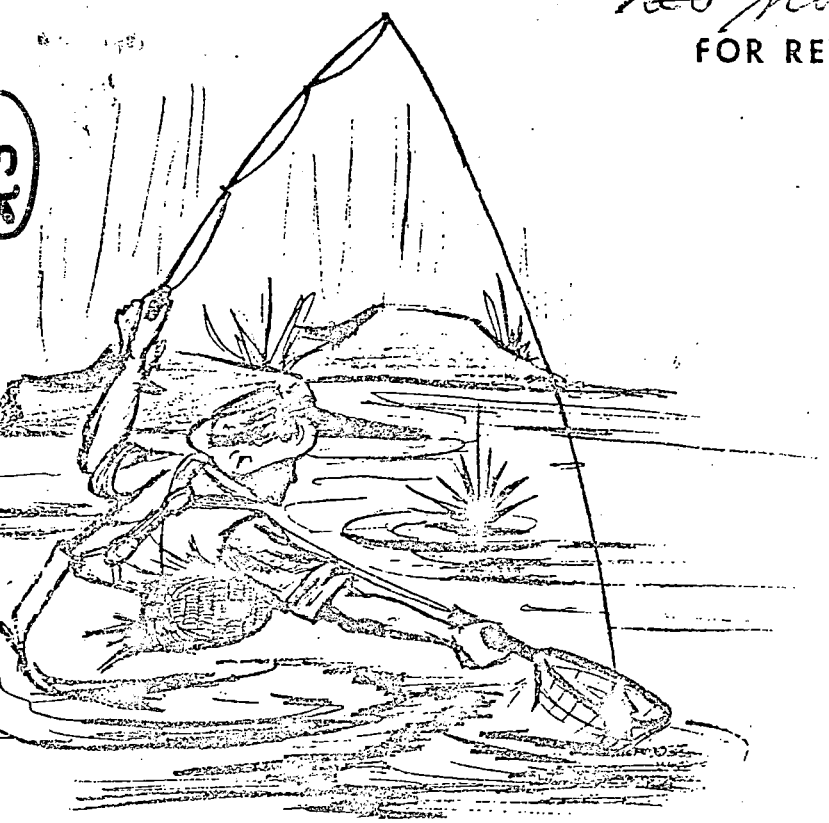
AN ECONOMIC EVALUATION OF COLUMBIA RIVER ANADROMOUS FISH PROGRAMS A PRELIMINARY STUDY



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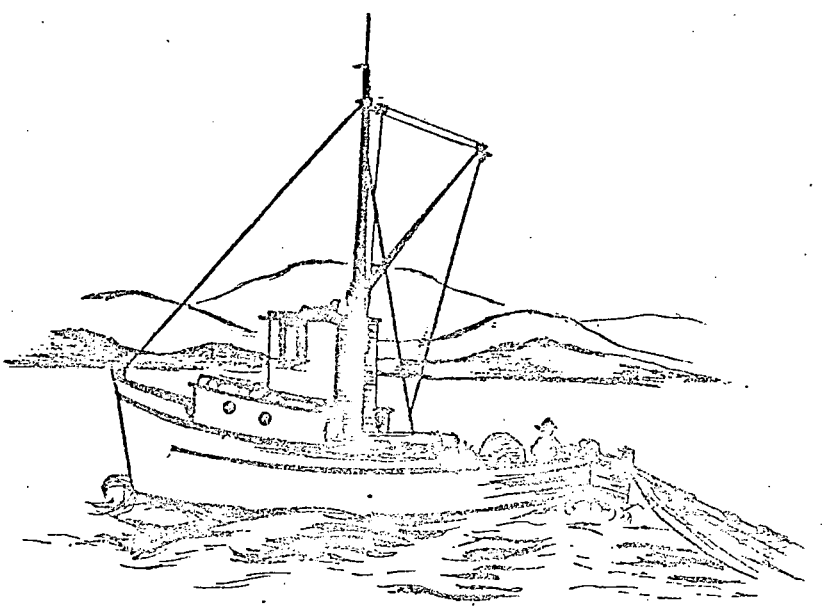

U. S. DEPARTMENT OF THE INTERIOR
Bureau of Commercial Fisheries
Division of Economics

PREFACE

This study and the preparation of the manuscript was carried out by Dr. Virgil J. Norton, Chief, Section of Supply and Resource Use Research; Dr. William G. Brown, Consultant Economist to Branch of Economic Research; and Jack A. Richards, Economist, Section of Supply and Resource Use Research.

Richard K. Kinoshita assisted in the collection and tabulation of data. Robert H. Forste assisted in collection of certain data in preliminary stages of the study.

In addition to furnishing biological and technical data, the staff of the Columbia River Fisheries Development Program Office, Bureau of Commercial Fisheries, Portland, Oregon, provided valuable help and advice during the study. The staff also reviewed the manuscript and offered many helpful comments.

Other agencies and organizations furnishing data and reviewing the study were: (1) Bureau of Sport Fisheries; Bureau of Reclamation; Market News Service, Fishery Statistics and Resource Management of the Bureau of Commercial Fisheries; (2) the Corps of Engineers, Federal Power Commission, and General Accounting Office; (3) private utility companies; (4) California Department of Fish and Game, Idaho Fish and Game Department, Oregon State Game Commission, Oregon State Fish Commission, Washington State Department of Fisheries, and Washington Department of Game; (5) Oregon State University; and (6) Columbia River Salmon and Tuna Packers Association and Columbia River Fishermen's Protective Union.

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INTRODUCTION

The anadromous fish resources of the Columbia River are important to the entire west coast. Commercial, sport and Indian fishing occur in the Columbia River and its tributaries. In addition, Columbia River spawned salmon make significant contributions to the coastal catches from Alaska to California including British Columbia, Canada.

The commercial fishery of the Columbia River is an important source of economic activity to areas in Washington and Oregon which are presently plagued with unemployment. Not only is employment provided at the fisherman level, but also large fish processing plants provide job opportunities for many workers. It has been estimated that the net income generated by the commercial anadromous fishery in Oregon alone approaches $10 million annually.1/ By far, the major portion of this fishery is attributable to the Columbia River.2/

In addition to the contribution of commercial fishing, the economic and recreation value of the Columbia River sport fishery is rapidly increasing. Rising incomes and the corresponding increases in leisure time available to the populace are bringing forth an ever rising demand for recreation activities such as sport fishing.

Thus, the economic and recreation activity produced by the Columbia River anadromous fish resource is essential to the areas along the Pacific Coast of the United States and Canada.

The Columbia River also produces other important benefits in the form of power, irrigation and navigation. The demand for these other uses

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1/ Ballaine, W.C. and S. Fiekowsky, Economic Value of Anadromous Fishes in Oregon Rivers, Interim Committee Report, Salem, Oregon, December 1952, p. 5.

2/ Ibid., p. 18.

on the river has expanded rapidly during the past few decades. This, along with the increasing demand for the benefits from commercial and sport fishing, has resulted in a continual struggle between interests favoring full river development and those primarily concerned with the maintenance of the fishery.

The Federal Government has recognized an obligation to mitigate detrimental effects to fish resources as the result of river development. To achieve this end, fish passage facilities have been included at dams below the Chief Joseph on the mainstream and the Brownlee Dam on the Snake River. Since 1949, the struggle to preserve fish and fish habitat has been supplemented by the Columbia River Fishery Development Program. This program established by Congress was necessary because fish passage facilities at the dams failed to maintain fish productivity.

Since 1958, with the adoption of the revised Fish and Wildlife Coordination Act, justifiable fish and wildlife improvements have been given equal consideration with power, flood control, navigation, water quality, and other purposes of the development of large multipurpose projects. As a result, enhancement as well as restoration of productivity is now considered a basic goal.

The valuable fish resources of the Columbia River have had to cope with continuously increasing difficulties resulting from population growth and river development. Both of these influence the fish habitat in the river. Although it is recognized that an interaction exists between changes resulting from full river development and changes associated with a growing population, it is not necessary for our purposes to isolate these causal factors. However, it is desirable at this point to understand the nature of these detrimental changes occurring on the Columbia River.

The Shrinking River

Anadromous fish are hatched in fresh water, migrate to the ocean for the growing stage of their life cycle and return to the fresh water of their birth for spawning. Thus, for natural propagation, it is necessary that these fish have freedom to migrate in the river. However, the construction of dams for power and other uses has impeded the migration of anadromous fish. With full river development, existing plus completion of planned and proposed projects will number over 75 dams and reservoirs in the Columbia River Basin.

The construction of, first, the impassable Grand Coulee Dam and, later, the Chief Joseph Dam on the mainstream of the Columbia River and the Swan Falls Dam on the Snake River have effectively eliminated access to the entire upper river spawning areas.1/ The result of these dams is that the Columbia River has shrunk for anadromous fish.

> "Dams have cut nearly in half the river area available to salmon and steelhead. Of the 190 miles of mainstream Columbia River still available in 1962, only 50 miles will remain after dams now under construction or authorized are completed. Even this remaining 50 miles is threatened by a potential project. The prospects for the Snake River are only slightly brighter.2/"

Total blockage of the river has been prevented only by the inclusion of costly fish passage facilities at dams in the Columbia River Basin below the Chief Joseph and Brownlee Dams. However, even these facilities have limitations. In some instances fish passways have failed to operate as planned. An example of this is the fishway at Swan Falls Dam on the Snake River. When this facility failed to provide the needed passage, the river above the dam was blocked to anadromous fish. To restore this run would require not only the expense of remodeling the fishway, but also the cost of artificially restoring the fish run in the area above the dam. In addition, at almost all facilities, some of the mature upstream migrants will not use the fishways and are, therefore, lost as potential spawners.

The movement of fish to upstream spawning areas is not the only problem created by the existence of the dams. The loss of small fish during their downstream journey to the ocean and the detrimental effect on fish habitat are also important.

Loss of Downstream Migrants

A three-year test at McNary Dam in the late 1950's demonstrated that the most serious loss of young downstream migrants occurred

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1/ Fishways were provided at Swan Falls Dam but have not functioned properly.

2/ Columbia River Fisheries Program Office, Columbia River Fishery Program, Circular 192, Bureau of Commercial Fisheries, Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C., November 1964, p. 6.

through the turbine system used to generate power. An estimated 9 to 13 percent loss of young fish occurred for each instance where movement took place through the turbine system at a dam. Only one or two percent was lost, however, via spillways or other bypasses at McNary Dam.[1/]

If proposed storage dams are built, the loss of young anadromous fish will be even greater. With full control of current through storage dams, it will be possible to utilize the full flow of the river through the power turbine system. Reduced flow over the spillways means young fish will have to pass through the turbines. Considerable research has been aimed at finding more efficient methods of moving downstream migrants through the dams. However, unless safe bypasses can be developed, it will be necessary to increase the number of fish moving downstream if losses resulting from additional dams are to be offset.

It is important to note that the loss of downstream migrants also affects hatchery-released fish. Many of the hatcheries of the Columbia River Program are located above dams on the River. These sites have been selected because of suitability for hatchery operations. Good hatchery sites are difficult to find, and they often must be accepted with some shortcomings. Fish are released at the hatchery to begin their migration to the ocean. They are not hauled around the dams because of the harmful effect on homing of the salmon.

The Changing Fish Habitat

The influence of dam construction combined with the effects of population growth and economic development of the Pacific Northwest have all had an influence on the fish habitat of the Columbia River. A description of this change has been provided by the staff of the Columbia River Fisheries Program Office.

> "The face of the land in the Columbia Basin has been changed drastically in the last 150 years, and none of the changes has benefited salmon. Farming has resulted in lost spawning areas, depleted stream flows, increased turbidity of the remaining water, and in some instances, changes in chemical and physical properties of the water. Logging has removed forest cover, and has hastened

1/ Schoeneman, Dale E., Richard T. Pressey, and Charles O. Junge, Jr. "Mortalities of Downstream Migrant Salmon at McNary Dam," Transactions of the American Fisheries Society. Vol. 90, No. 1, January 1961 pp. 66-67.

runoff which brings with it a number of evils--floods, low flows, silt, and high water temperatures. Mining has added silt and pollutants to the waters, and urban development and industry have depleted stream flows and added domestic and industrial waste to the remaining waters.

"Starting in the 1930's a series of multipurpose dams for flood control, hydroelectric-power, and navigation were constructed on the mainstream Columbia River, and with the completion of Wells Dam, the Columbia will be a series of pools from tidewater to the Canadian border except for a 50-mile stretch below Priest Rapids Dam. So instead of a normal-flowing river, there is a series of pools that interfere with both upstream and downstream migrations of salmon. In addition, the dams which form those pools delay passage of the upstream migrants and kill many of the young. The pools also have changed the temperature patterns of the river, generally raising temperatures, thus decreasing further the suitability of the river for salmon and steelhead production. Dams now under construction or proposed for the mainstream Snake River will change it also into a series of pools with all of the attendant problems of successful fish passage and survival."1/

The cumulative effect of Columbia River dams on the migration and habitat of salmon and steelhead is decreased productivity of these species. This is true even with the inclusion of fish facilities at many of the dams. Thus, unless supplemented by artificial methods of propagation and habitat improvement, salmon and steelhead will tend to disappear from the Columbia River.

The Columbia River Fishery Development Program

In 1949, Congress authorized funds to initiate the Columbia River Fishery Development Program. Justified by loss of fish and fish habitat at Federal water-use projects, this program authorizes the use of Federal funds to rehabilitate and develop maximum salmon and steelhead runs in the Columbia River and its tributaries.

1/ Columbia River Fisheries Program Office, op. cit., p. 5.

The program is a cooperative effort of the fishery agencies of Oregon, Washington and Idaho and the U.S. Fish and Wildlife Service. Important achievements have been attained since the authorization of this program.

> "The Columbia River Fishery Development Program has used all known means to increase salmon abundance. Twenty-one hatcheries have been constructed or reconstructed on the lower river and its tributaries, obstructions have been cleared from 1,700 miles of tributary streams, 22 major fishways have been built over barriers, and about 160 minor falls have been improved. Loss of young fish has been reduced by installing over 600 screens of diversion ditches and canals. Operational studies have sought improvements in techniques and tools to improve salmon and steelhead production. Such studies have been made on fish-cultural techniques, on improvements to natural habitat, on methods for predator control, on spawning or incubation channels, and on pond rearing. A constant check has been made of the value of all measures put into actual use."1/

The Columbia River Fishery Development Program is aimed primarily at restoring salmon-steelhead productivity. Although far more has been spent for fish passage facilities at major hydroelectric projects than for the Columbia River Fishery Development Program, the net result of new dams is a decrease in productivity. On the other hand, the Fishery Development Program and similar efforts conducted by other agencies have been utilized to offset the loss in productivity resulting from new dam construction. Restored productivity has been accomplished through hatchery operations, opening of new spawning areas, research, and similar projects.

The Economic Problem

As each new dam has been added, increased expenditures for replacement of lost fish and fish habitat has been required simply for the maintenance of productivity of anadromous fish. Thus, in the past, the primary aim of this type of expenditure has been to restore productivity of this resource. However, increased use of the

1/ Ibid., p. 6.

Columbia River fishery, both for commercial and sport, has led to an expansion in the value of this resource. The return to the fishery from sport fishing has recorded a particularly rapid increase. Increased value of the fish resources of the Columbia River can be associated primarily with a growing and affluent population. Income is important because of its influence on the demand for sport fishing and perhaps also on the demand for certain commercial commodities as well. Population growth would directly increase the demand for both commercial and sport fishing. Since the fishery would have otherwise seriously deteriorated, even with fish passage facilities at the dams, the increased value of the fishery has been made possible by the Columbia River Fishery Development Program.

The goal of this study is to compare the cost of programs initiated to restore the productivity of the Columbia River anadromous fishery with the economic value of this resource.

THE SPORT FISHERY

Basis for Estimating the Columbia River Sport Catch

The estimated total sport catch was based upon the following estimated percentages of total catch of the various fisheries involved:

1. Percentage chinook salmon sport catch in the Pacific Coast fisheries as indicated in table 1.

2. Percentage coho salmon sport catch in the Pacific Coast fisheries as indicated in table 2.

Although the percentages of Columbia River chinook in table 1 are based upon commercial fish catch, these data provide the best available estimate of percent Columbia River chinook taken by sport anglers in these areas. The Columbia River also contributes to the sport catch of areas other than those listed in tables 1 and 2. Unfortunately, there is no reliable basis presently available to use in estimating these other contributions. The sport catch within Puget Sound is an example of the Columbia River not receiving

Table 1.--Estimated Percent of Sport-Caught Chinook Salmon Attributable to the Columbia River[1/]

Area	Percent
Columbia River and Tributaries	100
Washington and Oregon Ocean (including Columbia River mouth)	55
California Ocean	1

1/ Percentages for areas other than Columbia River and tributaries are based on estimated commercial troll catch and reported in Fisheries Vol. III, Washington Department of Fisheries, Washington State Printer, Olympia, Washington, February 1960, p. 190.

Table 2.--Estimated Percent of Sport-Caught Coho Salmon Attributable to the Columbia River[1/]

Area	Percent
Columbia River and Tributaries	100
Washington and Oregon Ocean (including Columbia River mouth)	59
California Ocean	11

1/ Percentages for areas other than Columbia River and tributaries are estimates by Columbia River Fishery Program Office staff, Portland, Oregon, based on a study by the Washington Department of Fisheries on the 1963 brood of marked coho from Washougal hatchery.

credit. Another example is the contribution of the Columbia River to the British Columbia sport fishery. Thus, the sport catch of salmon and steelhead attributed to the Columbia River for the purpose of this study is almost certainly conservative.

The percentages of coho salmon in table 2 can be criticized for being based only on the marking of one brood from one hatchery. Year-to-year and cycle-to-cycle fluctuations in fish numbers would not be taken into account. Consequently, samples from additional hatcheries and over a longer period of time would be highly desirable. Nevertheless, the estimates in table 2 are the best available at the present time.

Information on the total sport catch is also needed, of course, as well as the percentages of the total catch attributable to the Columbia River. Sport catch figures for salmon and steelhead vary considerably in reliability from area to area. For example, in Oregon the sport catch for the non-ocean sport fishery is estimated by salmon-steelhead license punch cards which are returned by the anglers to the Oregon State Game Commission. However, only about 30 percent of the anglers mail their punch cards back to the Game Commission. Therefore, estimated total catch based on these incomplete returns are subject to sampling variation and bias.[1/] On the other hand, reports of the ocean catch off the Oregon, Washington and California coasts are based upon carefully planned sampling procedures; consequently, these ocean catch statistics are thought to be quite reliable.

Despite the uncertainty of some of the sport catch data, these data provide the only basis available for estimating the sport catch attributable to the Columbia River. Catch data for various species and areas are given in Appendix Tables 1, 2 and 3.

Sport catch data in four of the most important sport fishing areas are presented in table 3. These data show an overall increase in the salmon-steelhead sport catch for these four areas which are highly influenced by the Columbia River Program. In 1956, the

1/ Hicks, Ronald H. and Lyle D. Calvin, An Evaluation of the Punch Card Method of Estimating Salmon-Steelhead Sport Catch, Agricultural Experiment Station, Technical Bulletin 81, Oregon State University, Corvallis, Oregon, November 1964.

Table 3.--Total Sport Catch of Salmon and Steelhead in Four Major Sport Fishing Areas[1/]

Year	Columbia River Mouth	Washington Ocean[2/]	Oregon Ocean	Oregon Columbia River	Total
	Thousands of Fish				
1956	84.0	234.0	34.3	49.5	401.8
1957	57.2	298.2	22.0	41.7	419.2
1958	65.2	227.2	12.2	68.0	372.6
1959	73.9	249.5	28.3	109.5	461.2
1960	72.3	124.3	21.7	71.0	289.3
1961	106.0	225.3	62.8	73.5	467.6
1962	148.5	258.1	89.8	94.3	590.7
1963	148.8	268.9	146.7	79.9	644.3
1964	162.2	241.5	164.5	97.5	665.7

1/ Sources: Oregon State Game Commission, Washington State Department of Fisheries, and the Columbia River Fishery Development Program. Salmon are primarily coho and chinook.

2/ Includes Neah Bay and Straits, LaPush, Westport and Tokeland.

Table 4.--Total Sport Catch of Salmon and Steelhead Attributable to the Columbia River and Tributaries[1/]

Area	1962	1963	1964
	Thousands of Fish		
Oregon:			
Columbia River and Tributaries	94.3	79.9	97.5
Ocean	53.6	87.6	98.2
Washington:			
Columbia River and Tributaries	115.6	97.5	85.9
Ocean	96.1	101.1	100.5
Columbia River Mouth	134.5	133.7	148.4
California Ocean	2.7	4.6	5.4
Idaho	31.6	39.6	27.8
Total	528.5	543.9	563.7

1/ Catch attributable to the Columbia River was estimated by the application of percentages listed in tables 1 and 2 to the total catch in the respective areas.

sport catch was around 400,000 fish whereas in 1964 the catch was estimated to be over 650,000. The greatest increase during the past eight years occurred in the Oregon ocean and the Columbia River mouth ocean.

Sport fisheries in other areas are also affected by the Columbia River Fishery Development Program. These other areas would include the Columbia and its upriver tributaries in Washington and Columbia tributaries in Idaho. Sport fisheries in California and British Columbia are also influenced, although to a lesser extent. Nevertheless, the figures in table 3 do represent the most important fisheries in terms of sport catch affected by the Columbia River Fishery Development Program, and the figures do indicate the increasing importance of the sport fishery catch.

In table 4 estimates are given of the salmon-steelhead sport catch originating from hatcheries or natural spawning grounds of the Columbia River system. A total salmon-steelhead sport catch of over 500,000 is estimated for each year from 1962 to 1964. The total sport catch estimates in table 4 are believed to be conservative because of the omission of the Puget Sound and British Columbia sport fishing areas.

Gross Economic Value of the Columbia River Sport Fishery

Ideally, gross economic value of the Columbia River sport fishery would best be estimated by a survey of expenditures from a sample of all sport anglers fishing for Columbia River salmon and steelhead. Such a survey should also cover each month during the year in order to minimize error from memory bias or faulty recall. However, there would not have been sufficient time or money in this preliminary study to design this kind of survey and to collect and analyze the needed data from the anglers.

Fortunately, a comprehensive survey of Oregon salmon-steelhead anglers was conducted in 1962 and provides a reasonably accurate basis for estimating the present gross and net economic value of the Columbia River salmon-steelhead sport fishery.[1] Justification

[1] Brown, W.G., A. Singh, and E.N. Castle, An Economic Evaluation of the Oregon Salmon and Steelhead Sport Fishery, Oregon Agricultural Experiment Station Technical Bulletin 78, Oregon State University, Corvallis, Oregon, September 1964.

for this statement will be developed in more detail in the discussion of the net economic value of the Columbia River sport fishery. It will only be noted here that angler expenditures were positively associated with income and that Washington has a higher per capita income and greater population than Oregon. From these facts and from observation of the large and well-equipped population of Washington sport anglers, it seems plausible to assume that the demand for salmon-steelhead fishing by Washington residents is at least as great, if not greater, than the demand for Oregon residents. Since well over 90 percent of the sport catch of salmon and steelhead in table 4 are landed in Washington and Oregon, it will be assumed that average expenditure per salmon-steelhead from the Columbia River is the same as the average expenditure per salmon-steelhead recorded by Oregon anglers during 1962.

Oregon anglers spent an estimated $18 million on salmon-steelhead during 1964.[1] Based upon available information, the best estimate of the total 1962 salmon-steelhead catch by Oregon anglers was 351,956 fish.[2] Dividing $18 million by 351,956 yields an estimated spending per fish of approximately $51.14 by Oregon salmon-steelhead anglers in 1962.

Multiplying the total 1962 sport catch of the Columbia River (from table 4) by $51.14 gives $51.14 X 528,468 which equals slightly over $27 million. Therefore, our best estimate of gross value of the 1962 sport catch attributable to the Columbia River system is $27 million.

Following the same procedure based on the 1962 average expenditure of $51.14 per fish, the gross value of the 1963 sport catch attributable to the Columbia River is estimated to be $27.8 million. The 1964 estimated gross value is $28.8 million. These estimates of gross value are, of course, subject to the same limitations listed for the Oregon study[3] and assumptions mentioned above.

1/ Brown, et al., op. cit., pp. 27-28.

2/ This estimate assumed that 32 percent of the salmon caught in the Columbia River ocean fishery were landed by Oregonians as compared to 68 percent by Washington residents.

3/ Brown, et al., op. cit., pp. 18-28.

Although total angler expenditures are appropriate as a measure of gross economic value, these expenditures are not suitable for inferring net economic value. While it is true that salmon-steelhead angling is valued at least as high as other things which could be purchased with the same money, it is also true that if salmon and steelhead fishing were not available, some of the money would simply be spent for other goods and services. Spending lost from this shift, where the salmon-steelhead anglers would be forced to some second choice, would not be total expenditures but some lesser amount termed "net economic value." If only total expenditures were used, it would be difficult to compare sport fishery benefits with other benefits which could be received from alternative uses of the Columbia River resources. Using gross expenditures would be similar to using total farm expenses on an irrigated farm as the value of the water used in irrigation. Such a procedure applied to every Columbia River use would obviously lead to difficulty. Thus, the estimate wanted for most purposes of benefit evaluation is not gross value but rather the net economic value.

Net Economic Value of the Columbia River Sport Fishery

Estimation of the net economic value of the salmon and steelhead sport fishery attributable to the Columbia River was based on the guidelines established by Senate Document No. 97.[1] In the absence of market prices, it was recommended that the value of sport fishing be derived or established in the same manner as for general recreation benefits. These values for specific recreational activities were to be derived or estimated on the basis of a simulated market giving weight to all pertinent considerations, including charges that recreationists should be willing to pay and to any actual charges being paid by users for comparable opportunities at other installations or on the basis of justifiable alternative costs.[2]

1/ President's Water Resources Council, Policies, Standards and Procedures in the Formulation, Evaluation and Review of Plans for Use and Development of Water and Related Resources, Senate Document No. 97, U.S. Government Printing Office, Washington, D.C., 1962, pp. 10-11.

2/ Ibid., p. 10.

Sport fishing licenses have traditionally been sold to citizens in the United States at very low or nominal prices. Consequently, actual charges being paid by sport anglers for fishing opportunities at comparable locations is not a feasible way to estimate the recreational value of salmon-steelhead sport fishing. Therefore, the method to be used in this report was to estimate a simulated market. That is, "net economic value" is the best estimate of the monetary income which could be obtained by a single owner who could charge sport anglers for his permission to fish for salmon and steelhead.[1/] The advantage of the above procedure is that it comes closest to imputing a value to the fishery resource comparable to what its value might be if it were privately owned by a monopoly. The limitations and assumptions required will be specified in more detail by reviewing the estimation of the 1962 value of the Oregon salmon-steelhead sport fishery, which will be used as a basis for estimating the value of the salmon-steelhead sport fishery attributable to the Columbia River system.

Net Value of the 1962 Oregon Salmon-Steelhead Sport Fishery

The computation of the Oregon salmon-steelhead sport fishery was based upon demand functions that were statistically estimated from cross-sectional data obtained from Oregon anglers.[2/] The demand function which gave the best overall results, judged by criteria such as goodness of fit and economic logic, was of the following algebraic form:

$$Y_{3j} = b_o e^{b1 X_{2j}} + b_2 X_{3k} + b_3 Y_{2j}$$ [3/] (1)

The least squares fit in logarithms was:

$$\ln Y_{3j} = 0.95061 + 0.00727 X_{2j} - 0.00201 X_{3k} - 0.12769 Y_{2j} \quad (2)$$

where Y_{3j} was S-S (salmon-steelhead) days taken per unit of population of subzone J;

1/ This approach to the problem of measuring the demand for and value of outdoor recreation was first applied by Clawson. Cf. Marion Clawson, Methods of Measuring the Demand for and Value of Outdoor Recreation, Reprint No. 10, Resources for the Future, Inc., Washington, D.C., February 1959.

2/ Brown, et al., op. cit., pp. 28-42.

3/ Ibid., pp. 41-42.

X_{2j} was average family income of subzone j;
X_{3k} was average miles traveled per salmon-steelhead trip for the main distance zone in which the jth subzone falls.
Y_{2j} was average salmon-steelhead variable cost per day for subzone j.

Based upon the above demand function, total revenue to a monopolist able to charge for fishing rights to this fishery would have been maximized by an $8 charge per day. A predicted total of 390,300 salmon-steelhead days of fishing would be taken by Oregon anglers with an assumed increase in salmon-steelhead fishing costs per day of $8. Thus, assuming that the salmon-steelhead anglers would have reacted to a daily charge in the same way as to their other variable costs of fishing, Oregon anglers would have been willing to pay $8 X 390,300 or about $3,122,000 for the privilege of fishing for salmon and steelhead at $8 per day.1/ Therefore, the estimated net economic value of the Oregon salmon-steelhead sport fishery in 1962 was $3,122,000.

Extrapolation of Oregon Net Value to the Columbia River System

Knowing the net economic value of the Oregon salmon-steelhead sport fishery does not in itself indicate the net economic value of all sport catch of salmon and steelhead attributable to the Columbia River system. However, if the simplifying assumption can be made that all the sport-caught salmon and steelhead attributable to the Columbia River are equal in value to the sport-caught salmon and steelhead of Oregon, then the net economic value of the Columbia River salmon and steelhead can readily be estimated.

There is some justification for thinking that the average net economic value per fish of the salmon and steelhead of the Columbia

1/ Actually, even the possibility of an antagonistic reaction by salmon-steelhead anglers to an increase in license fees would not invalidate the above estimate of net value since this estimate is based upon the preferences of the anglers as revealed by their actual expenditures and fishing patterns during 1962.

River is at least equal to, if not greater than, the net economic value per fish for Oregon. In equation 2 of the preceding section, the average family income variable has a highly significant positive effect on the quantity of salmon-steelhead fishing days taken by the sport anglers. Since Washington residents enjoyed an average personal income of $2,522 per person in 1962 as compared to $2,380 for Oregonians,[1] results from equation 2 would indicate a relatively strong effective demand by Washington residents for salmon-steelhead sport fishing. The fact that Washington's population exceeds that of Oregon by about 60 percent would be another factor tending to give Washington a strong demand for salmon-steelhead sport fishing.

Given the assumption that the sport-caught salmon and steelhead attributable to the Columbia River are of equal value with the sport-caught salmon and steelhead of Oregon, the 1962 net economic value of all Columbia River salmon and steelhead was computed in a way similar to the estimate of gross economic value. Since the net economic value of the 1962 Oregon salmon-steelhead sport catch was an estimated $3,122,000[2] and the estimated Oregon catch was 351,956 fish,[3] the average net economic value per fish was $3,122,000 divided by 351,956 fish giving approximately $8.87 per fish. Multiplying this average net value of $8.87 per fish[4] times the total 1962 salmon-steelhead sport catch attributable to the Columbia River gives $8.87 times 528,468 which equals about $4.69 million. Therefore, the net economic value of the 1962 sport catch is estimated to be $4.69 million.

1/ Office of Business Economics, U.S. Department of Commerce, Survey of Current Business, Vol. 45, No. 4, April 1965, p. 19.

2/ Brown, et. al., op. cit., p. 41.

3/ From table 4 and with 32 percent of the salmon from the Columbia River ocean fishery landed by Oregon residents.

4/ It is important to interpret this value correctly. Senate Document No. 97 requires an estimate based on a simulated market. The estimate here is that a sport fisherman would be willing to pay an estimated $8.87 per fish if all fishing rights were controlled by a single owner attempting to obtain maximum profits in his charges to sport anglers for his permission to fish for salmon and steelhead.

Equation 2 could also be used to predict the net value of the 1963 and 1964 Oregon salmon-steelhead sport fishery. However, since the change in average family income and population from 1962 to 1963 and 1964 was relatively insignificant, the 1962 net value per fish is used instead. Multiplying $8.87 times 543,942 and 563,670 yields an estimated net economic value of $4.82 and $5.00 million for 1963 and 1964 respectively.

The above procedure for computing the 1963 and 1964 net value may be criticized since the original Oregon net economic value was based upon salmon-steelhead fishing days instead of fish caught. Nevertheless, the above procedure should be sufficiently accurate for present purposes since the number of fish is used only as a means of weighting the values of the various fisheries attributable to the Columbia River.

The estimates of net value obtained by the method used in this study are slightly higher than would be obtained by applying a unit day value of $6.00 as suggested by the Department of the Interior Departmental Manual on Water and Related Land Resources.1/ However, it is further stated in the manual that "a final check of the reasonableness of the selected unit value is whether or not it represents the amount prospective recreationists should be willing to pay to enjoy the recreational opportunities to be afforded by the project."2/

The method used in this study to estimate the net value of the Columbia River sport fishery was, in the judgment of the authors, a more reasonable estimate of what recreationists have been willing to pay than the unit value set up in the Departmental Manual.

It should be noted that the method used to estimate the net economic value of the Columbia River sport fishery yields a much lower estimate than do certain other methods which have been used in other studies. For example, Knetsch stated that "If primary benefits are viewed as the value of the project to those who use it, then the proper accounting of recreation benefits, or the social worth of this increased supply of project services, is measured by the area under the demand curve. This function indicates what

1/ Department of the Interior Departmental Manual, Water and Related Land Resources, p. 700.2.5B(4).

2/ Ibid., p. 700.2.7B(2).

consumers would pay for the various units of output. The measure estimated the total willingness to pay on the part of recreation users and is consistent with benefit calculations for irrigation, flood control and hydropower."1/

If Knetsch's argument is accepted for the moment, this area under the demand curve can be easily estimated from equation 2. This is similar to measuring the "consumer's surplus." See Appendix I for an explanation of the procedure used for estimating this area. This method yielded an estimated net benefit of $8.49 million for Oregon. Since the 1962 Oregon salmon-steelhead sport fishery was approximately 66.60 percent as large as the total Columbia River salmon-steelhead sport fishery, the net value estimated by this procedure for 1962 Columbia River sport anglers would amount to approximately $12.75 million. This estimate of annual net economic value for the 1962 Columbia River salmon-steelhead sport fishery is over two and one-half times as large as the estimate which was presented earlier.

Although there is some justification for using the area under the demand curve as a basis for estimating net economic value, there have been objections to this method. One objection raised is that this method is not used for computing most non-recreational benefits from water resources, such as for electric power. Therefore, such benefits might be difficult to use for making comparisons.2/ Another alleged difficulty is that benefits calculated by means of consumer's surplus could never, in practice, actually be captured.

However, this computation of value of nearly $13 million for 1962 does emphasize the conservative nature of the estimate of $4.69 million as the 1962 net economic value of the Columbia River sport fishery.

1/ Knetsch, Jack L., "Economics of Including Recreation as a Purpose of Eastern Water Projects," Journal of Farm Economics, December 1964, p. 1153. (Also, Reprint No. 50, Resources for the Future, Inc., 1755 Massachusetts Avenue, N.W., Washington, D.C. 20036, January 1965.)

2/ Knetsch disagrees with this conclusion, however. loc. cit., p. 1153.

Projection of Future Net Economic Value

One feature of equation 2 is that it partially explains the growing importance of the salmon-steelhead sport fishery. According to the estimated parameters of equation 2, increased family income is associated with increased salmon-steelhead angling. Also, the procedure involved in the estimation of equation 2 implies that a given constant increase in population will result in the same constant increase in the number of salmon-steelhead sport fishing days taken by the State. It should be recognized, of course, that equation 2 is an oversimplification of many complex factors which influence the fishing and spending patterns of sport anglers. For example, fishing success as measured by fish caught per hour of angling is likely an important factor. Nevertheless, disregarding the complication of omitted variables and errors of measurement, equation 2 can be used to project possible future net economic values under assumed future income and population conditions.

During the post war period from 1946 to 1962, United States per capita personal income increased at the rate of about four percent per year.[1] Assuming the same growth in per capita personal income for the years from 1962 to 1975, then personal income should increase approximately $(1.04)13$ which is an increase of over 66 percent. In order to be conservative, an increase in personal family income of only 60 percent by 1975 over 1962 was assumed.

Substituting a 60 percent increase of average income per family for each of the 35 subzones[2] and recomputing the predicted salmon-steelhead days for each subzone, a total of approximately 1,537,200 days is obtained. However, to complete the 1975 projection, it is necessary to estimate Oregon's 1975 population. Using the lowest projection given, Oregon projected 1975 population

1/ Office of Business Economics, U.S. Department of Commerce, Survey of Current Business, Vol. 45, No. 4, April 1965. p. 19.

2/ Brown, et al., op. cit., p. 43.

is 2,064,000.[1] This conservative projection represents an increase of slightly over 13 percent. Multiplying 1.13 times 1,537,200 yields a predicted number of approximately 1,737,000 salmon-steelhead sport fishing days for 1975 at the 1962 level of variable fishing costs per day.

To compute the predicted 1975 net economic value for the Oregon salmon-steelhead sport fishery, daily variable costs per subzone[2] were assumed to increase by $1, $2, $3, . . . etc., and the predicted quantities multiplied times these prices were computed. Maximum revenue again occurred at the $8 per day assumed increase in daily fishing costs. At $8 per day, a total of 625,400 days were predicted. Multiplying $8 times 625,400 yields a predicted net value of approximately $5,003,000 for the Oregon sport fishery.

The relative size of the 1962 Oregon sport catch to the total sport catch attributable to the Columbia River fishery was 351,956/528,468 or about 0.666. Dividing the 1975 Oregon projected net value by 0.666 yields a projected 1975 net economic value for the total Columbia River sport fishery of over $7.5 million.

Again, caution must be used with regard to the above projection since many factors, such as future sport angling success, will have an important influence on future salmon-steelhead sport fishing trends. Nevertheless, the above projection is at least indicative of the strong upward trend which can be expected of the demand for salmon and steelhead sport angling, especially if salmon and steelhead runs can be maintained or increased.

Conclusions Concerning Net Value of Sport Catch Attributable to the Columbia River

The 1962, 1963, and 1964 estimated net economic values of the salmon-steelhead sport catch attributable to the Columbia River were $4.69, $4.82, and $5.00 million respectively. These estimates were believed to be conservative for the following reasons:

1/ Bureau of the Census, U.S. Department of Commerce, Population Estimates, Current Population Reports, Series p-25, No. 301, February 1965, pp. 4-5.

2/ Brown, et al., op. cit., p. 43.

1. Percentages of total catch of the various sport fisheries which are attributable to the Columbia River are thought to be, on the average, low. For example, none of the British Columbia sport catch was attributed to the Columbia River, even though some of this catch is known to originate from the Columbia River.

2. Only the net economic values for salmon and steelhead were considered. Other anadromous fish, such as shad and smelt, were omitted. The shad sport fishery is reported to be increasing greatly in importance.

Projected 1975 net economic value of the salmon-steelhead sport fishery attributable to the Columbia River was $7.5 million, an increase of approximately 60 percent over 1962. This projection is indicative of the expected strong upward trend in the demand for salmon-steelhead sport angling.

THE COMMERCIAL FISHERY

Basis for Estimating Columbia River Commercial Catch

The value of the Columbia River commercial catch is based on the following estimated percentages of the total catch of the various fisheries involved:

1. Commercial chinook salmon catch in the Pacific Coast fisheries and the total catch in the Columbia River as indicated in table 5.

2. Commercial coho salmon catch in the Pacific Coast fisheries including the Columbia River catch as indicated in table 6.

3. Commercial chum salmon catch in the inner Columbia River only.

4. Commercial sockeye catch in the inner Columbia River only.

5. Commercial steelhead catch in the inner Columbia River only.

6. Commercial shad catch in the inner Columbia River.

Table 5.--Estimated Percent of Commercial Catch of Chinook Salmon Attributed to the Columbia River[1/]

Area	Percent
Columbia River (except troll)	100
Columbia River (troll)[2/]	55
Washington Ocean	55
Puget Sound (troll)	55
Oregon Ocean	55
Alaska (troll)	40
California (troll)	1
British Columbia, Canada (troll)	55

1/ Percentages for areas other than Columbia River are based on estimated commercial troll catch and reported in Fisheries, Vol. III, Washington Department of Fisheries, Washington State Printer, Olympia, Washington, February 1960, p. 190.

2/ Caught at the mouth of the Columbia River.

Table 6.--Estimated Percent of Commercial Catch of Coho Salmon Attributed to the Columbia River[1/]

Area	Percent
Columbia River (except troll)	100
Oregon Ocean	45
Oregon Columbia River (troll)[2/]	60
Washington Ocean	11
Washington Columbia River (troll)[2/]	80
Alaska (troll)	0
California (troll)	38
British Columbia, Canada, Zone 40 (troll)	1

1/ Percentages for areas other than Columbia River are estimates by Columbia River Fishery Program Office staff, Portland, Oregon, based on a study by the Washington State Department of Fisheries on the 1963 brood of marked coho from the Washougal hatchery.

2/ Caught at the mouth of the Columbia River.

The percentages used for the contribution of the Columbia River to commercial catch in various areas are limited in general by the same shortcomings as for sport catch.

The commercial catch attributed to the Columbia River is presented in table 7. A more detailed breakdown by areas is given in Appendix tables 4 and 5. As shown in table 7, the catch attributed to the Columbia River declined rather rapidly from 1948 to 1960. However, since 1960, there has been a marked increase in catch. The recovery in coho salmon catch has been particularly significant. This reversal of the downward trend in catch is an indication of the success of the Columbia River Fisheries Development Program.

Gross Economic Value of the Columbia River Commercial Fishery

Senate Document No. 97 indicates that, when dealing with water associated resources, benefits "result from the increase in market value of commercial fish and wildlife less the associated cost."[1/]

If the programs that are presently underway in the Columbia River for maintenance of the productivity of the fishery were eliminated, essentially no commercial benefits would be attained from anadromous fish. It follows from this that all the benefits attributable to the Columbia River anadromous fishing can be considered as an increase in market value arising from the Columbia River Fishery Development Program and other fish facility expenditures on the river.

Thus, the gross value of Columbia River commercial fishery was calculated as the ex-vessel market value of the anadromous fish attributable to the Columbia River. This is actually the total revenue at the fisherman level from all commercially-caught fish that can be attributed to the Columbia River.

For the purpose of this study, no value is attributed to the Columbia River for fish species that are affected by neither fish passage facilities nor the Fishery Development Program. For example, no value is included for the commercial sturgeon catch. The value of commercial caught shad is included, however, due to the apparent effect of fish passage facilities on this species.

1/ President's Water Resources Council, op. cit., p. 11.

Table 7.--Commercial Catch of Anadromous Fish Attributable to the Columbia River, 1948-64[1/]

Year	Chinook	Coho	Other[2/]	Total
	Thousands of Pounds			
1948	24,271	3,796	2,930	30,996
1949	18,509	2,805	1,820	23,133
1950	16,553	3,371	2,536	22,460
1951	21,983	4,007	2,334	28,324
1952	21,079	4,532	2,858	28,469
1953	20,057	3,156	2,574	25,786
1954	16,148	2,308	2,261	20,716
1955	19,845	2,926	1,932	24,703
1956	18,819	3,725	1,405	23,948
1957	16,630	3,388	1,174	21,193
1958	15,646	1,843	1,711	19,192
1959	12,869	1,661	1,494	16,025
1960	10,482	1,197	1,308	12,987
1961	10,203	2,789	1,280	14,272
1962	11,230	3,035	1,716	15,981
1963	11,753	3,573	1,898	17,223
1964[3/]	11,980	3,624	1,631	17,235

1/ Source: Bureau of Commercial Fisheries, U.S. Department of the Interior, and Department of Fisheries of Canada.

2/ Comprised of the Columbia River catch of chum and sockeye salmon, steelhead and shad.

3/ Alaska and British Columbia data are preliminary while Oregon and Washington data estimated by the 1961-63 average.

A value for the British Columbia, Canada, commercial catch is also included. Although this benefit does not represent a return to United States citizens, fish originating in Canadian waters are taken in American fisheries and provide income to U.S. fishermen. This reciprocal supply situation, due to intermingling in the ocean, is considered sufficient justification to include in the total value of the Columbia River fishery the contribution of the Columbia River to the British Columbia commercial fishery.

The gross value of the Columbia River commercial fishery is presented in table 8.1/ It is important to note that although the commercial catch attributable to the Columbia River has declined since 1948, the value of the commercial fishery has remained relatively constant. In fact, the average 1962, 1963, and 1964 gross value of $6,186,000 is more than $2 million higher than the low recorded in 1949 and is $1.24 million higher than the 1959-61 three-year average.

The reported prices and resulting value of the Oregon and Washington catch are actually biased downward. This underevaluation results from the unique arrangement of the fishermen with the Columbia River Salmon and Tuna Packers Association, in that the processors furnish part of the equipment necessary for the harvesting of the fish. Thus, these costs actually represent a portion of the total cost of production at the ex-vessel level. An adjustment in value was made on the basis of records provided by the Columbia River Salmon and Tuna Packers Association. The adjustment was applied only to the Washington and Oregon catch. These adjusted values, averaging $7 million annually, represent the actual cost to the processor of the fish at the ex-vessel level (table 9). Thus, the figures in table 9 are actually considered to be a more accurate representation of gross value of the Columbia River commercial fishery than that presented in table 8. It should also be noted that the gross value of the sport catch, reported in an earlier section, and the gross value of the commercial catch, reported here, are actually not comparable. The sport catch gross value would more nearly correspond to the gross value of the commercial catch valued at the retail level.

Net Economic Value of the Columbia River Commercial Fishery

Senate Document No. 97 indicated that more than gross benefits should be considered in evaluating benefits arising from a commercial fishery. The instructions state that the associated costs should be subtracted from the increase in market value or, in this case, from the total revenue obtained by the fishermen. Associated costs are defined as those costs necessary to make the immediate product available for use or sale.2/ Associated costs, therefore, can be considered as the cost

1/ This value excludes the value of the Indian fishery. The Indian fishery is discussed separately in a later section.
2/ President's Water Resources Council, op. cit., p. 11.

Table 8.--Gross Benefits Derived from Commercial Catch of Anadromous Fish Attributable to the Columbia River, 1948-64[1/]

Year	Chinook	Coho	Other[2/]	Total
	Thousands of Dollars			
1948	5,276	840	407	6,523
1949	3,496	401	192	4,090
1950	3,934	758	328	5,020
1951	5,437	803	397	6,636
1952	4,837	752	517	6,107
1953	4,443	522	429	4,394
1954	3,940	430	390	4,759
1955	5,286	628	350	6,264
1956	5,640	925	290	6,856
1957	4,763	694	260	5,717
1958	5,107	536	419	6,062
1959	4,096	472	369	4,937
1960	3,900	463	328	4,691
1961	4,102	833	288	5,224
1962	4,885	891	354	6,130
1963	4,704	948	324	5,976
1964[3/]	5,076	1,054	322	6,452

1/ Source: Bureau of Commercial Fisheries, U.S. Department of the Interior, and Department of Fisheries of Canada.
2/ Comprised of the Columbia River value of chum and sockeye salmon, steelhead and shad.
3/ Alaska and British Columbia data are preliminary while Oregon and Washington data estimated by the 1961-63 average.

Table 9.--Adjusted Gross Benefits Derived from Commercial Catch of Anadromous Fish Attributable to the Columbia River, 1961-64[1/]

	1961	1962	1963	1964
	Thousands of Dollars			
Washington:				
Chinook	1,485	1,762	1,518	1,588
Coho	419	441	377	413
Oregon:				
Chinook	1,838	2,108	1,841	1,929
Coho	423	509	549	494
All Other	1,761	2,180	2,487	2,818
Total Gross Value	5,927	7,000	6,772	7,242

1/ Washington and Oregon chinook and coho value adjusted on basis of information obtained from Columbia River Salmon and Tuna Packers Association. All other is as given in table 8.

of production of the fish, and in order to evaluate the total net benefit of Columbia River fish, it was necessary to determine the cost of harvesting this resource. The gross return to the fishery was reduced by the amount of these costs to obtain net value. Net value, then, should be considered as the equivalent of pure economic profit.

Two problems arise when an attempt is made to measure net value from a fishery such as the Columbia River anadromous fishery. The first is that, by law, the fishermen are restricted to inefficient methods of catching anadromous fish.

Efficiency of commercial fishing operations has been controlled by numerous restrictions. Set nets, that were used in fixed locations such as at the entrance to spawning streams; traps, which at one time accounted for about a fifth of the annual Columbia River salmon catch; and seines, have been outlawed. Perhaps the most efficient method, the fish wheel, was also banned. In this contraption, which first appeared in 1879:

> "The salmon were guided into revolving wheels (kept in motion by the current) and down a chute into a large bin on the shore. Some wheels had long leads of piling running out into the river directing the fish into the wheel's range. The wheels were 9 to 32 feet in diameter. Automatic contrivances, they were cheap to operate and vastly efficient. One wheel could take as many as 3,000 salmon a day. By 1899 there were 76 wheels on both sides of the river but much opposition to them arose and at last both Oregon and Washington outlawed wheels."1/

Elimination of more efficient gear is not the only method that has been used to control the catch of salmon and other species. Another effective method that found early use was the regulation of fishing seasons. This, of course, also affects efficiency. When fishing is prohibited during a portion of the year, men and equipment must either secure alternative uses or lay idle. In many cases, alternative uses may not be available. Furthermore, fishing is often prohibited during periods of peak salmon runs in order to allow escapement to upstream

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1/ Netboy, Anthony, Salmon of the Pacific Northwest. Binford and Mort Publishers, Portland, Oregon, 1958, p.27.

spawning areas. Often, the fishermen do not know in advance when they will or will not be allowed to fish. Thus, escapement of salmon to upstream spawning areas has been obtained by controlling fishing methods and season, which in turn result in inefficiency in the harvesting of these fish.

The problem of resource allocation in fishing operations is beyond the scope of this study. This problem involves highly complex features, such as social and political organization, effect of historical management practices on current operations and established areas of vested interests that inhibit change. However, in the absence of complete consideration of this problem, the net benefit derived by society from the Columbia River fish resource is difficult to clarify and calculation of net benefits for a fishery forced by law to be inefficient will result in an understatement of the net benefits attributable to that fishery.

The second problem is in the way the Senate Document describes net benefits. As mentioned before, net benefit according to the document is gross sales minus the cost of production. In a theoretical economic sense, regardless of the efficiency of the method, it would not be possible to have any net benefits in a fishery unless entry is limited. The Columbia River fishery at the fisherman level, in fact, approaches a pure competition model. That is, entry is not limited, there is no one producer large enough to significantly influence production, and the product is relatively standardized. Thus, if any net benefits or pure profit did exist, more fishermen would be attracted until the net benefits were eliminated.

Alternative methods have been suggested for deriving net benefits accruing to a fishery. Crutchfield has suggested that net benefits be calculated on the basis of the most efficient method of harvesting the resource under a system of limited entry into the fishery.1/ This approach would result in higher estimated net benefit to the fishery than is actually being accrued at the present. The method proposed by Crutchfield is appropriate for estimating the potential value of a fishery or for determining the effects of certain regulations on the efficiency of a fishery. However, where the objective of this study is to estimate the actual net benefits that have accrued

1/ Crutchfield, James A., Valuation of Fishery Resources, Land Economics, Vol. XXXVIII, No. 2 (May 1962), pp. 145-154, and Valuation of a Fishery, Transactions of the 27th North American Wildlife and Natural Resources Conference (Wildlife Management Institute, Washington, D.C., 1962), pp. 335-346.

from the fishery, this method would not seem to apply. Thus, a more realistic approach to net benefits for the purpose of this study seems to be to define net benefits as return on investment and return to the owner's management and labor. This approach is taken in this study.

Net Economic Value of the Gill Net Fishery

Because the only cost of production figures available were for the Columbia River gill net fishery, the cost of fishing operations for all commercial fish attributable to the Columbia River was estimated from this fishery.[1/] The average catch per full-time gill net fishing enterprise[2/] is estimated at 24,000 pounds of salmon and steelhead.

Assuming this average catch, the equivalent of 286, 219, and 242 full-time enterprises would have been required for harvesting the 1962, 1963, and 1964 catch, respectively. It should be noted that there is actually considerably more fishermen than this involved in the fishery. However, many of these are part-time or occasional fishermen. Thus, in terms of time spent fishing and catch, it takes several of these part-time or occasional fishermen to equal one full-time fisherman.

The average costs, excluding hired labor and depreciation were estimated to be $3,135 per year. Average investment for a full-time fisherman is estimated at $15,300. Assuming a straight line depreciation method and a period of 20 years, depreciation per enterprise is $765. About 15 percent of the gill net fishermen hire extra labor. This extra labor is paid at the rate of one-third of the catch. Thus, it follows that approximately five percent of the gross sales is paid to hired labor. The total costs and returns per full-time fisherman equivalent for 1962, 1963, and 1964 are given in table 10. The average figures were then expanded to totals. The total cost and return to the gill net fishery are presented in table 11. It follows from the definition used for this study that the return to the owners for management, labor, and investment are equivalent to the net value or net benefits attributable to the gill net fishery.

1/ Cost and catch data used in this section for full-time fishermen were obtained from the Columbia River Fishermen's Protective Union, Astoria, Oregon.

2/ A full-time fisherman is one fishing essentially all of the open commercial season.

Table 10.--Average Cost and Returns Per Full-Time Equivalent Columbia River Salmon-Steelhead Gill Net Fishing Enterprise[1]

	1962	1963	1964
Gross sales	$8,628	$7,620	$8,238
Cost excluding hired labor and depreciation	3,135	3,135	3,135
Hired labor	431	381	412
Depreciation	765	765	765
Total cost	4,331	4,281	4,312
Return to owner for his management, labor and investment	4,297	3,339	3,926

[1] Source: Columbia River Fishermen's Protective Union and Columbia River Salmon and Tuna Packers Association. Calculated on the basis of 286, 219, and 242 full-time equivalents for the years 1962, 1963, and 1964 respectively. These full-time equivalents are based on an average catch of 24,000 pounds.

Table 11.--Total Costs and Returns to Columbia River Salmon and Steelhead Gill Net Fishery[1]

	1962	1963	1964
Total catch (lbs.)	6,853,900	5,246,600	4,799,900
Full-time equivalent fishermen[2]	286	219	242
Gross value	$2,467,561	$1,668,871	$1,993,571
Total costs excluding hired labor and depreciation	$ 896,610	$ 686,565	$ 758,670
Total hired labor cost	$ 123,266	$ 83,439	$ 99,704
Depreciation	$ 218,790	$ 167,535	$ 185,130
Total cost	$1,238,666	$ 937,539	$1,043,504
Return to owners for management, labor and investment (net value of the gill net fishing)	$1,228,895	$ 731,332	$ 950,067

[1] Calculated on a full-time equivalent enterprise basis from Table 10.
[2] It is expected that the full-time equivalent fishermen would differ from year to year because of the entry and exit of part-time and occasional fishermen.

Extrapolation of Gill Net Fishery Net Value to Columbia River System

A simple expansion of the ratio of net value to gross value calculated for the gill net fishery was used for determination of net value for the entire fishery. For example, as indicated in table 12, in 1964 the net value was 48 percent of the gross value. This 48 percent figure was then applied to the total gross value of the commercial fishery attributable to the Columbia River. The resulting net value was $3,096,931.[1] The same procedure was used for 1962 and 1963. The expansion of the gill net fishery data to the entire Columbia River fishery seems justified because if a significant difference in returns existed between different anadromous fisheries in the area, there would be a tendency for resources to shift from the fishery with the lower return to the fishery with the higher return. The area being considered in this study is relatively small and contiguous. Therefore, it is reasonable to expect relatively free mobility of resources within the area. From this analysis, the net value of the commercial fisheries, excluding the Indian fishery, that can be attributable to the Columbia River was estimated to be slightly over $3 million in 1962 and 1964 and about $2.6 million in 1963 (table 12).

Net Economic Value of Columbia River Indian Fishery

The value of the Indian fishery was treated separately from the value of the commercial fishery due to the unique fishing rights granted to the Indians by the Federal Government. In the 1947-54 period, it was estimated by the Oregon Fish Commission and the Fish and Wildlife Service the average annual catch by the Indians at Celilo Falls and vicinity at over two million pounds. During the same period, it was estimated that almost one-fifth of the catch was retained for personal use.[2] In recent years, the catch was drastically cut with the elimination of dip net fishery at Celilo Falls due to the construction of the Dalles Dam.

In 1964, it was estimated that the Indians caught 67,500 salmon and steelhead (758,600 pounds) in the Bonneville-Dalles area, a 26 percent increase over the 53,500 fish landed in 1963. In 1964, the Indians

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1/ Using gross value of the fishery as given in table 8. The adjustment in gross value from table 8 to table 9 represents part of the cost of production to fishermen, even though it is furnished by the processors. Thus, it would not be appropriate to use the value in table 9 for determination of net value.

2/ Columbia River Program Office staff, Bureau of Commercial Fisheries, Portland, Oregon. Unpublished data.

Table 12.--Extrapolation of Columbia River Salmon-Steelhead Gill Net Fishery to Total Commercial Fishery Attributable to the Columbia River

	1962	1963	1964
Gross value of gill net fishery	$2,467,561	$1,668,871	$1,993,571
Net value of gill net fishery	1,228,895	731,332	950,067
Net value of gill net fishery as percent of gross value	50	44	48
Gross value of commercial fishery attributable to Columbia River	6,130,115	5,976,130	6,451,941
Net value of commercial fishery attributable to Columbia River[1]	3,965,057	2,629,497	3,096,931

[1] Calculated by net value of Columbia River salmon-steelhead gill net fishery as percent of gross value times gross value of commercial fishery attributable to Columbia River. Excludes Indian fishery.

retained an estimated 39,000 pounds of salmon and steelhead. In addition, 258,600 pounds of chinook and coho salmon were distributed to the Indians through Oregon and Federal salmon hatcheries.[1]

The total value of the Indian fishery, including the hatchery-distributed salmon in 1964, was estimated at $240,230. The Indians sold commercially $207,180 worth of salmon and steelhead. The value of the subsistence salmon was estimated at $17,550 (45 cents per pound) and that obtained from the hatcheries at $15,500 (6 cents per pound).

Net benefits as defined earlier are the return on investment and return to owner's management and labor. With investment in fishing gear at a minimum and with little alternative use for their labor, net value of the Indian fishery was calculated at 75 percent of the gross value of the catch plus all of the hatchery-obtained fish. The full value of the hatchery salmon was considered as net value because the salmon given to the Indians were a residual of hatchery operations. With gross value of the Indian commercial fishery estimated at $224,730 and hatchery fish at $15,500, net value of the total Indian fishery was calculated at $184,047

[1] Ibid.

Projected Future Net Economic Value of the Commercial Catch Attributable to the Columbia River

No specific projections of the net value of the commercial fishery were made. However, it is reasonable to expect that the net value in the future will be at least as high as that estimated for 1964.

Two important factors will tend to increase this net value in the future. Increasing population in the area and in the U.S. will exert upward pressure on the demand for these fishery products. Rising incomes will also tend to increase the retail demand, especially for fresh and frozen forms of the product. Thus, even if the physical productivity of the Columbia River anadromous fishery remains constant, the gross and net economic values of the resource will be expected to increase.

Conclusions Concerning Net Value of Commercial Catch Attributable to the Columbia River

The 1962, 1963, and 1964 estimated net economic value of the commercial anadromous catch attributable to the Columbia River were $3.07, $2.63, and $3.10 million respectively. In addition, the net value of the Indian fishery was approximately $184,000. For this analysis, net value was defined as return to the owners management, labor, and investment.

The estimates are considered to be conservative because the Puget Sound was excluded due to the lack of reliable data for this fishery.

COSTS FOR MAINTAINING ANADROMOUS FISH

Costs Subject to Control and Alteration

The basic goal of this study is to compare the cost of maintaining productivity with the value of the fishery as an aid to guiding future policy management decisions concerning the fishery. For the Columbia River anadromous fishery, it is more meaningful to compare costs with benefits on an annual basis rather than by considering totals over a period of years. The reason is that primary interest for policy or management decisions should be centered on those cost factors which are subject to control or alteration in present or future time periods.

Cost of operating and maintaining existing fish facilities is one of the two cost categories subject to change in the future. The other is funds for future construction needed to restore or maintain the physical productivity of the fishery.

Annual operation and maintenance cost represents essentially the only possible savings to society if efforts to maintain the physical productivity of the Columbia River anadromous fishery were discontinued. A minor exception to this would be those cases where a salvage value exists or facilities can be put to an alternative use. For the most part, facilities for anadromous fish in the Columbia River would have little salvage or alternative use value. Thus, at any point in time if efforts to maintain productivity of this resource should cease, funds already expended on fish passage facilities would be lost to society. This is, of course, equally true if in the future any dam should be constructed without passage facilities below existing structures with such facilities.

A special problem arises in connection with private utility companies due to the difference in accounting and financing procedures. In this case, costs are amortized and written off based on an annual rate. Nonetheless, if use of these facilities ceased, these costs for the most part would continue. The reason for this is the same as that of publicly-owned facilities--lack of salvage or alternative use value. A minor difference between private and public expenditures does exist for fixed costs such as taxes, insurance and similar items that would be affected by discontinued use.

The criteria for including an expense item, therefore, is the effect at any point in time on the cost to society, if efforts to maintain productivity are continued. In other words, an alterable cost would be those present or future funds that would not be committed if these efforts should cease. It is apparent that, except for minor salvage or alternative use values, a decision to discontinue efforts to maintain productivity of this resource would not alter the expenditures already invested. As a result, attention must be centered on those cost factors which remain subject to control. These are current operating expenditures and future requirements necessary to maintain productivity of the Columbia River fishery. These are, therefore, the cost categories singled out for special attention.

Operation and Maintenance Costs

Most annual operation and maintenance costs of Columbia River fish facilities and programs are incurred by the Bureau of Commercial Fisheries[1/] and the Corps of Engineers (table 13). It is important to note the difference in the objectives of the expenditures by the two agencies. The Corps of Engineers operation and maintenance costs are for mitigation of losses resulting from dams, primarily in the form of fish passways and screens. However, as was pointed out earlier, these expenditures have not been successful in maintaining productivity of this resource.

Table 13.--Annual Operation and Maintenance Costs of Columbia River Fish Facilities and Program

	1962	1963	1964
	Thousands of Dollars		
Columbia River Fisheries Development Program BCF[1/]	1,910	2,095	1,997
Corps of Engineers[2/]	1,053	1,053	1,053
Bureau of Reclamation[3/]			
Bureau of Sport Fisheries[4/]	168	168	168
State Agencies[5/]	793	793	793
Private Firms[6/]	515	564	764
Fish Passage Program BCF[7/]	1,172	1,730	1,747
Total	5,611	6,403	6,522

1/ Source: Columbia River Fisheries Development Program Office, Bureau of Commercial Fisheries.
2/ Source: Corps of Engineers, Portland, Oregon. Based on three-year average.
3/ Operation and maintenance costs of capital facilities built by Bureau of Reclamation are incurred by Bureau of Sport Fisheries and State of Washington.
4/ General Accounting Office, Washington, D.C.
5/ Estimated by State agencies involved.
6/ Obtained from records of the private utilities companies involved.
7/ Division of Biological Research, Bureau of Commercial Fisheries.

1/ Includes Columbia River Fisheries Development Program and Fish Passage Research Program.

On the other hand, expenditures by the Columbia River Fisheries Development Program have been aimed at restoring and improving productivity. These expenditures for hatcheries, habitat improvements, and research become more important as each new dam is built. Likewise, the studies carried out under the Fish Passage Research Program are also aimed at finding methods of improving productivity of anadromous fish in the Columbia River.

The application of the research findings arising from the Development Program and the Fish Passage Program is of broader scope than just the Columbia River. The results of these research programs are important to all areas, not for improving productivity of salmon and steelhead only, but for improved productivity of all anadromous fish. These research programs and the general applicability of the results become even more important in the light of a National Anadromous Fish Program Bill (H.R. 23) recently passed by the House of Representatives. The bill would authorize the Secretary of the Interior to initiate a program for the conservation, development, and enhancement of the Nation's anadromous fish in cooperation with the several States as reported with amendments. The title was later amended so as to read: "To authorize the Secretary of the Interior to initiate with the several States a cooperative program for the conservation, development, and enhancement of the Nation's anadromous fish, and for other purposes."

Therefore, although these research expenditures of almost $2 million are included with annual operation and maintenance costs for this study, excluding these costs from consideration may seem justifiable.

The annual operation and maintenance costs incurred by all Federal, State, and private agencies for the years 1962-64 are given in table 13.

Future of the Fishery

In addition to comparing the average annual value with the expenditures needed to maintain productivity under existing conditions, it is also important to consider future needs and value of the fishery. In this case, all expenditures required to maintain productivity must be considered since future construction costs as well as operation and maintenance costs are subject to change. However, the alternative of not including passage facilities at any new dam means loss of the river area above the dam for anadromous fish as well as loss to society of funds provided for existing facilities at dams further upstream.

Present data suggest that supplementary efforts may be the most productive in the future. Estimates indicate that 64 percent of the coho salmon landed by gill net in the Columbia River are of hatchery origin.[1] Since all fish in this area can be attributed to the Columbia River, this means that only 36 percent of the coho salmon taken by gill net can be traced to natural spawning according to this estimate. By far, the largest share of salmon released from hatcheries are from hatcheries financed by the Columbia River Fisheries Development Program. At the present, less than one-third of the annual operation and maintenance funds for anadromous fish are managed by the Columbia River Fisheries Development Program (table 13). However, as new dams are added in order to maintain productivity of the commercial and sport fishery even at its present level it may be necessary to expand the Columbia River Fisheries Development Program and other successful supplemental projects.

An example of the success of efforts by the Columbia River Fisheries Development Program to maintain productivity of the Columbia River Fishery is provided by the Klaskanine hatchery.[2]

SUMMARY

The net economic value of the commercial and sport fishery attributable to the Columbia River was estimated at approximately $8 million annually (table 14). Two points concerning this estimate are important. The first is that because of the tremendous amount of time and money that would be involved in gathering all of the biological and economic data necessary for a study of this type, many of the data used were preliminary estimates based on incomplete information. The second point is that this estimate of net economic value is thought to be conservative because in certain fisheries where adequate information was not available (such as the British Columbia sport catch and the Puget Sound sport and commercial catch) the fisheries were excluded from the analysis even though it is known that the Columbia River contributed anadromous fish to these areas. Further, the methodology used for estimating net value of both the sport fishery and the commercial fishery resulted in conservative estimates. The reason for this has been explained in detail in the respective sections of the text.

1/ Estimated by Columbia River Fishery Program Office staff, Portland, Oregon, based on a study by the Washington State Department of Fisheries on the 1963 brood of marked coho from the Washougal hatchery.

2/ Data on Klaskanine hatchery from report by Oregon Fish Commission. "A Report on the 1964 Coho Salmon Fishery in Youngs Bay."

Table 14.--Estimated Annual Net Economic Value as Compared to Operation and Maintenance Costs for the Columbia River Fishery

	1962	1963	1964
	Thousands of Dollars		
Net value of sport and commercial fishery	7,753	7,454	8,097
Net value of Indian fishery	184	184	184
Total net value	7,937	7,638	8,281
Operation and maintenance costs	5,611	6,403	6,522
Excess of net value over operation and maintenance costs	2,326	1,235	1,759

The average annual operation and maintenance costs necessary to maintain the Columbia River anadromous fishery were estimated at over $6 million (table 14). Thus, it was estimated that the net economic value of the sport and commercial anadromous fishery attributable to the Columbia River exceeded the cost of maintaining this fishery by an average of approximately $1.8 million annually during 1962, 1963, and 1964.

It should be noted that net value of net benefit of the fishery is an understatement of the economic contribution of the Columbia River anadromous fishery. The annual gross economic value of the sport fishery was estimated to be over $27 million.

The ex-vessel gross economic value of the commercial fishery was estimated to be over $7 million. It should be noted that these gross figures are not comparable. The sport figure would be more comparable to a commercial retail value. Here, however, only the ex-vessel commercial value is given. Thus, in addition to the $7 million gross value at the fisherman level, the economic activity created during processing and transportation should also be considered. For example, almost $800,000 of wages and salaries attributable directly to the Columbia River was paid to workers in processing plants in the Astoria, Oregon, area in 1964. This is important because this area has been

designated as a redevelopment area by the Area Redevelopment Administration because of economically depressed conditions. Other important sources of economic activity attributable to the Columbia River, but not included in the commercial gross value figure, are the can and fiberboard industries and other industries which produce supplies for the anadromous fish harvesting and processing firms.

It is important to point out once more the preliminary nature of this analysis.

To more adequately evaluate the contributions of the Columbia River anadromous fishery, further study of both biological and economic aspects are needed. The three most pressing needs are:

1. Increased effort in marking and recovery programs so that fish hatcheries can be evaluated individually and as a group. An expanded marking and recovery program will also provide information on the contribution of the Columbia River to different fisheries.

2. Further detailed studies of cost of production of coastal and river anadromous fisheries in order to better determine the net value of the commercial fishery.

3. Refinement in methodology for estimating both commercial and sport net value.

Program are also aimed at finding methods of improving productivity of anadromous fish in the Columbia River.

The application of the research findings arising from the Development Program and the Fish Passage Program is of broader scope than just the Columbia River. Results of these research programs are important to all areas, not for improving productivity of salmon and steelhead only, but for improved productivity of all anadromous fish. These research programs and the general applicability of the results become even more important in the light of a National Anadromous Fish Program bill (H.R. 23) recently passed by the House of Representatives. The bill would authorize the Secretary of the Interior to initiate a program for the conservation, development, and enhacement of the Nation's anadromous fish in cooperation with the several States as reported with amendments. The title was later amended so as to read: "To authorize the Secretary of the Interior to initiate with the several States a cooperative program for the conservation, development, and enhancement of the Nation's anadromous fish, and for other purposes."

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APPENDIX

Conceptually, the consumer's surplus would be estimated separately for each of the subzones which are listed in the Oregon study.[1] The demand function for each subzone would be integrated between two limits, the lower limit being the actual level of variable fishing costs incurred and the upper limit being positive infinity.

Since total salmon-steelhead days taken under 1962 salmon-steelhead variable cost and income conditions have already been computed, a much easier way to compute the sum of the definite integrals is to merely multiply the predicted 1962 salmon-steelhead fishing days by the constant, $1/.12769 = 7.831466$. The validity of this procedure can easily be seen. For any specific subzone under 1962 conditions, we can express the quantity of salmon-steelhead days taken as a function of salmon-steelhead variable costs per day (denoted by P). That is, $Y_{3j} = ke^{-.12769P}$

where k is a constant determined by the values of the income and distance variables for the jth subzone. For integration, denote the actual 1962 salmon-steelhead variable cost level of P_o. Then, the definite integral is given by

$$\int_{P_o}^{\infty} ke^{-.12769P}\,dP = \frac{-1}{.12769} \int_{P_o}^{\infty} ke^{-.12769P}(-.12679)dP.$$

Upon evaluation, this definite integral is easily seen to be

$$\frac{k}{.12769} e^{-.12769P_o} = 7.831466 \quad ke^{-.12769P_o}$$

However, except for 7.831466 the right side of the above equation is Y_{3j}, the 1962 quantity of salmon-steelhead fishing days for the jth subzone which has already been calculated.[2] Therefore, the total area under the demand curve for Oregon is simply 7.831466 X 1,084,000 which is approximately $8,489,000.

1/ Brown, et al., op. cit., p. 43.
2/ Brown, et al., loc. cit.

Appendix Table 1.--Chinook Salmon Sport Catch for Various Pacific Coast Fisheries, 1949-64[1/]

Year	Columbia River Mouth (Ocean)[2/]	Washington Ocean[3/]	Washington Columbia River and Tributaries[4/]	Oregon Ocean[5/]	Oregon Columbia River and Tributaries[4/]	California Ocean	Idaho[6/]
	Thousands of Fish						
1949	11	13	--	--	--	22	2
1950	17	24	--	--	--	56	2
1951	7	40	--	--	--	100	3
1952	11	93	--	--	--	120	4
1953	15	45	--	--	--	137	4
1954	12	73	--	--	--	166	15
1955	12	86	--	--	18	179	19
1956	34	110	--	2	26	158	21
1957	18	104	--	1	19	62	39
1958	26	85	--	1	36	72	25
1959	23	92	--	1	61	76	20
1960	38	70	--	1	37	50	22
1961	20	89	--	3	36	56	13
1962	30	71	15	4	46	121	12
1963	33	78	15	7	46	84	12
1964	28	110	22	8	59	95	9

1/ Sources: Washington State Department of Fisheries, Oregon State Game Commission, California Department of Fish and Game, and Idaho Fish and Game Department.
2/ Includes both Oregon and Washington catch.
3/ For Neah Bay and Straits, LaPush, Westport and Tokeland.
4/ Includes coho
5/ Apportioned between chinook and coho based on 1961-64 catch.
6/ Revised estimate based on 1964 sample of steelhead permits.

Appendix Table 2.--Coho Salmon Sport Catch for Various Pacific Coast Fisheries, 1949-64[1/]

Year	Columbia River Mouth (Ocean)[2/]	Washington Ocean[3/]	Oregon Ocean	California Ocean
	Thousands of Fish			
1949	3	4	--	2
1950	2	15	--	6
1951	2	19	--	11
1952	4	48	--	13
1953	8	56	--	15
1954	16	51	--	18
1955	15	65	--	20
1956	50	124	33	18
1957	39	194	21	7
1958	40	142	12	8
1959	50	158	27	8
1960	35	55	21	7
1961	86	136	60	4
1962	119	187	86	13
1963	116	191	140	33
1964	134	132	157	39

1/ Sources: Washington State Department of Fisheries, Oregon State Game Commission, and California Department of Fish and Game.
2/ Includes both Oregon and Washington catch.
3/ For Neah Bay and Straits, LaPush, Westport, and Tokeland.

Appendix Table 3.--Steelhead Sport Catch on Columbia River and Tributaries, 1956-64[1/]

Year	Washington	Oregon	Idaho[2/]
	Thousands of Fish		
1956	--	24	--
1957	--	22	--
1958	--	32	--
1959	--	49	--
1960	--	34	--
1961	--	37	--
1962	101	49	20
1963	82	34	27
1964	64	39	19

1/ Source: Washington State Department of Game, Oregon State Game Commission, and Idaho Department of Fish and Game.
2/ Revised estimate based on 1964 sample of steelhead permits.

Appendix Table 4.--Commercial Catch of Coho Salmon Attributable to the Columbia River, 1948-64[1/]

Year	Oregon	Washington	California	British Columbia	Total
	Thousands of Pounds				
1948	2,040	1,756	n.a.	n.a.	3,796
1949	1,576	1,229	n.a.	n.a.	2,805
1950	1,677	1,694	n.a.	n.a.	3,371
1951	2,180	1,761	n.a.	66	4,007
1952	2,449	1,731	282	70	4,532
1953	1,582	1,303	216	54	3,156
1954	1,175	928	160	44	2,308
1955	1,510	1,244	129	44	2,926
1956	2,014	1,388	276	46	3,725
1957	2,067	1,104	177	40	3,388
1958	761	904	113	65	1,843
1959	584	797	230	51	1,661
1960	545	540	85	27	1,197
1961	1,396	1,115	202	75	2,789
1962	1,499	1,321	140	74	3,035
1963	1,858	1,268	384	63	3,573
1964[2/]	1,585	1,234	719	86	3,624

1/ Source: Bureau of Commercial Fisheries, U.S. Department of the Interior, and Department of Fisheries of Canada.

2/ Alaska and British Columbia data are preliminary while Oregon and Washington data estimated by the 1961-63 average.

Appendix Table 5.--Commercial Catch of Chinook Salmon Attributable to the Columbia River, 1948-64[1/]

Year	Oregon	Washington	Alaska	British Columbia	California[2/]	Total
	Thousands of Pounds					
1948	13,066	7,473	3,673	n.a.	58	24,271
1949	8,728	5,948	3,777	n.a.	55	18,509
1950	7,953	5,717	2,824	n.a.	59	16,553
1951	8,041	6,913	3,610	3,360	58	21,983
1952	6,425	6,902	3,575	4,124	54	21,079
1953	5,654	6,379	3,701	4,260	62	20,057
1954	4,724	5,296	2,753	3,320	82	16,148
1955	7,670	6,226	2,608	3,248	93	19,845
1956	7,971	5,240	1,580	3,932	95	18,819
1957	5,455	5,101	2,155	3,872	47	16,630
1958	5,174	4,401	2,404	3,636	31	15,646
1959	3,401	3,386	2,560	3,460	62	12,869
1960	3,617	2,401	1,848	2,556	60	10,482
1961	3,669	3,060	1,009	2,384	81	10,203
1962	4,196	3,301	1,326	2,344	63	11,230
1963	4,037	3,179	1,736	2,732	68	11,753
1964[3/]	3,967	3,180	1,357	3,400	75	11,980

1/ Source: Bureau of Commercial Fisheries, U.S. Department of the Interior, and Department of Fisheries of Canada.

2/ Includes coho salmon, as catch was not reported separately. Data for Oregon, Washington, Alaska, and California are estimated by 1961-63 average.

3/ Alaska and British Columbia data are preliminary while Oregon and Washington data estimated by the 1961-63 average.