	66.7	12.0
54.7	67.5	12.8
55.0	67.3	12.3
55.5	65.7	10.2
55.5	69.0	13.5
56.3	70.3	14.0
61.3	73.3	12.0
70.7	84.0	13.3
73.0	86.7	13.7
73.0	90.7	17.7
83.0	97.0	14.0
90.0	105.0	15.0
91.0	104.0	13.0
94.0	105.0	11.0

Appendix Table 2. Carapace length-increase-per-molt of 84 captive juvenile male king crabs from Chiniak Bay, 1960

(carapace length in mm.)

Before Molt	After Molt	Increase
9.5	11.5	2.0
10.0	12.5	2.5
10.5	13.0	2.5
11.0	13.0	2.0
11.0	13.5	2.5
11.5	14.0	2.5
11.5	14.0	2.5
11.5	14.0	2.5
11.5	14.5	3.0
12.0	15.0	3.0
12.0	15.5	3.5
12.0	16.0	4.0
12.5	15.0	2.5
12.5	15.0	2.5
12.5	16.0	3.5
13.0	17.0	4.0
26.0	32.5	6.5
28.0	35.0	7.0
30.8	36.0	5.2
31.5	39.0	7.5
32.2	39.0	6.8
33.0	39.0	6.0
33.0	40.8	7.8
33.5	39.8	6.3
33.5	40.5	7.0
33.8	42.0	8.2
34.0	40.8	6.8
34.2	41.8	7.6
35.0	40.8	5.8
35.0	42.0	7.0
35.2	43.0	7.8
36.2	43.0	6.8
41.0	53.5	12.5
43.0	52.5	9.5
44.5	54.7	10.2
44.5	55.5	11.0
44.5	56.3	11.8
45.3	58.0	12.7
45.3	59.0	13.7
46.0	56.5	10.5
46.3	59.0	12.7
46.3	60.0	13.7
46.7	57.0	10.3
46.7	58.0	11.3

Appendix Table 2 (Continued)

Before Molt	After Molt	Increase
46.7	58.0	11.3
47.0	60.0	13.0
47.5	59.7	12.2
47.5	59.7	12.2
48.3	60.5	12.2
48.3	61.5	13.2
48.3	62.7	14.4
48.5	62.0	13.5
48.5	62.0	13.5
49.0	62.7	13.7
49.0	63.0	14.0
49.5	62.0	12.5
50.0	62.0	12.0
50.0	62.3	12.3
50.0	62.7	12.7
50.5	62.0	11.5
50.5	62.7	12.2
50.5	63.5	13.0
50.5	64.3	13.8
51.0	63.5	12.5
51.0	63.7	12.7
51.3	63.8	12.5
51.7	65.0	13.3
51.7	65.3	13.6
52.0	64.3	12.3
52.0	65.7	13.7
52.5	64.3	11.8
52.7	65.7	13.0
52.8	63.5	10.7
53.3	64.3	11.0
54.0	65.7	11.7
54.0	68.0	14.0
55.0	68.0	13.0
55.5	68.0	12.5
55.7	67.3	11.6
56.3	68.5	12.2
60.0	72.5	12.5
70.7	87.0	16.3
72.3	86.7	14.4
99.8	111.0	11.2

Appendix Table 3. 95 recoveries through July 23, 1960, of tagged female king crabs from all tagging programs, 1954-1958 (42 tag-only recoveries are omitted)

	Release	Recapture		Measure	
Tag No.	Length mm.	Date	Length mm	Error	Growth mm	Remarks
MARMOT BAY, JANUARY, 1955						
G 9	150	August 1955	151		1	1 molt
W 165	113	October 1955	117		4	1 molt
G 84	115	October 1955	125		10	1 molt
G 97	122	October 1955	125		3	1 molt
Y 179	123	October 1955	129		6	1 molt
W 143	128	October 1955	130		2	1 molt
Y 62	132	October 1955	136		4	1 molt
Y 89	154	October 1955	155		1	1 molt
G 31	159	October 1955	164		5	1 molt
G 23	168	October 1955	171		3	1 molt
Y 235	114	November 1955	124		10	1 molt
G 98	120	November 1955	124		4	1 molt
W 135	126	November 1955	133		7	1 molt
Y 86	127	November 1955	130		3	1 molt
R 100	128	November 1955	133		5	1 molt
W 181	133	November 1955	139		6	1 molt
Y 211	133	November 1955	138		5	1 molt
Y 36	134	November 1955	139		5	1 molt
Y 195	138	November 1955	140		2	1 molt
Y 97	148	November 1955	150		2	1 molt
R 197	156	November 1955	156		0	1 molt
R 45	165	November 1955	168		3	1 molt
G 2	124	December 1955	131		7	1 molt
G 125	146	December 1955	148		2	1 molt
Y 188	162	December 1955	162		0	1 molt
R 168	118	January 1956	121		3	1 molt
R 78	120	January 1956	129		9	1 molt
G 123	123	January 1956	132		9	1 molt
Y 206	123	January 1956	128		5	1 molt
R 126	129	January 1956	135		6	1 molt
Y 64	133	January 1956	141		8	1 molt
W 242	135	January 1956	139		4	1 molt
Y 162	136	January 1956	140		4	1 molt
G 120	137	January 1956	143		6	1 molt
Y 210	139	January 1956	151		12	1 molt
Y 158	156	January 1956	162		6	1 molt
R 27	157	January 1956	158		1	1 molt
Y 224	166	January 1956	171		5	1 molt
Y 168	157	March 1956	159		2	1 molt
Y 150	116	April 1956	120		4	1 molt
R 127	123	April 1956	127		4	1 molt
R 172	124	April 1956	128		4	1 molt

Appendix Table 3 (Continued)

	Release	Recapture		Measure		
Tag No.	Length mm.	Date	Length mm.	Error	Growth mm	Remarks
G 53	124	April 1956	130		6	1 molt
R 104	127	April 1956	133		6	1 molt
R 94	128	April 1956	133		5	1 molt
R 235	128	April 1956	134		6	1 molt
Y 122	128	April 1956	133		5	1 molt
W 131	129	April 1956	132		3	1 molt
Y 141	129	April 1956	131		2	1 molt
R 56	130	April 1956	134		4	1 molt
R 61	133	April 1956	139		6	1 molt
G 55	134	April 1956	141		7	1 molt
Y 148	135	April 1956	140		5	1 molt
G 14	136	April 1956	141		5	1 molt
Y 152	144	April 1956	147		3	1 molt
Y 157	145	April 1956	145		0	1 molt
R 92	146	April 1956	146		0	1 molt
R 230	148	April 1956	153		5	1 molt
R 32	152	April 1956	153		1	1 molt
R 22	154	April 1956	155		1	1 molt
W 250	155	April 1956	159		4	1 molt
Y 80	155	April 1956	160		5	1 molt
Y 181	156	April 1956	157		1	1 molt
R 52	157	April 1956	159		2	1 molt
G 113	157	April 1956	162		5	1 molt
R 26	160	April 1956	162		2	1 molt
G 47	160	April 1956	160		0	1 molt
R 210	160	April 1956	166		6	1 molt
W 203	162	April 1956	165		3	1 molt
G 71	133	August 1956	145		12	2 molts
R 113	162	January 1957	169		7	2 molts
W 223	163	January 1957	175		12	2 molts
R 196	170	January 1957	173		3	2 molts
Y 171	129	October 1959	148		19	5 molts
MARMOT BAY, OCTOBER - NOVEMBER, 1955						
Y 255	165	October 1955	168	3		
Y 277	123	November 1955	123	0		
Y 474	128	November 1955	128	0		
Y 308	128	January 1956	130	2		
Y 287	132	January 1956	135	3		
Y 258	137	January 1956	138	1		
Y 499	129	April 1956	129	0		
Y 265	130	April 1956	134	4		
Y 407	128	January 1957	134		6	1 molt
Y 322	128	January 1957	132		4	1 molt

Appendix Table 3 (Continued)

	Release	Recapture		Measure	
Tag No.	Length mm	Date	Length mm	Error	Growth mm	Remarks
Y 332	135	January 1957	144		9	1 molt
Y 245	136	January 1957	144		8	1 molt
Y 331	126	December 1959	142		16	4 molts
Y 339	135	December 1959	155		20	4 molts
MARMOT BAY, JULY, 1956						
Y 701	126	August 1956	126	0		
CHINIAK BAY, DECEMBER, 1954						
G 17	126	January 1957	135		9	2 molts
CHINIAK BAY, MAY-JUNE, 1958						
704	98	May 1960	123		25	2 molts*
ALITAK BAY, APRIL, 1956						
G 135	131	February 1958	143		12	2 molts
ALITAK BAY, FEBRUARY, 1957						
174	146	February 1960	158		12	3 molts
PERENOSA BAY, JULY, 1956						
Y 856	137	January 1957	137	0		
Y 713	146	January 1959	158		12	2 molts

* SEXUALLY IMMATURE AT RELEASE

Appendix Table 4. 835 recoveries through November 30, 1961 of male king crabs tagged and released in Chiniak Bay in September, 1959* (22 tag-only recoveries are omitted)

Date Recaptured	Initial Length mm	Recovered Length mm	Growth Increment mm	Remarks
September 1959	100	100	0	
September 1959	101	101	0	
September 1959	103	103	0	
September 1959	104	104	0	
September 1959	105	104	-1	
September 1959	106	106	0	
September 1959	107	107	0	
September 1959	107	106	-1	
September 1959	107	107	0	
September 1959	110	110	0	
September 1959	111	110	-1	
September 1959	111	110	-1	
September 1959	112	112	0	
September 1959	113	113	0	
September 1959	113	113	0	
September 1959	113	113	0	
September 1959	115	115	0	
September 1959	115	114	-1	
September 1959	115	115	0	
September 1959	116	116	0	
September 1959	116	116	0	
September 1959	117	117	0	
September 1959	117	116	-1	
September 1959	118	119	1	
September 1959	118	118	0	
September 1959	119	119	0	
September 1959	119	118	-1	
September 1959	120	120	0	
September 1959	120	120	0	
September 1959	120	119	-1	
September 1959	120	120	0	
September 1959	120	120	0	
September 1959	120	119	-1	
September 1959	120	119	-1	
September 1959	120	119	-1	
September 1959	121	121	0	
September 1959	121	121	0	
September 1959	122	122	0	

Appendix Table 4 (Continued)

Date Recaptured	Initial Length mm	Recovered Length mm	Growth Increment mm	Remarks
September 1959	123	124	1	
September 1959	123	124	1	
September 1959	123	123	0	
September 1959	124	124	0	
September 1959	125	125	0	
September 1959	126	126	0	
September 1959	127	126	-1	
September 1959	128	128	0	
September 1959	129	129	0	
September 1959	130	129	-1	
September 1959	130	130	0	
September 1959	130	130	0	
September 1959	130	130	0	
September 1959	133	133	0	
September 1959	137	137	0	
September 1959	138	138	0	
September 1959	138	138	0	
September 1959	140	140	0	
September 1959	142	142	0	
September 1959	145	145	0	
September 1959	145	145	0	
September 1959	145	145	0	
September 1959	147	146	-1	
October 1959	76	75	-1	
October 1959	84	84	0	
October 1959	85	85	0	
October 1959	88	88	0	
October 1959	88	88	0	
October 1959	90	89	-1	
October 1959	90	90	0	
October 1959	91	91	0	
October 1959	95	95	0	
October 1959	99	99	0	
October 1959	102	102	0	
October 1959	102	102	0	
October 1959	103	103	0	
October 1959	106	106	0	
October 1959	107	107	0	
October 1959	107	106	-1	
October 1959	107	108	1	

Appendix Table 4 (Continued)

Date Recaptured	Initial Length mm	Recovered Length mm	Growth Increment mm	Remarks
October 1959	108	108	0	
October 1959	109	109	0	
October 1959	109	109	0	
October 1959	111	110	-1	
October 1959	111	111	0	
October 1959	111	111	0	
October 1959	112	112	0	
October 1959	112	112	0	
October 1959	114	114	0	
October 1959	115	114	-1	
October 1959	116	116	0	
October 1959	116	115	-1	
October 1959	117	117	0	
October 1959	119	119	0	
October 1959	122	122	0	
October 1959	123	123	0	
October 1959	125	125	0	
October 1959	128	128	0	
October 1959	128	128	0	
October 1959	128	129	1	
October 1959	129	129	0	
October 1959	129	129	0	
October 1959	130	129	-1	
October 1959	132	131	-1	
October 1959	132	132	0	
October 1959	134	134	0	
October 1959	140	140	0	
October 1959	140	140	0	
October 1959	144	144	0	
October 1959	148	148	0	
October 1959	149	148	-1	
November 1959	107	107	0	
November 1959	120	119	-1	
November 1959	129	129	0	
November 1959	129	129	0	
November 1959	140	140	0	
November 1959	145	145	0	
December 1959	71	71	0	
December 1959	85	85	0	
December 1959	97	97	0	
December 1959	101	101	0	

Appendix Table 4 (Continued)

Date Recaptured	Initital Length mm	Recovered Length mm	Growth Increment mm	Remarks
December 1959	103	103	0	
December 1959	108	108	0	
December 1959	109	110	1	
December 1959	110	110	0	
December 1959	111	110	-1	
December 1959	112	112	0	
December 1959	112	112	0	
December 1959	113	113	0	
December 1959	114	114	0	
December 1959	114	114	0	
December 1959	114	114	0	
December 1959	114	114	0	
December 1959	114	114	0	
December 1959	118	118	0	
December 1959	119	119	0	
December 1959	120	119	-1	
December 1959	125	125	0	
December 1959	125	125	0	
December 1959	125	125	0	
December 1959	128	128	0	
December 1959	136	136	0	
December 1959	138	138	0	
January 1960	123	123	0	
January 1960	94	112	18	1 molt
April 1960	103	121	18	1 molt
April 1960	104	125	21	1 molt
April 1960	109	130	21	1 molt
April 1960	114	136	22	1 molt
April 1960	117	139	22	1 molt
April 1960	128	146	18	1 molt
April 1960	128	140	12	1 molt
April 1960	132	154	22	1 molt
April 1960	133	154	21	1 molt
April 1960	136	148	12	1 molt
April 1960	143	162	19	1 molt
May 1960	86	100	14	1 molt
May 1960	86	94	8**	1 molt
May 1960	86	101	15	1 molt
May 1960	87	103	16	1 molt
May 1960	101	122	21	1 molt

Appendix Table 4 (Continued)

Date Recaptured	Initial Length mm	Recovered Length mm	Growth Increment mm	Remarks
May 1960	102	116	14	1 molt
May 1960	102	122	20	1 molt
May 1960	104	122	18	1 molt
May 1960	107	127	20	1 molt
May 1960	113	133	20	1 molt
May 1960	119	137	18	1 molt
May 1960	129	148	19	1 molt
May 1960	133	151	18	1 molt
June 1960	93	110	17	1 molt
June 1960	95	114	19	1 molt
June 1960	99	118	19	1 molt
June 1960	102	122	20	1 molt
June 1960	102	120	18	1 molt
June 1960	102	119	17	1 molt
June 1960	104	121	17	1 molt
June 1960	105	126	21	1 molt
June 1960	108	126	18	1 molt
June 1960	109	128	19	1 molt
June 1960	110	129	19	1 molt
June 1960	110	122	12**	1 molt
June 1960	111	125	14**	1 molt
June 1960	111	134	23	1 molt
June 1960	112	130	18	1 molt
June 1960	112	131	19	1 molt
June 1960	117	137	20**	1 molt
June 1960	120	137	17	1 molt
June 1960	120	139	19	1 molt
June 1960	121	141	20	1 molt
June 1960	121	144	23	1 molt
June 1960	122	141	19	1 molt
June 1960	125	149	24	1 molt
June 1960	126	152	26	1 molt
June 1960	126	148	22	1 molt
June 1960	127	143	16**	1 molt
June 1960	127	146	19	1 molt
June 1960	127	145	18	1 molt
June 1960	128	149	21	1 molt
June 1960	129	153	24	1 molt
June 1960	132	151	19	1 molt
June 1960	134	155	21	1 molt

Appendix Table 4 (Continued)

Date Recaptured	Initial Length mm	Recovered Length mm	Growth Increment mm	Remarks
June 1960	135	154	19	1 molt
June 1960	136	158	22	1 molt
June 1960	137	156	19	1 molt
June 1960	138	157	19	1 molt
June 1960	139	158	19	1 molt
June 1960	140	161	21	1 molt
June 1960	143	155	12	1 molt
July 1960	76	92	16	1 molt
July 1960	87	105	18	1 molt
July 1960	90	106	16	1 molt
July 1960	94	112	18	1 molt
July 1960	96	115	19	1 molt
July 1960	96	117	21	1 molt
July 1960	97	113	16	1 molt
July 1960	99	116	17	1 molt
July 1960	100	119	19	1 molt
July 1960	100	120	20	1 molt
July 1960	100	121	21	1 molt
July 1960	101	115	14	1 molt
July 1960	102	118	16	1 molt
July 1960	102	121	19	1 molt
July 1960	103	124	21	1 molt
July 1960	104	123	19	1 molt
July 1960	104	124	20	1 molt
July 1960	104	124	20	1 molt
July 1960	104	125	21	1 molt
July 1960	106	123	17	1 molt
July 1960	108	126	18	1 molt
July 1960	108	129	21	1 molt
July 1960	109	133	24	1 molt
July 1960	110	128	18	1 molt
July 1960	110	132	22	1 molt
July 1960	111	131	20	1 molt
July 1960	111	132	21	1 molt
July 1960	112	132	20	1 molt
July 1960	112	132	20	1 molt
July 1960	112	132	20	1 molt
July 1960	112	135	23	1 molt
July 1960	113	134	21	1 molt
July 1960	114	134	20	1 molt
July 1960	114	135	21	1 molt

Appendix Table 4 (Continued)

Date Recaptured	Initial Length mm	Recovered Length mm	Growth Increment mm	Remarks
July 1960	115	132	17	1 molt
July 1960	115	134	19	1 molt
July 1960	115	134	19	1 molt
July 1960	115	134	19	1 molt
July 1960	115	135	20	1 molt
July 1960	115	138	23	1 molt
July 1960	117	137	20	1 molt
July 1960	117	138	21	1 molt
July 1960	117	138	21	1 molt
July 1960	117	139	22	1 molt
July 1960	117	139	22	1 molt
July 1960	118	133	15	1 molt
July 1960	118	138	20	1 molt
July 1960	118	138	20	1 molt
July 1960	118	138	20	1 molt
July 1960	118	140	22	1 molt
July 1960	118	141	23	1 molt
July 1960	119	136	17	1 molt
July 1960	119	138	19	1 molt
July 1960	119	142	23	1 molt
July 1960	119	143	24	1 molt
July 1960	120	140	20	1 molt
July 1960	121	140	19	1 molt
July 1960	122	141	19	1 molt
July 1960	122	142	20	1 molt
July 1960	122	144	22	1 molt
July 1960	123	141	18	1 molt
July 1960	123	142	19	1 molt
July 1960	123	142	19	1 molt
July 1960	123	143	20	1 molt
July 1960	124	146	22	1 molt
July 1960	125	144	19	1 molt
July 1960	125	144	19	1 molt
July 1960	126	146	20	1 molt
July 1960	126	146	20	1 molt
July 1960	126	148	22	1 molt
July 1960	126	148	22	1 molt
July 1960	127	144	17	1 molt
July 1960	127	146	19	1 molt
July 1960	127	147	20	1 molt
July 1960	128	147	19	1 molt

Appendix Table 4 (Continued)

Date Recaptured	Initial Length mm	Recovered Length mm	Growth Increment mm	Remarks
July 1960	128	148	20	1 molt
July 1960	128	150	22	1 molt
July 1960	128	150	22	1 molt
July 1960	128	151	23	1 molt
July 1960	129	149	20	1 molt
July 1960	129	150	21	1 molt
Juiy 1960	129	150	21	1 molt
July 1960	130	150	20	1 molt
July 1960	131	154	23	1 molt
July 1960	132	149	17	1 molt
July 1960	132	151	19	1 molt
July 1960	132	153	21	1 molt
July 1960	132	153	21	1 molt
July 1960	132	155	23	1 molt
July 1960	133	152	19	1 molt
July 1960	133	152	19	1 molt
July 1960	133	153	20	1 molt
July 1960	133	154	21	1 molt
July 1960	134	146	12	1 molt
July 1960	134	155	21	1 molt
July 1960	135	152	17	1 molt
July 1960	135	154	19	1 molt
July 1960	135	155	20	1 molt
July 1960	135	157	22	1 molt
July 1960	135	157	22	1 molt
July 1960	135	158	23	1 molt
July 1960	136	155	19	1 molt
July 1960	136	155	19	1 molt
July 1960	136	156	20**	1 molt
July 1960	136	156	20	1 molt
July 1960	136	158	22	1 molt
July 1960	137	158	21	1 molt
July 1960	137	158	21	1 molt
July 1960	137	158	21	1 molt
July 1960	138	157	19	1 molt
July 1960	138	158	20	1 molt
July 1960	138	159	21	1 molt
July 1960	138	159	21	1 molt
July 1960	138	160	22	1 molt
July 1960	138	161	23	1 molt
July 1960	140	157	17	1 molt

Appendix Table 4 (Continued)

Date Recaptured	Initial Length mm	Recovered Length mm	Growth Increment mm	Remarks
July 1960	140	159	19	1 molt
July 1960	140	160	20	1 molt
July 1960	140	161	21	1 molt
July 1960	141	164	23	1 molt
July 1960	141	165	24	1 molt
July 1960	141	165	24	1 molt
July 1960	142	159	17	1 molt
July 1960	142	164	22	1 molt
July 1960	144	164	20	1 molt
July 1960	146	166	20	1 molt
July 1960	147	168	21	1 molt
July 1960	148	148	0	1 skip, very old shell
July 1960	148	166	18	1 molt
July 1960	150	165	15	1 molt
July 1960	151	172	21	1 molt
August 1960	96	112	16	1 molt
August 1960	97	116	19	1 molt
August 1960	98	117	19	1 molt
August 1960	100	120	20	1 molt
August 1960	101	118	17	1 molt
August 1960	101	121	20	1 molt
August 1960	102	118	16**	1 molt
August 1960	102	122	20	1 molt
August 1960	102	122	20	1 molt
August 1960	103	120	17	1 molt
August 1960	103	123	20	1 molt
August 1960	106	124	18	1 molt
August 1960	106	125	19	1 molt
August 1960	106	127	21	1 molt
August 1960	107	128	21	1 molt
August 1960	108	127	19	1 molt
August 1960	108	130	22	1 molt
August 1960	108	130	22	1 molt
August 1960	109	129	20	1 molt
August 1960	111	129	18	1 molt
August 1960	112	127	15	1 molt
August 1960	112	130	18	1 molt
August 1960	112	132	20	1 molt
August 1960	112	132	20	1 molt
August 1960	112	133	21	1 molt

Appendix Table 4 (Continued)

Date Recapture	Initial Length mm	Recovered Length mm	Growth Increment mm	Remarks
August 1960	112	134	22	1 molt
August 1960	113	131	18	1 molt
August 1960	113	134	21	1 molt
August 1960	114	132	18	1 molt
August 1960	114	133	19	1 molt
August 1960	114	134	20	1 molt
August 1960	115	133	18	1 molt
August 1960	115	133	18	1 molt
August 1960	115	136	21	1 molt
August 1960	116	134	18	1 molt
August 1960	116	135	19	1 molt
August 1960	116	135	19	1 molt
August 1960	116	137	21	1 molt
August 1960	116	138	22	1 molt
August 1960	117	132	15	1 molt
August 1960	117	133	16**	1 molt
August 1960	117	138	21	1 molt
August 1960	117	139	22	1 molt
August 1960	118	140	22	1 molt
August 1960	119	139	20	1 molt
August 1960	119	139	20	1 molt
August 1960	119	141	22	1 molt
August 1960	119	141	22	1 molt
August 1960	120	141	21	1 molt
August 1960	120	143	23	1 molt
August 1960	120	143	23	1 molt
August 1960	120	144	24	1 molt
August 1960	121	143	22	1 molt
August 1960	122	138	16	1 molt
August 1960	122	146	24	1 molt
August 1960	123	144	21	1 molt
August 1960	124	145	21	1 molt
August 1960	125	146	21	1 molt
August 1960	126	146	20	1 molt
August 1960	127	143	16	1 molt
August 1960	127	147	20	1 molt
August 1960	128	147	19	1 molt
August 1960	128	151	23	1 molt
August 1960	129	145	16	1 molt
August 1960	129	145	16	1 molt
August 1960	129	148	19	1 molt

Appendix Table 4 (Continued)

Date Recaptured	Initial Length mm	Recovered Length mm	Growth Increment mm	Remarks
August 1960	129	149	20	1 molt
August 1960	129	152	23	1 molt
August 1960	130	145	15	1 molt
August 1960	130	149	19	1 molt
August 1960	130	150	20	1 molt
August 1960	130	150	20	1 molt
August 1960	131	150	19	1 molt
August 1960	131	152	21	1 molt
August 1960	131	153	22	1 molt
August 1960	131	155	23	1 molt
August 1960	132	146	14	1 molt
August 1960	132	152	20	1 molt
August 1960	132	152	20	1 molt
August 1960	132	155	23	1 molt
August 1960	133	154	21	1 molt
August 1960	134	154	20	1 molt
August 1960	134	154	20	1 molt
August 1960	135	151	16	1 molt
August 1960	135	153	18	1 molt
August 1960	135	156	21	1 molt
August 1960	136	156	20	1 molt
August 1960	137	159	22	1 molt
August 1960	138	156	18	1 molt
August 1960	138	163	25	1 molt
August 1960	139	156	17	1 molt
August 1960	139	160	21	1 molt
August 1960	140	159	19	1 molt
August 1960	141	158	17	1 molt
August 1960	142	160	18	1 molt
August 1960	142	163	21	1 molt
August 1960	147	167	20	1 molt
August 1960	147	168	21	1 molt
August 1960	150	170	20	1 molt
September 1960	93	111	18	1 molt
September 1960	95	114	19	1 molt
September 1960	99	116	17	1 molt
September 1960	103	122	19	1 molt
September 1960	105	130	25	1 molt
September 1960	108	128	20	1 molt
September 1960	109	132	23	1 molt
September 1960	110	130	20	1 molt

Appendix Table 4 (Continued)

Date Recaptured	Initial Length mm	Recovered Length mm	Growth Increment mm	Remarks
September 1960	110	130	20	1 molt
September 1960	111	128	17	1 molt
September 1960	111	132	21	1 molt
September 1960	111	134	23	1 molt
September 1960	112	129	17	1 molt
September 1960	113	129	16	1 molt
September 1960	113	130	17	1 molt
September 1960	113	131	18	1 molt
September 1960	114	134	20	1 molt
September 1960	115	138	23	1 molt
September 1960	116	138	22	1 molt
September 1960	117	134	17	1 molt
September 1960	117	136	19	1 molt
September 1960	118	136	18	1 molt
September 1960	118	139	21	1 molt
September 1960	119	140	21	1 molt
September 1960	119	140	21	1 molt
September 1960	119	141	22	1 molt
September 1960	119	141	22	1 molt
September 1960	121	140	19**	1 molt
September 1960	122	144	22	1 molt
September 1960	123	145	22	1 molt
September 1960	123	145	22	1 molt
September 1960	123	146	23	1 molt
September 1960	124	144	20	1 molt
September 1960	124	144	20	1 molt
September 1960	124	145	21	1 molt
September 1960	125	142	17	1 molt
September 1960	125	145	20	1 molt
September 1960	126	146	20	1 molt
September 1960	126	146	20	1 molt
September 1960	127	146	19	1 molt
September 1960	127	151	24	1 molt
September 1960	129	150	21	1 molt
September 1960	131	152	21	1 molt
September 1960	132	153	21	1 molt
September 1960	132	154	22**	1 molt
September 1960	134	154	20	1 molt
September 1960	134	156	22	1 molt
September 1960	135	157	22	1 molt
September 1960	135	158	23	1 molt

Appendix Table 4 (Continued)

Date Recaptured	Initital Length mm	Recovered Length mm	Growth Increment mm	Remarks
September 1960	136	155	19	1 molt
September 1960	136	158	22	1 molt
September 1960	136	158	22	1 molt
September 1960	137	159	22	1 molt
September 1960	138	152	14	1 molt
September 1960	142	164	22	1 molt
September 1960	144	162	18	1 molt
September 1960	146	166	20	1 molt
October 1960	112	123	11	1 molt
October 1960	117	139	22	1 molt
October 1960	121	141	20	1 molt
October 1960	136	148	12	1 molt
October 1960	136	159	23	1 molt
October 1960	143	162	19	1 molt
December 1960	95	114	19	1 molt
December 1960	101	117	16	1 molt
December 1960	133	154	21	1 molt
February 1961	114	148	34	2 molts
February 1961	118	134	16	1 molt
March 1961	99	132	33	2 molts
March 1961	103	141	38	2 molts
March 1961	141	158	17	1 molt
April 1961	94	134	40	2 molts
April 1961	103	136	33	2 molts
April 1961	103	136	33	2 molts
April 1961	103	138	35	2 molts
April 1961	104	145	41	2 molts
April 1961	122	143	21	1 molt
April 1961	136	157	21	1 molt
April 1961	137	177	40	2 molts
April 1961	138	156	18	1 molt
April 1961	138	157	19	1 molt
April 1961	138	174	36	2 molts
April 1961	142	161	19	1 molt
May 1961	89	121	32	2 molts
May 1961	93	131	38	2 molts
May 1961	102	143	41	2 molts
May 1961	107	145	38	2 molts
May 1961	115	147	32	2 molts
May 1961	120	149	29	2 molts
May 1961	123	144	21	1 molt

Appendix Table 4 (Continued)

Date Recaptured	Initial Length mm	Recovered Length mm	Growth Increment mm	Remarks
May 1961	123	162	39	2 molts
May 1961	126	164	38	2 molts
May 1961	132	153	21	1 molt
May 1961	133	171	38	2 molts
May 1961	138	156	18	1 molt
May 1961	141	156	15	1 molt
May 1961	144	167	23	1 molt
June 1961	78	115	37	2 molts
June 1961	85	117	32	2 molts
June 1961	86	125	39	2 molts
June 1961	91	128	37	2 molts
June 1961	93	133	40	2 molts
June 1961	93	148	55	3 molts
June 1961	94	132	38	2 molts
June 1961	99	140	41	2 molts
June 1961	99	154	55	3 molts
June 1961	100	138	38	2 molts
June 1961	100	140	40	2 molts
June 1961	103	136	33	2 molts
June 1961	105	136	31	2 molts
June 1961	106	138	32	2 molts
June 1961	106	139	33	2 molts
June 1961	106	144	38	2 molts
June 1961	107	142	35	2 molts
June 1961	109	144	35	2 molts
June 1961	110	145	35	2 molts
June 1961	110	153	43	2 molts
June 1961	111	148	37	2 molts
June 1961	111	149	38	2 molts
June 1961	111	156	45	2 molts
June 1961	114	154	30	2 molts
June 1961	114	155	31	2 molts
June 1961	115	145	30	2 molts
June 1961	115	155	40	2 molts
June 1961	115	156	41	2 molts
June 1961	117	156	39	2 molts
June 1961	118	157	39	2 molts
June 1961	118	161	43	2 molts
June 1961	119	156	37	2 molts
June 1961	120	155	35	2 molts
June 1961	123	166	43	2 molts

Appendix Table 4 (Continued)

Date Recaptured	Initial Length mm	Recovered Length mm	Growth Increment mm	Remarks
June 1961	124	163	39	2 molts
June 1961	126	162	36	2 molts
June 1961	128	166	38	2 molts
June 1961	132	167	35	2 molts
June 1961	132	167	35	2 molts
June 1961	135	168	33	2 molts
June 1961	137	172	35	2 molts
June 1961	133	157	119	1 skip, very old shell
June 1961	139	160	21	1 skip, very old shell
June 1961	142	160	18	1 skip, very old shell
July 1961	82	118	36	2 molts
July 1961	86	115	29	2 molts
July 1961	88	120	32	2 molts
July 1961	88	125	37	2 molts
July 1961	89	127	38	2 molts
July 1961	89	136	47	2 molts
July 1961	91	125	34	2 molts
July 1961	91	126	35	2 molts
July 1961	91	127	36	2 molts
July 1961	93	127	34**	2 molts
July 1961	94	134	40	2 molts
July 1961	95	129	34**	2 molts
July 1961	97	139	42	2 molts
July 1961	98	132	34	2 molts
July 1961	99	133	34	2 molts
July 1961	100	134	34	2 molts
July 1961	100	135	35	2 molts
July 1961	100	140	40	2 molts
July 1961	101	134	33	2 molts
July 1961	101	142	41	2 molts
July 1961	102	136	34	2 molts
July 1961	102	138	36	2 molts
July 1961	102	139	37	2 molts
July 1961	103	142	39	2 molts
July 1961	103	143	40	2 molts
July 1961	104	135	31	2 molts
July 1961	104	144	40	2 molts
July 1961	104	145	41	2 molts
July 1961	105	133	28	2 molts
July 1961	105	142	37	2 molts
July 1961	105	147	42	2 molts

Appendix Table 4 (Continued)

Date Recaptured	Initial Length mm	Recovered Length mm	Growth Increment mm	Remarks
July 1961	106	141	35**	2 molts
July 1961	106	148	42	2 molts
July 1961	107	142	35	2 molts
July 1961	107	144	37	2 molts
July 1961	107	147	40	2 molts
July 1961	108	144	36	2 molts
July 1961	108	145	37	2 molts
July 1961	108	147	39	2 molts
July 1961	109	149	40	2 molts
July 1961	109	150	41	2 molts
July 1961	109	153	44	2 molts
July 1961	111	142	31	2 molts
July 1961	111	148	37	2 molts
July 1961	111	156	45	2 molts
July 1961	112	142	38**	2 molts
July 1961	112	145	33	2 molts
July 1961	112	149	37	2 molts
July 1961	113	142	29	2 molts
July 1961	113	150	37	2 molts
July 1961	113	157	44	2 molts
July 1961	114	153	39	2 molts
July 1961	114	154	40	2 molts
July 1961	114	156	42	2 molts
July 1961	115	154	39	2 molts
July 1961	116	156	40**	2 molts
July 1961	117	150	33	2 molts
July 1961	117	156	39	2 molts
July 1961	119	157	38	2 molts
July 1961	119	160	41	2 molts
July 1961	119	160	41	2 molts
July 1961	120	159	39	2 molts
July 1961	121	160	39	2 molts
July 1961	123	154	31	2 molts
July 1961	125	168	43	2 molts
July 1961	126	162	36	2 molts
July 1961	126	164	38	2 molts
July 1961	126	167	41	2 molts
July 1961	127	166	39	2 molts
July 1961	128	145	17	1 skip, very old shell
July 1961	128	148	20	1 skip, very old shell
July 1961	128	165	37	2 molts

Appendix Table 4 (Continued)

Date Recaptured	Initial Length mm	Recovered Length mm	Growth Increment mm	Remarks
July 1961	129	153	24	1 skip, very old shell
July 1961	129	165	36	2 molts
July 1961	131	166	35	2 molts
July 1961	131	168	37	2 molts
July 1961	133	157	24	1 skip, very old shell
July 1961	134	152	18	1 skip, very old shell
July 1961	135	172	37	2 molts
July 1961	136	156	20	1 skip, very old shell
July 1961	138	150	12	1 skip, very old shell
August 1961	74	109	35	2 molts
August 1961	90	127	37	2 molts
August 1961	91	128	37	2 molts
August 1961	91	148	57	3 molts
August 1961	92	129	37	2 molts
August 1961	94	127	33	2 molts
August 1961	94	135	41	2 molts
August 1961	96	136	40	2 molts
August 1961	97	130	33	2 molts
August 1961	97	135	38	2 molts
August 1961	98	139	41	2 molts
August 1961	99	137	38	2 molts
August 1961	99	143	44	2 molts
August 1961	100	133	33	2 molts
August 1961	100	143	43	2 molts
August 1961	102	142	40	2 molts
August 1961	102	150	48**	2 molts
August 1961	105	140	35	2 molts
August 1961	105	142	37	2 molts
August 1961	105	142	37	2 molts
August 1961	105	148	43	2 molts
August 1961	106	144	38	2 molts
August 1961	106	145	39	2 molts
August 1961	106	148	42	2 molts
August 1961	107	143	36	2 molts
August 1961	107	146	39	2 molts
August 1961	107	147	40	2 molts
August 1961	108	144	36	2 molts
August 1961	108	145	37	2 molts
August 1961	108	146	38	2 molts
August 1961	108	146	38	2 molts
August 1961	108	147	39	2 molts

Appendix Table 4 (Continued)

Date Recaptured	Initial Length mm	Recovered Length mm	Growth Increment mm	Remarks
August 1961	108	147	39	2 molts
August 1961	108	150	42	2 molts
August 1961	109	144	35	2 molts
August 1961	109	145	36	2 molts
August 1961	109	146	37	2 molts
August 1961	109	148	39	2 molts
August 1961	110	147	37	2 molts
August 1961	110	147	37	2 molts
August 1961	110	148	38	2 molts
August 1961	110	148	38	2 molts
August 1961	110	150	40	2 molts
August 1961	110	152	42	2 molts
August 1961	111	146	35	2 molts
August 1961	111	146	35	2 molts
August 1961	112	143	31	2 molts
August 1961	112	155	43	2 molts
August 1961	113	146	33	2 molts
August 1961	113	152	39	2 molts
August 1961	113	155	42	2 molts
August 1961	114	148	34**	2 molts
August 1961	114	152	38	2 molts
August 1961	114	154	40	2 molts
August 1961	114	160	46	2 molts
August 1961	115	153	38	2 molts
August 1961	116	146	30	2 molts
August 1961	116	152	36	2 molts
August 1961	118	153	35	2 molts
August 1961	118	156	38	2 molts
August 1961	118	158	40	2 molts
August 1961	118	163	45	2 molts
August 1961	118	163	45	2 molts
August 1961	119	156	37	2 molts
August 1961	119	162	43	2 molts
August 1961	120	156	36	2 molts
August 1961	120	157	37**	2 molts
August 1961	121	158	37	2 molts
August 1961	122	158	36	2 molts
August 1961	122	163	41	2 molts
August 1961	122	164	42	2 molts
August 1961	123	159	36	2 molts
August 1961	123	161	38	2 molts

Appendix Table 4 (Continued)

Date Recaptured	Initial Length mm	Recovered Length mm	Growth Increment mm	Remarks
August 1961	123	162	39	2 molts
August 1961	124	161	37	2 molts
August 1961	124	171	47	2 molts
August 1961	125	160	35	2 molts
August 1961	127	143	16	1 skip, very old shell
August 1961	127	163	36	2 molts
August 1961	128	164	36	2 molts
August 1961	128	166	38	2 molts
August 1961	128	169	41	2 molts
August 1961	129	166	37	2 molts
August 1961	129	167	38	2 molts
August 1961	132	154	22	1 skip, very old shell
August 1961	132	168	36	2 molts
August 1961	132	172	40	2 molts
August 1961	135	156	21	1 skip, very old shell
August 1961	135	173	38	2 molts
August 1961	139	159	20	1 skip, very old shell
August 1961	144	166	22	1 skip, very old shell
August 1961	151	171	20	1 skip, very old shell
September 1961	91	127	36	2 molts
September 1961	94	128	34	2 molts
September 1961	98	135	37	2 molts
September 1961	99	150	51	3 molts
September 1961	100	136	36	2 molts
September 1961	101	138	37	2 molts
September 1961	101	143	42	2 molts
September 1961	106	145	39	2 molts
September 1961	106	148	42	2 molts
September 1961	108	148	40	2 molts
September 1961	110	147	37	2 molts
September 1961	110	149	39	2 molts
September 1961	110	150	40	2 molts
September 1961	111	150	39**	2 molts
September 1961	112	147	35	2 molts
September 1961	113	149	36	2 molts
September 1961	113	151	38	2 molts
September 1961	113	152	39	2 molts
September 1961	114	157	43	2 molts
September 1961	115	146	31	2 molts
September 1961	115	154	39	2 molts
September 1961	115	154	39	2 molts

Appendix Table 4 (Continued)

Date Recaptured	Initial Length mm	Recovered Length mm	Growth Increment mm	Remarks
September 1961	115	158	43	2 molts
September 1961	116	152	36	2 molts
September 1961	116	163	47	2 molts
September 1961	117	147	30	2 molts
September 1961	117	159	42	2 molts
September 1961	118	156	38	2 molts
September 1961	118	158	40	2 molts
September 1961	121	157	36	2 molts
September 1961	121	162	41	2 molts
September 1961	122	157	35	2 molts
September 1961	122	159	37	2 molts
September 1961	122	159	37	2 molts
September 1961	128	166	38	2 molts
September 1961	129	166	37	2 molts
September 1961	134	178	44	2 molts
September 1961	136	153	17	1 skip, very old shell
September 1961	140	160	20	1 skip, very old shell
October 1961	104	157	53**	2 molts
October 1961	107	135	28**	2 molts
October 1961	108	151	43	2 molts
October 1961	110	144	34**	2 molts
October 1961	110	150	40**	2 molts
October 1961	113	157	44**	2 molts
October 1961	114	150	36	2 molts
October 1961	120	161	41	2 molts
October 1961	120	166	46	2 molts
October 1961	121	162	41	2 molts
October 1961	122	166	44	2 molts
October 1961	127	150	23	1 skip, very old shell
October 1961	128	150	22	1 skip, very old shell
October 1961	129	152	23	1 skip, very old shell
October 1961	133	154	21	1 skip, very old shell
October 1961	138	158	20	1 skip, very old shell
October 1961	145	158	13	1 skip, very old shell
November 1961	88	117	29**	2 molts
November 1961	103	139	36**	2 molts
November 1961	109	151	42	2 molts
November 1961	115	151	36	2 molts
November 1961	115	159	44	2 molts
November 1961	118	153	35	2 molts
November 1961	138	156	18	1 skip, very old shell

Appendix Table 4 (Continued)

* No growth observed before January 1960; therefore, the 143 growth increment figures prior to that date indicate accuracy of measurements.

** 26 crabs had regenerating appendages; consequently, their growth was not used in the analysis.

Appendix Table 5. 423 recoveries through July 23, 1960, of tagged male king crabs from all tagging programs 1954-1959, except Chiniak Bay 1959 program. (106 tag-only recoveries are omitted.)

	Release	Recapture		Measure		
Tag No.	Length mm	Date	Length mm	Error	Growth mm	Remarks
MARMOT BAY, JANUARY, 1955						
Y 31	111	October 1955	120		9	1 molt
W 157	115	October 1955	131		16	1 molt
Y 116	123	October 1955	140		17	1 molt
Y 77	128	October 1955	146		18	1 molt
W 158	134	October 1955	154		20	1 molt
Y 46	135	October 1955	150		15	1 molt
W 152	141	November 1955	159		18	1 molt
Y 25	141	November 1955	160		19	1 molt
Y 42	139	April 1956	160		21	1 molt
Y 115	114	January 1957	147		33	2 molts
Y 76	139	January 1957	175		36	2 molts
Y 41	132	December 1958	194		62	4 molts
MARMOT BAY, OCTOBER - NOVEMBER, 1955						
Y 456	113	November 1955	113	0		
Y 426	95	December 1955	95	0		
Y 353	135	July 1956	138		3	No molts 1 skip
Y 348	137	July 1956	151		14	1 molt
Y 416	130	August 1956	142		12	1 molt
Y 365	131	August 1956	150		19	1 molt
Y 357	137	August 1956	156		19	1 molt
Y 475	124	September 1956	142		18	1 molt
Y 373	132	September 1956	142		10	1 molt
Y 340	137	September 1956	145		8	1 molt
Y 429	122	October 1956	133		11	Unrel. Meas.
Y 374	132	October 1956	142		10	1 molt
Y 347	135	October 1956	149		14	1 molt
Y 446	131	January 1957	140		9	1 molt
Y 400	132	January 1957	151		19	1 molt
Y 419	134	January 1957	152		18	1 molt
Y 436	125	November 1957	153		28	2 molts
Y 422	130	November 1957	163		33	2 molts
Y 428	86	October 1959	137		51	3 molts 1 skip
MARMOT BAY, NOVEMBER, 1957						
524	101	November 1958	118		17	1 molt
47	133	November 1958	147		14	1 molt
515	99	December 1958	111		12	1 molt
425	133	December 1958	151		18	1 molt

Appendix Table 5 (Continued)

	Release		Recapture	Measure		
Tag No.	Length mm	Date	Length mm	Error	Growth mm	Remarks
390	134	July 1959	156		22	1 molt 1 skip
308	96	August 1959	127		31	2 molts
63	101	September 1959	130		29	2 molts
336	127	September 1959	157		30	2 molts
377	90	October 1959	119		29	2 molts
421	98	October 1959	128		30	2 molts
300	100	October 1959	134		34	2 molts
330	100	October 1959	133		33	2 molts
309	108	October 1959	143		35	2 molts
346	120	October 1959	158		38	2 molts
76	122	October 1959	151		29	2 molts
438	80	November 1959	112		32	2 molts
363	96	November 1959	129		33	2 molts
48	97	November 1959	120		23	2 molts
350	97	November 1959	128		31	2 molts
359	98	November 1959	131		33	2 molts
449	101	November 1959	126		25	2 molts
423	101	November 1959	138		37	2 molts
345	102	November 1959	139		37	2 molts
84	102	November 1959	135		33	2 molts
393	103	November 1959	134		31	2 molts
476	104	November 1959	138		34	2 molts
389	104	November 1959	142		38	2 molts
314	105	November 1959	137		32	2 molts
326	105	November 1959	140		35	2 molts
401	107	November 1959	144		37	2 molts
477	109	November 1959	142		33	2 molts
490	111	November 1959	141		30	2 molts
488	116	November 1959	155		39	2 molts
385	117	November 1959	157		40	2 molts
383	123	November 1959	160		37	2 molts
44	130	November 1959	164		34	2 molts
49	132	November 1959	148		16	1 molt 1 skip
59	141	November 1959	170		29	2 molts
542	90	December 1959	121		31	2 molts
419	103	December 1959	139		36	2 molts
479	104	December 1959	147		43	2 molts
396	118	December 1959	159		41	2 molts
374	90	July 1960	132		42	3 molts
422	100	July 1960	152		52	3 molts

Appendix Table 5 (Continued)

	Release	Recapture		Measure		
Tag No.	Length mm	Date	Length mm	Error	Growth mm	Remarks
MARMOT BAY, SEPTEMBER, 1959						
2867	75	October 1959	75	0		
3257	82	October 1959	82	0		
3207	92	November 1959	92	0		
3119	101	November 1959	101	0		
2831	102	November 1959	102	0		
3288	107	November 1959	107	0		
3237	112	November 1959	112	0		
3357	116	November 1959	116	0		
2956	117	November 1959	117	0		
3171	119	November 1959	119	0		
3397	141	November 1959	141	0		
3402	160	November 1959	160	0		
3350	177	November 1959	177	0		
3365	95	December 1959	95	0		
3370	106	December 1959	106	0		
3431	126	December 1959	125	-1		
3149	94	December 1959	103		9	Unreliable*
3014	101	July 1960	116		15	1 molt
CHINIAK BAY, DECEMBER, 1954						
W 44	115	February 1956	133		18	1 molt
W 93	103	April 1956	122		19	
CHINIAK BAY, OCTOBER, 1957						
W 681	138	November 1957	138	0		
W 638	113	November 1958	123		10	1 molt
0000	132	November 1958	142		10	1 molt
0008	137	February 1959	153		16	1 molt
CHINIAK BAY, MAY-JUNE, 1958						
1920	139	September 1958	139	0		
2394	91	October 1958	91	0		
1097	102	October 1958	100	-2		
1628	116	October 1958	115	-1		
1593	119	October 1958	117	-2		
1576	125	October 1958	127	2		
1922	129	October 1958	131	2		
2173	130	October 1958	130	0		
1866	131	October 1958	130	-1		
2058	131	October 1958	130	-1		
1569	133	October 1958	132	-1		
2503	133	October 1958	133	0		
1022	135	October 1958	134	-1		

Appendix Table 5 (Continued)

	Release	Recapture		Measure		
Tag No.	Length mm	Date	Length mm	Error	Growth mm	Remarks
1293	136	October 1958	135	-1		
2281	136	October 1958	136	0		
2279	137	October 1958	136	-1		
1201	137	October 1958	135	-2		
2758	137	October 1958	139	2		
2043	138	October 1958	137	-1		
2419	139	October 1958	138	-1		
2775	140	October 1958	139	-1		
3096	140	October 1958	142	2		
1685	141	October 1958	141	0		
3106	142	October 1958	142	0		
1864	142	October 1958	144	2		
2145	143	October 1958	142	-1		
3108	144	October 1958	145	1		
876	144	October 1958	142	-2		
954	144	October 1958	144	0		
1198	144	October 1958	143	-1		
953	144	October 1958	144	0		
1882	145	October 1958	145	0		
1717	145	October 1958	143	-2		
1247	145	October 1958	144	-1		
746	145	October 1958	143	-2		
3107	146	October 1958	146	0		
2215	146	October 1958	145	-1		
2822	146	October 1958	147	1		
3102	147	October 1958	147	0		
3017	148	October 1958	148	0		
1811	149	October 1958	148	-1		
1328	149	October 1958	147	-2		
1873	149	October 1958	148	-1		
947	150	October 1958	148	-2		
2767	152	October 1958	152	0		
858	153	October 1958	153	0		
1652	153	October 1958	151	-2		
1635	153	October 1958	151	-2		
864	154	October 1958	151	-3		
1140	158	October 1958	158	0		
1639	158	October 1958	159	1		
1610	159	October 1958	158	-1		
877	161	October 1958	158	-3		
1135	162	October 1958	161	-1		
2033	162	October 1958	163	1		
1294	162	October 1958	160	-2		
1317	163	October 1958	161	-2		

Appendix Table 5 (Continued)

	Release	Recapture		Measure		
Tag No.	Length mm	Date	Length mm	Error	Growth mm	Remarks
0716	163	October 1958	161	-2		
2792	163	October 1958	162	-1		
1613	164	October 1958	162	-2		
1194	165	October 1958	164	-1		
2509	165	October 1958	169	4		
1645	167	October 1958	164	-3		
134	167	October 1958	166	-1		
1271	168	October 1958	166	-2		
730	168	October 1958	168	0		
908	169	October 1958	170	1		
1152	169	October 1958	169	0		
796	173	October 1958	171	-2		
816	177	October 1958	174	-3		
1253	177	October 1958	175	-2		
676	101	November 1958	102	1		
2616	101	November 1958	104	3		
2628	105	November 1958	108	3		
1117	111	November 1958	112	1		
2164	114	November 1958	116	2		
2276	119	November 1958	119	0		
1668	119	November 1958	120	1		
785	124	November 1958	124	0		
1229	128	November 1958	129	1		
927	130	November 1958	131	1		
1993	130	November 1958	133	3		
1686	131	November 1958	132	1		
2778	132	November 1958	134	2		
2023	132	November 1958	133	1		
798	133	November 1958	134	1		
1043	133	November 1958	135	2		
2378	135	November 1958	138	3		
3105	135	November 1958	138	3		
1138	136	November 1958	138	2		
2222	139	November 1958	141	2		
873	140	November 1958	141	1		
779	141	November 1958	143	2		
741	142	November 1958	143	1		
843	142	November 1958	142	0		
1828	145	November 1958	146	1		
2894	145	November 1958	146	1		
654	145	November 1958	146	1		
1690	146	November 1958	148	2		
1336	148	November 1958	149	1		
1078	149	November 1958	150	1		
745	151	November 1958	152	1		

Appendix Table 5 (Continued)

	Release	Recapture		Measure		
Tag No.	Length mm	Date	Length mm	Error	Growth mm	Remarks
754	152	November 1958	153	1		
1751	152	November 1958	153	1		
1213	155	November 1958	156	1		
1624	160	November 1958	161	1		
1893	164	November 1958	166	2		
2523	167	November 1958	170	3		
1665	168	November 1958	169	1		
2159	88	December 1958	90	2		
2706	95	December 1958	97	2		
1929	98	December 1958	100	2		
1089	119	December 1958	120	1		
1837	132	December 1958	134	2		
1792	133	December 1958	134	1		
3002	133	December 1958	137	4		
652	134	December 1958	135	1		
1193	135	December 1958	136	1		
984	139	December 1958	140	1		
1285	142	December 1958	143	1		
1184	144	December 1958	145	1		
914	148	December 1958	149	1		
1722	151	December 1958	152	1		
998	152	December 1958	152	0		
1291	156	December 1958	158	2		
1248	159	December 1958	160	1		
1413	172	December 1958	174	2		
744	181	December 1958	181	0		
2832	90	January 1959	92	2		
1284	90	January 1959	92	2		
2039	101	January 1959	103	2		
2828	115	January 1959	117	2		
1530	125	January 1959	126	1		
830	136	January 1959	136	0		
1637	150	January 1959	151	1		
1606	150	January 1959	151	1		
1701	157	January 1959	159	2		
710	99	February 1959	100	1		
1807	106	February 1959	107	1		
1300	113	February 1959	115	2		
1630	114	February 1959	115	1		
2172	115	February 1959	117	2		
713	118	February 1959	119	1		
950	120	February 1959	121	1		
917	132	February 1959	133	1		
1370	136	February 1959	136	0		
1916	140	February 1959	141	1		

Appendix Table 5 (Continued)

	Release	Recapture		Measure		
Tag No.	Length mm	Date	Length mm	Error	Growth mm	Remarks
3066	141	February 1959	144	3		
1158	142	February 1959	143	1		
2014	142	February 1959	144	2		
891	143	February 1959	143	0		
1838	143	February 1959	144	1		
2120	143	February 1959	146	3		
1238	143	February 1959	144	1		
3113	145	February 1959	148	3		
2227	145	February 1959	148	3		
1390	146	February 1959	147	1		
1588	146	February 1959	148	2		
1219	149	February 1959	150	1		
1599	149	February 1959	150	1		
2026	149	February 1959	152	3		
1295	150	February 1959	151	1		
891	151	February 1959	151	0		
3097	151	February 1959	154	3		
1818	152	February 1959	155	3		
1675	155	February 1959	156	1		
1166	155	February 1959	157	2		
909	157	February 1959	158	1		
658	160	February 1959	160	0		
3093	163	February 1959	165	2		
1196	167	February 1959	168	1		
755	167	February 1959	168	1		
1146	168	February 1959	170	2		
997	171	February 1959	171	0		
1827	182	February 1959	183	1		
1534	93	March 1959	95	2		
2105	96	March 1959	98	2		
1883	97	March 1959	99	2		
2044	99	March 1959	102	3		
2280	108	March 1959	111	3		
1788	113	March 1959	114	1		
1693	114	March 1959	116	2		
2643	116	March 1959	116	0		
963	118	March 1959	119	1		
1088	118	March 1959	119	1		
2414	119	March 1959	121	2		
1712	122	March 1959	123	1		
789	122	March 1959	124	2		
1236	123	March 1959	124	1		
751	124	March 1959	125	1		
1216	126	March 1959	128	2		

Appendix Table 5 (Continued)

	Release		Recapture	Measure		
Tag No.	Length mm	Date	Length mm	Error	Growth mm	Remarks
1726	129	March 1959	130	1		
1343	129	March 1959	131	2		
894	130	March 1959	130	0		
899	130	March 1959	130	0		
2517	132	March 1959	135	3		
2057	135	March 1959	136	1		
1913	136	March 1959	137	1		
2764	136	March 1959	138	2		
714	136	March 1959	137	1		
1890	137	March 1959	138	1		
887	137	March 1959	138	1		
966	139	March 1959	139	0		
1679	141	March 1959	142	1		
2032	141	March 1959	143	2		
3111	142	March 1959	145	3		
3119	142	March 1959	146	4		
715	143	March 1959	144	1		
1326	144	March 1959	145	1		
1907	144	March 1959	146	2		
1681	146	March 1959	147	1		
1240	146	March 1959	147	1		
1051	147	March 1959	148	1		
1776	148	March 1959	149	1		
840	148	March 1959	149	1		
770	150	March 1959	151	1		
763	151	March 1959	152	1		
895	152	March 1959	152	0		
1160	152	March 1959	153	1		
1255	155	March 1959	156	1		
880	156	March 1959	157	1		
869	156	March 1959	157	1		
2513	156	March 1959	159	3		
1262	157	March 1959	159	2		
847	158	March 1959	158	0		
804	159	March 1959	159	0		
1728	159	March 1959	160	1		
1745	159	March 1959	159	0		
1871	159	March 1959	160	1		
1176	160	March 1959	161	1		
1851	164	March 1959	165	1		
866	166	March 1959	165	-1		
3063	171	March 1959	175	4		
1163	177	March 1959	178	1		
2535	99	April 1959	102	3		
903	119	April 1959	119	0		
1912	123	April 1959	125	2		

Appendix Table 5 (Continued)

Tag No.	Release Length mm	Recapture Date	Recapture Length mm	Measure Error	Growth mm	Remarks
1114	128	April 1959	129	1		
907	130	April 1959	131	1		
1620	131	April 1959	132	1		
2443	136	April 1959	139	3		
1257	139	April 1959	140	1		
1192	144	April 1959	146	2		
1678	148	April 1959	149	1		
2320	148	April 1959	151	3		
872	150	April 1959	150	0		
2249	153	April 1959	155	2		
1275	158	April 1959	159	1		
2999	95	November 1958	110		15	1 molt
1169	125	November 1958	141		16	1 molt
2552	85	January 1959	98		13	1 molt
2902	90	February 1959	104		14	1 molt
2011	97	March 1959	110		13	1 molt
2867	112	March 1959	127		15	1 molt
2613	119	March 1959	142		23	1 molt
1884	127	March 1959	147		20	1 molt
2777	137	March 1959	157		20	1 molt
2697	81	May 1959	93		12	1 molt
996	146	July 1959	163		17	1 molt
2873	79	August 1959	96		17	1 molt
1815	96	August 1959	115		19	1 molt
1563	113	August 1959	136		23	1 molt
2089	114	August 1959	139		25	1 molt
1844	118	August 1959	141		23	1 molt
1854	126	August 1959	145		19	1 molt
1587	133	August 1959	153		20	1 molt
2402	137	August 1959	152		15	1 molt
1682	142	August 1959	163		21	1 molt
1872	142	August 1959	154		12	1 molt
1700	125	September 1959	145		20	1 molt
1565	95	October 1959	116		21	1 molt
2064	97	October 1959	116		19	1 molt
1560	89	November 1959	109		20	1 molt
2190	97	April 1960	109		12	1 molt
1845	84	June 1960	126		42	2 molts
2013	85	July 1960	140		55	3 molts 2 yrs.
1539	87	July 1960	143		56	3 molts 2 yrs.
2615	91	July 1960	128		37	2 molts
1575	104	July 1960	140		36	2 molts
2390	106	July 1960	152		46	2 molts
2853	120	July 1960	165		45	2 molts

Appendix Table 5 (Continued)

	Release		Recapture	Measure		
Tag No.	Length mm	Date	Length mm	Error	Growth mm	Remarks
ALITAK BAY, SEPTEMBER, 1956						
W 311	137	February 1957	137	0		
W 410	170	February 1957	174	4		
W 262	122	October 1957	131		9	Unrel. Meas.
W 288	132	November 1957	151		19	1 molt
W 286	136	November 1957	153		17	1 molt
W 457	127	December 1957	144	1	17	1 molt
W 271	128	February 1958	149		21	1 molt
W 272	139	February 1958	160		21	1 molt
W 321	130	October 1958	168		38	2 molts
W 398	121	January 1959	158		37	2 molts
W 279	130	February 1959	167		37	2 molts
W 425	130	March 1959	149		19	1 molt 1 skip
W 270	103	September 1959	159		56	3 molts
W 387	116	October 1959	154		38	2 molts 1 skip
W 344	122	October 1959	160		38	2 molts 1 skip
W 421	125	October 1959	159		34	2 molts 1 skip
W 405	126	October 1959	184		58	3 molts
W 323	134	December 1959	173		39	2 molts 1 skip
W 280	114	January 1960	156		42	2 molts 1 skip
W 395	125	January 1960	177		52	3 molts
ALITAK BAY, APRIL, 1956						
Y 662	150	August 1956	150	0		
Y 685	161	August 1956	161	0		
ALITAK BAY, FEBRUARY, 1957						
216	163	March 1958	162		-1	No molts 1 skip
ALITAK BAY, JANUARY, 1958						
560	171	February 1958	170	-1		
555	174	February 1958	172	-2		
620	177	February 1958	175	-2		
576	177	February 1958	176	-1		
563	155	March 1958	155	0		
580	179	March 1958	178	-1		
607	153	February 1959	150		-3	No molts 1 skip
561	174	February 1959	174		0	No molts 1 skip
627	141	April 1959	151		10	1 molt
602	137	September 1959	156		19	1 molt 1 skip
597	142	September 1959	153		11	1 molt 1 skip

Appendix Table 5 (Continued)

Tag No.	Release Length mm	Recapture Date	Recapture Length mm	Measure Error	Growth mm	Remarks
PERENOSA BAY, MARCH, 1956						
Y 526	109	February 1958	142		33	2 molts
Y 550	99	March 1958	145		46	3 molts 2 yrs.
PERENOSA BAY, JULY, 1956						
Y 784	133	January 1957	133	0		
Y 775	136	February 1958	154		18	1 molt
Y 731	141	February 1958	159		18	1 molt
Y 733	141	February 1958	163		22	1 molt
Y 752	133	November 1958	174		41	2 molts
Y 769	142	February 1959	170		28	2 molts
Y 753	125	March 1960	184		59	3 molts

* Molted in live box January 1960

Appendix Table 6. Relationship between growth and month of recapture for the 65 juvenile king crab tag recoveries, 71 to 99 mm. at release, from Chiniak Bay 1959 tagging. 1/

Release length	No growth: October December	Recoveries during 1960 with growth increases from one molt: January	February April	May	June	July	August	September	October November	December	Recoveries during 1961 with growth increases from two molts: January February	March	April	May	June	July	August	September	October November	Totals 1960-61
Mm.										Number										
71	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
74	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
76	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
79	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
81	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
82	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
84	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
85	2	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
86	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	4
87	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2
88	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2
89	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-	3
90	2	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	2
91	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	2*	1	-	7
92	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1

Appendix Table 6. (Continued)

93	-	-	-	-	1	-	-	1	-	-	-	-	-	1	2*	-	-	-	-	5
94	-	1	-	-	-	1	-	-	-	-	-	-	1	-	1	1	2	1	-	8
95	1	-	-	-	1	-	-	1	-	1	-	-	-	-	-	-	-	-	-	3
96	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	1	-	-	4
97	1	-	-	-	-	1	1	-	-	-	-	-	-	-	-	1	2	-	-	5
98	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	1	1	-	4
99	1	-	-	-	1	1	-	1	-	-	-	1	-	-	2*	1	2	1*	-	10
	13	1	0	3	3	8	3	3	0	1	0	1	1	2	9	13	13	4	0	65
Cumulative						22								39 plus 4						
totals from right to left		65	64	64	61	58	50	47	44	44	43	43	42	41	39	30	17	4		

1/ Every recovery captured after January 1960 increased in length.

* Three molts.

Appendix Table 7. Length distribution of the 306 smallest tag recoveries, 71 to 109 mm carapace length at release, from tagging programs, Chiniak Bay 1959, Chiniak Bay 1958, Marmot Bay 1957, and Marmot Bay 1959 by recovery month, showing number of molts occurring during freedom (4 small crabs from Perenosa Bay 1956, Alitak Bay 1956, and Chiniak Bay 1954 were omitted due to limited recoveries).[1/]

Carapace length at release	Molts during freedom	Chiniak Bay, September 1959 tagging — Date of recovery and duration of freedom in months												
		1959	1960					1961						
		September-December, 1-4	January, 5	April-May, 8-9	June-July, 10-11	August-September, 12-13	December, 16	March-April, 19-20	May-June, 21-22	July-August, 23-24	September, 25	October-November, 26-27	Sub-total	Total
Mm.	Number	Number of tag recoveries												
	None	2	0	0	0	0	0	0	0	0	0	0	2	
71-76	One	0	0	0	1	0	0	0	0	0	0	0	1	4
	Two	0	0	0	0	0	0	0	0	1	0	0	1	
	Three	0	0	0	0	0	0	0	0	0	0	0	0	
	None	0	0	0	0	0	0	0	0	0	0	0	0	
77-81	One	0	0	0	0	0	0	0	0	0	0	0	0	1
	Two	0	0	0	0	0	0	0	1	0	0	0	1	
	Three	0	0	0	0	0	0	0	0	0	0	0	0	
	None	3	0	0	0	0	0	0	0	0	0	0	3	
82-86	One	0	0	2	0	0	0	0	0	0	0	0	2	9
	Two	0	0	0	0	0	0	0	2	2	0	0	4	
	Three	0	0	0	0	0	0	0	0	0	0	0	0	
	None	5	0	0	0	0	0	0	0	0	0	0	5	
87-91	One	0	0	1	2	0	0	0	0	0	0	0	3	21
	Two	0	0	0	0	0	0	0	2	9	1	0	12	
	Three	0	0	0	0	0	0	0	0	1	0	0	1	
	None	1	0	0	0	0	0	0	0	0	0	0	1	
92-96	One	0	1	0	5	3	1	0	0	0	0	0	10	22
	Two	0	0	0	0	0	0	1	3	5	1	0	10	
	Three	0	0	0	0	0	0	0	1	0	0	0	1	
	None	5	0	0	0	0	0	0	0	0	0	0	5	
97-101	One	0	0	1	7	6	1	0	0	0	0	0	15	45
	Two	0	0	0	0	0	0	1	3	15	4	0	23	
	Three	0	0	0	0	0	0	0	1	0	1	0	2	

Appendix Table 7 (Continued)

	None	9	0	0	0	0	0	0	0	0	0	0	9	
102-106	One	0	0	5	13	9	0	0	0	0	0	0	27	69
	Two	0	0	0	0	0	0	5	6	20	2	0	33	
	Three	0	0	0	0	0	0	0	0	0	0	0	0	
	None	12	0	0	0	0	0	0	0	0	0	0	12	
107-109	One	0	0	2	5	7	0	0	0	0	0	0	14	55
	Two	0	0	0	0	0	0	0	3	23	1	2	29	
	Three	0	0	0	0	0	0	0	0	0	0	0	0	
	None	37	0	0	0	0	0	0	0	0	0	0	37	
Subtotal	One	0	1	11	33	25	2	0	0	0	0	0	70	226
	Two	0	0	0	0	0	0	7	20	75	9	2	115	
	Three	0	0	0	0	0	0	0	2	1	1	0	4	
		37	1	11	33	25	2	7	22	76	10	2	226	

Chiniak Bay, June 1958 tagging

Date of recovery and duration of freedom in months

Carapace length at release	Molts during freedom	1958 October, 5	1958 November, 6	1958 December, 7	1958 January-February, 8-9	1959 March-April, 10-11	1959 May, 12	1959 August, 15	1959 October-November, 17-18	1960 April, 23	1960 June, 25	1960 July, 26	Sub-total	Total
Mm.	Number	Number of tag recoveries												
	None	0	0	0	0	0	0	0	0	0	0	0	0	
71-76	One	0	0	0	0	0	0	0	0	0	0	0	0	0
	Two	0	0	0	0	0	0	0	0	0	0	0	0	
	Three	0	0	0	0	0	0	0	0	0	0	0	0	
	None	0	0	0	0	0	0	0	0	0	0	0	0	
77-81	One	0	0	0	0	0	1	1	0	0	0	0	2	2
	Two	0	0	0	0	0	0	0	0	0	0	0	0	
	Three	0	0	0	0	0	0	0	0	0	0	0	0	
	None	0	0	0	0	0	0	0	0	0	0	0	0	
82-86	One	0	0	0	1	0	0	0	0	0	0	0	1	3
	Two	0	0	0	0	0	0	0	0	0	1	0	1	
	Three	0	0	0	0	0	0	0	0	0	0	1	1	
	None	1	0	1	2	0	0	0	0	0	0	0	4	
87-91	One	0	0	0	1	0	0	0	1	0	0	0	2	8
	Two	0	0	0	0	0	0	0	0	0	0	1	1	
	Three	0	0	0	0	0	0	0	0	0	0	1	1	

Appendix Table 7 (Continued)

	None	0	0	1	0	2	0	0	0	0	0	0	3	
92-96	One	0	1	0	0	0	0	1	1	0	0	0	3	6
	Two	0	0	0	0	0	0	0	0	0	0	0	0	
	Three	0	0	0	0	0	0	0	0	0	0	0	0	
	None	0	2	1	2	3	0	0	0	0	0	0	8	
97-101	One	0	0	0	0	1	0	0	1	1	0	0	3	11
	Two	0	0	0	0	0	0	0	0	0	0	0	0	
	Three	0	0	0	0	0	0	0	0	0	0	0	0	
	None	1	1	0	1	0	0	0	0	0	0	0	3	
102-106	One	0	0	0	0	0	0	0	0	0	0	0	0	5
	Two	0	0	0	0	0	0	0	0	0	0	2	2	
	Three	0	0	0	0	0	0	0	0	0	0	0	0	
	None	0	0	0	0	1	0	0	0	0	0	0	1	
107-109	One	0	0	0	0	0	0	0	0	0	0	0	0	
	Two	0	0	0	0	0	0	0	0	0	0	0	0	1
	Three	0	0	0	0	0	0	0	0	0	0	0	0	
	None	2	3	3	5	6	0	0	0	0	0	0	19	
Sub	One	0	1	0	2	1	1	2	3	1	0	0	11	36
total	Two	0	0	0	0	0	0	0	0	0	1	3	4	
	Three	0	0	0	0	0	0	0	0	0	0	2	2	
Total		2	4	3	7	7	1	2	3	1	1	5	36	

Marmot Bay, November 1957 tagging

Date of recovery and duration of freedom in months

Carapace length at release	Molts during freedom	1958 November, 13	1958 December, 14	1959 August, 22	1959 September, 23	1959 October, 24	1959 November, 25	1959 December, 26	1960 July, 23	Sub-total	Total
Mm.	Number	Number of tag recoveries									
	None	0	0	0	0	0	0	0	0	0	
71-76	One	0	0	0	0	0	0	0	0	0	0
	Two	0	0	0	0	0	0	0	0	0	
	Three	0	0	0	0	0	0	0	0	0	
	None	0	0	0	0	0	0	0	0	0	
77-81	One	0	0	0	0	0	0	0	0	0	1
	Two	0	0	0	0	0	1	0	0	1	
	Three	0	0	0	0	0	0	0	0	0	

Appendix Table 7 (Continued)

	None	0	0	0	0	0	0	0	0	0	
82-86	One	0	0	0	0	0	0	0	0	0	0
	Two	0	0	0	0	0	0	0	0	0	
	Three	0	0	0	0	0	0	0	0	0	
	None	0	0	0	0	0	0	0	0	0	
87-91	One	0	0	0	0	0	0	0	0	0	3
	Two	0	0	0	0	1	0	1	0	2	
	Three	0	0	0	0	0	0	0	1	1	
	None	0	0	0	0	0	0	0	0	0	
92-96	One	0	0	0	0	0	0	0	0	0	2
	Two	0	0	1	0	0	1	0	0	2	
	Three	0	0	0	0	0	0	0	0	0	
	None	0	0	0	0	0	0	0	0	0	
97-101	One	1	1	0	0	0	0	0	0	2	12
	Two	0	0	0	1	3	5	0	0	9	
	Three	0	0	0	0	0	0	0	1	1	
	None	0	0	0	0	0	0	0	0	0	
102-106	One	0	0	0	0	0	0	0	0	0	9
	Two	0	0	0	0	0	7	2	0	9	
	Three	0	0	0	0	0	0	0	0	0	
	None	0	0	0	0	0	0	0	0	0	
107-109	One	0	0	0	0	0	0	0	0	0	3
	Two	0	0	0	0	1	2	0	0	3	
	Three	0	0	0	0	0	0	0	0	0	
	None	0	0	0	0	0	0	0	0	0	
Sub	One	1	1	0	0	0	0	0	0	2	30
total	Two	0	0	1	1	5	16	3	0	26	
	Three	0	0	0	0	0	0	0	2	2	
Total		1	1	1	1	5	16	3	2	30	

Appendix Table 7 (Continued)

Marmot Bay, September 1959 tagging
Date of recovery and duration of freedom in months

Carapace length at release	Molts during freedom	1959 October, 2	1959 November, 3	1959 December, 4	1960 July, 11	1960 Sub-totals	Total
Mm.	Number	Number of tag recoveries					
71-76	None	1	0	0	0	1	1
	One	0	0	0	0	0	
	Two	0	0	0	0	0	
	Three	0	0	0	0	0	
77-81	None	0	0	0	0	0	0
	One	0	0	0	0	0	
	Two	0	0	0	0	0	
	Three	0	0	0	0	0	
82-86	None	1	0	0	0	1	1
	One	0	0	0	0	0	
	Two	0	0	0	0	0	
	Three	0	0	0	0	0	
87-91	None	0	0	0	0	0	0
	One	0	0	0	0	0	
	Two	0	0	0	0	0	
	Three	0	0	0	0	0	
92-96	None	0	1	1	0	2	3
	One	0	0	1	0	1	
	Two	0	0	0	0	0	
	Three	0	0	0	0	0	
97-101	None	0	1	0	0	1	2
	One	0	0	0	1	1	
	Two	0	0	0	0	0	
	Three	0	0	0	0	0	

Appendix Table 7 (Continued)

	None	0	1	1	0	2	
102-106	One	0	0	0	0	0	2
	Two	0	0	0	0	0	
	Three	0	0	0	0	0	
	None	0	1	0	0	1	
107-109	One	0	0	0	0	0	1
	Two	0	0	0	0	0	
	Three	0	0	0	0	0	
	None	2	4	2	0	8	
Sub	One	0	0	1	1	2	10
total	Two	0	0	0	0	0	
	Three	0	0	0	0	0	
Total		2	4	3	1	10	

* Any months not appearing in the column headings indicate that no recoveries were made during those months.