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GAME FISH POPULATIONS OF THE COWICHAN RIVER

BY

FERRIS NEAVE

Pacific Biological Station

Nanaimo, B. C.

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INTRODUCTION

The Cowichan river has long been recognized as one of the most important watercourses of Vancouver island from the standpoint of fish production and fish exploitation. It owes this position not only to its relatively large size and considerable stocks of salmon and trout, but also to its ready accessibility from such centres of population as Victoria, Duncan and Nanaimo.

In spite of extensive fish-cultural operations carried out by the Department of Fisheries between 1910 and 1933 (summarized below), local anglers and those interested in attracting tourists to the district were of the opinion that fishing declined during this period. As a result of representations by the Cowichan Fish and Game Association and the Duncan Chamber of Commerce, the Fisheries Research Board made a preliminary examination of the Cowichan river system in 1934. A more intensive investigation was begun in 1937.

The objectives of this investigation were to assess the existing condition of the game fish populations and to determine the type of management policy which might lead to an improvement of the situation. Information was desired not only on the status of the native salmon and trout but also on the results of the many attempts which had been made to establish exotic fish in this river system.

The following species of salmonid fishes are indigenous:

Spring salmon (*Oncorhynchus tshawytscha* (Walbaum))
Coho salmon (*O. kisutch* (Walbaum))
Pink salmon (*O. gorbuscha* (Walbaum))
Chum salmon (*O. keta* (Walbaum))
Sockeye salmon (*O. nerka* (Walbaum))
Cutthroat trout (*Salmo clarkii* Richardson)
Steelhead trout (*Salmo gairdnerii* Richardson)
Dolly Varden (*Salvelinus malma* (Walbaum))

In addition, the following kinds have been introduced, as noted elsewhere in this account:

Atlantic salmon (*Salmo salar* L.)
Kamloops trout (*Salmo gairdnerii kamloops* Jordan)
Brown trout (*Salmo trutta* L.)
Speckled char (*Salvelinus fontinalis* (Mitchill))
Lake trout (*Cristivomer namaycush* (Walbaum))

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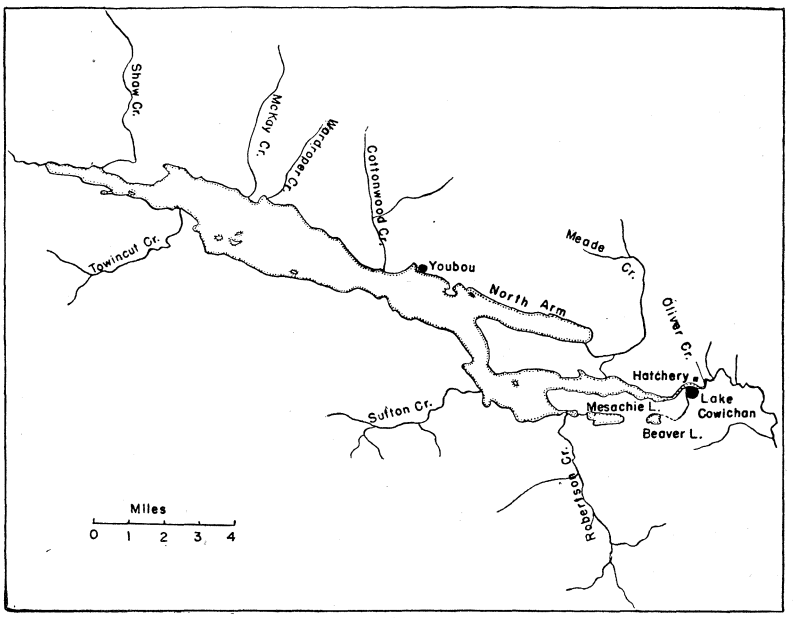

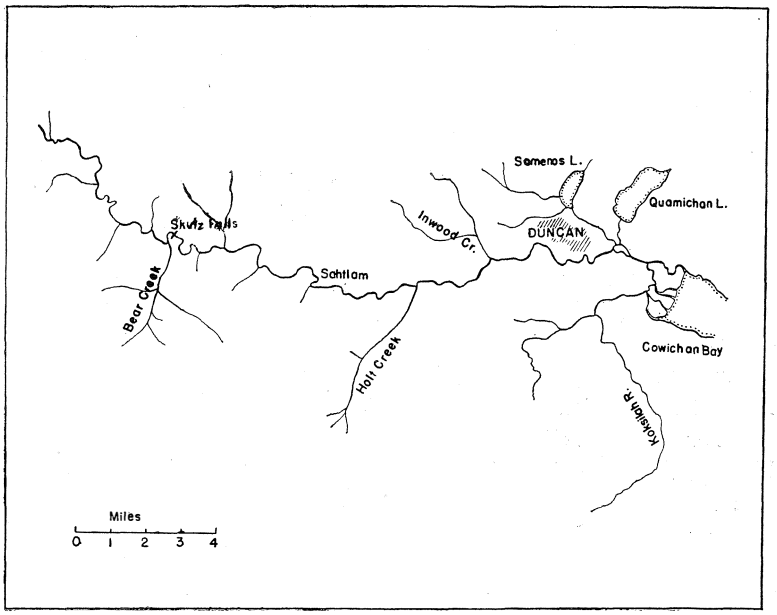

FIGURE 1. Cowichan lake and river system.

A hatchery was constructed on the river by the Dominion Department of Fisheries in 1910. Between that year and 1933 this establishment distributed nearly seventy million eggs and young fish, divided approximately as follows:

Derived from Cowichan river system	Millions
Spring salmon	19
Coho salmon	34
Cutthroat trout	2
Steelhead trout	2.5
Derived from elsewhere	
Cutthroat trout	2
Atlantic salmon	5.5
Kamloops trout	1.5
Brown trout	0.25
Speckled char	1
Lake trout	0.15

These eggs and fish were not all planted in the Cowichan river system, certain distributions in nearly all of the above-mentioned categories having been made in other waters. It appears, however, that these were more than counterbalanced by importations from elsewhere.

It is evident that the greater part of the hatchery effort was expended on the artificial propagation of native salmon and trout, in the belief that stocks could be more effectively maintained in this way than by natural reproduction. Efforts were also made to supplement the existing supply of rainbow-type fish by introducing Kamloops trout from the interior of British Columbia. The importation of Atlantic salmon and speckled char represented attempts to increase the variety and attractiveness of the fishing and to meet the wishes of anglers who were familiar with these species in other regions. Similar considerations led at a later date to the introduction of the brown trout. In the latter case, however, it was also hoped that the fish would remain in the river and provide angling at a season when most of the legal-sized native trout have migrated to sea or lake.

PHYSICAL CONDITIONS

The watershed of the Cowichan river occupies some 325 square miles and the system comprises about 28 miles of main river, flowing into the sea, a lake having an area of 24 square miles, five smaller lakes and numerous tributary streams of varying size entering these waters (fig. 1).

More than 90% of the drainage area (that is, all except a tract of low-lying country between Duncan and the sea) is hilly or mountainous, reaching elevations of over 4,000 feet at several points near Cowichan lake.

The Run-off

The annual precipitation has averaged 71.91 inches over a 33-year period at Cowichan lake (elevation 500 feet). This, of course, does not necessarily represent the average for the whole watershed. Some of this precipitation is in the form of snow. The Cowichan river system, however, is not fed by glaciers or permanent snowfields. The run-off is usually heavy during the winter months and becomes very light during the latter part of the summer. A sudden increase takes place with the onset of the autumn rains, usually about the middle of October. During the period of low water many tributaries dry up entirely or in part and the volume of the river becomes greatly reduced. These characteristics of the run-off determine to a large extent the nature and habits of the populations of fish.

A gauging station was maintained on the river near the outlet of Cowichan lake from 1913 to 1919. The re-establishment of this station has provided data regarding the river discharge since 1940 and has also permitted records of river and lake levels obtained during several years prior to that date to be converted into approximate terms of river flow.

Maximum discharge has occasionally reached 10,000 cubic feet per second. A low of 15 c.f.s. has been recorded. Mean flow for the high-water period of

Table I.—Discharge in second-feet of the Cowichan river.
(Year ending September 30)

	Whole year (mean)	December to February (mean)	July to September (mean)	Year's minimum
1913	——	——	540	230
1914	1980	3743	247	50
1915	1635	1960	140	32
1916	1860	2657	567	88
1917	1160	1510	393	175
1918	1770	4027	194	92
1919	1730	3110	361	90
Average	1689	2835	349	108
1940	——	——	117	76
1941	1330	2760	228	102
1942	1120	2440	209	50
1943	1190	1883	168	62
1944	819	1860	80	15
1945	1470	2620	183	82
1946	1650	2890	308	122
Average	1280	2409	196	73

December, January and February varies in different seasons from 1,500 c.f.s. to 4,000 c.f.s. The mean for the low-water period of July, August and September has varied from 80 c.f.s. to 567 c.f.s.

Since a decline in fishing is alleged to have taken place during the last twenty or twenty-five years (that is, following the earlier period of recorded discharges) and since, moreover, much of the watershed has been logged, and in part burned over, during the same time interval, a comparison between present and former water conditions is of interest.

Certain discharge figures for the two indicated periods are presented in table I. From these it appears that the average stream flow has been considerably less in recent years, particularly during the low water season, July to September, when it has averaged less than 60% of the 1913-1919 discharge. Precipitation records are available for Cowichan lake from 1915 onward. The absence of earlier records and the questionable applicability of data from a single station to a large watershed, prevents detailed comparisons. Available figures do not suggest that differences in rainfall would account for the discrepancies in stream flow between the earlier and later periods. Deforestation can therefore be suspected of having contributed to changes in the run-off. In any case, the fact remains that the average summer flow has been smaller during the later period and this difference might well produce a change in the abundance of fish and/or their availability to anglers.

Temperatures

The mean temperature of the river, based on readings taken twice a day over a period of about ten years at the gauging station, ranges from about 43°F. (6°C.) in February to 70°F. (21°C.) in August. Temperature conditions in general are much the same throughout the length of the river. Temperatures up to 77°F. (25°C.) have been recorded on certain days and minimal temperatures lower than the figures given also occur.

The surface waters of the lake show a very similar thermal condition to the river, shallow inshore areas becoming very warm in summer. A well-defined thermocline (that is, a zone in which the temperature falls rapidly with increasing depth) exists in summer at a level between 40 feet (12 metres) and 66 feet (20 metres) from the surface.

FOOD SUPPLIES

From studies of bottom fauna at representative stations in the Cowichan river and of the stomach contents of cutthroat, rainbow and brown trout, the general conclusion seems warranted that the bottom fauna is only moderately good from a quantitative standpoint. The types of bottom which predominate in the river have yielded an average of 1.42 grams (wet weight) of organisms per square foot. In view of the nature of the bottom, however, and the scarcity of pools serving as catchment areas, availability of these food supplies may be rather low.

The bottom fauna of such a river as the Cowichan cannot be regarded as a reliable indication of the total food supply, since it leaves out of account the large number of eggs and newly hatched fish which are contributed annually by anadromous fishes and which do not represent a conversion of local resources. In any case, comparisons with other waters may be misleading. It is quite likely that more food is required by fish living at the comparatively mild temperatures prevalent in the Cowichan river than by those which inhabit colder streams.

A series of bottom samples from Cowichan lake shows that the fauna is quantitatively poor, the productivity in this respect being probably of the same order as Okanagan lake. Moreover, the few relatively productive areas are mainly shallow bays with summer temperatures above the optimum. In general, the lake is very deep (maximal depth about 500 feet), the bottom sloping steeply from the shore, and hence providing a relatively small area of feeding grounds at intermediate depths.

SPRING SALMON

Fisheries

Spring salmon proceeding from the ocean to the spawning grounds of the Cowichan river are exposed to three different fisheries, namely: (1) the commercial fishery, operating off the west coast of Vancouver island and in the straits between Vancouver island and the mainland, (2) the sport fishery, which exploits the final stages of the salt-water journey, especially in Cowichan bay, and (3) the Indian fishery, which takes a toll just after the migrating fish have entered the river.

The numerical contribution which is made by Cowichan river fish to the commercial catch cannot be estimated at the present time. From a total of nearly 450,000 fingerlings marked and released in the Cowichan river between 1938 and 1944 only some 65 fish have been recovered to date from commercial fishing operations. These returns probably give an entirely inadequate picture of the incidence of Cowichan fish in the commercial catch. They do show, however, that Cowichan fish are caught during their fourth year of life (and to a less extent during their third and fifth years) along the west coast of Vancouver island from Kyuquot to the strait of Juan de Fuca and in the northern part of the strait of Georgia.

Sport fishing in Cowichan bay, which may be said to begin early in July, reaches its height in August and September, when maturing fish concentrate in this area prior to migrating up the river. Records of landings which have been kept since 1939 indicate that a minimum of 1,000 to 2,000 spring salmon are caught each year between August 1 and October 31 in this area.

The following figures indicate the average fishing effort expended for each spring salmon landed during the period from mid-August to mid-September. This period can be said to cover the peak of the spring salmon fishing at Cowichan Bay.

Year	1939	1940	1941	1942	1943	1944	1945
Line-hours per fish	9.9	5.8	8.1	12.4	12.1	12.4	16.1

The Indian fishery is conducted on the lower reaches of the river, the salmon being speared as they travel over shallows on their way upstream. This fishery is carefully controlled by the Department of Fisheries. Rough estimates by officers of the Department indicate that the number of spring salmon taken annually in this way has varied from about 200 to 2,000 in recent years. The Indian catch can therefore be regarded as being about equal to, or somewhat less than, the catch made by sport fishermen in the Cowichan bay area.

Age and Weight

The spring salmon landed by the game fishery at Cowichan bay can be grouped readily into two categories, namely (a) small "jacks" and (b) larger fish. The former, so far as is known, are all males in their second year of life. The individual weight of these fish is usually between 2 lb. and 5 lb. "Jacks" form a considerable but very variable proportion of the total number of fish caught. Records for the past eight years show the following percentages of jacks in the catches made by sportsmen: 1939, −58%; 1940, −21%; 1941, −25%; 1942, −62%; 1943, −48%; 1944, −29%; 1945, −17%; 1946, −57%. There is no evidence that the sport fishery selects a higher percentage of jacks than is actually present in the run. In 1939 a very similar proportion (64%) was found by observation of migrating spring salmon at Skutz falls, about 20 miles up the Cowichan river.

The category of the "larger fish" consists of individuals in their third, fourth and fifth years of life. Both sexes are represented in each of these age-groups. The proportions of these age groups, as determined from scale samples in 1939 and 1940 (combined) were: Third year, −33.2%; fourth year, −61.6%; fifth year, −5.2%. The average weight of all "larger" fish is about 17½ lb.

Escapement

A few fish, particularly jacks, move up the river while the latter is still at its low summer level. The main run coincides with the first large increase in river volume, which usually takes place quite suddenly about the middle of October. Since it has not been feasible to establish a counting fence near the mouth of the river, the size of the annual escapement cannot be stated precisely. In 1939 (a moderately good year) a minimum of 12,000 spring salmon was estimated to have passed Skutz falls. A greater number probably failed to ascend the river to this point. It seems reasonable to assume that in many years the escapement to the whole river system exceeds 20,000 fish. It is evident, therefore, that the sport fishery catch is not heavy in comparison with the escapement.

Spawning and Early Life History

Spawning takes place mainly between the beginning of November and the middle of December, at points throughout the length of the Cowichan river. Fish also enter Robertson creek which drains into Cowichan lake *via* Bear lake, but very few ascend the smaller tributaries.

Most of the young fish go to sea within a few months of the time of hatching. Examination of the scales of returning fish indicates that not more than 10% of these had spent their first year in fresh water.

In addition to the fall-running fish a few spring salmon ascend the river in winter and spring and are believed to remain in or near Cowichan lake through the summer. Trustworthy accounts agree that these early-running salmon were formerly fairly numerous and provided angling of a distinctive type. At the present time they are undoubtedly very scarce, only three or four unquestionable records of such fish having been obtained within the last few years. These individuals were caught, or found dead, in the river and lake between January and May.

Remarks

It seems likely that the disappearance of this early run is associated with the raising of summer temperatures which can be presumed to have occurred in the river in recent years as a result of diminished river flow and reduced forest cover. In the Columbia river system it has been noted (Fish, U.S. Fish and Wildlife Service, Special Scientific Rept. No. 27, 1944) that temperatures above 60°F. result in high mortality among ripening spring salmon held in ponds. The losses are probably not due to the direct effect of high temperatures, but to the favourable conditions created for bacterial and fungal infections. Cowichan river temperatures in recent years have usually exceeded 60° from early in June until early or middle October. The August mean is about 68° and the September mean about 64°. While the salmon could avoid high temperatures by remaining in the deeper parts of Cowichan lake, it is probable that unfavourably warm conditions usually prevail on all suitable spawning grounds during the period when these early running spring salmon reach a ripe condition.

The re-establishment of this run would not seem to be feasible under the prevailing conditions of summer flow. If these conditions became sufficiently changed, by a climatic cycle, by reforestation or by artificial control of the water system, consideration should be given to the possibility of re-establishing an early run of spring salmon by means of hatchery methods.

COHO SALMON

Fisheries

This species, like the spring salmon, is subjected to commercial, sport and Indian fisheries.

A large but undetermined number of Cowichan river cohos are caught by commercial fishermen in areas more or less remote from the parent stream. Fish marked as fingerlings at the Cowichan lake Hatchery have been reported from points throughout the length of the strait of Georgia, the whole of the west coast of Vancouver island and even in isolated instances from the Queen Charlotte islands, Hecate strait and Fitzhugh sound. The evidence indicates that while some Cowichan fish never go outside the strait of Georgia during their marine life, a considerable number travel around the south end of Vancouver island and find feeding grounds at various distances to the north and west.

Maturing cohos appear in numbers in Cowichan bay in the second half of September. They provide a celebrated game fishery during the weeks which precede their entry into the river. Records of landings by sportsmen at Cowichan bay during the main coho fishing season give totals varying from 1,900 to 4,300, with an average of 3,340, for the eight seasons beginning with 1939. These are minimal figures. The average number of line-hours required to catch an adult coho is shown in table II. This has been calculated for the period of September 22 to October 31 (or strictly speaking, the nearest week-ends to these dates) this being the season when the best catches are usually made.

In addition to the fish discussed above, a considerable number of young cohos (usually termed "grilse") are taken by sport fishermen in and near Cowichan bay. These are not included in the foregoing figures since (unlike the jack-springs) most of these small fish do not form a part of the spawning migration. The majority are immature, second-year fish which have left fresh water a few weeks or months previously and which are tending to move away from rather than towards the river mouth. The number of grilse reported in a season has varied from about 200 to over 1,100 but these figures may be much too low since it has not proved feasible to make continuous observations during the relatively long period when these fish are being taken.

After entering the river, cohos are taken by Indian fishermen at the same places and in the same manner as spring salmon. As in the case of that species, the numbers taken are probably roughly equivalent to the anglers' catch.

Age and Weight

Observations made at Skutz falls and on the spawning populations of Oliver and Beadnell creeks show that jacks (that is, mature second year fish) represent a much smaller proportion of the run than in the case of spring salmon. In the creeks mentioned, these small males have constituted from 1% to 13% of the adult migrants.

The remainder of the run consists entirely or almost entirely of third-year fish. The average individual weight of these, as determined from the Cowichan bay fishery, is about 9 lb.

Escapement

Migration up the river usually begins quite suddenly about the middle of

October, with very few fish preceding the main body. The upstream run sometimes starts about a day later than the main movement of spring salmon, in which case many of the latter fish are rapidly overtaken and passed by the wave of advancing cohos. Skutz falls, about twenty miles from the river mouth, is reached by the first fish in about two days. The peak of this initial run passes the falls during a period of two or three days and normally constitutes the high point for the whole upstream migration, with smaller waves of fish continuing to arrive for several weeks afterward. The 1946 migration was exceptional in that the main body did not reach Skutz falls until November 25, more than a month after the usual date.

In 1939, from counts made at the fishway, it was estimated that about 60,000 fish passed the falls. In succeeding years a small proportion of the run has been tagged at this point and the size of the run has been calculated by comparing the numbers of tagged and untagged fish found later on spawning grounds above the falls. The accuracy of these estimates is open to question but they probably serve to show the direction of major fluctuations in the annual escapement (table II). These estimates do not include the considerable number of cohos spawning in the river system below Skutz falls.

Spawning and Early Life History

Spawning takes place in nearly all accessible tributaries and in the main river, mainly in November and December. Most of the fry emerge in March and April. In the smaller streams a migration to the river begins immediately and continues throughout the spring. The young fish, however, do not usually enter salt water until May or June of the following year.

Fry marked during their descent of small tributaries near the upper end of the river were found to spread rapidly throughout the length of the latter. The movement is not entirely downstream, some fish proceeding up the river as far as the lake. At this season and again in the autumn or winter of their first year some fingerlings push up into small tributaries and rivulets, some of which are not visited by adult cohos.

Efficiency of Natural Propagation

This has been investigated during a number of years in two small streams entering the river close to the Hatchery. All adult fish entering the streams were trapped and the number of eggs carried by the females was estimated. The resulting fry were trapped and counted during their descent of the streams in the following spring and summer. The results of these experiments are summarized in table III.

The general average efficiency of 22.8% for all these experiments is high in comparison with percentages reported elsewhere in the province for pink and chum salmon at a similar stage of development. It probably results, at least in part, from the somewhat more stable conditions of stream flow and bottom materials which are apt to prevail on the grounds selected by cohos, and to less

crowding of the redds. The factors responsible for yearly variations in percentage fry production have not been satisfactorily analysed but it is evident that considerable losses are caused by predators, especially cutthroat trout. Some of the young fish remain near the spawning grounds and many of these are trapped by the drying up of the streams in summer.

TABLE II.—Number of cohos reported by sport fishery; fishing effort; and estimated escapement above Skutz falls.

Year	1939	1940	1941	1942	1943	1944	1945	1946
No. of cohos reported landed	3,410	1,900	3,560	3,928	4,333	3,835	3,750	2,000
Average line-hours per coho landed (Sept. 22 to Oct. 31)	3.6	5.8	4.7	4.8	4.9	5.2	5.1	6.3
Estimated escapement above Skutz falls	60,000	30,000	65,000	67,000	56,000	63,000	41,000	30,000

TABLE III.—Efficiency of coho fry production in natural propagation.

	Oliver creek		*Beadnell creek*	
Year	Potential egg deposition	Percentage efficiency	Potential egg deposition	Percentage efficiency
1938-39	330,176	14.4	—	—
1939-40	665,280	11.8	433,400	40.0
1940-41	481,650	30.4	74,100	30.1
1941-42	564,900	26.0	—	—
1942-43	199,500	25.6	78,100	16.3
1943-44	326,000	15.2	354,000	19.5
1944-45	173,000	22.3	—	—
1945-46	249,000	22.2	—	—

A close relation between the summer water levels and the availability of returning adults is indicated in fig. 2. The average number of fish caught in 100 hours of fishing at Cowichan bay is plotted against the minimum stream flow recorded two summers previously, that is, at the time when these adults were fingerlings in the river system. The occurrence of the two worst fishing seasons (1940 and 1946) two years after the lowest recorded water levels (1938 and 1944) is especially striking. Reduced water volume could be expected to result in trapping of fingerlings, greater exposure to predators and reduction of available feeding area.

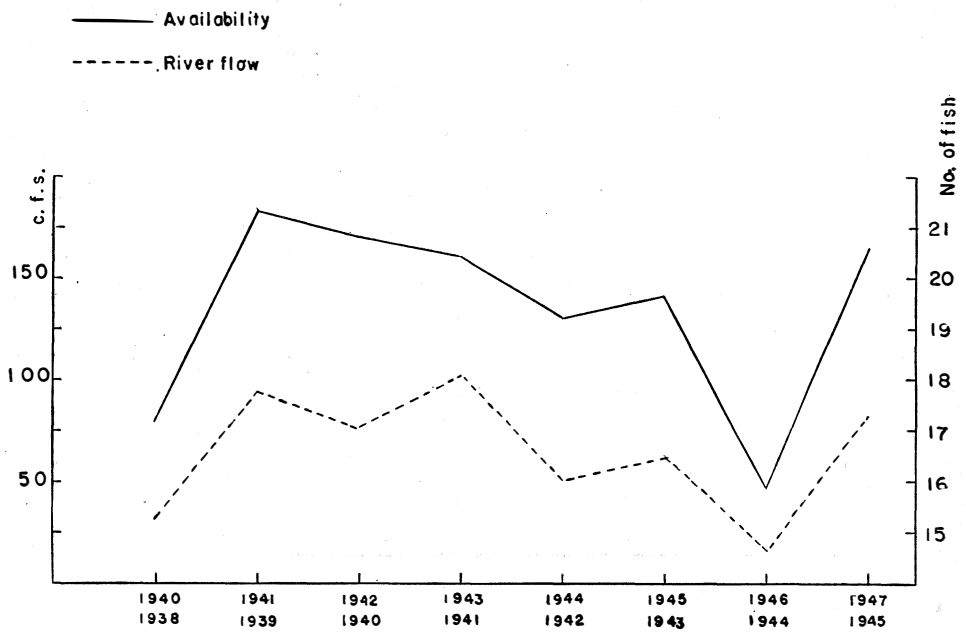

FIGURE 2. Availability of cohos to Cowichan Bay anglers (number of fish caught per 100 hours of fishing) compared with minimum summer flow of Cowichan river (cubic feet per second) two years previously.

REMARKS

The average number of cohos entering the Cowichan river is believed by many to have declined within the last two decades. In view of the apparent correlation between summer flow and numbers of returning fish, this may well be the case, since the average summer flow has been less in recent years.

The game fishery in Cowichan bay does not appear to constitute a serious drain on resources at the present time.

OTHER SPECIES OF PACIFIC SALMON

The chum salmon, the sockeye salmon and the pink salmon are not, or seldom, fished for sport. Since, however, they are closely related to the species previously discussed and since two of them are of definite importance in the ecology of the game fish, their status in the river system may be briefly indicated.

Large numbers of chum salmon enter the Cowichan in autumn and early winter. They spawn mainly within eighteen miles of the river mouth. A few fish ascend beyond Skutz falls and an occasional individual has been noted as far upstream as the outlet of the lake. No commercial chum fishery exists within the immediate area influenced by the Cowichan river and nothing is known concerning the extent to which Cowichan fish may enter into operations elsewhere. During the time of their seaward migration, that is, soon after

emerging in spring, the fry are a dominant element in the fish population of the lower part of the river. They are eaten in numbers by young steelheads, spring salmon and doubtless by other species and are therefore of indirect importance to existing fisheries. Furthermore, since the fry migrate to the sea immediately after emerging, they do not compete with resident fish for the food supplies of the river. Heavy losses of chum salmon eggs and fry result in some years from changes in water level and shifting of channels in the lower part of the Cowichan river (see p. 26).

A few sockeyes ascend the river in autumn in company with cohos and spring salmon but the run is of no practical importance. A population of kokanees, or permanently freshwater sockeyes, exists in Cowichan lake. The individuals are of small size in comparison with specimens from certain mainland lakes and are only moderately plentiful. They provide an important food supply for the lake-dwelling cutthroat trout and are also eaten by Dolly Varden char.

The pink salmon has been found in the Cowichan river only on rare occasions.

FIGURE 3. Lower Cowichan river, during a spring freshet. Collecting samples of migrating young salmon.

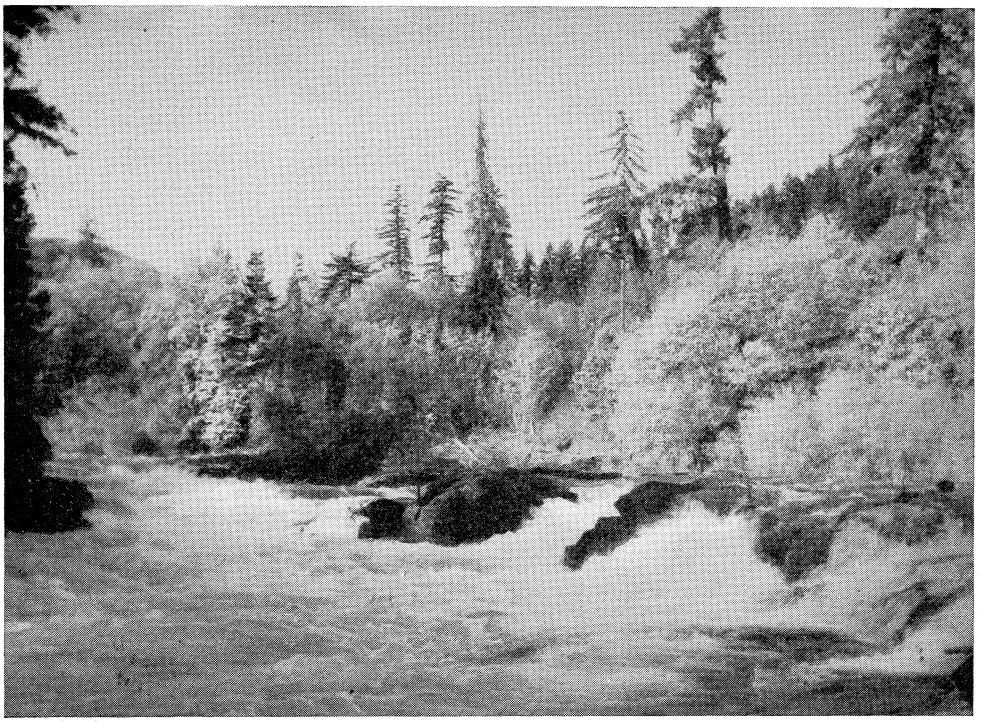

FIGURE 4. Skutz falls. Water level is high. Fish ladder at right centre.

STEELHEAD AND RAINBOW TROUT

This species (*Salmo gairdnerii*) is represented in the Cowichan river system by three types of fish: (a) steelheads which, after spending the early part of their lives in fresh water, migrate to sea and make a large part of their growth in salt water; (b) fish which spend their lives entirely in fresh water and are termed rainbow trout in the present account (the term "rainbow" as commonly used by anglers includes also young fish of group (a) which have not yet migrated to salt water); (c) Kamloops trout, introduced from the interior of British Columbia. In their native habitats these fish of course live permanently in fresh water.

Considerable effort has been made to investigate the characteristics of these several types and to evaluate their respective merits in relation to the future of the game fishery in the Cowichan river.

1. SEA-RUNNING STEELHEADS

FISHERIES

Fishing for adult steelheads takes place mainly in January and February and depends to a large extent on the water levels prevailing at this season. Few fish are taken when the water is high. Although steelheads migrate the full length of the river (and to certain tributaries of the lake) fishing is mainly

centred in the Duncan and Sahtlam areas and the intensity is not very great. The catch never exceeds a few hundred fish in any one season.

In addition to this fishery, young steelheads are taken by trout-fishermen, especially during their descent to the sea as smolts. At this season (April and May) they frequently constitute the major part of the trout catch in the lower river. They are also caught in the upper river and lake, where, however, they are mixed with individuals of the resident type of rainbow trout.

Since many steelheads go to sea as yearlings at a size much below the minimum legal length of 8 inches and since by no means all the two-year fish have attained this length, only a part of the population is subject to legal exploitation. Some undersized fish of course are hooked and may be killed or injured.

Winter-Spawning Steelheads

Escapement

The spawning migration of "winter" fish into the river begins in October, the earliest comers running in company with the main runs of spring and coho salmon. Fish continue to arrive throughout the winter.

The total number of adult migrants cannot be stated accurately but a comparison, based on gill-nettings and observations, between steelheads and the two species of Pacific salmon for which certain estimates are available, suggest that recent winter runs have comprised between 5,000 and 15,000 fish.

Age Composition of the Run

The ages of 400 fish were determined from scale samples collected during four consecutive winter seasons. These fish were caught by angling, gill-nets and to a small extent in traps. While there may have been some selection in the sampling, the figures obtained from netted fish agree fairly well with those from rod-caught fish and the general percentages given below probably provide a reasonably good general idea of the age grouping.

Table IV.—Age-composition of winter-spawning steelheads.

	Percentages of Age Groups					
Age in years	2	3	4	5	6	No. of fish
Season 1937-38	0	3	75	21	0	61
" 1938-39	0	4	82	11	4	82
" 1939-40	0	15	68	17	0	147
" 1940-41	1	15	41	40	3	115
All	0.25	9.25	66.5	22.25	1.75	405

In most years four-year-old fish predominate. In 1940-1 the run of four-

year-olds was relatively small and the fishing was poorer than for several years previously.

Average weight of winter-caught fish is generally between 8 lb. and 9 lb. Fish up to 16 lb. have been caught during the period of the investigation.

SPAWNING AND EARLY LIFE-HISTORY

Spawning takes place at least from the beginning of January until late in March and occurs in suitable localities throughout most of the length of the Cowichan river and in Robertson creek. Relatively few winter fish ascend the smaller tributaries.

Only a small proportion of the fish spawn more than once before death. The percentage of winter-run fish whose scales show a distinct spawning mark for a previous season varies from year to year and apparently differs in the two sexes, as with the Atlantic salmon. A general average of about 4% of males and 12% of females has been obtained from the samples examined. Fish showing two spawning marks previous to the season of their capture are very scarce.

Steelhead fry commonly appear in numbers in the river in May and June. During their life in fresh water the young fish, as shown by returns of marked individuals, may make local migrations from the river into small tributaries or from river to lake.

The scales of returning adults show a fairly equal division between fish which went to sea as yearlings and those which remained for two years in fresh water. The number of young steelheads which spend three years in fresh water is negligible. Yearlings are usually about 5 or 6 inches long at the time of their seaward migration. Most of the two-year-old migrants are between 6 and 10 inches in length. Some of these remain for a time in brackish water and make further growth before leaving the river system entirely. The height of the downstream run occurs in April and May.

SPRING-SPAWNING STEELHEADS

In common with other streams of Vancouver island the Cowichan river has a late run of steelheads which differs in certain respects from the winter run. The migration probably begins late in March and continues until at least the middle of May. In general the spring fish do not lose condition to the same extent as the winter fish and many are still quite silvery when ripe. A series of 150 fish trapped at Skutz falls between April 1 and May 12, 1941, showed the following age-composition.

Age in years	3	4	5	6
Percentage	6.67	66.0	24.0	3.33

While this age-composition appears very similar to that of winter runs, the average weight of all individuals was about two pounds less (6¾ lb.). This can

be ascribed to the fact that a much higher percentage of the fish (84%) had spent two years in fresh water before going to sea and also that most of the fifth- and sixth-year fish in the spring run had spawned in a previous season. With respect to the latter factor, the spring run showed the following composition.

	Males	*Females*
Number of fish	37	113
No. spawned previously	3	37
Per cent spawned previously	8.1	32.7

Reproduction takes place in April and May and while some fish undoubtedly spawn in the main river, a considerable number breed in certain tributaries of the river and lake.

A few immature sea-run steelheads appear in the lower part of the river in spring and early summer. They seem to travel in company with the ripe fish but so far as is known do not constitute an important part of the run.

REMARKS

The sea-going type of steelhead appears to be adequately protected in the Cowichan river at the present time. Winter fishing is of limited extent and the 8-inch size-limit ensures the escape to sea of a good proportion of the young fish. The spring spawning run is hardly tapped by anglers, some of whom do not realize its existence, while others are deterred by the possibility of catching a large percentage of kelts from the winter run, or have turned to trout fishing. It is probable, however, that by careful attention to the calendar and to the type of lure used, a short season of steelhead fishing could be enjoyed in the spring.

In general, the annual runs of anadromous steelheads appear to be maintaining themselves satisfactorily. Fluctuations in abundance are probably due more to river conditions than to fishing effort.

2. Rainbow Trout

These fish, which remain in fresh water throughout life, occur in the upper part of the Cowichan river and in Cowichan lake. In the former locality they are by far the most numerous element in the fisherman's catch and in the lake fishery they are also very important.

Some rainbow trout are to be found in the river at all seasons of the year, although in summer large individuals are quite scarce and remain chiefly in the deeper holes and pools. In September and October there is an influx of fish, both mature and immature, from the lake into the upper portion of the river, where they remain throughout the winter. About May, a migration in the reverse direction takes place, when fish over two years of age tend to move up into the lake. Fish under two years of age are numerous in the river at all seasons.

It has been demonstrated that these are not, in the main, offspring of sea-run fish which failed to migrate to salt water, but are a separate native stock with certain hereditary characteristics. Offspring from both the sea-run and rainbow types of parent have been raised under similar conditions in the hatchery and have been found to preserve the respective habits of the parents, that is, the steelhead offspring went to sea and the rainbow offspring moved upstream into the lake. On an average, the rainbows possess fewer scales than the sea-going fish, although there is a certain amount of overlapping in this respect.

Most of the rainbows appear to spawn during the same season, and frequently on the same grounds, as the winter sea-run steelheads, that is, from January to March, in the main river. The first spawning usually takes place at 4 years of age, sometimes at 3 or 5 years. It appears from the examination of scales that fish seldom spawn more than twice in a lifetime.

Like steelheads, young marked rainbow trout have been found in small streams which did not provide the original spawning ground.

At three years of age the average length is between 12 and 14 inches and four-year-old fish average over 16 inches. The largest fish examined by the writer was 21 inches long and weighed 4¾ lb. Rainbow trout over 4 lb. are seldom caught.

REMARKS

Whereas the steelhead is only fished in the Cowichan river during two brief periods of the life-history, it is evident that the rainbow trout has to withstand a much more continuous fishing effort, since it is present at all times in the river system. Moreover, the known spawning grounds of the latter only extend over a few miles of the upper part of the Cowichan river, whereas the steelhead spawns both in this area and in many other parts of the river system.

By reason of its importance as an angling attraction in the upper river and lake, and especially in view of the lack of success which has attended efforts to introduce the Kamloops trout, the stock of native rainbows should be watched carefully for any signs of decline in abundance. The relatively good returns which resulted from the artificial raising of a small number of young fish (see table V) suggest that larger-scale hatchery operations might be conducted with some degree of success. However, since there is as yet no evidence that such measures would increase the output which is being obtained from natural propagation, intensive efforts along these lines are not recommended at the present time. The natural spawning grounds of the rainbow are not in general being subjected to such severe physical conditions as those of the cutthroat and brown trout.

On the other hand, the non-migratory habit of the Cowichan rainbow, combined with its ability to live in relatively warm water and in competition with other species, might make it a very valuable fish for introduction into waters elsewhere. The establishment of a small brood stock would assure the availability of eggs for this purpose and would provide a nucleus for more extensive local

operations if these were deemed desirable at a future time. Since the spawning fish are not well concentrated in time or space and avoid the small tributaries, ripe individuals are very difficult to obtain at short notice. The brood stock could best be established by netting immature fish in the river.

3. Kamloops Trout

Since Kamloops trout eggs can be readily obtained from the interior of British Columbia, it has long been hoped that plantings of this form of rainbow trout would increase the number of fish available to anglers in the Cowichan river system. Among the chief objectives of the investigation were (a) to discover whether introduced Kamloops trout would remain in fresh water or assume a sea-going habit, and (b) to decide whether, in either event, they would materially improve the fishing.

Records show that during the period from 1922 to 1934, inclusive, more than a million and a half Kamloops trout (eggs, fry and fingerlings) were planted in the Cowichan river system. Nothing is known regarding the fate of these fish.

During the period 1938 to 1942, 136,000 marked fingerlings were released in Cowichan lake and the Cowichan river by the Fisheries Research Board, while 40,000 fingerlings were planted in Quamichan lake by the Provincial Game Commission. Of the latter, some, but not all, were marked.

The evidence with regard to a sea-going habit is entirely negative. No marked Kamloops trout have been reported from the sea, nor have any sea-run fish been found in fresh water. Neither have any young fish been discovered in the river in the immediate vicinity of the mouth. Facilities for capturing returned sea-run fish are not particularly good, since there is no weir on the main river. Reliance must consequently be placed on angling and on netting operations which can only be carried out at a few points. Nevertheless, the liberation of a smaller number (81,000) of marked *steelhead* fingerlings in 1938 and 1941 has yielded 18 authentic returns of sea-run fish. The available evidence therefore indicates that the Kamloops trout did not go to sea or, if they did, that they did not return to the Cowichan river. The movements of young marked fish recaptured in fresh water, while showing considerable scattering from the points of liberation, do not reveal any general tendency to move towards the sea.

As regards the showing made by the introduced fish in fresh water, results have been definitely poor. Table V shows the returns received from the planting of different kinds of (hatchery-raised) marked fish during the period of the present investigation. Since it was not possible to conduct an adequate creel census, the numbers of marked fish returned cannot be taken as an indication of the numbers which were actually caught or were available to fishermen. Nevertheless, the samples obtained should indicate the relative success of planting different types of fingerlings in these waters.

On the basis of anglers' catches in relation to the number of fish released, the Kamloops has by far the poorest record. Plantings of steelhead were four

TABLE V.—Returns of marked trout released in the Cowichan river system.

Species	Number released	No. of returns (all sources)	No. of returns (anglers only)	No. planted per each return	
				All sources	Anglers
Kamloops	136,011	25	11	5,440	12,365
Steelhead	80,834	78	26	1,036	3,109
Native rainbow	2,976	57	42	52	71
Cutthroat	23,989	120	40	200	600
Brown	2,949	58	11	51	268

times as effective, in spite of the fact that this type of fish escapes to sea at an early age, while there is no evidence that the Kamloops do so. Plantings of cutthroats were 21 times as productive of returns, brown trout 46 times and native rainbows 174 times. While the latter figure, based on a single planting, may be a far from accurate comparison, there can be no doubt that the Kamloops trout have yielded extremely low returns in comparison with all other types planted.

The above figures do not include plantings of Kamloops trout in Quamichan lake. Certain reports of these latter fish being caught by anglers have been received. In cases where the fish were seen by the investigators they proved to be cutthroats. On the occasion of a sudden mortality of fish in Quamichan lake in August 1945 about forty dead trout were examined. None of these were Kamloops trout.

REMARKS

It is reasonable to conclude that physical conditions, competition of other fish, or both these factors, have proved to be unfavourable to the Kamloops trout introduced into the Cowichan river system. A further planting of 25,000 fingerlings has been made in March, 1947. It is suggested that efforts be made to evaluate the results of this planting and that if it shows no greater degree of success than has been evidenced by previous introductions, the introduction of this type of fish be discontinued.

CUTTHROAT TROUT

The cutthroat is the most widely distributed species in the river system, occurring even in the upper portions of certain small tributaries which at the present time are inaccessible to ascending fish on account of falls. Generally speaking it is the predominant trout in the smaller streams, in the deeper portions of Cowichan lake and, during at least part of the year, in the lower stretches of the river. In the latter locality it is by no means abundant, however, and is frequently outnumbered in the spring catches of anglers by steelhead smolts which have attained legal size before reaching salt water.

Spawning takes place throughout the winter and early spring, many fish ascending tributaries of small or moderate size for this purpose. The young fish frequently remain for one or two years in the spawning streams. The main downstream migration to the river takes place in spring, coinciding closely with the heavy exodus of young cohos, on which the cutthroats feed extensively.

During the winter months there appears to be frequent random visiting of streams in addition to migrations connected with reproduction. Tag returns show that in spring some fish move from the river into the lake. Others, including some large individuals, remain in small tributaries.

In the neighbourhood of the river mouth the cutthroats lead a characteristic estuarine existence, moving in and out with the tide. Up-river migrations occur in autumn and spring but little is known of their extent or character. In the upper part of the river system sea-run cutthroats are scarce.

The rate of growth shows considerable variation. Many fish which have lived mainly or entirely in small streams are only 5 to 8 inches long at two years of age. Individuals in the river and lake may be from ten to seventeen inches long at the same age. A weight of at least 9 lb. is sometimes attained by fish in the lake.

Cutthroats usually spawn for the first time at 3 or 4 years of age, although some males become sexually ripe when 2 years old. Spawning more than twice appears to be rather exceptional.

REMARKS

The relative abundance of cutthroats, steelheads and rainbows appears to have changed somewhat in recent years, the cutthroat showing a decrease. In view of its spawning habitats, it is reasonable to assume that the present species has suffered more from the deterioration of the smaller streams (see p. 27). Until conditions in these nursery streams are improved, the artificial raising of fingerlings to be planted in the main river would be a logical step towards maintaining the stock. Unfortunately there is no assured source of supply of cutthroat eggs at the present time.

BROWN TROUT

The brown trout was introduced into the Cowichan river system in 1932, in response to repeated requests by anglers. During 1932, 1933, 1934 and 1935 a total of 20,275 fry and 234,858 fingerlings and older fish were planted in the river and lake. Since the autumn of 1937, and possibly earlier, natural reproduction has taken place.

At the present time the species is present in the portion of the river above Skutz falls, although it is not numerous in relation to the native trouts. In the lower river and in Cowichan lake it is infrequently caught. No increase in abundance has been noticed within the last few years. In fact the runs to the two best-known spawning streams have diminished. No authenticated records of sea-run fish are available and no returns of marked or tagged individuals have

shown a greater range of migration than two miles. Seasonal migration between river and lake has not been demonstrated. During the summer, however, there is a concentration of brown trout in the enlargement of the river known as the "Cowichan lake pool" or the "Hatchery pool." This concentration is especially noticeable since it occurs at a season when rainbow and cutthroat trout are relatively scarce in this locality.

Yearling marked brown trout released in the Hatchery pool at an average length of about 5 inches have shown rapid growth and a high percentage survival. From a planting of 303 such fish made in 1939, 56 (18.5%) were recovered in operations of the investigation and by anglers during the ensuing thirty-two months. All showed good growth, one fish reaching a length of 19 inches and a weight of 3½ lb. at two and one-half years of age. Older fish in the river have attained 5 lb.

Spawning migrations consisting of fish 3 years of age and older take place annually in two small streams near the hatchery. Although some individuals spawn at least twice, a considerable mortality has been observed in these streams at, and even just before, the time of reproduction.

In contrast to the environment of the main river, conditions on the breeding and nursery grounds do not appear to favour this species. The period of maximum spawning coincides with that of the coho, which dominates the gravelly areas of the small streams and tends to crowd out or drive off the trout. After hatching, the young trout have to compete for the limited food supplies of these waters against the far more numerous and also more active young cohos. Most of the latter leave the streams during the spring, while the trout tend to remain and are then faced with the difficulties of a dwindling and frequently an entirely inadequate water supply.

While the brown trout is not plentiful in the Cowichan river, the extent to which it appears in anglers' catches does not represent its true level of abundance in comparison with the native trouts. The percentage of brown trout in catches made by rod and line is much lower than the percentage obtained in gill-nets. It is probable that brown trout are harder to catch than rainbows and cutthroats because of greater wariness and a tendency to feed at more restricted periods of the day.

REMARKS

While the brown trout cannot be said to have fulfilled the hopes of those who advocated its introduction, it has established itself in small numbers in a restricted portion of the river. It is not increasing in numbers at the present time. Although it is less easily caught and probably less attractive to the average angler than the native species, it is present in the Pool in summer, when rainbows and cutthroats are scarce, and it is available for capture by those whose temperament and technique are adapted to this species. In view of its non-migratory habits there would seem to be little objection to attempting to increase its numbers in this particular part of the river. In view of the threatened

extinction of the spawning run in Oliver creek (the chief known breeding ground) it is suggested that the ripe fish in this stream be stripped and the young fish liberated in the river as yearlings. If the stock can be built up somewhat, its perpetuation might be assured by barring cohos from this or some other suitable breeding ground.

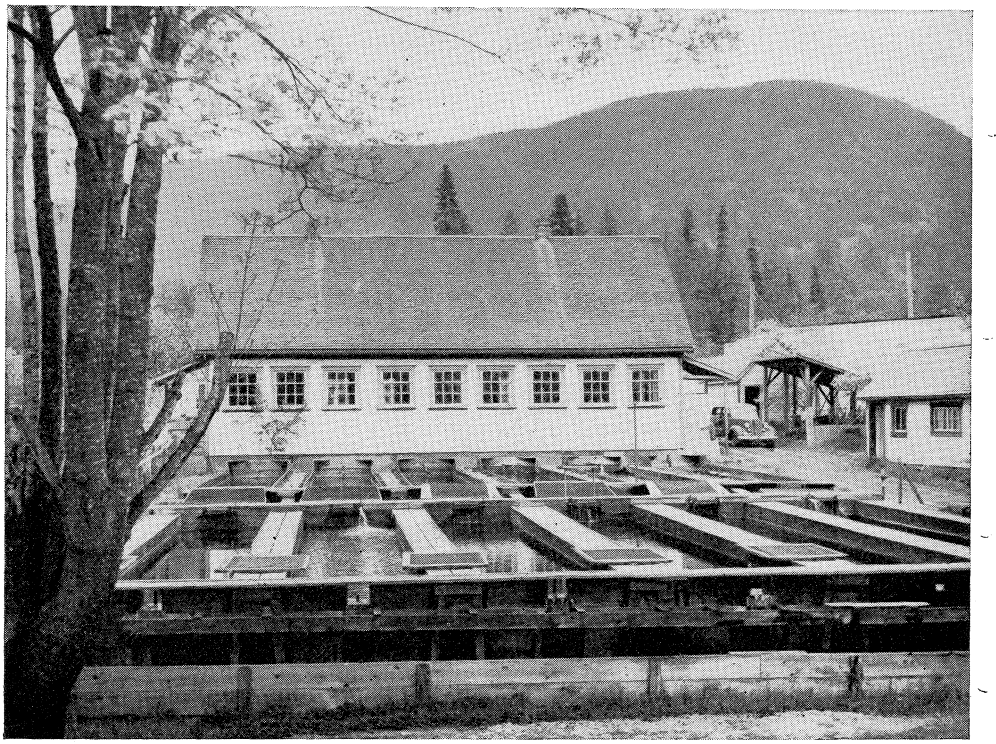

FIGURE 5. Cowichan lake Hatchery.

ATLANTIC SALMON

During the period from 1911 to 1934, inclusive, more than five and a half million Atlantic salmon (fry, fingerlings and yearlings) were released in the Cowichan river system in plantings varying from 5,000 to 890,000 individuals. While a few fish have been reported by anglers since these distributions were initiated, none has come to light during the period of the Board's investigations and it is evident that no practical result has been forthcoming from the expense and effort involved in these plantings.

It has been pointed out that any attempt to establish the Atlantic salmon in these waters should be based on an estimate of the number of fish required to produce a self-sustaining population, bearing in mind the extent of potential

spawning grounds available. It is unlikely, however, that the Cowichan river under present conditions would support a large Atlantic salmon population in addition to the existing stocks of fish. The anadromous steelhead, which is an essentially similar fish in life history, feeding habits and choice of spawning grounds, is already numerous in these waters. The large-scale introduction of

FIGURE 6. Fence and fry-trap on Oliver creek.

Atlantic salmon might reasonably be expected to result in severe inter-specific competition in which the advantage might well lie with the native steelhead. If a determined effort, which would probably have to be accompanied by restrictive regulations, succeeded in establishing the Atlantic salmon, there is little certainty that the fishing would thereby be improved from the viewpoint of the majority of anglers.

SPECKLED CHAR

Records show that 1,135,890 eggs, fry and older fish were planted in the Cowichan river system between 1911 and 1931, mainly in the smaller tributaries of the lake and river. From the angling point of view there has been no effect. The species exists in small numbers in Oliver creek, principally in the upper reaches, where some natural breeding must have occurred. Few individuals appear to reach legal size. The same is true of one or two tributaries of Robertson creek.

There appears to be no sufficient reason for attempting to establish the species more widely in these waters at the present time.

DOLLY VARDEN

This char is fairly numerous in Cowichan lake, particularly in the western portions, where it frequents the neighbourhood of logging settlements and the mouths of streams. It occurs in the river, more especially in winter and spring, and ascends various tributaries for spawning or feeding purposes. It is scarce in the lower reaches of the river and no sea-run fish have been observed.

The Dolly Varden is taken in some numbers by anglers in the lake but is not regarded with favour. The extent to which it affects other species, through predation or competition, is not known. Salmon eggs have been found in the stomachs of winter-caught fish.

LAKE TROUT

During the five-year period 1912 to 1916, 147,500 young lake trout were liberated in Cowichan lake. There is no record of any catch resulting from these plantings.

DISCUSSION

With regard to the general game fish population of the river, it may be emphasized that there is a notable lack of permanent residents. In the lower part of the river there are considerable winter and spring runs of adult anadromous steelheads. In April and May a seaward migration of steelhead smolts, some of which have attained legal size, passes through this section. A rather small population of cutthroats is present in the lower reaches during most of the year but many of these probably retreat to salt water in the warmer months. The summer fish population consists mainly of coho fingerlings in their first year and steelheads and cutthroats in their first and second years. These have not reached a size large enough to provide fishing.

In the upper part of the river (above Skutz falls) runs of anadromous steelheads also occur. The adult fish, however, do not "take" as well as in the lower stretches and consequently winter steelhead fishing is not very important. The resident rainbow trout is the mainstay of anglers in this portion of the river but most of the legal-sized fish, together with a large proportion of the cutthroats (which species is much less numerous than the rainbow) move into the lake in May and June. They reappear in the river in September or October and remain through the winter and spring.

In view of the exodus of fish from both ends of the river in early summer, trout fishing in the river (as distinct from the winter steelhead fishing) is largely restricted to the spring and autumn.

Effects of Physical Conditions

This general pattern of seasonal distribution probably prevailed long before any sport fishery existed. It is imposed by the physical characteristics of the

watershed. These latter, in addition to influencing the habits of the fish, can be regarded as factors which have continually limited productivity and also as probable causes of a recent decline in the number of fish available to anglers.

In a previous section it has been noted that comparatively large fluctuations in the discharge are characteristic of the Cowichan. The ill effects of both floods and drouths are apparent. Winter floods usually occur at a time when most of the salmon eggs and some of the trout eggs have been deposited in the redds. In many tributaries and in the lower portions of the main river spawning grounds are frequently torn up and the gravel deposited elsewhere, sometimes in drifts several feet high. Much loss of eggs is certainly caused in this manner. Further, in places where the stream banks are ill-defined, high water frequently results in the cutting of new channels and the diversion of the stream into these leaves spawning grounds elsewhere in a waterless condition. Another factor associated with floods is the silting up of portions of the stream bed. This can result in the smothering of eggs or alevins through reduction of the supply of fresh water in the gravel.

Destruction of eggs and young fish through reduction of the run-off is also heavy at times. In the main river the areas most affected are in the neighbourhood of Sahtlam and from Duncan to tide-water (figs. 8, 9). Falling water levels frequently result in many areas of spawning ground being left uncovered before emergence of the fry, which are left to die in the gravel. Other young fish are trapped in pools which dry up during the course of the summer. Predators, among which birds and snakes are conspicuous, take a heavy toll of these confined fingerlings before complete dessication occurs. The loss is not restricted to fish hatched in the areas where pools are formed by recession of the water. Cohos hatched and marked in streams near the outlet of the lake have been found trapped in pools 20 to 25 miles down the river. A definite relation between the minimum summer river flow and the number of returning adults of this species has already been indicated (fig. 2). Other species which are certainly affected by shrinkage of the main river are chum salmon, spring salmon and steelheads. Serious mortality of cutthroats and brown trout undoubtedly occurs in the smaller streams.

The effects of temperature appear to be important although less easy to evaluate than those of fluctuating water flow. The highest temperatures recorded (see p. 5) cannot be considered lethal for the species concerned if other conditions are favourable, but there is little doubt that they are well above the optimum. Many rainbow and cutthroat trout leave the river for the period when the highest temperatures prevail and those which remain appear to show a falling off in condition in the latter part of the summer. The smaller individuals, up to two years of age, seem to be less affected than the older fish.

Winter temperatures in general remain high enough to permit considerable growth during this period. Probably as a result of this relatively high winter growth rate, the size for age of Cowichan river fish tends to be large in com-

parison with many other streams. It is noteworthy that the scales of fish living in the river typically show an annulus which represents a retarded growth in the latter part of the summer. During the winter, on the other hand, the growth rings are widely spaced, with no indication of a check.

It is considered probable that higher summer water temperatures have accompanied deforestation and reduction of stream flow and have thereby contributed to a deterioration in the environment in recent years. A specific suggestion has been made on a previous page that the decline in early-running spring salmon is associated with changed temperature conditions.

In addition to the effects indicated above, large fluctuations in the run-off undoubtedly lower the general production of foodstuffs in the river system. The scouring action of floods kills, displaces or buries bottom-dwelling animals and the frequent shifting of the bottom hinders establishment of plant growth. During periods when the water level is falling, many food organisms are trapped in the same manner as the young fish.

The reduced summer flow which has been noted during the last twelve years as compared with previous conditions has undoubtedly accentuated these unfavourable factors and may have shortened the seasons when fishing is good, in addition to reducing the actual stocks of certain species (see under "Coho," p. 11). There has no doubt been a corresponding decline in the flow of the small tributaries which constitute nursery grounds for cutthroats. The deterioration of conditions in these streams has probably been relatively greater, indeed, than in the main river.

Food

As has been indicated, the natural productivity of the Cowichan river is not very high and may well have been lowered by recent changes in the run-off. Although the individual growth rate of fish is relatively high, this is supported in part by the eggs and fry of anadromous species. The condition factor (weight in relation to length) tends to be rather low in rainbows and cutthroats. It is considered unlikely that there is any large surplus of available food such as would be necessary to support appreciable populations of introduced species in addition to maintaining native stocks. The brown trout may be a partial exception to this statement, since its summer habitat enables it to utilize food which at that season is less available to the native species. Over the whole year, however, there may well be considerable competition between brown and cutthroat trout.

Hatchery Operations

It seems evident that in general the hatchery operations carried out over a long period on the Cowichan river system were not successful in their main objectives, namely, (a) the maintaining or increasing of the populations of native fish, and (b) the establishment of desirable non-indigenous stocks.

As regards the former objective, there is no reason to suppose that a repetition of the procedures, as a general management policy, would be any more effective today. The results of planting young fish in the Cowichan (so far as these are known) are in keeping with findings reported from many other localities which indicate that hatchery propagation is a costly and unreliable substitute for natural reproduction in a watershed of this size. Hatchery operations might be justified, however, for specific local purposes, as indicated in the following section.

FIGURE 7. The Hatchery pool, Cowichan river.

On the basis of available evidence, the attempts to establish Atlantic salmon, Kamloops trout, speckled char and lake trout must be regarded as having failed. It is further believed that the establishment of these kinds of fish in significant quantity could only be achieved at the expense of native species or varieties which are not less desirable. The status of the brown trout is precarious at the present time. This species could probably be encouraged more easily and with more justification than the other introduced types, in a limited part of the Cowichan river.

REMEDIAL MEASURES

For some years valuable salvage work has been done by the Department of Fisheries in releasing young fish which have been trapped in pools by the falling of water levels in spring and early summer. These are collected by hand-seines or are permitted to escape through channels dug in the gravel bars. Estimates of the number of fish released have run as high as 1,000,000 to 2,000,000 in certain years. Assuming a survival to maturity of between 1% and 2% of the rescued fish, it is evident that the salvaging of 250,000 coho fingerlings might produce the equivalent in adults of an average season's catch by the game

FIGURE 8. Cowichan river near Duncan. Salmon spawning ground left dry by receding water.

fishery in Cowichan Bay. The number of fish which can be salvaged, however, depends to a large extent on the time and extent of the critical drop in water level. Alevins trapped before emergence from the gravel can seldom be rescued and large numbers of eggs frequently perish even before hatching.

Much better and more widespread protection against losses caused by diminishing river flow would be afforded by the construction of a dam at the outlet of the lake to permit storage of water up to present high-water levels.

Storage of 3 to 5 feet of water in Cowichan lake (area 24 square miles) would provide a large volume for keeping spawning beds submerged in the spring and would also permit the maintenance of a much greater river flow from July to September. Such a dam should be provided with controllable outlets at the base and should permit passage of fish in both directions.

The actual saving of eggs and fry would benefit chiefly the Pacific salmon (coho, spring and chum) and the steelhead, which spawn in areas subject to drying up or whose fry enter such areas at an early stage of development. All fish which inhabit the river, however, (including rainbow, cutthroat and brown trout) should derive advantage from the improved food supply and greater freedom of movement which could be expected to result from partial control of the stream flow.

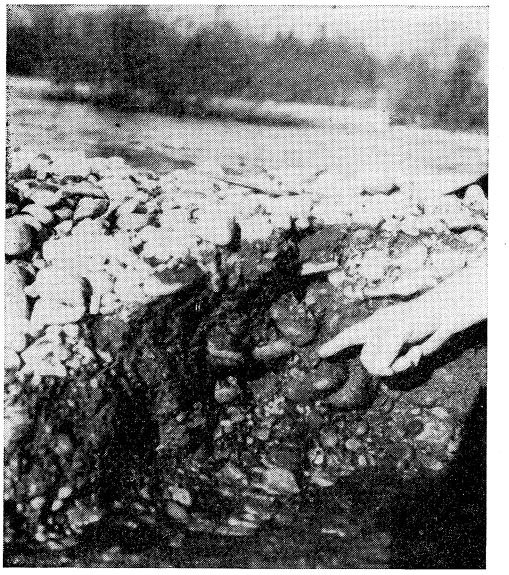

FIGURE 9. Chum salmon eggs in original position in now waterless gravel.

The improvement of stream flow conditions in tributaries of the river and lake would probably be more difficult. Since most of them are without lakes, the cost of storing water would probably be high in relation to the advantages gained, although engineering advice might well be sought on this point. These streams are chiefly important as breeding grounds for cutthroats and cohos. The young of the latter species tend to move down to the river or lake before water levels become very low (although considerable numbers are trapped at times). The young cutthroats are apt to remain for a year or two and hence are subject to the full effects of summer drouths.

Salvaging of trapped fry should certainly be continued on these tributaries. Improvements in conditions could sometimes be effected by the enlargement of existing pools and the provision of brush shelters, so that more space and cover would be available for those fish that remain in such streams during low-water periods. The cutting of channels through sand bars at the mouths of streams entering the lake would facilitate the passage of fish at certain seasons. Owing to the changed conditions produced by winter floods and varying run-off, the exact nature and extent of these small-scale operations should be determined annually.

In addition to measures intended to mitigate physical conditions and to increase existing food supplies, a brief reference may be made to the question of introducing specific food organisms. These would only be useful if they served as a needed link in the food chain between existing organic materials and the salmonid fishes, or if they influenced the feeding habits of the latter in a desired direction. The river system may be producing desirable food up to the limits imposed by prevailing physical and chemical conditions, in which case introductions can be expected to be unsuccessful or non-beneficial. It is possible, however, that more efficient utilization of organic detritus could be obtained by the introduction of certain organisms which do not appear to be present in the system. The crustaceans *Pontoporeia* and *Mysis* might do well in the deeper portions of the lake, while *Gammarus* and one of the burrowing mayflies, *Hexagenia* or *Ephemera*, could be tried in the shallower bays and in certain places in the river, notably the Hatchery pool. A well-defined "hatch" of these large mayflies would be a desirable feature from the fly-fisherman's point of view. No harm could result from the introduction of any or all of these organisms, if and when the opportunity to obtain them should arise.

While stream improvement and the salvaging of young fish are considered to be particularly important, it is recognized that such measures cannot immediately overcome the relatively poor conditions faced by brown and cutthroat trout on the spawning and nursery grounds of the small tributaries. It is suggested that the installation of a dam on the main river should be accompanied by the artificial propagation of fingerlings of these two species with the object of speeding up their increase in certain areas, the cutthroats to be liberated in the lower part of the river, the browns in the Hatchery pool. In both cases the number of fish which could be planted might be limited by the availability of eggs. No immediate and prolific source of supply of cutthroat eggs can be indicated at the present time. Brown trout propagation would have to depend on the very small number of fish which migrate annually into the small streams near the hatchery or on eggs imported from elsewhere.

It has been suggested previously that hatchery operations should include the establishment of a small brood stock of native rainbow trout, although such action would not be intended primarily as a remedy for present deficiencies.

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