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Incorporating Stochastic Harvests into an Analysis of Production: The U.S. Atlantic and Gulf of Mexico Pelagic Longline Fleet

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I. Introduction

Over a decade has passed since the Fishery Conservation Amendments of 1990 consolidated management of the highly migratory species (HMS) in the U.S. exclusive economic zones of the Atlantic Ocean, Gulf of Mexico and Caribbean Sea under the authority of the Secretary of Commerce; yet, pending legislation does not fully incorporate the economic linkages between these species.[1] The economic relationships arise in large part due to the non-discriminatory nature of longline gear, which is the dominant method of harvesting Atlantic HMS. The midwater longline is "a continuous mainline suspended in the water by a series of floats with regularly spaced leaders attached that end with baited hooks" causing indiscriminate harvests of not only targeted and non-targeted HMS but also commercially worthless species such as undersized juvenile HMS, marlin, birds and other marine animals (NMFS 1997, p.32). Recently, HMS managers have designated overfished stocks of Atlantic and Gulf HMS and excess fishing mortality caused by bycatch and discards due to longlines as two primary problems for resolution. If future policies and regulations are to be efficient and equitable, economic information from the longline industry must be duly considered.[2]

The U.S. Atlantic pelagic longline (PLL) fleet fishes out of harbors from Maine to Florida and from Texas to the Caribbean, comprises at least 354 vessels ranging in size from 34

[1] HMS are defined as tuna species, marlin (*Tetrapturus* spp. and *Makaira* spp.), oceanic sharks, sailfishes (*Istiophorus* spp.) and swordfish (*Xiphias gladius*). "Tuna species" are defined as albacore tuna (*Thunnus alalunga*), bigeye tuna (*Thunnus obesus*), bluefin tuna (*Thunnus thynnus*), skipjack tuna (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*).

[2] The Magnuson-Stevens Act, which is the prevailing legislation for Atlantic HMS, requires that adverse economic consequences due to proposed legislation must be minimized not only for industry participants but also for economically dependent fishing communities; however, no such consideration currently exists for domestic consumers of HMS species.

to 85 feet and specifically targets the highly migratory species.[3] In 1996, the fleet landed nearly 240,000 fish and sharks valued at $42 million dockside. Landings included swordfish, BAYS tunas (bigeye, albacore, yellowfin, and skipjack), dolphin fish (mahi-mahi), pelagic and large coastal sharks (i.e., makos, porbeagles, threshers, sandbars, silkys, blacktips, duskys, and hammerheads) and several other non-HMS species (such as king mackerel, wahoo, oilfish, amberjack, and banded rudderfish).

Management of Atlantic HMS is delegated from the Secretary of Commerce to the National Marine Fisheries Service (NMFS). NMFS has identified several of the HMS species targeted by the PLL fleet as being "overfished": west Atlantic bluefin tuna, Atlantic bigeye tuna, north Atlantic albacore, north Atlantic swordfish and large coastal sharks. Currently, these species are jointly managed by NMFS under the 1999 Fishery Management Plan (FMP) for Atlantic Tunas, Swordfish and Sharks. By attempting to manage these species under a single plan, regulators acknowledge the importance of biological and economic interactions among the HMS species. However, current and proposed time-area closures for individual species do not fully account for the multispecies nature of the fishery; this may lead vessels to adjust their input mix such that unregulated species are targeted more heavily, and industry production is inefficient.

Management goals for U.S. fish stocks in general are to conserve the biological resource and to achieve economic efficiency within the fishery. In doing so, the transition costs and economic displacement to the industry and fishery communities must be minimized according to the Magnuson-Stevens Fishery Conservation and Management Act (NMFS 1999). Any economic analysis should aim to generate information necessary for NMFS to calculate the

[3] The "U.S. Atlantic pelagic longline fleet" will henceforth be referred to as the "PLL fleet" or "the fleet" and includes U.S. commercial vessels fishing in the U.S. exclusive economic zones of the Atlantic Ocean, Gulf of Mexico and the Caribbean Sea while specifically targeting HMS species.

economic effects associated with regulating the multispecies, multifishery, pelagic longline fleet in the Atlantic and Gulf of Mexico.

The need for more detailed and realistic economic information is highlighted by recently proposed/enacted regulations that affect specific fishing areas and components of the fleet. For example, since March 2001, 133,000 square miles of U.S. waters in the south Atlantic and Gulf of Mexico have been closed partially or entirely to longline fishing to protect juvenile swordfish populations. On April 3, 2001 a bill (HR 1367) was introduced into the 107^{th} Congress to provide for the conservation and rebuilding of overfished stocks of Atlantic HMS. HR 1367 would allow for a limit to be placed on the cumulative number of fishing sets in certain regions (Mid-Atlantic Bight) that target certain species (swordfish and tuna) during specific months (June through September). HR 1367 also addresses bycatch by proposing a ban on the use of PLL gear for HMS in certain areas during specific seasons (i.e., in the Gulf of Mexico Conservation Zone from Memorial Day to Labor Day, the Northern Mid-Atlantic Conservation Zone from July 21 to August 31 and the Southern Mid-Atlantic Conservation Zone from September 1-30). The enactment and proposal of these set quotas and time-area closures suggests that resource managers are still willing to micromanage the fleet without considering the system-wide effects of the regulations (i.e., effects on all fisheries and fishing communities). If system-wide effects exist, then imposing blanket regulations on a heterogeneous fleet with nondiscriminatory gear may not be efficient or effective.

Effective economic analysis of a multispecies fishery starts with an examination of the harvest technology. Consequently, duality theory offers an advantageous means to empirically analyze the effect of fishery regulations. However, since longliners are assumed to face stochastic harvest levels, traditional dual methods may not be appropriate. This paper compares a traditional ex post dual analysis that incorporates actual output levels with a novel (to fisheries literature) approach that incorporates harvest uncertainty by replacing actual output levels with estimates of expected harvests in the dual cost system. Both the ex post and ex ante analyses are applied to a common data set containing economic and landings information for the 1996 U.S. PLL fleet.

II. Traditional ex post dual analysis

A number of studies in fisheries management have utilized duality theory to explain commercial harvest technologies and investigate policy implications within both single and multiple species fisheries. Many analyses (Kirkley and Strand (1988), Squires and Kirkley (1991), Thunberg, et al (1995) and Squires and Kirkley (1996)) have relied on the assumption that inputs are sufficiently specified with a single measure (typically a function of vessel capacity or some other set capital attribute) that is fixed during a trip. This assumption has allowed researchers to argue that firms participating in multiple fisheries attempt to maximize revenue subject to a single quasi-fixed input instead of maximizing profits directly. When assuming constant input prices and a fixed proportions harvest technology, maximization of the profit function is equivalent to a revenue maximization problem. Thus, a majority of the literature has focused on optimal harvest strategies while secondary attention has been paid to input mixes and factor prices.

However, some studies invoke the stronger behavioral assumption of profit maximization. Squires (1987b) specifies a translog functional form for a multiproduct profit function to estimate the harvest technology for the New England otter trawl fleet. Dupont (1990) specifies a normalized quadratic restricted profit function to ultimately generate measures of rent dissipation in the British Columbia commercial salmon fishery. Although dual profit specifications yield extensive information on harvest technologies, industry characteristics and data limitations sometimes preclude their application in multispecies fisheries such as the highly migratory species.

Longliners are assumed to be price takers in both input and output markets and face stochastic harvests (Mistiaen and Strand 2000). In this situation duality theory tells us that the profit maximization problem reduces to an optimal variable input mix decision that minimizes costs; thus, at the trip level PLL vessels are assumed cost minimizers. The only known article to the authors that models commercial fishers as cost minimizers is Dupont (2000). That study estimates a normalized quadratic restricted cost function for four separate gear types in the British Columbia salmon fishery generating measures necessary for a subsequent simulation of a market for individual transferable vessel quotas.

The PLL vessel owner is assumed to use variable inputs, $X_1, \ldots, X_K$, and a fixed capital input Z, in a way that minimizes harvesting costs for a random catch, $Y_1, \ldots, Y_M$, where X is a K x 1 vector of substitutable input quantities and Y is a M x 1 vector of landings for each group of HMS species. Furthermore, W is a K x 1 vector of variable input prices. The operator is assumed to be a price taker in both input and output markets. Thus, the vessel owner chooses a variable input mix in an effort to minimize trip-level harvest costs. This implies that captains choose a level of effort – based on an expected, stochastic catch distribution (Zellner, Kementa, and Dreze 1966) – to minimize variable costs. Consequently, in this study once a targeting strategy is specified, Atlantic and Gulf longliners are assumed to be able to only make variable input mix decisions that minimize trip costs and maximize trip profits and owner satisfaction.

For each trip a dual flexible cost function is specified by equation (1) in outputs, factor prices and a fixed input while dummy variables are used to account for the location of the arrival port, trip length and season. Note that $q(X;Z)$ is the short-run harvest production function.

$$C(W; Z, Y, f(D)) = \min_X \{W^T X; q(X; Z) \geq Y\}. \quad (1)$$

Since prevailing knowledge about the fishery and fleet does not dictate a particular functional form, following Dupont (2000) a normalized quadratic form is assumed for the empirical model. A normalized quadratic cost function for the Atlantic PLL fleet is expressed as follows.

$$C(r, Y, Z, f(D)) = \alpha_o + \sum_{i=1}^{3} \alpha_i r_i + \frac{1}{2}\sum_{i=1}^{3}\sum_{j=1}^{3} \alpha_{ij} r_i r_j \quad (2)$$

$$+ \sum_{k=1}^{5} \beta_k Y_k + \frac{1}{2}\sum_{k=1}^{5}\sum_{l=1}^{5} \beta_{kl} Y_k Y_l + \sum_{i=1}^{3}\sum_{k=1}^{5} \gamma_{kl} r_i Y_k$$

$$+ \mu Z + \omega Z^2 + \sum_{i=1}^{3} \lambda_i r_i Z + \sum_{k=1}^{5} \varsigma_k Y_k Z + \sum_{i=1}^{3} \rho_{in}^{m} r_i D_n^m \Big|_{mn}$$

In equation (2), r_i represents the prices of light sticks, bait and fuel (i.e., variable inputs) normalized by the price of ice. Ice is chosen as the normalizing price due to lack of information about individual vessel's onboard ice making equipment.[4] C is trip-level variable cost, also normalized by the price of ice. Normalized variable cost is a function of normalized input prices (r), stochastic output levels (Y), a fixed capital constraint represented by vessel length (Z),[5] and the dummy variables ($f(D)$), which represent trip differences due to arrival port, seasonality and length of trip. Using Shephard's lemma, the cost-minimizing demand functions can be easily obtained (i.e., $\partial C(\cdot)/\partial r_i = x_i(\cdot)$).

[4] Dupont (2000) notes that previous research shows parameter estimates are robust with respect to choice of the normalizing variable.

[5] It is assumed the operator is not able to change the vessel size from one trip to the next. Thus, capital decisions are fixed at the trip-level.

The empirical model is specified with normalized input prices (*r*) for light sticks, bait and fuel. The output quantities (*Y*) include BAYS tunas, dolphin fish, shark, swordfish, and other fish. Output prices (which are unavailable at the individual trip level) are derived from reported revenues and assumed fixed at the trip level. Furthermore, output levels are considered exogenous to the model since harvest levels are stochastically determined. Three categories of dummy variables are included to account for observed heterogeneity within the PLL fleet and Atlantic HMS fisheries (Larkin, Adams and Lee 2001), namely: geographic region of arrival port (D^G), quarter (D^Q) and trip length (D^L). The geographic regions are the Caribbean, Gulf of Mexico, Northeast (base region), and the Mid-Atlantic/Southeast. The seasons (quarters) are January-March (base quarter), April-June, July-September, and October-December. Trip lengths based on number of sets are grouped as follows: 1-3 sets, 4-6 sets, 7-9 sets or 10-21 sets (base category). Trip length approximated by the number of sets per trip is also a measure of fishing effort expended at the trip level. The input demand equations for light sticks (i=1), bait (i=2) and fuel (i=3) are given by:

$$x_i\big(r, Y, Z, f(D)\big) = \alpha_i + \sum_{i=1}^{3} \alpha_{ij} r_j + \sum_{k=1}^{5} \gamma_{ik} Y_k + \tau_i Z + \rho_{in}^{m} D_n^{m}\big|_{mn} \qquad (3)$$

The system of input demand functions given in equation (3) are appended with error term, ε_i and estimated using generalized least squares (GLS). The errors are assumed independently and identically normally distributed with mean zero and constant variance (i.e., ε_i is iid~N(0,σ^2)). Each error term is assumed correlated with the other error terms across equations in the system. This is a reasonable assumption because at the trip level input substitution is possible and likely if an operator decides to switch targeting strategies during a trip. Thus, the three input demand functions are estimated using Zellner's GLS procedure using 1996 logbook set and trip summary data collected by NMFS. All indices and variables are defined in Table 1. Theoretical restrictions of symmetry and homogeneity are imposed through specification of the functional form. The following analysis amends a previous study that may not have corrected for possible variable endogeneity (Larkin et al. 2001).

All results pertain to the demands for the three inputs estimated, namely: light sticks, bait, and fuel. The estimated constant intercept parameters reflect, in part, the input demands associated with the "base" trip (i.e., the dummy variable from each category that was not included as an independent variable in the regressions and for the most part chosen arbitrarily). In particular, the base trip is one that concluded at a northeast port (i.e., from Maine to Virginia) between January and March and had fished 10 to 21 sets in 1996. The estimated coefficients of the dummy variables represent mean differences in demands, *ceteris paribus*. Estimation results for the light stick, bait, and fuel equations are summarized in Tables 2-4, respectively.

Managers can use the information generated by the estimation to aid in the assessment of proposed policies. For instance, the price of bait is statistically significant (at the 1% level) in determining the demand for light sticks and in determining the demand for bait. Increasing bait price increases the demand for light sticks suggesting that these two inputs are complements. Bait price and bait demand are inversely correlated indicating that bait is a normal good. Light sticks are also shown to be a normal good. Due to imposed symmetry, the price of light sticks is positively correlated with the demand for bait. The price of fuel is not statistically significant in explaining the demand for any input, even fuel, indicating that fuel price does not affect any input purchase decisions.

Further information, such as fixed capital input effects, input-output relationships, mean differences in input demands with respect to dummy variables, and own and cross-price elasticities of input demand, can also be derived. These measures allow managers to investigate input control policies as an alternative to time-area closures and quotas in the HMS fisheries. Since the longline industry is characterized by stochastic harvests, regulations directed toward input utilization may be more effective than traditional restrictions. However, as the next section explains, stochastic harvest levels have a major theoretical implication for an empirical dual analysis.

III. Ex Ante Dual Analysis

Stochastic harvests common to the PLL fleet suggest that estimation of an ex post dual cost system by Zellner's GLS will yield biased and inconsistent estimates since error terms are correlated with actual output (Pope and Just 1996). Basically, an ex post analysis incorporates actual output data, but in the case of longliners this information is not known with certainty when input mix decisions are made by vessel operators. Instead, harvesting and targeting decisions are made ex ante using expectations of catch levels. Thus, information generated in section II may possibly lead to flawed policy decisions by HMS managers. As a corrective technique, this section applies a distance function approach proposed by Pope and Just (1996) to estimate ex ante cost functions for the PLL fleet using the same data set estimated in section II. This methodology incorporates the stochastic nature of harvest levels into estimation of the cost function using methodology that has (to our knowledge) never been applied in commercial fisheries economics.

Since output is not observed, a consistent estimate of expected output must be produced by the estimation procedure. The basic methodology proceeds as follows. First, an ex ante cost function is specified with respect to input prices, expected output and a vector of unknown parameters. The objective is to derive a measure of the production envelope that represents expected output by inverting the distance function. The resulting envelope equation is included in the system along with the cost and derived input demand equations that include the contrived estimate of expected output from the inverted distance function. The equations comprise a non-linear system. The system is then estimated using maximum likelihood techniques.

The basis for this methodology stems from the duality of the distance and cost functions (Shephard 1970). Following Pope and Just (1996) the distance function is defined over positive inputs and outputs as

$$\psi(Y,X) = \| X \| / \| \xi \|,$$

where $\xi = \lambda_0 X$ and $\lambda_0 = \min \{\lambda \mid \lambda X \in v(Y)\}$, $v(Y)$ is the input requirement set defined by $\{X \mid E[Y] \leq E[\, q(X,Z,\varepsilon)]\}$, E is the expectation operator and $\| \cdot \|$ is the Euclidean norm. Note that $q(X,Z,\varepsilon)$ is a stochastic production function which leads the vessel operator to solve an ex ante cost minimization problem. The duality between the cost and distance functions is represented as,

$$C(W; Z, Y, f(D)) = \min_X \{W^T X \mid \psi(Y,X) \geq 1\},$$

$$\psi(Y,X) = \min_W \{W^T X \mid C(W; Z, Y, f(D)) \geq 1\}.$$

Under output uncertainty the distance and production functions can be defined as

$$\min_W \{1 - C(W; Z, Y^*, f(D), \varepsilon) + W^T X\} = \psi(Y^*, X, \varepsilon),$$

$$\max_{Y^*} \{ Y^* \mid \psi(Y^*, X, \varepsilon) \geq 1 \} = q(X,Z,\varepsilon),$$

where Y^* equals expected output. Under monotonicity the distance function can be inverted to obtain expected output, $Y^* = \psi^{-1}(1, x, \varepsilon) = q(X,Z,\varepsilon)$.

Estimation of the ex ante cost system and policy implications for the PLL fleet are forthcoming. Additionally, a comparison of the estimation results for the ex ante and ex post models will address the applicability and robustness of the Pope-Just methodology.

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Table 1. Empirical Ex Post Model Components

Symbol	Description
Indices:	
i, j	Inputs (light sticks, bait, and fuel)
k, l	Outputs (swordfish, BAYS tunas, dolphin fish, sharks, and 'other')
m	Dummy Variable (geographic region, quarter, and trip length represented by G, Q, and L, respectively)
n	Number of Levels for each Dummy Variable (1, 2, 3 or 1, 2, 3, 4)
Variables:	
x_i	Cost-minimizing Input Demands (no. light sticks, lbs. bait, gal. fuel)
r_i	Normalized Input Price ($/unit)
Z	Fixed Capital Input (i.e., vessel length in ft.)
Y_k	Output Quantity (no. landed/trip)
$D^G{}_n$	Geographic Region Dummy Variables (n=3)
$D^Q{}_n$	Quarterly Dummy Variables (n=3)
$D^L{}_n$	Length of Trip Dummy Variables (n=3)

Table 2. Input Demand for Light Sticks (Ex Post Estimated Parameter Values for Equation 3, *i*=1)

Variable	Symbol	Estimate[a]	*p*-value
Constant[b]	α_1	1414.32***	0.0002
Input Price Variables:			
Light Sticks (r_1)	α_{11}	-24.15***	0.0083
Bait (r_2)	α_{12}	14.22***	0.0034
Fuel (r_3)	α_{13}	-1.23	0.8359
Vessel Length (Z)	τ_1	14.19***	0.0010
Output Quantity Variables:			
Swordfish (Y_1)	γ_{11}	14.70***	0.0001
BAYS Tunas (Y_2)	γ_{12}	-5.12***	0.0001
Dolphin Fish (Y_3)	γ_{13}	-1.69	0.2177
Sharks (Y_4)	γ_{14}	-2.08	0.3137
Other Fish (Y_5)	γ_{15}	0.56	0.9166
Dummy Variables[b]			
Geographic Region:			
North Carolina to Miami, FL ($D^G{}_1$)	$\rho^G{}_{11}$	162.31	0.3280
Texas to Key West, FL ($D^G{}_2$)	$\rho^G{}_{12}$	245.28	0.1244
Caribbean ($D^G{}_3$)	$\rho^G{}_{13}$	1,163.29***	0.0001
Quarter:			
April - June ($D^Q{}_1$)	$\rho^Q{}_{11}$	-165.96	0.2004
July - September ($D^Q{}_2$)	$\rho^Q{}_{12}$	-281.17**	0.0438
October - December ($D^Q{}_3$)	$\rho^Q{}_{13}$	116.72	0.4382
Length of Trip or Trip Effort:			
1-3 Sets ($D^L{}_1$)	$\rho^L{}_{11}$	-1,770.08***	0.0001
4-6 Sets ($D^L{}_2$)	$\rho^L{}_{12}$	-1,258.55***	0.0001
7-9 Sets ($D^L{}_3$)	$\rho^L{}_{13}$	-807.98***	0.0001

Note: R^2= 0.61 and R^2adj = 0.60

[a] Single, double, and triple asterisks indicate statistical significance at the 10, 5, and 1% levels.

[b] The constant will reflect values of the base categories of the dummy variables for geographic region (Maine to Virginia), quarter (January - March), and trip length (10-21 sets).

Table 3. Input Demand for Bait (Ex Post Estimated Parameter Values for Equation 3, *i*=2)

Variable	Symbol	Estimate[a]	*p*-value
Constant[b]	α_2	696.72*	0.0710
Input Price Variables:			
Light Sticks (r_1)	α_{21}	14.22***	0.0034
Bait (r_2)	α_{22}	-13.39***	0.0086
Fuel (r_3)	α_{23}	-0.07	0.9876
Vessel Length (Z)	τ_2	35.19***	0.0001
Output Quantity Variables:			
Swordfish (Y_1)	γ_{21}	11.72***	0.0001
BAYS Tunas (Y_2)	γ_{22}	4.80***	0.0004
Dolphin Fish (Y_3)	γ_{23}	2.63*	0.0665
Sharks (Y_4)	γ_{24}	1.13	0.5979
Other Fish (Y_5)	γ_{25}	4.20	0.4569
Dummy Variables[b]			
Geographic Region:			
North Carolina to Miami, FL ($D^G{}_1$)	$\rho^G{}_{21}$	-583.95***	0.0008
Texas to Key West, FL ($D^G{}_2$)	$\rho^G{}_{22}$	-481.25***	0.0040
Caribbean ($D^G{}_3$)	$\rho^G{}_{23}$	576.21**	0.0151
Quarter:			
April - June ($D^Q{}_1$)	$\rho^Q{}_{21}$	-317.11**	0.0195
July - September ($D^Q{}_2$)	$\rho^Q{}_{22}$	-413.72***	0.0046
October - December ($D^Q{}_3$)	$\rho^Q{}_{23}$	-412.92***	0.0087
Length of Trip or Trip Effort:			
1-3 Sets ($D^L{}_1$)	$\rho^L{}_{21}$	-1,091.08***	0.0001
4-6 Sets ($D^L{}_2$)	$\rho^L{}_{22}$	-794.69***	0.0001
7-9 Sets ($D^L{}_3$)	$\rho^L{}_{23}$	-299.02**	0.0687

Note: R^2= 0.58 and R^2adj = 0.57

[a] Single, double, and triple asterisks indicate statistical significance at the 10, 5, and 1% levels, respectively.

[b] The constant will reflect values of the base categories of the dummy variables for geographic region (Maine to Virginia), quarter (January - March) and trip length (10-21 sets).

Table 4. Input Demand for Fuel (Ex Post Estimated Parameter Values for Equation 3, *i*=3)

Variable	Symbol	Estimate[a]	*p*-value
Constant[b]	α_3	-1062.73**	0.0200
Input Price Variables:			
Light Sticks (r_1)	α_{31}	-1.23	0.8359
Bait (r_2)	α_{32}	-0.07	0.9876
Fuel (r_3)	α_{33}	-7.96	0.2444
Vessel Length (Z)	τ_3	57.08***	0.0001
Output Quantity Variables:			
Swordfish (Y_1)	γ_{31}	21.65***	0.0001
BAYS Tunas (Y_2)	γ_{32}	7.13***	0.0001
Dolphin Fish (Y_3)	γ_{33}	1.44	0.3884
Sharks (Y_4)	γ_{34}	3.48	0.1634
Other Fish (Y_5)	γ_{35}	-13.70**	0.0372
Dummy Variables[b]			
Geographic Region:			
North Carolina to Miami, FL ($D^G{}_1$)	$\rho^G{}_{31}$	-158.86	0.4297
Texas to Key West, FL ($D^G{}_2$)	$\rho^G{}_{32}$	-221.78	0.2514
Caribbean ($D^G{}_3$)	$\rho^G{}_{33}$	448.64	0.1036
Quarter:			
April - June ($D^Q{}_1$)	$\rho^Q{}_{31}$	-111.04	0.4803
July - September ($D^Q{}_2$)	$\rho^Q{}_{32}$	-108.02	0.5230
October - December ($D^Q{}_3$)	$\rho^Q{}_{33}$	-140.58	0.4416
Length of Trip or Trip Effort:			
1-3 Sets ($D^L{}_1$)	$\rho^L{}_{31}$	-834.10***	0.0002
4-6 Sets ($D^L{}_2$)	$\rho^L{}_{32}$	-673.41***	0.0007
7-9 Sets ($D^L{}_3$)	$\rho^L{}_{33}$	-687.12***	0.0003

Note: R^2= 0.64 and R^2adj = 0.63
[a] Single, double, and triple asterisks indicate statistical significance at the 10, 5, and 1% levels, respectively.
[b] The constant will reflect values of the base categories of the dummy variables for geographic region (Maine to Virginia), quarter (January - March) and trip length (10-21 sets).