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A BUDGET SIMULATION MODEL FOR WEST COAST ALBACORE TROLLERS

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Center

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1. Introduction

Private and public fisheries administrators require information about cost and earnings of fishing vessels when evaluating alternative investment opportunities, gauging the economic impacts on a fishery of proposed policy changes, and for assessing the effectiveness of existing fisheries policies. Data on the gross revenues of individual vessels are routinely collected by the Pacific coast states' fisheries agencies. On the other hand corresponding cost data, needed to derive estimates of the net earnings of vessels are not regularly collected. Data on vessel costs which are assembled for these purposes, are generally collected through periodic cost and earnings surveys, and the results from these surveys are used to provide point-in-time estimates of net returns for particular classes of vessels or an entire fleet.

To extend the usefulness of cost and earnings survey data beyond the survey period, vessel budget (or fiscal) simulation models (budget simulators) can be constructed which typically specify vessel costs and revenues as functions of variables, the values of which are collected on an ongoing basis (e.g., vessel characteristics that are recorded during the annual registration process). As new values of the explanatory variables become available they can be incorporated into the model together with expenditure specific price indices -- to adjust for relative changes in unit costs -- to predict vessel costs and earnings outside the survey period. In this way vessel budget simulators provide a means of generating predictions of net returns for years in which cost and earnings surveys are not conducted.

This report describes the development and application of a budget simulation model that can be used to monitor and predict the financial and economic performance of specific vessels or classes of vessels making up the north Pacific albacore fleet. The model is capable of generating budgetary information for west coast albacore trollers when the values of key variables describing vessel characteristics, fishing activities, and costs of inputs (e.g. fuel) are specified. This makes the model a particularly useful analytical tool for evaluating events that affect the fleet's operating environment.

In the following sections development of the west coast albacore troller budget simulation model (ALBSIM) is discussed in terms of (a) methodology and technical requirements, (b) data requirements, (c) estimation of relationships and parameters, and (d) the procedures for exercising the model. Finally some examples of ALBSIM's capabilities and outputs are presented.

2. Methodology

Existing vessel budget simulation models (Squires, 1985; Schelle and Muse, 1983; Griffin¤ et al., 1980) for the most part consist of individual, regression-estimated equations that predict a vessel's revenue, operating cost and fixed cost components. In principle all influences on a vessel's fishing performance enter these equations as independent variables. In practice this is difficult to accomplish because the number of variables can become unmanageably large and data on many of the variables are either unavailable or of questionable quality. Due to these practical considerations, the equations that make up vessel budget simulators are usually formulated on an ad hoc basis and therefore prone to misspecification. Implicit in this process is a willingness to accept a greater risk of specification bias in order to reduce the potentially greater error associated with a ponderous set of independent variables. In cases where data limitations are severe enough to preclude the estimation of revenue and cost equations, those costs and revenues are often approximated by incorporating historical averages, user supplied values, or engineering relationships (technical formulas) in the budget simulator.

Appropriate specification of the regression equations also requires an investigation of their functional form. In most cases some sort of interactive form (i.e. one in which the marginal contributions of units of some independent variables depend on the amounts of certain other independent variables) would seem advisable. This is particularly true when vessel characteristics enter the formulations, and underlying engineering/technological constraints limit the range of combinations of independent variables (e.g., a change in catch given a change in effort will usually depend on vessel design characteristics). Beyond this consideration the choice of functional form is an empirical question, which is decided on the basis of plausibility, goodness of fit, and the like. Under this approach the general form of the linear regression equation for predicting the i^{th} cost is:

$$C_{ijt} = a_{i0} + a_{i1}EFF + b_{i1}VES + b_{i2}(VES*EFF) + u$$

where:

C_{ijt} = the predicted expenditure on the i^{th} cost item for vessel j in year t dollars

EFF = a measure of vessel fishing activity or fishing effort

VES = a column vector of vessel characteristics

a_{i0} = intercept term for the i^{th} cost equation

a_{i1} = estimated parameter for the i^{th} cost equation

b_{i1}, b_{i2} = row vectors of estimated parameters for the i^{th} cost equation

u = error term.

Since the equation is estimated in nominal dollars of the survey year (or some base year), its predictions will be in nominal dollars of the base year. In other years, however, the prices of various inputs and outputs may be different from those prevailing in the base year. Therefore, to obtain nominal dollar estimates for periods other than the base year the procedure is as follows:

$$C_{ij,t+n} = C_{ijt} * P_{i,t+n}$$

where $C_{ij,t+n}$ is the expenditure on the i^{th} cost item for vessel j in nominal dollars of the t+n year, and $P_{i,t+n}$ is the i^{th} item specific conversion factor which converts base year t dollars predicted by the model to year t+n dollars. A similar approach is used to predict revenues. Net returns can then be predicted by taking the difference between the sum of predicted revenues and the sum of predicted costs.

ALBSIM incorporates functions that relate production, corresponding variable costs, and fixed costs to the design characteristics of the vessel, its home port, different species fished, and the degree to which the vessel is utilized on an annual basis, all of which are exogenous to the model. Such a structure allows the ALBSIM user to select a vessel of a given design and specify its pattern of operation in the fishery in order to generate annual budgets, cash flows and other types of financial reports. The vessel's design is determined by its length, carrying capacity, and age. The pattern of operation of the vessel in the north Pacific albacore fishery is described by its home port, the number of days it spends at sea annually, and the amount of time it engages in fishing for different target species, i.e., a measure of fishing effort.

3. Data

The data used to estimate ALBSIM came from several sources. Fishermen belonging to the Western Fishboat Owners Association, an organization representing west coast albacore fishermen, supplied annual data, for one or more years, on their vessel's fishing operations and corresponding economic performance. Additional vessel financial data were obtained from various lending institutions which finance fishing vessels. These sources provided 247 annual observations which contain catch, earnings, effort, expenditure, and physical characteristics data from 89 west coast vessels that fished primarily for albacore over the period 1972 through 1982. Each vessel is described by its length, beam, gross tons, carrying capacity, age, and home port. After eliminating incomplete observations, and observations from non-troller vessels, an unbalanced-panel cost and earnings data set[1] consisting of 127 vessel-year observations was used for estimation purposes.

The catch data provided consist of the vessel's annual albacore catch together with the annual catches of other species for each year the vessel was in the sample. Fishing effort was reported as the number of days fished for each species. The total number of fishing trips taken annually as well as the total number of days at sea for each vessel-year were also provided.

Vessel financial data that were furnished include total revenue from fishing and other operations, variable costs relating to vessel operations, and the fixed costs associated with vessel ownership. Variable costs can be separated into those not directly proportional to catch and those directly proportional to catch. Cost items in the former category consist of fuel (fuel and lubricants), provisions (galley and groceries), gear and supplies, equipment, and other (ice, salt, bait, etc.). Variable cost items that are directly proportional to catch include crew shares and payroll taxes. Crew share is the hired labor expense that is based on a percentage of the vessel's gross ex-vessel revenues. Payroll taxes are calculated as a percentage of crew shares. Fixed costs are those incurred regardless of the vessel's level of operation, and comprise scheduled repairs and maintenance, rent and moorage, insurance, interest, as well as fees for professional services, property taxes, permits, and association dues. All reported costs were converted to 1982 dollars using the U.S. gross national product, implicit price deflator. This adjusts for overall inflation but

[1]A combination of cross-sectional and time series data where the number of time series observations varies over the individuals constituting the cross section.

preserves the effect of relative unit price differences with regard to specific operating and fixed cost expenditures. Descriptive statistics for key variables used in the ALBSIM analysis are presented in Table 1.

4. Structure, Specification, and Estimation

The version of ALBSIM described here is designed to predict annual cash flows for north Pacific troll vessels whose primary target species is albacore tuna. A vessel's annual cash flow is an accounting of the actual cash outlays (the variable and fixed expenditures associated with owning and operating the vessel) that are required to generate a cash inflows (revenues) from fishing. The net cash flow is a measure of funds generated from operations that can be used to repay loans, pay taxes owed, or pay a wage to the vessel owner/operator for his labor and management. From an accounting standpoint it is the difference between actual expenditures and revenues, and can be expressed as:

Vessel Revenue

landings * ex-vessel price

- Operating Costs

fuel and oil
other

- Labor Costs

payments to crew
payments to skipper
payroll taxes

- Fixed Costs

interest payments
scheduled maintenance
moorage and rent
insurance

fees (professional services, property taxes, permits, and other)

Net Cash Flow.

ALBSIM is essentially a collection of regression-estimated equations that predict the vessel's revenues and expenditures according to the structure of the net cash flow account. Because the "true" relationship between the dependent and independent variables is unknown for each of the equations that make up ALBSIM, each equation was initially formulated as a second degree polynomial including cross product terms. By using the physical characteristics and effort in linear and non-linear combinations, the model should approximate the true function.[2] Insignificant independent variables and highly correlated independent variables were then removed from the initial estimations in order to maximize the adjusted R-squared (RBAR**2) or, equivalently, minimize the standard error of the estimate (SEE). This was done subject to a criterion of parsimony, i.e., given two models with equal explanatory power, choose the simpler one.

4.1 Catch and Revenue

ALBSIM employs separate equations to estimate a vessel's annual albacore catch and its annual catch of other species. In doing this it is assumed that fishing for albacore does not occur simultaneously with

[2]From Taylor's theorem it is possible to approximate a linear or nonlinear function by a polynomial of sufficient degree (see for example, Chiang, 1967). However, polynomial approximations can lead to markedly unexpected predictions when the values of independent variables become extreme. Predictions from polynomial approximations are superior to those from linear approximations when the values of independent variables are closer to the sample means.

fishing for other species. The catch of an individual vessel can be expressed functionally as:

$$Y = F(X_1, X_2, \ldots\ldots X_j \quad X_{j+1}, \ldots\ldots X_n)$$

where Y represents catch, X_1, X_2 ..... X_j represent factor inputs related to fishing effort which can be controlled by the owner or operator of the troller, and X_{j+1}, ... X_n denote factors beyond the control of the owner/operator such as the abundance of albacore and environmental conditions. No data are available for the uncontrollable factors, and therefore these factors are not included in the ALBSIM catch equation specifications. Furthermore, it is assumed that values of the included variables are uncorrelated with the true values of the variables excluded from the catch equation.[3]

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[3]By omitting the uncontrollable factors the catch equation is subject to the specification error discussed above. In addition, it is very likely that values of the included, controllable, effort-related variables are influenced by expectations of albacore abundance, environmental conditions, and other uncontrollable variables which have been omitted from the equation. To the extent that expected values approach the true values of these variables, the values which actually affect catch, the likelihood of contemporaneous correlation between the explanatory variables in the equation and the disturbance term (which will include the effect of the omitted uncontrollable factors) increases. This can result in biased regression coefficients and bias in the standard error of the catch estimator. From a practical standpoint the consequences of misspecification and contemporaneous correlation are often offsetting. Furthermore, the extent of bias in the regression coefficients and standard error of the estimate from these sources may be of little practical concern given relatively strong-fitting relations.

Fishing effort may be defined as the product of fishing power and the time spent fishing. The vessel's physical characteristics, crew size and operator skill are the major factors determining a vessel's fishing power. The role of physical characteristics in determining the vessel's fishing power seems to be related to its range of operation. In this sense, larger, newer, more powerful vessels are expected to be more productive than older, smaller, less powerful vessels by virtue of their being able to conduct more fishing per unit of time. The productivity of a particular vessel will also vary with crew size and the ability of its operator. Because there is little variability in crew size across the sample of vessels used in the ALBSIM estimation and there is no information on the relative fishing skills of their operators, these factors are excluded from the analysis. Nonetheless, profit maximizing behavior is assumed on the part of vessel owners and vessel operators. The individual vessel catch equations for albacore and other species take the form:

$$Y = a_{10} + a_{11}EFF + b_{11}VES + b_{12}(VES * EFF) + u_1$$

where Y = catch of albacore (TALB) in short tons (tons), or catch of other species (TOTH) in tons (see Table 2 for definitions of the variables used in the ALBSIM analysis.)

VES = vector of vessel physical characteristics (see Table 2).

EFF = days fishing, or effort, for either albacore or other species (see Table 2.)

VES * EFF = a vector of vessel characteristics and fishing effort interaction terms.

In estimating the catch equation for tons of albacore all 127 observations were used, while the tons of other catch equation was estimated using 57 vessel-years of data for which there was significant fishing activity directed toward other species. Limited observations on catches and effort for some of the individual species other than albacore and difficulty in dissaggregating the other catches and effort for some vessels precluded estimating separate catch equations for all of the non-albacore species. Thus, in certain cases (e.g. where a vessel fishes salmon and crab (SALMCRB)) the equation for catch of other species predicts the aggregate catch for a category of other species given the sum of the effort directed toward each. The results of the catch equation estimations are shown in Table 3.

The results were used to calculate catch elasticities for the three independent variables entering each catch equation. A catch elasticity denotes the percent change in catch for a one percent change in one of the independent variables with all other independent variables held constant. Catch elasticities for effort and carrying capacity are expected to be positive, but not greater than one. An elasticity greater than one suggests expanded use of the factor under consideration, a negative elasticity suggests a reduction in factor use, and an elasticity in the zero to one range is consistent with profit maximizing behavior. It is also hypothesized that as vessels get older, their productivity declines, which would be indicated by a negative catch elasticity for vessel age.

The elasticities (E) calculated for the albacore catch equation with respect to changes in carrying capacity (cap), effort (dalb), and age are:

$E_{cap} = 0.7337$

$E_{dalb} = 0.6627$

$E_{age} = -0.0887$

These elasticities are of the expected sign and magnitude, calculated at the sample mean values. For example, a 10.0% increase, from the sample mean, in the number of days albacore fishing is expected to result in a 6.6% increase in albacore catch when all the other variables remain constant.

The catch elasticities for tons of other species with respect to changes in carrying capacity and age are:

$E_{cap} = -1.4831$

$E_{age} = -0.9029$

The age elasticity reveals that vessels decline in productivity as they get old. The capacity elasticity indicates that the representative albacore troller is of sub-optimal size when fishing for species other than albacore. That is, there will be a disproportionate increase in non-albacore catch if carrying capacity decreases.

Effort elasticities for catches of other species are:

$E_{dtuna} = .9005$

$E_{dsalmon} = 1.1375$

$E_{dlobster} = 2.2120$

$E_{dtuna/gf}$ = .1889

$E_{dsalmon/gf}$ = 1.8156

$E_{dsalmon/crab}$ = 2.9926

$E_{dsalmon/misc}$ = 1.9175

$E_{dgf/misc}$ = 1.1241

All these elasticities have the expected sign. The magnitude of the effort elasticities for salmon, lobster, and salmon and other species indicates that these vessels would experience more than a proportional increase in catch for an increase in corresponding days fished. At first this suggests either misspecification of the equation or the fishermen in the sample are operating at a sub-optimal level in these catch categories -- sub-optimal in the sense the vessel would realize a relatively greater catch by redirecting effort from albacore to salmon, lobster, or to any of the other salmon categories. However, fishermen may not redirect effort toward these species due to differences in ex-vessel prices or fishing costs, or both. Furthermore, fishermen in the sample may be constrained from allocating more effort to salmon, lobster, or salmon and other species because of seasonal availability as well as west coast salmon and lobster fishing regulations.

The groundfish and miscellaneous species category also has an effort elasticity greater than that for albacore. However, because the dependent variable in the catch equation is tons caught rather than value, and in the data set the average value of albacore is substantially greater than the average values for groundfish and miscellaneous species, additional time would be allocated to albacore fishing vis a vis other species -- under profit maximizing conditions -- everything else remaining unchanged.

Although the effort elasticities indicate the expected change in catch in response to a change in effort, it should be further noted that both the albacore equation and other catch equation exhibit constant, short-run catch rates; that is, the catch per day for a particular size and age vessel does not depend on the number of days fished. Given the albacore and other species catch equations, a prediction of ex-vessel revenues is obtained by multiplying the predicted catches by the respective ex-vessel unit prices which are provided by the user of the model. In the case where there is an aggregate catch of non-albacore species, a composite ex-vessel unit price is required.

4.2 Operating Costs

ALBSIM incorporates an engineering-type relationship to predict fuel consumption where fuel consumption is dependent on the vessel's physical characteristics and the total amount of time the vessel spends at sea (days in transit plus days fishing).

Since the data used to estimate ALBSIM do not include observations on fuel consumption, the annual fuel expenditure reported for each vessel was divided by the corresponding annual average diesel fuel price for the Pacific region (Bureau of Labor Statistics, 1975 - 1983) to obtain estimates of actual fuel consumption. The fuel consumption relationship is expressed as:

$$FC = a_{20} + a_{21}DSEA + b_{21}VES + b_{22}(VES * DSEA) + u_2$$

where FC = fuel consumption in gallons

DSEA = number of days vessel is at sea.

Results of estimating the fuel consumption equation are presented in Table 4. As anticipated, fuel consumption increases with the size (represented by capacity and length) and age of the vessel and the amount of time it spends at sea. Fuel cost is derived by multiplying predicted fuel consumption by the fuel price furnished by the model user.

Variable expenditures on items other than fuel and labor include provisions, gear, ice, bait and other miscellaneous variable costs. ALBSIM predicts these costs, in 1982 dollars, as a group through an equation which specifies total, non-fuel, non-labor, operating costs as a function of the vessel's physical characteristics, the amount of time it spends at sea, the species targeted in addition to albacore, and its home port. This relationship is expressed as:

$$TRIP = a_{30} + a_{31}DSEA + b_{31}VES + b_{32}PORTS + b_{33}SPECIES + b_{34}(VES * DSEA) + u_3$$

where TRIP = total non-fuel, non-labor operating costs in 1982 dollars

PORTS = vector of dummy variables for home port location (see Table 2)

SPECIES = a vector of dummy variables denoting the species or species categories targeted other than albacore (see Table 2)

Estimation results for the other trip costs equation are shown in Table 4. With the two sets of dummy variables, the constant term represents a vessel home ported in the San Diego - Los Angeles port area that only fishes for albacore. Not unexpectedly, trip costs increase with increases in vessel size and age, as well as increases in the amount of time spent at sea. Trip costs are highest for vessels home ported in Hawaii, where, of the port areas considered, the cost of living is the highest. For vessels that fish albacore and other species, trip costs will be greatest for those also fishing salmon.

Labor costs include the payments to operator and crew and the associated payroll taxes. For albacore trollers the crew is typically remunerated via a share system, which, for the sample of vessels used to estimate ALBSIM, corresponds to a percentage of the vessel's gross revenues. As a percentage of gross revenues, there was a significant difference in crew share according to size of the vessel: for vessels 75 feet or greater in length, crew share averaged 31% of gross revenues; for vessels less than 75 feet, crew share averaged 21%. These shares also included any payment to the vessel operator. Payroll taxes are calculated as a percentage of crew earnings at the rates of 4% and 2% respectively for the two vessel size classes. ALBSIM predicts a vessel's labor expense based on the predicted gross revenues for the vessel and the appropriate crew share and payroll tax rate.

4.3 Fixed Costs

ALBSIM predicts vessel fixed costs, or the costs associated with owning the vessel, using a two stage procedure. The first stage consists of predicting the vessel's total fixed costs, i.e., the sum of the individual cost items under the fixed cost heading in the cash flow account shown on page 7. To do this, ALBSIM incorporates a total fixed costs equation which relates total fixed costs to the vessel's physical characteristics, home port, the amount of time it spends at sea annually, and the species fished other than albacore. In a strict sense, fixed costs should be insensitive to the amount of time the vessel is at sea or spends fishing. However, for some of the costs categorized as fixed (e.g. scheduled repairs and maintenance, or moorage) it seems reasonable to expect some correlation between the amount of the expenditure and the time spent at sea, and the time spent fishing. A preliminary analysis of the data supported this proposition. Therefore, these variables are included in the total fixed cost specification to enhance the model's predictive power. The total fixed costs equation takes the form:

$$FIXED = a_{40} + a_{41}DSEA + b_{41}VES + b_{42}PORTS + b_{43}SPECIES + u_4$$

where FIXED = total fixed costs in 1982 dollars

Results for the total fixed costs estimation are shown in Table 4. As expected, costs of vessel ownership increase with vessel size and the intensity of vessel use. Fixed costs are significantly higher for vessels home ported in Hawaii and for those that fish groundfish and miscellaneous species in addition to albacore.

The second stage of the fixed cost analysis consists of estimating expenditures for each of the items of fixed cost: interest, maintenance, moorage, insurance, and fees. These costs are estimated on a share basis using a system of equations that expresses the relative expenditure for each fixed cost item as a function of vessel characteristics, vessel activity, home port, and non-albacore target species. The system is estimated under the restriction that the shares must sum to unity. The system of fixed cost share equations can be represented in compact form as:

$$SHR_i = a_{i0} + a_{i1}VES + a_{i2}EFF + b_{i1}PORTS + b_{i2}SPECIES + u_i$$

$$i = 1,2, - -,5$$

subject to $\sum_i SHR_i = 1.0$

where

SHR_1 = interest expense as a proportion of total fixed costs

SHR_2 = maintenance expense as a proportion of total fixed costs

SHR_3 = moorage expense as a proportion of total fixed costs

SHR_4 = fees as a proportion of total fixed costs

SHR_5 = insurance expense as a proportionoftotal fixed costs.

Empirically, if the prediction error for one of the cost shares is positive, then the prediction error of some other share(s) must necessarily be negative. This implies that ordinary least squares is not the be negative. This implies that ordinary least squares is not the appropriate estimation technique, but instead an estimation procedure which uses the additional information about the correlation between errors should be used. Zellner's Seemingly Unrelated Regression estimation is such a procedure and is used here. The correlation of the errors can be explained behaviourly by noting that fishermen may decide to trade-off higher expenses in one category for lower expenses in another. The share equations were first estimated using ordinary least squares and then the error covariance matrix was used to increase the efficiency of estimation. This is done as a system with one equation dropped. In this case, the insurance equation was dropped.[4] With the constraint that the five shares add up to one (1.0), only four shares need to be estimated (see Pindyk and Rubinfeld, 1976). Results of the fixed cost share estimations are presented in Table 5.

An estimate of each fixed cost expenditure, in 1982 dollars, is then derived by multiplying the estimated total fixed costs by each of the respective shares with the insurance expenditure calculated as a residual. The vessel's net cash flow is estimated by then taking the difference between total vessel revenue and the sum of operating, labor and fixed costs. The way in which the catch, variable cost, and fixed cost equations are configured to form ALBSIM is described in the next section.

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[4]The choice as to which equation is dropped is arbitrary. However, ordinary least squares results showed that the insurance share equation had the lowest predictive power; therefore, that equation was dropped from the Seemingly Unrelated Regression estimation.

5. ALBSIM Configuration

To perform the sequence of calculations required to predict an albacore troller's net cash flow, ALBSIM was implemented using a microcomputer based electronic spreadsheet (Tables 6A-6C). To conduct an ALBSIM simulation the user must specify the following:

vessel characteristics
- length (feet)
- capacity (short tons)
- age (years)
- home port

trip characateristics
- days at sea
- days fishing albacore
- days fishing other species
- fuel price ($/gal)
- ex-vessel albacore price ($/ton)
- ex-vessel "other" price ($/ton)[5]
- other species or species category
- year

Once these inputs are entered into the spreadsheet, the program calculates revenues, costs and the vessel's net cash flow in nominal dollars of the year specified. User input is denoted by "***" in Table 6A. This user supplied information is used in the calculations of other variables and in the equations shown in Table 6B.

The spreadsheet has been set up so that most of the information needed as input and the final output fits onto the computer screen. The calculations being made in Table 6B are off the screen, but the output from the equations can be adjusted by the user. For example, Table 6C shows the output for a hypothetical vessel fishing for albacore, tuna, and groundfish out of southern California. (The spreadsheet nomenclature replaces the variable names used above with their cell location in the spreadsheet matrix - e.g. the vessel's carrying capacity, CAP, becomes B3 when entered into the spreadsheet.) If in the example the model user felt that the predicted catch of the other species was inappropriate for the vessel under consideration, by entering the applicable amount of the other catch into cell C20, cells D20, D26, F28, F29, and F30, the cells containing revenue and cash flow output will automatically be changed.

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[5] In the case where the "other" catch is a mixture of west coast commercial species, ALBSIM has been exercised using a weighted average price for these species.

6. Application

To demonstrate ALBSIM several cases from the data set that were not used in the estimations are analyzed.

Case 1. A vessel between 50 and 60 feet long, with a capacity between 20 and 30 short tons, and age between 25 and 30 years in 1982. The vessel was at sea more than 130 days, and fished more than 120 days for albacore only in 1982. The ex-vessel price of albacore for this case is $1,387 per short ton, and the price of fuel is $.94 per gallon.

	Reported	Predicted
Catches (st)		
albacore	46.0	44.5
Revenues		
albacore	$62,350	$61,735
Operating Costs		
fuel	12,500	11,786
trip	8,325	10,543
labor	19,305	12,656
Sub-total	40,130	34,985
Fixed Costs		
interest	13,870	12,248
maintenance	2,000	19,731
moorage	800	2,579
insurance	4,000	15,949
fees	300	2,169
Sub-total	20,970	52,676
Total Costs	61,100	87,661
Net Cash Flow.	1,250	-25,926

[6] In order to maintain confidentiality, the specific vessel characteristics for each case are not revealed.

Case 2. A vessel between 40 and 50 feet long, with a capacity between 10 and 20 short tons, and age between 25 and 35 years in 1981. This vessel was at sea for more than 120 days, fished albacore more than 60 days, and fished salmon more than 60 days in 1981. The ex-vessel price of albacore used in this case is $1,800 per short ton, the ex-vessel price of salmon used is $5,040 per short ton, and the price of fuel used is $.85 per gallon.

	Reported	Predicted
Catches (st)		
albacore	27.5	19.9
salmon	4.2	6.3
Revenues		
albacore	$ --0--	$35,874
salmon	--0--	31,802
Total	60,733	67,676
Operating Costs		
fuel	6,360	7,377
trip	11,530	7,555
labor	8,544	13,813
Sub-total	26,434	28,745
Fixed Costs		
interest	12,275	6,200
maintenance	6,013	10,403
moorage	600	1,681
insurance	2,450	5,586
fees	370	1,790
Sub-total	21,708	25,660
Total Costs	48,142	54,405
Net Cash Flow (1981 dollars)	12,591	13,271

Case 3. A 55 to 65 foot vessel with a capacity between 40 and 50 short tons, and age between 1 and 5 years in 1982. The vessel was at sea for more than 150 days, and fished albacore only for more than 120 days in 1982. In this case $1,387 per short ton is used for the ex-vessel price of albacore, and $.94 per gallon for the price of fuel.

	Reported	Predicted
Catches (st)		
albacore	65.0	63.6
Revenues		
albacore	$77,753	$88,199
Operating Costs		
fuel	26,569	22,580
trip	4,468	9,497
labor	--0--	18,081
Sub-total	31,307	50,158
Fixed Costs		
interest	17,905	20,687
maintenance	10,050	24,715
moorage	1,798	4,382
insurance	3,789	18,238
fees	8,842	3,221
Sub-total	43,384	71,243
Total Costs	74,691	121,401
Net Cash Flow	4,242	-33,202

Case 4. A vessel between 70 and 80 feet long, with a capacity between 60 and 70 short tons, and age between 10 and 20 years in 1980. The vessel was at sea for more than 200 days, and fished albacore more than 160 days, and other tuna more than 20 days in 1980. In this case the ex-vessel price of albacore used is $1,659 per short ton, the ex-vessel of other tuna used is $1,600 per short ton, and the price of fuel used is $.68 per gallon

	Reported	Predicted
Catches (st)		
albacore	83.0	84.2
other tuna	0.3	--0--
Revenues		
albacore	--0--	$139,605
other tuna	--0--	--0--
Total	$129,300	139,605
Operating Costs		
fuel	26,781	28,817
trip	9,737	8,188
labor	30,538	28,619
Sub-total	67,056	65,624
Fixed Costs		
interest	10,576	26,202
maintenance	37,466	59,102
moorage	496	4,464
insurance	9,304	6,390
fees	2,491	--0--
Sub-total	60,333	96,158
Total Cost	127,389	162,082
Net Cash Flow (1980 dollars)	1,911	-22,477

7. Discussion

The demonstration cases reveal some of the strengths and weaknesses of the ALBSIM model. The model is most adept at predicting each vessel's albacore catch, which is not unexpected given the relatively high overall goodness of fit measure (R^2) for the albacore catch equation (relatively high considering the data used to estimate the equations is dominated by cross-sectional observations). Moreover, no problems associated with heteroscedasticity -- a common occurrence when using cross-section data -- were detected in the albacore catch equation, which if present, would likely contribute toward overstating the significance of the equation's predictive ability.

The catch equation for the other species does not perform as well. To a large extent this can be attributed to limited observations on other catches, corresponding effort, the diversity of species making up the other catch, and great variability of other catch for the same vessel year to year, as well as accross vessels having similar physical characteristics and patterns of operation. Therefore, there is a lack of robustness when making predictions of other catch from observations outside the range of those used to estimate the model.

It must also be recognized that when predicting ex-vessel revenue, differences in actual versus predicted revenues reflect not only differences between actual and predicted catches, but also differences in actual and user provided ex-vessel prices. Thus, erroneous catch predictions can be offset inadvertently by compensatory error in the ex-vessel prices selected by the model user when predicting ex-vessel revenues.

Of the operating expenses, ALBSIM predicts fuel cost within 15% of the values reported in the four cases examined. The fuel consumption equation also has a relatively high R^2, the significance of which does not appear to be affected by heteroscedasticity. However, just as revenue calculations depend on the user supplied ex-vessel prices, predicted fuel expenditures depend not only on predicted fuel consumption, but on the user supplied fuel price as well. Predictions of labor cost are derived directly from estimates of ex-vessel revenue and therefore are as precise as estimated catches, user supplied ex-vessel prices and the correspondence of the vessel's actual labor share system to that incorporated in the model. The remaining operating costs are predicted as a group through the other trip costs equation. In the cases analyzed, the predicted other trip costs vary significantly from the reported values. These results are not surprising since vessels with similar physical characteristics and operating patterns (even the same vessels year to year) exhibit considerable variability in the costs which fall in this category. This is borne by the goodness of fit measure for the other trip costs equation which is relatively low even recognizing the dominance of cross-sectional observations in the data set.

Based on the cases examined and the goodness of fit measures, ALBSIM is weakest in predicting vessel fixed costs. As in the prediction of other trip costs, this weakness is probably due to a great deal of variability in the observations on fixed costs in both dimensions of the data set used to estimate the total fixed cost and the fixed cost share equations.

Furthermore, problems of heteroscedasticity were detected in estimating the total fixed cost and fixed cost share equations, which likely result in upward bias in the goodness of fit test statistics for these equations.

The variation in vessel costs and revenues left unexplained by ALBSIM can be partly ascribed to disparity in accounting methods, changes in tax codes, inconstant financial markets, and the preferences of individual vessel owners. Even though ALBSIM does not yield perfect predictions of costs, revenues, and cash flows -- point estimates of revenues or costs will always be questionable -- it does provide reasonable revenue and cost parameters which can be useful when attempting to measure the marginal value of fishing effort. In this regard ALBSIM can furnish fishermen and fisheries administrators with useful information regarding changes in the operating environment of west coast albacore trollers.

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Table 1. Summary statistics for the cost and earnings unbalanced-panel data set.

Variable	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
<u>Catch (tons)</u>					
Albacore	127	32.4	23.6	.2	104.5
Other species	57	12.5	29.7	.3	203.0
<u>Effort</u>					
Days fished albacore	127	73.7	34.8	5.0	172.0
Days fished other	57	56.9	43.8	20.0	300.0
Days at sea	127	115.3	39.2	12.0	210.0
<u>Physical Characteristics</u>					
Length overall (feet)	127	51.7	7.3	32.0	75.0
Capacity (tons)	127	25.5	11.8	3.0	70.0
Age (years)	127	19.4	14.6	.0	58.0
<u>Costs ($1,000's)</u>					
Fixed	127	13.2	11.2	1.5	52.2
Fuel	127	11.3	7.8	3.2	40.6
Trip	127	7.5	4.5	1.1	26.5
Labor	127	8.7	10.7	.0	56.9
Cost Shares (%)					
Fees	127	7.0	7.2	.0	51.7
Equipment and maintenance	127	42.5	20.1	.0	89.4
Interest	127	20.5	20.4	.0	65.8
Insurance	127	22.7	14.2	.0	82.2
Moorage	127	7.3	6.9	.0	33.1

Table 2. Definitions of variable mnemonics.

Dependent Variables:

EQMA	= equipment and maintenance share of fixed costs
FC	= fuel consumption in gallons
FEES	= fees and miscellaneous as a share of fixed costs
FIXED	= total fixed costs in thousands of 1982 dollars
INTE	= interest cost share of fixed costs
INSU	= insurance share of fixed costs
LABOR	= labor cost including payroll tax in thousands of 1982 dollars
MOOR	= moorage and rent as share of fixed costs
TALB	= catch of albacore in short tons
TOTH	= catch of other species in short tons
TRIP	= trip costs (ice, bait, gear, galley, etc.) thousands of 1982 dollars

Predetermined Variables:

EFF = a measure of vessel fishing activity or fishing effort such as:

DALB	= days of albacore fishing
DALBSQ	= DALB * DALB
DFISH	= total number of days fished all species
DGFMIS	= days fishing groundfish and miscellaneous species
DLOBSTER	= days fishing lobster
DSALM	= days fishing salmon
DSALMCRB	= days fishing salmon and crab
DSALMGF	= days fishing salmon and groundfish
DSALMMIS	= days fishing salmon and miscellaneous species (herring, squid, etc.)
DSEA	= days at sea steaming, idle, and fishing
DSEADALB	= DSEA * DALB
DSEASQ	= DSEA * DSEA
DTUNA	= days fishing other tuna
DTUNAGF	= days fishing tuna and groundfish

PORTS[1] = vector of dummy variables for home port location:

HI	= Hawaii
MPNP	= unspecified, or more than one area indicated
NCCA	= northern or central California
ORWA	= Oregon or Washington

SPECIES[2] = a vector of dummy variables denoting the species or species catagory targeted other than albacore

GFMIS	= groundfish and miscellaneous species
LOBSTER	= lobster
SALM	= salmon
SALMCRB	= salmon and crab
SALMGF	= salmon and groundfish

Table 2. (continued)

SALMMIS	=	salmon and miscellaneous species (herring, squid, etc.)
TUNA	=	other tuna
TUNAGF	=	tuna and groundfish
VES = a vector of vessel characteristics		
AGE	=	vessel age in years
AGESQ	=	AGE * AGE
CAP	=	vessel capacity in tons
CAPAGE	=	CAP * AGE
CAPSQ	=	CAP * CAP
LEN	=	vessel overall length in feet
LENCAP	=	LEN * CAP
LENSQ	=	LEN * LEN
VES * EFF = a vector of vessel characteristics and fishing effort interaction terms		
CAPDALB	=	CAP * DALB
CAPDSEA	=	CAP * DSEA

[1]San Diego - Los Angeles home port area is the base case.
[2]Albacore only is the base case.

Table 3. Estimation results for catch equations.

	Albacore (TALB)	Other Species (TOTH)
R**2	.63453739	.58909758
RBAR**2	.62255501	.49977097
SSR	25669.915	20127.064
SEE	14.505487	20.917573
F-STATISTIC	52.94	5.9952
Independent <u>Variable</u>	<u>Coefficient</u>	<u>Coefficient</u>
CONSTANT	-16.12975 (-1.876489)b	14.57281 (.3619939)
CAP	1.209455 (3.629648)a	-.3377517 (-.2430338)
AGE	-.1484619 (-1.442262)c	.1251164E-01 (.7793718E-02)
DALB	.3862112 (4.912684)a	
CAPDALB	-.3725696E-02 (-1.379043)c	
CAPAGE		-.2196737E-01 (-.3363192)
DTUNA		.1701901 (1.357840)c
DSALM		.9767663E-01 (.4960257)
DLOBSTER		.3058222E-01 (.1042846)
DTUNAGF		.5002390E-02 (.6542058E-01)
DSALMGF		.9767663E-01 (.4960257)
DSALMCRB		.5023546 (2.037248)b
DSALMMIS		.6113152 (1.601580)c

Table 3. (continued)

DGFMIS	1.350161 (5.062020)a

Notes: t-statistics in parentheses
a - significant at the 99% level
b - significant at the 95% level
c - significant at the 90% level

Table 4. Estimation results for the fuel consumption, other trip costs and fixed cost equations.

	Fuel consumption (FC)	Other trip costs (TRIP)	Fixed costs (FIXED)
R**2	.62361131	.35827193	.54562963
RBAR**2	.60147080	.26492967	.47476453
SSR	2912.7520	1625.4098	7213.2123
SEE	4.9474142	3.8440152	8.1348792
F-STATISTIC	28.1647	16.1241	7.6986
Independent variable	Coefficient	Coefficient	Coefficient
CONSTANT	-7.968425	-2.921635	-9.915595
	(-.9835813)	(-1.055954)	(-1.961920)b
NCCA		-1.892112	-1.697079
		(-1.710221)b	(-.7211754)
ORWA		.3708714	2.848552
		(.3153586)	(1.123641)
HI		2.496002	14.17605
		(1.671421)c	(4.410325)a
MPNP		-5.862331	-9.227783
		(-2.345187)b	(-1.562270)c
LEN	.2447698		
	(1.501044)c		
LENSQ		.1417694E-02	
		(2.498973)a	
CAP	.5149040		1.632974
	(1.981415)b		(3.576136)a
LENCAP	-.1181099E-01		-.1577351E-01
	(-3.243791)a		(-2.746255)a
AGE	.1985989	.8635873E-01	
	(1.548924)c	(2.371923)a	
AGESQ	-.5731104E-02		.1276294E-01
	(-2.469882)a		(3.200879)a
CAPAGE			-.2347007E-01
			(-3.740727)a

Table 4. (continued)

DSEA	-.3978260E-01 (-1.401754)c	.8170312E-01 (1.976501)b	.5950403E-01 (2.399861)a
DSEASQ		-.2363157E-03 (-1.407286)c	
CAPDSEA	.4651364E-02 (3.687877)a		
TUNA		-5.219284 (-1.625701)c	-12.40637 (-1.768125)b
SALM		1.021486 (.9252243)	-3.850858 (-1.748372)b
LOBSTER		-1.900998 (-.7923983)	-12.04875 (-2.292806)b
TUNAGF		-3.760706 (-1.450345)c	-18.82242 (-3.427295)a
SALMGF		-2.125618 (-.7416811)	3.077885 (.4932753)
SALMCRB		-8.591215 (-3.191109)a	-16.27070 (-2.151564)b
SALMMIS		-4.661404 (-1.929932)b	-2.569591 (-.5076613)
GFMIS		-.3355561 (-.1664704)	6.218109 (1.427443)c

Notes: t-statistics in parentheses
a - significant at the 99% level
b - significant at the 95% level
c - significant at the 90% level

Table 5. Estimation results for the fixed cost share equations.

	Equipment and maintenance (EQMA)	Moorage (MOOR)	Fees (FEES)	Interest (INTE)
R**2	.31337738	.25041045	.36906188	.15384837
RBAR**2	.19145373	.19959082	.32052818	.11888342
SSR	34881.091	4472.2670	4154.3810	44456.559
SEE	18.055235	6.1563437	5.9588195	19.167931
F-STAT	2.5706	4.9272	7.6055	4.3984
Independent variable	Coefficient	Coefficient	Coefficient	Coefficient
CONSTANT	40.82762	17.68847	191.8860	-18.21926
	(.2666529)	(5.124115)a	(3.358062)a	(-1.910008)b
NCCA		-3.899325		
		(-3.120437)a		
ORWA		-5.800285		
		(-4.112610)a		
HI		-1.629772		
		(-.9217693)		
MPNP		.3526071		
		(.1192260)		
LEN	2.755549		-9.723674	
	(.3233385)		(-3.105848)a	
LENSQ	-.3466680E-01		.1242809	
	(-.2893236)		(2.859161)a	
CAP	-2.814087	-.4912478E-01	5.782401	
	(-.4894146)	(-.9154492)	(2.760462)a	
CAPSQ	-.7401137E-02		.4150320E-01	
	(-.1344154)		(2.081202)b	
LENCAP	.4061211E-01		-.1415324	.6190296E-03
	(.2513100)		(-2.412370)a	(.2901954)
DALB	.2415872			
	(1.448545)c			
DALBSQ	-.1669324E-02		.1329500E-02	
	(-1.636608)c		(3.265458)a	
DSEA	-.7187638	-.1183968		.5933047
	(-3.675634)a	(-2.207452)b		(3.655155)a

Table 5. (continued)

DSEASQ	.1663341E-02	.3532269E-03	.9525925E-03	-.1531904E-02
	(2.284692)b	(1.569570)c	(6.230613)	(-2.274227)b
DSEADALB			-.2076056E-02	
			(-4.950053)a	
CAPDSEA	.7515524E-02		-.2370387E-02	
	(2.036661)b		(-1.742910)b	
DFISH				-.7550187E-01
				(-1.825798)b
AGE		.1171808		-.1963304E-01
		(2.841203)a		(-.1690914)
AGESQ	.4878352E-02			
	(1.802329)b			
TUNA	8.924066			
	(.7424904)			
SALM	1.875647			
	(.5403068)			
LOBSTER	12.09046			
	(1.823646)b			
TUNAGF	12.41405			
	(1.638682)c			
SALMGF	-3.352830			
	(-.3573529)			
SALMCRB	-23.29745			
	(-2.350708)b			
SALMMIS	9.080517			
	(1.270912)			
GFMIS	-6.050616			
	(-.9835183)			

Notes: t-statistics in parentheses
a - significant at the 99% level
b - significant at the 95% level
c - significant at the 90% level

Table 6A. ALBSIM Spreadsheet configuration, user inputs.

```
  |    A    ||  B  ||    C    ||  D  |
 1|ALBSIM
 2|       len: ***          year: ***
 3|       cap: ***
 4|       age: ***    PRICES:
 5|      dsea: ***          fuel: ***
 6|      dalb: ***      albacore: ***
 7|      doth: ***         other: ***
 8|HOME PORT:
 9|     sd&la: ***       (choose
10|     n&cca: ***          one)
11|     or&wa: ***
12|        hi: ***
13|CATCH:
14|  albacore:
15|      other species
16|        (one choice)
17|      tuna: ***
18|    salmon: ***
19|   lobster: ***
20|   tuna&gf: ***
21|   salm&gf: ***
22|  salm&crb: ***
23|   salmisc: ***
24|   gf&misc: ***
25|
26|
27|
28|
29|
```

Table 6B. ALBSIM Spreadsheet configuration, calculations.

	A	B	C	D
30				
31	lensq:	B2*B2		
32	capsq:	B3*B3		
33	lencap:	B2*B3		
34	capage:	B3*B4		
35	agesq:	B4*B4		
36	capdsea:	B3*B5		
37	dseasq:	B5*B5		
38	dalbsq:	B6*B6		
39	dfish:	B6+B7		
40	capdalb:	B3*B6		
41				
42	equations:			
43	talb:	-16.13+B3*1.209+B4*-.1485+B6*.3862+B40*-.003726	fees:	191.9+B2*-9.724+B31*.1243+B3*5.782+B32*.0415
44				D43+B33*-.1415+B38*.00133+B37*.0009526
45	toth:	14.57+B3*-.3378+B4*.01251+B34*-.02197		D44+B5*B6*-.002076+B36*-.00237
46		B45+B7*(B17*.1702+B18*.09768+B19*.03058)		
47		B46+B7*(B20*.005002+B21*.09768+B22*.5024)	moorage:	17.69+B10*-3.899+B11*-5.8+B12*-1.63
48		B47+B7*(B23*.6113+B24*1.350)		D47+B3*-.04912+B4*.1172+B5*-.1184+B37*.0003532
49		IF(B48>0,B48,0)		
50				
51	trip:	B9*-2.922+B10*-4.814+B11*-2.551+B12*-.4256	interest:	-18.22+B4*-.01963+B5*.5933+B37*-.001532
52		B51+B31*.001418+B4*.08636+B5*.0817+B37*-.0002363		D51+B39*-.0755+B33*.000619
53		B52+B17*-5.219+B18*1.022+B19*-1.901		
54		B53+B20*-3.761+B21*-2.126+B22*-8.591	eq & ma:	40.83+B2*2.756+B31*-.03467+B3*-2.814+B32*-.007401
55		B54+B23*-4.661+B24*-.3356		D54+B33*.04061+B6*.2416+B38*-.00167
56				D55+B5*-.7188+B37*.001663+B36*.007516+B35*.004878
57	fixed:	B9*-9.916+B10*-11.61+B11*-7.067+B12*4.26		D56+B17*8.924+B18*1.876+B19*12.09+B20*12.41
58		B57+B3*1.633+B35*.01276+B5*.0595		D57+B21*-3.353+B22*-23.3+B23*9.081+B24*-6.051
59		B58+B17*-12.41+B18*-3.851+B19*-12.05+B20*-18.82		
60		B59+B21*3.078+B22*-16.27+B23*-2.57+B24*6.218	insurance:	100-D45-D48-D52-D58
61				
62	fuel:	-7.968+B5*-.03978+B2*.2448+B3*.5149-B33*.01181	deflators:	IF(D2>=82,1.0,0.0)
63		B62+B36*.004651+B4*.1986-B35*.005731		IF(D2=81,.9432,0.0)
64				IF(D2=80,.86035,0.0)
65				IF(D2=79,.78802,0.0)
66				IF(D2=78,.72534,0.0)
67				IF(D2=77,.67533,0.0)
68				D62+D63+D64+D65+D66+D67

Table 6C. ALBSIM Spreadsheet configuration model output.

	A	B	C	D	E	F	G
1	ALBSIM						
2	len:	53	year:	85			
3	cap:	25					
4	age:	10	PRICES:				
5	dsea:	125	fuel:	.93			
6	dalb:	80	albacore:	1200.00			
7	doth:	30	other:	800.00			
8	HOME PORT:						
9	sd&la:	1	(choose				
10	n&cca:	0	one)				
11	or&wa:	0					
12	hi:	0					
13	CATCH:		tons:	$	COSTS:		
14	albacore:		36.05	43264.80	fuel:	12281.05	
15	other	species			trip:	4684.07	
16	(one	choice)			fixed:	20802.50	
17	tuna:	0	.00	.00		fees:	814.80
18	salmon:	0	.00	.00		moor:	1737.58
19	lobster:	0	.00	.00		eq&ma:	10297.71
20	tuna&gf:	1	.91	726.13		inte:	5059.97
21	salm&gf:	0	.00	.00		insu:	2892.44
22	salm&crb:	0	.00	.00			
23	salmisc:	0	.00	.00			
24	gf&misc:	0	.00	.00			
25				=========		========	
26			REVENUE:	43990.93	COST:	37767.62	
27							
28				CASH FLOW:	gross	6223.31	
29					- labor	9018.14	
30					= net	-2794.83	

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