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FATE OF UNFERTILIZED EGGS IN KING CRABS

Paralithodes camtschatica (Tilesius)

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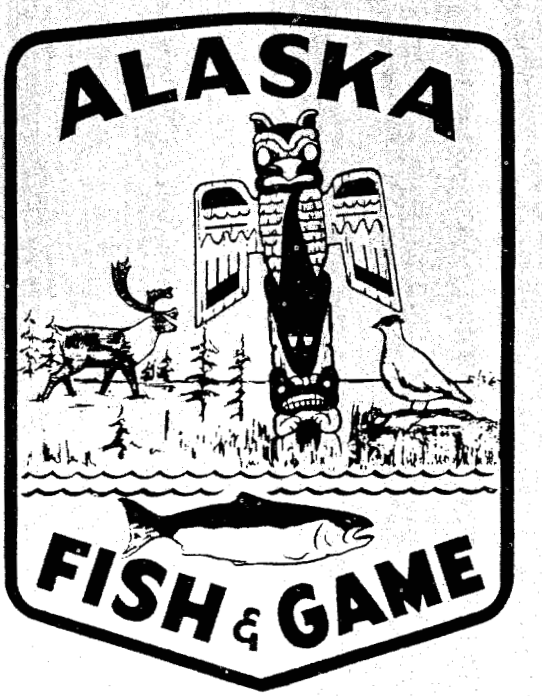

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Paralithodes camtschatica (Tilesius)[1]

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Fate of Unfertilized Eggs in King Crabs Paralithodes camtschatica (Tilesius)

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BACKGROUND STUDIES

King crabs, Paralithodes camtschatica (Tilesius), follow distinct annual migration patterns. During winter months, they migrate to water depths of less than 50 fathoms along the Kodiak Island shoreline (Wallace, et al., 1949; Powell and Reynolds, 1965) and onto the offshore ocean banks (McMullen, 1967). There, the females molt and mate during April and May. Females normally, but not necessarily, molt while being grasped by a male (Marukawa, 1933). Immediately after she molts, the attendant male deposits spermatophore material around the female's oviducts and releases her. The female then extrudes eggs into her abdominal pouch where they mix with the spermatophore material and are fertilized. Fertile eggs are carried by the female for 11-12 months, hatching prior to the female's next annual molt.

Capture of mature females without eggs was a rare occurrence in the histories of the northeast Pacific Ocean and Bering Sea fisheries. A departure from that condition was first noted during the fall of 1966, when Kodiak king crab fishermen began reporting the incidental capture of female king crabs not carrying eggs. Samples of those females, landed at Kodiak for examination by Alaska Department of Fish and Game personnel, were of two descriptions. The pleopods of one group were encumbered with membranes of decayed or ruptured eggs and the pleopods of a second group were free of membranaceous material.

Several theories were advanced concerning the absence of eggs on king crabs of the Kodiak area. Unfavorable water temperatures and disease were considered, but inadequate mating appeared more likely because large numbers of brood males were being removed from Kodiak stocks by the males

only commercial fishery. Studies begun in the spring of 1967 were designed to explain what natural occurrences might cause egg loss or complete absence of eggs from the pleopods of females.

Study of Egg Retention in Unmated Female King Crabs

A study of egg disposition in female king crabs not allowed to mate following their ecdysis was conducted during the spring and summer, 1967 at Kodiak. Fifteen pre-molt females ranging in carapace length from 107-121 mm were collected from grasping males by Alaska Department of Fish and Game SCUBA divers operating in Chiniak Bay, Kodiak Island. The females molted in captivity and were held in floating holding boxes at Kodiak from April 9 to July 21, 1967. There, they were periodically examined to determine if their ripe, unfertilized eggs were being extruded or retained. Eggs in the king crab females' ovaries were visible as a purple mass through the translucent arthroidal membranes of the abdomens, so dissection for examination was not necessary.

All king crab females used in that study retained their 1967 year class eggs in their ovaries, as determined visually by external and internal examinations (Table 1). The first indication that eggs of the unmated females would not eventually be extruded was the presence of tan-colored (assumed dead) eggs among the ripe eggs of one king crab examined on June 15, 1967, 58 days after she had molted. Later, only tan-colored eggs among liquid were observed in the ovaries of four unmated females dissected on July 7, 17, and 19, 1967. The study was terminated on July 21, 1967, with the release of six remaining females containing tan-colored eggs in their ovaries.

Results of that study phase seemed to indicate that female king crabs not allowed to mate after molting and then held widely separated from males would not extrude eggs. Over-ripe eggs in all king crabs held longer than 57 days began to die and decay in the ovaries of those unmated females.

Presence of Infertile Eggs on the Pleopods of Female King Crabs

During a study of delayed mating in king crabs, which was being conducted at the Alaska Department of Fish and Game Kitoi Bay research station during April and May, 1968, an unmated female king crab extruded and held a clutch of eggs. She had molted on April 19, 1968 and was being held with other unmated post-molt females when her eggs were extruded six days later. Groups of eggs removed from her clutch seven days after extrusion had not cleaved, indicating infertility.

Table 1. Condition of unfertilized eggs in female king crabs held in the absence of males following ecdysis, 1967.

Specimens number	Days observed range	Condition of eggs at final examination			
		Date 1967	Location	Color	Condition
1	28 -	5/13	ovaries	purple	ripe
1	41 -	5/21	ovaries	purple	ripe
2	52 - 53	6/ 7	ovaries	purple	ripe
1	67 -	6/15	ovaries	few tan	dying
1	81 -	7/ 7	ovaries	tan	dead
1	93 -	7/17	ovaries	tan	dead
2	96 - 98	7/19	ovaries	tan	dead
6	95 - 102	7/21	ovaries	tan	dead

Trawling from a chartered vessel was conducted during April and May 1968 along the east side of Kodiak Island to investigate mating success of king crabs (McMullen, 1968). One trawl haul at Kaguyak Bay caught 651 mature post-molt female king crabs and nine males. Seventy-six percent of those females were not carrying egg clutches, and although many of the females had soft exoskeletons, several firm post-molt females were carrying clutches of eggs not yet water hardened. All Kaguyak Bay females were examined for purple eggs through the arthroidal membranes of their abdomens, as an indication of maturity.

We assumed that the proportion of male king crabs on the Kaguyak Bay breeding ground was probably as small as the trawl catch indicated, and that a chemical attractant is secreted by pre-molt and molting females to attract brood males. Those assumptions caused us to question the presence of new eggs attached to the pleopods of the firm post-molt females. Ten female king crabs with firm exoskeletons and soft eggs were transported to the Kitoi Bay research station and held for observation. Groups of eggs were removed from each female at 8 and 10 days after capture and microscopically examined for fertility. None of the eggs examined had begun to cleave indicating that the ten females captured at Kaguyak Bay had extruded and held egg clutches without mating or after mating with incapable males. The latter of the two assumptions is probably not correct, for Schöne (1961) states that males of some studied crustacean species do not engage in sexual activity unless capable of fertilizing the female partner.

Further Examination of Mating Success of Kodiak King Crab Stocks

INTRODUCTION

Studies of king crab mating success were continued during the fall of 1968, at which time we accompanied fishing vessels and examined the egg clutches of females captured in pots. Presence of egg clutches and ovary condition of those females that had not extruded their eggs were recorded for each specimen examined. Those observations were conducted to determine the validity of data concerning unmated female king crabs gathered on breeding ground surveys during the spring of 1968.

METHODS

The authors examined two groups of mated and unmated female king crabs to standardize a method of reporting female condition, thereafter we

worked independently. The indoctrination period was especially essential in reporting occurrence of decaying eggs in the ovaries of female king crabs that had not extruded their ripe eggs during the spring of 1968.

After standardizing methods of data reporting, we accompanied fishing vessels where captured female king crabs were measured for carapace length. Generally, only those specimens over 120 mm were included for purposes of determining numbers and percentages of females without eggs. Female king crabs of the Kodiak area mature at 95-113 mm (Gray, 1963) so females included in this study were assumed mature. After being measured, each female was examined for the presence of an egg clutch. Females without eggs were recorded as carrying egg cases or having clean pleopod hairs. Finally, specimens with clean pleopod hairs were cut open to reveal their ovaries. Dissection was performed to determine if their decaying eggs were affecting the development of the following year's clutches or if they were being resorbed. Females carrying eggs were treated differently during October 1968. Their eggs were examined for fertility by placing groups of eggs in Bouin's solution for a few seconds. The immersed eggs absorbed the yellow picric acid of the Bouin's fluid. Fertile eggs were indicated by the appearance of white embryos that absorbed the yellow picric acid at a differential rate than the yolk portion of the eggs. This procedure was not continued in November because all fertile eggs were eyed and, therefore, easily apparent.

RESULTS

Incidences of Female King Crabs Without Eggs

Along the east and south sides of Kodiak Island (Figure 1) 2,475 female king crabs were examined between the dates of October 3 and November 26, 1968. Sample sizes ranged from 2 to 1,396 female king crabs and percentages of females not carrying eggs ranged from 0 to 72 percent among the various samples (Table 2).

Two collections from the Twoheaded Island area contained 72 and 63 percent female king crabs without eggs. Other geographical areas where sampling indicated the presence of at least 30 percent unmated females were Tugidak Island, Sitkalidak Island and Marmot Island. Less than 10 percent of the king crab females examined in the vicinity of Cape Alitak and Ugak Island and Tonki Cape were unmated. Ugak Island and Tonki Cape are not locations of large concentrations of king crab as are the Twoheaded Island and Alitak Bay areas, hence overfishing (resulting in unmated females) is

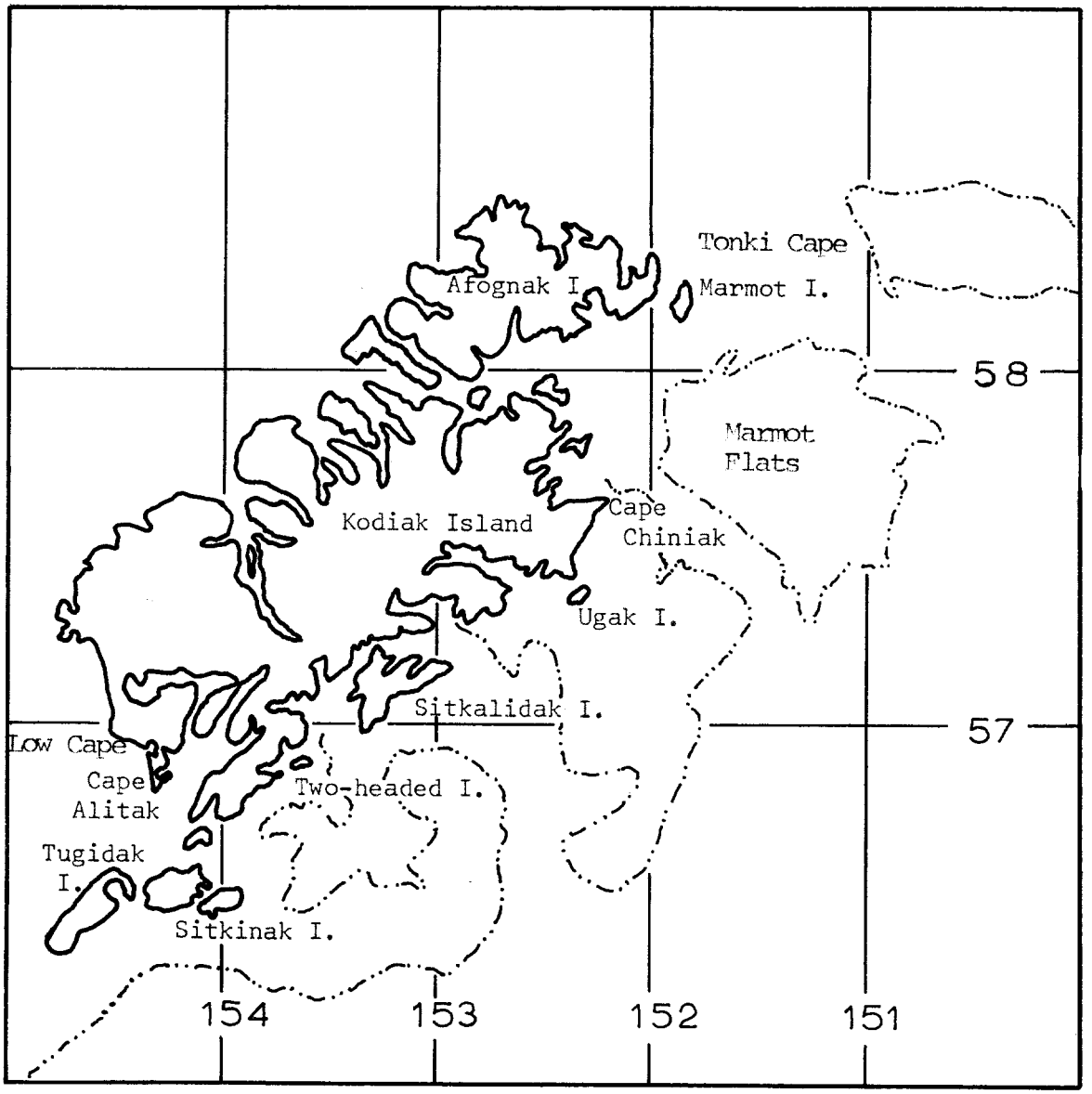

Figure 1. Location of prominent headlands and sampling areas for egg bearing female king crabs, Kodiak Island.

Table 2. -- Description of female king crabs obtained from catches aboard fishing vessels at Kodiak Island, Alaska - Fall of 1968.

Date 1968	Nearest headland	Description of females sampled: carapace length range (mm)	with fertile eggs: number	without eggs: number	without eggs: percent	Total females
10/3	Tugidak Island	95-159	57	34	37	91
10/4	Marmot Island	125-169	46	20	30	66
10/8	Tonki Cape	115-179	56	0	0	56
10/12-14	Twoheaded Island	120-150	26	44	63	70
10/12	Sitkalidak Island	123-145	1	1	50	2
10/12-17	Twoheaded Island	120-154	41	108	72	149
11/9-10	Ugak Island	133-172	103	2	2	105
11/16	Sitkalidak Island	124-158	82	18	18	100
11/19-21	Twoheaded Island	121-150	100	27	21	127
11/22	Ugak Island	121-183	163	16	9	179
11/23-25	Sitkalidak Island	124-169	53	25	32	78
11/25	Low Cape	130-151	50	6	11	56
11/26	Cape Alitak	99-161	1361	35	3	1396
Total			2139	336		2475

less likely to occur in these two areas. The low occurrence of unmated female king crabs in Alitak Bay was encouraging when compared with the high percentages of unmated females along the southeast side of Kodiak Island. A suggested explanation for that difference will be presented in the summary.

Ovary Condition

During the study, captured female king crabs that had not extruded their ripe eggs during 1968 were dissected to determine if those eggs were being resorbed (Table 3). Decaying eggs were common or abundant in 118 or 143 ovaries examined between October 12 and December 5, 1968. The remaining 25 ovaries of the same group of female king crabs contained few or no decaying eggs. However, eight of the 25 unencumbered ovaries were observed at the termination of the study (December 5, 1968) indicating that resorption of decaying eggs was advancing (Figure 2).

The effect of decaying eggs on the development of ripening eggs in the ovaries of the dissected females was also examined (Table 4). The developing eggs in ovaries containing little or no resorbing material appeared to be violet in color with individual eggs much in evidence. Eggs developing for extrusion in 1969 were present among the retained, decaying eggs. From October 12-17, the ovaries from the dissected females revealed a concentration of white stellular shaped eggs within a jellied matrix. At this point, these globular tumor-like masses were thought to affect the next year's reproductive capabilities of the female. However, as additional females were examined from November 16-22, rust-colored globules were found within the ovaries replacing the jellied-matrix masses. No rust-colored globules were observed on December 5 when 23 females were dissected. Although the observations were subjective, it does indicate that the condition of the ovaries which were thought to be affected were returning to the normal condition.

DISCUSSION

Two studies were conducted during the springs of 1967 and 1968 to determine the disposition of ripe eggs in female king crabs not allowed to mate following molting. Females held widely apart from males in an artificial environment did not extrude their ripe eggs over a period of about 100 days after molting. Female king crabs in a natural environment, and apparently not mated after molting, either extruded or held their ripe eggs. The newly

Table 3. Contents of ovaries of female king crabs not carrying egg clutches during the fall of 1968, Kodiak Island

Date 1968	Number females	Ovary contents: Presence of decaying eggs			
		abundant	common	rare	absent
10/12	17	7/17	8/17	1/17	1/17
10/12	3	3/3	0/3	0/3	0/3
10/13	26	18/26	7/26	1/26	0/26
10/14	10	4/10	4/10	2/10	0/10
10/14	11	9/11	0/11	2/11	0/11
10/15	16	11/16	3/16	2/16	0/16
10/17	22	10/22	6/22	5/22	1/22
11/10	1	1/1	0/1	0/1	0/1
11/16	14	4/14	8/14	0/14	2/14
12/5	23	5/23	10/23	3/23	5/23
Totals	143	72	46	16	9

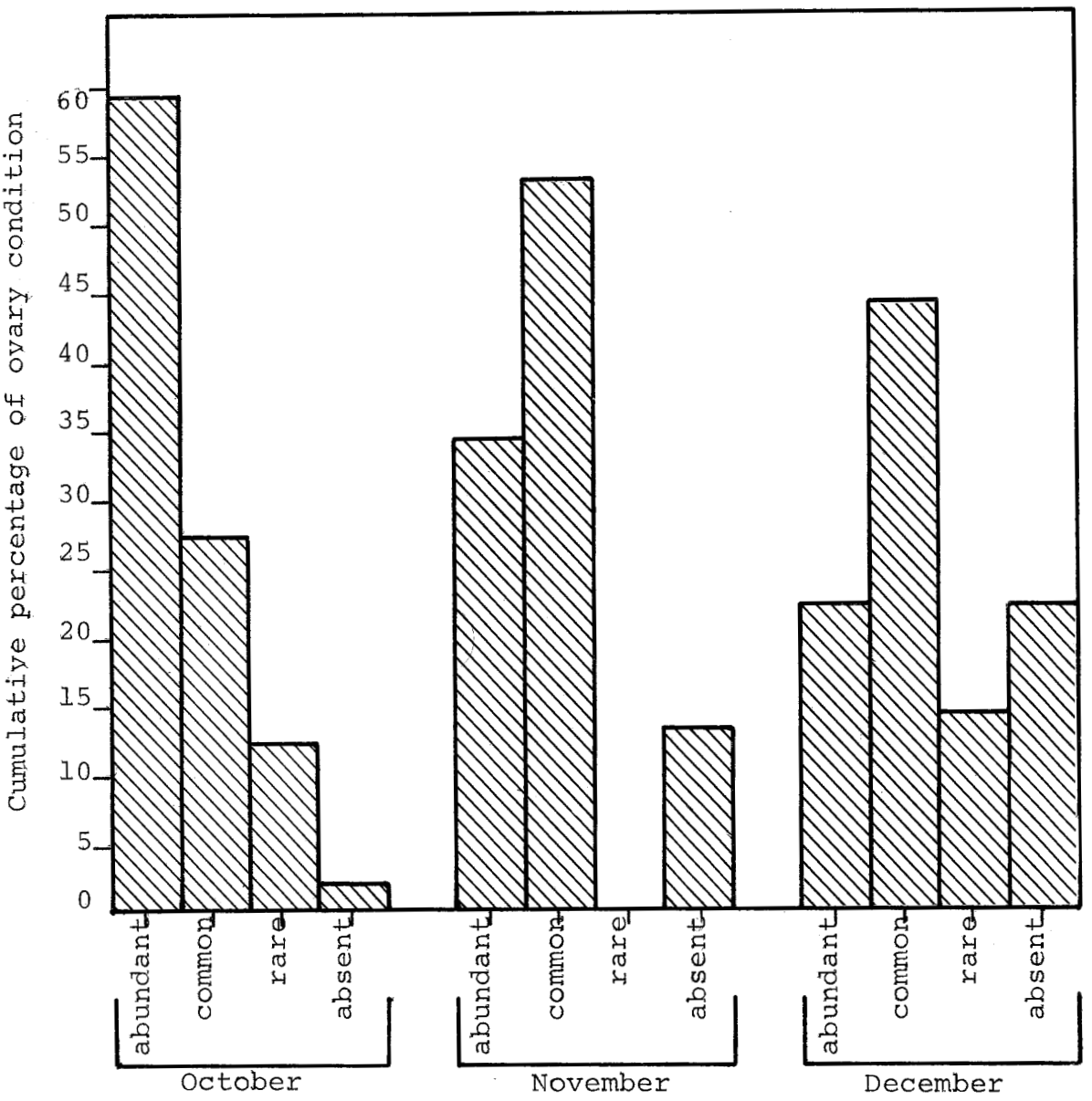

Figure 2. Relative abundance of decaying eggs within ovaries of female king crabs examined during October, November and December, 1968.

Table 4. -- Ovary condition of non-ovigerous female king crabs examined between October 12 and December 5, 1968.

Date 1968	Non-ovigerous females number	Affected ovaries number	Ovary condition
10/12	28	1	jellied matrix appearance
10/13	37	10	jellied matrix appearance
10/14	19	1	jellied matrix appearance
10/15	25	7	jellied matrix appearance
10/17	38	7	jellied matrix appearance
11/16	18	8	rust-colored globules
11/19	16	2	rust-colored globules
11/22	12	5	rust-colored globules
12/5	23	5	disappearance of rust-color

extruded eggs of a group of firm, new-shell females were determined to be infertile. Possibly, females extruding eggs did so in the presence of males or grasping pairs, as a result of visual or chemical stimulation. Females not extruding eggs may have been those that were widely separated from males after molting.

Other studies conducted during the spring of 1968, located large numbers of mature, unmated female king crabs along the south-east side of Kodiak Island. Further observations were conducted at different locations around the Island during the fall of 1968 to determine if the observations of the previous spring were valid. Sampling from aboard fishing boats, we observed as much as 72 percent unmated females in the area of Twoheaded Island during October and November 1968. Female king crabs not carrying eggs also comprised at least 30 percent of the crabs sampled at Tugidak, Sitkalidak and Marmot Islands.

It is evident that as the Kodiak king crab fishery has developed, older, larger crabs have been harvested to near extinction, as indicated by a decrease in average weight of king crabs landed from about ten pounds in 1961 to less than seven pounds in 1968[1/]. As males larger than the legal carapace length of 145 mm are cropped, it may be expected that some females of that size are without partners because Powell[2/] has found that male king crabs seldom mate with females larger than themselves. However, females of carapace length less than 145 mm have also been observed without eggs. In the Twoheaded Island-Tugidak Island area (east side) some female king crabs of all size classes present were observed without eggs. That departure from what might be termed the normal situation where large female king crabs failed to mate because large males were not available may be explained by an examination of the contribution of crabs of offshore southeast Kodiak Island to the entire Kodiak fishery.

King crabs landed in the Kodiak area from fall of 1964 to spring, 1967 totaled about 24.47 million in number. Of those, 14.43 million crabs were caught along the southeast side of the Island. The 1965-1966 fishery produced about 91 million pounds of king crabs of which 63.4 percent were taken from the southeast Island area. At that time a small percentage of sublegal king crabs were allowed to be landed. Many boats fishing the east side delivered to floating processors so our knowledge of actual numbers of sublegal crabs landed is incomplete. The extensive harvest of king crabs from the southeast side of Kodiak Island over the period of the three years mentioned probably reduced the numbers of small male king crabs available for mating. This is particularly evident because that area is known as one of

1/ ADF&G, unpublished data.
2/ Guy C. Powell, ADF&G, personal communication

large concentrations of king crab, which especially applies during the king crab mating season to the inshore areas of Kaguyak Bay, Geese Islands and Sitkinak and Tugidak Islands. In summary, the high percentages of unmated female king crabs observed along the southeast side of Kodiak Island have probably resulted from overharvest of the largest stock of king crabs off Kodiak Island.

Sampling female king crabs from other stocks has not revealed high percentages of unproductive female king crabs comparable to those of the southeast side of Kodiak Island. However, some female king crabs without eggs were located along the east and south side of Kodiak Island except north of Marmot Island.

Effects of retained, decaying eggs on the future reproductive capabilities of king crab females was also studied. Female king crabs examined in connection with this study, and that had not extruded eggs in 1968, contained decaying eggs in their ovaries. The eggs were mixed uniformly with those developing for extrusion in 1969. The masses of decaying eggs ranged from abundant to absent. A decline in amount of decaying material in ovaries examined in late November and December indicated that resorption was occurring. Twenty-five of 143 females examined possessed little or no decaying material in their ovaries, and their developing eggs appeared in good condition. The presence of those females indicated that a condition of total egg resorption might be obtained for most females not extruding eggs, and that female king crabs of that description may be capable of successful reproduction the following year.

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