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An International Marketing Model for Alaskan Salmon
Executive Summary

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Introduction

This report is designed to address potential impacts of future changes in the state and PNP salmon enhancement program to the economic returns from Alaska salmon fisheries. These impacts are analyzed through a econometric supply and demand equilibrium model of the world salmon market. This report represents one part of a cost/benefit analysis of the state and PNP salmon enhancement program. **The revenue projections from this model provide the benefits of the enhancement program. They are compared to estimated costs in a separate report.**

The econometric model is divided into two components: Component one provides a model of historical, international, salmon wholesale price formation. The model encompasses the wholesale salmon markets of North America, Japan, the European Economic Community, Chile, Australia, and New Zealand. In the second component, the historical relationship between North American wholesale prices and regional Alaska exvessel prices for the five salmon species harvested in Alaska (sockeye, coho, chinook, pink, and chum) are modelled.

The estimated econometric models are combined in model simulations. The simulations provide the vehicle for examining impacts of future changes in state and PNP enhancement salmon hatchery production to Alaska statewide and regional salmon exvessel revenues and prices. Eleven different future scenarios are simulated. These scenarios involve various adjustments to state and PNP hatchery production levels of the different salmon species. The future simulation time period is 1992-2006.

The econometric models in this study estimate the historical structure of the international salmon markets. Future revenue projections are based on the assumption that this historical structure continues into the future. In addition, the future simulations depend on specified future salmon harvests. Harvests of wild stock are

based on a ten-year average, while harvest of state and PNP hatchery stocks are based on projections provided by either Dr. Jerome Collie (University of Alaska Fairbanks, School of Fisheries) or state salmon hatchery operators. Additionally, the models are designed to project average revenue changes over the 15-year future time horizon, and not the returns to the Alaska salmon fisheries in any single year.

Estimation Results

This study is designed specifically to project future Alaska salmon exvessel prices through the year 2006 under varying state and PNP hatchery production levels.

Alaska exvessel prices are going to depend, in part, on wholesale prices. Thus, the economic model must consist of a system of equations that model salmon price formation at both the wholesale and exvessel levels. This modelling framework is considered particularly critical for this study, where the modelling emphasis is placed on projecting long-term price movements, rather than simply forecasting exvessel prices one-year into the future.

A model designed to project exvessel prices one year into the future might include ADF&G forecasted run sizes, current U.S., Canadian, and Japanese wholesale prices and inventories, and other supply and demand determinants. However, these variables are not available beyond the current time period. Thus, these variables must be internally generated within a model designed to project exvessel prices 15-years into the future (1992-2006). This model must explicitly account for the interlinkages which exist between the various salmon markets at the wholesale level, as well as the interlinkages between the wholesale and exvessel levels. Model performance is evaluated on the basis of the model's ability to predict long-term average price movements, rather than to predict exvessel prices in any single year.

The international salmon econometric model may be divided into two components, referred to in this report as Bloc 1 and Bloc 2. Bloc 1 provides a system of 23 equations that models the international salmon market. The complexity of this submodel reflects the highly integrated nature of world salmon markets. The flow chart provided in Figure 1 provides a representation of the structure of the international salmon market, that is modelled in Bloc 1. The arrows designate direction of trade flows.

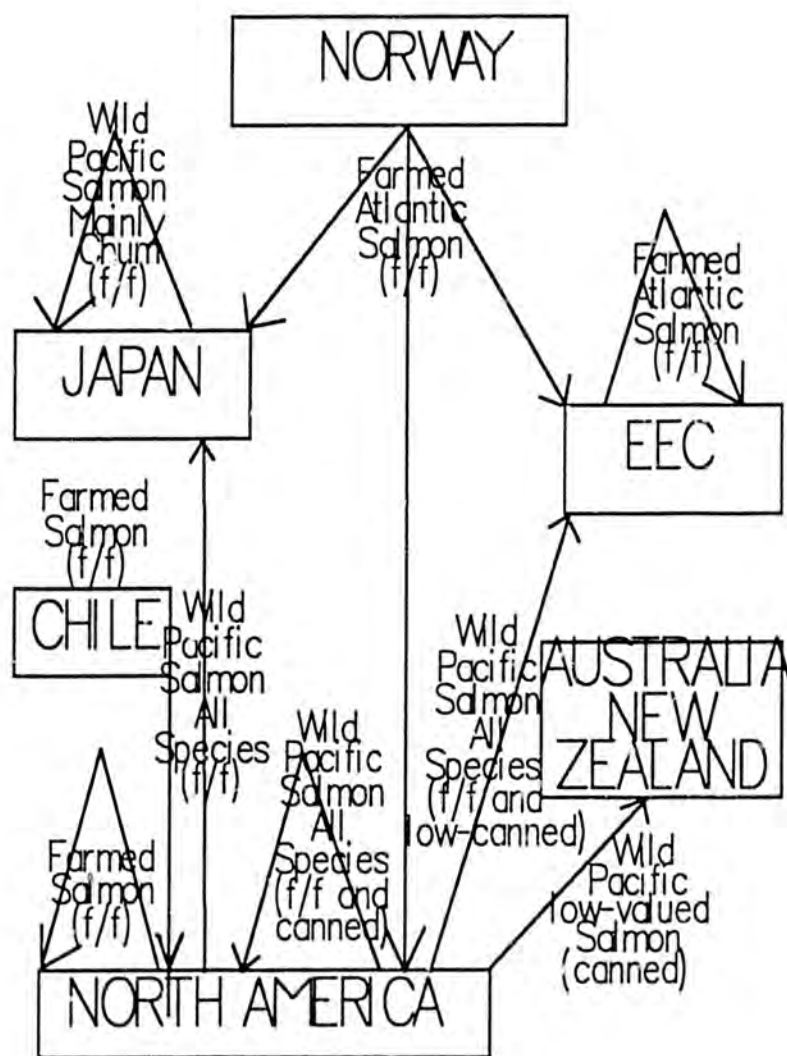


Figure 1. International Salmon Flow Chart

The final component of the Bloc 1 submodel is North American exvessel price formation. Exvessel prices depend on the current wholesale salmon prices and, therefore, are modelled recursively--wholesale prices feed into exvessel price formation. Two aggregate exvessel price equations are modelled in Bloc 1: North American high-valued salmon exvessel price, and North American low-valued salmon exvessel price. The North American high-valued exvessel price is a weighted average of Canadian and U.S. exvessel prices of high-valued salmon species: sockeye, coho, and chinook. The North American low-valued exvessel price is a weighted average of Canadian and U.S. exvessel prices of low-valued salmon species: pink and chum. These exvessel price equations are modelled in reduced form, based on derived demand theory.

Listed below are the dependent variables that are modelled in Bloc1. All quantities are fresh/frozen, unless otherwise noted as canned.

1. Norwegian allocation of farm-raised Atlantic salmon

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

2. EEC demand for salmon

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

3. Japanese demand for salmon

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

4. North American demand
 - Quantity demanded of Norwegian farmed Atlantic salmon
5. Australia and New Zealand Demand
 - Quantity demanded of North American low-valued canned salmon.
(combined demand with the EEC)
6. North American allocation of wild high-valued Pacific Salmon
 - Quantity allocated to Japan
 - Quantity allocated to the EEC
7. North American allocation of wild low-valued Pacific salmon
 - Quantity allocated to Japan
 - Quantity allocated to the EEC
8. North American allocation of wild canned low-valued Pacific salmon
 - Quantity allocated to the EEC, Australia, and New Zealand
9. North American inventory holdings
 - Quantity of wild high-valued salmon inventory
 - Quantity of wild low-valued salmon inventory
 - Quantity of canned wild low-valued salmon inventory
10. North American exvessel prices
 - Price of wild high-valued salmon
 - Price of wild low-valued salmon

The model includes flows of farmed salmon from Norway, Scotland, Chile, British Columbia, Ireland, and the United States. The farmed salmon from Norway, Ireland, and Scotland is exclusively Atlantic salmon. Farmed salmon from the United States, British Columbia, and Chile are a mixture of Pacific and Atlantic salmon. North American salmon exports include all species of Pacific salmon. Japanese landings of salmon also include all species of Pacific salmon, although most Japanese landings are chum salmon.

Data limitations, coupled with the need to keep this complex model tractable, require that certain countries and species be aggregated, and that some markets be omitted. Aggregated markets include the United States and Canada (designated as North America), and European Countries (designated as the EEC). Omitted countries include the Soviet Union, which historically supplied salmon only to Eastern Bloc countries. Even with these modifications, the model is sufficiently detailed to provide insight into price formation in the world salmon markets.

Alaska regional and statewide exvessel prices are modelled in Bloc 2. Within this submodel, exvessel prices are estimated for all Pacific salmon species (sockeye, coho, chinook, pink and chum) in four regions: Prince William Sound, Cook Inlet, Kodiak, and Southeast. In addition, exvessel prices for all other Alaska fishery regions are modelled as a single aggregate group. The Alaska regional exvessel prices are estimated on the basis of the econometrically identified relationship between the regional exvessel prices and relevant North American high-valued salmon exvessel price (sockeye, coho and chinook salmon) or low-valued salmon exvessel price (pink and chum salmon), which are modelled in Bloc 1.

The Bloc 1 submodel was constructed specifically to model the linkages between the international salmon wholesale market and exvessel price formation. This linkage occurs through the estimated North American high-valued and low-valued salmon exvessel price equations. These two exvessel price equations form the basis for subsequent estimation of Alaska regional salmon exvessel prices. Therefore, the discussion of Bloc 1 estimation results will focus on the North American high-valued and low-valued salmon exvessel price equations (the reader is referred to the full report for complete Bloc 1 estimation results).

The model results for the North American high-valued exvessel price equation indicated that 91.6 percent of the variation in North American high-valued exvessel prices, over the historical time period 1982-1991, were explained by variation in the equations explanatory variables. The predicted versus actual North American high-valued exvessel prices are provided in Figure 2. **One key finding from the Bloc 1 estimation was that there is a 99.6 percent probability that farmed Atlantic salmon is a substitute for sockeye, chinook, and coho salmon.**

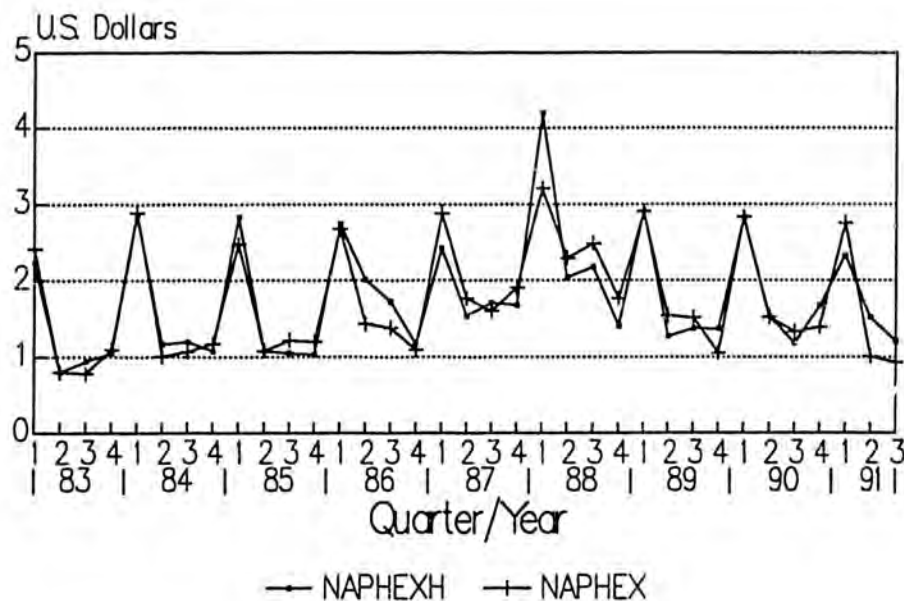


Figure 2. Predicted (NAPHEXH) vs. actual (NAPHEX) North American high-valued salmon exvessel price (1983 to 1991)

The variation in the explanatory variables within the North American low-valued salmon exvessel price equation explained 86.9 percent of the variation in North American low-valued exvessel prices over the historical time period. Actual versus

predicted North American low-valued salmon exvessel prices for the 1983-1991 time period are provided in Figure 3.

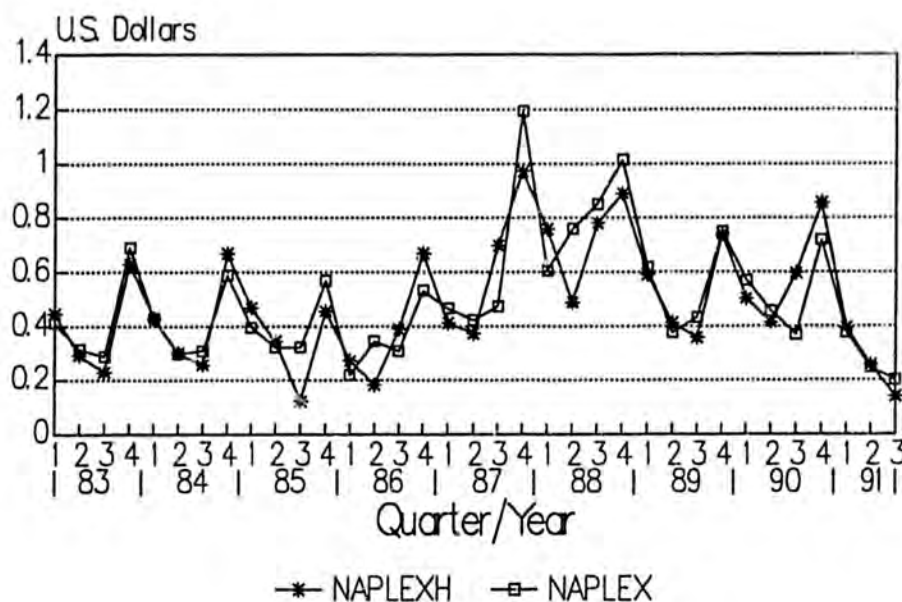


Figure 3. Predicted (NAPLEXH) vs. actual (NAPLEX) North American low-valued salmon exvessel price (1983 to 1991)

The Bloc 2 submodel included 20 equations within which regional Alaska exvessel prices across Pacific salmon species were regressed against the appropriate North American high-valued exvessel price or North American low-valued exvessel price. The correlation between the North American exvessel prices and the regional exvessel prices were in general quite strong. The strongest relationships occurred between Alaska regional sockeye salmon exvessel price and North American high-valued salmon exvessel price, and pink salmon exvessel price and North American low-valued salmon exvessel price. For example, 90 percent of the variation in Cook Inlet sockeye exvessel price was captured by variation in North American high-valued exvessel price.

The predicted versus actual Cook Inlet sockeye exvessel prices are provided in Figure 4.

The chinook salmon regional exvessel price equations generally had the poorest fits. This outcome was generally attributed to chinook salmon not being the target species in several Alaska fisheries, which resulted in regional chinook exvessel prices being based on few observations. The reader is referred to the full report for estimation results of all Alaska regional exvessel price equations.

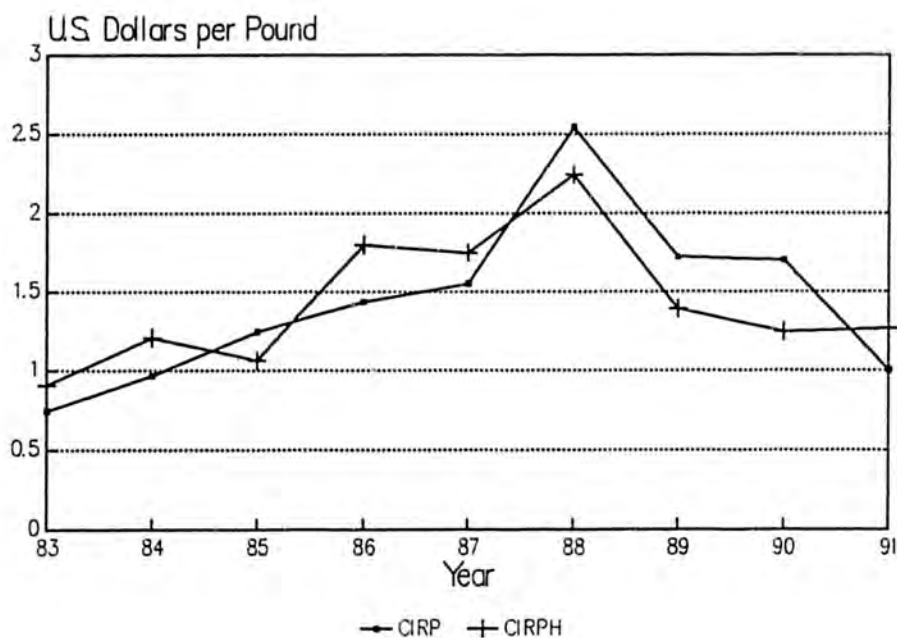


Figure 4. Predicted (CIRPH) vs. actual (CIRP) Cook Inlet sockeye salmon exvessel price (1983 to 1991).

Simulation Results

The estimated system of equations from Bloc 1 and Bloc 2 are combined in simulation to forecast future economic returns to the Alaska salmon industry. A variety of future

case scenarios were simulated. The various scenarios assumed different future state and PNP salmon hatchery production levels for the 1992-2006 time period. The base scenario, to which other scenarios were compared in deriving changes in exvessel revenues, assumes that state and PNP salmon hatchery production will continue at levels consistent with current production practices.

Forecasting future values of the variables determined within the system of equations (endogenous variables) requires specifying future values of the variables set outside the system of equations (exogenous variables) for the 1992-2006 time period. For example, values must be set for Japanese-U.S. exchange rates and Japanese personal income. A variety of techniques were used in specifying future values of the exogenous variables, including holding variable values constant at their most recently observed values, extrapolating future values from historic movements in the variables, and expert opinion. In addition to specifying their expected values, upper and lower bounds were specified for each of the exogenous variables. And, each scenario, for cases 1-6, was simulated for all three values, providing an expected, an optimistic, and a pessimistic set of simulation results. Only those simulation results using expected exogenous variable values are discussed in this report. A full listing of all simulation results are provided in the full report.

Although, the case scenarios involve altering state and PNP salmon hatchery production beginning in 1992, salmon harvests are not impacted until several years later, when the adult salmon return to the Alaska fisheries. Therefore, revenue and exvessel price impacts for the various case scenarios were reported for the 1997-2006 time period. All revenues and prices were reported in constant 1992 dollars (referred to as real revenues and prices).

The results presented in this section represent the 1997-2006 average annual real exvessel revenue changes from the base scenario that accompany some specific change in state and PNP salmon hatchery production. Two sets of results are provided for each of the case scenarios. Average real exvessel revenue changes are reported for each regional fishery harvesting the salmon species for which hatchery production is altered. In addition, Alaska statewide exvessel revenue changes are reported across all salmon species.

The aggregation of exvessel prices in Bloc 1 estimation (necessitated by data limitations and the need to maintain model tractability) resulted in the model providing the most reliable results when a change in the state and PNP hatchery production involves only a single salmon species. For this reason, only case scenarios 5-11 are reported in this summary document (refer to the full report for results of all case scenarios).

Tables 1-7 provide the expected average annual exvessel revenue changes for case scenarios 5-11.

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

Annual Revenue Changes
(Total 1992 Dollars)

PWP	-31,131,217
CIP	-2,927,398
SEP	13,325,571
KKP	1,988,567
AKOP	<u>4,324,181</u>
AKP	-14,420,296
AKR	2,226,193
AKC	5,787,079
AKS	284,549
AKK	<u>112,114</u>
TOTAL	<u>-6,010,361</u>

Table 2 -- Case 6 (Sockeye Salmon Enhancement Program is Eliminated) Predicted Changes in Total Annual Real Revenue from Base Scenario 1 for Prince William Sound Sockeye (PWR), Cook Inlet Sockeye (CIR), Southeast Sockeye (SER), Kodiak Sockeye (KKR), All All-Other-Regions Sockeye (AKOR), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

Annual Revenue Changes
(Total 1992 Dollars)

PWR	-12,655,458
CIR	-3,536,406
SER	-826,373
KKR	-7,763,960
AKOR	<u>12,978,386</u>
AKR	-11,803,811
AKP	1,059,023
AKC	482,415
AKS	637,039
AKK	<u>251,165</u>
TOTAL	<u>-9,374,169</u>

Table 3 -- Case 7 (Production from Pink Enhancement Changes by 15%) Predicted Changes in Total Annual Real Revenue from Base Scenario 1 for Prince William Sound Pink (PWP), Cook Inlet Pink (CIP), Southeast Pink (SEP), Kodiak Pink (KKP), All All-Other-Regions Pink (AKOP), Alaska Pink (AKP), Alaska Sockeye (AKR), Alaska Chum (AKC), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

Annual Revenue Changes
(Total 1992 Dollars)

	<u>Increase Production</u>	<u>Decrease Production</u>
PWP	1,509,859	-2,181,894
CIP	166,102	-244,389
SEP	-2,249,129	2,115,462
KKP	-588,007	493,543
AKOP	<u>-651,804</u>	<u>634,142</u>
AKP	-1,812,978	816,865
AKR	-208,925	219,899
AKC	-871,851	874,643
AKS	-26,705	28,114
AKK	<u>-10,522</u>	<u>11,079</u>
TOTAL	<u>-2,930,981</u>	<u>2,584,019</u>

Table 4 -- Case 8 (Production from Sockeye Enhancement Changes by 15%)
 Predicted Changes in Total Annual Real Revenue from Base Scenario 1 for Prince William Sound Sockeye (PWR), Cook Inlet Sockeye (CIR), Southeast Sockeye (SER), Kodiak Sockeye (KKR), All All-Other-Regions Sockeye (AKOR), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

	<u>Annual Revenue Changes</u> (Total 1992 Dollars)	
	<u>Increase</u> <u>Production</u>	<u>Decrease</u> <u>Production</u>
PWR	1,767,067	-1,800,062
CIR	545,179	-514,583
SER	114,284	-18,768
KKR	988,757	-1,050,612
AKOR	-1,820,309	1,848,276
AKR	1,594,978	-1,633,928
AKP	-114,944	150,275
AKC	-67,970	68,504
AKS	-89,349	90,972
AKK	-35,226	35,772
TOTAL	<u>1,287,489</u>	<u>-1,288,405</u>

Table 5 -- Case 9 (Production from Chum Enhancement Changes by 15%)
 Predicted Changes in Total Annual Real Revenue from Base Scenario 1 for Prince William Sound Chum (PWC), Cook Inlet Chum (CIC), Southeast Chum (SEC), Kodiak Chum (KCC), All All-Other-Regions Chum (AKOC), Alaska Chum (AKC), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Coho (AKS) and Alaska Chinook (AKK), for 1997-2006.

	<u>Annual Revenue Changes</u> (Total 1992 Dollars)	
	<u>Increase</u> <u>Production</u>	<u>Decrease</u> <u>Production</u>
PWC	646,243	-706,749
CIC	-57,581	57,770
SEC	2,938,214	-3,153,957
KCC	158,480	-186,022
AKOC	-209,369	210,040
AKC	3,475,987	-3,778,919
AKR	-19,341	21,155
AKP	-937,053	940,127
AKS	-2,466	2,699
AKK	-972	1,064
TOTAL	<u>2,516,155</u>	<u>-2,813,874</u>

Table 6 -- Case 10 (Production from Coho Enhancement Changes by 15%)
 Predicted Changes in Total Annual Real Revenue from Base Scenario 1 for Prince
 William Sound Coho (PWS), Cook Inlet Coho (CIS), Southeast Coho (SES), Kodiak
 Coho (KKS), All All-Other-Regions Coho (AKOS), Alaska Coho (AKS), Alaska
 Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), and Alaska Chinook
 (AKK), for 1997-2006.

	<u>Annual Revenue Changes</u> (Total 1992 Dollars)	
	<u>Increase Production</u>	<u>Decrease Production</u>
PWS	282,746	-283,697
CIS	11,942	-11,857
SES	864,086	-867,192
KKS	6,922	-6,885
AKOS	-22,954	23,543
AKS	1,142,742	-1,146,088
AKP	-30,271	32,787
AKR	-196,509	201,709
AKC	-13,808	14,923
AKK	-32,492	20,317
Total	<u>869,662</u>	<u>-876,352</u>

Table 7 -- Case 11 (Production from Chinook Enhancement Changes by 15%)
 Predicted Changes in Total Annual Real Revenue from Base Scenario 1 for Prince
 William Sound Chinook (PWK), Cook Inlet Chinook (CIK), Southeast Chinook (SEK),
 Kodiak Chinook (KKK), All All-Other-Regions Chinook (AKOK), Alaska Chinook
 (AKK), Alaska Sockeye (AKR), Alaska Pink (AKP), Alaska Chum (AKC), and Alaska
 Coho (AKS) for 1997-2006.

	<u>Annual Revenue Changes</u> (Total 1992 Dollars)	
	<u>Increase Production</u>	<u>Decrease Production</u>
PWK	115,924	-128,993
CIK	5,122	-5,809
SEK	1,103,841	-998,078
KKK	-120	111
AKOK	-8,451	7,711
AKK	1,216,316	-1,125,059
AKR	-174,507	159,734
AKP	-48,053	45,798
AKC	-21,692	20,894
AKS	-22,321	20,446
TOTAL	<u>949,743</u>	<u>-878,187</u>

Tables 1 and 3 provide the simulation results for those case scenarios where future hatchery pink salmon production are varied. Complete elimination of the pink hatchery program results in Alaska statewide average annual exvessel revenues decreasing by \$6.01 million (see Table 1). However, a 15 percent reduction in pink salmon hatchery production increases statewide average annual exvessel revenues by \$2.93 million, whereas increasing pink hatchery production by 15 percent results in statewide average annual exvessel revenues declining by \$2.58 million (Table 3).

The results indicate that given current market conditions and market structure, pink salmon are over produced. Reductions in pink salmon hatchery production provides economic gains to the state fisheries. However, these revenue gains occur only over some defined range of reductions in pink salmon hatchery production. A reduction in pink salmon hatchery production beyond this range will reduce statewide salmon exvessel revenues. This is demonstrated by statewide exvessel revenues decreasing when the pink salmon enhancement program is eliminated.

The revenue impacts of changes in the pink salmon state and PNP hatchery production are not equally distributed across Alaska regional pink fisheries. The two fisheries which have harvests significantly impacted by pink salmon hatchery production, Prince William Sound and Cook Inlet, experience increases in exvessel revenues when pink hatchery production is increased, and decreases in exvessel revenues when pink hatchery production is reduced. Exvessel revenues in the other pink fisheries, in which only a minor portion of harvest is comprised of pink salmon from the hatcheries, exhibit an inverse relationship with pink hatchery production--exvessel revenues increase when pink hatchery production is reduced, and decrease when pink salmon hatchery production is increased.

The impacts of changes in sockeye hatchery production to exvessel revenues are provided in Tables 2 and 4. Table 2 provides revenue impacts of eliminating the sockeye enhancement program, whereas Table 4 provides the impacts to fishery revenues of increasing/decreasing salmon sockeye hatchery production by 15 percent. **In all cases, statewide exvessel revenues decrease when sockeye hatchery production is reduced, and increase when sockeye hatchery production is increased.** Elimination of the sockeye enhancement program results in statewide average annual exvessel revenues decreasing by \$9.37 million; and reducing sockeye hatchery production by 15 percent results in statewide average annual exvessel revenues decreasing by \$1.29 million. A 15 percent increase in sockeye hatchery production increases statewide average annual exvessel revenues by \$1.29 million.

The principal beneficiary of an increase in sockeye hatchery production is the Prince William Sound fishery. The fifteen percent increase in hatchery production leads to a \$1.77 million increase in this fishery's average annual exvessel revenues. The largest losses from the 15 percent increase in sockeye hatchery production are incurred by the aggregate Alaska-Other-Regions sockeye fisheries (AKOR). These losses accrue primarily to the Bristol Bay fishery, which is the dominant fishery within this aggregate group.

Table 5 provides the predicted revenue impacts of increasing/decreasing chum hatchery production by 15 percent. Alaska statewide average annual exvessel revenues are projected to vary directly with changes in chum hatchery production. **Increasing chum hatchery production by 15 percent increases statewide exvessel revenues by \$2.52 million. Reducing chum hatchery production by 15 percent decreases statewide exvessel revenues by \$2.81 million.**

Average annual exvessel revenues in three of the modelled chum fisheries, Prince William Sound, Southeast, and Kodiak, vary directly with changes in chum hatchery production. Exvessel revenues in the Southeast fishery show the greatest variation, increasing \$2.94 million when chum hatchery production is increased by 15 percent, and decreasing by \$3.15 million when chum hatchery production is decreased by 15 percent. Average exvessel revenues in the other two chum fisheries, Cook Inlet and Alaska-Other-Regions, have an indirect relationship with changes in chum hatchery production.

The changes in average annual exvessel revenues associated with a 15 percent increase/decrease in coho hatchery production are provided in Table 6. Increasing hatchery production by 15 percent boosts statewide average annual exvessel revenues by \$869,662. The 15 percent reduction in hatchery production leads to statewide average annual exvessel revenues declining by \$876,352.

Exvessel revenues in only two of the coho fisheries, Southeast and Prince William Sound, are significantly impacted by the variations in coho hatchery production. The 15 percent increase in coho hatchery production increases average annual exvessel revenues in the Southeast and Prince William Sound coho fisheries by \$864,086 and \$282,746, respectively. Decreasing coho hatchery production by 15 percent reduces average annual exvessel revenues in the Southeast and Prince William Sound coho fisheries by \$867,192 and \$283,697, respectively.

The final case scenario involves increasing/decreasing chinook hatchery production by 15 percent. The exvessel revenue impacts of the variations in hatchery production are provided in Table 7. Statewide exvessel revenues vary directly with the changes in chinook hatchery production. **A 15 percent increase in chinook hatchery production results in statewide average annual exvessel revenues increasing by \$949,743. A 15**

percent reduction in chinook hatchery production leads to a \$867,352 decrease in statewide average annual exvessel revenues.

The primary beneficiary of an increase in chinook hatchery production is the Southeast chinook fishery. A \$1.10 million increase in this fishery's average annual exvessel revenues accompany the 15 percent increase in chinook hatchery production.

Conversely, this fishery's exvessel revenues decline by \$998,078 when chinook hatchery production is reduced by 15 percent.

Conclusion

The salmon marketing model was constructed to predict a 15-year exvessel price stream under various enhancement scenarios. The accuracy of the long term price predictions will depend on several factors including: (1) the specified future values of salmon price determinants; (2) the accuracy of the underlying salmon exvessel price models; and (3) the extent to which the current structure of the international salmon market continues into the future. The model was specifically designed to capture long-run price trends. Thus, even though actual outcomes may vary from those predicted through the model, the model results may still be valid in terms of projecting the direction of future price movements.

The results of the model simulations indicate that Alaska average annual exvessel revenues will increase over the 1997-2006 time period when sockeye, coho, chinook, and chum enhancement hatchery production are increased. However, these increases are moderate, and the actual profitability of increasing hatchery production of these species can only be determined when the revenue increase are compared to the costs of the enhancement program. Costs considerations and

determination of producer surpluses from the enhancement program are provided in a separate report.

The future simulation results for variation in the pink salmon enhancement program indicate that there is currently an over production of pink salmon. Reducing pink salmon production by 15 percent results in average annual exvessel revenue gains in both the statewide pink fisheries and the overall statewide salmon fisheries. However, there are distributional impacts which must be considered in conjunction with this result. The Prince William Sound pink fishery suffers a significant reduction in exvessel revenue when pink hatchery production is reduced by 15 percent.

The model results do not suggest that the pink salmon enhancement program should be eliminated. The large declines in pink salmon harvest that accompany this action depress statewide average annual exvessel revenues. This indicates that there is some exvessel revenue maximizing level of pink salmon enhancement which lies somewhere between the 15 percent reduction in pink hatchery production and the complete elimination of the enhancement program. Costs must be considered prior to determination of the profitability of the various future pink salmon enhancement programs.

Four points, which are not discussed elsewhere in this report, should be noted in evaluating the economic viability of various enhancement programs. Returns to only the commercial fleet are considered in the economic analysis. Increased enhancement production of some salmon species, e.g. chinook and coho, will increase sport-fishing harvests. Thus, the reported revenue increases provided in this report (which are confined to exvessel revenue) will understate actual benefits associated with increased salmon hatchery production. It may be useful in the future

to consider incorporating economic impacts of the sport segment of the fishery industry into the economic analysis of the salmon enhancement program.

Second, variation in salmon hatchery production may affect prices and/or recruitment/survivability of other fish species. Considerations of salmon enhancement impacts to other fisheries is beyond the scope of this analysis.

Third, it is clear from the model results that, across salmon species, increases in production/harvests will have only moderate impacts on salmon fisheries exvessel revenues, at best. **Current high levels of world salmon supplies severely hamper the ability of increased production to bolster economic returns to the salmon fisheries. It may be prudent to increase efforts aimed at expanding world demand for Pacific wild salmon. This would increase prices at all harvest levels, and increase the ability of the world salmon market to absorb additional salmon production.**

Represented in Figure 5 are demand curves (in the upper graph) and associated total revenues curves (in the lower graph). In order to illustrate the previous discussion, assume that the current demand for pink salmon is represented by the demand curve D_0 and supply is represented by S_0 . Given these demand and supply curves the current quantity is Q_0 and the current price is P_0 . The total revenue curve to the fishery is represented by TR_0 . Current production levels occur where the total revenue curve is downward sloping. This implies that the revenue associated with the last unit of fish harvested was negative. Therefore, decreasing harvest will increase total revenue. However, there is a range, beyond which this will no longer be true. If harvest is cut beyond Q_1 total revenue will decline.

If demand can be expanded to D_1 , the total revenue curve will be shifted up to TR_1 , as more salmon are demanded at each price level. In addition to increasing profits to the

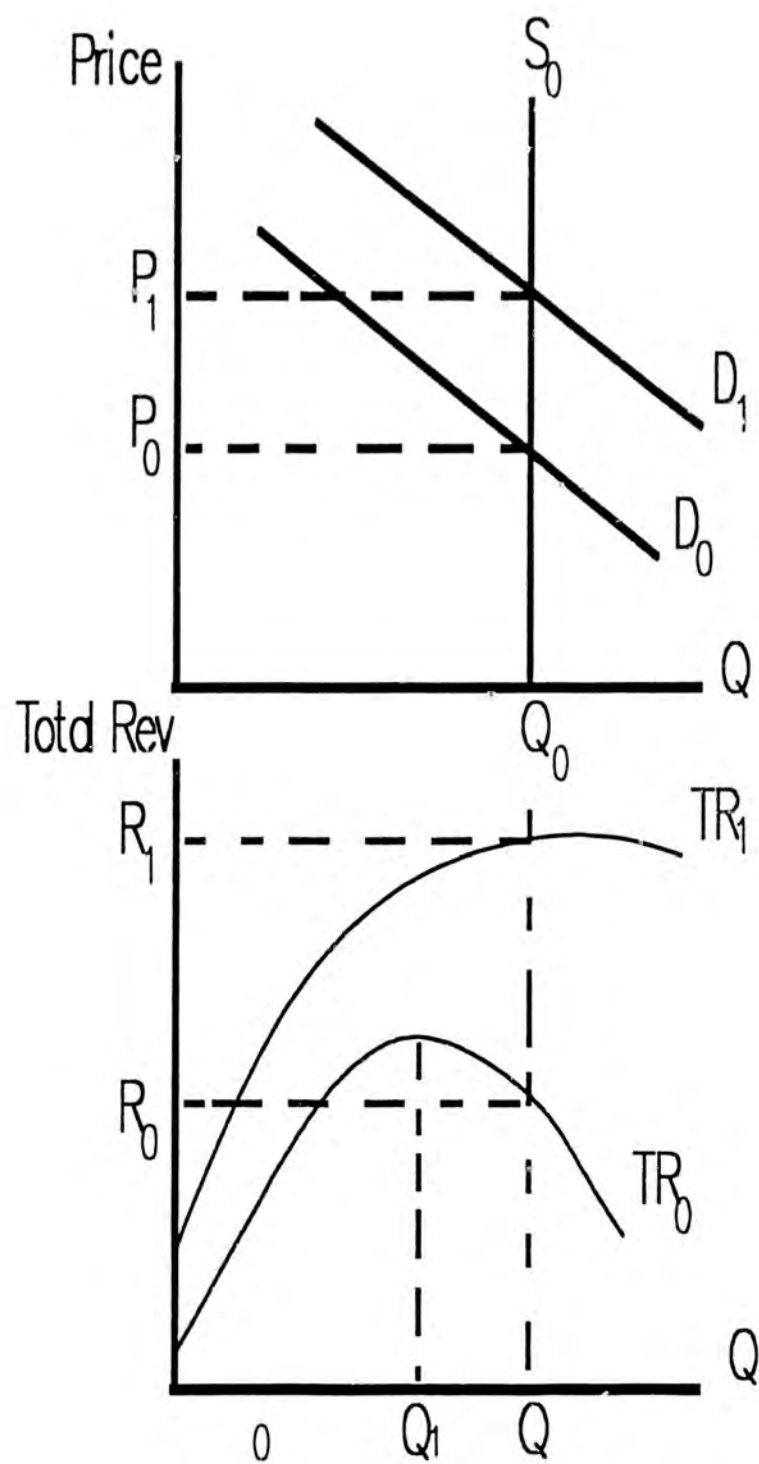


Figure 5. Supply, Demand, and Revenue Illustration

industry, the expanded demand may also lead to a situation where further increase in pink salmon production lead to increases in fishery revenues. Therefore, it may be advisable to increase efforts aimed at increasing demand for salmon, particularly pink salmon, through increased marketing and promotion, product development, market expansion, and the development of new markets. This investment may provide greater returns to the salmon industry than investment in increasing salmon hatchery production.

Finally, an increase or decrease in the production of any salmon species may trigger a counter move by competitors in the world salmon industry which may offset any potential gain from the production change. For example, a decrease in pink salmon harvest could provide incentive for the Japanese to invest in the potentially large Russian pink salmon industry. Thus, possible reactions of other participants in the world salmon industry must be considered when evaluating salmon enhancement policy.