An Economic And Environmental Analysis Of Commercial Catch In St. Thomas And St. John, U.S. Virgin Islands

WALTER R. KEITHLY, JR.[1] and GRACIELA GARCIA-MOLINER[2]
[1]*Coastal Fisheries Institute*
Louisiana State University
Baton Rouge, Louisiana 70803-7503 USA
[2]*Caribbean Fishery Management Council*
268 Munoz Rivera Ave., Suite 1108
San Juan, Puerto Rico 00918

ABSTRACT

Commercial fishermen in the United States Virgin Islands are required to submit trip tickets on a monthly basis. Some of the information reported on these tickets includes: (1) species harvested and related poundage, (2) area fished, (3) date of fishing trip, and (4) amount of gear employed on the specified trip. The trip ticket data for 1995 - 96 (July through June of the following year) were used to estimate production functions for two of the principal types of fishing in the St. Thomas and St. John area: (1) pot fishing for finfish and (2) pot fishing for lobster. The estimated production functions associated with these two identified fisheries were specified as catch per trip in the identified fishery in relation to boat length, amount of gear employed, other revenues generated on the identified trip, area fished, and seasonality. The two equations were estimated using a traditional Cobb-Douglas functional form. Results associated with the estimated equations, together with the economic linkages derived therefrom, were, for the most part consistent with theory. In addition, location associated with fishing activities and seasonality were found, in some instances, to influence catch per trip. Overall, the results suggest that merit exists in employing the trip ticket data in commercial catch analyses for the U.S. Virgin Islands and that the information collected from the trip ticket data can be used to assist managers in the decision making process.

KEY WORDS: Lobster, potfish, Production Function Analysis, U.S. Virgin Islands

INTRODUCTION

Reported fishery landings in St. Thomas and St. John U.S. Virgin Islands from July 1992 through June 1993 equaled almost 780 thousand pounds and had an associated value (at retail) in excess of $3.1 million (Newlin, 1994). Potfish represented almost 55% of the total landings by poundage (45% by value) while lobsters harvested with pots represented an additional 11% of the total poundage (18% by value). Combined, these two fisheries accounted for two-thirds of the

total reported landings in St. Thomas and St. John, by value, during the 1992-93 period.

In general, management of the potfish and lobster pot fisheries in the U.S. Virgin Islands has proceeded with only limited information. The overall purpose of this study is to add to the limited information base by developing and estimating production functions for these two defined fisheries. These production functions, which examine catch per trip in relation to economic and environmental variables of interest, can be used by fishery managers in the region to help analyze the impacts that may be associated with different management measures; particularly measures aimed at limiting the overall level of effort (such as pots).

The paper, to achieve the purpose stated above, proceeds as follows. In the next section, the methodology employed for purposes of analysis is presented. Then, results are given. Finally, a discussion of relevant findings and recommendations is presented.

METHODS

Commercial fishermen in the United States Virgin Islands are required to submit trip tickets on a monthly basis. Some of the information contained therein includes: (1) an identification code unique for each fisherman, (2) species harvested and related poundage on a per trip basis, (3) date of fishing trip, (4) amount of gear employed per trip, and (5) area fished on a given trip (see Figure 1 for specified areas). In addition, boat length is recorded when the fisherman obtains a commercial license each year.

To estimate production functions for the potfish fishery and the lobster pot fishery for the St. Thomas and St. John area, boat length was first merged with the trip ticket information based upon the unique identification number associated with each commercial fisherman. Deleting those observations where relevant data were missing left a total of 1,629 usable observations (i.e., trips) with respect to potfish activities in St. Thomas and St. John during the 1995-96 (July through June) year and 351 lobster pot trips. These two figures represent the number of observations used in estimation of the two respective production functions.

To estimate the production functions for the two fisheries included in the analysis (i.e., the potfish fishery and the lobster pot fishery), the Cobb-Douglas functional form was selected for the following reasons [see Beattie and Taylor (1985) for a discussion of the Cobb-Douglas production function]. First, it was assumed that within the range of the data, total catch per trip would not decline as additional inputs (i.e., pots) were employed by the fisherman.

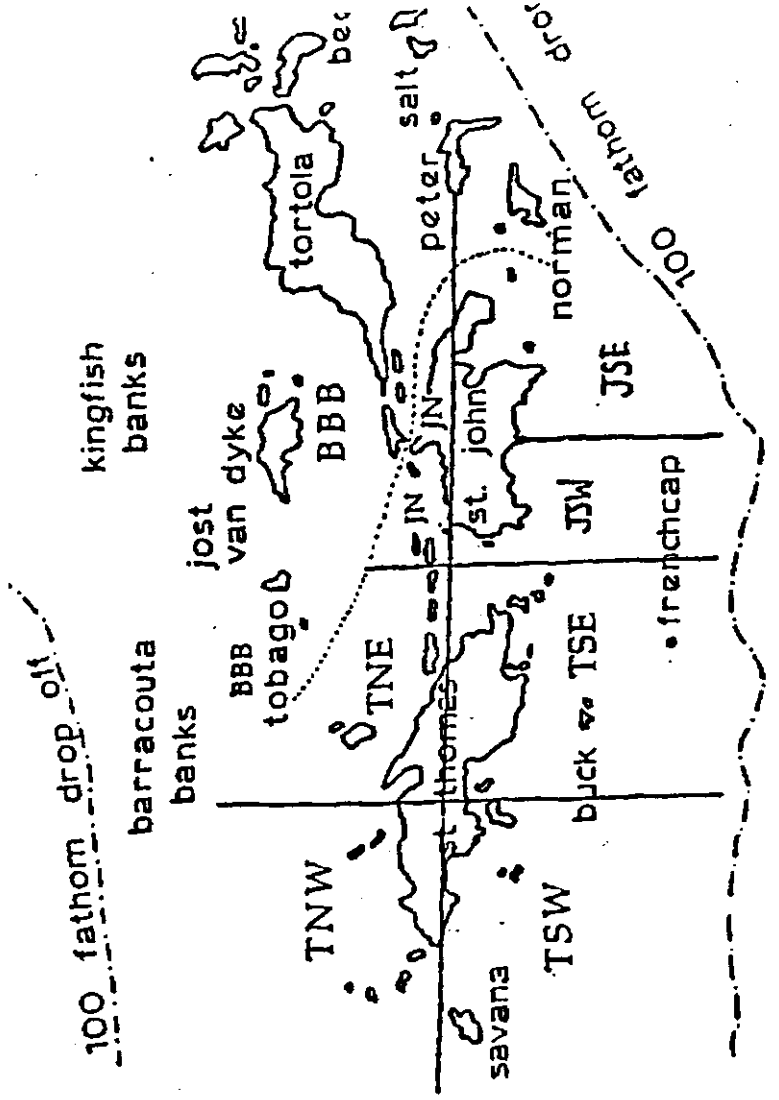

Figure 1. Fishing Areas of the U.S. Virgin Islands.

A second reason for choosing the Cobb-Douglas functional form for analysis of fishing practices is that it is expected, *a priori*, that each economic input in the production process (i.e., number of pots and boat length) should be limiting. Specifically, if zero level of either of the two economic inputs is used, output would also equal zero. A third reason for employing the Cobb-Douglas functional form for analysis is that it allows for estimation and testing of increasing, decreasing, or constant returns to scale with respect to the economic factors of production. Finally, the Cobb-Douglas functional form was selected because of its simplicity. Specifically, the Cobb-Douglas functional form tends to be relatively robust with respect to estimated parameters and is easy to estimate. At the same time, two shortcomings associated with this functional form should be noted. First, it implies a constant output elasticity with respect to input usage (i.e., the percentage change in output associated with a one percent change in input usage) and, hence, returns to scale remain unchanged throughout the production region. Second, a constant elasticity of substitution is implied. The implications associated with these two shortcomings, while of relatively little concern for small changes in input usage, may become unrealistic if inputs are changed by significant amounts.

For purposes of this study, specification of the production function employed in each of the two analyses (i.e., the potfish fishery and the lobster pot fishery) is presented as follows:

$$C = \beta_0 \bullet x_1^{B_1} \bullet x_2^{B_2} \bullet x_3^{B_3} \bullet \exp\left(\sum_{i=4}^{14} \bullet x_i \bullet B_i\right) \bullet \exp(x_{15} \bullet B_{15}) \bullet \exp\left(\sum_{i=16}^{N} x_i \bullet B_i\right) \bullet \exp(\varepsilon)$$

Where:

C = potfish or lobster catch per trip (expressed in pounds)
x_1 = boat length (in feet)
x_2 = number of pots fished per trip
x_3 = other revenues per trip
x_4 - x_{14} = vector of monthly dummy variables (July represents the excluded category)
x_{15} = dummy variable indicating whether trip occurred in federal or non-federal waters (equal to 1 if trip occurred in federal waters, 0 if otherwise)
x_{16} - x_n = vector of regional dummy variables (the Saint John South area was the excluded category)
ϵ = error term
B_0 - B_n = parameters to be estimated

As indicated, catch per trip in each of the two respective fisheries is specified as a function of boat length, number of pots fished on the specified trip, revenues related to the catch of other species on the identified trip, a vector of area dummy variables, and a vector of seasonal variables. In general, catch per trip in each of the two identified fisheries is expected to be positively related to both boat length (i.e., $\partial C/\partial x_1>0$) and the number of pots fished per trip (i.e., $\partial C/\partial x_2>0$), *ceteris paribus*. Conversely, as the revenues from the catch of other species increases, catch per trip in the estimated fishery (i.e., either the potfish fishery or the lobster pot fishery) is expected to decline (i.e., $\partial C/\partial x_3<0$), *ceteris paribus*. This expectation is based on the premise that the harvest of other species on a given trip detracts from the amount of time available for potfishing or lobster pot fishing activities. Insufficient information is available to *a priori* state the expected signs associated with the locational (area) and seasonal variables.

Before presenting the results, one deficiency associated with the model described above should be noted. Specifically, soak period is not included in the analysis. This variable, which is likely a relevant factor in the production process, was excluded because no information exists on the trip ticket information by which to infer its value. The implications associated with excluding soak time in the estimated equations, in a statistical framework, depend on the correlation of soak time with variables included in the respective models. If soak time is highly correlated with either boat length or number of pots fished per trip, for example, some bias associated with the estimated parameter(s) is expected [see Maddala (1977) for details]. Furthermore, the severity of bias will increase in relation to the degree of correlation between the excluded and included variable(s). Because of the lack of an understanding regarding the relationship between boat length (or pots fished) and soak time, the direction of bias can not be determined (if present).

Results pertaining to commercial potfish and lobster fishing activities in St. Thomas and St. John U.S. Virgin Islands for the 1995-96 (July through June) period are presented in two sections. In the first section, some relevant summary statistics are given. Then, results specific to the estimation of the Cobb-Douglas production functions associated with these two fisheries are presented.

Summary statistics

Summary statistics related to potfish and lobster fishing activities in St. Thomas and St. John for the 1995 - 96 period are presented in Table 1. Potfish catch per trip, as indicated, averaged 133 pounds with an associated standard deviation of 127 pounds. Lobster catch, by comparison, averaged 100 pounds per trip with an associated standard deviation of almost 80 pounds.

Average boat length reported in association with potfishing trips equaled

24.6 feet which was almost three feet less than the average boat length reported in association with lobster fishing activities (i.e., 27.3 feet). The average number of pots fished in association with pot fishing activities equaled 42 compared to 59 in association with lobster fishing activities.

Trips wherein potfish activities were reported (i.e., potfish catch was greater than zero and pots fished exceeded zero) also, in many instances, suggested catch of other species (for purposes of analysis, other species were limited to lobster pot catch and hookfish catch). The value of the other catch per trip was estimated to equal $95, on average. Similarly, trips wherein lobster pot activities were reported indicated catches of other species (i.e., potfish and hookfish) valued at approximately $200 per trip, on average. As indicated, there is a wide standard error associated with both of these estimates. This reflects the fact that in a large percentage of the cases, other catch (expressed in revenues earned) was equal to zero and, hence, the distribution of other catch was highly skewed.

An examination of area fished suggests that the Southwest area of St. Thomas was the "preferred" fishing region for both potfish and lobster fishing activities during the 1995 - 96 year. Specifically, an estimated 38% of the potfish trips and 43% of the lobster trips reported during 1995 - 96 occurred in this area. The Southeast area of St. Thomas accounted for another 24% of the potfish trips compared to 15% of the lobster pot trips. Potfish and lobster pot fishing activities on the north side of the two islands tended to be very limited with the exception of the Northwest area of St. Thomas which accounted for 16% of the total reported potfish trips and a quarter of the reported lobster pot trips.

The information contained in Table 1 also suggests that the vast majority of lobster pot fishing activities, as defined by the number of trips, occurred in Federal waters (71% of the total 351 trips). By comparison, less than one-half of the 1,629 potfish trips retained in the analysis occurred in Federal waters according to the trip ticket data.

Finally, an examination of percentage of trips by month, as provided in Table 1, suggests that almost a quarter of all potfish and lobster pot activities occurred in the months of July and August. Conversely, the percentage of trips in September through November tended to be relatively low, most likely the result of Hurricane Marilyn which hit the U.S. Virgin Islands on September 15,1995. Trips by month from December through the following June generally fell in the relatively narrow range of eight to ten percent.

Regression Results

Estimation results are presented in Table 2. The coefficient of determination associated with the two models (the R^2 for the potfish model equaled 0.756

while the R^2 for the lobster model equaled 0.669) suggests that, in general, the estimated models fit the respective data sets relatively well; particularly in light of the cross-sectional nature of the data. In addition, the parameter estimates associated with all of the economic variables included in the respective analyses (i.e., boat length, pots fished per trip, and other revenues per trip) exhibit the anticipated signs and are statistically significant (at the 10% level of significance).

Pots fished per trip — The results suggest, given the constant output elasticity nature embodied in the Cobb Douglas production function, that a ten percent increase (decrease) in the number of pots fished per trip in the two respective fisheries (i.e., the potfish fishery and the lobster pot fishery) will yield an estimated 7.9% increase (decrease) in potfish catch per trip and a 6.5% increase (decrease) in lobster catch per trip, *ceteris paribus*. The estimated output elasticity with respect to an additional pot in the lobster pot fishery (0.65) was nearly identical to that found by Keithly (1981) in his analysis of the Florida spiny lobster fishery. Parameter estimates associated with pots fished per trip in each of the two models (i.e., parameter estimates less than one) indicate declining return to scale in association with the hauling of additional pots on a per trip basis.

Boat length — Boat length was found to be a significant positive variable in both estimated models while holding the number of pots constant. The output elasticity per foot of boat in the potfish fishery was estimated to equal 0.437 indicating that a ten percent increase in boat size will result in an expected 4.4% increase in the harvest of potfish on a per trip basis, *ceteris paribus*. The estimated output elasticity in the lobster pot fishery (1.07) was more than twice that found in the potfish fishery and suggests relatively large increases in lobster catch in association with increasing the boat length. Specifically, a ten percent increase (decrease) in boat length will result in an anticipated 10.7% increase (decrease) in lobster catch, *ceteris paribus*.

Other revenues per trip — The harvesting of other species in association with potfishing and lobster pot fishing activities in St. Thomas and St. John, while significant in a statistical setting, was found to exhibit only minor economic impacts in relation to the harvesting of potfish and lobsters. Specifically, a ten percent increase in revenue generated from the harvest of other species was estimated to result in only a 0.066% decrease in the poundage of potfish harvested on a per trip basis and an approximate one-half of one percent (i.e., 0.043) decline in the harvest of lobster poundage, *ceteris paribus*.

Region — In order to examine catch by region, all independent variables in the two respective equations, with the exception of region fished, were set at their respective means (see Table 1). The region being considered was then assigned a value of one for its mean while the mean values of the other regions were assigned values of zero. This procedure provides an estimate of catch per trip by region; holding all other variables at their respective means. Results associated with this analysis are presented in Figure 2 for potfish and Figure 3 for lobster. Estimated potfish catch, as indicated, was found to equal approximately 120 pounds per trip in three regions: (1) the St. John South area, (2) the St. Thomas Southwest area, and (3) the St. Thomas Northeast area. Catch per trip in both the St. Thomas Northwest and St. Thomas Southeast areas was estimated to equal approximately 100 pounds. Potfish catch in the British Virgin Island and the North St. John areas was estimated to equal approximately 90 pounds per trip though the small sample size associated with the number of potfish trips reported in these two areas (see Table 1) suggests one should view these results with some caution.

With respect to lobster pot fishing activities (see Figure 3), lobster catch per trip was found to be highest in the area Northeast of St. Thomas (approx. 90 pounds), *ceteris paribus,* and lowest in the area Southwest of St. Thomas (approx. 65 pounds). Estimated lobster catch in the three remaining areas equaled approximately 75 pounds per trip.

Potfish catch per trip was estimated to be statistically significantly higher in Federal waters than in Territorial waters (by approx. ten percent), after controlling for all other factors of production (e.g., differences in number of pots fished and boat length), while lobster pot catch per trip was estimated to be significantly less in Federal waters than in the Territorial waters (by about a third). This finding is somewhat unique in the sense that the majority of lobster pot activities occurred in Federal waters while the majority of potfish activities occurred in Territorial waters (see Table 1). Providing a plausible explanation for these findings, in the absence of additional information, is beyond the scope of this paper.

Month of Trip — In general, the analysis, as indicated in Table 2, suggests a strong seasonal pattern with respect to potfish catch per trip when examined on a monthly basis. Specifically, potfish catch per trip was highest in September, *ceteris paribus*, and declined thereafter until reaching a minimum in the months of May and June. Overall, the estimated potfish catch per trip in June was estimated to be approximately 40% less than that in the peak month of September. This relationship is illustrated in Figure 4.

Table 1. Selected Summary Statistics Pertaining to Potfish (for Finfish) and Lobster Pot Fishing Activities in St. Thomas and St. John U.S. Virgin Islands, 1995 (July) - 1996 (June). BVI = British Virgin Islands, SJN = North side of St. John, SJS = South side of St. John, STSE = Southeast area of St. Thomas, STSW = Southwest area of St. Thomas, STNE = Northeast area of St. Thomas, and STNW = Northwest area of St. Thomas (see Figure 1).

	Potfish		Lobster	
	Mean	S.D.	Mean	S.D.
Catch/trip (lbs)	133.4	126.9	100.2	78.3
Other/trip ($)	95.6	214.4	207.4	406.9
Boat Length (ft)	24.6	6.6	27.3	3.4
Pots (no)	42.3	32.9	58.7	46.5
Region:[a]				
BVI	0.01	0.10	0.00	NA
SJN	0.01	0.11	0.00	NA
SJS	0.15	0.35	0.13	0.34
STSE	0.24	0.42	0.15	0.36
STSW	0.38	0.48	0.43	0.50
STNE	0.06	0.24	0.03	0.17
STNW	0.16	0.36	0.25	0.44
Waters (%):[b]				
Territorial	0.53	0.50	0.29	0.45
Federal	0.47	0.50	0.71	0.45
July	0.12	0.32	0.12	0.28
August	0.12	0.33	0.11	0.31
September	0.06	0.23	0.03	0.17
October	0.05	0.21	0.07	0.25
November	0.07	0.25	0.07	0.26
December	0.08	0.27	0.09	0.28
January	0.08	0.27	0.10	0.28
February	0.09	0.28	0.12	0.32
March	0.08	0.27	0.08	0.28
April	0.10	0.29	0.09	0.28
May	0.09	0.28	0.09	0.28
June	0.08	0.28	0.10	0.30

Trips in Territorial and Federal water included in the Federal waters category.

a) BVI refers to British Virgin Islands; SJN refers to the North side of St.John; SJS refers to the South side of St. John; STSE refers to the Southeast area of St. Thomas; STSW refers to the Southwest area of St. Thomas; STNE refers to the Northeast area of St. Thomas; and STNW refers to the Northwest area of St. Thomas (see Figure 1).

b) Trips occurring in both Territorial and Federal water were included in the Federal waters category.

Table 2. Parameter Estimates and Associated Statistics Related to Potfish (for Finfish) and Lobster Pot Activities in St. Thomas and St. John, U.S. Virgin Islands, 1995-96.

	Potfish		Lobster	
	Coefficient	S.E.[a]	Coefficient	S.E.
Intercept	0.3323*[b]	0.2002	-1.5674*	0.8403
Log (other revenues)	-0.0066*	0.0032	-0.0431*	0.0087
Log (boat length)	0.4375*	0.0734	1.0740*	0.2596
Log (pots)	0.7931*	0.0210	0.6537*	0.0458
Region:[c,d]				
BVI	-0.2672*	0.1273	NA	NA
SJN	-0.2803*	0.1194	NA	NA
STSE	-0.1387*	0.0425	-0.0648	0.1235
STSW	0.0031	0.0392	-0.2021*	0.1017
STNE	0.0425	0.0660	0.1250	0.2095
STNW	-0.1930*	0.0486	0.0002	0.1171
Waters:				
Federal	0.1060*	0.0302	-0.3338*	0.0760

Table 2 (continued).	Potfish		Lobster	
Month:				
August	0.0366	0.0504	-0.0673	0.1449
September	0.3183*	0.0643	0.5643*	0.2158
October	0.2053*	0.0696	0.3932*	0.0162
November	0.1121*	0.0610	0.4409*	0.1682
December	0.0691	0.0578	0.3538*	0.1575
January	0.0783	0.0572	0.4144*	0.1582
February	0.0722	0.0556	0.2150	0.1446
March	0.1303*	0.0566	0.1439	0.1563
April	0.0338	0.0541	0.3150*	0.1539
May	-0.0851	0.0558	-0.0416	0.1531
June	-0.0933*	0.0562	-0.2517*	0.1489
R^2	0.756		0.669	
# obs	1629		351	

[a] standard error; [b*] indicates coefficient is statistically significant at the 10% level; [c] For purposes of analysis, the variables St. John South, territorial waters, and the month of July were the omitted categories.; [d] See Table 1 for a description of areas.

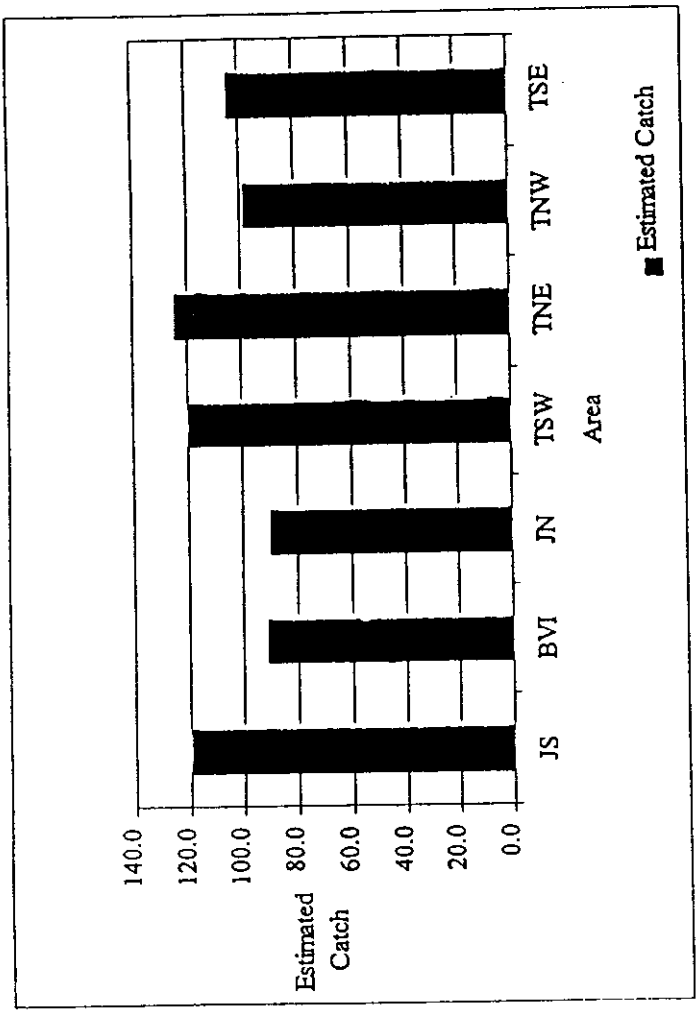

Figure 2. Potfish - Estimated Catch Per Trip by Region, 1995-96.

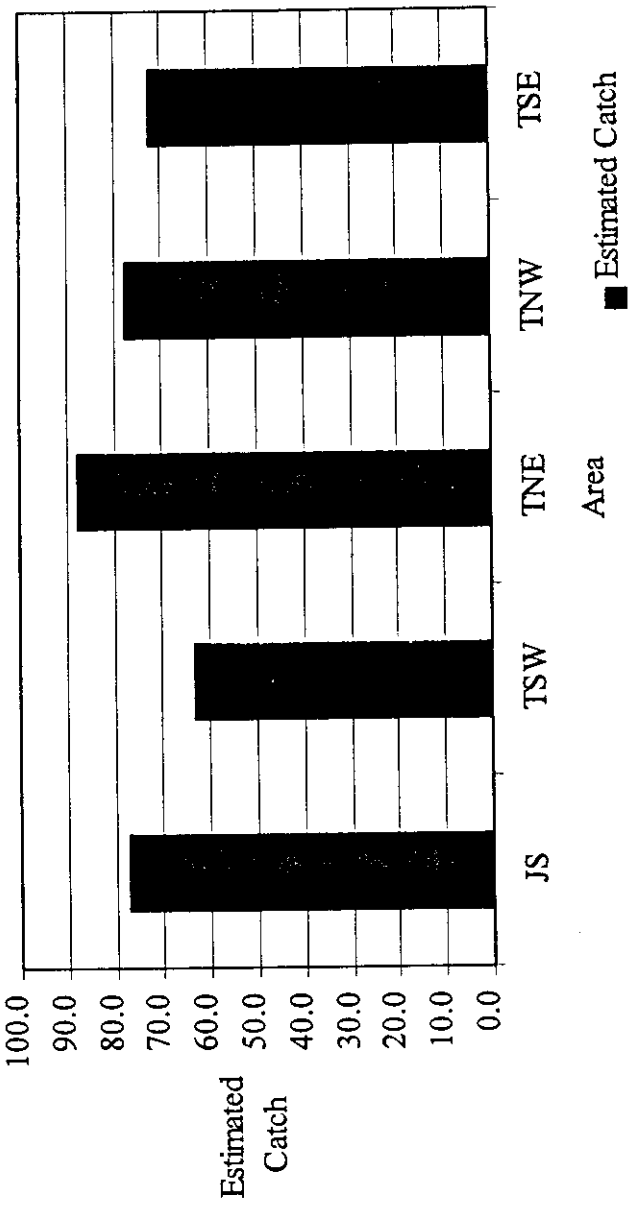

Figure 3. Lobster - Estimated Catch Per Trip by Region - 1995-96.

As with potfish activities, the estimated lobster catch was found to be lowest during the months of May, June, July, and August (see Figure 4). Similarly, as was the case with potfish, estimated lobster catch per trip was highest in September. However, the seasonality pattern evident with respect to estimated potfish catch per month was much less evident with respect to lobster.

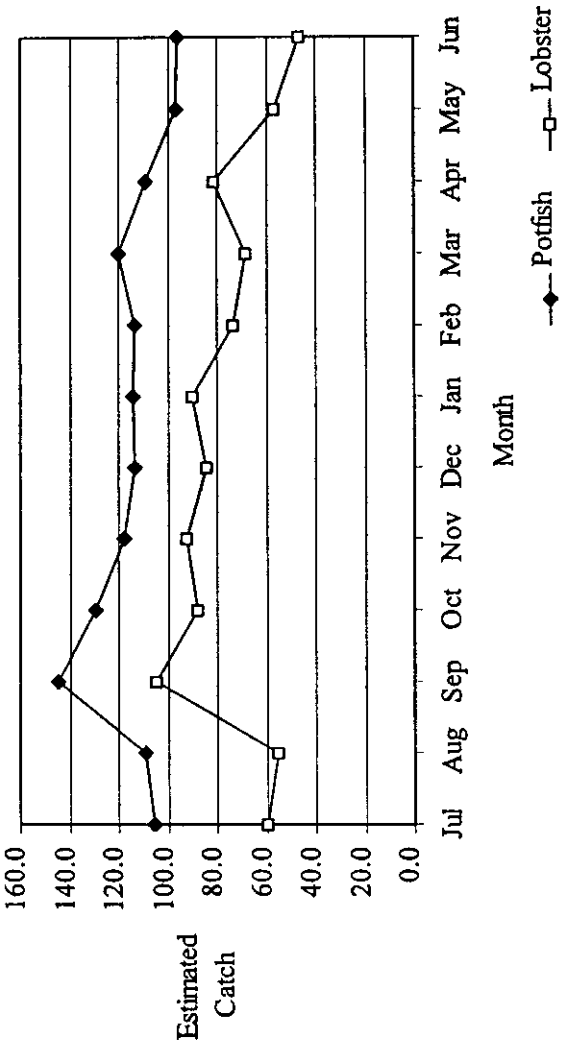

Figure 4. Estimated Catch Per Trip by Month, 1995-96.

DISCUSSION

The analysis presented in this paper, in general, supports the use of trip ticket data to examine the relationship between catch per trip and economic and environmental variables of importance. The economic variables included in the respective models, without exception, exhibited the anticipated signs and were statistically significant. Environmental variables included location factors and seasonality factors which could influence catch per trip. Results suggest that both of these group of factors do, indeed, influence per trip catch. With respect to area fished, specifically, certain areas were found to be more productive than others, after controlling for different levels of the economic inputs used in the production process. The estimated differences in area productivity likely reflect a combination of (1) different levels of aggregate effort which could influence catch on a per trip basis and (2) different bottom characteristics (habitat) that would influence the overall stock size by area.

While the overall results associated with the two estimated equations appear satisfactory, the absence of data related to soak time should not be discounted. As such, one enhancement with respect to the trip ticket data collected by commercial fishermen would be the reporting of soak time on the individual trips.

LITERATURE CITED

Beattie, B. R. and C. R. Taylor. 1985. *The Economics of Production.* John Wiley & Sons, Inc. New York. 258 p.

Keithly, W. R. 1981. Florida Spiny Lobster Fishing: Monthly Allocation of Economic Inputs With Consideration of Population Parameters and Alternative Fishing Enterprises. Unpublished Thesis, University of Florida. 159 p.

Maddala, G. S. 1977. *Econometrics.* McGraw-Hill Inc., New York.

Newlin, K. (ed.). 1994. Fishing trends and conditions in the Southeast region 1993. NOAA Technical Memorandum NMFS-SEFSC-354. 99 p. Unpubl. MS.

ENDNOTES

1. The term potfish, as employed in this paper, refers to the harvesting of finfish with the use of pots.

2. There is also a very small amount of commercial diving for lobsters. Harvest of lobsters by diving accounted for less than five percent of the total commercial take of lobsters in St. Thomas and St. John in 1992 - 93.

3. The other primary fisheries in St. Thomas and St. John include a hookfish fishery (19% of the 1992 - 93 total fishery production by poundage) and a netfish fishery which accounted for 12% of the total harvest by poundage.

4. Observations where lobsters were harvested by diving were not included in the lobster pot analysis.
5. A total of 345 observations related to potfish activities and 91 observations related to lobster pot activities were deleted due to missing data. All of the missing data pertained to boat length.
6. As previously noted, only those observations wherein all relevant information was available were included in the analysis (including summary statistics). Comparison with the complete data sets suggests only minor differences in mean values, in general.
7. For purposes of analysis, other catch was converted from pounds to revenues (based on the 1993 - 94 reported retail prices) to avoid having to add pounds of different species. In cases where no other catch was reported, value was arbitrarily set to $0.01. This was necessitated by the fact that the continuous independent variables included in the respective regression equations were specified in log form and the log of zero is undefined.
8. As indicated by the information contained in Table 1, a small amount of potfish activities occurred in the area of the British Virgin Islands even though that area is reportedly off limits to fishermen from the U.S. Virgin Islands. No lobster pot activities were reported in either the British Virgin Islands or the area north of St. John.
9. Fishermen, in many instances, reported that a given trip occurred in both Territorial and Federal waters. These trips, for purposes of analysis, were treated as having taken place entirely in Federal waters.
10. The output elasticity with respect to boat length in the lobster pot fishery, in general, appears to be unusually large given the nature of the input used in the production process. One possible explanation for the finding is that larger boats provide fishermen the mobility to more easily target lobster stocks in relation to migration patterns of the lobster stocks.
11. The reader may notice that the estimated potfish catch for all regions examined falls below the mean reported catch per trip of 133 pounds. This suggests that the number of pots (and boat length) fished in the more productive areas likely exceed the mean number used in the analysis.
12. The relatively high percentage of lobster pot activities in Federal waters in relation to potfish activities may, to some extent, related to the average size of boat used in the respective activities. Specifically, the average boat length associated with lobster pot activities exceeded that reported for potfishing activities by almost three feet. The larger boat size may encourage an increase in activities in Federal waters.
13. The one major exception to the declining trend after September was in the month of March wherein there was a large increase in the potfish catch per trip, *ceteris paribus*.