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INTRODUCTION

As a result of an appeal from the Cowichan Fish and Game Association and the Duncan Board of Trade a start was made during the past summer on a biological survey of the Cowichan river system. The work this year has been mainly of a preliminary nature.

The people of the Cowichan district are chiefly interested in the production of game fish comprising four native and two introduced species, namely rainbow (including steelhead) and cut-throat trout, coho and spring salmon, Atlantic salmon and brown trout. The people believe that these species of fish are extremely valuable as a tourist-attraction and as an inducement for wealthy anglers, retired from business, to settle in British Columbia. The residents of the district have expressed a feeling, which seems to be well-substantiated, that the number of native game fish is getting less every year. Although certain varieties appear to be more numerous at times, as in the case of the good run of steelhead last spring, nevertheless, there is, apparently, a gradually declining fishery.

To prove the existence of a downward trend by statistical methods is impossible in this instance, because the necessary data are not available for any particular district on the east coast of Vancouver island. The salmon roam so far afield, as tagging operations have shown, that the catch statistics are inextricably mingled. In the case of the trout and freshwater fisheries there has never been an adequate statistical indicator of the conditions. Consequently to look to the records, as has been done for sockeye salmon and halibut, in order to construct a clear-cut picture of the history of the situation is out of the question. The only course is to accept the statements of men who have fished in the district for the past

twenty years or more and to acknowledge for the time being at least that the total number of fish is becoming less.

If this conclusion is acknowledged then it becomes evident that the present methods of conservation are proving inadequate and that ways and means of increasing the production of game fish must be devised. Before going into this phase of the situation, however, the results of the routine, preliminary investigations including the physiographical data, the study of physical and chemical summer conditions and the qualitative survey of the food supplies carried out this year should be presented in order to serve as a background. Then, after an analysis of the existing facilities and possibilities for increasing production has been made, a concrete program of management for the district may be attempted.

Physiographical Data

The Cowichan river system may be divided into four natural divisions for the purpose of the survey:

1. Cowichan bay including the delta of the Koksilah and Cowichan rivers,
(see fig. 1).
2. Quamichan and Somenos lakes and their tributaries, (see fig. 2 and 3).
3. The main Cowichan river and its tributaries up to Cowichan lake.
4. Cowichan lake and its tributaries including Beaver, Mesachie and Bear lakes, (see figs. 4 and 5).

1. Cowichan bay was not studied but it should be included in the program of oceanographical investigation if future work is contemplated. The Koksilah river combines with the Cowichan in a many-channelled delta at tide level, but it was not included in the present investigation.

2. Quamichan and Somenos lakes are fairly typical of lakes at low elevations near the coast. They are shallow and are rapidly filling in. Logging off the neighbouring land has probably served to hasten this process by reducing the run-off, causing higher temperatures and tremendous pulses of algae result, which die and settle to the

bottom. Somenos is^s fed by several small streams throughout the year but there is no direct flow into Quamichan lake in summer. The lack of a permanent stream flowing into the latter is probably a very important factor in curtailing the production of trout, preventing a satisfactory survival from the spawning. There are a concrete dam and falls on Quamichan creek but these have been treated in a previous report and are being handled by the Fishery Department's engineers. Somenos lake is only a few feet above high tide level, while Quamichan is situated 100 feet above sea level.

3. The main Cowichan river is similar to the other east coast streams. It heads at Cowichan lake at an elevation of 540 feet and flows 22 miles to Cowichan bay, Skutza falls, with a height of 8-10 feet, are situated half way from the bay to the lake. These falls have been under the surveillance of the Fishery department for some years. Changes were made in 1921 to allow fish to pass up more easily and in 1931 a fish ladder was completed, the plan of which is appended for reference.

The Cowichan river is fairly swift throughout its entire length. The bed is composed chiefly of boulders and gravel. Logging operators used the river for log-driving for many years and the majority of the log-jams were removed. This work has been continued in recent years by the Department of Fisheries and there is some question as to the desirability of the practice, since log-jams favour the production of deep pools which are already at a premium in the river.

Between Duncan and Lake Cowichan there are very few tributary streams of importance. The run-off in them has probably become more seasonal in character owing to the logging off of the timber and the extensive forest fires which have occurred in this section. The flow of the hatchery water supply obtained from Oliver creek is typical of the section. It becomes reduced to a very small volume in August and September.

The average monthly run-off depth in inches, from the Cowichan lake drainage area is given in fig. 1. The figure shows the characteristic summer drought which occurs

in the east coast area. The autumn rains are accompanied by a tremendous increase in the run-off and this in turn coincides with the spawning runs of Pacific salmon and sea-run trout.

In January and early February the precipitation becomes partly bound in the form of snow and the run-off decreases somewhat but it increases again in March and this coincides with the runs of lake-resident trout (spring spawners) into the tributaries of Cowichan lake.

4. Cowichan lake covers an area of 24 sq. mi. and the area of the drainage basin is about 235 sq. mi. Near the outlet there are 3 small shallow lakes. Mesachie lake drains into Bear lake which in turn flows into Cowichan lake after receiving one of the main tributaries of the watershed, namely, Robertson river. Beaver lake drains into Cowichan river near the outlet of Cowichan lake. There are eight important tributaries in all draining into Cowichan lake. All are practically of a swift, mountainous character with a short stretch just above the level of the lake at a lower grade. This portion often goes dry during severe summer droughts and there is a tendency for the upper reaches to become a series of pools. This characteristic is an important consideration in developing the management policy and should be more thoroughly investigated next year.

Cowichan lake is very deep. Depths of over 600 feet are reported but the deepest sounding encountered in the lower part was about 90 metres (300 feet). The lake should be investigated next year.

Physical and Chemical Conditions

In order to obtain data with respect to summer conditions a series of temperature readings and water samples was taken in Quamichan, Somenos and Cowichan lakes. In each instance a sampling station was established over the deepest portion of the lake and the samples were taken in a vertical series extending from the bottom to the surface. The results obtained from the analyses of the samples are given in the tables, (tables 1, 2 and 3).

An unusual condition was found to exist in both the two smaller lakes examined. In each case there was associated with a high water temperature a complete lack of dissolved oxygen in the lower layers of water. The upper layers, however, within two or three metres of the surface contained an abundance of dissolved oxygen. The surface water of Quamichan lake was even super-saturated with oxygen due to the photosynthetic activity of large quantities of floating plant life. The fact that the lake bottom in both instances supported a thick layer of decaying organic matter suggested that the state of oxygen depletion might have been produced by processes of disintegration.

Cowichan lake being a much larger body of water exhibited a more typical set of conditions. Water samples taken at a station located near the lower end of the lake and over one of the deepest portions (see Map fig. 5) showed the presence of a well defined thermocline, fig. 7. The waters above and below this transition zone supported an abundance of dissolved oxygen at all depths.

The existence of such a deep layer of warm water at the surface of Cowichan lake probably determines the distribution of the game fish during the major part of the summer.

TABLE I

Quamichan lake, August 22, 1934

Depth	Temperature	Oxygen per litre	Saturation	pH
0 metres	23.1 ^o C.	8.09 c.c.	130%	8.5
4 "	- - -	5.73 c.c.	88%	- -
8 "	19.2 ^o C.	0	0	7.0

TABLE 2

Somenos lake, August 29, 1934

Depth	Temperature	Oxygen per litre	Saturation	pH
0 metres	23.0 ^o C.	5.58 c.c.	89%	8.8
2.5 "	21.6 ^o C.	4.94 c.c.	77%	- -
4 "	21.5 ^o C.	0	0	---
6 "	19.0 ^o C.	0	0	- -

TABLE 3

Cowichan lake, September 11, 1934

Depth	Temperature	Oxygen, per litre	Saturation	pH
0 metres	19.1 ^o C.	5.26 c.c.	78%	7.4
10 "	19.1 ^o C.	- - -	- -	- -
15 "	19.1 ^o C.	- - -	- -	- -
17.5 "	15.5 ^o C.	- - -	- -	- -
20 "	13.0 ^o C.	- - -	- -	- -
22 "	11.6 ^o C.	5.85 c.c.	74%	7.1
30 "	7.8 ^o C.	- - -	- -	- -
50 "	7.0 ^o C.	5.81 c.c.	66%	7.0
80 "	5.6 ^o C.	5.81 c.c.	65	6.95

Biological Conditions

Water Plants

Since the bed of Cowichan river is so rocky and the water so swiftly flowing few rooted aquatic plants are found along its length. The lakes, however, particularly the smaller ones, support a rich growth of plants in the shore zone. The variety of water plants was found to be small as shown by the following list:

- ← Nuphar polysepala - common water-lily;
- ✓ Scirpus robustus (?) - reed ;
- ✓ Potamogeton pusillus - water weed ;
- ✓ Ledum groenlandicum - Labrador Tea .

The reeds extend almost completely around Lake Quamichan in a thick belt of growth. Water-lilies and ²⁰Potamogeton were found only in restricted areas. The dominant growth around Somenos lake consisted of the bog plant Labrador Tea. Water-lilies and reeds formed the only other conspicuous aquatic vegetation.

Fish

The following species of salmonoid fishes have been recorded from the Cowichan watershed:

- Salmo - ^{Cutthroat trout} clarkii, ^{Steelhead trout} gairdneri, ^{Atlantic salmon} salar#, ^{Brown trout} trutta#,
- Salvelinus - ^{Char (pink salmon)} malma, ^{Arctic char (pink trout)} fontinalis.#
- Oncorhynchus - ^{Kokanee (landlocked sockeye)} nerka, ^{spring} tschawytscha, ^{choi} kisutch, ^{pink} gorbuscha, ^{chum} keta,
occasionally ^{sockeye} nerka.
- ^{Sculpin} Cottus asper and ^{Stickleback} Gasterosteus aculeatus are common and ^{cutthroat} Ameiurus nebulosus #

occurs in Somenos lake.

introduced species.

Bottom Fauna

A series of dredgings in Quamichan and Somenos lakes showed the bottom fauna to be almost entirely lacking. This absence of bottom forms is no doubt coupled with the total lack of dissolved oxygen in the lower layers of water. The organisms collected were found in the shallower parts of the lakes where there was an abundance of oxygen in the water. The bottom fauna of Quamichan lake which was typical consisted of the following forms.

HIRUDINEA

Two unidentified species were found, both few in numbers

AMPHIPODA

Hyaella azteca. This small fresh-water shrimp was found only in small numbers. Gammarus was not found.

INSECTA

Ephemera. A few May-fly nymphs were collected.

Trichoptera. Several larvae and egg-bunches were found along the shore only in a few places. None were collected away from shore.

Zygoptera. A few nymphs and adults of the genus Enallagma were found.

Anisoptera. Several species of Dragon-flies were observed and some were captured for later identification.

MOLLUSCA

GASTROPODA

Representatives of the three genera Planorbis, Lymnaea and Physa were collected. The species have not been identified.

Pelecypoda. A single individual of the genus Musculium was found. A few shells of Anodontidae (fresh-water mussels) were seen in Somenos lake.

Time did not allow an adequate investigation of the bottom fauna of Cowichan lake.

Plankton

At the time of investigation a "water bloom" was present on Lake Quamichan. In the morning before a breeze disturbed the water the bloom appeared as a slimy yellow-green scum floating on the surface of the lake. (~~See Photo~~). Later in the day the organisms making up the bloom became distributed in the upper two metre layer of water giving it a very turbid appearance. Examination of plankton samples showed that the dominant forms were two species of the blue-green alga Microcystis. A list of the organisms found is given in the Table.

No such bloom was present in near-by Somenos lake. Plankton samples from this body of water showed a more normal balance in relative numbers and a much greater variety of forms present. Organisms found are also shown in the Table.

Examination of samples taken in Cowichan lake shows forms typical of large bodies of water. Plankton organisms found are shown in the Table together with those in samples collected from the two small nearby lakes, Mesachie and Beaver. (See Map, Fig. 5).

Cowichan River System Plantion 1934

	Quamichan I. Aug. 22/34	Somenos I. Aug. 29/34	Cowichan I. Sept. 11/34	Mesachie I. Sept. 12/34	Beaver I. Sept. 12/34
<u>MYXOPHYCEAE</u>					
Microcystis aeruginosa	X	X			X
Microcystis flos-aquae	X				
Micractinium pusillum				X	
Anabaena Levanderi (?)	X	X			X
Anabaenopsis sp.	X	X		X	
Tribonema minus		X			
Hapalosiphon pumolus					X
<u>CHLOROPHYCEAE</u>					
Sphaeroszoma aubertianum				X	X
Staurastrum curvatum			X	X	X
Staurastrum paradoxum				X	
Staurastrum sp.		X			X
Eudorina elegans		X			
Micrasterias sp				X	
Pleurotaenium nodosum					X
Hyalotheca disiliens					X
Characium sp.			X		
Spirogyra sp.					X
Volvox sp.		X			
<u>DIATOMACEAE</u>					
Asterionella formosa			X		X
Tabellaria sp.					X
Fragillaria sp.			X		X

	Quamichan L.	Somenos L.	Cowichan L.	Mesachie L.	Beaver L.
<u>DIATOMACEAE</u>					
Tabellaria fenestrata		X			
Surirella sp.					X
<u>SARCODINA</u>					
Acanthocystis sp.			X		
<u>ROTIFERA</u>					
Anurea cochlearis	X	X	X	X	
Nothalca longispina		X	X	X	
Rattulus cylindricus	X	X			
Trochosphaera sp.		X			
Conochilus sp.			X		
<u>CLADOCERA</u>					
Diaphanosoma leuchtenbergianum	X	X	X	X	X
Daphnia longispina hyalina mendotae		X			
Daphnia longispina longiremis			X		X
Sida crystallina		X	X		
Bosmina obtusirostris			X		X
Polyphemus pediculus			X		
Scapholeberis mucronota			X		
Simocephalus serrulatus					X
Alona costata				X	X
Streblocerus serricaudatus				X	
<u>COPEPODA</u>					
<u>Cyclops bicuspidatus</u>	X		X	X	

	Quami chan I.	Somenos I.	Cowi chan I.	Mesachie I.	Beaver I.
<u>COPEPODA</u>					
Cyclops prasinus					X
Cyclops phaleratus		X			
Diaptomus oregonensis		X	X		
<u>OSTRACODA</u>					
Cypris sp.		X			X
<u>DINOFLLAGELLATA</u>					
Ceratium hirundinella		X			X
Dinobryon sertularia			X	X	X
<u>INSECTA</u>					
Corethra sp.	X	X			

THE MEANS OF INCREASING PRODUCTION

The Dominion Department of Fisheries has employed three chief means of increasing the production of fish in the Cowichan river. The first and most extensive has been the artificial propagation of fish at the hatchery and the introduction of new species. The second has been the attempt to increase the size of the escapement by bag limits, fishing boundaries, specified methods of fishing and closed seasons. The third has been the improvement of natural conditions through the construction of a fishway at Skutz falls and the removal of obstructions in the streams.

Artificial Propagation

Artificial propagation on the Cowichan river began about 1887 when sockeye salmon fry were brought over from the Fraser river hatchery and planted in the river. It was not until the Cowichan hatchery was constructed in 1910, however, that fish culture was employed extensively. It is not necessary for the purpose of the present discussion to go into the details of the operation of this hatchery. Between 1910 and 1933 approximately 56.5 million eggs and fry of the four native species of game fish (32 million coho, 20 million spring salmon, 2 million cut-throat and 2.5 million steelhead) were planted from the hatchery. In addition 10.5 million non-native game fish have been handled as follows, 5.5 million Atlantic salmon, 2 million cut-throat, 1.5 million Kamloops trout, 1 million eastern brook trout and 0.5 million brown trout. It should be noted that not all of these fish have been planted in the Cowichan watershed. In the case of the importations of cut-throat and Kamloops trout some have been planted from the hatchery in other bodies of water on Vancouver island and in certain years a proportion of the spring salmon and Native cut-throat was planted elsewhere. Some of the brown trout have been transferred to the Little Qualicum river.

The total cost of the hatchery has been about 160,000 dollars. It has cost on the average about 6000 dollars a year for operation and maintenance. The average cost of fish production has been about 2.40 dollars per thousand.

There is absolutely no way of checking the effectiveness of this work. The

only thing that can be said is that the fishery has declined in spite of the hatchery. Although Jaffe, Foerster and Calderwood have challenged the basic assumptions of hatchery efficiency which were laid down by Baird and Wilmot over 70 years ago it is still believed that by artificial propagation the eggs from one pair of fish are equivalent to the natural yield of about 100 pairs of parents. The principal difficulty lies in the fact that effectiveness ^{should be} ~~is~~ judged, not by the efficiency of the hatchery to produce eggs and fry, but by its ability to add to the natural production of adult fish, i.e. the harvest. It is now possible to state that production of harvestable fish at Paul lake amounts to about 3 per cent of the output of hatchery fry. Nature is capable of producing just as great a harvest except in the case when drought occurs but the efficiency is probably less than one per cent.

It is apparent that if artificial propagation is to be continued on the Cowichan river there should be a complete stock-taking of the underlying principles of hatchery operation in the light of the new data. If a certain number of fry of a certain species is being liberated each year, then the chances are that the harvest is being increased by not more than 2 per cent. The effect of this in producing an increased escapement may often be more than offset by the increased number of fishermen or in certain years by adverse conditions. It is obvious also that to ship eggs away from a stream whose production is in question as has been done in the case of native cut-throat and spring salmon is a dangerous practice.

The introduction of new species requires special consideration. The purpose of such introductions is to supply a need which has become evident through a natural deficiency or through some change in natural conditions whereby the environment has become unsuitable for the native fishes. It is obvious that such introductions should be treated experimentally.

The propagation of eastern brook trout started in 1912 and was continued until 1930. The consensus of opinion in the Cowichan district is that this species is not desirable. In British Columbia char are usually not desired if trout are available.

The importation of Kamloops trout and Cranbrook cut-throats for the Cowichan district should be placed on an experimental basis if continued at all. It does not seem to be a good policy to bring these fish down from a higher elevation where spawning occurs late in the spring, to compete with similar varieties which have had a six weeks start.

The brown trout introduction which started in 1932 should probably be suspended at the end of next year's operations until it is determined how successful the experiment has been and until the reaction of the anglers has been noted. There is evidence however, that the brown trout is fulfilling the purpose for which it was introduced, namely a summer fishery in the river. Nevertheless it is unfortunate that there will be no means of stating precisely just what effect these fish will have on other species, particularly the coho. It is possible that brown trout may be produced at the expense of the others.

The Atlantic salmon introduction has been again recommended by the people of the district, but they have expressed the opinion that the present facilities are inadequate for the purpose. The fish desired are the spring-running variety imported from Scotland by the Provincial Game Department during the past two years. The introduction is being held in abeyance this year but before any program is embarked upon it seems to be an important requirement to consider the situation carefully. In the period from 1911 to 1928 the Dominion Department of Fisheries imported and planted from the hatchery over 5 million Atlantic salmon. Less than a dozen fish have been reported by anglers, but it is possible that many may have been taken for steelheads. The mere fact that Atlantic salmon have been reported shows some merit in the attempt. On the other hand before any future introductions are made the following calculations should be considered.

1. The minimum size of a spawning run necessary to produce a self-sustaining population.

On Paul creek a small run of trout consisted of 250 pairs of trout per mile or

about 1 pair per 7 yards. The minimum density of the spawning population should be determined for Atlantic salmon on some eastern stream. Suppose that one pair per 10 yards in a river the size of the Cowichan is a minimum requirement. There are at least 10 miles of river where spawning might occur. This would make the size of the desired run about 1760 pairs or 3500 fish.

2. The number of eggs produced by each female and the total deposition of the run.

Atlantic salmon produce about 800 eggs per pound and the average weight is about 10 pounds. Each female would therefore carry about 8000 eggs. A run of 1760 females would produce about 14 million eggs.

3. The probable survival from the eggs deposition.

Under a balanced set of conditions where a run is just holding its own the mortality is greater than 99 per cent. In this case the expectation is that about 2 fish out of 8000 eggs will survive to spawn. There is every reason to believe that, in order to produce a run of 3500 fish, a seeding of 14 million eggs would be required.

4. The size of the planting necessary.

The estimate of 14 million eggs represents the potential natural seeding required. It is possible that by artificial propagation, hatchery methods and the protection afforded by ponds, this number could be considerably reduced for the original introduction. In order to arrive at the required figures it is necessary to calculate backwards from the required survival. Menzies calculated that the return from the sea of Atlantic salmon was about 3 per cent. This means that 3500 fish represent a smolt migration of about 120,000 fish. The size of a fish is the most important factor in determining its survival from predators under ordinary conditions. The average size of a smolt at migration is about 6 inches. On the basis of Embury's calculation of the expected mortality in streams 120,000 six-inch fish are produced from a planting of 200,000 three-inch fish. This in turn would re-

present the survival in nature from a planting of about 2,400,000 free-swimming fry which may be expected from an egg-collection of 2,700,000 eggs, which is approximately 20 per cent of the natural seeding.

By rearing the fry in ponds the tremendous mortality in nature might possibly be obviated. Under the present administration, however, the hatchery has produced this variety of Atlantic salmon as follows:

	No. of fish	Size	No. of fry	Percentage
1933	13,500	2 $\frac{3}{4}$ in.	74,800	18.0
1934 (Dec.)	5,500	2 $\frac{1}{2}$ in.	75,000	7.3

At Qualicum Beach ponds in 1933, 14,700 3-inch Atlantic salmon were produced from 20,000 fry showing a yield of 73 per cent.

If a yield of 70 per cent could be obtained, and it seems probable that the technique at Cowichan could be altered to approximate that employed at Qualicum Beach, then 285,700 free-swimming fry would be required. In order to provide a safe margin about 300,000 eyed eggs should be laid down at the hatchery. On the present basis with a yield less than 20%, over 1 million eggs would be required. In order to produce 200,000 three-inch fish it will cost at least 5000 dollars (25 dollars per thousand) and it will require at least 10 ponds of the type already in operation. The extra ponds will require more water than the present system can supply during the summer. It is probable that better results than have heretofore been evident would be obtained by pumping water from the main river and mixing it with the present supply. A comparison of the temperatures is shown in fig. 8. The natural food content in the water supply seems to be a very important consideration in pond culture. By pumping from the river this food supply would undoubtedly be increased.

The introduction should be carried out for at least five years. Then with special protection and possibly pond cultural work the run might be stepped up to productive proportions.

Increasing the size of the escapement

It is impossible to state from the preliminary investigation of the situation whether the restrictions on fishing are adequate or whether there will have to be a general scaling down of bag limits and increasing limitations imposed. One problem which requires immediate investigation pertains to the regulations on steelhead fishing. It should be determined, and the hatchery work could be turned in this direction, whether the migratory and non-migratory trout are derived from separate populations. This applies to both cut-throats and steelheads and is one of the most important problems to be solved before effective regulations can be enacted.

With respect to the formulation of regulations in general there is a pressing need for the investigation of the life-history of each species of game fish in the watershed.

Another question which requires immediate attention is the operation of the weirs by the Indians. The anglers report that the early run of spring salmon has been considerably reduced and that this variety has suffered more than any of the others. The cause of depletion is said to be over-fishing by the weirs. On the face of it these weirs appear to make drastic inroads on the escapement of late spring and summer run fish. Some means of eliminating these weirs could be devised. The fishing rights are held by a few families and not by the whole population of the reservation. It might be possible to purchase these rights. Even if 300 more female spring salmon were allowed to proceed up the river it would probably be equal to the production of half a million eggs in the hatchery worth 1200 dollars. It seems possible that the rights could be obtained by purchase for less than half this sum without causing ill-feeling among the Indians.

Improving Conditions.

Improving the conditions in the watershed to provide a greater survival of the fish hinges largely upon the outcome of a much more extensive investigation of the various populations.

The question of re-snagging the river and creating pools should be investigated at once. Two problems requiring attention are: the advisability of introducing a forage minnow such as the dace and the question of establishing a form of deep-water vegetation to provide shelter and increased foraging area for bottom organisms. Certain types of aquatic moss might prove suitable in the latter case.

In dry years salvaging operations might prove effective in increasing the production to a considerable extent. This problem is important in the production of fish such as the coho which spend the summer in the streams.

Many of the activities which come in this category could be handled by a fishery warden. In the past there has been too great a distinction drawn between fish cultural officers and the fishery inspectors or regulation enforcement officers and as a result field activities have been neglected. The two positions should be combined. The fishery warden could enforce the regulations in the course of his regular fish cultural work in the field. He would take as his duties the complete task of seeing that a certain watershed was kept up to a certain standard of production. He would undertake stream improvements, salvaging operations, the control of predators, handle the hatchery output and collect statistical data on the condition of his fisheries. He would undertake to make the body of water in his charge produce fish to its fullest extent, just as the Biological Board has undertaken the problem of fish production in the Kamloops lakes.

RECOMMENDATIONS

The attitude toward the conservation of the game fish resources of the Cowichan river which should be adopted is that embodied in the term, scientific management. The aim should be to bring each population into balance so that a self-sustaining spawning quota or escapement is maintained. This should come first and the fishery or harvest of the surplus should be the secondary consideration.

If it is admitted that the fishery is declining and there is apparently cause for this belief, then steps must be taken to increase production. Increasing produc-

tion in this type of water is vastly different from increasing it in lakes like Paul lake where the trout are in pure culture. There it was demonstrated that depletion had occurred but at the same time there was an abundant food supply, and it became a matter of determining an effective seeding. In the case of the Cowichan river system there is apparently no surplus supply of food, on which to draw, and the question of building up the number of fish must begin with increasing the supply of food materials. Studies of factors limiting production and life history studies must also be made in order to shape the management policy.

1. The lakes of the coast region are characterized by the absence of attached aquatic vegetation beyond the shore zone (3 feet). The richness of the alkaline interior lakes is definitely related to the presence of Chara beds which support a large population of food organisms. The introduction of a plant, such as an aquatic moss, might prove to be an important factor in increasing the production of bottom organisms. This should be investigated.
2. The forage fishes in the lakes are limited to two species the kokanee (O. nerka kennerlyi) and the stickleback, G. aculeatus. The introduction of a forage minnow, such as the dace, is recommended as a means of increasing the supply of food for large fish.
3. In the streams the supply of food organisms could be increased by constructing pools and cover. The question of re-snagging many of these streams should be considered.
4. Studies of the life history of the various varieties of game fish should be started in order to find out what factors are limiting production.
5. An intensive study of migration should be started and should include, not only tagging operations in the sea, but a systematic marking program in the river to determine where the fish go which are produced in the Cowichan river.

6. Steps should be taken to eliminate the Indian weirs as a means of building up the depleted early run of spring salmon.
7. The work of the hatchery should be directed toward definite objectives rather than the ineffectual dissipation of its efforts, on a number of projects at once.
8. If it is decided that a further attempt to introduce Atlantic salmon is desirable it should be attempted on the scale outlined in the report.
9. If the hatchery is to be used for pond cultural work it is recommended that water be pumped from the main river and mixed with the present supply.
10. It is suggested that the ponds might be placed completely under the control of the Biological Board next year in order to determine the cause of the poor survival of brown trout and Atlantic salmon and in order that a greater degree of efficiency might be attained through experimental methods.
11. It should be determined if sea-run rainbows (steelhead) and cut-throats are distinct from the non-migratory types, since the question has an important bearing on the effectiveness of the regulations. The hatchery could be operated with this objective in view and a marking program carried out.
12. In order to facilitate the studies, two counting fences should be constructed one near the sea to study the escapement of the sea-run forms and one near the lake to determine the lake component. The latter would also serve as a source for spawning fish for the hatchery work and would do away with many of the objections to gill-netting parent trout.
13. A fishery warden should be appointed for the Cowichan district to undertake the duties of scientific management as outlined in the report including improvement of natural conditions, salvaging operations, predator control, enforcement of regul-

ations and collection of statistics.

14. A system of obtaining statistics on the angling fisheries should be devised.

A lead in this regard has been taken at Paul lake, as reported in summary for 1933 and 1934, and might be extended to all types of angling. The question requires careful consideration, however, before such a system is adopted.