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COWICHAN RIVER INVESTIGATION

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The streams and lakes of Vancouver island have been favourably known to fishermen of at least two generations. Not only do they offer immediate opportunities for the fresh water angler, but they provide spawning and nursery grounds for considerable numbers of salmon which in later life yield tribute to the salt water fisheries of industry and sport.

The Cowichan river, one of the most important watercourses on the east side of the island by reason of size and accessibility, first came under investigation by the Fisheries Research Board of Canada in 1934. The present phase of the investigation was begun in 1937.

For some years prior to this time, and also more recently, complaints were made that fishing within the area of the river system had suffered a considerable decline as compared with former years, in spite of extensive fish planting operations carried on by the Cowichan Lake Hatchery, established in 1910.

The purpose of the survey was to investigate the factors limiting fish yield and to determine as far as possible the means whereby the various fisheries could be maintained in a healthy condition.

The magnitude of the problem is evident from a mere reference to a few obvious considerations. The watershed of the Cowichan river occupies some 325 square miles and the system comprises about twenty-eight miles of main river, open to the sea, a lake having an area of twenty-four square miles, five smaller but still sizeable lakes and numerous tributary streams of varying size entering these waters. Eight species of salmonoid fishes are native in the river system and at least five additional species or forms of non-native fishes have been introduced at various times. To understand fully the actual and potential condition of the fisheries associated with the Cowichan river it would be necessary to have accurate knowledge of the life histories, numbers and interrelationships of all these species, their migrations between various parts of the river system and between fresh and salt water, food requirements in relation to available supplies, reaction to existing physical and chemical conditions, reproductive powers, natural mortality, enemies and competitors, and the numbers which are caught annually by fishermen.

The present account summarizes existing knowledge on certain of these points and discusses briefly some of the problems connected with the present and future status of the more important species of fish within the river system.

SPRING SALMON

The fish which provide the main spring salmon population of the Cowichan river appear in Cowichan bay during the summer, increasing in numbers from July until September. They provide a considerable sport fishery while in these waters. Approximately 1,400 spring salmon were reported landed at Cowichan bay by anglers between August 23 and October 31, 1939 and 2,000 between August 1 and October 31, 1940.

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. Many ascending fish are speared by Indians in the lower reaches of the river. The number of fish entering the river cannot be stated with any assurance. In 1939 an estimated total of 12,000 spring salmon passed Skutz falls, situated about eight miles by river below Cowichan lake, during the main fall run. About sixty percent of these, however, were small "jacks" of 2 lb. to 5 lb. It

is probable that a greater number of fish do not ascend the river as far as the falls. In 1940 water conditions made counting impossible but from catch records obtained at Cowichan bay and from observations and nettings in the river it appeared probable that while the total number of fish was about the same as in 1939, the number of large fish was two or three times as great.

During the past two years the average weight of spring salmon caught in Cowichan bay (excluding jacks) has been 17 1/2 lb., the heaviest fish reported during this period being about 45 lb.

The fish referred to as "jacks" are all, or nearly all, males in their second year. Both sexes are represented in the older age groups, which include fish in their third, fourth and fifth years. The proportions of these groups, as determined from an examination of 211 scale samples from Cowichan bay were:- Third year - 33.2%; Fourth year - 61.6%; Fifth year - 5.2%.

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 the Robertson river, 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 ten percent of these had spent their first year in fresh water.

In addition to the fall-running fish, a certain number of 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 three years. These individuals were caught, or found dead, in the river and lake between January and May. While fishing methods formerly practised on the river may have contributed to their scarcity, there do not appear to be detrimental factors operating at the present time sufficient to account for the eclipse of this vernal run. It is possible that the cause is to be sought in salt water. If the early running habit is hereditary, there seems little hope that the present stock is sufficient to enable the run to be built up by hatchery methods, using local resources. An attempt might be made by importing eggs from elsewhere.

COHO SALMON

Maturing cohoes 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. 3,400 fish were reported at five boat-houses on the bay in the season of 1939 and 1,900 in 1940. This does not represent the total catch made by sportsmen in this area. The average weight of third year fish is about 9 lb. A few fish of 16 lb. to 20 lb. are caught each year.

The probable importance of Cowichan river cohoes in the commercial catch, previous to their entering Cowichan bay, is discussed in a progress report.

Migration up the river usually begins as a mass movement, very few fish preceding the main body. The upstream run may start about a day later than the main movement of spring salmon but many of the latter fish are rapidly overtaken and passed by the wave of advancing cohoes. Skutz falls, about twenty miles from the river mouth, is reached by the first fish in about two days. In the last two years the peak of the migration passed the falls during a two-day period but

smaller numbers of fish continued to arrive for several weeks thereafter. In 1939 the number of fish passing the falls was estimated as at least 50,000 to 60,000. In 1940, judging from the ratio between marked and unmarked fish in Cowichan bay catches and by the number of cohoes entering certain tributaries of the river, the total run of the whole river system did not amount to more than about half the figures given above.

The three year old fish, which form the main part of the run, are accompanied by a varying proportion of two year old "jacks". These fish, weighing from 1/2 lb. to 3 1/2 lb., are not infrequently caught by trout fishermen. In Oliver creek, a small stream near the hatchery, jack cohoes have constituted from 2% to 10% of the adult male migrants in three consecutive years.

Coho eggs collected in the fall of 1938 were divided into two groups, one group being fertilized by three year old males, the other by jacks, the offspring being given distinctive marks before liberation. In the fall of 1940 a few jacks from both groups were encountered at or near the point of liberation.

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. In two such tributaries five counts have been made of the number of young fish reaching the stream mouth in their first spring and summer. The survival from the estimated number of eggs deposited in these instances has been: 15%; 12%; 40%; 28%; 28%. 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, either temporarily or fatally, by the drying up of the streams in summer.

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 fall or winter of their first year some fingerlings push up into small tributaries and rivulets, some of which are not visited by adult cohoes.

Cohoos of the 1937 brood year, raised to an average length of about 3 3/4 inches in the hatchery and marked before liberation, showed a strong tendency to return in 1940 to the same restricted part of the river system in which they were hatched and released. They also appeared to show a much higher survival percentage than fish from natural spawnings.

While the average number of cohoes entering the Cowichan river is believed to have declined within the last two decades, it is evident that large runs still occur. The game fishery in Cowichan bay does not appear to constitute a serious drain on resources at the present time. Within the confines of the river system the chief factors limiting abundance are probably summer drouths, winter floods, predators and possibly food supplies.

OTHER SPECIES OF PACIFIC SALMON

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 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 sea-

ward migration, i.e., 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.

A few sockeyes ascend the river in the fall, in company with cohoes and spring salmon but the run is of no practical importance. A population of kokanees, or permanently fresh water 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. A consignment of kokanee eggs from Nelson has been raised in the hatchery this year. It is proposed to mark these fish and release them in the upper part of the river in order to discover, if possible, whether any of them will migrate to the sea.

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

STEELHEAD

This species 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 the 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 live permanently in fresh water and usually possess more scales than the native steelheads of the coastal region.

It is necessary to understand the habits and relationships of these types in order to attack the problem of conserving any of them. For example, if the rainbows are merely the incidental offspring of sea-going steelheads and are likely to produce sea-going fish in their turn, no special benefits to the trout fishermen will result from attempts to build up a stock of fish from rainbow parentage. If, on the other hand, the tendency to remain permanently in fresh water is hereditary, the two races present separate problems to the conservationist and independent action can be attempted for the protection or propagation of either. The Kamloops trout has been introduced in the hope that it would continue to spend its life in fresh water, as it does in its native localities. If such were the case, it would provide a ready means of replenishing or augmenting the stocks available to the trout fisherman. It cannot be assumed without evidence, however, that its habits would remain unchanged in a new environment which provides free access to the sea.

During the current operations of the Fisheries Research Board fingerlings from parent fish of these three types have been marked distinctively and released in the Cowichan river system. The recovery of a sufficient number of these fish, at various stages of their life history, would provide definite evidence on the points at issue. The collection of this evidence is, of course, a matter requiring several years and much reliance must naturally be placed on the willingness of anglers to co-operate by noticing and reporting marked fish.

I. Sea-running Steelheads

(1) Winter Fish

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. 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 the Robertson river. Relatively few winter fish ascend the smaller tributaries.

The total number of adult migrants entering the river cannot be estimated accurately but a comparison, based on gill nettings and observations, between steelheads and the two species of Pacific salmon of which rather more is known, suggests that the figures for recent winter runs might lie between 5,000 and 15,000 fish.

These spawning fish are of various ages. The ages of four hundred fish have been determined from scale samples collected during the last four 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.

Percentages of Age Groups

Age in years	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	
Season 1937/38	0	3	75	21	0	(61 fish)
" 1938/39	0	4	82	11	4	(82 ")
" 1939/40	0	15	68	17	0	(147 ")
" 1940/41	1	15	41	40	3	(115 ")
Average	0.25	9.25	66.5	22.25	1.75	

It will be seen that in most years four year old fish predominate. In 1940-41 the run of four year olds was relatively small and the fishing was poorer than for several years previously.

Average weight of individuals is generally between 8 lb. and 9 lb. Fish up to 16 lb. have been caught during the period under consideration.

Angling is carried on mainly in January and February and catches depend to a considerable extent on water conditions during these months.

A relatively 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 is the case in the Atlantic salmon. A general average of about 4% of males and 12% of females has been obtained from the samples examined to date. Fish showing two spawning marks previous to the season of their capture are very scarce.

Practically all the adult fish examined had spent either one or two years in fresh water before entering the sea for the first time. In the following table the fish used for age groupings are classified according to the age at which they first went to sea.

Percentages of returned fish which had gone to sea at various ages

	<u>1 year old</u>	<u>2 years old</u>	<u>3 years old</u>
1937/38	68.9	31.1	0
1938/39	64.64	34.15	1.22
1939/40	53.06	46.25	0.68
1940/41	43.45	56.50	0

During their early life in fresh water young steelheads, as indicated by returns of marked fish, may make local migrations from the river into small tributaries or from river to lake.

The individuals which go to sea as yearlings are usually about 5 inches or 6 inches in length at the time of their migration. Most of the two year old migrants are between 6 inches and 10 inches long. 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.

(2) Spring Fish

In common with some other streams of Vancouver island the Cowichan river has a late run of steelheads which differs in several respects from the winter run. The migration probably begins late in March and continues until at least the middle of May. 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. 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. Details given are based on a series of 150 fish taken in a trap at Skutz falls between April 1 and May 12, 1941.

The average weight of these fish was 6 3/4 lb., about 2 lb. less than the average of winter steelheads. Percentages of the different age groups were as follows:

Age in years	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
Percentage	6.67	66	24	3.33

This grouping appears very similar to the composition of the winter runs but conceals notable differences. In the winter run more than half the four year old fish are individuals which went to sea as yearlings and nearly all the five year olds are virgins entering fresh water for the first time. In the spring run only a small minority of fourth year fish had reached salt water before two years of age and most of the fifth and sixth year groups were individuals which had spawned in a previous season. Actually, 84% of the spring fish were in their fourth year or had first returned to fresh water at this age. The percentage grouping according to time of first migration to sea was:

<u>1 year old</u>	<u>2 years old</u>	<u>3 years old</u>
12.67	84	3.33

As indicated, a relatively high proportion of the spring steelheads were found to have spawned at least once prior to the season of their capture. The

findings in this respect can be summarized as follows:

	<u>Males</u>	<u>Females</u>
Number of fish	37	113
No. spawned previously	3	37
Percentage	8.1	32.7

The sea-going type of steelhead appears to be adequately protected in the Cowichan river at the present time. Probably not more than two hundred adult fish are taken annually by anglers in winter fishing operations in fresh water. A proportion of the young fish attain the legal length of eight inches before going to sea and are subject to the attentions of trout fishermen. Fish less than eight inches long cannot be legally retained but of course some are hooked and may be killed or injured. In general, overfishing cannot be charged and the annual runs appear to be holding up well.

The spring 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 good steelhead fishing could be enjoyed in the spring.

II. Rainbow Trout

Those steelheads which remain in fresh water throughout life are most numerous 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 important, though not dominant.

Some rainbow trout are to be found in the river at all seasons of the year, though in summer large individuals are much less numerous 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. Fish under two years old are numerous in the river at all seasons. Marked young of both rainbow trout and sea-run steelheads have been found in small streams which did not provide the original spawning ground.

Individuals up to two years of age cannot be distinguished with certainty from young steelheads of the sea-going type but, judging from the scales of older rainbow trout, the latter type of fish has a greater average growth during the second year of life. At three years of age the average length is between 12 inches 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 4 $\frac{3}{4}$ lb. Rainbow trout over four pounds are rarely caught.

Most of the fish appear to spawn during the same season, and frequently at the same spots, as the winter sea-run steelhead, i.e., from January to March, in the main river. The first spawning usually takes place at four years of age, sometimes at three years or five years. It appears from the examination of scales that fish seldom spawn more than twice in a lifetime.

The question as to whether the rainbow and the sea-going steelhead of the Cowichan river represent merely individuals which differ in their migratory habits or are separate races with hereditary tendencies cannot be answered completely until further recoveries of distinctively marked fish have been secured. However,

some information bearing on the question is now available. A comparison between adult steelheads and adult or nearly adult rainbows from the upper part of the river system shows that there is a significant difference in the average number of scales on the side of the body, the rainbow having fewer scales than the sea-run fish. In order to aid a decision as to whether these differences are hereditary, a batch of rainbow eggs and a batch of eggs from sea-run parents were taken at the same time and raised in the same water supply. After the scales had developed on the young fish a sample of each lot was examined. The average difference in scale count again proved to be significant.

It is quite possible that some offspring of sea-run parents may become "resident" fish and, indeed, in two or three instances marked fish of this type have been found to remain in fresh water somewhat longer than the usual two years. In view of the evidence outlined above, however, it is considered probable that there is a resident stock of rainbow trout in the upper part of the Cowichan river system which tends to perpetuate itself.

III. Kamloops Trout

Records show that during the period between 1922 and 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 survival or otherwise of these fish. Kamloops trout raised more recently from the late eyed-egg stage in the Cowichan Lake Hatchery have retained the fine-scaled condition characteristic of this fish in the interior but this may not hold good for subsequent generations and it is possible that descendants of earlier plantings have mixed with the types of steelhead previously discussed.

During the period 1938-1940, 74,000 marked fingerlings were released in Cowichan lake and the Cowichan river. No undoubted records have yet been obtained from those liberated in 1938 and 1939, amounting to 41,000 fish. Twenty returns from the 1940 planting of 33,000 fish have come to hand. These have all been from fresh water and indicate a considerable tendency to wander between different parts of the lake, from lake to river and into certain tributaries. A remarkable series of movements was shown by one tagged fish which had descended eleven miles of river to within three miles of salt water, then ascended a small stream, crossed Somenos lake and was captured in a tributary of the latter.

No sufficient evidence is yet available as to whether Kamloops trout tend to go to sea in their new environment. If subsequent returns show that a large proportion of the fish remain and thrive in fresh water, a definite programme of plantings of Kamloops trout would be a logical means of improving the trout fishing in the Cowichan river system.

CUTTHROAT TROUT

The cutthroat is the most widely distributed fish 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 of Cowichan lake, particularly the deeper portions, of the lower stretches of the river and of the smaller tributaries. In anglers' catches it is sometimes outnumbered in the two former localities in spring, when many steelhead smolts 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 takes place in spring, coinciding closely with the heavy exodus of young cohoes, 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 and its tributaries into the lake. Others, including some large individuals, remain in the cool water of small tributaries.

In the neighbourhood of the river mouth the cutthroats lead a characteristic estuarine existence, moving in and out with the tide. Upriver 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 five to eight 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.

Like the rainbows of these waters, cutthroats usually spawn for the first time at three or four years of age, though some males become sexually ripe when two years old. Spawning more than twice appears to be rather exceptional.

There is evidence that within the last few years the relative abundance of steelheads and cutthroats has changed markedly, the cutthroat showing a decided decrease. It is reasonable to assume that the present species has suffered more than the steelhead from the seasonal drying up of the smaller streams (see p. 13).

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 fall of 1937, and possibly earlier, natural reproduction has taken place.

At the present time the species is well established in the portion of the Cowichan river above Skutz falls, though it is not numerous in relation to the native trouts. In the lower river and in Cowichan lake it is infrequently caught. No marked increase in abundance has been noticed within the last few years. 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 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.

Rapid growth and a tendency not to travel far can be illustrated by reference to a small lot of 303 yearlings liberated in the above-mentioned pool in April, 1939. These fish at the time of their release were between three inches and seven inches in length, averaging five inches. Within the next twenty months forty-seven of these, or 15.5 percent, were recovered in operations of the Investigation and by anglers, all less than half a mile from the point at which they were released. Forty-three of these were eleven inches or more in length, the

largest being nineteen inches long and weighing 3 1/2 lb. at two and a half years of age. Older fish up to five pounds in weight have been caught.

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

While the brown trout is not plentiful in the Cowichan river, the extent to which it is represented in angler's 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 cut-throats because of greater wariness and a tendency to feed at more restricted periods of the day.

It is evident that survival is high and growth rate is good during the portion of the life history that is spent in the main river (at least in certain places). The average condition factor of brown trout is higher than that of the native species (see p. 15). On the breeding and nursery grounds conditions are probably less favourable. The period of maximum spawning coincides with that of the coho, which dominates the gravelly areas of the small streams and may 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 cohoes. 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.

It would probably be comparatively easy to maintain a good stock of brown trout in localities such as the hatchery pool by hatchery operations. Another possibility would be the barring of cohoes from certain spawning streams.

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.

Mottley has 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 numerous in these waters and, generally speaking, appears to be increasing in numbers. The large-scale introduction of Atlantic salmon might reasonably be expected to result in severe interspecific competition in which the advantage might well lie with the native steelhead. If a determined effort, probably 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 no effect has resulted. The species exists in small numbers in Oliver creek, principally in the upper reaches, where presumably some natural breeding has occurred. Few individuals appear to reach legal size. The same is very likely true of some other tributaries.

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 recorded.

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.

RELATIVE ABUNDANCE AND AVAILABILITY OF TROUT

Owing to the large size of the area, the many points of access to river and lake and the presence of a considerable resident population of anglers in addition to those visiting the district from farther afield, no estimate of the total annual catch of trout has hitherto been possible. Records of about 1,500 fish caught by rod and line during 1939-41 permit a few general statements to be made.

The relation between number of fish caught and time spent in fishing, judged by the total number of available records, works out at about two fish for every three hours of fishing. This figure, however, does not serve to indicate the differences between different parts of the river system and the seasonal changes in the quality of the fishing. For example, during most of the summer long stretches of the river contain very few legal sized fish and angling activity in these waters is very restricted, resulting in few records being available. The composition of the catch also varies according to locality and season. Owing to differences in fishery regulations in various parts of the water system and also from year to year, exact comparisons are difficult. In Cowichan lake fishing is

carried on mainly in spring and summer, for cutthroats and rainbows (the latter term in this instance being used in a broad sense to include the young of sea-going fish as well as permanent residents in fresh water). Cutthroats have constituted from 53% to 80% of the fish caught during 1939-41.

In the upper part of the river, between Cowichan lake and Skutz falls, fishing intensity falls off markedly after May. Records of spring catches during the past three years have shown the following proportions of the three species involved:

	<u>Cutthroat</u>	<u>Rainbow</u>	<u>Brown</u>
1939	16%	82%	2%
1940	7%	90%	2.5%
1941	7%	90%	2.5%

The decline in cutthroats between 1939 and 1940 appears to be quite definite.

In the lower part of the river, where fishing is heaviest in the Sahtlam district and from Duncan to the river mouth, the cutthroat outnumbers the rainbow in anglers' catches during the greater part of the year, though here, too, its numbers appear to have been considerably reduced of late. In April and May, when the fishing intensity is greatest, the steelhead smolts migrating seaward from various parts of the river system pass through the lower part of the river and may dominate the angling scene. Catches at this season vary greatly in accordance with the time and magnitude of this migration and the proportion of smolts which have attained legal size. Summer fishing is largely confined to the deeper pools and the number of fish taken is small.

PHYSICAL CONDITIONS

Among physical conditions, temperature and the character of the run-off appear to be of outstanding importance in relation to fishery problems.

The Run-off

Since the Cowichan drainage system is not fed by glaciers or permanent snowfields, the run-off is 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 fall 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.

A gauging station was maintained on the river near the outlet of Cowichan lake from 1913 to 1920. During this period the mean monthly discharge at this point varied from 2,700 second-feet in winter to about 200 second-feet in September. These figures, applying to whole months, naturally do not serve to indicate the extreme conditions which often prevail for short periods and which are of great importance.

Since much of the watershed has been logged, and in part burned over, since this period, it might be expected that seasonal changes in flow would tend to be still more violent at the present time, through destruction of forest cover with its buffering effect on precipitation. Since most of the alleged decline in fishing is said to have taken place during the last twenty or twenty-five years,

a comparison between present and former water conditions is of interest. The re-establishment of the gauging station in 1940 permits records of river and lake levels obtained during recent years to be converted into approximate terms of river flow. A preliminary examination of the data available for the period 1934-41 appears to lend some support to the view that conditions have become more extreme in recent years. The mean summer flow has certainly been lower than in the former period. It is impossible at present to assess all the meteorological and other conditions affecting summer flow. It may be stated with confidence, however, that seasonal changes in water level in this river system tend to be great and have been particularly extreme in a number of recent years.

The ill effects of both floods and drouths are very 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. The lethal effects of this process are well known and have been observed in the Cowichan river.

Destruction of eggs and young fish through reduction of the run-off is heavy. In the main river the areas most affected are in the neighbourhood of Sahtlam and from Duncan to tide water. 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 confined to fish hatched in the areas where pools are formed by recession of the water. Cohoes hatched and marked in streams near the outlet of the lake have been found trapped in pools twenty to twenty-five miles down the river. The species principally affected by the drying up of the main river are coho salmon and chum salmon, with a smaller proportion of spring salmon and steelheads. Serious mortality of cutthroats and brown trout undoubtedly occurs in the smaller streams.

In the last few years much salvage work has been done by the Department of Fisheries, trapped fish being released by seining them in the pools or by digging channels and driving them out. 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 number salvaged in 1938 would more than supply the probable catch of cohoes during one season of fishing in Cowichan bay and a winter of steelhead fishing in the Cowichan river. 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. In May, 1941 a rather unusual rise in water level undoubtedly released a good many fish without human assistance.

In addition to the direct 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 rubbly 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.

Temperatures

The mean daily temperature of the river, based on twice a day readings over a period of about four years in the Hatchery pool, ranges from about 6°C in February to 21°C in the summer. Temperature conditions in general are much the same throughout the length of the river. Temperatures up to about 25° have been recorded on certain days and minimum temperatures lower than the figure given also occur. The highest temperatures occur for only short periods and 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 one or 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 comparison with many other streams.

The surface waters of the lake show a very similar thermal condition to the river and consequently inshore areas become very warm in summer. A well-defined thermocline exists in summer at a level between 12 metres and 20 metres deep.

FOOD SUPPLIES

Studies of the bottom fauna at representative stations in the Cowichan river and of the stomach contents of cutthroat, rainbow and brown trout have been made by Mr. C.P. Idyll and manuscript reports have been prepared. 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 yielding 1.42 grams per square foot of organisms (wet weight). In view of the nature of the bottom, however, and the scarcity of pools serving as catchment areas, availability of 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 tend to be situated in shallow water the summer temperature of which appears to be above the optimum. In general, the lake is very deep (maximum depth about 150 metres), the bottom sloping down steeply from the shore and hence providing a relatively small area of feeding grounds at intermediate depths.

CONDITION FACTORS

The relation - $\frac{(\text{weight in lbs.}) \times 100,000}{(\text{length in inches})^3}$ has frequently been used as

an index of the condition of trout and inferentially of the sufficiency or otherwise of food supplies. Undoubtedly it should be applied with caution, since factors such as temperature influence the extent to which food is available and the efficiency with which it is utilized. A condition factor of 42 is usually considered to be average.

Factors have been worked out for about 500 Cowichan fish, caught at all seasons of the year. General averages for trout over nine inches in length are as follows:

Outthroat	38.8	(+ 0.579)
Rainbow	40.8	(+ 0.411)
Brown	44.4	(+ 0.798)

Judged by this criterion, brown trout show a good average condition, rainbows and cutthroats only fair. It is perhaps noteworthy that the cutthroat, which appears to be declining in abundance, shows the lowest condition factor.

DISCUSSION

From the point of view of the original object of the investigation, i.e., the improvement of angling in these waters, further information is desirable concerning:

1. Number of fish caught annually in the Cowichan river system.
2. Migratory habits and degree of prosperity of Kamloops trout introduced into these waters.
3. The extent to which anadromous and non-sea-going steelheads represent separate stocks requiring separate measures for their conservation.

The first point is important in estimating the requirements of a well-planned stocking policy. It would appear to involve considerable patrol work in various parts of the river system. Such work would not, in itself, require scientifically trained personnel.

The second and third points would be cleared up to a considerable extent by sufficient returns of marked and tagged fish already released. The number of such records has increased during the present year and should increase rather than diminish during the immediate future. Efficient collection of records, however, depends to a considerable extent on more or less continuous encouragement of anglers and inspection of catches when possible.

The measures which could be taken for increasing the catch within the river system would fall mainly under the headings of: Hatchery plantings; Introduction of food organisms; Stream improvements.

The size and nature of trout plantings (to be made as a definite stocking policy, as distinct from the experimental plantings hitherto undertaken) should depend to a large extent on the elucidation of the three points mentioned above. If it can be shown that Kamloops trout thrive in the Cowichan river system and do not go to sea in any numbers, an annual seeding of at least 500,000 fry or an equivalent number of larger fish would be a reasonable procedure for Cowichan lake on the basis of present knowledge.

The problem of maintaining a steady level of trout production from year to year is complicated by the abundance of natural spawning grounds. Access to these cannot be effectively controlled and the annual production of fish from natural spawnings is likely to vary considerably according to physical conditions prevailing after deposition of the eggs.

With regard to the introduction of food organisms, it is felt that caution should be exercised in cases where the total effect of introductions cannot be foreseen and might not be wholly beneficial. An increase in food supplies, however, is undoubtedly desirable and no harm would be likely to result from the planting of certain small organisms which at present do not occur in the system. Such introductions might include the crustaceans Pontoporeia and Mysis in the deeper portions of the lake and one of the burrowing mayflies, Hexagenia or Ephemera, in the shallower bays and in the Hatchery pool.

With regard to the improvement of natural conditions in the smaller streams, it seems likely that reforestation will effect some amelioration in the course of time, though this process will at best be a slow one. Second growth timber is already well advanced in some areas. It would doubtless be possible by removing obstructions, damming and tree planting to improve considerably the fish production of a selected small tributary, but to show an appreciable effect on the system as a whole such work would have to be on a very large scale which would be impracticable, at least under present conditions.

There is little doubt that if at some future time the construction of a suitable dam at the lake outlet were deemed feasible, conditions in the main river could be greatly improved. By such means an increased volume of water could be maintained during the summer, as has been demonstrated by the very successful experiments on a smaller scale in California. The losses caused by rapid changes of water level could be reduced and conditions made more favourable for the production of food supplies. The benefits would apply not only to the fish desired by the angler but also, and probably even more forcibly, to the commercially valuable species of salmon.

SUMMARY

1. While the average numbers of spring and coho salmon are probably somewhat lower than formerly, good fall runs of these species still occur. The early run of spring salmon, which was formerly of appreciable size, has been greatly depleted and is now of negligible proportions. The annual coho run during the last three years is considered to have varied from roughly 30,000 to 70,000 fish. The spring salmon run is much smaller. Good runs of chum salmon also take place in the lower part of the river.
2. The extensive sport fishery carried on in Cowichan bay during the summer and fall does not appear to be an active threat to existing stocks of salmon, the number of returning fish caught in this way being probably not more than 4,000 or 5,000 cohoes and 1,500 to 2,500 springs per annum. The toll taken by Indians is not known. There is evidence that a very considerable number of Cowichan river cohoes is caught by commercial fishermen in waters outside Cowichan bay.
3. Marked fish have shown that large numbers of cohoes hatched in the Cowichan river system return to their parent river and even to a small area within the river system.

4. The return of marked fish in 1940 indicated a higher percentage survival of hatchery raised cohoes than of fish from natural spawnings.
5. Survival of cohoes from naturally spawned eggs to the time of commencement of the downstream migration in two small streams has varied from 12% to 40% in five instances.
6. The anadromous steelhead appears to have increased in numbers in recent years. Under present conditions ample protection from overfishing is probably afforded by existing regulations. The existence of a vernal run of fish, differing in some respects from the fall and winter runs, has been demonstrated.
7. The non-sea-going steelhead provides the greater part of the trout catch of the upper part of the river. It is believed that a large proportion of "rainbow trout" are racially distinct from the anadromous steelhead but that their numbers may be augmented by individual offspring from the latter type.
8. Kamloops trout, introduced in the hope of augmenting the non-sea-going population, have been recaptured in various parts of the system. Evidence is not yet conclusive regarding the degree of success attained by these plantings or as to the proportion (if any) which go to sea.
9. Cutthroat trout have declined in numbers. The decrease is ascribed mainly to summer conditions in the smaller streams which are inhabited by the younger fish. The average condition factor of older fish suggests that even after migration from the spawning streams ecological conditions may be less favourable for this species than for rainbow and brown trout.
10. The brown trout, first introduced in 1932, has established itself locally in the Cowichan river and shows excellent growth in length and weight. It has not yet become very plentiful, probably owing to factors connected with reproduction and early life history. It is not quantitatively important in anglers' catches.
11. No appreciable results have been obtained from the introduction in former years of Atlantic salmon, speckled char and lake trout. Further attempts with these species are not considered to be advisable.
12. There is a migration of rainbow and cutthroat trout from lake to river in the fall and a reverse migration in the spring and early summer. This movement includes both mature and immature fish. Considerable local movement of trout in and out of tributary streams takes place. The summer population of the river consists mainly of young fish under legal size. Brown trout do not appear to migrate extensively.
13. Seasonal changes in water levels are very great and have been accentuated in recent years. These changes have very unfavourable effects on the fish population.
14. Temperatures in the main river are favourable during a large part of the year but rise above the optimum during the latter part of the summer.
15. Food supplies, as indicated by quantitative studies of bottom fauna, are fair in the Cowichan river and definitely poor in Cowichan lake. Supplementary supplies are provided by anadromous fishes.
16. The brown trout of the Cowichan river show a high condition factor, rainbows and cutthroats a less heavy condition.
17. Certain aspects of the investigation are discussed.

PROGRAMME OF FUTURE WORK

1. Sufficient information of a general nature has been obtained to indicate the present status of each species of trout in the Cowichan river system. At the present time the data are being collected on certain trout marking experiments. On the completion of this work a management policy will be recommended.

2. A closely directed study will be made of the salmon of the Cowichan (spring, coho and chum) with particular reference to route of migration in the sea, extent of commercial exploitation and degree of return. An effort will be made to determine how much a river such as the Cowichan contributed to the commercial fishery of British Columbia and in what way it may be increased.

Certain marking programs have already been attempted and at the present time the following experiments are under way:

	<u>Brood Year</u>	<u>Mark</u>	<u>Number</u>	<u>Years of Return</u>
Spring Salmon	1937	Adipose & right ventral	25,000	1941, 1942, 1943
	1938	Both ventrals	25,525	1942 to 1944
	1939	Dorsal & left ventral	9,393	1943 to 1945
	1940	Dorsal, adipose & left ventral	19,638	1944 to 1946
Coho Salmon	1938	Adipose & both ventrals	23,544	1941
	1938	Dorsal & adipose	8,568	1941
	1939	Dorsal & left ventral	169,991	1942
	1939	Dorsal & adipose	73,678	1942

The volume of the returns from these markings and the significance of the findings will depend largely on the degree of effort expended in making recovery of the marked fish, whether caught in commercial or sport fishing or returning to the spawning stream. It is proposed to concentrate on this phase of the work in 1942 and thereafter and collect as complete data as facilities will provide.

It is further proposed that more extensive work be undertaken next year with particular reference to spring and chum salmon. Eggs of the former will be collected by stripping spawning adults and the young fry will be reared in the hatchery and ponds until large enough to mark. Chum salmon fry for marking may, it is hoped, be obtained from pools in the lower reaches of the river. Further supplies of coho may be obtained from tributary streams of the upper part of the river.