Aspects of the Winter Ecology of Juvenile Coho Salmon (*Oncorhynchus kisutch*) and Steelhead Trout (*Salmo gairdneri*)

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The major physical characteristics of overwintering areas for juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*) are described for a small, unlogged, west coast Vancouver Island stream. During the winter months age I+ coho and steelhead were found at a range of depths mainly greater than 45 cm and in deeper water than age 0 of either species. About 45% of age 0 steelhead observed were in water <15 cm deep. The depth occupied by coho and age I+ steelhead was negatively correlated with water temperature below 8.5 C. Coho were associated less closely with the bottom than were steelhead. At 7 C or less most fish were associated with water velocities of <15 cm/s. Velocities in which steelhead occurred were positively correlated with rising temperature above 4 C. As water temperature decreased from 9 to 2 C, coho and steelhead moved closer to cover. Cover used by coho and age I+ steelhead most frequently was logs and upturned tree roots, although debris accumulations and overhanging banks were also used. Both age-groups of coho used overhanging brush but steelhead did not. Over 50% of age 0 steelhead were associated with rocks 10–25 cm in diameter. Sidepools and quiet back channels that contained water only in the winter and that had combinations of the above cover types were populated by coho during the winter. A series of unused beaver ponds, dry in the summer, was an important overwintering area for coho with a survival rate about twice as high as the 35% estimated for the entire stream system.

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Nous décrivons les principaux caractères physiques des aires d'hivernage de jeunes saumons coho (*Oncorhynchus kisutch*) et truites steelhead (*Salmo gairdneri*) dans un petit cours d'eau, libre d'exploitation forestière, de la côte occidentale de l'île Vancouver. Pendant les mois d'hiver, les saumons coho et truites steelhead d'âge I+ se trouvent surtout à des profondeurs dépassant 45 cm et en eau plus profonde que les poissons d'âge 0 de l'une ou l'autre espèce. Environ 45% des truites steelhead d'âge 0 observées se trouvent à des profondeurs de <15 cm. La profondeur occupée par les saumons coho et par les truites steelhead d'âge I+ est en relation inverse de la température de l'eau au-dessous de 8.5 C. Les saumons coho sont moins étroitement associés au fond que ne le sont les truites steelhead. A 7 C ou moins, la plupart des poissons se trouvent dans des courants de <15 cm/s. Les vitesses où se rencontrent les truites steelhead sont en relation directe d'une température ascendante au-delà de 4 C. A mesure que la température diminue de 9 à 2 C, les saumons et les truites se rapprochent d'un abri. Les abris le plus souvent utilisés par les saumons coho et les truites steelhead d'âge I+ sont des billots ou des racines d'arbre renversé, alors que des tas de débris et des berges en surplomb sont également utilisés. Les deux groupes d'âge de saumons coho utilisent la brousse qui surplombe, mais il n'en est pas ainsi de la truite steelhead. Plus de 50% des truites steelhead d'âge 0 sont associées à des roches de 10–25 cm de diamètre. Les fosses latérales et les chenaux de retour tranquilles contenant de l'eau seulement en hiver et combinant les mêmes types d'abri que ci-haut sont peuplés par le

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saumon coho en hiver. Une série d'étangs de castors abandonnés, à sec en été, sont une aire d'hivernage importante pour le saumon coho, avec un taux de survie d'environ le double du 35% estimé pour le réseau entier du cours d'eau.

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IN coastal British Columbia juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead (*Salmo gairdneri*) reside in streams for 1 or more years before migrating to sea. Much of this time in the stream is spent during the winter when physical conditions are severe. At this time salmonid nursery streams are characterized by low water temperatures accompanied by snow, ice, or severe freshets. Injury or death can result from inadequate nutrition (Hunt 1969; Reimers 1963), severe streamflow fluctuations causing scouring and displacement (Elwood and Waters 1969), collapsing snow (Needham and Jones 1959), or predation (Elson 1962). Important questions are, how do juvenile salmonids adapt to these hostile winter conditions, and how might man's activities, particularly timber harvesting, affect these overwintering fish?

In some streams the major factor limiting coho production may be the amount of adequate overwintering habitat rather than living space in low summer flow (Mason 1974). Some preliminary underwater observations by us in several small coastal streams during 1972 supported conclusions by Hartman (1965) and Everest (1969) that young salmonids occupy different habitats in the winter than in the summer, and that log jams and rubble provide important winter cover.

The objectives of this study were:

1) To describe quantitatively some of the major physical characteristics of overwintering areas in a coho and steelhead nursery stream.

2) To evaluate the role of a small tributary of this nursery stream in providing winter refuge for young coho.

Study Area

Carnation Creek, a small coastal British Columbia coho and trout nursery stream, and one of its tributaries (750 Creek), was studied (Fig. 1). The Carnation Creek watershed is approximately 10 km^2 and drains into Barkley Sound on the west coast of Vancouver Island. It is the site of a long-term study examining the effects of timber harvesting on salmonid production (Anon. 1974). The watershed consists of an unlogged, overmature western hemlock (*Tsuga heterophylla*), amabalis fir (*Abies amabalis*), and western red cedar (*Thuja plicata*) forest with Sitka spruce (*Picea sitchensis*), red alder (*Alnus rubra*), salmonberry (*Rubus spectablis*), and stink currant (*Ribes bracteosum*) common along the streams.

The watershed is in a region of high annual precipitation (275–450 cm), with most of it occurring as rainfall between October and April. Although streamflow ranged from 0.03 m^3/s (1 cfs) during late summer to 29 m^3/s (1000 cfs) during peak winter freshets, violent fluctuations within short time periods are characteristic of streamflow during autumn, winter, and spring.

Water temperatures in Carnation Creek reach a maximum of 13.5 C in the late summer and drop to near 1 C for short periods during the winter. Some surface ice forms in back channels during the coldest periods, and water temperatures remain less than 6 C from December through April.

The section of Carnation Creek that was examined in this study drops approximately 60 m in the lowest 2.5 km. The substrate, ranging from sand to 30 cm rubble, consists predominantly of rocks 2–15 cm in diameter. Extensive gravel bars suggest that considerable substrate movement occurs during freshets. Wind-felled trees with upturned roots, overhanging banks, and small accumulations of debris are common throughout the study area.

A tributary, 750 Creek, enters Carnation Creek 750 m above the head of tide and consists of a series of interconnected, mud-bottomed pools formed behind old, deserted beaver dams. It drains an area of approximately 14 ha. Winter flows are generally less than 0.03 m^3/s (1 cfs), but may range as high as 0.2 m^3/s (7 cfs) during freshets. The lowest 100 m of the creek is utilized by young salmonids at higher flows but is dry during the late summer. Adjacent vegetation consists primarily of western hemlock, and a dense understory of salmonberry, and tall blue huckleberry (*Vaccinium ovalifolium*).

The lowest 3.5 km of Carnation Creek is accessible to anadromous fish, and is utilized by coho and chum (*O. keta*) salmon, steelhead and cutthroat trout (*S. clarki*) as well as resident populations of two species of sculpins (*Cottus aleuticus* and *C. asper*). The upper section of the stream supports a population of resident cutthroat trout. Coho reside in the stream 1 or 2 yr and steelhead 2–4 yr (mainly 3) before migrating to the ocean (Narver and Andersen 1974). In this paper age 0 refers to fish of the year (fry) and age I+ are fish in their second year of life (yearlings) or older.

Some winter snorkle observations were also made in the Sarita River and Ritherdon Creek both adjacent to Carnation Creek (Fig. 1) and in Paton Creek, a tributary of the Seymour River near Vancouver, B.C.

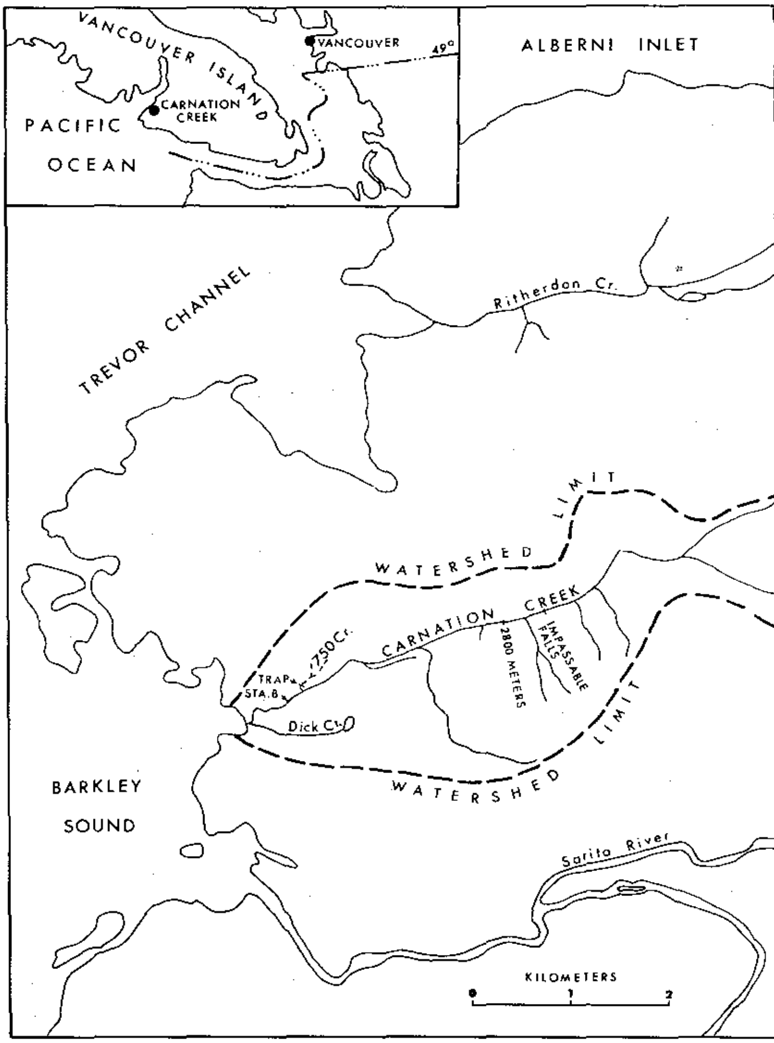

FIG. 1. Location of the Carnation Creek watershed and study sections (Scale: 1:50,000).

Methods

Coho and steelhead microhabitat information was collected by making observations while snorkeling with wet suit and face mask in the lowest 2800 m of Carnation Creek from September 1972 to April 1973. An observer entered the water and carefully worked upstream until an undisturbed fish or aggregations of fish were observed. Often the observer was on or near the bottom when observations of fish were made. In deeper water the observer was floating but observations were made from 3 to 6 m downstream. An underwater light was used for searching in log jams and other poorly lighted areas. A metal rod was used to overturn rocks and probe for fish within the substrate. Fish were visually separated by species and age-group (0 and I+). Observations were made between 1000 and 1600 and were restricted by fast currents and poor visibility to streamflows less than 3 m^3/s (105 cfs).

After an individual fish was observed for 1–5 min, its most frequent location or focal point (Wickham 1967) was marked with a lead weight. Coho were often found in close aggregations and a count of the number of fish in the aggregation was obtained. Water depth, velocity, size of substrate material, distance to suitable cover, and type of cover was recorded for each observation. A metal rod marked in

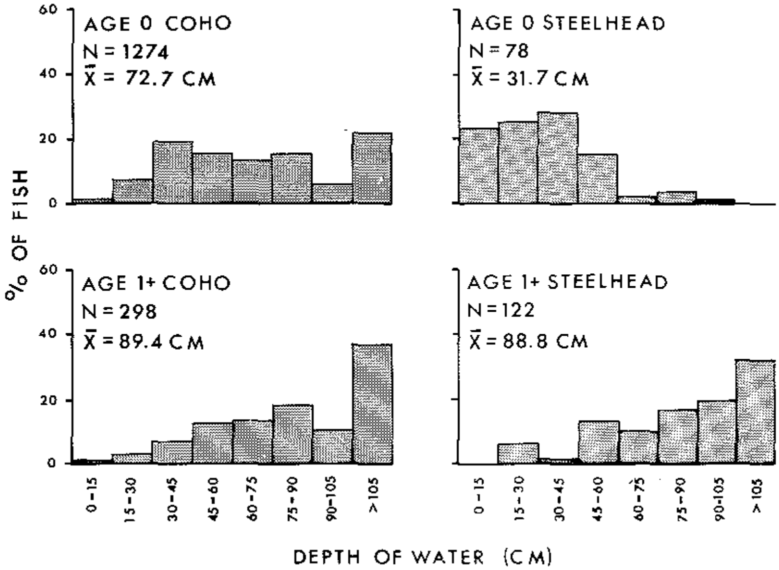

FIG. 2. Depth of water selected by juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*) at water temperatures of 7 C or less.

centimeter intervals was used for measuring water depth, cover distance, and substrate size. Water velocities, both focal point and maximum area (within 0.3 m of the point of observation for age 0 fish and 0.6 m for age I+ fish), were measured to the nearest centimeter per second with Midget Bentzel current speed tubes (Everest 1967). These instruments were suitable for measuring currents between 15 and 120 cm/s. Stream discharge (weir measurements) and water temperatures (recording thermograph) were obtained at the beginning and end of each observation period from a permanent hydrological installation maintained at Station B (Fig. 1). Upturned tree roots, logs, overhanging banks with and without roots, overhanging brush, debris (i.e. small, temporary accumulations of branches and snags), rubble, and turbulent surface water constituted potential areas of cover. Fish more than 2 m from cover were assigned to a "no cover" category.

Snorkeling has been used by other workers while examining young salmonid distribution in relation to their habitat (Hartman 1965; Edmundson et al. 1968; Everest 1969; Griffith 1972). A major difference in making summer and winter snorkel observations was the greater tendency for fish in the winter to flee an approaching swimmer. This pronounced fright reaction necessitated very slow, careful movements when approaching fish. Juvenile fish during the summer are usually more aggressive, less easily frightened, and therefore easier to observe. In the winter, hiding fish tend to seek the darkest areas available, twisting behind roots and taking on the color of their surroundings, making them difficult to find. Observations are also limited by high flows and associated turbidities. Finally, when water temperatures are less than 4 C, an observer in a wet suit experiences severe cold, sometimes after less than ½ h in the stream.

A trapping system near the outlet of 750 Creek (Fig. 1) measured upstream and downstream fish movements. A wire mesh (6 mm) fence diverted upstream and downstream migrants into small fyke traps. Rocks were placed in the traps to provide escape cover for the smaller fish. The traps were checked daily. All fish were anesthetized, fork length was recorded, and after recovery fish were released in the direction indicated by their capture.

Results

Coho were more common than steelhead in the study section; observations were made on 1311 age 0 and 351 age I+ coho, and 122 age 0 and 167 age I+ steelhead.

WATER DEPTH AND VELOCITY

There were major differences in the mean depths of water (surface to bottom) occupied by juvenile coho and steelhead during the winter (Fig. 2). Age 0 coho were found in a wide range of depths greater than 15 cm. Age I+ coho and steelhead also occupied a variety of depths, but favored significantly deeper water than age 0 coho (t-test, $P < .01$). Age 0 steelhead were strongly associated with shallow water, often in less than 15 cm. A

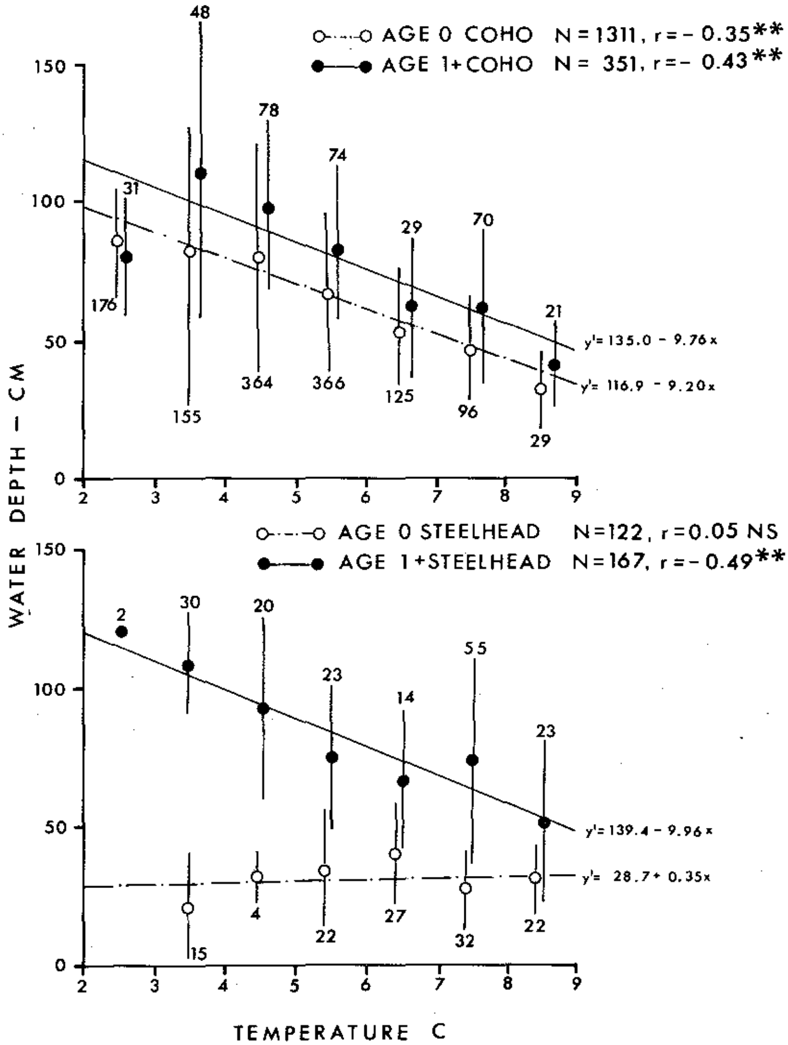

FIG. 3. Mean depth of water in which coho and steelhead were observed related to stream temperatures at time of observation. Vertical lines represent standard deviations and associated numbers are sample sizes. Regression lines were derived from N observations.

number of fry were found under rocks in water less than 5 cm deep.

Significant negative correlations ($P < .01$) were found between water temperatures below 8.5 C and water depth occupied by coho and age I+ steelhead (Fig. 3), indicating that as water temperatures drop in the late autumn and early winter these fish tend to move into deeper water. No significant correlation existed for the age 0 steelhead.

Coho usually associated less closely with the stream bottom than steelhead; their average distance from the stream bottom was 25 and 27 cm for age 0 and age I+ coho, respectively. The average distance above the stream bottom was 5 cm for age 0 and 12 cm for age I+ steelhead.

At low water temperatures 78–87% of all fish were found in focal point velocities of less than 15 cm/s (Table 1). Similarly 58–78% of the fish were in maximum area velocities less than 15 cm/s (Table 1).

For age 0 and I+ steelhead, focal point and maximum velocities in surrounding areas increased significantly with rising temperature above 4 C

TABLE 1. Breakdown into velocity categories of focal point and maximum area water velocities selected by juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*) at water temperatures of 7 C or less expressed as a percentage of all observations.

	Coho		Steelhead	
Age	0	I+	0	I+
Sample size	1272	298	78	122
	Focal point velocities			
Velocity (cm/s)				
0–15	86.8	84.7	87.1	78.0
15–30	13.1	14.7	11.6	22.0
30–45	0.1	0.6	1.3	0
>45	0	0	0	0
	Maximum area velocities[a]			
0–15	77.8	66.4	57.6	62.7
15–30	18.3	21.8	26.9	16.9
30–45	3.8	8.0	9.0	11.8
>45	0.1	3.8	6.5	8.5

[a]Refers to the maximum water velocity within 0.3 m for age 0 fish and within 0.6 m for age I+ fish.

(Fig. 4). Only measurements taken during moderate streamflows (0.3–0.7 m^3/s) are included because of apparent variability in fish activity relating to very low or high flows. The scatter around these means is very broad. These mean velocities do not represent the true mean velocities; because the current meters were of low sensitivity, velocities less than 15 cm/s were recorded as nil. Thus results should be used to indicate general relationships rather than actual values. No significant relationship between water velocity occupied by coho and water temperature was indicated other than at water temperatures less than 4 C when the mean water velocities selected by coho were between 0 and 15 cm/s.

WINTER COVER SELECTION

As water temperature decreased from 9 to 2 C, coho and steelhead moved closer to objects providing cover (Fig. 5). The observations were broadly scattered around the means. When water temperatures became low (usually accompanied by low water), feeding activity was reduced, and nearly all fish were found either within or very near cover (Fig. 6). These fish were heavily pigmented and strongly photonegative.

Upturned tree roots and logs were the most common type of cover used by both age-groups of coho and by age I+ steelhead (Fig. 7). Deep pools were often formed around these roots and logs, and the combination of deep, slow water and good cover made these sections of the stream important wintering areas, particularly for the older fish. Overhanging banks and debris such as branches and small snags were also used as cover. However, only those overhanging banks that had an associated complex of dense roots were utilized. Flooded brush such as salmonberry and stink currant provided some cover for coho, especially in backwater pools and tributary areas.

Sidepools combining a number of cover types described in Fig. 7 provided coho refuge from severe winter freshets. For example, in early January 1973 we electrofished a sidepool (approximately 10 m^2 with a maximum depth of 25 cm) located 50 m from the main stream and captured 54 coho which were removed. When electrofished again in early March, another 20 coho were found. During the summer this pool is dry.

Rubble was the principal source of cover for age 0 steelhead, and half of the fry observed at water temperatures of 7 C or less were either very close to or under rubble (Fig. 7). Of steelhead fry found in the rocky substrate, more than half were found under rocks less than 15 cm, and rocks as small as 10 cm provided cover as long as there were suitable interstices (Fig. 8). These overwintering sites were usually in shallow areas of low velocity near the stream margin (Fig. 8). In several instances two fry were found under the same rock.

Only four age I+ steelhead were found hiding

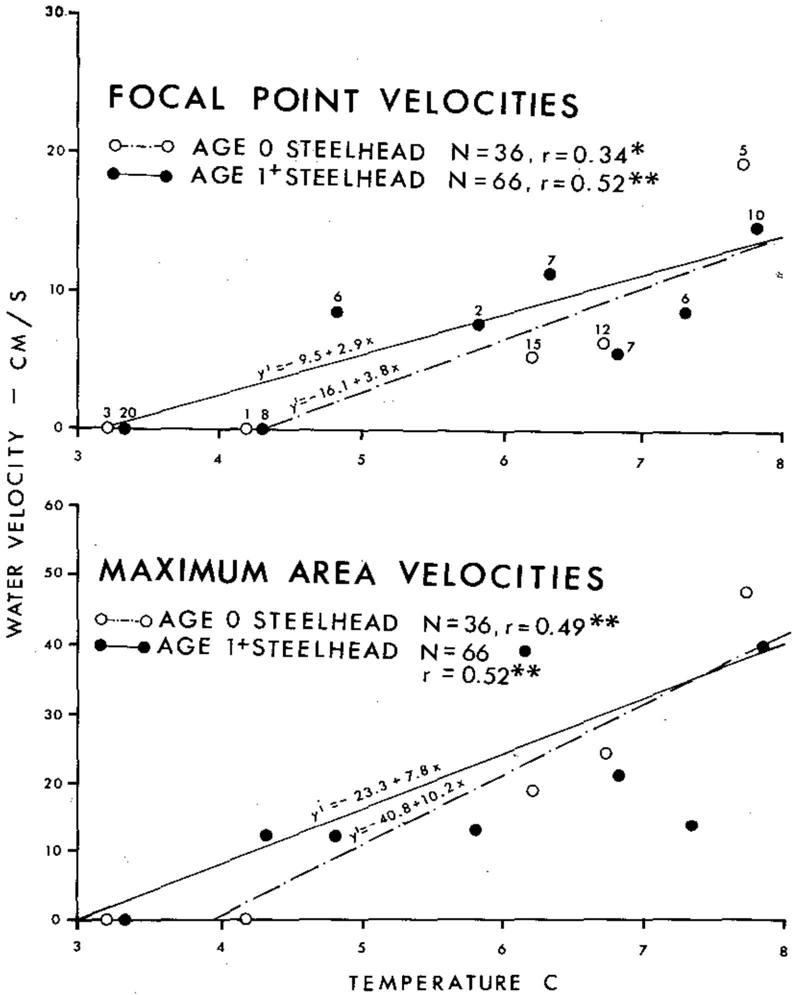

FIG. 4. Mean focal point and maximum area water velocities selected by age 0 and age I+ steelhead in relation to water temperature. Streamflows were between 0.3 and 0.7 m^3/s for all measurements. Sample size is indicated by the associated numbers. Regression lines were derived from N observations.

under rubble, and none were more than 70–80 mm in length. Age I+ steelhead were commonly found under boulders in the Sarita River. Older age-groups of cutthroat trout were found under boulders as well as log jams, upturned roots, and debris accumulations in upper Ritherdon Creek. Very few coho were found under rubble in Carnation Creek, although coho fry did utilize rubble for winter cover in Paton Creek.

Feeding and Hiding Behavior

When water temperatures were above 7 C, most fish in Carnation Creek were active and feeding. In water between 4 and 7 C coho and steelhead varied between being active and inactive depending on stream conditions. For example, at water temperatures of 7 C and streamflows of 0.03 m^3/s (1 cfs), virtually no steelhead fry could be observed above the substrate. With increased streamflow, steelhead fry were observed maintaining positions in moderate currents and actively feeding, even though the water temperature was 6 C.

During January and February, the period of coldest water, few coho and steelhead were ob-

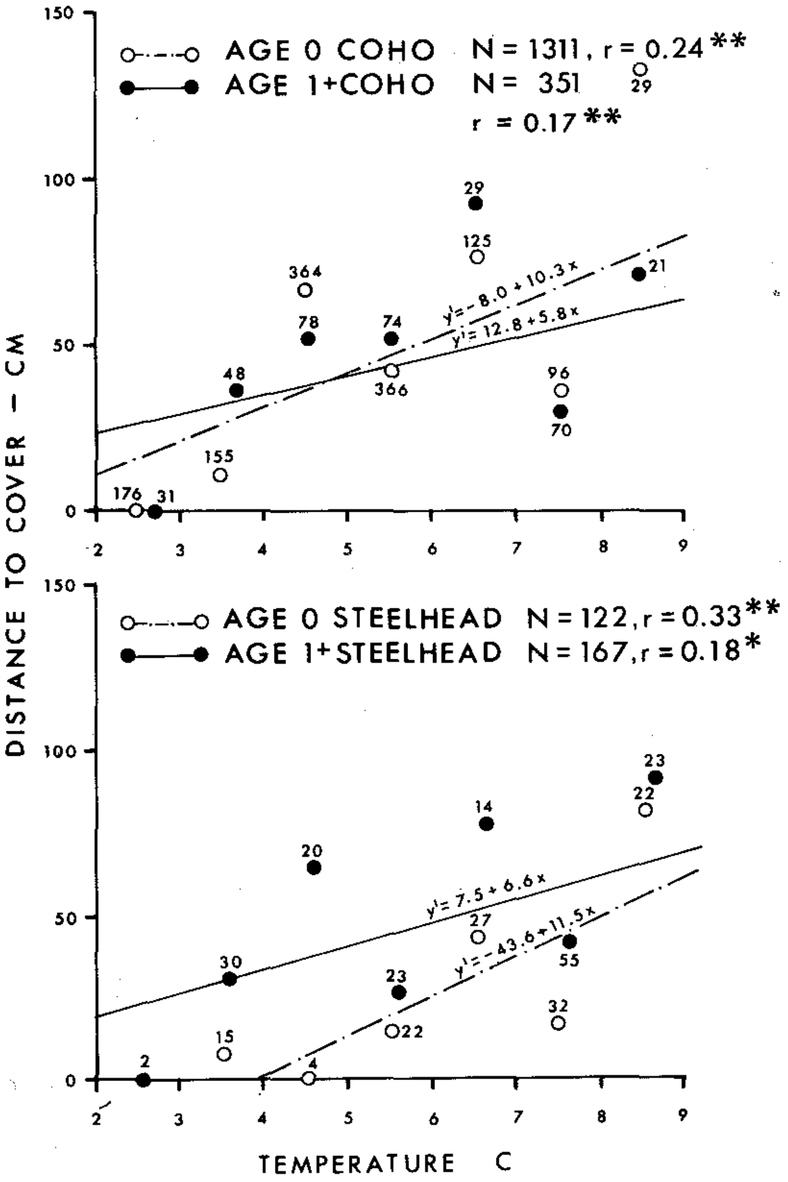

FIG. 5. Mean distance to cover of juvenile coho and steelhead in relation to water temperature. Sample size is indicated by the associated numbers. Regression lines were derived from N observations.

served in open areas. Only after intensive searching with a light a few fish could be located far under logs and undercut roots. Coho were more active at low water temperatures than steelhead, and some were observed feeding at water temperatures as low as 2.5 C.

No juvenile steelhead were ever observed feeding at low water temperatures in the Sarita River where the fry entered the rocky substrate in early October at water temperatures between 7 and 8 C and remained there into the following spring. Sarita River steelhead in the older age-groups appeared to enter the substrate later than the fry.

Tributary Movements

The 750 Creek system was used primarily by juvenile coho although several dozen sculpins and

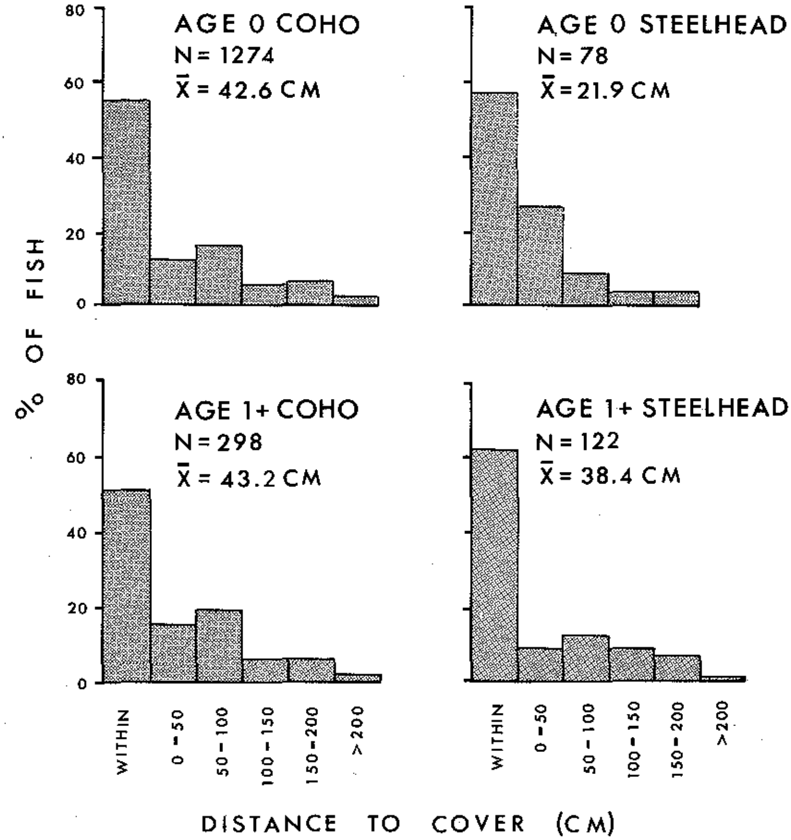

FIG. 6. Distance to nearest cover from juvenile coho and steelhead at water temperatures of 7 C or less.

three trout moved into it during the fall and winter. Monthly totals of the movements of coho through the traps are presented in Fig. 9. The traps were inoperative one day in December because of high water. Except for a few isolated pools, 750 Creek was dry throughout most of September and all of October. A small number of coho moved into the creek during a freshet in late September. Upstream movements occurred predominantly in November and December, whereas steady downstream movements occurred from February through May with a peak of over 60 coho in 1 day during a freshet in late May. Most movements were associated with freshets and water temperatures greater than 6 C. During the entire period 358 coho moved into 750 Creek and 266 left — a gross estimate of survival of 74%. A more meaningful estimate is obtained by considering only the net monthly movements which total 238 up and 145 down — 61%. During September to December mean length was 54.1 mm for upstream fish and 61.5 mm for downstream. The length of migrants from January to May was 62.5 mm for upstream fish and 64.5 mm for downstream.

Discussion

Beginning in early October, juvenile coho and steelhead in Carnation Creek undergo a behavioral change in response to approaching winter stream conditions. With decreasing water temperatures, these fish tend to be less active and spend much of their time hiding. This increased hiding with lower water temperatures appears to be characteristic of juvenile salmonids and has been discussed in some detail by Chapman and Bjornn (1969). Water depth and velocity and the availability of cover are important in determining the suitability of stream areas for these hiding fish.

INFLUENCE OF TEMPERATURE

Observations throughout autumn and winter in Carnation Creek suggest that shorter day length

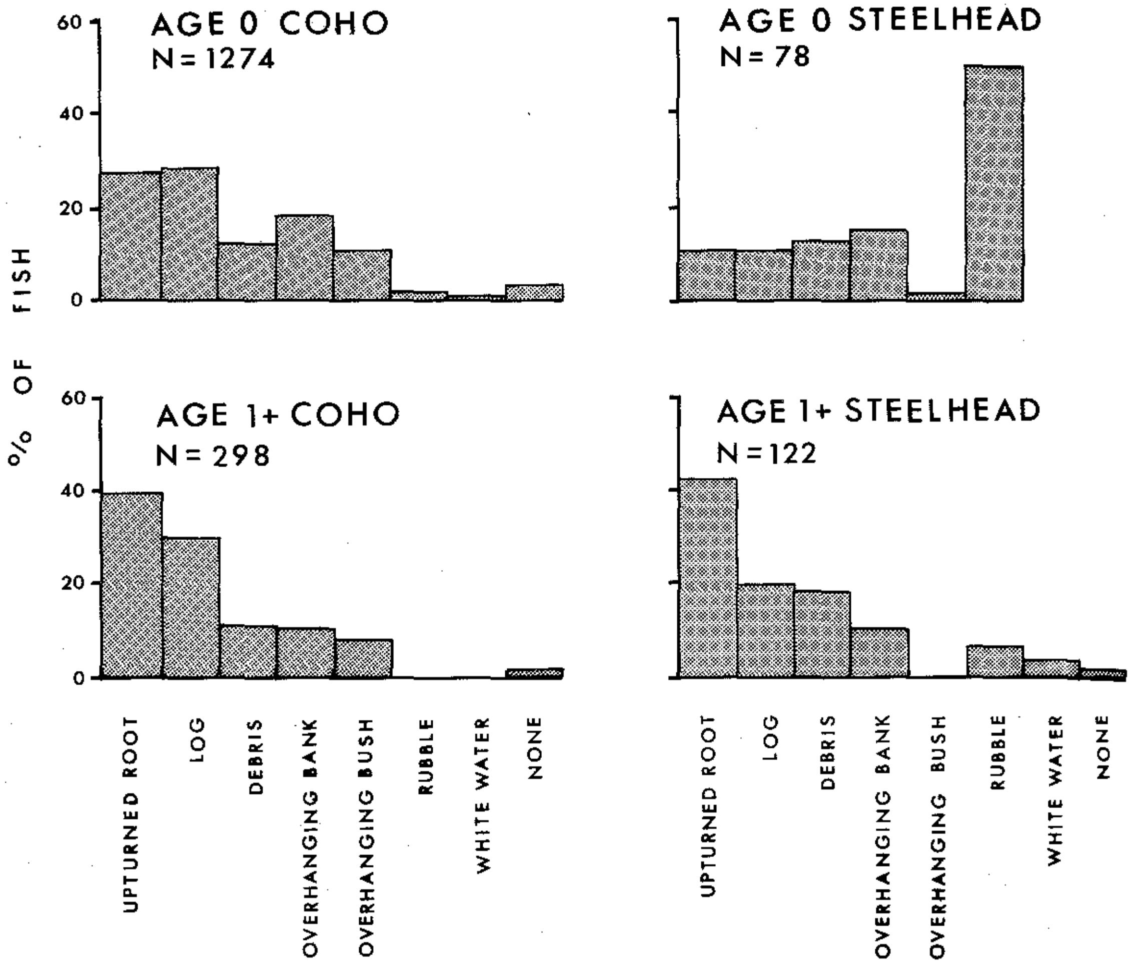

FIG. 7. Cover types selected by juvenile coho and steelhead at water temperatures of 7 C or less.

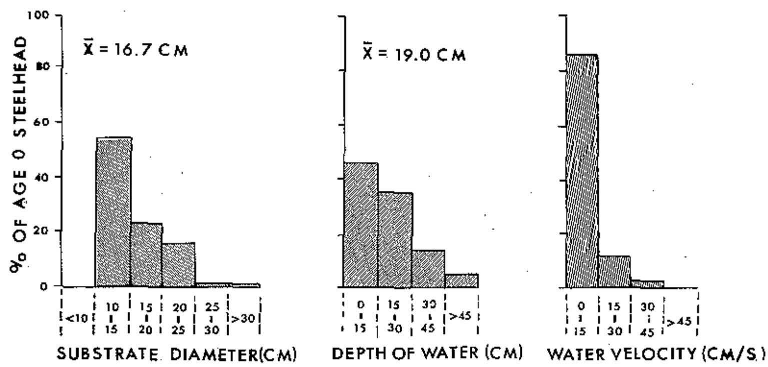

FIG. 8. Physical characteristics of substrate wintering areas selected by 43 age 0 steelhead.

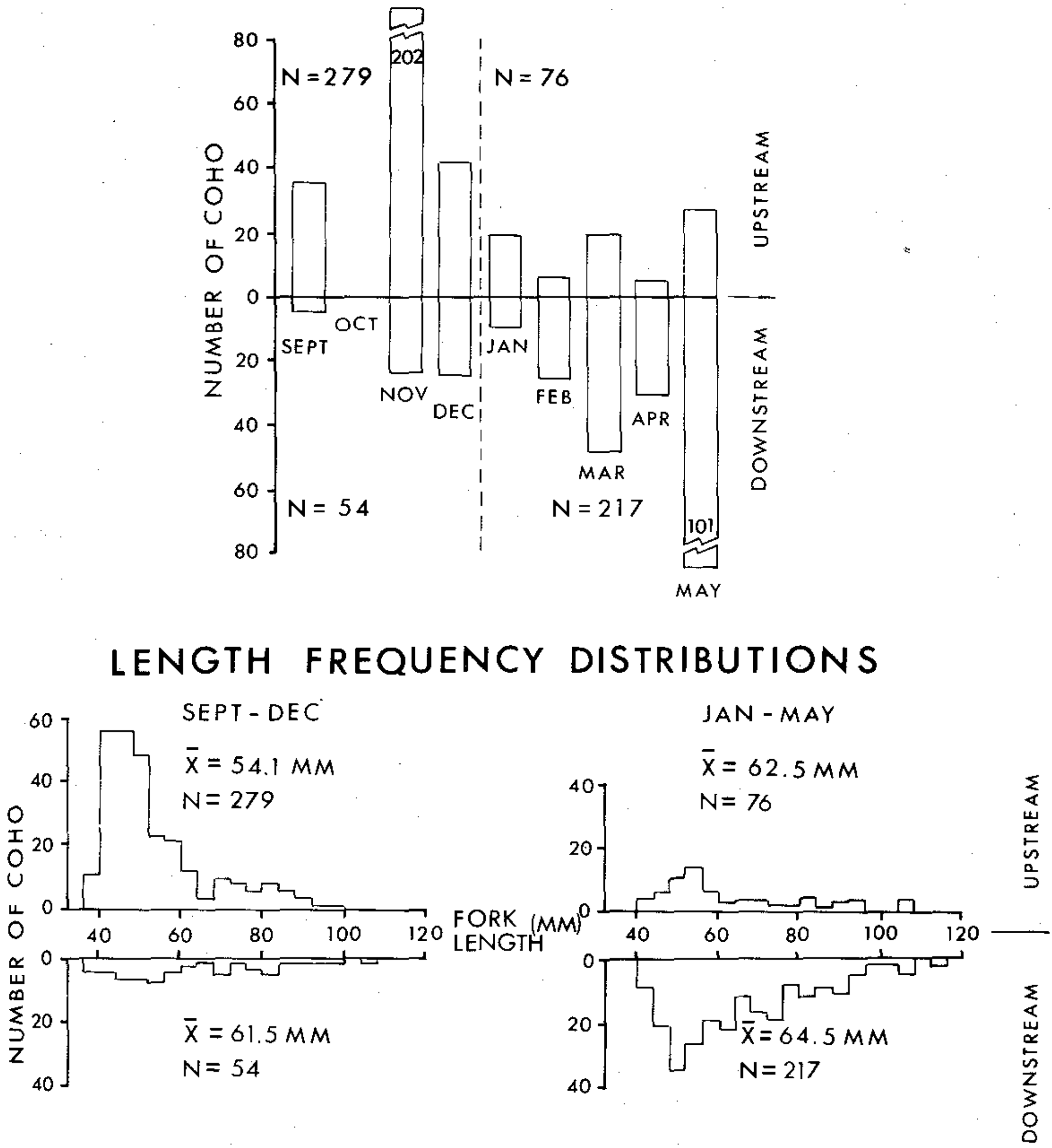

FIG. 9. Monthly upstream and downstream movements and length frequency distributions of juvenile coho in 750 Creek. Totals from spring do not include recently emerged fry.

did not have an important influence on the hiding behavior of juvenile coho and steelhead. For example, many of the steelhead fry which were hiding in the substrate in mid-October were actively feeding in November and early December. Hartman (1965) was able to induce steelhead and coho to hide in a stream aquarium by lowering the water temperature even though he maintained day length at a constant 12 h. Similarly, by maintaining a constant 13-h day length, Chapman and Bjornn (1969) showed that the number of yearling steelhead hiding in rubble cover was directly related to water temperature.

Although temperature was a major factor inducing a hiding response in fish in Carnation Creek, stream discharge also appeared to influence fish activity, especially at water temperature between 4 and 8 C. Increased activity may reflect a greater availability of food organisms than at lower temperatures and/or an increase in protection from predation provided by faster and more turbid water. More definitive investigation of the physiological and enviromental parameters controlling wintering behavior of juvenile salmonids is necessary to explain some of our observations.

Water Depth and Velocity

As water temperature dropped during the fall and early winter, coho and older steelhead in Carnation Creek moved into deeper water (Fig. 3). In stream aquarium experiments, underyearling coho and steelhead showed a strong preference for the deepest sections at lowest water temperatures (Hartman 1965). However, Everest (1969) suggests that water depth and overhead velocity were not important in determining steelhead overwintering areas. Most steelhead fry in Carnation Creek chose shallow areas near the stream margin for overwintering in the rubble substrate. For fish that do not enter the substrate in the winter, such as most of the coho and older steelhead in Carnation Creek, deep pools offer the advantages of cover and reduced water velocities. Steelhead fry overwintering within the rubble substrate may obtain these advantages from overhead rocks.

In the small rubble substrate typical of Carnation Creek, steelhead fry were not found as deep as has been reported in other river systems (Edmundson et al. 1968; Everest 1969). Some of the shallow areas used by the steelhead fry in Carnation Creek were dry during low winter flows. Fry hiding in these areas must shift location with changing stream discharge. Everest (1969) suggests that once fish move into the rocky substrate for the winter, no subsequent movements occur. In colder streams with less fluctuating winter flows than Carnation Creek, such as Everest's Idaho streams, this may be the case.

Steelhead of both age-groups occupied areas of lowest water velocity with decreasing temperature (Fig. 4). Such a relationship was not demonstrated for coho, probably for two reasons. First, most coho tend to occupy pool areas of lower velocity the year around. Therefore, the change in selected water velocities with decreasing water temperatures was not as obvious as for steelhead. Secondly, the current meters were not sensitive enough to detect differences between the "low velocity" feeding areas and the "no velocity" hiding areas.

Winter Cover

At low water temperatures, suitable cover areas appeared to be critical and few fish were found more than 1 m from potential cover (Fig. 5 and 6). Similar observations were made by Hartman (1965). Our observations also agree with Hartman's that steelhead fry and coho fry seek different cover types in the winter, with coho associated with logs, roots and bank cover areas and steelhead associated with rubble areas (Fig. 7). Older steelhead often selected the same types of cover as coho in Carnation Creek, but they were usually found closer to the bottom than coho, in deeper pools than the coho fry, and almost never associated with sidepools or bay areas as many of the coho were.

Steelhead fry utilized different winter cover than age I+ steelhead in Carnation Creek. Rubble in the 10–25 cm range was utilized by steelhead fry, whereas older steelhead hid in upturned roots and under logs and debris (Fig. 7). Everest (1969) indicated juvenile steelhead of several age-groups were found only under rubble larger than 40 cm in diameter, and Hartman (1965) found that most steelhead in the upper Chilliwack River were under 20–40 cm rocks. However, substrate of Carnation Creek was much smaller than in the above rivers. We commonly found older age-groups of steelhead and cutthroat in the much larger rocks of Sarita River and Ritherdon Creek.

Most juvenile steelhead spend two or three winters in Carnation Creek before smolting. Based on 3-yr data, survival from the late summer fry to midsummer age I is about 6% (range 5–13%). These low survival rates point to the winter–spring period as crucial to steelhead during their stream residence. This probably reflects the low availability of suitable winter cover in Carnation Creek. Steelhead fry used small rubble, often less than 15 cm in diameter, presumably because nothing larger was available. Such small substrate probably provides a hazardous refuge during winter freshets. C. Lyons (B.C. Fish and Wildlife Branch, personal communication) has found injured steelhead fry in late winter and suggests that injuries may have resulted from shifting substrate. Age I+ steelhead overwinter in large rubble and boulder areas in other streams, but in Carnation Creek where the substrate is mainly small rubble they used alternative (less suitable?) types of winter cover.

During the winter *Cottus aleuticus* were commonly found in pools under a similar rubble substrate as steelhead fry but often in deeper water. The two species were never found under the same rock, but in areas of limited rubble cover, competition during the winter might occur.

Tributary Movements

The overwinter survival of juvenile coho that moved into 750 Creek during the 1972–73 winter was considerably higher (61–74%) than the 35% estimated for coho in the whole Carnation Creek system. Presumably thick overhanging vegetation, fallen trees, and broad, slow pools provided protection from both predation and displacement during the winter. The survival of fish moving into small tributaries in the autumn and early winter is probably dependent on subsequent weather conditions. For example, dead coho fry were found in dried pools in 750 Creek during an extended period without rain following a September freshet. Coastal British Columbia winters are characterized by frequent major freshets, with presumed low coho survival in main streams. As indicated by the 750 Creek study, flooded side pools and small tributaries are probably the areas of highest coho overwinter survival. In March 1972, following a period of severe freshets, underwater observations indicated there were extremely low numbers of coho in the main Carnation Creek channel, especially in the lowest 1000 m. Sidepools and tributaries contained much higher densities of young fish.

Movements of juvenile coho in and out of 750 Creek is not unique. A similar autumn movement of juvenile coho into a tributary stream has been described by Skeesick (1970). In addition he mentions an October movement of 450 juvenile steelhead (60–200 mm in length) into a small tributary of the Elk River in Oregon. Large autumn movements of steelhead and chinook out of tributary streams with poor winter cover into larger streams with good boulder cover have been described by Chapman and Bjornn (1969) and Bjornn (1971).

Winter Hiding and its Adaptive Value

The hiding behavior demonstrated by juvenile salmonids in cold water has obvious adaptive value. A fish spending the winter in near freezing water temperature has a lowered metabolism, reduced food requirements, and less energy available for activity as discussed by Hartman (1968) and Reimers (1957). The hiding response is probably a means of avoiding predation during a period of low, clear water and reduced swimming ability. Another adaptive value of the hiding response is that it probably reduces downstream displacement during freshets.

Environmental Change

Juvenile coho and steelhead showed strong dependence on certain types of habitat during the winter. It appears that sidepools and back channels with logs, debris, and overhanging brush are important for coho. Age I+ steelhead and coho used logs, root masses, cutbanks, and debris for winter cover in the main stream. Age 0 steelhead used rocks at the stream margin. Most of this cover is associated with the streambank and is quite stable. We infer that streamside logging or road building, overzealous stream clearing, or channelizing could severely alter the salmonid winter habitat as defined in this paper and would probably result in reduced overwinter survival.

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