

ALASKA LEGISLATURE SPECIAL COMMITTEE/SUBJECT FILE 8672
1852 SCOMM 74: SEN. SPEC. COMM. ON DOMESTIC & INTL. FISH., 1991-92.

Linear regressions were fit to the data in Figure 21 to estimate the parameters a and b . Given the coastwise abundance index and hatchery production, hatchery contribution rate can be calculated for each fishery. In using these relationships I am assuming that future fisheries will be conducted in the same fashion as in the past nine years. Hatchery production is estimated from releases and marine survival rates. A mean marine survival rate and variance are required for the stochastic simulation.

Marine Survival of Chinook Salmon was estimated from coded-wire tag data. I compiled data from 128 tag lots from 11 hatcheries and 10 release years to examine factors affecting marine survival rates. General linear models were then fitted with the response variable being log survival. The variables--size at release, hatchery, and release year--are apparently all significant with a total r^2 of 0.78.

The simulation model included only the hatchery and release year effects because the future sizes at release are not known. The survival model is:

$$S_{hy} = M * L_h * T_y * R_{hy}$$

where

h is hatchery

y is year

M is the grand mean survival rate

L is a constant hatchery effect

T is a random, shared, year effect

R is a random effect not shared by hatcheries

The grand mean survival rate was 1.82%. The year effects suggest a temporal pattern (Figure 22). Hatcheries are plotted in rank order according to the estimated hatchery effects (Figure 23). Adding the constant back into the hatchery effects, the mean marine survival rate of each hatchery was calculated with year effects removed (Figure 24).

Chinook Salmon Releases

Smolt releases increase and become constant after 1995 (Figure 25). This production is a doubling from the 1988 levels. Most chinook spend 3 or 4 years at sea, so we are just beginning to see the returns from the large releases. The coastwise index is also increasing, although the rise is exaggerated in Figure 25. This makes it harder to catch the Alaska hatchery fish without overrunning the treaty quota.

Results

For all gear types, total catch is expected to increase as the large releases begin to return (Figure 26). The total 1991 catch was slightly overestimated by the model.

The troll harvest is expected to increase to about 300 thousand fish annually (Figure 27). Without hatchery production, the treaty harvest is approximately 200 thousand. The trollers are estimated to receive about 100 thousand additional chinook by 1996 under current production scenarios. In general, two hatchery chinook are required for the trollers to catch one. The 1991 troll catch was well predicted by the model.

Figure 22. Year effects ($\log[T_y]$) on Chinook smolt survival as estimated with the linearized version of the survival model.

Year Effects on Smolt Survival

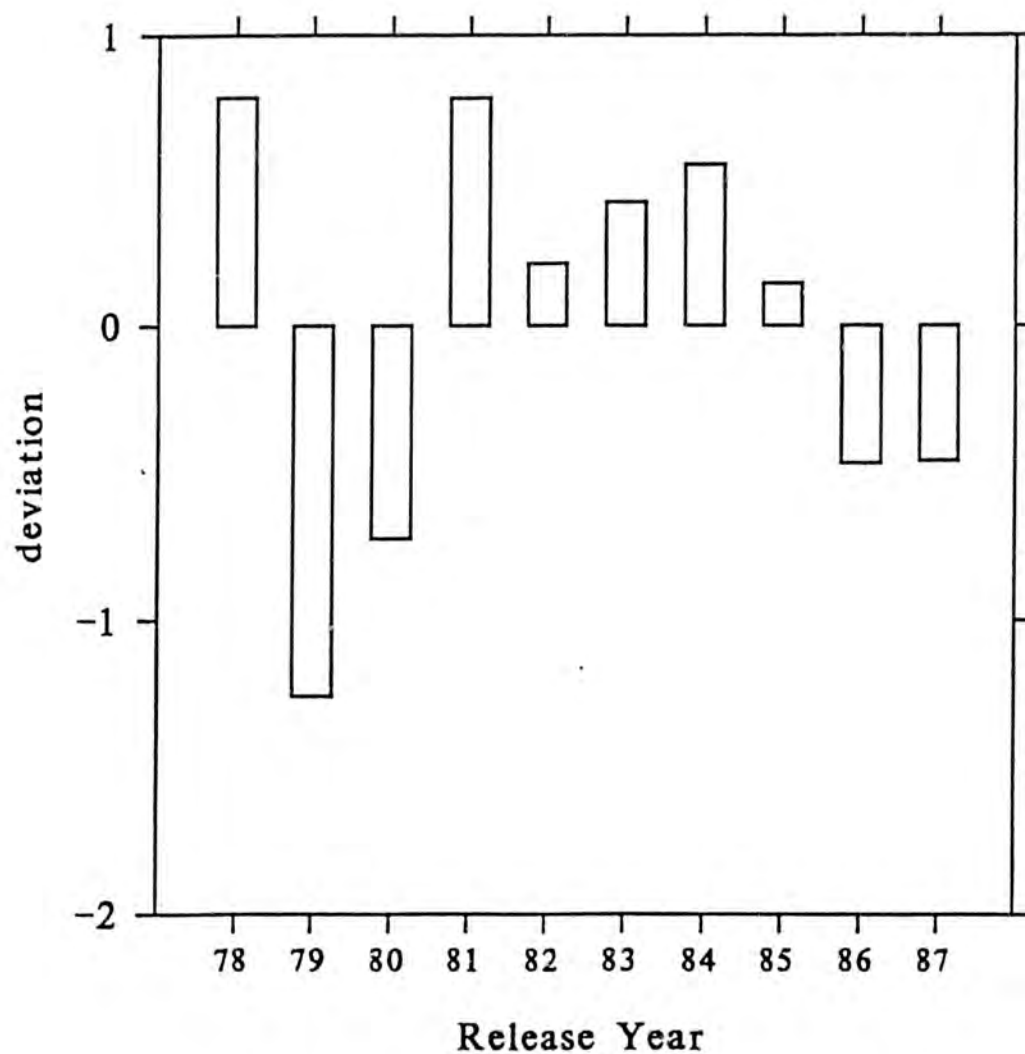


Figure 23. Location effects ($\log[L_h]$) on chinook smolt survival as estimated with the linearized version of the survival model. The hatcheries are Hidden Falls (HF), Sheldon Jackson (SJ), Snettisham (SN), Medvejie (MJ), Deer Mountain (DM), Crystal Lake (CL), Little Port Walter (LP), Neets Bay (NB), Earl West Cove (EW), Carroll Inlet (CI), and Whitman Lake (WL).

Location Effects on Smolt Survival

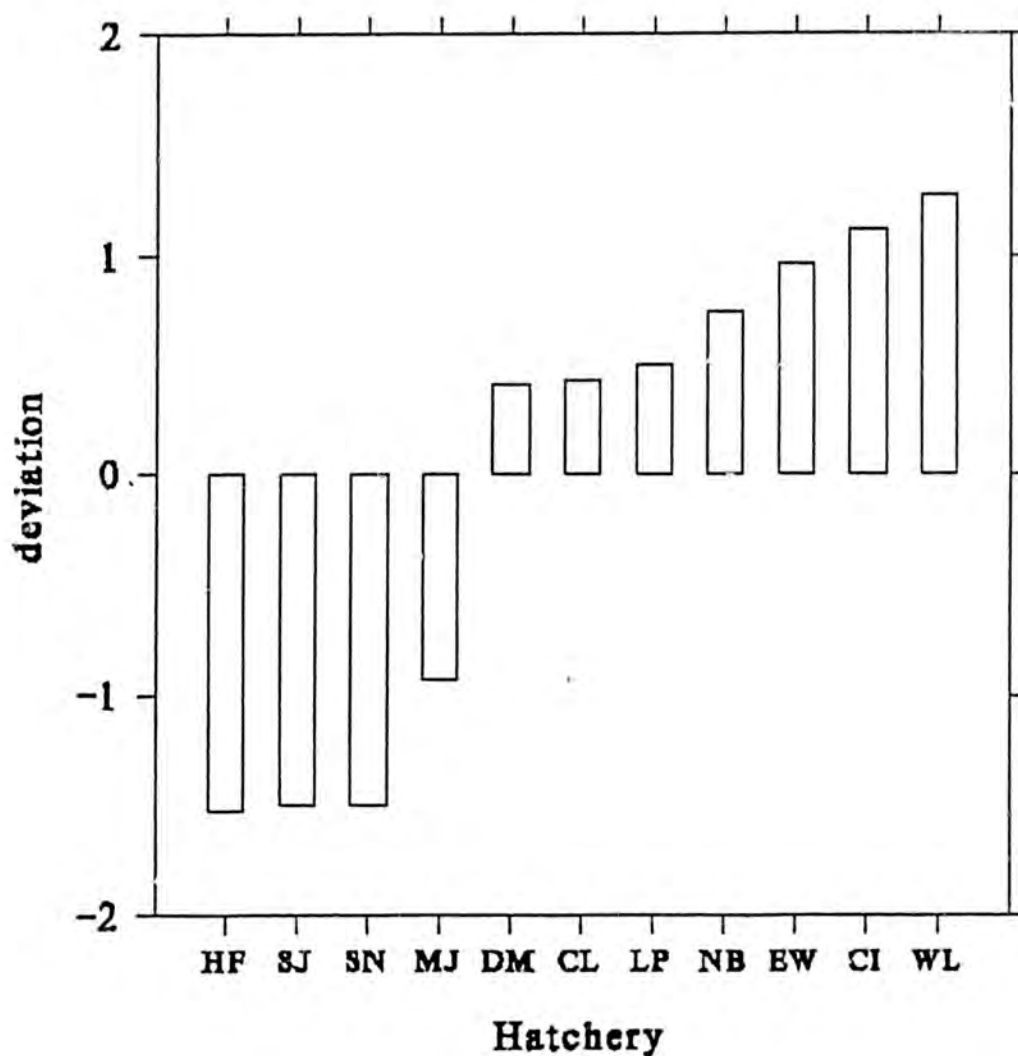
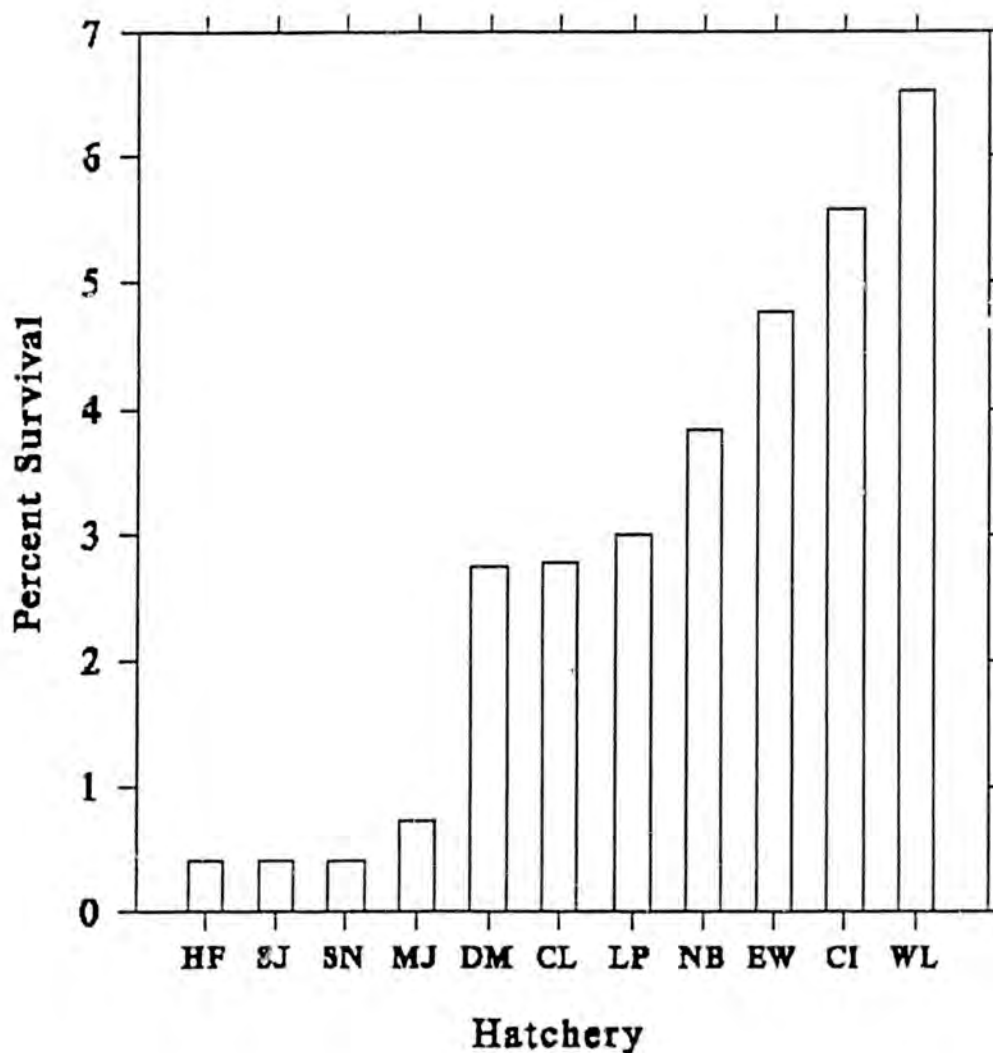


Figure 24. Marine survival rates ($M \cdot L_h$) of chinook smolts as estimated with the linearized version of the survival model. The hatcheries are Hidden Falls (HF), Sheldon Jackson (SJ), Snettisham (SN), Medvejie (MJ), Deer Mountain (DM), Crystal Lake (CL), Little Port Walter (LP), Neets Bay (NB), Earl West Cove (EW), Carroll Inlet (CI), and Whitman Lake (WL).

Smolt Marine Survival



Southeast Alaska Chinook Salmon

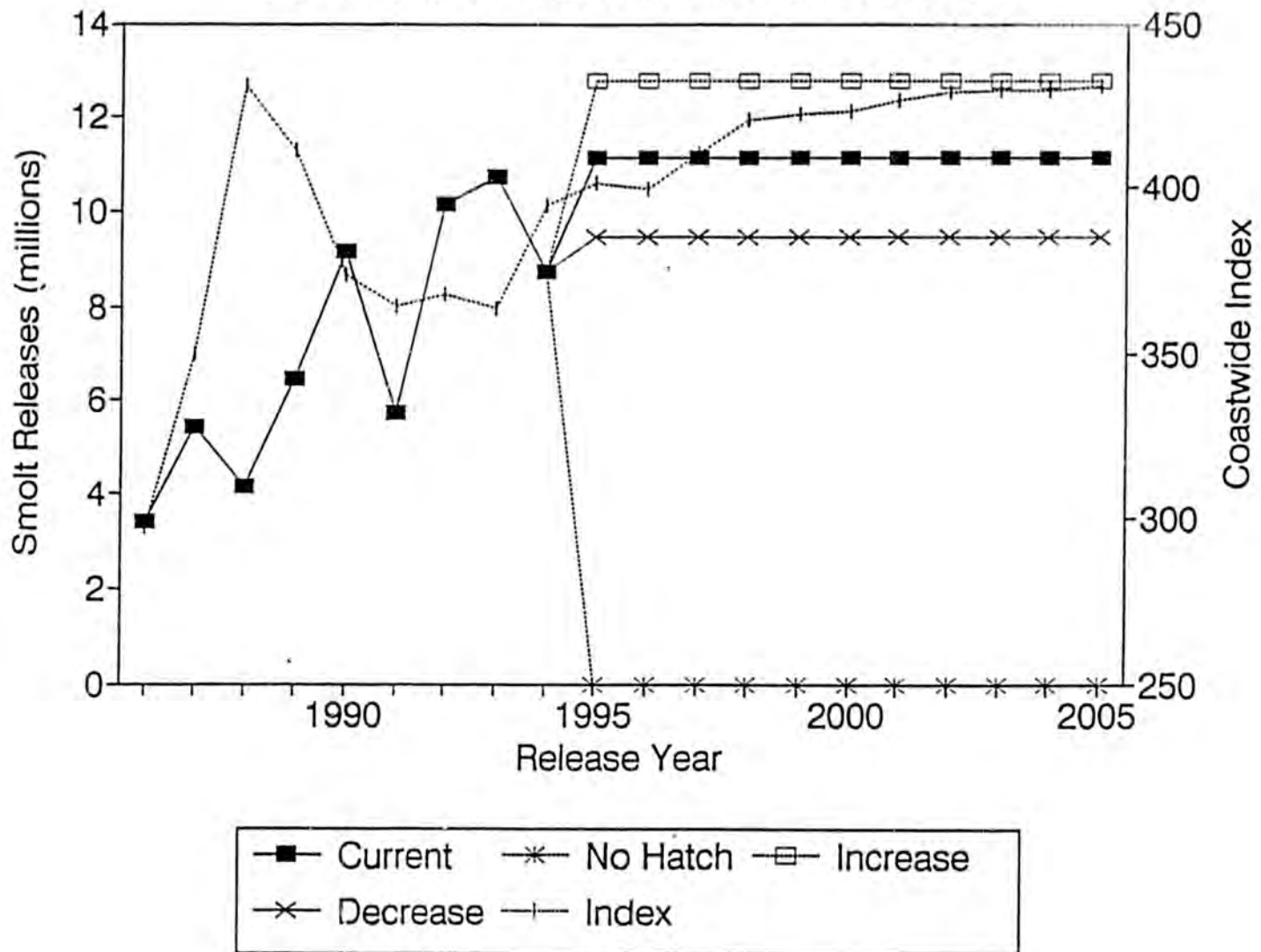


Figure 25. Southeast Alaska chinook salmon smolt releases. "Current" releases are actual releases until 1991 and projected releases starting in 1992. The index of non-Alaska hatchery chinook salmon in the waters of southeast Alaska is plotted for comparison.

Southeast Alaska Chinook Salmon Total Catch of All Gear

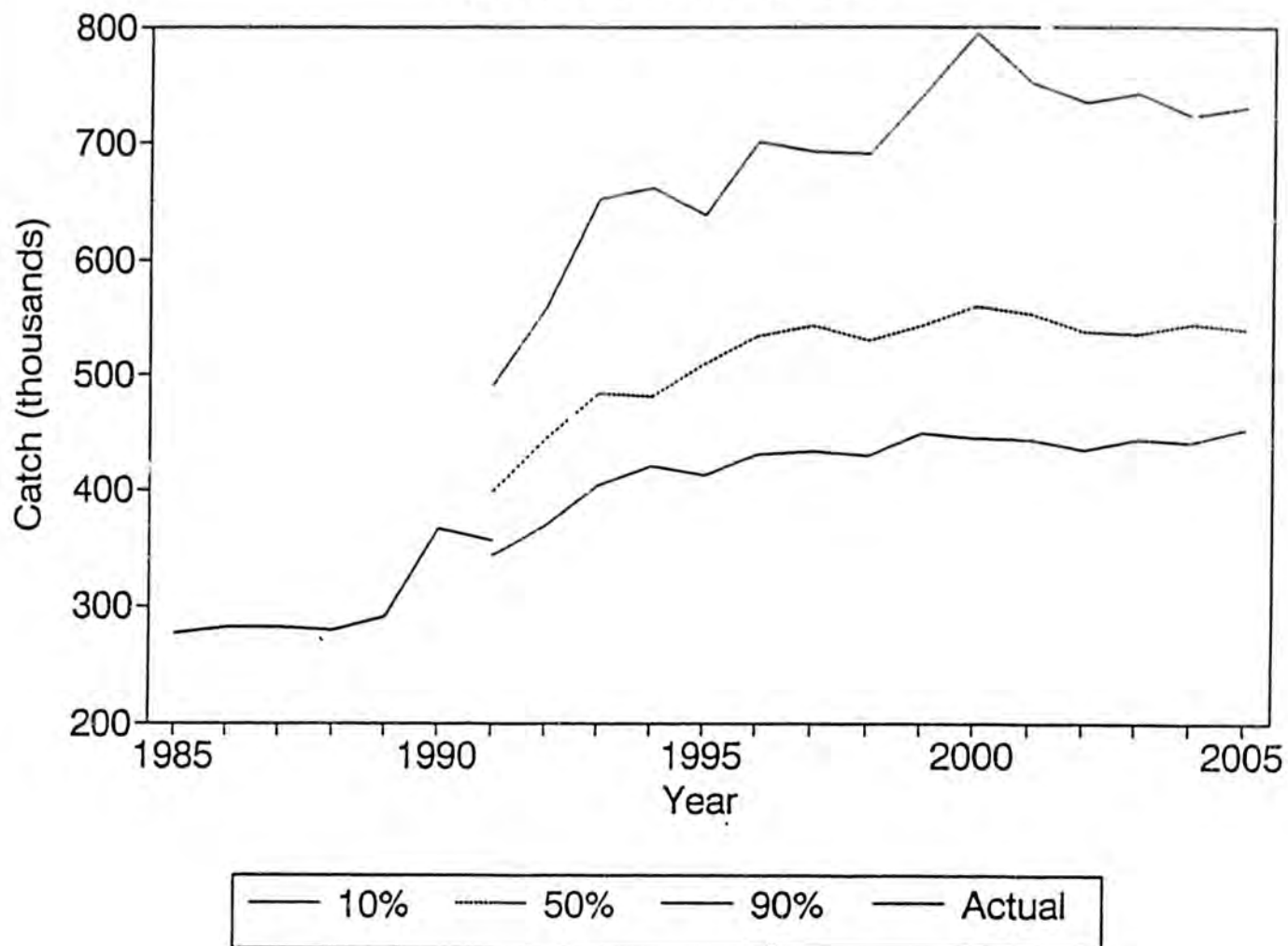


Figure 26. Actual and projected commercial catches of chinook salmon in southeast Alaska. The percentages indicate the distributions of 100 replicate simulations.

Southeast Alaska Chinook Salmon Total Troll

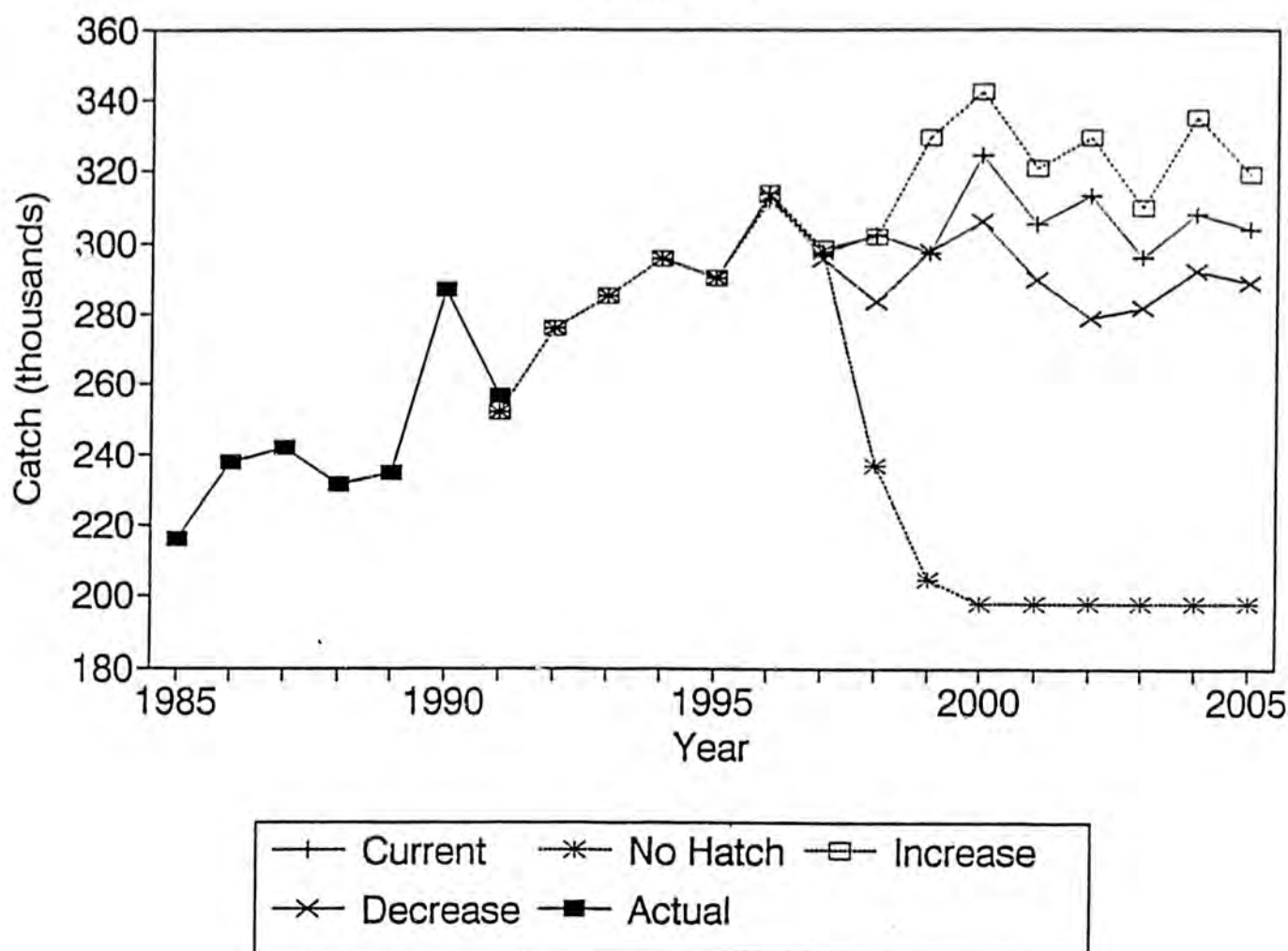


Figure 27. Actual and projected troll catches of chinook salmon in southeast Alaska for four production scenarios: Current releases, No hatchery releases, 15% Increase, and 15% Decrease in smolt releases.

Sport harvests are estimated to increase to 100 thousand by 1995 (Figure 28). Without hatchery production the sport fishing treaty allocation is 40 thousand. The model over-estimated the 1991 sport harvest. Terminal cost-recovery harvest is also estimated to increase to 100 thousand (Figure 29).

Conclusions

Alaska's hatchery program has been very successful in producing salmon. If survival rates continue to be high, we can expect lots more hatchery fish in the future. While lower than hatchery managers' estimates, these simulation results are, if anything, overly optimistic, for the following reasons.

Some oceanographers predict a return to the colder temperatures prevalent in the 1970s. If temperatures decrease, and if salmon production also decreases, realized salmon production may be closer to the lower 10% quantiles than to the median projections. Preliminary estimates of 1993 salmon returns indicate low survival of pink and chinook salmon. However, it should be remembered that my model projects the most likely level of salmon returns, not the exact number each year. Thus, deviations from the median projections are expected.

For most of the species/area combinations, projected catches appear to be realistic extensions of historical catches. The exception is southeast Alaska chinook salmon for which the model appears to over-predict catches. Smolt releases increased rapidly during the last decade and we are just beginning to experience returns from these releases. Thus, it is too early to tell whether such high levels of chinook production are realistic.

The abundance of wild stocks has increased dramatically since inception of Alaska's salmon enhancement program, because of favorable environmental conditions and more intensive management. There are still some wild stocks, such as Prince William Sound pink salmon and southeast Alaska chinook salmon, that could benefit from even more aggressive management to promote rebuilding.

Given a wild-stock preference mandated by the Alaska senate and the US-Canada Pacific Salmon Treaty, increases in hatchery production will increasingly have to be harvested by user groups in terminal areas.

Privatization of hatcheries creates a need for cost-recovery harvests, making fisheries management more costly and contentious.

In some regions, substantial yield increases are attainable by increasing the escapement targets of wild salmon stocks. In Cook Inlet it appears that an increase in sockeye production equal to the production of enhanced sockeye could be obtained by increasing the escapement targets. In Prince William Sound, increased escapement of wild pink salmon is desirable but difficult to achieve. At best, production of wild pink salmon could not equal the high level of hatchery production.

Maximizing yield is not the only important management objective. There is also a need to minimize the variance of yield to develop markets for Alaska salmon. Depending on the economics (see Boyce et al. 1992) lower escapement targets and hatchery releases may be desirable.

Southeast Alaska Chinook Salmon Total Sport Catch

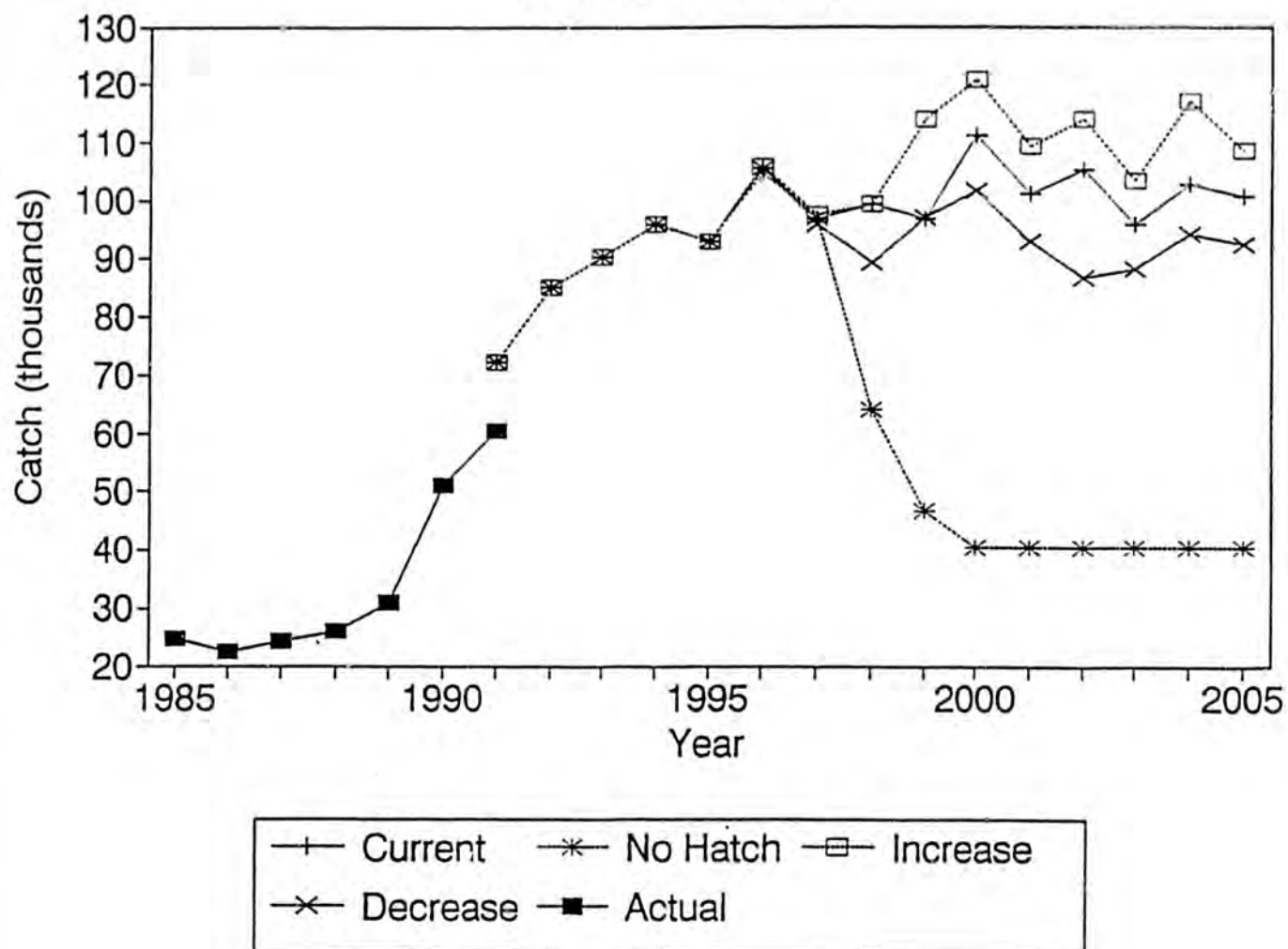


Figure 28. Actual and projected sport catches of chinook salmon in southeast Alaska for four production scenarios: Current releases, No hatchery releases, 15% Increase, and 15% Decrease in smolt releases.

Southeast Alaska Chinook Salmon Total Terminal Catch

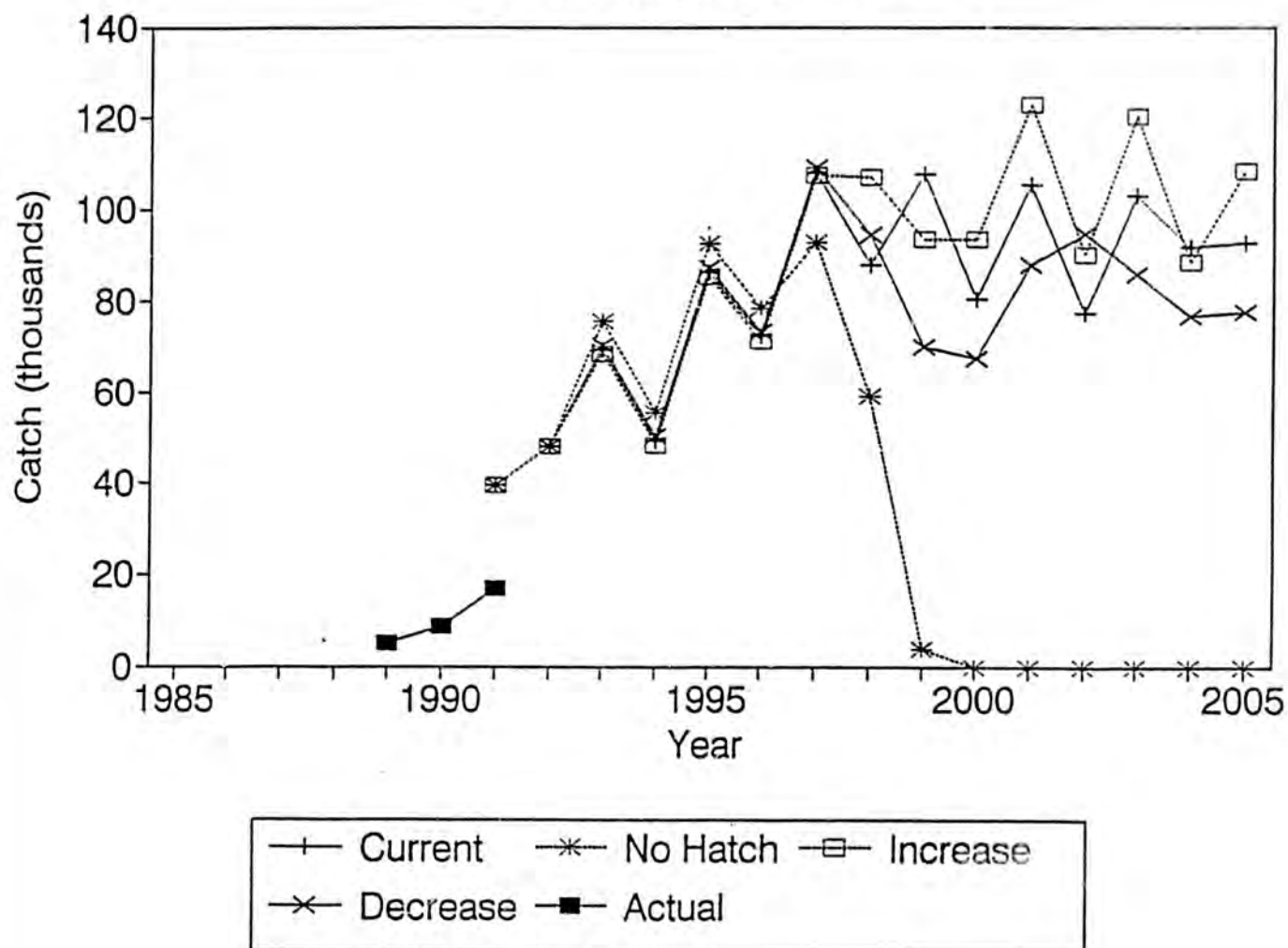


Figure 29. Actual and projected terminal catches of chinook salmon in southeast Alaska for four production scenarios: Current releases, No hatchery releases, 15% Increase, and 15% Decrease in smolt releases.

Acknowledgements

I thank the following people for contributing to this project by providing data and their expertise. To those whom I have omitted from this list, I am no less grateful.

Alaska State Legislature
Ginny Fay

Alaska Department of Fish and Game
Commercial Fisheries Division

Bob Clasby
Dr. Douglas Eggers
Hal Geiger
Dave Gaudet
John Carlile
Karl Hofmeister
John Clarke
Samuel Sharr
Todd Rosen
Kenneth Tarbox
Charles Swanton

FRED Division

Jeff Koenings
Jeff Hartman
Steve McGee
Marianne McKean
Ron Josephson
Ken Leon
Carol Denton
Richard Yanusz
Dana Schmidt
Gary Kyle

Auke Bay Laboratory
Dr. Joseph Greenough
Dr. William Heard
Alex Wertheimer
Frank Thrower
Ron Heintz

The students of Salmon Population Modeling (Fish 692, Fall 1992) developed the prototype simulation models:

Mike Jaenicke
Mary Whalen
Jim Finn
Jie Zheng
Bill Templin
Michio Fukushima
Randy Bates
Jim Griswold
Jim Murphy

SCOMM

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Salmon Price Forecasts for the 1990's

editor,
Dr. Don J. DeVoretz

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Acknowledgements: These original papers formed the basis of the Salmon Forecasting Workshop held at Simon Fraser University Burnaby, British Columbia, V5A 1S6 on May 15-19, 1989. The primary funding for this workshop was supplied by Department of Fisheries and Oceans, Pacific Region, Canada. The Department of Economics and the Institute for Aquaculture, Simon Fraser University offered their facilities. An on site fish farm tour was provided by Hardy Seafarms. In addition, critical comments of Dr. T. Heaps, Dr. Kjell Salvanes, Mr. Jim Fralick, Mr. Peter Leitz and Dr. Marvin Shaffer are noted with appreciation.

Preface

The Salmon Price Forecasting Workshop, held in May, 1989 at Simon Fraser University, was a joint undertaking between the Institute of Aquaculture at Simon Fraser University and the Department of Fisheries and Oceans, Pacific Region. It is the second such workshop initiated by Fisheries and Oceans, and demonstrates an ongoing commitment by the Department to work cooperatively with the academic community, industry and other levels of government to develop a better understanding of seafood markets in general, and salmon markets, in particular.

The appropriateness of such workshops is clear. Canada is the world's leading seafood exporter, and salmon is a significant contributor to export sales. At the same time export markets are becoming increasingly complex and competitive. An in depth understanding of seafood markets is critical to the future success of the Canadian seafood industry. Support provided by Simon Fraser University in organizing the workshop, providing facilities and producing these proceedings is gratefully acknowledged. In view of the growing importance of aquaculture worldwide, the support of the Institute of Aquaculture in this project was especially welcomed.

The contributions made by all participants of the workshop can not go unrecognized. Original papers, lively debate, broad interest and a growing number of new researchers are all testimony to the increasing importance being placed on salmon price forecasting.

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Summary of Proceedings

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Introduction

After a seven year hiatus the second Salmon Price Forecasting Workshop was convened during the week of May 15-19, 1989 at Simon Fraser University under the primary sponsorship of the Department of Fisheries and Oceans, Canada. The main goals of this workshop were to assess the state of the art in econometric salmon price forecasting models and to explore alternative forecasting techniques as well as to offer outside user groups a forum to criticize the efficacy of the current body of econometric salmon demand literature.¹

Given these goals and a recognition of the changing market place for salmon, participants were drawn from Norway, the United States and Canada based upon their expertise to comment on the above-mentioned themes.² Major structural changes have occurred since the first salmon price forecasting workshop was held in 1982. The spectacular growth of Norwegian and other countries' cultured salmon output now leads to a situation in which farmed salmon clearly rivals wild-caught salmon sales in certain markets. Thus, this conference focussed on both wild-caught and cultured salmon price forecasting. In addition, there has been a very large increase in the fish demand literature in the last seven years. New modelling techniques have been developed and a wide range of conflicting evidence on parameter stability has been presented. Finally, the original econometric models developed for governmental bodies in the early 1980's can now be better assessed in light of their predictive power. In fact, the substantial decline in farmed salmon prices circa 1989 provided a contemporary test of the predictive power of these econometrically estimated demand models.

This precis of the proceedings will be divided into four parts to correspond to the themes and accompanying sessions. The major section reported on will be the current state of farmed and wild caught salmon demand models. Next, a critical assessment of model specification and underlying market structure will be reviewed for both the wild caught and farmed salmon markets. Alternative forecasting models will be assessed in the third section with the fourth section consisting of a summary of the criticisms and suggestions of user groups.

Econometric Salmon Demand Models: The current State of Affairs

1. Appendix A presents the exact outline of the conference.

2. Appendix B presents a complete list of the participants.

Two sets of papers were presented on this topic. The first set consisted of a model of farmed salmon demand by Dr. Bing-Hwan Lin and associates, followed by an alternative model specification for Norwegian farmed salmon by Dr. Kjell Salvanes and Dr. Don J. DeVoretz. The second set of econometric papers dealt with two new strategies to investigate salmon markets in the USA and Japan. These papers were presented by Dr. James Anderson and Dr. Jim Wilen, respectively.

Lin et al.

The Lin et al. paper had as its primary aim the intention of forecasting Norwegian salmon imports into the United States. The authors employed a two sector model of the United States and EEC markets with standard arguments (i.e. income, substitute prices and seasonal dummy variables) over the 1982-1988 period. Their major parameter estimates reported for the United States market were for the own-price elasticity (-2.31 in the short-run) and income (3.1). For the EEC market the own-price, income and cross-price elasticities were respectively reported as -2.42, 1.55 and .42. Armed with these results, Lin et al. employed a Box-Jenkins technique to forecast their exogenous variables (i.e. supply, future Pacific salmon prices and income) and to forecast United States imports of Norwegian salmon and their accompanying prices. Their baseline prediction indicated a rise in United States imports from 39,000 to 49,000 metric tonnes in 1992. Baseline forecasted U.S. import prices (CIF) rose in real terms from \$3.27 US per lb. in 1989 to \$3.68 per lb in 1992. Among their major findings was the response of United States imports to a depreciation of the United States dollar. This led to a price rise and a decline in imports. In fact, under a combined Norwegian supply rise and United States currency depreciation, Norwegian exports shift to the EEC with a subsequent decline in the EEC price. The authors argued that the strengths of their approach were the flexibility in choosing exogenous variables and the ease of updating the model over time. Lin et al. admitted however that their model specification was limited in market coverage and that other major farmed salmon producing regions should be included.

Critical comments from other participants of the Lin et al. model focussed on the definition of the income variable and its associated high value which drove the price increases in the United States market. In addition, it was suggested that the United States and EEC were a single import market and any price differential was spurious; this difference more likely being an artifact of transport costs.

DeVoretz - Salvanes:

Dr. Kjell Salvanes and Dr. Don DeVoretz presented an alternative version of the Norwegian salmon market as the basis for a forecasting model. The authors argued that three unique characteristics of the Norwegian salmon market must be recognized: (1) the world salmon market is competitive and integrated (2) Norwegian supply increases have been very large and (3) these supply increases have been successively sold in first, Europe, then in the United States and now, back in Europe.

In order to incorporate these features, DeVoretz and Salvanes develop a competitive general equilibrium model using a Fisher world

price index for a quantity dependent model. They also estimate variations of this competitive general equilibrium model, namely a dynamic specification of the model and a simultaneous equations version of the model. Finally, they offer a market penetration model.

The DeVoretz-Salvanes results indicate how sensitive the parameter estimates are for the farmed salmon market to different model specifications. For example, in the world trade model their short and long run own price elasticities are respectively -1.31 and -6.3. However, employing a simultaneous equations system to remove the inherent estimating bias in the original formulation alters the short-run own-price elasticity to -2.95. DeVoretz and Salvanes also estimate a two sector market penetration model similar to the one presented by Lin et al.. However, DeVoretz and Salvanes include a specific behavioral hypothesis. This hypothesis states that Norwegians will export salmon until total revenue is maximized in each market.³ Again, the reported elasticities vary considerably according to model specification.

In sum, DeVoretz and Salvanes prefer their world wide competitive general equilibrium model for forecasting purposes. Since their preferred version is a quantity dependent model their model predicts the amount demanded at any given price.⁴ The forecasting power of the model is however unsatisfactory despite the strong econometric results. The model's inability to predict the actual movement in quantity demanded circa 1984 is due to the instability in Norwegian salmon market. DeVoretz and Salvanes argue that a disequilibrium general equilibrium model must be estimated before there exists a reasonable chance of accurate price prediction in the farmed salmon market.

Critical discussion of the DeVoretz - Salvanes paper was led by Mr. Don Reddick. He suggested that since the competitive general equilibrium model results were indistinguishable from the two sector market penetration model that we in fact do not fully understand the Norwegian farmed salmon market. Professor Wilen suggested that a third degree price discrimination model might improve the results of the DeVoretz - Salvanes two sector model. Again, there was substantial discussion on the credibility of the crucial income variable.

Anderson:

Dr. Anderson presented a model of a salmon farm to illustrate the impact of altering attributes of the fish product on profits. The profit maximizing model was structured in two stages. First, experimental information was collected in the northeastern United States restaurant markets on the decision to buy salmon with a certain set of attributes. This information allows the formation of a market share function in which a typical firm's market share is determined by the firm's product rating vis a vis the competitors' product rating. This restriction and the firm's cost function yields the profit to the firm. It then becomes possible to simulate profit and market shares under various market structures. The main market structures considered by Anderson were: monopoly, duopoly and a competitive market. Each

3. This implies that as the own-price elasticity approaches unity in any market Norway will switch to a market with a higher elasticity.

4. They note that the inverse i.e. price can be solved for by arguing the $Q_d = Q_s$ and projecting Q_s .

structure yielded different quality ratings and prices charged by the representative firm. For example, in the duopolistic world of two major farms two strategies arise. One firm's strategy is low quality, low cost production while the other firm produces a higher quality product at a higher price. On the other hand, under a perfectly competitive situation, the market produces a lower quality product at a lower price.

Discussion by participants focussed on extensions of the model including sensitivity analysis. For example, what are the effects of altering salmon flesh colour on market share and profit? It was pointed out moreover, that this research was expensive and basically static. Continuous replication by regional markets with updated information on product quality would be required to keep the results current.

Wilen

The presentation by Dr. Wilen concentrated on the modelling strategy of his "in progress" research for the Japanese market. Dr. Wilen suggested that Japan is a particularly interesting case study since it is a major importing country for Alaskan and British Columbian salmon as well as a future outlet for Norwegian farmed salmon. In addition, Wilen stated that his research would take a new tact in modelling the Japanese setting. First, he believes that the pre-occupation with the price of Norwegian salmon is misplaced. There is no need to attempt to forecast the price of farmed salmon since in the long-run, it would simply equal the minimum cost of the representative farm. Next, Wilen suggested that the importance placed on estimating cross-price elasticities between salmon and substitute products is misplaced since the prices of salmon and these substitutes are often spuriously correlated.⁵ Given these inherent problems with the standard demand model, Wilen argues that instead we should employ a trade flow model to predict the size, direction and price of salmon flows worldwide. In addition, Wilen suggested that an econometric estimates used in this methodology be pre-tested on cross-sectional data to avoid the spurious correlation over time as alluded to in his criticisms.

Remarks from the floor indicated a general agreement with Dr. Wilen's concern over spurious correlation in typical demand models. However, it was suggested that world trade models for other resources (e.g. Norwegian oil) have been very data intensive, expensive and have not led to accurate predictions. In addition, many participants were hesitant to agree with Dr. Wilen's suggestion that future farmed salmon price would equal the long-run minimum cost point of the representative farm.

Shaffer

Dr. Marvin Shaffer offered an alternative model to the structural demand forecasting models reported in the earlier sessions. He outlined a simulation model which is based upon a simultaneous equations system employing previously estimated parameter estimates. The Shaffer model covered 70 per cent or more of British Columbian sales for farmed and

5. For example, Dr. Wilen argued that wild salmon supply has a cyclical supply and could be spuriously correlated with the veal, pork, etc. cycles. These cyclical effects are spuriously captured in our models when the latter are used as substitutes.

wild-caught salmon. Specifically, the five wild species were: chum, coho, sockeye, pink and chinook in canned and/or frozen form and farmed coho. The countries covered were Canada, the United Kingdom, Japan and the United States. For simplicity, it was assumed that there would be competition between species but not product types (i.e. canned versus fresh/frozen).

The basic model used by Shaffer solved for the market clearing price that equalized quantity supplied and demanded. The quantity supplied was assumed to be exogenous and thus, was forecasted for each year of the simulation period with historical market shares assumed to be constant over the simulation period. Quantity demanded was a function of income per capita, population, and a basket of food prices. The chosen parameter estimates were taken from the available literature and it was further assumed that real CPI would grow at a zero rate and that the income elasticity was equal to 2.5. In addition, cross-price elasticities between the products, which were taken from previous estimates, were restricted such that a constant amount would be spent on farmed and wild salmon.

Shaffer's sensitivity analysis indicated the price forecasts were very sensitive to the assumed own-price elasticity values. Future price trends were not responsive to alternative assumed income elasticity values. The elasticity of future salmon prices with respect to population growth was unity. Finally, the greater the asserted cross-price elasticity, the greater the price decline for a given species with any simulated supply increase. Dr. Shaffer argued that the limitations of his simulation model could be greatly reduced if supply was made endogenous and Monte Carlo techniques were used to select from among the previously estimated parameters.

The discussion of Dr. Shaffer's model was led by Dr. Heaps who focussed his comments on the model's critical restriction on the cross-price elasticities between species. A lengthy discussion ensued about both the theoretical and factual basis for making this assumption. It was agreed that the price forecasts of the simulation model were extremely sensitive to this restriction and a suggestion was made to relax it. Additional comments on the simulation model surrounded the issue of testing. It was suggested that Dr. Shaffer, at a minimum, use backcasting techniques to see how well his model would have performed in some historical period. When this backcast it was also suggested that Dr. Shaffer assess the sources of any error by using Theil's inequality indices.

Schwindt-Bjorndal:

Dr. Schwindt's presented an investigation of the industrial organization of both the wild-caught and farmed salmon markets. The intention was to assess the suitability of assuming that salmon markets are competitive as done in many of the reported studies.

Three questions were posed to test this assumption. These queries were:

- a) What are the relevant markets?
- b) Are non-price variables important?
- c) Are the observed prices the "true" prices?

Using the criterion of "contestability" a market can be defined and then assessed for its degree of competitiveness. Defining "contestability" as a combination of actual and potential entrants one can dispense with

concentration ratios and focus on such measures as cross-price elasticity or price differentials to indicate the amount of competition in a fish market. Dr. Schwindt suggested that in wild caught salmon markets the landed price used in econometric studies is often not correctly specified.⁶ Given significant barriers to entry that exist in Canada and the complex manner in which landed prices are determined, the reported landed price is not an accurate indicator. For example, some biases result from the forces of collective bargaining and non-price competition. In short, the landed price does not reflect the services rendered by processing companies (e.g. ice, fuel, or willingness to accept all deliveries) and hence the landed price is an underestimate of the actual transaction price. Also, at the wholesale market for canned salmon the list price is often not the actual transaction price. List prices are often discounted, depending on supply, by the two dominant canners in British Columbia.⁷

For farmed salmon a different picture emerges. At the wholesale level, Norwegian production dominates because farmed salmon is sold in an international market with numerous substitutes. Furthermore, there is no evidence of technological control, no scale, capital or absolute cost barriers and little product differentiation to allow a price differential or non-price competition to emerge. Thus, for farmed salmon the observed price is the true transaction price in the above cited farmed salmon demand studies.

The discussion, which was led by Patricia Koss, focussed on the price bias in the wholesale market. In particular, questions concerning any possible systematic relationship between supply changes and price discounting were raised. Dr. Schwindt argued that actual prices could be above or below the reported prices depending on supply changes. Dr. DeVoretz felt that the Durbin-Watson test or tests for heteroscedasticity may be picking up the discounting or premium prices paid over time in the wild salmon market. Thus, rather than correct for these observed errors by standard methods, greater accuracy could be acquired by simply re-specifying the appropriate price variable. Finally, questions arose about the future industrial organization of the farmed salmon market in British Columbia. Dr. Schwindt forecast a cost plus contracting model with fish farmers contracted to produce on this basis for one or two large British Columbian processors. It was felt that this latter point should be kept in mind in future demand studies of British Columbian farmed salmon.

Price Forecast Users Panel

This panel discussion had as its main theme a critique of the efficacy of current salmon demand models and forecasts being provided by the academic research community. Each contributor was asked to identify why they required price forecasts and what the perceived shortcomings of the models were. In addition, suggestions for future research were solicited. All major user groups in British Columbia were present except a representative of the Fisheries Council of British Columbia.

6. It should be noted that few models rely on landed price models for forecasting.

7. This may be irrelevant though, if the error term is consistent over the historical time series used in price forecasting.

Mr. Peter Leitz from the Department of Fisheries and Oceans Canada was the first speaker. He indicated that Fisheries and Oceans was concerned with long term price forecasts, (i.e. ten to twenty years) in order to evaluate various management issues including:

- a. effect of enhancement on wild caught salmon prices
- b. the affect of aquaculture production on salmon prices
- c. quality degradation and associated price changes from discrete salmon stock management options.

Mr. Leitz presented his "scorecard" for the price forecasts under the structural demand models estimated circa 1980-1982. These models accurately projected sockeye and pink prices in all markets but, were unable to accurately predict prices for chinook or coho. As well, chum prices were overestimated. In addition, Mr. Leitz argued that the sockeye and pink price forecasts although accurate were based on faulty assumptions. Mr. Leitz suggestions for the future included:

- a. Investigate the market structure in Japan
- b. Integrate changing consumer tastes, demographics and new products into the demand models.

Finally, Mr. Leitz made a plea for a consensus by academics on a single approach and a likely set of long-run price projections.

Response from the floor was quick and enthusiastic. First, Dr. Wilen and Dr. Anderson noted Japanese market studies were underway (i.e. Wilen's work) and that several new farmed fish models were also reported earlier. However, Dr. Salvanes and Dr. Anderson indicated that studies at the retail level were expensive and, in perfectly competitive markets, unnecessary since prices could be inferred from existing wholesale market studies. Finally, there were several suggestions concerning the plea for one set of price projections. Rather than argue for uniformity, several economists in the audience argued that you take an average of the existing projections or pick the projection based upon what the policy maker perceives to be the most accurate set of assumptions.

Further, Dr. Anderson indicated that models for farmed salmon were uniform in predicting the decline in farmed salmon price as well as being accurate. In addition, Dr. Anderson argued that ARIMA models for exogenous variables should be attached to the structural demand models for more accurate and uniform predictions.

Mr. Jim Fralick from the British Columbian Ministry of Agriculture and Fisheries was the next panel speaker. He indicated that, given the primary mandate to supervise the development of fish farms, salmon price forecasts were of great interest. Mr. Fralick indicated however, even given these limited needs he found that, in the absence of expert staff, the models produced by academics were too obtuse to use. Thus, the Ministry often resorted to the assumption that salmon prices were constant for the near future.

The audience response was that it was ironic that farmed salmon projection models were rarely used given their accuracy. Academics in the audience also assured Mr. Fralick that the training of qualified specialists at the Universities was well underway.

Mr. John Spence presented a summary statement of the state of British Columbian salmon farmers circa May 1989. In his introductory remarks he outlined the dire straits that even a "best practice technique" British Columbian farmer found himself in early 1989. At that time, average chinook and/or coho farmgate prices did not cover

average variable costs. In addition, previous capital commitments meant that many farms were experiencing debt restructuring to survive. Mr. Spence emphasized in his presentation the unique set of problems facing British Columbian farmers including marketing, disease and finance. He argued that the key variables affecting profits (or losses) were fish growth rates, product price, feed price, the food conversion ratio, mortality rates and processing costs. In particular, Mr. Spence argued that there was scope for cost reduction through improved diets and food conversion ratios, rising growth and survival rates and more efficient management techniques. Mr. Spence emphasized that British Columbian cost of production in the near future must approach \$5.00 (Cdn.)/kg. if profitability is to be achieved. In sum, Mr. Spence indicated that the success of the industry crucially depended on overcoming the short-run financial crisis through cost reduction, debt re-financing and stable product prices.

The British Columbian Salmon Farmers Association was represented by Mr. Alan Archibald. His talk focussed on the changing market conditions in the British Columbian salmon farming industry. He argued that the March-April window for premium prices had disappeared circa 1989 because of a change in relative bargaining conditions between buyers and farmers. Given the vast increase in worldwide salmon output the market has switched from a sellers market to a buyers market with a resulting decline in farm gate prices. Contrary to the Bjorndal-Schwindt thesis, Archibald argued that for British Columbia a large number of sellers face few buyers. For example, Toronto has 3 to 4 major salmon buyers which dominate that market. In addition, these major processors are not passing on the lower costs and hence sales are not being increased. Finally, instability in supply from producers and uncertain prices faced by processors places an impediment on market development.

After this market analysis, Mr. Archibald provided several research suggestions that would benefit the industry. First, forecasts must be by cities; San Francisco, Tokyo, etc., and on a monthly basis. Mr. Archibald argued that ARIMA models for forecasting may be insufficient, since the industry must understand the workings of each city market. Remarks from the audience indicated that many of the research strategies suggested by Mr. Archibald are well underway (e.g. Anderson study). In addition, the suggestion for monthly ARIMA model forecasting was met with enthusiasm.

In sum, it is apparent why potential users are frustrated. On the one hand, Mr. Leitz of the Department of Fisheries and Oceans was primarily interested in long-term forecasts while Mr. Archibald is concerned with monthly prices. Mr. Leitz's call for one agreed upon model and Mr. Fralick's concern for an understandable model(s) also appear to be in conflict. The size and complexity of an agreed upon world-wide salmon model would probably defy any facile interpretation to the layman.

Conclusions

What lessons are to be learned from this exercise? First, following the recommendation of the first workshop the volume of professional literature on salmon demand has expanded greatly since the

1982 workshop. The financial and data support of the Dept. of Fisheries and Oceans, Pacific Region and the Norwegian government respectively for wild-caught and farmed salmon demand studies has facilitated this research effort. There now exist several published studies for the Canadian, United States and individual European salmon markets. Given that this body of literature now exists new studies with updated data and more sophisticated techniques are being produced by recent Ph.d. and Master degree candidates in Canada, the United States and Norway. Again, these new studies should be encouraged. For example, a recent Ph.d. dissertation in Norway has integrated cost and demand functions for farmed salmon. In the United States, the in depth study of demand for wild-caught salmon in Japan by Dr. Wilen's students is a promising new turn. The detailed work of Dr. Anderson on product characteristics for farmed salmon in the United States should be pursued for Canadian wild-caught salmon.

Moreover, the use of a "share equation" approach from actual budget data should be encouraged to correct the serious problems of aggregation (vis a vis income and substitute variables) reported in this conference. Since these new strains of research are time consuming and generally require a new generation of graduate students, there is no impending need for an immediate follow-up to this conference. A three to four year interval seems appropriate for these meetings. What is clear however is the need for a small grants programme of \$5,000 to \$10,000 to support quality graduate studies.

Another benefit to be noted from this salmon demand workshop and the previous one in 1982 has been the impetus given for other demand workshops on Canadian shellfish and Atlantic farmed salmon. For the Pacific region of Canada two crucial areas remain: the future demand for roe herring and farmed salmon. Since we have a modest body a research literature in these areas a future workshop in either area would no doubt give an impetus to future studies on the demand for British Columbian roe herring and pen-reared salmon.

Armed with a knowledge of demand characteristic for British Columbian fish products both internal trade-offs and international negotiations could be analyzed with more foresight and sophistication.

Effects of Exchange Rate and Production on Prices of Farmed Atlantic Salmon

by

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and Ron C. Mittelhammer

Introduction

The salmon fishery is the most valuable fishery in the west coast of the United States (U.S.) and Canada. In 1987, U.S. landings of wild Pacific salmon amounted to 562 million pounds worth 596 million dollars at the ex-vessel level. Past methods of production have been through the capture fisheries, in which the United States is the largest producer in the world. Recently, growing salmon in net-pens anchored in the ocean has become an increasingly important method of production. The species of salmon being farmed are mainly the highest-valued salmon species of Atlantic, chinook, and coho. Norway is the leader in salmon farming, having produced approximately 180 million pounds of Atlantic salmon in 1988, it is projected to produce 265,309, and 331 million pounds in 1989, 1990, and 1991, respectively (Sakta Facts, 1988). World production of farmed Atlantic and Pacific salmon in 1990 is projected to nearly match the projected catches of chinook, coho, and sockeye salmon in the U.S. and Canada.

A recent concern of the salmon industry has been the substantial growth of pen-raised salmon from Norway, Scotland, Chile, Canada, and other countries. Fishermen are concerned to what extent the domestic and foreign markets will be affected by increased farm production. Existing and potential salmon farmers are concerned about the extent to which future revenues from salmon farming will be affected. The salmon industry as a whole hopes that the recent surges in the demand for fish will lead to increases in salmon demand which would offset supply increases so that the price for salmon would remain high.

The U.S. and European Community (EC) are the main market targeted by the Norwegian salmon farmers. The major expansion in demand for salmon has been in the U.S. resulting from consumers' dietary concerns. In Europe, Norway has replaced the U.S. as the leading salmon supplier in some European countries such as France and Denmark.

Currently, salmon farming is only allowed in Washington and Maine, since Alaska issued another two-year moratorium on salmon farming in 1988. The start-up cost is high for salmon farming in the U.S. Heated and emotional political debates have resulted in an incredibly high cost for obtaining a farming license. Therefore, knowledge of future prices for farmed salmon is crucial.

The purpose of this study is to forecast the price of farmed Atlantic salmon in the U.S. and the EC for the period of 1989 through 1992. A dynamic simultaneous equation model is constructed to examine

the factors affecting the supply and demand for farmed Norwegian Atlantic salmon in the U.S. and EC. Then, time series (Box-Jenkins) analysis is conducted to forecast future values of some of the exogenous variables of the econometric model. The econometric and time series models are then combined via dynamic simulation to generate future supply and price of Norwegian Atlantic salmon in the U.S. and EC. Sensitivity analysis is also conducted to examine the effects of different Norwegian production on future supply and prices.

The Econometric Model

The econometric model contains three behavior equations (U.S. demand, EC's demand, and supply to the U.S.) and four identities as specified below:

- (1) $Q_{usd} = f(P_{us}, PS_{us}, Y_{us}, D_i, Q_{usd,t-12})$
- (2) $Q_{ecd} = g(P_{ec}, PS_{ec}, Y_{ec}, D_i, Q_{ecd,t-12})$
- (3) $Q_{uss} = h(NP_{us}, NP_{ec}, STOT, S_{j=1,3}^{W_j} Q_{uss,t-j})$
- (4) $Q_{usd} = Q_{uss}$
- (5) $Q_{usd} + Q_{ecd} = STOT$
- (6) $NP_{us} = P_{us} * ER_{us} * WPI_{us}$
- (7) $NP_{ec} = P_{ec} * ER_{ec} * PPI_{ec}$

where Q_{usd} and Q_{ecd} are the demand for Norwegian Atlantic salmon in the U.S. and EC, respectively; Q_{uss} is the supply of Norwegian Atlantic salmon to the U.S.; P_{us} and NP_{us} are the U.S. prices of Norwegian Atlantic salmon in U.S. dollars and Norwegian kroner, respectively; P_{ec} and NP_{ec} are the prices of Norwegian Atlantic salmon in the EC measured in the European Unit of Account (ECU) and kroner, respectively; PS_{us} is the ex-vessel price of chinook salmon in the U.S.; PS_{ec} is the FOB (free-on-board) price of chinook, sockeye, and coho salmon exported from the U.S. and Canada to the EC; Y_{us} and Y_{ec} are income variables for the U.S. and EC, respectively; D_i represents a monthly indicator variable which is equal to one for the i^{th} month and zero for other months; $S_{j=1,3}^{W_j} Q_{uss,t-j}$ is a three-month geometrically declining weighted average of past quantities with $S_{j=1,3}^{W_j} = 1$; $STOT$ is the total Norwegian exports to the U.S. and EC; ER_{us} and ER_{ec} are the number of kroner per U.S. dollar and ECU, respectively; and WPI_{us} and PPI_{ec} are the wholesale and producer price indexes in the U.S. and EC, respectively. All monetary variables are expressed in real terms in equations (1) and (2) and in nominal terms in equation (3).

The justification for the model specification and data sources are discussed in Herrmann and Lin (1988) and Lin et al. (1989), they are not repeated here for the interest of brevity. However, empirical results are briefly summarized below.

Empirical Results

The econometric model, equations (1)-(3), are estimated by using the two-stage least squares method for the sample period from January 1983 through December 1988. It should be mentioned that the 1988 figures for PS_{ec} are missing and substituted by using the results of time series analysis. Therefore, the econometric results should be regarded as preliminary. The Cochrane-Orcutt iterative technique is

used to correct the first-order autocorrelation problem which is present in equations (2) and (3). The empirical results of the double-log functional form are summarized below, with the absolute values of t statistics in parentheses.

$$(8) \ln Q_{usd} = -2.311 \ln P_{us} + 0.311 \ln P_{S_{us}} + 3.011 \ln Y_{us} + 0.241 \ln Q_{usd,t-12}$$

(6.40) (1.79) (3.73) (3.09)

$$5.10 - 0.18D2 - 0.05D3 - 0.07D4 - 0.14D5 - 0.14D6$$

(2.24) (1.05) (0.29) (0.44) (0.25) (0.89)

$$0.33D7 - 0.29D8 - 0.29D9 - 0.24D10 + 0.15D11 + 0.15D12$$

(2.03) (1.70) (1.50) (1.26) (0.76) (0.85)

$$R^2 = 0.864, \text{ Adj. } R^2 = 0.828, \text{ D-W} = 1.63$$

$$(9) \ln Q_{ecd} = -2.421 \ln P_{ec} + 0.541 \ln P_{S_{ec}} + 1.551 \ln Y_{ec} + 0.321 \ln Q_{ecd,t-12}$$

(3.80) (1.54) (1.46) (1.69)

$$0.72 + 0.01D2 + 0.13D3 + 0.15D4 + 0.27D5 + 0.39D6$$

(0.31) (0.15) (1.13) (1.19) (1.81) (2.44)

$$0.28D7 + 0.19D8 + 0.34D9 + 0.39D10 + 0.47D11 + 0.49D12$$

(1.81) (1.32) (2.37) (2.82) (3.32) (3.17)

$$R^2 = 0.919, \text{ Adj. } R^2 = 0.900, \text{ D-W} = 2.02, \text{ Rho} = 0.735$$

$$(10) \ln Q_{uss} =$$

$$0.54 + 3.751 \ln NP - 4.491 \ln NP_{ec} + 0.711 \ln STOT + 0.311 \ln S_{j=1,3} W^j Q_{uss,t-j}$$

(0.15) (2.60) (3.16) (6.46) (2.69)

$$R^2 = 0.860, \text{ Adj. } R^2 = 0.852, \text{ Rho} = 0.664$$

All estimated coefficients have signs consistent with a priori theoretical expectations and are significant at a 5% probability level with the exception of the monthly dummy variables, the EC income and the substitute prices in the EC. Judging from t statistics, R^2 , and other summary statistics (such as validation statistics developed by Theil), the model appears to have a good fit.

Because of the double log functional form, the estimated coefficients of the lagged consumption variables. These elasticities suggest that farmed Atlantic salmon is a luxury good and the demand is fairly price elastic in the U.S. and EC. Pacific salmon is found to be a substitute but, not a good substitute for farmed Atlantic salmon. Empirical results also suggest that the demand for farmed Atlantic salmon exhibits a seasonality in the U.S. and EC. In the U.S., the weakest demand occurs during the strongest part of the Pacific salmon fishing season from June to October. A particularly heavy demand is exhibited in the EC during November and December when the demand for smoked salmon in Europe is very intense over the holiday season.

Time Series Models

There are nine variables (PS_{us} , PS_{ec} , Y_{us} , Y_{ec} , $STOT$, ER_{us} , ER_{ec} , WPI_{us} , and WPI_{ec}) considered to be exogenous to the model and their future values need to be generated for forecasting the future supply and price of Norwegian Atlantic salmon in the U.S. and EC. Time series analysis was conducted to forecast future values of all exogenous variables except $STOT$, ER_{us} , and ER_{ec} .

Future production of Norwegian farmed Atlantic salmon for the period from 1989 through 1991 was discussed in the introduction section. Future production for 1992 is assumed to be 22 million pounds above the 1991 projected production. Because the projected production for 1989 is 33.3% above the actual production for 1988, a sensitivity analysis is performed in which future production is assumed to be 10% below the projection. Exchange rates are volatile and difficult to forecast, so ER_{us} is assumed to be equal to 6.53 and ER_{ec} equal to 7.70, the level occurred in December 1988.

Using monthly data from January 1982 through December 1987, six time series models were estimated. The results are summarized below, with the absolute values of t statistics shown in parentheses and measures of goodness of fit summarized in Table III.

$$(11) \quad d\ln Y_{us} = 0.0063 + (1 - 0.299B) e_1$$

(7.39) (2.60)

$$(12) \quad dY_{ec} = 3.25 + (1 - 0.763B + 0.206B^4) e_2$$

(4.98) (8.91) (2.39)

$$(13) \quad (1 - 0.719B) d_{12}PS_{us} = (1 - 0.413B - 0.587B^{12}) e_3$$

(5.54) (2.23) (2.79)

$$(14) \quad (1 + 0.24268B) dWPI_{us} = 0.36325 + e_4$$

(2.08) (2.13)

$$(15) \quad (1 - 0.8874B) d\ln WPI_{ec} = 0.004 + (1 - 0.678B) e_5$$

(8.49) (2.36) (3.95)

$$(16) \quad dPS_{ec} = (1 - 0.294B) e_6$$

(2.57)

where d is the first-order difference operator and $d_1 Y_t = Y_t - Y_{t-1}$; B is the backward shift operator and $B^1 Y_t = Y_{t-1}$; and e_i is the error term.

Future Supply and Price

Given the forecasted values of all exogenous variables, the estimated econometric equations and identities can be solved to generate the future supply and price of Norwegian Atlantic salmon in the U.S. and EC. For the interest of brevity, future supply and prices are aggregated from a monthly to a yearly basis and are shown in Tables 1-2. It should be pointed out that the estimated economic structures (econometric and time series) are assumed to remain unchanged during the forecasting period.

It is important to note that the forecasted values presented in Tables 1-2 are conditional on the predicted values of exogenous values discussed in the previous section. The time series models predict that U.S. and EC income figures will follow an upward trend during the prediction period. The ex-vessel price of chinook in the U.S. is predicted to repeat a seasonal pattern, and the FOB price of chinook, sockeye, and coho is set at a constant. Exchange rates are assumed to be constant, but in reality they will vary. One of the main advantages of the integrated econometric and time series approach is that the econometric model can be used to generate future supplies and prices under alternative predictions of the exogenous variables. This advantage is utilized in the sensitivity analysis in which Norwegian production is assumed to be 10 percent below the predictions given by the Norwegian source. It should be mentioned that sensitivity analysis can also be conducted to examine the effects of exchange rates, income, inflation, prices of substitutes on the supply and price of Norwegian farmed salmon in the U.S. and EC.

Table 1. Supply of Norwegian Farmed Atlantic Salmon: 1982-1992

Year	U.S.	EC
	1,000 pounds	
1982	1,501	16,125
1983	5,265	24,731
1984	10,404	28,547
1985	14,565	33,375
1986	20,597	57,002
1987	17,864	67,886
1988	21,351	107,732
1989	41,351	157,240
1990	50,070	181,413
1991	57,276	190,744
1992	65,894	198,660

Table 2. FOB Prices of Norwegian Farmed Atlantic Salmon: 1982-1992

*Year	U.S.	EC
	Dollars/lb	ECU/lb
1982	3.21	3.02
1983	3.00	3.19
1984	2.87	3.30
1985	3.06	3.57
1986	2.80	2.52
1987	3.50	2.85
1988	3.54	2.67
1989	2.86	2.34
1990	3.04	2.43
1991	3.21	2.51
1992	3.35	2.58

U.S. Market

The price of farmed Atlantic salmon has undergone a great deal of fluctuation from 1982 to 1987, as shown in Table 1. In the U.S., FOB prices declined from \$3.21 per pound in 1982 to \$2.87 in 1984, bottomed out at \$2.80 in 1986, skyrocketed to \$3.50 in 1987 caused by great reduction in supply due to disease problems, remained fairly high in early 1988 and then started declining in later 1988. The supply of Norwegian farmed salmon rose steadily from 1.5 million pounds in 1982 to 20.6 million pounds in 1986, dropped to 17.9 million pounds in 1987 due to disease problems, then rose again to 21.4 million pounds in 1988.

As Norwegian production is projected to increase from approximately 180 million pounds in 1988 to 265 million pounds in 1989, supply to the U.S. in 1989 is predicted to be nearly double the 1988 figure causing price to decline to the 1984 level which is 19 percent below the 1988 price. As growth in Norwegian production is predicted to slow down, increases in supply to the U.S. are predicted to slow down as well but FOB prices are predicted to follow an upward trend starting with \$3.04 per pound in 1990 and reaching \$3.35 in 1992. The predicted 1991-1992 prices are about 4.3-9.3% below the 1987-1988 prices.

When the projected production of Norwegian farmed supply is assumed to be smaller by 10 percent, supply to the U.S. is predicted to be 35, 45, 52, and 60 million pounds for 1989, 1990, 1991, and 1992, respectively. Consequently, future prices rise starting with \$3.03 per pound in 1989 and reaching \$3.40 in 1992.

EC Market

FOB prices and supply to the EC behaved somewhat differently compared to the U.S. market, possibly caused by the appreciation of the ECU in relation to the U.S. dollar. U.S. dollars appreciated from \$0.990 in 1986 and \$1.183 in 1988. Growth in the Norwegian supply to the EC was much smaller than to the U.S. during the period when the U.S. dollar appreciated against the ECU. Consequently, the FOB price of Norwegian salmon shipped to the EC went up from about 3.00 ECUs per pound to 3.57 ECUs in 1985.

When the ECU appreciated by almost 28% in 1986, supply to the EC rose from 33 million pounds to 57 million pounds causing price to plummet from \$3.57 ECUs per pound to only 2.52 ECUs in 1986. Continuing surging in the value of ECU kept the FOB price in 1987 to remain relatively low even though Norwegian total production was hit by disease problems. Continuous strength in the value of ECU coupled with recovered Norwegian production in 1987 caused the FOB price to drop from 2.85 ECUs per pound in 1987 to 2.67 ECUs in 1988 as traded volume increased from 68 million pounds in 1987 to 108 million pounds in 1988.

If, indeed, Norwegian production increases by 33.3% in 1989, Norwegian exports to the EC are predicted to rise to 157 million pounds resulting in a lower price of 2.34 ECUs per pound. After 1989, prices in the EC are predicted to follow an upward trend starting with 2.43 ECUs in 1990 and 2.58 ECUs in 1992, the same movement predicted for the U.S. market.

If Norwegian production is 10% below the projected figures for the period 1989-1992, exports to the EC are predicted to be 145, 166, 174, and 181 million pounds for 1989 through 1992, respectively. Prices are predicted to be 2.43, 2.49, 2.58, and 2.65 ECUs for the same period.

Summary and Future Research

Future prices of farmed Atlantic salmon is much needed information for decision making by the salmon industry. Because future demand for and supply of farmed salmon are expected to increase simultaneously, the future price movement of farmed salmon is uncertain. In this paper, econometric and time series models are integrated to generate future prices and supplies of Norwegian Atlantic salmon in the U.S. and EC.

Many salmon farmers in the U.S. and elsewhere believe that the rate of increase in the demand for salmon will keep pace with the phenomenal increase in supply so that the price will remain high in the near future. Indeed, the econometric results suggest that the demand for farmed salmon is very price elastic so that the market appears to be sizeable. However, it is predicted that the market demand, even under continuous economic growth in the U.S. and the EC, will not match the phenomenal growth in supply during the 1989-1992 period without some price decrease.

The high income elasticity generated by the econometric model suggests that the price of farmed Atlantic salmon is very sensitive to the world economy. Salmon farmers should be aware of the fact that the degree of price fluctuation for farmed salmon will be greater than the general fluctuations in the economy. Therefore, an economic recession worldwide would have significant adverse effects on farmed salmon prices.

The econometric model also suggests that farmed Atlantic salmon and high-valued Pacific salmon are substitutes in the U.S. and the EC. Because farmed salmon is usually marketed in fresh/chilled form, it commands a higher price than captured salmon. If the price of farmed salmon declines due to the faster increase in supply relative to demand, the degree of substitutability between farmed and captured salmon will intensify. This substitution may also intensify as more of the farmed salmon is targeted during the Pacific salmon fishing season when Pacific salmon is marketed fresh in the United States. Currently most farmed salmon is targeted during the winter and spring in the U.S., when Pacific salmon is sold frozen, as evident from the econometric results. Therefore, improved processing and marketing methods are needed by the Pacific salmon fishery. This appears to be particularly important in the European market, the second most important U.S. export market for captured salmon, because Norway has a locational advantage in supplying this market.

One of the main advantages in using econometric models for forecasting involves the possibility of conducting sensitivity analysis. In this paper, sensitivity analysis is conducted to examine the effects of Norwegian production on the prices and supply in the U.S. and EC. Sensitivity analysis can also be conducted for examining the effects of exchange rates, income, and inflation. However, it is well known that econometric and time series models can be useful tools for short-term forecasting. In addition, a continuous update of the econometric model is crucial in improving its usefulness for forecasting. Our modelling

experience clearly indicate that model specification in terms of variable and functional form selection requires special attention when the sample period is enlarged. In addition, specific work is needed to improve the forecasting accuracy of the approach adopted in this study. These points are briefly discussed here.

First, the price of Pacific salmon is treated as an exogenous variable in the econometric model. Endogenization of this variable will be useful in not only improving the forecasting ability of the approach by also studying the impact of salmon farming on the capture fishery.

Second, Norway is likely to diversify its export destinations for farmed salmon when its production expands. For example, Japan has increased its imports of Norwegian Atlantic salmon in recent years. Therefore, attempts should be made to expand the econometric model when sufficient data is available.

Finally, production of farmed salmon other than the Atlantic in countries other than Norway is expected to expand rapidly in the near future. The substitutional relationship between different species of farmed salmon from different origins needs to be included in econometric modelling. However, the current data base may not be sufficient to support such an attempt. For this reason, our price forecasts reported in this paper should be regarded as upper bounds if a large amount of other farmed salmon is placed on the market in the near future.

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Estimation and Forecasts of Demand for Farmed Salmon.

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Introduction

The aim of this paper is to specify models for the farmed salmon markets and to provide estimates of own-price, cross-price and income elasticities. The estimated models will also be tested for their forecasting properties and actual predictions for the demand for farmed salmon will be made.

The Norwegian production of farmed salmon has increased by about 40 per cent annually from 1980 till 1988. In 1980 the total world production of pen-reared salmon was about 5,000 tons and in 1988 about 130,000 tons. Norway is the predominant producer, but the success of the Norwegian industry has induced other countries to enter the industry. The rapid expansion and the production prognosis for the next two or three years will affect the profitability and further expansion of the industry since a drop in real-price is expected *ceteris paribus*.⁸ Furthermore, the increase in the production of farmed salmon may also have an impact on the wild-caught salmon fisheries and thus affect their profitability. We will try to highlight these relationships and consequences of the increased production of farmed salmon by undertaking an econometric demand analysis of the demand for farmed salmon utilizing Norwegian export data from 1981 to 1987.

The rapid expansion of the market for pen-reared salmon must be reflected when specifying models of market behavior. In particular we emphasize this by specifying two different behavioral models of market penetration and we formulate a simple dynamic model. The outline of the rest of the paper is as follows. In Section 2 an overview of the markets for farmed salmon and the structure of the market behavior is provided. Section 3 and 4 outline the models and data set. In Section 5 the results of the econometric testing are presented. The results of

9. This expansion was partly accomplished by Norwegian investment (Bjorndal and Schwindt, 1987).

the forecasting power of the models and the predictions of the future expansion of the industry are presented in Section 6. Section 7 contains concluding remarks.

Market Structure

We will emphasize two features of market behavior and the development of the market for Norwegian farmed salmon. The first feature to be emphasized is the rapid market expansion. From 1980 on, there has been an increase of about 40 per cent a year. About 90 per cent of the Norwegian production is exported and most of it is exported in fresh form. Hence, markets were developed fast and they have been able to absorb the production increase. Figure 1 below illustrates the expansion of the market (in aggregate) for farmed Norwegian salmon for our sample period.

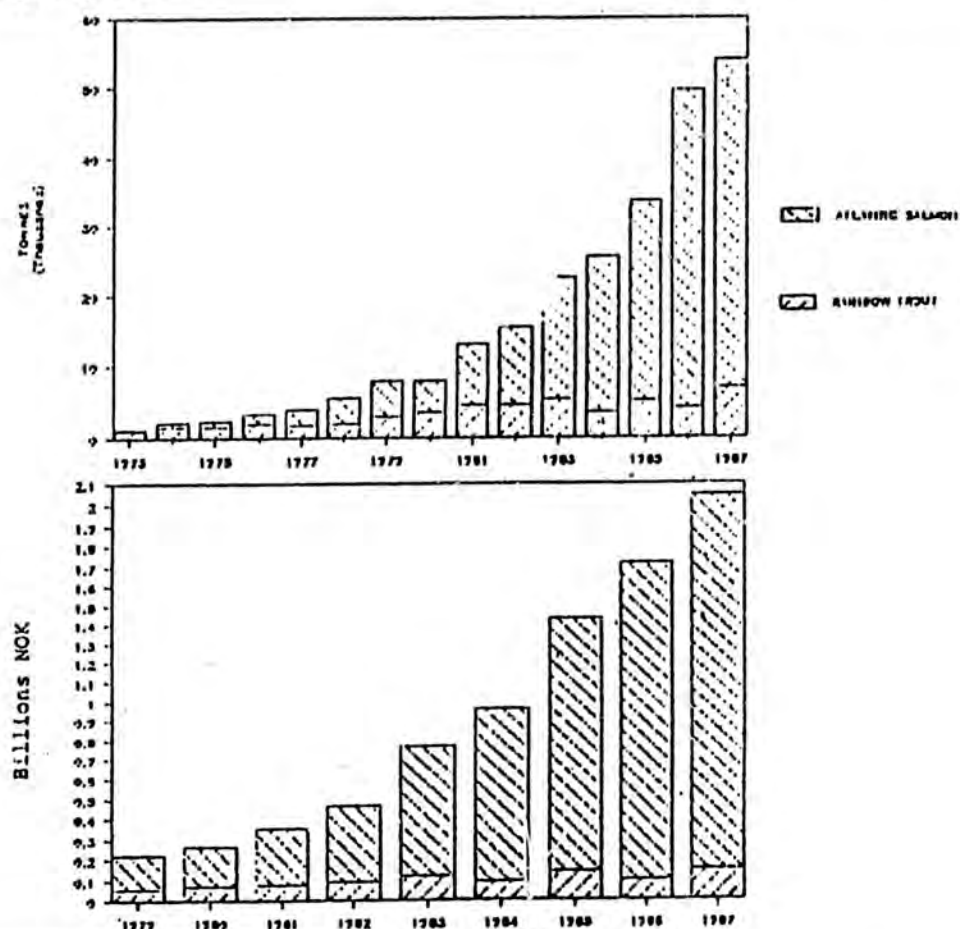


Figure 1. The production (in '000 metric tons) and value (in '000 NOK) of Norwegian pen-reared salmon and rainbow-trout.

This expansion in the production and consumption of a commodity has implications for how the markets are modelled. A static model assuming instantaneous demand adjustment is probably not suitable to describe the behaviour in a market like this. Hence, we specify a simple dynamic model including a partial adjustment process such that demand can

adjust to a rapidly increasing supply. Utilizing monthly and quarterly data sets reinforces the need for a dynamic specification. Stability tests in terms of forecasting properties of the models will also provide information on consequences of market expansion.

Given the above description of the rapidly growing industry and the fact that about 90% of the production is exported, we argue that to understand the demand for Norwegian salmon requires that we appreciate Norway's marketing strategy, namely successive market penetration. Table 1 illustrates the developments of markets.

Initially Norway sold in traditional European fish export markets, in particular France. From 1981 to 1983 France absorbed a share of fresh/frozen Norwegian salmon varying from 36 to 28 percent. Then, beginning modestly in 1981 Norway turned to the US market. In the end of 1984 the U.S. had become the largest market; 24 percent compared to France's share of 23 percent of the fresh/frozen and the U.S. fresh share was 27 percent compared to the French fresh share of 20 percent. This trend continued and in 1985 the U.S. absorbed 27 percent of fresh/frozen (30 percent of fresh) salmon as compared to France's share of 21 percent (18 percent of fresh).⁹ Now it appears that the next arena for Norwegian exploitation is Japan with a recent 105 per cent rise in sales from 1985 to 1986.

Table 1. Export of farmed salmon from Norway (in '000 tons) divided in fresh (fr) and frozen (fz) and by importing country.

Year	1981	1982	1983	1984	1985	1986
	fr/fz	fr/fz	fr/fz	fr/fz	fr/fz	fr/fz
Country						
US	0.7	2.4	4.6 -	6.5	9.4	0.1
France	1.8 0.9	2.3 0.3	3.3 1.1	3.5 0.9	3.9 1.2	8.2
Denmark	1.1	1.2	1.9	2.1 0.2	2.5 0.3	4.8 1
UK	0.3 0.2	0.5 0.4	0.9 0.5	1.2 0.5	1.3 0.5	1.3
W-Ger.	1.1 0.5	1.5 0.3	2.0 0.4	2.4 0.2	2.8 0.2	4.4
Sweden	0.5	0.6	0.8	0.9	1.0 e	1.2
Spain	0.1	0.3	0.4	0.8	1.1 -	1.6 -

10. The difference arises from the use of frozen salmon in the French smoking industry.

Italy	- -	- -	- -	- -	- -	0.2 -
Japan	- -	- -	- -	0.2 -	0.3 0.1	.6 .2
Belgium	0.3	0.3	0.5	0.7	0.9	1 .1
Netherl.	- -	- -	0.2	0.3	0.5	0.6
Switzerl	0.3	0.3	0.5	0.5	0.6	0.7
Total exports	5.5 1.9	7.8 1.2	12.9 2.3	17.2 2.3	21 3	35 4
Total Production	8.3	10.4	17.2	22.3	28.7	45.5

Source: Norwegian Council for Export of Fresh Fish

Alternative Models

Model I

Given the nature of this market the literature offers several possible modelling strategies. A general equilibrium world-wide model is conceivable (see Bird, 1986). Under this view the allocation of salmon to different markets depends on existing price differentials. One standard version of this general equilibrium model is a quantity dependent single-equation formulation since price is fixed for the single farmer/exporter.¹⁰ This view is made even more credible with the recent integration of some Norwegian farmers and brokers/exporters (DeVoretz and Salvanes, 1988).

Since we want to reflect a rapidly expanding market, a static model assuming instantaneous demand adjustment to price changes, probably does not provide a realistic market model. A rationale for a model of partial adjustment for a non-durable good (e.g. salmon) is habit formation (Phlips, 1983). In our case this view can be interpreted as follows: a supply increase induces real-price to drop, *ceteris paribus*, and the consumers adjust by slowly increasing their demand. In other words, tastes for a (new) good are affected by previous consumption experience as habits are formed. Utilizing quarterly and monthly data reinforces this argument for specifying a dynamic model. In addition to the individualistic view explaining habit formation, a social habit formation scheme exists (Deaton and Muelbauer,

11. In traditional demand literature for wild-caught salmon, supply is considered independent of prices since changes in harvest levels are due to changing natural conditions (DeVoretz, 1988). In that case a price-dependent model is preferred.

1980). Instead of lagged behavior within one individual household, there is a spread of fashions for consumption among households. Hence, there are lags between households similar to the lagged response by any individual households.

A simple dynamic model incorporating an endogenous lag (demand is lagged one period), is one way of modelling the partial adjustment process described above. The coefficient of the lagged consumption falls between 0 and 1; the bigger the coefficient the longer is the adjustment period. Moreover, theory a priori indicates larger long-run estimates than short-run.¹¹

A simultaneous-equations system with a price-dependent supply function which is not perfectly elastic, is possible as well. Thus, the fish farming industry (in particular the exporters in our case since export data is utilized) reacts to price signals but in a limited fashion. Certain restrictions on the farmers owing to harvest practices reduce their response to price movements.¹² Hence, the demand equations can be argued to be embedded in a simultaneous-equation framework. We formulated the following benchmark quantity dependent general equilibrium model:

Model I

$$\text{Eq.1 } Q^D = (P, Q_{\text{lag}}, Y, P_s, \text{Season})$$

12. The dependent variable lag model allowing consumer adjustment can be interpreted as Nerlove's partial adjustment model (Philips, 1983). If we denote X^* as the desired long-run level of consumption, for the linear model we then have (when substitute price and seasonal dummies are excluded for the sake of simple presentation):

$$1. X_t^* = a_1 + b_1 P_t + c_1 Y_t$$

The adjustment to a long-run equilibrium follows a process of the form:

$$2. dX_t = (1 - d_1) (X_t^* - X_{t-1}), \quad 0 < d_1 < 1$$

where d_1 is the adjustment coefficient. The interpretation of 2 is that the consumer adds to his consumption level a fraction of the gap between the desired level and last period's actual level. When substituting equation 1 into 2 the equation to estimate becomes:

$$3a. X_t = a_1 d_1 + (1 - d_1) X_{t-1} + b_1 d_1 P_t + c_1 d_1 Y_t$$

$$3b. \quad = a + e X_{t-1} + b P_t + c Y_t$$

From the parameters, the short-run and long-run own-price elasticities are

$$E_{SR}(X) = bP/X, \quad E_{LR}(X) = bP/(1-e)X$$

And the short-run and long-run income elasticities are as follows

$$E_{SR}(Y) = cY/X, \quad E_{LR}(Y) = cY/(1-e)X$$

13 It has been observed that Norwegian fish farmers harvest a year-class of salmon when the fish reaches its maximum weight.

where Q^D and P are Fisher price- and quantity indices for all countries, respectively. Q_{lag} is the lagged endogenous variable. And P_s is a Fisher substitute price index for fresh/frozen Pacific salmon. The remaining variables employed were income (Y) and a seasonality dummy variable (season). The rationale for the index is as follows. If we consider that the pen-reared Atlantic salmon market is in fact a general competitive equilibrium one, then, we argue that a representative world price is appropriate (Bird, 1986). For this particular market it was natural to use a price in Norwegian kroner as the representative market price, and we used a Fisher index to derive it.

In addition, we could not a priori exclude the possibility that the price is endogenous. This of course would yield a downward biased own-price elasticity when estimating a quantity dependent model (Johnston, 1984). Thus, we also estimated a simultaneous equation world model under two stage least squares with tons harvested as the extra supply shifter in the first stage. Hence, two versions of the dynamic competitive world model is specified and tested empirically.

Market Penetration Models

The alternative models contain segmented markets as opposed to an integrated general equilibrium version. Given the historical development of Norwegian export markets a marketing strategy may have been employed. First, the traditional channels in Europe with France as the core outlet were exploited. As output increased peripheral markets were penetrated. This strategy could be interpreted as a process of serving central markets first and then newer markets. However, to further develop these new markets under limited supply we argue that salmon was reallocated irrespective of price. Thus, the US market appears to have been developed at the cost of the French market between 1982-1985 (see Table 1). Thus, it is not quite clear which of the two markets segments is first served; the infant market or the established market. The main ingredient in this formulation is two or more distinct market segments where changes in relative market shares are not necessarily determined by relative prices. Thus, total Norwegian salmon output is now argued to be allocated on the margin by a limited number of major exporters in a systematic way to maximize total sales revenue. When any further allocation of salmon to a market led to a decline in total revenue, then it is argued that salmon was re-allocated to the second market. The rule which partitions the total supply into two parts is the traders' recognition that the own-price elasticity in the primary market has fallen at or below unity. When this occurs the remaining output is allocated to the second market with a higher own-price elasticity. The rationale for this behaviour is obvious; a less than unitary elasticity implies declining total revenue. Finally, the price in the second market is a function of the price in the primary market, thus, the system is closed.

This segmented view of markets is supported by the institutional framework of the industry. Although the sales cooperative does not control the farm-gate transactions or exports, it collects and provides market strategy information to the farmers and exporters. Furthermore, the sales cooperative itself, and the general entry regulations are devices to pursue the government goal of a "stable market" (Bjorndal and

Salvanes, 1987). However, it is important to note that this model has nothing to do with a monopoly model or a mark-up pricing model. The idea of the model is that one or more of the exporters open up a new market. The information is passed back to other exporters - in particular through the sales organization - and other exporters follow. It is a model with free entry (and exit) under free competition and information is a good available to a low cost.

Model II

We now concentrate on developing the two-stage market penetration model, i.e., Model II. Figure 2 depicts the sequence of events also described in equations 2 to 5.

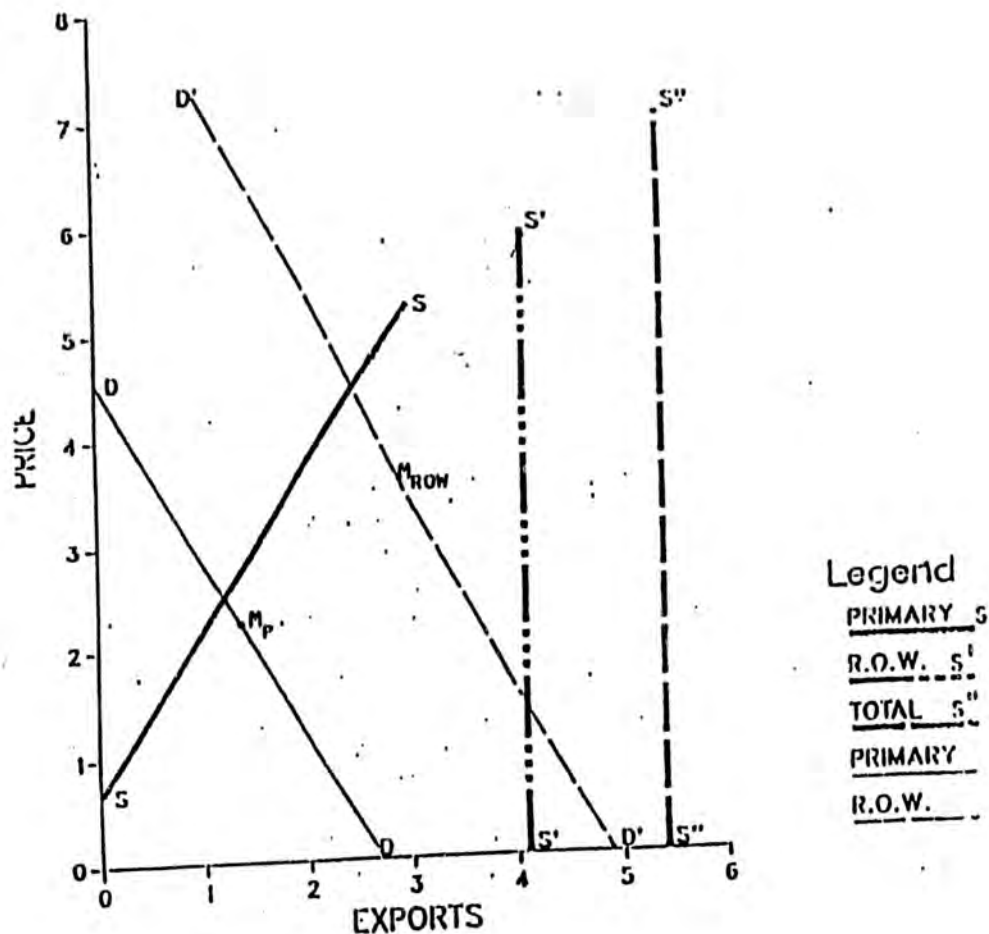


Figure 2. Distribution of Norwegian Salmon: Primary and ROW.

Equation 2 presents the accounting equation for the Norwegian salmon supply function:

$$\text{Eq.2 } Q_T^S - Q_P^S(P_P, Y) = Q_{ROW}^S$$

In any one month total Norwegian salmon supply (Q_T^S or S'') is given with the amount supplied to the primary market (Q_P^S or S) a function of the price in that market and of course the residual being allocated to the rest of the world (Q_{ROW}^S or S'). Y is other shifters.

The demand and supply conditions within the primary market which determines the primary market price appear below:

$$\text{Eq.3 } Q_P^S = (P_P, Y_P)$$

where the supply to the primary market depends upon own-price (P_P) and Y_P is other shifters.

$$\text{Eq.4 } Q_P^D = (P_P, Y_P, P_S, \text{Season})$$

or the demand in the primary market is a function of own price (P_P), income in the primary market (Y_P), price of the substitute (P_S) and a seasonality dummy. Given that the ROW market is a residual, i.e., the supply curve to the ROW is identified. Thus, the equilibrium demand and supply conditions for the ROW appear below.

$$\text{Eq.5 } Q_{ROW}^S = Q_{ROW}^D = (P_{ROW}, P_P, P_S, Y_{ROW}, \text{Season})$$

This market is in continuous equilibrium where quantity demanded depends upon own-price (P_{ROW}) and the equilibrium price in the primary market or (P_P), the substitute price (P_S), income and a seasonality dummy. Thus, the price in the ROW can be solved for by converting Eq. 5 into a price dependent equation. These equilibrium conditions are depicted in Figure 2. The results are self-explanatory but, we highlight two further hypotheses. First, (M_P) and (M_{ROW}) depict mid-points on the linear demand functions and hence are points of unitary elasticity. We argue that the primary market will be expanded until the supply of Norwegian salmon intersects at (M_P). Hence, in each period, i.e., month or quarter, the decision to further penetrate the primary market depends upon the relative own-price elasticities between the rest of the world and the primary market. Given that in Figure 2 the depicted own-price elasticity in the primary market exceeds that in the ROW, further allocation would occur to the primary market. When the equilibrium price in the primary market is at the point of unitary own-price elasticity, then a new market will be sought with a higher own-price elasticity.

In this market environment with rapidly increasing production it is also important to test for structural shifts in the period analyzed. These shifts could be revealed by changing marketing strategies. Within our data period two different stages can be identified in terms of a primary market and a secondary market. From 1981 to 1984 France was the primary market, and from sometime in 1984 the U.S. becomes the main

single market. Hence, we must be careful when testing our model to properly define the time periods utilized.

We posit that a structural shift occurs when France ceases being the primary market. This feature must be incorporated in the French demand function. Thus, we capture the expected change in the own-price elasticity between the two periods, by introducing an appropriate dummy variable. The dummy $X_2 = X_1P$, where $X_1=1$ in the period January 1982 to September 1984 and $X_2=0$ in the period October 1984 to December 1986. This particular month in 1984 was chosen based on the results from Chow-tests between every month in the sample for France (See Handry 1989) for the procedure which describes the testing). The estimated demand equation for France is:

$$\text{EQ. 4A } Q_P^D = (P_P, Y_P, P_S, X_2, \text{Season})$$

where we expect the sign of X_2 to be negative which implies that the French salmon is more elastic in the period when it was the primary market. When the own price elasticity approaches unity in France a new market is sought as the next core outlet. When France was the primary market, i.e., from 1982 to September 1984, we use the European countries (minus France) as the secondary market in the period. The European demand function in this first period is:

$$\text{EQ. 5A } Q_{\text{ROW}}^D = (P_{\text{ROW}}, P_P, P_S, Y_{\text{ROW}}, \text{Season})$$

A priori we expect the own-price elasticity in this period to exceed that in the french market.

Model III

A second more deterministic view of market segmentation is also possible, i.e., Model III. From this viewpoint, a fixed amount is allocated to the primary market to maintain or serve a traditional market. In this case the market supply curve(s) for Norwegian exports would appear as Eq. 6:

$$\text{Eq. 6 } Q_T^S - Q_P^S = Q_{\text{ROW}}^S$$

where the supply to the primary market (Q_T^S) is fixed. In the initial years, i.e., 1981-1983 (see Fig. 2) this has been argued to be the case for the Norwegian treatment of the French market. In other words, a fixed absolute amount of salmon was supplied to the French market and any residual resulting from fluctuations in total supply were exported to the rest of the world. In this case both of the demand curves would be identified as follows:

$$\text{Eq. 7 } Q_P^S = \text{constant} = Q_P^D(P_P, P_S, Y_P, \text{Season}) \text{ and}$$

$$\text{Eq. 8 } Q_T^S - Q_P^S = Q_{\text{ROW}}^S = Q_{\text{ROW}}^D(P_{\text{ROW}}, Y_{\text{ROW}}, P_S, \text{Season})$$

Thus, the equilibrium prices in both markets would result from the exogenous arguments in each market's demand equation. Hence, under this

regime substantial real price differentials could appear between the two markets. Also, for this model we split the sample into two periods in the same manner as under Model II.

Data

In this study we utilized Norwegian export data of fresh pen-reared Atlantic salmon (in addition frozen for France) for the period 1981 to 1987. The data base was provided by the Norwegian Bureau of Statistics and the Norwegian Council for Export of Fresh Fish. Data for the following countries (adding up to more than 95 percent of the total export) was used: France, Belgium, West-Germany, Great-Britain, Spain, Ireland, Italy, Sweden, Netherlands, Japan, USA and Canada. The observations are on a monthly basis and this data was utilized in Model II and III to ensure enough degrees of freedom when splitting the data by time periods. We aggregated the data set into quarterly data when estimating Model I. The income variable we used was a wage index for each country as reported in the International Financial Statistics (various issues). As a substitute variable we used in general, the Canadian export of fresh/frozen (all species) of Pacific salmon, and for the French market alone we used U.S. Chinook and Coho (fresh/frozen) values. All nominal values were deflated to real values using a country specific consumer price index obtained from the International Financial Statistics (various issues). To capture the possible effect of the marketing period of wild-caught Pacific salmon on the demand for Norwegian pen-reared salmon, we created a seasonal dummy. We gave it the value of one for the third quarter and a zero otherwise. Hence, a negative effect on the demand for Norwegian salmon is expected a priori by the seasonal dummy. The shifter in the TSLS model was the total harvest of Norwegian pen reared salmon provided by the Norwegian Fish Farmers' Association.

Results

In the following sections we report various disaggregations of the basic model for fresh salmon exports from Norway. First, we test two versions of the standard world-wide competitive general equilibrium and then report the results for our alternative versions of the segmented Models II and III.

MODEL I: World-wide model

The quantity dependent general equilibrium model reported in Table 2 (row1), provides a reasonably good fit, i.e., R^2 adjusted equals 0.84 and the standard error of the estimate is 0.22. Since the D-W statistic is biased downwards when an endogenous lag variable is specified a Lagrange multiplier test is used to detect first-order residual autocorrelation. An F-distribution of this test is used and the F-value is reported in Table 2 as 0.37 (Hendry, 1989). The critical value at the 5 per cent level is 4.49 and no autocorrelation of the first order is detected.

TABLE 2 MODEL I: WORLD-WIDE MODEL

Quarterly Model (1981-86): Fisher Index

Ols Q - dependent^a

constant	P	Qlag	Ps	Season	Y
-2.21 (0.96)	-1.31** (-2.57)	0.80** (8.72)	0.52 (1.31)	-0.5** (-4.65)	.54 (1.10)
$R^2 = 0.87$		$R^2 = 0.84$	Sigma = 0.22		F = 0.37

TSLS Q-dependent

constant	P	Qlag	Ps	Season	Y
1.40 (1.76)	-2.95** (-3.24)	0.79** (5.44)	0.98 (1.49)	-0.56** (-3.25)	0.10* (1.86)
$R^2 = 0.75$	$R^2 = 0.67$		Sigma = 0.33		F = 1.14

Notes:

a. All functions are in logs. Auto means corrected for first-order degree of autocorrelation by a Cochran-Orcutt procedure.

* Parameters are different from zero at the 90%

**Parameters are different from zero at the 95% significance level.

The own-price effect and the endogenous lag are significant at the 5 % level for a two tailed test. The short-run and long-run own-price elasticities are -1.31 and -6.53, respectively. The income variable and substitute price both have the a priori expected signs, but are not significant. Thus we conclude that all species of fresh/frozen Pacific salmon when used as a substitute is probably too broad a category to provide significant results. Furthermore, we notice that the seasonality dummy has the correct sign; the availability of wild-caught Pacific salmon influences significantly the demand for Atlantic salmon.

For reasons mentioned earlier, the single equation demand function may be imbedded in a simultaneous equation system. For the TSLS model in Table 2 (row2) we obtain an short-run own-price elasticity of -2.95. Therefore, we conclude that the own-price elasticity from the quantity dependent single equation model is probably biased downward. Moreover, the income effect in the TSLS model is significantly different from zero and the income elasticity is 0.10, i.e., pen-reared salmon cannot be established as a luxury good in this model only as a slightly normal

good. No significant first order autocorrelation is found as reported by the F-test for the Lagrange multiplier.

In the world-model we obtain a short-run estimate for the own-price elasticity varying between -1.31 and -2.95. This result is in the same range as Herrmann and Lin (1988) obtained for U.S. demand and E.C. demand, i.e., -1.97 and -1.83, respectively.

When specifying a very simple dynamic mechanism we obtain a long-run result which provides a more optimistic view concerning the salmon farming industry. The long-run own-price elasticity for the single equation model is -6.53. This means that if the real-price decreases by one per cent, demand increases by 6.53 per cent. This result is interesting and it needs more careful testing because there apparently is a contradiction between our result and Bird's (1985) study of the Pacific salmon market. Bird's results suggest a long-run response which is smaller than the short-run. He explains the inelastic long-run response by arguing habit persistence as a determinant for salmon consumption. The argument supporting our more elastic long-run elasticity might be that with a rise in the absolute price of the commodity its budget share rises. Hence, the consumer is more sensitive to price changes (Chang, 1977, Gemmill, 1980). More detailed research is required in specifying more general dynamic models to discriminate between the relative sizes of the long and short-run elasticities.

MODEL II: Two stage segmented market

Table 3, row 1, reports the results for the French portion of the two stage segmented model.

TABLE 3 MODEL II: TWO STAGE SEGMENTED MARKET

Market / Product (Monthly data set)

France / fresh/frozen (Jan 1982 - Dec 1986)

Auto Q - dependent^a

Constant	P	LX2	Ps	Season	Y
-4.39*	-1.41**	-0.15**	0.40**	-0.22**	12.6*
(-1.69)	(-3.04)	(-3.20)	(2.73)	(-1.99)	(2.4)

$R^2 = 0.75$

$R^2 = 0.72$

Sigma = 0.30

DW = 1.78

ROW(fresh)^a (Jan 1982 - Oct 1984)

Q - depend^a

Constant	P _{row}	P _s	Pred.P	Season	Y
-0.94	-2.64**	0.19	0.25*	-0.84	5.10*
(-1.36)	(-1.95)	(0.25)	(1.70)	(-1.20)	(1.6)
$R^2 = 0.83$		$R^2 = 0.79$ Sigma = 0.22 DW = 2.20			

Notes:

a. All functions are in logs. Auto means corrected for first-order degree of autocorrelation by a Cochran-Orcutt procedure.

* Parameters are different from zero at the 90% significance level.

**Parameters are different from zero at the 95% significance level.

All variables have the expected sign and are significantly different from zero. The standard error of the regression is 0.30 with an R^2 of 0.72. Unlike the world model, i.e., Model I where all Pacific salmon was an insignificant substitute, for the French market a more refined substitute, i.e., fresh/frozen Chinook and Coho, is a significant substitute. The cross-price elasticity is 0.40 which implies that the demand for Norwegian pen reared salmon will increase by 0.40 per cent for each one per cent rise in the wild caught Chinook/Coho price. Hence, wild Chinook and Coho is a weak substitute for Atlantic farmed salmon in the French market. Furthermore, an income elasticity of 12.66 implies that salmon is a luxury good¹³.

This model's results are further strengthened by the fact that the dummy variable X2 is significantly different from zero and has a negative sign. Our hypothesis of a more elastic market when France was the primary market is supported. The own-price elasticity in the first period is - 1.56 and - 1.41 when the U.S. was sought as the primary market. Hence, we conclude that our behavioral model of France as the primary market in the first period is supported by the results.

The results for the second stage of this model, the market for all countries except France, are reported in Table 3, row 2. All the variables have the correct sign. In addition, under Model II the predicted price from the primary market was argued to be positively and significantly related to the price in the R.O.W. market. Thus, the second stage of Model II uses the predicted primary market price in the equation for the primary market. Inspection of the equation in Table 3 row 2 confirms this hypothesis.

Model III: Totally segmented markets

13. This large elasticity no doubt reflects a spurious correlation with time. Thus, the income variable also, captures the effect of a trend variable.

Model III proposed that the French market was totally separable from the rest of the world. Given the relationship between relative prices and France's market share it was hypothesized in Model III that the supply of Norwegian salmon was fixed and the R.O.W. received a fluctuating residual amount of Norwegian salmon. The results for estimating this system (i.e., Eqs. 6-8) appear in Table 4.

TABLE 4 MODEL III: SEGMENTED MARKETS

Market / Product (Monthly data set)

France / fresh-frozen (Jan 1982 - Dec 1986)

Auto Q - dependent^a

Constant	P _p	X2	Ps	Season	Y _p
-4.39*	-1.41**	-0.15**	0.40**	-0.22**	12.6**
(-1.69)	(-3.04)	(-3.20)	(2.73)	(-1.99)	(2.42)

$R^2 = 0.75$ $R^2 = 0.72$ Sigma = 0.30 DW = 1.78

ROW(fresh)^a (Jan 1982-Oct 1984)Q - dependent^a

Constant	P _{row}	Ps	Season	Y _{row}
-1.21	-1.95**	0.25	-0.70	3.21*
(-1.36)	(-2.13)	(0.45)	(-1.34)	(1.83)

$R^2 = 0.77$ $R^2 = 0.70$ Sigma = 0.25 DW = 2.32

Notes:

a. All functions are in logs. Auto means corrected for first-order degree of autocorrelation by a Cochran-Orcutt procedure.

* Parameters are different from zero at the 90%

**Parameters are different from zero at the 95% significance level.

These results for France are identical to those reported in the first step of Model II (Table 3). In terms of both the general fit and the hypothesized a priori signs of the variable the French market provides the best results. The model for the second segment, i.e.,

R.O.W., also provides a good fit and the expected signs of the variables.

Forecasting

We have tested the forecasting power of Model I, i.e., how good the endogenous variable is predicted in the model given a change in the exogenous variables, by introducing actual observations for 1987. Figure 3 shows the fitted and the actual values of the dependent variable.

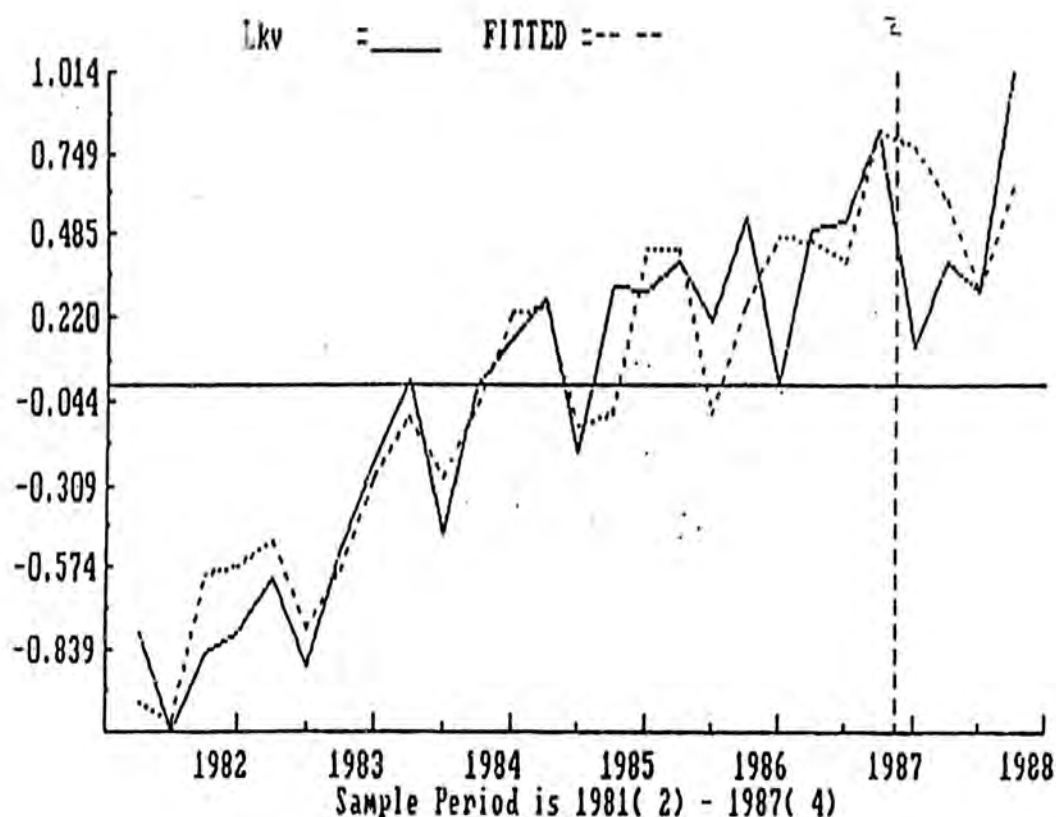


Figure 3. Predicted and actual values of demand for farmed salmon based on Model I.

Since price is the exogenous variable and quantity demanded the endogenous variable, we are forecasting how much the market can absorb given the estimated parameters of the econometric model and given a certain drop in real-price that can be predicted. We notice that the model predicts reasonably well the expansion in the consumption level from 1986 to 1987. The forecasted series is perhaps more smoothed than the real values, but it predicted the overall trend. But in late 1984 an instability is recognized by the model and thereafter the model does not predict very well actual consumption. Moreover, for the last quarter of 1987 we notice that the model does not predict the rise in demand. These changes may be due to an occurrence which is not properly modeled in the world wide model. The model is perhaps too aggregated to

capture changes for instance in the shares of consumption in different market segments. But we argue that the model predicts reasonably well and we are satisfied with the predictive performance of the world model.¹⁴

Table 5 Theil's test statistics for Model I.

Theil's U	Bias Prop(UM)	Variance Prop(US)	Covar. Prop(UC)
0.667	0.002	0.008	0.97

When we split the forecast variation into bias proportion, variance proportion and covariance proportion in Table 5, we notice that the error in the forecast is due to high correlation between predicted change in the dependent variable and actual change, i.e., U_c has the biggest proportion. This means that it is futile to attempt to improve the forecasting power of the model.

Summary and Conclusions

Before discussing the differences among the three models, we will present the main qualitative findings of this paper. First, under the Model I or the competitive world model demand for Norwegian pen-reared salmon is elastic, which means that one can expect a drop in real prices as supply increases. Second, the high income elasticity value from Model I or II indicates that Atlantic pen-reared salmon is a luxury good. The world-wide demand for Atlantic salmon (i.e., Model I) is also dependent on wild caught Pacific salmon in that our results indicate a negative shift in demand when wild caught salmon is available. Furthermore, when exploring the relationship more closely (Model II) we found that fresh/frozen Chinook and Coho are substitutes for fresh/frozen Norwegian salmon in the French market. Utilizing all species of fresh/frozen Pacific salmon in any segment of the salmon market did not provide significant results as a substitute. In addition, quantity dependent models had a tendency to generally underestimate the own-price elasticity. This was due to a simultaneous equation bias which we corrected for with our TSLS model. Furthermore, the dynamic model specification performed well and provided reasonable results in terms of the long-run statistics.

There are conclusions concerning modelling the Atlantic salmon market to be drawn at this point. A market penetration model, i.e., Model II, competes with the dynamic general equilibrium model, Model I,

15. Theil's inequality measure (see Table 5) decomposes the forecasting error.

of being superior. And they are both better than the completely segmented market model (Model III). However, it is not easy to pick either one of the two preferred models because they both provide us with useful information and their results are consistent. In a changing world perhaps Model II which is disaggregated over time and over markets is most reliable for forecasting purposes. This is so because the stability of the parameters are important and apparently the market for farmed salmon is volatile for changes. Furthermore, model I assumes the same shares for each market segment as in the past, while Model II has different shares.

In general, we conclude that a market penetration model is consistent with an industry that recognizes or experiences rent dissipation. Given the own-price elasticity of demand, one of the few strategies to retard rent dissipation in any one market is to successively find new markets. Thus, Norwegian expansion to the west coast of Canada which is predicated on opening new markets in Japan and the U.S.A. is the correct strategy.

Finally, there are many possible extensions of this initial modelling. For example, refining Model I by comparing fresh to frozen salmon markets, or seeking new primary markets, i.e., Europe minus France or Japan, may yield an even more robust model. Also, a more detailed investigation of possible fresh-frozen wild salmon substitutes could prove instructive, especially as we disaggregate the model into separate country and product type models. Furthermore, the dynamic modelling should be extended.

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VIEWPOINTS ON DEMAND AND MARKET FORECASTING FOR SALMON

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The objective of this presentation is to provide an introduction to some methods currently being explored to evaluate the salmon market. The approaches are based on primary firm level data, in contrast to commonly used conventional approaches which rely on secondary data. In this presentation, a brief summary will be given of the approaches that are currently being used by researchers at the University of Rhode Island and elsewhere to explain market behavior and forecast changes in market share and other market dynamics. Most of the work discussed is available, or will be forthcoming, in the professional literature and for details these documents should be read.

As is well known, the advent of farmed salmon has begun to make significant changes in the fresh, and more recently the frozen, salmon market. Farmed salmon accounted for approximately 30 percent of the worldwide harvest of salmon in 1989 (FAO 1989). This contribution, which is expected to grow for some time, will substantially change the nature of the salmon supply. In addition, purveyors of farmed salmon are more active marketers compared to their counterparts representing the wild fishery. These changes in the salmon market have created considerable interest among salmon farmers, salmon fishermen, and government officials as to how the salmon market functions and what future prices may result.

In particular, questions have arisen regarding how buyers of salmon evaluate attributes of farmed and wild salmon products. What can producers of salmon do to improve the relative position of their salmon vis a vis other salmon products? To what degree is the buyer concerned about factors such as: species, fresh versus frozen form, shelf life, farmed versus wild, year-round availability, country/region of origin? Would a whole, dressed, head-on salmon (most farmed salmon is currently sold this way) be preferred to a whole, dressed, head-off salmon (most Alaskan wild salmon is sold this way) in the buyer's eyes? Will different buyers have differing preferences? How will new products be received in the salmon market?

There are many characteristics of the salmon market which make developing an appropriate model which can address the aforementioned questions quite difficult. These include:

1. The produce is heterogeneous. Salmon products differ in quality, size, packaging, species and other attributes.
2. The market itself is heterogeneous. The demands for salmon by supermarkets, fish stores, restaurants and smokers are different and their knowledge of the product varies. In general, buyers have a highly variable range of knowledge of salmon. Some are quite well informed,

while others could not discern the difference between an Atlantic and a Sockeye salmon.

3. The market is exceptionally dynamic. On the supply side, the advent of aquaculture is increasing supplies. On the demand side, new marketing tools and promotional efforts are beginning to target the potential salmon consumer, thereby shifting demand. In addition, in North America there has been a major trend in consumer preference for seafood largely influenced by health issues. More recently, however, this trend may be reversing direction with recent negative publicity on seafood safety. Also, new salmon products are entering the market to expand demand including products such as microwavable salmon Wellington and salmon Kiev, pre-cut products and new cured products.

4. There are, of course, all types of other influencing factors in addition to price, quantity, and income which are needed to explain the salmon market. These include exchange rates, inventories, expectations and other factors.

5. Finally, the data from most secondary sources are poor. For example, valid monthly or even annual data on the distribution of salmon within the U.S. is essentially non-existent. Even market prices have wide margins of error at all market levels. In addition, a relatively long time series is necessary for estimation. However, not only has the quality of the data changed over the past several decades but the salmon market of the nineties, dominated by fresh and frozen products in North America, is much different from the market in the fifties and sixties in which canned salmon played a much greater role. Different, but no less extreme, changes have occurred in the Japanese market (Kusakabe and Anderson 1989).

All these complicating factors lead one to conclude that the 'garden variety' static demand model for salmon will be of marginal usefulness for many market questions. Buyers and sellers are not fully informed, price and quantity data are replete with errors or unavailable, salmon is not a homogeneous product, there are many market segments and the salmon market is dynamic and not necessarily in near equilibrium in the current situation. The work we have done recently (Anderson and Brooks, 1986; Kusakabe and Anderson, 1989; and Anderson, 1988) has taken the approach that primary firm level data will result in better understanding of and forecasts for the salmon market than traditional demand models based on secondary data. In particular, we wanted to determine to what degree buyers are concerned about factors such as: species, fresh versus frozen, shelf life, farmed versus wild, availability, country of origin, whole versus steaks and such in addition to price, and how these factors influence purchase decisions.

The methods used are similar to contingent valuation which is aimed at determining people's preferences by eliciting their willingness to pay for goods. (See Mitchell and Carson, 1989, for an in-depth discussion). The approach taken in our work is usually known as conjoint analysis (Green and Wind, 1975). The underlying concept is that the utility a purchaser derives from a product is a function of the product's attributes including price. Willingness to pay is not measured directly; rather, the degree of preference (utility) is measured. The inclusion of price is particularly justified for intermediate buyers of salmon, such as chefs or retail operators since their utility is partially derived from the profit resulting from the purchase and resale of salmon.

In practice, the approach uses an orthogonal experiment. Relevant attributes such as species, size, flesh color, and price are disaggregated into a finite number of attribute "levels." For example, size could be disaggregated into four levels: 2-4 lbs., 4-6 lbs., 6-9 lbs. and over 9 lb. salmon or species be disaggregated into Chinook, coho, sockeye, pink, chum and Atlantic salmon. The attribute levels are arranged in an orthogonal array to design a minimum size experiment which also minimizes any multicollinearity problems. The resultant experiment consists of a series of full products (such as Canadian, Chinook, wild, troll-caught, fresh, and so on). Salmon buyers are then asked (usually in-person) to rate the products in terms of overall preference or some other index such as likelihood of purchase. When the minimum size experiment is relatively large, for example greater than 6 to 10 choices, more than one buyer will be needed to obtain a complete ranking. These buyers should be aggregated by similar characteristics. Once a sufficiently large number of observations is obtained, frequently through in-person interview, analysis of the data to determine the marginal contribution of various attribute levels can be done by several approaches such as MANOVA, mathematical programming and various econometric approaches. Note, an alternative to this conjoint approach using full product ratings are experiments based on paired comparisons or self explicated utility analysis based on direct ratings of individual attribute levels by the subject. Unfortunately, only this brief overview of these methods can be addressed in this presentation. However, greater detail can be found in Cattin and Wittink (1982), Green (1984), Green and Srinivasan (1978), Green and Wind (1975), Johnson (1982) and Luce and Tukey (1964).

We have used these approaches and several variations of these approaches to characterize the New England salmon market (Anderson and Brooks, 1986; Anderson and Kusakabe, 1989), the Japanese herring roe market (Anderson, Gledhill and Kusakabe, 1990), and the Japanese salmon market (Kusakabe and Anderson, 1989; Anderson and Kusakabe, 1989). In general, the information derived from these studies is quite rich especially from the industry's perspective. The results give direct estimates of the relative value of various attributes and attribute levels. By using this information, specific products can be compared in terms of relative preference. For example, a fresh, farmed, Norwegian, Atlantic salmon, 9-11 lbs. available year-round in 50 lb. boxes at \$4.00/lb. delivered can be compared with a fresh, troll-caught, Canadian coho salmon, 6-9 lbs., seasonally available in 100 lb. boxes at \$2.75/lb. delivered. If one product is significantly preferred over the other, then one can expect the purchaser to buy the significantly preferred product. Therefore, if a product is introduced into the market with a significantly preferred attribute set, one can forecast that the new product will displace the existing product, all else held equal. In fact, in our studies of the New England salmon market, the results indicated that high quality farmed Atlantic salmon available year-round from places such as Norway and Scotland were generally judged superior to the Alaskan product which was being sold in New England in 1986. Since 1986, the Alaskan salmon products have largely been displaced by imported farmed salmon mostly from Norway. In addition, the West Coast salmon industry has begun an effort to improve quality and has expanded promotional activity to attempt to recover lost market share.

In addition to being able to compare specific products for specific market segments, there are several other strengths to this approach.

1. The firm level primary data collected in these studies is current and directly obtained from the market participants. This avoids the problem of the forecasts on the current and future states which are highly influenced by past market conditions which may not closely represent current and future market conditions. This is a problem with essentially all econometric demand models based on secondary data. Also, the demand analyst using secondary data rarely is fully aware of the data limitations and errors which arise from the data collection process.

2. Since the conjoint methods can be used to decompose the salmon product into its attributes, the market potential of new products currently not on the market can be evaluated.

3. The results are highly disaggregated, allowing the researcher to evaluate the market niches, such as restaurants in New England, specializing in seafood, with an average entree price exceeding \$10.99. (See Anderson and Brooks 1986).

4. Conjoint methods can be used to determine indifference prices between products. For example, assume salmon product A is priced the same as salmon product B, however, product B is less preferred than A. With conjoint methods, one can estimate how much the price of product B must be lowered to make the buyer indifferent between A and B, or determine the price for B such that it is preferred to A at a specified confidence level.

5. In North America, direct survey methods are essentially the only way to determine product distribution channels, because of the sparse data collection done by public agencies.

There are also several limitations to the primary data methods. These include:

1. The results are based on current tastes and preferences of the buyers sampled. These can change over time as a result of media and promotional efforts. Of course, demand studies based on secondary data series are also limited by the fact that the future must behave like the past for reasonable forecasts.

2. The greatest limitation is sample size and the expense of data collection. However, there is always a trade-off in applied research between relatively small samples of relatively high quality data and relatively large samples with relatively poor quality data.

In some more exploratory work, data on quantities demanded in addition to preference data have been collected in an effort to estimate firm-level demand (Anderson 1988). This is done by assuming that the salmon buyer has a two-stage decision process. In the first stage, the buyer chooses among relevant alternative salmon products to determine which will be purchased based on the product's attributes. The second stage is to determine the quantity to purchase based on the price, the degree of preference (based on product attributes), the price of other fish, and the characteristics of the firm's resale market. Upon completion of these estimates, these results can be used to explore firm-level behavior under various market scenarios. In particular, one can compare the characteristics of salmon products supplied to the market under different assumptions about the firm's objectives such as profit maximization versus market share maximization subject to minimum

acceptable profit levels. Another line of exploration would be to simulate firm behavior under different market structures such as perfect competition, monopoly and some oligopoly structures. This work is, as yet, unfinished but it is well on its way to some results which should be useful to better understand the highly complex and dynamic salmon market.

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Strategies for Salmon Demand Forecasting

by

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A couple of years ago we made a bet with a colleague who is a biologist that we could use econometric modeling to develop a better model than he had of salmon returns to a river system in California. Thirty years of data were gathered on return counts, critical month streamflow variables and other miscellaneous variables. The data were run through various permutations of large, autocorrelated error structures and functional forms until a model with an R^2 of .95 and low variance estimates emerged. The fit was truly remarkable, tracking several complicated turning points and, best of all, the signs of the coefficients suggested some plausible and provocative 'stories' of how streamflow affects salmon. The empirical results matched surprisingly with lab studies and we spent several days developing and refining new hypotheses about streamflow, temperature, and spawning bed scouring and salmon returns. About a year later we updated the model by adding two more data points. The model vanished like a handful of sand; not only did the predictive power drop to about .20, but the few coefficients which remained marginally significant switched signs to produce diametrically opposite stories to what we first found.

What lessons for salmon demand modeling are suggested by this anecdote? We think that there are several. First, one's modeling approach and philosophy ought to reflect the kinds of questions one is ultimately interested in answering. Is prediction of aquacultured salmon prices our main purpose? Are short run or long run predictions most important? Alternatively, are we interested in mechanisms and plausible 'stories' about how country specific and international salmon markets work? Will understanding of these mechanisms be used to predict variables after some hypothesized structural change? Is qualitative understanding more important than quantitative forecasting?

Answers to these questions dictate to some extent the relevant modeling approach and philosophy. There is little doubt that much of the recent interest in salmon demand modeling is a result of competing producers' concern (if not outright paranoia) over exploding supplies of aquacultured salmon. A considerable chunk of current research funding and activity focuses quite clearly on the question: how far will prices for competing products (e.g. wild caught chinook) fall as Norway and other producers continue to expand production? If indeed this is the 'big' question, then it seems that there are several indicated research strategies depending upon whether one is interested in the short run, the intermediate run, or the long run.

If the concern is the long run (i.e. after world aquaculture has reached some steady state) then the answer to part of the question is fairly obvious; namely, the price of aquacultured salmon will drop to a level dictated by economies of scale in production countered by transportation costs. This is probably most appropriately modeled with a general equilibrium simulation model which focuses on location and production costs, i.e. cost-side rather than demand side variables. The bottom line is that one can probably predict the long run price of aquacultured salmon with some accuracy right now.

The remaining part of the problem for long run concerns is to determine how these lower aquacultured salmon prices will affect the demand for substitute products, particularly the salmon produced by traditional suppliers, the U.S., Canada, Japan, and U.S.S.R. This is the more complicated and critical component of the 'impact analysis' of increased aquacultured salmon supplies. A quick scan of recent literature on salmon demand analysis reveals considerable interest in this issue either directly or indirectly. Recent studies include models of world salmon demand for all salmon, world demand for Norwegian salmon, individual country and regional demands for Norwegian and Canadian salmon, U.S. demand models for fresh and frozen salmon, etc.

An overriding feature which emerges out of much of the salmon demand literature is how unstable the parameters are. Estimates of own price elasticities range from $-.5$ to $-.13$, income elasticities likewise range from almost zero to values substantially greater than one, and cross-price elasticities range over results that are either intuitively incorrect or insignificantly small. In addition, most studies are liberally sprinkled with hints of very reasonable alternative specifications which were tried but 'did not work'. This extreme parameter instability in part suggests that aggregated country-level time series that we typically use to estimate demand functions are simply not rich enough to yield reliable 'stories', much like our experiment with salmon return data.

Put in proper perspective it should not be surprising that such data cannot tell us much about these critical substitution and price/income relationships. First, there are serious problems with existing data series in all of the major producing and consuming nations, ranging from over aggregation across product forms, to absence of key data (e.g. actual consumption), to calendar year rather than marketing year reporting, to changes in reporting methods, etc. Any one of these is sufficient to cause doubt about whether one is estimating a real demand curve or something else. Second, we are really asking too much of data series which do not span either enough time or enough variability over relevant ranges of time. In many cases, for example, we are looking for some believable picture of what a world awash in aquacultured salmon might look like, e.g. how wild caught salmon demand might be shifted outward (due to income increases) or inward (due to cross-price substitution relationships with aquacultured salmon). Unfortunately, aquaculture is the 'new kid on the block' in terms of its role in the world production/consumption system. While supply has grown impressively, reaching exports of 70,000 tons from Norway in 1988, it is still relatively small compared with Alaska's typical production of 230,000 to 300,000 tons over the last eight years, Japan's chum production of 120,000 to 180,000 tons, Russia's average 100,000 ton production of pink salmon. One can not really hope that data gathered

over a short time period where aquacultured salmon production has been relatively insignificant can tell us much about a future scenario where aquacultured salmon perhaps dominates. Thirdly, there are inherent problems associated with trying to do any serious hypothesis tests of elasticities in systems where all of the data trend roughly together. Salmon demand throughout the world has steadily increased over recent periods as has real income. The prices of commonly used substitutes such as chicken, pork and beef have also trended but with cycles typical of agricultural products ranging from short (chicken) to long (beef). With such data the task of model specification and testing is confounded by the multicollinearity and autocorrelated error structure. This is evident in the parameter instability reported in most studies. After having looked at and 'experimented with' several salmon consumption, price, income and substitute price series, we are willing to make another bet; namely that we can produce virtually any set of elasticities one might believe plausible.

If these problems are valid, then we may be chasing our tails in trying to pin down own-price, income and cross-price elasticities using simple and aggregated models. One might be less cautionary about all of this were it not for the fact that information about these relationships is so critically important. Whether or not British Columbia, Alaska or several other areas would gain or lose from large scale expensive expansion of salmon aquaculture literally hinges on a couple of numbers, namely price, income, and cross-price elasticities of world and individual country demands. A lot is thus riding on the 'story' summarized by the question: are elasticities greater or less than one?

What research options are likely to shed the most light on these issues? First, for relatively short planning horizons on the order of a couple years, it does not matter much. Policy makers and others interested in short term price forecasts can probably freely substitute simple structural models, time series models and even extrapolation without much difference in predictions. As the focus moves into the intermediate and long runs, however, it would seem that a much more comprehensive modeling approach is warranted, mainly because the relevant mechanisms are so much more complicated. Two general areas that warrant more attention are detailed micro-level market systems and systems of trade flows and their determinants.

Micro-level market system

The critical piece of missing information for long-term forecasting is the absorptive capacity or market potential for increased aquacultured salmon. It is naive to believe that the short history we have for which aquacultured salmon has been marketed can give much insight into a future with significantly larger quantities marketed. The only hope for any predictive accuracy lies in understanding at a very detailed level who consumes salmon and why in the various major markets such as the U.S., Japan and Europe. Additionally, understanding what it is that drives consumer preferences toward certain species of salmon or product types, for example salted sockeye and chum in Japan and fresh chinook in the U.S., is critical in determining whether there is or will be a market for pen-raised salmon, especially Atlantic salmon. While it is hard to place much faith in single country aggregate import demand elasticities at this point, it would be possible

(by doing some cross-section analysis for example) to investigate whether higher income families consume more salmon than mid-level income families. Similarly, a market-level study would reveal whether restaurant demand or home consumption is the most significant component of demand growth or whether consumption behavior in coastal areas (or large metropolitan centers) is different from that in inland areas. Likewise, detailed market analysis is probably the best hope for understanding the important Japanese market. Is there really much potential for more fresh salmon in a consumption system already dominated by large amounts of home consumed salted salmon? Are the primary substitute goods meats as we ascribe to our culture or are they other fish products? Will liberalization of trade in other food items (such as beef) play any role in shifting salmon demand? How will the continuing trend towards 'Westernized' eating habits, food away from home, convenience packaging, etc. affect the future market for all salmon? These questions can only be adequately addressed by examining cross-sectional and micro-level market details.

Trade flows and their determinants

The likely future scenario for world aquaculture will undoubtedly include several producing nations scattered over both northern and southern hemispheres. An adequate forecast of how this system will distribute production to potential markets must include accurate modeling of trade flows. To date there has been very little attention paid to multi-country fisheries trade by either fisheries economists or trade modelers. The general area of empirical trade flow modeling in a multi-country setting is a difficult one, partly because of the data problems discussed earlier, but agricultural economists who have had some success with models of agricultural commodity trade have also incorporated degrees of market power into the models to capture what are in many cases politically generated monopoly or oligopoly power.

In addition, there is a recent and growing body of literature associated with trade in differentiated products which is relevant to salmon trade modeling. This work builds on industrial organization models of interactions among small numbers of traders in products which appear to be identical, but in reality are differentiated. The implications can be quite provocative, often the opposite of those derived from competitive free trade assumptions. Given that aquaculture opens up the possibility to genetically 'engineer' fish characteristics, this product differentiation scenario is a likely one for the future and one which magnifies the modeling and long run forecasting problems significantly.

In summary, the stakes involved in salmon demand modeling are significant since several important policy choices hinge on understanding key mechanisms and parameters. Recent empirical work sheds some light on various components of the world's salmon demand systems. However, data problems and the partial equilibrium frameworks employed suggest that caution be exercised in using the estimated parameters. At the very minimum, aggregate structural models need to be supplemented with more detailed study of individual country and their characteristics in order to judge the model's robustness. A finding of a low income elasticity of demand in a cross-sectional study, for example, would lead one to question whether the very large elasticities

reported in many time-series based studies are confounded by other factors. In the final analysis, it is simply 'good science' to subject theories to a variety of tests in order to add confidence to major hypotheses. In our judgement, the likelihood is very high that a future under substantial expansion of aquaculture will look radically different from the recent past. Hence a more comprehensive approach to salmon price forecasting is important.

Salmon Pricing Trends: A Simulation Model

By

Marvin Shaffer & Associates Ltd.

Introduction

The purpose of this report is to describe a simulation model designed to facilitate forecasting trends in salmon product prices and to present some specific forecast results developed with the model.

The key elements of the model are market equations which define price trends based on supply and demand variables, and market linkages which recognize that prices for any one salmon product form or species are potentially interrelated with all others.

The forecast results are based on existing information regarding parameters in the different equations and trends in the independent variables. The emphasis in developing forecast prices was to analyze the importance of different underlying factors and to present plausible ranges of results. Understanding the circumstances under which prices might behave in certain ways was considered as important as the determination of a "most likely" outcome itself.

It should be noted that the model developed in this study is preliminary in nature. Considerably more effort is required to produce a model sufficiently flexible and sophisticated to capture the many inter-relationships among salmon prices and markets. Specific areas requiring further work are outlined in section 2.6 of the report.2.0

The Model

Basic Price Equation

General price equations are defined for each salmon species, by principal product form and market destination. In each case, the price equation was derived by equating supply and demand in the specific market. The assumed determinants of supply and demand and the assumed functional forms are outlined below.

Demand:- Demand for a particular salmon product is equal to the per capita consumption times the population in the market area. In accordance with economic theory, and the results of numerous empirical studies, per capita consumption is assumed to be a function of per capita income; the relative price of substitute food products (e.g. beef, tuna); the relative price of substitute salmon species; and the price of the product itself. A taste trend variable is also assumed to potentially affect per capita demand. This accounts for shifts in demand independent of the specified income and price variables. A log linear functional form is assumed in accordance with common practice and considerable empirical support.

In equation form,

$$D = C/N * N$$

D	-	demand
C/N	-	per capita food consumption
N	-	population
$C/N = f(Y/N, P_A/P, P_S/P, P) * T$		
Y/N	-	per capita income
P _A	-	price of alternative food product
P _S	-	price of competing salmon species
P	-	own price (in market currency and area)
T	-	taste trend variable

$$\ln D = \ln (C/N) + \ln N$$

$$= a_0 + a_1 * \ln (Y/N) + a_2 * \ln (P_A/P) + a_3 * \ln (P_S/P) + a_4 * \ln P + \ln T + \ln N$$

a ₁	-	income elasticity of demand
a ₂	-	cross price elasticity (alternative food)
a ₃	-	cross price elasticity (alternative salmon)

a₄own price
elasticity

Supply:- Supply of a particular product in a particular market area is equal to the sum of B.C. supply and the rest of the world supply. B.C. supply is equal to the landings of the given species times the proportion of landings (adjusted for shrinkage) directed to the product form, times the proportion of the product directed to a particular market area. In principle, the product and market destination coefficients are functions of relative net returns from the different product forms and market areas, though they are treated as exogenous variables in this formulation of the model. Rest of the world supply is also assumed to be exogenous.

In equation form,

$$S = S_{BC} + S_F$$

S	-	supply into market area
S_{BC}	-	B.C. supply
S_F	-	rest of world supply

$$S_{BC} = p * d * L$$

p	-	proportion (adj. for shrinkage) of landings into the product form
d	-	proportion of product into the market areas
L	-	B.C. landings

$$\ln S = \ln (p * d * L + S_F)$$

Price Equation:- The basic price equation is derived by equating supply and demand in logarithmic form. Because the full differential of the logs indicates the proportionate change, the price equation can be expressed in terms of the proportionate change in price as a function of the proportionate change in the underlying demand and supply-determining variables.

In equation form,

$$\ln D = \ln S$$

$$a_0 + a_1 \ln (Y/N) + a_2 \ln (P_A/P) + a_3 \ln (P_S/P) + a_4 \ln P + \ln T + \ln N = \ln S$$

Therefore,

$$\ln P = -1/a_4 [a_0 + a_1 \ln (Y/N) + a_2 \ln (P_A/P) + a_3 \ln (P_S/P) + \ln T + \ln N - \ln S]$$

Therefore,

$$\dot{P} = -1/a_4 * [a_1 * \dot{Y}/N + a_2 * (\dot{P}_A/P) + a_3 * (\dot{P}_S/P) + \dot{T} + \dot{N} - \dot{S}]$$

where the $\dot{}$ above the variable name refers to the proportionate change

$$\text{But } \dot{S} = B_1 \dot{S}_{BC} + B_2 \dot{S}_F$$

Where

$$B_1 = \text{B.C.'s share of supply}$$

and

$$B_2 = \text{rest of world's supply share.}$$

$$\text{And } \dot{S}_{BC} = \dot{p} + \dot{d} + \dot{L}$$

Therefore,

$$\dot{P} = -1/a_4 [a_1 (\dot{Y}/N) + a_2 (\dot{P}_A/P) + a_3 (\dot{P}_S/P) + \dot{T} + \dot{N} - \dot{p} - \dot{d} - \dot{L}]$$

$$(\dot{p} + \dot{d} + \dot{L}) - \dot{BS}_F]$$

This equation indicates the delivered (c.i.f.) price expressed in the market area currency. To express the price trend in Canadian currency one must adjust for changes in the exchange rate.

$$P^* = P * E$$

P^* - is the c.i.f. price expressed in Cdn. currency

E - is the exchange rate (\$Cdn./\$foreign)

Therefore,

$$\dot{P}^* = \dot{P} + \dot{E}$$

Products and Market Destinations

The basic price equation described above is used to forecast prices in the principal markets for British Columbia salmon. In Table 1, these markets are listed by species. They were selected on the basis of sales data for B.C. salmon products. For all species except chum, the selected markets typically represent 60 percent or more of the total sales. Not all markets were selected for separate analysis because it was assumed that prices in the smaller markets are largely governed by prices in the principal markets examined. Also, because of their small size, it is unlikely that they would have a significant impact on the weighted average species prices, even if their price trends were to differ from those in the principal market. In the case of chum, there is a large array of markets, none of which individually accounts for a large share of the production. In this case single markets were assumed to represent the behaviour of several. So, for example, the behaviour of prices in French frozen markets is taken to be similar to that shown in other EEC countries which consume this product.

TABLE 1
Principal Product and Market Areas

Production	Product Form (percent)	Share of B.C.
Sockeye	Domestic canned	33.5
	U.K. canned	21.1
	Japan f/f	30.7
Pink	Domestic canned	55.1
	U.K. canned	11.7
	U.S. f/f	1.0
Chum	France f/f	5.0
	Sweden f/f	15.1
	U.S. f/f	5.7
Coho (wild)	Domestic canned	20.5
	Japan f/f	9.4
	France f/f	32.6
Chinook (wild)	Domestic f/f	18.6
	U.S. f/f	26.7
	France f/f	23.8
	Italy f/f	7.4
Coho Farmed	U.S. f/f	N.A.
Chinook Farmed	U.S. f/f	N.A.

*Based on forecast landings and allocation by product form and market destination, provided to the study team by DFO. N.A. - not available separately from wild shares.

Market Linkages

While separate equations are used to forecast price trends in each market, the prices are interrelated because of potential demand responses to relative market prices. In principle, there is a potential linkage through supply responses to relative prices in different markets, but these are not incorporated in this formulation of the model.

On the demand side, the cross price elasticity of alternative species serves to link different species' prices. A rise in one price (e.g. canned sockeye) relative to a potentially competing salmon price (e.g. canned pink) will reduce the demand for sockeye and raise it for pink. This tends to soften the divergence in price trends between the

two species. The competing salmon products for each product form and market area that are assumed in the model are listed in Table 2.

On the supply side, the proportion of landings or production going to different product forms and market areas could link different product and market destination prices within each species. A rise in the price of one product form or market destination relative to the others could increase the supply into that area and reduce supply into the other areas. This would dampen any divergence in price trends within each species. This was not modelled, however, because of time and budget constraints. A first step here would be to incorporate B.C. supply responses. In a complete model, the effect of relative prices on world supply would also have to be considered.

TABLE 2
Competing Salmon Products

	Product Forms	Competing Species
Sockeye	Domestic canned	Pink, Coho
	U.K. canned	Pink
	Japan f/f	Coho
Pink	Domestic canned	Sockeye
	U.K. canned	Sockeye
	U.S. f/f	Chum, Chinook (wild)
Chum	France f/f	Coho -Chinook (wild)
	Sweden f/f	---
	U.S. f/f	Pink, Chinook Coho (wild)
	Domestic canned	Sockeye
	Japan f/f	Sockeye
	France f/f	Chinook, Chum, Chinook(wild)
	Domestic f/f	---
	U.S. f/f	Chinook (farmed), Pink, Chum
	France f/f	Coho (wild), Chum
	Italy f/f	---
Coho Farmed	U.S. f/f	Chinook (farmed)
Chinook Farmed	U.S. f/f	Chinook(wild), Coho(farm)

The market linkages incorporated into this model are important because they explicitly recognize that salmon price trends are interdependent. One of the advantages of this simulation approach, with hypotheses about the magnitude of different cross price elasticities, is that the potential significance of this interdependence can be assessed. Strong multicollinearity between different salmon prices has generally made econometric testing of these linkages very difficult.

Model Structure

The model is programmed in Lotus 1-2-3. It consists of four main blocks, as outlined below.

- (i) **Parameter Input Block:** Demand-related parameter values for per capita income elasticities, price elasticities, other food and other salmon cross price elasticities, and annual rate of taste-driven growth in per capita demand are specified by the user. They can vary by product and species, but are assumed constant over the forecast period. Supply-related parameter values include product shrinkage rates.
- (ii) **Demand-Determining Variable Input Block:-** Forecasts of the rates of change of population, per capita income and alternative food prices are specified by the user for each country where B.C. salmon is sold. Forecast levels of the exchange rate between Canada and each export destination are also specified.
- (iii) **Supply-Determining Variable Input Block:-** Forecasts of B.C. landings of wild salmon, and production of farmed salmon, are specified by the user. These are then converted in the model to forecasts of the supply of B.C. salmon into each product market on the basis of product mix and destination mix assumptions (which are also user definable). Forecasts of non-B.C. supply into each product market are also specified by the user. Forecast total aquaculture production of relevant species from relevant countries can also be user specified, along with the destination mix. This allows the user to experiment, for example, with a variety of assumptions about the future destinations of Norwegian farmed product.
- (iv) **Price Equation Block:-** The price equations for each product market draw on the input blocks as outlined above to produce ten year forecasts of changes in real prices. Finally, the model uses estimates of current prices to forecast absolute prices (\$/kg) based on these rates of change.

The model has simultaneous (or circular) elements. The simultaneous behaviour occurs in the price equations because of the cross price elasticity terms. The prices of competing salmon products depend upon one another.

To run the model, the input blocks must be specified or reviewed and then the spreadsheet calculated enough times for the price equation results to converge to specific annual values. Convergence occurs when one additional calculation does not change the result.

Model Limitations

The model is quite general and can accommodate a wide range of assumptions regarding factors determining demand and supply. However, there are significant limitations that the user should be aware of.

First, the log linear functional forms impose certain assumptions about price behaviour that may or may not be valid. This is potentially more serious the more significant the size of the changes in the independent variables.

Second, the structure of the salmon cross-price (substitution) effects is limited. Direct cross-price effects are only incorporated for

specific salmon products. Also, while an effort has been made to ensure that corresponding cross price elasticities are consistent with one another, they are fixed over the forecast period.

Third, the supply forecasts are quite simplistic. They do not consider the effect of price on total supply, which may be particularly relevant in the case of farmed production. Nor do they take account of the full complexity of product and market destinations, including the potential endogenous impact of relative market prices.

Finally, inventory change is not incorporated into the model. This was considered appropriate for a long term forecasting model, but does limit its use for year to year forecasting purposes, and may lead to overstating the price fluctuations caused by supply variations in certain markets.

Areas for Further Work

This model is a preliminary attempt to analyze the many factors affecting price trends over the long term. While it does provide some insights into the potential effects of increasing farmed supply, varying cross-price elasticities, and other factors affecting future prices, the usefulness of the model could be enhanced in a number of ways.

The most important enhancement would be to make supply into different market areas and product forms responsive to price differentials. While there are market structure, contractual, capacity and other "rigidities" that prevent a complete adjustment to different (netted back) prices in different markets, one could expect some supply adjustments as prices (and netbacks) start to diverge.

Three levels of enhancement are required on the supply side. First, the supply of a given product going to different market areas should be responsive to price differentials between markets. Second, the share of production processed into different product forms should be variable, possibly within specified limits and subject to specified lags. Finally, the supply of farmed product could be made a function of price levels, again subject to specified lags.

Another enhancement of the model would be to analyze, in much greater detail, the theoretical factors and empirical evidence on cross-price elasticities of demand. This parameter is very important in determining how the supply of one product (e.g. farmed chinook) affects the price of another (e.g. wild chinook or coho). Since this is an important policy area, contingent valuation or other techniques could be considered to develop specific estimates for the model.

Even with further research into specific parameters, there will remain considerable uncertainty regarding key factors and key exogenous variables which affect future prices. A further enhancement that might assist in analyzing this uncertainty would be to run Monte Carlo simulations. This would help identify a probable range of results, given the range (and distribution) of possible values for the parameters and exogenous variables.

Finally, this model was developed in a short time frame and warrants review. In particular, the selection of market areas and product destinations should be reconsidered. Greater flexibility in the functional forms and the relationship between cross price elasticities could be considered. Also linkage to -- or development of -- the landed price implications of these product price forecasts could be developed.

Assumptions for Initial Run

Demand-Related Parameters

A number of salmon demand studies were reviewed to develop "reasonable" estimates or ranges for the demand-related parameters in this model. All of these studies were econometric in approach, with the exception of Anderson (1988), which used the results of a survey to determine substitutability between wild salmon and farmed product. The majority of the econometric papers reviewed include the application of analytical results to forecast prices over varying time horizons (Lin et. al., Leitz, Barnes and DeVoretz, 1980). The Anderson paper attempted to predict the net impact (for 1990 and 1995) on prices of increased demand and increased supply of (particularly farmed) salmon to the U.S. market. The other three papers (Robinson, DeVoretz 88 and DeVoretz and Salvanes) seek to measure demand elasticities and/or to test hypotheses about market structure.

The most commonly used functional forms for estimating demand are single equation price dependent, single equation quantity dependent and simultaneous with a supply equation. In most cases, demand from each market area (usually a country) is analyzed (for a species or product type) separately without considering the supply interrelationships between different markets. This is true for the Barnes, DeVoretz (1980), Robinson and Leitz papers. The DeVoretz and Salvanes paper uses a four equation system to model demand and supply for Norwegian farmed salmon. The model includes equations for demand in a primary market and supply to the primary market, to all other markets and a supply identity. This model is quite specific to a hypothesized marketing strategy for Norwegian farmed salmon. Lin et. al. uses a seven equation model to analyze markets for Norwegian Atlantic salmon, including three structural equations relating to EEC demand, U.S. demand and U.S. supply, and four identities. Finally DeVoretz (1988), in which most reported results relate to single market areas, reports tests of two-market interrelationships between prices and quantities, and rejects such models on statistical grounds.

There is a large range of estimated values of the own price, cross price and income elasticities in these studies, even for a specific species, product form and market. In many cases, equations are not statistically reliable enough to use and, if they are, confidence intervals on specific parameters are often unacceptably large. In other cases, great ranges in values are observed which cannot be fully explained on theoretical grounds based on the use of price dependent versus quantity dependent formulations and on differences in the data used. Finally, equations are often misspecified from a theoretical point of view because of the inclusion or exclusion of variables based on statistical goodness of fit, multicollinearity, etc.

Because of the wide range in values, the approach taken in this simulation model is to select initial values as plausible estimates found in the literature and then to use sensitivity analysis to test the effects of some of the more extreme values.

Own price elasticities:- With respect to canned markets, most of the estimates reviewed relate to the domestic market. DeVoretz (1980) obtains own price elasticities using a single equation (price dependent)

model which range from -12.9 to -15.3 for canned sockeye, pink and chum. Use of a simultaneous (price dependent) model with a supply equation yields comparable estimates ranging from -10.4 to -12.9. Robinson (1987) argues that the DeVoretz values are overestimated due to the use of production data for a quantity variable along with a three year moving average for prices and that the use of a price dependent model also is likely to overestimate the own price elasticity. Robinson's own estimates (quantity dependent single equation) are -1.33 and -2.21 for canned domestic pink and sockeye, respectively, and -1.32 and -2.80, respectively, using a simultaneous equation approach. Barnes (1987) obtains estimates for domestic canned which range from -4.22 to -10.10 for sockeye, pink and chum using a price dependent formulation. Corresponding quantity dependent values are -1.37 to -2.98.

Based on Robinson's arguments in favour of lower elasticities, a value of -2.0 is used for initial domestic canned own price parameters in our analysis.

With respect to the canned export markets treated in our model, only the U.K. market is represented in the literature reviewed. DeVoretz (1980) obtains own price elasticities (single equation, quantity dependent) of -12.2 and -14.4 for canned sockeye and pink in the U.K. Later work by DeVoretz (1988) does not provide useable equations for these markets. It was thought that it would be inappropriate to use widely different own price elasticities based on different approaches for domestic and export markets. Accordingly, for the initial analysis, the domestic values are applied to all canned markets.

With respect to fresh/frozen markets, the available sources, although few in number, give a much narrower range of estimates of the own price elasticity. Barnes (1987) obtains values of -2.0 and -4.8 for frozen chinook and coho in the U.S. market, -3.7 for frozen chum in the Swedish market, and -3.2 and -6.4 for frozen chinook and coho, respectively, in the French market. Corresponding quantity dependent equations yielded estimates of -1.2 and -.46. DeVoretz (1988) obtains values of -2.9 for chum in the Swedish market and -.83 for coho in the French market. Initial values in our analysis assume own price elasticities of -2.0 for all species to represent the range of estimates given, and to reflect the considerations noted above for canned markets supporting a relatively low own price elasticity.

Cross-Price Elasticities: - Very little evidence is available with respect to cross price elasticities for substitute food products or substitute salmon products. Moreover, the estimates that are available are specific to the particular substitute (e.g. tuna, beef, etc.) used in the regression analyses.

In this analysis, substitute food products are defined very generally -- they refer to the basket of goods which make up the food component of the consumer price index. Because this price series is closely correlated with the overall CPI, the cross price effect here will in essence simply modify the own price effect. Consequently, a very low initial value (.002) is assumed. The reason here is not so much that substitution does not take place, but rather that it is assumed to be incorporated in the own price elasticity.

However, with respect to substitute salmon products, cross price effects are assumed. Initial values ranging from .1 to .8 are specified, with the higher end of the range reflecting greater substitutability between salmon species.

When specifying cross price parameters between two products, the relative size of the markets is considered to ensure that the estimates are consistent with one another. For example, if ϵ_1 is the cross price elasticity of wild coho price on farmed coho demand and ϵ_2 is the cross price elasticity of farmed coho on wild coho, ϵ_1 and ϵ_2 are related as follows:

$$\dot{D}_f = B_1 (\dot{P}_w - \dot{P}_f)$$

$$\dot{D}_w = B_2 (\dot{P}_f - \dot{P}_w)$$

=> for any given $\dot{P}_w$

$$dD_f = B_1 \dot{P}_w D_f$$

$$dD_w = B_2 \dot{P}_w D_w$$

$$\text{But } dD_f = -dD_w$$

$$\text{Therefore } B_1 \dot{P}_w D_f = B_2 \dot{P}_w D_w$$

$$\text{Therefore } B_1 = D_w / D_f B_2$$

In other words, if the wild market is 10 times the size of the farmed market, the percentage effect of a change in wild coho prices on farmed demand will be 10 times the effect of a change in farmed coho prices on wild demand. This constraint is built into all of the cross price parameter estimates, based on the initial quantities sold (at the outset of the forecast period) in each market.

Per Capita Income Elasticities: Estimates of income elasticities vary markedly in the different studies. For example, in the Canadian market for canned sockeye, Robinson obtains income elasticity estimates which are negative and statistically significant, while DeVoretz 1980 obtains significant estimates ranging from 3.37 to 9.2. Other species and product forms display similar variations. There are several reasons for this. First, income is not consistently defined -- in some cases picking up the effect of changes in per capita income; in others picking up the combined effect of changes in per capita income and population. Second, the income variable may be picking up the effect of other factors which have been correlated with income trends over time -- for example, changing tastes.

In our formulation, changes in population cause a proportionate change in demand. Also, changes in tastes are explicitly modelled. Consequently, the per capita income variable is meant to capture changes in per capita consumption solely due to changes in per capita income. A relatively low initial value of .5 is assumed for this in all markets.

Taste Change:- Two effects can be included in this factor. Per capita demand for fish has generally been rising in response to the perceived health benefits of eating fish. In addition, the expansion of winter markets for fresh salmon due to aquaculture production can be viewed as a trend increase in annual per capita consumption. Little empirical evidence with respect to this parameter was provided in the studies we reviewed, though it is generally acknowledged as an important factor in fresh/frozen and farmed markets. In the simulation this parameter is initially set at zero, but then increased in selected U.S. markets, based on past trends in per capita consumption of salmon. An increase of two percent per year is used for the farmed demand and an increase of one percent per year is used for wild fresh/frozen.

Supply-Related Parameters

Shrinkage rates by species and product form were derived from survey data obtained in 1985 along with assumptions regarding the mix of particular subspecies (e.g. red, pink and white chinook) and the proportions of fresh and frozen head-on vs. head-off sales.

Demand-Determining Variable Forecast

Forecasts of population growth in relevant countries (Canada, U.S., U.K., Sweden, France, Italy and Japan) were obtained from the Population Reference Bureau. Forecast population growth rates range from zero percent for Italy to 1.1 percent for Canada. Per capita income forecasts were derived by assuming the average growth in income over the last ten years to be continued into the future. Resulting average forecast growth rates range from 1.5 percent (France) to 3.4 percent (Japan).

For initial runs, a constant real price forecast is used for other food substitutes and currently prevailing exchange rates are held constant over the forecast period.

Supply-Determining Variable Forecast

The allocation of B.C. landings by product type and by market destination was calculated using a DFO paper which forecasts market shares for B.C. salmon to the year 2000. Forecast aquaculture production by country and species was obtained from background data to a 1988 paper. For initial analysis, Norwegian farmed production was allocated by destination based on shares of 1988 production.

The supply of wild salmon from the rest of the world was assessed on a market by market basis. In many cases, supply from the U.S. is the only major competitor to Canadian salmon. Forecasts of U.S. supply by species, product form, and destination were used for appropriate markets. For Japanese markets, it is assumed that Japanese production of relevant species is largely consumed domestically, and along with U.S.

supply, is the major competing supply to Canadian salmon. A forecast of Japanese landings by species to the year 2000 was provided by DFO.

In European markets, supplies of U.S. salmon and Norwegian aquaculture production were assumed to compete with Canadian products. Additional supplies to these markets were estimated from some recent historical data on imports by product type (for all species) into each country. The proportion of non-U.S., non-Canadian wild supply into these markets was in all cases less than 12 percent of the total supply, and was forecast to continue at the existing share through the forecast period.

In preliminary runs using the supply data noted above, the model displayed substantial price instability for particular products and markets through time. This was due to great fluctuations from year to year in the forecasts of U.S. and Canadian supply into these markets combined with the fact that the current version of the model neither takes account of inventory fluctuations (which would dampen the price swings) nor allows supply to shift from market to market based on relative prices in the model. Accordingly, Canadian and U.S. wild supply forecasts by species, product form and market were assumed to be fixed over the forecast period at the average levels shown in the forecasts. This has the effect of making the model very "long run" in nature, indicating the impact of underlying trends in aquaculture supply, income and taste change, rather than the impact of fluctuating wild supply. It does not incorporate an increasing (or decreasing) trend in wild production, which could occur as a result of enhancement and/or management changes. This could easily be changed in future analyses with this model.

It should be noted that the percentages refer to the year to year changes. The absolute price level in any given year can be calculated by multiplying one plus the average change in that year by one plus the percentage change in each previous year by the initial price level

Results

Initial Run

The initial run results indicate the price changes one could expect with fixed wild supply to each market and growing farmed production, with a particularly sharp increase in Norwegian supply in 1990. The results incorporate the parameter and demand-determining variable forecasts as discussed above. The results are shown in Table 3, and summarized below.

Sockeye, pink and coho canned prices:- These are forecast to grow at an annual rate of .86 percent in the domestic market and .47 percent (for sockeye and pink) in the U.K. market. In all cases the rising prices are due to

TABLE 3
SALMON PRODUCT
PRICE TRENDS
RATES OF REAL GROWTH
BASE CASE

	Sockeye Canned Domestic	Sockeye Canned U.K.	Sockeye Fr/Frozen Japan	Pink Canned Domestic	Pink Canned U.K.	Pink Fr/Frozen U.S.	Chum Fr/Frozen France	Chum Fr/Frozen Sweden	Chum Fr/Frozen U.S.
1990	0.86%	0.47%	0.71%	0.86%	0.47%	0.71%	-5.01%	0.30%	0.69%
1991	0.86%	0.47%	0.93%	0.86%	0.47%	0.76%	-1.16%	0.30%	0.76%
1992	0.86%	0.47%	0.93%	0.86%	0.47%	0.76%	-1.03%	0.30%	0.76%
1993	0.86%	0.47%	0.93%	0.86%	0.47%	0.77%	-0.93%	0.30%	0.76%
1994	0.86%	0.47%	0.94%	0.86%	0.47%	0.77%	-0.84%	0.30%	0.77%
1995	0.86%	0.47%	0.94%	0.86%	0.47%	0.78%	-0.76%	0.30%	0.77%
1996	0.86%	0.47%	0.99%	0.86%	0.47%	0.78%	-0.68%	0.30%	0.77%
1997	0.86%	0.47%	0.99%	0.86%	0.47%	0.78%	-0.62%	0.30%	0.77%
1998	0.86%	0.47%	0.99%	0.86%	0.47%	0.78%	-0.56%	0.30%	0.77%
1999	0.86%	0.47%	0.99%	0.86%	0.47%	0.78%	-0.51%	0.30%	0.78%
2000	0.86%	0.47%	0.99%	0.86%	0.47%	0.78%	-0.46%	0.30%	0.78%

	Chinook Fr/Frozen Domestic	Chinook Fr/Frozen U.S.	Chinook Fr/Frozen France	Chinook Fr/Frozen Italy	Coho Canned Domestic	Coho Fr/Frozen Japan	Coho Fr/Frozen France	Farmed Coho U.S.	Farmed Chinook U.S.
1990	0.86%	-1.22%	-13.89%	0.51%	0.86%	-2.06%	-9.30%	-13.74%	-15.85%
1991	0.86%	0.11%	-3.72%	0.51%	0.86%	-1.02%	-2.59%	-4.88%	-4.81%
1992	0.86%	0.16%	-3.38%	0.51%	0.86%	-0.93%	-2.40%	-4.03%	-4.46%
1993	0.86%	0.19%	-3.08%	0.51%	0.86%	-0.85%	-2.23%	-3.40%	-4.17%
1994	0.86%	0.38%	-2.83%	0.51%	0.86%	-0.77%	-2.08%	-2.48%	-2.61%
1995	0.86%	0.41%	-2.61%	0.51%	0.86%	-0.70%	-1.94%	-2.28%	-2.39%
1996	0.86%	0.43%	-2.42%	0.51%	0.86%	0.68%	-1.82%	-2.10%	-2.19%
1997	0.86%	0.45%	-2.24%	0.51%	0.86%	0.60%	-1.71%	-1.94%	-2.02%
1998	0.86%	0.47%	-2.09%	0.51%	0.86%	0.68%	-1.61%	-1.80%	-1.86%
1999	0.86%	0.49%	-1.96%	0.51%	0.86%	0.69%	-1.52%	-1.67%	-1.72%
2000	0.86%	0.50%	-1.83%	0.51%	0.86%	0.69%	-1.43%	-1.56%	-1.60%

population and income growth, coupled with the assumed fixed supply. The higher domestic increase is due to higher forecast population and per capita income growth than in the U.K.

Sockeye fresh/frozen prices (Japan):- These are forecast to increase initially by .71 percent, rising to .99 percent/year by 1996. The lower price increase in the early years is due to increased farmed production of coho and Norwegian Atlantic salmon, which have some dampening price effects in that market. Pink fresh/frozen prices (U.S.): - These are forecast to increase by .71 percent initially, rising to .78 percent/year by 1995. The lower initial price increase is due to weak cross price effects from other fresh/frozen markets in the U.S.

Chum fresh/frozen prices:- These are forecast to increase by .3 percent/year in Sweden and by .69 percent rising to .78 percent/year in the United States. In France they are forecast to fall by 5.01 percent initially and continue to fall at rates ranging from 1.16 percent to .46 percent in subsequent years. The falling price in France is due to competition from increased Norwegian supply.

Chinook fresh/frozen prices:- These are forecast to increase at annual rates of .86 percent in the domestic market and .51 percent in the Italian market, both due to population and income growth, combined with no assumed increase in competition from farmed production. In the U.S. market, a decline of 1.22 percent is forecast initially, followed by increases ranging from .11 percent to .5 percent in subsequent years. The initial reduction is due to the cross price impact of falling farmed prices. In the French market a decline of 13.89 percent is forecast initially, followed by declines of 3.72 percent to 1.83 percent in subsequent years. These reductions are due primarily to increases in Norwegian supply.

Coho fresh/frozen prices:- These are forecast to fall in the Japanese market by 2.06 percent initially and then by a lesser amount in subsequent years. By 1996 an increase of .68 percent per year is forecast. This price trend results from the impact of changing farmed coho production in Japan. In the French market, the coho price is forecast to fall by 9.3 percent initially and then by rates of 2.59 percent to 1.43 percent per year in subsequent years. The reduction is due to the forecast impact of growing Norwegian supply to that market.

Farmed Coho and Chinook prices (U.S.): These are forecast to fall by 13.74 percent (coho) and 15.85 percent (chinook) initially and then by rates ranging from 4.8 percent to 1.6 percent in subsequent years. This results from the assumed increase in supply, with no assumed offsetting taste-driven increase in demand.

Sensitivity Analysis

The effect of changing assumptions on the price forecasts are described below.

1 Higher Income Elasticity:- Doubling the income elasticity from .5 to 1 increases the price forecast (or reduces the rate of decline) relative to the base case. As shown in Table 4, the impact is relatively small, changing the forecast change in price by the change in the income elasticity (.5) divided by the own price elasticity (2) times the forecast rate of growth in per capita income. In Canada, for example, that increases the price forecast by about .5 percent per year.

TABLE 4
SALMON PRODUCT
PRICE TRENDS
RATES OF REAL GROWTH

	Sockeye Canned Domestic	Sockeye Canned U.K.	Sockeye Fr/Frozen Japan	Pink Canned Domestic	Pink Canned U.K.	Pink Fr/Frozen U.S.	Chum Fr/Frozen France	Chum Fr/Frozen Sweden	Chum Fr/Frozen U.S.
1990	1.36%	0.93%	1.58%	1.36%	0.93%	1.14%	-4.60%	0.64%	1.12%
1991	1.36%	0.93%	1.80%	1.36%	0.93%	1.20%	-0.75%	0.64%	1.19%
1992	1.36%	0.93%	1.80%	1.36%	0.93%	1.20%	-0.63%	0.64%	1.20%
1993	1.36%	0.93%	1.80%	1.36%	0.93%	1.20%	-0.52%	0.64%	1.20%
1994	1.36%	0.93%	1.80%	1.36%	0.93%	1.21%	-0.43%	0.64%	1.21%
1995	1.36%	0.93%	1.81%	1.36%	0.93%	1.21%	-0.35%	0.64%	1.21%
1996	1.36%	0.93%	1.85%	1.36%	0.93%	1.21%	-0.28%	0.64%	1.21%
1997	1.36%	0.93%	1.86%	1.36%	0.93%	1.21%	-0.21%	0.64%	1.21%
1998	1.36%	0.93%	1.86%	1.36%	0.93%	1.22%	-0.15%	0.64%	1.21%
1999	1.36%	0.93%	1.86%	1.36%	0.93%	1.22%	-0.10%	0.64%	1.21%
2000	1.36%	0.93%	1.86%	1.36%	0.93%	1.22%	-0.05%	0.64%	1.21%

	Chinook Fr/Frozen Domestic	Chinook Fr/Frozen U.S.	Chinook Fr/Frozen France	Chinook Fr/Frozen Italy	Coho Canned Domestic	Coho Fr/Frozen Japan	Coho Fr/Frozen France	Farmed Coho U.S.	Farmed Chinook U.S.
1990	1.36%	-0.79%	-13.48%	1.02%	1.36%	-1.19%	-8.89%	-13.31%	-15.41%
1991	1.36%	0.55%	-3.32%	1.02%	1.36%	-0.15%	-2.19%	-4.44%	-4.37%
1992	1.36%	0.59%	-2.97%	1.02%	1.36%	-0.06%	-1.99%	-3.59%	-4.02%
1993	1.36%	0.63%	-2.68%	1.02%	1.36%	0.02%	-1.82%	-2.96%	-3.73%
1994	1.36%	0.82%	-2.42%	1.02%	1.36%	0.10%	-1.67%	-2.05%	-2.18%
1995	1.36%	0.84%	-2.20%	1.02%	1.36%	0.17%	-1.54%	-1.85%	-1.95%
1996	1.36%	0.87%	-2.01%	1.02%	1.36%	1.55%	-1.42%	-1.67%	-1.75%
1997	1.36%	0.89%	-1.84%	1.02%	1.36%	1.55%	-1.30%	-1.51%	-1.58%
1998	1.36%	0.91%	-1.69%	1.02%	1.36%	1.55%	-1.20%	-1.36%	-1.42%
1999	1.36%	0.92%	-1.55%	1.02%	1.36%	1.56%	-1.11%	-1.24%	-1.28%
2000	1.36%	0.94%	-1.43%	1.02%	1.36%	1.56%	-1.03%	-1.12%	-1.16%

Shafter/Simulation

Having a higher income elasticity for one product (e.g. sockeye: domestic canned), but not a competing product (e.g. pink: domestic canned), raises the forecast increase of sockeye prices, but by less than in the previous case. It also increases the forecast price of pink through cross price effects. For example, raising the sockeye income elasticity to 1, while holding the pink elasticity at .5, results in the sockeye price increasing by .46 percent per year and the pink price rising by .02 percent per year relative to the initial run results (when both elasticities were .5). This is based on cross price elasticities of .10 (sockeye-->pink) and .18 (pink -->sockeye). If the cross price elasticities were much higher (10 and 18), then sockeye and pink prices would increase by roughly the same amount -- in this case by .30 percent over the base case results for sockeye and .27 percent for pink.

2. Higher own price elasticity:- Raising the own price elasticities from -2 to -8 significantly dampens the change in prices for all products. The effect, shown in Table 5, is roughly proportional to the change in elasticity -- the four-fold increase in the elasticity generally reduces the rate of price change by a factor of one-quarter, though because of cross price effects this is not always the case. For example, whereas fresh/frozen chinook prices in the U.S. exhibited a 1.22 percent decline in 1990 in the base case, they show a marginal increase (.04 percent) with the higher elasticities. This occurs because farmed prices fall so much less in the high elasticity case.

A high own price elasticity for only one market area has a similar effect as in the case of the income elasticity. The price increase in the market is dampened, but not by as much as when all price elasticities are higher. Also, the price changes in competing products are dampened because of cross price effects.

3. Taste Change:- To test for the effect of the taste change factor, it was assumed that farmed per capita demand would increase by two percent per year and wild fresh/frozen demand would increase by one percent per year. These results are given in Table 6, and show a lower rate of price decline for farmed prices and a higher rate of price increase for the wild products. However, the impact is relatively small -- with the farmed prices falling approximately one percent less per year and the wild prices rising approximately .5 percent more per year relative to the base case.

4. Higher Cross-Price Elasticity (Alternative Food):- Raising the alternative food cross price elasticity (results shown in Table 7) is very similar to raising the own price elasticity. It dampens the rate of price increase or decrease. An increase from .002 (negligible) to one reduces the rate of price increase by approximately one third. It should be noted that this result reflects the forecast of no real change in alternative food prices. The significance of the higher cross elasticity would vary if alternative food prices were rising or falling in real terms.

TABLE 5
SALMON PRODUCT
PRICE TRENDS
RATES OF REAL GROWTH

	Sockeye Canned Domestic	Sockeye Canned U.K.	Sockeye Fr/Frozen Japan	Pink Canned Domestic	Pink Canned U.K.	Pink Fr/Frozen U.S.	Chum Fr/Frozen France	Chum Fr/Frozen Sweden	Chum Fr/Frozen U.S.
1990	0.21%	0.12%	0.20%	0.21%	0.12%	0.20%	-0.41%	0.07%	0.20%
1991	0.21%	0.12%	0.24%	0.21%	0.12%	0.20%	-0.03%	0.07%	0.20%
1992	0.21%	0.12%	0.24%	0.21%	0.12%	0.20%	-0.02%	0.07%	0.20%
1993	0.21%	0.12%	0.25%	0.21%	0.12%	0.20%	-0.01%	0.07%	0.20%
1994	0.21%	0.12%	0.25%	0.21%	0.12%	0.20%	0.00%	0.07%	0.20%
1995	0.21%	0.12%	0.25%	0.21%	0.12%	0.20%	0.01%	0.07%	0.20%
1996	0.21%	0.12%	0.25%	0.21%	0.12%	0.20%	0.02%	0.07%	0.20%
1997	0.21%	0.12%	0.25%	0.21%	0.12%	0.20%	0.02%	0.07%	0.20%
1998	0.21%	0.12%	0.25%	0.21%	0.12%	0.20%	0.03%	0.07%	0.20%
1999	0.21%	0.12%	0.25%	0.21%	0.12%	0.20%	0.03%	0.07%	0.20%
2000	0.21%	0.12%	0.25%	0.21%	0.12%	0.20%	0.04%	0.07%	0.20%

	Chinook Fr/Frozen Domestic	Chinook Fr/Frozen U.S.	Chinook Fr/Frozen France	Chinook Fr/Frozen Italy	Coho Canned Domestic	Coho Fr/Frozen Japan	Coho Fr/Frozen France	Farmed Coho U.S.	Farmed Chinook U.S.
1990	0.21%	0.04%	-3.60%	0.13%	0.21%	-0.54%	-2.31%	-3.40%	-4.11%
1991	0.21%	0.15%	-0.97%	0.13%	0.21%	-0.27%	-0.65%	-1.22%	-1.25%
1992	0.21%	0.15%	-0.87%	0.13%	0.21%	-0.25%	-0.60%	-1.00%	-1.16%
1993	0.21%	0.15%	-0.80%	0.13%	0.21%	-0.23%	-0.56%	-0.84%	-1.09%
1994	0.21%	0.17%	-0.73%	0.13%	0.21%	-0.21%	-0.52%	-0.62%	-0.68%
1995	0.21%	0.17%	-0.68%	0.13%	0.21%	-0.19%	-0.49%	-0.57%	-0.62%
1996	0.21%	0.17%	-0.62%	0.13%	0.21%	0.17%	-0.46%	-0.53%	-0.57%
1997	0.21%	0.17%	-0.58%	0.13%	0.21%	0.17%	-0.43%	-0.49%	-0.53%
1998	0.21%	0.17%	-0.54%	0.13%	0.21%	0.17%	-0.41%	-0.45%	-0.49%
1999	0.21%	0.18%	-0.51%	0.13%	0.21%	0.17%	-0.38%	-0.42%	-0.45%
2000	0.21%	0.18%	-0.47%	0.13%	0.21%	0.17%	-0.36%	-0.39%	-0.42%

TABLE 6
SALMON PRODUCT
PRICE TRENDS
RATE OF REAL GROWTH

	Sockeye Canned Domestic	Sockeye Canned U.K.	Sockeye Fr/Frozen Japan	Pink Canned Domestic	Pink Canned U.K.	Pink Fr/Frozen U.S.	Chum Fr/Frozen France	Chum Fr/Frozen Sweden	Chum Fr/Frozen U.S.
1990	0.86%	0.47%	0.71%	0.86%	0.47%	0.75%	-5.01%	0.30%	1.17%
1991	0.86%	0.47%	0.93%	0.86%	0.47%	0.80%	-1.16%	0.30%	1.24%
1992	0.86%	0.47%	0.93%	0.86%	0.47%	0.80%	-1.03%	0.30%	1.24%
1993	0.86%	0.47%	0.93%	0.86%	0.47%	0.81%	-0.93%	0.30%	1.24%
1994	0.86%	0.47%	0.94%	0.86%	0.47%	0.81%	-0.64%	0.30%	1.25%
1995	0.86%	0.47%	0.94%	0.86%	0.47%	0.81%	-0.76%	0.30%	1.25%
1996	0.86%	0.47%	0.99%	0.86%	0.47%	0.82%	-0.68%	0.30%	1.25%
1997	0.86%	0.47%	0.99%	0.86%	0.47%	0.82%	-0.62%	0.30%	1.25%
1998	0.86%	0.47%	0.99%	0.86%	0.47%	0.82%	-0.56%	0.30%	1.26%
1999	0.86%	0.47%	0.99%	0.86%	0.47%	0.82%	-0.51%	0.30%	1.26%
2000	0.86%	0.47%	0.99%	0.86%	0.47%	0.82%	-0.46%	0.30%	1.26%

	Chinook Fr/Frozen Domestic	Chinook Fr/Frozen U.S.	Chinook Fr/Frozen France	Chinook Fr/Frozen Italy	Coho Canned Domestic	Coho Fr/Frozen Japan	Coho Fr/Frozen France	Farmed Coho U.S.	Farmed Chinook U.S.
1990	0.86%	-0.69%	-13.89%	0.51%	0.86%	-2.06%	-9.30%	-12.75%	-14.87%
1991	0.86%	0.65%	-3.72%	0.51%	0.86%	-1.02%	-2.59%	-3.88%	-3.83%
1992	0.86%	0.69%	-3.38%	0.51%	0.86%	-0.93%	-2.40%	-3.03%	-3.48%
1993	0.86%	0.73%	-3.08%	0.51%	0.86%	-0.85%	-2.23%	-2.40%	-3.19%
1994	0.86%	0.92%	-2.83%	0.51%	0.86%	-0.77%	-2.08%	-1.49%	-1.64%
1995	0.86%	0.94%	-2.61%	0.51%	0.86%	-0.70%	-1.94%	-1.29%	-1.41%
1996	0.86%	0.97%	-2.42%	0.51%	0.86%	0.68%	-1.82%	-1.11%	-1.21%
1997	0.86%	0.99%	-2.24%	0.51%	0.86%	0.68%	-1.71%	-0.95%	-1.04%
1998	0.86%	1.01%	-2.09%	0.51%	0.86%	0.68%	-1.61%	-0.80%	-0.88%
1999	0.86%	1.03%	-1.96%	0.51%	0.86%	0.69%	-1.52%	-0.68%	-0.74%
2000	0.86%	1.04%	-1.83%	0.51%	0.86%	0.69%	-1.43%	-0.56%	-0.62%

TABLE 7
SALMON PROJECT
PRICE TRENDS
RATES OF REAL GROWTH

	Sockeye Canned Domestic	Sockeye Canned U.K.	Sockeye Fr/Frozen Japan	Pink Canned Domestic	Pink Canned U.K.	Pink Fr/Frozen U.S.	Chum Fr/Frozen France	Chum Fr/Frozen Sweden	Chum Fr/Frozen U.S.
1990	0.57%	0.31%	0.50%	0.57%	0.31%	0.50%	-2.58%	0.20%	0.49%
1991	0.57%	0.31%	0.63%	0.57%	0.31%	0.52%	-0.54%	0.20%	0.52%
1992	0.57%	0.31%	0.63%	0.57%	0.31%	0.52%	-0.47%	0.20%	0.52%
1993	0.57%	0.31%	0.64%	0.57%	0.31%	0.52%	-0.42%	0.20%	0.52%
1994	0.57%	0.31%	0.64%	0.57%	0.31%	0.52%	-0.37%	0.20%	0.52%
1995	0.57%	0.31%	0.64%	0.57%	0.31%	0.52%	-0.33%	0.20%	0.52%
1996	0.57%	0.31%	0.66%	0.57%	0.31%	0.52%	-0.29%	0.20%	0.52%
1997	0.57%	0.31%	0.66%	0.57%	0.31%	0.52%	-0.25%	0.26%	0.52%
1998	0.57%	0.31%	0.66%	0.57%	0.31%	0.52%	-0.22%	0.20%	0.52%
1999	0.57%	0.31%	0.66%	0.57%	0.31%	0.52%	-0.19%	0.20%	0.52%
2000	0.57%	0.31%	0.66%	0.57%	0.31%	0.52%	-0.17%	0.20%	0.52%

	Chinook Fr/Frozen Domestic	Chinook Fr/Frozen U.S.	Chinook Fr/Frozen France	Chinook Fr/Frozen Italy	Coho Canned Domestic	Coho Fr/Frozen Japan	Coho Fr/Frozen France	Farmed Coho U.S.	Farmed Chinook U.S.
1990	0.57%	-0.45%	-9.40%	0.34%	0.57%	-1.40%	-6.18%	-9.13%	-10.74%
1991	0.57%	0.20%	-2.52%	0.34%	0.57%	-0.70%	-1.73%	-3.26%	-3.26%
1992	0.57%	0.22%	-2.28%	0.34%	0.57%	-0.64%	-1.60%	-2.68%	-3.02%
1993	0.57%	0.24%	-2.08%	0.34%	0.57%	-0.58%	-1.49%	-2.25%	-2.83%
1994	0.57%	0.33%	-1.91%	0.34%	0.57%	-0.53%	-1.39%	-1.66%	-1.77%
1995	0.57%	0.34%	-1.76%	0.34%	0.57%	-0.48%	-1.30%	-1.52%	-1.62%
1996	0.57%	0.35%	-1.63%	0.34%	0.57%	0.45%	-1.22%	-1.40%	-1.49%
1997	0.57%	0.36%	-1.52%	0.34%	0.57%	0.45%	-1.14%	-1.30%	-1.37%
1998	0.57%	0.37%	-1.41%	0.34%	0.57%	0.45%	-1.08%	-1.20%	-1.26%
1999	0.57%	0.38%	-1.32%	0.34%	0.57%	0.46%	-1.01%	-1.12%	-1.17%
2000	0.57%	0.39%	-1.24%	0.34%	0.57%	0.46%	-0.96%	-1.04%	-1.09%

Shaffer/Simulation

5, Cross Price Elasticity (Farmed/Wild Chinook U.S.): - The base case assumed .1 (wild-->farmed) and .3 (farmed-->wild) U.S. chinook cross price elasticities. Had there been no cross price elasticity, as shown in Table 8, the wild chinook prices would have been higher (increasing over the entire period at .79 percent/year) and the farmed chinook prices would have fallen more sharply (initially by 16.55 percent and then by 5.04 percent to 1.7 percent in subsequent years). On the other hand, had the cross price elasticities been higher, farmed prices would have fallen by less and wild prices would have fallen instead of risen. For example, as given in Table 9, at a cross price elasticity of 10 (wild-->farmed) and 30 (farmed-->wild), wild prices would have initially fallen by 11.43 percent and then by 3.32 percent to .96 percent in subsequent years. Farmed prices would initially have fallen by 12.31 percent and then by 3.62 percent and 1.09 percent in subsequent years. At markedly higher cross elasticities, the price trends would have moved even closer together, both falling at just over 12 percent initially and then by 3.65 percent to just over one percent in subsequent years.

TABLE 8
SALMON PRODUCT
PRICE TRENDS
RATES OF REAL GROWTH

	Sockeye Canned Domestic	Sockeye Canned U.K.	Sockeye Fr/Frozen Japan	Pink Canned Domestic	Pink Canned U.K.	Pink Fr/Frozen U.S.	Chum Fr/Frozen France	Chum Fr/Frozen Sweden	Chum Fr/Frozen U.S.
1990	0.86%	0.47%	0.71%	0.86%	0.47%	0.79%	-5.01%	0.30%	0.79%
1991	0.86%	0.47%	0.93%	0.86%	0.47%	0.79%	-1.16%	0.30%	0.79%
1992	0.86%	0.47%	0.93%	0.86%	0.47%	0.79%	-1.03%	0.30%	0.79%
1993	0.86%	0.47%	0.93%	0.86%	0.47%	0.79%	-0.93%	0.30%	0.79%
1994	0.86%	0.47%	0.94%	0.86%	0.47%	0.79%	-0.84%	0.30%	0.79%
1995	0.86%	0.47%	0.94%	0.86%	0.47%	0.79%	-0.76%	0.30%	0.79%
1996	0.86%	0.47%	0.99%	0.86%	0.47%	0.79%	-0.68%	0.30%	0.79%
1997	0.86%	0.47%	0.99%	0.86%	0.47%	0.79%	-0.62%	0.30%	0.79%
1998	0.86%	0.47%	0.99%	0.86%	0.47%	0.79%	-0.56%	0.30%	0.79%
1999	0.86%	0.47%	0.99%	0.86%	0.47%	0.79%	-0.51%	0.30%	0.79%
2000	0.86%	0.47%	0.99%	0.86%	0.47%	0.79%	-0.46%	0.30%	0.79%

	Chinook Fr/Frozen Domestic	Chinook Fr/Frozen U.S.	Chinook Fr/Frozen France	Chinook Fr/Frozen Italy	Coho Canned Domestic	Coho Fr/Frozen Japan	Coho Fr/Frozen France	Farmed Coho U.S.	Farmed Chinook U.S.
1990	0.86%	0.79%	-13.89%	0.51%	0.86%	-2.06%	-9.30%	-13.82%	-16.55%
1991	0.86%	0.79%	-3.72%	0.51%	0.86%	-1.02%	-2.59%	-4.90%	-5.04%
1992	0.86%	0.79%	-3.38%	0.51%	0.86%	-0.93%	-2.40%	-4.05%	-4.68%
1993	0.86%	0.79%	-3.08%	0.51%	0.86%	-0.85%	-2.23%	-3.42%	-4.38%
1994	0.86%	0.79%	-2.83%	0.51%	0.86%	-0.77%	-2.08%	-2.50%	-2.76%
1995	0.86%	0.79%	-2.61%	0.51%	0.86%	-0.70%	-1.94%	-2.30%	-2.52%
1996	0.86%	0.79%	-2.42%	0.51%	0.86%	0.68%	-1.82%	-2.12%	-2.32%
1997	0.86%	0.79%	-2.24%	0.51%	0.86%	0.68%	-1.71%	-1.96%	-2.13%
1998	0.86%	0.79%	-2.09%	0.51%	0.86%	0.68%	-1.61%	-1.81%	-1.97%
1999	0.86%	0.79%	-1.96%	0.51%	0.86%	0.69%	-1.52%	-1.68%	-1.83%
2000	0.86%	0.79%	-1.83%	0.51%	0.86%	0.69%	-1.43%	-1.57%	-1.70%