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Historic changes that have taken place on Oregon's commercial salmon fisheries are described in terms of their effects on the efficiency of fishermen. This historical analysis provides a background for comparative efficiency studies of Columbia River gillnetters and ocean trollers with the objective of determining which harvester group was more efficient and whether their method of fishing fully utilized the harvest potential of the resource.

Changes in efficiency for gillnetters on the Columbia River are reflected by the modernization of their fishing technology and the trend of management for increasing gillnetting restrictions. Concurrent changes in technology for ocean trollers are observed and provide a base for the study of a comparative vessel efficiency between gillnetters and trollers. The effect of the different harvesting methods upon the resource reflects differences in harvesting

efficiency between gillnetters and trollers. The lower harvesting efficiency among trollers is shown to partially limit the harvest potential of Columbia River chinook salmon.

Evolutionary trends in salmon fishery management have tended to decrease efficiencies for fishermen and to favor less efficient resource use by more people. Low levels of present fishermen efficiency characterized by declining vessel and harvest efficiency may result in reducing or limiting fishing effort in Oregon's future fisheries. The socioeconomic implications of such future restrictions require that management strategies incorporate new concepts of restricting the fishery for both efficiency and conservation purposes.

Efficiency In Oregon's Commercial Salmon Fisheries: A Historical Perspective

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I. INTRODUCTION

The commercial salmon fisheries on the Columbia River, developing in the 1870's, have undergone a series of technological and innovative changes resulting from attempts to manage a declining resource. Processes which brought about such changes have tended to affect the efficiency of fishermen in their harvesting of Columbia River salmon. A comparison of the changing efficiency of gillnetters and ocean trollers show the effects of historical developments upon the salmon resource, the fishermen who exploit it, and the present conditions of the fisheries. With the Columbia River system providing for the livelihood of Oregon's commercial salmon fishermen throughout history, its importance necessitates mention of some of its characteristics and native salmon runs.

The Setting and the Resource

The Columbia River, with headwaters at Lake Columbia in British Columbia, Canada, flows about 1,210 miles before emptying into the Pacific Ocean near Astoria, Oregon. Approximately 748 miles are in the United States and 462 miles are in Canada. Having a drainage area of 259,000 square miles of which 39,000 square miles are in Canada, its watershed embraces large parts of British Columbia, Washington, Oregon and Idaho and smaller portions of Montana, Wyoming, Utah and Nevada (Rich 1948:4).

From headwaters to mouth, the Columbia drops a total of 2,400 feet, creating a tremendous power potential that has been almost entirely harnessed by hydroelectric dams (Netboy 1973:264). Where the Columbia was at one time a free-flowing river, the many dams have turned it into a series of lakes. As the Columbia River is a major producer of anadromous fish, the large dams have created hazardous barriers to their migration. With the completion of impassable Grand Coulee Dam on the upper Columbia in 1938, 1140 miles of salmon spawning grounds were eliminated (Bullard 1968:99).

In spite of water resource developments throughout the Columbia River system, some suitable salmon and steelhead habitat remains below Grand Coulee Dam. The many runs of salmon and steelhead use the river to travel to and from the ocean, for spawning and as a nursery area for their young. Five species of salmon of the genus *Oncorhynchus* use the Columbia. Chinook salmon (*O. tshawytscha*), historically the most numerous and important of the salmon species, average over 20 pounds and have separate runs occurring in spring, summer and fall. Coho or silver salmon (*O. kisutch*), average 10 pounds and migrate in the late summer and fall months. Sockeye or blueback salmon (*O. nerka*), average six pounds and migrate to lakes in the upper Columbia in spring and summer. Chum or dog (O. keta), average nine pounds and occur mainly in the lowe during the fall months. The last species, pink or humpback salmon (O. gorbuscha), is infrequently found in the Columbia River and occurs mostly in the area of Puget Sound, Washington and northward. During their small run in the fall, they average about four pounds. One other important anadromous fish, the steelhead (Salmo gairdneri), averages 10 or 11 pounds and has separate runs in summer and in winter (Netboy 1973:28, 266).

Salmon and steelhead have been an important food resource and trading commodity for the people of the Columbia River area for many centuries. Many aboriginal groups harvested salmon to great extents without endangering the runs so far as we know. During the late 1800's, settlers of European descent harvested the resource with little restriction or apparent care for conservation. Increased industrialization, fishing pressure and deterioration of the habitat throughout the 1900's decreased the once numerous runs to a fraction of what they used to be (Netboy 1958). Presently in the 1970's, there still is a viable ocean troll, river gillnet, Indian and sport fishery operating on the salmon stocks produced from the Columbia River system. The question remains as to how the resource can best be preserved, enhanced, and utilized to the fullest potential, and yet distributed fairly among all fishermen groups.

Need for the Study

For the commercial salmon fisheries on the Columbia River, conservation of the resource has been the major objective of management regulations. When the need for conservation arose, the tendency in management was to restrict the most visible fishery. Generally, this appears to have been a curtailment of the more efficient commercial harvesting methods. After fishwheel operators, trapmen, seiners, dipnetters and setnetters were prohibited, only gillnetters and trollers were left as fishermen groups.

When public pressure influenced management towards decisions affecting the resource, new regulations did not appear to have always enhanced harvesting efficiency or conservation of the salmon resource. Since increasing public pressure would appear to favor trollers over gillnetters, more research input is needed now to determine if new management guidelines will assure efficiency of harvest and conservation of salmon as a food resource.

Problems with Excesses of Fishermen

With declines in the salmon resource, fishery managers have steadily reduced the time gillnetters have been allowed to fish in the lower Columbia River from 272 days in 1938, to 101 days in 1960, to 49 days in 1974. In comparison, the season for ocean trollers has remained at about six months since 1948. The numbers of licensed gillnet boats during this time period have remained fairly constant, fluctuating from 1191 in 1938, to 806 in 1960, to 1104 in 1973. In comparison, the number of licensed trolling boats operating in the Columbia River area have increased from 273 in 1938, to 267 in 1960, to 1528 in 1971, an increase of at least five-fold (see Appendix, Tables 13 and 14). With gillnetters fishing on returning adult salmon and trollers on intermingled stocks of salmon at various stages of maturity, the increased ocean fishing pressure on immature salmon has contributed to the declining harvest of the resource (c.f. Van Hyning 1968). Also, this has seriously impaired the ability of fishery managers to manage each stock as a separate unit and obtain from it the maximum sustained yield (Crutchfield and Pontecorvo 1969:136).

The basic problem of too many fishermen harvesting too few fish has been completely neglected. Unrestricted entry into the fisheries further compounds the problem. Efficiency goes down, cost of harvesting goes up, and the ability for fishermen to make suitable livings declines.

Increasing concern for the salmon resource and the fishermen who harvest it has led Alaska, British Columbia and to some extent Washington, to impose some form of control on entry into their salmon fisheries. If efficiency is to be increased or stabilized by limiting entry into Oregon's salmon fisheries, more consideration is needed to determine what social effects controls will have on commercial fishermen.

Purpose of the Study

This thesis develops material to show how adaptations and innovations by gillnetters increased their ability to harvest the resource, thus counteracting management regulations restricting their efficiency. Also, it intends to show how developments by trollers led to increased catches of immature salmon and thus caused them to be less efficient harvesters of the resource. This provides a background for the three primary purposes of the study.

First, a comparative study of vessel efficiency was undertaken between gillnetters and trollers from 1926 to 1973. Based on the average annual catch per vessel, the purpose was to determine which harvester group was more efficient and whether vessel efficiency changed substantially over time.

Second, the study compares harvest efficiency of gillnetters and trollers by examining the differences in average weight per fish harvested between fisheries. An estimate for the total loss in weight of Columbia River chinook salmon was then made by comparing the troll harvest of immature chinook to the gillnet harvest of mature chinook. From this, an estimate was made for the maximum potential harvest of Columbia River chinook salmon with no ocean fishery. Also, a comparative study was undertaken between lower Columbia River gillnetters (zones 1-5) and Indian fishermen (zone 6) to determine if there was a significant weight difference occurring among chinook salmon harvested within the Columbia River.

Third, the study discusses some of the characteristics of fishermen to show some of the problems and socioeconomic implications which could develop if programs designed to limit or reduce fishing effort were to be implemented in Oregon's salmon fisheries.

Method of the Study

The time period for this study was between September, 1974 and April, 1975. Data were primarily obtained through a literature survey. Other information was obtained through numerous telephone conversations and correspondence with members of various fishery agencies. Some direct contact with gillnetters and a few trollers was gained by personal work experience during the August gillnet seasons of 1973 and 1974. The data used for the comparative vessel efficiency study between gillnetters and trollers were collected from various sources. Data came from the Fish Commission of Oregon and the Washington Department of Fisheries; Status Report Columbia River Fish Runs and Commercial Fisheries, 1938-1970, 1974 addendum; U. S. Fish and Wildlife Service, Statistical Digests, 1939 to 1971;

U. S. Bureau of Fisheries, Administrative Report, 1929 to 1938; and U. S. Commission of Fisheries, Annual Report, 1926 to 1928. Although these sources furnished the most complete statistical data, there often was some discrepancy between these and other sources for the same data.

The data used for determining an estimate for the maximum potential harvest of Columbia River chinook salmon were collected from the sources previously mentioned. Added to this were enumerative data from British Columbia Catch Statistics, 1969 to 1973, and from the Alaska Catch and Production, Commercial Fisheries Statistics, Statistical Leaflet. For determining the percentage of Columbia River chinook salmon in the troll catch from Oregon to Alaska, a tabulation supplied by Richards (1968:82) was also used. Qualifications for the use of his table and the estimates presented are provided within the text of Chapter Four.

Statement of Thesis on Efficiency

It is my thesis that the efficiency of the Columbia River salmon harvest has decreased over time. This has resulted from public tendencies to eliminate the most efficient harvesters and management decisions restricting the harvesting ability of fishermen. Leaving greater numbers of less efficient harvesters with more restrictions and less fishing time, the idea was not to enhance efficiency but to counteract a declining resource. To get around these processes which were creating inefficiencies, many fishermen shifted to ocean fishing resulting in salmon being harvested when still immature. These conditions have generated a lessening of overall vessel and harvest efficiency in Oregon's commercial salmon fisheries and appears to have helped decrease the resource. Overabundances of fishermen are still present and contributing to declining efficiency. Consequent potential for further efficiency declines may cause future fishery management to have a look at individual levels of fishermen efficiency.

Any assessment of efficiency dealing with salmon harvesting is subject to the use of different measures and criteria. It can be assessed in relative or absolute terms depending upon the extent of precise measurement. Crutchfield and Pontecorvo (1969) discuss efficiency in several ways: (1) the efficiency of gear and improved technology, (2) the efficiency of the individual fishing unit such as on a yield-to-effort basis, (3) the efficiency in harvesting the resource, and (4) the amount, location and rate of fishing gear and effort which would yield maximum efficiency in the fishery from one period relative to another. In addition, mention is given to efficiency-reducing regulations, the affect of regulations on the resource and the additional administrative costs generated by these inefficiencies, to name a few.

The view taken here is that salmon harvester efficiency should be assessed in several ways to allow for cultural interpretations through time. Such interpretations must include both economic and non-economic attributes; they must show how these attributes affect one another in a changing society, in what sequence, over what period of time and with what consequences (Dalton 1971:21). These interpretations are necessarily relative in that they deal with substantive features of economy. As Dalton (1971:21) further points out:

> Modernization is a sequential process of cumulative change over time generated by the interaction of economic and cultural innovations impinging on traditional economy, polity, and society, with feedback effects on the innovating activities.

Hence, while these processes describe the mechanisms of change for groups exploiting a natural resource, its application to this thesis becomes one of describing the forces which create or change efficiency in that exploitation process.

Data included in this thesis are developed in discussion of Columbia River gillnetters, trollers operating on Columbia River salmon, a comparison of the two, and implications for their future management. In the first part of Chapter Two, efficiency is discussed as a relative change over time. It shows that while traditional methods used by gillnetters to exploit the resource became modernized and more efficient over time, social and political forces brought inefficiencies in order to preserve the resource. In the second part of the chapter, social and political forces are shown to have regulated out the most efficient gear operators within the Columbia River.

In Chapter Three, development of trollers as a cultural innovation is shown to have changed relative efficiency in two primary ways. First, efficiency increased with innovations to modernize and increase catches; second, efficiency decreased at the same time due to less maximization of the potential harvestable weight of salmon. Also undertaken is a comparative vessel efficiency study between gillnetters and trollers. In this instance, efficiency is measured by the average annual catch per vessel.

In Chapter Four, a comparison of harvest efficiency is made between Columbia River gillnetters and trollers in specific fishing areas. Efficiency in maximum utilization of the resource for each fishery is measured by a comparison of the estimated maximum potential weight obtainable by Columbia River chinook salmon and their actual harvested weight.

In Chapter Five, criteria for limiting fishing effort and its potential social implications on fishermen are discussed. The surplus fishing effort impinging upon the traditional economy of fishermen has resulted in a wide diversity of success among fishermen, thus bringing about changes in their overall efficiency and socio-economic well-being. Such changes may provide possible justification for limiting or reducing fishing effort in the future. Criteria used for limiting or reducing fishing effort with the least hardship accruing to fishermen may be established by measuring the differences in efficiency between fishermen. Such a measurement would be possible by comparing the ratio of gross returns to total costs.

II. THE DEVELOPMENT OF GILLNETTING ON THE COLUMBIA RIVER

Ever since the development of gillnetting, gillnetters have adapted and innovated to improve their method of harvesting salmon. Many conditions brought cause for change, including increasing numbers of fishermen, declines in the resource, and management practices which served to inhibit efficiency. As conservation of the resource caused regulations to become more stringent forcing more inefficiencies, gillnetters adapted by modifying their nets and redesigning their boats. These adjustments served to increase their efficiency temporarily, hence reducing the negative effect of regulations.

Of the many groups of fishermen once employed in the commercial salmon fisheries on the Columbia River, only gillnetters have been able to survive. Seiners (including beach, haul or horse seiners, purse seiners and whip seiners), trapmen, fishwheel operators, dipnetters and setnetters were important in their day, but changes in river conditions, public support and fishery laws finally forced them out of business. Their closure was not voluntary nor was it caused by lack of profit. It occurred because regulations were needed to limit fishing effort on declining runs of salmon. With declining runs, conservation of the resource became an issue. Numerous "fish fights" developed between gear owners over who was to blame and who should be excluded. Finally the public became the arbitrator of the battles. Regulations were adopted by a vote of the people beginning in 1908 and rather than promote efficiency, they tended to phase out groups which were the most efficient harvesters. Gillnetters, being a less efficient harvester group when compared to seiners, trapmen, and fishwheel operators (Smith 1974b:10), were allowed to continue, but not without restrictions. Being able to adapt to laws restricting their efficiency where competitors could not, gillnetters' resourcefulness and the nature of their fishing activity allowed them to survive and develop into the modern gillnet fishery of today.

The Early Fishing Industry

The first gillnet used by settlers on the Columbia River appeared in 1853 when Mr. Hodgkins and Mr. Sanders fished with one 60 fathoms in length at a place near Oak Point, Washington. Appearing at a time when the commercial salmon industry was just beginning, its impact was not significantly felt until after salmon canning had come into being. Previously, salmon had been salted and packed in barrels, then shipped to a few distant markets. In 1866, Hapgood, Hume and Company set up the first cannery at Eagle Cliff, Washington, two years after an earlier failure due to a disappointing run on the Sacramento River in California. This new method of preserving salmon was better suited for its shipment to distant markets.

Stimulating public consumption through an increasing number of distant markets, a demand for Columbia River salmon was created. It was at this time that gillnetting developed into a viable fishery (Craig and Hacker 1940:132-216). For summaries on the salmon industry see also Cobb (1930), Gile (1955:140-55); Hayden (1930); and Miller (1958).

Probably the largest abundance of salmon to migrate up the Columbia reached their spawning grounds in the years between 1830 and 1870. This was due to the decimation of the Indian people whose population had been severely reduced between 1792 and 1840 by epidemics of smallpox, measles, and malaria (Gill 1909:10). As a result, there was actually less harvesting of salmon from 1835 to 1865 as the Indian harvest was declining while the white harvest was just beginning.

By the time canneries became established in 1866, the river was literally swarming with salmon. Fish were readily available for all who entered the fishery and gillnets provided an effective way of catching them. Such abundance coupled with an increase in markets allowed the number of canneries on the Columbia to increase from eight in 1873 to a peak of 39 in 1883 (Craig and Hacker 1940:151). Having an abundant resource for commercial exploitation and offering a quick profit for a modest investment, these new canneries created a great deal of competition allowing many new fishermen to enter the fishery. During 1883 and 1884, the runs of salmon we large that the canneries could not handle all that were caught, resu ing in tons and tons being thrown overboard by the fishermen who had no place to sell them (Cobb 1911:14). Since conservation of the resource was just developing as an issue and few regulations had been placed on fishermen at the time, canneries could do no more than place a limit on the amount of salmon one fisherman could sell. Still, this was not adequate since many fishermen would catch more than the limit in just one drift. Such wastefulness of the resource quickly depleted the large spring and summer chinook runs, most heavily canned because of their richness in fat content. This did not stop fishing effort, however. Emphasis was redirected toward the summer blueback and steelhead runs in 1889, then the fall chinook, coho, and chum runs by 1893.

Gillnets

During the time when canneries were developing and Columbia River salmon were becoming famous through an increasing number of international markets, gillnetting was evolving into a major fishery. By 1871, gillnets had not significantly changed from earlier prototypes which ranged from 20 to 100 fathoms in length, approximately 23 feet deep with a mesh size of eight to nine inches. Gradually though, there was a change toward greater length. They reached 200 fathoms by

1875. With season closures coming into effect during 1877 and 1878 giving fishermen less fishing time, gillnetters continued to increase the size of their nets until in 1880 they reached between 300 and 350 fathoms (Craig and Hacker 1940:165).

Not until 1893, after the spring and summer chinook runs were depleted by wasteful practices, did the mesh size change. Needing more fish to can, canneries created a demand for smaller species of salmon by buying them on a price per pound basis. Previously, salmon were bought on a price-per-fish basis with small fish being discredited. Fishermen received one-half as much for a small fish of 10-15 pounds compared to one of 22 to 25 pounds (Smith 1895:245). With per pound pricing bringing about utilization of smaller fish, gillnetters decreased their mesh size to seven inches to be effective. Thus, nets became more specialized as fishermen used different mesh sizes depending upon the season or species of salmon most abundant in the river.

The first gillnets employed, commonly referred to as "floaters," consisted of three main parts: the webbing, cork line and lead line. The webbing was a rectangular piece of net composed of many meshes of equal size. The upper edge was attached to the cork line allowing it to float on the surface of the water while the lower edge was attached to the lead line allowing it to sink to the river bottom or whatever its full depth was beneath the water. To one end of the net was attached a marking buoy while the other end was made fast to the gillnetter's boat. The net was then allowed to drift with the current, intercepting whatever fish swam into it. Providing the fish were not big and powerful enough to break the mesh or small enough to pass completely through, they would be effectively gilled and prevented from backing out. Also, if the fish continued to thrash around in the net, it could easily be further entangled, making escape almost impossible.

During the early days of gillnetting two men were generally required to fish a gillnet effectively. To lay out the net, the boat puller would row across the stream while the other fisherman laid out the net as the boat moved ahead. After drifting for a length of time, depending upon the fluctuation of the tide, the fisherman would pick the net by working back and forth along it, taking out fish as they went. Not until the gillnet fleet became motorized was the net picked up and piled in the boat after every drift (Andrews and Larssen 1959: 35).

During the 1880's and 1890's, fishing industry regulations restricted the length, slat spacings, mesh sizes, and minimum distances between fixed gear. Regulations also required traps and fishwheels to allow free movement of fish during closed periods. Even more significant was the price discrimination between large and small fish. Generally fishermen were paid two cents per pound more for larger fish so pressure to harvest large chinook salmon increased. These conditions prompted gillnetters to change their gillnets in attempts to increase catches.

The first major change occurred about 1900 with the introduction of the "diver" gillnet. This type of gillnet, having the same parts as the earlier floating variety, differed only in that it had smaller corks on the cork line and a much leavier lead line. This enabled the net to dive to the river bottom first while allowing the cork line to be pulled up by the buoyancy of the corks. The lead line was weighted with a precise amount of lead so that it would hop along the river bottom at short intervals rather than to continually touch it. The experienced fisherman could tell if his net was fishing in this manner by the wear on the lead. As the majority of large chinook swam close to the river bottom, this technological innovation allowed fishermen to be more productive in the numbers of chinook salmon harvested over 25 pounds in weight.

The essential difference between the floater and diver type gillnets was that the floater fished from the top down while the diver fished from the bottom up. There was a difference, however, in the way and area that each fished. Whereas floaters fished both the flood and ebb tides, divers fished mainly on the ebbs. Commonly, diver and floater gillnets did not fish on the same drifts at the same time. Even though both drifted with the current, divers had much more weight and would drift at a slower speed. They were also not as visible in the water since the cork line was beneath the water, leaving only the buoy to show the direction of the net from the gillnetter's boat. Consequently, if a floating gillnet fished on the same drift, it would float on top of the diver net and create a mess to be untangled. This was rarely a problem, however, since by this time gillnetters had a drift right system which customarily prevented this type of situation from occurring.

Since the lead line of a diver gillnet always drifted on or near the river bottom, drifts could only be made where the bottom was free from snags and other debris. In order to prevent their nets from tangling up, gillnetters formed into small organized units called "snag unions" for the purpose of clearing the particular drifts they wanted to fish. Each drift, being anywhere from two to five miles long, was cleared by members of a "snag union" for that particular drift and only those who helped to clear obstructions would be allowed to fish the area. This was an unwritten law of exclusive rights, but it was well enforced by the members and usually observed by outsiders. Drifts were organized as to the place where the members started fishing. Each day, members would decide by lot the order in which they would begin fishing from the starting point of the drift or "towhead". The order in which a member drew his lot was very important since those who started first had the better chance of catching more fish. The transfer of rights for these drifts was possible and done largely on a father-to-son hand-me-down basis or by a monetary payment (Craig and Hacker 1940:166-7). The clearing of drifts goes back to 1876, although it wasn't well organized until after the diver gillnet made its appearance and "snag unions" were formed in the early 1900's.

Modern day "snag unions" are still in existence and methods used to clear drifts differ between fishermen who fish floater and diver gillnets. "Snag unions" for fishermen who fish a floater gillnet were organized fairly recently (about 1971). To clear snags, two boats drift downstream with a large 14-inch meshed net. When a snag is encountered, both gillnetters pick to it and pull it up if possible. If not, a skindiver is used to hook a cable around the snag. A scow is then brought in with a hydraulic lift to pull the snag up. Sometimes a high pressure fire hose is used to blow the sand away from the base of the snag if it is firmly entrenched.

Diver "snag unions" use the same type of meshed net but clear the river from the bottom up by use of a long steel cable tied between two boats. When the boats drift downstream with the cable on the river bottom, any snag caught by the cable will cause the boats to come together. A shackle is then put on the cable so that it slides to the bottom and forms a loop around the snag. Next, the cable ends are tied to both sterns as short as possible so that when power is applied, the cable will cinch around the snag. This creates an effective upward pull on the snag rather than a less effective horizontal pull. Also, the power from the propellers of the two boats may cause sand to be blown out from around the snag, helping to loosen it. Skindivers are also employed when necessary (Ed Lahti, personal communication).

Shortly after 1900, further modifications of the gillnet began to take place, allowing gillnetters again to increase their efficiency. This was done largely by adding auxiliary pieces of net to the main webbing. The first of these types, the trammel, was a very large meshed netting between 24 and 60 inches stretched measure which hung on either or both sides of the main gillnet. This was tied to the hangings at the cork line and lead line with its slack being taken up by tying it to the middle of the gillnet. Its effectiveness was particularly suited to the Columbia River where a large variety of salmon sizes were present. Small salmon would pass through the large meshed trammel but would be caught in the smaller meshed gillnet. Large salmon, often being too big to be effectively gilled, would force the small mesh through the trammel mesh and thus be in a net bag rather than gilled. From this position, escape would be much less probable than it would if an ordinary gillnet was used (Craig and Hacker 1940: 167).

The use of trammels increased efficiency by reducing much of the selectivity of the salmon catch. This was because the simple gillnet had only one mesh size. If a nine or ten inch meshed net was used, it could effectively catch large salmon but many smaller salmon could pass right through unscathed. A smaller seven or eight inch meshed net could effectively gill most salmon, but many larger ones would have heads too large to pass through such a small mesh opening. So instead of being effectively gilled, they might back out and pass around the net or fall out of the net while it was being picked. Thus, the trammel, instead of selectively taking more larger or smaller salmon, could more effectively take them all, resulting in larger and increased catches.

By 1906, another modification of the gillnet was developed. The combination net consisted of two different sized mesh walls of which the larger wall hung in front. Combination nets also referred to a variety of nets that were made up of several sizes and types of webbing woven into a single net. These were usually fished as divers and typically occurred on the Columbia above St. Helens (Craig and Hacker 1940:168).

An important offshoot of the combination net, which helped to increase salmon catches and bring another peak to the fishing industry, was the construction of the "apron," occurring around 1915. Being employed by more and more fishermen, the addition of aprons on gillnets seemed to be a response to fish prices which had nearly doubled between 1915 and 1920. The apron, being an auxiliary net attached to the cork line, always hung downstream from the main part of the net. It had a lightly weighted lead line to keep it hanging at an angle and apron strings attached to the main net lead line kept it from swinging too horizontally. Extending the whole length of the main net and having slightly larger meshes, the apron was designed to catch larger fish which had doubled back after not gilling in the main net. Aprons were primarily an apparatus for use on diver nets, but in later years they appeared on some floating gillnets. Also, many fishermen converted the apron into a trammel type net so that it would catch salmon on either side (Craig and Hacker 1940:168). All the early gillnets and variations that developed from them were made entirely of cotton or linen. They fished best at night, especially when there was suspended material in the water to impair visibility.

The ability to fish well depended on the skill of the fisherman. Besides having to understand the behavior of salmon, how changes in environmental conditions affected fishing conditions, and the relation of these to the area they planned to fish, they had to be sure their nets were fishing in the proper manner. From this, it was only natural that each fisherman would have his own ideas of what fished best and how he should go about it. Such a variety developed out of the simple gillnet that most every conceivable combination of net type was found to have beem employed. From the combined efforts of so many gillnetters, the efficiency and harvest capabilities of their nets improved greatly throughout the development of the fishing industry. Their resourcefulness and independence as fishermen provided sufficient capabilities for improving the gear needed for their livelihood.

After the 1920's, the salmon industry began to decline. Fewer fish were available and resource conservation became a prime issue. Fish fights occurred between the different gear operators with the less efficient gillnetters being the least affected. Since the 1930's, the curtailment of other gear forms helped gillnetters substantially by allowing their proportions of the total salmon harvested from the Columbia River to increase. Then, after World War II, a substantial increase in fish prices coupled with the beginnings of industrialization led modern technology to improve on gillnets.

Gillnet improvements developed through use of petroleum products as nylon and other synthetic fibered nets rapidly replaced the older vegetable fibered nets. They tended to last longer and were more resistant to wear and rot, therefore being more efficient. Still, the salmon resource was on the decline so gillnetters had to be curtailed with restrictions. Seasonal restrictions were made, reducing the available fishing time from 272 days in 1942 to 157.25 days 10 years later.

Introduction of the monofilament gillnet was another significant improvement although it came at a time while the fishing season continued to be shortened. Monofilament gillnets made day-fishing more profitable as they were much less visible to fish. However, their efficiency proved to be too great and they were soon prohibited. In their place, the multifilament gillnet came about. Although slightly less efficient than monofilament gillnets, it allowed gillnetting to continue being a more productive daytime activity.

Gillnet Boats

As gillnets changed from simple to more complex apparatus, the boats from which they were fished developed similarly. The first boats employed were Whitehall boats and small double-ended and flat-bottomed skiffs (Craig and Hacker 1940:183). These were powered by oars and since they were not particularly adapted for the Columbia, it took a hearty man with a strong back to row this boat all night long. The early styled boats did not last long and they were quickly replaced around 1870 with the distinctive styled Columbia River gillnet boat. Typically, these were characterized by a V-bottom, wide beam, raised and open bow, heavy construction and duck-like ability in the water. Also, the bow and stern were designed not to foul the process of laying out or picking up the net (Andrews and Larssen 1959:35-6, 125).

These new styled boats, being 22 to 23 feet long and entirely open, generally took two men to handle. They had quite an advantage over the older type boats as they no longer had only oars for a source of power. The addition of sails to take advantage of the frequent winds made river travel much easier (Craig and Hacker 1940:183-4).

The most significant improvement in gillnet boats occurred just after 1900 when gasoline engines were introduced. Replacing the sail, these small powered motors were easily installed without any major changes having to take place in the boat's design. This new addition greatly improved the gillnet fleet's efficiency and harvest capabilities. Coming at a time when regulations were making fixed gear and appliances more inefficient, gillnetters were able to capitalize on the resource with their new source of power. They could reach their fishing grounds or starting point on a drift in quicker time, increase their daily catch, and generally out-maneuver other sail-type gillnet boats. The use of motors caught on quickly among gillnetters and by 1915, the entire fleet had become motorized. About 1912, the gasoline engine increased the mobility of fishermen to the extent that day trips into ocean waters were possible.

Finding that salmon could be caught in the ocean with considerable success with hook and line, the ocean salmon troll fishery began. As it has had a pronounced effect on the commercial salmon fisheries of the Columbia River and still remains as a viable ocean fishery, its development will be discussed in Chapter Three.

With gear regulations in 1915 and 1917 further restricting trapmen, seiners, gillnetters and actually prohibiting purse seiners within the Columbia River, gillnetters set out to increase their own efficiency, hence counteracting the regulations. Besides improving their gillnets with numerous modifications, the next step was to redesign their boats to better utilize the new source of power. The rounded stern was made square allowing the cabin and engine to be set back. Length and width increased and the lines were refined for better handling. A wooden thwart roller which extended the full width of the boat was added slightly forward of the fish locker. This helped the net to be laid out smoothly as the boat was driven ahead under power. Controls were also added to the bow, enabling the fisherman to power the boat from either end. Such positioning was especially helpful when picking up the net. With the aid of a net roller located in the bow and close to the controls, the fisherman could accomplish two tasks at the same time. Rollers, too, became power-driven and along with the other changes, increased the boat's efficiency enough that only one man was needed to operate it (Andrews and Larssen 1959: 35-7; Craig and Hacker 1940:184-7).

By 1928, more one-man gillnet boats were being built than two-man boats. The change to these one-man "bow pickers" was primarily an economic move since one man could harvest nearly the same quantity of fish as two had formerly. Also, as fishwheels had been prohibited in Oregon in 1926, and fishwheels, traps and seines in

Washington in 1935, this economic change represented another move by gillnetters to utilize the restrictions placed on other gear to their own benefit.

In later years, the development of "drum boats" occurred. These had a distinct advantage as the nets were not pulled by hand at all, but rather were fully powered by the drum. Drums were located in the stern and in later years, the bow. While the boat moved forward or backward, whatever the case, the drum simply wound or unwound the net to pick it up or lay it out. Also, many of the "drum boats" were built of aluminum or fiberglass. With their lighter weight and greater speed, they were capable of being more productive.

Columbia River Fish Fights and Regulation of the Fisheries

The history of gillnetting on the Columbia River wouldn't be complete without some mention of the regulations affecting the fisheries and of the fish fights which took place between the different gear owners exploiting the salmon resource. One of the issues was conservation as rapid expansion of the fishing industry in the 1880's made people increasingly aware of the declining availability of the resource.

The idea of conservation brought forth a conflict of interest between the various fishery groups. Each group had tried to be more efficient, modifying their boats and gear, yet each was trying to exclude their competitors. A common feeling existed among fishermen that their method of fishing was the only proper one and the one least injurious to the fishing industry. Likewise, all other methods of fishing were considered to be far more detrimental (Oregon Legislature 1889:4). Seeking advantages that were entirely in the realm of self-interest, violent acts arose between groups as each sought to conserve the resource for themselves. Ensuing fish fights developed between gillnetters and other groups of trapmen, seiners, fishwheel operators and sports fishermen, and between lower river and upper river fishing interests. Eventually, this caused the Oregon State Legislature, and later the people by initiative and referendum, to enact laws restricting or outlawing groups from the river. Efficiency was not used as a criterion for better management. Rather, public opinion voted to prohibit those types of gear which took the largest amount of fish and needed the least amount of people to operate. Efficiency was regulated out, causing inefficient management practices within the fisheries.

One of the principal causes of the Columbia River fish fights and the subsequent regulation of the fishing industry resulted from too many fishermen and too few salmon. Overexploitation of the salmon resources by too many competitive fishermen (Craig and Hacker 1940: 151) coupled with increasing industrial uses and the growth of civilization along the Columbia River drainage basin (Netboy 1958; Bullard 1968) resulted in declining runs of salmon. At first efforts at conservation were directed towards regulating the fishing season and placing restrictions on gear. This made the fishermen less effective in catching salmon, but because of their innovative nature, they readily invented new methods to improve their gear and increase catches. Hence, there was still a problem of too many fishermen. One approach suggested by the Weekly Astorian and Daily Astorian in 1887 was to reduce the number of fishermen. However desirable this seemed to be, it was not implemented. Still conservation of the resource was an issue and each group of fishermen wanted more for themselves and more restrictions or exclusion of their competitors. As an example, an 1890 pamphlet by the Columbia River Fishermen's Protective Union provided discussion on how the traps, seines and fishwheels were reducing the numbers of fish. According to Smith, "this set the tone of what had been the pattern of fish fights, to eliminate kinds of fishing apparatus rather than control the number of fishermen using each kind of gear" (1974b:8).

Initially, fish fights developed between gillnetters of Astoria, Oregon and vicinity, and the trapmen living primarily near Baker's Bay, Washington. Each had formed an organization designed to protect their own interests. Gillnetters, forming the Columbia River Fishermen's Benefit Aid Society in August 1875 (changed to Columbia River Fishermen's Protective Union in 1884) (Andrus 1975:4), organized for the purpose of mutual aid, proposing and opposing legislation, bettering fish prices and maintaining drifts. Trapmen organized the Washington Fishermen's Association primarily to rival the actions of gillnetters (Washington Fishermen's Association 1894).

Fishing was usually better on the north side of the Columbia River except when winds were from the southwest. This meant both groups tended to compete in close proximity with one another for the salmon resource. As the number of trapmen increased so did their traps. Consequently, traps were built farther out into Baker's Bay into drifts normally fished by gillnetters (Smith 1974b:2). Many of these traps which were thought to be illegally placed or hazardous to navigation were pulled out by the gillnetter's scow. Understandably, this created a great deal of conflict between the two fishermen groups and acts of aggression and violence became common between them.

Fish fights between lower river fishermen and upper river fish-wheel operators were also common and heavy with verbal threats. Again, both sides argued that conservation was needed to save the salmon runs, but then, both sides were also convinced that only if the other side's gear would take less fish or was outlawed, would the salmon runs be saved (Donaldson and Cramer 1971:111). Consequently numerous fish fights occurred in the Oregon Legislature with each side being largely biased toward their own interests and working toward their own ends. The outcome of one such battle in 1908 resulted in two initiative petitions being decided at the ballot box by the voting public. One ballot measure, initiated by the lower river fishermen, closed the Columbia east of the Sandy River to all fishing except that done by hook and line. Its purpose was to eliminate the seines and especially the fishwheels used on the upper Columbia. The other ballot measure, initiated by upriver fishermen, restricted commercial fishing to daylight hours. Since gillnetting was primarily a nighttime activity, this severely curtailed the gillnetters. Surprisingly enough, both measures passed and it was left up to Master Fish Warden H. C. McAllister to try and enforce these new laws.

With commercial fishing on the Columbia River being under joint control by the states of Oregon and Washington, both of Oregon's newly passed ballot measures could only apply to Oregon licensed fishermen. However, Warden McAllister, trying to enforce both laws, arrested all violators on the river, regardless of whether they held an Oregon or Washington license (Cobb 1911:41). Understandably, both regulations were not enforced and were soon repealed (Wendler 1966:26), as the two states got together in an attempt to work out their problems dealing with fishery legislation.

Fish fights between commercial fishermen finally reached a peak in 1926 when an initiative petition banning the use of fishwheels, traps and seines above Cascade Locks was passed by the voters of Oregon. Those in favor of banning these types of gear included the Oregon State Grange, Oregon State Federation of Labor and Oregon

Fish Commission. They argued that all fish escaping tidewater should be allowed to continue upstream. Although admitting that fishwheels took only a small percentage of the catch, they maintained that this industry employed relatively few men, thus benefiting only a small minority rather than a much larger group as in the case of gillnetting (Donaldson and Cramer 1971:112). Those who opposed the issue were mainly upriver people such as the Warren and Seufert families, their employees and other businessmen, all of whom had certain interests in the industry. With the support of the Astoria newspaper, upriver people argued that the bill was initiated by vote-seeking politicians who sought to monopolize the fishing industry and control the price of fish to the consuming public (Donaldson and Cramer 1971:112). Since the initiative petition of 1926 which banned fishwheels and limited the use of traps and seines only applied to the Oregon waters of the Columbia River, their use continued for a short time by Washington fishermen. Then in 1935, the people of Washington followed Oregon and banned these types of gear from the river. The use of haul seines, however, was reallowed in 1935 by legislative action and permitted in Oregon waters above Cascade Locks. Finally, all fixed gear and appliances were prohibited in 1948 by another Oregon ballot measure. Thus ended the fish fights between groups of commercial fishermen, leaving only gillnetting and the Indian fishing to continue as commercial salmon fisheries on the Columbia River.

Even though gillnetting survived to be the Columbia River's major commercial fishery, the fish fights continued. In 1964 a ballot measure initiated by sport fishing interests attempted to gain control of the resource by closing the river to commercial gillnetting. Mounting an emotional campaign, some 1000 people from Astoria took their case to Salem. The measure was soundly defeated, thus helping to preserve their historic tradition.

Like Washington, steelhead in Oregon had been declared a game fish. Those caught by gillnetters had been regulated to be incidental. Still, this was not sufficient for sports fishermen as they initiated another petition in 1974 to ban the commercial sale of steelhead. Claiming that the steelhead was essentially a rainbow trout (Salmo gairdneri) and a "true game fish," the measure overwhelmingly passed. Now, having to increase their mesh size to eight inches, gillnetters must release unharmed steelhead back to the water. Since many are not alive when hauled aboard, they are handed over to the Oregon Wildlife Commission who in turn sells them at cost to state institutions such as schools. Although the purpose of this was to allow more steelhead to escape upriver, many fishermen believed that the additional escapement would not be as great as expected and that administrative costs and costs to themselves would provide for more inefficiency within the industry.

Regulated Inefficiencies and Management Practices

Management of the salmon fishery on the Columbia River, being under joint control by the states of Oregon and Washington, was never organized for the best interests of the fishermen or the resource. Each state developed its own management agency which in turn set up regulations that were often conflicting. Naturally, this created many conflicts among fishing interests as fishermen would commonly fish both sides of the river. Even more significant was that the first attempts at regulations by management, in the form of gear and seasonal restrictions, were not well enforced. Regulations were of little consequence since the state legislatures failed to provide adequate personnel and funding to enforce them. There was a real dichotomy between having laws and their enforcement. When season openings and closures differed between the states, the lack of law enforcement plus the difficulty in determining the residency of individual fishermen made it extremely difficult for regulations to help effectively conserve the resource.

Not until the Columbia River Compact was signed and ratified by Congress in 1918 was there an attempt to set up similar regulations between states. Still, regulations established by management did not always serve their intended purposes of providing greater escapement of breeding salmon to the spawning grounds. Before 1948, the peaks of both the spring and fall chinook runs came during the open spring season on the lower river. Although there was a weekly closed period from 6 p.m. Saturday to 6 p.m. Sunday, its effect was to spread the salmon harvest out over a longer stretch of the river. Also, the closed period on the lower river from August 25 to September 10 may have increased escapement through the lower river, but its desired effects were largely offset by the intensive fishery above Bonneville Dam during September and October (Rich 1942:131). Hence, in many instances, closed seasons acted only to distribute the salmon harvest over a greater portion of the river instead of significantly increasing escapement.

While seasonal closures served as an ineffectual method of increasing escapement, gear elimination did not produce the desired expectations either. The effect of eliminating fixed gear (fishwheels, traps, seines and set nets) from the Washington side of the Columbia River was presumably for reducing the catch and increasing escapement. While the chinook catch declined from a yearly average of 17.1 million pounds before the gear elimination (1928 to 1934) to 15.3 million pounds afterwards (1935 to 1946), the actual take by gillnets, Oregon's fixed gear and the Indian dip net fishery increased. The declining chinook catch over the years showed no noticeable change in trend coinciding with the fixed gear elimination and no major change appeared to have taken place in the overall escapement either. Hence, fixed gear elimination served to increase the catch by other gear forms rather than increasing escapement (Johnson et al. 1948:10-4, 31). These initial attempts of regulations served primarily to develop inefficiencies within the fisheries. The real problem of too many fishermen harvesting the existing resource was never dealt with and consequently management continued to further restrict efficiency.

With the people of Oregon getting the power to enact legislation in 1902 by initiative and referendum petition, fishery management changed markedly. Conflicts and fish fights between fishermen groups bypassed the managerial level and became arbitrated by the public at the ballot box. Deciding which types of gear should be fished, the trend of the voting public was to eliminate those which took the most fish per unit of gear, i.e. those that were the most efficient.

Important social considerations such as who should harvest salmon and how the harvest should be distributed among the different gear forms was never considered by management or the public. Emotional accusations over which method of fishing was more injurious to the salmon resource became the predominant issue. Rather than trying to enhance the equity of all fishing groups, emotionalism was carried to the public and exercised at the ballot box. In considering different methods of commercial fishing operations, a report by the

Oregon State Planning Board (1938:6) suggested that if no type of gear in use harmed the resource (other than catching fish), then their activities should not be curtailed without a corresponding curtailment in other groups. Furthermore, a more equitable method of conservation would be to limit the total catch of each run allowed to be taken by all gear. Whatever quantity was needed for the run's future perpetuation would then be allowed to escape. Although this procedure may have prevented the social injustices imposed on many fishermen, the Oregon Fish Commission regarded the social problem of resource allocation among fishing groups as outside of their jurisdiction (Johnson et al. 1948:5).

Since World War II, increased leisure time developed sports fishing as a major recreational activity. Where at one time the conflicts over the salmon resource were between different commercial gear forms, it has presently shifted to be between sports fishermen and gillnetters. Sports fishermen have stated that part of their purpose was to preserve the right to fish for everyone. Gillnetters are often sympathetic to the needs of their local economy and point to surplus fish at hatcheries for support of their activities. In any case, if more conflicts over the salmon resource are decided at the ballot box, then more social injustices will be done and added inefficiencies will occur.

The idea of managing a resource by democratic process through initiative and referendum petition has a number of problems. Often, a majority of the people do not know what is best for proper management of a resource because their knowledge of the more scientific aspects is limited. To effectively manage a limited but renewable resource, proper controls must be established in a scientific manner. For this reason, fishery biologists have been trained to manage the resource for its preservation, enhancement and continued equilibrium. The democratic process of initiative and referendum has tended to disrupt this.

Present management of Columbia River salmon means allocation of fish to gillnetters, sports fishermen, Indian fishermen and for escapement. Ocean salmon trollers, also harvesting Columbia River fish, are not considered in this allocation process since under 1974 management configurations, only those fish that return to the river can be allocated. However, 1975 Court rulings granting Indians an opportunity to harvest 50% of all salmon normally reaching their fishing grounds indicate that the allocation process will also be applied to ocean trollers.

Even though this study does not develop the circumstances of sports and Indian fisheries, it is recognized by law that both groups have a legitimate right to the resource. The right of gillnetters, however, has been increasingly questioned by the public and sportsmen. If gillnetting were to be eliminated, only ocean trolling would remain as a major commercial fishery of Columbia River salmon. Under these circumstances, one must ask if this constitutes best management of the resource. With only an ocean troll fishery, could management be assured of having proper controls on the resource, yet manage it on a sustained yield basis? Would this provide excessive escapement to some rivers and hatcheries? In retrospect, if no ocean fishery were present, could management provide sufficient fish for sportsmen, Indians and for escapement and still be able to crop the surplus with a commercial gillnet fishery? The answers to these questions should be sought before the sole surviving commercial fishery on the Columbia River is eliminated. If there is to be a commercial fishery, it must be determined where it would best be located to ensure the proper management of the resource and the people who exploit it.

III. DEVELOPMENT OF THE OCEAN SALMON TROLL FISHERY

As pointed out in the previous chapter, when increasing regulations were restricting the efficiency of gillnetters in the early 1900's, fishermen actively sought new ways to increase their harvest capabilities. The introduction of the gasoline engine made ocean travel possible and a few gillnetters found that salmon could be caught with considerable success off the Columbia River mouth with a hook and line. Also, the river fishery had become crowded with trapmen, seiners and gillnetters with drift rights but the ocean had plenty of room for new fishermen. By 1915, these factors and the high demand for salmon stimulated entry into the troll fishery. Fishermen found that ocean trolling was a way to get a jump on river fishermen as there were virtually no regulations to restrict their fishing effort. After improvements in the gasoline engine, the mobility of trollers increased and in the 1920's, fishing began to take place on the offshore feeding banks of immature salmon. With the beginnings of the albacore tuna fishery in the late 1930's, mobility again increased and salmon were caught in larger numbers up and down the coast. Development of the ocean sport fishery after World War II added other pressure to the salmon fisheries as more day boats became prevalent, many of these turning commercial after a period of time. Presently, many types of trolling boats exist with new ones being increasingly sophisticated and utilizing the most modern technology.

History of the Changing Troll Fishery

Beginning in the Columbia River area in 1912, troll fishermen consisted primarily of gillnetters who trolled during the day then gill-netted at night (Van Hyning 1951:46). Being able to fish in the ocean when the gillnet season was closed proved to be a profitable venture. The mild curers had created such a persistent and profitable demand for chinook salmon that it paid to fish in the ocean before and after the spawning runs (Cobb 1930:487). These demands and the demands from the military service during World War I caused the fishery to increase rapidly. From about 500 trolling boats taking part in 1915, the number swelled to over 2000 by 1919 (Smith [1920] 1921:43). However, with many fishermen participating only periodically, this number was subject to considerable fluctuations.

During the first few years, trolling was conducted mainly off the mouth of the Columbia River. Starting in the early morning, trollers left from Columbia River and coastal ports to reach their nearby fishing grounds. As early trolling vessels had been converted from Columbia River gillnet boats, they had not yet been modified to be seaworthy for any lengthy fishing effort. So, having only small horsepowered engines and lacking storage facilities, trollers returned to port each evening to deliver their catches. Still, trolling had its advantages as gear was relatively inexpensive and licenses weren't required beyond the three-mile jurisdictional limit (Cobb 1930:487).

Early fishing equipment consisted of two poles generally from 15 to 25 feet long, hinged at the bottom and fitted with lines and pulleys so they could be lowered at an angle when trolling. To these were fastened one to three trolling lines spaced at regular distances apart. Each line had one to nine hooks tied on with five or six being the average. The lines varied from 50 to 200 feet with the inside lines being fished the deepest. A variety of lead weights were used varying from five to 40 pounds and often weights were spaced at intervals along the line. Without the use of power gurdies, fishermen had to pull the lines in by hand, so such spacings made the lines much easier to handle. For bait, a variety of fresh bait, spoons and spinners were used depending upon the preference of the fishermen, availability, location, season and what the fish were biting. Detailed descriptions of trolling gear are given by Smith ([1920] 1921); Scofield (1921) and Chapman et al. (1936).

As it was essentially the gasoline engine which made trolling possible, the success of fishermen and the protection of their lives was very dependent upon its reliability. Consequently, early trolling vessels with their inferior engines were rapidly replaced in the 1920's by vessels with larger and more trustworthy engines. Along with this, the average vessel's size, efficiency and mobility increased. Power-driven gurdies replaced the tiring hand-pulling operations. Steel lines and new materials for lures and hardware added to the life and efficiency of the gear (Kauffman 1951:82). Also, many of the larger boats had comfortable living quarters and with the addition of freezing facilities, the ability to stay on the fishing grounds for a week or more became commonplace.

With trollers becoming increasingly mobile and better adapted to ocean fishing, new areas along the Pacific Coast were explored and exploited. Trollers from the Columbia River ranged as far as 25 miles out to sea and 40 to 50 miles up and down the coast (Craig and Hacker 1940:180). With new areas being fished even further from the Columbia River, closer places were needed to deliver catches so coastal ports along Oregon and Washington began developing as important troll centers.

One major finding in the early 1920's which coincided with these technological developments and helped to increase the mobility of trollers was the discovery that salmon could be caught with more success on their feeding banks up and down the coast than when concentrated off the mouths of rivers (Van Hyning 1951:46). While the shift in fishing pressure was an adaptation by trollers which represented a greater harvest in terms of numbers, the degree of immaturity of salmon on their feeding banks was more pronounced. Even though new stocks of salmon not previously exploited were fished, for a large part the immature salmon were destined for the Columbia River fisheries anyway (Smith 1973:6). According to Smith and Kincaid (1920:40-1), thousands of young chinook salmon weighing less than five pounds were caught especially in May and June which at maturity would have averaged 25 pounds apiece. The majority of these fish, representing a little less than half the entire number delivered to a cannery, were in the second year of their four or more year life cycle. Furthermore, not only did these immature fish represent a loss to the industry, but those under five pounds were considered to be of poor quality, having low fat content, ashy color and insipid taste.

Present troll regulations have size restrictions for harvesting salmon and this has helped somewhat in minimizing the loss to the industry. From 1969 to 1973, troll caught chinook in May and June from the Columbia River area averaged between 9 and 10 pounds (Fish Commission of Oregon, personal communication). Although still immature and lacking a large amount of fat content, these young chinook have a red color and are considered to be of good taste.

After 1936, development of the albacore (tuna) fishery had substantial effects on the salmon troll fishery. The larger trollers, being well suited for fishing albacore, began to fish for them when they appeared off the Oregon Coast. Not generally occurring until the latter part of the salmon season from July to September, many trollers restricted their salmon fishing to April, May, and June, then switched to tuna thereafter. If the albacore were not abundant in any year, trollers would readily shift back to salmon late in the season. With many trollers being combination salmon/tuna fishermen, the height of the salmon troll fishery tended to switch to the earlier part of the season when the fish were largely immature and still on their feeding banks (Van Hyning 1951:46).

Again while representing an adaptation by trollers to increase their catches and earnings, the potential for utilizing the resource to its fullest actually decreased. During the earlier part of the season, more salmon had to be caught to make up for their smaller size so expenses could be paid and a profit produced. The net result left less salmon available for trollers at the latter part of the season when their weight would have been closer to maximum and a greater poundage could have been harvested.

With many large trollers taking part in both the salmon and tuna fisheries, a tendency developed for increased mobility among the fishing fleet. Trollers based in Oregon were found to be following schools of salmon on their annual migration routes to distances as far north as Vancouver Island and as far south as the Northern California Coast. With increased mobility from Oregon, Washington and California troll fishermen, increased fishing pressure and competition developed on the salmon schools wherever they were found along the Pacific Coast.

Although much of the troll fleet was characterized by great mobility, a substantial proportion of it had always consisted of smaller day boats not suited to the early season type of mobility. Their restricted radius of operation caused them to depend upon fishing during the late summer and fall months when weather conditions were more favorable and maturing fish were concentrated off river mouths (Wright 1970:6).

The number of trollers fishing in any year depended a great deal on the success of other fisheries. Even though many only trolled for salmon, others were gillnetters or crab fishermen who would turn to salmon trolling after their respective season was over or when salmon were biting exceptionally well in the ocean.

Development of other fisheries after World War II, notably the sport and charter boat fisheries, had another impact on ocean trollers. As sport and charter boats were day boats fishing near the mouths of rivers, they came into direct competition with the smaller commercial trollers. During the 1960's when the coho hatchery program on the Columbia River greatly increased the run size, the effect was even more pronounced. Increasing the success of fishermen, some commercial fishermen realized the potential profits and became charter boat operators. Even more significant, many sport and charter boat operators utilized the experience gained from their sport operations and bought commercial licenses. Joining the fleet of small day boat trollers, the number of trolling boats in the Columbia River area rapidly increased from 289 in 1961 to 1528 in 1971 (see Table 14). Their presence helped to decrease the average success per vessel among trollers creating greater inefficiency of harvest within the troll fishery.

Samuel Wright (1970:6-8) gives a good description of the types of boats exploiting salmon in the ocean fishery. Characteristics included (1) regular trollers or "ice boats," having inboard gasoline or diesel engines, power gurdies and outrigger poles and trip fishing capabilities; (2) day boats, which included inboard or outboard boats utilizing four or more power or hand gurdies, lacking trip fishing capability, and with a minority using mobile sport-type gear; (3) kelpers, which included inboard and outboard powered crafts with less than four power or hand gurdies, lacking trip fishing capability, and with a majority using mobile sport-type gear; (4) charter boats, which included all licensed vessels fishing commercially and also conducting chartering operations for ocean sport anglers; and (5) commercial-sport boats, which included all boats except charter boats that were licensed commercially and relied exclusively on mobile, rod and reel gear. Although these terms and characteristics refer to Washington trolling boats, many of the same boats can be found in Oregon waters. The last category of commercial-sport boats, however, has been illegal in Oregon for some time.

Regular trollers or "ice boats" often have special characteristics which set them apart from other types. Being manned by fishermen who are more likely to be full-time or professional fishermen, the boat must often be used for more than one fishery. For instance, a combination gillnet-troll vessel would have a very specialized appearance. The characteristic long outrigger poles would typify its trolling ability while the large drum or reel in the stern would show its use as a gillnet vessel.

At present, many new trollers are being built for salmon, tuna and/or crab fishing which incorporate such technological advances as automatic pilots, sonar equipment, two or three radio-telephones, depth sounders, LORAN receivers, radar, a spray brine freezing system for quick refrigeration of fish, alarm systems, an automatic fire protection system and the new encapsulated ejection type life raft. Although this represents a sizeable monetary investment, it is often believed to be necessary for a safe and competitive operation (Klopfenstein and Klopfenstein 1975a:1-2). Then, before any fishing is conducted, the captain might make tests to determine if his boat generates a positive electrical field so that his boat will attract and not repel salmon and tuna when fishing (Klopfenstein and Klopfenstein 1975b:1, 11-2).

Comparison of Efficiency Between the Gillnet and Troll Fisheries

With the elimination of fishwheels, traps and seines in the river fishery and shifts in time, area and intensity of fishing pressure in the ocean troll fishery, the commercial harvest of Columbia River salmon has become noticeably affected. Where at one time the entire harvest took place in the river among the different gear forms, the harvest in 1973 has been changed to consist entirely of the Columbia River gillnet, Indian set net and ocean troll catch. This has resulted in a partial redistribution of the total harvest as well as changing the efficiency of each harvest method over time.

In order to determine what changes have taken place, a comparison has been made between the gillnet and troll fisheries of the Columbia River area. The comparison shows the total catch in pounds of chinook and coho salmon landed at Columbia River ports, percentage of the total catch, and average efficiency for both gear types from 1926 to 1973. These are shown graphically in Figures 1, 2, and 3, and the complete data are given in Tables 13, 14 and 15 (see appendix).

Although there are a number of ways to measure harvest efficiency, in this case the basis for comparing efficiency was the average catch per vessel. For the efficiency of trollers, data for 1926 may be somewhat incomparable to data for 1971. Trollers in the

1920's were just becoming mobile and most of the fishing was done near the river mouth. Although there are many day boats still fitting this pattern in 1971, the largest harvest occurred with trollers who were very mobile and followed the salmon schools wherever they were to be found. This resulted in some fish being caught outside the Columbia River area but being landed in Columbia River ports. Likewise, some fish caught in the Columbia River area were landed in ports outside of it. Whereas between 50% and 75% of Oregon's troll catch in the late 1920's was landed in the Columbia River area, the percentage dropped to between 10% and 15% in the early 1970's. While mobility has allowed trollers to increase efficiency in terms of the number of salmon caught, it has also caused a decrease in efficiency since the fish were harvested at a lesser average weight.

For comparison, only landings for chinook and coho salmon were used as these two species comprised the major target fish of both groups. Trollers occasionally had a sizeable catch of pink salmon but other salmon species do not readily take a hook. Gillnetters harvested varying amounts of steelhead, blueback (sockeye), chum and a few pink salmon. Hence, figures for the total harvest, percentage of the total Columbia River harvest and average efficiency would be different if the data for these species had been included. Presently though, they are insignificant when considering catch statistics.

The total catch for both the Columbia River gillnet and troll fisheries has exhibited similar trends since 1942 while varying somewhat before this time period (see Figure 1). From 1926 to 1949, the total gillnet catch was fairly stable at a high level of between 10 and 16 million pounds annually with one exceptionally high year in 1941. From 1949 to 1952, a period of decline was evident. Decreased fishing time may have had some influence, but the decline was more directly related to the deterioration of natural habitat and loss of spawning grounds. Not only did this affect the chinook and coho runs, but the catch of steelhead, blueback and chum salmon began to fall also. After the decline in salmon runs, the fishery stabilized at a lower level. Existing from 1952 through 1973, some fluctuations have been noticeable and they are largely due to the increased harvest of the improved coho runs.

From 1926 to 1943, the total salmon troll harvest in the Columbia River area underwent a decline. Although there was some fluctuation in the number of trolling vessels during these years, the differences did not correspond to the rise and fall of the total catch. Quite likely, the decreasing harvest was due to a combination of effects which brought about a depression in this country during the 1930's. At this time, the number of troll fishermen actually decreased as the price paid fishermen for salmon fell almost in half. From 1944 to 1957, the total catch was variable but generally stable

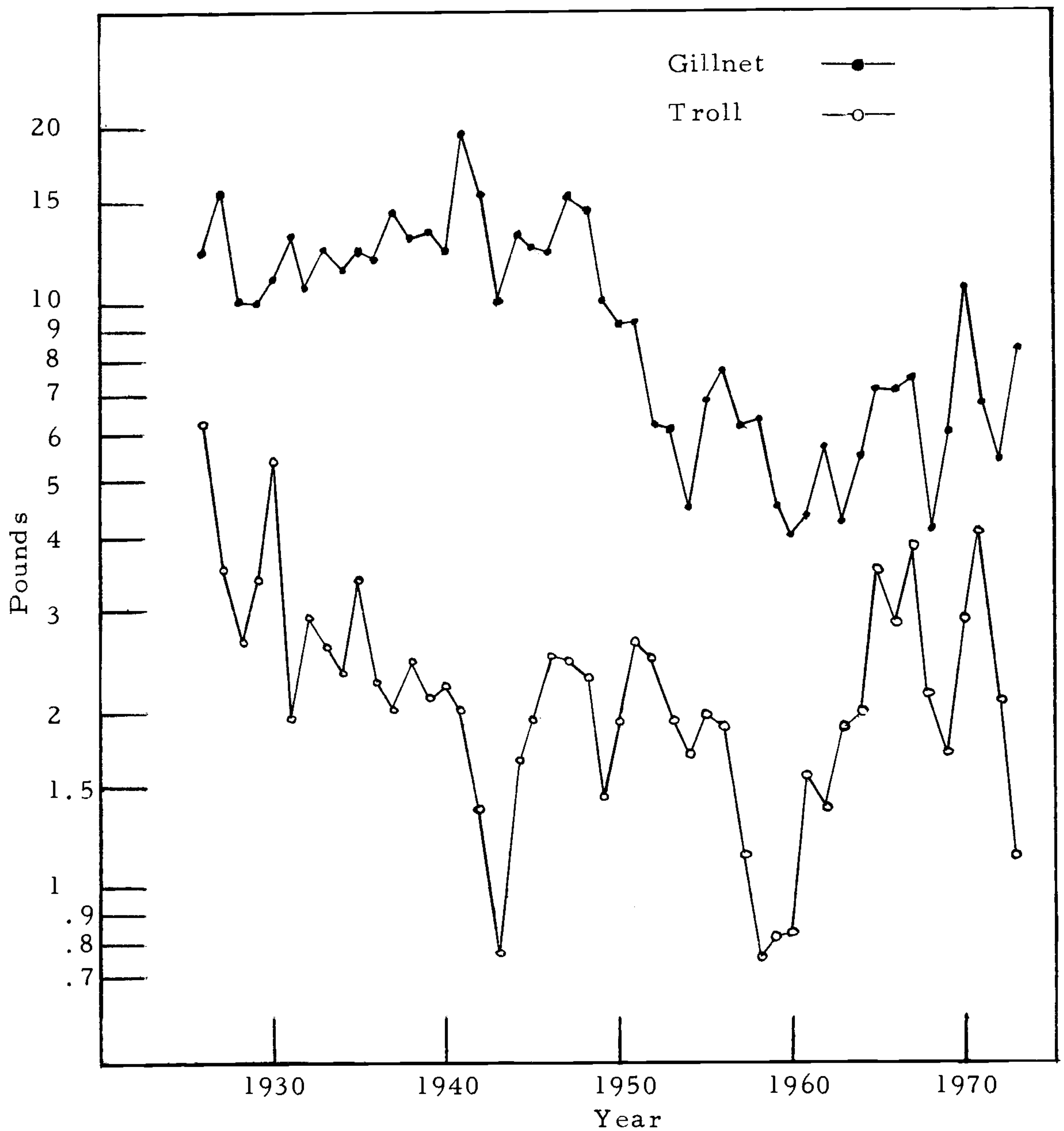

Figure 1. Total catch of chinook and coho salmon in millions of pounds from 1926 to 1973

overall. After a small period of decline from 1958 to 1960, the fishery began improving. Increasing considerably since 1965, the improved harvest was due to the coho hatchery program on the Columbia River and an increase in the number of trollers. Stabilizing until 1971, the total catch began declining, possibly because of direct competition with the growing numbers of sport fishermen.

Of the percentage of the total Columbia River chinook and coho salmon harvest (see Figure 2), the gillnet fishery has historically been the most significant. During the late 1920's and early 1930's, gillnetters took between 40% and 60% of the total harvest. Thereafter, from 1935 to 1973, a substantial increase occurred due to the elimination of fishwheels, traps and seines. The yearly fluctuations, corresponding with the fluctuations in the percentage of the troll harvest, remained at a fairly high level of between 55% and 90% annually.

The percentage of Columbia River salmon harvested by trollers from 1926 to 1943 has declined, dropping from above 20% to less than seven percent. After 1943, when World War II created new demands for salmon, their percentage of the total harvest increased. Remaining at a fairly stable level of between 10% and 23% through 1960, the increase reflected the redistribution of salmon from the historical gear types to the ocean troller. Since 1961, the percentage of the total harvest again increased, ranging between 18% and 34% annually with the exception of 1973. This was primarily due to a considerable

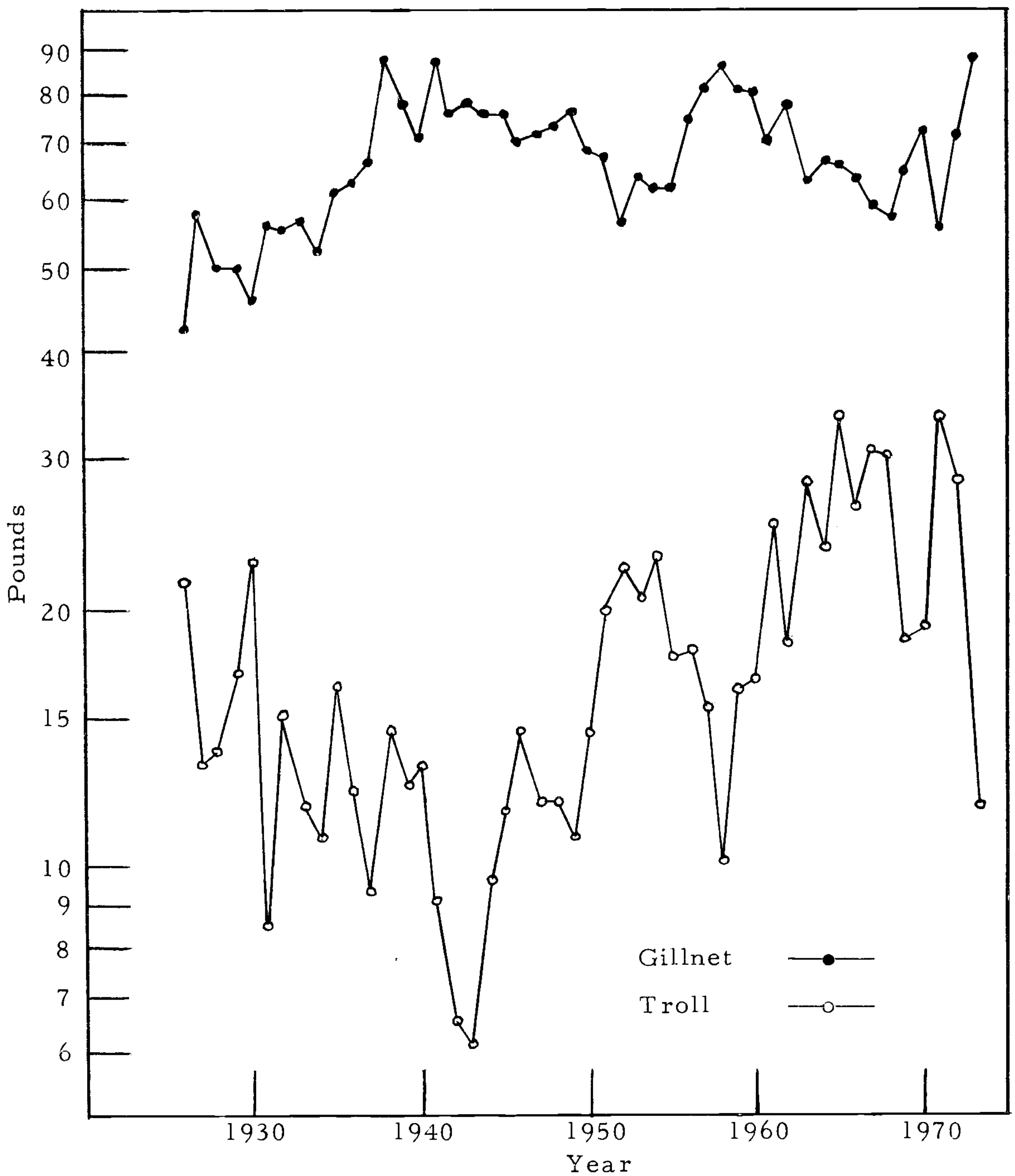

Figure 2. Percentage of total Columbia River chinook and coho catch from 1926 to 1973

increase in the harvest of coho salmon which presently comprises the largest fishery for trollers.

The average efficiency of pounds landed per vessel has shown considerable fluctuation for both the gillnet and troll fisheries from 1926 to 1973 (see Figure 3). From 1926 to 1948, innovations made by gillnetters upon their nets and boats helped increase their efficiency to an average of 10,954 pounds per vessel. After 1948, when post war industrialization damaged much of the river's natural environment and decreased the abundance of salmon, the efficiency of gillnetters declined. Oscillating widely from 1949 to 1973, the efficiency of gillnetters remained fairly stable overall, averaging 7,860 pounds per vessel annually. From 1926 to 1973, the total average chinook and coho catch per gillnet vessel was 9,606 pounds.

The average efficiency for trollers between 1926 and 1938 remained relatively high at 11,780 pounds per vessel. From 1939 to 1971, there was a trend of decreasing efficiency with the average dropping to 4,279 pounds ver vessel. Initially, this was due to declines in the coho harvest. Later, shifts by fishermen to the albacore fishery resulted in the height of the salmon season shifting to an earlier part of the season when salmon were more immature. Even though an upswing occurred in the early 1960's when hatchery efforts increased the coho population, the subsequent addition of considerably more day boats was the factor instrumental in continuing to

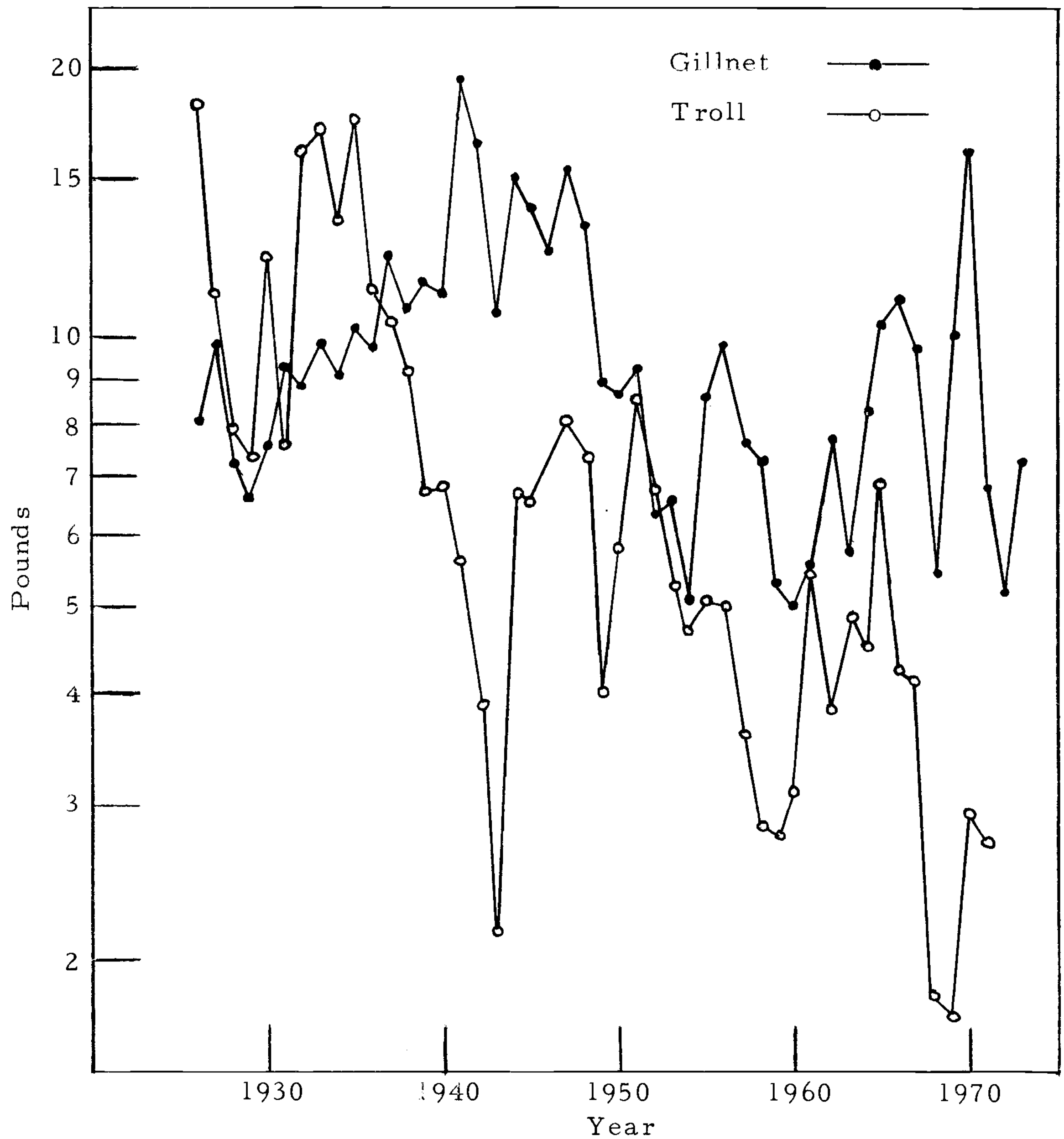

Figure 3. Average efficiency in thousands of pounds per vessel from 1926 to 1973

lower the average efficiency of trollers. Overall from 1926 to 1971 the average chinook and coho harvest per troll vessel was 5,693 pounds.[1] Essentially, while gillnetters have declined in efficiency since 1926, they have remained somewhat stable the last 25 years. In comparison, the efficiency of trollers has steadily declined from 1926 to 1971 causing the troll fishery to be characterized as one of declining average efficiency.

Another way to determine the efficiency of salmon fishermen would be to look at the ratio of their gross returns from fishing compared to their total costs. From such an analysis insight might be obtained for why the average catch per vessel efficiency for troll fishermen has been steadily declining. According to Liao and Stevens (1975:14-5), the average specialized salmon troll fisherman in 1972 had total costs of $60 to $400 greater than gross returns. Furthermore, of these specialized salmon troll fishermen which comprised nearly 80% of all commercial fishermen in Oregon, scarcely 10% netted more than $1,000 (Stevens 1975:7). Other characteristics of these primarily part-time fishermen, was that 85% of them had non-fishery employment and that their average time devoted to the fishery per year was only 45 to 50 days (Liao and Stevens 1975:10-2). From these factors, it becomes evident that the overall efficiency for

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[1] The year 1946 was omitted due to insufficient data.

Oregon's salmon troll fishery has reached a very low level in terms of average catch per vessel as well as costs of harvest versus value of the catch.

Even though the influence of specialized salmon troll fishermen seemed to predominate in the troll fishery, there were a number of combination fishermen who had substantially different commitments to trolling. Combination fishermen also differed in their fishing characteristics depending upon whether they fished for salmon and tuna or for salmon and/or tuna and crab. Salmon-tuna trollers, fishing an average of four months, had gross returns averaging \$3,400 more than total costs. Since 50% of them had non-fishery employment, the other 50% could be considered as true professional fishermen. In comparison, the fishermen for salmon and/or tuna and crab averaged seven months in the fishery and had gross returns averaging \$15,800 more than total costs. With only 20% of them having been employed in non-fishery jobs, the majority were full-time fishermen who tended to live in close proximity to coastal areas (Liao and Stevens 1975).

Comparing the characteristics of these two fishermen groups with the specialized salmon troller, it would be easy to see which group would be the most efficient harvester of the resource. While total costs for full-time fishermen were considerably higher than for part-time fishermen (Liao and Stevens 1975:13-4), their gross income and total harvest were higher allowing them to produce a profitable income. Depending upon fishing for a living, their efficiency levels had to be substantially greater than for part-time fishermen who had non-fishery employment to fall back on. Essentially, it was the predominance of the part-time specialized salmon troller which brought low levels of efficiency to the troll fishery and counteracted the higher levels of efficiency of full-time fishermen.

Different levels of vessel efficiency and profit margins existed for gillnetters but in a different perceptible form. Efficient gillnetters were those strongly committed to fishing despite a short season. Some fished in other fisheries and owned a second boat or had a combination vessel. Others participated in gillnet fisheries outside the Columbia River such as in Washington or Alaska. Still, others were "highliners" who would consistently harvest more salmon relative to their peers. For the most part, efficient gillnetters knew how and where to catch fish and would fish almost continually until the season was over. In contrast, gillnetters with low levels of efficiency might fish only during the peaks of the salmon runs or in areas where fishing was not as productive. Investment in gear would be much less and their actual income derived from the fishery would be low or even negligible.

Other methods of determining efficiency could be used for comparing gillnetters and trollers. One such method would be by comparing the distance traveled and necessary fuel consumption expended to obtain their respective harvests. Trollers are continually moving throughout the ocean, looking for hot spots or schools of salmon. Gillnetters remain in the river near home port and drift with the tides to intercept salmon. Operating smaller boats in general, their total energy expended would be considerably less than the farther ranging trollers. A more significant comparison of efficiency would be each fishery's method of harvest compared to the potential for resource maximization. This type of efficiency will be discussed in Chapter Four.

IV. HARVEST POTENTIAL OF COLUMBIA RIVER CHINOOK SALMON

As a result of the evolution of trolling, much of the harvest of Columbia River salmon takes place in the ocean. Trollers from California to Alaska take salmon which originate from spawning grounds in the Columbia River system. The various salmon runs produced by the Columbia system have different oceanic migration patterns which expose them to different troll fisheries throughout their life. Since salmon do not return to the river until maturity they continue to feed and grow while in the ocean. With trolling being an ocean based fishery, the salmon stocks fished are at various stages of maturity. The time and area of fishing pressure largely determines the amount of exposure and the degree of immaturity of a particular fish stock. Since many Columbia River salmon are harvested in the ocean when immature, some loss of weight is encountered by not allowing them to return to the river when at full maturity. This chapter provides an estimate for the weight loss of Columbia River chinook salmon because of their early immature ocean harvest. Also, it provides an estimate for the total potential Columbia River commercial chinook harvest with no ocean fishery.

When salmon enter the rivers and ascend to spawn, a physiological change occurs that allows them to discontinue feeding and live off their stored body fats. Consequently, some loss of weight is expected during their upriver migration. By comparing the salmon harvest between the lower river gillnet fishery below Bonneville Dam (zones 1-5) and the upper river Indian fishery above Bonneville Dam (zone 6), a difference in the average weight per fish harvested is shown to occur. However, due to the different nature of the fisheries, selectivity of gear is another factor which tends to influence the increase or decrease in average weight per fish harvested.

The study of the harvest potential of Columbia River chinook salmon, undertaken in late 1974, was for the purpose of ascertaining the best place to harvest the salmon resource to utilize its fullest potential. With increasing pressure being placed on eliminating the river gillnet fishery, it is hypothesized that its elimination would make Oregon's salmon fisheries increasingly inefficient.

Migrations and Distributions of Columbia River Salmon

Because of the migrations of salmon during their ocean life, stocks which Pacific Coast trollers fish upon tend to vary in origin with proportions of fish from each area of origin changing geographically with time. Based on studies of tagged hatchery fish, two-year-old chinook from the Columbia River first became available to ocean fisheries from Oregon to Vancouver Island (Cleaver 1969:36). With increasing age, these fish shifted northward as chinook caught southward of the west coast of Vancouver Island were dominantly three-year-olds, while more four-year-olds were caught from Central British Columbia northward (Pulford 1970:6). This indicates that older and immature chinook at age three migrated to more northerly waters than younger and mature fish at age three (Cleaver 1969:38). In general, the various Columbia River chinook stocks have been found to be distributed differently due to their run, age at maturity, area of origin and time and area of capture.

This means that while one area may abound in immature fish from the Columbia River, another area may have older fish which are larger and closer to maturity. Where certain stocks may be exposed to very little fishing pressure, others may become available for harvest by many fisheries for a longer period of time. Hence the contribution of Columbia River chinook to the various troll fisheries can vary widely between stocks.

Problems Associated with the Salmon Resource

The contribution of Columbia River chinook salmon to ocean trollers has been significant in the past and even more pronounced in recent years when more fishermen have entered into the fishery. Besides dams and the loss of spawning grounds, the addition of considerably more ocean fishing pressure has been a major reason for the decline of fall chinook runs in past years (Van Hyning 1968). This has also presented problems in effective management practices. The increased fishing power of the troll fishery which operates on large numbers of salmon stocks at various levels make it extremely difficult to manage these intermingled stocks as separate units.

In actual operation, trolling can be considered as an inefficient harvest technique since it exploits immature salmon stocks that are still feeding and gaining weight. If left to be captured in the river, these fish would be fully mature and at their maximum weight. Thus, the effect of trolling has been to inefficiently utilize the harvest potential of salmon, as those which were caught would have gained more than enough in weight to affect losses due to natural mortality (Crutchfield and Pontecorvo 1969:38). Only in cases where there exists a high degree of natural mortality would harvesting in the ocean provide a greater yield (Henry 1972:441). But since trollers fish on intermingled salmon stocks, it would be impossible for them to identify and discriminately harvest only those stocks whose natural mortality exceeded their growth rate.

Another problem associated with trollers is undersized fish which have to be released. Hooking mortality has a detrimental effect on salmon, killing and injuring many immature fish. Those which do survive exhibit rates of growth much slower than normal (Wright 1971:48). The problem becomes intensified when salmon are striking well because fishermen then are less apt to take care when shaking salmon off their hooks. Among trollers, the "shaker" problem is a very emotionally charged issue since it directly indicates resource waste.

The actual number of undersized chinook which are caught and released by trollers varies greatly with area and season. Van Hyning (1973:32), conservatively estimated that 25% of the troll chinook caught between central Oregon and Vancouver Island were undersized and returned to the water. Between northern British Columbia and Alaska, this figure drops to about 5%. Of this percentage, many would be fatally damaged. "Based on physical damage alone, Van Hyning and Naab (1957) estimated that 30% of a large sample of troll-caught chinook under 24 inches would probably die if released" (Van Hyning 1973:32). Other studies have shown that a hooking mortality of 40% would appear reasonable (Van Hyning 1973:33). Thus, hooking mortality can be considered as having a very detrimental effect on chinook salmon stocks. Up to 10% of the total number caught by trollers die from hooking mortality along the Oregon and Washington coast alone.

Discussion of Factors for Determining the Harvest Potential of Columbia River Chinook Salmon

Where should salmon be harvested to best utilize their weight and produce the largest quantity for commercial use? Salmon continue to feed and grow in the ocean, gaining their maximum weight the last month before reaching maturity. At maturity, feeding is considerably reduced and salmon enter the rivers and ascend to spawn.

Based on the reasoning that lower Columbia gillnetters harvest mature salmon which have attained their maximum weight and that trollers operate inefficiently for maximizing the weight of salmon by fishing on immature stocks, some measurable difference must arise between the two. This can be accounted for as the difference between the maximum yield of salmon and the amount lost from this yield due to their immature ocean harvest. In order to compute the amount of this difference, some estimate is needed to determine what proportion of the catch for each troll area originated from the Columbia River system.

Richards (1968:82), using information supplied primarily by Van Hyning (1968), gives a complete estimate by area for the percentage of the commercial catch attributable to the Columbia River system. This is shown in Table 1. By using this table and applying each area's percentage to its respective yearly catch statistics, it becomes possible to estimate the number of fish and total pounds caught which originated from the Columbia River system. Then, comparing the statistics of the Columbia River gillnet fishery with the statistics for each troll fishery area, the difference in average weight per fish times the number of Columbia River fish caught would

Table 1. Estimated percent and possible range of the commercial catch of chinook salmon attributable to the Columbia River by area.[1]

State and Region	% chinook salmon	possible range in %[5]
<u>Alaska</u>		
Southeastern Troll	45.0	40-52
<u>British Columbia</u>		
Queen Charlotte Islands (Areas 1, 2)	25.0	19-36
West Coast Vancouver Island (Areas C, 21-27)	45.0	36-62
<u>Washington</u>		
Puget Sound Troll[2]	50.0	37-63
Coastal Troll	65.0	62-71
<u>Oregon</u>		
Coastal Troll	47.0	28-47
<u>Columbia River</u>		
Columbia River Troll[3, 4]	80.0	72-80
Columbia River Gillnet[4]	100.0	100

[1] Source: Jack A. Richards (1968:82).

[2] Caught in ocean and landed in that district.

[3] Caught in ocean at mouth of Columbia River.

[4] Oregon and Washington landings combined.

[5] Sources: Van Hyning (1973:35), Silliman (1948:3-6), Richards (1968:82).

provide the amount of weight loss from the potential maximum yield. Adding the gillnet harvest to the catch of Columbia River fish for each troll area fishery plus the weight loss incurred from their premature harvest, an estimate of the total maximum potential yield of Columbia River salmon with no ocean fishery can be obtained. However, some explanation of the limitations of Richards' table is needed before this is undertaken. Also, since the data I have chosen to work with deals only with Columbia River chinook salmon, my comments will be directed towards the percentages expressed for them.

The estimated percentages derived by Richards were primarily based on ocean tagging studies with subsequent recoveries in various spawning areas. However, to determine what proportion of a troll area's chinook catch came from the Columbia River system, i.e., the contribution of Columbia River chinook to a particular troll fishery, it must be noted that there is tremendous variability in establishing such a percentage. Changing factors such as availability or vulnerability of a salmon stock, mortality rates of tagged salmon, recovery effort of tagged salmon, or amount of fishing pressure may cause changes in the percentage of one area's catch from year to year or even month to month. Hence, Richard's percentages may not reflect the true percentages in all instances but can only be regarded as perhaps a general average.

Even though only Richard's percentages were used for the estimates in this study, their limitations brought cause for including a possible range of the percentages of Columbia River fish in each troll fishery area. This range is also shown in Table 1.

The percentages are limited to areas in the ocean where trollers operate but this is justifiable as Columbia River salmon do not migrate into internal waters in any significant numbers (Van Hyning 1973:9-13). An exception would be the Columbia River proper and all chinook salmon entering would be from this system with the exception of an insignificant number of strays. Richards' table also fails to include catch percentages for California and the more northerly areas of Alaska but for California, its catch of the northerly migrating chinook would be negligible. Pulford (1970:6) found that 98% of all hatchery fall chinook in 1966 were taken northward of the Columbia River with most of these taken off the west coast of Vancouver Island. For northern Alaska, some of the spring, summer and possibly fall chinook originating from areas in the upper Columbia have been found to migrate to the central waters and northern Gulf of Alaska. Apparently some are taken by the troll fisheries, but their main migration in these areas appear to be over by the time the fishery reaches its peak (Van Hyning 1973:73). Although the sampling done in the Alaskan areas is limited, their catch of Columbia River chinook also appears to be negligible with the possible exception of a few upriver stocks.

Since the percentages used were only for determining the proportion of Columbia River chinook in commercial catches, no figures have been included for ocean sports anglers. They, too, take a considerable quantity of Columbia River chinook from Oregon to British Columbia and especially off Washington (Van Hyning 1973:31-2; Pulford 1970; Worlund et al. 1969). This catch would have to be considered if an estimate were made to determine the Columbia River's contribution to all fisheries. It would also have to be considered for a complete estimate of the total harvest potential yield. I have therefore limited my analysis to the commercial harvest of chinook salmon and have assumed that a certain percentage of chinook harvested by trollers would have returned to the Columbia River.

Statistics for analysis have been established to include individual data for eight different fishing districts for a five-year period from 1969 to 1973. Each area takes a significant proportion of Columbia River chinook salmon in their total catch. Also, each of these regions is geographically separate from one another and their respective catch statistics were recorded by the adjacent state. All troll-caught salmon were assumed to be caught in the district indicated. Possibly some troll-caught chinook were landed in districts other than where they were originally caught due to the mobility of many trollers. This was assumed to have little significance in determining each area's estimate for Columbia River caught chinook.

The Columbia River gillnet catch included figures for zones one through five. Zone six is treated separately in a comparison with zones one through five later in this chapter. The five-year period for the catch statistics provides for a general average, showing some of the variability of various fisheries and possibly some trends for the future.

With an understanding of the limitations in obtaining accurate estimates for each troll area's percentage of commercially caught Columbia River chinook salmon, estimates can be made leading to the theoretical total potential harvest with no ocean fishery. To explain the potential harvest, three major variables will be isolated and put into numerical form such that the potential Columbia River chinook salmon harvest equals $a_1 + a_2 + a_3 \pm \dots \pm a_n$. The variables include a_1, the Columbia River gillnet harvest of chinook; a_2, the troll harvest of Columbia River chinook; and a_3, the weight loss of Columbia River chinook because of their immature ocean harvest. For the last variable, a_3, weight loss is determined by a comparison of the average weight differences between gillnetters and trollers. However, as each troll area's harvest is comprised only partially by Columbia River fish, there is a possibility of another race of fish having a much different average weight. Hence, fish from another river system could raise or lower the actual average weight of Columbia River fish causing an error in the estimate for weight loss.

In this study, I have assumed that the average weight for chinook salmon from all river systems is equal.

The three variables identified were the only ones measured. Other identifiable factors which affect the potential yield will be discussed later but not included numerically within the equation. These factors, because of their variability, often become hard to measure and tend to offset each other. Also, the equation was left open-ended as some unidentified and unknown variables could have an effect on the potential yield.

Discussion and Explanation of Statistical Data

Table 2 shows the commercial landings of chinook salmon by area in numbers of fish from 1969 to 1973. In Table 3, for the same areas and years, the commercial landings are shown as pounds in the round. From these two tables, the average weight of chinook salmon for each area has been computed and this is shown in Table 4.

Chinook caught by Columbia River and Oregon coast trollers average less than any other area, generally between 10 and 12 pounds. North of this along the Washington coast the general average increases to slightly over 12 pounds. Further north, both the Washington Puget Sound and west coast of Vancouver Island, British Columbia troll areas have similar average weights of between 12 and 14 pounds although those caught in the former area do average slightly heavier.

Table 2. Commercial landings of chinook salmon by area in numbers of fish from 1969 to 1973.[1]

Area or Region	Year 1969	1970	1971	1972	1973
Southeast Alaska Troll	289,983	304,245	311,420	242,285	307,648
British Columbia Area 1. 2 Troll	95,925	106,139	122,922	112,474	95,037
British Columbia Area C, 21-27 Troll	466,164	408,102	685,233	617,996	655,770
Washington Puget Sound Troll	16,167	22,165	52,281	68,811	58,289
Washington Coast Troll	151,541	159,663	171,935	118,628	237,121
Oregon Coast Troll	126,010	135,083	85,270	116,109	350,244
Columbia River Troll	29,872	57,678	44,021	24,278	30,431
Columbia River Gillnet[2]	227,200	229,400	256,400	228,600	349,600

[1] Sources: Alaska Commercial Fisheries Statistics, Statistical Leaflet; British Columbia Catch Statistics; Status Report Columbia River Fish Runs and Commercial Fisheries, 1938-70, 1974 addendum; Washington Department of Fisheries; Fish Commission of Oregon.

[2] Gillnet statistics for zones 1-5 only.

Table 3. Commercial landings of chinook salmon by area in pounds round from 1969 to 1973.

Area or Region	Year				
	1969	1970	1971	1972	1973
Southeast Alaska Troll	3,914,744	4,352,339	4,215,066	2,852,159	4,283,082
British Columbia Area 1. 2 Troll[1]	1,568,392	1,641,806	1,947,460	1,573,686	1,334,151
British Columbia Area C, 21-27 Troll[1]	5,962,267	5,108,245	8,940,341	7,582,895	7,817,843
Washington Puget Sound Troll[2]	224,640	284,014	697,754	866,225	706,170
Washington Coast Troll[2]	1,841,224	1,919,739	2,045,229	1,520,452	2,866,522
Oregon Coast Troll	1,236,461	1,659,180	969,738	1,384,433	3,846,718
Columbia River Troll	330,900	590,100	473,500	271,100	319,900
Columbia River Gillnet	4,411,800	5,504,800	4,765,900	4,342,800	6,835,200

[1] British Columbia statistics converted from dressed weight to round weight by factor of 1. 1765.

[2] Washington statistics converted from dressed weight to round weight by factor of 1. 15.

Table 4. Average weight in pounds of chinook salmon by area from 1969 to 1973.

Area or Region	Year				
	1969	1970	1971	1972	1973
Southeast Alaska Troll	13.5	14.31	13.53	11.77	13.92
British Columbia Area 1.2 Troll	16.35	15.47	15.84	13.99	14.04
British Columbia Area C, 21-27 Troll	12.79	12.52	13.05	12.27	11.92
Washington Puget Sound Troll	13.89	12.81	13.35	12.59	12.11
Washington Coast Troll	12.15	12.02	11.9	12.82	12.09
Oregon Coast Troll	9.81	12.28	11.37	11.92	10.98
Columbia River Troll	11.08	10.23	10.76	11.17	10.51
Columbia River Gillnet	19.42	18.39	18.59	19.0	19.55

Again going north, chinook caught in the northern areas of British Columbia around the Queen Charlotte Islands and in southwestern Alaska have heavier average weights than areas in the south. For the Queen Charlotte Island troll area, the average weight runs from 14 to 16 pounds but then drops to about 13 1/2 pounds for the southwestern Alaska troll area.

The shifting from a smaller to larger average weight shows the characteristic northward migration of Columbia River chinook. Immature chinook tend to migrate slowly northward, increasing in weight and age the further northward they go from the Columbia River. Maturing three-year-old fish, tending to stay closer to the Columbia, become available to the fisheries from Vancouver Island south. Immature three-year-olds continue their migration northward and become available to the Queen Charlotte and southwestern Alaskan troll fisheries (Cleaver 1969:36-38). Hence, the average weight of chinook salmon tends to increase going north as the average age and size tends to increase.

Although the drop in average weight from the Queen Charlotte troll area to the southwestern Alaska troll area doesn't fit this pattern, the discrepancy is due to another factor. At the time of their northward migration, many chinook salmon from the Columbia River are not available to the troll fisheries because of the time of the troll season openings. Maturing in the Alaska area, they become available to the troll fisheries on their return migration (Cleaver 1969:37). Hence, their average weight would increase going south causing a larger average weight to occur in northern and central British Columbia than in the Alaskan area.[2]

Table 5, which is calculated from Table 4, shows the average weight difference of chinook salmon between each troll area and the Columbia River gillnet fishery. These differences will be used in Table 8 to estimate the weight loss of Columbia River chinook salmon due to their inefficient ocean harvest.

Table 6 gives an estimate for the number of landings of chinook salmon by the commercial fisheries which can be attributed as originating from the Columbia River system. This was done by applying the percentage of Columbia River chinook in each area's landings (Table 1) to their respective number of total chinook landings (Table 2). As a five-year average, approximately 920,000 chinook salmon from the Columbia River system were harvested. Of this number, only an average of about 270,000 chinook were caught at their most mature stage by the gillnet fishery. This represents a yearly average

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[2] Average weights for different zones are affected by variability in stocks, including immature fish migrating northward and larger, more mature fish returning to the Columbia River system. The proportion of large to small fish varies according to the different migrational patterns of fish maturing at age three and at age four, as well as the percentages of immature and maturing salmon in the stocks of any given zone.

Table 5. Average weight difference of chinook salmon of each area compared to the Columbia River gillnet fishery from 1969 to 1973.

Area or Region	Year				
	1969	1970	1971	1972	1973
Southeast Alaska Troll	5.92	4.08	5.06	7.23	5.63
British Columbia Area 1. 2 Troll	3.07	2.92	2.75	5.01	5.51
British Columbia Area C, 21-27 Troll	6.63	5.87	5.54	6.73	7.63
Washington Puget Sound Troll	5.53	5.58	5.24	6.41	7.44
Washington Coast Troll	7.27	6.37	6.69	6.18	7.46
Oregon Coast Troll	9.61	6.11	7.22	7.08	8.57
Columbia River Troll	8.34	8.16	7.83	7.83	9.04
Columbia River Gillnet	--	--	--	--	--

Table 6. Estimated commercial landings of chinook salmon in numbers of fish attributable to the Columbia River by area from 1969 to 1973.

Area or Region	Year 1969	1970	1971	1972	1973
Southeast Alaska Troll	130,492	136,910	140,139	109,028	138,442
British Columbia Area 1.2 Troll	23,981	26,535	30,731	28,119	23,759
British Columbia Area C, 21-27 Troll	209,774	183,646	308,355	278,098	295,097
Washington Puget Sound Troll	8,084	11,083	26,141	34,406	29,145
Washington Coast Troll	98,443	103,781	111,758	77,108	154,129
Oregon Coast Troll	59,225	63,489	40,077	54,571	164,615
Columbia River Troll	23,898	46,142	35,217	19,422	24,345
Columbia River Gillnet	227,200	299,400	256,400	228,600	349,600
Total	781,097	870,986	948,818	829,352	1,179,132

of about 650,000 chinook which were harvested at immaturity by the various coastal troll fisheries.

Table 7 gives an estimate for the poundage of chinook salmon harvested by the commercial fisheries which can be attributed as originating from the Columbia River system. Again, this was done by applying the percentage of Columbia River chinook (Table 1) to each area's respective landings in pounds round (Table 3). For a five-year period, a yearly average of over 13.3 million pounds of Columbia River chinook was estimated to have been caught by the various commercial fisheries. Of this amount an average of over 5.1 million pounds were caught by the gillnet fishery on the Columbia. This leaves an amount averaging over 8.1 million pounds yearly which are being caught by ocean trollers.

The troll harvest of these approximately 650,000 chinook, weighing over 8.1 million pounds, represents a significant amount of Columbia River chinook salmon, an even greater quantity than that harvested by the gillnet fishery. If these fish were left to return to the river when fully mature, they would have undoubtedly contributed more to the total poundage harvested, hence more efficiently utilizing the harvest potential of salmon.

An estimate of the weight loss in pounds of Columbia River chinook due to their inefficient ocean harvest has been calculated and is shown in Table 8. The figures derived for this computation were

Table 7. Estimated commercial landings of chinook salmon in pounds round attributable to the Columbia River from 1969 to 1973.

Area or Region	Year				
	1969	1970	1971	1972	1973
Southeast Alaska Troll	1,761,635	1,958,553	1,896,780	1,283,472	1,927,387
British Columbia Area 1.2 Troll	392,098	410,452	486,865	393,422	333,538
British Columbia Area C, 21-27 Troll	2,683,020	2,298,710	4,023,153	3,412,303	3,518,029
Washington Puget Sound Troll	112,320	142,007	348,877	433,113	353,085
Washington Coast Troll	1,196,796	1,247,830	1,329,399	988,294	1,863,239
Oregon Coast Troll	581,137	779,815	455,777	650,684	1,807,957
Columbia River Troll	264,720	472,080	378,800	216,880	255,920
Columbia River Gillnet	4,411,800	5,504,800	4,765,900	4,342,800	6,835,200
Total	11,403,526	12,814,247	13,685,551	11,720,968	16,894,355

Table 8. Estimated weight loss in pounds of Columbia River chinook salmon by area from 1969 to 1973.

Area or Region	Year				
	1969	1970	1971	1972	1973
Southeast Alaska Troll	772, 513	558, 593	709, 103	788, 272	779, 428
British Columbia Area 1. 2 Troll	73, 622	77, 482	84, 510	140, 876	130, 912
British Columbia Area C, 21-27 Troll	1, 390, 802	1, 078, 002	1, 708, 287	1, 871, 600	2, 251, 590
Washington Puget Sound Troll	44, 705	61, 843	136, 979	220, 542	216, 839
Washington Coast Troll	715, 681	661, 085	747, 661	476, 527	1, 149, 802
Oregon Coast Troll	569, 152	387, 918	289, 356	386, 363	1, 410, 751
Columbia River Troll	199, 309	376, 519	275, 749	152, 074	220, 079
Columbia River Gillnet	--	--	--	--	--
Total	3, 765, 784	3, 201, 442	3, 951, 645	4, 036, 254	6, 159, 401

obtained by multiplying the average weight difference of chinook salmon of each area (Table 5) by their respective estimate for the number of landings of Columbia River chinook (Table 6). The results approximate the weight loss for each area due to the various degrees of harvesting at immaturity. An assumption was made that the average weight of troll caught Columbia River fish was representative of all other fish caught in that area.

For a five-year period, the average weight loss of Columbia River chinook was estimated to be slightly over 4.2 million pounds per year. This varied from 3.2 million pounds in 1970 to over 6.1 million pounds in 1973. The loss is significant as it amounts to an average of nearly 32% of the estimated total ocean and river catch of Columbia River chinook and over 81% of the actual chinook catch by the gillnet fishery alone.

With the estimate for weight loss (Table 8) added to the estimated landed weight of Columbia River chinook (Table 7), an estimate can be made for the potential harvest of Columbia River chinook with no ocean fishery. The figures for each area, shown in Table 9, would require the total harvest to occur within the river in order to maximize this total potential harvest. For my estimate, the total potential harvest between 1969 and 1973 would have averaged over 17.5 million pounds yearly. The actual estimate varied from a low of just under 15.2 million pounds in 1969 to a high of over 23 million pounds in 1973.

Table 9. Estimated total potential harvest in pounds of Columbia River chinook salmon with no commercial ocean fishery from 1969 to 1973.

Area or Region	Year				
	1969	1970	1971	1972	1973
Southeast Alaska Troll	2,534,148	2,517,146	2,605,883	2,071,744	2,706,815
British Columbia Area 1.2 Troll	465,720	487,934	571,375	534,298	464,450
British Columbia Area C, 21-27 Troll	4,073,822	3,376,712	5,731,440	5,283,903	5,769,619
Washington Puget Sound Troll	157,025	203,850	485,856	653,655	569,924
Washington Coast Troll	1,912,477	1,908,915	2,077,060	1,464,821	3,013,041
Oregon Coast Troll	1,150,289	1,167,733	745,133	1,037,047	3,218,708
Columbia River Troll	464,029	848,599	654,549	368,954	475,999
Columbia River Gillnet	4,411,800	5,504,800	4,765,900	4,432,800	6,835,200
Total	15,169,310	16,015,689	17,637,196	15,757,222	23,053,756

Judging from the possible increases in potential yield, it is apparent that the troll fisheries reduced the number of chinook returning to the Columbia River by an average of nearly 70.5% while reducing the total yield by 24%. This is similar to the reduction in total yield obtained by Henry (1971) whose estimate of ocean fishing reduced the number of Kalama fall chinook returning to the Columbia River by 70% and the weight yield of hatchery chinook by 25%. Cleaver (1969:67) estimated that ocean fishing reduced the number of hatchery fall chinook returning to the Columbia River by more than 50% while reducing the total yield of hatchery chinook from the Kalama River by 19% and from Spring Creek by 22%.

Theoretically, the harvest of Columbia River chinook could potentially be increased by nearly a third more than what the actual harvest is estimated to be if no troll fishery existed. This is assuming the numbers of salmon escaping to spawn would remain constant. Such an increase in yield would require over a three-fold increase in the numbers of salmon harvested by gillnetters while forcing trollers out of business. Although this would require little or no increase in the number of gillnetters, the elimination of trollers would affect more than 6,000 trolling boats and vessels from Oregon and Washington alone. Moreover, increases of salmon in other rivers would be noticeable since trollers operate on all immature salmon stocks and not just stocks from the Columbia River.

Other Factors Affecting the Potential Yield Not Included Within the Estimate

There are many other factors which affect the harvest potential of Columbia River chinook salmon but these were not included because of the difficulty in estimating them numerically. One of the more important of these factors is the Indian harvest of chinook salmon in zone 6 between Bonneville and McNary Dams in the upper Columbia River. Because of its importance, this fishery will be discussed by comparing it to the fishery in the lower river.

Effects and Problems of the Catch in Zone 6 in Estimating Potential Yield

During their upstream migration, mature salmon undergo a physiological change which allows them to stop feeding and live off their stored body fats. Subsequently, a significant difference in average weight can occur between fish harvested in the lower river fishery (zones 1-5) and fish harvested in the upper river fishery (zone 6). However, the difference in average weight may be augmented by the differences in selectivity of gear between the lower and upper river fisheries. If lower river gillnets were more selective of larger sized salmon, then proportionately less large salmon would reach upriver. Hence, the catch by the Indian net fishery could be comprised of smaller sized salmon causing a further reduction in the average weight of salmon between fisheries. Even though many chinook salmon would have to be let through the lower river fishery to meet Indian needs, the maximum potential harvest, if it could be obtained, would have to occur in the lower river to fully maximize the weight of salmon.

The weight difference of upper river harvested chinook compared to the lower river harvest is apparent and is shown in Table 10. This gives the catch of chinook salmon by the gillnet fisheries in numbers of fish, pounds landed and average weight from 1969 to 1973 for zones 1-5, zone 6 and zones -16. Based on a five-year period, the yearly average weight of chinook salmon harvested in the lower river amounted to 19 pounds while those harvested in the upper river averaged about 15 3/4 pounds. This amounts to an average loss of almost 3 1/4 pounds per upper river chinook salmon harvested. When calculating the average weight of chinook salmon using the totals from zones 1-6 instead of only zones 1-5, the average weight drops from 19 to 18 1/4 pounds or nearly 3/4 of a pound. If the entire chinook harvest by the gillnet fishery on the Columbia were to be considered in computing the potential yield, the yield would be less than the average estimate of 17.5 million pounds and less than what the maximum potential yield could actually attain.

While the Indian chinook harvest should be included in calculating the maximum potential yield, there has been a problem of

Table 10. Catch of chinook salmon by the Columbia River gillnet fishery in numbers of fish, pounds and average weight per fish from 1969 to 1973 for zones 1-5, zone 6 and zones 1-6.

	Numbers of Fish				
Zone(s)	1969	1970	1971	1972	1973
1-5	227,200	299,400	256,400	228,600	349,600
6	90,700	57,100	75,000	90,100	104,000
1-6	317,900	356,500	331,400	318,700	453,600

	Pounds Landed				
Zone(s)	1969	1970	1971	1972	1973
1-5	4,411,800	5,504,800	4,765,900	4,342,800	6,835,200
6	1,364,000	956,900	1,201,300	1,341,800	1,716,300
1-6	5,775,800	6,461,700	5,967,200	5,684,600	8,551,500

	Average Weight Chinook Salmon				
Zone(s)	1969	1970	1971	1972	1973
1-5	19.42	18.39	18.59	19.0	19.55
6	15.04	16.76	16.02	14.89	16.5
1-6	18.17	18.13	18.01	17.84	18.85

obtaining accurate catch statistics for all fish harvested by the Indian fishery. Good statistics have been obtained from commercially sold fish, but those used for ceremonial and subsistence purposes have largely gone unreported. Thus, the accuracy of the total upper river zone 6 harvest can only be inadequately estimated. Chinook used for ceremonial and subsistence purposes could have a much different average weight than what was found in Tables 11 and 12. It would depend upon which fish were selected for ceremonial and subsistence purposes. This, then, is one other aspect which will have to be dealt with if an estimate of potential yield of Columbia River fish is undertaken and all influences are taken into consideration.

Comparison of the Gillnet Fishery Between Zones 1-5 and Zone 6

In a comparison of the lower river and upper river chinook salmon catch there was a considerable difference in average weight. This is shown in Tables 11 and 12 which has the Columbia River chinook catch by runs in numbers of fish landed, pounds landed, average weight per fish and percentage of the total catch from 1969 to 1973 for zones 1-5 and zone 6 respectively. In both the lower and upper river fisheries, the fall chinook run was predominate, comprising an average of nearly 81% of the total chinook catch for the former and 64.5% for the latter. The average weight of fall chinook was greatest for all runs of chinook for both fisheries at 19 1/2 and

Table 11. Zones 1-5 catch of chinook salmon by runs in numbers of fish, pounds, average weight per fish and percentage of the total catch from 1969 to 1973.[1]

Spring Chinook	1969	1970	1971	1972	1973
Number	39, 300	43, 900	36, 000	85, 700	77, 700
Pounds	682, 700	799, 300	641, 300	1, 407, 500	1, 266, 000
Average weight	17. 37	18. 21	17. 81	16. 42	16. 29
% total catch	17. 3	14. 66	14. 04	37. 49	18. 52

Summer Chinook	1969	1970	1971	1972	1973
Number	1, 600	3, 100	4, 500	3, 200	1, 200
Pounds	17, 200	33, 700	52, 600	42, 400	16, 900
Average weight	10. 75	10. 87	11. 69	13. 25	14. 08
% total catch	0. 7	1. 04	1. 76	1. 4	0. 25

Fall Chinook	1969	1970	1971	1972	1973
Number	186, 300	252, 400	215, 900	139, 700	270, 700
Pounds	3, 711, 900	4, 671, 800	4, 072, 000	2, 892, 900	5, 552, 300
Average weight	19. 92	18. 51	18. 86	20. 71	20. 51
% total catch	82. 0	84. 3	84. 2	61. 11	81. 23

[1] Percentages may not total 100% due to rounding error.

Table 12. Zone 6 catch of chinook salmon by runs in numbers of fish, pounds, average weight per fish and percentage of the total catch from 1969 to 1973.[1]

Spring Chinook	1969	1970	1971	1972	1973
Number	33,000	14,000	12,700	42,800	34,100
Pounds	415,200	210,200	162,500	637,900	533,900
Average weight	12.58	15.01	12.8	14.9	15.66
% total catch	36.38	24.52	16.93	47.5	32.91

Summer Chinook	1969	1970	1971	1972	1973
Number	9,400	4,000	5,800	4,400	2,000
Pounds	130,500	56,300	85,200	69,400	34,100
Average weight	13.88	14.08	14.69	15.77	17.05
% total catch	10.36	7.01	7.73	4.88	1.96

Fall Chinook	1969	1970	1971	1972	1973
Number	48,300	39,100	56,500	42,900	67,900
Pounds	818,300	690,400	953,600	634,500	1,148,300
Average weight	16.94	17.66	16.88	14.79	16.91
% total catch	53.25	68.48	75.33	47.61	65.13

[1] Percentages may not total 100% due to rounding error.

and 16 3/4 pounds respectively. The spring chinook run comprised 18.5% of the total lower river chinook catch and 30% of the upriver catch. The average weight of these fish ran approximately 17 and 14 1/2 pounds respectively. The summer chinook harvest was low in number and succeeded in making up less than 1% of the entire lower river catch and under 6% of the upriver catch. These fish averaged 12 pounds on the lower river and 14 1/2 pounds upriver.

For both the fall and spring chinook runs the average weight difference between fisheries based on a five-year average amounted to 2 3/4 pounds. This difference partially reflects the loss of weight salmon incurred while utilizing their body fats for upstream migration. Another significant factor was the minimum mesh size of 7 1/4 inches for lower river gillnetters while no similar restrictions were placed on Indian fishermen. These two factors in combination caused a uniform average weight difference to occur between fisheries for both the fall and spring chinook runs.

The average weight difference between fisheries for the summer chinook run was entirely different; those caught upriver averaged 2 3/4 pounds heavier. The switch in area of the larger average weight is readily explained by the nature of the fishery for summer chinook. Not since 1964 has there been a summer chinook gillnet season in the lower river. Those harvested were primarily taken during the blueback season until 1972 and in the shad season thereafter. Because of area and mesh size restrictions, most of the run was allowed to pass. Some small summer chinook were caught but the smaller mesh size requirements for those seasons prevented most of the larger chinook from being effectively gilled, hence they escaped upriver. Only in the upper river has there been an intentional fishery for summer chinook through 1973. The Indian fishery has operated effectively on all sizes, harvesting the largest proportion of summer chinook commercially since 1965. This seemed to suggest that the selectivity of gear was the principal factor in causing the larger average weight to occur upriver.

Other Factors Affecting the Potential Yield

Other factors have an effect on the total commercial harvest of Columbia River chinook and could cause an adjustment to my estimate for potential yield. One of these is the increase in natural mortality if no ocean fishery were to take place. According to Henry (1972:441),

> If should be pointed out that even if no fish had been caught in the ocean, the number returning to the river would have been less than the sum of river entry and ocean catch since some of the fish caught in the ocean fishery would have died from natural causes.

In both Henry's (1971) and Cleaver's (1969) study, an instantaneous mortality rate of .45 was used in estimating the potential yield with no ocean fishery. Other studies by Parker and Kirkness (1956) and Parker (1960) estimated that the mortality for chinook salmon after an initial period of loss in coastal waters was .417 and between .36-.51 respectively. However, only a mortality rate for chinook that would have died from natural causes but which were caught in the ocean fishery by commercial trollers would need to be included in this study. But other factors alone would seem to have an influence on this extra mortality rate that these studies failed to analyze. For instance, with no ocean fishery the increased natural mortality rate would seem to be offset by the absence of any hooking mortality. With no commercial trolling taking place, hooking mortality (except for the sport fishery) would be reduced to zero, thus tending to counteract the increase in natural mortality.

As indicated earlier, the effect of hooking mortality could cause a mortality rate of 10% for chinook salmon caught along the Oregon and Washington coast and drop to around 2% for areas farther north. With no ocean fishery, this variable, too, would have to be added to the estimate for potential yield.

With no ocean fishery, the larger biomass of the total salmon stocks may increase competition for food causing a reduction in the average weight per fish. This variable would undoubtedly be one of the causes for increased natural mortality.

The sport catch of Columbia River chinook is another variable which would significantly increase the estimate for total potential yield if included. Since the estimate was for determining the potential commercial harvest with no ocean troll fishery, the sport catch was assumed to be non-commercial fish and thus omitted from the estimate. However, with no ocean troll fishery, another variable would be the possible increase in landings and hooking mortality by the sport fishery with the larger numbers of salmon available to them.

The foreign catch of chinook salmon is also a variable that cannot be accurately estimated. Many fishermen have cited incidences where foreign vessels have operated on salmon stocks as their prime target fish (U. S. Congressional Record:1975), although official regulations are designed to make the foreign catch be incidental.

For troll areas in northern California and central and northern Alaska, no percentages were given for their possible catch of Columbia River chinook. Although little harvesting of chinook from the Columbia River is expected in these troll areas, some stocks may have had a significant contribution to these area fisheries. This is another variable which could have a slight affect on the estimate for potential yield.

The last variable identified was the possible difference in quality of interstate data. While it may be of little actual significance, human errors are always a potential source of inaccuracy.

Thus there are many factors which can have an influence on the potential increase in harvest of Columbia River chinook salmon. These become hard to estimate numerically; changes taking place yearly and geographically can cause considerable variation in estimates. Since the influence of these variables could have caused either an increase or decrease in the estimate for potential yield, their offsetting effect on one another was assumed to minimize whatever changes would occur.

The Basic Methodology Used for Computing the Estimate for the Potential Yield of Columbia River Chinook Salmon

Using these sets of identified factors and applying them to a basic arithmetic series formula, the estimate for the potential yield of commercially caught Columbia River chinook salmon was obtained. The basic methodology used was for the potential harvest to equal $a_1 + a_2 + a_3 + a_4 - a_5 + a_6 - a_7 + a_8 - a_9 + a_{10} + a_{11} \pm a_{12} \ldots \pm a_n$. Of these 12 identifiable factors, only the first three have been estimated and used in the computations for potential harvest. These included $+a_1$, the Columbia River gillnet harvest of chinook; $+a_2$, the troll harvest of Columbia River chinook; and $+a_3$, the weight loss of Columbia River chinook because of their inefficient and immature ocean harvest. These were undoubtedly the most important factors affecting the harvest potential of Columbia River chinook salmon. The Indian commercial and subsistence catch, $+a_4$, was considered to be important, but lack of accurate catch statistics prompted its omittance from the estimate.

The other eight factors included in the equation were considered but not included in the final estimate for the total potential yield. Some were of a negative value causing a reduction in yield to occur while others were positive causing an increase in yield. They were presumed to have an offsetting effect on one another. These factors included $-a_5$, the increase in natural mortality; $+a_6$, hooking mortality; $-a_7$, the larger biomass causing a possible reduction in the average weight per fish; $+a_8$, the sport catch; $-a_9$, the possible increase in sport catch; $+a_{10}$, the foreign incidental catch; $+a_{11}$, the catch of Columbia River chinook in areas not included; and $\pm a_{12}$, the differences in quality of interstate data. Also, as this was an open ended equation, $\pm a_n$ was included so that other factors or variables could be provided which were not accounted for in this study.

Summary of Error

For determining the harvest potential of Columbia River chinook salmon, many variables can contribute as sources of error. The most significant source of error is in factors leading to determining the percentages of Columbia River chinook salmon in each troll area. Although percentages were based on ocean tagging studies, salmon stocks change geographically with time. Their migrational patterns differ due to their age, river of origin and whether they are hatchery produced or wild fish. Hence their availability or vulnerability to a fishery may change. Also, the intensity of fishing pressure in any troll area may change.

Another potential source of error is with landing or catch statistics. Because of the mobility of trollers, many may land fish in districts other than where they were caught. Even though percentages for troll districts differ, such a small misrepresentation of catch data would only result in a small source of error and would probably balance out.

For determining the average weight of troll-caught Columbia River chinook, it was assumed that the average weight of all fish were equal. In some areas it is possible that Columbia River fish are larger than other fish, hence the estimate for weight loss would be somewhat large. Likewise, in some areas, Columbia River fish may be smaller than all other fish causing the weight loss to be larger than actually estimated. This source of error could be significant, causing a substantial change to occur in the estimate for potential yield of Columbia River chinook.

With no commercial salmon fishery in the ocean the river harvest of salmon would undoubtedly increase. However, this would be unfeasible due to the social ramifications for many troll fishermen and its inability to be applied along the entire Pacific Coast. Still, the numbers of ocean trollers and ocean sports anglers has been growing and the time gillnetters have been allowed to fish has steadily decreased. There has been increasing pressure by Indian and sports fishermen who are opting for a larger proportion of the resource. Future allocation of Columbia River salmon may result in a reduction in the commercial yield and potential yield if preference is given to the more inefficient commercial harvest method, recreational use and aboriginal Indian rights. The latter two groups are important and should receive a fair apportionment from the resource. That which is allocated to the commercial fisheries should be maximized; that is, minimizing the harvest losses by reducing the excessive number of inefficient fishermen while allowing those who are dependent upon ocean fishing to continue making a living.

V. INTERPRETIVE SUMMARY: CRITERIA FOR LIMITING FUTURE FISHING EFFORT AND ITS POTENTIAL SOCIAL IMPLICATIONS ON FISHERMEN

Evolutionary trends in salmon fishery management have tended towards increasing inefficiencies for fishermen. This long term trend of inefficiencies has resulted in large surpluses of gear and manpower over what is needed to adequately and efficiently harvest the resource. Realization of this problem has made it evident that some form of control on fishing effort would be desirable. A standard way of controlling fishing effort in a fishery is through the use of property rights.

With the establishment of property rights to limit fishing effort, some fishermen may be affected and others not. One probable way of determining which fishermen are most apt to be affected is by examining some of their characteristics. Some of the more important characteristics would include degree of commitment to fishing, mobility, and success and income. These tend to have an affect on a fisherman's vessel efficiency, a factor most significant in determining possible fisherman exclusion if a reduction in fishing effort is warranted.

Possible social hardships of limiting fishermen in a fishery may not be as great for inefficient fishermen as it would be for some businesses in coastal communities who are in direct support of them. For fishermen with large commitments to fishing, a limited fishery could noticeably affect them if it changed their patterns of fishing. One other aspect that should be considered is the future of the fishery and where additional fishermen will come from, when, and if, additional effort is needed.

Historic Trends of Efficiency

Recapitulating earlier chapters, in Oregon the most efficient groups of salmon harvesters have been regulated out in order to spread the harvest among a more numerous group of small scale fishermen. The voting public became arbitrator of disputes between groups of fishermen and in ballot measures favored groups which they perceived as being the least harmful or least injurious to the fish industry of the state. The political expediency of the measures tended to benefit the greatest numbers of fishermen rather than the fewest. Economic efficiency was not selected but political efficiency was. This was particularly true because the inefficiencies acted to create jobs. Such a process allowed gillnetters and trollers to continue developing where other more efficient river salmon harvesters with proportionately fewer fishermen were prohibited (the seiners, trapmen and fishwheel operators).

Since no effort was made initially to limit the numbers of river fishermen, improvements by fishermen which increased efficiency were counteracted with regulated inefficiencies. Season closures were established as conservation measures but they acted to distribute the salmon harvest over a greater proportion of the river rather than increasing escapement. Declining runs of salmon emphasized the need for resource conservation so questions of allocation brought conflicts between groups of river fishermen. The limitation of effort resulting from democratic balloting did little except to redistribute the salmon harvest among other gear forms.

Efficiency was never selected as a means of enhancing the productivity of fishermen. Fishermen whose innovative nature made them increasingly proficient had to be continually selected against to help conserve the resource. Any advances in efficiency such as technological innovations or modernizations over time were counteracted with subsequent restrictions. Time efficiency, in which the relative efficiency of fishermen's gear changed over time, could have been left unrestricted bringing needs for reducing the numbers of fishermen. As it was, continued restrictions to counteract increases in efficiency provided the means by which effort in numbers of fishermen could continue to increase without proportionately diminishing the salmon resource. Essentially, it became more expedient to employ the largest number of people possible, even if it did mean the resource would be harvested in a more inefficient manner.

The numbers of fishermen in the river and ocean fisheries actually decreased after World War I, during the early 1930's and after World War II. Due to less demand for salmon from world markets, the depression and inflation respectively, conditions selected for the more experienced fishermen while weeding out the less successful ones. This process of selection allowed the vessel efficiency or average catch per vessel for gillnetters and trollers to remain fairly high. Reductions in vessel efficiency were not noticeable until after 1938 for trollers and after 1948 for gillnetters. The less fish available for harvest began producing a lower average catch per vessel for both fisheries. During the 1960's vessel efficiency for gillnetters began improving due to a much improved coho fishery. Trollers, too, had an initial improvement but rapid increases in numbers of fishermen in the late 1960's caused average success to decline to its lowest level. Still with vessel efficiency declining and time efficiency restricted, the salmon fisheries had to support more fishermen than before. With increases in the price per pound fishermen received for salmon, the salmon fisheries overtly seemed to be able to support more fishermen. But when corrected for inflation, the increases were similar to the cost-of-living increases. Hence, profits had only been distributed among more and more fishermen.

Decisions to restrict efficiency rather than numbers of fishermen had been a political maneuver designed by fishery managers and politicians to benefit the greatest number of people. Not only did benefits apply to fishermen but also to people in occupations whose income was partially derived from supporting fishermen with their necessary goods. Such people were employed in boat building, marine hardware stores and other related activities. Many small coastal towns had fisherman populations which contributed to their local economy. Cannery personnel, processors, distributors and receivers were all affected. The longer troll season provided a greater source of income for more people than the shorter, more localized Columbia River gillnet fishery. Oregon licensed fishermen who had landings from salmon trolling numbered 3, 142 in 1971 while only 569 licensed gillnet vessels had landings during the same period (Lewis 1973:14). The difference was significant; it meant more people were utilized to support trollers than gillnetters. With more people in direct and indirect support and therefore acquiring a much broader public support base, it was logical that trolling began to be increasingly favored over gillnetting as the preferred commercial salmon fishery.

Another factor which brought favoritism of trollers over gill-netters developed from sport fishing interests. This was exemplified from the trend of Oregon's past initiative and referendum petitions. In deciding 22 fishery related ballot measures, 17 have dealt with issues between sports fishermen and commercial river fishermen (see Smith 1974b). Not one has been directed against the ocean salmon troller. Considering that 42% of Oregonians have fished recreationally (Falkenberry and Cowan 1974:16), the general public attitudes towards fishing have stemmed primarily from their experiences and concern for the recreational fisheries (Royce 1972:158). Little concern was actually given to the efficiency of commercial fishermen, especially when commercial fishermen could reduce the opportunity of sport fishermen to catch fish.

The influence of sport fishermen upon much of the public can be carried even further. Expenditures by sport fishermen in terms of transportation, lodging, gear, boat rentals, food, liquor and other items brought much income to many riverside towns and communities. Varying from about $4.00 to $12.00 spent for each salmon-steelhead day per person in 1962 (Brown et al. 1964:30), the large number of sports fishermen could potentially contribute a great deal to a local economy. If he spent this amount of money, a sport fisherman wanted to be assured of his opportunity to catch fish. Relating this to the commercial salmon fisheries, gillnetting was a visible fishery where trolling was not. During the time when gillnetters had their nets in the water, sports fishermen empirically felt that their opportunities for catching fish would be reduced to nothing. This was perceived as a threat to the extinction of salmon and steelhead stocks. Large numbers of sports fishermen subsequently obtained enough support to close all coastal rivers except the Columbia to commercial fishing.

Attempts were made to close the Columbia, but only regulations restricting the sale of steelhead were obtained by sports fishermen. Such economic effects on the coastal and riverine populations and communities coupled with personal prejudices by Oregonians have seemed to generate a public favoritism for trollers over gillnetters.

The public has a right to exploit and utilize anadromous and other fish stocks. Their right to enact changes in fishery laws from an efficiency standpoint, however, has helped generate a lessening of efficiency for fishermen and for harvest of the salmon resource. With ocean trolling taking the place of past river fisheries, the Columbia River salmon harvest has shifted from gillnetters to ocean trollers, especially during expansion of the troll fishery in the 1960's. Associated with this shift was a corresponding drop in the potential harvestable weight of salmon, the harvest efficiency of fishermen and salmon available for human consumption. Considering that an average of over 4.2 million pounds of harvestable salmon were lost due to trolling between 1969 and 1973 (see Table 8) when only 13.3 million pounds were harvested (see Table 9), the loss becomes sizeable. If gillnetters were to be eliminated through a ballot measure as has been the trend with other river fisheries, then the ocean fishery will further reduce harvest efficiency and the quantity of salmon potentially available for human consumption.

Unrestricted entry into the salmon fisheries and especially the troll fishery would continue to decrease Oregon's overall harvest efficiency. Increasing pressure on immature salmon can only result in less fish being available for harvest at maturity. Eliminating trollers and not gillnetters would undoubtably increase harvest efficiency, but this would put unneeded and unwanted hardship on troll fishermen. The socioeconomic effects of such a maneuver would cause too many repercussions, not only for fishermen but for all people who were in direct or partial support of them. The elimination of trollers from one state would only serve to help trollers from other states who fish partially on the same stocks of salmon. What seems desirable is for management to impose some policy which would limit declining efficiency so that future efficiency and productivity from the fishery could be enhanced.

Salmon management attempted to provide the greatest good for the greatest number, but according to Hardin (1968:1243) it was not mathematically possible to maximize two variables consecutively. Increases in numbers of fishermen became a human tragedy as the additional harvest effort upon a limited resource meant existing profits were distributed among more and more fishermen. The overinvestment of capital and labor produced such a low return to individual fishermen that the limited amount of benefits from the fisheries had to be used to pay for the unneeded inputs (Lewis 1973:2).

These conditions caused the National Marine Fisheries Service to realize that additional fishing effort in Oregon, Washington and California commercial salmon fisheries was unwarranted and to propose a policy which would deem them "Conditional Fisheries." This would mean that no future loans would be made by them to fishermen for purposes of adding more salmon vessels to the existing fleets. The only loans which would be considered would be for assisting owners in upgrading vessels or replacing vessels lost or withdrawn from the fleet (White 1975:3).

Property Rights in the Fisheries

Recognition that Oregon's commercial salmon fisheries have more than a sufficient amount of harvesters has resulted in the probability of limiting or reducing future fishing effort. How this will affect fishermen depends upon their present status and criteria used for implementing such a procedure. The social implications upon some fishermen could be pronounced although such a policy would likely be directed at those who would tend to experience the least hardship. But what are the social ramifications of a limited fishery upon fishermen and how will it affect them? Before discussing the possible social ramifications, an examination must be made of what constitutes a limited fishery.

According to Christy (1969:370), there are three property rights particularly important for a fishery which can be used to limit fishing effort: (1) the right to conserve, which provides the ability to establish and enforce rules and regulations to prevent depletion; (2) the right to control access, which provides the ability to control the number of users of the resource; and (3) the right to extract rent, which provides the ability to collect fees, taxes, etc., from users of the property.

Use of the right to conserve can help rehabilitate a depleted stock but it alone will not bring forth a reduction in fishing effort. By controlling access the limitation on effort would force fishermen out of the fishery who did not meet the criteria for retention. For those who were retained, the rights to fish would acquire considerable value providing fishermen were allowed to sell or transfer these rights. By extracting rents, an increase in taxes or license fees would place a value more equivalent with the right to fish. Fishermen whose potential earnings could not absorb such an increase would theoretically be forced to drop out of the fishery.

Relationship of Property Rights to Oregon's Salmon Fisheries

In relating the three property rights to Oregon's commercial salmon fisheries, implementation of the right to conserve has been directed against commercial fishermen in the Columbia River area since 1866 (Oregon State Planning Board 1938:38). Gear restrictions, season and area closures on the Columbia River, made gillnetters inefficient when compared to their potential. For conservation measures in the ocean troll fishery, regulations establishing an open season and a minimum size limit were imposed in 1948 then standardized in 1949 to conform with other Pacific Coast states (Van Hyning 1951:47).

The right to extract rent has also been employed to some extent. For instance, boat and commercial license fees cost $61.00 for gillnetters and $53.00 for trollers in 1973 while being raised to $210.00 for both in 1974. The overt purpose of the fee increase was to raise the ratio of commercial fees to the general fund from 33% to 67%, thus making the commercial fisheries more self-sufficient. Also, the fee increase was designed to minimize the cost for full-time fishermen while having maximum charges for weekend fishermen. This justification was due to the proliferation of part-time commercial fishermen using the modest fees for tax advantages (Joint Ways and Means Committee 1973:165).

After the increase in fees there was a resulting 17% decrease in the number of boat and commercial fishing licenses sold between 1973 and 1974. The number of boat licenses decreased from 3567 to 2978 while the number of commercial fishing licenses declined from 6668 to 5558 (Fish Commission of Oregon, preliminary tabulations). These numbers, however, include licenses for all of Oregon's fisheries so they may not reflect the actual pattern for the salmon fisheries. Since there are still many part-time salmon fishermen, it is possible the amount of rent extracted was not truly equivalent of the value for the right to fish. Hence, the reduction in numbers could possibly be minimal and temporary.

The right to control access, commonly called limited entry, is the only property right of the three not employed at all in Oregon's salmon fisheries. Studies of limitations on entry are being undertaken by the Fish Commission of Oregon to see if its implementation would be feasible. If a limited entry program were developed, theoretically the decrease in fishing effort would help to reduce inefficiencies, raise vessel efficiency and restore profits to the fishery. While the decreased fishing effort could also reduce the costs of harvest, it may not actually reduce the price of fish to the consuming public. The additional profits generated may more readily accrue to processors or possibly to fishermen.

Characteristics of Oregon's Commercial Fishermen

Historic trends in declining vessel and harvest efficiency have largely resulted from less fish available, increases in the number of fishermen and a greater percentage of the harvest by the troll fishery. While this was presented to show inter-fishery group efficiency changes between gillnetters and trollers, controls to limit future fishing effort may likely be developed from intra-fishery group efficiency levels, that is, the efficiency of individual fishermen within a particular fishery. For this reason, certain characteristics of fishermen and types of fishermen sub-groups will be examined to show their diversification in success and income. While such differences show a fisherman's individual efficiency as well as the present conditions of the fisheries, they also tend to portray part of the background for the historic declines in vessel efficiency of gillnetters and trollers.

Commercial salmon fishermen in Oregon have a variety of characteristics which relate directly to their efficiency. These include success and income, mobility, and whether fishing is a full-time or part-time activity. Through efforts to limit entry some fishermen may be excluded from any further fishing, some may be only partially affected and others may not be directly affected at all. It must be noted though that social implications on fishermen will largely depend upon what criteria management uses to limit or reduce fishing effort. It could mean that only the least efficient harvesters will be excluded. Or, it could mean that no new entrants will be allowed in the fishery unless they are able to purchase transferable rights to fish from others already in the fishery. In any case, it becomes a political decision as to what form fisherman access and/or elimination will be applied to the fisheries. Also, I have been assuming that a species approach will be taken in whatever scheme is used to limit effort. While this may or may not be the case, the characteristics of fishermen and their relation to a particular fishery will most likely have to be considered to some degree.

A minority of the fishermen from Oregon can be considered as professional fishermen, fishing in any one or more different fisheries. These are the truly full-time fishermen who have strong commitments to fishing with sizeable investments in terms of gear, equipment and experience. Those depending upon fishing for a living would likely fish a combination of fisheries in order to spread the season over more of the year, thus their lifestyle is one of mobility. After one season is over or if one fishery is on the decline, they may readily switch to another that is economically profitable. Having to depend upon the income derived from each fishery for their livelihood, these mobile fishermen may tend to be the most efficient harvesters of the resource. It would appear then, that Oregon's license fee of $210.00 to fish in all fisheries is best suited to the mobile patterns of the professional fisherman.

Due to the part-time nature of both the gillnet and troll fisheries, an adequate living can scarcely be made from fishing in only one of these fisheries. Historically many gillnetters were full-timers but as seasons were continually shortened they were forced to find other part-time jobs to supplement their income. Trollers had a high vessel efficiency which allowed their fishery to be profitable, but shifts to other ocean fisheries became necessary for successful fishermen to continue making a living in the fisheries. While some fishermen shifted to other fisheries, many others entered the fisheries to fish only part-time. Subsequently, part-timers make up the majority of Oregon's commercial fishermen. Some part-time fishermen committed to one fishery may fish the entire season while others may fish for only a part of a single season. Other part-time fishermen may fish part-time in a combination of fisheries. With greater numbers of fishermen less committed to fishing throughout the season, their overall vessel efficiency becomes lower. Since the majority of part-timers fish in Oregon's troll fishery, the overall average vessel efficiency for trollers has tended to be much reduced from historic times.

Mobility for some part-time trollers exists especially for those who have a fairly strong commitment to fishing. They generally operate larger and more valuable boats and may switch from salmon trolling to gillnetting or the albacore or crab fishery. While not depending totally on fishing for their income, their dependence on non-fishery jobs would be decidedly less than other part-time fishermen who were only specialized salmon trollers (Liao and Stevens 1975:12-3). Although probably not as efficient as the professional fishermen, their partial dependence on fishing would generally allow them to earn a profitable income.

Gillnetters from the Columbia River area have a historic tradition of mobility in another way. Since gillnet seasons are often very short, many gillnetters fish for salmon during the summer from various ports in Alaska. Then, after Alaska's seasons are closed, they return home to ready for the main August and fall seasons on the Columbia River. This historic pattern of mobility applies to some gillnetters in other areas as well. Finishing their local season, they may travel to the Columbia River and compete with those often called "homegrounders". Fishermen with this type of competitive nature and degree of commitment to commercial fishing may easily be more efficient than less active part-time fishermen.

Part-time fishermen, fishing for reasons that overshadow making a profit, are not strongly committed to fishing. For salmon trollers, many part-timers fish only a portion of the season during the late summer and early fall months when good weather prevails and the major salmon runs enter the rivers. These fishermen would include the sport-commercial trollers, so-called because many received their commercial fishing experience from sport fishing. Added to this group would be the specialized salmon troller. Not having to depend upon commercial fishing for a living, it was this group of fishermen who pursued fishing despite a net negative income (Smith 1974a:376). Because of their proliferation during the 1960's, their superior numbers and the low levels of their vessel efficiency has been delineative of the troll fishery. Also, the added pressure on immature salmon stocks has continually reduced harvest efficiency for the commercial salmon fisheries.

In the gillnet fishery, there are full-time and part-time gillnetters although the majority can be considered as part-time fishermen. Where full-time gillnetters may fish all the different seasons, part-time fishermen might fish only parts of different seasons or only during the August and fall seasons. Still, the vessel efficiency between the two groups could possibly overlap considerably since the August and fall gillnet seasons have generally comprised over 80% of the total gillnet catch (see Table 11). Since most gillnetters have other part-time or full-time jobs, their ability to participate may depend upon the rigidness of their non-fishery work employment. Characteristically, gillnetters have been employed at longshoring, teaching, logging and other types of work. Where many of these jobs have available slack periods during one time or another, they become somewhat suited to the short season nature of the gillnet fishery. Still, vessel efficiency for gillnetters is widely varied and is often related to degree of commitment, type of gear employed, method of fishing, experience, willingness to take chances and how many sleepless nights a gillnetter is willing to spend.

Due to the different patterns of fishing and different degrees fishermen commit themselves to fishing, a wide range of success and income develops between fishermen. Some would be considered as extremely efficient and others very inefficient. Presumably by analyzing individual fisherman vessel efficiency or their total catch value, it would be possible to ascertain where areas of fishing effort could be eliminated or limited with the least amount of social hardship accruing to present fishermen.

Fishing Success and Social Ramifications of Limiting Fishing Effort

Success among fishermen is widely varied. According to an estimate by Lewis (1973:18) between 12% and 16% of the gillnet and troll fishermen land 50% of the total value for their respective fishery. Full-time and part-time fishermen who are strongly committed to fishing and need to be more efficient to make a living would seem to be more prevalent in this group. Moreover, between 51% and 56% of the gillnet and troll fishermen land only 10% of the total value for their respective fishery (Lewis 1973:18). Part-time fishermen, often fishing for reasons other than making a living and often for a negative net income (see Smith 1974a), would appear to comprise this lesser efficient group. This leaves about 33% of the fishermen harvesting the remaining 40% of the total catch value. This range would include the average fishermen who are somewhat successful in making a profit from fishing.

Since about 83% of both gillnetters and trollers fish primarily (90% of their total catch value) in one fishery (Lewis 1973:14-6), there is considerable indication that Oregon's salmon fisheries are composed mostly of part-time fishermen. This is especially true when realizing the troll season lasts about six months out of the year and the gillnet season only 49 days in 1974.

If fishing effort is to be reduced with future implementation of property rights, it is likely that less efficient fishermen will be most apt to be subject to exclusion. For trollers, this would likely include the sport-commercial and specialized salmon fishermen with low levels of efficiency as their numbers have increased tremendously in the past 10 years. Having adapted to fishing for only part of the season and being the least affected of the fishermen, the social ramifications upon them may not produce significant economic hardship. Economic hardship may be more prevalent among the smaller coastal communities and their small businesses who derive part of their income by supplying these fishermen with gear and other supplies.

For gillnetters there is a wide difference in success between fishermen (see Lewis 1973). In a study by Smith (1975:5-8), the income distributions for gillnetters in 1899, 1926 and 1971 showed an increase in the average while the skew and kurtosis of fisherman income increased to larger positive values. This means that there has been a tendency for more incomes to be low while few are high and that less diversity is present since more fishermen are in the lower income range. With the establishment of property rights to limit or reduce fishing effort, possibly only the inefficient harvesters and new entrants would be excluded from participating in the fishery.

The social ramifications of a limited entry fishery could present the most significant hardship if it had an affect on the mobility of efficient fishermen. With possible establishment of property rights, fishermen could be affected in two primary ways. If rent equivalent of the value for the right to fish was extracted from each fishery, then a financial burden may develop for the mobile fisherman who would have to pay fees for each fishery he wished to participate in. Or, if a fisherman were excluded from participating in any one fishery, his mobile lifestyle may be disrupted. Being prevented from switching to more profitable fisheries and obtaining profits necessary to continue making a living may prove to be a socioeconomic burden for the characteristically mobile fisherman.

Trollers and gillnetters fishing for a negative net income or having very low levels of vessel efficiency are most likely to be excluded from the salmon fishery if a reduction in fishing effort is attempted. Economic hardship for them would be manifested in their not being able to receive any tax advantages. With no tax deductions from fishing, a significant increase in the taxable income for their non-fishery employment may result.

Another factor in fisherman exclusion would be their investment in terms of boat, gear and associated equipment. Gear and equipment may be resaleable but with a limited fishery demand for used vessels could be very poor. Some vessels could easily be converted to charter or sport operations but specialized salmon vessels may have a very poor resale value. Taking a loss on vessels may hurt fishermen financially unless management develops some form of a buy-back program. A program of this nature has been implemented in British Columbia to control fishing effort as well (Campbell 1972). However, the salmon fisheries in Oregon may not provide enough revenue to subsidize a program of this magnitude.

With a management scheme to limit effort in the salmon fisheries, there could be consequential effects of social hardship accruing in other Oregon fisheries as well. Since many fishermen participate in more than one fishery, the exclusion of some salmon fishermen could possibly mean their entrance in another fishery, providing it were not limited (Lewis 1973:14). This would bring additional fishing effort to those fisheries, forcing existing profits to be dissipated and possibly causing them to become less profitable overall.

As a case study, Alaska began its limited entry program in 1975 to stabilize the amount of gear and better economic goals. It was hoped that effort could be reduced by excluding only those who would experience the least hardship (Commercial Fisheries Entry

Commission 1974:5). Flexibility in the program was provided for as it was possible for a fisherman to receive permits to fish in more than one fishery if he had been doing so continuously (Rickey 1975:4). Since entry permits could be bought, sold, or traded, a would-be fisherman was not totally excluded from entering or changing fisheries.

In Alaska's program, hardship for some fishermen has already been acknowledged. Although it is probably only a small group, there has been an attempt by fishermen to repeal the limited entry law (Daily Astorian, April 24, 1975:2). As mentioned earlier, many fishermen are mobile and may switch fisheries from year to year. Since a fisherman had to have been fishing continually in a salmon fishery in Alaska to receive a salmon permit, those who had shifted to a different fishery were now excluded from participating in the salmon fishery. Although they could still buy entry, the exceptionally high price for which permits are being sold made it somewhat economically unfeasible for fishermen.

Fishery managers' implementation of policies sometimes fail to identify all areas where potential hardship lies. Hence, it is these problems and the problems and experiences of other working schemes designed to curtail fishing effort that need to be carefully surveyed before development of a similar program is undertaken for Oregon's salmon fisheries. Furthermore, it must be realized that the magnitude of Oregon's commercial salmon fisheries is on a very small scale when compared to the salmon fisheries in areas like British Columbia or Alaska. Since the conditions in Oregon's salmon fisheries are different than in any other area, so must its future program to curtail fishing effort to be effective. Essentially, the degree of successfulness of a program designed to limit effort will largely be met if its principles are effective and can readily be adapted to by fishermen without undue hardship.

From a historic standpoint, fishing has always been a free enterprise from which the competitive nature of fishermen has developed. This freedom, which became a value our country was partly founded upon, allowed fishermen to initiate and exploit new fisheries resulting in the development of viable fishing industries. Even today this freedom is prevalent in much of our fishing culture. But with management becoming increasingly distressed about the overall success of fishermen and the productivity of our fishing resources, the tradition of free fishing is steadily becoming a thing of the past. So how will this affect the fishermen of the future?

One serious consideration that should be evaluated before establishing any program which will restrict entry into a fishery, is its future. Where will additional entrants come from when enough older fishermen and/or vessels are retired to warrant additional fishing pressure? Many fishermen have grown up with their business, learning the trade from their fathers or other fishing relatives. Hence, many families have had a historic tradition of fishing with entry being largely associated with kinship. If, for instance, a son was prevented from following his father's footsteps when his enculturation process has already oriented him towards a fishing career, then serious social problems may arise if no effort is made to direct these future fishermen toward alternative careers (Gersuny and Poggie 1973:241-4).

VI. CONCLUSIONS AND IMPLICATIONS

This thesis has dealt with some of the processes that have influenced the efficiency of fishermen in Oregon's commercial salmon fisheries. Focusing on Columbia River gillnetters and Oregon based trollers, the purpose was to show some of the historical patterns which changed fisherman and harvest efficiency and made the commercial salmon fisheries what they are today.

According to Dalton (1969:75-6), processes of socioeconomic change generally take place over long periods of time and their analysis requires consideration of the official (legal) policies which impinge on the small group or segment of society. Furthermore, an empirical understanding can be obtained from the case study by asking "what is the nature of the initial incursion which starts the process of socioeconomic change, and to what extent does the character of the initial incursion shape the sequential changes that follows?"

From the 1870's on, Columbia River gillnetters were shown to have adapted and innovated, thus developing better methods of fishing to counteract management regulations restricting their efficiency. As overexploitation and deterioration of the environment caused a reduction in salmon runs, the idea of resource conservation brought about fish fights between the numerous river harvester groups over how the resource should be allocated. Through many ballot measures, Oregon voters decided to eliminate the most efficient harvester groups, those which took the most salmon and needed the fewest fishermen to operate. Gillnetters, the largest remaining group, were forced to adapt to continued management restrictions on length of seasons and use of gear. Such restrictions brought about a changing gillnet fishery, one which has tended towards decreasing the efficiency of gillnet fishermen.

The ocean salmon troll fishery developed as an adaptation by gillnetters to obtain more fishing time and increase catches. Improvements in gear and vessels provided fishermen mobility for extended periods of time such that trollers could shift from the Columbia River mouth to the feeding banks of immature salmon up and down the coast. Unlike gillnetters, the imposition of seasonal and size limit regulations did not restrict troller efficiency a great deal. Rather, their ability to exert continual fishing pressure upon the feeding salmon population left less salmon to be harvested at maturity later on. This, coupled with the prolific increase in numbers of troll fishermen, thereby reduced their overall efficiency.

A comparative efficiency study between gillnetters and trollers was based on the average annual catch per vessel. Both groups were shown to have decreased in vessel efficiency (see Table 3). For gillnetters, the decrease in vessel efficiency came in one big drop between 1948 and 1949 when a loss of spawning grounds from dams and industrialization caused a severe decline in the resource. For trollers, vessel efficiency has steadily fluctuated downward since 1935 due to declines in the coho harvest, shifts to the albacore fishery, further declines in the number of salmon runs after 1948 and increases in the number of fishermen after 1960. As a comparison, the average vessel efficiency for gillnetters from 1926 to 1973 was 9,606 pounds, while trollers averaged 5,693 pounds per vessel annually from 1926 to 1971. Also, since only landings for chinook and coho salmon were used to compute this average, the catch of other salmon species by gillnetters would have greatly increased their average vessel efficiency. Since most of these salmon species do not readily take a hook, only a minimal increase in the average vessel efficiency would have occurred for trollers.

A comparison of the harvest efficiency of gillnetters and trollers by the degree to which each utilized the resource to its fullest potential showed gillnetters to be considerably more efficient than any troll fishery. To compare harvest efficiency, it becomes necessary to look at the migrational patterns of salmon and their subsequent area of capture. Columbia River chinook salmon increased in age, size and weight as they migrated northward from the Columbia. Their maturity and full weight potential was not reached until their southward and return journey brought them back to the Columbia River. Gillnetters, harvesting mature, returning chinook salmon, caught them at an average of between 18 1/2 and 19 1/2 pounds. In comparison, the troll fisheries from Oregon to Alaska harvested immature and maturing Columbia River chinook salmon. Their average weight at time of capture ran from a low of between 10 and 12 pounds along the Oregon coast to a high of between 14 and 16 pounds along the British Columbia, Queen Charlotte Island troll area (see Table 4). Being substantially lower than the average weight harvested by gillnetters, the troll fisheries method of fishing underutilized the harvest potential of the resource. Based on a five-year average from 1969 to 1973, trollers were estimated to have reduced returning Columbia River chinook by 70.5% and their total harvest yield by 24%.

Trollers were shown to be less efficient than gillnetters in their vessel and harvest efficiency, but this was not presented to show a need for their elimination. Rather, the purpose was to show a reasoning for the retention of gillnetters if there is to be a commercial salmon fishery on Columbia River fish. Trollers may be less efficient in harvesting the salmon resource overall, but their complete elimination or the elimination of gillnetters would present severe socioeconomical problems. What seems desirable is to limit or reduce fishing effort so that further declines in efficiency can be averted.

Evolutionary trends in salmon fishery management on the Columbia River have tended to decrease efficiencies for fishermen and the salmon resource. Looking at Oregon's commercial salmon fishermen, these evolutionary trends have been illuminated by the efficiency changes which have taken place among gillnetters and trollers. Efficiency in the harvesting ability of fishermen increased over time, but regulated inefficiencies by management served to decrease it, overall. Failure to limit the numbers of fishermen when a declining resource was evident brought a decrease in average vessel efficiency. Elimination of the most efficient river fishery groups did help to decrease fishing effort, but the resulting redistribution of salmon went to other less efficient harvester groups. This also brought a reduction in harvest efficiency as a greater proportion of Columbia River salmon were taken before maturity by the troll fishery. Essentially, then, the political expediency in management regulations brought a continual decrease in efficiency for Oregon's commercial salmon fisheries.

While decreasing efficiency was evident, the expediency of management regulations seemed to be beneficial in other respects. Eliminating the most efficient river harvesters meant that considerably larger groups of less efficient harvesters were left to exploit the salmon resource. Since the selection for more fishermen largely resulted from Oregon's ballot measures, the public support needed for their passage seemed to create a favoritism of groups which employed the largest number of people. Hence, efficiency made way for expediency as public favoritism and support directed that more people be employed, including fishermen and other people who were in direct or indirect support of their activities.

The implication of one fishery group being favored over another by the public has generated a lessening of efficiency and will continue to do so if a resource such as the fisheries is allowed to be further managed by public referendum processes. The possibility is real and has been made evident by the growing numbers of sport fishermen who are trying to eliminate gillnetters from the Columbia River. Many of the sports fishermen's statements and accusations can be readily seen or heard through the mass media. In effect, this brings up the possibility of their influence swaying the attitudes of the general public towards a favoritism of one commercial fishery group, notably trollers. Seemingly in the best interest of the majority, public input for management of this nature would not help increase the efficiency levels of salmon fishermen. It would bring about a decline in their harvest efficiency. Possibly, what is needed is a survey to determine public attitudes towards fishery managers, commercial fishermen and the public role in the decision making process. Subsequent information could then be compiled and presented to help inform and educate the public of the necessary requisitions for a profitable, sustainable and equitable fishery.

The history of management decisions governing Oregon's commercial salmon fisheries has been full of regulations inhibiting efficiency. Public input has prompted a large part of them. Restitution of the decision making process to fishery managers may help to increase efficiency levels providing there is management of fishermen as well as fish. In any case, the low levels of efficiency characteristic of so many fishermen need to be assessed in future management of the salmon fisheries.

While this thesis has dealt with some levels of efficiency that compared gillnetters and trollers as groups, other efficiency models could be used to show an individual fisherman's economic efficiency. A model of this nature would be possible by comparing the ratio of a fisherman's gross returns to his total costs (c.f. Liao and Stevens 1975). Application of such statistics to the fisheries would be for limiting the number of part-time salmon fishermen who major economic benefit from salmon fishing is a tax write-off. Hence, its effect of limiting or reducing fishing effort may cause the least amount of hardship for fishermen. In the event that any program designed to limit or reduce fishing effort is implemented, care must be taken to insure minimal hardship accruing to fishermen, especially those who do nothing else but fish for a living.

BIBLIOGRAPHY

Alaska Dept. Fish and Game
1969-73 Alaska catch and production, commercial fisheries statistics. Statistical leaflets No. 18, 20, 22, 24, 26.

Andrews, Ralph W. and A. K. Larssen
1959 Fish and ships. Superior Publishing Company; Seattle, Wash., 173p.

Andrus, Fred
1975 CRFPU older than thought. Daily Astorian Jan. 9:4.

British Columbia
1969-73 British Columbia catch statistics. Dept. of the Environment, Fisheries and Marine Service, Pacific Region; Vancouver, British Columbia.

Brown, William G., Ajmer Singh and Emery N. Castle
1964 An economic evaluation of the Oregon salmon and steelhead sport fishery. Ore. Exp. Stat., Tech. Bull. 78: 47p., Ore. St. Univ., Corvallis, Ore.

Bullard, Oral
1968 Crisis on the Columbia. The Touchstone Press; Portland, Ore., 156p.

Campbell, Blake A.
1972 Limited entry in the salmon fishery: the British Columbia experience. Fisheries Programs, Centre for Continuing Education, PASGAP6; Univ. of British Columbia.

Chapman, Wilbert M., Richard T. Smith and C. H. Ellis
1936 The 1935 salmon fishery in State of Washington with the daily statistics of the catch. State of Wash., Dept. Fish., Biol. Rept. No. 35A:1-27, 30 Figs., Seattle, Wash.

Christy, Francis T., Jr.
1969 Fishery goals and the rights of property. Trans. Amer. Fish. Soc. 98(2):369-78.

Cleaver, F. C.
1969 Effects of ocean fishing on 1961-brood fall chinook salmon from Columbia River hatcheries. Fish Comm. Ore., Res. Rep. 1(1). 76p.

Cobb, John N.
1911 The salmon fisheries of the Pacific Coast. U. S. Bur. of Fish., Annual Rep., Doc. 751, 1-179, Govt. Printing Office, Wash., D. C.

1930 Pacific salmon fisheries. U. S. Bur. of Fish., Doc. No. 1092, App. XIII to the Rept. of the U. S. Comm. of Fish. for 1930:409-704, Wash., D. C.

Commercial Fisheries Entry Commission
1974 Proposed regulations limited entry report to the fishermen of Alaska. Juneau, Alaska, 26 p.

Craig, Joseph A. and Robert L. Hacker
1940 The history and development of the fisheries of the Columbia River. Bull. of the Bur. of Fish., 49(32):132-216, Govt. Printing Office, Wash., D. C.

Crutchfield, James A. and Giulio Pontecorvo
1969 The Pacific salmon fisheries: A study of irrational conservation. John Hopkins Press for Resources for the Future, Inc., Baltimore, Maryland, 220 p.

Daily Astorian
1887, 1973-5 Selected issues. Astoria, Ore.

Dalton, George
1969 Theoretical issues in economic anthropology. Current Anthropology 10(1):63-80.

1971 Introduction, Economic development and social change. The Natural History Press; Garden City, New York, 1-35.

Donaldson, Ivan J. and Fredrick K. Cramer
1971 Fishwheels of the Columbia. Binford and Mort; Portland, Ore., 124 p.

Faulkenberry, G. David and Charles D. Cowan
1974 Oregon wildlife preferences and activities survey. Survey Research Center, Ore. St. Univ.; Corvallis, Ore., 92 p.

Fish Commission of Oregon and Washington Department of Fisheries
1975 Status report Columbia River fish runs and commercial fisheries, 1938-70, 1974 addendum 1 (5):44 p.

Gersuny, Carl and John J. Poggie, Jr.
1973 The uncertain future of fishing families. The Family Coordinator 22(2):241-4.

Gile, Albion
1955 Notes on Columbia River salmon. Oregon Historical Quarterly 56:140-55.

Gill, John
1909 Gill's dictionary of the Chinook jargon. J. K. Gill Co.; Portland, Ore., 80p.

Hardin, Garrett
1968 The tragedy of the commons. Science 162:1243-8.

Hayden, Mildred Vera
1930 History of the salmon industry in Oregon. Master of Arts Thesis, Univ. of Ore., 54p.

Henry, Kenneth A.
1971 Estimates of maturation and ocean mortality based on marked 1962-brood Columbia River chinook salmon and effect of ocean fishing on the total stock. Fish. Comm. Ore., Res. Rep. 3:13-27.

1972 Ocean distribution, growth, and effect of the troll fishery on yield of fall chinook from Columbia River hatcheries. Nat. Mar. Fish. Ser., Fish. Bull. 70(2):431-45.

Johnson, D. R., W. M. Chapman and R. W. Schoning
1948 The effects of salmon populations of the partial elimination of fixed fishing gear on the Columbia River in 1935. Ore. Fish. Comm., Cont. No. 11, Portland, Ore., 32p.

Joint Ways and Means Committee
1973 Minutes, 57th regular session. 2 vols. HB 5078, Salem, Ore.

Kauffman, D. E.
1951 Research report on the Washington State offshore troll fishery. Pac. Mar. Fish. Comm., Bull. 2:77-91.

Klopfenstein, Don and Inez Klopfenstein
1975a Looking for an ocean. The Fishermen's News 31(7):1, 11-2, Seattle, Wash.

1975b Salmon and tuna attracted by positive fishing gear. The Fishermen's News 31(7):1-2, Seattle, Wash.

Lewis, Robert C.
1973 Preliminary economic analysis of management alternatives for limiting harvest effort by Oregon commercial fisheries. Fish. Comm. Ore., Portland, Ore., 42 p.

Liao, David S. and Joe B. Stevens
1975 Oregon's commercial fishermen: characteristics, profits, and incomes in 1972. Ore. St. Univ., Sea Grant College Program, Pub. No. ORESU-T1-75-001, 20 p.

Miller, Emma G.
1958 Clatsop County Oregon, its history, legends, and industries. Binford and Mort; Portland, Ore., 291 p.

Netboy, Anthony
1958 Salmon of the Pacific Northwest, fish vs. dams. Binford and Mort; Portland, Ore., 42 p.

1973 The salmon: their fight for survival. Houghton Mifflin Company; Boston, Mass., 613 p.

Oregon Legislature
1889 Report of special committee to the Legislature Committee to examine into and investigate the fishing industries of the state. Frank C. Baker, State Printer, Salem, Ore., 16 p.

Oregon State Planning Board
1938 A study of commercial fishing operations on the Columbia River. Salem, Ore., 73 p.

Parker, Robert R.
1960 Critical size and maximum yield for chinook salmon (Oncorhynchus tschawytscha), J. Fish. Res. Bd. Canada 17(2):199-210.

Parker, Robert R. and Walter Kirkness
1956 King salmon and the ocean troll fishery of Southeastern Alaska. Alaska Dept. Fish., Res. Rep. 1, 64 p.

Pulford, E. F.
1970 Estimated contribution of Columbia River hatchery fall chinook salmon to sport and commercial fisheries in 1966. Fish. Comm. Ore., Res. Rep. 2(1):3-14.

Rich, Willis H.
1942 The salmon runs of the Columbia River in 1938. U. S. Fish and Wildlife Ser. 50(37):103-47, Wash., D. C.

1948 A survey of the Columbia River and its tributaries with special reference to the management of its fishery resources. U. S. Fish and Wildlife Ser., Special Scientific Rep. No. 51, 26 p., Wash., D. C.

Richards, Jack Arthur
1968 An economic evaluation of Columbia River anadromous fish programs. Doctoral Thesis, Ore. St. Univ., 274 p.

Rickey, Roy A.
1975 Letter to the editor. The Fishermen's News 31(4):4.

Royce, William F.
1972 The gap between theory and policy in fishery development. pp. 156-63. (in) World Fishery Policy: Multidisciplinary Views. (ed) Brian J. Rothschild, Univ. of Wash. Press; Seattle, Wash., 252 p.

Scofield, W. L.
1921 Gear used for salmon trolling in California in 1920. Calif. Fish and Game 7(1):22-28, San Francisco, Calif.

Silliman, Ralph P.
1948 Estimation of the troll catch of Columbia River chinook salmon, Oncorhynchus tschawytscha. U. S. Fish and Wildlife Ser., Special Scientific Rep. No. 50, 15 p., Wash., D. C.

Smith, Courtland L.
1973 Growth and decline of fisheries as subsistence resources: the Columbia River salmon fishery. Unpublished paper, prepared for the symposium on "Maritime Anthropology" at the 1973 annual meeting of the American Anthropological Association, New Orleans, Nov. 28-Dec. 2.

1974a Fishing success in a regulated commons. Ocean Development and International Law Journal 1(4):369-81.

1974b Oregon fish fights. Sea Grant College Program, Ore. St. Univ.; Corvallis, Ore., 15p.

1975 Intracultural variation: decline and diversity in North Pacific fisheries. Human Organization, in press.

Smith, E. Victor

1921 The taking of immature salmon in the waters of the State of Washington. Wash. Dept. Fish. 30-31st Annual Rep. 38-76 [first published in 1920], Seattle, Wash.

Smith, E. Victor and Trevor Kincaid

1920 A report of the taking of immature salmon in the coastal waters of the State of Washington. Wash. Dept. Fish. 28-29th Annual Rep. 39-46; Seattle, Wash.

Smith, Hugh M.

1895 Notes on a reconnaissance of the fisheries of the Pacific Coast in 1894. Bull. of the U. S. Fish. Comm. 14:223-88, Govt. Printing Office, Wash., D. C.

Stevens, Joe B.

1975 Only 10% make living fishing commercially. Daily Astorian Aug. 20:7.

U. S. Bureau of Fisheries

1929-38 Fishery industries of the United States. Administrative Reps., Govt. Printing Office, Wash., D. C.

U. S. Commission of Fisheries

1926-8 Fishery industries of the United States. Annual Reps., Govt. Printing Office, Wash., D. C.

U. S. Fish and Wildlife Service

1939-71 Fishery statistics of the United States. Statistical Digest, Govt. Printing Office, Wash., D. C.

United States Congressional Record

1975 Proceedings and debates of the 94th Congress, First Session 121(90), Wash., D. C.

Van Hyning, Jack M.
1951 The ocean salmon troll fishery of Oregon. Pac. Mar. Fish. Comm., Bull. 2:43-76.

1968 Factors affecting the abundance of fall chinook salmon in the Columbia River. Doctoral thesis, Ore. St. Univ., 424 p.

1973 Factors affecting the abundance of fall chinook salmon in the Columbia River. Fish Comm. Ore., Res. Rep. 4(1): 87 p.

Van Hyning, Jack M. and R. C. Naab
1957 A preliminary study of salmon taken by the troll fishery in regard to size, hooking condition, and gear selectivity. Fish Comm. Ore., Unpublished Rep., 20 p.

Washington Fishermen's Association
1894 Washington's salmon fisheries on the Columbia River. Ilwaco, Wash.

Weekly Astorian
1887 August 20.

Wendler, Henry O.
1966 Regulation of commercial fishing gear and seasons on the Columbia River from 1859 to 1963. Wash. Dept. Fish., Fish. Res. Papers 2(4):19-31.

White, Jim
1975 Morro Bay Memo. The Fishermen's News 31(15):3, Seattle, Wash.

Worland, D. D., R. H. Wahle, and P. D. Zimmer
1969 Contributions of Columbia River hatcheries to harvest of fall chinook salmon (Oncorhynchus tshawytscha). U. S. Fish. Wildlife Ser., Fish. Bull. 67:361-91.

Wright, Samuel G.
1970 An examination of Washington's troll salmon fleet in 1967. Fish. Res. Papers, Wash. Dept. Fish. 3(2):5-17.

1971 Coho shaker problem and incidental catch concept in troll fishery. Comm. Fish. Rev. 33(6):48-50.

APPENDIX

Table 13. Columbia River gillnet chinook and coho catch in pounds (Oregon and Washington).

Year	No. boats licensed	Chinook	Coho	Total	% of total Col. R. chinook and coho catch	average success per vessel
1973	1104	6, 835, 200	1, 823, 200	8, 658, 400	88. 1	7, 843
72	1055	4, 342, 800	1, 177, 500	5, 520, 300	71. 6	5, 233
71	1016	4, 765, 900	2, 191, 500	6, 957, 400	55. 7	6, 848
70	682	5, 504, 800	5, 608, 000	11, 112, 800	72. 8	16, 294
69	597	4, 411, 800	1, 624, 900	6, 036, 700	65. 2	10, 112
68	768	3, 310, 800	912, 700	4, 223, 500	57. 6	5, 499
67	778	3, 953, 700	3, 715, 700	7, 669, 400	59. 7	9, 858
66	636	3, 409, 000	4, 317, 600	7, 124, 700	64. 4	11, 202
65	683	5, 269, 500	1, 880, 300	7, 149, 800	66. 6	10, 468
64	689	3, 838, 300	1, 943, 600	5, 781, 900	67. 2	8, 392
63	740	3, 802, 000	500, 600	4, 302, 600	63. 0	5, 814
62	754	5, 322, 200	582, 500	5, 904, 700	78. 3	7, 831
61	791	4, 043, 800	379, 100	4, 422, 900	70. 8	5, 592
60	806	3, 893, 500	158, 000	4, 051, 500	81. 0	5, 027
59	869	4, 562, 200	119, 500	4, 681, 700	82. 0	5, 387
58	873	6, 283, 700	165, 900	6, 449, 600	86. 4	7, 388
57	818	5, 863, 000	390, 500	6, 253, 500	82. 0	7, 645
56	792	7, 456, 300	447, 400	7, 903, 700	74. 6	9, 979
55	812	6, 469, 700	525, 200	6, 994, 900	62. 3	8, 614
54	890	4, 318, 400	295, 500	4, 613, 900	62. 3	5, 184
53	919	5, 644, 500	434, 500	6, 079, 000	64. 8	6, 615
52	966	5, 175, 400	1, 066, 600	6, 242, 000	56. 8	6, 462
51	1006	8, 366, 300	964, 900	9, 331, 200	67. 8	9, 276
50	1060	8, 247, 300	1, 041, 400	9, 288, 700	69. 0	8, 763
49	1119	9, 157, 300	897, 700	10, 055, 000	76. 8	8, 986
48	1102	13, 774, 100	1, 173, 300	14, 947, 400	73. 9	13, 564
47	998	13, 888, 700	1, 484, 800	15, 373, 500	71. 9	15, 404
46	992	11, 605, 800	1, 058, 400	12, 664, 200	71. 0	12, 766
45	916	11, 015, 800	1, 834, 300	12, 850, 100	76. 6	14, 028
44	878	11, 808, 400	1, 529, 700	13, 338, 100	76. 9	15, 191
43	931	9, 376, 300	705, 600	10, 081, 900	79. 3	10, 829
42	939	15, 086, 600	642, 700	15, 729, 300	77. 0	16, 751
41	1018	18, 891, 200	1, 022, 400	19, 913, 600	88. 6	19, 561
40	1108	11, 159, 900	1, 372, 400	12, 532, 300	71. 7	11, 311
39	1153	12, 004, 800	1, 528, 300	13, 533, 100	78. 3	11, 737
38	1191	10, 743, 200	2, 309, 900	13, 053, 100	88. 6	10, 960
37	1174	13, 647, 000	1, 068, 900	14, 715, 900	67. 1	12, 535
36	1239	11, 194, 100	883, 600	12, 077, 700	63. 4	9, 748
35	1225	11, 100, 000	1, 628, 700	12, 728, 700	61. 4	10, 391
34	1265	10, 793, 000	849, 300	11, 642, 300	52. 5	9, 203
33	1257	12, 016, 294	522, 158	12, 538, 452	56. 4	9, 975
32	1226	10, 607, 502	353, 699	10, 961, 201	55. 9	8, 941
31	1392	12, 821, 455	238, 015	13, 059, 470	56. 2	9, 382
30	1464	10, 547, 773	542, 597	11, 090, 370	46. 1	7, 575
29	1517	9, 325, 193	764, 171	10, 089, 364	50. 0	6, 651
28	1391	9, 639, 931	490, 809	10, 130, 740	50. 1	7, 283
27	1601	15, 080, 336	752, 337	15, 832, 673	58. 1	9, 889
26	1531	11, 899, 101	541, 426	12, 440, 527	42. 9	8, 126

Table 14. Columbia River Troll catch of chinook and coho in pounds (Oregon and Washingto

Year	No. boats licensed	Chinook	Coho	Total	% of total Col. R. chinook and coho catch	[a] success per vessel
1973	N. D. A.	319, 900	848, 800	1, 168, 700	11. 9	N. D. A.
72	N. D. A.	271, 100	1, 914, 900	2, 186, 000	28. 4	N. D. A.
71	1528	473, 500	3, 689, 200	4, 162, 700	33. 3	2, 724
70	1004	590, 100	2, 345, 600	2, 935, 700	19. 2	2, 924
69	1006	330, 900	1, 399, 600	1, 730, 500	18. 7	1, 720
68	1218	530, 200	1, 674, 900	2, 205, 100	30. 1	1, 810
67	927	472, 200	3, 440, 600	3, 912, 800	30. 4	4, 221
66	673	542, 700	2, 383, 600	2, 926, 300	26. 5	4, 348
65	521	164, 000	3, 451, 200	3, 615, 200	33. 7	6, 939
64	455	327, 800	1, 724, 500	2, 052, 300	23. 9	4, 511
63	393	402, 300	1, 524, 400	1, 926, 700	28. 2	4, 903
62	357	205, 100	1, 174, 200	1, 379, 300	18. 3	3, 864
61	289	289, 200	1, 297, 300	1, 586, 500	25. 1	5, 490
60	267	201, 200	635, 500	836, 700	16. 7	3, 134
59	293	178, 100	641, 500	819, 600	16. 1	2, 797
58	266	197, 900	560, 000	757, 900	10. 1	2, 849
57	326	297, 800	872, 100	1, 169, 900	15. 3	3, 589
56	379	765, 900	1, 145, 500	1, 911, 400	18. 0	5, 043
55	386	1, 035, 000	966, 600	2, 001, 600	17. 8	5, 185
54	363	1, 029, 800	690, 400	1, 720, 200	23. 2	4, 739
53	367	1, 033, 800	925, 900	1, 959, 700	20. 9	5, 340
52	360	1, 407, 000	1, 063, 600	2, 470, 600	22. 5	6, 863
51	322	1, 299, 800	1, 457, 600	2, 757, 400	20. 0	8, 563
50	333	765, 800	1, 188, 600	1, 954, 400	14. 5	5, 869
49	355	724, 500	701, 700	1, 426, 200	10. 9	4, 017
48	328	974, 300	1, 460, 700	2, 435, 000	12. 0	7, 424
47	316	1, 124, 200	1, 434, 100	2, 558, 300	12. 0	8, 096
46	N. D. A.	1, 636, 500	964, 400	2, 600, 900	14. 6	N. D. A.
45	296	1, 345, 900	612, 500	1, 958, 400	11. 7	6, 616
44	247	805, 900	875, 600	1, 681, 500	9. 7	6, 808
43	365	361, 100	422, 300	783, 400	6. 2	2, 146
42	345	826, 900	521, 200	1, 348, 100	6. 6	3, 908
41	363	1, 142, 000	894, 200	2, 036, 200	9. 1	5, 609
40	339	689, 500	1, 623, 600	2, 313, 100	13. 2	6, 823
39	320	363, 400	1, 806, 900	2, 170, 300	12. 6	6, 782
38	273	303, 700	2, 212, 200	2, 515, 900	14. 5	9, 216
37	194	555, 300	1, 490, 600	2, 045, 900	9. 3	10, 546
36	206	976, 000	1, 385, 300	2, 361, 300	12. 4	11, 463
35	193	275, 400	3, 125, 200	3, 400, 600	16. 4	17, 620
34	175	534, 600	1, 871, 700	2, 406, 300	10. 8	13, 750
33	155	1, 356, 436	1, 298, 688	2, 655, 124	11. 9	17, 130
32	183	209, 675	2, 755, 228	2, 964, 903	15. 1	16, 202
31	261	202, 369	1, 792, 929	1, 995, 298	8. 6	7, 645
30	442	1, 009, 481	4, 480, 531	5, 490, 012	22. 8	12, 421
29	461	1, 217, 835	2, 204, 385	3, 422, 220	17. 0	7, 423
28	349	958, 608	1, 811, 486	2, 770, 094	13. 7	7, 937
27	321	1, 396, 021	2, 200, 758	3, 596, 779	13. 2	11, 205
26	342	1, 163, 380	5, 090, 488	6, 253, 868	21. 6	18, 286

Table 15. Total Columbia River catch in pounds

Year	Chinook	Coho	Total
1973	7, 155, 100	2, 672, 000	9, 827, 100
72	4, 613, 900	3, 092, 400	7, 706, 300
71	6, 500, 800	5, 993, 300	12, 494, 100
70	7, 112, 000	8, 153, 000	15, 265, 000
69	6, 179, 500	3, 077, 000	9, 256, 500
68	4, 689, 200	2, 647, 600	7, 336, 800
67	5, 558, 000	7, 295, 900	12, 853, 900
66	4, 253, 500	6, 797, 000	11, 050, 500
65	5, 371, 200	5, 372, 100	10, 743, 300
64	4, 908, 800	3, 696, 100	8, 604, 900
63	4, 802, 200	2, 026, 000	6, 828, 200
62	5, 748, 200	1, 790, 000	7, 538, 200
61	4, 561, 900	1, 685, 500	6, 247, 400
60	4, 203, 700	795, 700	4, 999, 400
59	4, 945, 300	762, 700	5, 708, 000
58	6, 737, 600	731, 200	7, 468, 800
57	6, 358, 900	1, 265, 000	7, 623, 900
56	8, 986, 200	1, 614, 200	10, 600, 400
55	9, 658, 500	1, 569, 500	11, 228, 000
54	6, 416, 100	994, 900	7, 411, 000
53	7, 999, 700	1, 383, 900	9, 383, 600
52	8, 854, 400	2, 137, 500	10, 991, 900
51	11, 330, 400	2, 425, 500	13, 755, 900
50	11, 216, 000	2, 236, 700	13, 452, 700
49	11, 499, 200	1, 601, 400	13, 100, 600
48	17, 591, 100	2, 635, 100	20, 226, 200
47	18, 452, 700	2, 922, 500	21, 375, 200
46	15, 820, 000	2, 023, 900	17, 843, 900
45	14, 301, 900	2, 463, 400	16, 765, 300
44	14, 847, 300	2, 491, 000	17, 338, 300
43	11, 629, 300	1, 084, 200	12, 713, 500
42	19, 317, 000	1, 123, 100	20, 440, 100
41	20, 547, 200	1, 930, 400	22, 477, 600
40	14, 481, 200	3, 003, 800	17, 485, 000
39	13, 951, 000	3, 335, 800	17, 286, 800
38	12, 789, 200	4, 518, 800	17, 308, 000
37	19, 005, 700	2, 924, 400	21, 930, 100
36	16, 514, 200	2, 529, 100	19, 043, 300
35	15, 416, 600	5, 301, 800	20, 718, 400
34	18, 657, 300	3, 530, 300	22, 187, 600
33	19, 716, 007	2, 506, 223	22, 222, 230
32	16, 042, 220	3, 565, 292	19, 607, 512
31	20, 329, 004	2, 917, 113	23, 246, 117
30	17, 628, 842	6, 426, 213	24, 055, 055
29	15, 661, 519	4, 499, 067	20, 160, 586
28	16, 931, 438	3, 276, 424	20, 207, 862
27	23, 205, 548	4, 041, 832	27, 247, 380
26	21, 817, 592	7, 154, 334	28, 971, 926