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A CPUE Indicator for Crustacean Trap Fisheries Unbiased by Distribution of Soak Time

by

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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. Catch patterns in traps often describe an asymptotic function, therefore SOD distribution can bias CTHSOD. For example, a group of traps which have reached saturation catch levels after day X will have a higher CTHSOD than the same catch level after day X + 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. Regression techniques yield slope and intercept (theoretical zero SOD) values which are useful for comparitive purposes. This method allows significance testing of discrete time frames to compare spatial and/or temporal aspects of CPUE.

SPECIAL SESSION ON BIOLOGICAL SURVEYS

INTRODUCTION

The American lobster, *Homarus americanus*, is the target of the most valuable fishery on the eastern coast of North America. Nearly 98% of the 1980 landings of 16700 metric tons of lobster, worth 75 million dollars, were from the trap fishery (Fogarty et al., 1982). A great deal is known about the life history of lobsters in the northwest Atlantic (see Cooper and Uzmann, 1980 for an extensive review) but, as in most fisheries, little is known of stock-recrutiment relationships. Yield assessment techniques are restricted to those analyses which utilize catch-per-unit effort (CPUE) as an index of abundances.

Validation of CPUE from traps 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. Catch in fixed gear has 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/pot/day (C/P/D) 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 standardized for length of soak or unless estimates of ingress and escapement were included. Catch-per-trap-haul-set-over-day (CTHSOD), which is catch-per-trap when hauled divided by set-over time in days (SOD) summed over all traps, has been widely accepted as a CPUE index in crustacean trap fisheries. (Thomas, 1973; Caddy, 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 saturation levels at day X will have a higher CTHSOD than the same traps at day X + 1 with essentially no change in landings. These problems are especially acute when dealing with small data sets from fishermen logbooks or surveys, and when SOD for all traps is not of equal length or distribution.

In this paper, I propose a different method to evaluate CPUE, not biased by unequal distribution of SOD, and describe its usefullness for comparison of spatial/temporal differences in catch.

METHODOLOGY

Connecticut lobster fishermen are required to submit daily trip logs for the Department of Environmental Protection statistical reporting system. Log entries include the number of traps hauled, SOD, catch in pounds, and statistical area of capture for each day fished (Smith, 1977, 1980), although data could come from any trap assessment survey or fishermen logbook system.

Individual records are grouped by SOD for the time frame and area of interest. For each record, the number of traps fished was multiplied by the number of SOD (yielding trap-haul-set-over days; THSOD), and summed for each SOD group. SOD was limited to 5 and under because prior examination of CTHSOD trends revealed CTHSOD began to decline dramatically 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 frame/area being examined. To make spatial/temporal comparisons, 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 for significance testing (e.g. analysis of variance and covariance techniques). The CTHSOD value at the zero SOD (y-intercept) is a convenient numerical quantity for comparison as it is influenced by all points on the SOD axis.

EXAMPLE

Logbook records were used as a data base to test the hypothesis that (1) 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 (2) fishermen's belief that catch is greater on nights around a new moon than during any other lunar quarter phase.

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

The catch data was partitioned by time frame and SOD and is presented in Table 1. If cummulative CTHSOD is used for each time frame and plotted against lunar quarter (Fig. 2), it looks as though the second hypothesis is correct. However, an examination of SOD for each lunar quarter reveals differences in the distribution of effort, hence comparisons of cummulative CTHSOD are inappropriate. The data, when treated with the described procedure, and analyzed with a two-way ANOVA (Table 2) reveals no significant differences in CTHSOD between lunar quarters ($p < 0.005$) and t-tests revealed CTHSOD on the first SOD was significantly different from the remaining SOD groups ($p < 0.005$). Regressions were computed for each lunar quarter (Table 3). Slopes and intercepts (zero SOD) values for each quarter do not track the pattern of cummulative CTHSOD and reflect the lack of significant differences found by the two-way ANOVA.

DISCUSSION

The statistical manipulations presented here are nothing new. In fact, Skud (1979) used similar techniques to discern seasonal changes in CPUE in the offshore canyon fishery. The application of this technique for routine stock assessment objectives is new and I feel worthy of consideration in light of biases inherent to other techniques. The above example provides a source of justification in that CPUE was significantly different on the first SOD than all other days while no difference was found between the time frames of interest.

Reporting errors from logbook data is a source of unkown 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 measures of effort.

Although it is difficult to eliminate all sources of bias in commercial catch data, it is often the only data set available or practical for use in assessment and management schemes.

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Table 1. Catch data partitioned by SOD within each lunar quarter. Data is from Connecticut D.E.P. statistical area 2 in 1982.

Lunar Quarter	SOD	Number Fishermen's Records	Pounds Landed	THSOD	CTHSOD	Cummulative CTHSOD
Full (Apr 5-11)	1	2	19	56	.339	.339
	2	5	40	348	.115	.146
	3	7	136	999	.136	.139
	4	5	113	972	.116	.130
	5	2	16	175	.091	.127
Last (Apr 13-19)	1	7	64	240	.267	.267
	2	19	312	1926	.162	.174
	3	17	306	1974	.155	.165
	4	7	252	1556	.162	.164
	5	2	15	185	.081	.161
New (Apr 20-26)	1	13	126	411	.306	.306
	2	16	321	1348	.238	.254
	3	13	440	1659	.265	.260
	4	14	297	2524	.118	.199
	5	3	49	505	.097	.191
1st (Apr 27 - May 3)	1	3	35	98	.357	.357
	2	6	129	450	.287	.299
	3	7	87	699	.124	.201
	4	4	115	1240	.092	.129
	5	1	200	1500	.133	.130

Table 2. Two-way analysis of variance of Connecticut trap fishery CTHSOD by SOD versus lunar quarters.

Due to	DF	SS	MS=SS/DF	F
SOD	4	119769	29942	8.882 sig. $p < 0.001$
Lunar Quarter	3	7253	2418	NS
Error	12	30679	2557	
Total	19	157701		

Table 3. Slopes and intercepts (zero SOD) of linear models (CTHSOD vs. SOD) for each lunar quarter.

Lunar Quarter (1982)	Slope	Intercept (Zero SOD)
Full (Apr.5-11)	0.0495	0.308
Last Q. (Apr.13-19)	0.0372	0.277
New (Apr. 20-26)	0.0538	0.366
1st Q. (Apr.27-May 3)	0.0687	0.400

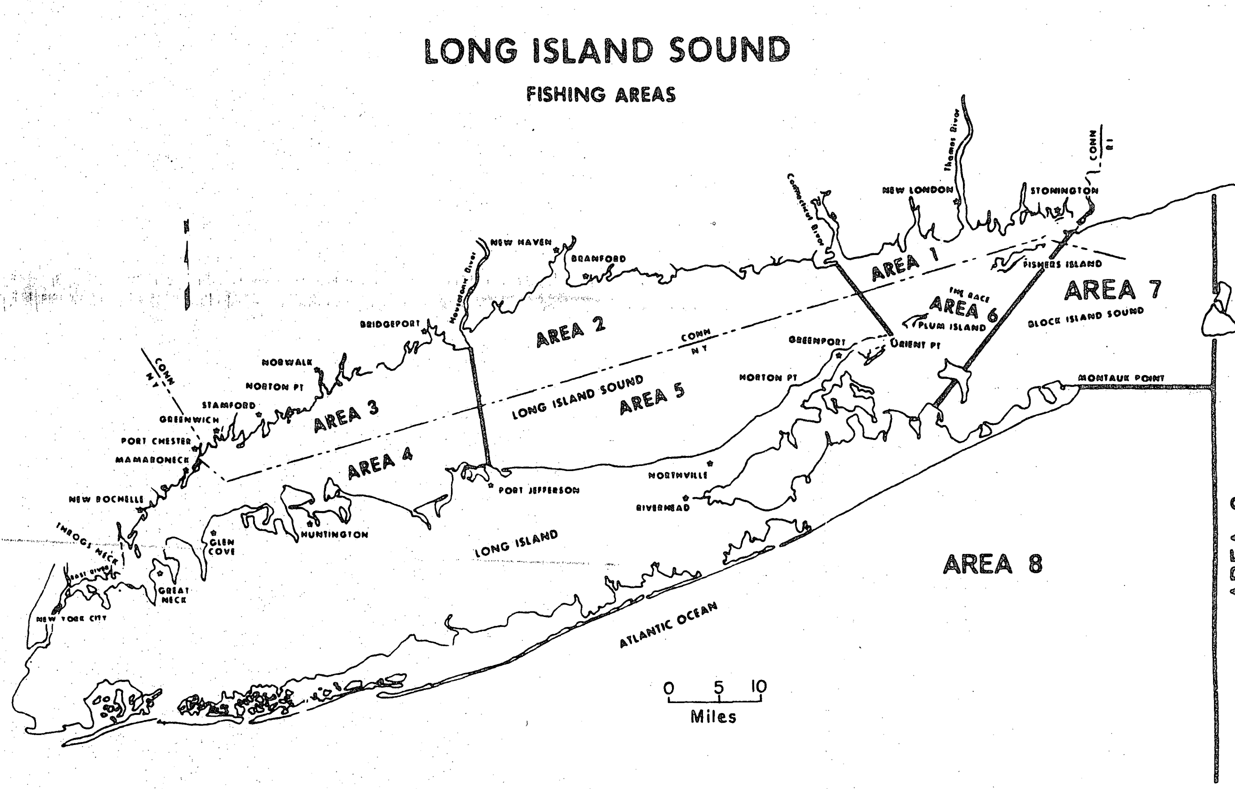

Figure 1. Connecticut Department of Environmental Protection statistical reporting system areas.

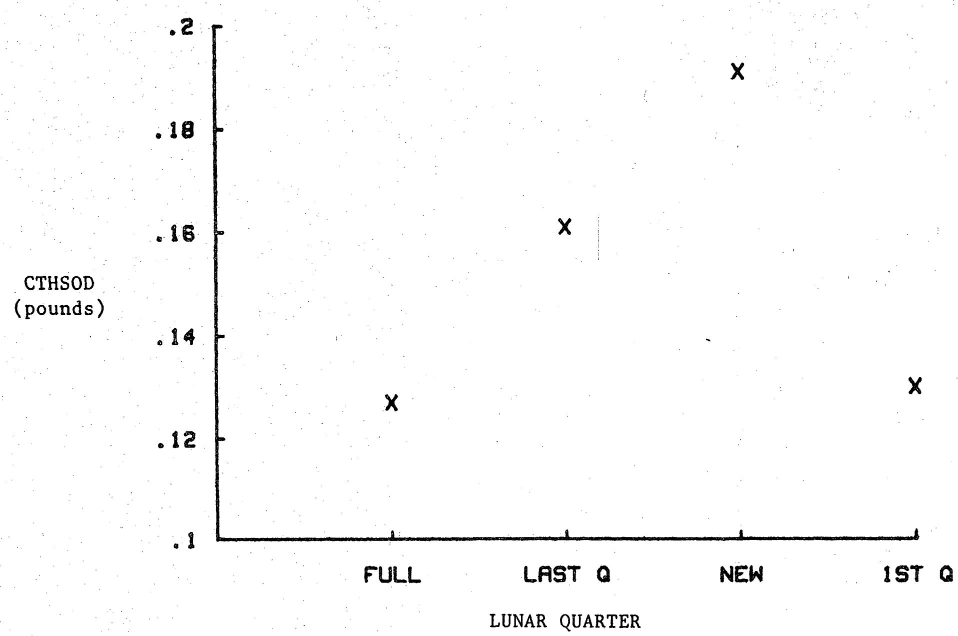

Figure 2. Cummulative CTHSOD for all SOD versus lunar quarter.