# Distributions of Juvenile Steelhead and Cutthroat Trout (*Salmo gairdneri* and *S. clarki clarki*) Within Streams in Southwestern British Columbia[1]

By G. F. Hartman and C. A. Gill

*Fish and Wildlife Branch*
*Fisheries Research Division, c/o Institute of Fisheries*
*University of British Columbia, Vancouver, B.C.*

## ABSTRACT

Trout were collected and identified from 66 streams or stream systems of different size and gradient. Total dissolved solids (T.D.S.) and *p*H were determined on most streams. Size and profile of streams to a large degree determined the species of trout present. Large streams, with drainage area over 130 $km^2$, were predominantly occupied by steelhead. Small streams, drainage area under 13 $km^2$, were predominantly occupied by cutthroat. Streams less than 120 $km^2$ in drainage area with steep gradients, and emptying directly into the sea, usually supported steelhead, as did large rivers. Those which dropped steeply and then levelled and ran through several miles of sloughs usually supported cutthroat. Where both species occurred, cutthroat were most often predominant in the small tributaries and headwaters, and steelhead in the lower reaches of the main stream. Stream *p*H's were usually lower in winter than in summer, but had no obvious effect on trout distribution. Many cutthroat streams had high T.D.S. readings in the lower reaches in summer and low T.D.S. readings in these areas in winter. Otherwise there were no marked differences between steelhead and cutthroat streams in terms of T.D.S.

## INTRODUCTION

The distributions of different species of fish within stream systems have been related to a number of physiographic factors, including temperature, *p*H, gradient, and size (Shelford, 1911; Thompson and Hunt, 1930; Trautman, 1942; Burton and Odum, 1945; Starmack, 1956; and Huet, 1959, 1962). Previous studies on distributions of salmonids in southwestern British Columbia (Hartman, 1965) showed that juvenile steelhead trout usually existed in close association with underyearling coho salmon along the lengths of streams. Steelhead and cutthroat trout juveniles, on the other hand, appeared to be segregated into streams of different sizes or into different areas of the same stream system.

In the present study a large number of collections of trout were made in a series of streams of different sizes and gradients in an effort to describe more fully the differences in distribution of young steelhead and cutthroat. The field work for the investigation was carried out between 1960 and 1966. Most of the data were gathered in 1964 and 1965. Stream profiles were determined and measurements of *p*H, total dissolved solids, temperature, and stream

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discharge were taken to determine if any of these factors bore an obvious relationship to the distribution of one species of trout or the other. The work is not intended to describe completely the distributional differences between the two species but is presented rather as a preliminary to a better understanding of their ecological relationships.

## STUDY AREA, MATERIALS, AND METHODS

The 66 streams sampled lie in the following regions of southwestern British Columbia: the east coast of Vancouver Island, 16 streams (Fig. 1);

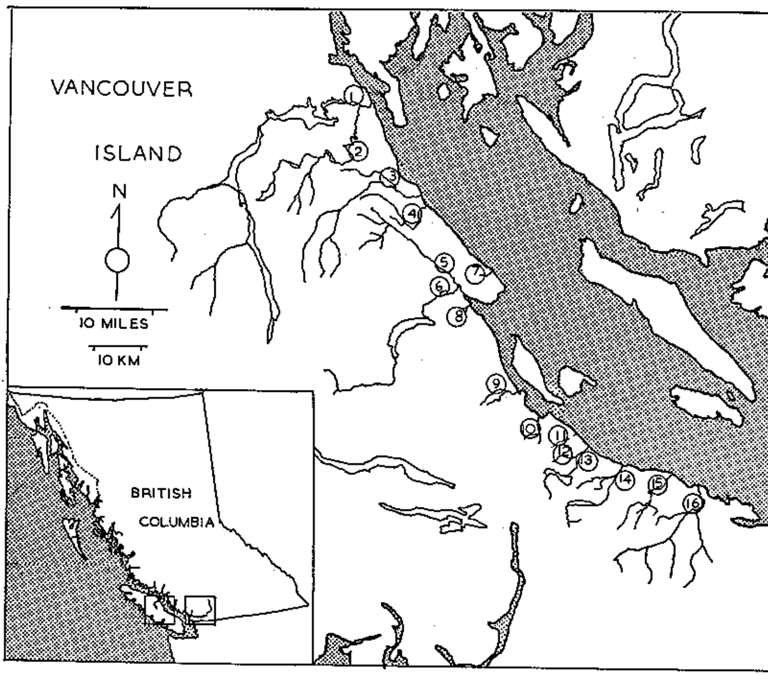


FIG. 1. Locations of streams sampled on the east side of Vancouver Island. Names of streams given in Table I (see text). Inset map shows locations of the two major sampling areas.

the Squamish area, 7 streams; and the lower Fraser Valley, 43 streams (Fig. 2). Names corresponding to stream numbers on Fig. 1 and 2, and approximate drainage areas, are given in Table I. The smaller streams are characterized by high winter and low summer discharge. The larger rivers normally have winter and summer run-off maxima, corresponding with heavy rainfall and snowmelt farther inland respectively.

Wherever access permitted, collections were made at a series of sites along the full length of each stream. Some inaccessible streams were sampled only at one location.

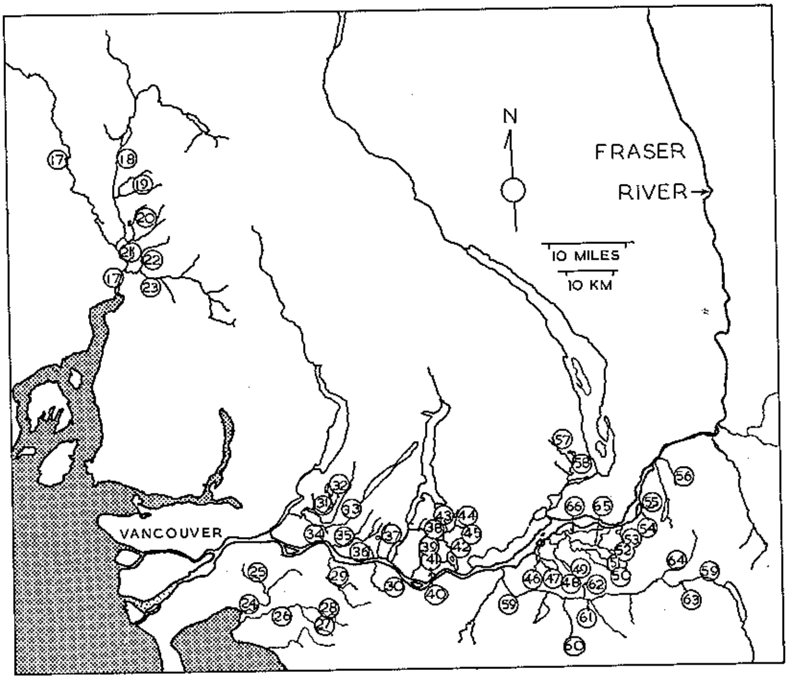


FIG. 2. Locations of streams sampled in the lower Fraser Valley and Squamish area. Names of streams given in Table I (see text).

Most collections were made with 3 × 2 m and 9 × 2 m seines with mesh size approximately 7 mm stretched mesh.

A 440 v, d-c fish shocker, Smith Root Laboratories Type IV, was used to make a limited number of collections. In situations where water depth or bottom topography prevented seining, fish were angled with No. 14 or No. 16 hooks and bait.

In many locations where streams were turbid or very turbulent, explosives were detonated in the water a few meters upstream from a positioned seine net, as described by Hartman (1965).

Measurements of *p*H were taken with a portable *p*H meter, Beckman N or E.I.L., 30C, within 1 min of the time the water sample was drawn from the stream. Total dissolved solids (T.D.S.) of stream water samples were determined in the laboratory with a conductivity bridge, Industrial Instrument R.C.7. Stream discharge data and some drainage areas were obtained from publications of Canada Department of Northern Affairs and National Resources (1960–1963). Stream discharges were estimated at collection sites by visual observations of cross section and velocity, where possible. Data on water chemistry, stream discharge, and drainage area are on file with the Fish and Wildlife Branch.

Trout were identified using six characters which were diagnostic on hatchery-reared fish of known parenthood (Hartman, MS, 1956). The characters were hyoid teeth, hyoid red pigmentation, mid-dorsal parr marks,

TABLE I. Names and drainage areas of streams shown in Fig. 1 and 2. Drainage areas with an asterisk (*) are from Water Resources Branch Papers (Canada Department of Northern Affairs and National Resources, 1960–1963). Other areas were calculated with a planimeter.

| No. | Stream | Drainage area ($km^2$) | No. | Stream | Drainage area ($km^2$) |
|---|---|---|---|---|---|
| **Fig. 1** | | | Fig. 2 (*con't*) | | |
| 1 | Campbell R. | 1461.0* | 35 | Kanaka Cr. | 55.0 |
| 2 | Quinsam R. | 277.1* | 36 | York Cr. | 5.3 |
| 3 | Oyster R. | 181.3* | 37 | Whonock Cr. | 20.0 |
| 4 | Black Cr. | 65.1 | 38 | Steelhead Cr. | 14.6 |
| 5 | Tsolum R. | 251.5* | 39 | Silverdale Cr. | 21.2 |
| 6 | Puntledge R. | 518.0* | 40 | St. Mary's Cr. | 2.5 |
| 7 | Little R. | 4.2 | 41 | Draper Cr. | 5.6 |
| 8 | Millard Cr. | 3.6 | 42 | Hatzic Sl. | 55.0 |
| 9 | Cougar Cr. | 24.0 | 43 | Legace Cr. | 5.2 |
| 10 | Chef Cr. | 21.0 | 44 | Allan L. outlet Cr. | 9.4 |
| 11 | Nile Cr. | 17.9* | 45 | Pattison Cr. | 7.3 |
| 12 | Hunts Cr. | 16.4 | 46 | Atchelitz Cr. | 7.4 |
| 13 | Big Qualicum R. | 147.6* | 47 | Luckakuck Cr. | 4.8 |
| 14 | Little Qualicum R. | 246.1* | 48 | Chilliwack Cr. | 15.2 |
| 15 | French Cr. | 73.3 | 49 | Semmihault Cr. | 8.3 |
| 16 | Englishman R. | 287.5* | 50 | Elk Cr. | 16.0 |
| | | | 51 | Ford Cr. | 8.5 |
| **Fig. 2** | | | 52 | Nevin and Dunnville cr. | 18.0 |
| 17 | Squamish R. | 1981.3* | 53 | Bridal Falls Cr. | 13.0 |
| 18 | Cheakamus R. | 813.3* | 54 | Fraser R. trib. ½ mile west of Jones Cr. | 7.0 |
| 19 | Culliton Cr. | 66.7 | 55 | Fraser R. trib. ½ mile east of Jones Cr. | 1.1 |
| 20 | Brohm Cr. | 24.5 | 56 | Lorenzetta Cr. | 35.0 |
| 21 | Schoonover Cr. | 6.2 | 57 | Sakwi Cr. | 18.6 |
| 22 | Mashiter Cr. | 46.0 | 58 | Weaver Cr. | 48.2 |
| 23 | Mamquam R. | 384.0 | 59 | Chilliwack R. | 1250.0* |
| 24 | Serpentine R. | 105.0 | 60 | Liumchen Cr. | 52.0 |
| 25 | Mahood Cr. | 19.7* | 61 | Chilliwack R. trib. ½ mile west of Tamihi Cr. | 6.0 |
| 26 | Nicomekl R. | 99.5 | 62 | Ryder Cr. | 7.3 |
| 27 | Anderson Cr. | 29.0 | 63 | Chilliwack R. trib. 5 miles east of Foley Cr. | 2.4 |
| 28 | Murray Cr. | 33.0 | 64 | Foley Cr. | 80.0 |
| 29 | Salmon R. | 83.0* | 65 | Hope Sl. | 85.7 |
| 30 | Nathan Cr. | 35.0 | 66 | Camp Sl. | 13.6 |
| 31 | Blaney Cr. | 18.9 | | | |
| 32 | Blaney Cr. (east trib.) | 2.0 | | | |
| 33 | S. Alouette R. | 205.0* | | | |
| 34 | S. Alouette R. trib. | 2.0 | | | |

maxillary length, and dorsal fin shape and color. Many trout under 1-year old, and some of those 1–2 years old, could not be classified with certainty, even though six characters were used. These fish are included in the results because of the possibility that they represent hybridization in some situations, particularly where both species are known to occur.

Stream profiles were calculated from topographic maps (British Columbia Surveys and Mapping Branch) with scales of 1:50,000 and 1:126,720. In cases where maps showed different elevations at a known point, the data were taken from the larger scale map.

Stream profiles shown (Fig. 3–7) begin at the ocean or where the stream in question enters a substantially larger tributary. Where a system consisting of two or more tributaries is shown, tributaries are placed in the horizontal scale to indicate where they enter the main stem of the system (see Salmon River, Fig. 7). If only a segment of a stream is shown (as is the case with the longer streams) the upper end of the profile is delimited with two diagonal lines.

## RESULTS

### Stream Size and Trout Distribution

The principal differences in distribution between steelhead and cutthroat juveniles related to stream size and profile. Steelhead trout appear to be adapted to large rivers or swift tributaries. In 34 of 40 collection sites on the mainstems of 13 large streams, drainage areas greater than 130 $km^2$ (50 $miles^2$), the identifiable trout were steelhead (Fig. 3). Cutthroat trout made up a minor part of the six other collections.

Cutthroat trout were found in the very small streams or in headwaters. In the 21 small streams with drainage areas up to 13 $km^2$ (5 $miles^2$), all identifiable fish were cutthroat in 24 out of 33 collections and steelhead in 5 out of 33 collections (Table I, Fig. 4–7). Both species occurred in 3 collections.

Table II, showing the numbers of streams in various drainage area categories in which one species of trout or the other or both occur, indicates that cutthroat trout are predominantly a small stream form. In the four large streams where they occurred, cutthroat made up a minor portion of the trout fauna. Steelhead occurred frequently over the range of stream sizes investigated.

### Effect of Stream Profiles

If all streams with drainage areas under 120 $km^2$ (46 $miles^2$) are considered it becomes evident that stream profile as well as size affects the trout species composition. The nine streams of this size in which all the identifiable trout were steelhead drop steeply into a large river or the ocean (Fig. 4). In those streams in which the identifiable trout were cutthroat the gradient is low to moderate (Fig. 5) or is near level and then increases sharply (Fig. 6). Eleven of these streams drain into large slough systems.

Spawning cutthroat trout enter Hope and Camp sloughs but young cutthroats were not obtained in these bodies of water. It is presumed that cutthroat spawners move through the sloughs and spawn in the steep tributaries. Figure 6 shows that cutthroat occur in streams with steep profiles. In all cases except Chef Creek, however, these streams flatten and run through an

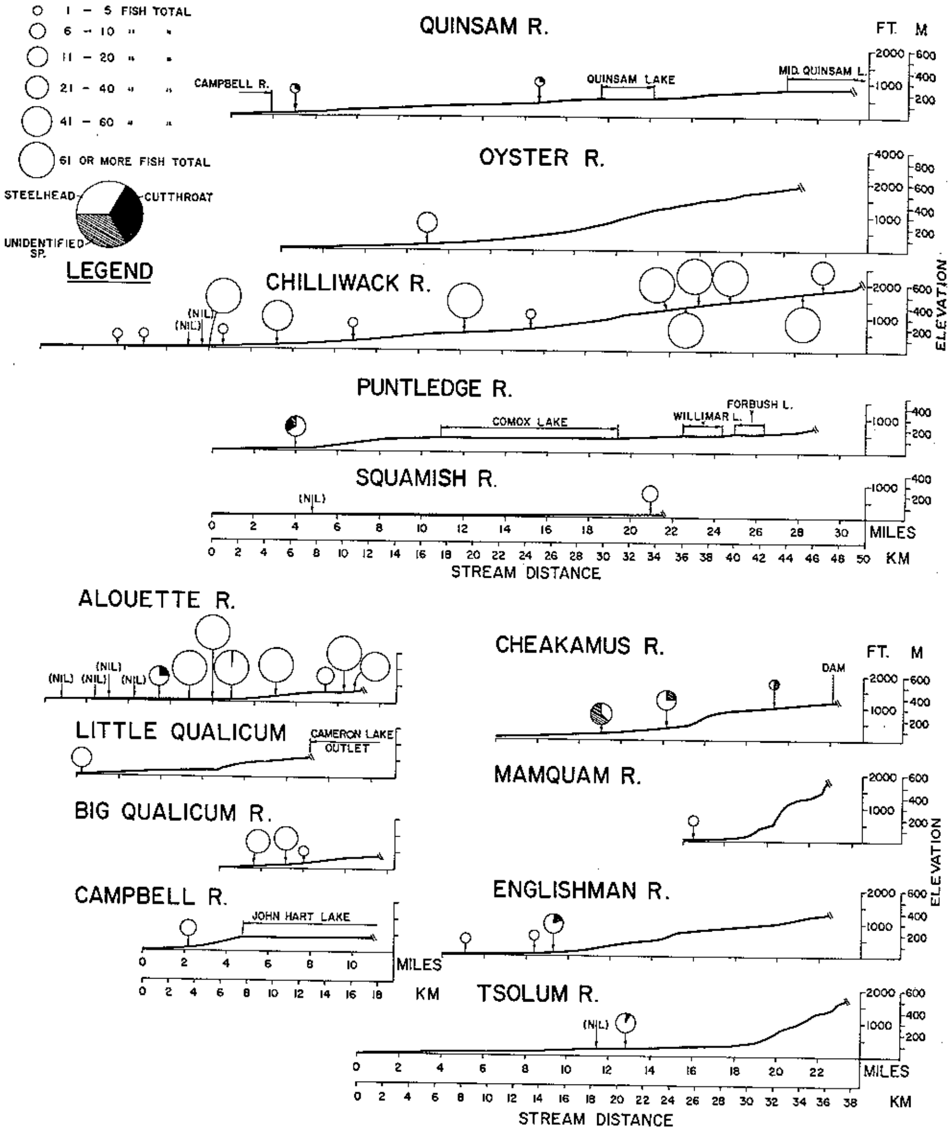


FIG. 3. Profiles of streams with drainage areas greater than 130 $km^2$, showing locations of sampling stations and sizes and compositions of trout collections. Legend showing sample sizes and composition applies to Fig. 3–7, all of which have the same scale. See text for further explanation of Fig. 3–7.

extensive area of meadowland or slough. The profiles of medium and small streams occupied by cutthroat trout are usually different than those occupied by steelhead trout. However, within either type of stream, cutthroat and steelhead trout were each generally found in riffle-pool complexes or in rocky

TABLE II. Numbers of streams of different drainage areas in which the trout sampled were cutthroat only, cutthroat and steelhead, or steelhead only.

| Stream drainage area ($km^2$) | No. of streams with: Cutthroat | Cutthroat & steelhead | Steelhead |
|---|---|---|---|
| 0–40 | 23 | 11 | 6 |
| 41–80 | 0 | 4 | 4 |
| 81–120 | 0 | 3 | 0 |
| 121–160 | 0 | 0 | 1 |
| 161–200 | 0 | 0 | 1 |
| >200 | 0 | 4[a] | 7 |

[a]Cutthroat comprised about 3 and 12% of the trout in two of the four streams and 25 and 29% in the other two.

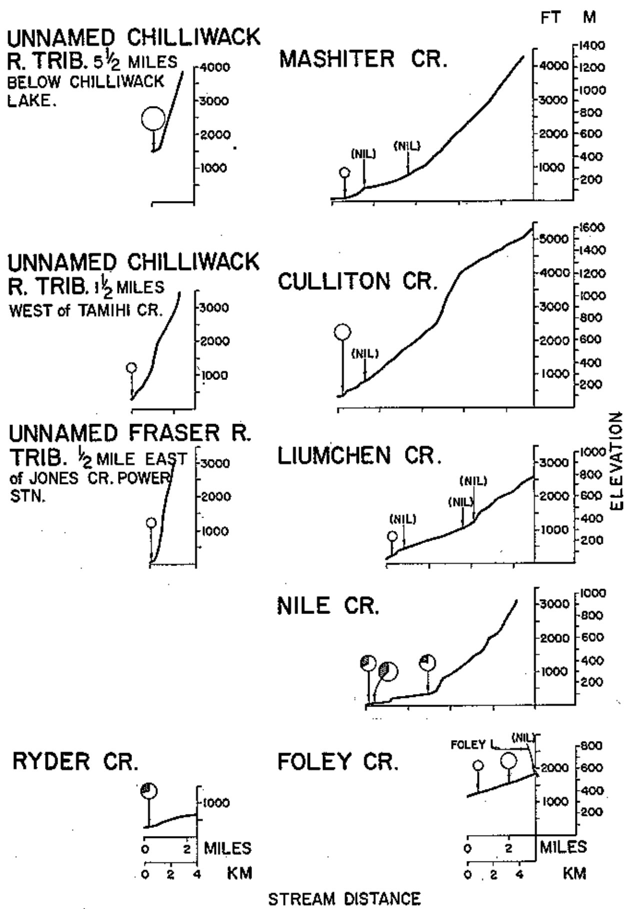


FIG. 4. Profiles of streams with drainage areas under 120 km² in in which all identifiable trout were steelhead. Sampling stations, sample size, and composition are indicated. See Fig. 3 for legend.

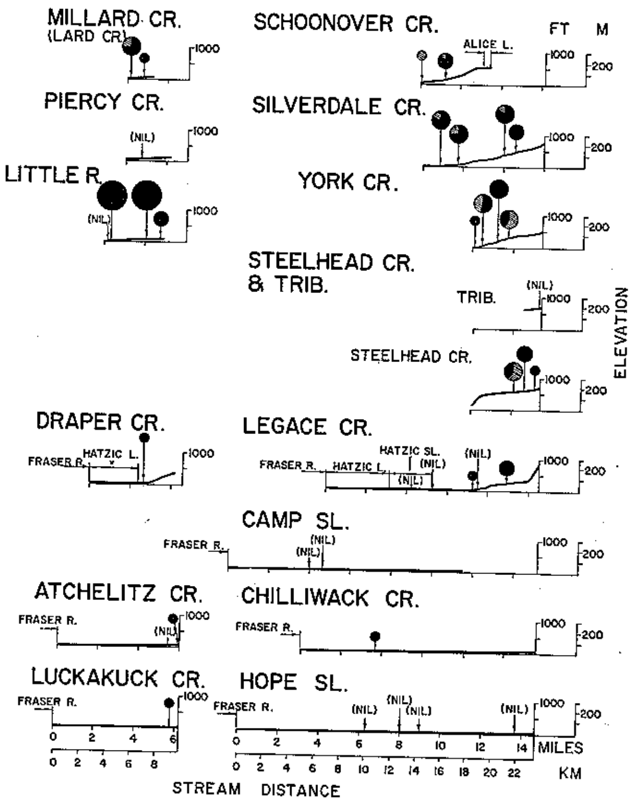


FIG. 5. Profiles of medium and low gradient streams with drainage areas under 120 km$^2$ in which all identifiable trout were cutthroat. Sampling stations, sample size, and composition are indicated. See Fig. 3 for legend.

stretches of stream. The micro-habitats of the two species appear to be similar although the major gradient characteristics of the stream they select are different.

In streams with drainage areas under 120 km$^2$ which supported both species of trout, those with relatively steep gradients, such as Cougar, Hunts, Brohm, and Weaver creeks (Fig. 7), were occupied predominantly by steelhead. On the other hand where collections were predominantly cutthroat, as in Kanaka, French, Pattison and Blaney creeks (Fig. 7), the profiles level at the downstream ends, where the creeks run through sloughs.

In the stream systems where both species occurred, cutthroat were the predominant species in upstream collections in 10 of 13 cases. Differences in distribution of steelhead and cutthroat along the length of a stream are best illustrated in the Salmon River, where trout collections were predominantly steelhead in the lower part of the main stem of the stream, and predominantly cutthroat in the upper part of the main stem and in the tributaries (Fig. 7).

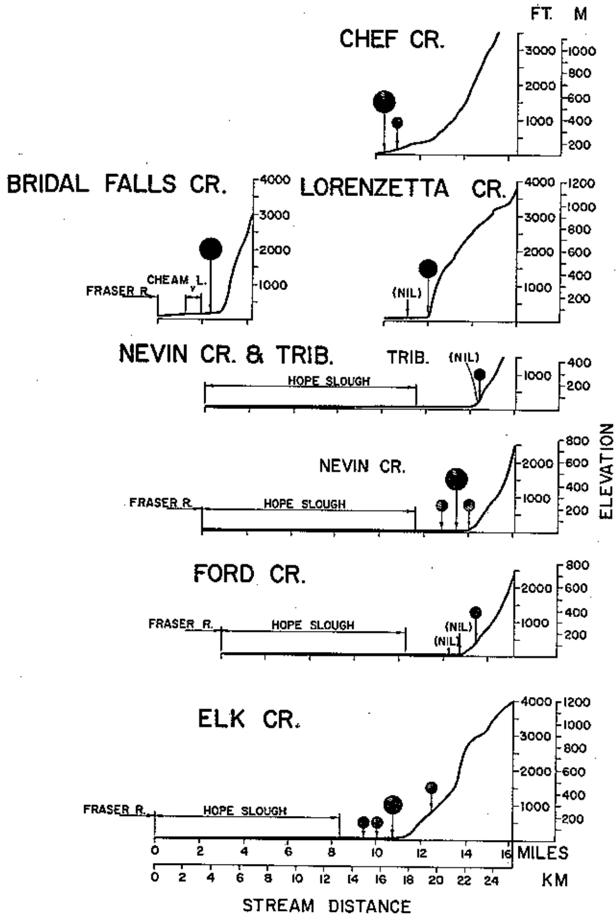


FIG. 6. Profiles of steep gradient streams which enter sloughs or level out in downstream areas. Drainage areas are under 120 km$^2$. All identifiable trout were cutthroat. Sampling stations, sample size, and composition are indicated. See Fig. 3 for legend.

## EFFECT OF *p*H AND DISSOLVED SOLIDS

Data on *p*H for the two periods (November 1 to March 31 and April 1 to October 31) are not strictly comparable because numbers of readings and stations chosen were not all replicated. However, the *p*H values were generally higher during the April to October period than from November to March (Fig. 8). In the April to October period most of the *p*H values for streams with steelhead only, cutthroat only, and the species mixed, fell within the same range. During the November to March period, streams occupied by steelhead only had a narrower range of *p*H's than those occupied by cutthroat only. However, mean values for *p*H were near 7.00 for both groups of streams. The range and mean of *p*H values for streams in which both species occurred were slightly lower than for streams which supported only one species.

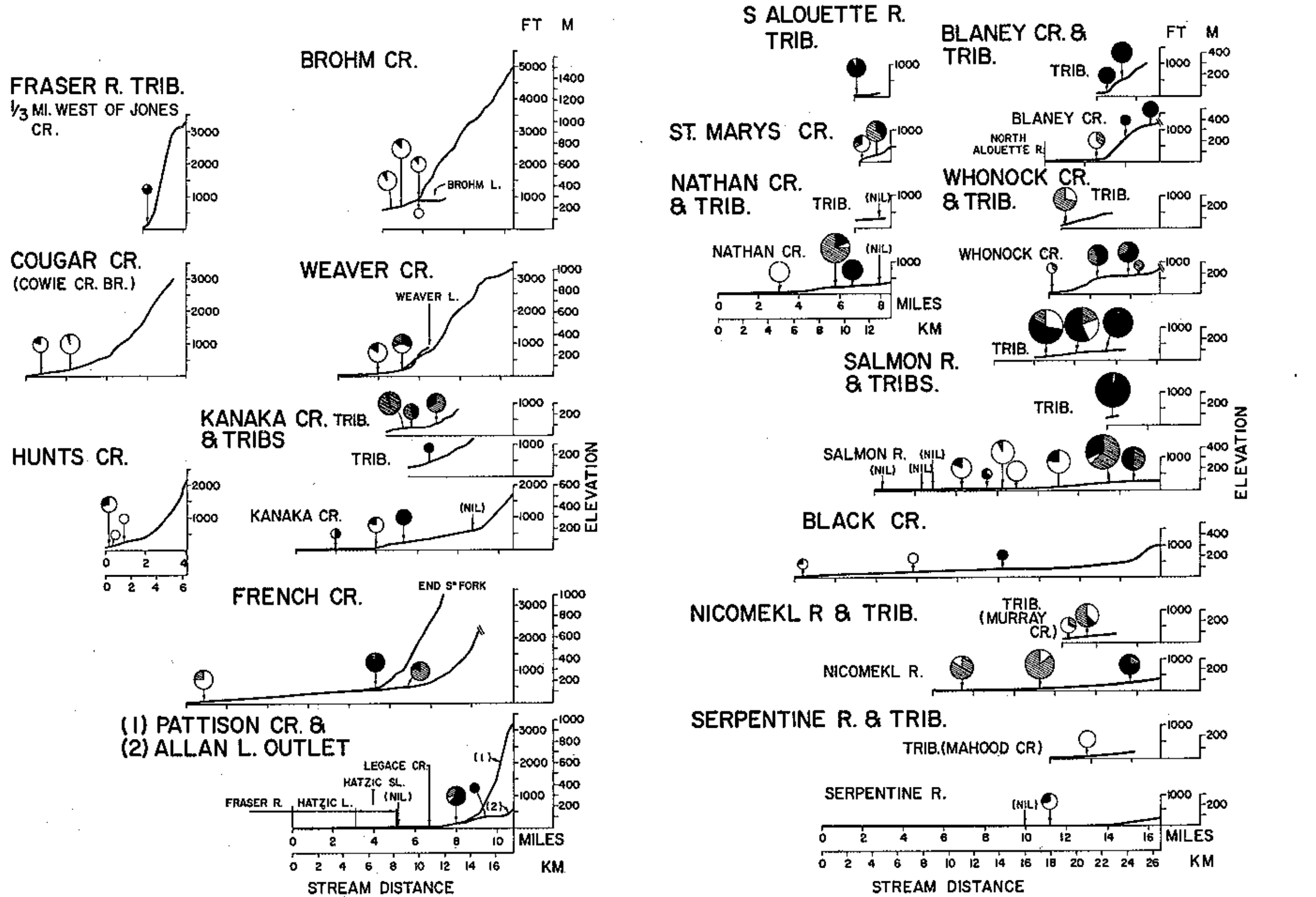


FIG. 7. Profiles of streams with drainage areas under 120 km$^2$ in which both steelhead and cutthroat occurred. Sampling stations, sample size, and composition are indicated. See *Fig. 3 for legend.*

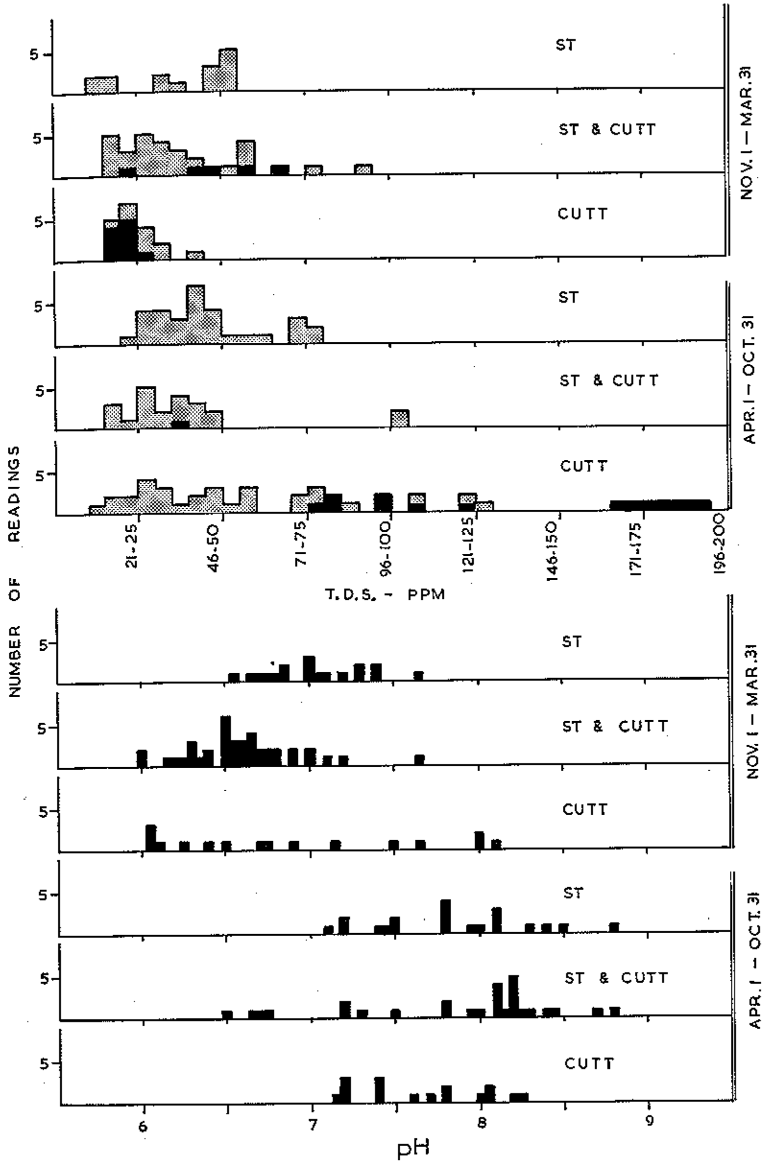


FIG. 8. Total dissolved solids and *p*H in streams with steelhead alone, both cutthroat and steelhead, and cutthroat alone. T.D.S. values indicated by black bars are from slough areas of streams.

Total dissolved solids values in the various streams ranged from 15 to 192 ppm in the April to October period and from 15 to 95 ppm in the November to March period (Fig. 8). During the November to March period virtually all the readings for streams with species both separate and mixed fell between

15 and 80 ppm. During the April to October period all the values fell between 16 and 105 ppm in the streams with steelhead alone and steelhead and cutthroat together. However, many T.D.S. readings in streams in which only cutthroat were obtained were high in the April to October period. Most of these high values were obtained in the slough areas of the cutthroat streams. Readings taken in corresponding locations in the November to March period were much lower (black bars in Fig. 8). Cutthroat streams were thus somewhat different from other streams in that their conductivity characteristics in many cases exhibited greater seasonal change. Neither *p*H or T.D.S., however, appeared to have any clear effect in limiting the distribution of either species.

## DISCUSSION

A considerable degree of variability in the types of stream occupied by *Salmo gairdneri* and *S. clarki clarki* leads to some overlap in the distribution of the two species. Whereas large and steep streams support mainly steelhead and small and level streams mainly cutthroat, both species were found in a number of streams which were intermediate in drainage area (Serpentine and Nicomekl rivers and French and Kanaka creeks, Fig. 7) or profile (Kanaka, Cougar, Weaver, and Whonock creeks, Fig. 7). In some cases steelhead enter small streams which are not characteristic of streams usually chosen by them (Blaney and St. Mary's creeks, Fig. 7).

The occurrence of cutthroat in certain streams may be related to their existence in nearby lakes in the system, e.g. Brohm Creek, Puntledge and Quinsam rivers. Cutthroat juveniles are known to move down through fish ladder facilities at the outlet of Comox Lake. This may account for their occurrence in the lower Puntledge River. Lakes in the Quinsam River system may contribute cutthroat to the river. The occurrence of cutthroat in the downstream collection in the South Alouette River (Fig. 3) is almost certainly related to their localized presence in the small tributary (Fig. 7) which enters the main river at that location. Trout sampled a few meters up the small tributary of the South Alouette River (Fig. 7) are predominantly cutthroat. In view of the foregoing, it seems likely that the occurrence of cutthroat in the large streams and in Brohm Creek represents special, though not rare, circumstances for the species.

Previous hatchery introductions as early as 1930 may have altered the distributional relationships of rainbow and cutthroat. Cutthroat were introduced into the Nicomekl, Serpentine, and Salmon rivers and Kanaka Creek in 1933, according to British Columbia Game Department records. Many fish plantings in the past have not been well documented; therefore, it is not clear to what extent past introductions of fish might affect present distributions. However, since introductions to occupied stream habitats are generally not successful, it is unlikely that the distributional characteristics of cutthroat have been seriously confounded by these plantings.

It was beyond the scope of the study to distinguish migratory and resident races of trout. But it was noted that resident populations of cutthroat occur in a tributary of Blaney Creek. Females 111–132 mm long contained eggs which were nearly mature. Small, sexually mature male trout were taken in a number of streams. Steelhead Creek, which contains cutthroat trout in abundance, is not accessible to fish from the Stave River into which it flows. Presumably Steelhead Creek fish are resident in the stream system. Sumner (1952) reports the occurrence of resident cutthroat in migrations in Sand Creek, Oregon. Neave (1949) reports coastal populations of cutthroat trout above impassable falls and in small tributaries in the Cowichan River system, indicating further the occurrence of some non-migratory forms. Neave (1949) also reports coastal populations of resident *Salmo gairdneri*. There was less evidence of residence among *S. gairdneri* in the present study: few small ripe male fish were obtained. The existence of non-migratory fish is pointed out because the role of migration in determining distribution is speculated upon later in this discussion. Although the size and age of most fish sampled suggest that the juvenile coastal trout are largely progeny of migratory forms, some distribution patterns in stream systems are more extensive because of resident forms.

The stream *p*H values did not bear obvious relationship to differences in trout distribution. The data gathered from April to October indicate that stream systems used by cutthroat have greater gradients in T.D.S. (conductivities increase greatly in meadowland and slough areas) (Fig. 8) than those used by steelhead. Although data on *p*H and conductivity do not shed light on the differences in trout distribution in this study, they should not be ruled out as having no effect. Conductivity, *p*H, and probably other features of stream limnology relate to gradient and size. Such features may differ in various stream systems, and hence affect fish, in fashions not indicated by a superficial series of measurements made over all systems.

The existence of ecological zones and specific faunistic groups within streams can be related directly and indirectly to gradient characteristics (Huet, 1959, 1962; Burton and Odum, 1945). Although many British Columbia coastal streams contain zones with different faunas, the distributions of the two species of *Salmo* do not depend only on a stream slope–breadth relation. As already pointed out, juvenile cutthroat occur as a minor species in large streams with drainage areas over 130 $km^2$ (50 $miles^2$). Within streams below this size both species occur over a wide range of stream slopes (Fig. 9).

Although the estimations of stream width are extremely rough, the data for British Columbia indicate a high slope–breadth relationship among the smaller streams. The difference between these high values and the curve given by Huet (1959) probably represents a difference between local trout (steelhead and cutthroat) and brown trout as well as a difference in topography.

The micro-habitats in which *Salmo gairdneri* and *S. clarki* are found are very similar; these areas include pools, gravel riffles and runs, rocky turbulent stretches and plunge pools in white water torrent areas. In many streams the

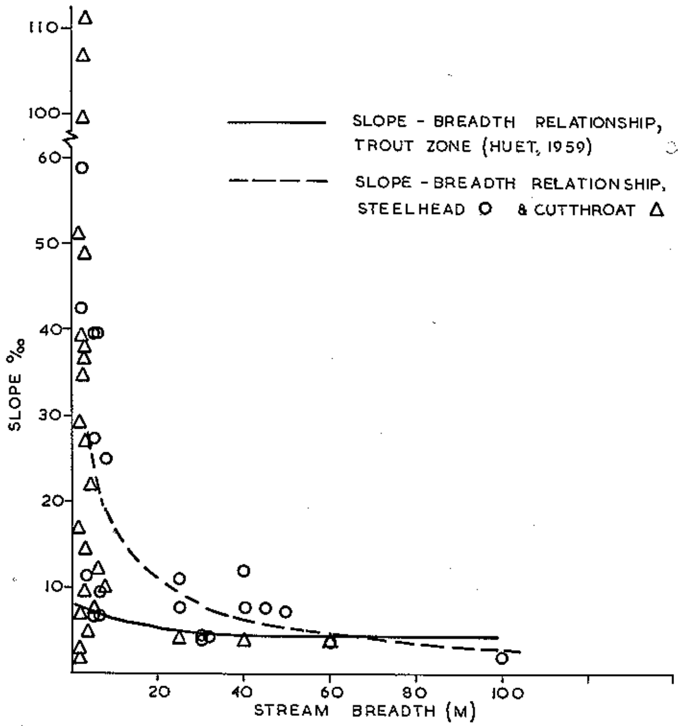


FIG. 9. Approximate relationship between stream gradient and breadth in British Columbia coastal trout streams and in the trout (*Salmo trutta*) zone of western European streams. Data for steelhead and cutthroat are for streams both above and below 130 $km^2$ in drainage area.

differences in species composition appear to be related to stream conditions below the areas where the fish occur. Such a situation leads to the speculation that differences in juvenile trout distribution may be related directly to differences in the migratory patterns of adults. Adult cutthroat trout presumably enter slough systems, slow-moving streams in meadowland areas, and small tributaries. The much larger adult steelhead, on the other hand, remain in larger streams or enter preferably into fast-flowing tributaries. At present, little comparative information on the migratory responses of the two species is available to support or contradict the idea that differences exist in their migratory behavior or choice of spawning areas.

Although sample sizes were small in some streams and collections were not numerous in others, the evidence that is available strongly indicates that stream size and profile affect trout distribution either directly or indirectly.

The implications of differences in distribution of juvenile steelhead and cutthroat trout in management are significant. In general the small cutthroat streams which run through farmland or sloughs are vulnerable to relocation, straightening, obstruction, and pollution. Fish habitat in the steeper regions of the streams may be destroyed by scouring and debris accumulation as a result of logging activities over a small area of the watershed. Steelhead trout growing in small streams are vulnerable to the same influences as cutthroat. Many steelhead trout, however, dwell in larger rivers, which are less susceptible to local influence or destruction.

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