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WEIGHT-SIZE RELATIONSHIPS FOR THREE POPULATIONS IN ALASKA OF THE BLUE KING CRAB, *PARALITHODES PLATYPUS* (BRANDT, 1850) (DECAPODA, LITHODIDAE)[1])

BY

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The blue king crab, *Paralithodes platypus* (Brandt, 1850), is a commercially harvested species which occurs in small isolated populations located sporadically throughout much of coastal Alaska. Populations within the eastern Bering Sea are primarily associated with offshore islands (Otto, 1981); populations south of the Alaska Peninsula are associated with enclosed bays and fjords.

The relationship between body weight and size, which is important information for fisheries management, has not been reported for blue king crab. In this paper, weight-size relationships of male blue king crab are estimated for and compared between two island populations and one bay population in Alaska.

MATERIALS AND METHODS OF COLLECTION

Male blue king crab were sampled from three populations; St. Matthew Island and Pribilof Islands, both in the eastern Bering Sea, and Olga Bay, in the Gulf of Alaska (fig. 1). Samples from the Bering Sea were collected using bottom trawls on research cruises conducted by the National Marine Fisheries Service during June and July each year from 1978 to 1981. Samples from Olga Bay were collected by SCUBA divers and with ring nets in March, June and October 1980, and January 1981. Except for Olga Bay, where crabs >1.5 kg were weighed to the nearest 5 gram using a hand held balance (Nippon Dyne-a-mat fish scale), weights were measured to the nearest 1 gram using a triple beam balance (Ohaus dial-o-gram). Shell condition, an index of postmolt age based on exoskeleton wear and accumulation of epifauna, was classified according to the following four point scale:

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Shell condition	Assumed age since last molt	Characteristics
1	< 2 weeks	carapace flexible, sternum without dark brown scratches or spots
2	> 2 weeks < 12 months	carapace firm, sternum without dark brown scratches or spots, little epifauna
3	> 12 months < 24 months	carapace firm, sternum with dark brown scratches and spots, dactyl tips worn or blunt, barnacles usually present
4	> 24 months	same as shell condition 3 except dactyl wear is more pronounced and barnacles are larger.

Crabs that had recently molted (shell condition 1), or had exoskeletons covered with encrusting epifauna (shell condition 4), or had partially regenerated appendages were not included in the weight samples. Carapace lengths (see Wallace et al., 1949 for a definition of this measurement) were measured with sliding jaw calipers to the nearest 1 mm.

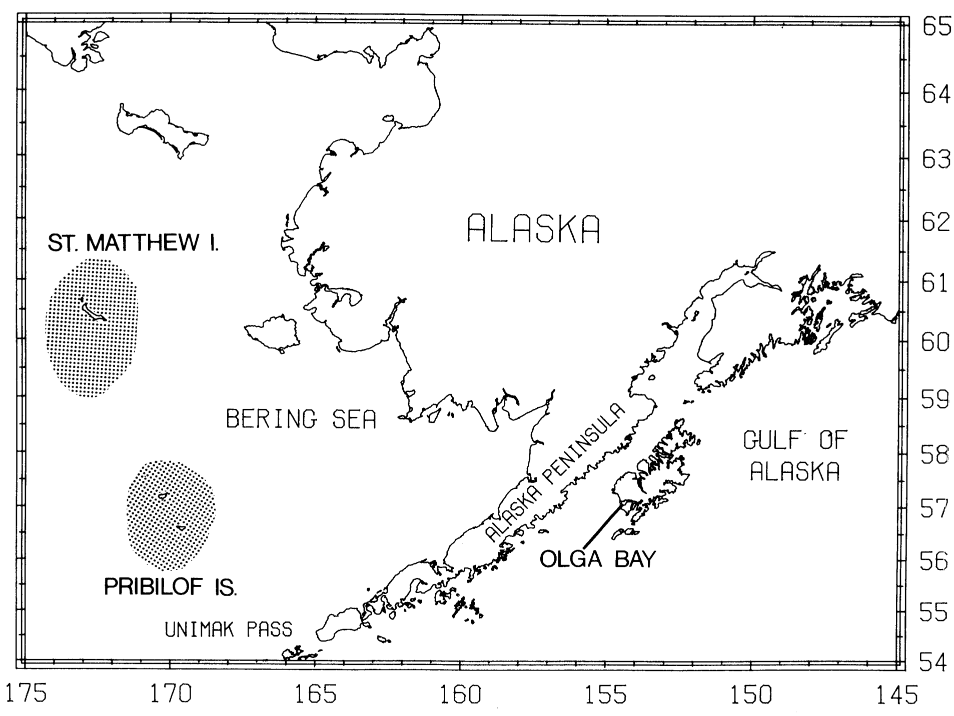

Fig. 1. Locations of the three sampled blue king crab populations (bold face letters). The shaded areas represent the approximate summer distributions, based on Otto (1981), of adult and juvenile blue king crab for each Bering Sea population.

RESULTS

Weight was assumed to be proportional to carapace length raised to a power, that is $W = AL^B$, where W is weight (g), L is carapace length (mm) and A and B are parameters. Since on log-log axes this relationship is linear ($\log W = \log A + B \cdot \log L$), the two parameters were estimated by fitting a straight line to the natural logarithms of weight and carapace length. Weight and carapace length data and the fitted curves are shown in fig. 2 for each population. Estimated parameters are shown in table I.

Equality of the weight-size relationships between populations was tested using Analysis of Covariance (ANCOVA). The slopes (B) of the weight-size relationships did not differ (P = .3279) between populations, but the intercepts (log

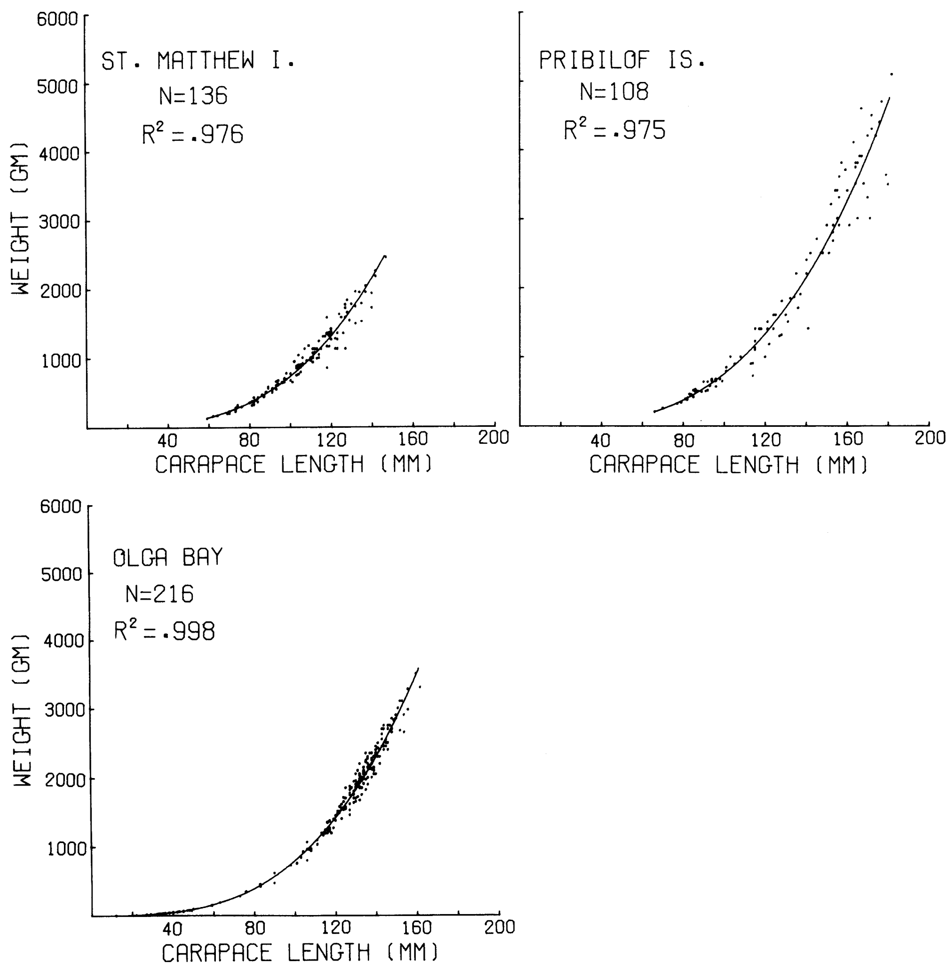

Fig. 2. Body weight and carapace length data and the fitted weight-length curves are shown for each of the three populations.

TABLE I

Estimated parameters of the fitted weight-length relationships for each of the three populations. A* are estimates of the proportionality constants (antilogs of the intercepts) assuming the slopes are all equal to the common slope (B*).

Population	A	B	A*	B*	N
St. Matthew Island	.000329	3.175	.000427	3.119	136
Pribilof Islands	.000470	3.103	.000434	3.119	108
Olga Bay	.000475	3.115	.000464	3.119	216

A), assuming a common slope, differed significantly ($P < .0001$). Pairwise comparisons of the intercepts (Bonferroni t test; Miller, 1966) showed that St. Matthew Island and Pribilof Islands populations did not differ ($> .1372$) but that Olga Bay population differed significantly ($P < .0001$) from each of the Bering Sea populations. Since the intercepts rather than the slopes of the weight-size relationships differ between the Olga Bay and each of the Bering Sea populations, the ratio of the weight of an Olga Bay crab to the weight of an equal size Bering Sea crab is a constant. Olga Bay blue king crab are therefore roughly 8-9% heavier at all sizes than either St. Matthew Island or Pribilof Islands crabs.

The differences in the weight-size relationship between Olga Bay and Bering Sea populations could have resulted from either differences in the times of sampling or differences in the size ranges and shell conditions of the crabs sampled. To obtain a comparison of weight-size relationships between populations which is free of the confounding effects of sampling differences, certain categories of data were excluded. The probable effects of sampling differences and the categories of excluded data are discussed below.

The Olga Bay population was sampled at three month intervals whereas the Bering Sea populations were sampled only in summer. Since the March, June, October, and January Olga Bay samples had significantly different slopes ($P = .0190$), the weight-size relationships change with season. To minimize this seasonal effect, the January and March Olga Bay samples, which were collected at a time of year most different from the Bering Sea samples, were eliminated. The June and October Olga Bay samples were then compared to determine whether seasonal differences could still be detected. Since neither the slopes ($P = .5389$) nor the intercepts ($P = .7804$) differed significantly, the June and October Olga Bay samples were pooled and retained for comparison with the Bering Sea populations.

The size ranges of the crabs included in the samples differed between populations (59-147 mm, St. Matthew Island; 66-182 mm, Pribilof Islands; 12-152 mm, Olga Bay). Since the probability of detecting differences in the weight-size relationships increases with a greater size range of data, the significance of the differences between Olga Bay and the Bering Sea populations may have been influenced by the greater size range of the Olga Bay sample. To minimize this effect, only crabs ≥ 60 mm in the Olga Bay sample were retained for comparison with the Bering Sea populations.

Blue king crab may skipmolt or defer molting for one or more years in succession. Depending on the time of sampling relative to the time of molting (the molting season of blue king crab is not known with certainty, but we believe it is in late spring or early summer), skipmolt (shell condition 3) crabs may be heavier than equal size non-skipmolt (shell condition 2) crabs due to greater calcification of their exoskeletons. To determine whether weight-size relationships differ with shell condition, Olga Bay skipmolt and non-skipmolt crabs were compared using ANCOVA. The slopes of the weight-size relationships did not differ ($P = .5306$), but the skipmolt intercept was significantly greater ($P = .0058$) than the non-skipmolt intercept (skipmolt crabs are approximately 3% heavier at all sizes than non-skipmolt crabs). Since the percent of skipmolt crabs was higher in the Olga Bay sample (19%) than in either the St. Matthew Island sample (5%) or the Pribilof Islands sample (14%) the average weight at a given size is greater. To minimize this effect, only non-skipmolt crabs from all populations were retained for comparison.

After eliminating the various confounding categories of data, the weight-size relationships were again compared between Olga Bay (reduced sample $N = 87$), St. Matthew Island ($N = 128$) and Pribilof Islands ($N = 92$) populations using ANCOVA. As before data elimination, the slopes did not differ ($P = .0696$) but the intercepts differed significantly ($P < .0001$). Pairwise comparisons of the intercepts again showed that St. Matthew Island and Pribilof Island populations did not differ but the Olga Bay population differed significantly ($P < .0001$) from each of the Bering Sea populations. Olga Bay crabs were 9.7% heavier than St. Matthew Island crabs and 8.4% heavier than Pribilof Islands crabs. The observed greater weight of Olga Bay crabs, therefore, reflects a true population difference rather than a difference in the sampling design.

DISCUSSION

Olga Bay blue king crab are roughly 8-9% heavier at all sizes than either St. Matthew Island or Pribilof Islands crabs. This constant weight ratio suggests that the morphology of blue king crab may differ between areas. Such a difference could reflect morphological divergence due to genetic isolation of the populations or it could reflect ontogenetic responses to environmental differences between areas.

Although we have not examined the morphology of blue king crab in detail, the height of the right chela (see Wallace et al., 1949 for a definition of this measurement) was measured on a number of specimens from both Olga Bay and Pribilof Islands. The relationship between chela height (C) and carapace length (L) of adult males was $Y = .1246L^{1.24}$ ($N = 284$) for Olga Bay and $Y = .0722L^{1.34}$ ($N = 553$) for Pribilof Islands. Since the exponents of these relationships differed between areas (ANCOVA, $p = .0028$), the ratio of Olga Bay chela height to Pribilof Islands chela height varied with carapace length. The proportionality constant differed by such a large amount, however, that Olga Bay chelae were larger than Pribilof Islands chelae over the entire adult size range in both areas. At 140 mm, for example, Olga Bay crabs had chelae which were 5.3% larger than those of Pribilof Island crabs. Chela size, however, is only one of the possible morphometric differences that could contribute to the observed weight-size difference between Olga Bay and Bering Sea blue king crabs.

The three blue king crab populations examined differ in degree of genetic isolation. Although St. Matthew Island and Pribilof Islands populations appear to be discrete based on the summer distributions of adults and juveniles (fig. 1), they may not be genetically isolated because the planktonic larvae of blue king crab could be exchanged between populations. The Olga Bay population is, however, genetically isolated from the Bering Sea populations both because the narrow (< 100 m) and shallow (< 5 m) entrance to Olga Bay limits the export of larvae and because Olga Bay is more than 1,000 km distant from the Bering Sea populations. Isolation may have allowed evolutionary divergence in the morphology of blue king crabs between the Olga Bay population and the Bering Sea populations.

The difference in the weight-size relationship between Olga Bay and the Bering Sea populations may also reflect environmental differences between areas. Another species of king crab, red king crab (*Paralithodes camtschatica* (Tilesius)), is also heavier at a given size in the Gulf of Alaska than it is in the eastern Bering Sea (Wallace et al., 1949). Unlike blue king crab, however, red king crab have a fairly continuous distribution between the Gulf of Alaska and the eastern Bering Sea (Otto, 1981). Currents westward along the Alaska Peninsula and northward through Unimak Pass probably advect red king crab larvae from the Pacific Ocean into the eastern Bering Sea (Kinder & Schumacher, 1981). In this case, weight-size differences are probably due to morphological responses to environmental variables rather than genetic isolation and morphological divergence. The morphology of blue king crab may be influenced by environmental variables in a similar manner.

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RÉSUMÉ

Les relations entre le poids du corps et la longueur de la carapace ont été calculées chez le Lithodidae, *Paralithodes platypus*, pour trois populations: Ile St. Matthew et Iles Pribilof dans la mer de Bering orientale et Olga Bay dans le golfe d'Alaska. Les exemplaires d'Olga Bay ont un poids significativement plus élevé (d'environ 8-9%) que ceux des îles St. Matthew et Pribilof. Les différences dans les relations poids/taille laissent supposer que la morphologie de *Paralithodes platypus* peut également différer d'une localité à l'autre.

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