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AN ECONOMIC ANALYSIS OF THE PACIFIC SALMON INDUSTRY:
EFFECTS OF SALMON FARMING

FINAL REPORT

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TABLE OF CONTENTS

I. EXECUTIVE SUMMARY	iv
II. INTRODUCTION	1
III. PURPOSE	3
A. Description of Problem	3
B. Objectives of the Project	15
IV. APPROACH	17
A. Description of Work Performed	17
1. Data Collection and Organization	18
2. Literature Review	20
3. Writing, Presentation and Publication of Research Papers on Papers on Preliminary Analyses	21
4. Econometric Modelling	28
Software Preparation	28
Model Specification and Estimation	40
Producing and Trading Regions	42
Species	44
General Model Overview	44
5. Model Simulation and Forecasting	46
Historical Goodness of Fit Measures	46
Scenario Generation Within Historical Derived	50
Forecasting Future Salmon Prices	52
Evaluating Future Farming Profitability	56
6. Writing Final Documents	62
Ph.D. Dissertation by Dr. Herrmann	62
Final Report to NMFS	62
B. Project Management	63

V. FINDINGS

A. Actual Accomplishments and Findings	64
1. Introduction	64
Endogenous Variables	64
Atlantic Salmon Variable	64
High-Valued Pacific Salmon Variable	65
Low-Valued Pacific Salmon Variable	67
Exogenous Variables	68
North American Variables	68
Japan Variables	69
EEC Variables	70
Exchange Rate Variables	70
Indicator Variables	70
Other Variables	72
Prior Densities and Equation Statistics	72
2. Estimated Equations	78
Norwegian Allocation of Farmed Raised Salmon	78
EEC Demand for Salmon	81
Japanese Demand for Salmon	87
North American Allocation of High-Valued Salmon	93
North American Allocation of Low-Valued Salmon	96
North American Demand	99
North American Inventory Holdings	103
North American Exvessel Prices	108
Summary Discussion	111
Model Closure	112
Model Goodness of Fit	113
3. Scenario Generation Within Historical Period	118
High-Valued Salmon Landings $\pm$ 10% Relative to Historical Levels	122
Low-Valued Pacific Salmon Landings $\pm$ 10% Relative to Historical Levels	129
Norwegian and Scottish Farmed Atlantic Salmon Total Exports $\pm$ 10% Relative to Historical Levels	137
Norwegian Farmed Atlantic Salmon Exports $\pm$ 10% Relative to Historical Levels	145
Chilean Exports $\pm$ 25% Relative to Historical Levels	152
Tariff Changes	160
Exchange Rate Changes	176
Canned Low-Valued Pacific Salmon Prices $\pm$ 10% Relative to Historical Levels	185
Summary of Simulations	192
4. Forecasting Salmon Prices for 1990-93	196

5. Profitability of Farming Salmon in the Puget Sound	203
6. Effect of Increased Puget Sound Farmed Salmon Production on Future Price	212
VI. EVALUATION	215
A. Original project goals and objectives, and context in which project benefited fishing industry	215
B. Description of specific accomplishments	221
C. How project benefited fishing industry	227
D. Specific economic or other benefits fishing industry received from project	233
E. Description of need for Federal assistance	234
VI. CONCLUSIONS	237
A. What conclusions can be derived from the work performed?	237
B. Was the project successful in solving the problem?	241
C. Need for future work	242

I. EXECUTIVE SUMMARY

The results of this research project represent an analysis of world salmon markets and were motivated by recent concerns regarding the rapid increase in the production of farmed salmon throughout the world. In particular, the project was designed to contribute to a National Marine Fisheries Service national priority, "Identify and analyze the impacts of foreign aquaculture on U.S. trade in fisheries products." The study had a number of objectives that can be summarized by the following two general objectives:

(1) to analyze the economic effects of an increasing supply of farmed salmon on markets for wild and farmed salmon, with an emphasis on changing trade patterns and resulting price effects; and

(2) given projections for the future course of world salmon markets, assess the economic viability of future expansion of commercial salmon farming operations in the Puget Sound of Washington State.

In order to address the objectives of the project, a model of world salmon trade between North America, the European Economic Community, Japan, and Norway which also accounted for shipments of farmed salmon from Scotland, Chile, and British Columbia was specified and estimated. The entire model included 36 equations, of which 16 were econometrically estimated using the new estimation technique of Bootstrapped Bayesian two-stage least-squares, which incorporates prior information contained in past research and information provided by industry experts together with historical sample information. The performance of the model for simulation purposes was

examined using accepted measures of goodness of fit, and the model performed very well overall.

Simulations were performed on alternative historical scenarios involving key variables in the trade model. Scenarios analyzed included variations in production/export levels of farmed salmon from Norway, Scotland, and Chile; exchange rate fluctuations; tariff structure changes; variations in the level of Pacific salmon landings; and fluctuations in the price of canned salmon. Conclusions were drawn regarding the importance of expanding farmed salmon production to salmon market outcomes both in absolute terms, and in comparison to other factors affecting market outcomes.

The trade model was also used to forecast prices of farmed Atlantic and wild Pacific salmon for the period 1990-1993. Ranges of forecasted prices were also presented to account for uncertainty regarding the future levels of key variables in the model, including production of farmed salmon in Norway and Scotland, landings of Pacific salmon, and exchange rates. Predicted prices of Norwegian farmed Atlantic salmon, together with marketing margins generated from an analysis of historical data, were then used to predict prices of farmed Atlantic salmon that Puget Sound salmon farmers might be expected to receive for their salmon supplies. Comparing future prices to costs of production, an analysis of profit margins was provided. Finally, the trade model was simulated under a future scenario of a 100 percent increase in Puget Sound farmed salmon production relative to current projected future production levels in order to assess the stability of Atlantic salmon prices under expanded Puget Sound production.

The study indicated that farmed Atlantic salmon and the higher-valued Pacific salmon substitute to some degree in the United States and the EEC,

although the price of Pacific salmon will be affected considerably more by changing level of Pacific salmon landings and varying exchange rates than by changes in the level of farmed Atlantic salmon production. The price of Norwegian farmed Atlantic salmon exported to the United States is relatively responsive to the level of Norwegian shipments, and Norway's level of exports to the United States vs. Europe is responsive to the relative price levels in the two markets. Given typical levels of Pacific salmon landings, and given projected increases in world farmed salmon production, Pacific and Atlantic salmon prices are anticipated to recover from the low prices of 1989, but are not expected to return to the high prices of 1988 anytime during the period 1990-1993. Profit margins for established salmon farms in the Puget Sound are expected to be positive, though not large, throughout the future period. However, negative profit margins for start-up farms, and less efficient farms, are also expected which may make expansion of the industry somewhat difficult in the short run. If Puget Sound production were to be expanded considerably (100 percent) over current projections for the period 1990-1993, price impacts are expected to be very modest.

II. INTRODUCTION

The proliferation of salmon production by means of salmon farming has been considered by many industry participants as the most important development in commercial fisheries in the 1980s. This increased supply of food from an efficient means of production is currently enjoyed by consumers throughout the world. But the success of salmon farming, mainly through net-pen production, is not without important ramifications to fishermen as well as potential and existing salmon farmers. Most importantly, worries about the effects of this increased production on salmon prices have surfaced.

Currently, salmon prices for fishermen and farmers have decreased from the high levels experienced in 1988. Much of the blame for these dwindling prices has been placed on the increased salmon supplies from salmon farming. But several factors affect the salmon product which is traded on international markets. Factors that to a major extent are external to the influence of fishermen and farmers, such as exchange rates, tariff levels, income levels in consuming nations, number of returning wild salmon, and so on, greatly affect the supply and demand for salmon. In addition, increased supplies of foreign farmed-raised salmon are, to a large degree, outside the influence of U.S. policy.

It is important to assess the significance and magnitude of the effects that these economic factors and other influences have on salmon prices in order to be able to better anticipate future salmon prices, to facilitate efficient resource allocations in the salmon fishing and farming industries, and to improve planning of salmon industry policy and marketing operations.

By the end of 1990, the value of farmed salmon production in the world could exceed North America's catch of chinook, coho, and sockeye salmon by 40 to 60 percent. Given the magnitude of expansion in farmed salmon production capacity, increased knowledge concerning factors that affect international salmon markets may be vital for the economic survivability of the salmon industry. This study was designed and performed to contribute to this knowledge base.

III. PURPOSE

A. Description of Problem

At the beginning of the 1980s, the west coast of the United States, British Columbia, and Alaska enjoyed a near monopoly on the production of high-valued salmon, namely, chinook, coho, and sockeye. In 1986, the United States and Canada accounted for 71 percent of the world's catch of Pacific salmon and 90 percent of the world's catch of high-valued salmon.

Commercial production of salmon grown in net pens began in earnest in the 1980s. In 1980, pen-raised salmon accounted for only 1 percent of the world's total salmon production; in 1990 it is predicted to account for approximately 29 percent (see Table 1). Because of the increasing prevalence of salmon farming, the commercial fishing industry in the United States and Canada is concerned that salmon supply will increase faster than demand and that prices will decline. Furthermore, current and prospective U.S. salmon farmers in Washington and Maine are also concerned about the effect of increased production on farm-gate prices for aquacultured salmon. The state of Alaska continues to debate the issue of whether to allow salmon farming in the state, with the current moratorium on salmon farming due to expire in July. Little analysis has been devoted to investigating the effects of salmon farming on the domestic and export markets of the U.S. salmon fishing and farming industries. This study attempts to help remedy this deficiency by responding to a National Marine Fisheries Service national priority, "Identify and analyze the impacts of foreign aquaculture on U.S. trade in fisheries products."

TABLE 1. Farmed Versus Wild World Salmon Production, 1980-90
(in 1,000 pounds)

Year	Farmed Salmon	Wild Salmon	Total Salmon	% Farmed
1980	16,979	1,280,417	1,297,396	1
1981	26,713	1,459,286	1,485,999	2
1982	35,396	1,273,232	1,308,628	3
1983	50,065	1,547,022	1,597,087	3
1984	74,435	1,440,285	1,514,720	5
1985	101,818	1,721,375	1,923,194	5
1986	158,831	1,455,165	1,611,996	10
1987	177,196	1,388,991	1,566,187	11
1988	321,453	1,347,023	1,666,476	19
1989	463,619	1,554,257	2,017,876	23
1990	618,997	1,543,234	2,162,231	29

ADAPTED FROM: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Draft of World Salmon Aquaculture, 1986-1987, Washington, D.C., Oct. 1987; "Salmon Market", Seafood Leader, Jan./Feb. 1990, p. 11; Atkinson, Clint, Personal communication, 1989; "Globefish Special on Salmon", Salmon Market Newsletter, Mar. 1990, pp. 4-7.

NOTE: Wild catches for 1987-90 are estimates.

Concerns of the U.S. salmon fishing industry focus primarily on the market for high-valued Pacific salmon. The most frequently farm-grown salmon, Atlantic salmon, is thought by some industry participants to compete favorably with high-valued wild-caught Pacific salmon because of its consistency in quality and supply (Herrmann, et.al., 1990). Whereas wild salmon are mainly caught in the summer months and frozen for consumption at other times during the year, farmed salmon can be harvested and sold fresh year-round to a large degree. Given the increasing and consistent availability of high-quality fresh Atlantic salmon, it is increasingly important for the U.S. salmon fishing industry to analyze the degree to which Atlantic salmon substitutes for high-valued (and perhaps lower-valued) Pacific salmon in domestic and foreign markets.

An substantial volume of trade in U.S. salmon products occurs in international markets (see Herrmann, et.al., 1990 and Herrmann, 1990, p. 208-220). In 1988, the U.S. exported 294 million pounds of fresh/frozen salmon worth \$830 million. Of this total, 238 million pounds, representing 82% of all U.S. exports, were shipped to the Japanese market, with the European Economic Community (EEC) representing the second largest export destination (see Tables 2 and 3). Canned exports, while much smaller in volume than salmon in the fresh/frozen form, are still significant and totaled 26.6 million pounds worth \$72.1 million in 1988. The primary export market for U.S. canned salmon has been the EEC (see Tables 4 and 5).

It is also the case that Norway, the leading producer of farmed Atlantic salmon, sells a substantial volume of salmon on international markets. In 1988, Norway exported 145.5 million pounds of Atlantic salmon, of which 123.4 million pounds was in fresh form, with the remainder being frozen. In recent

TABLE 2. U.S. Exports of Fresh/Frozen Salmon, 1982-88 (in pounds and U.S. dollars)

Species/Year	Quantity	Value	Price/lb.
<u>Chinook</u>			
1982	4,596,910	11,333,074	2.47
1983	6,325,967	13,256,938	2.10
1984	3,764,534	9,583,742	2.55
1985	4,438,882	10,209,473	2.30
1986	5,037,543	11,148,290	2.28
1987	9,885,217	30,862,940	3.12
1988	10,621,108	37,272,533	3.51
<u>Chum</u>			
1982	31,412,945	43,877,477	1.40
1983	28,432,538	33,486,801	1.18
1984	35,830,723	44,661,920	1.25
1985	38,180,451	47,404,919	1.24
1986	46,895,817	59,328,127	1.27
1987	41,435,031	59,537,031	1.44
1988	56,988,384	107,715,685	1.89
<u>Sockeye</u>			
1982	126,642,683	232,867,411	1.83
1983	163,583,775	257,416,163	1.57
1984	128,027,827	219,712,538	1.72
1985	154,598,890	302,529,741	1.96
1986	143,271,612	351,367,523	2.45
1987	138,291,675	369,143,817	2.67
1988	138,322,186	495,621,830	3.58
<u>Pink</u>			
1982	41,142,949	35,088,051	0.85
1983	10,190,782	9,285,182	0.91
1984	35,215,040	26,402,837	0.75
1985	53,187,254	37,280,182	0.70
1986	51,889,288	44,575,678	0.86
1987	35,601,408	47,999,332	1.35
1988	52,466,124	89,902,026	1.71
<u>Coho^a</u>			
1986	25,527,999	46,493,002	1.82
1987	21,253,007	50,605,263	2.38
1988	19,948,249	61,666,976	3.09

ADAPTED FROM: U.S. Department of Commerce. U.S. Exports, Schedule E Commodity by Country. Washington, D.C., 1982-89.

^aSeparation of U.S. coho exports from the "other" salmon category was not reported until 1986.

TABLE 3. Percent of Total U.S. Fresh/Frozen Salmon Exported to Various Regions by Species, 1988

Species	Japan	EEC	Canada	Other	Total
Chinook	76	17	7	0	100
Sockeye	97	1	2	0	100
Chum	64	21	11	4	100
Pink	73	17	2	8	100
Coho	65	24	9	2	100

ADAPTED FROM: U.S. Department of Commerce. U.S. Exports, Schedule E Commodity by Country. Washington, D.C., 1988-89.

NOTE: EEC includes EEC member countries and Switzerland and Sweden.

TABLE 4. Percent of Total 1988 U.S. Canned Exports to Various Regions by Species

Species	Importing Region			
	EEC	Australia and New Zealand	Canada	Other
Sockeye	71	9	18	2
Chum	70	1	28	1
Pink	52	31	16	1

ADAPTED FROM: U.S. Department of Commerce. U.S. Exports, Schedule E Commodity by Country. Washington, D.C., 1988-89.

NOTE: EEC includes the EEC countries plus Switzerland and Sweden.

TABLE 5. U.S. Exports of Canned Salmon, 1982-88 (in pounds and U.S. dollars)

Species/Year	Quantity	Value	Price/lb.
<u>Chum</u>			
1982	6,314,272	7,365,729	1.17
1983	5,004,091	6,066,832	1.21
1984	2,796,667	3,476,905	1.24
1985	2,550,887	3,114,801	1.22
1986	1,676,175	2,001,933	1.19
1987	2,456,410	3,491,933	1.42
1988	1,071,589	2,478,149	2.31
<u>Pink</u>			
1982	20,804,849	28,048,491	1.35
1983	22,145,538	31,532,533	1.42
1984	20,824,790	29,682,711	1.43
1985	19,830,797	27,462,868	1.38
1986	38,611,185	52,599,253	1.36
1987	17,389,530	32,077,077	1.84
1988	13,701,936	31,577,053	2.30
<u>Sockeye</u>			
1982	10,235,843	23,874,987	2.31
1983	21,963,683	50,315,000	2.29
1984	23,237,631	50,050,000	2.15
1985	24,094,303	49,386,000	2.05
1986	14,371,896	38,225,741	2.66
1987	11,083,829	27,680,703	3.40
1988	11,867,446	38,097,001	3.21

ADAPTED FROM: U.S. Department of Commerce. U.S. Exports, Schedule E
Commodity by Country. Washington, D.C., 1982-89.

years, the largest export market for Norwegian salmon has been the EEC, which purchased 74% of total Norwegian exports in 1988 (see Tables 6 and 7). The largest export market for Norwegian salmon is thus also a primary market for exports of U.S. Pacific salmon, and an important question to the U.S. salmon fishing industry (as well as to the Norwegian farming industry) is to what extent Pacific and Atlantic species compete in the EEC market. At this point in time, Norway exports only a minor amount of Atlantic salmon to the Japanese market, and thus competition for market share between Pacific and Atlantic salmon in this market does not appear to be significant. However, the Japanese continue to expand their own aquaculture production for domestic consumption, which represented 36.6 million pounds of pan-sized coho salmon in 1988, and is projected to reach 42 million pounds by 1990 (C. Atkinson, personal communication, 1990). There are also indications that Norway may currently be in a market development mode in the Japanese market, and that future shipments of Atlantic salmon to this market may increase. Similarly, Chile has very recently begun to ship farmed salmon to the Japanese market (see Table 8). From January to April, 1989, Japan imported 90% of the Chilean exports of frozen salmon, and during this period, Chile exported 83% of its volume of farmed salmon in frozen form. Thus, the threat of eroding U.S. market share in the important Japanese market due to expanding farmed salmon production exists and may increase in the near future.

The international markets also represent a significant source of salmon supply for the U.S. market. A large amount of fresh salmon is now being imported into the United States from the farming countries, especially during the off-fishing season, whereas, historically, all salmon consumed in the United States originated domestically or from Canada (see Table 9).

TABLE 6. Norwegian Exports of Fresh Farmed Atlantic Salmon in 1988 (in pounds and U.S. dollars per pound)

Importing Region	Quantity	Price
North America	20,893,281	3.53
Japan	4,619,755	3.53
EEC	88,973,086	3.11
Other	8,922,152	3.57
TOTAL	123,408,274	3.23

SOURCE: Norway, Central Bureau of Statistics. Norwegian Atlantic salmon export data, 1981-90. Oslo, Norway, 1988-89.

TABLE 7. Norwegian Exports of Frozen Farmed Atlantic Salmon, 1988 (in pounds and U.S. dollars per pound)

Importing Region	Quantity	Price
North America	482,080	3.72
EEC	18,759,277	3.34
Japan	1,776,800	3.55
Other	999,282	3.91
TOTAL	22,107,439	3.39

SOURCE: Norway, Central Bureau of Statistics. Norwegian Atlantic salmon export data, 1981-90. Oslo, Norway, 1988-89.

TABLE 8. Chilean Salmon Exports, 1987-88 Season

Importing Country	Quantity (lbs.)
United States	3,136,142
Japan	1,842,335
France	113,159
Italy	113,159
Other	84,256
TOTAL	6,213,210

ADAPTED FROM: Valenzuela, Alfred. "Keynote Report: Chile." JETRO International Forum on Salmon and Trout, International Symposium on Fisheries, Tokyo, Japan, 16-17 Nov. 1988.

TABLE 9. U.S. Imports of Fresh Salmon by Month, 1988 (in pounds and U.S. dollars)

Month	Quantity	Value	Price/lb.
January	3,084,984	10,753,058	3.49
February	2,801,792	9,206,929	3.29
March	3,145,740	10,874,601	3.46
April	3,188,210	11,313,176	3.55
May	2,413,393	8,633,674	3.58
June	2,076,015	7,641,199	3.68
July	2,493,284	8,033,920	3.22
August	3,553,516	11,304,105	3.18
September	3,504,354	11,168,904	3.19
October	4,786,403	12,405,279	2.59
November	4,141,973	11,558,232	2.79
December	4,047,285	12,662,363	3.13
TOTAL	39,236,949	125,555,440	3.20

ADAPTED FROM: U.S. Department of Commerce. U.S. Imports for Consumption and General Imports, Schedule A, Commodity by Country. Washington, D.C., 1988-89.

NOTE: Some of the imports from May to September are fresh salmon from Canada's wild catch.

Most of the fresh imports come from Canada and Norway. Nearly all of the imports from countries other than Canada are farmed; the fresh Canadian imports are a mixture of farmed and wild; and the frozen Canadian imports are wild salmon (see Tables 10 and 11).

If Peyton's (1988) U.S. consumption figure of 88 million pounds of fresh/frozen salmon is accurate for 1987, then approximately 48 percent of all U.S. salmon consumption is imported, and the percent would be higher in terms of value. This compares to just 12 percent in 1982. U.S. imports of fresh/frozen salmon have increased 385 percent from 1982 to 1988, with fresh salmon imports increasing 618 percent. Seventy-eight percent of U.S. imports are fresh salmon. In terms of fresh/frozen quantity, Canada is still the largest overall exporter to the United States, supplying almost 24 million pounds in 1988, with Norway second at 20 million pounds. But in terms of value, Norway is the leading exporter to the United States.

Imports of Scottish, Norwegian, Icelandic, and Irish salmon are farmed Atlantics, whereas imports from Canada and Chile are mainly chinooks and cohos for farmed salmon and all species of Pacific wild salmon. In 1984, Anderson and Hurst (DPA Group Inc., Anderson, and Hurst, 1987) estimated that, in order of volume, the United States produced frozen coho, chum, sockeye, chinook, pink, and Atlantic salmon. For fresh salmon, in order of volume, the United States produced Atlantic, chum, chinook, coho, and pink. Canned salmon is almost exclusively supplied from domestic sources. Peyton (1988) estimates approximately 82,624,000 pounds of canned salmon were consumed in the United States in 1987.

With the prospect of expanding farmed production in foreign countries, and concomitant increases in exports to the U.S. market, an analysis of the

TABLE 10. U.S. Imports of Fresh Salmon in 1988 by Country (in pounds and U.S. dollars)

Exporting Country	Quantity	Value	Price	% Quantity	% Value
Canada	14,248,878	39,319,782	2.76	36	31
Chile	2,590,872	6,661,836	2.55	7	5
Iceland	717,421	2,550,114	3.55	2	2
Norway	19,687,844	69,240,486	3.52	50	55
U.K.	830,651	3,616,540	4.35	2	3
Other	1,161,283	4,166,682	3.58	3	4
TOTAL	39,236,949	125,555,440	3.20	100	100

ADAPTED FROM: U.S. Department of Commerce. U.S. Imports for Consumption and General Imports, Schedule A, Commodity by Country. Washington, D.C., 1988-89.

TABLE 11. U.S. Imports of Frozen Salmon in 1988 (in pounds and U.S. dollars)

Exporting Country	Quantity	Value	Price	Quantity	Value
Canada	9,406,623	24,120,044	2.56	86	82
Norway	403,109	1,579,000	3.92	4	5
Other	1,097,130	3,918,772	3.57	10	13
TOTAL	10,906,862	29,617,816	2.72	100	100

ADAPTED FROM: U.S. Department of Commerce. U.S. Imports for Consumption and General Imports, Schedule A, Commodity by Country. Washington D.C., 1988-89.

substitution effects between farmed and wild caught salmon becomes highly relevant. In particular, the effect of changing import levels of farmed salmon on both exvessel and farmgate prices in the United States is critical in assessing the future profitability of the salmon fishery and domestic farming operations, as well as in contemplating trade policy and marketing strategies for the industry.

Since salmon is heavily traded in international markets it is also important to examine the effects of increasing farm-raised salmon production on trade flows and markets for both wild and farmed salmon in different regions, because trading and pricing patterns are interrelated and can change as farmed salmon is introduced and/or its availability expanded in these markets. Locational advantages and local tastes and preferences may favor importing more farmed salmon or more wild caught salmon into a particular region. Exogenous factors such as exchange rates and tariffs can also play an important role in determining trade patterns.

Consumers can benefit from the increased supply of salmon resulting from salmon aquaculture. With world fish harvest levels stable or declining, the proliferation of salmon production from the pen-raised salmon industry has made it the most important development in commercial fisheries in the 1980s. For producers of farmed salmon and the commercial fishing industry, though, this development has created more uncertainty and indecision as to future supplies and prices. The more knowledge that can be gained concerning how economic factors affect world salmon markets, the better the farmed and commercial fishing industries will be able to make important resource allocation and investment decisions.

The specific problem to be addressed is a quantitative assessment of the degree to which the expansion of salmon farming in major farming regions has impacted both wild and farmed salmon in domestic and foreign markets. The vehicle to perform such an assessment will be an econometric model which will be constructed to represent trade equilibrium in salmon products among the major trading partners of the U.S., in so far as existing data allows. Then, more specifically, the problem of this research is the construction of an econometric model of salmon trade, and the utilization of the model to quantify the economic impacts of expanding farmed salmon supplies on world salmon markets.

B. Objectives of the Project

The objectives of the project are:

1. To assess the present and future U.S. and world demand, supply, and price structure for canned and noncanned salmon products in the context of an econometric model that analyzes the effects of:
 - a. product form,
 - b. currency/trade barriers,
 - c. taste/preferences/health benefits,
 - d. substitution among food products,
 - e. interregional product distribution.
2. To analyze the effects of worldwide salmon farming and other salmon production on the demand for U.S. fresh, frozen, and canned salmon products, and the balance of trade.

3. To analyze the cost of production to grow farmed salmon using the Puget Sound as the example location, to compare the farming cost to reported costs of competing wild production, and to assess the profitability of producing and marketing salmon given the price structures generated in (1).
4. To examine production/marketing strategies and fish regulation/management policies that may enhance the economic returns to U.S. farmed and wild salmon production in light of the price structures suggested by (1). The examination will include an assessment of the influence that production capability, stability, and seasonality of the capture fishery have on policy and strategy formulation.
5. To assess the direction of and need for future research and development concerning the expansion of salmon farming operations in Puget Sound.

IV. APPROACH

A. Description of Work Performed

The research on the project preceded in a number of phases which sometimes overlapped. The phases can be categorized as:

1. data collection and organization
 - a) creation of computer data base
 - b) drafting data book on import/export statistics
2. literature review
 - a) review of salmon industry structure
 - b) review of previous econometric models
3. writing, presentation, and publication of research papers on preliminary analyses
4. econometric modelling
 - a) software preparation
 - b) model specification and estimation
5. model simulation and forecasting
 - a) historical goodness of fit measures
 - b) scenario generation within historical period
 - c) forecasting future salmon prices
 - d) evaluating future farming profitability
6. writing final documents
 - a) Ph.D. dissertation of Dr. Mark Herrmann
 - b) final report to NMFS

Each of the phases of the project will be discussed in turn below.

1. Data Collection and Organization

The data gathering effort was substantial, and involved: 1) trips by members of the research team to Denmark, Canada, and Japan, 2) contacting researchers, industry participants, and consultants both in North America and abroad for specific data requests, and 3) collection of data series from published sources. The data was collated and organized in the Lotus format on an IBM PC/2 microcomputer. A detailed presentation of export/import data for salmon products was published in a data book format under the title "World Salmon Trade: Export/Import Statistics" by Herrmann, et.al., (1990). A detailed listing of sources for the data presented in the data book can be found in that publication.

The data used in the econometric model constructed for assessing the economic effects of salmon farming on world salmon markets was quarterly data within a calendar year context. All salmon quantities represent aggregate quarterly totals, and all salmon prices represent quantity-weighted quarterly average prices.

All of the U.S. export quantity and price data were taken from U.S. Exports, Schedule E Commodity by Country (1982-89a), and the U.S. imports of Chilean salmon were taken from U.S. Imports for Consumption and General Imports, Schedule A, Commodity by Country (1982-89b), both published by the U.S. Department of Commerce. The Norwegian export quantity and price data was obtained from the Norwegian Central Bureau of Statistics (1982-90b).

U.S. landings and exvessel prices were obtained from the Alaska Department of Fish and Game (1988) (only Alaskan landings), Oregon Department of Fish and Wildlife (1988), and the U.S. Pacific Fisheries Management Council (1988) in Portland (California data). Alaskan exvessel prices were obtained

from the Alaska Commercial Fisheries Entry Commission (1989). British Columbian landings and exvessel prices came from the British Columbia Department of Fisheries and Oceans (1984-89). British Columbian farmed salmon production for 1988 was from the B.C. Salmon Farmers Association (1989). Scottish farmed salmon production came from a variety of sources including World Salmon Aquaculture 1986-1987, published by the U.S. Dept. of Commerce; "Keynote Report: United Kingdom", published in the proceedings of the International Symposium on Fisheries, Tokyo, Japan, Nov. 16-17, 1988; "Salmon Farming in Scotland", from the Salmon Market Newsletter, Jan. 1989; and "Developments in the U.K. Farmed Salmon Market", from the Salmon Market Newsletter, Apr. 1989. Prices of substitute fish in Japan were taken from the Fisheries Products Marketing Yearbook published by the Ministry of Agriculture, Forestry, and Fisheries (various issues).

Japanese landings of salmon, inventories of salmon, and fresh and frozen salmon sold in wholesale markets were prepared by Clint Atkinson (1988-89b) who is a fisheries consultant and advisor in Seattle, Washington. U.S. inventories were from Frozen Fishery Products, Annual Summary (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1984-89) and from Fishery Market News (National Marine Fisheries Service, various issues). The British Columbian inventories were obtained from the Canadian Ministry of Agriculture and Fisheries in Victoria (1983-90b).

Exchange rates and populations are from International Financial Statistics published by the International Monetary Fund (various issues). U.S. personal disposable income, the producer price index for foods and feeds, and the U.S. prime interest rate were taken from the Survey of Current Business, published by the U.S. Department of Commerce, Bureau of Economic

Analysis (various issues).

The private consumption expenditure for the EEC was published in the Quarterly National Accounts published by the OECD Department of Economics and Statistics (various issues). The consumer price index for foods in the EEC was found in Main Economic Indicators published by the same agency (various issues). The Japanese private consumption expenditure and the Japanese CPI came from Japan's Economic Planning Agency (Lin, 1990).

2. Literature Review

An extensive review of the literature was undertaken in two general topic areas: 1) salmon industry structure, and 2) past econometric models dealing with salmon demand/supply/trade. The review of salmon industry structure was undertaken to identify the market context in which world salmon trade occurs. Subtopics examined included 1) physical description of the Atlantic and Pacific salmon species, 2) methods of harvesting wild salmon, 3) techniques of fishery regulation and management in the North American industry, 4) trends in capture fishery and farmed salmon supplies, 5) techniques of salmon farming, 6) descriptions of the existing or developing salmon farming industries in Norway, U.S., Canada, and in other countries including Australia, Chile, Faroe Islands, Finland, France, Iceland, Ireland, Japan, New Zealand, Scotland, Spain, and Sweden, 7) costs of production for salmon farming, 8) the nature of salmon product demand in major salmon-consuming regions, 9) inventory holding behavior, 10) import/export flows involving North America, the EEC, and Japan, 11) marketing channels in major world markets, 12) marketing margins in North American markets, 13) historical trends in exchange rates, 14) the nature of tariffs and trade barriers among major salmon trading regions, and 15) transportation costs between major

salmon markets. The discussion of these subtopics is contained in Chapter 2, spanning pages 9-238 of the Ph.D dissertation by Herrmann (1990).

The review of past econometric studies was undertaken to identify previous modelling efforts that could provide insight into model specifications relevant for the present study. In addition, past econometric research was examined to identify magnitudes of key price and income elasticities that could be used as prior information in the Bayesian estimation techniques utilized in the present research effort. The past econometric modelling efforts reviewed were grouped into studies of the canned salmon markets, studies of the Pacific fresh/frozen salmon markets, and studies of Atlantic salmon markets. Overall, nineteen articles were reviewed, and the discussion is presented in Chapter 3, p. 244-290, of the Ph.D. dissertation by Herrmann (1990).

3. Writing, Presentation, and Publication of Research Papers on Preliminary Analyses

In the course of preparing the project proposal and pursuing the objectives of the project, a significant number of preliminary results were generated and disseminated in various forms. A principle objective in disseminating such results was to solicit industry and professional peer feedback on some of the analytical approaches being contemplated in the econometric analysis of world salmon trade. Furthermore, in cases where results were generated that were thought to be of direct interest to salmon industry participants, policy makers, and/or other researchers, presentation and/or publication of the results was pursued.

Initial work was done on price formation in the markets for Norwegian farmed Atlantic salmon and results were presented at the Symposium of Markets

for Seafood and Aquaculture Products in Charleston, South Carolina in August of 1987 under the title of "An Economic Analysis of Atlantic Salmon Markets." This paper was revised and published as an Alaska Sea Grant publication under the title of An Econometric Analysis of Atlantic Salmon Markets in the United States and France. The purpose of these two works was to identify factors affecting the demand for Norwegian farmed Atlantic salmon in Norway's two largest markets, (at that time) the United States and France. In particular, interest was focused on the possible substitution effect between Norwegian farmed Atlantic salmon and wild Pacific salmon. A case was made for this substitution in the United States. Also, for the first time, a supply equation was modelled for the Norwegian supply of farmed Atlantic salmon exported to the United States. Previous studies had only focused on the demand side of the market.

A more intricate simultaneous model was then developed which simultaneously modelled the allocation of Norwegian farmed Atlantic salmon to the United States and the EEC along with the demand for Norwegian farmed Atlantic salmon in these two regions. This was the first simultaneous equations model estimated for the farmed salmon industry. The initial work was presented at the American Agricultural Economics Association Annual Meeting in Knoxville, Tennessee and also presented at the Fourth Conference of the International Institute of Fisheries Economics and Trade in Esbjerg, Denmark under the title of "The Demand and Supply of Norwegian Atlantic Salmon in the United States and the European Community" in August of 1988.

The results of this research were well-received and the work was revised and published as a journal article in the Canadian Journal of Agricultural Economics under the title of "The Demand and Supply of Norwegian Atlantic

Salmon in the United States and the European Community." Results of this research revealed that the demand and allocation of Norwegian farmed Atlantic salmon was price responsive and subject to seasonal shifts (monthly shifts in demand). Substitution effects were found between Atlantic salmon and chinook salmon in the United States and Atlantic salmon and an aggregate of exported North American chinook, coho, and sockeye salmon in the EEC. However, the magnitudes of the substitution effects were relatively small.

To provide further exposure for the research being done for NMFS, and to solicit further expert opinion, a research note was published in the Northwest Environmental Journal under the title of "An Economic Analysis of the Pacific Salmon Industry: Effects of Salmon Farming" in the spring of 1989. This research note basically summarized the most important goals of the Saltonstall-Kennedy foundation-funded project.

The aforementioned simultaneous equation model for Norwegian farmed Atlantic salmon was re-estimated to facilitate price forecasting. Forecasts of the Norwegian farmed Atlantic salmon prices in the United States and the EEC were made for the time period of 1989 to 1992. This work was eventually published in Agribusiness: An International Journal under the title of "Forecasting the Price of Farmed Atlantic Salmon: An Integrated Econometric and Time Series Approach" in the spring of 1989. Papers that were presented to disseminate this work, and variations on this work, were delivered at the following meetings: the Aquaculture International Congress at Vancouver, British Columbia under the title of "Future Supply and Price of Norwegian Atlantic Salmon" in September of 1988; the Salmon Marketing Workshop at Simon Fraser University, British Columbia in May of 1989 under the title of "Effects of Exchange Rates and Supply on the Forecasted Price of Farmed Atlantic

Salmon"; the 64th Annual Western Economics Association International Conference in Lake Tahoe, California in June of 1989 under the title of "Forecasting the Price of Farmed Atlantic Salmon"; and the American Agricultural Economics Association Annual Meeting, Baton Rouge, Louisiana in August of 1989 under the title of "Future Price of Farmed Atlantic Salmon."

The research team was pleased that the two papers above that were presented in Canada and the paper delivered in California were invited papers, suggesting that the research had gained national and international recognition. A summary of the forecasting paper was also published in the Salmon Market Newsletter under the title of "Forecasting the Price of Farmed Norwegian Atlantic Salmon." The Salmon Market Newsletter was originated by Dr. Biing-Hwan Lin, Dr. Richard Johnston of Oregon State University, Mr. Peter Leitz of the Department of Fisheries and Oceans in British Columbia, Dr. Susan Shaw at the University of Stirling in Scotland, Mr. Carlos Wurmann, Chile, and Dr. Trond Bjorndal of the Norwegian School of Economics and Business Administration in Norway under the organization of the International Institute of Fisheries Economics and Trade (IIFET). The participation of Biing-Hwan Lin to help create this publication outlet was directly the result of the NMFS-funded trip by Lin and Herrmann to the IIFET meeting in Denmark.

The most satisfying result of the forecasting paper was that initial forecasts were quite good. The model predicted a decrease in U.S. farmed Atlantic salmon import (FOB Norway) prices from \$3.94 per pound at the end of 1987 to \$2.96 at the start of 1989. The actual price at the start of 1989 was \$2.87. But subsequent predictions were not as good because predictions of Norwegian farmed Atlantic supply were underestimated. Nevertheless, compliments on the relative accuracy of these price forecasts were received.

received from the industry, suggesting the industry has taken a keen interest in this research work.

In examining functional forms and estimation techniques a paper was written entitled "Applying Almon-Type Polynomials in Modelling Seasonality of Demand: The Case of the Japanese Demand for Salmon" and presented at the American Agricultural Economics Association Annual Meeting at Baton Rouge, Louisiana in August of 1989. Even though the final estimation technique developed in this paper was not used for the final salmon demand model, nevertheless, the results of the demand analysis for salted Japanese salmon were thought to be useful and contributed to the final specification of the Japanese demand models for Atlantic and Pacific salmon. This work received a favorable initial review, and is currently under second revision for consideration to be published in Marine Resource Economics under the title of "Applying Almon-Type Polynomials in Modelling Seasonality of the Japanese Demand for Salmon."

A seminar was given (by invitation) at the Aquaculture: Current Issues and Prospects seminar series at Washington State University, Pullman, Washington in December of 1989 entitled "Some Observations on the Demand for Farmed Atlantic Salmon and Effects on North American Commercial Pacific Salmon Fisheries." The purpose of this seminar was to present current work on the salmon model to other researchers interested in all facets of aquaculture.

After preliminary econometric work had been done on the Norwegian farmed Atlantic salmon markets, a survey of seafood wholesalers was undertaken to facilitate the specification of substitution relationships in the econometric model of world salmon markets for both farmed and wild salmon. In particular, the advantages of handling wild versus farmed salmon and the possible

substitution between the different species were explored by soliciting answers to a questionnaire sent to U.S. wholesalers. The results of the survey were thought to be interesting in and of themselves, and the work was published by Alaskan Sea Grant under the title of U.S. Salmon Markets: A Survey of Seafood Wholesalers in 1990. A summary of the survey results was also published in the Salmon Market Newsletter under the title of "Wholesalers' Opinions of the U.S. Salmon Market" in July of 1989.

Finally, a data book entitled World Salmon Trade: Export/Import Statistics that was promised under the grant proposal was accepted for publication by NMFS. The data book is currently in press.

A listing of the presentations and publications associated with the project to date is as follows:

JOURNAL ARTICLES REFEREED

- Herrmann, Mark, Ron C. Mittelhammer, and Biing-Hwan Lin. "Applying Almon-Type Polynomials in Modelling Seasonality of the Japanese Demand for Salmon." Marine Resource Economics, currently under 2nd review after favorable initial review.
- Lin, Biing-Hwan, Mark Herrmann, Tsae-Yun Lin, and Ron C. Mittelhammer. "Forecasting the Price of Farmed Atlantic Salmon: An Integrated Econometric and Time Series Approach." Agribusiness: An International Journal, 5(Spring 1989):477-488.
- Lin, Biing-Hwan, Mark Herrmann, and Ron C. Mittelhammer. "An Economic Analysis of the Pacific Salmon Industry: Effects of Salmon Farming", research note. Northwest Environmental Journal, 5(Spring/Summer 1989): 160-161.
- Herrmann, Mark, and Biing-Hwan Lin. "The Demand and Supply for Norwegian Atlantic Salmon in the United States and the European Community." Canadian Journal of Agricultural Economics, 36(November 1988):459-472.

OTHER PUBLICATIONS

- Herrmann, Mark L. An Economic Analysis of World Salmon Markets: Effects of Salmon Farming, Ph.D. dissertation, Dept. of Agricultural Economics, Washington State University, Pullman, 1990.

Herrmann, Mark, Biing-Hwan Lin, Ron C. Mittelhammer, and Joe Terry. World Salmon Trade: Export/Import Statistics. Seattle: National Marine Fisheries Service, June 1990.

Herrmann, Mark, Biing-Hwan Lin, and Ron C. Mittelhammer. U.S. Salmon Markets: A Survey of Seafood Wholesalers. Fairbanks: Alaska Sea Grant, 1990. 90-01.

Herrmann, Mark, Biing-Hwan Lin, and Ron C. Mittelhammer. "Wholesalers' Opinions of the U.S. Salmon Market." Salmon Market Newsletter, 1(July 1989):7-8.

Lin, Biing-Hwan, Mark Herrmann, and Ron C. Mittelhammer. "Forecasting the Price of Farmed Norwegian Atlantic Salmon." Salmon Market Newsletter 1(April 1989):2-3.

Lin, Biing-Hwan, and Mark Herrmann. An Econometric Analysis of Atlantic Salmon Markets in the United States and France. Fairbanks: Alaska Sea Grant, 1988. 88-5.

PROFESSIONAL PAPERS

Herrmann, Mark, Ron C. Mittelhammer, and Biing-Hwan Lin. "Applying Almon-Type Polynomials in Modeling Seasonality of Demand: The Case of the Japanese Demand for Salmon." Presented at the American Agricultural Economics Association Annual Meeting, Baton Rouge, LA, 30 July-2 August 1989.

Lin, Biing-Hwan, Mark Herrmann, Tsae-Yun Lin, and Ron C. Mittelhammer. "Future Price of Farmed Atlantic Salmon." Presented at the American Agricultural Economics Association Annual Meeting, Baton Rouge, LA, 30 July-2 August 1989.

Lin, Biing-Hwan, Mark Herrmann, Tsae-Yun Lin, and Ron C. Mittelhammer. "Forecasting the Price of Farmed Atlantic Salmon." Invited paper presented at the 64th Annual Western Economics Association International Conference, Lake Tahoe, CA, 18-22 June 1989.

Lin, Biing-Hwan, Mark Herrmann, Tsae-Yun Lin, Ron C. Mittelhammer. "Effects of Exchange Rates and Supply on the Forecasted Price of Farmed Atlantic Salmon." Invited paper presented at the Salmon Marketing Workshop at Simon Fraser University, B.C., Canada, 15-19 May 1989.

Lin, Biing-Hwan, Mark Herrmann, Tsae-Yun Lin, and Ron C. Mittelhammer. "Future Supply and Price of Norwegian Atlantic Salmon." Invited paper presented at the Aquaculture International Congress, Vancouver, B.C., Canada, 6-9 September 1988.

Herrmann, Mark, and Biing-Hwan Lin. "The Demand and Supply for Norwegian Atlantic Salmon in the United States and the European Community." Paper presented at the American Agricultural Economics Association Annual Meeting, Knoxville, TN, 31 July - 3 August 1988. Also presented at the Fourth Conference of the International Institute of Fisheries Economics and Trade, Esbjerg, Denmark, 6-10 August 1988.

Lin, Biing-Hwan, and Mark Herrmann. "An Economic Analysis of Atlantic Salmon Markets." Paper presented at the Symposium of Markets for Seafood and Aquaculture Products, Charleston, SC, 16-21 August 1987.

PROFESSIONAL PRESENTATIONS

Herrmann, Mark. "Some Observations on the Demand for Farmed Atlantic Salmon and Effects on North American Commercial Pacific Salmon Fisheries." Presented at the Aquaculture: Current Issues and Prospects seminar series at Washington State University, Pullman, 11 December 1989.

4. Econometric Modelling

Software Preparation

In the course of constructing the econometric model of world salmon trade, it became apparent that a Bayesian approach to incorporating prior ranges on key model parameters could be beneficial in the estimation of model parameters. This observation followed from the realization that past research and expert opinion existed that allowed meaningful prior distributions to be constructed for a number of key model parameters. Furthermore, the limited availability of sample data on model variables made the acquisition of additional information concerning model parameters attractive and, in some cases, practically necessary.

A number of characteristics of the estimation problems defined an estimation context for which no ready-made software was available with which to perform the required Bayesian estimation. First of all, the endogenous variables in the model were simultaneously determined, necessitating that some form of simultaneous equations estimation technique be utilized in the

estimation of model parameters. Secondly, there was no firm reason to assume that the likelihood functions associated with the model parameters in the model were based on normal distributions. Thirdly, the informative prior distributions used on model parameters were of the quadrilateral or spliced uniform-exponential type, which could not be assumed to be conjugate to the likelihood functions.

In order to accommodate the features of the estimation problem described above, a Bayesian Bootstrapped Two-Stage Least-Squares estimation technique was programmed in the GAUSS programming language and implemented on an IBM PC/2 microcomputer. The estimation technique represents an extension of the work of Boos and Monahan (1986) and Freedman and Peters (1983). A description of the basic technique implemented in the computer is described below.

Bootstrapping is a method that can be used to assess the sampling variability and distribution of an estimator of the parameters of a linear model without a priori assumptions regarding the specific family of distributions (e.g., normal) governing the likelihood of disturbance term outcomes. For the single-equation case, in which all explanatory variables are exogenous, the bootstrapping approach is conceptually straightforward. Let the single equation being analyzed be represented by:

$$(1) \quad Y = x\beta + e$$

where Y is an $(n \cdot 1)$ vector of observable values of the random variable Y , x is a known $(n \cdot k)$ matrix of nonstochastic explanatory variable values, β is a $(k \cdot 1)$ vector of unknown parameters, and e is an $(n \cdot 1)$ vector of unobservable random variables. The ordinary least-squares (OLS) estimator can be calculated as:

$$(2) \quad \hat{\beta} = (x'x)^{-1}x'y.$$

To perform bootstrapping, first the estimates of the error term e are derived as:

$$(3) \quad \hat{e} = Y - x\hat{\beta}$$

where $\hat{e}$ is an $(n \cdot 1)$ vector of the error term estimates. Then a random sample of the $\hat{e}_j$ s are drawn from $\hat{e}$, with replacement, until a new $(n \cdot 1)$ vector $\hat{e}^*$ is generated. In this sample, it is possible that some $\hat{e}_j$ s are drawn more than once and some may not be drawn at all. Once $\hat{e}^*$ is drawn, a new $(n \cdot 1)$ vector of simulated dependent variable outcomes is generated as

$$(4) \quad \hat{Y}^* = x\hat{\beta} + \hat{e}^*.$$

In the bootstrapping context, $(\hat{Y}^*|x)$ is then treated as a new set of observations on the process (1), and a new outcome for the OLS estimator is calculated as:

$$(5) \quad \hat{\beta}^* = (x'x)^{-1}x'\hat{Y}^*.$$

A given outcome of $\hat{\beta}^*$ is referred to as a "bootstrapped sample outcome."

Repeated random samples with replacement of size n from the elements in $\hat{e}$ are drawn, and Equations (4) and (5) are repeatedly used to generate a specified number of bootstrapped sample outcomes for $\hat{\beta}^*$. After reaching a number of specified bootstrapped samples (say t) at which the empirical distribution of the estimates have stabilized, the means of the bootstrap sample outcomes can be derived as:

$$(6) \quad \bar{\beta}_i^* = (1/t) \sum_{j=1}^t \beta_{ij}^* \text{ for } i = 1 \text{ to } k$$

where $\bar{\beta}_i^*$ is the bootstrapped mean estimate of the expected value of β_i . The sampling variance of β_i can then be defined by calculating the sample variance of the bootstrapped sample of β_i^* values, as:

$$(7) \quad \sum_{j=1}^t (\beta_{ij}^* - \bar{\beta}_i^*)^2 / t.$$

The empirical distribution of the β_i^* values can be interpreted as an approximation to the sampling distribution of β_i . This model can be straightforwardly extended to generalized least-squares estimators.

The above procedure can be applied to two-stage least-squares (2SLS) estimation; however, the right-hand side endogenous and lagged endogenous variables (including lagged dependent variables) must also become part of the bootstrapped sampling procedure. The basic ideas involved can be illustrated using the case where no lagged endogenous variables appear as explanatory variables, as discussed below.

In the first stage of the 2SLS estimation technique, the right-hand side variables are replaced with instrumental variables, as usual. The second stage is then the estimation of an equation which has instrumental variables and exogenous variables on the right-hand side.

Let the structural equation being analyzed be represented by:

$$(8) \quad y = Y\Gamma + x\beta + u$$

where y is an $(n \cdot 1)$ vector of observations on the dependent variable; Y is an $n \cdot g$ matrix of endogenous explanatory variables, x is an $n \cdot k$ matrix of exogenous variables; Γ and β are $(g \cdot 1)$ and $(k \cdot 1)$ vectors of parameters, respectively; and u is an $(n \cdot 1)$ vector of disturbances. Assume that the reduced form representation for the Y variables is given by:

$$(9) \quad Y = X\pi + v$$

where X is the $n \cdot K$ matrix of exogenous variables in the system; π is a $K \cdot g$ matrix of reduced form parameters; and v is an $n \cdot g$ matrix of reduced form residuals. Applying ordinary least squares to estimate the reduced form equation obtains:

$$(10) \quad \hat{Y} = Y\hat{\pi}.$$

Substituting $\hat{Y}$ for Y in (8) results in an alternative representation of y as:

$$(11) \quad y = \hat{Y}\Gamma + x\beta + \tilde{u}.$$

Ordinary least squares is used to estimate Γ and β in (11). Utilizing the explanatory variables $\hat{Y}$ and x results in the 2SLS estimate of Γ and β :

$$(12) \quad \hat{\beta}_{2SLS} = \begin{pmatrix} \hat{\Gamma}_{2SLS} \\ \hat{\beta}_{2SLS} \end{pmatrix} = (Z'Z)^{-1}Z'y$$

where $Z = (\hat{Y}|x)$.

Bootstrapping the 2SLS estimates proceeds as follows. First, estimated residuals for the structural equation (8) are obtained using (8) with parameters replaced by their 2SLS estimates, as:

$$(13) \quad \hat{u} = y - Y\hat{\Gamma}_{2SLS} - x\hat{\beta}_{2SLS}.$$

Similarly, estimated residuals for the reduced form equation (9) are obtained using (9) with parameters replaced by their OLS estimates, as:

$$(14) \quad \hat{v} = Y - X\hat{\pi}.$$

Then a random sample, with replacement, of the rows of the $n \cdot (g + 1)$ matrix $(\hat{u}|\hat{v})$ is drawn until a new $n \cdot (g + 1)$ matrix $(\hat{u}^*|\hat{v}^*)$ is generated. In this sample, it is possible that some rows of $(\hat{u}|\hat{v})$ are drawn more than once and some may not be drawn at all.

Once $(\hat{u}^*|\hat{v}^*)$ is drawn, a simulated $(n \cdot g)$ matrix of right-hand side endogenous variable outcomes is generated as

$$(15) \quad \hat{Y}^* = X\hat{\pi} + \hat{v}^*$$

and in turn an $(n \cdot 1)$ vector of simulated dependent variable outcomes is calculated as

$$(16) \quad \hat{y}^* = \hat{Y}^*\hat{\Gamma}_{2SLS} + x\hat{\beta}_{2SLS} + \hat{u}^*.$$

In the bootstrapping context, $(\hat{y}^*|\hat{Y}^*|X)$ is then treated as a new set of observations on the processes (8) and (9), and a new outcome for the 2SLS estimator is calculated from these new observations, yielding the bootstrapped sample outcome $\hat{\beta}_{2SLS}^*$. Repeated random samples of the rows of $(\hat{u}|\hat{v})$ having size n are drawn, equations (15) and (16) are used to calculate $\hat{Y}^*$ and $\hat{y}^*$ outcomes, and bootstrapped outcomes $\hat{\beta}_{2SLS}^*$ are generated until a prespecified bootstrap sample size of, say, t bootstrapped outcomes of $\hat{\beta}_{2SLS}^*$ are obtained. Then as in the OLS approach described previously, the bootstrapped sample

means, $\bar{\beta}_{2SLS}^*$, can be calculated and used to approximate the expectation of β_{2SLS} , the sample variances of the bootstrapped sample outcomes can be used to approximate the variances of the elements in β_{2SLS} , and the empirical distribution of bootstrap sample outcomes can be used to approximate the sampling distribution of β_{2SLS} .

The above approach is extended to the case where lagged endogenous variables appear as explanatory variables by simply maintaining the recursive nature of how the bootstrapped outcomes of lagged dependent variables evolve. Further details can be found in Herrmann (1990, p. 333-336).

The Bayesian bootstrapping technique is a computer-intensive method for performing Bayesian analysis of econometric models that utilizes the bootstrapping procedure discussed above. The procedure is robust in that it does not require any a priori assumption regarding the functional form of the likelihood function for the parameters of the model--the likelihood function is approximated using a bootstrapping procedure. Furthermore, the procedure essentially uses numerical as opposed to analytical integration to obtain posterior probabilities and moments regarding parameters of interest in the model, thereby allowing rather complex posterior distributions to be analyzed that would be quite difficult or impossible to analyze analytically. A related issue is that the use of conjugate prior distributions to obtain posteriors, a restriction often adopted in Bayesian analyses to attain analytical tractability in the posterior analysis, is quite unnecessary in the computer-based bootstrapped Bayesian approach.

In common with the usual limited information Bayesian approach to analyzing a given structural equation within a system of simultaneous

equations, the conceptualization of the problem begins with a likelihood function, $L(\beta, \pi, \Omega | y, Y)$, which summarizes the sample data information on the parameters, β , of the structural equation explaining y , on the parameters, π , of the reduced form representation of endogenous explanatory variables Y , and on the covariance matrix, Ω , of the structural equation and reduced form disturbances (see Zellner, 1971, pp. 267-268). The likelihood function can be thought of as being algebraically equivalent to the joint density function of the observations on y and Y . For the sake of expositional clarity, it will be assumed that there are no lagged endogenous variables in the system--the arguments that follow can be straightforwardly generalized to incorporate lags of endogenous variables.

It is assumed that the researcher has available a prior distribution on the parameters of the problem that summarizes his or her prior information regarding the structural parameters, β . In keeping with the limited information context of the analysis, it is assumed that the prior information on π is diffuse (uninformative), and it is assumed that the prior information on the covariance matrix parameters is diffuse as well. Thus the prior distribution will be of the general form:

$$(17) \quad P(\beta, \pi, \Omega) \propto f(\beta).$$

The posterior distribution for the parameters, summarizing both sample and prior information, is then defined via Bayes rule (up to a constant of proportionality) as:

$$(18) \quad h(\beta, \pi, \Omega | y, Y) \propto L(\beta, \pi, \Omega | y, Y) P(\beta, \pi, \Omega) \\ \propto L(\beta, \pi, \Omega | y, Y) f(\beta).$$

The marginal posterior distribution appropriate for making inferences about the structural parameters $\underline{\beta}$ is obtained by integrating out π and Ω from the joint posterior distribution (18) as:

$$\begin{aligned}
 (19) \quad h_{*}(\underline{\beta}|y, Y) &\propto \int_{\pi} \int_{\Omega} h(\underline{\beta}, \pi, \Omega|y, Y) d\Omega d\pi \\
 &\propto f(\underline{\beta}) \int_{\pi} \int_{\Omega} L(\underline{\beta}, \pi, \Omega|y, Y) d\Omega d\pi \\
 &\propto f(\underline{\beta}) L_{*}(\underline{\beta}|y, Y).
 \end{aligned}$$

At this point, the analytical approach to obtaining Bayesian point estimates for $\underline{\beta}$ (that minimize expected posterior quadratic loss) would be to calculate the mean of the marginal posterior distribution for $\underline{\beta}$. First of all, the constant factor of proportionality of the marginal posterior distribution can be found by integrating the right-hand side of (19) with respect to $\underline{\beta}$, as:

$$(20) \quad \gamma = \int_{\underline{\beta}} f(\underline{\beta}) L_{*}(\underline{\beta}|y, Y) d\underline{\beta}.$$

Then the marginal posterior distribution for $\underline{\beta}$ can be defined with equality as:

$$(21) \quad h_{*}(\underline{\beta}|y, Y) = \gamma^{-1} f(\underline{\beta}) L_{*}(\underline{\beta}|y, Y).$$

Finally, the posterior mean of $\underline{\beta}$ can be defined as:

$$(22) \quad \hat{\underline{\beta}}_B = E\underline{\beta} = \int_{\underline{\beta}} \underline{\beta} h_{*}(\underline{\beta}|y, Y) d\underline{\beta}.$$

Posterior probability statements regarding the parameter vector can be obtained by integrating $h_{*}(\underline{\beta}|y, Y)$ over the appropriate set of points for $\underline{\beta}$.

What differentiates the bootstrapping approach to Bayesian analysis from the analytical approach is the way the $L_*(\beta|y,Y)$ function in (19) is obtained. Essentially, the bootstrapping approach replaces the integrated likelihood function $L_*(\beta|y,Y)$ with a bootstrapped approximation defined by resampling the data, generating a bootstrapped sample of 2SLS estimator outcomes, and using the bootstrap sample to calculate a kernel density-based approximation to $L_*(\beta|y,Y)$ to be used in the Bayesian posterior analysis, similar to the suggestion of Boos and Monahan (1986). If interest centers exclusively on calculating posterior moments or posterior probabilities of given events for β , it will be shown that the explicit calculation of a kernel density estimate is not even necessary, so that the approach of Boos and Monahan can be simplified to some degree.

The Bayesian bootstrapping procedure begins with the generation of a bootstrap sample of m outcomes for the 2SLS estimator, say as $(\hat{\beta}_1^*, \dots, \hat{\beta}_m^*)$, using the bootstrapped 2SLS procedure described previously. Then the kernel density estimator,

$$(23) \quad \hat{g}(w) = (m\tau)^{-1} \sum_{j=1}^m K[(w - (\hat{\beta}_j^* - \hat{\beta}_{2SLS}))/\tau]$$

is used to estimate the sampling density of $(\hat{\beta}_{2SLS} - \beta)$, where τ is the usual bandwidth parameter of the kernel (see Eubank, 1988, Chapter 4 for an extensive discussion of kernel estimators). Letting $w = z - \beta$, $\hat{g}(z - \beta)$ can be interpreted as an estimate of the sampling density of $\hat{\beta}_{2SLS}$, given β , and fixing z at the observed 2SLS estimate as $z = \hat{\beta}_{2SLS}$, (23) can be interpreted as an estimate of the likelihood of β as:

$$\begin{aligned}
 (24) \quad \hat{L}_*(\beta | \hat{\beta}_{2SLS}) &= \hat{g}(\hat{\beta}_{2SLS} - \beta) \\
 &= (m\tau)^{-1} \sum_{j=1}^m K[(2\hat{\beta}_{2SLS} - \beta - \hat{\beta}_j^*)/\tau].
 \end{aligned}$$

Substituting $\hat{L}_*(\beta | \hat{\beta}_{2SLS})$ in place of $L_*(\beta | y, Y)$ in (19)-(21) results in the bootstrapped approximation to the posterior distribution of β , i.e.,

$$(25) \quad \hat{h}_*(\beta | \hat{\beta}_{2SLS}) = \hat{\tau}^{-1} f(\beta) \hat{L}_*(\beta | \hat{\beta}_{2SLS}).$$

At this point, $\hat{h}_*$ can be used for making inferences about β . In particular, to calculate the r^{th} posterior moment, one would evaluate:

$$(26) \quad \hat{E}\beta^r = \int_{\beta} \beta^r \hat{h}_*(\beta | \hat{\beta}_{2SLS}) d\beta.$$

It will now be shown that $\hat{L}_*(\beta | \hat{\beta}_{2SLS})$ need not actually be calculated to determine the posterior moments defined by (26).¹ Let $t_j = 2\hat{\beta}_{2SLS} - \hat{\beta}_j^*$, and define:

$$(27) \quad K_{\tau,r}^*(t) = \int_{\beta} \beta^r f(\beta) \tau^{-1} K((t - \beta)/\tau) d\beta.$$

Then it follows (compare to 26) that:

$$(28) \quad \hat{E}\beta^r = m^{-1} \sum_{j=1}^m K_{\tau,r}^*(t_j) / [m^{-1} \sum_{j=1}^m K_{\tau,0}^*(t_j)].$$

By the mean value theorem,

$$(29) \quad \lim_{\tau \rightarrow 0} K_{\tau,r}^*(t) = t^r f(t).$$

¹We are indebted to John Monahan (personal communication) for providing an outline of the proof of this proposition.

Therefore,

$$(30) \quad \tau \rightarrow 0 \Rightarrow \hat{E}\beta^r \rightarrow \frac{\sum_{j=1}^m t_j^r f(t_j)}{\sum_{j=1}^m f(t_j)}.$$

The result (30) states that as the bandwidth of the kernel density estimator decreases to zero, $\hat{E}\beta^r$ can be ever more accurately approximated by a weighted average of the bootstrapped outcomes of $t_j^r = (2\hat{\beta}_{2SLS} - \hat{\beta}_j^*)^r$. Now note that as $m \rightarrow \infty$, $\tau \rightarrow 0$, and $m\tau \rightarrow \infty$, the kernel density estimator of the density of $(\hat{\beta}_{2SLS} - \beta)$ will converge to the density derived from the empirical distribution function of the rows of the disturbance matrix $(\hat{u}|\hat{v})$ which is the operational objective of performing the bootstrapping procedure. Then for large enough bootstrapped sample sizes, and concurrently for small enough bandwidths, estimates of the posterior moments, $\hat{E}\beta^r$, can be calculated using the weighted average approach indicated by (30).

It is then straightforward to demonstrate that estimates of the posterior probability that $\beta \in \Omega$ can be calculated using an analogous weighted average approach. Specifically, if, in the preceding argument, r is set to zero, and the range of integration is set equal to Ω , then:

$$(31) \quad \hat{P}(\beta \in \Omega) = \frac{\sum_{j=1}^m f(t_j) I_{\Omega}(t_j)}{\sum_{j=1}^m f(t_j)}$$

where $I_{\Omega}(t_j)$ is a standard indicator function which equals 1 when $t_j \in \Omega$ and equals 0 when $t_j \notin \Omega$. Calculations of the type (31) can be used to assess the credibility of various hypotheses concerning the likely range of values for entries in the β -vector.

The Bootstrapped Bayesian 2SLS computer program is based on the weighted average calculation procedures for generating the Bayesian estimates and posterior probabilities defined by (30) (with $r = 1$) and (31). In all cases, bootstrapped sample sizes of 5000 were found to provide stable Bayesian parameter estimates. The range of prior distributions that is accommodated by the program is completely general.

The computer program was also written to perform Bayesian bootstrapped estimation of quarterly variance estimates to assess the presence of quarterly heteroskedasticity in the error terms of the equations in the model. Furthermore, first order autocorrelation was assessed by Bayesian bootstrapped estimates to the first order autocorrelation coefficient. Further information regarding how the assessment of heteroskedasticity and autocorrelation were made can be found in Herrmann (1990, pp. 346-350.)

Model Specification and Estimation

The flow chart in Figure 1 illustrates the modelled international world trade flows of fresh/frozen salmon between major salmon producing and salmon-consuming regions. The arrows designate direction of trade flows that are either directly or indirectly accounted for in the salmon model. The region designated as the European Economic Community (EEC) will, for this study, include all of the EEC member countries (Belgium, Luxembourg, Denmark, West Germany, France, Ireland, Italy, Netherlands, United Kingdom, Greece, Portugal, and Spain) as well as Sweden and Switzerland.

Japan is the major consumer of salmon, consuming more than half of the world's salmon production; it is also the major importer of salmon in the world. The EEC is the second largest importer of salmon, and different EEC member countries share many similarities in consumption patterns. Most of the

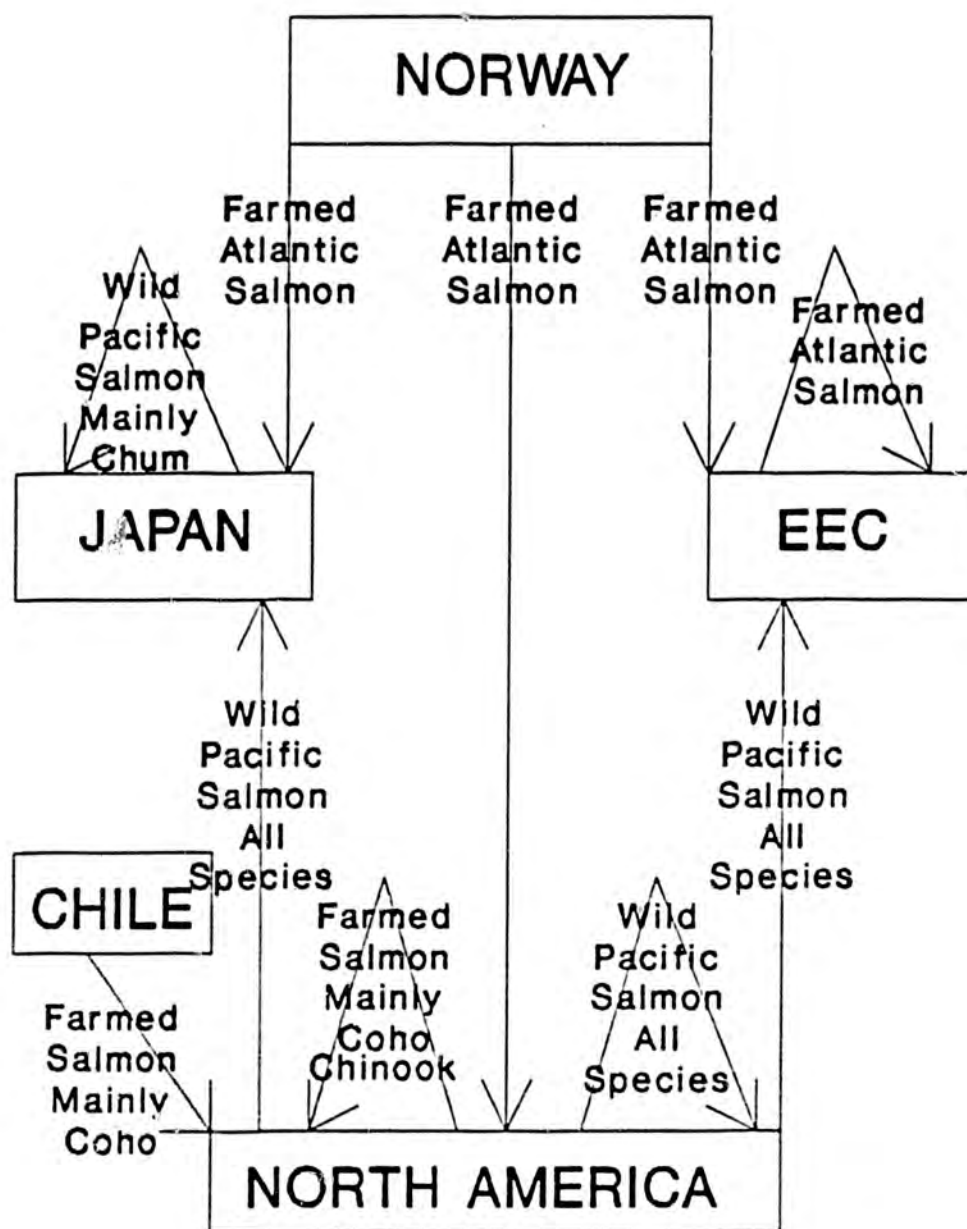


FIGURE 1. International Salmon Trade Flow Chart

EEC countries consume the majority of their salmon as cold smoked salmon. Also, because there are no tariffs among EEC countries, there is a significant trade volume of similar salmon products.

The model accounts for flows of farmed salmon from Norway, Scotland, Chile, and British Columbia. The farmed salmon from Norway and Scotland is Atlantic salmon, and most of the farmed salmon from Chile is coho. The Chilean shipments also include small amounts of farmed chinook and Atlantic salmon. North American salmon exports include all species of Pacific salmon. Japanese landings of salmon also include all species of Pacific salmon although almost all Japanese landings have been chum salmon.

To keep the model tractable and because of data limitations, some countries and salmon species were aggregated; in addition, some markets were omitted entirely. Nevertheless, it is felt that the resulting model is sufficiently inclusive so as to provide an appropriate tool for addressing the objectives of the project.

Producing and Trading Regions. The world salmon market was divided into five producing, consuming, and/or trading regions. These regions are North America (the United States and Canada), Japan, Norway, Chile, and EEC (member countries as well as two non-members, Sweden and Switzerland).

Norway, Scotland, Chile, and British Columbia represent the major sources of farmed salmon production: together they represent approximately 80 percent of the world's production of farmed salmon, and they represent 95 percent if the Japanese pan-sized coho production, which is all consumed domestically in Japan, is subtracted from the world totals. For Norway, the export markets of EEC, Japan, and North America were modelled. These three markets account for approximately 95 percent of Norwegian exports of farmed

Atlantic salmon. Norway's domestic consumption is approximately 10-15 percent of its production, and generally represents fish that does not make a high enough grade to be exported.

Chile's production is relatively recent, and the export market to the United States, the largest importer of Chilean salmon through 1988, was modelled. Recent trends indicate that, in the future, the Japanese market for Chilean salmon might become significant enough to be appropriate and feasible to model. Most Scottish farmed Atlantic salmon is consumed in the EEC countries; minor amounts are exported to the United States. Most of Canada's farmed production comes from British Columbia and is traded to the United States. British Columbia's salmon is mainly a mixture of coho and chinook. Other countries' farmed production, such as Ireland's and New Zealand's, was omitted because of lack of available data or because of its minor role in world markets.

For wild Pacific salmon supplies, the producing regions included are North America and Japan. The United States and Canada have been combined as "North America" because they share salmon which use the same migration patterns and because they also trade in most of the same markets. Furthermore, there are no trade barriers on salmon trade between Canada and the United States. Many experts believe that the catch from Alaska sets the prices for fresh/frozen salmon, with price differentials coming from quality differences due to harvest technique, handling care, area of ocean in which the salmon were caught, and timing of the harvest. The major export market for North America's salmon is Japan, with the EEC countries importing most of the remainder.

Virtually all of Japan's production is consumed domestically; therefore, Japan's own salmon is hypothesized to compete with other Pacific salmon imports into Japan. The USSR is the only region with a measurable catch of salmon other than North America and Japan. Most of this salmon is pink and chum and remains inside of the Soviet Union or is exported to other Eastern-bloc countries. Most of the Soviet pink salmon is canned. Lack of data and the relatively minor role of the Soviet catch in world salmon markets precluded the modelling of the Soviet influence.

Species. Salmon was divided into three product groups consisting of Atlantic salmon, high-valued Pacific salmon (chinook, coho, and sockeye), and low-valued Pacific salmon (chum and pink). The groupings of the Pacific salmon were made on the basis of the value received by fishermen. In 1988, the average exvessel prices received by the United States for high-valued Pacific species ranged from \$1.97 to \$2.57 per pound, while the average prices received for the low-valued species ranged from \$0.72 to \$0.92 per pound. Similar price differentials existed in Canada.

General Model Overview. The model contained 36 equations, of which 16 were behavioral equations estimated by the Bootstrapped Bayesian 2SLS technique. The following is a list of the behavioral equations that were econometrically estimated.

1. Norwegian allocation of farm-raised Atlantic salmon
 - Quantity allocated to the EEC
2. EEC demand for salmon
 - Quantity demanded of Scottish and Norwegian farmed Atlantic salmon

- Quantity demanded of North American high-valued Pacific salmon
 - Quantity demanded of North American low-valued Pacific salmon
3. Japanese demand for salmon
- Quantity demanded of Norwegian farmed Atlantic salmon
 - Quantity demanded of North American high-valued Pacific salmon
 - Quantity demanded of North American low-valued Pacific salmon
4. North American allocation of high-valued salmon
- Quantity allocated to Japan
 - Quantity allocated to the EEC
5. North American allocation of low-valued salmon
- Quantity allocated to Japan
 - Quantity allocated to the EEC
6. North American demand
- Quantity demanded of Norwegian farmed Atlantic salmon
7. North American inventory holdings
- Quantity of high-valued salmon inventory
 - Quantity of low-valued salmon inventory
8. North American exvessel prices
- Price of high-valued salmon
 - Price of low-valued salmon

Remaining equations in the model consisted of identities that generated closure of the model by enforcing demand and supply quantity equilibria in the various regional and world salmon markets, and that linked the various regional prices using exchange rates, tariffs, and price indices. The

estimation results and a listing of the various identities will be presented in the section "V. Findings".

5. Model Simulation and Forecasting

Historical Goodness of Fit Measures

The estimated model of world salmon trade was utilized to simulate the historical quarterly values of the endogenous variables for the period 1983-1988. Simulation was performed using the SAS SIMNLIN procedure. The goodness of fit between actual and simulated values was judged by an array of standard goodness of fit statistics which included:

- 1) mean absolute percent error
- 2) root mean square percent error
- 3) correlation between actual and simulated values
- 4) Theil's U_1 inequality coefficient
- 5) mean square error decomposition into U_m , U_r , and U_d proportions
(mean, regression, and disturbance proportions, respectively)

(see Theil, 1971; Maddala, 1977).

Problems can arise when the standard goodness of fit statistics are used to evaluate simulations of extremely volatile data. It is possible when one is simulating variables, such as quarterly salmon quantities, that the standard goodness of fit statistics overstate the importance of errors in the historical simulation period when salmon quantities are low and market outcomes less important, and understate forecasting accuracy when quantities are high and market outcomes more important.

Using the mean absolute percentage error as an example, if quantities are very low in a period, the absolute percentage error may be very high for a small nominal error in the simulation. For the same magnitude of error in

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

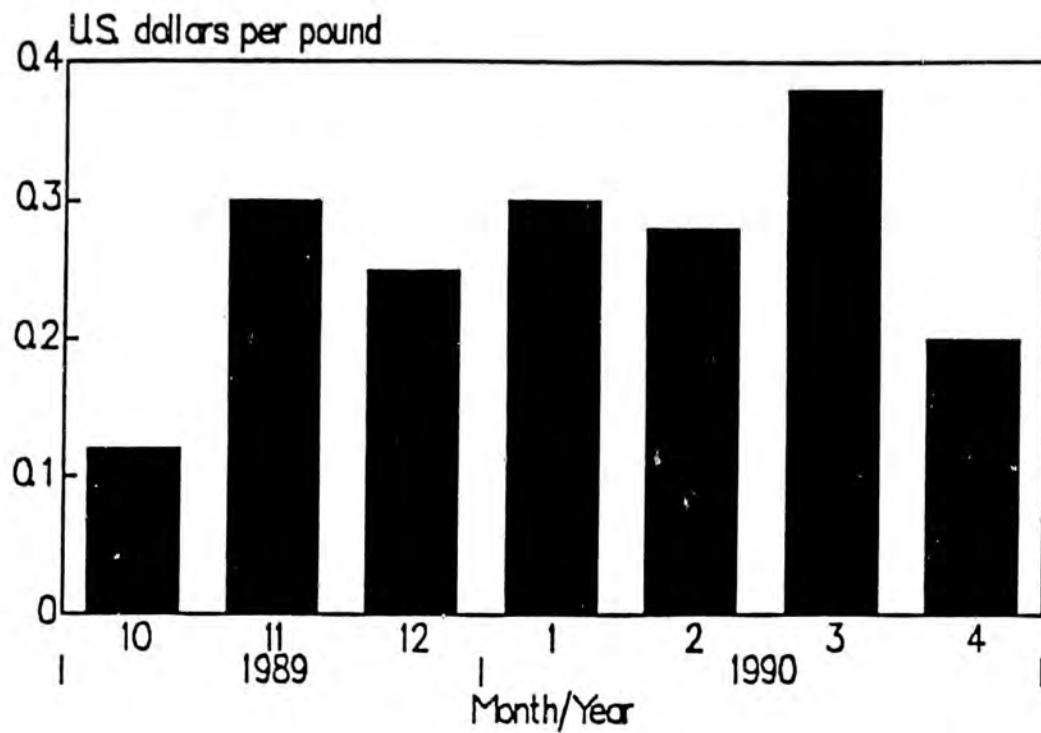


FIGURE 2. Differences Between Norwegian and North American Farmed Atlantic Salmon Prices from October 1989 to May 1990 (in U.S. dollars per pound) (ADAPTED FROM: Seafood Price-Current. Toms River, NJ: Urner Barry Publications, Inc. 1987-90, various dates; own model predictions.)

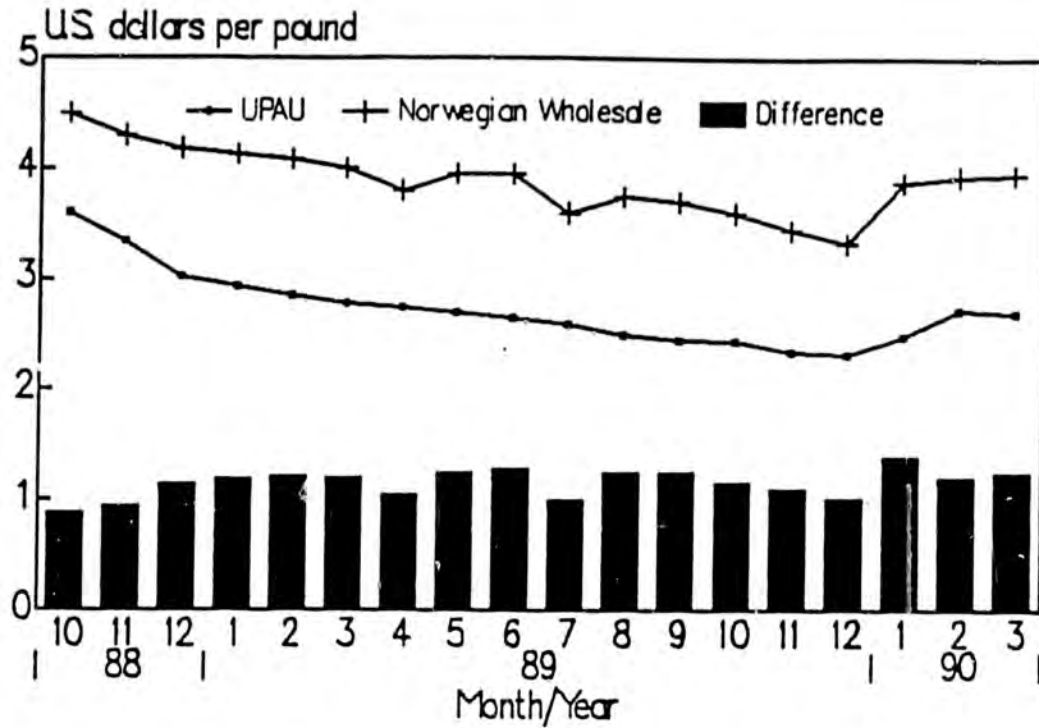


FIGURE 3. Norwegian Farmed Atlantic Salmon Wholesale Price in North America vs. Norwegian FOB Farmed Atlantic Salmon Export Price (UPAU) and the Spread (U.S. dollars per pound) (ADAPTED FROM: Seafood Price-Current. Toms River, NJ: Urner Barry Publications, Inc. 1987-90, various dates; own model predictions.)

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, $= \text{Ln}((\text{TSUPL}/\text{QLJ})-1)$

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

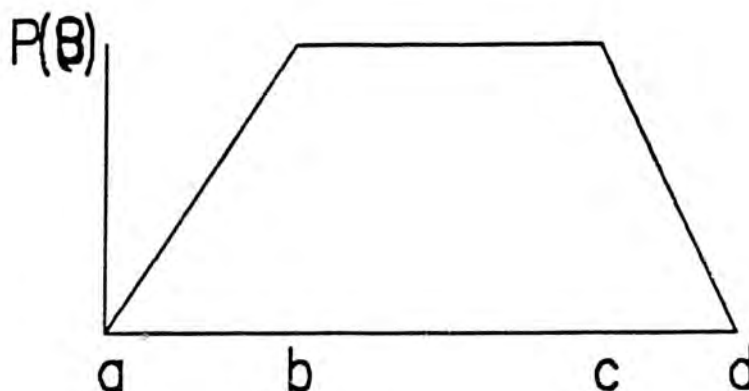


FIGURE 4. Quadrilateral Prior Probability Density Function.

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

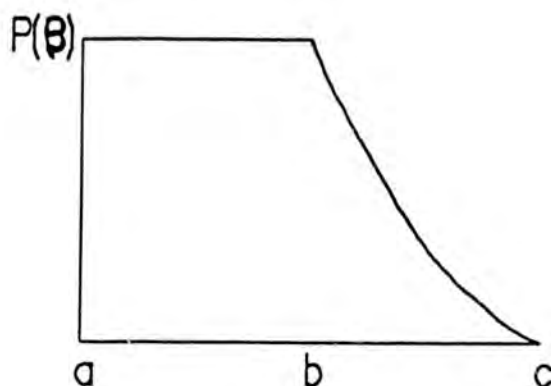


FIGURE 5. Spliced Uniform-Exponential Prior Probability Density Function

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>HYPOIG</u>	<u>HYPOIN</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>HYPOIG</u>	<u>HYPOIN</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) $UPLE = (EPL * USAECU) * (ECPI / ETARIFF);$
- (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

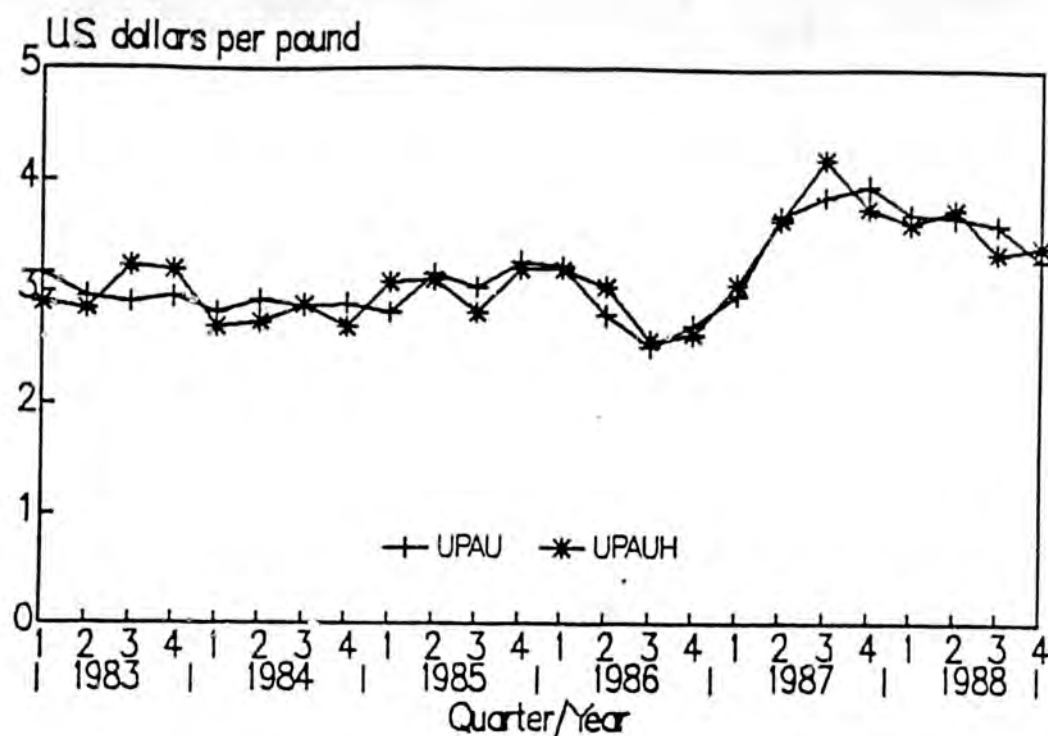


FIGURE 6. Predicted (UPAUH) vs. Actual (UPAU) North American Atlantic Salmon (FOB Norway) Price in U.S. Dollars for Norwegian Farmed Atlantic Salmon Imported into North America, 1983-88.

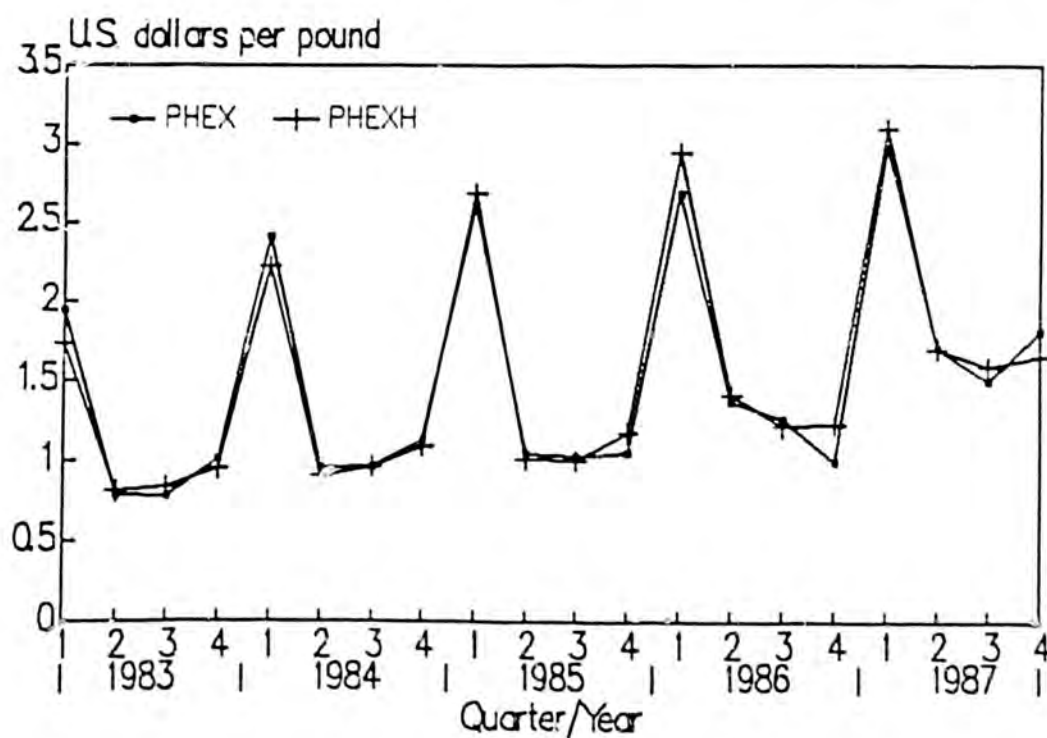


FIGURE 7. Predicted (PHEXH) vs. Actual (PHEX) North American Price of High-Valued Pacific Salmon at the Exvessel Level in U.S. Dollars, 1983-87.

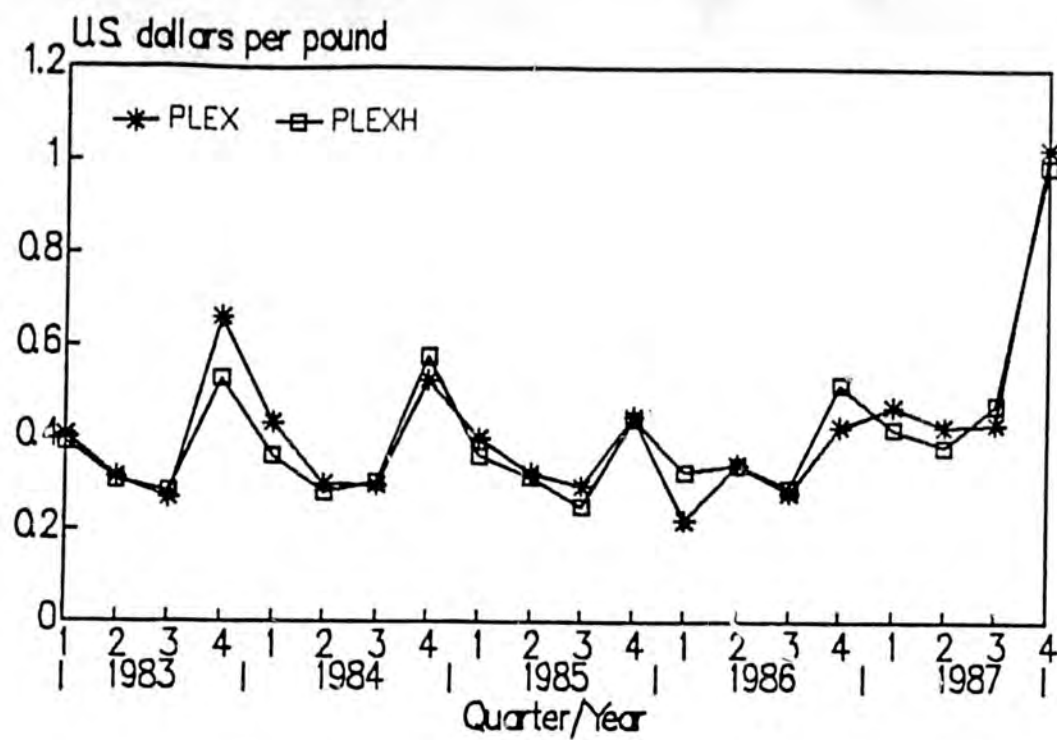


FIGURE 8. Predicted (PLEXH) vs. Actual (PLEX) North American Price of Low-Valued Pacific Salmon at the Exvessel Level in U.S. Dollars, 1983-87.

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 UPHM	Scenario UPHM3	Percentage Change	Base PHEXM	Scenario PHEXM3	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

TABLE 19. Continued

Quarter/ Year	Base PLEXH	Scenario PLEXH3	Percentage Change	Base UPLH	Scenario UPLH3	Percentage Change
1/1983	0.392	0.392	-0.01	1.45	1.45	0.01
2/1983	0.308	0.302	-1.93	1.19	1.28	-0.31
3/1983	0.285	0.268	-5.91	1.03	1.00	-2.28
4/1983	0.527	0.506	-3.99	1.35	1.33	-1.26
1/1984	0.358	0.349	-2.56	1.37	1.36	-0.82
2/1984	0.280	0.272	-3.06	1.16	1.15	-0.80
3/1984	0.303	0.286	-5.68	1.08	1.06	-2.04
4/1984	0.574	0.551	-4.00	1.44	1.42	-1.14
1/1985	0.360	0.350	-2.76	1.31	1.30	-0.88
2/1985	0.313	0.304	-2.78	1.19	1.18	-0.70
3/1985	0.250	0.235	-6.02	0.94	0.92	-2.36
4/1985	0.439	0.417	-4.98	1.31	1.28	-1.78
1/1986	0.326	0.314	-3.48	1.26	1.25	-1.22
2/1986	0.340	0.329	-3.19	1.14	1.13	-0.91
3/1986	0.291	0.274	-5.88	1.00	0.98	-2.24
4/1986	0.515	0.492	-4.45	1.39	1.37	-1.38
1/1987	0.418	0.406	-2.95	1.48	1.46	-0.96
2/1987	0.380	0.367	-3.42	1.35	1.34	-0.99
3/1987	0.471	0.446	-5.46	1.31	1.29	-1.83
4/1987	0.989	0.949	-4.07	2.01	1.99	-1.04
1/1988	0.827	0.805	-2.73	2.04	2.03	-0.78
2/1988	0.626	0.602	-3.84	2.04	2.02	-0.97
3/1988	0.615	0.584	-4.99	1.80	1.77	-1.36
4/1988	0.907	0.871	-4.00	2.07	2.05	-0.96

TABLE 20. Scenario 4, North American Low-Valued Salmon Landings Decrease by 10 Percent: Average Total Analysis

Variable	Base Quarter	Scenario Quarter	Percentage Change
EQAEH	19,811,930	19,811,887	0.00
NQAEH	14,578,054	14,578,012	0.00
QAUH	3,746,145	3,746,187	0.00
NPAEH	21.059	21.063	0.02
EPAEH	2.890	2.890	0.02
NPAUH	23.094	23.097	0.01
UPAUH	3.166	3.167	0.01
JPAJH	467.660	467.742	0.02
QHJH	42,002,766	41,939,223	-0.15
QHEH	6,958,529	7,012,927	0.78
UPHJH	2.356	2.357	0.06
JPHJH	426.640	426.852	0.05
UPHEH	2.419	2.423	0.15
EPHEH	2.576	2.580	0.17
UPHH	2.365	2.367	0.07
QLJH	10,939,052	10,511,306	-3.91
QLEH	8,242,731	8,141,653	-1.23
UPLJH	1.173	1.199	2.22
JPLJH	203.240	207.621	2.16
UPLEH	1.569	1.587	1.17
EPLH	1.618	1.637	1.15
UPLH	1.343	1.369	1.89
PHEXH	1.271	1.272	0.05
PLEXH	0.379	0.403	6.22

TABLE 21. Scenario 4, North American Low-Valued Salmon Landings Decrease by 10 Percent: Quarter-by-Quarter Analysis

Quarter/ Year	Base UPAUH	Scenario UPAUH4	Percentage Change	Base UPHH	Scenario UPHH4	Percentage Change	Base PHEXH	Scenario PHEXH4	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	3.232	0.03	1.722	1.724	0.12	0.843	0.844	0.10
4/1983	3.189	3.191	0.05	2.036	2.040	0.22	0.957	0.959	0.20
1/1984	2.678	2.678	0.01	1.750	1.750	0.03	2.231	2.232	0.05
2/1984	2.721	2.721	0.00	1.753	1.753	0.00	0.921	0.921	0.00
3/1984	2.875	2.876	0.03	1.851	1.854	0.12	0.975	0.976	0.10
4/1984	2.678	2.679	0.05	2.186	2.190	0.20	1.105	1.107	0.18
1/1985	3.084	3.085	0.01	1.833	1.833	0.02	2.689	2.690	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	2.809	0.03	1.928	1.930	0.08	1.008	1.008	0.07
4/1985	3.204	3.205	0.04	2.250	2.254	0.17	1.188	1.190	0.15
1/1986	3.200	3.200	0.00	1.996	1.997	0.02	2.946	2.947	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	2.552	0.02	2.405	2.406	0.05	1.232	1.223	0.04
4/1986	2.611	2.611	0.02	2.588	2.589	0.05	1.236	1.237	0.05
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	4.188	0.02	2.699	2.700	0.05	1.590	1.590	0.04
4/1987	3.753	3.754	0.02	3.122	3.125	0.08	1.663	1.664	0.03
1/1988	3.613	3.613	0.00	3.419	3.419	0.00	5.652	5.652	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	3.352	0.02	3.640	3.642	0.03	2.107	2.108	0.03
4/1988	3.406	3.407	0.01	3.701	3.702	0.02	2.000	2.000	0.02

TABLE 21. Continued

Quarter/ Year	Base PLEXH	Scenario PLEXH4	Percentage Change	Base UPLH	Scenario UPLH4	Percentage Change
1/1983	0.392	0.392	0.01	1.449	1.448	-0.01
2/1983	0.308	0.314	1.96	1.286	1.289	0.23
3/1983	0.285	0.305	6.90	1.028	1.054	2.53
4/1983	0.527	0.551	4.57	1.350	1.369	1.41
1/1984	0.358	0.368	2.92	1.375	1.387	0.91
2/1984	0.280	0.290	3.40	1.161	1.171	0.85
3/1984	0.303	0.323	6.63	1.082	1.107	2.27
4/1984	0.574	0.601	4.59	1.435	1.453	1.27
1/1985	0.360	0.372	3.15	1.314	1.327	0.98
2/1985	0.313	0.323	3.13	1.193	1.202	0.76
3/1985	0.250	0.268	7.05	0.942	0.967	2.63
4/1985	0.439	0.464	5.72	1.306	1.332	1.95
1/1986	0.326	0.339	3.95	1.262	1.279	1.34
2/1986	0.340	0.352	3.59	1.136	1.147	0.99
3/1986	0.291	0.311	6.89	1.002	1.027	2.50
4/1986	0.515	0.542	5.13	1.393	1.415	1.53
1/1987	0.418	0.432	3.36	1.477	1.493	1.07
2/1987	0.380	0.394	3.85	1.350	1.364	1.06
3/1987	0.471	0.501	6.37	1.315	1.341	2.04
4/1987	0.989	1.036	4.69	2.010	2.033	1.17
1/1988	0.827	0.853	3.13	2.044	2.062	0.88
2/1988	0.626	0.653	4.36	2.042	2.064	1.06
3/1988	0.615	0.651	5.81	1.796	1.823	1.51
4/1988	0.907	0.949	4.59	2.073	2.094	1.06

fourth quarters were 0.2 million pounds, 13.3 million pounds, and 28.6 million pounds, respectively.

From the average total analysis, it is evident that a 10 percent increase in low-valued salmon landings would largely impact the low-valued salmon markets with little impact on high-valued and farmed Atlantic salmon markets. Japan, with a high own-price demand elasticity for low-valued salmon, would receive much more of the increased supplies than would the EEC. The increased low-valued salmon landings would decrease the weighted average export price of low-valued salmon by 1.71 percent and the low-valued salmon exvessel price by 5.34 percent. The existence of a substitution effect between high- and low-valued salmon in the EEC, but not in Japan, contributes to the greater increase in low-valued landings being exported to Japan than to the EEC.

The largest percentage change in a variable other than variables pertaining to the low-valued salmon market occurred in the high-valued salmon exports to the EEC which decreased by 0.7 percent. Because of the substitution in the EEC between high- and low-valued salmon, there would be a small reallocation of high-valued salmon from the EEC to Japan. The overall decrease in the exvessel price of high-valued salmon was insignificant. The Atlantic salmon market was left largely unaffected.

As in the scenario for changes in high-valued landings, the results of a decrease in low-valued Pacific salmon landings induced effects that were largely opposites of those for the low-valued Pacific salmon landing increases. On average, a 10 percent decrease in low-valued salmon landings would increase the exvessel price of low-valued salmon by 6.22 percent. Quantities of high-valued salmon exports would increase slightly to the EEC

because of the positive cross-price elasticity between high- and low-valued salmon in the EEC.

Group 3: Norwegian and Scottish Farmed Atlantic Salmon Total Exports $\pm$ 10% Relative to Historical Levels

These scenarios were designed to measure the effects on the world salmon markets of increases or decreases in production and concomitantly increases or decreases in exportation from the main producers of farmed salmon. The results are presented in Tables 22-25.

The increases in Atlantic salmon exports would be disproportionately allocated to the EEC relative to the North American market. The EEC's importation of Norwegian Atlantic salmon would increase by 11.46 percent, and the importation of Scottish and Norwegian Atlantic salmon combined would increase by 11.08 percent. This larger increase in the EEC market is in part due to a larger short- and long-run demand price elasticity in the EEC as compared to the North American market for Atlantic salmon.

Prices of Atlantic salmon would decrease approximately 2.5 percent in all markets, except Japan, indicating that Atlantic salmon was allocated such that the price ratio between the EEC and North American markets remained relatively constant. The exports of Norwegian salmon to Japan were assumed exogenous during the historical time period as Norway sought to penetrate the Japanese market by introducing farmed Atlantic salmon to Japan. It should be noted that if total Norwegian salmon exports had increased by 10 percent, the Norwegian exporters might have been willing to send more Atlantic salmon to Japan in pursuit of their market development strategy. If Norway had also increased Atlantic salmon exports to Japan by 10 percent, the price of

TABLE 22. Scenario 5, Norwegian and Scottish Farmed Salmon Exports Increase by 10 Percent: Average Total Analysis

Variable	Base Quarter	Scenario Quarter	Percentage Change
EQAEH	19,811,930	22,006,324	11.08
NQAEH	14,578,054	16,249,061	11.46
QAUH	3,746,145	3,960,594	5.72
NPAEH	21.059	20.534	-2.49
EPAEH	2.890	2.817	-2.50
NPAUH	23.094	22.493	-2.60
UPAUH	3.166	3.083	-2.63
JPAJH	467.660	467.260	-0.09
QHJH	42,002,766	42,152,463	0.36
QHEH	6,958,529	6,767,433	-2.75
UPHJH	2.356	2.353	-0.13
JPHJH	426.640	426.129	-0.12
UPHEH	2.419	2.411	-0.35
EPHEH	2.576	2.565	-0.41
UPHH	2.365	2.361	-0.17
QLJH	10,939,052	10,942,828	0.03
QLEH	8,242,731	8,231,440	-0.14
UPLJH	1.173	1.173	-0.02
JPLJH	203.240	203.203	-0.02
UPLEH	1.569	1.569	-0.03
EPLH	1.618	1.618	-0.04
UPLH	1.343	1.343	-0.04
PHEXH	1.271	1.265	-0.50
PLEXH	0.379	0.379	-0.04

TABLE 23. Scenario 5, Norwegian and Scottish Farmed Salmon Production Increase by 10 Percent: Quarter-by-Quarter Analysis

Quarter/ Year	Base UPAUH	Scenario UPAUH5	Percentage Change	Base UPHH	Scenario UPHH5	Percentage Change	Base PHEXH	Scenario PHEXH5	Percentage Change
1/1983	2.901	2.717	-6.35	1.582	1.564	-1.16	1.731	1.695	-2.04
2/1983	2.849	2.736	-3.94	1.754	1.749	-0.26	0.815	0.808	-0.93
3/1983	3.231	3.105	-3.91	1.722	1.718	-0.26	0.843	0.836	-0.89
4/1983	3.189	3.066	-3.86	2.036	2.026	-0.48	0.957	0.947	-1.00
1/1984	2.678	2.602	-2.85	1.750	1.739	-0.61	2.231	2.210	-0.94
2/1984	2.721	2.648	-2.68	1.753	1.749	-0.23	0.921	0.915	-0.65
3/1984	2.875	2.816	-2.05	1.851	1.847	-0.25	0.975	0.969	-0.56
4/1984	2.678	2.610	-2.54	2.186	2.175	-0.47	1.105	1.097	-0.77
1/1985	3.084	2.979	-3.43	1.833	1.823	-0.54	2.689	2.662	-1.00
2/1985	3.103	3.014	-2.88	1.786	1.782	-0.22	1.022	1.015	-0.68
3/1985	2.808	2.748	-2.15	1.928	1.925	-0.16	1.008	1.003	-0.50
4/1985	3.204	3.133	-2.21	2.250	2.240	-0.44	1.188	1.180	-0.68
1/1986	3.200	3.104	-2.98	1.996	1.986	-0.50	2.946	2.920	-0.89
2/1986	3.040	2.961	-2.60	2.133	2.128	-0.20	1.419	1.410	-0.60
3/1986	2.552	2.500	-2.04	2.405	2.403	-0.08	1.222	1.217	-0.42
4/1986	2.611	2.553	-2.24	2.588	2.586	-0.08	1.236	1.231	-0.40
1/1987	3.064	2.965	-3.21	2.377	2.374	-0.12	3.097	3.079	-0.59
2/1987	3.649	3.572	-2.10	2.737	2.735	-0.08	1.705	1.698	-0.42
3/1987	4.187	4.124	-1.51	2.699	2.696	-0.12	1.590	1.584	-0.36
4/1987	3.753	3.694	-1.56	3.122	3.115	-0.23	1.663	1.655	-0.44
1/1988	3.613	3.525	-2.45	3.419	3.416	-0.09	5.652	5.624	-0.49
2/1988	3.747	3.643	-2.75	3.621	3.618	-0.06	2.268	2.256	-0.52
3/1988	3.351	3.287	-1.90	3.640	3.638	-0.07	2.107	2.099	-0.39
4/1988	3.406	3.340	-1.96	3.701	3.700	-0.05	2.000	1.993	-0.37

TABLE 23. Continued

Quarter/ Year	Base PLEXH	Scenario PLEXH5	Percentage Change	Base UPLH	Scenario UPLH5	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	0.285	-0.08	1.028	1.027	-0.08
4/1983	0.527	0.527	-0.13	1.350	1.349	-0.09
1/1984	0.358	0.358	-0.05	1.375	1.375	-0.02
2/1984	0.280	0.280	0.01	1.161	1.161	0.00
3/1984	0.303	0.303	-0.06	1.082	1.081	-0.06
4/1984	0.574	0.574	-0.10	1.435	1.434	-0.08
1/1985	0.360	0.360	-0.04	1.314	1.314	-0.01
2/1985	0.313	0.313	0.02	1.193	1.193	0.01
3/1985	0.250	0.250	-0.06	0.942	0.942	-0.05
4/1985	0.439	0.439	-0.10	1.306	1.305	-0.09
1/1986	0.326	0.326	-0.04	1.262	1.261	-0.02
2/1986	0.340	0.340	0.02	1.136	1.136	0.01
3/1986	0.291	0.291	-0.03	1.002	1.001	-0.02
4/1986	0.515	0.515	-0.03	1.393	1.393	-0.03
1/1987	0.418	0.418	0.00	1.477	1.477	0.00
2/1987	0.380	0.380	0.01	1.350	1.350	0.01
3/1987	0.471	0.471	-0.03	1.315	1.314	-0.03
4/1987	0.989	0.989	-0.04	2.010	2.009	-0.04
1/1988	0.827	0.827	-0.01	2.044	2.044	0.00
2/1988	0.626	0.626	0.00	2.042	2.042	0.00
3/1988	0.615	0.615	-0.02	1.796	1.796	-0.02
4/1988	0.907	0.907	-0.03	2.073	2.072	-0.03

TABLE 24. Scenario 6, Norwegian and Scottish Farmed Salmon Exports Decrease by 10 Percent: Average Total Analysis

Variable	Base Quarter	Scenario Quarter	Percentage Change
EQAEH	19,811,930	17,632,640	-11.00
NQAEH	14,578,054	12,922,149	-11.36
QAUH	3,746,145	3,516,593	-6.13
NPAEH	21.059	21.659	2.85
EPAEH	2.890	2.972	2.86
NPAUH	23.094	23.796	3.04
UPAUH	3.166	3.264	3.07
JPAJH	467.660	468.119	0.10
QHJH	42,002,766	41,832,638	-0.41
QHEH	6,958,529	7,183,713	3.24
UPHJH	2.356	2.360	0.15
JPHJH	426.640	427.224	0.14
UPHEH	2.419	2.429	0.40
EPHEH	2.576	2.588	0.47
UPHH	2.365	2.370	0.20
QLJH	10,939,052	10,934,745	-0.04
QLEH	8,242,731	8,255,665	0.16
UPLJH	1.173	1.173	0.02
JPLJH	203.240	203.281	0.02
UPLEH	1.569	1.570	0.04
EPLH	1.618	1.619	0.04
UPLH	1.343	1.344	0.04
PHEXH	1.271	1.279	0.58
PLEXH	0.379	0.379	0.05

TABLE 25. Scenario 6, Norwegian and Scottish Farmed Salmon Production Decrease by 10 Percent: Quarter-by-Quarter Analysis

Quarter/ Year	Base UPAUM	Scenario UPAUM6	Percentage Change	Base UPHN	Scenario UPHN6	Percentage Change	Base PHEXH	Scenario PHEXH6	Percentage Change
1/1983	2.901	3.120	7.53	1.582	1.605	1.40	1.731	1.772	2.40
2/1983	2.849	2.979	4.57	1.754	1.759	0.30	0.815	0.824	1.06
3/1983	3.231	3.378	4.54	1.722	1.727	0.30	0.843	0.852	1.01
4/1983	3.189	3.332	4.46	2.036	2.047	0.55	0.957	0.968	1.13
1/1984	2.678	2.767	3.31	1.750	1.762	0.70	2.231	2.255	1.08
2/1984	2.721	2.807	3.14	1.753	1.758	0.27	0.921	0.928	0.74
3/1984	2.875	2.944	2.38	1.851	1.857	0.30	0.975	0.981	0.64
4/1984	2.678	2.758	2.98	2.186	2.198	0.55	1.105	1.115	0.89
1/1985	3.084	3.208	3.99	1.833	1.845	0.63	2.689	2.720	1.14
2/1985	3.103	3.208	3.36	1.786	1.791	0.26	1.022	1.030	0.78
3/1985	2.808	2.879	2.52	1.928	1.932	0.18	1.008	1.013	0.58
4/1985	3.204	3.287	2.59	2.250	2.261	0.51	1.188	1.197	0.79
1/1986	3.200	3.311	3.49	1.996	2.008	0.58	2.946	2.976	1.02
2/1986	3.040	3.133	3.05	2.133	2.138	0.23	1.419	1.428	0.70
3/1986	2.552	2.613	2.39	2.405	2.407	0.09	1.222	1.228	0.48
4/1986	2.611	2.679	2.62	2.588	2.590	0.09	1.236	1.242	0.47
1/1987	3.064	3.180	3.79	2.377	2.380	0.14	3.097	3.118	0.68
2/1987	3.649	3.739	2.48	2.737	2.740	0.09	1.705	1.713	0.49
3/1987	4.187	4.262	1.78	2.699	2.703	0.14	1.590	1.596	0.42
4/1987	3.753	3.822	1.86	3.122	3.130	0.27	1.663	1.671	0.52
1/1988	3.613	3.719	2.92	3.419	3.423	0.11	5.652	5.684	0.58
2/1988	3.747	3.869	3.27	3.621	3.623	0.07	2.268	2.282	0.61
3/1988	3.351	3.426	2.24	3.640	3.643	0.08	2.107	2.116	0.45
4/1988	3.406	3.486	2.33	3.701	3.703	0.05	2.000	2.008	0.43

TABLE 25. Continued

Quarter/ Year	Base PLEXH	Scenario PLEXH6	Percentage Change	Base UPLH	Scenario UPLH6	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	0.285	0.09	1.028	1.029	0.09
4/1983	0.527	0.528	0.14	1.350	1.351	0.10
1/1984	0.358	0.358	0.06	1.375	1.375	0.02
2/1984	0.280	0.280	-0.01	1.161	1.161	-0.01
3/1984	0.303	0.303	0.07	1.082	1.083	0.07
4/1984	0.574	0.575	0.12	1.435	1.436	0.09
1/1985	0.360	0.360	0.04	1.314	1.314	0.01
2/1985	0.313	0.313	-0.02	1.193	1.193	-0.01
3/1985	0.250	0.250	0.07	0.942	0.943	0.06
4/1985	0.439	0.440	0.12	1.306	1.307	0.10
1/1986	0.326	0.326	0.05	1.262	1.262	0.02
2/1986	0.340	0.339	-0.02	1.136	1.136	-0.01
3/1986	0.291	0.291	0.03	1.002	1.002	0.03
4/1986	0.515	0.515	0.04	1.393	1.394	0.03
1/1987	0.418	0.418	0.00	1.477	1.477	0.00
2/1987	0.380	0.380	-0.02	1.350	1.350	-0.01
3/1987	0.471	0.472	0.03	1.315	1.315	0.03
4/1987	0.989	0.990	0.03	2.010	2.011	0.04
1/1988	0.827	0.827	0.02	2.044	2.044	0.00
2/1988	0.626	0.626	-0.01	2.042	2.042	0.00
3/1988	0.615	0.615	0.02	1.796	1.796	0.02
4/1988	0.907	0.907	0.03	2.073	2.073	0.03

Atlantic salmon in Japan would have decreased by 3.08 percent. In this case, other endogenous variables would also have been slightly affected. (This latter result was generated from a different scenario from the one reported here. In the interest of brevity, the details of this scenario are not reported here.)

Some high-valued Pacific salmon would be reallocated away from the EEC, with much of the reallocation going to Japan. Export prices of high-valued Pacific salmon to both markets would decline slightly, and the exvessel price of high-valued salmon declined by 0.5 percent. The directions of movements would be the same for low-valued salmon as those for the high-valued salmon although the magnitudes of changes in the low-valued salmon market would be less. The exvessel price of low-valued salmon would have decreased by only 0.04 percent. Most of the changes in low-valued salmon would have been in quarters 3 and 4 when some high-valued salmon would be substituted for low-valued salmon in the EEC.

A decrease in Norwegian and Scottish salmon exports of Atlantic salmon by 10 percent would increase prices of all salmon products. The price of Atlantic salmon in the United States would rise by 3.07 percent, and the exvessel price of high-valued Pacific salmon would rise by 0.58 percent. Allocation of Pacific salmon would shift away from Japan and toward the EEC, with the average North American export prices of both low- and high-valued Pacific salmon rising by approximately the same percentage in each market. The price of Pacific salmon exported to Japan would rise because of the reduction in supply due to the reallocation of Pacific salmon to the EEC. The price to the EEC would increase because of the upward shift in the EEC demand for Pacific salmon due to the decreased availability of farmed salmon and the

resulting higher prices of Atlantic salmon in the EEC. There is relatively little effect on the high-valued exvessel price because of the low cross-price substitution between farmed Atlantic salmon and high-valued Pacific salmon in all markets.

Group 4: Norwegian Farmed Atlantic Salmon Exports $\pm$ 10% Relative to Historical Levels

This group of scenarios refers to a situation where increased or decreased farmed salmon exports are isolated to Norwegian farmed salmon. Since Scottish farmed salmon is essentially only exported to the EEC, it is of interest to compare this group of scenarios to the previous group of scenarios.

Tables 26-29 present the results. The basic difference between these scenarios and the previous scenarios (in which both Norwegian and Scottish salmon were increased or decreased by 10 percent) is the magnitude of the effect on Norwegian farmed Atlantic salmon allocated to the EEC, which is slightly accentuated under the current set of assumptions. The increased allocation of Norwegian Atlantic salmon to the EEC under Scenario 7 in comparison to Scenario 5 is explained by the fact there would be increased Scottish salmon allocated to the EEC under Scenario 5. Under Scenario 7, the price decrease for Atlantic salmon in North America and the decrease in high-valued exvessel price would not be as great as under Scenario 5 because the allocation of Atlantic salmon to North American would not have increased as much. Ultimately, increased Scottish salmon exports would affect prices in North America through the extra allocation of Norwegian Atlantic salmon that would be exported to North America. In comparing the two scenarios, it is evident that, because Scottish production during the historical time period

TABLE 26. Scenario 7, Norwegian Farmed Salmon Exports
Increase by 10 Percent: Average Total Analysis

Variable	Base Quarter	Scenario Quarter	Percentage Change
EQA EH	19,811,930	21,507,678	8.56
NQA EH	14,578,054	16,273,799	11.63
QA UH	3,746,145	3,935,855	5.06
NPA EH	21.059	20.641	-1.99
EPA EH	2.890	2.832	-2.00
NPA UH	23.094	22.562	-2.30
UPA UH	3.166	3.092	-2.34
JPA JH	467.660	467.356	-0.07
QH JH	42,002,766	42,136,943	0.32
QHEH	6,958,529	6,796,452	-2.33
UPH JH	2.356	2.353	-0.12
JPH JH	426.640	426.182	-0.11
UPHEH	2.419	2.412	-0.30
EPHEH	2.576	2.567	-0.36
UPHH	2.365	2.361	-0.16
QL JH	10,939,052	10,942,485	0.03
QLEH	8,242,731	8,232,605	-0.12
UPL JH	1.173	1.173	-0.02
JPL JH	203.240	203.207	-0.02
UPLEH	1.569	1.569	-0.03
EPLH	1.618	1.618	-0.04
UPLH	1.343	1.343	-0.03
PHEXH	1.271	1.266	-0.47
PLEXH	0.379	0.379	-0.04

TABLE 27. Scenario 7, Norwegian Farmed Salmon Exports
Increase by 10 Percent: Quarter-by-Quarter Analysis

Quarter/ Year	Base UPAUH	Scenario UPAUH7	Percentage Change	Base UPHH	Scenario UPHH7	Percentage Change	Base PHEXH	Scenario PHEXH7	Percentage Change
1/1983	2.901	2.733	-5.80	1.582	1.568	-0.93	1.731	1.700	-1.76
2/1983	2.849	2.742	-3.76	1.754	1.750	-0.21	0.815	0.808	-0.86
3/1983	3.231	3.105	-3.89	1.722	1.718	-0.25	0.843	0.836	-0.88
4/1983	3.189	3.068	-3.80	2.036	2.026	-0.47	0.937	0.947	-1.00
1/1984	2.678	2.610	-2.54	1.750	1.741	-0.48	2.231	2.213	-0.80
2/1984	2.721	2.660	-2.25	1.753	1.751	-0.15	0.921	0.917	-0.50
3/1984	2.875	2.815	-2.10	1.851	1.847	-0.26	0.975	0.969	-0.57
4/1984	2.678	2.615	-2.37	2.186	2.176	-0.43	1.105	1.097	-0.73
1/1985	3.084	2.988	-3.14	1.833	1.826	-0.40	2.689	2.666	-0.85
2/1985	3.103	3.025	-2.51	1.786	1.783	-0.15	1.022	1.016	-0.55
3/1985	2.808	2.753	-1.96	1.928	1.926	-0.13	1.008	1.003	-0.44
4/1985	3.204	3.144	-1.88	2.250	2.242	-0.34	1.185	1.181	-0.56
1/1986	3.200	3.111	-2.77	1.996	1.988	-0.41	2.946	2.923	-0.80
2/1986	3.040	2.975	-2.14	2.133	2.130	-0.13	1.419	1.412	-0.47
3/1986	2.552	2.502	-1.95	2.405	2.403	-0.07	1.222	1.217	-0.40
4/1986	2.611	2.559	-1.99	2.588	2.586	-0.07	1.236	1.232	-0.37
1/1987	3.064	2.978	-2.79	2.377	2.375	-0.07	3.097	3.082	-0.50
2/1987	3.649	3.586	-1.71	2.737	2.736	-0.06	1.705	1.699	-0.34
3/1987	4.187	4.130	-1.37	2.699	2.696	-0.11	1.590	1.584	-0.32
4/1987	3.753	3.703	-1.31	3.122	3.116	-0.20	1.663	1.656	-0.38
1/1988	3.613	3.550	-1.77	3.519	3.417	-0.05	5.652	5.632	-0.35
2/1988	3.747	3.659	-2.33	3.621	3.619	-0.04	2.268	2.258	-0.44
3/1988	3.351	3.292	-1.77	3.640	3.638	-0.06	2.107	2.099	-0.36
4/1988	3.406	3.347	-1.73	3.701	3.700	-0.04	2.000	1.993	-0.33

TABLE 27. Continued

Quarter/ Year	Base PLEXH	Scenario PLEXH7	Percentage Change	Base UPLH	Scenario UPLH7	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	0.285	-0.08	1.028	1.027	-0.07
4/1983	0.527	0.527	-0.12	1.350	1.349	-0.08
1/1984	0.358	0.358	-0.05	1.375	1.375	-0.02
2/1984	0.280	0.280	0.01	1.161	1.161	0.00
3/1984	0.303	0.303	-0.06	1.082	1.081	-0.06
4/1984	0.574	0.574	-0.10	1.435	1.434	-0.07
1/1985	0.360	0.360	-0.03	1.314	1.314	-0.01
2/1985	0.313	0.313	0.02	1.193	1.193	0.01
3/1985	0.250	0.250	-0.05	0.942	0.942	-0.05
4/1985	0.439	0.439	-0.08	1.306	1.305	-0.07
1/1986	0.326	0.326	-0.03	1.262	1.261	-0.01
2/1986	0.340	0.340	0.02	1.136	1.136	0.01
3/1986	0.291	0.291	-0.02	1.002	1.001	-0.02
4/1986	0.515	0.515	-0.03	1.393	1.393	-0.03
1/1987	0.418	0.418	0.00	1.477	1.477	0.00
2/1987	0.380	0.380	0.01	1.350	1.350	0.00
3/1987	0.471	0.471	-0.03	1.315	1.314	-0.03
4/1987	0.989	0.989	-0.04	2.010	2.009	-0.03
1/1988	0.827	0.827	-0.01	2.044	2.044	0.00
2/1988	0.626	0.626	0.00	2.042	2.042	0.00
3/1988	0.615	0.615	-0.02	1.796	1.796	-0.02
4/1988	0.907	0.907	-0.03	2.073	2.072	-0.02

TABLE 28. Scenario 8, Norwegian Farmed Salmon Exports
Decrease by 10 Percent: Average Total Analysis

Variable	Base Quarter	Scenario Quarter	Percentage Change
EQA EH	19,811,930	18,130,567	-8.49
NQA EH	14,578,054	12,896,690	-11.53
QA UH	3,746,145	3,542,052	-5.45
NPA EH	21.059	21.523	2.20
EPA EH	2.890	2.954	2.22
NPA UH	23.094	23.712	2.67
UPA UH	3.166	3.252	2.71
JPA JH	467.660	467.997	0.07
QH JH	42,002,766	41,852,606	-0.36
QHEH	6,958,529	7,144,090	2.67
UPH JH	2.356	2.359	0.14
JPH JH	426.640	427.154	0.12
UPHEH	2.419	2.428	0.34
EPHEH	2.576	2.587	0.41
UPHH	2.365	2.369	0.18
QL JH	10,939,052	10,935,191	-0.04
QLEH	8,242,731	8,254,148	0.14
UPL JH	1.173	1.173	0.02
JPL JH	203.240	203.277	0.02
UPLEH	1.569	1.569	0.03
EPLH	1.618	1.619	0.04
UPLH	1.343	1.344	0.04
PHEXH	1.271	1.278	0.53
PLEXH	0.379	0.379	0.04

TABLE 29. Scenario 8, Norwegian Farmed Salmon Exports
Decrease by 10 Percent: Quarter-by-Quarter Analysis

Quarter/ Year	Base UPAUM	Scenario UPAUM8	Percentage Change	Base UPHH	Scenario UPHH8	Percentage Change	Base PHEXH	Scenario PHEXH8	Percentage Change
1/1983	2.901	3.098	6.79	1.582	1.599	1.08	1.731	1.765	2.01
2/1983	2.849	2.972	4.33	1.754	1.758	0.24	0.815	0.823	0.96
3/1983	3.231	3.377	4.50	1.722	1.727	0.29	0.843	0.852	0.99
4/1983	3.189	3.329	4.38	2.036	2.046	0.53	0.957	0.968	1.13
1/1984	2.678	2.757	2.93	1.750	1.759	0.53	2.231	2.251	0.90
2/1984	2.721	2.793	2.62	1.753	1.756	0.16	0.921	0.926	0.57
3/1984	2.875	2.946	2.45	1.851	1.857	0.30	0.975	0.981	0.65
4/1984	2.678	2.752	2.76	2.186	2.196	0.49	1.105	1.114	0.84
1/1985	3.084	3.197	3.64	1.833	1.841	0.43	2.689	2.714	0.95
2/1985	3.103	3.194	2.92	1.786	1.789	0.16	1.022	1.028	0.62
3/1985	2.808	2.872	2.29	1.928	1.931	0.15	1.008	1.013	0.51
4/1985	3.204	3.275	2.19	2.250	2.258	0.38	1.188	1.195	0.64
1/1986	3.200	3.303	3.24	1.996	2.006	0.46	2.946	2.973	0.91
2/1986	3.040	3.116	2.51	2.133	2.136	0.14	1.419	1.426	0.54
3/1986	2.552	2.610	2.27	2.405	2.407	0.08	1.222	1.228	0.45
4/1986	2.611	2.672	2.32	2.588	2.590	0.08	1.236	1.242	0.43
1/1987	3.064	3.164	3.27	2.377	2.379	0.07	3.097	3.115	0.57
2/1987	3.649	3.722	2.02	2.737	2.739	0.05	1.705	1.712	0.39
3/1987	4.187	4.255	1.61	2.699	2.702	0.12	1.590	1.595	0.38
4/1987	3.753	3.811	1.55	3.122	3.129	0.23	1.663	1.670	0.45
1/1988	3.613	3.689	2.10	3.419	3.421	0.06	5.652	5.675	0.41
2/1988	3.747	3.850	2.77	3.621	3.622	0.04	2.268	2.280	0.50
3/1988	3.351	3.421	2.08	3.640	3.643	0.07	2.107	2.116	0.41
4/1988	3.406	3.476	2.05	3.701	3.703	0.05	2.000	2.008	0.38

TABLE 29. Continued

QUP	Base PLEXH	Scenario PLEXH8	Percentage Change	Base UPLH	Scenario UPLH8	Percentage Change
	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	0.285	0.09	1.028	1.029	0.08
4/1983	0.527	0.528	0.14	1.350	1.351	0.09
1/1984	0.358	0.358	0.06	1.375	1.375	0.02
2/1984	0.280	0.280	-0.01	1.161	1.161	-0.01
3/1984	0.303	0.303	0.07	1.082	1.083	0.07
4/1984	0.574	0.575	0.11	1.435	1.436	0.08
1/1985	0.360	0.360	0.04	1.314	1.314	0.01
2/1985	0.313	0.313	-0.02	1.193	1.193	-0.01
3/1985	0.250	0.250	0.05	0.942	0.943	0.05
4/1985	0.439	0.440	0.09	1.306	1.307	0.07
1/1986	0.326	0.326	0.03	1.262	1.262	0.01
2/1986	0.340	0.339	-0.02	1.136	1.136	-0.01
3/1986	0.291	0.291	0.03	1.002	1.002	0.02
4/1986	0.515	0.515	0.03	1.393	1.394	0.03
1/1987	0.418	0.418	0.01	1.477	1.477	0.00
2/1987	0.380	0.380	-0.01	1.350	1.350	-0.01
3/1987	0.471	0.471	0.03	1.315	1.315	0.03
4/1987	0.989	0.990	0.04	2.010	2.010	0.04
1/1988	0.827	0.827	0.01	2.044	2.044	0.00
2/1988	0.626	0.626	-0.01	2.042	2.042	0.00
3/1988	0.615	0.615	0.02	1.796	1.796	0.02
4/1988	0.907	0.907	0.03	2.073	2.073	0.03

was small, a 10 percent increase in Scottish production would not have had a significant effect on the market since the changes in Scenarios 5 and 7 are not large in magnitude. But as Scottish production is projected to increase rapidly in the future, the effect of increased Scottish production may become very noticeable in the future.

The main difference between the scenario for a 10 percent decrease in Norwegian exports and the scenario for a 10 percent decrease in both Norwegian and Scottish exports was, again, the amount of Norwegian farmed Atlantic salmon allocated to the EEC and North America. With the decreased Norwegian farmed Atlantic salmon exports, the EEC markets would experience a larger decline in Norwegian exports than if Scottish exports also declined. Prices of all salmon would rise, with the Atlantic salmon price in the United States rising by 2.71 percent and the high-valued exvessel price rising by 0.53 percent. These price increases are less than if Scottish farmed salmon also decreased. Allocation of high- and low-valued Pacific salmon would shift in the EEC, replacing some of the decreases in Atlantic salmon.

Chilean Exports $\pm$ 25% Re

Historical Levels

These scenarios examined the effect of an increase or decrease in Chilean farmed salmon exports to North American (United States) would have on salmon markets. The Chilean scenario is particularly important to the United States since most of the Chilean exports of farmed salmon were shipped to the U.S. West Coast through 1988. Recently, Japan has also been importing a measurable amount of Chilean salmon, but over the historical period this amount has been insignificant.

Tables 30-33 present the effects of a 25 percent increase and decrease in Chilean exports to North America. The time period examined in the average

TABLE 30. Scenario 9, Chilean Farmed Salmon Exports
Increase by 25 Percent: Average Total Analysis

Variable	Base Quarter	Scenario Quarter	Percentage Change
EQA EH	19,811,930	19,854,867	0.22
NQA EH	14,578,054	14,620,992	0.29
QA UH	3,746,145	3,703,207	-1.15
NPA EH	21.06	21.05	-0.03
EPA EH	2.89	2.89	-0.04
NPA UH	23.09	22.97	-0.53
UPA UH	3.17	3.15	-0.65
JPA JH	467.660	467.65	-0.00
QH JH	42,002,766	42,002,388	-0.00
QHEH	6,958,529	6,956,266	-0.03
UPH JH	2.36	2.36	-0.00
JPH JH	426.64	426.64	0.00
UPHEH	2.42	2.42	-0.00
EPHEH	2.58	2.58	-0.01
UPHH	2.36	2.36	-0.00
QL JH	10,939,052	10,939,023	-0.00
QLEH	8,242,731	8,242,795	0.00
UPL JH	1.17	1.17	-0.00
JPL JH	203.240	203.24	0.00
UPLEH	1.57	1.57	0.00
EPLH	1.62	1.62	0.00
UPLH	1.34	1.34	0.00
PHEXH	1.27	1.27	-0.04
PLEXH	0.38	0.38	0.00

TABLE 31. Scenario 9, Chilean Farmed Salmon Exports
Increase by 25 Percent: Quarter-by-Quarter Analysis

Quarter/ Year	Base UPAUH	Scenario UPAUH9	Percentage Change	Base UPHH	Scenario UPHH9	Percentage Change	Base PHEXH	Scenario PHEXH9	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	3.231	0.00	1.722	1.722	0.00	0.843	0.843	0.00
4/1983	3.189	3.189	0.00	2.036	2.036	0.00	0.957	0.957	0.00
1/1984	2.678	2.675	-0.12	1.750	1.750	-0.01	2.231	2.231	-0.03
2/1984	2.721	2.721	-0.01	1.773	1.753	0.00	0.921	0.921	0.00
3/1984	2.875	2.875	0.00	1.771	1.851	0.00	0.975	0.975	0.00
4/1984	2.678	2.678	0.07	2.186	2.186	0.00	1.105	1.104	-0.09
1/1985	3.084	3.075	-0.30	1.833	1.833	-0.01	2.689	2.687	-0.06
2/1985	3.103	3.102	-0.03	1.786	1.786	0.00	1.022	1.022	0.00
3/1985	2.808	2.808	0.00	1.928	1.928	0.00	1.008	1.008	0.00
4/1985	3.204	3.204	0.00	2.250	2.250	0.00	1.188	1.186	-0.18
1/1986	3.200	3.121	-2.46	1.996	1.994	-0.10	2.946	2.931	-0.51
2/1986	3.040	3.032	-0.27	2.133	2.133	0.01	1.419	1.418	-0.04
3/1986	2.552	2.550	-0.05	2.405	2.405	0.00	1.222	1.222	-0.01
4/1986	2.611	2.610	-0.02	2.588	2.588	0.00	1.236	1.216	-1.68
1/1987	3.064	2.980	-2.73	2.377	2.376	-0.04	3.097	3.081	-0.50
2/1987	3.649	3.643	-0.16	2.737	2.738	0.01	1.705	1.705	-0.02
3/1987	4.187	4.186	-0.04	2.699	2.699	0.00	1.590	1.589	-0.01
4/1987	3.753	3.752	-0.02	3.122	3.122	0.00	1.663	1.614	-2.95
1/1988	3.613	3.515	-2.73	3.419	3.418	-0.02	5.652	5.624	-0.49
2/1988	3.747	3.722	-0.65	3.621	3.621	0.00	2.268	2.266	-0.11
3/1988	3.351	3.348	-0.10	3.640	3.641	0.00	2.107	2.107	-0.02
4/1988	3.406	3.405	-0.03	3.701	3.701	0.00	2.000	1.973	-1.35

TABLE 31. Continued

Quarter/ Year	Base PLEXH	Scenario PLEXH9	Percentage Change	Base UPLH	Scenario UPLH9	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	0.285	0.00	1.028	1.028	0.00
4/1983	0.527	0.527	0.00	1.350	1.350	0.00
1/1984	0.358	0.358	0.00	1.375	1.375	0.00
2/1984	0.280	0.280	0.00	1.161	1.161	0.00
3/1984	0.303	0.303	0.00	1.082	1.082	0.00
4/1984	0.574	0.574	0.00	1.435	1.435	0.00
1/1985	0.360	0.360	0.00	1.314	1.314	0.00
2/1985	0.313	0.313	0.00	1.193	1.193	0.00
3/1985	0.250	0.250	0.00	0.942	0.942	0.00
4/1985	0.439	0.439	0.00	1.306	1.306	0.00
1/1986	0.326	0.326	0.00	1.262	1.262	0.00
2/1986	0.340	0.340	0.00	1.136	1.136	0.00
3/1986	0.291	0.291	0.00	1.002	1.002	0.00
4/1986	0.515	0.515	0.00	1.393	1.393	0.00
1/1987	0.418	0.418	0.00	1.477	1.477	0.00
2/1987	0.380	0.380	0.00	1.350	1.350	0.00
3/1987	0.471	0.471	0.00	1.315	1.315	0.00
4/1987	0.989	0.989	0.00	2.010	2.010	0.00
1/1988	0.827	0.827	0.00	2.044	2.044	0.00
2/1988	0.626	0.626	0.00	2.042	2.042	0.00
3/1988	0.615	0.615	0.00	1.796	1.796	0.00
4/1988	0.907	0.907	0.00	2.073	2.073	0.00

TABLE 32. Scenario 10, Chilean Farmed Salmon Exports
Decrease by 25 Percent: Average Total Analysis

Variable	Base Quarter	Scenario Quarter	Percentage Change
EQAEH	19,811,930	19,768,397	-0.22
NQAEH	14,578,054	14,534,521	-0.30
QAUH	3,746,145	3,789,678	1.16
NPAEH	21.06	21.07	0.03
EPAEH	2.89	2.89	0.04
NPAUH	23.09	23.23	0.59
UPAUH	3.17	3.19	0.71
JPAJH	467.660	467.67	0.00
QHJH	42,002,766	42,003,130	0.00
QHEH	6,958,529	6,960,891	0.03
UPHJH	2.36	2.36	0.00
JPHJH	426.64	426.64	-0.00
UPHEH	2.42	2.42	0.00
EPHEH	2.58	2.58	0.01
UPHH	2.36	2.36	0.00
QLJH	10,939,052	10,939,080	0.00
QLEH	8,242,731	8,242,667	-0.00
UPLJH	1.17	1.17	0.00
JPLJH	203.240	203.24	-0.00
UPLEH	1.57	1.57	-0.00
EPLEH	1.62	1.62	-0.00
UPLH	1.34	1.34	-0.00
PHEXH	1.27	1.27	0.04
PLEXH	0.38	0.38	0.00

TABLE 33. Scenario 10, Chilean Farmed Salmon Exports
Decrease by 25 Percent: Quarter-by-Quarter Analysis

Quarter/ Year	Base UPAUH	Scenario UPAUH10	Percentage Change	Base UPHH	Scenario UPHH10	Percentage Change	Base PHEXH	Scenario PHEXH10	Percentage Change
1/1983	2.900	2.900	0.00	1.580	1.580	0.00	1.730	1.730	0.00
2/1983	2.850	2.850	0.00	1.750	1.750	0.00	0.820	0.820	0.00
3/1983	3.230	3.230	0.00	1.720	1.720	0.00	0.840	0.840	0.00
4/1983	3.190	3.190	0.00	2.040	2.040	0.00	0.960	0.960	0.00
1/1984	2.680	2.680	0.12	1.750	1.750	0.01	2.230	2.230	0.03
2/1984	2.720	2.720	0.01	1.750	1.750	0.00	0.920	0.920	0.00
3/1984	2.880	2.880	0.00	1.850	1.850	0.00	0.970	0.970	0.00
4/1984	2.680	2.680	0.00	2.190	2.190	0.00	1.110	1.110	0.09
1/1985	3.080	3.090	0.30	1.830	1.830	0.01	2.690	2.690	0.06
2/1985	3.100	3.100	0.02	1.790	1.790	0.00	1.020	1.020	0.00
3/1985	2.810	2.810	0.00	1.930	1.930	0.00	1.010	1.010	0.00
4/1985	3.200	3.200	0.00	2.250	2.250	0.00	1.190	1.190	0.18
1/1986	3.200	3.280	2.57	2.000	2.000	0.11	2.950	2.960	0.52
2/1986	3.040	3.050	0.26	2.130	2.130	-0.01	1.420	1.420	0.04
3/1986	2.550	2.550	0.05	2.410	2.410	0.00	1.220	1.220	0.01
4/1986	2.610	2.610	0.02	2.590	2.590	0.00	1.240	1.260	1.71
1/1987	3.060	3.150	2.89	2.380	2.380	0.04	3.100	3.110	0.52
2/1987	3.650	3.650	0.15	2.740	2.740	-0.01	1.700	1.710	0.02
3/1987	4.190	4.190	0.04	2.700	2.700	0.00	1.590	1.590	0.01
4/1987	3.750	3.750	0.02	3.120	3.120	0.00	1.660	1.710	3.05
1/1988	3.610	3.720	3.01	3.420	3.420	0.02	5.650	5.680	0.53
2/1988	3.750	3.770	0.63	3.620	3.620	0.00	2.270	2.270	0.11
3/1988	3.350	3.350	0.10	3.640	3.640	0.00	2.110	2.110	0.02
4/1988	3.410	3.410	0.03	3.700	3.700	0.00	2.000	2.030	1.37

TABLE 33. Continued

Quarter/ Year	Base PLEXH	Scenario PLEXH10	Percentage Change	Base UPLH	Scenario UPLH10	Percentage Change
1/1983	0.390	0.390	0.00	1.450	1.450	0.00
2/1983	0.310	0.310	0.00	1.290	1.290	0.00
3/1983	0.280	0.280	0.00	1.030	1.030	0.00
4/1983	0.530	0.530	0.00	1.350	1.350	0.00
1/1984	0.360	0.360	0.00	1.370	1.370	0.00
2/1984	0.280	0.280	0.00	1.160	1.160	0.00
3/1984	0.300	0.300	0.00	1.080	1.080	0.00
4/1984	0.570	0.570	0.00	1.440	1.440	0.00
1/1985	0.360	0.360	0.00	1.310	1.310	0.00
2/1985	0.310	0.310	0.00	1.190	1.190	0.00
3/1985	0.250	0.250	0.00	0.940	0.940	0.00
4/1985	0.440	0.440	0.00	1.310	1.310	0.00
1/1986	0.330	0.330	0.00	1.260	1.260	0.00
2/1986	0.340	0.340	0.00	1.140	1.140	0.00
3/1986	0.290	0.290	0.00	1.000	1.000	0.00
4/1986	0.520	0.520	0.00	1.390	1.390	0.00
1/1987	0.420	0.420	0.00	1.480	1.480	0.00
2/1987	0.380	0.380	0.00	1.350	1.350	0.00
3/1987	0.470	0.470	0.00	1.310	1.310	0.00
4/1987	0.990	0.990	0.00	2.010	2.010	0.00
1/1988	0.830	0.830	0.00	2.040	2.040	0.00
2/1988	0.630	0.630	0.00	2.040	2.040	0.00
3/1988	0.620	0.620	0.00	1.800	1.800	0.00
4/1988	0.910	0.910	0.00	2.070	2.070	0.00

total analysis was 1983-88. Before 1986, the Chilean exports to the United States were very small; 1986 was the first year that Chilean exports to the United States were over 1 million pounds.

The largest effect of the increased Chilean salmon exports to the United States was on the Norwegian Atlantic salmon shipments and prices to North America. Norwegian allocations to North American would decrease by 1.15 percent, and the price of Atlantic salmon in North American would decrease by 0.65 percent. There was a small effect (0.04 percent) on the exvessel price of high-valued Pacific salmon in North America. This is because over the historical time period, Chilean shipments were still very small in comparison to the consumption of high-valued Pacific salmon in the United States. No effect on the exvessel price of low-valued Pacific salmon was found.

Quarterly analysis showed that the largest effects of increased Chilean salmon on exvessel prices of high-valued Pacific salmon would be in the first and fourth quarters. First quarter prices of Atlantic salmon in the United States would decrease an average of 1.97 percent. This in turn was the main factor in a 0.32 percent decrease in the high-valued Pacific salmon exvessel price in the first quarter. Prices of Atlantic salmon also would decrease slightly in the EEC because of the increased allocation of Norwegian farmed Atlantic salmon to the EEC. Fourth quarter high-valued Pacific salmon exvessel price would decrease the most, declining an average of 1.5 percent. The effects of increased Chilean exports became more noticeable in the last two years when Chilean salmon exports became much larger in magnitude. For the first quarters of both 1987 and 1988, a 25 percent increase in Chilean shipments to the United States would decrease the Atlantic salmon prices in the United States by an average of 2.73 percent.

In comparison to increased Chilean exports, the effects of a 25 percent decrease in Chilean exports are opposite and very similar in magnitudes. If Chilean salmon exports decreased by 25 percent, more Norwegian farmed Atlantic salmon would be allocated to North America at a high price because of the increased demand for Atlantic salmon to replace farmed Chilean salmon. The price of Atlantic salmon would rise by 0.71 percent in North America, and the average exvessel price of high-valued Pacific salmon would rise by only 0.04 percent.

The quarterly patterns were also similar to Scenario 9 in magnitude, with the effect on the Atlantic salmon price in the United States being largest in quarter 1. The largest effect on high-valued exvessel price was in quarter 4. Again, noticeable effects of changing levels of Chilean salmon exports were mainly found in the later years.

Group 6: Tariff Changes

Free Trade

Scenario 11 examined the situation where the salmon market is operating under free trade. There has been much discussion recently among world leaders concerning tariff-free trade. Even though this possibility does not seem to be an immediate possibility for salmon, it is, nevertheless, interesting to examine what would happen if all markets were tariff-free.

Tables 34-35 present the results of the salmon market operating without tariffs. In this scenario, the Japanese tariff on fresh/frozen salmon would decrease from 5 to 0 percent and the EEC tariff which varied between 2.8 to 2 percent, over the historical time period, would drop to 0 percent.

Free trade would have effects on all species of salmon. Norwegian farmed Atlantic salmon exports would increase to the EEC by 0.45 percent and

TABLE 34. Scenario 11, Free Trade: Average Total Analysis

Variable	Base Quarter	Scenario Quarter	Percentage Change
EQAEH	19,811,930	19,877,722	0.33
NQAEH	14,578,054	14,643,845	0.45
QAUH	3,746,145	3,680,354	-1.76
NPAEH	21.06	21.51	2.15
EPAEH	2.89	2.95	2.17
NPAUH	23.09	23.39	1.28
UPAUH	3.17	3.21	1.28
JPAJH	467.66	488.52	4.46
QHJH	42,002,766	45,486,477	8.29
QHEH	6,958,529	6,868,941	-1.29
UPHJH	2.36	2.41	2.43
JPHJH	426.64	436.31	2.27
UPHEH	2.42	2.47	2.29
EPHEH	2.58	2.64	2.32
UPHH	2.36	2.42	2.38
QLJH	10,939,052	11,719,836	7.14
QLEH	8,242,731	8,401,551	1.93
UPLJH	1.17	1.19	1.36
JPLJH	203.24	205.91	1.31
UPLEH	1.57	1.58	0.59
EPLEH	1.62	1.63	0.64
UPLH	1.34	1.35	0.62
PHEXH	1.27	1.30	2.00
PLEXH	0.38	0.38	0.82

TABLE 35. Scenario 11, Free Trade: Quarter-by-Quarter Analysis

Quarter/ Year	Base UPAUI	Scenario UPAUI11	Percentage Change	Base UPHI	Scenario UPHI11	Percentage Change	Base PHEX	Scenario PHEX11	Percentage Change
1/1983	2.90	2.94	1.36	1.58	1.62	2.19	1.73	1.77	1.99
2/1983	2.85	2.90	1.74	1.75	1.79	2.29	0.82	0.83	2.20
3/1983	3.23	3.23	1.94	1.72	1.76	2.33	0.84	0.86	2.21
4/1983	3.19	3.24	1.71	2.04	2.07	1.74	0.96	0.97	1.59
1/1984	2.68	2.70	0.76	1.75	1.78	1.67	2.23	2.26	1.15
2/1984	2.72	2.76	1.47	1.75	1.79	2.17	0.92	0.94	1.93
3/1984	2.88	2.92	1.70	1.85	1.90	2.37	0.97	1.00	2.18
4/1984	2.68	2.72	1.43	2.19	2.22	1.57	1.11	1.12	1.33
1/1985	3.08	3.10	0.62	1.83	1.86	1.59	2.69	2.71	0.94
2/1985	3.10	3.14	1.29	1.79	1.82	2.12	1.02	1.04	1.86
3/1985	2.81	2.85	1.67	1.93	1.98	2.66	1.01	1.03	2.41
4/1985	3.20	3.25	1.43	2.25	2.28	1.55	1.19	1.20	1.36
1/1986	3.20	3.23	0.82	2.00	2.03	1.51	2.95	2.97	0.90
2/1986	3.04	3.08	1.27	2.13	2.17	1.83	1.42	1.44	1.55
3/1986	2.55	2.59	1.55	2.41	2.46	2.21	1.22	1.25	2.03
4/1986	2.61	2.65	1.46	2.59	2.65	2.31	1.24	1.26	1.96
1/1987	3.06	3.09	0.79	2.38	2.43	2.08	3.10	3.14	1.53
2/1987	3.65	3.70	1.42	2.74	2.79	1.86	1.70	1.73	1.67
3/1987	4.19	4.26	1.66	2.70	2.76	2.26	1.59	1.62	2.09
4/1987	3.75	3.81	1.53	3.12	3.18	1.93	1.66	1.69	1.66
1/1988	3.61	3.65	1.13	3.42	3.48	1.82	5.65	5.73	1.31
2/1988	3.75	3.79	1.18	3.62	3.68	1.51	2.27	2.30	1.36
3/1988	3.35	3.40	1.48	3.64	3.71	1.88	2.11	2.14	1.76
4/1988	3.41	3.46	1.46	3.70	3.77	1.88	2.00	2.03	1.61

TABLE 35. Continued

Quarter/ Year	Base PLEX	Scenario PLEXH11	Percentage Change	Base UPLH	Scenario UPLH11	Percentage Change
1/1983	0.39	0.40	0.88	1.45	1.46	0.82
2/1983	0.31	0.31	1.29	1.29	1.30	0.97
3/1983	0.28	0.29	0.75	1.03	1.04	0.69
4/1983	0.53	0.53	0.88	1.35	1.36	0.80
1/1984	0.36	0.36	0.97	1.37	1.39	0.87
2/1984	0.28	0.28	0.92	1.16	1.17	0.84
3/1984	0.30	0.31	1.02	1.08	1.09	0.95
4/1984	0.57	0.58	0.77	1.44	1.45	0.72
1/1985	0.36	0.36	0.65	1.31	1.32	0.77
2/1985	0.31	0.32	0.91	1.19	1.20	0.96
3/1985	0.25	0.25	1.01	0.94	0.95	0.94
4/1985	0.44	0.44	0.18	1.31	1.31	0.23
1/1986	0.33	0.33	-0.05	1.26	1.27	0.41
2/1986	0.34	0.34	0.54	1.14	1.14	0.74
3/1986	0.29	0.29	1.10	1.00	1.01	1.03
4/1986	0.52	0.52	0.64	1.39	1.40	0.58
1/1987	0.42	0.42	0.30	1.48	1.48	0.53
2/1987	0.38	0.38	0.36	1.35	1.36	0.49
3/1987	0.47	0.48	0.85	1.31	1.33	0.79
4/1987	0.99	0.99	0.40	2.01	2.02	0.39
1/1988	0.83	0.83	0.25	2.04	2.05	0.48
2/1988	0.63	0.63	0.23	2.04	2.05	0.29
3/1988	0.62	0.62	0.71	1.80	1.81	0.67
4/1988	0.91	0.91	0.31	2.07	2.08	0.28

decrease to North America by 1.76 percent. The price that Norway receives for farmed Atlantic salmon would rise in the EEC by 2.15 percent. The price paid by the EEC importer would decrease. In North America, prices would increase by 1.28 percent because of the decreased allocation of Atlantic salmon. High-valued Pacific salmon allocation would shift in favor of Japan and away from the EEC. There are two reasons for this: first, the tariff reduction was larger in Japan than the EEC; and second, increased exports of Norwegian salmon to the EEC would pressure the EEC high-valued Pacific salmon market. Prices received in North America for exports to both the Japanese and EEC markets would increase by approximately 2.3 to 2.4 percent, and the exvessel price of high-valued Pacific salmon would rise by 2 percent.

For low-valued Pacific salmon, the quantity exported would increase to both the EEC and Japan. More of the increased allocation would be exported to Japan due in part to the larger tariff reduction in Japan and due in part to the substitution of Atlantic salmon with high-valued Pacific salmon in the EEC market. The increase in the exvessel price of low-valued Pacific salmon was 0.82 percent.

Japanese Tariff Doubles to 10%

Scenario 12 represented a more restrictive trade policy in Japan. In this scenario, the tariffs placed on fresh/frozen salmon double to 10 percent. Tables 36-37 present the results of Scenario 12.

In this scenario, the allocation of high-valued salmon shifts dramatically away from Japan and increases slightly to the EEC. Much salmon would not be allocated to either export market. The average high-valued Pacific salmon price declines in export both markets by approximately 2 percent, and the high-valued Pacific salmon exvessel price declines by 1.6

TABLE 36. Scenario 12, Japanese Tariff on All Fresh/ Frozen Salmon Doubles to 10 Percent: Average Total Analysis

Variable	Base Quarter	Scenario Quarter	Percentage Change
EQAEH	19,811,930	19,817,522	0.03
NQAEH	14,578,054	14,583,646	0.04
QAUH	3,746,145	3,740,553	-0.15
NPAEH	21.059	20.983	-0.36
EPAEH	2.890	2.879	-0.36
NPAUH	23.094	23.014	-0.35
UPAUH	3.166	3.155	-0.35
JPAJH	467.660	449.234	-3.94
QHJH	42,002,766	38,808,190	-7.61
QHEH	6,958,529	7,160,220	2.90
UPHJH	2.356	2.305	-2.16
JPHJH	426.640	418.038	-2.02
UPHEH	2.419	2.372	-1.94
EPHEH	2.576	2.527	-1.90
UPHH	2.365	2.315	-2.09
QLJH	10,939,052	10,224,853	-6.53
QLEH	8,242,731	8,198,961	-0.53
UPLJH	1.173	1.159	-1.18
JPLJH	203.240	200.907	-1.15
UPLEH	1.569	1.563	-0.38
EPLEH	1.618	1.612	-0.38
UPLH	1.343	1.339	-0.32
PHEXH	1.271	1.251	-1.60
PLEXH	0.379	0.377	-0.56

TABLE 37. Scenario 12, Japanese Tariff on All Fresh/ Frozen Salmon Doubles to 10 Percent: Quarter-by-Quarter Analysis

Quarter/ Year	Base UPAUM	Scenario UPAUM12	Percentage Change	Base UPHH	Scenario UPHH12	Percentage Change	Base PHEXH	Scenario PHEXH12	Percentage Change
1/1983	2.901	2.896	-0.18	1.582	1.559	-1.51	1.731	1.709	-1.24
2/1983	2.849	2.836	-0.45	1.754	1.720	-1.92	0.815	0.802	-1.67
3/1983	3.231	3.217	-0.44	1.722	1.688	-2.00	0.843	0.829	-1.68
4/1983	3.189	3.178	-0.36	2.036	2.008	-1.36	0.957	0.946	-1.10
1/1984	2.678	2.674	-0.16	1.750	1.732	-1.01	2.231	2.218	-0.57
2/1984	2.721	2.709	-0.46	1.753	1.721	-1.83	0.921	0.907	-1.49
3/1984	2.875	2.862	-0.47	1.851	1.814	-2.01	0.975	0.958	-1.69
4/1984	2.678	2.669	-0.34	2.186	2.160	-1.18	1.105	1.095	-0.89
1/1985	3.084	3.081	-0.13	1.833	1.816	-0.92	2.689	2.678	-0.40
2/1985	3.103	3.089	-0.47	1.786	1.754	-1.81	1.022	1.007	-1.48
3/1985	2.808	2.793	-0.53	1.928	1.884	-2.31	1.008	0.988	-1.94
4/1985	3.204	3.193	-0.36	2.250	2.222	-1.25	1.188	1.176	-0.99
1/1986	3.200	3.195	-0.15	1.996	1.976	-1.02	2.946	2.932	-0.48
2/1986	3.040	3.029	-0.38	2.133	2.100	-1.53	1.419	1.402	-1.18
3/1986	2.552	2.539	-0.51	2.405	2.357	-2.00	1.222	1.202	-1.69
4/1986	2.611	2.598	-0.50	2.588	2.532	-2.15	1.236	1.215	-1.73
1/1987	3.064	3.057	-0.21	2.377	2.333	-1.85	3.097	3.056	-1.34
2/1987	3.649	3.634	-0.41	2.737	2.690	-1.72	1.705	1.681	-1.40
3/1987	4.187	4.167	-0.47	2.699	2.644	-2.02	1.590	1.563	-1.70
4/1987	3.753	3.739	-0.35	3.122	3.069	-1.69	1.663	1.641	-1.28
1/1988	3.613	3.606	-0.22	3.419	3.363	-1.64	5.652	5.593	-1.04
2/1988	3.747	3.733	-0.35	3.621	3.570	-1.40	2.268	2.242	-1.14
3/1988	3.351	3.337	-0.42	3.640	3.580	-1.67	2.107	2.077	-1.40
4/1988	3.406	3.394	-0.36	3.701	3.636	-1.75	2.000	1.973	-1.33

TABLE 37. Continued

Quarter/ Year	Base PLEXH	Scenario PLEXH12	Percentage Change	Base UPLH	Scenario UPLH12	Percentage Change
1/1983	0.392	0.391	-0.28	1.449	1.445	-0.26
2/1983	0.308	0.307	-0.40	1.286	1.282	-0.30
3/1983	0.285	0.284	-0.25	1.028	1.026	-0.23
4/1983	0.527	0.524	-0.53	1.350	1.343	-0.48
1/1984	0.358	0.356	-0.58	1.375	1.369	-0.42
2/1984	0.280	0.279	-0.41	1.161	1.157	-0.35
3/1984	0.303	0.301	-0.65	1.082	1.075	-0.60
4/1984	0.574	0.571	-0.57	1.435	1.428	-0.46
1/1985	0.360	0.359	-0.35	1.314	1.309	-0.34
2/1985	0.313	0.311	-0.60	1.193	1.186	-0.63
3/1985	0.250	0.248	-0.68	0.942	0.936	-0.63
4/1985	0.439	0.439	0.07	1.306	1.307	0.07
1/1986	0.326	0.327	0.30	1.262	1.260	-0.09
2/1986	0.340	0.338	-0.34	1.136	1.131	-0.49
3/1986	0.291	0.288	-0.90	1.002	0.993	-0.84
4/1986	0.515	0.512	-0.58	1.393	1.387	-0.46
1/1987	0.418	0.417	-0.21	1.477	1.472	-0.32
2/1987	0.380	0.379	-0.14	1.350	1.347	-0.24
3/1987	0.471	0.468	-0.67	1.315	1.306	-0.63
4/1987	0.989	0.987	-0.29	2.010	2.005	-0.24
1/1988	0.827	0.827	-0.04	2.044	2.040	-0.21
2/1988	0.626	0.627	0.12	2.042	2.043	0.04
3/1988	0.615	0.612	-0.52	1.796	1.787	-0.49
4/1988	0.907	0.905	-0.19	2.073	2.070	-0.12

percent. The effect on prices to the wholesalers in the EEC and the Japanese market was the opposite of that in Scenario 11. The tariff wedge would decrease the pre-tariff price exporters receive and increase the post-tariff price importers pay. In all markets and for all species the pre-tariff prices that the exporters received would decline, and the import prices that importers paid with the tariffs added would rise.

There was little effect on the Atlantic salmon market, with only a minor amount being reallocated from North America to the EEC as the average export price of high-valued Pacific salmon decreased in North America. The price of Norwegian Atlantic salmon exported to North America would decrease by only 0.35 percent. Low-valued Pacific salmon average export prices would decrease in both export markets, with prices decreasing more in the Japanese market. The exvessel price of low-valued Pacific salmon would decrease by 0.56 percent.

EEC Tariff Increases to 12%

Scenario 13 examined the case of the EEC tariff rate increasing to 12 percent. This increase in EEC tariffs on fresh/frozen salmon has been discussed by the EEC to protect its own salmon production, especially in light of its claim that Norway has been dumping salmon on the EEC market. (Salmon Market Newsletter, 1990).

Tables 38-39 present the results of Scenario 13. In this scenario, allocations of all species of salmon to the EEC would be reduced. Norwegian Atlantic salmon imports would decline in the EEC by 2.07 percent and increase in North America by 8.07 percent. The price received by Norway would decline in both markets, with the larger decline occurring in the EEC. The price of Atlantic salmon in North America would decline by 3.57 percent due to the

TABLE 38. Scenario 13, EEC Tariff on Fresh/Frozen Salmon
Increases by 12 Percent: Average Total Analysis

Variable	Base Quarter	Scenario Quarter	Percentage Change
EQA EH	19,811,930	19,509,724	-1.53
NQA EK	14,578,054	14,275,834	-2.07
QAUH	3,746,145	4,048,365	8.07
NPA EH	21.059	19.568	-7.08
EPA EH	2.890	2.685	-7.07
NPAUH	23.094	22.254	-3.64
UPAUH	3.166	3.053	-3.57
JPAJH	467.660	466.272	-0.3
QHJH	42,002,766	42,362,979	0.86
QHEH	6,958,529	6,491,418	-6.71
UPHJH	2.356	2.349	-0.31
JPHJH	426.640	425.426	-0.28
UPHEH	2.419	2.399	-0.85
EPHEH	2.576	2.551	-0.99
UPHH	2.365	2.355	-0.41
QLJH	10,939,052	11,027,782	0.81
QLEH	8,242,731	7,808,218	-5.27
UPLJH	1.173	1.168	-0.43
JPLJH	203.240	202.412	-0.41
UPLEH	1.569	1.555	-0.86
EPLH	1.618	1.604	-0.9
UPLH	1.343	1.329	-1.08
PHEXH	1.271	1.258	-1.03
PLEXH	0.379	0.376	-0.83

TABLE 39. Scenario 13, EEC Tariff on Fresh/Frozen Salmon Increases by 12 Percent: Quarter-by-Quarter Analysis

Quarter/ Year	Base UPAUM	Scenario UPAUM13	Percentage Change	Base UPHM	Scenario UPHM13	Percentage Change	Base PHEXH	Scenario PHEXH13	Percentage Change
1/1983	2.901	2.800	-3.48	1.582	1.554	-1.82	1.731	1.695	-2.07
2/1983	2.849	2.742	-3.74	1.754	1.740	-0.81	0.815	0.804	-1.36
3/1983	3.231	3.090	-4.36	1.722	1.714	-0.49	0.843	0.834	-1.15
4/1983	3.189	3.064	-3.92	2.036	2.017	-0.89	0.957	0.945	-1.27
1/1984	2.678	2.625	-1.97	1.750	1.714	-2.03	2.231	2.190	-1.86
2/1984	2.721	2.633	-3.24	1.753	1.739	-0.83	0.921	0.910	-1.23
3/1984	2.875	2.764	-3.86	1.851	1.842	-0.53	0.975	0.964	-1.09
4/1984	2.678	2.586	-3.43	2.186	2.163	-1.02	1.105	1.091	-1.23
1/1985	3.084	3.029	-1.79	1.833	1.793	-2.17	2.689	2.638	-1.88
2/1985	3.103	3.013	-2.89	1.786	1.771	-0.83	1.022	1.010	-1.16
3/1985	2.808	2.699	-3.88	1.928	1.920	-0.43	1.008	0.997	-1.02
4/1985	3.204	3.085	-3.71	2.250	2.232	-0.79	1.188	1.175	-1.07
1/1986	3.200	3.115	-2.64	1.996	1.963	-1.67	2.946	2.899	-1.58
2/1986	3.040	2.935	-3.45	2.133	2.115	-0.84	1.419	1.401	-1.25
3/1986	2.552	2.450	-3.97	2.405	2.400	-0.21	1.222	1.212	-0.86
4/1986	2.611	2.515	-3.66	2.588	2.584	-0.15	1.236	1.229	-0.58
1/1987	3.064	2.984	-2.62	2.377	2.363	-0.57	3.097	3.076	-0.67
2/1987	3.649	3.487	-4.43	2.737	2.728	-0.33	1.705	1.688	-1.01
3/1987	4.187	3.975	-5.07	2.699	2.693	-0.23	1.590	1.572	-1.08
4/1987	3.753	3.562	-5.07	3.122	3.108	-0.45	1.663	1.643	-1.18
1/1988	3.613	3.470	-3.98	3.419	3.406	-0.38	5.652	5.599	-0.93
2/1988	3.747	3.610	-3.66	3.621	3.611	-0.26	2.268	2.249	-0.84
3/1988	3.351	3.196	-4.61	3.640	3.633	-0.20	2.107	2.086	-0.97
4/1988	3.406	3.243	-4.80	3.701	3.697	-0.13	2.000	1.982	-0.90

TABLE 39. Continued

Quarter/ Year	Base PLEXH	Scenario PLEXH13	Percentage Change	Base UPLH	Scenario UPLH13	Percentage Change
1/1983	0.392	0.385	-1.83	1.449	1.424	-1.70
2/1983	0.308	0.300	-2.67	1.286	1.260	-2.02
3/1983	0.285	0.281	-1.47	1.028	1.014	-1.35
4/1983	0.527	0.522	-0.99	1.350	1.338	-0.92
1/1984	0.358	0.353	-1.27	1.375	1.355	-1.45
2/1984	0.280	0.275	-1.73	1.161	1.142	-1.63
3/1984	0.303	0.300	-1.09	1.082	1.071	-1.01
4/1984	0.574	0.571	-0.58	1.435	1.423	-0.82
1/1985	0.360	0.356	-1.21	1.314	1.293	-1.57
2/1985	0.313	0.309	-1.16	1.193	1.180	-1.14
3/1985	0.250	0.247	-1.00	0.942	0.933	-0.94
4/1985	0.439	0.434	-1.07	1.306	1.290	-1.20
1/1986	0.326	0.322	-1.29	1.262	1.244	-1.39
2/1986	0.340	0.337	-0.90	1.136	1.126	-0.93
3/1986	0.291	0.289	-0.55	1.002	0.996	-0.52
4/1986	0.515	0.514	-0.15	1.393	1.387	-0.43
1/1987	0.418	0.416	-0.56	1.477	1.463	-0.97
2/1987	0.380	0.375	-1.10	1.350	1.335	-1.11
3/1987	0.471	0.469	-0.56	1.315	1.308	-0.52
4/1987	0.989	0.985	-0.46	2.010	1.997	-0.65
1/1988	0.827	0.819	-1.01	2.044	2.020	-1.20
2/1988	0.626	0.616	-1.66	2.042	2.011	-1.54
3/1988	0.615	0.611	-0.67	1.796	1.785	-0.62
4/1988	0.907	0.902	-0.55	2.073	2.057	-0.74

combined effect of increased Atlantic salmon supplies allocated to North America and the decreased price of high-valued Pacific salmon.

Most of the high-valued Pacific salmon allocation decrease to the EEC would be diverted to Japan. Prices received by North American exporters of high-valued Pacific salmon would decline in both markets, and the exvessel price of high-valued Pacific salmon would decline by 1.03 percent. Low-valued Pacific salmon would follow a similar pattern, with the exvessel price decreasing by 0.83 percent. Most of the decrease in the low-valued Pacific salmon allocation to the EEC would remain in North America.

North American Imposes 5% Tariff

Scenario 14 represents the case where North America imposes a 5 percent tariff on salmon. On the surface, this scenario seems unrealistic given the general trend in North America to favor free trade. But there has been periodic talk about protecting U.S. salmon markets from Norwegian salmon because of Norwegian whaling practices. Also there is the possibility of retaliation against Norway if Norway is found guilty of dumping farmed Atlantic salmon in the United States. Since protectionism against Norwegian salmon has been discussed, it is interesting to examine the possible effects of a tariff.

Tables 40-41 present the effects on the salmon market of a 5 percent tariff imposed by North America on fresh/frozen salmon imports, excluding trade between Canada and the United States. In this scenario, the Norwegian Atlantic salmon allocations would increase to the EEC by 1.44 percent and decrease to North America by 5.60 percent. Prices received by Norway for Atlantic salmon shipped to North America would decrease by 2.20 percent, and the price of Atlantic salmon that North American importers would pay would

TABLE 40. Scenario 14, United States Places 5 Percent
Tariff on Norwegian Farmed Salmon: Average Total Analysis

Variable	Base Quarter	Scenario Quarter	Percentage Change
EQAEH	19,811,930	20,021,755	1.06
NQ JH	14,578,054	14,787,879	1.44
QAUH	3,746,145	3,536,320	-5.60
NPAEH	21.059	21.008	-0.24
EPAEH	2.890	2.883	-0.24
NPAUH	23.094	22.586	-2.20
UPAUH	3.166	3.095	-2.24
JPAJH	467.660	467.621	-0.01
QHJH	42,002,766	42,014,409	0.03
QHEH	6,958,529	6,937,909	-0.30
UPHJH	2.356	2.356	-0.01
JPHJH	426.640	426.599	-0.01
UPHEH	2.419	2.419	-0.03
EPHEH	2.576	2.575	-0.05
UPHH	2.365	2.365	-0.01
QLJH	10,939,052	10,939,340	0.00
QLEH	8,242,731	8,241,683	-0.01
UPLJH	1.173	1.173	0.00
JPLJH	203.240	203.237	0.00
UPLEH	1.569	1.569	0.00
EPLEH	1.618	1.618	0.00
UPLH	1.343	1.343	0.00
PHEXH	1.271	1.278	0.54
PLEXH	0.379	0.379	0.00

TABLE 41. Scenario 14, United States Places 5 Percent Tariff on Norwegian Farmed Salmon: Quarter-by-Quarter Analysis

Quarter/ Year	Base UPAH	Scenario UPAH14	Percentage Change	Base UPHH	Scenario UPHH14	Percentage Change	Base PHEX	Scenario PHEX14	Percentage Change
1/1983	2.901	2.838	-2.18	1.582	1.581	-0.11	1.731	1.737	0.38
2/1983	2.849	2.791	-2.04	1.754	1.753	-0.03	0.815	0.819	0.46
3/1983	3.231	3.184	-1.45	1.722	1.722	-0.01	0.843	0.848	0.58
4/1983	3.189	3.131	-1.84	2.036	2.034	-0.06	0.957	0.962	0.48
1/1984	2.678	2.588	-3.38	1.750	1.747	-0.15	2.231	2.234	0.14
2/1984	2.721	2.654	-2.48	1.753	1.753	-0.02	0.921	0.925	0.39
3/1984	2.875	2.820	-1.91	1.851	1.851	-0.02	0.975	0.980	0.49
4/1984	2.678	2.616	-2.31	2.186	2.184	-0.07	1.105	1.109	0.40
1/1985	3.084	2.975	-3.54	1.833	1.831	-0.12	2.689	2.692	0.13
2/1985	3.103	3.016	-2.80	1.786	1.786	-0.02	1.022	1.026	0.34
3/1985	2.808	2.753	-1.95	1.928	1.928	-0.01	1.008	1.013	0.50
4/1985	3.204	3.137	-2.09	2.250	2.249	-0.05	1.188	1.193	0.45
1/1986	3.200	3.106	-2.92	1.996	1.994	-0.09	2.946	2.954	0.26
2/1986	3.040	2.967	-2.40	2.133	2.132	-0.02	1.419	1.424	0.41
3/1986	2.552	2.503	-1.91	2.405	2.405	-0.01	1.222	1.228	0.51
4/1986	2.611	2.556	-2.10	2.588	2.587	-0.01	1.236	1.242	0.48
1/1987	3.064	2.974	-2.94	2.377	2.377	-0.02	3.097	3.107	0.32
2/1987	3.649	3.588	-1.67	2.737	2.737	0.00	1.705	1.714	0.55
3/1987	4.187	4.139	-1.15	2.699	2.699	-0.01	1.590	1.600	0.64
4/1987	3.753	3.709	-1.17	3.122	3.121	-0.02	1.663	1.673	0.63
1/1988	3.613	3.542	-1.97	3.419	3.419	-0.01	5.652	5.680	0.49
2/1988	3.747	3.663	-2.22	3.621	3.620	-0.01	2.268	2.278	0.45
3/1988	3.351	3.301	-1.50	3.640	3.640	0.00	2.107	2.119	0.58
4/1988	3.406	3.360	-1.36	3.701	3.701	0.00	2.000	2.012	0.61

TABLE 41. Continued

Quarter/ Year	Base PLEXH	Scenario PLEXH14	Percentage Change	Base UPLH	Scenario UPLH14	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	0.285	0.00	1.028	1.028	0.00
4/1983	0.527	0.527	-0.01	1.350	1.350	-0.01
1/1984	0.358	0.358	-0.01	1.375	1.375	0.00
2/1984	0.280	0.280	0.00	1.161	1.161	0.00
3/1984	0.303	0.303	-0.01	1.082	1.082	-0.01
4/1984	0.574	0.574	-0.01	1.435	1.435	-0.01
1/1985	0.360	0.360	-0.01	1.314	1.314	0.00
2/1985	0.313	0.313	0.00	1.193	1.193	0.00
3/1985	0.250	0.250	0.00	0.942	0.942	0.00
4/1985	0.439	0.439	-0.01	1.306	1.306	-0.01
1/1986	0.326	0.326	0.00	1.262	1.262	0.00
2/1986	0.340	0.340	0.00	1.136	1.136	0.00
3/1986	0.291	0.291	0.00	1.002	1.002	0.00
4/1986	0.515	0.515	0.00	1.393	1.393	0.00
1/1987	0.418	0.418	0.00	1.477	1.477	0.00
2/1987	0.380	0.380	0.00	1.350	1.350	0.00
3/1987	0.471	0.471	0.00	1.315	1.315	0.00
4/1987	0.989	0.989	0.00	2.010	2.010	0.00
1/1988	0.827	0.827	0.00	2.044	2.044	0.00
2/1988	0.626	0.626	0.00	2.042	2.042	0.00
3/1988	0.615	0.615	0.00	1.796	1.796	0.00
4/1988	0.907	0.907	0.00	2.073	2.072	0.00

increase by 2.65 percent after the 5 percent tariff was imposed

There were minor effects on the high-valued Pacific salmon market. North American exports of high-valued Pacific salmon would decrease by 0.30 percent with the exvessel price increasing by 0.54 percent. More of the decrease in Norwegian Atlantic salmon exports to North America was in the third and fourth quarters during and preceding the heavy fishing season for high-valued Pacific salmon in North America.

Group 7: Exchange Rate Changes

Scenario 15 examines changing exchange rates, with the U.S. dollar strengthening against foreign currencies, with the exception of the Canadian dollar. Since the exchange rate market has operated under a free-floating system, there will be a consistent relationship among all exchange rates maintained by arbitraging. The three exchange rates used in the simulation are U.S. dollar/yen, U.S. dollar/ECU, and U.S. dollar/Norwegian kroner. Table 42 shows the changes in all other combinations of exchange rates in the system if the U.S. dollar strengthens by 10 percent against all other currencies.

Tables 43-44 examine the results of a strengthening of the U.S. dollar against the yen, Norwegian kroner, and the ECU. (Implicit in this assumption is that the U.S. dollar/Canadian dollar exchange rate remained constant.)

If the U.S. dollar strengthened against other foreign currencies, there would be significant effects on the salmon market. Norwegian Atlantic salmon allocation to North America would be increased by 9.05 percent. Norwegian allocation of Atlantic salmon would decrease to the EEC by 2.33 percent. The price paid by North American importers of Norwegian salmon (in U.S. dollars) would decrease 4.8 percent.

TABLE 42. Changes in Exchange Rates When the U.S. Dollar Strengthens by 10 Percent Against the Yen, ECU, and Norwegian Kroner

Country	Norway	United States	Japan	EEC
Norway	1.0000	0.9091	1.0000	1.0000
United States	1.1000	1.0000	1.1000	1.1000
Japan	1.0000	0.9091	1.0000	1.0000
EEC	1.0000	0.9091	1.0000	1.0000

NOTE: This table is read as the column country's currency divided by the row country's currency. So, for example, the 1.1000 in the column under Norway means that the U.S. dollar can purchase ten percent more Norwegian kroners after the dollar strengthens. Thus, in the simulations, the Norwegian kroner/U.S. dollar exchange rate would be increased by a factor of 1.1000.

TABLE 43. Scenario 15, U.S. Dollar Strengthens by 10 Percent Against All Currencies: Average Total Analysis

Variable	Base Quarter	Scenario Quarter	Percentage Change
EQA EH	19,811,930	19,472,976	-1.71
NQA EH	14,578,054	14,239,101	-2.33
QA UH	3,746,145	4,085,098	9.05
NPA EH	21.059	21.347	1.37
EPA EH	2.890	2.929	1.35
NPA UH	23.094	24.168	4.65
UPA UH	3.166	3.014	-4.80
JPA JH	467.660	494.073	5.65
QH JH	42,002,766	36,040,643	-14.19
QHEH	6,958,529	6,827,689	-1.88
UPH JH	2.356	2.245	-4.71
JPH JH	426.640	448.760	5.18
UPHEH	2.419	2.302	-4.83
EPHEH	2.576	2.721	5.63
UPHH	2.365	2.254	-4.68
QL JH	10,939,052	9,621,157	-12.05
QLEH	8,242,731	7,646,588	-7.23
UPL JH	1.173	1.139	-2.93
JPL JH	203.240	217.239	6.89
UPLEH	1.569	1.541	-1.77
EPLEH	1.618	1.765	9.04
UPLH	1.343	1.317	-1.96
PHEXH	1.271	1.216	-4.39
PLEXH	0.379	0.371	-2.16

TABLE 44. Scenario 15, U.S. Dollar Strengthens by 10 Percent Against All Currencies: Quarter-by-Quarter Analysis

Quarter/ Year	Base UPAHH	Scenario UPAHH15	Percentage Change	Base UPHH	Scenario UPHH15	Percentage Change	Base PHEXH	Scenario PHEXH15	Percentage Change
1/1983	2.901	2.767	-4.61	1.582	1.499	-5.29	1.731	1.643	-5.03
2/1983	2.849	2.692	-5.49	1.754	1.668	-4.91	0.815	0.774	-5.05
3/1983	3.231	3.031	-6.19	1.722	1.643	-4.60	0.843	0.803	-4.76
4/1983	3.189	3.014	-5.51	2.036	1.958	-3.83	0.957	0.921	-3.75
1/1984	2.678	2.607	-2.64	1.750	1.671	-4.49	2.231	2.156	-3.38
2/1984	2.721	2.591	-4.81	1.753	1.670	-4.72	0.921	0.880	-4.50
3/1984	2.875	2.716	-5.55	1.851	1.765	-4.67	0.975	0.929	-4.69
4/1984	2.678	2.550	-4.79	2.186	2.107	-3.59	1.105	1.069	-3.25
1/1985	3.084	3.013	-2.32	1.833	1.751	-4.46	2.689	2.607	-3.05
2/1985	3.000	2.969	-1.00	1.786	1.703	-4.65	1.022	0.977	-4.37
3/1985	2.808	2.651	-5.61	1.928	1.829	-5.12	1.008	0.957	-5.06
4/1985	3.204	3.042	-5.06	2.250	2.173	-3.42	1.188	1.150	-3.21
1/1986	3.200	3.094	-3.31	1.996	1.917	-3.99	2.946	2.864	-2.78
2/1986	3.040	2.897	-4.73	2.133	2.045	-4.10	1.419	1.364	-3.85
3/1986	2.552	2.410	-5.57	2.405	2.303	-4.26	1.222	1.169	-4.37
4/1986	2.611	2.475	-5.22	2.588	2.470	-4.55	1.236	1.185	-4.16
1/1987	3.064	2.962	-3.33	2.377	2.272	-4.43	3.097	2.989	-3.47
2/1987	3.649	3.437	-5.80	2.737	2.632	-3.87	1.705	1.637	-3.97
3/1987	4.187	3.910	-6.63	2.699	2.583	-4.30	1.590	1.517	-4.59
4/1987	3.753	3.512	-6.41	3.122	3.000	-3.91	1.663	1.598	-3.89
1/1988	3.613	3.437	-4.88	3.419	3.290	-3.77	5.652	5.473	-3.16
2/1988	3.747	3.566	-4.81	3.621	3.507	-3.13	2.268	2.195	-3.24
3/1988	3.351	3.150	-5.99	3.640	3.511	-3.55	2.107	2.025	-3.88
4/1988	3.406	3.198	-6.11	3.701	3.564	-3.72	2.000	1.926	-3.70

TABLE 44. Continued

Quarter/ Year	Base PLEXH	Scenario PLEXH15	Percentage Change	Base UPLH	Scenario UPLH15	Percentage Change
1/1983	0.392	0.381	-2.84	1.449	1.410	-2.65
2/1983	0.308	0.296	-4.17	1.286	1.246	-3.16
3/1983	0.285	0.278	-2.40	1.028	1.005	-2.21
4/1983	0.527	0.515	-2.34	1.350	1.321	-2.14
1/1984	0.358	0.348	-2.72	1.375	1.339	-2.63
2/1984	0.280	0.272	-2.93	1.161	1.130	-2.70
3/1984	0.303	0.295	-2.70	1.082	1.055	-2.51
4/1984	0.574	0.564	-1.88	1.435	1.407	-1.94
1/1985	0.360	0.353	-2.12	1.314	1.280	-2.57
2/1985	0.313	0.305	-2.60	1.193	1.162	-2.66
3/1985	0.250	0.243	-2.63	0.942	0.919	-2.46
4/1985	0.439	0.434	-1.12	1.306	1.289	-1.29
1/1986	0.326	0.323	-0.84	1.262	1.239	-1.79
2/1986	0.340	0.334	-1.68	1.136	1.113	-2.08
3/1986	0.291	0.284	-2.50	1.002	0.978	-2.34
4/1986	0.515	0.508	-1.35	1.393	1.373	-1.43
1/1987	0.418	0.414	-1.04	1.477	1.451	-1.75
2/1987	0.380	0.374	-1.51	1.350	1.326	-1.76
3/1987	0.471	0.462	-2.02	1.315	1.290	-1.89
4/1987	0.989	0.978	-1.12	2.010	1.985	-1.23
1/1988	0.827	0.817	-1.24	2.044	2.007	-1.82
2/1988	0.626	0.616	-1.67	2.042	2.008	-1.70
3/1988	0.615	0.604	-1.85	1.796	1.765	-1.73
4/1988	0.907	0.898	-1.01	2.073	2.050	-1.10

Allocation of high-valued Pacific salmon to Japan would diminish significantly by 14.19 percent. The decreased allocation of 1.88 percent to the EEC market was much less because the price of Atlantic salmon would rise in the EEC due to a decreased allocation. The average export price of high valued Pacific salmon in the EEC would decrease by 4.83 percent, and the exvessel price of high-valued salmon would decrease by 4.39 percent. The Atlantic salmon price in Japan would increase by 5.65 percent because of the increased demand for Atlantic salmon as the price of high-valued Pacific salmon increases.

Low-valued Pacific salmon prices would be affected to a lesser extent but the effects are still quite significant. Low-valued Pacific salmon allocation would decrease to Japan by 12.05 percent and to the EEC by 7.23 percent. The weighted average export price of low-valued Pacific salmon would decrease by 1.96 percent, and the low-valued Pacific salmon exvessel price would decrease by 2.16 percent.

Scenario 16 was the opposite of Scenario 15, representing the U.S. dollar weakening by 10 percent against all other currencies. Tables 45-46 present the results of this scenario. A weakening of the U.S. dollar makes it cheaper for foreign countries to purchase U.S. salmon and makes it less lucrative to export salmon to the U.S. market. In this case, the allocation of Norwegian Atlantic salmon would increase to the EEC and decrease to North America. The average price of Norwegian Atlantic salmon exported to the U.S., measured in U.S. dollars, would increase by 5.99 percent.

North American high-valued Pacific salmon exports would increase dramatically to Japan by 18.12 percent, with a resulting export price (in dollars) increase in Japan of 5.51 percent. High-valued Pacific salmon

TABLE 45. Scenario 16, U.S. Dollar Weakens by 10 Percent
Against All Currencies: Average Total Analysis

Variable	Base Quarter	Scenario Quarter	Percentage Change
EQAEH	19,811,930	20,184,710	1.88
NQAEH	14,578,054	14,950,844	2.56
QAUH	3,746,145	3,373,334	-9.95
NPAEH	21.06	20.79	-1.29
EPAEH	2.89	2.86	-1.12
NPAUH	23.09	22.05	-4.53
UPAUH	3.17	3.36	5.99
JPAJH	467.66	440.19	-5.87
QHJH	42,002,766	49,614,568	18.12
QHEH	6,958,529	6,987,317	0.41
UPHJH	2.36	2.49	5.51
JPHJH	426.64	403.74	-5.37
UPHEH	2.42	2.55	5.51
EPHEH	2.58	2.47	-4.03
UPHH	2.36	2.49	5.46
QLJH	10,939,052	12,653,421	15.67
QLEH	8,242,731	8,802,035	6.79
UPLJH	1.17	1.21	3.13
JPLJH	203.24	188.45	-7.28
UPLEH	1.57	1.60	1.70
EPLH	1.62	1.50	-7.46
UPLH	1.34	1.37	1.85
PHEXH	1.27	1.34	5.21
PLEXH	0.38	0.39	2.16

TABLE 46. Scenario 16, U.S. Dollar Weakens by 10 Percent Against All Currencies: Quarter-by-Quarter Analysis

Quarter/ Year	Base UPAUM	Scenario UPAUM16	Percentage Change	Base UPHM	Scenario UPHM16	Percentage Change	Base PHEXH	Scenario PHEXH16	Percentage Change
1/1983	2.90	3.07	5.73	1.58	1.67	5.48	1.73	1.82	5.37
2/1983	2.85	3.04	6.76	1.75	1.85	5.28	0.82	0.86	5.56
3/1983	3.23	3.48	7.77	1.72	1.81	5.35	0.84	0.89	5.62
4/1983	3.19	3.41	6.89	2.04	2.12	4.12	0.96	1.00	4.24
1/1984	2.68	2.77	3.36	1.75	1.83	4.51	2.23	2.31	3.45
2/1984	2.72	2.88	5.86	1.75	1.84	5.07	0.92	0.97	4.93
3/1984	2.88	3.07	6.95	1.85	1.95	5.47	0.97	1.03	5.56
4/1984	2.68	2.84	5.97	2.19	2.27	3.86	1.11	1.15	3.68
1/1985	3.08	3.17	2.94	1.83	1.92	4.49	2.69	2.77	3.08
2/1985	3.10	3.27	5.26	1.79	1.88	5.01	1.02	1.07	4.78
3/1985	2.81	3.01	7.04	1.93	2.05	6.13	1.01	1.07	6.11
4/1985	3.20	3.41	6.35	2.25	2.33	3.77	1.19	1.23	3.75
1/1986	3.20	3.33	4.23	2.00	2.08	4.15	2.95	3.03	2.97
2/1986	3.04	3.22	5.84	2.13	2.23	4.41	1.42	1.48	4.23
3/1986	2.55	2.73	7.01	2.41	2.53	4.99	1.22	1.29	5.19
4/1986	2.61	2.78	6.53	2.59	2.72	5.10	1.24	1.30	4.82
1/1987	3.06	3.19	4.24	2.38	2.49	4.84	3.10	3.22	3.87
2/1987	3.65	3.91	7.25	2.74	2.85	4.21	1.70	1.78	4.45
3/1987	4.19	4.54	8.43	2.70	2.84	5.17	1.59	1.68	5.57
4/1987	3.75	4.06	8.14	3.12	3.26	4.49	1.66	1.74	4.64
1/1988	3.61	3.84	6.28	3.42	3.56	4.19	5.65	5.86	3.64
2/1988	3.75	3.97	6.02	3.62	3.74	3.41	2.27	2.35	3.65
3/1988	3.35	3.61	7.62	3.64	3.80	4.32	2.11	2.21	4.75
4/1988	3.41	3.67	7.72	3.70	3.86	4.17	2.00	2.09	4.32

TABLE 46. Continued

Quarter/ Year	Base PLEXH	Scenario PLEXH16	Percentage Change	Base UPLH	Scenario UPLH16	Percentage Change
1/1983	0.39	0.40	2.63	1.45	1.48	2.44
2/1983	0.31	0.32	3.85	1.29	1.32	2.89
3/1983	0.28	0.29	2.16	1.03	1.05	1.98
4/1983	0.53	0.54	2.24	1.35	1.38	2.06
1/1984	0.36	0.37	2.65	1.37	1.41	2.50
2/1984	0.28	0.29	2.78	1.16	1.19	2.53
3/1984	0.30	0.31	2.66	1.08	1.11	2.47
4/1984	0.57	0.58	1.88	1.44	1.46	1.88
1/1985	0.36	0.37	2.00	1.31	1.35	2.40
2/1985	0.31	0.32	2.59	1.19	1.22	2.65
3/1985	0.25	0.26	2.63	0.94	0.97	2.45
4/1985	0.44	0.44	0.83	1.31	1.32	0.99
1/1986	0.33	0.33	0.51	1.26	1.28	1.57
2/1986	0.34	0.35	1.67	1.14	1.16	2.09
3/1986	0.29	0.30	2.66	1.00	1.03	2.48
4/1986	0.52	0.52	1.44	1.39	1.41	1.44
1/1987	0.42	0.42	0.98	1.48	1.50	1.67
2/1987	0.38	0.38	1.39	1.35	1.37	1.67
3/1987	0.47	0.48	2.13	1.31	1.34	1.99
4/1987	0.99	1.00	1.10	2.01	2.03	1.17
1/1988	0.83	0.84	1.09	2.04	2.08	1.69
2/1988	0.63	0.63	1.37	2.04	2.07	1.44
3/1988	0.62	0.63	1.89	1.80	1.83	1.76
4/1988	0.91	0.92	0.92	2.07	2.09	0.97

allocation to the EEC would increase by only 0.41 percent, due in part to the lower price of Atlantic salmon in the EEC. The high-valued Pacific salmon exvessel price would increase by 5.21 percent. The Japanese price of Atlantic salmon (in yen) would decrease by 5.87 percent as the Atlantic salmon decreases due to lower high-valued Pacific salmon prices.

The low-valued Pacific salmon exports would also dramatically increase to both export markets which would leave less low-valued Pacific salmon for the domestic and canned markets. The resulting price increase in the average export price would be 1.85 percent, and the exvessel price of low-valued Pacific salmon would increase by 2.16 percent.

Group 8: Canned Low-Valued Pacific Salmon Prices $\pm$ 10% Relative to Historical Levels

This group of scenarios examined the effects of changes in the levels of low-valued canned Pacific salmon prices on salmon markets. Low-valued canned Pacific salmon prices were set exogenously in simulations. In reality, they are influenced by some of the same factors that affect the fresh/frozen markets so the results must be interpreted as being conditional on canned prices and care must be taken in interpreting the results as not allowing for feedback between the fresh/frozen and canned markets.

Tables 47-50 present the results of these scenarios. An increase in the canned salmon price would increase the price of low-valued salmon and would reduce the North American low-valued Pacific salmon allocation to both export markets. The allocation would be reduced by 9.48 percent to Japan and by 4.11 percent to the EEC. The low-valued salmon that is not exported would remain in North America to be canned or sold in fresh/frozen form. Prices received in both export markets would increase, and the exvessel price of low-valued

TABLE 47. Scenario 17, Prices of Canned Low-Valued Salmon Increase by 10 Percent: Average Total Analysis

Variable	Base Quarter	Scenario Quarter	Percentage Change
EQAEH	19,811,930	19,811,825	0.00
NQAEH	14,578,054	14,577,950	0.00
QAUH	3,746,145	3,746,249	0.00
NPAEH	21.059	21.070	0.05
EPAEH	2.890	2.891	0.05
NPAUH	23.094	23.103	0.04
UPAUH	3.166	3.167	0.04
JPAJH	467.660	467.962	0.06
QHJH	42,002,766	41,848,821	-0.37
QHEH	6,958,529	7,114,471	2.24
UPHJH	2.356	2.359	0.12
JPHJH	426.640	427.140	0.12
UPHEH	2.419	2.432	0.51
EPHEH	2.576	2.589	0.51
UPHH	2.365	2.369	0.19
QLJH	10,939,052	9,901,672	-9.48
QLEH	8,242,731	7,903,948	-4.11
UPLJH	1.173	1.234	5.23
JPLJH	203.240	213.942	5.27
UPLEH	1.569	1.629	3.85
EPLH	1.618	1.680	3.80
UPLH	1.343	1.410	4.95
PHEXH	1.271	1.273	0.12
PLEXH	0.379	0.401	5.85

TABLE 48. Scenario 17, Prices of Canned Low-Valued Salmon Increase by 10 Percent: Quarter-by-Quarter Analysis

Quarter/ Year	Base UPAUH	Scenario UPAUH17	Percentage Change	Base UPHH	Scenario UPHH17	Percentage Change	Base PHEXH	Scenario PHEXH17	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	3.234	0.08	1.722	1.727	0.28	0.843	0.845	0.24
4/1983	3.189	3.195	0.17	2.036	2.051	0.77	0.957	0.964	0.68
1/1984	2.678	2.679	0.03	1.750	1.751	0.10	2.231	2.235	0.18
2/1984	2.721	2.721	0.00	1.753	1.753	0.00	0.921	0.921	-0.01
3/1984	2.875	2.877	0.08	1.851	1.857	0.28	0.975	0.977	0.24
4/1984	2.678	2.682	0.15	2.186	2.200	0.66	1.105	1.111	0.58
1/1985	3.084	3.085	0.02	1.833	1.834	0.06	2.689	2.692	0.12
2/1985	3.103	3.103	0.00	1.786	1.786	0.00	1.022	1.022	-0.01
3/1985	2.808	2.810	0.05	1.928	1.931	0.16	1.008	1.009	0.14
4/1985	3.204	3.207	0.09	2.250	2.259	0.40	1.188	1.192	0.35
1/1986	3.200	3.200	0.01	1.996	1.997	0.04	2.946	2.948	0.07
2/1986	3.040	3.040	0.00	2.133	2.133	-0.01	1.419	1.418	-0.01
3/1986	2.552	2.553	0.04	2.405	2.407	0.08	1.222	1.223	0.07
4/1986	2.611	2.612	0.05	2.588	2.591	0.14	1.236	1.238	0.12
1/1987	3.064	3.064	0.00	2.377	2.377	0.01	3.097	3.097	0.01
2/1987	3.649	3.649	0.00	2.737	2.737	0.00	1.705	1.705	0.00
3/1987	4.187	4.189	0.05	2.699	2.702	0.11	1.590	1.591	0.10
4/1987	3.753	3.756	0.09	3.122	3.133	0.35	1.663	1.668	0.30
1/1988	3.613	3.614	0.01	3.419	3.420	0.03	5.652	5.655	0.06
2/1988	3.747	3.747	0.00	3.621	3.620	0.00	2.268	2.268	0.00
3/1988	3.351	3.353	0.07	3.640	3.646	0.14	2.107	2.110	0.13
4/1988	3.406	3.409	0.06	3.701	3.705	0.11	2.000	2.002	0.11

TABLE 48. Continued

Quarter/ Year	Base PLEXH	Scenario PLEXH17	Percentage Change	Base UPLH	Scenario UPLH17	Percentage Change
1/1983	0.392	0.408	4.23	1.449	1.505	3.92
2/1983	0.308	0.330	7.12	1.286	1.357	5.49
3/1983	0.285	0.303	6.25	1.028	1.087	5.75
4/1983	0.527	0.561	6.31	1.350	1.416	4.91
1/1984	0.358	0.375	4.72	1.375	1.432	4.13
2/1984	0.280	0.292	4.33	1.161	1.210	4.25
3/1984	0.303	0.321	6.05	1.082	1.143	5.62
4/1984	0.574	0.601	4.58	1.435	1.494	4.11
1/1985	0.360	0.371	2.95	1.314	1.361	3.56
2/1985	0.313	0.323	3.30	1.193	1.241	3.96
3/1985	0.250	0.265	5.90	0.942	0.994	5.49
4/1985	0.439	0.458	4.29	1.306	1.359	4.01
1/1986	0.326	0.334	2.45	1.262	1.303	3.27
2/1986	0.340	0.348	2.53	1.136	1.174	3.36
3/1986	0.291	0.305	4.74	1.002	1.046	4.43
4/1986	0.515	0.535	3.79	1.393	1.446	3.77
1/1987	0.418	0.431	3.02	1.477	1.531	3.66
2/1987	0.380	0.394	3.68	1.350	1.404	4.01
3/1987	0.471	0.496	5.22	1.315	1.379	4.86
4/1987	0.989	1.036	4.70	2.010	2.100	4.50
1/1988	0.827	0.858	3.72	2.044	2.127	4.05
2/1988	0.626	0.665	6.19	2.042	2.168	6.13
3/1988	0.615	0.659	7.16	1.796	1.915	6.63
4/1988	0.907	0.957	5.46	2.073	2.177	5.06

TABLE 49. Scenario 18, Prices of Canned Low-Valued Salmon
Decrease by 10 Percent: Average Total Analysis

Variable	Base Quarter	Scenario Quarter	Percentage Change
EQAEH	19,811,930	19,812,007	0.00
NQAEH	14,578,054	14,578,131	0.00
QAUH	3,746,145	3,746,067	0.00
NPAEH	21.06	21.05	-0.05
EPAEH	2.89	2.89	-0.05
NPAUH	23.09	23.09	-0.04
UPAUH	3.17	3.17	-0.03
JPAJH	467.66	467.36	-0.06
QHJH	42,002,766	42,156,440	0.37
QHEH	6,958,529	6,807,437	-2.17
UPHJH	2.36	2.35	-0.12
JPHJH	426.64	426.14	-0.12
UPHEH	2.42	2.41	-0.50
EPHEH	2.58	2.56	-0.50
UPHH	2.36	2.36	-0.18
QLJH	10,939,052	12,138,248	10.96
QLEH	8,242,731	8,595,825	4.28
UPLJH	1.17	1.11	-5.18
JPLJH	203.24	192.63	-5.22
UPLEH	1.57	1.51	-3.86
EPLH	1.62	1.56	-3.81
UPLH	1.34	1.28	-4.96
PHEXH	1.27	1.27	-0.11
PLEXH	0.38	0.36	-5.79

TABLE 50. Scenario 18, Prices of Canned Low-Valued Salmon
Decrease by 10 Percent: Quarter-by-Quarter Analysis

Quarter/ Year	Base UPAUM	Scenario UPAUM18	Percentage Change	Base UPHH	Scenario UPHH18	Percentage Change	Base PHEXH	Scenario PHEXH18	Percentage Change
1/1983	2.90	2.90	0.00	1.58	1.58	0.00	1.73	1.73	0.00
2/1983	2.85	2.85	0.00	1.75	1.75	0.00	0.82	0.82	0.00
3/1983	3.23	3.23	-0.08	1.72	1.72	-0.28	0.84	0.84	-0.23
4/1983	3.19	3.18	-0.17	2.04	2.02	-0.75	0.96	0.95	-0.67
1/1984	2.68	2.68	-0.03	1.75	1.75	-0.10	2.23	2.23	-0.18
2/1984	2.72	2.72	0.00	1.75	1.75	0.00	0.92	0.92	0.01
3/1984	2.88	2.87	-0.08	1.85	1.85	-0.28	0.97	0.97	-0.24
4/1984	2.68	2.67	-0.15	2.19	2.17	-0.64	1.11	1.10	-0.57
1/1985	3.08	3.08	-0.02	1.83	1.83	-0.06	2.69	2.69	-0.12
2/1985	3.10	3.10	0.00	1.79	1.79	0.00	1.02	1.02	0.01
3/1985	2.81	2.81	-0.05	1.93	1.93	-0.16	1.01	1.01	-0.13
4/1985	3.20	3.20	-0.09	2.25	2.24	-0.40	1.19	1.18	-0.34
1/1986	3.20	3.20	-0.01	2.00	2.00	-0.04	2.95	2.94	-0.07
2/1986	3.04	3.04	0.00	2.13	2.13	0.01	1.42	1.42	0.01
3/1986	2.55	2.55	-0.04	2.41	2.40	-0.08	1.22	1.22	-0.07
4/1986	2.61	2.61	-0.05	2.59	2.58	-0.13	1.24	1.23	-0.12
1/1987	3.06	3.06	0.00	2.38	2.38	-0.01	3.10	3.10	-0.01
2/1987	3.65	3.65	0.00	2.74	2.74	0.00	1.70	1.70	0.00
3/1987	4.19	4.19	-0.05	2.70	2.70	-0.11	1.59	1.59	-0.10
4/1987	3.75	3.75	-0.09	3.12	3.11	-0.33	1.66	1.66	-0.29
1/1988	3.61	3.61	-0.01	3.42	3.42	-0.02	5.65	5.65	-0.06
2/1988	3.75	3.75	0.00	3.62	3.62	0.00	2.27	2.27	0.00
3/1988	3.35	3.35	-0.07	3.64	3.64	-0.14	2.11	2.10	-0.13
4/1988	3.41	3.40	-0.06	3.70	3.70	-0.10	2.00	2.00	-0.11

TABLE 50. Continued

Quarter/ Year	Base PLEXH	Scenario PLEXH18	Percentage Change	Base UPLH	Scenario UPLH18	Percentage Change
1/1983	0.39	0.38	-3.82	1.45	1.39	-3.91
2/1983	0.31	0.29	-6.39	1.29	1.22	-5.50
3/1983	0.28	0.27	-5.63	1.03	0.97	-5.72
4/1983	0.53	0.50	-5.69	1.35	1.28	-4.93
1/1984	0.36	0.34	-4.27	1.37	1.32	-4.12
2/1984	0.28	0.27	-3.89	1.16	1.11	-4.22
3/1984	0.30	0.29	-5.43	1.08	1.02	-5.57
4/1984	0.57	0.55	-4.15	1.44	1.38	-4.10
1/1985	0.36	0.35	-2.64	1.31	1.27	-3.52
2/1985	0.31	0.30	-2.94	1.19	1.15	-3.90
3/1985	0.25	0.24	-5.29	0.94	0.89	-5.43
4/1985	0.44	0.42	-3.95	1.31	1.25	-4.06
1/1986	0.33	0.32	-2.26	1.26	1.22	-3.25
2/1986	0.34	0.33	-2.27	1.14	1.10	-3.32
3/1986	0.29	0.28	-4.25	1.00	0.96	-4.38
4/1986	0.52	0.50	-3.44	1.39	1.34	-3.77
1/1987	0.42	0.41	-2.75	1.48	1.42	-3.63
2/1987	0.38	0.37	-3.35	1.35	1.30	-4.00
3/1987	0.47	0.45	-4.69	1.31	1.25	-4.82
4/1987	0.99	0.95	-4.27	2.01	1.92	-4.50
1/1988	0.83	0.80	-3.39	2.04	1.96	-4.02
2/1988	0.63	0.59	-5.64	2.04	1.92	-6.14
3/1988	0.62	0.58	-6.42	1.80	1.68	-6.57
4/1988	0.91	0.86	-4.98	2.07	1.97	-5.09

salmon would rise by 5.85 percent. Prices would rise in the export markets because of the decreased allocation to both markets.

Some high-valued Pacific salmon would be reallocated to the EEC to replace some of the loss of low-valued Pacific salmon exports to the EEC, due to the increased use of low-valued Pacific salmon for canning. Both export markets experience increases in high-valued Pacific salmon prices because of the reduced supply of high-valued salmon to Japan and the increased demand in the EEC for high-valued salmon. Atlantic salmon markets would be largely unaffected.

When canned salmon prices are decreased, the allocation of low-valued Pacific fresh/frozen salmon would increase to all export markets and the exvessel price would decline by 5.79 percent. This decrease is caused by the low-valued Pacific salmon average export price declining by 4.96 percent due to the increased allocation of low-valued salmon to the export markets.

High-valued Pacific salmon would be reallocated from the EEC to Japan. The EEC market would be less lucrative for high-valued Pacific salmon because of the decreasing low-valued Pacific salmon price. The exvessel price of high-valued Pacific salmon would diminish slightly by 0.11 percent. The Atlantic salmon market, again, would be largely unaffected.

Summary of Simulations

In this section, some observations are made regarding comparisons of the effects of the scenarios on the key price variables in the model. Tables 51 and 52 compare the changes in the five key prices. Table 51 summarizes average total change in a quarter's price variables for scenarios that generally resulted in a decrease in the key prices. Table 52 summarizes average total change in a quarter's price variables for scenarios that

TABLE 51. Percentage Changes in Key Price Variables For Scenarios in Which at Least One Relevant Price Decreases: Average Total Analysis

Scenario	UPAUH	UPHH	UPLH	PHEXH	PLEXH
1	-0.42	-1.94	-0.29	-3.82	-0.30
3	-0.01	-0.07	-1.71	-0.04	-5.34
5	-2.63	-0.17	-0.04	-0.50	-0.04
7	-2.34	-0.16	-0.03	-0.47	-0.04
9	-0.87	0.00	0.00	-0.07	0.00
12	-0.35	-2.09	-0.32	-1.60	-0.56
13	-3.57	-0.41	-1.08	-1.03	-0.83
15	-4.80	-4.68	-1.96	-4.39	-2.16
18	-0.03	-0.18	-4.96	-0.11	-5.79

TABLE 52. Percentage Changes in Key Price Variables For Scenarios in Which at Least One Relevant Price Increases: Average Total Analysis

Scenario	UPAUH	UPHH	UPLH	PHEXH	PLEX
2	0.47	2.18	0.32	4.40	0.34
4	0.01	0.07	1.89	0.05	6.22
6	3.07	0.20	0.04	0.58	0.05
8	2.71	0.18	0.04	0.53	0.04
10	0.96	0.00	0.00	0.07	0.00
11	1.28	2.38	0.62	2.00	0.82
14	2.65	0.00	0.00	0.54	0.00
16	5.99	5.46	1.85	5.21	2.16
17	0.04	0.19	4.95	0.12	5.85

generally increased the level of the key prices.

Price decreases reported in Table 51 are for Scenarios 1, 3, 5, 7, 9, 12, 13, 15, and 18, in which: landings of North American high-valued salmon increased by 10 percent; landings of low-valued salmon increased by 10 percent; Norwegian and Scottish exports of farmed Atlantic salmon increased by 10 percent; Chilean farmed salmon exports to North America increased by 25 percent; Japanese tariffs on all fresh/frozen salmon doubled; the EEC tariff on all fresh/frozen salmon increased to 12 percent; the U.S. dollar strengthened by 10 percent against all foreign currencies except the Canadian dollar; and low-valued canned salmon prices decreased by 10 percent.

For the price of Norwegian Atlantic salmon exported to the United States, there were large effects when exports of Atlantic salmon increased, tariffs rose, or the U.S. dollar strengthened. The scenarios that generated the largest decrease in the high-valued Pacific salmon average export price and the exvessel price occurred when high-valued Pacific salmon landings increased, the EEC and Japanese tariffs increased, and the U.S. dollar strengthened. The effects of an increase in Norwegian and Scottish farmed Atlantic salmon exports on high-valued Pacific salmon prices were smaller due in part to the low cross-price demand elasticities found between the two species.

The scenarios that generated the largest decreases in the average export price and exvessel price of low-valued Pacific salmon occurred in scenarios in which low-valued landings increased, the U.S. dollar strengthened, or the low-valued canned Pacific salmon price decreased. The effects of tariffs were smaller than expected because the decreased shipments of high-valued Pacific salmon to the export markets strengthened the EEC demand for low-valued

Pacific salmon in quarters 3 and 4 and, therefore, dampened the decrease.

Increases in prices are reported in Table 52 and are associated with scenarios 2, 4, 6, 8, 10, 14, 16, and 17 in which: landings of North American high-valued salmon decreased by 10 percent; landings of low-valued salmon decreased by 10 percent; Norwegian and Scottish exports of farmed Atlantic salmon decreased by 10 percent; Chilean farmed salmon exports to North American decreased by 25 percent; salmon trade was tariff-free; a 5 percent North American tariff was placed on all fresh/frozen salmon imports; the North American currencies weakened against all other currencies by 10 percent; and the low-valued canned Pacific salmon price rose by 10 percent.

In comparison to the associated scenarios in Table 51, the effects were close in magnitude but opposite in signs. Atlantic salmon prices rose the most when the Norwegian and Scottish exports decreased, salmon trade was tariff-free, and the North American currencies weakened against all other currencies. When both Norwegian and Scottish exports were decreased, the Atlantic salmon price rose more in North America and there was movement to reallocate some Norwegian salmon to the EEC to make up for the decreased Scottish salmon supplies.

The prices of high-valued Pacific salmon (in U.S. dollars) rose the most when high-valued Pacific salmon landings decreased, trade was tariff-free, or North American currencies weakened. The low-valued salmon prices rose the most when low-valued landings decreased, the North American exchange rate weakened, or low-valued salmon canned prices rose.

4. Forecasting Salmon Prices for 1990-1993

In this section forecasts of five key salmon price variables are presented for the period 1990-1993. The price variables include:

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

An overview of the forecasting methodology was presented on pages 51-54 of section IV. Further details on the approach used for forecasting the price variables can be found in Herrmann (1990, p. 622-651).

In the tabled results, the letter "H" following a variable name stands for "hat" or prediction, as before. Also, the letter "R" following the "H" indicates that the price is expressed in real terms, i.e., the price is adjusted for the effects of general price inflation over time. The forecasts for the price variables are reported below in Tables 53-56. Real prices were derived by deflating nominal prices by the appropriate price index values using the first quarter of 1989 as the base quarter for the index (i.e., price index = 1.00 in the first quarter of 1989; see the definition of UPPI on page 65).

Both quarterly and yearly weighted average prices are reported. The quarterly forecasted prices generally exhibit a more pronounced seasonality than do the historical prices which may be a function of the seasonality projected for some of the exogenous variables in the model or the intercept adjustments. The yearly prices are quantity-weighted averages of the quarterly prices and provide an indication of the trend in future annual prices.

TABLE 53. Forecasts of Nominal Salmon Prices by Quarter from 1990 to 1993 (in U.S. dollars per pound)

Year:Qtr	Price Variables				
	UPAUH	UPHH	UPLH	PHEXH	PLEXH
1990:1	2.45	2.69	1.65	3.47	0.48
1990:2	2.79	3.16	1.64	1.89	0.41
1990:3	3.01	3.27	1.41	1.96	0.55
1990:4	2.48	3.13	1.66	1.40	0.88
1991:1	2.57	2.66	1.67	3.67	0.52
1991:2	2.99	3.21	1.68	2.02	0.44
1991:3	3.08	3.32	1.44	2.08	0.58
1991:4	2.67	3.20	1.70	1.46	0.93
1992:1	2.63	2.71	1.70	3.90	0.54
1992:2	3.11	3.24	1.71	2.13	0.47
1992:3	3.15	3.37	1.48	2.19	0.61
1992:4	2.81	3.25	1.74	1.50	0.98
1993:1	2.64	2.75	1.73	4.07	0.56
1993:2	3.20	3.28	1.74	2.23	0.48
1993:3	3.21	3.42	1.51	2.30	0.64
1993:4	2.90	3.31	1.77	1.53	1.02

TABLE 54. Forecasts of Quantity-Weighted Average Nominal Salmon Prices by Year from 1990 to 1993 (in U.S. dollars per pound)

Year	Price Variables				
	UPAUH	UPHH	UPLH	PHEXH	PLEXH
1990	2.62	3.20	1.48	1.94	0.57
1991	2.78	3.26	1.51	2.05	0.60
1992	2.89	3.31	1.55	2.17	0.63
1993	2.96	3.36	1.58	2.27	0.66

TABLE 55. Forecasts of Real Salmon Prices by Quarter from 1990 to 1993, Deflated to First Quarter 1989 Dollars (in U.S. dollars per pound)

Year:Qtr	Price Variables				
	UPAUHR	UPHHR	UPLHR	PHEXHR	PLEXHR
1990:1	2.45	2.68	1.64	3.46	0.48
1990:2	2.78	3.13	1.54	1.87	0.41
1990:3	2.97	3.23	1.51	1.94	0.54
1990:4	2.43	3.07	1.92	1.38	0.87
1991:1	2.51	2.60	1.64	3.58	0.50
1991:2	2.90	3.12	1.55	1.96	0.43
1991:3	2.98	3.21	1.51	2.01	0.56
1991:4	2.56	3.07	1.92	1.41	0.90
1992:1	2.52	2.59	1.63	3.72	0.52
1992:2	2.96	3.09	1.55	2.03	0.44
1992:3	2.98	3.19	1.51	2.07	0.57
1992:4	2.65	3.06	1.91	1.42	0.92
1993:1	2.47	2.58	1.62	3.82	0.53
1993:2	2.98	3.06	1.54	2.08	0.45
1993:3	2.98	3.17	1.51	2.13	0.59
1993:4	2.68	3.05	1.90	1.42	0.94

TABLE 56. Forecasts of Quantity-Weighted Real Salmon Prices by Year from 1990 to 1993, Deflated to First Quarter 1989 Dollars (in U.S. dollars per pound)

Year	Price Variables				
	UPAUHR	UPHHR	UPLHR	PHEXHR	PLEXHR
1990	2.59	3.16	1.58	1.92	0.56
1991	2.69	3.15	1.58	1.99	0.58
1992	2.75	3.14	1.57	2.05	0.59
1993	2.75	3.12	1.57	2.11	0.61

For the price of Norwegian Atlantic salmon exported to North America, the trend is for the nominal prices to increase about 13 percent from 1990 to 1993, but for the real prices to increase by only 6 percent. The forecasted real price of Norwegian farmed Atlantic salmon in 1993 is approximately one dollar lower than the 1988 prices, being more comparable to the real prices at the 1985 levels. It was forecasted that the real annual price will rise from \$2.59 per pound in 1990 to \$2.75 per pound in 1993. This price increase was largely a result of the decreased growth rate in production from Norway coupled with a moderately increasing demand for salmon over the time period. Sensitivity analyses on Norwegian production will be performed later in this section.

The quarterly prices show a peak in quarters 2 and 3 in comparison to quarters 1 and 4 due, to some extent, to Norway decreasing its allocation to North America in these quarters as the North American landings of Pacific salmon peak and also due to the downward shift in demand in the first quarter as Chilean salmon imports increase in the North American market. Since these swings have not been as pronounced or seasonally inclined in the past, these swings should be viewed with some caution.

For high-valued Pacific salmon, the nominal prices increased by 5 percent for the average export price and by 17 percent for the exvessel price from 1990 to 1993. The real prices indicate that the weighted average export price will remain relatively constant while the exvessel price increases by 9.8 percent between 1990 and 1993. The increase in the exvessel price of high-valued Pacific salmon is induced by landings being held constant into the future, while production of farmed salmon increases at a decreasing rate and the real growth rate of income is increasing. If landings increase due to

salmon enhancement, or if farmed salmon supplies grow faster than expected, then predicted prices may be overstated. The quarterly figures exhibit a diminishing price in the fourth quarter due to a rapid increase in Chilean production. This seasonality is probably overstated, because Chile may penetrate other markets in response to price changes.

The low-valued Pacific salmon price forecasts show a 6.7 percent increase in the FOB export price and a 15.7 percent increase for exvessel price for the nominal prices between 1990 and 1993. For real prices, UPLH remains essentially constant and the exvessel price of low-valued Pacific salmon rises by 5.1 percent. The increase in the exvessel price of low-valued Pacific salmon is due to factors that are similar to those that caused the increase in prices in the exvessel price of high-valued Pacific salmon, mainly due to rising real incomes and slowly expanding salmon demand.

Sensitivity analyses were performed on the total exports of farmed Atlantic salmon from Norway and Scotland, the exchange rates, and the landings of North American Pacific salmon. These variables were chosen for sensitivity analyses because of their volatility and because of their significant effects on salmon prices as found in the sensitivity analyses over the historical time period.

Production of farmed Atlantic salmon from Norway and Scotland was varied by 20 percent above and below the baseline forecast levels. The resulting changes in the real price of Norwegian farmed Atlantic salmon exported to North America and the real price of high-valued Pacific salmon at the exvessel level resulted in price differentials ranging from \$.29 to \$.63 per pound, and \$.03 to \$.08 per pound, respectively.

The Pacific salmon landings were varied one standard deviation above and below their yearly mean. This resulted in high-valued Pacific salmon landings being varied by 8.7 percent above and below its mean level and low-valued Pacific landings were varied by 17 percent. Differences in the price of Norwegian Atlantic salmon ranged between \$.05 to \$.07 per pound. The differences in the North American weighted average export price of high-valued salmon ranged between \$.05 - .08 per pound, and the differences in the North American high-valued exvessel price ranges between \$.01 - .23 per pound. Differences in the North American average export price of low-valued Pacific salmon and the exvessel prices of low-valued salmon ranged from \$.0 - .08 and \$.0 - \$.12 per pound, respectively.

The exchange rates were varied above and below their quarterly means calculated from values observed between 1982 to 1988. The standard deviations were equivalent to variations of 11 percent above and below the mean values for NORUSA, 9.1 percent for NORECU, 16 percent for USAECU, and 24.8 percent for JAPUSA. Since all the exchange rates were varied systematically, the percentage changes were incorporated for NORUSA, NORECU, and USAECU, with NORECU being changed by 14.2 percent to account for arbitraging clearing the exchange rates.

The price changes resulting from variations in exchange rates are quite large. The differences between the high and low values of the real price of Norwegian Atlantic salmon ranged from \$.48 to \$.66, and the real North American average export price differences for high-valued salmon ranged from \$.51 to \$.68 per pound. The range of differences in real high-valued Pacific salmon exvessel prices were between \$.28 and \$.36 per pound. The difference between the high and low real weighted average North American low-valued

Pacific salmon export price and the low-valued Pacific salmon exvessel price ranged from \$.06 to \$.18 and \$.04 to \$.06 per pound, respectively.

Tables 57-59 present the lowest and highest future salmon prices that were predicted in any of the sensitivity analyses reported above. It is obvious that the ranges between high and low real prices are quite large, indicating that accurate forecasts are difficult to make if changes in the predetermined variables do not follow the assumed or predicted values. For the price of Norwegian Atlantic salmon in the United States, it was found that the low and high prices resulted from sensitivity analyses that changed farmed Atlantic salmon exports and changed exchange rates. For the Pacific salmon, the low and high prices were generated solely from the changing exchange rate sensitivity analyses. For low-valued salmon, the high and low prices were generated from the sensitivity analyses for which the low-valued Pacific salmon landings and exchange rates were varied.

5. Profitability of Farming Salmon in the Puget Sound

As discussed in section IV., p. 54-60, the forecast of the future prices of Norwegian Atlantic salmon exported to North American were adjusted by marketing margins and by an apparent price premium relative to North American farmed Atlantic salmon to proxy the price received by Puget Sound salmon farmers for farm-raised Atlantic salmon. Farmers selling directly to retail buyers were assumed to obtain a 15% price premium over farmers selling to a first receiver (wholesaler). These prices were then compared to per pound costs of production to establish profit margins for Puget Sound farming operators. Costs of production (in real terms) were assumed to be \$3.00/pound for efficient established farms and \$3.50/pound for less efficient/startup

TABLE 57. Forecasts of Real High and Low Salmon Prices for UPAUH and UPHH by Quarter from 1990 to 1993, Deflated to First Quarter 1989 Dollars (in U.S. dollars per pound)

Year:Qtr	UPAUHR		UPHHR	
	Low	High	Low	High
1990:1	2.24	2.78	2.39	3.04
1990:2	2.47	3.11	2.87	3.45
1990:3	2.72	3.32	2.99	3.58
1990:4	2.17	2.79	2.75	3.48
1991:1	2.28	2.82	2.32	2.94
1991:2	2.62	3.27	2.88	3.41
1991:3	2.70	3.35	2.97	3.57
1991:4	2.27	2.94	2.77	3.46
1992:1	2.28	2.83	2.33	2.91
1992:2	2.67	3.31	2.86	3.37
1992:3	2.71	3.36	2.96	3.56
1992:4	2.35	3.04	2.76	3.44
1993:1	2.24	2.79	2.33	2.89
1993:2	2.69	3.35	2.84	3.33
1993:3	2.71	3.35	2.94	3.55
1993:4	2.38	3.08	2.76	3.42

TABLE 58. Forecasts of Real High and Low Salmon Prices for PHEXH and UPLH by Quarter from 1990 to 1993, Deflated to First Quarter 1989 Dollars (in U.S. dollars per pound)

Year:Qtr	PHEXHR		UPLHR	
	Low	High	Low	High
1990:1	3.11	3.90	1.59	1.71
1990:2	1.71	2.07	1.47	1.63
1990:3	1.79	2.15	1.47	1.56
1990:4	1.24	1.55	1.88	1.96
1991:1	3.23	4.01	1.59	1.70
1991:2	1.81	2.14	1.50	1.62
1991:3	1.86	2.23	1.47	1.56
1991:4	1.28	1.57	1.88	1.95
1992:1	3.40	4.13	1.59	1.68
1992:2	1.88	2.20	1.49	1.61
1992:3	1.91	2.31	1.47	1.56
1992:4	1.29	1.58	1.88	1.94
1993:1	3.58	4.21	1.58	1.67
1993:2	1.93	2.25	1.49	1.61
1993:3	1.97	2.38	1.47	1.56
1993:4	1.29	1.58	1.87	1.93

TABLE 59. Forecasts of Real High and Low Salmon Prices for PLEXHR by Quarter from 1990 to 1993, Deflated to First Quarter 1989 Dollars (in U.S. dollars per pound)

Year:Qtr	PLEXHR Low	PLEXHR High
1990:1	0.46	0.50
1990:2	0.39	0.44
1990:3	0.49	0.59
1990:4	0.81	0.92
1991:1	0.49	0.52
1991:2	0.41	0.45
1991:3	0.51	0.61
1991:4	0.84	0.96
1992:1	0.50	0.54
1992:2	0.42	0.47
1992:3	0.53	0.63
1992:4	0.87	0.98
1993:1	0.51	0.56
1993:2	0.43	0.47
1993:3	0.54	0.64
1993:4	0.89	1.01

farms. Production costs are interpreted to be dressed, packaged, and delivered priced FOB Seattle, but are not inclusive of a fair return to investment capital.

The profits margin per quarter for Puget Sound Atlantic salmon farmer selling to a first receiver, using the baseline price forecasts and a cost of production of \$3.00 per pound, ranged from -\$0.04 to \$0.33 per pound (see Figure 9). For a Puget Sound Atlantic salmon farmer who can bypass the first

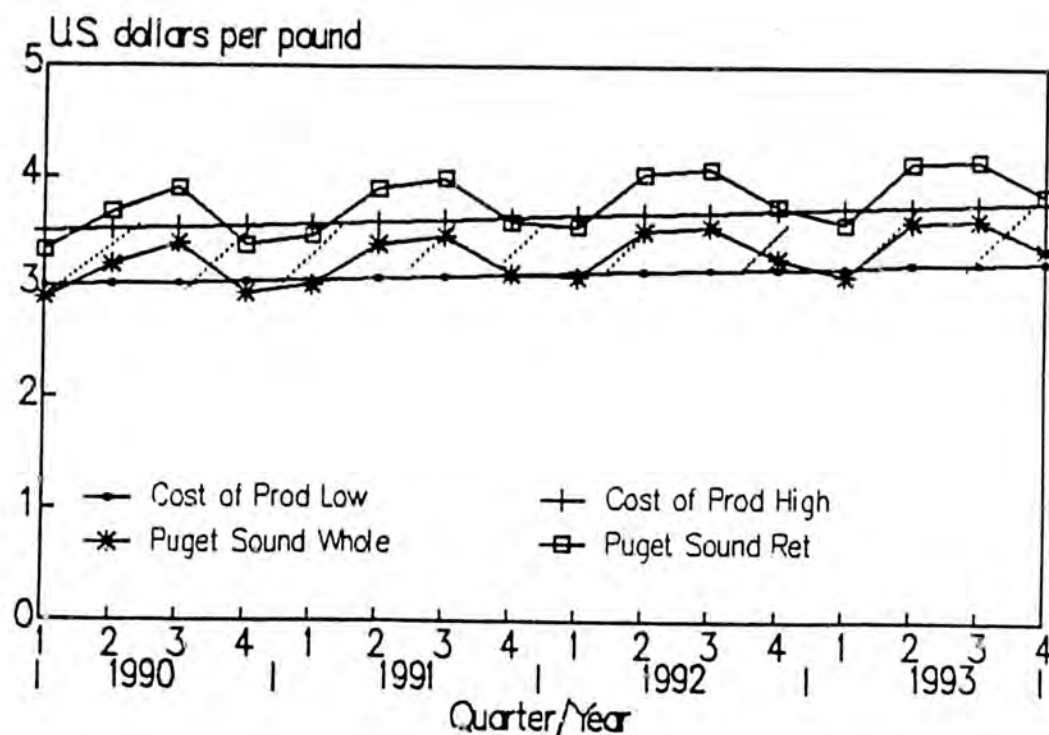


FIGURE 9. Estimated Future Nominal Costs of Production of Puget Sound Atlantic Farmed Salmon (for Low and High Costs of Production) vs. Estimated Nominal Future Wholesale and Retail Prices, 1990-93 (in U.S. dollars per pound)

receiver level, the profit margin ranged from \$0.39 to \$0.90 per pound. (The profit margins for farmers selling to a retailer reported here, and in the following sections do not account for any additional marketing costs associated with bypassing wholesalers. Actual profit margins from selling to a retailer will generally be lower since farmers will be performing additional services that wholesalers would otherwise perform).

As another perspective on profit margins, examine the quantity-weighted average annual prices reported in Table 60. For a farm that had a real cost of production of \$3.00 per pound, it is predicted that the real profit margins for 1990-93 would be between \$0.14 and \$0.25 per pound for farmers selling to first receivers and between \$0.61 and \$0.73 per pound for farms selling to retailers. Figure 10 compares real prices received for Puget Sound Atlantic salmon sold to first receivers and to receivers at the retail level with high and low costs of production.

Table 61 presents ranges for the forecasted average annual real prices for Puget Sound farmed Atlantic salmon sold at first receiver (wholesale) and retail levels. The ranges were developed from the sensitivity analysis performed on forecasted prices discussed previously. Real profit margins calculated on the basis of these ranges are presented in Table 62 for farmers selling at the first receiver (wholesale) level and in Table 63 for farmers selling to retailers directly. It is obvious that fluctuating market conditions which are outside the control of salmon farmers in Puget Sound can greatly affect forecasted profit margins. For salmon farmers that sell to wholesalers, all farmers experience losses in the scenarios where salmon prices are low. This low scenario is most likely to happen when exchange rates strengthen and/or foreign producers of farmed Atlantic salmon produce

TABLE 60. Quantity-Weighted Average Annual Forecasted Nominal and Real Prices of Puget Sound Farmed Atlantic Salmon (FOB Seattle) at the Wholesale and Retail Level (in U.S. dollars per pound)

Year	Nominal Wholesale Price	Nominal Retail Price	Real Wholesale Price	Real Retail Price
1990	3.17	3.64	3.14	3.61
1991	3.30	3.80	3.21	3.69
1992	3.40	3.91	3.24	3.72
1993	3.48	4.00	3.25	3.73

TABLE 61. Estimated Real Annual Future Puget Sound Farmed Atlantic Salmon Wholesale and Retail Prices, 1990-93 (U.S. Dollars per pound)

Year	Real Wholesale Price		Real Retail Price	
	Low Scenario	High Scenario	Low Scenario	High Scenario
1990	2.89	3.32	3.41	3.92
1991	2.89	3.33	3.43	3.95
1992	2.88	3.31	3.41	3.92
1993	2.84	3.27	3.36	3.87

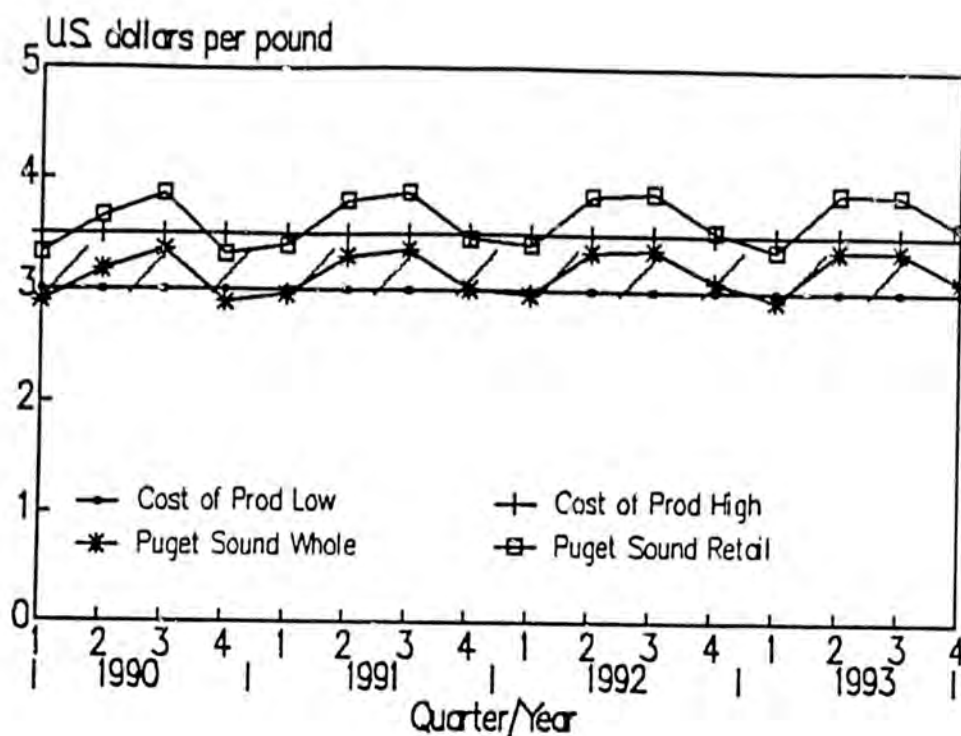


FIGURE 10. Estimated Real Future Costs of Production of Puget Sound Atlantic Salmon (for Low and High Costs of Production) vs. Estimated Real Future Wholesale and Retail Prices, 1990-93 (in U.S. dollars per pound)

more than was anticipated in the future baseline predictions. When conditions are favorable, i.e., the dollar weakens against foreign currencies or foreign producers of farmed Atlantic salmon produce less than anticipated in the future baseline predictions, the efficient farmers will have a positive profit margin, but the less efficient or start-up farms will experience losses. If sales are direct to retail, only the start-up or less efficient farmers have negative profit margins under the low price scenario, and all farmers will have positive profit margins under the high price scenario. It is obvious that the future profitability of salmon farms in Puget Sound depends on efficient farming and conditions favorable to higher salmon prices, and,

TABLE 62. Estimated Real Annual Future Puget Sound Farmed Atlantic Salmon Wholesale Profit Margins with Real Production at \$3.00 and \$3.50 per Pound, 1990-93 (in U.S. dollars per pound)

Year	Low Scenario		High Scenario	
	Cost \$3.00	Cost \$3.50	Cost \$3.00	Cost \$3.50
1990	-0.11	-0.61	0.32	-0.18
1991	-0.11	-0.61	0.33	-0.17
1992	-0.12	-0.62	0.31	-0.19
1993	-0.16	-0.64	0.27	-0.23

TABLE 63. Estimated Real Annual Future Puget Sound Farmed Atlantic Salmon Retail Profit with Real Costs of Production at \$3.00 and \$3.50 per Pound, 1990-93 (U.S. dollars per pound)

Year	Low Scenario		High Scenario	
	Cost \$3.00	Cost \$3.50	Cost \$3.00	Cost \$3.50
1990	0.41	-0.09	0.92	0.42
1991	0.43	-0.07	0.95	0.45
1992	0.41	-0.09	0.92	0.42
1993	0.36	-0.14	0.87	0.37

unfortunately, these conditions cannot be anticipated with a high degree of certainty. For farmers that can bypass the marketing margin of the first receiver, the possibilities of generating a positive profit margin are much higher, and under favorable conditions actual profits could be quite large. It should be noted that the high and low scenarios are for the scenarios simulated in this model, and actual swings in the economy could produce price swings that have even greater ranges.

Salmon farming, like all types of agricultural and aquacultural farming, is very risky, with the most efficient farms having a higher probability of generating profits. Favorable exchange rates and a reduction in the growth rate of farmed salmon from Norway will increase these probabilities. Also, if a concerted effort is made to market Puget Sound salmon as a high quality product, and this marketing effort is successful, then the price difference might narrow between the wholesale price of Norwegian and Puget Sound farmed Atlantic salmon. This price difference, if narrowed to the point of nonexistence, could mean an increase profit to Puget Sound Atlantic salmon farmers of up to \$.27 per pound, less advertising and other costs of quality enhancement.

6. Effect of Increase Puget Sound Farmed Salmon Production on Future Prices

An alternative future scenario was examined to assess the effects of an increase in North American farmed salmon production on the future price of Norwegian farmed Atlantic salmon exported to North America and on the exvessel price of high-valued Pacific salmon.

It was assumed that farmed Atlantic salmon from the United States and British Columbia are substitutable, and that there will remain a constant spread between the Norwegian export price of farmed Atlantic salmon from

Norway and farmed Atlantic salmon from North America. If farmed Atlantic salmon from the United States were increased by 100 percent above the baseline projected levels in the period 1990-93, this would mean an increase of 9,964,822 pounds of North American farmed Atlantic salmon by 1993. If eastern U.S. production was not effected by this increase, then this would represent more than a four-fold increase in the supply from Puget Sound. The effects of this magnitude of increase on Atlantic salmon prices and high-valued salmon exvessel prices in real terms in North America appeared to be minimal, as shown in Table 64.

The resulting decrease in Norwegian Atlantic salmon price would average \$0.05 per pound, and the decrease in the exvessel price of high-valued Pacific salmon would average \$0.01 per pound. The price decreases for Atlantic salmon are small because the quantity of this rise in farmed Atlantic salmon production is still quite small in comparison to the total amount of Atlantic salmon consumed and because Puget Sound farmed Atlantic salmon will, to some extent, replace imported Norwegian Atlantic salmon. For the high-valued Pacific salmon exvessel price, decreases are small because of the relatively small substitution coefficient between the two salmon species and the fact that the quantity of the increase in farmed Atlantic salmon from Puget Sound is very small in comparison to Pacific salmon landings.

TABLE 64. Real Norwegian Export Price (FOB Norway) and Real North American High-Valued Pacific Salmon Exvessel Price Predicted Using Baseline Assumptions with an Increase in North American Atlantic Salmon Scenarios, 1990-93 (in U.S. dollars per pound)

Year	UPAUHR	UPAURH1 ^a	PHEXHR	PHEXHR1 ^a
1990	2.59	2.54	1.92	1.91
1991	2.69	2.64	1.99	1.98
1992	2.75	2.70	2.05	2.04
1993	2.75	2.70	2.11	2.10

^aThe number 1 signifies, for the relevant price, the scenario in which North American farmed Atlantic salmon production increases.

IV. EVALUATION

A. Goals and Objectives

1. Original Goals and Objectives

There were five objectives listed in the project description, as shown below:

1. To assess the present and future U.S. and world demand, supply, and price structure for canned and noncanned salmon products in the context of an econometric model that analyzes the effects of:
 - a) product form,
 - b) currency/trade barriers,
 - c) taste/preferences/health benefits,
 - d) substitution among food products,
 - e) interregional product distribution.
2. To analyze the effects of worldwide salmon farming and other salmon production on the demand for U.S. fresh, frozen, and canned salmon products, and the balance of trade.
3. To analyze the cost of production to grow farmed salmon using the Puget Sound as the example location, to compare the farming cost to reported costs of competing wild production, and to assess the profitability of producing and marketing salmon given the price structures generated in (1).
4. To examine production/marketing strategies and fish regulation/management policies that may enhance the economic returns to U.S. farmed and wild salmon production in light of the price structures suggested by (1). The examination will include an assessment of the influence that production capability, stability, and seasonality of the capture fishery have on policy and strategy formulation.
5. To assess the direction of and need for future research and development concerning the expansion of salmon farming operations in the Puget Sound.

2. Were goals measurable or quantifiable?

A structural simultaneous equations model of salmon trade was econometrically estimated and simulated to address the majority of goals and objectives of the original project. Other information generated by the

project included presented papers, published articles, and a data book that also related to the goals and objectives of the project. The degree to which a goal or objective was attained can be measured by the provision of information relating to the given goal or objective. The soundness and usefulness of the structural model constructed to address goals and objectives can be partially measured by an array of goodness of fit statistics that were provided following the simulation of the system of equations, as well as equation-by-equation statistics that were also provided.

3. Modifications of the Goals or Objectives

The objectives as stated in the funded project proposal were not modified. Some of the objectives were accomplished only partially while other objectives were more than met, as discussed in section A.4.

4. Were goals and objectives attained?

The data collected for this project is, in our judgement, the most comprehensive and up-to-date database that has ever been constructed by any government agency, university, or private organization for modeling the international salmon markets. The database was collected through persistent effort and dedication, requiring numerous domestic and international trips, and consuming six months of time overall for data collection and compilation. Individuals and organizations which assisted us in data collection are: Joe Terry and the National Marine Fisheries Service, the Central Bureau of Statistics of Norway, Statistics of Canada, Peter Leitz and the Canadian Department of Fisheries and Oceans, Larry Neilson and the Ministry of Agriculture and Fisheries in Victoria Canada, Commercial Fisheries Entry Commission of Alaska, the Pacific Fisheries Management Council, the Alaska

Department of Fish and Game, the Washington Department of Fisheries, John Pitts and the Washington Department of Agriculture, the Oregon Department of Fisheries and Wildlife, the National Food Processors Association, Susan Shaw at the University of Stirling in Scotland, Clint Atkinson in Seattle, DPA Group, Inc. in Vancouver, B.C., Alan Archibald and B.C. Salmon Farmers Association, Trond Bjorndal and Kjell Salvannes of the Norwegian School of Economics and Business Administration, Jim Anderson of the University of Rhode Island, Windjammer Seafoods of Seattle, John Forster of Sea Farms of Washington, and an anonymous friend in Japan who assisted the research team in obtaining the privilege of using libraries in Japan and in introductions to various government agencies in Japan. In addition, libraries at Washington State University and the University of Idaho contained numerous documents for the needed data.

The techniques employed to construct the economic model utilized in this project represent the state of the art in the economics profession. In fact, theoretical and empirical refinements in Bayesian econometric methodology were provided by the project in the course of constructing the salmon trade model. The spirit of refining the model to the extent that the data would allow was maintained throughout the project. Comments and suggestions for model improvement from professional peers and industry participants were obtained through personal contacts and from reactions to numerous publications and presentations. An exhaustive literature review was undertaken to fully utilize the results of previous studies. A survey of seafood wholesalers was conducted, with assistance from the Alaska Sea Grant, so that expert opinions from the industry were incorporated into the model building process. The final models of this project, though far from ideal due to data limitations,

are the most comprehensive, ambitious, flexible, and powerful economic models constructed to date for modeling international salmon markets.

All of the above could not have been accomplished without frequent progress evaluations and consequent adjustments of the methodological approach and project scope. Among the five objectives proposed, two subcomponents of these five objectives were not fully accomplished for the reasons discussed below.

First, a comparison of the costs of producing wild and farmed salmon was not accomplished. While reasonably good and detailed cost estimates for farmed salmon in the Puget Sound were obtained, reasonable estimates for producing wild salmon are lacking for the relevant time period. In the late 1970s, Doug Larson of Alaska Sea Grant completed a survey of production cost for the Alaskan salmon fleet. Since then, license value, stock levels, fuel costs, and other factors affecting production cost changed dramatically. Because a production cost survey is expensive and time consuming to conduct, and since such a study was not intended in this research, this subcomponent failed to be accomplished.

Second, the world canned salmon market was not explicitly modeled. The most important reason for not modeling the canned market is a lack of Canadian inventory statistics. Two requests to the Fisheries Council of British Columbia were made for the most recent inventory data (monthly, 1982-1987), but our requests were rejected because of data confidentiality. Because Canadian and U.S. packs of canned salmon are of comparable magnitude, the research team had little confidence in building a reasonable model without the Canadian statistics. A second reason is that over time the canned market has been decreasing relative to the fresh/frozen market in terms of allocated

share of landings, motivating the research team to pay relatively more attention to the fresh/frozen market. Finally, it was recognized that canned salmon and fresh/frozen salmon do not compete directly for the consumers' dollar. Competition between these two components of the total salmon market takes place at the level of allocation of landings. This interaction of the two market components was accounted for in the modeling of the inventory for fresh/frozen salmon.

The failure to explicitly model the demand for canned salmon was a disappointment, but this allowed the research team to concentrate efforts on constructing a model of the fresh/frozen market. This adjustment actually resulted in a more useful final product for a number of reasons. First, the final models are comprehensive because they cover both farmed fish (Atlantic and Pacific species) and captured fish markets in the United States, Canada, European Economic Community, Norway, Japan, and Chile. Second, the final models appear sound, representing a reasonable abstraction of the real world markets while duplicating past market behavior quite closely. Third, the final models are flexible because they can be used for examining the effects of changing an array of market forces (e.g., exchange rates, trade barriers, production levels of farmed salmon in Norway and Chile, etc.) on the prices of captured Pacific salmon at both exvessel and export levels as well as on the price of farmed Atlantic salmon. Further, the future prices of captured and farmed salmon were estimated for the period of 1990-1993.

During the course of this project, numerous reports and presentations were made and their content was by and large accumulated in Herrmann's dissertation. The specific accomplishments are listed in section B. In the interest of brevity, the accomplishment of objectives is discussed here by

referring to sections of the final report and Herrmann's dissertation.

The first objective was to construct an econometric model of salmon trade in order to identify important factors affecting outcomes of salmon markets. This goal was accomplished, except for the proviso concerning canned markets discussed above, and discussions of the general model specification, parameter estimates and goodness of fit, and sensitivity analysis and forecasting can be found in Sections IV. and V. of the final report, as well as Chapters 4, 5, and 6, respectively, of Herrmann's dissertation. The second objective was to analyze the effects of salmon farming on the demand for U.S. salmon products. This was also accomplished and the sources of the discussion are the same as the preceding sources, subject to the same proviso. The third objective was to obtain the cost of producing farmed salmon, compare it to the cost of capturing wild salmon, and to analyze profitability questions. This objective was only partially accomplished, given the lack of information on the cost of wild harvesting noted above. The information pertaining to this objective is presented in Sections IV. and V. of the final report, and in Chapter 2 and the last two sections of Chapter 6 in Herrmann's dissertation. The fourth objective was to examine production/marketing strategies and fishery regulation/management policies that may enhance the return to the fishery. Parameter estimates of the econometric models allowed production/marketing strategies to be analyzed, and they are discussed in Section V. of the final report as well as in Chapter 5 of Herrmann's dissertation. The simulation approach was adopted to examine policy issues. Simulation results are shown in Section V. of the final report, and in Chapter 6 of Herrmann's dissertation. The final objective was to identify future research directions and needs. This objective was addressed in Section VII.

of the final report, and in Chapter 7 of Herrmann's dissertation.

B. Specific Accomplishments and Their Relationship to Goals

1. List of Specific Information, Products, or Services

Specific accomplishments of this project can best be summarized by a list of publications completed under the project. Before giving this list, a unique accomplishment of this project is singled out first. At the Fourth Conference of the International Institute of Fisheries Economics and Trade held in Denmark, special meetings were held and led to the decision to publish the "Salmon Market Newsletter". This Newsletter disseminates world-side salmon market developments and research findings to the salmon industry in the United States and elsewhere. Biing-Hwan Lin was one of the founders of the Newsletter and has served as a U.S. correspondent. This outlet was used to release research findings of the project to the industry. Ron Rogness of the National Fisheries Institute was very impressed with the Newsletter and launched a subscription drive in the United States. The Newsletter was subscribed to by many industry participants who became familiar with the research project and contacted the research team for additional information.

A listing of the presentations and publications associated with the project to date is given below:

JOURNAL ARTICLES REFERRED

Herrmann, Mark, Ron C. Mittelhammer, and Biing-Hwan Lin. "Applying Almon-Type Polynomials in Modelling Seasonality of the Japanese Demand for Salmon." Marine Resource Economics, currently under 2nd review after favorable initial review.

Lin, Biing-Hwan, Mark Herrmann, Tsae-Yun Lin, and Ron C. Mittelhammer. "Forecasting the Price of Farmed Atlantic Salmon: An Integrated Econometric and Time Series Approach." Agribusiness: An International Journal, 5(Spring 1989):477-488.

Lin, Biing-Hwan, Mark Herrmann, and Ron C. Mittelhammer. "An Economic Analysis of the Pacific Salmon Industry: Effects of Salmon Farming", research note. Northwest Environmental Journal, 5(Spring/Summer 1989):160-161.

Herrmann, Mark, and Biing-Hwan Lin. "The Demand and Supply for Norwegian Atlantic Salmon in the United States and the European Community." Canadian Journal of Agricultural Economics, 36(November 1988):459-472.

OTHER PUBLICATIONS

Herrmann, Mark L. An Economic Analysis of World Salmon Markets: Effects of Salmon Farming, Ph.D. dissertation, Dept. of Agricultural Economics, Washington State University, Pullman, 1990.

Herrmann, Mark, Biing-Hwan Lin, Ron C. Mittelhammer, and Joe Terry. World Salmon Trade: Export/Import Statistics. Seattle: National Marine Fisheries Service, June 1990.

Herrmann, Mark, Biing-Hwan Lin, and Ron C. Mittelhammer. U.S. Salmon Markets: A Survey of Seafood Wholesalers. Fairbanks: Alaska Sea Grant, 1990. 90-01.

Herrmann, Mark, Biing-Hwan Lin, and Ron C. Mittelhammer. "Wholesalers; Opinions of the U.S. Salmon Market." Salmon Market Newsletter, 1(July 1989):7-8.

Lin, Biing-Hwan, Mark Herrmann, and Ron C. Mittelhammer. "Forecasting the Price of Farmed Norwegian Atlantic Salmon." Salmon Market Newsletter, 1(April 1989):2-3.

Lin, Biing-Hwan, and Mark Herrmann. An Econometric Analysis of Atlantic Salmon Markets in the United States and France. Fairbanks: Alaska Sea Grant, 1988. 88-5.

PROFESSIONAL PAPERS

Herrmann, Mark, Ron C. Mittelhammer, and Biing-Hwan Lin. "Applying Salmon-Type Polynomials in Modeling Seasonality of Demand: The Case of the Japanese Demand for Salmon." Presented at the American Agricultural Economics Association Annual Meeting, Baton Rouge LA, 30 July-2 August 1989.

Lin, Biing-Hwan, Mark Herrmann, Tsae-Yun Lin, and Ron C. Mittelhammer. "Future Price of Farmed Atlantic Salmon." Presented at the American Agricultural economics Association Annual Meeting, Baton Rouge, LA, 30 July-2 August 1989.

Lin, Biing-Hwan, Mark Herrmann, Tsae-Yun Lin, and Ron C. Mittelhammer.
 "Forecasting the Price of Farmed Atlantic Salmon." Invited paper
 presented at the 64th Annual Western Economics Association International
 Conference, Lake Tahoe, CA, 18-22 June 1989.

Lin, Biing-Hwan, Mark Herrmann, Tsae-Yun Lin, and Ron C. Mittelhammer.
 "Future Supply and Price of Norwegian Atlantic Salmon." Invited paper
 presented at the Aquaculture International Congress, Vancouver, BC,
 Canada, 6-9 September 1988.

Herrmann, Mark and Biing-Hwan Lin. "The Demand and Supply for Norwegian
 Atlantic Salmon in the United States and the European Community." Paper
 presented at the American Agricultural Economics Association Annual
 Meeting, Knoxville, TN, 31 July-3 August 1988. Also presented at the
 Fourth Conference of the International Institute of Fisheries Economics
 and Trade, Esbjerg, Denmark, 6-10 August 1988.

Lin, Biing-Hwan, and Mark Herrmann. "An Economic Analysis of Atlantic Salmon
 Markets." Paper presented at the Symposium of Markets for Seafood and
 Aquaculture Products, Charleston, SC, 16-21 August 1987.

PROFESSIONAL PRESENTATIONS

Herrmann, Mark. "Some Observations on the Demand for Farmed Atlantic Salmon
 and Effects on North American Commercial Pacific Salmon Fisheries."
 Presented at the Aquaculture: Current Issues and Prospects seminar
 series at Washington State University, Pullman, 11 December 1989.

2. The Relationship of Products and Services to Original Project Goals and Objectives

A major task of the project was data collection. The research team was
 both effective and creative in utilizing the opportunities of presenting
 research findings to also solicit and obtain additional data. For example,
 Alan Archibald extended an invitation to present a paper at the Aquaculture
 International Congress, which then represented an opportunity to request
 production and price information on B.C. salmon farming from Archibald who is
 the Director for Marketing of the B.C. Salmon Farmers Association. A seminar
 was presented at the Canadian Ministry of Agriculture and Fisheries in
 Victoria on Idaho's trout industry, which presented an opportunity to obtain
 landings and price statistics regarding the B.C. salmon fishery from Larry

Neilson. A paper was delivered at the Fourth Conference of the IIFET which provided the opportunity to interact with Susan Shaw, Clint Atkinson, Trond Bjørndal, and Carlos Wurmann for information and statistics about world salmon trade. Though data collection per se most often does not lead to publication, a report of 300 some pages on the import/export data maintained by the NMFS was published providing other researchers with data that would facilitate analyses of salmon trade issues.

The paper presentations, articles, and data book all generated important and useful feedback from professional peers and industry personnel that facilitated the specification of the econometric model of world salmon trade. While the presented papers and written output was directly related to attaining project objectives by providing of research findings related to the objectives, a strong motive for producing the output was the process of refining model specification in reaction to peer and industry comment.

The econometric model of salmon trade played the prominent role in accomplishing the objectives of this project. Through simulation of the model according to various historical scenarios regarding the perturbation of key economic variables, through forecasting the future values of key prices in salmon markets, and through an analysis of the costs of producing farm-raised Atlantic salmon, the key questions raised in objectives 1-4 were addressed. An analysis of the shortcomings of the data, econometric model deficiencies, and dynamically changing structure of the salmon industry led to a discussion resulting in the achievement of objective 5.

The final report together with Herrmann's dissertation are the products that present the discussion (and attainment) of project objectives in final form (subject to the aforementioned provisos).

3. Extent to Which Products and Services Meet Industry Needs

The ultimate objective of any industry participant is to make a profit. As mentioned previously, parameter estimates contained in econometric models provide insights into improving production/marketing strategies. A good example is the paper on the Japanese demand for salmon. The paper estimates seasonal characteristics of the Japanese market and this information suggests export flows that could increase total returns to the industry.

The research team has written a number of reports on the future prices of farmed salmon. This is important information for the industry. The research team has been complimented by industry participants on the accuracy of our price forecasts. Our price forecasts have been used by many industry participants to facilitate decisions regarding the advisability of salmon farming.

Profitability of salmon farming was examined and its results should be of use to those who contemplate whether an attempt to obtain a farming license should be pursued. Effects of exchange rates, trade barriers, regulations, and other factors on prices of salmon were examined via econometric model simulation. These results should be of use not only to industry participants, but to government agencies as well. Norway has been sued for dumping in the United States and the European Community; our economic models can be used to estimate the implications of the ruling on world salmon trade and prices.

Overall, the products of the research project not only meet the immediate needs of the industry in securing an assessment of the relative impacts of salmon farming on current and future market outcomes of the industry, but also provides a flexible analytical tool with which to analyze other economic factors affecting market outcomes, such as tariffs, exchange

rates, landings variability, and changing income levels.

4. Value of Accomplishments

We contributed to the creation and various issues of the Salmon Market Newsletter. Through this vehicle, we were able to disseminate our research findings to the industry, which, in turn, provided us industry feedback with which to refine subsequent research endeavors.

Various papers have been written to inform salmon farmers of future prices for their fish. Existing and potential farmers can compare future prices with cost projections to reach rational decisions regarding expansion, contraction, exit, and entry.

The paper on the Japanese demand for salmon indicates that demand exhibited pronounced seasonal characteristics. These findings can be used to evaluate whether different export patterns over time can increase total return to the industry.

The survey of seafood wholesalers indicated that farmed Atlantic and high-valued, fresh Pacific salmon are substitutes in the United States. This substitutional relationship was confirmed in the econometric models of salmon demand estimated for Japan and the EEC. Therefore, our research findings suggest that increasing production of farmed Atlantic salmon will continue to depress the market (domestic and export) for Pacific salmon, although the magnitude of the substitution effect was found to be relatively small. The results suggest that fishermen, processors, and exporters need to improve efficiency in production, processing, and marketing in order to compete effectively in the future.

Additionally, Herrmann's dissertation has other value. New econometric methods were developed and applied successfully to international salmon

markets. The methodological accomplishment can benefit researchers in conducting other economic analyses. Important production/processing/marketing implications can be drawn from parameter estimates. For example, the EEC's demand for wild Pacific salmon (both high- and low-valued) for the first and second quarters has declined over time, suggesting a declining demand for freezing services in the future. Since high-valued and low-valued Pacific salmon are not substitutes in Japan, exporters of low-valued salmon may need to reallocate more of their fish to Japan. High-valued Pacific salmon substitutes for farmed Atlantic salmon in Japan. This suggests that exporters of high-valued Pacific salmon should consider informing Japanese consumers of important quality attributes enjoyed by Pacific salmon relative to Atlantic salmon. In addition to forecasting prices of farmed Atlantic salmon, Herrmann's dissertation also includes price forecasts for Pacific salmon at both wholesale/export and exvessel levels. Information on future prices of Pacific salmon should be of considerable value to the industry in facilitating resource allocation decisions. A major value of Herrmann's dissertation rests on the simulation of the effects of exchange rates, trade barriers, landing variability, and the like. Simulation results should be of interest to decision makers in both public and private organizations.

C. Description of How the Project Benefited the Fishing Industry

1. To what extent did the industry have access to the products or services produced by the project?

As was discussed in Section IV., there were many outlets for the dissemination of various stages of results generated from the project. In addition, there are plans for several papers to be distributed upon completion of the project. The salmon fishing and farming industry, as well as

professional peers were provided a number of opportunities to access, use, and comment on the results of the research. The research team made certain that, in every instance where results were published in an academic journal, equivalent information was published in outlets where industry participants would have access. In particular, the research team took advantage of invited paper sessions at conferences where industry participants would be in attendance, as well as publications that were accessible to industry participants.

An example of industry access was the invited paper on farmed Atlantic salmon price forecasting delivered at the Aquacultural International Congress where Biing-Hwan Lin was part of a panel of discussants which also included Jim Anderson of the University of Rhode Island and Larry Cope of Clear Springs Trout Company. The panel was moderated by Alan Archibald of the B.C. Salmon Farmers Association to discuss the future price of farmed Atlantic salmon. At that time, in 1988, Dr. Anderson and Dr. Lin forecasted an Atlantic salmon price decrease of approximately 25 percent by 1989, and that indeed happened by the beginning of 1989. In attendance at the discussion were salmon fishermen and farmers as well as others involved in the industry such as wholesalers, brokers, traders, and bankers. Another valuable outlet for the project's findings was a paper delivered at the International Institute of Fisheries Economics and Trade meeting in Denmark in August of 1988 where there were several fishing industry participants.

As well as presentations, the research team made liberal use of the Salmon Market Newsletter which is widely distributed to the fishing and aquaculture industry. In particular, Atlantic salmon price forecasts as well as survey work on U.S. seafood wholesalers' opinions regarding the decision

process for handling farmed or wild salmon were presented. In the Salmon Market Newsletter the original sources of the published works were cited. The research team has responded to several requests for the original published works made by various industry participants. In addition, the use of the Alaska Sea Grant for two publications further enhanced the salmon fishing industry's access to the research.

Quarterly reports to the National Marine Fisheries Service on the progression of the research have been frequently distributed to the salmon fishing and farming industry. In fact, Kevin Ford, the project overseer, reports that the National Marine Fisheries Service has had a record number of requests for the quarterly reports and that the information has been well received by the industry.

2. To what extent have the fishing industry and associated infrastructure (universities, financial institutions, etc.) used the project's products or services to satisfy a need or lessen business risks?

The research team spent a great deal of time in discussions with newspaper and magazine reporters concerning salmon fishing and farming. The quotes and citations in these outlets made research information available to the fishing and farming industry. For example, Mark Herrmann was recently quoted in an article by Steve Shapiro entitled "Farmed Atlantics vs. Wild Pacifics" in Pacific Fishing magazine. An example of work citation is in Seafood Business where the Alaska Sea Grant publication on U.S. wholesalers' opinions about handling of wild vs. farmed salmon was made known. In addition, the journal articles written by the research team have been cited and used in many other studies dealing with salmon markets. Also, ongoing discussion continues with other researchers, as well as industry participants.

An important use of the research has come from potential and existing salmon farmers who noted the forecasts of decreasing Atlantic salmon prices in making production decisions. There have been many requests for the forecasting information from a variety of sources. The research team has also been in contact with bankers, offering them an assessment regarding the future prices of farmed and wild salmon. U.S. wholesalers and foreign academic researchers have also contacted the research team to ascertain the future of farmed salmon in U.S. domestic markets.

The research performed has been used in courts by lawyers representing both the U.S. and Norwegian salmon farmers in a suit charging Norway with dumping salmon on the U.S. salmon markets. Additional information in this suit has been requested (see below).

3. To what extent are the project's results likely to be used
by the industry in the future?

Additional dissemination of information is scheduled. Ron Mittelhammer will deliver an invited paper at a conference scheduled in Anchorage, Alaska by the Alaska Commercial Fishing and Aquacultural Bank in November 1990. The audience attending will be primarily salmon fishermen. The purpose of the paper will be to increase awareness among fishermen that it is market development that holds the keys to future economic viability of the salmon fishing industry.

Evidence that the fishing and farming industry and associated infrastructure is using and/or plans to use the research performed came from many sources as well. In particular, the invited paper that Ron Mittelhammer is scheduled to give in Anchorage, Alaska will be used to help salmon fishermen understand the dynamics of salmon price movements and to better

understand the benefits of marketing strategies. Forecasted farmed Atlantic salmon prices have been requested and used by salmon farmers and bankers. A better understanding of the future of world salmon markets will continue to help financial institutions assemble appropriate financial packages for salmon farmers and fishermen.

The final results of the research may be used by the fishing and farming industry in a variety of ways in the future. Direct use of the forecasted salmon prices for Puget Sound may be used by potential farmers when making the decisions about the profitability of locating a farm in Puget Sound given their projected costs of production. In addition, sensitivity analysis on historical and future salmon prices will give the salmon industry some indication of the risks involved and the direction of price movements given the direction of factors affecting prices such as exchange rates, tariffs, fluctuating landings, and consumer income.

The study will be of value to the salmon fishing industry in the state of Washington as well as North America as a whole. Salmon fishermen in the United States operate under various limited entry programs. The values of salmon fishing permits are based, to some extent, on expected future fishing revenues. It is beneficial for fishermen to know the present value of these revenue streams to make decisions which affect these operations, especially decisions to enter or exit salmon fishing.

Processors face decisions on whether to freeze or can their products, and knowledge of future fresh/frozen prices will assist them in their decisions. Exporters of salmon will be assisted in their marketing strategies regarding where and when to export their fish in the face of increasing competition from foreign farmed salmon suppliers. As the degree of

competition between farmed and wild salmon is better understood, the salmon industry can also make informed decisions about the advisability, timing, and type of promotional activities.

4. To what extent are project results likely to be used by others in the future to provide benefits to the fishing industry?

The Salmon Market Newsletter will be used to summarize the final results, and to make known where this final report, as well as Mark Herrmann's dissertation, may be found. Other papers will be planned with the help of the National Marine Fisheries Service. Additional journal articles are being written and may be advertised in the Salmon Market Newsletter.

Further evidence of intentions to use the results came from a request for a position paper summarizing pertinent results of the research by Mudge Rose Guthrie Alexander and Ferdon who are representing the Norwegians in a case involving allegations that Norwegian salmon farmers are dumping salmon on the U.S. market. It should be noted that the authors are merely making present research known to Mudge Guthrie Alexander and Ferdon and have made no commitment to testify for either the Norwegian or U.S. salmon farmers, as no opinion as to the truth of the dumping allegations has been formed by the research team. The request for the position paper is reported here as further indication of the importance of this research and as evidence of possible uses for it. The bulk of the research is also available to U.S. salmon farmers for their use. Work performed by the research team has already been used in court proceedings on both sides of the dumping issue.

If the Norwegians are found guilty of dumping salmon, various retaliatory measures may be taken to protect the U.S. salmon markets. A paper is being written, as an extension of the project, to examine various effects

of protectionist measures that may be taken by North America and the EEC. These results will be made public through the Salmon Market Newsletter, as well as through the submission of the results to a professional journal.

The study can also assist government policy makers in deciding whether salmon farming should be allowed or expanded in a given location by providing information on the economic returns that might be expected, say in the Puget Sound of Washington State.

Government decisions on the length of commercial and sport fishing seasons, the number of smolts to be produced, hatchery policies, and so on will be enhanced by knowledge of potential changes in demand that may result from the changing nature of salmon production. If the present value of future commercial harvests will be affected by the influx of Atlantic salmon imports, harvest guidelines and the length of the commercial salmon fishing season might require modification. Operations of public and private salmon hatcheries and other measures (such as habitat improvement) have been utilized to enhance salmon stocks. From an economic efficiency standpoint, the optimal level of hatchery operation might be altered when the value of the commercial harvest is changed.

D. Description of the Specific Economic or Other Benefits
the Fishing Industry Received as a Result of Its Use
of the Products or Services of the Project or as a
Result of Others Using the Products or Services

The specific benefits provided to the fishing and fish-farming industry are somewhat indirect in nature, and are in the form of increased knowledge of the general working of the international salmon markets, a qualitative and quantitative assessment of important factors affecting outcomes in international salmon markets, a forecast of the future direction of salmon

prices, and an evaluation of the profitability of farming Atlantic salmon in the Puget Sound of Washington State. The economic benefits are demonstrable to the extent that the knowledge generated by the project is considered useful to industry participants and government policy makers, and to the extent that the information leads to more informed and efficient government policies and allocations of resources within the fishing and fish-farming industries. As discussed previously, results of the project have been well-received by members of the industry, and in fact some industry participants have used results of the project for decision-making purposes. Thus, it has already been demonstrated that the project results have positive value, at least in the opinion of a number of industry participants. Further evidence demonstrating the economic benefits of the project will be forthcoming only after additional time has elapsed to allow widespread dissemination of the results of the project in the form of the final report, paper presentations, and popular and professional publication outlets.

Given that the benefits are in the form of increased knowledge of various economic aspects of the salmon industry, the benefits are inherently continuing. More tangibly, the econometric trade model is flexible, and can be used in the future to simulate a myriad of alternative scenarios that were not investigated in this project. Thus the knowledge generating capability of the project is effectively ongoing.

E. Description of the Actual Need for Federal Assistance in this Project

Without support of the Saltonstall-Kennedy Foundation grant a trade model of this size and complexity could have never been constructed and a project of this scope could not have been completed. Financial assistance was necessary for salaries, computer time, data collection, trips to meet with

industry participants professional peers, to collect data, to present results, and miscellaneous expenses such as printing costs and the hiring of a technical editor to oversee the organization and presentation of the data book.

Portions of the salaries of Ron Mittelhammer, Mark Herrmann, and Biing-Hwan Lin were paid for. It should be noted that the actual amount of time spent on the project by the research team significantly exceeded the original time funded by the project, both from Federal and in-kind sources, and was a result of the complexity and scope of the project. Travel money was used for trips by Mark Herrmann and Biing-Hwan Lin to Denmark, British Columbia, Seattle, and to various meetings in the U.S. to deliver papers. In addition, Dr. Lin made two trips to Japan to gather data that was not available elsewhere. It was the direct result of Dr. Lin's trips to Japan that substitute prices of other fish products in Japan were gathered which allowed the modelling of the Japanese demand for salmon to be successful. Dr. Lin donated a portion of the second trip at the University of Idaho's expense.

Data expenses included the purchasing of Alaskan exvessel data from the Alaska Commercial Fisheries Entry Commission, the Canadian export/import data from Statistics Canada, wholesale salmon data from Urner Barry, and the Norwegian export data from the Central Statistics of Norway. Much of the Japanese data was purchased from Clint Atkinson such as Japanese landings and inventories of salmon. Papers written by salmon experts in various countries were also purchased. Also industry magazines such as Pacific Fishing and Seafood Leader were purchased with federal funds.

Other costs included mainframe computer time to run SAS. The modelling was extremely computer intensive and much of the costs were donated by

Washington State University.

Overall, and put quite succinctly, the project could not have been pursued nor completed by the research team without the support of the install-Kennedy Foundation grant.

VII. CONCLUSION

A. What Conclusions can be Derived From the Work Performed?

There are a myriad of conclusions that can be drawn from the research, and many of these appear in the narrative presented in section V. Findings of the report, and in Chapters 5-7 of Herrmann's dissertation. In this section, a number of the more important conclusions are highlighted.

1. High-valued Pacific salmon and Norwegian farmed Atlantic salmon are substitute products in the North American and EEC markets. However, in the North American market, the substitution effect is relatively small in magnitude.

2. High-valued Pacific salmon imports have a significant inverse relationship with Atlantic salmon prices in Japan (i.e., high-valued Pacific salmon substitutes for Atlantic salmon in Japan), but currently Atlantic salmon imports do not have a significant effect on high-valued Pacific salmon prices in Japan. This latter result is most likely due to the much larger relative size of high-valued Pacific salmon imports in Japan relative to Atlantic salmon imports. If Atlantic salmon imports increase, it might be expected that an inverse relationship between Atlantic salmon imports and high-valued Pacific salmon prices will eventually be detectable.

3. Recent commercially significant levels of exports of farmed salmon to the United States by Chile have had a small but significant depressing effect on Norwegian farmed Atlantic prices in the first quarter of the calendar year. Chilean imports have also had a relatively small but significant depressing effect on exvessel prices for high-valued Pacific salmon in the fourth quarter of the year. Continued increases in Chilean

imports by the United States may be a legitimate cause for concern, both by Atlantic salmon farmers and high-valued Pacific salmon fishermen.

4. Norway's allocation of farmed Atlantic salmon exports between the EEC and North American market is significantly responsive to price variations in both markets. Norway will reallocate salmon exports to/away from a market in response to a relative price increase/decrease.

5. The quantity of Norwegian farmed Atlantic salmon exported to the United States has a relatively large negative impact on the price of Atlantic salmon in the North American market. In the short run, at mean historical levels, a one percent increase in exports results in a 1.35 percent decrease in Norwegian Atlantic salmon price. Given that the price of Atlantic salmon farmed in the United States is closely related to the Norwegian Atlantic salmon price, fluctuations in Norwegian exports will be of concern to U.S. salmon farmers.

6. Increased production and exports of farmed Atlantic salmon currently have only a limited effect on Pacific salmon prices. Furthermore, allowing farmed production of Atlantic salmon in the United States to increase as much as 100 percent above current projected levels for 1990-1993 still generates only very small negative effects (\$.01-\$.02) on the per pound exvessel price of high-valued Pacific salmon, with no perceptible effect on low-valued Pacific salmon exvessel prices. Thus, a strong case cannot be made for restricting the development of U.S. salmon farming based on the fear of severe damage to the salmon fishing industry.

7. Increasing production of farmed Atlantic salmon from the Puget Sound of Washington State would have only a small negative effect on the price of farmed Atlantic salmon. Examining over a fourfold increase in production

over current production levels projected for the Sound during 1990-1993 resulted in a projected \$.05/pound decrease in Atlantic salmon prices (adjusted for general price inflation) during the period. Thus, restricting the development of salmon farming in the Puget Sound based on the fear of severe negative impacts on Atlantic salmon prices is not supported.

8. Positive profit margins for fish farming operations in the Puget Sound appear to be attainable in the period 1990-1993 for efficient salmon farms, ranging between \$.14 and \$.25 per pound in real terms for sales to first receivers (price adjusted for general price inflation - margins do not account for a fair return on investment capital). However, unanticipated fluctuations in exchange rates or increases in farmed Atlantic salmon imports into the United States can result in a negative profit margin, possibly as low as \$-.11 to \$-.16 per pound in real terms. Furthermore, start-up farms that are not yet operating at peak efficiency are anticipated to experience negative profit margins ranging from \$-.36 to \$-.25 per pound in real terms. Thus new salmon farming operations in the Puget Sound may be difficult to establish in the short run when considering operating profit and returns to invested capital. Furthermore, there is considerable price risk involved when planning farming operations.

9. A tariff of 5% on the imports of Norwegian farmed Atlantic salmon into the United States results in a significant curtailment of Norwegian imports and a rise in the Atlantic salmon price. Projecting market outcomes for the period 1983-1988 under the alternative historical scenario that the United States had imposed a modest 5 percent tariff on Norwegian imports, the level of imports would have decreased 5.6 percent per quarter on average, leading to an average price increase per quarter of 2.65 percent for Atlantic

salmon. Though the results of the project do not suggest that such a tariff is warranted, the results do suggest that such a tariff would be relatively effective. Tariff considerations would be relevant if Norway is found guilty of dumping salmon below cost in the United States, as is alleged in a recent suit brought against Norway by some U.S. Atlantic salmon farmers.

10. Fluctuations in exchange rates have appreciable impacts on the prices of Pacific and Atlantic salmon. A strengthening of the dollar by 10 percent against Japanese, European, and Norwegian currencies was projected to result in an average quarterly decrease of 4.8 percent in the Atlantic salmon prices, and decreases of 4.4 and 2.2 percent, respectively, in the exvessel prices of high- and low-valued Pacific salmon. A weakening of the U.S. dollar had effects opposite to the preceding effects, and were closely comparable in magnitude. A large persistent U.S. trade deficit weakens the U.S. dollar, and actually would benefit salmon fishermen and farmers by placing upward pressure on salmon prices in the United States by expanding exports and decreasing imports. In a relative sense, fluctuations in exchange rates have much more influence on exvessel prices of Pacific salmon and Atlantic salmon prices in the United States than fluctuations in the level of farmed salmon imports into the United States.

11. Farmed Atlantic salmon from Norway and Scotland is gradually displacing high-valued Pacific salmon in the EEC. This is especially pronounced in the first and second quarters of the year. Accentuated marketing efforts in the EEC to maintain market share, reallocation of salmon exports to the Japanese, or else new market development will have to be considered to maintain export volume and prices in the long run.

12. Exvessel prices for Pacific salmon will slowly recover in real terms from the prices existing in 1989. Expressed in U.S. dollars, in real terms (equivalent to 1989 dollars) the average Norwegian Atlantic salmon price, FOB Norway, is anticipated to be in the \$2.59 - \$2.75 range, with average high- and low-valued Pacific salmon exvessel prices in the ranges \$1.92 - \$2.11 and \$.56 - \$.61, respectively, during the period 1990-1993.

13. It is in the interest of Pacific salmon fishermen to support initiatives that aim to lower or remove tariffs on exports of salmon to the EEC and Japan. Under free trade in salmon products, the average exvessel price for high- and low-valued Pacific salmon during the 1983-1988 period would have been increased by 2 percent and .8 percent, respectively, according to projections. The average price of farmed Atlantic salmon would have been increased by 1.3 percent. Average export prices for high- and low-valued salmon would increase by 2.4 and .6 percent, respectively.

B. Was the Project Successful in Solving the Problem?

A substantial majority of the issues involved in the statement of project objectives were successfully addressed by the results of the project. In fact, in the opinion of the research team, the issues that were addressed were examined more thoroughly than was originally anticipated in the project proposal. There were some subobjectives that were not addressed thoroughly, or not addressed at all. The canned salmon market was included in the salmon trade model only to the extent that canned salmon prices affected the allocation of low-valued Pacific salmon to the fresh/frozen vs. canned market outlets. However, it was found that farmed salmon and low-valued Pacific salmon were not substitute products in any market, so that the omission of an explicit modelling of canned salmon trade did not hamper the analysis of the

effects of salmon farming on salmon markets.

An analysis of the costs of wild salmon production, and thus projections of profit margins for Pacific salmon fishing, could not be addressed due to data limitations. The only data available on fishing costs was of early 1970's vintage, and no meaningful means of updating the costs to the current time could be devised. Complicating the issues is the great heterogeneity in fishing technique and gear type making it extremely difficult to make general statements regarding cost of wild salmon production. The research team felt that obtaining estimates of fishing costs, although highly relevant, would require an in-depth survey and/or engineering approach to budget construction that required resources well beyond those available to the current project.

Overall, it was felt that providing information on the effects of salmon farming on the salmon industry was very successfully accomplished, and the finished project easily represents the most in-depth, complete, and rigorous analysis of the interaction of wild and farmed world salmon markets to date.

C. Need For Future Work

Because the farmed salmon industry is so new, time series data pertaining to this industry is still limited. A longer series of data would be of substantial benefit to future research. In particular, additional data may allow other sources of farmed salmon, such as Chilean and British Columbian salmon, to be endogenously determined within a modelling context. Also, as the Japanese market for farmed Atlantic salmon becomes more developed, an effort should be made to endogenously model the Norwegian allocation of farmed Atlantic salmon to Japan as opposed to treating the allocation as a given quantity set on the basis of a market development/penetration strategy. Atlantic salmon produced in the United States could also be

endogenized when a longer time series becomes available.

In this study, the species were aggregated into Atlantic salmon, high-valued salmon, and low-valued salmon. Care must be taken when discussing the effects on each species. For instance, the farmed Atlantic salmon imports into the U.S. may have only minor impact on the high-valued salmon exvessel price. This does not mean, however, that there may not be a larger effect on certain individual species comprising the high-valued Pacific salmon category. Since sockeye salmon accounts for the largest portion of high-valued salmon, and since this species is mainly traded to the Japanese market, the prevalence of Atlantic salmon may not have as great an effect on the market for sockeye salmon as it would have on the markets for chinook or coho salmon. Thus, in future research, it could be useful to disaggregate the species further.

In future research, an attempt to endogenously model the price-quantity equilibrium in the canned markets could be useful. In this study the low-valued canned price was treated as endogenous in the low-valued salmon supply allocation equations, but its determination was not modelled explicitly. As future time-series data becomes available, it might be possible to model the disappearance of North American salmon domestically by using annual data. U.S. wholesale prices from Urner Barry are being more consistently reported each year and may have modelling value at a later date. The existing forecasting model needs to be consistently updated with new data to continually update the model structure and predict future values more accurately.

Additional research devoted toward deriving consistent supply/utilization/disappearance tables for domestic salmon quantities might be quite useful. As discussed previously, modelling of U.S. domestic demand for

Pacific salmon at the wholesale level was precluded by the inability to generate sensible domestic disappearance data, so that only derived demand at the exvessel level could be explicitly modelled in the current research. The problem was related to the quarterly observation time frame chosen for the study in order that the inherent seasonality of salmon markets could be analyzed. Of course, even if seasonality were ignored and proper disappearance levels were derived on an annual basis, the number of observations that would be currently available would preclude any type of meaningful econometric analysis. This problem remains a frustrating one.

Eventually, production of other fish species may increase through aquaculture, and this may lead to added pressure on salmon markets. In addition, other meat products may affect total fish consumption which in turn may affect salmon demand. The construction of a model that includes other substitute meat products would require a major effort but could be a potentially useful undertaking.

The current study represents a major advance in the modelling of the world's salmon markets within a simultaneous equations market equilibrium context and is the most in-depth study to date on the interaction between farmed and wild salmon. The current research represents a firm foundation on which to base future quantitative analyses of factors affecting equilibrium in the world salmon markets.

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