SOUTHWEST FISHERIES CENTER

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August 1984

PROSPECTUS

ESCAPE VENT EXPERIMENTAL PROCEDURE FOR THE SPINY LOBSTER FISHERY UNDER MANAGEMENT OF THE MAGNUSON FISHERY CONSERVATION AND MANAGEMENT ACT

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INTRODUCTION

In September 1983 the Director of the Southwest Fisheries Center Honolulu Laboratory (SWFC) recommended to the Western Pacific Regional Fishery Management Council (Council) that traps used in the Northwestern Hawaiian Islands (NWHI) under the Council's fishery management plan for the spiny lobster fishery of the western Pacific region be required to have escape vents. The catch in the spiny lobster, Panulirus marginatus, fishery presently consists of 30-35% lobsters below the minimum legal size (hereafter referred to as "sublegal") that must then be handled on deck and returned to the sea by the fishers. Experiments carried out by the SWFC staff[1] and experiences in other fisheries (e.g., Pecci et al. 1978) suggest that these sublegals are subject to considerable mortality due to handling, predation immediately upon their return to the sea, and other predation due to displacement from their home territory or preferred habitat.

The Council's spiny lobster plan development team and its Scientific and Statistical Committee recommended to the Council that the efficacy of escape vents should be investigated by the SWFC, and the Council endorsed their recommendations during its February 1984 meeting. This document describes several experimental phases to provide data necessary to determine an optimum size of escape vents and to demonstrate the effectiveness of vented traps.

OBJECTIVE OF THE STUDY

To provide the degree of protection to the stock intended by the minimum size regulation, of 77-mm carapace length (CL), the SWFC believes that the size of the escape vent should be set so that virtually all undersized lobsters could escape. Given normal variation in body shape, clearly this could be reached only at the expense (from the viewpoint of the industry) of escapement of some legal lobsters around the 77-mm CL limit. Thus, the objective of this study is to determine the rate of escapement as a function of escape vent size and carapace length in the area of high escapement rate of sublegals and low to trivial escapement rate of legal sized lobsters.

PREMISES

Experience with escape vents in fisheries for lobsters of the genus Homarus and other Panulirus (Wilder 1949; Fishing Industry News Service 1972; Krouse and Thomas 1975; Fogarty and Borden 1980; Odemar et al.[2]), indicate

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[1]Gooding, R. M. 1982. Predation on surface and bottom released spiny lobster, Panulirus marginatus, in the Northwestern Hawaiian Islands. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812. Admin. Rep. H-82-1, 20 p. + 4 figs.

[2]Odemar, M. V., R. R. Bell, C. W. Haugan, and R. A. Hardy. 1975. Report on California spiny lobster, Panulirus interruptus (Randall) research with recommendations for management. Draft of a report presented to the California Fish and Game Commission, July 25, 1975, Monterey, Calif., 98 p.

that the catch of legal lobsters increases on an average of 5.9% in terms of number per trap when escape vents are used. Estimation of the optimum escape vent size will be done using the following premise. If a certain escape vent size allows the escapement of 5.9% of legal lobsters in an experimental laboratory stock, a trap so equipped in the field trials should result in a catch of legal lobsters approximately equal to traps without escape vents. For the sake of experimental testing and model building, we are going to assume that an escapement rate of 5% for 77-mm CL lobsters is "low or trivial" and estimate the escape vent that would result in this escapement rate.

CAPSULATED DESCRIPTION OF EXPERIMENTAL PHASES

I. FIRST ESTIMATION OF ESCAPE VENT SIZE

A. Objective: To obtain a gross, first estimate of the escape vent.

B. Procedure: Find escape vent through which 77-mm CL lobsters cannot easily pass.

II. REFINEMENT OF ESTIMATION OF ESCAPE VENT SIZE

A. Objective: To determine a vent resulting in high escapement of sublegals and no more than 5% escapement of legals under laboratory conditions.

B. Procedure:

1. Select appropriate statistical testing procedure and design laboratory trials accordingly.

2. Conduct experiments.

3. Perform statistical analysis to select best vent.

4. Prepare interim report.

III. FINAL ESTIMATION OF ESCAPE VENT SIZE AND FIELD VALIDATION

A. Objectives:

1. To provide a statistical model for the selection of the best escape vent under field conditions based on desired escapement rates for sublegal and legal lobsters.

2. To determine whether there are differences in catch rates of legal and sublegal sized lobsters between experimental and control traps.

B. Procedure:

1. Select appropriate statistical testing procedure and design field trials accordingly.

2. Conduct field trials on RV Townsend Cromwell.

3. Analyze data.

4. Prepare and issue interim report.

IV. COMMERCIAL DEMONSTRATION AND EFFICIENCY STUDY

A. Commercial Demonstration:

1. Objective: To demonstrate efficacy of the optimum escape vent under commercial conditions based on catch rates of legal and sublegal lobsters.

2. Design field trials based on paired t-test statistical procedure.

3. Conduct field trials on a commercial vessel.

4. Analyze data.

5. Prepare and issue interim report.

B. Efficiency Study:

1. Objective: To determine savings in handling time, if any, due to use of traps with escape vents.

2. Formulate statistical testing procedure and design field trials accordingly.

3. Conduct field trials on commercial vessel.

4. Analyze data.

5. Prepare interim report.

V. PREPARATION OF FINAL REPORT(S)

FIRST ESTIMATION OF ESCAPE VENT SIZE

Traditionally, rectangular shaped escape vents have been used with traps set exclusively for the capture of lobster. Recently, there has been some work on circular vents when both lobster and rock crabs are sought (Krouse 1978). Since there is no minimum size limit for slipper lobster, *Scyllarides squammosus*, which are caught incidentally to spiny lobster in the NWHI fishery, experiments to optimize the vent size will be done only with the spiny lobster, *P. marginatus*, the major component of the commercial catch.

Experiments with other lobster species suggest that the vertical dimension of the vent is most critical; variations in millimeters significantly influence the escapement curve (Krouse and Thomas 1975; Fogarty and Borden 1980; Paul 1982). The horizontal dimension, though apparently less critical, is commonly relatively large, 152-290 mm (Krouse 1978; Pecci et al. 1978); 100 mm was found to be too small in one study (footnote 2). Since Paul's (1982) experiments conducted at the SWFC's Kewalo Research Facility showed no difference in the ability of male and female spiny lobster to pass through escape vents, this variable will not be considered in the experiment. Research on spiny lobster in California (footnote 2) suggests that the best approach to determining the estimated optimum height is to avoid morphometric methods and merely find an opening through which (1) legal sized animals (77-mm CL for P. marginatus) can pass without damage to their appendages, (2) animals 1 mm larger can pass with some loss of appendages, and (3) animals 2 mm larger are unable to pass.

We will follow the latter approach in obtaining a preliminary estimate of the optimum vertical height of the escape vent. Specifically, we will obtain approximately five live lobsters in each 1-mm size class from 77- to 79-mm CL from the local commercial fleet, and these will be manipulated by hand through openings with heights of from 54 to 60 mm until an estimated optimum size is found.

Supplies needed:

1. Lobsters--approximately 15 (cost-$75)
2. Escape vent material (cost-nil)

REFINEMENT OF ESCAPE VENT SIZE

Once the preliminary estimate of the optimum opening size has been determined, trials will be conducted at the Kewalo Research Facility to obtain a more precise estimate. The typical approach followed in the literature is to take the escape vent found to be satisfactory in the previous step plus one or two alternative sizes, run laboratory trials with animals of known size to determine escapement rate curves by size of lobster for each alternative escape vent, and then to select what appears to be the best escape vent size for introduction into the fishery.

Our experiment at this step will deviate from this traditional procedure in that a statistical technique will be used involving response surface analysis, coupled with analysis of variance. Response surfaces are used in various manufacturing situations to determine the levels of various factors (e.g., grain, yeast, temperature) that will result in the maximum production of some product (e.g., alcohol). For our experiment, we will use the response surface model to estimate the size of the escape vent resulting in a maximum escapement of 5% for 77-mm CL lobsters. The model will also provide estimates of the escapement rate for undersized lobsters. The statistical procedure requires at least three levels of each factor. We will use three escape vent heights (the estimated best height, one which is 1 mm smaller, and one which is 1 mm larger), and size classes in 1 mm increments from 74- to 79-mm CL (three sublegal and three legal size classes).

In statistical terms, the proposed model that will be fitted to the data will be the following quadratic equation

$$ER = b_0 + b_1 VS + b_2 VS^2 + b_3 CL + b_4 CL^2 + b_5 VS*CL + Error$$

where, ER = escapement rate in percent

b_i = regression coefficients

VS = vent height in millimeters

CL = carapace length in millimeters.

Analysis of variance will be employed to test for escape vent effectiveness while controlling for any learning which may occur during the course of the experiment. Vent sizes will be adjusted as necessary and used in the next phase of the experiment.

A U-shaped concrete tank with continuous water flow will be utilized for the experimental work. To prevent sun blindness in the test animals (Phillips et al. 1980), the tank will be covered with greenhouse shading cloth. Wire mesh partitions will further divide the tank into four separate sections, and in each section suitable habitat will be set up to encourage lobster escapement. With this configuration, separate trials can be run concurrently in each section of the tank.

The black plastic, crab and lobster pot, which has almost completely replaced the wire mesh trap originally used in the NWHI fishery, will be utilized in the experiments. This dome shaped pot is single chambered and is 295 mm high, 980 mm long, and 770 mm wide. Mesh size is 45 x 45 mm. Two funnel entrances are molded into the pot, but these will not be open during the laboratory trials. Two rectangular areas 45 cm above the bottom of the pot and on opposite sides of the pot may be cut out as lobster escapement vents (there are also two circular areas on the top of the traps that may be cut out for escapement of crabs). One of these rectangular areas will be cut out, and an aluminum escape vent of appropriate size will be attached to each trap.

A single trap with one of the three experimental escape vents will be placed in the center of three of the tank sections and stocked with approximately 30 live lobsters consisting of at most 5 individuals in each millimeter size class from 74- to 79-mm CL. In addition as time and availability of animals allow, a trap without an escape vent and with the entrance cones open will be set in the fourth tank section and stocked with lobsters to test escapement through the entrance cones. Spines on the lobsters' tails will be clipped using a binary scheme to identify each millimeter size class. The traps will be stocked with live lobsters in the evening shortly before complete darkness and food will be distributed among the habitat (none in the traps). The next morning shortly after sunrise, the traps will be checked for determination of escapement by size class. We expect to conduct at least five replications each of the three escape vent configurations.

Supplies needed:	Cost:
1. Black plastic pots (3-4)	$95-$130
2. Rebar or other weight	nil
3. Fabricated escape vents	30
4. Lobsters--20 in each millimeter size class, 74-79-mm CL	1,350
5. Food	50
6. Black shade cloth	110
7. Frame materials	185
8. Habitat materials	20
9. Tank dividers	40

FINAL ESTIMATION OF ESCAPE VENT SIZE AND FIELD VALIDATION

As was indicated earlier, the next step undertaken in escape vent studies described in the literature has been to take traps with the selected best escape vent size and to compare them with unvented traps in the field on either research or commercial vessels. Specifically, tests are performed to determine whether there has been a statistically significant reduction in the catch rate of sublegals while there has been no reduction in the catch rate of legal lobsters. While the size of the escape vent may be adjusted following such trials, the design provides no statistical procedure for doing so.

Since the escapement rate of spiny lobsters under field conditions (e.g., variable habitat, a larger and more variable size composition, presence of bait, presence of predators, variable soaking times, possible deformation of the trap during hauling, and, of course, the entrance cones open) could differ considerably from the laboratory situation, we feel that field trials should be conducted to estimate the optimum escape vent size.

Although it is possible to design an experiment that will provide the statistical means of fine tuning the vent height based on what really happens on the fishing grounds, a larger sample size is required and the cost will be greater. The experimental procedure proposed involves the use of the response surface statistical method as was used in phase II, the laboratory trials. The response surface may be explored for the escape vent size resulting in a maximum escapement of sublegal lobsters given some acceptable escapement rate for legal lobsters. Variation in escape vent size in relation to various maximum escapement rates for legal lobsters may also be explored using the response surface model.

Statistical Design

As mentioned earlier, the response surface method requires that three levels of the controlling factors be employed. For the escape vent factor, the three vent heights determined in the laboratory trials will be used. Although it is clear that the carapace length must be included in the model to be able to investigate escapement rate in the area of the legal limit, it is not clear how to do this before the trials are run. It will probably not be practical to consider 1-mm size intervals as in the laboratory trials because of small catch rates and size variation between control and experimental traps. Nor do we feel that it would be reasonable to establish three arbitrary size classes before conducting the trials, e.g., sublegal, small legal, and large legal sizes. The best procedure would seem to be to measure each lobster and establish size categories based on the catches. The rate of escapement for lobsters in each carapace length class is the catch in the nonvented trap minus the catch in the vented trap divided by the catch in the nonvented trap. Although there is no prior knowledge of what the variance of such an estimate would be, we feel that the robustness of the regression technique should allow significant results using sample sizes of the same order of magnitude as the paired t-tests described below.

The hypothesized response surface model to be used is the same as before, namely

$$ER = b_0 + b_1VS + b_2VS^2 + b_3CL + b_4CL^2 + b_5VS*CL + Error$$

where, ER = escapement rate in percent

b_i = regression coefficients

VS = vent size in millimeters

CL = carapace length in millimeters,

but the definition of carapace length is not fixed.

With respect to testing for differences in catch of legal versus sublegal lobsters, the statistical analysis will consist of the application of the paired t-test to both legal catch count and the percentage of sublegals in each control and experimental trap pair for each escape vent height. Such a test is preferable to the conventional t-test in that it is not confounded by a large variance within trap categories (caused by changing lobster density along the trap string). However, if calculated differences are found not to be normally distributed, the Wilcoxon matched-pairs, signed-ranks test will be employed. Statistical analysis is dependent on an adequate sample size. Given the current sublegal catch in the industry of about 30% and an assumed subsequent increase in catch of legal lobsters of approximately 6% using the optimal escape vent configuration (based on other experiments), a sample size of 326 traps would be required to obtain a significance level of 0.01 and a power of 99% for the paired t-test of catch count, or, 978 traps for all three escape vent heights. The research vessel field trials will exceed the minimal required sample size if at least 18 fishing days are completed with 60 traps set each day.

Field Design

The field trials will be conducted on board the NOAA ship Townsend Cromwell at Necker Island using the black plastic crab and lobster trap. Experimental and control (unvented) traps will be placed alternately along a string. The experimental traps on one string will all have vents of the same height, and two vents will be placed in each trap. This experimental design will allow statistical control for the effect of any changes in lobster density along the string. Baited traps will be set one day and pulled during the early morning of the next day. Data collected will include string and trap number, depth of the set, and the number and length of the lobsters measured to the nearest millimeter carapace length. Catch of other species will also be recorded.

To carry out this step of the experiment, 30 control and 30 experimental traps for each of the three escape vent sizes must be fished for 6 to 9 days. This could be done by setting 180 traps per day for the 6-9 days on a single cruise. The cost of this experiment would be high due to the large number of traps needed and the overtime involved in processing the catch. We estimate that this procedure would cost approximately $12,500 just for gear and overtime. Alternatively, the field design could consist of separate trials of 6-9 days for each escape vent size. This design would use only 60 traps for each trial and moderate amounts of overtime and added cost due to lost gear. We estimate that this field design would cost about $6,000. As a third alternative, separate trials of 6-9 days duration could be run with each trial consisting of 60 traps (30 controls and 10 each of the three escape vent sizes). The cost of this design would be approximately the same as that of the second alternative. However, at the end of each trial, it would be possible to conduct the response surface model analysis and determine whether significant results were obtained. If statistically significant results are obtained at the end of the second or even the first trial, the experiment could be terminated early, thus saving valuable and expensive vessel time. It may be desirable to conduct the three 6-9 day trials of the last two alternatives in a reasonably short period to eliminate any confounding effects due to seasonal changes in catchability or size composition of the lobsters. We opt to conduct the last alternative field design.

This procedure will then result in a response surface that may be used to select the optimum escape vent size for the escapement of legal and sublegal lobsters. A paired t-test will also be employed to test for differences in catch rates of sublegal and legal lobsters between control and experimental traps.

The experimental design could incorporate a potential effect of density of lobsters on the grounds. A factor could be included in the response surface model for catch per control trap of, for example, total spiny lobster or for some combination of sublegal lobster, legal lobster, and berried lobster. The model might then be:

$$ER = b_0 + b_1VS + b_2VS^2 + b_3CL + b_4CL^2 + b_5D + b_6D^2 + b_7VS*CL + b_8VS*D + b_9CL*D + b_{10}VS*CL*D \quad .$$

Other experiments could be run to test for the effect of: (1) dominance of larger individuals (the design actually incorporates this effect but the range in size of animals in the experiment could be expanded by using fishing areas known to have larger individuals), (2) presence of potential predators (by running the trials in areas ascertained to have different levels of potential predators; at least three areas having different potential predator densities would have to be used), (3) habitat (trials run at three distances from known shelter areas or in three areas having different quantities or qualities of lobster shelter), (4) bait quantity in the traps, (5) time between setting and hauling, (6) trap design (wire with 2 x 2 inch mesh, wire with 2 x 4 inch mesh, and black plastic), and (7) escape gap placement and number. Some of these factors would be more subject to experimental variation, require care in carrying out, and probably a greater sample size. Since none of these factors is now subject to management manipulation (indeed some could never be), they will not be incorporated in the design of this experiment.

Supplies needed:	Cost:
1. Black plastic lobster pots (100)	$3,500
2. Escape vents (100)	950
3. Polypropylene rope (if not available from previous cruise)	200
4. Buckets, burlap bags, etc.	150
5. Ballast for traps (20 lb per trap)	500
6. Bridles (3/8 in. polypropylene rope, if needed)	200
7. Buoys and flagpoles (if needed)	?
8. Bait (most available in SWFC cold storage)	100
9. Saw blades	85

COMMERCIAL DEMONSTRATION AND EFFICIENCY STUDY

With successful completion of the laboratory and research vessel experiments and selection of the optimum escape vent height, trials will be conducted on board commercial vessels as a final demonstration of the feasibility and benefit of using escape vents.

Our plan is to conduct two types of experiments on a commercial vessel. The first experiment will be a direct comparison of the catchability of traps with and without escape vents. For the live market commercial lobster fishers generally set 6-8 strings of 35-40 lobster traps per string over an 8-10 day period. With this in mind, the commercial trials will consist of two strings of approximately 40 traps each. Experimental traps with escape vents and the standard traps used by the vessel will be placed alternately along the string. If the commercial vessel uses about 40 traps per string and fishes 6 strings for 8 days, the sample size should be more than sufficient for statistical purposes. Statistics on the catches resulting from the two strings with control and escape vented traps will be collected by an SWFC observer on the commercial boat. Data on catch (number of legal and sublegal lobsters), the ratio of males and females, and number of berried legal and sublegal females will be collected.

The second experiment will be to determine whether handling time is reduced using traps with escape vents, which would then imply a cost savings for the vessel operator. Detailed data on the time spent by the crew in sorting and processing the catch resulting from strings of traps with and without escape vents will be collected. Since the SWFC observer will not be able to collect data on both handling times and lobster sizes, this experiment must be run separately from the catch-rate and size-composition trials. Because of the limited fishing time on commercial cruises, especially those which bring back live lobsters, this experiment will have to be conducted on a separate cruise. With no prior knowledge of the time differences, we have no statistical basis for estimating sample size, but feel intuitively that 10-15 days using two strings of 40 traps should suffice.

Statistical tests of catch rate and legal to sublegal ratios will be similar to the research vessel experiment. The statistical tests of handling times will involve an analysis of variance.

Supplies and other needs:	Cost:
1. Black plastic traps (100)	$3,500
2. Escape vents (100)	950
3. Bridles and ballast	100
4. Calipers	200
5. Stopwatch	75
6. Food and bunk charges (20 days)	400
7. Vessel participation fee (20 days)	?

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