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An International Marketing Model for
Alaskan Salmon

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The purpose of this report is to give a progress report on the economic demand component of the Legislative Review of Alaska's Fisheries Enhancement Program and may not be quoted elsewhere without the permission of the authors. This report was made possible by a grant received from the Alaska State Legislature and is the result of research sponsored by Alaska Sea Grant with funds from the National Oceanic and Atmospheric Administration, Office of Sea Grant, Department of Commerce, under grant no. NA90AA-D-SG066, project #R/14-13, and from the University of Alaska Fairbanks Faculty Small Grants Program Awards.

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Abstract

This report is an executive summary of worked performed on the salmon demand model portion of the Legislative Review of Alaska's Fisheries Enhancement Program contracted by the Senate Special Committee on Domestic and International Fisheries. The salmon demand analysis is divided up into two parts, estimation and simulation. In the estimation section a theoretical model was developed to model the equilibrium supply and demand factors affecting world salmon exvessel prices. In the simulation section the effects of varying enhancement output is measured in terms of its predicted effect on future prices and revenues.

The modelled systems can be broken into two connected parts. The main body of the model is a 48-equation bloc in which salmon is traded among North America, Japan, the European Economic Community (EEC), Chile, Australia, and New Zealand. Both fresh/frozen and canned salmon forms are modelled. The salmon species were divided into fresh/frozen farmed Atlantic, farmed Pacific, high-valued wild Pacific, low-valued wild Pacific, and canned low-valued wild Pacific salmon. The flows were modelled recursively into two North American Pacific salmon exvessel prices (for high- and low-valued salmon). Quarterly data from 1982 to 1991 were used for this part of the model.

The second part of the model is a 20-equation bloc in which Alaskan exvessel prices by species and region are correlated with the North American exvessel prices from the main body of the modelling. Specifically, chinook, sockeye, and coho prices are correlated against North American high-valued Pacific salmon exvessel prices, and chum and pink prices are correlated against North American low-valued Pacific salmon exvessel prices.

In the simulations, real prices for all five Pacific salmon species in Prince William Sound, Cook Inlet, Southeast, and Kodiak are predicted for 1992-2006. The initial predictions are for the base scenario where future wild salmon harvests are predicted to be their 10 year historical average and future predicted hatchery harvests are either taken from the operator hatchery survey or, for five fisheries, wild and enhanced salmon are from Dr. Jerome Collie's (fisheries bilogist at UAF in Juneau) biological models. The new hatchery production figures for the simulated cases were then inserted into the simulations to investigate predicted changes in future prices from the changes in enhancement production. The predicted prices were then given to Dr. John Boyce (fisheries economist at UAF Fairbanks) to estimate producer surplus. In this report, average revenue changes for different enhancement scenarios over the period of 1997-2006 are reported.

The results from investigating the revenue changes from the differing enhancement scenarios suggests that increases in pink salmon enhancement will decrease future real revenues to the Alaska salmon fishers while increases in sockeye, chum, coho, and chinook salmon enhancement will increase future real revenue. The net result of the cost/benefit analysis, however, is reported in the policy analysis section.

Introduction

The purpose of this report is to describe the relationship between salmon prices, demand and supplies, and various market conditions that can influence these variables. The relationships between various market factors and salmon prices have a hypothesized structure. By use of econometric techniques, which is a blending of economic theory and regression analysis, we can test the validity of this hypothetical structure. Through model simulation, the developed system of equations can provide a framework for predicting, under various market conditions, future salmon quantities and prices as well as providing a basis for sensitivity analysis.

Much of the work here builds on the knowledge gained from a previous 36 equation international salmon supply and demand model which is explained more thoroughly in Herrmann (1990) and Mittelhammer et. al. (1990). When it was constructed, this model was the largest econometric salmon model existing and the only one which simultaneously modeled both wild and farmed salmon.

The current econometric model was constructed with the goal of projecting future prices of Alaskan salmon by region and species. These projections will be used in a cost/benefit analysis of the Alaska salmon hatchery system. Other benefits of the results will be estimated mean-level and own-price, cross-price, and substitution elasticities, as well as results from sensitivity analysis. Because the model is geared toward multi-year predictions, variables such as ADF&G forecasts of salmon runs are not included. Their inclusion would limit the models predictive capabilities to one-year. Rather, an aggregate approach has been adopted where trends in price movements are more important than predicting any single year's price accurately. In other words, the model will have achieved its objective if at any point in time it is able to predict a mean price level for the next several years better than a naive expectation. This will be true even if the variance of the model estimates are high indicating that any single year's predictions may not be entirely accurate.

Project Goals

The objectives of the international market modelling section of the salmon enhancement study are presented below. These objectives are modified from those found in the original proposal as necessitated by knowledge gained in initial modelling efforts.

The specific objectives of this project are:

1) Update the existing international econometric salmon model of fresh/frozen salmon as published in a work by Mittelhammer, Herrmann, and Lin for the National Marine Fisheries Service entitled *An Economic Analysis of World Salmon Markets: Effects of Salmon Farming*, using 1989 and 1990 data (and possibly 1991).

2) Examine the possibilities of changing the functional form of the relevant equations in the above models to linear (or log-linear) instead of double-log to allow for changing elasticities along the demand curve.

3) Expand the model to include canned pink and chum salmon (canned chum salmon is added merely to maintain the definition of low-valued salmon. Only minor quantities of canned chum salmon are produced).

4) Model the salmon industry at both at the exvessel and export levels. Factors affecting wholesale level demand and supply will be included in the reduced form exvessel price equations.

5) Disaggregate the salmon species at the exvessel level into Alaskan chinook, sockeye, coho, chum, and pink salmon by area and aggregated across gear type. Current targeted fisheries are Prince William Sound, Cook Inlet, Kodiak, and Southeast. In an attempt to locate regional price changes, these areas are being modelled by relating the aggregate North American price of salmon to the regional prices of salmon in Alaska through regression analysis.

6) Report all relevant own-price, cross-price, and income elasticities. Cross-price elasticities will be between relevant Pacific and farmed salmon species.

7) Prepare the model to be used in the "Combining of Models for Policy Analysis" part of the enhancement project. This will include price predictions and sensitivity analysis on future prices for cases 1-11 found in the original RFP.

8) To generate the revenue effects of changing salmon production from enhancement as dictated in cases 1-11.

9) To write a final report with a targeted completion date of February 15, 1992.

Cases to be Simulated in the Policy Analysis Section

Case 1: Base Case - the salmon enhancement program continues at currently permitted capacity levels.

Case 2 - The salmon enhancement program continues at state and PNP projected production levels.

Case 3 - The salmon enhancement program is eliminated in FY 93.

Case 4 - Salmon production from enhancement projects is increased/decreased by increments of 15 percent.

Case 5 - The pink salmon program is eliminated and all else remains at the currently permitted capacity level.

Case 6 - The sockeye salmon program is eliminated and all else remains at the currently permitted capacity levels.

Case 7 - Salmon production from pink salmon enhancement projects is increased/decreased by an increment of 15 percent and all else remains at the currently permitted capacity level.

Case 8 - Salmon production from sockeye salmon enhancement projects is increased/decreased by an increment of 15 percent and all else remains at the currently permitted capacity level.

Case 9 - Salmon production from chum salmon enhancement projects is increased/decreased by an increment of 15 percent and all else remains at the currently permitted capacity level.

Case 10 Salmon production from coho salmon enhancement projects is increased/decreased by an increment of 15 percent and all else remains at the currently permitted capacity level.

Case 11 Salmon production from king salmon enhancement projects is increased/decreased by an increment of 15 percent and all else remains at the currently permitted capacity level.

The project goals and all contractual obligations for Herrmann and Greenberg are fulfilled with this report.

THE BUDGET

The entire amount of $18,000 was spent. The expenditures fit into the previously listed categories. Joshua Greenberg and Mark Herrmann were paid on an overload basis with the money used as summer salary. The remainder of the money was used for data and miscellaneous expenses. Both Herrmann and Greenberg worked well beyond the budgeted time and donated their additional time to the project.

Additionally, the largest portion of the cost of the project was donated from an ongoing project for Alaska Sea Grant College entitled "An Economic Analysis of World Markets for Wild and Farmed Salmon" (which emphasized the interactions between farmed and wild salmon and the effects of wild salmon from Russia on Alaskan markets), program under grant no. NA90AA-D-SG066, project # R/14-13. We gratefully acknowledge the assistance help that Alaska Sea Grant has provided. Without this help the cost of data collection would have been beyond the means of this grant. We also would like to acknowledge the University of Alaska Faculty Small Grants Program Award for a stipend that further enabled the researchers to perform the data collection.

Salaries:	Allocated	Spent
Mark Herrmann 2 mo. @ $4,500/mo.	$9,000	$9,000
Joshua Greenberg 1.25 mo. at $4,000/mo.	$5,000	5,000
Benefits	$3,174	3,174
Data	$826	$826
Total	$18,000	$18,000

We would like to thank the University of Alaska Fairbanks (UAF) for waiving the overhead on this project in addition to their funding of independent research. UAF recognizes the importance of this project to the state of Alaska and we are grateful to them.

The Model

The following flow chart provides a visual presentation of the completed salmon model. The arrows designate direction of trade flows within 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.

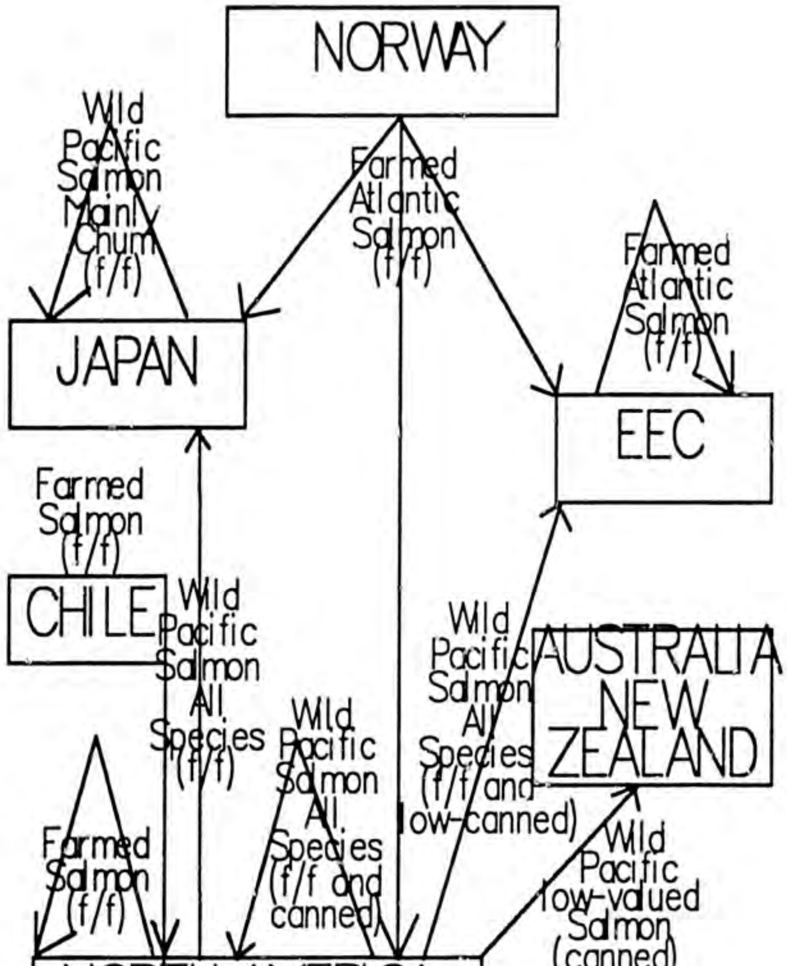

Figure 1. International Salmon Flow Chart

Listed below are components of the international salmon market that were modelled in bloc 1. Other salmon supplies such as Chilean, Scottish, Irish, Canadian, and U.S. farmed salmon are included in the model exogenously. All quantities are fresh/frozen unless otherwise noted as canned.

1. Norwegian allocation of farm-raised Atlantic salmon

   - Quantity allocated to the EEC
   - Quantity allocated to the Japan
   - Quantity allocated to the United States

2. EEC demand for salmon

   - Quantity demanded of Norwegian farmed Atlantic salmon
   - Quantity demanded of North American wild high-valued Pacific salmon
   - Quantity demanded of North American wild low-valued Pacific salmon
   - Quantity demanded of North American wild low-valued canned Pacific salmon (combined demand with Australia and New Zealand)

3. Japanese demand for salmon

   - Quantity demanded of Norwegian farmed Atlantic salmon
   - Quantity demanded of North American wild high-valued Pacific salmon
   - Quantity demanded of North American wild low-valued Pacific salmon

4. North American demand

   - Quantity demanded of Norwegian farmed Atlantic salmon

5. Australia and New Zealand Demand

   - Quantity demanded of North American low-valued canned salmon. (combined demand with the EEC)

6. North American allocation of wild high-valued Pacific Salmon

   - Quantity allocated to Japan
   - Quantity allocated to the EEC

7. North American allocation of wild low-valued Pacific salmon

   - Quantity allocated to Japan
   - Quantity allocated to the EEC

8. North American allocation of wild canned low-valued Pacific salmon

   - Quantity allocated to the EEC, Australia, and New Zealand

9. North American inventory holdings

   - Quantity of wild high-valued salmon inventory
   - Quantity of wild low-valued salmon inventory
   - Quantity of canned wild low-valued salmon inventory

10 Japanese inventory holdings

   - Quantity of Fresh/Frozen Inventory
   - Quantity of Salted Inventory

11. North American exvessel prices

   - Price of wild high-valued salmon
   - Price of wild low-valued salmon

12. Exvessel Regional Mappings

   - The exvessel prices of species and regions in Alaska as listed under project objective #5.

The model includes flows of fresh/frozen farmed salmon from Norway, Scotland, Chile, Ireland, Canada, and the United States. The farmed salmon from Norway, Ireland, and Scotland is exclusively Atlantic salmon. Farmed salmon from the United States, British Columbia, and Chile are a mixture of Pacific and Atlantic salmon. North American fresh/frozen salmon exports include all species of Pacific salmon. The modelled North American can salmon exports include chum and pink salmon. Japanese landings of salmon also include all species of Pacific salmon, although most 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. Nevertheless, it is felt that the resulting model is sufficiently inclusive to generate insights into the operations of world salmon markets.

Species

In the main modelling section, salmon was divided into five product groups, consisting of fresh/frozen Atlantic salmon, fresh/frozen farmed high-valued Pacific salmon (chinook and coho), fresh/frozen wild Pacific salmon (chinook, coho, and sockeye), fresh/frozen low-valued wild Pacific salmon (chum and pink), and canned low-valued Pacific salmon (pink and chum). The groupings of the Pacific salmon were necessary because of the high degree of collinearity among the prices. These aggregations were made on the basis of the value received by fishers. In 1990, the average exvessel prices received by the United States for high-valued Pacific species ranged from 1.04 to

1.83 dollars per pound, while the average prices received for the low-valued species ranged from 0.31 to 0.49 dollars per pound. Similar price differentials existed in Canada.

Examination of figure 2 reveals that Alaska salmon exvessel prices across species have been highly correlated during the 1980-91 time period. This correlation is further detailed in the estimation section.

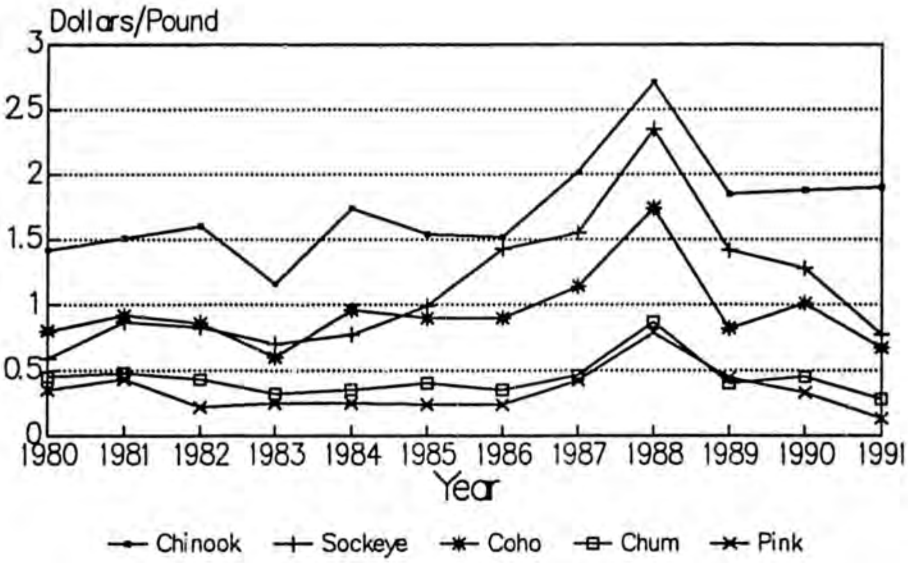

FIGURE 2. Alaska Salmon Exvessel Prices (1980-1991) (SOURCE: University of Alaska. 1992 Alaska Salmon Markets. Anchorage Alaska, May 1992.)

The individual Alaskan salmon prices by species and area (aggregated across gear types) are broken out in the second modelling section, and are correlated with the North American weighted average exvessel prices derived in the first section. The regional exvessel price equations for the relevant species of salmon harvested in Prince William Sound, Cook Inlet, Kodiak, Southeast, and all-other Alaska regions are presented.

Producing Regions

The world salmon industry was divided into six producing, consuming, and/or trading regions. These regions are North America (the United States and Canada), Japan, Norway, Chile, EEC (member countries as well as two non-members, Sweden and Switzerland), and Australia/New Zealand. These regions represent nearly the entire world supply of salmon. Russia accounts for most of the remaining world supply.

For Norway, the export markets of the EEC, Japan, and North America were modelled. These three markets accounted for approximately 99 percent of Norwegian 1990 exports of farmed Atlantic salmon. (Norway's domestic consumption is approximately 10-15 percent of farmed Atlantic salmon, and generally represents salmon of a lower grade than that exported). Indications are that future Norwegian exports may be targeted toward new markets. This is a consequence of heavy tariffs placed on Norwegian imports by the United States in 1991, and of recent imposition by the EEC of minimum price levels on imported farmed Norwegian Atlantic salmon. Norway should be expected to direct more of its exports to non-traditional market and Japan.

Chile's production is exported primarily to Japan and the United States. Chile, because of its southern hemisphere location, has the advantage that its farmed salmon naturally mature during the off Pacific fishing salmon season. Most Scottish and Irish farmed Atlantic salmon are consumed in the EEC countries; minor quantities are exported to the United States. Most of Canada's farmed production comes from British Columbia, and is consumed domestically or exported to the United States.

The producing regions for wild Pacific salmon supplies, included in the model are North America and Japan. The United States and Canada have been combined as "North America" because both countries harvest salmon which use the same migration patterns and because they trade in most of the same markets. Many experts believe that the catch from Alaska sets the prices for fresh/frozen salmon, with price differentials between the countries being the result of quality differences due to harvest procedure, handling care, area of ocean in which the salmon were caught, and timing of the harvest. The major export market for North America's fresh/frozen salmon is Japan, with the EEC countries accounting for most of the remaining exports. The EEC is the largest importer of North American canned salmon (led by the United Kingdom), followed by Australia.

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. Russia is the only region, other than North America and Japan, with a sizeable wild salmon harvest. Most of this salmon is pink and chum, and historically remained within the former Soviet Union and Eastern-bloc countries. Current Russian harvests, and the harvest distribution, (approximately 264 million pounds in 1990 (Pacific 1992)), are in a state of flux. It is believed that Japan may begin importing large quantities of Russian salmon in the near future. Russia could become a major competitor to Alaska in the world salmon markets. Efforts are currently underway at UAF toward studying the Russia salmon industry.

Consuming Regions

Japan is both the major consumer of salmon and the major world importer of salmon. The EEC is the second largest importer of salmon; and its member countries share many similarities in consumption patterns. Most of the EEC countries consume the majority of their salmon in the cold smoked product form. Also, because there are no tariffs among member EEC countries, there is a significant trade volume of similar salmon products. The United States is the largest consumer of salmon and is, in fact, a large import market for Canada. The United States has a 18-36 percent tariff on imported Norwegian Atlantic salmon. No tariff is imposed on fresh/frozen salmon imported from other countries.

The Model Equations

Presented below are the functional forms of the proposed behavioral equations[1]. Behavioral equations represent relationships where the left-hand-side variable (endogenous variable) is modelled as a function of the right-hand-side variables (explanatory variables). The right-hand-side variables may be endogenous (explained within the system), exogenous (explained outside of the system), or other predetermined variables (such as lagged endogenous variables). The equations that are not listed in functional form represent definitional identities. The identities link the equations. For example, identities are used to link foreign prices to domestic prices through appropriate exchange rate conversions. Bloc 1 represents the system of equations which model the world salmon flows, and recursively links the general Pacific salmon exvessel prices to international market conditions. Bloc 2 is where the individual Alaskan salmon prices by species and area are linked to the general movement in the aggregate exvessel prices.

Bloc One

Farmed Fresh/Frozen Atlantic

1) $NQAU^s = f_1(NPAU, NPAE, EXO_1)$
2) $NQAJ^s = f_2(NPAJ, NPAE, EXO_2)$
3) $NQAE^d = f_3(EPAERT, EPHERT, EXO_3)/EPOP$
4) $NQAJ^d = f_4(JPAJRT, JPHJRT, EXO_4)/JPOP$
5) $NQAU^d = f_5(UPAURT, UPHXRT, EXO_5)/UPOP$
6) $NQAE^s = NXQSUP - NQAJ^s - NQAU^s$
7) EPAERT = (((NPAE/NORECU)*ETARIFF))/ECPI
8) JPAJRT = (((NPAJ/NORJAP)*ETARIFF))/ECPI
9) UPAURT = (((NPAU/NORUSA)*ETARIFF))/ECPI
10) $NQAE^d = NQAE^s$
11) $NQAJ^d = NQAJ^s$
12) $NQAU^d = NQAU^s$

North American High-Valued Fresh/Frozen Salmon

13) $UQHX^s = f_6(UPHX, UHSUP, EXO_6)$
14) $UPHXE = f_7(UPHXJ, EXO_7)$
15) $UQHX^s = UQHXJ^d + UQHXE^d$
16) $UHINV = f_8(UPHX, UHSUP, EXO_8)$
17) $UQHXE^d = f_9(EPHERT, EPLERT, EPAERT, EXO_9)/EPOP$
18) $UQHXJ^d = f_{10}(JPHJRT, JPLJRT, JPAJRT, JINVZ, EXO_{10})/JPOP$
19) $UPHX = (UPHXE*UQHXE^d + UPHXJ*UQHXJ^d)/(UQHXE^d + UQHXJ^d)$
20) EPHERT = ((UPHXE / USAECU) * (ETARIFF) / ECPI)
21) JPHJRT = ((UPHXJ * JAPUSA) * (JTARIFF) / JCPI)
22) $UHSUP = ULANH + UHINV_{-1}$
23) $JINVZ = f_{11}(JPHXJT, UQHXJ^s, EXO_{11})$
24) JPHXJT = JPHXJRT * JCPI

1 The included variables here are theoretical and may deviate from the actual ones used.

North American Low-Valued Fresh/Frozen Salmon

25) $UQLXE^s = f_{12}(UPLXE, ULSUP, EXO_{12})$
26) $UPLXJ = f_{13}(UPLXE, EXO_{13})$
27) $ULINV = f_{14}(UPLX, ULSUP, EXO_{14})$
28) $UQLXE^d = f_{15}(EPHERT, EPLERT, EXO_{15})/EPOP$
29) $UQLXJ^d = f_{16}(JPLJRT, JINVT, EXO_{16})/JPOP$
30) $UPLX = (UPLXE*UQLXE^s + UPLXJ*UQLXJ^d)/(UQLXE^s + UQLXJ^d)$
31) EPLERT = ((UPLXE / USAECU) * (ETARIFF) / ECPI)
32) JPLJRT = ((UPLXJ * JAPUSA) * (JTARIFF) / JCPI)
33) $ULSUP = ULANL + ULINV_{-1}$
34) $JINVT = f_{17}(JPLXJ, UQLXJ^s, EXO_{17})$
35) JPLXJT = JPLXJRT * JCPI

North American Low-Valued Canned Salmon

36) $APHXAC = f_{18}(EPHXET, EXO_{18})$
37) $UQLXAC^d = f_{19}(APLACR, APHACR, EXO_{19})/EPOP$
38) $ULINVC = f_{20}(UPLXC, ULSUPC, EXO_{20})$
39) ULSUPC=ULSUP+1.6*LAG(ULINVC)
40) $UQLXAC^s = f_{21}(UPLC, ULINVC, EXO_{21})$
41) UPLXC=APLACR/(ECUUSA*ECPI)
42) APHACR = (APHXAC * ECUUSA) / ECPI
43) APLACR = (APLXAC * ECUUSA) / ECPI
44) $UQLXAC^d = UQLXAC^s$
45) EPHXET = EPHXERT * ECPI

North American Exvessel Price Equations

46) $NAPHEX = f_{22}(UPHX, UPLX, UHSUP, UPAU, EXO_{22})$
47) $NAPLEX = f_{23}(UPLX, UPHX, ULSUP, UPAU, EXO_{23})$
48) UPAU = (NPAU * USAECU)

Endogenous Variables: (bloc 1)

$NQAU^s$, $NQAJ^s$, $NQAE^d$, $NQAJ^d$, $NQAU^d$, $NQAE^s$, EPAERT, JPAJRT, EPAURT, NPAU, NPAE, NPAJ

$UQHX^s$, UPHXE, UHINV, $UQHXE^d$, $UQHXJ^d$, UPHX, EPHERT, JPHJRT, UHSUP, JINVH, UPHXJ, JPHXJT

$UQLXE^s$, UPLXJ, ULINV, $UQLXE^d$, $UQLXJ^d$, UPLX, EPLERT, JPLJRT, ULSUP, JINVL, LPLXJT

APHXAC, $AQLXAC^d$, ULINVC, ULSUPC, $UQLXAC^s$, APHXAC, APLACRT, APHACRT, APLXAC, UPLXC

NAPHEX, NAPLEX, UPAU

Glossary -- Endogenous Variables: (bloc 1)

Atlantic Salmon Variables

$NQAE^s$ = the quantity of Norwegian farmed Atlantic salmon exported to the EEC in millions of lbs.
$NQAJ^s$ = the quantity of Norwegian farmed Atlantic salmon exported to Japan in millions of lbs.
$NQAU^s$ = the quantity of Norwegian farmed Atlantic salmon exported to the U.S. in millions of lbs.
$NQAE^d$ = the quantity of imported Norwegian farmed Atlantic salmon in the EEC in millions of lbs.

$NQAJ^d$ = the quantity of imported Norwegian farmed Atlantic salmon in Japan in millions of lbs.
$NQAU^d$ = the quantity of imported Norwegian farmed Atlantic salmon in the U.S. in millions of lbs.
NPAE = the Norwegian price of Norwegian farmed Atlantic salmon exported to the EEC in Norwegian kroners.
NPAJ = the Norwegian price of Norwegian farmed Atlantic salmon exported to Japan in Norwegian kroners.
NPAU = the Norwegian price of Norwegian farmed Atlantic salmon exported to the United States in Norwegian kroners
EPAERT = the "real" after tariff price of Norwegian farmed Atlantic salmon in the EEC in ECUs.
JPAJRT = the "real" after tariff price of Norwegian farmed Atlantic salmon in Japan in Japanese yen.
UPAURT = the "real" after tariff price of Norwegian farmed Atlantic salmon in the United States in U.S. dollars.

High-Valued Pacific Salmon Variables

$UQHX^s$ = the total quantity of North American exports of high-valued salmon to the EEC and Japan in millions of lbs.
$UQHXE^d$ = the quantity of EEC imports of Nortn American high-valued salmon in millions of lbs.
$UQHXJ^d$ = the quantity of Japanese imports of North American high-valued salmon in millions of lbs.
UPHXE = the North American export price of high-valued salmon to the EEC in U.S. dollars.
UPHXJ = the North American export price of high-valued salmon to Japan in U.S. dollars.
UPHX = the North American weighted average export price of high-valued salmon to Japan and the EEC in U.S. dollars.
JPHXJ = the nominal after tariff price of North American high-valued Pacific salmon in Japan in Japanese yen.
EPHERT = the "real" after tariff price of North American high-valued Pacific salmon in the EEC in ECUs.
JPHJRT = the "real" after tariff price of North American high-valued Pacific salmon in Japan in Japanese yen.
UHSUP = the North American total available supply of high-valued salmon in millions of lbs.
UHINV = the ending inventory of North American high-valued salmon in millions of lbs.

$UHINV_{-1}$ = the beginning inventory of North American high-valued salmon in millions of lbs.
JINVZ = the ending total inventory of Japanese frozen salmon (less Pink inventories) in millions of lbs.

Low-Valued Pacific Salmon Variable (fresh/frozen)

$UQLXE^s$ = the quantity of North American exports of low-valued salmon to the EEC in millions of lbs.
$UQLXE^d$ = the quantity of EEC imports of North American low-valued salmon in millions of lbs.
$UQLXJ^d$ = the quantity of Japanese imports of North American low-valued salmon in millions of lbs.
UPLXE = the North American export price of low-valued salmon to the EEC in U.S. dollars.
UPLXJ = the North American export price of low-valued salmon to Japan in U.S. dollars.
UPLX = the North American weighted average export price of low-valued salmon to Japan and the EEC in U.S. dollars.
JPLXJ = the nominal after tariff price of North American low-valued Pacific salmon in Japan in Japanese yen.
EPLERT = the "real" after tariff price of North American low-valued Pacific salmon in the EEC in ECUs.
JPLJRT = the "real" after tariff price of North American low-valued Pacific salmon i in Japan in Japanese yen.
ULSUP = the North American total available supply of low-valued salmon in millions of lbs.
ULINV = the ending inventory of North American low-valued salmon in millions of lbs.
$ULINV_{-1}$ = the beginning inventory of North American low-valued salmon in millions of lbs.
JINVT = the ending total inventory of Japanese frozen and salted salmon in millions of lbs.

Low-Valued Pacific Salmon Variable (fresh/frozen)

$UQLXAC^s$ = the quantity of North American exports of low-valued canned salmon to the EEC, New Zealand, and Australia in millions of lbs.
$UQLXAC^d$ = the quantity of EEC, New Zealand, and Australia imports of North American low-valued canned salmon in millions of lbs.
APHXAC = the nominal export price of high-valued canned salmon exported to Australia and N.Z. in ECUs.
APHXACR = the "real" nominal export price of high-valued canned salmon exported to Australia and N.Z. in ECUs.
APLXAC = the nominal export price of low-valued canned salmon exported to Australia and N.Z. in ECUs.
APLXACR = the "real" nominal export price of low-valued canned salmon exported to Australia and N.Z. in ECUs.
UPLXC = the nominal export price of low-valued canned salmon exported to Australia and N.Z. in U.S. dollars.
EPHXET = the nominal after tariff price of North American high-valued Pacific salmon in the EEC in ECUs.

ULSUPC = the North American total available supply of low-valued salmon canned salmon in millions of lbs.
ULINVC = the ending inventory of North American low-valued canned salmon in millions of lbs.
NAPHEX = the North American exvessel price of high-valued Pacific salmon in U.S. dollars.
NAPLEX = the North American exvessel price of low-valued Pacific salmon in U.S. dollars.
UPAU = the nominal price of Norwegian farmed Atlantic salmon in the United States in U.S. dollars.

Glossary -- Exogenous Variables: (bloc 1)

EXOi = indicated exogenous factors included in equation i, i=1,...,23.
NXQSUP = total Norwegian exports of farmed Atlantic Salmon in millions of lbs.
NORECU = the Norwegian kroner/ECU exchange rate.
NOAJAP = the Norwegian kroner/yen exchange rate.
NORUSA = the Norwegian kroner/U.S. dollar exchange rate.
USAECU = the U.S. dollar/ECU exchange rate.
JAPUSA = the yen/U.S. dollar exchange rate.
ECPI = the EEC consumer price index for food.
UCPI = the U.S. producer price index for food.
JCPI = the Japanese consumer price index for food.
JTARRIF = The Japanese tariff rate on fresh/frozen salmon.
ETARRIF = The EEC tariff rate on fresh/frozen salmon.
EPOP = the population of the EEC.
JPOP = the population of the Japan.
UPOP = the population of the United States.
ULANH = U.S. landings of high-valued salmon in millions of lbs.
ULANL = U.S. landings of low-valued salmon in millions of lbs.

Bloc Two

Alaskan Exvessel Price Regressions

49) PWKP = (NAPHEX, C)
50) PWRP = (NAPHEX, C)
51) PWSP = (NAPHEX, C)
52) PWCP = (NAPLEX, C)
53) PWPP = (NAPLEX, C)
54) CIKP = (NAPHEX, C)
55) CIRP = (NAPHEX, C)
56) CISP = (NAPHEX, C)
57) CICP = (NAPLEX, C)
58) CIPP = (NAPLEX, C)
59) KKKP = (NAPHEX, C)
60) KKRP = (NAPHEX, C)
61) KKSP = (NAPHEX, C)
62) KKCP = (NAPLEX, C)
63) KKPP = (NAPLEX, C)
64) SEKP = (NAPHEX, C)
65) SERP = (NAPHEX, C)
66) SESP = (NAPHEX, C)

67) SECP = (NAPLEX, C)
68) SEPP = (NAPLEX, C)

Glossary -- Endogenous Variables: (bloc 2)

PWKP PWSP PWRP PWCP PWPP is the exvessel price in the Prince William Sound fishery for chinook, coho, sockeye, chum, and pink salmon, respectively.

CIKP CISP CIRP CICP CIPP is the exvessel price in the Cook Inlet fishery for chinook, coho, sockeye, chum, and pink salmon, respectively.

KKKP KKSP KKRP KKCP KKPP is the exvessel price in the Kodiak fishery for chinook, coho, sockeye, chum, and pink salmon, respectively.

SEKP SESP SERP SECP SEPP is the exvessel price in the Southeast fishery for chinook, coho, sockeye, chum, and pink salmon, respectively.

NAPHEX = the North American exvessel price of high-valued salmon, measured in U.S. dollars per pound

NAPLEX = the North American exvessel price of low-valued

Exogenous Variables: (bloc 2)

C = a constant.

Data Sources

All data used in bloc one represents quarterly values based on the calendar year. Bloc two data are annual values. Most equations were estimated for the time period 1982, or 1983, to 1990. The quantities represent quarterly totals, and the prices represent weighted averages for each quarter.

The data source for U.S. export quantities and prices was the National Marine Fisheries Service. The Canadian export quantity and price data came from Statistics Canada. The Norwegian export quantity and price data were obtained from the Norwegian Central Bureau of Statistics.

U.S. landings and exvessel prices were provided by the Commercial Fisheries Entry Commission (Alaska data), Oregon Department of Fish and Wildlife (Oregon data), Washington Department of Fisheries (Washington data), and the U.S. Pacific Fisheries Management Council in Portland (California data). British Columbian landings and exvessel prices came from the British Columbia Department of Fisheries and Oceans.

U.S. inventories of frozen salmon were from Frozen Fishery Products, Annual Summary (U.S. Department of Commerce, National Oceanic and Atmospheric Administration). U.S. inventories of canned frozen salmon were from the National Food Processor's Association. The British Columbian inventories were those reported by the Canadian Ministry of Agriculture and Fisheries in Victoria.

Exchange rates were obtained from International Financial Statistics published by the International Monetary Fund (various issues). The data source for U.S. private food consumption expenditure was the Quarterly National Accounts, published by the OECD Department of Economics and Statistics.

Japanese landings, exports, imports, and inventories of salmon as well as the wholesale price of substitute species were prepared by Clint Atkinson, a fisheries consultant.

Exchange rates and population data were obtained from International Financial Statistics, published by the International Monetary Fund (various issues). The private consumption expenditure data for the EEC were those reported 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 obtained from Main Economic Indicators, published by the same agency (various issues). The Japanese private consumption expenditure and the Japanese CPI data came from Japan's Economic Planning Agency (Lin, 1990).

Estimation Theory

Estimation, and fine tuning, of the hypothesized model is accomplished using econometrics. Econometrics is the blending of economic theory with regression analysis. Hypotheses are formed from economic theory. These hypothesis are then tested using regression analysis. For example, we might hypothesize that an increase Japanese income level in Japan will increase sockeye salmon exports to Japan. Using regression analysis, we can determine if the data supports this theory. And, if it does, we can determine the relative importance of this relationship.

Specifically, classical econometrics estimates the relationship between an endogenous variable and various explanatory variables. An example for a two variable case is shown in (1).

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

where Y is an $(n \bullet 1)$ vector of observable values of the random variable Y, x is a known $(n \bullet k)$ matrix of nonstochastic explanatory variables, β is a $(k \bullet 1)$ vector of unknown parameters, e is a $(n \bullet 1)$ vector of unobservable random variables, and n is the number of observations. The true parameters are unknown and are estimated through regression analysis. (Note that the equation specified in (1) is linear. Using a linear equation is desirable in many cases, although it is not necessary). Once the parameters in (1) are estimated there will be a difference between the actual value of the endogenous variable (Y) and the predicted value of the endogenous variable ($\hat{Y}$). This difference is called an error term and can be calculated by

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

The error term is a random variable that is sensitive to random disturbances in the specified causal relationships. The estimated parameters (β) are also random variables with their own distributions. The distributions are assumed to be normal in ordinary least-squares, and the means of these normal distributions are the values of the estimated coefficient parameters.

An alternative to classical econometrics is a bootstrapped Bayesian approach, Bayesian Bootstrapping analysis has several desirable features. (1) It uses a wealth of information that can be gleamed from non data sources; and (2) it does not assume normality of the error structure. (For a more rigorous development of the BB2SLS see

Herrmann (1990)). Bayesian Bootstrapped two-stage least-squares (BB2SLS) was used for the estimation of Bloc 1. Bloc 2, where there was no prior information available, utilized classical econometrics.

Bootstrapping Linear Models

Bootstrapping is a method by which the sampling variability and parameter distributions of a linear model can be examined 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 straightforward. Let the single equation being analyzed be represented by (1) above. To perform bootstrapping, first the estimates of the error term ($\hat{e}$) are derived as in (2) above. Then a random sample (with replacement) of the estimated error terms is taken until a new vector of error terms is generated ($\hat{e}^*$). Once the new vector of error terms is generated the estimate of Y is constructed by a new ($n \bullet 1$) vector as shown

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

In the bootstrapping context, a new dependent variable $\hat{Y}^*$ (from (3)) replaces the actual vector of Y, and the parameter coefficients are generated in the usual way (the reader can read any standard econometric text if he/she wishes to examine the way the coefficients are generated.) This process is repeated with the estimated errors being randomly sampled from the original OLS run as many times as is desired. After achieving parameter stability, the means of the sample parameter coefficients are derived by taking a simple mean of the resulting distribution. The sampling variance of parameter coefficients can be derived in like fashion. Note that the empirical distribution of the parameter bootstrapped coefficient values can be interpreted as an approximation to the sampling distribution for the OLS estimated values. This extension of the Bayesian this model to generalized least-squares estimators is straightforward.

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. Again, see Herrmann (1990) for further discussion.

The Bayesian Bootstrapping Technique

The Bayesian bootstrapping technique is robust in that it does not require any *a priori* assumption regarding the functional form of the likelihood function underlying the problem--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 problem. This feature permits analyses of complex posterior distributions that would otherwise be quite difficult, or impossible, analytically to analyze . For this study, we will stick to the inequality, uniform prior distributions, or quadrilateral distributions.

Prior restrictions, which are imposed on the bootstrapped parameter distributions, are used to incorporate prior information regarding the sign and magnitudes of the actual parameter levels. This information may come from economic theory, expert opinion from industry and academia, prior studies, and the modelers own expertise. Simply put, Bayesian analysis is a way to utilize this added information, and, thereby, enriching the study. BB2SLS in its entirety is far too complex to discuss here, once again, please see Herrmann (1990) for a theoretical discussion. However, a brief description of some of the more salient points of BB2SLS hypothesis testing are presented.

Posterior Probability Analysis

Three general types of hypothesis tests were examined in the study: tests on the structural coefficients; tests regarding the first-order autocorrelation coefficient; and tests regarding the presence of quarterly heteroscedasticity. Also, the probability in favor of the prior range of structural coefficient values were examined.

The equations in bloc 1 were estimated using the single-equation technique of Bayesian bootstrapped two-stage least squares (BB2SLS) and the results along with the relevant test statistics are reported in the following section. The reported test statistics are not the same as those associated with classical two-stage least-squares technique. This is a consequence of 2SLS test statistics are based on repeated sample properties, whereas the BB2SLS is a Bayesian approach. In the BB2SLS approach, the test statistics are based on posterior probabilities of hypotheses to test relevant null hypotheses, such as the significance of including a right hand side variable (If desired, the classical two-stage results for the same equations as well as the instruments used in the analysis can be obtained from the authors).

Reported along with the equation is a statistic referred to as "HYPOIG". This term represents an acronym for "hypothesis testing using an ignorance prior". HYPOIG represents the probability that a given parameter will be greater than zero for a coefficient estimated to be positive; and less than zero for a parameter estimated to be negative. These numbers can be read directly as probabilities. For example, a substitute price HYPOIG of .950 it can be interpreted as stating that there is a 95 percent probability that the chosen variable was a substitute for the dependent variable.

The "probability of the prior range (PPR)" is the joint probability that the coefficients of the model will reside within the subset of the parameter space represented by the range of values assigned positive density weightings by the prior density. It is calculated by counting the number of BB2SLS iterations that lie within the prior range and dividing the count by the total number of iterations. All of the above statistics were calculated from the final BB2SLS-stage of estimation in which bootstrapping continued until 1,000 iterations satisfied all prior ranges.

To provide a measure of support for the researcher's relative density weightings assigned to the prior range of parameter-values, as opposed to assigning equal weightings (uniform density) to all values of the parameters within the prior range, the "Odds in Favor of Non-Uniform Prior" is calculated. The measure is a ratio of the posterior expectation of the researcher's PPDF to the posterior expectation of a uniform density on the range of parameter-values assigned positive density weighting by the PPDF. Both expectations are calculated utilizing a posterior density that is based on a diffuse prior. The more the odds ratio exceeds the value 1, the more support is rendered to the pattern of differential weights to the parameter-values assigned by the researcher.

The first-order autocorrelation probabilities measure the probability that the first-order autocorrelation coefficient is positive. They were calculated by dividing the total number of times a positive autocorrelation coefficient was calculated in the bootstrapping procedure by the total number of iterations. Probabilities were calculated using diffused priors. The hypothesis of no autocorrelation was rejected if probability based on the ignorance prior was greater than 0.975 or less than 0.025. In the case of first-order autocorrelation, the model specification was reexamined in an attempt to correct for the problem. The first-order autocorrelation probabilities were generated from the BB2SLS runs not corrected for heteroscedasticity, in keeping with the testing procedure sequence suggested by Judge (1985, pp. 331-332).

The procedure for examining heteroscedasticity was based on examining the tables called "Probability [Column $\sigma_i <= $ Row σ_j]". These tables present comparisons of the standard deviations for each quarter of the BB2SLS. All pairwise comparisons of the σ_is can be made. A particular quarter was generally considered to have the same variances as another quarter if the probability that one standard deviation exceeded the other was between .025 and .975. Exceptions to this rule arose when transitivity of some sequence of variance equality/inequality relations would otherwise be violated. In this case, the relations between the variances were decided based upon the most probable of the relations given the pairwise comparison probabilities.

All heteroscedasticity and autocorrelation tests were performed on bootstrap runs for which 1,000 samples (post-samples) satisfied the given prior range. The tables of quarterly standard deviation comparison probabilities are reported for the ignorance (no prior distributions) models. Decisions regarding the presence of heteroscedasticity were based on the probabilities generated using the diffuse prior. Heteroscedasticity by quarters is theorized to be a possible problem because of the seasonal nature of salmon harvests and shipments.

The reported correlation coefficients measure the degree of linear correlation between predicted and observed values. For a more comprehensive discussion of the correlation coefficient please see the discussion starting on page 82.

Bloc 1 Estimates

Exvessel Price Equations

The North American exvessel price equations were hypothesized to be a function of the appropriate wholesale prices, substitute prices, income, a constant, and quarterly indicator variables. The functional form used for the high-valued exvessel price equation was log-linear. For the low-valued exvessel price equation the more standard linear form was utilized. One reason the linear and log-linear functional forms were chosen is that they allow the elasticities (or price flexibilities) to vary as landings vary. (The log-linear functional form was preferred for the high-valued exvessel price equation because it performed markedly better in simulation goodness of fit statistics.) Both these functional forms are seen to be an improvement over the functional form chosen in Herrmann (1990), where a double-log functional form forced constant elasticities.

Equation 1: Price of High-Valued Salmon

Endogenous variable = ln(NAPHEX)

Variable	Bayesian Coefficient	Standard Error	HYPOIG
UPHX	0.212	0.050	1.000
UPAU	0.197	0.065	0.996
UHSUP	-0.0014	0.0007	0.950
C	-0.261	0.218	0.848
DQ2	-0.722	0.070	1.000
DQ3	-0.301	0.245	0.896
DQ4	-0.850	0.059	1.000
D91	-0.476	0.132	0.999
UY	0.000086	0.0000047	0.890

Correlation coefficient = 0.957

Probability of prior range = 0.849

Probability of positive first-order autocorrelation (ignorance) = 0.451

Het Correction = Quarter 4

Sample period = 1982:1 to 1991:3

Probability [Column σ_i > = Row j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	0.154	0.565	0.146
σ_2	0.846	...	0.892	0.123
σ_3	0.435	0.108	...	0.005
σ_4	0.985	0.877	0.995	...

The short-run percentage change of dependent variable with 1 percent changes in right-hand side variables, all else remaining constant are:

UPHX	0.52
UPAU	0.62
UHSUP	-0.19
UY	0.28

Equation 2: Price of Low-Valued Salmon

Endogenous variable = NAPLEX

Variable	Bayesian Coefficient	Standard Error	HYPOIG
UPLX	0.338	0.077	1.000
UPLXC	0.101	0.028	0.999
ULSUP	-0.000329	0.0001	0.875
C	-0.256	0.085	0.998
DQ2	-0.00207	0.041	0.502
DQ3	0.188	0.073	0.982
DQ4	0.278	0.045	1.000
D91	-0.102	0.037	0.997

Correlation coefficient = 0.937

Probability of prior range = 0.874

Probability of positive first-order autocorrelation (ignorance) = 0.067

Het Correction = Quarter 3

Sample period = 1983:1 to 1991:3

Probability [Column $\sigma_i >= $ Row σ_j]:

	σ_1	σ_2	σ_3	σ_4
σ_1	...	0.641	0.006	0.971
σ_2	0.359	...	0.007	0.934
σ_3	0.994	0.993	...	1.000
σ_4	0.029	0.066	0.000	...

The short-run percentage change of dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

UPLX	0.97
UPLC	0.44
ULSUP	-0.14

Variable definitions:

UPHX = the North American weighted average export price of high-valued salmon to Japan and the EEC, in U.S. dollars.

UPAU = the nominal price of Norwegian farmed Atlantic salmon in the United States, in U.S. dollars.

UHSUP = the North American total available supply of high-valued salmon in millions of lbs.

D91 = an indicator variable which is assigned a value of 0 between 1983 and 1990, inclusive, and a value of 1 in 1991.

C = a constant.

UPLX = the North American weighted average export price of low-valued salmon to Japan and the EEC, in U.S. dollars.

UPLXC = the nominal export price of low-valued canned salmon exported to Australia and N.Z., in U.S. dollars.

ULSUP = the North American total available supply of low-valued salmon in millions of lbs.

UY = United States personal disposable income in millions of U.S. Dollars.

DQ_is = quarterly indicator variables for quarter i, where DQ_i is 1 in quarter i and 0 elsewhere.

UPHX = the North American weighted average export price of high-valued salmon to Japan and the EEC, in U.S. dollars.

The equation specifications were guided by the theory of derived demand. In both exvessel equations, the weighted average North American export prices (UPHX, UPLX, and UPLXC) are used in place of the wholesale price of fresh/frozen high- and low-valued Pacific salmon and canned low-valued Pacific salmon, respectively. This is necessary since quarterly wholesale prices for fresh/frozen salmon are not available. In addition, equations for the domestic demand for high- and low-valued salmon were not specified because the disappearance of fresh/frozen and canned salmon by quarter were unavailable and estimates of the representative quantities were deemed unreliable. However, some of the effect of the wholesale price should be picked up by both the weighted average export price and aggregate disposable North American income; both of these variable are highly correlated with wholesale price. Because of the absence of domestic demand equations for Pacific salmon, factors affecting wholesale demand are included in the reduced form equations.

The modelled equations were estimated in price-dependent form. This specification reflects that total available supply is essentially exogenous. North American landings are set by provincial and state governments, and it is assumed that these landings are not price-responsive once fishers have made the decision to fish actively.

The estimations performed well, as indicated by high correlation coefficients and high probabilities of the prior range. Neither equation exhibited first-order autocorrelation problems. The high and low-valued exvessel price equations were corrected for heteroscedasticity, which appeared in the fourth and second quarters, respectively. Prices of the high-valued salmon were not found to be significant in the low-valued exvessel equations, and vice versa.

In the high-valued exvessel price equation, farmed Norwegian Atlantic salmon was found to be a substitute for high value wild salmon, with a 99.6 percent probability, and income was found to be significant, with a 89 percent probability. Income was included, despite the lower probability, because of its potential importance in determining U.S. demand. The high-valued salmon exvessel price was positively correlated with the weighted average export price. In other words, as the export price increases (decreases) we would expect the exvessel price to move in the same direction, but not on less than one for one basis. The quarterly indicator variables in the high-valued exvessel equation indicate a large positive increment in the first quarter exvessel price. Only a small amount of winter troll chinook is sold fresh domestically in this quarter, usually as a specialty item with a corresponding high price.

In the low-valued exvessel equations, low-valued exvessel prices moved in the same direction as the weighted average export prices of both fresh/frozen, and canned salmon. Income was not found to be significant. This should not be taken to indicate that income has no effect on domestic demand for canned salmon. Rather, income probably is a less significant determinant of demand for low-valued salmon than high-valued salmon and, therefore, was not statistically discernable. (Tuna was expected to be a substitute for low-valued salmon, but tuna prices were not available at the time of this report.)

For a discussion of the priors used for this and any other equations -- please contact the authors.

Price Flexibilities and Elasticities

Price flexibilities and elasticities are a common tool that economists use to describe the responsiveness of an endogenous variable to a change in an explanatory variable, all else remaining constant. Specifically, a price flexibility coefficient represents the percentage change in price given a one percent change in quantity. A price elasticity represents the percentage change in quantity given a one percent change in price.

For salmon, these measures can be important first-round indicators of possible affects of changes in market conditions to salmon price and quantity levels. A salmon exvessel price flexibility of greater than one (in absolute value) indicates that a one percent increase in quantity landed would be accompanied by a price decrease greater than one percent, and accordingly, fishery revenue would decline. We can state with certainty that costs of increased supplies outweigh the benefits when expanding supply is associated with lower total revenues.

There are two problems with calculating price flexibilities from single equations. First, since these equations belong to a larger set of forty-eight equations, a change in a right-hand side variable will circulate throughout the system, affecting all variables simultaneously. Until the entire system is simulated, the interlinkages between different market components, such as salmon landings impact on price, cannot be estimated. Therefore, the price flexibilities and elasticities, reported below, are only first-round affects and should be treated only as a gross approximation to the true estimated affects. For example, a change in salmon landings will directly decrease the exvessel price through the derived demand equations, and additionally, indirectly decrease the price through the effect increased landings has on reducing the weighted average export price.

Secondly, elasticities will change by quarters. Again, using a change in landings as an example, an annual mean-level price flexibility does not capture the true nature of the price-landings relationship because most salmon is landed in just one or two quarters. Therefore, calculating the effects of a change in landings by a mere visual examination of the annual elasticities may be misleading.

The shortcomings of the reported price flexibilities and elasticities need to be recognized by the reader. Much more valuable information regarding the interlinkages between variables in the model can be gleaned from results reported in the simulation section. Simulations fully capture the interactions between all model variables, and therefore, more accurately represent the adjustments in salmon prices and quantities which will accompany changes in market conditions.

High-valued Pacific salmon mean-level price-flexibilities and elasticities for a change in beginning available supplies (in absolute values) are reported below:

Quarter	Price Flexibility	Upper-bound On Elasticity
1	-0.05	-22.05
2	-0.11	-9.26
3	-0.50	-2.02
4	-0.08	-13.73

These price flexibilities above are for total available supplies. For example, the third quarters' price flexibility can be interpreted as indicating that a one-percent increase in the North American total available supplies (including inventories) will lead to exvessel price decreasing by 2.02 percent, all else remaining equal. When the full model is simulated the effect of a change in landings alone can be calculated, with the model predicting the change in inventories.

The reported mean-level elasticities and flexibilities (for 1983 to 1991) indicate that an increase in supplies of high-level landings would increase high-level revenues in each quarter. Again, two cautions. First, these are mean-level elasticities over an 8 year period. The higher landings in the early 1990s increased the price flexibilities over the reported ones. Secondly, these are only first-round effects and do not take into account the effect that changes in wholesale prices, as a result of changes in landings, will have on exvessel prices.

Low-valued Pacific salmon mean-level price-flexibilities and elasticities for a change in beginning available supplies (in absolute values) are reported below:

Quarter	Price Flexibility	Upper-bound Elasticity
1	-0.09	-10.92
2	-0.07	-14.40
3	-0.38	-2.63
4	-0.09	-11.28

With virtually all the Alaskan catch in the third quarter, the effective weighted price flexibility is essentially -0.38. As in the high-valued exvessel equations, the price flexibilities are higher than those found in previous studies. These findings suggest that landings may be reaching that level which maximizes fishery revenue. This possibility will be more thoroughly examined in the simulation section.

Norwegian Allocation of Farm-Raised Atlantic Salmon

The Norwegian allocation of farmed Atlantic salmon to North America, the EEC, and Japan are examined in this section. Given that total supply of Norwegian exports is modeled as exogenous, two allocation equations were estimated, with the third equation of this model subcomponent derived from an identity. The Norwegian allocation of farm-raised Atlantic salmon to the United States and Japan are estimated directly. The Norwegian allocation to the United States and Japan were estimated as a function of the prices it received from the modelled region; the price it received from the EEC; the total supply to be allocated to North America, the EEC, and Japan; a one-quarter lagged dependent variable; a constant; and three quarterly indicator variables. The equations were estimated using the double-log functional form for the time period from the first quarter of 1983 to the third quarter of 1991.

Equation 3: Norwegian Supply of Farmed Atlantic Salmon to the United States

Endogenous variable = $\ln(NQAU^S)$

Variable	Bayesian Coefficient	Standard Error	HYPOIG
ln(NPAU)	2.170	0.969	0.972
ln(NPAE)	-1.633	1.033	0.932
ln(NXQSUP)	0.430	0.113	1.000
DQ2	-0.441	0.144	0.998
DQ3	-0.745	0.143	1.000
DQ4	-0.315	0.123	0.996
C	-2.024	1.410	0.925
DSEPT90	-1.468	0.134	1.000
DMAR91	-0.854	0.322	0.996
$\ln(NQAU^S_{-1})$	0.471	0.074	1.000

Correlation coefficient = 0.959

Probability of prior range = 0.972

Odds in Favor of P(B) = 1.250
Probability of positive first-order autocorrelation (ignorance) = 0.934

Het Correction = Quarter 4

Sample period = 1983:1 to 1991:3

Probability [Column σ_i >= Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	0.807	0.946	0.000
σ_2	0.192	...	0.788	0.000
σ_3	0.054	0.212	...	0.000
σ_4	1.000	1.000	1.000	...

The short-run percentage change of dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

NPAU	2.170
NPAE	-1.633
NXQSUP	0.430

The long-run percentage change of dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

NPAU	4.102
NPAE	3.087
NXQSUP	0.813

Equation 4: Norwegian Supply of Farmed Atlantic Salmon to Japan

Endogenous variable = $\ln(NQAJ^S)$

Variable	Bayesian Coefficient	Standard Error	HYPOIG
ln(NPAJ)	1.841	0.839	0.850
ln(NPAE)	-1.232	0.874	0.635
ln(NXQSUP)	0.798	0.255	0.996
C	-4.466	2.236	0.971
DQ2	-0.042	0.139	0.638
DQ3	-0.619	0.173	1.000
DQ4	-0.345	0.176	0.980
$\ln(NQAJ^S_{-1})$	0.496	0.118	1.000

Correlation coefficient = 0.973

Probability of prior range = 0.510

Ods in Favor of P(B) = 1.227

Probability of positive first-order autocorrelation (ignorance) = 0.663

Het Correction = Quarter 3

Sample period = 1983:1 to 1991:3

Probability [Column σ_i >= Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	0.382	0.988	0.575
σ_2	0.618	...	0.996	0.690
σ_3	0.117	0.004	...	0.016
σ_4	0.425	0.310	0.984	...

The short-run percentage change of dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

NPAJ	1.841
NPAE	-1.232
NXQSUP	0.798

The long-run percentage change of dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

NPAU	3.709
NPAE	-2.480
NXQSUP	1.608

Variable Definitions:

NQAU = the quantity of Norwegian farmed Atlantic salmon exported to the United States in millions of lbs.

$NQAU^{s}_{-1}$ = NQAU lagged one quarter.

NQAJ = the quantity of Norwegian farmed Atlantic salmon exported to Japan in millions of lbs.

$NQAJ^{s}_{-1}$ = NQAJ lagged one quarter.

NXQSUP = the total Norwegian exports of farmed Atlantic Salmon to the United States, the EEC, and Japan.

NPAU = the Norwegian price of Norwegian farmed Atlantic salmon exported to the United States, in Norwegian kroners per pound.

NPAJ = the Norwegian price of Norwegian farmed Atlantic salmon exported to the Japan, in Norwegian kroners per pound.

NPAE = the Norwegian price of Norwegian farmed Atlantic salmon exported to the EEC, in Norwegian kroners per pound.

DSEPT90 = An indicator variable that equals one beginning in the fourth quarter of 1990, and zero otherwise.

DMAR91 = An indicator variable that equals one beginning in the first quarter of 1991, and zero otherwise.

DQ_is = quarterly indicator variables for quarter i where DQ_i is 1 in quarter i and 0 elsewhere.

C = a constant.

The Norwegian allocation equations are quantity-dependent and estimated with a double-log functional form. Economic theory suggests that a quantity-dependent equation was the appropriate functional form since exports can be controlled by Norwegian exporters in order to take advantage of changes in importing countries' demand functions. The double log functional form provided a better fit than other examined functional forms, such as linear, log-linear. and linear-log.

In general, both models performed very well, exhibiting high correlation coefficients. The allocation equation to Japan had a somewhat lower probability of prior range, with slightly over 50 percent of the priors being jointly satisfied. Both "Odds" statistic were over 1.0 supporting the use of the weighted priors over the uniform prior. Neither equation exhibited autocorrelation problems. Both were corrected for quarterly heteroscedasticity.

In the Norwegian allocation equation to the United States the estimated equation indicates that Norway will allocate more salmon to the United States when the U.S. price received increases, and less when the price received from its main export market, the EEC, increases, all else remaining equal. The significance of the price coefficients suggest that some degree of market power and/or short-term arbitraging is occurring, with more salmon allocated to the markets whose prices move favorably, relative to other markets.

The elasticity of total supply was well below one, indicating that, given a one-percent increase in Norway's total exports, Norway will not increase its exports to the United States proportionally. This is not surprising since the United States has placed sizeable tariffs on imported Norwegian farm-raised Atlantic salmon. In fact, two indicator variables pick up downward shifts in exports to the United States beginning in the quarters that the original tariffs took place. In September of 1990, the U.S. placed a temporary 12 percent tariff on imports of Norwegian farmed Atlantic salmon, and in March of 1991 increased this tariff to 16 to 32 percent tariff. The negative coefficients on these two indicator variables suggest a structural decrease in salmon exports to the United States due to the tariffs.

The negative coefficient indictor variable suggests exports of Norwegian salmon to the United States are diminished during the quarter associated with the highest United States salmon landings. The long-run elasticity of total export supply reenforces the hypothesis that Norway will distribute a proportionally smaller portion of increasing supplies to the United States, all else remaining constant. Again, this is most likely due to U.S. tariffs placed on the EEC, which has led the U.S. being viewed as an unreliable trading partner.

The Norwegian allocation equation to Japan exhibits results similar to the U.S. equation. Again, exports will increase vis-a-vis the EEC price. Short-run exports to Japan will increase less than total exports. This indicates that the EEC is still the most desired market for Norwegian salmon. However, in the long-run, the total export supply suggests that there is a strong tendency among Norwegian producers toward distributing an increasing proportion of total supplies to Japan when supplies increase, all else remaining constant.

The seasonal indicator variables show a shift in the seasonal patterns of distribution. Proportionally less salmon is allocated to Japan in quarters 3 and 4 when there are substantial Japanese imports of North American salmon.

North American Demand Equations

The North American demand equation for Norwegian farmed Atlantic salmon imports was estimated as a function of own-price, a substitute price representing the North American weighted average export price of high-valued salmon, disposable personal income, a constant, quarterly indicator variables, imports of foreign-raised farmed salmon, and a one-quarter lagged dependent variable. The functional form was linear. The time period used for estimation was the first quarter of 1983 to the third quarter of 1991.

Equation 5: North American Demand of Norwegian Farmed-Raised Atlantic Salmon

Endogenous variable = $NQAUP^d$

Variable	Bayesian Coefficient	Standard Error	HYPOIG
UPAURT	-7.461	1.726	1.000
UPHXRT	4.087	1.600	0.996
UYRP	1.778	0.740	0.983
C	0.004	0.010	0.652
DQ2	-0.002	0.002	0.895
DQ3	-0.006	0.002	1.000
DQ4	-0.003	0.002	0.976
CFARMP	-0.259	0.094	0.994
$NQAUP^d_{-1}$	0.316	0.136	0.996

Correlation coefficient = 0.932

Probability of prior range = 0.971

Odds in Favor of P(B) = 1.330

Probability of positive first-order autocorrelation (ignorance) = 0.645

Het Correction = None

Sample period = 1983:1 to 1991:3

Probability [Column σ_i >= Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	0.465	0.083	0.294
σ_2	0.535	...	0.094	0.306
σ_3	0.917	0.906	...	0.812
σ_4	0.706	0.694	0.188	...

The short-run percentage change of dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

UPAURT	-1.716
UPHXRT	0.719
UYRP	1.691

The long-run percentage change of dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

UPAURT	-2.235
UPHXRT	0.937
UYRP	2.203

Variable definitions:

$NQAUP^d$ = the per capita quantity North American consumption of imported Norwegian farmed Atlantic salmon in millions of lbs.

UPAURT = the "real" price of Norwegian farmed Atlantic salmon in North America (FOB Norway), in U.S. dollars.

UPHXRT = the natural "real" weighted average export price of North American high-valued salmon (FOB North America) exported to Japan and the EEC in U.S. dollars.

UYRP = the "real" per capita United States personal disposable income in U.S. dollars.

DQ_is = quarterly indicator variables assigned the value 1 for quarter i and 0 elsewhere.

C = a constant.

CFARMP = the sum of Chilean, Canadian Pacific, and Canadian Atlantic salmon exported to the United States in millions of lbs.

$NQAUP^d_{-1}$ = a one-quarter lag for $NQAUP^d$.

In the above equation, all prices and income were divided by the U.S. producer price index for foods and feed to place monetary values in "real terms". Quantities and income are reported on a per capita basis. A partial adjustment hypothesis was incorporated into the specification because the Atlantic salmon market in the United States is still relatively new. This accounts for the inclusion of the lagged dependent variable.

The model performed well with a high correlation coefficient and probability of the prior range. The mean-level own-price elasticity of -1.761 indicates that Norwegian farmed Atlantic salmon is price elastic in the United States. This elasticity is larger than that found in Herrmann (1990). This may reflect that U.S. tariff related increases in prices lead to lower U.S. consumption of Norwegian farmed Atlantic salmon. The income elasticity of 1.691 suggests that farmed Norwegian Atlantic salmon is income superior.

The cross-price elasticity of high-valued salmon had a 99.6 percent probability of being a substitute for high-valued North American salmon, and a mean-level elasticity of 0.719. The cross-quantity elasticity of foreign-raised farm salmon (a sum of Canadian and Chilean farm exports to the United States) was negative at the 0.994 significance level. The negative coefficient of -0.259 means that a one-pound increase in imports of farm salmon from Chile or Canada displaces 0.259 pounds of imported salmon from Norway, everything else held equal. It is not surprising that the low-valued Pacific salmon substitute price was found to be insignificant since many knowledgeable U.S. industry participants do not believe that lower-valued salmon is a substitute for Norwegian farmed Atlantic salmon.

The coefficients on the seasonal indicator variables suggest that demand decreases during the heavy third-quarter Pacific fishing season. The high coefficient values are consist with those found in the Norwegian allocation equation of farmed Atlantic salmon to the United States. Please contact the authors for the discussion of the Bayesian prior distributions used in estimation.

EEC Demand Equations

The equations for the EEC demand for salmon focused on the demand for farmed Norwegian Atlantic salmon and high- and low-valued North American Pacific salmon. The demand equations were estimated as a function of own-price, substitute prices and/or quantities, private expenditures, a constant, quarterly indicator variables, and other relevant indicator variables. The EEC demand equation for farmed Norwegian Atlantic salmon has a four-quarter lagged dependent variable included to capture the partial adjustment process; and the demand for low-valued Pacific salmon has a one-quarter lagged dependent variable. The EEC demand equation for Norwegian farmed Atlantic salmon and low-valued Pacific salmon was estimated using a double-log functional form. The EEC demand for North American high-valued salmon was estimated using a linear functional form. The sample period used for estimation was from the first quarter of 1983 to the third quarter of 1991.

Equation 6: The EEC Demand of Norwegian Farmed-Raised Atlantic Salmon

Endogenous variable = $\ln(NQAEP^d)$

Variable	Bayesian Coefficient	Standard Error	HYPOIG
ln(EPAERT)	-1.283	0.207	1.000
ln(EPHERT)	0.157	0.114	0.610
ln(QSCOT12)	-0.008	0.005	0.903
ln(EYRP)	2.128	0.997	0.968
C	0.325	3.133	0.594
DISEASE	-0.139	0.077	0.964
D4T	0.029	0.012	0.990
$\ln(NQAEP^d_{-4})$	0.367	0.098	0.999

Correlation coefficient = 0.987

Probability of prior range = 0.513

Odds in Favor of P(B) = 1.736

Probability of positive first-order autocorrelation (ignorance) = 0.641

Het Correction = None

Sample period = 1983:1 to 1991:3

Probability [Column σ_i >= Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	0.899	0.668	0.244
σ_2	0.101	...	0.233	0.031
σ_3	0.332	0.767	...	0.128
σ_4	0.756	0.969	0.872	...

The short-run percentage change of dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

EPAERT	-1.283
EPHERT	0.157
EYRP	2.128

The long-run percentage change of dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

EPAERT	-2.041
EPHERT	0.248
EYRP	3.359

Equation 7: The EEC Demand for North American High-Valued Pacific Salmon

Endogenous variable = $\ln(UQHXEP^{d})$

Variable	Bayesian Coefficient	Standard Error	HYPOIG
EPHERT	-88.157	34.943	0.998
EPLERT3	112.892	52.031	0.963
EPAERT	59.719	21.968	0.976
EYRP	52.645	25.339	0.895
DQ2	0.498	0.572	0.781
DQ3	1.746	0.246	1.000
DQ4	0.847	0.205	1.000
D89	0.538	0.223	0.994
C	-7.878	1.441	0.997

Correlation coefficient = 0.942

Probability of prior range = 0.621

Odds in Favor of P(B) = 2.220

Probability of positive first-order autocorrelation (ignorance) = 0.942

Het Correction = None

Sample period = 1983:1 to 1991:3

Probability [Column σ_i > = Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	1.000	0.239	0.146
σ_2	0.000		0.000	0.000
σ_3	0.761	1.000	...	0.355
σ_4	0.854	1.000	0.634	...

The short-run percentage change of dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

ln(EPHERT)	-1.031
ln(EPLERT3)	1.052
ln(EPAERT)	1.104
ln(EYRP)	2.489

Equation 8: The EEC Demand of North American Low-Valued Pacific Salmon

Endogenous variable = $\ln(UQLXEP^d)$

Variable	Bayesian Coefficient	Standard Error	HYPOIG
ln(EPLXER)	-1.047	0.440	0.978
ln(EPHXER3)	1.245	0.448	0.993
ln(EYRP)	0.941	0.634	0.593
DQ2	-5.614	1.938	0.994
DQ3	2.195	0.279	1.000
DQ4	-0.715	0.298	0.994
C	1.469	2.950	0.474
$\ln(UQLXEP^d_{-1})$	0.623	0.147	1.000
D91	-0.511	0.292	0.934

Correlation coefficient = 0.935

Probability of prior range = 0.502

Odds in Favor of P(B) = 2.153

Probability of positive first-order autocorrelation (ignorance) = 0.107

Het Correction = Quarter 4

Sample period = 1983:1 to 1991:3

Probability [Column σ_i >= Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	0.997	0.899	0.006
σ_2	0.003		0.080	0.000
σ_3	0.092	0.926	...	0.000
σ_4	0.992	1.000	1.000	...

The short-run percentage change of dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

ln(EPLXER)	-1.047
ln(EPHXER3)	1.245
ln(EYRP)	0.941

The long-run percentage change of dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

ln(EPLXER)	-2.777
ln(EPHXER3)	3.302
ln(EYRP)	2.496

Variable definitions:

$NQAEP^d$ = the per capita quantity of imported Norwegian farmed Atlantic salmon (FOB Norway) in the EEC, in millions of lbs.

$UQHXEP^d$ = the per capita quantity of North American high-valued salmon imported in the EEC, in millions of lbs.

$UQLXEP^d$ = the per capita quantity of North American low-valued salmon imported in the EEC in millions of lbs.

EPAERT = the "real" price of Norwegian farmed Atlantic salmon in the EEC (FOB Norway), in ECUs per pound.

EPLERT3 = the "real" price of North American low-valued Pacific salmon in the EEC in quarters 1, 3, and 4 (FOB North America), in ECUs per pound, and zero elsewhere.

EPLERT = the "real" price of North American low-valued Pacific salmon in the EEC (FOB North America), in ECUs per pound.

EPHERT = the "real" price of North American high-valued Pacific salmon in the EEC (FOB North America), in ECUs per pound.

EPHERT3 = the "real" price of North American high-valued Pacific salmon in the EEC in quarters 1, 2, and 4 (FOB North America), in ECUs per pound, and zeros elsewhere.

QSCOT12 = the estimated amount of the quantity of Scottish and Irish farmed Atlantic salmon remaining in the EEC countries in millions of lbs.

EYRP = the "real" per capita private consumption expenditure in the EEC in millions of lbs.

$UQLXE^d_{-1}$ = $UQLXE^d$ lagged one quarter.

$NQAEP^d_{-4}$ = $NQAEP^d$ lagged four quarters.

D4T = an indicator variable which is assigned a value of 1 for quarter four and is multiplied by a time variable which starts at 1 for 1981 and ends at 11 for 1991, and is assigned a value of 0 elsewhere.

DISEASE = an indicator variable assigned a value of 1 for the last two quarters of 1986 and the first two quarters of 1987 and a value of 0 elsewhere.

D89 = an indicator variable which is assigned a value of 0 between 1983 and 1988, and a value of 1 in 1989.

D91 = an indicator variable which is assigned a value of 0 between 1983 and 1990 and a value of 1 in 1991.

DQ_is = quarterly indicator variables for quarter i where DQ_i is 1 in quarter i and 0 elsewhere.

C = a constant.

"Real" prices are prices that have been divided by the EEC's consumer price index (ECPI) and net of tariffs. ECPI is included to impose homogeneity on the demand equations. The Atlantic salmon equation performed fairly well with a correlation coefficient of 0.987, but a probability of prior range only slightly above 0.5. This latter feature is probably due to a low probability of high-valued salmon being a substitute for Atlantic salmon.

In the Atlantic salmon equation, the own-price elasticity indicates demand is slightly elastic. The income elasticity is over 2.0. These elasticities are both below the ones found in Herrmann (1990), possibly reflecting increased supplies and lower prices of world salmon in recent years.

High-valued Pacific salmon was found to be a substitute for Atlantic salmon at a posterior probability of 0.610. This probability of substitution is also lower than found in Herrmann (1990), and may reflect increased dominance of Norwegian, Scottish, and Irish farm-raised salmon in the EEC over U.S. exports of high-valued wild salmon (primarily chinook). Low-valued salmon was not found to be a substitute for Atlantic salmon. This is consistent with *a priori* expectations.

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 greater quantities of smaller salmon were placed on the market. Because of the Hitra disease problem in Norway in late 1986 and 1987, many small salmon were sold quickly. The quality and availability differences resulted in a structural change in the market, since smaller salmon generally receive lower prices than larger salmon. Perceived quality changes due to Norwegian disease problems may have contributed to market shifts. Additionally, European buyers may have perceived that increased supplies provided them with greater bargaining strength.

Another exogenous variable was D4T which represents a positive time-varying shift in the demand for farm-raised Norwegian salmon imports in the fourth quarter. The fourth quarter is a time of increased demand in the EEC for salmon imports because of the holiday season. Over time, D4T indicates that there has been structurally an outward shift in the demand for Norwegian farm-raised Atlantic salmon during the holiday season.

In the EEC demand equation for high-valued Pacific salmon, the correlation coefficient was 0.942 with 62 percent of the bootstrapped iterations jointly satisfying all constraints. The own-price elasticity of North American high-valued salmon imports differed only slightly from 1.0. This is well below the -1.883 own-price elasticity found in Herrmann (1990). This provides one more indication that the effect of rapidly increasing worldwide supply of salmon has been to decreased demand for U.S. salmon.

The reported income elasticity remains high, and is almost identical to the previous study.

Atlantic salmon was found to be a significant substitute for North America low-valued salmon (probability of 97.6 percent). Additionally, low-valued Pacific salmon was found to be a substitute in quarters 1, 3 and 4 (probability of 96.3 percent). That low-valued salmon was not found to be a substitute in quarter 2 may be due to only high-quality low-valued salmon being considered a substitute for the higher quality high-valued salmon. In quarters 3 and 4 (and to a lesser extent in quarter 1), low-valued salmon can be fresh or frozen and, therefore, considered a higher quality product.

Similar to the other two equations, the equation representing the EEC demand for imports of North-American imports of low-valued salmon exhibits a high correlation coefficient but a lower probability of prior range. Similar to the 1990 study, the own-price elasticity for low-valued Pacific salmon imports into the EEC exhibit an own-price elasticity close to 1.0. Surprisingly, this elasticity is almost identical to the own-price elasticity for high-valued salmon. This might be explained by the proliferation of Atlantic salmon consumption in the EEC directly impacting the demand for high-valued Pacific salmon imports through competition but only indirectly effecting the demand for low-valued Pacific salmon. This may have shifted the demand for high-valued salmon inward sufficiently such that it is no more profitable (in terms of marginal revenue) than low-valued salmon as an export commodity to the EEC. In fact, low-valued salmon exhibits a long-run elasticity that exceeds the own-price elasticity of high-valued salmon. However, examining the income elasticity, it is clear that an increase in income will expand the demand for high-valued Pacific salmon imports far more than it will low-valued Pacific salmon imports.

The negative value of the 1991 indictor variable suggests that the entire price decline of 1991 could not be captured through the other included variables. In other words, there was a structural break in quantity imported that was not captured through price or income changes.

Japanese Demand Equations

The Japanese demand for salmon was estimated as a function of its own-price, substitute prices, private expenditure, inventories, a constant, quarterly indicator variables, and Japanese landings. In addition, the Japanese demand for Norwegian farmed Atlantic salmon has a four-quarter lagged quantity to capture a partial adjustment process. The equations were estimated using a double-log functional form. The sample period for estimation was from the first quarter of 1983 to the third quarter of 1991.

Equation 9: Japanese Demand for Norwegian Farm-Raised Atlantic Salmon

Endogenous variable = $\ln(NQAJP^{d})$

Variable	Bayesian Coefficient	Standard Error	HYPOIG
ln(JPAJRT)	-2.537	0.516	1.000
ln(JPHJRT)	1.260	0.423	0.996
ln(JYRP)	2.002	1.245	0.532
C	-2.014	1.345	0.464
DQ2	0.016	0.199	0.680
DQ3	-0.288	0.338	0.481
DQ4	-0.640	0.363	0.403
$\ln(NQAJP^{d}_{-4})$	0.511	0.732	1.000

Correlation coefficient = 0.950

Probability of prior range = 0.448

Odds in Favor of P(B) = 1.367

Probability of positive first-order autocorrelation (ignorance) = 0.148

Het Correction = Quarter 1 and 3

Sample period = 1983:1 to 1991:3

Probability [Column σ_i >= Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	0.007	0.993	0.007
σ_2	0.993	...	1.000	0.433
σ_3	0.007	0.000	...	0.000
σ_4	0.993	0.567	1.000	...

The short-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

JPAJRT	-2.537
JPHXJR	1.260
JYRP	2.002

The long-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

JPAJRT	-5.188
JPHXJR	2.577
JYRP	4.094

Equation 10: Japanese Demand for North American High-Valued Pacific Salmon

Endogenous variable = $\ln(UQHXJP^d)$

Variable	Bayesian Coefficient	Standard Error	HYPOIG
ln(JPHJRT)	-1.252	0.363	0.999
$\ln(JINVZP_{-1})$	-0.626	0.257	0.980
ln(JYRP)	3.574	0.652	1.000
ln(PTUNAR)	1.188	0.395	0.994
C	-7.930	0.900	1.000
DQ3	2.036	0.251	1.000

Correlation coefficient = 0.968

Probability of prior range = 0.975

Odds in Favor of P(B) = 1.317

Probability of positive first-order autocorrelation (ignorance) = 0.751

Het Correction = Quarter 3 and 4

Sample period = 1983:1 to 1991:3

Probability [Column σ_i >= Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	0.316	0.000	0.002
σ_2	0.684	...	0.000	0.006
σ_3	1.000	1.000	...	0.963
σ_4	0.998	0.994	0.037	...

The short-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

JPHXJR	-1.252
$JINVZEP_{-1}$	-0.626
JYRP	3.574
FPFR	1.188

Equation 11: Japanese Demand for North American Low-Valued Pacific Salmon

Endogenous variable = $\ln(UQLXJP^d)$

Variable	Bayesian Coefficient	Standard Error	HYPOIG
ln(JPLJRT)	-0.827	0.277	0.995
$\ln(JINVTP_{-1})$	-0.639	0.332	0.948
ln(PSQUIDR)	0.369	0.191	0.879
ln(JYRP)	1.516	1.057	0.490
C	-4.026	1.467	0.745
DQ1	-0.417	0.316	0.910
DQ2	-1.574	0.332	1.000
DQ3	-0.469	0.346	0.913
D22	0.724	0.292	0.993

Correlation coefficient = 0.919

Probability of prior range = 0.425

Odds in Favor of P(B) = 22.831

Probability of positive first-order autocorrelation (ignorance) = 0.930

Het Correction = Quarter 1

Sample period = 1983:1 to 1991:3

Probability [Column $\sigma_i >= $ Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	0.998	0.054	0.024
σ_2	0.002	...	0.000	0.006
σ_3	0.946	1.000	...	0.335
σ_4	0.976	1.000	0.665	...

The short-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

JPLXJR	-0.827
$JINVTEP_{-1}$	-0.639
PSQUIDR	0.369
JYRP	1.516

Variable definitions:

$JINVZP_{-1}$ = the Japanese per capita beginning inventories of frozen salmon, in millions of lbs.

$JINVTP_{-1}$ = the Japanese per capita beginning inventories of frozen salmon and salted salmon, in millions of lbs.

JPAJRT = the "real" price of Norwegian farmed Atlantic salmon in Japan (FOB Norway), measured in Japanese yen per pound.

JPHJRT = the "real" price of North American high-valued Pacific salmon in Japan (FOB North America), measured in Japanese yen per pound.

JPLJRT = the "real" price of North American low-valued Pacific salmon in Japan (FOB North America), measured in yen per pound.

$NQAJP^d$ = the per capita quantity of imported Norwegian farmed Atlantic salmon (FOB Norway) in Japan, in millions of lbs.

$NQAJP^d_{-4}$ = NQAJP lagged four periods.

$UQHXJP^d$ = the per capita quantity of North American high-valued salmon imported in Japan, in millions of lbs.

$UQLXJP^d$ = the per capita quantity of North American low-valued salmon imported in Japan, in millions of lbs.

PTUNAR = the weighted average "real" price of a "high-valued" substitute fish consisting of fresh tuna, measured in yens per pound.

PSQUIDR = the weighted average "real" price of a "lower-valued" substitute fish consisting of fresh squid, measured in yens per pound

JYRP = the "real" per capita food consumption expenditure in Japan in billions of lbs.

D22 = an indicator variable which is assigned a value of 1 in the second quarter of 1986 and zero elsewhere.

DQ_is = quarterly indicator variables for quarter i where DQ_i is 1 in quarter i and 0 elsewhere.

C = a constant.

All imported salmon prices are multiplied by the tariff rate and then divided by the Japanese CPI. All domestic prices as well as private expenditure are divided by the Japanese CPI. All quantities and incomes are divided by Japanese population.

In the Japanese demand for Norwegian farm-raised Atlantic salmon, the correlation was high at 0.912, although the probability that the prior restrictions were jointly satisfied was a somewhat low 0.448. This was mainly due to the positive prior sign constraint on the income variable being satisfied in only 53.2 percent of the bootstrapped iterations.

The coefficients for Norwegian farmed salmon in Japan show high own-price and income elasticities of -2.537 and 2.002, respectively. High-valued salmon was found to be a substitute with a 99.6 percent probability. Low-valued salmon was not found to be a substitute for the high-priced Atlantic salmon. The long-run elasticities are twice that of the short-run elasticities. This seems to indicate that it may be very profitable for the Norwegians to continue penetration of the Japanese market, especially if the Japanese economy remains healthy.

The Japanese demand equation for high-valued salmon had a high correlation coefficient of 0.968. In addition, 97.5 percent of the bootstrapped iterations jointly satisfied the Bayesian constraints. The demand for high-valued salmon only includes an indicator variable for the third quarter, when nearly all the imports occur.

The own-price elasticity in the Japanese demand for North American high-valued salmon imports was slightly elastic at -1.252. The income elasticity was very high at 3.574. The own-price elasticity was, again, far lower than the -3.019 elasticity found in the 1990 study. This indicates that even in Japan, exports of high-valued salmon may be close to reaching the saturation point if demand is not expanded, all else remaining constant. The high income elasticity suggests that salmon exports to Japan are highly sensitive to the state of the Japanese economy.

The demand equation 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 indicates an asymmetric relationship regarding substitution. This is not surprising since, during the time period modelled, Atlantic salmon shipments to Japan were only a fraction of the high-valued Pacific salmon exports . Therefore, a price change in the Atlantic salmon would not significantly impact 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. 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 best salmon in the world and vastly superior to chum and pink salmon.

Frozen inventories of Japanese salmon were significant, as expected. A one-percent increase in the Japanese inventories of frozen salmon will decrease imports of North American high-values salmon by 0.62 percent. Beginning Japanese frozen inventories in the high-valued salmon equation included all salmon species except pink salmon. Inventories are not broken out by species in Japanese data, other than having inventories including and excluding pink salmon.

An additional substitute good, named "PTUNAR", was used in the Japanese demand for high-valued salmon. Wholesale tuna prices are generally similar to high-valued wholesale salmon prices. The tuna price can be seen as a proxy to similarly priced fish in Japan.

Similar to the Japanese demand equation for Norwegian farmed Atlantic salmon, the demand equation for low-valued North American salmon exhibited a high correlation coefficient (0.919) but a moderate probability of prior range of 0.425. This again reflected a low HYPOIG for income of 0.490.

There is indication that the own-price is inelastic for low-valued Pacific salmon (-0.827). This result was expected since low-valued salmon is priced at the lower end of the fish market in Japan and is plentiful because of large Japanese chum salmon harvest. Most of this salmon goes to the low quality segment of the salted salmon market. Therefore, the market is likely to be inelastic. The income elasticity was 1.516 which indicates some demand sensitivity to the Japanese economy, although not as much as high-valued salmon or Atlantic salmon.

The substitute price of a more similar valued substitute fish (squid) was used to proxy low-valued salmon substitute goods. In the low-valued Pacific salmon demand equations, other salmon species were not found to be significant substitutes for low-valued salmon. A one percent increase in the total inventory of Japanese salmon displaces 0.639 percent of North American low-valued salmon imports. This is nearly identical to the effect of inventory on high-valued salmon imports. D22 was used to account for an apparent outlier in the data.

Japanese Inventory Equations

The Japanese inventory equations for Pacific salmon were estimated as a function of Japanese import own-price of salmon, the lagged import price, a constant and quarterly indicator variables, other indicator variables, beginning inventory levels, and import quantities. In addition, for the Japanese frozen inventory equation, the Japanese discount rate was used to proxy the cost of storing salmon. Data was used from the first quarter of 1983 to the third quarter of 1991.

Equation 12: The Japanese Inventory of Frozen Salmon

Endogenous variable = ln(JINVZ^{d})

Variable	Bayesian Coefficient	Standard Error	HYPOIG
ln(JPHXJ)	-0.713	0.358	0.954
ln(UQHXJ)	0.209	0.093	0.973
ln(JINVZ$_{-1}$)	0.648	0.173	1.000
ln(JPHXJT$_{-1}$)	0.704	0.297	0.989
C	1.280	2.537	0.613
DQ1	-0.179	0.123	0.091
DQ2	-0.428	0.133	0.997
DQ3	0.313	0.317	0.859
ln(JINT)	-0.122	0.075	0.834

Correlation coefficient = 0.943

Probability of prior range = 0.790

Probability of positive first-order autocorrelation (ignorance) = 0.833

Het Correction = Quarter 1 and 4

Sample period = 1983:1 to 1991:3

Probability [Column σ_i >= Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	0.957	0.996	0.027
σ_2	0.043	...	0.814	0.000
σ_3	0.004	0.186	...	0.000
σ_4	0.973	1.000	1.000	...

The short-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

JPHXJ	-0.713
UQHXJ	0.209
JPHXJ$_{-1}$	0.704
JINT	-0.122

The long-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

JPHXJ	-2.026
UQHXJ	0.594
$JPHXJ_{-1}$	2.000
JINT	-0.347

Equation 13: The Japanese Inventory of Frozen and Salted Salmon

Endogenous variable = $\ln(JINVT^{d})$

Variable	Bayesian Coefficient	Standard Error	HYPOIG
ln(JPLXJT)	-0.210	0.134	0.920
ln(JTSUPL)	0.676	0.185	1.000
$\ln(JPHXJT_{-1})$	0.381	0.194	0.949
C	0.131	1.987	0.474
DQ2	-0.060	0.098	0.678
DQ3	0.519	0.076	1.000
DQ4	-0.132	0.156	0.830
D2728	-0.187	0.076	0.993

Correlation coefficient = 0.931

Probability of prior range = 0.790

Probability of positive first-order autocorrelation (ignorance) = 0.958

Het Correction = Quarter 4

Sample period = 1983:1 to 1991:3

Probability [Column σ_i >= Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	0.825	0.982	0.023
σ_2	0.175	...	0.861	0.002
σ_3	0.018	0.139	...	0.000
σ_4	0.977	0.998	1.000	...

The short-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

JPLXJ	-0.210
JTSUP	0.676
$JPHXJ_{-1}$	0.381

UQHXJ = the quantity of North American high-valued salmon imported in Japan in millions of lbs.

JINVZ = Japanese ending inventories of frozen salmon in millions of lbs.

$JINVZEP_{-1}$ = Japanese beginning inventories of frozen salmon in millions of lbs.

JINVT = the Japanese ending inventories of frozen salmon and salted salmon in millions of lbs.

JTSUPL = the summation of U.S. exports of low-valued Pacific salmon to Japan, the beginning inventories of the total frozen and salted salmon in Japan, and the landings of salmon in Japan in millions of lbs.

JPHXJT = the price of North American high-valued Pacific salmon in Japan (FOB North America), measured in yens per pound.

$JPHXJT_{-1}$ = JPHXJT lagged one quarter.

JPLXJT = the price of North American low-valued Pacific salmon in Japan (FOB North America), measured in yens per pound.

JINT = the Japanese discount rate.

D2728 = an indicator variable which is assigned a value of 1 in the last two quarters of 1987 and zero elsewhere.

DQ_is = quarterly indicator variables for quarter i where DQ_i is 1 in quarter i and 0 elsewhere.

C = the constant.

The inventory equations incorporate the notion of partial adjustment and price expectations. A complete theory of how the above specifications were formed can be found in Herrmann (1990). The theory involved a partial adjustment process and both a speculative motive and a transactions motive where a buffer is formed to alleviate the risk of running short on salmon supplies.

In summary, we would expect, as the current import price increases, that less inventory would be held and more released onto the market. As the lagged export price increases (which proxies the future expectation of the price level) we would expect more salmon to be held in inventory as a speculative maneuver. The ending inventory levels are also some function of the beginning levels in the theory of partial adjustment. The ending inventory levels are also a function of stocks on hand which is from the buffer theory of inventory motivation. Finally, the interest rate partially captures the cost of storing salmon reflecting its negative coefficient.

Both ending Japanese inventory equations performed well, with correlation coefficients greater than 0.90, and the Bayesian prior restrictions jointly holding 79 percent of the time. Neither equation exhibited autocorrelation problems. Both equations were also estimated using the double-log functional form.

In the Japanese ending inventory levels for frozen salmon, the Japanese discount rate was significant at the 83.4 percent level, although the effect was relatively minor. The elasticity indicates that a one-percent increase in the Japanese discount rate will decrease the Japanese inventory holdings of frozen salmon by 0.122 percent. The elasticity with respect to the import price suggests that when the import price of high-valued salmon increases by one-percent, the ending Japanese inventories will decrease by 0.713 percent.

The ending frozen inventories cf Japanese salmon is included in the right-hand-side equation as higher levels of inventory reduces the demand for imported high-valued salmon, and vice versa. This variable is not exact because it includes frozen chum salmon (chum salmon could not be separated out). For the imported low-valued salmon equation it was necessary to include inventory levels of salted salmon (a large portion of which is inventory levels of domestic chum landings) and frozen salmon. Because of the way the raw data is aggregated, the ending inventory variable of total salmon that was used in the Japanese demand equation for low-valued salmon will also include inventory levels of high-valued salmon.

The total available supply of Japanese salmon includes imports of North American low-valued salmon, beginning inventories, and Japanese landings of salmon. When the sum of these items increases by one-percent the total Japanese ending inventories of frozen and salted salmon increased by 0.676 percent. When the current import price of low-valued salmon increases by 1 percent, the inventory levels decrease by 0.21 percent.

The lagged high-valued import salmon price was used in place of the lagged low-valued import price because of estimation considerations. The equation performance was enhanced by this specification. There may be a satisfactory theoretical explanation if, in some sense, the low-valued salmon prices follow the high-valued price in Japan (which are dominated by sockeye salmon). In this case the previous year sockeye prices may be an indication of the future direction of all imported salmon prices. Also, the total inventory of all salmon includes high-valued salmon.

The seasonal indicator variables (for both equations) reflect that the North American fishing season, and subsequent export season, is strongest in the third quarter. Finally, the indicator variable (D2728) marks the last two quarters of 1988. This variable is negative indicating a downward structural shift in demand during these two quarters following the incredible Japanese purchasing frenzy of salmon during 1988.

North American Allocation Equations of High-Valued Salmon

The North American allocation of high-valued salmon was estimated in two parts. First, the total exports of North American high-valued salmon to the EEC and Japan was estimated as a function of its weighted average export price, the total available supply (landings plus beginning inventories), and seasonal indicator variables. Then the EEC export price was estimated as a function of the Japanese export prices, seasonal indicator variables, an indicator variable for 1989, and a one-quarter lagged dependent variable. The functional form used was linear and the estimation time period was from the first quarter of 1983 to the fourth quarter of 1990.

Equation 14 The North American Exports of High-Valued Salmon

Endogenous variable = $UQHX^S$

Variable	Bayesian Coefficient	Standard Error	HYPOIG
UPHX	3.067	1.651	0.931
UHSUP	0.345	0.057	1.000
C	-6.468	5.102	0.847
DQ2	-18.308	3.862	1.000
DQ3	44.102	18.331	0.994
DQ4	4.906	3.188	0.953

Correlation coefficient = 0.994

Probability of prior range = 0.931

Probability of positive first-order autocorrelation (ignorance) = 0.496

Het Correction = Quarter 3

Sample period = 1983:1 to 1990:4

Probability [Column σ_i >= Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	0.828	1.000	0.974
σ_2	0.172	...	1.000	0.874
σ_3	0.000	0.000	...	0.000
σ_4	0.026	0.126	1.000	...

The short-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

UPHX	0.14
UHSUP	0.83

Equation 15: High-Valued Salmon Price Mapping Equation

Endogenous variable = $UPHXE^S$

Variable	Bayesian Coefficient	Standard Error	HYPOIG
UPHXJ	0.528	0.113	1.000
C	0.112	0.242	0.727
DQ2	0.152	0.134	0.867
DQ3	0.189	0.108	0.945
DQ4	0.369	0.118	0.997
D89	-0.615	0.146	1.000
$UPHXE^S_{-1}$	0.359	0.134	0.998

Correlation coefficient = 0.[illegible]11

Probability of prior range = 0.998

Probability of positive first-order autocorrelation (ignorance) = 0.590

Het Correction = Quarters 1 and 2

Sample period = 1983:1 to 1990:4

Probability [Column σ_i >= Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	1.000	0.924	0.992
σ_2	0.000	...	0.019	0.130
σ_3	0.075	0.981	...	0.805
σ_4	0.998	0.870	0.195	...

The short-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

UPHXJ	0.54

The long-run percentage change of dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

UPHXJ	0.84

Variable definitions:

UHSUP = the North American total available supply of high-valued salmon (beginning inventories plus landings) in millions of lbs.

UQHX = the total North American quantity of high-valued salmon exports to Japan and the EEC in millions of lbs.

UPHX = the North American weighted average export price of high-valued salmon (FOB North America) exported to the EEC and Japan, measured in U.S. dollars per pound.

UPHXJ = the price of North American high-valued Pacific salmon exported to Japan (FOB North America), measured in U.S. dollars per pound.

UPHXE = the price of North American high-valued Pacific salmon exported to the EEC (FOB North America), measured in U.S. dollars per pound.

DQ_is = quarterly indicator variables for quarter i where DQ_i is 1 in quarter i and 0 elsewhere.

C = a constant.

The allocation equations were based on supply theory. It was assumed that the export price to the EEC and Japan differs only because of momentum and seasonal adjustments. Both equations performed very well, with correlation coefficients and the probability of the prior range exceeding 0.90, and the autocorrelation coefficients close to 0.50.

The North American wholesale market is not explicitly modelled because of data limitations. Data on wholesale prices for use in the context of this model were unavailable, and domestically derived wholesale quantities from utilization tables were often nonsensical (negative-valued).

In the equation for total North American high-valued salmon exports the exports rise. This is consistent with the theory of supply. Producers are willing to export more salmon as the price received for the salmon increases. Similarly, as total available supply increases exports will increase. The indicator variables reflect the highly seasonal nature of exports, which are mainly in the third quarter.

The price mapping equation links the EEC high-valued salmon price with that of Japan. A break occurred in 1989 when the Japanese price increased via the EEC prices, ceteris paribus. The lagged EEC price indicates that there is some systematic pattern in the drifting spread between the two prices.

North American Allocation Equations of Low-Valued Salmon

The North American allocation of low-valued salmon was also estimated in two parts. The estimation was slightly different than that for the high-valued salmon allocation equations. First, the total exports of North American low-valued salmon to the EEC were estimated as a function of the price received from the EEC, the total available supply (landings plus beginning inventories), and seasonal indicator variables. Then the Japanese export price was estimated as a function of the EEC export price, seasonal indicator variables, an indicator variable for 1989, and a one-quarter lagged dependent variable. The functional form used was linear, and the estimation time period was from the first quarter of 1983 to the fourth quarter of 1990. In effect, this specification works the same as the specification for the allocation of high-valued salmon but this form was more easily estimated.

Equation 16: The North American Allocation of Low-Valued Salmon to the EEC

Endogenous variable = $UQLXE^{S}$

Variable	Bayesian Coefficient	Standard Error	HYPOIG
UPLXE	4.290	2.275	0.932
ULSUP	0.123	0.043	0.996
C	-6.248	4.282	0.887
DQ2	-0.823	1.906	0.683
DQ3	-10.925	16.357	0.743
DQ4	-2.719	2.440	0.851

Correlation coefficient = 0.880

Probability of prior range = 0.929

Probability of positive first-order autocorrelation (ignorance) = 0.381

Het Correction = Quarter 3

Sample period = 1983:1 to 1990:4

Probability [Column σ_i >= Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	0.161	1.000	0.520
σ_2	0.839	...	1.000	0.864
σ_3	0.000	0.000	...	0.000
σ_4	0.480	0.136	1.000	...

The short-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

UPLXE	0.47
ULSUP	1.36

Equation 17 Low-Valued Salmon Price Mapping Equation

Endogenous variable = UPLXJ

Variable	Bayesian Coefficient	Standard Error	HYPOIG
UPLXE	0.421	0.099	1.000
C	-0.285	0.097	0.999
DQ2	0.001	0.051	0.515
DQ3	0.192	0.048	1.000
DQ4	0.029	0.049	0.723
D89	-0.129	0.053	0.994
$UPLXJ_{-1}$	0.761	0.088	1.000

Correlation coefficient = 0.955

Probability of prior range = 0.988

Probability of positive first-order autocorrelation (ignorance) = 0.131

Het Correction = Quarters 1 and 3

Sample period = 1983:1 to 1990:4

Probability [Column σ_i >= Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	1.000	0.642	1.000
σ_2	0.000	...	0.000	0.497
σ_3	0.358	1.000	...	1.000
σ_4	0.000	0.503	0.000	...

The short-run percentage change of dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

UPLXE	0.41

Variable definitions:

ULSUP = the North American total available supply of low-valued salmon (beginning inventories plus landings)

UPLXE = the North American export price of low-valued salmon exported to the EEC in U.S. dollars.

UPLXJ = the North American export price of low-valued salmon exported to Japan.

$UPLXJ_{-1}$ = UPLXJ lagged one quarter

$UQLXE^S$ = the quantity of North American low-valued salmon exported in the EEC

D89 = an indicator variable which is assigned a value of 0 between 1983 and 1988 and a value of 1 in 1989

DQ_is = quarterly indicator variables for quarter i where DQ_i is 1 in quarter i and 0 elsewhere

C = the constant

The allocation equations were also based on the theory of supply, and utilized one export price. The export price to the EEC and Japan are correlated to some degree, and it was assumed that price differences are a result of momentum and seasonal adjustments. Both equation performed very well with correlation coefficients and the probability of the prior range exceeding 0.88. No evidence of an autocorrelation problem was present.

Again, the North American wholesale market is not explicitly modelled because of data limitations Data on wholesale prices for use in the context of this model were unavailable, and domestically derived wholesale quantities from utilization tables were often nonsensical.

In the equation for total North American low-valued salmon exports to the EEC, the exports rise as the EEC [illegible]. Similarly, as total available supply increases exports will increase [illegible]

The price mapping e[illegible]he Japanese low-valued salmon price with that of Japan. As with North [illegible]igh-valued salmon allocations, a break occurred in 1989 when the EEC price increased relative to the Japanese price, ceteris paribus. This is opposite to the affect found in the high-valued equations. The lagged Japanese price also indicates that there is some systematic drifting pattern between the two prices.

North American Inventory Equations

The North American inventory equations for Pacific salmon were estimated as a function of North American weighted average export price of Pacific salmon, the total available supply of Pacific salmon, beginning inventories of Pacific salmon, a constant, quarterly indicator variables, a one-quarter lag of the North American weighted average export price of Pacific salmon, and an indicator variable assigned the value of 1 in 1987. The equations were estimated using a double-log functional form. The estimation time period was from the first quarter of 1983 to the fourth quarter of 1990. The specification of the equations are identical to the ones found in Herrmann (1990) and explained more fully in the Japanese inventory section.

Equation 18: North American High-Valued Salmon Inventory

Endogenous variable = ln (UHINV)

Variable	Bayesian Coefficient	Standard Error	HYPOIG
ln(UPHX)	-0.463	0.244	0.909
ln(UHSUP)	0.731	0.154	1.000
ln($UHINV_{-1}$)	0.337	0.115	1.000
C	-1.292	0.594	0.991
DQ2	-0.945	0.221	1.000
DQ3	0.118	0.476	0.598
DQ4	0.392	0.138	0.994
$UPHX_{-1}$	0.611	0.226	0.972
D87	-0.260	0.112	0.991

Correlation coefficient = 0.973

Probability of prior range = 0.773

Odds in Favor of P(B) = 1.372

Probability of positive first-order autocorrelation (ignorance) = 0.590

Het Correction = Quarter 3

Sample period = 1983:1 to 1990:4

Probability [Column σ_i >= Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	0.369	0.810	0.083
σ_2	0.632	...	0.876	0.163
σ_3	0.190	0.124	...	0.011
σ_4	0.918	0.837	0.989	...

The short-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

UPHX	-0.463
UHSUP	0.731

The long-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

UPHX	-1.315
UHSUP	2.077

Equa[illegible]merican Low-Valued Salmon Inv[illegible]

Endog[illegible] ln(ULINV)

fts Variable	Bayesian Coefficient	Standard Error	HYPOIG
ln(UPLX)	-0.673	0.296	0.962
ln(ULSUP)	0.573	0.111	1.000
ln($ULINV_{-1}$)	0.364	0.121	0.999
C	-0.419	0.470	0.800
DQ2	-0.571	0.119	1.000
DQ3	0.015	0.406	0.505
DQ4	0.472	0.119	0.999
$UPLX_{-1}$	0.541	0.245	0.943
D87	-0.186	0.079	0.991

Correlation coefficient = 0.979

Probability of prior range = 0.834

Odds in Favor of P(B) = 1.372

Probability of positive first-order autocorrelation (ignorance) = 0.282

Het Correction = Quarters 1 and 4

Sample period = 1983:1 to 1990:4

Probability [Column σ_i > = Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	1.000	1.000	0.250
σ_2	0.000	...	0.452	0.000
σ_3	0.000	0.548	...	0.0000
σ_4	0.750	1.000	1.000	...

The short-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

UPLX	-1.058
ULSUP	0.901

The long-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

UPLX	-1.315
ULSUP	2.077

Variable definitions:

UHINV = the ending inventory of North American high-valued salmon in millions of lbs.

ULINV = the ending inventory of North American low-valued salmon in millions of lbs.

$UHINV_{-1}$ = UHINV lagged one quarter.

$ULINV_{-1}$ = ULINV lagged one quarter.

UPHX = the North American weighted average export price of high-valued salmon (FOB North America) exported to the EEC and Japan, measured in U.S. dollars

$UPHX_{-1}$ = UPHX lagged one quarter.

UPLX = the North American weighted average export price of low-valued salmon (FOB North America) exported to the EEC and Japan, measured in U.S. dollars.

D87 = an indicator variable which is assigned a value of 1 in 1987 and zero elsewhere.

UHSUP = the North American total available supply of high-valued salmon (beginning inventories plus landings) in millions of lbs.

ULSUP = the North American total available supply of low-valued salmon (beginning inventories plus landings) in millions of lbs.

DQ_is = quarterly indicator variables for quarter i where DQ_i is 1 in quarter i and 0 elsewhere.

C = a constant.

The models performed well with high correlation coefficients and moderate to high probabilities of prior ranges. Both equations indicate that the holdings of North American inventories decrease when the current weighted average export price increases (used as a proxy for U.S. wholesale prices), and increases when the expectations of future wholesale price, (as proxied by the lagged weighted average export price) and beginning available supplies increase. Momentum (or friction), as stated in the partial adjustment theory, is incorporated in the equations through the beginning inventory variable. High-valued salmon was less responsive to prices and more responsive to the proportion held back from total supply than low-valued salmon. This indicates that processors have a more conservative attitude toward buffer stocks when dealing with the higher-priced product.

The indicator variables reflect the large buildup of inventory in the fourth quarter after the heavy third quarter fishing season. Besides quarterly indicator variables, the only other exogenous variable 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 Alaska catch which was under 100 million salmon for the first time in 8 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.

Can Salmon Equations

The can salmon equations are presented below as a group. They include the "world" demand for low-valued canned salmon (the EEC, Australia, and New Zealand), the North American allocation of low-valued canned salmon, the North American inventory level of low-valued canned salmon, and an equation proxying the high-valued canned salmon prices. All equations are estimated in the linear form. The demand and price mapping equations used data from the first quarter of 1983 to the third quarter of 1991. The other two equations incorporate data through the fourth quarter of 1990.

The demand for low-valued canned salmon is modelled as a function of its own-price, a substitute price, income, quarterly indicator variables, and an indicator variable marking 1986, and the lagged dependent variable. The allocation of low-valued salmon was estimated as a function of the export price, the total available supply, quarterly indicator variables, an indicator variable marking 1986, and the lagged dependent variable.

The inventory equation was based on the same theory as the frozen inventory equations, with an added indicator variable for 1986. Finally, the high-valued export canned salmon price was proxied as a function of the high-valued export fresh/frozen price, quarterly indicator variables, an indicator variable marking 1989, and the lagged dependent variable.

Equation 20: The Import Demand for Canned North American Low-Valued Pacific Salmon

Endogenous variable = $UQLXAC^d$

Variable	Bayesian Coefficient	Standard Error	HYPOIG
APLACR	-0.882	0.398	0.946
APHACR	0.555	0.322	0.789
EYRP	0.479	0.304	0.704
C	0.003	0.018	0.766
DQ2	-0.014	0.003	1.000
DQ3	-0.016	0.003	1.000
DQ4	0.013	0.004	0.994
D86	0.017	0.004	1.000
$UQLXAC^d_{-1}$	0.196	0.115	0.903

Correlation coefficient = 0.922

Probability of prior range = 0.518

Probability of positive first-order autocorrelation (ignorance) = 0.166

Het Correction = Quarters 2 and 3

Sample period = 1983:1 to 1991:3

Probability [Column σ_i >= Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	0.004	0.002	0.502
σ_2	0.996	...	0.366	0.996
σ_3	0.998	0.635	...	0.999
σ_4	0.498	0.004	0.001	...

The short-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

APLACRT	-0.423
APHACRT	0.398
EYRP	0.832

The long-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

APLACRT	-0.527
APHACRT	0.496
EYRP	1.034

Equation 21: North American Allocation of Low-Valued Canned Salmon

Endogenous variable = $UQLXAC^S$

Variable	Bayesian Coefficient	Standard Error	HYPOIG
UPLXC	1.013	0.559	0.866
ULSUPC	0.012	0.007	0.869
C	-0.774	2.065	0.528
DQ3	-5.833	2.300	0.957
DQ4	6.465	1.542	1.000
D86	6.346	1.511	1.000
$UQLXAC^S_{-1}$	0.411	0.125	1.000

Correlation coefficient = 0.887

Probability of prior range = 0.659

Probability of positive first-order autocorrelation (ignorance) = 0.000

Het Correction = None

Sample period = 1983:1 to 1990:4

Probability [Column σ_i >= Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	0.032	0.000	0.187
σ_2	0.967	...	0.085	0.814
σ_3	1.000	0.915	...	0.991
σ_4	0.813	0.186	0.009	...

The short-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

UPLXC	0.15
ULSUPC	0.40

The long-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

UPLC	0.25
ULSUPC	0.68

Equation 22: North American Ending Inventory of Low-Valued Canned Salmon

Endogenous variable = ULINVC

Variable	Bayesian Coefficient	Standard Error	HYPOIG
UPLXC	-12.050	5.489	0.980
ULSUPC	0.194	0.079	0.986
C	-26.707	10.851	0.995
DQ2	9.609	3.950	0.996
DQ3	35.438	30.127	0.878
DQ4	14.432	5.188	0.997
D86	-12.756	4.590	0.990
$UPLXC_{-1}$	11.817	4.088	0.996
$ULINVC_{-1}$	0.495	0.152	1.000

Correlation coefficient = 0.966

Probability of prior range = 0.965

Probability of positive first-order autocorrelation (ignorance) = 0.958

Het Correction = Quarters 3 and 4

Sample period = 1983:1 to 1990:4

Probability [Column σ_i >= Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	0.081	1.000	1.000
σ_2	0.919	...	1.000	1.000
σ_3	0.000	0.000	...	0.000
σ_4	0.000	0.000	1.000	...

The short-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

UPLXC	0.39
ULSUPC	0.73

The long-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

UPLXC	0.77
ULSUPC	1.45

Equation 23 Correlation of High-Valued Fresh/Frozen and Canned Low-Valued Salmon

Endogenous variable = APHXAC

Variable	Bayesian Coefficient	Standard Error	HYPOIG
EPHXE	0.5619	0.127	1.000
C	1.071	0.347	0.999
DQ2	-0.1023	0.163	0.712
DQ3	-0.3327	0.131	0.995
DQ4	-0.3366	0.147	0.988
D89	0.3940	0.204	0.968
$APHXAC_{-1}$	0.2444	0.134	0.922

Correlation coefficient = 0.753

Probability of prior range = 0.922

Probability of positive first-order autocorrelation (ignorance) = 0.777

Het Correction = Quarter 2

Sample period = 1983:1 to 1991:3

Probability [Column σ_i > = Row σ_j]

	σ_1	σ_2	σ_3	σ_4
σ_1	...	1.000	0.790	0.601
σ_2	0.000	...	0.156	0.002
σ_3	0.210	0.984	...	0.293
σ_4	0.399	0.998	0.707	...

The short-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

EPHXE	0.73

The long-run percentage change of the dependent variable with 1-percent changes in right-hand side variables, all else remaining constant are:

EPHXE	0.97

Variable definitions:

$UQLXAC^s$ = the quantity of North American low-valued canned salmon exported to the EEC, Australia, and N.Z. in millions of lbs.

ULSUPC = the North American total available supply of low-valued salmon (beginning fresh/frozen and canned inventories plus landings) in millions of lbs.

$UQLXAC^d$ = the quantity of imported North American low-valued canned salmon into the EEC, Australia, and N.Z. in millions of lbs.

$UQLXAC^d_{-1}$ = $UQLXAC^d$ lagged one quarter.

$UQLXAC^s$ = the quantity of North American exports of low-valued canned salmon to the EEC, Australia, and N.Z in millions of lbs..

$UQLXAC^s_{-1}$ = $UQLXAC^s$ lagged one quarter.

ULINVC = the ending inventory of North American low-valued canned salmon in millions of lbs.

$ULINVC_{-1}$ = the beginning inventory of North American low-valued canned salmon in millions of lbs.

APLACR = the "real" price of North American low-valued can Pacific salmon in the EEC, Australia, and New Zealand in ECUs per pound.

APHACR = the "real" price of North American high-valued can Pacific salmon in the EEC, Australia, and New Zealand in ECUs per pound.

APHXAC = the nominal price of North American high-valued can Pacific salmon in the EEC, Australia, and New Zealand per pound.

$APHXAC_{-1}$ = APHXAC lagged one quarter.

EPHXE = North American high-valued Pacific salmon export price to the EEC in ECUs per pound.

EYRP = the "real" per capita private consumption expenditure in the EEC in millions of ECUs

UPLXC = the North American weighted average export price of low-valued canned salmon (FOB North America) exported to the EEC, Australia, and New Zealand, in U.S. dollars per pound.

$UPLXC_{-1}$ = UPLXC lagged one quarter.

D89 = an indicator variable which is assigned a value of 1 in 1989, and 0 elsewhere.

D86 = an indicator variable which is assigned a value of 1 in 1986, and zero elsewhere.

DQ_is = quarterly indicator variables for quarter i, where DQ_i is 1 in quarter i and 0 elsewhere.

C = a constant.

For the low-valued Pacific can demand equation, "real" prices represent prices that have been divided by the EEC's consumer price index (ECPI). ECPI is included to impose homogeneity on the demand equations. Because the exports are a combined EEC, Australia, and New Zealand figure, the EEC income and CPI level will only proxy a combined level for the three countries.

The demand equation performed fairly well with a correlation coefficient of 0.922. The own-price elasticity for low-valued can salmon is very inelastic, and the income elasticity is also below 1.0. This low price elasticity is not a good sign for producers of canned salmon. The value of less than 1.0, indicates that exporters of canned salmon to the EEC, Australia, and New Zealand would increase revenues by decreasing canned exports, ceteris paribus. The low income elasticity indicates that the level of demand for canned salmon is not very sensitive to changes in income levels.

High-valued canned Pacific salmon was found to be a substitute for low valued can salmon at a posterior probability of 0.789. The low value of the lagged quantity coefficient indicates that adjustment is quite rapid, and that long-run own-price elasticity is still inelastic (although the income elasticity rises to unitary). There was also a positive shift in exports in 1986 which was not captured by the other variables in the equation. The positive 1986 shift is significant in all low-valued canned salmon equations.

The low-valued canned salmon allocation equation was based on the theory of supply. The equation had a correlation coefficient of 0.887 and a probability of prior range of 0.651. However, some caution must be taken as this is the only equation in the model which had persistent autocorrelation. Repeated efforts were unsuccessful in remedying this problem.

In the equation for total North American low-valued canned exports to the EEC, Australia and New Zealand, the exports increase as the weighted average export price to these countries (measured in ECUs) increases. Similarly, as total supply increases, exports to these countries also increase. Again, the indicator variable marking 1986 indicates a large 1986 increase in canned salmon exports.

For the low-valued canned salmon inventory equation the models performed well, with the correlation coefficients and the probability of prior range both exceeding 0.965. The equation indicates that the holdings of North American canned inventories decrease when the current weighted average export price increases (used as a proxy for U.S. canned wholesale prices), and increases when the expectations of future wholesale price (as proxied by the lagged wholesale price proxy) and beginning available supplies increase. Momentum (or friction) is incorporated through the beginning inventory variable.

The price mapping equation is used in lieu of explicitly modelling the high-valued canned salmon markets. This approach was taken, in part, due to time constraints and also because these markets are relatively unimportant. However, because high- and low-valued canned salmon were found to be substitutes, the high-valued canned salmon price needed to be internally generated. This was done by correlating it with the high-valued fresh/frozen export price.

Model Performance

Model performance is evaluated by examining the predicted versus observed values for each of the endogenous variables, and the generated fit statistics. A variety of statistics are available which measure the differences between the observed and predicted values. The most straightforward is the mean percent error (M%E) which is the average of the percentage differences between the actual and predicted values. The root mean squared percentage error (RMSE) measures the square root of the sum of squared deviations of the error, measured in percent terms. A substantial difference between M%E and RMSE indicates that there may be large outliers present in the data set. The correlation coefficient (r) measures how well that actual and predicted values are clustered around the estimated trend line. More discussion on this statistic is presented under the Bloc 2 discussion.

Four additional statistics, developed by Theil (1963) to further evaluate simulation fits are presented. The U-inequality coefficient, measures the turning point accuracy of the forecast. A coefficient of zero is associated with a perfect forecast, whereas, a coefficient of 1.0 implies that the model forecast is no better than a status quo forecast.

Measures of the systematic and unsystematic portions of forecast error can be derived by decomposing the U-inequality coefficient (Pindyck and Rubinfeld 1981). Three partial inequality coefficients are reported. UM measures forecast bias, reflecting the differences in central tendencies between predicted and observed changes in the variable. UR reflects the slope proportion of an optimal linear correction to the predicted change. Finally, UD indicates the portion of forecast error attributable to random disturbances. The three partial measures add to one, by definition, and the combined total of UM + UR reflects systematic forecast error. It is generally desirable that this combined figure be close to zero, i.e., most of the forecast error is attributable to random disturbances.

The historical simulation was performed over the time period of 1983 to the third quarter of 1991. Simulation statistics are presented for the quarterly predictions from Bloc 1 in Tables 1 and 2. Table 1 provides the mean absolute percentage error and root mean percentage error for each endogenous variable. The Theil U statistics are presented in Table 2. Graphical presentation of predicted versus actual values of the key variables are provided following the presentation of the fit statistics.

Table 1. **Mean-Absolute-Percent-Error** and Root-Mean-Percent-Error for Bloc 1 Endogenous Variables , 1983:1 to 1991:3.

Variable	Mean Abs % Error	RMS Percent Error
NQAU	17.77	36.35
NPAU	8.15	10.96
NPAE	8.82	10.69
NQAJ	25.49	34.30
NPAJ	9.74	11.92
UPHX	18.86	26.30
UPHXJ	21.74	29.67
NQAE	3.04	3.90
UPHXE	16.69	22.15
UHSUP	10.65	17.57
UHINV	24.51	29.63
UQHXJ	30.81	45.02
UQHX	20.90	29.72
UQHXE	36.81	51.22
JINVZ	22.76	30.89
UPLXE	16.60	21.44
UQLXE	44.88	62.72
UQLXJ	27.80	37.07
UPLXJ	11.27	13.88
JINVT	18.39	24.07
UPLX	14.29	17.68
ULSUP	8.93	12.92
ULINV	19.40	23.67
APHXA	19.77	24.20
UQLXAC	24.03	31.83
UPLXC	20.90	25.87
ULINVC	33.78	47.82
ULSUPC	11.84	15.22
NAPHEX	14.01	18.13
NAPLEX	18.59	24.28

Table 2. Theil U-Statistics for Bloc 1 Endogenous Variables, 1983:1 to 1991:3.

Variable	Corr (R)	Bias (UM)	Reg (UR)	DIST (UD)	Theil U
NQAU	0.975	0.013	0.002	0.965	0.1077
NPAU	0.752	0.015	0.250	0.953	0.1004
NPAE	0.784	0.000	0.197	0.982	0.1026
NQAJ	0.876	0.002	0.058	0.998	0.3484
NPAJ	0.653	0.000	0.267	0.985	0.1130
UPHX	0.637	0.006	0.292	0.973	0.2234
UPHXJ	0.612	0.011	0.318	0.963	0.2486
NQAE	0.999	0.009	0.132	0.847	0.0242
UPHXE	0.626	0.002	0.160	0.997	0.1968
UHSUP	0.999	0.003	0.000	0.997	0.0384
UHINV	0.898	0.000	0.071	0.998	0.2623
UQHXJ	0.993	0.001	0.003	0.999	0.0954
UQHX	0.996	0.003	0.001	0.995	0.0734
UQHXE	0.827	0.002	0.282	0.925	0.3910
JINVZ	0.843	0.005	0.079	0.995	0.2106
UPLXE	0.714	0.042	0.211	0.947	0.1915
UQLXE	0.853	0.009	0.040	0.985	0.4123
UQLXJ	0.861	0.003	0.051	0.995	0.2419
UPLXJ	0.836	0.100	0.096	0.898	0.1295
JINVT	0.839	0.005	0.228	0.947	0.2014
UPLX	0.795	0.056	0.231	0.906	0.1550
ULSUP	0.999	0.012	0.011	0.971	0.0340
ULINV	0.919	0.032	0.224	0.881	0.2416
APHXA	0.127	0.025	0.082	0.678	0.2265
UQLXAC	0.908	0.004	0.002	0.964	0.1976
UPLXC	0.628	0.008	0.142	0.988	0.2449
ULINVC	0.898	0.004	0.034	0.828	0.2382
ULSUPC	0.984	0.000	0.014	0.999	0.0911
NAPHEX	0.918	0.007	0.076	0.988	0.1598
NAPLEX	0.871	0.014	0.043	0.943	0.2078

Glossary -- Endogenous Variables (bloc 1 simulation)

NQAU = the quantity of Norwegian farmed Atlantic salmon exported to the U.S., in millions of lbs.

NPAU = the Norwegian price of Norwegian farmed Atlantic salmon exported to the United States, in Norwegian kroners per pound.

NPAE = the Norwegian price of Norwegian farmed Atlantic salmon exported to the EEC, in Norwegian kroners per pound.

NQAJ = the quantity of Norwegian farmed Atlantic salmon exported to Japan, in millions of lbs..

NPAJ = the Norwegian price of Norwegian farmed Atlantic salmon exported to Japan, in Norwegian kroners per pound.

UPHX = the North American weighted average export price of high-valued salmon to Japan and the EEC, in U.S. dollars per pound.

UPHXJ = the North American export price of high-valued salmon to Japan, in U.S. dollars per pound.

NQAE = the quantity of Norwegian farmed Atlantic salmon exported to the EEC, in millions of lbs..
UPHXE = the North American export price of high-valued salmon to the EEC, in U.S. dollars in millions of lbs..
UHSUP = the North American total available supply of high-valued salmon, in millions of lbs..
UHINV = the ending inventory of North American high-valued salmon, in millions of lbs..
UQHXJ = the quantity of Japanese imports of North American high-valued salmon, in millions of lbs..
UQHX = the total quantity of North American exports of high-valued salmon to the EEC and Japan, in millions of lbs..
UQHXE = the quantity of EEC imports of North American high-valued salmon in, millions of lbs..
JINVZ = the ending total inventory of Japanese frozen salmon (less Pink inventories), in millions of lbs..
UPLXE = the North American export price of low-valued salmon to the EEC in, U.S. dollars per pound.
UQLXE = the quantity of North American exports of low-valued salmon to the EEC, in millions of lbs..
UQLXJ = the quantity of Japanese imports of North American low-valued salmon in, millions of lbs.
UPLXJ = the North American export price of low-valued salmon to Japan, in U.S. dollars per pound.
JINVT = the ending total inventory of Japanese frozen and salted salmon, in millions of lbs..
UPLX = the North American weighted average export price of low-valued salmon to Japan and the EEC, in U.S. dollars per pound.
ULSUP = the North American total available supply of low-valued salmon, in millions of lbs...
ULINV = the ending inventory of North American low-valued salmon, in millions of lbs.
APHXA = the export price of high-valued canned salmon exported to Australia and N.Z., in ECUs per pound.
UQLXAC = the quantity of EEC, New Zealand, and Australia imports of North American low-valued canned salmon, in millions of lbs.
UPLXC = the weighted average export price of high-valued canned salmon exported to Australia, and N.Z. in U.S. Dollars, in millions of lbs.
ULINVC = the ending inventory of North American low-valued canned salmon, in millions of lbs.
ULSUPC = the North American total available supply of low-valued salmon canned salmon, in millions of lbs.
NAPHEX = the North American exvessel price of high-valued Pacific salmon, in U.S. dollars per pound.
NAPLEX = the North American exvessel price of low-valued Pacific salmon, in U.S. dollars per pound.

Examination of the goodness of fit statistics indicate that, in spite of the model's large size and complexity, it performed quite well in simulation. The key variables, the exvessel prices NAPLEX and NAPHEX, were accurately estimated, as shown by the various goodness of fit statistics. The mean absolute percentage errors and the root-mean-squared percentage errors were very low for both exvessel prices. The Thiel UD statistic for both exvessel prices approach 1.0, indicating that model error is nonsystematic. Finally the Theil U statistic are below 1.0 for both variables suggesting that the model accurately tracks changes in the exvessel prices over time.

The model's predictive capability is further demonstrated by comparing predicted versus actual historical values of the variables. A tabular listing of predicted and actual values is provided in Table 3 (an H following the variables name denoted predicted value). Figure 3-10 provide a graphical presentation of actual and predicted values. Due to length consideration, the tabular and graphical presentations are limited to those endogenous variables included in the exvessel price equations.

Table 3. Predicted and Actual Quarterly Historical Prices for North American High-Valued Exvessel Price (NAPHEXH and NAPHEX), North American Low-Valued Exvessel Price (NAPLEXH and NAPLEX), North American Weighted Average High-Valued Export Price (UPHXH and UPHX), North American Weighted Average Low-Valued Export Price (UPLXH and UPLX) for 1983:1 to 1991:3.

TIME	NAPHEXH	NAPHEX	NAPLEXH	NAPLEX	UPHXH	UPHX	UPLXH	UPLX
1983:1	2.23	2.42	0.47	0.41	1.55	1.85	1.39	1.46
1983:2	0.80	0.80	0.31	0.31	1.05	1.60	1.22	1.32
1983:3	0.94	0.78	0.33	0.28	1.28	1.62	0.67	0.99
1983:4	1.05	1.09	0.63	0.68	2.04	1.81	1.26	1.39
1984:1	2.86	2.88	0.48	0.42	2.37	1.67	1.29	1.37
1984:2	1.16	1.00	0.34	0.29	2.06	1.86	1.15	1.25
1984:3	1.19	1.07	0.33	0.30	1.65	1.77	0.75	0.95
1984:4	1.07	1.17	0.67	0.58	2.14	2.42	1.34	1.46
1985:1	2.82	2.47	0.51	0.39	2.35	1.90	1.38	1.43
1985:2	1.08	1.08	0.36	0.32	1.69	2.03	1.26	1.24
1985:3	1.05	1.21	0.23	0.32	1.43	2.00	0.55	0.99
1985:4	1.03	1.20	0.46	0.56	1.84	2.05	0.93	1.22
1986:1	2.73	2.67	0.35	0.22	2.17	2.02	1.07	1.28
1986:2	2.01	1.43	0.25	0.34	3.79	1.95	1.09	1.19
1986:3	1.72	1.38	0.28	0.30	3.37	2.45	1.45	1.06
1986:4	1.17	1.10	0.53	0.53	2.58	2.47	1.63	1.33
1987:1	2.42	2.88	0.41	0.46	1.96	2.38	1.42	1.28
1987:2	1.53	1.77	0.33	0.42	2.48	3.08	1.46	1.36
1987:3	1.71	1.60	0.65	0.47	2.52	2.72	1.73	1.31
1987:4	1.67	1.90	1.02	1.19	3.31	3.32	2.00	1.96
1988:1	4.19	3.20	0.76	0.60	3.37	3.22	1.99	2.17
1988:2	2.04	2.29	0.42	0.76	3.61	3.48	1.59	1.96
1988:3	2.18	2.48	0.63	0.85	3.59	3.63	2.01	1.80
1988:4	1.41	1.76	0.86	1.01	3.10	4.09	1.85	2.24
1989:1	2.91	2.90	0.61	0.61	2.49	3.03	1.59	1.83
1989:2	1.27	1.53	0.38	0.37	2.29	3.00	1.44	1.56
1989:3	1.37	1.51	0.35	0.43	2.74	2.68	1.01	1.17
1989:4	1.36	1.05	0.76	0.75	3.08	2.68	1.45	1.44
1990:1	2.82	2.83	0.55	0.57	2.42	2.38	1.39	1.40
1990:2	1.53	1.52	0.37	0.45	3.13	2.55	1.49	1.27
1990:3	1.18	1.33	0.48	0.37	2.70	2.51	1.61	1.28
1990:4	1.67	1.39	0.84	0.71	2.66	2.55	1.76	1.55
1991:1	2.33	2.75	0.41	0.37	1.91	2.28	1.34	1.57
1991:2	1.51	1.00	0.26	0.24	2.97	2.20	1.31	1.45
1991:3	1.20	0.93	0.21	0.19	2.96	1.86	0.76	0.96

Table 4. **Predicted** and Actual Quarterly Historical Prices for North American Import Price of Norwegian Farmed Atlantic salmon (NPAUH and NPAU), Total Available Supply of North American High-Valued Salmon (UHTSUPH and UHTSUP), North American Weighted Average Low-Valued Canned Salmon Export Price (UPLXCH and UPLXC), Total Available Supply of North American Low-Valued Salmon (ULSUPH and ULSUP) for 1983:1 to 1991:3.

TIME	NPAUH	NPAU	ULSUPH	ULSUP	UPLXCH	UPLXC	ULSUPH	ULSUP
1983:1	22.1	22.5	50.8	50.8	2.41	1.65	35.1	35.1
1983:2	18.7	21.2	112.1	118.0	1.46	1.71	31.5	33.9
1983:3	20.3	21.5	351.7	348.4	1.90	1.57	371.9	371.6
1983:4	22.9	22.1	52.2	40.3	1.99	1.80	69.4	48.0
1984:1	24.5	21.6	22.9	18.6	2.57	2.05	37.2	34.9
1984:2	23.8	22.5	85.3	83.3	1.77	1.61	32.6	28.9
1984:3	25.4	23.9	294.5	292.6	2.04	2.00	413.2	410.9
1984:4	25.9	25.5	50.6	49.5	2.16	1.79	75.2	63.4
1985:1	28.6	26.3	25.2	30.6	2.69	1.75	39.4	34.7
1985:2	26.5	28.0	88.6	95.0	1.83	1.56	28.0	28.9
1985:3	24.4	25.3	349.5	349.1	1.68	1.91	508.5	510.4
1985:4	23.6	25.4	58.2	72.1	1.60	1.46	130.0	113.4
1986:1	22.1	23.5	28.5	48.1	1.83	1.43	65.6	66.9
1986:2	25.9	20.5	48.8	56.5	0.84	1.33	42.2	44.4
1986:3	25.1	18.4	366.0	370.6	1.12	1.36	446.4	452.0
1986:4	20.6	20.1	59.1	68.3	1.18	1.52	79.8	96.0
1987:1	18.6	20.8	39.6	29.6	1.98	1.90	44.7	51.2
1987:2	24.7	24.6	73.2	68.7	1.46	1.93	33.2	34.3
1987:3	25.8	25.9	318.9	317.8	2.75	1.67	299.6	298.1
1987:4	23.1	25.5	38.8	44.1	2.86	2.66	48.9	56.9
1988:1	23.1	23.5	15.2	17.7	3.45	2.76	22.3	24.2
1988:2	22.8	22.9	59.2	58.7	2.16	2.57	36.6	35.8
1988:3	23.9	24.6	281.5	282.1	2.89	4.00	370.3	368.7
1988:4	18.9	21.6	49.5	51.5	2.68	3.75	93.0	109.9
1989:1	18.1	19.2	31.5	35.4	3.21	3.18	49.0	54.0
1989:2	19.2	18.9	86.9	87.5	1.95	2.99	42.7	45.0
1989:3	18.9	17.6	382.9	384.8	2.29	2.61	445.9	449.3
1989:4	18.2	16.3	58.6	59.3	2.50	2.71	78.1	72.3
1990:1	16.6	17.5	33.3	33.9	3.01	2.74	45.5	39.5
1990:2	16.5	18.2	63.9	65.9	1.78	2.33	39.1	35.3
1990:3	15.3	18.4	460.4	460.8	2.47	2.04	392.1	391.9
1990:4	22.0	19.4	67.7	49.5	2.56	2.24	70.5	63.6
1991:1	21.8	19.6	41.9	26.4	3.09	2.00	41.3	33.2
1991:2	27.4	23.8	66.0	59.9	1.82	1.82	35.1	28.0
1991:3	22.2	21.3	376.4	377.3	2.08	1.93	482.9	483.3

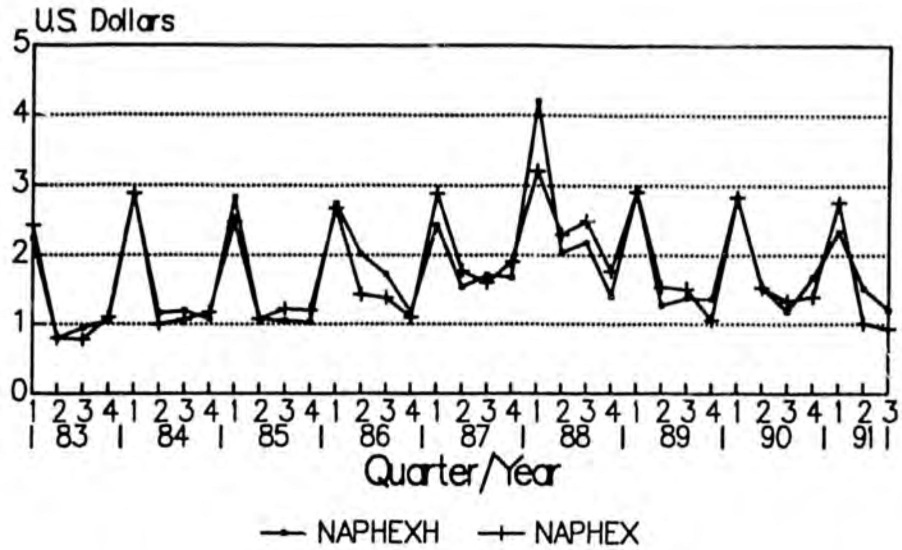

FIGURE 3. Predicted (NAPHEXH) vs. Actual (NAPHEX) North American High-Valued Salmon Exvessel Price (83:1 to 91:3)

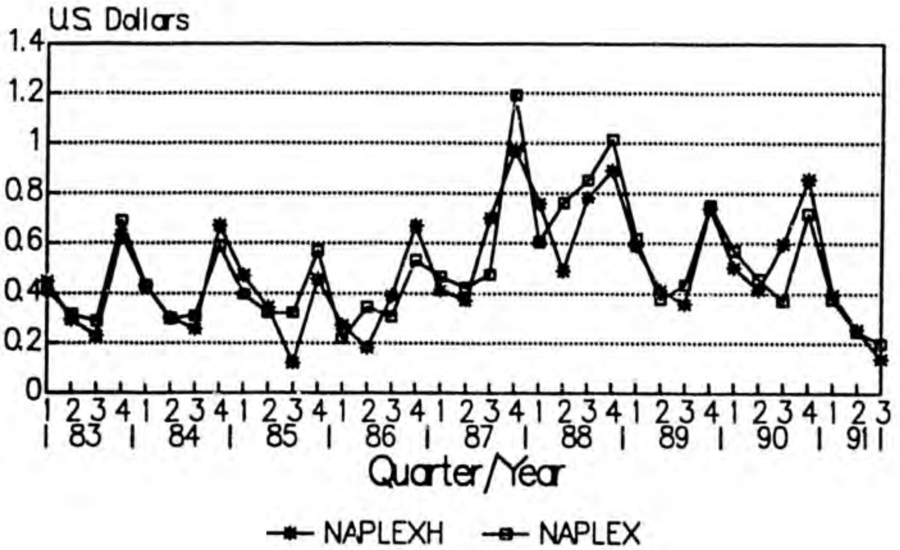

FIGURE 4. Predicted (NAPLEXH) vs. Actual (NAPLEX) North American Low-Valued Salmon Exvessel Price (83:1 to 91:3)

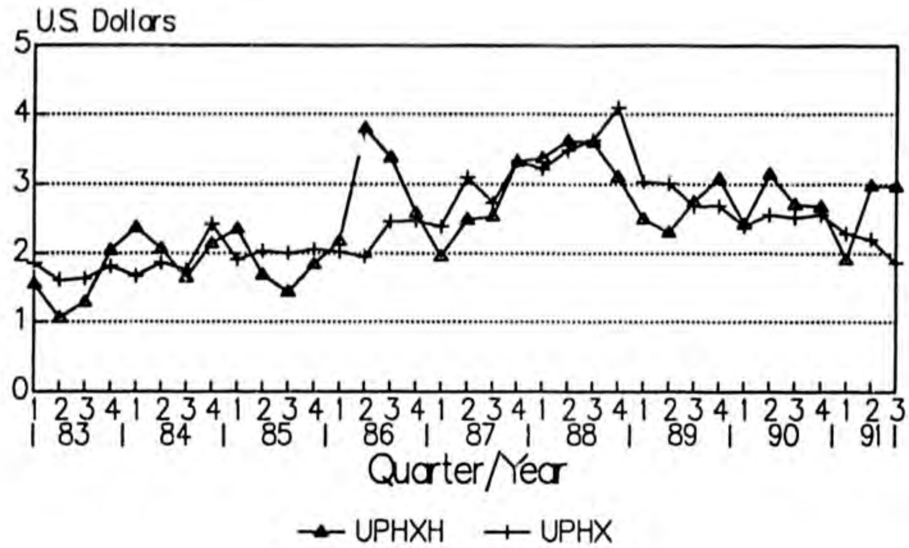

FIGURE 5. Predicted (UPHXH) vs. Actual (UPHX) North American Weighted Average Export Price (83:1 to 91:3)

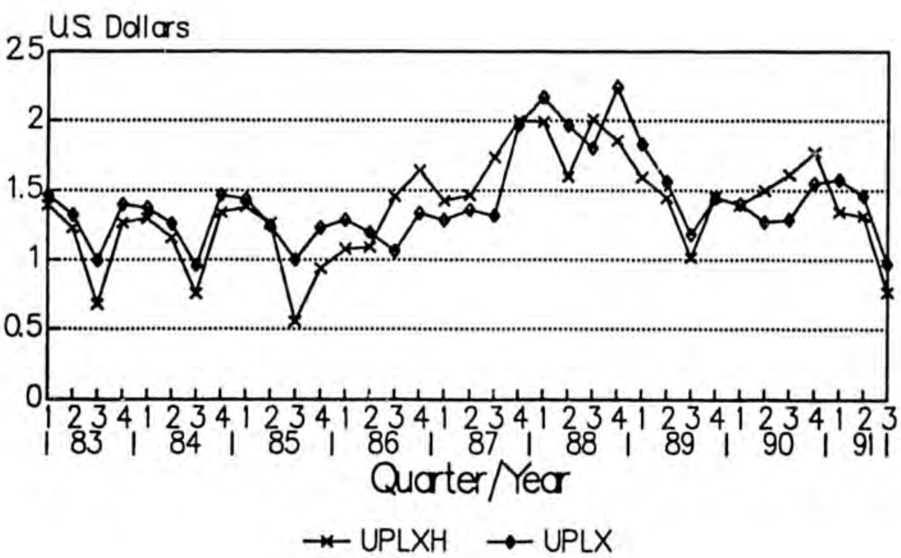

FIGURE 6. Predicted (UPLXH) vs. Actual (UPLX) North American Weighted Average Export Price (83:1 to 91:3)

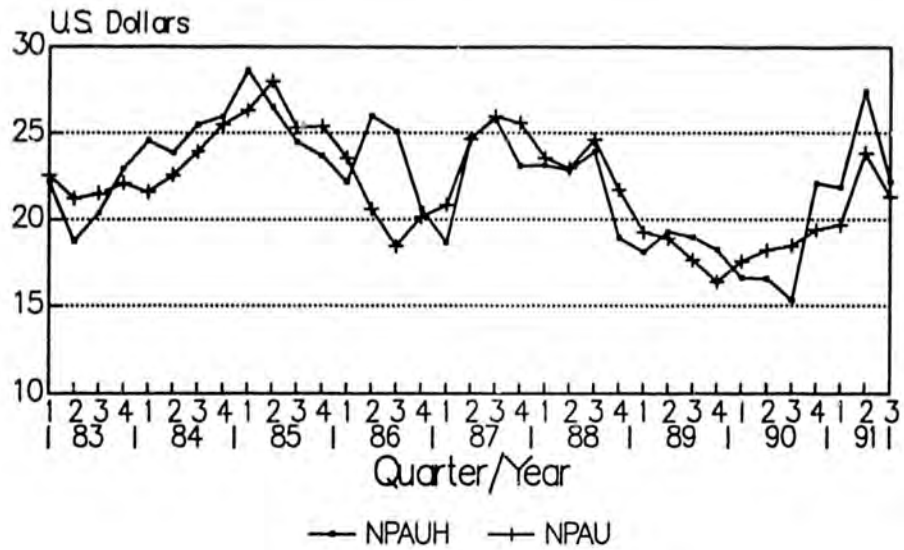

FIGURE 7. Predicted (UPAUH) vs. Actual (UPAU) North American Import Price of Norwegian Farmed Atlantic Salmon (83:1 to 91:3)

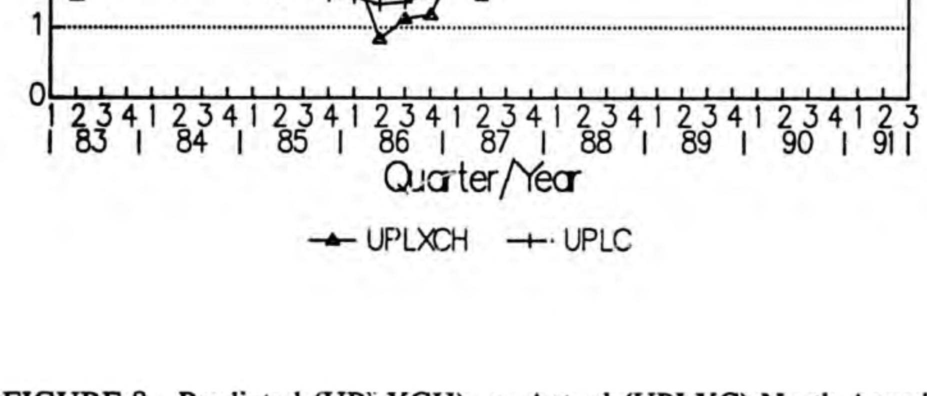

FIGURE 8. Predicted (UPLXCH) vs. Actual (UPLXC) North American Weighted Average Low-Valued Canned Salmon Price (83:1 to 91:3)

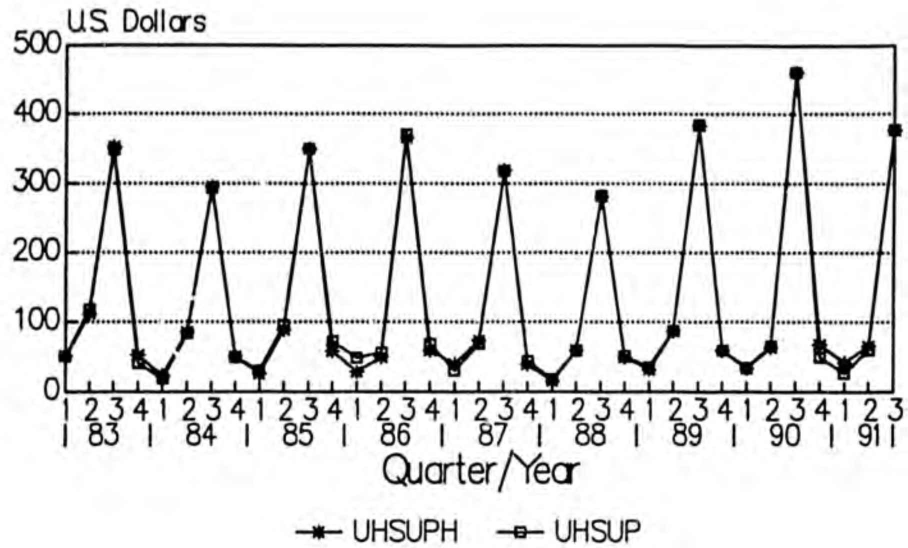

FIGURE 9. Predicted (NHSUPH) vs. Actual (NHSUP) North American Beginning Available Supplies of High-Valued Salmon(83:1 to 91:3)

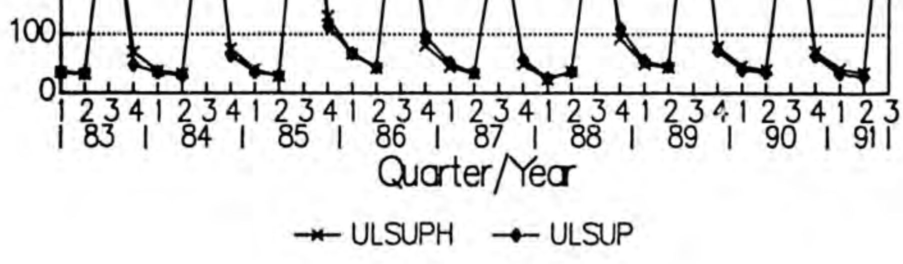

FIGURE 10. Predicted (NLSUPH) vs. Actual (NLSUP) North American Beginning Available Supplies of Low-Valued Salmon (83:1 to 91:3)

The reported prices and quantities tracked pretty well. Examination of Table 3 and figure 3 show an overprediction of the high-valued exvessel price in 1991 partly due to an over prediction for UPHX. It will be easier to examine the exvessel prices as we switch to annual data.

Annual Data

Only annual Alaska regional salmon exvessel prices are reported by CFEC. Thus, linking the quarterly predicted NAPHEX and NAPLEX to the appropriate regional exvessel prices required converting the quarterly predictions to annual predictions. This was accomplished by weighting the predicted quarterly exvessel prices by the associated harvest levels.

The goodness of fit statistics for the converted annual predictions of NAPLEX and NAPHEX are presented in Table 5.

Table 5. Goodness of Fit Statistics for the Low-Valued Annual Exvessel Prices (NAPLEX) and the High-Valued Annual Exvessel Prices (NAPHEX) for 1983 to 1991.

Mean Variable	Abs % Error	RMS % Error
NAPLEX	28.43	32.37
NAPHEX	14.67	16.93

Variable	Corr (R)	Bias (UM)	Reg (UR)	Dist (UD)	Theil U
NAPLEX	0.830	0.001	0.333	0.666	0.2763
NAPHEX	0.895	0.017	0.046	0.937	0.1460

The model performed fairly good as indicated by the goodness of fit statistics. The modelling of the high-valued exvessel price equation performed better than the low-valued exvessel price equation. In order to further illustrate the models historical predictive power the predicted versus actual NAPHEX and NAPLEX are provided in Table 6 and Figures 11-12.

Table 6. Actual and Predicted Historical Prices for North American High-Valued Exvessel Price (NAPHEX and NAPHEXH), and North American Low-Valued Exvessel Price (NAPLEX and NAPLEXH), 1983 to 1991.

YR	NAPLEX	NAPLEXH	NAPHEX	NAPHEXH
83	0.297	0.241	0.790	0.916
84	0.318	0.273	1.061	1.192
85	0.342	0.152	1.193	1.058
86	0.325	0.406	1.378	1.732
87	0.526	0.705	1.641	1.685
88	0.867	0.779	2.435	2.138
89	0.442	0.373	1.510	1.360
90	0.398	0.608	1.355	1.225
91	0.201	0.141	0.941	1.244

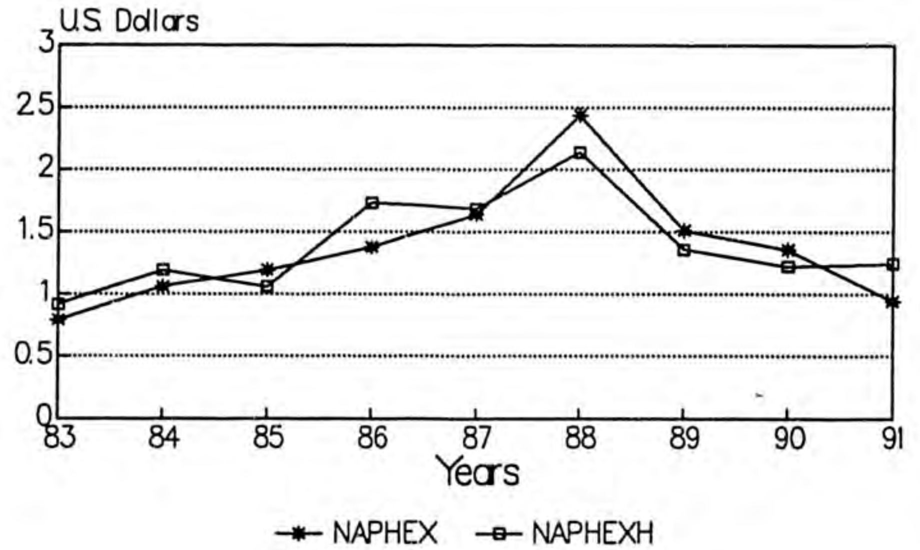

FIGURE 11. Actual (NAPHEX) vs. Predicted (NAPHEXH) Annual North American High-Valued Salmon Exvessel Price (1983 to 1991)

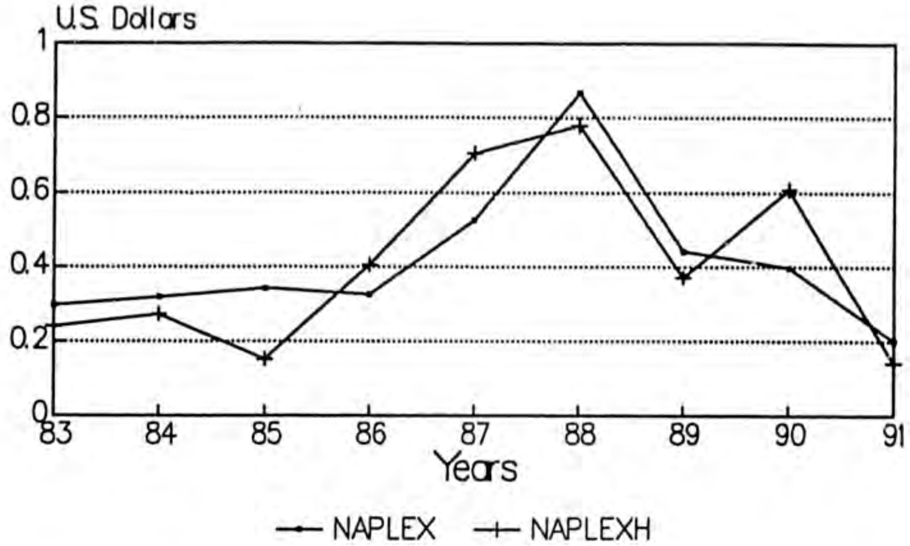

FIGURE 12. Actual (NAPLEX) vs. Predicted (NAPLEXH) Annual North American Low-Valued Salmon Exvessel Price (1983 to 1991)

Bloc 2 Estimates

The estimated exvessel prices for high- and low-valued salmon (NAPHEXH and NAPLEXH, respectively) will be utilized to derive the exvessel prices for the five salmon species harvested in the various regions. This derivation is based on the premise that there is a strong relationship, or equivalently, strong correlation, between NAPHEX and the various regional sockeye, chinook, and coho exvessel prices, as well as NAPLEX and the various regional pink and chum exvessel prices.

Correlation refers to the degree of the relationship which exists between various variables. Two variables are said to be positively correlated if the variables increase or decrease together. An example of two positively correlated variables is presented in figure 13. This figure presents pairs of annual exvessel prices for Cook Inlet sockeye salmon purse seine fishery (CIRPS) and NAPHEX. Diagrams of this type are referred to as scatter diagrams, showing the scatter of various data points.

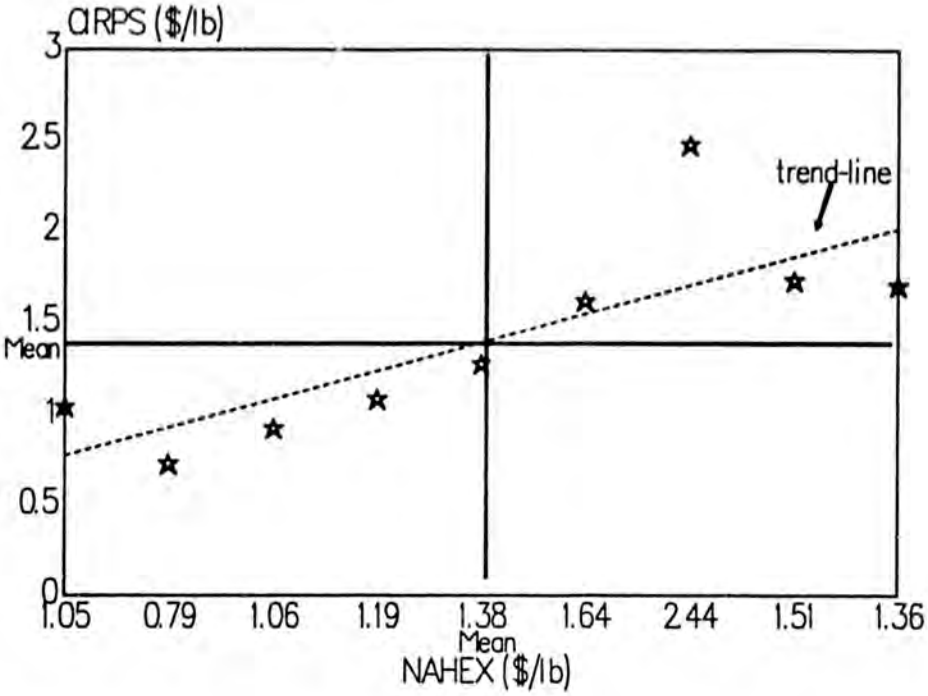

Figure 13. A Scatter Diagram Showing the Correlation Between Annual Cook Inlet Sockeye Salmon Purse Seine Fishery (CIRPS) and Weighted Average North American Exvessel Price of Sockeye, Chinook, and Coho (NAPHEX) from 1982 to 1990.

Examination of Figure 13 reveals that high (low) values of CIRPS are accompanied by high (low) values of NAPHEX. The degree of the relationship between the two variables is indicated by how closely the points are clustered around the linear trend line included in the figure. If all points lie directly on the trend line the two variables would be perfectly correlated. In this case the points, with few exceptions, are tightly clustered around the trend line, indicating that there is a strong degree of correlation between the two variables.

An example of a weaker correlation between two variables is shown in Figure 14. This figure provides a scatter diagram of exvessel price for the Cook Inlet chinook salmon purse seine fishery (CIKPS) and NAPHEX. Inspection of the figure reveals that the scatter of data points are dispersed widely around the positively sloped linear trend line. This indicates, that while the two variables are positively correlated, the relationship is relatively weak (a more detailed discussion of the relationship between salmon exvessel prices and NAPHEX is provided later in this section).

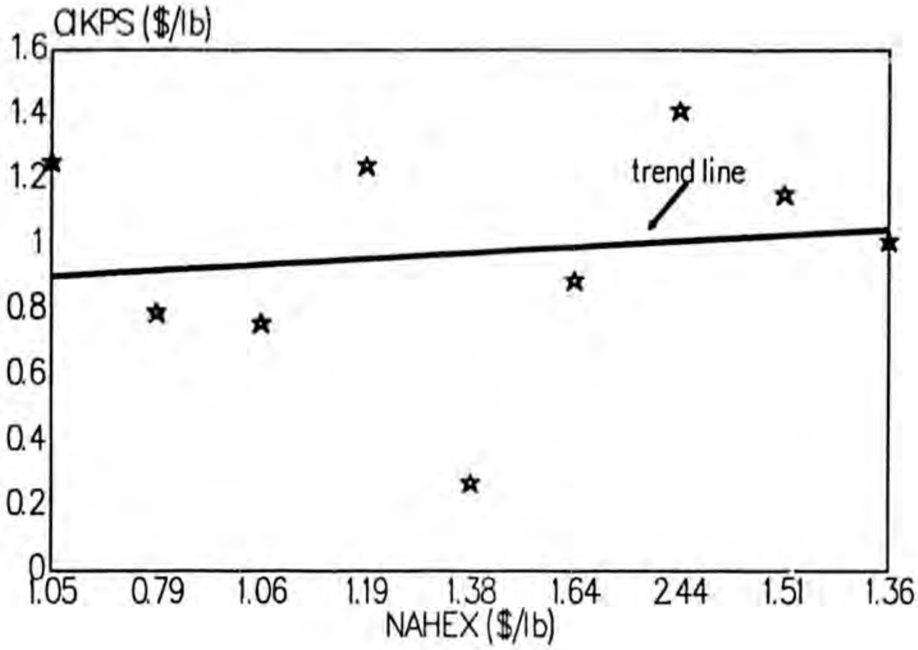

Figure 14. A Scatter Diagram Showing the Correlation Between Annual Cook Inlet Chinook Salmon Purse Seine Fishery (CIKPS) and Weighted Average North American Exvessel Price of Sockeye, Chinook, and Coho (NAPHEX) from 1982 to 1990.

Table 7 provides the means and standard deviations of the various exvessel prices. This is followed in Table 8-12 of the correlation coefficients between the various regional exvessel prices and the appropriate North American exvessel price. A glossary of the variable definitions are provided in Tables 13 and 14.

For example, Table 8 provides the exvessel price correlation coefficients associated with the sockeye salmon fisheries. The first row of Table 8 provides the correlation coefficients between the regional exvessel sockeye prices and NAPHEX. The first entry in this row is the correlation coefficient for NAPHEX and the Prince William Sound sockeye purse seine fishery (PWRPS). The value of 0.96 indicates that there is a strong positive correlation between the two exvessel prices. The correlation coefficient which corresponds to the relationship between CIRDG and NAPHEX that is represented in Figure 13, is given by the fourth entry of column one. The coefficient of 0.96, confirms that the two variables have a high positive correlation.

The remaining rows in Table 8 provide the interregional sockeye salmon exvessel price coefficients. For example, the eighth entry of the first column, 0.97, provides the correlation coefficient for the Prince William Sound sockeye purse seine (PWRPS) and Southeast sockeye hand troll (SERHT) fisheries.

In general, the exvessel price correlation coefficients for the sockeye salmon fisheries are quite high. This indicates, that as expected, a strong degree of correlation between exvessel prices exists across the various sockeye salmon fisheries. In addition, the sockeye salmon exvessel prices are strongly correlated with the aggregate North America high value exvessel price (NAPHEX).

The correlation coefficients range from a low of 0.91, for the Prince William Sound drift gill net (PWRDG) and the Juneau power troll (JURPT) fisheries, to a high of 0.99 for the Cook Inlet sockeye purse seine (CIRPS) and Cook Inlet sockeye drift gill net (CIRDG) fisheries. In part, this strong relationship is due to sockeye salmon having the highest annual harvest among the high value species, and therefore having the greatest weight in deriving the aggregate North America high exvessel price.

The correlation coefficients for the various coho salmon fisheries are provided in Table 9. Correlation coefficients are provided for each pair of fisheries and for each fishery and NAPHEX. The correlation coefficients, while in general lower than those for the respective sockeye salmon exvessel prices, still indicate that the exvessel prices across the various coho salmon fisheries are highly correlated with each other and the aggregate exvessel price NAPHEX. The exvessel price correlation coefficients for coho salmon range from a low of 0.80 for Prince William Sound coho purse seine fishery (PWSPS) and NAPHEX, to a high of 0.98 for Juneau coho power troll (JUSPT) and Prince William Sound coho purse seine (PWSPS) fisheries.

Among the high-valued salmon species, the chinook salmon exvessel prices displayed the weakest relationship (see Table 10) with each other and with NAPHEX. The exvessel price correlation coefficients range from a low of 0.14 for the Prince William Sound chinook purse seine (PWKPS) and Kodiak chinook purse seine (KOKPS) fisheries, to a high value of 0.95 for the Juneau chinook power troll (JUKPT) and hand troll (JUKHT) fisheries.

In part, low correlations associated with several of the chinook salmon fisheries is attributable to chinook salmon not being the targeted species in several regions. This results in low harvests, and subsequently the reported exvessel prices can easily be distorted by the activities of a single, or few, fishery participants. An example of this relates to the low correlation coefficient between CIKPS and PWKPS. Recall, CIKPS was one of the two exvessel prices included in Figure 14. Inspection of the figure shows that this fishery reported a exvessel price low for the data period of $0.27. This price corresponded to the 1986 fishery. In this same year, all other chinook salmon fisheries received substantially higher exvessel prices. For example, the 1986 exvessel prices in Prince William Sound purse seine and drift gill net fisheries were $0.877 and $1.463, respectively. The low exvessel price in this Cook Inlet fishery is apparently a direct consequence of the extremely low, 619 pound harvest. Similarly, the 1985 Prince William Sound purse seine fishery reported exvessel price of $0.249 was substantially below all other 1985 reported chinook salmon exvessel prices. Again, the low exvessel price corresponded to a low fishery harvest; the reported 1985 harvest was only 11,000 pounds.

The exvessel price correlation coefficients for pink salmon and the aggregate North America low exvessel price (NAPLEX) is reported in Table 11. Correlation coefficients report the degree of correlation between the various pink salmon fisheries, and the pink salmon fisheries and NAPLEX. The reported statistics indicate that the various regional exvessel prices are highly correlated with both each other and NAPLEX. The correlation coefficients range from a low of 0.88 for the Cook Inlet pink drift gill fishery (CIPDG) and NAPLEX, to a high of 0.99 for the Prince William Sound pink purse seine (PWPPS) and the Kodiak pink Set gill net (KKPSG) fisheries. In general, the correlation coefficients are greater than 0.90.

Table 12 presents the correlations coefficients measure the degree correlation between the various chum fisheries and NAPLEX. In general, the correlation coefficients indicate that exvessel prices for the various regions, and between the regions and NAPLEX have a high degree of correlation. The low correlation coefficient of 0.84 is reported for the Prince William Sound chum drift gill (PWCDG) and Juneau chum power troll (JUCPT) fisheries. The high correlation coefficient, 0.99, is reported for the Kodiak chum purse seine (KKCPS) and Kodiak chum set gill net (KKCSG) fisheries. The vast majority of the correlation coefficients exceed 0.90.

In summary, correlation coefficients for each species of salmon across all the relevant fisheries were reported in this section. The correlation coefficients measure the degree of correlation between the various exvessel prices within a given species. The reported statistics indicate that in general, within a given species, exvessel prices are highly correlated across all fisheries, and between the fisheries and the relevant aggregate North American exvessel price (either NAPHEX for high valued species, or NAPLEX for low valued species). This provides confidence that the exvessel prices for the various regions can be estimated on the basis of the historical relationship between each of the respective fishery exvessel prices and the appropriate North American exvessel price.

One area of concern is that several of the exvessel prices for the chinook salmon fisheries were weakly correlated with the aggregate North America high exvessel price. This problem was partially attributed to low harvests for specific fisheries within given years.

Table 7. Mean and Standard Deviation for Alaskan Salmon Exvessel Prices.

Variable	Mean	SD
PWKPS	1.22	0.59
PWKDG	1.90	0.68
CIKPS	0.98	0.34
CIKDG	1.23	0.20
KKKPS	1.12	0.21
KKKSG	1.11	0.25
SEKHT	2.51	0.60
SEKPT	2.56	0.61
PWRPS	1.44	0.54
PWRDG	1.71	0.72
CIRPS	1.39	0.53
CIRDG	1.44	0.53
KKRPS	1.45	0.56
KKRSG	1.46	[illegible]
SERHT	1.74	0.78
SERPT	1.75	0.77
PWSPS	0.79	0.40
PWSDG	0.99	0.40
CISPS	0.73	0.38
CISDG	0.75	0.25
KKSPS	0.82	0.20
KKSSG	0.70	0.26
SESHT	1.54	0.69
SESPT	1.53	0.69
PWPPS	0.35	0.20
PWPDG	0.34	0.19
CIPPS	0.32	0.19
CIPDG	0.26	0.11
KKPPS	0.36	0.20
KKPSG	0.33	0.19
SEPHT	0.43	0.17
SEPPT	0.43	0.18
PWCPS	0.47	0.25
PWCDG	0.50	0.25
CICPS	0.41	0.197
CICDG	0.47	0.155
KKCPS	0.46	0.258
KKCSG	0.45	0.274
SECHT	0.79	0.361
SECPT	0.77	0.366

Table 8. Correlations Coefficients for Alaskan Sockey Salmon Exvessel Prices.

SOCKEYE

	PWRPS	PWRDG	CIRPS	CIRDG	KKRPS	KKRSG	SERHT	SERPT
NAPHEX	0.96	0.92	0.96	0.96	0.98	0.98	0.98	0.98
PWRPS	1.00	0.93	0.97	0.97	0.96	0.96	0.97	0.97
PWRDG	0.93	1.00	0.97	0.96	0.95	0.97	0.92	0.91
CIRPS	0.97	0.97	1.00	0.99	0.95	0.98	0.95	0.95
CIRDG	0.97	0.96	0.99	1.00	0.96	0.98	0.96	0.96
KKRPS	0.96	0.95	0.95	0.96	1.00	0.98	0.98	0.97
KKRSG	0.96	0.97	0.98	0.98	0.98	1.00	0.97	0.97
SERHT	0.97	0.92	0.95	0.96	0.98	0.97	1.00	0.99
SERPT	0.97	0.91	0.95	0.96	0.97	0.97	0.99	1.00

Table 9. Correlations Coefficients for Alaskan Coho Salmon Exvessel Prices.

COHO

	PWSPS	PWSDG	CISPS	CISDG	KKSPS	KKSSG	SESHT	SESPT
NAPHEX	0.80	0.84	0.85	0.92	0.87	0.81	0.89	0.89
PWSPS	1.00	0.94	0.91	0.92	0.84	0.83	0.93	0.93
PWSDG	0.94	1.00	0.92	0.94	0.87	0.93	0.97	0.97
CISPS	0.91	0.92	1.00	0.89	0.85	0.84	0.96	0.95
CISDG	0.92	0.94	0.89	1.00	0.94	0.86	0.96	0.96
KKSPS	0.84	0.87	0.85	0.94	1.00	0.86	0.90	0.91
KKSSG	0.83	0.93	0.84	0.86	0.86	1.00	0.92	0.92
SESHT	0.93	0.97	0.96	0.96	0.90	0.92	1.00	0.99
SESPT	0.93	0.97	0.95	0.96	0.91	0.92	0.99	1.00

Table 10. Correlations Coefficients for Alaskan Chinook Salmon Exvessel Prices.

CHINOOK

	PWKPS	PWKDG	CIKPS	CIKDG	KKKPS	KKKSG	SEKHT	SEKPT
NAPHEX	0.74	0.94	0.93	0.37	0.87	0.72	0.82	0.74
PWKPS	1.00	0.73	0.39	0.70	0.14	0.41	0.73	0.75
PWKDG	0.73	1.00	0.53	0.89	0.66	0.75	0.77	0.68
CIKPS	0.39	0.53	1.00	0.73	0.48	0.43	0.50	0.59
CIKDG	0.70	0.89	0.73	1.00	0.69	0.82	0.81	0.82
KKKPS	0.14	0.66	0.48	0.69	1.00	0.81	0.65	0.56
KKKSG	0.41	0.75	0.43	0.82	0.81	1.00	0.73	0.72
SEKHT	0.73	0.77	0.50	0.81	0.65	0.73	1.00	0.95
SEKPT	0.75	0.68	0.59	0.82	0.56	0.72	0.95	1.00

Table 11. Correlations Coefficients for Alaskan Pink Salmon Exvessel Prices.

PINK

	PWPPS	PWPDG	CIPPS	CIPDG	KKPPS	KKPSG	SEPHT	SEPPT
NAPLEX	0.98	0.98	0.96	0.87	0.93	0.98	0.95	0.94
PWPPS	1.00	0.99	0.99	0.92	0.96	0.99	0.96	0.96
PWPDG	0.99	1.00	0.98	0.93	0.96	0.99	0.97	0.97
CIPPS	0.99	0.98	1.00	0.92	0.97	0.98	0.93	0.93
CIPDG	0.92	0.93	0.92	1.00	0.95	0.92	0.92	0.92
KKPPS	0.96	0.96	0.97	0.95	1.00	0.95	0.90	0.90
KKPSG	0.99	0.99	0.98	0.92	0.95	1.00	0.96	0.95
SEPHT	0.96	0.97	0.93	0.92	0.90	0.96	1.00	0.99
SEPPT	0.96	0.97	0.93	0.92	0.90	0.95	0.99	1.00

Table 12. Correlations Coefficients for Alaskan Chum Salmon Exvessel Prices.

CHUM

	PWCPS	PWCDG	CICPS	CICDG	KKCPS	KKCSG	SECHT	SECPT
NAPLEX	0.89	0.85	0.90	0.85	0.94	0.94	0.93	0.94
PWCPS	1.00	0.98	0.97	0.92	0.94	0.93	0.83	0.84
PWCDG	0.98	1.00	0.93	0.92	0.94	0.93	0.81	0.83
CICPS	0.97	0.93	1.00	0.95	0.95	0.94	0.89	0.87
CICDG	0.92	0.92	0.95	1.00	0.96	0.95	0.92	0.90
KKCPS	0.94	0.94	0.95	0.96	1.00	0.99	0.95	0.96
KKCSG	0.93	0.93	0.94	0.95	0.99	1.00	0.94	0.95
SECHT	0.83	0.81	0.89	0.92	0.95	0.94	1.00	0.99
SECPT	0.84	0.83	0.87	0.90	0.96	0.95	0.99	1.00

Table 13. Glossary -- Bloc 2 Regional Fisheries by Area, Species, and Gear Type

PWKPS, PWKDG - Price William Sound chinook purse seine and drift gill net fishery, respectively
CIKPS, CIKDG - Cook Inlet chinook purse seine and drift gill net fishery, respectively
KKKPS, KKKSG - Kodiak chinook purse seine and set net fishery, respectively
SEKHT, SEKPT - Southeast chinook hand and power troll fishery, respectively
PWRPS, PWRDG - Price William Sound sockeye purse seine and drift gill net fishery, respectively
CIRPS, CIRDG - Cook Inlet sockeye purse seine and drift gill net fishery, respectively
KKRPS, KKRSG - Kodiak sockeye purse seine and set net fishery, respectively
SERHT, SERPT - Southeast sockeye hand and power troll fishery, respectively
PWSPS, PWSDG - Price William Sound coho purse seine and drift gill net fishery, respectively
CISPS, CISDG - Cook Inlet coho purse seine and drift gill net fishery, respectively
KKSPS, KKSSG - Kodiak coho purse seine and set net fishery, respectively
SESHT, SESPT - Southeast coho hand and power troll fishery, respectively
PWPPS, PWPDG - Price William Sound pink purse seine and drift gill net fishery, respectively
CIPPS, CIPDG - Cook Inlet pink purse seine and drift gill net fishery, respectively
KKPPS, KKPSG - Kodiak pink purse seine and set net fishery, respectively
SEPHT, SEPPT - Southeast pink hand and power troll fishery, respectively
PWCPS, PWCDG - Price William Sound chum purse seine and drift gill net fishery, respectively
CICPS, CICDG - Cook Inlet chum purse seine and drift gill net fishery, respectively
KKCPS, KKCSG - Kodiak chum purse seine and set net fishery, respectively
SECHT, SECPT - Southeast chum hand and power troll fishery, respectively

In order to smooth out some of the outlier problems with the individual regional data and to somewhat simplify the Bloc 2 estimations the prices were aggregated across gear types before correlation with the exvessel prices from bloc 1. Table 14 gives the new glossary for the regional exvessel prices.

Table 14. Glossary -- Bloc 2 Species Aggregated across Gear Types

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PWKP PWSP PWRP PWCP PWPP is the exvessel price in the Prince William Sound fishery for chinook, coho, sockeye, chum, and pink salmon respectively.

CIKP CISP CIRP CICP CIPP is the exvessel price in the Cook Inlet fishery for chinook, coho, sockeye, chum, and pink salmon respectively.

KKKP KKSP KKRP KKCP KKPP is the exvessel price in the Kodiak fishery for chinook, coho, sockeye, chum, and pink salmon respectively.

SEKP SESP SERP SECP SEPP is the exvessel price in the Southeast fishery for chinook, coho, sockeye, chum, and pink salmon respectively.

Based on the generally high correlations between each of the high-valued Alaska regional Salmon exvessel prices (chinook, sockeye, and coho) and NAPHEX, and each of low-valued Salmon exvessel prices (pink and chum) and NAPLEX, the regional exvessel prices were estimated in Bloc 2 as a linear function of the appropriate North American exvessel price using ordinary-least-squares regression (OLS). In order to reduce the estimated number of exvessel price equations (and facilitate future simulations of the combined Bloc 1 and Bloc 2 models), one exvessel price per area and species was estimated. Thus, the estimated exvessel price for a given region and species represents a weighted average value of the associated exvessel prices across gear types. Regional exvessel prices for sockeye, coho, chinook, pinks, and chum were estimated for four regions Prince William Sound (PWRP, PWSP, PWKP, PWPP, and PWCP, respectively), Kodiak (KKRP, KKSP, KKKP, KKPP, and KKCP, respectively), and Southeast (SERP, SESP, SEKP, SEPP, and SECP, respectively). In addition, an aggregate all-other exvessel price equation incorporating all-other regions in Alaska was specified for each species, Sockeye, Coho, Chinook, Pink, and Chums (AKORP, AKOSP, AKOKP, AKOPP, and AKOCP, respectively). All equations were estimated for the 1983-91 time period.

In this section, estimation results are presented by species. For each species, the OLS regression results are provided first. This is followed by presentation of ex-post (historical) simulation results. The ex-post simulations provide a more robust evaluation of model performance. The simulations are performed by combining either the estimated NAPHEX (for sockeye, coho, and chinook) or NAPLEX (for pinks and chums), estimated in Bloc 1, with the appropriate Alaska regional price parameters, estimated in Bloc 2, to generate simulation predicted 1983-1991 Alaska regional exvessel prices.

Sockeye Salmon Exvessel Price Equations

The estimation results for the sockeye salmon exvessel price equations are presented in Table 15. The equations performed very well in estimating the Alaska regional and statewide sockeye exvessel prices for the 1983-1991 time period. The R^2s for the exvessel price equations ranged from 0.80 (PWRP) to 0.96 (SERP). Recall, R^2 represents the proportion of variation in the endogenous variables (regional exvessel prices) explained by variation in the exogenous variables (NAPHEX). For example, the R^2 of 0.89 for CIRP can be interpreted as stating that 89 percent of the variation in CIRP is explained by variation in the exogenous variable, NAPHEX.

Table 15. Estimation and Historical Simulation Result for Prince William Sound, Cook Inlet, Kodiak, Southeast, and Rest-of-Alaska, Sockeye exvessel prices, PWRP, CIRP, KKRP, SERP, and AKORP, respectively. For the 1983-91 time period (t-values are presented parenthetically).

Exvessel Price	Constant	NAPHEX* Coefficient	R^2	DW
PWRP	-0.332 (-0.93)	1.435 (5.76)	0.81	1.96
CIRP	-0.099 (-0.54)	1.096 (8.51)	0.90	2.01
KKRP	-0.271 (-1.22)	1.224 (7.94)	0.88	1.66
SERP	-0.369 (-1.75)	1.370 (9.34)	0.92	1.47
AKORP	-0.234 (-1.37)	0.995 (8.34)	0.90	1.83

*NAPHEX is a weighted average exvessel price for North American high-valued Salmon (Sockeye, Coho, and Chinook).

The ex-post simulation goodness-of-fit statistics for the Alaska regional and statewide sockeye salmon exvessel price equations are provided in Table 16. The statistics are indicative of the model performing satisfactorily in predicting the sockeye exvessel prices. The correlation coefficients (r) exceed 0.80, with the exception of PWRP, r=0.736 (correlation coefficients measure the degree of linear dependence between the Alaska exvessel prices and the exogenous variables in each of the equations). The UD statistics approach 1.0, indicating that virtually all the forecast error in the various models are attributable to random disturbances. Finally, the low Theil U statistics are indicative of the models accurately hitting turning points.

Table 16. Ex-post (historical) Simulation Forecast Goodness-of-Fit Statistics for Prince William Sound, Cook Inlet, Kodiak, Southeast, and Rest-of-Alaska, Sockeye Exvessel Prices (PWRP, CIRP, KKRP, SERP, and AKORP, respectively), 1983-1991 Time Period.

Exvessel Price	Corr (R)	Bias (UM)	Reg (UR)	Dist (UD)	THEIL U
PWRP	0.730	0.008	0.004	0.989	0.2521
CIRP	0.819	0.000	0.004	0.996	0.1920
KKRP	0.834	0.006	0.004	0.990	0.1969
SERP	0.854	0.000	0.014	0.985	0.1969
AKORP	0.936	0.008	0.132	0.860	0.1372

The predictive ability of the models are further illustrated in Figures 15-19. These figures provide the simulation generated predicted and actual values of PWRP, CIRP, KKRP, SERP, and AKORP, respectively. Examination of the figures reveals that the equations accurately track changes in the various sockeye exvessel prices for the 1983-91 time period. The equations did suffer from the common trait of underpredicting the high 1988 exvessel prices, and overpredicting the low 1991 exvessel prices.

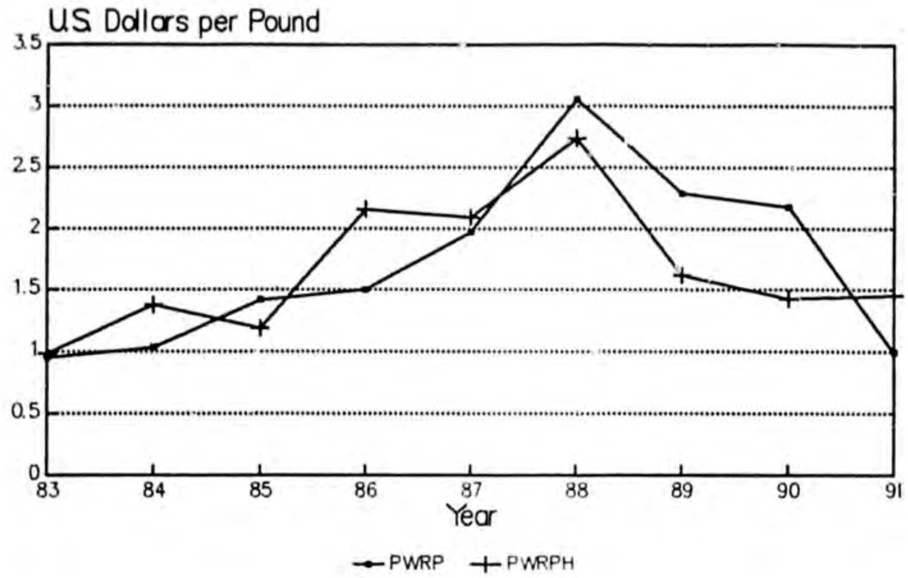

FIGURE 15. Actual (PWRP) versus Predicted (PWRPH) Historical Prince William Sound Sockeye Annual Exvessel Price (1983-1991)

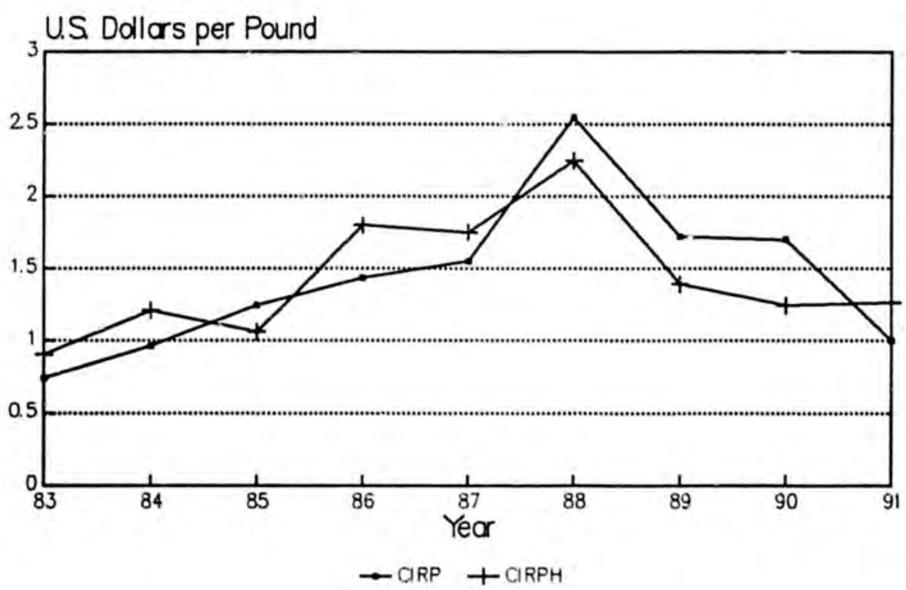

FIGURE 16. Actual (CIRP) versus Predicted (CIRPH) Historical Cook Inlet Sockeye Annual Exvessel Price (1983-1991)

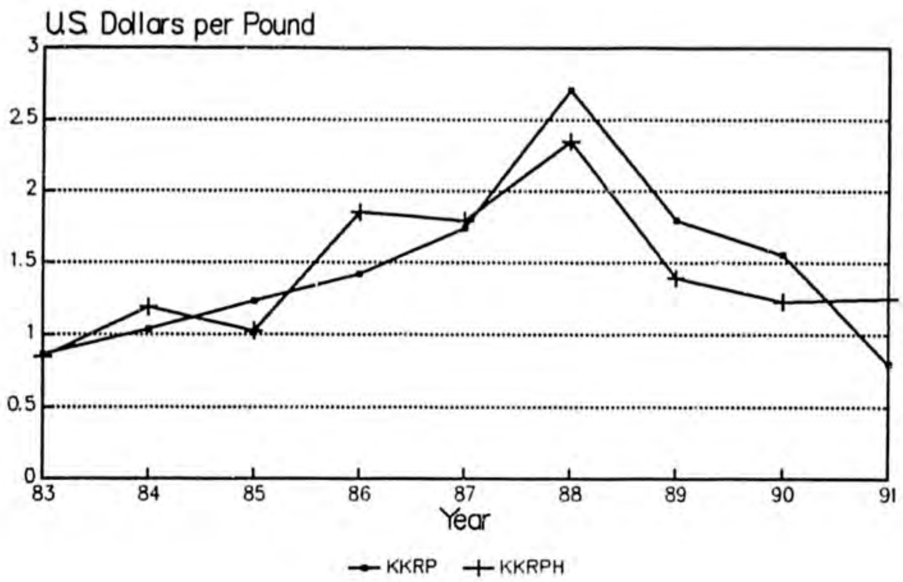

FIGURE 17 Actual (KKRP) versus Predicted (KKRPH) Historical Kodiak Sockeye Annual Exvessel Price (1983-1991)

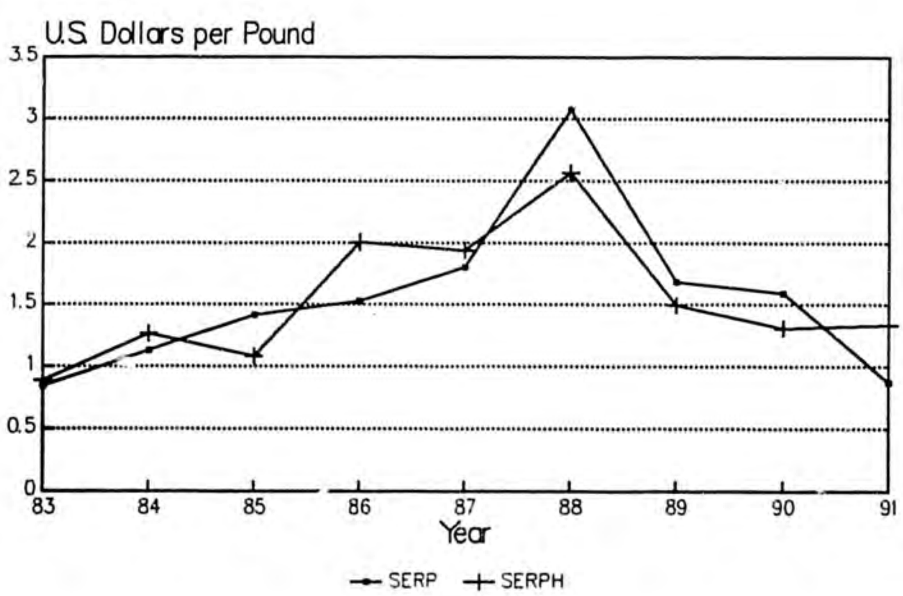

FIGURE 18 Actual (SERP) versus Predicted (SERPH) Historical Southeast Sockeye Annual Exvessel Price (1983-1991)

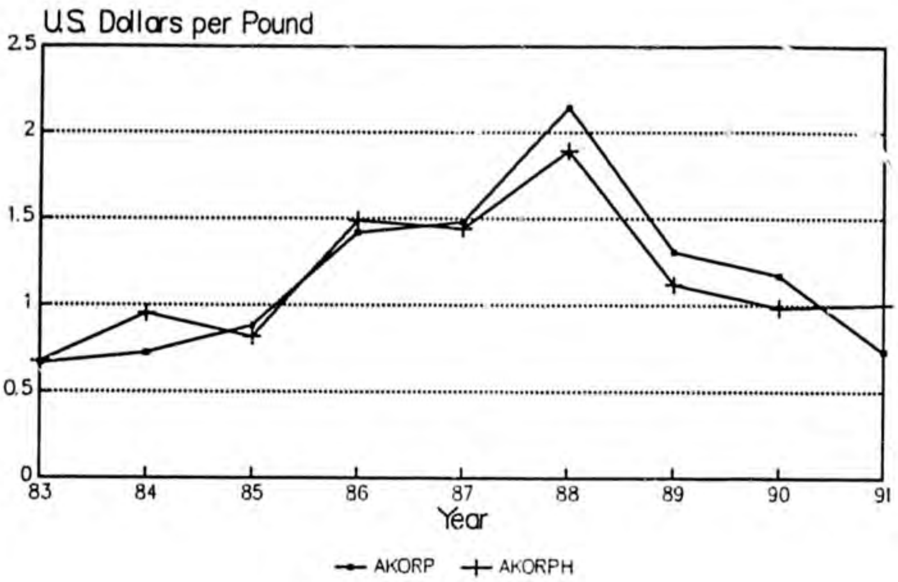

FIGURE 19 Actual (AKORP) versus Predicted (AKORPH) Historical Rest-of-Alaska Sockeye Annual Exvessel Price (1983-1991)

<u>Coho Salmon Exvessel Price Equations</u>

Alaska regional coho exvessel prices, PWSP, CISP, KKSP, SESP, and AKOSP, were estimated as linear functions of NAPHEX. The estimation results are provided in Table 17. The models performed satisfactorily, although not as well as the sockeye salmon exvessel price equations. The R^2s for the coho exvessel price equations ranged from 0.50 (KKSP) to 0.79 (CISP and AKOSP).

Table 17. Estimation Results for Prince William Sound, Cook Inlet, Kodiak, Southeast and Rest-of-Alaska, Coho Exvessel Prices, PWSP, CISP, KKSP, SESP, and AKOSP, respectively, for the 1983-1991 Time Period (t-values are presented parenthetically).

Exvessel Price	Constant	NAPHEX* Coefficient	R^2	DW
PWSP	-0.035 (-0.14)	0.722 (4.08)	0.68	2.32
CISP	0.025 (0.19)	0.511 (5.46)	0.79	1.80
KKSP	0.186 (0.91)	0.404 (2.85)	0.50	1.54
SESP	-0.190 (-0.64)	1.079 (5.23)	0.77	1.99
AKOSP	-0.025 (0.64)	0.578 (5.52)	0.79	0.74

*NAPHEX is a weighted average exvessel price for North American high-valued Salmon (Sockeye, Coho, and Chinook).

The ex-post simulation goodness-of-fit statistics for the coho exvessel price equations are provided in Table 18. The statistics provide a general indication that the models adequately forecast the historical coho exvessel prices. The correlation coefficients range from 0.657 (KKSP) to 0.837 (AKOSP). All of the UD statistics exceed 0.95, suggesting that model error is attributable to random disturbances. And Theil U statistics are all less than 0.250, indicating that the models are generally accurate in forecasting turning points of the exvessel prices.

Table 18. Ex-post (historical) Simulation Forecast Goodness-of-Fit Statistics for Prince William Sound, Cook Inlet, Kodiak, Southeast, and Rest-of-Alaska, Coho Exvessel Prices (PWSP, CISP, KKSP, SESP, and AKOSP, respectively), 1983-1991 Time Period.

Exvessel Price	Corr (R)	Bias (UM)	Reg (UR)	Dist (UD)	THEIL U
PWSP	0.755	0.000	0.017	0.983	0.2491
CISP	0.786	0.006	0.012	0.982	0.2096
KKSP	0.657	0.005	0.012	0.983	0.2494
SESP	0.809	0.003	0.026	0.971	0.2329
AKOSP	0.837	0.002	0.042	0.956	0.1972

The models predictive ability may also be evaluated by comparing the simulation predicted and actual coho exvessel prices, PWSP, CISP, KKSP, SESP, and AKOSP in Figures 20-24, respectively. As with the sockeye salmon exvessel price equations, the coho exvessel price equations failed to fully capture sharp upward movements in 1988 exvessel prices, and the dramatic downturn in 1991 exvessel prices.

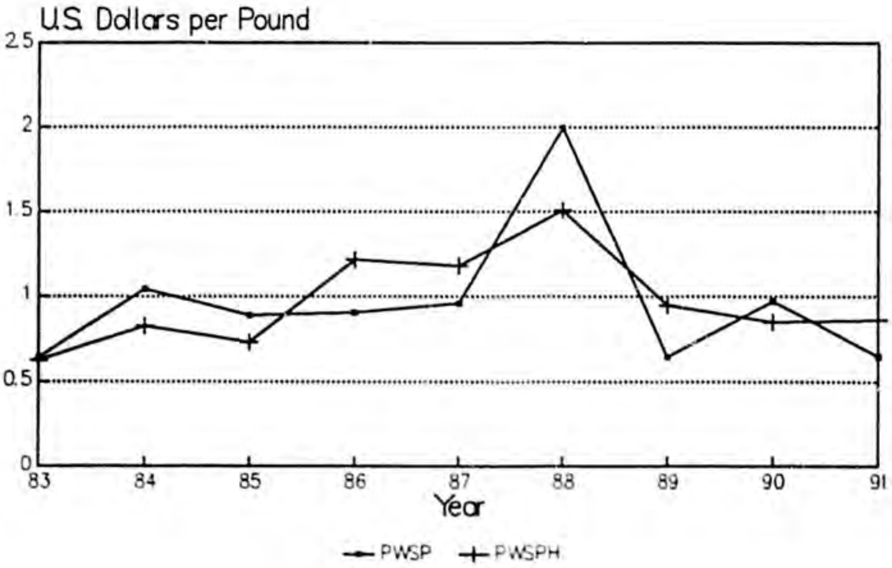

FIGURE 20. Actual (PWSP) versus Predicted (PWSPH) Historical Prince William Sound Coho Annual Exvessel Price (1983-1991)

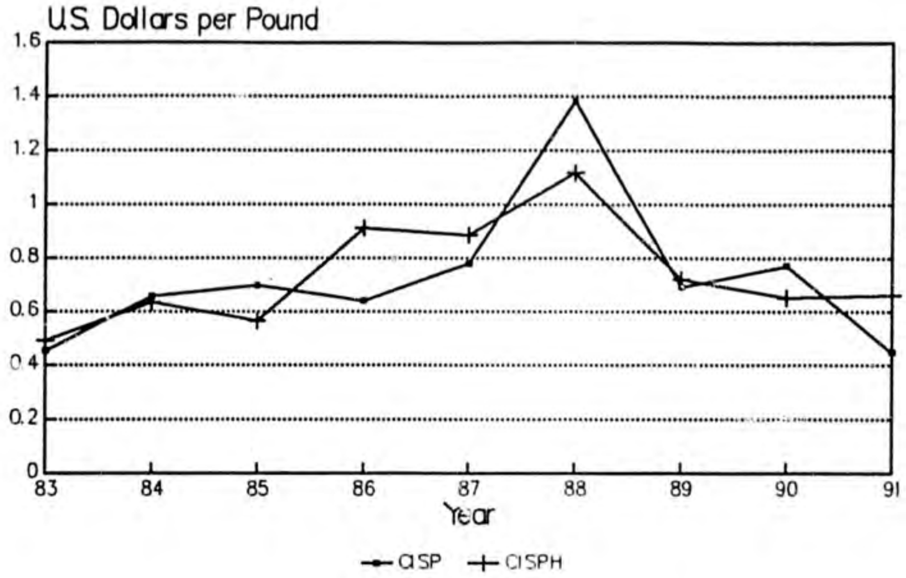

FIGURE 21. Actual (CISP) versus Predicted (CISPH) Historical Cook Inlet Coho Annual Exvessel Price (1983-1991)

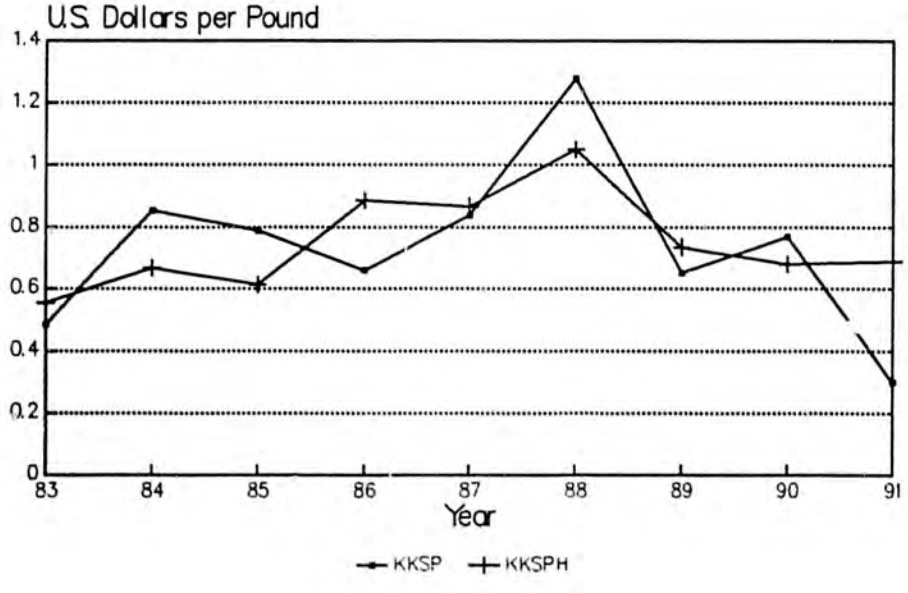

FIGURE 22 Actual (KKSP) versus Predicted (KKSPH) Historical Kodiak Coho Annual Exvessel Price (1983-1991)

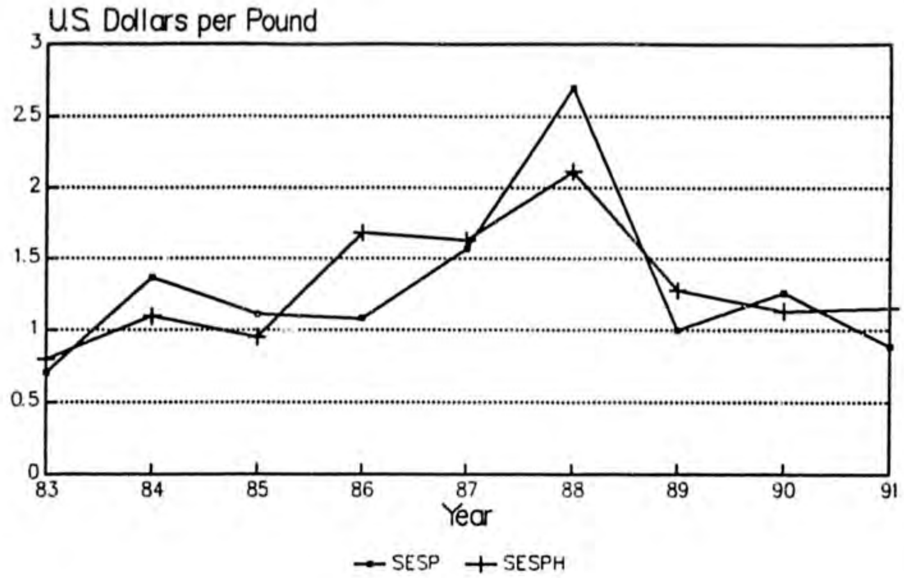

FIGURE 23 Actual (SESP) versus Predicted (SESPH) Historical Southeast Coho Annual Exvessel Price (1983-1991)

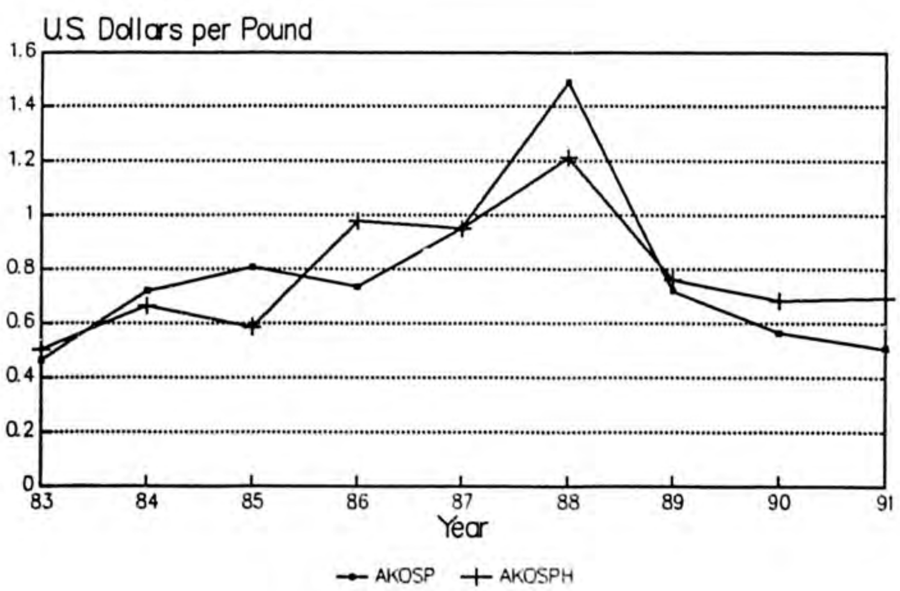

FIGURE 24 Actual (AKOSP) versus Predicted (AKOSPH) Historical Rest-of-Alaska Coho Annual Exvessel Price (1983-1991)

Chinook

The chinook salmon regional exvessel price estimation completes the modelling of 'regional' exvessel prices for high valued salmon species. The estimation results are presented in Table 19. As expected, the R^2 on several of the chinook equations are relatively low. It was noted in the previous section that chinook exvessel prices had the weakest relationship with NAPHEX among all high valued salmon species. This was attributed, in part, to chinook salmon not being the targeted species in sevearl fisheries. The R^2 range from a relatively low 0.43 (CIKP) to 0.85 (PWKP).

Table 19. Estimation Results for Prince William Sound, Cook Inlet, Kodiak, Southeast and Rest-of-Alaska, Chinook Exvessel Prices, PWKP, CIKP, KKKP, SEKP, and AKOKP, respectively, for the 1983-91 Time Period (t-values are presented parenthetically).

Exvessel Price	Constant	NAPHEX* Coefficient	R^2	DW
PWKP	-0.040 (-0.14)	1.375 (6.72)	0.85	2.07
CIKP	0.678 (5.08)	0.386 (4.14)	0.68	1.76
KKKP	0.609 (3.03)	0.347 (2.47)	0.43	1.43
SEKP	1.147 (2.61)	0.944 (3.07)	0.54	1.88
AKOKP	0.641 (1.95)	0.614 (2.68)	0.47	0.70

*NAPHEX is a weighted average exvessel price for North American high-valued Salmon (Sockeye, Coho, and Chinook).

The ex-post simulation goodness-of-fit statistics for the regional chinook exvessel price equations are provided in Table 20. The correlation coefficients range from 0.506 (AKOKP) to 0.724 (CIKP). The Thiel UD are either equal to close to 1.0, indicating that model error is nonsystematic. The Thiel U statistics are generally quite good, particularly when considering the aforementioned data inconsistencies.

Table 20. Ex-post (historical) Simulation Forecast Goodness-of-Fit Statistics for Prince William Sound, Cook Inlet, Kodiak, Southeast, and Rest-of-Alaska, Chinook Exvessel Prices (PWKP, CIKP, KKKP, SEKP, and AKOKP, respectively), 1983-1991 Time Period.

Exvessel Price	Corr (R)	Bias (UM)	Reg (UR)	Dist (UD)	THEIL U
PWKP	0.724	0.001	0.004	0.996	0.2258
CIKP	0.686	0.012	0.000	0.987	0.1255
KKKP	0.534	0.000	0.000	1.000	0.1777
SEKP	0.703	0.015	0.020	0.966	0.1667
AKOKP	0.506	0.001	0.006	0.993	0.2166

Figure 25-29 illustrate the predicted versus actual Alaska regional chinook exvessel prices, PWKP, CIKP, KKKP, SEKP, and AKOKP, respectively. The models adequately track the general movements in exvessel prices over 1983-1991 time periods. There are specific years in which the models generally perform less well. For example, the models generally overestimate 1986 exvessel prices.

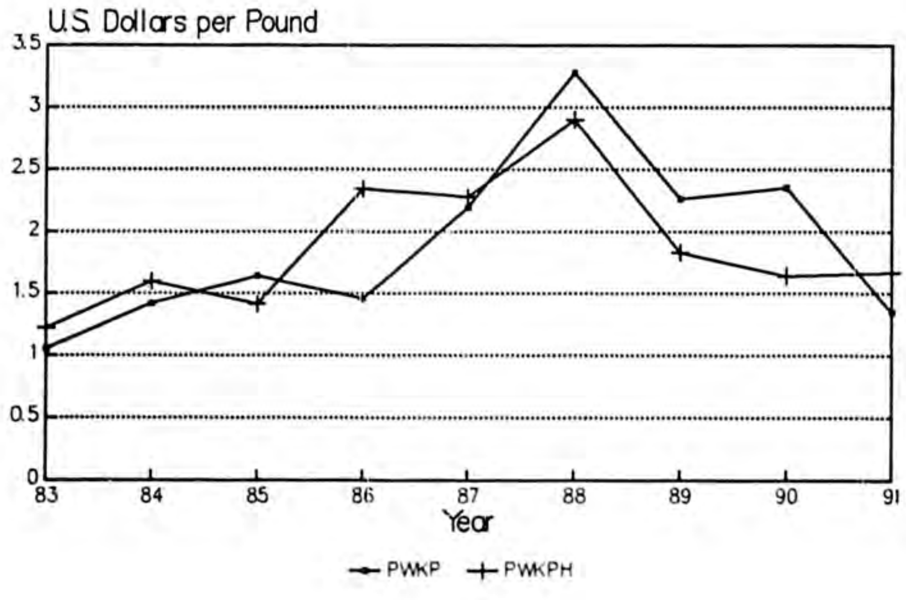

FIGURE 25 Actual (PWKP) versus Predicted (PWKPH) Historical Prince William Sound King Annual Exvessel Price (1983-1991)

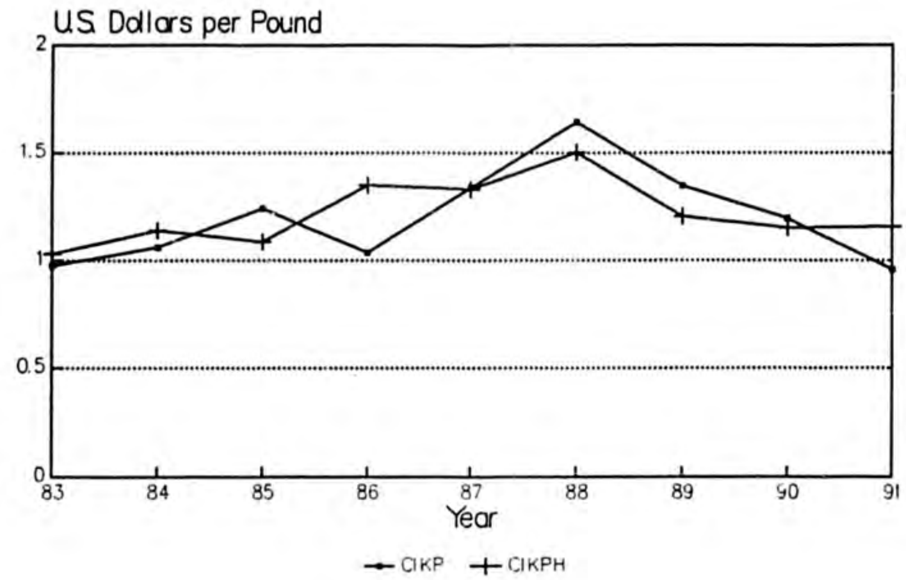

FIGURE 26 Actual (CIKP) versus Predicted (CIKPH) Historical Cook Inlet King Annual Exvessel Price (1983-1991)

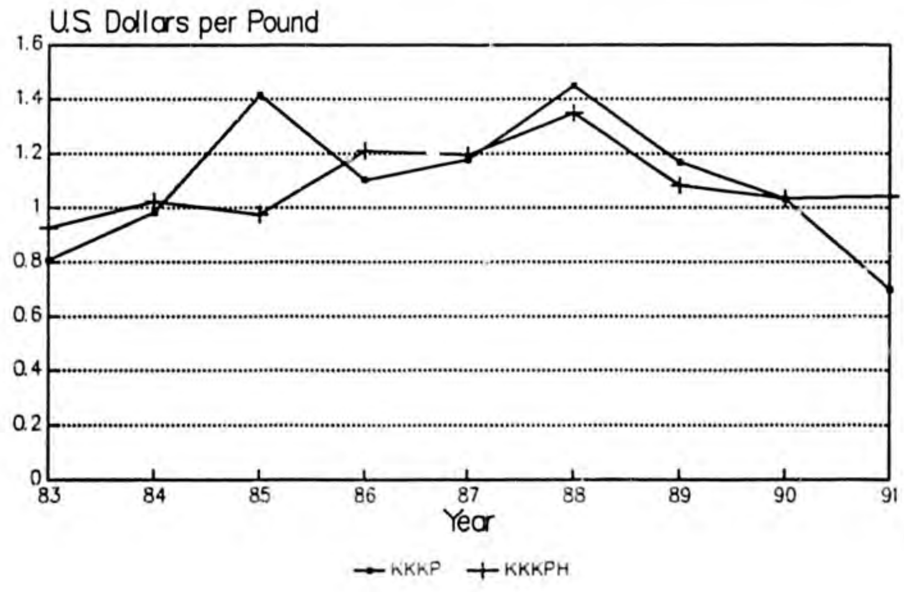

FIGURE 27 Actual (KKKP) versus Predicted (KKKPH) Historical Kodiak King Annual Exvessel Price (1983-1991)

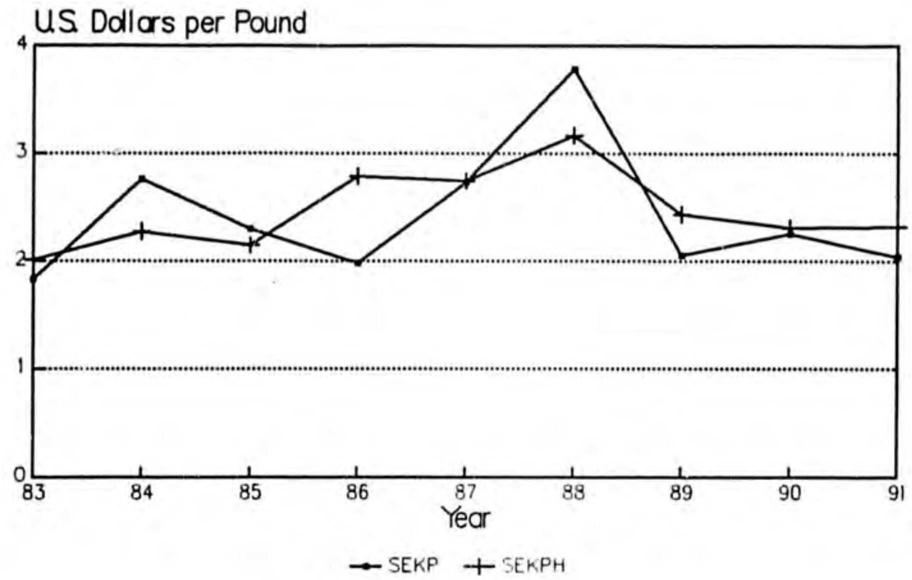

FIGURE 28 Actual (SEKP) versus Predicted (SEKPH) Historical Southeast King Annual Exvessel Price (1983-1991)

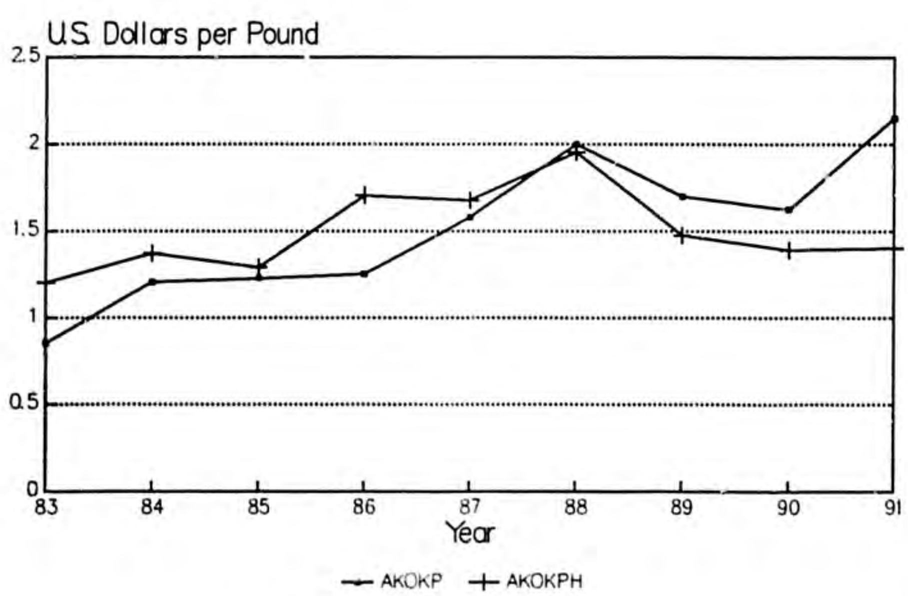

FIGURE 29 Actual (AKOKP) versus Predicted (AKOKPH) Historical Rest-of-Alaska King Annual Exvessel Price (1983-1991)

Pink Salmon Exvessel Price Equations

Alaska regional pink exvessel prices, PWPS, CIPS, KKPS, SEPS, and AKOPS, were estimated as linear functions of NAPLEX for the 1983-1991 time periods. Table 21 provides the estimation results. The models performed extremely well, with the R^2s ranging from 0.92 (CIPP and SEPP) TO 0.99 (KKPP and SEPP).

Table 21. Estimation Results for Prince William Sound, Cook Inlet, Kodiak, Southeast and Rest-of-Alaska, Pink Exvessel Prices, PWPP, CIPP, KKPP, SEPP, and AKOPP, respectively, for the 1983-91 Time Period (t-values are presented parenthetically).

Exvessel Price	Constant	NAPLEX* Coefficient	R^2	DW
PWPP	-0.112 (-4.77)	1.089 (20.55)	0.98	1.51
CIPP	-0.055 (-1.37)	0.838 (9.30)	0.91	1.48
KKPP	-0.109 (-5.49)	1.053 (23.57)	0.98	1.37
SEPP	-0.095 (-4.63)	1.075 (23.09)	0.98	2.24
AKOPP	-0.029 (-0.73)	0.867 (9.61)	0.91	1.76

*NAPLEX is a weighted average exvessel price for North American low-valued Salmon (Pink and Chum).

A more robust evaluation of the pink exvessel price equations are provided through models simulations. Replacement of the actual NAPLEX with the values predicted in Bloc 1, leads to a general reduction in the equations predictive accuracy. The simulation goodness-of-fit statistics are provided in Table 22. The correlation coefficients (r) range from 0.749 (CIPP) to 0.819 (KKPP). The majority of model error is attributable to random disturbances. However, there is significant systematic component to the model error, as evidence by the high UR values. Additionally, the models experience some difficulty in hitting the various turning points, as indicated by the Theil U statistics.

Table 22. Ex-post Simulation Forecast Goodness-of-Fit Statistics for Prince William Sound, Cook Inlet, Kodiak, Southeast, and Rest-of-Alaska, Pink Exvessel Prices (PWPP, CIPP, KKRP, SEPP, and AKOPP, respectively), 1983-1991 Time Period.

Exvessel Price	Corr (R)	Bias (UM)	Reg (UR)	Dist (UD)	THEIL U
PWPP	0.800	0.005	0.333	0.662	0.3687
CIPP	0.749	0.008	0.316	0.676	0.3717
KKPP	0.819	0.005	0.336	0.658	0.3533
SEPP	0.812	0.004	0.332	0.663	0.3479
AKOPP	0.801	0.019	0.341	0.640	0.3120

Evaluation of the pink exvessel price equations is completed by comparing the actual and simulation predicted values of PWFP, CIPP, KKPP, SEPP, and AKPP presented in Figures 30-34, respectively. The models are generally successful in tracking changes in pink exvessel prices. The exvessel price predictions fall short of the actual high 1988 exvessel prices and the low 1991 exvessel prices.

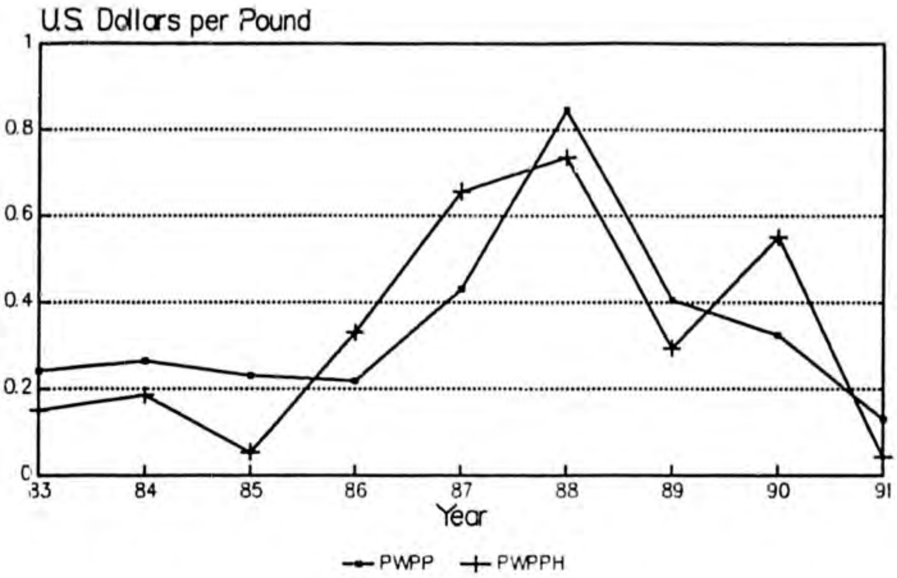

FIGURE 30 Actual (PWPP) versus Predicted (PWPPH) Historical Prince William Sound Pink Annual Exvessel Price (1983-1991)

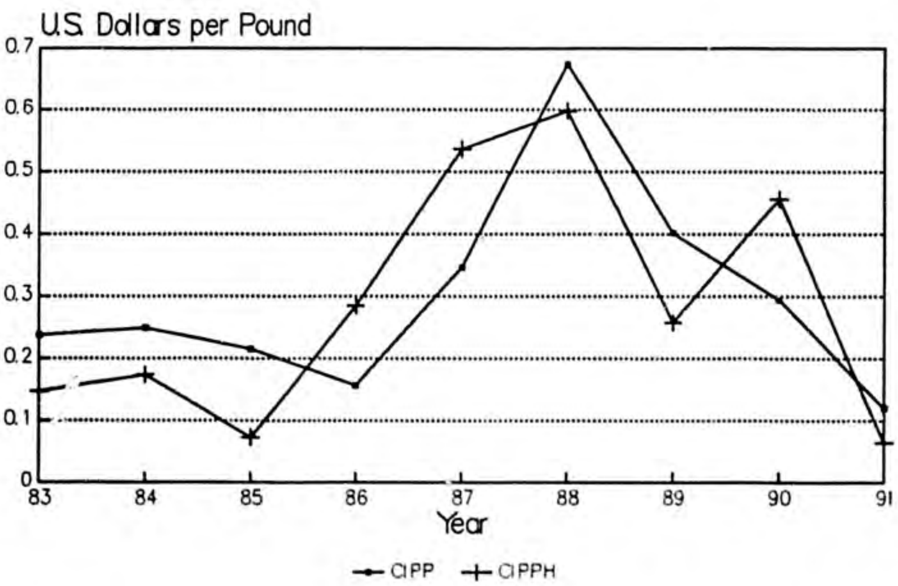

FIGURE 31 Actual (CIPP) versus Predicted (CIPPH) Historical Cook Inlet Pink Annual Exvessel Price (1983-1991)

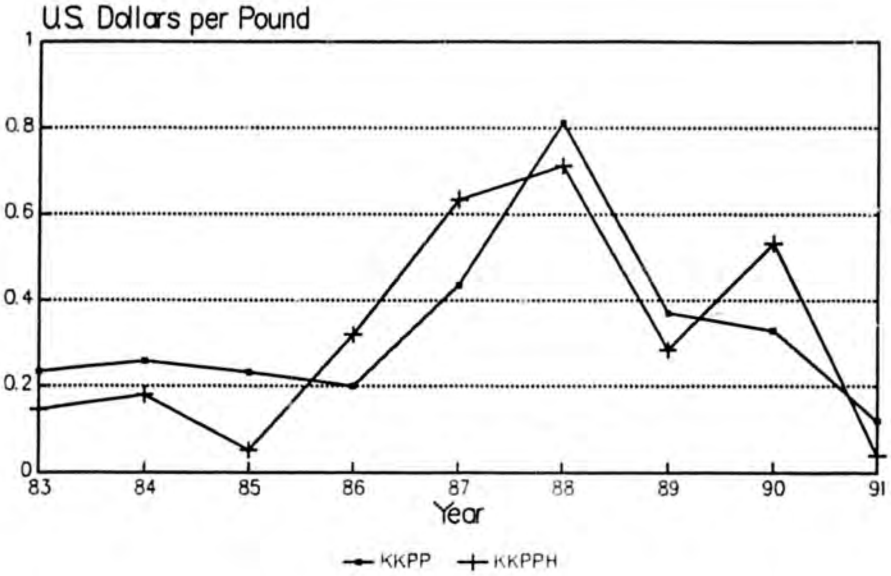

FIGURE 32 Actual (KKPP) versus Predicted (KKPPH) Historical Kodiak Pink Annual Exvessel Price (1983-1991)

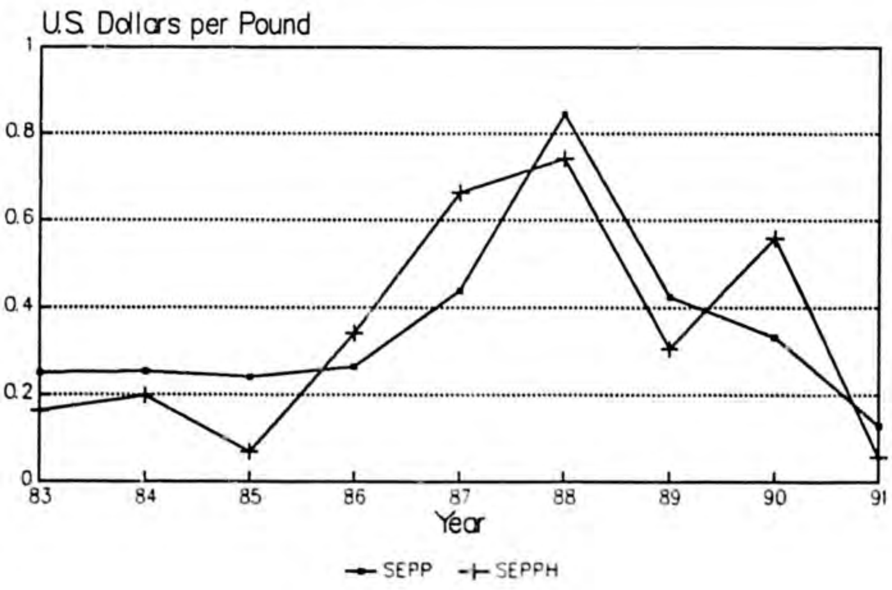

FIGURE 33 Actual (SEPP) versus Predicted (SEPPH) Historical Southeast Pink Annual Exvessel Price (1983-1991)

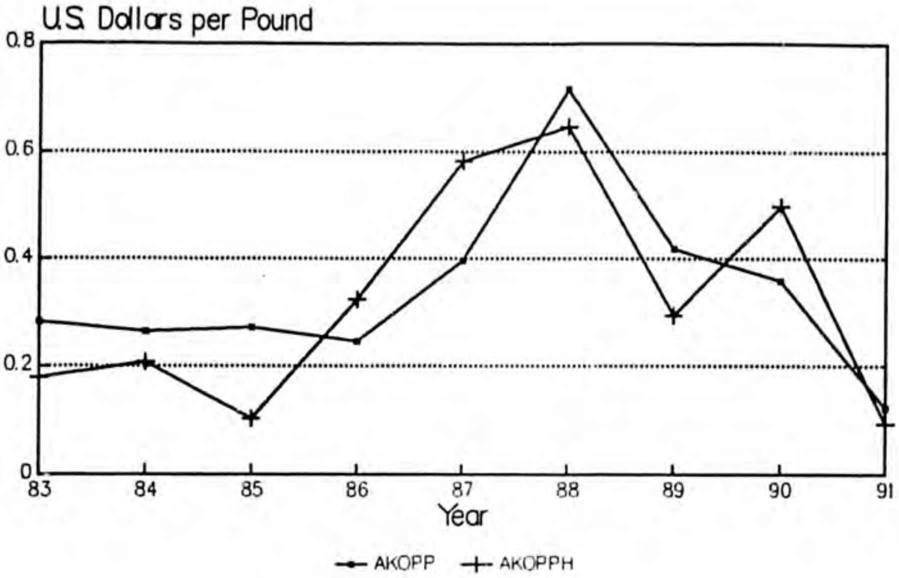

FIGURE 34 Actual (AKOPP) versus Predicted (AKOPPH) Historical Rest-of-Alaska Pink Annual Exvessel Price (1983-1991)

Chum Salmon Exvessel Price Equations

The estimation results for the various regional and statewide chum salmon exvessel price equations are presented in Table 23. As with pink salmon, chum exvessel prices were estimated as linear functions of NAPLEX. The equations performed moderately well. The reported R^2s for the chum exvessel price equations ranged from (PWCP) to 0.97 (SECP).

Table 23. Estimation Results for Prince William Sound, Cook Inlet, Kodiak, Southeast and Rest-of-Alaska, Chum Exvessel Prices, PWCP, CICP, KKCP, SECP, and AKOCP, respectively, for the 1983-91 Time Period (t-values are presented parenthetically).

Exvessel Price	Constant	NAPLEX* Coefficient	R^2	DW
PWCP	-0.025 (-0.24)	1.205 (5.22)	0.77	2.081
CICP	0.137 (2.18)	0.773 (5.44)	0.79	2.67
KKCP	-0.112 (1.70)	1.341 (9.00)	0.91	2.86
SECP	0.025 (0.72)	1.246 (16.09)	0.97	2.071
AKOCP	0.149 (3.58)	0.530 (5.63)	0.80	1.81

*NAPLEX is a weighted average exvessel price for North American low-valued Salmon (Pink and Chum).

The chum exvessel price equations, like the pink equations, perform adequately, although there are certain problems. The correlation coefficients range from 0.696 (AKOCP) to 0.803 (PWCP). The UR statistics were somewhat high, indicating some systematic error in the equations. Additionally, the Theil U statistics were considered somewhat high, exceeding 3.0 for two of the equations.

Table 24. Ex-post Simulation Forecast Goodness-of-Fit Statistics for Prince William Sound, Cook Inlet, Kodiak, Southeast, and Rest-of-Alaska, Chum Exvessel Prices (PWCP, CICP, KKCP, SECP, and AKOCP, respectively), 1983-1991 Time Period.

Exvessel Price	Corr (R)	Bias (UM)	Reg (UR)	Dist (UD)	THEIL U
PWCP	0.803	0.003	0.175	0.823	0.3052
CICP	0.700	0.001	0.220	0.778	0.2722
KKCP	0.743	0.001	0.286	0.713	0.3979
SECP	0.822	0.000	0.302	0.698	0.2719
AKOCP	0.696	0.008	0.246	0.746	0.2380

Concern over the high Theil U statistics is tempered by comparison of the simulation predicted and actual chum exvessel prices. Examination of Figures 35-39 (which provide actual and predicted PWCP, CICP, KKCP, SECP, and AKOCP, respectively), reveal that much of the prediction error is due to over-prediction of 1987 exvessel prices and under prediction of 1985 exvessel prices. The important criterion for measuring model success, in the context of this study, is whether the models are accurate in predicting average exvessel prices over time. Thus, the individual misses in 1987 and 1985 are not considered a general liability when evaluating model performance.

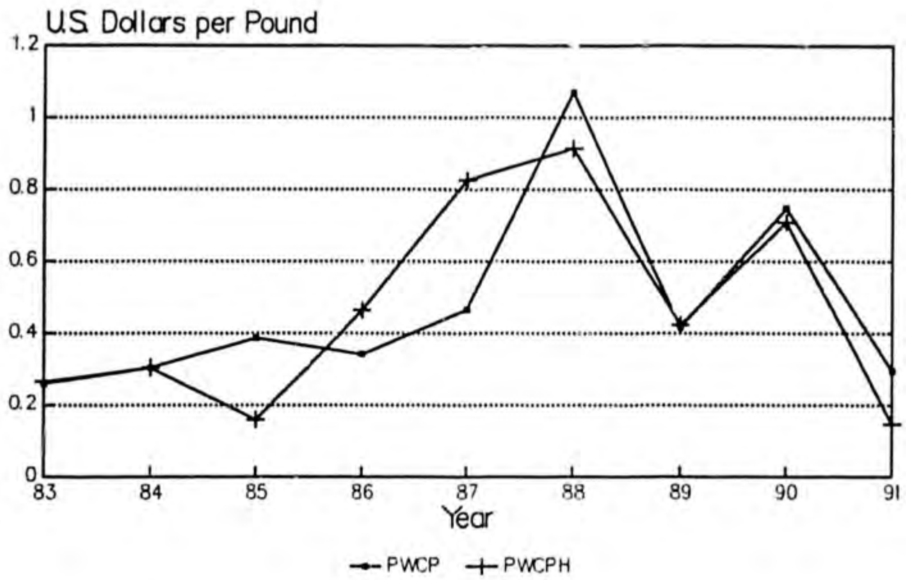

FIGURE 35 Actual (PWCP) versus Predicted (PWCPH) Historical Prince William Sound Chum Annual Exvessel Price (1983-1991)

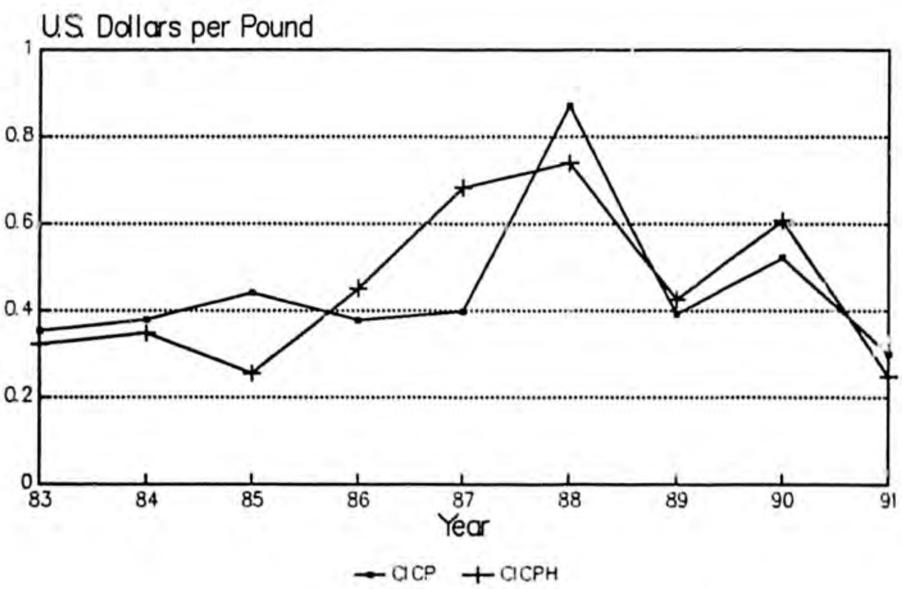

FIGURE 36 Actual (CICP) versus Predicted (CICPH) Historical Cook Inlet Chum Annual Exvessel Price (1983-1991)

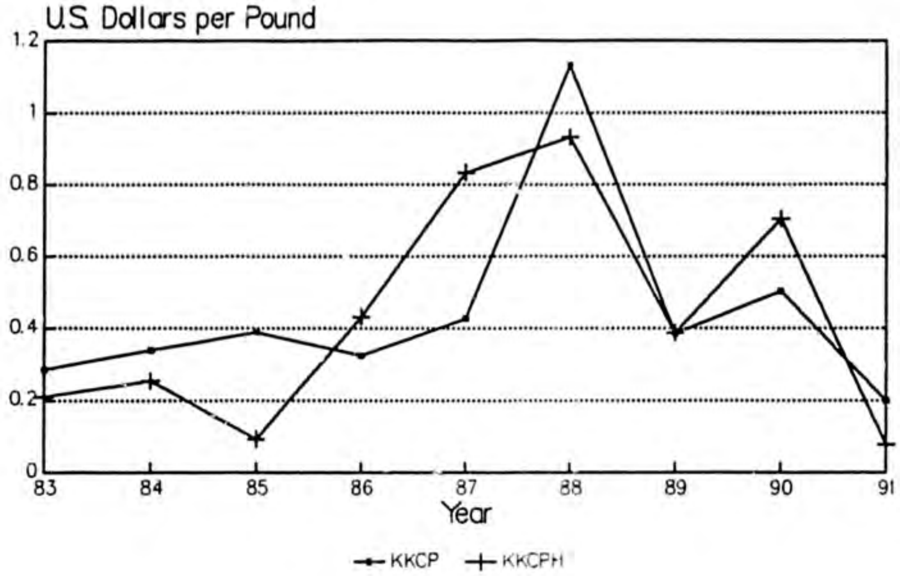

FIGURE 37 Actual (KKCP) versus Predicted (KKCPH) Historical Kodiak Chum Annual Exvessel Price (1983-1991)

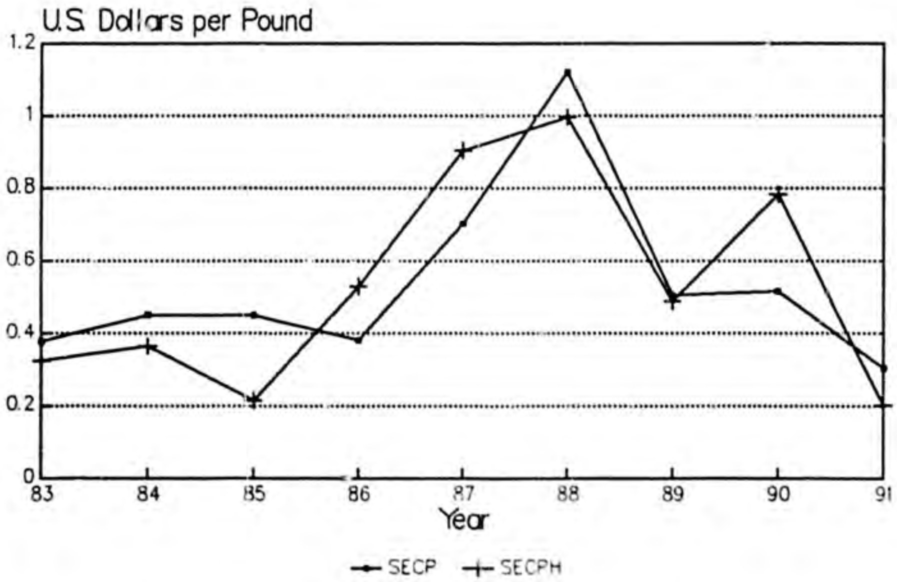

FIGURE 38 Actual (SECP) versus Predicted (SECPH) Historical Southeast Chum Annual Exvessel Price (1983-1991)

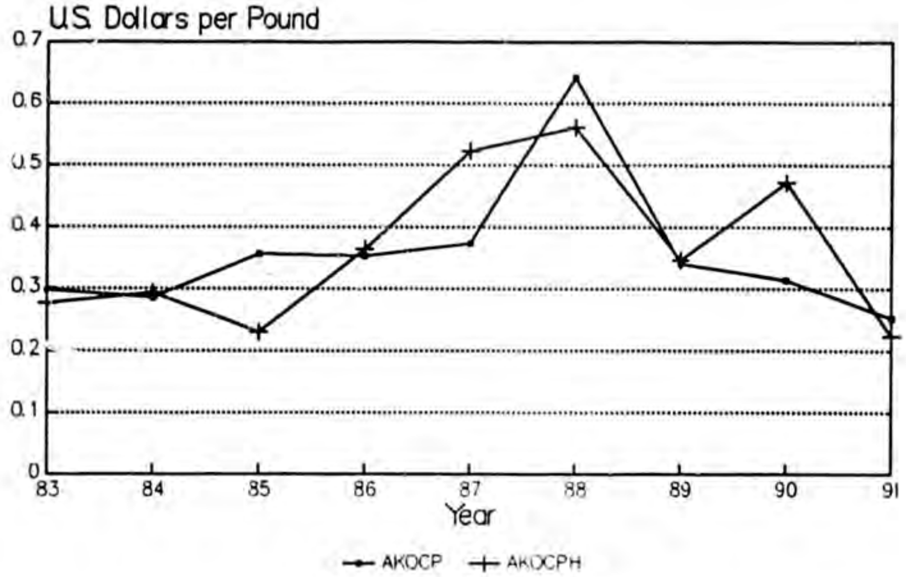

FIGURE 39 Actual (AKOCP) versus Predicted (AKOCPH) Historical Rest-of-Alaska Chum Annual Exvessel Price (1983-1991)

Forecasting

Forecasts of future salmon price levels are important for enhancement evaluation so policymakers and operators can make efficient resource allocation decisions. Three factors are critical in forecasting salmon prices. First, the estimated model must be a reasonably accurate representation of equilibrium price and quantity formation within salmon markets. One way to measure this accuracy is to see how well the model tracks the historical data, as was done in the previous sections. Second, past market structure, upon which the salmon models are based, need to continue into the future. And third, the predetermined explanatory variables in the model must be accurately forecasted. In this study the predicted salmon prices will be "real" prices. Real prices are prices that have been discounted to todays value. The use of discounted prices will also simplify the construction of future explanatory variable values.

Forecasting prices for any commodity is difficult at best. Uncertainty as to the future conditions under which the modelled markets will operate and the future values of predetermined variables have always plagued forecasters. In addition, changing exchange rates further compound the uncertainty about future price levels. Salmon price forecasting is further complicated by the recent emergence of the farmed salmon industry. This is a relatively new market that is still in its development stages. It is not possible to fully model the impact of this market on salmon prices given its continuing transition and brief history. Inability to fully capture structural changes in the salmon markets attributable to farmed salmon led to the inclusion of several indicator variables in the salmon price models. Since such changes cannot be anticipated ex ante, prices may deviate from the forecasted predictions. Nevertheless, it is hoped that the forecasted prices will at least indicate magnitudes and directions of price movement.

Forecasting Exogenous Variables

Forecasting salmon prices over a 15 year time horizon requires specifying values for all exogenous variables for the forecast period 1992-2006. Various methods were employed in specifying future exogenous variables including: econometric techniques involving time trends, holding the values of certain variables constant, and basing future values on the researchers knowledge of the industry and expert opinion.

Below are a list of all the exogenous variables for which future values were specified.

Indicator Variables

DQ_is = quarterly indicator variables for quarter i, where DQ_i is 1 in quarter i and 0 elsewhere, including the time period through 2006.

C = a constant assigned a value of through 2006

D86 = an indicator variable which is assigned a value of 1 in 1986, and zero elsewhere, including the time period of 1993-2006.

D87 = an indicator variable which is assigned a value of 1 in 1987, and zero elsewhere, including the time period of 1993-2006.

D89 = an indicator variable which is assigned a value of 1 in 1989, and zero elsewhere, including the time period of 1993-2006.

D91 = an indicator variable which is assigned a value of 0 between 1983 and 1990 and a value of 1 in 1991. For all equations except the high-valued exvessel equation the value of D91 was assigned 0 between 1992 and 2006. In the high-valued exvessel equation the value remained at 1 between 1992 and 2006.

D22 = an indicator variable which is assigned a value of 1 in the second quarter of 1986 and zero elsewhere, including the time period from 1992 to 2006.

DSEPT90 = An indicator variable that equals one beginning in the fourth quarter of 1990, and zero otherwise, including 1992-2006.

DMAR91 = An indicator variable that equals one beginning in the first quarter of 1991, and zero otherwise, including 1992-2006.

DISEASE = an indicator variable assigned a value of 1 for the last two quarters of 1986 and the first two quarters of 1987 and a value of 0 elsewhere including 1992-2006.

D4T = an indicator variable which is assigned a value of 1 for quarter four and is multiplied by a time variable which starts at 1 for 1981 and ends at 26 for 2006, and is assigned a value of 0 elsewhere.

In future forecast models of low-valued salmon the indicator variable D91 is set equal to one in 1991, and zero in all other years through 2006. This indicator variable captured unexplained variation in low-valued salmon prices that led to the extremely low 1991 prices.

In the high-valued salmon equation, D91 was given the value of one through 2006. High-valued salmon prices in 1991, were probably low, in part due to high volumes of salmon in the market including farmed salmon. D91 was specified to capture structural changes associated with the influx of additional salmon onto the market. Since these structural changes are expected to continue into the future, D91 was not turned off (given a zero value) in forecasting future high-valued salmon prices.

Exogenous variable predicted using ordinary-least-squares

EPOP = the population of the EEC, in millions.

JPOP = the population of the Japan, in millions.

UPOP = the population of the United States, in millions.

JYR = the "real" food consumption expenditure in Japan, in billions of lbs.

EYR = the "real" private consumption expenditure in the EEC, in millions of lbs.

Future values for each of the above variables were extrapolated on the basis of observed 1983 to 1991 growth rates.

Variables which had future values maintained at 1991 levels.

ECUUSA = the ECU/U.S. dollar exchange rate.

NORUSA = the Norwegian kroner/U.S. dollar exchange rate.

JAPUSA = the Norwegian kroner/U.S. dollar exchange rate.

NORJAP = the Norwegian kroner/Japanese yen exchange rate.

NORECU = the Norwegian kroner/ECU exchange rate.

ECPI = the EEC consumer price index for food.

UCPI = the U.S. producer price index for food.

JCPI = the Japanese consumer price index for food.

UTAX = the U.S. tariff placed on fresh imports of Norwegian farmed Atlantic salmon

ETAX = the EEC tariff placed on imports of fresh/frozen salmon

JTAXF = the Japanese tariff placed on imports of fresh/frozen salmon

JTAXC = the Japanese tariff placed on imports of canned/frozen salmon

JINT = the Japanese discount rate.

PTUNAR = the weighted average "real" price of a "high-valued" substitute fish consisting of fresh tuna, measured in yens per pound.

PSQUIDR = the weighted average "real" price of a "lower-valued" substitute fish consisting of fresh squid, measured in yens per pound

Each of the above variables were assigned the values observed in the fourth quarter of 1991, which was the first period to be predicted by the model. By assigning the values for the consumer price indices to the fourth quarter of 1991, the predicted prices will be in real terms at the beginning of 1992.

Variables in which expert opinion were used

UYR = the "real" United States personal disposable income, in millions of U.S. Dollars.

NXQSUP = total Norwegian exports of farmed Atlantic Salmon, in millions of lbs.

QSCOT12 = the estimated quantity of Scottish and Irish farmed Atlantic salmon remaining in the EEC countries in millions of lbs.

CFARMP = the sum of Chilean, Canadian Pacific, and Canadian Atlantic salmon exported to the United States in millions of lbs.

A 3 percent annual growth rate for U.S. real personal disposable income was specified, as based on discussions with macroeconomists. The total supply of farmed Atlantic salmon was held at its 1991 level, coinciding with the opinions of many experts that growth has reached its maximum sustainable point. However, there are some current indications that the industry may expend in the future. Farm salmon from Canada and Chile were allowed to grow at 3 percent quarterly.

Bloc 2 - Wild and farmed salmon harvests

All wild salmon harvests for Canada, Washington, Oregon, and California, were estimated based on 10-year historical averages. All Alaska non-hatchery wild salmon harvest were estimated on the same basis, with the exception of Prince William Sound Pinks, Cook Inlet sockeye, Kodiak sockeye and pink, and Southeast chinook salmon. Wild and hatchery harvests for these salmon species were predicted by Jerome Collie of UAF at Juneau. The 10-year average harvest was agreed upon by Ginny Fay of Senator Cotten's office and Jeff Hartman of FRED division and communicated to the principle investigators in a September meeting at Fairbanks Alaska.

The future hatchery harvests for the other Alaska regions and species were estimated by the hatchery operators in a survey conducted by the FRED division of ADF&G.

Forecast Results

The 1992-2006 forecasted prices by species, for the modelled regions of Prince William Sound, Cook Inlet, Southeast, and Kodiak are presented below. Also, a weighted average price for all other Alaska regions is included in the forecasted prices.

Table 25. Predicted Real Prices for the Selected Sockeye Fisheries of Prince William Sound (PWRPH), Cook Inlet (CIRPH), Kodiak (KKRPH), Southeast (SERPH), and Alaska--All Other Regions (AKORPH) for 1992-2006.

YEAR	PWRPH	CIRPH	KKRPH	SERPH	AKORPH
1992	1.30	1.15	1.12	1.19	0.90
1993	1.38	1.21	1.19	1.26	0.95
1994	1.34	1.18	1.15	1.23	0.92
1995	1.40	1.23	1.21	1.29	0.97
1996	1.45	1.26	1.25	1.33	1.00
1997	1.51	1.31	1.30	1.39	1.04
1998	1.57	1.35	1.35	1.44	1.08
1999	1.60	1.38	1.38	1.48	1.11
2000	1.63	1.40	1.41	1.51	1.13
2001	1.67	1.43	1.43	1.54	1.15
2002	1.71	1.46	1.47	1.58	1.18
2003	1.75	1.50	1.51	1.62	1.21
2004	1.80	1.53	1.55	1.67	1.25
2005	1.85	1.57	1.59	1.71	1.28
2006	1.90	1.60	1.63	1.76	1.31

Table 26. Predicted Real Prices for the Selected Pink Fisheries of Prince William Sound (PWPPH), Cook Inlet (CIPPH), Kodiak (KKPPH), Southeast (SEPPH), and Alaska--All Other Regions (AKOPPH) for 1992-2006.

YEAR	PWPPH	CIPPH	KKPPH	SEPPH	AKOPPH
1992	0.28	0.24	0.27	0.29	0.28
1993	0.27	0.24	0.26	0.28	0.27
1994	0.28	0.24	0.27	0.29	0.28
1995	0.26	0.23	0.25	0.27	0.26
1996	0.26	0.23	0.25	0.27	0.27
1997	0.27	0.24	0.26	0.28	0.28
1998	0.27	0.24	0.26	0.28	0.27
1999	0.27	0.24	0.26	0.28	0.28
2000	0.28	0.25	0.27	0.29	0.28
2001	0.30	0.26	0.29	0.31	0.30
2002	0.30	0.26	0.29	0.31	0.30
2003	0.30	0.26	0.29	0.31	0.30
2004	0.32	0.28	0.31	0.33	0.32
2005	0.34	0.29	0.33	0.35	0.33
2006	0.35	0.31	0.35	0.37	0.34

Table 27. Predicted Real Prices for the Selected Chum Fisheries of Prince William Sound (PWCPH), Cook Inlet (CICPH), Kodiak (KKCPH), Southeast (SECPH), and Alaska--All Other Regions (AKOCPH) for 1992-2006.

YEAR	PWCPH	CICPH	KKCPH	SECPH	AKOCPH
1992	0.40	0.41	0.37	0.47	0.34
1993	0.39	0.41	0.35	0.46	0.33
1994	0.41	0.41	0.37	0.47	0.34
1995	0.38	0.40	0.34	0.44	0.33
1996	0.39	0.40	0.35	0.45	0.33
1997	0.40	0.41	0.36	0.46	0.33
1998	0.40	0.41	0.36	0.46	0.33
1999	0.40	0.41	0.36	0.47	0.34
2000	0.41	0.42	0.37	0.48	0.34
2001	0.43	0.43	0.39	0.49	0.35
2002	0.43	0.43	0.39	0.49	0.35
2003	0.43	0.43	0.39	0.49	0.35
2004	0.46	0.45	0.42	0.52	0.36
2005	0.48	0.46	0.45	0.54	0.37
2006	0.49	0.47	0.47	0.56	0.38

Table 28. Predicted Real Prices for the Selected Coho Fisheries of Prince William Sound (PWSPH), Cook Inlet (CISPH), Kodiak (KKSPH), Southeast (SESPH), and Alaska--All Other Regions (AKOSPH) for 1992-2006.

YEAR	PWSPH	CISPH	KKSPH	SESPH	AKOSPH
1992	0.79	0.61	0.65	1.04	0.63
1993	0.82	0.63	0.67	1.09	0.66
1994	0.81	0.62	0.66	1.07	0.65
1995	0.84	0.64	0.67	1.11	0.67
1996	0.86	0.66	0.69	1.15	0.69
1997	0.89	0.68	0.70	1.19	0.72
1998	0.92	0.70	0.72	1.24	0.74
1999	0.94	0.71	0.73	1.26	0.75
2000	0.95	0.72	0.74	1.29	0.77
2001	0.97	0.74	0.75	1.31	0.78
2002	0.99	0.75	0.76	1.34	0.80
2003	1.01	0.77	0.77	1.38	0.82
2004	1.04	0.79	0.79	1.41	0.84
2005	1.06	0.80	0.80	1.45	0.85
2006	1.09	0.82	0.81	1.49	0.87

Table 29. Predicted Real Prices for the Selected Chinook Fisheries of Prince William Sound (PWKPH), Cook Inlet (CIKPH), Kodiak (KKKPH), Southeast (SEKPH), and Alaska--All Other Regions (AKOKPH) for 1992-2006.

YEAR	PWKPH	CIKPH	KKKPH	SEKPH	AKOKPH
1992	1.53	1.11	1.00	2.22	1.34
1993	1.60	1.13	1.02	2.27	1.37
1994	1.56	1.12	1.01	2.25	1.36
1995	1.62	1.14	1.03	2.29	1.38
1996	1.66	1.15	1.04	2.32	1.40
1997	1.72	1.17	1.05	2.36	1.43
1998	1.80	1.18	1.07	2.40	1.45
1999	1.81	1.19	1.08	2.42	1.47
2000	1.84	1.20	1.08	2.44	1.48
2001	1.87	1.21	1.09	2.46	1.50
2002	1.91	1.22	1.10	2.49	1.51
2003	1.96	1.23	1.11	2.52	1.53
2004	2.01	1.25	1.12	2.55	1.56
2005	2.05	1.26	1.14	2.58	1.57
2006	2.10	1.27	1.15	2.62	1.60

For all fisheries the price gradually increases from 1992 to 2006. The accuracy of these predictions are predicated on the accuracy of the estimated model, the structure of the salmon fishery remaining constant over the next 15 years, and all the explanatory variables, including wild harvests, being accurately forecasted. To the extent that these assumptions are violated the predictions will stray from actual future prices.

The model predicts that sockeye prices will rise 40 to 60 cents, on average, over the next 15 years at projected harvests as specified in base case scenario 1. Bristol Bay has the state's largest sockeye salmon harvest. Therefore, the "Other Alaska" column, which displays an increase of $0.90 to $1.30, is compromised mainly of Bristol Bay reds.

The pink salmon price is predicted to remain relatively low until the end of this decade when increases in demand surpass growth in supply, and the necessary levels of canned salmon are depleted. The overall growth in real prices for pink salmon is predicted to grow by approximately 7 cents, (in real terms) on average, over the 15 year period. The chum salmon fishery predicted real prices increase approximately 10 cents on average over the 15 year period. The coho fishery also shows a growth in real prices, from 25 cents to 50 cents on average over the 15 year period. The chinook prices display approximately the same growth, with prices remaining highest in Southeast.

The above predictions should not be judged on their accuracy for any given year or other short time periods. The model was designed to predict real price trend, so that the average real price for the entire 15 year period would be closer than naive speculation.

The price increases for sockeye, chinook, and coho salmon may be on the upper end of actual price increases. In other words, they may be overestimated if the general increase in prices from expanding demand induces greater activity in the farm salmon sector than predicted. The farmed production forecasts for the future were based on experts opinions. These opinions were formed during a period of low current prices. An increase in future salmon prices may provide an incentive for producers to increase farmed salmon supply. This would dampen real price increases for the high-end valued Pacific salmon such as chinook, coho and sockeye.

Confidence Intervals

Explanatory variables cannot be forecasted with great accuracy. Therefore, the above price forecasts will deviate from actual prices, in part, due to deviations between predicted future values and actual values of the explanatory variables. For this reason, the impact of deviations in the forecasted exogenous variables to predicted prices were examined. The price impact of the following changes in exogenous variable were examined:

1) Real forecasted income in the U.S., the EEC, and Japan was varied by 2 percent per year;

2) The Japanese-U.S. forecasted exchange rate was varied 25 percent per year;

3) The ECU-U.S. forecasted exchange rate was varied by 20 percent per year;

4) The real prices of substitute fish in Japan was varied by 20 percent per year;

5) Farm production from all regions was varied by 15 percent per year from forecasted levels.

These variations were made from examination of historical fluctuations in these variables. To construct the confidence intervals the explanatory variable listed above were simultaneously varied in the direction that would give the greatest increase to salmon prices, then varied in the opposite direction. The two set of exogenous variables were then used in the simulated cases. Figures 40 to 44 below show the average, high, and low predicted weighted Alaska exvessel prices resulting from the forecasts using actual predicted exogenous variable levels and the adjusted exogenous variable values.

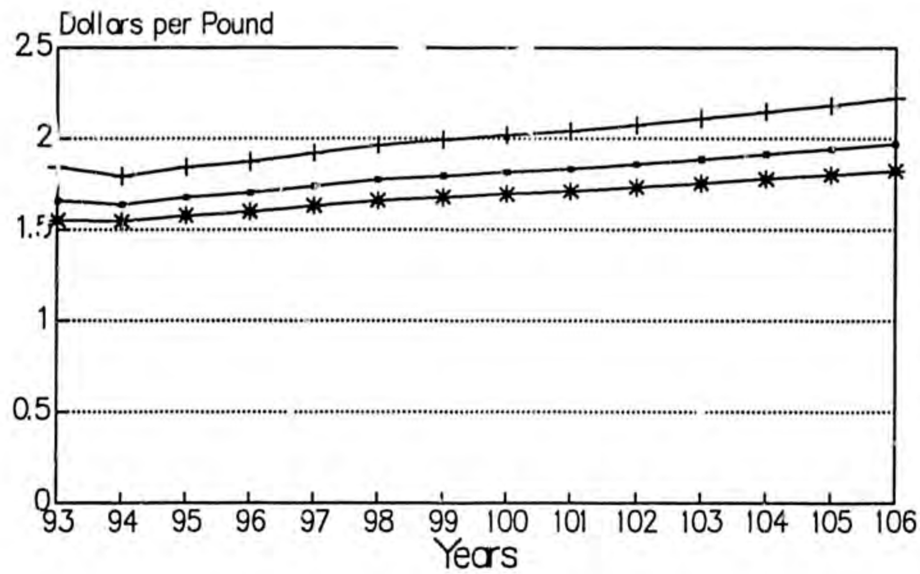

Figure 40. Predicted Annual Alaska Average, High, and Low Chinook Exvessel Prices, 1993-2006.

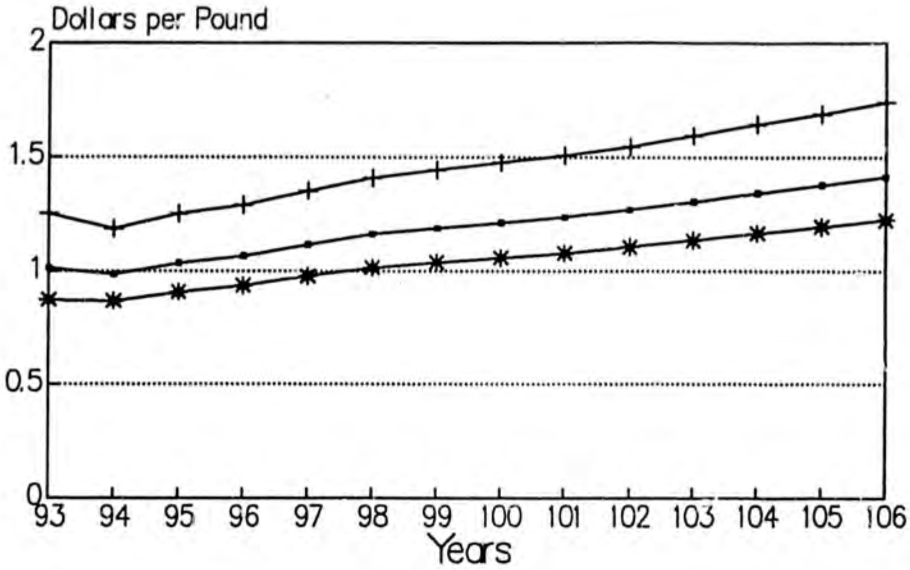

Figure 41. Predicted Annual Alaska Average, High, and Low Sockeye Exvessel Prices, 1993-2006.

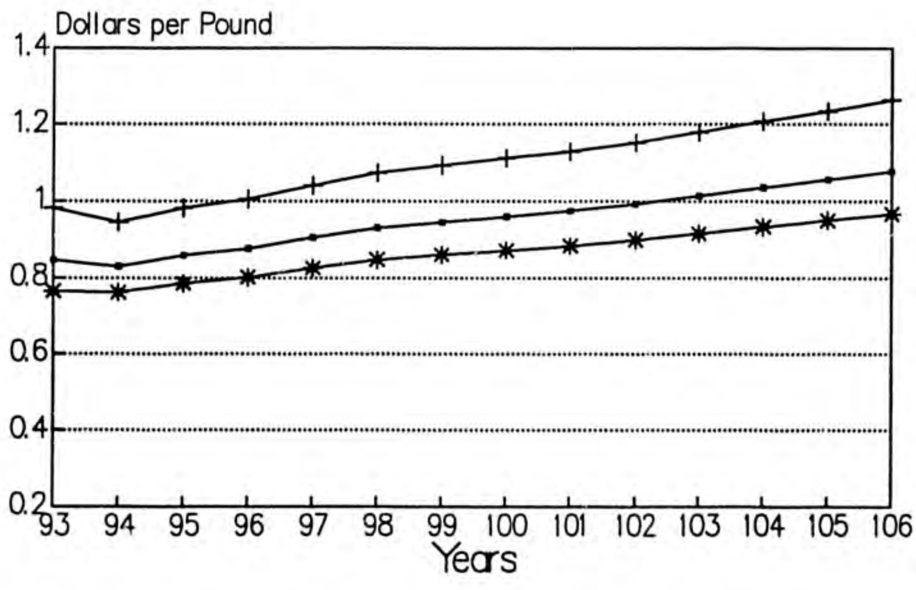

Figure 42. Predicted Annual Alaska Average, High, and Low Coho Exvessel Prices, 1993-2006.

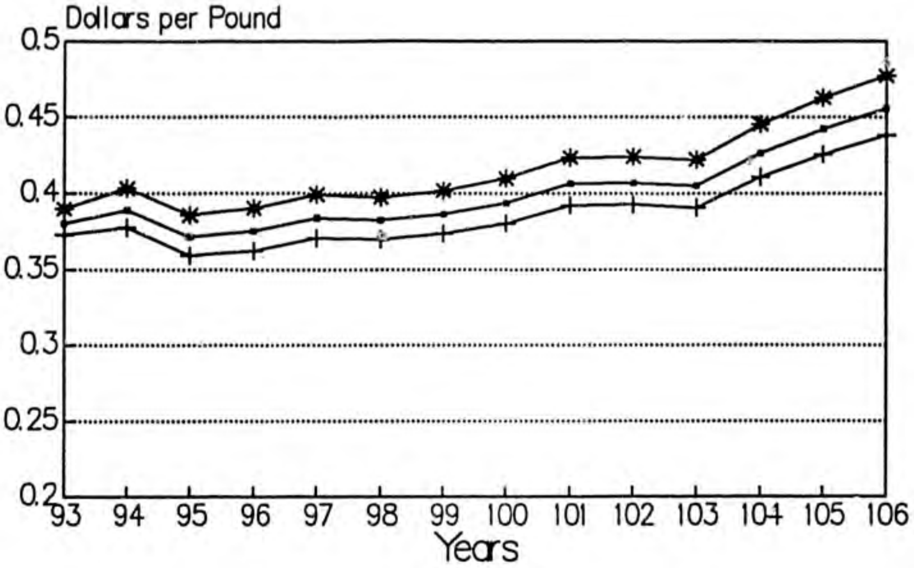

Figure 43. Predicted Annual Alaska Average, High, and Low Chum Exvessel Prices, 1993-2006.

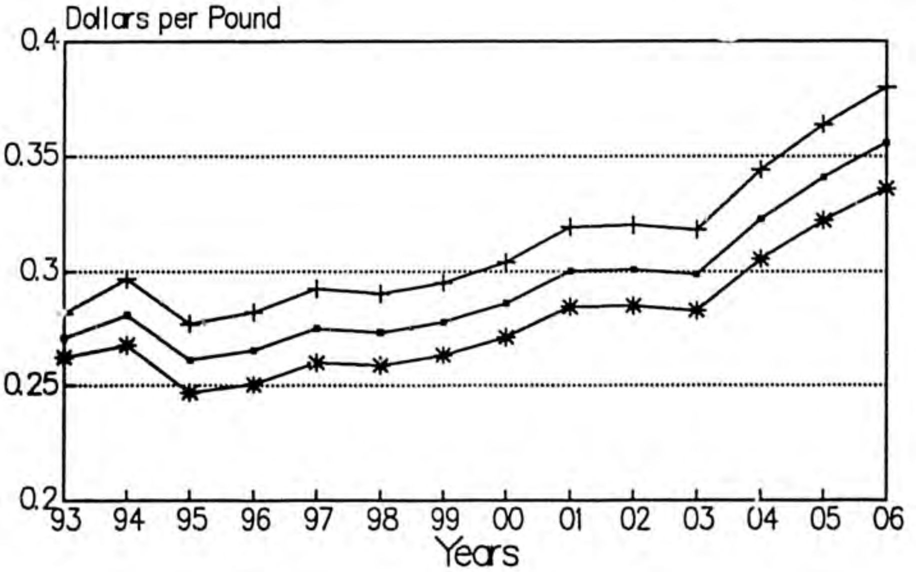

Figure 44. Predicted Annual Alaska Average, High, and Low Pink Exvessel Prices, 1993-2006.

As previously observed, increases in the values of demand variables (e.g. income and population) coupled with a predicted decrease in wild stocks led to an upward price trend over the 15 year future time horizon. These price increases would be dampened if farmed salmon producers increased supplies in response to the higher prices.

One factor that detracts from the predictive power of the model is that the Atlantic salmon portion of Bloc 1 is not included in the fu e simulations. Time constraints were too severe to get this section to simulate after initial problems were encountered. Consequently, future prices were set equal to the 1991 third quarter price of Norwegian salmon to the EEC and North America. Fine tuning of the model will continue into the future and, hopefully, this problem will be solved. Nonetheless, this model sho. :omings should not seriously affect the results presented for the cases examined in this section.

Predicted Revenue Effects of Cases 1-11

On pages 3 and 4 of this report the 11 cases to be analyzed were presented. These cases were put forward in the original RFP. At the September meeting with Ginny Fay and Jeff Hartman it was decided that cases 1- 6 would be simulated with the average, high, and low prices, and cases 7-11 would be simulated with the average prices. Forecasted revenue averages for the time period of 1997-2006 will be presented. The revenue figures represent 10-year averages which are based on the changes specified in the case scenarios for hatchery production and the associated changes in harvest (except chinook which starts in 1998).

Recall, in bloc 1 estimation it was necessary that chinook, coho, and sockeye be aggregated and that pink and chum be aggregated. These aggregations imposed on the model the use the assumption that chinook, coho, and sockeye salmon were perfect substitutes, and that chum and pink salmon were perfect substitutes. The overly restrictive nature of these assumptions are partially alleviated in Bloc 2 by correlating predicted North America high-valued and low-valued exvessel prices with species specific Alaska regional exvessel prices. Nevertheless, we cannot state, *a priori*, what the cross-price effects are within the high-valued and low-valued salmon groupings. Cross price effects could range from zero if species are not substitutes in the salmon markets, to the actual substitution effect indicated by the model if the species within the high-valued grouping and those within the low-valued grouping are strong substitutes for on another.

Therefore, only upper and lower bounds can be placed on the cross-price effects within salmon groupings. The lower bound would generate expected exvessel prices in the absence of any substitution effect. The upper-bound results in the initial model predicted exvessel prices, which are associated with a strong substitution effect. Both upper bound and lower bound exvessel prices are provided for each of the considered case scenarios.

For certain species, such as chinook and coho. There is expected to be a strong substitution effect because the species fill similar market niches. It should be noted that the substitution effect problems occur between species within the high-valued or low-valued grouping, and not between high-valued species and low-valued species.

As noted, the difficulty in sorting out the substitution effects within a Pacific salmon category are mitigated by placing bounds on the substitution effects. Therefore, special care should be taken when interpreting cases 2-4. Unfortunately, this is not possible when changes in production at multiple hatcheries are considered. i.e., case scenarios 2-4. Bounds cannot be specified in these scenarios because exvessel price changes will depend on own-price effects, in addition, to cross-price substitution effects. The results for cases 7-11 are the easiest to interpret, and , therefore, are presented first, following the base case. Cases 5-6 are presented next, with cases 2-4 provided last.

Case 1 -- Base Case Scenario

Table 30 Predicted Average Annual Harvests, Real Revenue, and Real Exvessel Prices for Prince William Sound Sockeye (PWR), Cook Inlet Sockeye (CIR), Southeast Sockeye (SER), Kodiak Sockeye (KKR), Other Alaska Regional Sockeye (AKOR), and All Alaska Sockeye (AKR), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
PWR	16,223,684	1.699	27,562,709
CIR	26,893,398	1.451	38,983,260
SER	9,693,268	1.570	15,218,431
KKR	21,278,567	1.461	31,067,467
AKOR	172,005,487	1.174	201,984,575
AKR	246,094,406	1.279	314,820,833

Table 31 Predicted Average Annual Harvests, Real Revenue, and Real Exvessel Prices for Prince William Sound Pink (PWP), Cook Inlet Pink (CIP), Southeast Pink (SEP), Kodiak Pink (KKP), Other Alaska Regional Pink (AKOP), and All Alaska Pink (AKP), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
PWP	124,099,162	0.301	37,270,908
CIP	15,687,819	0.263	4,125,1089
SEP	108,661,448	0.312	33,873,455
KKP	44,796,114	0.290	13,022,112
AKOP	33,476,156	0.299	10,009,330
AKP	326,720,701	0.301	98,300,914

Table 32 Predicted Average Annual Harvests, Real Revenue, and Real Exvessel Prices for Prince William Sound Chum (PWC), Cook Inlet Chum (CIC), Southeast Chum (SEC), Kodiak Chum (KKC), Other Alaska Regional Chum (AKOC), and All Alaska Chum (AKC), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
PWC	24,739,905	0.432	10,683,775
CIC	6,788,449	0.430	2,920,617
SEC	66,726,067	0.497	33,164,835
KKC	13,388,277	0.396	5,325,693
AKOC	36,113,753	0.350	12,631,744
AKC	147,756,451	0.436	64,726,666

Table 33 Predicted Average Annual Harvests, Real Revenue, and Real Exvessel Prices for Prince William Sound Coho (PWS), Cook Inlet Coho (CIS), Southeast Coho (SES), Kodiak Coho (KKS), Other Alaska Regional Coho (AKOS), and All Alaska Coho (AKS), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
PWS	6,649,055	0.987	6,561,277
CIS	4,085,305	0.748	3,056,781
SES	16,824,809	1.336	22,483,893
KKS	2,214,332	0.757	1,677,025
AKOS	13,281,378	0.793	10,533,505
AKS	43,054,879	1.029	44,312,483

Table 34 Predicted Average Annual Harvests, Real Revenue, and Real Exvessel Prices for Prince William Sound Chinook (PWK), Cook Inlet Chinook (CIK), Southeast Chinook (SEK), Kodiak Chinook (KKK), Other Alaska Regional Chinook (AKOK), and All Alaska Chinook' (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
PWK	1,512,850	1.906	2,883,069
CIK	686,856	1.223	840,649
SEK	7,329,879	2.484	18,204,606
KKK	130,865	1.100	143,890
AKOK	6,422,050	1.510	9,699,213
AKK	16,082,501	1.976	31,771,429

The predicted average harvests and real prices and revenues for 1997-2006 are within the bounds that have been historically observed in the past decade. The average sockeye salmon harvest is 246 million pounds and the average exvessel price is $1.28 per pound. The average predicted real revenue of 314 million dollars is approximately 60 million higher than those found in the 1980s, although lower than those found from 1987 to 1991.

The predicted average annual pink harvest for Alaska is 326 million pounds. Predicted average real exvessel price and revenues are $0.30 per pound and 98 million pounds, respectively. Both the predicted average revenue and harvest are slightly above those observed in the 1980s (the predicted price is 1 cent lower than the average 1980s price). The predicted price is also below actual 1987 to 1990 prices but well above the 1991 price.

The predicted average Alaska chum harvest, exvessel price, and exvessel revenue are 147 million pounds, $0.436 per pound, and $64 million, respectively. The predicted average Alaska harvest and exvessel revenue are nearly twice those of the 1980 to 1991 averages. The predicted price of $0.44 is 3 cents per pound under the 1980-1991 average.

The predicted coho harvest, revenue, and prices are all above the averages for the 1980 to 1991. The predicted average Alaska annual real exvessel price of $1.03 is 6 cents per pound above the average prices found from 1980-1991. The predicted average Alaska chinook harvest and revenues are also above the 1980 to 1991 averages. The predicted average Alaska annual price of $1.98 is 32 cents per pound above the 1980-1991 average.

Case 7 -- Production from Pink Salmon Enhancement Increases/Decreases 15 percent

Table 35 Base Scenario 7 (Increase) Predicted Average Annual Harvests, Real Revenue, and Real Prices for Prince William Sound Pink (PWP), Cook Inlet Pink (CIP), Southeast Pink (SEP), Kodiak Pink (KKP), Other Alaska Regional Pink (AKOP), Alaska Pink (AKP), Alaska Sockeye (AKR), Alaska Chum (AKC), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
PWP	140,600,522	0.276	38,780,767
CIP	17,577,819	0.244	4,291,210
SEP	109,956,746	0.288	31,624,326
KKP	46,565,542	0.267	12,434,105
AKOP	33,476,158	0.280	9,357,526
AKP	**348,176,789**	**0.277**	**96,487,936**
AKR	**246,094,406**	**1.278**	**314,611,908**
AKC	**147,756,451**	**0.414**	**61,239,262**
AKS	**43,054,879**	**1.029**	**44,285,778**
AKK	**16,082,501**	**1.975**	**31,760,907**

Table 36 Scenario 7 (Decrease) Predicted Average Annual Harvests, Real Revenue, and Real Prices Base for Prince William Sound Pink (PWP), Cook Inlet Pink (CIP), Southeast Pink (SEP), Kodiak Pink (KKP), Other Alaska Regional Pink (AKOP), Alaska Pink (AKP), Alaska Sockeye (AKR), Alaska Chum (AKC), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
PWP	108,265,361	0.324	35,089,014
CIP	13,797,819	0.281	3,880,719
SEP	107,366,150	0.335	35,988,917
KKP	43,033,080	0.313	13,515,655
AKOP	33,476,155	0.318	10,643,472
AKP	**305,938,565**	**0.324**	**99,117,779**
AKR	**246,094,406**	**1.280**	**315,040,732**
AKC	**147,756,451**	**0.461**	**68,117,239**
AKS	**43,054,879**	**1.030**	**44,340,597**
AKK	**16,082,501**	**1.976**	**31,782,508**

Table 37 Case 7 (Increase) Predicted Changes in Total Annual Real Revenue from Base Scenario 1 for Prince William Sound Pink (PWP), Cook Inlet Pink (CIP), Southeast Pink (SEP), Kodiak Pink (KKP), Other Alaska Regional Pink (AKOP), Alaska Pink (AKP), Alaska Sockeye (AKR), Alaska Chum (AKC), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

	Revenue Changes Production Increase		
	(L. Bound) ($/lbs)	(U. Bound) ($/lbs)	(Expected) ($/lbs)
PWP	1,509,859	1,509,859	1,509,859
CIP	166,102	166,102	166,102
SEP	-2,249,129	-2,249,129	-2,249,129
KKP	-588,007	-588,007	-588,007
AKOP	-651,804	-651,804	-651,804
AKP	**-1,812,978**	**-1,812,978**	**-1,812,978**
AKR	**-208,925**	**-208,925**	**-208,925**
AKC	**0**	**-3,487,404**	**-871,851**
AKS	**-26,705**	**-26,705**	**-26,705**
AKK	**-10,522**	**-10,522**	**-10,522**
TOTAL	-2,059,130	-5,546,534	-2,930,981

Table 38 Case 7 (Decrease) Predicted Changes in Total Annual Real Revenue from Base Scenario 1 for Prince William Sound Pink (PWP), Cook Inlet Pink (CIP), Southeast Pink (SEP), Kodiak Pink (KKP), Other Alaska Regional Pink (AKOP), Alaska Pink (AKP), Alaska Sockeye (AKR), Alaska Chum (AKC), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

	Revenue Changes Production Decrease		
	(L. Bound) ($/lbs)	(U. Bound) ($/lbs)	(Expected) ($/lbs)
PWP	-2,181,894	-2,181,894	-2,181,894
CIP	-244,389	-244,389	-244,389
SEP	2,115,462	2 115,462	2,115,462
KKP	493,543	493,543	493,543
AKOP	634,142	634,142	634,142
AKP	**816,865**	**816,865**	**816,865**
AKR	**219,899**	**219,899**	**219,899**
AKC	**0**	**3,390,573**	**874,643**
AKS	**28,114**	**28,114**	**28,114**
AKK	**11,079**	**11,079**	**11,079**
TOTAL	1,075,957	4,466,530	1,923,600

The forecast results indicate that a 15 percent increase in pink enhancement product will result in revenue losses between $2 and $5.5 million with an expected loss of $2.9 million. The losses are not shared equally. Prince William Sound, which gets the largest increase in harvest under scenario 7, gains $1.5 million a year. In contrast, gains from slight harvest increases in Southeast and Kodiak are more than offset by the price declines which accompany the higher statewide harvest. Southeast and Kodiak experience harvest declines of $2.249 million and $588,007, respectively. Additionally, the All-Other Alaska region, which does not experience a harvest increase, suffers a revenue decline of $651,804. The potential revenue decrease encountered in the Statewide chum fishery range from zero (no substitution effect) to 3.487 million (if the substitution effect is very strong). The expected revenue loss for chum salmon is $874,643 million. All other species experience negligible revenue decline.

In contrast to the previous results, a 15 percent decrease in the hatchery produced pink salmon leads to forecasted Alaska average annual exvessel revenue increasing between $1 million and $4.5 million, with an expected value of $1.9 million. As previously found, the revenue changes are not equally distributed across fishery regions. In both Price William Sound and Cook Inlet gains from exvessel prices increases, which accompany the lower harvests, are more than offset by harvest declines. Prince William Sound suffers a revenue decline of $2.8 million, while Cook Inlet exvessel revenues decline by $244,389. Southeast, Kodiak and the aggregate All-Other Alaska region experiences gains in exvessel revenues. These regions suffer only slight or no decrease in harvest while enjoying the benefit of the exvessel price increase.

The forecast results for Case 7 show that pink exvessel prices are very sensitive to changes in Pink harvest, given current harvest levels, demand conditions, and market structure. The proportional increase (decrease) in harvest associated with increases (decreases) in hatchery production will be less then the proportional decrease (increase) in pink exvessel prices. Thus, in the absence of any factors which expand demand for pink salmon, an increase (decrease) in hatchery production of pink salmon is expected to decrease (increase) Alaska exvessel revenues.

Case 8 -- Production from Sockeye Salmon Enhancement Increases/Decreases 15 percent

Table 39 Scenario 8 (Increase) Predicted Average Annual Harvests, Real Revenue, and Real Prices Base for Prince William Sound Sockeye (PWR), Cook Inlet Sockeye (CIR), Southeast Sockeye (SER), Kodiak Sockeye (KKR), Other Alaska Regional Sockeye (AKOR), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
PWR	17,420,271	1.684	29,329,776
CIR	27,479,609	1.440	39,528,439
SER	9,857,337	1.556	15,337,104
KKR	22,150,370	1.448	32,056,224
AKOR	172,005,487	1.164	200,164,266
AKR	**248,913,075**	**1.271**	**316,415,811**
AKP	**326,720,701**	**0.300**	**98,151,858**
AKC	**147,756,451**	**0.438**	**64,658,696**
AKS	**43,054,879**	**1.021**	**43,955,087**
AKK	**16,082,501**	**1.967**	**31,630,526**

Table 40 Scenario 8 (Decrease) Predicted Average Annual Harvests, Real Revenue, and Real Prices Base for Prince William Sound Sockeye (PWR), Cook Inlet Sockeye (CIR), Southeast Sockeye (SER), Kodiak Sockeye (KKR), Other Alaska Regional Sockeye (AKOR), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
PWR	15,027,098	1.714	25,762,647
CIR	26,331,976	1.463	38,468,677
SER	9,529,200	1.585	15,105,873
KKR	20,379,710	1.474	30,016,855
AKOR	172,005,485	1.185	203,832,851
AKR	**243,273,470**	**1.287**	**313,186,905**
AKP	**326,720,701**	**0.301**	**98,451,189**
AKC	**147,756,451**	**0.439**	**64,795,170**
AKS	**43,054,879**	**1.038**	**44,675,371**
AKK	**16,082,501**	**1.984**	**31,914,516**

Table 41 Case 8 (Increase) Predicted Changes in Total Annual Real Revenue from Base Scenario 1 for Prince William Sound Sockeye (PWR), Cook Inlet Sockeye (CIR), Southeast Sockeye (SER), Kodiak Sockeye (KKR), Other Alaska Regional Sockeye (AKOR), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

	Revenue Changes Production Increase		
	(L. Bound) ($/lbs)	(U. Bound) ($/lbs)	(Expected) ($/lbs)
PWR	1,767,067	1,767,067	1,767,067
CIR	545,179	545,179	545,179
SER	114,284	114,284	114,284
KKR	988,757	988,757	988,757
AKOR	-1,820,309	-1,820,309	-1,820,309
AKR	**1,594,978**	**1,594,978**	**1,594,978**
AKP	**-114,944**	**-114,944**	**-114,944**
AKC	**-67,970**	**-67,970**	**-67,970**
AKS	**0**	**-357,396**	**-89,349**
AKK	**0**	**-140,903**	**-35,226**
TOTAL	1,412,064	913,765	1,287,489

Table 42 Case 8 (Decrease) Predicted Changes in Total Annual Real Revenue from Base Scenario 1 for Prince William Sound Sockeye (PWR), Cook Inlet Sockeye (CIR), Southeast Sockeye (SER), Kodiak Sockeye (KKR), Other Alaska Regional Sockeye (AKOR), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

	Revenue Changes Production Decrease		
	(L. Bound) ($/lbs)	(U. Bound) ($/lbs)	(Expected) ($/lbs)
PWR	-1,800,062	-1,800,062	-1,800,062
CIR	-514,583	-514,583	-514,583
SER	-18,768	-18,768	-18,768
KKR	-1,050,612	-1,050,612	-1,050,612
AKOR	1,848,276	1,848,276	1,848,276
AKR	**-1,633,928**	**-1,633,928**	**-1,633,928**
AKP	**150,275**	**150,275**	**150,275**
AKC	**68,504**	**68,504**	**68,504**
AKS	**0**	**363,888**	**90,972**
AKK	**0**	**143,087**	**35,772**
TOTAL	-1,415,149	-908,174	-1,288,405

Each of the individual sockeye fishery regions, Prince William Sound, Cook Inlet, Kodiak, and Southeast experience increases in exvessel revenues when future sockeye hatchery production is increased by 15 percent, and incur decreases in exvessel revenue when sockeye hatchery production is reduced by 15 percent. The Prince William Sound sockeye fishery experiences the greatest changes in exvessel revenue. A 15 percent increase in sockeye hatchery production results in this fishery's exvessel revenues increasing by an average of $1.767 million annually for the 1997-2006 time period, whereas a 15 percent reduction in sockeye hatchery production results in an average $1.8 million annual decline in exvessel revenue.

The 15 percent increase in sockeye hatchery production increases average annual exvessel revenues to the Cook Inlet, Southeast, and Kodiak sockeye fisheries by $545,179, $114,284, and $988,757, respectively, for the 1997-2006 time period. In contrast, a 15 percent reduction in sockeye salmon hatchery production results in average annual exvessel revenues declines to the Cook Inlet, Southeast, and Kodiak sockeye fisheries of $514,583, $18,768, and $1.050 million, respectively, for the 1997-2006 time period.

The aggregate All-Other-Alaska-Regions harvest is not impacted by changes in sockeye salmon hatchery production. Yet, the exvessel revenues of the fisheries within this group are impacted by the changes in sockeye exvessel prices which accompany the changes in hatchery production. A 15 percent increase in hatchery production reduces average annual exvessel price by one cent per pound, reducing exvessel revenue to this group of fisheries by an annual average of $1.820 million for the 1997-2006 time period. These losses accrue primarily to the Bristol Bay fishery, which is the dominant sockeye fishery within this aggregate group. Sockeye exvessel prices increase if sockeye hatchery production is reduced, and this results in average annual exvessel revenue increases for All-Other-Alaska-Regions of $1.848 million.

The changes in exvessel revenues to the other high-valued salmon species associated with changes in sockeye salmon hatchery production vary depending on the strength of the substitution effect. In the absence of any substitution effect between sockeye salmon and coho and chinook salmon, exvessel revenues to the coho and chinook fisheries would not be affected by the changes in sockeye hatchery production. If the substitution effect is the expected effect, a 15 percent increase in sockeye salmon hatchery production results in coho and chinook salmon exvessel revenue declining by an annual average of $89,349 and $35,226, respectively, for the 1997-2006 time period. A 15 percent reduction in sockeye hatchery production would increase average annual exvessel revenues to the chinook and coho fisheries, given an expected substitution effect, by $90,972 and $35,772.

The exvessel revenues of the low-valued salmon fisheries are moderately impacted by the changes in sockeye salmon hatchery production. The state-wide pink and chum fisheries experience average annual exvessel revenue declines of $114,944 and $67,970, respectively, given a 15 percent increase in sockeye salmon hatchery production. A 15 percent reduction in sockeye salmon hatchery production results in average annual revenue increases to the pink and chum fisheries of $150,275 and $68,504, respectively.

Case 9 – Production from Chum Salmon Enhancement Increases/Decreases 15 percent

Table 43 Scenario 9 (Increase) Predicted Average Annual Harvests, Real Revenue, and Real Prices Base for Prince William Sound Chum (PWC), Cook Inlet Chum (CIC), Southeast Chum (SEC), Kodiak Chum (KKC), Other Alaska Regional Chum (AKOC), Alaska Chum (AKC), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
PWC	27,064,972	0.419	11,330,018
CIC	6,788,449	0.422	2,863,036
SEC	74,694,744	0.483	36,103,049
KKC	14,318,612	0.381	5,484,173
AKOC	36,115,385	0.344	12,422,375
AKC	**158,982,161**	**0.429**	**68,202,653**
AKR	**246,094,406**	**1.279**	**314,801,492**
AKP	**326,720,701**	**0.289**	**94,552,703**
AKS	**43,054,879**	**1.029**	**44,310,017**
AKK	**16,082,501**	**1.975**	**31,770,457**

Table 44 Scenario 9 (Decrease) Predicted Average Annual Harvests, Real Revenue, and Real Prices Base for Prince William Sound Chum (PWC), Cook Inlet Chum (CIC), Southeast Chum (SEC), Kodiak Chum (KKC), Other Alaska Regional Chum (AKOC), Alaska Chum (AKC), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

	Harvests	Price	Revenue
PWC	22,414,838	0.445	9,977,026
CIC	6,788,449	0.439	2,978,387
SEC	58,757,388	0.510	30,010,878
KKC	12,457,941	0.411	5,139,671
AKOC	36,112,122	0.356	12,841,784
AKC	**136,530,740**	**0.446**	**60,947,747**
AKR	**246,094,406**	**1.279**	**314,841,988**
AKP	**326,720,701**	**0.312**	**102,061,423**
AKS	**43,054,879**	**1.029**	**44,315,182**
AKK	**16,082,501**	**1.976**	**31,772,493**

Table 45 Case 9 (Increase) Predicted Changes in Total Annual Real Revenue from Base Scenario 1 for Prince William Sound Chum (PWR), Cook Inlet Chum (CIR), Southeast Chum (SER), Kodiak Chum (KKR), Other Alaska Regional Chum (AKOR), Alaska Chum (AKC), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

	Revenue Changes Production Increase		
	(L. Bound) ($/lbs)	(U. Bound) ($/lbs)	(Expected) ($/lbs)
PWC	646,243	646,243	646,243
CIC	-57,581	-57,581	-57,581
SEC	2,938,214	2,938,214	2,938,214
KKC	158,480	158,480	158,480
AKOC	-209,369	-209,369	-209,369
AKC	**3,475,987**	**3,475,987**	**3,475,987**
AKR	**-19,341**	**-19,341**	**-19,341**
AKP	**0**	**-3,748,211**	**-937,053**
AKS	**-2,466**	**-2,466**	**-2,466**
AKK	**-972**	**-972**	**-972**
TOTAL	3,453,208	-295,003	2,516,155

Table 46 Case 9 (Decrease) Predicted Changes in Total Annual Real Revenue from Base Scenario 1 for Prince William Sound Chum (PWR), Cook Inlet Chum (CIR), Southeast Chum (SER), Kodiak Chum (KKR), Other Alaska Regional Chum (AKOR), Alaska Chum (AKC), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

	Revenue Changes Production Decrease		
	(L. Bound) ($/lbs)	(U. Bound) ($/lbs)	(Expected) ($/lbs)
PWC	-706,749	-706,749	-706,749
CIC	57,770	57,770	57,770
SEC	-3,153,957	-3,153,957	-3,153,957
KKC	-186,022	-186,022	-186,022
AKOC	210,040	210,040	210,040
AKC	**-3,778,919**	**-3,778,919**	**-3,778,919**
AKR	**21,155**	**21,155**	**21,155**
AKP	**0**	**3,760,509**	**940,127**
AKS	**2,699**	**2,699**	**2,699**
AKK	**1,064**	**1,064**	**1,064**
TOTAL	-3,764,001	-3,492	-2,823,874

Case 9 involved increasing/decreasing state enhancement chum hatchery production by 15 percent beginning in 1993, and continuing through 2006. The increased/decreased hatchery production impacts state chum harvests beginning in 1997, when the adult chum return to the state fisheries. The impact of changes in chum hatchery production to statewide exvessel revenues depends on the strength of the substitution effect between chum and pink salmon. In the absence of any substitution effect, a 15 percent increase in chum hatchery production increases average annual state exvessel revenues by $3.456 million for the 1997-2006 time period. A 15 percent decrease in hatchery chum production reduces average annual statewide exvessel revenues by $3.778 million. For an expected substitution effect, a 15 percent increase in chum hatchery production increases average annual Alaska exvessel revenues by $2.516 million. A reduction in chum hatchery production of 15 percent leads to a decrease in average annual Alaska exvessel revenue of 2.823 million.

Exvessel revenues in three of the four individual chum fishery regions, Prince William Sound, Southeast, and Kodiak, vary directly with changes in chum hatchery production, i.e., increases in chum hatchery production leads to increases in exvessel revenues in these fisheries, and decreases in chum hatchery production lead to decreases in exvessel revenues in these fisheries. The changes in the Southeast chum fishery are particularly noteworthy. A 15 percent increase in chum hatchery production increases average annual Southeast chum exvessel revenues by $2.938 million, for the 1997-2006 time period. Reducing chum hatchery production by 15 percent decreases average annual Southeast exvessel revenues by $3.764 million.

The Cook Inlet chum fishery and the aggregate All-Other-Alaska-Regions suffer decreases in average annual exvessel revenues when chum hatchery production is increased, and increases in average annual exvessel revenue when chum hatchery production is reduced. The chum harvests in these two regions are not impacted by the changes in enhancement hatchery chum production. But the regions exvessel revenues are impacted by the changes in exvessel prices which accompany the changes in statewide chum harvests.

The impacts of changes in chum hatchery production to Alaska pink exvessel revenues depend on the strength of the substitution effect between chum and pink salmon (a similar outcome was reported with respect to changes in pink hatchery production). If the two salmon species are not substitutes in the market place, then changes in chum hatchery production will not impact Alaska pink exvessel revenues. If the two species are strong substitutes, then increasing chum hatchery production by 15 percent reduces average annual Alaska pink exvessel revenue by $3.748 million, for the 1997-2006 time period; and a 15 percent reduction in chum salmon hatchery production increases average annual Alaska pink exvessel revenue by $3.476 million.

The average annual Alaska exvessel revenue to the high-valued salmon fisheries are only mildly impacted by the changes in chum hatchery production. For example, average annual Alaska sockeye exvessel revenue increase by $19,341 given a 15 percent reduction in chum hatchery production, and decrease by $21,155 given a 15 percent increase in chum hatchery production.

Case 10 -- Production from Coho Salmon Enhancement Increases/Decreases 15 percent

Table 47 Scenario 10 (Increase) Predicted Average Annual Harvests, Real Revenue, and Real Prices Base for Prince William Sound Coho (PWS), Cook Inlet Coho (CIS), Southeast Coho (SES), Kodiak Coho (KKS), Other Alaska Regional Coho (AKOS), Alaska Coho (AKS), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC) and Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
PWS	6,950,788	0.985	6,844,023
CIS	4,109,651	0.747	3,068,723
SES	17,513,662	1.333	23,347,979
KKS	2,227,020	0.756	1,683,947
AKOS	13,281,380	0.791	10,510,551
AKS	**44,082,501**	**1.031**	**45,455,225**
AKR	**246,094,406**	**1.276**	**314,034,797**
AKP	**326,720,701**	**0.301**	**98,270,643**
AKC	**147,756,451**	**0.438**	**64,712,858**
AKK	**16,082,501**	**1.971**	**31,706,444**

Table 48 Scenario 10 (Decrease) Predicted Average Annual Harvests, Real Revenue, and Real Prices Base for Prince William Sound Coho (PWS), Cook Inlet Coho (CIS), Southeast Coho (SES), Kodiak Coho (KKS), Other Alaska Regional Coho (AKOS), Alaska Coho (AKS), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC) and Alaska Chinook (AKK), for 1997-2006.

	Harvests	Price	Revenue
PWS	6,347,323	0.989	6,277,580
CIS	4,060,959	0.750	3,044,924
SES	16,135,957	1.340	21,616,701
KKS	2,201,643	0.759	1,670,140
AKOS	3,281,376	0.795	10,557,048
AKS	**42,027,258**	**1.027**	**43,166,395**
AKR	**246,094,406**	**1.283**	**315,627,667**
AKP	**326,720,701**	**0.301**	**98,333,701**
AKC	**147,756,451**	**0.438**	**64,741,589**
AKK	**16,082,501**	**1.978**	**31,812,063**

Table 49 Case 10 (Increase) Predicted Changes in Total Annual Real Revenue from Base Scenario 1 for Prince William Sound Coho (PWS), Cook Inlet Coho (CIS), Southeast Coho (SES), Kodiak Coho (KKS), Other Alaska Regional Coho (AKOS), Alaska Coho (AKS), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), and Alaska Chinook (AKK), for 1997-2006.

	Revenue Changes Production Increase		
	(L. Bound) ($/lbs)	(U. Bound) ($/lbs)	(Expected) ($/lbs)
PWS	282,746	282,746	282,746
CIS	11,942	11,942	11,942
SES	864,086	864,086	864,086
KKS	6,922	6,922	6,922
AKOS	-22,954	-22,954	-22,954
AKS	**1,142,742**	**1,142,742**	**1,142,742**
AKP	**-30,271**	**-30,271**	**-30,271**
AKR	**0**	**-786,036**	**-196,509**
AKC	**-13,808**	**-13,808**	**-13,808**
AKK	**0**	**-64,985**	**-32,492**
TOTAL	1,098,663	247,642	869,662

Table 50 Case 10 (Decrease) Predicted Changes in Total Annual Real Revenue from Base Scenario 1 for Prince William Sound Coho (PWS), Cook Inlet Coho (CIS), Southeast Coho (SES), Kodiak Coho (KKS), Other Alaska Regional Coho (AKOS), Alaska Coho (AKS), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), and Alaska Chinook (AKK), for 1997-2006.

	Revenue Changes Production Decrease		
	(L. Bound) ($/lbs)	(U. Bound) ($/lbs)	(Expected) ($/lbs)
PWS	-283,697	-283,697	-283,697
CIS	-11,857	-11,857	-11,857
SES	-867,192	-867,192	-867,192
KKS	-6,885	-6,885	-6,885
AKOS	23,543	23,543	23,543
AKS	**-1,146,088**	**-1,146,088**	**-1,146,088**
AKP	**32,787**	**32,787**	**32,787**
AKR	**0**	**806,834**	**201,709**
AKC	**14,923**	**14,923**	**14,923**
AKK	**0**	**40,634**	**20,317**
TOTAL	-1,098,378	-250,910	-876,352

Case 10 examines impacts to Alaska fisheries of increasing/decreasing state enhancement coho hatchery production by 15 percent annually, beginning in 1993. Alaska exvessel revenues varies directly with the changes in coho hatchery production. The changes in revenue are moderate. A 15 percent increase in coho hatchery production results in average annual statewide exvessel revenue increasing by an expected $869,662. Reducing the coho hatchery production by 15 percent results in statewide exvessel revenue decreasing by an expected $876,352.

The average annual exvessel revenues for each of the four individually modelled coho fishery regions, Prince William Sound, Cook Inlet, Southeast, and Kodiak, vary directly with changes in coho hatchery production. A 15 percent increase in coho hatchery production results in increases in average annual exvessel revenues for the coho fishery regions which range from $864,086, for the Southeast coho fishery, to $11,942 for the Cook Inlet coho fishery. The reduction in average annual exvessel revenues in these fisheries associated with a 15 percent decease in coho hatchery production range from $867,192, for the Southeast coho fishery, to $11,857, for the Cook Inlet coho fishery.

The harvest of the aggregate All-Other-Alaska-Regions coho fisheries is not impacted by changes in coho hatchery production. As noted in conjunction with the previous cases, this results in average annual exvessel revenues for this region varying indirectly with changes in hatchery production. Average annual exvessel revenues decrease by $22,954 when coho hatchery production is increased by 15 percent, and increase by $23,543 when coho hatchery production is reduced by 15 percent.

Impacts of the changes in coho hatchery production to exvessel revenues in the other high-valued salmon fisheries depend on the strength of the substitution effect between coho salmon and chinook and sockeye salmon. If the substitution effect is as expected, a 15 percent increase in coho hatchery production decreases average annual sockeye and chinook revenues by $196,509 and $32,492, respectively; and a 15 percent decrease in coho hatchery production increases average annual exvessel revenue of the sockeye and chinook fisheries by $201,709 and $20,317, respectively. The impacts of changes in coho hatchery production to average annual exvessel revenue in the low-valued salmon species, pink and chum salmon, are negligible.

Case 11 -- Production from Chinook Salmon Enhancement Increases/Decreases 15 percent

Table 51 Base Scenario 11 (Increase) Predicted Average Annual Harvests, Real Revenue, and Real Prices for Prince William Sound Chinook (PWK), Cook Inlet Chinook (CIK), Southeast Chinook (SEK), Kodiak Chinook (KKK), Other Alaska Regional Chinook (AKOK), Alaska Chinook (AKK), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC) and All Alaska Coho (AKS), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
PWK	1,576,047	1.902	2,998,993
CIK	691,599	1.223	845,771
SEK	7,778,562	2.481	19,308,447
KKK	130,865	1.099	143,770
AKOK	6,423,383	1.509	9,690,762
AKK	**16,600,456**	**1.987**	**32,987,745**
AKR	**246,094,406**	**1.276**	**314,122,807**
AKP	**326,720,701**	**0.301**	**98,252,861**
AKC	**147,756,451**	**0.438**	**64,704,704**
AKS	**43,054,879**	**1.027**	**44,223,197**

Table 52 Scenario 11 (Decrease) Predicted Average Annual Harvests, Real Revenue, and Real Prices Base for Prince William Sound Chinook (PWK), Cook Inlet Chinook (CIK), Southeast Chinook (SEK), Kodiak Chinook (KKK), Other Alaska Regional Chinook (AKOK), Alaska Chinook (AKK), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC) and Alaska Coho (AKS), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
PWK	1,442,630	1.909	2,754,076
CIK	681,587	1.225	834,840
SEK	6,922,257	2.486	17,206,528
KKK	130,865	1.100	144,001
AKOK	6,420,804	1.512	9,706,924
AKK	**15,598,143**	**1.965**	**30,646,370**
AKR	**246,094,406**	**1.282**	**315,459,772**
AKP	**326,720,701**	**0.301**	**98,346,712**
AKC	**147,756,451**	**0.438**	**64,747,560**
AKS	**43,054,879**	**1.031**	**44,394,266**

Table 53 Case 11 (Increase) Predicted Changes in Total Annual Real Revenue from Base Scenario 1 for Prince William Sound Chinook (PWK), Cook Inlet Chinook (CIK), Southeast Chinook (SEK), Kodiak Chinook (KKK), Other Alaska Regional Chinook (AKOK), Alaska Chinook (AKK), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), and Alaska Coho (AKS) for 1997-2006.

	Revenue Changes Production Increase		
	(L. Bound) ($/lbs)	(U. Bound) ($/lbs)	(Expected) ($/lbs)
PWK	115,924	115,924	115,924
CIK	5,122	5,122	5,122
SEK	1,103,841	1,103,841	1,103,841
KKK	-120	-120	-120
AKOK	-8,451	-8,451	-8,451
AKK	**1,216,316**	**1,216,316**	**1,216,316**
AKR	**0**	**-698,026**	**-174,507**
AKP	**-48,053**	**-48,053**	**-48,053**
AKC	**-21,692**	**-21,692**	**-21,692**
AKS	**0**	**-89,286**	**-22,321**
TOTAL	1,146,571	359,259	949,743

Table 54 Case 11 (Decrease) Predicted Changes in Total Annual Real Revenue from Base Scenario 1 for Prince William Sound Chinook (PWK), Cook Inlet Chinook (CIK), Southeast Chinook (SEK), Kodiak Chinook (KKK), Other Alaska Regional Chinook (AKOK), Alaska Chinook (AKK), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), and Alaska Coho (AKS) for 1997-2006.

	Revenue Changes Production Decrease		
	(L. Bound) ($/lbs)	(U. Bound) ($/lbs)	(Expected) ($/lbs)
PWK	-128,993	-128,993	-128,993
CIK	-5,809	-5,809	-5,809
SEK	-998,078	-998,078	-998,078
KKK	111	111	111
AKOK	7,711	7,711	7,711
AKK	**-1,125,059**	**-1,125,059**	**-1,125,059**
AKR	**0**	**638,939**	**159,734**
AKP	**45,798**	**45,798**	**45,798**
AKC	**20,894**	**20,894**	**20,894**
AKS	**0**	**81,783**	**20,446**
TOTAL	-1,058,367	-337,645	878,187

Case 11 examines impacts to Alaska fisheries of increasing/decreasing state enhancement chinook hatchery production by 15 percent annually, beginning in 1993. As with the coho scenario, revenue changes are moderate. A 15 percent increase in chinook hatchery production results in average annual statewide exvessel revenue increasing by an expected $949,743. Reducing the chinook hatchery production by 15 percent results in statewide exvessel revenue decreasing by an expected $878,187.

The average annual exvessel revenues for each of the four individually modelled chinook fishery regions, Prince William Sound, Cook Inlet, Southeast, and Kodiak, vary directly with changes in chinook hatchery production. A 15 percent increase in chinook hatchery production results in increases in average annual exvessel revenues for the chinook fishery regions which range from $1,103,841, for the Southeast chinook fishery, to a loss of $120 for the Kodiak chinook fishery. The reduction in average annual exvessel revenues in these fisheries associated with a 15 percent decease in chinook hatchery production range from $998,078, for the Southeast chinook fishery, to a gain of $111, for the Kodiak chinook fishery.

The harvest of the aggregate All-Other-Alaska-Regions chinook fisheries is not impacted by changes in chinook hatchery production. As noted in conjunction with the previous cases, this results in average annual exvessel revenues for this region varying indirectly with changes in hatchery production. Average annual exvessel revenues decrease by $22,954 when chinook hatchery production is increased by 15 percent, and increase by $23,543 when chinook hatchery production is reduced by 15 percent.

Impacts of the changes in chinook hatchery production to exvessel revenues in the other high-valued salmon fisheries depend on the strength of the substitution effect between chinook salmon and coho and sockeye salmon. If the substitution effect is as expected, a 15 percent increase in chinook hatchery production decreases average annual sockeye and coho revenues by $196,509 and $32,492, respectively; and a 15 percent decrease in chinook hatchery production increases average annual exvessel revenue of the sockeye and coho fisheries by $201,709 and $20,317, respectively. The impacts of changes in chinook hatchery production to average annual exvessel revenue in the low-valued salmon species, pink and chum salmon, are negligible.

Case 5 -- Pink Salmon Program is Eliminated

Table 55 Base Scenario 5 Predicted Average Annual Harvests, Real Revenue, and Real Prices for Prince William Sound Pink (PWP), Cook Inlet Pink (CIP), Southeast Pink (SEP), Kodiak Pink (KKP), Other Alaska Regional Pink (AKOP), Alaska Pink (AKP), Alaska Sockeye (AKR), Alaska Chum (AKC), Alaska Coho (AKS) and All Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
PWP	13,266,300	0.463	6,139,691
CIP	3,087,819	0.398	1,197,710
SEP	100,026,126	0.472	47,199,026
KKP	33,450,037	0.447	15,010,679
AKOP	33,476,146	0.429	14,333,512
AKP	**183,306,430**	**0.458**	**83,880,620**
AKR	**246,094,406**	**1.288**	**317,047,026**
AKC	**147,756,451**	**0.595**	**87,874,981**
AKS	**43,054,879**	**1.036**	**44,597,032**
AKK	**16,082,501**	**1.982**	**31,883,543**

Table 56 Case 5 Base Scenario 1 Predicted Changes in Total Annual Real Revenue for Prince William Sound Pink (PWP), Cook Inlet Pink (CIP), Southeast Pink (SEP), Kodiak Pink (KKP), Other Alaska Regional Pink (AKOP), Alaska Pink (AKP), Alaska Sockeye (AKR), Alaska Chum (AKC), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

	Revenue Changes Production Decrease		
	(L. Bound) ($/lbs)	(U. Bound) ($/lbs)	(Expected) ($/lbs)
PWK	-31,131,217	-31,131,217	-31,131,217
CIK	-2,927,398	-2,927,398	-2,927,398
SEK	13,325,571	13,325,571	13,325,571
KKK	1,988,567	1,988,567	1,988,567
AKOK	4,324,181	4,324,181	4,324,181
AKP	**-14,420,294**	**-14,420,294**	**-14,420,296**
AKR	**2,226,193**	**2,226,193**	**2,226,193**
AKC	**0**	**23,148,315**	**5,787,079**
AKS	**284,549**	**284,549**	**284,549**
AKK	**112,114**	**112,114**	**112,114**
TOTAL	-11,797,440	11,350,875	-6,010,361

Case 5 examines impacts to Alaska fisheries of eliminating the pink salmon enhancement program beginning in 1993. Under this scenario the revenue losses that would occur to the pink salmon fishery are sizeable. An elimination of the pink salmon hatchery production results in average annual statewide expected exvessel revenue reduction of $6,010,361.

The average annual exvessel revenues for each of the four individually modelled pink fishery regions, Prince William Sound, Cook Inlet, Southeast, and Kodiak, differ widely in the expected revenue changes under an elimination of the pink salmon enhancement program. An elimination of the pink salmon enhancement program results in decreases in average annual exvessel revenues for Prince William Sound of $31.1 million. Cook Inlet loses nearly $3 million dollars. The largest gainer is the Southeast pink salmon fishery which takes advantage of an expected 16 cent per pound increase in exvessel price while losing very little harvest. Expected gains to Southeast is $13 million. The harvest of the aggregate All-Other-Alaska-Regions pink fisheries is also impacted by changes in pink hatchery production. The expected increase in revenues to other Alaska regions is $4.3 million.

Impacts of the changes in pink salmon hatchery production to exvessel revenues in the chum fishery depends on the strength of the substitution effect between pink and chum salmon. The expected revenue effect is for approximately a $5.8 million increase in the chum fishery revenues. Other salmon fisheries are also expected to see revenue increases. The revenue increase to the sockeye, coho, and chinook fishery is expected to be $2.2 million, $284,549, and $112,114, respectively.

Case 6 -- Sockeye Salmon Program is Eliminated

Table 57 Case Scenario 6 (Average Prices) Predicted Average Annual Harvests, Real Revenue, and Real Prices for Prince William Sound Sockeye (PWR), Cook Inlet Sockeye (CIR), Southeast Sockeye (SER), Kodiak Sockeye (KKR), Other Alaska Regional Sockeye (AKOR), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
PWR	8,246,440	1.808	14,907,251
CIR	23,173,027	1.535	35,446,854
SER	8,599,481	1.674	14,396,447
KKR	15,044,037	1.554	23,303,507
AKOR	172,005,481	1.250	214,962,961
AKR	**227,068,467**	**1.334**	**303,017,022**
AKP	**326,720,701**	**0.304**	**99,359,937**
AKC	**147,756,451**	**0.441**	**65,209,081**
AKS	**43,054,879**	**1.088**	**46,860,638**
AKK	**16,082,501**	**2.038**	**32,776,090**

Table 58 Case Scenario 6 (Average Prices) Predicted Changes in Total Annual Real Revenue for Prince William Sound Sockeye (PWR), Cook Inlet Sockeye (CIR), Southeast Sockeye (SER), Kodiak Sockeye (KKR), Other Alaska Regional Sockeye (AKOR), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

	Revenue Changes -- Average Prices Production Decrease		
	(L. Bound) ($/lbs)	(U. Bound) ($/lbs)	(Expected) ($/lbs)
PWR	-12,655,458	-12,655,458	-12,655,458
CIR	-3,536,406	-3,536,406	-3,536,406
SER	-826,373	-826,373	-826,373
KKR	-7,763,960	-7,763,960	-7,763,960
AKOR	12,978,386	12,978,386	12,978,386
AKR	**-11,803,811**	**-11,803,811**	**-11,803,811**
AKP	**1,059,023**	**1,059,023**	**1,059,023**
AKC	**482,415**	**482,415**	**482,415**
AKS	**0**	**2,548,155**	**637,039**
AKK	**0**	**1,004,666**	**251,165**
TOTAL	-10,262,373	-6,709,552	-9,374,169

Table 59 Case Scenario 6 (High Prices) Predicted Average Annual Harvests, Real Revenue, and Real Prices for Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), Alaska Coho (AKS) and All Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
AKR	227,068,467	1.858	368,584,313
AKP	326,720,701	0.324	105,806,173
AKC	147,756,451	0.461	68,147,380
AKS	43,054,879	1.303	56,104,930
AKK	16,082,501	2.265	36,421,291

Table 60 Case Scenario 6 (Low Prices) Predicted Average Annual Harvests, Real Revenue, and Real Prices for Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), Alaska Coho (AKS) and All Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
AKR	227,068,467	1.165	264,514,534
AKP	326,720,701	0.288	94,108,878
AKC	147,756,451	0.425	62,816,098
AKS	43,054,879	0.962	41,432,268
AKK	16,082,501	1.905	30,635,571

Table 61 Case Scenario 6 (High/Low) Predicted Changes in Total Annual Real Revenue for Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

	Revenue Changes - Expected High-Low Prices	
	(Expected High) (dollars)	(Expected Low) (dollars)
AKR	-12,850,034	-11,062,803
AKP	821,257	1,329,445
AKC	374,157	605,504
AKS	821,118	532,995
AKK	323,737	210,146
TOTAL	-10,509,765	-8,384,712

Case 6 examines impacts to Alaska fisheries of eliminating the sockeye salmon enhancement program beginning in 1993. Under this scenario the revenue losses that would occur to the sockeye salmon fishery are dramatic. An elimination of the sockeye salmon hatchery production results in average annual statewide expected exvessel revenue reduction of $9,374,169.

The average annual exvessel revenues for each of the four individually modelled sockeye fishery regions, Prince William Sound, Cook Inlet, Southeast, and Kodiak would also suffer revenue decreases under the elimination of the sockeye enhancement program. An elimination of the sockeye salmon enhancement program results in decreases in average annual exvessel revenues for Prince William Sound, Cook Inlet, Southeast, and Kodiak of $12.6 million, $3.5 million, $826,373, and $7.76 million, respectively. The harvest of the aggregate All-Other-Alaska-Regions sockeye fisheries is also impacted by changes in sockeye hatchery production. The expected increase in revenues to other Alaska regions is nearly $13 million. This sizeable increase would accrue mainly to Bristol Bay. The increase is an result of an increase in exvessel price of nearly 8 cents per pound.

Impacts of the changes in sockeye salmon hatchery production to exvessel revenues in the coho and chinook fisheries depend on the strength of the substitution effect between sockeye and coho and chinook salmon. The expected revenue increase is $637,039 and a $251,165. Other salmon fisheries are also expected to see revenue increases. The revenue increase to the pink and chum is expected to be $1,059,023 and $482,415, respectively.

When demand is stronger than the predicted demand then total revenue losses accruing to the Alaska salmon fisheries will increase to $10.5 million. When demand is weaker than expected losses decrease to $8.3 million.

Case 2 -- State Enhancement Program Continues at State and PNP Projected Production Levels.

Table 62 Case Scenario 2 (Average Prices) Predicted Average Annual Harvests, Real Revenue, and Real Prices, Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC) and All Alaska Coho (AKS), Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
AKR	259,353,687	1.243	322,287,029
AKP	333,650,263	0.287	95,788,118
AKC	151,630,219	0.426	64,546,534
AKS	43,258,370	[illegible]	42,842,911
AKK	16,187,568	[illegible]	31,347,465

Table 63 Case Scenar[illegible][illegible]ices) Predicted Average Annual Harvests, Real Revenue, and Real Pric[illegible] Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC) and All Alaska Co[illegible](AKS), Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
AKR	259,353,687	1.501	389,260,481
AKP	333,650,263	0.307	102,521,014
AKC	151,630,219	0.446	67,643,112
AKS	43,258,370	1.177	50,897,653
AKK	16,187,568	2.133	34,527,425

Table 64 Case Scenario 2 (Low Prices) Predicted Average Annual Harvests, Real Revenue, and Real Prices, Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC) and All Alaska Coho (AKS), Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
AKR	259,353,687	1.090	282,732,400
AKP	333,650,263	0.270	90,165,870
AKC	151,630,219	0.409	61,961,440
AKS	43,258,370	0.880	38,085,840
AKK	16,187,568	1.820	29,469,402

Table 65 Case 2 (High/Low Prices) Predicted Changes in Total Annual Real Revenue from Base Scenario 1 for Average, High, and Low Prices for Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), Alaska Coho (AKS), and All Alaska Chinook (AKK), for 1997-2006.

		Revenue Changes	
	(Ave. Price) (dollars)	(High Price) (dollars)	(Low Price) (dollars)
AKR	7,466,196	7,825,820	7,155,063
AKP	-2,512,796	-2,463,902	-2,613,563
AKC	-180,132	-130,111	-249,154
AKS	-1,469,572	-1,922,807	-1,214,446
AKK	-423,964	-598,917	-325,583
TOTAL	2,879,732	2,710,083	2,752,726

Because all the changes take place simultaneously in scenario 2, it is impossible to separate out expected cross-price effects from own-price effects. Furthermore, bounds on cross-price effects cannot be determined. So some of the negative effects from the competing species may be overstated. **Therefore, the above results are probably a minimum gain for sockeye salmon and maximum losses for the other fisheries. These results are not deemed overly reliable.**

Under the projected enhancement levels for future production the revenue to Alaska salmon fisheries increases from the base-line scenario. The increases in annual revenue ranges from $2.7 million to $2.8 million depending on the price scenario, however, only the sockeye fishery shows increases in revenue. The sockeye fishery gains an annual real revenue of over $7 million dollars. The largest decreases is to the pink salmon fishery which loses an annual real revenue of $2.5 million dollars.

Case 3 -- The Salmon Enhancement Program is Eliminated in Fiscal Year 1993.

Table 66 Case 3 Predicted Average Annual Harvests, Real Revenue, and Real Prices Base, Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC) and All Alaska Coho (AKS), Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
AKR	227,068,467	1.40	317,195,053
AKP	183,306,430	0.54	99,041,218
AKC	72,918,371	0.59	43,375,225
AKS	36,204,066	1.10	39,672,013
AKK	12,486,955	1.95	24,354,094

Table 67 Case 3 Pre cted Changes in Total Annual Real Revenue from Base Scenario 1 for Average, Hig.., and Low Prices for Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), Alaska Coho (AKS), and All Alaska Chinook (AKK), for 1997-2006.

	Revenue Changes (dollars)
AKR	2,374,220
AKP	740,304
AKC	-21,351,441
AKS	-4,640,470
AKK	-7,417,335
TOTAL	-30,294,722

To predict this case is really beyond the limits of this program. The problem is that econometrics estimates cause and effect relationships between explanatory and dependent variables. These relationships are estimated around a set of historical data points. When shocks to the system lead to data which is well beyond historically observed data the model's findings become suspect. In this case, with all enhancement eliminated, harvests for average annual harvests, sockeye salmon harvests are well below record levels every year and average annual harvest for pink salmon are close to record low levels. In addition, the predicted harvests for chum are less than half of the base scenario. If these shocks were just for one or two years the model could probably handle it. But these shocks are for every year. If this scenario were to happen it would drastically change the structure of salmon markets and any structural deviation from the historical pattern, in which the model was estimated, makes it extremely difficult to make accurate predictions.

Again, these scenarios are simultaneously determined. This does not allow bounds to be placed on the cross-price effects. This will overstate the benefit of the increases within the high- and low-valued salmon categories for species when competing species decline in production. **Therefore, the increases to salmon species prices because of competing species decline in harvest will be the upper bound on price increases and the resulting numbers will be understate the loss to the fishery. Therefore, the estimated loss of $30 million is probably underestimated and, in actuality, all species will most likely lose from elimination of the enhancement program.**

Because of the unreliability of the modelling effort dealing with case 3 -- the discussion of individual effects is meaningless.

Case 4 -- Salmon Production from Enhancement is Increased/Decreased by 15 percent.

Table 68 Case Scenario 4 -- Increase -- (Average Prices) Predicted Average Annual Harvests, Real Revenue, and Real Prices, Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC) and All Alaska Coho (AKS), Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
AKR	248,913,075	1.264	314,698,647
AKP	348,176,789	0.265	92,245,925
AKC	158,982,163	0.404	64,287,728
AKS	44,082,501	1.020	44,968,100
AKK	16,600,456	1.975	32,789,061

Table 69 Case Scenario 2 -- Increase -- (High Prices) Predicted Average Annual Harvests, Real Revenue, and Real Prices, Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC) and All Alaska Coho (AKS), Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
AKR	248,913,075	1.530	380,851,326
AKP	348,176,789	0.283	98,654,304
AKC	158,982,163	0.423	67,273,155
AKS	44,082,501	1.215	53,543,491
AKK	16,600,456	2.181	36,204,966

Table 70 Case Scenario 2 -- Increase -- (Low Prices) Predicted Average Annual Harvests, Real Revenue, and Real Prices, Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC) and All Alaska Coho (AKS), Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
AKR	248,913,075	1.108	275,690,690
AKP	348,176,789	0.250	86,874,376
AKC	158,982,163	0.389	61,786,235
AKS	44,082,501	0.905	39,911,496
AKK	16,600,456	1.854	30,774,835

Table 71 Case 2 -- Increase -- (High/Low Prices) Predicted Changes in Total Annual Real Revenue from Base Scenario 1 for Average, High, and Low Prices for Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), Alaska Coho (AKS), and All Alaska Chinook (AKK), for 1997-2006.

	Revenue Changes		
	(Ave. Price) (dollars)	(High Price) (dollars)	(Low Price) (dollars)
AKR	-122,186	-1,520,152	-496,492
AKP	-6,045,989	-6,368,395	-5,969,431
AKC	-438,938	-517,353	-435,805
AKS	655,578	603,193	533,199
AKK	1,017,632	1,938,427	1,719,881
TOTAL	-4,933,903	-5,864,280	-4,648,648

Table 72 Case Scenario 4 -- Increase -- (Average Prices) Predicted Average Annual Harvests, Real Revenue, and Real Prices, Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC) and All Alaska Coho (AKS), Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
AKR	243,273,470	1.294	314,789,244
AKP	321,772,368	0.319	102,585,890
AKC	136,530,740	0.452	61,777,802
AKS	42,027,258	1.038	43,620,364
AKK	15,550,595	1.974	30,699,935

Table 73 Case Scenario 2 -- Increase -- (High Prices) Predicted Average Annual Harvests, Real Revenue, and Real Prices, Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC) and All Alaska Coho (AKS), Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
AKR	243,273,470	1.569	381,781,704
AKP	321,772,368	0.340	109,475,655
AKC	136,530,740	0.474	64,675,601
AKS	42,027,258	1.238	52,045,372
AKK	15,550,595	2.185	33,982,864

Table 74 Case Scenario 2 -- Increase -- (Low Prices) Predicted Average Annual Harvests, Real Revenue, and Real Prices, Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC) and All Alaska Coho (AKS), Alaska Chinook (AKK), for 1997-2006.

	Harvests (lbs.)	Price ($/lbs.)	Revenue (dollars)
AKR	243,273,470	1.132	275,356,028
AKP	321,772,368	0.301	96,933,746
AKC	136,530,740	0.435	59,400,922
AKS	42,027,258	0.920	38,661,247
AKK	15,550,595	1.850	28,767,507

Table 75 Case 2 -- Increase -- (High/Low Prices) Predicted Changes in Total Annual Real Revenue from Base Scenario 1 for Average, High, and Low Prices for Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), Alaska Coho (AKS), and All Alaska Chinook (AKK), for 1997-2006.

		Revenue Changes	
	(Ave. Price) (dollars)	(High Price) (dollars)	(Low Price) (dollars)
AKR	-31,589	-589,774	-831,154
AKP	4,284,976	4,452,956	4,089,939
AKC	-2,948,864	-3,114,907	-2,839,118
AKS	-692,119	-894,926	-717,050
AKK	-1,071,494	-283,367	-287,447
TOTAL	-459,090	-429,988	-584,830

As in scenario 2, all the changes in scenario 4 take place simultaneously and it is impossible to separate out expected cross-price effects from own-price effects. Again, bounds on cross-price effects cannot be determined. So some of the negative effects from the competing species may be overstated. Because of these drawbacks, scenario 4 cannot be used with any degree of confidence and will not be further discussed here.

Conclusion

The salmon marketing model was constructed to predict a 15-year exvessel price stream under various enhancement scenarios. The accuracy of the long term price predictions will depend on several factors including: (1) the specified future values of salmon price determinants; (2) the accuracy of the underlying salmon exvessel price models; and (3) the extent to which the current structure of the international salmon market continues into the future. The model were specifically designed to capture long-run price trends. Thus, even though actual outcomes may vary from those predicted through the model, the model results may still be valid in terms of projecting the direction of future price movements.

The model performed best when the enhancement changes were examined in isolation. This was due to the fact that it was difficult to separate out the true substitution effects between coho, chinook, and sockeye salmon and pink and chum salmon. An ad hoc procedure was used to estimate the substitution effect between the species in the high-valued salmon grouping and the low-valued salmon grouping. This ad hoc procedure could not be used when there were simultaneous changes in the enhancement program.

The results of the model simulations indicate that Alaska average annual exvessel revenues will increase over the 1997-2006 time period when sockeye, coho, chinook, and chum enhancement hatchery production are increased. However, these increases are moderate, and the actual profitability of increasing hatchery production of these species can only be determined when the revenue increase are compared to the costs of the enhancement program. Costs considerations and determination of producer surpluses from the enhancement program are provided in a separate report.

The future simulation results for variation in the pink salmon enhancement program indicate that there is currently an over production of pink salmon. Reducing pink salmon production by 15 percent results in average annual exvessel revenue gains in both the statewide pink fisheries and the overall statewide salmon fisheries. However, there are distributional impacts which must be considered in conjunction with this result. The Prince William Sound pink fishery suffers a significant reduction in exvessel revenue when pink hatchery production is reduced by 15 percent.

The model results do not suggest that the pink salmon enhancement program should be eliminated. The large declines in pink salmon harvest that accompany this action depress statewide average annual exvessel revenues. This indicates that there is some exvessel revenue maximizing level of pink salmon enhancement which lies somewhere between the 15 percent reduction in pink hatchery production and the complete elimination of the enhancement program. Costs must be considered prior to determination of the profitability of the various future pink salmon enhancement programs.

Four points, which are not discussed elsewhere in the market or policy analyses, should be noted in evaluating the economic viability of various enhancement programs. Returns to only the commercial fleet are considered in the economic analysis. Increased enhancement production of some salmon species, e.g. chinook and coho, will increase sport-fishing harvests. Thus, the reported revenue increases provided in this report (which are confined to exvessel revenue) will understate actual benefits associated with increased salmon hatchery production. It may be useful in the future to consider incorporating economic impacts of the sport segment of the fishery industry into the economic analysis of the salmon enhancement program.

Second, variation in salmon hatchery production may affect prices and/or recruitment/survivability of other fish species. Considerations of salmon enhancement impacts to other fisheries is beyond the scope of this analysis.

Third, it is clear from the model results that, across salmon species, increases in production/harvests will have only moderate impacts on salmon fisheries exvessel revenues, at best. Current high levels of world salmon supplies severely hamper the ability of increased production to bolster economic returns to the salmon fisheries. It may be prudent to increase efforts aimed at expanding world demand for Pacific wild salmon. This would increase prices at all harvest levels, and increase the ability of the world salmon market to absorb additional salmon production.

Represented in Figure 45 are demand curves (in the upper graph) and associated total revenues curves (in the lower graph). In order to illustrate the previous discussion, assume that the current demand for pink salmon is represented by the demand curve D_0 and supply is represented by S_0. Given these demand and supply curves the current quantity is Q_0 and the current price is P_0. The total revenue curve to the fishery is represented by TR_0. Current production levels occur where the total revenue curve is downward sloping. This implies that the revenue associated with the last unit of fish harvested was negative. Therefore, decreasing harvest will increase total revenue. However, there is a range, beyond which this will no longer be true. If harvest is cut beyond Q_1 total revenue will decline.

If demand can be expanded to D_1, the total revenue curve will be shifted up to TR_1, as more salmon are demanded at each price level. In addition to increasing profits to the industry, the expanded demand may also lead to a situation were further increase in pink salmon production lead to increases in fishery revenues. Therefore, it may be advisable to increase efforts aimed at increasing demand for salmon, particularly pink salmon, through increased marketing and promotion, product development, market expansion, and the development of new markets. This investment may provide greater returns to the salmon industry than investment in increasing salmon hatchery production.

Finally, an increase or decrease in the production of any salmon species may trigger a counter move by competitors in the world salmon industry which may offset any potential gain from the production change. For example, a decrease in pink salmon harvest could provide incentive for the Japanese to invest in the potentially large Russian pink salmon industry. Thus, possible reactions of other participants in the world salmon industry must be considered when evaluating salmon enhancement policy.

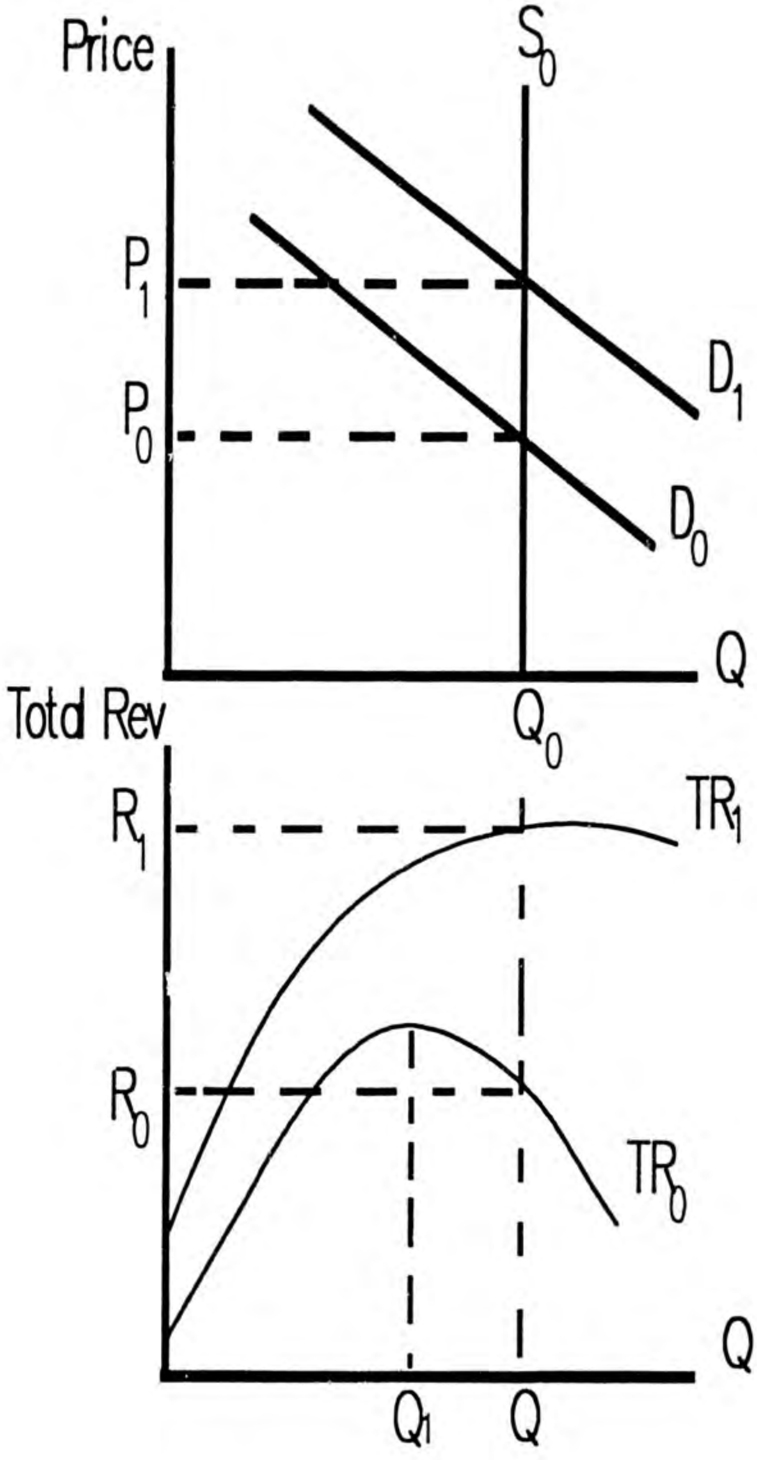

Figure 45. Supply, Demand, and Revenue Illustration

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