FEDERAL AID IN FISH RESTORATION

STUDY D-I

A STUDY OF LAND USE ACTIVITIES AND THEIR RELATIONSHIP TO THE SPORT FISH RESOURCES IN ALASKA

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Annual Performance Report for

A STUDY OF LAND USE ACTIVITIES AND THEIR RELATIONSHIP TO THE SPORT FISH RESOURCES IN ALASKA

by

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RESEARCH PROJECT SEGMENT

State: ALASKA Name: Sport Fish Investigations of Alaska

Project No.: F-9-8

Study No.: D-I 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, 1975 to June 30, 1976

ABSTRACT

This report summarizes the third season's work concerning the effects of logging practices on juvenile Dolly Varden, *Salvelinus malma* (Walbaum), and coho salmon, *Oncorhynchus kisutch* (Walbaum). Emphasis of the study is placed on determining the effects of the removal of logging debris on juvenile fish populations in small streams and on macrobenthos populations; the comparison of winter survival of juvenile salmonids wintering in spring-fed tributary streams and runoff streams; and the effects of forest canopy removal on winter temperatures and ice conditions in small salmonid rearing streams.

Population estimates in Spring Pond Creek, a small spring-fed stream, show a 30% difference in population size between November and the ensuing spring months (winter mortality). Winter population estimates have a mean of 1,085, with standard deviation of 182. Comparisons of winter mortality in runoff streams could not be made this year due to problems with high water and damage to the weir structure.

Population estimates of juvenile char in Spring Pond Creek have been conducted since 1973 to gather base-line data for experimental logging debris removal. The winter carrying capacity of the stream has been established to be approximately 1,200 juvenile char with a standing crop of 1.40 fish per m^2 (15.7 g/m^2). Experimental cleaning of the stream will take place in July, 1976. Study of the effects of logging debris on aquatic macroinvertebrates has shown that certain species, especially the mayfly, *Baetis bicaudatus* Dodds, have been eliminated from debris-littered areas. The loss of this species, and others, has reduced the biomass of macroinvertebrates in littered areas by as much as 50%.

A review of literature on the effects of canopy removal on ice and temperature conditions of small streams during the winter has revealed that forested areas tend to be warmer than nonforested areas and that streams without a canopy are more prone to develop anchor and frazil ice, which can be lethal to fish populations. A review of available literature also indicates that frost penetration in soils occurs earlier in the year and penetrates deeper in clear-cut areas than in forested areas. This may have considerable effect on groundwater temperatures, and thus stream temperatures.

BACKGROUND

Surveys of 21 logged watersheds in Southeast Alaska during the 1971-1972 field season indicated that a number of issues regarding the impact of logging on the aquatic environment had not been adequately addressed.

The surveys showed (Reed and Elliott, 1972) that many streams in Southeast Alaska had been altered by heavy accumulation of organic debris and slash from clearcutting operations. In most cases the debris accumulations were large enough to warrant removal in order to restore the stream to its original condition.

Another issue that warranted investigation was the value of small streams, especially spring-fed streams, to winter survival of juvenile salmonids. Past research at Hood Bay Creek, Alaska, suggests that young Dolly Varden, *Salvelinus malma* Walbaum, and coho salmon, *Oncorhynchus kisutch* (Walbaum), migrate upstream to warmer, spring-fed tributaries to overwinter (Blackett, 1968).

Temperature monitoring of these streams revealed stable temperatures of 5.0°-6.1°C while the main stream froze and developed heavy ice formations.

The effect of canopy removal on the winter stream environment is also poorly understood. Green (1950) indicates that lower temperatures are experienced during the winter in exposed streams. This may cause detrimental ice conditions and delay development of incubating salmon eggs.

In order to investigate these areas of concern, Job D-I-B, Ecology of Rearing Fish, was created under the auspices of the Land Use Study.

In 1972 one year's preliminary work was undertaken at Kadashan Creek. During this time methods of making population estimates were investigated (Elliott and Reed, 1973). The following year the study was moved to Starrigavan Creek near Sitka.

The first year at the Starrigavan site was devoted to the study of seasonal movement patterns of juvenile fish. It was established that many juvenile coho and Dolly Varden seek tributaries during the fall months (Elliott and Reed, 1974). Studies of overwinter survival and population dynamics were begun the following year in preparation for mortality studies and experimental debris removal (Dinneford and Elliott, 1975).

RECOMMENDATIONS

Procedures

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

    a. Determine the carrying capacity of Spring Pond Creek in terms of biomass and abundance of fish prior to and after debris removal. Debris removal will be conducted in July, 1976. Estimates of population size and biomass will be made using minnow-trap methods and by monitoring fish movement through a small migrant fish weir.

    b. Determine the biomass, standing crop, and species diversity of the macrobenthos prior to and after debris removal.

    c. Determine the transport of fine particulate debris and macrobenthos out of Spring Pond Creek before, during, and after debris removal.

    d. Determine the feeding habits of rearing fish populations after cleanup by taking samples for stomach analysis.

    e. Monitor streamside vegetation regrowth and debris breakdown by means of systematic photo documentation.

    f. Re-map stream after cleanup to determine effectiveness of cleaning operation.

    g. A small stream similar to Spring Pond Creek will be weired to serve as a control prior to and after debris removal.

2. Determination of the importance of spring-fed tributaries for the overwinter survival of rearing fish will be accomplished by:

    a. Monitoring the movement of rearing fish into and out of spring-fed and runoff tributaries. Migrant weirs have been built on two systems to monitor this movement.

    b. Establish minimum and maximum carrying capacity and determine the survival rate over the winter period using various estimating techniques in spring-fed and runoff streams.

    c. Monitor water temperature, air temperature, water depth, and water velocity differences between spring-fed and runoff systems.

    d. Monitor the movement of rearing fish in the watershed to determine how other tributaries are utilized.

    e. Monitor smolt out-migration of other tributaries to help determine smolt production in the watershed.

3. Determination of methods for future research on the effects of canopy removal on temperature and ice conditions of small streams during the winter months will be accomplished by:

   a. Conducting a literature search on monitoring methods that can determine the effects of canopy removal on groundwater temperature, frost depth, ice development, and ice penetration.

   b. Continue the search for an adequate study site. Study site must meet the following criteria:

      (1) Have an adequate number of tributary streams

      (2) Must be accessible during the winter

      (3) Must be destined to be logged by 1978 to assure adequate prelogging data.

4. Distribution, abundance, and species diversity of macrobenthos and its relationship to rearing fish populations will be accompanied by:

   a. Collection and identification of aquatic insects

   b. Obtaining data on biomass, standing crop, and distribution of species

   c. The above will be compared with estimates of fish abundance and biomass to determine if a correlation exists.

OBJECTIVES

1. To determine the effects of logging debris removal on fish populations in small streams.

2. To determine the importance of spring-fed tributaries for overwinter survival of rearing fish.

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

4. To determine distribution, abundance, and species diversity of macrobenthos and its relationships to rearing fish populations.

TECHNIQUES USED

Spring-Fed Tributary Study

To determine if spring-fed streams provide a better wintering environment than runoff streams, small migrant weirs were placed on Spring Pond Creek (spring-fed) and Skunk Cabbage Creek (runoff) to count migrating juveniles that move into the streams each fall to overwinter. Population estimates were made periodically throughout the season using Chapman's modification of the Peterson estimate or the Schnabel method:

Adjusted Peterson Estimate

$$N = \frac{(m + 1)(c + 1)}{(R + 1)}$$

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

Schnabel Estimate

$$N = \frac{\Sigma(C_t M_t)}{\Sigma R_t}$$

$$N \pm Z_{\alpha} \sqrt{R_t}$$

Estimates were made to ascertain seasonal changes in population size related to migration into and out of the tributaries and to determine maximum carrying capacity.

To determine the survival rates of juveniles in both streams over the 1975-1976 winter period, the following statistic was used:

$$S = \frac{R_{12} M_2}{M_1(R_{22} + 1)}$$

$$R(S) = S^2\left(\frac{1}{R_{12}} + \frac{1}{R_{12}} - \frac{1}{M_1} - \frac{1}{M_2}\right)$$

Populations of coho and Dolly Varden (about 50% of the wintering population) have already been marked during fall 1975. Mortality estimates will be completed in the spring prior to out-migration.

Debris Removal Study

To determine if the debris removal has any effect on fish populations in Spring Pond Creek, an accurate estimate of maximum carrying capacity prior to and following cleaning is required. These estimates have been made, using minnow traps and the Peterson estimate technique.

Peterson estimates were taken throughout the season to determine the population size during the year and also to indicate the overwinter carrying capacity. Estimates taken by these means will be used as baseline data for debris removal experiments.

A small debris-littered, spring-fed stream near Spring Pond Creek was selected as a control for debris removal experiments; and periodic estimates were conducted at this site.

Analysis of the macrobenthos population is also being conducted at the study site. Invertebrates are collected from the substrate with a surber sampler (.093 m^2 - 280 micron mesh) and drift sampler (.093 m^2 - 280 micron mesh) to determine benthos populations in debris littered and nonlittered areas. Specimens are frozen in water and shipped to Juneau where they are counted and the ash-free dry weight calculated.

A sample of 120 fish (10% of maximum population) were captured during the year for determination of age, sex, weight, and stomach contents.

Food profiles were constructed from the samples and compared to benthos and drift samples to determine if any correlation exists.

Canopy Removal Study

Most of the work conducted on this study was confined to a review of literature concerning techniques used in measuring the effects of icing on small stream environments.

FINDINGS

Spring-Fed Tributaries and Their Importance

Timing and Magnitude of Migrations:

Since this study was initiated in 1973, Spring Pond Creek has received annual fall in-migrations of juvenile Dolly Varden and coho. The young fish begin their migration into the tributary in September. Peak migration is usually in late September and early October and ceases by December (Table 1).

During fall 1975, however, Spring Pond Creek unexpectedly received a very small run of juvenile Dolly Varden. The number of in-migrating coho, however, was approximately the same as observed in prior years. Net movements of juvenile fish from fall 1973 to the current season are listed below:

	Dolly Varden	Coho
Fall In-migration		
1973	187	24
1974	171	47
1975	52	59
Spring Out-migration		
1974	330	42
1975	28	36

Movement pulses that did occur corresponded with freshets in the mainstream (Figure 1), indicating that the tributary is probably used as a velocity shelter by juveniles.

Table 1. Movement of Young Dolly Varden and Coho Salmon Through Spring Pond Creek Weir in Five-Day Intervals, 1975.

	Dolly Varden			Coho		
Interval	Upstream	Downstream	Net	Upstream	Downstream	Net
4/ 4-4/ 8	0	0	0	0	0	0
4/ 9-4/13	0	0	0	0	0	0
4/14-4/18	2	1	1	0	0	0
4/19-4/23	0	0	0	0	0	0
4/24-4/28	0	3	-3	0	0	0
4/29-5/ 3	1	0	+1	0	0	0
5/ 4-5/ 8	0	3	-3	0	0	0
5/ 9-5/13	2	2	0	0	1	-1
5/19-5/23	1	3	-2	0	2	-2
5/24-5/28	1	3	-2	0	6	-6
5/29-6/ 2	0	3	-3	0	6	-6
6/ 3-6/ 7	2	4	-2	0	0	0
6/ 8-6/12	0	1	-11	0	3	-3
6/13-6/17	0	3	-3	0	5	-5
6/18-6/22	0	3	-3	0	5	-5
6/23-6/27	0	1	-1	0	2	-2
6/28-7/ 2	7	9	-2	0	0	0
Spring Out-migration						
Total	16	39	-24	0	30	-30
7/ 3-7/ 7	1	1	0	0	2	-2
7/ 8-7/12	0	4	-4	2	1	1
7/13-7/17	5	5	0	1	0	1
7/18-7/22	1	0	1	4	0	4
7/23-7/27	1	1	0	1	0	1
7/28-8/ 1	1	1	0	3	0	3
8/ 2-8/ 6	4	2	2	1	0	1
8/ 7-8/11	3	1	2	2	0	2
8/12-8/16	1	0	1	2	1	1
8/17-8/21	0	2	-2	2	1	1
8/22-8/26	2	1	1	2	0	2
8/27-8/31	0	1	-1	2	0	2
Static Period						
Total	19	19	0	22	5	17

Table 1. (Cont.) Movement of Young Dolly Varden and Coho Salmon Through Spring Pond Creek Weir in Five-Day Intervals, 1975.

	Dolly Varden			Coho		
Interval	Upstream	Downstream	Net	Upstream	Downstream	Net
9/ 1- 9/ 5	0	0	0	2	0	2
9/ 6- 9/10	3	2	1	14	0	14
9/11- 9/15	0	0	0	2	0	2
9/16- 9/20	7	0	7	4	0	4
9/21- 9/25	12	0	12	5	0	5
9/26- 9/30	3	2	1	6	0	6
10/ 1-10/ 5	12	1	11	14	0	14
10/ 6-10/10	2	0	2	5	0	5
10/11-10/15	6	0	6	4	0	4
10/16-10/20	4	0	4	1	0	1
10/21-10/25	4	2	2	2	0	2
10/26-10/30	3	0	3	0	0	0
10/31-11/ 4	3	0	3	0	0	0
11/ 5-11/ 9	0	0	0	0	0	0
Fall In-migration						
Total	59	7	52	59	0	59

The 1975 spring out-migration of smolt and juveniles that overwintered in the tributary during the winter of 1974-1975 was also much smaller than expected. However, water temperatures eliciting migration (approximately 4°C) were somewhat depressed during most of the month of May (Figure 2) and may have resulted in the loss of volitional migration behavior. Just upstream of the Spring Pond Creek weir a number of Dolly Varden smolt were observed holding underneath litter cover and undercut banks. These fish remained there until July but never left the tributary.

Downstream movement of juveniles and smolt may have been inhibited or impeded by the Spring Pond Creek weir; or Spring Pond Creek fish, during their long stay in the stream, may have learned to avoid the structure. This is considered unlikely, as fish that wintered there in 1973 passed the weir with no apparent problem (Elliott, 1974). Skunk Cabbage Creek weir, an identical structure, consistently passes fish without any indication that their movement is impeded. Many fish in Skunk Cabbage Creek have been exposed to the presence of the weir as long as those in Spring Pond Creek. This indicates that learned avoidance may not be a factor in lack of movement.

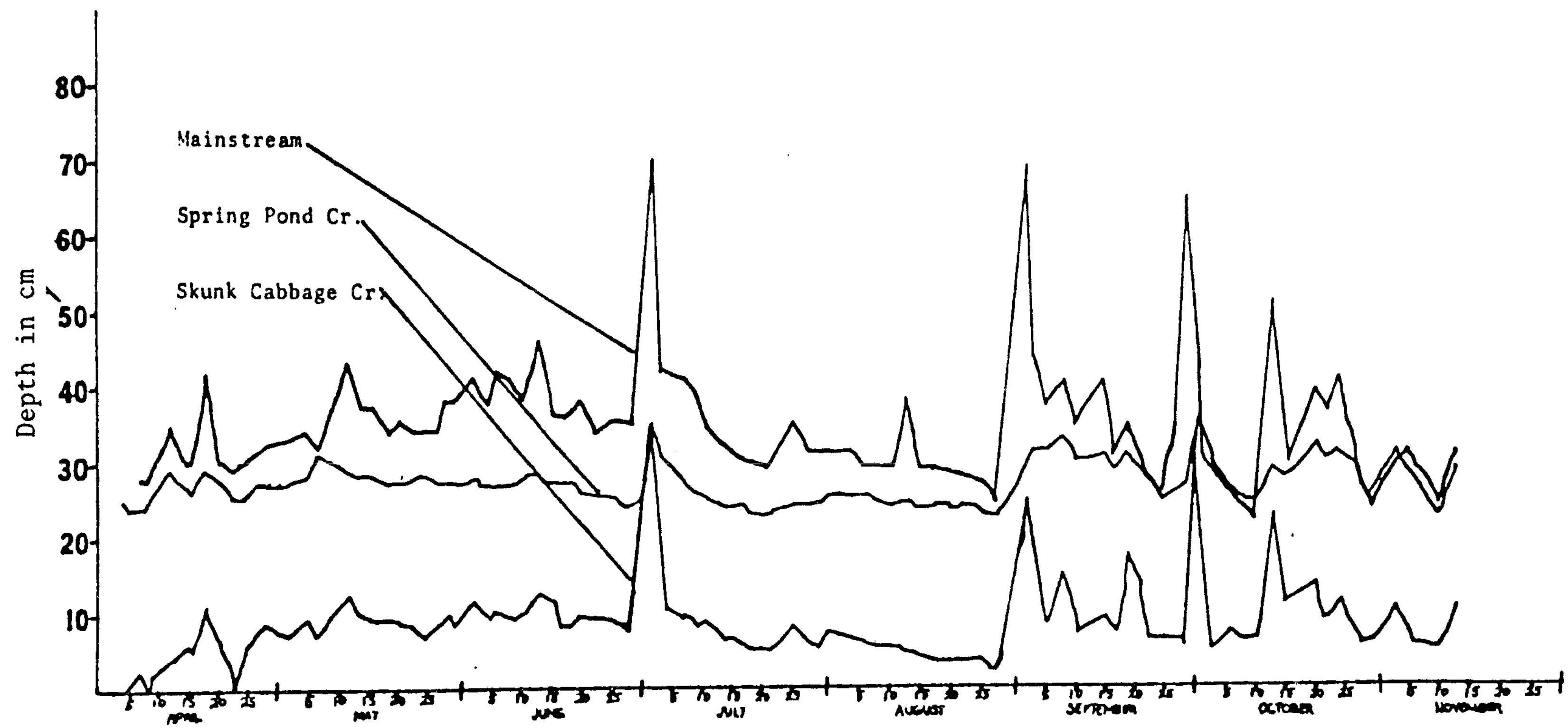

Figure 1. Water Depth Measured in Spring Pond Creek, Skunk Cabbage Creek, and Mainstream of Starrigavan Creek Watershed, 1975.

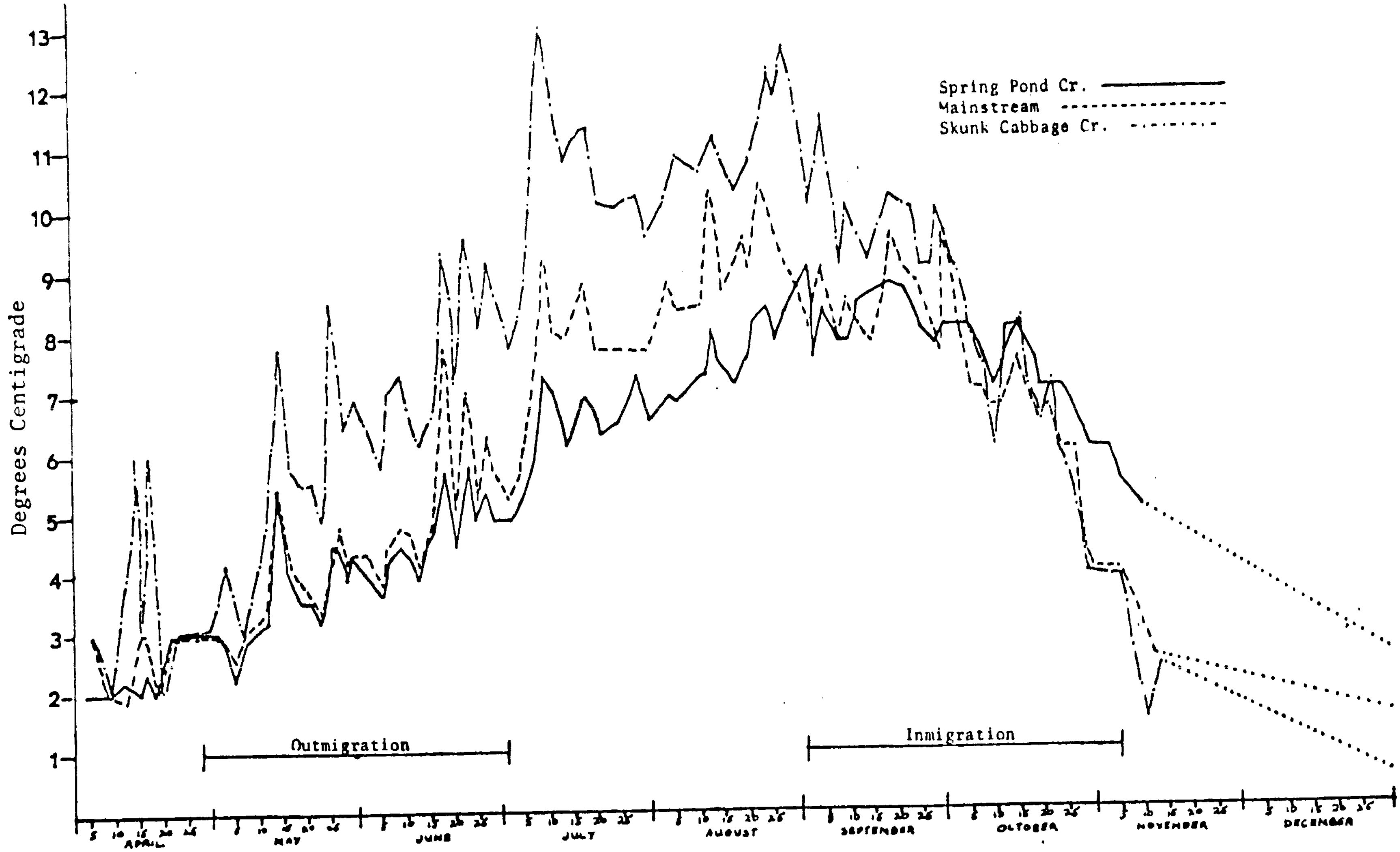

Figure 2. Temperature Regimes of Spring Pond Creek, Skunk Cabbage Creek, and the Mainstream of Starrigavan Watershed, 1975, With Periods of Migration Indicated.

Winter Mortality in Spring-Fed Tributaries:

The difference between consecutive population estimates in Spring Pond Creek (Table 2) indicates a loss of approximately 370 fish between September, 1974 and July, 1975. Taking out-migration into account, is 31.8% of the wintering population. These estimates are compatible with mortality estimates for winter 1973-1974. Estimates indicate an estimated mortality range of 16.9% (145.6 char) to 22.9% of the 1973-1974 wintering population (197.3 char).

Comparative population and mortality estimates in Skunk Cabbage Creek have been hampered by high water flows that necessitated weir removal on several occasions during the 1974 in-migration season. Estimates conducted after freshets in 1974 indicated a loss of approximately 40% of the population of juvenile Dolly Varden and coho. These losses could possibly be attributed to displacement during the flood. Estimates and in-migration figures are as follows:

	Dolly Varden	Coho	Total Community
Estimate 9/12/74	326 (291-361)	439 (352-519)	728 (690- 766)
In-migration	255	92	347
Calculated Population	581 (546-616)	531 (449-611)	1,074 (1,037-1,113)
Estimate 11/14/74	327 (301-353)	439 (426-452)	641 (612- 670)
Estimate 11/6/75	517 (484-550)	467 (441-493)	974 (931-1,017)

During the 1975 fall season, the weir was maintained without loss of data. Fall population estimates show approximately the same population size as in 1974; this suggests that a large portion of the overwintering population in 1974 was displaced by floods.

Fieldwork in the 1974 summer season has revealed that a small tributary flowing into Skunk Cabbage Creek is spring-fed and may contribute to the winter survival and carrying capacity of the Skunk Cabbage Creek system. Population level estimates concerning this stream reveal the following:

	Dolly Varden	Coho	Total
Estimate 10/14/75	576 (566-586)	381 (374-388)	949 (937-961)

This increases the estimate of winter carrying capacity to approximately 2,000 juvenile Dolly Varden and coho in the Skunk Cabbage Creek system.

The abilities of Spring Pond Creek and Skunk Cabbage Creek to absorb overwintering juveniles from the mainstream are approximately the same.

Table 2. Population Estimates of Juvenile Dolly Varden and Coho Salmon in Spring Pond Creek.*

	Dolly Varden	Coho
8/7/73	943 (853-1,033)	36 (22- 50)
9/26/73	1,051 (919-1,183)	75 (44-106)
1973 In-migration	140	24
1973-1974 Overwintering Population	1,191 (1,059-1,323)	99 (68-130)
1974 Out-migration	329	42
7/11/74	564 (461- 667)	ND
8/26/74	769 (691- 847)	ND
9/30/74	1,070 (990-1,150)	47 (12- 82)
1974 In-migration	120	46
1974-1975 Overwintering Population	1,190 (1,110-1,270)	93 (58-128)
1975 Out-migration	28	36
7/2/75	792 (701- 883)	ND
7/17/75	826 (718- 934)	ND
8/13/75	1,277 (1,195-1,359)	ND
9/12/75	1,206 (1,168-1,244)	ND
10/31/75	1,251 (1,090-1,412)	ND
1975 In-migration	3**	59***
1975-1976 Overwintering Population	1,254 (1,093-1,415)	ND

*95% confidence limits in parenthesis.
**In-migration following 10/31/75 estimate.
***Total in-migration.

Both streams accepted a net in-migration of approximately 15-16% of the overwintering population (see Table 3). However, floods and freezing conditions in Skunk Cabbage Creek may reduce the long-term ability of the stream to winter juveniles in contrast to Spring Pond Creek, which exhibits stable flow and temperature regimes. Winter mortality studies initiated during fall 1975 will be completed in the spring and should reveal significant information on winter mortality in these two types of streams.

Debris Removal Study

This portion of the study is designed to ascertain the difference in carrying capacity between; Spring Pond Creek hand cleared of logging debris, and that creek prior to debris clearing. 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.

Estimates of Dolly Varden char in Spring Pond Creek reveal a maximum winter population of 1,200 to 1,300. Minimum population occurring during the summer months is approximately 50% of the maximum or about 500 to 700 juvenile char. The standing crop expressed in numbers and biomass/m^2 are given below:

	Dolly Varden			Coho		
	Est.	No./m^2	g/m^2	Est.	No./m^2	g/m^2
Winter 1973-1974	1,191	1.28	ND	99	.10	ND
July, 1974	564	.6	ND	47	.05	ND
Winter 1974-1975	1,190	1.28	ND	93	.10	ND
July, 1975	792	.85	ND	ND	ND	ND
Winter 1975-1976	1,254	1.40	15.70	ND	ND	ND

Fieldwork in early 1975 revealed that another spring-fed stream existed relatively close to the Spring Pond Creek study area. It, too, is heavily laden with slash and supports good populations of Dolly Varden and coho. Estimates conducted on this stream reveal its suitability as a control stream for the debris removal study:

	Dolly Varden	Coho	Total
Estimate 7/75	246 (191-301)	165 (99-231)	394 (320-474)
Estimate 10/6/75	474 (441-507)	586 (569-603)	1,054 (914-1,091)

Table 3. Movement of Young Dolly Varden and Coho Salmon Through Skunk Cabbage Creek Weir in Five-Day Intervals, 1975.

	Dolly Varden			Coho		
Interval	Upstream	Downstream	Net	Upstream	Downstream	Net
4/ 4-4/ 8	0	0	0	0	0	0
4/ 9-4/13	0	0	0	0	0	0
4/14-4/18	0	0	0	0	0	0
4/19-4/23	1	0	1	0	1	-1
4/24-4/18	2	2	0	1	1	0
4/29-5/ 3	1	24	-23	1	17	-16
5/ 4-5/ 8	0	10	-10	0	29	-29
5/ 9-5/13	5	73	-68	2	74	-72
5/14-5/18	1	5	-4	0	7	-7
5/24-5/28	0	2	-2	0	8	-8
5/29-6/ 2	0	10	-10	1	3	-2
6/ 3-6/ 7	2	6	-4	0	12	-8
6/ 8-6/12	2	4	-2	1	12	-11
6/13-6/17	6	2	4	4	2	2
6/18-6/22	0	0	0	3	10	-7
6/24-6/27	1	2	-1	3	5	-2
6/28-7 2	2	8	-6	4	1	3
Spring Out-migration						
Total	23	148	125	20	178	158
7/ 5-7/ 7	5	4	1	4	5	-1
7/ 8-7/12	2	3	-1	3	3	0
7/13-7/17	1	0	1	4	2	2
7/18-7/22	1	0	1	10	2	8
7/23-7/27	11	5	6	4	6	-2
7/28-8/ 1	1	0	1	3	1	2
8/ 2-8/ 6	2	4	-2	7	4	3
8/ 7-8/11	2	0	2	4	0	4
8/12-8/16	0	0	0	0	1	-1
8/17-8/21	0	0	0	10	1	9
8/22-8/26	0	0	0	4	1	3
8/27-8/31	0	9	-9	3	1	2
Static Period						
Total	25	25	0	56	27	29

Table 3. (Cont.) Movement of Young Dolly Varden and Coho Salmon Through Skunk Cabbage Creek Weir in Five-Day Intervals, 1975.

	Dolly Varden			Coho		
Interval	Upstream	Downstream	Net	Upstream	Downstream	Net
9/1-9/5	13	26	-13	67	1	66
9/6-9/10	14	5	9	12	1	11
9/11-9/15	10	6	4	12	1	11
9/16-9/20	3	0	3	3	1	2
9/21-9/25	13	2	11	11	4	7
10/1-10/5	0	1	-1	13	8	5
10/6-10/10	1	0	1	1	1	0
10/11-10/15	100	4	96	39	10	29
10/16-10/20	32	11	21	6	2	4
10/21-10/25	4	8	-4	5	2	3
10/26-10/30	1	1	0	0	0	0
10/31-11/4	2	1	1	2	0	2
11/5-11/9	0	0	0	0	0	0
Fall In-migration						
Total	193	65	128	171	31	140
Seasonal Totals						
	268	241	+27	284	243	+41

This stream apparently undergoes seasonal population fluctuations similar to those of Spring Pond Creek. This is probably due to in-migration of juveniles in the fall months and growth of juveniles to a size catchable by the minnow-trap method.

The Effects of Logging Debris on the Macrobenthos

Analysis of the macrobenthic fauna continues to show major differences between the benthic populations inhabiting debris-free and debris-littered substrates (Table 4). Debris-littered substrates tend to have higher concentrations of insects such as *Zapata* sp., *Parlaleptophlebia* sp., *Dolophilus* sp., and *Pycnopsyche* sp., and a slightly larger composition of Chironomidae (mostly detritivores belonging to the genus *Diamesa*). As to be expected, debris-free areas are inhabitated by more *Baetis bicaudatus* Dodds, composing nearly 20% of the total benthos population inhabiting this type of substrate.

Gravimetric analyses of sample quadrats of macroinvertebrate communities in debris-free and debris-littered areas also show a substantial difference in the total organism weight in these areas (expressed in $\bar{x}$ m^2).

	Debris-Free N = 43	Debris-Littered N = 34
Benthos	31.7 mg	17.0 mg
Drift	7.0 mg	8.7 mg

The discrepancy between the organic weights of benthic animals in debris-free and debris-littered areas is probably due to reduced populations of *B. bicaudatus*, a major food organism for juvenile salmonids.

A total of 68 insect drift samples (Table 5) taken on debris-free and debris-littered substrates showed that little difference existed between the composition of drift organisms over the two substrates. Gravimetric analysis shows that the mean weight of the drifting populations is slightly higher over debris-covered substrates, probably due to high numbers of *Pycnopsyche* sp. and *Rhyacophila* spp.

Stomach Analysis of Juvenile Dolly Varden:

Stomach analysis shows that *Pycnopsyche* spp. and Chironomidae larvae are the two most important food items for juvenile Dolly Varden in Spring Pond Creek (Table 6). *B. bicaudatus* is an important component of the diet of fish feeding in unlittered areas (14% by number and 11% by weight).

Young char may obtain Chironomidae by foraging on the bottom or feeding from the drift. *Pycnophyche* spp. is mostly captured by foraging (see Table 5).

Pycnopsyche spp. is probably the most important component of the benthis fauna in relation to fish diet because of its large size. *Pycnopsyche* spp. composed approximately 50% of the total weight of the food consumed but

Table 4. Percent Composition of Macrobenthos Collected by Surber Samples From Debris-Free and Debris-Covered Substrates, Spring Pond Creek, 1974-1975.

	Debris-Free N = 43		Debris-Covered N = 34	
Taxa	No.	% Comp.	No.	% Comp.
Hydracarina	15	.67	16	1.20
A. sparsatus	15	.67	3	.23
B. bicaudatus	430	19.26	122	9.13
Cinygmula sp.	24	1.07	20	1.50
Paraleptophlebia sp.	15	.67	39	2.92
E. grandis	2	.09	1	.07
Zapata sp.	11	.49	36	2.69
Leuctra sp.	4	.18	6	.45
Capnia sp.	1	.04		
Alloperla sp.	112	5.01	70	5.24
Rhyacophila sp.	87	3.90	61	4.57
Dolophilus sp.	20	.89	16	1.20
Pycnopsyche sp.	36	1.61	30	2.25
Micrasema sp.	7	.31	6	.45
Dytiscidae	0	0	2	.15
Dicranota sp.	59	2.64	34	2.54
Dixa sp.				
Palpomyia sp.	14	.62	3	.22
Chironomidae larvae	1,349	60.41	859	64.30
Chironomidae pupae	23	1.03	5	.37
Prosimulium sp.	3	.13	3	.23
Atherix sp.	4	.18	1	.07
Terrestrials	2	.09	1	.07
Aquatic adults	1	.04	2	.15
Total	2,234	100.00	1,336	100.00

Table 5. Percent Composition of Macrobenthos Collected by Drift Samples From Debris-Free and Debris-Covered Substrates, Spring Pond Creek, 1974-1975.

	Debris-Free N = 30		Debris-Covered N = 38	
Taxa	No.	% Comp.	No.	% Comp.
Hydracarina	33	3.78	38	4.10
A. sparsatus	1	.11	2	.22
B. bicaudatus	105	12.01	109	11.77
Cinygmula sp.				
Paraleptophlebia sp.	7	.80	9	.97
E. grandis				
Zapata sp.	11	1.26	12	1.30
Leuctra sp.				
Capnia sp.			1	.11
Alloperla sp.	8	.92	6	.65
Rhyacophila sp.			13	1.40
Dolophilus sp.	1	.11	2	.22
Pycnopsyche sp.	24	2.75	28	3.02
Micrasema sp.	5	.57	1	.11
Dytiscidae	7	.80	11	1.19
Dicranota sp.	15	1.72	11	1.19
Dixa sp.	7	.80	11	1.19
Palpomyia sp.				
Chironomidae larvae	557	63.73	598	64.58
Chironomidae pupae	42	4.81	43	4.64
Prosimulium sp.	9	1.03	9	.97
Terrestrials	5	.57	12	1.29
Aquatic adults	37	4.23	10	1.08
Total	874	100.00	926	100.00

Table 6. Stomach Analysis of Dolly Varden Captured in Spring Pond Creek, 1975, Showing Percent Composition by Number, Weight, and Index for Major Insect Taxa.

Taxa	Organic Wt. (mg) No. Tested	Organic Wt. (mg) Mean Wt. (mg)	Debris-Free N = 14 No.	% Comp.	Wt. (mg)	% Comp.	Wt. Index	Debris-Covered N = 17 No.	% Comp.	Wt. (mg)	% Comp.	Wt. Index
Hydracarina	2	.45										
A. sparsatus	36	.58	2	.40	1.16	.64	.0023					
B. bicaudatus	173	.30	70	14.00	21.00	11.61	.0420	38	7.90	11.40	4.77	.0237
Cinygmula sp.	26	.22	1	.20	.22	.12	.0004	6	1.25	1.32	.55	.0011
Paraleptophlebia sp.	39	.56	1	.20	.56	.31	.0011	3	.62	1.68	.70	.0034
E. grandis	ND		1	.20								
Zapata sp.	69	.35										
Leuctra sp.	68	.60	1	.20	.60	.33	.0012					
Alloperla sp.	173	.78						3	.62	2.34	.98	.0048
Rhyacophila sp.	36	3.71	1	.20	3.71	2.05	.0074	3	.62	11.13	4.66	.0231
Dolophilus sp.	2	.85	18	3.60	15.30	8.46	.0306	24	4.99	20.40	8.54	.0424
Pycnopsyche sp.	7	5.07	18	3.60	91.26	50.46	.1825	26	5.41	131.82	55.16	.2740
Micrasema sp.	ND							1	.21			
Dytiscidae	ND		3	.60				21	4.37			
Dicranota sp.	19	1.87	2	.40	3.74	2.07	.0074	3	.62	5.61	2.35	.0116
Dixadae sp.	ND		4	.80				3	.62			
Chironomidae larvae	181	.19	228	45.60	43.32	23.95	.0866	274	56.97	52.06	21.79	.1082
Chironomidae pupae	ND		145	29.00				54	11.23			
Prosimulium sp.	2	.30						4	.83	1.20	.50	.0024
Atherix sp.	3	2.03										
Terrestrials			5	1.00				9	1.87			
Aquatic adults								9	1.87			
Total			500	100.00	180.87	100.00		481	100.00	238.96	100.00	

amounted to only 3-5% of the total weight of insects consumed. Conversely, Chironomidae larvae composed 45-56% of the number of animals consumed but only formed 21-23% of the total estimated weight of the diet. If we make the assumption that fish utilize the same amount of energy to capture and digest a Chironomidae larva as a Pycnopsyche spp., the benefit to the fish resulting from the larger food organism is readily apparent.

Canopy Removal Study

This study has involved a search of the literature to determine the methods needed to properly conduct research into the effects of canopy removal on the winter stream environment. The following summarizes some of the more pertinent literature.

No evidence exists directly linking canopy removal to adverse icing conditions during winter months. However, Barnes et al. (1974) states that trees can be warmer than the snow due to absorption of solar radiation reflected off the surrounding snow surfaces. Nonforested areas can lose heat in the form of radiation which can result in the supercooling of stream waters and the formation of anchor ice (Needham and Jones, 1957). Anchor ice and supercooling of stream waters never occurs in areas where the stream is covered by a canopy, since radiation is reflected back into the water instead of being lost (Barnes, 1906).

Barnes (1906) reports anchor ice carrying large chunks of stream-bottom aggregate downstream. This transportation of bottom material can cause destruction of eggs and alevins through annihilation of spawning redds; however, this same activity can cause dislodgment of bottom organisms, making them available as fish food (Needham and Jones, 1959). Benson (1955) reports such distribution of bottom organisms in a Michigan stream by floating anchor ice.

Dewatering of side channels by the formation of anchor ice dams can cause suffocation to fish trapped in these areas (Maciolek and Needham, 1952). Minor flooding can occur when these dams break, but it is generally felt these floods cause less disturbance than normal freshets.

Drifting frazil ice often tends to accumulate on anchor and/or surface ice, thus creating ice dams which can cause the problems discussed previously. However, the most direct detrimental effect frazil ice can have upon fish is that observed by Tack (1938). Tack reported that particles of drifting frazil ice actually became lodged in the gills of rainbow fingerlings, Salmo gairdneri Richardson, being held in an outdoor rearing pond. The ice accumulation was severe enough to cause about 100 mortalities.

Frazil ice (from the French Canadian term for fine spicular ice) forms throughout the water column as minute, irregular crystals (Maciolek and Needham, 1952). Greatest accumulations usually occur on cold, clear, windy nights when the water surface is agitated. It never forms under opaque surface ice. Frazil ice is formed under the same type of conditions as anchor ice, e.g., from loss of heat in the form of radiation. Streams enclosed by a timber canopy may not develop either anchor or frazil ice, as much of the radiation reflected from the stream is returned by surrounding vegetation.

Ice Observation at the Starrigavan Watershed:

Due to cutbacks in manpower this winter, no work was accomplished at the Starrigavan Creek study site after November. However, plans are being laid to develop a canopy removal study that will assume job status upon completion of the Starrigavan studies.

DISCUSSION

Spring-Fed Tributary Study

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 groundwater source, exhibits very stable discharges and warmer winter temperatures than does the main stream of Starrigavan and runoff tributaries such as Skunk Cabbage Creek. Bustard and Narver (1975) have also demonstrated that coho and steelhead, S. gairdneri Richardson, immigrate into and overwinter in small tributaries. Apparently, conditions found in small streams offer a greater survival benefit during the winter than those found in main stream areas.

Debris Removal Study

Continued work with the macrobenthos of Spring Pond Creek shows that definite relationships exist between debris-littered areas and the fauna that inhabit them.

The introduction of logging debris to the stream has 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, a detritivore and a detritivore-gatherer community. Gathering species such as B. bicaudatus have almost been eliminated from areas covered by detrital material, due in part to the feeding habits of B. bicaudatus, an algal and fine detrital feeder (Gilpen and Brusven, 1970). 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 (Cummins, 1975; Madsen, 1972; Triska and Sedell, 1975), since it serves as food for certain species of aquatic insects.

Changes in the community structure of the benthos in debris-littered areas is also reflected by changes in biomass. Areas covered with debris are generally much lower in biomass/m^2 than undisturbed areas. This may be due to the larger size and greater diversity of species in undisturbed areas. This difference should ultimately be of significance to fish feeding in unlittered 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. However, removal of slash may also result in a loss of cover for juvenile fish (Bustard and Narver, 1975) and cause a decrease in the standing crop of young salmonids.

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