# EFFECTS OF TRAP VENTING ON GEAR SELECTIVITY IN THE INSHORE RHODE ISLAND AMERICAN LOBSTER, *HOMARUS AMERICANUS*, FISHERY

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## ABSTRACT

The incorporation of escapement devices in lobster traps has proven effective in allowing the release of sublegal-sized American lobster, *Homarus americanus*, and reducing the potential for trap related injury and mortality. The present study was undertaken to assess the effects of trap venting on size selectivity and catch per unit effort in the inshore Rhode Island lobster fishery. The use of rectangular vents (42 × 152 mm) resulted in a 79% decrease in the sublegal <78 mm carapace length) catch. Vented traps tended to consistently catch greater numbers of legal-sized (≥78 mm carapace length) lobster, possibly due to a density dependent effect. The mean size of lobster caught in vented gear was significantly greater than in control traps. An analysis of the effect of trap immersion time indicated that the catch is asymptotic with increasing soak time up to 7 set over days.

Comparisons of the effectiveness of 42 × 152 mm and 44.5 × 152 mm vents indicated that no substantial loss of legal lobster would occur and that escapement rates of sublegal lobster would be dramatically improved with the use of the larger vent size. Vented traps tended to be more efficient in releasing sublegal lobster than traps with equivalent lath spacing, supporting the use of synthetic vents. Vent orientation (horizontal versus vertical) did not affect the escapement of sublegal-sized lobster.

Attempts to adjust the size selectivity of traps to minimize the retention of sublegal-sized lobster have received increasing attention in recent years (Krouse and Thomas 1975; Krouse 1978; Pecci et al. 1978; Nulk 1978; Fair and Estrella[2]). The inverse relationship between lath spacing and the sublegal catch has long been recognized (Templeman 1939; Wilder 1945), while current efforts have been directed toward the development of more precise escapement devices, specifically escape vents of various designs.

A clear reduction in lobster mortality and injury with the use of vented traps has been demonstrated (Pecci et al. 1978); sources of trap related mortality and injury include aggressive interactions within the trap and the effects of handling by fishermen. In addition, predation on surface released sublegal lobster may contribute significantly to mortality (Krouse and Thomas 1975).

Less information is available on the effects of trap venting on the incidental catch of commercially valuable species, particularly the rock crab, *Cancer irroratus*, and the jonah crab, *C. borealis*. Krouse (1978) demonstrated the effectiveness of vents with circular openings in retaining marketable northern crabs *Cancer* spp., while permitting the egress of sublegal-sized lobster. Stasko (1975) earlier promoted the use of circular escape openings in traps modified to retain crabs and release lobster.

A research program designed to substantiate data available on trap venting and apprise local fishermen of new concepts in gear modification was initiated by the Rhode Island Division of Fish and Wildlife in April 1976. This report presents the results of field and laboratory investigations on the effects of trap venting on catch per unit effort (CPUE) and size composition of the lobster catch.

## METHODS

Conventional lobster traps were purchased from commercial suppliers and distributed to eight cooperating fishermen. The fishermen participated on a voluntary basis and were chosen to represent a range of geographical areas within

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[2]Fair, J. J., and B. Estrella. 1976. A study on the effects of sublegal escape vents on the catch in lobster traps in five coastal areas of Massachusetts. Unpubl. manuscr., 9 p. Massachusetts Division of Marine Fisheries, P.O. Box 707, Sandwich, MA 02563.

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Narragansett Bay and Rhode Island Sound. Five trap styles, representing the most commonly used trap types in this area, were selected for use in the study. Each fisherman was given traps of one type only.

Seven of the fishermen were provided with equal numbers of vented and nonvented traps to be arranged in trawls (strings) of alternating vented and control traps. The escape panels were constructed of 6061 gage aluminum with a 42 mm × 152 mm opening placed in the parlor section of the trap. Single parlor traps were equipped with one vent placed vertically in the end section of the parlor. Double parlor traps were equipped with two vents positioned horizontally in the sides of each parlor section.

To determine the efficiency of vented traps when compared with traps having equivalent lath spacing and to evaluate the effects of vent orientation (horizontal vs. vertical) on escapement, one of the fishermen was given traps with the following characteristics:

1) control traps (mean lath spacing 31 mm, SD = 6 mm),
2) traps with horizontal vents (42 mm × 152 mm),
3) traps with vertical vents (42 mm × 152 mm),
4) traps with one vertical lath space opened to 42 mm,
5) traps with horizontal vents (44.5 mm × 152 mm),
6) traps with vertical vents (44.5 mm × 152 mm), and
7) traps with one vertical lath space opened to 44.5 mm.

Each trap type was represented once in each trawl and trap order was randomized both within and between trawls.

The fishermen provided with experimental gear recorded the number of legal and sublegal lobster per trap haul. Additional information on fishing location, depth, bottom type, and soak time (set over days) was also recorded. Periodic sampling trips were made by personnel of the Rhode Island Division of Fish and Wildlife, Marine Fisheries Section. While on board commercial lobster boats, we recorded the number of legal and sublegal lobster per trap haul; physical condition including molt status, appendage loss, and the presence of an external egg mass on females; and carapace length (measured from the posterodorsal edge of the eye socket to the posterior margin of the carapace).

## RESULTS AND DISCUSSION

### Catch Per Unit Effort

Catch per trap haul (CTH) and CTH weighted by immersion time (CTHSOD) were examined for the seven fishermen provided with unmodified control traps and traps equipped with rectangular (42 × 152 mm) escape vents. A total of 18,984 lobster were obtained in 7,002 trap hauls of the experimental gear. The overall catch of sublegal-sized lobster was reduced by 79% in vented traps. Dramatic reductions in the sublegal catch were evident for each individual fisherman with one exception (Table 1). The ratio of sublegal to legal lobster was 1.375:1 in vented gear and 2.746:1 in control traps, again indicating the efficiency of vented traps in releasing sublegal lobster (Table 1). The overall mean CTH for sublegal lobster was 1.299 and 2.330 in vented and control traps, respectively (Table 2). These results support the findings of Krouse and Thomas (1975), Krouse (1978), Pecci et al. (1978), and Fair and Estrella (see footnote 2) in establishing the effectiveness of employing vented gear.

TABLE 1.—Number of legal (≥78 mm CL), sublegal and percentage of legal American lobster; ratio of sublegal to legal lobster (S/L); and the number of trap hauls (TH) in vented and nonvented gear for individual fisherman. Numbers in parentheses are totals adjusted to retain equal sample sizes. Chi-square contingency table analyses ($\chi_1^2$) tested the hypothesis that the catch of legal and sublegal lobster is independent of trap type.

| | Vented | | | | | Control | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fisherman | Legal | Sublegal | % legal | S/L | TH | Legal | Sublegal | % legal | S/L | TH | $\chi_1^2$ |
| A | 404 | 1,069 | 27.42 | 2.646 | 528 | 377 | 1,526 | 19.81 | 4.047 | 528 | 26.66** |
| B | 404(401) | 743(740) | 35.22 | 1.839 | 768 | 401 | 1,783 | 18.36 | 4.446 | 765 | 114.44** |
| C | 366 | 397 | 47.96 | 1.084 | 368 | 343 | 789 | 30.30 | 2.300 | 368 | 60.01** |
| D | 392 | 273 | 58.94 | 0.696 | 335 | 249 | 431 | 36.61 | 1.730 | 335 | 66.31** |
| E | 253(251) | 505(486) | 33.36 | 1.996 | 209 | 247 | 494 | 33.33 | 2.000 | 204 | 0.05 ns |
| F | 320 | 729 | 30.50 | 2.278 | 349 | 243 | 1,947 | 11.09 | 8.012 | 349 | 184.71** |
| G | 1,174 | 838 | 58.34 | 0.713 | 948 | 1,107 | 1,180 | 48.40 | 1.065 | 948 | 42.11** |
| Total | 3,313 (3,308) | 4,554 (4,532) | 42.11 | 1.375 | 3,505 | 2,967 | 8,150 | 26.68 | 2.746 | 3,497 | 498.433** |

** = $P<0.005$; ns = not significant.

TABLE 2.—Catch per unit effort of American lobster in vented and nonvented traps for individual fishermen. CTH indicates catch per trap haul; CTHSOD indicates catch per trap haul/set over day; the subscripts L and S indicate the catch of legal (≥78 mm CL) and sublegal lobster, respectively. Data are expressed in numbers of lobster.

| Fisherman | Vented | | | | Control | | | |
|---|---|---|---|---|---|---|---|---|
| | $C_L$TH | $C_L$THSOD | $C_S$TH | $C_S$THSOD | $C_L$TH | $C_L$THSOD | $C_S$TH | $C_S$THSOD |
| A | 0.765 | 0.155 | 2.024 | 0.410 | 0.714 | 0.144 | 2.890 | 0.585 |
| B | .526 | .160 | .967 | .294 | .524 | .159 | 2.330 | .709 |
| C | .994 | .141 | 1.078 | .153 | .932 | .132 | 2.144 | .305 |
| D | 1.170 | .300 | .814 | .209 | .743 | .191 | 1.286 | .330 |
| E | 1.210 | .244 | 2.416 | .487 | 1.211 | .244 | 2.421 | .488 |
| F | .916 | .175 | 2.088 | .399 | .696 | .133 | 5.787 | 1.107 |
| G | 1.238 | .251 | .883 | .179 | 1.167 | .236 | 1.244 | .236 |
| Total | 0.945 | .230 | 1.299 | .317 | 0.848 | .207 | 2.330 | .569 |

Interestingly, vented traps tended to consistently catch more legal-sized lobster than control traps (Tables 1,2). The overall mean CTH for legal lobster was 0.945 in vented traps and 0.848 in nonvented gear (Table 2). We attributed the trend in lower legal catch in control traps to a saturation effect where the probability of a lobster entering a trap declines with increasing density within the trap. In nonvented traps, sublegal lobster occupy space which might otherwise be taken by legal-sized lobster. Direct evidence of catch density dependence of this type in a trap fishery has been demonstrated for two species of *Cancer* (Miller 1979).

The well-established aggressive behavior of lobster when held in confinement supports the concept of a saturation effect for this species. Lobster are characteristically solitary under natural conditions (Cobb 1971; O'Neill and Cobb 1979) and it is reasonable to assume that the presence of lobster within a trap deters further entries. Although relatively little is known of the trap-related behavior of this species, there is an apparent conflict between food (and/or shelter) seeking behavior and avoidance of conspecifics.

Krouse (1978) reported an increase in legal catch in vented traps, supporting conclusions derived in an earlier study conducted in Maine (Krouse and Thomas 1975). Templeman (1939) and Wilder (1945) had earlier demonstrated increased legal catch rates in traps with increased lath spacing.

In the present study, the impact of crowding on the legal catch was most pronounced in small mesh (2.5 cm × 2.5 cm) wire traps (Fisherman F). These traps retained extremely high numbers of sublegals. Vented traps not only retained fewer sublegal lobster, but caught substantially more legal-sized lobster (Tables 1, 2).

To further assess the effectiveness of the vented gear, we tested the hypothesis that the catch of legal and sublegal lobster was independent of trap type (vented vs. control). In two instances where loss of trap resulted in an unequal number of observations, catch totals were adjusted by deleting data from an adjacent trap to retain a balanced design. Lost traps were replaced as quickly as possible. These analyses confirmed that significant differences exist in the catch characteristics of vented and control traps for combined data ($\chi_1^2 = 498.433$; $P<0.005$) and for individual fishermen (Table 1) with a single exception.

## Effect of Immersion Time

The importance of incorporating soak time in measures of CPUE has been emphasized in several trap fisheries including that for the American lobster (Thomas 1973; Skud[3]), the European lobster, *H. gammarus* (Bennett 1974), the spiny lobster, *Panulirus argus* (Austin 1977), and the western rock lobster, *P. longipes cygnus* (Morgan[4]).

The immersion (soak) time utilized by individual fishermen is most often a function of the total number of traps deployed and the daily hauling capacity of the boat, although weather conditions frequently interrupt hauling schedules. Each fisherman typically has three or more sets of gear which are hauled in rotation.

Catch data were pooled and examined for the effect of immersion time up to a maximum of 7 set over days. Soak times of >7 days were omitted due to excessive variability. The catch of legal lobster

[3]Skud, B. E. 1976. Soak time and the catch per pot in an offshore fishery for lobsters (*Homarus americanus*). Int. Cons. Explor. Mer, Special meeting on population assessments of shellfish stocks, No. 8, 25 p.

[4]Morgan, G. R. 1976. Trap response and the measurement of effort in the fishery for the western rock lobster. Int. Cons. Explor. Mer, Special meeting on population assessments of shellfish stocks, Contrib. 16, 18 p.

per trap haul ($C_LTH$) tended to increase slightly with increasing soak time in both vented and control traps up to 6 days when a slight decline became evident (Figure 1).

A different pattern emerged for the catch of sublegal lobster per trap haul ($C_STH$) where we noted an initial increase in $C_STH$ in nonvented traps followed by a general decline with increasing soak time. In vented traps, $C_STH$ declined initially followed by a slight increase with time (Figure 1). The decline in $C_STH$ in control traps with immersion times in excess of 2 days may be the result of escapement through the trap heads and mortality within the trap (Bennett 1974; Austin 1977). We attributed the immediate decline in $C_STH$ in vented traps to escapement, indicating the effectiveness of the vents. It is unclear whether the increase in $C_STH$ for the sixth set over day was due to sampling bias or some other factor. Bennett ascribed catch increases with long soak times to decay of the bait with an associated renewed release of chemical attractants.

The catch of legal and sublegal lobster was not proportional to immersion time. This may be due to the combined effects of declining local availability, trap saturation, escapement, and mortality (Bennett 1974; Austin 1977; Skud see footnote 3; Bennett and Brown[5]). Catch per trap haul/set over day (CTHSOD) declined with time in both vented and control traps (Figure 2). Similar observations of declining CTHSOD with increasing soak time have been noted in the Maine lobster fishery (Thomas 1973), the spiny lobster fishery (Austin 1977) and the European lobster fishery (Bennett 1974).

Our data indicated that CTH approached an asymptote with increasing soak time for both legal and sublegal lobster. Following the approach of Sinoda and Kobayasi (1969) and Munro (1974) this relationship may be modelled as:

$$C_s = C_\infty(1 - \exp(-Rs))$$

[5]Bennett, D.B., and C.G. Brown. 1976. The problems of pot immersion time in recording and analysing catch-effort data from a trap fishery. Int. Cons. Explor. Mer, Special meeting on population assessment of shellfish stocks, No. 6, 8 p.

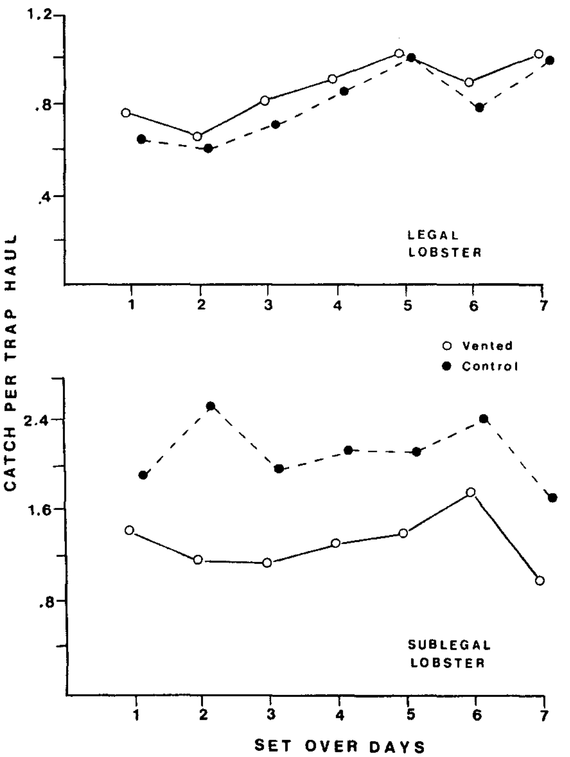


FIGURE 1.—Relationship between catch per trap haul of American lobster and trap immersion time in vented and control traps. Legal lobster are ≥78 mm CL.

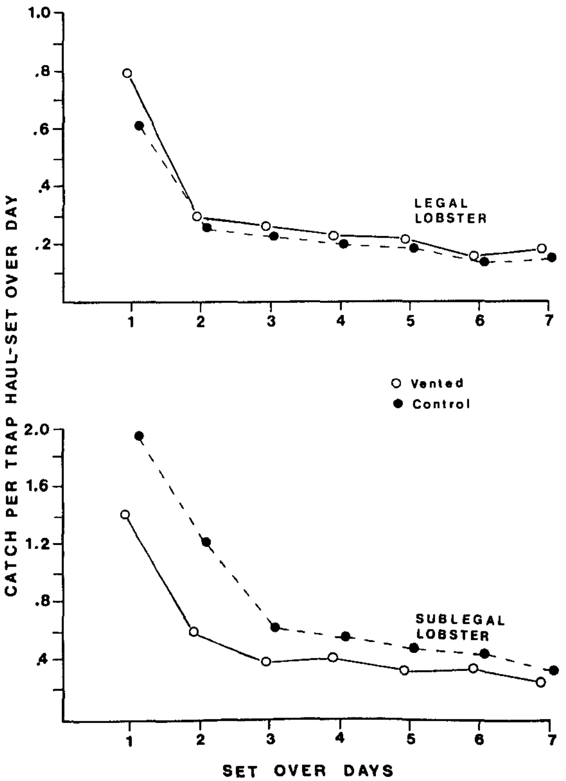


FIGURE 2.—The relationship between catch per trap haul/set over day of American lobster and trap immersion time in vented and control traps.

where $C_s$ is the cumulative catch on day $s$, $C_\infty$ is the asymptotic catch, and $R$ is the net retention rate assuming constant availability. The term $C_\infty$ is dependent on not only the physical holding capacity of the trap but on any behavioral interactions which serve to limit the catch. The asymptotic catch will be reached when ingress is balanced by escapement.

Parameters of the model were estimated by nonlinear least squares (Hartley 1961). The trend in greater legal catch in vented gear was reflected in the slightly higher estimate of $C_\infty$ in vented traps (Table 3). The substantially lower asymptotic catch level for sublegal-sized lobster in vented gear clearly demonstrated the effectiveness of these traps. Munro (1974) stressed the importance of escapement in determining saturation levels in fish traps.

This model may also be used to standardize effort to a common soak time. Adapting the approach of Sinoda and Kobayasi (1969) and Caddy,[6] weighting coefficients are given by

$$\omega = \frac{1 - \exp(-Rs)}{1 - \exp(-Rs^*)}$$

where $s^*$ is the standard soak time. The total effective effort ($f_{tot}$) is then the product of nominal effort (trap hauls) and the weighting coefficient (Caddy see footnote 6)

$$f_{tot} = \sum^{s} f_s \omega$$

and the standardized CPUE is given by the catch divided by $f_{tot}$. Adjustment for variable soak times should greatly improve the precision of catch effort data used in surplus yield modelling.

## Size Selectivity

Carapace length (CL) measurements were obtained for a sample catch of 2,943 lobster retained in the experimental traps. The reduction in the sublegal catch retained in vented gear was most pronounced for lobster <75 mm CL (Figure 3). Size selection for lobster >75 mm CL was virtually identical in vented and control traps. The mean size of lobster caught in nonvented traps (75.20 mm) and vented gear (78.99 mm) were significantly different ($t$ = 12.856; $P$<0.01).

Retention curves (Krouse and Thomas 1975) constructed for vented and control traps clearly reflect the differences in the retention characteristics for each trap type (Figure 4). The cumulative retention points for each curve at the Rhode Island minimum legal size at the time of this study (78 mm CL) were 56.0% and 69.5% for vented and control traps, respectively.

TABLE 3.—Coefficients and associated standard errors for the model $C_s = C_\infty[1—\exp(-Rs)]$ relating catch per trap haul and soak time in vented and control traps for legal- (≥78 mm CL) and sublegal-sized lobster.

| Item | $C_\infty$ | $R$ |
|---|---|---|
| Vented: | | |
| Legal | 0.9745±0.0715 | 0.9879±0.3610 |
| Sublegal | 1.3847±0.1598 | 0.8796±0.6289 |
| Control: | | |
| Legal | 0.9222±0.0811 | 0.7428±0.2664 |
| Sublegal | 2.1642±0.1127 | 2.5369±1.7001 |

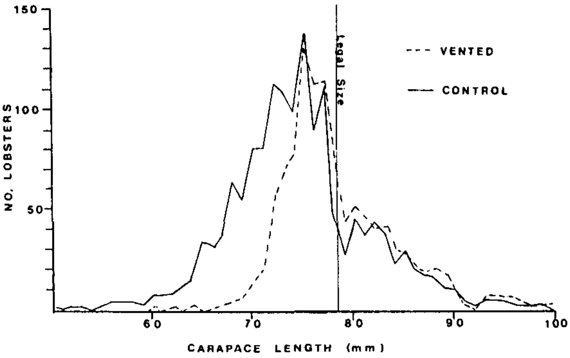


FIGURE 3.—Size-frequency distribution of American lobster collected in vented and control traps in Narragansett Bay-Rhode Island Sound (1976-77).

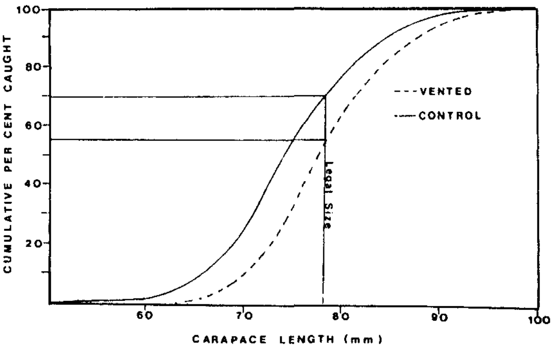


FIGURE 4.—Retention curves generated for vented and control traps for American lobster collected in Narragansett Bay-Rhode Island Sound (1976-77).

[6]Caddy, J. D. 1977. Some considerations underlying definitions of catchability and fishing effort in shellfish fisheries, and their relevance for stock assessment purposes. Int. Cons. Explor. Mer, Shellfish and Benthos Committee, C.M. 1977/K:18, 21 p.

We observed a general relationship between the mean size of lobster caught and fishing location. Comparisons of the mean size of lobster in sample catches (pooled by trap type) for six fishermen, for which adequate data were available, revealed a segregation by fishing location (Table 4). In general, lobster taken in Narragansett Bay and nearshore Rhode Island Sound samples were significantly smaller ($\alpha = 0.05$) than those taken in offshore Rhode Island Sound when compared using Duncan's multiple range procedure (Steel and Torrie 1960), although one offshore sample did not conform to this pattern. We attributed the smaller mean size in Narragansett Bay and nearshore Rhode Island Sound samples to intense fishing pressure in these easily accessible areas. Krouse (1973) noted a similar correspondence between fishing intensity and size composition of the catch. Areas within Narragansett and Rhode Island Sound with the smallest mean size of lobster also had the lowest CPUE (Table 4).

Characteristics of the habitat may also influence the size composition of the catch. Several authors have observed a correlation between the size of lobster and the size of available shelter sites (Scarratt 1968; Cobb 1971; Stewart 1972). Larger lobsters were found in areas with greater shelter size (Scarratt 1968; Cobb 1971) or in mud areas with a high clay fraction capable of supporting larger burrows (Stewart 1972). Inshore rocky habitats are characterized by ledge and mixed rocky debris which offer smaller shelter sites than offshore mud and rock substrates.

TABLE 4.—Results of Duncan's multiple range procedure comparing mean carapace length (rank ordered) of American lobster from offshore Rhode Island Sound (R.I.S.), nearshore Rhode Island Sound (R.I.S.N.) and Narragansett Bay (N.B.). Means with the same letter code are not significantly different ($\alpha = 0.05$).

| Fisherman | N | Mean (SD) | Grouping | Location |
|---|---|---|---|---|
| C | 149 | 78.382 (8.06) | A | R.I.S. |
| G | 801 | 78.052 (7.14) | A | R.I.S. |
| E | 107 | 75.738 (5.76) | B | R.I.S. |
| F | 958 | 75.603 (6.44) | B | N.B. |
| A | 71 | 74.845 (5.41) | B C | R.I.S.N. |
| B | 431 | 73.635 (5.31) | C | N.B. |

## Sex Ratios

Comparisons of sex ratios in vented and control traps revealed interesting differences. We noted a female:male ratio of 1.68:1 in nonvented traps and 2.15:1 in vented gear. Contingency table analyses indicated that the sex composition of the catch differed significantly in vented and control traps ($\chi_1^2 = 7.70; P<0.01$). These data suggest differential escapement by males and females. To further assess this possibility, we investigated the relationship between carapace length and carapace width for 437 male and 603 female lobster. Analyses of covariance (Steel and Torrie 1960) indicated that the regression coefficients were significantly different ($F_{1,1036} = 6.74$; $\alpha = 0.01$). The least squares regression equations were

$$CW_m = -0.8901 + 0.6186\, CL_m \ (r = 0.869) \text{ for males and}$$
$$CW_f = -4.3932 + 0.6755\, CL_f \ (r = 0.886) \text{ for females.}$$

In passing through a rectangular vent, the critical body dimension is the carapace width (the minimum body measure). The relatively broader carapace width for females of a given carapace length may result in the retention of proportionately more females, accounting for the observed discrepancy in sex ratios in the experimental gear. It should be noted that Krouse and Thomas (1975) found no significant differences in the carapace width-length relationship for 114 female and 103 male lobster.

## Vent Size, Orientation, and Lath Spacing

We examined the effect of vent orientation (horizontal vs. vertical) and lath spacing on escapement. The effectiveness of larger vents (44.5 mm × 152 mm) in retaining legal lobster was also tested. Vent orientation may affect either the probability of a lobster locating the vent or the time required to find the vent, a factor of importance with short immersion times. There may also be differences in size selectivity associated with vent orientation. Analysis of preliminary size composition data indicated that 42 mm vents may in fact be too small for a minimum legal size of 78 mm. Accordingly, we tested 44.5 mm × 152 mm vents in an attempt to determine if legal-sized lobster could escape with the use of this larger vent size. We also evaluated the effectiveness of opening lath spacing to 42 mm and 44.5 mm in comparisons with vents of equivalent size.

A total of 4,487 lobster were obtained in 2,222 trap hauls of the experimental gear. As might be expected, traps with 44.5 mm openings (vented and lath spaced traps) retained markedly fewer sublegal lobster than either traps with 42 mm openings or control traps (Table 5). The sublegal catch was substantially reduced in comparisons of traps with 42 mm escapement openings and control traps (Table 5). Contingency table analyses indicated that the catch characteristics of each vented trap type were significantly different from control traps (Table 5). Traps with horizontal vents (both size classes) tended to catch fewer legal-sized lobster than control traps (Table 5). We were unable to offer a direct explanation for this observation since, based on morphometric studies and laboratory observations, escapement of lobster ≥78 mm CL through 42 mm vents would be impossible and escapement of legal-sized lobster through 44.5 mm vents would be minimal. The effect of vent orientation on the sublegal catch was negligible. Krouse (1978) found no significant differences in the catch characteristics of traps equipped with horizontal and vertical vents.

Traps with increased lath spacing tended to retain more sublegals than traps equipped with equivalent-sized vents (Table 5) suggesting that synthetic vents were more efficient escapement devices. In this experiment the opened lath spacing was oriented vertically in the end panel of the parlor section of the trap. Although the vent width determines the selection characteristics of the trap, the length and orientation of the vent (or lath spacing) may directly affect the probability of locating the opening. Vertically positioned escape openings offer a target equal to the width of the opening, a relatively small area while horizontally positioned vents proffer a much larger target. Laboratory observations indicated that escapement openings were located by an apparently random search process, suggesting that larger target areas will be located more quickly and efficiently.

The catch of legal-sized lobster tended to increase slightly or remain constant with increasing soak time for each trap type with the exception of control traps, which demonstrated a decline as immersion time increased (Figures 5, 6). The catch of sublegal lobster remained consistently low with increasing soak time in traps with 44.5 mm escapement openings while that for traps with 42 mm openings exhibited considerable variability (Figures 5, 6).

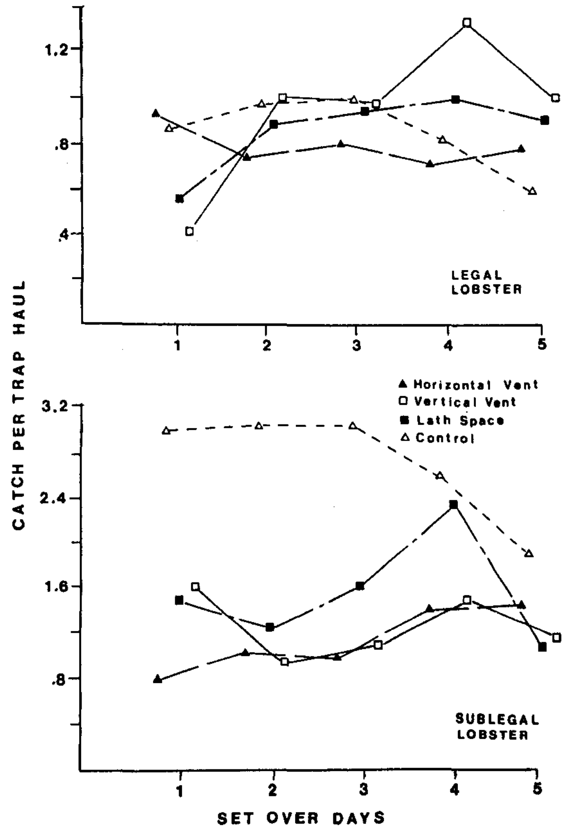


FIGURE 5.—Relationship between catch per trap haul of American lobster and trap immersion time in 42 mm vertical vented, 42 mm horizontal vented, 42 mm lath spaced, and control traps.

TABLE 5.—Number of legal (≥78 mm CL), sublegal, and percentage of legal American lobster; and ratio of sublegal to legal lobsters (S/L) and catch per unit effort in experimental traps. CTH and CTHSOD denote catch per trap haul and catch per trap haul/set over day, respectively. The subscripts L and S indicate the catch of legal and sublegal lobster. The abbreviations V, H, and L refer to vertical and horizontal vent orientation and lath spacing. Numbers in parentheses are totals adjusted to retain equal sample sizes. Chi-square contingency table analyses compared the catch characteristics of control traps with each individual trap type.

| Vent type | Legal | Sublegal | % Legal | S/L | TH | $C_LTH$ | $C_LTHSOD$ | $C_STH$ | $C_STHSOD$ | $\chi_1^2$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Control | 296(292) | 913(904) | 24.48 | 3.084 | 316 | 0.936 | 0.436 | 2.889 | 1.068 | |
| V 42 mm | 318(315) | 369(360) | 46.28 | 1.160 | 318 | 1.000 | 0.369 | 1.160 | .429 | 96.44** |
| H 42 mm | 245(243) | 357(352) | 40.69 | 1.457 | 319 | .768 | 0.284 | 1.119 | .414 | 50.39** |
| L 42 mm | 282(278) | 454(442) | 38.31 | 1.609 | 318 | .886 | 0.328 | 1.427 | .528 | 42.66** |
| V 44.5 mm | 288(284) | 136(132) | 67.92 | .472 | 318 | .905 | 0.335 | .427 | .158 | 256.58** |
| H 44.5 mm | 265(265) | 112(111) | 70.29 | .422 | 318 | .833 | 0.307 | .352 | .130 | 263.31** |
| L 44.5 mm | 299 | 153 | 66.15 | .511 | 313 | .955 | 0.353 | .488 | .180 | 246.60** |

**$P<0.005$.

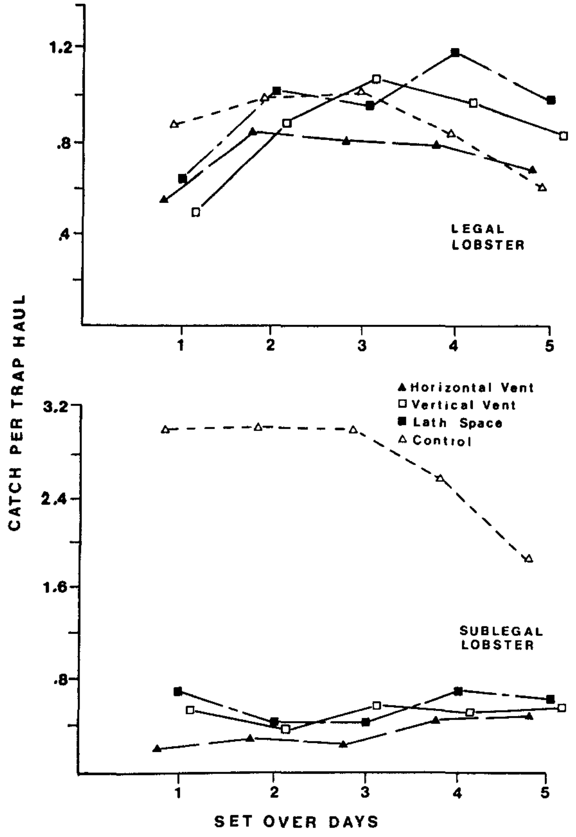


FIGURE 6.—Relationship between catch per trap haul of American lobster and trap immersion time in 44.5 mm vertical vented, 44.5 mm horizontal vented, 44.5 mm lath spaced, and control traps.

## CONCLUSIONS

The beneficial effects of incorporating escape vents in standard lobster traps are well established (Krouse and Thomas 1975; Krouse 1978; Pecci et al. 1978). A reduction in lobster injury and mortality and a reduction in onboard sorting time are among the benefits accrued through the use of escapement devices (Krouse and Thomas 1975; Pecci et al. 1978). Lobster damage is related to the effects of fishing activity both directly as a result of handling (Scarratt 1973; Krouse 1976) and indirectly as a result of aggressive encounters in the trap (Pecci et al. 1978). Although interspecific aggression levels are relatively low under natural conditions (Cooper and Uzmann 1977), the artificially close confines of a trap may increase the probability of aggressive behavior.

The results of the present study confirm the utility of employing escapement devices in lobster traps. We noted substantial reductions in the catch of sublegal-sized lobster, reducing the probability of injury and mortality. Vented traps tended to consistently capture more legal-sized lobster than control traps. We attributed this increase to an inverse relationship betweeen density in the trap and the probability of new entries.

This apparent increase in relative gear efficiency may have a significant impact on catch rates if widely applied and should be closely monitored. Given the critically high levels of fishing mortality for lobster in virtually all sectors, this increase in trap fishing power is presently inadvisable. The use of 100% retention of legal-sized lobster as the primary criterion for the establishment of escape vent dimensions should therefore be modified to allow for some minimal escapement of legal lobster and to maximize escapement of sublegal lobster.

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