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GEAR COMPETITION IN LOBSTER TRAPPING IN THE NORTHWESTERN HAWAIIAN ISLANDS

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INTRODUCTION

The gear used to catch the spiny lobster, Panulirus marginatus, in Hawaii is a wire mesh two-chambered California style trap (pot). Commercial fishermen use a string of these traps with as many as 250 traps equally spaced on a single line.

Each lobster trap exploits a population of lobsters within a certain radius of the trap. If the traps are sufficiently close to one another, then the area exploited by two or more traps overlap and we say there is gear competition. In this report, we will examine the relationship between trap spacing on a string and lobster catch per trap. We will use data collected from the RV Townsend Cromwell and data provided by commercial fishermen.

THE MODEL AND DATA

Suppose traps are set at I locations (stations) and suppose at each location (i), J different spacings are tested with K traps per string. Let C_{ijk} be the number of lobsters caught in the k^{th} trap ($k = 1, \ldots, K$) with spacing j ($j = 1, \ldots, J$) at location i ($i = 1, \ldots, I$). Then C_{ijk} can be expressed as

$$C_{ijk} = B_o + B_i^L + B_j^S + B_k^T + B_{ij}^{LS} + B_{ik}^{LT} + B_{jk}^{ST} + B_{ijk}^{LST} + e_{ijk}$$

where

B_o = overall mean catch per trap

B_i^L = location effect

B_j^S = spacing effect

B_k^T = trap position on string effect

B_{ij}^{LS} = location-spacing interaction effect

B_{ik}^{LT} = location-trap position interaction effect

B_{jk}^{ST} = spacing-trap position interaction effect

B_{ijk}^{LST} = spacing-location-trap position interaction

e_{ijk} = error random variable which is normally distributed

We are primarily interested in testing $H_o : B_j^S = 0$ for all j.

We have catch data collected from the Townsend Cromwell for 10 locations with one string consisting of 8 traps per string set at each of 5 spacings per location. The trap spacing tested were 10, 15, 20, 25, and 30 fathoms between traps.

The commercial data were obtained at six locations using approximately 20 traps per string with trap spacings set at 10 and 30 fathoms. At two of these six locations, spacing of 20 fathoms between traps was also used.

All data were collected at locations in the Northwestern Hawaiian Islands.

ANALYSIS

Research Data

A three-way ANOVA was used with catch rate per trap as the dependent variable and spacing, location, and position on the string as factors or treatments. Location and location-spacing interaction effects were significant ($P < 0.001$) while the trap position on string effect was not significant ($P > 0.05$). The lack of a trap position on string effect on catch rate per trap makes it possible to consider each trap on a string as a replicate for each location and spacing. Pooling across trap position reduces the three-way ANOVA to a two-way ANOVA with spacing and location treatments and eight observations (replicates) per cell. The significant location effect and location-spacing interaction effect suggest that the locations may represent sites with different lobster population densities and hence different mean catch rates.

An examination of the average catch rates over all spacings for the eight observations suggests that the locations can be pooled into three groups consisting of low, medium, and high catch rates representing estimates of lobster density (Table 1). Locations with catch rates of less than one lobster per trap are assigned to a low density group, those with 1-2.24 lobsters per trap are assigned to a medium density group, and locations with catch rates of 2.25 lobsters per trap or greater are assigned to a high density group.

Subsequent two-way ANOVA with catch rate per trap as the dependent variable and spacing and location within densities as treatments were performed for the three density levels. Location effects within the low, medium, and high density groups were not significant ($P > 0.10$) whereas spacing effects were significant for the medium density group ($P = 0.004$) but not for the low and high density groups ($P > 0.10$).

Commercial Data

Following the approach used with the Townsend Cromwell data, the average catch rate per trap by location for the commercial data is computed and the locations are partitioned into two groups representing high density and very high density (Table 2). At both densities, there is no difference between the catch rate between 20- and 30-fathom spacing. For high-density levels, the catch rate at the 10-fathom spacing is significantly lower than the catch rates at the 20- or 30-fathom spacing ($P < 0.05$). The difference between the catch rate at the 10-fathom spacing and the catch rates at the 20- or 30-fathom spacing is not significant at very high-density levels.

CONCLUSIONS

The results from both the Townsend Cromwell and commercial data suggest that gear competition does exist and that it is density dependent. Best catch rates per trap are obtained with spacing between traps in the range of 20 to 25 fathoms for the lobster densities in the Northwestern Hawaiian Islands.

One implication of the spacing and density interaction for researchers is that when estimating relative abundance by catch per unit effort (CPUE), one must be careful to use a large enough spacing to avoid density dependent gear competition. For example, based on the results of Table 2, if 10-fathom spacing were used, the CPUE for high-density levels would be two lobsters per trap and the CPUE for very high-density levels would be about eight lobsters per trap, and we would conclude that very high-density levels have four times the abundance as the high-density levels. However, if 30-fathom spacing were used on the traps, the CPUE for high-density levels would be about 4.4 lobsters per trap and the CPUE for very high-density levels would be 10.4 lobsters per trap, and we would conclude that the abundance at very high-density levels would be only 2.4 times the abundance of high-density levels.

Table 1.--Lobster catch (number) per eight-trap string from _Townsend Cromwell_ cruises.

Replicate	Spacing (fathom) 10	15	20	25	30	Total	Average per trap
I. Low density							
1	3	5	0	0	18	26	0.65
2	11	10	4	1	3	29	0.73
3	1	1	3	4	4	13	0.33
Total	15	16	7	5	[25]		
II. Medium density							
1	9	15	10	23	16	73	1.83
2	23	18	15	18	10	84	2.10
3	15	10	19	16	17	77	1.93
4	19	3	0	34	26	82	2.05
Total	66	46	44	[91]*	69		
III. High density							
1	24	22	35	9	23	113	2.83
2	14	34	31	9	6	94	2.35
3	23	44	38	78	35	218	5.45
Total	61	100	[104]	96	64		

*Spacing effect significant ($P \leq 0.05$)

Table 2.--Mean catch per trap (number of traps) from commercial data.

Replicate	Spacing (fathom) 10	20	30
I. High density			
1	2.40 (N = 17)	--	4.50 (N = 15)
2	2.29 (N = 24)	4.78 (N = 18)	2.46 (N = 27)
3	1.25 (N = 24)	--	5.27 (N = 26)
4	2.37 (N = 25)	--	5.52 (N = 25)
Total	2.06 (N = 90)*	4.78 (N = 18)	4.40 (N = 93)
II. Very high density			
1	7.25 (N = 16)	11.11 (N = 19)	10.18 (N = 11)
2	8.27 (N = 26)	--	10.52 (N = 25)
Total	7.87 (N = 42)	11.11 (N = 19)	10.42 (N = 36)

*Spacing effect significant ($P \leq 0.05$)