RESEARCH PROJECT SEGMENT

State: Alaska | Name: Sport Fish Investigations of Alaska

Project No.: F-9-7 | Study Title: A STUDY OF LAND-USE ACTIVITIES AND THEIR RELATIONSHIP TO THE SPORT FISH RESOURCES IN ALASKA.

Job No.: D-I-B | Job Title: Ecology of Rearing Fish.

Period Covered: July 1, 1974 to June 30, 1975

ABSTRACT

This report summarizes the second season's work on various aspects of the early life history of juvenile Dolly Varden Salvelinus malma and coho salmon Oncorhynchus kisutch at the Starrigavan Creek study site. Emphasis of the study was placed on the value of spring-fed tributary streams to the over-winter survival of young char and salmon, the effect of logging debris and debris removal on rearing char and salmon populations, and the effects of forest canopy removal on winter temperatures and ice conditions in salmonid rearing streams.

Spring Pond Creek, a groundwater fed tributary to the Starrigavan watershed, receives an annual fall in-migration of approximately 200 young Dolly Varden and 50 coho. The fall in-migration composes approximately 16% and 50% of the overwintering Dolly Varden and coho populations respectively. Fall upstream movement ceases when temperatures reach 4°C. The 1974 spring out-migration commenced when water temperatures reached 4°C in May. Juvenile Dolly Varden, numbering 330, and 42 coho left the tributary and moved into the mainstream. Many of the fish were rearing fish, ages II-IV, but about 29 were Dolly Varden smolt.

Approximately 1,200 Dolly Varden and 100 coho including in-migrants from the mainstream overwintered in Spring Pond Creek during the winter of 1973-74. Estimates taken after the 1974 spring out-migration indicate that the population suffered about 25% mortality but may range from 5 to 44% of the wintering population. Winter mortality was not detectable in the coho population due to its small size, but eight (33%) of the 24 fall in-migrants in 1973 are unaccounted for at this time, and may have been lost to winter mortality.

The study of the effects of logging debris on the aquatic environment has shown that debris covered areas of substrate have a lower invertebrate biomass than do debris free areas and also differ slightly in the composition of organisms living there. The ultimate result is a lower biomass contribution per item of food eaten by fish inhabiting debris littered areas. We postulate

that this condition will change upon removal of debris in August 1975 and that population levels of fish utilizing the test section will also change.

The study of the effects of canopy removal has shown that conditions detrimental to fish develop during the winter. Heavy freezing and low water temperatures are compounded by extremely low discharge and makes most of the stream normally used by rearing char and salmon during the summer uninhabitable during the winter. Whether these conditions can be attributed to removal of forest canopy is not known at this time.

RECOMMENDATIONS

Results of the 1974-75 field season indicate that accumulation of logging debris and litter in small streams has an effect on the aquatic environment by limiting the amount of invertebrate biomass by as much as 50% per unit of area. Most of the invertebrates that are excluded from debris covered areas are among the largest in the stream and would contribute the most in terms of biomass per organism to feeding fish.

Studies of the value of spring-fed tributaries has revealed an annual fall in-migration of about 200 char that form approximately 16% of the wintering population. In the spring most of these fish leave the system, primarily as 2 to 3-year-old juveniles.

Removal of forest canopy over streams may have a detrimental effect on winter ice conditions and temperatures. Observations of winter conditions in Skunk Cabbage Creek indicate that low water discharges and freezing may cause heavy mortality. However, to properly evaluate this, we feel that another site should be chosen in order to gather data on winter conditions prior to logging.

Using the data already gathered at the Starrigavan study site we recommend the continuation of the following objectives:

1. Determine the effects of logging debris removal on fish populations of small streams.

2. Determine the importance of spring-fed streams to the overwinter survival of rearing salmonids.

3. Determine methods for future research on the effects of canopy removal on ice conditions and winter temperatures of small streams during the winter months.

4. Determine the distribution, abundance and species diversity of the aquatic benthos and its relationship to rearing fish populations.

OBJECTIVES

1. To develop methods of conducting a study on the effects of logging debris removal on fish populations in small

streams.

2. To develop methods for conducting research on the importance of spring-fed tributaries for overwinter survival of rearing fish.

3. To determine methods of future research on the effect of canopy removal on temperature and ice conditions of small streams during winter months.

4. Determine the distribution, abundance and species diversity of the aquatic insects within certain types of rearing fish habitat and their relationship to rearing fish populations.

Since the entire Starrigavin watershed has been clearcut, we have no control streams in the watershed for experiments in canopy removal. Thus, emphasis of this objective has been placed on the study of how fish react to loss of habitat due to icing. This information can then be applied to a formal canopy removal study to be conducted in the future.

Study Site Location and Description

Starrigavin watershed is located on the west coast of Baranof Island approximately 8.86 kilometers (5.5 miles) north of Sitka. The watershed has recently been clearcut, with the final cutting occuring in February, 1974 (see Elliott and Reed, 1974).

Starrigavin Creek supports runs of coho salmon *Oncorhynchus kisutch*, pink salmon, *O. gorbuscha*, rainbow trout, *Salmo gairdneri*, cutthroat trout, *S. clarki*, Dolly Varden, *Salvelinus malma*, and sculpins, *Cottus* sp. The creek is approximately four miles in length and has five major tributaries. Access to the watershed is provided by logging roads which run the entire length of the valley. The valley is of the U-shaped glaciated type typical of Southeast Alaska.

Considerable stream channel damage occured during the logging operations. However, all tributaries have been hand cleared of debris, except Spring Pond Creek, which, due to request was left with the logging debris throughout.

The debris is composed primarily of thick beds 10-15 cm., (4" to 6") of needles and bark which upon decomposition forms a thick, oozy layer of fine, particulate material. Other areas of the stream are clogged with masses of branches, large logs and pieces of fractured bark and wood. It is evident that this material is decomposing as oils and gasses rise readily to the surface when organic beds are disturbed.

Spring Pond Creek is approximately 209 meters (637 feet) in length and originates in an upwelling spring area. The stream averages about .61 m., (2 feet) in width, and from 3 to 9 cm., (7 to 22 inches deep).

TECHNIQUES

Debris Removal Study

To determine if debris removal has any effect on the standing crop of juvenile salmonids in Spring Pond Creek, the stream was mapped and the mean surface area of the creek was determined. The stream was then divided into two equal test sections by surface area. Population estimates of rearing fish were taken periodically in each section to establish base-line population data prior to debris removal.

Benthic insect samples were collected with a 1 sq. ft. surber sampler (280 micron mesh) and drift samples with a 1 sq. ft. (280 micron mesh) insect drift net every two weeks from debris-covered and debris-free areas in each test section to establish base line invertebrate data prior to clean up. Specimens were frozen in water and shipped to Juneau where they were identified and the ash free dry weight (organic weight) determined for each species.

Food analysis of young Dolly Varden was conducted; diet profiles were established and the composition determined. This will serve as comparative data for stomach analysis after debris removal is completed.

Spring-Fed Tributary Study

A small migrant fish weir was established in September 1973 to monitor the movement of fish into Spring Pond Creek. All Dolly Varden entering or leaving the stream received a Floy FTF-69 fingerling tag and an adipose clip while all coho receive only the tag. Information for species composition and length frequency is taken at the weir.

A sample of 96 Dolly Varden are taken annually (8 per month) from the stream to determine age, sex, maturity and food habits.

Water temperature, air temperature, and water depth are measured every other day at the weir and in the mainstream to establish the physical parameters that influence fish movement and behavior.

Estimates are made periodically to determine seasonal changes in the population of fish inhabiting the stream. Estimates are made with baited minnow traps using either the Chapman's modification of the Peterson estimate or the Schnabel method. 95% confidence limits were calculated using the following:

$$\hat{N} \pm Z_{\alpha} \sqrt{\frac{(m+1)^2(c+1)(c-R)}{(R+1)^2(R+2)}}$$

N = population estimate.
M = number of marked fish released.
C = recapture sample.
R = number of marked fish in recapture.

Canopy Removal Study

A small runoff stream (Skunk Cabbage Creek) was selected as a site for the study of the effects of canopy removal on the winter stream environment. A small migrant fish weir was built near the mouth of the stream to monitor the movement of fish entering and leaving the stream. Periodic population estimates are used to determine the standing crop at different times of the season.

Ice and snow thickness and water depth beneath the ice were measured periodically during the winter to estimate how much of the summer rearing habitat was made uninhabitable by freezing conditions. Water temperature under the ice was also measured at this time.

FINDINGS

Spring-Fed Tributaries and Their Importance

Timing and Magnitude of Movement:

Spring Pond Creek annually receives a fall in-migration of approximately 180 juvenile and resident mature Dolly Varden from the mainstream waters of Starrigavin watershed. (187 in 1973 and 171 in 1974). The in-migration forms approximately 14.5-16% of the overwintering population of Dolly Varden in the stream.

The fall in-migration of coho is much smaller, as only 24 in-migrant coho were counted in 1973 and 46 in the fall of 1974.

To date only one spring out-migration has been monitored. A total of 330 Dolly Varden and 42 juvenile coho left Spring Pond Creek in the spring of 1974 (Table 1). Of the 330 char, 29 (8%) were smolt.

Movement of fish across the Spring Pond Creek weir is complex. Many of the fish that enter the stream return to the mainstream within a few days. The same is true for many fish leaving the stream during the spring; they often spend a few days in the mainstream then return to Spring Pond Creek. Some fish overwintered in Spring Pond Creek during the winter of 1973, left in the spring and resided in the mainstream until the following fall, when they again returned to the tributary to overwinter. A summary of the movement is given in Table 1.

Spring Pond Creek, due to its stable discharge and temperature regimes serves as a winter shelter for many fish living in the main Starrigavin watershed. Water temperatures begin to decline throughout the watershed in the last weeks of September (Figure 1). In-migration begins at this time and usually reaches its maximum by mid-October (Figure 2). From October through February the water of Spring Pond Creek is consistently warmer than that of the mainstream. This temperature difference is apparently detectable by fish seeking overwintering sites.

In-migration also coincides with fall freshets. Peaks in movement are positively correlated with flooding. However, movement of fish ceases altogether when the apparent temperature threshold of 4°C is reached in the mainstream. After reaching this point, flooding no longer has any effect on movement.

The reverse appears to hold true during the spring out-migration. This movement

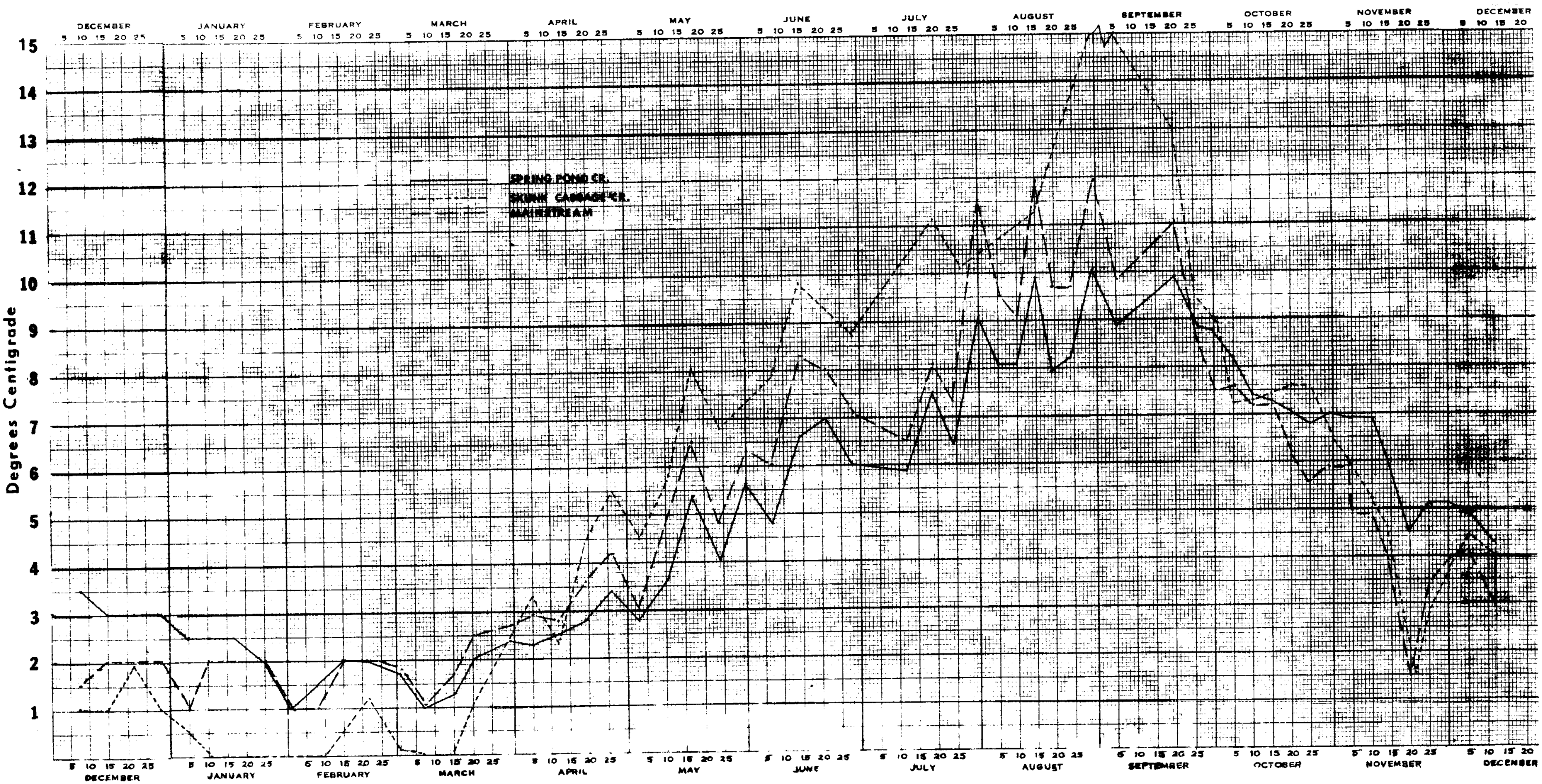

Figure 1 Temperature Profiles of Spring Pond Creek, Skunk Cabbage Creek, and Mainstream of Starrigavin Watershed, 1974

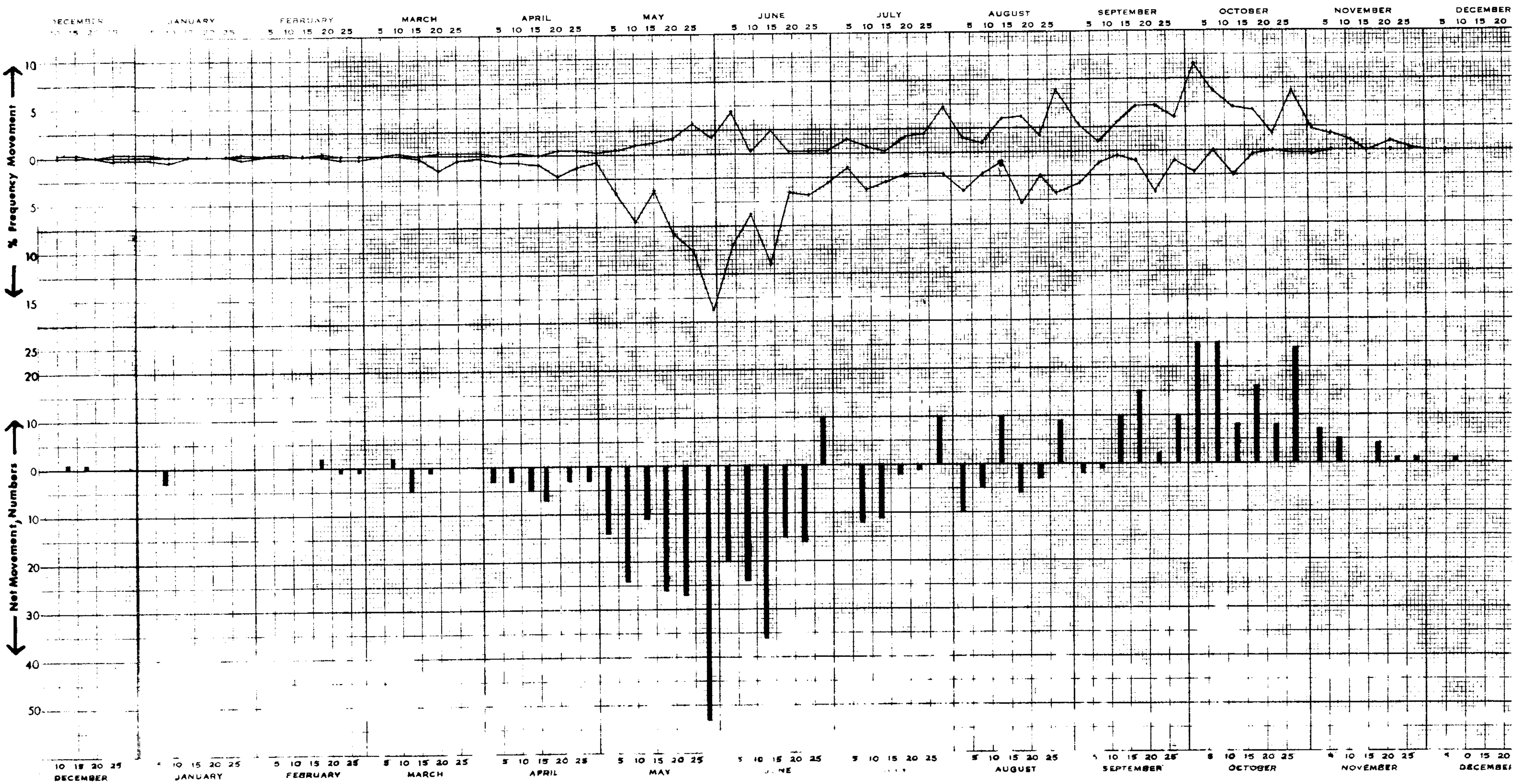

Figure 2 Percent Frequency of Movement and Net ovement of Do arden Moving Upstream (↑) and Downstream (↓) Pond Creek Weir, 1974.

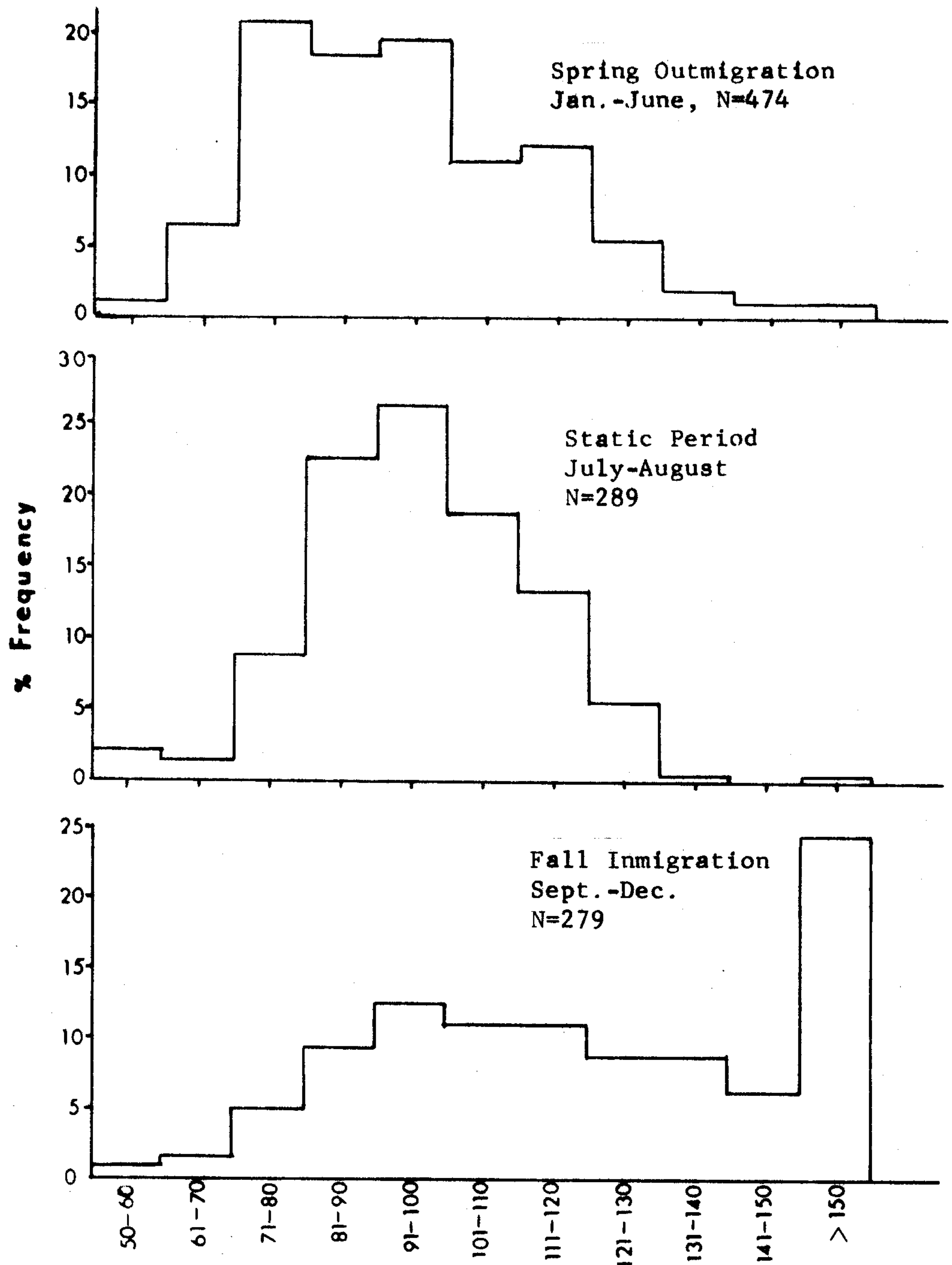

Fig. 3. Percent Length Frequency of Dolly Varden at Spring Pond Creek Weir During the Three Major Movement Periods.

Table 1. Summary of Young Dolly Varden and Coho Entering and Leaving Spring Pond Creek.

	Fall In-migration 1973		Spring Out-migration 1974		Fall In-migration 1974	
	D.V.	Coho	D.V.	Coho	D.V.	Coho
In-migrants (1)	18	0	0	0	32	1
In-migrants (2)	186	27	24	3	203	52
Temporary Residents	79	2	18	1	36	0
Temporary Out-migrants	17	0	55	2	22	5
Out-migrants (1)	4	0	121	15	0	0
Out-migrants (2)	13	1	233	30	64	6
Total Fish Enumerated:	317	30	451	51	321	64
Net Movement:	187	24	330	42	171	47

(1) Recoveries of previously marked fish.

(2) Unmarked fish.

begins during April as water temperatures reach 4° to 5°C, and appears to terminate in July. During May, the peak out-migration period, the rate of downstream movement appears to be depressed by flooding, then increases again when discharge levels decline.

From the end of July, fish are constantly moving in and out of the stream, but the net movement in either direction is close to zero. Movement remains static until the approaching fall months and declining water temperatures trigger an upstream trend of movement.

Length Frequency of Migrating Populations:

Length frequencies of all Dolly Varden crossing Spring Pond Creek weir were calculated for the major movement periods: the 1974 out-migration, January through June 1974; static movement period, July through August 1974; and the 1974 fall in-migration; September 1974 through January 1975. Length frequencies of the fish differ greatly (Figure 3). The bulk of the spring out-migration is composed primarily of fish between 71-100 mm. in fork length. The static period is more representative of mainstream populations with most of the fish falling into length intervals of 80-110 mm. in fork length. The fall in-migration tends to be bimodal. Approximately 25% of these in-migrants being 151 mm. or longer (mostly resident and anadromous spawners), and the rest juvenile char.

It is apparent that most of the spring out-migrating char are approximately Age II fish while the other movement periods are composed of older fish. The reason for the out-migration of such young fish is not known at this time, but it is possible that they are forced out of the system by older and/or more aggressive fish.

Composition of the Overwintering Population:

Population estimates in Spring Pond Creek in September 1974 indicate that approximately 59 (5.5% of the wintering population) were mature resident Dolly Varden males. A total of 13 mature males were also counted entering the system during the fall of 1974, or 7.2% of the in-migrating population. To date, external examination of fish entering the weir has not revealed any female spawners. The bulk of the wintering population is therefore composed of rearing Dolly Varden, e.g. all those Age IV and younger (Table 2). In-migrant age classes in the month of October are dominated primarily by mature spawning Dolly Varden, some of which are anadromous forms as large as 374 mm. Fish over 160 mm. (resident and anadromous spawners) compose almost 25% of the fall in-migration into Spring Pond Creek.

Presumably, mature female char also enter the creek and are able to spawn in the few debris-free areas of the stream, as eggs have been found in the gravel during the winter months. Also, Age I fish, occasionally taken in samples, suggest that recruitment from spawning is taking place, as zero age and Age I fish are rarely captured at the weir.

Table 2. Age, Length, Weight Composition of Dolly Varden Sampled in Spring Pond Creek, 1974. N = 92 Dolly Varden.

FL (mm)	AGE						
	I	II	III	IV	V	VI	VII
50-60							
61-70							
71-80		9(31.0%)					
81-90		10(34.4%)	1(2.4%)				
91-100		6(20.7%)	6(17.6%)	2(13.3%)			
101-110		2(6.9%)	9(26.4%)	3(20.0%)	2(18.1%)	1(50.0%)	
111-120		2(6.9%)	12(35.3%)	6(40.0%)	2(18.1%)		
121-130			6(17.6%)	1 (6.7%)	2(18.1%)	1(50.0%)	
131-140				2(13.3%)	2(18.1%)		
141-150				1(6.7%)	3(27.3%)		1(100%)
TOTAL (%)	0	29(31.6%)	34(36.9%)	15(16.3%)	11(11.9%)	2(2.2%)	1(1.1%)
$\bar{x}$ wt. (gm.)	0	6.8	12.1	14.1	19.8	12.7	24.5
Wt. Range (gm.)	0	3.1-12.8	6.6-21.4	4.8-31.5	8.2-29.4	8.4-17.0	

Overwinter Survival:

Population estimates show that approximately 1,191 Dolly Varden overwintered in Spring Pond Creek during the 1973-74 winter period. Estimates taken in July indicated a population of 564 Dolly Varden. Net Out-migration by July was established as 329 char, thus leaving 298 (25% of the overwintering population) Dolly Varden unaccounted for in the population.

Maximum and minimum mortality of the total wintering population was calculated by taking the difference between the 95% confidence limits of the December and July population estimates. Mortality ranges from 63 to 533 char, or 5.2 to 44.7% of the mean wintering population.

Estimation of winter mortality of in-migrant Dolly Varden that wintered in Spring Pond Creek appears to be higher. Of the 187 char that entered the creek in the fall of 1973, only 121 were counted moving out the following spring, leaving 66 char or 35.2% unaccounted for. Lower survival of the in-migrant population may be attributed to the relatively large number of spawning resident char that overwintered in the tributary. These fish may have died after spawning in the fall of 1973 as very few fish of the proper length frequency (150 mm+) were recorded leaving the stream in the spring of 1974.

Survival of the wintering coho population cannot be estimated as the population is too small to be detected with the estimate techniques in use. However, it appears that the in-migrating coho lost approximately 33% of their numbers during the winter as eight of the fish have never been recovered.

Debris Removal Study

The emphasis of this portion of the study has been placed upon the response of juvenile char and salmon carrying capacities to the hand clearing of logging debris in Spring Pond Creek. Thus, it is essential to determine precise population levels at different times of the season if changes resulting from debris removal are to be detected.

Population estimates conducted periodically since August 1973 reveal the seasonal nature of the salmonid carrying capacity. Estimates conducted to date, combined with movement data from Spring Pond Creek weir are as follows:

	Dolly Varden	Coho	Total Community
Estimated 8/7/73	943	36	981
95% Confidence Limits	853-1033	22-50	889-1073
Estimated 9/26/73	1051	75	1134
95% Confidence Limits	919-1183	44-106	993-1275
In-migration Following 9/26/73	+140	+24	+164
Calculated 73/74 overwintering pop.	1191	99	1290
95% Confidence Limits	1059-1323	68-130	1157-1439
1974 Spring Out-migration	-329	-42	-371

	Dolly Varden	Coho	Total Community
Estimated Winter Mortality	-298	- 8	-313
95% Confidence Limits	63-533		
Calculated Pop. after Out-Migration	564	49	613
Estimated 7/11/74	564	ND	+564
95% Confidence Limits	461-667		461-667
Estimated 8/26/74	769	ND	+769
95% Confidence Limits	691-847		691-847
Estimated 9/30/74	1070	47	1104
95% Confidence Limits	990-1150	12-82	1022-1186
In-migration following 9/30/74	+120	+46	+166
Calculated 74-75 Winter Population	1190	93	1283
95% Confidence Limits	1110-1270	58-128	1256-1316

The estimates indicate that the maximum carrying capacity for Dolly Varden is approximately 1,200 fish while the maximum population for coho is around 100 fish.

Minimum or base carrying capacity is roughly 50% of the wintering population with a mid-summer population of about 550 char and about 50 coho. From mid-July to September the char population doubles in size while the coho population appears to remain the same. The net in-migration at this time is very low and cannot explain the large increase in population. Apparently, this is due to recruitment into the population: e.g., Age I and II fish that have grown large enough to enter the "minnow-trap catchable" size ranges (see Elliott and Reed, 1973) and thus form part of the estimated population.

Preliminare experiment will continue to explore differential densities of fish that may occur after debris removal. The lower half of Spring Pond Creek will be cleared in August 1975, while the upper section will be left clogged with debris. Estimates were conducted in both sections with the following results:

	Dolly Varden		Coho	
	upper sect.	lower sect.	upper sect.	lower sect.
8/26/74	339	424	ND	ND
95% Confidence Limit	278-400	373-474		
9/30/74	643	428	5	18
95% Confidence Limit	581-705	378-478		

The upper section includes Spring Pond and has a total surface area of 564.5 sq. meters, while the lower section extends from the mid point of the stream to Spring Pond Creek Weir and has a surface area of 363.5 sq. meters.

Spring Pond, the terminus of the upper section and the upwelling source of the stream, is apparently desirable to overwintering fish as the population of young char increases greatly there. Fish densities per sq. meter in the two sections have been calculated at:

	Dolly Varden/sq. meter		Coho/sq. meter	
	upper sect.	lower sect.	upper sect.	lower sect.
8/26/74	0.60	1.66	ND	ND
9/30/74	1.39	1.77	.008	.049
Average Base Density	.57		.05	
Average Winter Density	1.14		.10	

Nature of Debris in Spring Pond Creek:

Transects were established every twenty feet along the length of Spring Pond Creek and the condition of the substrate was determined at 2 foot intervals across the width of the stream. The substrate at the sample points were classified as being either debris-free, or having either submerged debris, exposed debris, or logs and log fragments. The depth of the debris was determined by inserting a meter stick into the debris until gravel was struck.

It was found that 88.2% of the stations in the upper section and 84.0% of the stations in the lower section were covered with logging debris of various types (Table 3).

Composition of Macrobenthos in Spring Pond Creek:

Analysis of the benthos fauna revealed two discernable invertebrate communities existing in debris-free and debris-covered substrate (Table 4). Both habitat types are dominated by larval chironomidae (approximately 10 species) but differ in the number of gravel dwelling forms such as Ephemeroptera and Plecoptera (Baetis bicaudatus, Cinygmula sp., and Alloperla spp.), Trichoptera (Rhyacophila spp., Dolophilus sp.) and Diptera (Palpomyia sp.). Organisms such as Ameletus sparsatus, and Paraleptophlebia sp. (Ephemeroptera); Nemoura sp. and Leuctra sp. (Plecoptera); Pycnopsyche sp. (Trichoptera) and Dicranota sp. (Diptera) are more commonly associated with debris covered areas. A. sparsatus and Paraleptophlebia sp. are clinging animals and generally occur on submerged twigs and branches while Nemoura sp., Leuctra sp., and Pycnopsyche sp. are most commonly observed on the surface of detrital material.

Ash-free dry weights determined for samples from each type of habitat shows that the mean organic biomass for debris free areas is slightly higher per unit of area (mg./sq/ ft.) than that found in debris covered areas:

	Debris Free		Debris Covered	
	Benthos	Drift	Benthos	Drift
N	8	15	9	18
x weight/sq. ft.	19.8 mg.	3.4 mg.	8.8 mg.	4.7 mg.
Total x wt./sq/ ft.	9.1 mg.		6.0 mg.	

This is probably due to the presence of larger animals living in debris free areas such as Alloperla sp., Rhyacophila sp., and Dolophilus sp..

Table 3. Percent Frequency of Substrate Types and Depth of Debris at 189 Sample Points in Spring Pond Creek.

	Debris Free		Submerged Debris		Exposed Debris		Logs		Total Debris	
	No.	% Freq.	No.	% Freq.	No.	% Freq.	No.	% Freq.	No.	% Freq.
Upper Test Section	6	11.7%	24	47.0%	13	25.4%	8	15.6%	51	88.2%
Mean Debris Depth in Cm.	ND		16.2 cm.		11.6 cm.		ND		11.5 cm.	
Lower Test Section	22	15.9%	47	34.0%	47	34.0%	22	15.9%	138	84.0%
Mean Debris Depth in Cm.	ND		14.2 cm.		18.1 cm.		ND		16.2 cm.	

Table 4. Composition of Benthic Organisms Collected from Debris Covered and Debris Free Areas of Spring Pond Creek, 1974.

	Debris Free Area					
	Benthos N=9		Drift N=15		Total N=24	
Taxa	No.	% Comp.	No.	% Comp.	No.	% Comp.
Oligochaeta	1	.3			1	.2
Hydracarina			15	4.1	15	2.4
Pelecypoda						
A. sparsatus						
B. bicaudatus	77	26.1	41	12.2	118	18.7
Cinygmula sp.	1	.3	1	.2	2	.3
Paraleptophlebia sp.	6	2.0			6	1.0
E. grandis						
Nemoura sp.	5	1.6			5	.8
Leuctra sp.	2	.7			2	.3
Capnia sp.						
Alloperla sp.	12	4.0	1	.2	13	2.1
Rhyacophila sp.	21	7.2			21	3.3
Dolophilua sp.	8	2.9			8	1.3
Pycnopsyche sp.	6	2.0	6	1.7	12	1.9
Micrasema sp.			4	1.1	4	.6
Dytiscidae			6	1.7	6	1.0
Dicranota sp.	11	3.9	3	.9	14	2.2
Dixidae			4	1.1	4	.6
Palpomyia sp.	4	1.3			4	.6
Chironomidae larvae	136	46.1	204	60.9	340	54.0
Chironomidae pupae	5	1.6	41	12.2	46	7.3
Simulium sp.			2	.5	2	.3
Atherix sp.						
Terrestials			2	.5	2	.3
Aquatic adults			5	1.4	5	.8
TOTAL:	295	100%	335	100%	630	100%

Table 4, (con't.) Composition of Benthic Organisms Collected From Debris Covered and Debris Free Areas of Spring Pond Creek, 1974.

Debris Covered Areas

Taxa	Benthos N=9 No.	Benthos N=9 % Comp.	Drift N=18 No.	Drift N=18 % Comp.	Total N=27 No.	Total N=27 % Comp.
Oligochaeta	4	2.0			4	.6
Hydracarina	6	3.0	10	2.4	16	2.5
Pelecypoda						
A. sparsatus	1	.5	2	.6	3	.5
B. bicaudatus	20	10.2	53	12.5	73	11.8
Cinygmula sp.						
Paraleptophlebia sp.	19	9.6	3	.8	22	3.5
E. grandis	1	.5			1	.2
Nemoura sp.	8	4.1	1	.2	9	1.5
Leuctra sp.	2	1.0			2	.3
Capnia sp.			1	.2	1	.2
Alloperla sp.	5	2.5	1	.2	6	1.0
Rhyacophila sp.	13	6.6	11	2.7	24	3.8
Dolophilus sp.	1	.5	1	.2	2	.3
Pycnopsyche sp.	11	5.6	5	1.2	16	2.6
Micrasema sp.			1	.2	1	.2
Dytiscidae	1	.5	4	.9	5	.8
Dicranota sp.	10	5.1	4	.9	14	2.2
Dixidae			5	1.2	5	.8
Palpomyia	1	.5			1	.2
Chironomidae larvae	91	46.3	278	65.8	369	59.5
Chironomidae pupae	2	1.0	38	8.9	40	6.5
Simulium sp.	1	.5			1	.2
Atherix sp.						
Terrestrials			1	.2	1	.2
Aquatic adults			4	.9	4	.6
TOTAL:	197	100%	423	100%	620	100%

Stomach Analysis:

The composition of benthic organisms found in the stomachs of Dolly Varden captured in debris-free and debris-covered areas appears to be comparable to the composition of the macrobenthic organisms existing in the two types of habitat (Table 5). The most commonly consumed organisms were larvae and pupae of the family Chironomidae (Diptera). Fish captured in debris-free areas ate more B. bicaudatus, Cinygmula sp., Rhyacophila spp., Dolophilus sp., and ate fewer Chironomidae, Pycnopsyche sp. and Dytiscidae. However, even though Paraleptophlebia sp. and Nemoura spp. appear to occur more frequently in debris-covered areas, they were more prevalant in stomachs of fish captured over gravelly substrates.

The average organic weight of the most commonly occuring organisms was compared to the food composition of Dolly Varden captured in debris-free and debris-covered areas (Table 6) to determine the organic contribution of these species to the fish. A relative weight index was calculated for each major species using the expression:

$$W = \frac{(A)\ Na}{N}$$

Where: W = Weight index.
N = Total number of insects consumed.
Na = Total number of each species consumed.
A = Average weight of organism considered.

Percent composition of the calculated weight in the stomach samples show that Chironomidae larvae form a major portion of the fish's diet by weight, approximately 23.4% in debris-free areas and 27.4% in debris-covered areas. However, the weight index, a function of the small size of the animals, reveals a value as low or lower than that of organisms eaten in lesser quantities. Diet weight composition of char collected in the two habitat types differ mostly in the weight diverstiy of organisms consumed. Char collected in debris covered areas primarily consumed Pycnopsyche sp. and Chironomidae, but derived little from the other species. However, fish occupying debris-free areas tended to have a more diverse diet and consumed a larger number of species by weight e.g. B. bicaudatus, Dicranota sp., Rhyacophila sp., and Cinygmula sp..

Canopy Removal Study

The completion of a small migrant weir on Skunk Cabbage Creek has enabled us to monitor the movement of juvenile salmonids into the stream. It also facilitates the determination of the overwintering population. However, abnormally heavy flooding caused the loss of the weir for a short time during the fall and incomplete data on fish in-migration resulted.

A total of 353 Dolly Varden were counted at Skunk Cabbage weir, of which 256 were moving in an upstream direction (Table 7). One hundred and twenty-six juvenile coho crossed the weir during the fall months, of which 91 moved upstream. Since the weir was non-operational for almost two weeks, it is not known if these fished remained in the stream.

Periodic population estimates appear to indicate that maximum populations occur in the fall months as they do in Spring Pond Creek. However, it is

Table 5. Percent Composition of Food Organisms Ingested by Dolly Varden Captured in Debris Covered and Debris Free Areas of Spring Pond Creek, 1974.

	Debris Covered Areas N=42		Debris Free Areas N=42		Total	
	No.	% Comp.	No.	% Comp.	No.	% Comp.
Turbellaria sp.	0		0		0	
Oligochaeta	0		1	.1	1	.1
Ostracoda	0		0		0	
Pelecypoda	55	6.4	31	4.3	86	5.5
A. sparsatus	1	.1	2	.3	2	.2
B. bicaudatus	12	1.4	87	11.9	99	6.2
Cinygmula sp.	2	.2	11	1.5	13	.8
Paraleptophlebia sp.	1	.1	14	1.9	15	.9
Ephemerella (D.) *grandis*	0		2	.3	2	.1
Nemoura sp.	10	1.2	11	1.5	21	1.3
Leuctra sp.	0		1	.1	1	.1
Capnia sp.	2	.2	3	.4	5	.3
Alloperla sp.	0		1	.1	1	.1
Rhyacophila sp.	2	.2	10	1.4	12	.8
Pycnopsyche sp.	80	9.3	24	3.3	104	6.5
Dolophilus sp.	9	1.1	34	4.7	43	2.8
Micrasema sp.	3	.3	4	.6	7	.4
Dytiscidae	9	1.1	5	.7	14	.9
Dicranota sp.	2	.2	4	.6	6	.4
Dixidae	0		2	.3	2	.1
Palpomyia sp.	0		0		0	
Chironomidae larvae	514	59.3	359	49.4	873	54.8
Chironomidae pupae	143	16.5	102	14.0	245	15.3
Simulium sp.	8	.9	9	1.2	17	1.0
Atherix sp.	0		0		0	
Terrestrials	12	1.4	10	1.4	22	1.3
Aquatic adults	2	.2	0		2	.1
TOTAL:	867	100%	727	100%	1594	100%

Table 6. Organic Weights (mg) of Benthic Organisms Ingested by Dolly Varden Inhabiting Debris Free and Debris Covered Areas of Spring Pond Creek.

	Organic Wt. (mg)		Debris Free Areas N=42			Debris Covered Areas N=42		
	Number Tested	Average Weight	Number Consumed	Weight (mg) (% Comp.)	Weight Index	Number Consumed	Weight (mg) (% Comp.)	Weight Index
Rhyacophila sp.	22	3.0	10	30.0 (19.5%)	.057	0	0	0
Dicranota sp.	10	2.0	4	8.0 (5.21%)	.015	2	4.0 (2.1%)	.006
Pycnopsyche sp.	3	1.6	24	38.4 (25.0%)	.073	80	128.0 (67.6%)	.208
Alloperla sp.	136	.6	1	.6 (.4%)	.001	2	1.2 (.6%)	.009
Leuctra sp.	68	.6	1	.6 (.4%)	.001	0	0	0
Paraleptophlebia sp.	49	.4	14	5.6 (3.7%)	.010	1	.4 (.2%)	.0006
Ameletus sparsatus	35	.4	2	.8 (.5%)	.001	1	.4 (.2%)	.0006
Nemoura sp.	66	.3	11	3.3 (2.1%)	.006	0	0	0
Baetis bicaudatus	159	.3	87	26.1 (17.0%)	.049	12	3.6 (1.9%)	.005
Cinygmula sp.	21	.2	11	4.2 (2.7%)	.008	2	.4 (.2%)	.0006
Chironomidae larvae	127	.1	359	35.9 (23.4%)	.068	514	51.4 (27.4%)	.083
TOTAL:			524	153.5 (100%)		614	189.4 (100%)	

Table 7. Movement of Young Dolly Varden and Coho Salmon Through Skunk Cabbage Creek Weir, Fall 1974. Taken in Five Day Intervals.

	Dolly Varden			Coho		
	Upstream	Downstream	Net	Upstream	Downstream	Net
9/13- 9/15/74	146	25	121	66	16	50
9/18- 9/22/74	44	21	23	32	1	31
9/23- 9/27/74	18	7	11	3	3	0
9/28-10/02/74	18	8	10	4	0	4
10/03-10/07/74	5	1	4	4	1	3
10/08-10/12/74	67	21	46	10	2	8
10/13-10/17/74	40	0	40	2	6	-4
10/18-10/22/74	Weir non-operational due to flooding.					
10/23-10/27/74	Weir non-operational due to flooding.					
10/28-11/01/74	3	0	3	2	0	2
11/02-11/06/74	3	0	3	0	0	0
11/07-11/11/74	5	10	-5	3	3	0
11/12-11/16/74	4	2	2	0	2	-2
11/17-11/21/74	Water depth zero. No movement.					
11/22-11/26/74	0	0	0	0	0	0
11/27-11/31/74	0	1	-1	0	1	-1
12/01-12/05/74	0	0	0	0	0	0
12/06-12/10/74	0	1	-1	0	0	0
TOTAL:	353	97	256	126	35	91

possible that these fish are displaced downstream by fall spates. At this time water temperatures reach the 4°C threshold and all movement ceases until the spring season. The following is a summary of population estimates combined with in-migrations:

	Dolly Varden	Coho	Total
Estimated 8/3/73	239	222	465
Estimated 9/28/73	605	183	799
Estimated 11/27/73	155	346	421
December 1973	Stream dry--heavily frozen.		
Estimated 4/17/74	314	136	448
Estimated 9/12/74	326	438	728
In-migration	255	92	347
Calculated Population	581	531	1074
10/18 to 10/27/74	Heavy flooding--weir inoperative.		
Estimated 11/14/74	327	495	641
December 1974	Stream dry--heavily frozen.		

Winter Temperatures and Icing Conditions:

Little work was conducted on this portion of the study this year. However, water temperatures monitored periodically during the winter months indicate temperatures that hovered around .5°C during most of January.

Large pools, normally 2 feet deep during the summer months, are reduced to only a few inches deep and often freeze down to the substrate. Freezing conditions are compounded by extremely low discharge, water flow during most of the winter being reduced to intergravel perculation.

Because of low water levels, fish become trapped in the stream during the winter months and may incur heavy mortality. However, the magnitude of the mortality is still subject to speculation until more adequate and meaningful data can be collected during January and February 1976.

DISCUSSION

Effects of Debris on the Aquatic Environment

This seasons' work at Spring Pond Creek has revealed that accumulation of logging debris has significantly changed the character of the original streambed. Of 189 sample points in the stream, approximately 85% were covered with logging debris introduced during logging.

The introduction of logging debris to the stream probably resulted in changes in the structure of the aquatic communities living in the substrate, as two distinct insect communities have developed in the study stream. Egglishaw (1964) and Mackey (1969) found that distinct insect communities were associated with varying amounts of debris, and that debris is a major contributor to the trophic system of streams, (Chapman and Demory, 1963; Hynes et al. 1974;

Mackay 1969; Minshall, 1967) since it serves both directly and indirectly as food for certain species of aquatic insects.

The average size and diversity of the insect community that has developed in debris-laden areas of Spring Pond Creek has resulted in a lower biomass per unit of area than that of undisturbed areas. Organisms living in gravel areas are generally larger in size and of greater diversity. This difference should ultimately be of significance to fish feeding in undisturbed sections of the stream.

Clearance of debris and slash materials may effect the benthic community by increasing the amount of habitat for gravel dwelling invertebrates in the test section. However, removal of slash may also result in a loss of cover for juvenile fish (Bustard and Narver, 1975), and cause a decrease in standing crop in the test section.

Effects of Winter Conditions on Survival of Fish

Lister and Walker (1966) found that survival of juvenile fish was greater in streams with stable discharges. Overwinter survival is also increased in streams with warmer winter temperatures (Hunt, 1969). Spring Pond Creek, due to its ground water source, exhibits very stable discharges and warmer winter temperatures than does the mainstream of Starrigavin and runoff tributaries such as Skunk Cabbage Creek. Bustard and Narver (1975) demonstrated that survival of juvenile coho in small tributary streams was approximately 76%. Survival of indigenous juvenile Dolly Varden overwintering in Spring Pond Creek was approximately 75% but the in-migrant population apparently suffered mortality as high as 35%.

The relatively low winter temperatures of Spring Pond Creek may possibly be attributed to logging and loss of the insulative value of the forest canopy. Skunk Cabbage Creek, a runoff stream which has also been clear-cut logged develops extremely heavy ice conditions, often freezing down to the substrate in many of the deeper pools. Riffle areas of this stream are completely frozen in during the winter. It is doubtful if many fish can survive conditions of this nature.

In-migration of Fish into Tributary Streams

The upstream movement of juvenile fish into tributaries of Starrigavan watershed is not unique to the system. Skeesick (1970) has demonstrated that juvenile coho immigrate into tributary streams to overwinter, and leave as smolts that following spring. Bustard and Narver (1975) have also demonstrated that coho and steelhead immigrate and overwinter in small tributaries. Apparently, winter conditions found in small streams offer a greater survival benefit to fish than those in mainstream areas, probably due to more stable discharge and temperature regimes.

ACKNOWLEDGEMENTS

The authors would like to extend their appreciation to Steven Haavig, the field biologist at the Starrigavin study site, and to Doris Kirchhofer and Luann McVey, who conducted the laboratory work presented in this paper.

LITERATURE CITED

Bustard, D. R. and D.W. Narver. 1975. Aspects of the winter ecology of juvenile coho salmon (Oncorhynchus kisutch) and steelhead trout (Salmo gairdneri). J. Fish. Res. Board Can. 32:667-680.

Chapman, D.W. and R.L. Demory. 1963. Seasonal changes in the food ingested by aquatic insect larvae and nymphs in two Oregon streams. Ecol. 44:140-146.

Elliott, S.T. and R.D. Reed. 1974. Ecology of rearing fish. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1973-1974, Project F-9-6, 15 (D-I):9-43.

Egglishaw, H.J. 1964. The distributional relationship between the bottom fauna and plant detritus in streams. J. Anim. Ecol. 33:463-476.

Hunt, R.L. 1969. Overwintering survival of wild fingerling brook trout in Lawrence Creek, Wisconsin. J. Fish. Res. Bd. Canada 26:1473-1483.

Hynes, H.B.N., N.K. Kaushik, M.A. Lock, et al. 1974. Benthos and allochthonous organic matter in streams. J. Fish. Res. Bd. Canada 31(5):545-553.

Lister, D.B. and C.E. Walker. 1966. The effect of flow control on freshwater survival of chum, coho, and chinook salmon in the Big Qualicum River. Can. Fish. Cul. Vol. 37:3-26.

Mackay, R.J. 1969. Aquatic insect communities of a small stream on Mont. St. Hilaire, Quebeck. J. Fish. Res. Bd. Canada. 26(5):1157-1183.

Minshall, G.W. 1967. Role of allochthonous detritus in the trophic structures of a woodland spring brook community. Ecol. 48:139-149.

Skeesick, D.G. 1970. The fall immigration of juvenile coho salmon into a small tributary. Res. Rept. Dept. Fish Comm. Oregon. 2(1):90-95.

Prepared by:

Steven T. Elliott
Fishery Biologist

Approved by:

S/Michael Kaill
Chief/Sport Fish Research

S/Rupert E. Andrews
Director/Division of Sport Fish