Department of Research
Fish Commission of the State of Oregon

Contribution No. 6

The Future of the Columbia River Salmon Fisheries

by

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(From Stanford Ichthyological Bulletin, Volume 2, Number 2, December, 1940.)

STATE PRINTING DEPARTMENT
SALEM, OREGON
1940

STANFORD ICHTHYOLOGICAL BULLETIN

Published by the

NATURAL HISTORY MUSEUM OF STANFORD UNIVERSITY

Inquiries in regard to exchange should be addressed to the Editor of the Bulletin, Natural History Museum, Stanford University, California, U.S.A. Copies of this issue may be purchased from the Director of the Museum, price 25 cents.

Volume 2 December 23, 1940 Number 2

THE FUTURE OF THE COLUMBIA RIVER SALMON FISHERIES[1]

By Willis H. Rich

The salmon runs of the Columbia River constitute one of the most important natural resources of the states of Oregon and Washington. Thousands of people are dependent, wholly or in part, upon these resources for their livelihood; and their welfare is dependent upon the maintenance of the salmon runs. It is to the special interest of these people that the salmon supply be maintained at the level of maximum productivity and, indirectly, it is to the interest of all the citizens of these states that this be done.

In recent years it has become increasingly evident that these resources, taken as a whole, are decreasing in productivity and it has been frequently pointed out that this decrease is due primarily to the operation of two factors—a very intensive fishery and a reduction in spawning and rearing areas due to the utilization of the water resources of the Columbia basin for other purposes. These influences, however, have affected the several species of salmon that are found in the Columbia River quite differently; the more valuable species, Chinooks and bluebacks, showing more evidence of depletion than do the other species, silver salmon, chums and steelhead.

This has been treated in more detail in another paper of this series (Contribution No. 3). Publication of this has been delayed, however, and some of the data contained therein are here presented in order that the present discussion may be complete. Table 1 (copied from Contribution No. 3) shows the changes that have taken place in the salmon catches on the Columbia River from the beginning of the commercial industry to 1938 insofar as these may be determined from the available data. The entries in the table are estimates of the average annual catch in thousands of pounds for each five-year period. No actual catch records were kept during most of the period covered but Craig (1938) and Craig and Hacker (1940) have given estimates of the annual catch in pounds based on the records of production of canned, salted and frozen salmon. Previous to 1889 there was no segregation of catch on the basis of species although several species were undoubtedly utilized. It has commonly been assumed that the entire catch during these earlier years was composed of Chinooks; but it seems somewhat more reasonable to adjust the estimates of catch on the assumption that the

[1]Contribution No. 6, Department of Research, Fish Commission of Oregon. Based on a paper read at the Symposium on Salmon Problems on the Pacific Coast of North America held by the American Society of Ichthyologists and Herpetologists at the meeting of the American Association for the Advancement of Science in Seattle, Washington, June 19, 1940.

TABLE 1

Average annual catch of Columbia River salmon for the period 1866 to 1938 by five-year intervals. In thousands of pounds. Data from Craig, 1938, and Pacific Fisherman Yearbooks for 1938 and 1939. Up to and including 1888 the poundage of Chinooks has been estimated on the basis of 80 per cent of the total poundage as estimated from the figures of total pack given in Pacific Fisherman Yearbooks. During these early years the pack was not segregated according to species.

Five-year period	Species				
Years	Chinooks	Bluebacks	Silvers	Chums	Steelhead
1866-1870	3,264	---	---	---	---
-1875	14,348	---	---	---	---
-1880	25,024	---	---	---	---
-1885	31,493	---	---	---	---
-1890	20,998	---	---	---	---
-1895	24,248	2,371	2,986†	844‡	3,662
-1900	23,257	1,819	3,330	988§	2,104
-1905	28,941*	784	1,374*	1,138*	604*
-1910	23,282	723	2,934	2,154	624
-1915	26,982	899	3,472	3,010	1,899
-1920	30,437	809	4,519	3,476	1,980
-1925	22,014	1,198	6,237	2,077	2,393
-1930	20,326	725	5,995	3,975	2,885
-1935	18,192	299	4,279	1,158	1,781
1936-1938	16,540	708	4,044	2,241	1,720

*Average of 4 years. No data for 1901.
†Average of 4 years. No data for 1891.
‡Figures for 1893 and 1895 only.
§Figures for 1899 and 1900 only.

percentage of other species caught during these early years was approximately the same as during the years immediately following the time when segregation of species was begun. During the decade of the nineties approximately 73 per cent of the total estimated catch was of Chinook salmon and during the decade 1901-1910 approximately 83 per cent. It seems, therefore, not unreasonable to assume that about 80 per cent of the catch in the years before 1890 were of this species and the figures given in table 1 are based on that assumption.

On the basis of the data contained in this table the following statements were made in the earlier paper (Contribution No. 3): "From this table it is apparent that the catch of Chinooks has consistently declined during the past twenty years and that, during this period, the average catch has been lower than for any other period except one (that ending with 1890) since the period ending with 1875. The catch of bluebacks has declined even more markedly but much of this apparently took place rather suddenly about 1900. The trend of the catch of silvers and chums was upward from 1890 to about 1920. Since then the catches of these species have fluctuated considerably and it is difficult to see any marked change. What change there is, however, appears to be in the direction of reduced catches. The catch of steelhead has remained fairly constant so far as the general trend is concerned. The most important species are the Chinook and bluebacks and it is apparent that these are the very ones that show, most clearly, a reduced abundance."

This paper also pointed out the fact that the weekly closed periods are

relatively ineffective insofar as they tend to increase the escapement of breeding fish to the spawning grounds; that their chief effect was to extend, slightly, the productive fishing areas.

The following quotation from Contribution No. 3 summarizes that report: "We come then finally to this general picture of the present state of the salmon resources of the Columbia River: So far as our data show, the steelhead, silvers and chums are nearly, if not quite, holding their own. The blueback runs were greatly reduced as long ago as 1900, since which time there has been no marked change in the size of the catch. This depletion of the blueback was probably due chiefly to the reduced spawning area available. The Chinook salmon catch has held up remarkably in spite of a fishery that is evidently being conducted with terrific and increasing intensity, but the record since 1920 is one of constantly decreasing catches. Reduction of breeding areas, which at present is accelerated, and an oceanic troll fishery that annually takes large numbers of both mature and immature fish contribute to the environmental pressure against the species. Regulation of the fishery within the river protects only the runs of April and early May and those of late August and early September. In the face of this evidence the conclusion seems inevitable that the abundance of the Columbia River Chinook salmon will continue its present rapid decrease unless the species is given more adequate protection either through regulation of the fisheries both in the ocean and in the river or through enlarged and improved programs of artificial propagation."

Since this statement was written I have been able to make two additions to our knowledge of this fishery that are of some importance to an understanding of the problems of their conservation.

In the first place I have made a more complete study of the salmon runs of 1938 that has included the figures for the catch of the fall season. This has shown conclusively that the closed season extending from August 25 to September 10 does not improve the escapement of Chinook salmon to the breeding areas nearly as much as was thought at the time the previous paper was written. The fishery above Bonneville during the first two weeks of the open season that begins on September 10 is carried on with such great intensity that it almost completely nullifies the beneficial effect of the closed season. The major effect of the closed season is, therefore, merely to extend the fishing area and not to increase materially the escapement of breeding fish from which the next generation must come. It was pointed out in the previous report that the weekly closed periods act in very much the same manner, although on a smaller scale. The total catch on the Columbia River during the fall season of 1938 was approximately 2,700,000 pounds of which over half (nearly 1,400,000 pounds) was taken above Bonneville.

In the paper read last year it was mentioned that, during the season of 1938, the ratio of catch to escapement of Chinook salmon "varied from approximately 3.5 to 1 during May to over 6 to 1 in June and July but fell in August to about 1.5 to 1." In the newer calculations (for various reasons that need not be considered here) the entire run that enters the river after the first of August has been treated as a unit. It is believed that this gives a truer picture of the total effect of the August-September closed season insofar as it may tend to increase escapement. On the basis of these calculations the ratio of catch to escapement during the period from August 1 to the end of the year is nearly 2 to 1—considerably higher than the ratio of 1.5 to 1 previously given for August alone. This is the result of including the fall catch of which such a large part was taken above Bonneville. While this ratio of catch to escapement is not

as large as the ratios for the first three months of the season it is still dangerously high and raises a serious doubt as to the adequacy of the escapement.

The second addition which I make here to our knowledge of the Columbia River salmon fisheries has to do again with the Chinook salmon—the species that is by far the most important. I have recently had occasion to study the salmon fisheries of California and for certain phases of that study it was desirable to determine, if possible, the origin of the Chinook, or Quinnat, salmon that are taken in large numbers off the coast of that state. Clark (1940) has given detailed catch records for the California salmon fishery. In round numbers some four million pounds of salmon are taken annually in the commercial troll fishery in the ocean and about a million pounds are taken in the commercial net fishery conducted in the Sacramento-San Joaquin River system. It has generally been assumed that a large part of the Quinnat salmon taken in the ocean is derived from the runs breeding in California rivers and it was stated in our earlier report, referring to the troll fishery south of the Columbia River, that "it is not known how extensively, if at all, this draws upon the Columbia runs." On the evidence of work done during the past year it now appears probable that this ocean fishery off the coast of California draws very extensively upon the runs of Chinooks to the Columbia River—so extensively that Columbia River fish form a dominant element in the catch.

The evidence upon which I base this conclusion is primarily statistical and has involved a detailed analysis, making use of rather intricate methods. A full account of this analysis will be presented elsewhere and it must suffice here to give only a brief résumé of the final results.

The statistical study has followed the conventional lines of correlation analysis. An effort has been made to determine the degree of association between the ocean catch off the coast of California as the dependent variable, and the catches in the Sacramento and the Columbia Rivers as the independent variables. The available data are for the years 1916 to 1938 inclusive. Several lines of investigation were tried and all gave similar results.

The first, and in some ways the simplest, method was to study the similarity in deviations from the respective trends. The catches in all three of these localities show trends when plotted against time and these lines of trend have been calculated by using appropriate methods. The deviations of the actual catches from these trends were then obtained for each year and the association between the deviations measured by the Pearsonian coefficient of correlation, r.

The coefficient of correlation between deviations from the trends of the catch along the coast of California and that on the Columbia River is +.67 while the corresponding coefficient between the catch off the coast and that in the Sacramento River is only +.33. The first is highly significant; as great a value would occur by chance less than twice in a thousand times if there were no real positive correlation. On the other hand a coefficient of correlation as large as .33 might be expected to occur about once in eight times if there were no true correlation. Such a low value is commonly considered to be without statistical significance because it might so readily occur purely as a result of chance.

In addition to this study of the association between deviations from the trends a multiple correlation analysis was made using the original catch figures —not the deviations from the trends. In such an analysis the most significant values to the present study are the so-called beta coefficients or "standard partial regression coefficients." These measure the relative importance of the independent variables in making the best estimate of the dependent variable. The

beta coefficient that relates the catch off the coast of California to the catch on the Columbia River is +.86 while that relating the ocean catch to that made in the Sacramento-San Joaquin River system is only +.35. So far as these data show, therefore, it appears that a knowledge of the catch on the Columbia would be about two and a half times as effective in estimating the catch off the coast of California as would be a similar knowledge of the catch on the Sacramento River.

Various other measures of association have been developed in the course of this correlation analysis but all are in general agreement with the results here given. The conclusion seems fairly warranted that the majority of the salmon taken in the ocean fishery off the coast of California are Columbia River Chinooks that are maturing and would have entered the Columbia River later in the same year in which they were caught. So far as I know this is the first evidence that has been adduced to show that the Columbia River fish enter largely into the ocean fishery south of the mouth of the river.

There is available one bit of corroboratory evidence for this conclusion. McGregor (1923) has shown the existence of certain anatomical differences between the Quinnat salmon taken in the ocean in the region of Fort Bragg, California, as compared with those taken in the Sacramento and Klamath Rivers. Among these differences is the average number of eggs in the ovaries of the females. Data are available on the number of eggs of the Columbia River Chinooks so that a comparison of this character can be made. Unfortunately no data from Columbia River Chinooks is at hand bearing on the other characters recorded by McGregor. As for egg counts, however, McGregor gives the following:

Klamath River: 1,718 to 4,977; mean 3,760
Sacramento River: 4,795 to 11,012; mean 7,453
Fort Bragg: 3,147 to 9,021; mean 4,910

As compared with these we have the following figures on the number of eggs of Columbia River Chinooks. The Washington Department of Fisheries (1938) gives an average, based on 11 females taken at Rock Island in eastern Washington, of 4,885 eggs per female and an average of 6,670 from 5 females taken from the Kalama River, Washington. The Department states, however, that "The hatchery division of the State Department of Fisheries use an average of 5,600 eggs per chinook female at two hatcheries on the lower Columbia River (Wind River and Kalama River). Actual counts at these localities are, however, not available except for the fish listed above...." Mr. Hugh C. Mitchell, Director of the Department of Fish Culture of the Fish Commission of Oregon, has provided figures of the average number of eggs per female as recorded at four hatcheries on the Willamette River and its tributaries. These are as follows: Upper Willamette River (Middle Fork), 5,084; McKenzie River, 4,928; North Santiam River, 5,200 and South Santiam River, 4,000. The mean of these Oregon figures is 4,800.

The Oregon figures and the actual counts of fish at Rock Island are in substantial agreement and both are very close to the figure given by McGregor for the fish taken in the ocean in the region of Fort Bragg. The figure of 5,600 used in the hatcheries of the State of Washington is somewhat larger but, everything considered, is not widely divergent. It is quite apparent that the number of eggs per female taken in the ocean near Fort Bragg agrees far better with the number of eggs per female in the Columbia River than with the egg counts in either the Sacramento or the Klamath Rivers. These data support the conclusion reached from the statistical analysis; namely, that a large part of the Chinook salmon taken off the coast of California are derived from the Columbia River

runs. It is true that a proper combination of Klamath River and Sacramento River fish would give a similar mean but it seems rather unlikely that this would occur. Furthermore, the distribution of egg counts given by McGregor for the Fort Bragg salmon does not appear to be a simple combination of the distributions given for the egg counts of Klamath and Sacramento fish. McGregor recognized the possibility that "there may be represented in the Fort Bragg series salmon from streams other than the Sacramento and Klamath Rivers."

It is of interest to estimate the total drain on the Columbia River Chinook salmon runs from this source. The making of such an estimate is complicated by the fact that silver salmon enter into the total catches as recorded by Clark. He estimates that 10 per cent of the salmon caught south of Point Arena and "between 20 and 30 per cent" of those taken north of Point Arena are silver salmon. His figures for the nine years, 1931 to 1939 inclusive, are given so that the total catches in these two regions can be determined. The averages for the nine years are 845,000 pounds for the region south of Point Arena and 2,850,000 pounds for the northern region. Using Clark's estimates of the percentages of Chinooks in the two regions (taking 25 per cent for the northern region) the total average annual catch of Chinook salmon during the nine years is approximately 3,000,000 pounds. These fish average not over 15 pounds in weight which means a catch of not less than 200,000 fish. It seems quite safe to infer from the correlation analysis that well over half of these are from the Columbia River and it follows that probably over 100,000 Columbia River Chinooks are caught annually off the California coast—a number that would materially affect the abundance of these fish in the Columbia River itself.

With these data, combined with those given in the earlier paper (Contribution No. 3), it seems possible to make a first approximation to the total number of Columbia River Chinooks taken in the troll fishery along the entire coast. Translating the poundage figures to numbers of fish on the basis of 15 pounds per fish we reach the following estimates:

Alaska	13,000
British Columbia	13,000
Washington	100,000
Oregon	50,000
California	100,000
Total	276,000

These figures are presented for whatever they may be worth, with full realization of their incompleteness and of the fact that they are based upon a number of assumptions. It is believed to be a conservative estimate, however, and one that may have some practical value. The total number of Chinook salmon taken in the commercial fishery on the Columbia River has been estimated at between five and six hundred thousand fish for each of the last two seasons, so that, even with a liberal allowance for the inaccuracies of this estimate of the number of fish taken in the troll fishery, it is quite apparent that this is a major element in the drain upon the salmon resources of the Columbia River.

It seems clear that we have here additional evidence, from two independent sources, of the intensity of the fishery for Chinook salmon both in the ocean and in the river. The other major factor tending to deplete this and the other species as well is, of course, the reduction in extent and fitness of the breeding areas through the increased utilization of the water resources for other purposes. Nothing more need be said on this subject here; but it should be

constantly borne in mind that this reduction of suitable breeding areas is going on at an accelerated rate and that all signs point to a continuation of this development. Unfortunately the direct effect of this factor alone upon the abundance of any one species cannot be measured as it cannot be separated from the coincident effect of the intensive fishery.

The dominant features of the present picture are these: First, we have a fishery involving five species of which two, the bluebacks and the Chinooks, show constantly reduced catches over a period of some 20 years; second, the fishery is one of such great intensity that the escapement of breeding fish, at least of these two species, is dangerously low; third, there is a constant reduction in the extent and fitness of the breeding areas which in all probability will continue.

What may be said of the probable future?

The answer, as does any other prophecy made on a scientific basis, partakes of the nature of extrapolation. A trend is observed and related to as many of the determining factors as possible. Then, assuming that these determining factors will remain constant, or, at least, that they will continue to change as observed in the past, the trend in which we are primarily interested may be extrapolated. This extrapolation constitutes our prophecy, and, as with all extrapolations, it is an uncertain procedure which, at best, cannot be expected to hold except insofar as the past conditions may continue into the future. If there are any material changes in the various independent variables on which the calculated trend of the dependent variable is estimated our prophecy is immediately invalidated. With this reservation and granting that the yield of the fishery is determined predominantly by the complex effect of the intensity of the fishery itself and the extent to which the breeding areas are reduced we may examine particularly the trends of the yield of the two species that most clearly show depletion—the bluebacks and the Chinooks.

It has already been remarked that the blueback run was depleted as early as 1900, probably in large part through reduction of the breeding areas, and that since then the yield has been fairly constant. Many of the original races (or stocks) of this species have been completely exterminated due to the cutting off or destroying the effectiveness of their breeding grounds by dams and diversions of one sort or another. These are gone forever although there is a possibility that new runs might be introduced and established provided suitable conditions can be restored. But even the maintenance of the present small remnant of the original blueback runs is questionable. The requirement of lakes in which to spawn and in which the young live for at least a year before making the migration to the sea exposes this species particularly to the effects of the development of water resources since natural lakes are so often converted into reservoirs. Without doubt the continuing development of water resources for other purposes will still further reduce the supply of this species unless careful provision is made to maintain suitable conditions for bluebacks in the lakes and streams affected. This is probably the chief present danger to this species because the yield is already so low that there is little danger that the intensity of the fishery will be increased. There has been little change in yield for several decades and probably little change in intensity of fishing although this cannot be stated positively because there has been a considerable change in the method of the fishery.

The only hope of restoring these lost runs of bluebacks is through (1) making the lakes that form their breeding areas again available by construction of proper ladders and screens; (2) restoring the biological productiveness of

these lakes and (3) stocking these lakes with young fish. The fish used for such stocking must be of races adapted to survive under the particular conditions presented by the lake in question, the planting must be done on a large scale and continued over a period of at least one full cycle for the race that is being introduced. Only through some such a program can the now barren lakes be restored to productiveness in respect of blueback salmon. This is probably a forlorn hope but it is one that should not be entirely forgotten.

It is to be noted in this connection that the biological productiveness of the lakes into which the several races of Columbia River bluebacks originally spawned has been seriously affected by developments that have transformed natural lakes into fluctuating reservoirs and there is good reason to think that the productiveness of such bodies of water is in inverse ratio to the amount of fluctuation. It is certainly true that widely fluctuating reservoirs are far less productive than are natural lakes.

The future of the blueback run therefore seems to be something like this: There will be no material reduction in yield except as may result from further reduction of the breeding areas. With the present tendency toward development of water resources for agriculture and power and particularly the extensive transformation of lakes into reservoirs it seems inevitable that such reduction in breeding areas will take place. These effects may be minimized by providing proper fish-ladders and screens but it is unlikely that they can be entirely eliminated. There is, on the other hand, a possibility of restoring lost runs to lakes now barren and thus to increase the yield. The difficulties and cost of doing this will probably prevent it but it remains a possibility worthy of consideration and experiment.

The situation in respect of the Chinook salmon is less clear. This species has not been so reduced from the original abundance as has the blueback, partly because it does not depend upon lakes for breeding. It must be remembered also that the apparent reduction in yield of the Chinook salmon fishery of the Columbia River is exaggerated when based only upon the catch within the river. The troll fishery off the coast was developed chiefly between the years 1915 and 1920 and I have just shown that a considerable portion of the total ocean catch of Chinooks is properly to be credited to the Columbia River run. However, unless the percentage of Columbia River fish in the ocean catch is considerably greater than I have estimated it still remains probable that the total yield has decreased. This follows from the fact that the yield within the river has steadily declined since about 1920 while the yield of the ocean fishery has not increased. In the case of the California troll fishery, in fact, the general trend has been downward since 1920 also.

It is, of course, conceivable that this reduction in yield inside the river is due to a reduction in the intensity of fishing; but there is no evidence that such is the case and it has been shown (Calkins, Durand and Rich, 1939) that the river fishery is so intense for at least part of the season that an increase in the number of fish entering the river means only an increased catch and no increase in the number of fish escaping the fishery and passing on to the spawning grounds. It seems safe to assume that the reduction in yield is due chiefly, if not exclusively, to reduction in abundance.

Although we can be sure that the abundance has been materially reduced, it is impossible to say just what part of this reduction can be laid to the effect of the intense fishery in reducing the spawning population and what part is due to reduced breeding area. Without doubt both of these major influences have been operating. Some of the loss in breeding area is undoubtedly made up

by the extensive program of artificial propagation of this species in which the federal government and the states of Oregon and Washington all participate; but it is unlikely that artificial propagation replaces more than a relatively small fraction of the breeding areas that have been lost. The habits of this species are, fortunately, such that its breeding areas are somewhat less likely to be affected by the development of water resources than are those of the bluebacks. The Chinooks spawn in relatively large tributaries, usually below lakes, and the young tend to pass out to sea at an earlier age than the young bluebacks. On the whole it would seem to be a far easier task to provide adequate protection to the breeding areas of the Chinook salmon than to those of the bluebacks under the conditions brought about by the use of the water resources for other purposes. That is not to say, however, that there has been no serious loss in breeding areas of Chinook salmon from this influence—there unquestionably has been and it is of the greatest importance to restore more favorable conditions and to prevent, so far as possible, the further reduction in effective breeding areas. There has come to be, within the past few years, a definite and well directed movement toward improvements of this kind. It is to be hoped that this movement is strong enough so that the total effect will be to maintain the spawning areas at their present efficiency and, perhaps, to effect an increase in total productive capacity.

It seems probable, however, that the more potent of the two major influences that act to reduce abundance of Chinooks is the fishery itself. It has been shown (Calkins, Durand and Rich, 1939) that the fishery during June and July is so intense that less than 20 per cent of the Chinook salmon entering the Columbia River escape to the spawning grounds and this involves no consideration of the fish taken in the ocean. The escapement of both the earlier and the later fish is somewhat better but is still dangerously low. The capacity of these fish to withstand such an extensive reduction of the breeding population is certainly remarkable but it does have its limitations. The continued effect of such over-fishing will undoubtedly be to still further reduce the abundance of these fish to a point where the total fishing effort will be curtailed on account of diminished returns to the fishermen. There will be the usual interaction between abundance and return to the fishermen to the end that the total catch, in both ocean and river, will be stabilized at a level more or less below the present yield and undoubtedly far below the yield that the resource could provide if properly managed, even under the present conditions of reduced breeding areas. It seems very unlikely that there will be any material reduction in the intensity of fishing in the near future and altogether probable that the fishery will run its course toward senility along somewhat these lines.

The situation in respect of the other three species, silver salmon, chums and steelhead, is, in my opinion, less critical. Only the silver salmon is taken in large numbers in the ocean fishery and there is some reason to think that these fish do not range as widely in the ocean as do the Chinooks and so are not subjected to as much drain from this cause. Neither the silver salmon nor the chums spawn in large numbers in the upper tributaries where most of the developments have taken place that reduce the breeding areas and both the silvers and the chums enter the river chiefly in the fall when the fishing intensity is normally greatly reduced in the lower part of the river. The steelheads are probably in greater danger than any other of these three because their spawning areas are widespread over the basin and an important part of the steelhead run occurs at the height of fishing intensity. They are protected to some extent, however, by the fact that they are smaller than the Chinooks which

form a much more important element in the fishery. The mesh of the gill nets is adapted particularly to take Chinooks and therefore permits the escapement of a larger proportion of the steelhead.

The future outlook for the salmon fishery of the Columbia River is not bright, but neither is it hopeless. The situation calls for energetic measures if further depletion is to be prevented to say nothing of attaining some measure of restoration. Much additional information will be needed if our efforts to maintain and improve the runs are to be efficient. It will be necessary to restrict the commercial fishery to reduced catches, to improve conditions on the breeding grounds and to be eternally watchful that in the further development of water resources due consideration is given *from the beginning* to the needs of salmon conservation. The effects of whatever measures are adopted must be continually studied in order that their efficiency may be accurately determined, that good methods may be improved and poor ones discarded. This will mean on the part of all elements in the salmon industry the sacrifice of immediate gain for the benefit of the future. It will even mean sacrifice on the part of some of the agencies whose duty it will be to impose restrictions and which depend upon taxation of the catch for their income. Such sacrifices require courage as well as foresight and will bring a certain amount of hardship: But, if the courage is lacking now to take the steps necessary to sensible conservation, we shall have the losses and the hardships eventually anyway; with the difference that, if action is delayed, depletion will have progressed further and rehabilitation made just so much more difficult. This will mean also unselfish cooperation on the part of all agencies directly concerned with the development and prosecution of a conservation program: They must be able to present a strong and united front to the opposing forces, and they must act promptly. A few more years of inaction, of failure to attack the fundamental phases of these problems, and the runs may well have been reduced to a state of commercial extinction from which, if recovery is possible at all, it can be accomplished only after a long time and at great expense.

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LIST OF CONTRIBUTIONS

from the

DEPARTMENT OF RESEARCH

of the

FISH COMMISSION OF THE STATE OF OREGON

(These are offered in exchange for similar publications dealing with fishery research.)

1. Local populations and migration in relation to the conservation of Pacific salmon in the western states and Alaska. By Willis H. Rich. (Reprinted from "The Migration and Conservation of Salmon", Publication No. 8 of the American Association for the Advancement of Science. 1939.)

2. Symposium on "Dams and the Problem of Migratory Fishes" including the following papers:

   a. Fishery problems raised by the development of water resources. By Willis H. Rich, Fish Commission of Oregon.

   b. The passage of fish at Bonneville Dam. By Harlan B. Holmes, U. S. Bureau of Fisheries.

   c. Fish problems connected with Grand Coulee Dam. By Wilbert M. Chapman, Washington Department of Fisheries.

   d. Preliminary report on an investigation to determine possible methods of salvaging the Sacramento River salmon and steelhead trout at Shasta Dam. By Harry A. Hanson, U. S. Bureau of Reclamation.

   e. A summary of the present status of dams versus migratory fishes on the Pacific coast with especial reference to problems in California. By Alan C. Taft, California Division of Fish and Game.

   (Special number of the Stanford Ichthyological Bulletin. 1940. Published in cooperation with the Fish Commission of Oregon.)

3. The present state of the Columbia River salmon resources. By Willis H. Rich. (Proceedings of the Sixth Pacific Science Congress. In press.)

4. Note on the young of the Sable Fish (*Anoplopoma fimbria*). By Vernon Brock. (Copeia. In press.)

5. Seasonal variations in weight of Columbia River Chinook salmon. By Willis H. Rich. (Reprinted from Copeia, 1940, No. 1.)

6. The future of the Columbia River salmon fisheries. By Willis H. Rich. (Stanford Ichthyological Bulletin, Vol. 2, No. 2. 1940.)