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SIZE AT SEXUAL MATURITY AND INCIDENCE OF PARTIAL CLUTCHES IN
FEMALE KING CRAB (Paralithodes camtschatica and P. platypus)
AND TANNER CRAB (Chionoecetes bairdi, C. opilio and C. bairdi
x C. opilio) IN THE SOUTHEASTERN BERING SEA IN 1975-1979. C

by

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SIZE AT SEXUAL MATURITY AND INCIDENCE OF PARTIAL CLUTCHES IN FEMALE KING CRAB (Paralithodes camtschatica and P. platypus) AND TANNER CRAB (Chionoecetes bairdi, C. opilio and C. bairdi x C. opilio) IN THE SOUTHEASTERN BERING SEA IN 1975-1979.

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Introduction

Size at sexual maturity is used as part of the rationale for establishing size limits in Bering Sea crab fisheries. The accepted management strategy is to harvest males, only after they have had an opportunity to mate in one or several seasons in order to protect the reproductive potential of the stock. There have been recent changes in these fisheries and in the population abundance of several important stocks. These changes have co-occurred with a warming trend in western Alaska that has been responsible for reduced ice coverage and increased water temperatures over the last several years.

In view of the above changes and the importance of reproductive potential as a concept in fishery management, a review of the 1975-1979 U.S. trawl survey data on the reproductive condition of several eastern Bering Sea stocks seems necessary. This review covers stocks of the red king crab (Paralithodes camtschatica), blue king crab (P. platypus), bairdi Tanner crab (Chionoecetes bairdi), opilio Tanner crab (C. opilio) and the Tanner crab hybrid (C. bairdi x C. opilio). The purpose of this report is to provide an estimate of size at maturity for various stocks and to compare these estimates with those of previous investigators. Estimates of the incidence of partial clutches are also given.

Methods

Data from the 1975-1979 U.S. trawl surveys in the eastern Bering Sea were used in these analyses. Inclusive dates of trawling for the five survey years were: 31 May-10 August, 1975; 29 May-9 August, 1976; 25 May-30 July, 1977; 20 May-18 August, 1978; 22 May-24 August, 1979. Data from the St. Matthew Island and St. Lawrence Island blue king crab populations (i.e., north of 58° N. latitude) were not included in these analyses because data from these areas is scant. Additionally, red king crab data taken prior to June 19, 1975 and June 16, 1976 were not used because many old shell females with partially or completely hatched egg clutches were found prior to those dates.

The area covered by the survey was not the same in each year (Figure 1). In 1975 and 1976, coverage was the same as in 1977. In 1978, however, coverage was expanded northwest to St. Matthew Island and, in 1979, it was expanded again to the latitude of St. Lawrence Island. During the annual trawl survey, crabs are sorted by species and sex and measured to the nearest mm. All females are categorized by the presence or absence of external eggs and relative clutch size. These categories are: immature, no eggs, trace, 1/4 full, 1/2 full, 3/4 full, and full clutch.

A computer program was used to summarize female crab data by 5 mm carapace length (king crab) or carapace width (Tanner crab) increments, listing the number and proportions of crabs in each of the seven clutch size categories. The program also expands the number of crab measured at each tow to the number actually caught if the entire catch was not measured. The percentages of egg-bearing females in a size group are hence weighted by the sampling fraction of each station before being summarized. The numbers of crabs measured are given in Table 1. Crabs larger than 199 mm or smaller than 21 mm were not included in the analysis.

The 5 mm size group at which 50 percent of the females are ovigerous (from trace to full clutch) was chosen as the size of maturity. This technique has been used by many investigators including Wallace et al (1949), Weber (1967), and Somerton (1975). In addition to analyzing the data by year, the data were pooled for all years, and a five year average size at 50 percent maturity calculated.

Subsets of the data for 1976, 1977 and 1978 that excluded old shell crab were also analyzed. The resultant size at maturity curves should represent only primiparous females among Tanner crab but virtually all mature females among king crab. For determining the percent occurrence of full versus partial egg clutches, females with egg clutch sizes from trace to 1/2 full were considered to have partial clutches while females with 3/4 full to full clutches were considered to have full clutches. These data are presented in Table 2.

Results

RED KING CRAB - The five year average size at 50 percent maturity was in the 86-90 mm size increment. The plots of data by year show virtually no variation in size at maturity from year to year (Figure 2). Almost all females reach maturity at sizes between 76-105 mm. There is no tendency for the largest crabs in the population to be barren. Eliminating old shell crab from the data analysis predictably had no effect on the apparent size at maturity.

The average size at maturity calculated is about 10 mm less than that reported by Wallace, et al (1949) and Weber (1967). As Weber (1967) and Somerton (1975) point out, the calculated size at 50 percent maturity might be too low if regions inhabited by juvenile crabs are inadequately sampled. Table 1

shows that sample sizes for both immature and mature crab are large although the percentage of mature crab measured is quite high. Wallace, et al (1949) and Weber (1967) calculated size at maturity based on data collected before 1959; a period when commercial crab catches were at a fraction of their current levels and when population abundance may have been lower. Since the mid 1970's, there has been a marked warming trend in the eastern Bering Sea caused by a succession of mild winters. Increased annual fishery removals, large increases in the estimated population size of both male and female crab over the last 10 years and shifting trends in environmental parameters, such as temperature, may all be causing slight adjustments in the dynamics of the population. One possible result is a slight downward shift in the size at maturity.

The percent of egg-bearing crab with full clutches of eggs ranges from 80 percent in 1976 to 98 percent in 1977. Four of the five values exceed 90 percent suggesting that clutch size is a stable population parameter.

BLUE KING CRAB - The five year average size at 50 percent maturity is in the 101-105 mm increment. The composite maturity curve does not reflect the annual cyclic variations that appear to be occurring in the population (Figure 3). Most crab in the 101-110 mm size interval carry eggs yearly, but radical biennial (odd year) decreases in the fraction of egg-carrying animals begin at 111-115 mm and continue through the largest size groups. No size group in the 1975 population contained 50 percent ovigerous animals. While the percent of ovigerous females varies drastically from year to year, the percent of ovigerous females with full clutches remains virtually constant at 95-100 percent (Table 2). Elimination of old shell crab from the analysis has little effect on the percent maturity curve.

Sasakawa (1973, 1975) has postulated a biennial breeding cycle that consists of a 19-month ovigerous, and 5-month barren period. His studies were conducted primarily in the western Bering Sea between Cape Navarin and Cape Olyutorskiy, although some supportive Pribilof Island population data were included.

Our data suggest that there is a fundamental difference between the reproductive cycle of blue and red king crabs. The odd year occurrence of large females without eggs in our samples tends to support Sasakawa's theory. Other evidence, some of which suggests that spawning occurs soon after egg hatching in at least part of the population, is not supportive of his theory.

BAIRDI TANNER CRAB - The five year average size at 50 percent maturity was in the 71-75 mm increment. This is about 10 mm smaller than the size calculated by Somerton (1975) from data collected on U.S. trawl surveys in 1969-1973. It is interesting to note that Figure 4 shows a progressive decrease in the size at maturity from 1975 to 1979.

Most crabs mature between the sizes of 61-106 mm, showing a rather wide range in size at sexual maturity. Somerton (1975) found a similar range of from 65 to 100 mm. Eliminating old shell crabs from the analysis had little effect on the size at maturity curve. Table 2 shows that the percent occurrence of full clutches ranges from 83-97 percent.

OPILIO TANNER CRAB - The five year average size at maturity is in the 46-50 mm increment. This value is essentially identical to the 50 mm calculated by Somerton (1975) for crabs collected on the 1975 U.S. eastern Bering Sea trawl survey. The plots of data by year (Figure 5) show some variation about the 5 year average although no trend is evident. The range of sizes at which most C. opilio mature is 36 to 65 mm (Figure 5). This is slightly larger than the 20 mm range calculated by Somerton (1975).

There is a greater incidence of barren mature females among C. opilio than among C. bairdi. The percent occurrence of full clutches by year, ranging from 89 to 99%, is given in Table 2. Eliminating old shell crab from the analysis has no effect on the size at maturity curve.

HYBRID TANNER CRAB - (C. bairdi x C. opilio) - The five year average size at maturity for hybrid Tanner crab is in the 46-50 mm increment, the same size as for C. opilio. The major features used to identify hybrids are the shape of the epistome and the relative proportions of the carapace. Figure 6 suggests that, in terms of the size at maturity, most of the crab used in the analysis resembled one or the other of the parent species. Three of the five curves rise sharply at the size at which C. opilio mature, fall steeply, then rise abruptly again at about the size at maturity of C. bairdi (Figure 6). This suggests either that size at maturity among true hybrids is a heterozygous character not prone to intermediate expression or, more likely, that many crabs were incorrectly identified as hybrids.

The proportion of ovigerous females with partial clutches is generally higher among hybrids than among C. bairdi or C. opilio (Table 2), which suggests reduced fecundity of hybrid crab. The wide annual variations in the percentage of partial clutches could well be caused by variable contributions of C. bairdi and C. opilio to the group identified as hybrids from year to year. If large numbers of C. bairdi and/or C. opilio are misidentified as hybrid Tanners, then the actual fecundity of the hybrid is probably considerably lower than that shown in Table 2.

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Table 1. -- Numbers of mature and immature female crabs measured, by species and year.

		1975	1976	1977	1978	1979
<u>Paralithodes camtschatica</u>	≤ 90	971	838	624	561	1088
	> 90	1169	2120	3537	3170	3578
	Total	2140	2958	4161	3731	4666
<u>P. platypus</u>	≤ 105	105	76	58	66	82
	> 105	134	14	87	286	66
	Total	239	90	145	352	148
<u>Chionoecetes bairdi</u>	≤ 70	1657	211	689	2413	1654
	> 70	3926	719	4322	2665	2600
	Total	5583	930	5011	5078	4254
<u>C. opilio</u>	≤ 45	488	592	356	1315	3488
	> 45	3963	7995	4756	7542	7963
	Total	4451	8587	5112	8857	11451
<u>C. bairdi</u> x <u>C. opilio</u>	≤ 45	126	1	252	4	8
	> 45	1226	355	780	251	250
	Total	1352	356	1032	255	258

Table 2. -- Percent of ovigerous king and Tanner crab having a full clutch of eggs (defined as 3/4 full to full). P. platypus data are from south of 58° N only (Pribilof Islands population).

	1975	1976	1977	1978	1979
<u>Paralithodes camtschatica</u>	90	80	98	94	97
<u>P. platypus</u>	95	100	99	97	96
<u>Chionoecetes bairdi</u>	97	83	98	90	92
<u>C. opilio</u>	95	95	99	97	89
<u>C. bairdi</u> x <u>C. opilio</u>	90	29	85	72	93

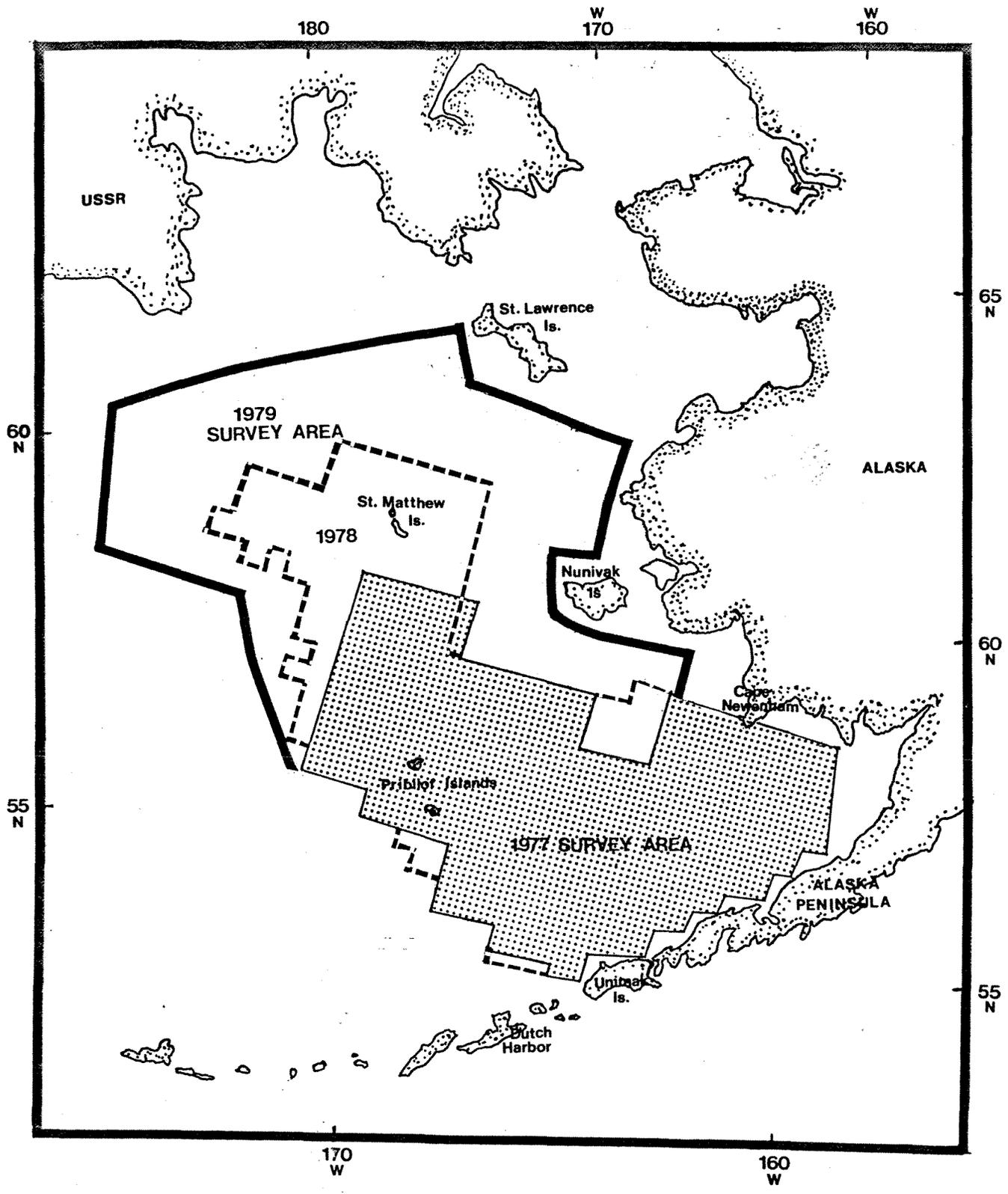


Figure 1. -- NMFS eastern Bering Sea crab survey areas in 1977 (shaded), 1978 and 1979.

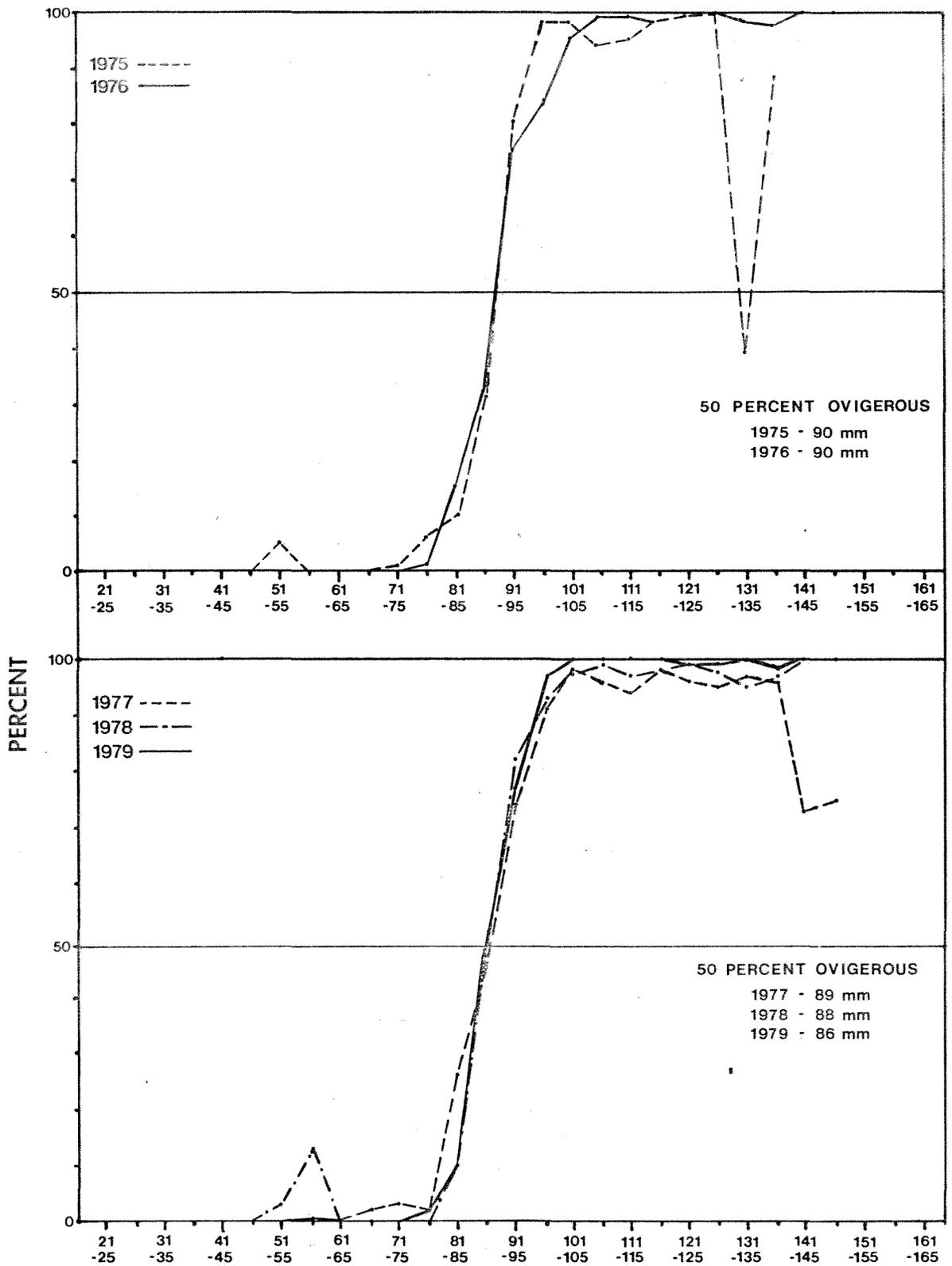


Figure 2. -- Percentage of female red king crab bearing eggs, by 5 mm size group, 1975-1979.

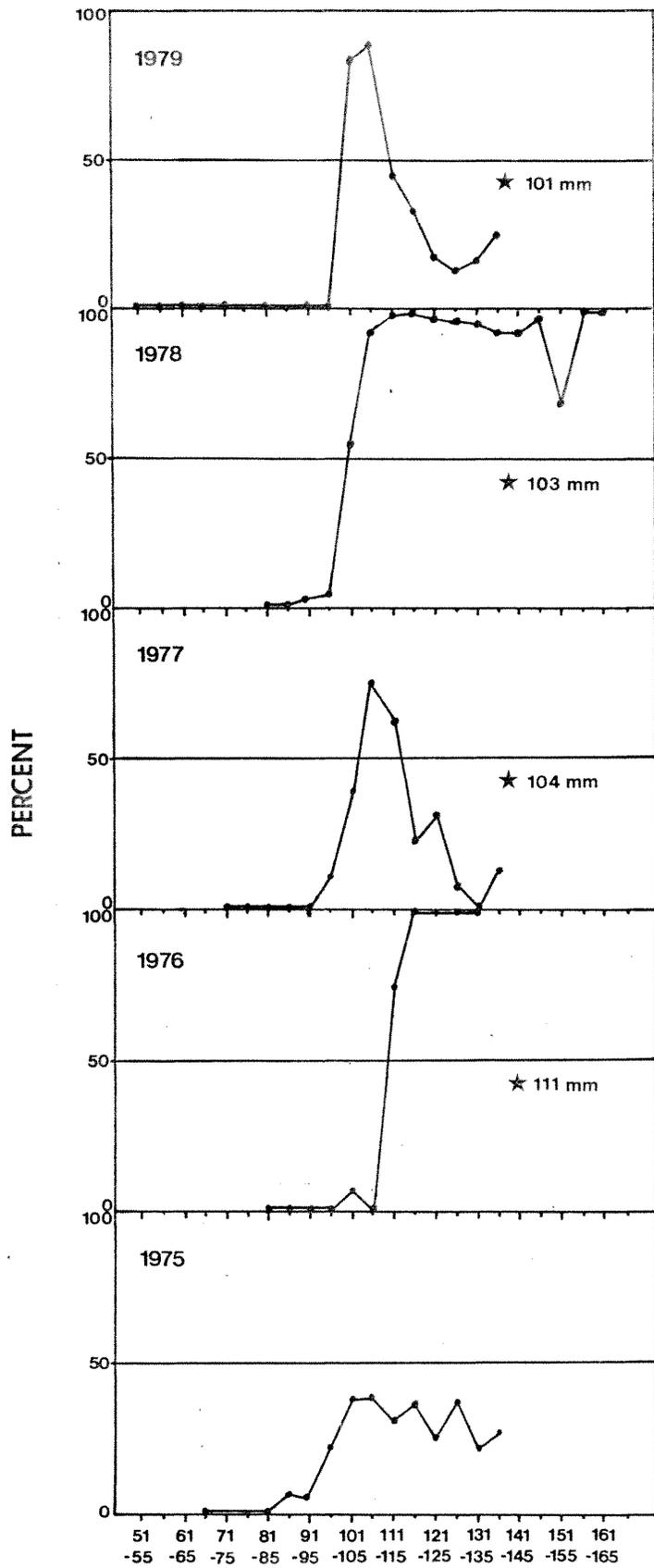


Figure 3. -- Percentage of female Pribilof Island blue king crab bearing eggs, by 5 mm group, 1975-1979.
 * = size at 50 percent maturity.

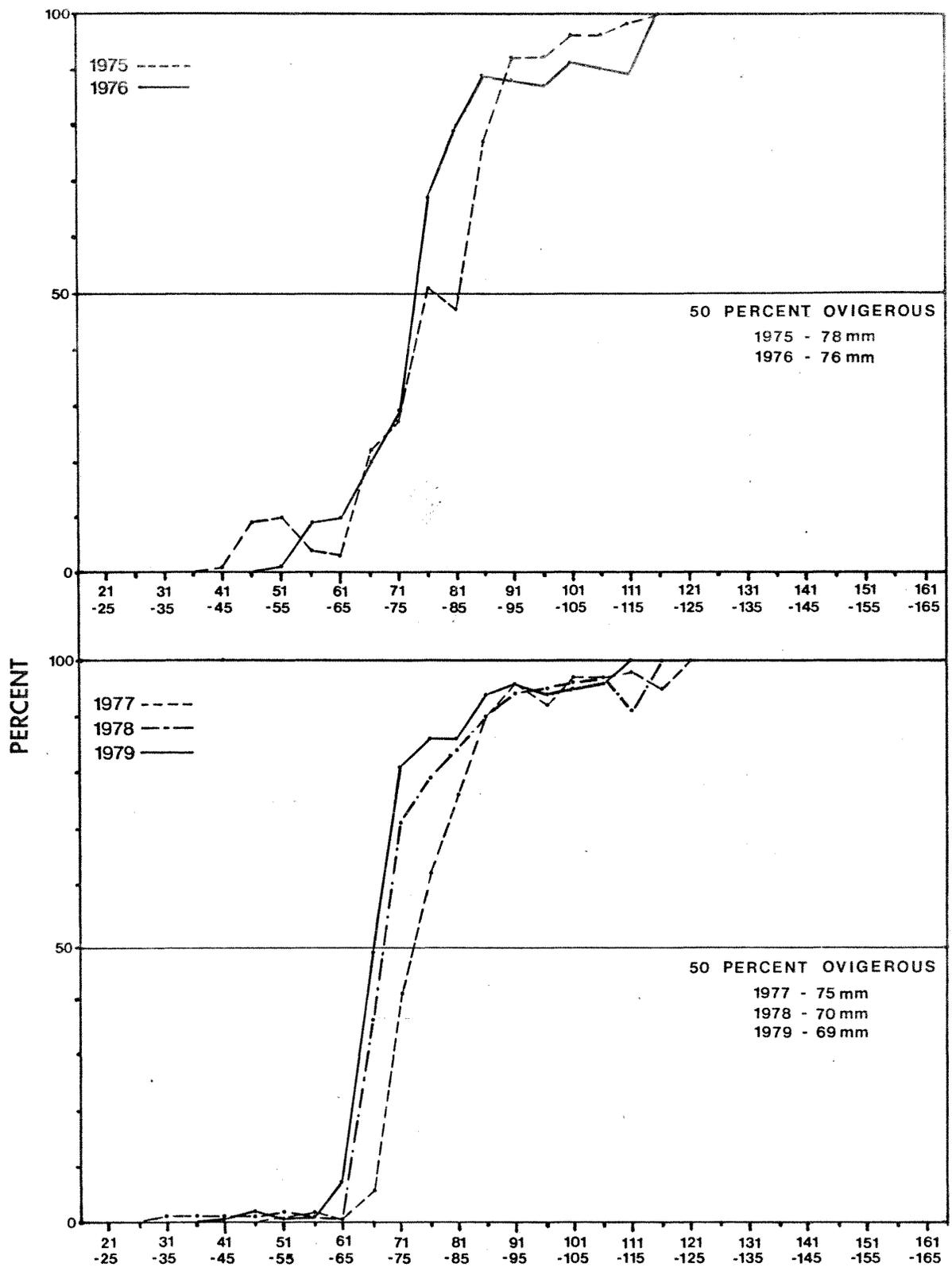


Figure 4. -- Percentage of female *Chionoecetes bairdi* bearing eggs, by 5 mm size group, 1975-1979.

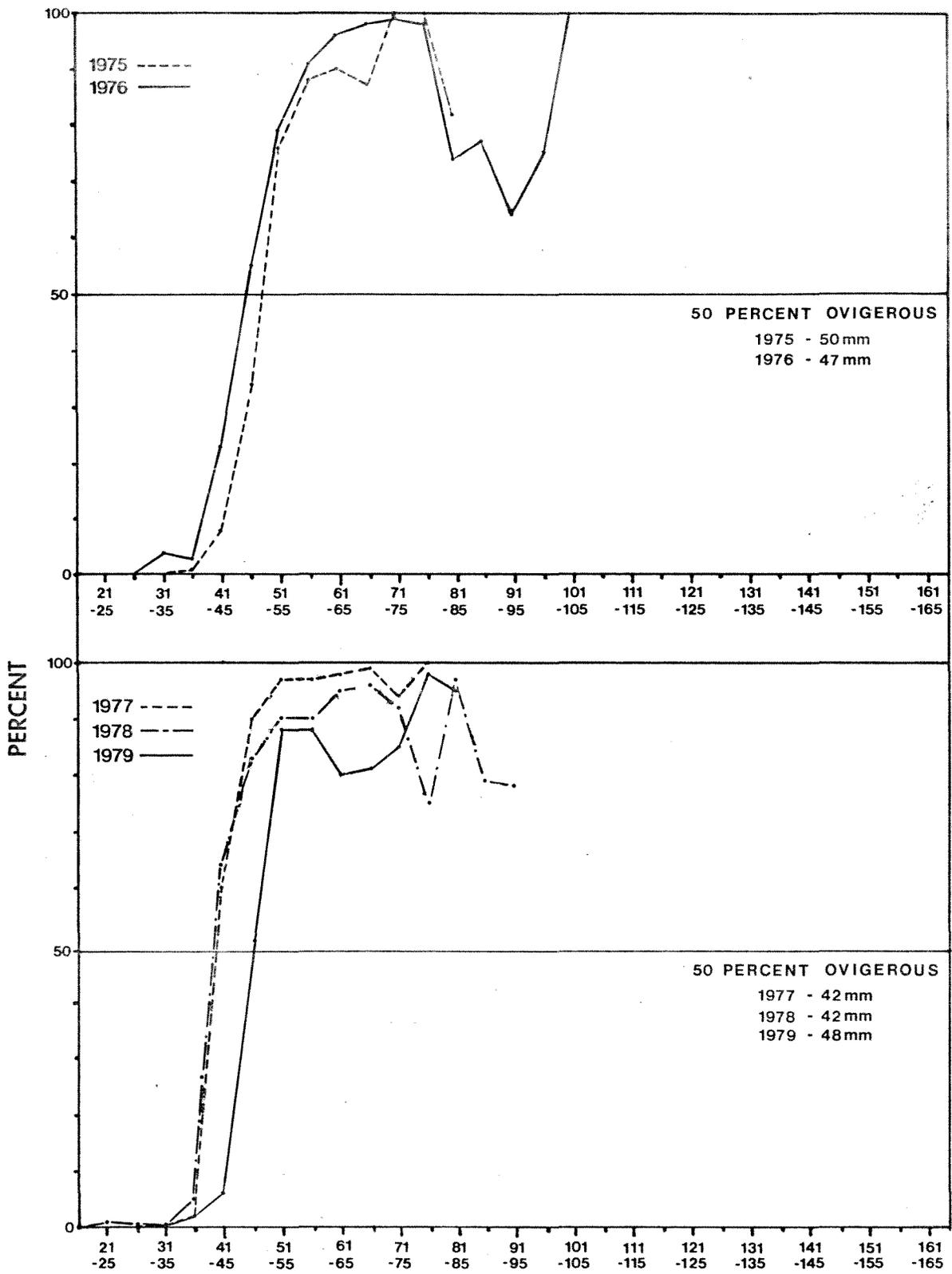


Figure 5. -- Percentage of female *Chionoecetes opilio* bearing eggs, by 5 mm size group, 1975-1979.

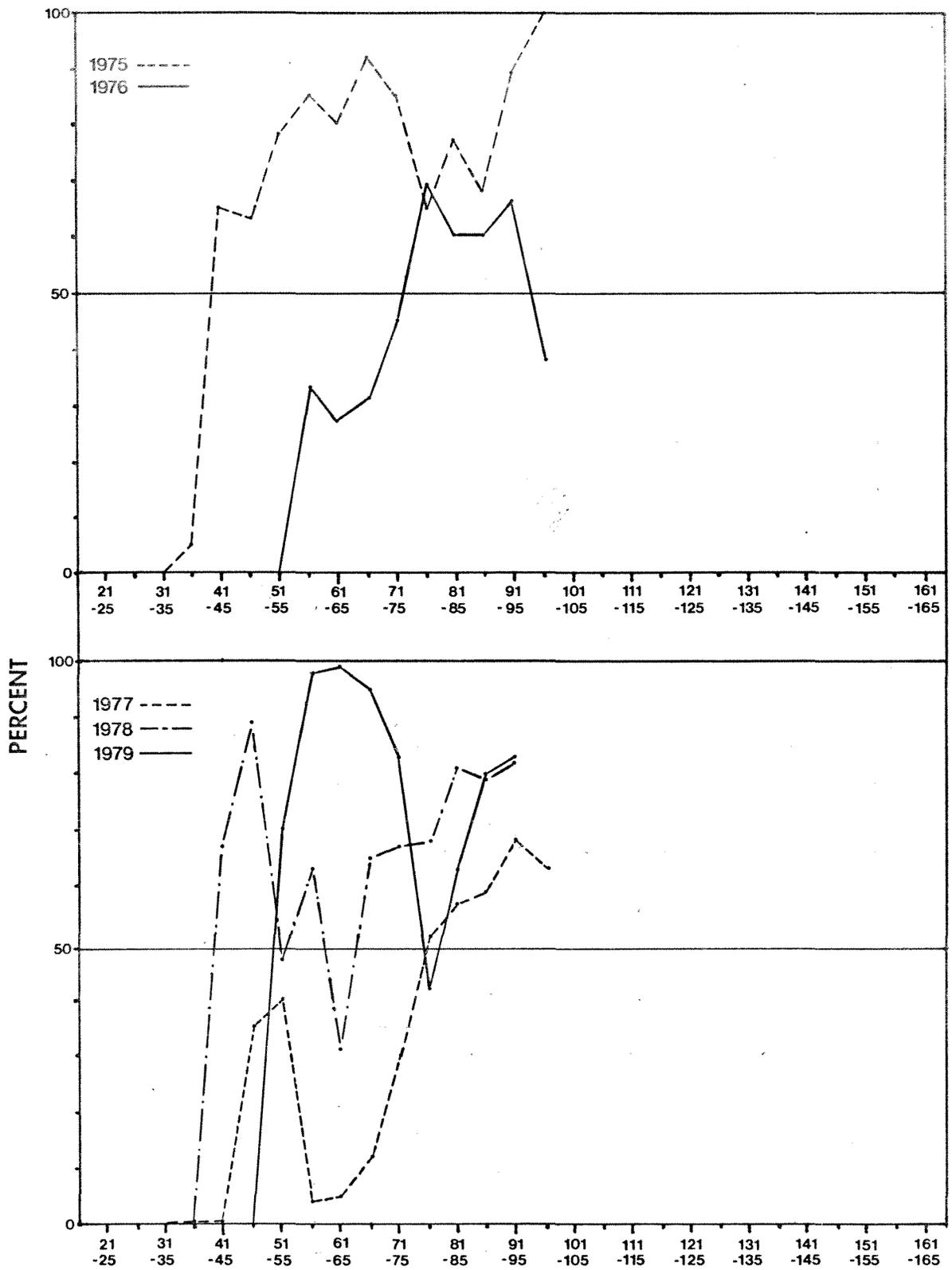


Figure 6. -- Percentage of female hybrid Tanner crab bearing eggs, by 5 mm size group, 1975-1979.