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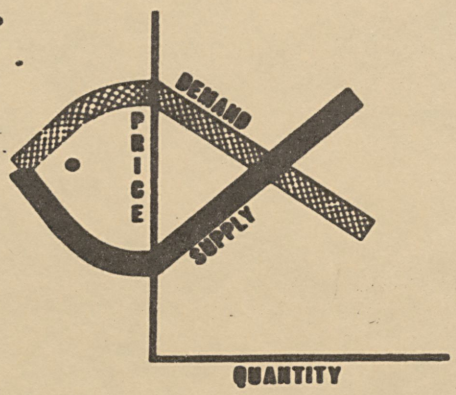

DISTRIBUTION OF FRESH AND FROZEN SALMON: ANALYSIS AND SIMULATION

by

Philip B. Schary
Robert E. Shirley
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Distribution of Fresh and Frozen Salmon: Analysis and Simulation

By

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ABSTRACT

This study describes and analyzes the distribution system for marketing of fresh and frozen Pacific salmon as it existed during the period immediately prior to this research, which was conducted from the fall of 1968 to the spring of 1970. The system is composed of two channels: one for negotiation and exchange, the other for the physical distribution of the product itself. While there are many common elements between these systems each channel performs separable functions.

The exchange channel is supply oriented because of the uncertainty of provision of adequate volume of fish to meet market demands. There is little dominance by individual firms over channel operations other than that exerted by processors who exercise a primary decision role in the buying, selling, and determination of product form. This power is limited by the presence on the buying side of large retail food chains, which are in turn balanced by the presence of significant export markets.

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The physical distribution system is dominated by transportation mode choice decisions. Product form is determined by the extent and costs of serving particular markets given transit time and movement cost considerations. Fresh salmon is shipped either by motor carrier within regional areas, or by air, where distance and price factors warrant the decision. Frozen salmon has substantially lower time constraints. However, while it does not require premium transportation such as air, it does require the provision of special facilities for holding and handling inventory.

From the available evidence, industry returns appear to be low or negative, with the result that capital is not being replaced. This indicates future decline for the industry despite long-term trends toward increased consumption of fresh and frozen salmon.

To describe the channel as an operating system, a computer simulation model has been developed to indicate the nature of the market allocation process, as the supply system responds to changes in both market demands and supply costs. The model can then be used to test for the impact of proposed changes on system operation.

I. INTRODUCTION

Very little is known about distribution channels for fishery products with regard to how well they are performing their functions. Are they efficient? Are they profitable? Do they provide adequately for marketing of the products once they have reached dockside? The present study of the distribution of fresh and frozen Pacific salmon was undertaken with these questions in mind. It was designed to provide answers for these products and to test out analytical techniques for use in other market studies.

The final goal was to develop and use a computer simulation model of this distribution channel, and it was toward this end that the effort was directed. A model must describe the real world, but the information desired prescribes those aspects of the real world to include in the model. In the process, the individual elements of the channel were thoroughly analyzed to assure a reasonably accurate representation of reality.

The distribution of seafood involves channel relationships similar to those of other food products, moving from a source of supply through a processor towards a final retail market. Seafood is unique, however, in that there is an element of randomness in the volume of supply available, either by area or within a market, requiring unique characteristics of adaptation by markets to the changes in supply.

The project had two interrelated objectives. The first was to describe the present structure and functional organization of the channel,

and to identify the forces which have shaped its development. This was accomplished using two sources of data: information from industry and government sources, and a direct interview survey of 107 firms involved in all stages of the distribution channel over the four Pacific states and British Columbia. The second objective was to describe the channel as a functioning system, so that effects of changes in channel operation parameters could be measured. This was developed through a computer simulation model of channel operation.

While study of the individual stages describes the channel in as much breadth as possible, the simulation model itself is restricted to describing the product flow from source to market, allocating products to markets on the basis of costs and prices. This choice was made in anticipation of potential demands on the model; that the most immediate needs of industry and government would require estimation of the effects of changes in these parameters on product movement. Inasmuch as other parameters such as changes in distribution structure can be related to costs and prices, the effects of other changes in channels can also be measured. The emphasis in this model differs from other channel simulation studies such as those of Hoggatt and Balderston (1962) or Preston and Collins (1966) who were concerned with the characteristics of structure and competition within the market, Amstutz (1967), who was interested in the micro-analytic behavior of firms in the market, or Bonini (1963) who was concerned with information processes in the channel. While these areas are also of interest in channel analysis, the limited resources dictated the development of a model with broader appeal.

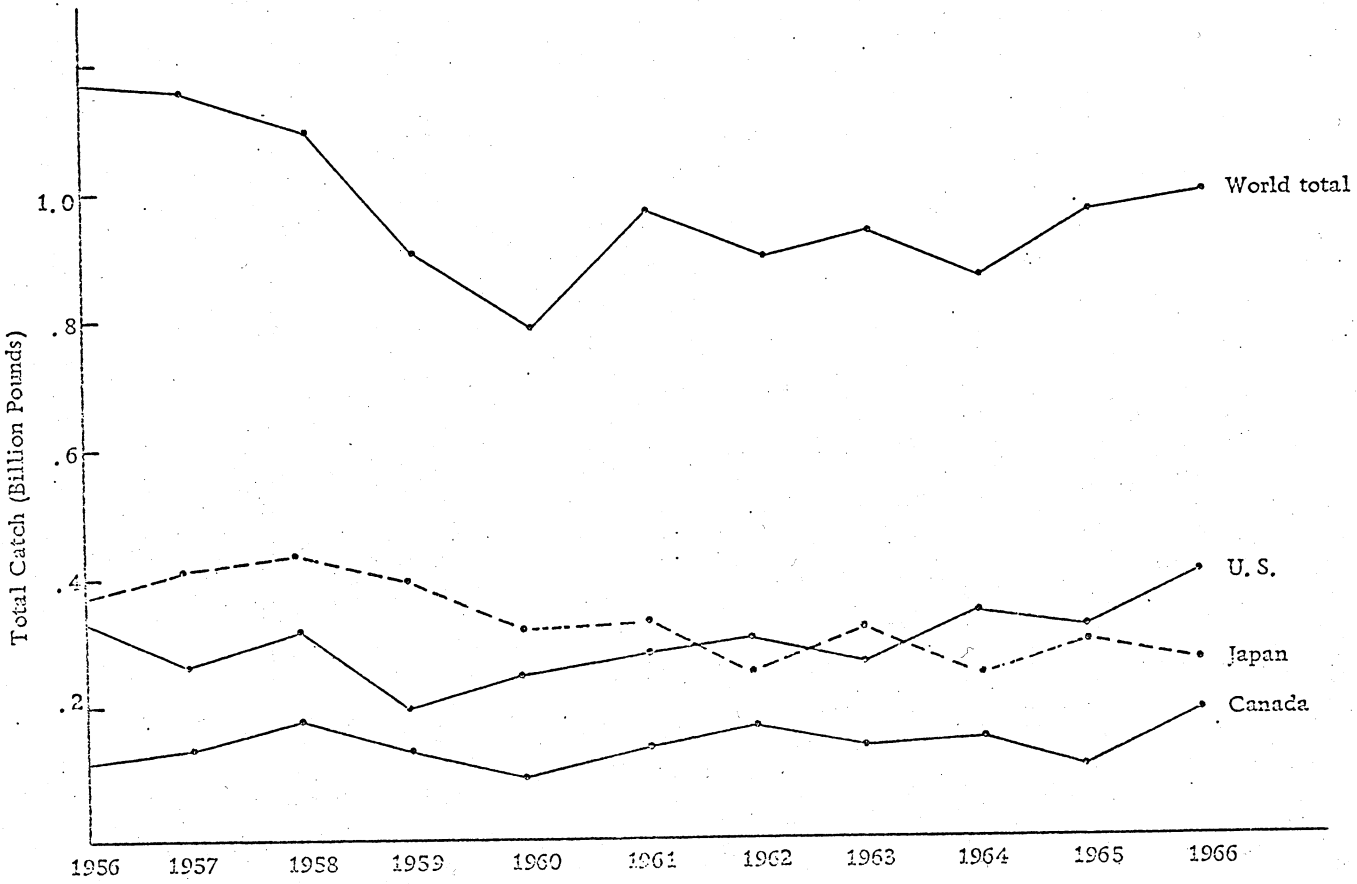
II. DESCRIPTION OF THE FRESH AND FROZEN SALMON CHANNEL

Products and Flow

The channel is organized for the movement of fresh and frozen product forms of chinook and coho Pacific salmon from the areas where they are caught to their final markets. The two most important species of salmon in these markets are chinook and coho; while other species of salmon--sockeye, pink, and chum--are occasionally sold in fresh or frozen form, they are not an important part of this market and are normally sold in canned form.

Two characteristics of the supply dominate channel organization. First, salmon are caught within a limited geographic area, involving fishing activity of only three countries: the United States, Canada, and Japan (with almost all exports from Japan in canned form), leaving the West Coast areas of the United States and Canada as the sole suppliers of fresh and frozen products. Second, there is a wide annual fluctuation in the total salmon catch seen in the summary data of Figure 1 as well as considerable fluctuation by species and area. The extent of this variation forces a high degree of flexibility on the channel structure in order to respond to the potentially extreme changes in supply characteristic of this industry.

The distribution of chinook and coho catch by state and province is shown in Table 1 for 1966, the most recent year for which complete data was available at the time of the study. British Columbia and Alaska clearly dominate the supply of these species, with the Canadian share reaching almost half the total. The narrow geographic base,



Source: Fishery Statistics of the U.S., U.S. Department of Interior, annual editions.
Fisheries Statistics of British Columbia, Department of Fisheries and Forestry, Vancouver, British Columbia.
FAO Yearbook of Fishery Statistics, Rome, Italy, annual editions.

Figure 1.--World Commercial Pacific Salmon Catch--All Species

much of which is remote from final markets, has had an important bearing on the development of the marketing channel, apparently resulting in the movement of products into a relatively concentrated flow through a few major cities, and has been an important factor in increasing the control by a few firms over what it might be with a more dispersed supply.

The long-term world trend for consumption of salmon products in general has been toward increased use of fresh and frozen product forms. This is clearly evident in the data shown in Table 2 indicating world-wide consumption patterns of fresh, frozen, canned, and cured forms. These data are calculated in 3-year averages in order to take account of the fluctuations in production volumes. These shifts have taken place in an apparently trendless but erratic supply. They are the result not only of changes in consumer preferences, but also the ability of the channel to make these product forms available over a wider area through technological advances in production and distribution.

The markets for fresh and frozen salmon are also relatively concentrated spatically, although not to the same degree as the supply. In general there is a limited domestic market on the West Coast and in selected Midwestern and Eastern cities plus Canada. The major export markets are Great Britain and France, which together take over half of the combined American and Canadian export volume. Significant amounts of exports also go to a few other Northern European countries and Japan. The domestic shipments and exports of fresh and frozen product originating from or entering the United States were estimated for the year 1968 using a combination of catch, freezing, and export statistics, plus data from interviews with

Table 1

Distribution of Catch, Coho, and Chinook, by State and Province (1966)

State/Province	Chinook	Coho	Total	Percent of Total
	(million pounds)			
Alaska	9.4	16.1	25.5	19.9
California	9.7	7.4	17.1	13.4
Oregon	3.7	8.7	12.4	9.8
Washington	5.9	12.8	18.7	14.6
British Columbia	15.3	38.7	54.0	42.3
TOTAL	44.0	85.7	127.7	100.0%

Source: Fishery Statistics of the United States, U.S. Department of the Interior, 1966; Fisheries Statistics of British Columiba, Department of Fisheries and Forestry, Vancouver, British Columbia.

Table 2

World-wide Consumption of Pacific Salmon Products
3-Year Average Percentages by Weight, 1956-8 and 1964-6

Product Form	1956-8	1964-6
Fresh	6.7%	10.3%
Frozen	6.8%	9.2%
Canned	83.4%	77.0%
Cured*	3.1%	3.5%
TOTAL**	100.0%	100.0%
Fresh + Frozen	13.5%	19.5%

Source: Derived from Food and Agricultural Organization Yearbook of Fishery Statistics, Rome, Italy, selected years.

* Cured, smoked, pickled, and other processed forms may be understated in that fresh and frozen imports may be transformed in the importing country.

** Does not include unspecified consumption of Japan and the U.S.S.R.

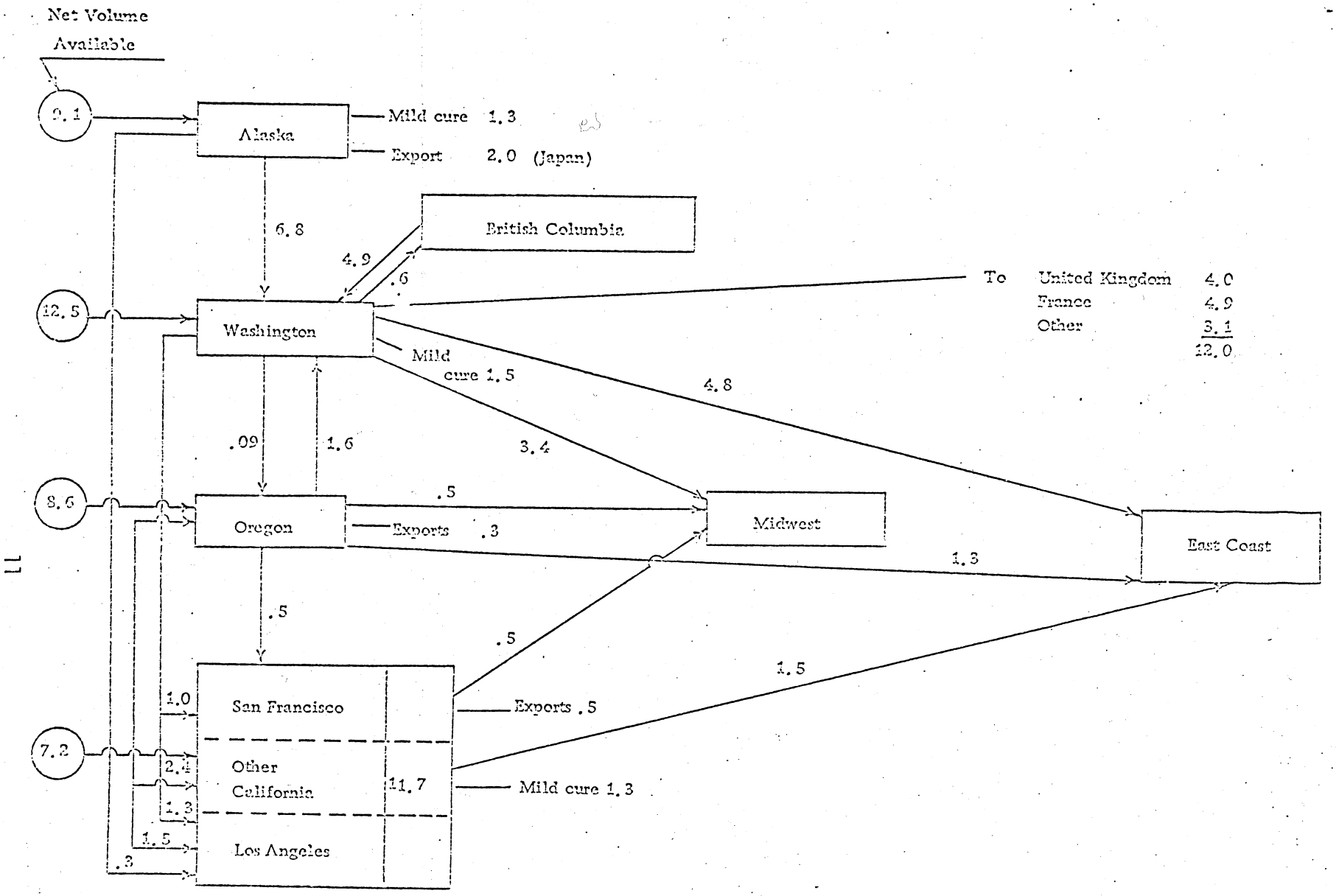
channel members. Results are shown in Figure 2 and the supporting Table 3. From a total catch of coho and chinook salmon of 66 million pounds (round weight), about 37 million pounds were distributed as dressed fresh and frozen salmon to final markets, the differences being accounted for in production shrinkage, diversion to curing, and canned forms. The market volume was divided into three approximately equal shares distributed among the West Coast, other United States markets, and Europe, with a much smaller movement to Japan. While fresh salmon is higher priced than frozen salmon, the markets for fresh products are limited by the length of the season and the availability of transportation. Frozen salmon tends to be sold in distant markets as well as being held in storage for sale between catching seasons.

Channel Structure

Channels are relationships between firms, organized in order to link sources of supply with final markets. Salmon distribution involves two sets of market structures: a) the exchange channel, concerned with the negotiation and transaction of product sales; and b) the physical distribution channel organized to both move the product to market, and perform certain physical processing operations such as cleaning, freezing, and storage while the product is en route.

Exchange Channel Stages

The exchange channel as described in Figure 3 typically involves a path from fisherman to receiving station to processor to wholesaler to retailer; however, there are sufficient variations in channel linkage to



Source: Fishery Statistics of the U.S., U.S. Department of Interior, annual editions.
Fisheries Statistics of British Columbia, Department of Fisheries and Forestry, Vancouver, British Columbia.
FAO Yearbook of Fishery Statistics, Rome, Italy, annual editions.

Figure 2.--The Major Movements of Fresh and Frozen Salmon for the 1968 Season (Millions of pounds)

TABLE 3

Source and Destination of Pacific Coho and Chinook Salmon
As Estimated for 1968
(000,000) lbs.

Product						Flow						Distribution							
												Destination Areas							
State of Origin	Catch Volume	Shrinkage (1-.85)	Canned Equiv.	Mild-Cure	Net	Imports	Net	From Other Sources: Alaska	From Other Sources: Wash.	From Other Sources: Oregon	Net of Intermediate Source	Alaska	Wash.	Oregon	Calif.	MidWest	East Coast	Export	Total
Alaska	25.5	3.8	11.3	1.3	9.1	-	9.1	-	-	-	9.1	not esti-	6.8	-	0.3	-	-	2.0	9.1
Wash.	18.7	2.8	1.9	1.5	12.5	4.9	17.4	6.8	-	1.6	25.8	mated	2.6	0.1	2.3	3.4	4.8	12.6	25.8
Oregon	12.4	1.9	1.9	-	8.6	-	8.6	-	0.1	-	8.7		1.6	0.8	4.4	0.5	1.3	0.1	8.7
Calif.	9.4	1.4	-	0.8	7.2	-	7.2	0.3	2.3	4.4	14.2		-	-	11.7	0.5	1.5	0.5	14.2
Total	66.0	9.9	15.1	3.6	37.4	4.9	42.3	7.1	2.4	6.0	57.8	Total Distribution	11.0	0.9	18.7	4.4	7.6	15.2	57.8
												Flow out of Area	8.4	0.1	7.0	-	-	-	15.5
												End Consumption by Area	2.6	0.8	11.7	4.4	7.6	15.2	42.3

Total West Coast Consumption 15.1

Source: Estimates from published data and survey.

make a generalization of only limited value. There is an increasing tendency to make direct sales from processor to large retailer, by-passing the wholesaler. Brokers are used intermittently, primarily in frozen product markets where buyers and sellers are widely separated. As Figure 3 indicates, there is also considerable transfer of product among firms at the same stage in the channel, a practice which appears to be necessary because of the random nature of the supply and the need to match overages against shortages. The flow of transactions is further confused when it is recognized that categorization of firms by the functions they perform is not unequivocal; a firm may perform combinations of functions drawn from several different stages in the channel simultaneously.

A summary of the paths of exchange transactions between firms in the channel as found in our survey is shown in Table 4. The proliferation of these linkages (i.e., points in the channel where an exchange can take place), even by individual firms, suggests they are not stable over time, but have developed in response to the need for flexibility within the channel.

Market Structure.

Market power in the channel has been argued to be related to the shares of the market held by buyer and seller. The evidence in the salmon channel, while not conclusive, clearly suggests where the power to dominate the channel lies. The discussion which follows will examine this structure by stage.

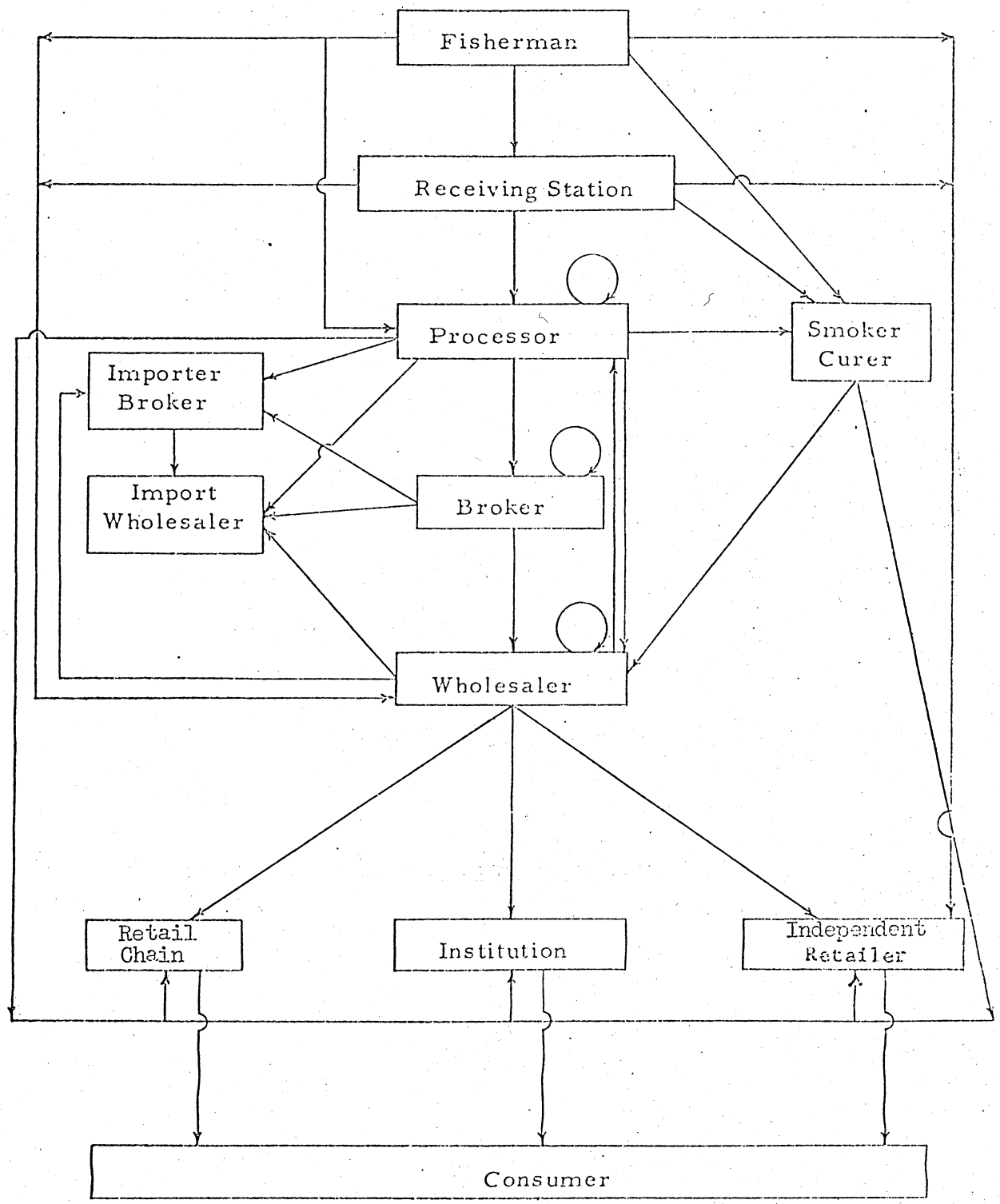


Figure 3.---Negotiation Channels

Table 4

Number of Linkages Reported in the Exchange Channel

To:	(Total Number of Firms Reporting = 96*) Processor	Wholesaler	Retailer	Broker
From:				
Receiving Station	41	42	11	7
Processor	14	63	42	45
Wholesaler	18	54	66	26
Retailer	1	0	7	3
Broker	1	9	8	15

Source: Survey data

* The total includes four receiving stations, 32 processors, 34 wholesalers, 14 retailers, and 12 brokers. Linkages were included if reported by either party.

Market structure at the fisherman stage appears to be highly competitive. The restriction of fishing technology to trolling in major portions of the supply area encourages an operation with limited investment and hence ease of entry, resulting in increased numbers of fishermen over time. Little growth in catch has been displayed. Other forms of technology which involve the use of nets, are more restricted in geographic scope and are more capital-intensive. Changes in manpower and techniques are shown in Table 5. The result of a competitive market structure is the lack of ability to control prices. There has been little success in achieving market control despite sustained organizing efforts among fishermen. Further, the increases in numbers of fishermen in the face of the erratic and trendless supply suggests a change in the nature of fishing from primarily a full time to more of a part-time occupation.

Receiving stations provide an initial market and transfer point for fishing activity. Their tasks are normally buying fish, packing, and icing them for shipment. The data on purchasing activity by receiving stations show relatively low levels of concentration. This is indicated in Table 6 which presents purchasing data by all receiving stations in California, Oregon, and Washington. This, however, obscures contractual and other agency relationships which commonly exist between these buying stations and the processors, the next stage in the channel. In a supply oriented channel, the processors must make extensive arrangements to purchase fish over

Table 5

Trends in Salmon Fishing Activity

	1956	1968	Annual Rate of Change
	Number		
British Columbia			
Gill Nets	7,014	11,470	4.2%
Troll Lines	13,984	16,124	1.1%
Purse Seines	499	493	-0.1%
Washington			
Gill Nets	1,333	1,421	0.6%
Troll	716	1,635	10.6%
Purse Seines, Other	574	580	0.1%
Oregon			
Gill Nets	675	570	-1.4%
Troll (All Species)	2,899 (1964)	5,932 (1968)	15.4%
Troll	970 (1956)	(1963)	-1.4%
California			
Salmon Troll Lines	2,264	6,189	8.7%
Alaska			
Fishermen Employed	11,666	21,359	5.2%
Seines	1,392	1,291	--
Gill Nets	8,072	6,758	-1.4%

Source: Oregon, Washington, Alaska: International North Pacific Fisheries Statistics, International Commission for the North Pacific Fisheries, selected years.
Fisheries Statistics of British Columbia, Department of Fisheries and Forestry, Vancouver, British Columbia.
California: Fishery Statistics of the United States, U.S. Department of the Interior, selected years.

wide geographic areas. When all of these relationships are traced, what ostensibly appears to be a low level of concentration may ultimately prove to be quite high.

Processors are also supply oriented in that production of dressed fish must take place in a short period of time after the fish are caught. Processors normally will prepare products, buy and sell, and sometimes freeze and store, and search out markets for their product. Of all the channel members who are specialists in seafood, the processors appear to dominate. The volume of processor freezings is reported annually in the National Fisherman Yearbook and the data which are summarized in Table 7 indicate highly concentrated although unstable market shares. Their sales by species are not directly measurable because sales are not being reported to any governmental agency. The number of firms which deal exclusively with fresh salmon products is limited, and freezings, which reflect purchase activity, provide a limited measure of market power. These data may be understated since many processors likely are tied to dominant firms through ownership patterns not apparent by available information. The fact that members of the industry refer to the "Big Six" is inferential evidence of strong market control at this level.

Wholesalers tend to be oriented toward local markets, serving in effect as buying agents for their client retailers. However, their role has declined as indicated by the reduction in their numbers, shown in Table 8. There also appears to be a change in the character of wholesaling; rising sales volume with fewer firms indicates that the survivors are larger than before. This appears to be particularly true with

Table 6

Concentration of Purchases of Fresh Salmon
from Fishermen by Dealers
(% of Total Pounds)

	California Data		Oregon Data	Washington Data
	1967 Salmon	1968 Salmon	1968 Salmon	1968 Salmon
Four Largest	31.8%	25.2%	45.9%	36.2%
Eight Largest	49.4%	39.6%	71.2%	52.9%
Twenty Largest	81.2%	68.5%	94.7%	81.8%
Other Dealers	18.8%	31.5%	6.3%	18.2%
	100.0%	100.0%	100.0%	100.0%
Other Dealers	78	71	30	55

Source: California Special Tabulation, California Department of Fish and Game, Marine Resources Operation, Biostatistics, Terminal Island, California.
Oregon: Tabulation from Oregon Tax Records, Oregon Fish Commission, Portland, Oregon.
Washington: Tabulation from Washington Fisheries Department, Seattle, Washington.

Note: Since the four and eight largest are included in the twenty largest, the last two categories account for all dealers, i.e., add to 100%.

TABLE 7

Concentration in Frozen Salmon Production
(% of freezing volume in lbs)

	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
Alaska													
4 largest companies	43.8	39.7	40.0	53.5	47.9	54.5	71.4	66.6	75.7	86.7	63.3	45.7	50.6
8 largest	75.2	51.1	50.0	70.5	54.2	100.0	80.9	78.5	93.4	97.4	76.0	57.7	72.7
20 largest	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		100.0			96.8
Total co.'s reporting*	19	10	11	10	8	7	10	12	11	13	12	10	28
Puget Sound													
4 largest	67.1	74.6	70.4	80.8	51.9	57.1	42.4	48.8	42.9	76.9	60.3	80.3	77.4
8 largest	91.4	96.9	87.8	100.0	63.0	78.3		70.4	64.7	99.9	96.7	98.2	99.8
20 largest		100.0		100.0						100.0	100.0	100.0	100.0
Total co.'s reporting*	12	10	9	8	8	8	7	9	8	9	12	10	9
British Columbia													
4 largest	95.6	98.1	97.2	98.9	98.3	99.2	97.9	98.7	97.7	98.9	100.0	97.7	90.3
8 largest	100.0	100.0	100.0	100.0	100.0	100.0		100.0	100.0	100.0	100.0	100.0	100.0
Total co.'s reporting*	6	5	5	5	5	5	4	5	7	5	4	5	6

Source: Calculated from data reported in Pacific Fishermen Yearbook for years 1957-1967; and National Fisherman Yearbook, 1968.

* The proportion of reporting firms to the total industry in each market area could not be determined.

merchant wholesalers. Whether their sales gains are a result of annexation of other functions as well as seafood wholesaling cannot be determined. Brokerage showed similar declines through 1963, but now appears to be increasing. In the course of the survey, the distinct impression was gained that brokerage in salmon was becoming less important.

The role of the local wholesaler appears to be tied to the future of his client customers. This role is strongest in serving institutions such as clubs and restaurants, somewhat weaker in serving small retailers because of their decline in the market, and far weaker but not completely eliminated in dealing with the large chains. The increase in direct dealing between processor and the large chain essentially by-passes the wholesaler, although in the Northwest, it has been noted that the channel is divided. Fresh salmon is handled through local wholesalers in many cases, while frozen salmon is handled by direct sales.

The most important challenge to the market power of the processor comes, therefore, not from seafood specialist members of the salmon channel but from the large retail chains. This is supported by an extensive literature on retail food concentration. Suffice it to note as a general measure of retail food concentration that the Federal Trade Commission in a recent study noted that in 15 major metropolitan areas, four retailers accounted for a mean combined share of 63% of the total retail sales.

Table 8

Comparison of Seafood Wholesale Structure--
All Seafood Products
(1958, 1963, and 1967)

	Number of Firms			Sales		
	1958	1963	1967	1958	1963	1967
All Seafood Wholesalers	1701	1673	1633	$758,833	$785,448	$1,022,151
Merchant Wholesalers	1612	1602	1534	631,237	692,888	856,352
Manufacturers' Sale Brokers	----	----	12	-------	-------	6,667
Agents and Brokers	89	71	87	127,596	92,610	139,132

Source: Census of Business, U.S. Department of Commerce, 1963, 1967.

A test of retail versus processor market power would appear to be that of price behavior. However, only limited price data are available on which to make comparisons, specifically that reported by Market News Service of the U.S. National Marine Fisheries Service for landing prices at Seattle and Alaskan points, and wholesale prices in the Chicago and New York City markets.

Evidence of constant price differences among markets, or even constant percentage differences would suggest the exertion of market power to achieve target margins or rates of return by either side. However, the erratic nature of the evidence over a 12-year period does not suggest this. Long-term supply contracts are probably more likely to prevail in the bargaining relationships, but evidence of this is not available. While the chains control access to the domestic retail market to an increasing degree, processors have the alternative to ship to markets which are becoming increasingly attractive, i.e., the European markets for frozen salmon, which have increased rapidly over the last few years. The result has been to augment the number of alternatives available to processors and hence their market power.

The Physical Distribution Channel

The physical distribution of salmon moves through a channel which in many respects parallels the exchange channel. This can be seen in Figures 4 and 5 which describe the channels for fresh and frozen products specifically. However, while these channels frequently involve the same channel members, e.g., fishermen, processors, and retailers, they also involve the use of specialist firms such as

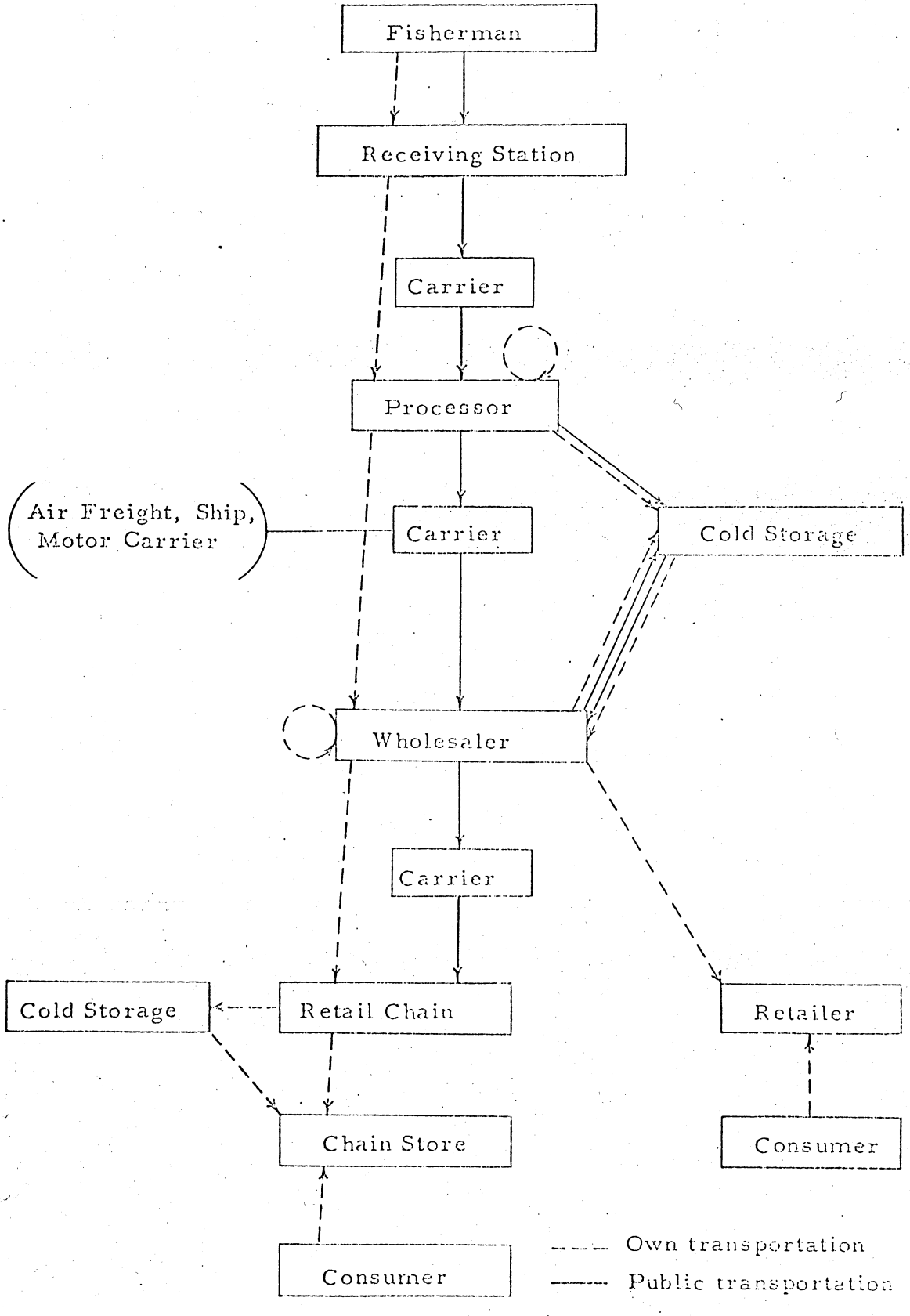


Figure 4.--Physical Distribution Channel (Fresh)

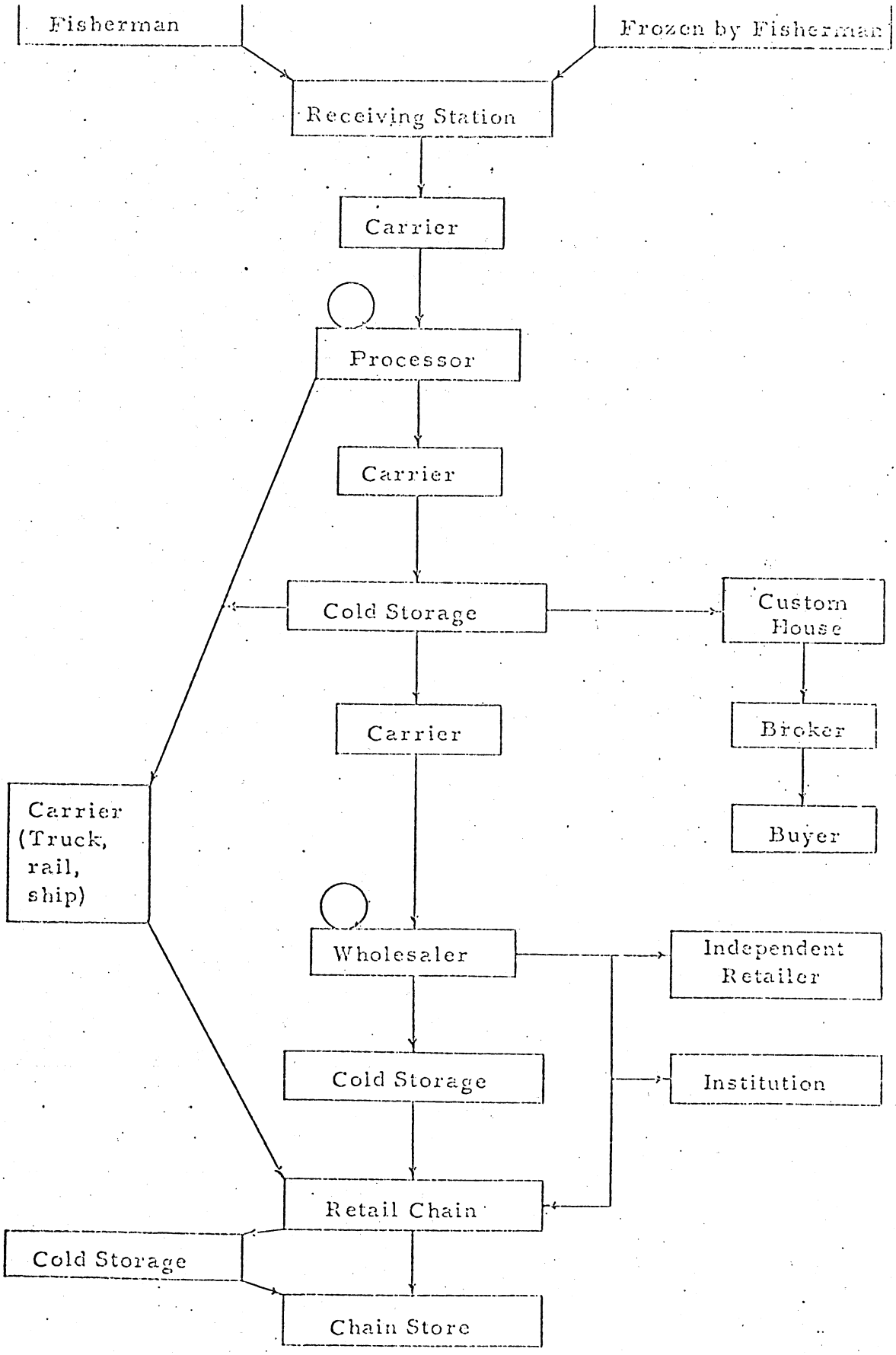


Figure 5.---Physical Distribution Channel (Frozen)

transportation companies and cold storage warehouses, to the point that in many instances these channels are completely separate. Occasional instances were reported where the fish were handled, dressed, frozen, and stored by the cold storage warehouse, and the only function of the processor was ownership of the product, and it was not uncommon to find major functions of the physical distribution channel performed by specialist firms without a direct product ownership responsibility.

The fresh salmon channel is organized around movement, i.e. transportation, with few inventory holding points because of the obvious necessity to minimize transit time and handlings. Transportation determines the extent of the fresh market. The volume to be shipped is determined by the geographic extent (of the market encompassed by the maximum safe transit time). The geographic extent expands or contracts as the price premium of fresh to frozen changes. This determines whether (higher cost) air freight can be used for shipping fresh salmon. In the West Coast market, this has meant that the Los Angeles market can be served from some Northwest locations by motor carrier, but not from others. Some shippers have indicated that even to enter this market, air shipment was necessary. Air freight has, however, provided new opportunities to serve the East Coast market by introducing low backhaul rates. The result has been to increase fresh salmon substantially in the New York City and Chicago markets each year. At the time of the study, shipments of fresh salmon by air to Europe were reported, despite the necessity of increasing the price of salmon by 35¢ to 40¢ per pound to cover the transportation cost alone.

The decision to freeze the product provides the processor with a different set of alternatives. The product once frozen is able to move more freely within the constraints of the availability of cold storage facilities, without a significant loss of product quality. It can also then be made available to markets in the off-season. The choice of offering fresh or frozen product is constrained by a lack of available facilities, forcing processors to sell their product in the fresh market.

Freezing, however, also changes the nature of the product in the market. Aside from the question of product quality vis-a-vis its fresh counterpart, there are additional costs incurred for freezing and holding the frozen product in storage. Further, freezing introduces a new set of risks in price fluctuation and product spoilage. Despite these problems, freezing is becoming more attractive because product quality can be maintained more easily than with fresh product, a factor quite important in this distribution system which involves multiple handling.

The choice of transportation is partly a function of market location and partly one of maintaining control. This is indicated in Table 9 which identifies both inbound and outbound transportation choices by channel stage. The heavy use of private transportation in intraregional movement is occasioned by the lack of commercial alternatives, or their inability to maintain schedules to suit the convenience of channel members. As would be expected, transportation shifts to public carriers as the physical distance between stages increases. This is due largely to the difficulty of securing backhaul loads. The heavy use of public

Table 9

Transport Mode by Firm Type and Direction of Movement

	Own Truck	Rail	Air	Ship	Public Motor Carrier	Customer or Supplier Truck	Totals
INBOUND							
Wholesale only	5		1		9	4	19
Whl - Retail	10				9	6	25
Processor	4	1	1	4	3	3	16
Processor - Whl	10	1	2	1	8	2	24
Broker			1	4	5		10
Buyer					2	1	3
Retail only	2				1	4	7
Totals	31	2	5	9	37	20	104
OUTBOUND							
Wholesale only	10		4		13	3	30
Whl - Retail	14	1	4		5		24
Processor	4	4	1	4	8		21
Processor - Whl	8	3	7	6	12		36
Broker		2	2	4	7		15
Buyer	2	1	1	1	1	1	7
Totals	38	11	19	15	46	4	133

Note: Many firms use multiple modes, such as rail and truck. There are 88 firms represented in the above tallies.

Source: Survey Data.

motor carriers, however, does not normally involve the use of regulated common carriers except on a few specific movements, but rather the use of those carriers exempt from regulation under the Fisheries Exemption of the Motor Carrier Act of 1935, and the Transportation Act of 1958.[2] This exemption has produced a market in which freight rates on frozen fish are substantially lower than those offered by competing transportation services, and as a result, the exempt carriers have taken over a large share of the movement of salmon to market from both rail and regulated motor transportation. The market for exempt motor carriers is maintained through independent brokers who find loads for small fleet and single vehicle operators who are searching for loads. The use of air and ship is naturally heavier in outbound than inbound shipments because of the distance from processors to their markets. The occasional inbound use of air was also reported by Alaskan processors due to the lack of alternatives. These transportation links are summarized in Table 10, which again emphasizes the heavy use of motor carriers, and the heavier use of rail, air, and ship in shipment to final markets.

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[2] PL 85-625, 85th Congress, Second Session. According to one survey of the impact of this exemption, about two-thirds of the shipments of fresh and frozen fishery products in 1956 and 1958 were made under the agricultural exemption. U.S. Bureau of Commercial Fisheries, Exempt Trucking of Fresh and Frozen Fish and Shellfish in Interstate Commerce, Circular 133 (Washington, D.C.; U.S. Government Printing Office, 1961), p. 10.

Table 10

Transportation Choice by Link in Channel

	No. of choices reported			
	Motor	Rail	Air	Ship
Receiving Station - Processor	15	1	1	2
Processor - Wholesale	38	8	10	11
Wholesaler - Retailer	37	5	5	2

Source: Survey Data

III. COSTS AND RETURNS

The manifestations of market structure at the successive stages of the channel should be apparent in the rate of return which firms would earn, were it not for one thing: nowhere is there a typical single product firm within the channel. When dealing with multiple product situations, it is impossible to separate the effect of jointly incurred costs and assets by product in such a way that the charge of arbitrary choice can be avoided. Hence the one way available to examine profitability is through the use of the contribution margin (sometimes called gross margin), which is merely the difference between revenues and direct costs. This avoids the problem of cost allocation and also that of division of assets which are jointly used; however, it only permits limited comparisons. Actual profitability can only be inferred from observation, or from combining all products handled by the firm; it cannot be directly measured by examining a single product moving through the channel.

Based on calculations made in other studies, fishermen would appear to earn low or negative returns, however the contribution margin in salmon fishing appears to create the illusion of high earnings, attracting more entrants to this stage of the industry. Receiving station margins were only reported as costs. Costs are presumed to be proportional to output. These are about 3¢ to 4¢ per pound. For processors, studies were made of production costs; however, these direct costs do not include overhead allocations which have been typically reported to be between 50% and 100% of the direct costs.

These allocations depend on the volume of both salmon and other species processed during the accounting period and are misleading in determining total costs of salmon processing.

Data on wholesaling and retailing encounters similar cost allocation problems. Costs can only be measured by gross and net margins, and direct cost estimates are necessarily subjective.

Estimating typical costs at various stages of the channel has resulted in a measure of distribution costs for a typical channel. In this case, the channel describes a local distribution system in the Northwest with no long transportation movements to market. The directly measurable costs for salmon processing were compared to the gross margins which include both profit and unallocated overhead. The results are shown in Table 11.

By these estimates, out of a total margin for all stages of 44¢, only 16¢ can be traced directly to salmon movement. The remaining cost of 28¢ per pound would then be charged as a result of allocation over the entire product line at each stage. This then emphasizes the arbitrary nature of distribution costs as they are recapitulated through a vertical pricing structure. The size of the contribution margin will depend on the alternatives available to firms at each stage as well as the market power of the dominant firm in the channel. The degree to which these influences are felt by other channel members is still unclear.

Returns in this industry therefore can only be inferred; however, at almost every stage other than retail and processing, they appear to be low and declining. Even here the decline in numbers of firms is

Table 11

Total and Direct Cost of Distribution for Salmon in the Pacific Northwest

Channel Member	Price at Input to Stage	Gross Margin	Direct Cost
Fisherman	0	15	40
Receiving Station	55	3	2.5
Freight to Processor	58	2	1.5
Processor	60	9	4
Wholesaler	69	9	8
Retailer	78	21	0
Consumer	99	0	0

Total margin*.....44¢

Direct Cost*.....16¢

*Excluding fisherman

Source: Survey Data.

indicative of typically low or negative returns. From observation there appears to be a substantial consumption of capital (the economic term corresponding to high net depreciation), in that most firms do not appear to be financially able to modernize their facilities. The returns on salmon measured by contribution margins appear to be substantially better than on other species handled, ensuring interest by processors in maintaining control over a limited supply.

IV. THE SIMULATION MODEL

The distribution channel has been described in terms of function, market organization, and cost. Useful as these models have been in analyzing the forces which have shaped the development of the salmon channel in each of its individual components, more powerful techniques are needed to analyze the distribution system as a unit. One very useful technique is simulation whereby a mathematical model is developed to describe the operation of a system. Its usefulness is derived from the ability to change elements in the system and trace through the effects. Recommendation can then be made as to whether these changes should be made given the objectives of the system.

Many choices are available for model specification depending upon the needs of the user. One is whether to model individual firms, i.e., a micro-approach, or the collective decisions of all firms in a stage in the channel (macro). In this case the macro-analytic approach was taken in order to keep computational time within cost limits. Also this is more likely to suit the needs of the users; the micro-approach is too specific for general usage.

For these reasons the effort has been to concentrate on product flow from source to market, viewing the channel as an aggregative system rather than as a series of structured links between individual firms. The resulting simulation model is thus oriented to provide answers to specific questions which are of underlying concern to the salmon distribution industry such as (1) given the market conditions governing supply and demand, how should allocations be

made among products and markets to achieve near optimal conditions for the industry, and (2) if changes take place in either the demand for products or the cost levels or technology of supply, what effects would they have on final market allocations?

The model begins with the simulated generation of an initial catch, and follows it through product transformation to final markets, taking into account raw material inputs, product form choice by producers, channel costs, and demand schedules in various markets.

In essence, the simulation deals with two elements: the source, and markets. Salmon can be sold directly as fresh product or if unprofitable can be converted to frozen form, sold in other time periods, or to distant markets. The basic model system is described in Figure 6.

The salmon industry is a supply limited system, and the fisherman's catch is therefore viewed as the initiator of system activity. Simulation begins with the determination of weekly catch volume of six different products: three size ranges of each of two species, chinook and coho salmon. The volume of catch for each species and size is calculated deterministically for a typical season, using a profile to describe the level of volume for each specific week during the season.

To simplify calculations a trapezoidal form was used to describe catch volume. A typical volume profile over the production season is shown in Figure 7. For a typical week, catch volume is determined by the position on the profile curve. A further elaboration for additional realism would be to introduce stochastic elements into the

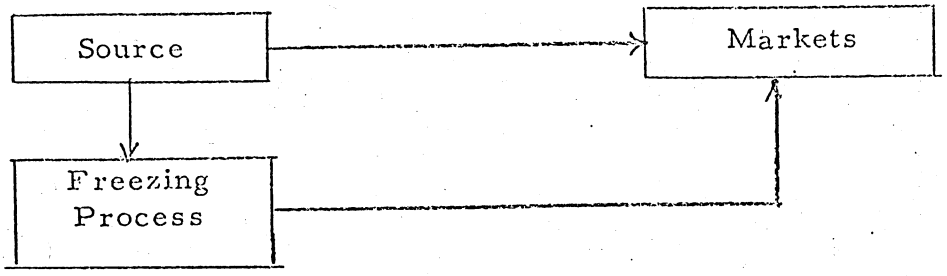


Figure 6.---Basic Simulation Model

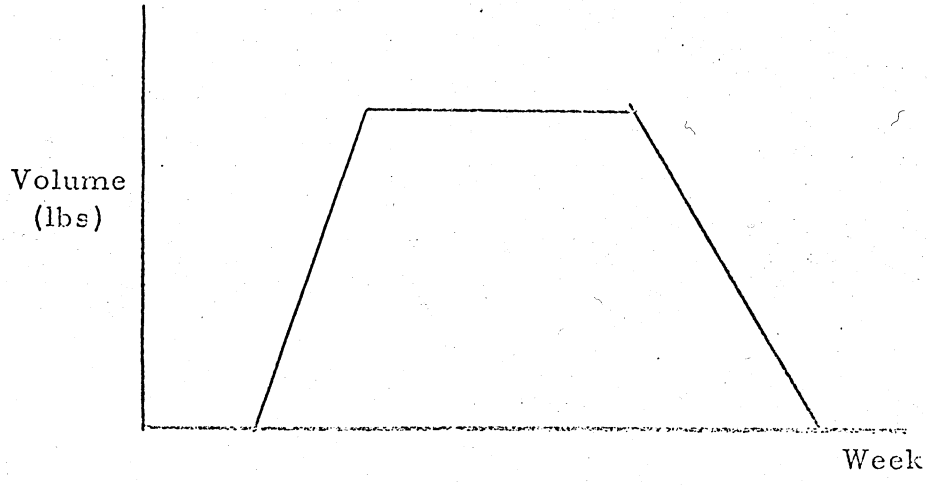


Figure 7.--Typical Catch Volume Profile (Volume)

catch volume calculation following apparent behavior of the fishery. This was not included here in order to focus on specific elements in the distribution allocation process.

Corresponding to the production season is the price behavior at the landing stage. From observation of price data over the period from 1956 to 1968, a typical price time trend was developed. This is also correlated to the production season as shown in Figure 8; at week x, fishermen will receive price Px.

The sole production source is the Pacific Northwest, and distribution is made on a weekly basis to six different geographic markets which approximate the actual world-wide markets for salmon. These markets and their general characteristics are noted in Figure 9. Channel activity includes both processing and distribution costs (including a return to channel members). This is expressed in aggregate markups over the raw material costs, which when added to the raw product cost results in offering prices to the market. The model will then compare quantities and offering prices to the demand schedules in the market and will then allocate product to market on a basis of searching for that combination of prices and quantities which will yield the highest possible return. The procedure that the model follows is to compare supply with demand at the offering price, note any imbalance, and then to reallocate until the quantities are absorbed. This results in either an upward movement of prices paid in the case of excess demand, or a downward movement in the case of an excess supply. Suppliers will not however deliver a

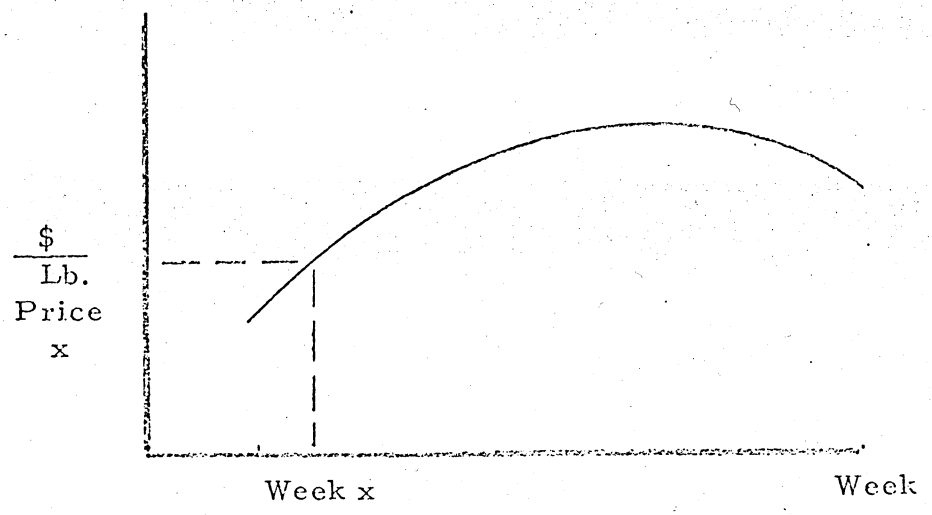
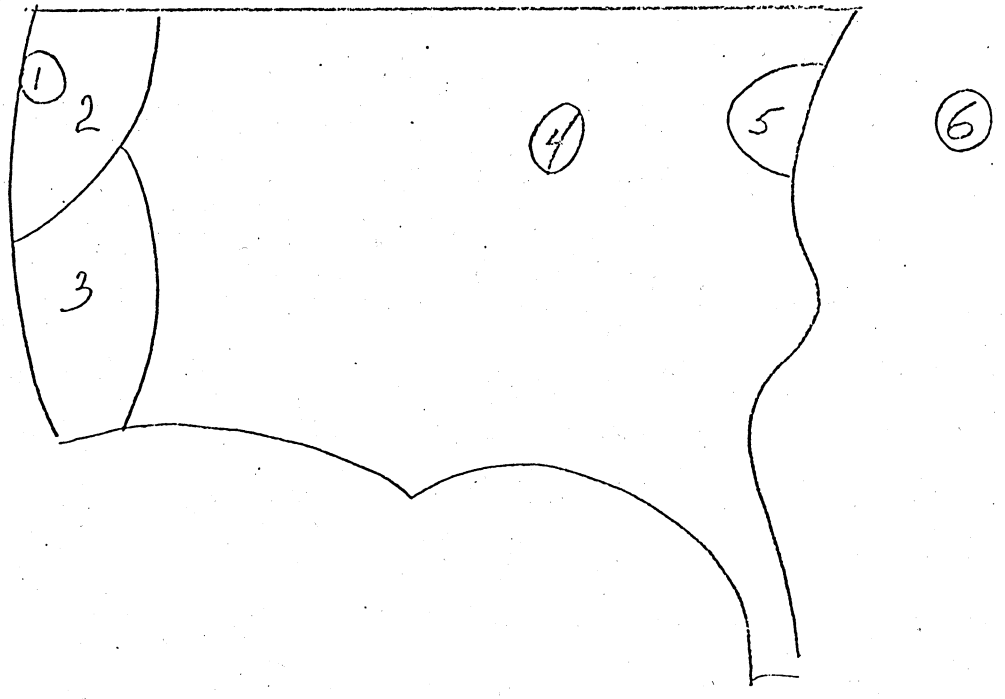


Figure 8.---Typical Catch Volume Profile (Price)



Market Number	Description
1.	Local - minimum distribution costs and risk
2.	Non-local intra-regional market (direct distribution and low transport costs).
3.	California markets (increased distribution costs and complexity).
4.	Midwest Region - higher cost of transportation.
5.	East Coast (transportation over 2,000 miles).
6.	Export market to Europe (transportation includes air and water).

Figure 9.--Product Markets in the Simulation Model

product to market at prices which would result in losses, but will withhold these quantities in frozen form for future delivery.

The available supply is limited by the size of the catch which is highly seasonal, beginning in late spring, rising to a midsummer peak and declining in the fall to zero. During this season, most processors may elect to sell all or part of their product as fresh salmon, to withhold part of their supply for freezing for sale either in the off-season, or to facilitate movement to distant markets by lower cost transportation. The seasonal characteristics of production result in supply shortages during the early part of the season, excesses in the peak period, and shortages again toward the end of the season. The high perishability of fresh salmon then requires that excesses of supply be frozen for holding as inventory for later sale. The model incorporates interactive supply and demand schedules in that early season demand, which when greater than supply, will drive market prices upward until production catches up and finally exceeds demand; market prices then move downward as inventories of frozen stocks accumulate. These stocks will move into the market first as competition for fresh salmon, and later as a replacement when further production is halted. Some salmon will be allocated to frozen products as suppliers will wish to set aside some supply to maintain the distribution channel over the off season.

Because fresh salmon is regarded as a superior product to its frozen counterpart, the initial model formulation treated fresh and frozen markets as separate, with no competitive interaction between

them. However, this was later modified to permit these two products to compete in the same market, recognizing that the supply cost of the frozen product dictates a higher offering price, making it more attractive only when fresh supply is diminished.

In summary, the model simulates the flow of twelve distinct but related products with independently determined markets through the production process to be distributed to six independent markets. Market prices and quantities are determined by the interaction of 36 separate supply and demand schedules. For ease of experimentation, 127 parameter values are read by the program from data cards as exogenously determined variables (i.e., determined outside the model) although there is no reason why many of these cannot also be determined by possible component submodels within the system. The model is currently implemented for simulation in FORTRAN IV on the CDC 3300 computer. A summary flow chart for this model is shown in Figure 10.

At the present time validation of this model is possible only to a limited degree. Much of the data generated for the model were either gathered specifically for this project or were estimated based on informed judgment. Therefore the principal validation procedure was to test known values of inventories, market prices and volumes against model results to see if model performance was reasonable. As far as the data permits, the results appear to approximate performance of the real world channel. Sample output data for a typical season for landed volumes, prices and market demands are shown for a single market and product category in Figure 11. The behavior of these series over the season appears to approximate observed patterns within the industry.

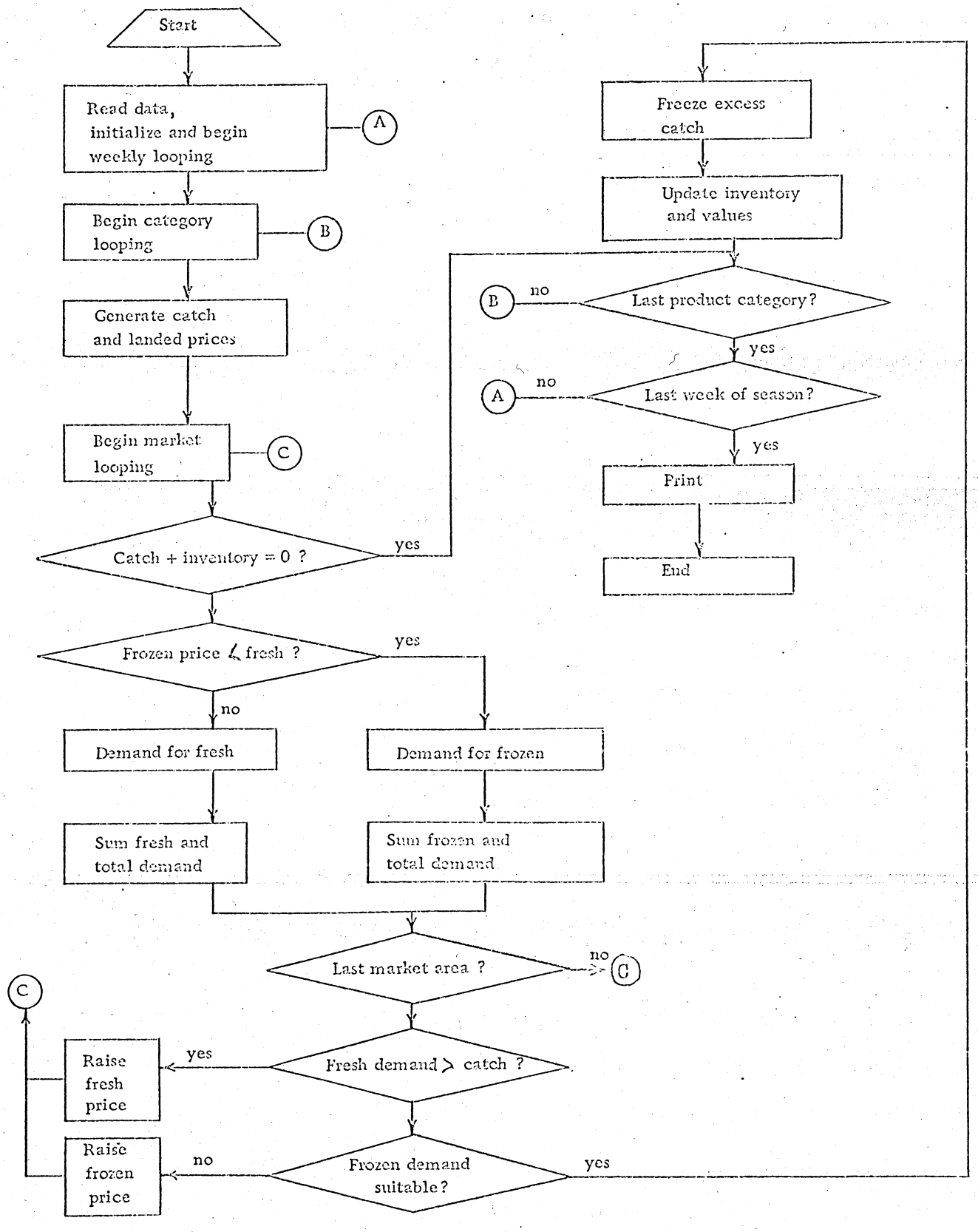


Figure 10.--Flow Chart

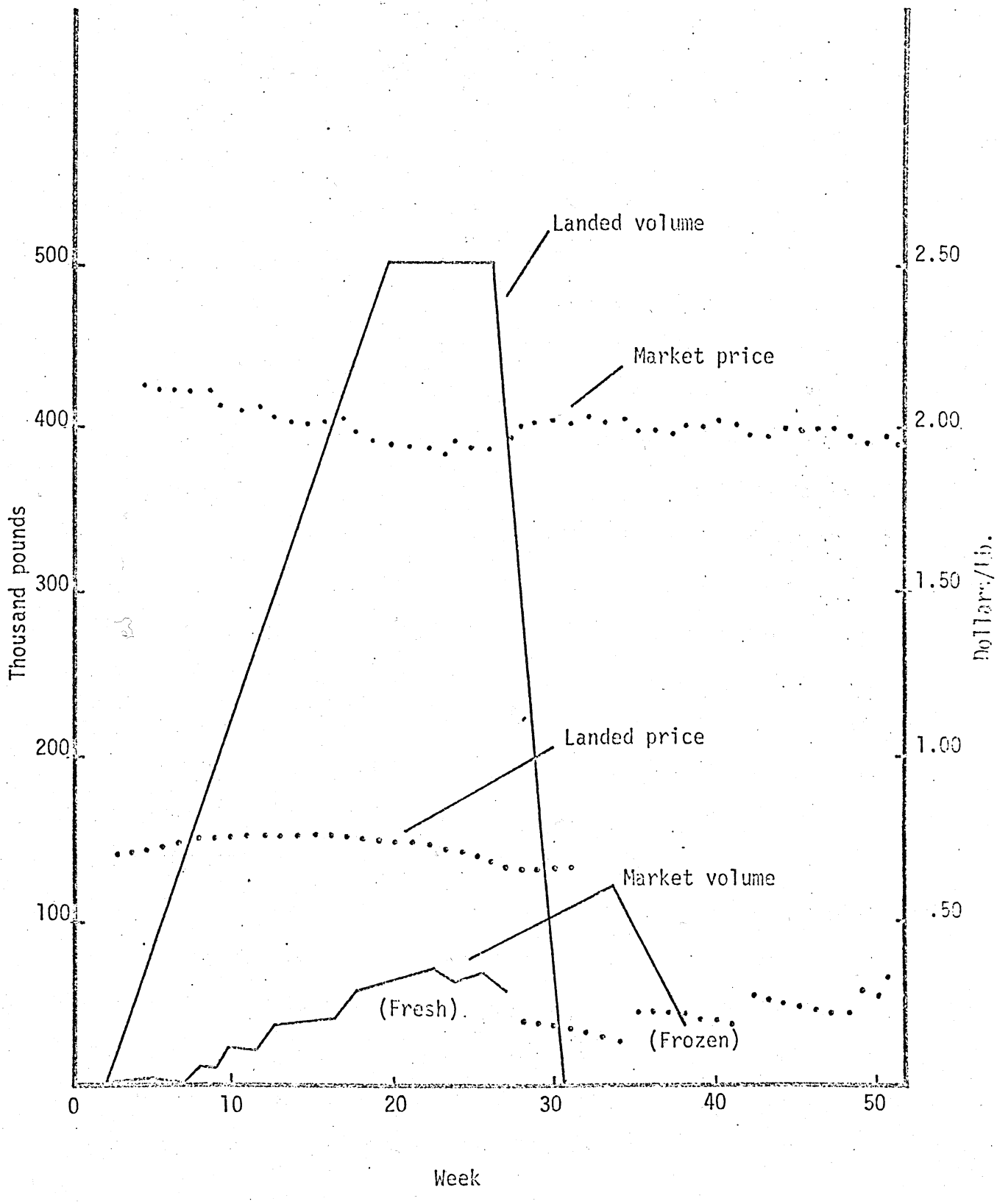


Figure 11.--Weekly Volumes and Prices

Within the present model configuration there are many types of experiments which might be employed to investigate the effects of changes in either markets or supply parameters on channel behavior. Two which come to mind are the impact of relative changes in distribution costs of market allocation, and the possibility of changes in market allocation because of changing demand functions.

The results of one empirical investigation are cited here as a pragmatic example of the value of this model. The objective was to determine the sensitivity of market allocation to variation in distribution costs. Distribution costs to three selected market combinations were incrementally increased while costs for the other three markets were held constant. The experiment was performed in three stages; distribution cost changes were (1) to increase distribution costs to market five by 8%, (2) to increase distribution costs by 8% to market four, five, and six, and (3) to increase distribution costs to markets four, five, and six by 15%. The effects of these changes (based on movement within the season) are shown in Table 12.

The results show, as we would expect, that market allocation is sensitive to changes in distribution cost, so sensitive that with the given market demand schedule an 8% increase in market five resulted in a 38% reduction in market volume. A 15% cost increase resulted in a 62% reduction in market transaction volume, and a 15% increase almost completely eliminated market six from the system. Following the logical development of the model, increased costs to one market results in increased supplies being available for both competing

Table 12

Sensitivity Analysis

Selected Distribution Costs

Market	Base Value	Change in Market Volume		
		Run 1	Run 2	Run 3
	million pounds	---------- percent ----------		
1	4,456	+ 3	+ 4	+ 8
2	10,402	+ 2	+ 3	+ 5
3	1,872	+ 3	+ 5	+18
4	1,981	+ 1	-37	-66
5	3,391	-38	-35	-62
6	374	+ 2	-56	-89
Frozen inventory				
	11,012	+ 7	+14	+20

Run 1 (8% increase in distribution cost to market five)
Run 2 (8% increase in distribution cost to markets four, five, and six)
Run 3 (15% increase in distribution cost to markets four, five, and six)

markets and frozen inventory. The extent of the reduction will depend on the specific relations between market supply and demand elasticity.

The results should be of interest not only to those involved in specific channels but also to transportation firms and others concerned with regional import problems. The real world counterpart problems would be to measure the impact of higher freight rates or other costs of processing and distribution on the volume of product moving through a specific channel, and hence to derive a demand schedule for the transportation function.

A further elaboration of the model could be developed to treat the fresh and frozen markets in each geographic area as separate but interrelated, in order to provide additional realism to the market allocation process. For each market area, there would be separate demand and supply schedules for fresh and frozen product. Allocation within the model would therefore reflect the currently observed phenomenon of the simultaneous movement to the same market of both fresh and frozen product. This would permit the user of the model to examine the effect of changes in supply cost on both market area allocation and the type of product moving into each area. This should be of value to channel members who contemplate changes in the cost of their operation. Specifically, this should be useful to transportation companies who by the rates they charge are capable of changing channel costs by significant amounts and hence can influence the volume of traffic they carry. This should also be useful to other firms considering new forms of technology such as processing, handling,or freezing in terms of their potential markets.

While we have been concerned in the discussion above with changing supply schedules, the model is also useful in examining changed allocation under shifting demand schedules. Demand may change for many reasons: secular shifts in tastes over time, decline in the availability of substitute products, or as a result of deliberate promotional policy. This model has the potential to evaluate change in demand resulting from any of these conditions, provided that knowledge of the demand schedules is known, or estimated. Market allocation under conditions before the shift would be compared to those after the shift has been fully absorbed in the market, and the differences in allocation would then be attributable to changes in the demand schedules.

Hypothetically, the most interesting case is that of deliberate promotional activity. However this requires an additional piece of knowledge, the shape and parameters of the market promotional response curve, i.e., the relationship between promotional expenditures and sales. For this case we might presume that these are either known or can be determined. A typical curve is illustrated in Figure 12.

This function expresses a deterministic relationship between industry promotional expenditures and the resulting shift in the demand schedule. This could be translated into a potential profit and loss measure of the effectiveness of promotional activity. While the present model does not make explicit provision for calculation of profit and loss, this could be included with little difficulty, making possible calculation of optimal promotional strategies, based on knowledge of promotional response functions. At the present time this requires a

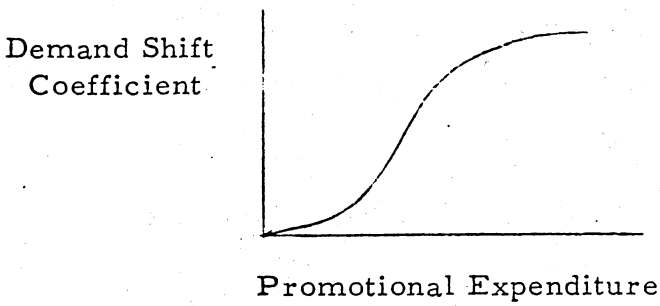


Figure 12.--Promotion Response Function

knowledge about markets which is not yet existent. An alternative is to test for the sensitivity of results to changes in intuitively plausible functions and parameter values. In either case, the model provides a useful tool in guiding industry decisions.

As a further development, the model can be useful in predicting changes in channel structure as a result of changes in the supply and demand parameters. Comments from industry members during the course of interviews have indicated that under conditions where unit profits tend to be high, speculators appear to take positions in frozen inventory in anticipation of still higher prices out of season. Development of submodels to describe the costs of channel members as individual entities may thus also define the conditions under which speculators are likely to appear. The model itself thus provides a basis for much greater elaboration and development than we have shown here.

V. SUMMARY AND CONCLUSIONS

This paper provides a description of the distribution and marketing systems for Northwest originated fresh and frozen salmon. Production volume is shown to have followed a fairly stable trend, with little growth or decline, while demand has generally been increasing, and the popular product forms have moved away from the canned variety toward fresh and frozen. The limited information available for cost and earnings analysis indicate that no stage in the marketing channel has a high return and in some cases, have insufficient income to reinvest to replace worn out capital.

In addition to the channel description in qualitative and quantitative terms, a computer simulation model written in FORTRAN IV and implemented on a CDC 3300 digital computer is described. This industry can be characterized as supply limited dealing with a perishable product which is storable for intermediate periods of time if transformed by a freezing process. The production process functions on an annual operating cycle, peaking in late summer from zero values earlier and later in the year.

The computer model simulates the production distribution process on an aggregated scale. It includes a dynamic market distribution function and is sufficiently general to be adaptable to any product form having the same general characteristics of the product analyzed here. The model has demonstrated the capability of reasonably portraying the operation of an intricate real world system in an aggregate sense, and of being useful for practical study of the system. At this point the model needs to be refined in the sense of being made less

aggregative of detail, and additional effort is required to improve the accuracy of several of the parameter values which are critical in deriving reliable results.

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FIGURE LEGEND