Evaluation of Circular and Rectangular Escape Vents in a Multispecies Lobster Fishery in Hawaii

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ABSTRACT

The Hawaiian lobster fishery harvests approximately equal quantities of the spiny lobster, *Panulirus marginatus*, and the slipper lobster, *Scyllarides squammosus*. Minimum sizes have been established for both spiny and slipper lobsters. Concern that capture and release of sublegal lobsters results in high mortality led to the evaluation of escape vents placed in traps. Field trials aboard a commercial vessel tested both rectangular and circular escape vents of varying sizes. Circular vents performed better than rectangular vents in maximizing the escapement of both sublegal spiny and slipper lobsters without a significant loss of catches of legal lobsters. The use of the circular escape vents should eliminate most of the capture and release mortalities of sublegal lobsters and will translate into improved catches of legal lobsters.

INTRODUCTION

The use of escape vents in lobster traps has long been recognized in most major lobster fisheries throughout the world as an effective means of reducing sublegal lobster retention without compromising legal lobster catch. Use of such vents is required by law in many of these fisheries. The Honolulu Laboratory initiated research in 1984 to ascertain the effectiveness of escape vents for use in the lobster trap fishery of the Northwestern Hawaiian Islands (NWHI).

At the time of the initial vent study, the fishery in the NWHI targeted primarily a single species of spiny lobster, *Panulirus marginatus*. All other species caught were considered incidental. The results of this research established that a rectangular vent was extremely effective in releasing sublegal spiny lobsters while retaining all legal lobsters. In many instances, the catch rate of legal spiny lobsters was higher in the vented traps. However, as this research was being conducted, a new lobster trap was introduced in the fishery, greatly increasing the catchability of the slipper lobster, *Scyllarides squammosus*. Within a short period of time, the commercial landing of slipper lobsters equaled that of spiny lobsters. Unfortunately, the rectangular vent type allowed the escapement of a large percentage of this slipper lobster catch. The problem was compounded by the lack of a minimum size restriction on slipper lobster.

Designing a vent that would be equally effective in allowing a high percentage of sublegal lobster escapement without compromising legal lobster retention for both species simultaneously presented a unique challenge, and little prior research had been completed on this specific problem. The body dimensions of the two species are quite different. Slipper lobsters are wider than they are high, whereas the inverse is true of spiny lobsters. Therefore, a circular vent selecting simultaneously for slipper lobster body width and spiny lobster body height might have potential for optimizing escapement. This idea was further supported by the observation of a Hawaiian lobster fisherman that slipper lobsters seem to have more difficulty than spiny lobsters in negotiating a small, round opening.

Additional laboratory tank trials conducted in March-April 1986 established that circular escape vents could indeed be a viable means of releasing specific-sized lobsters of both species. Based upon these results, field trials were conducted onboard a commercial vessel under actual working conditions, to refine the selection size. A gradient of selection sizes was established on the basis of both the regression analysis performed on the morphometrics of the two species and the response surface model established from previous vent trials.

EXPERIMENTAL DESIGN

Four rectangular and four circular vent sizes were selected for evaluation in field trials onboard the commercial lobster vessel Shaman. The four rectangular vents had heights of 43, 45, 47, and 49 mm; the four circular vents had diameters of 60, 62, 65, and 67 mm. The rectangular and circular vent sizes were selected to provide a range of retention sizes that would cover the minimum (5.0 cm) tail widths for legal spiny lobster and possible minimum (5.2 , 5.4, and 5.6 mm) tail widths for slipper lobsters. Both of these escape vents were made of No. 12 gauge aluminum plate cut into 335 x 113 mm rectangles. The circular vent had four equal equal-sized holes cut in the panel, and the rectangular vent had a single 285-mm-long slot cut in the center of the panel (Figure 1). The small, mesh, black plastic, Fathom Plus (reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA) traps used in the lobster fishery were modified with the vents. Tank tests suggested that the best position for the rectangular vents was near the top of the trap while the circular vents should be placed near the bottom. Thus, one trap design had two rectangular vents placed on opposite sides in the upper left-hand corners, whereas the other design had two circular vents placed on opposite sides in the lower right-hand corners.

The Shaman typically sets 6 to 12 strings of traps, for a total of 1,100 traps set each day. The number of traps per string varied from 50 to 250. Because variation in catch rates can be considerable for traps along a string and between traps of different strings and is typically minimum between adjacent traps on a string, vented and control traps were set in adjacent sites on a string of traps. Specifically, a trap triplet, consisting of one rectangular vented trap, one nonvented control trap, and one circular vented trap, was set at regular intervals

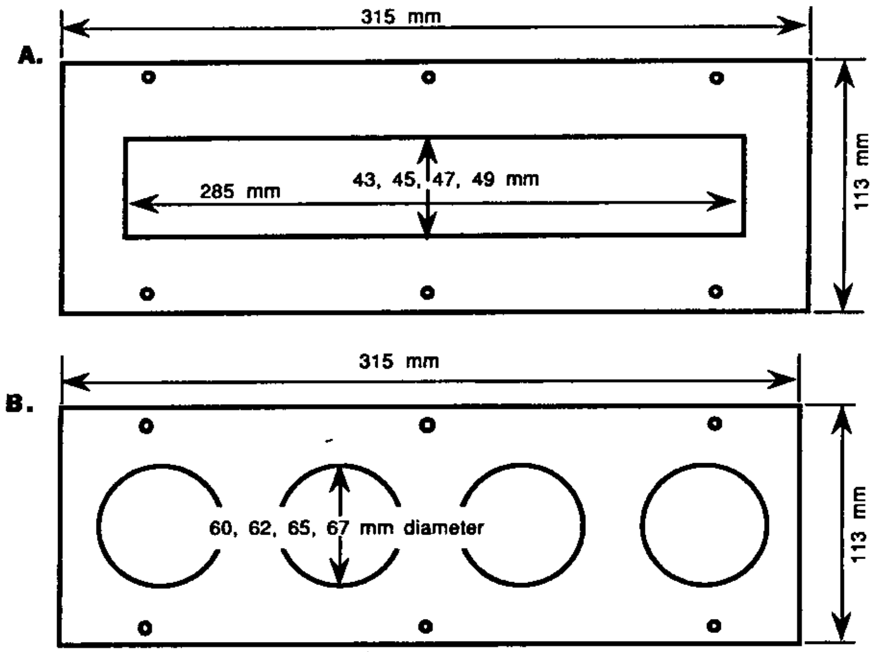


Figure 1. Escape vent designs tested aboard the fishing vessel Shaman (A = rectangular; B = circular).

on the Shaman's groundline. The spacing between the traps in each triplet was 50 m. Care was taken to ensure that the control trap was inserted between the two vented traps and that none of the Shaman's traps were inserted between the control and vented traps within a triplet.

For comparison purposes, the rectangular and circular vents with the same relative sizes were paired by triplet *e.g.*, the smallest (43 mm) rectangular vent and the smallest (60 mm) circular vent were fished in the same triplet). Comparing the differences in catch per unit of effort (CPUE) between a vented trap and a control trap within a triplet reduced the large variation in CPUW between strings, days, and banks. A paired t-test was used to test the difference in the CPUE between control and vented traps. Each triplet was fished for at least 1,800 total trap-nights from August to November 1986 at Maro Reef, Gardner Pinnacles, Raita Bank, and Brooks Banks. A total of 2,716 sublegal spiny lobsters, 5,353 legal spiny lobsters, and 13,353 slipper lobsters were caught in the vented and control traps during the entire field trial.

RESULTS AND DISCUSSION

For each of the four triplets, the mean CPUE for each trap type and the mean differences in CPUE's between vented and control traps within triplets for legal and sublegal size classes are given for spiny lobsters in Table 1 and for slipper lobsters in Table 2. These mean differences are expressed as percentages of mean control CPUE's for spiny and slipper lobsters in Table 3 and Figure 2.

In general, the vented traps substantially reduced the number of sublegal spiny and slipper lobsters caught in the traps, whereas the catches of legal spiny lobsters and medium and large slipper lobsters in the vented traps were comparable to catches in the control traps. The escapement of sublegal spiny and slipper lobsters increased as vent size increased (Table 3; Figure 2).

The circular vents performed better than the rectangular vents in maximizing sublegal escapement for sublegal spiny and slipper lobsters while minimizing loss of legal spiny and slipper lobsters. For example, to achieve a sublegal lobster escapement from a rectangular trap that is >70% of the control, it was necessary to use the largest (49 mm) rectangular vent. However, this vent reduced the CPUE for sublegal slipper lobsters from 32 to 43% of the control, depending on the minimum legal tail width used for slipper lobsters. Using a smaller rectangular vent increased the retention of sublegal spiny lobsters substantially. However, the circular 65-mm-diameter vent reduced the CPUE for sublegal spiny lobster by 73% of the control and, depending on the minimum legal tail width, reduced the CPUE's for sublegal slipper lobsters by 56 to 82% of the control (Table 3). This vent produces CPUE's for legal spiny and slipper lobsters that equal or exceed those for control traps.

Although the selection of the circular vent over the rectangular vent is easy, the choice of the diameter of the circular vent is more difficult and requires weighing the relative importance of sublegal lobster escapement against retention of legal lobsters. For example, the circular vent with the 67 mm diameter provided almost complete escapement of sublegal slipper lobsters but produced a 17% reduction in CPUE of legal slipper lobsters. The smaller, 65-mm-diameter vent slightly increased CPUE of legal lobsters over the control but only reduced CPUE of sublegal lobsters by 67% of the control (Table 3).

Because the landings of spiny and slipper lobsters were about equal in 1985 and 1986, it is reasonable to consider the combined CPUE for spiny and slipper lobsters as a function of vent size and minimum tail width of slipper lobsters. The values in Table 3 are averaged for spiny and slipper lobsters to give a measure of the average performance of the circular vent traps for combined catch (Table 4).

Table 1. Mean catch per unit effort (CPUE) and mean differences in CPUE's between trap types within triplets for legal (>5.0 cm tail width) and sublegal spiny lobsters (* = $P < 0.05$; ** = < 0.01; N = number of triplets; CPUE = number per trap type; R = rectangular vent; C = circular vent; control (con) = nonvented traps).

		Legal CPUE					Sublegal CPUE				
Vent type and size (mm)	N	R	Con	C	R - con	C - con	R	Con	C	R - con	C - con
C-60, R-43	457	0.96	1.03	1.03	-0.06	0.0	0.36	0.46	0.32	-0.09	-0.14**
C-62, R-45	340	0.97	0.74	0.86	0.06	0.11	0.16	0.23	0.19	-0.07	-0.4
C-65, R-47	338	0.66	0.66	0.76	0.0	0.10	0.37	0.64	0.17	-0.27**	-0.47**
C-67, R-49	627	1.34	1.18	1.30	0.16*	0.12	0.51	1.75	0.29	-1.23**	-1.46**

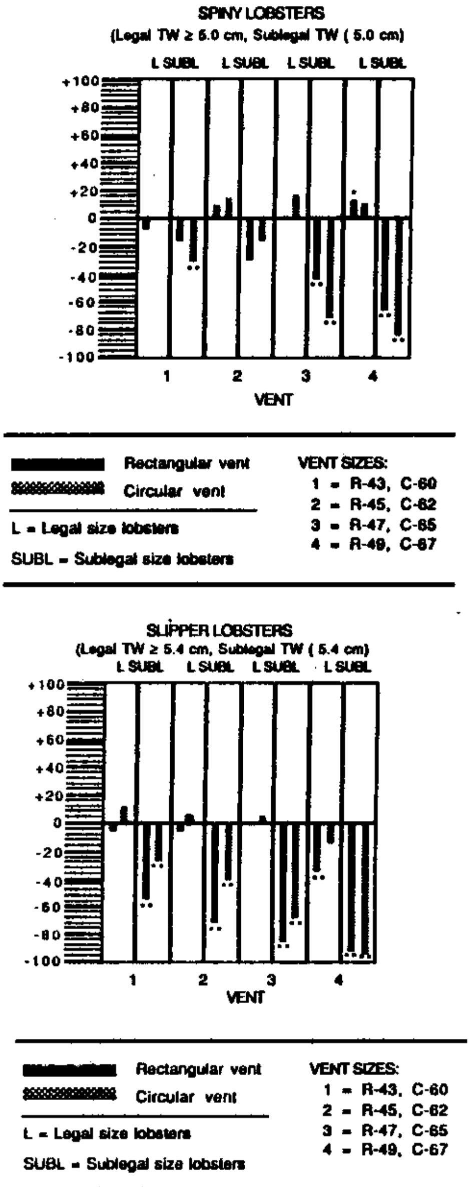
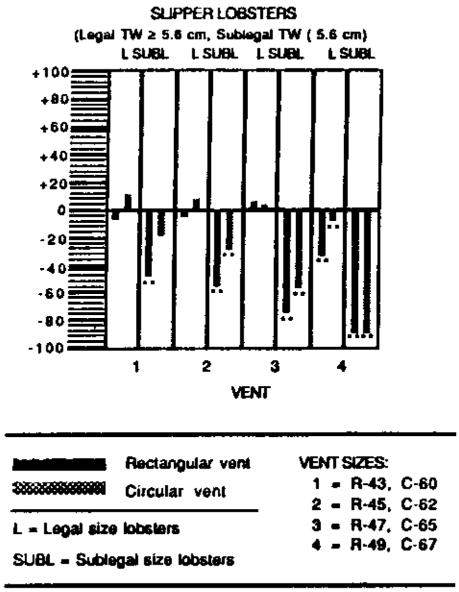


Figure 2. The catch per unit effort (CPUE) of vent traps minus control traps expressed as a percent of control trap CPUE for spiny and slipper lobsters. Based on values given in Table 3 (* = $P \leq 0.05$, ** = $P \leq 0.01$).



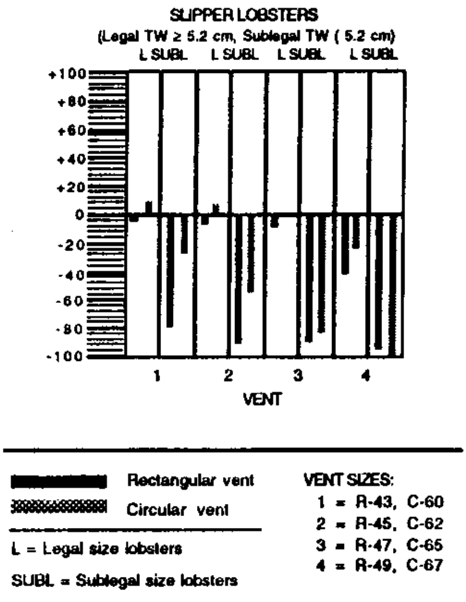


Figure 2. (continued)

Table 2. Mean catch per unit effort (CPUE) and mean differences in CPUE's between trap types within triplets for legal (tail width (TW) ≥ 5.6, 5.4, or 5.2 cm) and sublegal slipper lobsters (* = $P \leq 0.05$; ** = $P \leq 0.01$; N = number of triplets; CPUE = number per trap type; R = rectangular vent; C = circular vent; control (con) = nonvented traps).

Vent type and size (mm)	N	Legal CPUE R	Legal CPUE Con	Legal CPUE C	Legal CPUE R - con	Legal CPUE C - con	Sublegal CPUE R	Sublegal CPUE Con	Sublegal CPUE C	Sublegal CPUE R - con	Sublegal CPUE C - con
(TW ≥ 5.6 cm)											
C-60, R-43	354	0.62	0.64	0.73	-0.03	0.08	0.29	0.56	0.45	-0.27**	-0.11
C-62, R-45	486	1.84	1.93	20.6	-0.09	0.13	0.40	0.93	0.64	-0.53**	-0.3**
C-65, R-47	504	3.71	3.52	3.66	0.19	0.14	0.59	2.54	1.13	-1.95**	–1.41**
C-67, R-49	315	0.50	0.74	0.67	-0.24**	-0.07	0.03	0.43	0.03	-0.40**	-0.40**
(TW ≥ 5.4 cm)											
C-60, R-43	354	0.72	0.75	0.85	-0.03	0.10	0.18	0.45	0.32	-0.26**	-0.12*
C-62, R-45	486	2.05	2.15	2.26	-0.10	0.11	0.20	0.72	0.44	-0.52**	-0.28**
C-65, R-47	504	4.01	4.01	4.11	0.00	0.10	0.30	2.06	0.69	-1.76**	-1.37**
C-67, R-49	315	0.51	0.83	0.69	-0.31**	-0.14	0.02	0.34	0.01	-0.32**	-0.33**
(TW ≥ 5.2 cm)											
C-60, R-43	354	0.84	0.87	0.95	-0.03	0.08	0.07	0.33	0.23	-0.26**	-0.10*
C-62, R-45	486	2.19	2.31	2.44	-0.12	0.13	0.05	0.55	0.26	-0.50**	-0.30**
C-65, R-49	504	4.12	4.54	4.53	-0.42*	-0.01	0.18	1.53	0.27	-1.34**	-1.26**
C-67, R-49	315	0.52	0.90	0.69	-0.39**	-0.21*	0.01	0.26	0.01	-0.25**	-0.26**

Table 3. Mean difference between catch per unit effort (CPUE)for legal and sublegal spiny and slipper lobsters between vented and control traps (Tables 1 and 2) expressed as a percent of the control CPUE (* = $\underline{P} \leq 0.05$, ** = $\underline{P} \leq 0.01$; TW = tail width).

Vent type and size (mm)	Rectangular	Circular	Rectangular	Circular
		Spiny lobster		
	Legal		**Sublegal**	
C-60, R-43	-6	0	-20	-30**
C-62, R-45	8	15	-30	-17
C-65, R-47	0	15	-42**	-73**
C-67, R-49	14*	10	-70**	-83**
		Slipper lobster		
	Legal (TW ≥ 5.6 cm)		**Sublegal (TW <5.6 cm)**	
C-60, R-43	-5	13	-48**	-20
C-62, R-45	-5	7	-57**	-32**
C-65, R-47	5	4	-77**	-56**
C-67, R-49	-32**	-10	-93**	-93**
	Legal (TW ≥ 5.4 cm)		**Sublegal (TW < 5.4 cm)**	
C-60, R-43	-4	13	-58**	-27**
C-62, R-45	-5	5	-72**	-39**
C-65, R-47	0	3	-85**	-67**
C-67, R-49	-37**	-17	-94**	-97**
	Legal (TW ≥ 5.2 cm)		**Sublegal (TW < 5.2 cm)**	
C-60, R-43	-3	9	-79**	-30**
C-62, R-45	-5	6	-91**	-55**
C-65, R-47	-9*	0	-88**	-82**
C-67, R-49	-43**	-23**	-96**	-100**

When the minimum tail width for slipper lobsters was 5.6 cm, the circular, 67-mm-diameter vent was ideal: no decrease occurred in the combined CPUE for legal spiny and slipper lobsters relative to the control, and retention of combined species of sublegal lobsters was reduced by 88% of the control (Table 4). Even when the minimum legal tail width for slipper lobsters was 5.4 or 5.2 cm, the circular, 67-mm-diameter vent performed very well; it only allowed a very slight (nonsignificant) reduction in the combined legal CPUE while

Table 4. The performance of circular vented traps relative to control traps for the combined spiny and slipper lobster catch per unit effort (CPUE). Values are the average of values from Table 3 for both species (* = $\underline{P} \leq 0.05$, ** = $\underline{P} \leq 0.01$; TW = tail width).

Vent	Combined legal CPUE (%)	Combined sublegal CPUE (%)
	Slipper legal TW ≥ 5.6 cm	
C-60	6.5	-25.0
C-62	11.0	-24.5
C-65	9.5	-64.5**
C-67	0.0	-88.0**
	Slipper legal TW ≥ 5.4 cm	
C-60	6.5	-28.5**
C-62	10.0	-28.0**
C-65	9.0	-70.0**
C-67	-3.5	-90.0**
	Slipper legal TW ≥ 5.2 cm	
C-60	4.5	30.0**
C-62	10.5	-36.0**
C-65	7.5	-77.5**
C-67	-6.5	-91.5**

reducing sublegal retention of combined species by at least 90% of the control.

Should it be necessary to interpolate the values in Table 3 and 4 for the circular vents with intermediate vent sizes or minimum tail widths, two predictive equations have been derived. A predictive equation for slipper lobsters—relating the difference, between the CPUE of the circular vented and control traps, expressed as a percentage of the control CPUE (Y)—can be described as a function of the legal minimumsize (MS) expressed in millimeters, the vent size (VS) expressed in millimeters, and a dummy variable (C) that equals 1 if Y refers to legal lobsters and O if Y refers to sublegal lobsters as follows:

$$Y=361.6 - 9.4(VS) + 3.3(MS) - 374.4(C) + 6.8 (C) (VS) \quad (R^2 = 0.96).$$

A predictive equation for the combined catch of spiny and slipper lobsters relates the difference, between combined CPUE of the circular vented and control traps, expressed as a percentage of its control CPUE (Table 4).

$$Y = 567.1 - 11.2(VS) + 1.6(MS) - 594.3(C) + 10.3(C)(VS) \quad (R^2 = 0.98).$$

The economic benefits to the fishery from the use of escape vents may be substantial. In 1986, 310,000 sublegal spiny lobsters were reported caught and released in the NWHI. If just 20% of these lobsters suffer mortality from handling, exposure, or displacement due to capture and release, this amounts to 62,000 lobsters. If the use of escape vents effectively eliminates this mortality and 80% of these 62,000 lobsters are subsequently captured as legal lobsters by the fishery, then at $5.00/lobster, the annual benefit to the fishery is $248,000. The value of slipper lobsters saved by the use of escape vents also will be substantial. Further, the fishery will benefit from the spawning contribution of these lobsters before they are caught and the vents will greatly reduce sorting work on vessels.

ACKNOWLEDGEMENTS

We wish to acknowledge the assistance and cooperation of the owners, skipper, and crew of the fishing vessel Shaman during the field trials on their vessel. Their enthusiastic support was very helpful to this work.