SIZE COMPOSITION AND GROWTH OF YOUNG ROCK CRAB, *CANCER IRRORATUS*, ON A ROCKY BEACH IN MAINE[1]

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ABSTRACT

Monthly hand collections of small rock crab, *Cancer irroratus*, were made from an intertidal zone in East Boothbay, Maine, from June 1972 through April 1975. An analysis of size and sex frequencies indicated: 1) young-of-the-year crabs (≤5 mm carapace width) entered the intertidal area in late summer-early fall and remained there through the second fall with a resultant width range between 15 and 40 mm; 2) a deceleration and/or cessation of growth in winter; 3) an emigration of crabs >40 mm carapace width from the intertidal area associated with declining winter temperatures and/or behavioral changes; 4) sex ratios approximated a 1:1 relationship; and 5) small male and female rock crabs (<60 mm carapace width) had a common growth rate.

While searcing beneath the rocky substrate of an intertidal zone for juvenile American lobster, *Homarus americanus* Milne Edwards, whose early distribution and abundance is generally unknown, I discovered numerous small rock crab, *Cancer irroratus* Say, burrowed under the rubble. Because rock crab is a valuable commercial species as well as an important food source of lobsters (Ennis 1973), I believe it important to describe the distribution of young crabs in their natural environment along with other life history information (size structure, sex ratio, and growth).

METHODS

Rock crabs were carefully hand collected about once a month during extreme low slack tides from the intertidal zone of Grimes Cove, East Boothbay, Maine (Figure 1). The rocky substrate of this unsheltered seaward cove consists of rocks of assorted sizes intermingled amongst areas of bedrock, sand, and pulverized shells. By using large boulders as landmarks, it was possible to sample consistently the same general area near the low water mark. Unfortunately, for various reasons, samples could not be obtained for all months of the study.

After two biologists concurrently expended 1 h gathering crabs, their catches were immediately returned to the laboratory where sex and carapace width (distance between the two most posterior notches on the anterolateral border) to the nearest millimeter were recorded. The sex of crabs <10 mm carapace width (CW) was determined under a dissecting microscope.

Width-frequency histograms were compiled by 2-mm increments for rock crabs caught each month from June 1972 through April 1975.

RESULTS AND DISCUSSION

Size Composition and Seasonal Distribution

Since there were no discernible differences in size distribution between male and female crabs, the data for sexes were combined in monthly width-frequency histograms (Figure 2). This similarity in size composition of male and female crabs <60 mm CW suggested a common growth rate for both sexes up to this size, unlike the marked size disparity of larger male and female rock crabs (>60 mm CW) caught in commercial lobster traps which was primarily attributed to a decrease in the growth rate of females after the onset of sexual maturity (Krouse 1972).

Modal groups, which most likely represented one or, perhaps, more molt classes, were quite conspicuous in each of the monthly histograms. However, due to extensive overlapping of modes I was unable to quantitatively follow these modal groupings from month to month for purposes of estimating mortality rates.

Inspection of monthly histograms revealed that young-of-the-year crabs (recently metamorphosed from megalops to first crab, ≤5 mm CW) initially

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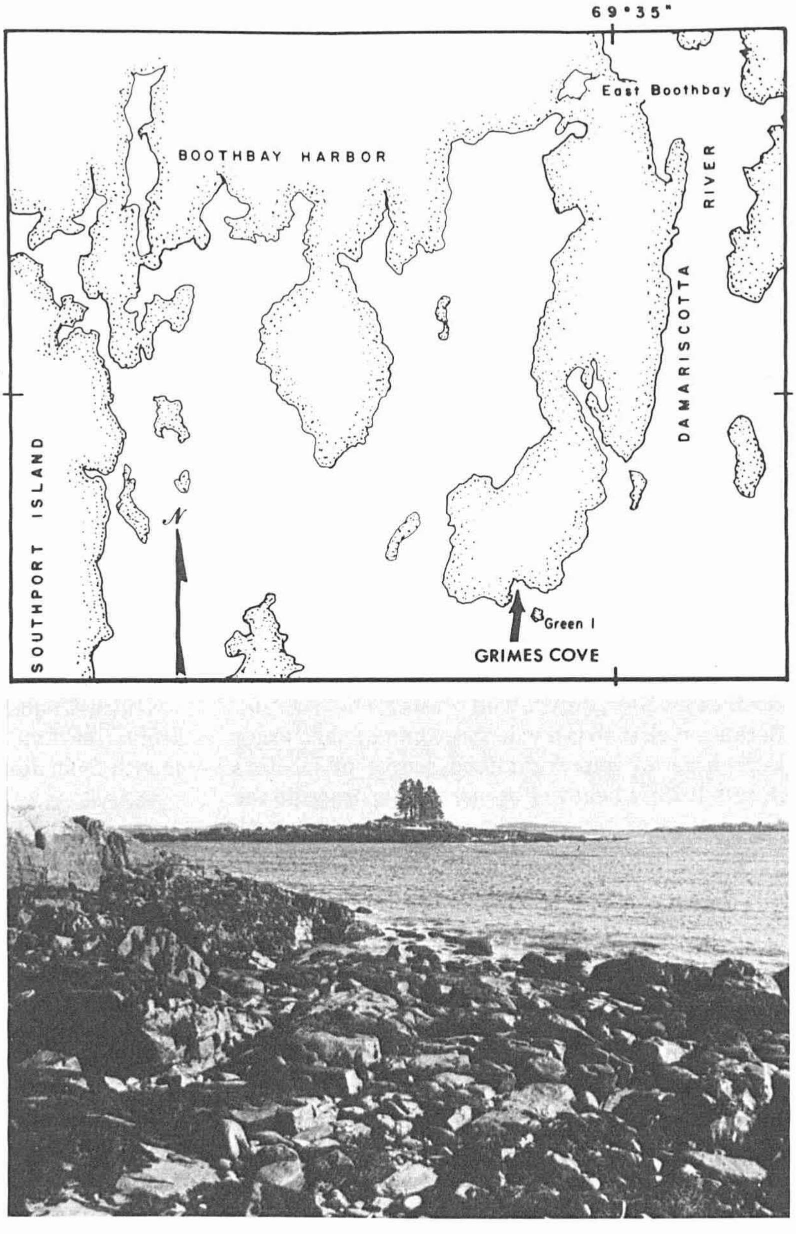

FIGURE 1.–Chart of Boothbay region with a seaward view at low tide of the intertidal beach of Grimes Cove, East Boothbay, Maine.

appeared during September 1972 and late August 1973 and 1974. This seasonal appearance of young crabs agreed with earlier observations of female rock crabs hatching their eggs in late spring and early summer in Maine waters (Krouse 1972) and the culture work of Sastry (1970) which demonstrated that 40 - 60 days are required for rock crabs to develop through the pelagic larval stages to the first crab stage at 15°C and a salinity of 30‰.

Histograms showed a gradual upward progression of the first modal grouping (comprised of young-of-the-year crabs, <10 mm CW) from August through December 1974, while distributions from January through April 1975 revealed relatively little change (Figure 2). This apparent cessation of growth was further supported by sighting very few, if any, cast exoskeletons and/or soft-shelled crabs while sampling during the winter. At other times of the year, when crabs were growing, numerous recently cast shells and/or shedders were readily observed. In spring when growth resumed, the percentages of in-

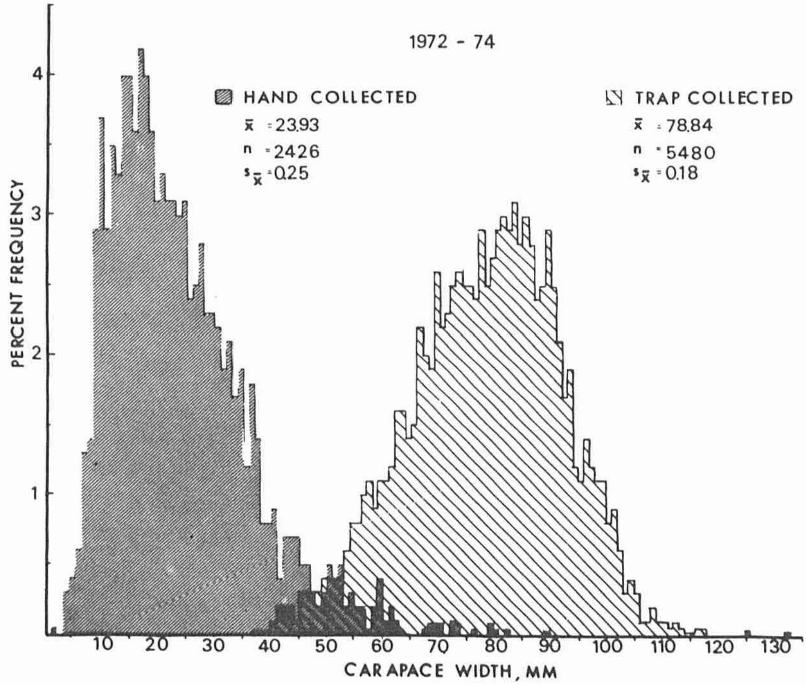

FIGURE 2.–Width-frequency distributions for rock crabs collected monthly by hand at an intertidal area in East Boothbay, Maine, 1972-75.

dividuals <10 mm CW began to diminish progressively until late summer when young-of-the-year crabs once again settled to the bottom (Table 1).

Rock crabs >40 mm CW were decidedly less abundant during the fall and winter (Table 1). In fact, not a single crab >50 mm CW was captured from January through April (Figure 2). This seasonal shift in size distribution suggested that crabs >40 mm CW moved seaward from the intertidal zone with declining temperatures. Jeffries (1966) reported that *C. irroratus* moved from Narragansett Bay, R.I., in winter to the deeper and warmer ocean waters. Conversely, in southern waters during the late fall and winter, rock crabs moved into Delaware Bay (Winget et al. 1974) and inshore waters of Virginia (Shotton 1973; Terretta 1973) as the water temperatures fell within a preferred range.

Aside from the apparent thermal effects and/or behavioral changes on the seasonal displacement of these large crabs from the intertidal zone, this movement may also be associated with the larger crabs' physical ability to emigrate with ease from an area of low temperature. In addition, the size of these crabs may inhibit their ability to find suitable burrows in the littoral zone necessary to afford protection from the often tempestuous winter sea. Jeffries (1966) stated that *C. irroratus* was not well suited for burrowing into coarse bottom.

TABLE 1.–Percentage of rock crabs of two carapace widths in monthly samples for 1972-75.

Month	≤10 mm (%)	≥40 mm (%)	Month	≤10 mm (%)	≥40 mm (%)
Jan.	39.6	0	Aug.	1.6	16.6
Mar.	47.4	2.6	Sept.	13.7	12.7
Apr.	34.8	2.7	Oct.	31.4	6.7
May	32.8	2.9	Nov.	40.9	8.0
June	7.8	8.5	Dec.	40.7	3.7
July	2.4	8.8			

Sex Ratio

Ratios of males to females for each of the monthly samples ranged from 0.60:1 to 1.57:1 (Table 2). The chi-square test revealed that only sex ratios of catches of July and August 1973 deviated significantly ($P = 0.05$) from a 1:1 relationship. Thus I concluded that sex ratios of the intertidal catches approximated a 1:1 relationship (1,353 males: 1,376 females); whereas, rock crabs larger than 50 mm CW collected in traps near Boothbay Harbor, Maine, showed disproportionate sex ratios which varied by season and locality (Krouse 1972). It appears that these disparate sex ratios were primarily a function of the onset of sexual maturity which subsequently altered the growth rate and seasonal distribution of male and female crabs.

TABLE 2.–Sex ratios of the monthly collections of rock crabs taken intertidally in East Boothbay, Maine, 1972-75. Sex ratios that deviated significantly ($P = 0.05$) from 1:1 are marked *.

Mo.	1972 M:F	1973 M:F	1974 M:F	1975 M:F	Mo.	1972 M:F	1973 M:F	1974 M:F	1975 M:F
Jan.	—	1.27:1	—	0.96:1	Sept.	0.89:1	—	1.57:1	—
Mar.	—	—	—	1.23:1		0.71:1			
Apr.	—	0.60:1	0.76:1	1.08:1	Oct.	0.68:1	—	1.23:1	—
May	—	1.07:1	1:1	—	Nov.	—	—	0.96:1	—
June	1.02:1	0.95:1	1.03:1	—	Dec.	—	—	0.93:1	—
July	1.25:1	1.55:1*	0.82:1	—	Total	0.98:1	0.99:1	0.95:1	1.08:1
Aug.	1.01:1	0.71:1*	0.86:1	—					
		0.87:1							

Growth

Carapace width prior to shedding was plotted against the new carapace width after shedding for 45 crabs that molted while captive in the laboratory. This relationship was fitted by the method of least squares using the simple linear equation $Y = a + bX$, where Y = postmolt CW, X = premolt CW, and a and b were constants. Analysis of covariance, which was used to test homogeneity of regression coefficients, revealed no statistical differences between growth increments of males and females, so all data were pooled. The calculated equation for crabs ranging from 9 to 48 mm CW was $Y = 0.566 + 1.247X$. This relation was similar to Cleaver's (1949) constants ($a = 0.57$; $b = 1.23$) calculated for Dungeness crab, *C. magister*, juveniles (5-91 mm CW).

Based on the relationship between premolt vs. postmolt and measurements of cultured post-larval crabs (stages I-V) obtained from Herbert C. Perkins, formerly of the National Marine Fisheries Service, West Boothbay Harbor, Maine, I estimated sizes for instars I-XIII (Table 3). Sizes for instars above XIII were not computed because of the inherent uncertainties of extrapolating beyond the data range. If we assume that Maine rock crabs begin to attain maturity about 60 mm CW (Krouse 1972; Scarratt and Lowe 1972) and if as suggested by Butler's (1961) work with *C. magister* the premolt vs. postmolt relationship changes with the onset of sexual maturity, then sizes for instars beyond XIII (53 mm CW) are inadequately described by the aforementioned regression.

Because the increments of growth (24.3-28.3%) for post-larval crabs (instars III-V) cultured in the laboratory were appreciably less than those growth increments (29.2 to 30.6%) for instars VI-VIII of the captive wild crabs, widths for instars II-XIII were estimated by the empirical value (2.6 mm CW) for stage I and then the subsequent stages were calculated with the linear regression (Table 3). Instar sizes calculated by this procedure were larger (about one instar size greater) than those sizes based on empirical data for stages I-V and predicted by regression for instars VI-XIII, e.g., instar V (estimated by regression) = 9.5 mm and instar VI (other method) = 9.6 mm. For purposes of this study, those instar sizes calculated with the empirical post-larval data were favored.

TABLE 3.–Comparison of instar sizes of rock crabs. For one group, instars I-V represent actual measurements and instars VI-XIII are calculated by the relationship $Y = 0.566 + 1.247X$; for the other group, instar I is an actual measurement and the remaining instars are estimated from the aforementioned equation.

	I-V: Actual measurements VI-XIII: regression values		Regression values	
Instar	Carapace width (mm)	Increase (%)	Carapace width (mm)	Increase (%)
I	2.6		2.6	
II	3.7	42.3	3.8	46.4
III	4.6	24.3	5.3	39.5
IV	5.9	28.3	7.2	35.3
V	7.4	25.4	9.5	32.5
VI	9.6	30.3	12.4	30.6
VII	12.5	30.6	16.1	29.2
VIII	16.2	29.2	20.6	28.2
IX	20.8	28.2	26.3	27.4
X	26.4	27.4	33.3	26.8
XI	33.5	26.8	42.1	26.4
XII	42.4	26.4	53.0	26.0
XIII	53.4	26.0	66.7	25.7

An attempt was made to objectively assign size with age by correlating instar size with the monthly width-frequencies (Figure 2). As mentioned previously, post-larval crabs (2-5 mm CW) first entered the sampling area in August or September after having hatched in late spring or summer and having developed through the larval stages during the remainder of the summer. Size distributions for April 1974 through April 1975 revealed first entry of young-of-the-year crabs in August followed by subsequent growth of young crabs until about January when growth ceased and this modal group stabilized at about 4-20 mm CW (instars III-IX). This wide size range is best explained by varying hatching and settling dates whereby some crabs entered the population perhaps 1 to 2 mo later than the rest. These crabs settled to the bottom when temperatures were likely to be declining; thus these individuals experienced little growth until the following spring.

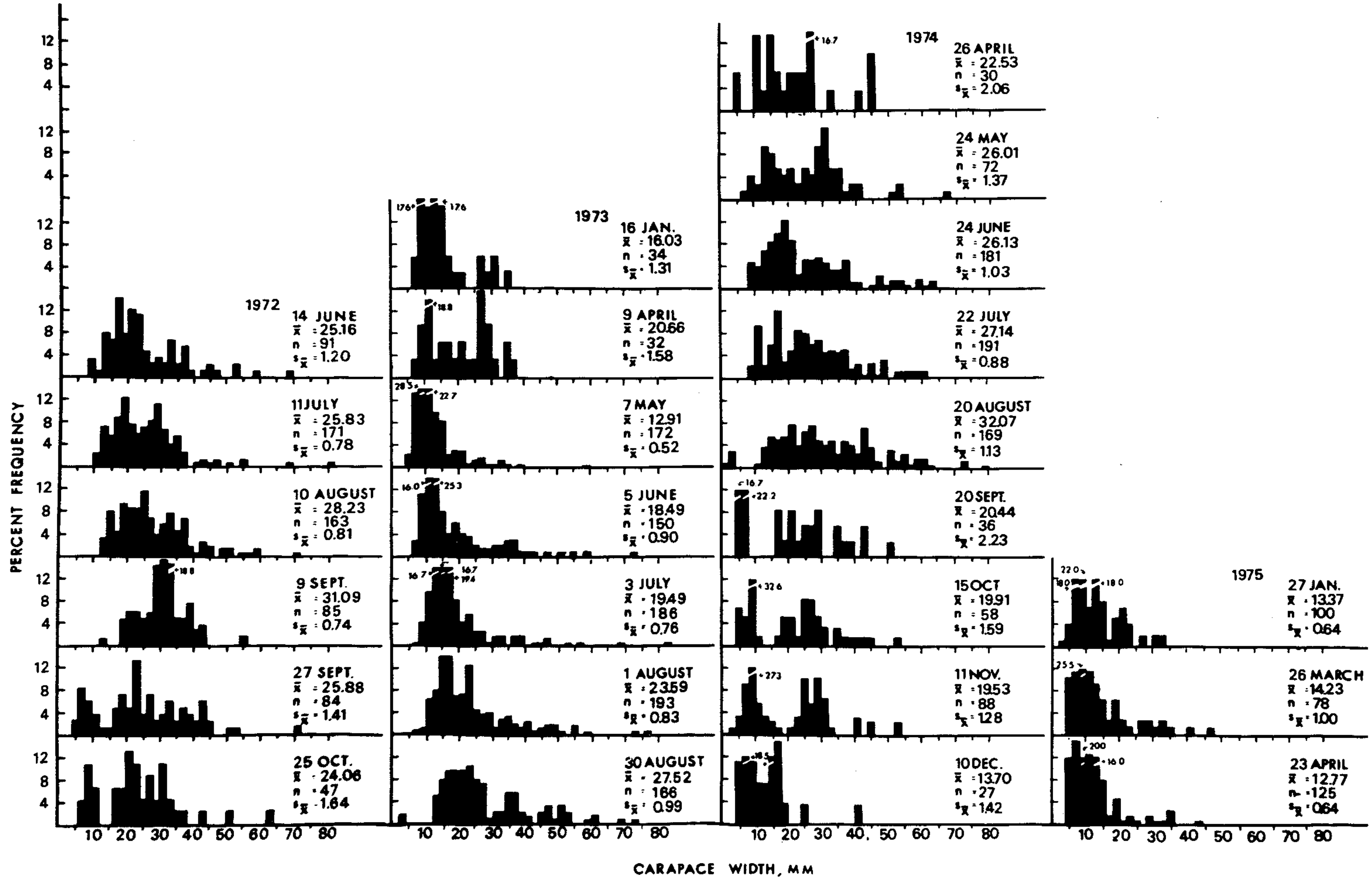

FIGURE 3.—Width-frequency distributions for rock crabs collected by hand in an intertidal area and by trap in the Boothbay region, 1972-74.

When growth resumed in late spring and summer, only a few juveniles (previous year's young-of-the-year) were <10 mm CW (stage VI). Unfortunately, the overlapping of modes prevented any objective determination of the upper limit of this second modal grouping that represented the juvenile crabs. Nevertheless, several of the monthly distributions (September-October 1972 and August 1973) exhibited an upper limit around 40 mm CW for this second modal grouping (Figure 2).

Although it was not possible to make precise determinations of age and growth from information of this study, the data suggest that young-of-the-year crabs ranged in size from about 4 to 20 mm CW (instars III-IX) and the juveniles in their second fall ranged from approximately 15 to 40 mm CW (instars VIII-XII).

Hand-Collected Vs. Trap-Caught Crabs

Prior to sampling small crabs in the intertidal zone, our rock crab work was based on incidental catches of crabs with wire lobster traps (25.4- × 25.4-mm mesh) in the Boothbay Harbor area (Krouse 1972). Histograms plotted by 1-mm increments for 2,426 hand-collected and 5,480 trap-caught crabs (1972-74) graphically revealed marked differences in size composition of the catches for these two methods of capture (Figure 3). Average width for hand-collected crabs was 23.9 mm and 78.8 mm for trapped crabs. Even though these two complementary modes of capture sampled a broad range of sizes (2-133 mm CW), many crabs between 40 and 60 mm CW eluded either type of collection. This scarcity of crabs between 40 and 60 mm CW can be attributed to: 1) selectivity of traps against sizes <60 mm CW (based on Figure 3, crabs <70 mm CW were not fully vulnerable to the gear), and 2) movement of crabs >40 mm CW from the intertidal zone in association with low winter temperatures and possible behavioral changes with size. Scarratt and Lowe (1972) reported that small rock crabs (<65 mm CW) in the Northumberland Strait, Gulf of St. Lawrence, inhabited rocky areas, whereas larger crabs left the rocky substrate for sand and mud bottoms. Jeffries (1966) noted that *C. irroratus* dwelled chiefly on sand in the Narragansett Bay—the type of bottom this species is adapted to because of its well developed walking and burrowing abilities.

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