Projections of Future Bristol Bay Salmon Prices

by

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www.iser.uaa.alaska.edu/iser/people/knapp and at
www.cfec.state.ak.us.

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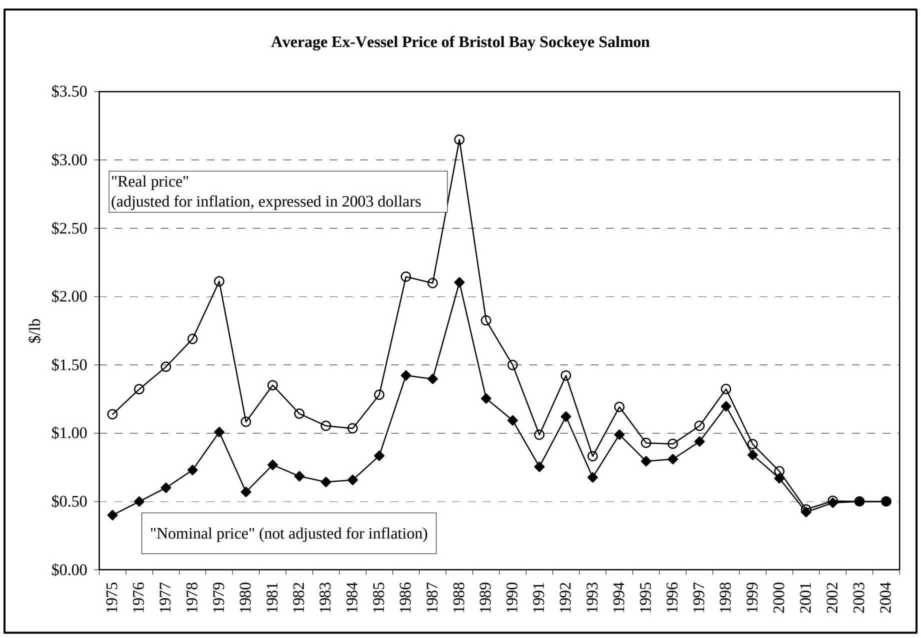
EXECUTIVE SUMMARY

The Commercial Fisheries Entry Commission (CFEC) requested this study for help in forecasting future ex-vessel prices of Bristol Bay sockeye salmon. CFEC plans to use the forecasts in analyzing the "optimum number" of limited entry permits in the Bristol Bay drift gillnet salmon fishery.

The study describes markets for Bristol Bay sockeye salmon products and how market conditions affect ex-vessel prices. The study develops an equation for forecasting future sockeye salmon ex-vessel prices based on assumptions about future Bristol Bay harvests and future farmed salmon wholesale prices. This equation is used to forecast a range within which future sockeye salmon ex-vessel prices are likely to fall.

EX-VESSEL PRICE TRENDS

Ex-vessel prices for Bristol Bay sockeye salmon have fluctuated widely over the past three decades. "Real" prices (adjusted for inflation) have declined significantly. Since 2000, prices have averaged only about one-third the average price level of the 1980s.



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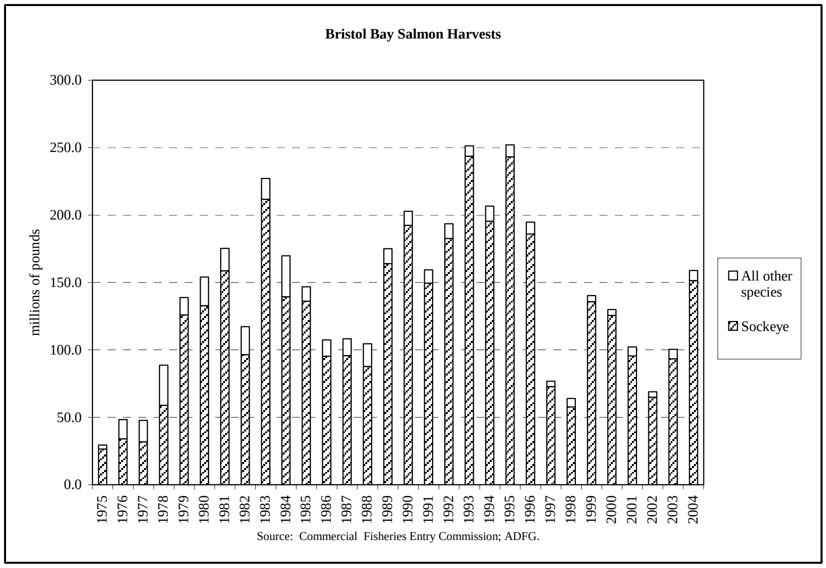
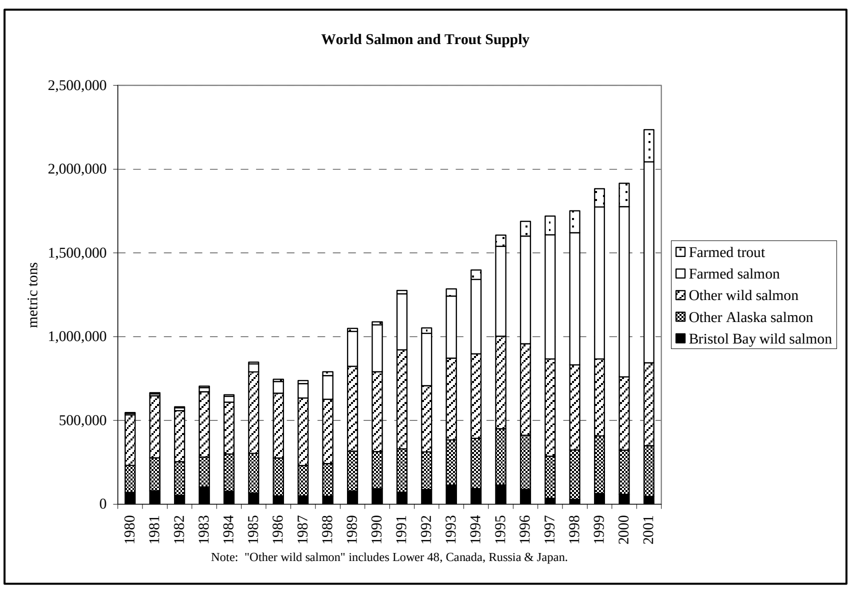
BRISTOL BAY SALMON HARVESTS

Bristol Bay sockeye salmon harvests increased from depressed levels of less than 50 million pounds in the mid-1970s to more than 150 million pounds annually for the years 1989-1996. Since 1997, sockeye salmon harvests have averaged much lower, with harvests of less than 140 million pounds in every year since 1997 except for 2004, and less than 75 million pounds in 1997, 1998 and 2002.



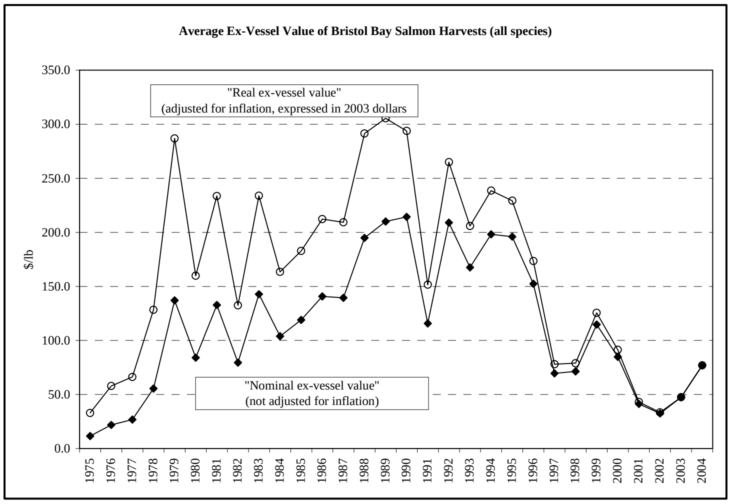
BRISTOL BAY SHARE OF WORLD SALMON SUPPLY

In 1980, total world salmon supply was less than 550 thousand tons, of which 98% was wild. By 2001 world supply had more than quadrupled to more than 2.2 million tons, 62% of which was farmed.



In 1980, Bristol Bay salmon accounted for 13% of world salmon supply, and the Bristol Bay catch was a significant factor affecting world salmon prices. By 2001, Bristol Bay accounted for only 2% of world salmon supply, and Bristol Bay catch was a far less important factor affecting world salmon prices.

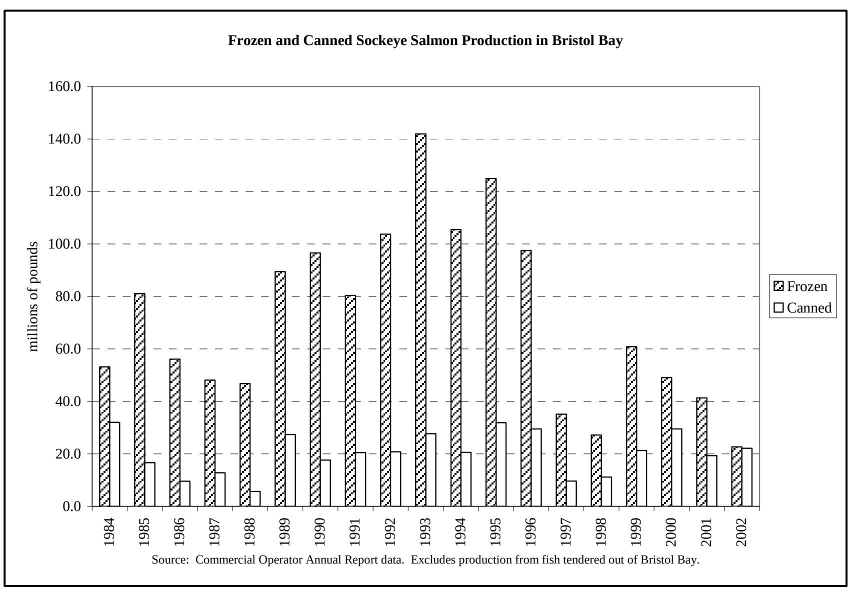
VALUE OF BRISTOL BAY SALMON HARVESTS



The combined effect of a decline in prices and a decline in harvests has been a dramatic decline in the ex-vessel value of the Bristol Bay salmon fishery. In twelve of the seventeen years between 1979 and 1995, the real ex-vessel value of the Bristol Bay salmon harvest exceeded $200 million. During seven of the eight years between 1997 and 2004, the real ex-vessel value of the Bristol Bay harvest was less than $80 million.

BRISTOL BAY SALMON PRODUCTS AND MARKETS

Almost all Bristol Bay sockeye salmon is processed into frozen or canned salmon. Very little is sold fresh. The relative share of canned production has increased in recent years. The combined result of lower harvests and a lower frozen share of production has been a dramatic decrease in frozen salmon production.

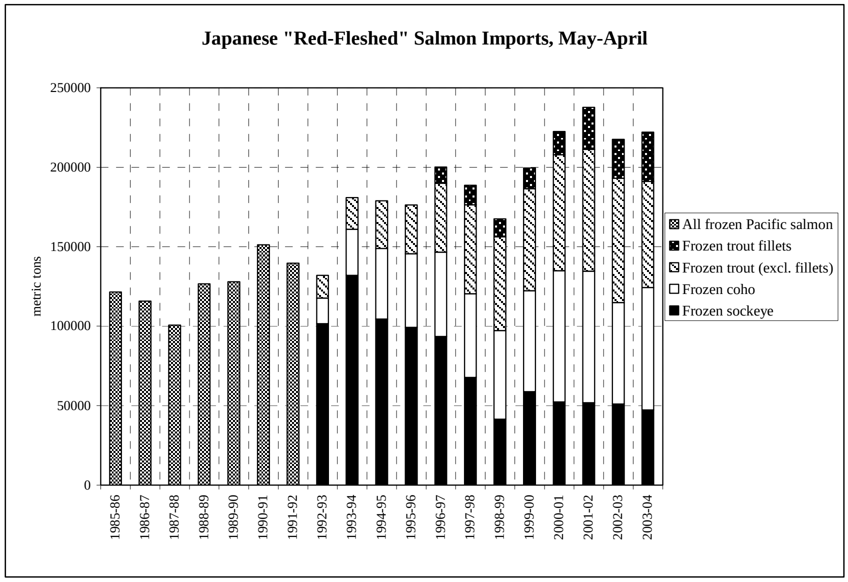


Most Bristol Bay frozen sockeye salmon is exported to Japan. Most Bristol Bay canned salmon is exported to the United Kingdom, Canada and other markets. Relatively little Bristol Bay sockeye salmon is consumed in the United States domestic market.

FROZEN SOCKEYE SALMON MARKET

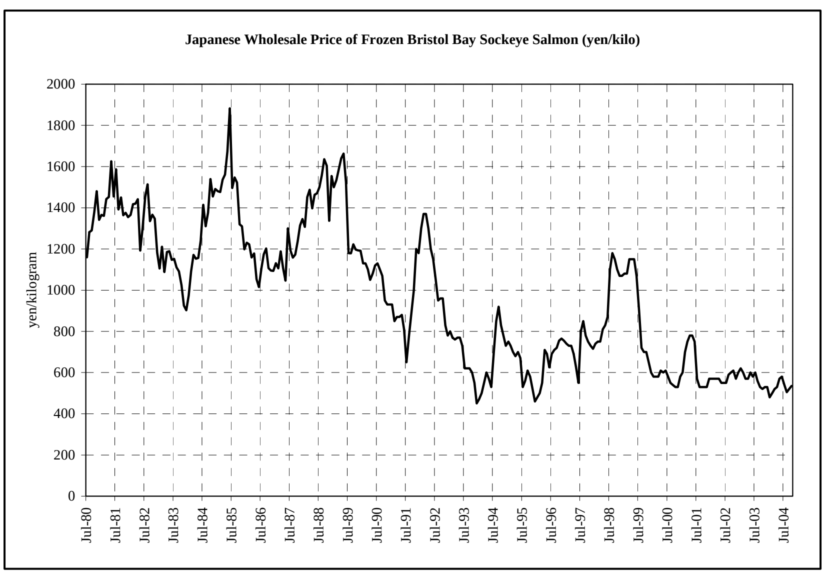
The Japanese frozen salmon market is the most important market for Bristol Bay sockeye salmon. In the Japanese market, wild sockeye salmon competes directly with farmed coho salmon and farmed trout. The Japanese consider these species to be “red-fleshed” salmon.

During the 1990s, Japanese imports of farmed Chilean coho and farmed Chilean and Norwegian trout grew rapidly, while imports of wild sockeye declined. As a result, the share of frozen sockeye in Japanese red-fleshed salmon imports declined from 77% in 1992 to just 21% in 2001.



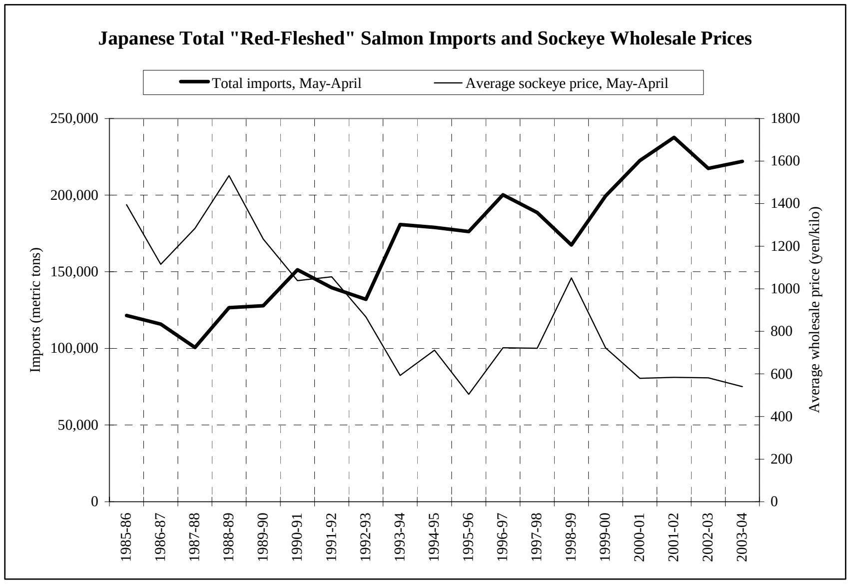
Japan imports sockeye salmon from Bristol Bay, other parts of Alaska, Canada and Russia. Japanese imports of sockeye salmon from Bristol Bay and other parts of Alaska declined dramatically after 1995, while imports of sockeye from Russia increased. The Bristol Bay share of Japanese sockeye salmon imports fell from 59% in 1995 to only 27% in 2003. This, together with increasing farmed salmon imports, caused the share of Bristol Bay sockeye in total red-fleshed salmon imports to fall from 33% in 1995 to only 6% in 2003.

Japanese wholesale prices for sockeye salmon ranged between 1100 and 1500 yen/kilogram for most of the 1980s. In the 1990s, prices fell to much lower levels, and have been below 600 yen per kilogram for most of the past three years.



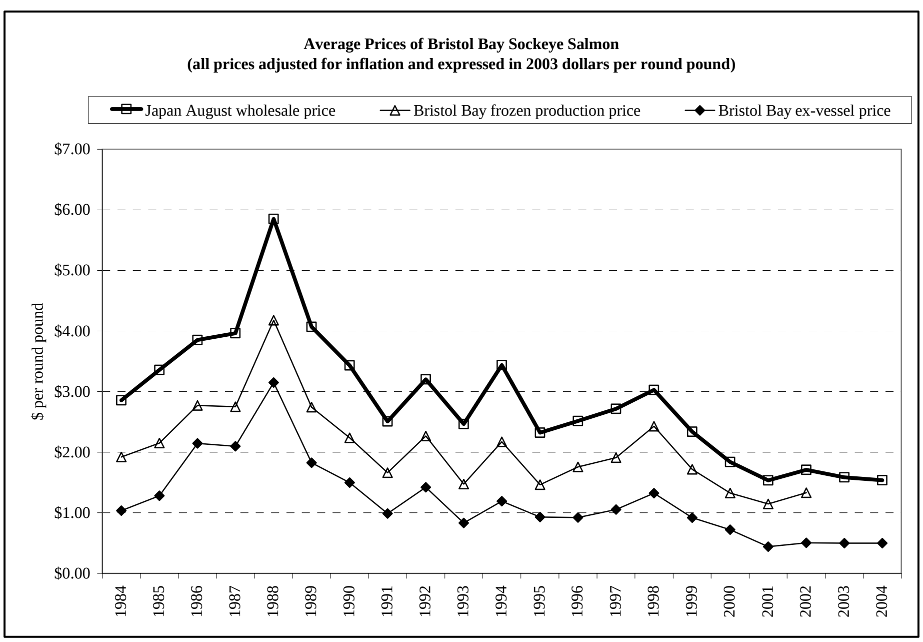
Historically, Japanese wholesale prices have cycled over periods of 1-3 years. A major factor contributing to these price cycles has been variations in wild salmon harvests. Sockeye wholesale prices have often risen or fallen sharply in July, when the total wild sockeye harvest first becomes apparent.

Historically there has been an inverse relationship between total Japanese imports of frozen "red-fleshed" salmon and average annual sockeye wholesale prices received by importers. Prices have generally fallen when total imports have risen, and vice versa, resulting in a "mirror-image" relationship between total imports and average annual sockeye prices.



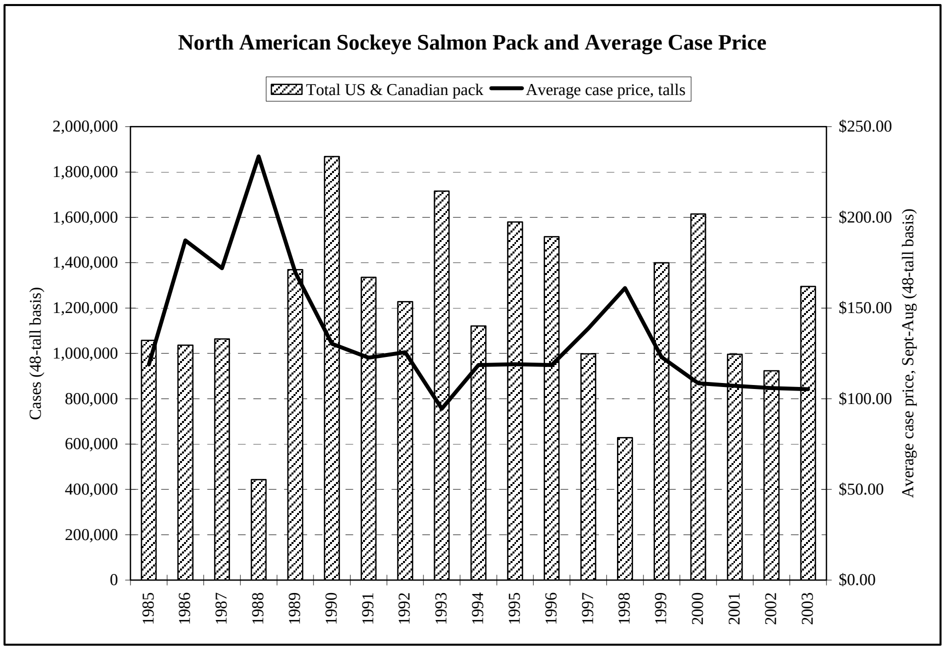
The Japanese wholesale price received by importers determines what importers are willing (and able) to pay processors for frozen sockeye salmon in yen. The exchange rate between the yen and the dollar, in turn, determines how these yen prices convert to prices importers are willing (and able) to pay processors for frozen sockeye salmon in dollars. Increases in the value of the yen contributed to a rapid increase in Japanese wholesale prices, expressed in dollars per pound, between 1985 and 1988. Increases in the value of the yen helped offset the effects of declining Japanese wholesale prices during the 1990s.

For the past two decades, both the frozen production price importers pay to processors, as well as the ex-vessel price processors pay to fishermen, have clearly tracked with Japanese wholesale prices for frozen Bristol Bay salmon. When Japanese wholesale prices have gone up, ex-vessel prices have gone up. When Japanese wholesale prices gone down, ex-vessel prices have gone down. This suggests that Japanese wholesale prices have a direct effect on ex-vessel prices.

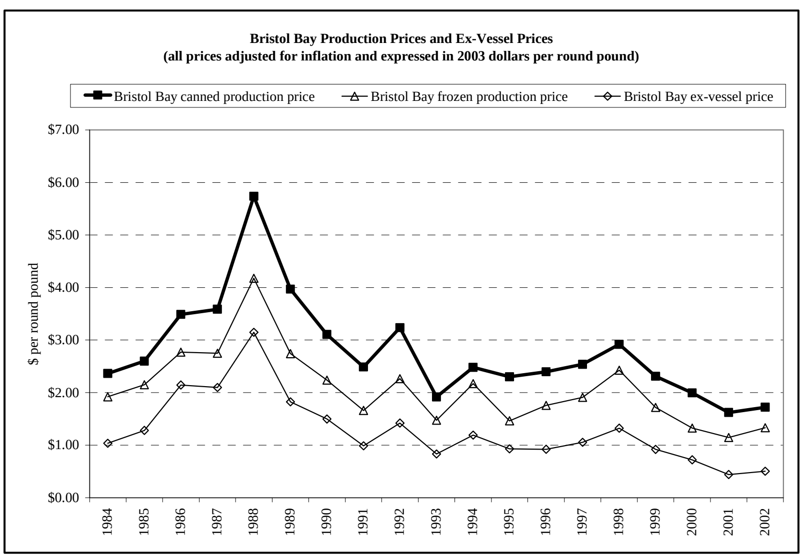


CANNED SOCKEYE SALMON MARKET

Bristol Bay typically accounts for between one-third and one-half of the North American canned sockeye salmon pack. In the short-term, canned sockeye salmon wholesale prices tend to be driven by the available supply. Prices tend to fall when the canned sockeye pack is large, and especially when there is a large pack combined with large carryover inventories from previous years' pack—and vice versa. Other factors affecting canned sockeye salmon wholesale prices include supply and price trends for canned pink salmon as well as exchange rates between the British pound and the dollar.



Production prices (first wholesale prices) for Bristol Bay canned sockeye are closely correlated with production prices for frozen sockeye and ex-vessel prices. The higher production prices for canned sockeye salmon reflect higher costs of canning compared with freezing.



The close correlation between canned and frozen wholesale prices suggests that similar factors affect wholesale prices for both products, most importantly total North American sockeye harvests. Shifts in the relative shares of canned and frozen production, in response to changes in relative prices, also help to keep wholesale price trends similar for both products.

EX-VESSEL PRICE FORECASTING EQUATION

This study recommends that CFEC use the following equation for purposes of forecasting future Bristol Bay sockeye salmon ex-vessel prices:

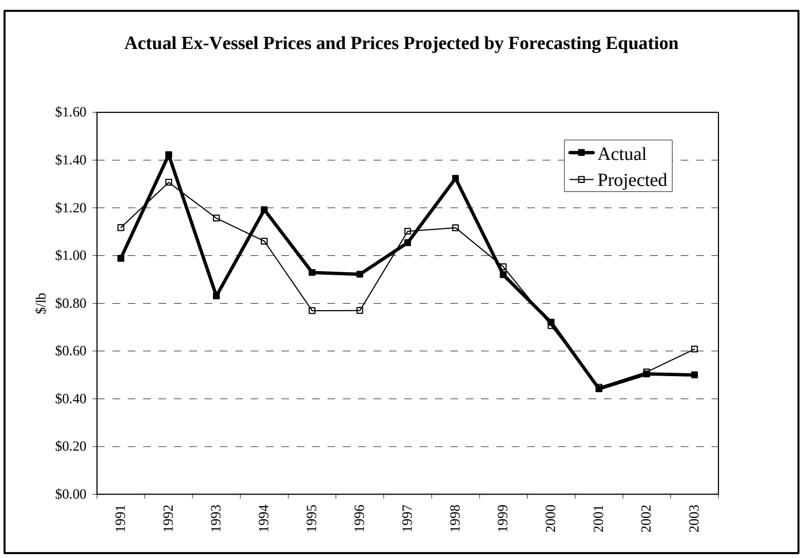
ln (Ex-Vessel Price)	= 4.22 - .531 ln (Bristol Bay Sockeye Harvest) + 1.39 ln (Farmed Coho Wholesale Price), where:
Ex-Vessel Price	= Bristol Bay sockeye real ex-vessel price (real 2003 dollars per pound)
Bristol Bay Sockeye Harvest	= Total Bristol Bay commercial sockeye harvest (metric tons)
Farmed Coho Wholesale Price	= Simple annual average Japanese wholesale price for frozen coho (real 2003 dollars per pound)

This equation was estimated using Ordinary Least Squares regression analysis, as summarized below:

Independent variables	Estimated coefficient	Standard deviation	t-statistic
Intercept	4.215984836	1.509903613	2.79
ln (Bristol Bay Sockeye Harvest)	-0.530561022	0.152111312	-3.49
ln (Farmed Coho Wholesale Price)	1.397895537	0.212012462	6.59

Years	1991-2003
Number of observations	13
Degrees of freedom	10
R-squared	0.830
Adjusted R-squared	0.796

The negative coefficient for the Bristol Bay sockeye harvest in the price forecasting equation implies that higher Bristol Bay sockeye harvests result in lower ex-vessel prices, and vice versa. This inverse effect reflects the effects of harvests on supply to the Japanese frozen salmon market, the canned sockeye market, and the sockeye roe market. The positive coefficient for the farmed coho wholesale price in the price forecasting equation implies that higher farmed salmon prices result in higher ex-vessel prices, and vice versa.



Higher wholesale prices for farmed salmon (a substitute for sockeye salmon) tend to increase demand for sockeye salmon, and vice versa.

This equation was recommended for forecasting future ex-vessel prices because it is theoretically sound, it does reasonably well at projecting historical changes in ex-vessel prices, and it is possible to make informed assumptions about future values of the two explanatory variables—Bristol Bay sockeye harvests and farmed coho wholesale prices—which "drive" the forecasts.

Forecasted Bristol Bay Prices for Different Combinations of Explanatory Variables

Ex-change rate	Farmed Coho Wholesale Price		Bristol Bay Sockeye Salmon Harvest (metric tons)							
	yen/kilo	$/lb	30,000	40,000	50,000	60,000	70,000	80,000	90,000	100,000
90	350	$1.76	$0.63	$0.54	$0.48	$0.44	$0.40	$0.38	$0.35	$0.33
	400	$2.02	$0.76	$0.65	$0.58	$0.53	$0.49	$0.45	$0.42	$0.40
	450	$2.27	$0.90	$0.77	$0.68	$0.62	$0.57	$0.53	$0.50	$0.47
	500	$2.52	$1.04	$0.89	$0.79	$0.72	$0.66	$0.62	$0.58	$0.55
	550	$2.77	$1.19	$1.02	$0.91	$0.82	$0.76	$0.71	$0.66	$0.63
	600	$3.02	$1.34	$1.15	$1.02	$0.93	$0.86	$0.80	$0.75	$0.71
	650	$3.28	$1.50	$1.29	$1.14	$1.04	$0.96	$0.89	$0.84	$0.79
100	350	$1.59	$0.54	$0.47	$0.42	$0.38	$0.35	$0.32	$0.30	$0.29
	400	$1.81	$0.66	$0.56	$0.50	$0.45	$0.42	$0.39	$0.37	$0.35
	450	$2.04	$0.77	$0.66	$0.59	$0.54	$0.49	$0.46	$0.43	$0.41
	500	$2.27	$0.90	$0.77	$0.68	$0.62	$0.57	$0.53	$0.50	$0.47
	550	$2.49	$1.02	$0.88	$0.78	$0.71	$0.65	$0.61	$0.57	$0.54
	600	$2.72	$1.16	$0.99	$0.88	$0.80	$0.74	$0.69	$0.65	$0.61
	650	$2.95	$1.29	$1.11	$0.99	$0.90	$0.83	$0.77	$0.72	$0.68
110	350	$1.44	$0.48	$0.41	$0.36	$0.33	$0.30	$0.28	$0.27	$0.25
	400	$1.65	$0.57	$0.49	$0.44	$0.40	$0.37	$0.34	$0.32	$0.30
	450	$1.86	$0.68	$0.58	$0.52	$0.47	$0.43	$0.40	$0.38	$0.36
	500	$2.06	$0.79	$0.67	$0.60	$0.54	$0.50	$0.47	$0.44	$0.41
	550	$2.27	$0.90	$0.77	$0.68	$0.62	$0.57	$0.53	$0.50	$0.47
	600	$2.47	$1.01	$0.87	$0.77	$0.70	$0.65	$0.60	$0.57	$0.53
	650	$2.68	$1.13	$0.97	$0.86	$0.78	$0.72	$0.67	$0.63	$0.60
120	350	$1.32	$0.42	$0.36	$0.32	$0.29	$0.27	$0.25	$0.24	$0.22
	400	$1.51	$0.51	$0.44	$0.39	$0.35	$0.32	$0.30	$0.28	$0.27
	450	$1.70	$0.60	$0.51	$0.46	$0.42	$0.38	$0.36	$0.33	$0.32
	500	$1.89	$0.70	$0.60	$0.53	$0.48	$0.44	$0.41	$0.39	$0.37
	550	$2.08	$0.79	$0.68	$0.61	$0.55	$0.51	$0.47	$0.44	$0.42
	600	$2.27	$0.90	$0.77	$0.68	$0.62	$0.57	$0.53	$0.50	$0.47
	650	$2.46	$1.00	$0.86	$0.76	$0.69	$0.64	$0.60	$0.56	$0.53
130	350	$1.22	$0.38	$0.32	$0.29	$0.26	$0.24	$0.22	$0.21	$0.20
	400	$1.40	$0.45	$0.39	$0.35	$0.31	$0.29	$0.27	$0.25	$0.24
	450	$1.57	$0.54	$0.46	$0.41	$0.37	$0.34	$0.32	$0.30	$0.28
	500	$1.74	$0.62	$0.53	$0.47	$0.43	$0.40	$0.37	$0.35	$0.33
	550	$1.92	$0.71	$0.61	$0.54	$0.49	$0.45	$0.42	$0.40	$0.37
	600	$2.09	$0.80	$0.69	$0.61	$0.56	$0.51	$0.48	$0.45	$0.42
	650	$2.27	$0.90	$0.77	$0.68	$0.62	$0.57	$0.53	$0.50	$0.47

Note: Between 1978 and 2003 the Bristol Bay sockeye harvest averaged 62,000 mt, and ranged from a low of 26,000 mt to a high of 110,000 mt. Between 1990 and 2004 the exchange rate between the yen and the dollar averaged about 118 yen/dollar, with a high of 158 and a low of 84. Between 1995 and 2003 the Japanese wholesale price for farmed Chilean coho averaged 566 yen/kilo, with an (annual average) low of 350 yen/kilo and a high of 800 yen/kilo.

EX-VESSEL PRICE FORECASTS

For the purpose of forecasting ex-vessel prices, this study assumes that future Bristol Bay sockeye harvests will be in the same range as they were during the period 1978-2003.

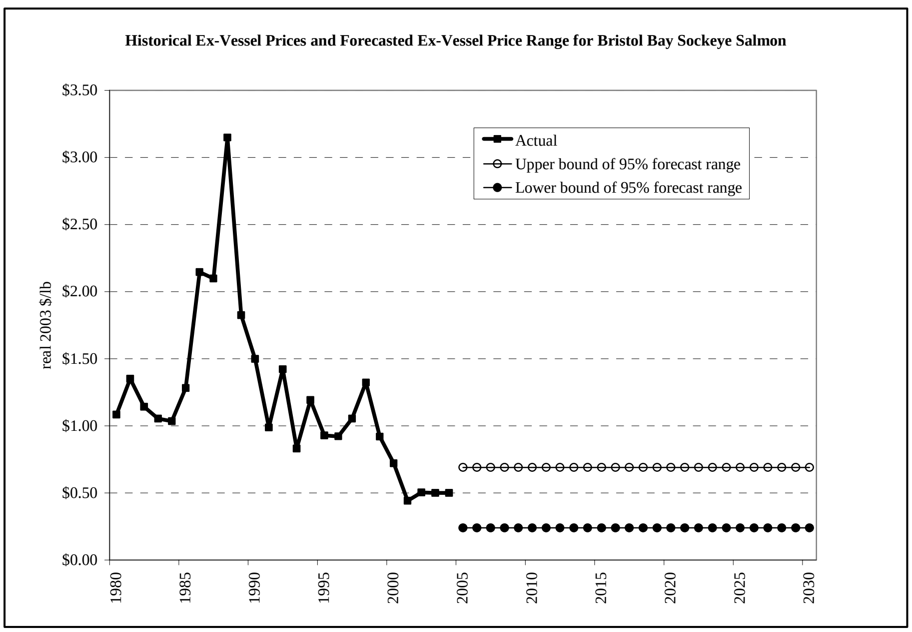
Distribution of Bristol Bay Sockeye Harvest Volume, 1978-2003 (metric tons)

Bristol Bay sockeye harvest (mt)	20,000-40,000	40,000-60,000	60,000-80,000	80,000-100,000	100,000-120,000
Number of years	5	7	7	5	2

Economic theory suggests that future farmed salmon prices will average—over the long-term--close to the cost of production. When prices are above the cost of production, profits will cause salmon farmers to increase production, causing prices to fall. When prices are below the cost of production, losses will cause salmon farmers to decrease production, causing prices to rise. However, over shorter periods of time, prices may fluctuate well above or below the average cost of production.

For forecasting purposes, the study recommends that CFEC assume that future Japanese wholesale prices for coho salmon will average about $1.63/lb. This is a rough estimate of the current total production and distribution cost for Chilean farmed coho salmon sold in Japan. The study recommends assuming that farmed coho wholesale prices will vary above and below this average with a standard deviation of $.20/lb (implying that 95% of the time average annual coho wholesale prices would be between $1.24/lb and $2.02/lb).

Given these assumptions, the equation forecasts that 95% of the time, future ex-vessel prices for Bristol Bay sockeye salmon will be between $.24/lb and $.69/lb.



Forecasted Cumulative Probability Distribution for Ex-Vessel Price

Cum. Probability	1.0%	2.5%	5.0%	50.0%	95.0%	97.5%	99.0%
Price	$0.22	$0.24	$0.26	$0.40	$0.64	$0.69	$0.75

Note. The top row shows the probability that the actual price would be less than price shown in bottom row.

This forecasted price range depends upon numerous assumptions, including the range of future Bristol Bay harvests, the range of future Japanese wholesale prices for farmed coho salmon, and the ability of the simple forecasting equation to correctly predict prices in complex world salmon markets for decades into the future. Actual future ex-vessel prices for Bristol Bay salmon could be outside of this range for many reasons. The following are only a few examples:

- Future Bristol Bay harvests—as well as other wild salmon harvests--could be lower or higher than they were in the period 1978-2003.

- Average farmed salmon wholesale prices could trend downward if farmed salmon production costs continue to decline due to factors such as improved survival rates, growth rates, feed conversion efficiency, and productivity. This would put downward pressure on wild salmon prices, including Bristol Bay ex-vessel prices.

- Average farmed salmon prices could rise if farmed salmon production costs rise due to increasing feed prices, stricter environmental regulation, or higher marginal costs as farming expands into higher-cost regions. Higher farmed salmon prices would likely lead to higher wild salmon prices, including Bristol Bay ex-vessel prices.

- Relative consumer preferences between farmed and wild salmon could shift over time. Depending on how preferences shift, this could either tend to raise or lower prices for wild salmon.

- Improved transportation infrastructure for the Bristol Bay region could lower costs for Bristol Bay processors, which would tend to raise ex-vessel prices.

Total world demand for salmon is likely to grow as population and income increases, but this will not necessarily cause Bristol Bay prices to rise above levels projected by the forecasting. Rising demand will bring about increased production of farmed salmon, which will tend to hold down future prices of both farmed and wild salmon.

The price forecasting equation recommended by this study is relatively simple. Much more complex equations could be estimated to examine how different factors affected past prices. However, complex equations are of little use for forecasting future prices unless there is a way to forecast the explanatory variables which drive them.

This study's forecasts for the range of future ex-vessel prices for Bristol Bay sockeye salmon are reasonable given the inherent constraints of limited data, the complexity of world salmon markets, and the likelihood of continued rapid change in salmon markets.

Table of Contents

I. INTRODUCTION

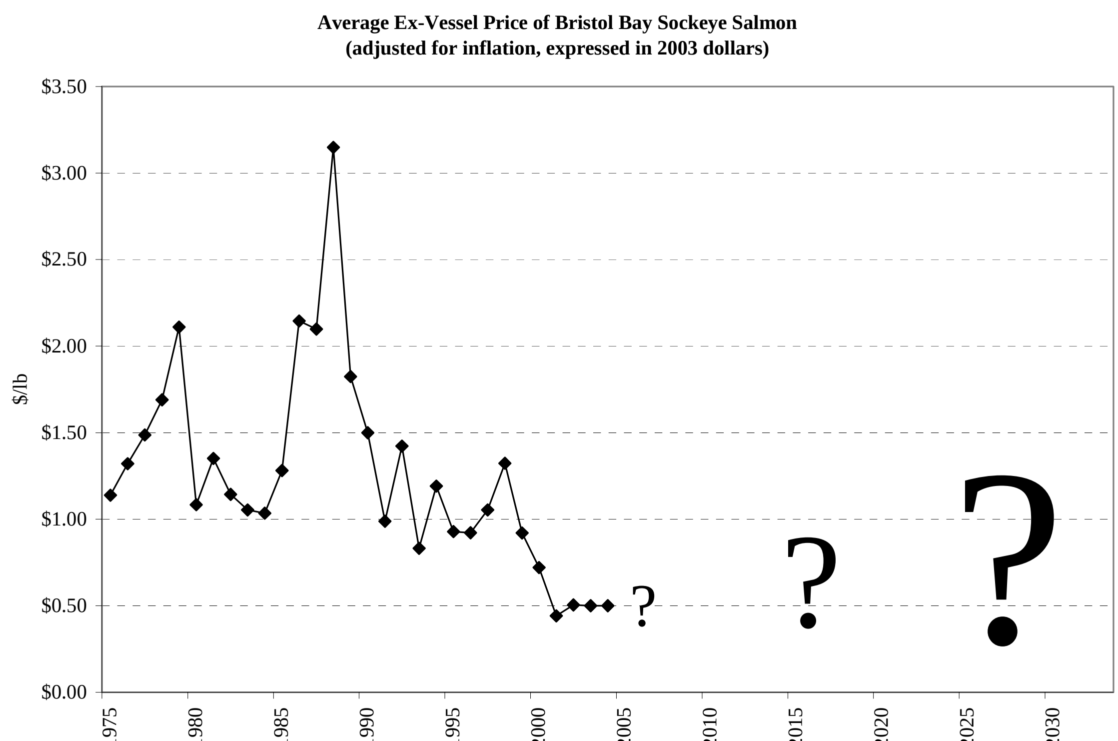
In recent years, the ex-vessel value of Bristol Bay salmon harvests has declined dramatically, due to a combination of lower prices and lower catches. Because of the decline in value, there is interest in the industry in a possible permit buyback or other changes in the structure of the harvesting sector.

In response to interest in a potential permit buyback, the Commercial Fisheries Entry Commission (CFEC) is doing an optimum number study for the Bristol Bay salmon drift gill net fishery. The purpose of the optimum number study is to examine how many limited entry permits the Bristol Bay drift gill net fishery is likely to be able to support in the future.

In order to prepare an optimum number study, CFEC needs reasonable forecasts of future ex-vessel prices for Bristol Bay sockeye salmon. By combining estimates of future ex-vessel prices, catches and costs, CFEC will be able to estimate how future average gross earnings and net returns will vary with the number of entry permits in the fishery.

Ex-vessel prices for Bristol Bay sockeye salmon have fluctuated widely over the past three decades. Since the 1980s there has been a dramatic downward trend in prices (Figure I-1). It is not obvious how prices will change in the future—whether they will continue to trend downwards, level off, or trend back upwards. The farther we attempt to project into the future, the more difficult it is to predict what may happen.

Figure I-1



To examine this question, CFEC contracted with the University of Alaska Anchorage Institute of Social and Economic Research (ISER) to prepare a report:

> ". . . that includes forecasts of the probable range of future salmon ex-vessel prices in Bristol Bay, providing data and a written description of the assumptions used and how the forecasts were derived. To the extent practicable, [the report] will provide forecasts of how future Bristol Bay ex-vessel prices will vary with changes in harvest levels given assumptions about probable levels of other relevant factors."

ISER received a total of $9500 in funding from CFEC to prepare this study.

Organization of this Report

Chapter II provides an overview of world salmon markets and how they are changing. First we describe trends in total world salmon and trout supply. We then discuss supply and price trends in the world's four most important salmon markets: the Japanese fresh and frozen salmon market, the United States fresh and frozen salmon market, the European fresh and frozen salmon market, and canned salmon markets.

Chapters III describes historical Bristol Bay salmon catches. Chapter IV describes the products made from Bristol Bay salmon and the markets they are sold to.

Chapter V describes the Japanese market for frozen salmon, which has historically been the most important single market for Bristol Bay sockeye salmon. We review historical trends in supply and wholesale prices, factors affecting Japanese wholesale prices, and the relationships between Japanese wholesale prices, first wholesale prices and ex-vessel prices.

Chapter VI examines other markets for Bristol Bay salmon, including the canned sockeye salmon market, the sockeye salmon roe market, and emerging markets for fresh sockeye salmon.

Chapter VII reviews economic theory of the formation of ex-vessel salmon prices. We begin with a brief review of basic supply and demand theory. We then examine specific characteristics of ex-vessel salmon supply and demand, and the changing dynamics of salmon markets resulting from the ability of salmon farmers to expand production. Finally, we discuss the complexity of interrelated markets for multiple salmon products at multiple levels of the salmon distribution system, and the resulting challenges in forecasting future prices.

Chapter VIII examines trends in farmed salmon costs of production, which are likely to be a critical factor affecting long-term average prices of farmed salmon and trout which compete with Bristol Bay salmon.

Chapter IX examines general considerations in forecasting future Bristol Bay sockeye salmon prices, differences between explaining past prices and forecasting future prices, and inherent challenges in long-range price projections.

Chapter X discusses the results of four regression analyses of past Bristol Bay sockeye salmon ex-vessel prices which we estimated as potential forecasting equations. We recommend one of these equations for use in forecasting future prices for this project.

Chapter XI uses this equation to forecast a potential range for future Bristol Bay ex-vessel sockeye salmon prices. We develop assumptions for future ranges of the explanatory variables which “drive” the forecasting equation, and examine the forecasted prices implied by these assumptions. Finally, we discuss how other factors not accounted for by our forecasting equation might affect future ex-vessel prices.

Finally, Chapter XII suggests some considerations for CFEC in developing future price assumptions for species other than sockeye.

Throughout the report, we assume that readers are generally familiar with the Bristol Bay salmon fishery. Thus we do not discuss details of the fishery timing, gear, location, management, or processing methods. Instead, we focus on issues specifically related to understanding markets and prices for Bristol Bay sockeye.

This report is based on a wide range of data sources. For convenience, we refer to each of these data sources by a short descriptive name. Appendix A provides descriptions of these data sources, arranged alphabetically by name.

Because of space limitations, not all of the tables and figures in this report include source references. Appendix B provides a listing of source references for all tables and figures.

Appendix C provides tables of selected data used in preparation of this report.

II. AN OVERVIEW OF WORLD SALMON MARKETS

Bristol Bay salmon are processed into many different products—mostly frozen salmon, canned salmon and salmon roe—which are sold in markets around the world. The most important of these markets are the Japanese market for frozen salmon, the United Kingdom market for canned sockeye salmon, and the Japanese market for sockeye salmon sujiko (a salmon roe product).

Ultimately, the prices in these markets for Bristol Bay salmon products drive the prices paid to Bristol Bay fishermen. These markets are affected by many different factors, of which the most important include the supply of Bristol Bay salmon; the supply of other kinds of salmon—wild and farmed—which compete with Bristol Bay salmon; and the numerous factors which influence demand for all the different salmon products made from Bristol Bay salmon and its competitors in world markets.

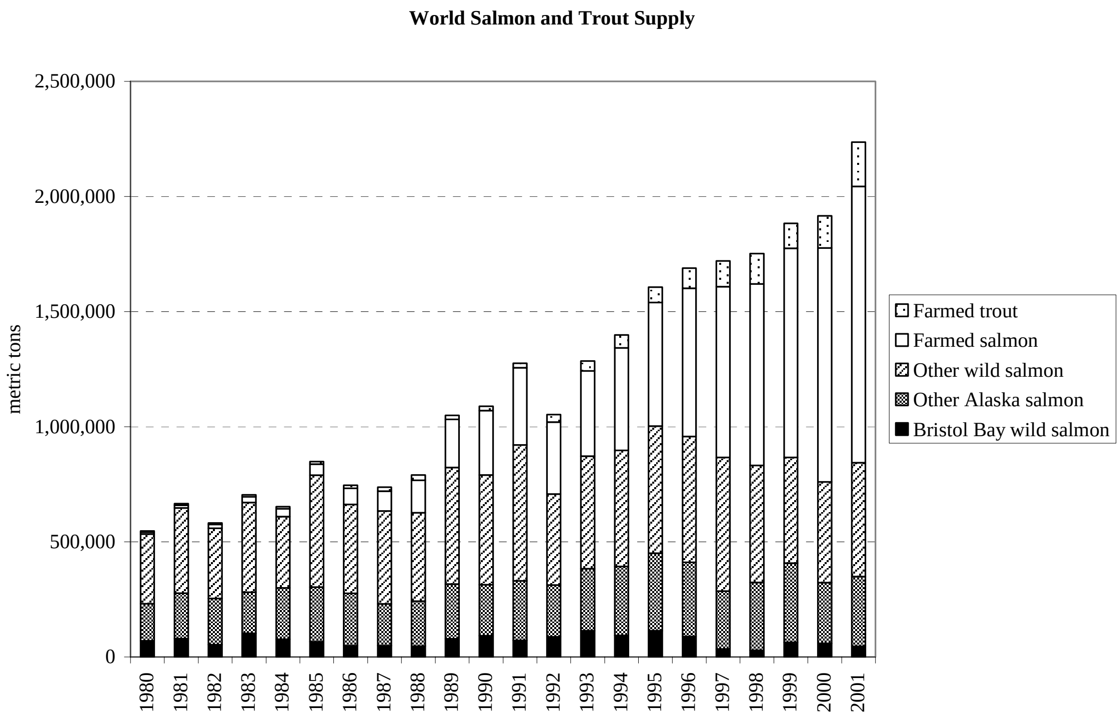
In subsequent chapters of this report, we describe different markets for Bristol Bay salmon products in detail. However, it to understand these markets, it is useful to first have a general understanding of the "big picture" of world salmon markets and how they are changing.

For this reason, in this chapter we begin with an overview of world salmon markets. Our purpose is to provide a context for the more detailed discussion in subsequent chapters of markets for Bristol Bay salmon products. We begin by reviewing trends in total world salmon and trout supply. We then review supply and price trends in the world's four most important salmon markets: the Japanese fresh and frozen salmon market, the United States fresh and frozen salmon market, the European fresh and frozen salmon market, and canned salmon markets.

World Salmon Supply

Figure II-1 shows world salmon and trout supply for the years 1980-2001. Major sources of supply shown in the figure include Bristol Bay salmon, other Alaska salmon, other wild salmon (from the Lower 48, Canada, Russia and Japan), farmed salmon and farmed trout.

Figure II-1



Note: "Other wild salmon" includes Lower 48, Canada, Russia & Japan.

In this report, we use the term "trout" to refer specifically to farmed rainbow trout (*Onchorhyncus mykiss)* raised in salt water pens, mostly in Scandinavia and Chile. These farmed trout are similar in size, color and taste to salmon, and they compete directly with salmon in the Japanese and European markets fresh and frozen markets and in the salmon roe market. In general when we refer to "farmed salmon" we are also including farmed trout.

The volume and sources of world salmon supply have changed dramatically over the past two decades. In 1980, total world salmon supply was less than 550 thousand tons, of which 98% was wild.[1] By 2001 world supply had more than quadrupled to more than 2.2 million tons, 62% of which was farmed.

In 1980, Bristol Bay salmon accounted for 13% of world salmon supply, and the volume of the Bristol Bay catch was a significant factor affecting world salmon supply and salmon prices. By 2001, Bristol Bay accounted for only 2% of world salmon supply, and the volume of the Bristol Bay catch was a far less important factor affecting world salmon supply and prices.

World production of farmed salmon grew dramatically from less than 10,000 tons in 1980 to more than 1.2 million tons in 2001. Farmed trout production grew from 5,000

[1] Throughout this report, we use the term "tons" to mean "metric tons." One metric ton = 2,204.6 pounds.

tons to 190 thousand tons. In 2001, farmed salmon and trout accounted for almost two-thirds of world supply.

Table II-1 provides more detail on the contribution of Bristol Bay to total world salmon supply in 2001. Bristol Bay accounted for 40% of world sockeye salmon supply in 2001, followed by other Alaska areas (31%), Russia (20%), and Canada (6%). However, Bristol Bay accounted for only 2% of total world salmon and trout supply.

Table II-1

World Wild and Farmed Salmon and Trout Supply, by Species, 2001

	Species	Bristol Bay	Other Alaska	Lower 48	Canada	Japan	Russia	Farmed	**Total**
Metric tons	Chinook	195	2,736	4,851	636	111	499	23,331	**32,359**
	Sockeye	43,380	34,202	700	6,231	2,740	22,475	0	**109,728**
	Coho	58	15,823	2,923	46	502	2,034	151,386	**172,772**
	Pink	1	193,952	1,433	10,575	9,765	167,566	0	**383,291**
	Chum	2,708	55,729	6,675	5,549	217,359	32,067	0	**320,087**
	Atlantic							1,025,287	**1,025,287**
	Trout							192,332	**192,332**
	Total	**46,342**	**302,442**	**16,582**	**23,037**	**230,477**	**224,641**	**1,392,336**	**2,235,856**
Share of world supply, by region	Chinook	1%	8%	15%	2%	0%	2%	72%	**100%**
	Sockeye	40%	31%	1%	6%	2%	20%	0%	**100%**
	Coho	0%	9%	2%	0%	0%	1%	88%	**100%**
	Pink	0%	51%	0%	3%	3%	44%	0%	**100%**
	Chum	1%	17%	2%	2%	68%	10%	0%	**100%**
	Atlantic							100%	**100%**
	Trout							100%	**100%**
	Total	2%	14%	1%	1%	10%	10%	62%	**100%**
Share of regional supply, by species	Chinook	0%	1%	29%	3%	0%	0%	2%	1%
	Sockeye	94%	11%	4%	27%	1%	10%	0%	5%
	Coho	0%	5%	18%	0%	0%	1%	11%	8%
	Pink	0%	64%	9%	46%	4%	75%	0%	17%
	Chum	6%	18%	40%	24%	94%	14%	0%	14%
	Atlantic							74%	46%
	Trout							14%	9%
	Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Sources: Alaska Department of Fish and Game; National Marine Fisheries Service; FAO Fishstat+ database.

World production of sockeye, pink and chum salmon production is entirely wild.[2] However, for two Pacific salmon species—coho and chinook—there is both significant wild and farmed production. By 2001 farmed production of these species greatly exceeded wild production. World farmed coho salmon production in 2001 was 151 thousand tons—more than three times the volume of Bristol Bay sockeye salmon. This farmed coho production—almost all from Chile—competes directly with Bristol Bay sockeye salmon in the Japanese frozen salmon market.

Major World Salmon Markets

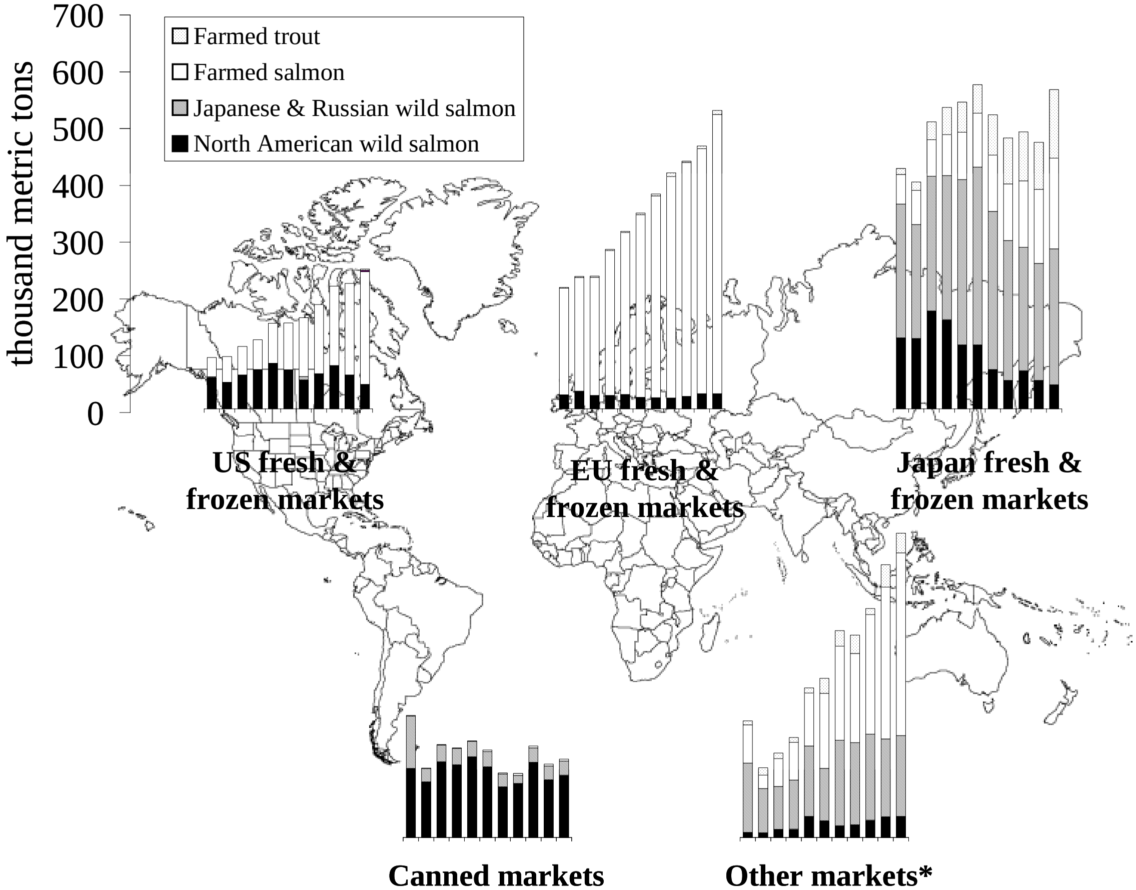
World salmon consumption may be divided among five major markets: the European Union fresh and frozen market, the Japanese fresh and frozen market, the United States fresh and frozen market, canned salmon markets (all canned salmon markets worldwide),

[2] Note, however, that a large share of the world's chum and pink salmon harvests are hatchery fish.

and other markets. There are significant differences between these markets in their sources of supply, species and products consumed, and short-run market conditions.

Figure II-2

Estimated World Salmon Consumption, 1991-2001



*Note: estimates of consumption in other markets are highly sensitive to yield assumptions and are less reliable than other estimates shown.

Figure II-2 shows estimated salmon and trout consumption in each of these major markets for the period 1991-2001, by source of supply. These estimates are based on numerous assumptions and should be considered only approximate. However, they are reasonable indicators of the relative scale of different markets, the relative rates of growth of consumption in different markets, and the relative importance of different sources of supply for each market.[3]

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[3]The estimates shown in Figure II-2 are from a more detailed description of world salmon markets developed by Gunnar Knapp for a report by Gunnar Knapp, Cathy Roheim, and James L. Anderson, tentatively titled *North American Wild Salmon: Economic Interactions with Farmed Salmon*, to be published by TRAFFIC North America in 2004 or early 2005. Because the focus of that analysis was on North American salmon markets, wild salmon supply is divided between "North American wild salmon" and "Japanese and Russian wild salmon." Developing these estimates posed numerous challenges

There are two important points to be noted from Figure VI-2. First, until recently, the Japanese fresh and frozen salmon market was the world's largest market by far. However, the rapidly growing European Union market now consumes about the same amount of fresh and frozen salmon & trout as Japan. In 2001, United States fresh and frozen salmon consumption was less than half that of both Japan and the European Union.

Second, farmed salmon and trout consumption grew dramatically between 1991 and 2001 in all markets except for "canned salmon." In both relative and absolute terms, the growth in consumption of farmed salmon and trout was greatest in the European fresh and frozen market, which accounted for one third (32%) of the increase in world farmed salmon and trout consumption during this period. Japan accounted for 22% of the growth in world farmed salmon and trout consumption, and the United States accounted for 17%.

Tables II-2 and III-3 provide more detailed estimates of supply to each market in 2001 from major wild and farmed salmon producers. (Note again that these estimates are based on numerous different--and sometimes conflicting--data sources and assumptions and should be considered only approximate.)

In 2001, the Japanese fresh and frozen salmon market consumed about 494 thousand tons of salmon, or about 30% of world consumption. Japanese wild salmon accounted for the largest share of supply to the Japanese fresh and frozen salmon market (37%) followed by Chilean farmed salmon (19%).

The European fresh and frozen market consumed about 461 thousand tons of salmon and trout, or about 30% of world consumption. Norwegian farmed salmon accounted for the largest share of supply to the European market (48%) followed by United Kingdom farmed salmon (24%).

The United States fresh and frozen market consumed about 214 thousand tons of salmon, or about 13% of world salmon and trout consumption. Chilean farmed salmon accounted for the largest share of supply (40%) followed by Canadian farmed salmon (31%).

including inconsistencies in data between different sources; absence of data on product mix and end-markets for some regions; and variation in product yields. The estimates required numerous assumptions and should be considered only approximate. Tables II-2 and II-3 are based on the same analysis.

Table II-2

Approximate World Salmon Production and Consumption, 2001 (thousands of metric tons)

Type of salmon	Producing country	Total production (round weight basis)	Consumption by End-Market (processed weight basis): United States fresh & frozen markets	EU fresh & frozen markets	Japanese fresh & frozen markets	Canned salmon markets	Other markets	TOTAL	*Weight loss in processing*
North American wild salmon	United States	365	32	21	32	84	33	202	*163*
	Canada	23	5	2	5	12	0	25	*0*
	Total	**388**	**38**	**24**	**38**	**96**	**33**	**228**	***163***
Japanese & Russian wild salmon	Japan	230	0	0	183	5	0	188	*42*
	Russia	225	0	0	27	16	125	168	*56*
	Total	**455**	**0**	**0**	**210**	**22**	**0**	**232**	***98***
Farmed salmon	Norway	438	7	223	30	2	111	372	*66*
	Chile	395	85	18	92	0	140	335	*59*
	UK	139	6	111	1	0	0	118	*21*
	Canada	105	66	0	1	0	23	90	*16*
	United States	21	9	0	0	0	8	17	*3*
	Japan	12	0	0	12	0	0	12	*0*
	Others	91	2	80	5	0	0	87	*4*
	Total	**1,200**	**174**	**432**	**140**	**3**	**282**	**1,031**	***169***
Farmed trout	Norway	71	0	5	33	0	19	57	*14*
	Chile	109	2	0	70	0	6	78	*22*
	Others	12	0	1	3	0	5	10	*2*
	Total	**192**	**2**	**6**	**106**	**0**	**30**	**144**	***38***
Total		**2,236**	**214**	**461**	**494**	**121**	**345**	**1,635**	***469***

Note: The estimates shown in the table for consumption by end-market are based on numerous assumptions of varying reliability and should be used only as approximate indicators of relative volumes going to different markets.

Table II-3

Approximate Shares of World Salmon Consumption, by Producing Country, 2001

Type of salmon	Producing country	Consuming Markets (processed weight basis): United States fresh & frozen markets	EU fresh & frozen markets	Japanese fresh & frozen markets	Canned salmon markets	Other markets	TOTAL
North American wild salmon	United States	15%	5%	7%	70%	9%	12%
	Canada	3%	1%	1%	10%	0%	2%
	Total	**18%**	**5%**	**8%**	**80%**	**9%**	**14%**
Japanese & Russian wild salmon	Japan	0%	0%	37%	4%	0%	12%
	Russia	0%	0%	5%	14%	36%	10%
	Total	**0%**	**0%**	**43%**	**18%**	**0%**	**14%**
Farmed salmon	Norway	3%	48%	6%	2%	32%	23%
	Chile	40%	4%	19%	0%	41%	21%
	UK	3%	24%	0%	0%	0%	7%
	Canada	31%	0%	0%	0%	7%	5%
	United States	4%	0%	0%	0%	2%	1%
	Japan	0%	0%	2%	0%	0%	1%
	Others	1%	17%	1%	0%	0%	5%
	Total	**82%**	**94%**	**28%**	**2%**	**82%**	**63%**
Farmed trout	Norway	0%	1%	7%	0%	6%	3%
	Chile	1%	0%	14%	0%	2%	5%
	Others	0%	0%	1%	0%	1%	1%
	Total	**1%**	**1%**	**21%**	**0%**	**9%**	**9%**
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Canned salmon markets consumed about 121 thousand tons of salmon, or about 7% of world consumption.[4,5] The United States (mostly Alaska) accounted for the largest share of canned salmon supply (70%), followed by Russia (14%) and Canada (10%). Below, we examine the markets described above in greater detail. For each market we discuss trends in total supply, trends in wholesale prices, and major factors affecting wholesale prices.

[4] " Other salmon markets" include fresh and frozen markets in Canada, Russia, Eastern Europe, South America and the Far East. Our estimates of consumption for these markets are less reliable because they were calculated as residual volumes after subtracting volumes consumed in other markets and assumed yield losses in processing.

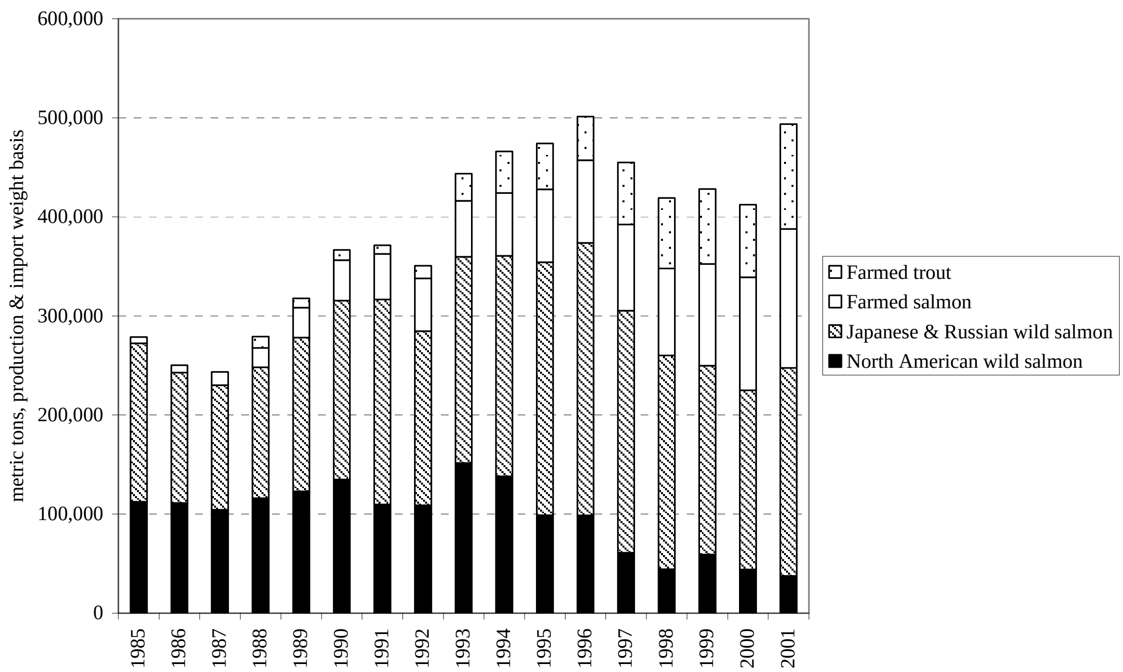
[5] Salmon roe, which is not included in the supply and consumption estimates, is also a valuable salmon product. Most salmon roe production is from wild salmon. Japan accounts for the largest share of production, followed by the United States and Russia. Japan is by far the largest consuming market for salmon roe, followed by Russia.

The Japanese Fresh & Frozen Salmon Market

Japan was by far the largest salmon market in the world until the late 1990s when the European salmon market grew to about the same size. Japan consumes significant volumes of all wild and farmed salmon species from almost every major salmon producing country.

Figure II-3

Estimated Japanese Fresh & Frozen Salmon Consumption, 1991-2001



As in the United States and Europe, since the late 1980s there has been dramatic growth in consumption of farmed salmon and trout in Japan. However, Japan has experienced different trends in total salmon and trout consumption than the United States and European markets. The reason is that Japan also consumes very large volumes of wild salmon, including both Japanese wild salmon catches as well as wild salmon imported from North America and Russia. Trends in wild salmon consumption have also had important effects on total consumption trends.

Japanese salmon consumption grew rapidly from less than 300 thousand tons in the mid-1980s to 500 thousand tons in 1996 due to growth in consumption of both wild and farmed salmon. Between 1996 and 2000, however, wild salmon consumption declined sharply due to lower imports of North American wild salmon and lower Japanese catches of wild salmon. As a result, total consumption fell to about 410 thousand tons in 2000 before increasing sharply again in 2001. Farmed salmon and trout increased from 11% of total Japanese consumption in 1988 to 50% in 2001.

The Japanese consume a wider variety of salmon products than Americans or Europeans. Sliced salmon fillets, known as *kirimi*, are one of the most common salmon product forms. These may be salted, marinated or unsalted. Grilled sliced salmon, served with a bowl of steamed rice, may be part of lunch, dinner, or traditional Japanese breakfast. Salmon is a common element in a range of prepared meals, sold either “ready-to-eat”, “ready-to-heat,” or “ready-to-cook.” It is a common filling for rice balls, a popular lunch item. Numerous other traditional and modern preparations of salmon are sold in supermarkets and fish stores. As with other fish and food products in Japan, quality standards for salmon products are very high.

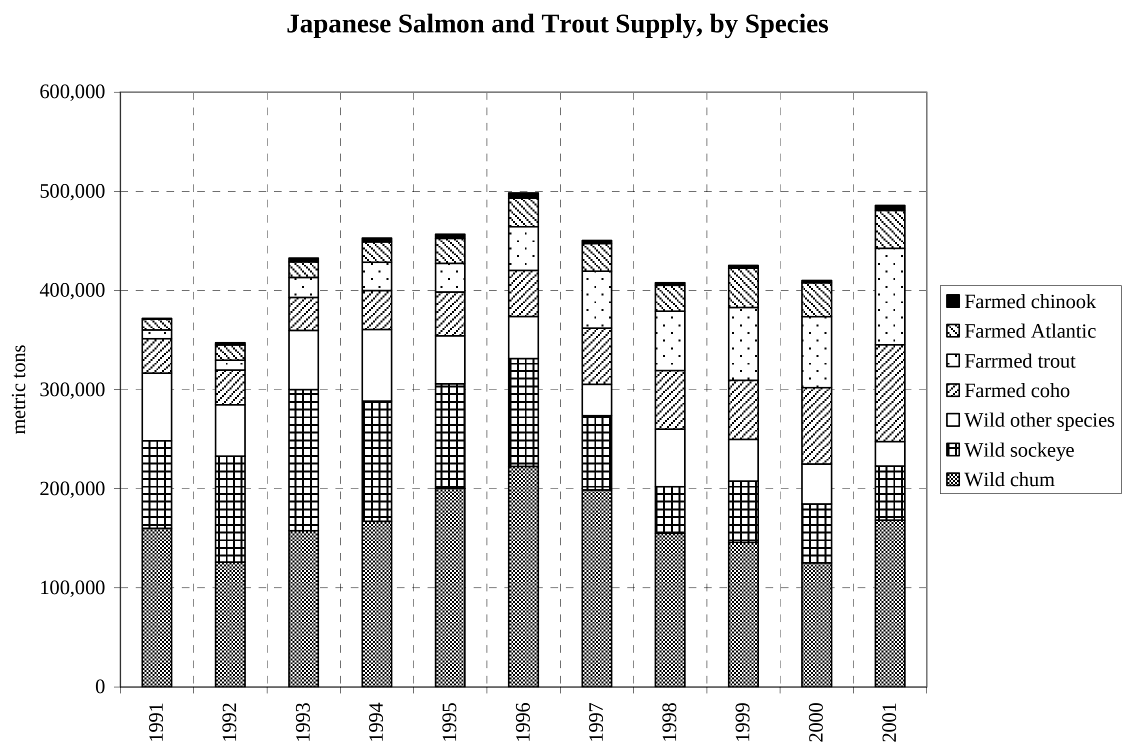
Japanese salmon consumption patterns and preferences vary by geographical area and by age group. Usage and preparation of salmon differs by species depending on the texture of the meat, the oil content and the color. In markets where wild salmon was traditionally preferred, farmed salmon has gained increasing acceptance in the Japanese market as wild salmon supply has declined and farmed supply has expanded dramatically. Japanese salmon consumption patterns are also highly seasonal, reflecting the timing of wild salmon runs in Japan and other countries. However, seasonal consumption patterns have weakened over time as freezing technology has allowed wild salmon to be consumed year round, and with the year-round availability of farmed salmon and trout.

Sliced salmon fillets (kirimi) in a Japanese Department Store

Photographs by Gunnar Knapp

The largest component of Japanese supply is wild chum salmon, almost all of which is fish released from hatcheries in northern Japan which are caught in coastal fisheries during the fall. (Figure II-4). Catches of these hatchery “fall chum” salmon have varied significantly from year to year, reflecting changes in fish releases and ocean survival rates. Fall chum salmon catches peaked in 1996 at 206,000 tons, fell by almost half to 108,000 tons in 2000, and rose again to 158,000 tons in 2001.

Figure II-4



Until 1997, wild sockeye salmon—most of it imported frozen from North America—accounted for the second largest share of Japanese salmon supply. However, the share of wild sockeye in total supply declined dramatically from 33% in 1993 to just 11% in 2001 as sockeye supply declined and the supply of farmed salmon increased rapidly.

Most of the growth in Japanese salmon supply during the 1990s resulted from rapid growth in the supply of farmed coho salmon (mostly from Chile), farmed Atlantic salmon (mostly from Norway), and farmed trout (from Chile and Norway).

The North American wild salmon industry—including Bristol Bay--has been most affected by changes in the Japanese market for “red-fleshed” salmon. “Red-fleshed” salmon species which compete directly in the Japanese market-place include sockeye salmon, coho salmon, chinook salmon, and trout. During the 1990s, the total supply of red-fleshed salmon expanded dramatically as a result of rapid growth in Japanese imports of farmed coho and farmed trout. During the same time period, the supply of wild sockeye declined dramatically as North American catches (particularly Bristol Bay) declined and a smaller share of North American catches was frozen. As a result, the wild share of the Japanese red-fleshed salmon market declined from 73% in 1993 to just 24% in 2001 (Figure II-5).

Figure II-5

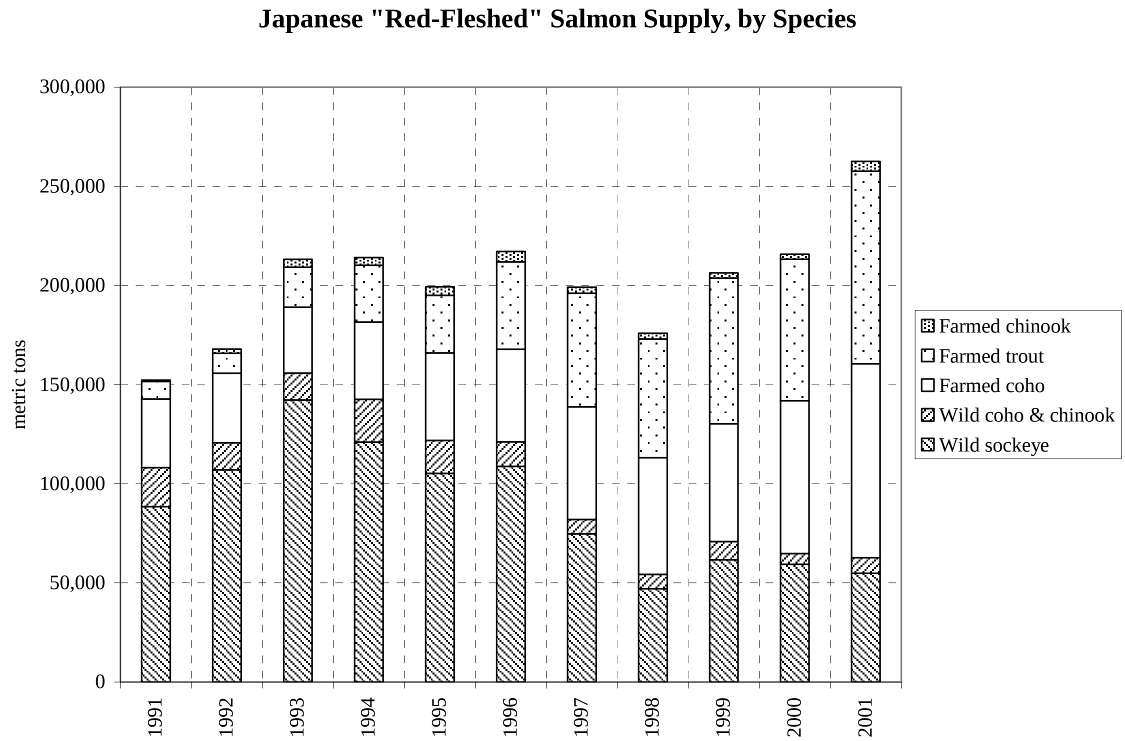


Figure II-6 shows Japanese monthly average wholesale prices for frozen wild sockeye salmon and frozen farmed coho salmon for the twenty-two year period 1981-2003, measured in yen per kilogram. Figure II-7 shows the same prices measured in $/lb, after adjusting for dramatic changes in the yen-dollar exchange rate which occurred over this period.

There are three important points to be noted about Japanese wholesale prices. First, measured in yen, Japanese wholesale prices for frozen salmon have declined dramatically. During the 1980s most of the time prices for frozen sockeye salmon were more than 1200 yen per kilogram. Since 2000, most of the time prices have been below 600 yen per kilogram—only half the level of the 1980s. As we discuss in greater detail in Chapter V, the decline in prices was driven partly by the increase in total salmon supply and partly by other factors including a slowdown in the Japanese economy and changes in the Japanese food distribution system.

Figure II-6

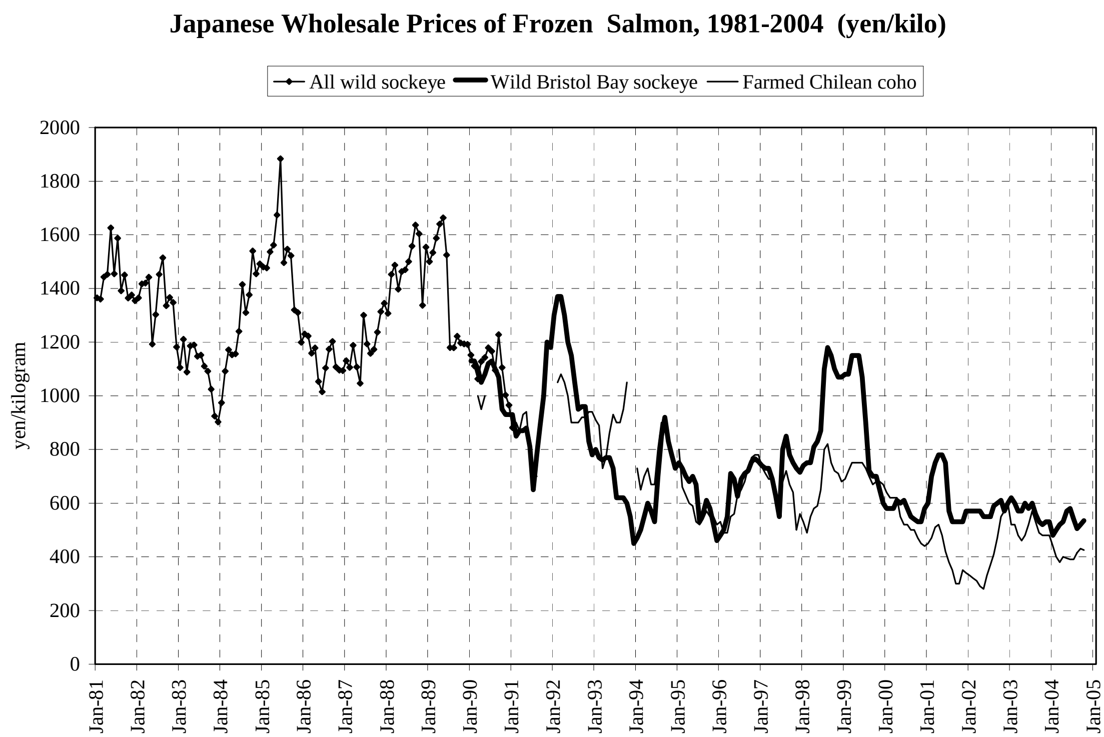
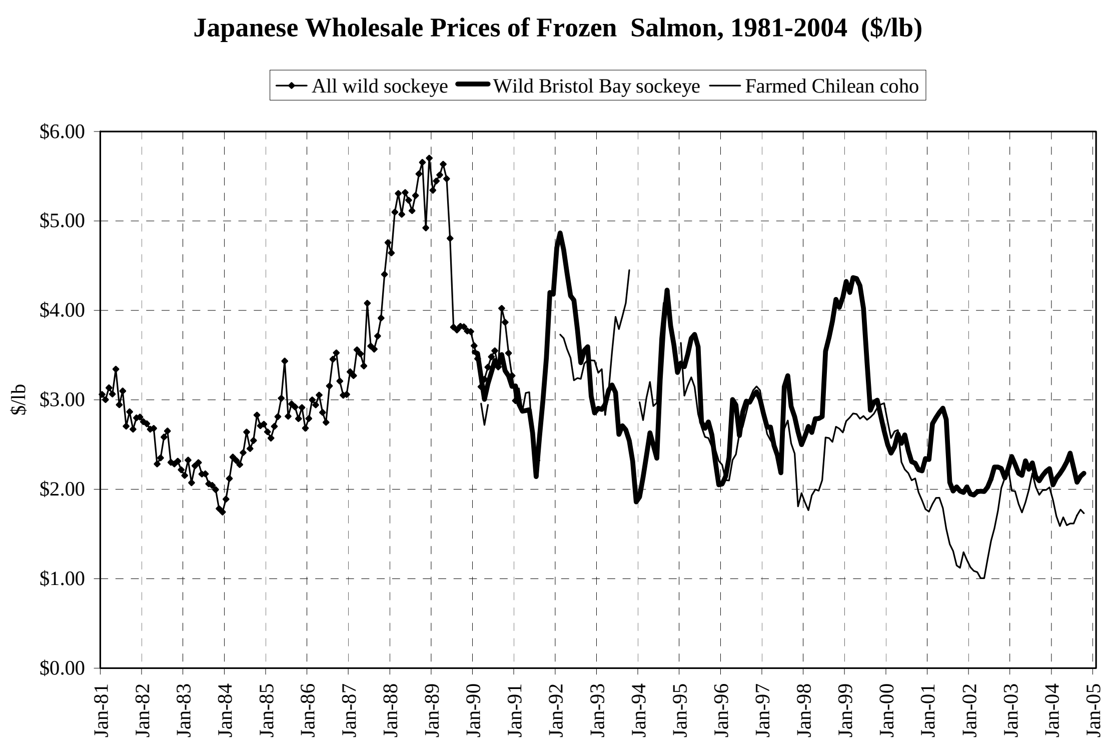


Figure II-7



Second, along with the longer-term trend of declining wholesale salmon prices have been up-and-down price cycles lasting 2-3 years. These price cycles have been driven primarily by periods of lower or higher total salmon supply caused by changes in wild salmon catches and farmed salmon production.

Third, long-term price trends in Japan are different when expressed in yen (Figure II-8) than when expressed in dollars (Figure II-7). This is because the value of the yen relative to the dollar changed substantially over the past two decades. During the mid-1980s the value of the yen relative to the dollar was rising very rapidly. This is the main reason why Japanese wholesale prices expressed in dollars rose dramatically between 1984 and 1988. After 1989 the value of the yen continued to rise, but not as rapidly. As a result wholesale prices expressed in dollars trended downwards, but the relative decline was not as great as for prices expressed in yen.

In contrast to the United States and most countries in Europe, Japan may be considered a mature market for salmon. Per capita consumption is high, salmon is widely available, and consumers are very familiar with salmon. Thus it seems unlikely that total Japanese salmon demand will grow significantly in the future.

The United States Fresh & Frozen Salmon Market

As shown in Figure II-8, United States fresh and frozen salmon consumption grew very rapidly from about 60 thousand tons in 1989 to about 214 thousand tons in 2001.[6] Almost all of this growth in consumption was from imported farmed Atlantic salmon from Canada and Chile. In contrast, United States fresh and frozen market consumption of wild salmon has fluctuated with North American wild salmon catches but has not increased substantially over time.

Most of the wild salmon consumed in the United States (in relative order of importance) is chum, pink, chinook and coho salmon. Despite the publicity associated with Copper River sockeye salmon, a comparison of U.S. export data and Alaska production data suggests that relatively little fresh or frozen sockeye is consumed in the United States. In most years, reported U.S. exports of fresh and frozen sockeye salmon (mostly to Japan) are close to (or even exceed) reported Alaska production.

Growth in farmed salmon consumption has transformed the structure of United States fresh and frozen salmon consumption. Between 1989 and 2001, the share of farmed salmon in total estimated consumption increased from 40% to 82%, while the share of wild salmon in total estimated consumption fell from 60% to only 18%.

Figure II-9 shows trends in United States wholesale prices for three important salmon products: fresh farmed Atlantic fillets, fresh farmed Atlantic whole fish, and frozen wild

[6] The estimates in Figure II-8 were prepared for the same study as discussed above for Figure II-2. They should be considered only approximate. As discussed in the next paragraph, in some years reported U.S. exports of sockeye salmon exceed reported production—which is clearly impossible. This is an example of the fact that not all salmon market data are necessarily completely accurate, and the kinds of difficulties encountered in estimating U.S. consumption.

Figure II-8

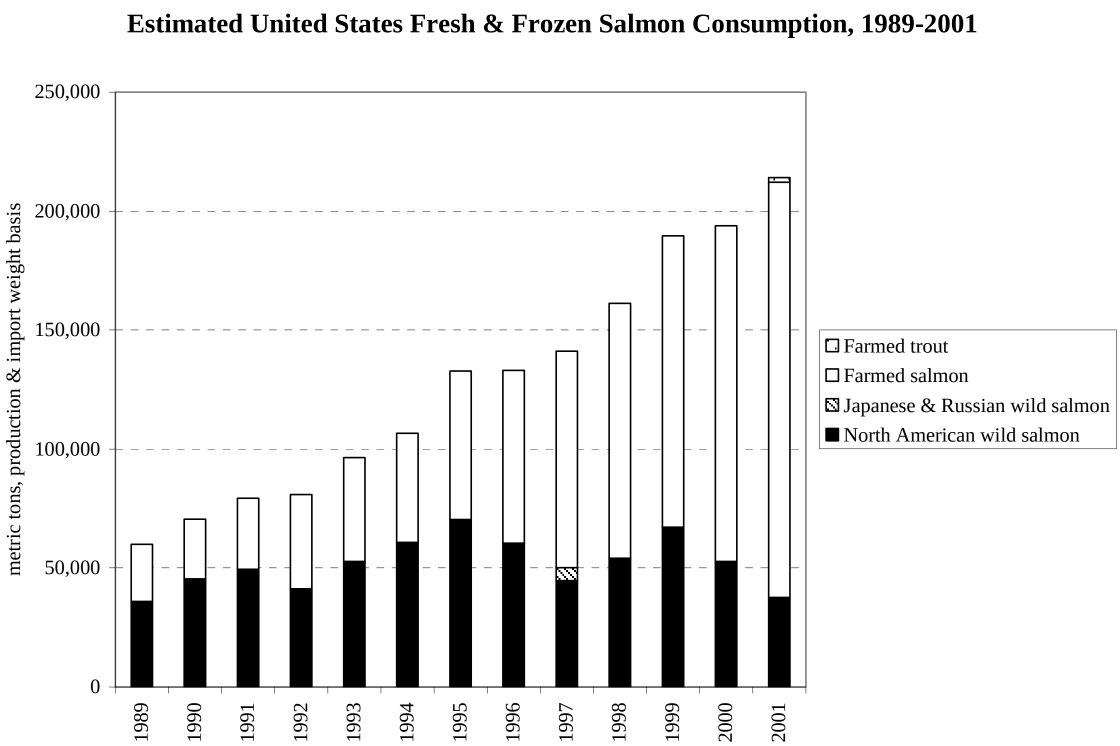
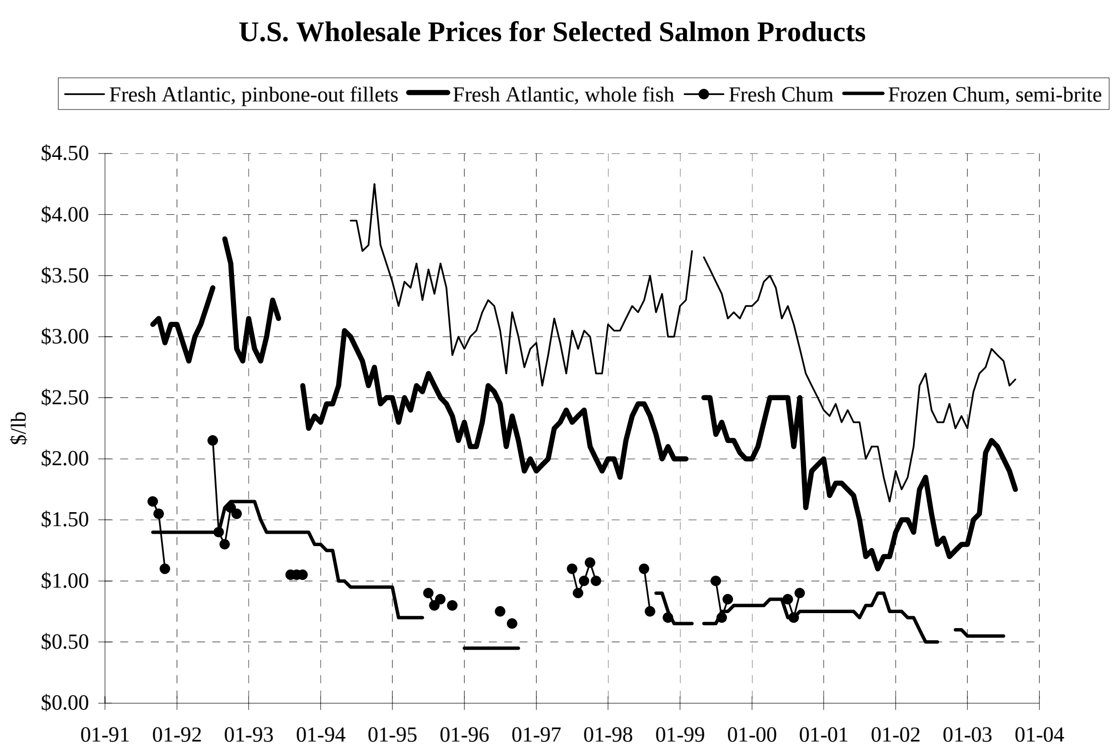


Figure II-9



Source: Urner Barry Publications, Inc., Seafood Price Current. Prices are low list prices for Chilean 2-3 lb fillets, FOB Miami; 6-8 lb Atlantics, FOB Northeast; 6-9 lb H&G Chum, FOB Seattle.

chums.[7] There are three important points to be noted about U.S. price trends. First, within any given year, there is significant variation in prices from month to month. Within any given year, prices of fresh farmed salmon may vary by as much as $.50/lb or more. For example, prices for fresh whole Atlantic salmon typically peak in the summer and decline in the winter. These variations are caused by seasonal variation in demand and availability. Similarly, fresh wild chum salmon prices vary during the season, typically falling as catches increase.

Secondly, different products command different wholesale prices. Wholesale prices for fresh farmed Atlantic salmon fillets are typically about $1.00/lb higher than for fresh whole farmed Atlantic salmon. Fresh whole farmed Atlantic salmon command much higher wholesale prices than frozen wild chum salmon.[8]

Third, prices for all salmon products have declined significantly since the early 1990s. Wholesale prices for all three products shown in Figure II-9 were about $1.00/lb lower in 2003 than they were in the early 1990s. The decline in prices has not been steady or continuous. Prices fell dramatically between 1993 and 1996 and then leveled off for several years. In 2000 and 2001 fell prices for farmed salmon fell dramatically, declining by 50% or more in less than two years. Since late 2001, however, prices have recovered significantly.

The European Fresh & Frozen Salmon Market

European fresh and frozen salmon consumption grew very rapidly from about 100 thousand tons in 1989 to about 450 thousand tons in 2001 (Figure II-10).[9] Almost all of this growth in consumption was of farmed Atlantic salmon. Norway has accounted for about half of total European consumption, while the United Kingdom has accounted for about one-quarter. North American wild salmon accounts for only about 5% of total consumption.

Between 1989 and 2002 United States total annual exports to the European Union ranged between 13 and 21 thousand tons. Most exports were frozen chum, frozen pink and frozen coho salmon (Figure II-11). The most important export markets were France, Germany and Spain.

As European salmon consumption has grown, prices for both farmed and wild salmon declined since the early 1990s (Figures II-12 and II-13). Between 1989 and 2002, average export prices for United States salmon exports to the European Union fell by about $.60/lb for frozen chum salmon, by about $.70 lb for frozen coho salmon, and by about $.30/lb for frozen pink salmon.

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[7] Note that the figure shows wholesale prices for specific sizes and grades in specific regions of the country. Prices trends for other sizes, grades and regions are generally similar but not identical.
[8] No consistent U.S. wholesale price data are available for fresh or frozen sockeye salmon.
[9] The estimates in Figure II-8 were prepared for the same study as discussed above for Figure II-2. They should be considered only approximate.

Figure II-10

Estimated European Union Fresh & Frozen Salmon & Trout Consumption, 1988-2001

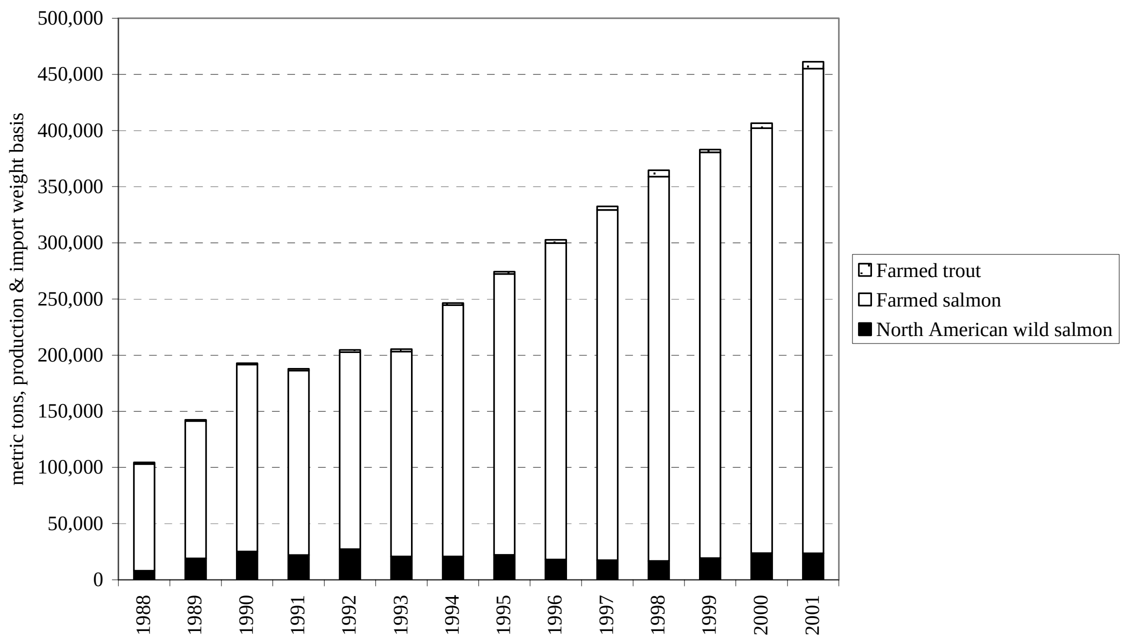


Figure II-11

United States Wild Salmon Exports to the European Union, by Product

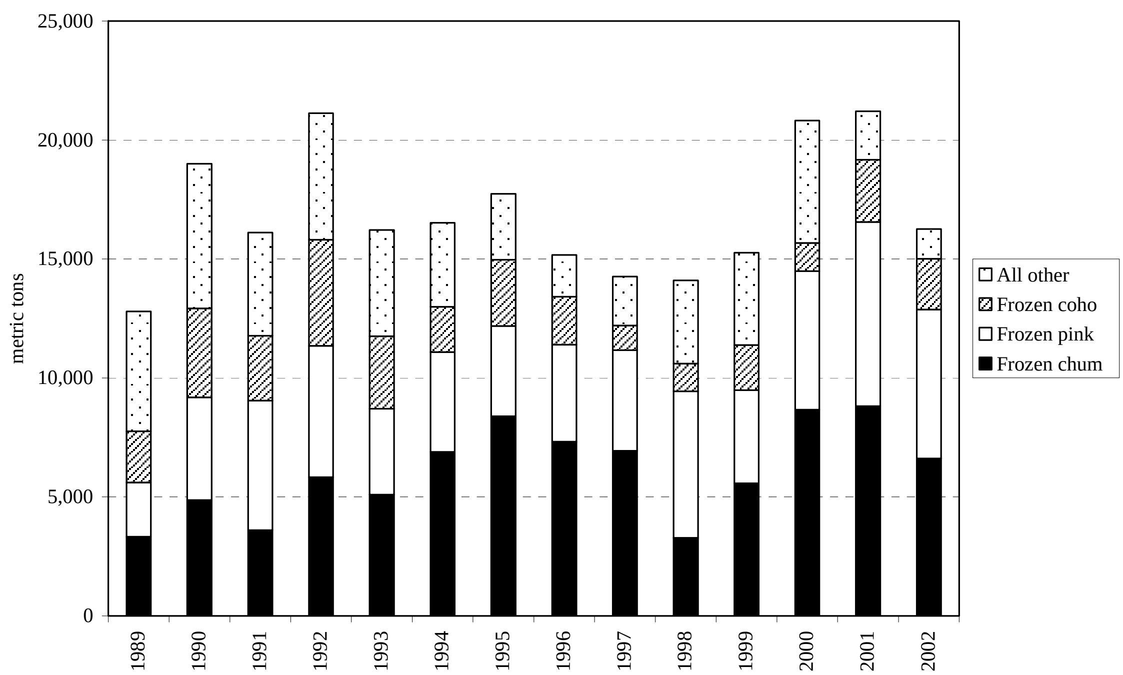


Figure II-12

Wholesale Prices of Fresh Atlantic Salmon at the Paris Rungis Market ($/lb)

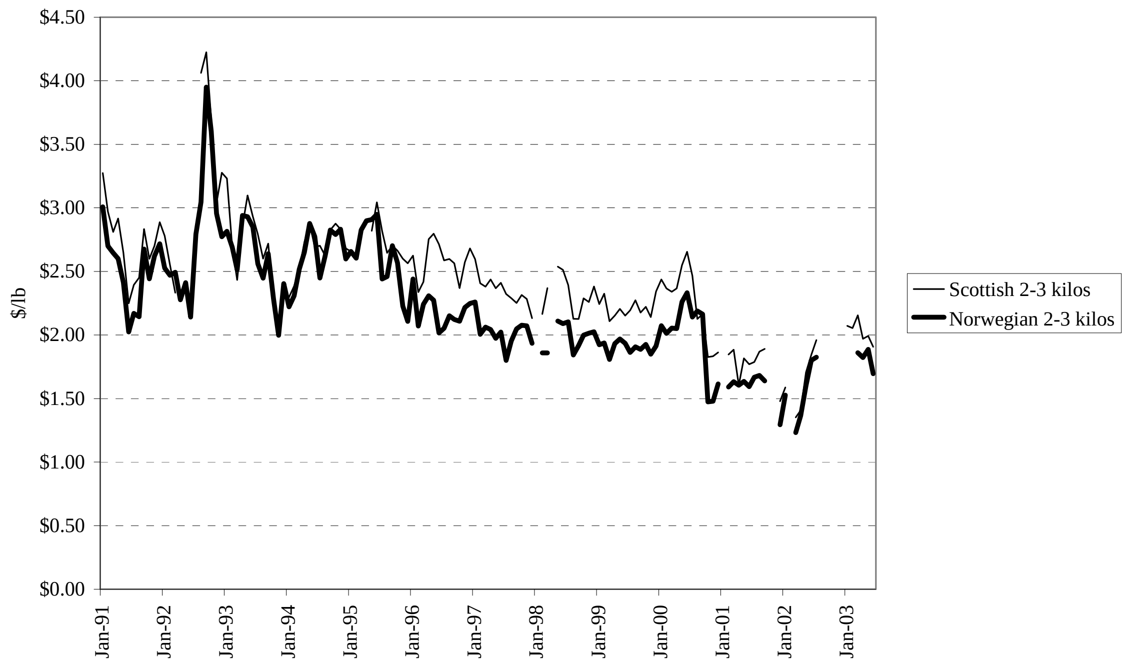
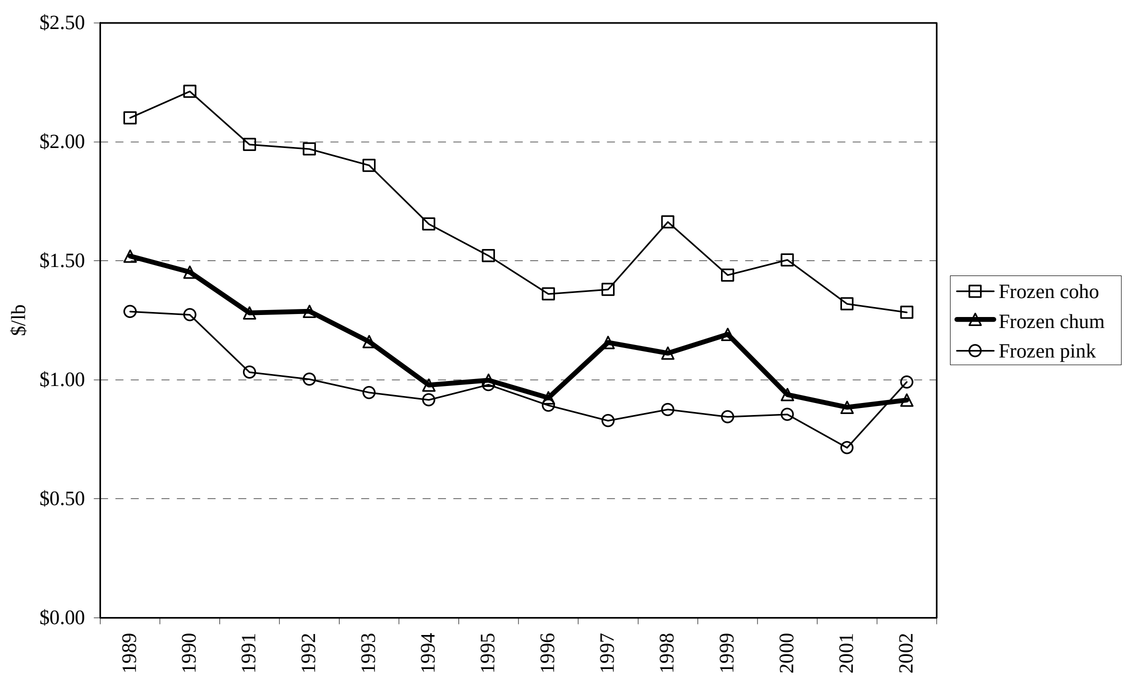


Figure II-13

Average Export Prices of U.S. Salmon Exports to the European Union

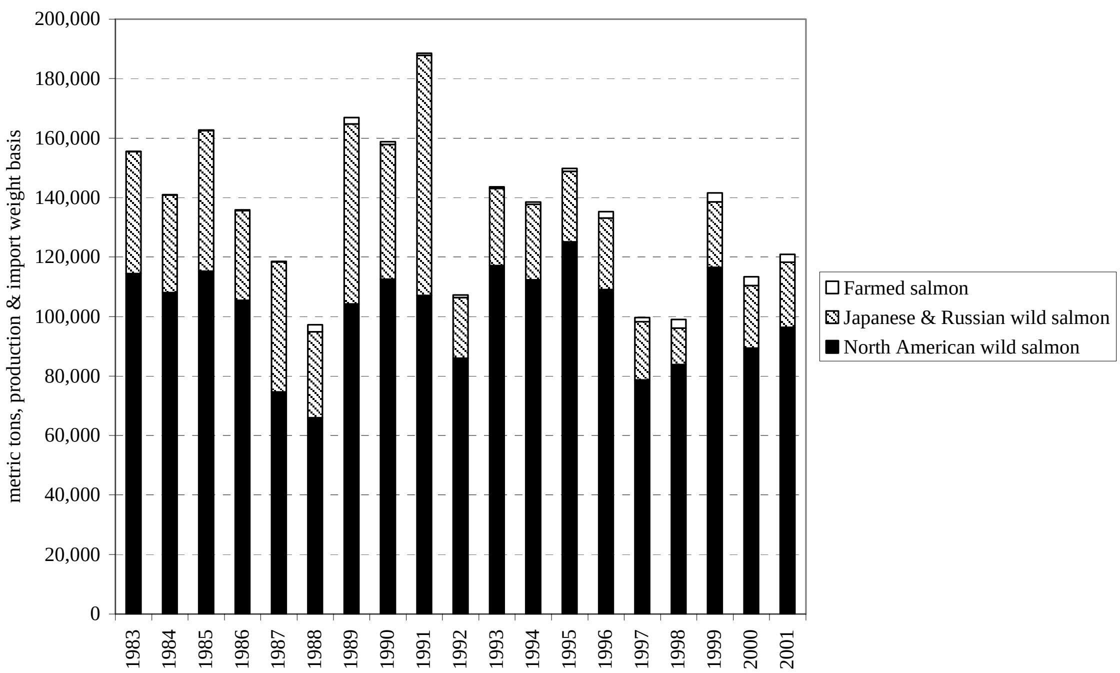


Canned Salmon Markets

For most of the history of the North American salmon industry, canned salmon was by far the most important product. It was only in the 1970s, with the development of freezing technology and the rapid growth in Japanese demand for imported frozen salmon from America, that other products—in particular frozen salmon—became important. Canned salmon remains an important and valuable product form for United States, Canadian and Russian wild salmon fisheries.

Figure II-14

Estimated World Canned Salmon Consumption, 1983-2001



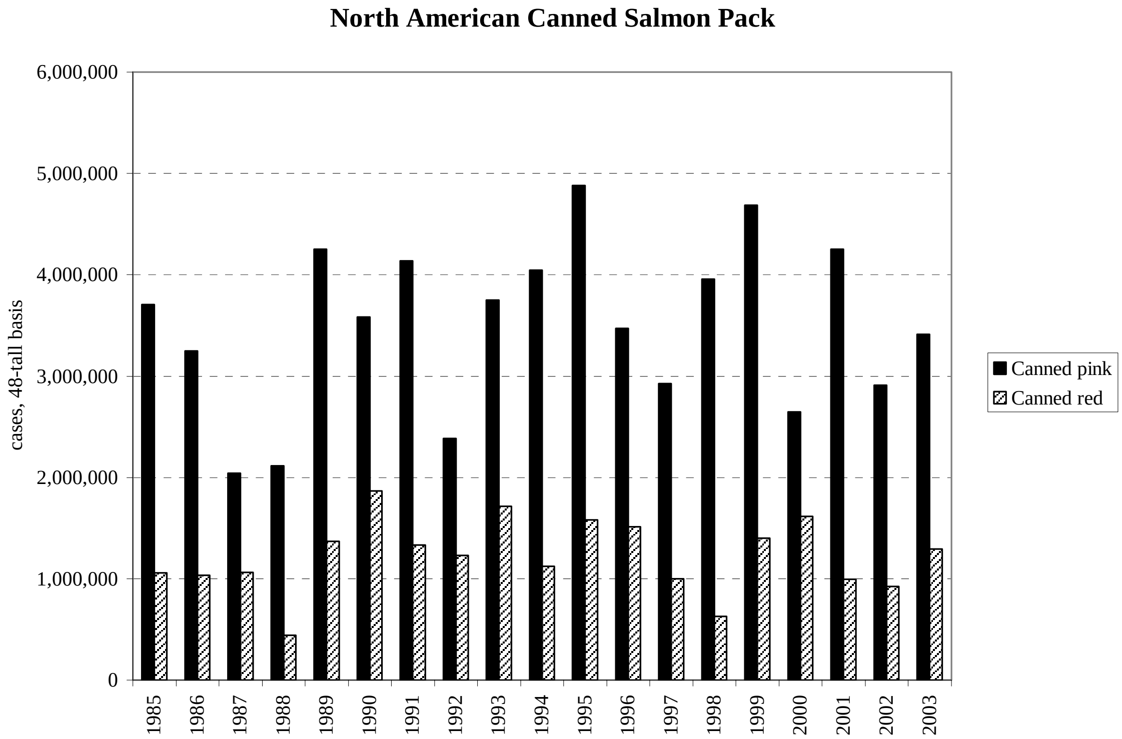
Until very recently, almost all canned salmon production was from wild salmon. The United States is the largest producer of canned salmon, followed by Russia or Canada, depending on the year.[10] Recently, canned farmed salmon production is increasing, as salmon farmers seek new markets as production increases and prices for fresh farmed salmon decrease.

[10]The estimates in Figure II-8 were prepared for the same study as discussed above for Figure II-2. They should be considered only approximate. Estimates of Russian wild canned salmon production are of uncertain reliability. Increasing volumes of Russian salmon are being frozen and shipped to other countries such as Korea and Thailand for canning. It is difficult to trace the scale of this canned production or to quantify its role in world markets. In 2001, U.S. and Canadian salmon accounted for 92% of imports in the United Kingdom, the largest European market for canned salmon, but only 45% of imports in the Netherlands, the second largest European market for canned salmon.

Total world canned salmon production varies widely from year to year. This reflects high annual variation in harvests of wild Pacific salmon, particularly for pink salmon.

Canned pink typically accounts for about three-quarters of North American canned salmon production, while canned sockeye accounts for most of the rest. Higher wild salmon catches led to high canned pink salmon production in the 1980s and 1990s, including several years of record or near-record production (Figure II-15). In recent years, despite a decline in sockeye harvests, canned sockeye salmon production has remained relatively high as the canned share of sockeye production has increased.

Figure II-15



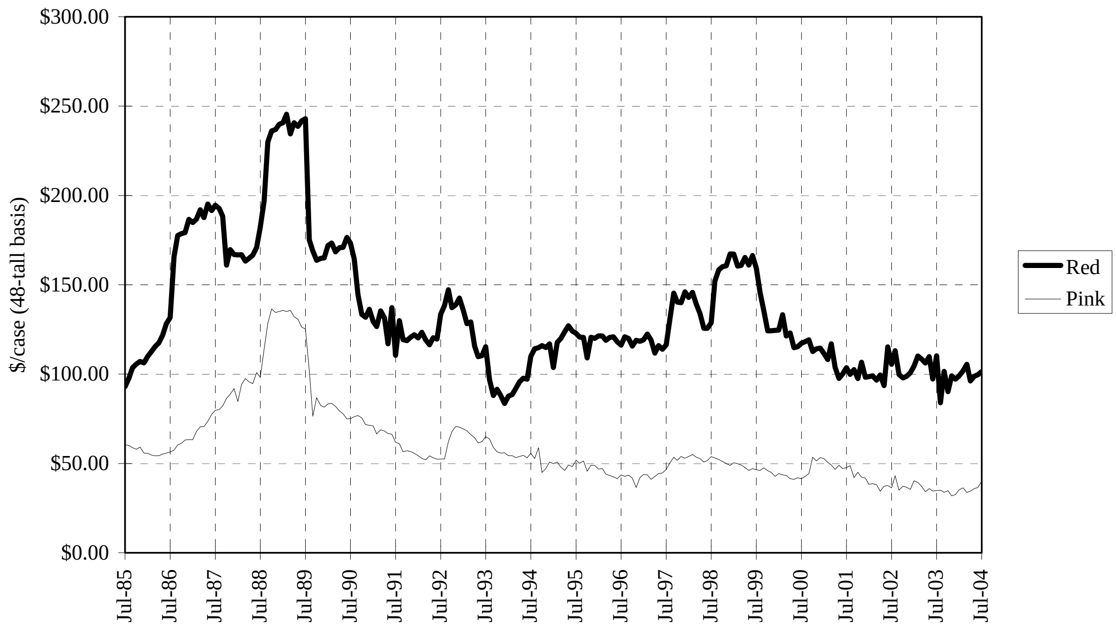
The United States is the most important market for North American canned pink salmon, while Europe (particularly the United Kingdom) is the most important market for canned red salmon.

Canned salmon is processed during the summer harvest season but sold over the course of the entire year. As a result, large inventories of canned salmon are built up during the late summer and early fall, which are then drawn down over the winter and spring. The level of "carryover" inventories at the start of a new harvest season—an indicator of the tightness of supply conditions for canned salmon—is considered a key market indicator by the industry.

Wholesale case prices for Alaska canned salmon peaked in 1987 and 1988, fell sharply between 1989 and 1991, and have since fluctuated while trending downwards (Figure II-16). Wholesale prices for canned red salmon have been more than twice as high as prices for canned pink salmon in recent years.

Figure II-16

Monthly Average Wholesale Prices for Alaska Canned Salmon (48-Tall Cases)



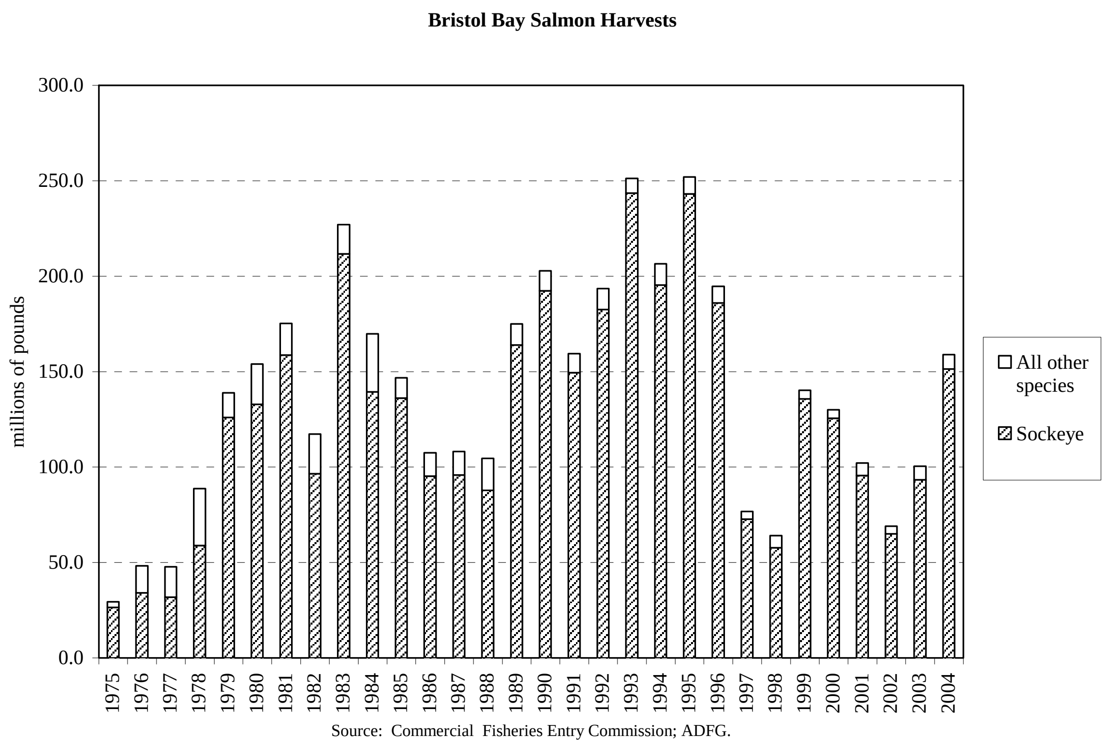
Source: Alaska Department of Revenue salmon price reports. Data prior to August 2000 are statewide average prices; later data are average prices for Bristol Bay sockeye and Southeast Alaska pinks.

III. BRISTOL BAY SALMON HARVESTS AND PRICES

Bristol Bay Salmon Harvests

Figure III-1 shows harvests of Bristol Bay salmon for the years 1975-2004. Bristol Bay salmon harvests are overwhelmingly sockeye salmon. Between 2000 and 2004, species other than sockeye accounted for only 5% of the total Bristol Bay catch volume.

Figure III-1



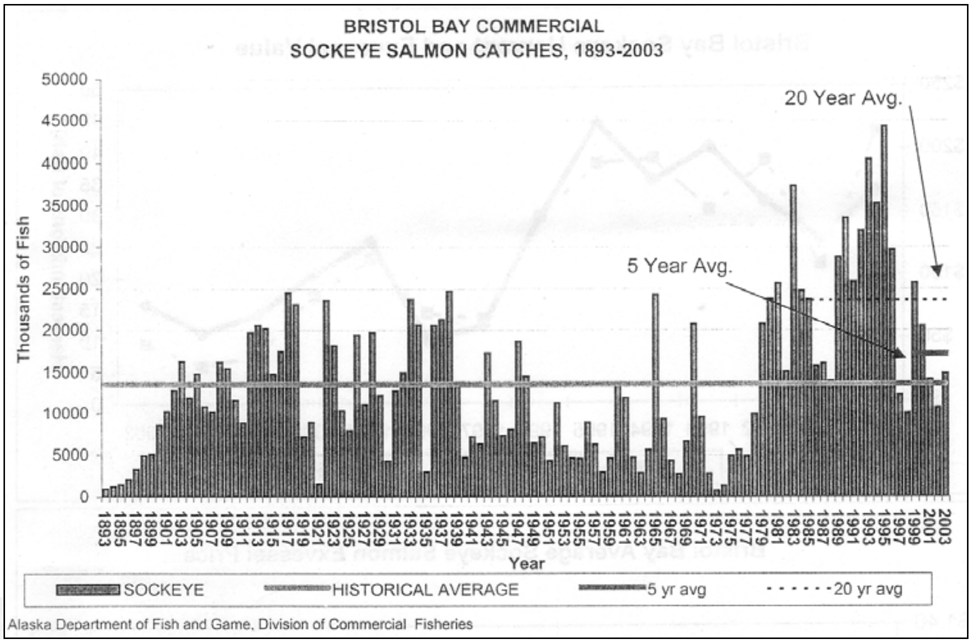
Because the Bristol Bay fishery is almost entirely a sockeye salmon fishery, almost all of this report focuses on sockeye salmon markets and prices. In the last chapter of this report, we discuss catches, markets and prices for other species. In this report, except where otherwise noted, when we refer to "Bristol Bay" catches, production and prices, we are referring specifically to Bristol Bay *sockeye*.

Bristol Bay sockeye salmon catches increased from depressed levels of less than 50 million pounds in the mid-1970s to more than 100 million pounds for most of the 1980s and more than 150 million pounds annually for the years 1989-1996. Sockeye salmon harvests peaked at 243 million pounds in both 1993 and 1995.

Since 1997, sockeye salmon harvests have averaged much lower, with harvests of less than 140 million pounds in every year since 1997 except for 2004, and less than 75 million pounds in 1997, 1998 and 2002.

Figure III-2 shows Bristol Bay sockeye salmon harvests (in thousands of fish) over the much longer historical period from 1893-2003. Harvests have averaged much higher since 1979 than the longer term historical average. This may be attributed partly to better management (including the end of high-seas interceptions of Bristol Bay salmon) and partly to changes in ocean conditions.

Figure III-2



Bristol Bay Sockeye Salmon Ex-Vessel Prices

Figure III-3 shows historical ex-vessel prices for Bristol Bay sockeye salmon. The bottom line shows prices in *nominal* dollars (not adjusted for inflation). The top line shows the same price trends for Bristol Bay sockeye salmon in *real* (2003) dollars (adjusted for inflation).[11]

After peaking in 1986-1988, real ex-vessel prices for Bristol Bay sockeye salmon declined sharply in the early 1990s and again in the late 1990s. Real ex-vessel prices averaged $1.13/lb for 1980-84, $2.10/lb for 1985-89; $1.19 for 1990-94;$1.03 for 1995-99, and $0.54 for 2000-2003. Clearly there has been a dramatic decline in real prices. In subsequent chapters of this report, we explore the reasons for this decline.

[11] All adjustments for inflation in this report are based on the Anchorage Consumer Price Index (CPI-U), which is the only measure of inflation available for Alaska. Data for and information about this index is available at the website of the Alaska Department of Labor and Workforce Development at http://almis.labor.state.ak.us/. Because the 2004 CPI was not available at the time of writing, in places in this report where we discuss 2004 prices, the 2004 CPI was assumed to be the same as in 2003.

Figure III-3

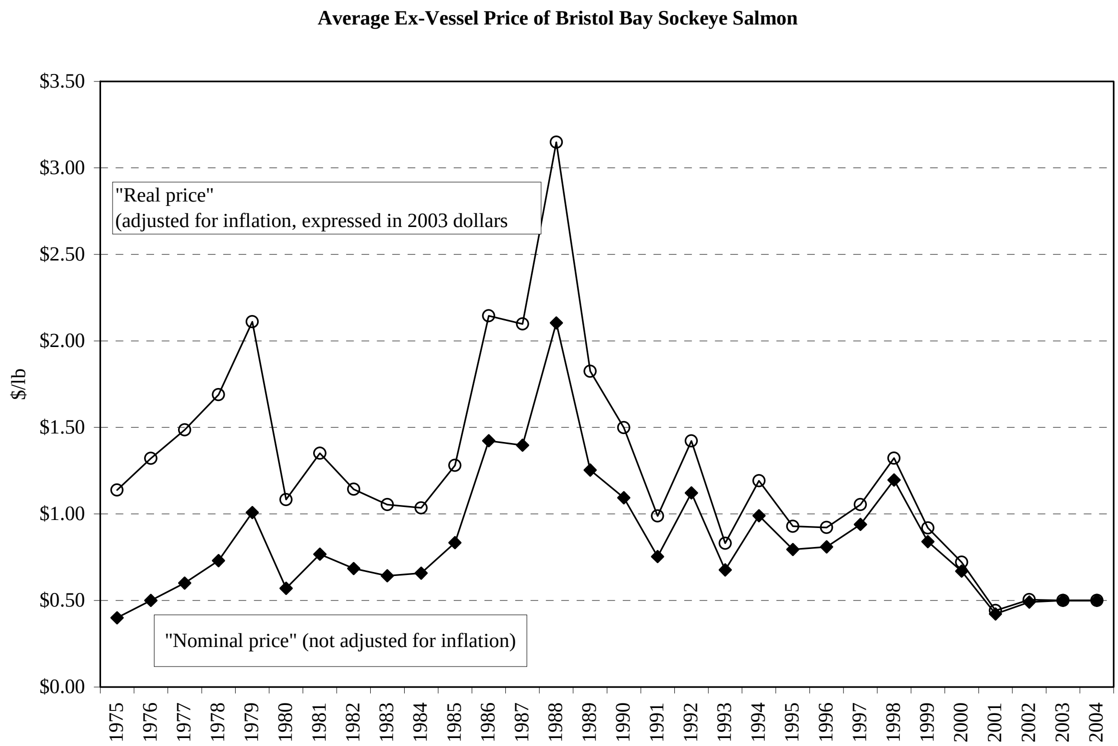
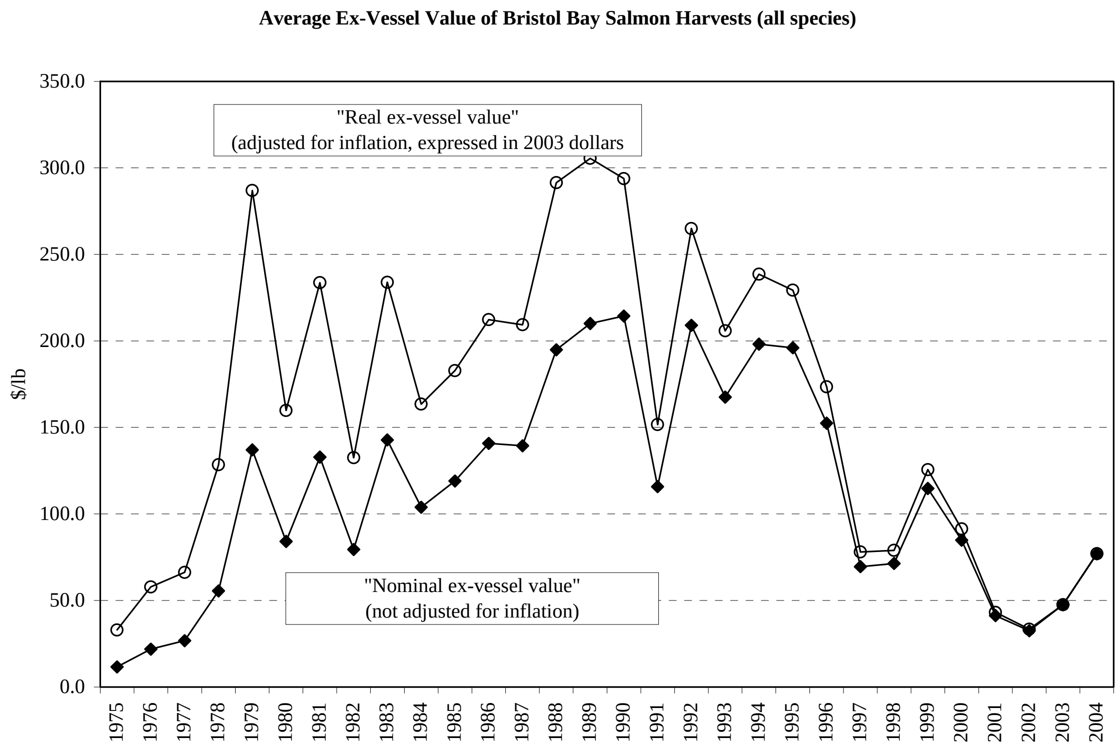


Figure III-4 shows historical ex-vessel values for Bristol Bay salmon harvests (all species). The bottom line shows values in nominal dollars, and the top line shows values in real (2003) dollars.

In twelve of the seventeen years between 1979 and 1995, the real ex-vessel value of the Bristol Bay salmon harvest exceeded $200 million. In contrast, during seven of the eight years between 1977 and 2004, the real ex-vessel value of the Bristol Bay harvest was less than $80 million. This dramatic drop in value was the combined result of a decline in prices *and* a decline in harvests.

Figure III-4


Average Ex-Vessel Value of Bristol Bay Salmon Harvests (all species)
"Real ex-vessel value"
(adjusted for inflation, expressed in 2003 dollars
"Nominal ex-vessel value"
(not adjusted for inflation)
$/lb
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
1975
1976
1977
1978
1979
1980
1981
1982
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2004

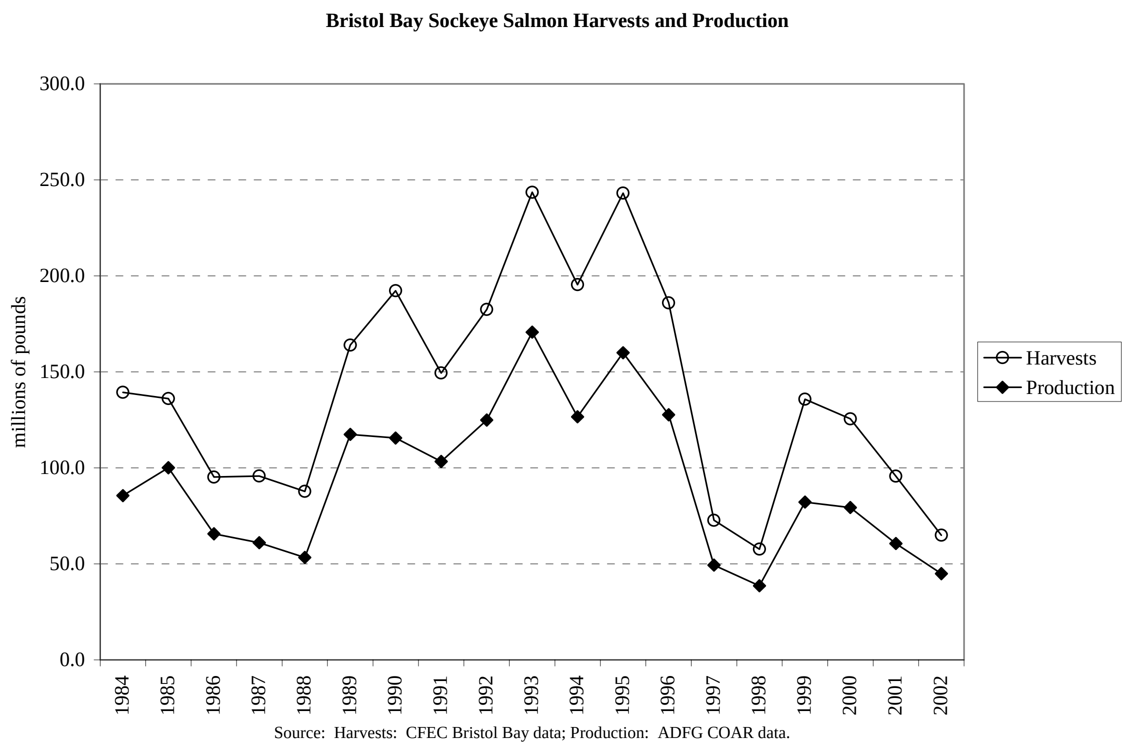
IV. BRISTOL BAY SALMON PRODUCTS AND MARKETS

Bristol Bay Salmon Production

We use the term "production" to refer to the volume of products produced from Bristol Bay salmon, measured in product weight. The best available source of information on Bristol Bay production is data from the "Commercial Operator Annual Reports" submitted by Alaska seafood processors every year in April to the Alaska Department of Fish and Game (ADFG). The "COAR" data from these reports are not published, but are kept in a database by ADFG and are available upon request, in aggregated format so that the production of individual operators remains confidential. A limitation of the COAR data is that they do not include production from Bristol Bay salmon tendered outside the Bristol Bay region for processing.

Figure IV-1 compares total Bristol Bay harvests and production as reported in the COAR database for the years 1984-2002.[12] Production is lower than harvests, primarily because part of the weight is lost in processing as fish are headed and gutted, and also because some fish are shipped outside the Bristol Bay region for processing.

Figure IV-1

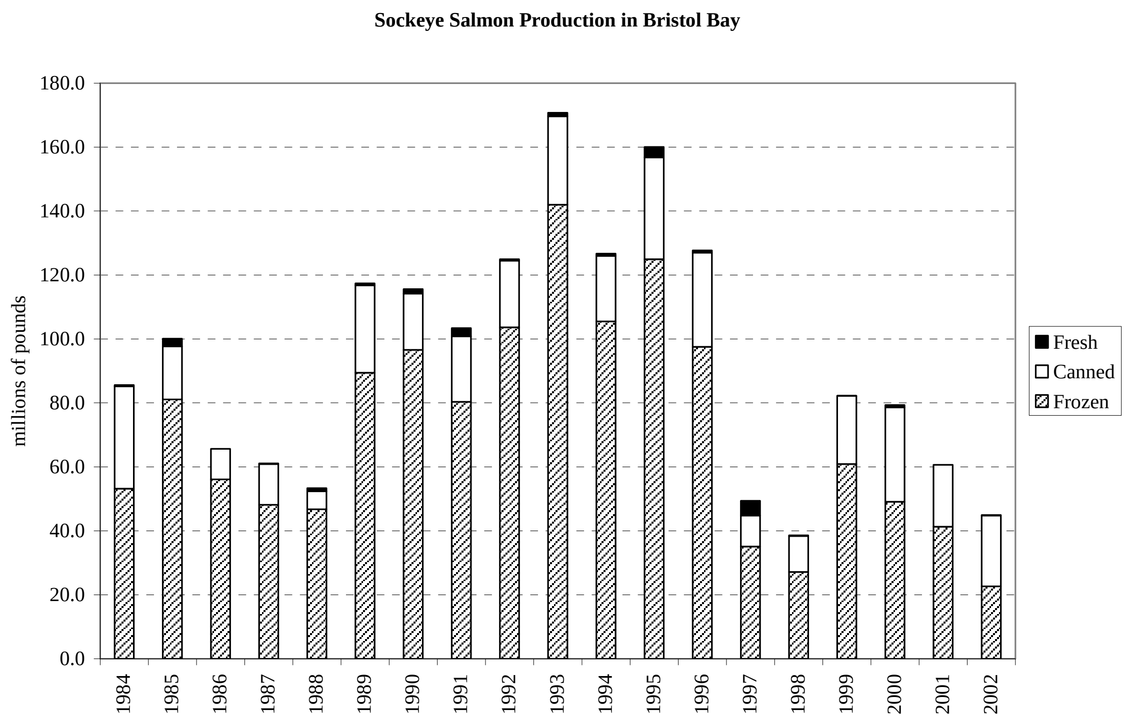


[12]COAR production data for 2003 and 2004 were not available at the time this report was written. Processors submit annual production reports every April for the preceding calendar year, and it usually takes several months for ADFG to enter the data in the COAR database.

The ratio of production weight to harvest weight changes somewhat from year to year, partly because of changes in the mix of products (yields differ for different products), partly because of year-to-year differences in yields because of factors such as changes in average fish size, and partly because the share of catch volume shipped outside the region for processing varies from year to year.

The major products produced from Bristol Bay sockeye salmon are frozen salmon, canned salmon, and fresh salmon. Figure IV-2 shows production of these three product forms for the years 1984-2002.[13] Frozen and canned salmon account for most of the production. In most years, fresh production is very small.[14, 15]

Figure IV-2



Source: Commercial Operator Annual Report data. Does not include production from fish tendered out of Bristol Bay.

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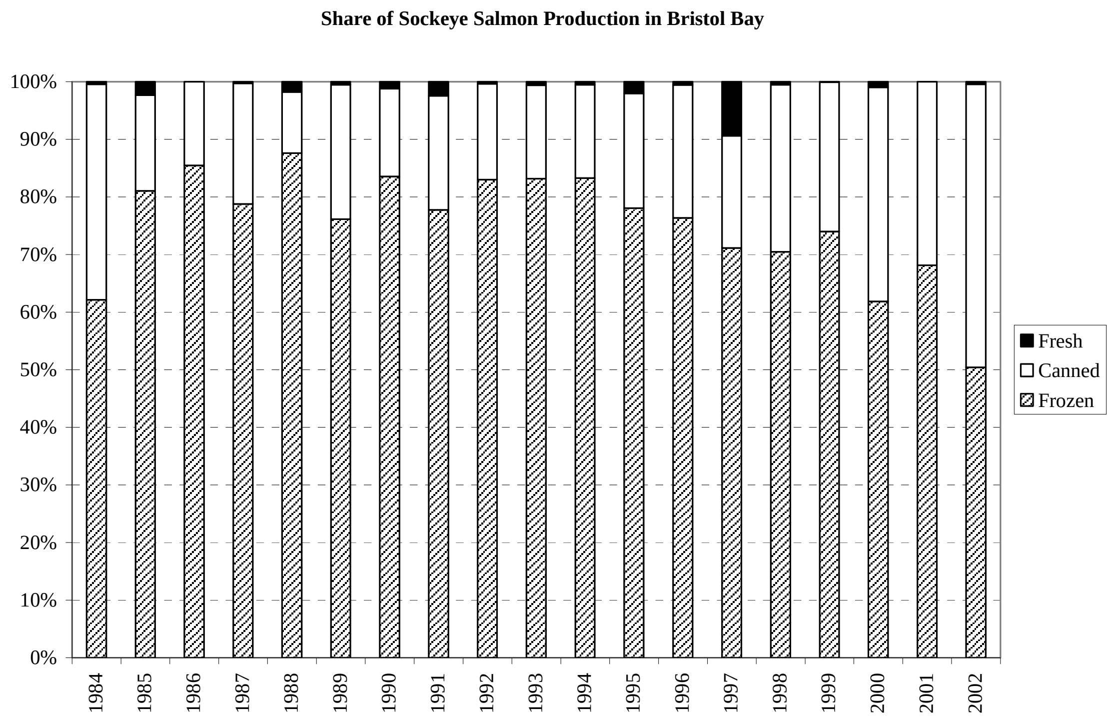
[13] Figure IV-2 excludes roe production from Bristol Bay sockeye salmon. We discuss roe production and markets separately in Chapter VII.
[14] Flying fresh salmon to markets in the Lower 48 is more expensive than from other regions such as Southeast, Prince William Sound, and Cook Inlet, making it relatively more difficult for Bristol Bay salmon to compete with these other areas in the U.S. fresh salmon market.
[15] The COAR data provided by ADFG for this project did not include other products such as pickled salmon and smoked salmon; however these represent only a very small share of statewide production and presumably also a very small share of Bristol Bay production.

Figure IV-3 shows the relative share of each major product in Bristol Bay production. Since the mid-1990s, the frozen share of Bristol Bay production has trended downwards while the canned share has increased. Frozen salmon accounted for more than 80% of total production for much of the 1980s and early 1990s. By 2002, the frozen share declined to only 50%.

Figure IV-3

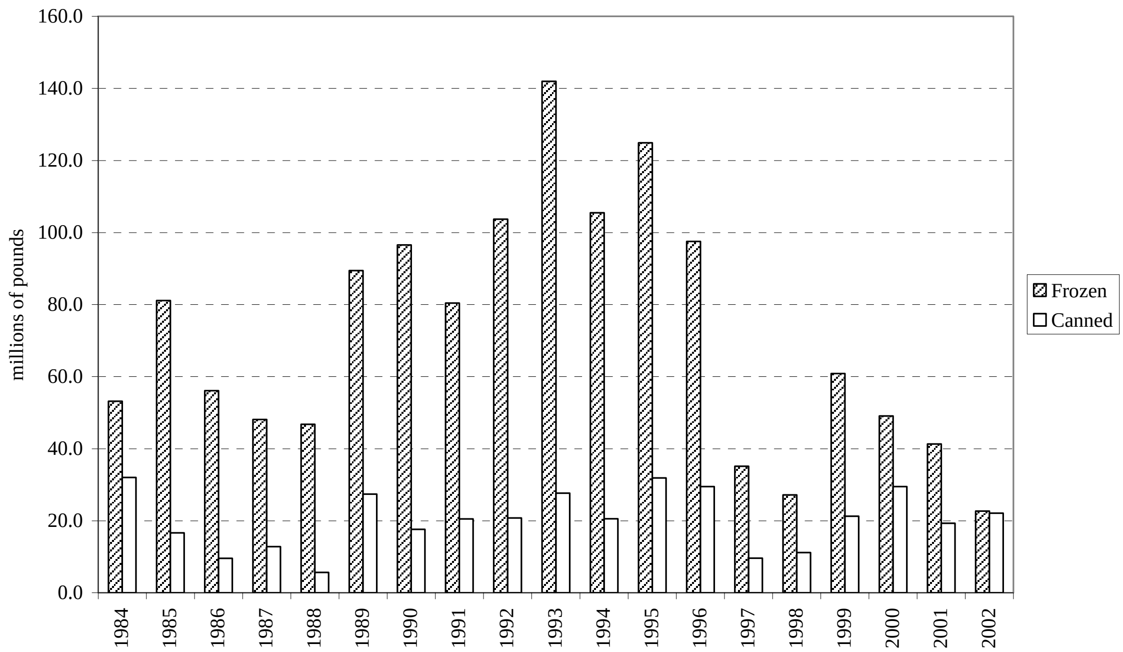


Source: Commercial Operator Annual Report data. Excludes production from fish tendered out of Bristol Bay.

The combined effect of lower harvests and a lower frozen share of production has been a dramatic decline in Bristol Bay production of frozen salmon since the early 1990s, from a peak of more than 140 million pounds in 1993 to just over 20 million pounds in 2002 (Figure IV-4). In contrast, canned salmon production does not show a similar downward trend (although production varies widely from year to year), because the effect of the decline in catches has been offset by the increase in the canned share of production.

Figure IV-4

Frozen and Canned Sockeye Salmon Production in Bristol Bay



Source: Commercial Operator Annual Report data. Excludes production from fish tendered out of Bristol Bay.

United States Sockeye Salmon Exports

No data are publicly available to track United States exports of Bristol Bay sockeye salmon specifically.[16] However, because Bristol Bay accounts for more than half of total U.S. sockeye salmon harvests in most years (Table IV-1) it is reasonable to assume that exports of Bristol Bay salmon go to the same countries as total U.S. exports. This is particularly likely to be the case given the fact that U.S. exports of sockeye salmon are highly concentrated among a few countries.

Tables IV-2 shows United States exports of sockeye salmon by product and country for the years 1989-2003.[17] Table IV-3 shows the shares of canned, frozen and fresh salmon

[16] United States export data do not distinguish between salmon products by the region where salmon were caught. Although export data are available by port, the ports from which salmon products are exported do not necessarily correspond to the region where the fish were caught or processed.
[17] Export data for years prior to 1989 are not easily available because they are not on the NMFS foreign trade information website.

Table IV-1

United States Sockeye Salmon Harvests, 1989-2002 (thousand metric tons)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Bristol Bay	74.4	87.2	67.8	82.8	110.5	88.7	110.3	84.3	33.0	26.2	61.6	57.0	43.4	29.5	42.4
Other Alaska	43.7	51.3	48.0	72.2	60.8	43.5	48.3	58.0	52.5	31.9	50.7	36.7	33.6	32.4	43.7
Lower 48	5.6	5.6	4.4	1.6	6.3	4.8	1.0	0.9	3.1	1.5	0.1	1.5	0.7	1.4	
Total US	123.6	144.1	120.3	156.6	177.6	137.0	159.6	143.2	88.7	59.5	112.3	95.2	77.7	63.3	86.1
Bristol Bay %	60%	61%	56%	53%	62%	65%	69%	59%	37%	44%	55%	60%	56%	47%	

Sources: Bristol Bay: CFEC Bristol Bay data; Other Alaska: Estimated by subtracting Bristol Bay from ADFG catch data; Lower 48: NMFS catch data.

Table IV-2

United States Sockeye Salmon Exports, 1989-2003 (metric tons)

Product	Country	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Canned	**Total**	**6,810**	**10,481**	**12,258**	**16,603**	**20,120**	**18,969**	**22,477**	**18,273**	**14,399**	**14,503**	**25,770**	**15,721**	**19,139**	**21,354**	**20,077**
	United Kingdom	3,608	7,725	9,407	12,758	13,451	11,738	12,879	9,617	8,302	9,513	18,892	10,038	12,181	12,450	10,079
	Canada	1,875	769	1,005	1,083	3,373	2,934	5,572	4,351	2,401	2,242	2,651	3,818	4,378	5,935	7,252
	Australia	891	771	963	1,078	1,201	1,799	1,360	2,751	2,115	948	1,309	585	945	1,261	1,761
	Netherlands	315	1,116	735	1,193	1,534	2,024	1,900	1,065	1,371	1,316	1,261	573	868	1,222	782
	Other	121	100	147	491	562	474	766	490	210	485	1,657	708	767	487	203
Frozen	**Total**	**82,584**	**88,258**	**72,797**	**88,987**	**103,795**	**79,026**	**84,047**	**70,190**	**45,575**	**23,561**	**37,631**	**32,911**	**30,448**	**20,270**	**23,593**
	Japan	80,983	86,519	70,779	87,400	102,153	77,062	80,011	66,662	43,481	21,188	32,331	27,430	26,587	18,719	21,185
	Canada	1,344	738	1,128	571	763	341	2,033	1,804	1,228	574	2,315	2,504	610	335	1,092
	China				116	272	308	1,160	292	207	721	806	1,111	332	148	185
	Thailand		1	70		13	4					68	574	2,060	748	246
	Other	257	1,000	820	900	594	1,311	843	1,431	659	1,078	2,112	1,292	860	321	885
Fresh	**Total**	**4,790**	**4,126**	**1,662**	**3,165**	**3,449**	**2,181**	**2,652**	**5,507**	**3,420**	**3,277**	**5,002**	**3,098**	**1,290**	**5,423**	**6,282**
	Canada	2,307	1,433	614	682	2,768	1,519	2,328	2,343	588	805	2,790	2,931	1,015	1,643	2,391
	Japan	1,846	1,499	655	2,433	435	533	253	3,103	2,609	2,365	2,106	55	247	3,048	3,547
	Other	637	1,194	393	49	246	129	72	62	223	107	105	113	28	732	344
Total		**94,184**	**102,864**	**86,717**	**108,755**	**127,364**	**100,175**	**109,177**	**93,970**	**63,394**	**41,341**	**68,402**	**51,730**	**50,877**	**47,047**	**49,952**

Source: NMFS Trade data, from NMFS "Foreign Trade Information" website: www.st.nmfs.gov/st1/trade/index.html.

Table IV-3

Share of United States Sockeye Salmon Exports, by Product & Country, 1989-2003

Product	Country	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Canned	**Total**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
	United Kingdom	53%	74%	77%	77%	67%	62%	57%	53%	58%	66%	73%	64%	64%	58%	50%
	Canada	28%	7%	8%	7%	17%	15%	25%	24%	17%	15%	10%	24%	23%	28%	36%
	Australia	13%	7%	8%	6%	6%	9%	6%	15%	15%	7%	5%	4%	5%	6%	9%
	Netherlands	5%	11%	6%	7%	8%	11%	8%	6%	10%	9%	5%	4%	5%	6%	4%
	Other	2%	1%	1%	3%	3%	2%	3%	3%	1%	3%	6%	5%	4%	2%	1%
Frozen	**Total**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
	Japan	98%	98%	97%	98%	98%	98%	95%	95%	95%	90%	86%	83%	87%	92%	90%
	Canada	2%	1%	2%	1%	1%	0%	2%	3%	3%	2%	6%	8%	2%	2%	5%
	China	0%	0%	0%	0%	0%	0%	1%	0%	0%	3%	2%	3%	1%	1%	1%
	Thailand	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	7%	4%	1%
	Other	0%	1%	1%	1%	1%	2%	1%	2%	1%	5%	6%	4%	3%	2%	4%
Fresh	**Total**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
	Canada	48%	35%	37%	22%	80%	70%	88%	43%	17%	25%	56%	95%	79%	30%	38%
	Japan	39%	36%	39%	77%	13%	24%	10%	56%	76%	72%	42%	2%	19%	56%	56%
	Other	13%	29%	24%	2%	7%	6%	3%	1%	7%	3%	2%	4%	2%	13%	5%

exported to major end-market countries. Most sockeye salmon exports go to Japan, Canada or the United Kingdom.

The United Kingdom is the most important export market for canned sockeye salmon, typically accounting for more than half of all exports. Canada is the second most important market. In recent years, countries other than the United Kingdom and Canada have accounted for only about 15% of total canned salmon exports.

Japan is by far the most important export market for frozen sockeye salmon. In all but two of the years between 1989 and 2003, Japan accounted for more than 90% of U.S. frozen sockeye salmon exports. Canada is a distant second, accounting for a maximum of 8% of U.S. frozen sockeye salmon exports. Exports countries other than Japan or Canada accounted for only about 1% of frozen salmon exports during the early 1990s, but have risen to between 6% and 11% of frozen salmon exports since 2000. Of these other countries, China and Thailand are the most important. It is likely that some of the frozen sockeye salmon exported to China and Thailand is reprocessed for sale to other end-markets (including Japan).

U.S. exports of fresh sockeye salmon are much smaller than exports of canned or frozen sockeye salmon. Canada and Japan are the most important export markets for fresh sockeye salmon. It is likely that part of the fresh sockeye salmon exported to Canada is salmon tendered to Canadian plants for processing. Probably relatively little of the U.S. sockeye salmon processed in Canada is from Bristol Bay.

Estimated Domestic Consumption of United States Sockeye Salmon

No data are publicly available to track domestic consumption of Bristol Bay sockeye salmon or U.S. sockeye salmon. Table IV-4 provides rough estimates of the volume of U.S. sockeye salmon consumed domestically or added to net inventories. To develop these estimates, we first estimated total U.S. production of canned, frozen and fresh sockeye salmon, by multiplying Alaska production by the ratio of total U.S. harvests to Alaska harvests.[18] We then subtracted U.S. exports of these products to estimate the volume which was either consumed or added to net inventories.[19]

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[18] We did this because no data are available for Lower 48 production. For these estimates, we assumed that the shares of canned, frozen and fresh production were the same for Lower 48 sockeye salmon as for Alaska. In fact, it is likely that the share of fresh production is significantly higher for Lower 48 sockeye harvests than for Alaska (and the shares of canned and frozen production corresponding lower) but we had no data with which to estimate how much higher it might be. Thus our estimates of total U.S. production probably slightly understate fresh production and slightly overstate canned and frozen production. But because Lower 48 harvests are relatively small compared to Alaska harvests, this should not greatly affect the estimates of the relative shares of different end-markets for U.S. sockeye salmon.

[19] Net inventory accumulation may be either positive or negative. In years when large volumes are withdrawn from inventories, exports may exceed estimated production.

Table IV-4

Estimation of U.S. Domestic Consumption and Net Inventory Accumulation of U.S. Sockeye Salmon (thousand metric tons)

		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Harvests	Alaska	118.1	138.5	115.8	155.0	171.3	132.1	158.6	142.3	85.5	58.0	112.2	93.7	77.0	61.9
	Lower	5.6	5.6	4.4	1.6	6.3	4.8	1.0	0.9	3.1	1.5	0.1	1.5	0.7	1.4
	Total US	123.6	144.1	120.3	156.6	177.6	137.0	159.6	143.2	88.7	59.5	112.3	95.2	77.7	63.3
	Ratio, US/AK	1.047	1.041	1.038	1.010	1.037	1.036	1.007	1.006	1.037	1.025	1.000	1.016	1.009	1.022
Alaska production	Canned	16.9	16.1	18.3	18.9	22.0	13.7	23.2	22.6	10.9	10.3	24.3	25.0	15.2	15.4
	Frozen	74.4	74.2	65.0	93.4	103.9	79.1	85.9	77.2	46.3	27.4	50.0	36.7	35.3	26.6
	Fresh	0.6	1.3	3.2	1.6	3.0	2.9	3.2	2.6	5.2	2.4	2.8	4.1	2.5	3.2
Estimated U.S. production*	Canned	17.7	16.7	19.0	19.1	22.8	14.2	23.4	22.7	11.3	10.6	24.3	25.4	15.4	15.7
	Frozen	77.9	77.2	67.5	94.4	107.7	81.9	86.4	77.7	48.0	28.1	50.0	37.3	35.6	27.2
	Fresh	0.7	1.3	3.3	1.6	3.1	3.0	3.2	2.6	5.4	2.5	2.8	4.2	2.5	3.2
U.S. Exports	Canned	6.8	10.5	12.3	16.6	20.1	19.0	22.5	18.3	14.4	14.5	25.8	15.7	19.1	21.4
	Frozen	82.6	88.3	72.8	89.0	103.8	79.0	84.0	70.2	45.6	23.6	37.6	32.9	30.4	20.3
	Fresh	4.8	4.1	1.7	3.2	3.4	2.2	2.7	5.5	3.4	3.3	5.0	3.1	1.3	5.4
Est. U.S. Consumption and Net Inventory Accumulation**	Canned	10.9	6.2	6.8	2.5	2.7	-4.7	0.9	4.5	-3.1	-3.9	-1.4	9.7	-3.8	-5.6
	Frozen	-4.7	-11.1	-5.3	5.4	3.9	2.9	2.4	7.5	2.4	4.5	12.4	4.4	5.1	6.9
	Fresh	-4.1	-2.8	1.6	-1.6	-0.4	0.8	0.5	-2.9	2.0	-0.8	-2.2	1.1	1.2	-2.2

Sources: Alaska harvests: ADFG catch data; Lower 48 harvests: NMFS catch data; Alaska production: ADFG COAR data; U.S. Exports: NMFS trade data.

*Calculated by multiplying Alaska production by the ratio of US to Alaska harvests.

**Calculated by subtracting U.S. exports from estimated U.S. production. Negative numbers may result from (a) inventory reductions in excess of domestic consumption, and (b) data errors and inconsistencies.

For all three product forms, the residual volume after subtracting exports from estimated total production is low, and in some years is negative. These estimates should not be viewed as precise estimates of domestic consumption, because of the potential for data errors, and also the difficulty of distinguishing between domestic consumption and net inventory accumulation. Note that if the COAR data are incomplete—if not all Alaska production is reported—then U.S. consumption and inventory accumulation would be underestimated by these estimates. The fact that estimates are negative in some years for fresh salmon suggests that at least some data errors are present, because inventory accumulation does not occur for fresh salmon.

The important point to note is that for all product forms, reported U.S. export volumes are as large as (and in some years larger than) estimated U.S. production. This suggests that most Alaska sockeye salmon of all three product forms has been exported (at least through 2002, the most recent year for which COAR production data are available). This in turn suggests that most Bristol Bay sockeye salmon--canned and frozen—has also been exported.

Estimated End-Markets for United States Sockeye Salmon

Table IV-6 (on the following page) presents estimates of end-markets for U.S. sockeye salmon, by product form, derived by combining the data presented earlier for exports and domestic consumption and inventory accumulation. Table VI-5 (below) summarizes the estimated shares of production volume going to major end-markets for three periods: 1989-94, 1995-1999, and 2000-2002.

Table VI-5
Estimated End-Markets for United States Sockeye Salmon

Market	1989-94	1995-99	2000-02
UK canned market	9.3%	14.8%	20.8%
Other canned markets	8.1%	8.3%	13.1%
Japanese frozen market	80.3%	61.0%	43.7%
Other frozen markets	0.3%	11.7%	16.4%
Fresh markets	2.1%	4.2%	5.9%
Total	100.0%	100.0%	100.0%

Note: Percentages are shares of estimated total production for the period.

As noted above, these estimates should be considered only approximate. However, we may draw some general conclusions about end-markets for U.S. sockeye salmon, which likely also apply to Bristol Bay sockeye salmon:

- The most important market for U.S. sockeye salmon is the Japanese frozen market. During the period 1989-1994, about 80% of U.S. sockeye production went to the Japanese frozen market. However, this share has fallen dramatically as the frozen share of production has declined and the share of frozen production going to other markets (mostly domestic) has increased. Between 2000 and 2002, only about 44% of U.S. sockeye salmon production went to the Japanese frozen market.

Table IV-5

Estimated End-Markets for United States Sockeye Salmon (thousands of metric tons)

Product		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Canned	United Kingdom	3.6	7.7	9.4	12.8	13.5	11.7	12.9	9.6	8.3	9.5	18.9	10.0	12.2	12.4
	Canada	1.9	0.8	1.0	1.1	3.4	2.9	5.6	4.4	2.4	2.2	2.7	3.8	4.4	5.9
	Other export markets	1.3	2.0	1.8	2.8	3.3	4.3	4.0	4.3	3.7	2.7	4.2	1.9	2.6	3.0
	United States*	10.9	6.2	6.8	2.5	2.7	-4.7	0.9	4.5	-3.1	-3.9	-1.4	9.7	-3.8	-5.6
	Total	**17.7**	**16.7**	**19.0**	**19.1**	**22.8**	**14.2**	**23.4**	**22.7**	**11.3**	**10.6**	**24.3**	**25.4**	**15.4**	**15.7**
Frozen	Japan	81.0	86.5	70.8	87.4	102.2	77.1	80.0	66.7	43.5	21.2	32.3	27.4	26.6	18.7
	Other export markets	1.6	1.7	2.0	1.6	1.6	2.0	4.0	3.5	2.1	2.4	5.3	5.5	3.9	1.6
	United States*	-4.7	-11.1	-5.3	5.4	3.9	2.9	2.4	7.5	2.4	4.5	12.4	4.4	5.1	6.9
	Total	**77.9**	**77.2**	**67.5**	**94.4**	**107.7**	**81.9**	**86.4**	**77.7**	**48.0**	**28.1**	**50.0**	**37.3**	**35.6**	**27.2**
Fresh	Japan	2.3	1.4	0.6	0.7	2.8	1.5	2.3	2.3	0.6	0.8	2.8	2.9	1.0	1.6
	Other export markets	2.5	2.7	1.0	2.5	0.7	0.7	0.3	3.2	2.8	2.5	2.2	0.2	0.3	3.8
	United States*	-4.1	-2.8	1.6	-1.6	-0.4	0.8	0.5	-2.9	2.0	-0.8	-2.2	1.1	1.2	-2.2
	Total	**0.7**	**1.3**	**3.3**	**1.6**	**3.1**	**3.0**	**3.2**	**2.6**	**5.4**	**2.5**	**2.8**	**4.2**	**2.5**	**3.2**
Total		**96.3**	**95.2**	**89.8**	**115.1**	**133.5**	**99.2**	**113.0**	**103.0**	**64.8**	**41.1**	**77.2**	**66.9**	**53.5**	**46.1**

*Includes both consumption and net inventory accumulation (which may be negative). Should be viewed as only approximate estimate.

- The second most important market for U.S. sockeye salmon is the UK canned salmon market, which increased its share from 9% in 1989-94 to 21% in 2000-02. The share of all canned markets combined increased from 18% in 1989-94 to 34% in 2002, as a larger share of the U.S. sockeye catch was canned.[20]

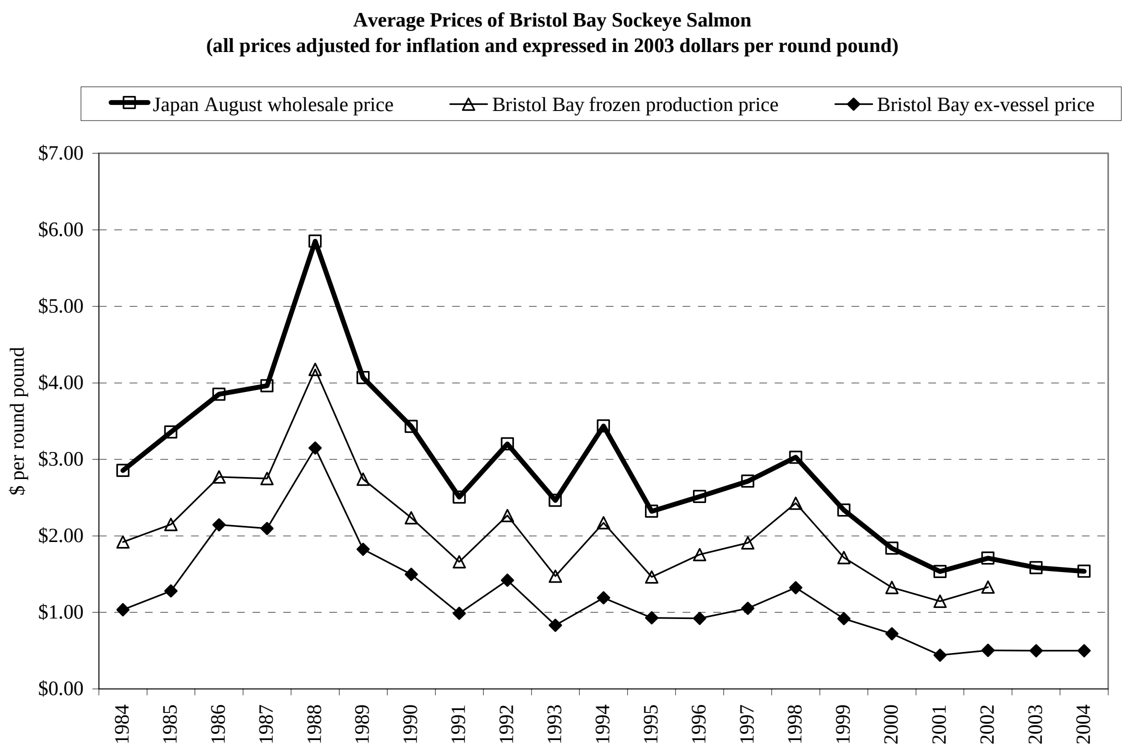
- The share of U.S. sockeye salmon production going to fresh markets is increasing, but remains relatively small—less than 6% in 2000-02.

[20] Note that these estimates are for all U.S. sockeye salmon, not just Bristol Bay salmon. Thus, they reflect production trends (as reported in ADFG COAR data) for all Alaska sockeye salmon. As with the production data for Bristol Bay reported earlier in this chapter, the statewide COAR data show a significant increased in the canned share of sockeye salmon production since the early 1990s.

V. THE JAPANESE MARKET FOR FROZEN BRISTOL BAY SOCKEYE SALMON

As we discussed in Chapter IV, the Japanese frozen market is the most important single market for Bristol Bay sockeye salmon. Japanese market conditions clearly affect ex-vessel prices for Bristol Bay sockeye. As shown in Figure V-1, for the past two decades, both the frozen production price[21] as well as the ex-vessel for Bristol Bay sockeye have clearly tracked with Japanese wholesale prices for frozen Bristol Bay salmon.

Figure V-1



In this chapter we discuss the Japanese market for frozen sockeye salmon in greater detail. We review factors affecting Japanese wholesale prices, and the relationships between Japanese wholesale prices, first wholesale prices and ex-vessel prices.

Japanese Supply of "Red-Fleshed" Salmon

As we discussed in Chapter II, sockeye salmon is one of several species of salmon which compete directly in the Japanese market which the Japanese refer to as "red-fleshed salmon." Other "red-fleshed" salmon species include coho salmon, chinook salmon, and trout. During the 1990s, the total supply of red-fleshed salmon expanded dramatically as

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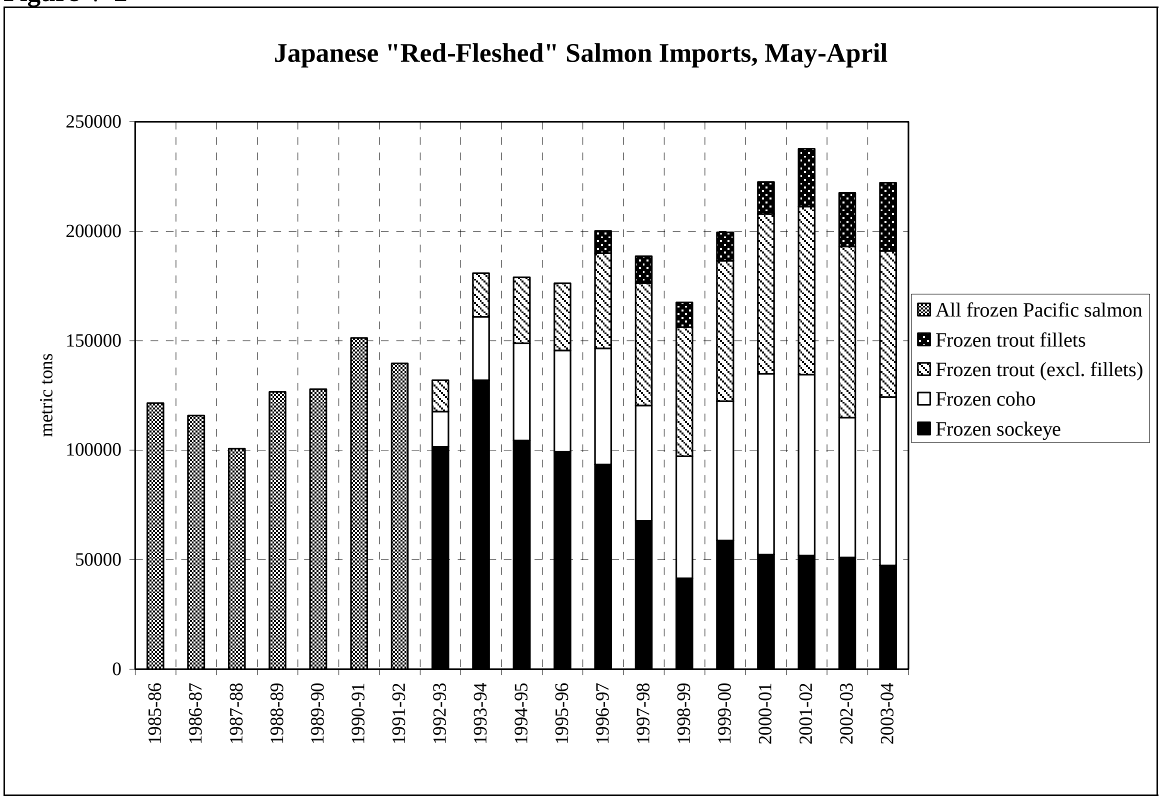
[21] We use the term "frozen production price" to refer to the first wholesale price for frozen salmon paid to processors FOB Alaska, as reported in ADFG COAR data. We use the term "Japanese wholesale price" to refer to prices paid to salmon importers in Japan.

a result of rapid growth in Japanese imports of farmed coho (from Chile) and farmed trout (mainly from Chile and Norway).

During the same time period, the supply of wild sockeye declined dramatically as North American catches (particularly Bristol Bay) declined and a smaller share of North American catches was frozen. As a result, the share of frozen sockeye in the Japanese red-fleshed salmon market declined from 77% in 1992 to just 21% in 2001 (Figure V-2).[22]

Figure V-2



As shown in Figure V-3 (on the following page) Japanese imports of Bristol Bay sockeye salmon (and other Alaska sockeye salmon) declined dramatically after 1995, while imports of sockeye salmon from Russia increased. As a result, the share of Bristol Bay sockeye in total Japanese sockeye imports fell from 59% in 1995 to only 27% in 2003-04.

The decline in the share of sockeye in total imports, together with the decline in the share of Bristol Bay sockeye in total sockeye imports, greatly reduced the relative importance of Bristol Bay sockeye salmon in the Japanese salmon market. Bristol Bay sockeye fell from 33% of red-fleshed salmon imports in 1995 to only 6% in 2003 (Figure V-4).

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[22] Japanese imports data reported imports of sockeye separately from other salmon imports beginning in 1991; imports of coho beginning in 1992, and imports of trout fillets beginning in 1996. It is likely that sockeye accounted for as high or higher a percentage of imports in the years prior to 1992 as it did in 1992. We present import data for the "salmon year" May-April because this corresponds to the marketing year for North American wild salmon harvests.

Figure V-3

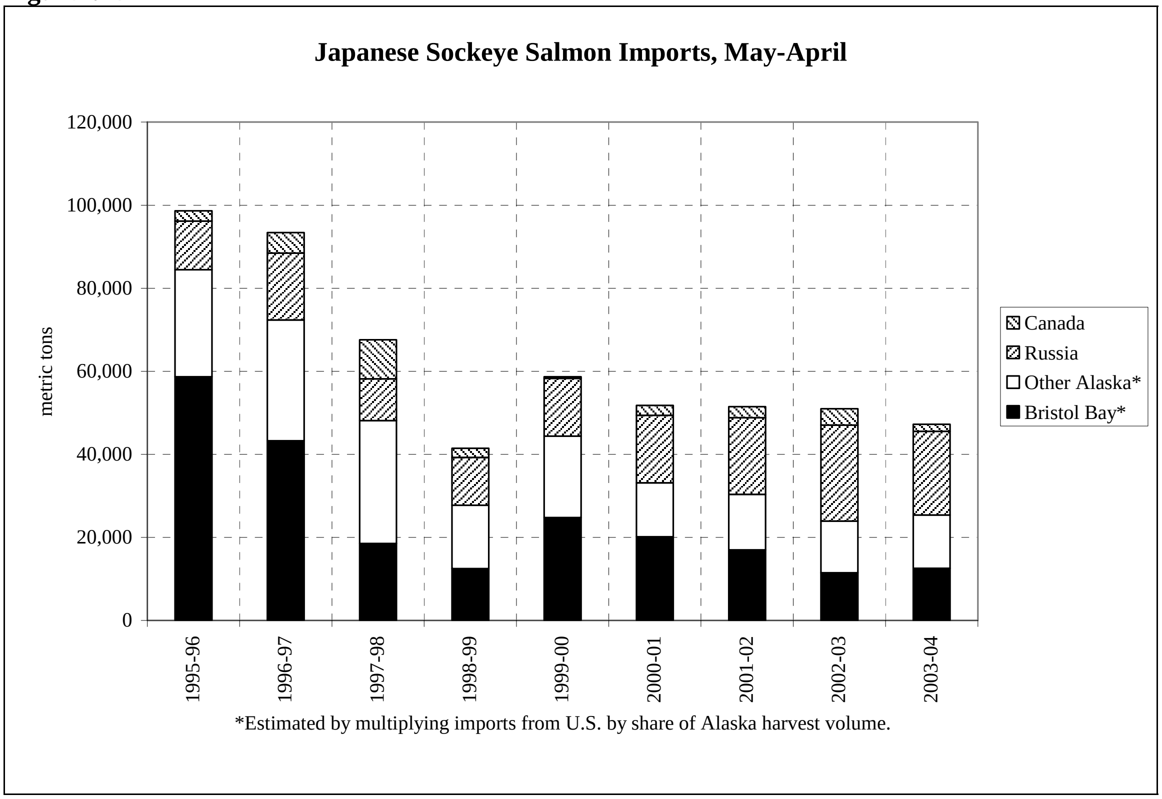
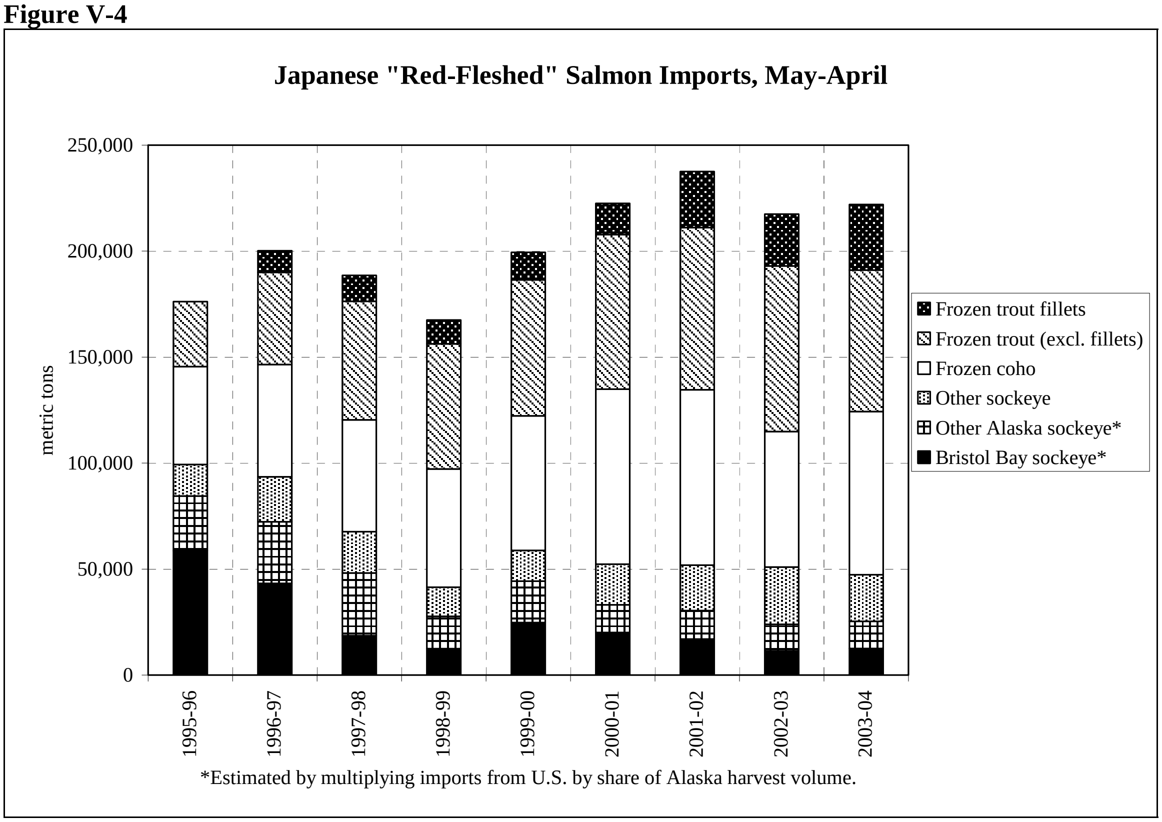


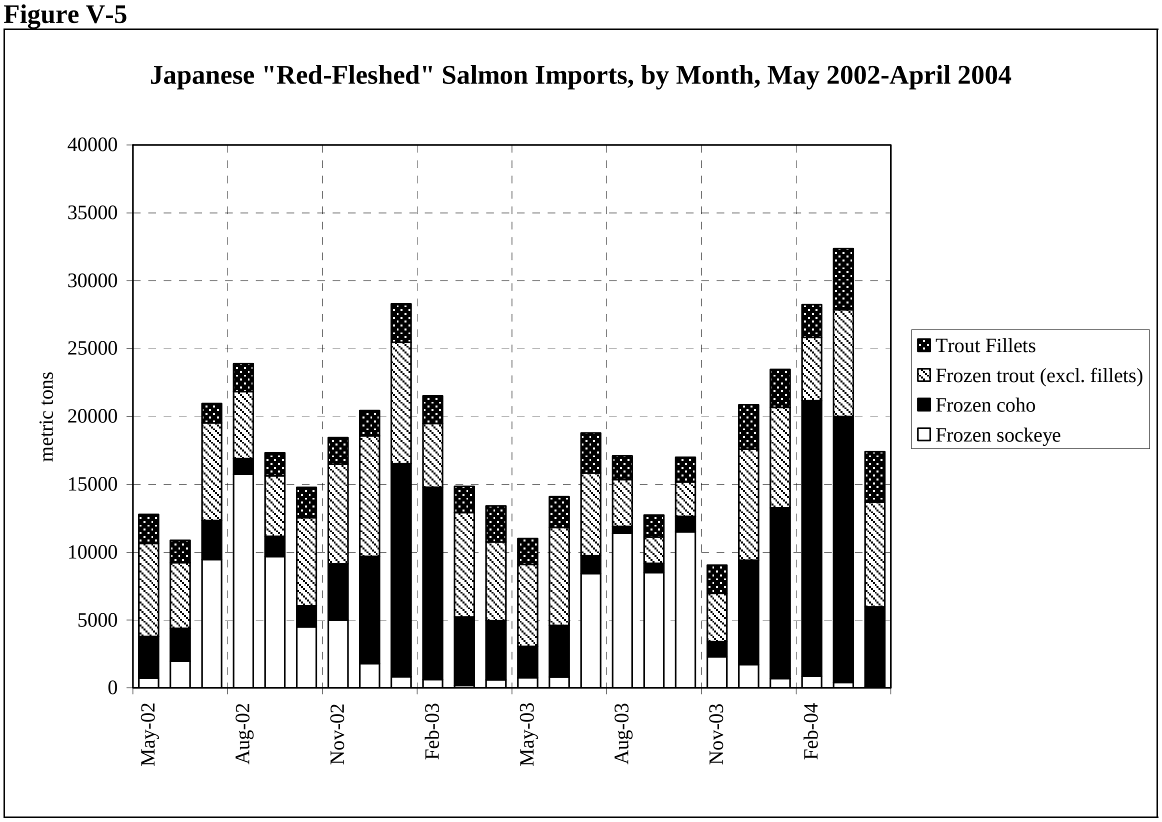
Figure V-4



Japanese frozen salmon imports for different species exhibit strong seasonality (Figure V-5). Imports of frozen wild sockeye arrive primarily during and after the wild salmon season, with most imports arriving in the period from July through November. Similarly, imports of frozen farmed coho arrive primarily during and after the Chilean (southern hemisphere) harvest season, with most imports arriving in the period from November through May. Imports of frozen trout are distributed more evenly over the year, reflecting the fact that trout is imported both from the southern hemisphere (Chile) and the northern hemisphere (Norway and Denmark).

The relative timing of imports varies from year to year. For example, in 2002-03, imports were highest in January, while February and March imports were significantly lower than in January. In contrast, in 2003-04, imports were highest in March. These differences in the annual timing of imports is due to a number of factors, such as water temperatures (which affect farmed fish sizes) and market conditions (which affect when producers want to sell and importers want to buy).

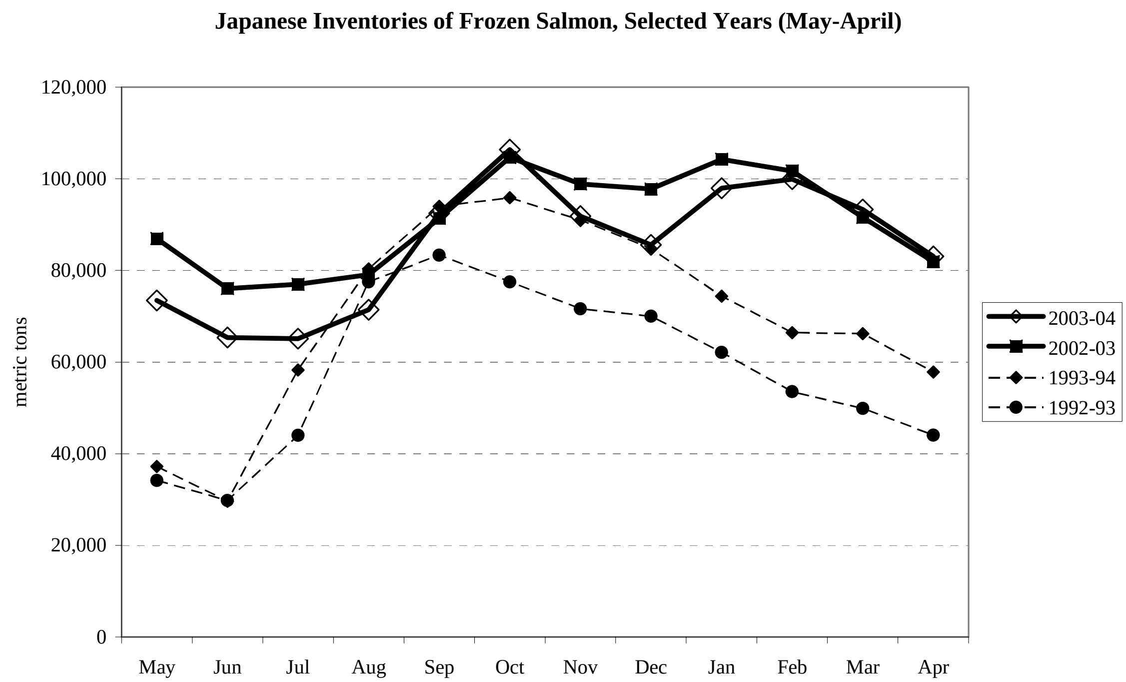
Figure V-5



The rapid growth in Japanese imports of farmed salmon has dramatically changed the relative timing of aggregate salmon imports. This in turn has affected the timing of the build-up and draw-down of Japanese inventories of frozen salmon over the course of the year.

Formerly Japanese frozen salmon inventories were built up rapidly as wild salmon imports arrived during the summer, and were then drawn down at a fairly even rate over the remainder of the year, as shown in Figure V-6 for the 1992-93 and 1993-94 seasons. Now frozen salmon inventories are more even over the course of the year, as farmed salmon replaces wild salmon in frozen inventories during the fall and winter, as shown in Figure V-6 for the 2002-03 and 2003-04 seasons.

Figure V-6



Source: Japanese Ministry of Agriculture, Forestry and Fisheries monthly inventory data.
Data show end-of-month inventory levels.

Trends in Japanese Wholesale Prices

Figure V-7 shows Japanese monthly wholesale prices for frozen wild sockeye salmon for the twenty-two year period 1981-2003, measured in yen per kilogram. As is typical for many commodities, Japanese wholesale prices for sockeye salmon exhibit substantial fluctuation from month to month, from year to year, and over longer periods of time.

Historically, Japanese sockeye salmon wholesale prices have tended to cycle over periods of one to three years. A major factor contributing to these price cycles has been variations in wild salmon harvests.

For most of the 1980s, prices were in the 1100-1500 yen/kilo range. After 1989, prices fell dramatically, to below 500 yen/kilo in 1993. After rising to above 1000 yen/kilo for part of 1998 and 1999, prices fell off again, and have been below 600 yen/kilo for most of the time since 2001.

Figure V-7

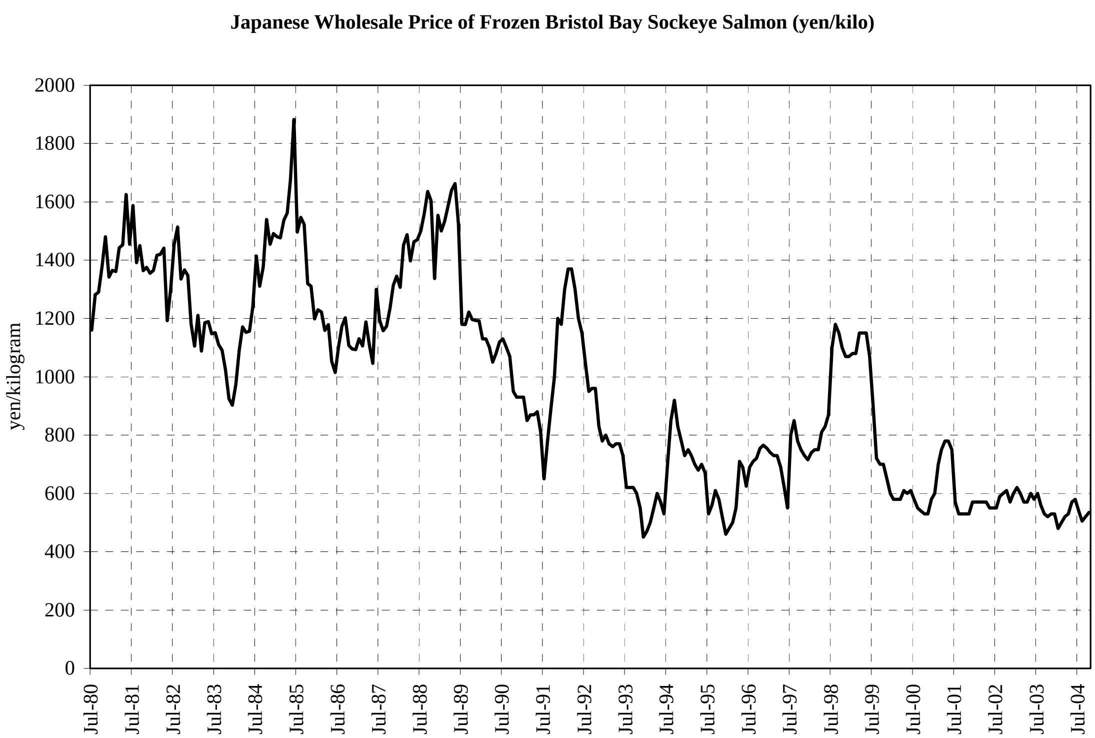
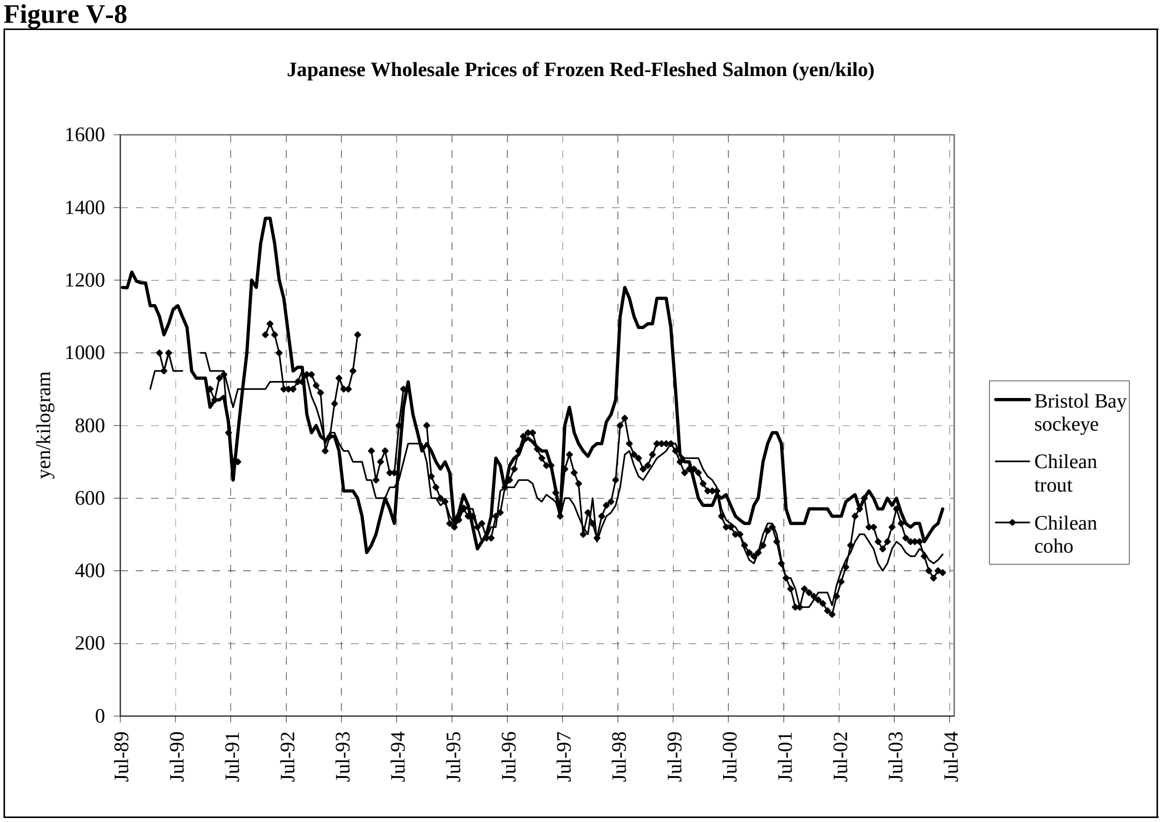


Figure V-8 compares Japanese wholesale prices for frozen sockeye with wholesale prices for frozen farmed coho and frozen farmed trout. This graph begins in 1989 because prices for farmed salmon and trout are not available for earlier years, when import volumes were very small.

In the early 1990s, wholesale prices for frozen sockeye, coho and trout exhibited some correlation, moving together for much (although not all) of the time. However, since the mid-1990s, prices for sockeye have diverged widely at times from coho and trout prices.

Figure V-8



The "sockeye salmon" prices in Figures V-7 and V-8 are monthly "low"[23] wholesale prices for Bristol Bay sockeye salmon, number one grade, 4-6 lbs. Although this reference price is commonly used when talking about sockeye salmon prices, there is in fact significant variation in sockeye salmon prices depending upon the size, grade and origin of the salmon. As shown in Table V-1, historically Japanese wholesale prices for "local" (non Bristol Bay) sockeye have been higher than for Bristol Bay sockeye, although the size of the price differential has shrunk over time.[24] The differential

[23] At any given time, prices at which importers are offering Bristol Bay sockeye vary. Price reports generally report the "low" and "high" end of the range of prices offered.

[24] This is one reason why ex-vessel prices for Bristol Bay sockeye have generally been lower than ex-vessel prices for sockeye from other areas. Other factors contributing to differences between areas in ex-vessel prices include differences in costs of tendering and processing, differences in the timing of when fish are harvested and sold, and differences in the mix of products produced..

between prices paid for different sizes also varies from year to year, reflecting changes in the relative mix of fish sizes in the harvest, and the relative balance of supply and demand for fish of different sizes classes.

Table V-1
Japanese September Wholesale Prices for Frozen Sockeye Salmon

Size	Origin	1989	1994	1999	2004
4-6 lbs	Bristol Bay	1220	930	730	480
	Local	1320	980	870	500
6-9 lbs	Bristol Bay	1260	980	800	480
	Local	1320	1050	900	500

Note: Prices are Tokyo wholesale market low list prices from Bill Atkinson's News Report. "Local" prices for 1999 and 2004 are for Kodiak salmon. Prices are the first prices reported for September.

Factors Affecting Japanese Wholesale Prices

What explains the historical trends in Japanese wholesale prices, and the substantial variation in prices over time? This is not an easy question to answer. The Japanese salmon market is very complex. Many different species of salmon, of many different sizes, grades and origins, are supplied to the market each year. These salmon are purchased by many different users for use in many different products. Salmon of different species, sizes, grades and origins vary in the extent to which they are substitutes for each other.

In the short term—in any given month--prices of different kinds of salmon—including Bristol Bay sockeye--adjust to bring supply and demand of each kind of salmon into balance. If buyers (reprocessors and retailers) want more of a particular kind of salmon than sellers are offering, they tend to bid the price up; if buyers want less than sellers are offering, sellers tend to lower their prices.[25]

The market is complicated by the fact that frozen salmon can be stored. Thus buyers do not necessarily need to buy at any particular time (unless they have run out of inventories on hand), and buyers do not necessarily need to sell at any particular time. Buyers may delay buying if they expect prices to fall, and may rush to buy if they expect prices to rise—causing their expectations to become self-fulfilling, at least in the short-term. Thus at any given time, prices adjust not only to bring current supply and demand into balance, but also to bring current prices in line with buyers and sellers' expectations about future prices.

From month to month, and from year to year, the supply of salmon coming onto the market varies. Similarly, from month to month, and from year to year, demand for different kinds of salmon varies, reflecting changes in income, prices of other kinds of fish, and many other factors. For all of these reasons, prices are constantly adjusting and changing from month to month and from year to year. Inventories that are lower or higher

[25] We present a more formal discussion of salmon price theory in Chapter VII.

than usual or expected are an indicator that supply is lower or greater than usual or expected, and tend to be accompanied by rising or falling prices.

As can be seen in Figures V-7 and V-8, frequently wholesale prices for sockeye salmon have risen or fallen sharply in July. This is because it is in July that the annual supply of sockeye salmon to the Japanese market (from Bristol Bay and other areas) first becomes apparent. Low (or lower than expected) supply tends to cause prices to rise; high (or higher than expected) supply tends to cause prices to fall.

In general, as illustrated in Figure V-9, historically there has been an inverse relationship between total Japanese imports of frozen "red-fleshed" salmon (sockeye, coho, and trout) and average annual sockeye wholesale price levels.[26] Prices have generally fallen when total imports have risen, and vice versa, resulting in a "mirror-image" relationship between total imports and average annual sockeye prices.

Figure V-9

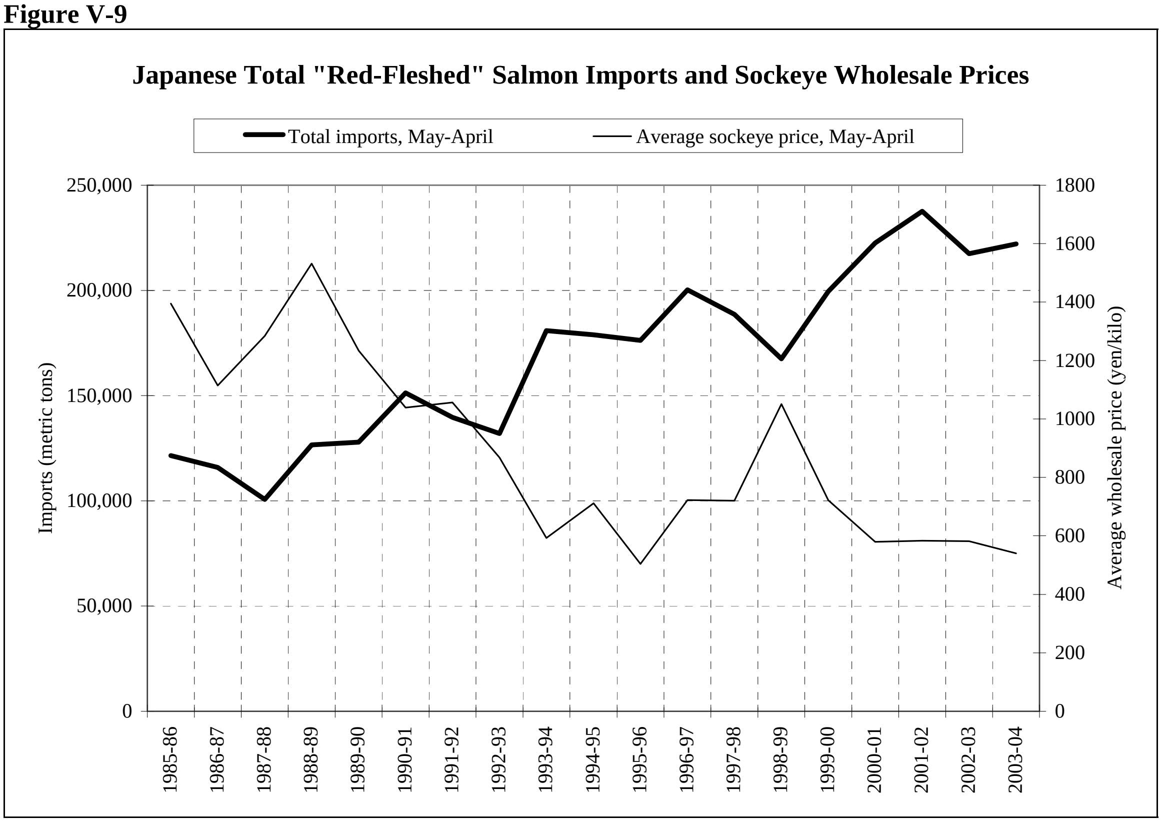


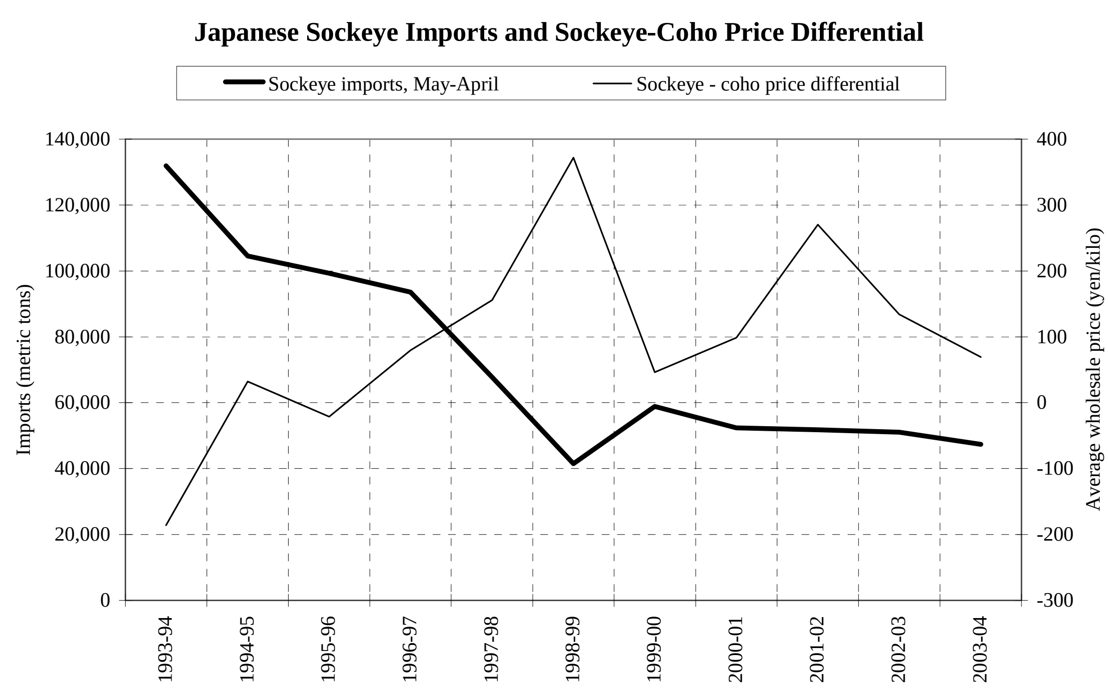
Figure V-9 is not a perfect "mirror-image" inverse relationship—but we should not expect one, because many other factors besides imports also affect wholesale prices. These include inventory levels, the supply of other kinds of salmon (such as Japanese fall chum salmon and Atlantic salmon imports), and demand conditions. In any given year, these factors may influence prices in a different direction than import levels.

[26] Prior to the 1990s, because Bristol Bay sockeye accounted for a large share of the supply, there also tended to be an inverse relationship between Bristol Bay harvests and wholesale price levels.

As was illustrated in Figure V-8, since the mid-1990s some of the time wholesale prices for sockeye salmon have been close to prices for farmed coho and trout, while at other times sockeye prices have been significantly above prices for farmed coho and trout. A potential explanation for this is that Japanese salmon reprocessors, retailers and consumers vary in the extent to which they are willing to substitute other species for sockeye salmon. When only limited volumes of sockeye salmon are available, sockeye is purchased by those users with the most “sockeye-specific” demand, who are willing to pay a greater price differential. As the supply of sockeye increases, an increasing share must be sold to users will less sockeye-specific demand, and the lower the price differential which sockeye can command over other red-fleshed salmon.

As shown in Figure V-10, as Japanese sockeye salmon imports declined during the 1990s, the wholesale price differential between sockeye and coho salmon increased. In 1988-99, when sockeye imports fell to very low levels, sockeye prices rose sharply above coho price levels. In 1999-00, as sockeye imports increased again, this differential fell.

Figure V-10



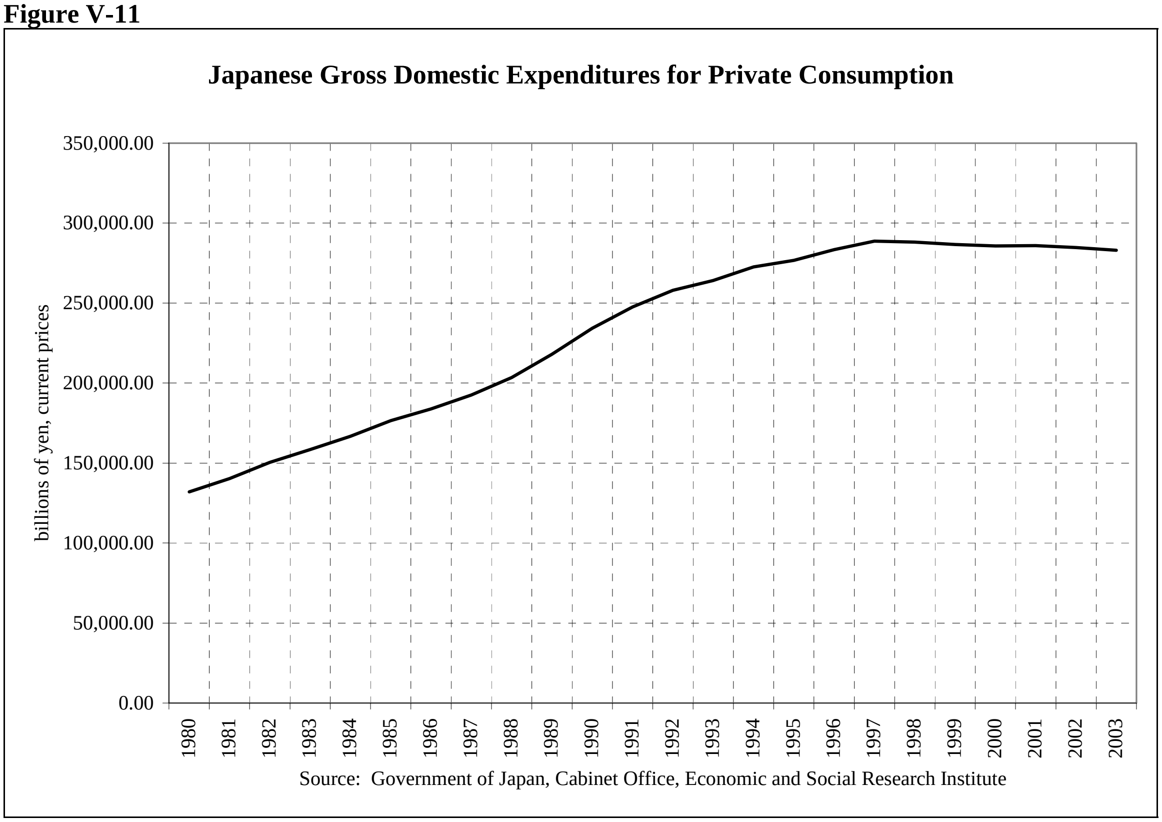
Note: Sockeye - coho price differential is the unweighted average sockeye price (May-April) minus the unweighted average coho price (May-April)

This is consistent with the theory that users with more sockeye-specific demand bid up the sockeye price relative to other red-fleshed salmon species when sockeye volumes are low. But the price differential is clearly also affected by other factors besides sockeye supply, as illustrated by the high price differential in 2001-02, when sockeye supply was similar to the preceding and following years.

The fact that supply changes significantly from year to year makes it easier to discern the relationship between supply and prices in graphs and in regression analysis such as that which we present in Chapter X. It is harder to see the effects of factors which change less dramatically or less frequently.

One such factor is the condition of the Japanese economy. After a period of very rapid growth in the 1980s, Japanese economic growth slowed significantly in the 1990s. Growth in consumer expenditures slowed in the early 1990s, and consumer expenditures fell after 1997 (Figure V-11).

Figure V-11



The Japanese unemployment rate increased from about 2% in 1990 to more than 5% in 2002 (Figure V-12). The rate of inflation declined, and by 1999 Japanese inflation rates were negative: consumer prices were falling (Figure V-13).

The economic slowdown put downward pressure on salmon prices in numerous ways. Consumers became more cautious in their spending, and businesses—including salmon importers, reprocessors, and retailers—found financing more difficult to obtain.

Figure V-12

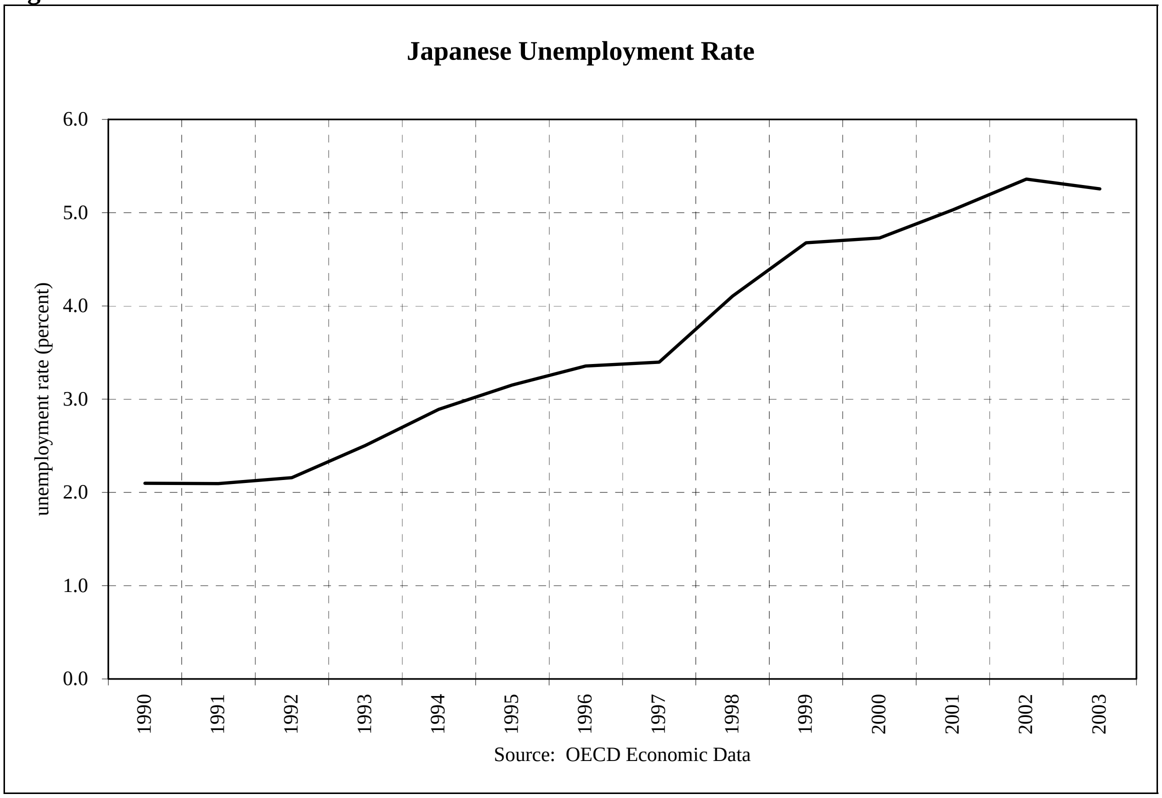
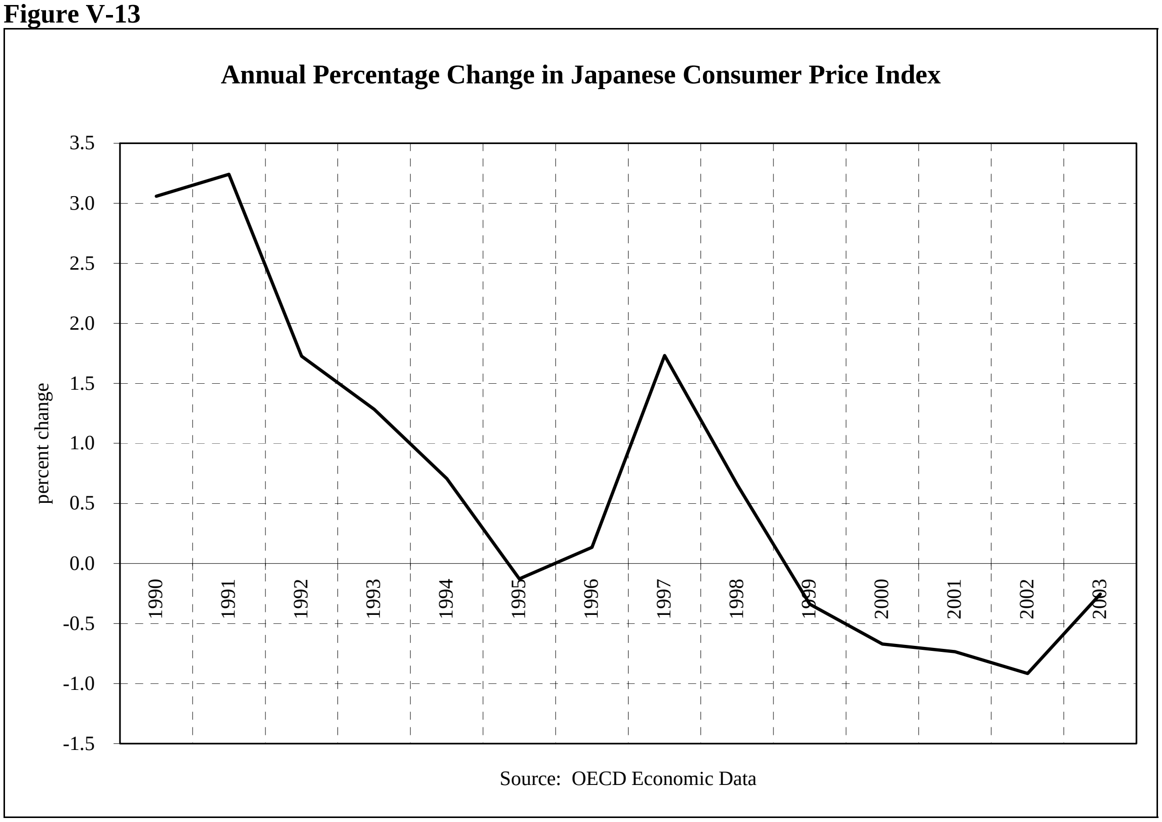


Figure V-13



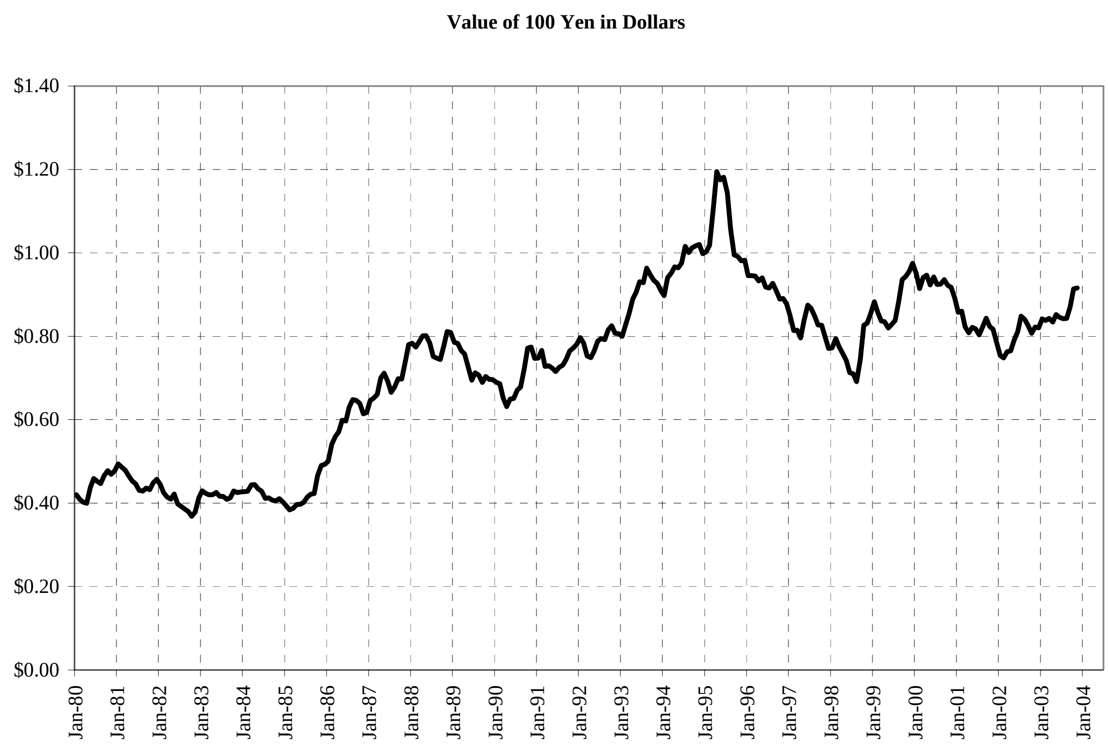
The Relationship Between Japanese Wholesale Prices and Bristol Bay Ex-Vessel Prices

How do Japanese wholesale prices for frozen sockeye salmon affect Bristol Bay ex-vessel prices? Put simply, Japanese wholesale prices affect what importers are willing (and able) to pay processors, and in turn what processors are willing (and able) to pay fishermen. Thus when Japanese wholesale prices rise, ex-vessel prices usually rise, and when Japanese wholesale prices fall, ex-vessel prices usually fall.[27]

The exchange rate between the yen and the dollar plays an important role in the relationship between Japanese wholesale prices and ex-vessel prices. The wholesale prices that Japanese importers expect to receive—as measured in yen--affect the prices importers are willing (and able) to pay processors in yen. The exchange rate, in turn, determines how the prices importers are willing to pay in yen convert to prices they are willing (and able) to pay in dollars.

At certain times over the past two decades—in particular between 1986 and 1988 and between 1990 and 1995--the value of the yen relative to the dollar rose rapidly (Figure V-14). During these periods, for any given yen wholesale price, the rising yen value had the effect of raising wholesale prices as measured in dollars. At other times, the value of the yen was falling, with an opposite effect on wholesale prices measured in dollars.

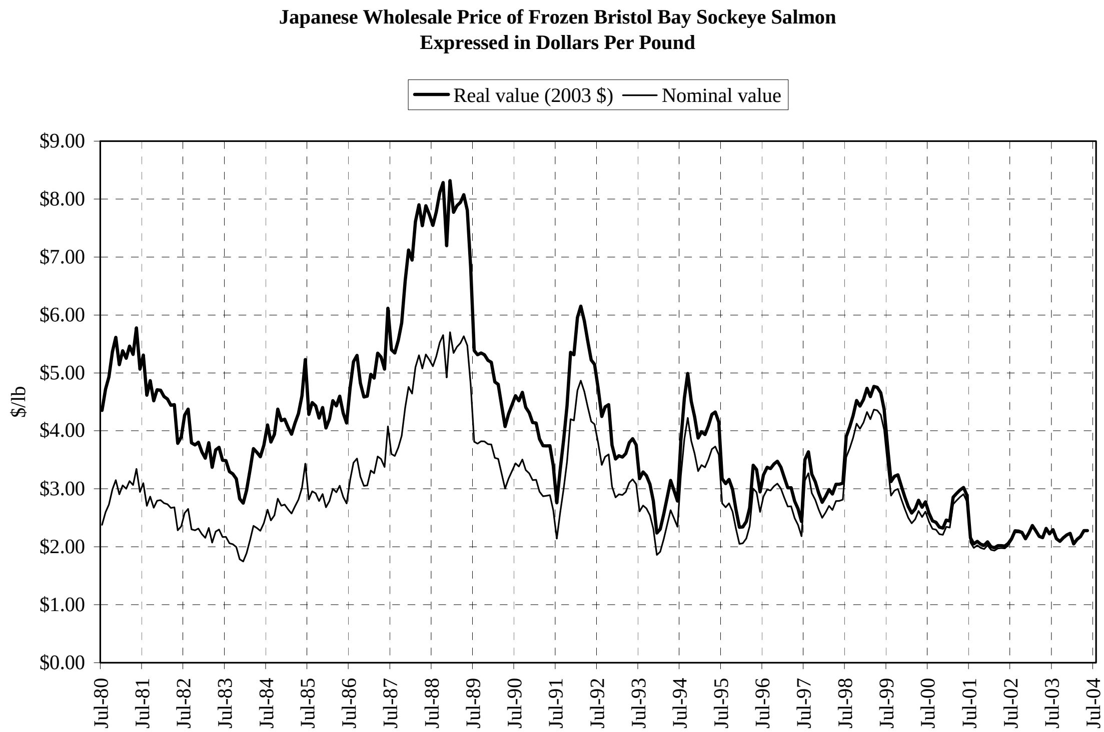
Figure V-14



[27] Chapter VII provides a more theoretical discussion of the relationship between prices at different levels in the salmon distribution chain.

Figure V-15 shows the same monthly Japanese wholesale price data for sockeye salmon, converted to dollars per pound. The bottom line shows the price in “nominal dollars,” converted from yen using the exchange rates shown in Figure V-14. The top line shows the price in “real 2003 dollars/lb,” after adjusting for inflation.

Figure V-15



In comparing wholesale prices with ex-vessel prices, the issue arises as to which monthly wholesale price or prices to compare with ex-vessel prices. In the subsequent discussion we use August wholesale prices. August usually accounts for the largest share of sales from Bristol Bay processors to Japanese importers (as well as the largest volume of Japanese sockeye salmon imports, as shown in Figure V-5). Thus the August wholesale price represents the best indicator, at the time the largest volume of Bristol Bay salmon sales occurs, of the prices the salmon will command on the Japanese market.

Figure V-16 (on the following page) shows Japanese August wholesale prices expressed in real (2003) dollars per pound. The top line of the graph shows prices per H&G pound. The bottom line shows prices converted to dollars per round pound, after adjusting for an assumed 74% yield from round salmon to H&G salmon. Expressing prices using a common measure (dollars per round pound) is necessary for comparing prices at different levels.

Figure V-17 (also on the following page) shows prices of Bristol Bay sockeye at three levels: the Japan August wholesale price, the first wholesale price paid to Bristol Bay processors for frozen sockeye (the “frozen production price”), and the ex-vessel price. All of the prices as expressed in real 2003 dollars per pound.

Figure V-16

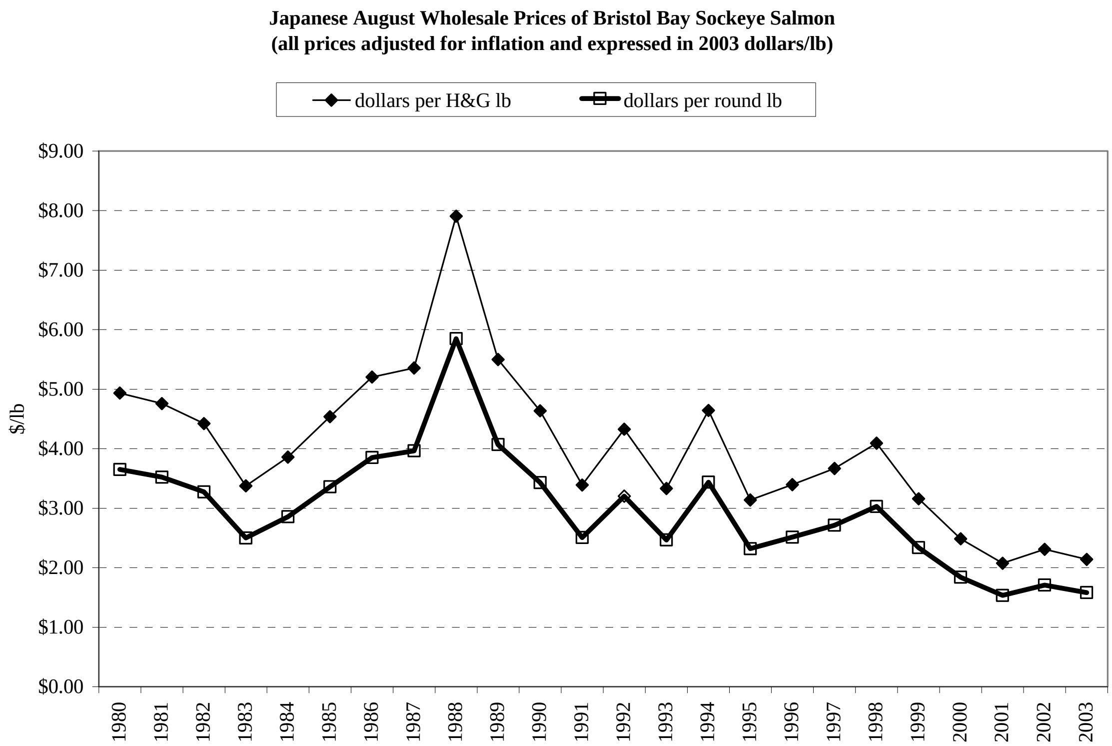
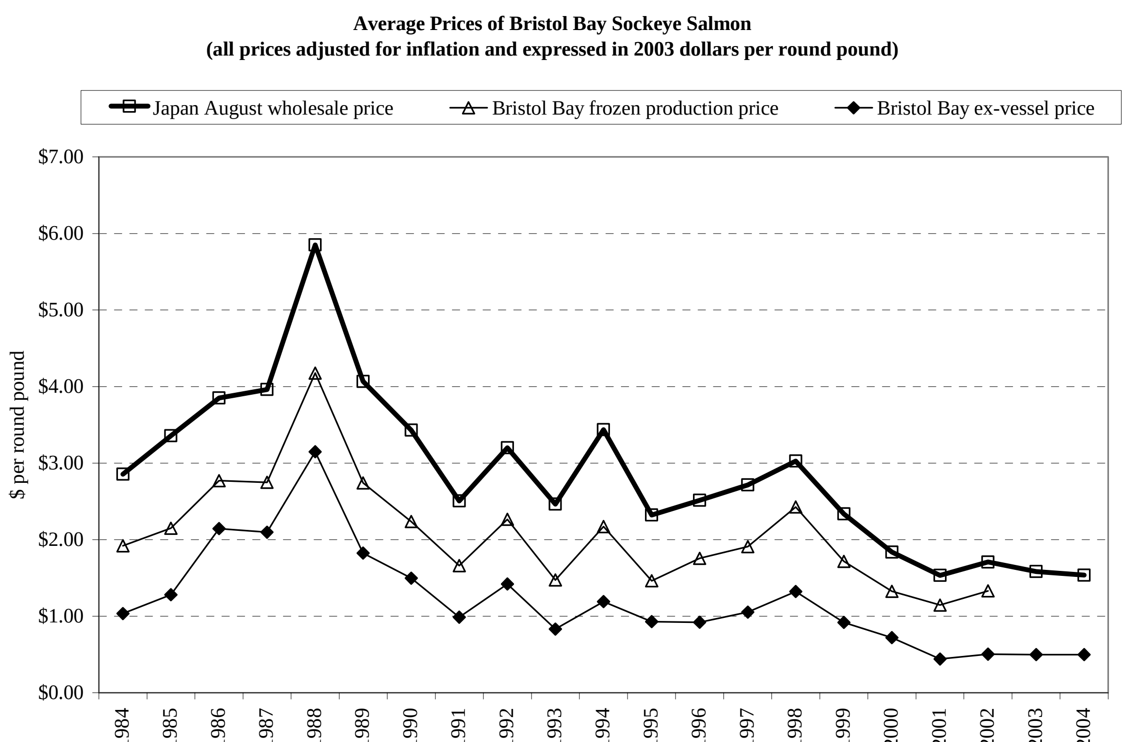


Figure V-17

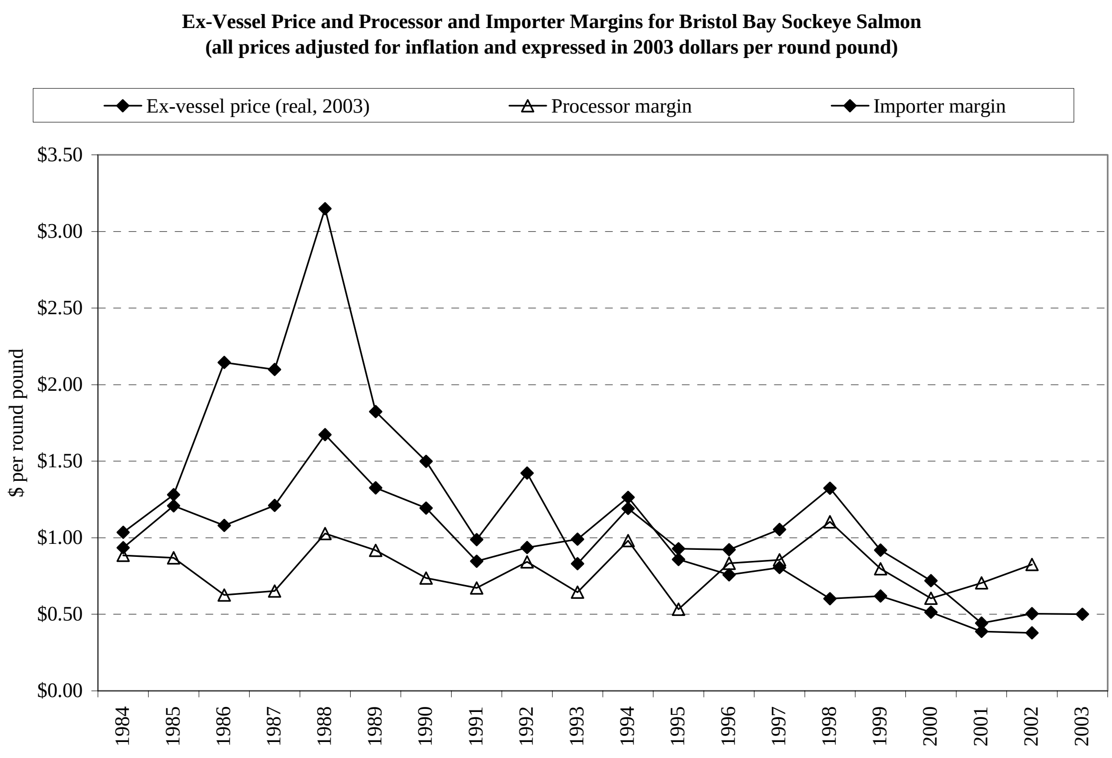


As shown in Figure V-17, for the past two decades, both the first wholesale price as well as the ex-vessel price have clearly tracked with Japanese wholesale prices for frozen Bristol Bay salmon. This suggests that Japanese wholesale prices have a direct effect on ex-vessel prices. When Japanese wholesale prices go up, ex-vessel prices go up. When Japanese wholesale prices go down, ex-vessel prices go down.[28] Thus the key factors affecting Japanese wholesale prices, such as Japanese salmon imports and inventories, are also key factors affecting ex-vessel prices.

Figure V-18 shows the ex-vessel price and the processor and importer margins for frozen Bristol Bay sockeye salmon exported to Japan. The "processor margin" was calculated by subtracting the ex-vessel price from the frozen production price. The "importer margin" was calculated by subtracting the frozen production price from the Japanese wholesale price.

Together the ex-vessel price and the processor and importer margins sum to the Japanese wholesale price. They show how the wholesale price has been distributed among fishermen, processors and importers. Note that these measures are not the same as "profit" for any of these groups, since fishermen, processors and importers all have costs.

Figure V-18



Both the ex-vessel price and the importer margin have trended downwards significantly since the 1980s. In contrast, the processor margin, although it has varied significantly from year to year, does not exhibit any significant downward trend.

[28] We examine this relationship econometrically in Chapter X.

As with the wholesale price and the ex-vessel price, there is considerable year-to-year variation in processor and importer margins. Like ex-vessel prices, processor and importer margins usually (but not always) move in the same direction as the wholesale price.

Table V-2 examines the shares of the ex-vessel price, processor margin and importer margin in the annual changes in the Japanese wholesale price. On average, in years when the wholesale price increased, the increase in ex-vessel price accounted for 52% of the increase in the wholesale price; the increase in the processor margin accounted for 37% of the wholesale price increase; and the increase in the importer margin accounted for 11% of the wholesale price increase. In years when the wholesale price decreased, these averages were 59% for the ex-vessel prices, 20% for the processor margin, and 21% for the importer margin.

Table V-2
Share of Ex-Vessel Price, Processor Margin and Importer Margin in Annual Changes in Japanese Wholesale Price

		Years when wholesale price increased			Years when wholesale price decreased		
		Ex-Vessel Price	Processor Margin	Importer Margin	Ex-Vessel Price	Processor Margin	Importer Margin
Average		52%	37%	11%	59%	20%	21%
Number of years	Less than 0%	2	2	4	0	1	2
	0-19%	0	1	1	0	2	1
	20-39%	2	4	3	1	3	4
	40-59%	2	0	1	4	2	1
	60-79%	2	2	0	2	0	0
	80-99%	1	0	0	1	0	0
	100% or more	1	1	1	0	0	0
	Total	10	10	10	8	8	8

There was considerable year-to-year variation in these relative shares. For example, there were some years when the wholesale price went up but the ex-vessel price, processor margin, or importer margin went down. Similarly, there were years when the ex-vessel price, processor margin, or importer margin increased by more than the wholesale price.

In general, however, changes in ex-vessel prices accounted for more of the annual variation in wholesale prices than did processor margins or importer margins. Put differently, fishermen tended to gain more from wholesale price increases than did processors or importers, and to lose more from price decreases than did processors or importers.[29]

[29] Although the comparison of margins and ex-vessel prices provides useful broad insights about how different groups are affected by changes in wholesale prices, it is important to keep in mind several limitations of this analysis. First, the August wholesale price, while a useful measure of expected wholesale prices at the time processors sell to fishermen, does not necessarily represent prices that importers actually sold for in subsequent months. Second, the wholesale price used for this analysis is the price of #1 4-6 lb fish; prices are different (and generally lower) for other grades and sizes. Thus, the importer margins shown in Figure V-18 and Table V-2 do not necessarily represent actual average margins

Potential Implications of Future Japanese Market Changes

Here we briefly note two long-run trends which might affect future Japanese wholesale prices, and in turn Bristol Bay ex-vessel prices.

Per capita salmon consumption in Japan is very high relative to the United States and most countries in Europe. Salmon is widely available, and consumers are very familiar with salmon. The Japanese population is projected to stabilize or decline in the future. Thus neither total Japanese salmon demand, nor Japanese demand for wild sockeye salmon, seems likely to grow substantially in the future.

One potentially important future trend is a shift in salmon reprocessing from Japan to lower-cost countries. Increasingly, farmed trout are being imported from Chile in fillet form (Figure V-4). In addition, a growing share of the fish eaten in Japan are being processed in China (although the share of salmon processed in China remains relatively low).

Lower foreign processing costs could tend to reduce Japanese prices for value-added salmon products (such as fillets), which could tend to reduce Japanese wholesale prices for headed and gutted salmon (such as Bristol Bay sockeye) sold to Japanese reprocessors. Put differently, any reduction in costs for the salmon which competes with Bristol Bay salmon—including a reduction in costs of reprocessing—could put downward pressure on Japanese wholesale prices.

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received by importers for their sockeye salmon sales. Third, processor margins for frozen salmon are not necessarily an indication of how well processors are doing economically. A large share of production is canned rather than frozen. The overall profitability of salmon processing thus depends not only on processor margins for frozen production but also on processor margins for canned production (we discuss processor margins for canned production in Chapter VI). In addition, margins are not the same as profits. The profitability of salmon processing depends not only on the margins between wholesale and ex-vessel prices, but also on processors' costs. Processors' costs, like fishermen's costs, may vary widely from year to year, for example because of changes in fixed costs per pound as harvest volumes change. Over the long-term, processors' margins cannot fall below average costs of production.

VI. OTHER MARKETS FOR BRISTOL BAY SOCKEYE SALMON

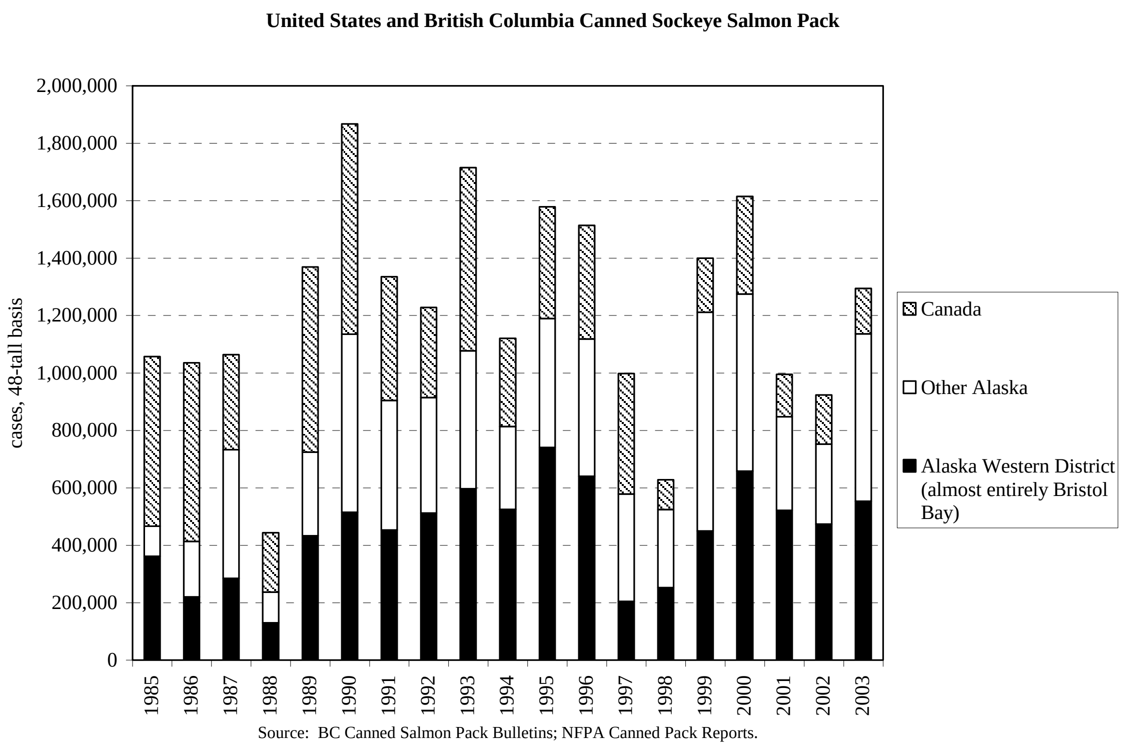
In the previous chapter, we examined the Japanese market for frozen sockeye salmon. In this chapter we look at two other important markets for Bristol Bay sockeye salmon: the canned sockeye salmon market and the sockeye salmon roe market.

The Canned Sockeye Salmon Market

As we discussed in Chapter IV, in recent years an increasing share of Bristol Bay sockeye salmon has been canned. In 2002, canned salmon accounted for approximately half of total Bristol Bay production.

As shown in Figure VI-1, the North American canned sockeye salmon pack (which accounts for almost all of world supply) varies widely from year to year. Bristol Bay typically accounts for between one-third and one-half of the North American canned sockeye salmon pack. Since the early 1990s, the canned sockeye salmon pack has trended downwards in Canada, but not in Alaska, where the canned sockeye pack has remained high in most years.

Figure VI-1



Peter Pan Salmon Cannery, Dillingham

Containers for Shipping Bristol Bay Canned Salmon

Most Bristol Bay sockeye salmon production is either "talls" or "halves." Historically, a "tall" was a 1-pound can and a "half" was a ½ pound can. Over time, the actual fish weight in a standard can has declined, so that a standard "tall" can now contains 14.75 ounces of fish.

Canned salmon are typically sold in cases of 24 or 48 cans. Production is commonly reported in cases on a "48-tall basis," or the fish weight equivalent of a case of 48 "tall" cans. (On a 48-tall basis, one million cases is equivalent to 20,072 metric tons.) Canned salmon wholesale prices are often reported as prices per case or 48-talls or 24-talls.

As shown in Table VI-1, halves are the most common can size for Bristol Bay sockeye (as well as for other regions). The relative share of different sizes in the total pack varies from year to year, reflecting annual differences in the regional distribution of harvests (because different regions have different relative capacity for producing cans of different sizes) as well as annual differences in relative prices of cans of different sizes.

Table VI-1
Alaska Westward District Canned Sockeye Pack, by Can Size (48-can cases)

	2001	2002	2003
Talls	101,828	158,430	220,839
Halves	825,398	606,769	634,790
Quarters	27,681	49,240	61,070
Total (48-tall basis)	521,447	474,124	553,501

Source: National Food Processors Association, Canned Salmon Pack Reports. Note: Alaska Westward District production is mostly from Bristol Bay.

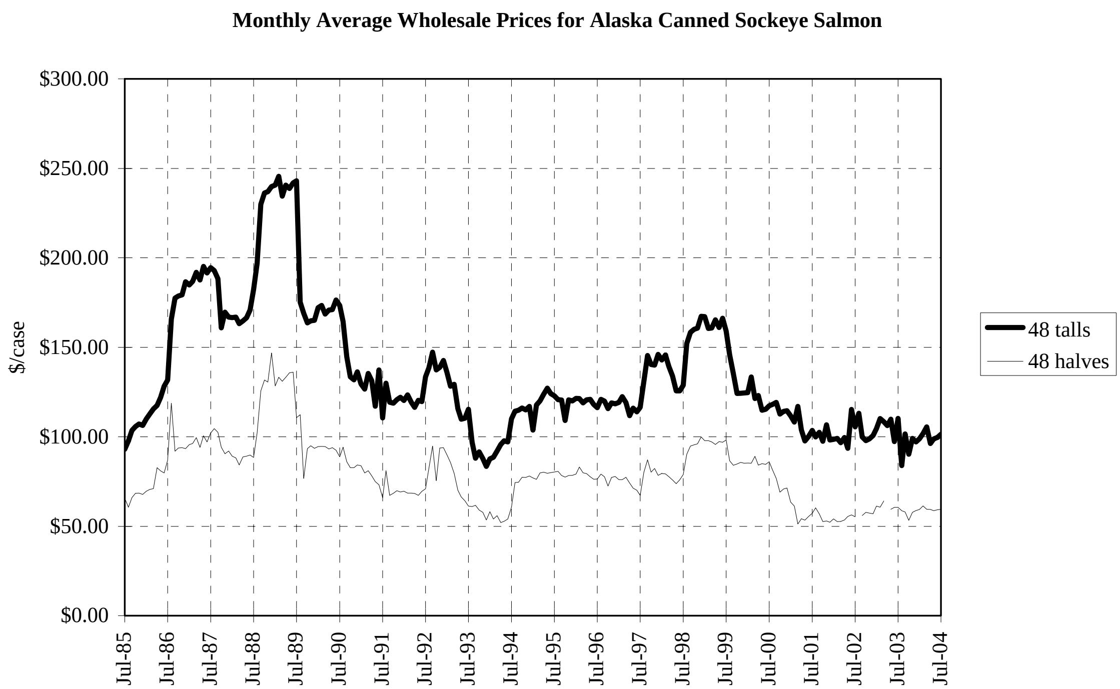
Figure VI-2 shows average wholesale case prices for Alaska canned salmon. Prices peaked in 1987 and 1988 due to two consecutive years of low harvests and low canned salmon packs. Wholesale prices fell sharply between 1989 and 1991, and have since fluctuated while trending downwards.

In the short-term, canned salmon wholesale prices tend to be driven by the available supply. Prices tend to fall when the canned pack is large, and especially when there is a large pack combined with large carryover inventories from previous years' pack. Prices tend to rise when the canned pack is small, and especially when there is a small pack combined with small carryover inventories.[30]

This inverse or "mirror-image" relationship between supply and price is somewhat apparent in Figure VI-3, which compares the total North American canned sockeye pack with the annual average wholesale case price. Prices rose sharply in 1988 and 1998, two years of low canned sockeye packs.

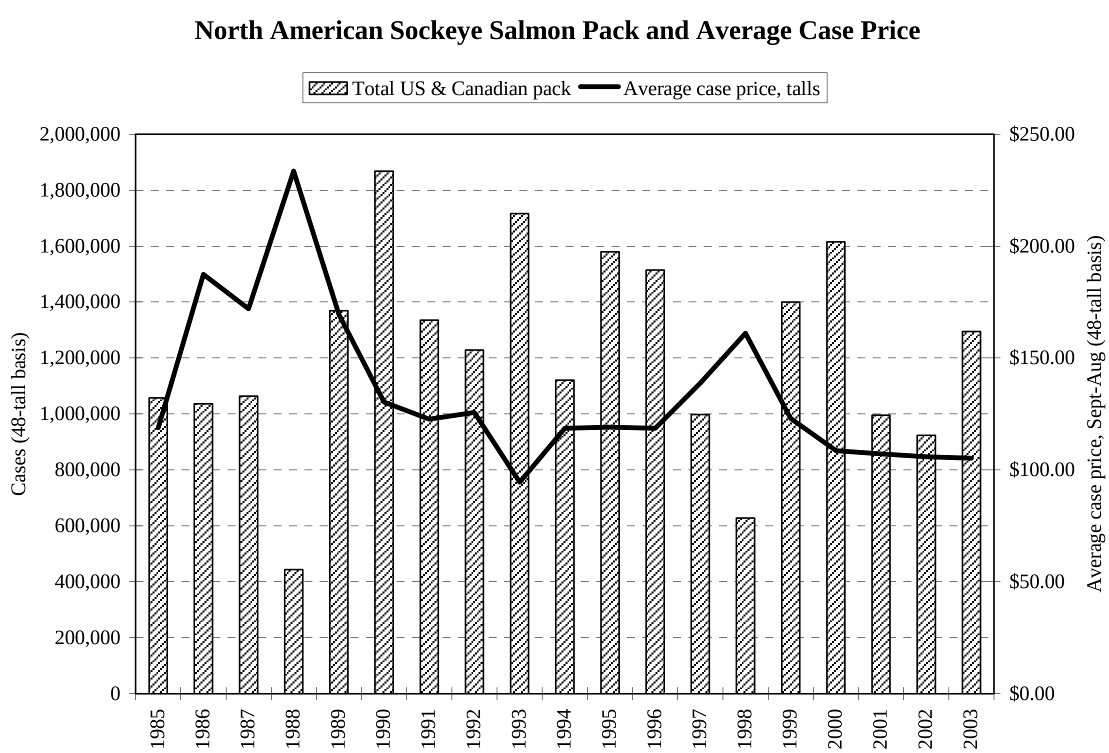
[30] Canned salmon inventory data, formerly published by the National Food Processors Association, are no longer publicly available.

Figure VI-2



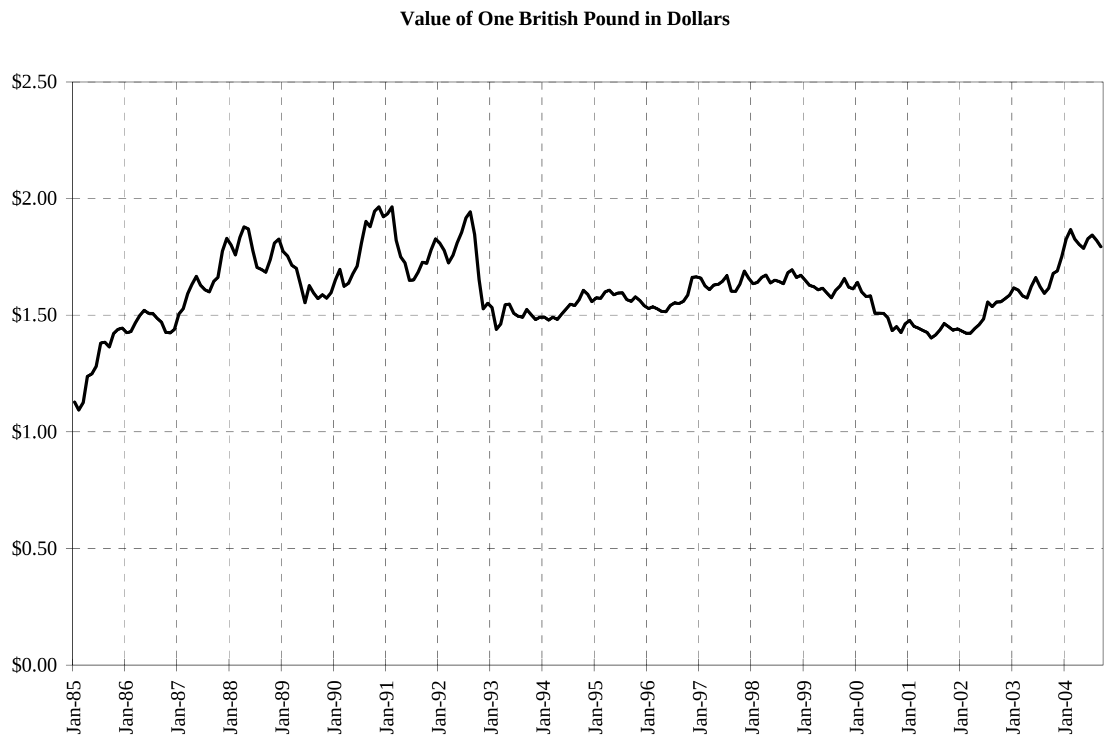
Source: Alaska Department of Revenue salmon price reports. Data prior to August 2000 are statewide average canned sockeye prices; later data are average prices for Bristol Bay canned sockeye.

Figure VI-3



In addition to the canned sockeye pack and canned sockeye inventories, canned sockeye prices are also affected by other factors such as supply and price trends for canned pink salmon (which substitute for canned sockeye to a limited extent). Because of the importance of the United Kingdom as a market for canned sockeye salmon, exchange rates between the British pound and the dollar also affect canned salmon prices.[31] It is likely that the increase in the value of the pound between 1985 and 1988 contributed to the rapid rise in canned sockeye salmon case prices during that period. The rise in the value of the pound in 2003 likely also helped to support prices in that year—keeping them from falling despite a substantial increase in the pack.

Figure VI-4

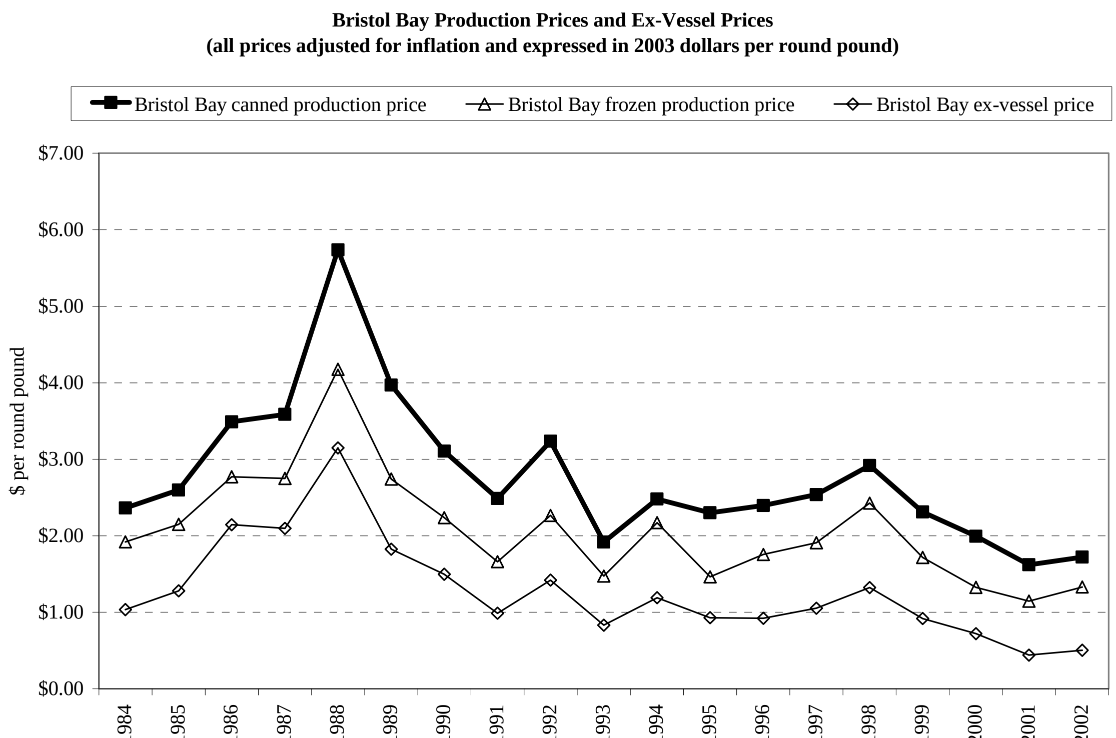


[31] We discuss end-markets for canned sockeye salmon in Chapter IV.

Figure VI-5 shows production prices (average first wholesale prices paid to processors) for Bristol Bay canned sockeye and frozen sockeye, as well as ex-vessel prices paid to fishermen. All three price series are closely correlated. The higher production prices for canned sockeye salmon reflect higher costs of canning compared with freezing.

The close correlation between production prices for canned and frozen sockeye suggests that similar factors drive first wholesale prices for both products, most importantly the total supply of sockeye from Bristol Bay and other areas of North America. In addition, the correlation may reflect the ability of processors—in Bristol Bay and other areas—to shift between canned and frozen production in response to changes in relative wholesale prices. The decline in Japanese demand for frozen sockeye salmon, in response to lower prices of competing farmed salmon, has caused Bristol Bay processors to reduce frozen production and increase canned production. This in turn has tended to raise frozen production prices and lower canned production prices, compared to what they would have been without the shift from frozen to canned production—thus helping to keep the gap between canned and frozen production prices from increasing.

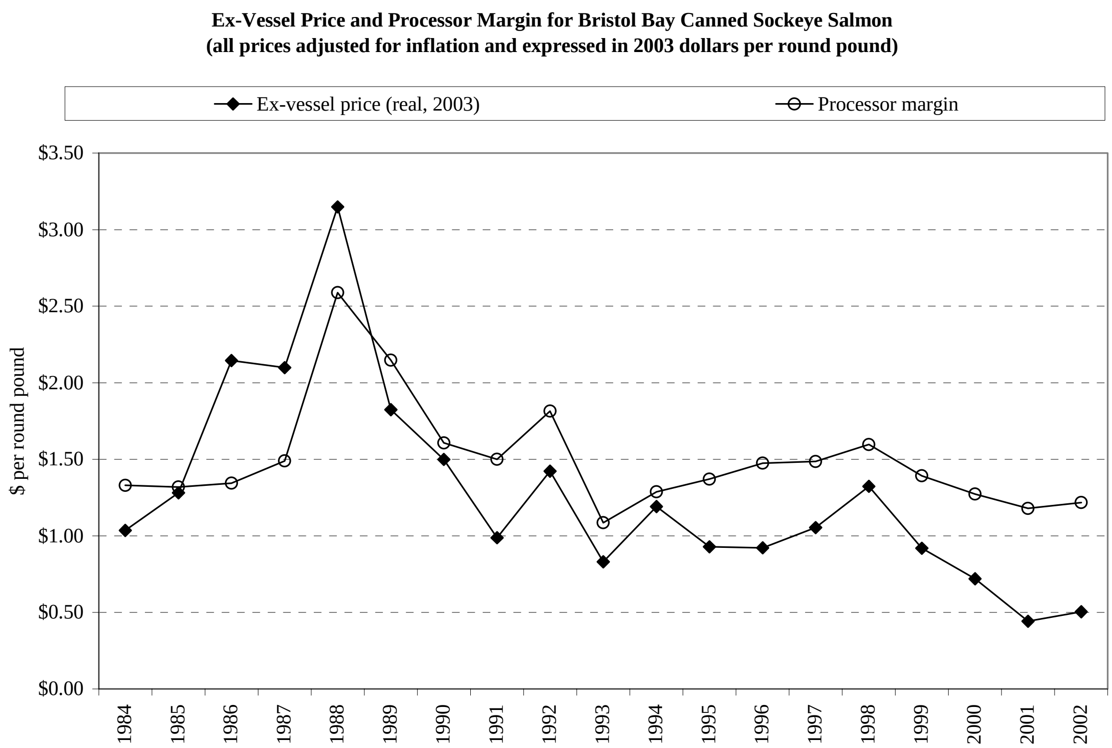
Figure VI-5



Given the significant share of canned salmon in Bristol Bay production, and the close relationship between all three of the price series in Figure VI-5, it is clear that ex-vessel prices are affected by canned salmon market conditions as well as by frozen salmon market conditions. For the past ten years, ex-vessel prices appears to track as well, if not better, with canned production prices as they do with frozen production prices.

Figure VI-6 shows the ex-vessel price and the processor margin for canned salmon. Both have declined since the late 1980s. Ex-vessel prices have fallen more than the processor margin. This means that fishermen have accounted for a greater share of the long-term decline in the canned production price than have processors.[32]

Figure VI-6



What is the outlook for the canned sockeye salmon market in the future? Looking at Figure VI-3 suggests that demand for canned sockeye salmon may be gradually declining. In recent years, prices associated with any given pack volume appear to be lower than they were 10-15 years ago. It is likely that the availability of new, more convenient consumer products is gradually reducing demand for canned sockeye in traditional markets such as the United Kingdom.[33] This could tend to reduce canned sockeye salmon prices over time.

Another factor that might also have a negative effect on canned sockeye salmon markets in the future is competition from canned farmed salmon. Until recently, very little farmed salmon was canned. However, canned farmed salmon production is increasing, particularly in Chile, as salmon farmers seek new markets in response to falling prices for

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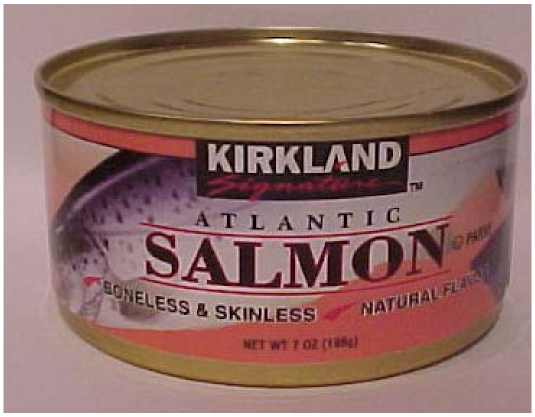
[32] Note, as discussed in Chapter V, that this does not necessarily mean that fishermen have accounted for a greater share of the decline in total profits from fishing and canned salmon processing. Profits depend not only on the ex-vessel price and processor margin, but also on the costs of fishing and processing.
[33] Recall that "demand" is different than volume consumed. As we discuss in Chapter VI, "demand" refers to the volume which consumers are willing to purchase at any given price. If prices are falling, demand may be declining even if consumption is steady or increasing.

fresh and frozen farmed salmon. One indicator of growth in canned farmed production is a rapid increase in United States imports of canned farmed salmon from Chile, from 60 metric tons in 2001 to 2961 metric tons in 2003.[34]

Chilean Canned Atlantic Salmon



Canned sockeye salmon markets could be strengthened by the development of new canned salmon products, such as "skinless-boneless" canned salmon and pull-top cans. Another recent new product form has been plastic pouches, which are thermally processed similarly to canned salmon. At present however these products, which cost more to produce, represent only a small share of total canned sockeye production in Bristol Bay or elsewhere.

The Sockeye Salmon Roe Market

Salmon roe is a valuable product of the Alaska wild salmon industry. Salmon roe is processed into two major product forms: *ikura* (individual eggs or salmon caviar) and *sujiko* (eggs in whole skeins). Most Bristol Bay sockeye salmon roe is processed into *sujiko*.

Ikura

Source: web site of Sanraku Japanese Restaurant: http://www.sanraku.com/sanraku.html#sushi

Sujiko

Source: web site www.tarako.com

To make sujiko, egg skeins are removed from the fish, soaked in brine, and then sorted, culled (for broken skeins) and graded by color and size. They are then carefully packed in wooden boxes and dried for several days at air temperature. Heavy weights are placed

[34]Press reports attributed the closure of a major salmon cannery in Cordova following the 2003 season to the loss of a market for boneless-skinless canned pink salmon at Costco and Sam's Club stores, which chose instead to buy canned Atlantic salmon from Chile (Laine Welch, "Low salmon prices, plant closures marked 2003," *Anchorage Daily News*, January 3, 2004).

on pallets of eggs to compress the eggs in the boxes. High quality sujiko requires firm, unbroken skeins and full, tender eggs.

In Japan, sujiko is eaten both in restaurants and at home. In restaurants, sujiko is cut into bite-size pieces and served with soy sauce and grated radish along with hot sake. At home sujiko is usually served over steamed rice.

Both sujiko and ikura are traditional Japanese food products. While demand for ikura remains strong, sujiko is gradually declining in popularity, which has contributed to a gradual long-term decline in sujiko wholesale prices.

Table VI-2 provides an overview of Alaska statewide sockeye salmon roe production and prices for the years 1991-2002.[35] The value of roe depends upon roe yields (roe volume as a percentage of harvest volume) and roe wholesale prices. Between 1991 and 2002, roe production volume ranged from 1.7% to 2.3% of the total sockeye harvest volume. The real average wholesale price received by Alaska processors trended downwards from more than $7/lb in the early 1990s to less than $5/lb in 2001 and 2002.

Roe accounted for between 3.5% and 8.7% of the total production value (first wholesale value) received by Alaska sockeye salmon processors. The real wholesale value of sockeye roe to Alaska processors *per round pound* processed trended downwards from $.16/lb in the early 1990s to $.10/lb since 2000.[36]

Table VI-2

Overview of Alaska Sockeye Salmon Roe Production and Prices, 1991-2002

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Total harvest volume (million lbs)	255.4	341.8	377.7	291.3	349.6	313.7	188.6	128.0	247.4	206.6	169.8	136.5
Total volume of roe production (million $)	5.0	7.4	8.4	5.8	6.1	5.8	4.0	2.4	4.4	3.9	3.9	2.9
Roe volume as percent of harvest volume	1.9%	2.2%	2.2%	2.0%	1.7%	1.8%	2.1%	1.8%	1.8%	1.9%	2.3%	2.1%
Total value of roe production (million $)	29.5	43.4	50.6	39.0	36.9	27.2	17.6	10.2	22.3	19.5	18.0	13.2
Total value of flesh production: canned, frozen & fresh (million $)	410.8	700.8	530.7	550.6	517.8	565.4	335.8	278.8	444.4	315.8	213.1	206.1
Total production value, flesh & roe (million $)	440.3	744.2	581.3	589.6	554.7	592.7	353.3	289.0	466.8	335.2	231.1	219.3
Roe value as % of total wholesale value	6.7%	5.8%	8.7%	6.6%	6.6%	4.6%	5.0%	3.5%	4.8%	5.8%	7.8%	6.0%
Roe wholesale price per pound ($/lb)	$5.95	$5.88	$6.04	$6.68	$6.09	$4.73	$4.43	$4.31	$5.05	$5.03	$4.62	$4.52
Roe wholesale value per round pound ($/lb)	$0.12	$0.13	$0.13	$0.13	$0.11	$0.09	$0.09	$0.08	$0.09	$0.09	$0.11	$0.10
Roe wholesale price per pound (real 2003 $/lb)	$7.79	$7.45	$7.42	$8.04	$7.12	$5.38	$4.97	$4.77	$5.53	$5.42	$4.84	$4.64
Roe wholesale value per round pound (real 2003 $/lb)	$0.15	$0.16	$0.16	$0.16	$0.12	$0.10	$0.10	$0.09	$0.10	$0.10	$0.11	$0.10

Sources: ADFG Harvest Data; ADFG COAR Data: Note: Roe production data by species are not available for years prior to 1991. All values and prices are in nominal dollars except where otherwise stated.

As shown by Table VI-2, year-to-year changes in sockeye roe value per round pound are relatively small compared to year-to-year changes in wholesale prices of frozen and canned sockeye. Over time, the decline in roe value per round pound would account for

[35]ADFG COAR production data for Bristol Bay sockeye salmon roe are confidential. However, because Bristol Bay accounts for a large share of statewide sockeye salmon harvests and production, it is likely that the statewide roe yields and prices shown in Table VI-2 are similar to Bristol Bay roe yields and prices.

[36] Processors typically use the term "roe credit" for roe value per round pound or processed pound (of frozen or canned product), and account for it as an offset to processing costs.

about \$.05/lb-\$.06/lb of the decline in real ex-vessel prices which has occurred since the early 1990s.

Almost all Alaska salmon roe production is exported. Until the mid-1990s, more than 90% of U.S. salmon roe exports were to Japan. Over the past few years, exports to other countries have risen, particularly Russia. In 2002, 79% of U.S. salmon roe exports went to Japan and 9% went to Russia. However, U.S. export data do not distinguish between sujiko and ikura. It is likely that most salmon roe exports to countries other than Japan are ikura, and that almost all sockeye salmon sujiko is exported to Japan.

Prices paid to Alaska processors for sockeye salmon roe reflect Japanese wholesale prices for sockeye salmon sujiko. In the short term, Japanese sujiko wholesale prices vary from year to year depending upon the total supply of sujiko, which is mostly sockeye and pink sujiko from both North America and Russia (most chum salmon roe is processed into ikura).

Unlike the Japanese frozen salmon market, Japanese salmon roe markets have not been significantly affected by farmed salmon. This is because relatively little roe is produced from farmed salmon, because salmon farmers usually harvest their salmon before the eggs are mature.

Processing Salmon Roe in Bristol Bay

VII. EX-VESSEL SALMON PRICE THEORY

In this chapter we review economic theory of the formation of ex-vessel salmon prices. Our purpose is to identify important factors to consider in forecasting future prices for Bristol Bay round (unprocessed) sockeye salmon.[37]

Basic Supply and Demand Theory

We assume that the reader is already familiar with the economic concepts of supply and demand and how they interact to determine prices.[38] Our may begin by briefly reviewing these concepts as a foundation for applying them to looking at ex-vessel prices.

Supply and demand analysis provides a highly simplified model of how markets work. How useful supply and demand analysis is for understanding any real market—such as the market between processors and fishermen for Bristol Bay salmon—depends on the extent to which the assumptions implicit in the model actually apply for that market. We begin with a very simple model of price formation, which can nevertheless provide useful insights. We then discuss several ways to make the model more realistic in its depiction of the market for Bristol Bay salmon.

Figure VII-1: Supply and Demand Curves

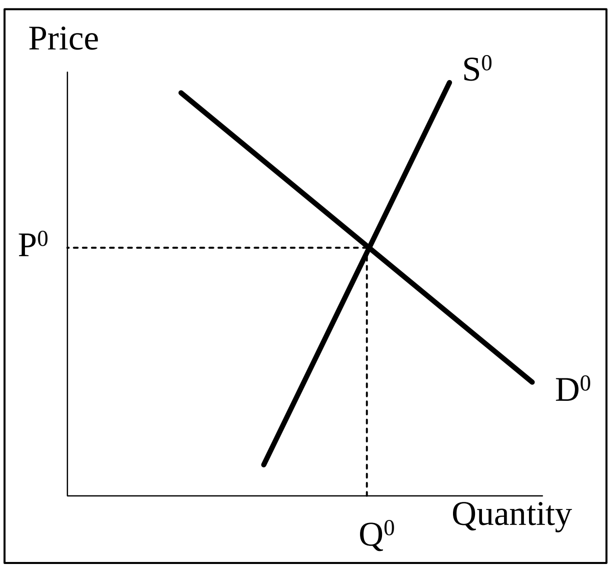


Figure VII-1 shows a supply and demand curves for a hypothetical product (such as Bristol Bay salmon). The upward sloping supply curve S^0 represents the quantity of the product offered for sale at any given price during a specific time period by producers (Bristol Bay fishermen). The downward sloping supply curve D^0 represents the quantity of the product that buyers (processors) wish to purchase at any given price during the specific time period.

"Demand" and "supply" are not fixed quantities. Rather they are relationships between price and how much buyers want to buy, and how much sellers want to sell. How much of a particular product buyers want to buy and how much sellers want to sell depends upon the price.

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[37] For the remainder of this chapter, we will use the term "Bristol Bay salmon" to refer specifically to round or unprocessed salmon, as opposed to processed products such as frozen and canned salmon.

[38] These concepts—which are more subtle than commonly assumed—are explained in any introductory economics textbook. Supply and demand theory is an essential starting point for understanding price formation, regardless of whether markets are the simple "competitive market" ideal or influenced by more complex factors such as oligopsonistic behavior.

Prices are determined by both demand and supply conditions. The price P^0 and the quantity Q^0 represent the price and quantity at which supply and demand are in equilibrium—where the quantity which sellers wish to supply is equal to the quantity buyers wish to sell. Supply and demand theory suggests that the actual price and production will be at (or near to) those represented by the equilibrium levels P^0 and $Q^{0.}$

Numerous factors affect prices. Everything which affects the shape of the demand and the supply curves--as well as the process by which prices approach equilibrium--affects prices.

Figure VII-2: Effect of an Increase in Supply

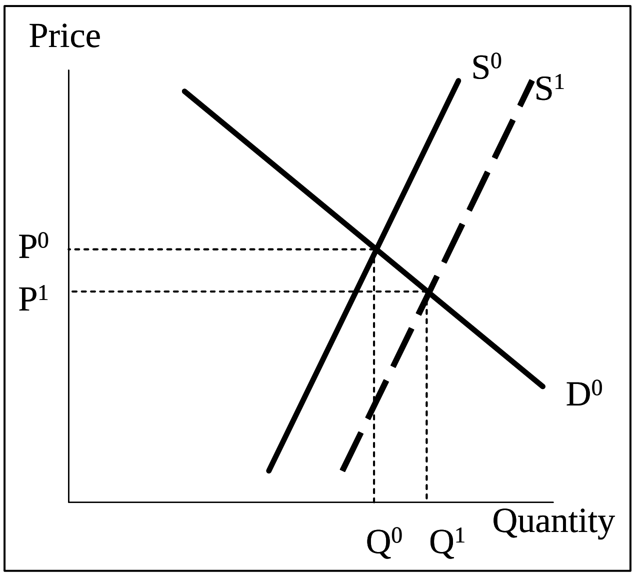


Figure VII-2 shows the effect of an outward shift in supply. At any given price, sellers are willing to supply more of the product than previously. For example, we would expect an increase in the run size to cause the supply curve for Bristol Bay salmon to shift outward, because fishermen are willing to supply more fish at any given price level (because they are able to catch more).

The effect of the outward shift in supply is to lower the equilibrium price at which demand and supply are equal from P^0 to P^1. Note that even though the quantity sold has increased from Q^0 to Q^2, there has been no change in the demand curve.

Figure VII-3: Effect of a Reduction in Demand

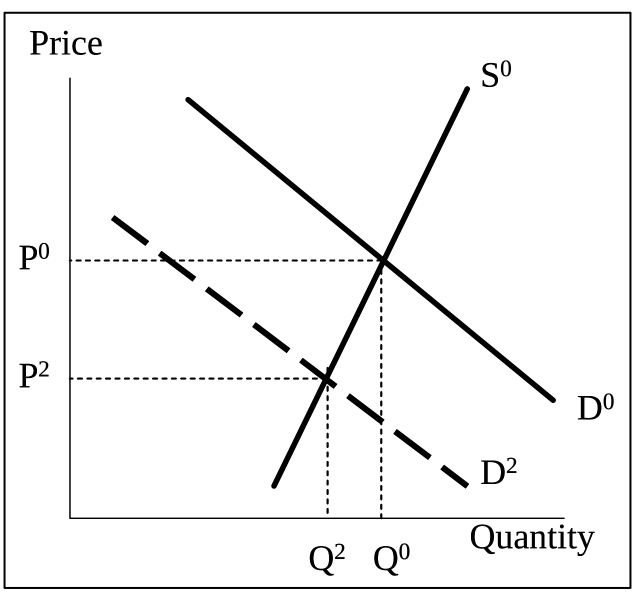


Figure VII-3 shows the effect of an inward (or downward) shift in demand. At any give price, buyers wish to purchase less of the product than previously. For example, we would expect a decrease in the wholesale price for frozen salmon to cause the supply curve for Bristol Bay salmon to shift inward (or downward)

The effect of the inward or downward shift in demand is to lower the equilibrium price at which demand and supply are equal from P^0 to P^2. Note that even though the quantity sold has declined from Q^0 to Q^1, there has been no change in the supply curve.

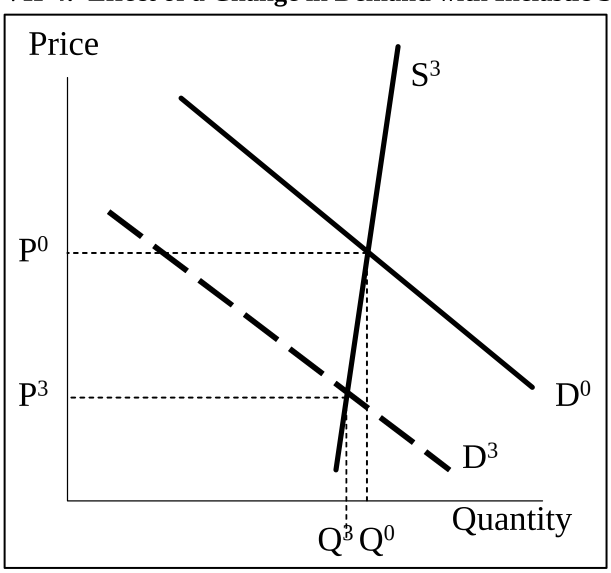
Many different factors affect the shape of the supply and demand curves, and/or may cause these curves to shift over time. Changes in prices may reflect the combined influence of more than one factor. Shifts in both supply and demand may happen at the same time. Different factors may tend to shift the supply curve or the demand curve in different directions.

The Supply Curve for Salmon

Above, we have depicted the supply curve as upward sloping. The logic of this common assumption is that as the price of a good increases, the volume that can be produced profitably increases.

However, rather than being upward sloping, the supply curve for round (unprocessed) Bristol Bay salmon is probably vertical (or nearly vertical) at prices above the level necessary to cover fishermen's costs. This is because as long as ex-vessel prices are high enough to cover fishermen's costs, changes in price will have little effect on the volume that fishermen catch and are willing to supply. If the price rises, fishermen cannot respond by catching significantly more fish, because the supply of fish is limited by nature and by the fishery managers. If the price falls, fishermen will still continue to catch all or most of the available fish, as long as the price exceeds the marginal cost of catching the fish.[39] As a result, over a broad price range, the supply of round (unprocessed) salmon is probably relatively "inelastic" or unresponsive to price, and the supply curve is vertical (or nearly vertical).

VII-4: Effect of a Change in Demand with Inelastic Supply



In Figure VII-4, the supply curve is depicted as more vertical or "inelastic," so that supply is less responsive to a change in price. Note (by comparing with Figure VII-3) that when supply is relatively inelastic, changes in demand have a relatively bigger effect on prices.

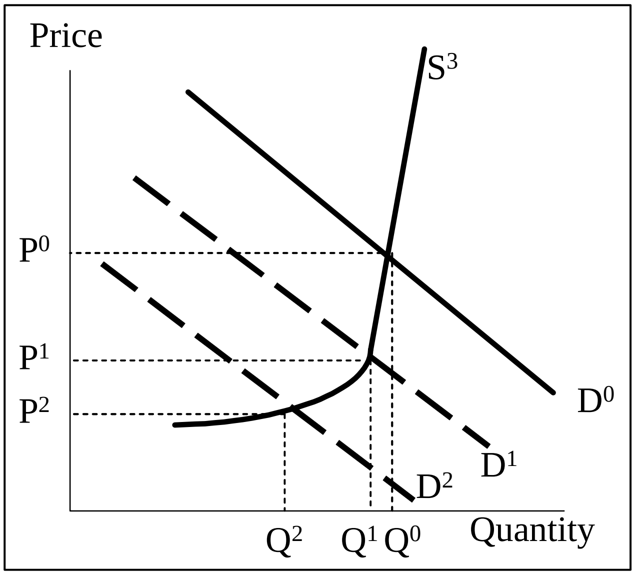
In addition, when supply is inelastic, outward or inward shifts in the supply curve have a relatively bigger effect on prices. Because the volume harvested by fishermen does not adjust to changes in prices, prices must fall or rise more along the demand curve to adjust to

[39] Even though some fishermen may quit fishing as prices fall, the remaining fishermen catch more fish, so that most or all of the available fish are caught—unless prices fall to very low levels—as discussed below.

shifts in the supply curve. The relative inelasticity of supply contributes to relatively large fluctuations in Bristol Bay prices from year to year as salmon runs vary.

Although supply is relatively inelastic at higher prices levels, at lower prices it is likely that the supply curve for Bristol Bay salmon becomes more price elastic. As prices fall to very low levels fishermen may leave an increasing share of the run uncaught, even though the fishery may be open to fishing.

VII-5: Effect of a Changes in Demand When Supply Is Relatively More Elastic at Lower Prices



In Figure VII-5, the supply curve is depicted as relatively more elastic at lower prices. A downward shift in the demand curve from D^0 to D^1 causes a large drop in price (from P^0 to P^1) but only a small drop in quantity supplied (from Q^0 to $Q^{1)}$. However, a similar further downward shift in demand from D^1 to D^2 causes a smaller drop in price (from P^1 to P^2) but a larger drop in quantity (from Q^1 to Q^2).

Note that while the supply of round (unprocessed) Bristol Bay salmon is fairly inelastic (at prices high enough to cover fishermen's costs), the supply of the products made from Bristol Bay salmon (such as frozen and canned salmon) are likely more elastic. While the total catch is driven by nature (run sizes), the production of particular products such as frozen or canned salmon is more elastic (price-responsive) because processors can shift the relative mix of products (frozen vs. canned) in response to changes in prices.

The Demand Curve for Salmon

Processors' demand for round (unprocessed) Bristol Bay salmon is "derived" from the wholesale demand for the products made from the round salmon--frozen, canned, and fresh Bristol Bay salmon and salmon roe. The price processors are willing to pay fishermen for round fish depends on both the wholesale prices they expect to receive for these products, as well as the "margins" they wish to receive between wholesale prices and the ex-vessel price paid to fishermen.

Figure VII-6: Supply and Demand for Round Fish

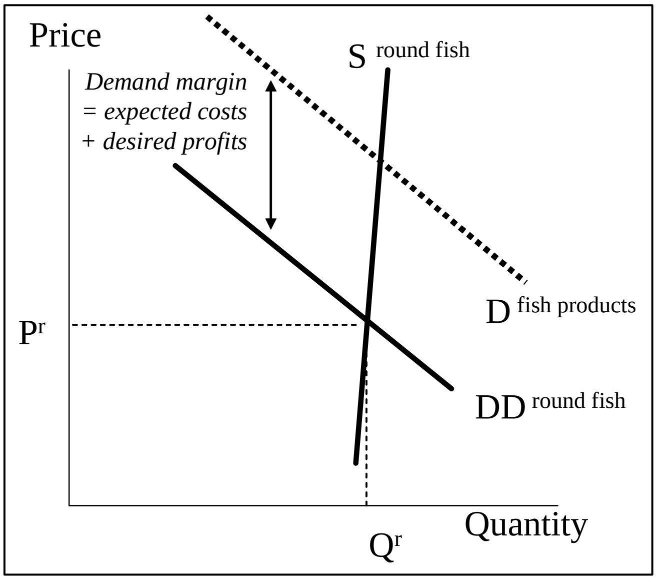


Figure VII-6 shows supply and demand curves for "round" (unprocessed) fish sold by fishermen to processors. The demand curve for round fish ($DD^{\text{round fish}}$) is "derived" from the wholesale demand curve for fish products ($D^{\text{fish products}}$). We refer to the vertical difference between the two demand curves as the "demand margin." The demand margin may vary depending upon the quantity. Below we discuss factors affecting the demand margin and how it is affected by quantity and price.

Mathematically, the demand margin is equal to processors' expected cost per pound plus the profit per pound sought by processors. This can be seen by noting that, for any given quantity:

Desired profit = Expected wholesale price - Ex-vessel price offered - Expected processing cost

and

Demand margin = Expected wholesale price - Ex-vessel price

Therefore

Desired profit = Demand margin - Expected processing cost

and

Demand margin = Expected processing cost + Desired profit

Note that "expected processing cost" refers to the economic definition of "cost," which includes a normal rate of return (from an investment of similar risk) on processors' investment in plant and equipment. Similarly, "profit" refers to the economic definition of "profit" which is that profit over and above a normal rate of return on processors' investment.

Cost of Yield Loss

One element of cost faced by processors is the "cost of yield loss." Technically, this is not an actual cost, but rather the increase in cost "per pound" which results from the loss of weight during processing. As a simple example, suppose a processor buys 1000 pounds of fish from a fisherman for an ex-vessel cost of $1.00 per round pound, or $1000. Suppose (for simplicity) that the product yield is 66.6%, so that the processor gets 666 pounds worth of product from the 1000 pounds of fish he purchased. The cost of fish for the processor is therefore $1.50 per processed pound (= $1000/666 lbs). The increase in cost from $1.00 per round pound to $1.50 per processed pound may be considered a "cost of yield loss." The lower the product yield, the higher the cost of yield loss.[40]

For a meaningful comparison of prices at two different levels in the salmon distribution chain is important to account for the cost of yield loss. One way to do this—which is preferable for comparison of prices in a graph such as Figure VII-6—is to express prices at both levels using the same "weight basis." To compare prices on the same weight basis, both prices can be expressed in dollars per round pound or dollars per processed pound, using one of the following formulas to convert one of the prices:

$$Wr = Wp\,(Y)$$
$$Ep = Er / Y$$

where

Wr & Wr	=	Wholesale prices per round pound and per processed pound
Er & Ep	=	Ex-vessel prices per round pound and per processed pound
Y	=	Percentage yield from round pounds to processed pounds

For our discussion below of the margin between ex-vessel and wholesale prices, we will assume that prices at both levels are expressed on the same weight basis, so that the cost of yield loss has already been accounted for.

Processing Costs

As noted above, one element of the demand margin is processors' expected processing costs. The higher expected processing costs per pound, the greater the margin a processor will "demand" between the wholesale price per pound he expects to receive

[40] The cost of yield loss, expressed in dollars per processed pound, equals the ex-vessel price x (1/yield – 1).

and the ex-vessel price per pound he is willing to offer. Thus any increase in processing costs will, by itself, tend to shift the ex-vessel demand curve down, resulting in a lower equilibrium ex-vessel price.

The effect of quantity purchased on expected processing cost per pound is not obvious. There are some "economies of scale" in fish processing, which tend to reduce costs per pound as the volume processed increases. For example, the larger the volume of fish processed by a given plant and equipment, the lower the cost per pound of the investment in the plant and the equipment. However, other costs per pound may increase as the volume processed increases. For example, costs per pound may increase if workers have to be paid at overtime rates or if the additional fish have to be processed in higher-cost plants, or shipped to other areas for processing.

Processors' Profit

The other element of the demand margin, besides processors' expected processing costs, is processors' desired profit per pound. Recall, as discussed above, that "profit" refers to the economic definition of "profit" which is that profit over and above a normal rate of return on processors' investment.

We might expect processors (like any business) to desire as high a profit per pound as possible, which would imply that they would offer fishermen as low an ex-vessel price per pound as possible. What limits processors' desired profit per pound (and thus the demand margin) is competition among processors. The greater the extent to which processors are competing with each other to buy fish from fishermen, the higher they will bid up the ex-vessel price they offer to fishermen, and the lower the profit per pound they will be willing to accept. As a result, an increase in competition between processors will, by itself, tend to shift the ex-vessel demand curve up, resulting in a higher equilibrium ex-vessel price. The greater the degree of competition between processors, the closer the desired profit will be to zero (implying that processors would earn only a normal rate of return on their investment, equivalent to that which they could earn on an alternative investment of comparable risk). If there is "perfect competition" between processors (so that desired profit is zero), the demand curve for round fish will be equal to the demand curve for fish products minus processing costs.

Similarly, the greater the degree of competition between processors, the greater the extent to which an upward or downward shift in the demand curve for processed fish products will result in a similar upward or downward shift in the ex-vessel demand curve for round fish. To the extent that the processing sector is competitive, equilibrium wholesale prices for fish products and ex-vessel prices for round fish will shift by about the same absolute amount.[41]

[41] Put differently, the less the degree of competition between processors, the less the extent to which an upward or downward shift in the demand curve for processed fish products will result in a similar upward or downward shift in the ex-vessel demand curve for round fish. At the extreme, if there were no competition between processors (if there were only a single "monopolist" fish buyer, or if processors colluded to act like a single monopolist buyer) then a processor could offer fishermen a price just high

The level of competition among Bristol Bay salmon processors has long been a subject of intense debate. It is far beyond the scope of this report to fully discuss the arguments in this debate. Nor would any such discussion be likely to convince those who have already made up their minds about this issue.

For the purpose of this report, we will simply state that a wide variety of evidence suggests that there has been substantial competition among Bristol Bay processors for fish, and that this competition has tended to keep processors' profits at or near "normal" profit levels (for investments of comparable risk), so that upward or downward shifts in the demand curves for fish products have been reflected in upward or downward shifts in ex-vessel demand. This evidence includes the fact that there have been numerous processors; it is relatively easy for new buyers to enter the industry by bringing in floating processors; and historically ex-vessel prices have moved up and down as wholesale prices have moved up and down.[42]

For purposes of projecting future ex-vessel prices, what matters is not how competitive the Bristol Bay processing industry has been in the past, but whether it is likely to become more or less competitive in the future, thus tending to increase or decrease ex-vessel prices. Although the number of processors has declined in recent years, the cause of the decline has clearly been a decline in profitability of the processing industry. If less competition were to cause an increase in processors' profits above normal levels, it is likely that the number of buyers would once again increase, increasing competition and holding profits down. Thus it seems unlikely that changes in competition and processor profits will have a significant effect on future ex-vessel prices in Bristol Bay.

In Figure VII-6, the derived demand curve for round fish was drawn as parallel to the demand curve for fish products—which would imply a constant processing cost per pound and a constant desired profit per pound regardless of the volume processed. However, these two demand curves would not necessarily be parallel. As quantity increases, they might come closer together, or they might diverge.

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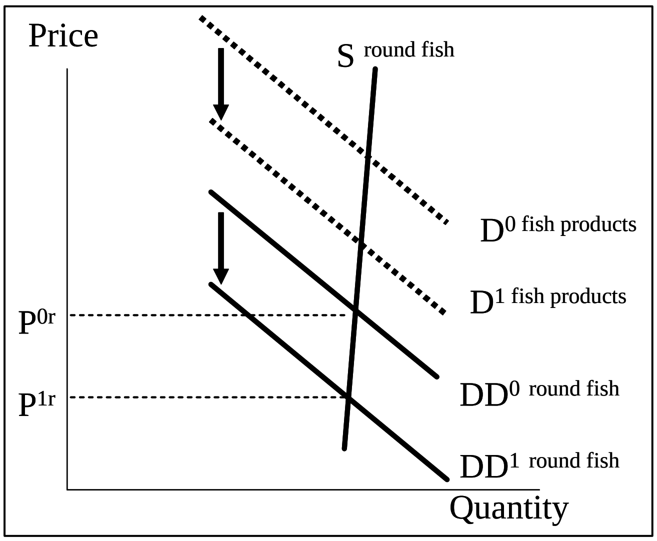
enough to get them to supply fish, and a shift in the demand curve for processed products would have no effect on the ex-vessel demand curve.

[42]The degree of competition in the Bristol Bay fish processing industry was a central issue in *Alakayak vs. All Alaskan Seafoods,* a class-action suit filed in 1996 in which Bristol Bay fishermen alleged price-fixing by Bristol Bay salmon processors and Japanese importers. In 2003, after a widely publicized four-month trial, an Anchorage jury found no evidence of a conspiracy to fix prices after just five hours of deliberation (Wesley Loy, "Seafood Companies Win Trial: Bristol Bay: Fishermen Fail To Convince Jury Of Price-Fixing Claim," *Anchorage Daily News*, May 24, 2003).

Relative Shifts in Wholesale and Ex-Vessel Prices

One important implication of the derived nature of demand for round (unprocessed) fish is that fishermen tend to experience greater relative (percentage) changes in ex-vessel prices than the relative (percentage) changes processors experience in wholesale prices. This is illustrated by Figure VII-7, which depicts the effect of a downward shift in the demand curve for fish products.

Figure VII-7: Effect of a Decrease in Demand for Fish Products



The downward shift in demand for fish products causes a similar downward shift in the derived demand for round fish. Prices paid to both processors and fishermen fall by a similar absolute amount—but the relative (percentage) change in price is greater for fishermen.[43]

This helps to explain why ex-vessel prices tend to be relatively more sensitive to changes in market conditions than wholesale or retail prices. Ex-vessel prices received by salmon fishermen are much lower than retail or wholesale prices, after deducting the significant costs of processing, distribution, and retailing. As a result, changes in retail or wholesale prices tend to result in a greater proportional decline in the prices paid to fishermen—even if only part of the price changes are passed on to fishermen.

Ex-Vessel Demand with Multiple Products and End-Markets

Figures VII-6 and VII-7 depicted situations in which there was just one product made from round salmon and one wholesale demand curve for this product. However, multiple products are made from Bristol Bay salmon—most importantly frozen salmon and canned salmon. We next examine how ex-vessel demand and price is affected when wholesale demand for only one product changes.

[43] Figure VII-7 depicts the downward shift in demand as being similar at both levels, so that the entire decline in demand for fish products is passed on to fishermen. Even if this is not the case—if processors absorb part of the decline in demand for fish through lower profits—fishermen may still experience a greater relative (percentage) decline in prices, because ex-vessel prices are so much lower than wholesale prices.

Figure VII-8: Derived Ex-Vessel Demand from Two Products

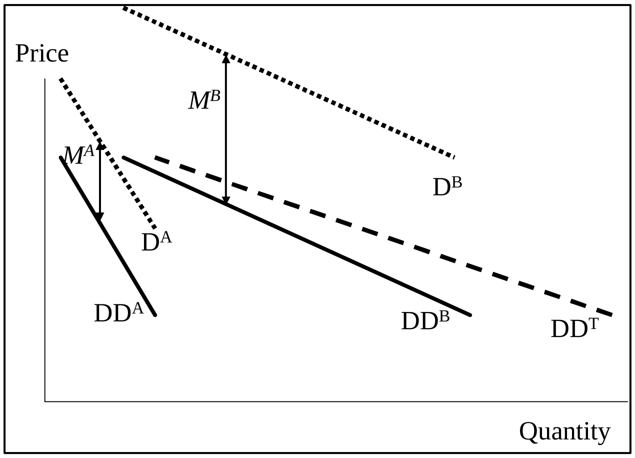
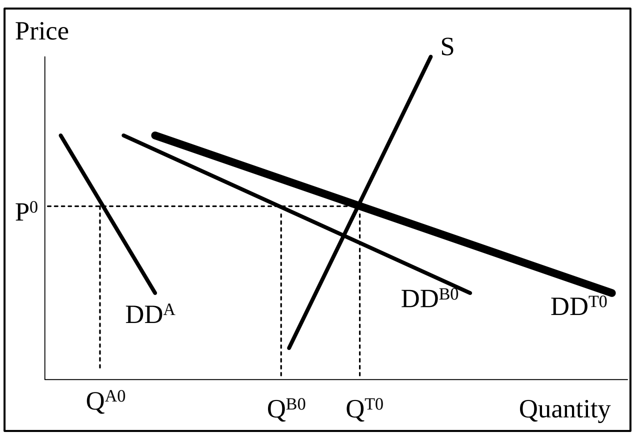


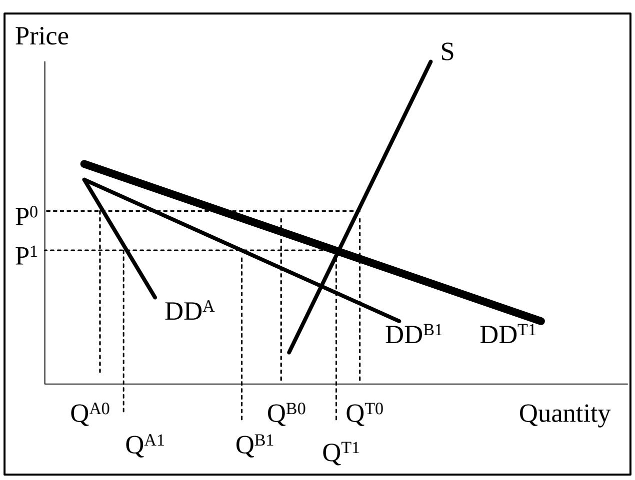
Figure VII-8 depicts the ex-vessel demand curve derived from the wholesale demand curves for two products (A and B). The wholesale demand curve D^A for product A results in a derived ex-vessel demand curve D^{AA} for fish to be used for making product A, separated by demand margin M^A. Similarly, the wholesale demand curve D^B for product B results in a derived ex-vessel demand curve D^{BB} for fish to be used for making product B, separated by a different demand margin M^B, reflecting the fact that processing costs are different for products A and B. The total ex-vessel demand curve DD^T is the horizontal sum of the ex-vessel demand curves DD^A and DD^B.

Figure VII-9: Ex-Vessel Price and Quantity with Two Products



As shown in Figure VII-9, the ex-vessel price P is determined by the intersection of the supply curve S with the total ex-vessel demand curve DD^{T0}. At this price, a total of Q^{T0} fish is purchased from fishermen. The volume of fish used to produce each product is shown by ex-vessel demand for each product at this price, Q^{A0} and Q^{B0}.

Figure VII-10: Effect of a Shift in Demand for One Product



In Figure VII-10 the wholesale and ex-vessel demand curves for product A have stayed the same, but the wholesale demand curve for product B has shifted down, resulting in a downward shift in the ex-vessel demand curve for product B to DD^{B1}. This results in a downward shift in the total ex-vessel demand curve from DD^{T0} (not shown) to DD^{T1}. This in turn causes the ex-vessel price to fall from Q^{T0} to Q^{T1}. It causes the volume of fish used to produce product B to fall from Q^{B0} to Q^{B1}. But it causes the volume of fish used to produce product A (for which demand has not shifted) to *increase* from Q^{A0} to Q^{A1}.

If multiple products are produced from round fish, the effects of a shift in wholesale demand for one product may be summarized as follows. It results in a downward shift in the ex-vessel demand curve and a corresponding decline in ex-vessel price. However, the downward shift in ex-vessel demand and the decline in price are not as great as would have occurred if there had been only one product. There will also be a shift in production away from the product for which demand has decreased towards production of other products. In effect, having multiple products tends to dampen the effect of changes in wholesale demand for any one product on ex-vessel prices.

Complexity of Bristol Bay Salmon Markets

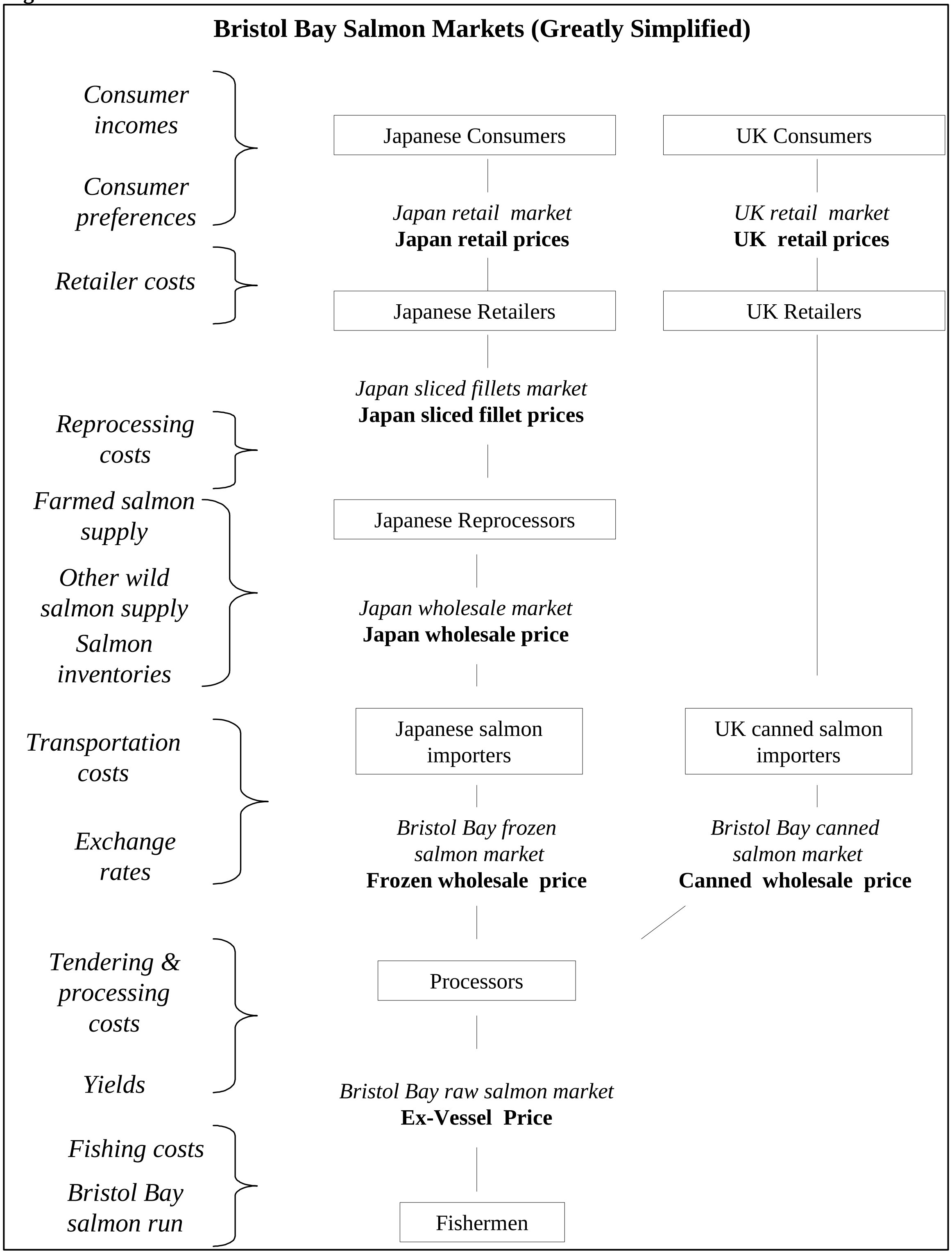
Markets for Bristol Bay salmon are, of course, much more complex than the simple supply and demand graphs discussed above. As depicted in Figure VII-11 (on the following page), there are multiple market levels in multiple distribution chains between fishermen and consumers of multiple products. For a given product, there are also multiple grades and sizes—not shown in the figure--which command different prices. For example, frozen sockeye salmon is typically sold on the Japanese wholesale markets in three different grades (#1, #2 and #3) and three different sizes (2-4 lbs, 4-6 lbs, and 6-9 lbs). Canned sockeye salmon is sold in four different can sizes.

Ex-vessel demand for Bristol Bay round (unprocessed salmon) is affected by demand for all of these products at all of these higher market levels. Similarly, supply at each market level is affected by supply at all lower levels in the distribution chain, beginning with ex-vessel supply by fishermen. Equilibrium prices and quantities in all of these different markets are affected by each other, and are all affected by numerous external or exogenous factors (some of which are shown in italics on the left side of the figure).

A given exogenous factor may affect demand at lower market levels as well as supply at higher market levels. For example, an increase in the value of the Japanese yen will tend to strengthen the buying power (in dollars) of Japanese importers, which increases the demand for frozen salmon, which in turn increases demand for round salmon. This tends to raise both the equilibrium frozen wholesale price and the equilibrium ex-vessel price. An increase in the value of the yen also tends to reduce the cost (in yen) of frozen salmon supplied to the Japanese wholesale market, which tends to lower prices at the Japanese first wholesale level and higher levels.

As another example, if Japanese retail labor costs rise, over time this may result in a downward shift in demand at all lower market levels (causing prices at all lower levels to fall), as well as an increase in the retail supply curve (causing retail prices to rise). More generally, a shift in costs anywhere along the distribution chain may ultimately affect prices at all levels. These effects do not occur instantaneously, but may occur over weeks, months or years.

Figure VII-7


Bristol Bay Salmon Markets (Greatly Simplified)
Consumer incomes
Consumer preferences
Retailer costs
Reprocessing costs
Farmed salmon supply
Other wild salmon supply
Salmon inventories
Transportation costs
Exchange rates
Tendering & processing costs
Yields
Fishing costs
Bristol Bay salmon run
Japanese Consumers
UK Consumers
Japan retail market
Japan retail prices
UK retail market
UK retail prices
Japanese Retailers
UK Retailers
Japan sliced fillets market
Japan sliced fillet prices
Japanese Reprocessors
Japan wholesale market
Japan wholesale price
Japanese salmon importers
UK canned salmon importers
Bristol Bay frozen salmon market
Frozen wholesale price
Bristol Bay canned salmon market
Canned wholesale price
Processors
Bristol Bay raw salmon market
Ex-Vessel Price
Fishermen

Effects of Farmed Salmon on Bristol Bay Salmon Prices

We may use the models developed above to examine expected effects of farmed salmon on past and future Bristol Bay salmon prices. The most obvious expected effect of the growth in farmed salmon supply on Bristol Bay salmon prices is to lower prices by increasing the supply and lowering the price of a substitute.

Farmed salmon is a substitute for wild Bristol Bay salmon, particularly in the Japanese frozen market for red-fleshed salmon. As the supply of farmed salmon to the Japanese market increases, the Japanese wholesale price of farmed salmon declines. This in turn results in a downward (or leftward) shift in demand for frozen Bristol Bay salmon, which in turn results in a downward or leftward shift in the ex-vessel demand for Bristol Bay salmon, and a reduction in wholesale and ex-vessel prices.

Figure VII-10 (above) provides a simple way of depicting the expected static effects of farmed salmon on ex-vessel prices. Competition from farmed salmon has caused the demand curve for frozen Bristol Bay salmon (product B) to shift down, resulting in a downward shift in the ex-vessel demand curve for product B. This results in a downward shift in the total ex-vessel demand curve and the ex-vessel price. It also results in a shift in production away from frozen salmon (product B) to canned salmon (product A), which has been less affected by competition from farmed salmon

The introduction of farmed salmon has also changed the dynamics of salmon markets—how and why prices change over time. Unlike wild salmon fishermen, salmon farmers can adjust production in response to changes in expected profits. If farmers expect to make profits, they have an incentive to expand production; if farmers expect to lose money in the future, they have an incentive to reduce production.

Because of the ability of salmon farmers to adjust production in response to profitability, economic theory suggests that future prices of farmed salmon will average (over periods of several years) close to the cost of production. This is because when the price is above the cost of production—making salmon farming more profitable than other investments of comparable risk—salmon farmers are likely to increase production, causing prices to fall. Conversely, when the price is below the cost of production—making salmon farming less profitable than other investments of comparable risk—farmers will cut back on production, causing prices to rise.[44]

Over shorter periods of time, of course, the price of farmed salmon may be significantly higher or lower than the cost of production. This is because farmers do not know precisely, at the time they begin growing fish, what their collective production will be or how it will affect future prices. Thus they may produce "too much," causing prices to fall below costs of production, so that most or all farmers lose money. Or they may produce "too little," driving prices well above the cost of production.

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[44] We use the term "cost of production" in the economic sense to include the rate of return that could be earned from alternative investments of equal risk. This economic definition of "cost of production" is higher than accounting definitions of cost which do not include opportunity costs of capital.

As average farmed salmon prices rise or fall, average prices for wild salmon which compete with farmed salmon are also likely to rise or fall, in both the long-term and the short-term. The long-term average price of Bristol Bay salmon is likely to move up or down with the long-term average price of competing farmed salmon—which in turn will reflect long-term costs of production of farmed salmon.

Implications for Bristol Bay Price Forecasting

What implications does this brief review of ex-vessel salmon price theory suggest for forecasting future ex-vessel prices of Bristol Bay salmon? A first implication is that forecasting ex-vessel prices based on historical market data is likely to be a challenging exercise.

Ex-vessel prices are determined by complex interactions of supply and demand for many different products at many different market levels. Important factors affecting supply, demand and prices include (but are not limited to):

- The supply of Bristol Bay salmon
- The supply of, and prices of, other kinds of salmon that compete with Bristol Bay salmon, including sockeye salmon from other areas of Alaska and other countries; other species of wild salmon from Alaska and other countries; and farmed salmon and trout.
- Factors affecting demand for the products made from Bristol Bay salmon, such as exchange rates, consumer incomes, demographics, marketing, regulations, and consumer tastes.
- Costs of processing and reprocessing Bristol Bay salmon into different product forms, transporting it to and distributing it within different end markets.
- Costs of fishing for Bristol Bay salmon and other factors which may affect the willingness of Bristol Bay fishermen to supply fish at different ex-vessel prices.

Adjustments to changes in these factors occur over differing periods of time. Partly because of the complexity of Bristol Bay salmon markets and partly because of the lack of data, it is difficult to model ex-vessel price determination empirically to measure how all these factors have interacted in the past to affect prices. At best we are likely to be able to measure the effects of a few key variables.

In addition, year-to-year changes in prices may be driven primarily by different factors from those which drive longer-run changes in prices. Probably most year-to-year changes in prices are driven by factors which change significantly from year to year, such as the supply of Bristol Bay salmon, the prices of other competing salmon, and exchange rates. Other factors which change only gradually from year to year, such as consumer tastes, demographics, and costs of processing, transportation and distribution, may have a much larger cumulative effect on prices over the long time period for which we wish to forecast prices. However, the effects of these slower-changing factors may be difficult to measure empirically because they have varied less historically.

A second--and more subtle--implication of our review of salmon price theory is that farmed salmon has likely changed the long-term dynamics of salmon markets and prices, including Bristol Bay ex-vessel prices. The long-term average price of Bristol Bay salmon is likely to move up or down with the long-term average price and production costs of competing farmed salmon. In effect, the ability of farmers to expand production at prices above their cost of production is likely to keep long-term average prices for both farmed and wild salmon from rising significantly in the future. Similarly, the fact that farmers can not produce for long periods of time for prices below their costs of production may also help to keep long-term average prices for both farmed and wild salmon from falling significantly in the future.

This new dynamic may help to simplify the challenge of projecting future ex-vessel prices for Bristol Bay salmon, if trends in long-term average prices are likely to be tied to trends in farmed salmon costs of production. For this reason, in the following chapter we examine trends in farmed salmon costs of production.

VIII. FARMED SALMON COSTS OF PRODUCTION

As we discussed in the previous chapter, one of the most important factors affecting prices of all salmon is likely to be the cost of production of farmed salmon. Economic theory suggests that future prices of farmed salmon will average (over periods of several years) close to the cost of production. This is because when the price is above the cost of production—making salmon farming more profitable than other investments of comparable risk—salmon farmers are likely to increase production, causing prices to fall. Conversely, when the price is below the cost of production—making salmon farming less profitable than other investments of comparable risk—farmers will cut back on production, causing prices to rise.[45]

Over shorter periods of time, of course, the price of farmed salmon may be significantly higher or lower than the cost of production. This is because farmers do not know precisely, at the time they begin growing fish, what their collective production will be or how it will affect future prices. Thus they may produce "too much," causing prices to fall below costs of production, so that most or all farmers lose money. Or they may produce "too little," driving prices well above the cost of production.

As average farmed salmon prices rise or fall, average prices for wild salmon which compete with farmed salmon are also likely to rise or fall, in both the long-term and the short-term. The long-term average price of Bristol Bay salmon is likely to move up or down with the long-term average price of competing farmed salmon—which in turn will reflect long-term costs of production of farmed salmon.

For these reasons, in projecting the future price of Bristol Bay sockeye salmon, it is important to consider how the costs of farmed salmon which compete with Bristol Bay sockeye salmon may change in the future. In this chapter, we review available evidence about these costs and how they are likely to change in the future

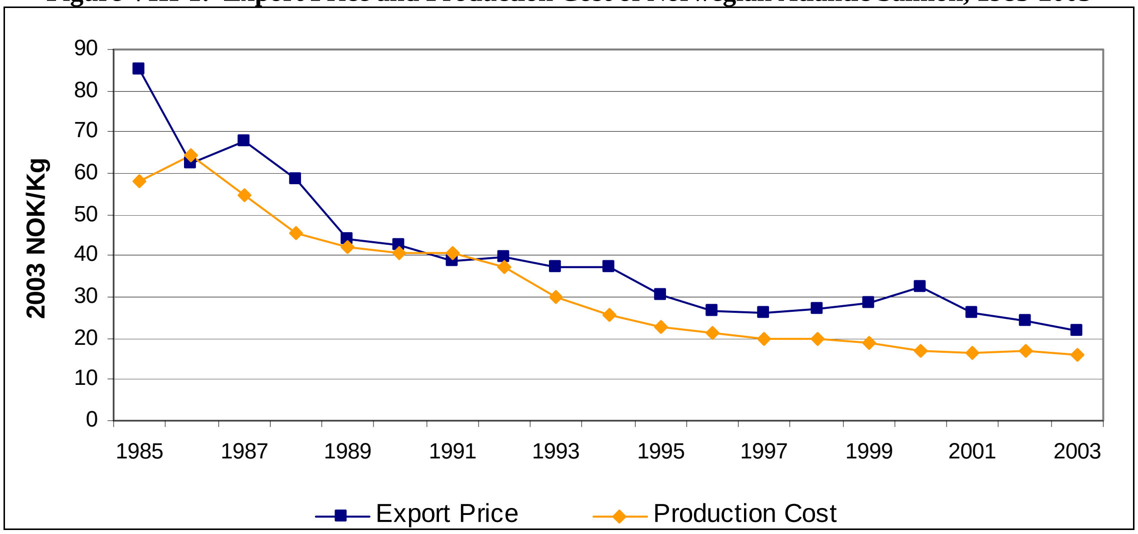
Price and Cost Trends for Norwegian Farmed Atlantic Salmon

This long-term relationship between farmed salmon prices and production costs is best illustrated by price and cost trends for Norwegian farmed Atlantic salmon, as shown in Figure VIII-1. For many years, the Norwegian Directorate of Fisheries has collected aggregate production cost data for the Norwegian fish farming industry, which it has used to calculate the annual average cost of production. The cost of production of Norwegian Atlantic salmon has declined dramatically over time, from more than 50 Norwegian kronor/kg in the mid-1890s to less than 20 kronor/kg since 2000. However, in recent years the rate of decline has slowed.

As costs of production have declined, production has expanded dramatically, driving prices down at a long-run rate similar to the decline in production costs.

[45] We use the term "cost of production" in the economic sense to include the rate of return that could be earned from alternative investments of equal risk. This economic definition of "cost of production" is higher than accounting definitions of cost which do not include opportunity costs of capital.

Figure VIII-1: Export Price and Production Cost of Norwegian Atlantic Salmon, 1985-2003

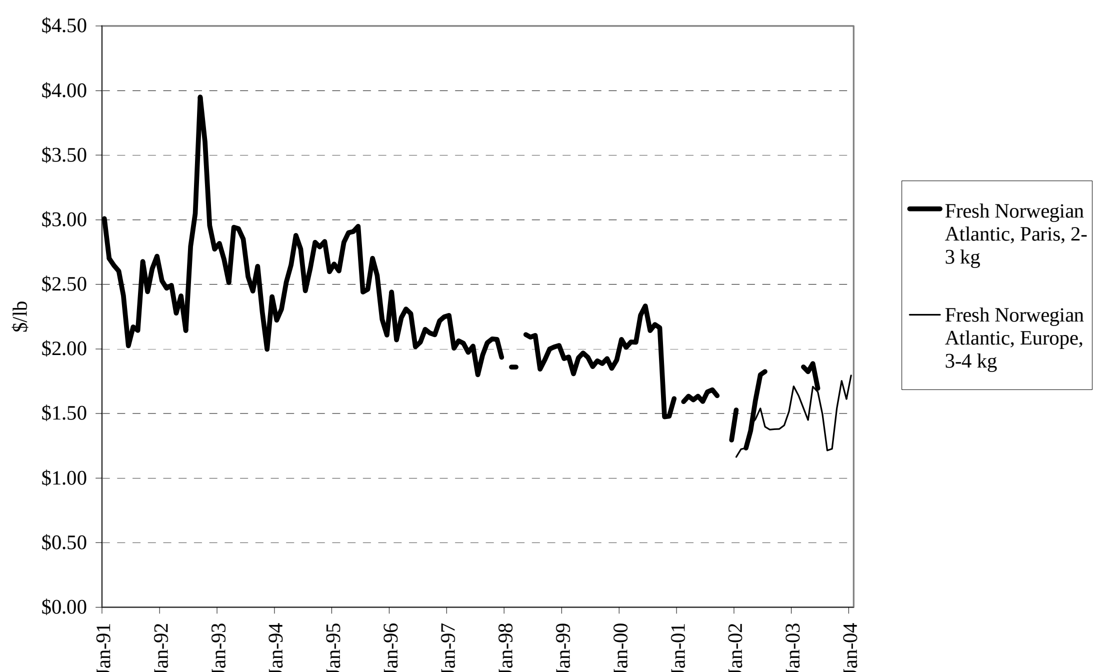


Source: Knapp, Wessells, & Anderson, *North American Wild Salmon and its Economic Interactions with Farmed Salmon* (forthcoming 2004 or 2005). Original source is Norwegian Directorate of Fisheries. 2003 data provided by Frank Asche.

As expected, annual average prices do not track exactly with average costs. There is significant year-to year variation in prices. As shown in Figure VIII-2, within any given year, prices may fluctuate even more widely.

Figure VIII-2

Wholesale Prices of Fresh Atlantic Salmon at the Paris Rungis Market ($/lb)



Challenges in Analyzing Farmed Salmon Costs of Production

A number of challenges arise in analyzing farmed salmon costs of production. One challenge is that the farmed salmon which compete most directly with Bristol Bay salmon are farmed Chilean coho and farmed Chilean and Norwegian Salmon-Trout. However, most of the published studies of salmon farming costs have been for farmed Atlantic salmon. Although the general technology is similar for farming Atlantics, cohos and trouts, there are differences in survival rates, growth rates and feed conversion rates. We cannot necessarily assume that costs are the same—although general trends in costs are likely similar.

Another challenge is that in thinking about the implications of salmon farming costs for wild salmon, what matters is not just the cost of growing the fish, but rather all of the costs involved in getting the fish to the markets where they compete with wild salmon. These include three broad types of costs: "farming costs" (all costs of growing the fish to the point at which they leave the farm), "processing costs" (all costs from when the fish leave the farm until they leave the processing plant in the country of origin); and "distribution costs" (all costs of transporting the fish to market, marketing and sales).

Of the available studies (for any species), most estimate either only farming costs or both farming and processing costs. Very few also estimate distribution costs—in particular distribution costs for supplying farmed salmon to the Japanese market from Chile or Norway.

In estimating and comparing salmon farming costs it is important to measure costs on a common weight basis. Not all available studies specify the weight basis precisely, nor is it always clear what yields should be used to convert costs from different studies to a common weight basis. For our discussion in this chapter, we have attempted to convert all costs to dressed weight basis (gutted, head-on), assuming a dressed weight yield of 90% of round weight.

A problem in comparing costs among countries is the fact that relative exchange rates between currencies vary over time, which affects the relative costs of salmon farming in different countries as expressed in dollars. If the value of the currency in country A rises with respect to the dollar and the value of the currency in country B falls with respect to the dollar, apparent costs in dollars will rise in Country A and fall in Country B.

However, for some cost elements, changes in exchange rates may affect costs in local currencies. One example is the cost of feed, which reflects the costs of internationally traded fish meal and fish oil commodities. For feed, a change in the exchange rate between the dollar and the currency of the producing country is likely to be reflected primarily in the cost of feed as expressed in the currency of the producing country, rather than in the cost of feed as expressed in dollars.

The differing effects of changes in exchange rates complicate attempts to compare costs of salmon farming over time and between countries using dollars or any other common currency. Trends in salmon farming costs over time expressed in dollars partly reflect changes in exchange rates. In addition, apparent relative costs of salmon farming in different countries depend upon the year (and corresponding exchange rates) at which the comparison is made.

Overview of Cost Estimates for Fresh Farmed Atlantic Salmon

Several studies have estimated costs for fresh farmed Atlantic salmon in different countries. In this section we briefly summarize the cost estimates presented in these studies:

- Table VIII-1 summarizes cost estimates prepared by aquaculture business consultant John Forster in a 1995 report for the State of Alaska.

- Table VIII-2 presents estimates prepared by Forster of "indicative costs for an Atlantic salmon farm in 2000."

- Table VIII-3 presents estimates of costs of farming and processing in Chile in 2000 summarized by the Norwegian aquaculture economist Trond Bjørndal.

- Table VIII-4 presents estimated farming and processing costs in 2001 for five different countries by the Norwegian salmon industry consultant Lars Liabø of the firm Kontali Analyse.

- Table VIII-5 presents details for 1998-2002 of the cost estimates prepared by the Norwegian Directorate of Fisheries which were shown in Figure VIII-1. These are the only detailed data on long-term trends in salmon farming costs which are publicly available, as well as the only estimates which are based on aggregate industry averages.

- Table VIII-6 compares salmon farming and processing costs as estimated by these different studies.

Because our primary purpose in this study is to project future Bristol Bay prices, we will not discuss the cost estimates presented above in detail. Rather, we focus on a few points relevant to consideration of current and future costs of salmon farming.

Salmon farming costs vary from farm to farm, from country to country, and from year to year. Thus, there is no single "cost of salmon farming," but rather a range of costs between different regions. Estimates of Atlantic salmon farming costs for the years 2000-2002 vary from as low as $.68/lb (dressed weight basis) to as high as $1.12/lb.

Table VIII-1

Estimates of Costs of Farming, Processing and Distribution for Atlantic Salmon, 1995 (Forster)
($US/lb, dressed weight basis)

	Chile	Norway	Canada West Coast	Canada East Coast
Farming Direct Costs				
Smolt	$.015 - $.025	$0.17 - $0.22	$0.32-$0.38	$0.39 - $0.47
Feed	$0.55 - $0.65	$0.58 - $0.65	$0.60 - $0.75	$0.65 - $0.75
Labor	$0.09 - $0.12	$0.19 - $0.22	$0.16 - $0.23	$0.27 - $0.33
Vaccine/Medication/Health	$0.02 - $0.04	$0.01 - $0.03	$0.03 - $0.05	$0.03 - $0.05
Fish Insurance	$0.02 - $0.05	$0.02 - $0.05	$0.02 - $0.06	$0.02 - $0.06
Other	$0.06 - $0.08	$0.02 - $0.06	$0.05 - $0.10	$0.02 - $0.07
Total Farming Direct Costs	**$0.89 - $1.19**	**$0.99 - $1.23**	**$1.18 - $1.57**	**$1.38 - $1.73**
Farming Fixed Costs				
Operations/Overhead	$0.16 - $0.20	$0.11 - $0.16	$0.13 - $0.17	$0.14 - $0.20
Depreciation	$0.08 - $0.13	$0.05 - $0.10	$0.02 - $0.06	$0.01 - $0.03
Total Farming Fixed Costs	**$0.24 - $0.33**	**$0.16 - $0.26**	**$0.15 - $0.23**	**$0.15 - $0.23**
Finance/Interest Charges	$0.01 - $0.03	$0.05 - $0.13	$0.03 - $0.06	$0.03 - $0.07
TOTAL FARMING COST (FOB Farm Production Cost)	**$1.14 - $1.55**	**$1.20 - $1.62**	**$1.36 - $1.86**	**$1.56 - $2.03**
PROCESSING COST (primary processing & boxing)	**$0.15 - $0.20**	**$0.23 - $0.28**	**$0.25 - $0.29**	**$0.25 - $0.30**
Distribution Costs				
Sales/Marketing	$0.16 - $0.18	$0.14 - $0.18	$0.14 - $0.16	$0.12 - $0.16
Transport to Major Market	$0.45 - $0.55	$0.37 - $0.42	$0.15 - $0.18	$0.10 - $0.15
TOTAL DISTRIBUTION COSTS	**$0.61 - $0.73**	**$0.51 - $0.60**	**$0.29 - $0.34**	**$0.22 - $0.31**
Total Cost F.O.B. Major North American Market	**$1.90 - $2.48 New York**	**$1.94 - $2.50 New York**	**$1.90 - $2.49 Los Angeles**	**$2.03 - $2.64 New York**

Notes: Dressed weight basis is gutted, head on and gills in. Canadian Costs based on exchange rate of $1.00 U.S. = $1.38 CND. Original source is "various industry sources."

Source: John Forster, *Cost Trends in Farmed Salmon*, prepared for Alaska Department of Commerce and Economic Development, June 1995. Available on the website of the Alaska Division of Economic Development at www.dced.state.ak.us/oed/seafood/pub/farmedprices.pdf.

Table VIII-2

Indicative Costs for an Efficiently Run Atlantic Salmon Farm in 2000 (Forster 2002)

Cost item	$/kg (round weight)	$/lb (round weight)	$/lb (dressed weight)*
Juveniles	$0.33	$0.15	$0.17
Feed	$1.10	$0.50	$0.55
Labor	$0.16	$0.07	$0.08
Other cost & overhead	$0.29	$0.13	$0.15
Depreciation	$0.12	$0.05	$0.06
TOTAL FARMING COST	**$2.00**	**$0.91**	**$1.01**

*Cost per pound in dressed weight calculated by dividing by assumed yield of 0.9.
Source: John Forster, "Farming salmon: an example of aquaculture for the mass market," *Reviews in Fisheries Science,* 10 (2002): 577-591.

Table VIII-3

Estimates of Costs of Farming for Atlantic Salmon, Chile, 2000 (Bjørndal)
($US/lb, round weight basis)

Input	Low Technology Centers		High Technology Centers	
	Minimum	Maximum	Minimum	Maximum
Smolt	$0.13	$0.13	$0.12	$0.18
Feed	$0.34	$0.41	$0.31	$0.35
Pigmentation	$0.10	$0.10	$0.07	$0.09
Medication	$0.01	$0.01	$0.00	$0.01
Transport*	$0.00	$0.01	$0.00	$0.01
Labour	$0.05	$0.03	$0.02	$0.01
Subtotal, variable costs	$0.63	$0.69	$0.54	$0.65
Depreciation	$0.04	$0.02	$0.01	$0.01
Administrative costs	$0.02	$0.02	$0.01	$0.01
(Not explained)**	$0.10	$0.07	$0.04	$0.05
Cost of production round weight basis	$0.78	$0.81	$0.61	$0.73
Cost of production, dressed weight basis* **	$0.87	$0.90	$0.68	$0.81

*Transportation of smolts and feed. **Difference between the reported "cost of production" and the total of other costs reported in the table. ***Calculated by dividing by assumed yield of 0.9.
Source: Trond Bjørndal, "The competitiveness of the Chilean salmon aquaculture industry," *Aquaculture Economics and Management,* 6(1/2) 2002. The original source is cited as L. Norheim, "Chilensk oppdrettsnaering sin konkurranseevne paa det internasjonale markedet for laks og oerret," Tredje avdelings utgreiing, NHH, Bergen, Norway, 2000.

Table VIII-4

Estimated Costs of Production for Atlantic Salmon in 2001, Selected Countries (Liabø)
($US/lb, dressed weight basis)

Cost element	How calculated	Norway	Chile	Faroe Islands	United Kingdom	Canada
Farming costs						
Smolt	A	0.12	0.11	0.13	0.23	0.11
Feed	B	0.54	0.64	0.62	0.64	0.42
Labour	C	0.08	0.03	0.05	0.00	0.00
Other operational costs	D	0.21	0.22	0.18	0.15	0.00
Interest/Depreciation	E	0.04	0.10	0.03	0.00	0.00
Subtotal	F = A+B+C+D+E	0.99	1.09	1.00	1.01	0.86
Est. cost delivered cage (round weight)	F = F(adjusted)*	0.99	0.75	1.01	1.06	0.86
Gutting loss	H = G - F	0.11	0.08	0.11	0.12	0.09
TOTAL FARMING COST (Est. cost delivered cage, gutted weight)	**G = F(adjusted)/.9**	**1.10**	**0.83**	**1.12**	**1.18**	**0.96**
PROCESSING COST Harvesting, packing, wellboat	**I**	**0.18**	**0.15**	**0.19**	**0.21**	**0.20**
Total cost, FOB gutted packed salmon	**J = G + I**	**1.28**	**0.98**	**1.31**	**1.40**	**1.16**

Notes: All cost estimates are for 2001. All cost estimates are converted from currency of the producing country to US dollars per pound based on exchange rates provided with the presentation.
*The presentation does not provide any explanation of how or why this adjustment was done.
Source: Lars Liabø, "The Atlantic Salmon Market," powerpoint presentation for "La Industria del Salmón en Chile y su Inserción International," Santiago, Chile, November 2002.

Table VIII-5

Average Costs of Production for Norwegian Farmed Salmon and Trout, 1998-2002

		1998	1999	2000	2001	2002
Costs in NEK/kilo (round-weight basis)	Smolt costs	2.23	2.51	2.40	2.17	2.00
	Feeding costs	9.71	8.53	7.80	7.87	9.02
	Insurance costs (fish)	0.25	0.28	0.26	0.35	0.29
	Wages and salaries	1.61	1.48	1.54	1.44	1.30
	Estimated depreciation	0.65	0.66	0.74	0.85	0.84
	Other operating expenses	2.61	2.82	2.89	2.63	2.72
	NET financial expenses	0.77	0.86	0.50	0.49	0.82
	FARMING COSTS, TOTAL	**17.83**	**17.14**	**16.13**	**15.8**	**17.01**
	PROCESSING COSTS*	**2.19**	**2.54**	**2.39**	**2.49**	**2.51**
	TOTAL, FARMING & PROCESSING COSTS	**20.03**	**19.68**	**18.51**	**18.29**	**19.52**
Exchange rate (NEK/$)		7.55	7.80	8.81	8.99	7.97
Costs in $/lb (round-weight basis)	Smolt costs	$0.13	$0.15	$0.12	$0.11	$0.11
	Feeding costs	$0.58	$0.50	$0.40	$0.40	$0.51
	Insurance costs (fish)	$0.02	$0.02	$0.01	$0.02	$0.02
	Wages and salaries	$0.10	$0.09	$0.08	$0.07	$0.07
	Estimated depreciation	$0.04	$0.04	$0.04	$0.04	$0.05
	Other operating expenses	$0.16	$0.16	$0.15	$0.13	$0.15
	NET financial expenses	$0.05	$0.05	$0.03	$0.02	$0.05
	FARMING COSTS, TOTAL	**$1.07**	**$1.00**	**$0.83**	**$0.80**	**$0.97**
	PROCESSING COSTS*	**$0.13**	**$0.15**	**$0.12**	**$0.13**	**$0.14**
	TOTAL, FARMING & PROCESSING COSTS	**$1.20**	**$1.14**	**$0.95**	**$0.92**	**$1.11**
Costs in $-lb (dressed-weight basis)**	FARMING COSTS, TOTAL	$1.19	$1.11	$0.92	$0.89	$1.08
	PROCESSING COSTS*	$0.15	$0.16	$0.14	$0.14	$0.16
	TOTAL, FARMING & PROCESSING COSTS	$1.34	$1.27	$1.06	$1.03	$1.23

*Includes freight, slaughter and packaging costs. **Calculated by dividing by assumed yield of 90%.
Source: Norwegian Directorate of Fisheries, http://www.fiskeridir.no/english/pages/statistics/index.html. Costs in NEK per kilogram were calculated by the Directorate of Fisheries by dividing total pounds by total reported costs. Exchange rate data are annual rates posted on the Bank of Norway website: http://www.norges-bank.no/stat/valutakurser/.

Table VIII-6
Comparision of Selected Estimates of Atlantic Salmon Farming and Processing Costs

Study	Producing area & species	Year	Feed cost	Other farming costs	Total farming cost	Processing cost	Total cost, farming & processing
Forster 1995	Chile	1995	$0.55 - $0.65	$0.59-$0.90	$1.14 - $1.55	$0.15 - $0.20	$1.29 - $1.45
Forster 1995	Norway	1995	$0.58 - $0.65	$0.62-$0.97	$1.20 - $1.62	$0.23 - $0.28	$1.43 - $1.90
Forster 1995	Canada West Coast	1995	$0.60 - $0.75	$0.76-$1.11	$1.36 - $1.86	$0.25 - $0.29	$1.61 - $2.15
Forster 1995	Canada East Coast	1995	$0.65 - $0.75	$0.91-$1.28	$1.56 - $2.03	$0.25 - $0.30	$1.81 - $2.33
Forster 2002	Unspecified	2000	$0.55	$0.46	$1.01		
Bjørndal 2002	Chile	2000	$0.31-$0.41	$0.37-$0.49	$0.68-$0.90		
Liabø 2002	Norway	2001	$0.54	$0.55	$1.10	$0.18	$1.28
Liabø 2002	Chile	2001	$0.64	$0.20	$0.83	$0.15	$0.98
Liabø 2002	Faroe Islands	2001	$0.62	$0.50	$1.12	$0.19	$1.31
Liabø 2002	United Kingdom	2001	$0.64	$0.55	$1.18	$0.21	$1.40
Liabø 2002	Canada	2001	$0.42	$0.54	$0.96	$0.20	$1.16
Norway DOF	Norway	1998	$0.65	$0.54	$1.19	$0.15	$1.34
Norway DOF	Norway	1999	$0.55	$0.56	$1.11	$0.16	$1.27
Norway DOF	Norway	2000	$0.45	$0.48	$0.92	$0.14	$1.06
Norway DOF	Norway	2001	$0.44	$0.44	$0.89	$0.14	$1.03
Norway DOF	Norway	2002	$0.57	$0.51	$1.08	$0.16	$1.23

Note: All costs are on a dressed-weight basis. Sources for studies are reported in Tables VIII-1 through VIII-5, as follows: Forster 1995: Table VIII-1; Forster 2002: Table VIII-2; Bjørndal 2002: Table VIII-3; Liabø 2002: Table VIII-4; Norway DOF: Table VIII-5.

Salmon farming costs have declined significantly in recent years. This is reflected most dramatically and reliably in Norwegian average farming costs (Figure VIII-1 and Table VIII-5). However, other cost estimates also show dramatic cost reductions. For example, Forster estimated Chilean costs at $1.14-$1.55/lb (dressed weight basis) in 1995, while Bjørndal and Liabø estimated Chilean costs at $0.68-$0.90 lb in 2000.

A number of different factors have contributed to the decline in salmon farming costs.[46] One of the most important factors has been increased feed conversion efficiency. In Norway, feed conversion ratios (FCR), measured in terms of kilograms of feed per kilogram of salmon fell from around 3 in the 1980s to 1.19 in 1999. The reduction in FCR resulted from a number of factors including better broodstock, improvements in nutrition, better feeding technology, and more effective disease management. These in turn allowed for a higher share of feed to be eaten by salmon, better growth per kilogram of feed eaten by salmon, and better survival rates (so that less feed was eaten by fish which did not survive to marketable size).

A second factor important factor has been economies of scale. Both individual salmon farms and salmon farming companies have grown larger, which has resulted in increased labor efficiency and a reduction in management and overhead expenses.

[46]Our discussion of factors contributing to the decline in costs is based on Knapp et al, North American Wild Salmon and Its Economic Interactions with Farmed Salmon (forthcoming 2004), citing A. Guttormsen, "Input factor substitutability in salmon aquaculture," *Marine Resource Economics* 17:91-102 (2002) F. Asche, F., T. Bjørndal, and E.H. Sissener, "Relative productivity development in salmon aquaculture," *Marine Resource Economics* 18:205-210 (2003).

More generally, the decline in salmon farming costs reflects a continuous search by the industry for opportunities to reduce costs.

Note that while costs have trended downwards over time, there is significant year-to-year variation in costs. For example, average Norwegian costs of farming and processing rose from $1.03 per dressed pound in 2001 to $1.23/lb in 2002 (Tables VIII-5 and VIII-6), driven mostly by an increase in feed costs. Year-to-year variation in costs results from primarily from variation in growth and survival rates due to factors such as water temperature and disease.

As noted above, in thinking about competition between farmed and wild salmon what matters is not just farming costs, but rather all of the costs involved in getting the fish to the markets where they compete with wild salmon—including processing costs and distribution costs. Limited available data suggests—not surprisingly—that distribution costs vary widely for different combinations of producing countries and end-markets. Countries with relatively higher farming and processing costs (such as Canada) can compete with countries with lower farming and processing costs (such as Chile) in part because they face lower costs of transportation to end-markets (the United States).

As discussed above, relatively little data about distribution costs are available publicly. This complicates any attempts to analyze the important question of the cost at which farmed salmon can be delivered to the different markets in which it competes with Bristol Bay salmon and other wild salmon. Note that distribution costs include not only costs of transportation by air or sea, but also costs of cold storage, marketing and sales.

Cost Estimates Reported in the Japanese Trade Press

Because fresh Atlantic salmon accounts for by far the largest share of world farmed salmon production, most studies of salmon farming costs have focused on costs of production for fresh Atlantic salmon. We were unable to locate any detailed studies of costs for the frozen farmed coho salmon and trout which compete with Bristol Bay sockeye salmon in the Japanese market.

However, from time to time articles in the Japanese seafood industry trade press, as translated in the newsletter *Bill Atkinson's News Report*, refer explicitly or implicitly to costs of coho and trout farming, production and/or distribution. Tables VIII-7 and VIII-8 present some of these references for recent years.

Table VIII-7

Estimates of Costs of Supplying Farmed Coho and Trout to the Japanese Market
Derived from Japanese Trade Press Articles Translated in *Bill Atkinson's News Report*

Type of cost	Estimate	Basis for Estimate
Total costs for for Chilean farmed coho sold at wholesale in Japan	Well above $1.12/lb	"The current wholesale prices [300 to 330 ¥/kilo ($1.02-$1.12/lb) are well below the production, shipping and marketing costs for the Chilean salmon farmers." [BANR, Issue 940, February 27, 2002]
	Considerably more than $1.21/lb	"One of the major brokers [at the Tokyo Central Wholesale Market] released their list prices for new sales of frozen Chilean coho. Daito Gyorui announced that 4-6 lb coho from Chile will be offered at ¥350/kilo ($1.21/lb), with 2-4 and 6-9 lb sizes to be listed at ¥330/kilo ($1.15/lb). These wholesale list prices are between ¥20 and ¥30/kilo (7¢-10¢/lb) higher than the prices at the end of last year. Daito explained that the Chilean producers face considerable losses, even at the slightly higher wholesale price levels. And the situation will only be made worse by the recent rapid decline in the value of the yen. In addition, Daito feels that wholesale prices are low enough for the users, and further reductions will only make it more difficult for the Chilean producers to reorganize and restructure their industry. [BANR, Issue 933, January 9, 2002]
	$1.53-$1.56/lb	"In order to cover the $1.00/kilo (45 cents/lb) shortage currently faced by the producers, the wholesale price would have to be somewhere between ¥420 and ¥430/kilo ($1.53-$1.56/lb)." [BANR, Issue 952, May 29, 2002]
	$1.59/lb	"Although the prices are relatively low, compared with six months ago, many are more interested in a stable market more than pushing for price increases. Some have indicated that the current price of just over ¥400/kilo ($1.59/lb) is enough to sustain operations, and they currently hope that the market will remain stable through the start of the next season in the fall." [BANR, Issue 1049, May 19, 2004].
	$1.60-$1.64/lb	"The pace of reducing the number of [Chilean coho] salmon in the pens could increase over the next couple of months, if it doesn't appear that prices in Japan will increase, and maintain levels, that can cover the estimated $1.00/kilo (45 cents/lb) losses being sustained at the current wholesale price levels ["current" prices are unclear from this article, but are apparently ¥330-¥340/kilo, $1.20-$1.24/lb] [BANR, Issue 952, 5/29/02]
	$1.65/lb	One major importer indicates that they need to learn from the trends seen in the Chilean coho market this season. They feel that a wholesale price of just over ¥400/kilo ($1.65/lb) is enough to cover the producers' costs, and they shouldn't be concerned about ¥10 to ¥20/ kilo (4¢-8¢/lb) fluctuations in the price. It is more important that the producers/importers have confirmed sales outlets for their coho. The development of stable sales routes should allow them to smoothly market their production throughout the year. [BANR, Issue 1048, May 12, 2004].
	Only slightly lower than $1.84/lb	"The wholesale price for premium 4-6 lb Chilean coho is currently around ¥430/kilo ($1.84/lb) . . . The current wholesale price is already at levels that are close to the actual production costs of the Chilean producers, which only adds to the problems faced by both importers and producers." [BANR, Issue 1034, February 4, 2004]
	$1.70-$1.86	"To the extent they think about it at all, the Japanese (buyers) talk about the minimum long-term sustainable price of farmed coho and trout as being about 450 yen/kilo. What that means depends of course on the exchange rate." [Personal discussion with an Alaska seafood processor, May 2004.] [Note: ¥450/kilo = $1.70/lb at an exchange rate of ¥120/$ and $1.86/lb at an exchange rate of ¥110/$.]
Total costs for for farmed trout sold at wholesale in Japan	Considerably above $1.09-$1.12/lb	"At this point, the wholesale price for 4-7 lb salmon trout has recovered to around ¥320 to ¥300/kilo ($1.09-1.12/lb) . . . The current wholesale prices are considerably lower than the actual production cost." [BANR, Issue 936, January 30, 2002]
	Supply to Japan limited at prices less than $1.72/lb	"Chilean salmon-trout won't fill the supply gap in Japan [for salmon-trout]. Unlike farmed coho, the Chilean producers have a variety of different markets for their salmon-trout . . . At this point opinions about the supply vary among the importers and users in Japan. Most concur that wholesale prices will be the main determining factor. At prices of more than ¥400/kilo ($1.72/lb, the supply will increase, at lower levels, the supply will remain limited." [BANR, Issue 1046, April 28, 2004; conversion to $/lb based on April 2004 rate of 105 yen/$.]
Cost of Production for Japanese Farmed Coho Producers	$1.61/lb	"Based on production costs, the [Japanese farmed coho] producers will need a minimum average price of ¥380/kilo ($1.61/lb), with something over ¥400/kilo ($1.70/lb) more in the comfort area." [BANR, Issue 886, February 7, 2001]

Presumably these references to cost in the Japanese press are based on industry rules-of-thumb about costs. We do not know how reliable they may be. Different references suggest different cost levels Some of this variation results from variation over time in the exchange rates used to convert costs into dollars.

Despite these limitations, Japanese press estimates present a useful general indication of the cost range faced by Chilean producers and Japanese importers in supplying Japanese farmed coho and trout to the Japanese market, as well as how the trade press discusses costs and the implications of prices at different market levels for whether Chilean farmers and Japanese importers are making or losing money.

Most of the references in the top part of Table VIII-7 suggest that the total cost of supplying Chilean farmed coho salmon to the Japanese wholesale market have been in the range of $1.53-$1.65 over the past several years. We could not find any corresponding specific costs estimates for farmed trout, although costs similar to those for farmed coho would be consistent with the available references, shown in the middle of Table VIII-7. At the bottom of Table VIII-7, one reference suggests a "cost of production" for Japanese farmed coho of $1.63/lb (but it is unclear whether this includes cost of transportation within Japan, marketing and sales).

Another approach to estimating the cost of supplying farmed Chilean salmon and trout to the Japanese market is to add estimated costs of production in Chile to estimates of distribution costs derived from Japanese press articles. Liabø estimated total farming and processing costs for fresh farmed Chilean Atlantic salmon at $0.98 per dressed pound. There are at least two important differences in costs of farming and processing for Chilean coho sold to Japan. First, coho are sold frozen rather than fresh. Secondly, they are sold head-off rather than head-on. We have no data on the difference between Chilean processing costs for frozen and fresh salmon. However, adjusting for the lower yield of head-off farmed coho we may assume that the cost per pound of farming and processing for frozen farmed Chilean coho would be at least 12.5% higher[47] than the $0.98/lb for estimated by Liabø , or $1.10/lb.

Table VIII-8 shows estimates of the spread between the Chilean FOB price and Japanese wholesale cost, which range between $0.25/lb and $0.34/lb for recent years. Adding $0.25-$0.34/lb for distribution costs to farming and processing costs of at least $1.10/lb would suggest a Japan wholesale cost of at least $1.35-$1.44/lb. This is consistent with the total supply cost of $1.53-$1.65/lb suggested by press articles.

[47] Based on the assumption that the yield for head-off dressed frozen farmed coho salmon is 80% compared with the standard assumed yield of 90% for head-on dressed fresh Atlantic salmon, thus increasing costs/lb by 1/8 or 12.5%. Note that the yield for frozen headed and gutted frozen wild coho is typically assumed to be about 75%. (Chuck Crapo, Brian Paust and Jerry Babbitt, Recoveries and Yields from Pacific Fish and Shellfish, Alaska Sea-Grant College Program, MAB-37, Revised 1993. Available at http://www.uaf.edu/seagrant/Pubs_Videos/pubs/MAB-37.pdf.)

Table VIII-8

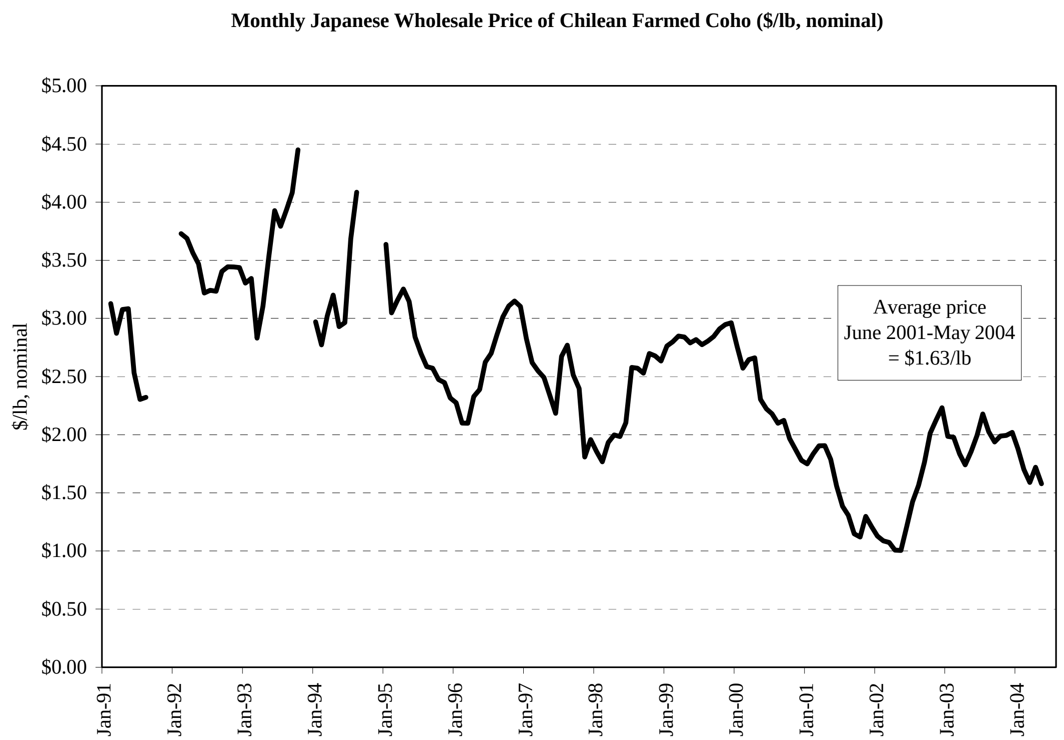
Estimates of Distribution Costs of Farmed Coho and Trout Supplied to the Japanese Market Derived from Japanese Trade Press Articles Translated in *Bill Atkinson's News Report*

Spread Between Chile FOB Price and Japan Wholesale Cost	$.25-$.30/lb	"Reports place the purchase price somewhere between $3.50 and $3.60/kilo ($1.59-1.64/lb) FOB Chile. At the current exchange rates, this would result in a Japan wholesale cost of about ¥ 500/kilo ($1.89/lb) for this product." [BANR Issue 963, August 14, 2002]
	$.29-$.32/lb	". . . Japanese importers started buying the coho at FOB prices of about $3.00/kilo ($1.36/lb) last December. . . This FOB price allowed for a Japan wholesale cost of ¥420 to ¥430/kilo ($1.65-$1.68/lb)." [BANR, Issue 886, February 7, 2001
	$.34/lb	"[Chilean coho salmon] was reportedly sold to two Japanese buyers at a fixed FOB price of about $3.50/kilo ($1.59/lb) . . . Based on this FOB price and the current exchange rate [about 118 yen/dollar], the coho from this first round of shipments willl arrive in Japan with a wholesale cost of about ¥500/kilo ($1.93/lb)." [BANR Issue 964, August 21, 2002]

Inferring Costs from Long-Term Price Trends for Farmed Salmon

Another way to infer costs of production for farmed salmon is from long-term price trends for farmed salmon. As suggested above, we would expect that over time the price of farmed salmon is likely to average (over periods of several years) close to the cost of production. As has occurred with Norwegian salmon, we would expect that average prices to decline as costs of production decline.

Figure VIII-3

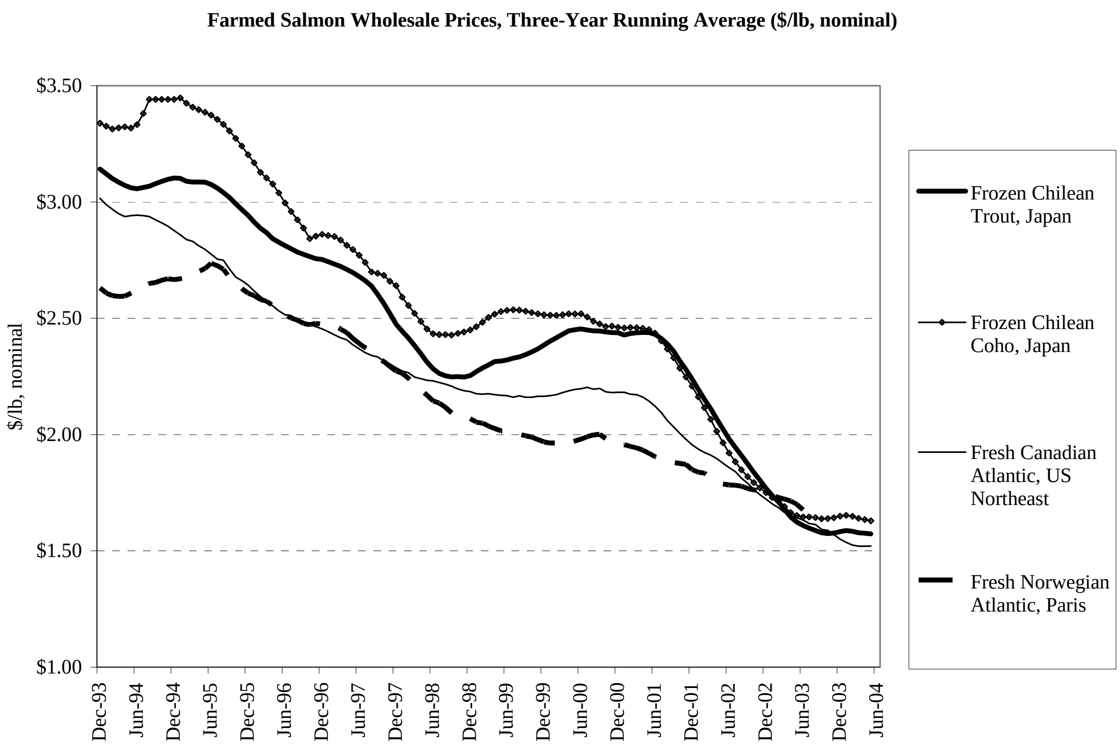


What can we infer from Japanese wholesale prices about costs of supplying Chilean farmed coho salmon to the Japanese market? As shown in Figure VIII-3, monthly Japanese wholesale prices of Chilean coho have fluctuated widely in recent years--from $2.96/lb (December 1999) to $1.00/lb (May 2002) to $2.23/lb (December 2002) to $1.76/lb (March 2004).

These prices are consistent with the wholesale cost range of $1.53-$1.65/lb implied by articles in the Japanese trade press. Although the price fell below this level for part of 2001 and 2002, it rose above this level in 2003 and then fell to within this range in 2004.

Figure VIII-4 shows three-year running averages for prices of farmed Atlantic salmon, coho salmon and trout in markets in Japan, the United States, and Europe.[48] In all markets, average prices have declined dramatically. Over the past five years (three-year running averages for the past two years), average prices have been similar for all three markets. This suggests that costs are similar for all three markets, or that all three markets are part of a world market in which prices move together, or both. For the past year, the three-year running average wholesale price of Chilean coho in Japan has been about $1.63/lb.

Figure VIII-4



To deduce more about costs from wholesale prices, we would need to examine additional evidence about the causes of the changes in prices, and whether they are consistent with the theory outlined at the beginning of this chapter: that prices below average costs cause production to fall (causing prices to rise) and prices above average costs cause production to rise (causing prices to fall). These are not easy questions to answer, partly because of the multi-year time lag between when farmers begin growing salmon and when they

[48] The price plotted for each month is the average of prices for that month and the preceding 35 months.

reach marketable size, which make it difficult to examine the relationship between supply and prices.

Assumption about Current Farmed Salmon Cost of Production

For this study we will assume, based upon the limited available data,that the current average cost of farming, processing and distributing farmed coho and trout to the Japanese market is about $1.63/lb. This is not a precise estimate but it is consistent with the available information. It is likely that costs are lower for some producers and higher for other producers.

Note that this assumption does *not* imply that the Japanese wholesale price in any given year is equal to or even close to $1.63/lb. Rather it implies that at current costs of production, if the price rises significantly above $1.63/lb, production will increase, eventually causing prices to fall. If the prices falls significantly below $1.63 lb, production will decrease, causing prices to rise.

Future Trends in Farmed Salmon Costs of Production

What can we assume about future farmed salmon costs of production? Reasonable arguments can be made that costs will continue to decline—or that costs will stabilize or rise.

The argument for a continued decline in costs rests on a continuation of the trends that have caused costs and prices to fall since the beginnings of the salmon farming industry, including better survival rates, faster growth rates, improvements in feed conversion efficiency, increased productivity (lower labor costs), and economies of scale. The most efficient farms have lower costs than the average, demonstrating the potential for further cost reductions. Salmon farming remains a very young industry in comparison with most forms of animal husbandry: there is little reason to think that current farming techniques cannot be improved upon.

Of particular importance in lowering future costs could be the development of genetically superior broodstocks with faster growth rates, better feed conversion efficiencies, increased disease resistance, and tolerance for a broader range of oxygen levels and water temperatures. This could come about gradually through traditional selection of better-performing fish as broodstock, or more rapidly through transgenic technology.[49]

[49] Massachusetts-based Aqua Bounty Technologies has developed stable lines of transgenic Atlantic salmon with economically desirable traits such as cold tolerance, disease resistance and faster growth rates. The company has applied to the US Food and Drug Administration (FDA) for permission to market these transgenic salmon. Whether, by whom, and on what basis permission should be granted is a subject of considerable controversy. More generally, successful use of genetically modified organisms by salmon farmers will require overcoming not only technological obstacles but also a variety of political and consumer concerns related to food safety and environmental safety. (Knapp et al, *North American Wild Salmon and Its Economic Interactions with Farmed Salmon* forthcoming 2004 or 2005. See Chapter II, footnote 3 for a more detailed reference to this report.)

The argument for stable or rising costs rests on increases in some costs as world production of farmed salmon (and other farmed species) increases. Feed makes up a large proportion of farming costs—generally half or more. As production of salmon and other carnivorous fish species such as cod increases, demand for fish meal and fish oil will increase. Eventually this may lead to increases in the costs of feed and in turn salmon farming costs.

As shown in Figures VIII-5 and VIII-6 (on the following page), the rapid growth of farmed salmon production has not been accompanied by any clear trend in fish meal and fish oil prices. Rather, prices for fish meal and fish oil have fluctuated significantly, without any obvious upward or downward long-term trend, reflecting changes in supply which affect the stocks of the species which account for most world production of fish meal and fish oil. Increased use of fish meal and fish oil for aquaculture feed has been possible by reducing the share going to other agricultural industries, which still account for most world consumption. Eventually, however, supply limitations combined with increased demand could cause fish meal and fish oil prices to rise.

However, extensive research is underway to develop feeds which use less fish meal and fish oil (and more vegetable-based proteins), as well as to develop fish less dependent on fish-based feeds. This could help to offset potential increases in feed costs resulting from scarcity of fish meal and fish oil.

Another argument for stable or rising costs is the potential for stricter regulation of aquaculture as public concerns about environmental effects of salmon farming increase. These concerns could lead, for example, to requirements for better safeguards against fish escapes, reduced stocking densities, or more frequent "fallowing" of fish sites—all of which might lead to higher costs. In the extreme, they could lead to prohibitions on farming in some areas.

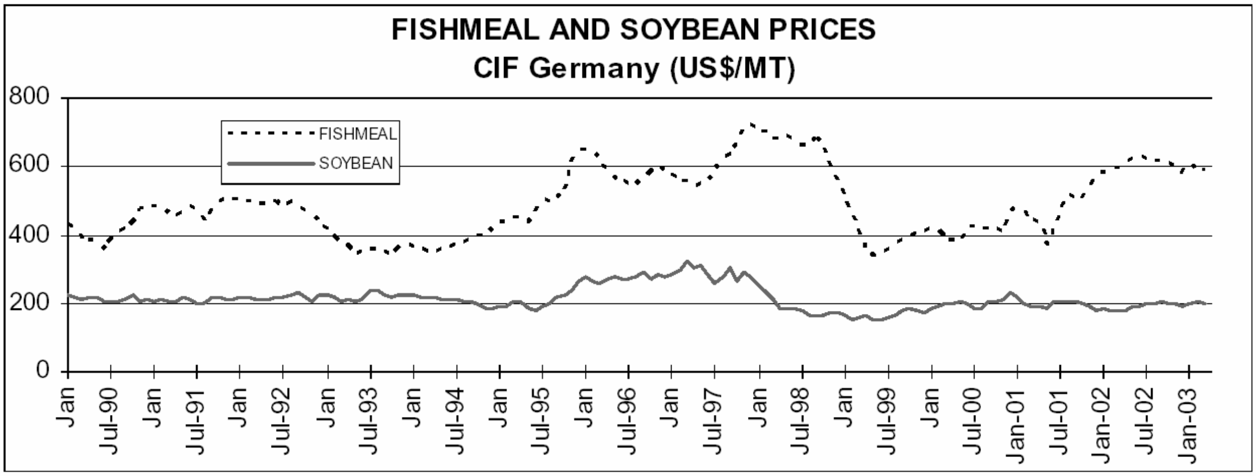
As farmed salmon production grows, as well as farmed production of other species, new farming sites may need to be developed which may have higher costs of infrastructure and transportation. For example, as Chilean farmed salmon production expands, new production sites are located increasing farther south.

Finally, as noted earlier, although Norwegian salmon farming costs (shown in Figure VIII-1) have continued to decline in recent years, the rate of decline has slowed greatly, with very little change in costs for the four most recent years.

Given these different arguments, it is difficult to conclude with any certainty whether farmed salmon costs of production will fall or rise in the future. However it appears reasonable to conclude that that costs may either fall or may rise, but will not change rapidly or dramatically.

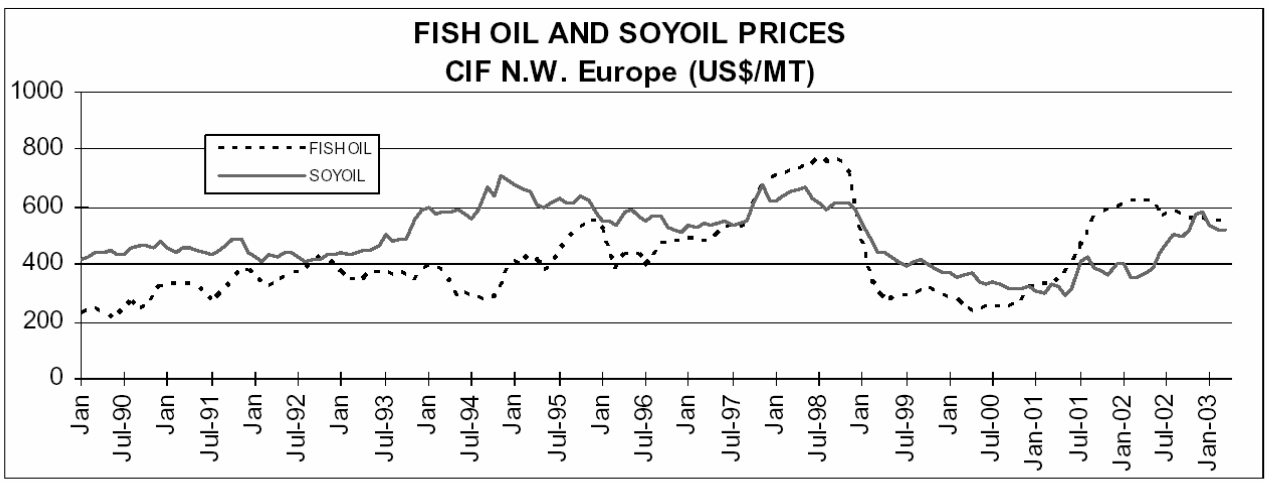
For this study we will assume that future salmon farming costs will be stable at current levels, with the factors tending to lower costs balanced by the factors tending to raise costs.

Figure VIII-5



Source: FAO Fisheries Industries Division, *Globefish Commodity Update, Fishmeal and Fish Oil*, March 2003.

Figure VIII-6



Source: FAO Fisheries Industries Division, *Globefish Commodity Update, Fishmeal and Fish Oil*, March 2003.

IX. GENERAL CONSIDERATIONS IN FORECASTING FUTURE BRISTOL BAY SOCKEYE SALMON PRICES

As we discussed in Chapter I, a specific goal of this report was to provide the Commercial Fisheries Entry Commission (CFEC) with

> ". . . forecasts of the probable range of future salmon ex-vessel prices in Bristol Bay, [including a] written description of the assumptions used and how the forecasts were derived, [as well as] forecasts of how future Bristol Bay ex-vessel prices will vary with changes in harvest levels given assumptions about probable levels of other relevant factors."

In this chapter, we describe general considerations in developing forecasts of future Bristol Bay salmon prices. These form the basis for our approach to developing a price forecasting equation and assumptions in Chapters X and XI.

General Mathematical Form of the Price Forecasting Equation

Upon consultation with CFEC, we agreed that the specific objective of the analysis was to provide CFEC with a mathematical equation which could be used to forecast future Bristol Bay sockeye salmon prices, given assumptions about future Bristol Bay sockeye salmon harvests as well as other explanatory variables. While CFEC would develop its own assumptions about harvests (consistent with its assumptions for analysis of optimum permit numbers), we would provide CFEC with recommendations for assumptions about other explanatory variables in the equation.

In mathematical terms, our objective was to develop an equation of the form:

$$P^t = f\,(H^t, X_1^t, X_2^t, \text{etc.})$$

where

t = year
P^t = ex-vessel price of Bristol Bay salmon in year t
H^t = assumed harvest of Bristol Bay salmon in year t
X_i^t = assumed value of explanatory variable X_i in year t

We recognized the inherent uncertainty in long-term assumptions about the explanatory variables H^t and X_i^t. Rather than attempt to develop "best" point estimates of these explanatory variables, we recommended that CFEC consider the future values of these variables to be probability distributions rather than single point estimates. The future Bristol Bay price would then also be a probability distribution. Through repeated calculations of the forecasting equation drawing explanatory variables randomly from their assumed distributions, it would be possible to estimate a forecasted probability distribution for the future price.

For example, in forecasting the price of Bristol Bay sockeye in some future year, what the harvest might be in that future year is clearly uncertain. Rather than attempting to predict a single best point estimate of what the harvest might be in that future year, it makes more sense to think of that harvest as being within a given range—such as the range that past harvests have fallen within. Similarly, we may also think of other potential explanatory variables in the price forecasting equation as being within a given range, which can be described by a probability distribution.

For its optimum number analysis, CFEC planned to assume that distribution of future harvests would be similar to that of past harvests within the historical time period 1978-2003. For other explanatory variables in the equation, we recommended to CFEC that assumptions for future years be expressed in terms of a mean and standard deviation of a normal distribution. Thus in mathematical terms, for each explanatory variable $X_{i,}$ our objective was to develop assumptions, for a future 25-year period (2005 through 2030), about the normally distributed random variables X_i^t , expressed as $E(X_i^t)$ = expected value of X_i in year t and $SD(X_i^t)$ = standard deviation of X_i in year t.

Differences Between Explaining Past Prices and Forecasting Future Prices

As we discuss in Chapter X, to develop our price forecasting equation, we first used regression analysis to examine historical relationships between ex-vessel prices and potential model explanatory variables. We then assumed that these historical economic relationships would continue to hold in the future. This is a common and useful approach for developing a forecasting model.

Often the goal of regression analysis is limited to understanding historical relationships among economic variables. A wide variety of sophisticated statistical techniques have been developed for this purpose. These allow us to test for how statistically significant our results may be, to test and correct for potential sources of bias in our results, and to decide which models or equations are "better."

For explaining historical price variation, we want to choose the models or equations which "best" explains historical price variation and is least likely to be biased as to the estimated effects of each explanatory factor. However, it is important to understand that the models or equations which are "best" for explaining historical price variation are not necessarily "best" for forecasting future prices, for several reasons.

Availability of Explanatory Variables

In explaining historical price formation, we have a wide variety of data about different potential explanatory variables which may have affected prices in the past. We should incorporate available data into a model of historical price formation if they make theoretical sense and if they are statistically significant. In contrast, in forecasting future prices, we do not have data for future values of explanatory variables. Instead we must make assumptions about their future values. Our confidence in our forecasts is limited by our confidence in these assumptions. If we have no independent ability to forecast future values of a potential explanatory variable, it does not help to include it in the model. A model which does well at "predicting" historical prices based on known historical values of explanatory variables will not help at forecasting future prices if the explanatory variables are unknown and we have no reasonable way to forecast them. A simpler model which doesn't do as well predicting historical prices may be more useful if it is based on explanatory variables whose future values we can forecast with greater confidence.

Potential for Future Structural Change

If structural change occurs in the future, a model which "fits" past data well will not necessarily do well at forecasting future prices. Thus the fact that a model fits historical data well—while encouraging--does not necessarily mean that it will be a good forecasting model. In the extreme, if we believe the future period will be different from the past, it may be more useful to develop a forecasting equation in a different way, rather than basing it on historical economic relationships among variables.[50]

There is no statistical solution to the problem of future structural change. Statistical analysis of past relationships between variables cannot provide insights into whether future structural change may occur.

The farther we attempt to forecast into the future, the greater the potential for structural change to occur between the time period over which the equation was estimated and the period for which the forecasts will be made. The dramatic changes that have occurred in world salmon markets and the Bristol Bay fishery in recent years suggest that future structural relationships in the market could well differ from those which prevailed over most of the period for which we have data.

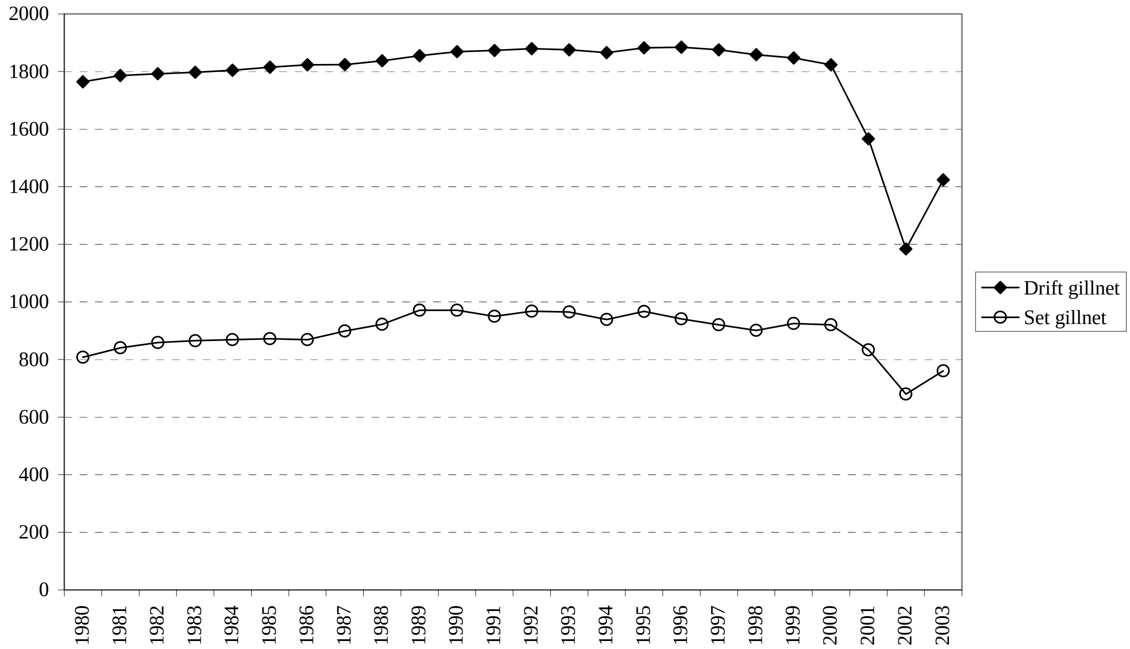
One indicator of potential recent structural change is the abrupt drop in the number of Bristol Bay permits fished after 2000. As shown in Figure XI-1 (on the following page), for a twenty-year period prior to 2000, almost all Bristol Bay permits were fished, and there was very little variation from year to year in the number of permits fished. Clearly, significant change occurred in the fishery. Whether this change would affect the process of ex-vessel price determination is uncertain. However, it suggests that we can not be indifferent to the potential for future structural change.

As we discuss in the following chapter, historically when Japanese wholesale prices have fallen, Bristol Bay ex-vessel prices have also fallen. Future structural change might possibly change this relationship, because further declines in ex-vessel prices are limited by the prices at which fishermen would be willing to continue fishing.[51]

[50] One example of a different approach would be to survey knowledgeable people in the industry about their expectations for future price levels.
[51]This potential response to low prices is illustrated in Figure VII-5 in Chapter V. At low prices, the supply curve becomes more horizontal (less steep), limiting the extent to which prices fall in response to an inward shift in the demand curve.

Figure IX-1

Number of Limited Entry Permits Fished in Bristol Bay



Source: CFEC Basic Information Tables

Incremental Benefit from a "Better" Equation

In explaining historical price variation, a model or equation which is "better"—as measured by indicators such as R-squared or statistical significance of particular coefficients—is clearly a better model. But in choosing among potential forecasting equations, an equation with a better historical fit is not necessarily the best for forecasting purposes. The fundamental uncertainty associated with a forecast may be so great that a "better" equation makes an insignificant contribution to our confidence in the forecasts. Other criteria, such as simplicity or transparency (our ability to understand what is driving the forecasts) may be more relevant.

General Considerations

As in any forecasting exercise, the choice of how to model future Bristol Bay prices, as reflected in the answers to these questions, ultimately depends on the judgment of the modelers. In developing a model or equation to forecast future Bristol Bay prices, we sought to balance several different considerations:

- Historical Performance. As discussed above, one way of evaluating a model is to look at how well it would have predicted prices in the past. A model should do reasonably well at forecasting what prices would have been in the past. However, this is not the sole or necessarily the most important consideration.

- Ability to Forecast Explanatory Variables. We must have a reasonable way of forecasting the explanatory variables which drive the model. This was a particularly important consideration for this study, because of the long forecasting period.

- Reasonableness. Our model should make sense. It should give forecasts that are plausible. Changing the explanatory variables that drive the model should change the forecasts in ways that experience and theory suggest make sense.

- Usefulness. How useful a model is depends upon its intended use. The issue is not whether the forecasts are perfect, but whether they are good enough for what they will be used for.

- Simplicity. For forecasts to be useful, we need to be able to understand them, and we need to be able to explain them to other people. A model and the assumptions behind it cannot be so complex that we (and others who are evaluating our analysis) can't understand how the forecasts are derived.

- Cost. We do not have unlimited time or budget to develop our forecasting equation. As in any kind of analysis, the potential benefits from improving the model through further analysis must be balanced against the costs of further analysis.

As we discuss in Chapter X, we ended up recommending that CFEC use a relatively "simple" equation, with only two explanatory variables, to forecast ex-vessel prices for its optimum number study. We also recommended that CFEC use relatively "simple" assumptions about future values for these explanatory variables.

We are well aware of numerous limitations to this equation. We are well aware that it does not represent a perfect forecast of future ex-vessel prices. We can suggest many reasons why future prices might be higher or lower than the range of prices we have projected.

However, we believe that our forecasting equation represents a reasonable way to balance the considerations discussed above--given the inherent constraints of the complexity of markets for Bristol Bay salmon and other competing salmon, the limitations of available data, the uncertainty associated with future values of the factors which will drive future prices, and the uncertainty about the future economic relationships between those variables and Bristol Bay prices.

The issue is not whether the approach we have used to forecast future prices is perfect, or whether our forecasts will prove accurate. It is whether a more reasonable and practical approach for forecasting future prices is available, and whether it is possible to derive forecasts which are likely to prove more accurate.

X. REGRESSION ANALYSIS OF BRISTOL BAY EX-VESSEL PRICES

As discussed in the previous chapter, an important goal of this study was to develop an equation which CFEC could use to forecast future ex-vessel prices for Bristol Bay sockeye salmon in its optimum number study. For this study, we estimated several different potential specifications for a forecasting equation using Ordinary Least Squares regression analysis of annual data for part or all of the period 1980-2003.

For all of these equations, the dependent variable was either the real ex-vessel price of Bristol Bay sockeye salmon, or its natural logarithm. We used independent variables which we considered potential explanatory variables for Bristol Bay ex-vessel prices, and for which it might also be possible to develop independent future assumptions which could "drive" ex-vessel price forecasts. We estimated linear, log-linear and log-log specifications of different equations[52]; we report on the most statistically significant functional forms of each equation.

In this chapter we discuss four regressions for which the results were most interesting, significant, and/or potentially useful as price forecasting equations. These regressions are summarized in Table X-1. Tables X-2 and X-3 (on the following page) provide information on the data used for these equations. As we discuss below, we recommend that CFEC use Regression 4 to forecast ex-vessel prices for its optimum number study.

Table X-1
Summary of Regression Results

Reg.	Y	C0	C1	X1	C2	X2	C3	X3	Years	n	Deg. of fr.	Adj. R^2
1	Ex-Vessel Price	-0.53	+0.435	Sockeye Wholesale Price					1980-2003	24	22	.88
2	ln (Ex-Vessel Price)	2.37	-.00000931	Bristol Bay Sockeye Harvest	-.00000131	World Farmed Salmon Supply	-0.00667	Exchange Rate	1980-2002	23	19	.83
3	ln (Ex-Vessel Price)	2.56	-.00000847	Bristol Bay Sockeye Harvest	-.0000148	World Farmed Coho Supply	-0.00759	Exchange Rate	1980-2002	23	19	.80
4	ln (Ex-Vessel Price)	4.22	-0.531	ln (Bristol Bay Sockeye Harvest)	+1.40	ln (Farmed Coho Wholesale Price)			1991-2003	13	10	.80

Note: All equations were of the form Y = C0 + C1(X1) + C2(X2) + C3(X3) and were estimated using Ordinary Least Squares in Excel. All estimated coefficients were significant at the 1% level except for the intercept of Regression 4 which was significant at the 2% level.

[52] We use the term "log-linear" to refer to regressions of the form $\ln(Y) = C_0 + C_1(X)$, and the term "log-log" to refer to regressions of the form $\ln(Y) = C_0 + C_1\ln(X)$, as defined in James H. Stock and Mark W. Watson, *Introduction to Econometrics* (Addison-Wesley, 2003).

Table X-2

Regression Analysis Variables: Definitions, Sources, and Years for Which Data Were Available

Simple variable name	Formal variable name	Definition	Source	Years
Ex-Vessel Price	R03_BB_S420_XVP	Bristol Bay sockeye real ex-vessel price (2003 dollars per pound)	CFEC Bristol Bay data	1980-2003
Bristol Bay Sockeye Harvest	BB_S420_MT	Total Bristol Bay commercial sockeye harvest (metric tons)	CFEC Bristol Bay data	1980-2003
Sockeye Wholesale Price	JAWHPRI_BBSOCK_ AUGREAL03	August real Japanese wholesale price of sockeye salmon (real 2003 dollars per pound)	Tokyo Central Wholesale Market Data; Seafood News Power Data Book; FIS Japan Frozen Wholesale Prices Data	1980-2003
Farmed Coho Wholesale Price	JAWHPRI_ FARMCOHO_ ANNREAL03	Simple annual average Japanese wholesale price for frozen farmed Chilean coho (real 2003 dollars per pound)	Seafood News Power Data Book; FIS Japan Frozen Wholesale Prices Data	1991-2003
World Farmed Salmon Supply	WWFARMED_MT	Total world farmed salmon and trout production (metric tons)	FAO Fishstat+ data	1980-2002
World Farmed Coho Supply	WWFARMED_COHO_MT	Total world farmed coho salmon production (metric tons)	FAO Fishstat+ data	1980-2002
Exchange Rate	NOM_XR_YENDOL	Nominal exchange rate between the yen and the dollar (expressed in yen per dollar)	Federal Reserve Bank of St. Louis Exchange Rate Data	1980-2003

Table X-3

Data Used for Regression Analysis

Year	Ex-Vessel Price	Bristol Bay Sockeye Harvest	Sockeye Wholesale Price	Farmed Coho Wholesale Price	World Farmed Salmon Supply	World Farmed Coho Supply	Exchange Rate
1980	$1.08	60,264	$4.93		13,053	2,560	225.717
1981	$1.35	71,991	$4.76		18,577	1,746	221.463
1982	$1.14	43,806	$4.42		22,890	2,921	250.058
1983	$1.05	96,029	$3.38		32,663	3,509	237.667
1984	$1.04	63,238	$3.86		42,429	6,412	238.571
1985	$1.28	61,758	$4.54		59,375	9,361	235.383
1986	$2.15	43,223	$5.20		83,047	10,416	166.933
1987	$2.10	43,465	$5.35		103,330	16,556	142.879
1988	$3.15	39,821	$7.91		163,842	25,812	128.213
1989	$1.82	74,370	$5.50		226,015	30,293	138.175
1990	$1.50	87,223	$4.64		299,007	39,164	145.017
1991	$0.99	67,818	$3.39	$3.62	353,766	44,385	134.279
1992	$1.42	82,810	$4.33	$4.36	344,625	48,513	126.453
1993	$0.83	110,476	$3.33	$4.46	412,355	49,154	110.608
1994	$1.19	88,660	$4.64	$3.86	501,176	58,700	101.418
1995	$0.93	110,299	$3.14	$3.33	603,327	58,360	94.034
1996	$0.92	84,349	$3.40	$3.01	731,368	76,197	109.296
1997	$1.05	32,989	$3.67	$2.72	853,078	84,867	121.715
1998	$1.32	26,175	$4.09	$2.52	920,572	88,302	131.205
1999	$0.92	61,572	$3.16	$3.11	1,017,177	89,575	113.356
2000	$0.72	56,962	$2.49	$2.44	1,159,396	108,626	108.363
2001	$0.44	43,380	$2.07	$1.59	1,396,923	150,986	122.039
2002	$0.50	29,473	$2.31	$1.51	1,425,263	112,845	124.654
2003	$0.50	42,362	$2.14	$1.96			117.668
Average	$1.23	63,438	$4.03	$2.96	468,837	48,663	151.882
Minimum	$0.44	26,175	$2.07	$1.51	13,053	1,746	94.034
Maximum	$3.15	110,476	$7.91	$4.46	1,425,263	150,986	250.058

Regression 1: Ex-Vessel Price = C0 + C1 (Sockeye Wholesale Price)

For Regression 1, the dependent variable is the ex-vessel price and the single explanatory variable is the Japanese August wholesale price for sockeye salmon, converted to real dollars per pound using the nominal August exchange rate between the yen and the dollar and the Anchorage CPI. We estimated this equation to test the statistical significance of the relationship between the Japanese wholesale price and the Bristol Bay ex-vessel price. Clearly the August Japanese wholesale price has been a good predictor of the Bristol Bay ex-vessel price, given the adjusted R^2 value of .884 and the close fit between the actual and predicted prices.

Table X-4

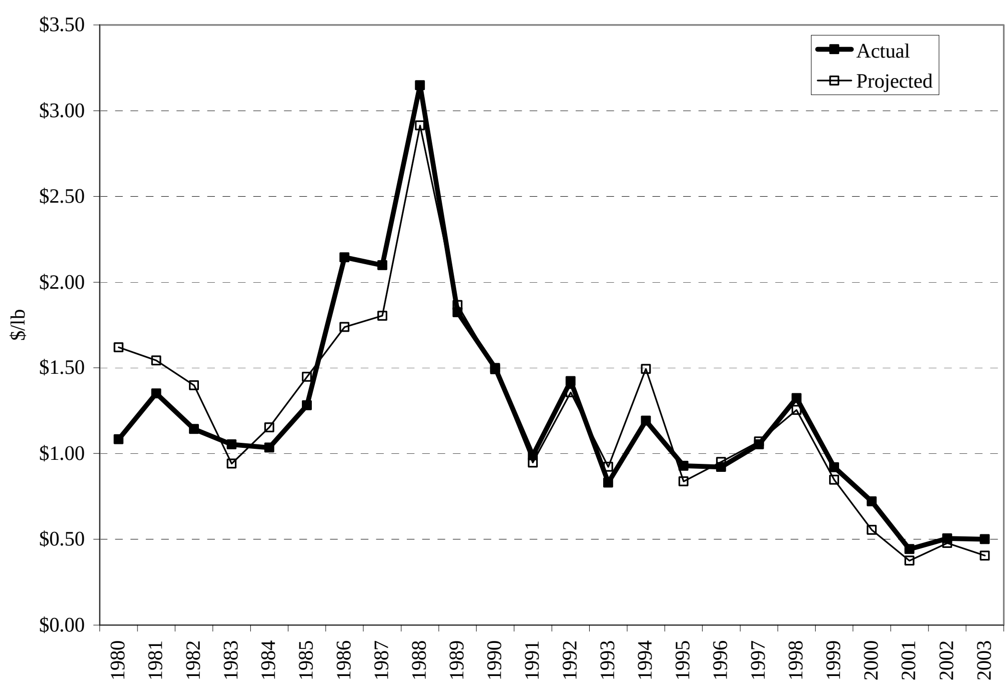
Regression 1 Dependent variable: Ex-Vessel Price

Independent variables	Estimated coefficient	Standard deviation	t-statistic
Intercept	-0.52784	0.13823	-3.82
Sockeye Wholesale Price	0.43538	0.03273	13.30

Years	1980-2003
Number of observations	24
Degrees of freedom	22
R-squared	0.889
Adjusted R-squared	0.884

Figure X-1

Regression 1: Comparison of Actual and Projected Price



For our regression equation, we used the August wholesale price as a measure of Japanese wholesale prices. This is only one of many different annual wholesale price measures which could be constructed from Japanese monthly wholesale price data. In effect, in this measure he August wholesale price has a weight of 1 and all other months have a weight of 0. The August wholesale price had the best fit (the highest R^2) of any of several measures that we tested, including other single months such as July and averages of several months such as July-August or July-September.

A likely explanation for this is that August usually accounts for the largest share of sales from Bristol Bay processors to Japanese importers.[53] The August wholesale price represents the best indicator at the time these sales occur of the value the salmon will command when it is sold in Japan, which in turn drives what importers are willing to pay processors, and what processors are willing (and able) to pay fishermen.

Although Regression 1 is useful for explaining historical variation in Bristol Bay ex-vessel prices, it is not a practical forecasting equation for Bristol Bay ex-vessel, for two reasons. First, to use Regression 1 as a price forecasting equation for ex-vessel prices we would need to develop another forecasting equation for wholesale prices. Secondly, Regression 1 does not explicitly forecast the effect of the Bristol Bay sockeye harvest on the ex-vessel price, as needed by CFEC for its optimum permit number analysis.

[53] The relative concentration of sales in August is based on accounts in the Japanese press as well as personal communications with processors and importers. The timing of sales varies from year to year.

Regression 2: ln (Ex-Vessel Price) = C0 + C1 (Bristol Bay Sockeye Harvest) + C2 (World Farmed Salmon Supply) + C3 (Exchange Rate)

For Regression 2, the dependent variable is the natural logarithm of the ex-vessel price and the explanatory variables are the Bristol Bay sockeye harvest, the total world supply of farmed salmon and trout, and the exchange rate. All of the variables in the equation had the expected signs and were highly significant. The model has a high explanatory power, given the adjusted R^2 value of .833 and the relatively close fit between the actual and predicted prices (Figure X-2).

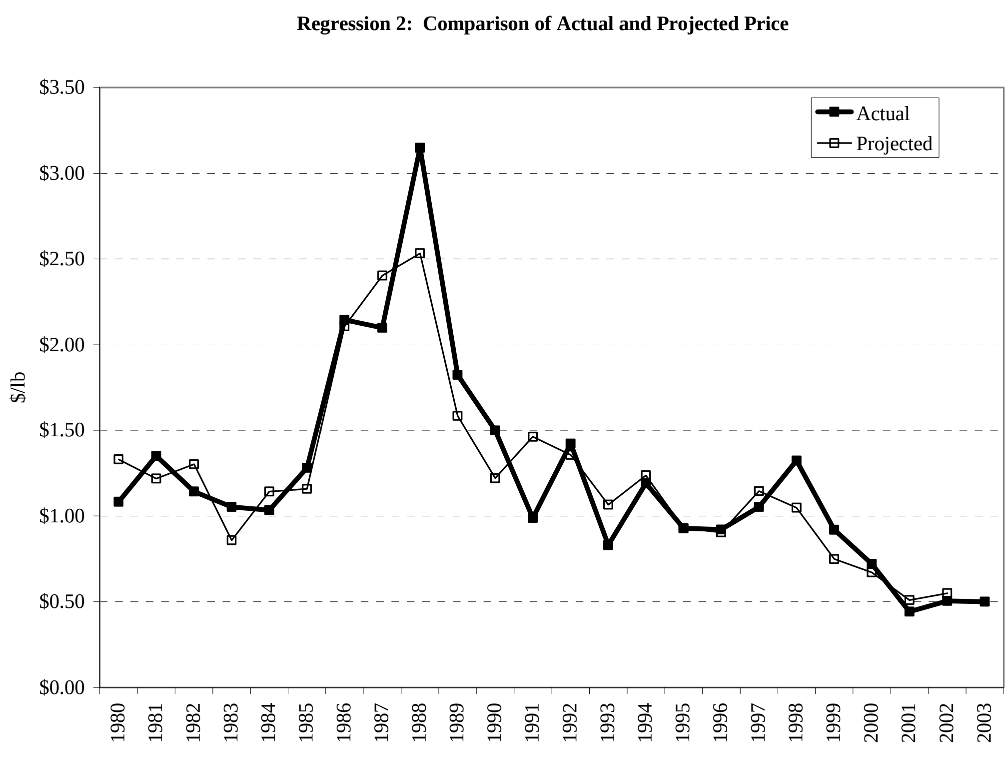
Table X-5

Regression 2 — Dependent variable: ln (Ex-Vessel Price)

Independent variables	Estimated coefficient	Standard deviation	t-statistic
Intercept	2.369368307	0.280233244	8.45
Bristol Bay Sockeye Harvest	-9.31177E-06	1.75908E-06	-5.29
World Farmed Salmon Supply	-1.30636E-06	1.25175E-07	-10.44
Exchange Rate	-0.006669329	0.001065403	-6.26

Years	1980-2002
Number of observations	23
Degrees of freedom	19
R-squared	0.856
Adjusted R-squared	0.833

Figure X-2



We expect an increase in the Bristol Bay sockeye harvest to have a negative effect on the ex-vessel price. Outward or inward shifts in the supply curve, due to natural variations in the sockeye run, cause the equilibrium price and harvest to shift along a negatively sloping demand curve. If the effects of shifts in the demand curve are fully explained by other variables in the equation, then the coefficient for the sockeye harvest variable measures the price effects of shifts along the demand curve.

Note that the sockeye harvest coefficient incorporates effects of changes in harvests not only on the Japanese frozen market but also on other markets including the canned market and the roe market. All of these markets combine to determine the derived ex-vessel demand curve for round Bristol Bay sockeye salmon. As discussed in Chapter VII, as harvests change, prices change to bring supply and demand into equilibrium in all of these markets.

We expect an increase in world farmed salmon and trout supply to have a negative effect on the ex-vessel price, by lowering the price of farmed substitutes for Bristol Bay sockeye salmon, which in turn results in a downward (or leftward) shift in the demand curve for Bristol Bay sockeye.

We expect an increase in the exchange rate (expressed in yen per dollars) to have a negative effect on the ex-vessel price. The higher the number of yen per dollar, the lower the dollar value of any given yen wholesale price, and the lower the price in dollars that a Japanese importer is able and willing to pay for frozen Bristol Bay sockeye salmon. Thus an increase in the exchange rate results in a downward (or leftward) shift in the demand curve for Bristol Bay sockeye.

The log-linear functional form of Regression 2 implies that a change in an exogenous variable results in a constant percentage change in the endogenous variable (ex-vessel price). Because their signs are negative, the relative effects of changes in the exogenous variables declines as they increase in value. Table X-6 shows the price effects of changes in each exogenous variable at historical minimum, average and maximum values for the variable. The price effect of a 10,000 ton increase in harvests declines from -$0.15/lb to -$.07/lb between the minimum and maximum harvest levels of the 1980-2002 period.

This declining price effect implied by the log-linear functional form is particularly important for the “world farmed salmon supply” variable, because of the dramatic increases in world supply since 1980. At the 1980 world farmed salmon production level, a 100,000 mt increase in production would have represented a 700% increase in world supply, causing a $.26/lb drop in the ex-vessel price of Bristol Bay sockeye. In 2002 the same increase would have represented only a 7% increase in world supply, causing a $.04/lb drop in the ex-vessel price.

Table X-6
Price Effects of Changes in Exogenous Variables Implied by Regression 2

Assumed change	Assumed Values Before Change*: Bristol Bay Sockeye Harvest	World Farmed Salmon Supply	Exchange Rate	Price Effect of Change
Increase in Bristol Bay Harvest of 10,000 mt	**Minimum**	Average	Average	-$0.15
	Average	Average	Average	-$0.10
	Maximum	Average	Average	-$0.07
Increase in World Farmed Salmon Supply of 100,000 mt	Average	**Minimum**	Average	-$0.26
	Average	**Average**	Average	-$0.14
	Average	**Maximum**	Average	-$0.04
Increase in Exchange Rate of 10 yen/dollar	Average	Average	**Minimum**	-$0.11
	Average	Average	**Average**	-$0.08
	Average	Average	**Maximum**	-$0.04
Minimum value, 1980-2002	*26,175*	*13,053*	*94.034*	
Average value, 1980-2002	*63,438*	*468,837*	*151.882*	
Maximum value, 1980-2002	*110,476*	*1,425,263*	*250.058*	

*Refers to the minimum, average and maximum values of the variables between 1980 and 2002.

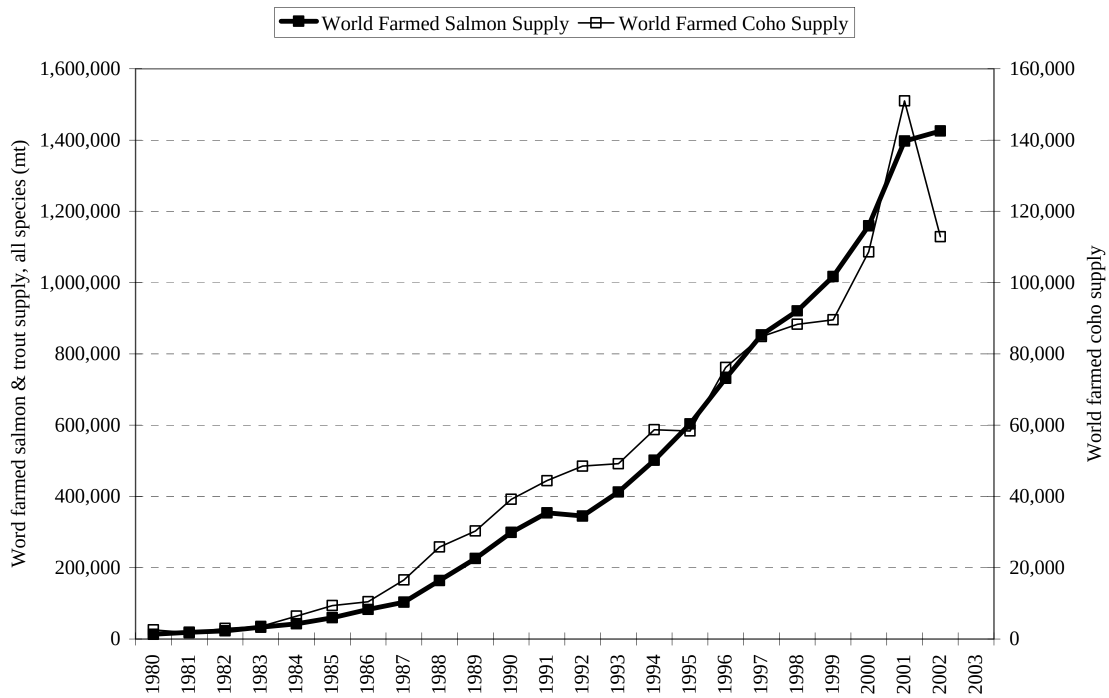
Regression 2 represented a potential price forecasting equation for use by CFEC in its optimum number analysis. It predicted prices well over a long historical time period, including the low prices of the recent years 2000-2002.

However, using Regression 2 as a price forecasting equation would have required developing assumptions for future world salmon and trout supply over a long time period. This would be difficult. There is no obvious way to predict for how long the historical rapid and almost continuous growth in world supply (Figure X-3) which has occurred since 1980 may continue.

If we only needed to predict prices a few years into the future, it might be reasonable to assume that world farmed salmon production would continue to increase by the same absolute or relative volumes each year, implying continued downward pressure on Bristol Bay ex-vessel prices. However, over a longer period of time, it seems likely that at some point the growth in farmed salmon production will slow or stop, as lower prices make farming less profitable. We have no obvious basis to forecast the world supply level at which this may occur, or when it might occur.

Figure X-3

Total World Farmed Salmon Supply and Farmed Coho Salmon Supply

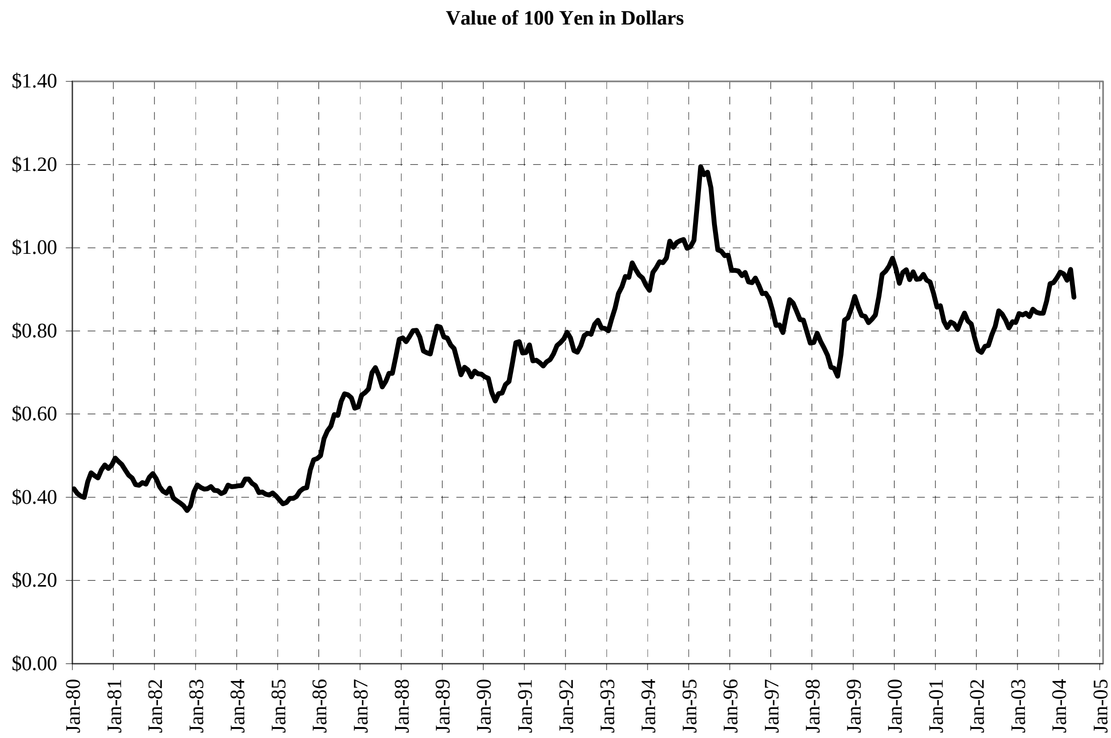


It is also uncertain whether the historical effects of changes in world farmed salmon supply on ex-vessel prices implied by Regression 2 would continue at supply levels outside of their historical range.

Another problem in using Regression 2 as a price forecasting equation results from the difficulty of predicting future values of the exchange rate between the yen and the dollar. As shown in Figure X-4 (on the following page), although the yen strengthened dramatically between 1985 and 1995, it declined after 1995. There is no obvious trend in the exchange rate since 1994. There is no obvious theoretical basis for forecasting how the exchange rate may change in the future—given the uncertainty associated with factors affecting the exchange rate, such as monetary policy, trade policy, and relative rates of economic growth in the United States, Japan and other countries with which they trade.

For these reasons, although Regression 2 provides interesting and useful insights into the causes of changes in ex-vessel prices of Bristol Bay sockeye over the period 1980-2002, we concluded that it could not meet our needs for a price forecasting equation for this study.

Figure X-4


Value of 100 Yen in Dollars
$1.40
$1.20
$1.00
$0.80
$0.60
$0.40
$0.20
$0.00
Jan-80
Jan-81
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05

Regression 3: ln (Ex-Vessel Price)
= C0 + C1 (Bristol Bay Sockeye Harvest) + C2 (World Farmed Coho Supply)
+ C3 (Exchange Rate)

For Regression 3, the dependent variable is the natural logarithm of the ex-vessel price and the explanatory variables are the Bristol Bay sockeye harvest, the world supply of farmed coho salmon, and the exchange rate. All of the variables in the equation had the expected signs and were highly significant. The model has a high explanatory power given the adjusted R^2 value of .797 and the relatively close fit between the actual and predicted prices (Figure X-2).

Table X-7

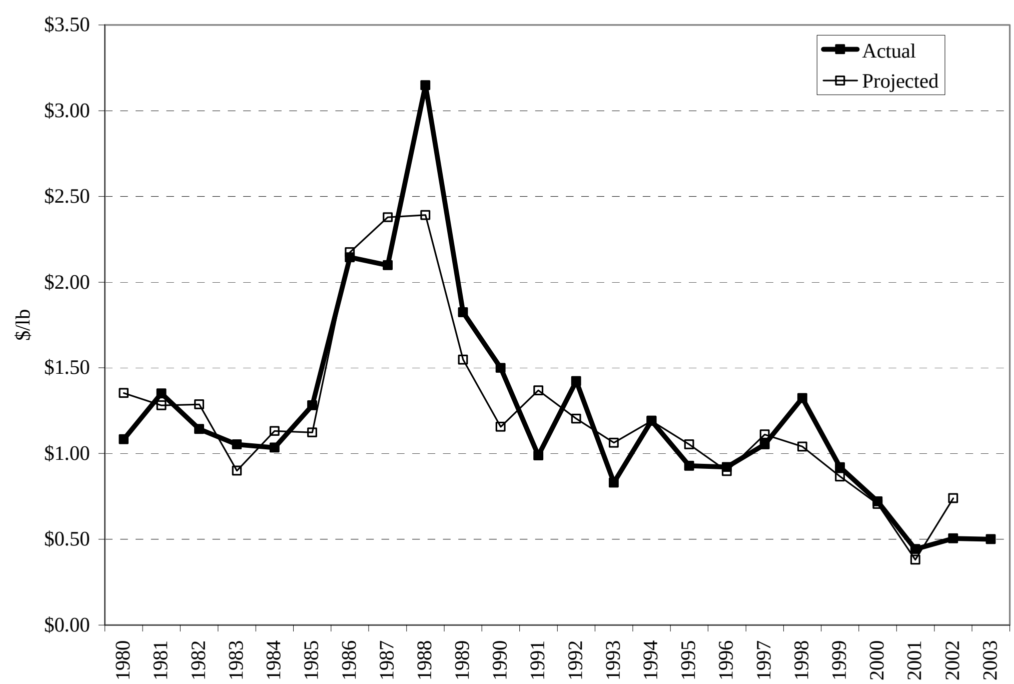
Regression 3 — Dependent variable: ln (Ex-Vessel Price)

Independent variables	Estimated coefficient	Standard deviation	t-statistic
Intercept	2.563880075	0.329731286	7.78
Bristol Bay Sockeye Harvest	-8.47177E-06	1.90414E-06	-4.45
World Farmed Coho Supply	-1.47982E-05	1.59074E-06	-9.30
Exchange Rate	-0.007588077	0.001257931	-6.03

Years	1980-2002
Number of observations	23
Degrees of freedom	19
R-squared	0.825
Adjusted R-squared	0.797

Figure X-5

Regression 3: Comparison of Actual and Projected Price



Regression 3 is the same as Regression 2 except that the world supply of farmed coho salmon is used as an explanatory variable instead of the total world supply of farmed salmon and trout. Our reason for testing this regression was that most direct competition between Bristol Bay sockeye salmon and farmed salmon and trout has occurred in the Japanese market. Most of the world's Atlantic salmon production—which accounts for by far the largest share of farmed salmon—has gone to markets other than Japan, in particular Europe and the United States. Thus the supply effects of farmed salmon on Bristol Bay prices might be better understood by using world production of farmed coho salmon as a regression variable, since most farmed coho production is Chilean coho which is exported frozen to Japan, where it competes directly with Bristol Bay sockeye salmon.

As shown in Figure X-3, world farmed coho salmon production has followed a very similar growth trend as total world farmed salmon and trout production, except for a sharp drop in reported production in 2002 (the final year for which FAO Fishstat+ data were farmed salmon supply were available). In general, farmed coho has represented about 10% of total world farmed salmon and trout supply. For this reason it is not surprising that the estimated coefficients and adjusted R^2 are very similar for Regressions 2 and 3, except that the estimated coefficient for the farmed salmon variable is an order of magnitude larger in Regression 3. The "fit" for Regression 3 is not quite as good as for Regression 2; in particular the drop in farmed coho production in 2002 results in a projected increase in the ex-vessel price which did not occur.

It is likely that both measures of farmed supply are measuring the effects on the sockeye price of falling prices for farmed salmon in the Japanese market and other world markets –since both (rising) farmed supply measures are inversely correlated with (falling) farmed salmon prices.

We concluded that Regression 3 could not meet our needs for a price forecasting equation for this study, for the same reasons as for Regression 2: we had no basis on which to develop future assumptions for trends in farmed coho production or the exchange rate, and we were uncertain whether the effects of changes in farmed coho production would stay the same at levels outside of their historical range.

Regression 4: ln (Ex-Vessel Price)
= C0 + C1 ln (Bristol Bay Sockeye Harvest) + C2 ln (Farmed Coho Wholesale Price)

For Regression 4, the dependent variable is the natural logarithm of the ex-vessel price and the explanatory variables are the natural logarithms of the Bristol Bay sockeye harvest and the Japanese wholesale price for farmed coho salmon. Both variables in the equation had the expected signs and were highly significant. The model has a high explanatory power given the adjusted R^2 value of .796 and the relatively close fit between the actual and predicted prices (Figure X-6).

Table X-8

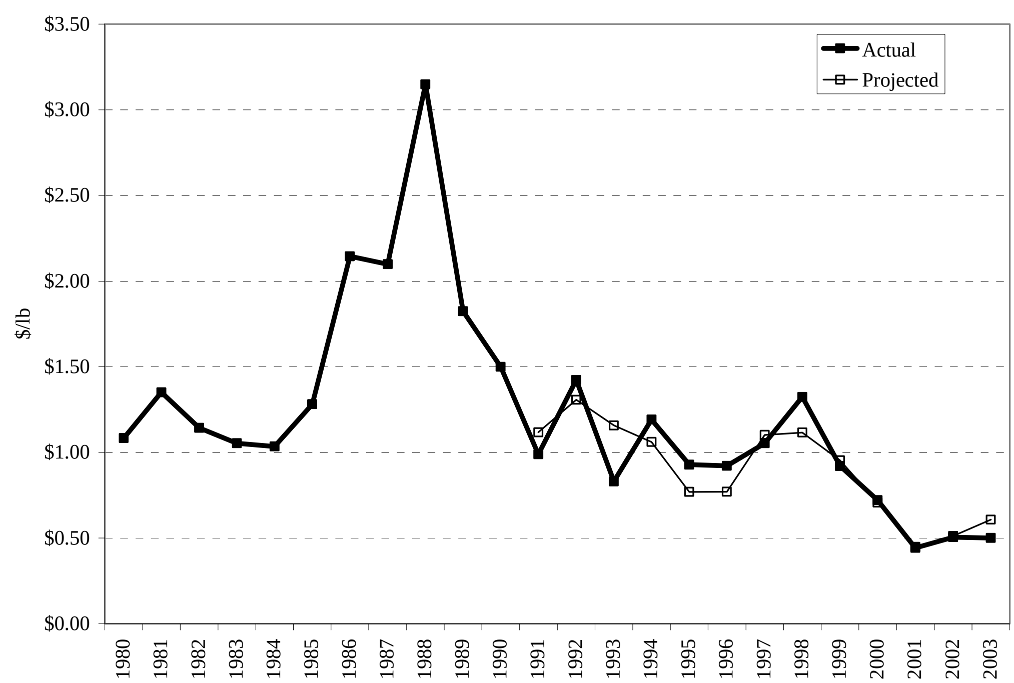
Regression 4 — Dependent variable: ln (Ex-Vessel Price)

Independent variables	Estimated coefficient	Standard deviation	t-statistic
Intercept	4.215984836	1.509903613	2.79
Bristol Bay Sockeye Harvest	-0.530561022	0.152111312	-3.49
Farmed Coho Wholesale Price	1.397895537	0.212012462	6.59

Years	1991-2003
Number of observations	13
Degrees of freedom	10
R-squared	0.830
Adjusted R-squared	0.796

Figure X-6

Regression 4: Comparison of Actual and Projected Price



In Regression 4, the farmed coho wholesale price is a measure of the price competition faced by Bristol Bay frozen salmon from farmed salmon in the Japanese frozen market. All else equal (*ceteris paribus*), the lower the Japanese wholesale price of farmed coho, the lower the wholesale price that competing Bristol Bay salmon will be able to command. Given the log-log form of the equation, the estimated coefficient for the farmed coho price of 1.39 may be interpreted to mean that a 1% change in the farmed coho wholesale price results in a 1.39% change in the projected ex-vessel price of sockeye.[54]

We recommend that CFEC use Regression 4 to forecast future ex-vessel prices for its optimum number, for the following reasons:

- Regression 4 performs reasonably well historically: It does reasonably well at projecting historical changes in ex-vessel prices, especially for the more recent years 1999-2003.

- Regression 4 is reasonably theoretically sound: it is reasonable to assume that changes in Bristol Bay harvests and farmed salmon wholesale prices could predict much or most of the change in future ex-vessel prices.

- Regression 4 is reasonably practical as a price forecasting equation: we can make informed assumptions about future long-run trends in the explanatory variables.

Below we discuss several technical and theoretical issues related to Regression 4. Although there are some concerns associated with this equation, it provides a reasonable approach for forecasting future ex-vessel prices, which is better than any alternative approaches we have been able to devise.

Coho Price Measurement

Unlike the regressions discussed above, which used data beginning in 1980, Regression 4 is estimated using data beginning with 1991. This is because Japanese wholesale price data for Chilean farmed coho salmon were not published for earlier years, because Japanese imports of Chilean farmed salmon were still relatively small.

[54] This coefficient may seem high. Why should a 1% change in the price of one species result in a change in price of greater than 1% for another species? Keep in mind, however, that the farmed coho price is a wholesale price, while the sockeye price is an ex-vessel price. As we discussed in Chapter VII, if processor and importer margins are relatively constant (if processors and importers receive a relatively constant margin to cover relatively constant costs of processing and transportation), so that most of any upward or downward shift in the wholesale price is passed through to fishermen, then a given percentage change in the wholesale price results in a relatively greater percentage change in the ex-vessel price. Thus a 1% change in the Japanese sockeye wholesale price might have a greater than 1% increase in the sockeye ex-vessel price. Similarly, a 1% change in the Japanese coho wholesale price might lead to a sufficiently large percentage change in the Japanese sockeye wholesale price to lead to a greater than 1% increase in the sockeye ex-vessel price.

As with the sockeye wholesale price data discussed above for Regression 1, Japanese wholesale price data for farmed coho salmon are available by month. For Regression 1, we used the August wholesale price of sockeye salmon. For farmed coho salmon, we used the annual unweighted average of monthly prices for the calendar year (after first converting them to dollars per pounds using monthly exchange rates). This annual unweighted average was more statistically significant in the regression equation and resulted in a higher R^2 value than any other annual wholesale price measure.

The issue of how to weight monthly wholesale prices is important because prices can change significantly over a year (Figure II-6). Which monthly prices for farmed coho salmon are most likely to measure the competition from farmed salmon on ex-vessel prices for Bristol Bay sockeye salmon? We would expect prices paid by sockeye importers to sockeye processors (which in turn affect prices paid by processors to fishermen) to be influenced by importers' expectations, at the time they purchase sockeye salmon, for prices of competing farmed salmon in the months following the summer wild salmon season. We would expect importers' expectations to be influenced partly by actual farmed salmon prices earlier in the year, and also to reflect their (partly correct) expectations for farmed salmon prices later in the year. This is one possible rationale for why an annual average price might result in a better "fit" than any other weighting of monthly prices.

Structural Change

The rapid growth in Japanese imports of farmed coho and other farmed salmon and trout beginning in the late 1980s represented significant change in the Japanese market for frozen sockeye salmon, with rapidly increasing competition from a new product which entered the market in a different way at a different time of year. It is possible that the relationship between the Chilean coho wholesale price and the Bristol Bay ex-vessel price changed over time as the supply of coho increased and the supply of Bristol Bay sockeye decreased.[55] Thus a model based in part on the statistical relationship between these prices over the entire time period may be a biased estimate of the current or future relationship.

Although this is a concern, there is no obvious way to adjust or correct for it. Moreover, we note that the model fits prices for recent years (1999-2003) reasonably well. An additional practical consideration, discussed in the following chapter, is that we assume that Japanese wholesale prices for farmed coho will remain within their recent historical range over the entire projection period. As a result, changes in this variable will not drive long-run changes in the forecasted price.

Structural change could occur in the future if Bristol Bay sockeye prices were to fall to levels at which fishermen no longer necessarily harvested all or most of the sockeye

[55] These effects might offset each other. The larger the supply of coho, the more markets and uses in which it will compete with sockeye, and the greater the expected effect of a change in the coho price on the sockeye price. The smaller the supply of sockeye, the more it will be bought by users with specific preferences for sockeye, and the less the expected effect of a change in the coho price on the sockeye price.

made available by nature and fishery managers. This could cause future natural variations in the sockeye run—which CFEC assumes, for their optimum number study, will be similar to variations over the period 1978-2003--to have less of an effect on both harvest and price than they did in the past. Suppose, as an extreme example, there is a "floor price" below which fishermen will not fish. While Regression 4 might predict prices below this floor price, for certain combinations of (assumed) high harvests and low coho wholesale prices, they could not actually occur.

While the potential for future structural change is a concern in this or any other long-range price projection model, there is no empirical way to correct for future structural change in a model estimated from historical data.

Other Sockeye Markets

Regresson 4 does not include any variables which specifically measure market conditions in markets for other Bristol Bay sockeye salmon products such as canned sockeye salmon, fresh sockeye salmon, and sockeye salmon roe. With these markets increasing in relative importance as the share of Bristol Bay sockeye going to the Japanese frozen market declines, we may expect the effects of these markets on the ex-vessel price to increase in importance.

An important practical consideration is that we have only a limited number of annual observations and degrees of freedom with which to estimate a model—especially one that includes Japanese wholesale prices for farmed salmon. Thus we must limit the model to only a small number of explanatory variables.

Part of the historical (and expected future) effect of these markets on Bristol Bay ex-vessel prices is captured by the sockeye harvest variable. Changes in the share of the harvest going to different markets have corresponding effects on the significance of Bristol Bay harvest for those markets. More generally, long-run average prices in all salmon markets tend to move towards equilibrium (with adjustments for differences in transportation costs, tariffs, exchange rates, and etc. are taken into consideration) and thus exhibit similar long-run trends. Thus the future Japanese wholesale price farmed coho salmon (the price of a major substitute) serves as a rough index for the price trends for all salmon.

Projections for the 2004 Season

We estimated Regression 4—and decided to recommend its use by CFEC--prior to the 2004 Bristol Bay salmon season. Thus, preliminary data now available for 2004 provides us an opportunity to test the model's forecasting ability.

Based on preliminary ADFG estimates, the 2004 Bristol Bay sockeye harvest was 151.3 million pounds, and the average ex-vessel price was $0.50/lb.[56]

[56] Memorandum from Keith Weiland, Bristol Bay Area Management Biologist, to Doug Mecum, Director of Commercial Fisheries, September 20, 2004. Media reports as of September 2004 also indicated that

The simple average of monthly Japanese wholesale prices for Chilean coho salmon for January through October 2004 (as reported by FIS and converted to dollars at monthly exchange rates as reported by the Federal Reserve Bank of St. Louis) was $1.69. Using our price forecasting equation these result in a projected 2004 ex-vessel price of $0.38.

Thus our regression equation, based on data available as of October 2004, under-predicts the 2004 ex-vessel price by about $.12/lb.[57, 58] Note that the annual average Japanese wholesale price for farmed coho salmon, based on prices for all months of 2004, is not yet available. Thus the model's final projection could be for a higher or lower price, depending on wholesale prices for November and December.

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several major Bristol Bay processors had paid base prices and post-season payments totaling $0.50/lb (Aleutians East Borough, "Fish News" e-mail newsletter, Thursday, Sept. 30, 2004.

[57] October price data were available because prices in this series are measured for the first weekday of the month.

[58] Japanese press accounts suggest that several factors may have accounted for stronger than expected sockeye wholesale prices in Japan following the 2004 season, including a low supply of "local" (non-Bristol Bay Alaska) sockeye salmon and tight supplies of farmed salmon-trout—neither of which are accounted for directly in our Regression 4 model. These factors could account for higher ex-vessel prices than projected by our model. The following is from a recent Japanese press account describing the market in September 2004: "Prices for North American sockeye salmon continue their gradual increase in Japan. Even with the increased production in the Bristol Bay fishery, the wholesale price for Bristol sockeye has returned to its starting level. And with the extremely limited supply of "local" (non-Bristol Alaska) sockeye, the importers are limiting the amount of product that they place on the market at any one time. For the past several years, the Japanese market for red-fleshed salmon has been totally dominated by farmed product. This year, however, wild sockeye salmon seems to have regained some of its position in the marketplace. Over the past month, the wholesale price for sockeye has continued a gradual increase. . . The improved market for wild sockeye salmon doesn't necessarily represent a renewed long-term position in the marketplace, however. The low prices for Chilean coho during much of the year has resulted in a rapid decline in inventories, with the possibility of total depletion by the time that new product arrives in Japan late next month. Conditions are even more severe for farmed salmon-trout, where Japanese buyers have had a difficult time competing with a strong demand from other markets. With the limited supply of farmed red-fleshed salmon, the sliced-salmon processors have turned to sockeye salmon to fill their operating needs. . . For the first time in quite a while, it is a seller's market for the importers of sockeye salmon. The change in market conditions this year is largely the product of the weak market for salmon in Japan. The North American packers are no longer able to rely on Japan to be the focus of the operations, and they finally started to look at developing other markets for their production. This follows the trend seen for many other fish species, where the low Japanese prices have forced producers to turn the focus of their operations to other products and/or markets. As long as these new efforts continue, the Japanese will continue to lose their competitiveness in the world marketplace. The market for various fish species in Japan has become very short-sighted. As import supplies decline, the users continue their push for low prices to meet the demands of supermarkets and other large retailers. Before they know it, available supplies of raw material for their operations disappear. While this results in a short-term spurt in demand, it has the longer-term affect of weakening the overall Japanese market for fisheries products. . . While the strong prices for sockeye salmon are attributed to a series of "unexpected" developments in the fisheries and the supply, the main question is how the end-users will respond to the conditions." (*Bill Atkinson's News Report*, Issue 1067, September 22, 2004, citing an article from the *Hokkai Keizai Shinbun*, September 13, 2004).

Conclusions

Regression 4 does not perfectly explain past variation in Bristol Bay ex-vessel prices, nor does it perfectly project the 2004 ex-vessel price. There are some theoretical concerns related to its specification and robustness over long periods into the future. And (as discussed in the following chapter) it is not easy to forecast how Japanese wholesale prices for farmed coho may change over the next twenty-five years.

Despite these concerns, however, Regression 4 provides a reasonable approach for CFEC to use in forecasting future ex-vessel prices for its optimum number analysis. The issue is not whether this approach is perfect, but rather whether a more reasonable and practical approach for forecasting future prices is available. We have not been able to devise one.

XI. BRISTOL BAY SOCKEYE SALMON EX-VESSEL PRICE FORECASTS

In the previous chapter we developed the following price forecasting equation for Bristol Bay salmon prices:

Ln (Ex-Vessel Price)

= 4.215984836 - 0.530561022 ln (Bristol Bay Sockeye Harvest)

+ 1.397895537 ln (Farmed Coho Wholesale Price)

where

Ex-Vessel Price	= Bristol Bay sockeye real ex-vessel price (real 2003 dollars per pound)
Bristol Bay Sockeye Harvest	= Total Bristol Bay commercial sockeye harvest (metric tons)
Farmed Coho Wholesale Price	= Simple annual average Japanese wholesale price for frozen coho (real 2003 dollars per pound)

In this chapter we use this equation to forecast future Bristol Bay ex-vessel prices. We begin by examining the forecasted prices for different combinations of the explanatory variables. We then develop assumptions for future levels of the explanatory variables, and examine the forecasted prices implied by these assumptions. Finally, we discuss how other factors not accounted for by our forecasting equation might affect future ex-vessel prices.

Forecasted Prices Under Different Combinations of Assumptions For Explanatory Variables

Table XI-1 (on the following page) shows the forecasted prices which result from different combinations of the two explanatory variables in the price forecasting equation, the sockeye harvest and the coho wholesale price. The purpose of the table is only to help the reader gain a general sense of the range of prices forecasted by the equation. Although the ranges shown in the table for the explanatory variables are comparable to those experienced in recent years, we do not intend, at this stage of our discussion, to imply anything about the future likelihood about any of the explanatory variables or prices in the table.

Note that the forecasted ex-vessel price falls as the sockeye harvest rises or as the coho wholesale price falls; the forecasted ex-vessel price rises as the sockeye harvest falls or as the coho wholesale price rises. Thus the lowest forecasted prices are in the upper right-hand part of the table, and the highest forecasted prices are in the lower left-hand part of the table. (Keep in mind that extreme levels of both variables at the same time, resulting in these lowest and highest forecasted prices, are unlikely.)

Table XI-1
Forecasted Bristol Bay Prices for Different Combinations of Explanatory Variables

	Bristol Bay Sockeye Salmon Harvest (metric tons)									
Real Japanese Wholesale Price of Farmed Chilean Coho (2003 $/lb)	20,000	30,000	40,000	50,000	60,000	70,000	80,000	90,000	100,000	110,000
$1.00	$0.35	$0.29	$0.25	$0.22	$0.20	$0.18	$0.17	$0.16	$0.15	$0.14
$1.10	$0.40	$0.33	$0.28	$0.25	$0.23	$0.21	$0.19	$0.18	$0.17	$0.16
$1.20	$0.46	$0.37	$0.32	$0.28	$0.26	$0.23	$0.22	$0.21	$0.19	$0.18
$1.30	$0.51	$0.41	$0.35	$0.31	$0.29	$0.26	$0.24	$0.23	$0.22	$0.21
$1.40	$0.57	$0.46	$0.39	$0.35	$0.32	$0.29	$0.27	$0.26	$0.24	$0.23
$1.50	$0.62	$0.50	$0.43	$0.38	$0.35	$0.32	$0.30	$0.28	$0.27	$0.25
$1.60	$0.68	$0.55	$0.47	$0.42	$0.38	$0.35	$0.33	$0.31	$0.29	$0.28
$1.70	$0.74	$0.60	$0.51	$0.46	$0.41	$0.38	$0.36	$0.33	$0.32	$0.30
$1.80	$0.81	$0.65	$0.56	$0.50	$0.45	$0.41	$0.39	$0.36	$0.34	$0.33
$1.90	$0.87	$0.70	$0.60	$0.53	$0.48	$0.45	$0.42	$0.39	$0.37	$0.35
$2.00	$0.93	$0.75	$0.65	$0.57	$0.52	$0.48	$0.45	$0.42	$0.40	$0.38
$2.10	$1.00	$0.81	$0.69	$0.61	$0.56	$0.51	$0.48	$0.45	$0.43	$0.40
$2.20	$1.07	$0.86	$0.74	$0.66	$0.60	$0.55	$0.51	$0.48	$0.45	$0.43
$2.30	$1.13	$0.91	$0.79	$0.70	$0.63	$0.58	$0.54	$0.51	$0.48	$0.46
$2.40	$1.20	$0.97	$0.83	$0.74	$0.67	$0.62	$0.58	$0.54	$0.51	$0.49
$2.50	$1.27	$1.03	$0.88	$0.78	$0.71	$0.66	$0.61	$0.57	$0.54	$0.52
$2.60	$1.35	$1.09	$0.93	$0.83	$0.75	$0.69	$0.65	$0.61	$0.57	$0.54
$2.70	$1.42	$1.14	$0.98	$0.87	$0.79	$0.73	$0.68	$0.64	$0.60	$0.57
$2.80	$1.49	$1.20	$1.03	$0.92	$0.83	$0.77	$0.72	$0.67	$0.64	$0.60
$2.90	$1.57	$1.26	$1.09	$0.96	$0.88	$0.81	$0.75	$0.71	$0.67	$0.63
$3.00	$1.64	$1.33	$1.14	$1.01	$0.92	$0.85	$0.79	$0.74	$0.70	$0.67
$3.10	$1.72	$1.39	$1.19	$1.06	$0.96	$0.89	$0.83	$0.78	$0.73	$0.70
$3.20	$1.80	$1.45	$1.25	$1.11	$1.00	$0.93	$0.86	$0.81	$0.77	$0.73
$3.30	$1.88	$1.52	$1.30	$1.16	$1.05	$0.97	$0.90	$0.85	$0.80	$0.76
$3.40	$1.96	$1.58	$1.36	$1.20	$1.09	$1.01	$0.94	$0.88	$0.83	$0.79

Note: Between 1978 and 2003 the Bristol Bay sockeye harvest averaged 62,000 mt, and ranged from a low of 26,000 mt to a high of 110,000 mt. Between 1995 and 2003 the real Japanese wholesale price for farmed Chilean coho (expressed in 2003 $/lb) averaged $2.47/lb, and ranged from a low of $1.51 to a high of $3.33.

Table XI-2 (on the following page) is similar to Table XI-1, except that the rows represent different combinations of the Japanese exchange rate and the Chilean coho wholesale price expressed in yen (which imply Chilean coho wholesale prices expressed in dollars per pound). These help to illustrate how the exchange rate affects forecasted prices. For any given wholesale price expressed in yen, as the yen per dollar exchange rate rises (implying a fall in the value of the yen relative to the dollar), the forecasted ex-vessel price falls. Again, note that the table is intended to help the reader gain a sense of the range of prices forecasted by the equation, but is not intended to imply anything about the future likelihood about any of the explanatory variables or prices in the table.

Table XI-2

Forecasted Bristol Bay Prices for Different Combinations of Explanatory Variables

Ex-change rate	Farmed Coho Wholesale Price		Bristol Bay Sockeye Salmon Harvest (metric tons)							
	yen/kilo	$/lb	30,000	40,000	50,000	60,000	70,000	80,000	90,000	100,000
90	350	$1.76	$0.63	$0.54	$0.48	$0.44	$0.40	$0.38	$0.35	$0.33
	400	$2.02	$0.76	$0.65	$0.58	$0.53	$0.49	$0.45	$0.42	$0.40
	450	$2.27	$0.90	$0.77	$0.68	$0.62	$0.57	$0.53	$0.50	$0.47
	500	$2.52	$1.04	$0.89	$0.79	$0.72	$0.66	$0.62	$0.58	$0.55
	550	$2.77	$1.19	$1.02	$0.91	$0.82	$0.76	$0.71	$0.66	$0.63
	600	$3.02	$1.34	$1.15	$1.02	$0.93	$0.86	$0.80	$0.75	$0.71
	650	$3.28	$1.50	$1.29	$1.14	$1.04	$0.96	$0.89	$0.84	$0.79
100	350	$1.59	$0.54	$0.47	$0.42	$0.38	$0.35	$0.32	$0.30	$0.29
	400	$1.81	$0.66	$0.56	$0.50	$0.45	$0.42	$0.39	$0.37	$0.35
	450	$2.04	$0.77	$0.66	$0.59	$0.54	$0.49	$0.46	$0.43	$0.41
	500	$2.27	$0.90	$0.77	$0.68	$0.62	$0.57	$0.53	$0.50	$0.47
	550	$2.49	$1.02	$0.88	$0.78	$0.71	$0.65	$0.61	$0.57	$0.54
	600	$2.72	$1.16	$0.99	$0.88	$0.80	$0.74	$0.69	$0.65	$0.61
	650	$2.95	$1.29	$1.11	$0.99	$0.90	$0.83	$0.77	$0.72	$0.68
110	350	$1.44	$0.48	$0.41	$0.36	$0.33	$0.30	$0.28	$0.27	$0.25
	400	$1.65	$0.57	$0.49	$0.44	$0.40	$0.37	$0.34	$0.32	$0.30
	450	$1.86	$0.68	$0.58	$0.52	$0.47	$0.43	$0.40	$0.38	$0.36
	500	$2.06	$0.79	$0.67	$0.60	$0.54	$0.50	$0.47	$0.44	$0.41
	550	$2.27	$0.90	$0.77	$0.68	$0.62	$0.57	$0.53	$0.50	$0.47
	600	$2.47	$1.01	$0.87	$0.77	$0.70	$0.65	$0.60	$0.57	$0.53
	650	$2.68	$1.13	$0.97	$0.86	$0.78	$0.72	$0.67	$0.63	$0.60
120	350	$1.32	$0.42	$0.36	$0.32	$0.29	$0.27	$0.25	$0.24	$0.22
	400	$1.51	$0.51	$0.44	$0.39	$0.35	$0.32	$0.30	$0.28	$0.27
	450	$1.70	$0.60	$0.51	$0.46	$0.42	$0.38	$0.36	$0.33	$0.32
	500	$1.89	$0.70	$0.60	$0.53	$0.48	$0.44	$0.41	$0.39	$0.37
	550	$2.08	$0.79	$0.68	$0.61	$0.55	$0.51	$0.47	$0.44	$0.42
	600	$2.27	$0.90	$0.77	$0.68	$0.62	$0.57	$0.53	$0.50	$0.47
	650	$2.46	$1.00	$0.86	$0.76	$0.69	$0.64	$0.60	$0.56	$0.53
130	350	$1.22	$0.38	$0.32	$0.29	$0.26	$0.24	$0.22	$0.21	$0.20
	400	$1.40	$0.45	$0.39	$0.35	$0.31	$0.29	$0.27	$0.25	$0.24
	450	$1.57	$0.54	$0.46	$0.41	$0.37	$0.34	$0.32	$0.30	$0.28
	500	$1.74	$0.62	$0.53	$0.47	$0.43	$0.40	$0.37	$0.35	$0.33
	550	$1.92	$0.71	$0.61	$0.54	$0.49	$0.45	$0.42	$0.40	$0.37
	600	$2.09	$0.80	$0.69	$0.61	$0.56	$0.51	$0.48	$0.45	$0.42
	650	$2.27	$0.90	$0.77	$0.68	$0.62	$0.57	$0.53	$0.50	$0.47

Note: Between 1978 and 2003 the Bristol Bay sockeye harvest averaged 62,000 mt, and ranged from a low of 26,000 mt to a high of 110,000 mt. Between 1990 and 2004 the exchange rate between the yen and the dollar averaged about 118 yen/dollar, with a high of 158 and a low of 84. Between 1995 and 2003 the Japanese wholesale price for farmed Chilean coho averaged 566 yen/kilo, with an (annual average) low of 350 yen/kilo and a high of 800 yen/kilo.

Future Bristol Bay Sockeye Harvest Assumptions

It is impossible to predict future Bristol Bay sockeye salmon harvests accurately even a year into the future, much less decades into the future. It seems certain that Bristol Bay harvests will continue to vary widely from year to year, causing prices to vary from year to year.

For their optimum number study, CFEC plans to assume that sockeye harvests over the next twenty-five years will be similar to those which occurred over the period 1978-2003. For the purposes of our discussion in this chapter, we make the same assumption, which is reasonable given the absence of reliable long-term harvest forecasts.

Twenty-six different harvest levels occurred during the period 1978-2003. Technically, we assume that in any given future year, there is an equal probability that any of these harvest levels will occur.

Table XI-3 summarizes the size distribution of harvests over the period 1978-2003. Harvests were fairly evenly distributed over a wide range. Given the width of this range, fluctuations in harvest volumes could continue to result in significant fluctuations in ex-vessel prices. For example, referring to Table XI-1, assuming a Japanese farmed coho wholesale price of $1.70/lb, a harvest of 30,000 metric tons would result in a forecasted ex-vessel price of $.60/lb, while a harvest of 100,000 metric tons would result in a forecasted ex-vessel price of $.32/lb.

Table XI-3
Distribution of Bristol Bay Sockeye Harvest Volume, 1978-2003

Bristol Bay sockeye harvest (mt)	20,000-40,000	40,000-60,000	60,000-80,000	80,000-100,000	100,000-120,000
Number of years	5	7	7	5	2

It is important to note that salmon returns to Bristol Bay over the next quarter-century will not necessarily be similar in average volume or range to those of the past quarter-century. As noted in a recent review by Adkison and Finney:

> "The abundance of Alaskan salmon stocks has fluctuated greatly, both in modern times and prehistorically. These fluctuations are thought to be caused by multi-decadal changes in environmental conditions over large areas that affect many other species as well as salmon. Forecasts of salmon returns are not very reliable, and the potential for significant improvement in their accuracy is low in the short term. A viable fishing industry must be able to adapt to dramatic, persistent, and unanticipated changes in harvest levels.[59]

[59]Milo D. Adkison and Bruce P. Finney, "The Long-Term Outlook for Salmon Returns to Alaska," Alaska Fishery Research Bulletin, Vol. 10(2):83–94 (2003). Available at http://www.adfg.state.ak.us/pubs/afrb/afrbabst.php.

Future Farmed Coho Wholesale Price Assumptions

As noted in Chapter VIII, for this study we assume that the current average cost of farming, processing and distributing farmed coho and trout to the Japanese market is about $1.63/lb. Although this is not a precise estimate, it is consistent with the limited available information.

In addition, we assume that future salmon farming costs will be stable at current levels, with the factors tending to lower costs balanced by the factors tending to raise costs. As we noted, a number of arguments can be made as to why future costs may continue their historical decline, or may alternatively rise. Especially given the long time period for our projections, it is impossible to conclude with any certainty whether farmed salmon costs of production will fall or rise, but it seems unlikely that costs will change rapidly or dramatically.

Given our assumption that farmed salmon costs of production will be stable at $1.63/lb, what can we assume about future Japanese wholesale price of farmed Chilean coho salmon? As we discussed in Chapter VIII, economic theory suggests that future prices of farmed salmon will average—over the long-term--close to this cost of production. When prices are above the cost of production, profits will cause salmon farmers to increase production, which will eventually cause prices to fall. When prices are above the cost of production, losses will cause salmon farmers to decrease production, which will eventually cause prices to rise. Over shorter periods of time, prices may fluctuate well above or below the average cost of production.

Given an assumed long-term average price of $1.63/lb, how much might prices fluctuate? One indication is the degree of fluctuation—as measured by standard deviation--of prices for recent periods of time.[60]

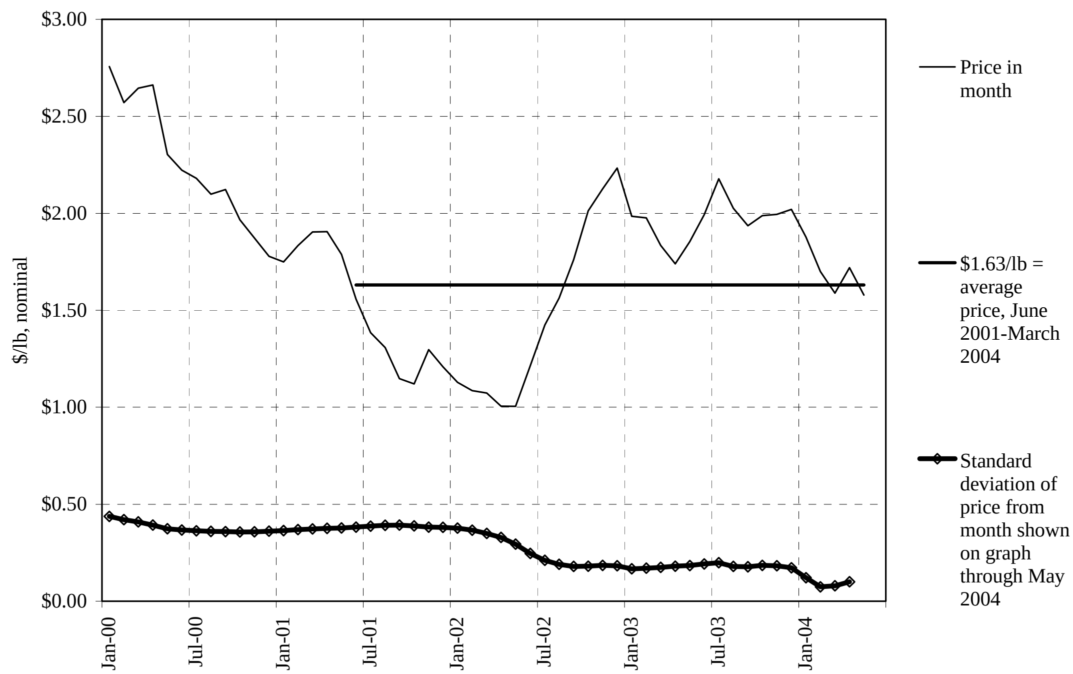
Figure XI-1 shows Japanese wholesale prices of farmed Chilean coho since 2000. The darker line at the bottom of the graph shows the standard deviation of the wholesale price, for the period from the month shown on the graph through May 2004. For example, the standard deviation of the price from January 2003 to May 2004 was about $.17/lb.

Because prices have varied more over longer periods of time, the standard deviation of the price increases, the earlier the month it is measured from. The standard deviation of the wholesale price was about $.40/lb when measured from 2002 or earlier through 2004; the standard deviation was about $.20/lb when measured from early 2003 through mid-2004.

[60] "Standard deviation" is a statistical measure of variation of a series from the mean of that series. If the variation from the mean has a "normal" distribution, then approximately 95% of the observations will be within two standard deviations of the mean.

Figure XI-1

Japanese Wholesale Price of Farmed Chilean Coho, 2000-2004 ($/lb, nominal)



For our forecasts we assume that the future Japanese wholesale price of farmed Chilean coho salmon will be normally distributed with a mean of $1.63/lb and a standard deviation of $.20/lb. The assumption of a standard deviation of $.20/lb is somewhat arbitrary. How much farmed salmon prices fluctuated in the recent past is not necessarily a good guide to how much they may fluctuate in the future. We have assumed that prices will fluctuate somewhat less than in recent years as the farmed salmon industry matures.

Table XI-4 shows the "cumulative" probabilities, given these assumptions, that the Japanese wholesale price would be below particular price levels. Our assumptions imply that there is a 2.5% probability that the price would be less than $1.24/lb, and a 97.5% probability that the price will be less than $2.02/lb. As illustrated in Figure XI-2, this implies that there is a 95% probability that the price would be between $1.24/lb and $2.02/lb.

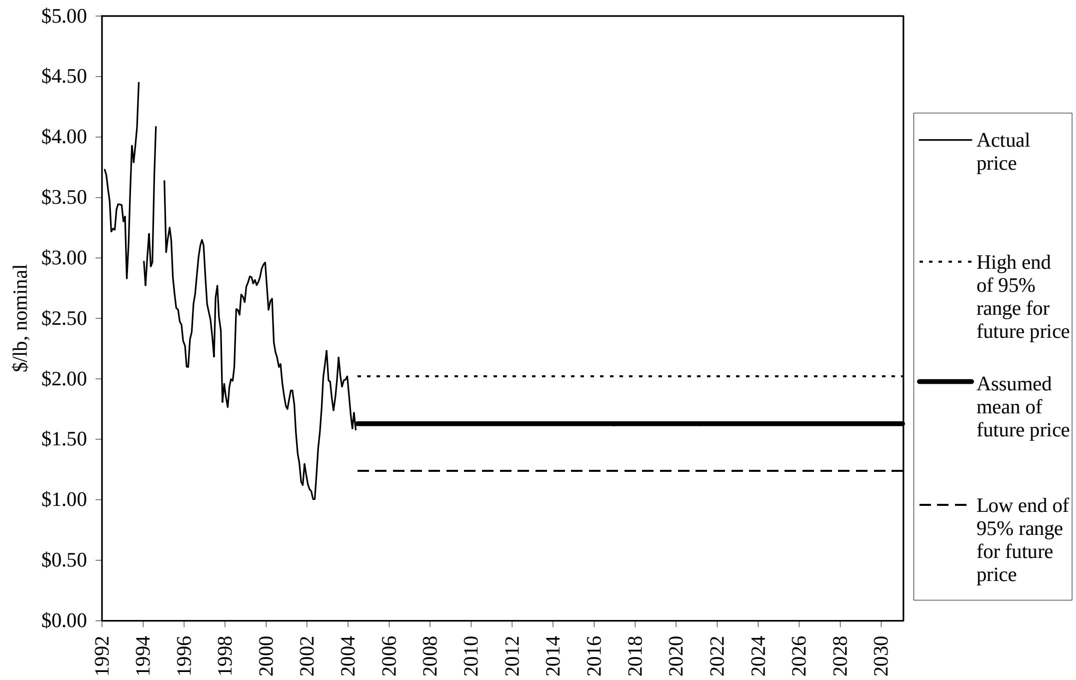
Table XI-4
Cumulative Probability Distribution for Japanese Wholesale Price for Farmed Coho

Cum. Probability	1.0%	2.5%	5.0%	50.0%	95.0%	97.5%	99.0%
Price	$1.16	$1.24	$1.30	$1.63	$1.96	$2.02	$2.10

Note. The top row shows the probability that the actual price would be less than price shown in bottom row. Based on assumption of a normally distributed price with a mean of $1.63/lb and a standard error of $0.20.

Figure XI-2

Assumptions for Japanese Wholesale Price of Farmed Chilean Coho



Ex-Vessel Price Forecasts

Having developed assumptions for the explanatory variables in our forecasting equation, we may now use the equation to forecast ex-vessel prices. Our forecasts are not specific future prices, but rather probability distributions for future prices. These show the probability—given our assumptions—that future prices will be within a particular range.[61]

Our forecasts are probability distributions because we assume that both of the explanatory variables of the equation are probability distributions. Recall that we assume that the Bristol Bay sockeye harvest has an equal probability of being any of the 26 harvest levels which occurred between 1978 and 2003, while the Japanese farmed coho price has a normal distribution with a mean of $1.63/lb and a standard deviation of $.20/lb.

Table XI-5 summarizes the cumulative probability distribution of the forecasted ex-vessel price for each harvest level. For lower harvest levels, shown at the top of the table, forecasted prices are within a higher probability range. For higher harvest levels, shown at the bottom of the table, forecasted prices are within a lower probability range. For

[61] More technically, a cumulative probability distribution shows, for every price level, the probability that the actual price will be below (or above) that price level. By calculating the probability that the actual price will be below (or above) two different price levels, we can calculate the probability that the actual price will fall between those two price levels.

example, at the lowest harvest level of 26,175 metric tons, there is a 95% chance that the ex-vessel price would be between $.41/lb and $.82/lb, with a 50% probability that the price would be below (or above) $.61/lb. At the highest harvest level of 110,476 metric tons, there is a 95% chance that the ex-vessel price would be between $.19/lb and $.38/lb, with a 50% probability that the price would be below (or above) $.28/lb.

Table XI-5
Forecasted Ex-Vessel Prices for Historical Bristol Bay Sockeye Harvest Levels, 1978-2003

		Probability*						
Year**	Harvest	1.0%	2.5%	5.0%	50.0%	95.0%	97.5%	99.0%
1998	26,175	$0.38	$0.41	$0.44	$0.61	$0.79	$0.82	$0.86
1978	26,687	$0.38	$0.41	$0.44	$0.60	$0.78	$0.81	$0.85
2002	29,473	$0.36	$0.39	$0.42	$0.57	$0.74	$0.77	$0.81
1997	32,989	$0.34	$0.37	$0.39	$0.54	$0.69	$0.73	$0.76
1988	39,821	$0.30	$0.33	$0.35	$0.49	$0.63	$0.66	$0.69
2003	42,362	$0.29	$0.32	$0.34	$0.47	$0.61	$0.64	$0.67
1986	43,223	$0.29	$0.32	$0.34	$0.47	$0.60	$0.63	$0.66
2001	43,380	$0.29	$0.32	$0.34	$0.46	$0.60	$0.63	$0.66
1987	43,465	$0.29	$0.32	$0.34	$0.46	$0.60	$0.63	$0.66
1982	43,806	$0.29	$0.31	$0.34	$0.46	$0.60	$0.62	$0.66
2000	56,962	$0.25	$0.27	$0.29	$0.40	$0.52	$0.54	$0.57
1979	57,119	$0.25	$0.27	$0.29	$0.40	$0.52	$0.54	$0.57
1980	60,264	$0.24	$0.27	$0.28	$0.39	$0.50	$0.53	$0.55
1999	61,572	$0.24	$0.26	$0.28	$0.39	$0.50	$0.52	$0.55
1985	61,758	$0.24	$0.26	$0.28	$0.39	$0.50	$0.52	$0.55
1984	63,238	$0.24	$0.26	$0.28	$0.38	$0.49	$0.51	$0.54
1991	67,818	$0.23	$0.25	$0.27	$0.37	$0.47	$0.50	$0.52
1981	71,991	$0.22	$0.24	$0.26	$0.36	$0.46	$0.48	$0.50
1989	74,370	$0.22	$0.24	$0.25	$0.35	$0.45	$0.47	$0.50
1992	82,810	$0.21	$0.22	$0.24	$0.33	$0.43	$0.45	$0.47
1996	84,349	$0.20	$0.22	$0.24	$0.33	$0.42	$0.44	$0.46
1990	87,223	$0.20	$0.22	$0.23	$0.32	$0.41	$0.43	$0.46
1994	88,660	$0.20	$0.22	$0.23	$0.32	$0.41	$0.43	$0.45
1983	96,029	$0.19	$0.21	$0.22	$0.30	$0.39	$0.41	$0.43
1995	110,299	$0.18	$0.19	$0.21	$0.28	$0.37	$0.38	$0.40
1993	110,476	$0.18	$0.19	$0.21	$0.28	$0.37	$0.38	$0.40

*Refers to the probability that, for the harvest level shown in the row, the actual price would be less than the price shown in the column. For a given harvest level, the mean price forecast is that shown in the 50% column.
**Sorted in ascending order of year of historical harvest

Figures XI-3 and XI-4 (on the following page) show the probability distribution for future ex-vessel prices given our assumptions about the probability distributions for both future Bristol Bay sockeye harvests and future Japanese farmed coho wholesale prices. In effect, these figures show the probability distribution that results from combining the twenty-six different probability distributions summarized in Table XI-5 above. The low end of this distribution corresponds to the lowest prices at the bottom-left corner of the table (resulting from high sockeye harvests and low Japanese farmed coho wholesale prices), while the high end of this distribution corresponds to the highest prices at the top-right corner of the table (resulting from low sockeye harvests and high Japanese farmed coho wholesale prices).

Figure XI-3

Forecasted Probability of Ex-Vessel Price

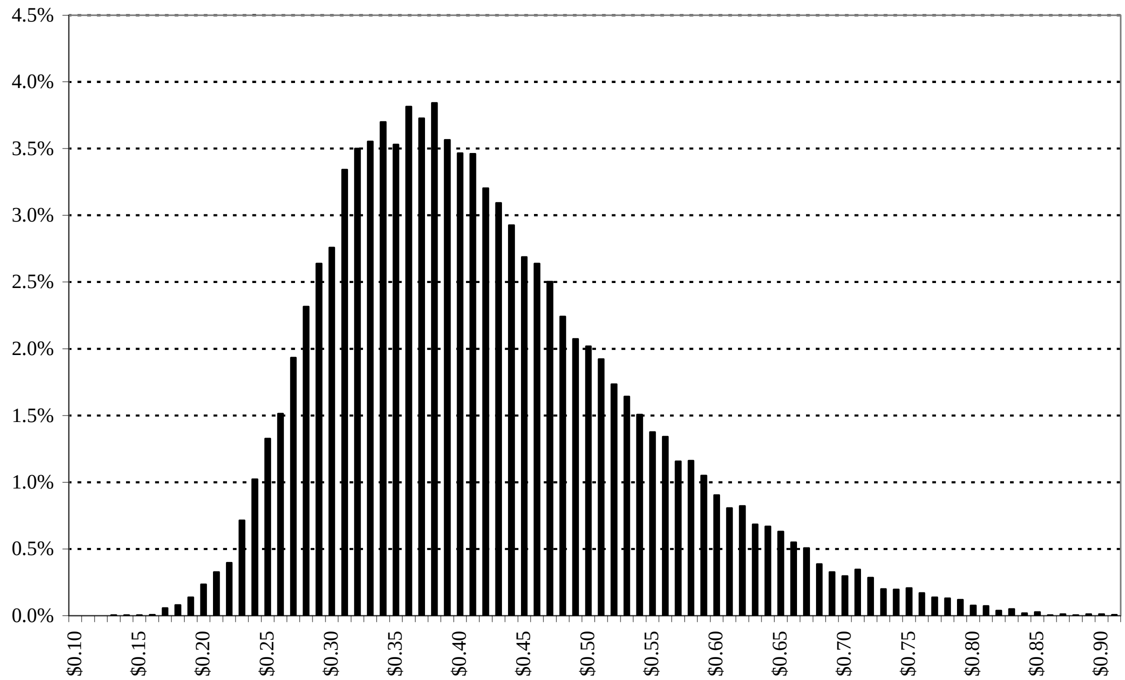


Figure XI-4

Forecasted Cumulative Probability of Ex-Vessel Price

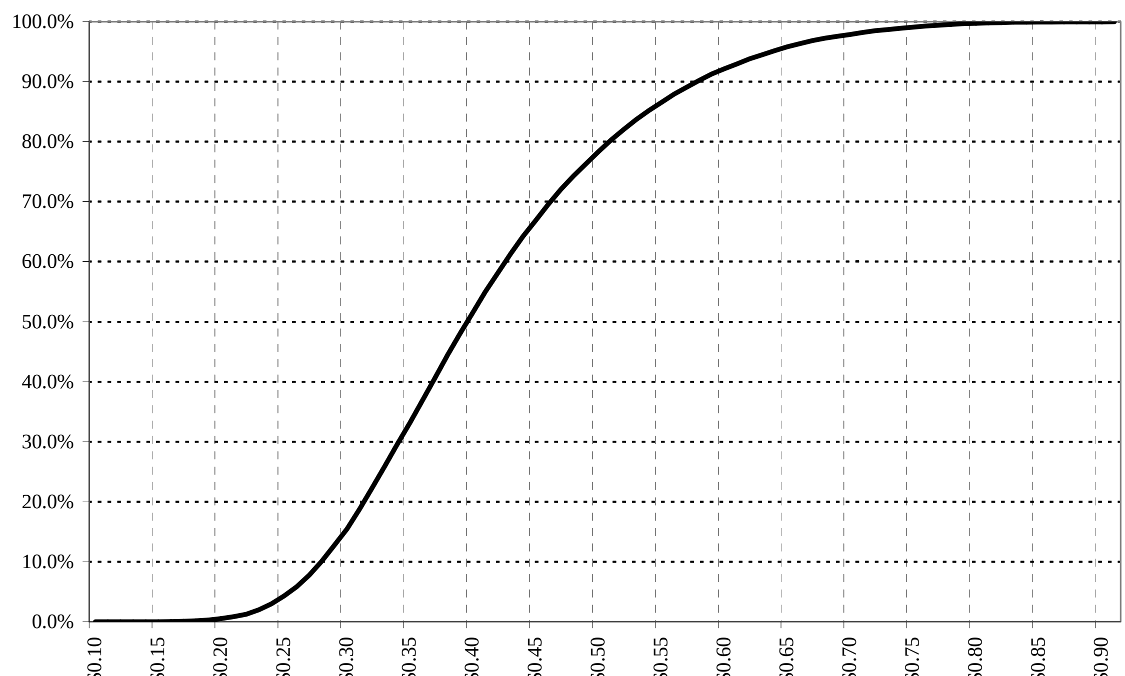


Figure XI-3 (the top figure), which looks like an off-center bell curve, shows the probability of any particular ex-vessel price. For example, in any given year, there is a 3.8% probability that the price will be \$.39/lb, a 1.2% chance that the price will be \$.57/lb, and a 0.3% chance that the price will be \$.21/lb.

Figure XI-4 (the bottom figure), shows the "cumulative" probability that the ex-vessel price will be below a given level. Table XI-6 summarizes this cumulative probability distribution. There is only a 2.5% chance that the ex-vessel price will be below \$.24/lb, while there is a 97.5% chance that the ex-vessel price will be below \$.69/lb. This implies that there is 95% chance that the ex-vessel price will be between \$.24/lb and \$.69/lb. There is a 50% probability that the price would be below (or above) \$.40/lb.[62]

Table XI-6
Cumulative Probability Distribution for Ex-Vessel Price

Cum. Probability	1.0%	2.5%	5.0%	50.0%	95.0%	97.5%	99.0%
Price	\$0.22	\$0.24	\$0.26	\$0.40	\$0.64	\$0.69	\$0.75

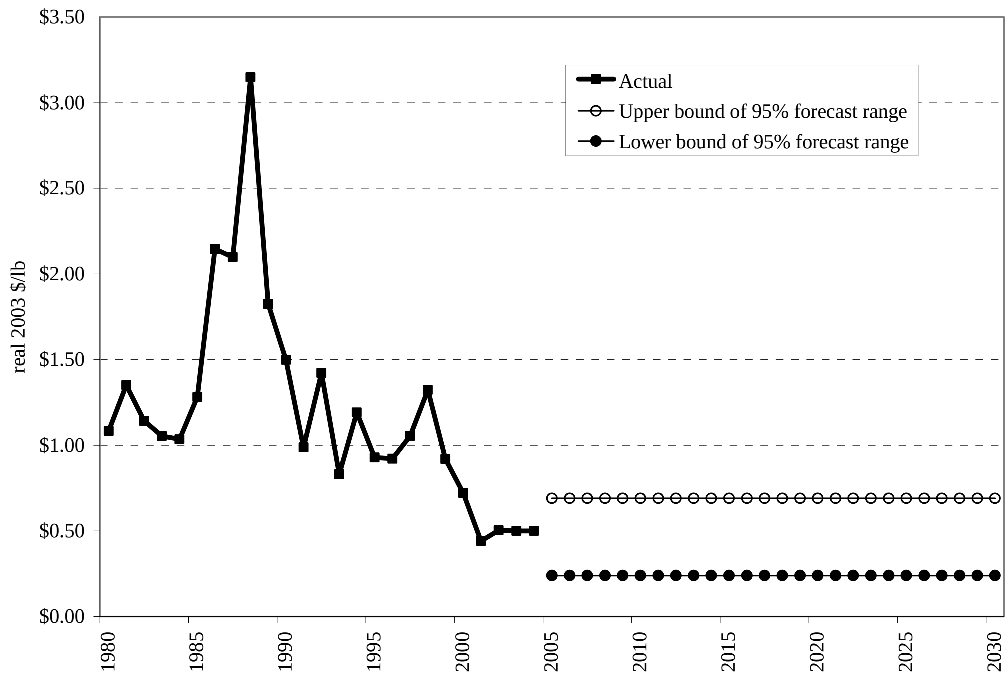
Note. The top row shows the probability that the actual price would be less than price shown in bottom row.

Figure XI-5 (on the following page) compares prices during the 1980-2003 period with the 95% forecasted price range of \$.24/lb to \$.69/lb. Prices since have been within this forecasted price range only since 2001; prior to that they were above the forecasted price range.

[62] The prices shown in Table XI-5 were calculated based on the wholesale prices shown in Table VI-4, which were calculated based on the assumption of a standard normal distribution with a mean of \$1.63 and a standard deviation of \$.20/lb. It was not possible to calculate the probability distribution for ex-vessel prices in this way, because the assumed distribution of harvests does not correspond to any well-known statistical distribution. To derive the probability distribution depicted in Figures XI-3 and XI-4 and Table XI-6, we simulated prices forecasted by the projection equation 1000 times for each of the 26 harvest levels that occurred between 1978 and 2003. The probability distribution shown in the figures and table is based on the frequencies with which different ex-vessel prices were observed among the resulting 26,000 price observations simulated in this way. Note that the probability distribution of shown in Figure XI-3 is not "smooth": the probability of a particular price may be less than the probability of both a price 1 cent higher and a price 1 cent lower. This is because the assumed harvest distribution is not "smooth."

Figure XI-5

Historical Ex-Vessel Prices and Forecasted Ex-Vessel Price Range for Bristol Bay Sockeye Salmon



Interpretation of Ex-Vessel Price Forecasts

Our forecasted probability distribution for future ex-vessel prices of Bristol Bay sockeye salmon is based on the following assumptions:

1. <u>The future ex-vessel price can be forecasted by the following equation:</u>

$$\text{Ln (Ex-Vessel Price)} = 4.22 - 0.531 \ln(\text{Harvest}) + 1.398 \ln(\text{Wholesale Price})$$

where "Harvest" is the Bristol Bay sockeye harvest and "Wholesale Price" is the Japanese wholesale price for farmed Chilean coho salmon. We used this equation because it "explained" historical changes in ex-vessel prices reasonably well over the period 1991-2003; it is theoretically reasonable to assume that harvests and the wholesale price affect the ex-vessel price; and it is possible to make reasonable assumptions about future harvests and wholesale prices.

2. <u>The range of future Bristol Bay sockeye harvests will be similar to the range of harvests over the period 1978-2003.</u>

3. <u>The future Japanese wholesale price for farmed Chilean coho salmon will be normally distributed with a mean of $1.63/lb and a standard deviation of $.20/lb.</u> We assumed a fixed future mean price of $1.63 based on the theory that over time farmed salmon prices will average close to farmed salmon costs of production, and the assumptions that current

costs of farming, processing and distributing Chilean coho salmon to the Japanese wholesale market are about $1.63, and that future costs are likely to stay at about this level. We assumed a standard deviation of $.20/lb based on recent variation in wholesale prices, and the assumption that variation will decline somewhat as the farmed salmon industry continues to mature.

It is useful to review the limitations of our forecasted probability distribution. First, note that while our forecasted probability distribution specifically reflects assumed potential variation in the model's explanatory variables, it does not account for any additional variation which might occur if the forecasting equation does not fully capture all the factors which might affect ex-vessel prices. If we allowed for this additional potential source of variation, our forecasted probability distribution for future ex-vessel prices might have a slightly higher maximum value and a slightly lower minimum value.

More generally, the forecasted probability distribution is only as reliable as all of the assumptions on which it is based. Especially given the long time period for which we are projecting prices, it is impossible to be confident that either the forecasting equation or the explanatory variable assumptions are "correct" for the entire time period. Put differently, the longer into the future we attempt to project, the less certain we can be of our assumptions.

If we were to try to correct for all of the sources of uncertainty in our forecasts, we would have a much wider probability distribution—which would increase in width the farther into the future that we attempted to forecast. We can imagine circumstances which could greatly strengthen future prices (for example, repeated wild salmon run failures in other areas) or greatly depress future prices (for example, repeated incidents of botulism from Bristol Bay salmon products). But trying to account for all of these possibilities would make the resulting forecasts of little use: a projection that "future prices will be between $.10/lb and $2.50/lb." would be of little help to CFEC or anyone else.

Despite the limitations of our forecasted probability distribution, it is nevertheless useful. It represents a structured, formal approach for making assumptions about future ex-vessel prices which can be applied for the optimum number analysis which CFEC is charged with undertaking. As discussed in earlier chapters, the issue is not whether this approach has limitations—it clearly does—but whether there is a better, more reasonable way to make assumptions about future prices, given the limits of available data and the inherent uncertainty about the future.

Note that our forecasting methodology was developed for the purpose of making long-run rather than short-run forecasts. If our objective had been to forecast prices over the next year or two, we might have developed a more detailed model with more explanatory variables. However, a more detailed model would have been of little use for long-term forecasts, given the difficulty of developing long-run assumptions for most potential explanatory variables.

Note also that the ex-vessel prices which may occur over the next few years will neither "prove" nor "disprove" our forecasts. In any given year a price near the high or low end of our forecast range—or even outside the forecast range—is entirely possible. Only repeated occurrences of prices near the end of (or outside of) the forecast range would clearly show the forecasted price range to be unreasonable.

Reasons Why Actual Future Prices Could Differ From Forecasts

The actual range of future Bristol Bay sockeye salmon prices could differ from our forecast range, for two broad reasons. One reason is assumption errors: the actual future ranges of the explanatory variables which "drive" the forecasts could differ from those which we assumed.

Another reason is equation errors: our forecasting equation may not account for all of the factors which may affect future prices.[63] Given the complexity of salmon markets, it is very likely that our equation does not take account of all of these factors. It is particularly likely given that the equation did not project past prices perfectly (as can be seen in Figure X-6).

Below we briefly review some examples of how these two types of errors could cause the actual future price range for Bristol Bay sockeye to be higher or lower than our projected price range. These are only a few examples, which we offer for purposes of illustration. Many other factors could also affect future prices.

More generally, it is not hard to think of reasons why future Bristol Bay sockeye salmon prices could be higher or lower than we have projected. But it is hard—indeed impossible—to know what will actually occur, or what probabilities we should assign to potential future developments that could result in higher or lower prices. We believe our projections are reasonable given the inherent difficulties of long-run price projections. But we also believe that the limitations of the projections, and their inherent uncertainty, should be kept in mind.

Lower or Higher Future Bristol Bay Sockeye Harvests

Our forecasts are based on the assumption that the range of future Bristol Bay sockeye harvests will be similar to the range of harvests over the period 1978-2003. A lower range of harvests than occurred during this period would tend to result in a higher range of prices than our forecast range, while a higher range of harvests would tend to result in a lower range of prices than our forecast range.

As noted earlier in this chapter and in Chapter III, Bristol Bay sockeye harvests during the 1978-2003 period averaged considerably higher than in any earlier twenty-five

[63] Technically, this kind of error may occur for several reasons. Among these are (1) the coefficients in the equation are estimated rather than true values; (2) the equation may have a random error term (which represents the combined effects of factors not included in the model); and (3) future structural change may cause relationships between variables in the equation to change in the future.

period. If future harvests averaged lower than harvests during the 1978-2003 period, the range of future prices would likely be higher than we have forecasted.

Lower or Higher Future Farmed Salmon Prices

Our forecasts are based on the assumption that future Japanese wholesale prices of farmed coho salmon will have a normal distribution with a constant mean of $1.63 and a standard deviation of $.20. As we discussed in Chapter VIII, actual future farmed salmon wholesale prices could trend downward or upward. Potential reasons for a future downward trend in prices include continued improvements in survival rates, growth rates, feed conversion efficiency, and productivity. Potential reasons for a future upward trend in prices include increasing feed prices, stricter (and more-costly) environmental regulation, higher marginal costs as farming expands into higher-cost regions, and controls on aggregate supply by the farmed salmon industry for the purpose of raising prices. Plausible arguments could be made for either scenario, although an upward trend in prices would represent a reversal of the historical trend.

If future farmed salmon wholesale prices were in a lower or higher range than we have assumed, future ex-vessel prices would also likely be in higher or lower range than we have forecasted.

Changes in Relative Consumer Preferences Between Farmed and Wild Salmon

In our forecasting equation the wholesale price of farmed salmon variable represents a measure of shifts in demand for Bristol Bay salmon (because the demand for a product changes as the price of substitutes changes). However, this variable would not capture the effects of changes in relative consumer preferences between farmed and wild salmon. For example, if consumers grew more accustomed to the taste of farmed salmon, they might be willing to pay relatively less for wild salmon, for any given price of farmed salmon. This would cause future prices to be lower than our projected price range.

In contrast, if consumers, perhaps because of press reports or marketing, became less confident about the healthiness of farmed salmon, they might be willing to pay relatively more for wild salmon, for any given price of farmed salmon. This might cause future prices to be higher than our projected price range.

Changes in the relative scale of salmon demand between two markets with different relative preferences for wild and farmed salmon could also affect Bristol Bay salmon prices in ways that would not be captured by the farmed salmon wholesale price variable. For example, if U.S. consumers had a relatively greater preference for wild salmon than Japanese consumers, and if U.S. salmon demand grew more rapidly than Japanese salmon demand, this would tend to increase the price wild salmon could command, for any given price of farmed salmon.

Note that world demand for salmon could potentially grow significantly in the future, due to growth in world population, growth in consumer incomes, and changes in consumer preferences for salmon relative to other forms of protein. However, growth in world demand will not necessarily cause prices for Bristol Bay salmon to rise above levels projected by our forecast equation. Rising demand will tend, by itself, to increase prices for both wild and farmed salmon. However this will in turn call forth increased production of farmed salmon, which will tend to hold down prices of both farmed and wild salmon.[64] Our assumption of a constant expected value for the Japanese wholesale price of farmed coho salmon reflects, in part, an assumption that this kind of supply response to rising demand will occur.

Changes in Costs of Processing and Distribution

Changes in costs anywhere along the distribution chain from fishermen to consumers could affect future ex-vessel demand for Bristol Bay sockeye salmon. Increases in costs would tend to reduce demand and prices; decreases in costs would tend to increase demand and prices.

For example, an improved transportation system for the Bristol Bay region, by reducing costs for processors, would tend to increase what processors would be able and willing to pay for fish. In contrast, higher wages or medical insurance costs for processing sector workers could have the opposite effect.

Improved Quality

Improving the quality of Bristol Bay salmon—for example through more careful handling, more icing and chilling, and reducing the time between when fish are caught and when they are processed, could help to expand demand for Bristol Bay salmon relative to other salmon products. This might result over time in increased ex-vessel demand and higher prices for fishermen.[65]

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[64] More generally, rising demand does not necessarily mean rising prices. Prices depend on the supply curve as well as the demand curve. Keep in mind that real prices for many agricultural products have fallen in recent decades despite dramatic growth in world population and incomes.

[65] Note that higher quality will increase prices only if the higher prices paid to processors are not offset by higher costs. For example, if a processor reduces the time between when fish are caught and when they are processed by deploying more tenders, he may get a higher price for his products but his costs will also be higher. Thus his ex-vessel demand for fish will not necessarily increase.

XII. CONSIDERATIONS IN FORECASTING PRICES FOR OTHER BRISTOL BAY SALMON SPECIES

The preceding chapters of this report have focused on forecasting future ex-vessel prices for Bristol Bay sockeye salmon. In this chapter we suggest some considerations for CFEC in developing future price assumptions for species other than sockeye.

As shown in Table XII-1, other species are far less significant than sockeye in the total earnings of Bristol Bay fishermen. This is partly because other species represent a much smaller share of the total harvest volume, and partly ex-vessel prices are lower for other species.

For example, chum salmon—the second most important species in contribution to value after sockeye—accounted for only 1.5% of average earnings during the period 1978-2003. For more recent periods, such as the past ten or five years, no other species has accounted for even 1% of total ex-vessel value.

Table XII-1

Relative Significance of Different Species in Earnings of Bristol Bay Permit Holders

	Period	Sockeye	Chum	Chinook	Coho	Pink	Total
Average Annual Earnings (millions of $)	1978-2003	120.0	1.9	1.7	1.1	0.5	125.2
	1994-2003	99.2	0.6	0.7	0.4	0.0	100.8
	1999-2003	63.4	0.4	0.2	0.1	0.0	64.2
Percentage of Average Annual Earnings	1978-2003	95.8%	1.5%	1.4%	0.9%	0.4%	100.0%
	1994-2003	98.4%	0.6%	0.7%	0.4%	0.01%	100.0%
	1999-2003	98.8%	0.7%	0.3%	0.2%	0.00%	100.0%

The practical implication of the fact that other species represent a relatively small share of total ex-vessel value is that assumptions about future ex-vessel prices for these species are likely to have relatively little practical significance for CFEC's optimum number study. Whether CFEC assumes high or low prices for these species will have very little effect on projected future earnings, or the profitability of the fishery for any given level of participation in the fishery.

To see this, suppose that the price of chum salmon had been twice as high during the 1978-2003 period. As can be seen from Table XII-1, the effect would have been to increase total earnings by only 1.5%. If the price of chum salmon had been only half as high during this period, the effect would have been to decrease total earnings by only 0.75%.

Given the fact that price assumptions for other species will have little effect on projected future earnings, we recommend that CFEC use a simple, straightforward approach to develop price assumptions for these species. One such approach would be to estimate ex-vessel prices for these species as a function of the ex-vessel price of sockeye salmon.

Figures XII-1 (on the following page) shows real average Bristol Bay ex- vessel prices for all five salmon species for the years 1978-2003. Figure XII-2 shows the same price information expressed as an index, where 100 is the average real price for the years 1975 through 2003.

Real prices for all species declined significantly over the 1975-2003 period. Visual inspection of Figure XII-2 suggests that chinook and coho prices tracked relatively more closely to sockeye prices than did chum and pink prices.

Table XII-2 shows correlation coefficients between prices of sockeye and prices of other species for the past 5, 10, 15, 20, 25 and 29 years. For all but one of these periods, the correlation coefficients are greater for chinook and coho salmon than for pink and chum salmon. This is not surprising, given the fact that chinook and coho salmon are higher-valued "red-fleshed" species, some of which are exported to Japan.

Table XII-2

Correlation Coefficients Between Real Ex-Vessel Prices of Sockeye and Other Species

	1975-2003	1979-2003	1984-2003	1989-2003	1994-2003	1998-2003
Chinook	0.64	0.63	0.79	0.86	0.89	0.98
Coho	0.80	0.83	0.89	0.85	0.73	0.84
Pink	0.52	0.68	0.77	0.72	0.49	0.52
Chum	0.55	0.64	0.82	0.72	0.41	0.14

Given the high degree of historical correlation a reasonable approach to projecting future ex-vessel prices for chinook and coho salmon would be to estimate a regression equation for these prices (or their logarithms) as a function of the historical ex-vessel price of sockeye salmon (or its logarithm). This equation could then be used to project future ex-vessel prices for chinook and coho salmon, based on the projected ex-vessel prices for sockeye salmon in any given year.

The same approach could be used to project future ex-vessel prices for pink and chum salmon, but an equation with only the sockeye price as an explanatory variable would likely not be as good a predictor of sockeye prices. For these species, it might be useful to include statewide harvest levels as a second explanatory variables. Unlike for chinook and coho salmon, Alaska harvest volumes of pink and chum salmon are large relative to the total supply of potential substitutes. Thus statewide harvest volumes of these species likely have a negative effects on ex-vessel prices in Bristol Bay as well as other areas.

Figure XII-1

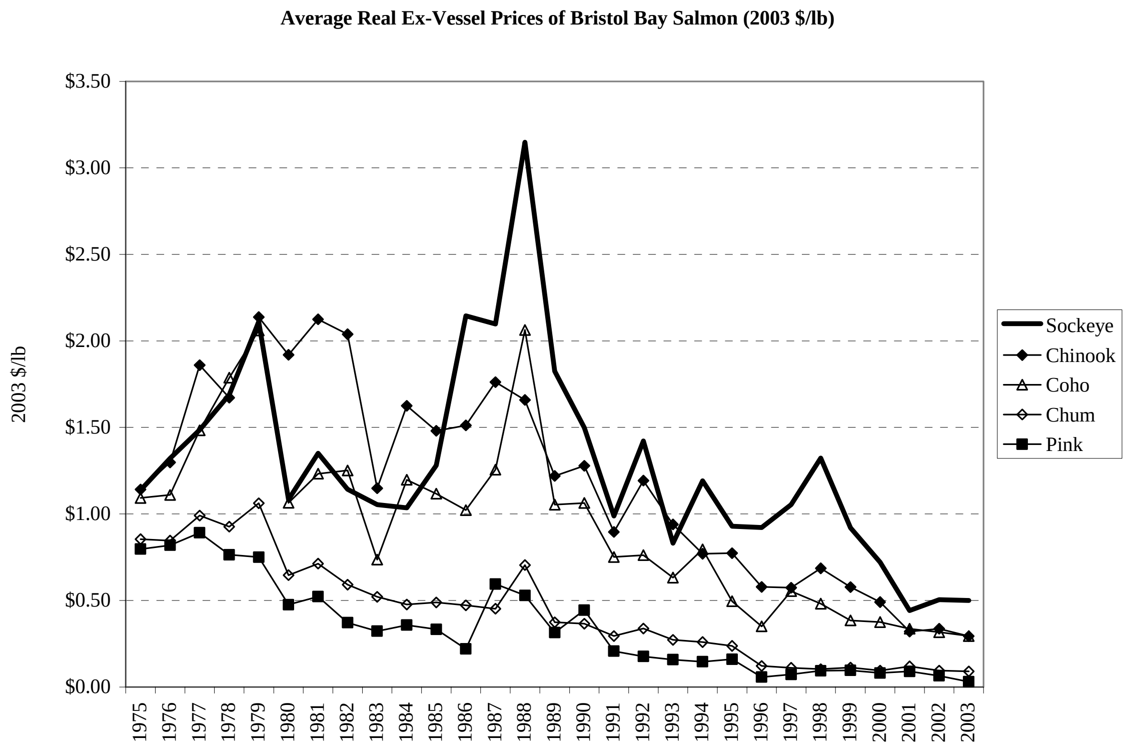
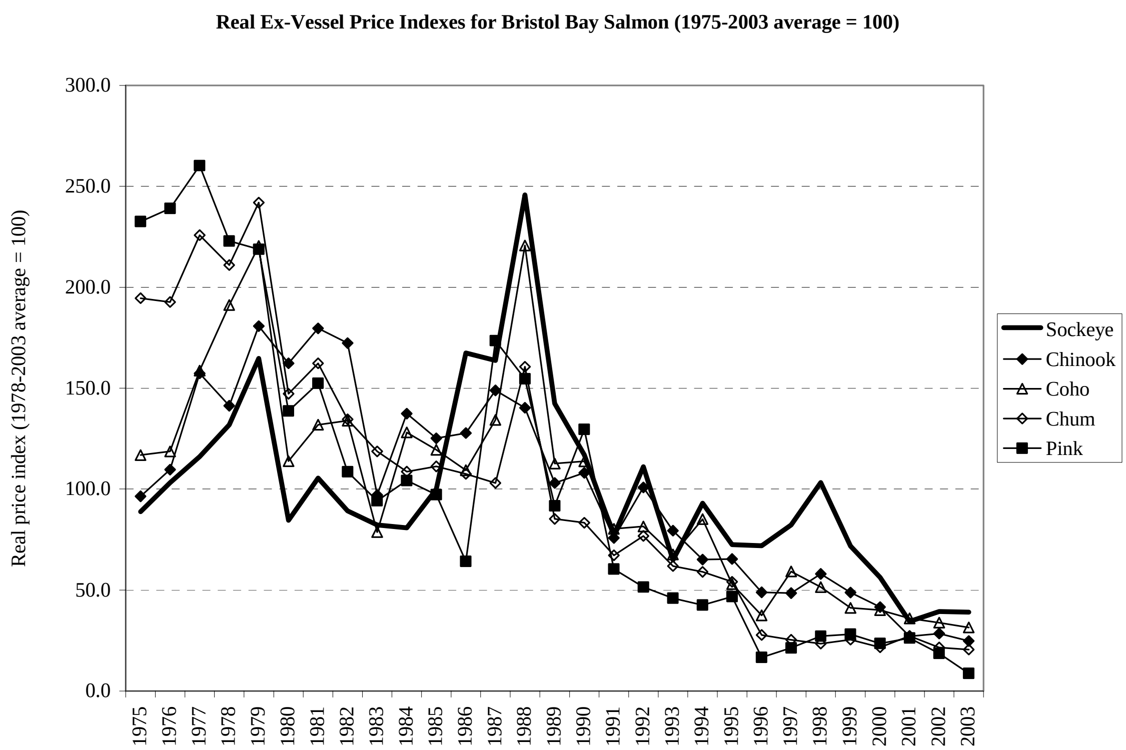


Figure XII-2



APPENDIX A: MAJOR DATA SOURCES

This appendix provides an overview of major data sources used for this study. We list these data sources alphabetically. The **bold headings** for each data source are the names which we use in the report in referring to these data sources.

ADFG Catch Data

The Alaska Department of Fish and Game (ADFG) reports data for Alaska salmon catches based on “fish tickets” filled out for all deliveries by commercial salmon fishermen to fish processors, as well as direct sales by fishermen to other buyers. These data are available from several different sources.

A problem with the ADFG catch data is that there is no single “official” website or publication where “final” data are reported. Data reported on different websites or in different ADFG publications frequently vary slightly One reason for this is that the ADFG “fish ticket” database is continuously being updated for reasons such as the discovery of misplaced fish tickets or the correction of coding errors in previously entered fish ticket data. Another reason is inconsistencies in whether or not the data include catches from test fisheries, hatchery cost-recovery catches, and other non-typical fisheries.

ADFG catch data reported in this study were downloaded from the Alaska Department of Fish and Game commercial salmon fisheries website:

www.cf.adfg.state.ak.us/geninfo/finfish/salmon/salmhome.php

ADFG COAR Data

In April of every year, all Alaska fish processors are required to submit “Commercial Operator Annual Reports” to the Alaska Department of Fish and Game. In these reports they are required to report the total volume of fish purchased, by species and area; the total amount paid for fish purchased, by species and area; the total volume (weight) of production, by product, species and area; and the total first wholesale value of production. We refer to the production data reported by processors as “Alaska production data.” and we refer to the average prices calculated by dividing first wholesale value by production volume as “Alaska production prices.” These prices are also sometimes referred to as “first wholesale prices.”

ADFG COAR data are available upon request from the Alaska Department of Fish and Game for years beginning with 1984. For this study, we used both ADFG COAR data for statewide production as well as ADFG COAR data for Bristol Bay production. The Bristol Bay data are shown in Table C-3.

ADFG 2004 Bristol Bay Season Summary

This is a memorandum, dated September 20, 2004, from Bristol Bay Area Management Biologist Keith Weiland to Division of Commercial Fisheries Director Doug Mecum. The memorandum includes preliminary estimates of Bristol Bay 2004 catches, value and average prices by species.

ADOR Salmon Price Reports

Since 2000, the Alaska Department of Revenue (ADOR) has prepared "Salmon Price Reports" which report total monthly sales volume (pounds) and sales value (dollars) reported by Alaska processors, by species, product and region. In theory, these reports provide more detailed data on Alaska wholesale price trends than the COAR reports, because they are monthly data and they are for a more detailed product breakdown (for example, data are reported separately for different can sizes). In practice however, much of the reports is left blank because of confidentiality restrictions. However, the data provide a very useful source for tracking monthly sales volumes and wholesale price trends for major products such as southeast Alaska canned pink salmon and Bristol Bay frozen sockeye salmon, for which sufficient processors report sales each month that the data are not confidential. The ADOR Salmon Price reports are available at:

http://www.tax.state.ak.us/reports.asp

For many years prior to 2000, the Alaska Department of Revenue prepared annual wholesale case price reports for canned salmon. These reported average monthly case prices on a statewide basis for canned salmon only.

Anchorage CPI

For some of the tables and figures in this report, Alaska salmon prices were adjusted for inflation (converted to "real" prices") using the U.S. Department of Labor, Bureau of Labor Statistics' "Annual Average Consumer Price Index , All Items - All Urban Consumers" (CPI-U) for the Municipality of Anchorage. Note that this is the only measure of inflation available for Alaska. The data are posted at the posted at the website of the Alaska Department of Commerce and Workforce Development's Research and Analysis Division:

http://almis.labor.state.ak.us/

The CPI for 2004 was not available at the time this report was written. For the purposes of this report, the 2004 price level was assumed to be the same as for 2003.

BANR

BANR is an abbreviation for *Bill Atkinson's News Report.* BANR is a weekly eight-page summary of articles and data from the Japanese seafood trade press, translated into

English by Bill Atkinson. Published since the early 1980s, BANR is a very useful source of information on Japanese markets for salmon and other species. Subscription information for BANR may be obtained from Bill Atkinson, P.O. Box 85020, Seattle, Washington 981454-1020; Phone: (206) 525-3235; FAX : (206) 525-3379; E-Mail: banrbill@msn.com.

BANR Japanese Fisheries Import Data

Bill Atkinson's News Report reports monthly data for the volume and value of Japanese fisheries imports for all major species, with an approximately two-month lag. These data are reprinted from reports in the Japanese trade press. The same data are also posted online, beginning with November 1996, by the National Marine Fisheries Service Southwest Regional Office (see NMFS Japanese Fisheries Imports Data). The data show total imports (from all countries combined) of fresh and frozen salmon, by species. Note that these data are for total imports, by species, from all countries. (Salmon imports by country are reported in BANR Japanese Salmon Imports Data.) The data do not distinguish between wild and farmed salmon.

Until 1991, Japanese sockeye and coho salmon imports were aggregated with the "Pacific Salmon" category. Beginning in 1991, sockeye salmon imports were reported separately from "Other Pacific Salmon." Beginning in 1992, coho salmon imports were also reported separately from "Other Pacific Salmon."

BANR Japanese Inventories Data

Bill Atkinson's News Report reports Japanese fisheries cold storage holdings (inventories) by month. Beginning with November 1996, the data have also been posted on the internet by the National Marine Fisheries Service (see NMFS Japanese Inventories Data).

BANR Japanese Salmon Import Data

Bill Atkinson's News Report reports monthly data for the volume of Japanese salmon imports by country, with an approximately two-month lag. Beginning with 1996, the data also include imports of trout fillets. Value is not reported separately by country.

BANR Salmon Prices

Bill Atkinson's News Report reports Tokyo Wholesale Market "list" prices every week for a number of different salmon products, by species, size, and region of origin, as reported in the Japanese trade press. An advantage of these data over other sources, such as FIS Japan Frozen Wholesale Prices Data, is that they report prices not only of Bristol Bay #1 4-6 pound sockeye salmon, but also of sockeye salmon from other areas of Alaska and for other sizes categories. A disadvantage is that the products for which prices are reported are not consistent over time, so that it is difficult to track long-term changes in prices for salmon from particular areas. Prices are sometimes reported for sockeye from specific areas such as Kodiak or Cook Inlet. At other times, prices are reported for “local” sockeye, a term used by the Japanese to refer to sockeye salmon from all areas other than Bristol Bay.

BC Canned Salmon Pack Bulletin

The British Columbia reports data on the British Columbia Canned Salmon Pack, by species, on a 48-lb case basis. This bulletin is updated regularly over the summer salmon season. The report also distinguishes between production from Canadian fish and production from imported salmon (most of which is likely from Alaska). The Bulletin is available at:

www.agf.gov.bc.ca/fish_stats/stats-process-can.htm.

CFEC Bristol Bay Data

For this study, the Commercial Fisheries Entry Commission provided us with the following data for Bristol Bay salmon harvests, by species, for the years 1975-2003: number of fish, pounds of fish, earnings, and average price (Excel file BBayEarnHarv1.xls, provided by Kurt Iverson, June 9, 2004). These data are shown in Table C-1.

CFEC Basic Information Tables Data

The Alaska Commercial Fisheries Entry Commission (CFEC) posts “Basic Information Tables” (BIT) for each Alaska salmon fishery which report annual data for number of permits issued (by residency of permit holders), total catch weight and value (all species combined), and average annual permit prices. These data are posted at the CFEC website under “Fishing Statistics and Activities” at:

http://www.cfec.state.ak.us/Mnu_Summary_Info.htm

FAO Fishstat+ Data

FAO FISHSTAT+ is a set of software and databases developed and maintained by the Fooad and Agriculture Organization of the United Nations (FAO) Fisheries Division to provide access to various FAO fisheries statistics. FAO FISHSTAT+ includes data for both wild salmon catches and aquaculture production, by country and species. Note that the FAO Fishstat+ data appear to substantially understate U.S.wild pink and chum salmon harvests. This is likely because FAO obtains the data from the National Marine Fisheries Service, which does not include hatchery cost-recovery harvests in commercial salmon catches.

The FAO Fishstat+ software and databases may be downloaded from the FAO website at

www.fao.org/fi/statist/FISOFT/FISHPLUS.asp.

In reporting "wild" salmon catches, we include only the five major Pacific salmon species (chinook, sockeye, coho, pink and chum). We exclude "wild" catches of Atlantic salmon and cherry salmon, because commercial harvests of both of these species are very small.

In reporting farmed salmon production, we include farmed salmon-trout, which we refer to as "trout." The FAO Fishstat+ reports production of a number of species of trout. For "salmon-trout" we only include rainbow trout produced in a "mariculture" (saltwater) environment.

Federal Reserve Bank of St. Louis Exchange Rate Data

The Federal Reserve Bank of St. Louis posts monthly exchange rate data between the dollar and other major currencies, include useful long historical monthly time series.

Monthly data for the exchange rate between the Japanese yen and the U.S. dollar are posted at:

www.stls.frb.org/fred/data/exchange/exjpus

Monthly data for the exchange rate between the Japanese yen and the U.S. dollar are posted at:

www.stls.frb.org/fred/data/exchange/exusuk

FIS Japan Frozen Wholesale Prices Data

The proprietary website www.fis.com posts prices from numerous fish markets around the world. The "Market Prices" section of this website includes prices which are updated weekly for the "Japanese Frozen" market. These include weekly minimum and maximum Japanese wholesale prices for frozen Atlantic salmon, Alaska (presumably Bristol Bay) sockeye salmon, Chilean farmed coho salmon, and Chilean and Norwegian rainbow trout, by size.

The monthly market prices for frozen sockeye, coho and trout reported in this publication are "minimum" prices for 4-6 pound sockeye salmon, 4-6 pound Chilean coho, and 4-6 pound Chilean trout, as reported for the first week of the month. This data series begins in February 1997 (at that time the website was known as "Sea-World"). The data are generally consistent with wholesale price data reported in the Seafood News Power Data Book.

Japan Economic and Social Research Institute Data

The Economic and Social Research Institute of the Government of Japan's Cabinet Office posts data about the Japanese economy at:

www.esri.cao.go.jp

NFPA Canned Pack Data

The National Food Processors Association (NFPA), which tests all canned salmon lots produced in the United States, prepares annual "Canned Salmon Pack" reports. These reports summarize total United States canned salmon production (in number of cases) by species, can-size and four regions: the Southeast Alaska District, the Central Alaska District, the Western Alaska District, and Washington.

NMFS Catch Data

Data for fish catches by state and species are posted on the National Marine Fisheries Service (NMFS) "Annual Commercial Landings Statistics" website:

http://www.st.nmfs.gov/commercial/landings/annual_landings.html

This website has data for annual volume and value of landings by state and species. As of June 2004, data were available for the years 1950-2002.

Note that the NMFS catch data for Alaska differ from the ADFG catch data for Alaska. This can be seen in the comparison of Alaska salmon catch with NMFS salmon catch data for the years 1998-2002 shown in the table below. While the data for sockeye and chinook salmon catches are relatively close, the NMFS catch data are significantly lower than the ADFG catch data for coho, pink and chum salmon.

Comparison of NMFS and ADFG Data for Alaska Salmon Catches, 1998-2002

Source	Species	1998	1999	2000	2001	2002
NMFS Catch Data (000 lbs)	Chinook	9,798	7,128	5,237	5,427	9,272
	Sockeye	125,502	244,226	204,924	168,604	132,821
	Coho	34,417	27,038	29,091	32,141	32,887
	Pink	332,581	381,888	208,200	378,386	255,826
	Chum	123,767	141,391	159,264	101,831	92,251
ADFG Catch Data (000 lbs)	Chinook	10,170	7,340	6,000	5,930	8,960
	Sockeye	127,950	247,410	206,570	169,770	136,495
	Coho	36,840	28,450	31,650	33,100	36,853
	Pink	373,740	431,600	244,860	427,300	298,741
	Chum	164,100	183,800	215,500	129,090	127,388
NMFS as % of ADFG	Chinook	96.3%	97.1%	87.3%	91.5%	103.5%
	Sockeye	98.1%	98.7%	99.2%	99.3%	97.3%
	Coho	93.4%	95.0%	91.9%	97.1%	89.2%
	Pink	89.0%	88.5%	85.0%	88.6%	85.6%
	Chum	75.4%	76.9%	73.9%	78.9%	72.4%

According to the National Marine Fisheries Service, the differences between the NMFS catch data and the ADFG catch data arise because the NMFS data exclude "harvests by private hatcheries" [Personal communication, David Sutherland, NOAA, August 9, 2004, citing the following personal communication from Peggy Murphy of the Pacific States Marine Fisheries Commission (which manages the AKFIN database), June 21, 2002: "The difference between FUS (Fisheries of the United States) salmon and ADFG salmon landings is FUS only includes commercial landings. This impacts the chum salmon poundage most as private hatchery harvests are not considered commercial landings."]

Note that cost-recovery harvests by private hatcheries are sold commercially, and that the fish are harvested by commercial fishermen operating under contract to the hatcheries. From a market-supply perspective, these fish, which are omitted from the NMFS Catch data, are clearly "commercial harvests."

NMFS Japanese Fisheries Imports Data

The National Marine Fisheries Service Southwest Regional Office reports monthly Japanese fisheries imports (volume and value), by species. Beginning with November 1996, the data are available at:

http://swr.ucsd.edu/fmd/sunee/imports/jimp.htm

The same data are reported in *Bill Atkinson's News Report* (see BANR Japanese Fisheries Imports Data). Note that these data are for total imports, by species, from all countries. Salmon imports by country are reported in BANR Japanese Salmon Imports Data.

NMFS Japanese Inventories Data

The National Marine Fisheries Service Southwest Regional Office reports Japanese fisheries cold storage holdings (inventories) by month. Beginning with November 1996, the data are available at:

http://swr.ucsd.edu/fmd/sunee/imports/jimp.htm

The same data are reported in *Bill Atkinson's News Report* (see BANR Japanese Inventories Data).

NMFS Trade Data

The National Marine Fisheries Service reports detailed data on U.S. imports, exports and re-exports of salmon (and other fish species) at its "Foreign Trade Information" website: www.st.nmfs.gov/st1/trade/index.html.

OECD Economic Data

The Organization for Economic Cooperation and Development (OECD) publishes annual data for a number of industrialized countries for a wide variety of economic indicators, including unemployment rates and consumer price indexes. These data are available at:

www.oecd.org.

Seafood News Power Data Book

The Japanese Company *Suisan Tsushin* (Seafood News) publishes an annual collection of seafood market data in Japanese which is named the "Marine Products Power Data Book." This publication includes extensive data about Japanese salmon harvests, salmon imports, wholesale prices and other Japanese data as well as international data. Data referenced in this study are from the 2002 Edition.

Tokyo Central Wholesale Market Data

The Tokyo Central Wholesale Market, which is operated by the Metropolitan Government of Tokyo, publishes monthly and annual data for total sales of frozen salmon, by species, including the volume of sales and the average price. These official monthly and annual publications are in Japanese and are expensive as well as difficult to obtain except by visiting Japan. These data are reprinted from time to time in other sources such as Bill Atkinson's News Report and the Seafood News Marine Products Power Data Book.

Several limitations should be kept in mind in using the Tokyo Central Wholesale Market data. First, the data aggregate all sales of frozen salmon for each species, regardless of country of origin, size and grade, and whether the salmon are farmed or wild. Second, the data include only actual sales at the Tokyo Central Wholesale Market.

In contrast, other data series typically present prices for a particular size and grade of salmon (such as Bristol Bay #1 grade 4-6 pounds). An advantage of the Tokyo Central Wholesale Market data is that they provide continuous price data series going back at least to the 1970s.

Urner-Barry Wholesale Price Data

Urner-Barry Publications, Inc. is a New Jersey-based company which tracks market conditions for a wide variety of food products, including seafood. Twice each week Urner-Barry publishes *Urner Barry's Seafood Price Current*, an eight-page newsletter which reports United States wholesale prices for a wide variety of seafood products. Most of the salmon products for which prices are regularly reported are farmed salmon. For most wild salmon products, price data are reported only occasionally or rarely. Fresh salmon prices, for example, are only reported during wild salmon seasons.

The Urner Barry price data are the best available data for tracking long-term wholesale price trends for farmed salmon in the United States. They also provide the most detailed U.S. wholesale price data available for certain wild salmon products, particularly frozen wild chum salmon.

Multi-year weekly data series for selected salmon product forms are available in print and CD format from Urner Barry. Information about ordering these data are available at the Urner Barry web site at:

http://www.urnerbarry.com/

Information about the price series in CD-Rom format is available at:

http://www.urnerbarry.com/frameset/products_frameset.htm

APPENDIX B: CITATIONS FOR FIGURES AND TABLES

This appendix provides citations for the figures and tables in this report. Figures and tables are listed in the order in which they appear in the report. All source citations refer to the source names listed alphabetically in Appendix A.

Figure or Table Number	Figure or Table Title	Figure or Table Source
CHAPTER I: INTRODUCTION		
Figure I-1	Average Ex-Vessel Price of Bristol Bay Sockeye Salmon	Ex-vessel prices are from CFEC Bristol Bay Data. Prices were adjusted for inflation based on the Anchorage CPI.
CHAPTER II: AN OVERVIEW OF WORLD SALMON MARKETS		
Figure II-1	World Salmon and Trout Supply	Bristol Bay harvests are from CFEC Bristol Bay data. Other Alaska salmon harvests were calculated by subtracting Bristol Bay harvests from total Alaska harvests as reported in ADFG Catch Data. Data for states of Washington, Oregon and California (included in "Other Wild Salmon") are NMFS Catch Data. All other data are FAO Fishstat+ data.
Table II-1	World Wild Salmon and Farmed Trout Supply	(same sources as for Figure II-1)
Figure II-2	Estimated World Salmon Consumption, 1991-2001	As indicated in a text footnote, Figure II-2 was developed by Gunnar Knapp for a report by Gunnar Knapp, Cathy Roheim, and James L. Anderson, tentatively titled *North American Wild Salmon: Economic Interactions with Farmed Salmon*, to be published by TRAFFIC North America in 2004 or early 2005. The derivation of the estimates is discussed in that report. Developing the estimates shown in Figure II-2 posed numerous challenges including inconsistencies in data between different sources; absence of data on product mix and end-markets for some regions; and variation in product yields. The estimates required numerous assumptions and should be considered only approximate.
Table II-2	Approximate World Salmon Production and Consumption, 2001	(same sources as for Figure II-2)
Table II-3	Approximate Shares of World Salmon Consumption, by Producing Country, 2001	(same sources as for Figure II-2)
Figure II-3	Estimated Japanese Fresh & Frozen Salmon Consumption, 1991-2001	Seafood News Power Data Book. Note that the 2002 Edition, which is the source for these data, only included data through the year 2001.
Figure II-4	Japanese Salmon and Trout Supply, by Species	(same source as for Figure II-3)
Figure II-5	Japanese "Red-Fleshed" Salmon Supply, by Species	(same source as for Figure II-3)
Figure II-6	Japanese Wholesale Prices of Frozen Salmon, 1981-2004 (yen/kilo)	The prices for "all wild sockeye" are Tokyo Central Wholesale Market data. From 1990 through April 2002, prices for "wild Bristol Bay sockeye" and "Farmed Chilean Coho" are from the Seafood News Power Data Book. Beginning in May 2002, prices are FIS Japan Frozen Wholesale Prices Data.

Figure II-7	Japanese Wholesale Prices of Frozen Salmon, 1981-2004 ($/lb)	Wholesale price data are from the same sources as for Figure II-6. Prices were converted to $/lb using Federal Reserve Bank of St. Louis Exchange rate data and a conversion rate of 1 kilogram = 2.2046 pounds. Note that the prices shown in the figure are nominal dollars (not adjusted for inflation).
Figure II-8	Estimated United States Fresh and Frozen Salmon Consumption, 1981-2001	The estimates in this table are from the same source as Figure II-2. Note that the methodology used to estimate consumption of North American wild salmon is similar to that used in Table IV-4 to estimate U.S. domestic consumption of U.S. sockeye salmon. The estimates should be considered only approximate.
Figure II-9	U.S. Wholesale Prices for Selected Salmon Products	Urner Barry Wholesale Price Data.
Figure II-10	Estimated European Union Fresh & Frozen Salmon & Trout Consumption, 1998-2001	(same source as for Figure II-2)
Figure II-11	United States Wild Salmon Exports to the European Union, by Product	NMFS Trade Data.
Figure II-12	Wholesale Prices of Fresh Atlantic Salmon at the Paris Rungis Market ($/lb)	FAO Globefish Salmon Commodity Update.
Figure II-13	Average Export Prices of U.S. Salmon Exports to the European Union	NMFS Trade Data.
Figure II-14	Estimated World Canned Salmon Consumption, 1983-2001	(same source as for Figure II-2)
Figure II-15	North American Canned Salmon Pack	NFPA Canned Pack Data; BC Canned Salmon Pack Bulletin.
Figure II-16	Monthly Average Wholesale Prices for Alaska Canned Salmon (48-Tall Cases)	ADOR Salmon Price Reports
CHAPTER III: BRISTOL BAY SALMON HARVESTS AND PRICES		
Figure III-1	Bristol Bay Salmon Harvests	CFEC Bristol Bay Data for years through 2003; ADFG 2004 Bristol Bay Season Summary for 2004.
Figure III-2	Bristol Bay Commercial Sockeye Salmon Catches, 1893-2003.	This figure is copied from an ADFG information packet distributed at the Fish Expo trade show in November 2003.
Figure III-3	Average Ex-Vessel Price of Bristol Bay Sockeye Salmon	Nominal prices are from CFEC Bristol Bay Data for years through 2003 and ADFG 2004 Bristol Bay Season Summary for 2004. Real prices were calculated using Anchorage CPI data.
Figure III-4	Average Ex-Vessel Value of Bristol Bay Salmon Harvests (all species)	CFEC Bristol Bay Data for years through 2003; ADFG 2004 Bristol Bay Season Summary for 2004. Real prices were calculated using Anchorage CPI data.
CHAPTER IV: BRISTOL BAY SALMON PRODUCTS AND MARKETS		
Figure IV-1	Bristol Bay Salmon Production	Harvests are from CFEC Bristol Bay Data. Production is from ADFG COAR data.
Figure IV-2	Sockeye Salmon Production in Bristol Bay	ADFG COAR data
Figure IV-3	Share of Sockeye Salmon Production in Bristol Bay	ADFG COAR data
Figure IV-4	Frozen and Canned Sockeye Salmon Production in Bristol Bay	ADFG COAR data

Table IV-1	United States Sockeye Salmon Harvests, 1989-2002	Bristol Bay harvests are from CFEC Bristol Bay data. Other Alaska salmon harvests were calculated by substracting Bristol Bay harvests from total Alaska harvests as reported in ADFG Catch Data. Data for Lower 48 are NMFS Catch Data.
Table IV-2	United States Sockeye Salmon Exports, 1989-2002	NMFS Trade Data.
Table IV-3	United States Sockeye Salmon Exports, by Product & Country, 1989-2003	NMFS Trade Data.
Table IV-4	Estimation of U.S. Domestic Consumption and Net Inventory Accumulation of U.S. Sockeye Salmon	Refer to sources for Tables IV-1 and IV-2, as well at notes at the bottom of the table.
Table IV-5	Estimated End-Markets for United States Sockeye Salmon	Calculated from Table IV-6.
Table IV-6	Estimated End-Markets for United States Sockeye Salmon	Calculated from Table IV-3 and Table IV-4.
CHAPTER V: THE JAPANESE MARKET FOR FROZEN BRISTOL BAY SALMON		
Figure V-1	Average Prices of Bristol Bay Sockeye Salmon	Japanese Wholesale Prices are August wholesale prices. Sources for Japanese wholesale prices are Tokyo Central Wholesale Market data for years prior to 1990; Seafood News Power Data Book from 1990 through 2001; and FIS Japan Frozen Wholesale Prices for years beginning with 2001. Prices were converted from yen to dollars using August exchange rate data reported in Federal Reserve Bank of St. Louis Exchange Rate Data. Frozen production prices are from ADFG COAR data. Ex-vessel prices are from CFEC Bristol Bay Data. All prices were adjusted for inflation based on the Anchorage CPI. (See discussion for Figure V-15 about derivation of assumptions for the August CPI.)
Figure V-2	Japanese Red-Fleshed Salmon Imports, May-April	BANR Japanese Fisheries Imports Data and NMFS Japanese Fisheries Imports Data. Data for frozen trout fillets are from BANR Japanese Salmon Imports Data.
Figure V-3	Japanese Sockeye Salmon Imports, May-April	BANR Japanese Salmon Imports Data
Figure V-4	Japanese "Red-Fleshed" Salmon Imports, May-April	Same sources as for Figure V-2.
Figure V-5	Japanese "Red-Fleshed" Salmon Imports, by Month, May 2002-April 2004	Same sources as for Figure V-2.
Figure V-6	Japanese Inventories of Frozen Salmon, Selected Years (May-April)	BANR Japanese Inventories Data and NMFS Japanese Inventories Data
Figure V-7	Japanese Wholesale Prices of Frozen Bristol Bay Sockeye Salmon (yen/kilo)	Tokyo Central Wholesale Market data for years prior to 1990; Seafood News Power Data Book from 1990 through April 2002; FIS Japan Frozen Wholesale Prices beginning May 2002.
Figure V-8	Japanese Wholesale Prices of Frozen Red-Fleshed Salmon (yen/kilo)	Same sources as for Figure V-7
Table V-1	Japanese September Wholesale Prices for Frozen Sockeye Salmon	BANR Salmon Prices
Figure V-9	Japanese Total "Red-Fleshed" Salmon Imports and Sockeye Wholesale Prices	Same sources as Figure V-2 and Figure V-7. Prices are unweighted averages of monthly prices.
Figure V-10	Japanese Sockeye Imports and Sockeye-Coho Price Differential	Same sources as for Figure V-9
Figure V-11	Japanese Gross Domestic Expenditures for Private Consumption	Japan Economic and Social Research Institute Data.

Figure V-12	Japanese Unemployment Rate	OECD Economic Data.
Figure V-13	Annual Percentage Change in Japanese Consumer Price Index	OECD Economic Data.
Figure V-14	Value of 100 Yen in Dollars	Federal Reserve Bank of St. Louis Exchange Rate Data
Figure V-15	Japanese Wholesale Price of Frozen Bristol Bay Sockeye Salmon Expressed in Dollars Per Pound	Calculated from Japanese wholesale prices in yen from the same data sources as Figure V-7. Yen/kilo prices were converted to nominal $/lb prices using Federal Reserve Bank of St. Louis Exchange Rate Data, and weights of 1 kilogram = 2.2046 pounds. Nominal $/lb prices were converted to real $/lb prices using Anchorage CPI data. The annual CPI value was assigned to January of each year. For each subsequent month, the CPI was assumed to change by 1/12 of the change in the annual CPI.
Figure V-16	Japanese August Wholesale Prices of Bristol Bay Sockeye Salmon	Same sources as for Figure V-15. Prices in dollars per round pound were calculated by multiplying by an assumed yield of 74%.
Figure V-17	Average Prices of Bristol Bay Sockeye Salmon	Same sources as for Figure V-1.
Figure V-18	Ex-Vessel Price and Processor and Importer Margins for Bristol Bay Sockeye Salmon	Calculated from data used for Figure V-17. Importer margin is Japan August wholesale price minus Bristol Bay frozen production price. Processor margin is Bristol Bay frozen production price minus ex-vessel price.
Table V-2	Share of Ex-Vessel Price, Processor Margin and Importer Margin in Annual Changes in Japanese Wholesale Price	Calculated from annual changes in data used for Figure V-18.
CHAPTER VI: OTHER MARKETS FOR BRISTOL BAY SOCKEYE SALMON		
Figure VI-1	United States and British Columbia Canned Sockeye Salmon Pack	NFPA Canned Pack Data; BC Canned Salmon Pack Bulletin.
Table VI-1	Alaska Westward District Canned Sockeye Pack, by Can Size	NFPA Canned Pack Data.
Figure VI-2	Monthly Average Wholesale Prices for Alaska Canned Sockeye Salmon	ADOR Salmon Price Reports.
Figure VI-3	North American Sockeye Salmon Pack and Average Case Price	NFPA Canned Pack Data; BC Canned Salmon Pack Bulletin; ADOR Salmon Price Reports. Average case price is the unweighted average of monthly prices for the "canned salmon sales year" September-August.
Figure VI-4	Value of One British Pound in Dollars	Federal Reserve Bank of St. Louis Exchange Rate Data
Figure VI-5	Bristol Bay Production Prices and Ex-Vessel Prices	ADFG COAR data; CFEC Bristol Bay data. Adjusted for inflation based on Anchorage CPI data. Production prices converted to prices per round pound based on assumed yields of 74% for frozen sockeye and 67% for canned sockeye.
Figure VI-6	Ex-Vessel Price and Processor Margin for Bristol Bay Canned Sockeye Salmon	Calculated from data used for Figure V-5. Processor margin is Bristol Bay canned production price minus ex-vessel price.
Table VI-2	Overview of Alaska Sockeye Salmon Roe Production and Prices, 1991-2002	ADFG Harvest Data; ADFG COAR data.
CHAPTER VII: EX-VESSEL SALMON PRICE THEORY (no data are presented in this chapter)		
CHAPTER VIII: FARMED SALMON COSTS OF PRODUCTION		

Figure VIII-1	Export Price and Production Cost of Norwegian Atlantic Salmon, 1985-2003	Source is provided below the figure. For a more detailed discussion of the source, see Chapter II, footnote 3.
Figure VIII-2	Wholesale Prices of Fresh Atlantic Salmon at the Paris Rungis Market ($/lb)	FAO Globefish Salmon Commodity Update.
Tables VIII-1 through VIII-8	(Various estimates of salmon farming costs)	See source citations in tables.
Figure VIII-3	Monthly Japanese Wholesale Price of Chilean Farmed Coho	Seafood News Power Data Book from 1991 through April 2002; FIS Japan Frozen Wholesale Prices beginning May 2002. Converted to nominal $/lb using exchange rates from Federal Reserve Bank of St. Louis Exchange Rate data.
Figure VIII-4	Farmed Salmon Wholesale Prices, Three-Year Running Average	All prices are running averages for the current month and the 35 preceding months. Japan and Paris prices are converted to nominal dollars per pound using Federal Reserve Bank of St. Louis Exchange Rate data. Frozen Chilean Trout and Frozen Chilean Coho prices are from the same source as for Figure VIII-3. Prices for Fresh Canadian Atlantic, US Northeast, are from Urner Barry Wholesale Price Data. Prices for Fresh Norwegian Atlantic Salmon, Paris, are from FAO Globefish Salmon Commodity Update.
Figure VIII-5	Fishmeal and Soybean Prices, CIF Germany	See source citation at bottom of figure.
Figure VIII-6	Fish Oil and Soyoil Prices, CIF N.W. Europe	See source citation at bottom of figure.
CHAPTER IX: GENERAL CONSIDERATIONS IN FORECASTING FUTURE BRISTOL BAY SOCKEYE SALMON PRICES		
Figure IX-1	Number of Limited Entry Permits Fished in Bristol Bay	CFEC Basic Information Tables Data.
CHAPTER X: REGRESSION ANALYSIS OF BRISTOL BAY PRICES		
Table X-1	Summary of Regression Results	See discussion in chapter.
Table X-2	Regression Analysis Variables: Definitions, Sources, and Years for Which Data Were Available	See "Source" column in Table. Wholesale price data are from the same sources as Chapter V-7. Conversions to real 2003 $/lb were done as described above for Figure V-15.
Table X-3	Data Used for Regression Analysis	Sources listed in "Source" column of Table X-2. Conversions to real 2003 $/lb were done as described above for Figure V-15.
Tables X-4, X-5, X-7, X-8	(Regression results)	Results of Ordinary Least Squares regressions, as discussed in chapter
Figures X-1, X-2, X-5, X-6	Comparisons of Actual and Projected Prices	For each regression, the figure shows actual ex-vessel prices and the ex-prices projected by the regression given actual values of explanatory variables. Note that both prices are in real 2003 $/lb. Actual prices are CFEC Bristol Bay data, adjusted for inflation using Anchorage CPI data.
Table X-6	Price Effects of Changes in Exogenous Variables Implied by Regression 2	Calculated from Regression 2 and data shown in Table X-3
Figure X-3	Total World Farmed Salmon Supply and Farmed Coho Salmon Supply	Data shown in Table X-3; original source is FAO Fishstat+ data.
Figure X-4	Value of 100 Yen in Dollars	Federal Reserve Bank of St. Louis Exchange Rate Data

CHAPTER XI: BRISTOL BAY SOCKEYE SALMON EX-VESSEL PRICE FORECASTS		
Table XI-1	Forecasted Bristol Bay Prices for Different Combinations of Explanatory Variables	Calculated using Price Forecasting Equation. Ranges and averages discussed in the footnote are calculated from CFEC Bristol Bay data (for sockeye harvest) and the data shown in Table X-3 for farmed Chilean coho wholesale prices.
Table XI-2	Forecasted Bristol Bay Prices for Different Combinations of Explanatory Variables	Calculated using Price Forecasting Equation. Sources used to calculate the ranges and averages discussed in the footnote are as follows: Sockeye harvests: CFEC Bristol Bay data; Farmed coho wholesale prices: Seafood News Power Data Book from 1990 through April 2002; FIS Japan Frozen Wholesale Prices beginning May 2002; Exchange rates: Federal Reserve Bank of St. Louis Exchange Rate Data.
Table XI-3	Distribution of Bristol Bay Sockeye Harvest Volume	CFEC Bristol Bay Data.
Figure XI-1	Japanese Wholesale Prices of Farmed Chilean Coho, 2000-2004 ($/lb, nominal)	Chilean Coho wholesale prices are from the same source as for Figure VIII-3.
Table XI-4	Cumulative Probability Distribution for Japanese Wholesale Price for Farmed Coho	Based on assumptions described in the text.
Figure XI-2	Assumptions for Japanese Wholesale Price of Farmed Chilean Coho	Historical data are from the same source as for Figure VIII-3. Assumed future range is based on assumptions described in the text.
Table XI-5	Forecasted Ex-Vessel Prices for Historical Bristol Bay Sockeye Harvest Levels, 1978-2003	Calculated from Price Forecasting Equation, based on assumptions described in the text.
Figure XI-3	Forecasted Probability of Ex-Vessel Price	See discussion in chapter.
Figure XI-4	Forecasted Cumulative Probability of Ex-Vessel Price	See discussion in chapter.
Table XI-6	Cumulative Probability Distribution for Ex-Vessel Price	See discussion in chapter.
Figure XI-5	Historical Ex-Vessel Prices and Forecasted Ex-Vessel Price Range for Bristol Bay Sockeye Salmon	Historical prices are from CFEC Bristol Bay data and ADFG 2004 Bristol Bay Season Summary, adjusted for inflation using Anchorage CPI data. See chapter for discussion of forecast range.
CHAPTER XII: CONSIDERATIONS IN FORECASTING PRICES FOR OTHER BRISTOL BAY SALMON SPECIES		
Table XII-1	Relative Significance of Different Species in Earnings of Bristol Bay Permit Holders	CFEC Bristol Bay Data.
Table XII-2	Correlation Coefficients Between Real Ex-Vessel Prices of Sockeye and Other Species	Calculated from CFEC Bristol Bay Data after adjusting for inflation using Anchorage CPI data.
Figure XII-1	Average Real Ex-Vessel Prices of Bristol Bay Salmon (2003 $/lb)	CFEC Bristol Bay Data, adjusted for inflation using Anchorage CPI data.
Figure XII-2	Real Ex-Vessel Price Indexes for Bristol Bay Salmon (1975-2003 average = 100)	Calculated from CFEC Bristol Bay Data after adjusting for inflation using Anchorage CPI data.

APPENDIX C. SELECTED DATA TABLES

Table C-1

Bristol Bay Salmon Harvests, All Gear Types Combined: Number of Fish, Pounds of Fish, Earnings, and Average Price

	Chinook	Sockeye	Coho	Pink	Chum	Chinook	Sockeye	Coho	Pink	Chum	Chinook	Sockeye	Coho	Pink	Chum	Chinook	Sockeye	Coho	Pink	Chum
Year	Num Fish	Num Fish	Num Fish	Num Fish	Num Fish	Lbs	Lbs	Lbs	Lbs	Lbs	Earnings	Earnings	Earnings	Earnings	Earnings	Price	Price	Price	Price	Price
1975	30,110	4,842,254	50,982	422	323,182	538,840	26,444,925	436,187	1,806	2,018,032	$215,943	$10,577,970	$167,285	$506	$605,410	$0.40	$0.40	$0.38	$0.28	$0.30
1976	96,692	5,581,108	31,775	1,034,250	1,321,752	1,662,824	34,116,765	236,160	3,550,488	8,745,076	$816,062	$17,057,415	$99,204	$1,100,651	$2,798,454	$0.49	$0.50	$0.42	$0.31	$0.32
1977	131,911	4,855,304	117,055	4,517	1,592,890	3,008,778	31,873,877	942,059	27,436	11,920,315	$2,260,239	$19,124,644	$564,480	$9,877	$4,768,086	$0.75	$0.60	$0.60	$0.36	$0.40
1978	198,597	9,908,096	115,464	5,144,397	1,155,053	4,350,313	58,834,945	885,409	16,576,695	8,038,967	$3,142,946	$42,949,588	$683,731	$5,470,309	$3,215,767	$0.72	$0.73	$0.77	$0.33	$0.40
1979	219,463	21,417,609	316,940	3,875	905,854	4,464,774	125,925,441	2,496,182	18,685	5,984,334	$4,557,878	$126,959,868	$2,456,114	$6,682	$3,033,246	$1.02	$1.01	$0.98	$0.36	$0.51
1980	100,184	23,738,037	389,028	2,557,108	1,300,084	1,980,704	132,858,956	2,791,963	8,600,642	7,806,507	$2,001,376	$75,728,339	$1,563,046	$2,150,196	$2,654,155	$1.01	$0.57	$0.56	$0.25	$0.34
1981	242,256	25,573,099	327,713	7,280	1,503,753	4,540,927	158,711,688	2,105,843	25,279	9,930,304	$5,486,762	$121,890,962	$1,476,934	$7,509	$4,021,928	$1.21	$0.77	$0.70	$0.30	$0.41
1982	261,536	15,085,626	664,606	1,492,007	822,344	5,267,478	96,575,481	4,974,943	4,991,269	5,521,833	$6,435,840	$66,155,718	$3,733,443	$1,113,062	$1,954,726	$1.22	$0.69	$0.75	$0.22	$0.35
1983	204,278	37,356,710	130,182	484	1,630,917	4,268,588	211,705,822	843,282	2,178	10,224,849	$2,991,221	$136,126,986	$378,265	$429	$3,251,499	$0.70	$0.64	$0.45	$0.20	$0.32
1984	107,433	24,703,683	627,211	3,366,090	2,022,104	2,147,651	139,413,820	4,827,432	10,762,332	12,597,739	$2,218,176	$91,734,899	$3,675,583	$2,443,059	$3,817,142	$1.03	$0.66	$0.76	$0.23	$0.30
1985	123,544	23,681,909	194,828	457	1,067,683	2,258,172	136,151,438	1,602,651	1,798	6,832,406	$2,175,749	$113,551,009	$1,165,854	$390	$2,172,706	$0.96	$0.83	$0.73	$0.22	$0.32
1986	95,094	15,688,833	167,602	373,345	1,214,738	1,772,292	95,288,914	1,147,586	1,319,509	7,900,367	$1,778,340	$135,595,898	$777,723	$192,651	$2,472,854	$1.00	$1.42	$0.68	$0.15	$0.31
1987	78,442	16,076,656	115,479	600	1,530,922	1,573,004	95,822,019	866,894	2,247	9,898,864	$1,844,909	$133,874,378	$725,006	$889	$2,980,806	$1.17	$1.40	$0.84	$0.40	$0.30
1988	50,919	14,003,352	283,764	958,213	1,472,368	949,886	87,788,813	2,183,645	3,424,970	10,219,116	$1,053,890	$184,714,261	$3,012,334	$1,211,869	$4,813,368	$1.11	$2.10	$1.38	$0.35	$0.47
1989	42,639	28,745,998	306,552	579	1,259,144	814,139	163,955,080	2,303,384	2,180	7,874,014	$682,653	$205,621,955	$1,667,545	$471	$2,024,774	$0.84	$1.25	$0.72	$0.22	$0.26
1990	38,616	33,442,617	176,617	496,662	1,055,432	661,688	192,291,652	1,365,661	1,913,896	6,538,478	$617,649	$210,377,306	$1,059,318	$620,087	$1,746,040	$0.93	$1.09	$0.78	$0.32	$0.27
1991	33,452	25,815,016	204,596	305	1,288,957	525,314	149,510,798	1,482,830	1,043	7,927,164	$359,098	$112,731,629	$849,925	$165	$1,783,780	$0.68	$0.75	$0.57	$0.16	$0.23
1992	74,186	31,883,513	281,015	499,520	921,242	1,243,804	182,562,814	2,020,628	1,809,639	5,841,820	$1,169,941	$204,848,928	$1,213,392	$251,552	$1,554,282	$0.94	$1.12	$0.60	$0.14	$0.27
1993	98,703	40,467,185	89,359	413	838,507	1,727,759	243,554,354	623,076	1,394	5,395,076	$1,320,831	$164,649,760	$320,543	$178	$1,192,415	$0.76	$0.68	$0.51	$0.13	$0.22
1994	152,183	35,212,355	290,142	89,950	895,110	2,753,987	195,460,819	2,421,345	339,738	5,588,741	$1,763,858	$193,545,568	$1,600,319	$41,115	$1,201,803	$0.64	$0.99	$0.66	$0.12	$0.22
1995	101,843	44,202,434	97,513	471	977,848	2,009,846	243,165,221	689,792	1,674	6,202,438	$1,328,824	$193,113,094	$291,938	$229	$1,258,517	$0.66	$0.79	$0.42	$0.14	$0.20
1996	87,151	29,593,619	169,928	37,590	826,538	1,485,952	185,955,118	1,443,722	131,135	5,685,524	$755,385	$150,625,535	$444,052	$6,557	$608,390	$0.51	$0.81	$0.31	$0.05	$0.11
1997	80,092	12,162,106	92,277	110	317,348	1,321,596	72,727,349	714,766	372	2,009,408	$675,044	$68,291,497	$352,272	$24	$198,920	$0.51	$0.94	$0.49	$0.07	$0.10
1998	137,246	10,041,230	182,097	26,925	396,414	2,296,907	57,705,452	1,531,574	90,613	2,466,850	$1,423,949	$69,024,766	$665,952	$7,596	$229,081	$0.62	$1.20	$0.44	$0.08	$0.09
1999	27,205	25,655,320	21,265	71	685,277	396,458	135,742,596	146,576	234	4,005,554	$209,013	$114,025,718	$51,445	$20	$408,563	$0.53	$0.84	$0.35	$0.09	$0.10
2000	23,004	20,448,518	155,417	58,735	397,730	360,577	125,579,002	1,163,863	208,915	2,647,112	$164,423	$84,014,315	$405,295	$15,674	$232,955	$0.46	$0.67	$0.35	$0.08	$0.09
2001	24,666	14,180,595	17,764	428	831,952	430,527	95,636,585	126,814	1,176	5,969,862	$131,741	$40,358,639	$40,702	$101	$680,562	$0.31	$0.42	$0.32	$0.09	$0.11
2002	44,749	10,678,568	8,730	528	468,339	815,640	64,975,271	61,233	2,043	3,149,610	$267,647	$31,898,131	$18,875	$127	$289,752	$0.33	$0.49	$0.31	$0.06	$0.09
2003	47,940	14,765,554	45,327	244	933,031	770,713	93,391,756	304,141	1,195	6,027,087	$225,553	$46,684,430	$89,435	$36	$542,375	$0.29	$0.50	$0.29	$0.03	$0.09

Note: Harvest and earnings figures include set and drift gill net, test fishing, confiscated and educational permit harvests, and any other harvest where the product was sold.

Source: Commerical Fisheries Entry Commission, File BBayEarnHarv1.xls

Table C-2
Annual Average Consumer Price Index, Anchorage and United States

Year	Anchorage		United States	
	Average	% Change from Previous Year	Average	% Change from Previous Year
1960	34.0		29.6	
1961	34.5	1.5	29.9	1.0
1962	34.7	0.6	30.2	1.0
1963	34.8	0.3	30.6	1.3
1964	35.0	0.6	31.0	1.3
1965	35.3	0.9	31.5	1.6
1966	36.3	2.8	32.4	2.9
1967	37.2	2.5	33.4	3.1
1968	38.1	2.4	34.8	4.2
1969	39.6	3.9	36.7	5.5
1970	41.1	3.8	38.8	5.7
1971	42.3	2.9	40.5	4.4
1972	43.4	2.6	41.8	3.2
1973	45.3	4.4	44.4	6.2
1974	50.2	10.8	49.3	11.0
1975	57.1	13.7	53.8	9.1
1976	61.5	7.7	56.9	5.8
1977	65.6	6.7	60.6	6.5
1978	70.2	7.0	65.2	7.6
1979	77.6	10.5	72.6	11.3
1980	85.5	10.2	82.4	13.5
1981	92.4	8.1	90.9	10.3
1982	97.4	5.4	96.5	6.2
1983	99.2	1.8	99.6	3.2
1984	103.3	4.1	103.9	4.3
1985	105.8	2.4	107.6	3.6
1986	107.8	1.9	109.6	1.9
1987	108.2	0.4	113.6	3.6
1988	108.6	0.4	118.3	4.1
1989	111.7	2.9	124.0	4.8
1990	118.6	6.2	130.7	5.4
1991	124.0	4.6	136.2	4.2
1992	128.2	3.4	140.3	3.0
1993	132.2	3.1	144.5	3.0
1994	135.0	2.1	148.2	2.6
1995	138.9	2.9	152.4	2.8
1996	142.7	2.7	156.9	3.0
1997	144.8	1.5	160.5	2.3
1998	146.9	1.5	163.0	1.6
1999	148.4	1.0	166.6	2.2
2000	150.9	1.7	172.2	3.4
2001	155.2	2.8	177.1	2.8
2002	158.2	1.9	179.9	1.6
2003	162.5	2.7	184.0	2.3

Source: Price indexes are for All Items - All Urban Consumers (CPI-U). Data are available at the website of the Research and Analysis Division of the Alaska Department of Labor and Workforce Development: http://almis.labor.state.ak.us.

Table C-3

Bristol Bay Sockeye Salmon Production Volume, Production Value, and Average Production Prices as Reported by Processors in Commercial Operator's Annual Reports

	Year	Canned	Frozen	Fresh	Total
Pounds	1984	32,023,257	53,167,166	388,888	85,579,311
	1985	16,602,769	81,123,489	2,350,305	100,076,563
	1986	9,543,086	56,106,509	0	65,649,595
	1987	12,794,318	48,120,901	181,174	61,096,393
	1988	5,652,436	46,753,263	959,944	53,365,643
	1989	27,389,562	89,420,330	612,499	117,422,391
	1990	17,645,892	96,567,604	1,367,527	115,581,023
	1991	20,475,984	80,365,080	2,532,436	103,373,500
	1992	20,794,899	103,665,168	472,648	124,932,715
	1993	27,663,699	141,982,529	1,066,197	170,712,425
	1994	20,533,094	105,498,327	651,935	126,683,356
	1995	31,888,119	124,895,533	3,253,312	160,036,964
	1996	29,460,454	97,527,329	735,325	127,723,108
	1997	9,623,060	35,128,699	4,638,710	49,390,469
	1998	11,197,532	27,184,184	209,248	38,590,964
	1999	21,303,347	60,864,211	82,411	82,249,969
	2000	29,496,622	49,053,741	765,538	79,315,901
	2001	19,323,602	41,327,780	0	60,651,382
	2002	22,097,595	22,686,595	212,571	44,996,761
Value ($)	1984	71,860,941	87,712,873	469,775	160,043,589
	1985	41,952,500	153,455,777	2,477,203	197,885,480
	1986	32,967,120	139,364,634	0	172,331,754
	1987	45,615,840	119,119,981	517,603	165,253,424
	1988	32,343,353	176,326,824	2,848,079	211,518,256
	1989	111,597,846	227,801,428	1,146,594	340,545,868
	1990	59,708,141	213,008,728	2,481,121	275,197,990
	1991	58,028,817	137,618,679	5,491,549	201,139,045
	1992	79,243,280	250,347,256	862,131	330,452,667
	1993	64,391,129	230,239,128	1,383,341	296,013,598
	1994	63,142,213	257,317,948	1,260,889	321,721,050
	1995	93,581,027	211,041,763	6,489,872	311,112,662
	1996	92,602,414	203,310,211	1,030,991	296,943,616
	1997	32,496,101	80,777,800	9,525,013	122,798,914
	1998	44,105,863	80,586,028	458,466	125,150,357
	1999	67,124,345	129,032,973	191,148	196,348,466
	2000	81,510,432	81,566,418	1,594,751	164,671,601
	2001	44,669,900	61,157,667	0	105,827,567
	2002	55,275,886	39,698,079	327,357	95,301,322
Average price ($/lb)	1984	$2.24	$1.65	$1.21	
	1985	$2.53	$1.89	$1.05	
	1986	$3.45	$2.48	$0.00	
	1987	$3.57	$2.48	$2.86	
	1988	$5.72	$3.77	$2.97	
	1989	$4.07	$2.55	$1.87	
	1990	$3.38	$2.21	$1.81	
	1991	$2.83	$1.71	$2.17	
	1992	$3.81	$2.41	$1.82	
	1993	$2.33	$1.62	$1.30	
	1994	$3.08	$2.44	$1.93	
	1995	$2.93	$1.69	$1.99	
	1996	$3.14	$2.08	$1.40	
	1997	$3.38	$2.30	$2.05	
	1998	$3.94	$2.96	$2.19	
	1999	$3.15	$2.12	$2.32	
	2000	$2.76	$1.66	$2.08	
	2001	$2.31	$1.48	$0.00	
	2002	$2.50	$1.75	$1.54	

Source: Alaska Department of Fish and Game, Commercial Operator Annual Report data provided February 3, 2004 as file Knapp_SalmonProd_ByArea84-02.xls.