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Title: THE PACIFIC COHO SALMON FISHERY: AN INTRASEASONAL AND INTERREGIONAL ECONOMIC ANALYSIS OF THE EX-VESSEL MARKET

Abstract approved: Richard S. Johnston

The ex-vessel coho salmon market has been paid scant attention in the study of the salmon resources. This study is an attempt to advance an understanding of the variations of ex-vessel prices and landings during the coho season as well as between the various coastal ports where the fish is landed.

This study presents an empirical analysis of the ex-vessel port markets for coho salmon in Oregon and Washington. The objectives of the study are to investigate the variation in landings and prices during the fishing season and to compare those differences between ports for both states. This study focuses on the determination of the ex-vessel price mechanism and the decision behavior of coho fishermen in their choice of ports to land the catch.

An economic model of each port is developed to explain the buying behavior of processors and the selling behavior of fishermen. Each

port is treated as a distinctive market subject to external changes in the abundance of coho, the conditions of the wholesale markets, and the responsiveness of fishermen to prices in other ports.

Several econometric models are constructed to determine the distinctive characteristics of the Oregon and Washington ex-vessel port markets. The demand and supply at the different ports are estimated by applying regression analysis to 32 different sets of data. These data include a single year (1976) of transaction records for the twelve Oregon ports, and four years (1973-1976) of landings records for the five Washington coastal ports. Three different models are used: a simultaneous equations model, a recursive model, and a single equation model.

The major findings in the study are as follows: the ex-vessel demand in most Oregon or Washington ports is highly elastic, which suggests that changes in seasonal landings at a port do not have any significant impact on the ex-vessel price.

While fishermen and other industry observers have noted differences in seasonal ex-vessel price between ports, such differences do not appear to exist. Average seasonal price differences between ports do not vary when appropriate weights are applied to the average price calculations.

The size (in pounds) of the coho salmon plays a major role in the determination of the intraseasonal ex-vessel demand at all ports.

Estimations performed without accounting for this variation fail to adequately explain ex-vessel price variation.

Another variable found to be a key factor in the explanation of ex-vessel prices is the wholesale price. This factor and the size variable accounted for most of the variation in ex-vessel port prices.

Even though the seasonal prices between ports are similar, the intraseasonal variation in port price is partly the result of competition for the fisherman's catch of coho. When two ports are located in such a way that fishermen may easily land at either one, fishermen appear to land at the port where price is greater. Ports such as La Push and Neah Bay in Washington, and Bandon and Winchester Bay in Oregon are the ports found to be alternative ports for the fishermen catching coho in those areas.

Coastal ex-vessel prices do not appear to be established as a result of equilibrium conditions at any particular port. Rather, ex-vessel price and market clearing quantities are determined in the aggregate. Each port's buyers will establish port price based on the current aggregate equilibrium condition.

The aggregate coastal demand for coho at the ex-vessel level was estimated for the 1976 season and found to be highly price elastic. Given that aggregate supplies are augmentable, increases in coastal landings will increase total returns to the ex-vessel fishery.

One additional finding suggests that the number of buyers in most ports does not play a significant role in the determination of intraseasonal variation of port ex-vessel prices.

The Pacific Coho Salmon Fishery: An Intraseasonal and Interregional Economic Analysis of the Ex-Vessel Market

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The salmon industry of the Pacific coast has furnished lucrative employment to thousands, and has been both directly and indirectly the means by which very many have made fortunes, and who without its benefits would perhaps find themselves out of employment and lighter in pocket.

R.D. Hume, 1893 (18 p. 12)

THE PACIFIC COHO SALMON FISHERY: AN INTRASEASONAL AND INTERREGIONAL ECONOMIC ANALYSIS OF THE EX-VESSEL MARKET

I. INTRODUCTION

The Problem

The Pacific coho salmon is a highly sought after fish which is caught in the waters off the western coast of the United States and Canada. The coho is one of five species of salmon found in these waters although only four, pink, sockeye, chinook and coho, are caught commercially on a hook in a process called trolling.

The salmon fishery is an important resource to the Northwest in terms of direct and indirect economic benefits. Besides providing fresh, frozen and cured products to well established commercial markets, the industry employs many people in the coastal communities. The recreational use of the resource generated additional benefits to the fishing communities as well as to the state.

At one time, the salmon runs were quite large. However, over the last 70 years, landings have diminished partly as a result of the inability of the returning mature salmon to navigate the numerous dams and thereby spawn. Other factors contributing to a smaller stock include increased fishing pressure, loss of gravel spawning beds due to siltation from clear-cut logging and damage and subsequent loss of smolts when passing through turbines at hydro-electric facilities. During the last decade, however, hatchery production has been increasing such that landings are stabilizing (27).

Even though the catch of coho has increased in recent years due to the increased hatchery output, the number of users of the resource has also increased, such that the problem frequently stated by fisheries managers is how to allocate the few fish to the many users. This problem has partly come about because the salmon stocks are a common property resource. This means that anyone who feels it is profitable to utilize the stock of salmon can enter the fishery and compete with other users of the resource (12). Presently the barriers to entry, both economic and legal, are not very high in Oregon although Washington has implemented a program to restrict entry of new commercial salmon fishermen. Consequently, there is an excess number of individuals and vessels in the salmon fishery which has encouraged over-capitalization and a lower return to effort. Specifically, the fishing effort is beyond that corresponding to the maximum sustained yield. The same yield of salmon could be produced with less effort. Hence, resources are not being employed where they could earn the most. This inefficiency has been argued to represent a loss of returns to the "owner" of the resource, namely, society at large. Such problems develop because there is no incentive for the individuals to stop using the resource at the point where marginal social benefits are equal to marginal social costs. Nor is there an incentive to encourage future production of the resource because the individual cannot maintain his rights to reap the benefits without a high cost. Therefore, the rates of use are faster than they would be in the case of a resource with easily defendable rights (13). One of the many solutions which have been proposed to solve this problem is to limit entry of new participants into the fishery thereby limiting effort and preventing economic loss. The impact of these solutions on the prices and markets among the various ports where salmon are landed is not obvious from the available information.

Limiting effort usually means limiting the number of fishermen in the fishery. But which fishermen to eliminate is a complex question. Indications are that the fisherman first to be exluded is the part-time and recreational fisherman fishing with a commercial license.

It is argued that these fishermen are not in fishing for the purposes of generating income, but to increase catch potential and maintain a sizeable tax advantage. Since these fishermen are in the industry principally as a pastime, they will catch all the fish possible regardless of the price paid for the catch. Hence, some fishermen may not be responsive to price or changes in price.

Is it possible then, to distinguish between the ports where these fishermen constitute a significant proportion of the total and to measure their impact on the landings price? Would reducing fishermen from the fishery impact port landings and prices in significant ways?

Until recently the augmentation of the salmon stocks has been achieved by state hatchery operations. Now, however, the salmon ranching private enterprise has become a reality. As in the state operation, salmon ocean ranching involves the release of millions of fingerling sized fish into ocean estuaries. While the state operations are not organized to commercially reap the harvest of returning salmon except for brood stock, the ocean rancher expects a small percentage of his original release to return. A one to three percent return is considered great enough to insure profitable operations, depending on species. Because the returning fish are considered a common property stock, they are available to any fishermen for capture at sea. If the quantity of salmon returning to the ocean rancher is sufficient, then the rancher has an incentive to continue or expand his production of released salmon. This, in turn, increases the salmon available to the ocean fishermen. Whether the fisherman captures the fish or the rancher takes then out of his raceway, the supply of salmon will be increased. How such an increase would affect prices and landings in each port is a topic to be investigated in this study.

In 1974, a federal court judge rocked the entire salmon industry with his decision that guaranteed treaty Indians the opportunity to harvest 50% of the returning harvestable salmon. The mandate had far-reaching effects and placed an additional burden on the salmon resource. While the decision has tended to have a more direct impact on the net salmon fisheries, the troll salmon fishermen are also under attack. It is currently being argued that the troll fishermen are reducing the potential poundage available from the fishery by taking too many immature salmon.

Prior to 1976, there had not been any systematic, legally organized method to deal with salmon resource management problems. Each state essentially took care of its own matters pertaining to the fishery. During that year, however, the Fisheries Conservation and Management Act was signed into existence as Public Law 04-265 (28). For the first time in commercial salmon history a resource management plan could be developed and enforced.

This Act mandated the preparation of management plans for each fishery unit of which the salmon resource is part. Subsequently, plans have been developed and will continue to be developed and updated to comprehensively manage the fishery.

With the forming of the management agencies (Regional Councils) the demand for qualitative and quantitative information on the operation of all fisheries has exploded. Specifically, information about the structural relationships in the salmon markets is needed to help make plans pertaining to the management of the troll fishery.

One example of such relationships concerns price determination at ports of landing. Some time ago it was observed that an average price difference appeared to exist during the season between ports where troll coho salmon are landed. The reasons for its existence have not been understood. If the ex-vessel market with its geographically separated ports was a perfect market and all processors experienced similar costs, then the ex-vessel price for coho, ceteris paribus should vary only by the transportation cost. That is, those ports farther from the areas of available transportation would receive a lower price than would ports closer to major transportation centers. But from observations of the prices, this does not appear to explain the variation. Industry observers are quick to point to the observed differences in the number of buyers and fishermen at a port as a possible explanation of this phenomenon.

Except for a few descriptive economic studies on the salmon fishery, there have been (to date) no quantiative regional analyses dealing with the ex-vessel portion of the salmon market or its participants. This is the gap this study attempts to fill. The major focus of this study is on the Pacific coho salmon fishery ex-vessel markets for Oregon and Washington ports.

Admittedly, a study incorporating only two states is not as comprehensive as it could possibly be. However, due to confidentiality laws in California and Alaska, detailed information was obtained only from Oregon and Washington. In addition, this information was limited to a single year of Oregon landings reports. Washington provided four years of landings data.

Purpose and Organization

The basic purpose of this study is to assess the factors affecting the ex-vessel port to port price variations and equilibrium processes for coho salmon and to provide a basis for evaluating the effect of alternative industry or public policy related to this fishery.

This objective will be accomplished by describing the coho market structure and developing an econometric behavior model to represent the ex-vessel port market and its underlying relationships. These relationships may provide needed information about the factors associated with ex-vessel markets among the various coastal ports: for example, why prices and landings vary from port to port.

This study is organized into two major parts. The first is a descriptive analysis of the coho salmon fishery and its associated marketing system. This part provides information about the history, regulation, historical landing trends, fishermen and stock abundance in the fishery. Included is an outline of the market system that is thought to exist beyond the ex-vessel level.

The second part of the study incorporates the above framework into an econometric analysis of the ex-vessel port-by-port markets. Since detailed data were limited, and the behavioral aspects of the ex-vessel markets not known, several models are specified and estimated.

It is hoped that this pioneering effort will provide a groundword for longer term analysis as the data become available.

Review of Literature--The Ex-Vessel Salmon Market

Most studies of the salmon market have dealt with the description of the various market levels. This has been likely due to the scarcity of data at the ex-vessel level, especially those data reflecting ex-vessel prices. Consequently, researchers have focused on the canned salmon markets where information has been much more plentiful and complete.

This section presents a discussion of some of those studies of salmon and is followed by a review of the studies that have examined the ex-vessel market for other species of fish.

It should be noted that none of the studies examined in the review were focused on the intraseasonal ramifications of the market, nor did any appear to have used individual landings transaction data.

One of the most comprehensive descriptive studies of the salmon market was conducted in 1969 by Schary, Shirley and Soule (34). This work is divided into two volumes. The first volume describes the distributional aspects of the Northwest salmon market. Included are details of the flow of salmon to domestic and export markets, the organization of the marketing channel from fishermen to retailer, price making processes, physical distribution characteristics, and channel processes. Volume II pursues the identification of revenues and costs for boat operators, receiving stations, processors, wholesalers, and retailers. Also included in this volume is a computer simulation model of the entire distribution system.

The market structure of the salmon processing industry was investigated in 1975 by William S. Jensen (19). This descriptive study traces the development of the salmon industry, then details the processing industry in the state of Washington to include an analysis of the market structure, conduct and performance. The study is quantitative and relies on observations of relative concentrations of salmon buyers to analyze market characteristics.

Jensen observed that salmon processors do not determine the prices for their inputs independently. He cites the combination of inelastic supply and possible reactions of rival buyers as principal causes for price dependence. He also states that

> the processing industry is not characterized by obvious collusion between the buying firms so much as the paralleled action of those firms in their buying decisions. Although there is not express agreement, no buying takes place each year until the prices are established with the fishermen . . . (10 p. 32).

According to Jensen, the season's buying does not begin until the prices to be paid to the fishermen have been set. This price usually is established by a major firm in agreement with the fishermen or fishermen's organizations.

A study by Gruen and Bruen in 1972 (17) descriptively evaluated the California sport and commercial fishing industry. While the work is focused on the primary and secondary economic benefits of the various California fisheries, the authors did point out the inadequacies of the existing resources of data for economic analysis.

In the run of a year, they stated that the actual supply of a species landed depends on the level and movements of fish populations, on fishermen's skills, and on the weather far more than on changes in price. They did not imply that there was not a short run price related supply function. Price, they hypothesize, can influence the amount of effort expended on a specific species. However, the lack of a known relationship between catch and effort would deter a fisherman from increasing his effort since he does not know how much more fish he will catch with an extra unit of effort. In effect, therefore, the short run supply curve for a species would be inelastic. Luck, they hypothesized is a more important determinant of short run landings. Thus, fishermen do not respond to price unless it is far different from "normal" price. Price, they add, will be insignificant due to the uncertainty created by the lack of a linear relationship between effort and catch.

Ex-Vessel Market Studies

To date there have not been any econometric studies of the domestic ex-vessel salmon market. Recently, however, a few researchers have been focusing on other ex-vessel markets.

A study by Altobello, Stoney, and Conrad (1) investigated the Atlantic Sea Scallop fishery. The work relates biological and environmental factors which influence the supply of sea scallops as well as the factors responsible for ex-vessel demand. An econometric analysis of the ex-vessel market of sea scallops employs a simultaneous system of equations to quantitatively investigate the supply and demand characteristics of the market. Several variations of the exactly identified equations are used to estimate the reduced form coefficients. From these coefficients the structural coefficients are derived. The researchers were able to estimate fairly consistent and statistically significant relationships.

The estimated equations showed a high degree of explanatory power with most demand coefficients having the expected signs and being significant at the 5% level. The estimate of the supply price quantity relationship was negative. Factors found to be important determinants of the ex-vessel price of sea scallops included: Estimates of natural abundance, ex-vessel price, disposable income, imports, and beginning stocks. They found that a priori expectations of a decline in ex-vessel price and an increase in scallop landings would occur if natural abundance were to increase. The disposable income variable was found to have a significant positive effect on ex-vessel prices. Total imports and ex-vessel prices were negatively related, and the relative size of the beginning stocks had a significant (negative) impact on ex-vessel price.

A study by Wang (43) in 1976 sought to delineate the various levels for the Canadian salmon market and to develop an econometric model to provide estimates of the demand and supply for Canadian salmon products. Wang's study focused on the markets from retail to the fishing effort market. This study bypasses the ex-vessel market due to the nonavailability of information to observe the true market equilibrium prices.

The study consisted of five major segments; domestic retail, whosesale, export, ex-vessel, and fishing effort markets. Although the ex-vessel market is discussed, it is not specified nor estimated since the unknown end of season bonus payment to fishermen would obscure the market equilibrium price. The model emphasized the distinctive characteristics of the sockeye market and treated policy variables exogenously subject to the influence of fishery programs. The author found that the final demand for canned sockeye is price inflexible while the cross price flexibility of sockeye with respect to the retail price of canned pink salmon was relatively low.

Canadian annual data from 1947 to 1970 were used to estimate the ex-vessel demand equations for pink and sockeye salmon in a study by Onuorah (26). A linear relationship was specified where the ex-vessel prices of pink and sockeye salmon were treated as endogenous variables. While the demand analysis for pink salmon did not pick up any significant relationships, the demand for sockeye as the ex-vessel level was shown to be price inflexible (-0.0161). Due to the bonus structure in this market, the observed minimum price may not adequately reflect the true equilibrium price and the reported flexibility may be suspect.

Another econometric study by Queirolo and Johnston (32) investigated the factors governing the demand for domestically produced rainbow trout in a representative west coast market. In addition they assessed the impact on retail demand resulting from the introduction of pan size salmon into the salmon market. After a discussion of salmonid aquaculture, the study presents an econometric model of the market. Pan size salmon in the retail markets were found to be a close substitute for domestically produced rainbow trout.

The results of the study also showed that a negative relationship exists between the price of trout at the brokerage level and the quantity demanded.

A frequently cited study by Waugh and Norton (45) gives some interesting observations for analyses of ex-vessel fish prices. In this work a distributed lag function is employed in the analysis of monthly frozen fish of differing species. This particular specification is argued to explain lag effects of landings in fish prices by accounting for landings in three previous time periods. The lags help account for the accumulation of frozen inventories of fish. The other variable included in the relation was current monthly undeflated personal income.

In order to sort out the possible confusion between lag effects and seasonality factors, a trigonometric function is added to the distributed lag function. This appears to increase the explanatory ability of the model. The estimated price dependent equations showed statistically significant coefficients for the income and quantity variables.

Bockstael (6) conducted a two part study of the ground fish market in the United States, with an interest in providing input for the formation of policy in the fisheries. This researcher first modelled disaggregated firm investment behavior in the ground fish industry using logit analysis. This type of analysis is designed to be applied to alternative decision making systems.

In the second part, the econometric analysis of the ground fish market successfully explained the interaction of consumer demand, imports and domestic landings in determining ex-vessel ground fish prices to domestic fishermen. Bockstael argues that the ex-vessel demand for a single species is a derived demand reflecting chiefly the demand for fresh fish. This demand, however, is affected by the situation in the frozen market. A glut in the frozen market may depress the ex-vessel price indirectly if the final consumer faces sufficient lower priced frozen fish and shifts his demand to these products. On the other hand, if the final consumer faces higher frozen fish prices through a shortage of frozen fish, this will increase his demand for fresh fish.

While estimates were made of the retail and wholesale market levels, the ex-vessel level is of greater interest for this review. The results show that a 1% change in the annual quantity of ground fish landed resulted in a .67% change in ex-vessel price. This finding is based on a log linear specification where ex-vessel price is dependent upon pork and poultry prices, income, population, imports and landings. The pork and poultry prices, population, imports and landings variables were statistically significant and collectively "explained" 90% of the variation in the dependent variable. Other market level specifications showed similar results.

The Bishop's decree of 1966 prompted Bell (4) to investigate the importance of Lent and altered Catholic meat abstinence laws. Bell used monthly data for yellowtail flounder, large and small haddock and cod to estimate ex-vessel demand. Those variables found to be significant were the decree variables, weighted average ex-vessel prices of other species, the consumer price index, and cold storage holdings. A significant shift in demand was found to occur during Lent for the years 1957 through 1967. According to Bell, the decree changed the consumption patterns for fish after 1966.

This review shows that studies of the ex-vessel market have concentrated on aggregate relationships. None were found to have investigated the relationships existing between ports within the season. In short, most studies deal with the longer term aggregates of the market.

The Pacific Salmon

There are five species of Pacific salmon populating the northern Pacific coastal waters. Only two, the coho and the chinook, are traditionally regarded as "fresh" although the other species of salmon have been entering the fresh and frozen markets in ever increasing numbers. These other species, sockeye pink and chum, tend to even out the gaps in the chinook and coho supply (13).

The species investigated in this study is the coho salmon and is clearly the most common fresh frozen product. The coho, (Oncorhynchus kisutch) is also known as the silver[1] or medium red, averages eight pounds, and lives about three years. The quality of the animal when prepared for consumption, the traditional pricing structure, and the end market all may account for a different ex-vessel (dock) price.

The chinook salmon (Oncorhynchus tshawytscha) is also known as the king, spring, tyee or quinnat. The chinook has a lifespan of four to six years and is the largest of the salmon species. When prepared for human consumption, it is considered by some individuals to be superior to the coho. This difference between the chinook and the coho could be due to the content of body fats and oils. While the chinook has commercially appeared in the can, most, if not all is now marketed fresh, frozen, mild cured, or smoked.

Salmon are a migratory fish originating in areas different from the areas they are captured. Coho as a group move both northward and southward from the streams and rivers in which they hatch. The movements of those fish originating from a specific waterway have been charted and may be related to catch areas in a very general way

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[1] According to R.D. Hume, this term was used in the late 1800's by Alaska fishermen while the term silversides was used by fishermen on the Oregon coast (18).

(see Table 1). Those coho originating from California do not provide a significant contribution to the landings in Washington or Oregon. However, the coho from the Columbia River and the Oregon coast are important to both the California and Oregon fishermen. The Oregon coast stocks' importance falls off rapidly farther north along the Washington coast. The Columbia River stock is an integral portion of the Washington catch (28). It appears that those stocks originating in Washington are not an important part of the landings in Oregon or California but are important to British Columbia and northern Washington coastal fishermen.

Table 1. Landing areas and origin for coho salmon.

Landing Area	Stock Origin
California coast	Oregon coast California coast Columbia River
Oregon coast	Oregon coast Columbia River Washington coast Puget Sound
Washington coast	Oregon coast Columbia River Washington coast Puget Sound South British Columbia coast

Source: Pacific Fishery Management Council (1978).

Abundance of Coho Salmon

California hatchery production of coho salmon is approximately one million yearlings annually and is less than that produced by Washington and Oregon (27). Most of California's catch appears to originate from wild coho which have spawned in streams north of San Francisco.

After several years of decline Oregon production seems to have stabilized. Hatchery production is high for Oregon, and escapement to the hatcheries has increased substantially. However, the natural stock of coho returning to the Columbia River to spawn has decreased as have the natural coho stocks of Washington coast and Puget Sound due to the loss of spawning grounds from dams and pollution (29).

Historical Landings of Coho Salmon

The landings of coho since 1947 (Table 2) show a record number in 1951 of over 48 million pounds, and a low in 1960 of less than 14 million pounds. While the landings in the 1950's showed a marked decrease from previous years, the overall landing pattern in seasons since 1970 has stabilized. Except for a poor year in 1975, the latest landings are back to the levels recorded in the late 1940's. The outlook for future supplies of coho is good. The one factor that is most responsible for this change is the increased output from salmon hatcheries in Oregon and Washington.

Table 2. Annual U.S. coho salmon landings, all catch methods (1947-1974).

	Thousands of Pounds
1947	35,672
1948	39,009
1949	37,034
1950	40,883
1951	48,284
1952	41,406
1953	28.533
1954	33,256
1955	26,212
1956	29,173
1957	22,894
1958	23,311
1959	20,205
1960	13,665
1961	23,201
1962	37,752
1963	28,131
1964	38,071
1965	38,515
1966	38,755
1967	38,290
1968	37,786
1969	21,326
1970	43,708
1971	39,870
1972	31,520
1973	32,867
1974	37,839
1975	28,020

Source: Current Fisheries Statistics No. 6129 for 1947-1970.
Current Fisheries Statistics No. 6900 for 1971-1975.

These figures underscore the observation that the coho resource is not showing signs of declining in the same manner as some other fisheries. This is probably due, however, to the unique character of salmon. These fish have the ability to find their way back to the hatcheries. Thus, the stock is easily controlled and may be manipulated by man to produce more fish and larger returns.

The troll coho catch by region (Table 3) indicates that British Columbia is the largest producer. In 1975, fully 61 percent of the total landings in North America occurred in that region, and over 72 million pounds have been landed since 1973.

In the U.S., the largest catch of troll coho, percentage-wise, is that in Oregon, followed by Washington, Alaska and California. Oregon's largest catch year since 1973 was 1976 when 10.5 million pounds or 27.5% were landed. Oregon's catch has varied from 3.2 million in 1977 to 10.5 in 1976. For Washington, the high year was also 1976 and the low year, 1977. While Oregon and Washington landings of coho vary in the same direction each season, the percentage of the total quantity landed is much different each season. Accounting for this variation in the analysis of ex-vessel markets may help explain why prices and quantities vary in each region.

The catch in terms of <u>numbers</u> of fish reveals a very different situation (Table 4). From 1961 through 1972, Alaska fishermen consistently caught more coho than fishermen in any other region in North

Table 3. Troll coho salmon landings.

	Millions of Pounds										
	Alaska	%	Wash-ington	%	Oregon	%	Cali-fornia	%	British Columbia	%	Total
1973	2.9	9.3	4.9	15.8	5.6	18.0	2.3	7.4	15.4	49.5	31.1
74	4.2	10.6	6.3	15.9	7.0	17.7	4.4	11.1	17.7	44.7	39.6
75	0.9	2.9	5.1	16.2	4.7	14.9	1.4	4.4	19.4	61.6	31.5
76	4.7	12.3	7.2	18.8	10.5	27.5	3.7	9.7	12.1	31.7	38.2
77	3.7	10.7	3.9	11.3	3.2	9.3	0.3	0.9	7.6	22.0	34.5

Source: Pacific Fisheries Review (1978).

Table 4. Number of coho salmon landed all methods by state (1961-1977).

Year	Alaska	%	Washington	%	Oregon	%	California	%	Total
1961	1313	47.2	1035	37.2	356	12.8	79	2.8	2783
62	2038	57.1	1142	32.0	343	9.6	48	1.3	3571
63	2023	56.6	881	24.6	510	14.3	162	4.5	3576
64	2559	56.0	1128	2.7	723	15.8	247	4.7	4567
65	1998	43.7	1496	32.7	858	18.8	217	4.7	4569
66	1920	38.1	1681	33.4	990	19.7	445	8.8	5036
67	1488	33.7	1213	28.8	1306	29.5	414	9.4	4421
68	2751	51.8	1275	24.0	925	17.4	363	6.8	5314
69	1133	38.3	920	31.1	709	24.0	193	6.5	2955
1970	1527	30.6	1870	37.5	1412	28.3	183	3.7	4992
71	1447	25.9	2002	35.8	1695	30.3	442	7.9	5586
72	1830	43.9	1253	30.1	925	22.2	158	3.8	4166
73	1456	33.0	1672	37.9	937	21.2	348	7.9	4413
74	1855	31.3	2117	35.7	1328	22.4	636	10.7	5936
75	1014	26.5	1837	48.0	772	20.2	204	5.3	3827
76	1426	20.1	3031	42.8	1936	27.3	695	9.8	7088
77	1593	43.0	1590	42.9	467	12.6	54	1.5	3704

Source: Pacific Fisheries Review, 1978.

America. After 1972, Washington fishermen caught more coho. The peak year for all regions for coho in both numbers and pounds landed was 1976. For Washington, Oregon, and California, the years during which the smallest number of coho were landed occurred in 1963, 1962, and 1962, respectively. If the number of fish is different relative to the total poundage caught in a region, then average sizes of fish in one region are different than in another region. Hence, the size of coho account for differences between regions and should be investigated as a possible explanatory factor on the ex-vessel markets.

With respect to coho landings by country, Table 5 shows that the U.S. has consistently been the largest single producer of coho since 1967 (Table 5). Canada and Japan have been second and third, respectively.

These countries become quite important when consideration is given to their eventual impact on the world markets of salmon. More importantly, the landings in these countries will shift supply in international markets and the subsequent impact on the wholesale, retail, and ex-vessel prices may be substantial.

History of Trolling

Trolling for salmon began around 1912 with small day fishing boats from the gillnet fleet. Just six years later there were an

Table 5. North Pacific coho salmon landings all methods by county.

Year	Millions of Pounds								
	Japan	%	USSR	%	Canada	%	USA	%	Total
1967	8.38	10.9	7.94	10.3	22.49	29.3	37.92	49.4	76.72
1968	12.35	13.6	7.05	7.8	33.29	36.7	38.14	42.0	90.83
1969	21.16	31.3	7.28	10.8	17.64	26.1	21.61	31.9	67.69
1970	11.90	12.5	10.14	10.6	29.98	31.5	43.21	45.4	95.24
1971	14.99	15.6	9.70	10.1	31.09	32.3	40.34	42.0	96.12
1972	16.53	21.9	4.19	5.5	23.15	30.6	31.75	42.0	75.62
1973	23.37	27.1	7.63	8.9	24.69	28.6	33.51	38.9	86.20
1974	21.38	22.2	8.60	8.9	22.93	23.8	43.42	45.1	96.34
1975	19.08	26.4	8.38	11.6	16.98	23.5	28.88	39.9	72.31
1976	16.98	19.0	7.94	8.9	20.50	23.0	43.87	49.1	89.29

Source: Pacific Fisheries Review, 1978.

estimated 500 boats off Neah Bay, 20 to 30 off Grays Harbor and 2,000 off the mouth of the Columbia River. Yet during the next 33 years the commercial fleet size in Washington remained at approximately 1,300 boats (28).

The advent of power driven gurdies and diesel engines in 1920 enabled fisherment to become more efficient in their catch potential and at the same time, fishing began to expand from the mouth of the Columbia River to the more southern ports of Newport and Coos Bay (27). Furthermore, vessel size increased enabling fishermen to stay out of port for periods of time greater than a single day. This was the beginning of the "trip" fishing fleet.

The combination of salmon, albacore and crab fishing by the same fisherman and same boat began to occur after 1935. The Second World War stimulated a greater demand for salmon and technological advances such as radar, depth sounders, LORAN, and radio direction finders further inhanced the productivity of fishermen (27). The numbers of fishermen in the fleet continued to increase, so that a high proportion of the fleet was committed to the capture of salmon. The introduction of the small day-boat, or dory, around 1965 required low capital expenditures relative to other troll fishermen. The day-boats also did not require a great deal of skill to operate. Since access to the fishery resource was completely open, a large number of recreational fishermen took the opportunity to supplement their income, and yet at the same time derive a great deal of pleasure from doing something they enjoyed. Thus there have been, over the years, some changes in harvesting techniques.

Salmon Regulations

In order to maintain a sustained yield of coho from season to season, the state fisheries management agencies developed regulations to control the amount of effort expended by fishermen. These regulations employ different combinations of the following methods: limit the efficiency of catch gear; limit the number of fishing units; limit the size and or age of captured fish; and limit the fishing season (12).

Catch Regulations. The methods used to capture coho have remained essentially the same since the first salmon was caught on a hook. Regulations on the efficiency of gear have been imposed to limit trollers to the use of barbless hooks. This type of hook causes less damage to the fish when the fisherman retracts the hook from the mouth of the fish. A reduction in tissue damage means that those fish which are smaller than the minimum legal catch size may be returned with a greater chance of survival. The cost to the fisherman is measured in terms of the number of legal sized fish that are lost because they are able to shake the hook out of their mouths.

The methods employed to limit the number of fishing units are also related to limiting the entry of new vessels and/or fishermen to the fishery. Both Washington and Alaska have imposed such programs and Oregon and California are considering doing the same.

Troll Size Regulations. Until 1948, the minimum size of coho that could be legally landed in Washington was 18 inches except during August and September of odd numbered years, when 15 inches was the legal minimum. In 1948 the limit was changed to 22 inches and yet again in 1969 to 20 inches. The next change came in 1971 whan a size limit was removed until August 1. After this date a 16 inch minimum was enforced. In 1976, a 16 inch minimum was imposed for the entire season (24).

Oregon imposed a 27 inch minimum in 1948 for both coho and chinook but the regulations were changed the following year to 22 inches in order to conform to the size limits in Washington and California. The next change occurred in 1965 when the limit was lowered to 15 inches. The fish buyers, however, preferred coho measuring 22 inches (28) so that this became the effective minimum size for Oregon fishermen.

Troll Season Regulations. Season regulations attempt to maximize the advantage gained by delaying capture until a larger size is attained. This is the most common method of regulation because it is both effective and flexible.

The current harvest regulations closely coincide with the time the coho has attained maximum size. That is, coho growth is rapid during the late spring, and a later season opening allows larger fish to be captured (12).

In the same year that Oregon size regulations were applied (1948), a season was also established starting June 15. In order for Oregon to conform with the season in Washington and California, the opening was changed the following year to July 1 through November 15 (28).

A Washington season restriction also did not exist before 1948. During that year a July 1 to November 15 season was established (28). The state of California followed Washington in setting season limits of July 1 through November 15 until 1970. At that time a legislative statute relating to fishery resource use was repealed and a May 15 opening date was enacted (28).

II. THE MARKET SYSTEM

Introduction

The market system for fresh and frozen salmon is diverse and complex. There are many participants at all levels and strong institutional relationships bind those individuals together. Much of the market's characteristics are unknown even to those operating within its framework.

It is the nature of any market system to have many factors in common, with changes or disruptions at any point in the market causing repercussions at other points. Consequently, an understanding of any one part requires an understanding of other parts. Herein, then, is a description of the market system for coho salmon based on observations of the system operations by many individuals, previous studies, and theoretical expectations.

Since explorations of the ex-vessel market have been bypassed by previous researchers, there was a felt need to concentrate on some of the workings of this primary production market. Due to this desire to unravel some of the characteristics of the ex-vessel market, no attempt has been made to test or estimate the relationships at other market levels. Nonetheless some understanding of these relationships is essential to the present analysis.

The market system for fresh and frozen salmon from the fisherman to the consumer is composed of three major markets (see Figure 1). The retail market is characterized by a diverse number of consumers and nearly as equally diverse, but not as numerous, retail suppliers. The sellers include the retail food establishments such as fish markets, grocers, and restaurants.

Domestic Retail Market
 Demand: Consumers
 Supply: Retailers-Grocery-Chain Stores
 Restaurants-Institution
 Fish Markets-Independent

Domestic Wholesale Market
 Demand: Domestic Retailers
 Exporters
 Supply: Processor-Wholesaler-Broker

Ex-Vessel Market
 Demand: Processor-Fish Buyers-Receiving Stations
 Supply: Fishermen

Figure 1. Market system for fresh salmon troll caught.

The second component in the market is the wholesale sellers and buyers. Wholesalers purchase their fresh salmon from the processor or fish buyer. While wholesalers are widely distributed around the U.S., the processor is, except for some smokers, located in the Pacific coast area, close to the primary supplier. The last stage of the salmon market system is the ex-vessel market. Processors purchase fish as buyers directly from the primary producer, the fishermen. This market is characterized by many fishermen in each port and fewer processors.

Coho are landed fresh and frozen by the fisherman at the fish buyer or processor's dock. Few, if any, fishermen bypass the processor and sell directly to a wholesaler or other market participant. The buyer, however, may sell to any one of the other points along the chain (see Figure 2). Buyers have a direct relationship with every participant including the final consumer (34).

For the frozen and prepared product however, the traditional channels require that the coho will be passed on to the broker or wholesaler. At this stage the participants perform storage and distribution functions. The broker may act as or deal with exporters. The wholesalers and brokers distribute the remaining coho to the restaurants, stores and markets in their area.

Retail Demand

Coho salmon reaches the consumer in a variety of forms; fresh, frozen, canned, smoked, and cured. Each form is unique and requires a different specification. The fresh and frozen forms are close substitutes for each other in consumption and assumed to be relatively independent from all other forms. Troll coho salmon reaches the consumer mostly as fresh or frozen steaks, fillets or whole carcass.

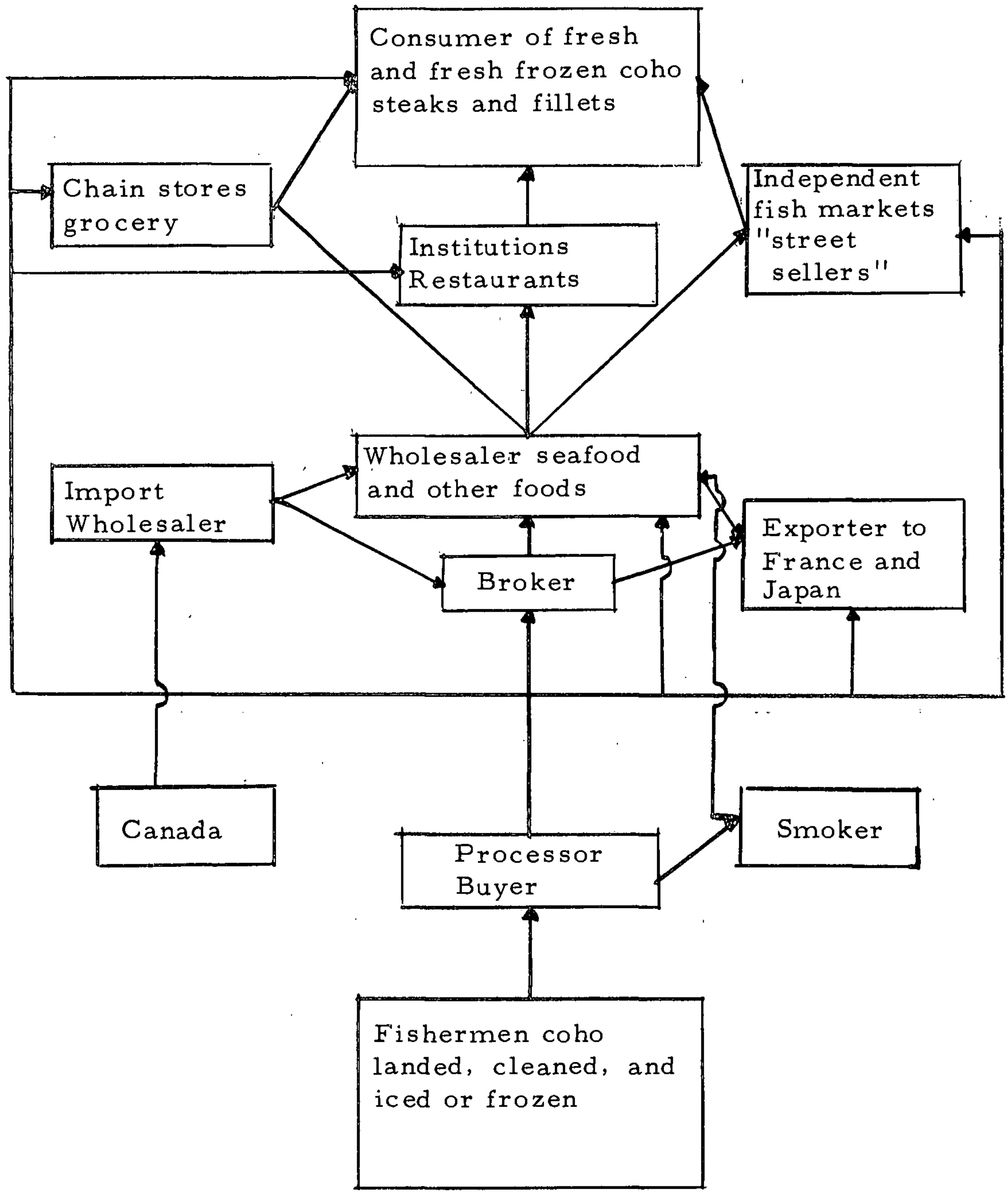

Figure 2. Coho salmon market chain.

The form in which coho is marketed is dictated by the size (in pounds) of the carcass. The smallest size, two-four pounds rarely are found on the domestic market, although this seems to be changing. The medium, or six-ten pound coho, is the size found at the grocer's fish counter as well as on the restaurant plate. Larger coho, over ten pounds, will be used in the cured market.

The cured or pickled form of salmon is the oldest known product. Cured salmon may be preserved by drying or smoking or a salting technique which pickles the fish (19). This processing requires a larger amount of labor and time than do the other forms of salmon.

A portion of the commercial salmon catch (all species) is processed into the canned form, the second oldest final product of salmon. Although canned coho has an excellent flavor and good texture, the fish is not favored by the canneries because of its light color (18).

While the canned salmon pack has shown a general decline over the last 30 years, the percentage of coho going into the can has remained somewhat constant (see Table 6). The years of unusually high percentages of canned coho (1951 and 1974) appear to correspond to either low landings of the other species of salmon traditionally canned or large quantities of coho landed.

As a result of an increase in U.S. population, declines in natural supplies of salmon, and better fresh and frozen distribution conditions,

Table 6. United States canned coho salmon (1941-1976).

Year	Total Salmon Canned	Total Coho Canned	Percentage Coho Canned of Total Salmon
1941	7,779,654	440,653	5.66
42	5,852,515	406,032	6.94
43	5,676,391	191,135	3.37
44	5,119,079	202,364	3.95
45	4,910,580	239,086	4.87
46	4,563,115	217,004	4.76
47	5,612,664	293,058	5.22
48	4,826,426	370,610	7.66
49	5,524,916	277,495	5.02
1950	4,274,462	352,126	8.24
51	4,645,570	466,880	10.05
52	4,455,022	397,534	8.92
53	3,910,646	207,144	5.30
54	4,163,147	215,123	5.17
55	3,286,885	198,806	6.05
56	3,432,658	188,571	5.49
57	3,184,897	203,553	6.39
58	3,705,243	150,699	4.07
59	2,465,538	190,560	7.73
1960	2,912,016	94,560	3.25
61	3,696,726	165,217	4.47
62	3,837,031	163,482	4.26
63	3,289,577	165,549	5.03
64	3,745,307	219,037	5.85
65	3,672,435	176,391	4.80
66	4,344,047	204,431	4.71
67	3,077,065	139,079	6.70
68	3,390,374	167,330	4.94
69	2,519,750	59,424	2.36
1970	3,913,346	134,024	3.42
71	3,393,356	164,250	4.84
72	3,076,798	66,182	3.19
73	1,300,561	65,216	5.01
74	1,907,376	224,198	11.75
75	1,361,403	23,680	1.74
1976	2,727,378	48,218	1.76
10 year average	2,711,468	120,395	

Source: Pacific Packers Report 1977.

the per capita consumption of canned salmon has been decreasing since the 1930's (21). In addition it appears that tuna has replaced salmon as the consumer's preferenced of canned fish (45).

The average consumer cannot distinguish the difference between the frozen and fresh forms of salmon if the carcass has been properly frozen and packed (14). Therefore, the two forms are considered to be perfect substitutes for the retail markets.

Also at the retail level the cross price elasticity between fresh or frozen salmon and all other forms of processed salmon (canned, cured, smoked, etc.) is likely to be quite small. Fresh and frozen meat and poultry products are much more likely to function as substitutes for fresh or frozen salmon.

Per capita consumption of non-canned forms of salmon declined during the 1950's and did not show a significant increase until the early 1970's (see Table 7). Part of this decline was due to the effect of shrinking supplies of salmon and the corresponding increase in price. Further, while per capita consumption of all fish may not rise with increases in consumer incomes the percapita expenditures on fish consumption have been noted to rise as income rises (33).

Increases in the early 1970's correspond not only to the increases in availability but also to the sudden interest in seafood spawned by the collective fear of saturated fat in diets. This latter

Table 7. Aggregate and per capita consumption of coho salmon in the United States (1947-1971).

Year	Aggregate Million lbs.	Per Capita lbs.
1947	44.9	.311
48	34.0	.232
49	41.0	.275
1950	36.4	.240
51	42.3	.275
52	39.9	.255
53	42.7	.268
54	40.9	.253
1955	39.8	.241
56	29.3	.174
57	32.5	.190
58	36.0	.207
59	29.7	.168
1960	23.3	.129
61	32.7	.179
62	26.1	.140
63	36.4	.193
64	34.3	.179
1965	36.6	.189
66	35.5	.181
67	33.8	.171
68	36.2	.182
69	40.8	.202
1970	51.1	.251
71*	77.3	.375

*Preliminary.

Source: Fishery Statistics of the United States, various years.

effect may be much more responsible for the change in per capita consumption.

Salmon consumption is also responsive to changes in income. As consumers income increases by one percent, his consumption is reported to increase by 1.62 percent (8) for the fresh and frozen forms as compared to no change in the canned form. This phenomenon plus the change in tastes due to a desire for less animal fat in one's diet may be largely responsible for the phenomenal increases in the fresh and frozen salmon prices during the 1970's.

Conventionally, the quality of coho demanded at retail will depend upon: price per pound of coho; prices of close substitute foods such as (fresh) chinook and chum salmon; prices of the more distant substitutes such as tuna and halibut, some of the ground fishes; beef-steak, and poultry (34). Except for the case of canned salmon, the more distant substitute relationships have not been tested.

Other factors which are part of the demand for fresh salmon include: income of consumers, the numbers of consumers (population), consumers' tastes and preferences, and prices of complement goods (tartar sauce for example) (33).

In addition, consumption of salmon appears to be dependent upon social, ethnic and regional characteristics of the consumer. For example, those individuals with more education might tend to prefer and consumer more salmon products over those individuals with less education (9).

The regional demand for salmon is especially apparent in the case of chinook, a fish that is used for the mild cured form of salmon called lox. Consequently, major markets for the fish may be found in New York and Florida where major populations of persons of the Jewish faith live.

Although it is not the intention of this study to actually estimate any of the structural relationships except at the ex-vessel market, it is helpful, when modeling the ex-vessel market, to hypothesize some of the forces pertaining to other market levels. Therefore the retail demand for fresh and frozen salmon is hypothesized to be as follows:

$$Q^r_{dr_t} = f(P_{r_t}, P_{rs_t}, P_{rd_t}, I_t, N_t, P_{c_t}, E_t, G_t)$$

where

$Q^r_{dr_t}$ = quantity (in pounds of coho - fresh or frozen salmon demanded at retail

P_{r_t} = retail price per pound of coho

P_{rs_t} = retail price of close substitutes such as chinook, chum, tuna, halibut, etc.

P_{rd_t} = retail price of distant substitutes such as beet, poultry, etc.

N_t = U.S. population

I_t = disposable income for consumers in the U.S.

P_{c_t} = prices of complement goods

E_t = Social, ethnic characteristics such as education, age, religion, etc.

G_t = quality of final product (i. e., freshness)

All money variables are expressed in real terms.

A single species was specified in order to facilitate the identification of substitute relationships and to maintain continuity because the ex-vessel market elaborated below focuses on coho.

Retail Supply

The source of the consumer's fresh and frozen troll salmon is the retail establishment such as the chain grocery store, restaurant and specialty stores. The species of salmon helps determine the type of market. Due to smaller size and lower prices, coho will be favored by the chain stores and supermarkets. While chinook is occasionally offered as a specialty item at those stores, its primary market appears to be in the institutional trade (34) and in outlets selling smoked salmon.

Final preparation of the fresh coho for retail sales takes place in the store. Schary et al, predicted in 1969 that due to the declining role of the meat cutter (who also prepares salmon), and the small sales volume of salmon products, retailers would lose interest in fresh salmon.

Frozen salmon are sold in two forms; steaks and fillets. Steaks are sold fresh and frozen, but the frozen form is preferred by retailers since the carcass may be cut with a band saw (34).

In passing, it is interesting to note that a recent attempt by Oregon Aquafoods of Newport, Oregon to market pan-sized chinook and coho in retail chain stores has not been entirely successful. The firm was faced with considerable consumer resistance because the yearling salmon appeared and tasted more like trout than ocean troll salmon. After little more than a year on the retail market, the product, which was handsomely branded with the firm's trademark was discontinued. The firm is now operating as an ocean ranch, selling to institutional markets. Chinook, coho, and chum salmon are reared in land ponds. As soon as the small fish are two to three inches in size, they are released to the open ocean. Recapture of these fish, which are indistinguishable from troll salmon, takes place two years later at the release facility.

Prompt delivery of fresh salmon to the retailer is one characteristic that is quite important for this product. This means that coho must be transported to market in 2-3 days and inventories maintained only at the retail level. As a result, the fresh salmon is generally sold at a higher price than frozen.

Because of the rapid deterioration of fresh salmon, the market areas may be limited to those regions accessible to high speed motor freight or air transport. A survey by Schary *et al* in 1969 indicated that the market area for fresh salmon exist mostly on the west coast. During the coho season the retailer has the option of purchasing either fresh or frozen coho.

Market Margin

The difference in price from one market stage to another is called the marketing margin. This accounts for some of the expenses at that particular level. Those costs include: labor, advertising, allowance for profit, administrative costs, etc. The margin, at retail, is the difference between the retail price and the price paid to the wholesaler. Margins for fish steaks have been reported to be over 20 percent of retail price (31).

The retail supply of coho salmon relates prices charged by retailers and the quantities supplied. Since the retail price for coho appears to be established by the retailers, the specification of the retail supply is as follows:

$$P_{rt} = g(Q_{rt}, P_{wt}, P_{wzt}, M_r, Q_i)$$

where

P_{rt} is the current retail price per pound for coho fresh and frozen deflated by the consumer price index.

Q_{rt} is the quantity in pounds of coho salmon supplied by retailers.

P_{wt} is the current wholesale price for fresh coho salmon deflated by the wholesale price index.

P_{wzt} is the current wholesale price for frozen coho salmon deflated by the wholesale price index.

M_r is the retail marketing cost for coho salmon in time t.

Q_i is the inventory of coho held by retailers.

Wholesale Market

The wholesale market is composed of fewer sellers than buyers. It is a market in which buyers are the large and small institutions such as chain stores, grocery, wholesalers and small specialy shops. During the late 1960's the concentration of retailers in this market appeared to be increasing. Large retail food chains may be responsible for a larger percentage of the total purchases (32). Buyers in this market also include the brokers functioning as intermediaries to small retail establishments or as exporters to overseas markets.

The demand for salmon at wholesale is derived from the demand at retail so that some of the same factors that are important aspects of the retail market are also important factors in the wholesale markets. The quantities of coho demanded at wholesale are dependent upon the wholesale price the retailer must pay, the selling price he expects to receive, the prices for coho in export market of prices in major coho consuming countries, prices of other species such as chum and chinook that the retailer may substitute for coho, and inventory levels.

An investigation of the frozen wholesale prices since 1969 (see Table 8) shows that a major market change may have occurred during the 1975 and 1976 seasons. Some observers have argued that this is the result of active trading in coho by overseas importing countries.

Table 8. Monthly wholesale prices for frozen dressed coho salmon at New York (1969-1976).

	$/lb							
Month	1969	1970	1971	1972	1973	1974	1975	1976
Jan	.83	.96	1.03	1.01	1.40	1.85	1.61	2.10
Feb	.88	1.00	1.00	1.04	1.40	1.85	1.60	2.10
Mar	.85	.98	.98	1.05	1.45	1.85	1.61	2.15
Apr	.85	1.00	.96	1.05	1.50	1.85	1.60	2.15
May	.85	.99	.83	1.05	1.50	1.80	1.60	2.15
June	.85	.98	.80	1.05	1 50	1.75	1.60	2.15
July	.85	1.05	.80	1.05	1.50	1.75	1.60	--
Aug	.89	1.10	.80	1.07	1.50	1.75	1.62	--
Sept	.88	1.08	.80	1.10	1.50	1.75	1.74	2.50
Oct	.93	1.10	.80	1.30	1.65	1.60	1.87	2.50
Nov	.95	1.10	--	1.30	1.65	1.60	2.00	2.50
Dec	.95	1.03	--	1.30	1.65	1.60	2.10	2.50

Prices Exwarehouse - New York reported by original receivers.
Source: Current Economic Analysis F-25, various years.

The wholesale demand for coho is derived from the retail demand and is likely to be in the following form:

$$Q_{wt} = h(P_{wt}, P_{rt}, P_{wst}, P_{et}, I_t, N, INV)$$

where:

Q_{wt} is the quantity in pounds demanded by retailers, exporters, etc., for fresh or frozen coho.

P_{wt} is the wholesale price per pound for coho deflated by the wholesale price index.

P_{rt} is the retail price for pound for coho deflated by the consumer price index.

P_{wst} is the wholesale price per pound for substitute forms of salmon deflated by the wholesale price index.

P_{et} is the export price for coho deflated by the wholesale price index.

I_t is the U.S. total personal disposable income, deflated by the Consumer Price Index.

INV is the beginning level of inventories held by retailers, exporters, etc.

Wholesale Supply

Sellers in the wholesale market include the broker and processor (also referred to as the buyer). The broker is included as a separate activity because the broker's function is to bring buyers and sellers together in return for a fee. The broker rarely takes possession of fish and will occasionally speculate on prices of salmon in inventory (34).

Brokers have been less active in recent years because the retailers are apparently buying directly from the processor. Instead, the broker is dealing more and more as an exporter.

Market margins at this level in the market have been observed to change in response to changes in the ex-vessel price (31), or to changes in the total landings for the season. In 1963 the margin for salmon was found to be 15% of gross sales (34), and the margin for salmon steaks was reported to be 29% of gross sales in 1969 and through 1971 (31).

The processor as a seller has the greatest number of choices relative to the other members of the market system. The processor may sell directly to the retail chain, institution, independent broker or exporter. Some salmon processors along the Northwest coast have retail establishments located near they buying station that sell directly to the consumer.

Not only does the processor have many customers, he also may have the additional option to divert current fresh landings into frozen storage. Salmon may only be held in inventory in the fresh iced form for a day or so and freezing the carcass permits more flexibility in the handling and movement of the product. For example, freezing allows lower transportation costs while maintaining the fish at a constant quality. While most processors have some space to store frozen salmon, the available frozen storage is likely to be in competition with the landings of other species. Therefore, some of the branch buying stations along the coast will ship coho to other company storage locations or to large commercial frozen establishments.

Freezing operations enable the processors that are supplying the large chain store to insure year around inventories. At the same time holdings of frozen inventories maintain the processors' bargaining position in the wholesale market.

The processors' decision whether to divert some of the fish he purchases are based upon his expectations of frozen sales to wholesalers or retailers during the season and after the season has closed. A strong movement of frozen holdings during the winter will deplete inventories and processors will want to restock a supply of salmon for the coming winter either to insure an allocation to a specific customer, to speculate on future salmon prices, or to insure a supply of coho for processing during the winter months.

Those frozen salmon not sold during the winter are usually canned, which serves as an additional buffer for the processor in that it protects him from lower price due to excess supplies in the fresh frozen market.

Table 9 shows the monthly inventories since 1973 of frozen coho and frozen salmon, and the percentage of total freezings that are coho.

Table 9. Monthly frozen fishery holdings (1973-1976).

	1000 lbs.											
	1973			1974			1975			1976		
Date	Coho	All Salmon	% Coho of Total	Coho	All Salmon	% Coho of Total	Coho	All Salmon	% Coho of Total	Coho	All Salmon	% Coho of Total
Jan 31	3579	14,770	24	5,013	21,237	24	8107	19,900	41	2562	13,189	19
Feb 28	2096	11,890	24	4,061	18,115	22	5979	16,452	36	2051	11,189	18
Mar 31	2139	8,368	18	3,067	13,625	23	3674	11,253	33	1713	8,754	20
Apr 30	1284	5,918	26	2,570	11,166	23	2454	8,314	30	1295	3,858	22
May 31	1291	6,032	22	2,380	10,344	23	2129	7,496	28	1259	5,885	21
June 30	2345	8,933	21	2,122	10,773	20	2284	8,535	27	2024	8,141	25
July 31	4026	20,070	26	3,979	15,546	26	3324	12,871	26	5048	15,976	32
Aug 31	7097	27,447	20	7,256	23,328	31	4970	20,712	24	7170	24,220	30
Sept 31	9416	33,813	26	9,542	28,084	34	7630	26,864	28	9193	32,381	28
Oct 31	9129	30,705	28	10,458	26,929	39	7705	25,574	30	8980	31,401	29
Nov 30	8902	30,814	30	10,775	26,635	40	6012	29,972	29	8067	29,741	27
Dec 31	6935	26,615	26	9,734	22,939	42	4053	16,406	25	7469	23,899	31

Source: Current Fisheries Statistics No. 6406 (1973-1977).

It appears that total holdings gradually decrease during the late winter and spring and begin to show replenishment at the beginning of the coho season in July. Holdings of coho continue to increase throughout the season.

Large scale freezing activity appears to take place only at a few firms along the entire coast. In the late 1960's there were four firms freezing salmon in Puget Sound. These firms included the New England Fish Company, Whiz-Eardley (and San Juan Fish Co.), McCallum-Legaz, and Whitney-Fidalgo. In Oregon, the concentration of freezing firms was higher; Bumblebee and Portland Fish dominated the market. For California, the dominant firms were Meredith Fish Co. and Tom Lazio Fish Co. (34).

The number of firms and their location appears to have changed little in 10 years. The figures shown in Table 10 show the quantity and location of frozen salmon in 1976. It appears that Newport and Astoria are still significant freezing locations for Oregon. Most of the frozen salmon in Washington is held in Puget Sound. The only coastal port of chinook was reported to have salmon holding.

The supply of coho in the wholesale market model is hypothesized to be as follows:

$$P_{wt} = i(Q_{wt}, Q_{it}, M, P_{et})$$

where:

P_{wt} is the wholesale price per pound for coho deflated by the WPI.

Q_{wt} is the quantity in pounds supplied by processors of coho salmon.

Q_{it} is the quantity of coho salmon in frozen inventory in time t.

M is the marketing margin from ex-vessel to wholesale for coho.

P_{et} is the ex-vessel price per pound for coho deflated by the WPI.

Table 10. Frozen salmon in Oregon and Washington (1976).

Company	Port	Pounds all Salmon
Washington		
Bumble Bee Seafoods	Bellingham	45,283
Chinook Packing Co.	Chinook	518,785
Harbor Bell, Inc.	Bay Center	98,717
J.J. Theodore Co., Inc.	Friday Harbor	181,000
New England Fish Co.	Seattle	1,986,477
Northern Products	Bellingham	21,005
	Seattle	551,418
Peter Pan Seafoods, Inc.	Bellingham	134,913
	Puget Sound	503,373
Sebastion Stuart Fish Co.	Seattle	511,750
Sninomish Indian Fish Co.	La Conner	30,000
Total Washington		3,872,721
Oregon		
Alaska Packers Assoc., Inc.	Point Adams Division, Newport	2,255,000
Bell Bouy Crab Co.	Seaside	60,000
Bumble Bee Seafoods	Astoria	1,097,535
	Newport	
New England Fish Co.	Warrenton	
Pacific Shrimp Inc.	Warrenton	
Total Oregon		3,412,526

Source: Pacific Packers Report (1977).

III. THE EX-VESSEL PORT MARKET FOR TROLL COHO

The intent of this chapter is to provide a basis for testing certain hypotheses about the operation of the port ex-vessel markets. In addition, hypotheses related to the determination of market equilibrium forces will be generated.

Introduction

What is of interest are the processes by which prices are established and the mechanism that fishermen employ to allocate their landings to the individual ports along the coast. To examine this, the study focuses on the theorized market decision process for fishermen as suppliers, and processors as demanders. Since the behavior of the individuals of the ex-vessel market cannot be observed by studying the seasonal equilibriums for the entire ex-vessel market, it has been necessary to disaggregate the functions of the market over time and space. The limit of this disaggregation is to investigate a behavior of a single economic entity: the fisherman and the fish buyer for a single transaction. This, however, requires that the individual choose for analysis what is representative of the entire system. The likelihood of such a choice is remote. The same is true for the choice of time. Hence, a compromise is in order.

What is needed is a length of time long enough to allow the establishment of an equilibrium, yet short enough to allow observation of the process by which the equilibrium was established. For the coho ex-vessel markets, the season only lasts 20 weeks, so that an analysis based on a time period of a month produces only five periods of observation. Hence the logical period of analysis that might avoid serious statistical problems is the week.

The ex-vessel market already exists in distinctly discrete units over space and, thus, geographical classifications by the analyst are less arbitrary. Transactions of troll coho take place in the geographically separate ports. Therefore, the port was the chosen representative of the individual ex-vessel markets.

It is important for the reader comfortable with annual or longer analysis involving industry wide aggregates, to keep in mind that the discussions that follow are formulated to represent the time and space units just mentioned.

Price Variation

Both fishermen and fish buyers have noted that ex-vessel prices vary from port to port, and from week to week during the season. Many explanations of this phenomenon have been advanced and it is the purpose of this study to investigate some of the most likely hypotheses.

The two types of price variation are the price differences between ports, here defined as interregional variations, and the variations during the season, defined as intraseasonal variations.

Interregional Price Variation

Fishermen and fishermen's organizations have contended that the differences in the ex-vessel prices between ports is the result of the relative market power of the buyers of coho. They assert that the lack of competition between ports keeps the price for coho lower than it would be under a different market structure. On the other hand, buyers content that the ex-vessel prices vary due to the relative manipulative actions of the fishermen.

In order to evaluate these contentions, an investigation of the structure of the ex-vessel markets is conducted. This approach considers the price differences between ports. The role of market structure is evaluated by examining the relationship of the ex-vessel price to the numbers of buyers and sellers (fishermen).

Intraseasonal Price Variation

The intraseasonal price variation is the result of movement that is observed in ex-vessel prices as a response to changing market conditions. Price is observed to change when something happens in the market to disturb the equilibrium conditions. Such market disturbances are hypothesized to be due to factors that shift the port supply of coho, or they may be the influence of changing conditions for port demanders (buyers) that shift the port demand.

It is hypothesized that market-to-market equilibriums do exist and that once a disturbance does move a port market away from equilibrium, the market will respond and a new equilibrium will be established during the period of observation.

The analysis of the intraseasonal price variations is dependent upon the explanation of the port ex-vessel demand and supply of coho. In the next section, the first part of this market, ex-vessel demand, is discussed.

Ex-Vessel Demand

The port ex-vessel demand for coho represents the various prices buyers in a port are willing to pay for various quantities of coho. In order to model the demand for coho it is helpful to look at the factors that are thought to be important to the individual buyer in his purchase decision process. This means that, given some quantity of landings available to the buyer, he will consider how the coho relates to his production process, the quantity of fish he is currently processing and storing, the relative difference between the price he might pay and the price he expects to receive for coho, knowledge about the quantity of coho in frozen storage, the way coho are moving in local, national and export markets, and the response of other buyers to his actions.

Previous Week's Landings

The decision to purchase coho in the current period will be dependent upon how much the buyer has in his own storage, or waiting to be processed into other forms. During the season the quantity of coho will vary with the relative abundance of coho. Sometimes so much salmon is available that the buyer's process capacity is overloaded. Hence, if he has purchased more fish than he can handle the previous week he will be either out of the market or not willing to pay a higher current price.

Production Process

The buyer of coho also purchases many other species of fish in the port market. Coho is only one of the many inputs he purchases to produce the total product.

If one of the other species the buyer is producing is abundant, the buyer may not be interested in buying small quantities of coho. Because processing resources are idle much of the time, fixed costs may be relatively high and hence, the greater the quantity of fish, the greater his receipts relative to costs. That is, he must employ many of his employees regardless of the quantity of fish landed. This is due to the variability in landing, and the need to have a crew ready when the fish are landed.

If a coho buyer is assumed to behave to maximize profits, he will consider conditions of the wholesale market and the price he expects to receive for the fish he sells, and will purchase up to that quantity where the additional wholesale sale's revenue is equal to the ex-vessel price. In the case of fresh coho where no coho will be stored and all must be quickly passed on to the consumer, the quantity the buyer purchases from the fisherman is equal to the quantity he sells. But while the buyer is purchasing coho for the fresh market he will also buy with the frozen market in mind. Since the buyer appears to be selling into a wholesale market where his actions do not change the equilibrium price because he is such a small part, the port buyer is able to sell all he desires at the equilibrium market (wholesale) price. The buyer will decide how much fish to purchase from the fisherman by equating the extra cost of purchasing and running another fish through his plant to the wholesale price. The extra cost are those costs associated with all the variable resources the buyer must employ to move the coho to market.

Aggregate Port Demand

Assuming that all buyers in a port behave similar to the hypothetical buyer above, and if these buyers also sell into the same wholesale market, the collected actions of all the buyers in a port will be the summation of all buyers' individual actions. An increase in the wholesale price will encourage all buyers to attempt to expand sales of coho by equating the new price to their marginal costs associated with coho. This in turn will increase their individual demands for coho. In the port, the increased demand from each buyer will mean more coho is demanded at the current ex-vessel price.

Short Term Entry for Port Buyers

Some of the buyers on the coast are mobile; that is, they may be successful at establishing a temporary buying station during the salmon season to purchase the fish as the fishermen return. However, such buyers usually must be willing to pay a higher price to get a portion of the available fish away from the established buyers.

Buyer mobility also exists in another form. Because the processors and buyers are frequently one and the same, they can move in and out of the coho market. If the port price becomes too high, they can simply stop purchasing salmon. If landings in that port decline, the buyer turns his attention to other species. In both cases the number of buyers will change in response to changing market conditions. The effect of more (less) buyers is to increase (decrease) the port demand. Hence, the aggregate port demand is hypothesized to shift in direct response to the number of buyers.

Model of Port Demand

The following model has been formulated to represent the aggregate behavior of the coho salmon buyers in an individual port during the season:

$$P = f(Q, PFZN, BUY, INV)$$

where

P is the weekly weighted ex-vessel price in cents per pound of coho salmon at port. This variable is endogenous to the system.

Q is the weekly quantity of troll coho salmon demanded by buyers at port. This variable is endogenous to the system and, in accordance with traditional demand theory, its coefficient is expected to have a negative sign.

PFZN represents the lagged weekly wholesale price for coho salmon in cents per pound. The rationale for the inclusion of this variable is derived from an understanding of the complete market system beyond the ex-vessel level. This price is common to all ports and represents the major shifting mechanism of ex-vessel demand resulting from changes in the wholesale and retail markets. The coefficient of wholesale price is expected to be positive. Since it is assumed that this information is not available to a buyer during the current week of observation, the variable is lagged one week. It is therefore a predetermined explanatory variable.

BUY is the weekly number of coho purchasers within a week in the port. This variable is assumed to be endogenously determined and is hypothesized to account for demand determining forces resulting from the number of buyers in the port. It is expected to act as a positive demand shifter.

INV The weekly quantity of coho held at major frozen storage locations. This variable is hypothesized to represent the accumulation of coho from all ports. The variable is considered exogenous and is expected to have a negative sign.

Ex-vessel demand is specified as price dependent. The rationale for this specification relates to the assumption that given a quantity of coho landings, buyers will adjust their price accordingly.

Ex-Vessel Port Supply of Coho

When discussing the supply of coho landings at a port it is necessary to distinguish between two phenomena: the decisions associated with the harvest of coho, and the landing of the catch.

The decision to harvest is associated with both long and short run behavior. The long run is a period of time greater than the season and involves the decisions associated with entry into a particular fishery, to type of equipment to purchase etc. While the short run involves decisions associated with shorter run objectives such as which port to land the catch.

The decisions where to land is based on many factors but the factor hypothesized to be most important is the port ex-vessel price. The fisherman's behavior in responding to this price is the central issue of the determination of a particular port's allocation of fish.

The Coho Fishing Activity

Once the stocks of coho begin their annual migration along the Pacific Coast, they are preyed upon, captured, and transported to port buying station by the commercial and recreational fishermen. While the primary producer of coho may actually be the natural environmental conditions in the case of wild stocks, and state or commercial hatchery operations in the case of salmon that man has attempted to replace, the first member of the market chain to provide the tangible input is the fisherman.

Troll coho are generally processed at sea by the fisherman. This requires cleaning, and storing in ice immediately after the animal is brought aboard the vessel.

When the fisherman cleans the coho, he removes the gill structure and all internal organs. State regulations require that heads and tails be retained in order that minimum size is accurately measured.

Buyers expect troll coho to be "brights", meaning fresh and of a high quality. The quality of the landed coho is measured in terms of 1) the time that has elapsed from capture, cleaning and transporting to the buyer and 2) the care it is given while in the possession of the fisherman. There are some differences in the way the coho are handled while in the hold. The temperature and length of time that the fish stay in the hold of the vessel are critical in determining the quality of the fish. In fact, many fishermen are quite proud of the high quality of their landed fish.

When the fisherman arrives at his port of choice, he will immediately unload the catch onto the buyer's dock or dock bucket. Since the troll fisherman will land other salmon along with coho, the buyer must sort out the catch by species and size. The catch is weighed and the total return to the fisherman is determined according to the current ex-vessel price for each species and size category.

Differing prices are paid for each size category. Generally the sizes are organized into three different groups: 4 to 6 pounds, 6 to 9 pounds and over 9 pounds. The size criteria have been noted to vary from season to season.

In order to reduce some of the risk and uncertainties in the fishing business, many fishermen have begun to combine several fisheries during a year. These seasonal substitutions among fisheries require greater skill, and more equipment from the fisherman. However the benefits are derived from a reduced dependence on ay particular fishery which may be suffering from a poor biological performance or where domestic and foreign market conditions are such that the ex-vessel price is depressed relative to other fisheries.

According to a study by Liao and Stevens (25) the majority of Oregon fishermen specialize in one fishery. But eleven percent tend to combine salmon with tuna, while seven percent enter the salmon-tuna-crab fisheries, and only two percent of salmon fishermen are estimated to land shrimp and/or bottom fish, crab and/or tuna. The trawl or drag fishermen are less likely to enter the salmon fishery due to the type of vessel used in the shrimp or bottom fisheries.

The seasonal nature of the fishery and the fluctuations in production are perhaps responsible for the share system of labor payments for crew members. This means that the crew member becomes a risk co-venturer with the boat owner because crewmen are paid a percentage of the landings revenue rather than a regular salary. This system provides an incentive for crew members to work harder in catching the coho (36). It also means that a poor year in landings or price paid, is shared by both crew and owner.

The Production Function

The relationship between the quantity of coho caught and the amount of effort employed to catch the fish is the fishery production function. The amount of effort can be measured by an index of number of boats, numbers of fishermen, quantity of trolling gear, and days spent fishing (36).

Except for the improvements in navigation, electronic fish finding equipment and the power gurdie, the techniques of trolling developed 80 years ago still apply with little change. These changes have evolved slowly and variation between recent seasonal catches are not likely the result of technological change.

Entry Decision

Fishermen are attracted to the coho fishery for many reasons. Some base the decision on non-economic reasons such as the desire to be independent, to live the life style of a fisherman. Many simply enjoy catching fish and do not care if they cover all their costs.

Getting into the coho fishery requires operating capital, a suitable vessel, a place to moor it locally, knowledge of the sea, some skill and knowledge associated with trolling and, in addition, fishing and vessel license issued by the state.

Some fishermen decide to fish for coho because they say that they can "make money at it". They expect to derive profits from fishing because they have observed that revenues from coho are generally greater than relative costs.

One of the problems of an open access resource such as the coho fishery is that without an economic incentive to stop fishing at some level where profits in the industry are maximized, fishermen will not only continue to supply greater levels of effort as long as the returns to effort is greater than the costs of effort, but other fishermen will perceive an economic profit and will be attracted into the fishery (2).

Assuming that the fishery effort to revenue yield relationship is as shown in Figure 3 and that total costs of effort are TC, expansion of effort in the fishery continues until the effort level E_3 is reached. At that equilibrium total costs are equal to total revenues in the fishery and no additional effort would be supplied, and the rational prospective fisherman would perceive no economic profits and would not enter the fishery.

It is clear that the maximum revenue would be attained at effort E_2 and industry profits would be maximized at effort E_1. However, because of the open access nature of the fishery there is not necessarily a positive relationship between effort and yield over all levels of effort. The important point here is that effort may respond to perceived opportunity for economic gain, while production may not.

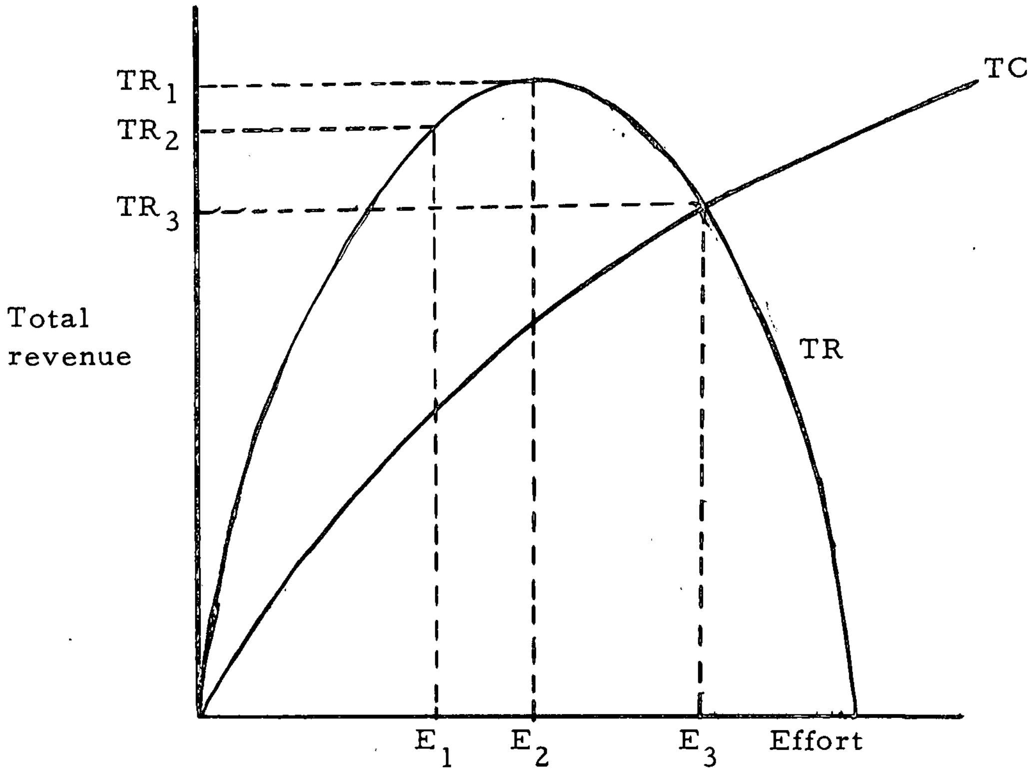

Figure 3. Yield effort function.

During the season, however, the number of fishermen may be assumed to remain fixed. The rationale for this assumption is based on the amount of time that is necessary to prepare a vessel for harvest catching fish and the time necessary to obtain a commercial fishing license.

Different Utility Functions

There may be many reasons that fishermen go to sea in order to capture fish, but the salmon fishery appears to be unique from other fisheries due to the sporting component of fishing. In this fishery, a differential is observed in fishermen's utility functions. Fishermen may be generally divided into two categories. The first includes the full time fisherman who fishes all year, who derives all or most of his income from the sea, and who has a considerable capital investment in his vessel. These fishermen are the most mobile and are hypothesized to seek the areas and fisheries where their revenues will be greatest. These fishermen appear to land the largest percentage of fish while actually representing only a fraction of the total number of fishermen (23).

In contrast, the part time commercial fisherman may be categorized as a person who derives only part of his income from fishing, fishes only part of the year, may land a few fish during the year as compared to the full-time fishermen, has little capital invested in his vessel, and perhaps most important, this fisherman uses fishing not only to obtain additional income, but to increase consumptive utility derived from fishing. His objective is to maximize satisfaction and as such, is hypothesized to be not very concerned with the current ex-vessel prices. Since these fishermen have other incomes, they have found that fishing has some indirect advantages. These fishermen may be using part-time commercial fishing as an income tax reduction device. Tax laws allow the commercial fisherman to deduct losses and since the revenue from occasional fishing may not cover all costs of fishing, the reduction in income tax may provide a significant supplement in income. These fishermen would be sport fishing in most instances, and the costs from vessel operation is deductible from the yearly taxes. The number of these part-time fishermen in a port may affect the responsiveness of landings to price.

The Decision to Harvest

Once the fisherman has entered the coho fishery for the season, the shorter term decision process now becomes important. The fisherman has two options. He can stay in port and not fish that day or any day, leaving his capital investment idle, or he can fish.

If he fishes, he must decide what level of inputs (effort) he will employ to secure a catch. For the profit maximizing fisherman, the level of fishing effort is dependent on the relative costs of effort and the expected return to that effort.

Weather as Part of the Decision Process

The coho salmon fisherman must base his decision to fish upon the expected weather conditions. If summer Northwest winds exceed 10 knots, the seas become very rough. When a fisherman trolls in choppy seas, he is likely to damage or lose fishing gear. Larger vessels may be able to withstand a heavier chop than smaller vessels but trolling is difficult regardless of the size of the vessel.

In addition to the problems of trolling, heavy sea conditions will cause the entrances (bars) to ports to become dangerous or impossible to cross. Therefore bar conditions affect landings decisions.

Hence, weather plays a role in not only the amount of effort but also the choice of landing port. However, this effect is reduced to a certain extent by the generally good weather conditions during most fishing seasons.

Fishermen appear to be indifferent to salmon prices until it is time to land the catch. They accept whatever the current price may be and seek to maximize their catch. In fact, troll fishermen take great pride in relating to other fishermen how much coho they caught. The goal for many fishermen is to be the port "highliner", the fisherman consistently catching the most salmon.

Much of this behavior is derived from the very independent owner-operator nature of the fishermen. However, if the ex-vessel price is far above the normal price, or the fisherman perceives a large change in price from the previous week, he will not be indifferent. The decision of the amount of effort to employ is not independent of the ex-vessel price. Fishermen will fish longer, try more types of gear, use more fuel if they know that they will receive a higher price for their fish.

Landings Behavior

Once the fisherman has caught, cleaned and stored his harvest of salmon, one phase of the production process is over. After he has decided at which port to land, he must transport the catch to that port. The decision where to land the catch is highly dependent upon the type of vessel the fisherman is using. Some have smaller day boats that cannot be expected to remain at sea for extended periods of time. These fishermen are effectively restricted to their home port. Alternatively, the trip fisherman usually employs a larger vessel which enables him to stay out at sea for longer periods of time, accumulate catch because of his storage capacity, and allows him to choose the port at which to land the catch. Thus, the landings of coho in a port not only depend upon the activities of day fishermen, but the relative attractiveness of that port to those fishermen able to choose ports to land.

Storage by Fishermen

Troll coho are a perishable commodity and begin to deteriorate rapidly after being caught. The fisherman must attempt to cool the fish sufficiently to slow this process as much as possible. Many fishermen use ice in their holds if they have a large enough capacity for fish and ice. Day boats, however, are usually small and do not carry much, if any, ice. They cannot store the fish for very long periods of time. Hence, here is another difference profoundly distinguishing day and trip vessels. Not only can the trip vessel hold more fish, it can usually hold it longer due to the addition of many boats of freezing or cold storage equipment. Such landings of frozen fish are becoming much more common because frozen storage capacity allows the trip fishermen to land their catch when the price is higher.

Day fishermen without storage capability must sell their entire catch the day it is caught. Hence, the day fisherman would be expected to land at most any positive price. If a port is composed of only day boats, it will have a supply schedule that is less responsive to price. On the other hand, a port that is supplied entirely by trip fishermen capable of storage and landing at other ports would be expected to have a more elastic supply schedule, that is, it would be expected to show responsiveness to price.

The combined effect of these two types of fishermen in the same port is diagrammed in Figure 4. The supply by "day" fishermen with no other alternatives for landing, is represented by supply curve S_d. These fishermen will be willing to supply Q_0 at any positive price.

The trip fishermen on the other hand, are responsive to different prices and are shown in the diagram to increase landings in that port at greater ex-vessel prices. Assuming that these fishermen do have an alternative to land or store their fish and would therefore not land below some minimum price, say P_a, then the supply of coho for that port would be Q_0AS_t, and the equilibrium price for coho will be P_e at quantity Q_e.

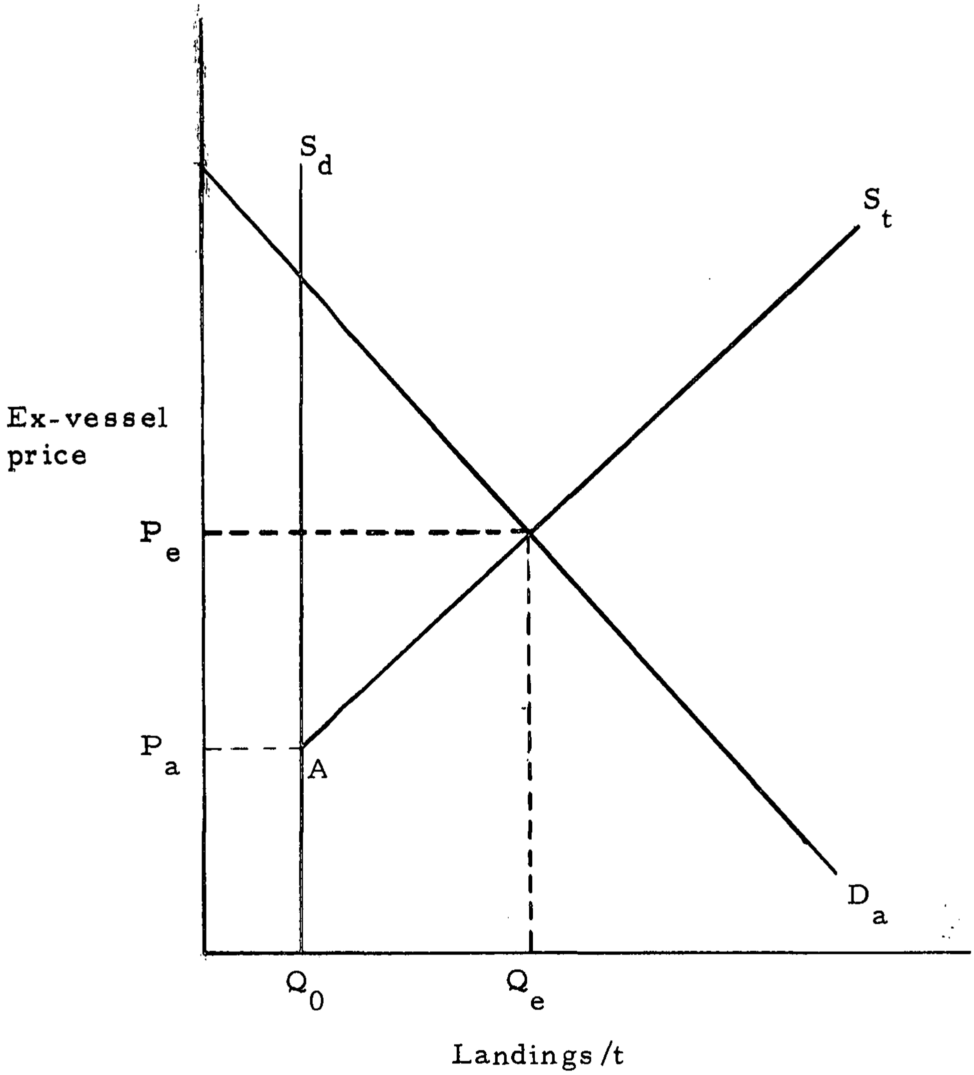

Figure 4. Ex-vessel port market.

Oregon ports offer a unique opportunity to compare some of the differences in landings behavior between a port that is composed of small day type fishermen and other ports where there are both day and trip boats. The port of Pacific City is unique from all other ports because it has no dock facilities and all vessels are launched from the beach. Its fleet consists of day boats.

Landings of Other Species

Coho salmon are not the only salmon that troll fishermen catch. Even though the technique for attracting chinook is different from that for coho, fishermen do catch them while trolling for coho. In addition, pink salmon, also known as humpies, are occasionally caught in the attempt to catch coho. The catch of these fish is considered incidental to coho because the ocean abundance is frequently spotty. During some years the sea conditions are such that the pinks will linger in an area. Fishermen will land these fish as troll caught salmon. The price for these fish is usually less than prices paid for coho. Consequently, fishermen do not like to catch humpies and will change gear in order to avoid them.

Ex-Vessel Bonus

While prices for coho are established at several stages along the marketing channel, this study deals principally with the price received at the first point of sale of the fish. The reported ex-vessel prices for coho are observable. What is not directly observable is an additional price paid to fishermen. The ex-vessel prices reported by state agencies do not show this bonus paid to fishermen, but the incidence of the extra benefit (bonus), whether paid in price or nonprice concessions (ice, bait, refreshments, credit, etc.) are common along the Northwest coast commercial fisheries (19). The bonus is generally recognized to be paid for a variety of reasons, most notably, to encourage the continued loyalty of the fishermen to the processor and hence, assure the processor a continuous supply of salmon.

Unfortunately, the amount of the bonus payments is something fishermen or processors do not like to talk about. Explanations vary, but one reason frequently mentioned by fishermen is that the price bonus is not always reported to the Internal Revenue Service (payments are cash). Hence, fishermen and processor will not willingly release information that could indicate illegal conduct. The nonprice bonus is probably never recorded as a payment to fishermen, although it certainly is part of the processor's costs.

All is not lost, however. Interviews with the coastal troll fishermen indicate that the structure of the bonus has a random characteristic. Some fishermen say they are paid a bonus and others rarely receive anything other than ice.

Nonloyal multi-fishery fishermen selling outside the established relationship during the coho season may find that the processor is unwilling to purchase his less desirable fish, for example ground fish and crab in the off season. Buyers may also discriminate against the errant fisherman by forcing him to wait to unload his catch. This is apparently a very powerful motivator since many fishermen are quite anxious to sell their catch and tie the vessel up for the day.

Other researchers of the ex-vessel markets for products where an unobservable bonus is paid has elected not to attempt to estimate the market relationship due to the inability to observe the bonus component of price. The bonus is certainly part and parcel of the ex-vessel price, but interviews with fishermen along the coastal ports have shown that the bonus is not as important as some individuals outside the market have indicated. In addition, the bonus is paid to the fisherman in many different ways, the most common being the year end payment. Hence, for these fishermen, the bonus has very little to do with their short run decision to fish or their decision to land since the amount of the bonus is usually unknown until the end of the season.

Fishermen have also indicated that when the bonus is paid at the time of landing, it is not paid to all fishermen at all times. That is, the bonus at a port appears to vary unsystematically from fisherman to fisherman. At times a processor will include a bonus and at other times he will not. The same situation was found to exist at all ports along the coast. Some processors in a port will pay and others will not. No port was noted to have a consistently greater bonus than any other port.

From these observations, there appear to be no systematic payment of a bonus. The bonus, therefore, for the purposes of this study is assumed to be part of the random, unexplained residual variation of the port market variables.

Additional Decision Criteria

Other factors also play a role in the decision process for a fisherman as to where to land his catch. Such factors include the availability of moorage space, repair and fueling facilities, availability of ice if the vessel has no cold storage equipment, personal relationships with buyers, credit arrangements and short waiting queues at buyers' docks.

Response to Alternate Port Price

Interviews with several trip salmon fishermen indicate that they compare prices at ports where they expect to land their catch. The information for this comparison is passed from fisherman to fisherman most commonly by radio. Hence, fishermen miles away from a port will know the new port price for a species of interest within a matter of hours.

It is hypothesized that fishermen respond to these price differences by landing at the port offering the higher price. Depending upon the region the day fishermen may also be able to take advantage of this price differential, but the trip fisherman is the one hypothesized to have a greater impact since he probably lands larger quantities of fish over a longer period of time at sea.

Hence, it is the fishermen that have port to port mobility and storage capacity that are hypothesized to respond to alternate port prices. It is these fishermen, making their decision on the basis of the extra costs and extra returns relative to each port that will shift the port supply of coho.

Suppose that there is a coho fisherman somewhere off the Pacific coast who thinks it is time to quit catching fish and find a port to land. He knows that there are two ports nearby, call them Port A and Port B, and is indifferent to everything about these ports except the distance he must travel to land at either one, and the current ex-vessel price. This fisherman knows that no matter which port he chooses, his landings will not change the port price and because he will want to return to the fishing grounds as soon as possible, he will never consider allocating his catch to more than one port at a time.

Assuming that the prices in the two ports are the same, and the fisherman is equidistant from each port, his decision to land will be indeterminent; that is, he might as well flip a coint to determine the port to land. If the fisherman however, is not the same distance from each port, then he is no longer indifferent and will choose the nearest port because it will minimize his cost of transportation.

Now assume that the fisherman is still the same distance from each port but that he has heard on his radio that the price in port A has increased and is higher than port B. In this case the fisherman is no longer indifferent to price and will choose port A because the higher price will increase his revenue. That is, the extra revenue from the greater price in Port A represents an increase in the fisherman's total revenue while his total costs remain the same.

Finally, suppose that the fisherman is close to Port B but has heard over his radio that Port A is offering a higher price. Now he must evaluate the extra revenue he will derive if he goes to port A versus the extra cost of transportation. As long as the differences in revenue are greater than the differences in cost, he will choose the higher price port.

Assuming that all trip fishermen follow the same type of decision process, they will allocate the regional catch to those ports offering the highest price. They are responding to differences in prices and allocating their catch in a way to maximize the net returns associated with their catch. Note that once the decision to land had been made, the quantity of the catch of coho is not relevant to the allocation decision.

If the fisherman has a variable cost of transportation, and the price in any port is regarded as the marginal return to transportation, then the fisherman will equate the extra cost of travelling the extra miles to the extra revenue of landing at a particular port. Hence, it is possible to hypothesize the aggregate response to price by all fishermen in any particular two port region.

In order to illustrate the price adjusting mechanism between two ports, it is convenient to present the two port case with a back to back diagram of Figure 5. Here, the right half of the diagram, the supply and demand curves for port A are plotted exactly as in Figure 4. On the left half of the figure the supply and demand curves for port B have been reversed. Quantities are measured to the right of origin 0 for port A but to the left for port B. Now suppose we only consider the supplies of coho to port B from fishermen that might have landed in port A. That is, we ignore the supplies of coho to port B that do not depend upon the market in port A. In doing this we need only consider the excess supply from port A.

At ex-vessel price P_0, port A is in equilibrium at landings Q_{a0}. However, at prices greater than P_0, fishermen are willing to supply greater quantities of fish to the port, while buyers will be willing to purchase less fish. Hence excess supplies of coho could exist at prices greater than the equilibrium price. Now suppose we plot the quantities of fish that are excess for port A on port B's quadrant showing the amount by which the quantity offered for sale exceeds the quantity demanded at various prices in port A. This curve is represented by S_{b1} in port B.

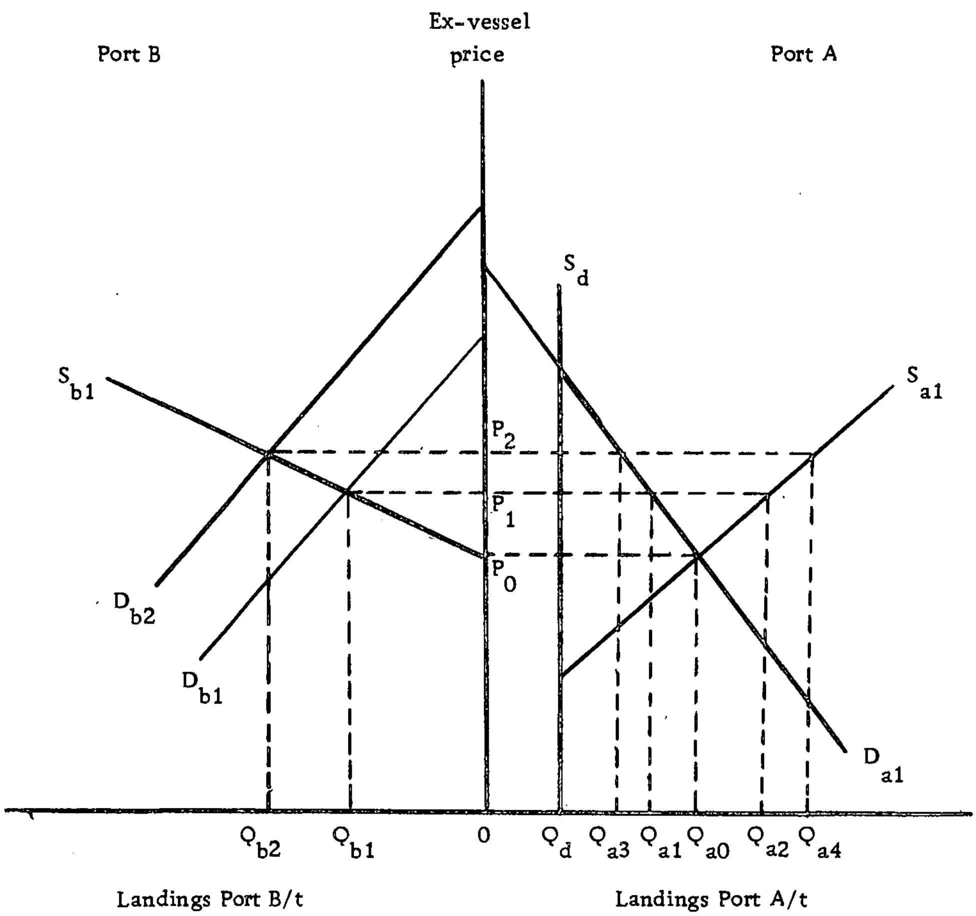

Figure 5. Two port model.

Given ex-vessel demand D_{b1} for port B, the price between the two ports is P_1 and fishermen from port A would be willing to supply Q_{a2}, but buyers in that port are willing to purchase Q_{a1}. Hence the quantity $Q_{a1}Q_{a2}$ is landed at port B (Q_{b1}). If demand for coho in port B should increase to D_{b2}, a new price is established between the ports and quantity Q_{b2} (port A excess $Q_{a3}Q_{a4}$) would be landed in port B while quantity Q_{a3} will be landed in port A.

The reader should keep in mind that these diagrams are representative of equilibrium conditions and do not adequately show the mechanism of adjustment to equilibriums which is the phenomena the current economic model purports to explain.

Some of the ceteris paribus conditions that are assumed constant in this analysis include: there are no external economies or diseconomies impacting the fisherman's landings of coho; that all other inputs in the landings process are constant; the differences between ports in terms of economic and noneconomic variables are the same; bonus payments in either port are the same; and weather conditions are the same for both ports.

Abundance and Landings

When discussing the quantity of coho landed for all ports collectively during any period of time, a major consideration is the level of abundance of a particular species. This is related to the biological status of the fishery and is relatively independent of any economic considerations. Run sizes during any one year are determined principally by environmental and biological factors. The state of the art in determining measures of abundance has not advanced sufficiently to predict the actual size of the weekly coho run, that is, the quantity of coho in a region actually available for capture.

In contrast to non-hatchery fisheries, the abundance of hatchery coho could be argued to be indirectly dependent upon the social, political, and economic factors that are part of the hatchery manager's production function. Without that information however, the size of the run must be assumed to be determined outside the economic system.

In any case some measure of this variation must be considered since increases in the abundance of coho will reduce the amount of effort necessary to catch the same quantity of coho, or given the same level of effort, increased abundance will increase to supply of coho and reduce ex-vessel price.

Model of the Port Supply of Coho

The following model has been formulated to explain the quantity of coho landed in a port. This model is based on the aggregate weekly landings behavior of the troll fisherman:

$$Q = f(P, PA, FERS, W, A)$$

where

Q is the weekly quantity landed, in pounds, of troll coho by fishermen in port.

P is the weighted weekly ex-vessel price in cents per pound for coho salmon. The primary suppliers (fishermen) are hypothesized to be responsive to this price and all other prices specified in the supply equation. The variable is endogenous to the system and is expected to have a positive coefficient.

PA is the alternative port price. This is the weekly weighted ex-vessel price for coho salmon in a port which is hypothesized to be an alternative landing port in terms of distance and market effect. This variable is endogenous to the port of analysis market system. The price serves not only as an explanatory variable in the ex-vessel supply, but as the mechanism linking all ports into a single system.

The rationale for this price on the supply side results from the hypothesized behavior of fishermen. If price for coho is greater in a nearby port, and everything else is equal, then the fisherman expecting to maximize his returns from fishing will be attracted to the port of the higher price, thereby increasing the quantity of coho offered for sale at that port. Hence, the prices are expected to act positively to the quantities supplied in the port.

FERS represents the number of fishermen selling coho. The supply of coho in a port is expected to increase (decrease) with larger (smaller) number of fishing units, everything else constant. Consequently, the coefficient of this variable is expected to be positive.

W is a variable representing the average weekly weather conditions. If the variable is formulated with higher values representing good weather, then the variable should act as a positive exogenous shifter of supply.

A represents the regional weekly abundance of soho available for capture by troll fishermen.

Interregional Price Variation

In addition to the explanation of within-season price adjustments, there is variation between ports. This variation is thought to be the result of differences in market structure, and will be examined by looking at the price determining mechanism at each port.

The ex-vessel market has been thought by some to be a market of atomistic sellers facing oligopsonistic buyers. The seller (fisherman) has the problem "compounded by the perishable nature of his product and his inability--financial, technological, or both--to provide storage capacity" (13 p. 35).

Market Structure

Market structure is defined by Bain as "those characteristics of the organization of a market that seem to influence strategically the nature of competition and pricing within the market" (3 p. 7). The characteristics are related to this study as follows:

1. The degree of seller concentration of coho salmon at each port, that is, the number and size distribution of fishermen landing coho.
2. The degree of fish buyer concentration at each port in terms of numbers and size distribution. If the concentration of buyers is high, that is, the number of buyers small, then the buying patterns of one firm are expected to affect the pricing decisions of other firms.
3. Bain also points to product differentiation as an important aspect of market structure. In this study coho salmon landed by the Pacific coast fisherman are assumed essentially indistinguishable from another fisherman's landings.
4. The last characteristic of market structure considered here is the condition of entry to the market. This is the relative ease or difficulty fishermen or fish buyers encounter while attempting to enter the market. Of course, the relative ease or difficulty of exit from the market is also important.

Some of these characteristics were discussed in previous sections.

In addition to the information derived from an investigation of the market structure, an understanding of the determinants of market conduct is also useful. Market conduct, according to Bain, encompasses "the patterns of behavior which enterprises follow in adapting or adjusting to the markets in which they sell (or buy)" (3 p. 9). The behavior to which this refers are the prices to charge, outputs to produce, product designs, and the mechanisms of interaction-coordination of policies of competing units in the market (3).

The study by Schary, Shirley, and Soule noted that the pricing at the ex-vessel stage

> has some elements of collective bargaining, but the power of the fisherman is limited by the ease of entry into the market. On the other hand, the processor must pay enough to maintain a supply, so that the reservation price of the fisherman becomes a counterweight to the potential power of the processor (34 p. III-35).

Buyer Conduct

Salmon is only one of several species of fish processors buy. Both on the buying side and on the selling side the subject of institutional and noninstitutional factors plays an important role and processors have well established relationships with the customers they serve.

Markets are served not only by historical relationships, but territories are well established. Any processor selling (or buying) outside his territory may experience sudden competitive action not only on the selling side, but on the buying side as well. The larger processors with branch buying stations in different ports have the power to change prices between ports to influence the quantities flowing from fishermen. This, combined with the ability to manipulate the buying of other species of fish may form a formidable barrier restricting other processors from entering permanent markets. The same action is possible on the buying side. A fisherman continuously selling his catch to one processor could face repercussions when attempting to move to another processor in order to obtain a higher price.

Many of the other seafoods, such as bottom fish and crab, are purchased on a quota system. Generally, this means that the fisherman knows how much fish the processor will buy before his boat leaves the dock (35). Established relationships are quite important if the fisherman expects to have that processor continue to purchase his fish.

There have been incidents in the past where the same processor in one port will offer a different price than in another port. Given the nature of the processor's objectives, that is, to maximize net revenue for all locations, the plant in any one port has the ability to take advantage of market structure differences and pay fishermen a different price.

The actions of processors may be dependent to a much greater degree on plant ownership when considering the entire market. Since individual plants sell to customers (retailers, wholesalers, etc.) in established relationships, a buyer that proposes to purchase his products elsewhere may find the availability of one of his more important products substantially reduced.

Fishermen Organizations

Ex-vessel price minimums are established prior to the beginning of each season, by negotiations between the processors and fishermen organizations (34). While the minimum can serve as a base for the season, the situations recently has been that actual market price is always greater than the minimum price.

It is interesting to note that fishermen are treated by the Federal Trade Commission as independent businessmen rather than laborers for anti-trust purposes. This has tended to limit the formation of strong labor unions (19).

IV. THE EMPIRICAL ANALYSIS AND IMPLICATION OF THE RESULTS

In this chapter the hypothesized ex-vessel port models are estimated. The statistical methods used to estimate the model are not unusual but the disaggregated market and the short periods of observation are unique.

Data Collection

The investigation of the coho markets and the description of the various ports of the ex-vessel market produced a number of hypotheses to be tested and it was necessary to find primary data to test the various concepts.

Several possible avenues of approach were advanced. They were: (1) Collect price, quantity and other data directly from the fishermen, (2) secure data directly from the fish buyers, or (3) collect data from the state agencies.

The problem of other data sources, e.g., the National Marine Fisheries Service Market News, was that ex-vessel prices did not exist in a port by port form. With regard to staff agency data, it appeared that some published prices are averaged over time rather than being weighted by the quantity of landings. Collection of ex-vessel prices from the fishermen would have been an expensive and arduous task.

Another proposed source of information was the coho buyers. The buyers had all the individual landings information, but unfortunately, they were quite hesitant to release information they felt could be used against them by other buyers.

It appeared that the only way to obtain the ex-vessel price by port was to appeal directly to the state agencies collecting such information. The initial response for landings records was negative.

It was mentioned in the first chapter that the Fisheries Conservation and Management Act was passed in 1976. This law tended to change cooperative atmosphere in the industry and in the state agencies. Many people were suddenly aware of the lack of information that existed, especially in relation to the economics of the fisheries. Now, at last, the information needed for a port to port analysis of the salmon fishery was made available from the states of Oregon and Washington.

These data contained the necessary information to investigate the market from port to port and within the season. Never before had this information been provided to researchers for investigation. These data originated with the individual landings records held by the state departments of fish. All states collect this information for a variety of reasons but mostly to secure a basis to assess the landings tax placed by the state on all fish purchased by the processor. This information is collected directly from the fishermen at the time the catch is landed. Prior to 1976, ex-vessel prices were not recorded on any landings records in Oregon. Hence, only a single year of Oregon landings data was obtained.

Ports of Analysis

The coastal ports or port areas from which landings information was originally obtained are shown in Table 11. Readers not familiar with the Oregon and Washington coast are referred to Figure 5, which shows the relative locations of the various ports employed in the analysis. The 12 ports in Oregon represent all of the coastal landings of troll coho in Oregon. The five ports in Washington represent most of the total troll landings in Washington. The choice of Washington ports was based on the 1973 season and only those coastal ports showing major contributions to the total catch were included.

Also shown in Table 11 are the minimum ocean to river entrance depths. Any depth grater than six feet is sufficient for most salmon trollers. While the port of Pacific City has a small river opening most salmon landings are made by dory fishermen launching their vessels from the beach. Other ports such as Coos Bay and Newport have entrance depths great enough for very large vessels such as lumber freighters.

Table 11. Physical descriptions of Oregon and Washington Ports.

Port	River	Number of Berths as of 1976	Minimum Entrance Depth (Feet)	Approximate Distance From Ocean (Miles)	Approximate Distance to Next Port (Miles)
Oregon					
1. Brookings	Chetco	500	11	0.3	19
2. Gold Beach	Rogue	170	13	1.0	19
3. Port Orford		none	5 to 9	0.8	23
4. Bandon	Coquille	180	8	0.8	18
5. Coos Bay	Coos	1000	30	8 to 12	24
(Charleston)				3.0	
6. Winchester Bay	Umpqua	Apx. 150	8	1.5	23
(Salmon Harbor)					
7. Florence	Siuslaw	80	9	6.4	22
(Cushman)			4.4		
8. Newport	Yaquina	620	30	1.3	13
9. Depoe Bay		100	2 to 8	1.0	53
10. Pacific City	Nestucca	none	N/A extremely dangerous bar	0.0	28
11. Tillamook	Tillamook				
(Garibaldi)		200	13	2.0	43
(Bay City)			6	4.4	
(Tillamook)			3	11.0	
12. Astoria	Columbia	500	35	14.0	15
Washington					
1. Ilwaco	Columbia		8	3.0	65
2. Greys Harbor		550	7	9.0	4
(Westport)					
(West Haven)					
(Chehalis)					
3. Copalis	Hoquiam	150	5	9.0	86
(Pt. Brown)					
4. La Push	Quillayute	Apx. 200	10	0.4	48
5. Neah Bay		Apx. 200 large anchorage	14	5.0	--

Source: Mostly United States Coast Pilot 7. Port to port distances and approximate number of berths from author's vessel log.

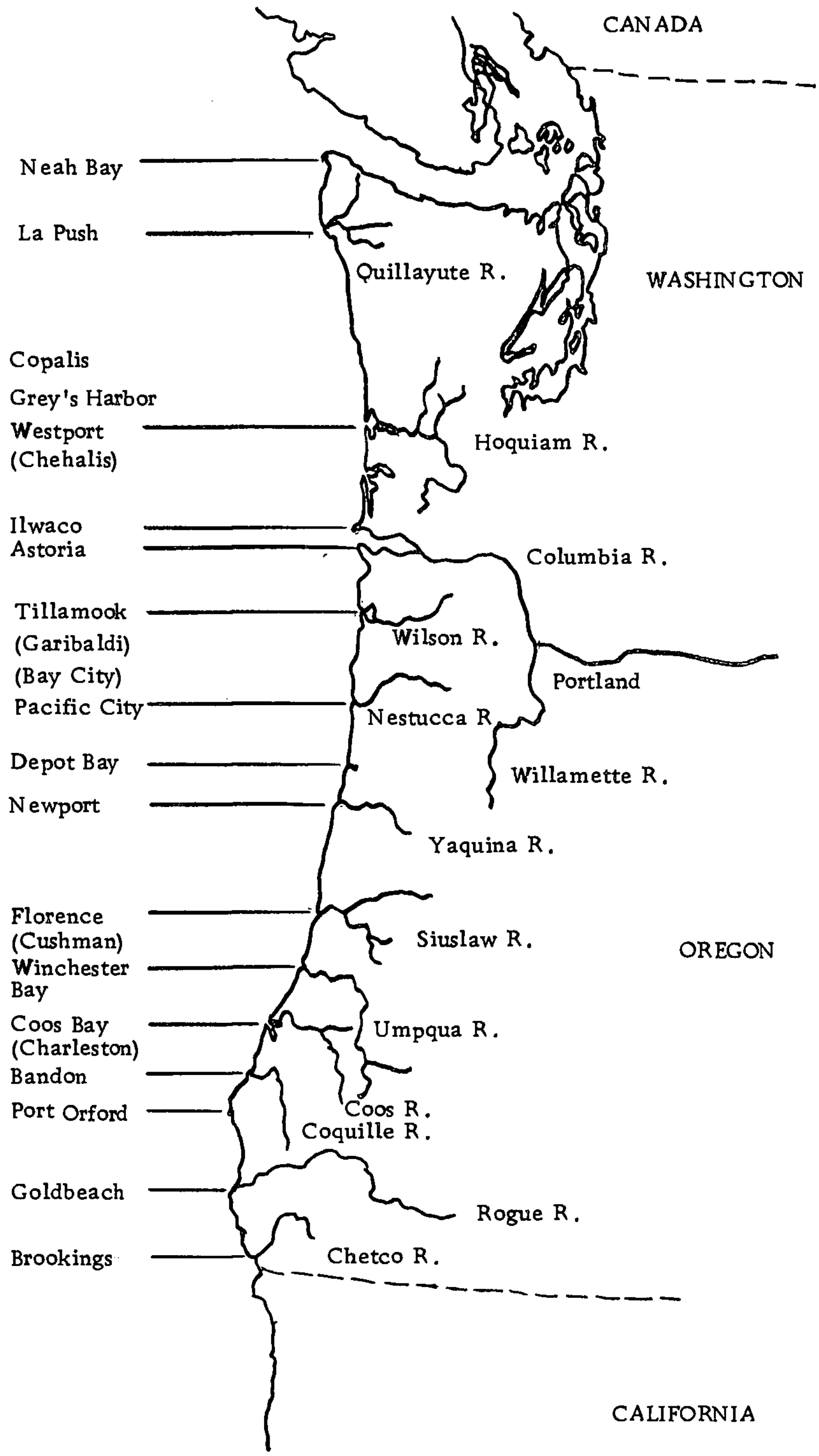

Figure 6. Oregon and Washington ports and river systems.

Informal Interviews

Much of the preliminary conduct and structure information was derived from informal interviews with salmon buyers, salmon processors, salmon fishermen and fishermen marketing organizations. Because of the competitive nature of the industry and the tradition for its members to retain information, the sources of this information are not revealed in this study.

Computing the Average Weighted Price

All prices used in the analysis, either weekly or aggregate, were weighted by the appropriate landings. To do this each price was multiplied by the quantity of coho recorded in the catch. Hence, the price shown in the analysis will account for bias due to a buyer paying an excessive high (low) price for a small catch.

Deflating the Prices

Some researchers favor the use of various deflators as a means of accounting for changes in the price. Since this study focuses on the seasonal relationships, and weekly deflators are unavailable, the prices used in the analysis are actual weighted prices.

Abundance

In order to account for the variation in the overall abundance of coho, an aggregate landings variable was created from regional weekly landings. The rationale for including this variable is based upon the assumed limiting effect of the overall fish stock. Fishermen in a particular region may be able to increase landings through more effort. However the sum of all landings in all ports in a given week is assumed to represent, the "abundance" that week.

Inventories

One of the variables not included in the analysis of ex-vessel port demand was the weekly inventory of fresh or frozen coho. The variable was thought to be important in the determination of the buyers willingness to purchase fish during any given period.

Inventory information is collected only on a monthly basis and is known for shorter periods by the frozen warehouses. Attempts to extract weekly data were futile. Operators of the frozen plants feel that the contents of their warehouse are the property of the individual owners (wholesalers, processors, etc.) and hence, information about the quantities in storage is also private.

The variable would have been included to investigate the importance of freezings in short term price determination. However, it is assumed here that the levels of inventory are reflected in the wholesale price.

Weather

The specification of the supply port supply called for weather as an explanatory variable. Every attempt was made to find a weekly quantification of the results from weather conditions. The information simply did not exist on a port by port week by week basis. Hence, the effects of weather cannot be and were not treated explicitly.

Oregon Data

The analysis of Oregon ports for 1976 required a somewhat different approach than that for Washington due to the differences in the information found on the landings reports. While Oregon does not record the number of fish landed, it does record the coho by size. These categories are: large; over 10 pounds, medium; 4 1/2 to 10 pounds, and small; under 4 1/2 pounds.

Herein is a problem that should be considered in the interpretation of the results. Buyers traditionally break the landings at 6 to 10 pounds for coho. Consequently, the prices and other factors associated with the "medium" coho will include some fish that the buyer refers to as "small".

Wholesale Price

Information for the wholesale price explanatory variable was obtained from the National Marine Fisheries Service (NMFS) Market News sheets by special request. Wholesale prices are published weekly by NMFS offices in Seattle, Los Angeles, Chicago and New York. New York however was the only office that has maintained prices since 1973. This office was most helpful in providing the prices used in the analysis.

Specification of the System

A failure to identify unique hypotheses complicates the step from economic theory to econometric analysis. Theory suggests the nature of the econometric relation and suggests conceptual variables of interest and some restrictions on coefficients. It is rare that theory will provide much *a priori* information about the mathematical form of the hypothesized relationships. Hence, the theory will suggest many plausible ideas for establishment of behavioral relations, but not how the relation exists. With this in mind and what has been observed from a preliminary investigation of the ex-vessel markets, there is no *a priori* reason to expect the relations to take any particular algebraic form.

Empirical studies of real economic structures which are based on time series data frequently face the difficulty that the structures are not stable. This term, stability, is used to mean the constancy of the relations (coefficients and specifications) over time (16). The ex-vessel market is undoubtedly no exception. It is likely that the season to season structure of the industry has not been stable. Changes in structure due to changing fishing patterns, reallocation of fishing units, etc., have occurred.

Changing structure however, is probably most evident in the analysis of data over longer periods of time. In the data used for this study, there are no previous observations for each port. However, it is not expected that there will be significant structural changes during that period of time. Each season will be treated independently so that any major changes that occur from one year to the next may be observed in the relative differences between the estimated coefficients.

The difficulty in an analysis of this type is the scarcity of previous studies of an intraseasonal nature from which to base a priori notions. Researchers prefer to look at monthly or yearly information for four very good reasons: 1) the data are generally easy to obtain; 2) it is expected that there will be fewer statistical estimation problems in longer term analysis; 3) economists are frequently interested in analyzing the effects of aggregates on clearly observable institutional factors, and 4) to forecast many economic variables requires a study of the specific aggregate relationships.

Therefore, it was felt that the best approach with the limited amount of data would be to test the hypothesized relations of the ex-vessel market based on the information presented in the previous chapter on a portion of the data obtained. From these tests, preliminary hypotheses could or could not be maintained. Hence, the 1973 Washington season was used to test and establish relationships for the remaining Washington data (1974-1976) and Oregon (1976) data.

The acquisition of the landings variables from more than 15,000 records required a costly computer program to sort and accumulate factors. Thus, it was important to determine from the test exactly which variables should be extracted from the data.

What appears in the following discussions of the results of the estimations of the port to port markets is based on a priori information about the nature of the market process, that is, the system by which equilibria were established. Many different hypotheses were tested or rejected on the basis of the results of the single season for Washington.

The integrity of the investigation process is preserved by the use of a single year of information. All other data were reserved for estimation when the final choice of a system of equilibrium process had been made.

In the initial specification of each port market model, it was hypothesized that the ex-vessel price of coho and the quantity of landings were endogenous variables, that is, that both of these variables were jointly determined by the marketing system.

The assumption of jointly determined endogenous variables necessitated the initial estimation of a simultaneous equation system for each port model. In such a system, the major question is related to the ability of the model and data to identify a unique numerical structure for the unobservable disturbances.

This problem arises because the observed price-quantity levels in each port market are generated by demanders and suppliers acting simultaneously. Hence, it is not possible to identify and estimate either the demand or the supply relationship without some additional assumptions about the possible structure of the market.

One method that is used to deal with this problem is to assume that either the demand or the supply relation is stable while fuctuations in the non stable relation were responsible for most of the observed fluctuation in price and market clearing quantities. In this case the assumed stable relationship would be estimated by the model (15).

For the ex-vessel port markets however, there is no a priori reason to expect either demand or supply relationship to remain stable during the period of analysis. Therefore, the relationships are considered to interact simultaneously. Other factors are assumed to be at work to shift the supply and demand curves. These factors are represented below as the exogenous or predetermined variables.

Equations Estimated

The port demand and supply model to be estimated is as follows:

$$P = a_0 = a_1Q + a_2PFZN + a_3BUY + \mu$$

$$Q = b_0 + b_1P + b_2FERS + b_3PA + b_4A + \mu$$

where μ represents a stochastic disturbance due to the basic unpredictable element of randomness in human responses or the net effect of excluded variables, and/or errors in measurement or observations. The disturbances are assumed to be distributed normally with a mean of zero, a constant variance, and be independent of the explanatory variables.

The variables P, Q, and PA, as defined in the previous chapter (see page 83), are endogenous to each port model. P and Q are variables the model purports to explain in the current time period on the basis of the values taken by the remaining variables, which are exogenous. Definitions of these variables appear on pages 59, 60, 83 and 84.

Two Stage Procedure

Each port's supply and demand equations are assumed to represent a part of a simultaneous system. Several variables are endogenous and therefore are to be explained by the model, while others are exogenous and are assumed to be determined outside the system.

The problem with endogenous variables among the explanatory variables is that the endogenous variables are correlated with the disturbance term of the equation in which they are a part. Consequently, the Ordinary least squares (OLS) estimators of the structural coefficients are biased and inconsistent (22). Since the system of equations in the present model are overidentified, the technique of choice for this study to allow consistent estimation is the method of two stage least squares. In order to purge the endogenous stochastic element, all endogenous variables shown as explanatory variables of the structural equations are regressed on all the predetermined variables in the complete model (20). In the second stage, predicted version of those variables are then substituted back into the original equation as predetermined variables and the structural equation is estimated again by OLS. Predetermined variables in such a system are not contemporaneously correlated with the residuals (11).

Several other methods are available to estimate unbiased coefficients. Indirect least squares method is sometimes applied when equations are exactly identified. If the equations are over identified then application of this method results in indeterminate estimates (11).

Even though the full-information maximum likelihood estimators and the three stage least squares estimators are helpful when there is expected correlation of the residual across the system of equations (22) and do offer unbiased, asymptotically efficient, and consistent estimates, they are considered much too difficult to use on the anticipated number of equations that are estimated for the Oregon and Washington ports. It was necessary to estimate over 50 different equations (not including test estimations), and even two stage least squares imposes a high computational cost.

Choice of Alternate Port

The hypothesized relationship of the other port likely to have a direct impact on the port to be analyzed was based on the nearest port most likely to serve as an alternative.

For the estimation process, two ports were generally tested in the complete supply equation as the alternative. The port price most consistently indicating a significant impact is presented in the results of the analysis. This criterion could be criticized on the grounds that the relevant alternate port may change over the season. However, some decision rule was necessary and it is hoped that the present one is reasonable.

In the presentation of the results that follow, the alternative port is shown in the column with the port of analysis for Washington ports, or is shown in its own column under the symbol PA.

Criteria for Evaluation

The evaluation of the estimated relation is based on how well the relations agree with a priori expectations discussed in the previous chapter, and the consistency between the sample observation of their estimated values.

To evaluate the estimated coefficients, statistical tests of significance are used. Those coefficients whose calculated "t" values exceed the lower bound of a one tail 95% confidence interval are considered significant.

One of the assumptions of the ordinary least squares estimation method is that successive observations are random. But when regression estimates are based on analysis of very short time series data, the assumption is likely to be violated.

This means that the unexplained residuals for successive weeks may be significantly correlated and that successive residuals in the estimated equations are correlated rather than being random. If estimates are made when this violation has occurred, the standard errors of the regression coefficients are underestimated and for a specific level of significance, the calculated acceptance region will be smaller than it would be when the assumption is not violated (20).

One method commonly used to test for the presence of serially correlated residuals in small samples is the Durbin and Watson Test. The Durbin-Watson (D. W.) method tests the hypothesis that the residuals are uncorrelated over time against the alternate hypothesis that they follow a first order autoregressive scheme (22). The d statistic is reported for all regression results in the following sections. A symbol above the d value indicates the result of tests of the hypothesis of no autocorrelation at the 5% level of significance against the alternate hypothesis of positive autocorrelation. These symbols above all D-W statistics are as follows:

+ = Hypothesis rejected-Positive autocorrelation

- = Hypothesis rejected-Negative autocorrelation

I = Test is inconclusive

0 = Indicates that the hypothesis of no autocorrelation cannot be rejected.

Positive autocorrelation indicates that the standard errors of the regression coefficients are underestimated and tests of significance must be accepted with caution.

If autocorrelation is encountered, one way to detect the absence of some unexplained systematic influence on the dependent variable is to plot the residuals, then try to find some variable whose variation resembles the pattern shown by the residuals. An attempt can be made to re-estimate the equations by including the missing variable.

Another method requires the transformation of all variables into new variables that measure only the period-to-period changes. These transformed variables are called first differences and are then used in the regression analysis (15).

When the hypothesis of no autocorrelation is not rejected, then the least squares estimates are retained without expecting loss of efficiency or bias of the standard errors (22).

All Durbin-Watson test results are shown in the last column on the right side of the page. The interpretation of the test according to the above mentioned symbols will be found just above the d value.

The coefficient of multiple determination (R^2) is reported as a measure of the explanatory power of the regression equation. This measure indicates the percentage of variation in the dependent variable which is explained by the variations in the independent variables taken together. This measure will be shown in the far right hand column under "R^2".

Under the column labeled "F" are F values for testing the hypothesis that the explanatory variables are significant as a group in simultaneously explaining the variation in the dependent variable. These statistics may be compared to the critical values of the F distribution to test the null hypothesis that the regression coefficients taken in combination are equal to zero. Directly below this value is listed the appropriate number of degrees of freedom for this test. The reader interested in determining the total number of observations in the data from which the regressions were performed may simply add one to the sum of the numerator and denominator.

Due to the large quantity of results to be shown in the following sections, some of the values of the estimated coefficients are reported in a modified scientific notation. In order to save space between column, only the exponential power of the result is shown. Hence, 7.12×10^{-7} is shown as 7.12^{-7}.

Initial Estimations

The results of the port demand equations from initial estimations indicated that a very fundamental relationship was not being considered. When plotting the residuals against time, a pattern began to emerge that was consistent for all the ports. Plots of price over time show that a positive linear relationship was present. Hence, a search was begun to uncover which variable was not included to account for this problem.

Recall the discussion about the breakdown of coho at the time of landing by size. The buyer pays a higher price for a larger fish because the larger fish is preferred at all levels of the market system. Consumers prefer a larger coho steak to smaller steaks, and the larger coho appears to have a greater range of substitutes than do the smaller fish.

Interviews with processors and fishermen inciated that size of the coho was an important variable in the determinations of ex-vessel price. Plots of the 1973 data do show that prices move up over time as the size of the fish increases (see Appendix I). Accounting for size in Washington ports would be a greater problem than for Oregon ports, because Washington data did not record the fish landings by size. The Washington Department of Fisheries stated that they did not record landings by size because at any time during the season, size differences were not significant. That is, coho appeared to mature uniformly as a group, and consequently one price existed for coho during any given week.

To account for this variation in size, a variable was constructed with information on the quantities (total weight) and numbers of fish landed. While this variable does not account for the variance in the size distribution during any period of observation, it is assumed that the coho matures uniformly so that a single average size is available at any given period of observation. The size variation was accounted for by including a variable (SIZE) representing the average weekly size in pounds for troll coho.

Port equations with size as another explanatory variable were re-estimated. The estimation results of the 1973 Washington ports are presented in Table 12. The estimated structural coefficients for the demand equation (price dependent) appear on the left hand column of the table. Supply estimates with quantity as the dependent variable are on the right side. Directly below the name of each port is the name of the port from which the alternative price variable (PA) was obtained. All variables with the "$\wedge$" symbol are stage two estimates.

The coefficients of determination (R^2) for the demand equations are .97 or better indicating that more than ninety percent of the variation in the port ex-vessel prices is associated with the variations in the explanatory variables associated with each port. The R^2 are very high due to the inclusion of the size variable, suggesting that the size is explaining much of the price variation.

The ex-vessel demand relationships are as expected for the demand equations in La Push and Westport, but positive relationships between ex-vessel prices and quantities purchased in Ilwaco and Neah Bay suggest that one or both of the relations have not been adequately specified. Only one of the price and quantity variables in the demand and supply equation has a significant t statistic. Hence, for most ports the null hypothesis that quantities demanded have no influence on the ex-vessel price ($H_0 : a_2 = 0$) can not be rejected at the 95 percent level of confidence since the t ratio for the estimated

Table 12. Simultaneous equation model for Washington ports (1973).

Port	Demand					Supply					F		
	C	$\hat{Q}$	PFZN	SIZE	BUY	C	$\hat{P}$	FERS	A	$\hat{P}A$	df	R^2	D.W.
Ilwaco/	-.687	3.47^{-8}	1.01	.020	-.014						137.6 4/15	.973	1.48^{I}
Westport	(-3.58*)	(.12)	(6.70*)	(1.82*)	(-2.20*)								
						1.54^{+4}	-531.3	80.2	.117	-2.15^{-4}	5.96 4/15	.614	1.13^{I}
						(.31)	(-.03)	(1.12)	(2.50*)	(-.12)			
La Push/	.189	-3.89^{-8}	.412	.073	8.09^{-5}						144.9 4/15	.975	1.77^{0}
Neah Bay	(.58)	(-.19)	(1.37)	(3.38*)	(.01)								
						-2,330	-2.96^{-5}	51.6	.321	2.95^{5}	26.5 4/15	.876	2.50^{0}
						(-.05)	(-1.11)	(.676)	(6.47*)	(1.06)			
Neah Bay/	-.517	1.06^{-6}	.753	.044	-.009						122.6 4/15	.970	1.36^{I}
La Push	(-2.19*)	(2.31*)	(3.85*)	(3.42*)	(-.66)								
						-53,700	2.09^{5}	91.1	.115	-1.57^{5}	29.2 4/15	.886	1.59^{0}
						(-3.61*)	(2.20*)	(2.55*)	(6.97*)	(-.176)			
Westport/	-.237	-1.89^{-8}	.466	.066	.002						242.2 4/15	.985	1.56^{I}
La Push	(-1.31)	(-.120)	(2.83*)	(5.52*)	(.33)								
						-4.36^{+4}	-4.27^{+5}	174.2	.305	4.27^{+5}	37.1 4/15	.908	1.78^{0}
						(-1.20)	(-1.78*)	(3.21*)	(7.85*)	(1.90*)			

*Significant at 5% level.

coefficient of Q is not greater than the t statistic for the appropriate degrees of freedom.

The estimated effect of the wholesale price variable (PFZN) is as expected in all ports, and in all but La Push is significant at the 5% level. The same situation is true for the size variable (SIZE) except that this variable is significant in all ports. Hence, increases in the weekly size of coho increase ex-vessel port price.

The buyer variable does not appear to be important for most ports. Only in the port of Ilwaco was a significant but negative relationship found. This suggests that the greater (fewer) the number of buyers in a port the lower (higher) the ex-vessel price. This is contrary to the expected relationship where more buyers in a port would shift port demand along an (assumed) positive supply curve and thereby increase port equilibrium price. This assumption is not unreasonable since the results just presented indicate a positive supply curve for Ilwaco.

The R^2's in the supply equations range from .61 to .91 which suggests that 61% or more of the variation in landings is associated with the variation in the explanatory variables. The ex-vessel price variable (P) appears not to have behaved as expected. Only the port of Neah Bay has a positive and significant price relation.

The fishermen variable (FERS) has the expected sign in all ports but is not significant in Ilwaco and La Push. The abundance variable (A) also appears to be important in explaining the variations in landings by week.

Four of the Durbin-Watson (D. W.) test statistics indicate the absence of autocorrelation. The remaining four statistics are in the inconclusive zone. Since the data used in this analysis covered such short periods of time, it was expected that the unexplained disturbances from the previous week might be carried over into the current week. The suspicion of the presence of autocorrelation is greater in shorter time periods (22).

While the inclusion of the size variable did improve the explanatory power of the model the results just presented remain just as unsatisfactory. The next step necessitated the re-evaluation of some of the assumptions about the model.

Model Linearity

The residuals were plotted around the sample regression line to see if the assumption of a linear relationship was valid. This method has been suggested by Johnston (20) as a way to observe the possibility of misspecifying the form of the estimated model.

This test becomes quite subjective in its evaluation when the number of observations is small. With so few observations it is difficult to accurately determine whether the scatter represents a random pattern around the regression line. However, from the best interpretation of this author, it appears that the assumption of linear supply and demand relationships are justified.

Recursive Model

The results of the system of equations just shown prompted the re-evaluation of the assumption of the basic equilibrium model.

Since the period of analysis (one week) was so short, it was suspected that the demand supply forces would not have time to generate a market-clearing equilibrium. That is, economic adjustments are not made instantaneously without time lags. There are frictions in the systems. Buyers take time to adjust prices they are willing to pay for various quantities landed.

The relationships among factors in an explanatory behavioral model rest on the proper specification of the economic system. The relationships among components may be interdependent, or simultaneous in nature or they may be recursive, where one variable has an impact on another in successive time periods (5). The models just discussed are based on the assumption that one week is long enough for "equilibrium" prices to be established; i.e., that prices and quantities are simultaneously determined.

Simultaneous systems have been long recognized by economic analysts as the model of choice. Proponents of this system see the world of economic events as largely simultaneous. If these events are perceived over a period of time great enough to allow casual relations to work themselves out, then one may be observing equilibriums established between period of analysis. On the other hand, Wold and others view economic systems as recursive (46). The choice of the causal relationship in this case, is dependent on the desire to observe the mechanism of change between successive periods of time (44). If sufficiently short periods are used in the analysis one is likely to reflect the decisions of the economic agent reacting after some lag.

Since the port demand function did not include the effects of changes in weekly inventory at each port, it was suspected that the current quantity of landings was not appropriate for the specification of demand. It has been mentioned that inventories seem to have a major impact on the buyers' decision even in the short run. This problem was previously thought to be less important because the quantity of coho was assumed to move as fresh, or be stored in larger freezing establishments. The current landings were therefore clearing the market and not part of the current week's buying decisions. However, the lack of a significant price response by buyers to various quantities of coho suggested that an alternative hypothesis of market adjustment might be appropriate.

Cobweb Theorem

If the quantities of coho in port inventories were a significant factor, then the landings in any previous time period would affect the purchase decision in the current time period. The kind of adjustment process where there are time lags in either supply or demand functions is known as the cobweb theorem (5).

The newly hypothesized basic model of port price adjustment without shifts in supply or demand is shown in Figure 7. The S curve represents the supply schedule in the same sense as before. That is, it shows the quantities that will be supplied by fishermen at the various prices during the week, ceteris paribus. D represents the demand curve where a time lag has been included. That is, it shows the relationship between prices offered this week and quantities landed last week.

If it is supposed that Q_{t-1} represents that quantity landed in the previous week, then buyers in a port will be willing to pay P_t, in the current week. At that price, fishermen will supply Q_t in the current week. This quantity, however, overloads the clearing capacity of the buyers in that port and buyers will not be willing to pay as high a price in the coming week. Therefore, the price in the next week will be P_{t+1}.

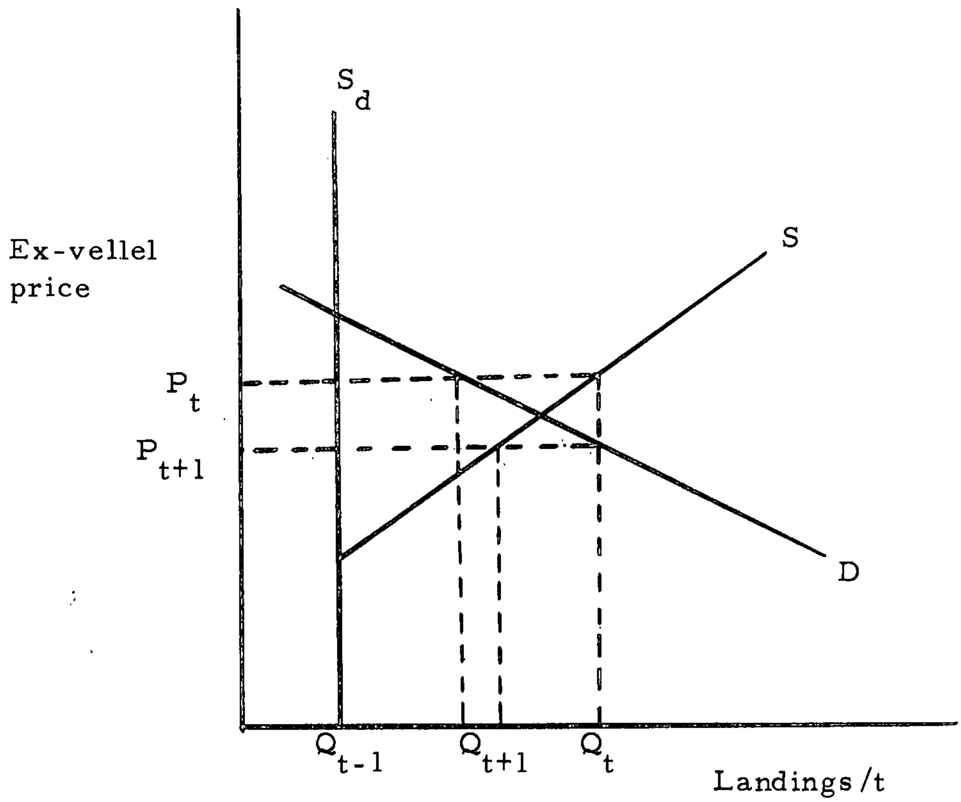

Figure 7. Cobweb model of a port market.

This adjustment process will continue over the season and if the demand and supply curves slope in the "normal" directions, then there is a movement toward the point where demand and supply are in equilibrium. This system appears to move toward a seasonal equilibrium if it is assumed that the absolute value of the slope of the supply curve is greater than the absolute value of the slope of the demand curve (5).

The hypothesis of a lag in the quantity variable implies that it is no longer endogenous in the demand equation. Due to this lag it is now predetermined and since the other variables in the equation are also hypothesized to be exogenous, the demand equation contains the single endogenous variable, P. A system of equations where this is the situation is known as a recursive system (22). A generalized form of a recursive model is:

$$P_t = f(Q_{t-1} \ldots$$

$$Q_t = g(P_t \ldots$$

According to Foote (15), consistent estimates of a recursive set of equations may be obtained if one equation that contains a single endogenous variable is estimated by OLS and included in the second equation with the other endogenous variables. That is, the calculated values of the first endogenous variable (P) are included in the second equation. The reasons for using the estimated value in the second equation are that the unexplained residuals in the equations of the fish market model are expected to be correlated with each other, so that the endogenous variables in an equation will be by definition correlated with the unexplained residuals in that equation. However, calculated value for a variable should not be correlated with the unexplained residuals (15). Therefore, the calculated values for the P variable are expected to be uncorrelated with the unexplained residuals in the supply equation.

Re-Specification of Alternate Port Price

The reader may note that an early specification of the port supply equation showed the alternative port price as a separate explanatory variable. Several methods were considered as to how to include the effect of attraction and impact on a port's supply through the alternative port price. One method already shown was to simply include the price as a separate variable. However, this was found to be unsatisfactory due to the high degree of correlation of the alternate port price and the own port price.

The presence of correlation between any of the explanatory variables is known as multicollinearity, and may be indicated by the change associated with the variance in variables when another variable is added or subtracted (22). The problem is also sometimes indicated when the partial correlation coefficients are relatively high. However, if there are more than two explanatory variables in an equation, this is only a sufficient condition for multicollinearity (20).

While this problem does not tend to upset the estimation of noncorrelated variables, it does lead to imprecise estimates of the correlated variables' coefficients (21). Thus, such estimates of structural coefficients cloud the interpretation of the effect of an explanatory variable when holding the other variables constant.

There are some procedures available to deal with this difficulty. One method involves the use of an estimation described by Brown (7) called "ridge regression". This technique is appropriate when the signs of the expected true values are the same. Since the alternative port price is expected to shift the own port supply in an inverse fashion, the sign of the coefficient of the alternative port variable is expected to be negative, whereas the price variable in the own port is expected to be positive. Therefore, this technique was not employed.[3]

The method that was used to avoid the problem was to simply construct a ratio of the prices (P/PA). In this case fishermen are expected to respond to the ratio of two port prices rather than the absolute price.

The recursive model with the respecification of the port price variable was estimated with the following equations:

$$P = a_0 + a_1 Qlag + a_2 PFZN + a_3 SIZE + a_4 BUY$$

$$Q = b_0 + b_1 P/PA + b_2 A + b_3 FERS$$

where the quantity variable in the demand equation was lagged one week. The "hat" on the price variables (P and PA) indicates that the fitted values of the price dependent demand equations were

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[3] Brown's recent work has been modified to account for different signs but this information was not available at the time the analysis was performed.

included in the supply equation as the price ratio.

The estimated coefficients and the associated statistics for the recursive model using the same Washington ports (1973) appear in Table 13. As in Table 12, the alternative ports are shown below the port name. The demand equations (price is the dependent variable) are on the right hand side while the supply equations (quantity is the dependent variable) are on the left hand side.

These results appear to be more consistent with prior expectation than the previous model. Most of the signs on the quantity variable in the demand equations are negative although none are significant at the 5% level. Only the port of Neah Bay has a positive sign.

Three ports appear with a significant wholesale price variable, and five with significant size variables, although all the signs on these two variables are as expected. The buyer variable is inconsistent in sign in Ilwaco, Neah Bay, and Copalis.

The coefficients of determination for the demand equations are .95 or better whereas the values for the supply equations were much lower, ranging from .64 to .91. An extra set of supply equations is shown with a slightly different specification. These were included to indicate how the fishermen variable was interacting with the other three supply variables. Note that in all ports except Ilwaco this variable has a significant coefficient.

Table 13. Results of recursive model for Washington ports (1973).

	Demand P Dependent					Supply Q Dependent						
Port	C	Qlag	PFZN	SIZE	BUY	C	$\hat{P}/\hat{PA}$	A	FERS	F df	R^2	D.W.
Ilwaco/	-.539	-5.87^{-8}	.949	.018	-.019					158.4 4/15	.977	1.59^{0}
Westport	(-2.29*)	(-.204)	(5.71*)	(1.79*)	(-2.86*)							
						-135,000	124,000	.122	99	8.69 3/16	.620	1.22^{I}
						(-.744)	(.674)	(3.03*)	(1.57)			
						-91,000	86,500	.153		10.9 2/17	.561	1.40^{I}
						(-.489)	(.457)	(4.23*)				
Neah Bay/	-.501	4.19^{-7}	.744	.042	-.001					78.5 4/14	.957	1.02^{I}
La Push	(-1.80*)	(.876)	(3.22*)	(2.78*)	(-.062)							
						114,000	-121,000	.099	117	21.8 3/15	.814	$.936^{I}$
						(1.73)	(-1.82*)	(5.47*)	(3.03*)			
						162,000	-161,000	.122		18.7 2/16	.700	$.649^{+}$
						(2.06*)	(-2.01*)	(6.07*)				
La Push/	-.190	-1.79^{-7}	.425	.070	.002					134 4/14	.975	1.76^{0}
Neah Bay	(-.596)	(-1.04)	(1.42)	(3.24*)	(.310)							
						251,000	-264,000	.306	109	40.6 3/15	.890	2.39^{0}
						(1.57)	(-1.69)	(7.27*)	(1.84*)			
						268,000	-266,000	.340		51.5 2/16	.866	2.00^{0}
						(1.57)	(-1.59)	(8.36*)				

Table 13. Continued.

	Demand P Dependent					Supply Q Dependent						
Port	C	Qlag	PFZN	SIZE	BUY	C	$\hat{P}/\hat{PA}$	A	FERS	F df	R^2	D.W.
Copalis/	-.854	-3.07^{-6}	1.14	.012	-.024					106.5 4/14	.968	2.39^{0}
Westport	(-6.36*)	(-.357)	(1.15)	(1.96*)	(-1.16)							
						-3,220	3,030	-.0004	85	8.80 3/15	.638	2.77^{-}
						(-.694)	(.649)	(-.420)	(4.89*)			
						-5,070	6,020	.0005		.518 2/16	.061	1.16^{I}
						(-.703)	(.833)	(.326)				
Westport/	-.265	-1.35^{-7}	.435	.071	.010					262 4/15	.986	1.48^{I}
La Push	(-1.54)	(-.895)	(2.77*)	(5.60*)	(1.38)							
						174,000	-228,000	.300	211	49.3 3/15	.908	1.27^{I}
						(1.23)	(-1.64)	(1.04)	(3.41*)			
						316,000	-314,000	.326		40.9 2/16	.836	1.79^{0}
						(1.80*)	(-1.78*)	(9.01*)				

*Significant at 5% level.

The results of the demand estimation reveal the importance of both the wholesale price and size as the determinants of the weekly ex-vessel price whereas the quantity of coho landed even in this recursive model is not significant in any port during the 1973 season. This result along with the finding from the estimated relationship in the previous section, suggest that ex-vessel prices are not responsive to current or prior week's landings. A distributed lag model where the landings variable was lagged two and three periods was also estimated, but no significant relationship was found. It appears that for each port, quantity of coho demanded during the 1973 season does not usually have a significant and negative response to ex-vessel prices.

The impact of a change in wholesale coho prices versus the size of coho landed appears to be worthy of some additional attention. The magnitudes of the wholesale price coefficients suggest that if all other variables are held constant, the impact of a change in wholesale price will change the port ex-vessel price differently in each port. For example, a ten cent increase (decrease) in the wholesale price at Neah Bay will increase (decrease) the exvessel price by 7.4 cents whereas in the port of La Push, the same increase (decrease) will increase (decrease) the ex-vessel port price by 4.3 cents.

The situation is much different, however, in consideration of the size variable. If all other variables are held constant, a two pound increase (decrease) in the average size of coho landed in La Push will increase (decrease) the ex-vessel price by about .14 cents. That same change will increase Neah Bay's price by about .08 cents, and Ilwaco's price by approximately .04 cents.

Except for the port of Ilwaco, the number of buyers does not appear to have any significant effect on the weekly ex-vessel price for coho. This result is the same as shown with the previous model. As a matter of fact, the estimates of the demand coefficients have not shown any striking changes between the two estimation methods.

The supply equations do not show the same consistency in the signs as do the demand relations. Three ports, Neah Bay, Westport and La Push have unexpected negative coefficients. Furthermore, a one-tailed test of the statistical significance reveals that the price ratio is significant in Westport and Neah Bay. This indicates that higher (lower) expvessel prices in Neah Bay will result in fewer (greater) pounds landed. It is difficult to see how the port of Neah Bay, located at the entrance to the Strait of Juan De Fuca, with many vessels passing by, would not attract more landings with a higher price. This finding will be investigated further in a subsequent section.

For the remaining ports the results indicate that a change in the ex-vessel price ratio will not have any impact on the weekly landings of coho.

The signs for the abundance variable are as expected for all ports except Copalis, where the sign is negative but statistically insignificant.

The fishermen variable is significant and, except for the port of La Push, all signs are as expected. This suggests that the number of fishermen functions as a positive supply shifter. If all other variables are held constant in the equation, then an increase of one fisherman in say, Neah Bay, will result in an increase of 117 pounds of coho, 17 more pounds than would be landed in Ilwaco as a result of the same change. In Westport, the same change will increase landings by 211 pounds. These results, however, must be accepted with caution until further estimations are presented for the remaining years in Washington.

Generally it appears that the recursive method of estimation has produced results somewhat consistent with expectations, but the statistical tests of significance and measures of explanatory power of the variables on the demand side do not confirm the hypothesis that the system could be recursive.

The lack of confidence comes about because the phenomenon that has persistently appeared in both methods and all demand specifications is the lack of a significant relationship between the quantity landed and ex-vessel price which suggests that the demand schedule for these ports is a horizontal line. This would indicate that each port functions similar to a single purchaser in a competitive market. Once the port price is set, the equilibrium quantity is determined by the quantity of landings.

However, the question is: how is that price set? If the buyers in each port were indeed operating as a part of a larger market, then one would expect to find a high correlation of prices between ports. In addition, if all ports were responding to the same market, then the plots of price versus time would be similar.

To see if this might be happening, the weekly ex-vessel prices for the five Washington ports in 1973 are shown in Figure 8. All prices begin on week 24 (June 15) when the season opens and increase as a group until the season closes in week 44 (October 31). The prices that year range from less than $.67 a pound to $1.15 a pound. Except for the larger variation in price at the end of the season, the prices in all ports tend to follow a similar weekly variation. The simple correlation coefficients for pairs of these prices were found to be .96 or greater.

It was previously mentioned that other seasonal data would be reserved until the appropriate hypotheses were tested with the 1973 data. Since it appeared that the basic equations just presented were suitable for testing with the remaining data, the variables for Washington (1974-1976) and Oregon (1976) were created from the original landings records of each state.

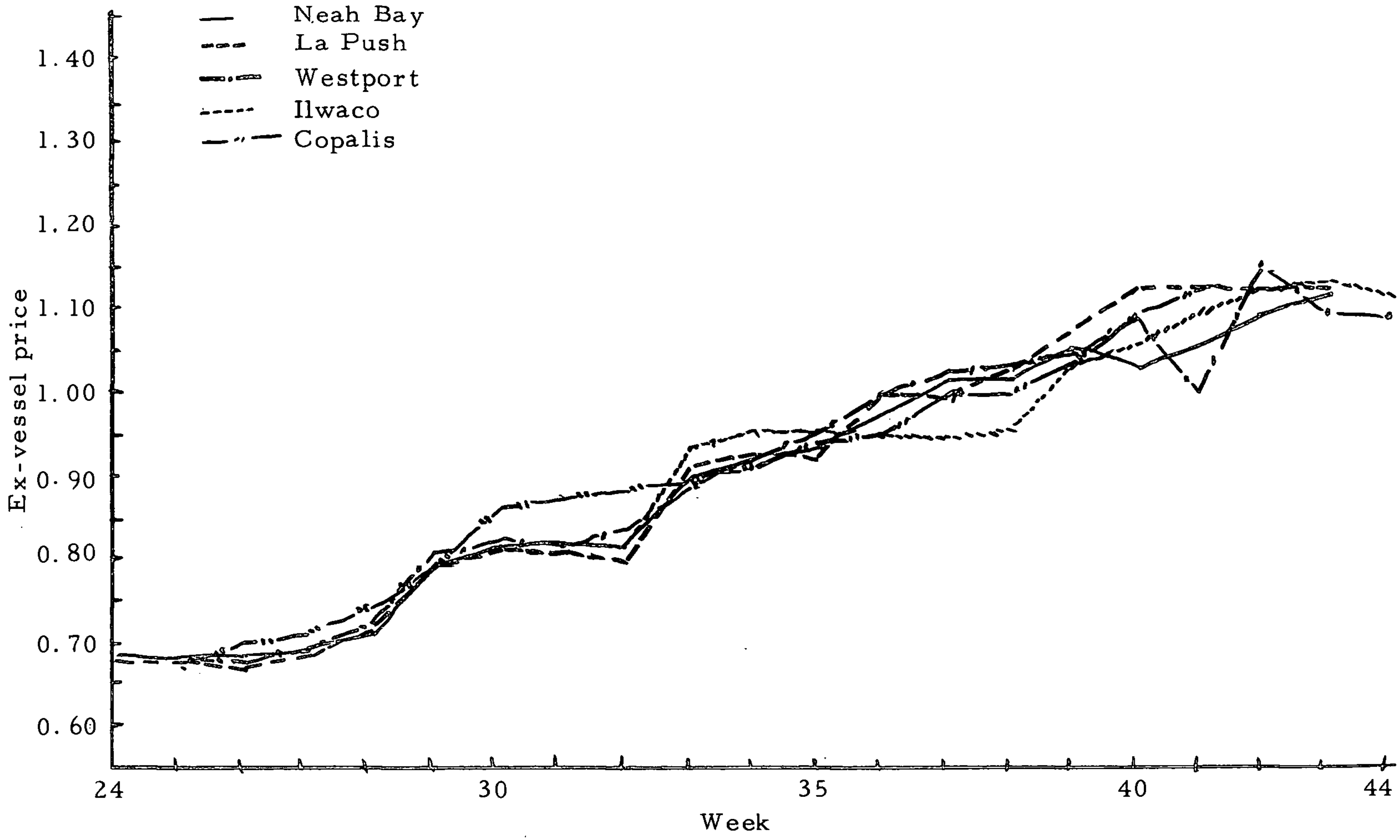

Figure 8. Ex-vessel prices for Washington ports, 1973.

The average weighted ex-vessel prices for all periods and ports of analysis are shown in Table 14.[4] It is interesting to note the similarity of prices from 1973 through 1975 in Washington ports. Even though prices between ports may vary during the season, the final weighted season price for each port is very similar to all other ports. It may be that observers of port to port differences in seasonal prices have based their observations on the arithmetic average of the prices observed rather than average weighted price.

Single Equation Supply Model

It was resolved that if the estimated demand equations for the other seasons continued to reveal the same findings as the 1973 test year, then the hypothesis of a horizontal port demand could not be rejected. This would mean that the ex-vessel port price could be included in the port supply equations as an exogenous variable.

The demand equations for the other years of Washington and Oregon data were estimated and the results may be found in Appendix III. As expected, most of the quantity coefficients were not significantly different from zero. Those that were significant had positive signs. As before, most of the intraseasonal variation in ex-vessel

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[4] Data on average weighted prices and average numbers of fishermen and salmon buyers in each port are shown in Appendix II.

Table 14. Average weighted ex-vessel prices for Washington and Oregon ports. (In dollars, Washington-1973-1976, Oregon-1976).

Port	1973	1974	1975	1976
Washington:				
Ilwaco	.773	.757	.759	1.24
Westport	.838	.721	.771	1.25
Copalis	.867	.773	.791	1.01
La Push	.807	.753	.771	1.23
Neah Bay	.858	.773	.777	1.20
Oregon:				
Brookings				1.24
Goldbeach				1.29
Port Orford				1.25
Bandon				1.25
Coos Bay				1.24
Winchester Bay				1.24
Florence				1.17
Newport				1.26
Depoe Bay				1.23
Tillamook				1.22
Pacific City				1.25
Astoria				1.26

port price was explained by the variations in the wholesale price and size variables.

The lack of a port price response to changes in the quantity of landings indicate that each port is a price taker. That is, each port is such a small portion of the total demand for coho that the port demand has no significant effect on aggregate price.

The aggregate ex-vessel demand appears to be determined by the demand of all the buyers in all ports. The aggregate supply of troll coho, and the aggregate ex-vessel demand determine the ex-vessel equilibrium price. The aggregate supply and demand will be explored later. What is important at this point is the rationale for ex-vessel prices to vary in each port in light of the price determination via the aggregates.

It is hypothesized that buyers of coho compete with other ports for the available catch. The impact on an individual port from changes in the aggregate ex-vessel price is hypothesized to function as a price adjustment model.

This can be best illustrated by using an example. Suppose that there are two ports that are perfect substitutes for the fishermen and that the only difference between the two ports is the price. Let us also assume that a buyer in port A obtains an order for more fish. In order to fill that order he will offer an ex-vessel price that is equal to the basic ex-vessel price plus some amount necessary to attract fishermen to his port or dock. The fact that one buyer offers a higher price in port A will encourage other buyers in port A to offer the same higher price if they wish to continue to receive fish. If one buyer in port A raises his price, the fishermen will either tend to land at that buyer's dock or will let the other buyers know that they will not sell fish to them unless the price is the same or greater. The buyers or buyer in port B will soon know that the buyers in port A are paying a higher price and either match that price or raise their price above the port A price. This higher price will attract some fishermen and landings will increase in port B.

Note that in port B, coho continue to be landed even when the ratio of prices is not equal to 1. The fishermen in port B may realize that prices are different between ports but are not interested, or able, to take their catch to port A for the following reasons: those fishermen closer to port B will not travel the distance to port A if they cannot increase their net returns. If the difference in price between ports is not great enough they continue to land in port B; also, as mentioned previously, many of the fishermen in a port engage mostly in day boat fishing. Consequently, these fishermen are hypothesized to continue landing in port B despite the difference in price between ports; and finally, there are some fishermen that are "loyal" to a particular buyer in a port and will rarely, if ever, consider landing in other ports.

Even though some of the fishermen in port B continue to supply to the buyers in that port, that quantity will not be great enough to fill their customer's orders. Hence, the buyers in port B will find it necessary to raise their price in order to increase landings at their docks.

The physical and economic characteristics of the port markets and the preliminary relations have been discussed in the previous sections. The following port-to-port model was specified to account for the important aspects noted from the previous analysis. The following model was applied to the 1973-1976 Washington data.

$$Q = b_0 + b_1 P/PA + b_2 A + b_3 FERS$$

The results of the estimated supply relation with ex-vessel price treated exogeneously, are presented in Table 15. As with previous estimations, some of the estimates of the coefficients have the expected signs.

The coefficient of determination (R^2) for estimated equations (seasons) are mostly .80 or better. Some season regressions show R^2 as low as .53 (Port of Copalis in 1976). The relatively high R^2 from season to season indicates that the hypothesized relation for 1973 is also applicable to the 1974 through the 1976 seasons.

Table 15. Estimated values of ex-vessel supply for Washington ports (1973-1976).

		Quantity Dependent										
Port & Alts.	Yr	C	t	P/PA	t	A	t	FERS	t	F df	R^2	D.W.
Ilwaco	73	-1.62^{+5}	-1.12	Westport 1.52^{+5}	1.05	.138	3.73*	69.8	1.12	9.70 3/17	.631	1.20^{I}
	74	3.99^{+5}	.795	Westport -4.15^{+5}	-.820	.142	3.72*	14.0	1.72	42.5 3/16	.888	1.99^{0}
	75	9.34^{+4}	.500	Westport -1.06^{+5}	-.546	.209	3.37*	41.3	.386	20.3 3/16	.792	$.779^{I}$
	76	-2.06^{+5}	-.647	Astoria 2.19^{+5}	.670	.255	5.64*	-136	-1.37	21.8 3/16	.804	2.11^{0}
	76	-7110	-.044	La Push 1.42^{+4}	.087	.264	5.83*	-144	-1.37	21.1 3/16	.798	2.06^{0}
Neah Bay	73	23,100	-.174	Westport 17,700	1.32	.0831	4.89*	128	3.21*	20.1 3/16	.790	1.19^{I}
	74	49,800	.360	La Push -61,200	-4.38*	.0531	1.90*	290	4.24*	30.6 3/15	.860	1.08^{I}
	75	-59,000	-1.75*	La Push 47,400	1.56	.0122	.649	327	8.17*	46.0 3/15	.890	1.49^{0}
	76	-72,300	-1.72	La Push 80,000	1.77*	.0669	6.90*	107	3.79*	66.5 3/16	.926	2.57^{0}
La Push	73	195,000	.841	Neah Bay -203,000	-.908	.324	7.83*	70.1	1.01	36.4 3/16	.872	2.46^{0}
	74	-87,500	-.342	Neah Bay 62,000	2.47*	.278	5.88*	132	1.76*	53.1 3/15	.914	2.04^{0}
	75	99,600	1.43	Neah Bay -125,000	-1.69	.176	3.35*	234	3.60*	39.8 3/17	.875	1.50^{0}
	76	-278,000	-2.55*	Neah Bay 243,000	2.39*	.143	4.16*	294	5.11*	79.5 3/16	.937	2.13^{0}

Table 15. Continued

		Quantity Dependent										
Port & Alts.	Yr	C	t	P/PA	t	A	t	FERS	t	F df	R^2	D.W.
Copalis	73	-380	-1.26	Westport 341,000	1.47	-2.55^{-5}	-.028	86.9	5.74*	11.8 3.16	.689	2.50^{0}
	74	3640	.524	Westport -4,330	-.625	.00586	3.72*	63.4	2.57*	32.5 3/14	.874	2.16^{0}
	75	4430	.601	La Push -5,160	-.726	.00259	1.22	97.3	3.31*	12.6 3/12	.759	3.06^{I}
	76	-43,200	-2.77*	Astoria 41,900	2.53*	-9.95^{-4}	-.291	208	2.54*	7.66 3/9	.719	1.33^{I}
	76	-17,700	-.719	La Push 13,800	.548	-.00180	-.384	278	2.79*	3.43 3/9	.534	1.00^{I}
Westport	73	351,000	1.82*	La Push -395,000	-2.04*	.305	10.3*	178	3.45*	52.1 3/16	.907	1.71^{0}
	74	-109,000	-.164	La Push 61,100	.093	.160	1.80*	314	1.91*	20.3 3/16	.792	1.14^{I}
	75	250,000	1.43	Neah Bay -265,000	-1.58	.153	1.82*	213	1.88*	23.7 3/17	.807	$.666^{+}$
	76	-23,000	-1.33	La Push 26,900	1.43	.304	5.40*	18.7	-.145	42.8 3/16	.889	2.67^{I}

*Significant at 5% level.

The test of autocorrelation in the residuals show only one port (Westport 1975) with indications of positive autocorrelation. The implications of this finding have already been mentioned. The remaining ports estimates indicate either no autocorrelation or the tests are inconclusive.

The abundance variable is also significant for all ports in most years. The exceptions are Neah Bay in 1975 and Copalis in 1973, 1975 and 1976. The lack of a significant relationship would indicate that landings in these ports did not change as the abundance of coho changed.

Some of the statistically significant coefficients for the price and fishermen variables have the expected signs: positive for price, fishermen, and abundance proxy. The positive coefficients for price mean that increases in price, given the number of fishermen and size of the run, will result in greater landings at the port represented.

The elasticities of supply for the four years of observation were calculated and are presented in Table 16. The different measures from year to year indicate the inability to estimate stable relationships. Neah Bay shows three periods of elasticities greater than unity and with the expected sign. The value for 1976, however, is not consistent with the expected result and tends to indicate that ex-vessel supplies due to unexplained factors may be shifting back as port prices are increasing.

Table 16. Elasticities of supply for Washington ports (1973-1976).

Port	1973	1974	1975	1976
Ilwaco	-0.68	-2.20	-0.40	-0.64
Westport	0.36	-0.32	0.85	2.76
Copalis	0.49	0.27	-0.63	-4.62
La Push	-0.22	1.38	2.39	-1.74
Neah Bay	3.01	5.94	1.20	-1.59

Based on single price estimates in Appendix II.

Table 17 presents the results of the estimated supply equation for all 12 Oregon ports in 1976. The names of the alternative ports appear in the price ratio column adjacent to the coefficient of price.

The coefficient of determination for these estimations range from .58 to .92. That is, 58 to 92 percent of the variation in the landings variable is associated with the variation in the explanatory variables.

The tests for autocorrelation fail to reject any hypothesis of autocorrelation. Some of the tests do indicate that the presence or absence of this violation of the assumptions of ordinary least squares regression is inconclusive.

The abundance variable reveals a significant relationship among eight of the total (12) ports. It is interesting that the ports from Florence to Depoe Bay do not indicate a significant relationship where one would be most expected. That is, the ports most centrally

Table 17. Estimated values of ex-vessel supply for Oregon ports (1976).

Port	Quantity Dependent										
	C	t	P/PA	t	A	t	FERS	t	F df	R^2	D.W.
Brookings	-19, 200	-3.94*	Coos Bay 293,000	1.50	-.0086	-.772	471	5.60*	20.6 3/17	.784	1.13[I]
Gold Beach	-19, 300	-2.44*	Bandon 4, 880, 000	1.62	.029	2.69*	391	1.60	6.05 3/12	.602	1.03[I]
Port Orford	5, 280	.164	Coos Bay -10, 000	-.309	.0137	3.13*	187	3.56*	13.3 3/17	.701	2.27[0]
Bandon	-135,000	-2.38*	Coos Bay 128,000	2.27*	.0337	6.34*	175	2.39*	4.79 3/14	.911	1.79[0]
Coos Bay	-1, 020, 000	-1.23	Bandon 1, 010, 000	1.20	.363	3.91*	-9.94	-.071	38.5 3/14	.892	1.05[I]
Winchester Bay	-244, 000	-2.39*	Bandon 234, 000	2.31*	.0544	3.23*	109	1.77*	57.3 3/14	.925	2.25[0]
Florence	11, 000	1.17	Bandon -13, 100	-1.38	2.76	.847	212	2.99*	12.6 3/12	.760	1.91[0]
Newport	-80, 600	-.252	Depoe Bay 60, 900	1.52	.057	.198	193	3.49*	19.8 3/16	.787	2.18[0]
Depoe Bay	70, 900	.750	Newport -77, 800	-.802	.0172	1.17	263	2.49*	20.5 3/15	.804	2.19[0]
Tillamook	153, 000	.914	Newport -158, 000	-.937	.0404	2.47*	205	1.80*	13.1 3/15	.724	2.38[0]
Pacific City	64, 900	.674	Astoria -75, 500	-.774	.0073	.438	302	6.14*	39.1 3/16	.880	1.01[I]
Astoria	35, 000	.353	Neah Bay -36, 800	-.428	354	2.48*	316	1.91*	7.14 3/15	.588	1.15[I]
Astoria	2, 460	.015	Pacific City -9, 460	-.058	.036	2.50*	341	2.18*	7.00 3/15	.583	1.15[I]

*Significant at 5% level.

located were expected to be more affected by the changes in stock than were other ports.

The fisherman variable is positive in all but the port of Coos Bay. This is the largest port of landings on the coast of Oregon and the negative but insignificant relation indicates that changes in the number of fishermen would not tend to change landings at that port. One could possibly argue that the fishermen in this port are so numerous that they either get in each other's way or may "spook" the fish so much that the catch of each fisherman decreases as numbers of fishermen increase. That is, at this port the fishermen are imposing significant external diseconomies upon each other.

Assuming no change in other variables, the results in the estimated equations suggest that an additional fisherman in the port of Coos Bay would result in a decrease in coho landed by ten pounds, while in Newport, the same addition would result in an increased landing of 193 pounds. The ports where a change in the number of fishermen would have the greatest impact are the ports of Brookings, Gold Beach, Astoria, and Pacific City.

As it was shown in the results for Washington ports, the estimates of the abundance coefficients are not very stable from year to year. Hence, the situation just mentioned at Coos Bay must be considered very tentative. As more data become available, it would certainly be interesting to see if this relationship holds over time.

However, from those estimations shown for Washington, it is not likely one would find this to be the result for all years.

Only two ports, Bandon and Winchester Bay, show a significant supply price response. Both ports are close to Coos Bay and have been observed to be alternate ports for Coos Bay fishermen. However, in the results for both ports, the significant alternate port is different. Bandon has a difficult ocean entrance and fishermen would rather land in Coos Bay if there were not other differences. Bandon buyers recognize this preference and have responded by actively changing the price to attract fishermen from Coos Bay buyers. This relation appears to be shown in the significant relation of the price ratio variable. The same situation is also true for Winchester Bay buyers.

The calculated elasticities for the two ports where a significant price ratio variable was found indicate that a one percent increase (decrease) in the ex-vessel price ratio in either Bandon or Winchester Bay would result in an approximately eight percent increase (decrease) in the landings of coho in either port, ceteris paribus.

While these estimations appeared to be acceptable, a high degree of correlation was found to exist between the quantity variable (Q) and the fishermen variable (FERS). These variables appeared to be measurements of the same phenomena. A study of the fishermen variable will by bypassed for the moment so that another specification of the landings function may be presented without the fishermen variable present. A later section will show the results of using the fishermen variable in place of the landings variable.

In order to study the effect the removal of the fishermen variable would have an R^2 and standard errors, the previous equations were re-estimated with the price ration and abundance variables only. Table 18 presents the results of the estimation for four years in the test Washington ports.

The d statistics for several equations show that the hypothesis of no autocorrelation cannot be rejected at the five percent level. This difference from the previous specification suggests that the equation may not be as useful as the previous result.

The price ratio variable exhibits even fewer significant coefficients for the ports. Only two ports, Neah Bay and Copalis, show any response to price. Neah Bay has been somewhat consistent in each attempt to determine the possible specification, while Copalis has not been a price responsive port in most estimations.

From the results just presented, it appears that some ports do function as alternatives and that fishermen are responsive to relative prices in two ports. It is interesting that more ports did not show significant price landings relationships but there are so many other factors that may enter into a fisherman's decision to land that the price variable may be clouded by the other variables.

Table 18. Estimated values of ex-vessel supply for Washington ports (1973-1976).

Port	Yr	Quantity Dependent								
		C	t	P/PA	t	A	t	F df	R^2	D.W.
Ilwaco/ Westport	73	-205,000	-1.48	201,000	1.44	.161	5.14*	13.7 2/18	.604	1.42^{0}
	74	473,000	.894	-484,000	-.908	.199	1.06	55.8 2/17	.868	1.95^{0}
	75	86,100	.475	-95,800	-.512	.229	7.58*	31.9 2/17	.790	$.837^{+}$
	76	229,000	.826	-224,000	-.843	.195	5.82*	34.3 2/18	.792	1.89^{0}
Neah Bay/ La Push	73	-99,400	-.914	104,000	.945	.100	4.83*	16.6 2/17	.661	$.916^{I}$
	74	-151,000	-.806	156,000	.835	.144	5.63*	17.9 2/16	.691	$.569^{+}$
	75	103,000	1.75	-85,200	-1.54	.102	3.13*	7.65 2/18	.459	$.755^{I}$
	76	-138,000	-2.69	157,000	2.90*	.904	9.06*	51.8 2/17	.859	1.71^{0}
La Push/ Neah Bay	73	311,000	1.54	-308,000	-1.56	.339	8.83*	54.1 2/17	.864	2.41^{0}
	74	158,000	.693	-168,000	-.740	.344	1.13	69.0 2/16	.896	2.01^{0}
	75	-5620	-.069	3,610	.043	.326	7.86*	32.0 2/18	.781	$.785^{+}$
	76	-18,600	-1.01	18,300,000	.806	.295	8.95*	44.1 2/17	.838	1.96^{0}

Table 18. Continued.

Port	Yr	C	t	P/PA	t	A	t	F df	R^2	D.W.
Copalis/ Westport	73	-2,570	-.373	3,380	.494	.001	.798	.447 2/17	.050	1.08^{I}
	74	6,611	.825	-6,618	-.821	.009	8.05*	33.0 2/15	.815	2.04^{O}
	75	12,300	1.40	-11,600	-1.34	.007	3.65*	7.67 2/13	.541	2.74^{O}
	76	-40,600	-2.05*	42,100	2.27*	.008	1.65	3.04 2/10	.378	.733
Westport/ La Push	73	396,000	1.61	-395,000	-1.59	.334	9.13*	44.0 2/17	.838	2.24^{O}
	74	142,000	.202	-147,000	-.210	.306	6.43*	24.7 2/17	.744	1.21^{I}
	75	-4,080	-.320	-1,490,000	-.192	.309	7.14*	27.1 2/18	.750	$.812^{+}$
	76	-10,100	-.070	11,000	.074	.297	1.05	68.1 2/17	.889	2.66^{O}

*Significant at 5% level.

Results of Size Variable

The size variable added to the Washington 1973 test was shown to be an important explanatory variable for the explanation of variation in weekly prices. The situation was also true for the remaining Washington years, which confirms the importance of size in the determination of the average ex-vessel port price. Observed price increases over the season are the result of the maturation and increasing size of the fish. In the single year of Oregon data, however, the three sizes of coho were specifically recorded on the landings records. There was no need to construct a size variable because the data analyzed were for medium coho only. Nonetheless, the Oregon prices during the 1976 season do increase in the same fashion seen in the Washington results.

There are two likely explanations for this outcome. First, as previously mentioned, the Oregon agency recording the information from the fish landings reports, placed all four and one-half to ten pound fish in the "medium" category. Buyers, however, call "medium" a fish weighing from six to nine and one-half or ten pounds. Hence, the two methods of categorization are not in agreement and the Oregon data may be showing the same price increase due to the inclusion of two size classes observed as a single size. As the fish mature, the recorded price will show a seasonal change. Because

Oregon does not record the number of fish landed along with the pounds landed, there was no way to construct a size variable in the same method as the Washington variable.

A study of the landings data also indicates that, as the season progresses, the size of coho is increasing, yet the total quantity of fish landed is decreasing. Hence, the aggregate quantity of coho available to the ex-vessel market is reduced thereby shifting the ex-vessel supply schedule to the left. Given a stable aggregate ex-vessel demand, the change in supply will increase ex-vessel price. This change will raise the base from which port buyers base their individual ex-vessel price. The ex-vessel prices, therefore, are observed to increase due to the fewer pounds of fish landed. This will be shown in a later section which deals with aggregate demand.

Evaluation of the Abundance Proxy Variable

As was previously mentioned, the variable representing the level of relative abundance was an artificial proxy created from the aggregation of all landings. The results of the estimations have shown that this variable has not been consistently significant in Brookings, Florence, Newport, Depoe Bay and Copalis.

It was expected that this variable would be significant and show its greatest influence in the ports where the landings constituted the greatest percentage of the abundance variable. That is, the variable would more closely represent abundance for the ports of large landings than for ports where fewer landings occurred, and the variance in the abundance variable would be representative of the landings variance in the larger ports rather than the smaller ports.

The results already shown do not support this expectation. Landings in the larger ports were no more correlated with the variable than were landings in the smaller ports. In one case, the second largest coho port in Oregon (Newport) had an insignificant abundance variable. This port is far from the effects of other coho stocks not accounted for by the variable, yet the ports abundance variable has failed to be a significant factor in explaining port landings.

One other area of concern about the explanatory power for this variable centered around the fact that different fishermen at the extreme points along the coast catch from different stocks of fish. The variance of these stocks might be different from that for the stock of fish the variable represents. Hence, the variable would not explain the fluctuation in abundance for ports where these fishermen land.

For Oregon the abundance proxy was constructed from landings in Oregon for 1976. The ports of Brookings and Astoria represent the extreme ends of the state and are most likely to have landings that represent different coho stocks. In Brookings, the California stocks are probably more important, and in Astoria, the Columbia River and Washington stocks should be important. For Washington, Ilwaco is expected to be most influenced by Columbia River and Washington stocks, while Neah Bay should show the effects of Vancouver Island stocks.

The only extreme port, however, to have a consistently insignificant abundance variable was Brookings. Possibly the relevant stocks on which to base the variance in abundance should be the landings in California.

Although the abundance proxy is admittedly an imperfect measure of the relative abundance of coho because it is based on the quantity of fish landed rather than the quantity available, it is nonetheless interesting to look at the possible impact of a change in the proxy variable on the landings distribution for the ports used in the analysis. Using the estimated structural coefficients for Washington ports, the effect of a percentage change in total troll landings along the coast on an individual port are shown in Table 19. Sensitivity measures are interpreted as the percentage change in the dependent variable associated with a percentage change of the explanatory variable in question. The measure is calculated as follows:

$$S = \frac{\partial Y}{\partial X} \cdot \frac{\overline{X}}{\overline{Y}}$$

where Y is the dependent variable and X is the independent variable.

Table 19. Sensitivity of port landings to changes in abundance proxy, Washington ports (1973-1976).

Port	1973	1974	1975	1976
Ilwaco	.93	.79	1.07	.28
Westport	.82	.64	.74	1.09
Copalis	.02*	.63	.14*	.00*
La Push	.90	.91	.82	-.01
Neah Bay	.92	.55	.16*	.08

* Indicates coefficient of stock abundance proxy not significant at 5% level. These figures are based on the estimated coefficients in Appendix IV.

On the average, a one percent increase (decrease) in total coast landings will increase (decrease) landings in Ilwaco (1973), for example, by .93 percent, <u>ceteris paribus</u>.

Landings and the Number of Fishermen in Washington

The supply relation in Table 15 yielded many significant coefficients for the number of fishermen at each port. With these values, the sensitivity of changes in landings to changes in the number of fishermen were calculated and are presented in Table 20. These values may be interpreted in the following fashion.

On the average, a one percent change in the number of fishermen in Ilwaco for example would imply an approximately 0.4 percent change in landings, <u>ceteris paribus</u>, for the years 1973 and 1974.

Table 20. Sensitivity of port landings of coho to a change in number of fishermen.

Port	1973	1974	1975	1976
Ilwaco	.44	.36	.09*	-.43*
Westport	.82	.62*	.93	-.14*
Copalis	1.22	.64	1.17	1.65
La Push	.28	.44	.63	.64
Neah Bay	.70	.01	1.22	.49

From estimates found in Table 15.
*Indicate that the measure is not based on a significant (5% level) coefficient of fishermen.

The only consistency that is apparent from the result is for the port of Copalis. This sensitivity is consistently there higher than for most other ports.

Additional Hypothesis

In the majority of the supply equations just presented the price or price ratio variable was not significant and showed a functional relationship different from what was expected. This prompted an additional hypothesis about the behavior of fishermen and landings.

The previous relationships tested the hypothesis that fishermen respond to price by changing their port of choice to land, but perhaps it is related in a different way. Because fishermen may not know the relationship between their effort and the quantity of coho captured, it is hypothesized that the quantity of coho landed is not the observable result of a change in the ex-vessel price in the port, or a ratio of prices between ports. Due to the lack of a definite linking between effort and landings, it may be interesting to test the hypothesis that fishermen, not landings, respond to price.

The specification of this "supply" function is as follows:

$$FERS = {}_c0 + c_1P/PA + c_2A$$

where the number of fishermen participating in the coho fishery is dependent upon the ex-vessel price and the relative abundance of coho. Both of these variables are assumed to be exogenous and are expected to have positive coefficients. This relation was estimated for all ports in Washington for the 1973-1976 seasons and the results are presented in Table 21.

The coefficient of determination for the Washington ports ranged from .09 to .84 for all ports during the 1973 through the 1974 seasons. There does not appear to be any port with a stable R^2 for four seasons. Westport does shown an R^2 of .77 or more for three consecutive years while La Push has the smallest range of R^2's.

The functional relationships are as expected for most estimations in Neah Bay. In other words, the positive price relation suggests that an increase in the port ex-vessel price will increase the number of fishermen at that port.

Table 21. Fisherman supply estimations for Washington ports (1973-1976).

Port	Yr	Fishermen Dependent								
		C	t	P/PA	t	A	t	F df	R^2	D.W.
Ilwaco/ Westport	73	-632	-1.21	700	1.34	.0003	2.76*	4.41 2/18	.329	.679^{+}
	74	524	.351	-491	-.326	.0004	7.75*	30.0 2/17	.779	1.05^{I}
	75	-178	-.421	242	.557	.0005	7.11*	31.4 2/17	.787	.907^{I}
	76	537	.803	-441	-.688	.0003	4.03*	17.0 2/18	.654	.416^{+}
Neah Bay/ La Push	73	-884	-1.76	968	1.90*	.0001	1.22	4.13 2/17	.327	.728^{+}
	74	-690	-1.45	747	1.58	.0003	4.82*	15.1 2/16	.653	.482^{+}
	75	495	3.08	-405	-2.68*	.003	3.09*	10.9 2/16	.548	.509^{+}
	76	-618	-1.86	720	2.06*	.0002	3.42*	9.59 2/17	.530	.434^{+}
La Push/ Neah Bay	73	1,660	2.36*	-1,500	-2.17*	.0002	1.64	6.08 2/17	.417	.488^{+}
	74	1,860	2.60*	-1,750	-2.45*	.0005	5.23*	20.5 2/16	.720	.778^{+}
	75	-449	-1.96*	550	2.34*	.0006	.550*	20.9 2/18	.699	.308^{+}
	76	81.7	1.60	-6,110	-.961	.0005	5.21*	18.7 2/17	.687	.801^{+}

Table 21. Continued.

Port	Yr	C	t	P/PA	t	A	t	F df	R^2	D.W.
Copalis/ Westport	73	-56.5	-.891	67.8	1.08	.00002	1.30	1.45 2/17	.145	$.745^{+}$
	74	47.0	.655	-36.1	-.501	.00005	5.03*	12.9 2/15	.632	1.79^{0}
	75	87.9	1.42	-72.4	-1.19	.00005	3.53*	7.02 2/13	.519	1.63^{0}
	76	-61.0	-1.19	85.0	1.77*	.00002	2.05*	2.79 2/10	.358	$.902^{I}$
Westport/ La Push	73	25.1	.278	-1.39	-.002	.0002	1.20	.845 2/17	.090	1.39^{+}
	74	801	.830	-662	-.690	.0005	7.14*	29.1 2/17	.774	1.00^{I}
	75	125	5.22*	-14, 500	-.997	.0006	7.31*	30.1 2/18	.770	1.55^{0}
	76	-689	-2.47*	850	2.98*	.0004	6.77*	45.0 2/17	.841	$.714^{+}$

*Significant at 5% level.

The percentage of explained variation in these equations is much lower than was seen in the case of the quantity dependent supply equations. This indicates that, generally, the number of fishermen in a port is not being explained as well by the included variables.

Some of the Durbin-Watson tests for autocorrelation indicate that positive autocorrelation is present in the residuals. The disturbances in one week are carrying over to successive weeks. This indicates that the specification used to explain the variation in fishermen is not complete, or that the decisions fishermen may make in one week are continuing to be important to decisions in subsequent weeks.

In order to explore the impact of the port buyers on the decision process of fishermen the number of buyers was included as an additional exogenous explanatory variable.

The rationale for this variable is obtained from the observed behavior that fishermen prefer to land at ports where there are more buyers. The fishermen believe that competition between buyers will result in a higher port price. In addition, some buyers will offer better service and enable the fishermen to discharge their catch sooner.

These results of the estimations are presented in Table 22 and some ports show a significant relationship between the number of buyers and the fishermen landing coho. In the port of La Push, for example,

Table 22. Fisherman supply estimations for Washington ports (1973-1976).

Port	Yr	C	t	P/PA	t	A	t	BUY	t	F df	R^2	D.W.
Ilwaco/ Westport	73	-148	-.974	-4.05	-.037	-.000003	-.022	51.9	4.40*	13.1 3/17	.697	$.819^{I}$
	74	-386	-1.54	340	1.21	.000276	6.04*	39.2	4.53*	56.7 3/16	.914	1.63^{0}
	75	59.4	.250	-121	-.590	.000381	4.46*	24.5	1.53	29.1 3/16	.845	1.09^{I}
	76	-220	-1.21	132	1.08	.0002	2.36*	27.5	3.19*	20.0 3/17	.780	1.18^{I}
Neah Bay/ La Push	73	49.4	.300	22.6	.177	.000208	1.56	-1.58	-.057	1.22 3/16	.186	$.388^{+}$
	74	-247	-.570	219	.433	.00036	4.35*	59.3	2.08*	11.1 3/15	.690	$.777^{I}$
	75	25.2	1.21	-270	-1.41	.000205	1.73*	25.1	1.18	6.74 3/17	.543	$.510^{+}$
	76	-695	-1.93*	533	1.97*	.00036	4.05*	25.0	1.13	7.54 3/17	.571	$.816^{I}$
La Push/ Neah Bay	73	72.9	.641	-132	-1.38	.000174	1.54	61.0	5.04*	15.1 3/16	.739	$.897^{I}$
	74	190	.347	-352	-.596	.000305	2.74*	74.7	2.24*	22.3 3/16	.807	$.910^{I}$
	75	-171	-.528	141	.381	.000401	2.58*	41.7	4.79*	28.4 3/17	.834	1.08^{I}
	76	-292	-.902	162	.740	.0035	3.17*	48.1	2.63*	18.0 3/16	.771	1.45^{I}

Table 22. Continued

Port	Yr	C	t	P/PA	t	A	t	BUY	t	F df	R^2	D.W.
Copalis/ Westport	73	18.1	.940	-9.11	-.521	.000055	.260	3.50	.554	.718 3/16	.119	.818^{I}
	74	89.5	1.22	-105	-1.12	.0000585	2.80*	6.76	.631	9.03 3/14	.659	1.60^{I}
	75	-112	-1.46	124	1.58	.0008492	2.76*	15.0	1.66	5.43 3/12	.576	2.36^{-}
	76	matrix is singular for buyers										
Westport/ La Push	73	-20.1	-.110	142	1.01	.000140	.754	25.2	1.22	1.41 3/16	.209	1.69^{0}
	74	487	1.33	-562	-1.52	.000353	5.85*	18.8	1.17	29.9 3/66	.849	1.16^{I}
	75	235	1.45	-205	-1.39	.000409	4.33*	14.2	2.03	32.8 3/17	.853	1.59^{0}
	76	329	-1.89*	284	2.22*	.000414	4.46*	15.9	1.66	31.6 3/17	.848	.515^{+}

*Significant at 5% level.

an increase of a single coho buyer is associated with an increase of approximately 55 fishermen, while in Westport the increase in fishermen is closer to 20. For the port of Copalis, the response of fishermen is only around ten. It is clear then that the rates of response by fishermen to buyers differs greatly from port to port. Those ports with lower values are perhaps representative of the ports with mostly day fishermen.

Using only those estimations where a significant buyer coefficient was found, the fishermen response rate appears to be greater in Neah Bay and La Push than in Ilwaco. The latter port is a small Columbia River port that would be expected to be frequented mostly by day or non-trip fishermen, while the other two are expected to be ports where trip fishermen will likely land.

The Oregon ports were not neglected in the analysis of this functional form. Since the Washington analysis appears to be one in which little confidence may be placed in the seasonal results, the Oregon results are also suspect. However, the interested reader may find the results of these equations in Appendix V.

Aggregate Ex-Vessel Demand and Supply

In an earlier section the discussion and estimation of a port ex-vessel demand relation was discontinued due to the apparent lack of price responsiveness of buyers to changes in landings. At that point it was found that ex-vessel demand at each port was very elastic. An hypothesis was presented to the effect that the aggregation of demands at all ports determined the aggregate demand and the ex-vessel price equilibrium was actually established by the equilibrium of aggregate demand and supply. In this section, we focus on the estimation of an aggregate coastal ex-vessel demand and supply.

To estimate the aggregate ex-vessel demand during a season, the information used in the port to port estimations was aggregated by week. Because this involved a costly reorganization of the data, only one season was employed. Since Oregon data contained ex-vessel prices representing a single size, these data were used to produce the estimated coefficients seen below.

Earlier in this chapter, it was suggested that the aggregate ex-vessel market equations might be estimated by a recursive model in the following form:

$$P = f(Qlag, PFZN, BUY)$$

$$Q = g(P, FERS)$$

The results of demand estimation were:

$$P = .118 \quad 5.85 \times 10^{-8} Qlag + 0.380 PFZN + 4.66 \times 10^{-4} BUY$$

$$(-1.18) \qquad\qquad (7.95)^{*} \qquad\qquad (0.381)$$

$R^2 = .80$ D-W = 1.28[I] r(P, PFZN) = .888 F = 26.01 3/19

The coefficient of determination for this equation was .80, indicating that 80 percent of the variation in the quantity demanded is associated with the variation in the ex-vessel price, the number of coastal buyers, and the wholesale price for coho.

The functional relationships for all variables confirm the prior expectations. Once again, however, the price-quantity relation is not statistically significant. This suggests that the adjustment process during the season may be interfering with the estimation of an aggregate demand. It is also notable that the test of no autocorrelation is indeterminant. Hence, positive autocorrelation may be present in the sample and the tests of significance are suspect.

On the supply side, the estimates were:

$$Q = 3.60 \times 10^5 - 3.09 \times 10^5 P + 326FERS$$
$$(.787) \qquad (-.945) \qquad (7.97)^*$$

$R^2 = .820$ D-W = $.773^+$ F = 45.54 2/20

This equation has an unexpected negative sign on the estimated price coefficient; however, that coefficient is also insignificant at the 5 percent level. On the other hand, the fishermen variable appears to be an important determinant of aggregate ex-vessel supply. These results indicate that an increase (decrease) of one fisherman during the season would increase (decrease) the aggregate supply of coho by 3260 pounds. This does not appear to be a reasonable result of such a change in number of fishermen. While the hypothesis of no autocorrelation cannot be rejected, and the tests of significance are apparently not biased, the estimate of the fishermen coefficient should not have been affected.

A closer look at the plots of price and quantity showed that ex-vessel equilibrium appeared to be stable at the beginning and the end of the season. Thus, the middle of the season possibly represented the adjustment from one seasonal equilibrium to another.

In order to purge the data of the adjustment information that appears to be preventing estimation of aggregate demand, the 28th through the 39th weeks were removed. The remaining information was regressed as a single equation with a single explanatory variable. The estimated equation using these data is:

$$Q = 3.7917 \times 10^5 - 2.529 \times 10^5 P$$
$$(2.83^*) \qquad\qquad (-2.58^*)$$

The t values are in parenthesis. Ex-vessel (P) has the expected sign and is statistically significant from zero at the 5 percent level.

The R^2 statistic for the equation is .54, and the d value for the test of autocorrelation is 2.25 which is in the inconclusive region of the test interpretation. Thus, one can neither reject nor accept the hypothesis of autocorrelation in the residuals.

The price elasticity of demand (Oregon) calculated at mean values of P and Q indicate that an increase in ex-vessel price by one percent will result in a drop of coho demanded by 9.68 percent, ceteris paribus. Note that this result supports the earlier finding of very elastic port demand.

V. SUMMARY AND CONCLUSIONS

The main objective of the present study has been to analyze quantitatively the ex-vessel market for coho salmon. The discussions in the introductory chapter demonstrated that this market is an integral part of the total coho salmon market. The ex-vessel market has been analyzed as a separate entity to provide a basis to investigate intraseasonal and interregional characteristics of the market.

A description of the main parts of the retail and wholesale components of the industry and their interrelation was first undertaken. This provided a basis of certain *ceteris paribus* assumptions with respect to the rest of the industry.

In order to identify the relevant variables entering the ex-vessel relations, a theoretical analysis was first undertaken. In addition to the identification of variables, use of economic theory led to *a priori* determination of signs of certain relations representing the behavior of buyers and sellers of coho at the ex-vessel level.

Due to the desire to investigate intraseasonal relations, the port models were estimated using a weekly period of observation during the coho season. Due to the limited amount of detailed ex-vessel information available, the hypothesized relations were developed with a portion of the total set of data. The bulk of information was held for estimation to verify the reliability of the supposed relations. Since the expected port relationship was assumed to generate a weekly equilibrium, the system was hypothesized to be simultaneous. However, initial estimations did not justify this system and additional information suggested the process to be recursive.

A model of a recursive ex-vessel market was presented and the same test information was applied using ordinary least squares for estimation of the structural coefficients. Since the determination of ex-vessel demand was not very intriguing at the port level, the focus of the study turned to estimations of ex-vessel supply and fishermen response functions.

The model originally presented in the study was modified due to a lack of suitable data. Other modifications were suggested by results of exploratory analyses based on the original formulation. Various criteria were employed to evaluate the formulae and a final choice of model was found. Certain formulations were rejected because of the explanatory power of the model and because the signs of certain estimated coefficients were in contradiction to accepted economic theory.

The simple demand equation used for each port with the ex-vessel price as the dependent variable, generally provided excellent statistical fits of the data. Most of the values of the correlation coefficient exceeded .90. Considerable difficulty was experienced, however, in securing a significant response of price to landings.

The size of the fish was found to be a much more important variable than expected. The initial estimations did not include this variable and were subsequently re-estimated with size as an additional explanatory variable.

When the market processes for each port on the coast were explored, it was concluded that short-run fluctuations in ex-vessel price were primarily due to changes in the wholesale price and size of fish. The number of buyers in a port played an insignificant role and the inclusion of this variable led to ambiguous results due to the functional relation. In general, however, the greater the number of buyers in a port, the greater the ex-vessel port price.

The contention that ex-vessel seasonal prices tend to increase at ports farther north was not supported by the analysis of the data. Prices for coho are very close to the same price at any port for the season. Variation in ex-vessel prices during the season as a result of the pricing action of buyers attempting to attract landings to their individual stations does appear to exist in a few ports.

The simple supply equation used to estimate structural coefficients for each port contained the quantities of coho landed as the dependent variable. This single supply equation generally provided good statistical fits of the data. However, the range of coefficients of determination varied from season to season, and from port to port much more than did the R^2's in the demand equations.

Landings in any port are the result of the relative abundance of coho, and the number of fishermen. The results of the Oregon and Washington estimations of ex-vessel supply indicate that changes in the ex-vessel price will not significantly change the quantity of coho landed during any particular time during the season for some ports. On the other hand, there are ports along the coast where the fishermen are responsive to changes in price. This is particularly true of the larger ports which may attract more mobile trip boat fishermen. An increase in the ex-vessel price will enable buyers in those ports to obtain greater quantities of salmon. In yet other ports, the price quantity supply response was negative. Buyers in those ports may not benefit from greater landings even though they raise their price for coho.

The search for an alternative "supply" relation led to a model explaining the number of fishermen landing coho in a port. This model was intended to test the hypothesis that fishermen rather than landings respond to ex-vessel prices. This situation was shown to exist in only a few ports along the coast. In most ports the number of coho troll fishermen were not responsive to differences in ex-vessel price.

The apparent lack of a significant price response at the port level led to the specification and estimation of an aggregate ex-vessel demand. The results of this analysis indicate that while an increase in the landings of coho would decrease ex-vessel prices, total receipts in the aggregate would increase. If true, this suggests that activities by ocean ranching operations to increase the available stock of coho would tend to increase industry revenues.

The reader will note that whenever the hypothesis of no autocorrelation could not be rejected because the Durbin-Watson test was inconclusive, no further attempt was made to estimate the relationships taking this problem into account. William Brown has pointed out however, that there is some recent evidence suggesting that it is safer to assume autocorrelation does exist when the test is inconclusive than to consider the estimations relatively free of this problem. Hence, the researcher should consider using one of the various available methods to remove autocorrelation from the data.

Suggestions for Additional Research

Turning now to some of the shortcomings of the analysis, the daily landings records were very costly to sort and aggregate in a weekly manner. This was due to the great quantity of records that had to be sorted. At the present time this is the only way to obtain accurate landings information of the ex-vessel market. It is recommended, however, that future analysis of these data be correlated with other ex-vessel studies to obtain the maximum use of the available information.

For example, both the states of Washington and Oregon have a separate data file available that contains the vessel license information about all troll fishermen. The landings records used in the study show all the licensed numbers of troll fishermen. It would be possible to use the license data to find which fishermen were using various types of vessels. The information could also be used to test various hypotheses of fishermen landing patterns.

This investigation has only involved the landings information from the state of Oregon and Washington. Significant quantities of coho are landed in California and Alaska. A complete investigation of the ex-vessel market cannot be accomplished without inclusion of these landings. Perhaps at a later date, the confidentiality laws in those states will change such that the information will be available to researchers desiring to complete an investigation of the entire ex-vessel market for all species of salmon.

The assumption of an exogenous or predetermined wholesale price variable was necessary because the focus of this research was only on the ex-vessel market. However, the adjustment of ex-vessel price is dependent upon the conditions at each stage of the market system. The price most likely to respond to weekly changes would be the wholesale price. Hence, an analysis of intraseasonal markets including the entire wholesale market would offer insights to the interaction of the ex-vessel price and the wholesale price.

Since this study has focused on the coho ex-vessel markets, no evidence has been presented from which to base any results on the markets of other species. Future researchers may want to study the interaction of coho and other troll or even perhaps non troll fisheries at the ex-vessel level. Although the coho pricing structure has been observed to be similar to that for other salmon there is the possibility that fishermen may react differently to prices of other salmon.

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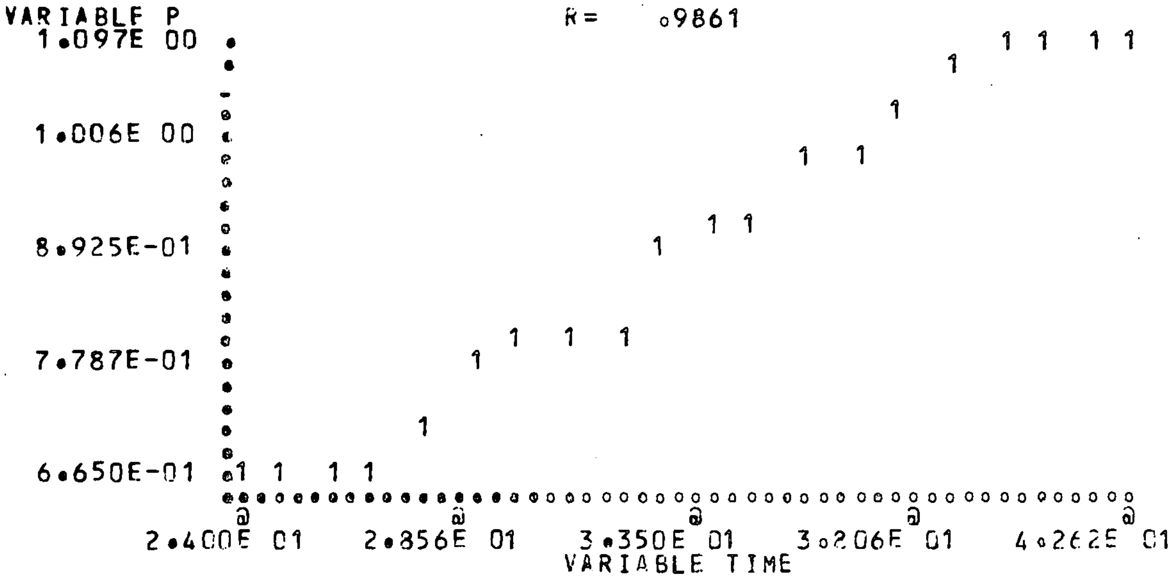
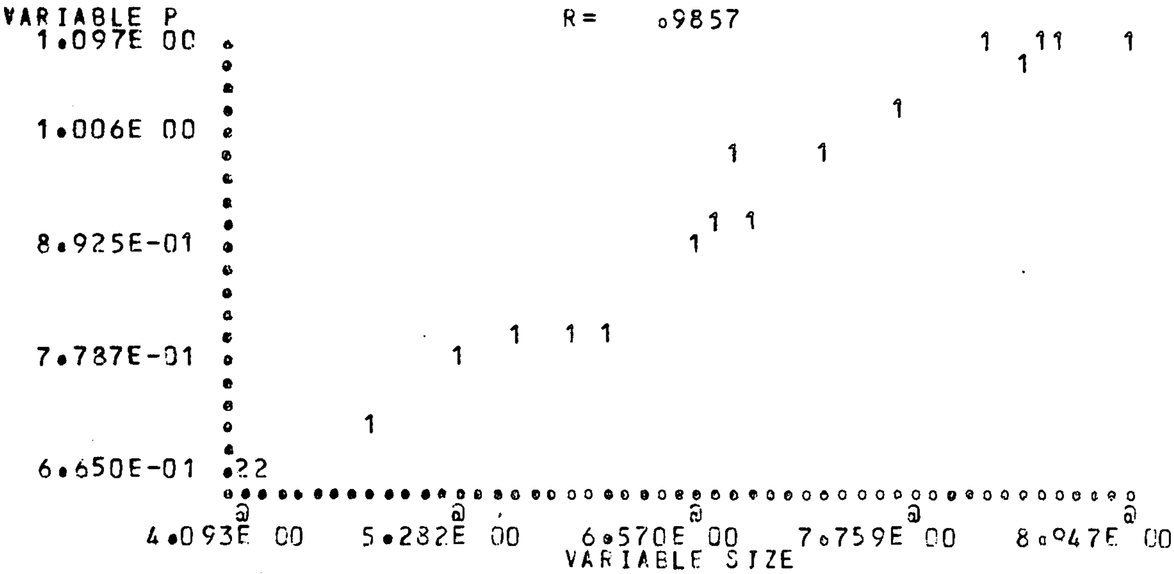
APPENDICES

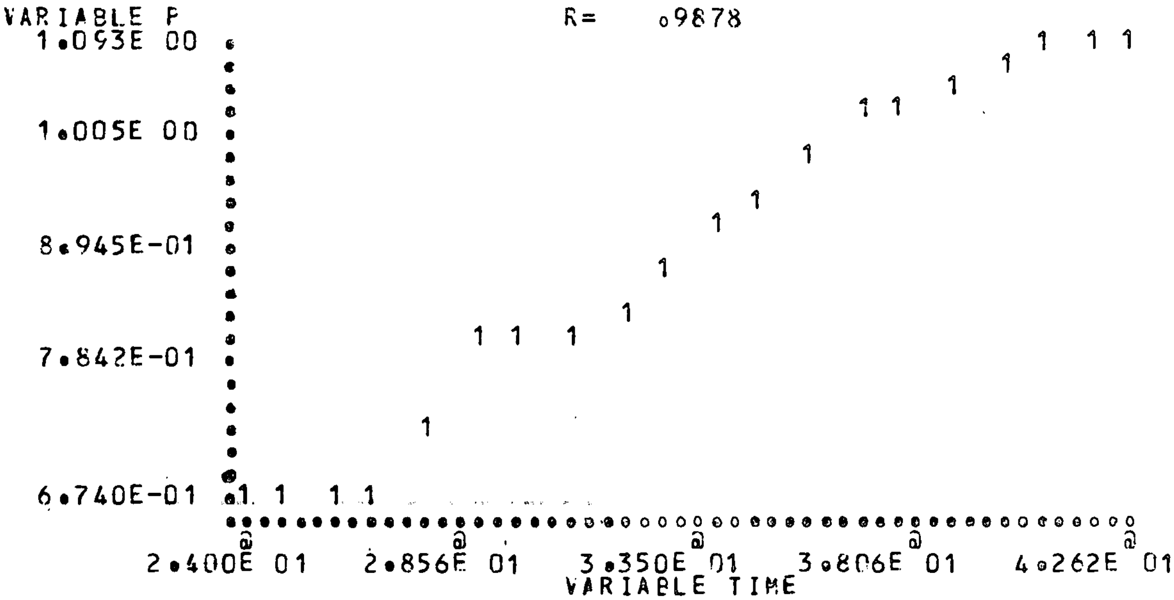
APPENDIX I

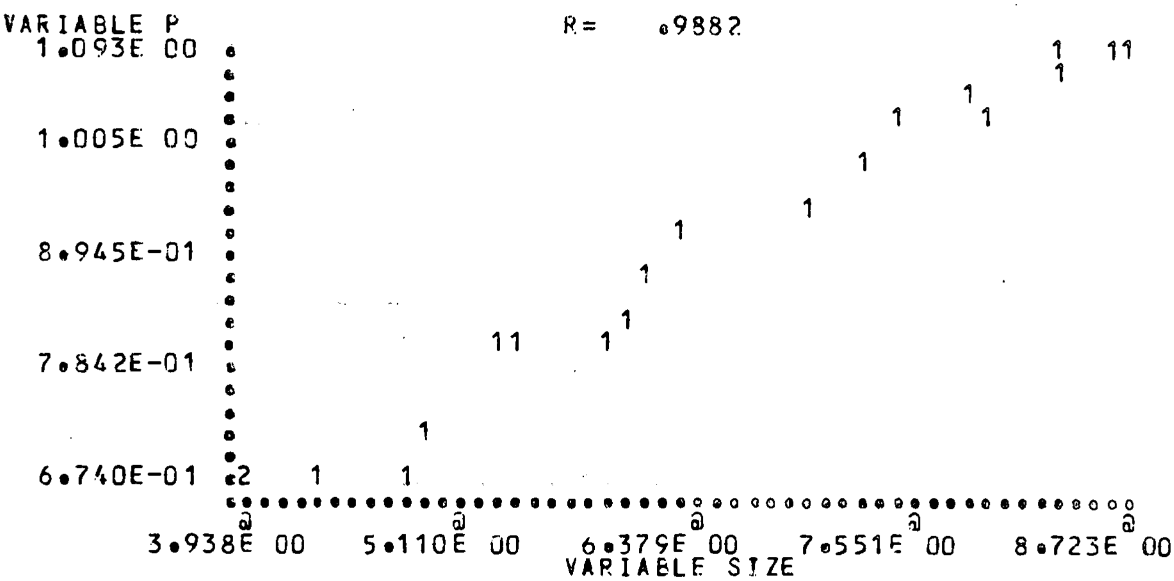
Washington Port Price and Size of Coho Over Time



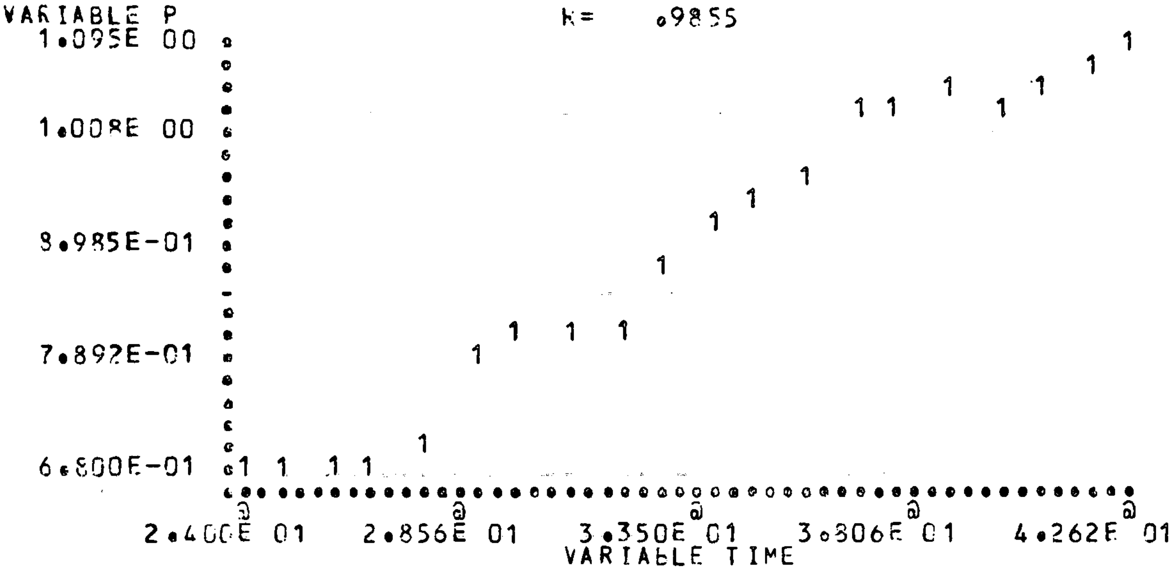


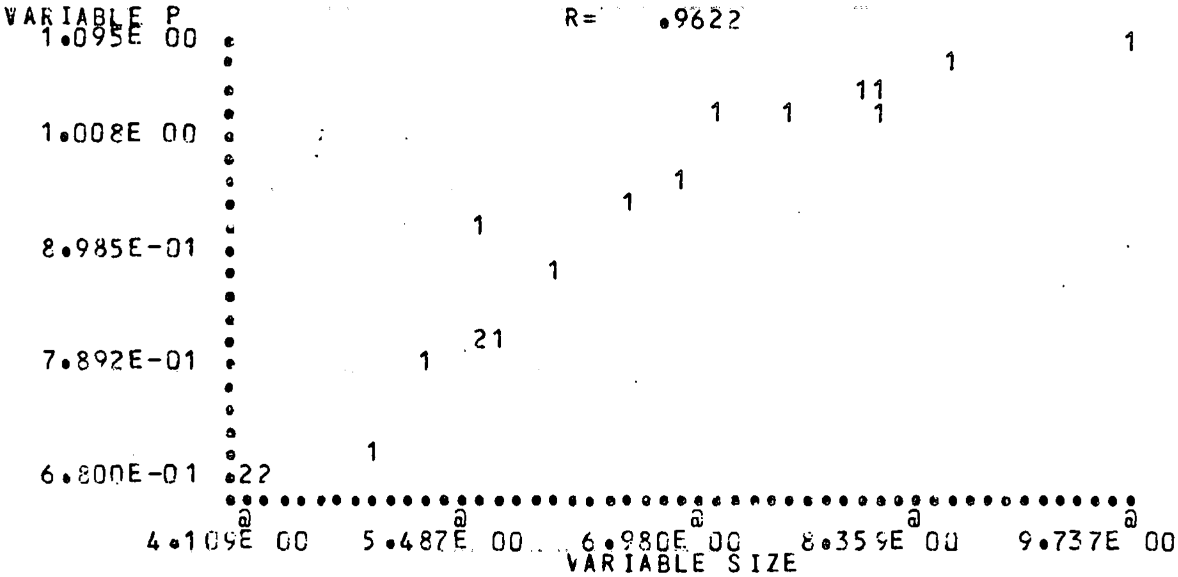
Ex-Vessel Price and Size of Coho in La Push, Washington (1973).



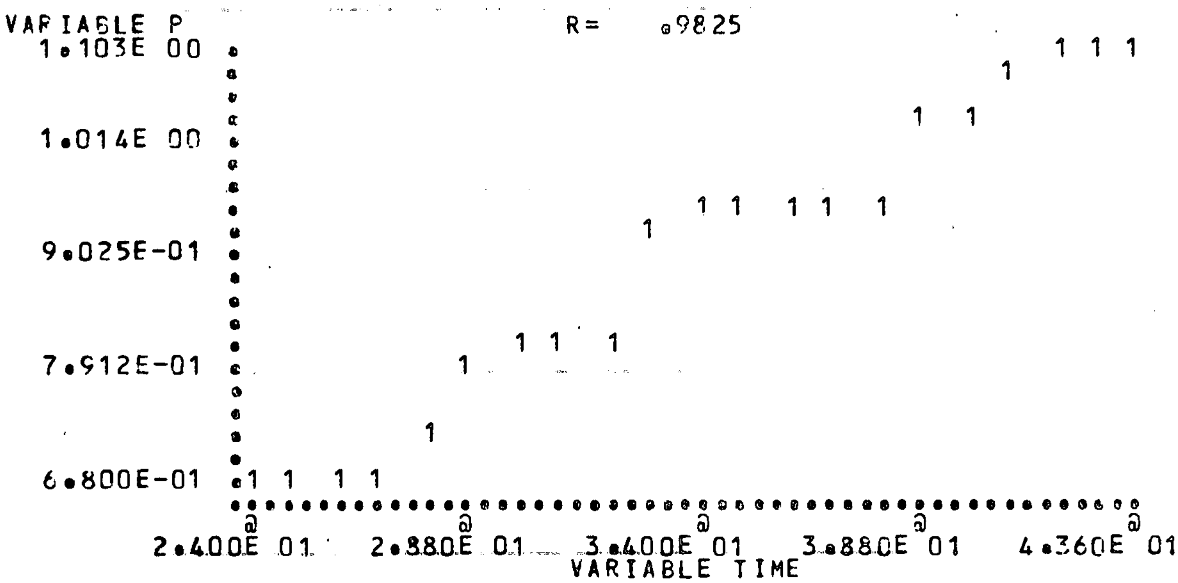


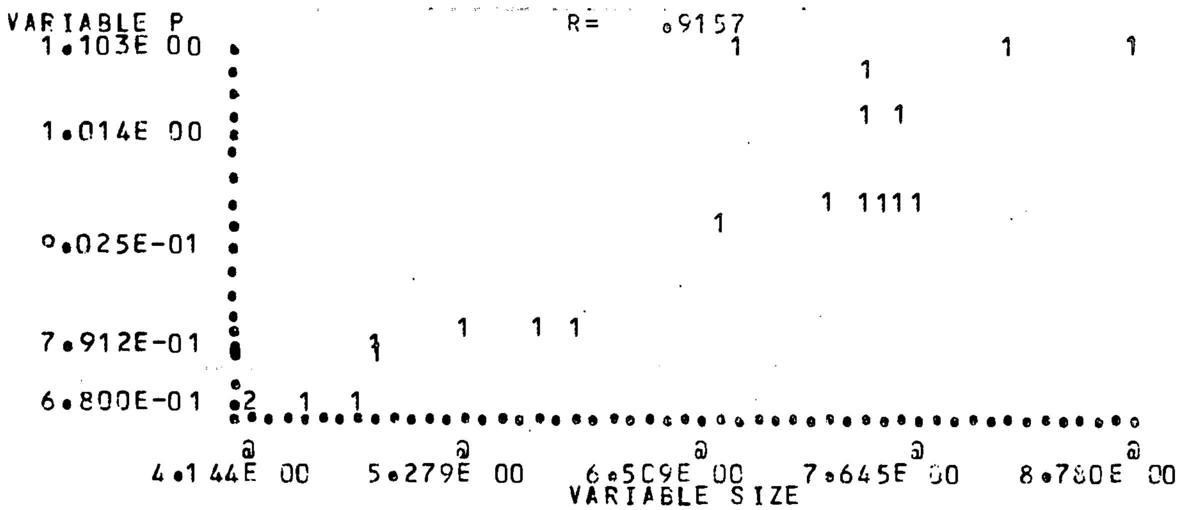
Ex-Vessel Price and Size of Coho in Westport, Washington (1973).





Ex-Vessel Price and Size of Coho in Neah Bay, Washington (1973).





Ex-Vessel Price and Size of Coho in Ilwaco, Washington (1973).

APPENDIX II

Average Weighted Prices and Average Number of Fishermen and Salmon Buyers in Washington and Oregon Ports

Average weekly number of buyers and fishermen and average weighted price for Washington ports (1973-1976).

Port	Yr	Average Number of Buyers	Average Number Fishermen	Price
Ilwaco	73	5.24	120.	.773
	74	4.95	151	.757
	75	5.10	162	.759
	76	6.40	191	1.242
Westport	73	5.75	278	.838
	74	6.25	258	.721
	75	6.48	230	.771
	76	6.80	276	1.251
Copalis	73	1.15	15	.867
	74	1.10	26	.773
	75	1.75	27	.791
	76	1.00	37	1.010
La Push	73	3.45	197	.807
	74	3.51	260	.753
	75	4.67	215	.771
	76	3.70	201	1.230
Neah Bay	73	2.55	103	.858
	74	2.16	154	.773
	75	2.67	133	.777
	76	2.67	132	1.203

Average number of buyers and fishermen and average weighted price for Oregon ports (1976).

Port	Average Number of Buyers	Average Number of Fishermen	Season Price
Brookings	2.52	67.4	$1.24
Gold Beach	2.00	21.9	1.29
Port Orford	2.57	36.3	1.25
Bandon	1.44	41.1	1.25
Coos Bay	5.71	323.0	1.24
Winchester Bay	4.10	128.0	1.24
Florence	1.88	30.0	1.17
Newport	9.29	397.0	1.26
Depoe Bay	1.63	75.3	1.23
Tillamook	3.42	89.0	1.22
Pacific City	2.75	135.0	1.25
Astoria	8.58	72.7	1.26

APPENDIX III

Estimates of Demand at Washington and Oregon Ports

Demand estimates for Washington ports (1973-1976).

		Price Dependent												
Port	Yr	C	t	Q	t	PFZN	t	SIZE	t	BUY	t	F df	R^2	D.W.
Ilwaco	73	-.694	-3.86*	-1.30^{-8}	-.049	1.0	7.26*	.019	1.91*	-.013	-2.29*	162 4/16	.976	1.61^{0}
	74	.870	4.52*	-7.14^{-8}	-.865	-1.2	-1.04	.022	7.83*	-.007	-2.84*	90.9 4/15	.960	1.41^{I}
	75	.396	3.21*	-2.59^{-7}	-1.44	20.4	3.48*	.033	3.71*	-.024	-2.70*	56.4 4/15	.938	1.78^{0}
	76	.715	3.52*	2.31^{-7}	.698	11.7	1.38	.082	3.25*	-.027	-3.37*	20.4 4/16	.836	1.90^{0}
Neah Bay	73	-.493	-2.04*	8.97^{-7}	2.09*	0.7	3.71	.043	3.31*	-.011	-.743	116 4/15	.968	1.39^{I}
	74	1.17	3.69*	-1.15^{-9}	-.008	-27.7	-1.52	.013	2.62*	-.002	-.213	13.2 4/14	.790	1.44^{I}
	75	-.009	-.036	5.54^{-7}	.936	49.8	2.92*	.007	.574	-.038	-2.14*	18.5 4/16	.823	1.22^{I}
	76	.712	3.99*	-6.16^{-7}	-1.35	176	2.04*	.006	.320	-.003	-.213	12.2 4/16	.753	1.00^{I}
La Push	73	-.193	-.602	-9.73^{-9}	-.057	0.4	1.36	.074	3.45*	.0001	.017	145 4/15	.974	1.75^{0}
	74	1.59	4.10*	6.65^{-8}	.713	-50.4	-2.07*	.007	2.29*	-.009	-.781	19.7 4/15	.840	1.25^{I}
	75	.296	.936	-2.88^{-7}	-1.14	24.0	1.21	.006	.652	.013	1.71	8.64 4/16	.684	1.69^{0}
	76	1.09	1.68	2.88^{-7}	7.11*	8.8	-1.10	.106	5.07*	-.026	-3.30	40.8 4/15	.916	1.51^{I}

		Price Dependent												
Port	Yr	C	t	Q	t	PFZN	t	SIZE	t	BUY	t	F df	R^2	D.W.
Copalis	73	-.876	-7.43*	-1.20^{-5}	-1.49	1.14	1.26	0.13	2.45*	-.009	-.458	148 4/15	.975	2.18^{0}
	74	1.17	3.71*	-1.38^{-6}	-.469	-26.0	-1.45	.006	1.47	.010	.497	8.36 4/13	.720	$.843^{I}$
	75	.437	2.71*	-2.62^{-6}	-.896	-10.7	1.39	.034	5.37*	-.013	-.583	32.9 4/11	.923	1.79^{0}
	76	.651	1.73	1.09^{-5}	2.21*	8.9	.525	.061	1.85*	single buyer		7.37 3/9	.711	1.69^{0}
Westport	73	-.236	-1.30	2.95^{-8}	.214	0.46	2.82*	-.067	5.62*	.001	.177	243 4/15	.985	1.52^{I}
	74	.818	4.21*	-4.08^{-8}	-.820	-8.9	-.813	.019	6.52*	-.001	-.319	63.2 4/15	.944	1.12^{I}
	75	.153	.802	-6.86^{-8}	-.308	29.4	2.21*	.031	2.15*	-4.40	-.704	34.1 4/16	.895	$.851^{I}$
	76	11.4	4.93*	-1.44^{-7}	-.632	-17.7	-1.53	.105	4.46*	.013	1.67	17.9 4/16	.818	1.18^{I}

*Significant at 5% level.

Demand estimates for Oregon ports (1976).

Port	Price Dependent										
	C	t	Q	t	PFZN	t	BUY	t	F df	R^2	D.W.
Brookings	.300	1.26	9.35^{-9}	.010	34.6	4.72*	.0039	.143	8.79 3/17	.608	.611[+]
Gold Beach	.108	.270	1.39^{-6}	.865	38.5	2.76*	.043	.850	3.03 3/12	.431	.645[I]
Port Orford	.515	2.08*	-3.40^{-6}	-1.67	29.7	3.65*	-.0064	-.340	7.39 3/17	.566	1.10[I]
Bandon	.188	.488	-1.11^{-6}	-.701	41.3	3.11*	-.026	-.602	5.02 3/14	.518	.969[I]
Coos Bay	.432	.987	-6.34^{-8}	-.293	36.0	2.94*	-.023	-1.04	9.17 3/17	.618	.881[I]
Winchester Bay	.690	2.91*	-4.75^{-7}	-.786	28.5	3.96*	-.041	-3.44*	26.5 3/16	.832	1.87[0]
Florence	.546	1.64	-4.03^{-6}	-.953	31.0	2.82*	-.080	-3.30*	16.9 3/12	.808	2.45[0]
Newport	.393	1.51	-5.98^{-7}	-2.33*	31.8	4.64*	.0057	.493	14.8 3/17	.723	.850[I]
Depoe Bay	.372	1.43	-1.47^{-6}	-1.42	33.8	3.80*	-.0114	-.362	8.74 3/15	.636	.920[I]
Tillamook	1.03	2.66*	-6.21^{-7}	-7.46*	18.6	1.62	-.072	-2.93*	14.8 3/15	.747	.909[I]
Pacific City	-.055	-.133	-9.03^{-7}	-1.50	43.5	4.01*	.051	.907	7.55 3/16	.586	.862[I]
Astoria	.358	1.09	-1.62^{-7}	-.194	40.5	3.98*	-.022	-2.14*	13.2 3/15	.726	1.09[I]

*Significant at 5% level.

APPENDIX IV

Results of Supply Equation for Washington and Oregon Ports

Single price supply estimates for Washinton ports (1973-1976).

		Quantity Dependent										
Port	Yr	C	t	P	t	FERS	t	A	t	F df	R^2	D.W.
Ilwaco	73	8,950	.186	-19,000	-.430	79.6	1.22	.117	2.54*	8.94 3/17	.612	1.10^{I}
	74	101,000	1.04	-138,000	-1.17	112	1.32	1.37	3.70*	44.5 3/16	.893	2.25^{0}
	75	10,500	1.25	-20,200	-.228	22.0	.187	.204	3.24*	19.9 3/16	.789	$.815^{I}$
	76	46,100	.527	-28,300	-.452	-135	-1.34	.252	5.06*	21.4 3/16	.801	2.17^{0}
Neah Bay	73	-93,500	-5.55*	80,300	5.28*	155	6.18*	.148	9.21*	57.9 3/15	.921	2.06^{0}
	74	-313,000	-4.01*	371,000	3.88*	289	6.37*	.091	4.19*	65.4 3/15	.929	1.94^{0}
	75	-59,400	-2.02*	55,100	1.81*	.326	8.69*	.0295	1.52	48.2 3/17	.895	1.52^{0}
	76	41,600	.915	-31,300	-.882	140	4.98*	.0546	3.64*	67.9 3/17	.923	2.43^{0}
La Push	73	3,730	.078	-17,200	-.406	91.4	1.38	.319	6.42*	34.8 3/16	.876	2.40^{0}
	74	-152,000	-1.09	158,000	.949	145	2.05*	.283	6.50*	61.2 3/16	.920	2.32^{0}
	75	-181,000	-1.51	189,000	1.37	177	3.02*	.260	3.88*	37.6 3/17	.869	1.35^{I}
	76	-95,900	-1.16	56,200	.946	254	4.11*	.171	4.12*	60.7 3/16	.919	1.83^{0}

		Quantity Dependent										
Port	Yr	C	t	P	t	FERS	t	A	t	F df	R^2	D.W.
Copalis	73	-78,100	-.630	59,200	.519	85.2	5.32*	.00117	.095	10.0 3/16	.652	2.76[I]
	74	-14,500	-.197	92,700	.103	66.0	2.58*	.00566	3.56*	31.5 3/14	.871	2.13[0]
	75	71,800	.137	-1,920	-.311	105	3.61*	.00169	.670	12.0 3/12	.752	2.96[I]
	76	17,400	.796	-17,100	-1.01	268	2.78*	.000485	.109	3.93 3/9	.567	1.13[I]
Westport	73	-63,900	-1.73*	24,300	.684	169	2.89*	.302	7.24*	41.6 3/16	.886	1.31[I]
	74	250,000	1.04	-343,000	-1.24	187	1.01	.179	2.23*	22.7 3/16	.810	1.37[I]
	75	-880,000	-.893	60,500	.647	220	1.63	2.08	2.52*	20.6 3/17	.784	.471[+]
	76	-48,500	-4.90*	41,500	.575	-47.6	-.368	.327	4.50*	43.6 3/16	.891	2.63[I]

*Significant at 5% level.

Single price supply estimates for Oregon ports (1976).

Port	Quantity Dependent										
	C	t	P	t	A	t	FERS	t	F df	R^2	D.W.
Brookings	-4.70?	-1.04	22, 100	.694	-.00285	-.191	436	4.92*	18.2 3/17	.762	1.03[1]
Gold Beach	-62, 600	-1.37	39,000	1.15	.0313	2.43*	205	.751	5.15 3/12	.563	1.25[I]
Port Orford	-4,210	-.193	-297	-.020	.0137	2.42*	183	3.57*	13.2 3/17	.700	2.25[0]
Bandon	41, 800	-1.94*	25, 600	1.66	.0379	5.52*	181	2.31*	41.4 3/14	.899	1.82[0]
Coos Bay	-25, 100	-.161	8, 500	.083	.408	4.95*	-55.0	-.404	47.4 3/17	.893	1.05[I]
Winchester Bay	-76, 400	-2.35*	47, 500	2.17*	.0523	3.16*	147	2.29*	63.9 3/16	.923	2.52[0]
Florence	689.0	.790	-6, 310	-1.02	.00244	.719	194	2.56*	11.6 3/12	.743	1.89[0]
Newport	-45, 800	-.350	21, 400	.238	.0605	1.54	189	3.59*	22.3 3/17	.798	2.15[0]
Depoe Bay	-89, 400	-1.52	59, 400	1.44	.0160	1.15	341	2.95*	24.8 3/15	.832	2.26[0]
Tillamook	54, 700	1.02	-40, 600	-1.10	.0339	2.04*	183	1.58	13.5 3/15	.729	2.54[0]
Pacific City	-52, 300	-1.20	30, 100	.993	.0154	.858	299	6.16*	40.2 3/16	.883	1.24[1]
Astoria	40, 900	.580	-32, 800	-.692	.0299	1.78*	315	1.99(	7.38 3/15	.596	1.24[1]

*Significant at 5% level.

APPENDIX V

Results of Fishermen Equations for Oregon

Fishermen equations for Oregon ports (1976).

Port	Fishermen Dependent										
	C	t	P	t	A	t	BUY	t	F df	R^2	D.W.
Brookings	-16.2	-1.31	99.4	1.24	.00014	4.99*	17.6	1.76*	12.5 3/17	.688	2.02^{0}
Gold Beach	-52.3	-1.18	36.2	1.05	2.78^{-5}	2.66*	6.61	.922	3.45 3/12	.463	1.87^{0}
Port Orford	-45.2	-.533	16.1	2.84	4.93^{-5}	2.39*	15.8	3.18*	5.43 3/17	.489	2.42^{0}
Bandon	-39.1	-.539	37.5	.727	5.64^{-5}	2.96*	3.78	.389	5.22 3/14	.528	1.30^{I}
Coos Bay	14.7	.568	-197	-1.33	4.88^{-4}	7.91*	44.4	2.59*	61.2 3/17	.915	2.34^{0}
Winchester Bay	-113	-.814	50.8	.593	2.23^{-4}	8.98*	20.1	3.06*	77.1 3/16	.935	2.16^{0}
Florence	-23.6	-.393	18.8	.480	3.61^{-5}	3.84*	6.32	1.21	8.20 3/12	.672	1.05^{I}
Newport	74.0	.122	-181	-.482	4.34^{-4}	3.40*	42.6	1.94*	13.9 3/17	.711	$.934^{I}$
Depoe Bay	123	1.70	-87.8	-1.68	9.85^{-5}	5.52*	15.4	1.79*	29.9 3/15	.857	1.68^{0}
Tillamook	-95.5	-.575	42.2	.434	6.00^{-5}	2.03*	30.3	2.00*	11.0 3/15	.689	1.86^{0}
Pacific City	-107	-.440	17.9	.118	2.51^{-4}	3.95*	42.1	1.09	10.5 3/16	.663	1.13^{I}
Astoria	51.9	.515	-58.8	-.925	-6.42^{-6}	-.246	11.9	2.48*	4.68 3/15	.484	1.36^{I}

*Significant at 5% level.