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THE SALMON PROCESSING INDUSTRY

part one:

the institutional framework and its evolution

William S. Jensen

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author

WILLIAM S. JENSEN is Professor of Administration at the Graduate School of Administration, Willamette University. He received his Ph.D. degree from Oregon State University in Agricultural Economics.

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related publications

A DEMAND ANALYSIS FOR CANNED RED (SOCKEYE) SALMON AT WHOLESALE, by Richard S. Johnston and W. Robert Wood. Publication no. T-74-001. 36 pp.

Briefly explores the production and consumption of Pacific Coast salmon, canned salmon market structure, and earlier work concerning demand for canned salmon. The report centers on the presentation of a new econometric model, developed to estimate the parameters of postulated demand relationships; results of the statistical analysis are also related.

MARKETING CHARACTERISTICS OF OREGON'S FRESH FROZEN SHRIMP INDUSTRY, by R.D. Langmo, C.N. Carter and R.O. Bailey. Publication no. T-75-002. 23 pp.

Consolidates from many sources features of the fresh frozen shrimp industry in terms of its product volume, value, growth trends and position relative to other Oregon seafood commodities. Market structure and functions are described as the product moves from the fisherman through the processor, broker, wholesaler and retailer to the consumer. There is brief speculation on needs for future studies of marketing.

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introduction

The Pacific salmon industry established a vigorous growth pattern in the first 30 years of its existence. The salmon were abundant and easy to catch and the market for canned salmon seemed insatiable. The future appeared very bright for this infant industry. In 1890, only 25 years after the first salmon cannery was built in the western states, there were an estimated 110 canneries on the Pacific Coast: 21 on the Columbia River, 8 on the Oregon Coast, 6 in the State of Washington (other than the Columbia River area), 7 in California, 35 in Alaska, and 33 in British Columbia. The annual pack of canned salmon exceeded 1½ million cases and the catch was in excess of 10 million salmon.

The State of Washington was a major participant in this bonanza and the Puget Sound area of that state was the "mother lode" for the salmon harvest. At the peak of the harvest in 1913, the Puget Sound area produced a catch of 40 million salmon. These fish were caught by several hundred gear units (predominantly net or trap) and processed by 31 canneries owned by about two dozen firms. In 1971, these same waters produced a catch of about 6 2/3 million salmon. These salmon were caught by about the same number of net units and six times the number of troll units used in 1913. There were 18 canneries to process the 1971 harvest and the largest one accounted for 30 per cent of the total production that year.

Economic theory attempts to uncover the basic relationships of cause and effect hidden by the diverse surface manifestation of economic activity in the marketplace. Abstract models of industry have been constructed for this purpose but the diversity of organizational form between industry groups precludes an effective, universal theory. Market structure analysis consists of isolating those significant organizational characteristics of a market which may affect the behavior of firms participating in that market. These firms organize the resources for the production of goods and services and allocate those resources. The salmon industry is particularly unique, both in organizational characteristics and geographic

location. It would, therefore, seem logical to hypothesize that the industry is acted upon by certain unique forces. If policy measures are to be formulated for this important fishery, they should be founded upon a sound informational base, including a comprehensive description of the organizational structure and its relevant variables.

During 1969, computer printouts of the 1968 aggregate purchases of all seafood products, by species, for all processors in the State of Washington were made available to researchers at Oregon State University. An initial summation of those purchases gave an indication of substantial industry concentration.

The State of Washington is the only political entity which makes available statistical data (Oregon has a limited data collection system; necessary data for Alaska, British Columbia, and California have been unavailable to researchers). With the exception of its limited reef net fishery, however, the State of Washington is thought to provide an excellent surrogate for the entire West Coast salmon industry. All principal species of salmon are represented in the waters of the state, the processing and catching methods are comparable, and the markets and processed market forms are the same as those of other salmon-producing regions.

Given the 1968 levels of concentration in Washington and the potential for further horizontal mergers within the salmon processing industry, the levels of concentration could be subject to increase over time. Such levels of increasing concentration are believed by many to be detrimental to the goal of efficient resource usage--especially with the exponential increase in the number of catch units. This view is clearly evident in the writings of economists (7, 30) and in the actions of the Federal Trade Commission against the salmon industry. Therefore, it was felt that a thorough market structure analysis of the salmon industry would provide information for government policy pertaining to the salmon industry.

The next printout of salmon purchases was for 1970. It was puzzling to find that concentration had actually diminished from the 1968 levels. It was apparent that the levels of concentration were conditioned by variables not clearly evident in aggregations of available data. Several steps were taken to isolate variables. First, the aggregate data were subjected to a four-year moving average; a clear picture of a long-term cycle became evident. This was followed by an evaluation of the impact of the various species (five) upon the total aggregation of salmon purchases. At this point it became clear that two principal species dominated the industry--the sockeye (red) salmon and the humpback (pink) salmon. Evaluation then turned to catch method and market form for each species. As a result of these efforts it became apparent that the level of industry concentration was the result of a complex set of exogenous variables which included the aggregate catch of all salmon, biological eccentricities of the various species, market form preference for the processed product, and government policy.

Nicholas Georgescu-Roegen in the introduction to his study, The Entropy Law and the Economic Process, notes: "Economists do speak occasionally of natural resources. Yet the fact remains that, search as one may, in none of the numerous economic models in existence is there a variable standing for nature's perennial contribution" (18, p.2). This study does not propose changing market structure analysis; it does, however, argue that each industry may have unique characteristics and forces which will shape the structure of that industry. These factors may be completely outside the control of the decision makers within the industry. The traditional approach to market structure analysis is founded upon the assumption that decision makers within an industry have control of their destinies and policies are formulated toward that end. This researcher takes strong exception to that concept. This monograph represents the first in a two-part series dealing with the impact of a natural resource upon the market structure of the industry it services as a factor of production.

PART I - THE INSTITUTIONAL FRAMEWORK AND ITS EVOLUTION

In Part I it is intended that the reader be immersed in a background study of the Northwest salmon industry so the unique factors affecting it are clearly in mind. The starting point for the study is not a review of theory but a comprehensive coverage of industry characteristics and history. Only then is it possible to approach the market structure analysis within an institutional framework and reflect upon optimal policy considerations. This is the subject matter of Part II of this study, Market Structure Analysis and Policy Considerations. An economic analysis of the various aspects of the Puget Sound salmon fishery should improve our understanding of the factors underlying observed historical trends. Therefore, the

study examines the relationship between the structure of the salmon species. This structural analysis provides a sound basis for a number of observations about the behavior of industry participants. Further, it may provide a more rational framework for future policy decisions concerning the salmon fishery.

the development of the salmon industry

Salmon have a long history of commerical exploitation. As early as 1273, Aberdeen merchants were exporting salmon to England and the European Continent. "Newcastle salmon," highly esteemed in London, were also introduced to the early American colonies:

> Mrs. Gardiner's Receipts from 1763, published at Boston, Mass., gives a recipe 'To Pickle Salmon the Newcastle Way, according to a Receipt procured from England, as is said by the infamous Governor Sir Francis Bernard.' After scaling, splitting down the back and removing the backbone and washing, it is cut into 'Junks of about four or five inches thick. Put on your Pot of Water, making it sharp with salt, and when it boils put in your Junks of Salmon, and let them boil for twenty-three Minutes. Then take it off the fire and let it cool. Make a Pickle with two ounces of Allspice, two ounces of black Pepper and one Gallon of Vinegar, which boil, and into which, when cold, put a handfull of Salt. Place the Salmon in a Keg, and , when the Salt is dissolved, pour the Pickle upon the Salmon. After it has stood one night in this manner, strain off the Oyl that may have arisen on the Top, to prevent its acquiring a strong taste and then head up the Keg (13, p.86).

When the early settlers came to the Pacific Coast of North America, salmon was a principal food of the native Indians. Russian and English trading companies were soon shipping substantial quantities of salt and pickled salmon to their mother countries. However, it was not until 1864, when Hapgood, Hume, and Company established the first salmon cannery in Yolo County, California, that the salmon processing industry, as we know it, began to take form. The short

supplies of salmon in the Sacramento River and glowing reports of its abundance in the Oregon Territory caused William Hume to move canning operations north to the Columbia River. Subsequently, British Columbia and Alaska began major salmon cannin industries. Very little has been written about the development of the salmon industry in the Puget Sound area of the State of Washington but Cobb noted that there were numerous canneries by 1900 and that San Juan Fishing and Packing Company was the first firm to pickle salmon in that area (1901) (10). There is evidence that the fisheries of Puget Sound also attracted processors for the halibut fishery to satisfy the growing eastern demand for that important white fish (5). Since that time, Puget Sound has been the dominant salmon producing and processing area for the State of Washington

THE PACIFIC SALMON

It is important to understand that there is not one but six species of salmon in Pacific waters. Five of these species are abundant in the waters of the western United States. All the Pacific salmon are included in the genus *Oncorhynchus* (meaning hooked nose). Fishermen and others incorrectly group the steelhead trout, which belongs to the closely related genus Salmo, with the Pacific salmon. The principal difference between the Pacific and Atlantic (Salmo) salmon is the fact that the latter may spawn more than once, while the Pacific salmon always dies after spawning. Pacific salmon are anadromous, that is, they are hatched in fresh water, move into salt water for their major growth, and return to the fresh water to spawn. The five species of salmon peculiar to the Western United States are: (1) chinook--also known as king, spring, tyee or quinnat salmon, (2) chum--also known as fall, dog or keta salmon, (3) pink--also known as humpy or humpback salmon, (4) silver--also known as coho or medium red salmon, and (5) sockeye--also known as the red or blueback salmon. The sixth species of Pacific salmon is the rose salmon, which, apparently, is unique to the northern waters of Japan.

Chinook Salmon

The chinook salmon is the largest of the salmon. It averages about 15 pounds but has been known to achieve a size of 100 pounds. It has a flesh which is generally red but has been found in varying shades, including white. Its flesh has a softer texture than the other species, is very rich in oil content, and breaks into large flakes when cooked. Although it was highly prized in its canned form in earlier days, it is now marketed, principally, in fresh and frozen form. It has a life span of 4 to 6 years. It may be caught with any form of salmon gear.

Chum Salmon

Because of its low oil content and light color, the chum salmon has been the least desirable of the species. It is also more coarsely textured when cooked. Until recently it had been processed predominantly in the canned form. However, its size (average weight 9 pounds) has made it a suitable fish for processing into frozen salmon steaks so fewer fish now are being canned. It has a life span of 3 to 5 years. It is caught with net or trap type salmon gear.

Pink Salmon

Although it is the smallest of the species, the pink salmon has accounted for a major portion of the salmon catch each year because of the size of the salmon runs for this species. It has an average size of about 4 pounds and is noted for its delicate flavor and light color. It has an invariable life cycle of 2 years. It is processed only in the canned form. It is usually caught with net or trap type salmon gear.

Silver Salmon

The silver salmon is somewhat lighter than the red salmon but much larger in size (average size of about 8 pounds). It has a very desirable texture and flavor similar to, but not as rich as, the chinook. Its principal market form is as fresh and frozen salmon. It has a life span of about 3 years and may be caught with any form of salmon gear.

Sockeye Salmon

The sockeye or red salmon is relatively small in size (averaging 5 or 6 pounds) but is highly prized for its dark red color and rich flavor. The texture is firm. It early became the most highly desired type of canned salmon. Young sockeye require from one to two years of life in a fresh water lake before they migrate to the sea to complete a life cycle of 4 to 6 years. The sockeye is marketed only in the canned form and, like the pink salmon, is a dominant factor in the total catch of salmon. The sockeye salmon is caught almost exclusively by a trap or net form of salmon gear.

METHODS OF CATCHING SALMON

Salmon catching techniques are, for the most part, as old as the industry. With the outlawing of fixed location gear such as fish wheels and fish traps, the principal types of commercial salmon catching gear are the purse seine, the gill net, and trolling gear. Additionally, reef nets and dip nets, adopted from the Indian fishery, may account for 5 or 6 per cent of the total commerical catch in the State of Washington.

The Purse Seine

Fish traps in Alaska and the State of Washington were the primary catch methods during the major growth phase of the salmon industry at the turn of the century. At that time, the purse seine was relatively inefficient because it was restricted to hand or sail power. The advent of the internal combustion engine and the power block made a dramatic change and, with the elimination of salmon traps, purse seines now account for more than 40 per cent of the total commercial salmon catch.

A seine is a net of varying length, mesh size, and depth which is used for catching schooling-type fish such as the salmon. The purse seine is 200 or 300 fathoms long and has a depth of 10 to 15 fathoms. It is carried aboard a boat 60 to 90 feet long which is broad-beamed and square sterned. When set in the water, the net is supported by floats threaded on the head- or cork-line. The net is let out in almost a straight line, then closed by the boat moving in a circle. When the circle is closed, the fish are trapped with the closing of the "purse"--this is accomplished by a purse-line strung through large metal rings at the bottom of the net. After this drawing-in or "pursing-up" of the purse line, the fish may be easily lifted to the deck of the seine vessel. Once this procedure is completed, the net is made ready for another "set" and the technique is repeated.

The Gillnet

Salmon gillnets now account for more than 30 per cent of the salmon commercially harvested. It is one of the oldest forms of gear used in commerical fisheries on the Pacific Coast. With new handling technology and because the necessary investment is substantially less than the purse seine, there has been a renewed interest in this method of salmon fishing.

The salmon gillnet is also 200 to 300 fathoms long. The nets hang to a depth of 14 to 20 feet and are set in the path of the schools of salmon. As its name implies, the gillnet catches fish by entangling their gill covers in the mesh. Now that set nets (having one end stationary on shore) are unlawful, the operating gillnets are the drift net variety: These are one- or two-man boats of up to 40 feet long. The net is dropped over the stern by a power reel. There are floats on the top of the net; weights on the bottom hold it down. After the "set," the boat and net drift with the tide for a period, then the net is hauled in, and the fish removed.

Trolling

Trolling is a method of catching fish, particularly salmon, that consists of dragging a hook and line through the water at a slow speed. The hooks are baited with either fresh herring or with artificial lures. Trolling may be accomplished with almost any size boat; commercial vessels range in size from a skiff to a 50-foot troller. The only species of salmon consistently caught by this technique are the silver and the chinook. The pink salmon will strike at some artificial lures. The modest investment required and the increase of hatchery silver salmon have caused a tripling of the number of these catch units during the last 40 years. Trolling now accounts for about 20 per cent of the total commercial salmon catch.

Reef Nets

The reef net has been adopted from the Indian fishery and appears to be unique to the Puget Sound area. Its use was rather limited until the set net fishery was outlawed but it now accounts for 5 to 6 per cent of the total commercial salmon catch.

The reef net consists of two large skiffs anchored about 50 feet apart, with a net 50 feet square rigged between them. One end of the net is floated at water level. The balance of the net sags below the water to form a cup. A lead of cable with rope ties hanging from it is used to direct the school of salmon into the net area. When a lookout spots fish entering the net area he calls for the crew to draw up the net and fish.

SALMON AS A PROCESSED MARKET FORM

Fish is one of the most perishable of all foods. The remote geographic locations of harvest and the susceptibility of the fresh fish to severe enzymatic, oxidative, and bacterial action have had a major influence upon the final market form. Salmon, because

it is a schooling fish, accentuates the problem even more--the bulk of the fish are caught within a relatively short period of time (July and August of each year) so that the type of processing facility capable of handling these massive inputs of fish is rather limited.

Initially, salmon was marketed almost exclusively in the pickled or salted form. The advent of the canning process in the nineteenth century allowed, for the first time, a practicable means to preserve and market large quantities of the highly perishable salmon. Although highly developed processing technology and transportation means are beginning to have some impact on the market form composition of processed salmon, that composition has changed very little over the last 40 years. In 1937, the market form composition of processed salmon in the U.S. was estimated as 77 per cent canned, 19 per cent fresh, 2 per cent cured, and 2 per cent frozen. By 1968, the estimate was 77 per cent canned, 10 per cent fresh, 4 per cent cured, and 9 per cent frozen. Because changes in the consumption patterns for processed salmon may have a considerable impact upon the market structure for that industry, it seems advisable to include a brief description of the major market forms.

Cured Salmon

The preservation of fish for consumption after the catch season is a very old concept. Drying and smoking processes developed shortly after the discovery of fire. Salting dates back to the Stone Age and pickling methods are credited to the Greeks and Romans. Modernly, these preservation techniques are referred to as "curing." One hundred years ago, curing methods represented the dominant technique for handling salmon. Now, less than 5 per cent of the catch is processed and marketed in this manner.

Preservation of fish by curing is achieved by retarding the bacterial action through drying and the application of chemicals. The curing processes require large inputs of labor and necessitate longer periods of time than the other processes. Additionally, the flavor characteristics of the fish are altered substantially.

Fresh Salmon

"Fresh" implies that the original qualities of the salmon are largely unimpaired and that there has been no storage or preservation. Fresh salmon has always been a valuable fish. However, it did not achieve large-scale distribution until the coming of the railroad in the 19th century and the use of ice for storage and distribution in the late 18th century (salmon was, in fact, the first fish on which ice was systematically used for preservation in England at the end of the 18th century). In the 20th century, rapid air transport and refined handling techniques have given even greater flexibility in the use of fresh salmon.

While at sea, salmon tend to increase in size but during their spawning migration back to the fresh water they cease to eat, using their body oils for energy. As a result, the flavor characteristics of salmon differ significantly. Historically, fresh salmon originated from those species which take a hook (still eat) and the troll fishery, which consists mostly of silvers and chinooks, has dominated this market form (as well as the frozen form). With the continued demand for fresh and frozen salmon, larger quantities of net-caught salmon are being used and such species as the chum salmon are being used in this form with more regularity.

Frozen Salmon

Although the first patents on the freezing of fish were granted in 1869, the most important advance in the artificial refrigeration of fish came with the development and use of ammonia refrigerating machines in 1892. Refrigerating the salmon to 32°F (0°C) cannot result in actual freezing because of dissolved salts in water of the fishes' flesh. Although fish may appear to be frozen quite solidly at temperatures above 15°F (-9.5°C), substantial bacterial action is still taking place. Because of the dehydrating action upon the fish, the freezing process must be accomplished with either a brine or plate freezing method--both more costly than the blower freezing used in other food processing industries. Additionally, this dehydration effect forces repetitive glazing during the storage life of the frozen product. Although substantial improvement has been made in the technology of this increasingly important has been made in the technology of this increasingly important market form, it can still be said that after 100 years "little is known of the biochemical properties of fishery products and how they influence the suitability of the product for freezing" (35, p.289).

For the salmon industry, the major use of frozen product has been in frozen steaks,

both bulk (for institutional use) and packaged retail units. In addition, much salmon is frozen for transport and subsequent processing into another market form (canning and/or curing). Because of the tendency of the oil to go rancid, salmon does not have a satisfactory storage life of much beyond one year in its frozen state.

Canned Salmon

The major portion of the commercial salmon catch is processed by canning. This is particularly true of the sockeye and pink salmon which are landed in such large quantities in such a short period of time that canning has been the only practical method of preservation. Because both these fish are small, thereby preventing their use as frozen steaks, and because preservation and distribution technology are not far enough advanced, continued domination by the canned form can be predicted for the commercial salmon industry.

The father of the canning process is generally recognized to be Nicolas Appert, a French chef who developed the technique in response to a prize offered by the Napoleonic government in 1795. The process was perfected and the results published in 1810 (13). The process was first used in the United States in 1820 when oysters, lobster, and fruit were packed in glass. But it was not until 1874, when A.K. Shriver introduced the pressure kettle or retort, that the modern canning industry began its dramatic growth. It was not until 1900 that the hand-soldered "hole-in-cap" can was replaced by what we know as the "sanitary" or open-top can of today. An expert tinsmith could turn out about 60 cans per day of the "hole-in-cap" cans, while the can-making industry of today can process cans at the rate of 1,000 per minute.

The development of the canning industry can be attributed to the design of suitable containers and an economically feasible process. Canning has been defined as "the packing of foods in hermetically sealed containers and obtaining commercial sterility through the use of heat processing" (et, p. 311). Although Crosse and Blackwell are credited with establishing the world's first salmon cannery, the major commercial expansion in the United States came with the heavy demand arising during the Civil War. As mentioned earlier, it was in 1864 that the brothers Hume and Andrew Hapgood, experienced canners of Maine lobsters and salmon, came west to build the first commercial salmon cannery on the Sacramento River at Washington, Yolo County, California. Hapgood, Hume & Company moved north with the discovery of the remarkable salmon runs of the Pacific Northwest and Alaska. With a pack of 2,000 cases of canned salmon in the year 1864, the industry grew to its peak production level of 10 million cases in the war year of 1917. In 1864, there was one salmon cannery on the Pacific Coast. It is a sad postscript to note that currently, although canning accounts for more than three-quarters of the total commercial salmon catch, the total pack is less than 40 percent of the 1917 peak and the number of cannery facilities has dwindled to about one-third the number of producing units during the peak period.

the salmon processing industry in the state of Washington

Although it is a significant salmon fishery, the Columbia River is contiguous to both the State of Oregon and the State of Washington; it is, therefore, treated as a separate and distinct regional fishery. The salmon fishery of the State of Washington has long been centered in the Puget Sound area of that state. This dominant indentation in the coast, with its numerous islands and excellent harbors, has fostered a large and successful fishery. This is particularly true of the salmon fishery because of the numerous rivers and creeks which enter the Sound.

Strictly speaking, the designation Puget Sound should be restricted to that long, narrow arm extending south from the Strait of Juan de Fuca, but a practice has developed, and is common among fishermen and others, of designating all the great water area in the State of Washington comprising Puget Sound proper, Strait of Juan de Fuca, Rosario Strait, the Gulf of Georgia, and numerous other small straits, bays and sounds, as Puget Sound. Because of these factors and because this designated area produces more than three-quarters of the total salmon production in the State of Washington, this study will limit its analytical foundation to the more broadly designated Puget Sound area. The State of Washington, represented by the Puget Sound area, provides an excellent surrogate for the salmon processing industry--the composition of the catch, the catch methods (with the exception of the reef net), and the composition of the market form are comparable to the other major salmon producing regions of the Pacific coast.

Both the Northwest Company and Hudson's Bay Company developed a large salt salmon production in Puget Sound in the early part of the 19th century. The first salmon cannery on Puget Sound was built by Jackson, Myers & Co., in 1877, in Mukilteo; it produced 5,000 cases of salmon in its first season (10). Later the first pink salmon were put up at this plant. Cobb notes:

> In order to divert the minds of purchasers from the fact that the meat of the humpback

> was much lighter in color than the grades then known to the consuming public, the company printed on its label the legend, 'Warranted not to turn red in the can.' Even with this shrewd sizing up of the weak side of the consuming public, the demand for humpback or pink salmon developed very slowly, and it was some years before it became a factor in the markets (10, p.21).

In 1917, one of the peak years, pink salmon accounted for one-half of the total Puget Sound canned salmon production.

It was the extension of the railroad to Puget Sound that provided the major stimulus for the growth of the fishing industry. By 1889, the first fresh halibut and salmon were shipped to the population centers of the Midwest and East, the number of salmon canneries had increased by 4 and the pack was about 22,000 cases. By 1899, the canning process dominated the salmon fishery--19 canneries were producing almost one million cases of canned salmon. In the largest packing season in Puget Sound history, there were 2½ million cases of salmon packed by more than 30 canneries. Overfishing and the refinements of civilization have insured that this impressive performance likely is never again to be matched. Table 1 and Figure 1 indicate the dramatic reduction in the available supply of salmon from the record catch of almost 40 million fish in 1913 to the recent high in the cycle of less than 7 million salmon in 1971.

As has been previously indicated and is further clearly evident from the data in Table 1, the runs of sockeye and pink salmon dominate the total catch of salmon. These two principal species migrate to the catch grounds in varying cycles--two years for the pink salmon and four, five or six years for the sockeye salmon. These major migration cycles for the different species of salmon create a longer term cycle of 17 to 18 years. This fact is not immediately evident from the new data, so a four-year moving average has been compiled and plotted (Figure 2). addition to the evidence of a strong, long-term cycle, it can be seen from the smoothed data that the average catch level has diminished over time and that the harmonic range has narrowed substantially during that same period of time. This general trend in what might be described as the biological force affecting the salmon industry gives some indication of stability in the average catch levels and reduction in cyclical extremities. This may present substantially less uncertainty for fishermen and processors. The table at the bottom of the page summarizes the Puget Sound salmon fishery from 1913 to 1969.

Cobb indicates that the salmon catch in 1917 was distributed between the various gear forms in the following manner: traps 50 per cent, purse seines 30 per cent, gillnets 10 per cent, Indian gear 7 per cent, and troll gear 3 per cent (10, pp.148-149). With removal of fixed location gear (traps) in the mid-1930's (Washington State Legislature, Initiative 77 of 1934), the distribution of the catch was substantially altered. Table 2 shows the catch distribution for 1937, 1955, and 1967 (note that data are for total Washington State catch). It can be observed that most of the catch is taken by the net-type gear and the dominant species contributing to the total catch are the pink and sockeye salmon. Gregory and Barnes state that the prices paid to fishermen for salmon in the year 1937 were (20):

	Troll	Net
Sockeye	---	10¼¢ per lb.
Pink	---	2¼¢ per lb.
Silver	7¢ per lb.	4 ¢ per lb.
Chinook	11¢ per lb.	11 ¢ per lb.

	Catch (numbers of fish)			
Period	Maximum	Average	Minimum	Range
1913-19	39,626,690	13,669,931	3,910,622	35,716,068
1920-39	11,285,566	5,538,868	1,566,833	9,718,733
1940-59	10,450,875	4,748,246	1,017,532	9,433,343
1960-69	7,608,633	3,076,503	1,233,714	6,374,919

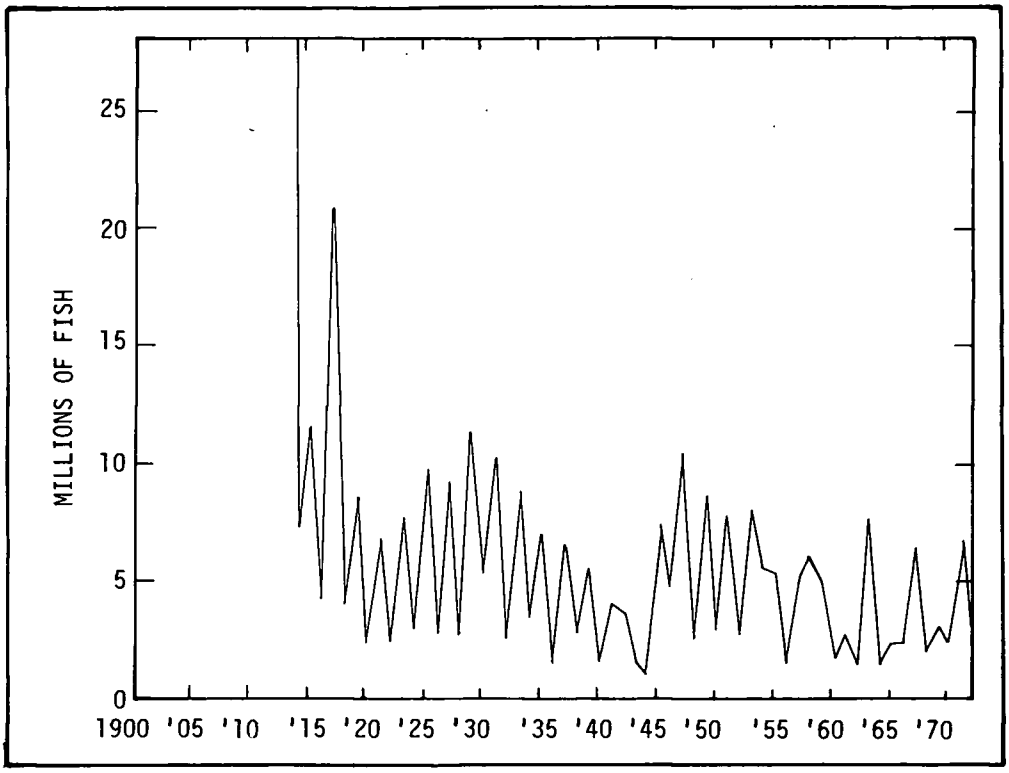

Fig. 1. Annual Puget Sound salmon catch.

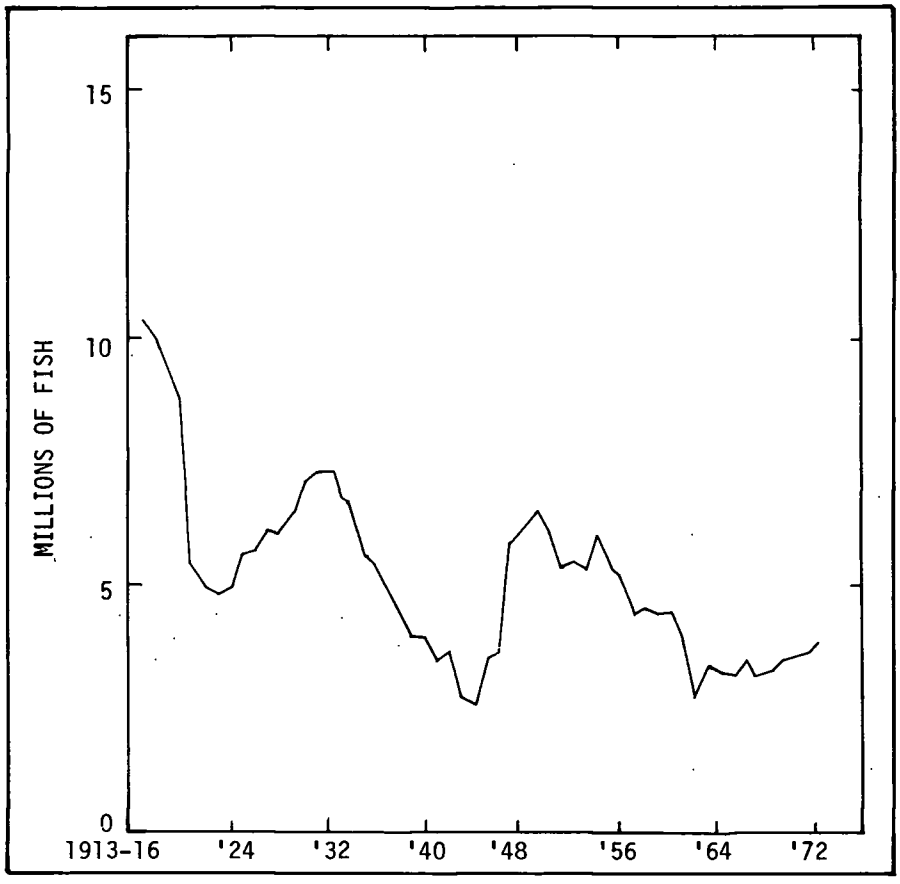

Fig. 2. Puget Sound salmon catch (number of fish) plotted as a 4-year moving average.

Table 1. Catch of salmon on Puget Sound, excluding offshore catches (in numbers of fish)
Source: 1972 Fisheries Statistical Report, Washington State Department of Fisheries

Year	Chinook	Chum	Pink	Silver	Sockeye	Total	4-Year Moving Average
1913	290,044	604,857	15,907,710	1,225,115	21,598,964	39,626,690	
1914	425,979	1,686,137	75,491	1,499,306	3,451,402	7,138,315	
1915	301,192	1,884,144	7,368,713	1,108,896	804,385	11,467,330	
1916	301,178	1,884,147	68,098	1,108,898	804,387	4,166,708	15,599,761
1917	440,864	1,095,015	13,345,280	936,242	4,961,933	20,779,334	10,887,922
1918	477,246	1,156,571	77,849	1,637,525	561,431	3,910,622	10,080,999
1919	347,766	1,475,091	4,667,820	1,363,153	746,694	8,600,524	9,364,297
1920	271,926	683,070	19,566	569,505	652,613	2,196,680	8,871,790
1921	268,982	270,193	4,401,516	762,221	1,135,473	6,838,385	5,386,553
1922	208,359	502,230	32,389	892,260	505,551	2,140,889	4,944,120
1923	224,624	637,882	5,534,086	887,471	482,387	7,766,450	4,735,601
1924	245,601	859,983	100,046	946,720	746,839	2,899,189	4,911,228
1925	284,496	534,812	6,665,345	869,013	1,242,820	9,596,486	5,600,754
1926	253,129	1,063,695	24,489	703,292	431,767	2,476,372	5,684,624
1927	287,762	526,868	6,526,034	1,028,815	987,749	9,357,228	6,082,319
1928	243,214	1,044,101	9,481	760,697	608,569	2,666,062	6,024,037
1929	311,642	1,486,434	7,432,802	806,971	1,247,717	11,285,566	6,446,597
1930	280,145	1,011,360	17,393	574,944	3,237,423	5,121,265	7,107,780
1931	207,898	682,495	8,131,922	512,867	723,275	10,258,457	7,333,088
1932	179,566	1,092,309	8,839	457,204	818,561	2,556,479	7,305,692
1933	210,602	504,139	6,039,870	535,978	1,575,236	8,865,825	6,700,757
1934	209,482	866,829	13,090	451,176	2,648,295	4,188,872	6,467,658
1935	76,043	718,647	4,993,613	577,401	535,385	6,901,089	5,628,316
1936	78,789	783,361	5,990	246,895	451,798	1,566,833	5,378,405
1937	93,060	774,195	4,167,791	347,858	870,275	6,253,179	4,725,243
1938	58,325	802,177	7,865	321,215	1,408,069	2,597,651	4,327,438
1939	61,003	331,350	3,945,844	358,619	547,587	5,244,403	3,913,267
1940	70,816	565,033	4,999	260,796	652,319	1,553,960	3,910,048
1941	72,166	672,715	1,451,640	275,514	1,548,130	4,020,165	3,351,795
1942	42,309	643,976	1,896	180,147	2,922,860	3,791,188	3,650,179
1943	56,583	396,191	757,176	217,745	196,587	1,624,282	2,745,149
1944	67,827	320,271	4,251	299,060	326,123	1,017,532	2,611,042
1945	87,501	421,096	5,768,811	378,946	718,414	7,374,768	3,449,693
1946	62,262	1,250,821	190	205,790	3,099,743	4,618,806	3,656,597
1947	37,380	595,104	9,273,596	468,642	76,153	10,450,875	5,863,245
1948	41,491	940,771	201	370,662	922,344	2,275,469	6,177,730
1949	51,913	439,933	6,754,592	425,733	908,753	8,580,924	6,479,269
1950	45,542	886,559	9,854	605,717	1,217,315	2,765,987	6,016,064
1951	51,797	796,293	5,392,848	423,324	1,128,829	7,793,091	5,351,618

Table 1. continued.

Year	Chinook	Chum	Pink	Silver	Sockeye	Total	4-Year Moving Average
1952	59,559	772,887	1,708	653,610	1,113,508	2,601,272	5,433,069
1953	58,659	346,293	5,359,585	341,518	1,961,005	8,067,060	5,304,603
1954	58,632	422,780	218	214,394	4,757,588	5,453,612	5,976,509
1955	57,244	212,360	3,837,862	300,048	933,725	5,313,258	5,356,551
1956	46,413	105,346	381	409,211	900,128	1,461,479	5,071,602
1957	48,623	103,495	2,986,258	293,949	1,688,945	5,121,270	4,335,155
1958	50,416	420,093	2,907	351,812	5,254,738	6,080,776	4,491,946
1959	55,323	361,095	2,427,036	347,820	1,807,862	4,999,136	4,413,415
1960	64,719	135,017	305	103,787	1,190,726	1,494,554	4,421,684
1961	81,084	133,243	688,213	384,177	1,377,712	2,664,429	3,807,474
1962	48,207	173,681	121	414,208	754,488	1,390,705	2,634,956
1963	94,007	295,367	5,671,717	232,822	1,314,725	7,608,633	3,287,330
1964	75,202	247,345	490	401,763	508,914	1,233,714	3,222,120
1965	96,297	191,684	624,177	405,060	1,022,984	2,340,202	3,141,064
1966	102,852	404,462	809	634,588	1,338,518	2,481,224	3,413,693
1967	98,752	271,632	3,696,657	287,763	2,094,774	6,449,578	3,123,930
1968	107,929	462,399	289	450,207	901,003	1,921,827	3,295,958
1969	104,076	145,365	942,178	360,185	1,628,185	3,180,165	3,505,949
1970	150,750	217,649	1,796	849,998	1,362,262	2,582,455	3,531,256
1971	212,230	151,416	2,490,854	705,793	3,063,116	6,623,409	3,574,714
1972	186,500	788,196	3,446	643,643	1,144,987	2,766,772	3,785,950

Records of the Washington State Department of Fishery Statistics indicate the following average prices per pound for salmon since 1965:

	Chinook Troll/Net	Chum Troll/Net	Pink Troll/Net	Silver Troll/Net	Sockeye Troll/Net
1965	55 ¢/35 ¢	19 ¢/23 ¢	17 ¢/13¼¢	37 ¢/27¼¢	31 ¢/35 ¢
1966	58 ¢/37 ¢	28 ¢/24 ¢	27 ¢/24 ¢	40 ¢/31 ¢	46 ¢/35 ¢
1967	62 ¢/43 ¢	18 ¢/30 ¢	20½¢/14 ¢	46½¢/33 ¢	31 ¢/34 ¢
1968	67 ¢/48½¢	29½¢/27 ¢	28½¢/16½¢	46 ¢/35 ¢	43½¢/38½¢
1969	76 ¢/56 ¢	41½¢/35 ¢	25½¢/20 ¢	48½¢/40 ¢	50 ¢/43 ¢
1970	84½¢/60 ¢	33½¢/26 ¢	34 ¢/19 ¢	58 ¢/40 ¢	53½¢/43½¢
1971	68 ¢/43 ¢	29 ¢/31 ¢	26 ¢/19 ¢	39 ¢/32 ¢	45 ¢/44 ¢
1972	84 ¢/65 ¢	31 ¢/42 ¢	36 ¢/18½¢	64 ¢/59 ¢	59 ¢/50 ¢

Those same statistical records also indicate that there were 3,032 licensed salmon-catching units in 1965 (almost evenly divided between troll and net gear) and 102 licensed salmon buyers. Twenty-two salmon buyers purchased the net-caught salmon. During the 1964-1971 period, the average number of buyers remained fairly stable, as did the number of net-type catch units.* However, the number of troll fishing units trebled during this same time period. It is interesting to note from Table 2 that the catch per unit of net gear between 1955-1967 remained fairly stable, while the catch per unit of troll gear was reduced to almost one-half of the 1955 average. With a stabilized yield, the average catch per fishing unit is directly related to the intensity (number of units) of the fishing effort.

THE SUPPLY OF SALMON

"Freshly caught" salmon are necessary inputs for the production of processed salmon. There is an extensive literature on the theory of fisheries supply but an analysis and review of that literature are beyond the scope of this study (6, 11, 42).

The data presented in this study give indication that the annual harvest of salmon declined until the mid-1950s. Since that time, there is evidence that the annual harvest of salmon has become relatively stable. During the last 20 years, the average catch per unit for the net fishery has remained reasonably constant but the average catch per unit in the troll fishery has declined. The total catch has increased but not at the same rate that the number of troll fishing units have increased. It is important that these features of the supply of salmon be differentiated because the net-fishery continues to account for three-quarters of the supply of all salmon and the buyers for that portion number about 20.

THE PRODUCTION OF SALMON

Because the canned form is still dominant in the salmon industry, it would seem obvious that the aggregate pack of canned salmon has declined along with the diminishing schools of fish. This fact is clearly depicted by the production data in Table 3. During the four decades since 1913, the pack of canned salmon has dropped to about one-fifth of its level in the early years of this century. This decline is plotted in Figure 3; Figure 4 provides a 4-year moving average of smoothed data for a clearer portrayal of the long-term trend. During this same period, the number of canneries on Puget Sound decreased from 45 to 16. Chart 4 also provides evidence that, along with the net catch of salmon, the average level and the range of the canning pack have stabilized subsequent to the mid-1950s. This trend toward stability is best summarized in the following format:

*Recent data suggest that the number of gill net licenses may have increased since 1971.

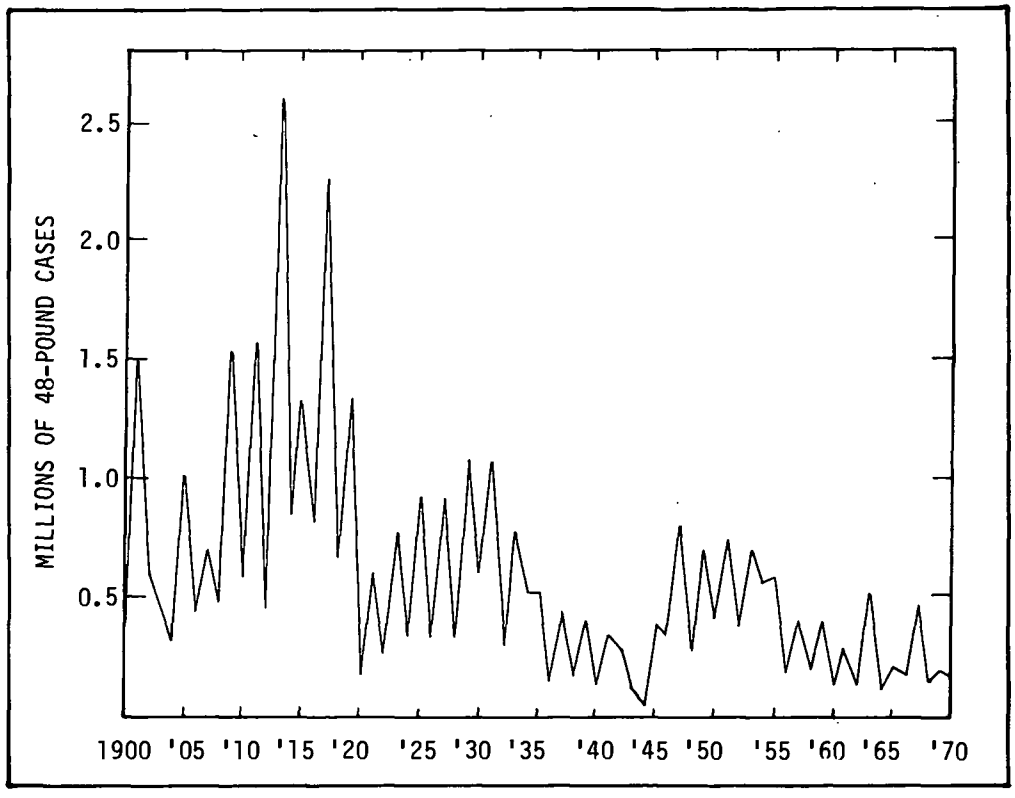

Fig. 3. Annual Puget Sound salmon pack.

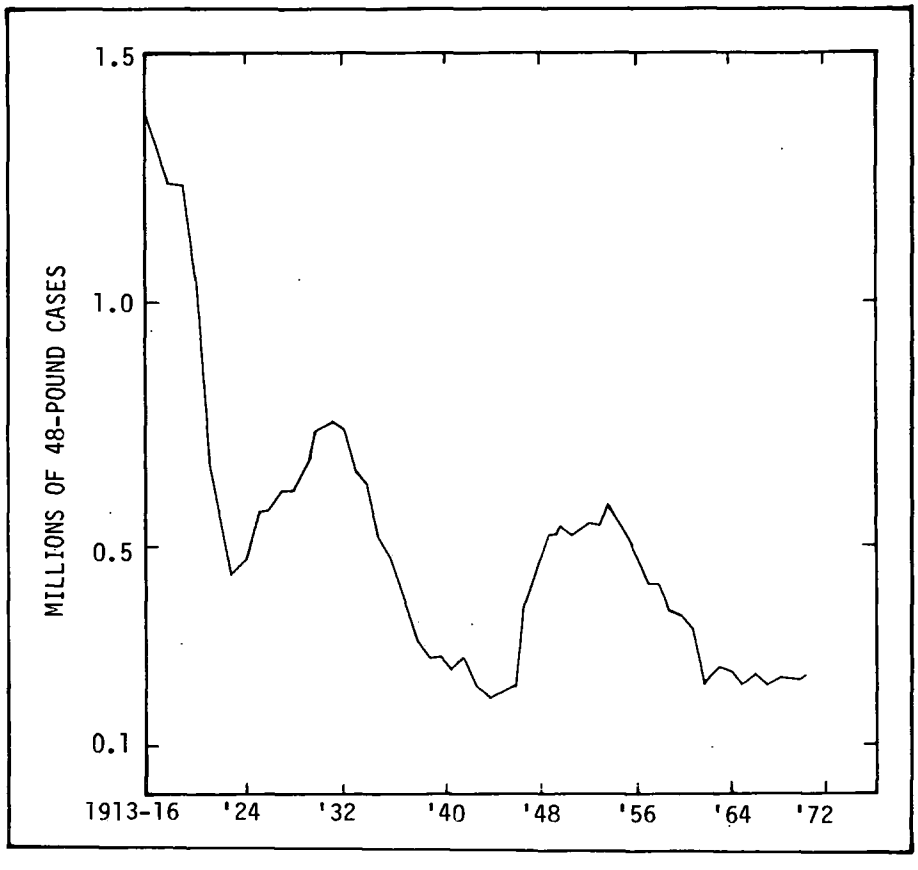

Fig. 4. Puget Sound canned salmon pack (48-pound cases) plotted as a 4-year moving average.

Period	Canned Salmon Pack for Puget Sound (48# cases) Maximum	Average	Minimum	Range	Average Number of Canneries
1913-19	2,585,065	1,383,970	622,731	1,962,334	34
1920-39	1,139,351	521,371	122,806	1,106,545	16
1940-59	793,142	408,733	39,484	753,658	18
1960-69	514,973	223,500	85,915	428,058	16

Averages can be misleading. For example, it is worth noting that in 1971 there were 18 canneries reported operating on Puget Sound (28). Of this group, 3 packed less than 1,000 cases and only 8 packed more than 10,000 cases of canned salmon. The picture presented suggests confirmation of the Crutchfield and Pontecorvo thesis that the salmon industry is plagued with chronic overcapacity at the processor as well as at the catch-unit level (12).

Little has been or will be said concerning the productive capacity for the fresh and frozen salmon. As has been stated by numerous fish processors and wholesalers, "all it takes to get into the fresh fish business is a box of ice and a pickup truck." These small purveyors make up the bulk of the fish buyers for fresh salmon in the State of Washington. Their primary purchases are the troll salmon and they have a significant impact upon the competitive price structure for troll caught chinook and silver salmon. With the units of purchase small and the buyers numbering more than 100, the troll salmon market appears competitive in its structure. Nevertheless, the same processors who dominate the salmon fishery because of cannery facilities also maintain the necessary freezer facilities to support a well rounded operation. With canned and frozen salmon accounting for more than 85 per cent of the total salmon catch, there is little benefit in studying the market for fresh salmon. However, because of the importance of the effect of alternative forms of some species of salmon it is necessary to understand that price differentials exist. The following average prices for canned and fresh salmon were taken from the Pacific Packers Report and the Market News Service of the Bureau of Fisheries:

AVERAGE WHOLESALE CANNED SALMON PRICES (48/1# CASE)

YEAR	CHINOOK	CHUM	PINK	SOCKEYE	SILVER
1965	$ 31	$ 31	$ 28	$ 37	$ 30
1966	31	25	28	37	30
1967	31	27	31	40	34
1968	34	28	31	42	34
1969	38	29	33	46	38
1970	39	30	34	41	38
1971	39	32	36	46	38
1972	No quotes	40	45	57	48

WHOLESALE FRESH SALMON PRICES

YEAR	MED. CHINOOK	SILVER
1965	.70/lb.	.70/lb.
1966	.75	.70
1967	.95	.80
1968	.95	.80
1969	.95	.90
1970	1.00	.90
1971	1.10	.95
1972	1.20	1.00

	Chinook	Silver	Pink	Sockeye	Chum	Total	VESSEL INFORMATION No. of Licensed Units	VESSEL INFORMATION Average Catch Per Unit
1937								
Purse seines	35,467	506,349	4,342,087	795,004	672,780	6,351,687	213	29,820
Gill nets	295,291	162,804	461,367	135,033	265,388	1,319,883	1,111	1,188
Other nets[1]	62,208	53,076	265,928	71,270	44,368	496,850	450	1,104
Total net units	392,966	722,229	5,069,382	1,001,307	982,536	8,168,420	1,774	
Troll gear[2]	259,432	347,208	16,906	--	--	623,546	395	1,579
TOTAL OF ALL GEAR	652,398	1,069,437	5,086,288	1,001,307	982,536	8,791,966	2,169	4,053
Canned salmon pack (48# cases)	87,849	38,921	326,371	65,288	29,285	547,714		
1955								
Purse seines	20,048	243,881	4,141,711	628,365	120,516	5,154,521	375	13,721
Gill nets	179,710	231,617	502,539	385,535	204,749	1,504,150	1,395	1,078
Other nets[1]	66,768	73,700	453,373	103,692	49,736	747,269	180	4,151
Total net units	266,526	549,198	5,097,623	1,117,592	375,001	7,405,940	1,950	
Troll gear[2]	384,695	493,856	109,925	549	86	989,111	604	1,638
TOTAL OF ALL GEAR	651,221	1,043,054	5,207,548	1,118,141	375,087	8,395,051	2,554	3,287
Canned salmon pack (48# cases)	18,929	50,251	412,159	87,558	44,901	613,798		
1967								
Purse seines	48,971	102,306	3,146,174	1,398,624	130,220	4,817,295	346	14,169
Gill nets	97,822	251,386	359,765	664,543	108,833	1,482,349	1,397	1,061
Other nets[1]	77,849	80,050	190,727	106,027	52,609	507,262	146	3,474
Total net units	224,642	433,742	3,696,666	2,160,194	291,662	6,806,906	1,889	
Troll gear[2]	131,736	779,417	380,576	177	393	1,292,299	1,635	790
TOTAL OF ALL GEAR	356,378	1,213,159	4,077,242	2,160,371	292,055	8,099,205	3,524	2,323
Canned salmon pack (48# cases)	6,753	21,104	263,052	162,856	13,263	467,028		

[1] Includes traps, reef nets, dip nets, fish wheels, set nets and drag seines.

[2] Denoted as hook and line during 1937.

Source: Washington State Department of Fisheries, 1968 Fisheries Statistical Report.

Table 2. Distribution of salmon catch in the state of Washington (numbers of salmon caught)

Table 3. Puget Sound salmon pack (48-pound cases).
Source: 1972 Fisheries Statistical Report, Washington State Department of Fisheries

Year	Chinook	Chum	Pink	Silver	Sockeye	Total	4-Year Moving Average
1913	1,805	55,786	802,040	62,492	1,662,942	2,585,065	
1914	27,140	290,476	1,016	158,932	339,786	817,350	
1915	28,942	422,728	589,195	185,522	85,430	1,311,816	
1916	26,942	393,445	138,798	148,824	82,349	795,358	1,377,397
1917	89,048	384,726	1,135,169	176,003	462,852	2,247,802	1,293,082
1918	62,821	264,922	6,607	235,795	52,587	622,731	1,244,427
1919	71,190	529,967	437,731	201,696	67,087	1,307,670	1,243,390
1920	27,482	47,831	4,921	25,321	62,751	168,306	1,086,627
1921	25,662	27,315	375,900	65,303	95,667	589,847	672,139
1922	21,911	66,746	2,985	115,405	50,235	257,282	580,776
1923	16,103	100,652	469,869	120,908	50,003	757,535	443,243
1924	16,319	143,074	6,699	84,850	70,749	321,691	481,589
1925	29,983	42,715	557,086	172,007	104,973	906,764	560,818
1926	27,780	112,201	2,128	120,950	44,567	307,625	573,404
1927	42,575	41,813	585,869	134,254	103,550	908,060	611,035
1928	24,628	145,735	5,816	92,770	61,044	329,993	613,111
1929	32,776	149,860	737,508	106,825	112,383	1,139,351	671,257
1930	33,073	66,801	3,976	122,592	360,190	586,632	741,009
1931	28,009	55,117	706,288	76,471	87,745	953,630	752,402
1932	20,337	124,833	1,659	60,326	74,605	281,760	740,343
1933	21,490	39,976	540,033	44,515	128,518	774,532	649,139
1934	15,274	69,303	3,687	68,849	349,602	506,815	629,184
1935	9,737	15,319	371,296	71,445	51,146	518,943	520,513
1936	6,029	43,307	1,345	29,191	42,894	122,806	480,774
1937	8,968	17,061	326,371	32,559	60,355	445,314	398,470
1938	2,787	7,852	193	9,820	139,173	159,825	311,722
1939	2,439	14,505	275,485	54,773	43,511	390,713	279,665
1940	1,991	21,168	2,732	30,376	59,354	115,621	277,868
1941	4,706	21,170	153,686	45,968	110,605	336,135	250,574
1942	1,460	3,932	843	7,032	267,855	281,122	280,898
1943	2,872	224	61,480	26,220	19,117	109,913	210,698
1944	1,178	15	306	476	37,509	39,484	191,664
1945	5,095	1,512	305,213	19,104	53,055	383,979	203,625
1946	8,367	43,843	92	11,533	268,561	332,386	216,441
1947	18,248	93,749	607,330	65,722	8,119	793,142	387,248
1948	22,387	94,238	1,502	65,744	90,441	274,312	445,955
1949	5,922	14,904	527,478	57,960	80,547	686,811	521,663
1950	6,407	182,119	967	78,360	116,458	384,311	534,644
1951	7,570	94,113	438,732	76,580	118,151	735,146	520,145
1952	5,750	126,372	760	108,161	114,638	355,681	540,487

Table 3. continued

Year	Chinook	Chum	Pink	Silver	Sockeye	Total	4-Year Moving Average
1953	2,965	35,598	443,524	35,705	178,323	696,115	542,813
1954	2,799	39,260	25	16,489	501,496	560,069	586,753
1955	7,117	32,532	412,044	47,848	85,136	584,677	549,136
1956	2,513	21,831	786	54,528	84,052	163,710	501,143
1957	2,928	10,006	221,014	45,218	119,985	399,151	426,902
1958	1,464	68,969	1,570	27,249	450,066	549,318	424,214
1959	4,586	36,175	168,322	49,785	135,480	394,357	376,632
1960	2,575	7,159	41	6,363	96,627	112,705	363,883
1961	3,819	22,211	73,117	50,092	122,751	271,990	332,093
1962	4,447	8,144	232	24,156	71,953	108,932	221,996
1963	5,622	6,194	378,515	14,364	110,278	514,973	252,150
1964	5,176	9,601	30	22,411	49,697	86,915	245,703
1965	3,149	12,760	62,227	30,334	84,059	192,529	225,837
1966	5,364	10,445	330	22,441	133,006	171,586	241,501
1967	3,396	12,067	260,931	18,891	159,990	455,275	226,576
1968	8,352	16,386	--	28,004	71,279	124,021	235,853
1969	3,832	3,847	67,026	15,696	99,079	189,480	235,091
1970	589	2,038	1,142	65,252	102,101	171,122	234,975

The purpose of this chapter was to give the reader some background for the Puget Sound salmon fishery. This includes the dynamics of the salmon fishery itself, the production units involved in the processing of the salmon, and the prices received for both freshly caught and processed salmon. The picture is one of a generally diminishing supply of salmon with current supplies appearing to be stable. At the same time, the number of net-catch units appears to be stable and those units account for more than three-quarters of the entire catch. The troll units continue to increase and the resulting catch per unit has decreased (the average cost has increased). Less than 24 buyers are available to receive the net fish while more than 100 buyers bid for the troll-caught salmon. This is because only cannery facilities can handle the net-caught salmon and the average number of canneries on Puget Sound has been less than 20 for more than 30 years.

the production of canned salmon

Salmon, like other foodstuffs, is canned to preserve it for use by individuals distantly remote from the original catch location. When packs of 5,000 to 15,000 cases were made during the catch seasons in the early history of the salmon canning industry, the bulk of the work was done by hand. Demand increased for the canned product and hand labor was incapable of packing enough salmon during the short summer season. Additionally, there was a substantial increase in labor costs, especially in the large canneries being opened in Alaska during the last decade of the 19th century. The result was the development of machines of increasing complexity and speed to substitute for the massive amount of labor. Because this transformation from a labor to a capital intensive industry has had a substantial impact upon the structure of the salmon canning industry, a review of the canning process and its development is provided in this chapter.

THE TECHNOLOGICAL EVOLUTION OF SALMON CANNING

When salmon canning was in its infancy, a pack of from 150 to 200 cases was considered a normal level of production in a given day. Now it is possible for a modern cannery to turn out 9,000 cases per day, if the fish were available. The concept of canning has not changed dramatically since the early days on the Sacramento River, only the production technology. The following excerpts contrasting these changes are provided from accounts of an early salmon canner, R.D. Hume, and one of the modern giants of the salmon canning industry, New England Fish Co. (5). Mr. Hume describes the early process of can-making as follows:

> The bodies of the cans were first cut to proper size by the squaring shears, a line was then scribed with a gauge about three-sixteenths of an inch from one edge, and they were next formed into cylindrical shape by the rolls. They were then taken to the soldering bench and one edge lapped by the other until

the edge met the line that had been scribed and fastened there by being soldered a small part of the length to hold them in place for the further purpose of seaming. They were then placed in either the iron clamp, which had a piece of wood attached to its underside, and held firmly, the clamp being closed by the operation of a treadle, or were slipped on a piece of wood, which was bolted to the bench, while being held in place by the triangular hand seamer, which was pressed down on the lap of the seam by the left hand of the operator. When this had been done a piece of solder, which had been prepared by shaking in a can together with rosin, was placed on the seam and melted and rubbed lengthwise of the seam. After cooling the bodies were ready for the end or bottom, which operation was brought about by first cutting out circular blanks with the rotary shears, and then placing them in the cast-iron die and bringing the handle of the screw press around with a swing with force enough to form up the end or bottom. In this operation there were many difficulties, as the ends or bottoms would many times stick to the upper part of the die and refuse to come off, and finger nails were pretty short in those days. To get the ends out of the lower part of the die was not so bad, as a wooden plunger operated by a treadle knocked them out, but sometimes they were in pretty bad shape. When the bottoms or ends were ready they were slipped on the bodies and the edge of the bottom rolled about in a pan of powdered rosin until the seam was well dusted. A piece of solder similar in size and preparation as used for the side seam was placed in the can. They were then placed on the smooth side of the cast iron slabs, and the operator, with a hot soldering copper shaped to fit the circle of the can, melted the solder and by turning the can rapidly soldered the full circumference. The out-put of this can factory was imperfect, as at least one-half of the seams burst, owing to the lack of experience of the manager or want of good judgement (22, pp. 19-20).

By the early 1880s, California Can Company was making cans in San Francisco and, shortly after that, Pacific Sheet Metal Works built a can-making facility at Astoria. Both these operations were ultimately purchased by American Can Company. The first sanitary can-packing machinery for the salmon industry was installed at its Astoria facility in 1911. The dramatic development of can-making technology was reflected in the following statement by New England Fish Company in describing the source for its cans in 1953:

> Cans are made in the can factory at Portland, Seattle, or Vancouver and are shipped to the cannery with bottoms attached, in bags, or flattened and without bottoms attached, in cartons that will receive the finished product. Both the pound-tall and the half-flat can usually are shipped flat. A regular shipping case that will hold only 48 filled, sealed, tall cans will hold 360 flattened cans. At the cannery, machines round out these flattened can bodies and attach the bottoms, timed to the speed of the filling machines (5, pp.54-55).

The changes wrought in the processing of canned salmon are no less remarkable. Mr. Hume's account of the early salmon canning process is as follows:

> When the can making was well underway Mr. Hapgood then turned his attention to getting the apparatus for canning on board the houseboat. This in the cooking department consisted of a kettle made of boiler iron about 36 inches in diameter and 5 feet in depth, set in a brick furnace and fired from underneath. Alongside was a round-bottom, cast-iron pot holding about 60 gallons of water and heated in the same manner. These kettles, with a dozen coolers or circular sheet-iron

pans with ropes attached and with holes cut in the bottom for drainage, a set of 5-inch blocks and tackle, with a sheet-iron fire pot and a scratch awl, completed the bathroom outfit. The can filling and soldering room was furnished with a table through the center, where cutting the salmon into pieces to suit and the filling of the cans was done. On each side of the room there was a bench running the full length, on the end of one of which the cans were placed to receive the pickle, which was used at that time instead of the small quantity of salt that is placed in the cans during the operations of these later days. After the salmon had been cleaned by removing the entrails and washing them outside the covered portion of the scow, they were brought inside and placed on the table, and a man with a butcher knife in one hand and a stick in the other, which had a mark on it showing the length of the pieces desired, cut the fish into sections corresponding to the length of the mark on the stick. He then proceeded to cut the sections into pieces to suit the cans. Then three or four operators placed the salmon in the cans and shoved them along the table to where a boy wiped the top edge and passed them along to two others who placed tops which fitted inside the rim. The cans were then taken in wooden trays to the bench opposite the starting point, which was fitted with four sheet-iron pots, and at the one nearest the entrance to the entrance to the house on the scow a man put a soldering flux on the top edge, which was made by adding zinc to muriatic acid, and then with a pointed soldering copper and a stick of solder melted the solder until a small portion could be drawn around the grove formed by the edge of the can and the bevel of the top. From there the two cans were taken to the other parts of the bench, where two men finished soldering the head in, and then taken to the third man, who soldered, or, as it was called, buttoned, the end of the seam lap. The cooking department or bathroom, as it was called, was separated from the filling or soldering room by a partition. The cans were shoved through a hole in the partition.

...When the cans had been soldered and entered the bathroom they were put in the coolers and lowered into the cast-iron pot, one cooler of cans being cooked at a time. The cooler was lowered into the boiling fresh water until the cans were submerged to within one inch of the top ends and left to cook one hour; then they were hoisted out and the vent holes in the center of the top soldered up, after which they were dumped in the boiler-iron kettle, which held a solution of salt and water of density sufficient to produce, when boiling, a heat of 228° to 230°F. They were cooked in this solution for one hour and then taken out of the kettle with an iron scoop shaped like a dip net, with a wooden handle about 6 feet in length. They were dumped into a tank of water on the other side of the partition, receiving many a bump and bruise in the operation. Then they were washed with soap and a rag to remove the dirt and grease, each can being handled separately. When this was done they were piled on the floor of the packing room and in a few days were painted with a mixture of red lead, turpentine, and linseed oil, for at that time buyers would have no canned salmon, no matter how good the quality, unless the cans were painted red (22, pp.20-21).

Within 30 years the Jensen can-filling machine and can-topping machines were developed in the Columbia River area; in 1906, the first "Iron Chink" was used for butchering the freshly caught salmon. The 1920s saw the development of high-speed fillers and automatic vacuum sealers; automatic cutters were well developed by the early 1930s. These developments, along with

the widespread use of the sanitary can since the turn of the century, have permitted the modernization of the salmon canning industry so aptly described by New England Fish Company in 1953:

> Salmon, when they arrive at the cannery by seiner, troller, gill-netter or packer, are removed from the boats by power elevators with the aid of water, counted and segregated in bins according to species and grades...
>
> Modern salmon canning has become a very highly mechanized, straight line production unit. This is necessary to handle large quantities of salmon during a very short production season. Only by speed of handling can quality be preserved. Labor for a short season is very hard to get and very expensive and this is another reason for highly mechanized production lines.
>
> The machine that cleans the salmon, the "Iron-Chink," is a marvelous product of inventive genius. It handles whole fish at the rate of about 75 a minute, removing head, fins, tail, scales and entrails, also washing away the blood along the backbone. From the "Iron Chink" the fish are conveyed to the "sliming" tables where they are thoroughly scrubbed with running fresh water to remove the last traces of blood and slime.
>
> For hand filled cans, the next step is to cut the fish into lengths that properly fit the height of the can. This is done by a series of evenly spaced sharp knives cutting the fish into many pieces of the proper length. These pieces are then ready for hand filling. Cutting for machine filling is done by the same machine that fills the can...
>
> Hand filling is done by women. Automatic filling is accomplished by remarkable machines which take whole, dressed fish and empty cans, fills and salts them at the rate of 240 per minute.
>
> Filled cans are checked by an automatic weighing machine which throws out light weight cans. The cans are conveyed in a steady stream, passing, if not already salted, first under a salting machine which adds the correct amount of pure dry salt to each can, then to an automatic weighing machine to separate light weight cans, and next they pass between inspectors who remove off grade cans and those showing defects in workmanship. The latter are repacked, the former are placed in a separate lot. From the inspection tables, the cans pass through closing machines which affix covers on the cans and seal them under high vacuum at the rate of 240 per minute.
>
> From the sealing or closing machines, the cans go into metal trays or "coolers," which are stacked on trucks. These trucks of cans are run into retorts, where they are cooked for an hour and a half with "live" steam at 240 degrees Fahrenheit. This sterilizes the contents of the cans and softens the bones so that they, too, are edible.
>
> After cooking, the "coolers" go through a continuous washer then rinsing vat, and again are stacked, this time on pallets. Lift trucks convey the stacks of cans to a cooling room, where they are cooled overnight. The stacks of cooled cans then go to a machine which inverts the "coolers" and places the cans on a mechanism that feeds them in a steady stream to the conveyor to the labeling machine.
>
> From the labeling machine they go to a machine that automatically fills the empty cases. These cases then pass through a case sealing machine and then by conveyor to the warehouse, where they are stacked and later shipped to another warehouse, or to the market (5, pp.54-57).

In 1905, a cannery required at least 300 laborers to produce a pack of 3,000 cases (48/1#) of canned salmon per day. By the

mid-20s, this same cannery could get along with only 150 laborers, and by 1935, a salmon cannery could turn out 3,000 cases per day with only 75 laborers. A modern salmon cannery is capable of producing 9,000 cases of canned salmon per day with the help of only 100 laborers. Even with a short production season (June 15 through October 15), a modern salmon cannery has the potential annual capacity of more than 700,000 cases--there were less than 500,000 cases of canned salmon packed in Puget Sound canneries in 1971, a peak year. During that year, the largest single packer, Whitney-Fidalgo seafoods, Inc., canned only 150,000 cases while the second largest packer, New England Fish Company, canned 75,000 cases.

By 1950, technological change had plateaued for the salmon canning industry. Not only had the supply of the necessary input for the process--salmon--become obviously scarce; the capital investment had become substantial. The cost of a salmon canning facility has gone from $100,000 in 1910 to more than $3,000,000 in 1974. A brief summary of this transition from a labor to a capital intensive industry is depicted in the following tabular format--source references are bracketed "( )":

SOURCES OF CAPITAL FOR THE SALMON CANNING INDUSTRY

Cobb's early study of the salmon industry (10) indicates that it was relatively easy to enter the salmon canning industry in the late 19th century because of the modest capital requirements and high labor usage. Subsequent to that time, the transition from labor to a highly mechanized form of production required large inputs of capital. Salmon canning operations have traditionally been too small for the usual sources of capital--stocks and bonds--and have been forced to internal financing and short-term credit sources. In 1940, Homer Gregory noted: "Generous credit offered by supply houses and brokers has kept the salmon industry well filled with small-sized packing concerns. Cannery equipment (except the Iron Chink) is rented by operators from machine and can manufacturing companies" (19, p.410). This, perhaps, contributed to the long history of business failure within the industry.

A major source of capital for the salmon canning industry during this period of growth and development was the can manufacturing company. The extent to which this financing device (leasing equipment) was being used was detailed dramatically in the 1949 anti-trust action against American Can Company (87 F. SUPP. 18). Through the use of the equipment leasing device, the can companies were able not only to establish tieing contracts for the sale of their cans but to maintain differential pricing by varying the lease terms for different sized canners. The decision went against American Can Company, and, subsequently, the can manufacturing companies stopped manufacturing and leasing canning equipment. A 20-year source of funds for the salmon canning industry was premanently eliminated by that decision.

Currently a few large firms have resorted to the capital markets for their financial requirements (Whitney-Fidalgo, New England Fish Company, and Bumblebee Packing Company, but the remainder of the industry participants continue to rely heavily upon short-term credit as the major source of operating and capital funds.

THE COST OF PROCESSING SALMON

In general, data on salmon processing costs are rather skimpy and inconclusive. Until very recently the industry tended to avoid the use of production costing techniques and joint rather than segregated cost information has been the accounting rule. In his interviews with a number of the early packers, DeLoach found that no production cost information was kept--a factor which may have contributed to the large number of business failures in those years (14). Gregory and Barnes calculated the

Year	Capital Investment (exclusive of site cost & unadjusted for price level)	Maximum Required Daily Labor Hours	Maximum Daily Capacity (48/1# cases)
1910	$ 100,000 (1)	2,400 (8)	3,000 (8)
1937	250,000 (8)	600 (8)	4,000 (8, 14)
1965	1,000,000 (31)	800 (23)	9,000 (5,23,12)
1974	3,000,000 (28)	800 (23)	9,000 (5,28,12)

1937 operating costs for a case of canned salmon to be (20, p.193):

Raw Salmon	$ 2.80
Labor	.64
Materials & Overhead	.30
Total Cost of Packing	$ 3.74

With an average selling price of $5.10 per case this yeilds a gross margin (sales less cost of goods manufactured/sales price) of approximately 27 per cent. Interviews with a number of processors in 1968 permitted the following cost of processing estimates for canned salmon:

Raw Salmon	$ 28.00
Labor	1.20
Supplies	1.80
Overhead	1.00
Total Cost of Packing	$ 32.00

With an average selling price of $42 per case this indicates a gross margin of approximately 24 per cent for the canned product. These same processors also indicated that the average gross margin for the fresh and frozen processed salmon was also approximately 24 per cent. Certain of these large processors indicated that the resulting return on investment was substantially higher for fresh and frozen than for the canned product because of the high opportunity cost for replacement of canning facilities as contrasted to the cost of facilities for fresh and frozen production.

However, they also pointed out that decisions are made on the basis of "bottom line" accounting (where one looks only at the accounting net income) and that most canning facilities are fully depreciated (hence no cost assigned for use of the fully depreciated production facilities). Because of the current excess capacity, cannery facilities are considered as having a zero opportunity cost in terms of their real value* (a view supported by the number of canneries which have been abandoned rather than sold). There is no indication that any new canning facilities are planned and some processors talk of closing facilities and having other processors custom-can their requirements. A new entrant into the salmon processing industry would have to assign a relevant cost for the capitalized buying rights and any equipment purchased. This provides a stark contrast to the cost base for existing industry decision makers.

*Because of the unique characteristics of salmon canning equipment, no suitable alternative use has been found.

summary

Chapter III provided some insight into the dynamics of the biological forces which have affected the salmon processing industry while this chapter addresses itself to the technological changes which have transformed the salmon canning industry. Economists have been less than kind in their evaluation of the current overcapacity which has plagued the industry but change is never even and predictable.

As late as the early 1930s, the industry was not viewed in terms of overcapacity. If anything, it was undercapacity in times of major fish runs which received the attention of government authorities and economists. In a report submitted to the Secretary of Agriculture in 1933, W.G. Campbell, chief of the Food and Drug Administration, made the following statement:

> The salmon pack of 1932 approximated 5,867,590 cases and included some of the worst fish encountered in recent years. The large run experienced was undoubtedly the primary cause; canneries apparently could not handle the volume of fish received (39, p.6).

DeLoach in his 1939 study of the salmon canning industry pointed out that no cannery at that time had the capacity for the largest possible catch and, yet, few ever used their maximum capacity at that time for more than two or three days each season (14, p.49). One passage from that study does seem descriptive of the salmon industry:

> The extreme seasonality of the canning industry exposes estimates of practical capacity to the danger of serious error as a result of the necessity for deciding somewhat arbitrarily what number of working days shall be taken as the length of the working year. Furthermore, the perishable character of the product and the importance of weather considerations result

> in considerable uncertainty as to the length of day which should be used in estimates. Actual operations may drop to a few hours or be extended by night work to practically a double shift basis (14, p.49).

It is obvious that, up to the mid-1950s, two long term trends were taking place in the salmon processing industry. One was the diminishing availability of the supply of fresh salmon, both in the amplitude of the runs and the average annual catch size. The second was a corresponding growth in production technology. Both these forces appear to have stabilized, but their impact upon the long-term structure of the industry and the duration that impact will be felt remain indeterminate.

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