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The Utility of Computing CPUE at Each Level of Effort in the Lobster Trap Fishery*

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Abstract

Catch-per-trap-haul-set-over-day (CTHSOD) has been widely used as a catch-per-unit-effort (CPUE) indicator in crustacean trap surveys and fisheries. CTHSOD is sensitive to the distribution of set-over-days (SOD) used to calculate CPUE. Because catch patterns in traps often describe an asymptotic function, SOD distribution can bias CTHSOD. For example, a group of traps which have reached saturation catch level after day t will have a higher CTHSOD than the same catch level after day t + 1. Partitioning CPUE by SOD for each time frame of interest is proposed. This technique standardizes the weight of each SOD in a time series and is less biased when the distribution of SOD is not equal between time frames or locations being compared. The technique involves summing total trap-set-over-days and catch (numbers or weight) for each discrete SOD in a time series and computing CTHSOD for each SOD. Analysis of variance techniques provide a robust statistical treatment for discerning effects of factors on CPUE. Regression techniques yield slope and intercept (theoretical zero SOD) values which are also useful for comparative purposes.

Introduction

The American lobster, *Homarus americanus*, is one of the most valuable species in the fisheries along the east coast of North America. Nearly 98% of the 1980 catch of the 16,700 (metric) tons of lobster, worth 75 million US dollars, were from the trap fishery (Fogarty *et al.*, MS 1982). A great deal is known about the life history of lobsters in the Northwest Atlantic (see extensive review by Cooper and Uzmann, 1980), but, as for most fisheries, little is known of stock-recruitment relationships. Yield-assessment techniques are restricted to those analyses which utilize catch-per-unit-effort (CPUE) as an index of abundance.

Validation of CPUE from trap fisheries as an index of abundance requires an understanding of the dynamics of the capture process and how different variables influence the magnitude of the catch. Catches in fixed gear have been shown to increase towards an asymptote (saturation) with increasing soak time (Gulland, 1955; Munro, 1974; Bennett and Brown, 1979; Auster, 1985). Skud (1979) found that catch-per-pot-per-day in the New England offshore lobster-pot fishery was substantially higher in the summer and early autumn than in other seasons. Catch-per-trap-haul was found to be an unreliable measure of CPUE unless it is standardized for length of soak time or unless estimates of ingress and escapement were included. Catch-per-trap-haul-set-over-day (CTHSOD), which is the sum of catch-per-trap when hauled divided by the sum of the number of traps multiplied by set-over time in days (SOD), has been widely accepted as a CPUE index in crustacean trap fisheries. (Thomas, 1973; Caddy, MS 1977; Skud, 1979).

The asymptotic nature of catch curves allows them to be extremely biased by slight changes in distribution of SOD. For example, a group of traps which have reached the saturation level on day t will have a higher CTHSOD than the same traps at day t + 1 with essentially no change in catch. These problems are especially acute when dealing with small data sets from fishermen's logbooks or surveys, and when SOD for all traps is not of equal length or distribution. In this paper, a different method to evaluate CPUE, not biased by unequal distribution of SOD, is proposed and its usefullness for comparison of spatial and temporal differences in catch is described.

Methodology

Connecticut lobster fishermen are required to provide the State of Connecticut Marine Fisheries Information System with records of their fishing activity. Logbook entries include the number of traps hauled, SOD, catch in pounds, and statistical area of capture for each day fished (Smith, 1977, 1980).

Individual records were grouped by SOD for the time frame and area of interest. For each record, the number of traps was multiplied by the number of SOD (yielding trap-haul-set-over-days, THSOD), and summed for each SOD group. SOD was limited to a maximum of 5 days, because prior examination of CTHSOD trends revealed that CTHSOD began to decline rapidly after 5 SOD. Catch was also summed for each SOD group. Total catch was divided by total THSOD for each SOD group, yielding CTHSOD as a CPUE indicator for each level of effort within the time

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frame and area being examined. To make spatial-temporal comparisions, regressions of CTHSOD versus SOD were computed for each data set and slopes and intercepts (theoretical zero SOD) were determined. This method allows use of statistical techniques (e.g. analysis of variance and covariance techniques) for testing the significance of differences. The CTHSOD value at the zero SOD (y-intercept) is a convenient numerical quantity for comparison, because it is influenced by all points on the SOD axis.

Example

Logbook records were used as a data base to simultaneously test the hypotheses that (a) catch rate is negatively correlated with increasing mean current velocity (CPUE would be higher for lunar quarter phases than for new or full moon phases which have higher mean current velocities), and (b) that catch is greater on nights around a new moon than during any other lunar quarter phase (CPUE would be higher around a new moon than any other lunar quarter).

A time frame within the data base was needed to test the above hypotheses minimizing bias created by wide temperature fluctuations, inshore-offshore migration, and increasing molt frequency. A review of Smith's (1977) CPUE data and raw catch data from the 1982 lobster fishery revealed that the April and early May period fitted these criteria. Records from Area 2 (Fig. 1) provided the most complete data set. They were edited for traps that were set and hauled within a time period of ± 3 days around each lunar quarter (United States Naval Observatory, 1980).

The catch data were partitioned by lunar quarter and SOD (Table 1). From the plot of cumulative CTHSOD against lunar quarter (Fig. 2), the first hypothesis seems to be wrong and the second hypothesis seems to be correct. However, an examination of SOD for each lunar quarter reveals differences in the distribution of effort, and, hence, comparisons of cumulative CTHSOD are inappropriate. The data, when treated with the described procedure and a two-way analysis of variance (Table 2), reveal significant differences in CTHSOD due to SOD ($P < 0.01$), but no significant differences in CTHSOD between lunar quarters ($P > 0.05$), indicating neither hypothesis is correct. Comparisons of CPUE at each SOD level (t-test) revealed that CTHSOD on the first SOD was significantly different from the remaining SOD groups ($P < 0.05$). Regressions were computed for each lunar quarter (Table 3). Slopes and intercepts (zero SOD) values for each quarter do not tract the pattern of cumulative CTHSOD and reflect the lack of significant differences that were found by the two-way analysis of variance.

Analysis of variance techniques are robust. They are not as sensitive to deviations from normality of the data in a layout of equal cell sizes as other tests (Box, 1953; Scheffe, 1959). This allows significant testing of factors that affect CPUE where all data are not normally distributed.

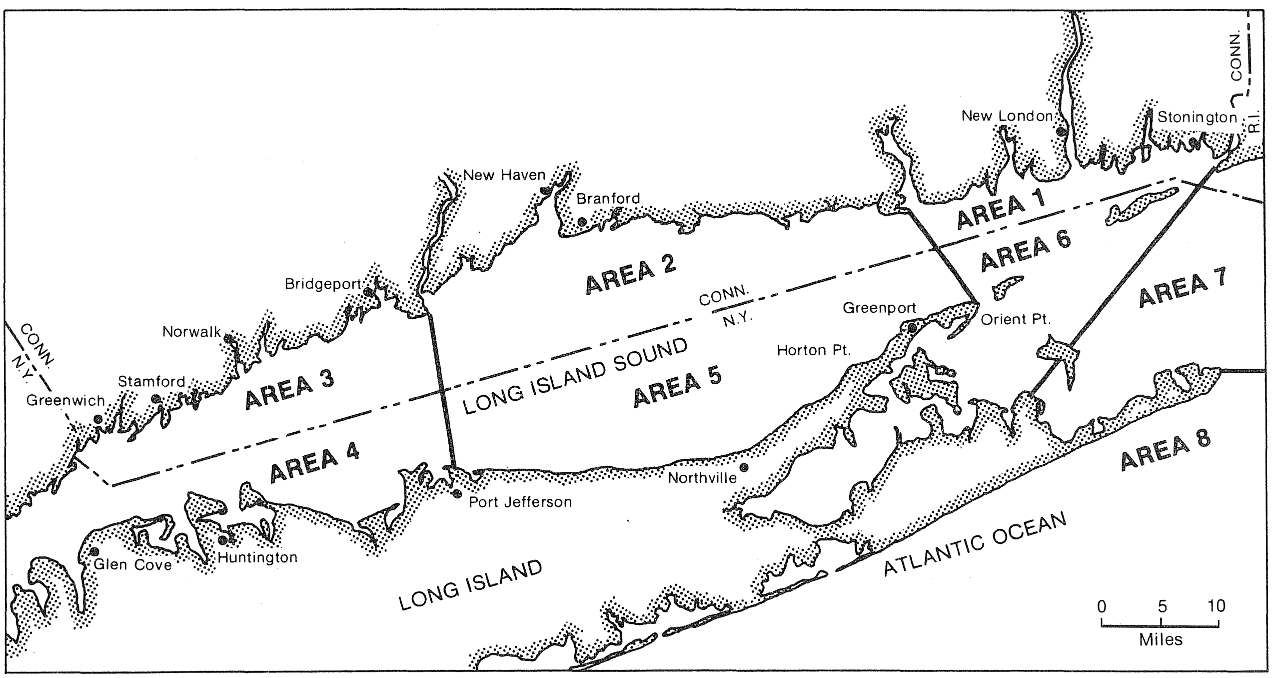

Fig. 1. Statistical reporting system areas of the Connecticut Department of Environmental Protection.

TABLE 1. Catch and effort data, by lunar quarter and SOD, for a sector of the lobster trap fishery off Connecticut during a lunar cycle in 1982.

Lunar quarter	SOD	No. of records	Catch (lb)	Effort THSOD	Catch rate (CTHSOD) Actual	Catch rate (CTHSOD) Cumulative
Full moon	1	2	19	56	0.339	0.339
(5–11 Apr)	2	5	40	348	0.115	0.146
	3	7	136	999	0.136	0.139
	4	5	113	972	0.116	0.130
	5	2	16	175	0.091	0.127
Last quarter	1	7	64	240	0.267	0.267
(13–19 Apr)	2	19	312	1,926	0.162	0.174
	3	17	306	1,974	0.155	0.165
	4	7	252	1,556	0.162	0.164
	5	2	15	185	0.081	0.161
New moon	1	13	126	411	0.306	0.306
(20–26 Apr)	2	16	321	1,348	0.238	0.254
	3	13	440	1,659	0.265	0.260
	4	14	297	2,524	0.118	0.199
	5	3	49	505	0.097	0.191
1st quarter	1	3	35	98	0.357	0.357
(27 Apr–3 May)	2	6	129	450	0.287	0.299
	3	7	87	699	0.124	0.201
	4	4	115	1,240	0.092	0.129
	5	1	200	1,500	0.111	0.130

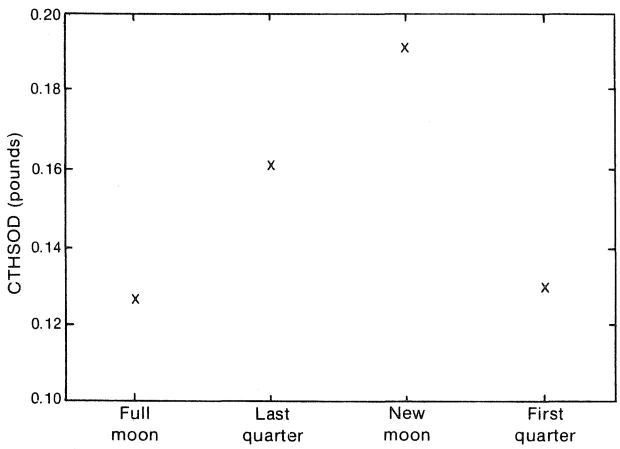

Fig. 2. Relationship between cumulative STHSOD for all SOD and lunar quarter.

TABLE 2. Two-way analysis of variance of CTHSOD data from a sector of the Connecticut lobster trap fishery by SOD and lunar quarter.

Variance due to	df	Sum of squares	Mean square	F-test
SOD	4	119,769	29,942	$P < 0.01$
Lunar quarter	3	7,253	2,418	$P > 0.05$
Error	12	30,679	2,557	
Total	19	157,701		

TABLE 3. Parameters of linear relationship between CTHSOD and SOD by quarter for a sector of the Connecticut lobster trap fishery in 1982.

Lunar quarter	Slope	Intercept
Full moon (5–11 Apr)	−0.0495	0.308
Last quarter (13–19 Apr)	−0.0372	0.277
New moon (20–26 Apr)	−0.0538	0.366
1st quarter (27 Apr–3 May)	−0.0687	0.400

Discussion

Catch-effort data bases of different monitoring agencies vary in the parameters that are utilized, and, hence, the ability to perform an analysis like the one described here may be limited. Unpublished logbook data and interviews with fishermen in the coastal fishery reveal seasonal changes in distribution of fishing effort. Therefore, published reports of yearly CPUE trends may be biased due to seasonal changes in nonstandard effort values that were used in the computations.

The technique in this paper can be applied to lobster management and assessment objectives that are related to spatial or temporal aspects of CPUE. For example, analyses could be conducted to discern if significant differences in CPUE occur between management areas or aid in dividing a geographic region into units based on CPUE.

Reporting errors from logbook data are a source of unknown error. The larger the sample of individual records, the less effect any individual reporting error would have. Also, effects of non-random distribution of fishing gear, gear types, bait types and set orientation introduce unknown sources of error in measure of effort. Although it is difficult to eliminate all sources of bias in commercial catch records, such data often represent the only information available or practical for use in assessment and management schemes.

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