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simulating a large quantity, the absolute percentage error will be very small. When these two percentages are averaged to obtain a mean absolute percent error, a high value of the statistic may result, which may lead to the mistaken conclusion that the forecasts are missing the actual values to a large degree.

A simple example may help to clarify this point. Suppose the quantity of salmon exported in four periods is given as:

<u>Period</u>	<u>Actual Quantities</u>	<u>Predicted Quantities</u>	<u>Mean Absolute Percent Error</u>
1	10	25	150
2	50	20	60
3	5,000	4,800	4
4	100,000	103,000	3

In this case, predictions of actual quantities have increasingly large errors in absolute value, but the absolute percent error for each period decreases. A simple average of the four-period time series gives the mean absolute percent error for the entire set of predictions as 54.25 percent. It is clear, however, that the predictions are relatively accurate in the time periods of 3 and 4 when the quantities are at their highest level. In quarters 1 and 2 the absolute percentage error is quite large, but the quantities are very small in a relative sense. To better capture the accuracy of simulations in relation to quarters with significant quantity levels, the concept of weighted goodness of fit statistics is put forth.

Weighted goodness of fit statistics are the standard goodness of fit statistics except the statistics are weighted by the relative importance of each observation in the sample. For example, salmon exports to the EEC in a given period would be weighted by the proportion of total salmon exported to

the EEC in the given time period relative to the total salmon quantity exported by the EEC in the simulation periods (thus the total weights adding to 1). For the above example, the weighting scheme would be as follows:

<u>Period</u>	<u>Actual Quantities</u>	<u>Predicted Quantities</u>	<u>Weights</u>	<u>Weighted Mean Absolute % Error</u>
1	10	25	0.000010	0.0015
2	50	20	0.000050	0.003
3	5,000	4,800	0.004975	0.019900
4	100,000	103,000	0.994965	2.984895
	1,005,060			3.009295

In this case the mean absolute error decreases from the unweighted value of 54.25 percent to the weighted value of 3.01 percent, reflecting the relative accuracy with which the high quantity levels were simulated in the third and fourth quarters. It is clear that when all weights are identical, the standard and weighted goodness of fit statistics are identical.

The definitions of the goodness of fit statistics used in assessing the adequacy of the estimated world trade model are given below. When all weighting values are identical as $W_i = 1/n$, for $i = 1, \dots, n$, then the formulae define the standard goodness of fit statistics found in the literature. A_i refers to the i^{th} observation on actual data, and S_i refers to simulated data for the i^{th} observation.

Weighted Mean Absolute Percent Error (WMAPE)

$$\text{WMAPE} = 100 \sum_{i=1}^n W_i \cdot (|S_i - A_i|/A_i)$$

Weighted Root Mean Squared Percent Error (WRMSPE)

$$\text{WRMSPE} = [100 \sum_{i=1}^n W_i \cdot (S_i - A_i)^2 / A_i^2]^{1/2}$$

Weighted Correlation Coefficient (r_W)

$$r_W = \frac{\sum_{i=1}^n (A_i - \bar{A})(S_i - \bar{S})W_i}{\sigma_A \sigma_S}$$

where $\sigma_A = \left(\sum_{i=1}^n W_i (A_i - \bar{A})^2 \right)^{1/2}$

$$\sigma_S = \left(\sum_{i=1}^n W_i (S_i - \bar{S})^2 \right)^{1/2}$$

$$\bar{A} = \sum_{i=1}^n W_i A_i$$

$$\bar{S} = \sum_{i=1}^n W_i S_i$$

Weighted Theil U_1 Statistic (U_{1W})

$$U_{1W} = \left[\frac{\sum_{i=1}^n [(S_i - A_i)^2 \cdot W_i]}{\sum_{i=1}^n [A_i^2 \cdot W_i]} \right]^{1/2}$$

Mean Square Error Decomposition Statistics

Weighted Regression Proportion (U_r)

$$U_r = (\sigma_S - r_W \sigma_A)^2 / \text{WMSE}$$

Weighted Disturbance Proportion (U_d)

$$U_d = (1 - r_W^2) \sigma_A^2 / \text{WMSE}$$

Weighted Mean Proportion (U_m)

$$U_m = (\bar{S} - \bar{A})^2 / \text{WMSE}$$

where

$$WMSE = \sum_{i=1}^n W_i (S_i - A_i)^2.$$

Both the weighted and unweighted goodness of fit statistics are valuable in assessing the fit of the system of equations. The unweighted goodness of fit statistics give an indication of how all variables are predicted assuming equal importance of each observation. There may be cases where it is equally as important to forecast low values as high values. However, in the salmon model, the levels of quantity flows are usually quite seasonal and using the weighted average goodness of fit statistics may lead to a better understanding of how well the model is fitting the actual data in terms of the most commercially important quarters. Comparing the simple average and weighted average goodness of fit statistics provides an indication of how seasonality affects the forecasting.

Both the standard and weighted goodness of fit statistics were calculated for the estimated model, and are reported in section "V. Findings".

Scenario Generation Within Historical Period

A number of scenarios relating to changing the historical levels of key exogenous variables in the salmon trade model were simulated using the SAS SIMNLIN procedure. The purpose of this exercise was to identify key factors having an important influence on equilibrium prices and quantities in the salmon market, as well as to provide an indication of the relative quantitative importance of the effects. The results serve to identify factors that should be of concern to policymakers and industry participants who are

confronted with decisions regarding resource allocations within the salmon industry.

A listing of the various scenarios that were performed is given below:

1. North American high-valued salmon landings are increased by 10 percent.
2. North American high-valued salmon landings are decreased by 10 percent.
3. North American low-valued salmon landings are increased by 10 percent.
4. North American low-valued salmon landings are decreased by 10 percent.
5. Norwegian and Scottish farmed Atlantic salmon exports are increased by 10 percent.
6. Norwegian and Scottish farmed Atlantic salmon exports are decreased by 10 percent.
7. Norwegian farmed Atlantic salmon exports are increased by 10 percent.
8. Norwegian farmed Atlantic salmon exports are decreased by 10 percent.
9. Chilean farmed salmon exports to North America are increased by 25 percent.
10. Chilean farmed salmon exports to North America are decreased by 25 percent.
11. Salmon trade is tariff-free.
12. The Japanese tariff on all fresh/frozen salmon is doubled to 10 percent.
13. The EEC tariff on all fresh/frozen salmon is increased to 12 percent.
14. A North American tariff of 5 percent is placed on Norwegian salmon exports.
15. The U.S. dollar is strengthened by 10 percent against all currencies.
16. The U.S. dollar is weakened by 10 percent against all currencies.

17. Prices for canned low-valued salmon is increased by 10 percent.

18. Prices for canned low-valued salmon is decreased by 10 percent.

The results of the scenario generation are present in the section "V. Findings".

Forecasting Future Salmon Prices

Forecasts for 1990-1993 were made to determine the potential future course of five key prices in the salmon trade model:

- 1) the price of Norwegian farmed Atlantic salmon exported to North America (FOB Norway)
- 2) the average North American export price of high-valued salmon (FOB North America)
- 3) the average North American export price of low-valued salmon (FOB North America)
- 4) the North American exvessel price of high-valued salmon
- 5) the North American exvessel price of low-valued salmon.

Forecasts of the endogenous variables were made using a "baseline" set of assumptions regarding the future course of the exogenous variables in the salmon trade model for 1990-1993. There were also forecasts made that incorporated variations on the baseline assumptions with regard to future exchange rates, landings of Pacific salmon, and the future supplies of Norwegian and Scottish farmed Atlantic salmon.

The forecasting of exogenous variables was done by a variety of different methods. For exogenous variables whose values followed a definite time trend or growth rate, ordinary least squares was used to fit an appropriate trend line, and then future values of the exogenous variables represented an extrapolation of the trend. In all cases where this procedure of forecasting was used, the semilog functional form in which the natural

logarithm of the variable in question was regressed on a linear function of time resulted in the best representation of historical values. Thus, in these forecasts, future values were generated by using the growth rates implied by the estimated value of the parameter on the time variable in the semilogarithmic regression. Variables forecasted in this way included populations, incomes or expenditures, and price deflators in North America, Japan, and the EEC.

Exchange rates could not be forecasted with a sufficient degree of accuracy. Exchange rates for the first quarter of 1990 were the actual level of exchange rates reported by the Federal Reserve Bank. Future values of the exchange rates were set equal to the most recent exchange rates available at the time the forecasts were made - the exchange rates as published in the Wall Street Journal on May 3, 1990. In recognition of the importance of exchange rate effects, and the likelihood that some fluctuation in these rates would occur over the forecast period, sensitivity analysis was performed by varying exchange rates above and below the baseline projection by an amount equal to one standard deviation calculated with respect to exchange rate variation in the historical period 1983-1989. Of course, the fact that exchange rates must be in equilibrium was maintained in the sensitivity analysis by allowing the Norwegian kroner/ECU exchange rate to assume the appropriate value required to clear the currency markets after the other exchange rates in the model were perturbed.

The future levels of the tariff rates in the EEC and Japan are uncertain, although they have remained unchanged for a number of years. The future values of the tariff rates on chilled or frozen round fish were assumed

to be equal to their most recent values existing in 1989 (2% in the EEC and 5% in Japan).

A number of variables were forecasted by extrapolating averages by quarter as future values. In the case of North American and Japanese landings of salmon, Japanese salmon inventories, and the quantity of fresh fish being sold in the Tokyo wholesale market, the historical averages by quarter were used directly as future quarterly values for the respective quantities. In the case of wholesale prices of substitute fish in Japan and the FOB prices of canned salmon in North America, averages by quarter for 1987 and 1988 were used to establish baseline quarterly nominal prices, and then projections into the future were generated by holding the prices constant in real terms by inflation using projections of appropriate price indices. Sensitivity analysis was performed on North American Pacific salmon landings by varying landings above and below baseline projections. The amount of the variation was calculated by finding the standard deviation of yearly landings over the historical period, and then prorating a one standard deviation change in landings in proportion to the baseline forecasted quarterly landing levels.

Forecasts for a number of exogenous variables were taken directly from previous forecasts generated by other researchers. Variables in this category included the total supply of Norwegian farmed Atlantic salmon, the supply of Scottish farmed Atlantic salmon, the supply of farmed salmon produced in British Columbia, Chilean imports of farmed salmon into North America, and the amount of Norwegian farmed Atlantic salmon imported by Japan. Levels and sources of these forecasts are discussed in greater detail in Herrmann (1990, p. 640-652).

A number of indicator variables were used in the model to represent structural changes in the model and outliers in the data set. Decisions were made regarding which indicator variables would be effective in the future period and which would have no future effect. The decisions and their rationale are discussed in Herrmann (1990, p. 637-640).

Because increasing amounts of farmed Atlantic salmon are being produced in Canada and the United States, these quantities are considered important for future modelling although they were insignificant in the past. A new variable was created for forecasting purposes which is North American farmed Atlantic salmon supply. Since these supplies could not be modelled using historical data, an assumption as to the effect of this new Atlantic salmon supply on salmon markets needed to be made. For forecasting purposes, this North American farmed Atlantic salmon was assumed to be substitutable for farmed Norwegian Atlantic salmon on a 1-to-1 basis (dressed weight). This new variable was added exogenously to the amount of Norwegian farmed Atlantic salmon being imported into North America when predicting the market clearing price of Atlantic salmon in the United States.

The salmon trade model was also calibrated, through the use of add factors, to generate actual price and quantity outcomes observed in the Norwegian Atlantic salmon markets for the year 1989. Furthermore, certain partial adjustment processes in the model were altered when making future predictions of salmon market outcomes. For further detail on model adjustments, see Herrmann (1990, p. 648-650). The price forecasts for the period 1990-1993 under the baseline assumptions, as well as variation around the baseline induced by the sensitivity analyses on exchange rates, North

American Pacific landings, and Norwegian/Scottish farmed Atlantic salmon supply, are reported in the section "V. Findings".

Evaluating Future Farming Profitability

Forecasted prices for Norwegian farmed Atlantic salmon generated by the salmon trade model, together with costs of producing farmed salmon generated from previous studies and consultations with key industry personnel involved in Puget Sound operations, were utilized to assess the future profitability of farmed salmon operations in the Puget Sound. The forecasted Norwegian prices generated by the model are FOB prices. These FOB prices would need to have the costs of marketing, mainly transportation costs, added in order to define import-level (CIF, cost-insurance-freight) prices. If farmed Atlantic salmon from Norway and Puget Sound are sold at similar price levels in the North American market, the Norwegian FOB prices, adjusted to the CIF level, would give an indication of prices that Puget Sound farmers could expect to receive for their salmon after it had been dressed, packaged, and sold to a first receiver.

However, it is by no means certain that Norwegian and Puget Sound farmed Atlantic salmon sell at identical prices in the North American market. A price differential could exist because of quality differences (perceived or real), size differences, availability of a guaranteed supply, and the like. Since farmed Atlantic salmon from Puget Sound is such a new commodity, there is insufficient data on farmed prices that can be correlated with Norwegian prices. Urner Barry, in Seafood Price Current, reports wholesale price for 3- to 4-kilogram (6- to 9-pound) Norwegian farmed Atlantic salmon from Canada and the United States for the Mid-Atlantic/New England Region. The prices reported by Urner Barry are first-receiver prices and, therefore, are prices

that the first receiver would receive upon selling the salmon to buyers further up the marketing chain. The Urner Barry prices are also reported for top quality farmed Atlantic salmon. In reality, not all farmed salmon produced is top quality and thus these reported prices may not be received (Forster, 1990).

The North American Atlantic salmon to which the Urner Barry prices would mainly pertain come from the east coast of Canada and Maine. Figure 2 shows the differences between the U.S. wholesale prices of Norwegian and North American Atlantic salmon starting in October of 1989, the time period when the prices of Canadian-U.S. Atlantic salmon were most recently reported (there was a gap in reporting the North American farmed Atlantic price from 6/89 - 9/89).

Starting at the end of 1989, the Norwegian Atlantic wholesale price was generally \$0.20 to \$0.30 per pound higher than the North American Atlantic wholesale price. From October 1989 to March 1990, the average real difference (denominated in first quarter 1989 dollars) between the Norwegian Atlantic salmon wholesale price and the North American wholesale price was \$.27 per pound, with the Norwegian price being higher than the North American price. Figure 3 shows the Norwegian farmed Atlantic salmon export price (FOB Norway) to North America, the Norwegian farmed Atlantic salmon wholesale price reported by Urner Barry, and the spread between these two prices. The spread between these two prices varies, and starting in October of 1988 the average real price spread between the Norwegian wholesale and FOB price averaged \$1.15 per pound.

An estimate can be made, then, as to the nature of future wholesale prices of North American farmed Atlantic salmon in the Mid-Atlantic/New England region. A proxy for future Norwegian wholesale prices in North

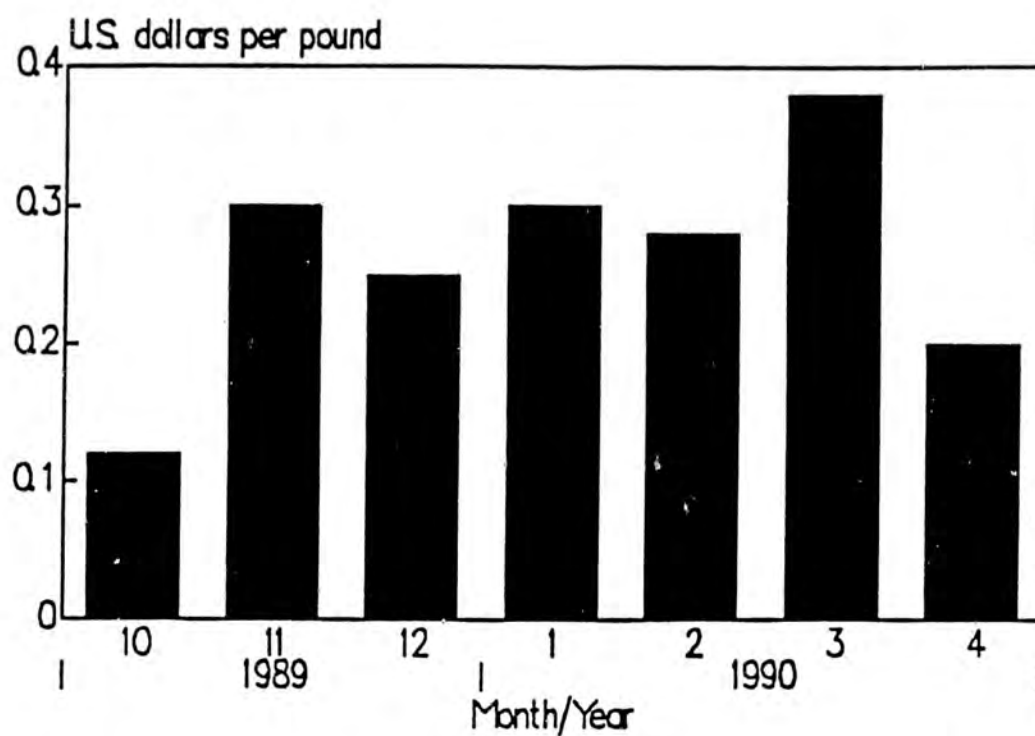


FIGURE 2. Differences Between Norwegian and North American Farmed Atlantic Salmon Prices from October 1989 to May 1990 (in U.S. dollars per pound) (ADAPTED FROM: Seafood Price-Current. Toms River, NJ: Urner Barry Publications, Inc. 1987-90, various dates; own model predictions.)

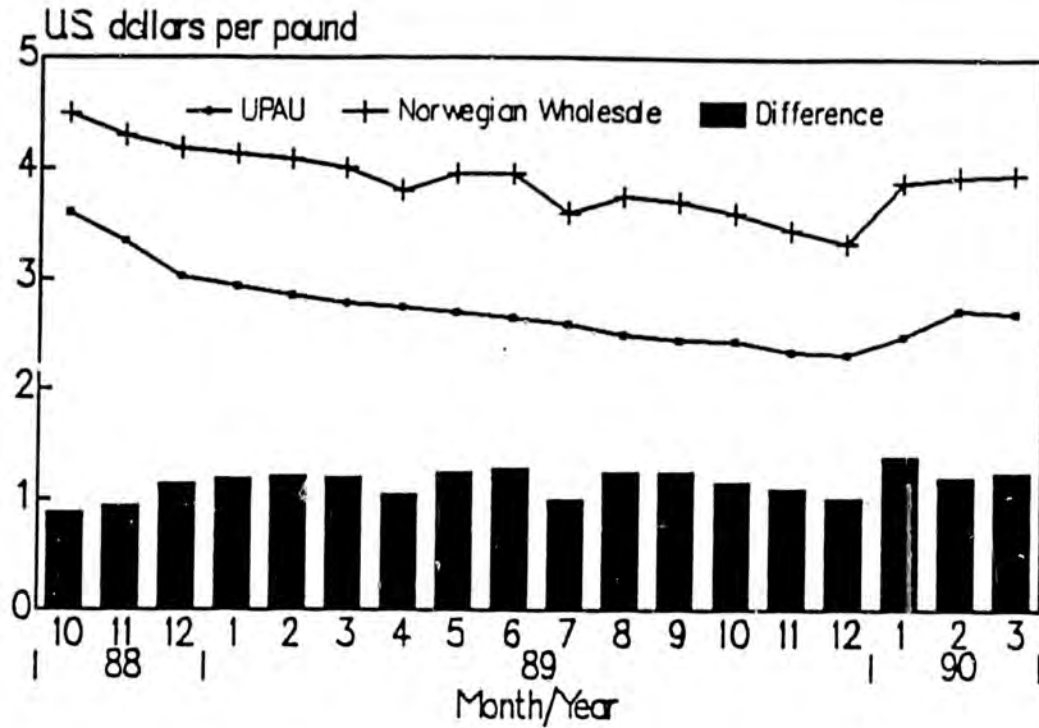


FIGURE 3. Norwegian Farmed Atlantic Salmon Wholesale Price in North America vs. Norwegian FOB Farmed Atlantic Salmon Export Price (UPAU) and the Spread (U.S. dollars per pound) (ADAPTED FROM: Seafood Price-Current. Toms River, NJ: Urner Barry Publications, Inc. 1987-90, various dates; own model predictions.)

American can be obtained by adding a price differential of \$1.15 per pound, in real terms, to future Norwegian FOB export prices. Then a proxy for the North American Atlantic salmon wholesale price can be obtained by subtracting a price differential of \$.27 per pound, in real terms, from the future Norwegian wholesale prices. This is, of course, assuming that the historical spreads between Norwegian FOB and first receiver prices, and between Norwegian and North American first receiver prices remain constant in real terms into the future. Recall that these prices refer to farmed Atlantic salmon having an average weight of 6-9 pounds. It should be noted that Puget Sound farmed Atlantic salmon average 8-9 pounds, so that the reported prices may underestimate the price of Puget Sound salmon to the extent that the 6-9 pound category includes a large amount of smaller fish. If Puget Sound Atlantic salmon wholesale prices (FOB Seattle) and North American wholesale prices (FOB Mid-Atlantic/New England) for farmed Atlantic salmon are similar, then this constructed wholesale price can be used to approximate future prices of farmed salmon from Puget Sound.

Costs of production in Puget Sound for 1990 were assumed to range between \$3.00 per pound for efficient farms to \$3.50 per pound for less efficient/start-up farms based on a consultation with John Forster, President of Sea Farms of Washington (1990). These cost-of-production figures are to be interpreted as dressed per-pound prices FOB Seattle, which means the price the farmer received would be for dressed salmon which has been packaged and delivered to Seattle by the farmer. Most farmers process, package, and deliver their own salmon to markets across the United States, especially to the western markets. The cost-of-production figure is not inclusive of a fair return to investment capital, but does include management salary (Forster,

1990). When selling Puget Sound farmed Atlantic salmon, the farmer can either sell to a first receiver (wholesale level) or to a receiver at the retail level. Two prices were constructed to examine these two possible selling points. The markup included in the first receiver price that is received upon resale to a retailer is assumed to be 15 percent (B.C. Salmon Farmers Association, 1988b; Peyton, 1988). Thus, projected wholesale prices for Atlantic salmon are reduced by the 15 percent markup to establish the farm-level prices of salmon sold to a first receiver, and the projected wholesale prices that are not reduced by 15 percent are prices for salmon sold to a receiver at the retail level.

The assumption that Atlantic salmon sells for the same amount on the East Coast as on the West Coast is by no means certain. The prices could differ between the two markets, but these differences may not be significant in magnitude. For a Puget Sound Atlantic salmon farmer to compete in the marketplace, the farmer would have to accept a price that would be within a transportation cost differential of the price received by salmon farmers from Maine and eastern Canada who are supplying the East Coast market, assuming salmon of comparable size and quality. Transportation costs can be as little as \$.10-\$.11 per pound (Anderson, 1988a) for refrigerated truck transportation across the country, or \$.30-\$.40 per pound for cross-country air freight (Riely, 1986). For the purposes of these projections, it assumed that the FOB prices are the same on both coasts and that deliveries to markets away from Seattle will cover transportation costs. The results of the profitability analysis of Puget Sound salmon farming are reported in the section "V. Findings".

A scenario was examined that assessed the impact of additional salmon production from Puget Sound farming on Atlantic salmon prices and prices of high-valued Pacific salmon. Specifically, the salmon trade model was used to forecast prices under the baseline assumptions, except it was assumed that U.S. production of farmed Atlantic salmon would increase in the future period by 100 percent over baseline assumptions, which was equivalent to a 10 million pound increase by 1993. If all of the increase originated in Puget Sound, it would represent over a four-fold increase in projected production from the Puget Sound. The results are provided in the "V. Findings" section.

6. Writing Final Documents

Ph.D. Dissertation by Dr. Herrmann

The writing of Dr. Herrmann's dissertation was performed during the period 12/89 - 6/90 and was closely supervised by Dr. Mittelhammer and Dr. Lin of the research team, as well as read and evaluated in final draft form by Dr. Raymond Folwell and Dr. David Price of the Dept. of Agricultural Economics, Washington State University. The organization and content of the dissertation was intentionally designed to allow the dissertation to operate as a detailed reference for the construction and results of the salmon trade model, as well as for background material related to salmon industry structure and a review of related salmon market analyses. The dissertation is submitted to NMFS as an addendum/supplement to the final report.

Final Report to NMFS

The final report was written during 5/90 - 6/90 by the research team following the standard format for S-K project final reports. The final report was written using a level of detail sufficient for the final report to act as

a stand-alone report on the method and results of the project. However, finer details on methods, most background material on industry structure and past salmon market analyses, and some results obtained from the salmon trade model were not discussed in the final report, but can be found in the addendum/supplement represented by Dr. Herrmann's dissertation.

B. PROJECT MANAGEMENT

All research work and writing phases of the project were performed by the research team consisting of Dr. Ron C. Mittelhammer and Dr. Mark Herrmann from the Dept. of Agricultural Economics, Washington State University, Pullman, WA, and Dr. Biing-Hwan Lin from the Dept. of Agricultural Economics, University of Idaho, Moscow, ID. A number of cases arose where data required by the project could not be secured by any other means than by contracting with outside organizations for its provision. These organizations included the Alaska Commercial Fisheries Entry Commission, the Norwegian Central Bureau of Statistics, Urner Barry, Inc., and Mr. Clint Atkinson, who is a fisheries industry consultant headquartered in Seattle, WA. Furthermore, the services of a technical editor were secured in editing the data book entitled "World Salmon Trade: Export/Import Statistics."

The close geographic proximity of Washington State University and the University of Idaho (7 miles) facilitated frequent and regular meetings of the research team to monitor, evaluate, and plan research activities in pursuit of project objectives. The final project results were a product of continual interactive involvement of the research team.

V. FINDINGS

A. Actual Accomplishments and Findings

1. Introduction

An extensive review of salmon industry structure was accomplished, but the details of the review will not be provided in this report. The review can be found in the dissertation by Dr. Herrmann, presented as Chapter 2, "The World Salmon Industry", pp. 9-243. Similarly, a detailed review of past quantitative analyses of salmon markets was also accomplished, but the content of the review is not reported here. This review can also be found in the dissertation by Herrmann, presented as Chapter 3, "Literature Review: Econometric Analyses of Salmon Markets", pp. 244-300. The accomplishments and findings reported in the remainder of this section are related to the estimation and simulation of the salmon trade model, and how the results of the model relate to the objectives of the project reported in III.B. of the final report.

The following glossary of variable names and definitions refers to the variables that are used in the estimated salmon trade model.

Endogenous Variables

Atlantic Salmon Variables

NQAE	=	the Norwegian exports of farmed Atlantic salmon to the EEC, measured pounds
EQAE	=	the quantity of imported Norwegian and Scottish farmed Atlantic salmon (FOB Norway) in the EEC, measured in pounds
QAEC	=	the per capita quantity of imported Norwegian and Scottish farmed Atlantic salmon (FOB Norway) in the EEC, measured in pounds

QAJC	=	the per capita quantity of imported Norwegian farmed Atlantic salmon in Japan, measured in pounds
QAJ	=	the quantity of imported Norwegian farmed Atlantic salmon in Japan, measured in pounds
QAUC	=	the per capita quantity demand of imported Norwegian farmed Atlantic salmon into North America, measured in pounds
QAU	=	the quantity of Norwegian farmed Atlantic salmon imported into North America, measured in pounds
TSUPA	=	the total supply of Norwegian farmed Atlantic salmon to be exported to North America, the EEC, and Japan, measured in pounds
JPAJRT	=	the "real" price of Norwegian farmed Atlantic salmon in Japan (FOB Norway), measured in yens per pound (including tariff)
JPAJ	=	the nominal price of Norwegian farmed Atlantic salmon in Japan (FOB Norway), measured in yens per pound
NPAE	=	the Norwegian price of Norwegian farmed Atlantic salmon exported to the EEC (FOB Norway), measured in Norwegian kroners per pound
EPAE	=	the nominal price of Norwegian farmed Atlantic salmon in the EEC (FOB Norway), measured in ECUs per pound
EPAERT	=	the "real" price of Norwegian farmed Atlantic salmon in the EEC (FOB Norway), measured in ECUs per pound (including tariff)
NPAU	=	the nominal price of Norwegian farmed Atlantic salmon exported to North America (FOB Norway), measured in Norwegian kroners per pound
UPAUR	=	the "real" price of Norwegian farmed Atlantic salmon in North America (FOB Norway), measured in U.S. dollars per pound
UPAU	=	the nominal price of Norwegian farmed Atlantic salmon in North America (FOB Norway), measured in U.S. dollars per pound

High-Valued Pacific Salmon Variables

QHEC	=	the per capita quantity of North American high-valued salmon imported in the EEC, measured in pounds
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QHE	=	the quantity of North American high-valued salmon imported in the EEC, measured in pounds
QHJC	=	the per capita quantity of imported North American high-valued salmon in Japan, measured in pounds
QHJ	=	the quantity of imported North American high-valued salmon in Japan, measured in pounds
EPHERT	=	the "real" price of North American high-valued Pacific salmon in the EEC (FOB North America), measured in ECUs per pound (including tariff)
EPHERT34	=	the "real" price of North America high-valued Pacific salmon in the EEC (FOB North America) in the quarters 3 and 4, measured in ECU's per pound (including tariff)
UPHE	=	the nominal price of North American high-valued salmon exported to the EEC in North America (FOB North America), measured in U.S. dollars per pound
EPHE	=	the nominal price of North American high-valued Pacific salmon in the EEC (FOB North America), measured in ECUs per pound
JPHJRT	=	the "real" price of North American high-valued salmon in Japan (FOB North America), measured in yens per pound (including tariff)
JPHJ	=	the nominal price of North American high-valued salmon in Japan (FOB North America), measured in yens per pound
UPHJ	=	the price of North American high-valued salmon exported to Japan in North America (FOB North America), measured in U.S. dollars per pound
UPH	=	the North American weighted average export price of high-valued salmon exported to the EEC and Japan (FOB North America), measured in U.S. dollars
UPHR234	=	the "real" weighted average export price of North American salmon (FOB North America) exported to the EEC and Japan, measured in U.S. dollars
PHEX	=	the North American exvessel price of high-valued salmon, measured in U.S. dollars per pound
LOGITHJ	=	logit variables for North American high-valued salmon exported to Japan, $= \ln((TSUPH/QHJ)-1)$
LOGITHE	=	logit variables for North American high-valued salmon exported to the EEC, $= \ln((TSUPH/QHE)-1)$

Low-Valued Pacific Salmon Variables

QLEC	=	the per capita quantity of North American low-valued salmon imported in the EEC, measured in pounds
QLE	=	the quantity of North American low-valued salmon exported to the EEC measured in pounds
QLJC	=	the per capita quantity of imported North American low-valued salmon in Japan, measured in pounds
QLJ	=	the quantity of imported North American low-valued salmon in Japan, measured in pounds
EPLERT	=	the "real" price of North American low-valued Pacific salmon in the EEC (FOB North America), measured in ECUs per pound (including tariff)
EPLERT34	=	the "real" price of North American low-valued Pacific salmon in the EEC (FOB North America) in quarters 3 and 4, measured in ECUs per pound (including tariff)
EPLE	=	the nominal price of North American low-valued Pacific salmon in the EEC (FOB North America), measured in ECUs per pound
UPLE	=	the price of North American low-valued salmon exported to the EEC in North America (FOB North America), measured in U.S. dollars per pound
JPLJRT	=	the "real" price of North American low-valued salmon in (FOB Norway), measured in yens per pound (including
JPLJ	=	the nominal price of North American low-valued salmon in (FOB Norway), measured in yens per pound
UPLJ	=	the price of North American low-valued salmon exported to Japan in North America (FOB North America), measured in U.S. dollars per pound
UPL	=	the North American weighted average export price of low-valued salmon exported to the EEC and Japan (FOB North America), measured in U.S. dollars per pound
PLEX	=	the North American exvessel price of low-valued salmon, measured in U.S. dollars per pound
LOGITLJ	=	logit variables for North American low-valued salmon exported to Japan, $= \ln((TSUPL/QLJ)-1)$

LOGITLE = logit variables for North American high-valued salmon
exported to the EEC, $= \text{Ln}((\text{TSUPL}/\text{QLE})-1)$

Exogenous Variables

North American Variables

UPPI = the producer price index in the United States for foods and feed

NAPOP = the aggregate population in North America

UPCANL = the weighted average North American export price of low-valued canned salmon in North America); measured in U.S. dollars per pound

UPCANH = the weighted average North American export price of high-valued canned salmon in North America (FOB North America); measured in U.S. dollars per pound

TSUPH = the North American total available supply of high-valued salmon, measured in pounds (beginning inventories plus landings plus British Columbian farmed salmon imports)

TSUPL = the North American total available supply of low-valued salmon, measured in pounds (beginning inventories plus landings)

YNARC = the "real" per capita aggregate of North America's personal disposable income

YNA = the aggregate of North America's personal disposable income measured in U.S. dollars

LANL = the North American landings of low-valued salmon, measured in pounds

LANH = the North American landings of high-valued salmon, measured in pounds

INVH₋₁ = the beginning North American inventories of high-valued salmon, measured in pounds

INVL₋₁ = the beginning North American inventories of low-valued salmon, measured in pounds

INVH = the ending North American inventories of high-valued salmon, measured in pounds

INVL	=	the ending North American inventories of low-valued salmon, measured in pounds
RELINVH	=	the ratio of available North American high-valued salmon inventories to total North American high-valued available salmon supply
RELINVL	=	the ratio of available North American low-valued salmon inventories to total North American low-valued available salmon supply

Japan Variables

JCPI	=	the general consumer price index in Japan
JTARIFF	=	the Japanese tariff on imported fresh/frozen salmon
JPOP	=	the Japanese population
JPO	=	the wholesale price for other fish species consumed in Japan as well as beef, chicken, and pork, in yens per pound;
JFRC	=	the wholesale per capita quantity of fresh fish being sold at the Tokyo wholesale market, measured in pounds
JFR	=	the wholesale quantity of fresh fish being sold at the Tokyo wholesale market, measured in pounds
JYRC	=	the "real" per capita private expenditure for Japan, measured in yen
JLANC	=	the per capita Japanese per capita landings of salmon, measured in pounds
JY	=	the private consumption expenditure for Japan, measured in yen
JLAN	=	the Japanese landings of salmon, measured in pounds
JINV	=	the inventories of Japanese frozen salmon, measured in pounds
JINV1C ₋₁	=	the beginning Japanese per capita inventories of frozen salmon not including pink salmon, measured in pounds
JINV2C ₋₁	=	the beginning Japanese per capita inventories of frozen salmon including pink salmon, measured in pounds

- JPF1R = the weighted average "real" price of a "high-valued" substitute fish consisting of fresh bluefin, bigeye, skipjack, yellowfin, and other tuna, measured in yens per pound
- JPF2R = the weighted average "real" price of a "lower-valued" substitute fish consisting of fresh and frozen sardine, mackerel, saury, cod, jack mackerel, flatfish, squid, rockfish, cuttlefish, and octopus, measured in yens per pound
- JPF1 = the weighted average nominal price of a "high-valued" substitute fish consisting of fresh bluefin, bigeye, skipjack, yellowfin, and other tuna measured in yens per pound
- JPF2 = the weighted average nominal price of a "lower-valued" substitute fish consisting of fresh and frozen sardine, mackerel, saury, cod, jack mackerel, flatfish, squid, rockfish, cuttlefish, and octopus, measured in yens per pound

EEC Variables

- EPOP = the aggregate population in the EEC
- ETARIFF = the tariff placed on fresh/frozen salmon imports in the EEC
- ECPI = the EEC consumer price index for food
- YEECRC = the "real" per capita private consumption expenditure in the EEC
- YEEC = the private consumption expenditure in the EEC

Exchange Rates

- NORECU = the Norwegian kroner/ECU exchange rate
- NORUSA = the Norwegian kroner/U.S. dollar exchange rate
- JAPUSA = the yen/U.S. dollar exchange rate
- USAECU = the U.S. dollar/ECU exchange rate

Indicator Variables

- D234 = assigned a value of 1 in quarters 2, 3, and 4, and 0 otherwise

DQ_i	=	quarterly indicator variables for quarter i where DQ_i is 1 in quarter i and 0 elsewhere
C	=	the constant
$D83$	=	an indicator variable which is assigned a value of 1 in 1983 and a value of 0 from 1984 to 1988
$D88$	=	an indicator variable which is assigned a value of 0 between 1982 and 1987 and a value of 1 in 1988
$DISEASE$	=	an indicator variable assigned a value of 1 for the last two quarters of 1986 and the first two quarter of 1987 and a value of 0 elsewhere
$D12T$	=	an indicator variable which is assigned a value of 1 for quarters one and two and is multiplied by a time variable which starts at 1 for 1982 and ends at 7 for 1988 and is assigned a value of 0 elsewhere
$D7$	=	an indicator variable which is assigned a value of 1 in the third quarter of 1983, and 0 elsewhere
$D85$	=	an indicator variable which is assigned a value of 1 from the first quarter of 1985 until the fourth quarter of 1988, and 0 elsewhere
$D88$	=	an indicator variable that is assigned the value 1 in 1988, and 0 elsewhere
$DUMNOR2$	=	an indicator variable that is assigned the value 1 in the first two quarter of 1987, and 0 elsewhere
$D16$	=	an indicator variable that is assigned the value 1 in the fourth quarter of 1985, and 0 elsewhere
$D34N$	=	an indicator variable assigned the value 1 in quarters 3 and 4, and 0 otherwise
$D22$	=	an indicator variable assigned the value 1 for the second quarter of 1987, and 0 elsewhere
$D87$	=	an indicator variable assigned the variable 1 in 1987 and 0 elsewhere
$D21$	=	an indicator variable assigned the value 1 in the first quarter of 1987, and 0 elsewhere
$D18$	=	an indicator assigned the value 1 in the second quarter of 1986, and 0 elsewhere.

Other Variables

QCH	=	the imports of Chilean salmon into North America, measured in pounds
QCHD1	=	the imports of Chilean salmon into North America in quarter 1, measured in pounds
QCHD4	=	the imports of Chilean salmon into North America in quarter 4, measured in pounds
BCFARM88	=	the British Columbian farmed salmon exports to North America in 1988, measured in pounds
BCFARM	=	the British Columbian farmed salmon exports to North America, measured in pounds
QSCOT	=	the quantity of Scottish farmed Atlantic salmon allocated to the EEC, measured in pounds
CHQCD1	=	the per capita Chilean imports of farmed salmon into North America in the first quarter, measured in pounds
CHQCD4	=	the per capita Chilean imports of farmed salmon into North America in the fourth quarter, measured in pounds
CHQ	=	the Chilean imports of farmed salmon into North America, measured in pounds

If a model variable name is preceded by the letter "L", then the variable is interpreted as having been transformed into natural logarithmic terms. For example, LNQAE would refer to the natural logarithm of the pounds of Norwegian exports of farmed Atlantic salmon to the EEC.

Prior Densities and Equation Statistics

The 16 behavioral equations referred to on pp. 44-45 were estimated using the bootstrapped Bayesian 2SLS estimation technique described in section IV.4. All equations were estimated based on quarterly observations for the period 1983-1988 except the EEC demand equations which were based on the period 1982-1988, and the exvessel price equations which were based on data for the period 1983-1987. Classical 2SLS results were also obtained, and can be found in Appendix A of Herrmann (1990), and the instrumental variables used

in the classical 2SLS estimation can be found in Appendix B of Herrmann (1990).

In estimation, four types of prior probability density functions (PPDF) were utilized. First of all, improper uniform densities were used in the forms:

$$\begin{aligned} (32) \quad f_i(\beta_i) &= I_{[0,\infty)}(\beta_i); \text{ or} \\ f_i(\beta_i) &= I_{(-\infty,0]}(\beta_i); \text{ or} \\ f_i(\beta_i) &= I_{(-\infty,\infty)}(\beta_i) \end{aligned}$$

to indicate nonnegativity, nonpositivity, and ignorance of the sign of a particular structural coefficient, β_i , where $I_A(\beta_i)$ is the standard indicator function which equals 1 when β_i is in the set A and equal to 0 when β_i is not in the set A. Secondly, proper uniform densities of the form:

$$(33) \quad f_i(\beta_i) = (\tau_2 - \tau_1)^{-1} I_{[\tau_1, \tau_2]}(\beta_i)$$

were used to indicate when it was believed that it was equally likely for the parameter β_i to be any of the values indicated within the interval $[\tau_1, \tau_2]$.

A third type of PPDF utilized was the quadrilateral PPDF, which is illustrated in Figure 4. The quadrilateral prior in Figure 4 indicates that, with probability 1, the value of the structural coefficient β_i is contained in the interval $[a,d]$. The values in the interval $[b,c]$ are considered equally likely, and these values are also assigned the highest likelihoods of occurrence. The density weights assigned to the points in the interval $[a,b]$ increase linearly when moving from the left to the right boundary, while the density weights assigned to the points in the interval $(c,d]$ decrease linearly when moving from the left to the right boundary. Although not shown in the

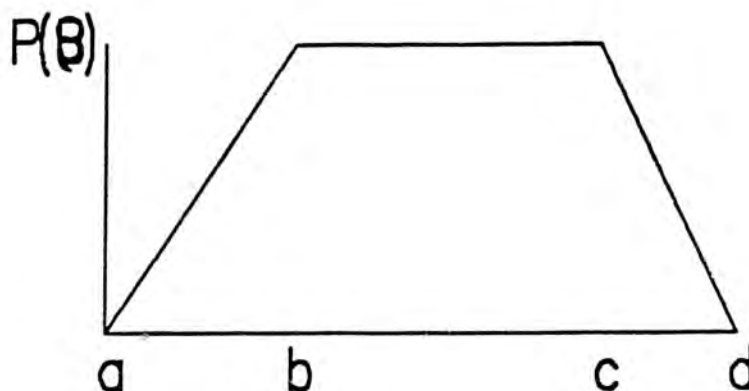


FIGURE 4. Quadrilateral Prior Probability Density Function.

figure, it is also possible that the quadrilateral prior will have only one sloped side, in which case, either the positive sloped or negative sloped portion of the graph would be missing. The general form of the quadrilateral prior is given by:

$$(34) \quad f_i(\beta_i) = (w_1 + w_2\beta_i)I_{[a,b)}(\beta_i) + w_3I_{[b,c]}(\beta_i) \\ + (w_4 - w_5\beta_i)I_{(c,d]}(\beta_i)$$

for appropriately chosen values of $w_1, \dots, w_5$, with $\int_a^d f_i(\beta_i) d\beta_i = 1$.

The fourth type of PPDF was defined by splicing together a truncated uniform and a truncated exponential density as illustrated in Figure 5. With this density, all points in the interval $[a,b]$ are considered to be equally

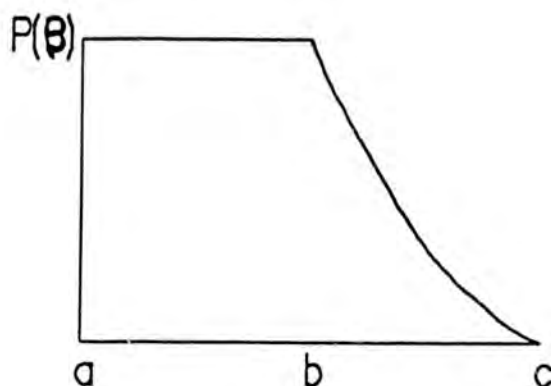


FIGURE 5. Spliced Uniform-Exponential Prior Probability Density Function

likely as the value of the structural coefficient β_i , with the likelihood of the values in the interval $(b, c]$ declining exponentially when moving from the left to the right interval boundary. The probability that the structural coefficient β_i has a value in the interval $[a, c]$ is assigned to be 1. The general form of the Spliced Uniform-Exponential PPDF is given by:

$$(35) \quad f_i(\beta_i) = w_1 I_{[a, b]}(\beta_i) + w_2 e^{-\beta_i/w_3} I_{(b, c]}(\beta_i)$$

for the appropriate choices of w_1 , w_2 , w_3 , where one also specifies

$$P(\beta_i \in [a, b]) = 1 - P(\beta_i \in (b, c]), \text{ and of course } \int_a^c f_i(\beta_i) d\beta_i = 1.$$

The joint prior density function for the parameters of a given structural equation was defined as the product of the marginal prior densities

for the individual β_i 's in the equation, as:

$$(36) \quad f(\underline{\beta}) = \prod_i f_i(\beta_i).$$

The f_i 's were chosen in various combinations from the types of prior densities discussed above, and as is evident from (36), the prior densities of the β_i 's were assumed to be independent of one another. In the discussion of the estimated equations, the characteristics of all non-ignorance type PPDFs used in estimation will be presented.

Along with the parameter estimates themselves, a number of additional statistics are reported that provide an indication of the efficacy of the estimation process on an equation by equation basis. First of all, standard errors derived from the posterior distribution of the parameters are provided and can be interpreted in the usual way as measuring spread - in this case referring to the spread of the marginal posterior density function of the parameter to which it pertains. Secondly, two posterior probability calculations, referred to as "HYPOIG" (hypothesis testing using an ignorance prior) and "HYPOIN" (hypothesis testing using an informative prior) are presented for each parameter estimate. These quantities represent posterior probabilities that a parameter will be greater than zero for a coefficient estimated to be positive and that a parameter will be less than zero for a parameter estimated to be negative. The HYPOIG probabilities are based on a posterior distribution that utilizes an uninformative ignorance-based prior density, whereas the HYPOIN probabilities are based on a posterior distribution that incorporates any informative prior densities specified on the parameters of an equation. The probabilities can be interpreted as the strength of belief in the estimated signs of the coefficients. The

"probability of the prior range" is the posterior probability, based on an uninformative ignorance-based prior, that the coefficients of an estimated equation reside within the subset of the parameter space represented by the range of values assigned positive density weighting by the informative prior density specified for the given equation. This measure can be interpreted as the degree of support that the sample information lends to the prior range specified for the coefficients of the equations. The "Odds in Favor of Non-Uniform Prior" are the odds that the actual prior distribution imposed is preferred to imposing a uniform distribution on the prior range. This measure can be interpreted as indicating the degree to which any differential weighting of parameter values indicated in the prior density is more compatible with the likelihood function for the parameters than is equal weighting of all parameter values within the prior range. The measure is defined by calculating the ratio of the posterior expectation of the informative prior density relative to the posterior expectation of a uniform distribution on the range of β -values for which the informative prior density assigns positive density weighting. The posterior density used in taking both expectations is one that is based on a noninformative ignorance-based prior. Of course, in the case where a uniform distribution was used at the outset as the prior density of β , this measure equals 1 and hence is not reported. The more the "Odds in Favor of Non-Uniform Prior" exceeds 1, the more support is rendered to the pattern of differential weights to β -values assigned by the informative prior density relative to an equal weighting scheme.

Correlations between actual and predicted values of the dependent variable are reported for each estimated equation. Hypothesis tests for first-order autocorrelation and for quarterly heteroskedasticity were also

performed, but they are not reported here. For each equation, an indication is given regarding whether a correction was made for a violation of classical assumptions. Details on the results of the hypothesis tests are provided in Herrmann, (1990), Chapter 5.

In the description of equation results below, an abbreviated description of any quadrilateral prior densities will be utilized. Specifically, $\uparrow$ will be used to designate an upward sloping portion of the prior, $\downarrow$ will be used to designate a downward sloping portion of the prior, and $\leftrightarrow$ will designate a horizontal portion of the density. Then for example, $\uparrow[a,b)$, $\leftrightarrow[b,c]$, $\downarrow(c,d]$ will denote a quadrilateral prior that slopes up on the range $[a,b)$, is constant on the range $[b,c]$, and then slopes down on the range $(c,d]$.

2. Estimated Equations

Group 1: Norwegian Allocation of Farm Raised Salmon

Equation 1: Quantity Allocated to the EEC

Dependent Variable: LNQAE

<u>Variable</u>	<u>Bayesian Coefficient</u>	<u>Standard Error</u>	<u>HYP0IG</u>	<u>HYP0IN</u>
LNPAE	0.59052462	0.248	0.984	1.000
LNPAU	-0.65500526	0.254	0.990	1.000
LTSUPA	0.90216752	0.052	1.000	1.000
D83	0.19712590	0.029	1.000	1.000
C	-1.83487940	0.521	0.999	0.999
DQ1	-0.10220869	0.026	1.000	1.000
DQ2	-0.08488451	0.021	1.000	1.000
DQ3	0.01138748	0.025	0.678	0.674
LNQAE ₋₄	0.21500868	0.054	1.000	1.000

Notes:

- a) $\bar{Y}$ vs. $\hat{Y}$ correlation = .998
- b) Probability of Prior Range = .981

- c) Heteroskedasticity correction = Quarter 2
- d) Prior Density: (on elasticities)
 - 1) LNPAE signed positive
 - 2) LTSUPA signed positive
 - 3) LNPAU signed negative
 - 4) LNQAE₋₄ uniformly distributed in [0,1].
- e) Elasticities:
 - Short Run: NPAE = .591
 - NPAU = -.655
 - TSUPA = .902
 - Long Run: NPAE = .753
 - NPAU = -.834
 - TSUPA = 1.149
- f) Sample Period = 1983:1 - 1988:4

Discussion:

In general, this equation performed very well, exhibiting a high correlation coefficient and probability of the prior range. The short-run elasticity of supply, TSUPA, was slightly below 1. An elasticity of 1 for total exports would imply, holding all else equal, that a 1 percent increase in total export supply would increase exports to the EEC by the same percentage. In Norway's case, with Norwegian exporters having the potential to exhibit some market power, the coefficient on this variable suggests that in the short run, *ceteris paribus*, an increase in the quantity of Norwegian exportable salmon is not allocated in a way that maintains relative distributional patterns, but is slightly oriented toward a proportionately smaller allotment to the EEC in the short run, suggesting a slightly larger

proportional allocation to other markets.

The significance of the price coefficients suggests that some degree of market power and/or short-term arbitraging is taking place, with more salmon allocated to the markets whose prices move favorably in comparison to other markets. The indicator variable for 1983 shows that the Norwegian exporters were willing to ship more to the EEC market at a given price in 1983 than in subsequent years. This indicates that there may have been a transition in the marketing of Norwegian farmed Atlantic salmon leading to North America, and particularly the United States, becoming a more important export market from 1984 on. The seasonal indicator variables show a shift in the seasonal patterns of distribution with proportionally more salmon being allocated to the EEC than to North America in quarters 3 and 4 when domestic consumption of freshly caught salmon in the United States increases dramatically.

The partial adjustment coefficient, indicated by the coefficient on the lagged EEC allocation quantity, is relatively small, meaning that there is relatively rapid adjustment when exporters respond to changes in importing countries' prices. This may mean that exporters' allocation decisions are not impeded by long-term contracts (Shaw and Gabbot [1990] report that Norway engages mainly in spot trading) and/or there is not much apprehension with respect to losing market share when redistributing exports.

The long-run elasticity of total export supply indicates a slight tendency to distribute a proportionally larger portion of increasing supplies to the EEC, all else remaining constant. But again, the elasticity of total export supply is close to 1.00. Both short- and long-run elasticities with respect to prices show redistribution to be slightly higher in percentage terms in response to a change in the price to North America. This may in part

be reflecting the fact that a given percentage change in both prices results in the nominal price to the North American market changing more because it is a consistently higher-priced market.

Group 2: EEC Demand for Salmon

Equation 1: Quantity Demanded of Norwegian and Scottish Farmed Atlantic Salmon

Dependent Variable : LEQAEC

<u>Variable</u>	<u>Bayesian Coefficient</u>	<u>Standard Error</u>	<u>HYP0IG</u>	<u>HYP0IN</u>
LEPAERT	-1.94138520	0.352	1.000	1.000
LEPHERT	0.35390836	0.151	0.955	1.000
LYEECRC	2.58901270	1.105	0.874	1.000
C	2.29010740	0.591	0.648	0.698
DQ1	-0.43710290	0.063	1.000	1.000
DQ2	0.05114066	0.076	0.717	0.749
DQ3	-0.26292191	0.071	1.000	1.000
D88	-0.34127784	0.120	0.984	0.996
DISEASE	-0.51820075	0.123	1.000	1.000
LEQAEC ^d ₋₁	0.55077779	0.130	0.992	1.000

Notes:

- a) Y vs. $\hat{Y}$ correlation = .980
- b) Probability of Prior Range = .684
- c) Heteroskedasticity Correction = Quarter 1
- d) Odds in Favor of Non-Uniform Prior = 1.477
- e) Prior Density: (on elasticities)
 - 1) LPAERT - Quadrilateral: $\uparrow [-5, -4]$, $\leftrightarrow [-4, -1]$, $\downarrow (-1, 0]$.
 - 2) LEPHERT - Quadrilateral: $\leftrightarrow [0, 4]$, $\downarrow (4, 5]$.
 - 3) LYEECRC - Quadrilateral: $\uparrow [0, 1]$, $\leftrightarrow [1, 4]$, $\downarrow (4, 5]$.
 - 4) LEQAEC - Uniform on $[0, 1]$.

f) Elasticities:

Short Run: EPAERT = -1.941

EPHERT = .354

YEECRC = 2.589

Long Run: EPAERT = -4.320

EPHERT = .788

YEECRC = 5.762

9) Sample Period = 1982:1 - 1988:4

Equation 2: Quantity Demanded of North American High-Valued Pacific Salmon

Dependent Variable: LQHEC

<u>Variable</u>	<u>Bayesian Coefficient</u>	<u>Standard Error</u>	<u>HYPOIG</u>	<u>HYPOIN</u>
EPAERT	62.23275100	21.112	0.986	1.000
EPHERT	-101.77875000	23.900	0.998	1.000
EPLERT34	81.86498000	46.628	0.909	0.959
YEECRC	90.25678400	41.122	0.837	1.000
C	7.80895436	1.791	0.972	1.000
DQ1	0.57468882	0.678	0.732	0.807
DQ2	-0.97165705	0.695	0.871	0.929
DQ3	-0.34765680	0.120	0.995	0.997
D12T	-0.12840243	0.048	0.975	0.994
D88	-0.90528453	0.217	0.991	1.000

Notes:

- a) Y vs. $\hat{Y}$ correlation = .935
- b) Probability of Prior Range = .700
- c) Heteroskedasticity Correction = Quarters 2 and 3
- d) Odds in Favor of Non-Uniform Prior = 1.457

- e) Prior Density: (on mean level elasticities)
- 1) EPHERT - Quadrilateral: $\uparrow [-5, -4)$, $\leftrightarrow [-4, -1]$, $\downarrow (-1, 0]$.
 - 2) EPAERT - Quadrilateral: $\leftrightarrow [0, 4]$, $\downarrow (4, 5]$.
 - 3) YEECRC - Quadrilateral: $\uparrow [0, 1)$, $\leftrightarrow [1, 4]$, $\downarrow (4, 5]$.
- f) Elasticities (at mean levels):
- EPAERT = 1.395
- EPHERT = -1.883
- EPLERT34 = .496
- YEECRC = 2.454
- g) Sample Period = 1982:1 - 1988:4

Equation 3: Quantity Demanded of North American Low-Valued Pacific Salmon

Dependent Variable: LQLEC

<u>Variable</u>	<u>Bayesian Coefficient</u>	<u>Standard Error</u>	<u>HYPOIG</u>	<u>HYPOIN</u>
EPLERT	-98.42049600	26.371	0.999	1.000
EPHERT34	35.59511000	19.734	0.949	0.964
YEECRC	22.36690000	9.754	0.961	1.000
C	10.51866606	1.142	1.000	1.000
DQ1	0.10758931	0.490	0.554	0.592
DQ2	-0.84996849	0.505	0.941	0.956
DQ3	-0.33290190	0.078	1.000	1.000
D12T	-0.04285891	0.045	0.825	0.826

Notes:

- a) Y vs. $\hat{Y}$ correlation = .909
- b) Probability of Prior Range = .959
- c) Heteroskedasticity Correction = Quarters 2 and 4.
- d) Odds in Favor of Non-Uniform Prior = 211.664

- e) Prior Density: (on mean level elasticities)
- 1) EPLERT - Spliced Uniform-Exponential: Uniform on $[-1,0]$ with probability .5 exponentially increasing on $[-5,-1]$.
 - 2) YEECRC - Spliced Uniform-Exponential: Uniform on $[0,1]$ with probability .5, exponentially declining on $(1,5]$.
- f) Elasticities (at mean levels):
- EPLERT = -1.160
- EPHERT34 = .342
- YEECRC = .608
- g) Sample Period = 1982:1 - 1988:4

Discussion:

In the Atlantic equation, high-valued Pacific salmon was a substitute for Atlantic salmon at a HYPOIG probability of 0.955. Low-valued salmon was not found to be a substitute for Atlantic salmon. This is not surprising, given very little prior indication that this would be so. The coefficient on the variable DISEASE was negative, which indicates that there may have been significant quality and availability changes for Norwegian Atlantic salmon in the last two quarters of 1986 and the first two quarters of 1987 when larger quantities of smaller salmon were placed on the market. Perceived quality changes due to Norwegian disease problems may contribute to this phenomenon, as might the perception by European processors that the temporarily increased availability of Atlantic salmon results in a buyer's advantage in price negotiations.

The indicator variable for 1988 (D88) had a significantly negative coefficient. This indicator variable may signify Norwegian salmon flooding the EEC market and indicate a downward shift (reduction) in the demand

schedule in the short-run due to the substantially increased availability. These increased exports of Norwegian salmon are seen as a structural shift both in 1988 and into the future. It is hypothesized that, because of the substantial increase in salmon availability, importers in the EEC may desire to pay less to import a given quantity of salmon beginning in 1988. The 1988 indicator variable may also be taking the high inventory levels of Pacific salmon held by smokers in the EEC into account, reducing the demand for additional salmon. The lagged dependent variable indicates a slow response to changes in explanatory variables due to habit formation, where long-run elasticities are more than twice the short-run elasticities. Seasonal indicator variables indicate a downward shift in demand during the third quarter when most of the high-valued salmon is being caught. Quarter 4 shows an outward shift in demand relative to quarters 1 and 3 because of the increased demand for salmon during the holiday season. A downward shift also occurred in the first quarter when compared to quarter 4, possibly reflecting the tapering off of the demand for Atlantic salmon following the holidays.

In the EEC demand equation for high-valued Pacific salmon, low-valued Pacific salmon was found to be a substitute in quarters 3 and 4, in addition to Atlantic salmon being a significant substitute year round. That low-valued salmon was not found to be a substitute in quarters 1 and 2 may be due to the fact that a higher-quality low-valued salmon product would be required to be considered a substitute for the higher quality high-valued salmon. In quarters 3 and 4, low-valued salmon can be fresher, or at least might have been frozen for a shorter period of time and thus might be considered a somewhat higher quality product. D88 was negative as expected, which indicates that there has been a structural shift downward in the demand for

high-valued Pacific salmon in 1988. This shift in demand may be a result of a shift away from Pacific salmon to the farmed Atlantic salmon and/or because of high inventory levels of Pacific salmon held in the EEC by smokers. This variable has a notably stronger impact than in the Atlantic salmon equation. D12T is also significant and represents a time-varying decline in the demand for high-valued Pacific salmon in the first two quarters of the year, which is mainly inventoried salmon stored for a relatively long period of time. The EEC can purchase fresh Norwegian and Scottish salmon during these two quarters, obtaining a fresher product and one that does not incur storage costs.

The EEC demand for low-valued Pacific salmon was symmetric with respect to the substitution relationship with the high-valued Pacific salmon. D12T also shows a time-varying decline in demand for quarters 1 and 2, but not to the extent that high-valued salmon does. This may be partly due to the fact that low-valued salmon is not considered a likely substitute for Atlantic salmon, which is further indicated by the insignificance of the Atlantic salmon price in the equation.

When comparing elasticities, Atlantic salmon had the highest own-price and income elasticities, with the low-valued Pacific salmon having the lowest own- and cross-price elasticities, as expected. The spread between Atlantic and high-valued salmon elasticities is even more pronounced when the long-run Atlantic elasticities are considered. With high-valued and low-valued salmon having firmly established markets, no habit formation phenomenon could be detected in these two markets during the period of analysis, but continued development appears to be taking place in the Atlantic salmon market.

Group 3: Japanese Demand for Salmon

Equation 1: Quantity Demanded of Norwegian Farmed Atlantic Salmon

Dependent Variable: LQAJC

<u>Variable</u>	<u>Bayesian Coefficient</u>	<u>Standard Error</u>	<u>HYP0IG</u>	<u>HYP0IN</u>
LJPAJRT	-2.28247230	0.633	0.999	1.000
LJPHJRT	2.03825930	0.900	0.987	1.000
LJYRC	3.68085500	1.854	0.864	1.000
LJFRC	-0.56071877	0.209	0.968	1.000
D85	0.54783263	0.288	0.970	0.969
C	-9.94415410	9.693	0.705	0.826
LJQAJC-4	0.27050580	0.125	0.954	1.000

Notes:

- a) Y vs. $\hat{Y}$ correlation = .912
- b) Probability of Prior Range = .792
- c) Odds in Favor of Non-Uniform Prior = 1.726
- d) Heteroskedasticity Correction = Quarter 4
- e) Prior Density (on elasticities):
 - 1) LJPAJRT - Quadrilateral: $\uparrow [-10, -5]$, $\leftrightarrow [-5, -1]$, $\downarrow (-1, 0]$.
 - 2) LJPHJRT - Uniform on $[0, 10]$.
 - 3) LJFRC - Uniform on $[-10, 0]$.
 - 4) LJYRC - Quadrilateral: $\uparrow [0, 1]$, $\leftrightarrow [1, 5]$, $\downarrow (5, 10]$.
 - 5) LJQAJC-4 - Uniform on $[0, 1]$.
 - 6) Elasticities:

Short Run: JPAJRT = -2.282

JPHJRT = 2.038

JYRC = 3.681

JFRC = -.561

Long Run: JPAJRT = -3.128

JPHJRT = 2.794

JYRC = 5.046

JFRC = -.769

f) Sample Period = 1983:1 - 1988:4

Equation 2: Quantity Demanded of North American High-Valued Pacific Salmon

Dependent Variable = LQHJC

<u>Variable</u>	<u>Bayesian Coefficient</u>	<u>Standard Error</u>	<u>HYP0IG</u>	<u>HYP0IN</u>
LJPHJRT	-3.01943090	0.790	0.994	1.000
LJPF1R	2.55652430	0.767	0.996	1.000
LJYRC	2.95780310	0.949	0.990	1.000
LJINV1C ₋₁	-0.69612705	0.279	0.969	1.000
C	1.78573290	7.613	0.441	0.609
DQ1	-0.49415325	0.265	0.887	0.979
DQ2	0.19797238	0.432	0.755	0.662
DQ3	2.21977250	0.401	1.000	1.000

Notes:

- a) $\bar{Y}$ vs. $\hat{Y}$ correlation = .981
- b) Probability of Prior Range = .648
- c) Odds in Favor of Prior Density = 21.398
- d) Heteroskedasticity Correction = Quarter 3
- e) Prior Density (on elasticities):
 - 1) LJPHJRT - Quadrilateral: $\uparrow [-5, -4]$, $\leftrightarrow [-4, -1]$, $\downarrow (-1, 0]$.
 - 2) LJPF1R - Quadrilateral: $\leftrightarrow [0, 4]$, $\downarrow (4, 5]$.
 - 3) LJYRC - Quadrilateral: $\uparrow [0, 1]$, $\leftrightarrow [1, 4]$, $\downarrow (4, 5]$.
 - 4) LJINV1C - Uniform on $[0, 10]$.

f) Elasticities:

$$JPHJRT = -3.019$$

$$JPF1R = 2.557$$

$$JYRC = 2.958$$

$$JINV1C = -.696$$

g) Sample Period = 1983:1 - 1988:4

Equation 3: Quantity Demanded of North American Low-Valued Pacific Salmon

Dependent Variable: LQLJC

<u>Variable</u>	<u>Bayesian Coefficient</u>	<u>Standard Error</u>	<u>HYP0IG</u>	<u>HYP0IN</u>
LJPLJRT	-1.91821370	0.660	0.980	1.000
LJPF2R	2.71255580	1.711	0.860	1.000
LJLANC	-0.97840764	0.488	0.946	1.000
LJINV2C-1	-1.07758460	0.517	0.938	1.000
LJYRC	1.71972840	1.004	0.817	1.000
D7	-0.68869903	0.257	0.991	0.998
DQ1	-3.34860270	1.851	0.922	0.980
DQ2	-2.26898860	0.941	0.961	0.999
DQ3	0.67668339	0.890	0.728	0.773
C	19.15564600	10.673	0.763	0.964

Notes:

- a) Y vs. $\hat{Y}$ correlation = .951
- b) Probability of Prior Range = .536
- c) Odds in Favor of Non-Uniform Prior = 7.478
- d) Heteroskedasticity Correction = Quarter 4
- e) Prior Density (on elasticities):
 - 1) LJPLJRT - Spliced Uniform-Exponential: Uniform on $[-1,0]$ with probability .75, exponentially increasing on $[-5,-1)$.
 - 2) LJYRC - Spliced Uniform-Exponential: Uniform on $[0,1]$ with probability .75, exponentially declining on $(1,5]$.

- 3) LJPF2R - Uniform on $[0,10]$.
- 4) LJLANC - Uniform on $[-10,0]$.
- 5) LJINV2C - Uniform on $[-10,0]$.
- f) Elasticities:
 - JPLJRT = -1.918
 - JPF2R = 2.713
 - JLANC = -.978
 - JINV2C₋₁ = -1.078
 - JYRC = 1.720
- g) Sample Period = 1983:1 - 1988:4

Discussion:

The demand for Norwegian farmed Atlantic salmon in Japan has high-valued Pacific salmon as a substitute. Low-valued salmon was not found to be a substitute for the high-priced Atlantic salmon. This may not be surprising since the average real weighted price (FOB from exporting country) in yen for 1983-87 was 577 for Atlantic salmon, 416 for high-valued salmon, and 237 for low-valued salmon. The structural shift shows a significantly higher demand for Atlantic salmon in Japan after 1985. The seasonal quarterly indicator variables were substantially insignificant and were eliminated from the model specification. This may be due to the fact that low quantities of Atlantic salmon are shipped to Japan and consumption of Atlantic salmon currently suggests a developing market phenomenon where consumers are still learning about the product. Also, the four-period lagged dependent variable may be capturing some of the seasonality effect. In the future, as the market for Atlantic salmon becomes established, seasonality in demand may develop similarly to other regions importing Atlantic salmon.

The demand for high-valued Pacific salmon did not have either Atlantic salmon or low-valued Pacific salmon appearing as a significant substitute. For the high-valued Pacific salmon, this would indicate an asymmetric relationship regarding substitution. This is not surprising since, during the time period modelled, Atlantic salmon shipments to Japan were only slightly above 1 percent of the high-valued Pacific shipments. Therefore, a price change in Atlantic salmon would not significantly affect high-valued salmon, but a price change in high-valued salmon could significantly affect the import demand for Atlantic salmon. The fact that low- and high-valued Pacific salmon were not substitutes may be explained by the Japanese market for salmon being fully developed, with these species competing with many other fish species of similar price and quality. The Japanese, more than any other consumers in the world, are aware of the quality differences between all salmon species. It may be the case that, when a decision is made to consume or import fish, a decision in favor of either high- or low-valued Pacific salmon is made in comparison to other similarly priced fish and not with regard to each other. This is particularly true with sockeye salmon, which Japanese consumers consider to be the most desirable salmon in the world and vastly superior to chum and pink salmon.

Frozen inventories of Japanese salmon were significant in explaining demand, as expected. In absolute terms, a 1-pound increase in frozen Japanese inventories available at the beginning of a quarter will decrease imports of high-valued Pacific salmon by 0.518 pounds, *ceteris paribus* and evaluated at the mean levels of the data. Seasonal variables indicate a large shift in import demand for high-valued salmon in the third quarter. This is as expected, since the Japanese are known to take "the first cut" of North

American Pacific salmon landings and the vast majority of their imports have historically occurred in the third quarter.

In the low-valued Pacific salmon demand equations, the substitute price of low-valued substitute fish included fish species of similar value. The price of the low-valued fish substitute was constructed by taking a weighted average price of fish species in the similar price range of low-valued salmon as reported by the Fisheries Production Marketing Yearbook. Landings of all salmon in Japan (of which 90-98 percent between 1980 and 1988 were either pink or chum salmon) were included as a substitute. D7 was used to account for an apparent outlier in the data.

Other salmon species were not found to be significant substitutes for low-valued salmon. The cross-price elasticity with respect to other low-valued fish seems high, but in sheer magnitude the quantity of low-valued fish consumed dwarfs the consumption of low-valued salmon. The model coefficients suggest that in absolute value at the mean level, 1 pound of landed Japanese salmon displaces 0.238 pounds of imports of low-valued salmon, *ceteris paribus*. One additional pound of beginning available frozen Japanese salmon inventory displaces 0.117 pounds of low-valued Pacific salmon imports at the mean level, *ceteris paribus*. Seasonal indicator variables indicate an increase in low-valued salmon imports in quarters 3 and 4, when North American low-valued Pacific salmon is caught.

In comparing elasticities, *a priori* expectations were that Atlantic salmon would have the highest own-price and cross-price elasticities because Atlantic salmon represents the newest market and the highest-priced salmon. In the short-run, the own-price elasticity for Atlantic salmon (-2.282) was lower than for high-valued salmon (-3.019), but the long-run Atlantic own-

price elasticity was slightly higher (-3.128). As expected, the low-valued salmon own-price elasticity was lowest at -1.92. The fact that the low-valued salmon was own-price elastic was somewhat surprising. All goods were normal goods with short-run income elasticities for Atlantic, high-, and low-valued Pacific salmon of 3.681, 2.958, and 1.810, respectively. The income elasticity for low-valued salmon was also unexpectedly high given that it is a relatively low-valued fish and is consumed in large quantities.

Group 4: North American Allocation of High-Valued Pacific Salmon

Equation 1: Quantity Allocated to Japan

Dependent Variable: UPHJ

<u>Variable</u>	<u>Bayesian Coefficient</u>	<u>Standard Error</u>	<u>HYPOIG</u>	<u>HYPOIN</u>
LOGITHJ	-0.17253165	0.068	0.991	1.000
UPHE	0.41890665	0.115	0.999	1.000
C	1.22009300	0.319	1.000	1.000
DQ1	-0.27040792	0.112	0.991	0.992
DQ2	0.24264411	0.113	0.983	0.984
DQ3	-0.34563044	0.083	1.000	1.000
D34N	0.72492103	0.094	1.000	1.000
D88	1.41459850	0.098	1.000	1.000
DUMNOR2	0.68730562	0.154	1.000	1.000

Notes:

- a) Y vs. $\hat{Y}$ correlation = .977
- b) Probability of Prior Range = .990
- c) Heteroskedasticity Correction = Quarters 3 and 4
- d) Prior Density:
 - 1) LOGITHJ signed negative
 - 2) UPHE signed positive

e) Elasticities (at mean level):

1) UPHE = .994

2) Elasticities of allocated quantity with respect to prices:

UPHJ = 5.859

UPHE = -2.573

f) Sample Period = 1983:1 - 1988:4

Equation 2: Quantity Allocated to the EEC

Dependent Variable: UPHE

<u>Variable</u>	<u>Bayesian Coefficient</u>	<u>Standard Error</u>	<u>HYP0IG</u>	<u>HYP0IN</u>
LOGITHE	-0.18752923	0.054	0.997	1.000
UPHJ	1.35975640	0.096	1.000	1.000
C	-0.13214265	0.244	0.741	0.741
DQ1	0.25770644	0.157	0.947	0.947
DQ2	0.23656522	0.154	0.940	0.941
DQ3	0.66922812	0.098	1.000	1.000
D34N	-0.94023244	0.105	1.000	1.000
D88	-1.41395760	0.129	1.000	1.000
DUMNOR2	-0.80057800	0.267	1.000	1.000

Notes:

a) Y vs. $\hat{Y}$ correlation = .871

b) Probability of Prior Range = .997

c) Heteroskedasticity Correction = Quarters 3 and 4

d) Prior Density:

1) LOGITHE signed negative

2) UPHJ signed positive

- e) Elasticities (at mean levels)
 - 1) $UPHJ = 3.075$
 - 2) Elasticities of allocated quantity with respect to prices:
 - $UPHE = 4.869$
 - $UPHJ = -6.312$
- f) Sample Period = 1983:1 - 1988:4

Discussion:

The specification of the equations is based on the notion of price arbitraging. A higher quantity of salmon will be allocated to the import market whose price rises with respect to the other markets. The North American wholesale market is not explicitly modelled because data on wholesale prices for use in the context of this model was unavailable and domestically derived wholesale quantities from utilization tables on a quarterly basis were often nonsensical (negative-valued). The logit variable specification models the proportion of total high-valued Pacific salmon supplies that are allocated to each of the markets explicitly modelled. Other exogenous variables added, besides quarterly indicator variables, were D34N, D88, and DUMNOR2. D34N, DUMNOR2, and D88 were used to model shifts in the allocation of Pacific salmon in response to the alteration of Norwegian production and allocation for reasons mentioned in the discussion of the EEC demand equations. This reallocation of salmon in favor of the EEC, *ceteris paribus*, might be a result of a subset of the Pacific salmon exporters altering their export behavior in an attempt to maintain market shares in the EEC in the face of rising Norwegian and Scottish exports of farmed Atlantic salmon to the EEC.

The functional form was semilog, with the exception that the logit variable was moved to the right-hand side and the equations were normalized on

the price variables. This specification performed notably better than having the logit variable as the dependent variable. Note that in this form, the derivative of quantity allocated with respect to any other variable in the equation has a sign opposite to the sign of the coefficient of the explanatory variable.

Group 5: North American Allocation of Low-Valued Pacific Salmon

Equation 1: Quantity Allocated to Japan

Dependent variable: UPLJ

<u>Variable</u>	<u>Bayesian Coefficient</u>	<u>Standard Error</u>	<u>HYP0IG</u>	<u>HYP0IN</u>
LOGITLJ	-0.12240325	0.046	0.993	1.000
UPLE	0.52561227	0.224	0.961	1.000
UPCANL	0.25744158	0.143	0.904	1.000
C	-0.46467087	0.435	0.840	0.856
DQ1	-0.25044467	0.120	0.977	0.980
DQ2	0.16928015	0.097	0.952	0.959
DQ3	0.54333638	0.251	0.980	0.984
RELINVL	1.31570730	0.348	1.000	1.000
D34N	0.14495427	0.070	0.974	0.979
D16	-0.26254521	0.142	0.961	0.961

Notes:

- a) Y vs. $\hat{Y}$ correlation = .952
- b) Probability of Prior Range = .859
- c) Prior Density:
 - 1) LOGITLJ signed negative
 - 2) UPLE signed positive
 - 3) UPCANL signed positive

d) Elasticities (at mean levels):

1) $UPLE = .755$

$UPCANL = .423$

$RELINVL = .714$

2) Elasticities of allocated quantities with respect to selected variables

$UPLJ = 4.330$

$UPLE = -2.750$

$UPCANL = -1.441$

$RELINVL = -2.432$

e) Sample Period = 1983:1 - 1988:4

Equation 2: Quantity Allocated to the EEC

Dependent Variable: UPLE

<u>Variable</u>	<u>Bayesian Coefficient</u>	<u>Standard Error</u>	<u>HYP0IG</u>	<u>HYP0IN</u>
LOGITLE	-0.20720628	0.071	0.996	1.000
UPLJ	0.36513212	0.127	0.995	1.000
UPCANL	0.30434085	0.093	0.998	1.000
C	1.84731060	0.419	1.000	1.000
DQ1	0.30138410	0.129	0.987	0.990
DQ2	-0.15150778	0.068	0.981	0.982
DQ3	-0.37947787	0.189	0.977	0.989
RELINVL	-1.33258640	0.405	0.997	0.999
D34N	-0.13559420	0.054	0.989	0.992
D16	0.20806625	0.106	0.982	0.982

Notes:a) Y vs. $\hat{Y}$ correlation = .969

b) Probability of Prior Range = .989

c) Heteroskedasticity Correction = Quarter 3

- d) Prior Density:
 - 1) LOGITLE signed negative
 - 2) UPLJ signed positive
 - 3) UPCANL signed positive
- e) Elasticities (at mean levels):
 - 1)
 - UPLJ = .466
 - UPCANL = .500
 - RELINVL = -.723
 - 2) Elasticities of allocated quantities with respect to selected variables:
 - UPLE = 2.830
 - UPLJ = -.855
 - UPCANL = -.921
 - RELINVL = 2.875
- f) Sample Period = 1983:1 - 1988:4

Discussion:

As in the specification of the high-valued Pacific salmon allocation equations, the specification of the low-valued Pacific salmon allocation equations are based on the notion of price arbitraging between markets. The logit variables specification models the proportion of total low-value Pacific salmon supplies that is allocated to each of the markets explicitly modelled. The variable D34N accounts for an apparent willingness to shift allocation of supplies toward the EEC market and away from the Japanese market during the third and fourth quarters of the year relative to quarters 1 and 2.

In the low-valued salmon allocation equations canned prices were found to be a significant determinant of allocation decisions. The relative inventory was found to significantly alter low-valued Pacific allocations, with allocations increasing to the EEC and decreasing to Japan, as inventories became a larger part of total allocable supply. This may be the case because allocation of low-valued salmon will increase to the EEC for high levels of inventories, at a given price, as EEC smokers are willing to receive increased quantities of salmon to smoke when market conditions/price conditions are favorable. The EEC also holds inventory holdings in the U.S. which they ship mainly in the fourth quarter. The indicator variable D16 was found to account for an outlier in both low-valued salmon market equations.

Group 6: North American Demand

Equation 1: Quantity Demanded of Norwegian Atlantic Salmon

Dependent Variable: LQAUC

<u>Variable</u>	<u>Bayesian Coefficient</u>	<u>Standard Error</u>	<u>HYP0IG</u>	<u>HYP0IN</u>
LUPAUR	-1.34975490	0.327	0.999	1.000
LUPHR234	0.44779848	0.183	0.971	1.000
LYNARC	3.27889790	0.786	0.999	1.000
C	15.14716800	3.084	1.000	1.000
DQ1	-2.25231830	1.098	0.947	0.987
DQ2	0.10177976	0.965	0.851	0.849
DQ3	-0.50039219	0.882	1.000	1.000
CHQCD1	-0.00005263	0.000016	1.000	1.000
D22	-0.55586647	0.163	1.000	1.000
LQAUC ₋₁	0.38071425	0.112	0.997	1.000

Notes:

- a) Y vs. $\hat{Y}$ correlation = .980
- b) Probability of Prior Range = .908
- c) Odds in Favor of Non-Uniform Prior = 2.194

- d) Heteroskedasticity Correction = Quarters 1 and 4
- e) Prior Density (on elasticities):
 - 1) LUPAUR - Quadrilateral: $\uparrow [-5, -4]$, $\leftrightarrow [-4, -1]$, $\downarrow (-1, 0]$.
 - 2) LUPHRD234 - Quadrilateral: $\leftrightarrow [0, 4]$, $\downarrow (4, 5]$.
 - 3) LYNARC - $\uparrow [0, 1]$, $\leftrightarrow [1, 4]$, $\downarrow (4, 5]$.
 - 4) LQAUC₋₁ - Uniform on $[0, 1]$.
- f) Elasticities
 - 1) Short Run:
 - UPAUR = -1.350
 - UPHRD234 = .448
 - NYARC = 3.279
 - 2) Long Run:
 - UPAUR = -2.180
 - UPHRD234 = .723
 - NYARC = 5.295
- g) Sample Period = 1983:1 - 1988:4

Discussion:

The price of high-valued Pacific salmon is effective in quarters 2, 3, and 4. This was expected because in quarter 1 there is essentially only frozen high-valued salmon on the market, and most industry participants believe that the majority of the substitution between Atlantic and Pacific salmon in the United States, which consumes nearly all of North America's imports of Norwegian farmed Atlantic salmon, is between fresh Atlantic and fresh wild caught high-valued salmon. Evidence for this comes from the survey of U.S. seafood wholesalers by Herrmann, Lin, and Mittelhammer (1990) in which the majority of U.S. seafood wholesalers reported fresh high-valued Pacific

salmon to be a substitute for farmed Atlantic salmon. Farmed Atlantic salmon in the United States is nearly all consumed fresh. Most U.S. wholesalers did not believe that farmed Atlantic salmon and frozen wild-caught Pacific salmon were substitutes. Since most of the high-valued salmon is landed in quarters 2 and 3, these quarters would have the most fresh high-valued salmon marketed in the United States.

The substitution effect was also examined for significance in quarters 1 and 4. Quarter 1 was not found to be significant. Somewhat surprisingly, quarter 4 was. This may be a result of a perception that at the beginning of quarter 4 the carry-over salmon may be perceived as somewhat fresher, or perhaps that there is a built-up demand for Pacific salmon which carries over from the summer months to the fourth quarter.

Caution should be exercised when interpreting the seasonal substitutions. There is theoretically a high enough price of Atlantic salmon in the first quarter that will induce high-valued frozen salmon to become a substitute for Atlantic salmon. It appears, that the price of Atlantic salmon has not been high enough over the time period modelled to estimate this substitution effect.

Chile, because of its location in the southern hemisphere, has its coho salmon naturally maturing during the northern hemisphere's winter months. Most of its exports are in quarters 1 and 4. Quarter 1 accounts for over 85 percent of Chile's exports. It is hypothesized that fresh farmed coho salmon will compete with farmed Norwegian salmon in quarter 1 given the results found in the aforementioned survey that wild fresh coho and farmed Atlantic salmon are substitutes. Quarter 4 was also tested but found not to be significant, probably because of the extremely low levels of Chilean imports in this

quarter when compared to Atlantic salmon imports. In the first quarter of 1988, the relatively new imports of Chilean salmon amounted to over 50 percent of the level of Norwegian Atlantic salmon imports in that quarter for the first time. In absolute terms, in the first quarter, 1 pound of Chilean salmon imported into North America was estimated to displace .78 pounds of Norwegian Atlantic salmon, *ceteris paribus* at mean levels.

D22 was used to account for an outlier in the data and resulted in the mitigation of an autocorrelation problem that existed when the outlying observation was not accounted for. The low-valued salmon substitute price was not found to be significant. This is not surprising since many knowledgeable industry participants do not feel that the lower-valued salmon is a substitute for Norwegian farmed Atlantic salmon.

The seasonal indicator variables suggested that demand decreases during the heavy (third-quarter) Pacific fishing season and is fairly high during the fourth quarter when demand peaks during the holidays. Seasonality was not as pronounced as in prior studies, possibly reflecting the fact that a better substitute effect had been found in the current study. The partial adjustment effect results in significantly higher long-run elasticities, with these levels being very close to previous studies.

Group 7: North American Inventory HoldingsEquation 1: Quantity of High-Valued Pacific Salmon Inventory

Dependent Variable: LINVH

<u>Variable</u>	<u>Bayesian Coefficient</u>	<u>Standard Error</u>	<u>HYP0IG</u>	<u>HYP0IN</u>
LUPH	-0.58130346	0.304	0.935	1.000
LTSUPH	0.72402381	0.224	1.000	1.000
LINVH ₋₁	0.37079709	0.166	0.983	1.000
C	-2.38153690	3.651	0.751	0.738
DQ1	-0.43253072	0.186	0.984	0.991
DQ2	-1.34393440	0.311	1.000	1.000
DQ3	-0.05403924	0.662	0.544	0.530
LUPH ₋₁	0.80201772	0.318	1.000	1.000
D87	-0.24938979	0.119	0.985	0.985

Notes:

- a) Y vs. $\hat{Y}$ correlation = .975
- b) Probability of Prior Range = .907
- c) Prior Density (on elasticities):
 - 1) LINVH₋₁ - Uniform on [0,1]
 - 2) LTSUPH signed positive
 - 3) LUPH signed negative
- d) Elasticities:
 - 1) Short Run:

UPH = -.581

TSUPH = .724

UPH₋₁ = .802

2) Long Run:

$$UPH = -.924$$

$$TSUPH = 1.151$$

$$UPH_{-1} = 1.275$$

e) Sample Period = 1983:1 - 1988:4

Equation 2: Quantity of Low-Valued Pacific Salmon Inventory

Dependent Variable: LINVL

<u>Variable</u>	<u>Bayesian Coefficient</u>	<u>Standard Error</u>	<u>HYP0IG</u>	<u>HYP0IN</u>
LUPL	-1.34299950	0.521	0.980	1.000
LTSUPL	0.31499595	0.191	0.867	1.000
LINVL ₋₁	0.58984251	0.175	0.998	1.000
C	1.82045930	2.846	0.765	0.767
DQ1	-0.89547962	0.236	0.997	1.000
DQ2	-1.42283000	0.284	1.000	1.000
DQ3	0.03419080	0.532	0.611	0.548
LUPL ₋₁	1.47578140	0.558	0.984	1.000
D87	-0.15753270	0.088	0.950	0.965

Notes:

- a) $\hat{Y}$ vs. $\hat{Y}$ correlation = .979
- b) Probability of Prior Range = .826
- c) Heteroskedasticity Correction = Quarters 1 and 4
- d) Prior Density (on elasticities):
 - 1) LINVL₋₁ - Uniform on [0,1]
 - 2) LTSUPL signed positive
 - 3) LUPL signed negative

e) Elasticities:

1) Short Run:

$$UPL = -1.343$$

$$TSUPL = .315$$

$$UPL_{-1} = 1.476$$

2) Long Run:

$$UPL = 3.274$$

$$TSUPL = .768$$

$$UPL_{-1} = 3.598$$

f) Sample Period = 1988:1 - 1988:4

Discussion:

The inventory equations incorporate the notion of partial adjustment and price expectations. Two theories of how price expectations are formed are reviewed within the partial adjustment context.

One can specify a partial adjustment to ending inventories as a geometric mean of desired ending inventories and beginning inventories:

$$(37) \quad I_t = (I_t^d)^\delta (I_{t-1})^{1-\delta}$$

where I_t is current inventory; I_t^d is desired inventory; and δ is a parameter of adjustment where $\delta \in (0,1)$. Desired inventories are a function of current and expected prices and other exogenous variables:

$$(38) \quad I_t^d = \beta_0 P_t^{\beta_1} P_t^e \beta_2 Z_1^{\beta_3}$$

where P_t is current price; P_t^e is expected price; Z_1 represents predetermined variables; and β_i s are parameters. For this equation, it is anticipated that $|\beta_1| > |\beta_2|$, implying that if both prices rise by an equal percentage, then more inventory would be sold in the current quarter and less would be held for the next quarter due to storage costs and risk aversion. One proxy for price expectation is a value proportional to the geometric mean of current and last quarter's prices:

$$(39) \quad P_t^e = \phi(P_t)^\tau (P_{t-1})^{1-\tau}$$

where τ is a proportional parameter and $\tau \in (0,1)$. An equation for desired inventory would then be:

$$(40) \quad I_t^d = \beta_0 P_t^{\beta_1} [\phi(P_t)^\tau (P_{t-1})^{1-\tau}]^{\beta_2} Z^{\beta_3}$$

or

$$(41) \quad I_t^d = \beta_0^* P_t^{(\beta_1 + \tau\beta_2)} P_{t-1}^{(1-\tau)\beta_2} Z^{\beta_3}$$

All that would be left to complete the partial adjustment specification would be to substitute Equation (41) into (37) for I_t^d . The current price has two effects on ending inventories. If current price rose, for example, one effect would be a motivation to sell during the current time period while prices were high, this being captured by the parameter β_1 . Another effect would be to motivate selling later in part because current prices are part of the future price expectation process. By assuming $|\beta_1| > |\beta_2|$, the effect of the current price can be negatively signed.

Another proxy for the price expectation process involves the extrapolative price expectation:

$$(42) \quad P_t^e = P_t (P_t / P_{t-1})^\tau = P_t^{(1+\tau)} P_{t-1}^{-\tau}$$

which, when substituted into (38), yields:

$$(43) \quad I_t^d = \beta_0 P_t^{(\beta_1 + \beta_2(1+\tau))} P_t^{-\beta_2 \tau} Z_t^{\beta_3}$$

For the coefficient on current price to be positive, β_1 must be greater than $\beta_2(1+\tau)$ in absolute value. This would be true if the expected price equals the current price under the previous assumption regarding the relative magnitudes of $|\beta_1|$ and $|\beta_2|$. If τ is greater than zero, then the price variable theoretically cannot be signed with absolute certainty. Nonetheless, it is anticipated that the net effect of a change in current price is negatively related to the level of ending inventories held.

The speculative motive is only a partial explanation of why inventories might be held. Inventories also may be held due to a transactions motive as a buffer against short salmon supplies. For this reason LTSUPH and LTSUPL are included so that ending inventories are some fraction of beginning supplies of salmon, i.e., there is a pipeline motive for holding stocks.

Besides quarterly indicator variables, the only other exogenous variable in the equation is D87. This variable was used to capture a structural change in 1987 that is not well represented by the partial adjustment framework. In 1987, North American ending inventories were approximately 50 percent of 1986 ending levels. Levels in 1987 were, in part, drawn down by a low Alaskan catch which was under 100 million salmon for the first time in eight years.

Japanese buyers bid up prices and inventories were depleted. By the end of 1988, continued high prices started to depress purchases so that, at the end of 1988, inventory levels were up to slightly higher than 1986 levels. The coefficient on D87 was estimated to be negative, as might be expected.

High-valued salmon was less responsive to prices and more responsive to the pipeline motive for holding stocks than low-valued salmon, indicating a possibly more conservative attitude toward buffer stocks in dealing with the higher-priced product. Quarterly indicator variables reflect a shift in inventory holdings due to the seasonal nature of the catch with the third and fourth quarters being the highest outward shift in inventory levels.

Group 8: North American Exvessel Prices

Equation 1: Price of High-Valued Pacific Salmon

Dependent Variable: LPHEX

<u>Variable</u>	<u>Bayesian Coefficient</u>	<u>Standard Error</u>	<u>HYP0IG</u>	<u>HYP0IN</u>
LUPH	0.80101599	0.135	1.000	1.000
LUPAU	0.17282145	0.092	0.924	1.000
LTSUPH	-0.25375927	0.048	1.000	1.000
LYNA	0.66596056	0.209	0.999	1.000
D21	-0.10277697	0.510	0.983	0.983
C	-1.4617046	2.045	0.765	0.760
DQ1	0.80683157	0.043	1.000	1.000
DQ2	0.16700420	0.046	1.000	1.000
DQ3	0.45933859	0.977	0.999	0.999
CHQD4	-0.00000051	0.0000003	0.958	0.961

Notes:

- a) Y vs. $\hat{Y}$ correlation = .994
- b) Probability of Prior Range = .923
- c) Heteroskedasticity Correction = Quarters 1 and 3

- d) Prior Density:
- 1) LUPH signed positive
 - 2) LUPAU signed positive
 - 3) LYNA signed positive
 - 4) LTSUPH signed negative
- e) Elasticities:
- UPH = .801
- UPAU = .173
- TSUPH = -.254
- YNA = .666
- f) Sample Period = 1983:1 - 1987:4

Equation 2: Price of Low-Valued Pacific Salmon

Dependent Variable: LPLEX

<u>Variable</u>	<u>Bayesian Coefficient</u>	<u>Standard Error</u>	<u>HYP0IG</u>	<u>HYP0IN</u>
LUPL	1.07604830	0.376	0.996	1.000
LTSUPL	-0.38554912	0.173	0.970	1.000
LYNA	0.50305616	0.285	0.894	1.000
C	2.01769340	2.744	0.760	0.759
DQ1	-0.54960024	0.140	1.000	1.000
DQ2	-0.70807833	0.184	1.000	1.000
DQ3	0.38890203	0.235	0.922	0.957
D18	0.17687129	0.122	0.929	0.926

Notes:

- a) Y vs. $\hat{Y}$ correlation = .924
- b) Probability of Prior Range = .876
- c) Heteroskedasticity Correction = Quarter 1

d) Prior Density (on elasticities)

- 1) LUPL signed positive
- 2) LYNA signed positive
- 3) LTSUPL signed negative

e) Elasticities:

UPL = 1.0760

TSUPL = -.3855

YNA = .5030

f) Sample Period = 1983:1 - 1987:4

Discussion:

The specification of the exvessel price equations was guided by the theory of derived demand. Prices of the high-valued salmon were not found to be significant in the low-valued exvessel equations and vice versa, thus suggesting that low- and high-valued Pacific salmon are not significant substitutes in the North American market. This finding is consistent with the result of the Japanese demand for high- and low-valued Pacific salmon. Atlantic price and Chilean quantity were not found to be significant in the low-valued Pacific salmon price equation. However, both Atlantic salmon and Chilean farmed salmon were found to substitute for high-valued Pacific salmon. The magnitudes on the estimated price flexibilities seem reasonable. It should be noted that due to a lack of data, the U.S. wholesale price of high-valued and low-valued Pacific salmon is not available. However, some of the effects of the wholesale price are proxied both by the weighted average export price and aggregate disposable North American income, both of which should be highly correlated with wholesale price.

The estimated model indicates that an increase in income will increase the price of high-valued salmon more than that of low-valued salmon, and a given percentage increase in available supply will decrease the price of low-valued salmon more than that of high-valued salmon. The first quarter indicator variable in the high-value Pacific exvessel price equation indicates a large positive increment in the first quarter, reflecting the fact that only a small amount of Washington chinook is sold in the first quarter in fresh form domestically or as a specialty item, and is usually priced very high.

Summary Discussion:

Atlantic and high-valued Pacific salmon were found to substitute for one another in all markets. There was no substitution found between low-valued Pacific salmon and Atlantic salmon in any market. Substitution between high-valued and low-valued Pacific salmon was significant only in the EEC market, and then only in the third and fourth quarters. For high- and low-valued salmon, the Japanese market is more income elastic than the EEC market. If the Japanese economy remains strong and the income of Japanese consumers continues to rise or the Japanese yen strengthens against the U.S. dollar, there may be reason to increase allocation of U.S. salmon to Japan. For the demand equations, recent trends show a lessening of demand for both high- and low-valued salmon in 1988 in the EEC market and for quarters 1 and 2 over time. With more Atlantic salmon being produced in Scotland and being sold in the EEC, this trend may be expected to continue.

The allocation equation in Norway indicates a willingness to reallocate farmed Atlantic salmon to the higher-priced market. Likewise, high-valued Pacific salmon is redistributed in response to changing prices, and the higher allocation elasticities corresponding to the Japanese price are consistent

with results that show the Japanese demand for high-valued salmon to be much more own-price elastic than the EEC demand. Starting in 1988, however, there is an indication that some North American exporters may have shifted away from this allocation structure to attempt to maintain market shares in the EEC in the face of increasing Norwegian and Scottish competition. For the low-valued Pacific salmon markets, the canned market is still important, with total allocations of fresh/frozen salmon to export markets reduced if canned prices rise. Inventories are also an important part of the salmon market system, with the quantity of inventories held being a function of total supply allocated, current prices, and expectations of future prices.

Exvessel prices are affected by activity in all markets. Prices are dictated by the strength of demand in all markets and the amount of salmon landed. Substitution appears directly in the high-valued salmon markets through Atlantic salmon prices and imports of Chilean salmon. Low-valued Pacific salmon did not exhibit direct substitution effects with other salmon species in the North American market.

Model Closure

The identities used to close the system of equations are shown below. By closing the system, all endogenous variables can be simulated simultaneously using the NEWTON algorithm for dynamic simulation in SAS:

- (1) $NPAE = (EPAERT * NORECU) * (ECPI / ETARIFF);$
- (2) $UPH = ((UPHE * QHE) + (UPHJ * QHJ)) / (QHE + QHJ);$
- (3) $QAU = TSUPA - QAJ - NQAE;$
- (4) $NPAU = UPAUR * NORUSA * UPPI;$
- (5) $UPHE = (EPHERT * USAECU) * (ECPI / ETARIFF);$

- (6) $NQAE = (EQAEC * EPOP) - QSCOT;$
- (7) $UPHJ = (JPHJRT / JAPUSA) * (JCPI / JTARIFF);$
- (8) $UPLJ = (JPLJRT / JAPUSA) * (JCPI / JTARIFF);$
- (9) $UPL = ((UPLJ * QLJ) + (UPLE * QLE)) / (QLJ + QLE);$
- (10) $UPLE = (EPLJ * USAECU) * (ECPI / ETARIFF);$
- (11) $TSUPL = INVL_{-1} + LANL;$
- (12) $TSUPH = INVH_{-1} + LANH + BCFARM88;$
- (13) $QHE = QHEC * EPOP$
- (14) $QHJ = QHJC * JPOP$
- (15) $QLE = QLEC * EPOP$
- (16) $QLJ = QLJC * JPOP$
- (17) $QAU = QAUC * NAPOP$
- (18) $EPLERT34 = EPLERT * D34$
- (19) $EPHERT34 = EPHERT * D34$
- (20) $UPHR234 = (UPH * D234) / UPPI$

The total set of endogenous variables in the salmon trade model include NQAE, EQAEC, QAU, QAUC, NPAE, EPAERT, NPAU, UPAUR, JPAJRT, QHJ, QHJC, QHE, QAEC, UPHJ, JPHJRT, UPHE, EPHERT, UPH, QLJC, QLJ, QLEC, QLE, UPLJ, UPLE, EPLERT, JPLERT, UPL, PHEX, PLEX, TSUPL, INVL, TSUPH, INVH, EPLERT34, EPHERT34, and LUPHRD234. There are 16 estimated behavioral equations specified and 20 identities to yield a complete system of 36 equations.

Model Goodness of Fit

The entire model was simulated and the following goodness of fit statistics are reported below: the mean absolute percentage error, the root mean absolute percentage error, the correlation between actual and predicted

endogenous variables, and Theil's inequality coefficients (Theil U_1) where U_M , U_R , and U_D are the mean proportion, the regression proportion, and the disturbance proportion of Theil's prediction decomposition, respectively. Simulation of the model was performed using the "DYNAMIC" option in SAS Proc SIMNLIN, so that lagged endogenous variable values were generated recursively through time and not reset to actual values. Both unweighted and quantity-weighted goodness of fit statistics are reported, as discussed in section IV.5.

All goodness of fit statistics are calculated for the period 1983-1988, except for statistics associated with the variables PHEX, PLEX, and JPAJ. The exvessel price data was only available for 1983-1987, and so goodness of fit statistics for PHEX and PLEX refer to the abbreviated time span. The Japanese price of Atlantic salmon was very erratic and quantities traded were very small prior to 1985. Predictions prior to 1985 for JPAJ were poor and are not considered useful. Since 1985, Atlantic salmon imports have increased to commercially relevant levels, and the goodness of fit statistics for JPAJ are reported for the years 1985-1988. Table 12 represents the standard (unweighted) goodness of fit statistics for the 36-equation salmon trade model, while Table 13 presents the corresponding quantity-weighted statistics. All weights on quantities and prices of exported salmon are derived from the relevant quarterly export quantities. The weights on exvessel prices are derived from the corresponding quarterly levels of landings. The weights on total supply and inventory variables were derived from the respective quarterly supply and inventory levels.

Overall, the fits were very good with relatively high correlations, low absolute mean and root mean percentage errors, high U_D s, and low values of

TABLE 12. Unweighted Goodness of Fit Statistics for the Salmon Trade Model

Variable	Mean Absolute % Error	Root Mean Squared % Error	Correlation	UM	UR	UD	THEIL U ₁
EQAE	1.687	1.956	1.000	0.001	0.000	0.999	0.013
NQAE	2.238	2.572	1.000	0.001	0.000	0.999	0.017
QAU	8.817	10.963	0.984	0.001	0.002	0.997	0.073
NPAE	4.579	6.219	0.790	0.009	0.092	0.899	0.063
EPAE	4.579	6.219	0.887	0.012	0.005	0.983	0.064
NPAU	4.978	5.913	0.823	0.001	0.175	0.824	0.059
UPAU	4.978	5.913	0.896	0.001	0.110	0.889	0.058
JPAJ	11.599	13.742	0.744	0.038	0.210	0.751	0.145
QHJ	16.780	20.480	0.988	0.027	0.005	0.967	0.127
QHE	22.689	34.926	0.958	0.000	0.015	0.984	0.159
UPHJ	6.010	6.951	0.982	0.003	0.001	0.996	0.059
JPHJ	6.010	6.951	0.849	0.003	0.000	0.997	0.067
UPHE	9.889	11.534	0.870	0.004	0.001	0.995	0.106
EPHE	9.889	11.534	0.835	0.001	0.044	0.955	0.116
UPH	6.413	7.387	0.970	0.004	0.004	0.992	0.067
PHEX	6.114	7.924	0.985	0.009	0.055	0.936	0.072
QLJ	43.331	70.434	0.971	0.017	0.086	0.897	0.213
QLE	23.024	36.687	0.948	0.015	0.013	0.972	0.143
UPLJ	6.166	8.516	0.952	0.005	0.014	0.980	0.074
JPLJ	6.166	8.516	0.935	0.008	0.031	0.961	0.080
UPLE	4.340	6.158	0.969	0.000	0.136	0.866	0.054
EPLE	4.340	6.158	0.941	0.010	0.015	0.975	0.057
UPL	4.216	5.688	0.977	0.000	0.082	0.918	0.050
PLEX	10.078	14.632	0.953	0.020	0.006	0.974	0.118
TSUPL	8.303	11.829	0.999	0.002	0.001	0.997	0.026
TSUPH	12.080	21.935	0.998	0.002	0.003	0.995	0.154
INVL	17.346	22.935	0.959	0.002	0.003	0.995	0.154
INVH	25.482	36.569	0.880	0.022	0.001	0.977	0.290

TABLE 13. Quantity-Weighted Goodness of Fit Statistics for the Salmon Trade Model

Variable	Mean Absolute % Error	Root Mean Squared % Error	Correlation	UM	UR	UD	THEIL U ₁
EQAE	1.306	1.631	1.000	0.000	0.031	0.969	0.009
NQAE	1.776	2.191	1.000	0.000	0.022	0.978	0.013
QAU	6.894	8.600	0.981	0.006	0.030	0.964	0.065
NPAE	4.070	5.621	0.837	0.007	0.074	0.919	0.058
EPAE	4.070	5.621	0.909	0.008	0.014	0.978	0.058
NPAU	4.518	5.378	0.864	0.008	0.112	0.887	0.055
UPAU	4.518	5.378	0.915	0.000	0.046	0.954	0.052
JPAJ	11.085	12.938	0.739	0.098	0.294	0.608	0.133
QHJ	11.735	14.109	0.952	0.070	0.038	0.892	0.125
QHE	14.285	20.394	0.930	0.013	0.020	0.967	0.140
UPHJ	3.911	4.615	0.991	0.030	0.001	0.969	0.038
JPHJ	3.911	4.615	0.906	0.034	0.001	0.965	0.045
UPHE	8.263	9.405	0.899	0.004	0.016	0.980	0.087
EPHE	8.263	9.405	0.875	0.002	0.043	0.955	0.092
UPH	4.275	5.305	0.986	0.025	0.005	0.970	0.045
PHEX	4.122	5.074	0.980	0.040	0.050	0.910	0.049
QLJ	19.388	24.920	0.908	0.164	0.090	0.746	0.231
QLE	13.984	20.250	0.940	0.052	0.020	0.928	0.118
UPLJ	6.186	9.442	0.975	0.003	0.018	0.979	0.066
JPLJ	6.186	9.442	0.873	0.000	0.167	0.883	0.090
UPLE	3.703	5.515	0.976	0.012	0.018	0.970	0.046
EPLE	3.703	5.515	0.964	0.001	0.066	0.933	0.047
UPL	4.039	5.569	0.981	0.014	0.023	0.963	0.046
PLEX	7.489	9.163	0.955	0.003	0.162	0.835	0.093
TSUPL	2.530	6.520	1.000	0.010	0.022	0.968	0.009
TSUPH	4.379	11.692	0.999	0.053	0.098	0.849	0.021
INVL	13.891	17.890	0.933	0.050	0.005	0.945	0.142
INVH	23.402	31.318	0.788	0.126	0.002	0.872	0.282

Theil U_1 statistics. The specific statistics discussed below are for the weighted measures unless otherwise noted.

For Atlantic salmon variables, the goodness of fit statistics were very good, with the exception of the Atlantic price in Japan. The majority of correlation coefficients were over 0.90, and with the exception of JPAJ, all correlations were greater than .83, and only one UR, for NPAU, was over 0.10. All Theil U_1 s were under 0.10, and all mean absolute and root mean squared errors were under 10 percent. Even with only simulating over the last four commercially relevant years, the Atlantic price in Japan had very marginal fit statistics, which may not be surprising since it is still a new product whose market is not well established. Because Atlantic salmon does not exhibit the pronounced seasonality of Pacific salmon, the unweighted and weighted goodness of fit statistics are relatively close in magnitude.

The predictions of Pacific salmon variables exhibited slightly higher mean absolute error and root-mean absolute errors than the Atlantic equations. QHJ and QHE had root mean square errors over 10 percent. However, the UD statistics, with the exception of QHJ (0.892), were over 0.90. Two Theil U_1 statistics were between 0.10 and 0.15 for QHE and QHJ, respectively. All correlation coefficients were .875 or higher. There was a noticeable difference in the unweighted and weighted goodness of fit statistics for high-valued salmon.

The low-valued Pacific salmon equations also performed reasonably well. QLJ and QLE were somewhat disappointing in terms of absolute mean percent error and the root mean percent error, and QLJ had the highest bias, $UM = 0.164$, of any equation in the system. All correlations were over 0.90. The QLJ equation obviously had the poorest fit with a UD of 0.746 and a Theil U_1

of 0.231. The low-valued Pacific salmon equations exhibited the largest differences when comparing the unweighted to the weighted goodness of fit statistics.

The total supply and inventory predictions also fit well. Only the high-valued Pacific salmon inventory had a correlation of less than 0.90 with a relatively high Theil U_1 statistic of 0.282.

Arguably the three most important sets of predictions for this study are the Atlantic salmon price in North America and the exvessel price equations. All of these equations had correlations over 0.90, mean absolute and root mean squared errors under 10 percent, and Theil U_1 s under 0.10. Only the low-valued Pacific salmon exvessel price had a UD of under 0.90 at 0.835. Graphs of predicted versus actual values for these variables are presented in Figures 6-8.

3. Scenario Generation Within Historical Period

Eighteen alternative historical scenarios were simulated to assess the effects of changes in key exogenous variables on the endogenous variables in the salmon trade model (a listing of the scenarios is provided on pp. 50-51). The historical period ranged from 1983 to 1988 except for the scenarios regarding Chilean farmed salmon exports, which was restricted to the period 1986-1988 since Chilean exports were not significant until 1986. Also the predictions of JPAJ are only reported for the period 1985-1988 for the reasons presented earlier. The results of the scenarios are used for identifying factors that have important influences on equilibrium prices and quantities in the salmon industry. In particular, a quantitative assessment of the economic impact of salmon farming on salmon markets, both in a nominal and relative

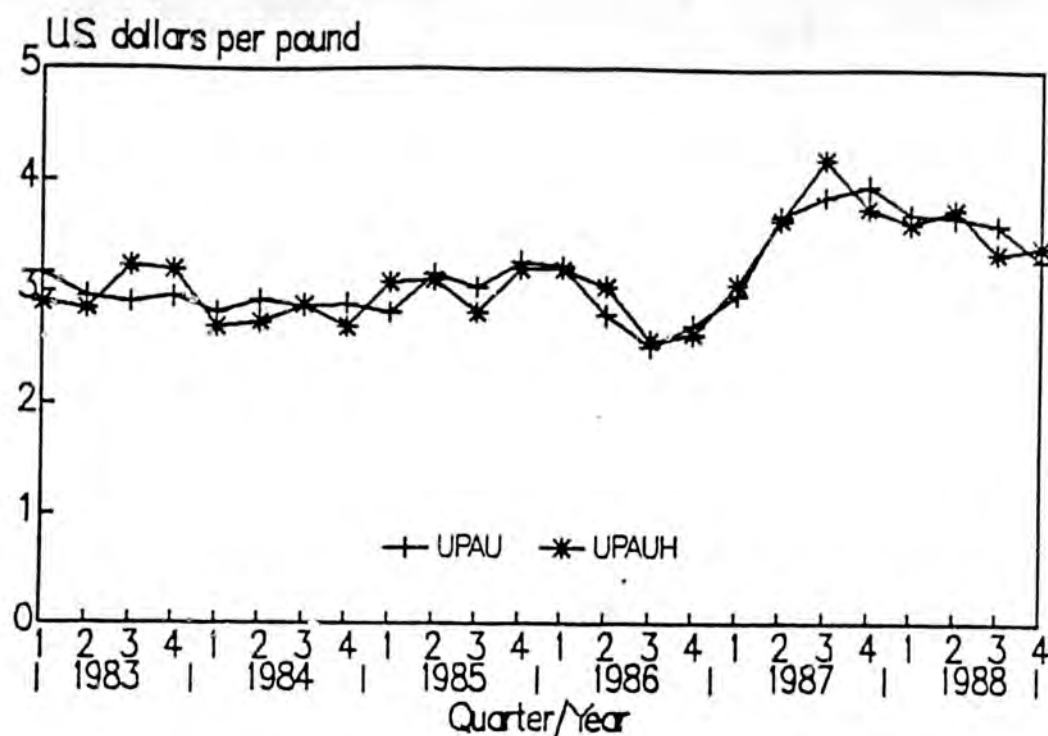


FIGURE 6. Predicted (UPAUH) vs. Actual (UPAU) North American Atlantic Salmon (FOB Norway) Price in U.S. Dollars for Norwegian Farmed Atlantic Salmon Imported into North America, 1983-88.

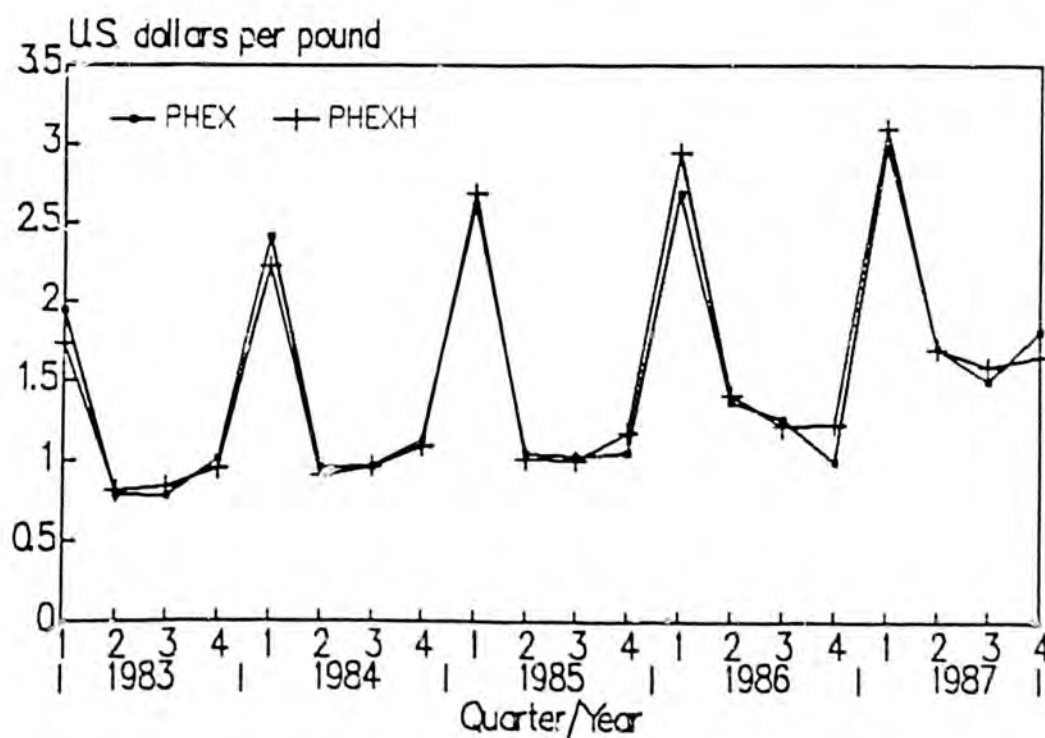


FIGURE 7. Predicted (PHEXH) vs. Actual (PHEX) North American Price of High-Valued Pacific Salmon at the Exvessel Level in U.S. Dollars, 1983-87.

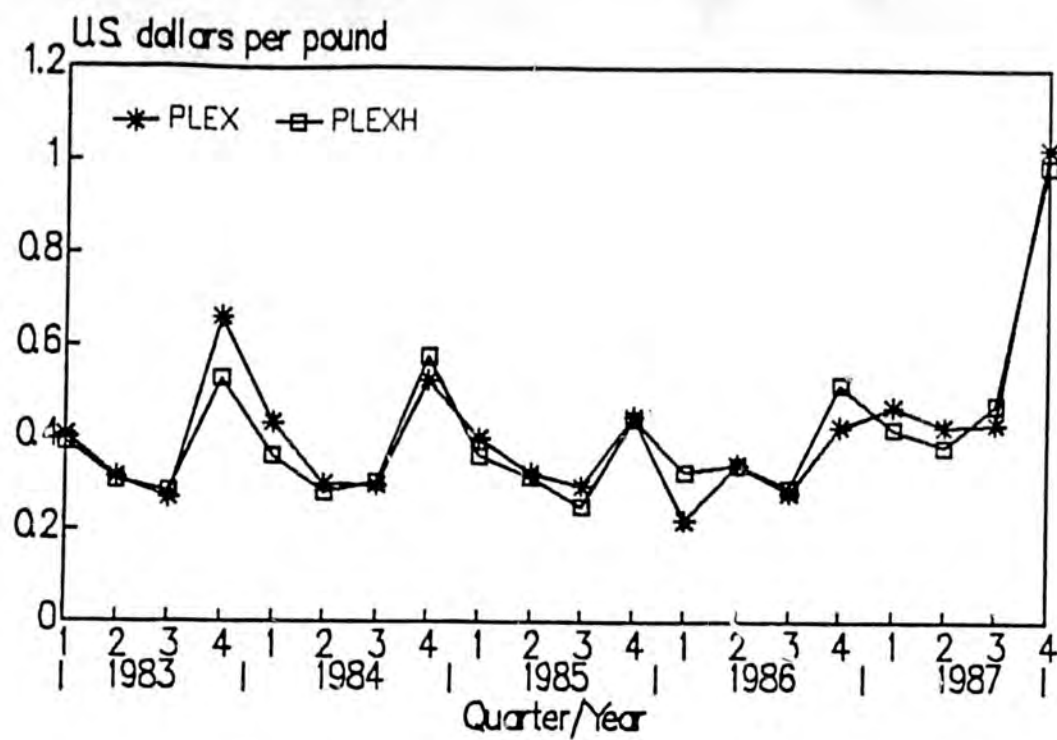


FIGURE 8. Predicted (PLEXH) vs. Actual (PLEX) North American Price of Low-Valued Pacific Salmon at the Exvessel Level in U.S. Dollars, 1983-87.

sense, is made available through examining and comparing the results of the scenarios.

Two types of results are reported for each scenario. First of all, average values across all quarters for 24 key endogenous variables in the trade model are reported, where "Base Quarter" refers to the results of model simulation using the actual historical values of the exogenous variables and "Scenario Quarter" refers to simulation results using values of exogenous variables as defined in a particular scenario. Results for quantities represent simple averages over all quarters simulated, while results for prices represent quantity-weighted averages over all quarters (the weights used here are precisely the same weights used in calculating the weighted averaged goodness of fit statistics described previously). Percentage differences between the Base and Scenario results are also presented. Secondly, individual quarter-by-quarter results are presented for five key price variables, including Base and Scenario values, as well as percentage differences between the Base and Scenario values. The price results are reported in U.S. dollars and include the price of Norwegian Atlantic salmon sold in North America, FOB Norway, as well as the average export prices and exvessel prices for both high-valued and low-valued Pacific salmon in North America. In the presentation of these results, the letter "H" following a variable name stands for "hat", i.e., a predicted value, and an integer value following the "H" refers to the scenario number to which the prediction applies.

Averaged quarter-by-quarter results were also tabulated for 24 key endogenous variables, but are not reported here. Tables of these results can be found in Herrmann (1990, Chapter 6).

Group 1: High-Valued Pacific Salmon Landings $\pm$ 10% Relative to Historical Levels

This group of scenarios measured the effects of an enlarged or decreased supply of high-valued Pacific salmon on salmon trade and prices. The results are presented in Tables 14-17. The average landings for all quarters for the period 1983 to 1988 were 98.6 million pounds per quarter and 394.4 million pounds per year. Most of the landings of high-valued salmon were in the third quarter with a mean of 319.6 million pounds. The means for the first, second, and fourth quarters were 0.4 million, 67.0 million, and 7.3 million pounds, respectively.

A 10 percent increase in landings resulted in the exports of high-valued salmon to Japan and the EEC increasing by 5.40 percent and 4.09 percent, respectively. The increase in landings would decrease prices of high-valued salmon in all markets and subsequently decrease the exvessel price of high-valued salmon by 3.82 percent. The EEC market would experience a smaller increase in imports than Japan, but the prices in the EEC would decrease more than those in Japan. This is in part due to the relatively more inelastic demand for high-valued salmon in the EEC than in Japan and the smaller size of the EEC market relative to Japan.

Because of the existence of a small substitution effect between low- and high-valued salmon in the EEC and a lack of substitution effect in Japan, there would be a small decrease in low-valued Pacific salmon allocation to the EEC with Japanese imports increasing slightly. All prices of low-valued salmon would diminish slightly. The exvessel price for low-valued salmon would be slightly diminished, indicating that there is only a small effect on the price of low-valued salmon when high-valued salmon landings increase.

TABLE 14. Scenario 1, North American High-Valued Salmon Landings Increase by 10 Percent: Average Total Analysis

Variable	Base Quarter	Scenario Quarter	Percentage Change
EQA EH	19,811,930	19,812,974	0.01
NQA EH	14,578,054	14,579,098	0.01
QA UH	3,746,145	3,745,100	-0.03
NPA EH	21.059	20.956	-0.49
EPA EH	2.890	2.876	-0.49
NPA UH	23.094	22.995	-0.43
UPA UH	3.166	3.153	-0.42
JPA JH	467.660	461.373	-1.34
QH JH	42,002,766	44,271,672	5.40
QHEH	6,958,529	7,243,395	4.09
UPH JH	2.356	2.313	-1.83
JPH JH	426.640	419.261	-1.73
UPHEH	2.419	2.358	-2.55
EPHEH	2.576	2.512	-2.48
UPHH	2.365	2.319	-1.94
QL JH	10,939,052	10,967,474	0.26
QLEH	8,242,731	8,160,829	-0.99
UPL JH	1.173	1.171	-0.14
JPL JH	203.240	202.959	-0.14
UPLEH	1.569	1.565	-0.25
EPLH	1.618	1.614	-0.26
UPLH	1.343	1.339	-0.29
PHEXH	1.271	1.223	-3.82
PLEXH	0.379	0.378	-0.30

TABLE 15. Scenario 1, North American High-Valued Salmon Landings Increase by 10 Percent: Quarter-by-Quarter Analysis

Quarter/ Year	Base UPAUM	Scenario UPAUM1	Percentage Change	Base UPHH	Scenario UPHH1	Percentage Change	Base PHEXH	Scenario PHEXH1	Percentage Change
1/1983	2.901	2.901	0.00	1.582	1.582	-0.02	1.731	1.730	-0.04
2/1983	2.849	2.836	-0.44	1.754	1.726	-1.55	0.815	0.789	-3.22
3/1983	3.231	3.215	-0.5	1.722	1.688	-2.00	0.843	0.809	-4.02
4/1983	3.189	3.172	-0.54	2.036	1.990	-2.26	0.957	0.917	-4.17
1/1984	2.678	2.671	-0.26	1.750	1.705	-2.53	2.231	2.132	-4.47
2/1984	2.721	2.706	-0.54	1.753	1.719	-1.95	0.921	0.884	-4.03
3/1984	2.875	2.861	-0.49	1.851	1.815	-1.98	0.975	0.935	-4.03
4/1984	2.678	2.663	-0.57	2.186	2.137	-2.23	1.105	1.057	-4.37
1/1985	3.084	3.077	-0.24	1.833	1.787	-2.49	2.689	2.563	-4.68
2/1985	3.103	3.087	-0.54	1.786	1.752	-1.89	1.022	0.981	-4.01
3/1985	2.808	2.794	-0.52	1.928	1.889	-2.03	1.008	0.967	-4.07
4/1985	3.204	3.185	-0.60	2.250	2.196	-2.41	1.188	1.134	-4.57
1/1986	3.200	3.190	-0.30	1.996	1.942	-2.71	2.946	2.800	-4.94
2/1986	3.040	3.025	-0.49	2.133	2.094	-1.84	1.419	1.361	-4.03
3/1986	2.552	2.539	-0.52	2.405	2.364	-1.70	1.222	1.176	-3.81
4/1986	2.611	2.596	-0.57	2.588	2.533	-2.11	1.236	1.183	-4.28
1/1987	3.064	3.055	-0.30	2.377	2.321	-2.34	3.097	2.954	-4.63
2/1987	3.649	3.633	-0.45	2.737	2.696	-1.52	1.705	1.641	-3.73
3/1987	4.187	4.167	-0.48	2.699	2.652	-1.74	1.590	1.529	-3.84
4/1987	3.753	3.733	-0.53	3.122	3.053	-2.22	1.663	1.589	-4.42
1/1988	3.613	3.601	-0.35	3.419	3.357	-1.81	5.652	5.409	-4.30
2/1988	3.747	3.733	-0.37	3.621	3.578	-1.17	2.268	2.191	-3.42
3/1988	3.351	3.338	-0.40	3.640	3.590	-1.39	2.107	2.032	-3.55
4/1988	3.406	3.392	-0.43	3.701	3.642	-1.59	2.000	1.921	-3.96

TABLE 15. Continued

Quarter/ Year	Base PLEXH	Scenario PLEXH1	Percentage Change	Base UPLH	Scenario UPLH1	Percentage Change
1/1983	0.392	0.392	0.00	1.449	1.449	0.00
2/1983	0.308	0.308	0.00	1.286	1.286	0.00
3/1983	0.285	0.284	-0.47	1.028	1.024	-0.44
4/1983	0.527	0.524	-0.69	1.350	1.344	-0.46
1/1984	0.358	0.357	-0.28	1.375	1.374	-0.09
2/1984	0.280	0.280	0.06	1.161	1.161	0.02
3/1984	0.303	0.302	-0.36	1.082	1.078	-0.33
4/1984	0.574	0.571	-0.56	1.435	1.429	-0.43
1/1985	0.360	0.359	-0.21	1.314	1.313	-0.07
2/1985	0.313	0.313	0.11	1.193	1.194	0.05
3/1985	0.250	0.249	-0.43	0.942	0.939	-0.40
4/1985	0.439	0.436	-0.70	1.306	1.299	-0.57
1/1986	0.326	0.325	-0.30	1.262	1.260	-0.10
2/1986	0.340	0.340	0.14	1.136	1.137	0.06
3/1986	0.291	0.290	-0.26	1.002	0.999	-0.25
4/1986	0.515	0.513	-0.39	1.393	1.389	-0.33
1/1987	0.418	0.417	-0.12	1.477	1.477	-0.04
2/1987	0.380	0.380	0.10	1.350	1.351	0.04
3/1987	0.471	0.470	-0.23	1.315	1.312	-0.21
4/1987	0.989	0.986	-0.34	2.010	2.004	-0.28
1/1988	0.827	0.826	-0.10	2.044	2.043	-0.03
2/1988	0.626	0.626	0.04	2.042	2.043	0.01
3/1988	0.615	0.614	-0.18	1.796	1.793	-0.17
4/1988	0.907	0.904	-0.31	2.073	2.067	-0.27

TABLE 16. Scenario 2, North American High-Valued Salmon Landings Decrease by 10 Percent: Average Total Analysis

Variable	Base Quarter	Scenario Quarter	Percentage Change
EQA EH	19,811,930	19,810,507	-0.01
NQA EH	14,578,054	14,576,631	-0.01
QAUH	3,746,145	3,747,568	0.04
NPA EH	21.059	21.172	0.54
EPA EH	2.890	2.905	0.54
NPAUH	23.094	23.203	0.47
UPAUH	3.166	3.181	0.47
JPAJH	467.660	474.721	1.51
QHJH	42,002,766	39,630,177	-5.65
QHEH	6,958,529	6,652,336	-4.4
UPHJH	2.356	2.404	2.06
JPHJH	426.640	434.935	1.94
UPHEH	2.419	2.488	2.84
EPHEH	2.576	2.647	2.76
UPHH	2.365	2.415	2.18
QLJH	10,939,052	10,907,252	-0.29
QLEH	8,242,731	8,336,028	1.13
UPLJH	1.173	1.175	0.16
JPLJH	203.240	203.555	0.16
UPLEH	1.569	1.573	0.28
EPLH	1.618	1.623	0.29
UPLH	1.343	1.348	0.32
PHEXH	1.271	1.327	4.40
PLEXH	0.379	0.380	0.34

TABLE 17. Scenario 2, North American High-Valued Salmon Landings Decrease by 10 Percent: Quarter-by-Quarter Analysis

Quarter/ Year	Base UPAUM	Scenario UPAUM2	Percentage Change	Base UPHH	Scenario UPHH2	Percentage Change	Base PHEXH	Scenario PHEXH2	Percentage Change
1/1983	2.901	2.901	0.00	1.582	1.583	0.02	1.731	1.731	0.04
2/1983	2.849	2.862	0.47	1.754	1.783	1.69	0.815	0.844	3.59
3/1983	3.231	3.248	0.53	1.722	1.761	2.25	0.843	0.882	4.63
4/1983	3.189	3.208	0.59	2.036	2.087	2.52	0.957	1.003	4.78
1/1984	2.678	2.686	0.28	1.750	1.799	2.82	2.231	2.346	5.13
2/1984	2.721	2.738	0.60	1.753	1.791	2.17	0.921	0.964	4.63
3/1984	2.875	2.891	0.55	1.851	1.893	2.23	0.975	1.020	4.64
4/1984	2.678	2.695	0.63	2.186	2.240	2.49	1.105	1.161	5.04
1/1985	3.084	3.092	0.26	1.833	1.884	2.78	2.689	2.834	5.41
2/1985	3.103	3.122	0.59	1.786	1.824	2.10	1.022	1.069	4.60
3/1985	2.808	2.824	0.57	1.928	1.972	2.30	1.008	1.055	4.71
4/1985	3.204	3.225	0.66	2.250	2.311	2.71	1.188	1.251	5.30
1/1986	3.200	3.210	0.33	1.996	2.058	3.06	2.946	3.115	5.75
2/1986	3.040	3.057	0.54	2.133	2.176	2.05	1.419	1.484	4.63
3/1986	2.552	2.565	0.57	2.405	2.451	1.91	1.222	1.276	4.38
4/1986	2.611	2.627	0.63	2.588	2.649	2.37	1.236	1.297	4.94
1/1987	3.064	3.074	0.33	2.377	2.440	2.64	3.097	3.263	5.37
2/1987	3.649	3.667	0.49	2.737	2.784	1.70	1.705	1.778	4.28
3/1987	4.187	4.209	0.53	2.699	2.752	1.97	1.590	1.660	4.43
4/1987	3.753	3.775	0.59	3.122	3.201	2.52	1.663	1.748	5.14
1/1988	3.613	3.627	0.38	3.419	3.489	2.05	5.652	5.933	4.98
2/1988	3.747	3.762	0.40	3.621	3.668	1.30	2.268	2.357	3.91
3/1988	3.351	3.366	0.45	3.640	3.698	1.57	2.107	2.193	4.09
4/1988	3.406	3.423	0.48	3.701	3.768	1.79	2.000	2.091	4.57

TABLE 17. Continued

Quarter/ Year	Base PLEXH	Scenario PLEXH2	Percentage Change	Base UPLH	Scenario UPLH2	Percentage Change
1/1983	0.39	0.39	0.00	1.45	1.45	0.00
2/1983	0.31	0.31	0.00	1.29	1.29	0.00
3/1983	0.28	0.29	0.53	1.03	1.03	0.50
4/1983	0.53	0.53	0.78	1.35	1.36	0.52
1/1984	0.36	0.36	0.31	1.37	1.38	0.10
2/1984	0.28	0.28	-0.06	1.16	1.16	-0.03
3/1984	0.30	0.30	0.40	1.08	1.09	0.38
4/1984	0.57	0.58	0.63	1.44	1.44	0.49
1/1985	0.36	0.36	0.24	1.31	1.31	0.08
2/1985	0.31	0.31	-0.13	1.19	1.19	-0.05
3/1985	0.25	0.25	0.49	0.94	0.95	0.46
4/1985	0.44	0.44	0.79	1.31	1.31	0.64
1/1986	0.33	0.33	0.33	1.26	1.26	0.11
2/1986	0.34	0.34	-0.15	1.14	1.14	-0.07
3/1986	0.29	0.29	0.29	1.00	1.00	0.28
4/1986	0.52	0.52	0.44	1.39	1.40	0.37
1/1987	0.42	0.42	0.13	1.48	1.48	0.04
2/1987	0.38	0.38	-0.12	1.35	1.35	-0.05
3/1987	0.47	0.47	0.26	1.31	1.32	0.24
4/1987	0.99	0.99	0.39	2.01	2.02	0.32
1/1988	0.83	0.83	0.12	2.04	2.04	0.03
2/1988	0.63	0.63	-0.05	2.04	2.04	-0.01
3/1988	0.62	0.62	0.21	1.80	1.80	0.19
4/1988	0.91	0.91	0.35	2.07	2.08	0.30

There would be similarly minor effects on the Norwegian farmed salmon prices, as most prices would decrease about one-half of a percent in response to decreasing Pacific salmon prices in all markets. The Japanese price of Atlantic salmon would decrease slightly more than the EEC price in part due to the cross-price substitution effect between Atlantic and high-valued Pacific salmon in Japan being slightly larger than it is in the EEC.

The results for a 10 percent decrease in landings of high-valued Pacific salmon were almost a mirror image of those corresponding to the increase in high-valued salmon landings. As landings of high-valued salmon decreased, the quantities of high-valued salmon exported would decrease and all salmon prices would rise. The price of high-valued salmon in the EEC would rise more than it would in Japan, partly due to the difference in demand own-price elasticities. The exvessel price of high-valued salmon for the total time period would rise 4.40 percent. Low-valued salmon exports to the EEC would increase because the substitution effect between high- and low-valued salmon only exists in the EEC. The low-valued salmon exvessel price would rise slightly as would the Atlantic salmon price in North America.

Group 2: Low-Valued Pacific Salmon Landings $\pm$ 10% Relative to Historical Levels

This group of scenarios measured the effects of an enlarged or decreased supply of low-valued Pacific salmon on salmon trade and prices. The results are presented in Tables 18-21. The average landings of low-valued salmon for all quarters from 1983 to 1988 was 109.6 million pounds per quarter, and the yearly average was 439.6 million pounds. As in the case for high-valued landings, most of the landings were in the third quarter, which had an average landing of 397.5 million pounds. The mean landings for the first, second, and

TABLE 18. Scenario 3, North American Low-Valued Salmon Landings Increase by 10 Percent: Average Total Analysis

Variable	Base Quarter	Scenario Quarter	Percentage Change
EQAEH	19,811,930	19,811,965	0.00
NQAEH	14,578,054	14,578,089	0.00
QAUH	3,746,145	3,746,109	0.00
NPAEH	21.059	21.056	-0.01
EPAEH	2.890	2.889	-0.01
NPAUH	23.094	23.092	-0.01
UPAUH	3.166	3.166	-0.01
JPAJH	467.660	467.587	-0.02
QHJH	42,002,766	42,060,338	0.14
QHEH	6,958,529	6,909,992	-0.70
UPHJH	2.356	2.355	-0.05
JPHJH	426.640	426.448	-0.04
UPHEH	2.419	2.416	-0.14
EPHEH	2.576	2.572	-0.15
UPHH	2.365	2.363	-0.07
QLJH	10,939,052	11,346,957	3.73
QLEH	8,242,731	8,335,004	1.12
UPLJH	1.173	1.150	-1.99
JPLJH	203.240	199.296	-1.94
UPLEH	1.569	1.552	-1.06
EPLH	1.618	1.602	-1.04
UPLH	1.343	1.320	-1.71
PHEXH	1.271	1.271	-0.04
PLEXH	0.379	0.359	-5.34

TABLE 19. Scenario 3, North American Low-Valued Salmon Landings Increase by 10 Percent: Quarter-by-Quarter Analysis

Quarter/ Year	Base UPAUM	Scenario UPAUM3	Percentage Change	Base UPHH	Scenario UPHH3	Percentage Change	Base PHEXH	Scenario PHEXH3	Percentage Change
1/1983	2.901	2.901	0.00	1.582	1.582	0.00	1.731	1.731	0.00
2/1983	2.849	2.849	0.00	1.754	1.754	0.00	0.815	0.815	0.00
3/1983	3.231	3.230	-0.03	1.722	1.720	-0.11	0.843	0.843	-0.09
4/1983	3.189	3.188	-0.04	2.036	2.032	-0.20	0.957	0.955	-0.18
1/1984	2.678	2.678	-0.01	1.750	1.749	-0.02	2.231	2.230	-0.04
2/1984	2.721	2.721	0.00	1.753	1.753	0.00	0.921	0.921	0.00
3/1984	2.875	2.874	-0.03	1.851	1.849	-0.11	0.975	0.974	-0.09
4/1984	2.678	2.677	-0.04	2.186	2.182	-0.18	1.105	1.103	-0.16
1/1985	3.084	3.084	0.00	1.833	1.833	-0.01	2.689	2.688	-0.03
2/1985	3.103	3.103	0.00	1.786	1.786	0.00	1.022	1.022	0.00
3/1985	2.808	2.807	-0.02	1.928	1.927	-0.07	1.008	1.007	-0.06
4/1985	3.204	3.203	-0.03	2.250	2.246	-0.15	1.188	1.186	-0.14
1/1986	3.200	3.199	0.00	1.996	1.996	-0.01	2.946	2.945	-0.03
2/1986	3.040	3.040	0.00	2.133	2.133	0.00	1.419	1.419	0.00
3/1986	2.552	2.551	-0.02	2.405	2.404	-0.04	1.222	1.222	-0.04
4/1986	2.611	2.610	-0.02	2.588	2.586	-0.05	1.236	1.236	-0.04
1/1987	3.064	3.064	0.00	2.377	2.377	0.00	3.097	3.097	0.00
2/1987	3.649	3.649	0.00	2.737	2.737	0.00	1.705	1.705	0.00
3/1987	4.187	4.186	-0.02	2.699	2.698	-0.04	1.590	1.589	-0.04
4/1987	3.753	3.752	-0.02	3.122	3.120	-0.07	1.663	1.662	-0.07
1/1988	3.613	3.613	0.00	3.419	3.419	0.00	5.652	5.651	-0.01
2/1988	3.747	3.747	0.00	3.621	3.621	0.00	2.268	2.268	0.00
3/1988	3.351	3.350	-0.02	3.640	3.639	-0.03	2.107	2.106	-0.03
4/1988	3.406	3.406	-0.01	3.701	3.701	-0.02	2.000	2.000	-0.02