EFFECTIVENESS OF ESCAPE VENT SHAPE IN TRAPS FOR CATCHING LEGAL-SIZED LOBSTER, *HOMARUS AMERICANUS*, AND HARVESTABLE-SIZED CRABS, *CANCER BOREALIS* AND *CANCER IRRORATUS*[1]

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ABSTRACT

During 1976 a study was conducted to find an escape vent that would select similar sized lobsters as the rectangular vent, yet retain *Cancer* crabs ≥90 mm carapace width. Analysis of the size composition of research and commercial catches from experimental traps revealed that circular (58 mm in diameter) and rectangular (44.5 × 152.4 mm) vents release shorts and retain legal lobsters (≥81 mm carapace length) equally well, and decidedly more marketable-sized crabs were captured in traps with circular vents. Length-width relationship shows that crabs ≥90 mm carapace width have lengths ≥58 mm, thus precluding the possibility of marketable-sized crabs exiting through an opening 58 mm in diameter. Escapement studies for lobsters confirm that with the present minimum legal size of $3^{3}/_{16}$ in, a 58-mm diameter vent will select legals and allow most of the sublegals to escape.

Accordingly, the Maine Department of Marine Resources recommends that either circular (≥58 mm in diameter) or oblong (≥44.5 × 152.4 mm) escape vents be incorporated in all crab and lobster traps along the Maine coast.

Although rectangular escape vents are a very beneficial type of savings gear for the lobster fishery (Templeman 1939; Wilder 1945, 1948, 1954; Krouse and Thomas 1975; Krouse 1976), this vent does not retain marketable-sized rock crab, *Cancer irroratus*, and Jonah crab, *C. borealis*. Since these commercially important crab species are often caught incidental to lobsters, I undertook the present study to find an escape opening that would retain harvestable-sized crabs and have similar fishing selectivities for the lobster, *Homarus americanus*, as the rectangular vent.

In designing a trap to catch crabs and exclude lobsters, Stasko (1975) observed in laboratory tests that circular holes retained commercial-sized crabs yet allowed small lobsters to escape; however, the effectiveness of escape holes was not tested in the field. Jow (1961) demonstrated the advantages of circular escape openings in the trap fishery for Dungeness crab, *C. magister*.

In this paper I evaluate the relative efficiency of circular and rectangular vents by examining data from: 1) commercial and research catches compiled from vented and nonvented traps; 2) studies of escapement from traps; and 3) certain morphometric relationships of crabs and lobsters.

METHODS

From November 1976 through March 1977 a commercial fisherman recorded and provided me with catch data from traps with circular vents (58-mm diameter) fished alongside traps without vents. This experimental gear was arranged into two groups with four trawls [series of six traps spaced about 6 fathoms (11.0 m) apart with a surface buoy at either end] per group. In each group half the traps in a trawl had no vents, while the remainder had either single (end of trap) or paired (side of trap) vents depending upon the group (Figure 1B, D). Every time the fisherman hauled these traps he recorded the following information: 1) number of days traps were set between hauls; and 2) number of lobsters ≥81 mm carapace length, CL (keepers), and <81 mm CL (shorts) caught in the vented and nonvented traps for each trawl string.

From July through November 1976, project personnel fished commercial lobster traps near

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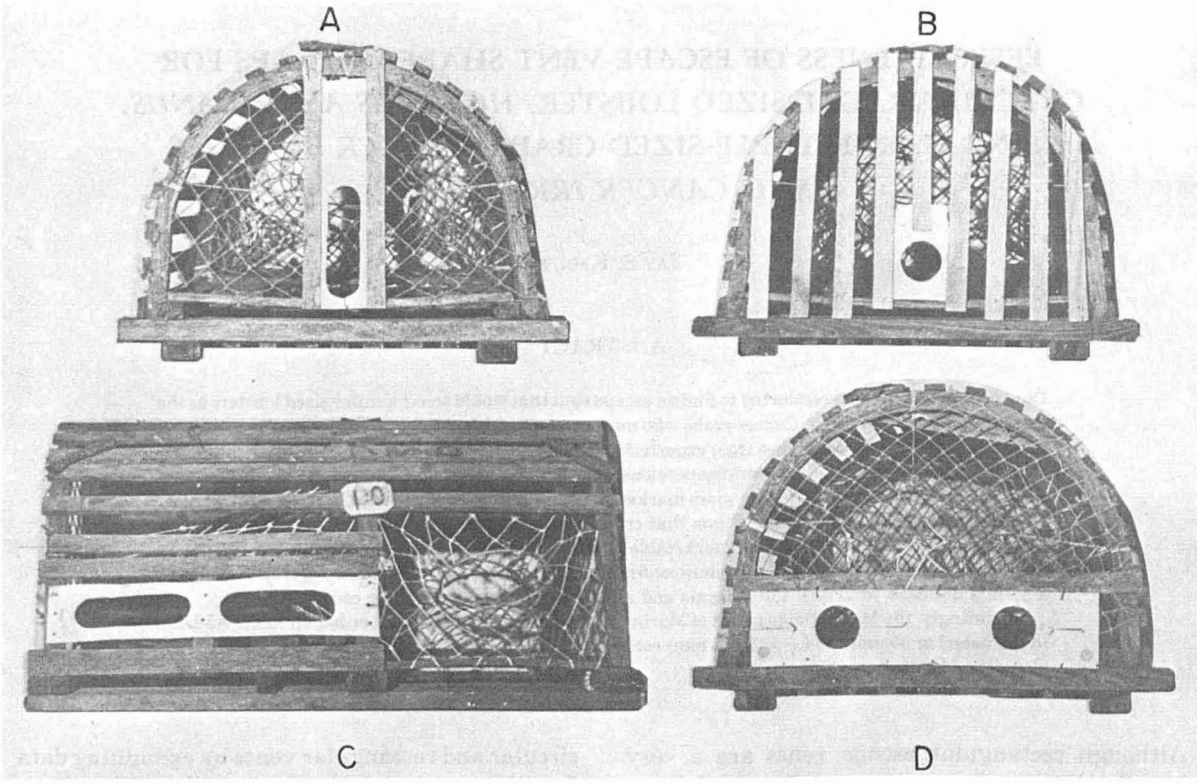

FIGURE 1.—Lobster traps having a rectangular vent positioned vertically (A) and horizontally (C) and single (B) and paired (D) circular vents.

Boothbay Harbor, Maine, with: 1) circular [58-mm (2.3 in) and 61-mm (2.4 in) diameter] vents; 2) vertical and horizontal rectangular [44.5 mm (1.8 in) × 152.4 mm (6.0 in)] vents; and 3) traps without vents. Carapace length of lobsters was measured from posterodorsal edge of eye socket to posterior margin of carapace and carapace width (CW) of crabs, distance between the two most posterior notches on the anterolateral border of the carapace, to the nearest millimeter.

Trap escapement was studied by placing lobsters of known sizes in traps with circular openings of 58, 60, and 61 mm in diameter. Side entrances of each trap were closed so escapement had to be via the vents. Traps were secured to the laboratory dock and usually checked daily for escapement for about a week.

To determine whether or not a crab or lobster could pass through a round opening of a given size, we correlated carapace length of lobsters with carapace height (CH), and the carapace width of crabs with carapace length. For 217 lobsters (sexes combined), ranging from 70 to 98 mm CL, carapace height was determined by positioning the lobster's ventral surface on a flat board and then measuring the greatest perpendicular distance from the board to the top of the carapace. Carapace length of crabs was measured from the anterior margin of the frontal region to the posterior border of the intestinal region. Measurements for the two *Cancer* species were treated separately due to the species disparities in body shapes. We recorded carapace length for 103 male rock crabs (females were excluded due to commercial unimportance) ranging from 90 to 122 mm CW, and 96 Jonah crabs (sexes combined) ranging from 96 to 132 mm CW.

RESULTS AND DISCUSSION

Lobsters in Research Gear

There are marked differences in size composition and number of lobsters caught in nonvented

TABLE 1.—Lobsters caught with nonvented and various types of vented traps from July through November 1976.

Vent type	Catch				Catch effort		
	Total no.	Sublegals: legals	Mean carapace length (mm)	Standard error	Legals per trap haul	No. of trap hauls	Months fished
Nonvented	749	4.3:1	76.2	±0.28	0.53	265	July-Nov.
Horizontal	198	0.6:1	83.9	±0.62	0.54	229	July-Nov.
Vertical	107	0.5:1	84.3	±1.05	0.56	129	July-Sept.
Circular:							
58 mm	25	0.6:1	82.8	±1.35	0.30	53	Oct.-Nov.
61 mm	42	0.4:1	85.9	±1.35	0.47	66	Sept.

and vented traps (Table 1). Vented traps caught fewer sublegal lobsters per trap-haul than nonvented traps (t-test, $P<0.01$).

The ratio of sublegal to legal lobsters did not differ among the four types of vents (t-test, $P>0.1$), with the exception of 61-mm circular vents which caught fewer sublegals than horizontal vents ($P<0.01$). As will be discussed later, the 61-mm hole is slightly oversize for a minimum size of 81 mm CL, thus some smaller legal lobsters and most shorts escape. Nevertheless this information suggests that circular openings are as effective as the rectangular vent (Krouse and Thomas 1975) in permitting escapement of short lobsters.

To further assess the relative efficiencies of the various vents, catch-effort values (numbers of lobsters per trap haul set over day, CPUE) were calculated and plotted for legal-sized and all-sized lobsters combined for each vent type (Figure 2). For this figure, 58- and 61-mm circular vent data were pooled because of the small sample size and similar catch values. Figure 2 graphically shows that the CPUE for legal-sized lobsters was similar for all vent types; however, for combined catches of legals and sublegals, the CPUE for nonvented traps was several fold greater. Thus, this indicates that all traps tested were about equally efficient in capturing legal lobsters; but, as to be expected, nonvented traps caught substantial numbers of short lobsters which probably would have escaped from vented traps. Most importantly, these data support an earlier conclusion that circular vents select about the same size lobsters as do rectangular vents.

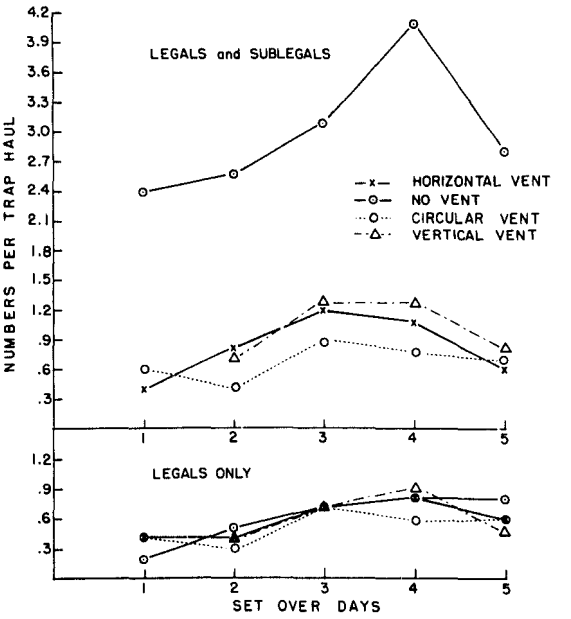

FIGURE 2.—Comparison of the number of lobsters (legals only; sublegal and legals combined) per trap haul set over day for lobster traps with rectangular (horizontal and vertical) and circular vents (58 and 61 mm combined) and traps without vents.

Lobsters in Commercial Gear

Catch data provided by a local lobsterman were compiled according to the following categories of gear: 1) end vented traps with a single circular hole of 58 mm diameter (Figure 1B); 2) side vented traps with paired round openings of 58 mm diameter (Figure 1D); and 3) two groups of nonvented traps (one for nonvented traps fished in the same trawl string with end vented traps and the second for traps paired with side vented traps). Comparisons of the CPUE and the ratios of sublegals to legals indicated that vented traps caught fewer sublegal-sized lobsters than the corresponding groups of nonvented traps (t-test, $P<0.01$) (Table 2). Higher CPUE values for vented traps show that circular vents are at least as efficient if not more effective in catching legal-sized lobsters than nonvented traps (t-test, $P<0.01$). In an earlier study Krouse and Thomas (1975) reported that traps with 44.5 × 152.4 mm rectangular vents were more successful in catching legal lobsters than traps with smaller vents or no vents.

TABLE 2.—Comparison of commercial catches of sublegal and legal-sized lobsters caught in traps with 58-mm circular vents and traps without vents.

Trap type	No. of sublegals/ trap haul	No. of legals/ trap haul	No. of trap hauls	Sublegals: legals
Side vent:				
double opening	0.98	0.56	144	1.8:1
No vent	2.33	0.49	132	4.7:1
End vent:				
single opening	1.80	0.72	144	2.5:1
No vent	2.76	0.57	144	4.9:1

Possible explanations for these disparities in efficiency may be that: 1) larger lobsters are less likely to enter traps containing several other lobsters, and/or 2) after legal lobsters are caught, their attempts to escape might be intensified as the density of lobsters increases within the trap.

Aside from the previously mentioned differences in the number of shorts caught per trap haul for vented and nonvented traps, end vents (single hole) captured 1.80 shorts/trap haul, whereas side vents (double hole) caught only 0.98 shorts/trap haul (t-test, $P<0.01$). Apparently, the additional vent will insure greater escapement.

Crabs in Research Gear

Since male *C. irroratus* attain larger sizes than females (Krouse 1972), commercial catches of this species are comprised almost entirely of males, so in the following analyses only catches of male crabs are considered. Variations in size composition of catches with different vents as manifested by width-frequency histograms (Figure 3) and mean carapace widths which are statistically different (Duncan's new multiple range test, $P<0.01$) indicate that: 1) fewer large crabs (≥90 mm CW) were captured in traps with horizontal vents (mean 91.2 mm CW); and 2) as many, if not more, larger crabs were collected with circular (mean 96.5 mm CW) than nonvented traps (mean 93.8 mm CW). According to this data, the 58-mm circular vent is at least as efficient in retaining marketable-sized crabs as the nonvented trap and certainly much more efficient than the horizontal vent. Escapement of subcommercial-sized crabs through circular openings has long been recognized by west coast States with Dungeness crab fisheries (Miller 1976). These states require crab traps to have one or two escape rings with diameters ≥4 in.

This situation was further evaluated by comparing the numbers (crabs ≥90 mm CW) per trap haul

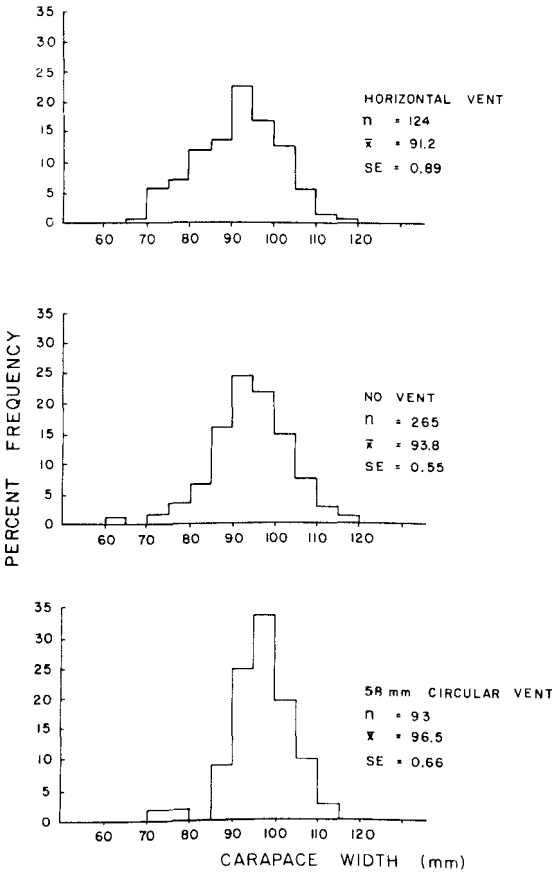

FIGURE 3.—Width-frequency distributions for male rock crabs caught with nonvented traps, traps with 58-mm circular vents, and traps with horizontal vents fished near Boothbay Harbor, Maine.

set over day for each of the different vents (Figure 4). CPUE values were highest for circular vents, lowest for horizontal vents, and intermediate for vertical and nonvented traps. Thus circular vents relative to the other vents were most effective in retaining crabs ≥90 mm CW and based on the following ratios of nonkeepers (<90 mm CW) to keepers (≥90 mm CW), selectively fished for larger crabs:

	Vent type			
	Circular	Nonvented	Horizontal	Vertical
Nonkeepers:keepers	1.5:1	2.5:1	4.1:1	5.7:1

Even though smaller crabs can egress quite readily from traps with horizontal and vertical vents, the above values at first glance appear to reflect the converse, i.e., more nonkeepers are caught in

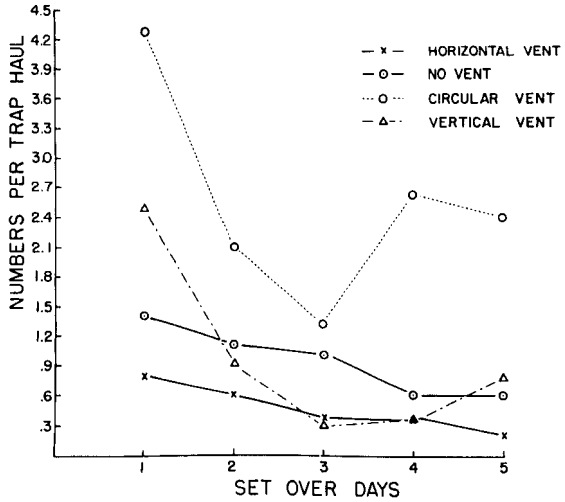

FIGURE 4.—Comparison of the number of rock crabs (≥90 mm carapace width) per trap haul set over day captured with nonvented and circular and rectangular (horizontal and vertical) vented lobster traps.

horizontal and vertical vented traps than in the circular and nonvented traps. Actually, horizontal and vertical vents, unlike circular and nonvented traps, also permit harvestable crabs to escape, resulting in reduced catches of keepers. Consequently, the proportion of nonkeepers to keepers is markedly greater for horizontal and vertical holes.

As evidenced by the aforementioned catch data, selectivity features of horizontal and vertical rectangular vents are similar; however, compared to circular vents they are unsatisfactory for catching large crabs. Prior to field testing, guided by opinions of some fishermen and our own thoughts, it seemed plausible that a vertically positioned rectangular opening (Figure 1A) might inhibit escapement of those crabs with carapace length exceeding the vent's width (smallest dimension). Of course, this was predicated on the assumption that when a crab encounters such a narrow upright opening it will only attempt to egress in a horizontal plane and will not tilt the body diagonally. However, laboratory observations and size composition of catches in traps with vertical vents indicate crabs will readily turn on end or side to exit.

Prior to this, only escapement through the vent itself has been discussed; this certainly does not preclude escapement through entrance heads. Diminishing CPUE values plotted against set over days in Figure 4, particularly for circular and nonvented traps where escapement could only result via the entrances, vividly demonstrate the crab's ability to escape as trap soak time is increased. Evidently, after the voracious crabs become satiated by eating the trap's bait, which frequently occurs in 1 or 2 days during the summer, the trap loses its attractiveness and crabs try to escape. Therefore, crab fishermen can maximize their catches by hauling their traps daily, particularly during periods of high catches. Contrasted to declining crab catches with greater soak times are lobster CPUE values which increase until 4 or 5 set over days, after which catches begin to diminish (Figure 2). Similar trends in CPUE data for commercial catches have been reported by Thomas (1973). Thus it appears that crabs are more adept at escaping from traps than lobsters.

Escapement and Morphometric Studies

Lobsters

Passage of lobsters through a round hole is related to the lobster's carapace height (greatest cross-sectional dimension) relative to hole diameter. Figure 5 shows that: 1) most legal-sized

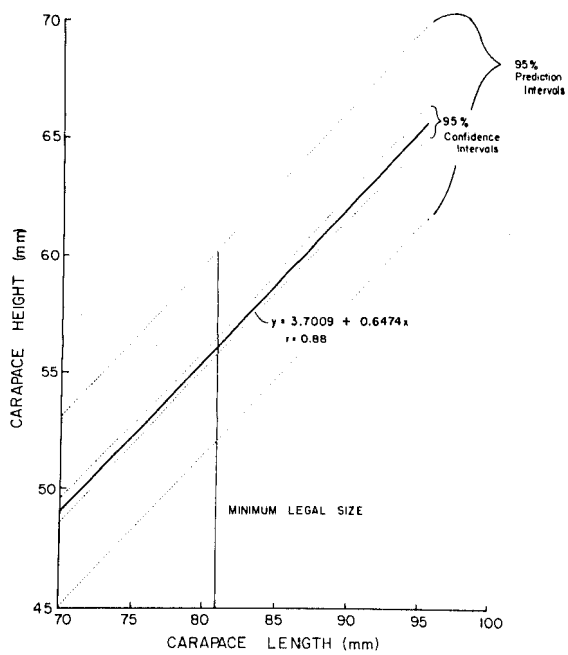

FIGURE 5.—Carapace length-carapace height relationship for lobsters with 95% confidence and prediction intervals.

lobsters with 81 mm CL had <58 mm CH; 2) about half those lobsters with 84 mm CL had <58 mm CH; and 3) lobsters ≥90 mm CL had ≥58 mm CH. Based on this relationship alone, it appears that many lobsters ranging from 81 to 89 mm CL would be able to squeeze through a 58-mm diameter hole; however, this is refuted by the previous sections on the commercial and research catches of lobsters with circular vented traps and the following discussion of escapement studies. Lobster escapement through a round opening cannot be accurately determined by carapace height alone since this measurement excludes the walking legs which contribute to the lobster's overall height or depth. Whether or not a lobster is successful in passing through a round hole will be determined not only by the lobster's greatest transverse dimension (carapace height plus protruding legs) but also by the lobster's ability to maneuver through a tight opening.

Obvious limitations with the aforementioned morphometric relationship caused me to seek an alternate approach to assess escapement. Thus, I decided to determine the largest size lobster that could be manually passed through a 58-mm diameter hole. Lobsters 81 mm CL passed through the hole rather easily following careful manipulation of the walking legs and 82-mm CL lobsters required considerable force, often causing bodily harm, while larger lobsters (>82 mm CL) could not pass through the opening.

Patterns of escapement for lobsters ranging from 78 to 84 mm CL from traps with 58-, 60-, and 61-mm diameter vents varied decidedly as depicted by retention curves in Figure 6. Only the 58-mm vent retained all legal-sized lobsters and still had reasonably high escapement of sublegals; whereas, the other vents which were merely 2 or 3 mm larger allowed legal-sized lobsters to escape. These data emphasize the importance of accurately producing the 58-mm opening, else the vent's desired effect will be lost.

Crabs

Carapace width-length relationships for *C. borealis* and *C. irroratus* graphically show that crabs ≥90 mm CW (commercially harvested size) have carapace lengths (dimension limiting escapement) which exceed 58 mm (Figures 7, 8). Accordingly, commercial-sized crabs of either species cannot egress through a circular opening 58 mm in diameter. In fact, if the vent diameter

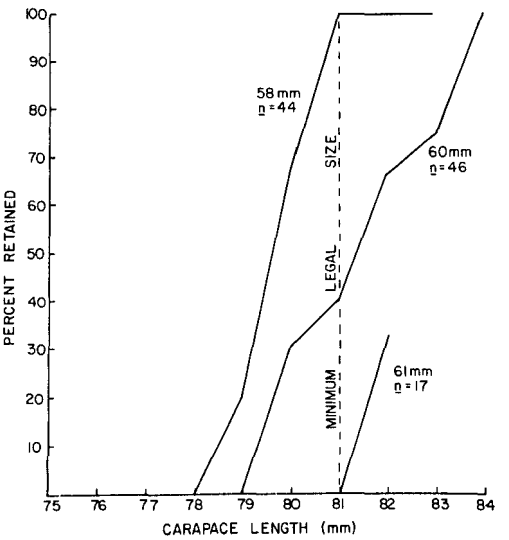

FIGURE 6.—Retention curves for lobsters placed in lobster traps with circular vents of 58, 60, and 61 mm in diameter.

were increased to as large as 65 mm (certainly, an over estimate) to accommodate an upward shift in the lobster minimum size (Maine Department of Marine Resources recommends an increase from $3^3/_{16}$ to 3½ in CL by $^1/_{16}$-in increments annually over a 5-year period) this would have little or more likely no effect on catches of marketable crabs.

RECOMMENDATIONS

In view of the findings of this study and past investigations (Krouse and Thomas 1975; Krouse 1976), all lobster and crab traps fished in Maine waters should have a rectangular escape vent not less than 1.75 in (44.5 mm) by 6 in (152.4 mm) or at least two circular escape vents not less than 2.28 in (58 mm) in diameter. To insure maximum escapement of sublegal lobsters, vents should be installed next to the sill on the side or end of the trap's parlor section.

Although fishermen should certainly have the option to fabricate their own vents, provided that the prescribed dimensions are adhered to, the use of synthetic, prefabricated vents is highly recommended (Krouse and Thomas 1975). Recently, a plastics manufacturer assured me that vents could be produced and retailed for about 20¢ each. At this low price and with today's high price of laths (about 5¢ each), if a synthetic vent replaces two laths every 3 yr, then after 6 yr the original cost of

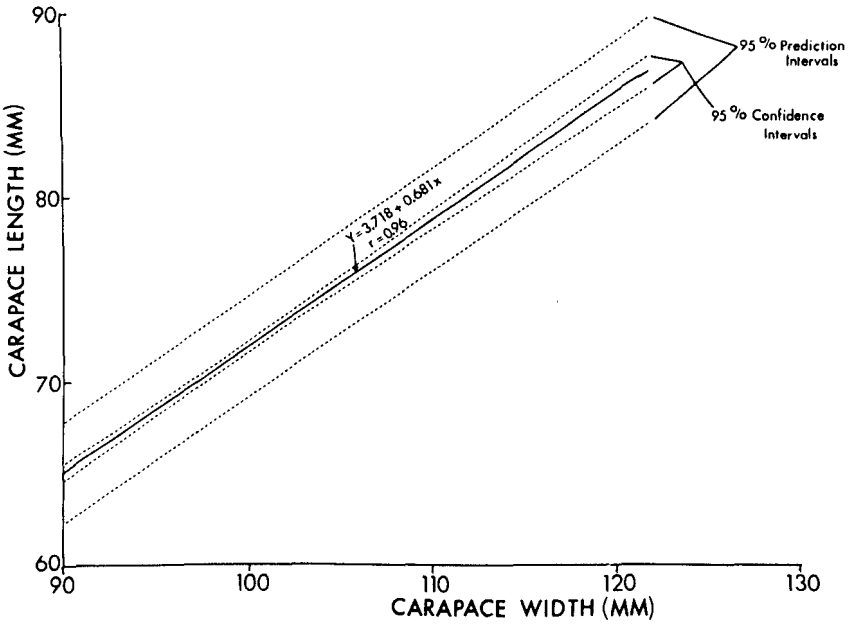

FIGURE 7.—Carapace width-carapace length relationship for male rock crabs with 95% confidence and prediction intervals.

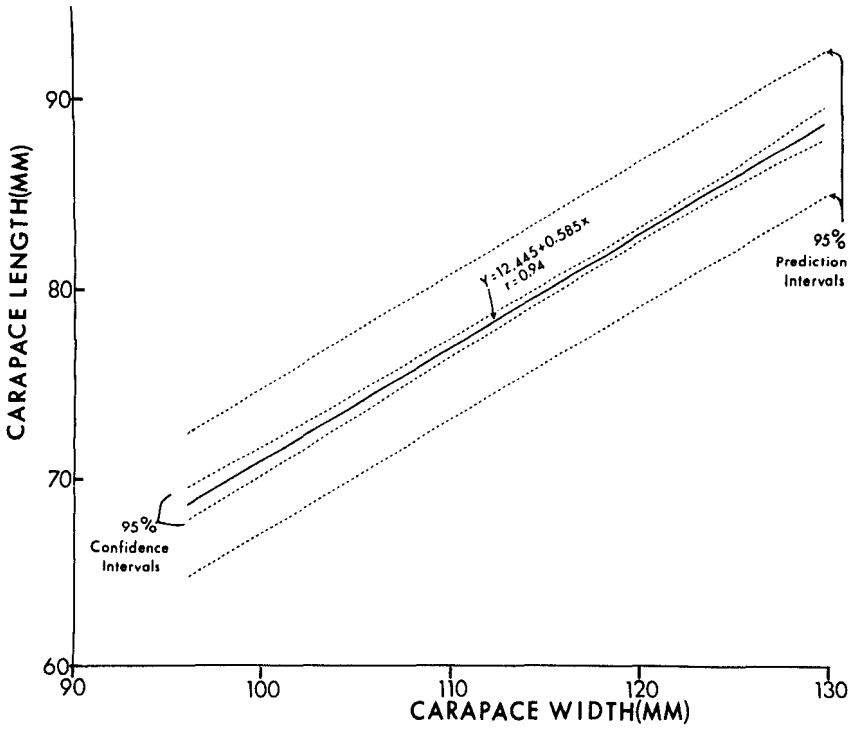

FIGURE 8.—Carapace width-carapace length relationship for Jonah crabs with 95% confidence and prediction intervals.

the vent will be defrayed by the replacement cost of the laths, resulting in a cost savings.

Therefore, those fishermen interested in capturing only lobsters and, perhaps, minimizing their crab catches, would be encouraged to use rectangular vents, while fishermen interested in both lobsters and crabs or solely the latter should employ circular vents.

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