DISTRIBUTION AND CATCH COMPOSITION OF JONAH CRAB, *CANCER BOREALIS*, AND ROCK CRAB, *CANCER IRRORATUS*, NEAR BOOTHBAY HARBOR, MAINE[1]

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ABSTRACT

An analysis of research and commercial catch data of Jonah crab, *Cancer borealis*, and rock crab, *C. irroratus*, collected near Boothbay Harbor, Maine, revealed dissimilarities in the distribution of the two species. Jonah crabs were more numerous at the deeper, seaward sampling sites with rocky substrates, while rock crabs were more abundant on soft mud bottoms of the shallower estuarine stations. Distribution of both species is dependent upon the environmental factors of temperature, depth, and substrate type. Absence of Jonah crabs <67 mm carapace width in all collections, indicates that, unlike the rock crab, the nursery areas of the Jonah crab are not in nearshore waters. Sex ratios varied seasonally and spatially for rock crabs and seasonally for Jonah crabs. These variations seem to be related to changes in local abundance as the result of movement in association with the reproductive and molting cycles.

Jonah crab, *Cancer borealis*, and rock crab, *C. irroratus*, make up a small but increasingly important commercial fishery along the Maine coast. Since 1966, the price per pound of crabs paid to the fisherman has increased from 4¢ to 12¢ (Figure 1). As a result the Maine lobstermen have been selling their incidental catches of crabs to offset increasing operational costs (bait, fuel, etc.). In view of the current retail price of American lobster, *Homarus americanus*, which often exceeds $3.00/lb, the value of the very palatable crab may be expected to continue to increase. In fact, some dealers are now paying 20¢ to 25¢/lb for crab.

Despite the present economic value (reported 1977 landed value was $142,106) of Maine's crab fishery and its potential for future growth, there is little information on the biology of either of the cancrid crabs. While several investigators have studied various aspects of the life history of *C. irroratus*, very little work has been done on *C. borealis* other than by Haefner (1977) and Carpenter (1978) on the distribution and biology of *C. borealis* on the continental shelf of the Mid-Atlantic Bight and by Sastry (1977) on the larval development of *C. borealis*.

To supplement these studies, I have: 1) examined the size and sex composition and distribution of Jonah crabs in commercial and research catches in Maine waters; 2) described the width-weight relationship of the Jonah crab; and 3) compared the distribution, size, and sex composition of Jonah and rock crabs from commercial and research catches.

METHODS

Jonah crabs were caught incidental to the lobster sampling program of the Maine Department of Marine Resources during which vinyl-coated wire (2.54 × 2.54 cm mesh) and conventional wooden lobster traps were fished at nine locations (Figure 2) near Boothbay Harbor, Maine, from July 1968 to December 1974.

At the time of capture, each crab was sexed and measured. Carapace width (CW), distance between the two outermost notches on the anterolateral border of the carapace, was recorded to the nearest millimeter.

Width-weight relations were calculated for 110 male (89-160 mm CW) and 90 female (96-131 mm) Jonah crabs caught by commercial fishermen near Boothbay Harbor, 1973 through 1976. Wet weights were recorded to the nearest 10 g. Linear regression of weight on carapace width was fitted by the method of least squares to logarithmically (base 10) transformed data, and analysis of covariance was used to evaluate the regression coefficients of males and females for differences.

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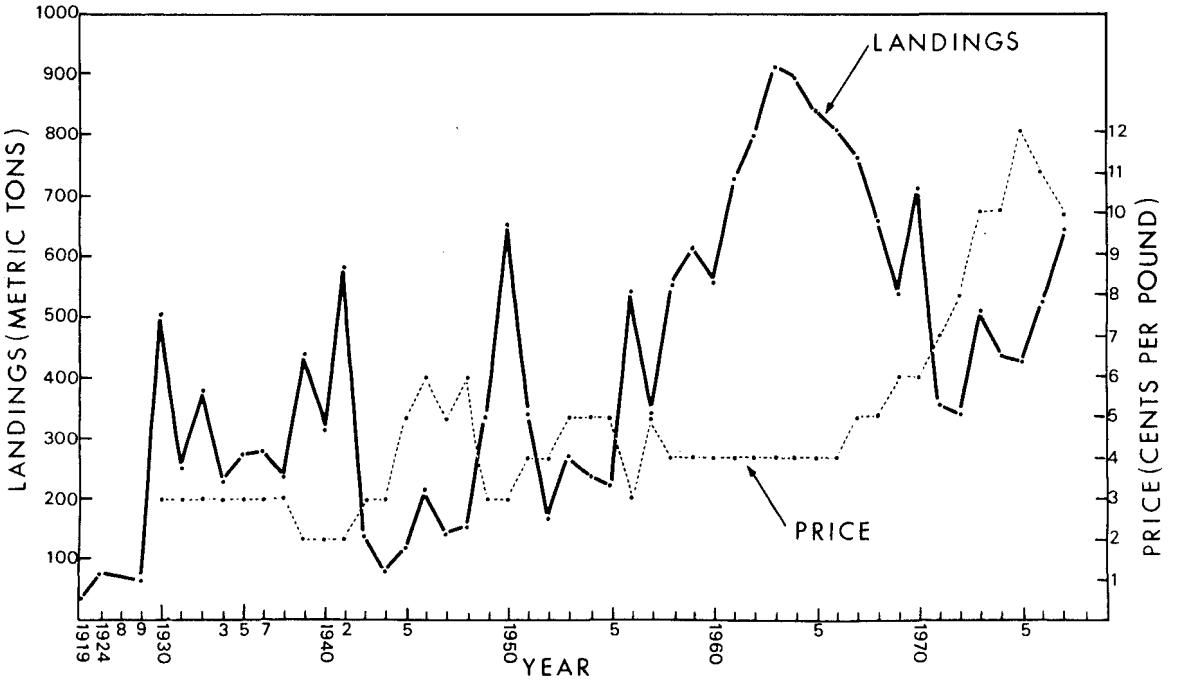

FIGURE 1.—Catch and ex-vessel price of Jonah and rock crabs (species combined) landed in Maine, 1919-77.

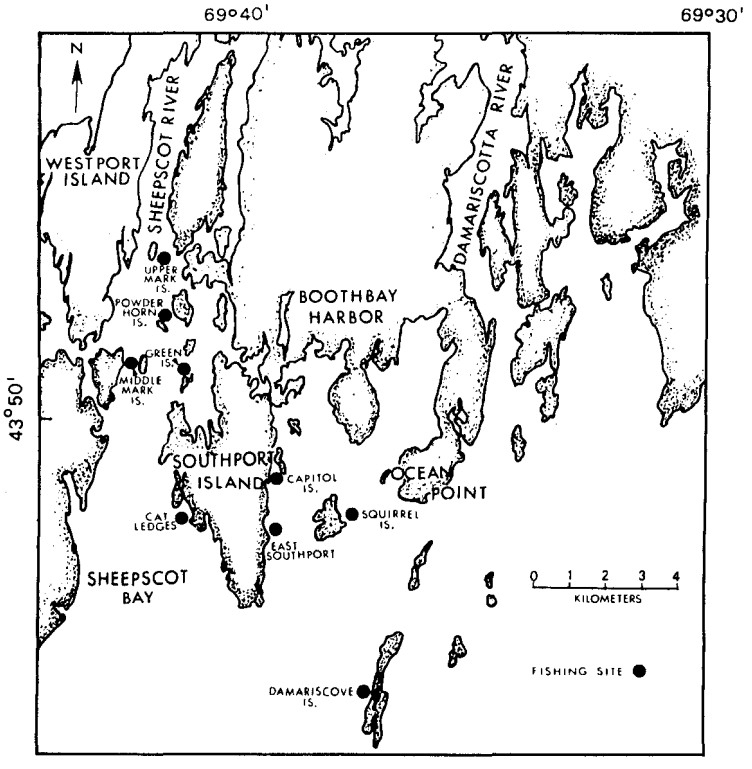

FIGURE 2.—Boothbay Harbor region and location of sampling sites.

Additional commercial catch data were provided by Joel Cowger, Maine Department of Marine Resources, West Boothbay Harbor, Maine, who obtained measurements of 299 commercially caught Jonah crabs from the Maine coast (September 1977-March 1978). Carapace widths were measured between the tips of the outermost anterolateral spines. These long carapace width measurements can be converted to short carapace width (distance between notches) by the linear regression $Y = -1.669 + 0.973X$ where Y = short CW and X = long CW (Carpenter 1978).

RESULTS AND DISCUSSION

Size Composition

Jonah crabs captured with research traps (mean 104.8 mm CW for females and 113.7 mm for males) were significantly smaller (t-test, $P<0.01$) than those crabs commercially landed at either Boothbay Harbor (mean 114.0 mm CW for females and 128.6 mm for males) or at other Maine ports (mean 114.0 mm CW for females and 141.1 mm for males) (Figures 3-5). At first it was thought that disparities in size composition might be associated to variations in selectivity of the research and commercial gear for crabs <95 mm CW; however, since similar proportions of small crabs appeared in both the research and commercial catches (Figures 3-5), the effects of gear selectivity must be minimal. The near total absence of crabs <95 mm CW in the commercial catch from Boothbay Harbor (Figure 4) was the result of fishermen discarding the smaller crabs before their landed catches were measured; whereas, the catches shown in Figures 3 and 5, which were measured at sea, included all crabs caught. Thus, I attribute these size disparities to spatial variations in the distribution of different size crabs. For instance, research traps were fished at depths of 3-20 m, whereas, most commercial traps were fished at depths of 12-91 m. In support of this contention, different size groups of Jonah crabs have been observed to be distributed within the Mid-Atlantic Bight according to depth (Haefner 1977; Carpenter 1978).

Male Jonah crabs averaged larger than females in all catches (Figures 3-5); similarly, male rock crabs generally averaged larger than females (Krouse 1972). Unlike female rock crabs, which have no commercial value because of their small size (rarely >100 mm CW, Krouse 1972), female Jonah crabs, which approximate the size of male rock crabs, are commercially harvested along with male Jonah crabs.

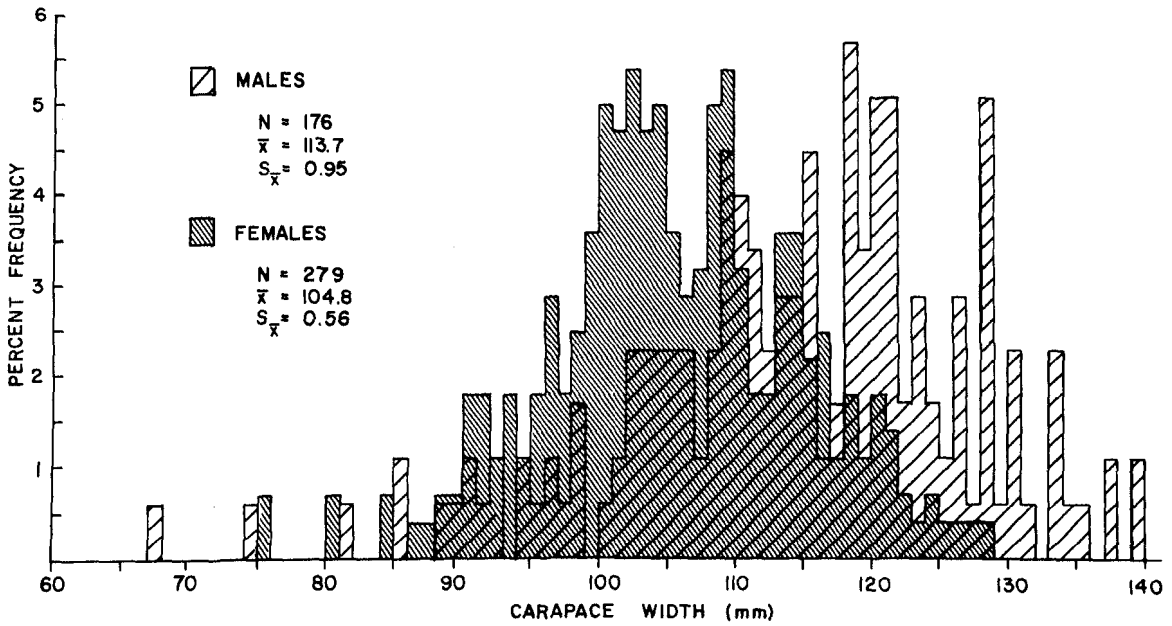

FIGURE 3.—Width-frequency distributions of male and female Jonah crabs caught with research traps in the Boothbay Harbor region, 1968-74.

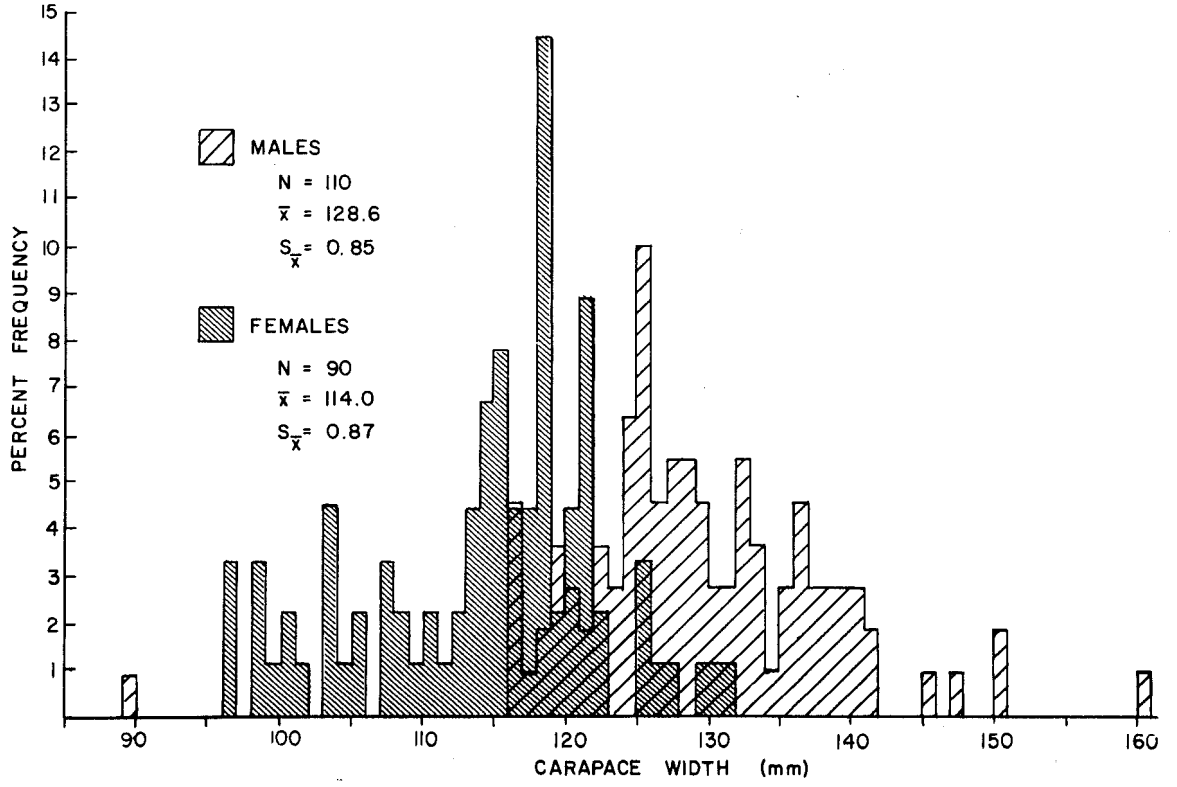

FIGURE 4.—Width-frequency distributions of male and female Jonah crabs caught by commercial fishermen in the Boothbay Harbor region, 1973-76.

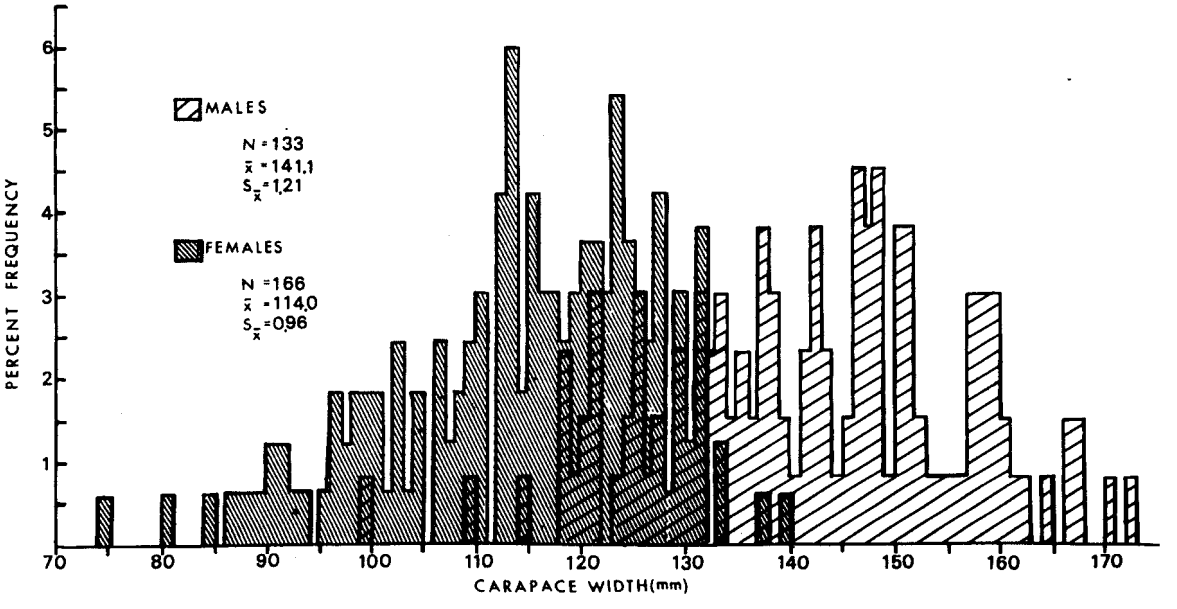

FIGURE 5.—Width-frequency distributions of male and female Jonah crabs caught by commercial fishermen at various locations along the Maine coast, 1977-78.

The total commercial and research catch of 954 Jonah crabs included only 27 (2.8%) individuals <90 mm. This might be related to gear selectivity, but this explanation loses credibility given that numerous rock crabs (equivalent catchability to Jonah crab) from 40 to 60 mm CW have been sampled previously with conventional and modified lobster traps (Krouse 1976). Moreover, the fact that no Jonah crabs <67 mm CW were observed while hand-collecting 2,426 rock crabs (mean 23.9 mm CW) during a 3-yr intertidal study (Krouse 1976) or hauling research gear over a 9-yr period (juvenile rock crabs were frequently seen in traps) is evidence that small Jonah crabs in Maine waters, unlike juvenile rock crabs, inhabit deeper water exclusively. In the Mid-Atlantic Bight, Carpenter (1978) reported that Jonah crabs <30 mm CW were most abundant in depths <150 m, while Haefner (1976) found crabs ≤40 mm CW to be most numerous between 75 and 150 m. Both investigators noted that the maximum abundance of the larger crabs (>40 mm) occured in the 150-400 m strata.

Distribution

From July 1968 through 1974, 459 Jonah crabs were captured in 7,055 trap hauls (0.07 crab/trap haul) with research gear fished near Boothbay Harbor (Table 1). Fluctuations in the catch in association with temporal and spatial variations in fishing effort were assessed by plotting mean monthly values of catch in numbers per trap haul (catch per unit of effort, CPUE) for each fishing area (Figure 6). In areas with relatively high CPUE (average >0.1), catches gradually increased throughout the summer, peaked in the fall, and then diminished rapidly. Because most crabs in the research catch were at least two molt increments larger than the lower size limit of the gear's selectivity range, the seasonal rise in CPUE

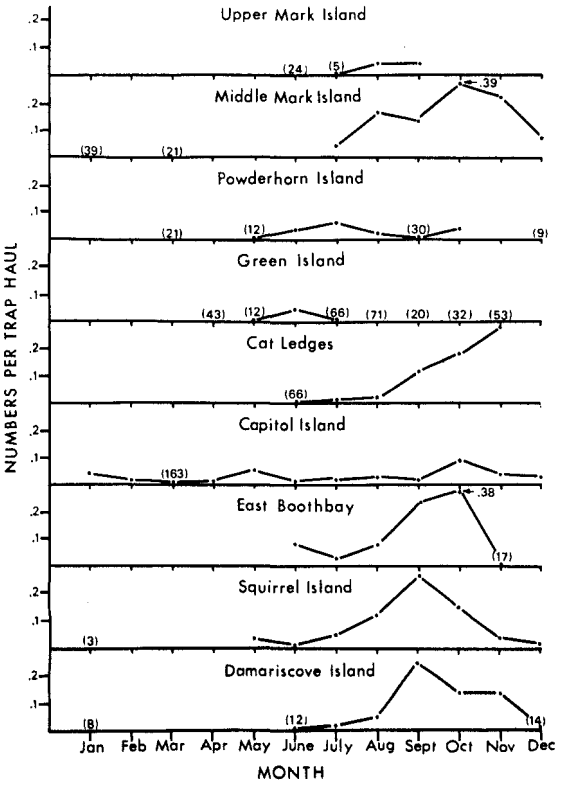

FIGURE 6.—Monthly catch per unit of effort values for Jonah crabs collected at various stations in the Boothbay Harbor region, 1968-74. Number of trap hauls are in parentheses. Catch per unit of effort outliers are marked by arrows.

may be explained by recruits migrating into the fishing areas. Conversely, the decline in CPUE in winter may be attributed to the effects of fishing mortality as well as emigration. Jonah crabs have been reported by Jeffries (1966) to move into the warmer waters of Narragansett Bay, R.I., from spring through fall, followed in winter by a movement to deeper, relatively warmer waters as inshore water temperature declined. The closely re-

TABLE 1.—Trap catch-effort values of Jonah and rock crabs caught in research traps at various stations near Boothbay Harbor, Maine, 1968-74.

Area	Depth range (m)	Substrate	Hauls	Jonah crab		Rock crab	
				Total no. caught	No. per haul	Total no. caught	No. per haul
Upper Mark Island	5-15	Mud	157	5	0.03	645	4.11
Powderhorn Island	3-10	Mud	271	8	0.03	2,062	7.61
Green Island	3-10	Mud	396	4	0.01	1,025	2.59
Middle Mark Island	10-20	Mud-rock outcroppings	522	65	0.12	671	1.29
Cat Ledges	5-15	Sand-bedrock	656	41	0.06	660	1.01
Capitol Island	5-15	Mud	2,794	75	0.03	4,869	1.74
East Southport	5-15	Mud-rock outcroppings	253	30	0.12	318	1.25
Squirrel Island	5-20	Mud-rock outcroppings	1,267	149	0.12	2,674	2.11
Damariscove Island	5-20	Sand-bedrock	739	82	0.11	535	0.72
Total	3-20		7,055	459	0.07	13,459	1.91

lated European edible crab, *C. pagurus,* have also been observed to undertake similar seasonal movements off the coast of England (Brown[3]). Limited population movements of Jonah crabs has also been suggested by Haefner (1977).

Although Jonah crabs were caught at each station, their relative abundance varied markedly by area as reflected by CPUE values which ranged from 0.01 to 0.12 (Table 1). Jonah crabs were more numerous at the generally deeper, more seaward stations (East Southport, Squirrel Island, and Damariscove Island) characterized by rocky substrates and within the Sheepscot River at Middle Mark Island where the fishing area borders relatively deep water (45 m) and the bottom is hard-packed mud interspersed with rock outcroppings. Conversely, Jonah crabs were sparsely distributed at the other stations in the Sheepscot estuary (Upper Mark Island, Green Island, and Powderhorn Island) which in contrast to Middle Mark Island are quite shallow with soft mud bottoms. Thus, the data indicate that the distribution and abundance of Jonah crabs reflects bottom type as well as depth.

Comparisons of CPUE for rock crabs with those for Jonah crabs at different sampling sites revealed an inverse relationship (Table 1). Rock crabs were very abundant at those stations within the Sheepscot River (CPUE: 2.6-7.6) where Jonah crabs were scarce; whereas, at other areas where Jonah crabs were more plentiful rock crabs were less common (CPUE: 0.7-2.1). Based on these observations, rock crabs seem to prefer inshore areas with mud bottoms while Jonah crabs favor seaward locations with rocky substrates. This agrees with Jeffries (1966) findings that the same two cancrid crabs are separated spatially in Narragansett Bay according to bottom type: rock and Jonah crabs inhabit sand and rock substrates, respectively. Interestingly, in the more northern latitudes, juvenile rock crabs, unlike the adults, show preference for coarse, rocky bottoms (Scarratt and Lowe 1972; Krouse 1972; Reilly and Saila 1978), where protection from predators would be optimum.

Distribution of both cancrid crabs is not only related to substrate type and depth, but is also dependent upon water temperature. For example, in the mid-Atlantic region, Carpenter (1978) found Jonah crabs at temperatures from 5° to 15° C with maximum abundance between 6° and 12° C. Similarly, Haefner (1977) reported Jonah crabs to be most numerous in the temperature range of 8°-14° C. The more eurythermal rock crabs have been observed to be widely distributed over the continental shelf of the Mid-Atlantic Bight and most abundant inshore particularly during winter when temperatures are lowest (as low as 2° C) (Musick and McEachran 1972; Haefner 1976). In Chesapeake Bay rock crab abundance increases markedly in winter (2°-8° C) and declines in spring as temperatures warm (Shotton 1973; Terretta 1973). In view of these data, the distribution of the two cancrid crabs along the Maine coast may be further examined in relation to temperature. Rock crabs have been found to be most abundant in shallow nearshore waters where temperatures may vary from near 0° C in winter to 18° C in summer (Welch[4]); whereas, Jonah crabs are more numerous at greater depths where temperatures are more stable. Likewise, in the Gulf of St. Lawrence where the temperature regime is great (−2° to 20° C [Lauzier and Hull[5]]), rock crabs are common and Jonah crabs are nonexistent (Squires 1966; Scarratt and Lowe 1972).

Thus, it appears that the distribution of these congeneric species in the northern part of their range is dependent upon substrate, depth, and temperature.

Sex Ratios

Initially, I examined ratios of male to female Jonah crabs in monthly catches at each fishing site; however, due to the small sample sizes for several of the groups, area catches were combined by month (Table 2). The chi-square test, which was used only when the monthly N was ≥ 10, indicated that July through September ratios deviated significantly ($P = 0.05$) from 1:1. Males dominated in July while during August and September there was a preponderance of females. This shift in sex ratios may be attributed to an apparent movement of female crabs into warmer shoal water during summer and early fall as the result of behavior associated with molting and copulating. The closely related Dungeness crab, *C. magister,* and

[3]Brown, G. G. 1975. Norfolk crab investigations 1969-73. Lab. Leafl. 30, 12 p. Fish. Lab., Lowestoft, Suffolk, England.

[4]W. R. Welch, Marine Resources Scientist, Maine Department of Marine Resources, West Boothbay Harbor, ME 04575, pers. commun. February 1979.

[5]Lauzier, L. M., and J. H. Hull 1969. Coastal station data temperatures along the Canadian Atlantic coast 1921-1969. Fish. Res. Board Can. Tech. Rep. 150, 25 p.

TABLE 2.—Monthly captures and sex ratios of Jonah crabs caught with research traps, 1968-74. Asterisks denote significant deviation from 1:1 (chi-square).

Month	♂	♀	Ratio (♂:♀)	Month	♂	♀	Ratio (♂:♀)
Dec.-Apr.	10	4	2.5:1NS	Aug.	39	81	1:2.1**
May	7	3	2.3:1NS	Sept.	38	117	1:3.1**
June	8	2	4:1NS	Oct.	44	45	1:1NS
July	24	7	3.4:1*	Nov.	11	19	1:1.7NS

NS = not significant.
* = $P<0.05$.
** = $P<0.01$.

European edible crab have been reported to move inshore in spring and offshore in fall (Dewberry 1956; Hoopes 1973; Brown see footnote 3). In fact, mature female European edible crabs have been observed to move considerable distances (≥225 km) along the coast of England (Brown see footnote 3).

Sex ratios of rock crabs caught with research gear varied not only by season but also by area (Figure 7). From July through September females generally outnumbered males, throughout the fall many of the sex ratios approximated a 1:1 relation, and then in winter males were dominant except in the upper Sheepscot River where they predominated only in May. Similar to Jonah crabs, seasonal variations in rock crab sex ratios may best be explained by changes in the crabs' availability and vulnerability to the research traps in association with shedding and mating behavior. For instance, peak catches of females during summer and early fall coincided with egg hatching (summer) and molting (fall) in Maine waters (Krouse 1972).

Higher proportions of male rock crabs in winter and spring catches may be attributed to: 1) recruitment of males as the result of winter-spring shedding (Krouse 1972) and, possibly, inshore movement (Haefner [1976] suggested that male rock crabs in the Mid-Atlantic Bight undertake seasonal inshore-offshore migrations); 2) increased feeding activity of newly molted crabs; and 3) a reduction in the availability and vulnerability of females during the winter spawning period (Dewberry [1956] noted that ovigerous female *C. pagurus* consume little food). Throughout summer the number of male rock crabs, particularly those >90 mm CW, diminished due to fishing mortality and, perhaps, an offshore movement.

The upper Sheepscot River sites, unlike the other locations, had a preponderance of females during fall and winter, yet in spring, similar to other areas, males were more numerous (Figure 7). Perhaps this relatively high abundance of

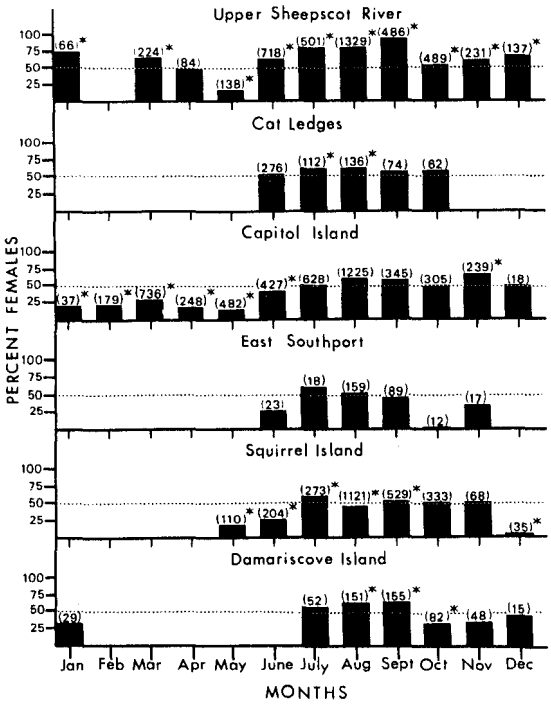

FIGURE 7.—Monthly percent frequencies of female rock crabs caught by research traps at different locations in the Boothbay region, 1968-74. Numbers in parentheses represent total number of males and females. Those ratios differing significantly from 1:1 ($P = 0.05$ by chi-square) are marked with asterisks. Blank bars represent no fishing effort.

females may be related to the Sheepscot River sites' soft mud substrate, which females apparently seek during the spawning season. From laboratory observations it appears that unless females are burrowed in the substrate at the time of egg extrusion, many eggs will not become attached to the pleopods resulting in a significantly reduced complement of eggs. Edwards and Early (1972) reported that female *C. pagurus* also show preference for soft substrates during the spring.

Lindsay (1973) also noted that sex ratios of Maine rock crabs vary by locality and season. He also found males to be more abundant in the winter and spring.

Width-Weight Relations

Because the overlap of data of males and females composed only a small segment of the total range of sizes, I applied analysis of covariance to the total regressions as well as the partial regressions derived from the data that

overlapped. Significant differences ($P = 0.05$) were found between the y-intercepts of either sex for both the complete and partial regressions, so males and females were treated separately. Plots of the predictive regressions show that male Jonah crabs averaged about 8% heavier than females of the same CW over the range 115-130 mm (Figure 8).

SUMMARY

From July 1968 through March 1978, 419 male (67-168 mm CW) and 535 female (74-136 mm) Jonah crabs were collected from research traps and commercial fishermen. Even though male Jonah crabs attain larger sizes (mean sample 113.7-141.1 mm CW) than females (mean sample 104.8-114.0 mm), many female Jonah crabs are harvested commercially whereas, rock crab landings are chiefly composed of males.

No Jonah crabs <67 mm CW were caught and only 2.7% of the total catch were <90 mm CW. This with other evidence indicates that small Jonah crabs inhabit greater depths (>20 m) than those sampled.

Catch per unit of effort values for Jonah crabs caught with research gear generally increased during summer, peaked in fall, and then declined sharply. Fluctuations in the catch were attributed primarily to movement. Catches were highest at the deeper, more seaward sampling sites where the substrate was predominantly rocky. In contrast, rock crabs were more abundant at those relatively shallow estuarine stations having soft

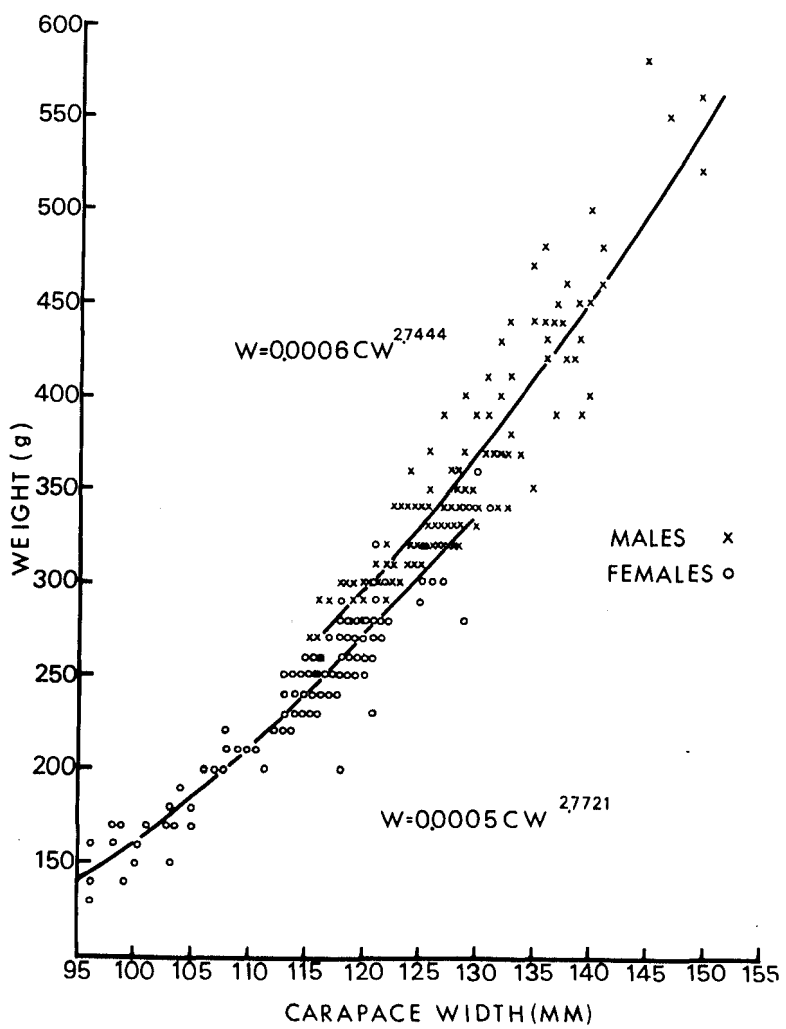

FIGURE 8.—Carapace width-weight relationships calculated for 110 male and 90 female Jonah crabs from the Boothbay Harbor region. Standard errors of the regression coefficients are 0.1793 (a) and 0.0850 (b) for males and 0.2023 (a) and 0.0984 (b) for females.

mud bottoms. Distribution of both cancrid crabs appears to be controlled by substrate type, depth, and temperature.

Male Jonah crabs outnumbered females in the catch in July; the opposite occured in August and September; during the remaining months, sex ratios did not differ significantly from 1:1. In comparison, female rock crabs generally predominated July through September, during fall most ratios approximated 1:1, and in winter and spring males usually dominated with the exception of most estuarine locations where males were only in the majority during May.

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LITERATURE CITED

CARPENTER, R. K.
1978. Aspects of growth, reproduction, distribution and abundance of the Jonah crab, (*Cancer borealis*) Stimpson, in Norfolk Canyon and the adjacent slope. M.A. Thesis, Univ. Virginia, Charlottesville, 68 p.

DEWBERRY, E. B.
1956. The characteristics, habits and life history of the edible crab. Naturalist (Leeds) 858:91-96.

EDWARDS, E., AND J. C. EARLY.
[1972.] Catching, handling and processing crabs. Dep. Trade Ind., Torry Res. Stn., Torry Advis. Note 26 (rev.), 17 p.

HAEFNER, P. A., JR.
1976. Distribution, reproduction and moulting of the rock crab, *Cancer irroratus* Say, 1917, in the mid-Atlantic Bight. J. Nat. Hist. 10:377-397.
1977. Aspects of the biology of the jonah crab, *Cancer borealis* Stimpson, 1859 in the mid-Atlantic Bight. J. Nat. Hist. 11:303-320.

HOOPES, D. T.
1973. Alaska's fishery resources — the Dungeness crab. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Fish. Facts-6, 14 p.

JEFFRIES, H. P.
1966. Partitioning of the estuarine environment by two species of *Cancer*. Ecology 47:477-481.

KROUSE, J. S.
1972. Some life history aspects of the rock crab, *Cancer irroratus*, in the Gulf of Maine. J. Fish. Res. Board Can. 29:1479-1482.
1976. Size composition and growth of young rock crab, *Cancer irroratus*, on a rocky beach in Maine. Fish. Bull., U.S. 74:949-954.

LINDSAY, B. P.
1973. Some aspects of mobility and feeding activity of the rock crab, *Cancer irroratus*. M.S. Thesis, Univ. Maine, Orono, 57 p.

MUSICK, J. A., AND J. D. MCEACHRAN.
1972. Autumn and winter occurrence of decapod crustaceans in Chesapeake Bight, U.S.A. Crustaceana 22:190-200.

REILLY, P. N., AND S. B. SAILA.
1978. Biology and ecology of the rock crab, *Cancer irroratus* Say, 1817, in southern New England waters (Decapoda, Brachyura). Crustaceana 34:121-140.

SASTRY, A. N.
1977. The larval development of the Jonah crab, *Cancer borealis* Stimpson, 1859, under laboratory conditions (Decapoda Brachyura). Crustaceana 32:290-303.

SCARRATT, D. J., AND R. LOWE.
1972. Biology of rock crab (*Cancer borealis*) in Northumberland Strait. J. Fish. Res. Board Can. 29:161-166.

SHOTTON, L. R.
1973. Biology of the rock crab, *Cancer irroratus* Say, in the coastal waters of Virginia. M.A. Thesis, Univ. Virginia, Charlottesville, 72 p.

SQUIRES, H. J.
1966. Distribution of decapod Crustacea in the northwest Atlantic. Ser. Atlas Mar. Environ. Am. Geogr. Soc. Folio 12, unpaged.

TERRETTA, R. T.
1973. Relative growth, reproduction and distribution of the rock crab, *Cancer irroratus*, in Chesapeake Bay during the winter. M.A. Thesis, Coll. William and Mary, Williamsburg, Va., 104 p.