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A Comparison of Demand Models for Alaska Salmon

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1. Introduction

Upon the implementation of the limited entry program in Alaska's commercial salmon fisheries in the 1970's the State of Alaska became heavily involved in aquacultural fisheries enhancement programs. From a purely biological perspective, the programs have enjoyed tremendous success as measured by increased landings for each of the five species of salmon. However, economic theory suggests that the market clearing price will decrease when larger quantities are supplied. Thus whether or not fishermen have benefited from the increased landings depends upon whether or not the reduction in prices has been larger than the increase in quantity.[1]

A market clearing price is determined by conditions on the demand side and on the supply side of a market. On the demand side, higher prices generally imply that less will be demanded. On the supply side, higher prices generally imply that more will be supplied. However, for salmon at the ex-vessel level, the supply in the market is determined by Alaska Department of Fish and Game (ADF&G) biologists who control the escapement levels. Due to this regulation of the market, the price responsiveness of supply at the ex-vessel level is negligible. This means that an important parameter is the price responsiveness at the ex-vessel demand level.

The relationship between price and the quantity demanded can be summarized by the "elasticity of demand" which is defined as the percentage change in quantity demanded due to a one percent change in the price. The inverse of the elasticity of demand is called the "price flexibility"; it measures the

[1]Another measure (ignored in this study) which also determines whether the fishermen benefit from enhancement programs is the additional costs incurred to catch the larger quantity of fish. Additionally, the price and cost measures only examine the benefits to the fishermen. Whether or not the State (fishermen, processors, taxpayers, etc.) benefits also depends upon the cost of the enhancement programs.

percentage change in price due to a one percent change in the quantity. Which measure is used depends upon whether the causal relationship is that quantity depends upon price, in which case the elasticity is the directly observable measure, or whether price depends upon quantity, in which case the price flexibility is the directly observable measure. For salmon, the quantity is determined by ADF&G escapement goals, so the appropriate measure is the price flexibility. If the price flexibility is less than one (or elasticity is greater than one) in absolute value, then an increase in the quantity will increase total revenues. Conversely, if the price flexibility is greater than one (or elasticity of demand is less than one), then an increase in the quantity landed will cause total revenues to decrease.

Due to the importance of the price flexibility parameter, several models have been proposed to measure the price flexibility of demand for Alaskan salmon. This study compares three sets of ex-vessel demand models for Alaskan salmon. The first two models are single equation models, focusing on the demand equation using the notion that the supply is determined by conditions not affected by the market. One of these models was developed in 1984 by Ben Muse of the Commercial Fisheries Entry Commission (CFEC).[2] The other single equation model was developed in 1989 by Nick Ronan of the Institute of Economic and Social Research (ISER) at the University of Alaska, Anchorage under a contract with the ADF&G's Fisheries Research and Enhancement Division (FRED). An alternative model has been proposed in a Master's Thesis by Hongru Zhang (1990) at the University of Alaska Fairbanks (UAF). This model follows DeVortz (1982) in assuming that even though the landings are exogenously determined, the allocation of raw salmon between fresh/frozen and canned salmon is controlled by processors who make this decision based on relative prices and technological factors. Thus instead of simply modelling the ex-vessel demand in isolation from higher levels of the market, Zhang's model estimates ex-vessel demand simultaneously with fresh/frozen and canned supply and demand equations. These equations

[2]Muse actually uses a two equation model for pink and chum salmon. The first equation regresses the January 1 inventory holdings of pink salmon as a function of lagged US landings and the prime rate of interest. The price of the species is then regressed against the estimated pink inventory holdings, exchange rates with Japan, and the quantity of pink and chum salmon. However, his implicit assumption is that the errors of the two equations are unrelated. This, plus the recursive structure of the equations, implies that an equivalent estimation procedure would be to estimate price as a function of all of the exogenous variables. It is for this reason that we refer to the CFEC model as a single equation model.

are estimated using Two-Stage-Least-Squares (2SLS). For convenience of reference, the three models are referred to as the CFEC model, the ISER model, and the 2SLS model, respectively, in the text.

The purpose of this paper is to compare these three models for their ability to predict ex-vessel prices for Alaskan salmon. In addition, we also perform out of sample predictions based on the linear trends of the explanatory variables.

We find that the 2SLS model appears to have superior predictive capability within the sample. This conclusion is based primarily on statistical and graphical analysis of the estimated (or predicted) ex-vessel prices for each model. The 2SLS estimates indicate that the price flexibilities are statistically zero for all species except for pink salmon (for which the prices responsiveness is extremely small), indicating that at the ex-vessel level, the enhancement program serves to increase fishermen's revenues. The processing sector also benefits from enhancement of each species (all processing flexibilities are less than one in absolute value). However, the processing sector price flexibilities are not as low as the harvesting sector price flexibilities except for king salmon. Red salmon have the highest price flexibility (-0.7462 for fresh/frozen red salmon using average price and quantity data from 1978-1988), indicating that the processing sector benefits are the least for red salmon.

The conclusions just stated are based on *partial equilibrium* price response estimates. This means that the ex-vessel price flexibility estimates are based on changes in quantities estimated by assuming that the wholesale prices do not change. In a *general equilibrium* model, changes in the wholesale prices are taken into account. We estimate the general equilibrium price flexibilities using comparative statics techniques for systems of equations. In general, one would expect that these estimates would show a larger price flexibility at the ex-vessel level because increases in landings tend to depress wholesale prices, which, in turn, depress ex-vessel prices. We find that this conclusion is generally supported by the data, but that the conclusion that enhancement programs increase revenues at the ex-vessel level remains unchanged.

All models are estimated using annual state-wide ex-vessel price data. This price includes post season adjustments. We do not differentiate the data by region or by gear type. However, a separate demand function is estimated for each species: king (*Oncorhynchus tshawytscha*), red (*O. kisutch*), silver (*O. nerka*), pink (*O. gorbusha*), and chum (*O. keta*). The data used in the analysis is for the period 1964-1988. This sample is chosen because it covers the entire period for which canned inventory data is available (data for 1989 was not available for the analysis). A detailed description of the data used in the analysis is contained in Appendix A.

There are several sources for the price and quantity data for Alaskan caught salmon. The CFEC data begins in 1975 for ex-vessel data, and in 1984 for wholesale data on canned and fresh/frozen prices and quantities. The ADF&G data covers the period 1964-1985. Thus the two data sets must be combined to obtain a complete data set. The CFEC data differs slightly from the ADF&G data in that the CFEC data excludes data from test fisheries, fishing derbies, and illegally caught fish. The ADF&G data includes these categories. The difference is generally quite small (less than 1% of the quantity from all sources). Each model is estimated using CFEC data from 1975-1988 for ex-vessel level data and using CFEC data from 1984-1988 for wholesale data.

The 2SLS model does not exactly replicate Zhang's (1990) model.[3] His data set differed slightly in the years covered. He had data from 1962-1985 plus data for 1987. We have data from 1964-1988, inclusive. Zhang estimated his model using data transformed by taking the natural logarithm of all variables. We estimate the model using data in natural units. The reason for this difference is that the double-logged functional form implies a constant elasticity (flexibility). The untransformed model allows the elasticity (flexibility) to change as quantities increase. This enables us to ask whether or not there exists a quantity such that further enhancement will depress revenues to the harvesting or processing sector.

[3] This is also true for the CFEC and ISER models. The differences are outlined in more detail in the text.

2 Economic description of the demand models

Since economic data is not generated in a controlled experiment, all of the factors which could be controlled in a laboratory but are not in an actual economy must be taken into account. Demand modelling encompasses determining which variables need to be controlled directly by measuring their effect upon the price variable, and which variables can be relegated to the random noise of the model.

For "normal" goods, the effect of an increase in the income level of consumers should result in an increase in the quantity demanded holding all else (including price) constant. This results in a shift of the demand curve in the sense that on a price and quantity diagram, the location of the entire demand schedule shifts when income or some other variable (other than the price of the commodity) changes. Changes in prices of alternatives goods also can shift the demand curve. If the price of a substitute were to increase, the expected result is that quantity demanded of the commodity would increase; that is, the demand curve would shift out so that a larger quantity would be demanded of the commodity at the same price given the increase in the price of the substitute. Finally, tastes and preferences may also change over time. As an example, increased awareness in health considerations may cause consumers to purchase more fish products in lieu of red meats such as beef.

The foregoing discussion has been concerned with the demand that is faced at the final product (retail) level. However, each of the models considered in this paper focus on the market at the harvesting and processing levels since these are the levels of the market in which Alaskan participation is the greatest. The vertical configuration of the market may be thought of as comprised of several levels. At the ex-vessel demand level, a harvesting sector catches the fish and sells it to the processing sector. The processing sector prepares the fish by converting the raw fish into fresh/frozen, canned, or a variety of other processed products (smoked, cured, etc.). The processors goods are demanded by wholesalers, brokers, and other processing plants. The goods produced by the wholesale level are then purchased by retailers (this demand is called the wholesale demand) and, ultimately, to consumers (in the final product, or retail demand). Thus occurrences in the wholesale and final goods markets can effect the processor and ex-vessel markets.

The demand for raw products such as the demand faced at the ex-vessel level involves a variables which directly and indirectly effect the decisions of processors. Processors are buying a raw product and are turning it into various processed commodities. Thus the prices for processed products should act as shifters for the demand at the ex-vessel level. In particular, an increase in the price of a processed output should have the effect of increasing the quantity that would be demanded of the raw commodity, or, conversely of increasing the price that the firm would be willing to pay for the same quantity of the commodity. Thus the ex-vessel demand is effected by conditions at the processing level.

Similarly, factors which influence the demand for the processor's goods are factors which affect the markets for the wholesalers and brokers who purchase the processed goods. For example, if at the beginning of the season the holdings of inventories from the previous year's harvest is high, this should have the effect of decreasing (shifting in) the demand for the processed product. Other factors, such as the cost of holding the product in storage (eg., the cost of borrowing money) will also act as a demand shifter at the processing level.

Unfortunately, for Alaska salmon, transactions between wholesalers and retailers are not observed. A major data limitation is that price and quantity data above the processing level is costly to obtain on a time series basis. This means that the demand functions for the retail and wholesale levels are not observable given the data available for this analysis. However, we expect that factors which influence these markets will have an influence on the demand faced by processors. Thus income, population, and other shifters at the higher, unobservable levels may be included in the demand at the processing level. Each of the models reviewed in this paper take these considerations into account in one form or another.

Another set of variables which impacts the demand for Alaskan salmon are due to the fact that much of Alaska's salmon is exported. Fresh/Frozen salmon products are primarily consumed by domestic or Japanese consumers, and canned products are primarily consumed by domestic or United Kingdom consumers. Muse (1984) reports evidence that the Japanese are a primary consumer of exported fresh/frozen salmon products and that the United Kingdom is a major consumer of exported canned salmon products. Thus the price levels in each of these countries, relative to the US price levels, will influence the demand for Alaskan salmon products. For example, an increase in the exchange rate between the US dollar and the Japanese *yen* (expressed as *yen*/$) means that a dollar purchases more *yen* (or, conversely, that it now takes more *yen* to purchase a dollars worth of US goods), thus the price of US goods relative to Japanese goods has increased, so US salmon has become more expensive to the Japanese. This will result in a decrease in the quantity of salmon demanded by the Japanese. The exchange rate between the US and the UK would have a similar interpretation. In general, the trend has been for the exchange rate between the US and Japan to decrease (the dollar buys less *yen*), so the exchange rate relationship should have increased Japanese demand for US salmon. The exchange rate between the US and the UK has increased over time (the dollar buys more Sterling Pounds), thus the exchange rate relationship should have decreased the demand for Alaskan salmon by the United Kingdom. It is interesting to note that the market has in fact shifted from an emphasis in canned to an emphasis in fresh/frozen products.

Economic theory is based on relative prices. That is, what is important is how prices change relative to one another. For example, if all prices increase at the same percentage rate, then the relative price ratio between a pair of prices will not have changed. It is for this reason that economists convert prices into constant dollars, that is, price changes which affect all prices in the same way are removed by "deflating" prices. In this way, prices between two different years may be compared. All prices in this study have been converted into 1988 dollars by using the gross national product deflator (which was the only deflator that could be found that was reported consistently across nations).

While it is important to remove inflationary effects from relative prices, it is just as important to express the rental cost of money (the interest rate) in real terms. The reason is that if interest rates are expressed in nominal terms, one has ignored the fact that inflation has reduced the value of the money that is being paid back on a loan. We use the Fisher equation in its simplest form to convert nominal interest rates into real interest rates. The equation is

$$\rho = r - dp/dt,$$

where ρ is the real rate of interest, r is the nominal rate of interest, and dp/dt is the inflation rate.

Similarly, it is real exchange rates that matter, not nominal exchange rates. The nominal exchange rate, say between the yen and the dollar, given by E_n = ¥/$ is an inappropriate measure of the exchange rate when prices are in real (adjusted for inflation) terms. If prices are deflated in each country by a deflator i_{us}, i_{jp}, i_{uk}, (respectively, for the US, Japan, and the UK) so that the real prices are given by $¥_r$ = ¥/i_{jp}, and $\$_r = \$/i_{us}$, then the real exchange rate E_r, which shows the relationship between real prices, is given by

$$E_r = E_n(i_{us}/i_{jp}).$$

It is with these general observations in mind that we now turn to a description of the three models being compared.

The CFEC models (Muse, 1984)

Muse (1984) estimated models for ex-vessel demand for each of the five species. Each model assumes that the supply of the species at the ex-vessel level is independent of price since it is determined by regulatory edict rather than due to marginal economic decisions. This assumption had been made by Terry, et al (1980) and others in estimation of ex-vessel demand. The statistical problem given these assumptions it to take into account factors which shift the demand curves so that the relationship between price and quantity may be determined. Muse identified a potential shifter as the exchange rate between the US and Japan.[4] However, he used the nominal exchange rate which we have shown to be incorrect.

For king and silver, this shifter was deemed sufficient, and the entire demand equation consisted of

$$\text{Price}_{i,t} = a0 + a1^*(\text{Quantity silver}) + a2^*(\text{Exchange rate, yen/\$})$$

for i = King, silver.

For pink and chum salmon, Muse specified two shifters in addition to the Japanese exchange rate.[5] One shifter is that in each of the pink and chum equations, the other quantity (eg., pink in the chum equation) appear as arguments as recognition that the species may be substitutes. The other shifter is a forecast of the inventory of pink salmon. He estimates the forecasted inventory as a function of the lagged US landings of pink salmon and the prime rate of interest (also in nominal terms). The pair of equations estimated are

January 1 Pink Inventory forecast equation:

$$\text{Pink Inventory} = a0 + a1^*(\text{US Pink landings, t-1}) + a2^*(\text{prime rate})$$

Ex-vessel demand equation:

$$\text{Price(i)} = b0 + b1^*(\text{Pink landings}) + b2^*(\text{chum landings}) + b3^*(\textit{yen}/\$) + b4^*(\text{Pink Inventory})$$

for i = Pink, Chum

The equation for Red salmon ex-vessel price is the most ad hoc of the equations in the model. Muse estimates the prices of Red salmon simply as a function of the ex-vessel price of Chum.

$$\text{Price red} = c0 + c1^*(\text{price chum})$$

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[4]Muse argues that the exchange rate between the US and Japan is appropriate even for species such as Pink which are primarily canned because the Japanese are a large supplier in the UK canned salmon market.

[5]Muse measured the exchange rates as dollar/*yen*, which is the inverse of what each of the other models detailed in this paper use. To allow for consistent interpretation, exchange rates are measured as *yen*/dollar.

A criticism of these models is that they exclude potential shifters such as population and income. If it is theoretically correct to have included these variables, then to omit them biases the estimation results. (Muse recognized these problems, and warned of them.) Other problems, such as the use of nominal exchange rates and a nominal interest rate have been corrected in the versions we estimate below. As the nominal interest rate has been greater than the real (adjusted for inflation) interest rate over the sample period, this would tend to understate the impact of a change in the real interest rate. As the estimated real exchange rates are smaller than the nominal exchange rates, the impact of a change in exchange rates would be overstated. In this paper, these models are estimated with the data adjusted for inflation, and the estimated coefficients are biased in the directions indicated.

The ISER models (Ronan, 1989)

Ronan (1989) estimated a series of four models using linear and log-linear functional forms and lagged and contemporaneous landings to predict price. Each of the models used only one shifter, the nominal exchange rates. The models are of the form

Ex-vessel price = a0 + a1*(Quantity landed) + a2*(*yen*/dollar)

or

Ex-vessel price = a0 + a1*(Quantity landed, t-1) + a2*(*yen*/dollar)

where the data (both independent and dependent variables) are either logged or left in natural units. Ronan used nominal exchange rates in his estimation procedures. We use the real exchange rates in the estimation below. Also, we only report the linear (variables left in natural units) versions of the models.

2SLS model (Zhang, 1990)

Again, the basic idea behind the 2SLS model is that even though the supply of salmon is fixed in each season at the ex-vessel level, there still remains an allocation decision which must be made by processors. Under the assumption that processing firms choose the allocation of canned and fresh/frozen fish from the quantity of landings, one needs to postulate a model which describes how the market conditions for the canned and frozen products effect the ex-vessel price.

A simple formulation of the optimization problem by a representative competitive firm makes clear the relationship between ex-vessel demand and the variables from the processor demand equations. Let P_x be the exvessel price, P_c be the canned price, and P_f be the fresh/frozen price. Then a processor chooses Q_c, and Q_f, the canned quantity supplied, and the fresh/frozen quantity supplied, respectively, to maximize

$$\pi(Q_f,Q_c|Q_x) = P_cQ_c + P_fQ_f - P_xQ_x,$$

subject to a production relationship between the outputs Q_f and Q_c and the input (ex-vessel landings) Q_x which we denote by,

$$Q_x = f(Q_c,Q_f).$$

The optimization program is thus to choose $\{Qf,Qc\}$ to maximize

$$L = P_cQ_c + P_fQ_f - P_xQ_x + \lambda[Q_x - f(Q_c,Q_f)].$$

The system of first order conditions are

$$P_f - \lambda\, \delta f/\delta Q_f = 0$$
$$P_c - \lambda\, \delta f/\delta Q_c = 0$$
$$Q_x - f(Q_c,Q_f) = 0.$$

If we solve this system of equations implicitly for the two processor output quantities (and the Lagrange multiplier which can be eliminated by the equating the first two first order conditions), and each of these equations will be a function of the two output prices in the system and the landings quantity. Thus the system of supply and input demand equations is of the form

$$Q_f^* = Q_f(P_c, P_f, Q_x)$$
$$Q_c^* = Q_c(P_c, P_f, Q_x)$$
$$\lambda^* = Q_c(P_c, P_f, Q_x)$$

The ex-vessel demand may be obtained by substituting in for each of the variables and creating an indirect function

$$M(Q_x) = P_c Q_c^* + P_f Q_f^* - P_x Q_x + \lambda^*[Q_x - f(Q_c^*, Q_f^*)].$$

If we differentiate this function with respect to the landings Q_x, we obtain the familiar envelope theorem result that[6]

$$P_x = \lambda^*(P_c, P_f, Q_x).$$

The prices in the two processing output markets are determined by the demands in those markets as well as by the supply in those markets. This means that the output prices are endogenous variables in the system encompassing the output supply equations plus the ex-vessel demand equation and the processing demand equations yet to be specified. The demand equations that the processors face depend upon the conditions at the wholesale and the retail levels that exist between the processors and the final consumers. Since final consumption data as well as wholesale data is not available, the method used (following Zhang) is to assume that the demand curves faced by processors reflects conditions at both the wholesale and at the retail level.

[6] This result may be seen by preforming the differentiation and then using the implicit functions from the first order conditions of the original maximization problem.

This means that the variables included in the output demand equations are: income, the price of a substitute (canned tuna), interest rates (to reflect holding costs), and inventory holdings (to reflect the scarcity value of the species. Since the majority of frozen salmon products in Alaska go to Japan or to the continental U.S., the weighted average (with populations as the weights) of U.S. and Japanese per capita incomes is used income in the frozen demand equation. In the canned demand equation, income is the weighted average of U.S. and U.K. incomes since much of the canned salmon goes to the U.K. All prices and incomes are in real 1988 dollars. Exchange rates and interest rates have also been converted into real terms. Population is in millions and is the sum of the populations of the major consuming countries (Japan and the US for fresh/frozen and the UK and US for the canned). Inventories for fresh/frozen and canned inventories are measured in thousands of pounds of holdings on June 30 of each year.

The inverse (price dependent) demand for the two output goods are,

$P_{f,i} = P_{f,i}$(Fresh/frozen Quantity, Tuna Price, Real Interest rates, Population US+Japan, Exchange rate yen/dollar, Weighted Real Income, Fresh/frozen Inventory)

$P_{c,i} = P_{c,i}$(Canned Quantity, Tuna Price, Real Interest rates, Population US+UK, Exchange rate pound/dollar, Weighted Real Income, Canned Inventory)

These two equations plus the two supply equations and the demand equation at the ex-vessel level, plus the identity that the quantity demanded at the ex-vessel level equals the quantity supplied at the ex-vessel level complete the system of equations.

3 Estimation Results Using Annual Data 1964–1988

In the estimation of the models described in Section 2, we correct for first order autocorrelation when the data indicates that this type of serial correlation is significant. We test for autocorrelation by first looking at the Durbin–Watson test statistic, and then by regressing the actual residuals on the lagged residuals plus the explanatory variables in the equation. This method gives an estimate of first order autocorrelation that is asymptotically distributed as a t-distribution. Throughout the discussion we refer to the estimate of ρ, where ρ is defined as

$$Y_t = X_t\beta + e_t, \text{ where } e_t = \rho e_{t-1} + u_t, \text{ and } u_t \text{ is distributed as } N(0,\sigma^2).$$

We also look for signs of heteroskedasticity and for bias in the prediction, but this analysis is left until Section 4 where we plot the model predictions against the actual values for the ex-vessel prices. All of the ex-vessel models are estimated as price dependent models.

3.1 CFEC model estimation results

Again, it should be noted that the variables in this data set differ slightly from those used by Muse (1984). We use real interest rates and real exchange rates, and the exchange rate is defined as yen/dollar. We measure the landings quantity in millions of pounds instead of thousands of metric tons. In addition, we have used July 1 inventory data instead of January 1 inventory data. Thus the coefficients are not directly comparable. In this section we report the linear version of his model.

KING: For king salmon the estimated equation is given in Table 3.1.1. The estimated regression equation suggests that the price of king salmon is not related to the quantity of silver salmon landed since the coefficient on silver quantity is not statistically significant. An increase in the yen/dollar exchange rate is small but statistically significant. The coefficient indicates that an increase in the exchange rate of one more yen per dollar would decrease the price of king salmon by 4/1000 of a dollar, or by less than 1/2 of a cent. The Durbin-Watson (DW) statistic is low, but is in the inconclusive region.[7] The R statistic is low, 0.402, indicating that this equation explains approximately 60% of the variance of king salmon prices.

RED: The estimated demand equation for red salmon is given in Table 3.2.2. This equation was corrected for first order autocorrelation using a point estimate of $\rho=0.684$, where ρ is the autocorrelation coefficient. The regression equation indicates that the price of pink salmon fails to predict red salmon prices.

SILVER: The estimating equation for silver salmon is given in Table 3.1.3. The silver ex-vessel price equation is also corrected for autocorrelation with an estimated r=0.399. The silver equation does not fit well, with all variables other than the intercept insignificant.

PINK: Both the pink and chum equations are estimated using recursively by estimating the inventory equation first and using the estimated pink inventory holdings in place of the actual holdings in the demand equation estimations. The results of the pink salmon inventory forecast equation estimation are contained in Table 3.1.4a. This equation indicates that an increase in US pink landings in the previous year by a million pounds increases the June 30 inventory holdings by 108,000 pounds. The US prime rate of interest is not statistically significant. The equation explains less than 50% of the variance in inventory holdings as measured by the R statistic.

[7]In addition to the Durbin-Watson statistic, we estimate the coeficient for first order autocorrelation by regressing the observed errors in time t on lagged errors and the independent variables. This method gives an asypmptotically consistent estimate of the autocorrelation coefficient, and the estimated t-ratio for this coefficient is asymptotically normally distributed. We correct for autocorrelation if the coefficient is significant at the 10% (one-tailed) level.

The pink salmon demand equation is given in Table 3.1.4b. The coefficient for pink landings QXPINK is -0.000022, which means that an increase in the quantity of pink salmon landings by a 10^9 pounds would decrease the price by 2.2 cents. Thus price is not very responsive to changes in the quantity, although the response is significantly different from zero. The Japanese exchange rate coefficient ERJAPAN is also statistically significant, indicating that an increase in the yen/dollar ratio by 10 yen would lower the pink salmon price by 1.7 cents. The equation explains 60.9% of the variation in the pink salmon price as indicated by the $\bar{R}$ statistic.

CHUM: The estimation results for the chum equation are contained in table 3.1.5. The coefficient for the quantity landed of pink salmon is statistically significant, but is quite small (an increase in the landings by a billion pounds lowers the chum price by 3 cents). The coefficient for chum quantity is insignificant, indicating that chum prices are not affected by chum landings. However, pink inventories and Japanese exchange rates are significant, each having the expected sign. The DW statistic is low, but in the inconclusive region. Overall, the equation explains about 60% of the variation in chum prices.

Table 3.1.1: CFEC Linear Ex-vessel Demand Equation Estimation (1964-1988)

KING

Valid cases:	25	Dependent variable:	PXKING
Total SS:	6.552	Degrees of freedom:	22
R-squared:	0.452	Rbar-squared:	0.402
Residual SS:	3.590	Std error of est:	0.404
F(2,22):	9.075	Probability of F:	0.001
Durbin-Watson:	1.398		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	3.410621	0.612707	5.566477	0.000	---	---
QXSILV	-0.011570	0.009948	-1.163044	0.257	-0.278917	0.366218
ERJAPAN	-0.004403	0.001232	-3.572793	0.002	-0.856815	-0.646806

Table 3.1.2: CFEC Linear Ex-vessel Demand Equation Estimation (1964-1988)

RED

rho & asymptotic t-ratio
0.684
2.748

Valid cases:	24	Dependent variable:	PXRED
Total SS:	12.706	Degrees of freedom:	22
R-squared:	0.097	Rbar-squared:	0.056
Residual SS:	11.469	Std error of est:	0.722
F(1,22):	2.372	Probability of F:	0.138
Durbin-Watson:	2.061		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	-1.196109	0.383769	-3.116737	0.005	---	---
PXPINK	0.672787	0.436807	1.540239	0.138	0.311989	0.311989

Table 3.1.3 CFEC Linear Ex-vessel Demand Equation Estimation (1964-1988)

SILVER

rho & asymptotic t-ratio
0.398
1.853

Valid cases:	24	Dependent variable:	PXSILV
Total SS:	8.527	Degrees of freedom:	21
R-squared:	0.007	Rbar-squared:	-0.088
Residual SS:	8.471	Std error of est:	0.635
F(2,21):	0.070	Probability of F:	0.933
Durbin-Watson:	1.562		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	-1.144593	0.609983	-1.876432	0.075	---	---
QXSILV	-0.000291	0.008401	-0.034638	0.973	-0.007938	0.018331
ERJAPAN	-0.000618	0.001699	-0.363679	0.720	-0.083347	-0.080845

Table 3.1.4a CFEC Model Pink Inventory Equation Estimation (1964-1988)

Valid cases:	25	Dependent variable:	Pink Inventory
Total SS:	2905321834.470	Degrees of freedom:	22
R-squared:	0.487	Rbar-squared:	0.440
Residual SS:	1490995553.156	Std error of est:	8232.407
F(2,22):	10.434	Probability of F:	0.001
Durbin-Watson:	1.430		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	35.623830	3822.151727	0.009320	0.993	---	---
USPink(t-1)	0.108164	0.037249	2.903806	0.008	0.804939	0.693849
USPrime	-485.955726	1011.934206	-0.480225	0.636	-0.133119	0.538618

Table 3.1.4b CFEC Linear Ex-vessel Demand Equation Estimation (1964-1988)

PINK

Valid cases:	25	Dependent variable:	PXPINK3
Total SS:	0.673	Degrees of freedom:	20
R-squared:	0.674	Rbar-squared:	0.609
Residual SS:	0.219	Std error of est:	0.105
F(4,20):	10.347	Probability of F:	0.000
Durbin-Watson:	1.462		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	1.635864	0.256815	6.369823	0.000	---	---
QXPINK	-0.000022	0.000005	-4.709578	0.000	-1.019604	-0.606811
QXCHUM	-0.000426	0.000496	-0.858086	0.401	-0.200345	-0.480564
PINKINV	-0.002411	0.001740	-1.385590	0.181	-0.366100	-0.254235
ERJAPAN	-0.001740	0.000437	-3.981118	0.001	-1.056478	0.126696

Table 3.1.5 CFEC Linear Ex-vessel Demand Equation Estimation (1964-1988)

CHUM

Valid cases:	25	Dependent variable:	PXCHUM3
Total SS:	1.271	Degrees of freedom:	20
R-squared:	0.522	Rbar-squared:	0.427
Residual SS:	0.607	Std error of est:	0.174
F(4,20):	5.470	Probability of F:	0.004
Durbin-Watson:	1.309		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	2.333654	0.427348	5.460782	0.000	---	---
QXPINK	-0.000030	0.000008	-3.808702	0.001	-0.998316	-0.303977
QXCHUM	0.000471	0.000826	0.570101	0.575	0.161154	-0.141874
PINKINV	-0.005878	0.002895	-2.030051	0.056	-0.649403	-0.037425
ERJAPAN	-0.002975	0.000727	-4.090826	0.001	-1.314341	-0.165513

3.2 ISER model estimation results

In this section, we present and discuss the results of estimation of the ISER models (Ronan, 1989) using 1964-1988 data. As with the CFEC models, we have estimated these models using real exchange rates rather than with nominal exchange rates. As expected, the results differ slightly from Ronan's results, however, they appear to be very similar in general terms.[8] Two regressions were run per species, one using lagged quantities and one using contemporaneous quantities, each measured in natural units. The discussions are confined to the results using contemporaneous independent variables. The exchange rate between the US and Japan is measured as yen/dollar. The quantity variables are measured in millions of pounds for contemporaneous and lagged quantities.

KING: The king salmon equation estimation results are in Table 3.2.1. The dependent variable is the price of king salmon. Both the contemporaneous quantity and lagged quantity equations have been corrected first order autocorrelation with ρ approximately equal to 0.5. The DW statistic on the corrected model indicates that the residuals do not show signs of serial correlation. Exchange rates are statistically significant in each equation (an increase in the yen/dollar ratio by 10 yen/dollar will decrease the king price by between 3 and 4 cents). The coefficient for king landings QXKING, and LQXKING are statistically indistinguishible from zero, indicating that king salmon prices are not responsive to king landings. However, the R statistics are low (R = 0.372 and R = 0.364 for the contemporaneous and lagged quantity equations, respectively).

RED: The red salmon equation is given in Table 3.2.2. The red salmon equation shows much better fit than the king salmon equation. All variables are significant at the 99% confidence level, and the R are 0.587, and 0.594, respectively in the contemporaneous and lagged quantity equations. In each case, the DW is very close to 2, indicating that there is no evidence of serial correlation. In the contemporaneous landings equation, an increase in the red salmon landings by 10 million pounds will

[8] There are two other differences between the models used here and the model estimated by Ronan: first, Ronan used data from 1970-1986 to estimate his model (predicting on the observations for 1987 and 1988); second, Ronan used units which are accurate to the pound, our units have been rounded at the 1000 pound level for all data except the CFEC data (from 1975-1988).

decrease the red salmon price by 3.7 cents, and an increase in the yen/dollar ratio by 10 yen will decrease the price by about 5 cents. These parameter values hold for the equation using lagged quantities also.

SILVER: The silver salmon equation estimates are given in Table 3.2.3. The silver equations are each corrected for positive autocorrelation (with ρ approximately equal to 0.4). The parameter estimates for quantity and exchange rates in the contemporaneous quantity equation are statistically insignificant. However, when lagged quantities are used as the explanatory variable, the estimates of each of the parameters are significantly different from zero at the 99% confidence level. An increase in the lagged quantity landed by a million pounds will decrease the contemporaneous price by 2.6 cents per pound, and an increase in the exchange rate by 10 yen per dollar will decrease the price by 3.2 cents.

PINK: The pink salmon equation estimates are given in Table 3.2.4. The pink salmon equation using contemporaneous variables has an $R = 0.25$, and a DW in the inconclusive region for positive autocorrelation. The quantity of pink salmon has a significant coefficient, indicating that an increase in the quantity of pink salmon by 10 million pounds decreases the price by 1.6 cents. The Japanese exchange rate is not significant at the 10% confidence level. When lagged quantity is used as an explanatory variable, the coefficients for both quantity and exchange rates double in magnitude and significance.

CHUM: The equation estimates for chum are contained in Table 3.2.5. The chum equations are each corrected for positive autocorrelation with a ρ approximately equal to 0.6. In each case, the coefficients for chum landings (contemporaneous and lagged) and exchange rates are insignificant. Thus the equation has no explanatory power relative to a simple prediction of the mean for explaining the variance of chum salmon prices.

Table 3.2.1: ISER Q(t) model Ex-vessel Demand Equation Estimation (1964-1988)

KING

rho & asymptotic t-ratio
0.551
2.374

second order rho & asymptotic t-ratios
0.440 0.210
1.727 0.824

corrected for ar(1) since rho significant at 5% one-tail level

Valid cases:	24	Dependent variable:	PXKING
Total SS:	3.641	Degrees of freedom:	21
R-squared:	0.200	Rbar-squared:	0.124
Residual SS:	2.912	Std error of est:	0.372
F(2,21):	2.628	Probability of F:	0.096
Durbin-Watson:	2.216		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	1.384245	0.357486	3.872161	0.001	---	---
QXKING	-0.023172	0.042664	-0.543128	0.593	-0.110118	0.015808
ERJAPAN	-0.003270	0.001427	-2.291224	0.032	-0.464541	-0.434691

ISER Q(t-1) model Ex-vessel Demand Equation Estimation (1964-1988)

KING

rho & asymptotic t-ratio
0.435
2.027

second order rho & asymptotic t-ratios
0.291 0.277
1.197 1.090

corrected for ar(1) since rho significant at 5% one-tail level

Valid cases:	24	Dependent variable:	PXKING
Total SS:	3.937	Degrees of freedom:	21
R-squared:	0.293	Rbar-squared:	0.225
Residual SS:	2.785	Std error of est:	0.364
F(2,21):	4.345	Probability of F:	0.026
Durbin-Watson:	2.136		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	2.012729	0.478289	4.208185	0.000	---	---
LQXKING	-0.047743	0.044390	-1.075524	0.294	-0.223389	0.061426
ERJAPAN	-0.003834	0.001309	-2.928658	0.008	-0.608289	-0.503693

Table 3.2.2: ISER Q(t) model Ex-vessel Demand Equation Estimation (1964-1988)

RED

rho & asymptotic t-ratio
-0.110
-0.482

second order rho & asymptotic t-ratios
-0.095 -0.040
-0.405 -0.176

not corrected for ar(1) since rho not significant at 5% 1-tail level

Valid cases:	25	Dependent variable:	PXRED
Total SS:	4.074	Degrees of freedom:	22
R-squared:	0.622	Rbar-squared:	0.587
Residual SS:	1.542	Std error of est:	0.265
F(2,22):	18.062	Probability of F:	0.000
Durbin-Watson:	2.038		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	3.240162	0.419963	7.715353	0.000	---	---
QXRED	-0.003671	0.001110	-3.307628	0.003	-0.696155	0.244411
ERJAPAN	-0.004873	0.000853	-5.714257	0.000	-1.202677	-0.658242

ISER Q(t-1) model Ex-vessel Demand Equation Estimation (1964-1988)

RED

rho & asymptotic t-ratio
-0.358
-1.415

second order rho & asymptotic t-ratios
-0.576 -0.326
-2.033 -1.189

not corrected for ar(1) since rho not significant at 5% 1-tail level

Valid cases:	25	Dependent variable:	PXRED
Total SS:	4.074	Degrees of freedom:	22
R-squared:	0.628	Rbar-squared:	0.594
Residual SS:	1.517	Std error of est:	0.263
F(2,22):	18.530	Probability of F:	0.000
Durbin-Watson:	2.224		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	3.250536	0.414200	7.847746	0.000	---	---
LQXRED	-0.003720	0.001099	-3.386869	0.003	-0.715779	0.247340
ERJAPAN	-0.004952	0.000856	-5.783406	0.000	-1.222262	-0.658242

Table 3.2.3: ISER Q(t) model Ex-vessel Demand Equation Estimation (1964-1988)

SILVER

rho & asymptotic t-ratio
0.398
1.853

second order rho & asymptotic t-ratios
0.315 0.192
1.315 0.759

corrected for ar(1) since rho significant at 5% one-tail level

Valid cases:	24	Dependent variable:	PXSILV
Total SS:	2.703	Degrees of freedom:	21
R-squared:	0.049	Rbar-squared:	-0.042
Residual SS:	2.572	Std error of est:	0.350
F(2,21):	0.537	Probability of F:	0.592
Durbin-Watson:	1.490		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	1.061642	0.342936	3.095744	0.005	---	---
QXSILV	-0.003884	0.008807	-0.441071	0.664	-0.112091	0.030412
ERJAPAN	-0.001302	0.001269	-1.026264	0.316	-0.260808	-0.199563

ISER Q(t-1) model Ex-vessel Demand Equation Estimation (1964-1988)

SILVER

rho & asymptotic t-ratio
0.383
1.724

second order rho & asymptotic t-ratios
0.365 0.129
1.536 0.563

corrected for ar(1) since rho significant at 5% one-tail level

Valid cases:	24	Dependent variable:	PXSILV
Total SS:	2.735	Degrees of freedom:	21
R-squared:	0.381	Rbar-squared:	0.322
Residual SS:	1.693	Std error of est:	0.284
F(2,21):	6.468	Probability of F:	0.006
Durbin-Watson:	1.729		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	1.770006	0.298946	5.920827	0.000	---	---
LQXSILV	-0.026184	0.007692	-3.404273	0.003	-0.733620	-0.345037
ERJAPAN	-0.003172	0.001063	-2.982644	0.007	-0.642759	-0.199246

Table 3.2.4: ISER Q(t) model Ex-vessel Demand Equation Estimation (1964-1988)

PINK

rho & asymptotic t-ratio
0.313
1.369

second order rho & asymptotic t-ratios
0.218 0.197
0.907 0.795

not corrected for ar(1) since rho not significant at 5% 1-tail level

Valid cases:	25	Dependent variable:	PXPINK
Total SS:	0.673	Degrees of freedom:	22
R-squared:	0.313	Rbar-squared:	0.250
Residual SS:	0.462	Std error of est:	0.145
F(2,22):	5.009	Probability of F:	0.016
Durbin-Watson:	1.355		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	0.951299	0.202818	4.690408	0.000	---	---
QXPINK	-0.001606	0.000521	-3.082982	0.005	-0.755818	-0.480564
ERJAPAN	-0.000654	0.000404	-1.619958	0.119	-0.397146	0.126696

ISER Q(t-1) model Ex-vessel Demand Equation Estimation (1964-1988)

PINK

rho & asymptotic t-ratio
-0.045
-0.197

second order rho & asymptotic t-ratios
-0.028 0.337
-0.122 1.574

not corrected for ar(1) since rho not significant at 5% 1-tail level

Valid cases:	25	Dependent variable:	PXPINK
Total SS:	0.673	Degrees of freedom:	22
R-squared:	0.638	Rbar-squared:	0.605
Residual SS:	0.244	Std error of est:	0.105
F(2,22):	19.386	Probability of F:	0.000
Durbin-Watson:	2.047		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	1.314862	0.164775	7.979768	0.000	---	---
LQXPINK	-0.002577	0.000419	-6.147925	0.000	-1.211327	-0.609606
ERJAPAN	-0.001306	0.000324	-4.023466	0.001	-0.792745	0.126696

Table 3.2.5: ISER Q(t) model Ex-vessel Demand Equation Estimation (1964-1988)

CHUM

rho & asymptotic t-ratio
0.653
2.848

second order rho & asymptotic t-ratios
0.431 0.229
1.334 0.746

corrected for ar(1) since rho significant at 5% one-tail level

Valid cases:	24	Dependent variable:	PXCHUM
Total SS:	0.593	Degrees of freedom:	21
R-squared:	0.027	Rbar-squared:	-0.066
Residual SS:	0.577	Std error of est:	0.166
F(2,21):	0.288	Probability of F:	0.752
Durbin-Watson:	1.713		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	0.278422	0.118440	2.350742	0.029	---	---
QXCHUM	-0.000114	0.001920	-0.059347	0.953	-0.014226	0.060219
ERJAPAN	-0.000554	0.000784	-0.706020	0.488	-0.169246	-0.162988

ISER Q(t-1) model Ex-vessel Demand Equation Estimation (1964-1988)

CHUM

rho & asymptotic t-ratio
0.617
2.760

second order rho & asymptotic t-ratios
0.504 0.170
1.800 0.660

corrected for ar(1) since rho significant at 5% one-tail level

Valid cases:	24	Dependent variable:	PXCHUM
Total SS:	0.600	Degrees of freedom:	21
R-squared:	0.038	Rbar-squared:	-0.054
Residual SS:	0.577	Std error of est:	0.166
F(2,21):	0.414	Probability of F:	0.666
Durbin-Watson:	1.719		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	0.337368	0.120502	2.799682	0.011	---	---
LQXCHUM	-0.000988	0.002012	-0.491115	0.628	-0.112817	-0.038387
ERJAPAN	-0.000641	0.000719	-0.892333	0.382	-0.204982	-0.164019

3.3 2SLS model estimation results

In this section, we present results for the ex-vessel demand equations estimated from a systems of equations in which the ex-vessel demand curve is estimated as a price dependent function, and the system of demand and supply functions at the processing level are estimated using the quantity of ex-vessel landings as an exogenous variable. The other four equations (fresh/frozen demand and supply and canned demand and supply) are contained in Appendix B. These equations are the foundation of the model estimated by Zhang (1990), although Zhang estimated his model on data transformed by natural logarithms (we use natural units so that we ma ask questions about where the quantity is such that the elasticity of demand is unitary, which is impossible in a double-logged or constant elasticity model).[9]

The ex-vessel demand equations are price dependent rather than quantity dependent as the landings are assumed to be determined exogenous to the system. (However, the canned supply and fresh/frozen supply equations are estimated as quantity dependent.) The variables in each ex-vessel demand (and wholesale supply) equation are the output prices for canned and fresh frozen, and the landings quantity. Each price coefficient is expected to have a positive sign since an increase in the output price of either product should increase the amount that processors are willing to pay for the raw product. The quantity coefficient is expected to have a negative sign.

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[9] There are some other differences between the models estimated in this paper and that in Zhang's thesis. One set of differences is in the variables used as proxy variables for income, population, interest rates, fresh/frozen and canned inventories, and for dummy variables. Here, we use population weighted average per capita income with the populations being the US and Japan for fresh/frozen products and the US and UK for canned products. Zhang used US per capita income. We use the sum of populations of the US and Japan in the fresh/frozen market and the US and UK in the canned market. The inventory data in Zhang's thesis were aggregated across species. We have completely disaggregated canned inventory data, and have constructed disaggregated indices for fresh/frozen inventory data. Zhang did not use interest rate data. Our interest rate data is real pr[illegible] rates for Japan and the UK, for the fresh/frozen and canned markets, respectively.

Following Muse (1984) both Zhang's model and the model estimated here use a dummy variable for 1979 (a price shock occured in 1979 that does not appear to be related to any other variable). Zhang used a dummy variable which equalled one for 1979 and was zero elsewhere. Following Ronan (1989), we note that this essentially eliminates the observation from the regression equation; therefore, we use a geometrically declining dummy variable (D1979 = 2^4, D1980 = 2^3, D1981 = 2^2, etc.). We also use a dummy variable for canned inventory for the years 1975-1981, where the inventory data is for June 1 rather than for July 1.

Finally, Zhang estimated his model using an additional substitute variable in the demand equations. His substitutes were the other species of salmon (red for king, king for silver, silver for red, pink for chum, and chum for pink). However, he treated these variables as exogenous variables, and did not estimate the models using an instrumental variable, so he probably introduced simultaneous equation bias into the model. Another difference is that Zhang left exchange rates in the ex-vessel demand equation, which is only correct if the Japanese also buy unprocessed salmon directly from the harvesting sector. This author has not been able to determine whether or not this is true.

The regression estimates are obtained using 2SLS regression methods. This method creates an instrumental variable for the fresh/frozen and canned prices by regressing these variables against all of the exogenous variables in the system of equations. The estimated fresh/frozen and canned prices from these regressions are used as explanatory variables in the ex-vessel demand equations.

KING: The king ex-vessel demand equation results are in Table 3.3.1. Although the DW statistic is low (DW = 1.403), it is in the inconclusive region and the estimate for ρ is not significantly different from zero. The fit appears to be good, as the R = 0.855. However, only the fresh/frozen price (PFKING) is statistically significant of the slope coefficients. An increase in the price of fresh/frozen king salmon raises the ex-vessel price by 0.58 cents.

RED: The red salmon equation estimates are given in Table 3.3.2. The red salmon ex-vessel price equation has a low DW (DW = 1.571, in the inconclusive region), but the estimate of ρ could not be distinguished from zero. The coefficient for quantity landed (QXRED) and for fresh/frozen price (PFRED) are each insignificant, but the coefficient for canned red salmon is significant and positive. An increase in the price of canned red salmon by one cent will increase the ex-vessel price by 0.18 cents. The equation explains only 51.4% of the variance of red salmon ex-vessel prices as given by the R.

SILVER: The silver salmon results are contained in Table 3.3.3. The silver salmon ex-vessel price equation also has a low DW (DW = 1.365, in the inconclusive region), but the estimate of ρ was statistically indistinguishible from zero, so no correction was made for autocorrelation. The landings variable and the intercept each had statistically insignificant coefficients, but both of the wholesale price variables were significant and positive. An increase in the price of fresh/frozen silver salmon by one cent will increase the ex-vessel price by 0.32 cents, and an increase in the canned price will increase the ex-vessel price by 0.25 cents.

PINK: The pink salmon ex-vessel demand equation results are contained in Table 3.3.4. The pink salmon ex-vessel demand equation was not corrected for autocorrelation (DW = 2.221 implies no autocorrelation, and ρ was statistically zero). Landings of pink salmon were significant at the 90%

confidence level, indicating that an increase of a million pounds of pink landings would decrease pink price by 0.04 cents. Thus pink salmon prices are not very responsive, but the response is distinguishable from zero. Canned pink prices were statistically insignificant, but fresh/frozen prices were positive and significant (an increase in the fresh/frozen price by one cent increases ex-vessel prices by 0.32 cents). The R was relatively high, $R = 0.697$.

CHUM: The chum ex-vessel demand equation results are in Table 3.3.5. The chum equation was also not corrected for autocorrelation. The DW statistic was in the inconclusive region (DW = 1.461), and the estimated ρ was statistically indistinguishible from zero. The intercept was negative and statistically significant. Landings (QXCHUM) were statistically insignificant, implying no price response to increased landings, but the ex-vessel price was statistically positively correlated with both canned and fresh/frozen chum prices. An increase in canned prices by one cent would increase ex-vessel price by 0.18 cents, and an increase in fresh/frozen chum prices will increase ex-vessel chum prices by 0.33 cents. This equation had an $R = 0.772$, which is the second highest of the five species (behind king).

In general, the ex-vessel demand equations show that the price is perfectly elastic, or close to it (pink is the only one that is not completely elastic. Thus as a first order approximation, small changes in the ex-vessel landings has no effect upon price according to these results. In Section 5 we shall compare this result with the estimates of the price flexibility when larger changes in the quantity landed occur by considering secondary effects through the wholesale markets. In addition, price at the ex-vessel level is positively related to the price at the wholesale level. However, the amount that gets passed on is quite small. This could be an indication that the market power is in the hands of the processors, although it is not by itself sufficient evidence of this hypothesis. It is interesting to note that in none of the ex-vessel demand equations did the results change sign or magnitude (none by even a factor of 2) in the 2SLS relative to the OLS estimates (which are not reported).

Table 3.3.1: 2SLS Linear Ex-vessel Demand Equation Estimation (1964-1988)

KING

rho & asymptotic t-ratio
0.284
1.225

second order rho & asymptotic t-ratios
0.339 -0.146
1.355 -0.644

not corrected for ar(1) since rho not significant at 5% 1-tail level

Valid cases:	25	Dependent variable:	QXKING
Total SS:	6.552	Degrees of freedom:	21
R-squared:	0.873	Rbar-squared:	0.855
Residual SS:	0.834	Std error of est:	0.199
F(3,21):	48.008	Probability of F:	0.000
Durbin-Watson:	1.403		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	-0.987387	0.383736	-2.573092	0.018	---	---
QXKING	0.033175	0.022709	1.460888	0.159	0.158486	0.282298
PCKING	0.124785	0.096642	1.291207	0.211	0.154907	0.472011
PFFING	0.586356	0.078989	7.423219	0.000	0.814600	0.926697

Table 3.3.2: 2SLS Linear Ex-vessel Demand Equation Estimation (1964-1988)

RED

rho & asymptotic t-ratio
-0.073
-0.211

second order rho & asymptotic t-ratios
-0.170 0.272
-0.452 1.004

not corrected for ar(1) since rho not significant at 5% 1-tail level

Valid cases:	25	Dependent variable:	~~Q~~PXRED
Total SS:	4.074	Degrees of freedom:	21
R-squared:	0.575	Rbar-squared:	0.514
Residual SS:	1.731	Std error of est:	0.287
F(3,21):	9.477	Probability of F:	0.000
Durbin-Watson:	1.571		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	0.133252	0.198905	0.669929	0.510	---	---
QXRED	0.001017	0.000812	1.251670	0.224	0.192866	0.244411
PCRED	0.180551	0.060011	3.008653	0.007	0.545858	0.683535
PFRED	0.083151	0.063289	1.313822	0.203	0.248844	0.622514

Table 3.3.3: 2SLS Linear Ex-vessel Demand Equation Estimation (1964-1988)

SILVER

rho & asymptotic t-ratio
0.293
1.373

second order rho & asymptotic t-ratios
0.41[illegible] -0.260
1.748 -1.083

not corrected for ar(1) since rho not significant at 5% 1-tail level

Valid cases:	25	Dependent variable:	QXSILV
Total SS:	4.527	Degrees of freedom:	21
R-squared:	0.698	Rbar-squared:	0.655
Residual SS:	1.365	Std error of est:	0.255
F(3,21):	16.211	Probability of F:	0.000
Durbin-Watson:	1.365		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	-0.203175	0.286609	-0.708894	0.486	---	---
QXSILV	-0.002779	0.004203	-0.661314	0.516	-0.080609	-0.089380
PCSILV	0.245699	0.097737	2.513889	0.020	0.321117	0.538238
PFSILV	0.319582	0.059913	5.334140	0.000	0.674984	0.767979

Table 3.3.4: 2SLS Linear Ex-vessel Demand Equation Estimation (1964-1988)

PINK

rho & asymptotic t-ratio
-0.294
-1.158

second order rho & asymptotic t-ratios
-0.392 -0.425
-1.539 -1.705

not corrected for ar(1) since rho not significant at 5% 1-tail level

Valid cases:	25	Dependent variable:	QXPINK
Total SS:	0.673	Degrees of freedom:	21
R-squared:	0.735	Rbar-squared:	0.697
Residual SS:	0.178	Std error of est:	0.092
F(3,21):	19.404	Probability of F:	0.000
Durbin-Watson:	2.221		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	0.156744	0.089483	1.751664	0.094	---	---
QXPINK	-0.000460	0.000258	-1.782325	0.089	-0.216554	-0.480564
PCPINK	0.011484	0.035694	0.321731	0.751	0.054195	0.660030
PFPINK	0.324697	0.075565	4.296947	0.000	0.716672	0.830295

Table 3.3.5: 2SLS Linear Ex-vessel Demand Equation Estimation (1964-1988)

CHUM

rho & asymptotic t-ratio
0.231
1.048

second order rho & asymptotic t-ratios
0.266 -0.530
1.026 -2.320

not correct or ar(1) since rho not significant at 5% 1-tail level

Valid cases:	25	Dependent variable:	QXCHUM
Total SS:	1.271	Degrees of freedom:	21
R-squared:	0.801	Rbar-squared:	0.772
Residual SS:	0.253	Std error of est:	0.110
F(3,21):	28.122	Probability of F:	0.000
Durbin-Watson:	1.461		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	-0.316812	0.137304	-2.307385	0.031	---	---
QXCHUM	0.000484	0.001077	0.449408	0.658	0.053491	-0.037425
PCCHUM	0.185220	0.084678	2.187353	0.040	0.373481	0.780111
PFCHUM	0.332136	0.089980	3.691206	0.001	0.591936	0.863843

4. Comparisons of the models

In this section we discuss the ability of each of the models to predict within the sample period 1964-1988, and within the more recent period of 1978-1988. We present statistical and graphical evidence of the how well each model predicts. The statistical evidence is in the form of mean squared error (MSE) estimates, Theil's U^1 statistic, and Theil's decomposition of the MSE into the U^M, U^R, and U^D statistics. The graphical evidence is given by plotting the actual and predicted price series over time, and by plotting the actual versus the predicted values against each other. The plotting of the time series allows one to examine how well each model predicts increases and decreases in prices, and the plotting of the actual values versus the predicted values shows how well each model predicts over the range of values of the ex-vessel prices.

Statistical tests

The statistical tests used to examine the forecasts are the following.[10] The first, and most general is the root mean squared error (MSE) statistic. This [illegible] asures the sum of the squared differences between the relative change in the ac[illegible] the relative change in the predicted variable. If we let A_t be the actual value at time [illegible] predicted value at time t, the relative changes are given by $a_t = [A_t - A_{t-1}]/A_{t-1}$, and $p_t = [P_t - P_{t-1}]/P_{t-1}$. The MSE is thus

$$MSE = \sum_{t=1}^{n} (p_t - a_t)^2$$

$$= (\bar{p} - \bar{a})^2 + S_{p-a}^2,$$

where the S_{p-a}^2 term is the variance of the prediction errors. Maddala (p. 344) shows that MSE can be broken down by the following decompositions,

$$S_{p-a}^2 = (S_p - rS_a)^2 + (1 - r^2)S_a^2,$$

where r is the correlation between a_t and p_t, and the following statistics can be derived

$$U^m = \frac{(\bar{p} - \bar{a})^2}{MSE} = \text{bias proportion}$$

$$U^R = \frac{(S_p - rS_a)^2}{MSE} = \text{regression proportion}$$

$$U^D = \frac{(1 - r^2)S_a^2}{MSE} = \text{disturbance proportion}$$

The interpretation of the statistics is as follows. "If U^M is large, it means that the average predicted change deviates substantially from the average actual change. *This is clearly a serious error, because we should expect that forecasters must be able to reduce such errors in the course of time*" (Maddala, p

[10]This section follows the discussion in Maddala (1977).

345, emphasis added). The statistic U^R gets its name from the fact that if a regression were to be run with

$$A_t = \alpha + \beta P_t,$$

then the statistic U^R, the 'regression proportion', goes to zero as $\beta \to 1$. Thus an ideal predictor will have the statistics U^R and U^M as small as possible (note that $U^M + U^R + U^D = 1$)

We also report the U^1 statistic as well as the mean absolute error (MAE) statistic as defined in Maddala (1977).[11] Table 4.1 reports the MSE, MAE, U^1, U^M, U^R, and U^D statistics for the entire period of the sample (1964–1988) for each of the above models. Table 4.2 reports the same statistics for the period 1978–1988. Our analysis will proceed by species. The ISER models are listed as ISER1 and ISER2 for the contemporaneous and lagged quantity models, respectively.

King: The 2SLS appears to be superior to any of the other models by any one of the statistics chosen. The 2SLS model has an MSE that is more than 5 times lower than the CFEC model, and more than 25 times lower than either of the ISER models. The ISER models are the poorest fit in terms of the U^M, U^R, and U^D statistics. Neither the [illegible] CFEC model appear to show systematic bias according to the Theil statistics.

Red: The 2SLS model and t[illegible]ity model) each appear to be close i[illegible] MSE, MAE, and U statistics, althoug[illegible] CFEC models are not much worse. None [illegible] models shows systematic bias or regression error.

Silver: The ISER models each show the highest MSE and signs of persistent bias as indicated by the high U^M statistic. The 2SLS model has a MSE of 0.041, compared to a MSE of 0.074 for the CFEC model. Neither the 2SLS nor the CFEC models show any signs of either bias or systematic regression error.

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[11] The U^C and U^S statistics were calculated but are not reported. Maddala, pp. 344–7, gives strong evidence that these two statistics are devoid of meaningful interpretation.

Pink: None of the models shows signs of systematic bias as given by the U^M statistic. However, the models differ markedly in the regression proportion given by U^R. The 2SLS model has the lowest U^R (and U^M) statistics, with an U^R statistic of 0.192 compared to an U^R between 0.369 and 0.456 for the other models. The 2SLS model also has the lowest MSE, MAE, and U^I statistics.

Chum: As with the king and silver salmon, the ISER models have a large U^M statistic, indicating a systematic bias over time. The CFEC model has a low U^M statistic (U^M = 0.056), but a large U^R statistic (U^R = 0.505). The 2SLS model has the lowest MSE, MAE, U^I, U^M, and U^R statistics of all of the models.

Table 4.2, which displays the same set of statistics calculated over the period 1978-1988, shows that the 2SLS model also out-performs the other models for this period. An exception to this generalization is for red salmon. In this case, the ISER1 model (contemporaneous quantities) has a lower MSE and MAE than the 2SLS model. Another observation is that for red salmon, the CFEC has a fairly large U^M statistic (U^M = 0.394), showing that there appears to be systematic bias over the period 1978-1988 for the CFEC model.

Table 4.1: Goodness of fit statistics (1964-1988)

KING

model	MSE	MAE	U^1	U^M	U^R	U^D
2SLS	0.014	0.141	0.369	0.000	0.002	0.997
CFEC	0.072	0.326	0.837	0.009	0.105	0.886
ISER1	0.384	0.775	1.906	0.732	0.014	0.254
ISER2	0.457	0.885	2.081	0.785	0.009	0.205

RED

model	MSE	MAE	U^1	U^M	U^R	U^D
2SLS	0.047	0.188	0.732	0.001	0.003	0.996
CFEC	0.089	0.249	0.985	0.157	0.044	0.799
ISER1	0.059	0.197	0.822	0.002	0.235	0.763
ISER2	0.050	0.188	0.756	0.000	0.127	0.873

SILVER

model	MSE	MAE	U^1	U^M	U^R	U^D
2SLS	0.041	0.180	0.645	0.004	0.030	0.965
CFEC	0.074	0.264	0.874	0.003	0.059	0.938
ISER1	0.211	0.439	1.478	0.644	0.003	0.353
ISER2	0.417	0.674	2.075	0.872	0.000	0.128

PINK

model	MSE	MAE	U^1	U^M	U^R	U^D
2SLS	0.054	0.076	0.[illegible]7	0.006	0.192	0.802
CFEC	0.059	0.076	0.802	0.041	0.384	0.576
ISER1	0.116	0.126	1.128	0.035	0.456	0.509
ISER2	0.065	0.082	0.841	0.021	0.369	0.610

CHUM

model	MSE	MAE	U^1	U^M	U^R	U^D
2SLS	0.050	0.077	0.702	0.003	0.072	0.925
CFEC	0.111	0.128	1.050	0.056	0.505	0.438
ISER1	0.226	0.193	1.467	0.594	0.002	0.404
ISER2	0.262	0.214	1.579	0.654	0.001	0.345

Note: ISER1 uses contemporaneous quantities and ISER2 uses lagged quantities as explanatory variables.

Table 4.2: Goodness of fit summary statistics (1978-1988).

KING

model	MSE	MAE	U^1	U^M	U^R	U^D
2SLS	0.020	0.190	0.600	0.162	0.017	0.821
CFEC	0.034	0.275	0.777	0.034	0.133	0.832
ISER1	0.197	0.709	1.880	0.775	0.002	0.222
ISER2	0.241	0.813	2.081	0.819	0.000	0.181

RED

model	MSE	MAE	U^1	U^M	U^R	U^D
2SLS	0.041	0.211	0.648	0.029	0.014	0.956
CFEC	0.099	0.323	1.004	0.394	0.004	0.602
ISER1	0.031	0.173	0.566	0.202	0.002	0.797
ISER2	0.047	0.202	0.691	0.094	0.012	0.894

SILVER

model	MSE	MAE	U^1	U^M	U^R	U^D
2SLS	0.038	0.182	0.623	0.040	0.109	0.850
CFEC	0.148	0.314	1.222	0.519	0.040	0.441
ISER1	0.148	0.314	1.222	0.519	0.040	0.441
ISER2	0.335	0.573	1.838	0.893	0.003	0.104

PINK

model	MSE	MAE	U^1	U^M	U^R	U^D
2SLS	0.089	0.091	0.725	0.052	0.212	0.737
CFEC	0.122	0.100	0.849	0.067	0.390	0.543
ISER1	0.193	0.135	1.068	0.145	0.366	0.489
ISER2	0.091	0.078	0.733	0.117	0.189	0.695

CHUM

model	MSE	MAE	U^1	U^M	U^R	U^D
2SLS	0.033	0.074	0.521	0.016	0.032	0.952
CFEC	0.108	0.131	0.950	0.061	0.506	0.433
ISER1	0.174	0.138	1.203	0.407	0.075	0.518
ISER2	0.204	0.154	1.304	0.502	0.034	0.465

Note: ISER1 uses contemporaneous quantities and ISER2 uses lagged quantities as explanatory variables.

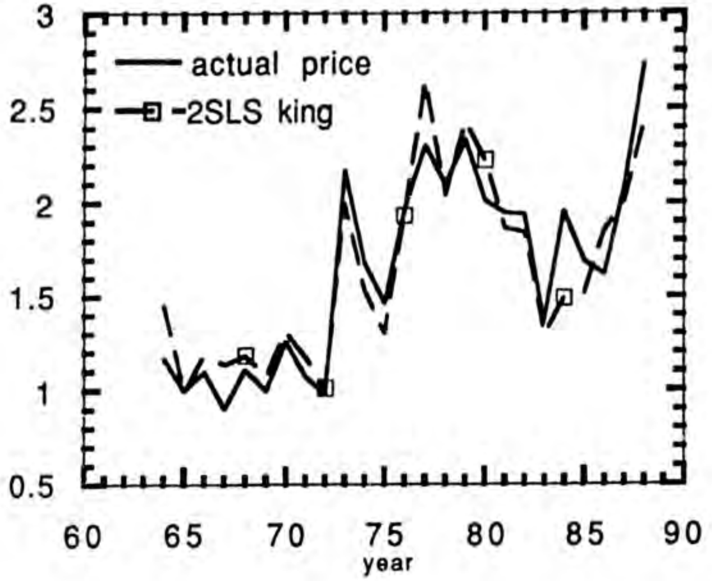
Graphical Analysis

We have plotted two graphs for each model for each species. The first graph shows the actual and predicted ex-vessel price series over time. This allows the reader to see how well each model tracks the data over time.

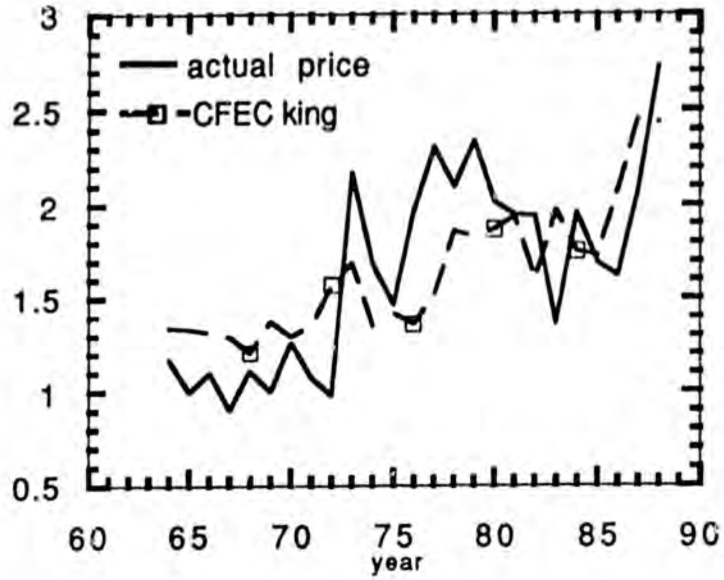
The second graph plots the predicted price against the actual price. A 45 degree line is also provided as a reference. If the models predicted exactly, the plot of predicted versus actual values would line up exactly along these lines. A point plotted above the line means that the actual value is larger than the predicted value, a point below the 45 degree line means that the actual value is smaller than the predicted value. This graph allows the reader to see how well the various models perform at different levels of prices. Biases in the prediction are readily evident by observing that most of the data points lie on one side of the 45 degree line (an unbiased predictor will have roughly equal numbers of misses on each side of the 45 degree line). An example of bias is the two ISER models for king salmon, where the data points all appear above the 45 degree line indicating that the predictions are all lower than the actual values (compare with the time series plots for the same series). The variance of the predictions are also apparent from these diagrams. A model which has most of the predictions close to the 45 degree line has a lower variance than a model which has data points dispersed throughout the diagram. A striking example of this phenomenon is in a comparison of the king salmon diagrams for 2SLS and the CFEC models. This diagram also allows one to see whether or not the model exhibits signs of heteroskedasticity, which means that the standard error of the estimate is not constant across values of the dependent variable. About the only example of heteroskedasticity is with the 2SLS red salmon model in which for low prices the plots appear close to the 45 degree line, but for the higher prices, the data points are much farther from the 45 degree line.

In general, the results of the graphical analysis concur with the statistical analysis contained in Table 4.1 and 4.2. The reader is invited to confirm this claim for themselves.

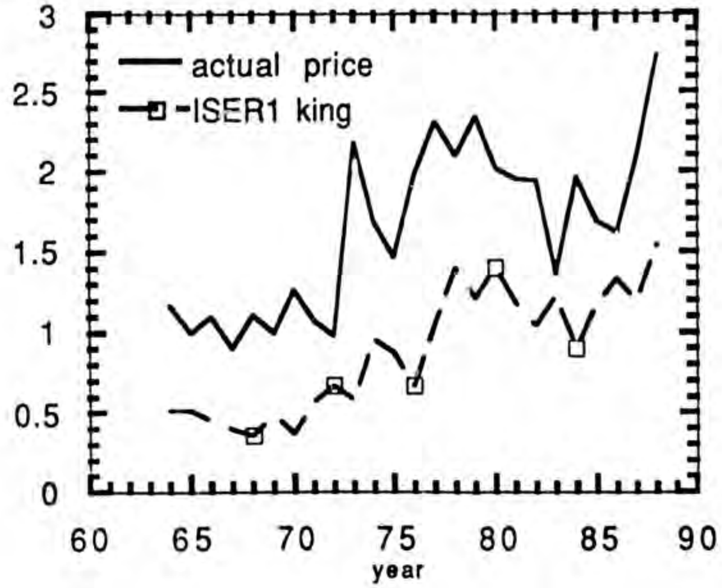
2SLS king salmon price predictions



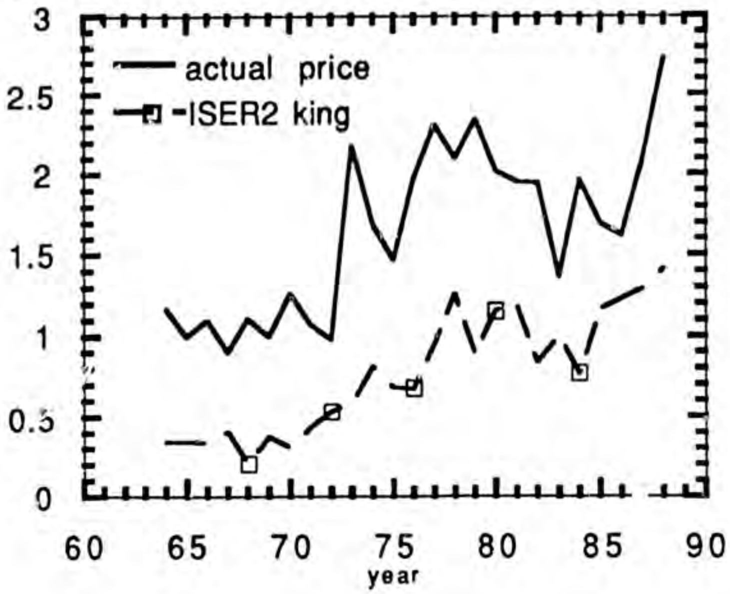
CFEC king salmon price predictions



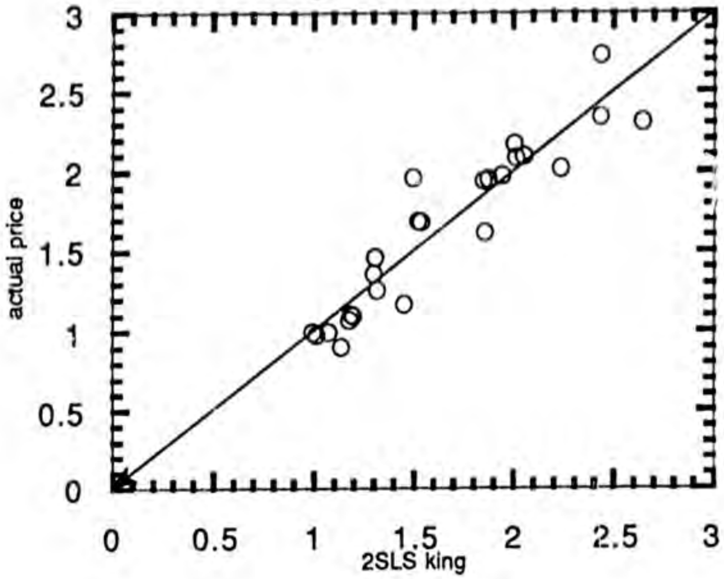
ISER1 king salmon price predictions



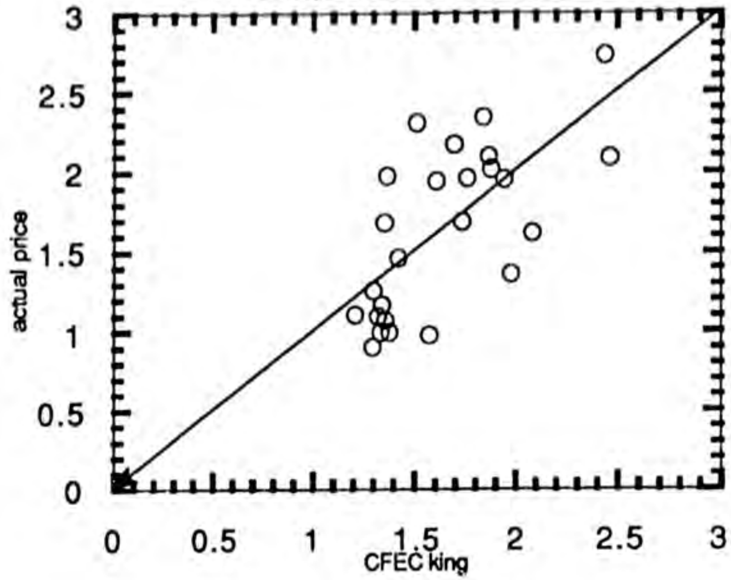
ISER2 king salmon price predictions



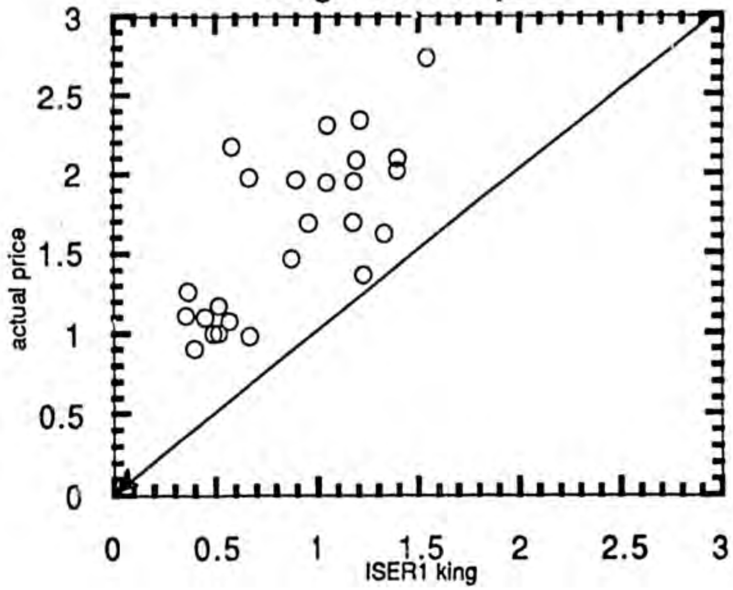
2SLS predicted vs. actual king salmon price



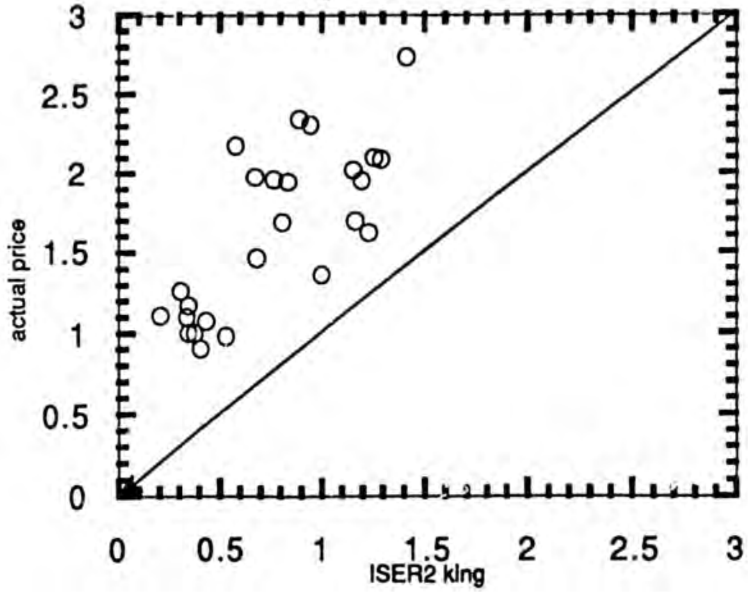
CFEC predicted vs. actual king salmon price



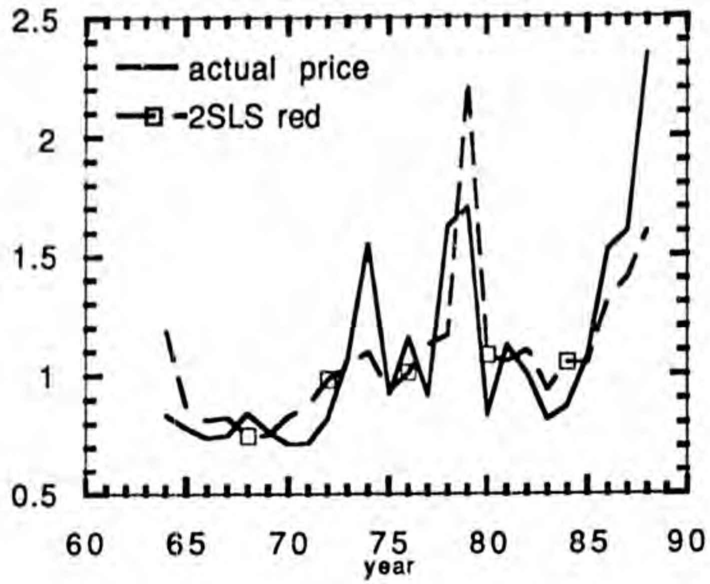
ISER1 predicted vs. actual king salmon price



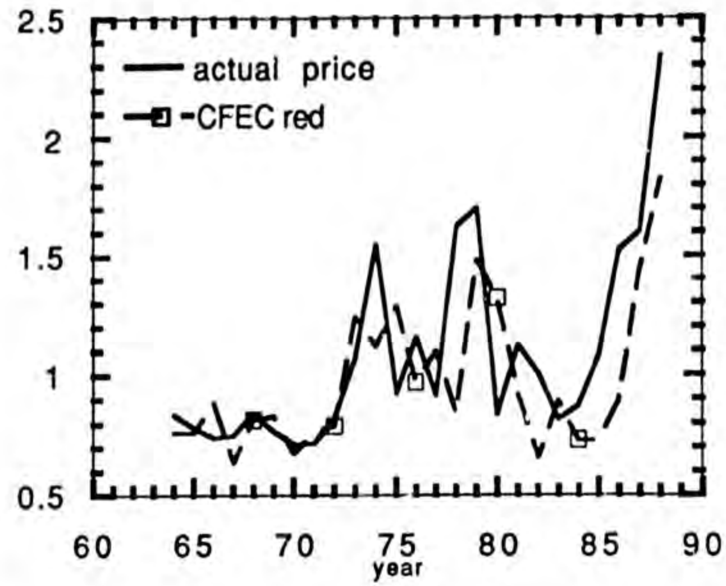
ISER2 predicted vs. actual king salmon price



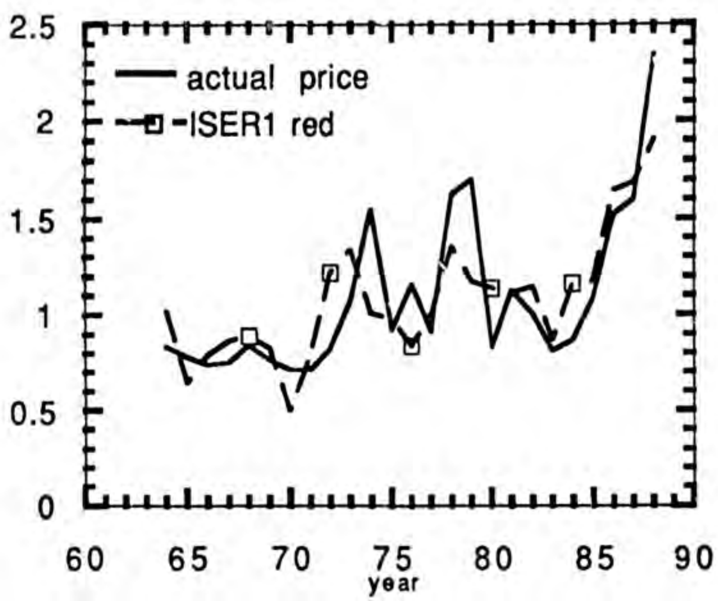
2SLS red salmon price predictions



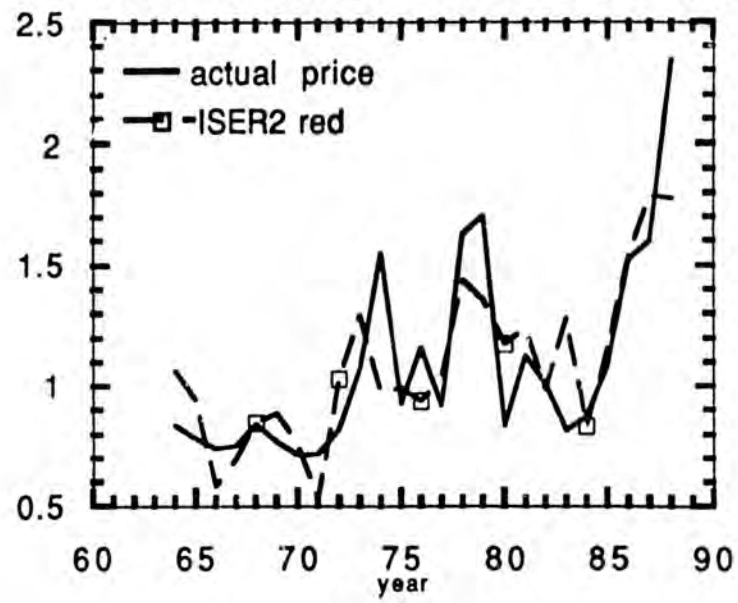
CFEC red salmon price predictions

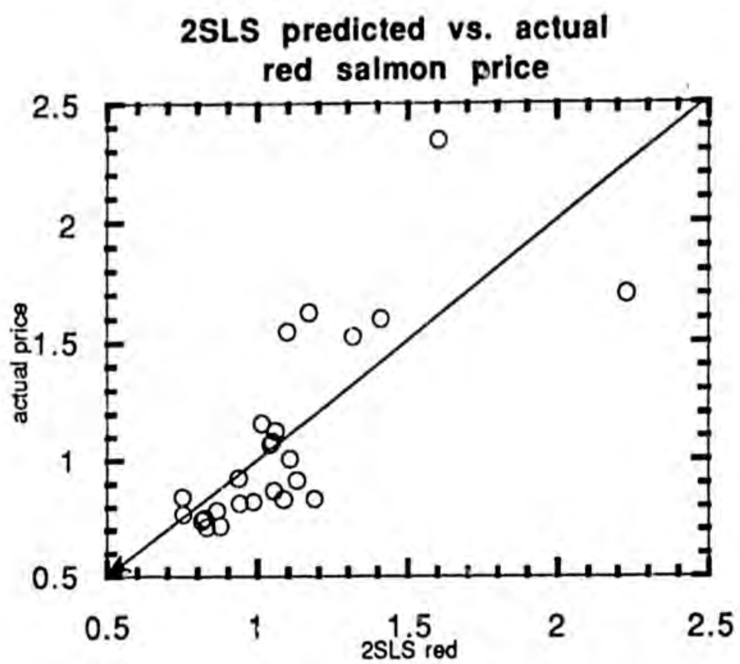


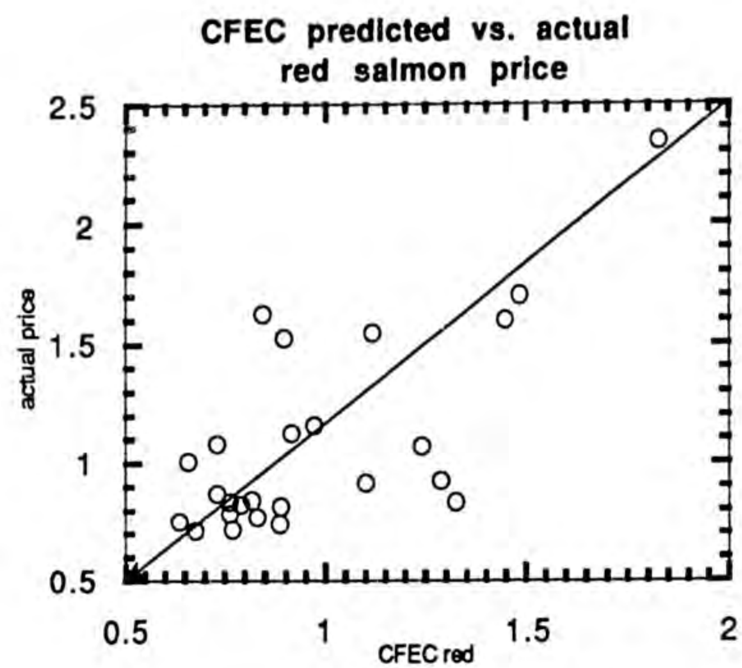
ISER1 red salmon price predictions

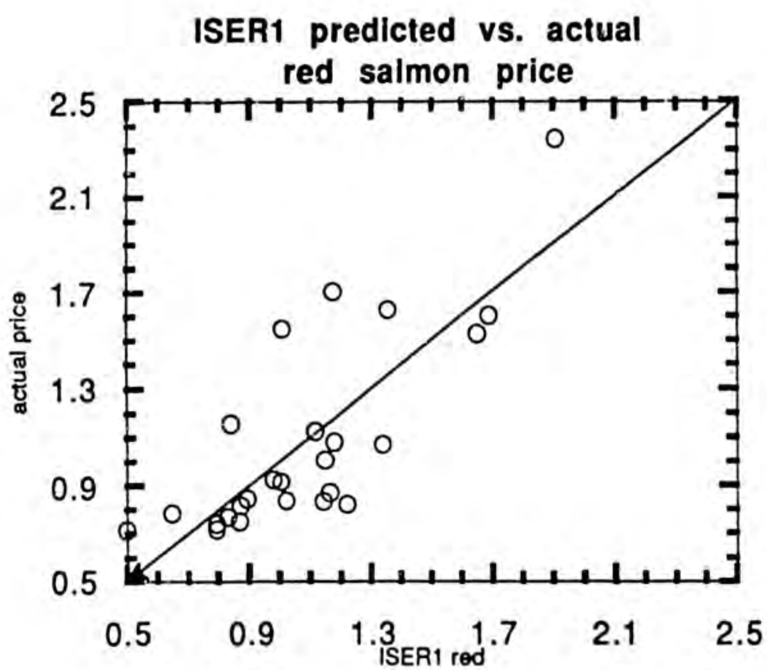


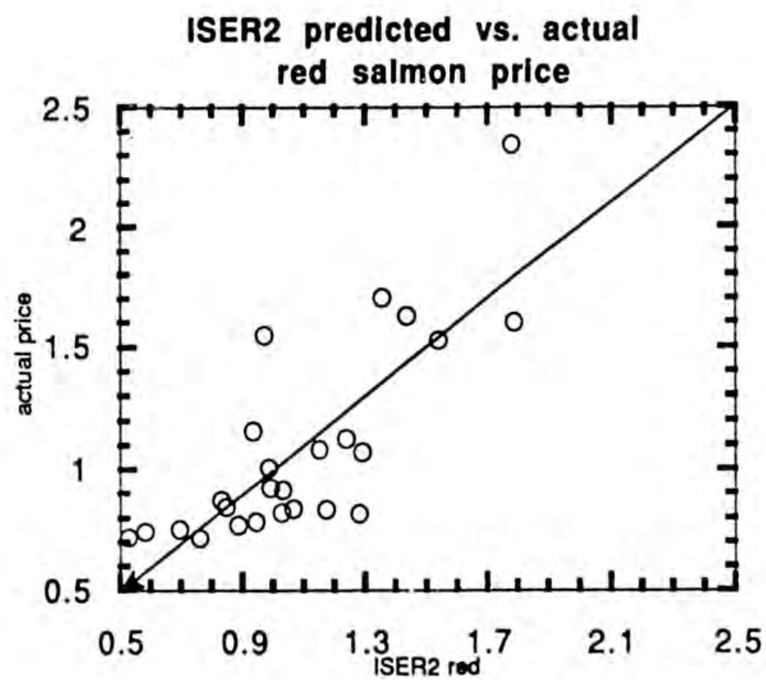
ISER2 red salmon price predictions



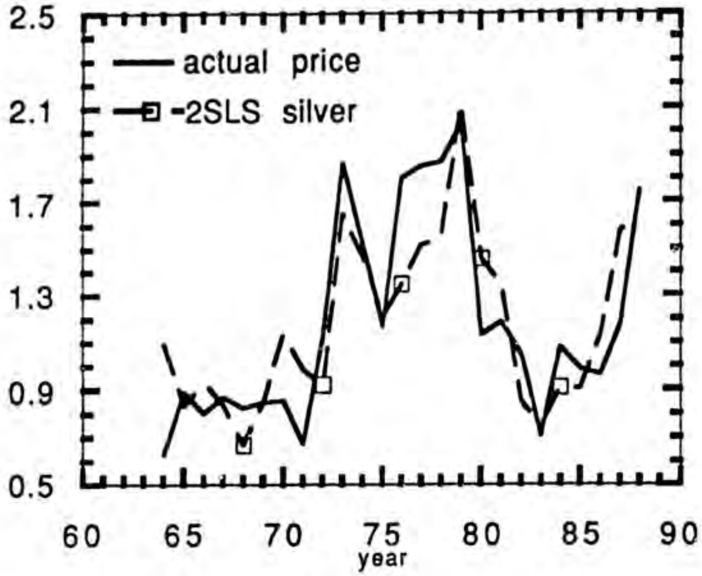

2SLS predicted vs. actual
red salmon price
actual price
2SLS red
0.5
1
1.5
2
2.5


CFEC predicted vs. actual
red salmon price
actual price
CFEC red
0.5
1
1.5
2
2.5

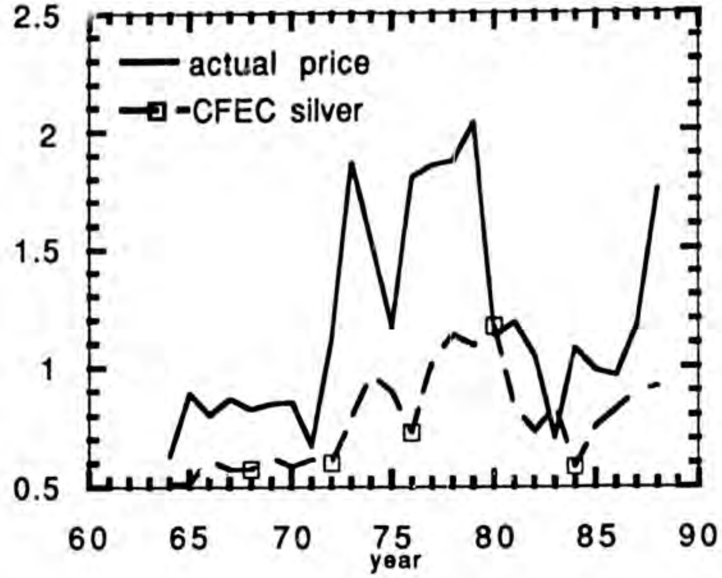

ISER1 predicted vs. actual
red salmon price
actual price
ISER1 red
0.5
0.9
1.3
1.7
2.1
2.5


ISER2 predicted vs. actual
red salmon price
actual price
ISER2 red
0.5
0.9
1.3
1.7
2.1
2.5
1
1.5
2

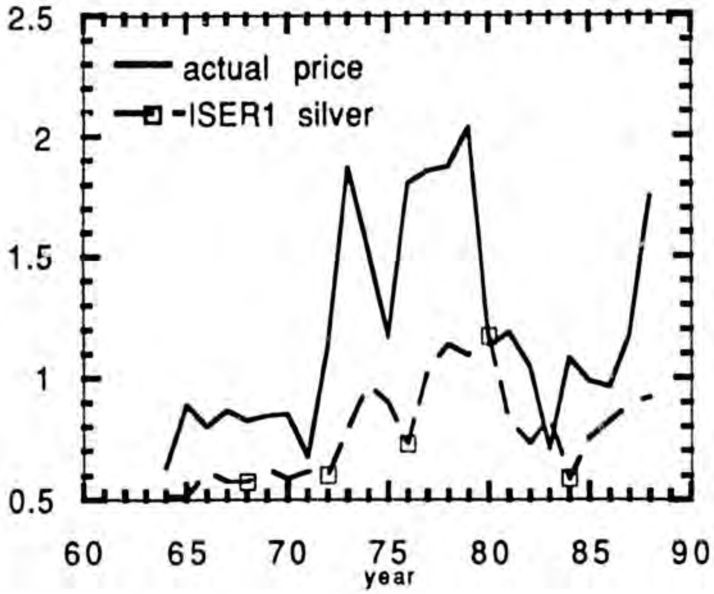
2SLS silver salmon price predictions



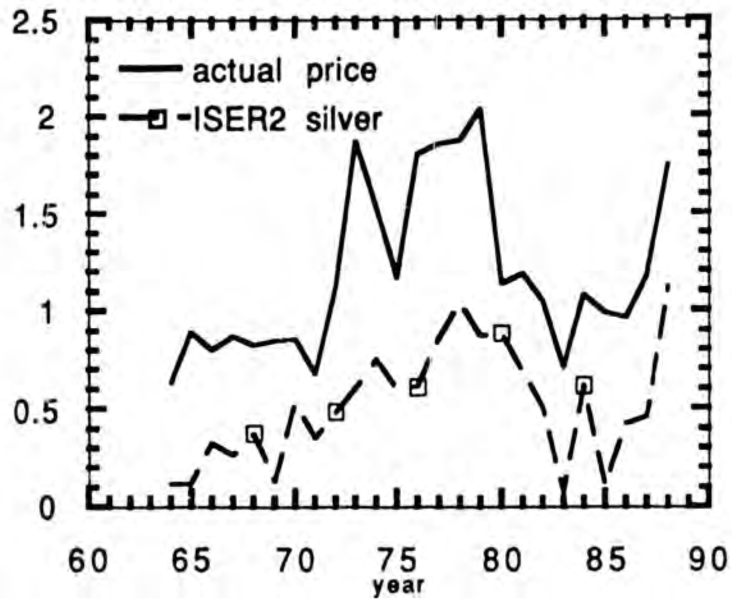
CFEC silver salmon price predictions



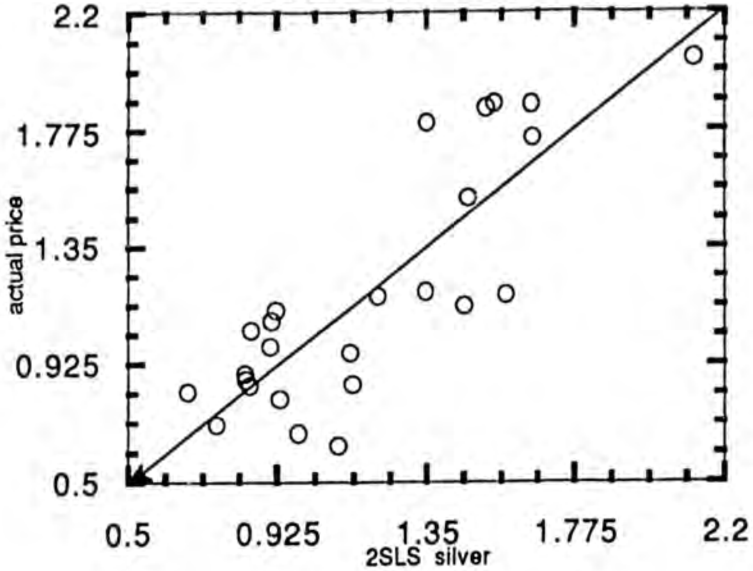
ISER1 silver salmon price predictions



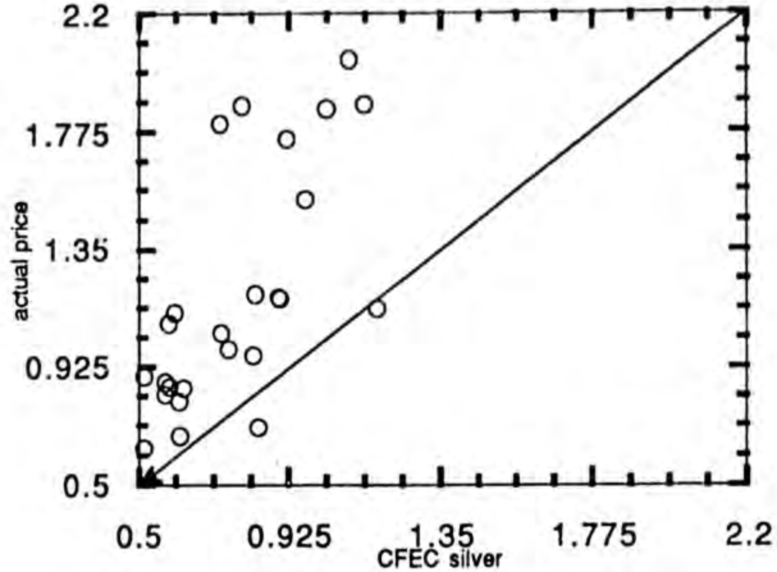
ISER2 silver salmon predictions



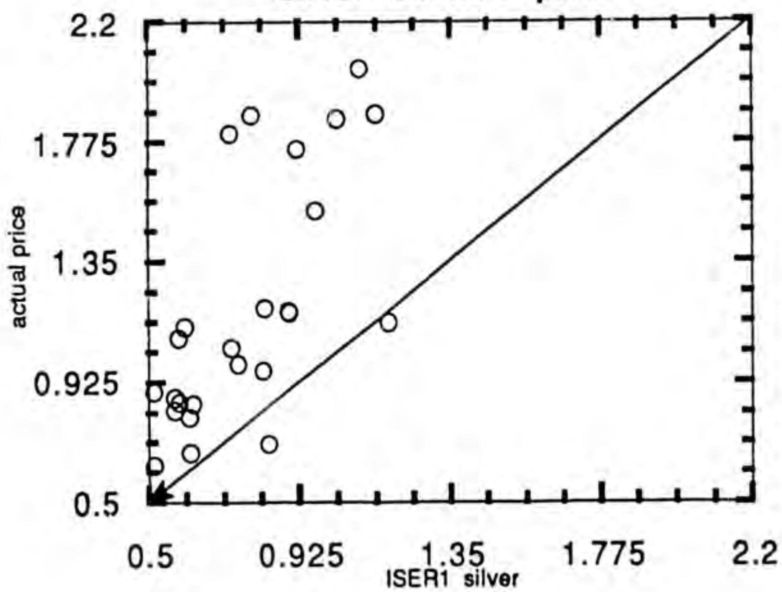
2SLS predicted vs. actual silver salmon price



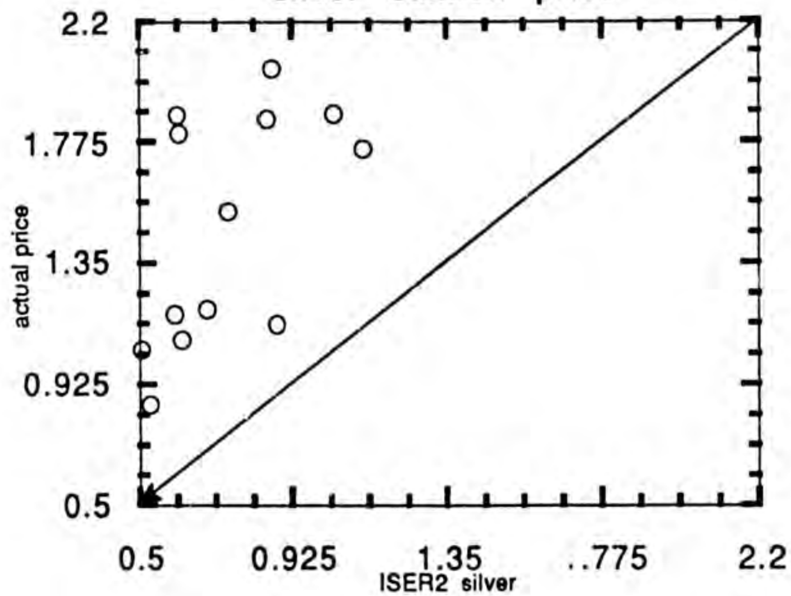
CFEC predicted vs. actual silver salmon price



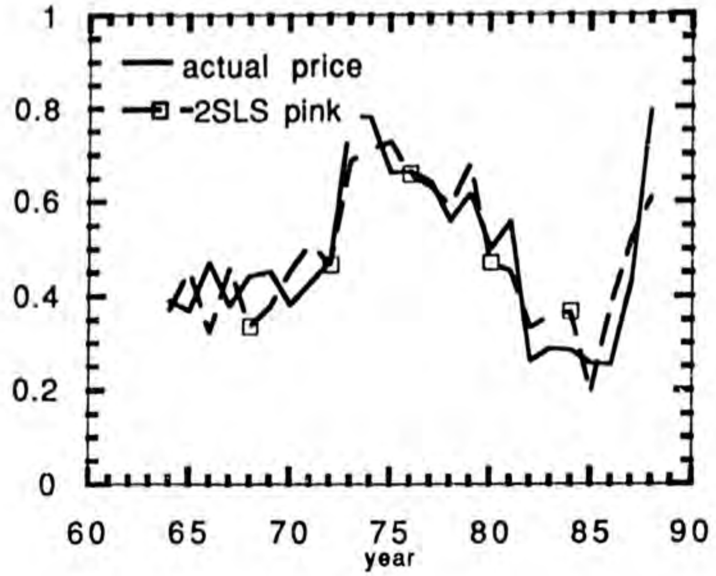
ISER1 predicted vs. actual silver salmon price



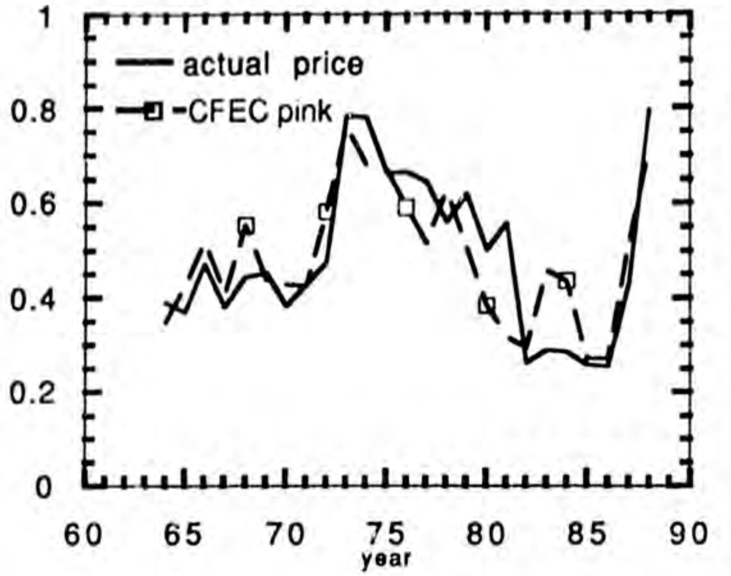
ISER2 predicted vs. actual silver salmon price



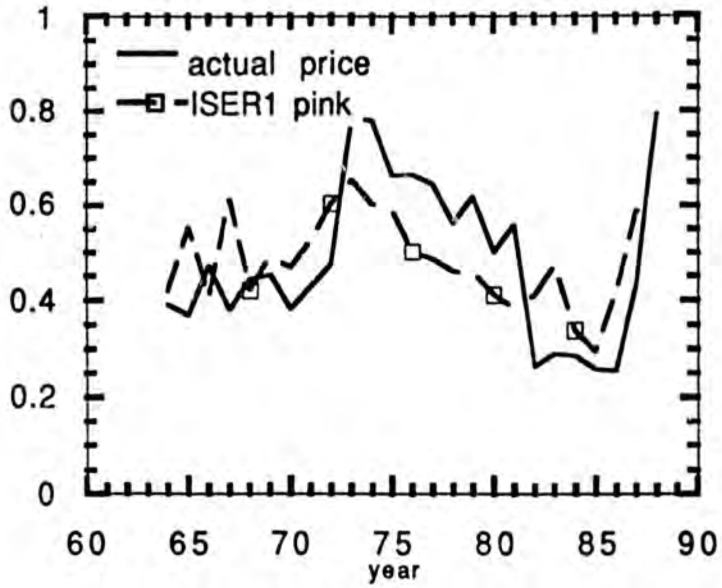
2SLS pink salmon price predictions



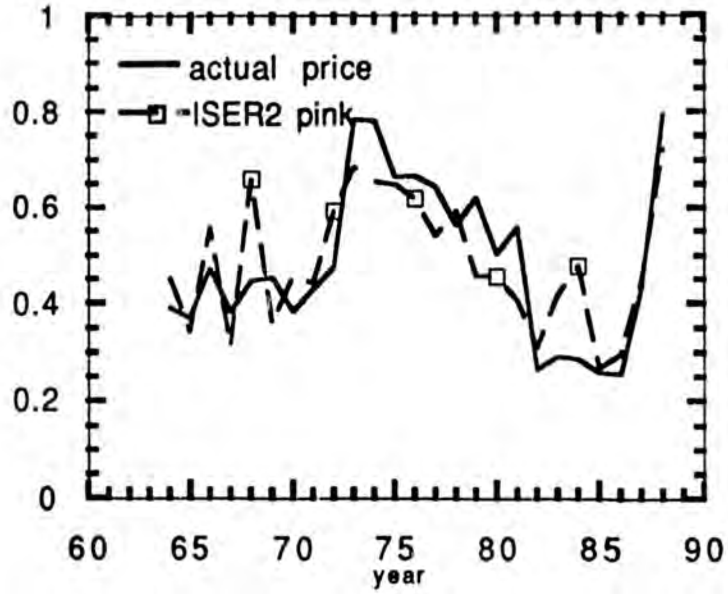
CFEC pink salmon price predictions

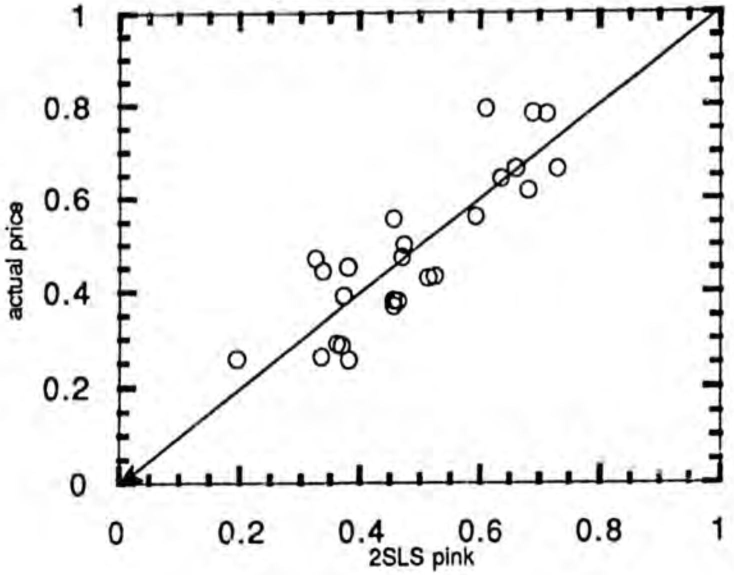


ISER1 pink salmon price predictions

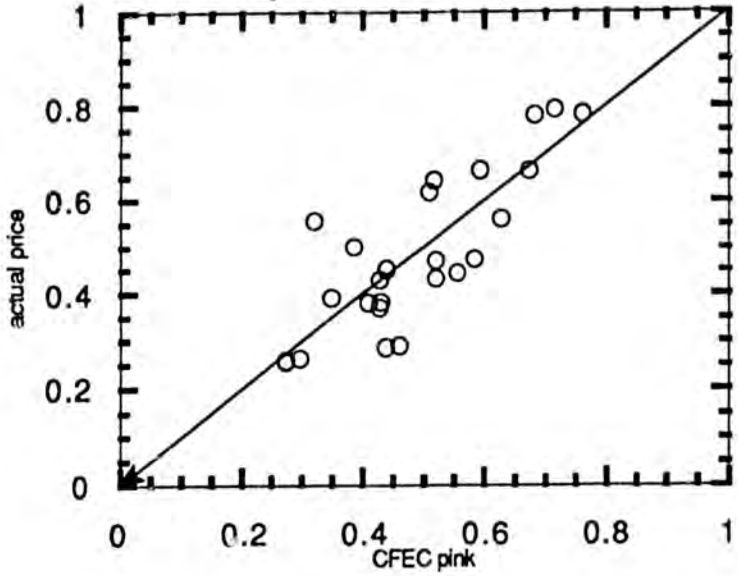


ISER2 pink salmon price predictions

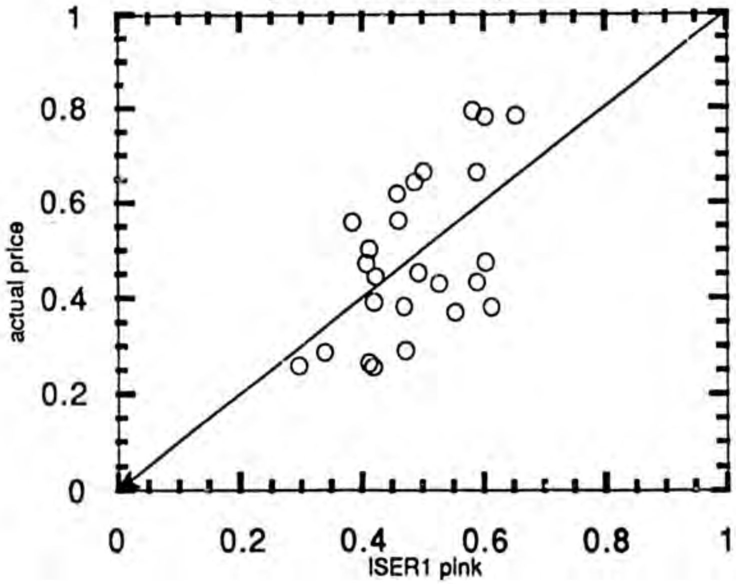




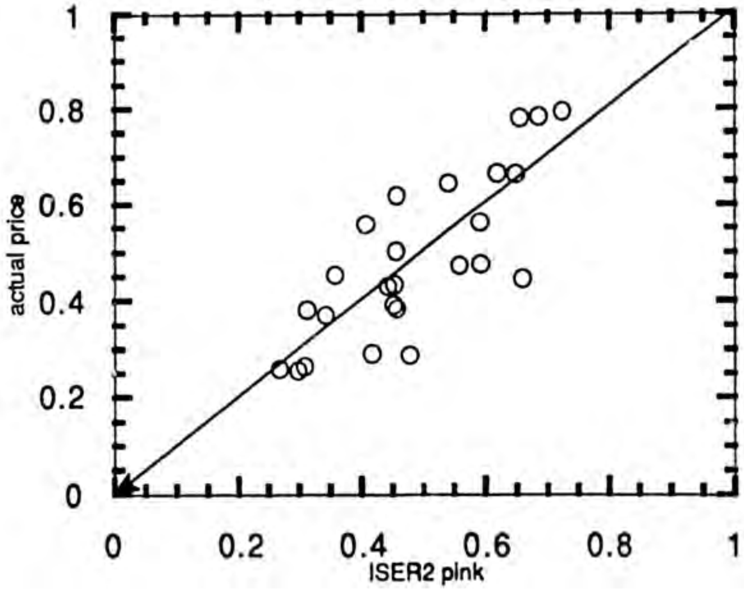
2SLS predicted vs. actual pink salmon price



CFEC predicted vs. actual pink salmon price

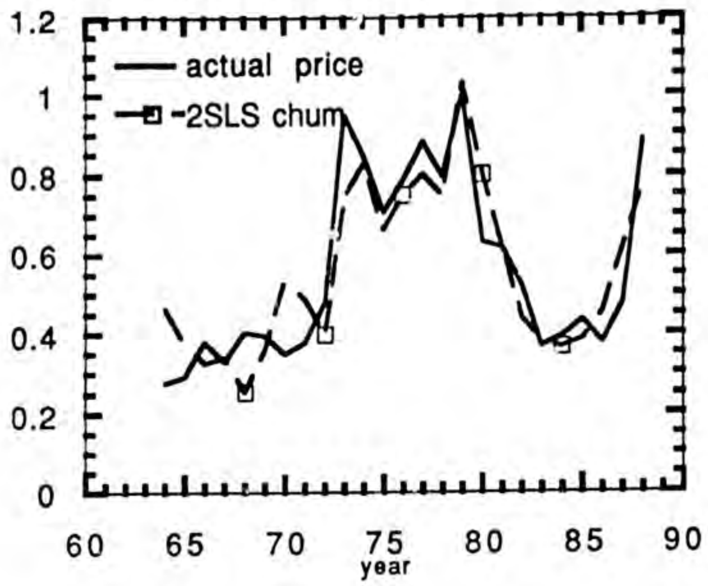


ISER1 predicted vs. actual pink salmon price

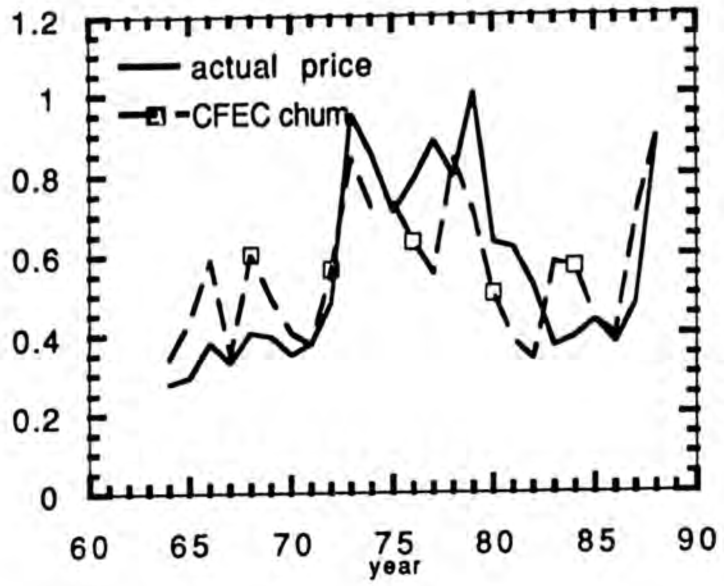


ISER2 predicted vs. actual pink salmon price

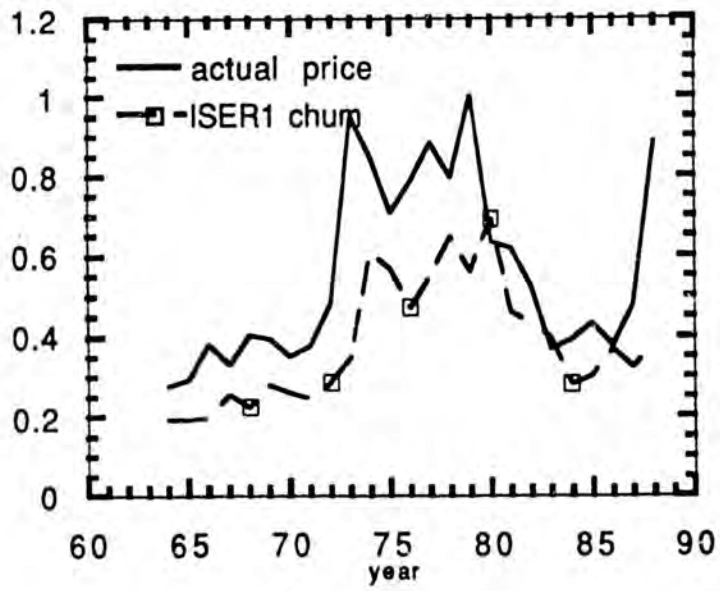
2SLS chum salmon price predictions



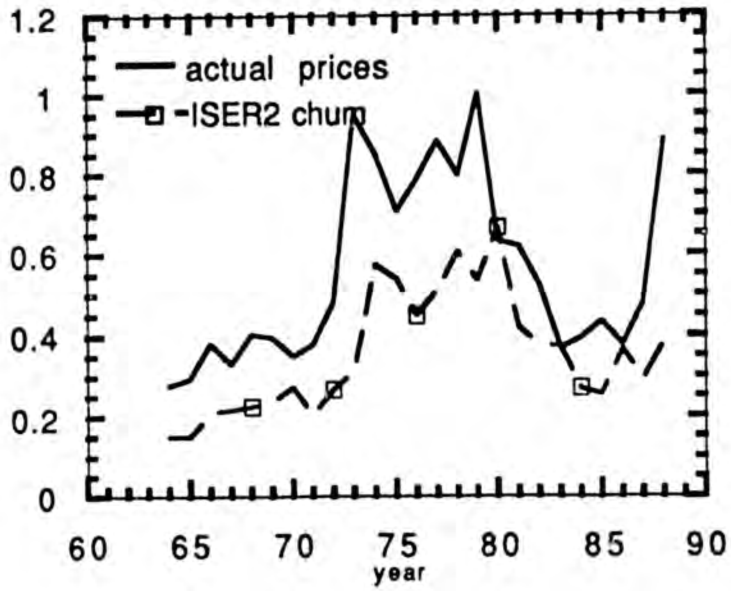
CFEC chum salmon price predictions

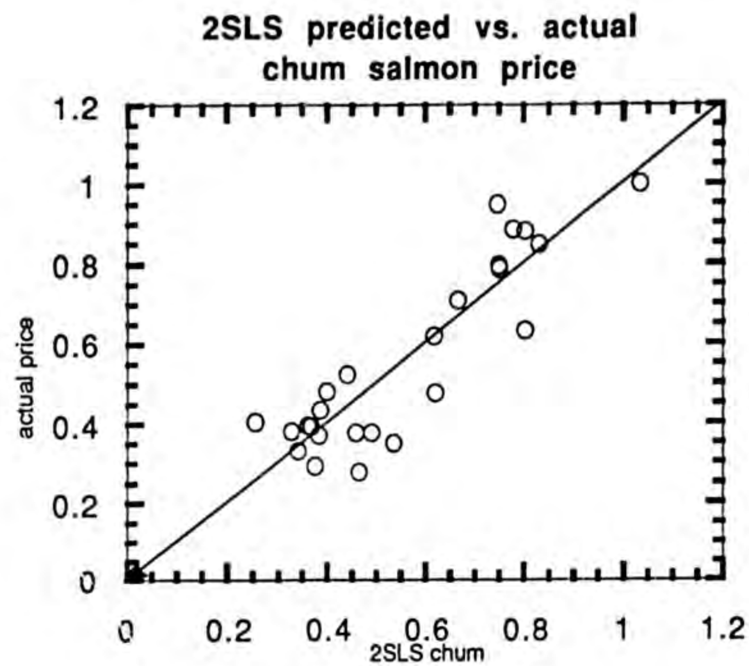


ISER1 chum salmon price predictions

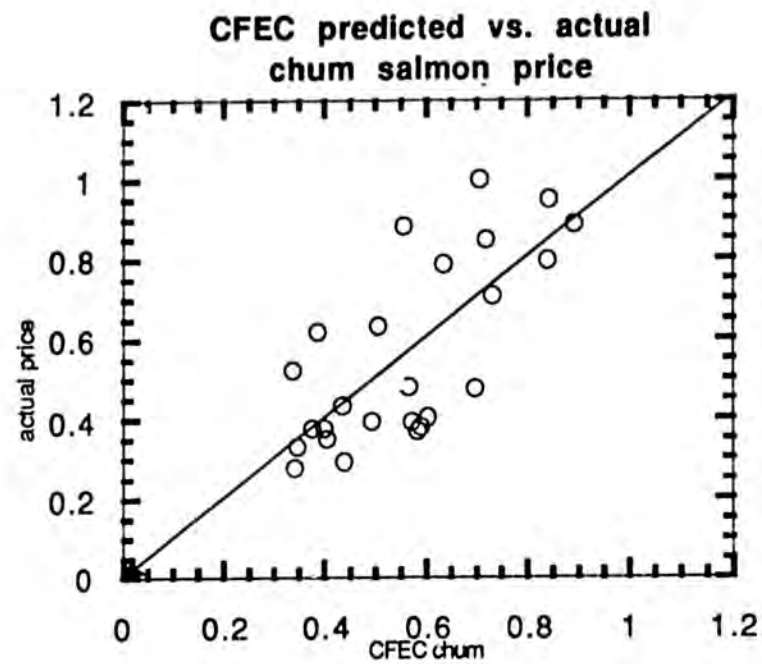


ISER2 chum salmon price predictions

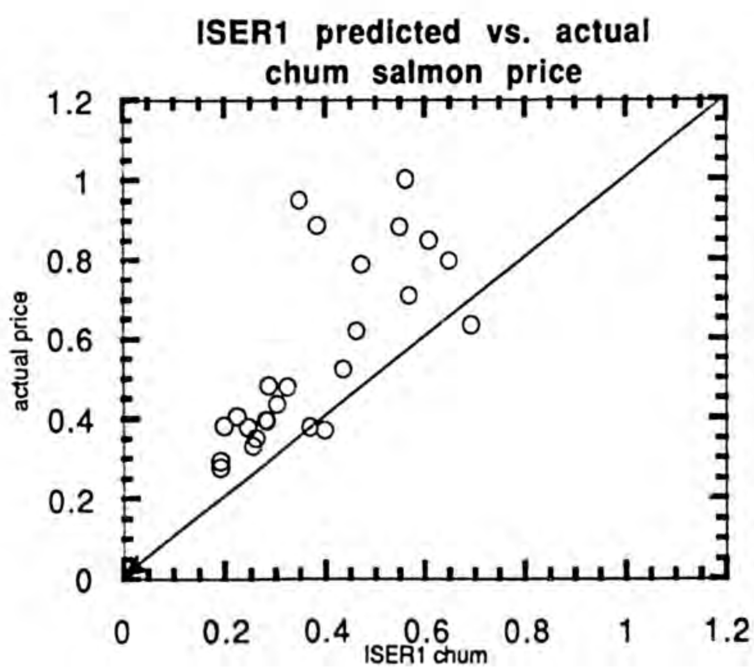




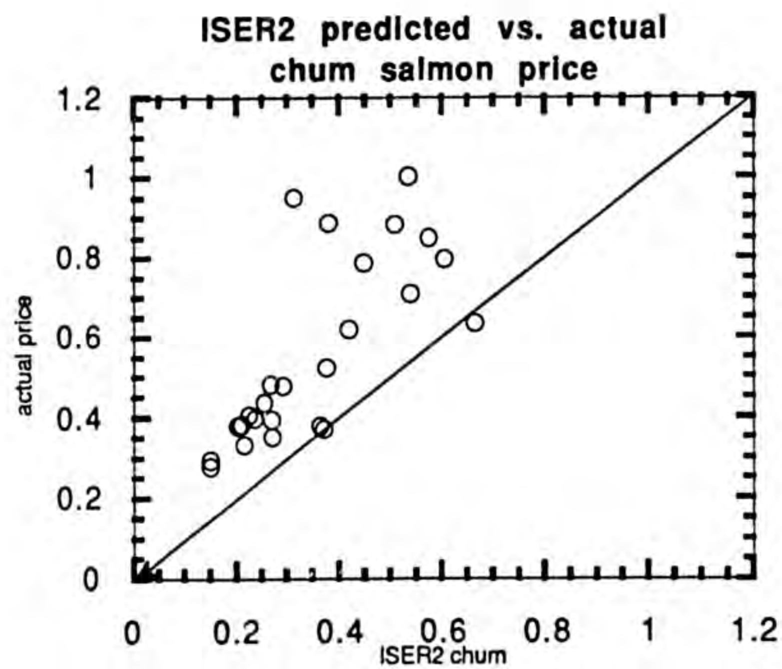
2SLS predicted vs. actual chum salmon price
actual price
2SLS chum
0
0.2
0.4
0.6
0.8
1
1.2



CFEC predicted vs. actual chum salmon price
actual price
CFEC chum
0
0.2
0.4
0.6
0.8
1
1.2



ISER1 predicted vs. actual chum salmon price
actual price
ISER1 chum
0
0.2
0.4
0.6
0.8
1
1.2



ISER2 predicted vs. actual chum salmon price
actual price
ISER2 chum
0
0.2
0.4
0.6
0.8
1
1.2

5 Calculation of price flexibility parameters

5.1 Partial equilibrium estimates of price flexibility parameters

In this section we calculate the price flexibility parameters for the 2SLS model. We we do this by two different methods. The first method simply calculates the price flexibility parameter by multiplying the coefficient for quantity in the demand equation (ex-vessel, canned, and fresh/frozen) by the ratio of quantity to prices. This gives the *partial equilibrium* estimate of the price flexibility. Again, the partial equilibrium price flexibility assumes that conditions in other parts of the market do not change. This gives a good approximation for small changes in the quantity supplied.

Table 5.1 lists the average price and average quantity for each of the species at the ex-vessel, canned, and fresh/frozen levels for the entire sample (1964-1988) and for the most recent period (1978-1988) of the sample. Prices are in 1988 dollars, and quantities are in millions of pounds.

Table 5.1: Means of price and quantity data

1964-1988 data

	ex-vessel quantity	canned quantity	fresh/frozen quantity	ex-vessel price	canned price	fresh/frozen price
king	11.978	0.879	8.375	1.641	2.967	3.173
red	130.830	39.469	48.665	1.085	3.379	2.501
silver	22.183	2.655	13.763	1.187	2.661	2.496
pink	149.428	69.473	17.035	0.486	2.273	1.147
chum	62.884	17.129	24.338	0.559	1.926	1.472

1978-1988 data

	ex-vessel quantity	canned quantity	fresh/frozen quantity	ex-vessel price	canned price	fresh/frozen price
king	13.997	0.239	11.194	1.983	2.813	3.560
red	204.724	36.005	104.126	1.321	3.627	3.291
silver	33.136	1.750	22.923	1.267	2.629	2.907
pink	220.897	91.623	34.128	0.439	2.210	1.134
chum	83.674	12.600	43.041	0.592	1.853	1.592

Table 5.2 presents the results of the point estimates for the demand price flexibilities for ex-vessel, canned, and fresh/frozen salmon by species. Estimates are calculated using the mean prices and quantities for the whole sample (1964-1988) and for the most recent period (1978-1988). In the event that the quantity coefficient is statistically insignificant at the 90% confidence level, the coefficient is set equal to zero.

In all cases, the estimate is less than unity in absolute value, indicating that a percentage increase in quantity will result in less than a percentage decrease in price. This means that from a partial equilibrium focus, enhancement programs benefit both processors and the harvesting sector, although the benefits to each group are *not* the same magnitude. King, silver and chum salmon appear to be the species for which further enhancement would be most beneficial when considered only in terms of increased revenues since the prices for these species are the least responsive in each of the markets.

Table 5.2: Partial equilibrium price flexibility estimates

1964-1988

	EX-VESSEL	CANNED	FRESH/FROZEN
king	0	0	0
red	0	-0.009	-0.459
silver	0	0	-0.319
pink	-0.141	-0.341	-0.288
chum	0	-0.280	0

1978-1988

	EX-VESSEL	CANNED	FRESH/FROZEN
king	0	0	0
red	0	-0.003	-0.746
silver	0	0	-0.456
pink	-0.235	-0.463	-0.584
chum	0	-0.214	0

5.2 General equilibrium estimates of price flexibility parameters

For large changes in the quantity supplied we calculate a *general equilibrium* price flexibility estimate. By general equilibrium, we mean that the estimate takes into account changes in other parts of the system. In the case of ex-vessel quantity increases due to enhancement programs, these estimates indicate how ex-vessel prices will respond given that quantity increases at the ex-vessel level imply quantity increases at the canned and fresh/frozen quantity levels, which further imply that prices at these levels will decline, causing a decline in ex-vessel prices which is not taken into account in the partial equilibrium estimations.

While we are specifically interested in changes in the ex-vessel quantity, the method used can evaluate the general equilibrium elasticity for any of the exogenous variables to the system. We first demonstrate the method, which is a straight-forward application of Crammer's rule. Let the system of equations be defined by

$$PF = \alpha_{FD} + \beta_{FF}{}^{*}QF + \beta_{FZ}{}^{*}ZF \qquad \text{(Fresh/frozen demand)}$$

$$PC = \alpha_{CD} + \beta_{CF}{}^{*}QC + \beta_{CZ}{}^{*}ZC \qquad \text{(Canned demand)}$$

$$QF = \alpha_{FS} + \gamma_{FF}{}^{*}PF + \gamma_{FC}{}^{*}PC + \gamma_{FX}{}^{*}QX \qquad \text{(Fresh/frozen supply)}$$

$$QC = \alpha_{CS} + \gamma_{CF}{}^{*}PF + \gamma_{CC}{}^{*}PC + \gamma_{CX}{}^{*}QX \qquad \text{(Canned supply)}$$

$$PX = \alpha_{XD} + \gamma_{XF}{}^{*}PF + \gamma_{XC}{}^{*}PC + \gamma_{XX}{}^{*}QX \qquad \text{(Ex-vessel demand)}$$

where the variables PF, PC, QF, QC, and PX are the five endogenous variables corresponding to fresh/frozen price, canned price, fresh/frozen quantity, canned quantity, and ex-vessel price. The exogenous variables are the demand shifters ZF, and ZC, respectively for the exogenous variables in the fresh/frozen and canned demand equations, and QX which is ex-vessel landings. If we were interested in how the five endogenous variables would change when one of the exogenous variables changes, we recognize that in equilibrium each of the endogenous variables is a function of all of the exogenous variables in the system. We may thus totally differentiate the system with respect to one of the exogenous variables (we shall do this for QX). This results in the following matrix equation

$$\begin{bmatrix} -1 & 0 & \beta_{FF} & 0 & 0 \\ 0 & -1 & 0 & \beta_{CF} & 0 \\ \gamma_{FF} & \gamma_{FC} & -1 & 0 & 0 \\ \gamma_{CF} & \gamma_{CC} & 0 & -1 & 0 \\ \gamma_{XF} & \gamma_{XC} & 0 & 0 & -1 \end{bmatrix} \cdot \begin{bmatrix} dPF/dQX \\ dPC/dQX \\ dQF/dQX \\ dQC/dQX \\ dPX/dQX \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ -\gamma_{FX} \\ -\gamma_{CX} \\ -\gamma_{XX} \end{bmatrix}$$

Define by $Hx = b$ the above system. Then $x = H^{-1}b$ will give the general equilibrium slope coefficients. The price flexibilities and supply elasticities are obtained by multiplying the general equilibrium slope coefficients by the respective quantity/price ratios (price/quantity ratios in the case of the supply elasticities).

An alternative method is to use Crammer's rule on the above system by substituting the b vector in the column corresponding to the endogenous variable of interest, say column i, creating a new matrix which we denote as H_i. Crammer's rule states that $x_i = |H_i|/|H|$, where '$|A|$' denotes the determinant of the matrix **A**. The vector b would be ($-\gamma_{FZ}$,0, 0, 0, 0)' for an exogenous variable in the fresh/frozen demand equation, and (0, $-\gamma_{CZ}$, 0, 0, 0)' for an exogenous variable in the canned demand equation.

It is by the process just described that we calculate the general equilibrium price flexibility parameters and the supply elasticity parameters for each of the exogenous variables in the system. We use the coefficients estimated for the 2SLS models given in Section 3 for the ex-vessel demand equation and in Appendix B for the other equations. We consider a coefficient whose t-value is insignificant at the 90% confidence level to be equal to zero.

Table 5.3 reports the point estimates of the partial and general equilibrium price flexibilities and supply elasticities with respect to each of the exogenous variables. The rows correspond to the endogneous variables, and the columns correspond to the exogenous variables. The coefficient in the ith row and the jth column is the percentage change in the ith endogenous variable for a one percent change in the jth exogenous variable. The flexibilities (elasticities) in Table 5.3 are calculated using the average price and quantity for the entire sample 1964-1988. Table 5.4 reports these same estimates using the means from the period 1978-1988. Note that the own-price flexibilities are not calculated for the canned and fresh/frozen demand functions. The reason is simply that both price and quantity are endogenous, so it is meaningless to ask how one changes with respect to the other since each is determined simultaneously with the other as a function of the common set of exogenous variables.

We confine our discussion to the ex-vessel landings variable. For king salmon, the general equilibrium price flexibility parameter is positive in sign, due to the positve sign on quantity in the ex-vessel demand equation (this is the opposite of what is expected). For red salmon, the general equilibrium ex-vessel demand flexibility is zero (as is the partial equilibrium flexibility at the 90% confidence level). However, the red salmon fresh/frozen price is found to be much more responsive in the general equilibrium model relative to the partial equilibrium model (an increase in magnitude to -0.63 from 0). Silver salmon also becomes more responsive at the ex-vessel level and at the fresh/frozen level (canned remains perfectly inflexible). Pink salmon shows the largest change, with all of the prices having change of -0.52 percent in price due to a one percent increase in ex-vessel landings. Chum salmon prices are not repsonsive at the 90% confidence level in either the partial or general equilibrium models. These results generally hold when using the mean price and quantity data for the period 1978-1988 as reported in Table 5.4. The signs hold exactly since the same slope coefficients are used as in Table 5.3. The prices appear to be more flexible when evaluated using the 1978-1988 means than when using the means for the whole data set.

Table 5.3a: General equilibrium price flexibilities and supply elasticities

price and quantity means from 1964-1988

KING SALMON

Partial Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	0.00	0.00	0.00	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PC	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.07
PX	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

General Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	0.00	0.00	0.00	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PC	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.07
PX	0.24	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Partial Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QF	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

General Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QF	0.69	0.00	0.00	3.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.44
QC	0.00	0.00	0.00	-0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02

PF = fresh/frozen price, PC = canned price, PX = ex-vessel price, QF = fresh/frozen quantity, QC = canned quantity, QX = ex-vessel landings, CI = canned inventory holdings on july 1, FI = fresh/frozen inventory holdings on June 30, PT = tuna price, YJP = real per capita income average for US and Japan, PJP = sum of US and Japan populations, ERJP = exchange rate in yen/dollar, IRJP = real Japanese short term interest rates, YUK = real per capita income averages of US and UK, PUK = sum of US and UK populations, ERUK = exchange rate in pounds/dollar, UK short term real interest rates.

Table 5.3b: General equilibrium price flexibilities and supply elasticities

price and quantity means from 1964-1988

RED SALMON

Partial Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	0.00	0.00	0.00	0.78	-2.08	6.04	-2.52	0.00	0.00	0.00	0.00	0.00
PC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-2.62	4.00	0.00	0.00
PX	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

General Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	-0.63	0.00	0.00	0.78	-2.08	6.04	-2.52	0.00	0.00	0.00	0.00	0.00
PC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-3.67	5.61	0.00	0.00
PX	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-2.06	3.15	0.00	0.00

Partial Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QF	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

General Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QF	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.68	-0.10	0.00	0.00

PF = fresh/frozen price, PC = canned price, PX = ex-vessel price, QF = fresh/frozen quantity, QC = canned quantity, QX = ex-vessel landings, CI = canned inventory holdings on july 1, FI = fresh/frozen inventory holdings on June 30, PT = tuna price, YJP = real per capita income average for US and Japan, PJP = sum of US and Japan populations, ERJP = exchange rate in yen/dollar, IRJP = real Japanese short term interest rates, YUK = real per capita income averages of US and UK, PUK = sum of US and UK populations, ERUK = exchange rate in pounds/dollar, UK short term real interest rates.

Table 5.3c: General equilibrium price flexibilities and supply elasticities

price and quantity means from 1964–1988

SILVER SALMON

Partial Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	0.00	0.00	0.00	0.72	-2.27	5.96	-1.44	-0.08	0.00	0.00	0.00	0.00
PC	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	1.40	-1.65	0.00	-0.08
PX	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

General Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	-0.40	0.00	0.00	0.72	-2.27	5.96	-1.44	-0.08	0.00	0.00	0.00	0.00
PC	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	1.40	-1.65	0.00	-0.08
PX	-0.27	0.00	0.00	0.75	-1.53	4.00	-0.97	-0.06	0.77	-0.91	0.00	-0.04

Partial Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QF	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QC	0.00	0.00	0.00	-0.51	0.04	-0.00	0.00	0.03	0.00	0.00	0.00	0.00

General Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QF	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PF = fresh/frozen price, PC = canned price, PX = ex-vessel price, QF = fresh/frozen quantity, QC = canned quantity, QX = ex-vessel landings, CI = canned inventory holdings on july 1, FI = fresh/frozen inventory holdings on June 30, PT = tuna price, YJP = real per capita income average for US and Japan, PJP = sum of US and Japan populations, ERJP = exchange rate in yen/dollar, IRJP = real Japanese short term interest rates, YUK = real per capita income averages of US and UK, PUK = sum of US and UK populations, ERUK = exchange rate in pounds/dollar, UK short term real interest rates.

Table 5.3d: General equilibrium price flexibilities and supply elasticities

price and quantity means from 1964-1988

PINK SALMON

Partial Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	0.00	0.00	0.00	0.00	0.00	3.77	0.00	-0.11	0.00	0.00	0.00	0.00
PC	0.00	-0.23	0.00	0.00	0.00	0.00	0.00	0.00	-3.03	5.10	-0.00	-0.03
PX	-0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

General Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	-0.50	0.00	0.00	0.00	0.00	3.77	0.00	-0.11	0.00	0.00	0.00	0.00
PC	-0.29	-0.27	0.00	0.00	0.00	0.00	0.00	0.00	-3.54	5.96	-0.00	-0.03
PX	-0.52	0.00	0.00	0.00	0.00	2.89	0.00	-0.08	0.00	0.00	0.00	0.00

Partial Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QF	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QC	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

General Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QF	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QC	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.16	-0.16	18.46	18.85

PF = fresh/frozen price, PC = canned price, PX = ex-vessel price, QF = fresh/frozen quantity, QC = canned quantity, QX = ex-vessel landings, CI = canned inventory holdings on July 1, FI = fresh/frozen inventory holdings on June 30, PT = tuna price, YJP = real per capita income average for US and Japan, PJP = sum of US and Japan populations, ERJP = exchange rate in yen/dollar, IRJP = real Japanese short term interest rates, YUK = real per capita income averages of US and UK, PUK = sum of US and UK populations, ERUK = exchange rate in pounds/dollar, UK short term real interest rates.

Table 5.3e: General equilibrium price flexibilities and supply elasticities

price and quantity means from 1964-1988

CHUM SALMON

Partial Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	0.00	0.00	0.00	1.24	0.00	2.32	0.00	0.00	0.00	0.00	0.00	0.00
PC	0.00	-0.10	0.00	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.05
PX	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

General Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	0.00	0.00	0.00	1.24	0.00	2.32	0.00	0.00	0.00	0.00	0.00	0.00
PC	0.00	-0.10	0.00	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.05
PX	0.00	-0.06	0.00	1.59	0.00	2.03	0.00	0.00	0.00	0.00	0.00	-0.03

Partial Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QF	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

General Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QF	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5.4a: General equilibrium price flexibilities and supply elasticities

price and quantity means from 1978–1988

KING SALMON

Partial Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PC	0.00	0.00	0.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.17
PX	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

General Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PC	0.00	0.00	0.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.17
PX	0.23	0.00	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Partial Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QF	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

General Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QF	0.79	0.00	0.00	4.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.25
QC	0.00	0.00	0.00	-0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PF = fresh/frozen price, PC = canned price, PX = ex-vessel price, QF = fresh/frozen quantity, QC = canned quantity, QX = ex-vessel landings, CI = canned inventory holdings on july 1, FI = fresh/frozen inventory holdings on June 30, PT = tuna price, YJP = real per capita income average for US and Japan, PJP = sum of US and Japan populations, ERJP = exchange rate in yen/dollar, IRJP = real Japanese short term interest rates, YUK = real per capita income averages of US and UK, PUK = sum of US and UK populations, ERUK = exchange rate in pounds/dollar, UK short term real interest rates.

Table 5.4b: General equilibrium price flexibilities and supply elasticities

price and quantity means from 1978-1988

RED SALMON

Partial Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	0.00	0.00	0.00	0.52	-1.83	4.93	-1.35	0.00	0.00	0.00	0.00	0.00
PC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-2.91	3.97	0.00	0.00
PX	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

General Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	-0.75	0.00	0.00	0.52	-1.83	4.93	-1.35	0.00	0.00	0.00	0.00	0.00
PC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-4.07	5.57	0.00	0.00
PX	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-2.02	2.76	0.00	0.00

Partial Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QF	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

General Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QF	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.74	-0.08	0.00	0.00

PF = fresh/frozen price, PC = canned price, PX = ex-vessel price, QF = fresh/frozen quantity, QC = canned quantity, QX = ex-vessel landings, CI = canned inventory holdings on july 1, FI = fresh/frozen inventory holdings on June 30, PT = tuna price, YJP = real per capita income average for US and Japan, PJP = sum of US and Japan populations, ERJP = exchange rate in yen/dollar, IRJP = real Japanese short term interest rates, YUK = real per capita income averages of US and UK, PUK = sum of US and UK populations, ERUK = exchange rate in pounds/dollar, UK short term real interest rates.

Table 5.4c: General equilibrium price flexibilities and supply elasticities

price and quantity means from 1978-1988

SILVER SALMON

Partial Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	0.00	0.00	0.00	0.55	-2.26	5.50	-0.87	-0.13	0.00	0.00	0.00	0.00
PC	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	1.69	-1.78	0.00	-0.19
PX	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

General Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	-0.51	0.00	0.00	0.55	-2.26	5.50	-0.87	-0.13	0.00	0.00	0.00	0.00
PC	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	1.69	-1.78	0.00	-0.19
PX	-0.37	0.00	0.00	0.62	-1.66	4.03	-0.64	-0.09	0.86	-0.91	0.00	-0.10

Partial Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QF	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

General Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QF	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QC	0.00	0.00	0.00	-0.38	0.02	-0.00	0.00	0.01	0.00	0.00	0.00	0.00

PF = fresh/frozen price, PC = canned price, PX = ex-vessel price, QF = fresh/frozen quantity, QC = canned quantity, QX = ex-vessel landings, CI = canned inventory holdings on July 1, FI = fresh/frozen inventory holdings on June 30, PT = tuna price, YJP = real per capita income average for US and Japan, PJP = sum of US and Japan populations, ERJP = exchange rate in yen/dollar, IRJP = real Japanese short term interest rates, YUK = real per capita income averages of US and UK, PUK = sum of US and UK populations, ERUK = exchange rate in pounds/dollar, UK short term real interest rates.

Table 5.4d: General equilibrium price flexibilities and supply elasticities

price and quantity means from 1978-1988

PINK SALMON

Partial Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	0.00	0.00	0.00	0.00	0.00	4.10	0.00	-0.19	0.00	0.00	0.00	0.00
PC	0.00	-0.32	0.00	0.00	0.00	0.00	0.00	0.00	-3.71	5.59	-0.00	-0.07
PX	-0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

General Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	-0.75	0.00	0.00	0.00	0.00	4.10	0.00	-0.19	0.00	0.00	0.00	0.00
PC	-0.44	-0.37	0.00	0.00	0.00	0.00	0.00	0.00	-4.34	6.53	-0.00	-0.08
PX	-0.86	0.00	0.00	0.00	0.00	3.44	0.00	-0.16	0.00	0.00	0.00	0.00

Partial Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QF	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QC	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

General Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QF	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QC	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.03	-0.20	16.56	10.59

PF = fresh/frozen price, PC = canned price, PX = ex-vessel price, QF = fresh/frozen quantity, QC = canned quantity, QX = ex-vessel landings, CI = canned inventory holdings on july 1, FI = fresh/frozen inventory holdings on June 30, PT = tuna price, YJP = real per capita income average for US and Japan, PJP = sum of US and Japan populations, ERJP = exchange rate in yen/dollar, IRJP = real Japanese short term interest rates, YUK = real per capita income averages of US and UK, PUK = sum of US and UK populations, ERUK = exchange rate in pounds/dollar, UK short term real interest rates.

Table 5.4e: General equilibrium price flexibilities and supply elasticities

price and quantity means from 1978-1988

CHUM SALMON

Partial Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	0.00	0.00	0.00	1.01	0.00	2.31	0.00	0.00	0.00	0.00	0.00	0.00
PC	0.00	-0.09	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.12
PX	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

General Equilibrium Flexibilities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
PF	0.00	0.00	0.00	1.01	0.00	2.31	0.00	0.00	0.00	0.00	0.00	0.00
PC	0.00	-0.09	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.12
PX	0.00	-0.05	0.00	1.33	0.00	2.06	0.00	0.00	0.00	0.00	0.00	-0.07

Partial Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QF	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

General Equilibrium Elasticities

	QX	CI	FI	PT	YJP	PJP	ERJP	IRJP	YUK	PUK	ERUK	IRUK
QC	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PF = fresh/frozen price, PC = canned price, PX = ex-vessel price, QF = fresh/frozen quantity, QC = canned quantity, QX = ex-vessel landings, CI = canned inventory holdings on july 1, FI = fresh/frozen inventory holdings on June 30, PT = tuna price, YJP = real per capita income average for US and Japan, PJP = sum of US and Japan populations, ERJP = exchange rate in yen/dollar, IRJP = real Japanese short term interest rates, YUK = real per capita income averages of US and UK, PUK = sum of US and UK populations, ERUK = exchange rate in pounds/dollar, UK short term real interest rates.

6 Out of sample predictions (1989-1998)

This section contains estimates of the ex-vessel prices for 1989-1998. These predictions are generated by using linear trend forecasts for the exogenous variables and are computed for three levels of ex vessel landings quantity, one using the 1978-1988 average, and another using the ten percent higher quantities, and another using twenty percent higher quantities than the 1978-1988 average.

Several caveats are in order. First, by definition, exogenous variables are variables which the model is not designed to predict. Thus our estimates of the future values of these variables are little better than guesses. The way we estimated these values was to run a regression of the exogenous variable against time and a constant. The coefficient for time is the linear trend. A positive and significant value was interpreted as meaning that the trend was for the variable to continue to increase. In the event that the t-ratio indicated no time trend, we used the 1978-1988 average value for that variable.

Second, in the event that the 1988 value differed significantly from the predicted trend, the starting point for the trend analysis may be biased. This is particularly a problem when the time pattern for the exogenous variable does not follow a linear progression (which is, unfortunately, true of many of the variables). This means that estimates for the first several years are bound to be off by possibly large margins.

Third, the values given are simply the point estimates of the price. That is, they represent the average or expected value given the exogenous variables equal the value predicted by the trend analysis. Even in the event that the trend analysis exactly predicted the exogenous variable's value, there would still exist variability due to the imprecision of the prediction model. Compound this with the variance in the predictions of the exogenous variables, and it is impossible to state what the prediction error is. We suspect that it is at least an order of magnitude larger than the prediction error within the sample.

Table 6.1 presents the predictions for ex-vessel prices given the quantity equals the average for 1978-1988 for each species. Table 6.2 presents the predictions for ex-vessel prices given a ten percent increase over the average for 1978-1988, and Table 6.3 presents the predictions for ex-vessel prices given a twenty percent increase over the average for 1978-1988. Appendix C contains the models used to predict the linear trend analysis.

The results generally indicate that prices in real 1988 dollars should be increasing over the forecast period. King and chum salmon seem to be the least responsive to changes in the quantities. Pink salmon are predicted to grow in value the most in percentage terms by 20 percent or so over the period. However, pink salmon is also the most responsive to increases in quantity in terms of reductions in price.

Note that for none of the species does a twenty percent increase in quantity imply a price decrease of near twenty percent (the highest is pink salmon with a price decrease of 12.5% on a twenty percent quantity increase). This indicates that with current enhancement capabilities, an increase of up to twenty percent appears to be warranted at least on revenues grounds. Of course, a complete analysis of this would require information regarding costs of expanding enhancement capabilities.

Table 6.1 Ex-vessel price predictions using 1978-1988 average landings

YEAR	KING	RED	SILVER	PINK	CHUM
89	1.96	1.37	1.40	0.48	0.60
90	1.96	1.40	1.42	0.49	0.61
91	1.96	1.44	1.45	0.50	0.62
92	1.96	1.47	1.48	0.51	0.63
93	1.96	1.51	1.51	0.52	0.63
94	1.96	1.55	1.53	0.54	0.64
95	1.97	1.58	1.56	0.55	0.65
96	1.97	1.62	1.59	0.56	0.66
97	1.97	1.65	1.62	0.57	0.67
98	1.97	1.69	1.64	0.58	0.68

Table 6.2 Ex-vessel price predictions using 1978-1988 average landings plus 10%

YEAR	KING	RED	SILVER	PINK	CHUM
89	1.93	1.34	1.36	0.45	0.59
90	1.93	1.37	1.39	0.46	0.60
91	1.94	1.41	1.42	0.47	0.61
92	1.94	1.44	1.44	0.48	0.62
93	1.94	1.48	1.47	0.49	0.63
94	1.94	1.51	1.50	0.50	0.64
95	1.94	1.55	1.53	0.52	0.65
96	1.94	1.58	1.55	0.53	0.66
97	1.94	1.62	1.58	0.54	0.67
98	1.94	1.66	1.61	0.55	0.68

Table 6.3 Ex-vessel price predictions using 1978-1988 average landings plus 20%

YEAR	KING	RED	SILVER	PINK	CHUM
89	1.93	1.34	1.36	0.45	0.59
90	1.93	1.37	1.39	0.46	0.60
91	1.94	1.41	1.42	0.47	0.61
92	1.94	1.44	1.44	0.48	0.62
93	1.94	1.48	1.47	0.49	0.63
94	1.94	1.51	1.50	0.50	0.64
95	1.94	1.55	1.53	0.52	0.65
96	1.94	1.58	1.55	0.53	0.66
97	1.94	1.62	1.58	0.54	0.67
98	1.94	1.66	1.61	0.55	0.68

7. Summary of results and recommendations for further research

This paper has studied three different demand models for Alaskan salmon with the purpose of using the information to quide policy with respect to salmon enhancement programs. The results are that the 2SLS model appears to preform better at predicting ex-vessel prices than either the CFEC (Muse, 1984) or ISER (Ronan, 1989) models. The 2SLS model suggests that prices are relatively inflexible with respect to quantity changes. This implies that from a revenues standpoint, further enhancement appears to be warranted. However, we do not believe that the data is robust enough to make a prediction as to what quantity would maximize revenues. In this regard, it appears that continued expansion of the enhancement program will continue to increase revenues., but that as quantities conditinue to increase, that the demand flexibility coefficients need to be re-estimated.[12]

The revenue effects are not the same across all species nor for different sectors of the fishing economy. King, silver, and chum salmon appear to have the greatest potential from a revenue increasing point of view due to their low price flexibility estimates. However, specific recommendations regarding species selection would require a more indepth analysis of the cost side of both the fishing industry (harvesting and processing) and of the enhancement process itself.

[12] One test that may be worthwhile pursuing would be to test functional forms. Recall that Zhang estimated his model using a double logged form, implying a constant elasticity of demand. We estimated the demand function linearly on the assumption that the elasticity may decrease as quantity increased. One way to test this is to use the Box-Cox transformation.

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APPENDIX A: DATA USED IN THE ANALYSIS.

Table A.1: ADF&G Ex-vessel total values (nominal dollars)

YEAR	PXKING	PXRED	PXSILV	PXPINK	PXCHUM
1964.00	3662.00	12247.00	3582.00	17174.00	4695.00
1965.00	3049.00	30802.00	4362.00	7684.00	2377.00
1966.00	2949.00	19737.00	3705.00	22093.00	5718.00
1967.00	3100.00	11865.00	3343.00	3241.00	3083.00
1968.00	3865.00	12723.00	5362.00	20490.00	7015.00
1969.00	3506.00	18046.00	2229.00	15712.00	2934.00
1970.00	5035.00	37249.00	3512.00	15563.00	6616.00
1971.00	4688.00	22849.00	2820.00	13518.00	7536.00
1972.00	3731.00	13180.00	5583.00	10882.00	11919.00
1973.00	7880.00	15327.00	7470.00	11666.00	17716.00
1974.00	6945.00	22119.00	8678.00	13861.00	13975.00
1975.00	5345.00	19262.00	4405.00	16053.00	10850.00
1976.00	8446.00	45991.00	10064.00	34871.00	18582.00
1977.00	14449.00	68273.00	14624.00	45574.00	27802.00
1978.00	20179.00	113992.00	21119.00	62502.00	26105.00
1979.00	22597.00	189592.00	28053.00	74908.00	29008.00
1980.00	17035.00	114123.00	17796.00	84517.00	34386.00
1981.00	23748.00	196301.00	23853.00	105851.00	47578.00
1982.00	27080.00	156533.00	40146.00	47476.00	38752.00
1983.00	18233.00	212817.00	16186.00	47974.00	25015.00
1984.00	21779.00	171470.00	42742.00	70360.00	36281.00

Table A.2: ADF&G Canned total values (nominal dollars)

YEAR	PCKING	PCRED	PCSILV	PCPINK	PCCHUM
1964.00	1268.00	29289.00	4770.00	39429.00	12674.00
1965.00	1793.00	72153.00	3156.00	24015.00	6621.00
1966.00	1328.00	46182.00	3596.00	55547.00	13923.00
1967.00	1829.00	28915.00	2228.00	10057.00	9093.00
1968.00	1666.00	28530.00	4105.00	58181.00	16965.00
1969.00	1385.00	29581.00	1026.00	37735.00	5763.00
1970.00	1087.00	67446.00	1939.00	42108.00	12032.00
1971.00	1293.00	50737.00	3063.00	36104.00	16831.00
1972.00	1045.00	29469.00	2278.00	25682.00	16872.00
1973.00	889.00	31652.00	2924.00	31588.00	19843.00
1974.00	1430.00	38189.00	4461.00	34891.00	19923.00
1975.00	696.00	43383.00	3294.00	36176.00	11875.00
1976.00	2854.00	78732.00	2514.00	74117.00	19979.00
1977.00	826.00	74974.00	1654.00	84777.00	26603.00
1978.00	1344.00	88866.00	2136.00	110341.00	17751.00
1979.00	1065.00	108958.00	3142.00	126508.00	13462.00
1980.00	1002.00	16094.00	4327.00	173885.00	31234.00
1981.00	337.00	130339.00	3302.00	192670.00	36009.00
1982.00	179.00	37962.00	2516.00	112539.00	12364.00
1983.00	706.00	148025.00	4035.00	136234.00	15866.00
1984.00	201.00	119089.00	4523.00	180763.00	17907.00

Table A.3: ADF&G Canned plus Fresh/froxen total value (nominal dollars)

YEAR	TRKING	TRRED	TRSILV	TRPINK	TRCHUM
1964.00	6524.00	30738.00	8737.00	43065.00	14513.00
1965.00	5290.00	72841.00	5697.00	24265.00	7075.00
1966.00	5226.00	47381.00	6290.00	57089.00	15459.00
1967.00	5900.00	29710.00	5814.00	10384.00	10603.00
1968.00	5728.00	30505.00	10085.00	58795.00	18732.00
1969.00	5953.00	31138.00	3833.00	38149.00	7242.00
1970.00	7883.00	70101.00	5800.00	43326.00	16653.00
1971.00	6952.00	52709.00	4806.00	36736.00	20127.00
1972.00	6462.00	30957.00	8810.00	26476.00	23672.00
1973.00	11525.00	39213.00	11202.00	32547.00	32881.00
1974.00	8225.00	39804.00	11066.00	36675.00	28086.00
1975.00	7466.00	48178.00	8957.00	38294.00	24867.00
1976.00	13392.00	88725.00	12296.00	76207.00	35078.00
1977.00	23764.00	111346.00	20717.00	90075.00	44793.00
1978.00	28827.00	184470.00	34107.00	120863.00	42051.00
1979.00	31148.00	257873.00	58857.00	153218.00	46845.00
1980.00	26444.00	245518.00	30153.00	189485.00	63519.00
1981.00	32096.00	325965.00	37117.00	216094.00	77744.00
1982.00	38846.00	260233.00	59850.00	149694.00	73405.00
1983.00	30685.00	395359.00	37817.00	151718.00	58607.00
1984.00	28950.00	326386.00	63849.00	207634.00	73760.00

Table A.4: ADF&G Ex-vessel total quantity (1000 lbs)

YEAR	QXKING	QXRED	QXSILV	QXPINK	QXCHUM
1964.00	11567.00	54132.00	20954.00	162281.00	62690.00
1965.00	11009.00	142034.00	17666.00	74873.00	29263.00
1966.00	9350.00	92767.00	16113.00	162866.00	52230.00
1967.00	11632.00	53522.00	13022.00	28822.00	31518.00
1968.00	11246.00	48696.00	20968.00	148456.00	55916.00
1969.00	10746.00	71735.00	8034.00	105967.00	22668.00
1970.00	11547.00	150812.00	11898.00	117718.00	54491.00
1971.00	11972.00	87288.00	11459.00	86260.00	54726.00
1972.00	9973.00	41984.00	13035.00	59969.00	64823.00
1973.00	8917.00	35248.00	9837.00	36610.00	45881.00
1974.00	9290.00	32246.00	12820.00	40072.00	37174.00
1975.00	6942.00	42762.00	7128.00	49969.00	30805.00
1976.00	8915.00	75689.00	11158.00	102419.00	47675.00
1977.00	12102.00	89770.00	15403.00	129554.00	60548.00
1978.00	16304.00	116767.00	19978.00	183993.00	52614.00
1979.00	15054.00	171824.00	23918.00	186838.00	45043.00
1980.00	12536.00	186644.00	22462.00	217866.00	71812.00
1981.00	15746.00	225956.00	26051.00	244677.00	99572.00
1982.00	16897.00	189555.00	46559.00	219426.00	90247.00
1983.00	15683.00	305661.00	26890.00	193977.00	79186.00
1984.00	12519.00	222250.00	44583.00	276265.00	104453.00

Table A.5: ADF&G Canned total quantity (1000 lbs)

YEAR	QCKING	QCRED	QCSILV	QCPINK	QCCHUM
1964.00	1818.00	34357.00	7929.00	92555.00	33742.00
1965.00	2401.00	92708.00	5056.00	42393.00	14321.00
1966.00	1678.00	59394.00	5620.00	96767.00	28100.00
1967.00	2172.00	32761.00	3201.00	15798.00	16363.00
1968.00	2099.00	30088.00	5761.00	87274.00	30237.00
1969.00	1579.00	36788.00	1321.00	56909.00	10092.00
1970.00	1309.00	81871.00	2567.00	63772.00	21599.00
1971.00	1537.00	53200.00	3943.00	51578.00	28887.00
1972.00	968.00	26049.00	2372.00	28935.00	23556.00
1973.00	439.00	16568.00	1532.00	22742.00	17046.00
1974.00	788.00	20809.00	2837.00	24711.00	15339.00
1975.00	384.00	26559.00	2356.00	26524.00	10609.00
1976.00	1747.00	42974.00	1575.00	54589.00	17640.00
1977.00	413.00	36559.00	1052.00	64430.00	22089.00
1978.00	721.00	42942.00	1313.00	87569.00	15397.00
1979.00	499.00	20162.00	2036.00	36960.00	6709.00
1980.00	391.00	66603.00	2204.00	108355.00	20758.00
1981.00	184.00	54656.00	1784.00	122175.00	28065.00
1982.00	73.00	14303.00	1303.00	83821.00	9178.00
1983.00	381.00	66262.00	2156.00	98028.00	12969.00
1984.00	104.00	53285.00	2713.00	130563.00	16409.00

Table A.6: ADF&G Canned plus Fresh/froxen total quantity (1000 lbs)

YEAR	TQKING	TQRED	TQSILV	TQPINK	TQCHUM
1964.00	8636.00	36509.00	14557.00	107033.00	38552.00
1965.00	7375.00	94585.00	11147.00	43583.00	16307.00
1966.00	6969.00	62331.00	11424.00	103625.00	34671.00
1967.00	8048.00	34650.00	9933.00	16986.00	21139.00
1968.00	7592.00	34580.00	15407.00	90025.00	35614.00
1969.00	7128.00	40494.00	6793.00	58622.00	14427.00
1970.00	8622.00	88361.00	8794.00	67349.00	34190.00
1971.00	8449.00	57081.00	7231.00	53407.00	36908.00
1972.00	7197.00	28453.00	10375.00	31151.00	36780.00
1973.00	7666.00	23142.00	8179.00	24008.00	33821.00
1974.00	6174.00	22466.00	9254.00	27387.00	27058.00
1975.00	5505.00	31246.00	7710.00	28913.00	27397.00
1976.00	7080.00	50930.00	7372.00	57049.00	30378.00
1977.00	9123.00	57106.00	10870.00	70300.00	37377.00
1978.00	13683.00	86176.00	16272.00	100008.00	35766.00
1979.00	11429.00	58991.00	16635.00	61155.00	28086.00
1980.00	9449.00	121918.00	14891.00	128297.00	46461.00
1981.00	11854.00	154220.00	18716.00	146098.00	61950.00
1982.00	14247.00	139696.00	34421.00	136927.00	60867.00
1983.00	14416.00	221087.00	22648.00	118635.00	52288.00
1984.00	9509.00	165596.00	32198.00	169406.00	67287.00

Table A.7: Ex-Vessel prices (nominal dollars)

YEAR	PXKING	PXRED	PXSILV	PXPINK	PXCHUM
1964.00	0.32	0.23	0.17	0.11	0.07
1965.00	0.28	0.22	0.25	0.10	0.08
1966.00	0.32	0.21	0.23	0.14	0.11
1967.00	0.27	0.22	0.26	0.11	0.10
1968.00	0.34	0.26	0.26	0.14	0.13
1969.00	0.33	0.25	0.28	0.15	0.13
1970.00	0.44	0.25	0.30	0.13	0.12
1971.00	0.39	0.26	0.25	0.16	0.14
1972.00	0.37	0.31	0.43	0.18	0.18
1973.00	0.88	0.43	0.76	0.32	0.39
1974.00	0.75	0.69	0.68	0.35	0.38
1975.00	0.71	0.45	0.57	0.32	0.35
1976.00	1.02	0.60	0.93	0.34	0.41
1977.00	1.27	0.51	1.02	0.36	0.49
1978.00	1.25	0.97	1.11	0.33	0.47
1979.00	1.51	1.10	1.31	0.40	0.65
1980.00	1.42	0.59	0.80	0.35	0.45
1981.00	1.51	0.87	0.92	0.43	0.48
1982.00	1.60	0.83	0.86	0.22	0.43
1983.00	1.16	0.70	0.60	0.25	0.32
1984.00	1.74	0.77	0.96	0.25	0.35
1985.00	1.54	0.99	0.90	0.24	0.40
1986.00	1.52	1.43	0.90	0.24	0.35
1987.00	2.02	1.55	1.14	0.42	0.46
1988.00	2.73	2.35	1.75	0.79	0.89

Source: ADF&G (1964-1974), CFEC (1975-1988)

Table A.8: Canned prices (nominal dollars)

YEAR	PCKING	PCRED	PCSILV	PCPINK	PCCHUM
1964.00	0.70	0.85	0.60	0.43	0.38
1965.00	0.75	0.78	0.62	0.57	0.46
1966.00	0.79	0.78	0.64	0.57	0.50
1967.00	0.84	0.88	0.70	0.64	0.56
1968.00	0.79	0.95	0.71	0.67	0.56
1969.00	0.88	0.80	0.78	0.66	0.57
1970.00	0.83	0.82	0.76	0.66	0.56
1971.00	0.84	0.95	0.78	0.70	0.58
1972.00	1.08	1.13	0.96	0.89	0.72
1973.00	2.03	1.91	1.91	1.39	1.16
1974.00	1.81	1.84	1.57	1.41	1.30
1975.00	1.81	1.63	1.40	1.36	1.12
1976.00	1.63	1.83	1.60	1.36	1.13
1977.00	2.00	2.05	1.57	1.32	1.20
1978.00	1.86	2.07	1.63	1.26	1.15
1979.00	2.13	5.40	1.54	3.42	2.01
1980.00	2.56	0.24	1.96	1.60	1.50
1981.00	1.83	2.38	1.85	1.58	1.28
1982.00	2.45	2.65	1.93	1.34	1.35
1983.00	1.85	2.23	1.87	1.39	1.22
1984.00	1.91	2.25	1.68	1.40	1.09
1985.00	1.82	2.62	2.06	1.19	1.34
1986.00	2.94	3.64	2.95	1.34	1.21
1987.00	2.28	3.62	2.45	1.97	1.67
1988.00	3.68	5.71	4.22	2.95	2.74

Source: ADF&G (1964-1983), CFEC (1984-1988)

Table A.9: Fresh/Frozen prices (nominal dollars)

YEAR	TRKING	TRRED	TRSILV	TRPINK	TRCHUM
1964.00	0.77	0.67	0.60	0.[illegible]5	0.38
1965.00	0.70	0.37	0.42	0.21	0.23
1966.00	0.74	0.41	0.46	0.22	0.23
1967.00	0.69	0.42	0.53	0.28	0.32
1968.00	0.74	0.44	0.62	0.22	0.33
1969.00	0.82	0.42	0.51	0.24	0.34
1970.00	0.93	0.41	0.62	0.34	0.37
1971.00	0.82	0.51	0.53	0.35	0.41
1972.00	0.87	0.62	0.82	0.36	0.51
1973.00	1.47	1.15	1.25	0.76	0.78
1974.00	1.26	0.97	1.03	0.67	0.70
1975.00	1.32	1.02	1.06	0.89	0.77
1976.00	1.98	1.26	1.69	0.85	1.19
1977.00	2.63	1.77	1.94	0.90	1.19
1978.00	2.12	2.21	2.14	0.85	1.19
1979.00	2.75	3.84	3.82	1.10	1.56
1980.00	2.81	4.15	2.04	0.78	1.26
1981.00	2.72	1.96	2.00	0.98	1.23
1982.00	2.73	1.77	1.73	0.70	1.18
1983.00	2.14	1.60	1.65	0.75	1.09
1984.00	3.06	1.82	2.01	0.73	1.10
1985.00	2.73	2.03	1.84	0.68	1.09
1986.00	2.84	2.54	1.99	0.73	1.07
1987.00	3.78	2.85	2.96	1.15	1.48
1988.00	4.60	4.13	3.47	1.69	1.90

Source: ADF&G (1964-1983), CFEC (1984-1988)

Table A.10: Ex-vessel quantity (1000 lbs)

YEAR	QXKING	QXRED	QXSILV	QXPINK	QXCHUM
1964.00	11567.00	54132.00	20954.00	162281.00	62690.00
1965.00	11009.00	142034.00	17666.00	74873.00	29263.00
1966.00	9350.00	92767.00	16113.00	162866.00	52230.00
1967.00	11632.00	53522.00	13022.00	28822.00	31518.00
1968.00	11246.00	48696.00	20968.00	148456.00	55916.00
1969.00	10746.00	71735.00	8034.00	105967.00	22668.00
1970.00	11547.00	150812.00	11898.00	117718.00	54491.00
1971.00	11972.00	87288.00	11459.00	86260.00	54726.00
1972.00	9973.00	41984.00	13035.00	59969.00	64823.00
1973.00	8917.00	35248.00	9837.00	36610.00	45881.00
1974.00	9290.00	32246.00	12820.00	40072.00	37174.00
1975.00	7184.38	42866.85	7687.62	49971.04	32063.77
1976.00	8947.89	75689.93	11178.81	102411.48	47662.68
1977.00	12102.64	89772.51	15402.41	129554.18	60569.56
1978.00	16305.36	116767.42	19978.86	183993.98	52614.79
1979.00	15059.76	171826.93	23922.43	186842.40	45044.95
1980.00	12501.30	186700.17	22424.63	217944.19	71802.49
1981.00	15738.25	225955.79	25847.19	244968.47	99540.88
1982.00	16903.89	188550.21	46541.16	219147.48	91188.56
1983.00	15683.57	305641.04	26793.39	194080.83	79117.34
1984.00	12524.04	222698.89	44514.79	276681.29	104068.04
1985.00	13476.81	221508.10	47262.31	304258.42	83363.31
1986.00	11712.22	194556.61	46602.98	259254.91	97096.83
1987.00	13282.48	224831.36	25312.49	164811.93	80346.79
1988.00	10784.33	192929.30	35291.40	177882.96	116207.06

Source: ADF&G (1964-1974), CFEC (1975-1988)

Table A.11: Canned quantity (1000 lbs)

YEAR	QCKING	QCRED	QCSILV	QCPINK	QCCHUM
1964.00	1818.00	34357.00	7929.00	92555.00	33742.00
1965.00	2401.00	92708.00	5056.00	42393.00	14321.00
1966.00	1678.00	59394.00	5620.00	96767.00	28100.00
1967.00	2172.00	32761.00	3201.00	15798.00	16363.00
1968.00	2099.00	30088.00	5761.00	87274.00	30237.00
1969.00	1579.00	36788.00	1321.00	56909.00	10092.00
1970.00	1309.00	81871.00	2567.00	63772.00	21599.00
1971.00	1537.00	53200.00	3943.00	51578.00	28887.00
1972.00	968.00	26049.00	2372.00	28935.00	23556.00
1973.00	439.00	16568.00	1532.00	22742.00	17046.00
1974.00	788.00	20809.00	2837.00	24711.00	15339.00
1975.00	384.00	26559.00	2356.00	26524.00	10609.00
1976.00	1747.00	42974.00	1575.00	54589.00	17640.00
1977.00	413.00	36559.00	1052.00	64430.00	22089.00
1978.00	721.00	42942.00	1313.00	87569.00	15397.00
1979.00	499.00	20162.00	2036.00	36960.00	6709.00
1980.00	391.00	66603.00	2204.00	108355.00	20758.00
1981.00	184.00	54656.00	1784.00	122175.00	28065.00
1982.00	73.00	[illegible]	1303.00	83821.00	9178.00
1983.00	381.00	[illegible]	2156.00	98028.00	12969.00
1984.00	97.84	[illegible]	2673.09	122628.80	15958.02
1985.00	122.77	21406.26	826.41	120791.41	7738.03
1986.00	40.47	17913.38	2409.72	106695.56	6263.55
1987.00	57.16	32184.77	1117.51	65073.38	8543.29
1988.00	64.16	10179.39	[illegible]	55752.32	7017.34

Source: ADF&G (1964-1983), CFEC (1984-1988)

Table A.12: Fresh/froxen quantity (1000 lbs)

YEAR	TQKING	TQRED	TQSILV	TQPINK	TQCHUM
1964.00	6818.00	2152.00	6628.00	14478.00	4810.00
1965.00	4974.00	1877.00	6091.00	1190.00	1986.00
1966.00	5291.00	2937.00	5804.00	6858.00	6571.00
1967.00	5876.00	1889.00	6732.00	1188.00	4776.00
1968.00	5493.00	4492.00	9646.00	2751.00	5377.00
1969.00	5549.00	3706.00	5472.00	1713.00	4335.00
1970.00	7313.00	6490.00	6227.00	3577.00	12591.00
1971.00	6912.00	3881.00	3288.00	1829.00	8021.00
1972.00	6229.00	2404.00	8003.00	2216.00	13224.00
1973.00	7227.00	6574.00	6647.00	1266.00	16775.00
1974.00	5386.00	1657.00	6417.00	2676.00	11719.00
1975.00	5121.00	4687.00	5354.00	2389.00	16788.00
1976.00	5333.00	7956.00	5797.00	2460.00	12738.00
1977.00	8710.00	20547.00	9818.00	5870.00	15288.00
1978.00	12962.00	43234.00	14959.00	12439.00	20369.00
1979.00	10930.00	38829.00	14599.00	24195.00	21377.00
1980.00	9058.00	55315.00	12687.00	19942.00	25703.00
1981.00	11670.00	99564.00	16932.00	23923.00	33885.00
1982.00	14174.00	125393.00	33118.00	53106.00	51689.00
1983.00	14035.00	154825.00	20492.00	20607.00	39319.00
1984.00	9409.07	114387.57	29491.75	43146.09	50906.25
1985.00	10085.23	149028.77	35328.37	57954.84	54830.28
1986.00	8645.77	120428.75	34187.61	39227.73	54341.55
1987.00	10419.45	126915.63	17508.28	35373.37	45242.74
1988.00	11746.46	117462.40	22849.37	45499.44	75786.55

Source: ADF&G (1964-1983), CFEC (1984-1988)

Table A.13: Nominal National Income in own currency (billions)

YEAR	USNYDOL	JPNYYEN	UKNYLBS
1964.00	649.80	25408.00	33.82
1965.00	705.10	28233.00	36.35
1966.00	772.00	32797.00	38.70
1967.00	816.40	38755.00	40.92
1968.00	892.70	45652.00	44.35
1969.00	964.00	53535.00	47.53
1970.00	1015.50	63550.00	52.19
1971.00	1102.70	69452.00	58.50
1972.00	1212.80	80027.00	64.73
1973.00	1359.30	98532.00	75.25
1974.00	1472.80	116193.00	85.68
1975.00	1598.40	128557.00	107.24
1976.00	1782.80	145808.00	128.27
1977.00	1990.50	161816.00	146.19
1978.00	2249.70	178771.00	169.24
1979.00	2508.20	193966.00	198.34
1980.00	2732.00	209142.00	231.01
1981.00	3052.60	221234.00	256.04
1982.00	3166.00	232544.00	279.05
1983.00	3405.70	241085.00	306.07
1984.00	3774.50	256460.00	327.46
1985.00	4014.90	272484.00	356.76
1986.00	4240.30	283598.00	383.93
1987.00	4526.70	295444.00	419.57
1988.00	4864.30	311447.15	459.05

Source: International Financial Statisitics (IMF Yearbook, 1989).

Table A.14: Real National Incomes in own currency (1988 billions)

YEAR	USRYDOL	JPRYYEN	UKRYLBS
1964.00	2400.10	81932.76	268.41
1965.00	2544.39	86654.90	275.38
1966.00	2688.52	95759.72	280.43
1967.00	2764.17	106445.67	286.15
1968.00	2880.27	119280.48	297.65
1969.00	2945.70	133054.06	302.74
1970.00	2939.32	146842.29	308.82
1971.00	3024.15	151870.36	317.93
1972.00	3175.28	165746.98	323.65
1973.00	3343.39	180582.93	353.29
1974.00	3324.41	176454.05	349.71
1975.00	3277.47	181188.91	344.82
1976.00	3443.19	191714.00	358.30
1977.00	3603.26	201085.98	358.31
1978.00	3790.97	212069.44	373.60
1979.00	3886.29	223334.86	382.90
1980.00	3877.11	231899.56	372.60
1981.00	3953.60	237803.21	370.54
1982.00	3854.72	245302.63	375.07
1983.00	3991.51	262183.15	391.39
1984.00	4255.53	265312.43	400.32
1985.00	4404.35	277661.20	412.44
1986.00	4529.32	284155.71	428.97
1987.00	4680.29	296608.31	447.30
1988.00	4864.30	311447.15	459.05

Table A.15: Price Indexes for own currency (1988=1.00)

YEAR	USPRICE	JPPRICE	UKPRICE
1964.00	0.27	0.31	0.13
1965.00	0.28	0.33	0.13
1966.00	0.29	0.34	0.14
1967.00	0.30	0.36	0.14
1968.00	0.31	0.38	0.15
1969.00	0.33	0.40	0.16
1970.00	0.35	0.43	0.17
1971.00	0.36	0.46	0.18
1972.00	0.38	0.48	0.20
1973.00	0.41	0.55	0.21
1974.00	0.44	0.66	0.25
1975.00	0.49	0.71	0.31
1976.00	0.52	0.76	0.36
1977.00	0.55	0.80	0.41
1978.00	0.59	0.84	0.45
1979.00	0.65	0.87	0.52
1980.00	0.70	0.90	0.62
1981.00	0.77	0.93	0.69
1982.00	0.82	0.95	0.74
1983.00	0.85	0.92	0.78
1984.00	0.89	0.97	0.82
1985.00	0.91	0.98	0.87
1986.00	0.94	1.00	0.90
1987.00	0.97	1.00	0.94
1988.00	1.00	1.00	1.00

Source: International Financial Statistics (IMF Yearbook, 1989).

Table A.16: Populations of major consuming nations (millions)

YEAR	USPOP	JPPOP	UKPOP
1964.00	191.89	97.83	53.85
1965.00	194.30	98.88	54.18
1966.00	196.56	99.79	54.50
1967.00	198.71	100.83	54.80
1968.00	200.71	101.96	55.05
1969.00	202.68	103.17	55.27
1970.00	205.05	104.34	55.42
1971.00	207.66	105.70	55.61
1972.00	209.90	107.19	55.78
1973.00	211.91	108.71	55.91
1974.00	213.85	110.16	55.92
1975.00	215.97	111.57	55.90
1976.00	218.04	112.77	55.89
1977.00	220.24	113.86	55.85
1978.00	222.59	114.90	55.84
1979.00	256.06	115.87	55.88
1980.00	227.76	116.78	55.95
1981.00	230.14	117.65	56.35
1982.00	232.52	118.45	56.34
1983.00	234.80	119.26	56.38
1984.00	237.00	120.02	56.49
1985.00	239.28	120.75	56.62
1986.00	241.62	121.49	56.76
1987.00	242.93	122.09	56.93
1988.00	246.33	122.93	57.08

Source: International Financial Statistics (IMF Yearbook, 1989)

Table A.17: Ex-Vessel prices (1988 dollars)

YEAR	PXKING	PXRED	PXSILV	PXPINK	PXCHUM
1964.00	1.17	0.84	0.63	0.39	0.28
1965.00	1.00	0.78	0.89	0.37	0.29
1966.00	1.10	0.74	0.80	0.47	0.38
1967.00	0.90	0.75	0.87	0.38	0.33
1968.00	1.11	0.84	0.83	0.45	0.40
1969.00	1.00	0.77	0.85	0.45	0.40
1970.00	1.26	0.71	0.85	0.38	0.35
1971.00	1.07	0.72	0.67	0.43	0.38
1972.00	0.98	0.82	1.12	0.48	0.48
1973.00	2.17	1.07	1.87	0.78	0.95
1974.00	1.69	1.55	1.53	0.78	0.85
1975.00	1.47	0.92	1.17	0.66	0.71
1976.00	1.98	1.16	1.80	0.67	0.79
1977.00	2.31	0.91	1.85	0.64	0.88
1978.00	2.10	1.63	1.87	0.56	0.80
1979.00	2.34	1.70	2.03	0.62	1.00
1980.00	2.02	0.83	1.13	0.50	0.63
1981.00	1.95	1.13	1.19	0.56	0.62
1982.00	1.94	1.01	1.05	0.26	0.52
1983.00	1.36	0.82	0.71	0.29	0.37
1984.00	1.96	0.87	1.08	0.29	0.39
1985.00	1.69	1.08	0.79	0.26	0.43
1986.00	1.62	1.53	0.96	0.26	0.38
1987.00	2.09	1.60	1.18	0.43	0.48
1988.00	2.73	2.35	1.75	0.79	0.89

Source: constructed from Table A.7 using the price index in Table A.15.

Table A.18: Canned prices (1988 dollars)

YEAR	PCKING	PCRED	PCSILV	PCPINK	PCCHUM
1964.00	2.58	3.15	2.22	1.57	1.39
1965.00	2.69	2.81	2.25	2.04	1.67
1966.00	2.76	2.71	2.23	2.00	1.73
1967.00	2.85	2.99	2.36	2.16	1.88
1968.00	2.56	3.06	2.30	2.15	1.81
1969.00	2.68	2.46	2.37	2.03	1.74
1970.00	2.40	2.38	2.19	1.91	1.61
1971.00	2.31	2.62	2.13	1.92	1.60
1972.00	2.83	2.96	2.51	2.32	1.88
1973.00	4.98	4.70	4.69	3.42	2.86
1974.00	4.10	4.14	3.55	3.19	2.93
1975.00	3.72	3.35	2.87	2.80	2.30
1976.00	3.16	3.54	3.08	2.62	2.19
1977.00	3.62	3.71	2.85	2.38	2.18
1978.00	3.14	3.49	2.74	2.12	1.94
1979.00	3.31	8.37	2.39	5.30	3.11
1980.00	3.64	0.34	2.79	2.28	2.14
1981.00	2.37	3.09	2.40	2.04	1.66
1982.00	2.99	3.23	2.35	1.63	1.64
1983.00	2.17	2.62	2.19	1.63	1.43
1984.00	2.15	2.54	1.89	1.58	1.23
1985.00	2.00	2.87	2.26	1.31	1.47
1986.00	3.14	3.89	3.15	1.43	1.29
1987.00	2.36	3.74	2.53	2.04	1.73
1988.00	3.68	5.71	4.22	2.95	2.74

Source: constructed from Table A.8 using the price index in Table A.15.

Table A.19: Fresh/Frozen prices (1988 dollars)

YEAR	PFKING	PFRED	PFSILV	PFPINK	PFCHUM
1964.00	2.85	2.49	2.21	0.93	1.41
1965.00	2.54	1.32	1.51	0.76	0.82
1966.00	2.57	1.42	1.62	0.78	0.81
1967.00	2.35	1.42	1.80	0.93	1.07
1968.00	2.39	1.42	2.00	0.72	1.06
1969.00	2.52	1.28	1.57	0.74	1.04
1970.00	2.69	1.18	1.79	0.99	1.06
1971.00	2.25	1.39	1.45	0.95	1.13
1972.00	2.28	1.62	2.14	0.94	1.35
1973.00	3.62	2.83	3.06	1.86	1.91
1974.00	2.85	2.20	2.32	1.50	1.57
1975.00	2.71	2.10	2.17	1.82	1.59
1976.00	3.82	2.43	3.26	1.64	2.29
1977.00	4.77	3.20	3.51	1.63	2.15
1978.00	3.57	3.73	3.60	1.43	2.01
1979.00	4.26	5.94	5.91	1.71	2.42
1980.00	3.99	5.89	2.89	1.11	1.78
1981.00	3.52	2.54	2.59	1.27	1.60
1982.00	3.32	2.16	2.11	0.85	1.44
1983.00	2.50	1.87	1.93	0.88	1.27
1984.00	3.45	2.05	2.27	0.83	1.24
1985.00	2.99	2.23	2.02	0.75	1.19
1986.00	3.04	2.71	2.13	0.78	1.14
1987.00	3.91	2.94	3.06	1.19	1.53
1988.00	4.60	4.13	3.47	1.69	1.90

Source: constructed from Table A.10 using the price index in Table A.15.

Table 20: US landings, salmon species (1000 lbs)

YEAR	USLKING	USLRED	USLSILV	USLPINK	USLCHUM
1964.00	28732.00	57350.00	38071.00	162325.00	65842.00
1965.00	29316.00	148119.00	38515.00	79655.00	31266.00
1966.00	27223.00	102021.00	38755.00	163016.00	56506.00
1967.00	26181.00	66013.00	38290.00	51721.00	34459.00
1968.00	25838.00	54047.00	37786.00	148472.00	61466.00
1969.00	28028.00	81444.00	21326.00	112214.00	24816.00
1970.00	31685.00	159568.00	43708.00	117762.00	57396.00
1971.00	31770.00	104314.00	36500.00	87334.00	52153.00
1972.00	28254.00	48218.00	30285.00	55414.00	54514.00
1973.00	31008.00	45911.00	31892.00	47024.00	57174.00
1974.00	26829.00	53916.00	37839.00	37347.00	40889.00
1975.00	31252.00	52324.00	28070.00	56198.00	33797.00
1976.00	34511.00	83159.00	39[illegible]0.00	99237.00	52645.00
1977.00	32676.00	89932.00	29992.00	125644.00	57398.00
1978.00	29776.00	98707.00	30648.00	194873.00	50485.00
1979.00	33008.00	190727.00	39767.00	226830.00	45784.00
1980.00	28553.00	207551.00	39270.00	253541.00	84916.00
1981.00	31070.00	226173.00	35210.00	257106.00	98880.00
1982.00	34602.00	200172.00	59151.00	221472.00	92023.00
1983.00	24424.00	310146.00	30663.00	194140.00	79920.00
1984.00	21711.00	229666.00	51077.00	275615.00	113340.00
1985.00	27187.00	236077.00	52044.00	319139.00	92499.00
1986.00	30845.00	212212.00	60359.00	268646.00	86459.00
1987.00	39938.00	227411.00	39041.00	169308.00	86320.00
1988.00	45672.00	190036.00	47486.00	176487.00	146467.00

Source: Fishery Statistics of the United States

Table A.21: Real (1988 US dollars) and nominal tuna prices

YEAR	NPTUNA	RPTUNA
1964.00	0.62	2.30
1965.00	0.65	2.35
1966.00	0.69	2.39
1967.00	0.67	2.28
1968.00	0.68	2.19
1969.00	0.75	2.28
1970.00	0.87	2.52
1971.00	0.94	2.58
1972.00	1.02	2.67
1973.00	1.11	2.73
1974.00	1.25	2.82
1975.00	1.23	2.53
1976.00	1.42	2.75
1977.00	1.66	3.00
1978.00	1.81	3.04
1979.00	1.78	2.76
1980.00	1.90	2.70
1981.00	1.88	2.44
1982.00	1.70	2.07
1983.00	1.45	1.70
1984.00	1.42	1.60
1985.00	1.51	1.65
1986.00	1.38	1.48
1987.00	1.56	1.61
1988.00	1.41	1.41

Source: Fishery Statistics of the US.

Table A.22: July 1 Canned Inventory holdings (1000 lbs)

YEAR	CIKING	CIRED	CISILV	CIPINK	CICHUM
1964.00	887.60	4931.71	2014.56	32794.24	10479.68
1965.00	646.02	2629.18	2339.85	17480.68	12065.86
1966.00	978.85	30058.58	974.33	2785.79	874.39
1967.00	1248.13	28975.18	2603.92	22680.40	4634.57
1968.00	1710.10	21309.01	1460.02	4997.47	2732.78
1969.00	960.80	6808.07	2047.43	20592.40	11627.28
1970.00	663.36	2222.33	666.95	6021.50	2106.01
1971.00	429.00	14847.44	1635.76	6578.18	4500.22
1972.00	1045.98	11304.10	2554.79	7099.63	6141.55
1973.00	486.23	2278.45	453.28	1588.60	3246.00
1974.00	642.26	2731.92	1915.20	933.73	5443.02
1975.00	931.67	7973.72	4601.54	6742.99	13399.38
1976.00	275.92	2960.32	976.72	8849.72	3206.28
1977.00	361.43	5571.60	757.37	13429.73	4699.54
1978.00	250.62	8168.63	660.58	19833.59	8809.51
1979.00	246.85	11166.41	578.09	14525.74	4376.29
1980.00	235.40	9728.56	652.74	12500.69	1615.51
1981.00	89.30	6461.93	424.81	14602.10	5795.50
1982.00	278.92	18836.51	689.92	43182.91	16295.80
1983.00	171.80	6923.02	611.75	23575.74	3937.42
1984.00	379.60	13272.88	373.60	18943.12	2329.22
1985.00	148.87	14390.62	418.58	34254.47	5215.26
1986.00	80.98	2841.85	137.32	25932.90	2092.58
1987.00	9.14	4250.54	211.61	15470.96	2306.59
1988.00	27.04	5067.76	169.45	3186.94	303.23

Source: National Canners Association, Division of Statistics and Economics

Table A.23: July 1 Fresh/Frozen inventory holdings (1000 lbs)

YEAR	FIKING	FIRED	FISILV	FIPINK	FICHUM
1964.00	7402.00	4393.00	4227.00	4393.00	3921.00
1965.00	5907.00	3522.00	3672.00	3522.00	2892.00
1966.00	4970.00	2651.00	2837.00	2651.00	2080.00
1967.00	3834.00	1920.00	1799.00	1920.00	1607.00
1968.00	3957.00	2240.00	1883.00	2240.00	1341.00
1969.00	5522.00	2765.00	3059.00	2765.00	2457.00
1970.00	5328.00	2353.00	3143.00	2353.00	2206.00
1971.00	10072.00	3272.00	4717.00	3272.00	1890.00
1972.00	7050.00	2370.00	2499.00	2370.00	1745.00
1973.00	10524.00	6179.00	9097.00	6179.00	9463.00
1974.00	6642.00	3268.00	3469.00	3268.00	2782.00
1975.00	5147.00	3773.00	3867.00	3773.00	2080.00
1976.00	3736.00	2917.00	2775.00	2917.00	1717.00
1977.00	6043.00	3724.00	1928.00	3724.00	2910.00
1978.00	7893.00	4991.00	3694.00	4991.00	4264.00
1979.00	4735.00	6469.00	2349.00	6469.00	3269.00
1980.00	4590.00	4041.00	5037.00	4041.00	4125.00
1981.00	3994.00	3477.00	2290.00	3477.00	3745.00
1982.00	4068.00	4215.00	1840.00	4215.00	1573.00
1983.00	5222.00	3076.00	2442.00	3076.00	5768.00
1984.00	3891.00	6642.00	3202.00	6642.00	6104.00
1985.00	2181.00	5166.00	3083.00	5166.00	6840.00
1986.00	1974.00	5741.00	1678.00	5741.00	6084.00
1987.00	1994.00	3593.00	1889.00	3593.00	3518.00
1988.00	2334.00	2737.00	1700.00	2737.00	3505.00

Source: Fishery Statistics of the United States.

Note: King, Silver, & Chum include own holdings plus Steaks/Fillets & Cured. Red and Pink data is Unclassified plus Steaks/Fillets and Cured.

Table A.24: Per Capita Income own currency (nominal and 1988 values)

YEAR	USNINC	JPNINC	UKNINC	USRINC	JPRINC	UKRINC
1964	3.39	259.72	0.63	12.51	837.50	4.98
1965	3.63	285.53	0.67	13.10	876.36	5.08
1966	3.93	328.66	0.71	13.68	959.61	5.15
1967	4.11	384.36	0.75	13.91	1055.69	5.22
1968	4.45	447.74	0.81	14.35	1169.88	5.41
1969	4.76	518.90	0.86	14.53	1289.66	5.48
1970	4.95	609.07	0.94	14.33	1407.34	5.57
1971	5.31	657.07	1.05	14.56	1436.81	5.72
1972	5.78	746.59	1.16	15.13	1546.[illegible]	5.80
1973	6.41	906.37	1.35	15.78	1661.14	6.32
1974	6.89	1054.77	1.53	15.55	1601.80	6.25
1975	7.40	1152.25	1.92	15.18	1623.99	6.17
1976	8.18	1292.97	2.30	15.79	1700.04	6.41
1977	9.04	1421.18	2.62	16.36	1766.08	6.42
1978	10.11	1555.88	3.03	17.03	1845.69	6.69
1979	9.80	1674.00	3.55	15.18	1927.46	6.85
1980	12.00	1790.91	4.13	17.02	1985.78	6.66
1981	13.26	1880.44	4.54	17.18	2021.28	6.58
1982	13.62	1963.22	4.95	16.58	2070.94	6.66
1983	14.50	2021.51	5.43	17.00	2198.42	6.94
1984	15.93	2136.81	5.80	17.96	2210.57	7.09
1985	16.78	2256.60	6.30	18.41	2299.47	7.28
1986	17.55	2334.33	6.76	18.75	2338.92	7.56
1987	18.63	2419.89	7.37	19.27	2429.42	7.86
1988	19.75	2533.59	8.04	19.75	2533.59	8.04

Table A.25: Exchange rates, real and nominal (currency/dollars)

YEAR	JPNER	UKNER	JPRER	UKRER
1964.00	361.99	0.36	414.63	0.17
1965.00	361.51	0.36	425.03	0.17
1966.00	362.35	0.36	432.19	0.17
1967.00	362.13	0.36	446.40	0.18
1968.00	360.55	0.42	445.23	0.20
1969.00	358.36	0.42	440.60	0.20
1970.00	358.16	0.42	448.65	0.20
1971.00	347.78	0.41	436.18	0.21
1972.00	303.12	0.40	383.18	0.21
1973.00	271.30	0.41	364.10	0.21
1974.00	291.84	0.43	433.77	0.24
1975.00	296.78	0.45	431.77	0.29
1976.00	296.45	0.55	435.45	0.38
1977.00	268.62	0.57	391.30	0.42
1978.00	210.38	0.52	298.85	0.40
1979.00	219.02	0.47	294.73	0.38
1980.00	226.63	0.44	290.06	0.39
1981.00	220.63	0.49	265.84	0.44
1982.00	249.06	0.57	287.47	0.52
1983.00	237.55	0.66	256.01	0.60
1984.00	237.45	0.75	258.78	0.69
1985.00	238.47	0.77	256.72	0.73
1986.00	168.35	0.68	179.47	0.65
1987.00	144.60	0.61	148.92	0.59
1988.00	128.17	0.56	128.17	0.56

Source: Nominal Exchange rates: Federal Reserve Board Bulletin (various years), Deflators: International Financial Statistics, IMF yearbook 1989

Table A.26: Real Per Capita Income (in own currency and in dollars)

YEAR	USRINC $	JPRINC yen	JPRINC $	UKRINC Lb	UKRINC $
1964.00	12.51	837.50	2.02	4.98	29.90
1965.00	13.10	876.36	2.06	5.08	29.83
1966.00	13.68	959.61	2.22	5.15	29.90
1967.00	13.91	1055.69	2.36	5.22	29.66
1968.00	14.35	1169.88	2.63	5.41	26.92
1969.00	14.53	1289.66	2.93	5.48	27.29
1970.00	14.33	1407.34	3.14	5.57	27.29
1971.00	14.56	1436.81	3.29	5.72	27.69
1972.00	15.13	1546.29	4.04	5.80	27.74
1973.00	15.78	1661.14	4.56	6.32	29.58
1974.00	15.55	1601.80	3.69	6.25	26.47
1975.00	15.18	1623.99	3.76	6.17	21.49
1976.00	15.79	1700.04	3.90	6.41	16.73
1977.00	16.36	1766.08	4.51	6.42	15.16
1978.00	17.03	1845.69	6.18	6.69	16.81
1979.00	15.18	1927.46	6.54	6.85	18.12
1980.00	17.02	1985.78	6.83	6.66	17.24
1981.00	17.18	2021.28	7.60	6.58	14.87
1982.00	16.58	2070.94	7.20	6.66	12.85
1983.00	17.00	2198.42	8.59	6.94	11.48
1984.00	17.96	2210.57	8.54	7.09	10.27
1985.00	18.41	2299.47	8.96	7.28	9.96
1986.00	18.75	2336.92	13.03	7.56	11.60
1987.00	19.27	2429.42	16.31	7.86	13.28
1988.00	19.75	2533.59	19.77	8.04	14.33

Table A.27: Short term interest rates (nominal and real)

YEAR	USNSTI	JPNSTI	UKNSTI	USRSTI	JPRSTI	UKRSTI
1964	4.50	7.90	6.16	2.79	-2.56	2.86
1965	4.54	7.80	7.18	2.18	2.74	2.42
1966	5.63	7.48	7.25	2.01	2.36	2.70
1967	5.63	7.31	5.50	2.77	1.01	1.88
1968	6.31	7.46	6.13	1.37	2.34	1.93
1969	7.95	7.41	6.63	2.36	2.28	1.26
1970	7.91	7.66	7.25	2.34	0.10	-0.39
1971	5.72	7.59	7.50	0.18	1.92	-1.38
1972	5.25	7.05	7.50	0.50	1.47	-1.20
1973	8.02	7.19	8.00	1.58	-5.82	1.50
1974	10.80	9.11	9.00	1.83	-11.57	-6.02
1975	7.86	9.10	9.00	-2.22	1.35	-17.94
1976	6.84	8.26	9.00	0.67	1.07	-6.11
1977	6.82	7.56	9.75	0.13	1.75	-4.22
1978	9.06	6.31	8.83	1.63	1.55	-2.20
1979	12.67	6.29	13.88	3.91	3.26	-0.47
1980	15.27	8.32	16.17	6.09	4.48	-3.52
1981	18.87	7.79	13.25	9.30	4.63	1.80
1982	14.86	7.23	11.79	8.48	5.33	4.12
1983	10.79	7.05	9.79	6.91	10.05	4.68
1984	12.04	6.66	9.65	8.09	1.54	5.05
1985	9.93	6.52	12.29	7.16	5.00	6.54
1986	8.35	5.91	10.83	5.65	4.21	7.36
1987	8.21	5.09	9.63	4.90	5.29	4.83
1988	9.32	4.93	10.29	5.93	4.54	3.68

Calculated by: $r(t) = i(t) - [P(t)-P(t-1)]/P(t)$,

$r(t)$ = real interest rate

$i(t)$ = nominal interest rate (prime rate)

$P(t)$ = price index (GNP deflator) for year t

Table A.28: Inflation rates: $[P(t)-P(t-1)]/P(t)$.

YEAR	USINFL	JPINFL	UKINFL
1964.00	1.71	10.46	3.30
1965.00	2.36	5.06	4.76
1966.00	3.62	5.12	4.55
1967.00	2.86	6.30	3.62
1968.00	4.94	5.12	4.20
1969.00	5.59	5.13	5.37
1970.00	5.57	7.56	7.64
1971.00	5.54	5.67	8.88
1972.00	4.75	5.58	8.70
1973.00	6.44	13.01	6.50
1974.00	8.97	20.68	15.02
1975.00	10.08	7.75	26.94
1976.00	6.17	7.19	15.11
1977.00	6.69	5.81	13.97
1978.00	7.43	4.76	11.03
1979.00	8.76	3.03	14.35
1980.00	9.18	3.84	19.69
1981.00	9.57	3.16	11.45
1982.00	6.38	1.90	7.67
1983.00	3.88	-3.00	5.11
1984.00	3.95	5.12	4.60
1985.00	2.77	1.52	5.75
1986.00	2.70	1.70	3.47
1987.00	3.31	-0.20	4.80
1988.00	3.39	0.39	6.61

Source: International Financial Statistics, IMF 1989 Yearbook

APPENDIX B: 2SLS ESTIMATES OF THE WHOLESALE DEMAND AND SUPPLY FUNCTIONS

2SLS Linear Canned Supply Equation Estimation (1964-1988)

KING

rho & asymptotic t-ratio
0.592
2.765

second order rho & asymptotic t-ratios
0.302 0.523
1.224 1.838

corrected for ar(1) since rho significant at 5% one-tail level

Valid cases:	24	Dependent variable:	QCKING
Total SS:	5.941	Degrees of freedom:	20
R-squared:	0.252	Rbar-squared:	0.139
Residual SS:	4.446	Std error of est:	0.472
F(3,20):	2.240	Probability of F:	0.115
Durbin-Watson:	2.264		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	1.274546	0.474936	2.683613	0.014	---	---
PCKING	-0.464472	0.269934	-1.720685	0.101	-0.537795	-0.438058
PFFING	-0.047416	0.239072	-0.198333	0.845	-0.053493	-0.374917
QXKING	-0.071136	0.065668	-1.083265	0.292	-0.262394	0.015670

t=1978-1988

MSE	MAE	U1	UM	UR	UD
39.617	0.488	4.250	0.574	0.374	0.053

t=1964-1988

MSE	MAE	U1	UM	UR	UD
17.226	0.729	3.355	0.375	0.539	0.086

2SLS Linear Canned Supply Equation Estimation (1964-1988)

RED

rho & asymptotic t-ratio
0.371
1.606

second order rho & asymptotic t-ratios
0.315 -0.226
1.543 -1.143

not corrected for ar(1) since rho not significant at 5% one-tail level

Valid cases:	25	Dependent variable:	QCRED
Total SS:	11128.528	Degrees of freedom:	21
R-squared:	0.362	Rbar-squared:	0.271
Residual SS:	7103.423	Std error of est:	18.392
F(3,21):	3.967	Probability of F:	0.022
Durbin-Watson:	1.317		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	64.957533	12.742958	5.097524	0.000	---	---
PCRED	-9.719394	3.844628	-2.528046	0.020	-0.562205	-0.566877
PFRED	0.084085	4.054667	0.020738	0.984	0.004815	-0.264851
QXRED	0.054968	0.052049	1.056074	0.303	0.199463	0.221929

t=1978-1988

MSE	MAE	U1	UM	UR	UD
0.216	12.223	0.307	0.172	0.325	0.503

t=1964-1988

MSE	MAE	U1	UM	UR	UD
0.241	12.896	0.465	0.005	0.012	0.983

2SLS Linear Canned Supply Equation Estimation (1964-1988)

SILVER

rho & asymptotic t-ratio
0.155
0.885

second order rho & asymptotic t-ratios

-0.072	0.363
-0.317	2.229

not corrected for ar(1) since rho not significant at 5% one-tail level

Valid cases:	25	Dependent variable:	QCSILV
Total SS:	73.469	Degrees of freedom:	21
R-squared:	0.223	Rbar-squared:	0.112
Residual SS:	57.069	Std error of est:	1.649
F(3,21):	2.012	Probability of F:	0.143
Durbin-Watson:	1.321		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	6.639220	1.853024	3.582911	0.002	---	---
PCSILV	-0.714990	0.631901	-1.131490	0.271	-0.231960	-0.290212
PFSILV	-0.566355	0.387355	-1.462110	0.159	-0.296930	-0.379866
QXSILV	-0.030065	0.027173	-1.106406	0.281	-0.216439	-0.199165

t=1978-1988

MSE	MAE	U1	UM	UR	UD
0.276	0.706	0.697	0.111	0.030	0.860

t=1964-1988

MSE	MAE	U1	UM	UR	UD
0.238	0.958	0.777	0.050	0.088	0.861

2SLS Linear Canned Supply Equation Estimation (1964-1988)

PINK

rho & asymptotic t-ratio
-0.211
-0.932

second order rho & asymptotic t-ratios
-0.210 0.000
-0.859 0.002

not corrected for ar(1) since rho not significant at 5% one-tail level

Valid cases:	25	Dependent variable:	QCPINK
Total SS:	27389.244	Degrees of freedom:	21
R-squared:	0.890	Rbar-squared:	0.875
Residual SS:	3005.395	Std error of est:	11.963
F(3,21):	56.794	Probability of F:	0.000
Durbin-Watson:	2.211		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	47.810592	11.613305	4.116881	0.000	---	---
PCPINK	-12.935849	4.632446	-2.792445	0.011	-0.302621	-0.589393
PFPINK	0.312580	9.806914	0.031873	0.975	0.003420	-0.488805
QXPINK	0.339404	0.033506	10.129662	0.000	0.791807	0.901204

t=1978-1988

MSE	MAE	U1	UM	UR	UD
0.050	13.481	0.329	0.000	0.600	0.400

t=1964-1988

MSE	MAE	U1	UM	UR	UD
0.060	8.950	0.221	0.050	0.652	0.297

2SLS Linear Canned Supply Equation Estimation (1964-1988)

CHUM

rho & asymptotic t-ratio
-0.043
-0.197

second order rho & asymptotic t-ratios

0.036	0.107
0.157	0.503

not corrected for ar(1) since rho not significant at 5% one-tail level

Valid cases:	25	Dependent variable:	QCCHUM
Total SS:	1604.733	Degrees of freedom:	21
R-squared:	0.084	Rbar-squared:	-0.047
Residual SS:	1469.553	Std error of est:	8.365
F(3,21):	0.644	Probability of F:	0.595
Durbin-Watson:	1.911		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	30.778190	10.456185	2.943539	0.008	---	---
PCCHUM	-4.217176	6.448541	-0.653974	0.520	-0.239355	-0.194956
PFCHUM	-0.829075	6.852334	-0.120992	0.905	-0.041590	-0.227744
QXCHUM	-0.068435	0.082042	-0.834147	0.414	-0.212819	-0.132048

t=1978-1988

MSE	MAE	U1	UM	UR	UD
0.598	7.398	0.976	0.179	0.090	0.731

t=1964-1988

MSE	MAE	U1	UM	UR	UD
0.302	6.265	0.819	0.018	0.065	0.917

2SLS Linear Canned Demand Equation Estimation (1964-1988)

KING

rho & asymptotic t-ratio
-0.427
-1.712

second order rho & asymptotic t-ratios
-0.467 -0.153
-1.755 -0.537

corrected for ar(1) since rho significant at 5% one-tail level

Valid cases:	24	Dependent variable:	PCKING
Total SS:	17.739	Degrees of freedom:	16
R-squared:	0.756	Rbar-squared:	0.650
Residual SS:	4.324	Std error of est:	0.520
F(7,16):	7.090	Probability of F:	0.001
Durbin-Watson:	2.100		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	4.354449	6.936100	0.627795	0.539	---	---
QCKING	-0.278213	0.406032	-0.685200	0.503	-0.323680	-0.145816
CIKING	0.000467	0.000410	1.139965	0.271	0.309162	0.000397
PTUNA	0.890825	0.291494	3.056064	0.008	0.691522	0.563382
RPCIUK	0.095123	0.141102	0.674148	0.510	0.358745	-0.068856
POPLUK	-0.006605	0.014376	-0.459455	0.652	-0.265507	-0.024100
ERUK	-0.003145	0.003155	-0.996667	0.334	-0.505144	0.156871
PRIMEUK	-0.103785	0.035728	-2.904831	0.010	-0.602264	-0.692138

t=1978-1988

MSE	MAE	U1	UM	UR	UD
0.596	1.866	2.337	0.891	0.039	0.070

t=1964-1988

MSE	MAE	U1	UM	UR	UD
0.504	1.865	2.576	0.889	0.048	0.064

CIKING = July 1 inventory holdings of king salmon (1000 lbs), PTUNA = tuna price (1988 dollars), RPCIUK = Real per capita income population weighted average of US and UK ($1000 1988), POPLUK = sum of populations in US and UK (millions), ERUK = exchange rate in pounds/dollar, PRIMEUK = real prime rate in UK (%/year).

2SLS Linear Canned Demand Equation Estimation (1964-1988)

RED

rho & asymptotic t-ratio
-0.142
-0.504

second order rho & asymptotic t-ratios

-0.053	0.256
-0.179	0.878

not corrected for ar(1) since rho not significant at 5% one-tail level

Valid cases:	25	Dependent variable:	PCRED
Total SS:	47.789	Degrees of freedom:	17
R-squared:	0.499	Rbar-squared:	0.293
Residual SS:	23.944	Std error of est:	1.187
F(7,17):	2.419	Probability of F:	0.065
Durbin-Watson:	1.987		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	0.965433	9.006733	0.107190	0.916	---	---
QCRED	-0.029464	0.015725	-1.873710	0.078	-0.432030	-0.509374
CIRED	-0.000026	0.000038	-0.683980	0.503	-0.145042	-0.167084
PTUNA	0.038028	0.772232	0.049244	0.961	0.013098	0.026242
RPCIUK	-0.699014	0.343010	-2.037883	0.057	-1.222670	0.215950
POPLUK	0.049033	0.024915	1.967985	0.066	0.902506	0.388439
ERUK	-0.007663	0.007891	-0.971100	0.345	-0.552207	-0.256196
PRIMEUK	-0.063378	0.095531	-0.663435	0.516	-0.182272	-0.144439

t=1978-1988

MSE	MAE	U1	UM	UR	UD
0.108	0.998	0.122	0.187	0.059	0.754

t=1964-1988

MSE	MAE	U1	UM	UR	UD
0.074	0.719	0.162	0.002	0.085	0.913

CIRED = July 1 inventory holdings of red salmon (1000 lbs), PTUNA = tuna price (1988 dollars), RPCIUK = Real per capita income population weighted average of US and UK ($1000 1988), POPLUK = sum of populations in US and UK (millions), ERUK = exchange rate in pounds/dollar, PRIMEUK = real prime rate in UK (%/year).

2SLS Linear Canned Demand Equation Estimation (1964-1988)

SILVER

rho & asymptotic t-ratio
-0.748
-2.220

second order rho & asymptotic t-ratios
-0.789 -0.365
-2.329 -1.173

corrected for ar(1) since rho significant at 5% one-tail level

Valid cases:	25	Dependent variable:	PCSILVER
Total SS:	19.826	Degrees of freedom:	16
R-squared:	0.806	Rbar-squared:	0.721
Residual SS:	3.847	Std error of est:	0.490
F(7,16):	9.494	Probability of F:	0.000
Durbin-Watson:	2.323		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	5.996168	9.348481	0.641406	0.530	---	---
QCSILV	-0.014284	0.176210	-0.081063	0.936	-0.033309	-0.344731
CISILV	0.000113	0.000121	0.930225	0.366	0.180226	0.043755
PTUNA	0.551265	0.312571	1.763649	0.097	0.489288	0.243536
RPCIUK	0.294675	0.171157	1.721666	0.104	1.272417	0.233554
POPLUK	-0.015892	0.009142	-1.738391	0.101	-0.739447	0.154854
ERUK	-0.002266	0.003007	-0.753697	0.462	-0.415650	-0.097641
PRIMEUK	-0.110531	0.026282	-4.205659	0.001	-0.727212	-0.610800

t=1978-1988

MSE	MAE	U1	UM	UR	UD
3.649	4.482	6.639	0.965	0.023	0.012

t=1964-1988

MSE	MAE	U1	UM	UR	UD
3.326	4.478	6.774	0.957	0.030	0.013

CISILVER = July 1 inventory holdings of silver salmon (1000 lbs), PTUNA = tuna price (1988 dollars), RPCIUK = Real per capita income population weighted average of US and UK ($1000 1988), POPLUK = sum of populations in US and UK (millions), ERUK = exchange rate in pounds/dollar, PRIMEUK = real prime rate in UK (%/year).

2SLS Linear Canned Demand Equation Estimation (1964-1988)

PINK

rho & asymptotic t-ratio
0.209
0.831

second order rho & asymptotic t-rat.os
0.273 -0.395
1.064 -1.329

not corrected for ar(i) since rho not significant at 5% one-tail level

Valid cases:	25	Dependent variable:	PCPINK
Total SS:	16.238	Degrees of freedom:	17
R-squared:	0.860	Rbar-squared:	0.803
Residual SS:	2.268	Std error of est:	0.365
F(7,17):	14.963	Probability of F:	0.000
Durbin-Watson:	1.544		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	-0.863518	2.743467	-0.314754	0.757	---	---
QCPINK	-0.011164	0.002822	-3.955719	0.001	-0.452094	-0.572252
CIPINK	-0.000034	0.000009	-3.880036	0.001	-0.460825	-0.478888
PTUNA	0.166089	0.242850	0.683917	0.503	0.098137	0.446498
RPCIUK	-0.544405	0.116792	-4.661314	0.00[illegible]	-1.633579	-0.060965
POPLUK	0.042046	0.007706	5.455992	0.000	1.327653	0.176043
ERUK	-0.006471	0.002527	-2.560948	0.020	-0.799914	0.064451
PRIMEUK	-0.034677	0.024271	-1.428714	0.171	-0.171084	-0.323724

t=1978-1988

MSE	MAE	U1	UM	UR	UD
0.034	0.257	0.622	0.062	0.220	0.718

t=1964-1988

MSE	MAE	U1	UM	UR	UD
0.026	0.253	0.423	0.004	0.038	0.958

CIPINK = July 1 inventory holdings of pink salmon (1000 lbs), PTUNA = tuna price (1988 dollars), RPCIUK = Real per capita income population weighted average of US and UK ($1000 1988), POPLUK = sum of populations in US and UK (millions), ERUK = exchange rate in pounds/dollar, PRIMEUK = real prime rate in UK (%/year).

2SLS Linear Canned Demand Equation Estimation (1964-1988)

CHUM

rho & asymptotic t-ratio
-0.042
-0.123

second order rho & asymptotic t-ratios
-0.081 -0.431
-0.231 -1.065

not corrected for ar(1) since rho not significant at 5% one-tail level

Valid cases:	25	Dependent variable:	PCCHUM
Total SS:	6.448	Degrees of freedom:	17
R-squared:	0.606	Rbar-squared:	0.443
Residual SS:	2.542	Std error of est:	0.387
F(7,17):	3.730	Probability of F:	0.013
Durbin-Watson:	1.605		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	0.253382	3.280982	0.077227	0.939	---	---
QCCHUM	-0.031490	0.016778	-1.876884	0.078	-0.461337	-0.174532
CICHUM	-0.000034	0.000024	-1.456808	0.163	-0.279681	-0.123337
PTUNA	0.658589	0.261219	2.521212	0.022	0.617561	0.460858
RPCIUK	-0.034322	0.116296	-0.295125	0.771	-0.163442	0.023723
POPLUK	0.005018	0.008700	0.576748	0.572	0.251453	0.144370
ERUK	-0.000612	0.002608	-0.234581	0.817	-0.120040	0.062039
PRIMEUK	-0.049993	0.025099	-1.991793	0.063	-0.391431	-0.462923

t=1978-1988

MSE	MAE	U1	UM	UR	UD
0.077	0.320	0.997	0.035	0.228	0.737

t=1964-1988

MSE	MAE	U1	UM	UR	UD
0.037	0.236	0.774	0.001	0.092	0.907

CICHUM = July 1 inventory holdings of chum salmon (1000 lbs), PTUNA = tuna price (1988 dollars), RPCIUK = Real per capita income population weighted average of US and UK ($1000 1988), POPLUK = sum of populations in US and UK (millions), ERUK = exchange rate in pounds/dollar, PRIMEUK = real prime rate in UK (%/year).

2SLS Linear Fresh/Frozen Supply Equation Estimation (1964-1988)

KING

rho & asymptotic t-ratio
0.293
1.162

second order rho & asymptotic t-ratios

0.234	0.276
0.934	1.010

not corrected for ar(1) since rho not significant at 5% one-tail level

Valid cases:	25	Dependent variable:	QFKING
Total SS:	208.289	Degrees of freedom:	21
R-squared:	0.813	Rbar-squared:	0.786
Residual SS:	38.991	Std error of est:	1.363
F(3,21):	30.394	Probability of F:	0.000
Durbin-Watson:	1.350		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	-7.702465	2.723829	-2.827808	0.010	---	---
PFFING	0.989129	0.524112	1.887246	0.073	0.236898	0.477188
PCKING	0.376148	0.669351	0.561959	0.580	0.077943	-0.226107
QXKING	0.987074	0.153729	6.420871	0.000	0.836359	0.857745

t=1978-1988

MSE	MAE	U1	UM	UR	UD
0.018	1.187	0.670	0.272	0.137	0.592

t=1964-1988

MSE	MAE	U1	UM	UR	UD
0.026	1.025	0.689	0.006	0.320	0.673

Note: PF...= fresh/frozen price (1988 dollars), PC...= canned price (1988 dollars), QX...= ex-vessel landings (millions)

2SLS Linear Fresh/Frozen Supply Equation Estimation (1964-1988)

RED

rho & asymptotic t-ratio
0.425
1.652

second order rho & asymptotic t-ratios

0.375	-0.066
1.573	-0.310

corrected for ar(1) since rho significant at 10% one-tail level

Valid cases:	24	Dependent variable:	QFRED
Total SS:	28727.831	Degrees of freedom:	20
R-squared:	0.605	Rbar-squared:	0.546
Residual SS:	11351.530	Std error of est:	23.824
F(3,20):	10.205	Probability of F:	0.000
Durbin-Watson:	1.312		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	-9.082755	11.943921	-0.760450	0.456	---	---
PFRED	-4.917535	7.002706	-0.702233	0.491	-0.130074	0.046852
PCRED	3.700253	4.947503	0.747903	0.463	0.137869	0.010260
QXRED	0.509491	0.092297	5.520129	0.000	0.792092	0.769530

t=1978-1988

MSE	MAE	U1	UM	UR	UD
0.037	15.761	0.537	0.458	0.042	0.501

t=1964-1988

MSE	MAE	U1	UM	UR	UD
12.452	13.970	4.295	0.1[illegible]0	0.773	0.038

Note: PF...= fresh/frozen price (1988 dollars), PC...= canned price (1988 dollars), QX...= ex-vessel landings (millions)

2SLS Linear Fresh/Frozen Supply Equation Estimation (1964-1988)

SILVER

rho & asymptotic t-ratio
0.244
1.111

second order rho & asymptotic t-ratios

0.009	0.244
0.037	1.319

not corrected for ar(1) since rho not significant at 5% one-tail level

Valid cases:	25	Dependent variable:	QFSILV
Total SS:	2421.704	Degrees of freedom:	21
R-squared:	0.944	Rbar-squared:	0.936
Residual SS:	135.565	Std error of est:	2.541
F(3,21):	118.046	Probability of F:	0.000
Durbin-Watson:	1.377		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	-5.251024	2.884783	-1.820249	0.083	---	---
PFSILV	0.211862	0.595878	0.355546	0.726	0.019350	0.082550
PCSILV	0.472754	0.983823	0.480527	0.636	0.026407	-0.113650
QXSILV	0.776571	0.041888	13.539093	0.000	0.973759	0.970902

t=1978-1988

MSE	MAE	U1	UM	UR	UD
0.006	1.581	0.171	0.003	0.103	0.894

t=1964-1988

MSE	MAE	U1	UM	UR	UD
0.067	1.736	0.551	0.003	0.092	0.906

Note: PF...= fresh/frozen price (1988 dollars), PC...= canned price (1988 dollars), QX...= ex-vessel landings (millions)

2SLS Linear Fresh/Frozen Supply Equation Estimation (1964-1988)

PINK

rho & asymptotic t-ratio
0.106
0.436

second order rho & asymptotic t-ratios

0.142	0.267
0.577	0.987

not corrected for ar(1) since rho not significant at 5% one-tail level

Valid cases:	25	Dependent variable:	QFPINK
Total SS:	8126.896	Degrees of freedom:	21
R-squared:	0.693	Rbar-squared:	0.650
Residual SS:	2492.247	Std error of est:	10.894
F(3,21):	15.826	Probability of F:	0.000
Durbin-Watson:	1.652		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	-16.123567	10.552117	-1.527994	0.141	---	---
PFPINK	5.29[illegible]108	8.801663	0.601149	0.554	0.107138	-0.214778
PCPINK	-1.100144	4.198609	-0.262026	0.796	-0.047210	-0.279244
QXPINK	0.198027	0.030512	6.490134	0.000	0.848116	0.829086

t=1978-1988

MSE	MAE	U1	UM	UR	UD
0.236	11.166	0.705	0.068	0.102	0.830

t=1964-1988

MSE	MAE	U1	UM	UR	UD
11.396	8.107	2.737	0.078	0.874	0.048

Note: PF...= fresh/frozen price (1988 dollars), PC...= canned price (1988 dollars), QX...= ex-vessel landings (millions)

2SLS Linear Fresh/Frozen Supply Equation Estimation (1964-1988)

CHUM

rho & asymptotic t-ratio
0.024
0.112

second order rho & asymptotic t-ratios

0.070	0.134
0.305	0.628

not corrected for ar(1) since rho not significant at 5% one-tail level

Valid cases:	25	Dependent variable:	QFCHUM
Total SS:	10066.456	Degrees of freedom:	21
R-squared:	0.784	Rbar-squared:	0.753
Residual SS:	2173.632	Std error of est:	10.174
F(3,21):	25.418	Probability of F:	0.000
Durbin-Watson:	1.803		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	-36.209187	12.600590	-2.873610	0.009	---	---
PFCHUM	-1.757609	7.930704	-0.221621	0.827	-0.035470	0.153663
PCCHUM	8.075650	7.502206	1.076437	0.294	0.183374	-0.168219
QXCHUM	0.756567	0.098136	7.709351	0.000	0.939383	0.873307

t=1978-1988

MSE	MAE	U1	UM	UR	UD
0.094	9.104	0.894	0.005	0.570	0.425

t=1964-1988

MSE	MAE	U1	UM	UR	UD
1.337	7.417	1.663	0.035	0.879	0.085

Note: PF...= fresh/frozen price (1988 dollars), PC...= canned price (1988 dollars), QX...= ex-vessel landings (millions)

2SLS Fresh/Frozen Demand Equation Estimation (1964-1988)

KING

rho & asymptotic t-ratio
-0.172
-0.642

second order rho & asymptotic t-ratios
-0.339 -0.013
-1.170 -0.039

not corrected for ar(1) since rho not significant at 5% one-tail level

Valid cases:	25	Dependent variable:	PFFING
Total SS:	13.305	Degrees of freedom:	17
R-squared:	0.654	Rbar-squared:	0.511
Residual SS:	4.605	Std error of est:	0.520
F(7,17):	4.588	Probability of F:	0.005
Durbin-Watson:	2.069		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	0.345812	4.096435	0.084418	0.934	---	---
QFKING	-0.025452	0.082375	-0.308971	0.761	-0.098066	0.459560
FIKING	-0.000087	0.000077	-1.117595	0.279	-0.259593	-0.235337
PTUNA	1.211411	0.384809	3.148083	0.006	0.790755	0.050686
RPCIJP	0.086452	0.157743	0.548058	0.591	0.286585	0.584056
POPLJP	0.003602	0.011710	0.307596	0.762	0.125650	0.636865
ERJP	-0.004882	0.004169	-1.170953	0.258	-0.666743	-0.541171
PRIMEJP	-0.019376	0.038862	-0.498594	0.624	-0.105610	0.098978

t=1978-1988

MSE	MAE	U1	UM	UR	UD
0.012	0.300	0.557	0.009	0.007	0.985

t=1964-1988

MSE	MAE	U1	UM	UR	UD
0.019	0.319	0.634	0.005	0.000	0.994

2SLS Fresh/Frozen Demand Equation Estimation (1964-1988)

RED

rho & asymptotic t-ratio
-0.125
-0.551

second order rho & asymptotic t-ratios
-0.188 -0.232
-0.792 -0.936

not corrected for ar(1) since rho not significant at 5% one-tail level

Valid cases:	25	Dependent variable:	PFRED
Total SS:	39.465	Degrees of freedom:	17
R-squared:	0.800	Rbar-squared:	0.718
Residual SS:	7.878	Std error of est:	0.681
F(7,17):	9.737	Probability of F:	0.000
Durbin-Watson:	2.112		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	-1.986586	5.006339	-0.396814	0.696	---	---
QFRED	-0.023585	0.007824	-3.014423	0.008	-1.036894	0.227103
FIRED	0.000016	0.000158	0.103214	0.919	0.017237	0.477262
PTUNA	0.840698	0.539593	1.558023	0.138	0.318638	0.152652
RPCIJP	-0.373643	0.239410	-1.560681	0.137	-0.719183	0.441974
POPLJP	0.045539	0.018139	2.510514	0.022	0.922372	0.599162
ERJP	-0.018333	0.005252	-3.490981	0.003	-1.453763	-0.505032
PRIMEJP	0.025542	0.053656	0.476027	0.640	0.080832	0.123741

t=1978-1988

MSE	MAE	U1	UM	UR	UD
0.026	0.505	0.625	0.013	0.135	0.852

t=1964-1988

MSE	MAE	U1	UM	UR	UD
0.053	0.384	0.797	0.037	0.414	0.549

rho & asymptotic t-ratio
0.200
0.843

second order rho & asymptotic t-ratios

0.203	-0.142
0.835	-0.528

not corrected for ar(1) since rho not significant at 5% one-tail level

Valid cases:	25	Dependent variable:	PFSILV
Total SS:	22.420	Degrees of freedom:	17
R-squared:	0.780	Rbar-squared:	0.690
Residual SS:	4.930	Std error of est:	0.539
F(7,17):	8.615	Probability of F:	0.000
Durbin-Watson:	1.602		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	-3.644810	4.077141	-0.893962	0.384	---	---
QFSILV	-0.057783	0.023353	-2.474356	0.024	-0.592[illegible]2	0.083628
FISILV	-0.000110	0.000085	-1.290507	0.214	-0.178507	-0.023987
PTUNA	0.779770	0.412757	1.889175	0.076	0.392113	0.266755
RPCIJP	-0.406876	0.160253	-2.538961	0.021	-1.039040	0.337012
POPLJP	0.044875	0.012331	3.639039	0.002	1.205900	0.555946
ERJP	-0.010478	0.003808	-2.751855	0.014	-1.102339	-0.365033
PRIMEJP	-0.060722	0.037184	-1.633013	0.121	-0.254962	0.007220

t=1978-1988

MSE	MAE	U1	UM	UR	UD
0.026	0.359	0.637	0.096	0.119	0.785

t=1964-1988

MSE	MAE	U1	UM	UR	UD
0.040	0.384	0.700	0.004	0.122	0.874

2SLS Fresh/Frozen Demand Equation Estimation (1964-1988)

CHUM

rho & asymptotic t-ratio
0.151
0.646

second order rho & asymptotic t-ratios
0.085 -0.389
0.300 -1.573

not corrected for ar(1) since rho not significant at 5% one-tail level

Valid cases:	25	Dependent variable:	PFCHUM
Total SS:	4.790	Degrees of freedom:	17
R-squared:	0.729	Rbar-squared:	0.617
Residual SS:	1.300	Std error of est:	0.276
F(7,17):	6.523	Probability of F:	0.001
Durbin-Watson:	1.533		

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	-3.864904	2.096606	-1.843410	0.083	---	---
QFCHUM	0.005178	0.013292	0.389512	0.702	0.232356	0.155036
FICHUM	-0.000004	0.000036	-0.119078	0.907	-0.019008	0.134184
PTUNA	0.789720	0.254106	3.107842	0.006	0.859109	0.412375
RPCIJP	0.009705	0.086560	0.112124	0.912	0.053619	0.307900
POPLJP	0.010302	0.006234	1.652453	0.117	0.598899	0.482897
ERJP	-0.000360	0.002081	-0.172984	0.865	-0.081930	-0.243601
PRIMEJP	-0.014400	0.019617	-0.734057	0.473	-0.130806	-0.116768

t=1978-1988

MSE	MAE	U1	UM	UR	UD
0.019	0.170	0.769	0.079	0.027	0.894

t=1964-1988

MSE	MAE	U1	UM	UR	UD
0.024	0.179	0.737	0.018	0.036	0.946

APPENDIX C: TIME TREND PREDICTIONS FOR EXOGENOUS VARIABLES

TUNA PRICES

Valid cases:	25	Dependent variable:	Y
Total SS:	5.669	Degrees of freedom:	23
R-squared:	0.270	Rbar-squared:	0.238
Residual SS:	4.141	Std error of est:	0.424
F(1,23):	8.487	Probability of F:	0.008

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	4.919585	0.898428	5.475768	0.000	---	---
YEAR	-0.034286	0.011769	-2.913327	0.008	-0.519183	-0.519183

POPULUATION WEIGHTED US AND JAPAN REAL PER CAPITA INCOME

Valid cases:	25	Dependent variable:	Y
Total SS:	146.210	Degrees of freedom:	23
R-squared:	0.920	Rbar-squared:	0.917
Residual SS:	11.629	Std error of est:	0.711
F(1,23):	266.169	Probability of F:	0.000

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	-10.502339	1.505572	-6.975648	0.000	---	---
YEAR	0.321751	0.019722	16.314686	0.000	0.959407	0.959407

POPULATION WEIGHTED US AND UK REAL PER CAPITA INCOME

Valid cases:	25	Dependent variable:	Y
Total SS:	179.307	Degrees of freedom:	23
R-squared:	0.878	Rbar-squared:	0.873
Residual SS:	21.849	Std error of est:	0.975
F(1,23):	165.751	Probability of F:	0.000

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	-13.787778	2.063681	-6.681157	0.000	---	---
YEAR	0.348025	0.027032	12.874418	0.000	0.937095	0.937095

SUM OF POPULATIONS IN US AND JAPAN

Valid cases:	25	Dependent variable:	Y
Total SS:	16190.358	Degrees of freedom:	23
R-squared:	0.940	Rbar-squared:	0.937
Residual SS:	972.403	Std error of est:	6.502
F(1,23):	359.947	Probability of F:	0.000

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	71.389916	13.767251	5.185488	0.000	---	---
YEAR	3.421421	0.180338	18.972258	0.000	0.969505	0.969505

SUM OF POPULATIONS IN US AND UK

Valid cases:	25	Dependent variable:	Y
Total SS:	8557.428	Degrees of freedom:	23
R-squared:	0.897	Rbar-squared:	0.892
Residual SS:	881.836	Std error of est:	6.192
F(1,23):	200.194	Probability of F:	0.000

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	91.051354	13.110462	6.944939	0.000	---	---
YEAR	2.429877	0.171735	14.149010	0.000	0.947075	0.947075

EXCHANGE RATES US AND JAPAN (YEN/DOLLAR)

Valid cases:	25	Dependent variable:	Y
Total SS:	248156.656	Degrees of freedom:	23
R-squared:	0.814	Rbar-squared:	0.806
Residual SS:	46219.614	Std error of est:	44.828
F(1,23):	100.489	Probability of F:	0.000

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	1290.957555	94.915542	13.601119	0.000	---	---
YEAR	-12.463394	1.243305	-10.024409	0.000	-0.902080	-0.902080

EXCHANGE RATES US AND UK (POUNDS/DOLLAR)

Valid cases:	25	Dependent variable:	Y
Total SS:	0.829	Degrees of freedom:	23
R-squared:	0.871	Rbar-squared:	0.865
Residual SS:	0.107	Std error of est:	0.068
F(1,23):	154.749	Probability of F:	0.000

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	-1.422164	0.144561	-9.837810	0.000	---	---
YEAR	0.023556	0.001894	12.439806	0.000	0.933062	0.933062

CANNED INVENTORY KING SALMON

Valid cases:	25	Dependent variable:	Y
Missing cases:	0	Deletion method:	None
Total SS:	4523969.470	Degrees of freedom:	23
R-squared:	0.647	Rbar-squared:	0.632
Residual SS:	1596479.441	Std error of est:	263.462
F(1,23):	42.175	Probability of F:	0.000

Variable	Estimate	Standard Error	t-value	Prob >|t|	Standardized Estimate	Cor with Dep Var
CONSTANT	4133.965698	557.835107	7.410731	0.000	---	---
YEAR	-47.454351	7.307117	-6.494264	0.000	-0.804429	-0.804429